mWater: Mobile technology for social water monitoring in low-resource settings

Implementation Plan

Phase I

United States Agency for International Development (USAID)

Development Innovation Ventures Program

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1. Introduction

Worldwide, waterborne disease represent the greatest risk to life for children, resulting in 10.6 million direct deaths per year and millions more indirect deaths through malnutrition caused by repeated infection[1]. Additionally, diarrheal disease directly causes an estimated 96 million disability adjusted life years (DALYs) and indirectly contributes to a staggering 145 million DALYs1. Through the Millennium Development Goals, the United Nations recognized the severity of this problem by creating a global goal to "halve the proportion of people without sustainable access to safe drinking-water and basic sanitation," by 2015. An unprecedented campaign ensued and over 1.2 billion people gained access to an improved water source between 1990 and 2010[2]. Earlier this year, that target was met, with 89 percent of the planet's population having achieved access to improved water sources2. Unfortunately, in these 20 years of successful water infrastructure building, the incidence of diarrheal disease declined by only about 15 percent[3]. It is now clear that geographic nearness of a water source is not enough to change health outcomes, but rather nearby improved water sources that are safe from contamination. Monitoring water sources for contamination is the last mile step in achieving the purpose of MDG 7, subtarget C: reducing child mortality due to diarrheal disease.

mWater creates innovative technology that enables low-income communities to monitor their own water supplies at a locally-sustainable cost. Building on the rapid growth of the mobile phone market in developing countries, mWater's monitoring system uses a mobile phone app to read low-cost water quality tests and instantly upload the results to the cloud, creating a mapped database accessible to healthcare workers, water managers, and the general public. In the past year the mWater suite of water tests and free mobile app have successfully completed rigorous scientific validation under field conditions, producing an integrated system that is now ready for an urban pilot. In this grant, funded by the United States Agency for International Development (USAID), mWater will work with local utility and public health partners in the city of Mwanza, Tanzania, to demonstrate cost-effective, locally managed water monitoring using mobile technology.

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1. Lopez, A. D., Mathers, C. D., Ezzati, M., Jamison, D. T. and Murray, C. J. L. (2006) Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. The Lancet, 367(9524), 1747-1757.

2. UNICEF/WHO (2012) *Progress on Drinking Water and Sanitation 2012 Update.*

3. Walker, C. L., Aryee, M. J., Boschi-Pinto, C. and Black, R. E. (2012) Estimating diarrhea mortality among young children in low and middle income countries. PLoS One, 7(1), e29151.

2. Project Objectives

The Phase 1 project design is grounded in the Development Innovation Ventures (DIV) goal of identifying innovative approaches to development that have the potential to scale to millions of beneficiaries worldwide within 10 years[4]. The purpose of Phase 1 is to build a water monitoring system at the scale of a large municipality by engaging the public health and utility sectors and identifying local distribution channels for supplies. The project will also include a social dimension by providing the public with access to information about nearby water sources and accepting comments and updates from the general public about the quality of service.

The project objectives, as defined in the Grant Agreement, are as follows:

1. Implement a mobile phone-based system for monitoring drinking water service and quality at the scale of a large city within a developing country.
2. Demonstrate that local ward health officers can perform effective water quality monitoring using low-cost tests.
3. Evaluate the effectiveness of providing quantitative water quality data to motivate behavior changes in households who have a choice of water sources.
4. Transition water quality monitoring to local authorities using local equipment distributors.

3. Beneficiaries

The primary beneficiaries for the project are the local health authorities at the ward (sub-municipal) level, utility workers and other organizations from the local water sector in Mwanza, Tanzania. These individuals are currently responsible for providing safe water and identifying populations at risk of water-related disease, and the project will increase their effectiveness by enabling quantitative assessments of water quality and santitary risk, which will be mapped and rapidly communicated to stakeholders and agencies with oversight authority.

The larger, secondary group of beneficiaries include all citizens of Mwanza, Tanzania. Results will be shared By adding users of so-called "dumb phones," the project will reach a much larger, economically diverse and local group of water users, sending them information about their own water source and suggesting alternative sources that are safer.

Finally, since the mWater app and database of water sources are open source and provided as a free service, anyone with access to a smartphone will benefit from the improvements made to the mWater software as a result of this project. Specifically, the expansion of mWater to include survey capabilities, improvements to the user interface and the ability to enroll SMS users are all

4. USAID (2012). FY2012 & FY2013 Development Innovation Ventures Annual Program Statement. APS# APS-OAA-12-000004.

new features that will be introduced as the result of the USAID DIV Phase I grant.

4. Partnerships

To achieve Objective 4, the transition to local control, a number of key partnerships are required with the Mwanza City government and utility sector. These critical relationships were established in 2012 during the joint mWater / UN HABITAT Validation Study, when mWater personnel worked alongside local ward-level health workers to obtain water samples for comparison tesing of the low cost methods that will be used in this project.

The critical partners and their expected roles and responsibilities are as follows:

- **Mwanza City Council Health Office.** Responsible for oversight of city-level community health workers and city-wide public health efforts.
- **Mwanza Urban Water and Sewerage Authority (MWUWASA).** Public water utility for the metropolitan area of Mwanza, responsible for needs definition, data gathering and system monitoring.
- **Local Ward office environmental or health officers.** Environmental health and public health field workers who operate from the local ward officers, responsible for data gathering and communication of results at the community level.

We will also seek to expand our partnerships beyond these critical groups, both at the municipal and national level, during the Phase I DIV project. This expanded list of partners may include local NGOs working water and sanitation, international NGOs operating in Mwanza, UN Habitat, UNICEF, the USAID Country Office, and the Lake Victoria Basin Commission.

5. Work Plan and Schedule

The project begins with a Preparation phase, when mWater will consult with project stakeholders and partners, purchase supplies and obtain necessary approvals. This is followed by a field implementation phase that begins with training the water testers, recruiting distributors for supplies and installing monitoring equipment. Monitoring and evaluation will be performed throughout the project, beginning with a baseline assessment followed by mid-term and final assessments, which are fully described in Section 7 below. The mid-term assessment will be an opportunity for learning and knowledge sharing with the primary and secondary beneficiaries and will guide any updates in procedures or software for the remainder of the project. At the conclusion of the project, local distributors will be capable of ordering supplies independently from mWater and local group administrators will have control over the management of all data generated.

The updated project schedule and milestones are shown in Gantt chart format below.

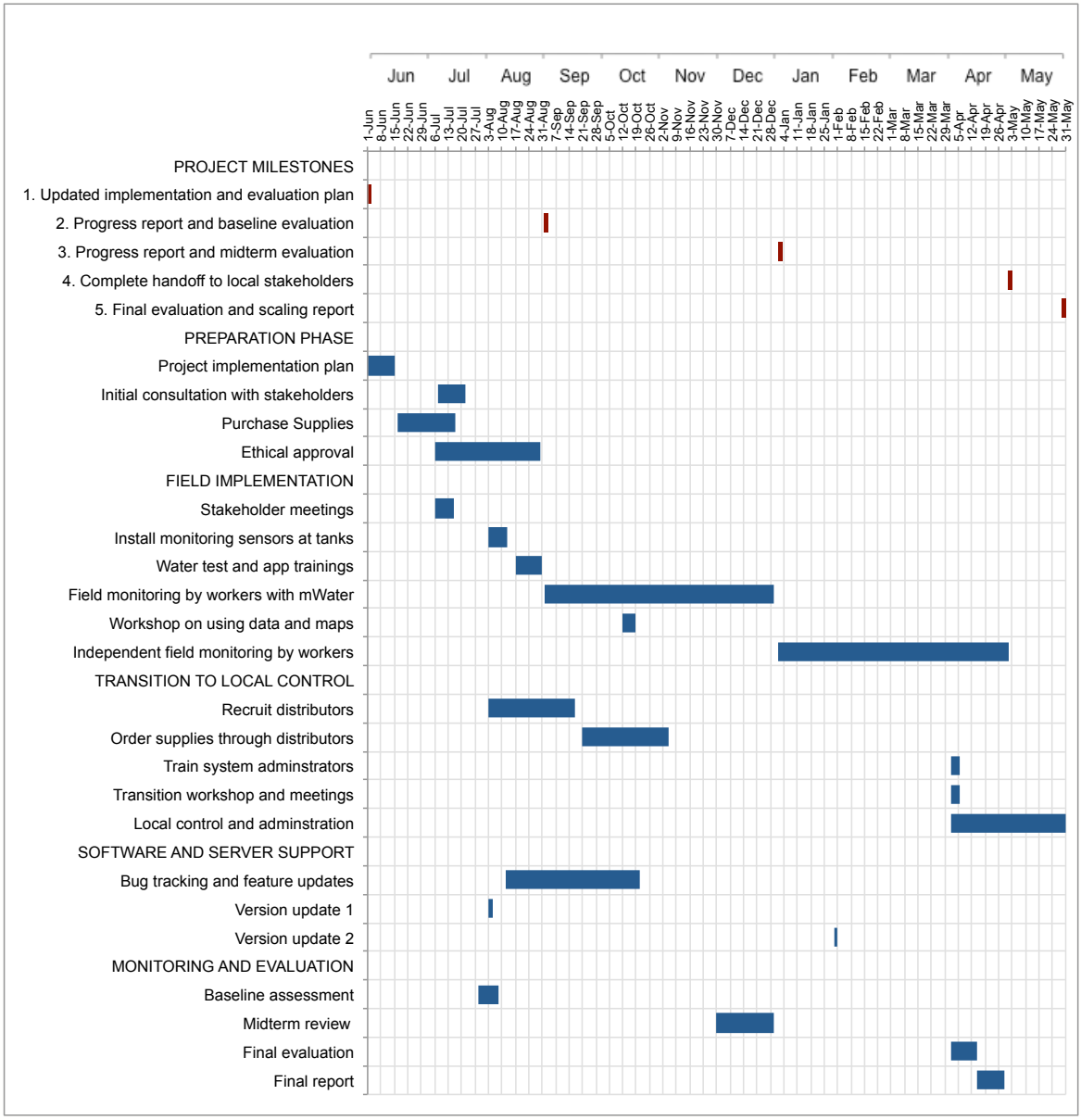

Figure 1: Project schedule and milestones in Gantt Chart format

6. Management Plan

6.1 Risk management

Project risks will be tracked and prioritized based on both the impact of the risk if it occurred and the probability of occurrence. Any risks identified that represent a significant threat to meeting the project objectives, milestone schedule or overall budget constraints will be communicated to USAID via reports provided on the dates identified in the Milestone Schedule. Mitigation plans will be developed for any risk that mWater determines is likely to result in a schedule impact of

more than 4 weeks, a cost overrun of greater than 10% or a failure to achieve one of the Project Objectives by the end of the period of performance.

