Insight in Resolving the World's Socio-Economic Water Scarcity Crisis

In 2006, Pentair committed $4.7 million to fund Project SafeWater-Colón, Honduras and partnered on-the-ground in Honduras with Water Missions International. This five year project to deliver safe drinking water to the state of Colón, Honduras, has provided new insights into the key facets required to develop a "sustainable" community based clean water resource. The four main components required to establish a self sustaining solution are: 1) A thorough baseline assessment to understand the cultural paradigms of the community as well as identify the technology best suited to treat the water, 2) A rigorous community development program that includes health and hygiene education in addition to involving the community in the financing, construction, installation, start-up and operation/maintenance training of the water treatment system, 3) Operation and maintenance of the water treatment system and development of a sustainable micro-enterprise model to ensure continued focus on effective operation of the system, and 4) Continued monitoring of the treatment system performance, as well as monitoring and documentation of improvements in the health and productivity of the community to ensure ongoing effective operation of the system. Our research has confirmed that by taking this multi-faceted approach, safe clean water can be sustainably delivered to communities in developing countries around the world and help contribute to achieving the United Nation's Millennium Development Goals.

Introduction

From the America's to the Far East our societies continue to grow and the demand for water to support that growth is being severely stressed through the production of food, energy and products used by our societies. The increasing demand for water is somewhat invisible to most of us as the demand we place on this precious resource through the water we directly consume and use for hygienic purposes daily seems relatively small. But it is the virtual water footprint used to help produce the food and energy we consume as well as the products we purchase that is the real driver behind the stress we are now beginning to experience worldwide. As an example, on a daily basis the average person in the US consumes about 100 gallons of water for drinking and hygienic purposes. But if we factor in the demand from the food and energy we consume and products we use that average jumps to nearly 1,800 gallons per person per day. Specifically, it takes approximately 53 gallons of water to produce one glass of milk; 1,000 gallons of water to produce enough electricity to operate a home for a family of four; and about 1,000 gallons of water to produce a cotton shirt. This hidden demand for water is the real catalyst behind our looming scarcity challenges and is being amplified as the economic positions of the societies in fast growing regions of the world continue to rise. With increasing wealth and education, there comes a higher demand for food, energy, and products that have progressively higher needs for water in the processes used to produce them. One of the most profound examples is in the shift from carbohydrate rich to protein rich foods that occurs as societies become wealthier. As an example, the demand for beef in China increased by 38 percent from 2001 to 2006. This shifting trend in food preferences alone can increase an individual's daily water footprint by 100 to 200 percent.

The good news is that the challenge to ensure we manage this natural resource to support our socio-economic development is being met with a tremendous effort from industry, academia and an entrepreneurial spirit around the world. Today we have technologies that not only reduce our water footprint by conserving water, but technologies developed over the past 30 years that can expand our water supply by reliably desalinating seawater and purifying wastewaters to a potable standard have come of age. With a high level of certainty, these technologies will continue to advance along with the invention of new ones making the water challenges our societies face more manageable. Undoubtedly, the inventiveness of our societies will find their way to ensuring the supply and demand of this precious resource is in balance.

But hidden behind the water challenges being experienced and anticipated by the growing economies of the world is another form of water scarcity often clouded by and confused with the scarcity issues discussed above that we call "socio-economic water scarcity." This form of water scarcity is driven by the lack of cultural insights into the importance of clean, sanitary water and the lack of financial means to resolve the problem. In many ways this issue is more complex and definitively more tragic than what we experience in the growing economic and developed worlds.

Imagine tomorrow that you wake up, turn on CNN and learn that 50 jumbo jets carrying 120 children and 380 adults crashed during the night. For sure this event would shake

you and the world. But if you awoke the next day, and the next day, and the next day, continuously finding that the previous evening was host to the same tragedy night after night, would you be become numb to it? Or would it spark a call to action to find the root cause of the plane malfunctions and stop this tragedy?

