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Evaluation of the Operational and Financial Sustainability of Water Purification Plants in the Yucatán Peninsula, Mexico

By

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Master of Public Health

Global Health

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Committee Chair

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By

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B.A.
University of Chicago
2006

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An abstract of
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Evaluation of the Operational and Financial Sustainability of Water Purification Plants in the Yucatán Peninsula, Mexico

By Janelle Hartman

Background: Access to clean water may reduce up to 25% of the 1.8 million deaths each year from diarrheal diseases. An estimated 300,000 people in the Yucatán Peninsula of Mexico do not have access to clean water in their homes. Living Waters for the World (LWW), a faith-based organization, partners with churches in the Yucatán to install water purification systems to increase distribution of clean water. In order to promote sustainability, LWW encourages their partners to sell the clean water to their communities at an accessible rate. LWW has not yet evaluated their model to ensure its sustainability or to find areas of potential improvement.

Objective: LWW wants to evaluate whether the people managing the water purification plants will continue to distribute clean water in their communities without long-term support from LWW. The purpose of this project was to evaluate the operational and financial sustainability of the plants in the Yucatán and LWW's model.

Methods: The researcher developed a tool to systematically evaluate the sustainability of each site. Financial records and a survey were used at 15 sites in the Yucatán to assess the sustainability of the plants in three areas: management, operations, and maintenance; cost recovery and financing; and understanding of demand. In-depth interviews were conducted at ten of those sites to understand the motivations of water plant lead operators, and analyzed for themes related to sustainability.

Results: Thirteen sites achieved a score categorized as sustainable or sustainable with reservations. Management, operations, and maintenance can improve the most, followed by understanding of demand. Motivators for operators include helping their community, improving plant performance, financial support, and positive feedback.

Discussion: Overall, LWW's plants demonstrate potential for sustainability. To improve their sustainability, LWW should: 1.) Develop and implement a consistent monitoring process for operation, maintenance, and financial activities at each site, 2.) Develop a clear maintenance schedule to post in each plant, 3.) Encourage plants to perform marketing activities, 4.) Encourage plants to create a fund for plant improvements, and 5.) Continue to promote the ministry aspect of providing water and the importance of increasing access to clean water.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Part I:
Evaluation the Operational and Financial Sustainability of Water Purification Plants in the Yucatán Peninsula, Mexico

1 INTRODUCTION

Although non-governmental water suppliers are the main source of drinking water for many people around the world, there is no standard model for independent suppliers, nor is there a complete understanding of the elements that are important for their long-term sustainability. Living Waters for the World (LWW), a faith-based organization that helps to install water purification plants in areas in need of greater access to water, emphasizes sustainability in its processes and is interested in understanding the results of their efforts.

LWW is based in Spring Hill, Tennessee and is associated with the Presbyterian Church. It was established in the early 1990s and has as its mission to enable and empower mission teams to partner with communities that do not have universal access to clean water, and to help those communities install sustainable water purification plants. LWW currently has plants in 24 countries and has grown from 36 sites in 2004 to nearly 400 in 2011 (LWW, 2011). Their goal is to improve access to clean water for the 884 million people who currently lack access to safe drinking water (WHO/UNICEF JMP, 2010). LWW trains mission teams to develop relationships with churches or other community-based organizations in communities in need of greater access to clean water. Through these relationships, the mission teams help the community organization install a water purification plant. The mission teams also establish an agreement with the community organization regarding operating procedures and plans for sustainability, including follow-up by the mission team. Plants are encouraged to sell water in order to

earn enough money to cover the costs of operating the plant. They are also encouraged to promote the mission and ministry aspects of LWW, particularly by donating water to those who cannot pay and ensuring that those in need have access to clean water.

LWW is interested in evaluating the impact they are having on the communities where they have helped to install water purification plants. As a first step to this, LWW would like to understand various aspects of the effectiveness of their model. The operational and financial sustainability of the water purification plants, discussed in this study, is only one component. Other components, discussed in the theses of Joanna Galvez (2011) and Stephen Crabbe (2011), researched consumers' use of LWW purified water and characteristics of users and nonusers, as well as the quality of LWW water both at the water treatment system and in customers' homes. Research on each of these occurred simultaneously, along with the research on sustainability. LWW will use the results of all three studies to determine areas of improvement for their model and their plants.

1.1 Problem Statement

The World Health Organization (WHO)(2005) estimated that 1.8 million people die each year from diarrheal diseases, and that 88% of diarrheal diseases are attributable to lack of safe water and adequate sanitation and hygiene. Ninety percent of those deaths are of children under 5. In Mexico, only 72% of the rural population has piped water into their homes, and there is evidence that piped water and service quality vary across socio-economic groups and between urban and rural areas (Barkin & Klooster, 2006; WHO/UNICEF JMP, 2010). Many people in communities in the Yucatán Peninsula in

Mexico do not have convenient access to clean, affordable drinking water. LWW's goal is to increase access in those communities. In order to achieve this goal, LWW will need to ensure that their existing plants will continue to operate and provide clean water to their communities. This will ensure that new plants will result in a net gain in the number of people that have access to clean water.

Although many organizations are involved in water supply projects, few have shown the ability to be sustainable several years after implementation. There is no single model that is applicable in all situations or that has been shown to be universally successful. There is particularly a lack of knowledge about the sustainability of small water enterprises in Mexico and of faith-based water suppliers, of which there are many. Although LWW is unique in some ways, information regarding its sustainability will potentially be useful for other independent water suppliers and organizations that work with them.

LWW has not yet evaluated their model to ensure its sustainability or to find areas of potential improvement. They want to evaluate whether the plants will continue to operate and whether the people managing the treatment of water will continue to distribute clean water in their communities without long-term support from LWW.

1.2 Purpose

The overall objective of this study was to evaluate the operational sustainability of water purification plants installed by LWW and their mission teams. Specific objectives were to:

1.) Develop a tool and data collection process with which to systematically assess the sustainability of small-scale water purification plants.
2.) Use the data collection instruments and the sustainability tool to evaluate the sustainability of LWW's water purification plants in the Yucatan Peninsula of Mexico.
3.) Understand the motivations of those leading the operation of the LWW plants and how those motivations influence the sustainability of the plants.
4.) Determine areas where LWW can improve its process and plants.

1.3 Significance

There is a gap in the literature about the success factors of independent water suppliers and small water enterprises, although they are the primary source of clean water for many people in the developing world (Opryszko, Huang, Soderlund, Schwab, 2009). There is not a single model that such plants can be evaluated against. This research will inform the current literature on factors influencing the success of small water enterprises, particularly those in Mexico and associated with faith-based organizations.

The number of LWW-served communities is expanding rapidly, and therefore, so is the number of people who are relying on the clean water produced from LWW's water treatment systems. Given these factors, it is important to assess whether LWW's systems are sustainable and what factors contribute to its success. Results from this research will help LWW determine what to emphasize when training their mission teams and community partners in sustainability, which factors are specific to each community, and how communities in the Yucatán Peninsula should be targeted for improvement.

Ultimately, this research will help LWW and their partners improve their programs so that they can continue to provide clean water in the communities they serve. Additionally, the research will provide information for LWW and possibly other public health student researchers to continue to assess LWW's overall impact on communities.

1.4 Definitions

Many of the terms used in this study are used and defined in a variety of ways in the literature. For this study:

- 'Operational sustainability' for LWW is defined as **the ability of properly-maintained and adequately-staffed LWW plants to exist into the future and to continue to provide clean water to their communities without long-term support, financial or otherwise, from LWW or the mission teams.**
- The term 'community' refers to **the town, village, or city area in which the plant is located and which the plant serves.** In some cases, the term community will refer specifically to the congregation of the Presbyterian church associated with the plant, and this will be made explicit.
- 'Cost recovery' is defined as the ability of plants to **fully cover the total costs of the plant, including operation, maintenance, repairs, upgrades, and expansion, using solely the revenues made from the sale of water.** In some cases, it may refer more generally to revenues on average being greater than costs, which again will be made explicit.

2 BACKGROUND AND LITERATURE REVIEW

This study aimed to understand how to comprehensively assess the operational and financial sustainability of water purification plants and to apply that knowledge to an evaluation of LWW's plants in Mexico. To do so, literature was reviewed to determine the current status and understanding of several different aspects of water supply and how they apply to LWW's model. First, the status of worldwide access to safe drinking water and factors influencing it are discussed, followed by additional factors that are specific to Mexico and the Yucatán Peninsula. Next, the current understanding of and evidence from small water enterprises and faith-based social enterprises are discussed. Finally, suggestions on how to measure sustainability and the appropriateness of existing tools to do so are examined.

Throughout, it becomes clear that much of the focus on the availability of safe drinking water and factors affecting it are specific to Africa, where the most dramatic gaps in access exist. However, there are still a significant number of people in Latin America, and Mexico specifically, that lack access to safe drinking water, and it is important to understand what can be done to improve access for them. Also, many of the problems facing water projects in Africa likely affect those in Mexico as well, although less information about the current state of water projects in Mexico is available. This is especially true of small water enterprises, even though there are a large number of small, non-state providers in Mexico. Finally, almost none of the information available on water supply projects and their sustainability is focused on faith-based enterprises, and faith may play an influential role in the sustainability of water projects. The current study will contribute to knowledge about factors affecting access to water in Mexico, the role

of small water enterprises in Mexico and factors influencing their success, the role that faith plays in influencing the sustainability of faith-based enterprises, and will evaluate the sustainability of LWW's plants using a tool that is specific to its model and appropriate for the Mexican context.

2.1 Worldwide Access to Safe Drinking Water

LWWs mission is to address a problem that affects many people around the world. Worldwide, 884 million people lack access to improved sources of drinking water. Improved sources include public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs or rainwater collection, and piped water. 84% of the people without access to any of these sources live in rural areas (WHO/UNICEF JMP, 2010).

Evidence shows that 87% of the world's population has access to improved sources of water, which is an increase of 1.8 billion since 1990, the year against which progress on the Millennium Development Goals is measured. 57% of the world's population has a piped connection in their home, though only 31% of those living in rural areas of developing countries do (WHO/UNICEF JMP, 2010).

However, despite the real gains made in the past two decades, there are several outstanding concerns regarding how gains are measured. First, the statistics available primarily only measure access to improved sources of water, not necessarily access to safe (WHO/UNICEF JMP, 2010) or operationally sustainable sources. Second, internationally recognized definitions of safe drinking water do not include water supplied by small, private water vendors since it is not considered to come from a

protected source, although they may be an important source for clean water to many around the world (Opryszko, Huang, Soderlund, & Schwab, 2009). The current study aims to shed some light on considerations for safe and sustainable water, as well as on the ability of small water vendors to improve the proportion of people with access to clean water.

2.1.1 Importance of Access to Safe Drinking Water

Access to clean water has health and other indirect benefits. The UN officially recognized access to water as a basic human right in 2010 (United Nations General Assembly, 2010). The WHO (2005) estimates that improved water supply reduces diarrhea morbidity by between 6% and 25% and that increasing access would significantly reduce the number of people that die each year from diarrheal diseases.

Other benefits of water interventions include averted health-care costs and time-savings due to closer accessibility to improved sources of water. Using data on from a cost-benefit analysis conducted by Hutton and Haller (2004), Sanctuary, et al (2005) suggest an association between improved water and sanitation and economic growth at the country level. They estimate that the potential economic benefits from increased productivity, due to lower rates of illness and increased time-savings, outweigh the costs of providing access to improved sources of water (Guy Hutton & Haller, 2004; Sanctuary, et al., 2005). Sanctuary, et al. (2005) also suggest that improved water supply attracts investment opportunities and that access to improved water sources results in higher school attendance due to decreased illness and less time spent on collecting water.

2.1.2 Increasing Access to Safe Drinking Water

According to the Joint Monitoring Program of the WHO and UNICEF, the world is on track to meet the safe drinking water part of Target 10 of Millennium Development Goal (MDG) 7, which is to halve the proportion of the population without access to safe drinking water by 2015 (United Nations, 2002). Goal 7 is the only MDG specifically addressing access to clean water. However, even then, an estimated 672 million people will still lack access to improved water sources (WHO/UNICEF JMP, 2010). In 2004, it was calculated that, to meet this target, an additional 100 million people annually, or 274,000 daily, will need to gain access to improved water sources (Sanctuary, et al., 2005). It has been estimated that the cost of achieving the MDG target for water by 2015 would be USD$11.3 billion annually, but that the potential economic gains are USD$84 billion (Guy Hutton & Haller, 2004; G. Hutton, Haller, & Bartram, 2007; Sanctuary, et al., 2005). Depending on the region, economic returns for meeting the MDG target for water were estimated at between USD$4.4 and USD$31.6 for every USD$1 invested(G. Hutton, et al., 2007).

The Millennium Development Project is one of several international commitments made to improve the problem of inadequate access to safe water. Others include Agenda 21, an action plan developed for the 1992 Earth Summit in Rio de Janeiro, Brazil, as well as the Johannesburg Plan of Implementation, in which the UN reaffirmed its commitment to the MDGs and Agenda 21 at the Earth Summit of 2002. The UN also named 2005-2015 as the Water for Life Decade (United Nations, 2010), and the World Water Assessment Programme, through the UN, was founded in 2000 to

monitor freshwater issues (UNESCO, 2011). Many organizations worldwide are involved in projects to increase access to safe drinking water.

2.1.3 Other Factors Influencing Access to Safe Drinking Water

In addition to increasing the number of improved water sources, other issues related to access need to be addressed. One is the inequality in access to water. Rural populations have lower access to improved water sources than urban populations, and research indicates that poor and less powerful groups have lower access than their counterparts (Ennis-McMillan, 2001; Moran & Batley, 2004). A second is that many improved water sources become inoperable within only a few years (Breslin, 2010; Ennis-McMillan, 2001; Skinner, 2009). Other concerns are the distance, reliability, and quality of existing sources (Carter, Tyrrel, & Howsam, 1999) and the difficulty with establishing an effective supply chain for technology and spare parts, especially for rural areas (Water and Sanitation Program, 2001). Small-scale water providers often focus their efforts in disadvantaged areas affected by one or more of these factors. Therefore quality of water and sustainability of small water enterprises are important factors for increasing access to the rural and poor.

2.1.4 Structure of Water Supply

The structure for the supply of purified, non-naturally occurring water around the world can be categorized into networked and non-networked. Networked water supply typically comes from a central source and involves a network of pipes to transmit water, often directly into homes. Non-networked supply includes discrete pieces of

infrastructure that either supply water directly or treat water and then bottle it, such as handpumps or kiosks. Networked water is typically state-provided and supply-driven (Moran & Batley, 2004), though there are examples of private networked suppliers that may be demand-driven (Solo, 2003). Non-networked water supplies are almost always private and tend to be more demand-driven (Solo, 2003).

Although urban areas typically have state-provided, networked water supply, non-networked providers often serve poorer and less central areas of cities where access to the network is not available. Research suggests that in many countries, wealthier families live in areas supplied by public and networked supply of water and pay less than poorer families that live in areas that are not serviced as well. The less wealthy are forced to pay for non-state provided water or pay an expensive fee for connection to the network (Moran & Batley, 2004). Also, state-provided networked supply often undercharges for its services, resulting in an inability to expand the network due to a lack of funds (Moran & Batley, 2004). Evidence from Latin America indicates that private networked suppliers are able to recover costs more consistently and provide connections at lower rates than publicly-provided networked water supply (Solo, 2003), although there is also evidence that they charge slightly more per volume sold (Kariuki & Schwartz, 2005). Non-networked water supply is typically more expensive than private- or state-provided networked supply. LWW is an example of private, non-networked supply, but aims to make its water supply available to the poorest members of a community. This study will consider whether that is possible and what influences the ability of an independent water provider to do so.

2.2 Access to Safe Drinking Water in Mexico

Barkin and Klooster (2006) noted that Mexico is one of the better-serviced countries in Latin America in terms of water supply, though the Organization for Economic Cooperation and Development (OECD) reported that it is one of the OECD countries where there are still significant gaps in access to water, with over 11 million people lacking access to piped water (OECD, 2006). In 2008, 94% of the population had access to improved sources, including 87% of the rural population. 87% of the population had piped water into their homes, including 72% of the rural population (WHO/UNICEF JMP, 2010). These percentages are slightly higher than the average for the entire Latin American and Caribbean region. Between 1990 and 2008, a net 6 million additional people gained access to improved water sources (WHO/UNICEF JMP, 2010). Despite these high numbers, 27% of Mexico's population, and 45% of its rural population, have reported having inadequate access to safe drinking water (Ennis-McMillan, 2001). The piped water, counted as an improved source, is often inconsistent, interrupted, and of poor quality, and it varies across socio-economic groups and between urban and rural areas (Barkin & Klooster, 2006; Ennis-McMillan, 2001; OECD, 2006; Vasquez, Mozumder, Hernandez-Arce, & Berrens, 2009). Also, evidence indicates that people without access to piped water, which are typically the poorer families, pay more – both as a proportion of their income and absolutely – for water than those who do have access to piped water (Barkin & Klooster, 2006; Ennis-McMillan, 2001; OECD, 2006).

2.2.1 Sources of Drinking Water in Mexico

Due to lack of access to piped water or the low quality of piped water supply and service, many people in both cities and rural areas in Mexico purchase water from other sources. Some purchase it from water trucks that drive through their communities, which they then store in tanks on their property, or they purchase it in individual 20-liter bottles from stores or delivery vehicles. Research indicates that piped water in Mexico is often poor quality, either due to inadequate water treatment or contamination from pipes or holding tanks (Barkin & Klooster, 2006; Vasquez, et al., 2009). Equally problematic is the lack of consistency and volume of the piped water supply in some areas. Technical reasons for inconsistency and low volume include elevation differences which cause water to flow to lower elevations, outdated infrastructure causing breakdowns and water loss, and electricity outages (Ennis-McMillan, 2001; OECD, 2006; Vasquez, et al., 2009). Social reasons are also reported, including tampering with pipes, storage and use of water for non-essential purposes, changes in the water schedule to according to preferences of some parts of the community, and differential access for people in urban centers compared with people on the outskirts of cities or in rural areas (Barkin & Klooster, 2006; Ennis-McMillan, 2001). As of 2010, Mexico is now the largest consumer of privately supplied bottled water (FAN, 2010). At least in the short term, independent suppliers of water are an important source of safe drinking water for many people in Mexico, and therefore their operational sustainability is imperative to continue to provide additional water supply options to people in Mexico.

2.2.2 Institutional Structure for Water Supply in Mexico

In 1983, a constitutional reform in Mexico transferred the responsibility for drinking water and sewage from the federal government to states and municipalities. Although direct responsibility for the supply of water to consumers remains with local agencies at the state and municipality levels, the *Comisión Nacional del Agua* (National Water Commission, also known as CNA and *Conagua*) was established in 1989 to centralize overall water management. It is the main public institution responsible for water allocation to all public and private users (Barkin & Klooster, 2006; OECD, 2006; Wilder & Lankao, 2006). The federal government has implemented programs to increase water supply coverage, including *PROMAGUA* (Program for the Modernization of Water Utilities), which has promoted private investment in water infrastructure and has provided incentives for municipalities to invest in water infrastructure. However, states continue to lack the financial and technical resources necessary for improving service (Barkin & Klooster, 2006; GWI, 2004; OECD, 2006). A 2006 OECD brief on Mexico identified several concerns and suggestions regarding the future of institutional water supply in Mexico. The brief suggests that Mexico should clarify the responsibilities of each level of government for water supply and management; increase financing available for upgrades and expansions; use cost recovery financing, accompanied by increases in quality and targeted lower prices for the poor and supported by the increased ability to monitor exact usage of water; and put a greater emphasis on environmental considerations and total volume of water (OECD, 2006). Until Mexico is able to improve the institutional supply of water, Mexicans will continue to rely on independent suppliers for safe drinking water.

2.2.3 Yucatán Peninsula Water Supply

Map 1: Yucatán Peninsula in Mexico (Google Maps, 2011b)

Nearly 300,000 people in the Yucatán Peninsula states of Campeche, Yucatán, and Quintana Roo do not have piped water in their homes (INEGI, 2006). However, the water quality of those that do is inconsistent, as in the rest of Mexico, and long-term may be further threatened by contamination of the water supply in the Yucatán. In the Yucatán, groundwater is the only permanent source of water supply. There is an aquifer under the peninsula that includes a series of underground rivers and caves (Meacham, 2007). Freshwater in the Yucatán is threatened by disposal of domestic and industrial sewage and solid waste into the aquifer, either directly or through the leaching of

wastewater into the ground (Marin, 2007; Meacham, 2007). Although hotels along the quickly developing Riviera Maya tourist region are required to have wastewater facilities, there are only a few facilities throughout the region whose services are available to the local populations (Marin, 2007). Research from 1994 showed that then, the first 20 meters of the 60 meters of freshwater under Mérida, the capital city of Yucatán state, is contaminated by human waste and unfit for consumption (Meacham, 2007). Due to the underground river network, contaminants in the groundwater may travel quickly throughout the region (Marin, 2007). The threat of contaminated water makes the availability of adequately treated water especially important for people who live in the Yucatán Peninsula.

2.2.4 Cost-Benefit Analysis of Improving Access to Water in Mexico

The evidence indicates that it would be cost-effective both in terms of health and economics to increase access to clean water for people in Mexico. Hutton and Haller (2004) performed cost-benefit analyses for all 17 WHO sub-regions, including the AMR-B region which includes Mexico as well as most of the rest of Latin America. They considered five potential interventions, ranging from simply meeting the MDG 7 Target 10 for only water (that is, halving the number of people without water, beginning with those that already have sanitation) to access for everyone in the world to regulated piped water and sewage in their house. They calculated that interventions would result in between 9.4 million and 308 million cases of diarrheal disease averted each year in the AMR-B region, depending on the intervention selected. Potential health sector treatment savings would be between USD$212 million and USD$7 billion and patients would save

between USD$6 million and USD$192 million. School days gained would be between 7,951 and 261,619 depending on the intervention. The final cost-benefit ratios calculated, using expected costs and benefits, were between 5.12 and 21.07. The cost-benefit ratio for simply halving the proportion of people without access to water was 13.68, though this ratio was reduced to 1.61 when ratios were calculated using high cost and low benefit assumptions. This was the only in-depth cost-benefit analysis of water supply interventions found.

2.3 Small Water Enterprises

It has been estimated that, in Latin American cities, 25% of the population depends on independent providers for drinking water, and that the percentage may be higher in smaller cities and towns (Solo, 1999). This research did not include Mexico, and no current estimates of the percentage for Mexico were found. However, independent water suppliers are increasingly being recognized for their contribution to access to safe drinking water around the world. They often operate in areas that are underserviced or not serviced by utilities and their customers are often from marginalized populations. Independent vendors are typically referred to as 'small water enterprises,' which one report by the Water, Engineering and Development Centre defined as "private enterprises, usually operated by small-scale entrepreneurs (with a maximum of 50, and usually far fewer employees), which earn money from the sale of water" (McGranahan, Njiru, Albu, Smith, & Mitlin, 2006). Researchers have found that there is a wide range of models, and that small water providers have some distinct advantages and disadvantages compared to publicly provided utilities.

2.3.1 Models/Types of Independent Water Providers

Small water enterprises are generally categorized by how they source and distribute their water (see Table 1). The first category by distribution method is wholesale vendors, who typically source their water from their own boreholes, another private borehole owner, and sometimes from a water utility. They typically own or rent tankers or trucks to sell water in bulk quantities, either to consumers or to other vendors (McGranahan, et al., 2006; Opryszko, et al., 2009). In some cases, independent suppliers have also developed their own water networks in areas where the public network does not reach, such as in Paraguay (Snell, 1998).

Table 1: Models/Types of Small Water Enterprises

Distribution Type	Customers	Source of Water	Method of Distribution	Volume
Wholesale vendors	• Other vendors • Consumers (less often)	• Own private boreholes/wells • Other private borehole owners • Public water utility (less often)	• Bulk quantities via tanker trucks	• Bulk quantities
Private networked suppliers	• Consumers	• Private boreholes/wells • Other sources that are treated in a private treatment facility	• Piped network	• As needed
Distributing vendors	• Consumers	• Private boreholes/wells • Public water utility	• Carts (drawn by hand, bicycle, or animals) • Vehicles • Tanker trucks	• 20-L bottles (or other standard size)
Direct vendors	• Consumers	• Private boreholes/wells • Public water utility	• At the source • Standpipes • Kiosks	• 20-L bottles • Sachets • Others (cups, buckets)

Note: These types are not necessarily mutually exclusive, and the information provided is what is generally found, not inclusive of all cases.

Distributing vendors sell directly to consumers by vehicles or carts drawn by animals, bicycles, or the distributors themselves. They sell water in a variety of volumes, perhaps most commonly in 20-liter bottles. They often charge the highest prices due to their door-to-door delivery (Opryszko, et al., 2009; Snell, 1998), and they are most common in areas that are underserved by the public utilities (Snell, 1998). In a study of independent providers in Latin American cities, Solo (2003) estimated that an individual seller with a push cart could reach between 100 and 200 people daily, while a trucker could reach between 400 and 1500 people daily. Water vendors that either partner with public utilities or use the public utility's water are also sometimes referred to as 'intermediate providers,' while those that do not are termed 'independent service providers' (Moran & Batley, 2004).

The last category is direct vendors, whose customers come to them and the water is sold at the source, usually through standpipes or kiosks (McGranahan, et al., 2006; Opryszko, et al., 2009; Snell, 1998). One way that a kiosk is defined is as "a stationary water sales point with an operator who monitors the quantity – and in rare instances the quality – of water sold and collects payments. Kiosks may be divided into two categories based on water source: those that are extensions of public utilities and those that are erected from private or community-owned water sources" (Opryszko, et al., 2009). These vendors typically charge mid-range prices and operate in areas where well water is of poor quality or is too expensive (Opryszko, et al., 2009; Snell, 1998). They are often implemented with government or NGO support and are managed by an individual, group, or community management committee. The poorest households are often served by direct vendors, since they charge less than distributing vendors and often enable the

customer to control the amount of water purchased (such as a cup or bucket full of water rather than always a 20-Liter bottle)(Opryszko, et al., 2009).

None of these typical models is perfectly descriptive of the model used by LWW and many other water vendors in Mexico, but the definition of a kiosk is the closest. For Living Waters, the source of water is either from the public utility or from a private well. It is sold at the source, like the water kiosk model, and also delivered. The plants use a community-managed model, except that the community is that of the Presbyterian church, which is a subset of the wider community each plant serves. In this study, the source and distribution are considered in terms of cost and availability (for source) and potential for increasing sales (for distribution method), as is the management structure.

2.3.2 Advantages and Disadvantages of Small Water Enterprises

Researchers have found many advantages that small water enterprises have over public water utilities. In terms of customers, they are able to access markets that public water utilities either cannot or will not due to high expansion costs, since small water enterprises generally have lower entry and investment costs (McGranahan, et al., 2006; Opryszko, et al., 2009). They are able to provide water to poorer households by providing flexible payment – and often credit – options and the ability to buy water as needed and in affordable quantities (McGranahan, et al., 2006; Opryszko, et al., 2009), although they are not limited to any income group (Solo, 1999). Other advantages that have been noted are that small water enterprises typically have good local knowledge, are demand-driven and have the capacity to grow with demand, are flexible and adaptable to local conditions, typically do not charge upfront connection fees, and have good customer

service quality in terms of flexibility and knowledge of customers (McGranahan, et al., 2006; Opryszko, et al., 2009; Solo, 1999; Water and Sanitation Program, 2001).

Researchers have also identified several disadvantages of small water enterprises. The first is that rates for water are generally higher than water supplied by the public utility. Solo (1999) did report that some independent providers charge lower rates than public providers, which may be especially true in the case of independent, private networks. However, others, and a later report by Solo, have noted that small water enterprises often charge more, and delivered water can cost up to 12 times the cost of water provided by the public utility (Kariuki & Schwartz, 2005; Solo, 2003). The second main disadvantage is that many small water enterprises are not regulated and many governments do not have a framework that acknowledges or encourages small water enterprises, possibly resulting in lower quality water, misuse of resources, and an inability to use legal processes to penalize crimes against the small water provider (McGranahan, et al., 2006; Opryszko, et al., 2009; Snell, 1998; Solo, 2003). The final commonly recognized disadvantage is that small water enterprises lack access to credit and lack the resources to make capital investments or achieve economies of scale through expansion (McGranahan, et al., 2006; Moran & Batley, 2004; Snell, 1998). There is not much evidence of effective microfinancing schemes, although some suppliers are able to access financing through informal sources (Opryszko, et al., 2009). This study intended to assess the extent to which each of these disadvantages affect LWW plants, and whether there is anything unique in LWW's model, such as the faith-based and ministry aspect, that mitigates any of these factors.

2.3.3 Evidence of Success of Small Water Enterprises

The evidence on the extent to which small water enterprises have been successful is mixed. Solo (2003) reported that small water enterprises are most successful when the public and private sectors are operated independently of each other, when independent suppliers are able to operate legitimately and network with the community they are in, and when physical conditions permit their operation. Other factors contributing to the success of independent providers include appropriate technology, the availability of water, effective marketing and raising awareness of health benefits, an entrepreneurial approach to competition, and accessible entry costs (Opryszko, et al., 2009; Snell, 1998).

Regarding water quality specifically, little research has been done to confirm whether or not small water enterprises produce quality water. One study from Ghana found that 23-43% of 179 brands of sachet water were unfit for human consumption, though the same result was not found for the 17 brands of bottled water tested (Ampofo, Andoh, Tetteh, & Bello, 2007). Many reports do suggest that water supplied by independent providers is lower quality, although there is little published research using water analysis supports that finding (Opryszko, et al., 2009).

In terms of operational and financial sustainability, findings are also mixed. One review reported that water supplies that are community-managed typically operate at the lowest possible cost, with prices barely covering costs, and therefore do not invest in improvements and may minimize money spent on preventive maintenance (Moran & Batley, 2004). This finding is supported by Snell (1998), who reported case studies of independent providers around the world. Snell (1998) also reported a case where the limiting factor for sustainability was the availability of water, not of customers, and

another where she predicted that truckers and standpipes will continue to exist as long as there is a gap in service provision by the public utility and unaffordable connection costs. Some suggest that NGO involvement and oversight is essential for community-managed operations to ensure proper maintenance, monitoring, and handling of money (P. A. Harvey & Reed, 2007; Snell, 1998). Solo (1999) reported that independent providers necessarily fully cover all costs, require no public financing, and have no debt, although these findings seem to apply specifically to truly independent providers without any NGO or government involvement. Other research indicates that community-managed water supplies are not achieving sustainability (P. A. Harvey & Reed, 2007; Haysom, 2006; Snell, 1998).

2.4 Faith-based Organizations

The role of faith-based organizations (FBOs) in public health interventions and development has been increasingly recognized in the last decade. The United Nations Population Fund noted that faith-based organizations provide 30-60% of health care and educational services in many developing countries. In UNFPA's Guidelines for Engaging Faith-based Organizations as Agents of Change, they state that "we can no longer avoid acknowledging these parallel faith-based development interventions which reach so many and provide so much" (UNFPA, 2009). Similarly, USAID created the Center for Faith-Based and Community Initiatives in 2002 to encourage engagement of faith-based organizations in international development work and to help faith-based organizations effectively compete for USAID funds(USAID, 2009).

Factors unique to faith-based social enterprises include their additional mission to create and sustain social value and their increased feeling of accountability to their customers and to having an impact (Ndemo, 2006). Ndemo (2006) suggests that the success of faith-based enterprises should be measured in terms of social stability and human capital in addition to their business performance, and that their managers are likely to feel obligated to their sponsors to sustain their enterprise. He notes that faith-based interventions have historically included primarily humanitarian assistance without concern for sustainability, but that their interventions in health and education are increasingly showing long-term benefits.

Other faith-based organizations with water supply projects include, among others, Healing Waters International, Blood Water Mission, Living Water International, and Lifewater International (USAID, 2009). No studies were found that specifically assess the sustainability and impact of faith-based water supply enterprises. In this study, the impact of the faith-based component is considered in terms of the network and support received by each plant, as well as the impact it has on operator motivations for continuing to operate the plant and achieve success.

2.5 Sustainability

Sustainability is defined in myriad ways, with different groups placing emphasis on different factors influencing it. Different conceptualizations of sustainability and how it should be measured were considered for this study.

2.5.1 Definitions

Several proposed definitions of sustainability focus more on the environmental sustainability of water supply rather than the operational and financial sustainability. One of the commonly cited definitions in this vein is from the World Commission on Environment and Development, and states that a sustainable intervention is one that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). Although environmental sustainability is indeed important, it was not the focus of this study, and therefore factors influencing environmental sustainability are not considered for the sustainability of LWW's plants.