6.2 Communications

mWater communicates with beneficiaries and the general public extensively through traditional media, print and social media channels. At the beginning of the project, printed program summaries will be distributed to partners and beneficiaries explaining the objectives of the project and the anticipated outcomes. Once the project is underway, information about water quality will be shared using brochures and signs at public places such as ward offices, schools, clinics and at water sources themselves. The health workers will also use the app to share test results, including photos of positive tests, with residents and provide information on safer water sources nearby. Finally, water quality results will be directly communicated with residents via SMS messages if they choose to enroll their phone number and water point identification number. In the event of poor water quality results, suggestions will be provided on safer sources or methods of household treatment.

In accordance with the Branding and Marking Plan, all printed project materials and test kits will include the USAID logo and brandmark with the tagline "from the American people." In all trainings and workshops held under this project, mWater will include display of the USAID logo and brandmark with the tagline “from the American people.” In the event that journal articles or reports are written about this project, mWater will include clear shared branding and acknowledgement of USAID funding.

6.3 Local capacity building and knowledge sharing

In accordance with Objective 4, a major ongoing goal of the management team will be to increase the capacity of both direct beneficiaries and other organizations within the Tanzanian water sector to independently monitor and update water data. Workshops will be conducted with health workers, utility workers and healthcare providers on how to perform water tests and use the mobile app. In addition, training materials will be provided to all local stakeholders within the water and health sectors as well as made freely available on the mWater website. All results from public water sources are immediately viewable by anyone with a computer or mobile device that has a modern web browser, providing unrestricted opportunities for education and real time response to problems. By default, anyone who can access the mWater website or install the mobile app can update the status of a water point. The utility and health workers enrolled in the project can choose to view only their own group's data when necessary, or view the entire croudsourced database to obtain direct feedback from the public. These groups will be the 'owners' of the sources they create and can administer them as they see fit (any app user is free to add new sources, but cannot modify the basic information of a source added by someone else). In addition, mWater has included an open-access Application Programming Interface (API) that allows other software programs to access and update the database, meaning that local programmers can develop their own applications to use this data.

6.4 Key Personnel

Dr. John Feighery, Co-founder and Chief Operational Officer of mWater, project lead

John Feighery is an environmental engineer and researcher with extensive experience in water quality, environmental microbiology, and groundwater hydrology with a focus on water and sanitation issues in developing countries. Dr. Feighery holds a BS in Mechanical Engineering and a PhD in Earth and Environmental Engineering from Columbia University.

Dr. Annie Feighery, Co-founder and CEO of mWater, training ond evaluation lead

Annie Feighery is a behavioral health scientist and expert in the application of emerging technologies to health in low-resource and crisis settings. Dr. Feighery holds a Masters of Public Administration in Environmental Science and Policy from Columbia University's School of lnternational and Public Affairs, a Masters of Education in lnternational Educational Development and a doctorate in Health and Behavior from Columbia University's Teachers College.

Clayton Grassick, Co-founder and Chief lnformation Officer, software development lead

Clayton Grassick is a software architect with specialized skills in scalable database and server design, rapid application development, and image processing. Mr. Grassick holds a BASc in Computer Engineering from the University of Waterloo.

Interns, to be recruited

Intern 1 will be a local Mwanza resident and will be responsible for establishing early communications with key stakeholders, maintaining communication with local participants, translating messages and the app interface into Kiswahili, and making appointments for stakeholder meetings and evaluations. Intern 2 will assist with Monitoring and Evaluation activities, external communications and documenting the project through blog postings and social media.

7. Monitoring and Evaluation Plan

The monitoring and evaluation effort is designed to determine how the mWater water test and mobile phone reporting technology was used, in order to answer the key research question: can a large city in a developing country setting have an effective water monitoring system at an affordable cost? The monitoring and evaluation effort, particularly the midterm evaluation, is designed to identify challenges and opportunities for improvement. Where improvements to the monitoring approach, user interface, citizen engagement or intersectoral communication can be identified, changes will be made midway through the project and these lessons will be captured in the final evaluation.

7.1 Quantitative methodology

mWater has built into its technology a system of ongoing program monitoring based on digital metadata, including website visits over time, tallies of individual water source queries and geographic saturation of users' site visits over time, as informed by internet protocol (IP) addresses tracked through Google Analytics Beta. Also, mWater's mobile app contains a notes function

that allows for constant feedback and bug tracking by the user population. New sources and tests added by field workers are tracked by date, location and username.

According to the project budget, mWater will provide participants with an initial supply of 2000 test kits for the initial 4-month mWater-supported testing phase. A total of 25 workers will receive test kits and mobile smartphones; therefore, each worker will be encouraged to perform 20 water tests per month during the supported phase. It is anticipated that the rate of testing will vary depending the motivation, aptitude and resources of the worker. Following the supported phase and again after the independent testing phase, the key outcome variables of samples per week and site visits to water sources within each ward will be modeled using logistic regression against variables from a baseline survey completed by the participants that will assess their desire to participate, level of expertise with mobile technology, and resources devoted to environmental health. This will help identify key training and organizational issues that must be addressed in scaling up and sustaining the intervention.

7.2 Qualitative methodology

mWater will begin this project with a baseline evaluation of Mwanza's water sector, establishing the existing capacity for monitoring water sources and intersectoral communication within the city. This will be conducted through a literature search of the most recent studies available and through interviews of stakeholders, including: USAID district managers, UN regional managers, Mwanza Urban Water and Sewerage Authority managers, Local NGO leaders, City-wide public health officers, Ward-based health workers, Hospital- and clinic-based physicians.

The qualitative interviews will inform the adaptation of the implementation plan with locally-relevant priorities and values. Interviews will be guided by the following questions:

- What are the most important issues Mwanza faces when it comes to water monitoring?
- Who represents leadership in the Mwanza water and health community?
- Where do you think outages are most common?
- What parts of the city have the worst problems with water quality?
- Do you generally know when your water is safe or not?

Project impact will be assessed during midterm and final evaluations using a mixed methods approach based on semi-structured qualitative interviews that have been coded for quantitative evaluation[5]. The purpose of this assessment is to determine the knowledge, attitudes and behaviors that individuals attribute to community-level changes resulting from the project. Interviews will be semi-structured, guided with open questions and exhaustive answers in order to protect findings from recall bias. At the conclusion of each location's interviews, the field assistants and mWater staff will work together to translate the answers into English. mWater staff will then

5. Bolton, P., J. Bass, L. Murray, K. Lee, W. Weiss, and S. M. McDonnell (2007), Expanding the scope of humanitarian program evaluation, *Prehospital and Disaster Medicine*, 22(5), 390.

code the results by frequency and depth. The result is a mixed-method, detail-rich measure of positive and negative perceptions of the intervention at the community level. This approach is uniquely designed to provide knowledge on a topic that often belies successful health promotion, but is seldom observed: how community members perceive the intervention innovation. The assessment questions measure what results, positive and negative, the community members perceive to be a direct result of the intervention.

Respondents will be identified using a quota-based snowball method, wherein additional respondents are identified until the quota for each group is reached. The respondents in the sampling frame will include: upper management in Mwanza City and MWAUWASA administration; field workers representing the Mwanza City Health Office and MWAUWASA; community leaders representing faith-based groups, schools and health clinics; and MWAUWASA water users at the individual and household level.

7.3 Impacts on water users

Phase I is necessarily focused on determining effective strategies for achieving a monitored water supply, but will also include many opportunities for local citizens to obtain water quality data, as described in the Communications section. In order to capture the project impacts on average citizens, water users will be included in the qualitative evaluations. The responses from water users will be used to design a scaled up intervention for Phase II that directly engages citizens through interactive text messaging to generate demand for safe water and help people identify safer water sources.

8. Strategy for scaling up

mWater seeks to create transformative technology and innovative programming that has the potential to improve the effectiveness of a wide range of WASH services by gathering real time data on water and sanitation via mobile phones, merging this with real-time health data and empowering individuals to seek change within their households and local communities. The premise of efforts to scale up the mWater approach is that families value child health and survival and will be motivated to change their behaviors to support child health and survival if information can be made available to them in a way that inspires change.

Having demonstrated that the municipality and water managers can maintain a database of water sources and their quality during Phase I, scale up in Phase II seeks to build on this to create an interactive citizen engagement network that empowers citizens to make the safest water choices everyday. Water source choices depend on daily changing variables that include the cost of water at kiosks, the working condition of taps and the sanitary environment around wells. Using SMS relay, feature and smartphone networks and free and open-source online maps, the water database established in Phase I will be scaled up to an information network about water. This will drive demand generation for safe water, as opposed to numerous prior approaches that involve supplying households with water treatment supplies or equipment and encouraging their use.

Appendix A: Schedule of Milestones

Milestone	Estimated Completion Day	Deliverable	Amount
1	Start date + 14 days	This milestone requirement is considered fulfilled when the following actions have occurred and the deliverables and/or associated narrative have been submitted to the AOR for review/concurrence • Updated implementation plan, including a Gantt chart. The plan should also discuss plans to assess the feasibility of scaling beyond Mwanza after this project, and/or to engage stakeholders in other target communities. • Updated evaluation plan, including detailed plans for the baseline assessment. The plan should also include targets for the number and frequency of tests, which will inform the end-line evaluation. These targets may be revised after implementation.	25%

2	Start date + 3 months	This milestone requirement is considered fulfilled when the following actions have occurred and the deliverables and/or associated narrative have been submitted to the AOR for review/concurrence. • Provide a brief report summarizing progress to date, including challenges identified and strategies to overcome them. The report should discuss progress recruit local distributors, issues regarding import duties and restrictions, and progress obtaining buy-in from local stakeholders. It should also describe the desired characteristics of local distributors. • Conduct a baseline assessment for the evaluation of Mwanza's water monitoring capacity and inter-sectorial communications. The assessment should draw on a review of any available literature and qualitative interviews with local stakeholders. The report s should describe the assessment process and report any available findings. The report should also discuss results from the survey regarding desire to participate, expertise with mobile technology, and resources devoted to environmental health. • Conduct stakeholder meetings • Purchase supplies • Obtain ethics approval • Conduct water test and app trainings • Complete installation at water plant and take sites	25%
3	Start date + 7 months	This milestone requirement is considered fulfilled when the following actions have occurred and the deliverables and/or associated narrative have been submitted to the AOR for review/concurrence. • Provide a brief report summarizing progress to date, including challenges identified and strategies to overcome them. The report should discuss progress recruit local distributors, issues regarding import duties and restrictions, and progress obtaining buy-in from local stakeholders. • Submit the midterm evaluation report. The report should assess the effectiveness of the approach at the individual, health worker, and water management levels, using mixed methods including qualitative semi-structured interviews.	25%

4	Start date + 11 months	This milestone requirement is considered fulfilled when the following actions have occurred and the deliverables and/or associated narrative have been submitted to the AOR for review/concurrence.
		• Conduct bug tracking and software updates.
		• Complete handoff to local stakeholders, including:
		  ○ Reach agreements with and order supplies through local distributors.
		  ○ Train systems administrator, health officers, and water utility workers. Hold transition workshops and meetings.
		Submit the midterm evaluation report. The report should assess the effectiveness of the approach at the individual, health worker, and water management levels, using mixed methods including qualitative semi-structured interviews.
			25%

5	Award closing + 90 days	This milestone requirement is considered fulfilled when the following actions have occurred and the deliverables and/or associated narrative have been submitted to the AOR for review/concurrence. • Deliver a final evaluation (including lessons for project improvement) and scaling report, addressing: **Impact evaluation**: The report should incorporate information from the mid-term evaluation, to serve as a stand-alone report. It should include: • A discussion of efficacy of the Mwanza project, including users' perceptions of changes. The qualitative portion will draw on semi-structured interviews from stakeholders (including community leaders, health workers, healthcare providers, water utility workers and government officials). • A discussion of the sustainability of the program under local control, including an assessment of how successfully local distributors are handling resupply.	