The fact is that today nearly 6,000 children and 19,000 adults actually die per day, not from such a graphic event, but from a more silent tragedy caused by waterborne illnesses. Distinct and separate from the water scarcity challenges being addressed by the world's growing economies, solutions to "socio-economic water scarcity" are much more complex. Many well intentioned organizations from around the world have spent millions of dollars in an attempt to bring safe water to communities in need. But to ensure that the solution is sustainable far past the time these organizations leave, requires a more complex approach that fully understands the economic, cultural and geographical constraints of the affected community in addition to the technical solution required to treat the local water to safe standards. The time and monies afforded by many well intentioned organizations often are not sufficient to adequately address these complex issues. Through our five year study, we have explored the impact these co-dependent parameters have on creating a truly sustainable solution and have gained some remarkable insights - while ensuring over 260,000 people in Colón Honduras now have sustainable access to safe, clean water.

Project SafeWater Colón Summary

In January 2007 the Pentair Foundation took a significant step to address the challenge of "socio-economic" water scarcity when it awarded Water Missions International a 4.7 million dollar grant to design and execute a comprehensive community-based water and sanitation project for the state of Colón Honduras. According to Honduran government statistics, 33 percent of the 220,000 people believed to be living in Colón lacked access to safe water for cooking and drinking and 43 percent of these people lacked access to adequate sanitation facilities. Named Project SafeWater-Colón, Pentair's project was designed to demonstrate that the global water crisis can be solved cost effectively and sustainably while providing access to safe water and sanitation to a statistically large population of people in Colón. We set out to accomplish two primary goals:

- Provide access to safe water and adequate sanitation facilities for up to 100 percent of the population of the Colón; and

- Develop and validate methods and cost effective water treatment systems that would become the foundation of standard practices that could be replicated around the world in socio-economic water stressed communities.

Water Missions International, a nonprofit organization that addresses the water and sanitation needs of people in developing countries, served as Pentair's project leader and on-the-ground partner in Colón. The project was divided into 4 phases: 1) Establish

baseline data on the population demographics, health indicators and water source and quality; 2) Design, build and install a suitable water treatment system and develop a community development program that would engage the community by having them both financially and intellectually engaged in the implementation of the solutions; 3) Begin system training and operation and implement a community based micro-enterprise model to ensure the water systems are operated and maintained in a sustainable manner; 4) Monitor and Control operation of the system and evaluate the shift in the communities' health indicators.

Once the project began, the baseline assessment and health surveys of 613 communities in Colón were completed in 2007. This took 12 teams of two technicians each and nearly 8 months to complete. It was determined that the population of the region was actually 350,000 people. It was also discovered that virtually the entire population lived without clean water as 100 percent of the water sources tested had high counts of *coliform* bacteria, indicative of fecal contamination; and approximately one quarter of them lacked adequate sanitation facilities. This thorough assessment helped develop a scientifically defensible baseline of health information and a detailed demographic of water quality data, required for designing suitable safe water and sanitation solution for each community.

During the second phase of the project, a comprehensive community development program was established and executed to ensure the sustainability of the project in each community. The community development work began with analyzing the community assessments from phase 1 and helping each community establish a Safe Water Committee which would be responsible for the long-term success of the safe water program. Detailed community education programs were delivered to heighten awareness of the importance of safe, clean drinking water and to educate the people on the connection between good hygiene practices and health. Suitable drinking water (i.e., the Living Water Treatment System to remove suspended debris and microbiological contamination) and sanitation systems designed to effectively treat the water found in Colón also were developed, manufactured and installed during this phase. More than 200 water treatment systems and nearly 13,000 individual sanitation facilities were installed in Colón during this phase of the project, serving approximately 75 percent of the entire region. Timing for effective community development averaged 12 months.

The purpose of the third phase of the project was to ensure the sustainable operation of the water and sanitation systems delivered to the communities well beyond Pentair's initial funding period. The main two tasks of this phase of the project focused on extensive training on operating the water treatment system and the establishment of a microenterprise business model. This would be where the local community owns the water treatment systems and users pay their communities a nominal fee for potable water. The water distribution model and individual user fee is established by the local community to cover the ongoing operation and maintenance of their system. Once installed, the system costs less than five cents per person per day to operate.