Definitions that were more appropriate for consideration of the sustainability of LWW's plants include:

- "A sustainable water supply and sanitation project maintains, or expands, a flow of benefits at a specified level for a long period after external funding has been withdrawn" (Hodgkin, 1994).
- "Sustainability is constancy in water and sanitation services which may be achieved through evolving and adaptive mechanisms," "continued delivery and uptake of services," operation that "continues to work over time," and where "water continues to be abstracted at the same rate and quality as when the supply system was designed" (Carter, et al., 1999).
- Sustainable interventions require "minimal external assistance in the long-term", finance "regular operation and maintenance costs by users", and have the "continued flow of benefits over a long period"(S. Parry-Jones, 2001).

- **“**Sustainability is the capacity of an organization to achieve long-term success and stability and to serve its clients and consumers without the threat or loss of financial support and the quality of services. Sustainability is about maintaining and continuing program services after a funding period is over and ensuring that the organization has become a permanent part of community resources” (USAID, 2009).

The main themes in the definitions are continued operation and service at a constant level over time and the ability to continue operation after external support is no longer available.

2.5.2 Emphasis on Sustainability

Focusing on sustainability is critical if interventions are going to be able to contribute to the access of the world’s population to safe drinking water. Unsustainable water supply interventions may increase access in the short-term, but will ultimately have no impact on the total number of people with access to water, and those that benefited will once again be without access. A number of researchers have documented this phenomenon around the world. Ennis-McMillan (2001) reported the results of a 1981 study that as many as 50% of rural drinking water interventions become inoperable within five years. Despite the increased focus on sustainability since then, newer evidence suggests similar success rates. Montgomery, Bartram, & Elimelech (2009) reported the results of several studies from Africa, including one from Sub-Saharan Africa that found that only 35-80% of all rural water systems were functioning, one from South Africa that reported that up to 70% of all boreholes in the Eastern Cape were not

functional, and another from Tanzania that found that only 45% of 7,000 wells and boreholes were still in operation. The International Institute for Environment and Development (IIED) reported that 80% of wells in the Menaca region of Mali are dysfunctional, that 58% of waterpoints in northern Ghana need repair, and that the failure of water supply interventions has cost USD$215-360 million (Skinner, 2009). Another study from Kenya reported that only 57% of wells still had 'normal' water flow (Miguel & Gugerty, 2004).

Lack of sustainability is often attributed to the focus on expansion of services at the expense of investment in maintenance (Breslin, 2010; Montgomery, et al., 2009; Skinner, 2009). A WHO report estimating the costs of reaching the water supply target of MDG 7 estimated that, while the cost of extending service to additional people to meet the goal would cost USD$42 billion between 2005 and 2015, the cost of maintaining existing services would be USD$322 billion (G. Hutton & Bartram, 2008). However, most studies and programs estimating the cost do not take into account the costs of operation and maintenance.

The bulk of literature on the sustainability of water supply interventions focuses primarily on Africa, but the issues for community-based systems in Latin America are likely similar to those in Africa. This study will provide some insight into factors that may be specific to Mexico, and whether LWW's model adequately accounts for operation and maintenance costs.

2.5.3 Issues Impacting Sustainability

Researchers have identified several factors that contribute to a lack of sustainability. In the planning stages, these include inadequate engagement of users in technology selection, inadequate training, and inadequate planning for cost recovery (Carter, et al., 1999; P. Harvey & Reed, 2004; S. Parry-Jones, 2001). Reasons also include lack of engagement of local government officials and inadequate attention to water quality in terms of bacteria or taste (Montgomery, et al., 2009; S. Parry-Jones, 2001). In the execution phase, lack of preventive maintenance, lack of cost recovery, lack of monitoring, and lack of adequate supply (either due to breakdowns or low supply of source water) also threaten sustainability (Carter, et al., 1999; Montgomery, et al., 2009; S. Parry-Jones, 2001). Long-term, sustainability may be impacted by lack of ongoing support from an outside agency, lack of community engagement, the inability of customers to see promised health benefits, lack of accountability for operators and implementing organizations, and inability to finance repairs and upgrades (Carter, et al., 1999; S. Parry-Jones, 2001)

Suggestions for how to improve sustainability include focusing more on financial and cost recovery planning and establishing a reliable supply of spare parts (Montgomery, et al., 2009). Several authors suggest using a revenue-generating model, managed either by an individual or a community, to increase incentives for good operations and maintenance (Carter, et al., 1999; P. Harvey & Reed, 2004; Haysom, 2006; Montgomery, et al., 2009). However, evidence has also shown that “nowhere is there full cost-recovery of operation and maintenance from rural communities, since the cost of spare parts, distribution, storage and technical support is often subsidized,” (P.

Harvey & Reed, 2004), again questioning the role of a supporting NGO or government in projects. Also, community-managed models have frequently been shown to be no more sustainable than other management models (P. A. Harvey & Reed, 2007). However, some evidence has shown that enterprises where a private operator can make a profit from operating and maintaining a water supply have been successful (Haysom, 2006; Montgomery, et al., 2009).

2.5.4 Models/Factors for Assessment of Sustainability

Methods for assessing sustainability range from specific ones, such as determining whether the intervention is achieving cost recovery, to broad ones that consider the wider context and environment the intervention exists in. Table 2 summarizes some of the frameworks for assessing sustainability. Researchers that take a broad view typically suggest that sustainability can be achieved only if it is considered and planned for in every stage of the implementation process, includes community participation, and engages the appropriate stakeholders in each phase (Carter, et al., 1999; P. Harvey & Reed, 2004; Hodgkin, 1994; McConville & Mihelcic, 2007).

Models that are more focused specifically on the operation of the system and less on the wider contextual factors ultimately tend to incorporate most of the broad factors as well. Carter (1999) suggests that the factors contributing to sustainability include *motivation* of consumers to purchase water from the small water enterprise, which is potentially influenced by the taste, resistance of the community to change, education on the health benefits of safe drinking water, and price; *maintenance* of the system, which requires available resources, supplies, and trained individuals; *cost recovery*; and

continuing support from a partnering NGO or donor until the project can no longer fail. Montgomery, et al (2009) suggest a similar framework. The factors they include are 'effective community demand,' which includes a demand-responsive approach, takes willingness and ability to pay into consideration, and includes social marketing; 'local financing and cost recovery,' which involves financial planning, local borrowing and saving schemes, and collaboration with other communities to provide equitable access to benefits; and 'dynamic operations and maintenance,' which includes clearly defined roles, effective supply chains, monitoring and evaluation, and technical training and support. Another framework, suggested by White (2005), suggests that the factors possibly influencing sustainability can be categorized as financial (government, communities, and donors), institutional (government, NGO, communities), and technical (design, operations and maintenance, and environmental).

Table 2: Factors to Consider When Assessing Sustainability	
Author	**Suggested Factors Influencing Sustainability**
(P. Harvey & Reed, 2004)	• Policy context • Institutional arrangements • Financial and economic issues • Community and social aspects • Technology and the natural environment • Spare parts supply • Maintenance systems • Monitoring
(S. Parry-Jones, 2001)	• Policy context • Institutional arrangements • Technology • Natural environment • Community and social aspects • Financing and cost recovery • The project process • Key inputs or linkages
(McConville & Mihelcic, 2007)	• Sociocultural respect • Community participation • Political cohesion • Economic sustainability • Environmental sustainability
(Carter, et al., 1999)	• Motivation (of consumers) • Maintenance • Cost recovery • Continuing support
(Montgomery, et al., 2009)	• Effective community demand • Local financing and cost recovery • Dynamic operation and maintenance
(White, 2005)	• Financial • Institutional • Technical

Among those proposing models for assessing sustainability, there are differing opinions on how cost recovery should be achieved and the extent of NGO involvement that is appropriate. While several of the definitions listed above suggest the lack of long-term support, financial or otherwise, by a partnering NGO, some practitioners advocate for continued NGO involvement to provide for long-term structure and support (Carter, et al., 1999; P. A. Harvey & Reed, 2007; Haysom, 2006), and some are lenient with respect to the source of financing. For example, Hodgkin (1994) proposes that "to be called sustainable, projects do not have to recover all costs so that all the resources for

replacement and maintenance or new investments are raised internally. We do, however, require that the WS&S [Water Supply & Sanitation] sector be able to sustain the flow of capital subsidies for replacement and subsidy of other support costs." This study will consider both the importance of LWW's involvement and the source of funding for the water systems.

2.5.5 Tools and Indicators

With consideration for the factors influencing sustainability described above, several practitioners and researchers have identified useful tools and indicators with which to measure sustainability. First, some of the indicators suggested for sustainability will be presented, followed by examples of tools that can be used to assess sustainability.

Examples of proposed indicators and/or goals include those from Carter (1999) and Breslin (2010). Carter and Breslin proposed these as standalone goals or indicators for water supply project success, and both recognized that there may be additional factors to consider as well, such as financial indicators.

Carter:

- Caretakers should be in post and fulfilling their assigned job descriptions.
- Committees should be meeting regularly, keeping minutes, and functioning in a manner which is acceptable to the community.
- Revenue collection should be taking place in the manner agreed at the construction phase, or in some other effective way.

- The backstopping agency (government or NGO) should be in regular and effective contact with the community.
- The use of water supply… should be continuing at high levels.
- Physical infrastructure should be fully functional.

Breslin:

- The quality of water meets host country government standards over time—with a focus on bacteriological parameters (E. coli and total coliforms) plus any other water quality challenges that are known in the area and that undermine household health
- The quantity of water available to households meets host country government standards over time.
- The water system is inoperable for no more than one day per month.
- The number of users per water point meets host country government standards.

Others have developed tools incorporating indicators that can be used to assess sustainability of water supply systems. Most produce some type of score that can be used to compare countries, projects, or sites. They range in complexity and scope. They will be discussed from largest scope and greatest complexity to the most simple. Table 3 summarizes the different tools discussed.

Table 3: Existing Tools for Assessing Sustainability		
Name/Author	**Scope**	**Complexity**
Sustainability Scorecard(World Bank, 2006)	Country (entire water supply sector)	Medium to High
Sustainability Matrix(McConville & Mihelcic, 2007)	Project or site*	High
LWW System Sustainability Tool (Living Waters for the World, 2010)	Site	Medium
Questions for Assessment of Sustainability(Hodgkin, 1994)	Project	Low to Medium
Sustainability Snapshot(Sugden, 2001)	Site	Low
*'Project' refers to tools that attempt to evaluate the sustainability of an intervention that may have installed/implemented water supplies at more than one site. 'Site' refers to tools that evaluate the sustainability of a specific site.		

One with a particularly large scope is the Sustainability Scorecard used to evaluate sustainability for 16 African countries on a national level in terms of their progress toward MDG 7. It was developed and used by partnering organizations including the United Nations Development Programme and the World Bank. It scored each country on a scale from 0-100 for both institutional and financial domains using both quantitative and qualitative measures (World Bank, 2006). While this tool may be helpful for assessing progress on a national scale, it is less applicable to small-scale water supply projects.

A tool developed by McConville and Mihelcic (2007) is tailored more to specific water projects and incorporates a large amount of data. It assesses the sustainability of a project from a life-cycles approach, evaluating the project at five different stages: needs assessment, conceptual design and feasibility, design and action planning, implementation, and operation and maintenance. Each stage is evaluated using five domains: sociocultural respect, community participation, political cohesion, economic sustainability, and environmental sustainability. A 5x5 matrix is used, incorporating the

different stages and domains, and a 0-4 score is determined for each square in the matrix using a checklist of project characteristics applicable to that square. Rather than being usable to assess sustainability in a post-project phase, this tool may be more appropriate to "aid engineers, organizations, and other individuals in improving their project approach."

Living Waters for the World (2010) developed their own System Sustainability Tool to evaluate the sustainability of their projects. It includes 16 measures, including topics such as functionality, regulatory compliance, community participation, maintenance and technical competency, capital improvements, leadership, financial management, environmental considerations, and supply of spare parts. Each measure falls into a domain of either 'Management, Operations, and Maintenance' or 'Value and Mission,' with the second one measuring the site's performance in promoting the values and mission of LWW. Each measure is ranked 0-4 depending on performance. The System Sustainability Tool had not been used yet to assess its performance when this study began.

Hodgkin and Water and Sanitation for Health (WASH) project staff (1994) developed a questionnaire to assess sustainability of WASH projects to be used by donor or project staff. It includes eight key questions, as well as 29 more in-depth questions. The eight key questions address coverage, whether facilities are operational, whether management committees are functioning, whether there is external support, the availability of technical expertise and spare parts, compliance with government regulation, whether there is a long-term supply of spare parts, and whether there are adequate financial resources. The 29 questions cover the same key areas and others in

the categories of institutions, development processes, project, donors, and contexts. Each is to be answered with a yes or no. Hodgkin recognizes that "most of the questions are not measurable in a quantitative manner and can be addressed only in a general sense." The use of this questionnaire in two case studies was found to be "generally… effective in drawing out important factors determining sustainability," and the developers noted that it could be adapted to fit other countries or projects. Its definition of sustainability "allows for some dependence on external support as long as the major tasks are carried out by internal institutions."

On the simplest end is a Sustainability Snapshot tool developed and used by Sugden (2001) of WaterAid for WaterAid Country Programmes to assess sustainability of their handpump projects in Africa. It has only three indicators, ranked on a 1-3 scale, measuring financial performance, technical skills, and equipment and spare parts. In practice, the tool was found to be "useful, easy-to-use, discussion provoking and applicable to the circumstances in which it was tested" (Sugden, 2001).

Despite the range of options available for assessing sustainability, none of the existing tools appropriately met the needs of evaluating the sustainability of LWW's projects, due to their inappropriate scope, lack of specificity, and inability to measure all aspects of LWW's approach. The World Bank Sustainability Scorecard was too high-level, as was Hodgkin's questionnaire. The Hogdkin questionnaire, LWW System Sustainability Tool, and the WaterAid Sustainability Snapshot are all attractive in their relative simplicity, and incorporate many of the key factors that have been identified as important for sustainability. However, their simplicity decreased their usability for this project since they were less specific and therefore they would be difficult to use by an

independent evaluator who had had no involvement in the design or implementation phase of the project. Although the LWW tool incorporated many aspects that would ultimately be evaluated in the study, it did not incorporate all the factors considered important for sustainability. Also, the tool did not provide specific enough questions for systematically determining a score that was consistent across all sites. The McConville and Mihelcic tool was more appropriately specific, especially with the checklist of characteristics that are used to determine a score for each box in the matrix, but this study was primarily interested only in the final operations and maintenance phase. Finally, besides LWW's tool, none of the other tools specifically evaluated LWW's model and incorporated the faith aspect and their specific technology and business considerations.

Despite the many studies and practitioners that have considered factors influencing access to safe drinking water around the world, little is known about the independent water providers that fill the gap in access for those in Mexico. Also, literature exists on sustainability, factors influencing it, and how to measure it, but none of the existing approaches is specific to the model used by Living Waters, and they do not take into account the impact of faith in the sustainability of faith-based enterprises. The goal of this study was to understand the role of LWW's small water enterprises in Mexico, the factors influencing their sustainability, and the long-term role that LWW may play for each plant.

2.6 Living Waters for the World – Background, Model, and Technology

2.6.1 Background

Living Waters for the World (LWW) is a faith-based organization based in Spring Hill, Tennessee and is associated with the Synod of Living Waters of the Presbyterian Church, which serves 12 presbyteries covering the states of Kentucky, Tennessee, Mississippi, and Alabama.[1] It was established in the early 1990s and the first installation was in 1999 in an orphanage outside of Reynoso, Mexico. The mission of LWW is "to serve as a resource to churches of all denominations, civic organizations and others in mission, enabling them to provide clean water to their partners in need" (LWW, 2011).

2.6.2 Partnership Model and Sustainability:

LWW's model is to train mission teams to create partnerships with communities in need of clean water, equip them with the materials and knowledge to help their partnering communities install a water purification system, and guide them in helping their partners become sustainable enterprises. LWW launched Clean Water U (CWU), a 5-day training program, in 2004 to "train the trainers." At CWU, LWW trains the missionaries (whom they call 'Initiating Partners') and provides the missionaries with the resources to help members of communities ('Operating Partners') install their own water treatment system and implement a small water enterprise (LWW, 2011).

To encourage sustainability, LWW missionaries allow their partners to sell the water in order to recover the cost of operating and maintaining the water treatment

[1] A presbytery is a unit of organization for the Presbyterian Church. Individual churches have a leadership group known as a 'consistory,' made up of church elders. Members of those consistories make up the presbytery, which is a governing body for a group of individual churches.

system. LWW guides the Initiating Partners to establish an agreement with the communities they work in that the water may be sold to ensure sustainability, but that it will be sold at a cost that is at most half the cost of commercial water in the area. The goal is to recover costs, but be not-for-profit. The Operating and Initiating Partners (OPs and IPs) typically sign a Covenant agreeing to these terms. The Covenant emphasizes the importance of providing water for free to those that are unable to pay (LWW, 2011).

LWW also encourages sustainability through follow-up visits by the IPs and facilitation of in-country networks of operators and plants. Typically, Initiating Partner teams are guided to plan four total trips to the site. The first is for assessment and signing of the Covenant with the Operating Partners, the second is for education and installation of the plant, and the final two are at the end of years one and two for follow-up. After that, the goal is to transition support to an in-country network, although LWW recognizes that additional trips by the IP may be needed. Currently, the largest and strongest network of plants is in the Yucatán Peninsula, where operators are also invited to attend an annual training conference led by LWW (LWW, 2010, 2011).

2.6.3 Operation Model:[2]

In the Yucatán, all water purification plants are located on the site of a Presbyterian church, although in other areas, they may be in community centers, orphanages, or other locations. In some cases, the site of the plant is the only Presbyterian church in the town, but in some cases, there is more than one.

[2] The source for most of the information in this section is observations that the researcher and others doing research simultaneously made while visiting the plants.

In all cases in the Yucatán, the water purification plant is operated by one or more members of the church. In some cases, the pastor of the church is involved in plant operation, but not always. The operators of the plants, in almost all cases, earn an income for operating the plant, which is often 1 or 2 pesos for each bottle they fill. Some operators are volunteers, as is the pastor typically when he is involved.

LWW encourages sites to create a water committee to govern the water purification plant. Most sites in the Yucatán do have a group of people governing the water plant, although in most cases, the committee is not specific to the water plant and is instead a committee of the church. The committee often selects the operator and determines what his or her salary will be. In most cases, it also manages the finances over the long-term. For sites that do not have an active water committee, the pastor of the church usually assumes this role.

Since all plants are on the property of Presbyterian churches in the Yucatán and the operators and plant leadership are typically members of the church, the plants and congregations are linked. Water is sold primarily to church members, who have familiarity with the plant through its physical presence and through interacting with their fellow church members. However, plants also make the water available to those who are not affiliated with the church and many have at least some customers who are not members of the church. Most plants do not perform marketing activities, but water purification plants are increasingly common in Mexico and therefore people are familiar with them and what they do.

2.6.4 Technology and Bottling Process:

LWW purification plants use a batch treatment process to disinfect water, typically using 600-gallon tanks. It takes about two hours to process the full tank. Water is treated using chlorine, filtration, microfiltration, and either ozone or UV disinfection. The raw water is first treated with chlorine. It is then filtered using a 20 micron (μm) filter to remove larger particles. Next, a 0.5 micron carbon filter is designed to remove single-celled microorganisms, as well as the chlorine, which would harm the reverse osmosis membrane used later in the process. Then, a reverse osmosis process removes all salt (Personal communication with LWW representatives, 2011). Although chlorine is used to disinfect bottles, it is no longer used by LWW as a final water disinfectant because it has caused the water to be rejected by consumers due to the taste. Instead, ozone or UV is used as a final disinfectant (Compernolle & Howie, 2005). Due to maintenance difficulties with ozonators, LWW is increasingly recommending UV disinfection. Not all LWW sites around the world use a reverse osmosis and softening (ROS) system. Due to the hardness of water in the Yucatán, all systems in the Yucatán use ROS combined with either the standard UV or ozone system (LWW, 2009, 2010).

After water is treated in batches in the clean water system, it is bottled in 20-liter plastic bottles and a seal is applied with heat. Operators typically check the chlorine levels in the raw water tank and adjust as necessary before processing water, they check the pressure of the filters and membranes during processing, and they check the hardness of the water after it has passed through the softener. Water is typically purified and bottled in the afternoon and sold the following day, or it is purified and bottled the same morning it is sold. Water is sold at the plant, and many sites also deliver water using a

vehicle or *triciclo*, a cart attached to a bicycle or motorcycle. Empty bottles are typically returned for cleaning and refilling and may be resold to a different customer in exchange for their empty bottles. Operators typically work Mondays through Saturdays, although some sites operate fewer days each week.

3 METHODS

3.1 Study Overview

This evaluation was cross-sectional and used both quantitative and qualitative methods to assess the sustainability of the LWW water purification plants in the Yucatán Peninsula, Mexico. Both types of data were collected and analyzed simultaneously and information from both was used to determine which factors influence the sustainability of LWW-installed plants and how sustainability may be improved. However, each method was used to address a different research question.

The quantitative portion of this evaluation sought to answer the question of whether LWW's water purification plants are sustainable according a tool that the researcher developed by drawing upon criteria for sustainability found primarily in the literature and from LWW's input. The tool was used to apply consistent criteria across sites and to establish a sustainability score based on those criteria for sustainability. A survey was conducted and financial and managerial records were collected to gather the information needed to use the sustainability score tool for each site visited.

The purpose of the qualitative portion of this evaluation was to determine how community members involved in the operation of the water purification plants define sustainability and what motivates them to continue operating the plants. Ritchie and Lewis (2003) suggest that "the purpose of bringing different approaches together is to yield different types of intelligence about the study subject…." The researcher wanted to understand other factors influencing sustainability that would not be captured by her criteria or the sustainability tool. Additionally, researchers suggest that the success of faith-based enterprises should be measured for their social impact in addition to their

business performance, and also that faith-based organizations may feel obliged to live up to the expectation of their sponsors (Ndemo, 2006). Qualitative research enabled the researcher to understand whether these ideas play a part in the overall success of the water plants. The researcher chose to conduct in-depth interviews with plant operators since she was interested in each individual operator's experience as an operator, their ideas about success and sustainability, and personal motivators.

The following sections will provide additional details regarding instrument development, study site, target population, process for site selection, and recruitment of participants. These sections are followed by the actual data collection process and a description of the data analysis methods.

3.2 Development of Instruments

3.2.1 Sustainability Tool

For the quantitative portion of this evaluation, a tool was developed using information and suggestions from the literature, LWW, and the researcher's own knowledge. This tool guided the development of the survey and enabled the researcher to determine a sustainability score based on the survey responses on a 0-4 scale. Appendix 1 contains the actual sustainability tool.

The tool has several layers. Each layer will be explained in greater detail.

<u>Domains:</u>

Montgomery, et al (2009) suggest three areas to consider when evaluating sustainability of water supply interventions: effective community demand, financing and

cost recovery, and dynamic operation and maintenance. These domains were found to be appropriate for evaluating small-scale water suppliers, including LWW, after a review of more of the literature. The domains were also similar to ones found in the preliminary sustainability tool that LWW had been developing. Therefore, this framework was used to assess the sustainability of LWW's systems. The final domains used were Management, Operations, and Maintenance (MO&M); Cost Recovery and Financing; and Understanding of Demand.[3]

Subcategories:[4]

Within each domain, several subcategories were identified that were specific to different aspects of the water plants and their operation.

In the MO&M category, these included staff, operations, maintenance, and network/support. 'Staff' questions asked about the employees: their work hours, whether they are paid, whether they are trained, and the leadership structure. 'Operations' questions asked about the plant operation and management: availability and use of raw water, monitoring of activities, and cooperation with local authorities. 'Maintenance' questions asked about the maintenance activities, schedule, water testing, and availability of spare parts. 'Network/support' questions asked about potential

[3] Each of these domains was considered from the perspective of the plant and the supply of water. In research that was taking place simultaneously, another researcher was also considering factors affecting demand from the consumer's perspective.

[4] The subcategories were not considered throughout the tool development process, but rather once all survey questions had been developed. They were grouped into subcategories for two purposes. First, it allowed the survey to flow better, since respondents could respond to questions that were on the same topic all together. Second, it provided the opportunity to analyze responses at an intermediate level, in addition to the domain and broad question level.

sources of support for the plant: whether there was a water committee, whether they work with operators from other plants in any capacity, whether they or anyone in the church leadership are in touch with LWW.

In the Cost Recovery and Financing domain, the two subcategories were Cost Recovery and Financing. Questions in the 'Cost Recovery' subcategory were about the costs of the plant, the ability to pay employees, the price of water, and whether revenues are greater than costs. 'Financing' questions asked about savings, outstanding debt, and access to and reliance on loans or subsidies.

In the Understanding of Demand domain, the two subcategories were 'Demand Generation' and 'Awareness of Demand.' For 'Demand Generation,' questions were about utilization within the community, delivery, and activities such as marketing or health education. For 'Awareness of Demand,' questions asked about whether the plant or its workers provided more inputs (such as bottles filled or hours worked) than were necessary to meet demand and whether there was evidence that the plant responded to changes in demand.

Broad Questions:

The broad questions used to evaluate sustainability were developed primarily from LWW's sustainability tool and the literature. LWW's sustainability tool included 16 'Best Practices' that the researcher used as the basis for most of the broad questions (Living Waters for the World, 2010). Additional broad questions were taken from factors of sustainability suggested in the literature (Carter, et al., 1999; Hodgkin, 1994; Montgomery, et al., 2009; S. Parry-Jones, 2001; Sugden, 2001; White, 2005). Examples

of broad questions include: “Is there an operator working often enough to ensure that the community is able to depend on clean water being available?” (from the ‘Staff’ subcategory) and “Is there a reliable water source that provides the quality and quantity of water to meet demand?” (from the ‘Operations’ subcategory). The final tool included 29 broad questions. Table 4 shows the number of broad questions and categories in each domain.

Table 4: Domains and Subcategories of the Sustainability Tool

Domain	Subcategory	Number of Associated Broad Questions
Management, Operations, and Maintenance (MO&M)	Staff	3
	Operations	3
	Maintenance	6
	Network/Support	2
Cost Recovery and Financing	Cost Recovery	6
	Financing	4
Understanding of Demand	Demand Generation	3
	Awareness of Demand	2

Metrics:

In order to answer the broad questions, metrics were developed that could be used to evaluate performance in response to each broad question. Most of the literature on sustainability tools did not include specific metrics related to each factor affecting sustainability it suggested, which may be a reflection of the uniqueness of each intervention. Therefore, the researcher developed most metrics based on her knowledge of the LWW systems and their processes. Additionally, many metrics were chosen based on the distinctions between levels in the 0-4 scale that LWW had outlined in their sustainability tool for each Best Practice (Living Waters for the World, 2010). For

example, in response to whether there is a reliable source of water, LWW's tool suggested a score of 4 if raw water is available '24/7,' so one metric included in the final tool for this study was the number of hours raw water is available.

As additional examples of metrics, for the broad question mentioned above regarding whether there is an operator working frequently enough for the community to be able to depend on clean water being available, metrics included:

- Number of days per week an operator is assigned
- Number of hours per day an operator is assigned
- Whether there is a replacement operator identified if the lead operator cannot work

For the broad question regarding whether there is a reliable source of water to meet customer demands, metrics included:

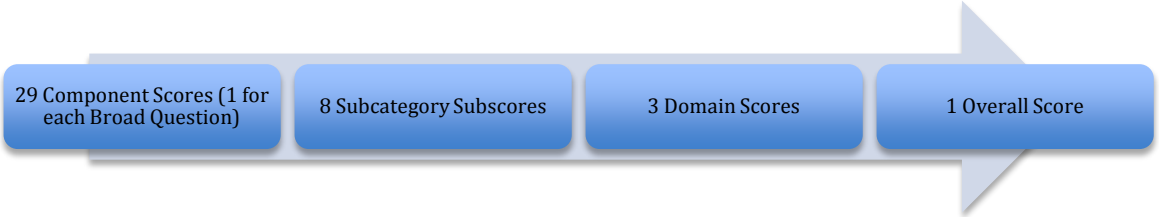
- Number of hours per day that raw water is available
- Primary source of raw water
- Whether there is a well on the property

Survey Questions:

The survey questions and metrics were developed simultaneously. A question was developed for each metric to be used to gather the information for the metric from the operator. For example, to know how many hours each day that raw water was available to the plant from the municipal water system, participants were asked, "What hours is raw water available?" In some cases, data for a metric was more appropriately gathered by reviewing financial records kept by the operators. For example, to answer

the broad question of “How much do recurring expenses cost monthly, and what is the source of funding for them?”, one desired metric was the average monthly recurring operational and maintenance costs. The ideal source for this information was the financial records. However, there was also a question on the survey asking operators to estimate it in case financial records were not available. To facilitate and validate the estimation, the survey had additional questions, such as “What are the monthly costs of water and electricity?” and “What are the monthly costs of bottles, caps, and seals?”

Figure 1: Layers of Sustainability Scores



Calculation of Score**:**

Finally, a method was developed to create a score for each site based on the information gathered. Figure 1 shows the layers of the sustainability score. Using the model provided by LWW, the researcher created a 0-4 scale with which to evaluate each broad question. The researcher used the preliminary tool from LWW as a starting point for distinguishing each level of the scale, and introduced additional detail to the description of each level in order to create clear distinctions.

In developing what would constitute the different score levels, the researcher created score levels so that a 2 would describe responses that did not quite meet the criteria for sustainability (as suggested by the literature, LWW’s preliminary tool, or the researcher’s own determination), and a 3 was likely to be sustainable, at least according

to those same sources. Therefore, a 2.5 was used as the ultimate cutoff for sustainability, though with reservations if it was below 3.0. The data gathered in the survey and from the plant records would be used to determine which score, in whole numbers, the site had earned for each broad question. These scores (29 in total) would then be used to calculate a score for each subcategory, each domain, and finally, for the site overall. At each level, each broad question was given equal weight in calculating the intermediate and final scores. Since the researcher planned to visit only operational plants, the score would be a predictor of future sustainability.

3.2.2 Quantitative: Survey

The final survey had 118 questions on it, some of which were follow-up questions and dependent on a previous answer. It was intended to last approximately one hour. The final data collection tool also had space to collect data that were more appropriately gathered from financial and managerial records kept for each plant. Although there was intent to gather much of the data from records, questions were also included on the survey to get as much information from the respondent as possible in case records were not available or were incomplete. The survey was piloted at the first three sites after which minor updates were made.

The survey was translated into Spanish from English by another researcher. After the initial translation, both researchers reviewed the translation and updated it based on the researcher's clarification of questions and their intent.

3.2.2 Qualitative: In-Depth Interview Guide

The researcher developed an interview guide for use during the in-depth interviews. The interview guide began with two easily answerable and warm-up questions, in order to create conversation and build rapport between the interviewer and participant. These were followed by ten key questions to address three topic areas: the respondent's personal motivations, their definition of success and their goals in the plant, and their perception of the plant's achievements. It ended with two broad closing questions. These key areas were identified from the research question, rather than from the literature. Prompts to probe further were included for some of the questions, but the researcher did not want to create too much structure for the interviews or encourage the interviewer to rely too heavily on the interview guide. The questions were intended to draw out the respondent's own ideas about each of the topics rather than guide the conversation completely. Therefore, the researcher did not expect that each question or topic would be addressed in each interview. The in-depth interview was also intended to last for approximately one hour.

The researcher worked with a field assistant to discuss and translate the in-depth interview guide into Spanish before the first in-depth interviews.

3.3 Project Site

The study was conducted in the communities with an LWW water purification plant in the Yucatán Peninsula, which consists of three states in southeastern Mexico (Quintana Roo, Yucatán, and Campeche). The communities are typically rural. In some cases, the people in the towns have few options for access to clean water. In most,

though, purified water (*agua purificada*) in 20-liter bottles is sold in stores, in competing plants, or delivered by a corporate retailer (such as Cristal, a Coke product) or another local water purifier. All communities have at least one Presbyterian church, which is the site of the LWW water purification plant, although most people in the region are Catholic. This region was chosen as the study site due to the proximity of a relatively large sample of LWW water purification plants and the length of time LWW plants have been in the region.

3.4 Target Population

The target population for both the quantitative and the qualitative portions of this evaluation was the same. For each, the researcher was interested in surveying and interviewing the individuals that were primarily responsible for managing each purification plant and who were involved in its operation.