		• An analysis of quantitative data gathered on the usage and uptake of the app and website and qualitative interviews to evaluate project impacts, motivations of the users and beneficiaries, and local water quality concerns. For the quantitative portion, key outcome variables of samples per week and site visits to water sources within each ward should be modeled using logistic regression against variables from a baseline survey. The report should also discuss the extent to which local authorities appear to be drawing on the information to improve water quality. **Project improvement:** The report should assess the success to date, lessons learned and action steps regarding improving the software; better mechanisms for engaging the local community, utility workers and health officers; better strategies for collecting and presenting water data; obstacles to responsiveness and problem resolution; and improved approaches for local sourcing and resupply of water test kits, and other key lessons. **Cost-effectiveness:** The report should include an update on the competitive landscape, and on the extent to which the project is (or has the potential to be) more cost-effective than competing alternatives. This includes assessing the unit cost of the intervention, and projecting the cost per development outcome. Provide a breakdown of all sources of revenue (including from other public funders). Additional information about the format may be provided by the AOR. **Scaling:** If the project is successful enough to merit ongoing efforts, the report should provide an update on anticipated demand for the product (locally and globally) and prospects for financial sustainability (e.g. support from local or donor governments). The report should assess the potential for successful results to continue at scale given cost and quality issues. It should also discuss progress to date engaging stakeholders, and planned next steps regarding scaling. This includes plans to engage stakeholders and encourage local governments to act on the information generated by mWater in order to improve water quality. The report should include lessons from the pilot about scaling, including regarding the local water authority's 1) interest and ability to implement the program 2) interest and ability to draw on this data to improve water quality.	

mWater Mobile technology for social water monitoring in low-resource settings

Milestone 2 Report

October 2013

United States Agency for International Development (USAID)

Development Innovation Ventures Program

Summary of progress to date

mWater began field implementation of the Development Innovation Ventures Phase I project in June 2013, with field operations in Mwanza, Tanzania, commencing in July. The project is on schedule and on budget, with major accomplishments for this period that include registration as a local NGO, release of an update to the mWater app to allow mobile surveys, training and equipping of 25 water utility and public health workers to perform water quality testing and a baseline assessment of water users and the water and health sectors in Mwanza. Progress was also made on identifying a supply chain for water test supplies through the local Lake Victoria Basin Water Lab. Minor challenges were encountered in obtaining adequate mobile phone supplies and a source for the 100 mL test reagent, but effective solutions were implemented. In response to difficulties in obtaining level sensors for the large water supply tanks serving customers in the project area, mWater has implemented an alternative approach wherein the sensors will be built using open-source hardware for a much lower cost per unit, which will be beneficial to this project and freely shared with other water utilities as a lower cost alternative to current solutions.

The baseline survey of 112 water users found that people in the peri-urban areas of the Mwanza study generally choose from 2 to 3 water sources for their daily needs and consider contaminated water to be a significant health concern. Water users also identified economic impacts from missed work due to illness or caring for a sick child to be major concerns. Availability and reliability of water from both the piped network and point sources were major problems encountered by people, forcing them to use less safe sources at times.

mWater is currently monitoring the frequency of tests and other uses of the mWater app by project participants throughout this initial baseline implementation stage. The local mWater project director is available to provide support to the participants upon request and maintain smartphones and data packages. After data is analyzed from the midterm assessment, to be conducted in January 2014, obstacles will be identified and specific mechanisms to increase participation will be implemented and tested during the final phase between February and May 2014.

Major accomplishments

- Hired local project director
- Obtained agreements with the Mwanza City Council Public Health Office and the Mwanza Urban Water and Sewerage Authority to implement the 9-month demonstration project
- Released mWater App version 3.0 with surveys and improved user interface
- Purchased water test supplies, mobile smartphones and hired local staff
- Completed training of 23 participants in water quality testing and use of the mWater app

- Registered mWater as a NGO in Tanzania
- Submitted ethical approval application
- Completed baseline survey of stakeholders and water users in Mwanza

Progress on key objectives for Milestone 2

Hired local project director

Upon receipt of stage 1 project funds, mWater recruited and hired an individual from Mwanza to serve as the local project direct. Amandus Mashamba had previously worked for mWater as an intern during his university education. Mr. Mashamba graduated in June 2013 with a bachelor degree in education, with an emphasis in business. Mr. Mashamba has a firm understanding of the stakeholders involved in Mwanza health and water. In addition, during his tenure as an intern, Mr. Mashamba became knowledgeable about mWater's technology, smartphone apps, and emerging water monitoring issues. mWater secured an office for Mr. Mashamba that provides a consistent source of electricity and internet.

Obtaining buy-in from local stakeholders

Stakeholder discussions were held with high level officials from all the organizations involved in the project and in general the reaction to the project was strongly positive among decision makers in each organization. On more than one occasion, a stakeholder mentioned that they were proud that Mwanza was chosen as the project site and believed that it would serve as an example to be emulated in other parts of the country. Specific stakeholders included:

- City Director
- City Engineer, responsible for water supply works in the city
- City Public Health Director, responsible for community health and environmental health workers
- MWAUWASA Managing Director, the government mandated water supply utility
- MWAUWASA Assistant Director for Water Quality
- Lake Victoria Basin Water Laboratory Director

Prior to beginning the baseline assessment of water users and health workers, presentations about the project were made individually to the above stakeholders and a letter of approval was signed by the City Engineer. In these meetings, city officials requested that the project focus on two wards, Igoma and Mkolani, with total populations of 56,350 and 32,119, respectively. These wards were selected because they contain a wide variety of water sources and both urban and peri-urban neighborhoods. The stakeholders also determined the composition of the group of project participants who would receive supplies and training. This degree of local leadership and support was the result of nearly 4 weeks of consultation with stakeholders, adapting the project to meet local concerns and priorities.

mWater App upgrades

The mWater app has undergone an entire software development cycle since initiating our work in Mwanza. The app is no longer in the Beta stage and has been formally rolled out to the public, still free of charge. Since beginning this program, mWater has introduced the following improvements to the app:

- Surveys: the app now includes a flexible survey utility that can work in offline mode. The utility was created with health workers in mind as the end user. Its features include common survey question types, conditional questions, GPS capabilities, and voice dictation.
- Privacy: water sources and surveys can be labeled private to protect individuals when the information is sensitive. Sensitive information may include household water sources or water sources that have a stigma-inducing quality.
- Groups: users can now see and edit data that were created by other members of their group and surveys can be pushed to groups of users at a time.
- Offline performance: the app now keeps a list of nearby sources available when offline and synchronizes the list with the server once a data connection becomes available again.
- Multiple platform compatibility: the app now works on any model of smartphone or tablet. This has been achieved by re-writing the software in HTML5, which means the app now runs in the browser window at the URL http://app.mwater.co. mWater is still available as a native Android application, accessible through the Google Play Store.
- Database upgrade: mWater database has been upgraded to the latest modern database technology, a NoSQL database that makes it easier to add new fields to water sources for different groups without re-writing the app.
- Background software upgrade: users no longer need to visit the app store for upgrading the app. New generations of mWater are now seamlessly upgraded in the background on an ongoing basis. This usability feature makes it easier for individuals new to smartphone apps to continue using mWater as updates and upgrades become available.

Import duties and restrictions

A small scale test of the delivery of water test supplies to Tanzania was completed in July when mWater purchased an initial supply of 1000 Compact Dry EC Plates from Hyserv, based in Germany. Delivery was made via DHL from Germany and transferred to Tanzanian Post and held for pickup at the local post office in Mwanza. The process took less than 2 weeks but the duty applied was 25% of the declared value plus 18% value added tax, which was applied after the addition of the import duty. This import process results in a 47% total markup on all supplies, which puts the goal of low-cost water test kits further out of reach for local organizations in Tanzania.

Recruitment of local distributor for test supplies

The options under consideration for recruiting a local distributor for test supplies include a local business with a tangential connection to water quality, such as a pool supply company or scientific equipment supplier; the water utility itself or local non-profit organizations. As illustrated by the challenges encountered in purchasing smartphone units, discussed below, the import market for many manufactured consumer goods in Tanzania is dominated by small-scale traders who lack access to traditional lines of credit with manufactures, instead paying cash up front at trading hubs such as Dubai or Hong Kong. Thus, most small business owners in Tanzania prefer to trade in items with a reliable demand that can be purchased and brought into the country in small lots under various arrangements with customs officials. Due to the extremely high duties imposed on water test components, which amount to 47% of the assessed value, recruiting a local for-profit import company or entrepreneur is not feasible for Phase 1 of this project or until significant local demand is created for the supplies.

Discussions with the water utility MWAUWASA revealed that although they enjoy a duty-free status on certain equipment, this status only applies to construction supplies such as pipes or building materials. Therefore, having ruled out a local business and the water utility, the remaining possibility was to purchase through a non-profit organization. We evaluated two options: (1) purchasing on an ongoing basis through mWater itself -- now a registered national NGO in Tanzania – or, (2) a local partner organization. Since mWater's business model is to develop local capacity rather than build a dependence on international experts and aid, we chose the latter option. Through stakeholder discussions, we learned that the Lake Victoria Basin Water Laboratory, one of the regional laboratories in Tanzania managed by the Ministry of Water, held duty-free status on imports of water testing supplies. The Lab is willing to receive supplies on behalf of mWater and MWAUWASA for water quality testing and is a participant in the mWater Mwanza project. Future supplies for the next phase of the project will be delivered to the lab and the results will be discussed in the Milestone 3 report.