Today, each of the communities is monitored daily during phase 4 of this project. The system operator is responsible for sending the operating and performance data daily by a 'pre-formatted text message' via a cell phone back to a central service center managed by Water Missions International. This ongoing support and monitoring is a critical to ensuring the sustainability of the project.

The impact of this project on the lives of the people in Colón has been profound. The results to date demonstrate that sustainable access to safe water and adequate sanitation can be provided cost effectively, and that the health and welfare of the recipients are significantly improved. The baseline data, and data collected during subsequent years, has been used to demonstrate the correlation between lack of access to safe water and adequate sanitation facilities and the incidence of waterborne diseases. The study's methodologies incorporated a combination of ethnographic data, medical chart reviews and immunoassays for three of the most common waterborne protozoan pathogens. Final data compiled in 2010 demonstrated a significant difference between those who received access to treated water, sanitation and education, and those in the control group who did not. In fact, the results showed that only 4.5 percent of the group that had access only to clean water and 3.8 percent of the group that had access to both clean water and new sanitation systems tested positive for parasites, as compared to 25.0 percent for the control group (In essence an 80 percent improvement). Additionally, medical records from four Colón health clinics pointed to a decline of over 50 percent in the number of diarrhea disease cases they encountered once Project SafeWater was fully operational, following a 34-month post-installation timeframe. Additionally, ethnographic data gathered following the installation of water treatment and sanitation systems, and community education, now suggests a high level of understanding of the causes and prevention of waterborne illness or disease among people in the communities studied.

The results of this project have the potential to change current paradigms for providing access to safe water and adequate sanitation facilities to people in developing countries and form the basis for a standard best practice that can be replicated in other water stressed communities around the world.

Establishing Best Standard Practices to Create Sustainable Safe Water Solutions

Based on the positive results from the SafeWater Colón project, we have identified four critical project phases required to establish a self sustaining solution to socio-economically stresses communities:

Phase 1: Perform a thorough baseline assessment to identify key leaders in the community, fully understand the cultural paradigms of the community, determine the source and quality of the water to be treated and identify the technology best suited to treat the water;

Phase 2: Create a sustainable technical solutions and rigorous community development program that includes health and hygiene education in addition to involving the community in the financing, construction, installation, operation and maintenance of the water treatment system;

Phase 3: Develop and implement a sustainable micro-enterprise model that includes system operation and maintenance training to ensure continued focus on effective operation of the system; and

Phase 4: Establish an ongoing monitoring program to review and manage proper operation of the water treatment system and also trend improvements in the health and productivity of the community.

Phase 1 - Baseline Statistics and Site Assessments

Following are the key steps to fully establishing the baseline information required to initiate the community development program:

1. Recruit one 2 person team per eight communities to be served.
2. Train the technicians locally in the target country to collect baseline health, site assessment, demographic, and water quality data.
3. Use the technicians to conduct baseline surveys and site assessments in the target community.
4. While conducting the surveys, use the technicians to identify and meet with community leaders to establish trust and form a Safe Water Committee in each community.
5. While conducting the surveys, lead an ethnographic study to identify and assess possible cultural barriers to the safe water program.
6. After the baseline assessment is completed and the Safe Water Committee has been formed, write a comprehensive report summarizing the findings of the assessments and a detailed project plan that outlines the technical solution to treat the water and a full community development plan to drive education and adoption. The plan should also include a cost analysis, micro-enterprise model and monitoring plan to ensure continued use and the sustainability of the solution.
7. Review the report with the Steering Committee and finalize (i.e. redefine if necessary) the geographic size of the Target Area.