To complete the survey and ultimately develop a sustainability score for each site, the researcher planned to survey an individual or group of individuals at each site that was familiar with, or primarily responsible for, the management, finances, and operation of the purification plant. The goal was to identify the individuals that would be able to answer the most questions on the survey. Information given to the researcher from LWW suggested that each plant had a lead operator that met these criteria. In many cases, the lead operator was the primary manager for the water plant and one of only a few employees.

These characteristics made the lead operator of each site an ideal person for the qualitative in-depth interviews as well. Rubin and Rubin (2005) recommend

interviewing participants that are experienced, knowledgeable, and have a variety of perspectives. The researcher understood that lead operators in most cases are primarily responsible for managing and operating the plants. These individuals were targeted due to their ability to provide first-hand information about the relationship of the plant to the town, the operator's personal role in the plant and in the community, their perceptions of the benefits and disadvantages to their role, and the thought processes and motivations behind decisions related to plant operation and management. Other characteristics, such as gender or age, were not considered in targeting the study population.

3.5 Site Selection

The primary goal for site selection for both the quantitative and qualitative portions of the study was to include the widest variety of sites possible in terms of success, size, population served, location, and history in order to understand the spectrum of factors that may or may not influence sustainability. The researcher wanted to visit sites with lead operators that had a wide range of experiences and different perspectives. Given a large sample frame and extensive resources, an evaluation that randomly sampled all potential sites would be preferred. However, this evaluation was limited by both factors. A combination of convenience and random sampling was used to select sites, and information about each site was used to make a final selection. Also, only sites that are currently operational were considered.

3.5.1 Quantitative

At the time of site selection, there were 43 LWW sites in the Yucatán Peninsula. Five were in the state of Quintana Roo, 16 were in the state of Yucatán, and 22 were in the state of Campeche. Based on time and financial constraints, the researcher decided to visit and survey 16 sites. This number maximized the number possible given the financial constraints, and amounted to approximately three sites per week for each of the weeks available for field research. Three sites per week seemed to be an appropriate goal for several reasons. First, both the researcher and LWW were interested in communicating the site visit schedule to potential participants before field research began, and the researcher did not want to commit to more sites than could likely be visited. Transportation to and from each site would not be readily available, and the researcher wanted to have additional time in order to be able to visit sites multiple times, if necessary. Second, on some occasions, the researcher utilized the help of another researcher to conduct her surveys, and the visits had to be possible with her schedule. Third, the researcher contributed to the data collection for other researchers doing research simultaneously in the region, and so was not available for data collection on her project every day of the week.

Due to their relative proximity to the majority of the sites, the cities of Mérida in Yucatán and Campeche (City) in Campeche were selected as cities from which the researcher would conduct the majority of research. Originally, a third city (Ticul) was considered, and sites within a days' drive from each city were separated into three categories: Mérida, Campeche, and Ticul. However, considering the number of sites and transportation resources available in and near Mérida and Campeche, Ticul was removed

as a category. Therefore, only sites that had been grouped into the Mérida and Campeche categories were considered. This limited the number of potential sites to 27. A random sample of 14 was selected from these 27 sites in Excel. Only 14 were selected because, given the small sample size, the researcher planned to augment the random selection with sites that would contribute to the variety of the total sample. The sites were listed in an Excel spreadsheet in the same order that LWW had listed the sites for the researcher. A number was randomly generated for each site, and the list of sites was then sorted by that number. Every other site was selected for visiting.

The researcher then considered additional sites that would be useful to visit. Some of the 13 sites that were not randomly selected were not ultimately considered because they were not appropriate for the research. One served only the seminary where it was located and did not operate as a business. Another on the list had recently been selected as an LWW site, but had not yet installed the water purification system. Visits to these sites would therefore not be useful in understanding the sustainability of LWW's model. Several of the sites were too distant for a one-day round trip visit. The researcher developed a list of six additional sites that might add to the overall variety. Table 5 provides a list of the sites considered for final selection, with descriptions.

The researcher reviewed the list of 14 randomly selected sites and six other potential sites with a representative from LWW to confirm that the sites would be appropriate for the research and would maximize the variety of sites. The LWW representative provided additional information, but the researcher made the final decision about which sites to visit. Three of the 14 randomly selected sites were replaced by three of the potential additions, and two additional sites from the list of six potential additions

were included as well. The three replaced sites were not chosen because they were similar to other sites, too distant, and/or were not under LWW's umbrella. The site not under LWW's umbrella was more associated with the church that had helped to install it than with LWW, and LWW had little to no contact with the site or the church group that helped to install it. The final list included three sites in the state of Yucatán and 13 sites in the state of Campeche. These are shown on Map 2.

Map 2: Map of All LWW Sites in the Yucatán and Sites Selected for Project (in Green)(Google Maps, 2011a)

Table 5: Details of Each Site Considered for Final Selection		
Random Selection	**Selected**	**Profile of Site***
Miguel de Colorado, Campeche	No	Very small, remote, poor village with many obstacles. *Reason not selected:* Replaced with Revolución, Pueblo - see below
Lerma, Campeche	Yes**	Oldest system in Peninsula (2004), but upgraded. Run by the regional Yucatán coordinator. Good operation and good business.
Quintana Roo, Yucatán	Yes	Small town, unknown how it is doing, little to no contact with LWW.
Betania, Campeche	Yes**	Small town of about 2000 people, excellent system from 2009, has competition in the town. Has a drilled well.
Chuiná (Aquilas Serdan), Campeche	Yes**	Small town. Older system but has been upgraded. Has a drilled well. "Diligent in overcoming obstacles."
Hampolol, Campeche	Yes**	Small town. Older system but has been upgraded and is well operated.
Oxcabal, Campeche	Yes**	Very small village with a surprisingly good operation.
Chiná, Campeche	Yes**	Town of about 4000 people. Low production because it only serves the church. Good use of small space.
Campeche – Montiah Moriah	Yes	Urban, with a successful business and good leadership. Delivery by truck 3x/day.
Xmaben, Campeche	No	Small, remote village that had a difficult install but has since been upgraded. No recent reports. *Reason not selected:* Too distant for a one-day trip, and also similar to other sites already planned for visit.
Carrillo Puerto, Campeche	Yes**	Small, remote village with an old system that is poorly managed. There may be political problems in the church. No recent contact with LWW.
Pich, Campeche	Yes	Small, remote town. One of the largest producers and serves entire town of about 2000 people.
Kancabdzonot, Yucatán	Yes	Very small village, very poor, and struggling. Sells to adjacent villages.
Santa Clara Camp, Yucatán	No	A children's camp. One of the northern most sites, on the coast with very salty water that was too difficult for the system to handle, and it closed after the first week. Not under the LWW 'umbrella.' *Reason not selected:* Santa Clara Camp is less associated with LWW than with the church group that installed them, and therefore no contacts with LWW. Also, it was not a business, and it is closed.
Potential Additions	**Selected**	**Profile of Site***
Villa Madero, Campeche	Yes**	Small and poor, but well-operated and maintained. *Reason selected:* Interesting because it was described as well-operated, and it was one of few that did not provide delivery.
Xkeulil, Campeche	Yes**	Small, poor village. Broadly accepted, successful, and provides real ministry. This town may have seen the most health benefits. *Reason selected:* Well-run and well-accepted, and the ministry aspect is strong and very integrated into the operation.
Suc Tuc, Campeche	No	Small, remote town. Older system in need of an upgrade and has obstacles, but has community support. *Reason not selected*: Too distant for a one-day trip, and also similar to other sites I already planned to visit.
Champoton, Antioquia	Yes	Urban, but with low production due to lack of delivery. *Reason selected*: Another urban site, and interesting due to the lack of delivery.
Kímbila, Yucatán	Yes	Good install, well-run, and original operators left and opened their own plant. *Reason selected:* The researcher wanted a site that was described as doing especially well, and it was interesting that the original operators opened their own plant.
Revolución, Pueblo, Campeche	Yes**	Small village, struggling. *Reason selected*: Similar in most respects to Miguel de Colorado and also near to it, but had the additional interesting aspect of being closed down and reopened by a group of women who believed in its importance.
*All descriptions based on knowledge of town **prior** to visits. Descriptions are adapted from or taken directly from information provided by a representative of LWW. **Site also selected for an in-depth interview		

3.5.2 Qualitative

The researcher conducted in-depth interviews at 10 different sites, with a different lead operator at each site. Although some qualitative researchers suggest interviewing between six and 60 people from the target population (for example, see Morse (2000)) depending on the depth of data received from each participant, the decision to conduct 10 interviews was made based on the Guest, et al (2006) study suggesting that 6-12 interviews may be appropriate for identifying the majority of themes. It was also made based on resource and time constraints that limited the number of operators that could be reached. Because of the similarities between the plants (including a similar geographic area, a relatively consistent model for installation and follow-up by LWW, and management structure) 10 interviews was deemed adequate to likely identify the range of perceptions and ideas.

The 10 sites were selected from the 13 that were selected for the survey in Campeche. Although the researcher conducted surveys at sites in both Yucatán and Campeche, there were only enough resources to have a field assistant as an interpreter for in-depth interviews in one state. This would allow the researcher to utilize the same field assistant for all interviews without having to use additional resources to provide for travel and lodging. The researcher chose to have an assistant while staying in Campeche, since there were more sites from which to choose. The researcher planned to utilize her assistant two days a week for five weeks. The 10 sites were selected based on their characteristics, again attempting to have the widest range of potential perspectives possible, based on the criteria already mentioned. The researcher was aware that the necessary number of interviews would potentially need adjustment after conducting

several, due either to saturation of concepts being discussed or to a need to explore the research topics more. She and her assistant planned for potential adjustments to the schedule, though ultimately, no additional or fewer interviews took place. Refer to Table 5 for the sites selected for an in-depth interview.

3.6 Recruitment of Participants

Initial Contact - Through LWW:

LWW maintains a relationship with the churches in each town where a site has been installed. This relationship is either direct, through visits that LWW representatives make annually to many of the sites, or indirect, through a regional coordinator living near Campeche or through the Initiating US Partner. LWW was therefore able to facilitate initial contact with the sites. They did this by communicating the details of the project in several ways. Several months before fieldwork began, they communicated information about the project to people who had been or were Initiating Partners for sites in the Yucatán so that these people could communicate to the sites with which they were in contact. Participants in LWW's Clean Water U were also informed of the study throughout the several months before the project began. Additionally, LWW informed the regional coordinator living near Campeche of the schedule as soon as it became available and requested that he disseminate the schedule and information about the study to potential participants. Similarly, LWW representatives that were visiting the Yucatán were asked to inform sites they visited in the Yucatán of the upcoming visits.

Follow-up Contact - Through Researcher:

Before fieldwork began, the researcher attempted to find phone numbers or email addresses for as many operators as possible in order to call them several days in advance of the visit. However, only one site was reached in this way. Also, in some cases, the researcher was able to visit a site before the date she planned to conduct the survey in order to inform the lead operators of the project, determine whether they were interested in participating, and schedule a date and time for the survey and interview. The researcher visited all three sites in Yucatán before the planned date, and four of the sites in Campeche were visited early either by the researcher or the other researchers that were simultaneously working in the region. At one of the Campeche sites, no one was available with whom to schedule. After the researcher realized that the first several sites she visited were unaware that she would be coming, she contacted the regional coordinator, who quickly re-communicated with the remaining sites. All remaining sites were prepared for her visit, except one, where no contact was ever made, and the plant was closed and empty the day the researcher arrived for the interview and survey.

Contact on Day of Visit:

A fluent Spanish speaker was present with the researcher at each site. This person was either another researcher or the researcher's field assistant. When the researcher arrived at each site, regardless of whether the site had been previously informed of her arrival, the researcher and her assistant explained the study to whoever was present at the water plant and requested their participation. In most cases, that person was the desired participant. In others, the researcher was directed to another individual. Informed

consent was received for each participant before the survey or interview began. In most cases, there was only one person surveyed or interviewed, but in some cases, an additional person was present. This person was either another operator or a member of the water committee. At several sites, the lead operator informed the researcher that the treasurer or other member of the water committee maintained the majority of the financial records, so the researcher began requesting their participation as well. However, that person was typically unavailable.

3.7 Ethical Considerations and Confidentiality

The proposed evaluation and preliminary data collection tools were submitted to the Emory Institutional Review Board (IRB) in April 2010 for approval. The IRB determined that the evaluation did not meet the definition of research with human subjects since it was primarily intended for quality improvement. The researcher received a letter confirming this decision (see Appendix 3). However, the researcher chose to comply with all IRB guidelines throughout the study. An informed consent process, including a translated consent form in the format suggested by the Emory IRB, was used with all participants. All participants were given the opportunity to withdraw their participation at any point during or after data collection. Additionally, all data has been de-identified to the extent possible. A letter in the sustainability score analysis and a number in the qualitative analysis will identify all sites, and no participant's names will be used. During data collection and analysis, the information and data received from sites was kept or saved in a secure location. All paper records, except for consent forms,

have been destroyed. Consent forms remain in a secure location. Most data were collected digitally and were identified solely by the letter assigned to each site.

3.8 Data Collection Process

3.8.1 Field Assistance

Due to the researcher's lack of Spanish fluency, she utilized, at different times, two different assistants, both of whom spoke Spanish fluently. The researcher administered the survey herself in Spanish and her assistant helped to interpret questions for the participant and responses for the researcher.

The primary field assistant was hired in Campeche and conducted and transcribed the in-depth interviews for each of the ten sites. LWW facilitated the search for a field assistant by contacting past interpreters they had used in the Yucatán. The field assistant that was hired had never been an interpreter for LWW, but was familiar with LWW and had spent a summer working as an operator in one of the plants. It is possible that this connection could have biased the data collection. However, the researcher was present at the first several interviews and reviewed the transcripts of the first two early in the data collection process to determine whether that bias may be influencing the interviews. No evidence of that was found, and the benefit of his experience in a plant outweighed the concern for a risk of bias related to it. Also, the site he had worked at had not been selected as a site for an interview prior to selecting him as a field assistant, so he was not involved in any data collection at that site.

Before beginning data collection, the researcher trained the primary field assistant for the data collection on qualitative methods, the goals of the study, and ethical research

of human subjects. Materials from Family Health International were used for the training of ethical research of human subjects (Family Health International, 2009).

The secondary field assistant was one of the other researchers doing research simultaneously in the region and assisted only with surveys.

3.8.2 Survey and Record Collection

A total of 15 out of 16 sites selected were surveyed between June and July of 2010, and records were requested at each one. The 16th plant was visited, but the plant was closed and no one was present to be surveyed.

The survey was piloted at the first three sites, after which the order of questions changed, some questions were removed, and additional questions were added. However, because the majority of questions did not change, data from the first three sites were used for analysis, although there are some missing data.

All surveys were conducted with operators of the plants, in person. In two cases, the operator interviewed was not the lead operator, but a secondary operator in the plant. In three cases, an additional person was present, who was either another operator or a member of the water committee for the plant. The surveys were conducted at each operator's site, typically outside in a quiet, private area. All surveys were conducted mid-morning to early afternoon, which was typically after the initial morning cleaning and filling of bottles, on a Monday through Saturday. They each took approximately 30-60 minutes to complete.

With the permission of the operators, all surveys were recorded with a digital audio recorder. They were administered orally in Spanish, with the assistance of a field

assistant, and responses and notes were recorded electronically during the survey. The responses were recorded into an Excel spreadsheet that automatically copied them into the tool that was being used to determine a sustainability score for each site.

Records kept by the plants were not standardized across plants. No two plants kept records in the same way. Those that did have records available for the researcher typically kept day-by-day records. In some cases, these were available for the entire past year, as requested, and in others they were available only for the previous few days, weeks, or months. These data included some or all of the following desired data: number of bottles filled, number of bottles sold, price of each bottle sold, number of bottles donated, and costs. In some cases, the operator informed the researcher that the treasurer of the water committee kept more records, but they were not available. Also, most sites in Campeche said they reported their records to the regional coordinator in Campeche, so the researcher met with him after concluding her final visit. He provided the records he had available, which filled in some of the gaps. However, there was ultimately a wide variety in the type of data made available to the researcher, and the time frame it represented. With the permission of the operators, photos were taken of each site's records. In some cases, a photocopy or slip of paper with some of the requested information was provided to the researcher. The data were later entered from the photos into the database with all survey information.

3.8.3 In-depth interviews

A total of ten in-depth interviews were conducted in June and July of 2010 in sites around Campeche. The interviews ranged from approximately 25 minutes to one hour.

They were conducted in Spanish by the researcher's field assistant. The in-depth interviews took place after the survey was completed, either immediately or with a short break. In most cases, the participant for the in-depth interview was the same as for the survey, but in the two cases where the surveyed operator was not the lead operator, the lead operator did participate in the interview. Although operators were targeted because they were believed to be the primary decision-makers for the plant, they were not actually always the primary decision makers; however, they were the most involved in the actual operation of the plant. Since the operators in all cases seemed to devote the most time and energy to the operation of the plants, and for consistency, the researcher continued to target only the operator, even in cases where he or she was not the primary decision maker.

The researcher sat in on the first several interviews. This was because the researcher hoped to learn from the participants during the interview and also because the field assistant was not confident in his abilities as an interviewer. The researcher felt her presence was appropriate since the subject matter was not particularly sensitive and the operators agreed. However, as the interviewer gained confidence, the researcher decided that the possible distraction she posed was not worth the amount of information she was able to understand in the interview, due to the language barrier. She was not present at the majority of the interviews.

As with the surveys, all interviews were digitally recorded, with the operators' permission. They took place at the water plants, typically outdoors or in a partially covered area. In most cases, no other people were nearby. However, in a few cases, other operators, the pastor of the church, or members of the water committee were

present at the interview or within earshot for all or a part of the interview. In some cases, this was at the request of either the operator or the additional person. This may have affected some of the data from these interviews, although all operators appeared to be comfortable and willing to speak openly and honestly. Interviews were originally planned for Tuesdays and Thursdays, but due to scheduling conflicts for both the plants and the field assistant, interviews occurred on all days of the week and sometimes more than twice per week.

The researcher received the first two transcripts in English before the fifth interview. She reviewed them with her field assistant to clarify some information and to provide feedback on interviewing technique. Additionally, the researcher and her field assistant discussed each interview after it occurred. This allowed the researcher to record some notes about the interview and determine if or how the interview guide should be changed and whether the number of interviews seemed appropriate. Ultimately, few changes were made to the interview guide. Based on these conversations, the number of interviews originally planned seemed appropriate. An unexpected need to change the original schedule and conduct more interviews each week than originally planned made it difficult for the interpreter to work on transcription during fieldwork. A third transcript was received while fieldwork continued, and the final seven were completed after fieldwork was finished and the researcher had left the country.

3.9 Data Analysis

3.9.1 Quantitative

After completion of each survey, the data were reviewed for accuracy and plausibility. When necessary, the audio of the survey was reviewed to confirm a response. The researcher confirmed that the sustainability tool copy for each site had been appropriately filled in from the survey. Additionally, data from each of the 15 sites were entered into an Excel database that compiled the data from all surveys. The database included over 300 variables, including demographics; at least one variable for each of the survey questions; one for the sustainability subscore of each broad question, subcategory, and domain per site (see below); and weekly and monthly financial data. There was a significant amount of missing data across variables and sites, especially for financial records and other information related to the finances. Missing data will be noted in the results section where relevant. The sustainability tool was used to develop a sustainability scores for each site, and the data in the database were used to create descriptive tables and explore correlations.

3.9.1a Sustainability Score:

Sustainability scores were calculated using the sustainability tool for each site based on the information gathered during the site visits, from the survey, and from the financial records. The data from each question was copied directly into the Excel spreadsheet where the answers could be viewed in addition to the broad question and the descriptions of each score level (0-4) for each broad question. A score level was then selected for each broad question based on the answers to the survey questions that applied

to that question. Since the formulas had been built into the Excel spreadsheet, each of the 29 individual scores were then automatically included in calculations for a subscore of each category, each domain, and finally each site.

The scores for each site were calculated before the researcher moved on to the calculations for the next site. Despite the researcher's intention to make the score levels appropriately distinct during the creation of the tool, she did have to update many of the level descriptions during the analysis process. This was necessary to make them truly distinct and applicable for each site. Each time this was done, the updated description was then applied to sites for which a score had already been developed to ensure consistency. Scores that had already been calculated were updated if necessary, and many were unaffected by later changes. The tool included in Appendix 1 is the final result of this process, and was the tool ultimately applied to each site.

Additionally, in some cases, due to missing data, the researcher was unable to determine a score for each broad question for each site. In most cases, that broad question was simply left out of each level of score calculation. However, if fewer than half of the broad questions in a particular subcategory were missing, then no score for that subcategory for that site was calculated. For example, Site E was missing four out of six scores in the 'Cost Recovery' subcategory and three out of four scores in the 'Financing' subcategory. Therefore, neither a 'Cost Recovery' nor 'Financing' subcategory score was calculated for Site E. Also, since those are the only two subcategories in the Cost Recovery and Financing domain, no subscore for that domain was calculated either. If only one had been left out, the subscore for the domain would have been based only off the one subcategory for which there was a score. Therefore, the

final site score for Site E is based only off the other two domains. This information will be noted in the results.

Ultimately, while most score calculation was objective and systematic, the researcher does recognize that some subjectivity, missing data, and additional information (either from other parts of the survey or the qualitative interviews) may have influenced scores.

3.9.1b Correlations:

The researcher would have liked to determine which factors most influence sustainability by comparing sustainability scores for sites with and without particular characteristics. However, most of those characteristics were included in the development of the sustainability score, often through multiple questions, so the conclusions to be drawn from comparisons would be limited. However, correlations were explored between the sustainability scores and characteristics that, by themselves, were not used to develop the sustainability score. These included average monthly revenues, average monthly bottles sold, population of the town where the water plant is, and years in existence. None of these by themselves was used to develop a sustainability score, although monthly revenues in relation to monthly costs was used, and monthly bottles sold was in some cases used to determine monthly revenues. SAS 9.2 (Cary, NC) was used to determine correlation coefficients. Although the sample size is low, normality of the distributions of both the score and each characteristic was first assessed. If there was evidence that the distribution may be normal (by comparing the mean and median, visually viewing a histogram of the distribution, and considering the Sharpiro-Wilk

statistic), the Pearson correlation coefficient is reported. If there was strong evidence that the distribution was not normal, the Spearman correlation coefficient is reported.

3.9.2 Qualitative

All ten in-depth interviews were simultaneously translated and transcribed into English by the researcher's field assistant into Microsoft Word using the audio recordings. The researcher and her assistant intended to produce word-for-word transcriptions that were as true to the verbal interview as possible. However, the need for translation and the field assistant's own difficulty with the nuances of English prevented the transcripts from being exactly true to the audio. In some cases, the assistant used Google Translate to facilitate the translation process.

After receiving the transcripts, the researcher reviewed each one. She made English grammar updates and reviewed the audio to clarify parts of the translation. In some cases, large sections of the transcript data were updated by the researcher to make the transcripts as true as possible to the audio and as clear as possible. The researcher used a few interviews that her field assistant had also transcribed into Spanish to verify and update the English translations. Despite the attempts to get the most out of the data, some quality may have been lost in translation, and the quality was also affected by the researcher and field assistant's lack of extensive experience with interviewing.

The final translated transcripts were fully de-identified and then imported into MAXqda 10 (2010) for thematic analysis. The researcher attempted to use a grounded theory approach to qualitative data collection and analysis, as described by Glaser and Strauss (1968). However, the constraints present in the data collection process and the

lack of depth of the data received prevented the use of a robust grounded theory approach. However, its principles were applied to the qualitative data analysis, and the results have been grounded in the data to the extent possible. The actual analysis more closely resembles 'thematic content analysis' or 'thematic analysis' as described by Green and Thorogood (2004) and Liamputtong and Ezzy (2005), respectively.

To begin analysis, the researcher read through three interviews and created memos about recurring inductive and deductive concepts. After reviewing the memos, the researcher developed an initial set of codes based on the readings of the interviews and the memos. The researcher then read two other interviews to test the application of those codes and further develop the codebook. Examples of deductive codes include 'Operator Likes' and 'Success/Achievement,' which the interviewer specifically asked about. Examples of inductive codes include, 'Donating Water,' 'Evangelism/Ministry,' and 'Health Department/Inspectors,' which many operators spoke about, but were not asked specifically about.

The researcher then reread all interviews and coded them according to the finalized codebook. After coding was complete, using cross-case comparison, the researcher created memos describing the range of issues, ideas, and opinions being mentioned for most individual codes in order to get an idea of the breadth of the data, and included a notation of the number of times a particular idea was repeated between interviews. Sometimes this was done for groups of codes, such as 'Operator Likes' and 'Operator Benefits,' which had been coded separately, but were often grouped together during analysis. This helped the interviewer become familiar with *what* was being talked about.

During this process, in order to begin to understand *how* issues were being discussed, a comparison of how operators with different deductive characteristics spoke about different concepts was attempted. However, for the most part, the sample was not large enough to include enough interviews in each deductive subgroup to be able to ascribe any differences to that characteristic. For example, only one operator interviewed was female, the rest were male. All but one of the plants had a water committee supporting the plant. Eight of the ten were in rural areas, and of the two that were not, one was only semi-urban, but still somewhat remote. Two of the ten respondents were categorized as 'older,' but the remaining eight were categorized as 'young,' (i.e., appeared to be 30 or younger). Despite the low numbers in each category, contrasts between groups were considered, but were ultimately not very helpful.

Comparisons by inductive subgroups, which became apparent through the data, were slightly more helpful. For example, knowing whether the plant had ever been closed for a period of time, and whether the regional coordinator was involved in the site, were helpful in providing context and depth to some of the data. Again, though, the sample in each category was small, and contrasts may not be definitively grounded in the data.

To continue understanding how the participants were discussing each topic, the researcher developed several questions that led to specific searches of the data. This process led to further questions, and further searches of the data. Through this process, the researcher developed potential conclusions about relationships in the data, for which she conducted additional searches to ground the conclusions in the data.

The researcher utilized the Analytic Process as described in Hennink, et al (2010) to develop conclusions from the data, although she did not go so far as to develop an overarching theory tying all of the data together, given the limitations of the quality of the data. Through the process of searching, memoing, tentatively concluding, and searching again, the researcher began to categorize the codes and concepts into broader categorizations, such as 'Money' and 'Plant Operation,' as well as more conceptual categories such as 'Positive (or Negative) Motivator' and 'Long-term (or Short-term) Motivator'. Relationships between the codes and the categorizations were conceptualized and grounded in the data in order to explain the factors affecting the motivations of operators. Throughout the process, the researcher constantly read and reread the data to confirm which operators were discussing issues, whether and how they could be set apart from the other operators in any way, and the relative importance of each issue to each operator interviewed.

The process of reading, coding, comparing, categorizing, conceptualizing, and theorizing was somewhat circular, and the researcher ultimately arrived at conclusions that are grounded in the existing data. The analysis produced an understanding of the elements related to operators' experiences influencing sustainability as well as the linkages and tensions between different aspects of the operators' experiences.

4 RESULTS

4.1 Quantitative

4.1.1 Sustainability Scores

Fifteen sites were included in the sustainability score analysis. Table 6 shows descriptive characteristics about each site. The majority of plants are rural, and all but one has a population below 5,000. The plants have been in existence for between 1.5 and 6 years. In most communities, less than 5% of the residents are without piped water into their homes, but one town had greater than 50% without piped water. Between 0% and 4.8% of residents in each community do not have access to piped water, sewage, nor electricity in their homes, indicating that relatively few have no access to public services, but there are some residents that do not.

Table 6: Descriptive Information About Each Site Visited in the Yucatán Peninsula															
Site	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**P**
Urban/ Rural	Urban	Rural	Rural	Rural	Rural	Rural	Rural	Urban	Rural	Rural	Urban	Rural	Rural	Rural	Rural
Population	211671	3531	931	1200	3507	2100	3000	4767	1300	1800	.	2662	649	564	965
Year Plant in Existence	3	2	1.5	1.5	5.5	6	5	5	3	3.5	6	5	3	2.5	1.5
Number of Staff	3	3	3	3	2	3	5	3	1	2	3	3	1	4	2
Type of Technology*	ROS+ Ozone	ROS+ UV	ROS+ Ozone	ROS+ UV	ROS+ UV	ROS+ Ozone	ROS+ Ozone	ROS+ Ozone	ROS+ UV	ROS+ UV	ROS+ Ozone	ROS+ Ozone	ROS+ Ozone	ROS+ Ozone	ROS+ UV
Percent of houses without piped water	2.8%	3.0%	16.9%	8.4%	52.8%	0.5%	3.4%	4.8%	17.8%	4.2%	.	9.6%	2.3%	2.4%	2.5%
Percent of inhabited houses with no piped water, sewage, nor electricity	0.2%	0.1%	4.8%	0.0%	0.5%	0.0%	0.5%	1.1%	3.8%	1.9%	.	1.2%	0.0%	0.0%	0.8%

*ROS = Reverse Osmosis and Softening. All sites have ROS, but Sites A, G, J, and P may have the incorrect disinfection method listed.
**Source: INEGI (2005). For sites I and J, INEGI (2005) says that the population was 983 and 886 respectively, but the staff at the plant estimated the numbers in the table. Based on site visits, the plant's estimate was considered to be more accurate for analysis, which is plausible since 5 years had passed since the 2005 census, and population is increasing in the region overall. Site K was evidently urban, but the population was unknown.

The results of the sustainability score analysis are presented in Table 7. Charts 1 and 2 graphically show the overall sustainability scores and the domain-specific scores. Charts 3 and 4 show box plots and the distributions of each subcategory score as well as each site's score. Both the average and median score across all sites was 2.9 (n=15), which is above the threshold set for sustainability with reservations (2.5), but below the threshold set for sustainability without reservations (3.0). Since the overall score is simply an average, no individual score had the potential to result in a site being assessed as unsustainable or sustainable. However, a high (or low) score suggests that a site scored better (or worse) on more measures in order to achieve that score, and therefore that the site has greater potential for sustainability than sites that scored lower. Sites overall had a sustainability score ranging from 2.2 to 3.4. Only two were below the 2.5 threshold, and five were above the 3.0 threshold, so the majority fell into the 'sustainable, with reservations' category, meaning that they will possibly be sustainable into the future, but enough of their scores were low enough to cause concern.

Table 7: Sustainability Scores by Site*

Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Average
Management, Operations, and Maintenance	**2.9**	**3.1**	**2.5**	**2.7**	**3.0**	**2.4**	**2.6**	**2.4**	**2.5**	**2.9**	**3.2**	**3.1**	**2.4**	**2.4**	**2.1**	**2.7**
Staff	3.0	4.0	3.0	3.3	3.3	2.7	2.0	2.3	2.0	2.7	4.0	4.0	2.0	3.0	3.0	3.0
Operations	2.3	3.0	2.5	2.7	3.0	3.0	3.0	2.3	2.3	3.3	2.3	2.3	2.3	3.0	2.7	2.7
Maintenance	3.2	2.5	1.8	2.2	2.7	1.7	2.5	2.0	2.8	2.7	3.4	2.8	2.2	1.8	2.2	2.4
Network/Support	3.0	4.0	3.5	3.5	3.5	3.5	3.5	3.5	2.5	3.0	3.0	3.5	3.5	2.0	0.0	3.0
Cost Recovery and Financing	**3.5**	**4.0**	**3.1**	**3.9**	**.**	**3.8**	**3.2**	**3.3**	**3.4**	**3.4**	**3.7**	**3.5**	**3.0**	**1.7**	**3.1**	**3.3**
Cost Recovery	3.2	4.0	3.2	3.8	.	3.7	2.8	3.0	3.7	3.5	3.7	3.6	2.8	1.3	3.3	3.3
Financing	4.0	4.0	3.0	4.0	.	4.0	3.8	3.8	3.0	3.3	.	3.3	3.3	2.3	2.8	3.4
Understanding of Demand	**2.5**	**3.4**	**3.0**	**3.0**	**1.2**	**2.8**	**2.8**	**2.3**	**3.0**	**2.4**	**2.3**	**3.3**	**2.8**	**2.8**	**3.2**	**2.7**
Demand Generation	2.0	3.7	2.7	2.7	0.0	2.7	2.7	2.3	3.7	2.0	2.0	3.7	3.0	2.7	3.0	2.6
Awareness of Demand	3.0	3.0	3.5	3.5	3.0	3.0	3.0	2.0	2.0	3.0	2.5	2.0	2.0	3.0	3.5	2.8
Overall Score	**3.1**	**3.4**	**2.8**	**3.2**	**2.3**	**3.0**	**2.9**	**2.7**	**2.9**	**3.0**	**3.2**	**3.3**	**2.6**	**2.2**	**2.7**	**2.9**

*Scores are black if they are 3.0 or greater (likely sustainable), orange if they are greater than or equal to 2.5 but less than 3.0 (maybe sustainable), and red (likely not sustainable) if they are less than 2.5.