Challenges identified and mitigation strategies

Increase in sensor costs

The Project Implementation Plan includes a small budget ($2500) reserved for experimenting with emerging low-cost sensors that transmit data via mobile data connections. Unfortunately, upon inquiring about purchasing the water level sensors proposed for installation in several of the remote tanks that store piped water for residents far from the treatment plant, we learned that no current manufacturing runs were planned and a large minimum purchase of at least 50 units would be required. In response to this challenge, we reached out to a local

group of open-source hardware designers in New York who will integrate a commercially available ultrasonic level sensor with a mobile-enabled arduino microprocessor. This approach can provide several prototype units within the available budget and has the added advantage of testing out an open-source approach that could significantly reduce the costs of these sensors for financial strained water utilities and governments in developing countries.

Supplies for 100 mL test

A key innovation in the mWater test kit is the use of a simple color-change test for *E. coli* detection at the 100 mL volume required by the WHO that does not require the use of a UV light or incubation at elevated temperature. The reagent used in these tests was originally sourced from HiMedia Labs in India, based on the favorable results with this reagent during UN HABITAT-sponsored validity testing in 2012. Since that time, HiMedia Labs became the supplier for the new commercial version of the Compartment Bag Test (CBT), which was developed at the University of North Carolina and later spun off into a new company called Aquagenx. HiMedia initially indicated that the reagent was now only available through Aquagenx in the form of the CBT product; however, the price and complexity of the CBT exceeds the requirements for the Mwanza study. mWater engaged the assistance of a business consultant who works frequently in India at a reduced pro-bono rate to negotiate directly with HiMedia Labs. The result was an agreement to sell the reagent itself directly to mWater, but the price is approximately 50% higher than previous purchases. A market analysis revealed that there are no alternatives at the present time to this product that also meet the required simplicity (no UV light required) and demonstrated validity in a controlled scientific study. The unexpected price increase will result in a 25% reduction in available samples per month.

Smartphone supplies in Tanzania

mWater initially identified the Huawei Y300 as the ideal smartphone for using the mWater app in Tanzania. The Y300 has an adequate quality camera for performing the bacteria counting procedure, yet could still be purchased for USD 125. The project required 25 phones. Over the course of a month, 25 Y300s were not able to be procured in Mwanza, Dar es Salaam, or Nairobi. mWater then identified the Intel Yolo as a possible replacement and quickly purchased one for field testing. This phone has not yet been introduced to the market in Tanzania, so the phone was sourced in Nairobi.

The difficulty of purchasing 25 smartphones in Tanzania was unexpected. This difficulty is due to the overwhelming popularity of smartphones and the lack of distribution systems for smartphones through the major mobile network operators.

Baseline assessment of Mwanza water monitoring capacity

mWater conducted baselines assessments of three main populations:

- Water stakeholders in Mwanza
- Water end-users for both municipal water and private water sources
- Health professionals, including health care providers and health workers

Stakeholder interviews

mWater staff met individually or in small groups with a number of senior officials representing the MWUAWASA and the City of Mwanza. Individuals were generally eager to talk about their priorities for water in this region. Stakeholder interviews were conversational, guided by the following goals:

- Understand the local priorities for safe water
- Understand what problems are currently being addressed and what problems are perceived as beyond local capacity for resolving
- Engage stakeholders as partners in this initiative

The following individuals took part in stakeholder interviews:

- Mwanza City Director - Mr. Hida H. Halifa
- Mwanza Acting City Engineer (water) - Eng. Stanslaus Buluba
- Mwanza City Development Officer - Samwel Juma
- Mwanza City Health Officer - Mr. Danford Kamenya
- MWAUWASA Public Relations Manager - Mr. Robert Masunya
- MWAUWASA Assistant Manager Quality Control - Eng. Gogadi Mgwatu
- Tanzania Ministry of Health representative - Dr. Elias Chinamo, Deputy Director, Ministry of Health and Social Welfare
- Tanzania Ministry of Water representative - Ms. Chanzi Hamidar, Assistant Director, Division of Water Quality Services
- Tanzania Ministry of Water representative - Ms. Nadhifa Kemikimba, Director, Division of Water Quality Services
- World Bank - Mr. Kristoffer Welsien, Country Officer
- UNICEF - Dr. Paul Edwards, Deputy Representative, Tanzania Country Office

Water managers

Water managers in Mwanza were consulted through informal interviews that included the Managing Director, Assistant Director for Water Quality, Assistant Director for Public Relations and the City Water Engineer. MWAUWASA is perceived in Tanzania as a high-performing organization, both by employees and many stakeholders, that is faced with challenges related to purchasing supplies, non-revenue water (lost or unaccounted for water) and increasing capacity for water supply and sewage treatment. The rapid growth of Mwanza as a center for business and trade has increased both the population needing water supplies and the demand for higher levels of service for the rapidly growing middle class. The entire local water sector is enthusiastic about incorporating technology into their work and

most individuals expressed a desire to be seen as a leader and innovator in the water supply sector.

Regular water quality monitoring is performed both at the Capri Point central treatment plant and at the satellite tanks that pressurize the distribution network for outlying areas. The greatest challenges associated with water quality are the cost of supplies for testing and drinking water treatment, transportation costs due to high fuel and vehicle maintenance costs, difficulty in purchasing laboratory supplies and the lack of public awareness that piped water is superior to other local sources and worth the cost. Following the previous training in low-cost water quality testing by UN HABITAT in 2010, MWAUWASA attempted to purchase the Petrifilms and other supplies used in the training but encountered two obstacles that prevented successfully obtaining them. First, the local scientific equipment distributors could not order the supplies since they were not licensed distributors of the US-based manufacturer. When MWAUWASA attempted to order directly from the manufacturer, they encountered a bureaucratic hurdle that governments in many countries often face. In order to prevent corruption, a public utility is required to obtain at least three competitive bids when purchasing supplies from a manufacturer. However, in the world of water quality this is very difficult because validation testing is performed on specific product lines and the ingredients for these products are usually proprietary. Therefore, it is generally impossible to substitute a major supply such as reagent because using a different supplier would require a costly re-certification effort involving extensive laboratory testing.

According to the most recent MWAUWASA Business Plan[1], the most pressing business challenge for the utility is the high level of non-revenue water, which is estimated to be as high as approximately 40% of overall production. The causes of non-revenue water include physical losses due to leaks and commercial losses caused by failed metering systems, meter-tampering and illegal connections. A Dutch firm, Dunea, is partnering with MWAUWASA using European Investment Bank funding to perform system modeling that will lead to better identification of physical losses. Methods for reducing commercial losses is a significant area of interest and a potential opportunity for mobile technology to play a role, by providing a tool for non-revenue water inspectors or meter readers to report problems and follow up on repairs. mWater is investigating how the mobile app can be configured using custom surveys for this purpose.

Public health sector

A major concern regarding water quality that was expressed by both MWAUWASA and city officials is inadequate service provision in the peri-urban areas surrounding Mwanza that have experienced rapid population growth in recent years. MWAUWASA has a mandate to provide water at a nominal fee to poor residents who cannot afford a household connection through a system of public water Kiosks throughout the city. However, the reality is that in many of

[1] WATER, MWANZA URBAN, and SEWERAGE AUTHORITY. "Business Plan." (2001).

these areas the distance from the home to a Kiosk is too great, or the availability of water at the Kiosk is not reliable due to their distance from tanks and pumping stations. In these areas, the City Health Department has a program administered through community health workers to promote good water, sanitation and hygiene practices in the household and perform shock treatment of contaminated wells[2], which typically become highly polluted in the rainy season. Although wells used for drinking water are required to be tested by the regional Lake Victoria Water Laboratory, in reality the testing is rarely performed due to the high cost of testing (over USD 100) compared to the cost of constructing the well. Therefore, most residents who do not use MWAUWASA-provided water are drinking from unmonitored supplies.

mWater met with the Mwanza City Public Health Officer, Mr. Danford Kamenya. Because Mr. Kamenya oversees the health worker program for all of the city's districts, he is among the most critical voices. Mr. Kamenya was energetic with his support and eager to see results at each stage, including the baseline assessment. He assisted mWater staff with identifying the ideal districts in which the pilot would be conducted--two districts with a range of population over urban, peri-urban, and rural communities; and who use a range of city and private water sources. Mr. Kamenya also provided a letter of introduction that facilitated the baseline assessment interviews in hospitals, clinics, health worker posts, and communities.

National water sector

mWater met with several officials involved in the national water sector during a trip to Dar es Salaam in August 2013, including representatives from the Ministry of Water, Ministry of Health, private consultants, UNICEF and the World Bank. Tanzania is not on track to achieve the Millennium Development Goal targets for water or sanitation in spite of a quadrupling of funding since 2002 and the adoption of a Sector-wide Approach (SWAP) to improve coordination[3]. Much of the recent focus of the Ministry of Water has been with the Big Results Now initiative, which is intended to support the national vision of becoming a middle developed country by 2025[4]. Current water sector development efforts have focused on mapping rural water sources, increasing performance of urban water utilities and establishing the quality of rural water sources.

The activities of the Ministry of Water reflects its institutional structure, which is split into rural and urban divisions. Rural water supply is focused on point sources in villages and towns, and urban water supply has an emphasis on improving utility management and supply. As a first step toward bringing rural water supplies into a management framework, Tanzania

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[2] Shock chlorination, essentially adding chlorine bleach to the well, is a common practice but the available research suggests that this is ineffective at reducing microbiology contamination, see Luby, S, Md S Islam, and R Johnston. "Chlorine spot treatment of flooded tube wells, an efficacy trial." *Journal of applied microbiology* 100.5 (2006): 1154-1158.

[3] "Water Supply and Sanitation in Tanzania: Turning Finance Into Services for 2015 and Beyond" WSP. 2012. <http://www.wsp.org/sites/wsp.org/files/publications/CSO-Tanzania.pdf>

[4] "BIG RESULTS NOW - BRN | PMORALG TANZANIA." 2013. <http://www.pmoralg.go.tz/quick-menu/brn/>

recently completed an exhaustive national inventory of rural water points. The water point data was collected by trained enumerators using custom surveys loaded onto handheld GPS devices and integrated into a web-accessible database[5] by Geodata Consultants, Ltd. There is a desire on the part of the Ministry and the government to keep centralized management authority over this data for the sake of validity. However, it was also noted by several stakeholders that a mechanism does not currently exist to keep this data updated with reports from the field, particularly regarding the functional status of mapped water points. Additional water quality data is also desired, since the initial mapping effort was limited to inorganic parameters such as fluoride because the samples could be returned from the field and analyzed days or weeks later in the regional basin laboratories. Surveyors also recorded users perceptions of water quality such as taste, odor and appearance.