The Community Assessment Form should be designed to record the following baseline data: 1) Demographic Information; 2) Community Leader(s) identification; 3) Community population; 4) Number and locations of houses; 5) Geographic area covered; 5) Economic base; 6) Poverty indicators; 7) Type and reliability of water source; 8) Location of water source; 9) Water quality analyses; 10) Uses of water in the community and individual homes; 11) Source of available energy (i.e., grid, diesel generators, solar, wind); 12) Sanitation practices; 13) Hygiene practices; 14) Public Health Information related to the incidence of waterborne diseases; 15) Previous health education and nutrition training

Phase 2 - Community Development Plan

Establishing the Community Development Program and forming the Safe Water Committee (SWC) is one of the most critical aspects of the entire project to ensure adoption and long term sustainability of the program. The Community Development Program has 3 main activities:

- **2.1** Safe Water Committee Formation and Training
- **2.2** Health and Hygiene Training
- **2.3** Drinking Water and Sanitation System Design, Installation, Start-up and Operation Training

Each of these tasks is discussed in the following paragraphs.

Phase 2.1: Safe Water Committee Formation and Training

The Community Development Program actually begins during the first site assessment visit in Phase 1 when the assessment team meets with the community leaders and explains the project. This begins by explaining and educating the leaders on the connection between dirty water and waterborne diseases. The community leaders are then trained to teach the people of the community that safe water is essential to a healthy and productive life. Multiple visits are typically necessary before the community understands the importance and value of safe water and is ready to accept responsibility for a safe water program. Once the community leaders and the community are ready to accept responsibility for the long-term safe water and hygiene program, each community is asked to form a Safe Water Committee that will be responsible for:

- Ensuring that everyone in the community will be provided access to a minimum daily amount of safe water regardless of age, sex, nationality, faith, or ability to pay
- Operating and maintaining the equipment

- Participating in basic health and hygiene training and implementing a community-wide health and hygiene training program
- Developing a fee structure during the first 12 months that will ensure the long term sustainability and independence of the safe water program and, at the same time, ensure that no one is denied access to safe water
- Implementing and maintaining a monitoring and evaluation program
- Providing a location for the water treatment equipment that is accessible to everyone in the community.
- Constructing an enclosure to protect the water treatment equipment.

Once this is accomplished, and prior to installing the water treatment system, the technicians meet periodically with the SWC to help them get organized and build the enclosure for the drinking water system. To drive local ownership of this project, the community is asked to provide the materials and the labor to construct the treatment enclosure.

Phase 2.2 - Health and Hygiene Training

Once the SWC has been formed, the technician uses a “Train the Trainer” approach to teach the members of the committee basic health and hygiene practices so that they, in turn, can teach the rest of the community. Local health and hygiene programs are carried out in accordance with the Participatory Hygiene and Sanitation Transformation (PHAST) Series approved by the World Health Organization and should be combined with local health education techniques used by the local Health Department. The programs need to include a contextualized communication of personal health practices including proper storage of water, cleanliness of water containers, hand-washing, proper cooking methods, and proper disposal of feces.

Training materials for the health and hygiene training sessions could include posters, manuals, leaflets and local media. This training is accomplished through multiple sessions that take place before installation and during the first year of operation of each installation. It is recommended that each SWC is trained during an average of four to five sessions of approximately four hours during one week. Then, typically the SWC is given a 'hands-on' opportunity to 'practice' the principles learned by 'training' a trial group of other non-participant community leaders (village leaders who are not part of the SWC or are not receiving the Health and Hygiene Training). The trainer teaching sessions should be conducted under the supervision of local technical personnel to provide coaching and instructive feedback.

Following completion of this training, the SWC selects community groups for training (e.g., individual community neighborhoods or appropriate local organizations such as the water board, parent's association, churches, teachers’ association, etc.). To determine whether additional health and hygiene training is required, quarterly surveys should be conducted one year following the installation of the safe water and/or sanitation systems. The results of these surveys are then compared with results of

surveys conducted prior to the training. Follow-up training should be provided as required.