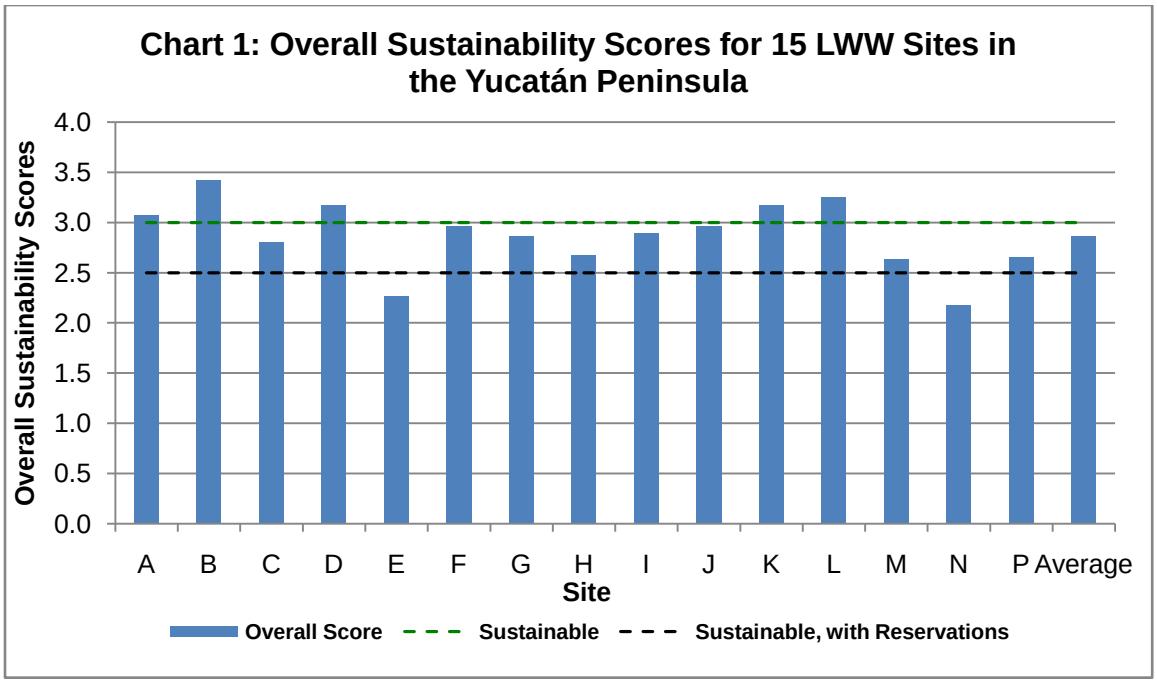


Chart 1: Overall Sustainability Scores for 15 LWW Sites in the Yucatán Peninsula
Overall Sustainability Scores
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
A
B
C
D
E
F
G
H
I
J
K
L
M
N
P Average
Site
Overall Score
Sustainable
Sustainable, with Reservations

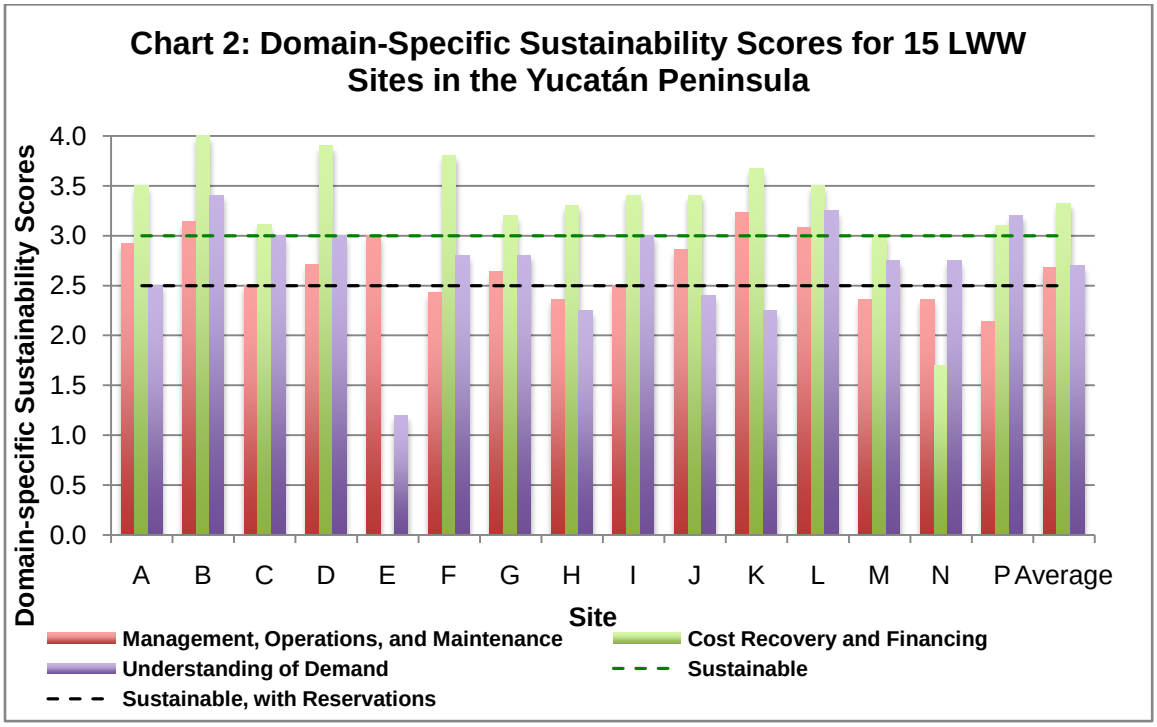


Chart 2: Domain-Specific Sustainability Scores for 15 LWW Sites in the Yucatán Peninsula
Domain-specific Sustainability Scores
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
A
B
C
D
E
F
G
H
I
J
K
L
M
N
P Average
Site
Management, Operations, and Maintenance
Cost Recovery and Financing
Understanding of Demand
Sustainable
Sustainable, with Reservations

Chart 4: Box Plots of Component Scores of Overall Sustainability Scores for 15 LWW Sites in the Yucatán Peninsula

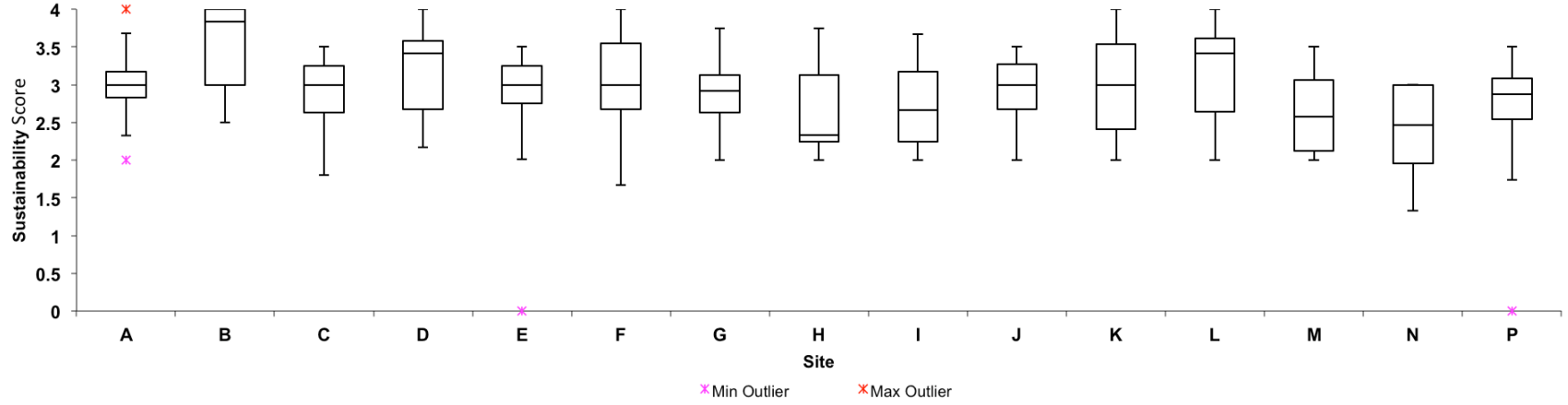
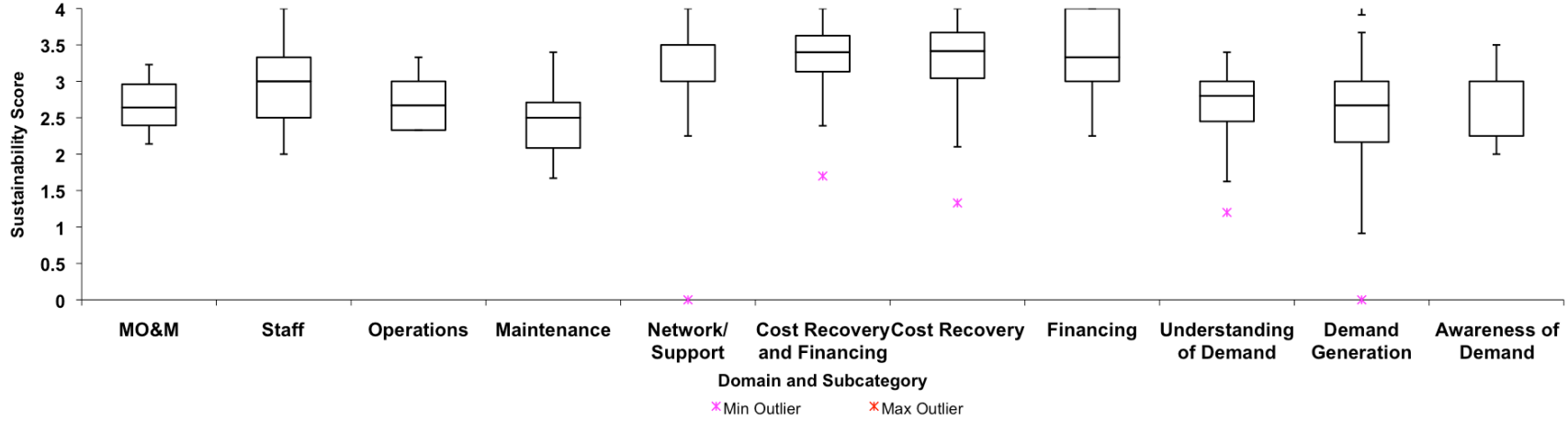


Chart 3: Box Plots of Sustainability Scores for Domans and Subcategories for 15 LWW Sites in the Yucatán Peninsula



Of the three domains, sites overall had the best average scores for Cost Recovery and Financing (3.3, range: 1.7-4.0, n=14), followed by Understanding of Demand (2.7, range: 1.2-3.4, n=15) and MO&M (2.7, range: 2.1-3.2, n=15). The median scores for each of these were similar (3.4, 2.8, and 2.6, respectively).

The subscores that made up the **Cost Recovery and Financing** domain score, which included a subscore for Cost Recovery and a subscore for Financing, were both above 3.0; the average subscore for Cost Recovery was 3.3 (range: 1.3-4.0, n=14) and the average subscore for Financing was 3.4 (range: 2.3-4.0, n=13). Most sites achieved a domain score that was in the 'sustainable' category. Only one (Site N) did not, receiving a score of 1.7, and the score for Site E was missing due to lack of available data. Also, for Site K, this score was based only on Cost Recovery, as information about their access to and utilization of loans or subsidies was inadequate to determine a score for the Financing subcategory.

Additional information about each site and some measures of performance are in Table 8. This information shows that, for all sites except Site N, monthly revenues from sales were overall greater than monthly costs, although in two cases (Sites G and P), revenues were not more than USD$5 greater than costs. Five indicated they currently had loans or had recently received subsidies to help them cover the cost of something for the plant. In some cases, this was a donation in the form of an upgraded system or the construction of a well, but in others it was unclear. The only site that clearly stated they had loans, Site N, owed money for the construction of a well and for the purchase of a delivery vehicle.

The subscores that made up the **Understanding of Demand** domain were Awareness of Demand (2.8, range: 2.0-3.5, n=15) and Demand Generation (2.6, range: 0.0-3.7, n=15), both of which are considered sustainable, with reservations. As discussed later, these measures may not have been the most indicative of what they were intending to measure, but they suggest that there is room for improvement in both responding appropriately to the level of demand as well as in generating additional demand for the water produced at each plant. Many plants charged different prices to customers for delivery and did not generally bottle more bottles than were demanded, contributing to higher scores for Awareness of Demand. The range in scores for Demand Generation is large, and one site (Site E) received a score of 0.0, as they did not meet several of the criteria, including providing delivery, reaching at least 10% coverage of their town, or performing marketing or educational activities. Although most plants achieved the first two, few plants performed any marketing or educational activities or seemed to change prices in response to demand, such as in peak seasons.

In the **MO&M** domain, subscores for Staff, Operations, Maintenance, and Network/Support made up the overall domain score. The only one that was 3.0 or higher was for Network/Support (3.0, range: 0.0-4.0, n=15). Most sites received a 'sustainable' score for this subcategory, but one site (Site P) received a score of 0.0. This was because Site P did not demonstrate any of the characteristics measured, including attending annual trainings or having contact with other operators, having a water committee, or communicating with LWW. The operator had little contact with the pastor of the church where his plant was, because the pastor did not live in the town and only came sometimes. However, anecdotally, this particular operator appeared extremely dedicated

to his plant, to the mission of LWW, and to his community, and the site overall was considered sustainable, with reservations.

The lowest subscore of all eight subscores from all domains, and the only one below 2.5, was for Maintenance (2.4, range: 1.7-3.4, n=15). Although the median, 2.5, is similar to the average, the range is fairly large and suggests that, although some sites are doing poorly, some sites are doing well. Many plants received lower scores on **MO&M** for experiencing downtime, lacking someone on plant that can perform all repairs, and lacking an inventory of spare parts and supplies on plant.

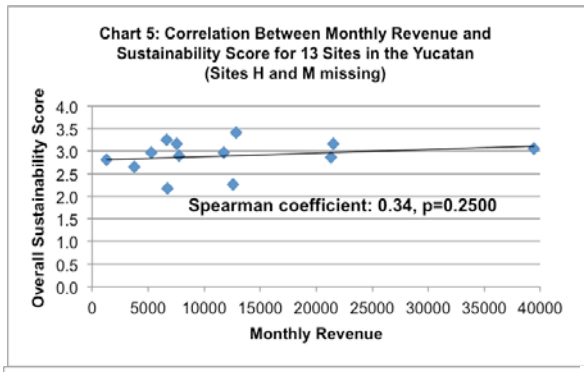
4.1.2 Other Measures of Performance and Correlations

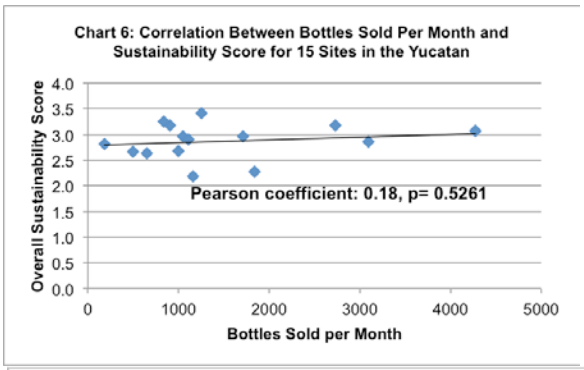
Table 8 includes additional descriptive statistics about each site and its performance, including average monthly bottles sold, costs, revenues, and other information. Most of this information influenced the sustainability scores in some way. Some of the information in this table and from Table 1 that was not used in determining a sustainability score was used in Charts 5-8 to explore correlations between the sustainability scores and other measures of each site's performance. The sample sizes are low, so it would be difficult to find any statistical significance. Charts 5-8 and the correlation coefficients suggest that the sustainability scores may be slightly positively correlated with monthly revenue, average bottles sold per month, and town's population, although the correlation results are not statistically significant. There is no evidence of a relationship between the years the plant has existed and its sustainability score, though again, that result is not statistically significant.

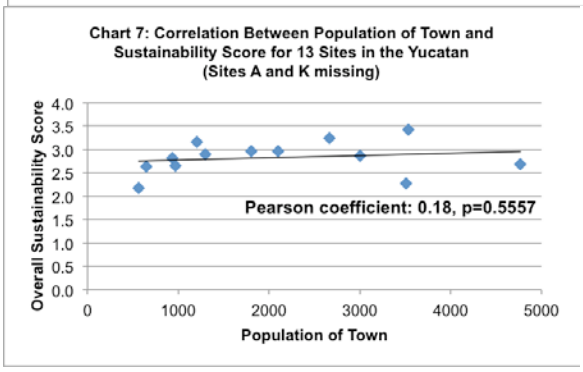
Table 8: Descriptive Statistics and Performance of Site in the Yucatán Peninsula

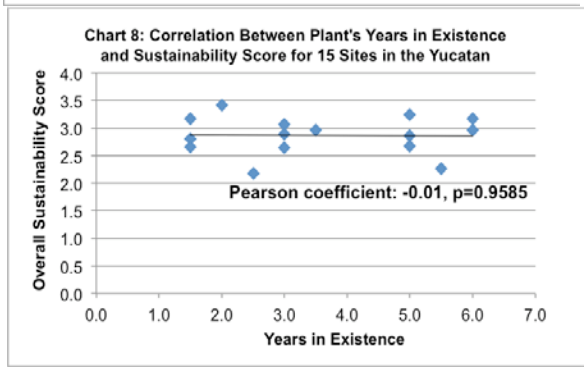
Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	P
Average Bottles Sold per Month	4000	1257	182	908	1838	1052	3094	1000	1109	1712	2731	833	650	1159	496
Average Monthly Revenues ($USD)*	3,130 (1)	1,018 (2)	103 (1)	600 (1)	996 (2)	417 (2)	1,693 (1)	?	616 (1)	931 (2)	1,706 (1)	529 (1)	?	532 (1)	301 (1)
Average Monthly Costs ($USD)*	2,546 (2)	259 (3)	85 (1)	482 (1)	?	235 (2)	1,690 (1)	?	416 (1)	641 (2)	1,429 (1)	479 (1)	?	570 (1)	300 (1)
Active Water Committee?**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No
Delivery?	**Yes**	**Yes**	**Yes**	**Yes**	No	Yes	**Yes**	No	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Current use of loans or subisidies	No	No	No	No	No	No	No	No	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**	No
Current OR past access to loans or subisidies	**Yes**	**Yes**	?	No	?	No	**Yes**	**Yes**	**Yes**	**Yes**	?	**Yes**	**Yes**	**Yes**	**Yes**
Future access to loans or subsidies	**Yes**	No	No	**Yes**	No	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**	No
Someone on site can do all maintenance and repairs	**Yes**	**Yes**	?	No	No	No	No	No	**Yes**	No	**Yes**	**Yes**	No	No	**Yes**
Replacement operator identified	No	?	?	**Yes**	**Yes**	No	?	**Yes**	No	No	**Yes**	**Yes**	**Yes**	**Yes**	?
Overall Score	**3.1**	**3.4**	**2.8**	**3.2**	**2.3**	**3.0**	**2.9**	**2.7**	**2.9**	**3.0**	**3.2**	**3.3**	**2.6**	**2.2**	**2.7**

***The amount in $USD was calculated using an exchange rate of 12.6MX/1USD, which was about average for June-July 2010.**
(1) = Most reliable (based off records for at least 4 months), (2) = Somewhat reliable (based off records, but fewer than 4 months of records),
(3) = Least reliable (estimate based on estimates provided by the operator)
****This was coded as yes for a site if the last water committee meeting had occurred within the previous 6 months and if the operator could describe what had been discussed.**

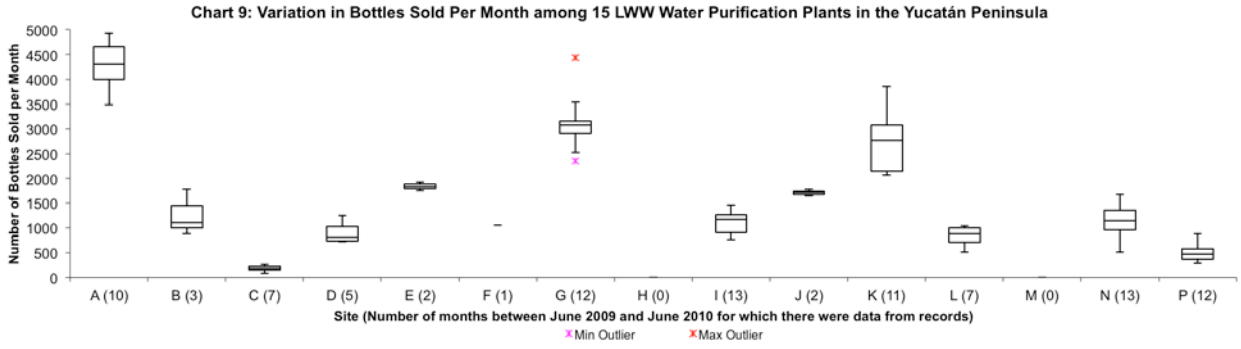








Lastly, Chart 9 shows the variation in bottles sold per month for each site, which is also a reflection of monthly revenues and general monthly activity. The numbers next to the site name on the chart indicate the number of months represented by the data. Some of the sites for which there are more data show greater variance in bottles per month. The operators explained that they typically sell more water during the hottest months of the year (April to June) and less in the colder and rainier months of the year.



4.2 Qualitative

While the sustainability score data focused on the plant's overall performance, the qualitative data focused on the specific experience of the lead operator, who is largely responsible for the plant's success, and how their experiences can impact sustainability. The data from the 10 in-depth interviews related to operator motivations were categorized broadly into four main categories: Money, External Factors, Church-Related, and Plant Operation. The data and concepts that arose from the data did not generally fit perfectly into any one category, and the interactions between them were considered. Some themes could not be primarily categorized into any single category, so they will be discussed in relation to each of the applicable categories. These categories are not exhaustive or perfect for incorporating all of the data related to motivations in the interviews. However, they are helpful for beginning to understand, broadly, the factors affecting the motivations of operators and the long-term sustainability of plants. Additionally, the interactions between them identify the tensions of different feelings, pressures, and goals that operators experience.

4.2.1 Money

The concept of money, including salaries, profits, costs, loans, price, and customers' ability to pay, plays an important and fundamental role in how the operators relate to the plant they work in, their customers, and their long-term goals. Some of the operators were asked about how they felt charging people for water, but most spoke about money as a recurring element of each interview, in response to a variety of questions.

4.2.1a Plant Income:

One aspect of the plant that several operators spoke of was that the plant's mission, and often their personal goal, is to 'help people,' rather than earn money. Three of the sites specifically described the plants as not-for-profit, and there were others that expressed non-monetary motives as primary for their plant, including serving the community and helping people. Two of the sites that described the plant as not-for-profit also explained that this was part of their contract with their American partners. Speaking about the plant initiation talks with the Americans, one operator said, "One of the responsibilities was that… that we see this as… as social work of the church to the community, that we don't see it like… a project, like, of profit, that we see it as, as a ministry of the church" (IDI7). When asked about why he charges people for money, another explained that, "The American people… told us that it is not to make profit, it is for maintaining the plant" (IDI10). However, although no operator indicated that one of their goals for themselves or the plant is to make money, one did express a desire for the plant to "prosper more" (IDI1) and another that "it would be good to have some resources to invest" (IDI4). The operators also suggest a variety of reasons for why the plants' income is important, including maintenance of the system, self-sufficiency, and the ability to use the income for the plant's needs as well as for helping needy people and the congregation.

4.2.1b Personal Income:

Operators at all but one site were paid a salary, and they recognize the salary as one of the benefits they and their fellow operators receive from the plant. For all but one,

the salary for the plant was their only source of income. Salary is also viewed as something that is necessary to entice additional employees. Four of the operators specifically described the salary they or their fellow operators receive as a benefit of being an operator. One of these stated that money is important in order to have food to eat. Two others indicated that their salaries are low. One suggested that he views the work as more like a "social work" (IDI4) and the other said he can manage because he lives with his parents, is unmarried, and does not spend much money (IDI10). At three plants, the operator explained that, while an additional employee (either a deliverer or a washer/filler) would be helpful, the plant does not have enough money to pay another person a salary, even though that additional employee had the potential for increasing the plant's revenue (especially in the case of delivery). Another way some operators benefit monetarily from the plant is by receiving free water for their personal consumption, which the committee in some cases has allowed them to do.

4.2.1c Resources Available for Plant:

Several of the operators, especially those from struggling plants, expressed frustrations regarding lack of money for the plant. In response to a question about things they struggle with as an operator, several said they are not able to achieve their plans for the plant due to lack of adequate resources. One said, "…there is more we want to achieve in the plant, to try to cover all the buildings that the plant has, well we haven't achieved that yet. So this has also been a little bit of a discouragement" (IDI9). Operators were also concerned about the high cost of utilities, particularly electricity, and replacement parts, and described these costs as 'hard' and sources of frustration and

discouragement. The inability to have resources to invest was also a source of discouragement. Conversely, other operators, some from plants that were struggling less, have felt pride from the plants' ability to do well. One described their plant as a success because they have "in one year achieved more than [they] expected" (IDI1) and another because "[they] have been covering all the expenses [they] have, payments and everything…" (IDI4).

The availability of resources, both for personal and plant use, seems to play an important role in operator's sense of accomplishment and personal benefit from the plants they operate. While no one expressed a desire specifically to earn more money for the plant or for their selves, they do express desires and potential benefits gained from having additional resources, especially for the plant. Earning a salary and being able to make investments and achieve plant goals through increased resources are motivators for the operators.

4.2.2 Internal Plant Operation:

Aspects of the plant operation, including daily tasks and interactions as well as longer-term plant regulations and improvements, influence operators' views and feelings about their work. Many of the themes in this category overlap with the other categories, especially external factors and money, but they are discussed here due to their being primarily internal to each plant's operation.

4.2.2a Producing Clean Water:

For many operators, their position as a provider of clean water is a point of pride, and they take their duty to provide it seriously. One operator pointed out that he has a strict rule to not let anyone enter the plant room with shoes (as opposed to the boots they wear), and his advice for other operators was that they always be clean and have appropriate hair and clothing. Operators said that it is important for all plants to do what the health department asks and to be careful with the water. As a result, one operator said, "Today, the health department has said that [the plant] doesn't give [gastrointestinal illnesses]… So we feel that this is a success, it's an achievement that is, that we have obtained" (IDI7). Other operators indicated that they feel pride to be the best "because they are careful with the water" or that they feel happy to have achieved a higher health department qualification through their efforts. Through daily obliging with good practices, the operators are able to produce water they can feel proud about and know that they are contributing to the health of their customers.

4.2.2b Coworkers:

Additionally, several operators work with other employees of the plant, including other operators and delivery people. Sometimes there is a breakdown of tasks, and the lead operator works the purification system while another person does the cleaning or filling of bottles. For most operators, coworkers seem to be a source of pleasure in operating the plant. They point out that it makes the job more enjoyable, that they feel a close spiritual connection with their fellow employees, and that it makes the job easier. Some suggested that additional workers either do or would provide relief in the work,

presumably because they would relieve some of the stress by taking on some of the work. However, tensions did exist between coworkers. One said that there are problems of "inconformity" when working with other people, perhaps because different people perform tasks in different ways. Another preferred to work alone because he then had more control over the operation and knew what to expect when he came in the morning. One lead operator, who worked with two adolescent operators, had to have "difficult" discussions with the younger operators when something was done incorrectly. Having coworkers seems to contribute in primarily a positive way to the plant environment, for emotional support and friendship and the relief in work they provide, but can also cause additional stress or tension, especially when different operators have different ways of doing tasks in the plant.

4.2.2c Physical Plant:

The physical state of the plant also has an impact on how operators feel about their work. Many feel pride that the plant exists at all, and they also feel pride in improvements that have been made in the plant. One operator said that he feels they are achieving their goals because they have "invested in everything that the health department required" (IDI1), although it caused them to go into debt. Others pointed out improvements that had already been made to the plant or plant site, such as ceilings, floors, an upgraded purification system, or the installation of the well.

As with other aspects of plant operation, though, the failure to make desired improvements or to have fully functioning equipment also has a negative impact. Most operators, both struggling and not, had a list of equipment that needed replacing and

improvements they would like to make to the plant. Equipment needing replacement included pumps, which were not working well; an improved filter; more modern tanks; and an additional membrane. One operator went so far as to say that he would improve the whole system, because several parts were failing. Several operators expressed frustration that the purification process had slowed down significantly since installation, likely due to needed filter replacements. Most had a list for desired plant site improvements as well, including one or more of the following: ceilings, fences, walls, windows, mosquito screens for the windows, an additional room for storage, and a vehicle for delivery. However, as evidenced by the operator that went into debt to invest in all the requirements for the health department, the ability to pay for replacement parts and improvements is beyond the financial abilities of most plants. Another noted that he was in debt for replacing the reverse osmosis machine, and still another for replacing a pump and installing a well. In some cases, the plants seem to be able to pay off these debts, but not all, and they would prefer to have a fund with money in it to pay for needed repairs and improvements ahead of time. For replacements, it is not only the price of the part that is expensive, but if they do not know how to install it themselves, the cost of the labor can also be expensive. This leads some operators to try to figure it out for themselves. This can be another source of pride, or frustrating. One operator, from a struggling plant, said, “I think what I do not like the most in the plant is that, well, we could not improve, we could not get what we want or reach our goals” (IDI9). A plant that is running well and has been improved creates a sense of accomplishment for operators, but most operators seem to struggle with not being able to achieve things that the plant needs to continue operating at its full potential.

4.2.2d Confidence/Job Comfort*:*

Also worth noting is that several operators seemed to especially feel comfortable in their role as plant operator if they feel like they are good at the job or have prior experience with it. One operator explained that the work came easily to him, and that even though he did not originally know anything about the plant, he is now very knowledgeable about it. He can tell when something is not working appropriately and can figure out how to fix it, and that makes him happy. Another had worked in a factory previously where he also had to be familiar with the requirements of the health department, and that experience helped him to be selected as an operator for the plant. On the other side, one operator expressed feeling discomfort when he began his role as an operator because he did not know anything about it, and became frustrated when he had to go seek out someone else for help and answers.

The ability to work productively in the plant and to provide a service that operators view as important and serving the community contributes to operator's feelings of satisfaction with their role. The production of clean water, the ability to follow health department guidelines and receive recognition, positive relationships with coworkers, the ability to repair and improve the plant, and confidence in the ability to operate the system all positively influence operators. The inability to do any of these things can lead to discomfort or dissatisfaction with the daily and long-term tasks of plant operation.

4.2.3 External Factors

The operators spoke of several aspects of their jobs that were part of operating the plant, but that were more external to the plant than the internal factors. These include

family, the ability to serve their community and their relationship with the community they live in, their interactions with customers, and struggles with the health department. Although these factors may be a part of daily routine like many of the internal factors are, they are separated for discussion due to the fact that the operators themselves have less perceived direct control over them.

4.2.3a Family:

For operators, family or a sense of family seems to be an important component of their commitment to the plant. In several cases, family members actually worked together at the plant, which may reinforce commitment. Others expressed that their family supported them in the job, perhaps meaning that their family encouraged them to have and maintain their role. One operator said that "[The plant] is something good, because it helps me a lot with my family" (IDI2), perhaps referring to the income it provides. Just as important as benefits to actual family, though, seems to be the sense of family operators feel with other people. All operators referred to their fellow operators, church members, or non-church member customers as 'brothers.' This is partly the language of Presbyterians in the Yucatán; they refer to many people, typically other church members, as brothers. However, it is meaningful that they feel this connection with their customers, coworkers, and American partners, all of whom they interact with in their work. Similarly, several described their coworkers or customers as "like brothers" or "like family." These comments about family suggest that operators not only want to provide support for their own families, but that they feel a deeper connection with

the people they interact with through their work than perhaps many people do. This may lead to a greater sense of commitment or satisfaction.

4.2.3b Service to Community and Customer Relations:

For most operators, the ability to help and to serve their community is central to their desire to operate the plant and to ensure the plant's sustainability. When asked about what they like about working in the plant, almost all operators responded with the fact that they are able to provide a benefit to the town, serve the town, help people, or some other variation of that idea. Several were happy to be contributing to a reduction in sickness in the community, particularly of children. Also, all plants are required to give some water away for free, per their contract with LWW. Most operators commented on the importance of giving water to people that cannot pay for it, and none commented negatively about it. Similarly, the operators feel that the plants are unique and important because they sell water more cheaply than other water providers. Indeed, one operator was pleased that the plant's presence in a community has forced down the price of other sellers in the area. He said, "They started to lower prices and when our plant was a success they had the lowest prices, so I think that is a success and we won against them, and now they can't raise prices here…" (IDI5).