The Division of Water Quality Services expressed strong interest in the field test methods that mWater is currently demonstrating, particularly for the purpose of collecting water quality data in the rural areas where samples could not be returned to labs within the 6 hours required for microbiological analysis. There is also strong interest in improved field methods for measuring fluoride, a contaminant commonly found at high levels throughout the African Rift Valley. The next steps toward scaling up field water quality monitoring would be to plan a demonstration of the mWater approach in a rural district with involvement from the Ministry of Water, the District Water Engineer and the Division of Water Quality Services. The World Bank, which helped fund the initial water point inventory effort, might also be able to provide sector coordination for such a program.

Baseline assessment of water users

Two teams of two survey-takers, one of whom was fluent in Swahili, were sent to the districts in which the mWater pilot will take place. Water users were initially identified through recommendations by environmental health officers, however, it was noticed within the first two days of surveys that these users tended to be males with household staff. The survey enumerators adjusted to identifying people collecting water themselves, typically at a kiosk or water source. They would then utilize the snowball methodology with the prompt, "Who do you recommend I also talk to about this?"

In total, over two weeks, 112 individuals took part. All were located in their neighborhoods or at the location of a water source they frequent. Survey questions were modeled after a rapid assessment model. The survey comprised semi-structured interview questions modeled to assess current values and opinions that impact water choices in this community. The questions were conducted with an exhaustive design, meaning the surveyer continued with the prompt, "Can you tell me more?" until the participant said there is nothing more to say. Results were coded by the freelisting methodology, in which issues or specific answers given by participants were listed by coders, then rated in terms of the frequency with which they arose. This method allows coders to identify the most typical, or common feelings, concerns,

[5] Water point data is available from the Ministry of Water at: <http://www.maji.go.tz/>

and problems shared by community members. The issues that had the highest score were further investigated for sub-issues that could help provide an understanding of the participant's specific perspectives. The following is a summary of significant results.

112 individuals were asked the exhaustive question **"In general, do you think for your community, contaminated water is a health problem."**
Of the 112 responses to the mWater qualitative survey on health problems caused by contaminated water, 87 reported stomach problems. Top level reports within stomach problems included diarrhea (42), typhoid (30), worms (21), general abdominal pain (21), and bilharzia (16). Other reports included amoeba (12), cholera (7) and vomiting (4). 5 mentioned risk of death and others (3) talked about overall weakness, malaria (3) and cough or fever (5). After the general report of stomach problems, the specific diseases were segregated so the researchers could note the specific numbers of each illness reported.

When people become sick from unsafe water, many reported fiscal tolls: they cannot work and there is a general loss of productivity. Also discussed was the expense of medication and doctor visits. Parents raised the issue of lost wages when they have to stop working to take a sick child to the doctor.

20 participants discussed the skin problems related to bathing in contaminated water including rashes and acne. Shortage of water can increase chance of unsafe choices including fetching water from shallow wells (which are contaminated) or quarreling on a long line or over the limited supply. Walking a long distance to gather water may not be safe.

8 of the 112 participants discussed the risks contaminated water posed to children. Children can acquire waterborne diseases by playing in the water, drinking it or getting it on their hands.

23 of the 112 participants talked about the numerous and variable ways water can get contaminated. Many reported bacteria (7), rainfall (3), proximity of the animals to water (2) and human excretion (3). Others (3) said water from Lake Victoria is dirty. Water can also become contaminated when pipes break or by dirty pipes. Keeping water in containers that are not properly sanitized can also cause contamination.

Participants were asked: **"How do safe water sources benefit your community?"**
Of the 112 participants, 81 water users reported numerous benefits of safe water including confidence and no fear of disease (25), good health (61), prevention of disease (61), productivity and economic gain (14) and saving money by not spending on medications or doctor's visits (8). Survey coders grouped the sub-benefits of safe water under the greater umbrella of general acknowledgement that safe water brings an array of benefits. Prevention of disease through use of clean water was acknowledged differently than the general emotions of confidence and lack of fear that comes with knowing that the water one is using is safe.

A second major category noted were the many uses of safe water. 30 noted that safe water was extremely useful. Sub-categories are the ways safe water can be used. These include: drinking (20), cooking (16), bathing (10), doing laundry (8), house cleaning (2) and preparing fruits and vegetables (2). The researchers separated cooking and preparing fruits and vegetables into two separate categories because the water users interviewed differentiated between generally cooking with unsafe water as compared to specifically washing a fruit or vegetable with contaminated water and then eating it directly.

Discussion of results. The results indicate that the participants are well aware of the connection between safe water and health. Safe water and the good health it can entail is also important to these individuals for economic reasons. Suffering from diarrheal disease and other waterborne diseases was associated with loss of income from work, both from first-hand illness, but also from sick children who required a parent to take time off work for care and doctor visits. Participants are also aware of the environmental risks to maintaining safe water sources. When asked what makes water unsafe, the most frequently raised answer was bacteria.

Baseline assessment of health professionals

30 health care providers, including doctors, nurses, midwives, and health workers were interviewed at their place of work which included a hospital and multiple healthy centers and clinics. Surveyors were directed to locations by the city public health officer, who also provided a letter of introduction.

The survey comprised semi-structured, open-ended questions and participants were prompted with the question, "Can you tell me more?" until the participants indicated they were finished talking about this subject. This methodology helps overcome recall bias by the most immediate memories that come to mind.

The single most common response to the question: **"Is diarrheal disease a problem for your patients and you community? If so, how?"** was an unequivocal yes (27) and three with reservations saying it was a problem, but not a big problem. The most common way that diarrheal disease impacts the community is sickness. 19 participants identified sickness as the way diarrheal disease impacts their community, providing examples that include bilharzia, diarrhea, typhoid and malaria. One participant, a nurse midwife, further explained that "most mothers do not know how to attend to children with diarrheal disease, and this might cause them to spread it to other people."

Participants identified mechanisms for causing sickness including drinking, preparing food, using dirty utensils, not washing hands, a shortage of clean water sources and no available toilets.

Finally, diarrheal disease was perceived to cause the following impacts to the community: missing work/lost productivity, medical bills, weakness, dehydration and death. One participant, a nurse, specifically mentioned the issue of co-morbidity saying, "diarrheal disease might cause a person to have a low immunity against infections, making that person vulnerable to other diseases."

All healthcare providers were asked "What are the symptoms of diarrheal disease that you observe?" The most common symptom observed was dehydration which was sometimes also referred to as "thirsty" (19), the second most frequently given response was weakness or tiredness (16). 14 participants named profuse or watery feces. 11 participants said abdominal pain was a symptom. 9 said 3 or more trips to the toilet a day, of the 9, most specified a number between 3 and 5 trips to the toilet per day. Vomiting and fever were also common responses, with 8 and 7 respectively. 5 participants listed bloody diarrhea. A remaining 13 symptoms were named by 1 to 2 participants: dry lips, pale, mucus, patient self reports, bulging fontanelle, dizziness, protruding tongue, unhappy and crying, poor blood circulation, malnutrition, weight loss, uncommon stools and headache.

The results to the question regarding symptoms were further disaggregated by type of healthcare worker. Among nurses, the most common respondents in the survey: weakness, dehydration and profuse diarrhea/watery feces were the most common answers (10 each). Red or sunken eyes and elastic skin were also commonly listed. 6 nurses listed 3 or more stools a day as a symptom. The only doctor in the survey listed abdominal pain/stomach cramps, vomiting and fever. The WHO and DHS definition of diarrhea is experiencing 3 or more watery stools a day. It is significant finding that among our participants overall, this ranked fifth in the frequency of answers provided. Our findings suggest future research is needed to investigate whether standard survey questions querying incidents of diarrhea focus on the most accurate symptoms observed.

Discussion of results. Health care professionals shared the concern that diarrheal disease and safe water are significant priorities in this community. The participants were accurate with their assessments of risks to health from waterborne disease, as the most frequent responses were drinking unsafe water, unsafe food preparation, and not washing hands.

Participants did not have unified responses regarding how diarrheal disease should be reported. While reporting mechanisms do exist in this district, health workers did not show a clear understanding of the monthly reports required of them. None were aware of a reporting system that involved different sectors. This suggests a more standardized reporting system would benefit these health professionals representing different sectors.

The most significant finding was the lack of uniformity among health care providers when they were asked what are the symptoms of diarrhea. Diarrheal disease is notoriously difficult to define in low-resource areas where it is not uncommon for individuals to spend years without

experiencing a solid stool. The official symptom used by DHS and others, three or more loose stools in one day, is of little relevance. As a result, accompanying symptoms, such as weakness (lethargy) and fever are more important. The participants provided a range of 24 symptoms. The most common symptom was dehydration or thirst, followed by weakness. Loose or watery stools were only the third most common answer given, provided by 14 of the 30 respondents. This finding is significant because it indicates more work is needed to educate health professionals about diarrhea; and large-scale population surveys querying the incidence of diarrheal disease may not be accurately defining diarrhea in local terminology.

Status of milestone objectives

Requirement	Status
Obtain legal standing for mWater in Tanzania	complete, see Appendix A: Certificate of Registration for mWater Foundation Tanzania
Progress report	complete - included in current Milestone Report
Conduct baseline assessment	complete - included in current Milestone Report
Conduct stakeholder meetings	complete - included in current Milestone Report
Purchase supplies	complete - initial supply of test kits provided at Mwanza training in August 2013
Obtain ethics approval	submitted, awaiting response from National Institute of Medical Research. Data collection for baseline survey was approved by the Mwanza City Council Public Health Office (see attached letter, Appendix B)
Conduct water test and app trainings	complete - training of 23 participants conducted August 19-20, 2013
Complete installation at water plant and take sites	Current cost of sensors out of scope, propose developing an alternative open-source design using off-the-shelf components (see Challenges section in current report for more details). As a workaround, tank and plant workers are to be supplied with a survey that visually estimates tank level.