Phase 2.3a - Drinking Water Systems Design, Installation and Start-up

Based on the water quality identified in the phase 1 baseline assessment a simple, reliable water treatment system needs to be developed. Depending upon the source and quality of the water available, the technologies needed to treat it to safe drinking water standard can vary significantly. If the water is from an uncontaminated well simple chlorination may be adequate to insure the water is disinfected. Typically, however, more complex technologies will be required to treat the water to safe a standard by removing suspended debris, harmful inorganic chemicals (e.g., arsenic and fluoride) or disease producing bacteria, parasites and viruses. In cases where only biological contamination is noted, simple flocculation and filtration followed by chlorination (e.g., Water Mission's Living Water Treatment System) may be adequate to treat the water to safe standards. However, a reverse osmosis system may be needed to treat the water to safe standards in cases where the water is contaminated with harmful inorganic chemicals like arsenic, fluoride or lead. In all cases, however, disinfection post filtration will be required through the dosing of chlorine.

The last and critically important information that needs to be determined is the reliability of the power source. If there is a reliable source of electricity from the grid this will always be the lowest cost capital solution. However, it is often discovered that there is no source of centrally distributed electricity in most of these regions, so self sustaining solar powered solutions or a diesel generator would be needed to operate the system.

The system design should ensure that user control of the system is made as "mistake proof" as possible to ensure simple, reliable operation. Once the system is designed it needs to be manufactured and installed. After installation, the SWC members must be trained on the operation and maintenance of the equipment. Engaging the SWC in the development and installation of the equipment continues to drive ownership of the project by the local community. During this training the technicians should perform a simple review of the value of safe water, the connection between contaminated water and waterborne disease, and the importance of good health and hygiene practices. The SWC is then responsible for training the rest of the community.

Phase 2.3b - Sanitation Systems Design and Construction (optional pending site assessment)

Community-based wastewater treatment systems require community-based water distribution systems to facilitate transport of the waste to the treatment system via a wastewater collection system. Because community-based water distribution systems are generally not available in the rural areas of developing countries the solution to providing adequate sanitation facilities is typically sanitary latrines for individual family units.

To accomplish this in Colón, an efficient, cost effective means of constructing latrines was developed by Water Mission International. This led to the design of an aluminum form set that is used to construct a 3' X 3' monolithic concrete latrine house. Sand and gravel was sourced locally by the community from a local river. Portland cement, reinforcing fiber, pour-flush toilets, and miscellaneous supplies were provided by the project funding. Each family was responsible for constructing a cobble stone lined seepage pit and a concrete slab that covers the pit. The residents of the community were then trained to set up the form on the concrete slab, mix the fiber reinforced concrete, and pour it into the form set. The next day they disassembled the form set, leaving the fiber reinforced concrete latrine house in place. A pour-flush toilet was then installed, and the family trained in the proper use of their new sanitary pit latrine. This solution is available for other projects through Water Missions International.

Phase 3: Micro-Enterprise Development and System Operation Training

Phase 3.1- Micro-enterprise Development and Training

The members of the SWC are also taught how to create and implement a micro-enterprise plan that will generate sufficient income from the sale of the treated water to cover the operating costs and set aside a small fund for ongoing maintenance.

The technician helps the SWC develop a budget that covers the following operating costs and sets aside a small amount for ongoing maintenance:

- System operation and maintenance costs (electricity, chlorine, alum, repair of equipment)
- System operator's salary and expenses
- System improvement costs (extra treated water storage tanks, purchase of safe water bottles for families, enclosure improvements, provisions for a better water source)
- A capital replacement fund (typically a percentage of the monthly fees collected is placed in an account to allow system components to be replaced at some future date)

The typical micro-enterprise involves the sale of bottles of safe water at the treatment system installation or by means of distribution within the community served to cover all budgeted costs. Where distribution is utilized, the distributor is paid a set fee for each container of safe water delivered.