The operators feel a strong commitment to the idea of prioritizing providing clean water to people over generating income. One operator expressed frustration at not being able to provide more free water, although it was unclear whether this was due to a need to collect enough money to sustain the plant or due to a limit on the amount of water they were able to purify due to time or raw water supply constraints. Another explained that

he became very worried when the raw water flow was interrupted by a lack of electricity. It meant he might not be able to provide water to people who needed it, rather than meaning that he would not be able to make money that day.

Other aspects of customer interaction may be typical of many businesses. Several operators expressed pride and appreciation at receiving positive feedback from customers and hearing that their water was the best in taste, clarity, or testing. Several also described frustrating interactions with customers, including customers not returning bottles, customers returning dirty bottles, or customers becoming unhappy when they expect the plant to be open but it is not. Although the operators mentioned these aspects of their relationship with customers, they did not seem as central to the operators' experience as the ability to serve their community, since they were not mentioned as frequently by each operator nor as consistently across operators. One exception was an operator that mentioned problems with customers more than once, and elaborated that he had had problems with giving water to people on credit and experienced resistance upon requesting that the customer(s) pay their debt.

4.2.3c Relationship with Wider Community and Institutions:

However, the interaction of the plant and the town in general – especially with the regulatory bodies such as the town authorities and the health department – more significantly influenced their experience than the specific interactions with customers. Three of the operators said that there had been complaints in the town that the plant was using too much of the town's water source. One said this prevented them from expanding to selling in another town for fear that their community would complain, and

another said that twice community members tried to get the town authorities to close the plant for this reason. However, several operators also explained that they had the support of the town authorities and others in the town because of the quality water and the help that the plant is providing. This relationship may be facilitated by the fact that most plants, in addition to giving free water to people in the community that cannot pay, are elderly, or sick, often also provide free or reduced water to schools or community events. These relationships and interactions with the town are important for operators' long-term job security and acceptance in the community.

The interactions with the health department directly affect operator's day-to-day experiences, and can cause a wide range of feelings among operators. Several operators expressed dissatisfaction with the health department. Two described the health department as the plant's biggest problem, and a third described it as one of the biggest problems. One subset of operators feels that the health department has too many requirements and is inconsistent. Only one plant had been shut down temporarily in the past by the health department (although another had been closed at one point for an unspecified reason), and the health department had threatened another with closure. One operator described the health department as making him very nervous, and another was frustrated because the health department's priorities for the plant did not align with his own desired improvements. At one site, the operator explained that the health department demanded bribes, which they refused to provide, and that other plants were able to get away with things they should not have. However, there was another set of plants that had little to say about the health department. One shared that the plant had only been visited once by the health department, and two others that their relationship

with the health department was fine and that the tests of their water had been fine. Lastly, one plant was unique in promoting the health department as a source of good information and recommended that all plants should work closely with it. Several plants, across this range from frustrated with the health department to promoting the health department, expressed satisfaction when they receive approval from the health department, though, and associated that approval with their pride in providing clean water. The health department seems to play an important role for operators in their work, and it can strongly influence their satisfaction with the plant and their work.

Although each plant is on the property of a church, the plant and the operators are part of a wider community. The operators' interactions with the people and institutions in that community factor significantly into the pleasures and displeasures each operator experiences as part of his or her work.

4.2.4 Church-Related

The relationship of each plant to the Presbyterian Church may be the single most influential element contributing to operator satisfaction and motivation. The operators' goals and motivations for the plant are heavily influenced by church doctrine and ideals. To varying degrees, each plant, and each operator, has a mutually beneficial relationship with the church it is in. The operator feels that he or she is supporting the church, and the operator and plant receive support from the church and the congregation. There is an exchange of financial resources, staff, and social support between the two.

4.2.4a Ministry:

Many of the themes influenced by the church have already been discussed, including the not-for-profit status of the plants, the desire to help and serve communities, and the goal of providing free water. The main driver behind these intentions is the fact that the primary purpose of the water plants is to provide a ministry through clean water. Several of the operators expressed this as their own purpose. One remarked that he feels "sincerely… good because the Lord's word says that we should give help to the needy and sick people" (IDI1). Another said that providing clean water is a medium through which he is able to reach those who are economically and spiritually poor. These comments are reflective of what many operators said.

While operators themselves are driven by this purpose out of their own faith, it also seems as if they are influenced to some extent by either their pastors or American partners. In several of the interviews, the operator stated that they had been reminded by an American that the purpose of the plants was for ministry, not profit. Similarly, the pastors reinforced the idea that the plant was for ministry purposes. In two cases, the lead operator was also the pastor of the church, and the ministry component was especially strong in these two plants. In another, the operator explained that the pastor of the church says that money is not important and that the priority is to give people water, and so not to worry if customers cannot pay. There is no evidence to suggest that operators were pressured to view the plant in a particular way, or that they disagreed in any way with their American partners or pastors regarding this purpose of the plant.

Also, for several operators, selling or delivering clean water provided an opportunity to evangelize or speak to people about Jesus and the Bible. This was

especially true in the two plants where operators were also pastors. Those two, as well as a third, expressed generally or provided a specific example of a time that they had evangelized and encouraged others to come to the church. Other operators, on the other hand, explained that they did not use the plant to evangelize to customers or to invite more people to the church. However, some of those who said they did not use the water in this way did still say that the purpose of the plant was for ministry and that they liked the opportunity to provide a ministry to their customers. One said, "sometimes with our actions [the customers] can learn a lot more than just using language" (IDI4). Regardless of whether the operators used the plant to bring additional people to the church, all seemed to find the ministry aspect of the plant to be an important part of their own role and the purpose of the plant.

4.2.4b Church/Plant Relationship:

The church and plant mutually support each other in several ways. First, all plant employees that the researcher interacted with were members of the church congregation. All operators were asked during the survey who would replace them if they could no longer work, and even if a specific person could not be identified, all operators indicated that it would be someone from the church. Additionally, during the interviews, many of the operators said that they or their family members were or had been elders of the church. As mentioned previously, two were pastors of the church themselves, and others described the pastor of the church as either actual family or "like family." The church seems to be the main source of employees to the plant, and many have familial ties with church leadership. In fact, one site suggested that they could not hire from outside the

church because “the plant could not weekly pay someone a good salary. That is… no problem for me, I’m Christian, but another person who was outside we assume he is not Christian and will want a good salary and the system does not have the money to pay it and to cover expenses and needs here” (IDI10). Another operator indicated that he did not have a salary when the plant was first installed. This suggests that dedication to the church is a characteristic of plant employees, beyond the desire for a salary. The church members are also a source of temporary labor for the plant. Several operators said that the church members had been involved in the building of the plant or improvements of the plant.

Secondly, in most cases, the plant – and the operator specifically – are supported financially by the church in addition to their salary, and vice versa. Although the operator mentioned above receives what he considered a low salary, he explained that the church did offer to help him with medical expenses when he was sick. Several operators indicated that they themselves would be able to get a loan from the church, or that the plant could. Others explained that the congregation has bought parts for the plant. For some plants, this goes both ways – the plant will contribute money to the church, and the church will lend the plant money, making the sustainability of the plant on its own difficult to discern from that of the church. At most plants, the church and the plant shared the cost of utilities. Several operators also said that the congregation supports the plant by buying water from the plant, and in turn, they support the congregation with clean water. Additionally, one of the operators explained that his plant contributes 10% of the plant’s income to the presbytery, and the financial records indicate that other sites contribute some amount to the presbytery as well.

Lastly, although many of the financial contributions the church makes directly benefit the plant rather than the operator, they indirectly benefit the operator by providing more resources for the operator's salary, and by providing an opportunity for the operators to be involved in the church. Most operators referred to the plant and the church as a single community. Operators expressed that they liked that their role provided an opportunity to be a part in the church. One described the plant and congregation as linked, and another described the relationship of the church committee, the congregation, and the plant as one of friendship. The operators explained that they benefitted the congregation and its health with water, and that they also provided water for free to church groups and church activities. Two of the plants, which had both had to close for some length of time, said that many of their non-Christian clients had not returned when they reopened, but the ones from the church did. All of these elements indicate that there is a strong connection between the church, its members, the plant operators, and the plant itself.

Only one operator had little to say about the church or the ministry aspect, but even he was happy to be helping people and providing water for free to some people in the community. This operator worked at a plant without a water committee and the pastor was also heavily involved in the plant operation, so it is possible that the interaction between plant and church occurred through the pastor rather than the operator. This particular operator still seemed strongly dedicated to the plant and satisfied with his work, and the church/plant connection was an important element of most operators' role and identity as a plant operator. It provided them with a supportive community that they could also contribute to in a fundamental way. More than anything else, the relationship

with the church drives the operators to provide water to the communities and sustain the plants.

5 DISCUSSION

This evaluation of the sustainability of LWW's water purification plants in the Yucatán Peninsula of Mexico suggests that overall, the plants visited have the potential to be sustainable, and it offers insight into areas of improvement for LWW regarding their implementation model. Since only sites that are currently operational were evaluated, and therefore sites were evaluated against criteria suggested as important for sustainability rather than against sites that are no longer operational, it is difficult to say for certain that sites will continue to exist into the future. However, most sites met many of the criteria suggested in the literature as necessary for sustainability.

This evaluation also offers a potential method for assessing sustainability. While the specific conclusions of the study have limited application beyond LWW, others can utilize many of the considerations and recommendations this study proposes.

The mixed methods approach of this study provided a wide range of information and different perspectives on factors that influence the success of each site. The quantitative portion provided a view of the plant and its operation as a whole, and the qualitative portion focused specifically on lead operators and their personal experiences and motivations. While the target for each portion of the study was different, the data from each was helpful for informing the other, and both can be used to draw conclusions about each site. For example, knowing whether the plant as a whole was struggling or not was helpful in providing additional context regarding whether the plant operator felt frustration about the ability to make improvements to the plant. Similarly, information gathered in the interviews regarding, for example, the plant/church relationship, helped to

fill in information gaps and provide context regarding support for and finances of the plant.

Both the quantitative and qualitative components were influenced by the researcher's understanding that the lead operator was the *primary* person responsible for management of the plant, including finances, decision-making, monitoring, and operation. This therefore led the researcher to target the lead operator for the survey, since they would likely have the most information. It also led the researcher to propose a qualitative method for asking why, considering the lead operator's influential role in the plant and its long-term operation, lead operators do what they do and invest their time and energy into plant operation, and how that impacts sustainability.

It became clear during data collection that this understanding of the lead operator's role was not, in most cases, correct, and that there are more people involved in the management of each plant. At most plants, the water committee (which in some cases was actually a committee for the church also charged with managing the water plant) actually held greater authority over plant management than the operator. In many cases, the treasurer of the water committee or the pastor of the church handled all long-term financial information, and the operators only had daily records. While the operator often reported attending committee meetings and helping to prioritize plant needs, it appears that they are not, in most cases, primarily responsible for making decisions regarding plant operation. Indeed, generally, the pastor of the church seems to hold this role.

This clarification influences the study in several ways. First, regarding the survey, the lead operator was not always the most appropriate source of information.

This is especially true of financial data, but also to some degree of data regarding repairs and accessibility of spare parts, since the operators themselves did not always perform the repairs or purchase the parts. This was partially mitigated by asking for access to records for the past year while scheduling the survey and by informing the operator of the types of questions that would be asked, but in many cases, the information was never made available. Second, regarding the interviews, the informant chosen may not have been the most appropriate for understanding the links between motivation and sustainability, since the operators are apparently not the primary decision-makers and drivers behind each plant. However, their role and motivations are important for understanding the sustainability of the plants, particularly since their personal motivations and desires for success reflect areas of improvement for the plant. Also, although they may not have been the best source for information regarding the plant management, they were the best source for information regarding internal plant operation and the impact of decisions on daily plant experience. They therefore filled in gaps that existed in much of the survey data and provided an important perspective regarding the plant's success.

5.1 Successes and Areas for Improvement

The sustainability score results of the study show that the plants are, overall, performing best in the domain of **Cost Recovery and Financing**, followed by **Understanding of Demand** and then **MO&M**. The elements that went in to assessing each of these areas were developed using existing literature, LWW's own sustainability tool, and the researcher's own determinations of how to measure each area. The tool used to assess sustainability was a preliminary tool that had been adapted to LWW's

context and that had never been used previously. The results of the evaluation need to be understood in that context.

In some cases, sites were consistently impacted by one or two particular factors that affected most sites. In other cases, several factors varied among sites that caused scores to vary. Sustainability scores were ultimately simply an average of each site's performance on a variety of characteristics, meaning that a single poor score and a single well-performing score could even out to result in a middle score. The underlying assumption is that the well-performing areas make up for poor-performing areas to some extent, and all areas were measured with equal weight. Since this may not always be true, this may be a limitation of the sustainability score analysis.

5.1.1 Cost Recovery and Financing

The results of the **Cost Recovery and Financing** domain indicate that all but one site are achieving cost recovery and are appropriately using financing resources. Two subscores, one for Cost Recovery and one for Financing, contributed to the overall domain score. The most data were missing from this domain compared with other domains. Factors that contributed to high scores overall were that, in most cases, all daily and regularly recurring costs were met through the sales revenue, most operators were paid, and many sites thought they had access to loans or subsidies. About one-third of the sites had recently used loans or subsidies, which brought down some scores for the Cost Recovery subscore. This was particularly true for the one site with several loans, as the plant's loans seem to be far beyond its ability to pay them.

The qualitative data, however, suggest some additional aspects of cost recovery and financing that were not captured by the survey or sustainability tool. First, several operators indicated that, though they had a salary, it was low, and difficult to live on. They also said that the plant did not have money to pay the salary of a non-Christian (who they presumed would demand a higher salary) or an additional employee of the plant, even though that person would in some cases be financially or operationally beneficial. Second, although most sites evidenced monthly cost recovery, almost all sites had desired improvements to make that they were limited in making due to lack of resources. Third, several sites seemed to put off performing regular preventative maintenance due to the cost of replacement parts, such as filters, and/or labor. Lastly, it is unclear the extent to which the plant is supported by the church financially, especially for higher cost and unexpected expense items.

Also, although most sites said yes to whether they had any money in a fund to finance future improvements to the plant, most also said it was only a little. Evidence from the financial records suggests that, by 'fund,' they meant only the carryover from each month, rather than a separate account or fund where they save money. This carryover varied considerably from month to month but was rarely high enough to cover a major cost. Additionally, although the sites in general showed monthly cost recovery, in many cases, the larger cost items such as the system upgrade and well construction were donated. These did not show up in the revenues and costs accounts because they were not considered costs in the operators' daily costs logs.

Altogether, the data suggest that most sites are on their way achieving financial sustainability and that day to day, they are able to support themselves. However, to be

sustainable in the long-term, sites need to be able to finance their own preventive maintenance, repairs, unexpected costs, and plant improvements, in addition to paying their operators a salary that will increase their motivation to continue to invest their time with the plant.

5.1.2 Understanding of Demand

Understanding of Demand also had two component scores, which measured Demand Generation and Awareness of Demand. There was a range of scores, with multiple sites falling into each of the sustainability categories (unsustainable, sustainable with reservations, and sustainable). The average score for Awareness of Demand was higher.

The Awareness of Demand score intended to measure whether the plant responds to changes in demand by seeing whether they were often at the plant when there was no work to be done, whether they had changed the price of water in the last year, and whether they generally only bottled the amount of water needed for sale. All but five sites achieved scores indicating they were aware of the level of demand by these measures. However, the measures that were used may not have been effective in measuring what they intended. All plants bottle and sell daily, which does show awareness of demand. However, changes in price are not necessarily indicative of a change in demand for these plants, since price changes never occurred more than once in the previous year and when it did, the purpose seemed more to do with increasing revenue than responding to a change in demand. Most plants, though, did charge different prices to customers based on whether the water was delivered or sold at the

plant, which suggests that they have some awareness of what their customers demand and are willing to pay for. The question that was used to try and determine whether people worked unnecessarily was changed after the survey was pilot-tested. However, it was likely still not effective at measuring the intended characteristic. Also, it may not be relevant since operators are paid per bottle filled and sold, not per time worked.

The measurement for Demand Generation seemed to be more effective at measuring the intended characteristics. There was some variety in the percentage of their community the plants reached and whether they delivered, but most reached greater than 10% of their community, a threshold suggested by a representative of LWW, and most delivered water. The accuracy of the coverage percentage is limited by the respondent's estimation of the number of customers and the accuracy of the total population provided by INEGI(2006). Sites received lower scores if they did not perform and educational or marketing activities. None of the sites had held educational activities in the previous year, although one said they had when the plant first opened. However, most said they did not do so because the town's health clinic held health and hygiene education session, so health and hygiene education may be contributing to demand for the plant's water, even though the plant itself is not providing the education. Only a few plants indicated that they did any promotional or marketing activities, but the activity described was primarily labels on the bottles, which more sites may have done without considering it to be a promotional activity.

The qualitative data added little information to this domain, although it did provide some additional clarity on customer base, whether the site had considered expanding, and why they did or did not provide delivery.

Overall, due to inadequate indicators, these data are limited in providing information about each plant's awareness of changes in demand. However, the data that exists suggests that most plants have an effective process for determining how many bottles to fill, most achieve greater than 10% coverage, most charge different prices to different customers based on some characteristic, and many have delivery, all of which contributed to higher scores. Areas for improvement may include providing delivery for those that do not currently, changing prices in relation to demand (perhaps in peak seasons), and increasing demand generation activities such as health education or marketing.

5.1.3 Management, Operations, and Maintenance (MO&M)

Four components made up the overall **MO&M** score. Overall, the average score for all sites was almost equal to the average score for **Understanding of Demand**, but the average component scores (for Staff, Operations, Maintenance, and Network/Support) varied more from unsustainable to sustainable. On average, sites did best on Network/Support and worst on Maintenance.

In general, sites did particularly well on presence and availability of staff with maintenance capabilities. Most plants had workers that were paid and that showed dedication to their work. In many cases, the operator was one of only a few employees and worked every day of the week except Sunday. In three cases, the lead operator was volunteer, but in two of these, the lead operator was also the pastor of the church and presumably had another source of income. Also in most cases, roles were clearly defined and leadership was clear. One measure that negatively affected the Staff score for several

plants was whether it was clear that there would be a replacement operator if the operator could no longer work. This question changed after pilot testing in an attempt to better capture this information, but it may still have been inadequate. The score for sites was negatively impacted if the answer lacked specificity, but this may not have been a good indicator. Most sites were not sure who the replacement would be, but said that it would likely be someone from the church. It was difficult for the researcher to determine whether this would negatively impact sustainability. While the lack of a specific replacement might in some cases be concerning regarding sustainability, in this case, the close church/plant relationship suggests that it is actually very likely that a replacement would be easily found, though the plant might experience some days without service.

Regarding the network and support system, most plants evidenced being part of a network beyond their own plant, which is a goal that LWW has to encourage sustainability beyond their own involvement. However, much of the networking is facilitated by LWW. Most sites said they sent operators to the annual trainings in the region provided by LWW, which was counted positively toward the score due to interacting with other operators. Similarly, the sustainability tool measured whether the sites were in contact with their US Initiating Partners or anyone from LWW. If they were, the score was impacted positively, which was in agreement with LWW's own sustainability tool from which this question was taken. Although most sites also had church-specific water committees and some also worked with operators independently of LWW (all of which contributed positively toward the score as well), currently, much of the network and support received by each plant is facilitated by LWW. Most sites received a 'sustainable' score for this subcategory.

Sites, on average, did not score as well on the Operations or Maintenance subcategories. Regarding Operations, there were three component broad questions that fed into this score, and sites were affected differently by all of them. Factors influencing this score included the availability of raw water, which varied among sites, especially those without wells; the engagement of local authorities/officials, which in most cases did not occur, though several sites described their relationship with local officials as positive; and whether the plant performs any monitoring activities and/or reports to another entity. Although most plants did daily monitor things like pressure, hardness of water, and bottles filled, the process for monitoring differed across plants and often did not include the same details. Monitoring of financial data was particularly lacking and difficult to understand.

In the **MO&M** domain, only the average subscore for Maintenance was categorized as unsustainable. A few factors negatively impacted this score for the majority of sites. First, most sites listed one, and sometimes two or three, reasons that they frequently experience downtime, with lack of electricity and lack of water being the most common ones. Perhaps this should not have negatively impacted the maintenance score, though, since lack of electricity and water is not evidence of a lack of maintenance on the plant's part. Only a few plants said that they experienced downtime for routine maintenance, and none said that it was due to waiting for spare parts. Second, no sites received a score higher than 2 for the broad question regarding inventory of spare supplies and parts stored at the plant, since most plants did not keep any spare parts on site. Again, it is difficult to know whether this is actually a concern regarding sustainability. All plants visited were within 1-2 hours of a major urban area by car (and

all plants in the Yucatán, visited or not, are within 2-3 hours), and most plants used the same reliable supplier in Campeche or Mérida for most replacement parts. Therefore, although the plants did not generally keep parts on site, they did have reasonable access to them. Lastly, many sites were negatively impacted by not having someone on site that could perform all repair activities. Sites scored higher if there was someone on site who could do some or all repairs, and lower if they had access to someone who could perform repairs, but that person was not on site. Most plants, especially in Campeche, fell into this last category. Most plants in the state of Campeche rely on the regional coordinator for many of their repair activities, including purchasing, delivery, and labor. While this seems to work fine so far, and few plants reported having to wait for several days for repairs to be made, sustainability may be impacted by the reliance on one individual to serve so many plants in the region.

Also, maintenance scores for following and documenting appropriate maintenance procedures may have been higher than they should have been. The researcher lacked familiarity with the different technology and the differences between maintenance requirements required for each technology among the plants, and was therefore unable to make a fully-informed evaluation of whether the plants appeared to be appropriately following procedures. Some scores may therefore be artificially high on this measure. Some sites may also have been underscored on this for the same reason.

The qualitative data provided additional insight into some additional maintenance needs. Several plants suggested that expensive maintenance procedures, such as changing filters, are put off due to the cost of parts or labor. Several sites also complained of the purification process slowing down over time, which may be further

evidence that filters are not changed according to an appropriate schedule. Also related to the maintenance score is the frustration many operators expressed in the interviews about the impact on their plants of the failure of electricity. In addition to preventing water from being available, several operators also said this caused their pumps to burn out. Although there is a root cause that could be addressed regarding the burning of the pumps, their failure due to frequent problems of electricity may also be an argument for maintaining a supply of the parts on site. Most operators, in the interviews, seemed to want to make their plant as effective as possible, which means investing in maintenance activities, but they also recognized the difficulties of the expense.

These data overall suggest that there is varied performance regarding **MO&M,** and that there are gains to be made especially in terms of maintenance procedures and the availability of resources to invest in maintenance. Additionally, there are some factors that impact the plants, such as electricity interruptions and the availability of water, which cannot be influenced by the plants or LWW.

5.1.4 Factors Potentially Correlated with Sustainability

The analysis of factors potentially correlated with sustainability, which included bottles sold per month, monthly revenues, town population, and years in existence, are limited by the low sample size. Although all but years in existence seem to have a somewhat positive relationship with the sustainability score, it is difficult to know what the data would show if more sites were included in the analysis. However, it is interesting that there is potentially no correlation between years in existence and the sustainability score, since the greater number of years in existence is an indicator of

sustainability on its own. If this result is accurate (though it is not statistically significant with this data), it may mean that ongoing support by LWW has so far been sustained, that the break-even status at which most sites currently operate is actually sustainable, or that the time frame for the break-even status to finally negatively impact each site is greater than six years (the age of the oldest site visited).

5.2 Operator Motivations

In addition to providing complementary information in areas that were measured by the sustainability tool, the qualitative data on operator motivations provides useful insight into factors that may influence the long-term sustainability of plants. Although the operators were discussing their own perspectives and the impact on themselves, many of their observations are reflective of the plant.

One key area that has already been discussed to some extent is the potential need for greater maintenance efforts, and the operators also expressed interest in improving the physical plant through construction, upgrades, and additions. Long-term, the plants will need to have the resources available to make such improvements. Currently, it seems as if the resources for some of these improvements comes from LWW or the plant's Initiating Partner. As discussed in the literature review, some sustainability practitioners argue that reliance on NGOs can be an element of sustainability as long as that reliance can be sustained. However, LWW has said that one of their goals is to no longer have to provide extensive support to the plants, and so the plants will therefore need to find internal ways to fund improvements in the future. Additionally, these improvements will

not only improve operator morale by contributing to their sense of achievement, they may also contribute to better quality water and qualifications through the health department.

A second key area brought up in the interviews is the relationship that the plants have with the health department. Plants have been at risk for being closed down by the health department, so meeting their requirements and developing a good relationship with them appears critical for long-term plant sustainability. A productive relationship will not only decrease operator stress and increase their sense of pride, but it will likely also contribute to cleaner water and the ability to continue to purify.

A final key area is support for operators. Although they are not the primary decision-makers for the plant, their role is essential for plant sustainability, so efforts to motivate them are important. It seems evident that operators feel, in most cases, supported by their church and their pastors. They also, in some cases, express feeling supported by their family, coworkers, and other church members. This type of support will encourage operators to stay in their roles, preventing the need to find a replacement operator and reinvest in training and development of a new employee. Operators should also be supported financially. LWW encourages operators to have a salary. Managing the balance between limited resources and the mission to serve as many people as possible is difficult, but valuing the input provided by operators and their dedication is important for having and maintaining consistent plant operation.

5.3 Water Infrastructure Affecting Independent Water Plants in Mexico

The qualitative data also highlighted details about water supply infrastructure in Mexico, which affects both LWW and other independent water vendors. Although LWW

cannot directly improve the infrastructure, the infrastructure does potentially impact their sustainability. One factor affecting plants is that the municipal water supply is often only available for a few hours a day and is frequently interrupted. Also, there is an authoritative entity (the health department) governing the quality of water, but its standards seem to be inconsistently implemented and its demands sometimes seem unreasonable to purification plants. Lastly, there are an increasing number of independent water suppliers in the Yucatán, increasing the level of competition between plants. LWW should be aware of and consider these factors.

5.4 Sustainability Tool Usability

The sustainability tool used to assess sustainability proved to be useful in at least pointing out potential areas for improvement and for further research. The survey was easily administered and incorporated into the tool. While it seemed to effectively measure many things, it also has room for improvement. Measuring **Awareness of Demand** in particular was difficult, and the questions used may not have reflected the true level of awareness each site had for demand.

Additionally, some questions may not have been understood correctly or interpreted the same across sites, especially those about subsidies and loans. The term ‘subsidy’ did not translate well. ‘Donation’ worked better, but some respondents may not have perceived some things (such as plant upgrades, the well construction, or even a donation of materials) as a donation. Understanding access to loans was also problematic, as some operators were confused about whether they were being asked about personal loans or loans for the plant. Likewise, some may have interpreted this as

only asking about loans from a financial institution rather than also considering ones from LWW or their IP or members of their community.

Questions about maintenance procedures were also difficult to evaluate and may not have appropriately measured adherence to maintenance protocols. The researcher was unfamiliar with all appropriate maintenance procedures and with the spare parts that would be appropriate for sites to have on hand. Also, different sites used slightly different technology and had different sources for raw water, but all were evaluated in the same way. However, actual maintenance procedures were not directly measured; they were only asked questions to try and evaluate whether sites had a consistent schedule that was documented and that they said met LWW's recommendations. This indirectness may also have contributed to the difficulty of this measure.

Several questions in the survey were not ultimately useful and often were not even asked. One example is what level of commitment each employee has. The respondent in most cases was not an objective observer and was generally evaluating themselves and possibly one other person. This question was deemed ineffective and was not usually asked. Another example is whether the plant's maintenance schedule was in line with LWW's recommendations. This question was asked, but the response is suspect considering the fact that respondents knew the researcher was doing this research for LWW and that the results would likely get back to LWW.

Additionally, some questions were difficult for operators to answer or did not result in the desired amount of information. Table 9 assesses the usability of the tool in this respect. Although most parts of the tool were usable at most sites, this was not true across the board. In some cases, not enough information was gathered from a particular

site to use that information to determine a score for one of the 29 component broad questions. This table shows where missing scores occurred most frequently. For example, overall, of the 14 broad questions that made up the **MO&M** domain, on average, a score was developed for all but 0.46 (or 3%) of them at each site. Measured slightly differently, 10 sites had a score for all 14 **MO&M** questions. Similarly, within the **MO&M** domain, three broad questions measured the Staff subcategory. There were no instances where there was not enough information to determine a score for each of these three categories. Therefore, an average of 0% of component scores were missing per site, and all 15 sites had a score for all three components in this subcategory.

Table 9: Usability of the Sustainability Tool

Category	Average Number of Missing Scores	Out Of	Average % Missing	Sites with all Questions Fully Completed (X/15)
MOM	0.46	14	3%	10
Staff	0	3	0%	15
Operations	0.13	3	4%	13
Maintenance	0.27	6	5%	12
Network/Support	0.07	2	4%	14
Cost Recovery and Financing	1.07	10	11%	11
Cost Recovery	0.4	6	7%	12
Financing	0.67	4	17%	11
Understanding of Demand	0.27	5	5%	11
Demand Generation	0.2	3	7%	12
Awareness of Demand	0.07	2	4%	14

This table shows that the most difficulty in measurement was in **Cost Recovery and Financing**, particularly regarding Financing. Perhaps because it had the most component questions, **MO&M** performed the worst in terms of the number of sites that had a score for all component questions. In general, the **MO&M** domain performed

slightly better than the **Understanding of Demand** domain in terms of number of questions in the domain answered overall, but only the Staff subcategory had scores for all components for all sites.

The sustainability tool was not perfect in capturing all information from all sites or in determining a fully consistent score across sites, due to missing data. However, it did provide guidance, structure, and in most cases had appropriate detail for distinguishing scores as systematically as possible, given the data. It also incorporated measurements of important elements of sustainability gathered from the literature and from LWW and therefore is reflective of best practices in the field of sustainability.

5.5 Limitations

Many of the limitations of this study have already been discussed. One that should be emphasized is the fact that the small sample size prevents the results from being truly representative, although the sites were chosen to increase representation as much as possible. It also prevented rigorous statistical analysis of the data.

Regarding the qualitative data, due to both the researcher's and her field assistant's difficulty with one of the languages, it is possible that some data and meaning was lost in the translation of the interviews. Additionally, the quality of the data was affected by the field assistant's lack of previous experience in qualitative interviewing, the language barrier that made teaching qualitative methods and communicating feedback difficult, and the lack of the researcher's full knowledge of interview content during the fieldwork period.

Also, the data only represent sites that are currently functioning. The inclusion of sites that are no longer functioning, of which there are a few in the Yucatán, would have added the possibility of having a comparison group. It was decided that logistical and resource constraints outweighed the potential benefit gained from visiting these sites or talking with their former operators, but the data might have been helpful in understanding factors that truly lead to a lack of sustainability.

Although there was a mix of the age of sites among those that were surveyed, only one of the sites that were interviewed had been in existence for less than two years. While this may contribute more to knowledge regarding long-term sustainability, the data may also not reflect the particular struggles that operators in newer plants face.

Additionally the researcher's lack of knowledge about LWW's particular technology and of what to expect in the Yucatán impacted the ability to make clear distinctions between sites. Distinctions between scores in the sustainability tool were updated during analysis to reflect additional knowledge as it was gained, but some distinctions remained difficult. However, this lack of prior information may have also increased the objectivity of the researcher and consistency across sites, in some cases.

Lastly, the tool used to assess sustainability has never been used before, and though it was derived from other tools and information in the literature, it can be improved. It did not fully capture all information intended. Also, little research went in to how to weight the component scores or domains in determining overall sustainability, and everything is weighted equally. Because of this equal weighting, some domain scores may be more easily influenced by a bad component score (for example, **Understanding of Demand** with 6 component scores compared with **MO&M** with 14

component scores). However, it is also true that a good score will more easily influence them as well. Additionally, all component scores were equally weighted for the overall score, so each domain score did not directly affect the overall sustainability score.

6 RECOMMENDATIONS

This evaluation has led to several recommendations, both for the sustainability tool itself as well as for LWW and their processes. Other evaluators that wish to use the tool or elements of it can use the recommendations to improve the sustainability tool and adapt it to their needs. LWW may also be able to use the recommendations for the sustainability tool to improve their own sustainability tool and incorporate elements of the one used in this study.