Appendix A: Certificate of Registration for mWater Foundation Tanzania

NGO A-Form No. 2

00006605

THE UNITED REPUBLIC OF TANZANIA

THE NON-GOVERNMENTAL ORGANISATION ACT, 2002

Made Under section 12(2) of Act No. 24 of 2002

CERTIFICATE OF REGISTRATION

I hereby Certify that mWATER FOUNDATION TANZANIA ..... has this 8TH day of OCTOBER, 20 13 been duly registered under Non-Governmental Organizations Act, 2002 with Registration No. I-NGO/00006605. This certificate is subjected to following condition/directions:

That the aforesaid Organization shall operate in Tanzania mainland

That the aforesaid Organization shall operate in accordance with its governing Constitution

Issued this 8TH day of OCTOBER, 20 13

REGISTRAR

Appendix B: Approval letter for baseline survey from Mwanza City Council

HALMASHAURI YA JIJI LA MWANZA

Barua zote zitumwe kwa Mkurugenzi wa Jiji

TEL: CITY DIRECTOR :225 28 2501375
ALL OFFICES : 255-28-40334
FAX : 255 -028 -2500785
Email.mwacity@thenet.co.tz

P.O. BOX 1333
MWANZA

Kumb. Na. W.10/1/IV 22/07/2013

Afisa Mtendaji,
Kata ya Mkolani,
Wilaya ya Nyamagana.

YAH: UTAMBULISHO WA WATAALAM WA KUPIMA UBORA WA MAJI.

Husika na somo tajwa hapo juu,

Naomba kuwatambulisha kwako wataalam wa ubora wa maji, wanaokusudia kufanyakazi ya kupima ubora wa maji toka vyanzo vya maji vinavyopatikana katika kata yako. Naomba uwape ushirikiano kwa kadri ya mahitaji yao ili kufanikisha zoezi hili ambalo kisingi ni kwa faida ya Afya zetu.

Wataalam hawa ni:

1. Annie Feighery
2. John Feighry
3. Amandus Mashamba
4. Miquela Wiegel
5. Amanda Sperber

Natanguliza shukrani zangu kwa ushirikiano wako,

Ahsante,

S.S. Buluba
K.n.y. MKURUGENZI WA JIJI
MWANZA

FOR CITY DIRECTOR
MWANZA

mWater Mobile technology for social water monitoring in low-resource settings

Milestone 3 Report

August 2014

United States Agency for International Development (USAID)

Development Innovation Ventures Program

Introduction

This report forms the deliverable for the Milestone 3, which had the following objectives:

- Provide a brief report summarizing progress to date, including challenges identified and strategies to overcome them. The report should discuss progress recruiting local distributors, issues regarding import duties and restrictions, and progress obtaining buy-in from local stakeholders.
- Submit the midterm evaluation report. The report should assess the effectiveness of the approach at the individual, health worker, and water management levels, using mixed methods including qualitative semi-structured interviews.

Summary of progress to date

In response to insights gathered during the interim review, the program was been divided into two phases: (i) baseline and (ii) incentivized. At the conclusion of the baseline phase (approximately 6 months after the initial training and launch), approximately 20 of the 25 originally trained could be considered active users. In total, over 500 water quality tests were conducted by this group, meaning that each active user contributed roughly 6 tests per month. This was lower than the target number of 15 per month, but as documented in the Interim Report, performance was hampered by external issues such as having a working mobile data plan.

Challenges identified and mitigation strategies

Several challenges of varying scales were identified during this phase of the project. In terms of users, variation in participant capacity to operate the phone, use email addresses and remember login details meant that mWater staff had to be attentive to users who struggled more and spend more time training and reviewing with them.

Full understanding of customs restrictions (and exemptions) around equipment import (mobile phones and water test kit components) is important to avoid delays around project implementation. This problem is being resolved by applying for tax exempt status from the Tanzania Revenue Authority via mWater status as a registered NGO in Tanzania.

Activation of data bundles undertaken by third parties (cell service providers) can cause delays to the app use, and data upload and analysis. Where possible, future data plans should be agreed and activated prior to cell phone distribution to avoid users negative feedback around inactive data plans.

More structured support may be required for users such as health workers. Some were requested by the community to give follow-up seminars, but were unsure of what material to deliver. Health officers recommended mWater host community meetings at the start of a new monitoring effort in a neighborhood. Also, a follow-up pack and more written material with safe water advice could be an option for mWater to develop with clients where it is deemed necessary. Additionally, other users who were not formal health workers felt difficulty in communicating results (especially negative ones) directly to the community. mWater suggested this be done through the Environmental Health Workers.

Finally, mWater staff reported that only “doing tests and providing feedback regarding safety only to the community members without any assistance seems to be somewhat dissatisfactory to them (the community members)”. Many community members and also the project enumerators had questions around “What happens after you get a bad test reading? Can you/will you

fix/improve the water source?". Staff also found that some users had their own responses to the community that were not entirely in line with the mWater message that;
mWater mainly tries to aid access to safe water by providing important information to the public regarding safety of the different water sources the latter uses, and from such real-time info, the public can then choose safer water sources, and treat their water properly by using water guard, boiling, solar disinfection or by letting the water stand and settle.'

From this experience, mWater learned that very clear messaging from mWater should be passed from the water monitors to the water users. It is critical that individuals mapping and monitoring the water are properly trained on how to pass the same message to the community, to avoid miscommunication around what a solution may be to a contaminated water source.

Progress on key objectives for Milestone 3

Recruiting local distributors of the water quality testing kit supplies

The project's original strategy of recruiting commercial distributors was not viable due to low volume of purchase orders and the limited profit margin available to the distributors. Therefore we explored ordering supplies through the Lake Victoria Basin Water Lab and MWAUWASA Lab, but found that their supplies were all purchased through a central purchasing authority in the Ministry of Water.

After several conversations with MWAUWASA and the Ministry of Water, we settled on mWater acting as a non-profit distributor of supplies. Since mWater has NGO status in Tanzania, it is possible to apply for tax exempt status from the Tanzania Revenue Authority. This process has been initiated but will take several months.

One benefit of this approach is that mWater can provide supplies to projects throughout Sub Saharan Africa. This model was actually utilized for a different mWater project in Nigeria. In May 2014, mWater staff in Tanzania assembled several hundred units of the testing kit, comprising components that had previously been delivered directly from manufacturers in India and Germany to mWater's Mwanza office. The kits were ordered for a World Bank-sponsored mWater project in Niegeria and were shipped to the Ekiti State Water Corporation offices in Nigeria, where they were successfully used to monitor water sources. This experience provides some validation of the non-profit test kit distribution model mWater is proposing for local distribution of supplies.

Import duties and restrictions

The challenges in overcoming the extremely high import duties imposed on scientific supplies in Tanzania were discussed in the Milestone 2 report and a solution was proposed. This solution involved receiving supplies purchased by mWater at the Lake Victoria Basin Commission Water Laboratory, who enjoy an import duty exemption as a government entity. A minimum purchase of 1,000 units of the key reagent in the mWater test kit, HiEcoli test buds, was ordered from the manufacturer in India and delivered to this laboratory. However, upon arrival at the airport the shipment was confiscated by customs officials who maintained that the items should not have been ordered by another entity than the recipient. Despite several weeks of high level appeals within the Ministry of Water by the laboratory staff, this issue could not be overcome. Finally, mWater was forced to engage a customs agent to negotiate payment of the full duty plus storage fees incurred during the lengthy appeal process.

mWater recognized that even if this strategy had been more successful, the risk of these misunderstandings could put delivery of critical project supplies at risk in the future. Therefore,

mWater Tanzania has begun the process to apply for an exemption from the Tanzania Revenue Authority for test kit supplies.

Progress obtaining buy-in from local stakeholders

mWater made initial connections with the City Manager, Public Health Minister, and MWUAWASA leadership in advance of the August 2013 training. These individuals' buy-in has continued to be a critical component of mWater progress. mWater Tanzania program director Amandus Mashamba makes regular visits to these individuals' offices to update them on project status and learn about changing or emerging issues in their sectors.

The City Public Health Minister, Mr. Kamenya, is among mWater's strongest supporters. He provides letters of introduction to regions of the city that require authentication, advice on worker inclusion and guidance on which regions have the most severe water stress. Mr. Kamenya is uniquely open to new technologies and new ideas about integrating technology into the public sector.

Engineer Gogadi of MWUAWASA is the lead contact for mWater with the water utility. Mr. Gogadi oversees both the water plant staff and the field staff that take part in the mWater effort to map and monitor water sources. Recently, one staff member's phone malfunctioned and Mr. Gogadi gave him his own to protect the effort to keep data collection on-going. Under Mr. Gogadi's leadership, a new priority for mWater is to include the Tank Operators in the monitoring scheme at a higher priority.

Midterm evaluation report

In the midterm evaluation, several stakeholder groups were asked for feedback using qualitative one-to-one interviews and small focus group sessions three to four persons. These groups were;

1. City Utility Water Tank Operators
2. Environmental Health Workers
3. MWAUWASA staff
4. Lake Victoria Water Basin Lab staff.

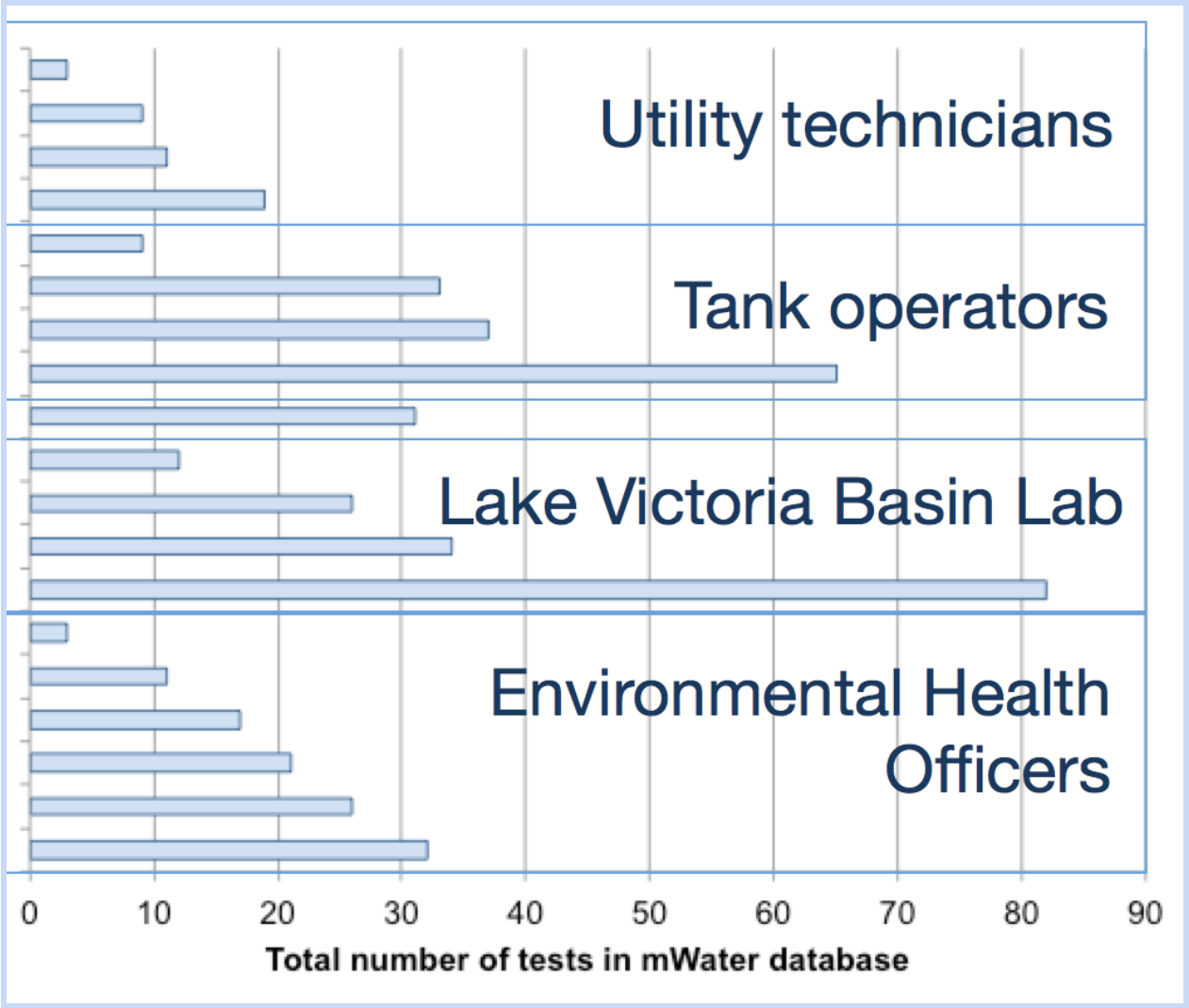
The qualitative interviews asked respondents the following questions:

1. How should the water quality data collected be used?
2. How can the data best be communicated?
3. Could the app be improved to be more useful in your work?
4. Was the training adequate?
5. Do you have general suggestions for improving the program?

General notes also made by mWater staff throughout the training and surveying period are also included at the end of this section.

Participation by group

An analysis of test results entered into the mWater database by user revealed that two groups of users were generally more active: technicians from the Lake Victoria Basin Water Lab and tank operators from the water utility (see figure below). One common attribute that unites these groups is that they deal with water quality testing on a daily basis. Tank operators perform free chlorine tests every morning and the water lab technicians work with water samples throughout their daily routine. This data will be useful in targeting mWater to subgroups of users in the future.



Participation levels as measured by tests added by each user

Summary of feedback by user group

Water Tank Operators

Three of the four Water Tank Operators that participated in the pilot are considered by the project to be "power users", in that they had high levels of participation and even overcame obstacles such as inadequate data bundles to do their work. Therefore their feedback is highly valuable to the project. The Tank Operators reported that they used the mWater test strips alongside their usual water quality monitoring equipment (a color-comparison method using powdered reagents) in order to verify their test results. However, they did report that they continued to monitor the tank level on their own using a ladder. In terms of the results delivered by the mWater app, the Tank Operators suggested that a weekly results table generated by the app would help them in their reporting duties and allow for patterns or 'red flags' to be more easily observed over longer time periods.


Above right: A Water Tank Operator by the water tank he is responsible for.
Above left: Ladder by which Tank Operators measure water level

Environmental Health Workers

Environmental Health Workers that participated in the pilot reported a high public demand for testing water, commonly posing the question “What will you do to help?” to the health workers. They reported that ‘high risk’ water sources are those which are most remote, and most difficult to access. In order to assist their reporting, this stakeholder group suggested that the app produce reports in a format such that water safety information can be posted on local boards.

Water utility (MWAUWASA)

MWAUWASA’s feedback centered around the outputs of the app; a request for a results view in the app was made, alongside a request for the app to provide health workers with suggestions and best practices based on the results from the survey(s) conducted. MWAUWASA also expressed interest in water meter reading applications, in order for their staff to more easily be able to incorporate this information into a digital form.

Lake Victoria Basin Water Lab

As with several of the Water Tank Operators, the project considers the Lake Victoria Basin WAter Lab to be a “power user”. Their feedback from the pilot stage included the need for a simple spreadsheet export for their data, as well as custom forms, and forms that can measure additional parameters such as Fluoride.

General notes on participant feedback from mWater staff

mWater staff observed problems during initial sessions with users that are being trained (e.g. Environmental Health Workers) who may not have previously owned an email address or are not accustomed to regularly accessing an account where they are required to memorise a username and password. Staff observed issues with inability to log in to emails and the mWater app as they had forgotten their usernames and/or passwords. Future projects could issue users with a small card where they can note their username and password to avoid this issue.

mWater staff observed that some participants who were not as familiar with the use of smartphones and/or computers required more support throughout the pilot. This was achieved through dedication from the mWater staff, spending more time with these users, however it should be noted that it is important for the implementing staff (mWater or a client) to carefully observe which users may need more help learning how to use a smartphone and/or the app.

Where English is not a first language, some users preferred to take notes in their first language (in Mwanza, Swahili), in order to improve levels of data when surveying. However, this means that data is collected in two languages and requires translation. Translations of notes could be added within the app to allow for all to data to be collected in the same language for analysis.

Some participants reported that camera focus (how closely the user held the camera to the test) affected test results; too closely and the app reported an error, and varying distances from medium to far away from the test gave different readings. The interface for counting colonies requires improvement to ensure accuracy and prevent user error. Future software support is needed to overcome the focus problems that are common with various smartphone cameras. Until this can be funded, mWater is adapting by training users on the correct distance to take the photo for the test and asking them to also enter their own visual count of colonies.

Status of milestone objectives

Requirement	Status
Provide a brief report summarizing progress to date, including challenges identified and strategies to overcome them. The report should discuss progress recruiting local distributors, issues regarding import duties and restrictions, and progress obtaining buy-in from local stakeholders.	Complete - included in this report
Submit the midterm evaluation report. The report should assess the effectiveness of the approach at the individual, health worker, and water management levels, using mixed methods including qualitative semi-structured interviews.	Complete - included in this report

mWater Mobile technology for social water monitoring in low-resource settings

Milestone 4 Report

September 2014

United States Agency for International Development (USAID)

Development Innovation Ventures Program

Introduction

This report forms the deliverable for the Milestone 4, which had the following objectives:

- Conduct bug tracking and software updates.
- Complete handoff to local stakeholders, including:
  o Reach agreements with and order supplies through local distributors.
  o Train systems administrator, health officers, and water utility workers. Hold transition workshops and meetings.
- Submit the midterm evaluation report. The report should assess the effectiveness of the approach at the individual, health worker, and water management levels, using mixed methods including qualitative semi-structured interviews.

Summary of progress to date

During the final phases of the the project, the team carried out refresher training to 23 participants from MWAUWASA head office, Environmental Health Officers, Water Tank Operators, staff from the City Health office and staff from the Lake Victoria Basin Lab. These participants were refreshed on the use of the app (including new features), the portal and water quality testing.

Individual transition meetings were held with all available stakeholders, where further feedback on the app, portal and water quality testing kits was collected in order to further improve the technology and mWater process.

Ten new versions of the app have been released in the last stages of the project (from version 3.0 to 3.10) and there have been major upgrades to the app, the platform and the portal, allowing for more intuitive use, specific features requested by stakeholders, translation to Swahili and use of the application on a wider range of handsets.

Progress on key objectives for Milestone 4

Bug tracking and software updates

Since the software updates and bug tracking reported in the Milestone 2 report, mWater has released 10 new versions of the app (v3.0 to v3.10), incorporating 180 smaller updates and fixed. These included the following updates to the mWater app and platform:

- The native camera plugin was re-written in order to improve quality of photos taken and results determined from these, and to reduce crashes.
- Performance increases were updated on the mapping page.
- Upgrades were made to the mapping library.
- Bug fixes and workarounds for device-specific issues were undertaken, with special focus on fixes and workaround for the Intel Yolo, the handset utilised in the project.

- The smartphone database system was replaced with WebSQL for larger data sets on client.
- The app was localized into Swahili for ease of use by surveyors in Tanzania and other East African countries, which also allowed adding a framework for further easy localization into other languages at later dates.
- Fully offline maps capability was incorporated into the app.
- Surveys are now available with a WYSIWYG survey builder, full localization, multi-stage approval systems and complex conditions.
- Automatic data visualization with filtering was incorporated.
- Graphing of user activity by time frame, per survey has been added.
- Permissions system with multiple group memberships was incorporated.
- Quick functional status updating of sites was added.
- Data export and import via the portal was made possible.

Handoff to local stakeholders

The project has trained 23 participants in water quality testing and use of the mWater app, including 4 water utility workers, 4 environmental health workers and 4 staff members from the Lake Victoria Basin Laboratory, alongside other participants involved in school WASH and the health office. Local mWater staff are currently in the final stages of training a systems administrator. The original training was held at Ryan's Bay Hotel, Mwanza, with all participants present at the same time. The participants were given a thorough training in water contamination, water monitoring, water point mapping,

During the final stages of the project, a handoff to the local stakeholders has been undertaken. Rather than holding one large workshop, that would have been costly to run, the mWater team visited stakeholders, including health officers and water managers, in person where transition meetings were held as in depth one-on-one and focus group feedback sessions with the trained participants. The team conducted qualitative interviews focussing on lessons learned, what worked best, what needs to be changed, eliminated, or improved. Specifically with Mr. Kamenya, the city health minister, the team demonstrated the management portal and how he could monitor the water contamination status from his desk; as with Mr. Gogadi of MWUAWASA who oversees the water managers. Because a key finding in interviews was that the water and health sectors were still not communicating often, we added a new strategy of each ward nominating one health officer and one water manager who would meet in person each month. We evaluated who among the originally training water monitors was actively conducting apps and tests and we agreed to eliminate the non-active monitors from the stipend plan and to collect their phones. Further feedback from these interviews is detailed in the mid-term evaluation in the Milestone 3 report.

Mwanza's Assistant Regional Administrative Secretary for Water, Eng. Waryoba, requested to be trained on the system and informed of the water activities. The mWater team met with him

and provided a thorough explanation of mWater and the collaboration. He requested and received a phone.

Local mWater staff also re-trained each individually on the upgrades in the software, including the addition of the management portal. Two phones were replaced: one that had malfunctioned and one with a broken lens, and provided new messenger-style bags (a request from the participants as they didn't like backpacks). Training materials in Swahili were also distributed.