Phase 3.2 - Drinking Water System Operation and Maintenance Training

The members of the SWC must agree to accept responsibility for the operation, and maintenance of the safe water system. During the installation, all members of the SWC, as well as any operators who may not be members of the SWC, are taught how to

properly operate and maintain the system. Depending upon the technology used to provide safe water to the community, the critical operating parameters that need to be monitored and controlled must be clearly identified on the equipment. As stated in Phase 2.3a, the controls for the system should be designed to ensure "mistake proof" operation. As a baseline, the operator must be trained for all systems on how to:

- Prepare flocculent (i.e. alum solution) and install chlorine tablets in the chlorination device
- Set both the raw and treated water flow rates and operating pressures
- Adjust both the flocculent and chlorine feed rates
- Analyze feed and treated water clarity
- Analyze chlorine concentration
- Repair leaks and rebuild or replace critical system components

Phase 4 - Monitoring, Control and Evaluation

In this final phase of the program, quantitative data is collected to monitor and evaluate the performance of the SWC and the operation and maintenance of the water treatment and sanitation systems. If sanitation systems are installed, SWC representatives are also responsible for periodically visiting the community families to ensure that good health and hygiene practices are understood and being practiced.

The SWC members are responsible for monitoring the water treatment system operating parameters listed below on a daily basis. The following system performance parameters should be monitored and sent via a convenient method (e.g., cell phone text messaging) back to a central control center daily:

- Daily water production (gallons/day)
- Treated water quality
  - Turbidity (NTU)
  - Chlorine (mg/L)
- Number of families served
- All routine maintenance actions
- Actual expenditures and receipts of funds versus the micro-enterprise budget

On a quarterly basis during the 12 months following installation of a water treatment system It is recommended that a technician visit each SWC to review this data as well as the functioning of the micro-enterprise against its original plan. At this time it is also recommended to collect both ethnographic and health indicator data (i.e., bio-marker organism prevalence and/or incidence rate of water borne diseases) to track improvements in the communities' health profile and cultural shifts in the understanding of the benefits from clean water and proper sanitation and hygiene methods.

The ultimate goal of the monitoring and evaluation program is to ensure that each community will have long-term, sustainable access to safe water and adequate sanitation facilities, and that the people understand and use good health and hygiene practices. If, at the end of the 12 month monitoring period, it is determined that more effort is required to achieve success, then an extension plan should be developed and implemented.

Conclusions and Next Steps

Through this humanitarian effort, over 75 percent of the population of Colón, Honduras now has access to safe, clean drinking water and improved sanitation facilities. But of even more importance is the demonstration and development of a best standard practice to sustainably deliver safe water to millions of people around the world that are experiencing socio-economic water scarcity. This 4-phase methodology not only helps to guide the proper choice of technology to treat the local water problem, but also addresses the challenges of transforming the local cultural and economic paradigms of the affected community. At this stage of the project the incident rate of waterborne diseases has been reduced significantly, resulting in a huge win for the people of Colón.

As we move forward into the next phase of this study we plan to continue to monitor the sustainability of the project and examine the impact of this project on the productivity and economic growth of Colón.

For More Information
The Pentair Foundation is making its findings publicly available for other organizations and municipalities interested in replicating its cost-effective model to bring clean, safe water to people in need. This information may be found at www.projectsafewater.com.

About The Pentair Foundation
Established in 1998, The Pentair Foundation supports communities in which Pentair operates. The Foundation funds programs that promote education, sustainability in water and energy, and workforce readiness. Pentair dedicates two percent of its annual pre-tax income to charitable efforts. Over the years, The Pentair Foundation has directed more than $25 million to Pentair communities.

About Pentair, Inc.
Pentair (www.pentair.com) is a global diversified industrial company headquartered in Minneapolis, Minnesota. Its Water Group is a global leader in providing innovative products and systems used worldwide in the movement, treatment, storage and enjoyment of water. Pentair's Technical Products Group is a leader in the global enclosures and thermal management markets, designing and manufacturing thermal management products and standard, modified, and custom enclosures that protect sensitive electronics and the people that use them. With 2010 revenues of $3.0 billion, Pentair employs over 15,000 people worldwide.

About Water Missions International
Water Missions International is a nonprofit engineering organization serving the water and sanitation needs of people in developing countries and disaster areas. It uses low-maintenance, appropriate water technologies for drinking water treatment and distribution and wastewater management. Comprehensive community development programs have been designed and implemented to ensure the sustainability of the water projects. The organization has brought relief and hope to more than a million people across the globe.