LWW can also use the recommendations presented here for their plants and processes to potentially improve the sustainability of LWW-installed water purification plants in the Yucatán. These recommendations are based on the use of the sustainability tool, the in-depth interviews, and the evaluator's experiences and knowledge gained at each site.

6.1 Recommendations for Improving the Sustainability Tool and its Use

The sustainability tool used for this evaluation was developed by the researcher based primarily on LWW's own un-piloted sustainability tool, literature and other tools related to sustainability, and the researcher's own determinations of appropriate indicators. It was useful in providing systematic criteria to the assessment of sustainability across sites, but there are several improvements that could be made by future evaluators.

First, the tool is specific to LWW water plants, and therefore would need to be reviewed for applicability to non-LWW water supply projects before use. Although many of its elements can be applied across projects, some will not be applicable to all

projects, such as the questions about reporting to LWW or the Initiating Partner, the specific technology they use, and the leadership structure of the plants.

Second, many questions in the tool could be made more specific or reference a more appropriate indicator. Many yes/no questions were asked, and a yes or no did not necessarily appropriately indicate the actual measure of interest. For example, plants were asked questions such as, "Do you perform any marketing activities?" and "Do you receive any subsidies or donations?" The respondents were then asked to describe that activity, and those descriptions were used in the sustainability tool. However, for the sustainability tool to be more objective and systematic, more specific questions should be asked, such as, "Do you provide buy-ten-get-one-free punch cards to your customers?" or "Have you or the plant received money to pay for [*X*, such as the well] that you do not have to pay back?" This would require the evaluator to know more in-depth information about a project or program so that evaluators know which questions will provide the best indicators for a certain activity.

Third, for the evaluation of faith-based water suppliers, additional questions or measures should be added to the tool to capture the faith-based element. The ministry/service aspect of LWW's mission is very important for LWW and provides a structure of support that may not be present in non-faith-based organizations. Questions were asked regarding network and support, but not specifically about the role that faith plays in encouraging plants to achieve sustainability, about the relationship between the plant and the church, and how an FBO may have different characteristics from other community-managed projects.

Fourth, an evaluator updating or revising the tool may consider weighting the categories differently, rather than weighting everything equally. For example, the Sustainability Scorecard used by the World Bank to assess the sustainability of water supply and sanitation sectors in 16 African countries broke the overall score down into institutional aspects and financial aspects of the sector (World Bank, 2006). The final score was weighted 70% by institutional factors and 30% by financial factors. Different weights could be used throughout the tool or at a high level, depending on the needs and appropriateness for the project for which the tool is being used. For example, it may be more appropriate to weight understanding of demand less than cost recovery.

Fifth, the criteria distinguishing each score level should be very explicitly described. Evaluators should be aware of any changes made to the tool and consider how the descriptions of each level should be updated to be appropriately distinct.

Lastly, any use of the tool or a revision should consider and confirm who the appropriate respondents are. If the ideal respondent is not available or accessible, the tool should be adjusted to be most appropriate for whoever will be answering the survey questions and providing the information necessary to use the tool.

There are several additional, specific recommendations that reflect difficulty the researcher had in assigning a score to some of the broad questions. During analysis, the researcher realized that a question could have been asked differently to better capture the intended information.

- The tool should differentiate between the *ability* to pay all operators and whether sites are actually doing it. In some cases, pastors are volunteers, and although the

site may have the ability to pay them, they choose not to be paid. This does not necessarily reflect a lack of sustainability.

- A question or questions should be added to take into consideration whether plants are operating at the expected capacity and at the capacity at which they were operating when the plant was installed. Carter, et al (1999) suggest that sustainable water supplies are ones where "water continues to be abstracted at the same rate and quality as when the supply system was designed." Several operators mentioned that the plant had slowed down, but no questions specifically asked about this.
- The tool should ask not only about long-term replacement operators, but also whether there is a short-term replacement for days when the primary operator is unable to work. This should be taken into consideration when determining the availability of staff.
- The tool should be more specific about asking about the appropriate level of training for each staff. For example, consider how many staff know how to perform daily maintenance tasks separately from the number of staff that know how to perform irregular maintenance or repair tasks. The current tool distinguished only between all maintenance and all repair tasks.
- Additional questions could be asked regarding the water committees to verify whether they meet regularly and what is discussed.
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6.2 Recommendations for Improving LWW's Processes and Implementation Model

Many LWW sites exhibit many of the factors that contribute to sustainability and contributed to high sustainability scores. Additionally, LWW focuses on sustainability in their Clean Water U training program as well as in the agreements made between Operating Partners and Initiating Partners. However, this evaluation produced several recommendations to increase sustainability both directly and indirectly. The specific recommendations and additional detail are in Appendix 2.

The recommendations are in four main categories: Operational, Maintenance, Financial, and Demand and are color-coded. Those in red will be the most difficult, in terms of time and effort, for LWW or their plants to implement, but also tend to be the most likely to have the greatest effect. Those in green will have a smaller effect, but are likely to be more easily implemented. Those in yellow are in the middle in terms of effort and impact.

Several of the recommendations suggest activities or elements that LWW already incorporates or encourages to some extent. The recommendation, therefore, is intended to highlight the importance of those elements and encourage LWW to promote that element and the importance of its implementation with their current and future partner plants.

Also, each recommendation should be considered in terms of cultural appropriateness. LWW or their partners may determine that a particular recommendation may not be culturally appropriate, and then an alternative way of achieving a similar result should be considered.

Finally, LWW should consider ways in which the implementation of each recommendation may need to differ between sites in order to make it more applicable to a particular site. The acceptability and feasibility of each recommendation may not be the same everywhere, and the plant leadership should be involved in determining what is most appropriate for each site.

7 CONCLUSIONS

Many people around the world rely on independent water suppliers as their primary source for safe drinking water. This is particularly true in Mexico, which is currently the largest consumer of bottled water. Additionally, faith-based organizations are increasingly recognized as important actors in the water supply sector in many countries. However, little information in the literature is available on independent water suppliers in Mexico specifically, and especially on faith-based small water enterprises. This evaluation sought to understand whether water purification plants installed in the Yucatán Peninsula of Mexico through Living Waters for the World, a faith-based organization, are operationally and financially sustainable and what factors can be improved to further promote sustainability.

LWW focuses on sustainability in their processes and had developed their own tool with which their Initiating Partners could assess the sustainability of their partner's water purification plants. However, the tool had not been piloted, and no evaluation had been done of LWW's plants or LWW's model for implementation and operation. LWW therefore requested this study to be done.

To perform the evaluation, the researcher created a sustainability tool to systematically determine a sustainability score for each site. The literature on measuring sustainability of water supply projects was reviewed, and although six potential sustainability tools were found, none seemed appropriate for this external evaluation of LWW. Based on information gathered in the literature and from LWW, the researcher created a tool to assess sustainability in three domains: Management, Operations, and Maintenance; Cost Recovery and Financing; and Understanding of Demand. These were

then broken down further into subcategories. Using the preliminary tool developed by LWW as well as information from the literature, 29 broad questions for assessing sustainability were then categorized into each subcategory and domain. The final tool provided a method for gathering information via a survey to determine an overall sustainability score for each site on a 0-4 scale, broken down also by each domain and each subcategory.

The tool that was used to assess sustainability in this evaluation can potentially be used for evaluation of other water supply projects. It will need to be revised to be appropriate for the project's context as well as to take into consideration the lessons learned from this study.

To evaluate LWW, the researcher visited 15 sites, using the survey and in-depth interviews to understand the information needed for the sustainability tool and the motivations of plant employees to operate the plants and contribute to its long-term sustainability. Because all sites visited were currently operational, the results predict future sustainability based on factors considered important for sustainability rather than based on what caused nonoperational sites to lack sustainability.

The evidence from this study indicates that, overall, sites are likely sustainable, but with reservations, meaning that they achieved relatively high scores, but not high enough to prevent concerns. Several of the concerns are reflective of those found in the literature. First, there is some evidence that sites are not performing the necessary preventive maintenance. This may contribute to the slowing down of water purification that some sites have experienced over time. Second, sites may not be adequately planning for and saving money for long-term operation and maintenance activities,

including non-routine maintenance, repairs, upgrades, and expansions. Third, the long-term sustainability of sites without the support of their US Initiating Partners is in question, especially because LWW seems to be the facilitator of most in-country training and networking and many sites continue to receive donations from their Initiating Partners. Lastly, sites could benefit from increasing the technical capacity of the operators or other plant employees to manage difficult maintenance and repairs.

This study also provided some information, particularly from the qualitative results, on the infrastructure for water supply in Mexico, which affects LWW and other water vendors, and is also reflective of problems frequently facing water suppliers in the literature. Municipal water supply is unreliable in many areas, the regulations governing water quality are inconsistent, and there is an increasing number of independent suppliers to compete with. These factors may influence the sustainability of LWW plants.

Living Waters for the World plants in the Yucatán showed evidence of being sustainable long-term, and though there are several improvements that should be made, LWW's focus on sustainability, on creating an in-country support network, and on recovering costs has gone a long way to laying the foundation for a sustainable model. Additionally, the faith-based aspect of their model seems to contribute importantly to the motivation of the plant employees, its customers, and the church to achieve success and sustainability. Additional research is needed to determine how representative this study is, how sustainable plants in other countries where LWW works are, and how operational sites compare with sites that are no longer operational.

Although Living Waters for the World is unique in many ways, many of the factors potentially affecting the long-term operational sustainability of LWW purification

plants apply to a variety of water suppliers. Increased access to s*ustainable* clean water is necessary for meeting the water component of MDG Goal 7 and also to achieve basic human health. As Breslin (Breslin, 2010) and others note, focusing on the short-term goal of increasing the number of beneficiaries of water supply projects ignores the long-term reality that water supplies require investment in management, hardware, and technical capacity. Issues related to maintenance, planning for cost recovery, infrastructure, and long-term NGO (or government) involvement are relevant for most water supply projects. LWW, like other water supply projects, will need to find long-term solutions for these issues to be sustainable. However, other organizations would do well to follow LWW's example of focusing on sustainability and seeking to improve the sustainability of its projects.

Part II:
Evaluating the Operational and Financial Sustainability of Independent, Small-Scale Water Supply Projects: Development of a Systematic Tool

(Manuscript for Submission)

80-Character Title: Evaluating Sustainability of Independent Water Supply Projects: A Systematic Tool

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Abstract:

Aim: The project aim was to develop a tool to evaluate the operational and financial sustainability of small-scale, independent water enterprises. It was subsequently used to evaluate sustainability of water purification plants in the Yucatán installed by Living Waters for the World, a faith-based organization.

Methods: A tool was developed to systematically evaluate sustainability of each plant in three domains: management, operations and maintenance; cost recovery and financing; and understanding of demand. For LWW's evaluation, records and a survey were used at 15 plants to collect information and determine a sustainability score using the tool.

Results: The sustainability tool was usable and effective in highlighting areas for water plants to improve in order to increase the likelihood of sustainability. The tool can be improved by being made more specific and appropriate for the local context it will be used in. Its use demonstrated that LWW sites are overall likely sustainable, but they can improve, mainly in terms of maintenance.

Conclusions: With some specific improvements, the sustainability tool can be used to evaluate the sustainability of small-scale, independent water enterprises.

Keywords: Sustainability, Water, Faith-Based Organization, Mexico

Contribution of Student

For the research described in this manuscript for submission, I developed the instruments (sustainability tool and survey) after reviewing the literature. I designed the study for which the instruments were developed. I spent several months during the summer of 2010 collecting data, using the instruments I developed. I also performed all analysis on the data collected, with suggestions and guidance by my advisor, Dr. Clair Null.

INTRODUCTION

The World Health Organization (WHO) estimated that 1.8 million people die each year from diarrheal diseases, and that 88% of diarrheal diseases are attributable to lack of safe water and adequate sanitation and hygiene. Ninety percent of those deaths are of children under five (WHO, 2005). Millennium Development Goal (MDG) 7 specifically addresses this problem by setting a target to halve the proportion of people without access to safe drinking water and basic sanitation by 2015 (United Nations, 2002). Potential benefits of achieving this target include, in addition to basic health, averted healthcare costs, increased school attendance, increased productivity, and economic growth (Hutton & Haller, 2004; Sanctuary, Tropp, & Berntell, 2005).

Although the world is on track to meet the target for halving the proportion of people without access to safe drinking water, research has shown that many water interventions lack sustainability and become inoperable within a few years of their implementation (Ennis-McMillan, 2001; Montgomery, Bartram, & Elimelech, 2009; Skinner, 2009). Others have shown that water projects produce less water over time (Miguel & Gugerty, 2004). Lack of sustainability has been attributed to the focus on expansion of services at the expense of investments in operations and maintenance (Breslin, 2010; Montgomery et al., 2009; Skinner, 2009). Other factors possibly contributing to lack of sustainability include inappropriate technology, lack of engagement of local government, poor quality water, lack of supply chains, lack of proper support by implementing organization, and inability to invest in repairs and upgrades (Carter, Tyrrel, & Howsam, 1999; Harvey &

Reed, 2004; Montgomery et al., 2009; S. Parry-Jones, 2001).

As awareness of unsustainable water supply interventions has grown, frameworks for assessing sustainability and factors impacting sustainability have been proposed. Some frameworks include a broader, ecological conception of sustainability and the determinants of sustainability in water interventions (Harvey & Reed, 2004; McConville & Mihelcic, 2007; S. Parry-Jones, 2001), and others focus more specifically on the intervention itself (Carter et al., 1999; Montgomery et al., 2009; White, 2005). These are summarized in Table 1. Additionally, several tools have been developed with which to assess sustainability (Hodgkin, 1994; Living Waters for the World, 2010; McConville & Mihelcic, 2007; Sugden, 2001; World Bank, 2006). These are summarized in Table 2.

Table 1: Factors for Assessing Sustainability	
Author	**Suggested Factors Influencing Sustainability**
(P. Harvey & Reed, 2004)	• Policy context • Institutional arrangements • Financial and economic issues • Community and social aspects • Technology and the natural environment • Spare parts supply • Maintenance systems • Monitoring
(S. Parry-Jones, 2001)	• Policy context • Institutional arrangements • Technology • Natural environment • Community and social aspects • Financing and cost recovery • The project process • Key inputs or linkages
(McConville & Mihelcic, 2007)	• Sociocultural respect • Community participation • Political cohesion • Economic sustainability • Environmental sustainability
(Carter et al., 1999)	• Motivation (of consumers) • Maintenance • Cost recovery • Continuing support
(Montgomery et al., 2009)	• Effective community demand • Local financing and cost recovery • Dynamic operation and maintenance
(White, 2005)	• Financial • Institutional • Technical

Table 2: Existing Tools for Assessing Sustainability		
Name/Author	**Scope**	**Complexity**
Sustainability Scorecard (World Bank, 2006)	Country (entire sector)	Medium to High
Sustainability Matrix (McConville & Mihelcic, 2007)	Project or site*	High
LWW System Sustainability Tool (Living Waters for the World, 2010)	Site	Medium
Questions for Assessment of Sustainability (Hodgkin, 1994)	Project	Low to Medium
Sustainability Snapshot (Sugden, 2001)	Site	Low
*'Project' refers to tools that attempt to evaluate the sustainability of an intervention that may have installed/implemented water supplies at more than one site. 'Site' refers to tools that evaluate the sustainability of a specific site.		

The purpose of this project was to develop a tool with which to externally evaluate the operational and financial sustainability of small-scale water supply systems installed with support from a non-governmental organization after the implementation process has been completed. The existing tools did not meet this criteria for several reasons: their scope was not appropriate, they were not specific enough for use by an external evaluator, they did not incorporate all aspects found to be important for sustainability, or they were intended for use during the implementation phase of a project rather than post-implementation. This paper presents the process of development for the tool, lessons learned from its use in a case study, and suggestions for improvement.

The tool was used in an evaluation of Living Waters for the World (LWW), a faith-based organization (FBO) associated with the Presbyterian Church and based in Spring Hill, Tennessee, which seeks to increase access to safe drinking water in the Yucatán Peninsula in Mexico by facilitating the implementation and management of water purification plants in churches there. In 2008, 6,513,300 people in Mexico still lacked access to safe drinking water (WHO/UNICEF JMP, 2010). Although 87% of their country has access to piped water into their homes, nearly 300,000 people in the Yucatán Peninsula do not (INEGI, 2006; WHO/UNICEF JMP, 2010). LWW trains mission groups from the US to partner with churches in communities in Mexico desiring greater access to water. Mission teams are trained in LWW's mission, the installation process, health and hygiene, and in creating a water plant and partnership that is sustainable. While LWW's primary mission is to make water accessible and affordable to those who do not otherwise have access, they encourage plants to sell the clean water they produce in order to recover

the costs of operating and maintaining their plants. LWW also facilitates and promotes in-country networks and water committees to support plants long-term as their implementing mission groups become increasingly less involved.

METHODS

Instrument Development:

The objectives for the development of a sustainability tool were to create an instrument that would be systematic, comprehensive, specific, and usable by an external evaluator. Following Montgomery, et al (2009), we considered three areas when evaluating sustainability of water supply interventions: effective community demand, financing and cost recovery, and dynamic operation and maintenance. Incorporating suggestions in other tools as well, the final domains used were Management, Operations, and Maintenance (MO&M), Cost Recovery and Financing, and Understanding of Demand.

Using the literature, other tools, and the researchers' own knowledge, we included twenty-nine broad questions/areas to consider for sustainability in the tool. Each of these was categorized into one of the three domains. In addition, each question was also categorized into

subcategories of each domain. Table 3 shows the breakdown of categories in the tool. The full tool is available in one author's Master's thesis (Hartman, 2011).

Table 3: Domains and Subcategories of the Sustainability Tool		
Domain	**Subcategory**	**Number of Associated Broad Questions**
Management, Operations, and Maintenance (MO&M)	Staff	3
	Operations	3
	Maintenance	6
	Network/Support	2
Cost Recovery and Financing	Cost Recovery	6
	Financing	4
Understanding of Demand	Demand Generation	3
	Awareness of Demand	2

To use the tool, the evaluator would develop a score on a scale from 0 to 4 for each of the 29 questions based on criteria that needed to be met for each score. In developing what would constitute the different score levels, the researcher created score levels so that a 2 would describe responses that did not quite meet the criteria for sustainability (as suggested by the literature or the researchers' own determination), and a 3 was likely to be sustainable, at least according to those same sources. Therefore, a 2.5 was used as the ultimate cutoff for sustainability, though with reservations if it was below 3.0. Each of those component scores would be equally weighted in the calculation of the subcategory scores, domain scores, and finally, an overall score for the plant. The researcher developed a survey and a list of financial record data needed in order to gather the information required to determine a 0 to 4 score for each of the 29 broad questions.

Figure 1: Process for Developing an Overall Sustainability Score

The survey and sustainability tool were tested and used in a case study as part of a mixed-methods evaluation of Living Waters for the World's water purification plants in the Yucatán Peninsula in Mexico.

Case study region and plant selection:

The evaluation was conducted in the communities with an LWW water treatment system in the Yucatán Peninsula. Each community has a water purification plant that is operated and managed by people associated with the Presbyterian church in the community, either as members, elders, or pastors. The communities are typically rural. In some cases, the people in the towns have few options for access to clean water. In most, though, purified water (*agua purificada*) in 20-liter bottles is sold in stores, in competing plants, or delivered by a corporate retailer or another local water purifier. All communities visited have at least one Presbyterian church, which is the plant of the LWW water purification plant, although most people in the region are Catholic. This region was chosen as the study plant due to the proximity of a relatively large sample of LWW water purification plants and the length of time LWW plants have been in the region.

At the time of plant selection, there were 43 LWW plants in the Yucatán Peninsula, 16 of which were selected for the evaluation based on time and financial constraints. The plants were selected using a mixture of convenience and random sampling, and final selections were made to maximize the variety of plants to be evaluated. First, the 43 plants were narrowed down to the 27 that were within a days' drive from two urban areas where the researcher stayed, Mérida

in the state of Yucatán and Campeche City in the state of Campeche. Second, plants were randomly selected from those 27 using Excel. Finally, a few adjustments were made to the randomized list in order to add additional variety to the sample in terms of years in existence, location, size, population served, and awareness of whether they were struggling or not.

The survey and study protocol were submitted to the Emory Institutional Review Board (IRB) for ethical approval. Although IRB determined that the study did not require IRB approval since its primary purpose was for quality improvement, the researcher adhered to all IRB guidelines and recommendations. No plant or participant names are used.

Case study data collection:

The evaluator surveyed and collected available records from lead operators at 15 plants in the Yucatán during June and July of 2010. Lead operators were targeted for the survey since they have the most involvement in the plant and are involved in plant operation and management. In some cases, the pastor of the church where the plant was located or a member of the water committee was present at the survey as well.

A field assistant that was fluent in Spanish was present with the researcher at each plant. Contact was made with several plants before the researcher arrived for the survey, which was facilitated by LWW. When the researcher arrived at each plant, she and her assistant explained the study to the desired participant and requested their participation. Informed consent was received from each participant before the survey began.

All surveys were conducted in person at each operator's plant. Each survey took approximately 30-60 minutes. They were administered orally in Spanish, with the assistance of the field assistant, and responses and notes were recorded electronically into Excel during the survey. With the permission of the operators, all surveys were recorded with a digital audio recorder. The data collection in Excel automatically populated the sustainability tool with the participant's answers so that, during data analysis, the operator's responses would be available for reference.

The available financial and managerial records were collected, in most cases, at the time of the survey. Record keeping was not standardized across plants, and in some cases, records were available for some data and not others. Also, the length of time for which records were available varied from only a few days to a year or more, in which case only the past 12-13 months were requested. Some plants were not able to make any records available. With the permission of the operators, photos were taken of the records and the data from them was later entered into a database that contained all data from each survey and set of records.

Case study data analysis:

After completion of each survey, the data were reviewed for accuracy and plausibility. They were entered into an Excel database that compiled the data from all surveys and records. The database included over 300 variables for each survey question, each score component, and each piece of data gathered from the records. There was a significant

amount of missing data across variables and plants, especially for the records. Missing data will be noted in the results section where relevant. The sustainability tool was used to develop sustainability scores for each plant, and the data in the database were used to create descriptive tables and explore correlations.

The data gathered from the survey and records were used to determine a 0-4 score for each of the 29 questions in the sustainability tool for each plant. The Excel file then automatically used each of these scores to calculate the scores for each subcategory, each domain, and finally for the plant overall.

Due to missing data, not all plants have a score in each area. In some cases, there was not enough information with which to determine a score for one or more of the twenty-nine questions. If at least half were missing from a particular subcategory, no score was calculated for that subcategory. Missing scores will be noted in the results.

Finally, SAS 9.2 (Cary, NC) was used to explore correlations between characteristics of each plant and its final sustainability score. Characteristics considered were years in existence, average number of bottles sold per month, average monthly revenue, and population of the town where the plant was located. If there was strong evidence that one of the variables was not distributed normally, Spearman's correlation coefficient is reported. Otherwise, Pearson's correlation coefficient is reported.

RESULTS

The sustainability tool used to assess sustainability proved to be useful in pointing out potential areas for improvement and for further research. The survey was easily administered and incorporated into the tool and the tool was useful in providing systematic criteria to the assessment of sustainability across sites. The survey was piloted at the first three plants, after which the order of questions changed, some questions were removed, and additional questions were added. Also, updates to the score level descriptions were necessarily made during data analysis to make each level appropriately distinct. Each time this was done, the updated description was then applied to sites for which a score had already been developed to ensure consistency. Due to missing data, in some cases, the researcher was unable to determine a score for each broad question, and therefore, some component scores were left out of the final score calculation for a particular site.

Table 4 provides some measurements on the usability of the tool. It shows the average number of missing scores per site for each domain and subcategory. It also shows the number of sites out of 15 that had scores for all questions in that domain or subcategory.

Table 4: Usability of the Sustainability Tool				
Category	**Average Number of Missing Scores**	**Out Of**	**Average % Missing**	**Sites with all Questions Fully Completed (X/15)**
MOM	0.46	14	3%	10
Staff	0	3	0%	15
Operations	0.13	3	4%	13
Maintenance	0.27	6	5%	12
Network/Support	0.07	2	4%	14
Cost Recovery and Financing	1.07	10	11%	11
Cost Recovery	0.4	6	7%	12
Financing	0.67	4	17%	11
Understanding of Demand	0.27	5	5%	11
Demand Generation	0.2	3	7%	12
Awareness of Demand	0.07	2	4%	14

Case study results:

Sustainability Scores

Fifteen plants were included in the sustainability score analysis. Table 5 shows descriptive characteristics about each plant.

Table 5: Descriptive Information About Each Site Visited in the Yucatán Peninsula															
Site	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**P**
Urban/ Rural	Urban	Rural	Rural	Rural	Rural	Rural	Rural	Urban	Rural	Rural	Urban	Rural	Rural	Rural	Rural
Population	211671	3531	931	1200	3507	2100	3000	4767	1300	1800	.	2662	649	564	965
Year Plant in Existence	3	2	1.5	1.5	5.5	6	5	5	3	3.5	6	5	3	2.5	1.5
Number of Staff	3	3	3	3	2	3	5	3	1	2	3	3	1	4	2
Type of Technology*	ROS+ Ozone	ROS+ UV	ROS+ Ozone	ROS+ UV	ROS+ UV	ROS+ Ozone	ROS+ Ozone	ROS+ Ozone	ROS+ UV	ROS+ UV	ROS+ Ozone	ROS+ Ozone	ROS+ Ozone	ROS+ Ozone	ROS+ UV
Percent of houses without piped water	2.8%	3.0%	16.9%	8.4%	52.8%	0.5%	3.4%	4.8%	17.8%	4.2%	.	9.6%	2.3%	2.4%	2.5%
Percent of inhabited houses with no piped water, sewage, nor electricity	0.2%	0.1%	4.8%	0.0%	0.5%	0.0%	0.5%	1.1%	3.8%	1.9%	.	1.2%	0.0%	0.0%	0.8%

*ROS = Reverse Osmosis and Softening. All sites have ROS, but Sites A, G, J, and P may have the incorrect disinfection method listed.
**Source: INEGI (2005). For sites I and J, INEGI (2005) says that the population was 983 and 886 respectively, but the staff at the plant estimated the numbers in the table. Based on site visits, the plant's estimate was considered to be more accurate for analysis, which is plausible since 5 years had passed since the 2005 census, and population is increasing in the region overall. Site K was evidently urban, but the population was unknown.

Charts 1 and 2 graphically show the overall sustainability scores and the domain-specific scores. Charts 3 and 4 show box plots and the distributions of each subcategory score as well as each plant's score. Both the average and median score across all plants was 2.9 (range: 2.2-3.4, n=15), which is above the threshold set for sustainability with reservations (2.5), but below the threshold set for sustainability without reservations (3.0). Since the overall score is simply an average, no individual score had the potential to result in a plant being assessed as unsustainable or sustainable. However, a high (or low) score suggests that a plant scored better (or worse) on more measures in order to achieve that score, and therefore that the plant has greater potential for sustainability than plants that scored lower. Only two plants were below the 2.5 threshold, and five were above the 3.0 threshold, so the majority fell into the 'sustainable, with reservations' category, meaning that they will possibly be sustainable into the future, according to what the literature said is necessary for sustainability, but enough of their scores were low enough to cause concern.

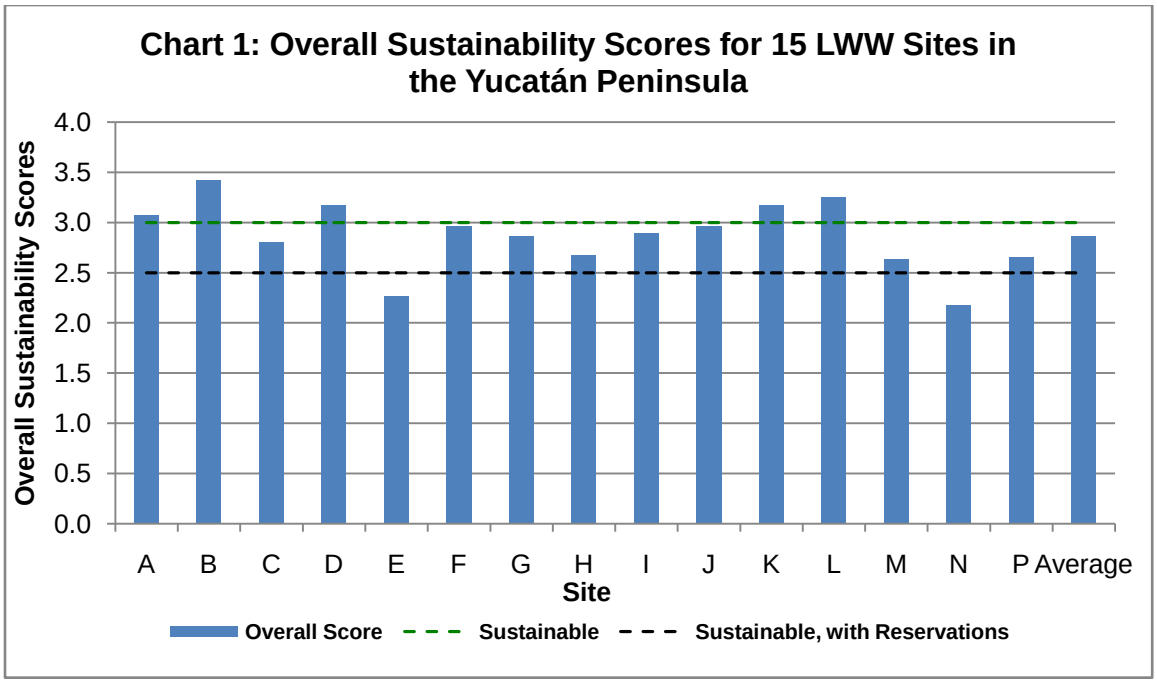


Chart 1: Overall Sustainability Scores for 15 LWW Sites in the Yucatán Peninsula
Overall Sustainability Scores
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
A B C D E F G H I J K L M N P Average
Site
Overall Score
Sustainable
Sustainable, with Reservations

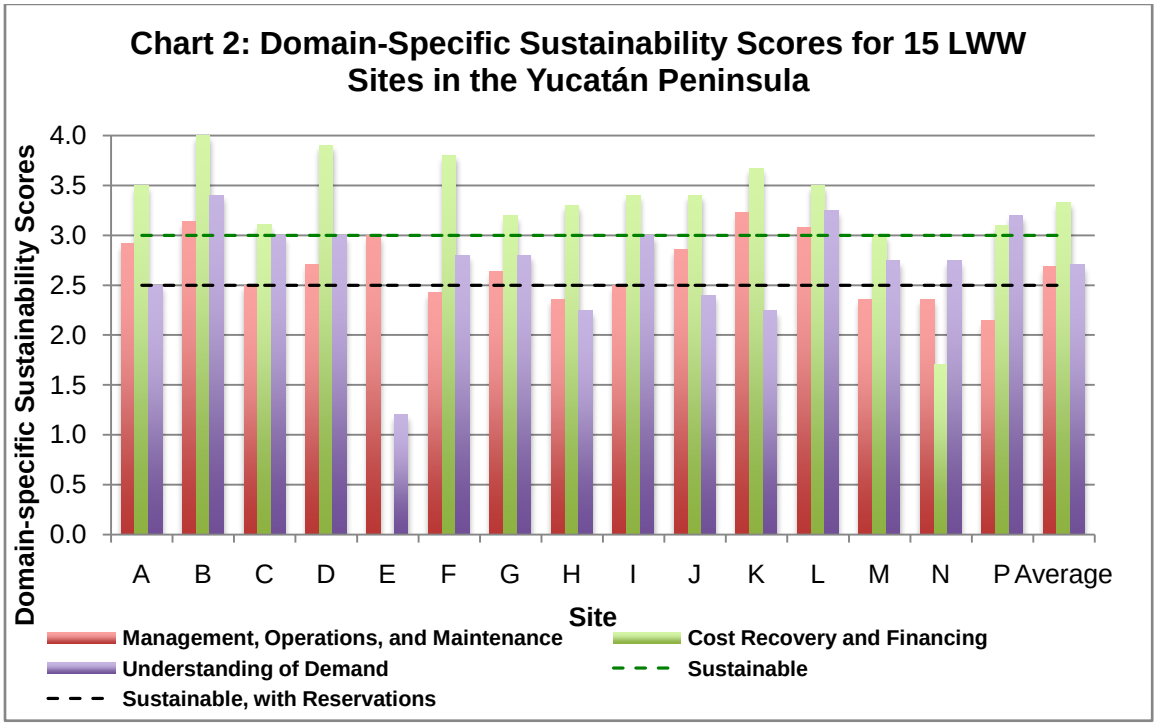


Chart 2: Domain-Specific Sustainability Scores for 15 LWW Sites in the Yucatán Peninsula
Domain-specific Sustainability Scores
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
A B C D E F G H I J K L M N P Average
Site
Management, Operations, and Maintenance
Cost Recovery and Financing
Understanding of Demand
Sustainable
Sustainable, with Reservations

Chart 4: Box Plots of Component Scores of Overall Sustainability Scores for 15 LWW Sites in the Yucatán Peninsula

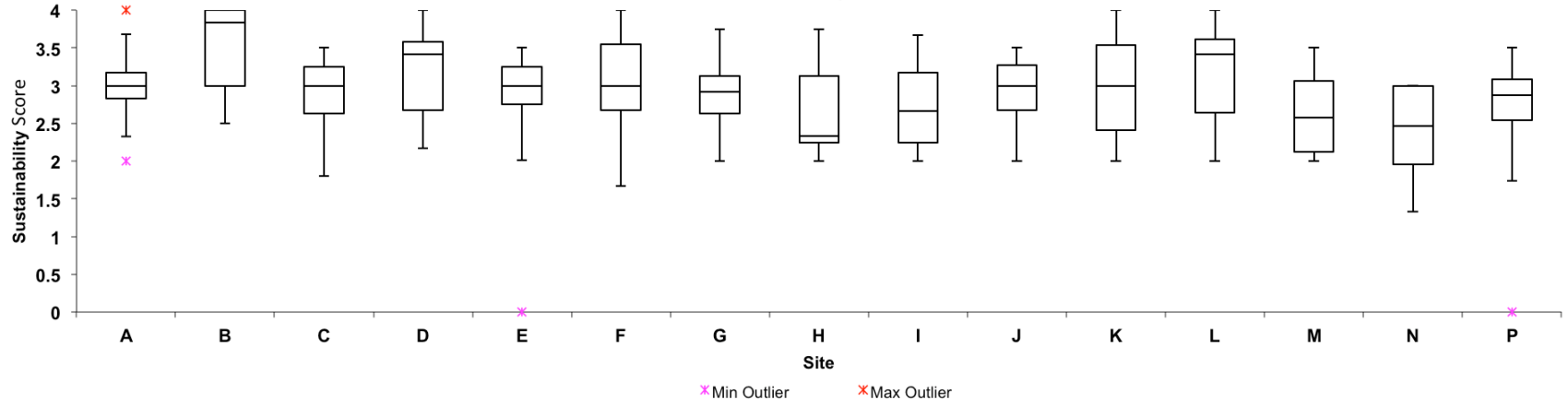
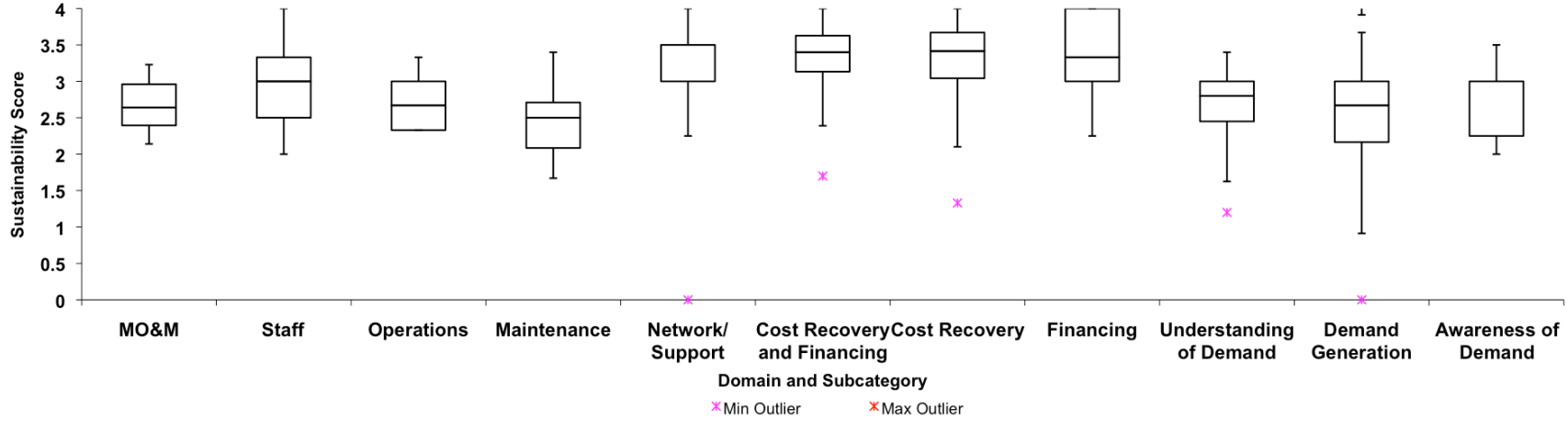


Chart 3: Box Plots of Sustainability Scores for Domans and Subcategories for 15 LWW Sites in the Yucatán Peninsula



Of the three domains, plants overall had the best average scores for **Cost Recovery and Financing** (3.3, range: 1.7-4.0, n=14). Most plants achieved a domain score that was in the 'sustainable' category. Only one (Plant N) did not, receiving a score of 1.7, and the score for Plant E was missing due to lack of available data. Also, for Plant K, this score was based only on the Cost Recovery subcategory, as information about their access to and utilization of loans or subsidies was inadequate to determine a score for the Financing subcategory. Factors that contributed to high scores for **Cost Recovery and Financing** overall were that, in most cases, all daily and regularly recurring costs were met through the sales revenue, most operators were paid, and many plants thought they had access to capital. Some scores were brought down by the use of loans or donations from their LWW partners or the church. This was particularly true for the one plant with several loans, as the plant's loans seem to be far beyond its ability to pay them, but several plants had had plant improvements donated by their LWW partners.

The **Understanding of Demand** domain was considered sustainable, with reservations (2.7, range: 1.2-3.4, n=15). These measures suggest that there is room for improvement in both responding appropriately to the level of demand as well as in generating additional demand for the water produced at each plant. Many plants charged different prices to customers for delivery and did not generally bottle more bottles than were demanded, contributing to higher scores for Awareness of Demand. The range in scores for Demand Generation is large, and one plant (Plant E) received a score of 0.0, as they did not meet several of the criteria, including providing delivery, reaching at least 10% coverage of their town, or performing marketing or educational activities. Although most

plants achieved the first two, few plants performed any marketing or educational activities or seemed to change prices in response to demand, such as in peak seasons.

The **MO&M** score was also considered sustainable, with reservations (2.7, range: 2.1-3.2, n=15). Of the subcategories that made up this domain score, the only one that was 3.0 or higher was for Network/Support (3.0, range: 0.0-4.0, n=15). Most plants received a 'sustainable' score for this subcategory, but one plant (Plant P) received a score of 0.0. This was because Plant P did not demonstrate any of the characteristics measured, including attending annual trainings or having contact with other operators, having a water committee, or communicating with LWW. The lowest subscore of all eight subscores from all domains, and the only one below 2.5, was for Maintenance (2.4, range: 1.7-3.4, n=15). The median, 2.5, is similar to the average, but the range is fairly large and suggests that, although some plants are doing poorly, some plants are doing well. Many plants received lower scores on **MO&M** for experiencing downtime, lacking someone on plant that can perform all repairs, and lacking an inventory of spare parts and supplies on plant.

Other Measures of Performance and Correlations

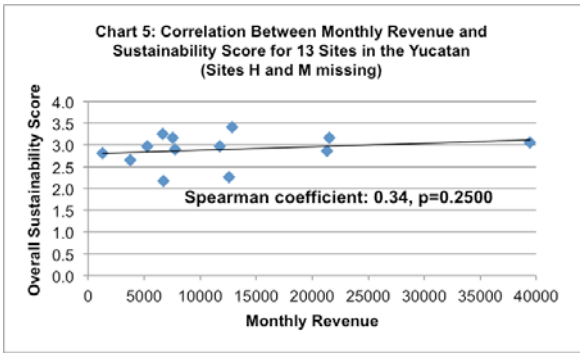
Table 6 includes additional descriptive statistics about each plant and its performance, including average monthly bottles sold, costs, revenues, and other information. Most of this information influenced the sustainability scores in some way. Some of the information in this table and from Table 1 that was not used in determining a sustainability score was used in Charts 5-8 to explore correlations between the

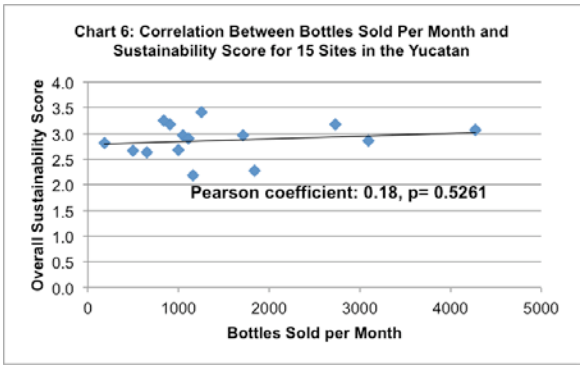
Table 6: Descriptive Statistics and Performance of Site in the Yucatán Peninsula

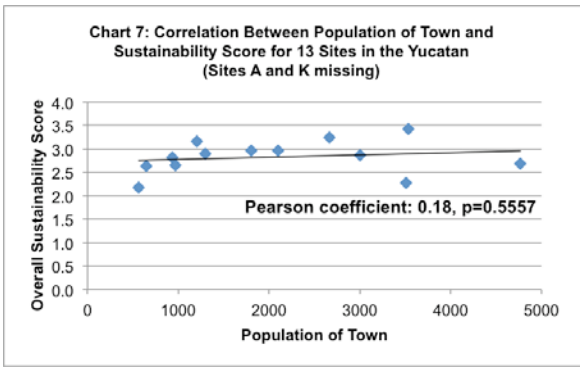
Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	P
Average Bottles Sold per Month	4000	1257	182	908	1838	1052	3094	1000	1109	1712	2731	833	650	1159	496
Average Monthly Revenues ($USD)*	3,130 (1)	1,018 (2)	103 (1)	600 (1)	996 (2)	417 (2)	1,693 (1)	?	616 (1)	931 (2)	1,706 (1)	529 (1)	?	532 (1)	301 (1)
Average Monthly Costs ($USD)*	2,546 (2)	259 (3)	85 (1)	482 (1)	?	235 (2)	1,690 (1)	?	416 (1)	641 (2)	1,429 (1)	479 (1)	?	570 (1)	300 (1)
Active Water Committee?**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No
Delivery?	**Yes**	**Yes**	**Yes**	**Yes**	No	Yes	**Yes**	No	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Current use of loans or subisidies	No	No	No	No	No	No	No	No	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**	No
Current OR past access to loans or subisidies	**Yes**	**Yes**	?	No	?	No	**Yes**	**Yes**	**Yes**	**Yes**	?	**Yes**	**Yes**	**Yes**	**Yes**
Future access to loans or subsidies	**Yes**	No	No	**Yes**	No	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**	No
Someone on site can do all maintenance and repairs	**Yes**	**Yes**	?	No	No	No	No	No	**Yes**	No	**Yes**	**Yes**	No	No	**Yes**
Replacement operator identified	No	?	?	**Yes**	**Yes**	No	?	**Yes**	No	No	**Yes**	**Yes**	**Yes**	**Yes**	?
Overall Score	**3.1**	**3.4**	**2.8**	**3.2**	**2.3**	**3.0**	**2.9**	**2.7**	**2.9**	**3.0**	**3.2**	**3.3**	**2.6**	**2.2**	**2.7**

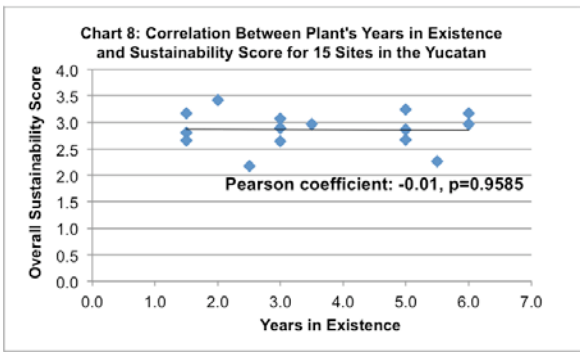
***The amount in $USD was calculated using an exchange rate of 12.6MX/1USD, which was about average for June-July 2010.**
(1) = Most reliable (based off records for at least 4 months), (2) = Somewhat reliable (based off records, but fewer than 4 months of records),
(3) = Least reliable (estimate based on estimates provided by the operator)
****This was coded as yes for a site if the last water committee meeting had occurred within the previous 6 months and if the operator could describe what had been discussed.**

sustainability scores and other characteristic of each plant and its performance. The sample sizes are low, so it would be difficult to find any statistical significance. Charts 5-8 and the correlation coefficients suggest that the sustainability scores might be slightly positively correlated with monthly revenue, average bottles sold per month, and town's population, although the correlation results are not statistically significant. There is no evidence of a relationship between the years the plant has existed and its sustainability score, though again, that result is not statistically significant.









DISCUSSION

This study provides a potential tool for assessing sustainability. Although the sustainability tool was useful in evaluating plants, it can be improved.

In the **Cost Recovery and Financing** domain, although most plants experience day-to-day cost recovery, anecdotal information suggests additional insight that the sustainability tool did not capture. First, although operators are paid a salary, it is difficult for many to live on. Second, almost all plants expressed a desire for plant improvements that they could not make due to lack of resources. Third, many plants may have received more financial support from their associated church than was apparent from the records. Lastly, although most plants said they had a fund for repairs or plant improvements, the records indicate that the 'fund' was the carryover of revenue from month to month, which varied considerably but was rarely high enough to cover a major cost, rather than a separate fund.

The indicators for **Understanding of Demand** intended to capture whether the plants are aware of changes in demand and respond accordingly, and whether they do anything to generate demand. The indicators, though, which included changes in price and numbers bottled, may not have actually reflected awareness of demand. For example, some sites had changed prices, but did not seem to do it in response to changes in demand.

Downtime, lack of onsite technical capacity, and lack of on-plant inventory all lowered the **MO&M** score for many plants. However, the extent to which each of these actually affects the sustainability of plants is questionable, since most plants experience downtime due to lack of the provision of water or electricity, which are not indicative of a lack of maintenance, and also because repair services and supplies are reasonably accessible

within the region. Also, the researcher was not familiar with the technology and appropriate maintenance procedures at each plant, which may have affected the accuracy of scores in this area.

The case study highlighted some other issues with the tool that may be specific to LWW's context, but should be considered for other organizations as well. Some questions may not have been understood correctly or interpreted the same across sites, especially those about subsidies and loans. The term 'subsidy' did not translate well. 'Donation' worked better, but some respondents may not have perceived some things (such as plant upgrades, the well construction, or even a donation of materials) as a donation. Understanding access to loans was also problematic, as some operators were confused about whether they were being asked about personal loans or loans for the plant. Likewise, some may have interpreted this as only asking about loans from a financial institution rather than also considering ones from LWW or their IP or members of their community.

Also, several questions in the survey were not ultimately useful and often were not even asked. One example is what level of commitment each employee has. The respondent in most cases was not an objective observer and was generally evaluating themselves and possibly one other person. Another example is whether the plant's maintenance schedule was in line with LWW's recommendations. The response is suspect considering the fact that respondents knew the researcher was doing the evaluation for LWW and that the results would likely get back to LWW.

Regarding the case study, this evaluation of the sustainability of LWW's water purification plants in the Yucatán Peninsula of Mexico suggests that overall, the plants visited have the potential to be sustainable, and it offers insight into areas of improvement for LWW regarding their implementation model. Several of the concerns are reflective of those found in the literature. First, there is some evidence that plants are not performing the necessary preventive maintenance. Second, plants may not be adequately planning for and saving money for long-term operation and maintenance activities, including non-routine maintenance, repairs, upgrades, and expansions. Third, the long-term sustainability of plants without the support of their LWW Partners is in question, particularly because LWW seems to be the facilitator of most in-country training and networking and many plants continue to receive donations from their Partners. Lastly, plants could benefit from increasing the technical capacity of the operators or other plant employees to manage difficult maintenance and repairs.

LWW plants are performing particularly well in terms of day-to-day cost recovery, appropriate use of financing sources, and the in-country support structure. While the specific conclusions of the study have limited application beyond LWW, others can utilize many of the considerations and recommendations this study proposes.

Limitations:

The sustainability tool had several limitations and could be improved. Some of the questions could have asked more specifically about certain activities, such as whether they perform one of several specific marketing activities rather than whether they

perform any marketing activities at all. Also, additional questions should be added to the tool to specifically address the faith-based element. This was addressed in the qualitative component of the case study evaluation, but its potential relevance for the success of the LWW plants warrants consideration in the quantitative aspects of sustainability measurement as well. Many operators spoke of the ministry aspect as a motivator for themselves and as a driver of the success of the plant. Finally, future versions of the tool may consider weighting the categories differently, as some factors may arguably be more important for sustainability than others, and some individual factors influenced multiple scores.

Additionally, experience from the case study highlighted the importance of targeting the correct individual(s) to provide the information needed to use the tool. In some cases, although the lead operators have the most day to day involvement in their respective plants, pastors and/or water committee members may have been able to provide more, or more accurate, information about each plant. Also, a larger sample size would enable an evaluator to do more statistical analysis with scores and plant characteristics. The case study's results are also limited by the fact that the nonoperational sites were not used as a comparison; rather, the characteristics of operational sites were compared to characteristics that the literature said were ideal for sustainability. The tool developed in this project would need to be adapted for use with nonoperational sites if an evaluator chose to include those sites in an evaluation as well.

CONCLUSIONS

Though the tool used to assess sustainability in this study was preliminary and can be improved, it was effective in drawing out important factors influencing LWW's sustainability. It can potentially be used for evaluation of other water supply projects, though it will need to be revised to be appropriate for the project's context as well as to take into consideration the lessons learned from this study.

The tool demonstrates that LWW plants are performing particularly well in terms of day-to-day cost recovery, appropriate use of financing sources, and the in-country support structure. It allowed for the development of specific recommendations for LWW, including to 1.) Develop and implement a consistent monitoring process for operation, maintenance, and financial activities to make oversight and evaluation more effective, 2.) Develop a clear technology-specific maintenance schedule to post in each plant to make it clear when and how often each preventative maintenance activity should occur, and 3.) Encourage plants to create a separate fund for plant improvements and to contribute regularly to it.

Increased access to s*ustainable* clean water is necessary for meeting the water component of MDG Goal 7 and also to achieve basic human health. Considering the number of water supply projects that fail within a few years of their implementation, organizations helping to increase access to water should focus more on improving the capacity of water supplies to be sustainable. The tool developed in this project provides one potential method for evaluating the sustainability of small-scale, independent water enterprises.

REFERENCES

Ampofo, J., Andoh, A., Tetteh, W., & Bello, M. (2007). Microbiological Quality and Health Risks of Packaged Water Produced in Southern Ghana. *Journal of Applied Science and Technology, 12*(1&2), 88-97.

Barkin, D., & Klooster, D. (2006). Water management strategies in urban Mexico: Limitations of the privatization debate. *Unpublished*.

Breslin, E. D. (2010). Rethinking Hydro-Philanthropy: Smart Money for Transformative Impact.

Carter, R. C., Tyrrel, S. F., & Howsam, P. (1999). The Impact and Sustainability of Community Water Supply and Sanitation Programmes in Developing Countries. *Water and Environment Journal, 13*(4), 292-296.

Compernolle, R. v., & Howie, W. (2005). Technical summary of filtration, microfiltration and ozone treatment.

Crabbe, S. (2011). *Analysis of Water Quality at Water Purification Plants and in Households in the Yucatan Peninsula, Mexico.* Emory University, Atlanta.

Ennis-McMillan, M. C. (2001). Suffering from Water: Social Origin of Bodily Distress in a Mexican Community. *Medical Anthropology Quarterly, 15*(3), 368-390.

Family Health International. (2009). Research Ethics Training Curriculum. Research Triangle Park, NC: FHI.

FAN (Producer). (2010, February 26, 2011) Mexico now world's biggest consumer of bottled water. retrieved from http://www.freshwateraction.net/node/39

Galvez, J. (2011). *Small Water Enterprises: A cross-sectional study of bottled water consumption in the Yucatan Peninsula, Mexico.* Emory University, Atlanta.

Glaser, B. G., & Strauss, A. L. (1968). *The discovery of grounded theory: strategies for qualitative research*. London,: Weidenfeld and Nicolson.

Google Maps. (2011a, 4 April). All LWW Sites in the Yucatan and Sites Selected for LWW Study. Retrieved 4 April, from http://maps.google.com/maps/ms?ie=UTF8&hl=en&msa=0&msid=210478492011432120848.000480383fcc201d24c4b&z=7

Google Maps. (2011b, 13 April). Mexico. Retrieved 13 April

Green, J., & Thorogood, N. (2004). *Qualitative methods for health research*. London: SAGE Publications.

Guest, G., Bunce, A., & Johnson, L. (2006). How Many Interviews Are Enough? An Experiment with Data Saturation and Variability. *Field Methods, 18*(59).

GWI. (2004). Mexico: time to get serious. *Global Water Intelligence, 5*(9).

Harvey, P., & Reed, B. (2004). *Rural water supply in Africa : building blocks for handpump sustainability*. Loughborough, UK: Water, Engineering and Development Centre.

Harvey, P. A., & Reed, R. A. (2007). Community-managed water supplies in Africa: sustainable or dispensable. *Community Development Journal, 42*(365-378).

Haysom, A. (2006). *A Study of the Factors Affecting Sustainability of Rural Water Supplies in Tanzania (A report for WaterAid)*: Cranfield University.

Hennink, M. (2010). *Qualitative research methods* (1st ed.). Thousand Oaks, CA: SAGE Publications.

Hodgkin, J. (1994). *The sustainability of donor-assisted rural water supply projects*. Washington, D.C.: USAID.

Hutton, G., & Bartram, J. (2008). Global costs of attaining the Millennium Development Goal for water supply and sanitation. *Bull World Health Organ, 86*(1), 13-19.

Hutton, G., & Haller, L. (2004). *Evaluation of the costs and benefits of water and sanitation improvements at the global level*. Geneva: World Health Organization.

Hutton, G., Haller, L., & Bartram, J. (2007). Global cost-benefit analysis of water supply and sanitation interventions. *Journal of water and health, 5*(4), 481-502.

INEGI. (2006). Retrieved March 1, 2010, from Instituto Nacional de Estadistica y Geografia: http://www.inegi.mx/default.aspx

Kariuki, M., & Schwartz, J. (2005). *Small-Scale Private Service Providers of Water Supply and Electricity: A Review of Incidence, Structure, Pricing and Operating Characteristics*: World Bank.

Liamputtong, P., & Ezzy, D. (2005). *Qualitative research methods* (2nd ed.). South Melbourne, Vic. ; New York: Oxford University Press.

Living Waters for the World. (2010). System Sustainability Tool. Unpublished Excel Spreadsheet.

LWW. (2009). Treatment Selection and Effictiveness Guide Version 1.1 Chapter 2: Clean Water Systems.

LWW. (2010). Yucatan Network Handbook.

LWW. (2011). Living Waters for the World. Retrieved March 9, 2011, from http://www.livingwatersfortheworld.org/

Marin, L. E. (2007). *The Role of Science in Managing Yucatan's Groundwater*. Paper presented at the Sustainable Management of Groundwater in Mexico.

McConville, J. R., & Mihelcic, J. R. (2007). Adapting Life-Cycle Thinking Tools to Evaluate Project Sustainability in International Water and Sanitation Development Work. *Environmental Engineering Science, 24*(7).

McGranahan, G., Njiru, C., Albu, M., Smith, M., & Mitlin, D. (2006). *How Small Water Enterprises can contribute to the Millennium Development Goals: Evidence form Dar es Salaam, Nairobi, Khartoum and Accra*. Leicestershire: Water, Engineering and Development Centre, Loughborough University.

Meacham, S. (2007). *Freshwater Resources in the Yucatan Peninsula.* Paper presented at the Sustainable Management of Groundwater in Mexico.

Miguel, E., & Gugerty, M. K. (2004). *Ethnic Diversity, Social Sanctions, and Public Goods in Kenya*. Berkeley: University of California.

Montgomery, M. A., Bartram, J., & Elimelech, M. (2009). Increasing Functional Sustainability of Water and Sanitation Supplies in Rural Sub-Saharan Africa. [Article]. *Environmental Engineering Science, 26*(5), 1017-1023.

Moran, D., & Batley, R. (2004). *Literature Review of Non-State Provision of Basic Services* (Literature Review). Birmingham: International Development Department, School of Public Policy, The University of Birmingham.

Morse, J. M. (2000). Determining Sample Size. [Editorial]. *Qualitative Health Research, 10*(3).

Ndemo, E. B. (2006). Assessing sustainability of faith-based enterprises in Kenya. *International Journal of Social Economics, 33*(5/6).

OECD. (2006). Water Management: Policy brief for the Mexican Project. Retrieved from http://www.oecd.org/dataoecd/61/6/38108376.pdf

Opryszko, M. C., Huang, H., Soderlund, K., & Schwab, K. J. (2009). Data gaps in evidence-based research on small water enterprises in developing countries. *J Water Health, 7*(4), 609-622.

Ritchie, J., & Lewis, J. (2003). *Qualitative research practice : a guide for social science students and researchers*. London ; Thousand Oaks, Calif.: Sage Publications.

Rubin, H. J., & Rubin, I. S. (2005). *Qualitative Interviewing: The Art of Hearing Data Second Edition* (Second ed.). Northern Illinois University: SAGE Publications, Inc.

S. Parry-Jones, R. R. a. B. H. S. (2001). Sustainable Handpump Projects in Africa. Loughborough University: Water, Engineering and Development Center.

Sanctuary, M., Tropp, H., & Berntell, A. (2005). *Making Water a Part of Economic Development: The Economic Benefits of Improved Water Management and Services*: Stockholm International Water Institute.

Skinner, J. (2009). *Where every drop counts: tacking rural Africa's water crisis*. London: International Institute for Environment and Development.

Snell, S. (1998). Water and Sanitation Services for the Urban Poor: Small-scale Providers - Typology&Profiles.

Solo, T. M. (1999). Small-scale entrepreneurs in the urban water and sanitation market. *Environment and Urbanization, 11*(1), 117-132.

Solo, T. M. (2003). Independent water entrepreneurs in Latin America: The other private sector in water services. Washington, D.C.: The World Bank.

Sugden, S. (2001). *Assessing sustainability - the sustainability snap shot*. Paper presented at the 27th WEDC Conference.

UNESCO. (2011). World Water Assessment Programme. Retrieved 6 April, 2011, from http://www.unesco.org/water/wwap/

UNFPA. (2009). *Guidelines for Engaging Faith-based Organizations as Agents of Change*: United Nations Population Fund.

United Nations. (2002). Goals, targets and indicators. Retrieved February 23, 2011, from http://www.unmillenniumproject.org/goals/gti.htm

United Nations. (2010). Background: International Decade for Action: Water for Life, 2005-2015. Retrieved February 25, 2011, from http://www.un.org/waterforlifedecade/background.html

United Nations General Assembly. (2010, 28 July). *General Assembly Adopts Resolution Recognizing Access to Clean Water, Sanitation As Human Right, by Recorded Vote of 122 in Favour, None Against, 41 Abstentions*. Paper presented at the Sixty-fourth General Assembly, Plenary, 108th Meeting (AM)

USAID. (2009). Faith-Based and Community Initatives. Retrieved 6 March, 2011, from http://www.usaid.gov/our_work/global_partnerships/fbci/about.html

Vasquez, W. F., Mozumder, P., Hernandez-Arce, J., & Berrens, R. P. (2009). Willingness to pay for safe drinking water: Evidence from Parral, Mexico. *J Environ Manage, 90*(11), 3391-3400.

Water and Sanitation Program. (2001). *Connecting Private Sector Suppliers to Rural Customers: Promoting Robust Supply Chains for Rural Water and Sanitation Goods and Services* (No. 31428).

White, H. (2005). *Challenges in evaluating development effectiveness*. Brighton: Institute of Development Studies.

WHO. (2005). Water, Sanitation and Hygiene Links to Health: Facts and Figures. from http://www.who.int/water_sanitation_health/factsfigures2005.pdf

WHO/UNICEF JMP. (2010). *Progress on Sanitation and Drinking-Water: 2010 Update*: WHO/UNICEF.

Wilder, M., & Lankao, P. R. (2006). Paradoxes of Decentralization: Water Reform and Social Implications in Mexico. *World Development, 34*(11), 1977-1995.

World Bank. (2006). *Getting Africa on track to meet the MDGs on water and sanitation: a status review of sixteen African countries*.

World Commission on Environment and Development. (1987). *Report of the World Commission on Environment and Development*.

Appendix 1: Sustainability Tool

Domain: Management, Operations, and Maintenance
Subcategory: Staff

Broad Questions	Survey Questions and Metrics	Score 0	1	2	3	4
Is there an operator working often enough to ensure that the community is able to depend on clean water being available?	How many days per week is an operator assigned? Of those days, how many hours per day is an operator assigned? If you couldn't work anymore, who would take your position?	No operator assigned and/or works inconsistently.	Operator assigned at least 1 day per week but there is evidence that they do not work their assigned shift consistently.	Operator assigned and works fewer than 3 days/wk OR more than that, but there is no plan for a replacement.	Operator is assigned and works at least 3 but less than 5 days per week and there is a plan for a replacement.	Operator is assigned and works 5 days/wk (assuming there is enough demand for 5 days of work - if not, then a 4 for the highest level of demand being met) and there is a plan for replacement.
Does the OP maintain sufficient trained personnel to manage, maintain, and operate the plant? Has the OP has assumed responsibility for managing, maintaining, and operating the project?	How many staff are there? Are you paid? (Do you have a salary?) Is the lead operator volunteer? Are any operators volunteer? How often do each staff work? Is there one person in charge of / leading this site, and do you know who it is? What are the roles of each of the people involved in this site? (Repeat Question) How are staff compensated? (multiple answers allowed) On a scale of 1-5, how committed are each of the staff (5=very committed, 1=not very committed)? Is there any ongoing training for staff? How many staff at each site have been trained in all maintenance and repair tasks? How many perform maintenance tasks on a regular basis?	Project is run by one or two people when demanded or needed. Operators are volunteers.	Project is run by one or two people OR all operators are volunteers. Commitment of operators may be in question.	Project is run by the leader and at least one other person consistently works. Not all (but at least one operator) are compensated OR there is not at least one person trained in all maintenance and repair tasks on site.	Project is staffed with lead operator and 1 or 2 others. At least one operator is compensated and at least one person on site has been trained in all maintenance and repair tasks.	Project is well staffed with leader, lead operator, and other operators. All operaters are paid. At least one operator on site regularly performs all maintenance and repair tasks.
Does the plant have clear leadership and a clearly defined organizational structure? Are staff roles clearly defined?	Is there one person in charge of / leading this site, and do you know who it is? What are the roles of each of the people involved in this site? (Repeat Question) Would you say each staff understand their responsibilities?	It is not clear who is in charge, and there are no defined roles.	It is not clear who is in charge, but there are specific roles.	There is one person in charge, and no one else is dedicated to the plant.	There is one person in charge, and the roles of others are unclear or responsibilities are not clear.	There is one person in charge and several others with specific roles, and staff understand their responsibilities.

Domain: **Management, Operations, and Maintenance**

Subcategory: **Operations**

		Score				
Broad Questions	**Survey Questions and Metrics**	**0**	**1**	**2**	**3**	**4**
Is there a reliable water source that provides the quality and quantity of water to meet demand?	What are the hours that raw water is available? *How many hours per day is raw water avaialble?* What is your primary source for raw water? Is there a well on the property? Is there a raw water tank in your community that you use?	Water availability unknown or not scheduled.	Water available fewer than 3 hours per day.	Water available fewer than 8 hours/day, but more than 3.	Water available fewer than 24 hours per day, but 8 or more.	Raw water is available 24/7 (if there is a well, then this is the case, unless they say it's not so or it is not functioning)
Are local appointed/elected officials engaged in the plant?	Do you work with local officials? Are local officials a part of the water committee or otherwise a part of the decision making? Are local officials consulted on decisions? How is the relationship with local officials?	The local officials frequently prevent the system from operating.	The relationship between the plant and local officials is strained.	Local officials are not consulted, but there is no tension.	Local officials are consulted on decisions.	Local officials are involved in decision-making process.
Does the plant perform monitoring activities and is there oversight by another entity / transparency?	Do you keep records of your maintenance activites? Do you keep records of your bottling activities? Do you keep records of your finances? Do you keep records of your sales? Are your records accessible by the public? Who do you report your records to? How often do you report your records to someone? Does anyone audit your records?	System keeps little to no records on file, and what is there is not accessible to outside reviewers.	System keeps little to no records on file, but what is there is accessible to outside reviewers.	System keeps some records regularly, but they are either not easily understandable to an independent reviewer and/or are incomplete, OR one of the types is not collected (financial, bottling, maintenance).	System keeps well-organized and clear financial and operating records and reports for follow-up visits. Records may not be accessible to the public.	System organization keeps financial and operating records on file, reports every 1-3 months to IP and/or larger in-country organization and gets audited by parent organization. They are accessible to the public.

Domain: **Management, Operations, and Maintenance**

Subcategory: **Maintenance**

Broad Questions	**Survey Questions and Metrics**	**Score** 0	1	2	3	4
Does the system consistently produce clean water per LWW standards and local health regulations?	How often is the water tested for contaminants like salt and sediment? How often is the water tested for contaminants like bacteria and parasites? How many times in the past year has the water failed testing? Are health regulators engaged? When was the last visit by the health department? Do health regulations apply to your operation? Does the system meet health regulations? If not, do you have an plan for correcting the problems?	Wateris never tested or the plant has been shut down by health regulators and the OP is making no progress in correcting problems.	Water meets health regulations most of the time but is not tested regularly or health regulators are not engaged OR regulators have shut down the system due to exceptions but the OP is actively working to resolve issues.	Health regulators are engaged and the system is in service and the water is tested regularly, but the testing has failed more than 2 times in the last year and/or there are regulation exceptions.	Water meets health regulations and is tested regularly, but has failed testing 1-2 times in the last year.	Regulatory and LWW requirements/standards are consistently met or exceeded, and water is tested and passes regularly.
Is there limited downtime in the operation of the plant?	For what reasons do you experience downtime? *How many reasons were listed as causing downtime?* How many days in the past 12 months was the system without service due to a needed repair or maintenance?	The system has been without service due to needed repairs for at least 30 days in the previous 12 months.	The system has been without service 11+ days in the previous 12 months OR there are several problems that frequently lead to inactivity.	The system has been without service 4-10 days OR fewer than that, but the operator mentions at least one reason of inactivity as being a frequent problem.	The system has been without service 2-3 days OR fewer than that, but the operator can list at least one reason that causes inactivity.	The system has been without service due to a needed maintenance or repair fewer than 2 days in the previous 12 months AND the operator can not list any reasons that cause inactivity.
Do at least two people involved in the plant know how to correct and manage technical problems?	How many people at each site have been trained in all maintenance and repair tasks? How many people perform maintenance tasks on a regular basis?	No one knows how to make repairs.	At least 1 person knows how to make all repairs, but is not on site, and the others can only do regular maintenance.	One onsite person knows how to make most repairs, and there is someone to complete other repairs.	At least 1 person knows how to make all repairs and is onsite.	At least 2 people know how to make all repairs and have shown evidence that they can do so (at least 1 onsite).

Domain: **Management, Operations, and Maintenance**
Subcategory: **Maintenance (continued)**

Broad Questions	Survey Questions and Metrics	Score 0	1	2	3	4
Are routine maintenance procedures followed and documented?	How often do you perform each of the following tasks?: Changing of filters	There is no regular maintenance schedule, and maintenance performed is not documented.	There is not a clear schedule though maintenance is done OR it is unclear whether the current schedule meets LWW's recommendations.	There is a maintenance schedule that seems to be followed, but it is either unclear and/or not documented, and it reportedly meets LWW's recommendations.	There is a clear maintenance schedule that seems to be followed, but it is not fully documented, and it meets LWW's recommendations.	There is a clear maintenance schedule documented, it is followed and documented, and it meets LWW's recommendations.
	How often do you perform each of the following tasks?: Regeneration of the softener					
	How often do you perform each of the following tasks?: Cleaning of the RO membrane					
	How often do you perform each of the following tasks?: Cleaning of softener head					
	When was the last time you changed the filter?					
	Did they know when they last changed the filter and was it within the last year?					
	Have you been given maintenance recommendations from LWW?					
	Does the maintenance schedule align with LWW's recommendations?					
	Do you keep records of your maintenance activites?					
	What do you keep?					
Is there a vendor or supplier for each major component? Are they local?	Do you have someone who sells important parts locally?	Not all parts are available, and the OP has not identified a source for them.	Most parts are available in-country, but they are not affordable or are frequently not available when needed.	Most parts and supplies are available (though not necessarily affordable) for all equipment in-country within a 2 hour drive, and the others are available through an In Country Coordinator.	Parts and supplies are available and affordable for all equipment in-country within a 2 hour drive.	Parts and supplies are available and affordable for all equipment in-country within a 1 hour drive. The plant has experienced fewer than 2 days without service in the last year.
	How many?					
	How many days have you experienced a lack of service due to the inability to get a replacement part in the last 12 months?					
	Are local supplies affordable?					
	Are there any supplies for which you have no local vendor?					
	Which ones?					
Is an inventory of replacement/spare parts maintained at the plant site or nearby for routine maintenance?	For which parts, such as filters, do you keep an inventory on or near the plant site (only system parts – not bottles, etc.)?	No inventory is kept on hand.	An inventory of only a few minor pieces is kept.	An inventory of at least one major parts is kept.	An inventory of all major parts is kept (at least 1).	An inventory is kept of all major parts and some minor parts for maintenance (at least 1 of each item).
	How many of each part do you have on hand at the moment?					
	How many of each part do you typically have on hand?					

Domain: **Management, Operations, and Maintenance**

Subcategory: **Network and Support**

Broad Questions	Survey Questions and Metrics	Score 0	1	2	3	4
Does the community participate in management and operations through a water committee?	Is there a water committee?	There is no water committee and the OP seeks no input.	There is a water committee, but it does not meet regularly, and/or the operator(s) make decisions without input.	OP makes all water project decisions with input from other stakeholders (no water committee OR the water committee does not meet regularly).	There is a functioning water committee that meets semi-regularly to review project results.	There is a functioning water committee that meets regularly to review the business records, project results, and contingencies for project continuity.
	How many people are on the water committee?					
	How often does the water committee meet?					
	When was the last water committee meeting?					
	Was the last water committee meeting within the last 6 months, and do they meet regularly?					
	What is discussed at the water committee meetings?					
	If no water committee, is anyone included in decision-making process? Who?					
Is the Plant part of a larger network?	Do you have contact with your IP or anyone from LWW?	Plant is not part of a network and has no communications with IP or LWW.	Plant is not part of a network and has sparse communications with IP, LWW, and other operators.	Plant has regular contact with their IP or ICC, but do not attend water conferences or work with other operators.	Plant is part of a network. They have regular contact with either their IP or their ICC. They attend water conferences.	Plant is part of a network. They have regular contact with their IP, ICC, and other operators and attend water conferences annually.
	How frequently do you communicate?					
	Is the pastor or anyone from the church in contact with the IP or LWW?					
	How frequently do they communicate?					
	Do you have contact with your in-country coordinator?					
	How frequently do you communicate?					
	Do you work with other Ops in any capacity?					
	Do you attend regular operator conferences?					
	How frequently?					
How much do recurring expenses cost, and what is the source of funding for them (utilities, wages, supplies)?	What are the monthly operational and maintenance costs, on average? (Asked of them)	Monthly operational and maintenance costs are not met.	Subsidies are usually required to cover operational costs.	Recurring expenses are paid for using primarily revenues from plant, but occasionally it is supplemented by a subsidy OR the site has loans that it will not be able to pay off in the next few months.	Recurring expenses are paid for using primarily revenues from plant, but occasionally it is supplemented by a loan that the plant is able to pay off within the next several months OR there is evidence that the site is operating only on a breakeven basis.	Recurring expenses are paid for using only revenues from the plant, and the site is doing better than breakeven.
	What are the monthly operational and maintenance costs, on average? (Assessed by me)					
	What are the monthy costs of wáter and electricity?					
	What are the monthly costs of bottles, caps, and seals?					
	What are the monthly costs of bleach and other chemicals?					
	Where does the money come from to pay for these costs?					

Domain: **Cost Recovery and Financing**

Subcategory: **Cost Recovery**

Broad Questions	**Survey Questions and Metrics**	**Score** 0	1	2	3	4
How much do other expenses (major parts, repairs, upgrades, expansions) cost, and how are they funded?	Do you have money set aside for needed repairs or unexpected maintenance?	No money has been set aside for non-recurring expenses, and there is no plan to do so.	No money has been set aside for non-recurring expenses, but there is an intention to do so OR there is money set aside, but it is funded out of subsidies/ donations.	Money has been set aside for non-recurring expenses in the past but has been used AND It was not funded solely by the plant revenues.	Money is set aside for non-recurring expenses, is funded solely by revenues, but is only a little.	Money is set aside for non-recurring expenses, and it is funded solely by revenues from the plant. It is described as or is evidently enough to cover a major repair.
	How much money has been spent in each of the previous 12 months on non-routine maintenance?					
	Where does the money come from to pay for non-routine maintenance and upgrades?					
Is the plant able to pay operators?	Is the operator paid out of system revenue?	Operator is volunteer and there is no intention (or it is not feasible in the near future) to switch to a paid volunteer.	Operator is volunteer, but the plant is planning to begin paying an operator (and it is feasible).	At least one operator is paid, but not out of plant revenue.	Operator is paid out of plant revenue and congregation donations OR not all operators are paid, but those that are are paid out of revenue.	Operator is paid out of plant revenue solely, and all operators are paid.
	Is the operator paid out of congregation donations?					
	Is the operator paid some other way (specify)?					
	Is there a plan in place to begin paying operators?					
	Is the lead operator volunteer?					
Is water accessible to those in the community who cannot pay for it?	Does your covenant or business plan stipulate that you give any water away for free?	All water is given away for free.	There is an intention to give away water for free (in covenant or business plan) (but not doing it).	Water price is set to cover free water distribution, but the plant is not doing it yet.	Water price is set to cover free water distribution, and the plant is doing it, but is not always covering costs or just barely breaking even.	System regularly generates excess income over expenses and still distributes free water.
	Do you give any water away for free?					
	Approximately how many bottles of water do you give away free each week?					
	How many bottles of water have been given away free in each of the past four weeks?					
	How many bottles of water have been given away free in each of the past 12 months?					
	Do you set prices to cover free water distribution?					
	Does the system generate excess cash income over expenses and still distribute free water?					

Domain: **Cost Recovery and Financing**
Subcategory: **Cost Recovery (Continued)**

Broad Questions	**Survey Questions and Metrics**	**Score** 0	1	2	3	4
Are revenues greater than costs and is the price of water set at a rate that will sustain the system?	*What are the monthly operational and maintenance costs (recurring and non-recurring), on average? (Assessed by me)*	The organization exists solely from subsidies.	The plant revenues are greater than costs 6 or fewer times in a year OR exists from loans which it has a plan to pay back OR water project is depending on subsidy from another organization to keep it going (ie, it is generally spending less than it makes)	Revenues are greater than costs most of the time (at least 6 times in the past year), and the organization receives loans to cover other costs which it is able to pay back regularly (ie, it's operating on a break-even status)	Revenues are usually greater than costs (9 or more months out of last 12).	Revenues are consistently greater than costs and the price of water is set to sustain the system.
	What have monthly revenues been in each of the previous 12 months?					
	What have been the total costs in each of the previous 12 months?					
	Are the monthly revenues on average greater than the monthly costs? (asked of them)					
	Are the monthly revenues on average greater than the monthly costs? (assessed by me)					
	What was the average price of water (for all SOLD bottles) over each of the past 12 months? (Repeat Question)					
	Do subsidies or loans cover the rest of your costs (above what you can pay with revenues from the plant?)					
Is there a place to securely store revenues?	Do you have a secure place to store your revenue?	There is no secure place to store money and there have been numerous losses and/or thefts.	There is no secure place, but there have been no or only a few losses or thefts.	Money is stored in a secure place, and there have been a few losses or thefts.	Money is stored in a secure place (not a bank) and has never been lost or stolen.	Money is stored in a bank and has never been lost or stolen.
	If so, what is it?					
	Have you ever lost or had stolen any of your revenue?					
	How frequently has that happened?					

Domain: **Cost Recovery and Financing**

Subcategory: **Financing**

Broad Questions	Survey Questions and Metrics	Score 0	1	2	3	4
Have provisions been made to internally fund upgrades, expansion, and capital improvements?	Is there a plan for capital improvements?	No provisions have been made to internally fund upgrades, and no money is available to do so.	The plant is not financially stable enough to set money aside for funds, though it would like to.	There is an intention and ability to set aside funds for upgrades, but so far it hasn't been done.	There are funds, but account has only a little money.	There is money set aside for these purposes and the fund has money available OR the fund has recently funded capital improvements solely from profits.
	Does a fund exist for capital improvements?					
	Is there any money in the fund for capital improvements?					
	Have any capital improvements been funded solely by profits from the plant?					
Does the plant have access to capital?	If you need a loan in the next year, will you be able to get one?	No access to loans or subsidies.	--	The plant has had access to loans or subsidies in the past.	The plant has access to subsidies (and possibly loans).	The plant has access to loans.
	If you request a subsidy in the next year, will you be able to get it?					
	Have you had access to loans or subsidies previously?					
Does the plant have the ability to service any outstanding debts?	Do you have any loans?	No access to loans, or loans have been given but not paid back at all and there is no plan to do so.	Loans exist, but there is no plan for paying them and no ability to pay.	Loans exist and there is a plan for paying them, but they aren't being paid consistently.	Loans exist but have been paid for the past 12 months (or time of the loan), but at a varying amount.	No loans, or loans exist but have been paid at a constant or increasing rate for the past 12 months (or time of the loan).
	What is the amount of your outstanding debt?					
	How much have you paid on your loans in each of the past 12 months?					
Does the plant rely on subsidies?	Do you receive subsidies from your IP? (Repeat question)	The plant uses subsidies to cover its costs almost exclusively.	The plant has used subsides for at least one project in the last year, and is not financially stable.	The plant has used subsidies for at least one project in the past year, but is financially stable.	The plant has not used any subsidies or loans, but is considering aksing.	The plant does not receive any subsidies.
	How much have you received in subsidies in the last year?					
	How much have you received in subsidies in each of the last 12 months?					
	How many of the past 12 months have you had to use subsidy money to cover your costs?					

Domain: Understanding of Demand

Subcategory: **Demand Generation**

Broad Questions	**Survey Questions and Metrics**	**Score** 0	1	2	3	4
Is water accessible and utilized by at least 10% of the community?	How many people are in the community?	The plant has not served at least 5% of the community in at least 5 of the previous 12 months?	The plant has served at least 5% of the community in at least five of the previous 12 months.	The plant served more than 5% of the community in each of the last 12 months.	The plant served more than 10% of the community in the last month, and at least 5 additional of the last 12 months.	The plant served more than 10% of the community in each of the last 12 months.
	How many individual clients/households do you have?					
	How many unique customers did you have in each of the last four weeks?					
	How many unique customers did you have in each of the last 12 months?					
	What percentage of the community is served by the plant? (asked of the respondent).					
	What percentage of the community is served by the plant? (self-calculated)					
Is delivery used to increase accessibility?	Do you deliver water?	Water not delivered and customers would like delivery.	Water not delivered and unknown whether customers would like it/use it.	Water is delivered, but inconsistently.	Water is delivered, but to fewer than 50% of customers.	Water is delivered to more than 50% of customers.
	For how long have you done so?					
	How many unique customers do you deliver to?					
	How many unique customers did you deliver to in each of the past 4 weeks?					
	How many unique customers did you deliver to in each of the past 12 months?					
	If you do not deliver, would your customers like delivery?					
Does the OP engage in activities to increase demand for the water?	Do you do any marketing activities? What are they?	No evidence of marketing or educational activities ever.	The plant has held no educational activities ever, but there is a history of marketing OR bottle labels are their marketing.	The plant has held at least 1 educational activity ever, and has a history of marketing activities.	The plant has held educational sessions in the last year OR does some marketing.	The plant has done some marketing and held educational sessions in the past 12 months.
	Do you hold any educational sessions with the community?					
	If so, how many times in the past year did you hold an educational activity?					
	If so, how many times in each of the past 12 months did you hold an educational activity?					
	What are a few examples of educational activities?					

Domain: Understanding of Demand

Subcategory: **Awareness of Demand**

Broad Questions	**Survey Questions and Metrics**	**Score** 0	1	2	3	4
Does the plant supply more inputs than is required to meet demand?	How many bottles of water were bottled in each of the previous four weeks? (Repeat Question)	An operator often works unnecessarily.	--	The plant sometimes has someone working when it's not necessary, but it's because they are open a certain number of hours consistently.	The plant sometimes has someone working when it's not necessary, but only parts of days while waiting for more work to come in OR there is evidence that they have adjusted to work the appropriate amount of time in order to meet demand.	The plant never has people working unnecessarily.
	How many bottles of water are bottled each week, on average?					
	How many bottles of water were sold in each of the previous four weeks? (Repeat Question)					
	How many hours did an operator work in each of the past 4 weeks, on average?					
	Are there ever people at the plant to work when there isn't any work to do?					
Is the plant aware of changes in demand?	How many bottles of water were bottled in each of the previous four weeks? (Repeat Question)	No evidence of changes in number of bottles bottled and/or price changes.	No evidence in changes in price or bottles, but the plant expresses awareness of knowing to change based on demand.	The price of water is constant, but the number of bottles bottled and sold changes over time for a demand-related reason. Different amounts may not be charged to different clients.	The number of bottles bottled and sold is roughly equivalent, the number changes over time. Different amounts are charged to different clients OR there has been a change in the price.	The number of bottles bottled and sold is roughly equivalent, the number changes over time, and the price of water has changed over time. Also, different amounts are charged for different reasons.
	How many bottles of water were bottled in each of the previous 12 months, on average?					
	How many bottles of water were bottled in each of the previous 12 months?					
	How many bottles of water were sold in each of the previous four weeks? (Repeat Question)					
	How many bottles of water were sold in each of the previous 12 months?					
	Has the average price of water changed over the past 12 months (assessed by me)?					
	What was the average price of water (for all SOLD bottles) over each of the past 12 months? (Repeat Question)					
	Do you charge different prices for different customers? Based on what?					
	Based on what?					
	How do you know how many bottles of water to produce?					

Appendix 2: Recommendations for Living Waters for the World

Number	Category	Recommendation	Justification / Intended Outcome	Suggested Methods / Considerations
1	Financial (red)	Perform a full cost recovery analysis for each site.	While it is clear that LWW and their partners are aware of the costs of equipment and spare parts, it does not seem that each site has performed a cost recovery analysis to determine total expected costs over a period of several years. Doing so will help LWW and its partners to understand the full costs of operation and the financial resources needed on a daily, weekly, monthly, and yearly basis to meet those needs.	- LWW or another independent researcher, with adequate information, could pilot this activity with existing sites, and it could later be incorporated into the agreement process with partnering communities. - Determine total likely costs (including installation, operation, routine maintenance, and non-routine maintenance) over at least a 5-year period. - Consider the size of the potential market, and determine a price that will be necessary to collect enough revenues to cover costs into the future. - Consider including as a cost a salary that is reasonably comfortable for plant employees. - Consider using Harvey and Reed's (2007) book, sections 5.2.1 - 5.2.3, as a guide to perform a cost recovery analysis that includes recurring operations and maintenance costs as well as rehabilitiation and expansion.
2	Financial (red)	Encourage IPs to develop a reasonable, long-term plan for decreasing support to their sites in collaboration with their sites.	The current template covenant for use with new sites encourages transfer of long-term support to in-country resources. This process should be implemented even with existing sites and provide specific guidelines as to long-term support by the IP so that both the IP and OP have the appropriate expectations and are planning appropriately for the future.	- For existing sites, encourage IPs and OPs to have regular, collaborative conversations regarding long-term financing and support. If it is not already detailed, encourage them to develop a long-term plan that incorporates the cost recovery analysis, is specific, and involves eventual transfer to in-country sources. - For new sites, continue to encourage IPs and OPs to plan for long-term involvement and eventual transfer to in-country resources. Encourage sites to be specific about what form support will take, when it can be expected, and the expectations regarding its use.
3	Financial (yellow)	If IPs are interested in providing financial support, consider investing in delivery infrastructure, system upgrades, marketing activities, and plant improvements (especially those required by the health department).	In the context of Recommendation 2 (providing planned, specific support), these investments may help plants to expand or improve their operations and possibly increase revenue.	- In the context of a specific long-term support plan, consider fully or partially financing areas of the plant that have the potential to increase plant production and revenues. - While financial support to help sites perform preventive maintenance or needed repairs may also benefit the plant, a long-term plan for transitioning these costs to the plant needs to be developed.
4	Financial (yellow)	Consider encouraging plants to increase the salary of their operators.	The operator's salary is one of many costs competing for the limited revenues at each site, and operators gain an additional spiritual and emotional reward for their work. However, in some cases, their salary is small and difficult for operators to live on. If possible, an increased salary may increase employee satisfaction and prevent operators from leaving their position.	- When developing a cost recovery plan with sites, attempt to achieve cost recovery with a higher salary than operators currently receive. - If an increased salary is not possible, consider other ways to provide benefit to employees (free water, some health expenses covered by church perhaps, etc.).
5	Financial (yellow)	Brainstorm with plants how to store and save revenues.	Several sites said they do not have a safe place to store their money. Working with plants to determine a secure location for large amounts of money may encourage them to save more of their revenue from month to month.	- If commercial banks are not an option (and they aren't, in most cases), consider encouraging plants to invest in a locked storage place where money is monitored on a regular basis by more than one person.
6	Financial (green)	Consider allowing the price for water to rise higher than half the price of commercial water.	Currently, all plants visited follow the current LWW guideline. However, most plants are also struggling financially and have difficulty financing non-routine expenditures. If the demand allows for increased prices, higher prices may result in additional revenue and savings. This can be used to improve salaries and/or invest in preventive maintenance or plant improvements.	- See Recommendation 1. Perform a full cost recovery analysis to determine the necessary price for each site to recover all short- and long-term costs. - Consider performing an ability-to-pay and willingness-to-pay assessment to determine how much you can charge without losing customers. - To ensure that those who are unable to afford higher-priced water still have access to water, consider using a sliding scale based on ability to pay.

7	Operation (yellow)	Implement consistent monitoring practices across all sites for all aspects of plant management (maintenance, bottling, financial, quality control).	Currently, all sites monitor different things, particularly regarding financial and bottling data. They also monitor it in different ways, using different formats and measures. A consistent process will allow for better management, better oversight, and more effective evaluations. Additionally, by tracking mission-related statistics (such as bottles given away free, number of customers, etc.), the plant can be aware of and track how many people they are reaching with clean water, which may be a motivator.	- Provide a document or format to all sites to track all data in the same way and at the same intervals. - Provide space to tabulate daily, weekly, monthly, and yearly totals - Encourage sites to continue to track the water/system quality - Consider including the following data (per each time period suggested above) as part of the regular monitoring process: -- # bottles bottled -- # unique customers -- # bottles sold -- Price each bottle sold at (or number sold at a particular price) -- # bottles given away free -- For each of the above, break the data down into delivery vs. sold at plant (or even further, such as delivery route, if appropriate) -- Costs by category ---(Operation costs: labor/staff, food, gas, utilities, money regularly provided to church or presbytery, etc.) ---(Regular maintenance costs: parts/materials, labor if different than that for regular operation, etc.) ---(Repair costs: parts, labor, etc.) ---(Investments/Capital improvements: wells, cars, loan payments, etc.) ---(Other costs?) -- Income from sales -- Income from donations/subsidies (church/presbytery/LWW/IP) -- Other income
8	Operation (yellow)	Encourage plants to deliver water and work with them to brainstorm ways to invest in the infrastructure to do so.	Sites that deliver water have higher sustainability scores. Water delivery can increase the access of people to Living Waters' water, thereby allowing further outreach to those who cannot otherwise access the water and also possibly increasing overall revenues.	- Delivery requires a person who has availability to deliver and a delivery vehicle/mechanism. Brainstorm with sites the costs/benefits of achieving each of these things, and encourage them to forecast potential additional revenue gains to determine whether the investment is beneficial.
9	Operation (yellow)	Encourage plants to create water committees if they do not currently have them. Encourage all water committees to cover standard topics at their meeting and to meet at suggested intervals.	Most plants currently have water committees, and they take a variety of forms and operate in different ways. Water committees involve more of the community in the plant and provide more oversight and support for the plant. To ensure that all water committees are being effective, suggest a standard set of areas they should cover and frequency for meetings.	- Consider establishing water committees separate from the church committee, but only if it makes sense and will improve oversight and support of the water plant rather than simply increasing bureaucracy. - Make the roles of water committee members clear and distinct by developing recommended guidelines and role descriptions for each water committee member. - Encourage water committees to meet at regular intervals, and possibly have them initially report committee activity to their IP. - Develop a set of topics to discuss at each meeting that will encourage site performance, possibly including: -- Weekly/monthly statistics regarding bottles sold, costs, revenues, bottles given away free, etc. -- Maintenance concerns, upcoming maintenance needs, plan for addressing them -- Upcoming expenditures and plans for financing them -- Upcoming marketing opportunities -- Opportunities for service to the community through water

10	Operation (green)	Recognize operators and others involved in the plants for their contributions to their community.	Operators, and likely others involved in plant operation, are motivated by their ability to contribute to their communities. Promoting the achievements of the plant employees may build support for the plant in general and encourage plant employees to continue to invest in the plant.	- Encourage pastors to recognize the plant employees occasionally to church audiences, if appropriate. - Encourage church leadership to personally recognize the operators and others involved in the water plant for their work. - Provide positive feedback to operators during site visits (possibly using statistics regarding number of people reached, etc. - see Recommendation 7).
11	Operation (green)	Continue to promote the service and ministry aspects of Living Waters.	The mission of LWW is a strong motivator for everyone involved in the distribution of LWW water. The churches and plants in the Yucatan have a strong, supportive relationship in most cases, which furher contributes to motivation. This mission and these relationships should continue to be encouraged and operationalized so that plants are able to achieve that mission.	- Continue to provide mechanisms for water to be provided to those who cannot pay. - Continue to try to expand the number of people that access water from each LWW plant. - Practice good preventive maintenance, repair, and quality assurance practices to ensure that the water being provided is clean and safe. - Encourage churches to support plants in a variety of ways. - Provide opportunities for the plant to support the church (ie, financially, with water donations at events, etc.)
12	Operation (green)	Encourage plants to develop a positive relationship with health departments.	Few plants described their relationship with the health department positively, although not all described it negatively either. A positive relationship is important for receiving a health department certification, for maintaining the trust of communities, and for gaining information that may be valuable to plants.	- Engage health department during planning and installation processes. - Encouarge all plants to have health department certification (see Recommendation 15). - Engage health department regularly while in operation. - Encourage plants to view the health department as a source of useful information that will allow them to provide cleaner, safer water.
13	Operation (green)	If they do not currently, encourage all plants to regularly have their water quality checked by an objective source.	Since LWW's main goal is to increase the availability of clean water, LWW should confirm and provide objective evidence that their water meets quality standards by using an outside entity to test their water, such as the health department. This will contribute to trust for LWW water within the community and pride for operators that have achieved quality water.	- Provide the appropriate water samples to health department officials or labs to be tested on a regular basis.
14	Operation (green)	Encourage camaraderie between employees.	Several operators indicated that they enjoy working with others and feel supported by their coworkers. Others indicated that lack of conformity between operators was frustrating. Employee satisfaction may increase by promoting a positive relationship between coworkers and by implementing policies to prevent frustration.	- Encourage plants to use a standard method of performing tasks so that employees know they can rely on each other and know what to expect. - Consider encouraging employee social activities or events.
15	Maintenance (red)	Work with plants to achieve health department certification.	Most plants currently are certified by the health department, but ensuring that everyone is will increase trust and respect from customers as well as contribute to a positive and potentially beneficial relationship with the health department. Also, operators seem to feel pride when the health department praises their water, so it may increase employee satisfaction.	- Work with health department *prior* to plant implementation to understand their requirements and plan appropriately. - Encourage plants to invest in all health department requirements. - Recognize plants that have achieved a health department certification (either verbally, with a reward of some kind, etc.).

16	Maintenance (red)	Increase the technical capacity of operators or other staff in the region to perform all maintenance and repair tasks.	Currently, most sites have at least one person on site that can perform some maintenance. However, many sites in the region rely on the regional coordinator for technical assistance for more in-depth maintenance and repair activities. Increasing the number of people who can perform these activities will ensure that sites have limited downtime when maintenance is required. It may also increase employee satisfaction by increasing ownership, comfort, and pride.	- Include maintenance and repair training in annual operator trainings, if it is not already. - Encourage the in-country regional coordinator to involve site operators in maintenance and repair activities in order to transfer his knowledge and provide oversight while operators practice. - Create the expectation during the agreement process that someone at each site will be able to perform all main maintenance and repair tasks, and have a plan for transitioning employees.
17	Maintenance (yellow)	Require each plant to maintain a maintenance schedule that includes the due dates and frequency for necessary maintenance and perform monitoring for all parts of the plant.	While it may be that all plants are following an appropriate maintenance schedule, it is difficult for an outside evaluator to determine whether that is true. Displaying a maintenance schedule that is tracked and reported on (to LWW, the plant's IP, a regional coordinator, or someone else) will ensure that all plants are following appropriate preventive maintenance procedures and that an outside evaluator can verify that.	- Post a clear and visible maintenance schedule for each plant part and plant process that is specific to each plant's technology. - Provide a format for all sites to use so that a consistent monitoring format is used. - Require plants to provide their maintenance monitoring to an objective reviewer to ensure that all processes are being completed appropriately.
18	Maintenance (green)	Consider encouraging plants to keep an inventory of spare parts and supplies on site.	Currently, few sites keep spare parts available on site. Although most are available within a few hours' drive, some downtime could be prevented by storing replacements on site.	- Determine which parts are needed most frequently, and keep those on site. - Determine which parts are most difficult to acquire, and keep an inventory of those on site in case they are needed and unavailable.
19	Demand (yellow)	Consider using marketing techniques.	Currently, most plants do not perform any type of marketing. Doing so could increase customer base, especially among non-church members.	- At least one site used a punch card system where every nth bottle of water was free. Consider expanding this promotional technique to other sites. - Advertise at community events. - Donate water to community events (with some amount of advertising so that community members know its source).

EMORY UNIVERSITY

Institutional Review Board

TO: Janelle Hartman
Principal Investigator

DATE: April 28, 2010

RE: **Notification of Submission Determination: No IRB Review Required**
IRB00043139
Evaluation of Living Waters for the World Water Treatment System in the Yucatan Peninsula, Mexico

The above-referenced study has been vetted by the Institutional Review Board (IRB), and it was determined that it does not require IRB review because it does not meet the definition of "Research" or the definition of "Clinical Investigation" under applicable federal regulations. Accordingly, IRB review is not required.

45 CFR Section 46.102(d) defines "Research" as follows:

Research means a systematic investigation, including research development, testing and evaluation, designed to develop or contribute to generalizable knowledge. Activities which meet this definition constitute research for purposes of this policy, whether or not they are conducted or supported under a program which is considered research for other purposes.

Based on information included in the submission, the results from this evaluation will assist Living Waters of the World determine what to emphasize when training their partners in sustainability, which factors are specific to each community, and whether any communities in the Yucatan Peninsula should be targeted for improvement. Ultimately, this evaluation will help Living Waters of the World and their partners improve their programs so that they can continue to provide clean water in the communities they serve. The purpose of this project is Quality Improvement and the intent is to improve the local system of care. The results of the evaluation are not generalizable outside of the communities served by Living Waters of the World.

The IRB has determined that this study does not constitute "Research" under the foregoing definition.

In addition, the IRB has determined that the study is not a "Clinical Investigation" under applicable Food & Drug Administration regulations because it does not involve a test article and does not otherwise meet the requirements of the definition of "Clinical Investigation" as set forth in 21 CFR Section 50.3(c).

Please note that any changes to the protocol could conceivably alter the status of this research under the federal regulations cited above. Accordingly, any substantive changes in the protocol should be presented to the IRB for consideration prior to their implementation in the research.

Sincerely,

Carol Corkran, MPH, CIP
Senior Research Protocol Analyst
This letter has been digitally signed