Regarding reaching agreements with local distributors, the project's original strategy of recruiting commercial distributors was found not to be viable due to low volume of purchase orders and the limited profit margin available to the distributors, as mentioned in Milestone 3 report. The possibility of ordering supplies through the Lake Victoria Basin Water Lab and MWAUWASA Lab was explored, but we found that their supplies were all purchased through a central purchasing authority in the Ministry of Water and we could not partake in this.

After several conversations with MWAUWASA and the Ministry of Water, we settled on mWater acting as a non-profit distributor of supplies. Since mWater has NGO status in Tanzania, it is possible to apply for tax exempt status from the Tanzania Revenue Authority. This process was initiated several months ago and is still in process.

Midterm evaluation report

The midterm evaluation report was also listed in the contract as a deliverable for the Milestone 3 report, and as such is detailed as a separate section in that report. Please refer to the previously submitted Milestone 3 report for this evaluation.

Status of milestone objectives

Requirement	**Status**
Conduct bug tracking and software updates.	Complete - included in this Milestone report
Complete handoff to local stakeholders, including: o Reach agreements with and order supplies through local distributors. o Train systems administrator, health officers, and water utility workers. Hold transition workshops and meetings.	Complete - included in this Milestone report
Submit the midterm evaluation report.	Complete - please see Milestone 3 report

USAID Development Innovations Grant – Phase I
Final Report
AID-OAA-F-13-00034
mWater: Mobile technology for social water monitoring in low-resource settings

Executive Summary

This project aimed to work in collaboration with the Mwanza Urban Water And Sewerage Authority (MWAUWASA) in order to create a database of water quality information ready for data-mining and epidemiological monitoring; and create a scalable water system, making safe, monitored water feasible for the developing urban municipality.

mWater proposed to achieve this by training Mwanza's city health workers and the urban water authority's field staff to use the inexpensive water tests read with a mobile app, resulting in an online network of information about the region's water sources. Training aimed to create health worker awareness of the opportunities for remote epidemiological monitoring made possible by the mapped water source quality data, and to support city utility workers in their tasks related to water quality.

The project demonstrated a significant need for improved data collection and reporting of water supply-related data in Mwanza, both in terms of quality and quantity of data recorded. The initial data gathered in this project identified the need for safe water sources; the Baseline Assessment of Water Users (112 users) found that people in the peri-urban areas of the Mwanza study generally choose from 2 to 3 water sources for their daily needs and consider contaminated water to be a significant health concern. Water users also identified economic impacts from missed work due to illness or caring for a sick child to be major concerns. Availability and reliability of water from both the piped network and point sources were major problems encountered by people, forcing them to use less safe sources at times.

Specific feedback during the interim review of the project informed several aspects of mWater software development, including the translation of the app to Swahili, creation of a flexible survey utility, development of privacy settings, creation and management of Groups of users and offline performance of the app. Other significant development drive by feedback were the development of multiple platform compatibility across all smart phones, tablets and computers through a

browser window or the native android app, a database upgrade to NoSQL and background software upgrade capability.

The project findings displayed a demand from the community for improved water services, alongside a need for better education of Environmental Health Workers on the basic links between water quality and illness, and an improved definition of diarrhea in the local terminology should be utilized by the City Health Department. Findings analyzed from the data collected by trained mWater users showed that age, gender and managerial role were not significant factors on participation of different users. However, results showed that users in Utility Tank Operator and Utility worker roles were likely to create a lower number of sites. This may be explained by the geographic limitations of these workers; Tank Operators remain at their tank stations, whilst Utility Workers are largely based at the Water Treatment plant in Capri point and limited by transportation arrangements.

The project's success is highlighted by the overarching response from MWAUWASA and the City Health Department. Following the official close of the project, after reviewing the data from the water quality tests undertaken, the City does not wish to continue supporting outside development (mainly INGO) of hand-dug wells that showed high levels of contamination. Rather the City now aims to direct outside investment towards expansion of piped-chlorinated supply, to ensure that safe drinking water is delivered in underserved areas.

The project aims to further develop in Mwanza by supporting MWAUWASA's plans to expand the piped-water system. Decision making tools will be developed through the comprehensive mapping of non-piped water sources and socio-economic indicators using mWater. By overlaying the map and indicator mWater will be able to show where there is possibility for expansion of the piped network to areas that can support the expansion through MWAUWASA revenue via metering. For areas that cannot support expansion through MWAUWASA revenue, the map may indicate locations for water kiosks that can utilize piped-network supply running nearby. Additionally mWater plans to seek further funds to develop support to move MWAUWASA's metering process from paper to digital. According to the most recent MWAUWASA Business Plan, the most pressing business challenge for the utility is the high level of non-revenue water, which is estimated to be as high as approximately 40% of overall production. The causes of non-revenue water include physical losses due to leaks and commercial losses caused by failed metering systems, meter-tampering and illegal connections. Therefore this is also an important aspect of MWAUWASA's that mWater could support. Finally, there may also be opportunity for mWater to begin working with a second mWater application in Mwanza, BroadStreet, designed to support health worker reporting of diarrheal diseases and associated needs. This could be coordinated with the expansion of safe, piped water supply, or may be developed as a stand-alone intervention.

Contents

Background

During Summer 2012, prior to the DIV project, mWater undertook a UN Habitat funded study in Mwanza. The study focused on validating low cost water quality test methods, including testing the Aquagenx Compartment Bag Test and the Petri film test, both for microbiological testing. The study showed that dug wells, springs and surface water sample sites throughout Mwanza were all highly contaminated with E.Coli, whereas Boreholes and Piped water sample sites showed undetectable levels of E.Coli. Alongside this study, the initial stages of mWater software development were begun. This study was the impetus for the DIV Phase I work.

Discussion that developed with City officials after this study showed that a major concern regarding water quality is inadequate service provision in the peri-urban areas surrounding Mwanza that have experienced rapid population growth in recent years. MWAUWASA has a mandate to provide water at a nominal fee to poor residents who cannot afford a household connection through a system of public water Kiosks throughout the city. However, the reality is that in many of these areas the distance from the home to a Kiosk is too great, or the availability of water at the Kiosk is not reliable due to their distance from tanks and pumping stations. In these areas, the City Health Department has a program administered through community health workers to promote good water, sanitation and hygiene practices in the household and perform shock treatment of contaminated wells[1], which typically become highly polluted in the rainy season. Although wells used for drinking water are required to be tested by the regional Lake Victoria Water Laboratory, in reality the testing is rarely performed due to the high cost of testing (over USD 100) compared to the cost of constructing the well. Therefore, most residents who do not use MWAUWASA-provided water are drinking from unmonitored water supplies.

Additionally, Tanzania recently completed an exhaustive national inventory of rural water points. The water point data was collected by trained enumerators using custom surveys loaded onto handheld GPS devices and integrated into a web-accessible database[2] by Geodata Consultants, Ltd. There is a desire on the part of the Ministry and the government to keep centralized management authority over this data for the sake of validity. However, it was also noted by several stakeholders during this project that a mechanism does not currently exist to keep this data updated with reports from the field, particularly regarding the functional status of mapped water points. Additional water quality data is also desired, since the initial mapping effort was limited to inorganic parameters such as fluoride

[1] Shock chlorination, essentially adding chlorine bleach to the well, is a common practice but the available research suggests that this is ineffective at reducing microbiology contamination, see Luby, S, Md S Islam, and R Johnston. "Chlorine spot treatment of flooded tube wells, an efficacy trial." *Journal of applied microbiology* 100.5 (2006): 1154-1158.

[2] Water point data is available from the Ministry of Water at: <http://www.maji.go.tz/>

These factors led to the development of the DIV proposal, to address the need for simple and accurate field testing of water sources that trained health workers and MWAUWASA staff can undertake, alongside an intuitive reporting system provided by mWater software.

The DIV Phase I project work was undertaken from June 2013 until May 2014, with an overall DIV grant amount of US$ 100,000. The project work was undertaken in two municipal wards of Mwanza, Tanzania; Igoma and Mkolani, with total populations of 56,350 and 32,119, respectively (at the time of the project). These wards were selected by City officials because they contain a wide variety of water sources and both urban and peri-urban neighborhoods.

Program Design & Implementation

The overall goals for the grant included:

- Implement a mobile phone-based system for monitoring drinking water service and quality at the scale of a large city within a developing country.
- Demonstrate that local ward health officers can perform effective water quality monitoring using low-cost tests.
- Evaluate the effectiveness of providing quantitative water quality data to motivate behavior changes in households who have a choice of water sources.
- Transition water quality monitoring to local authorities using local equipment distributors.

Additionally, grant deliverables included the registration of mWater as a local NGO and updates and bug trafficking of the mWater software. These goals and deliverables were achieved throughout the 12 month implementation period of the project.

Stakeholders

Various stakeholder groups were engaged throughout the project in order to successfully achieve its implementation. Within the first quarter of the project implementation stakeholder discussions were held in both Mwanza and Dar Es Salaam with high level officials from all the organizations involved in the project. Specific stakeholders included:

- City Director - Mr. Hida H. Halifa
- Mwanza Acting City Engineer (water) - Eng. Stanslaus Buluba
- Mwanza City Development Officer - Samwel Juma
- Mwanza City Health Officer - Mr. Danford Kamenya
- MWAUWASA Public Relations Manager - Mr. Robert Masunya
- MWAUWASA Assistant Manager Quality Control - Eng. Gogadi Mgwatu
- Tanzania Ministry of Health representative - Dr. Elias Chinamo, Deputy Director, Ministry of Health and Social Welfare
- Tanzania Ministry of Water representative - Ms. Chanzi Hamidar, Assistant Director, Division of Water Quality Services

- Tanzania Ministry of Water representative - Ms. Nadhifa Kemikimba, Director, Division of Water Quality Services
- World Bank - Mr. Kristoffer Welsien, Country Officer
- UNICEF - Dr. Paul Edwards, Deputy Representative, Tanzania Country Office
- Lake Victoria Basin Water Laboratory Director

These stakeholders were engaged at various stages of the project including the Baseline Assessment of Mwanza water monitoring capacity, the Baseline Assessment of water users and the Baseline Assessment of Health Workers.

mWater users were selected from these stakeholder groups through nomination by their respective organizations; City Health workers who worked in the pilot wards, MWAUWASA field technicians and tank operators and Lake Victoria Laboratory Water Quality Technicians.

Additionally stakeholders were engaged in the midterm evaluation of the project, where several stakeholder groups were asked for feedback using qualitative one-to-one interviews and small focus group sessions three to four persons. These groups included the City Utility Water Tank Operators, Environmental Health Workers, MWAUWASA staff and the Lake Victoria Water Basin Lab staff.

Image 1: Conducting Baseline Assessments

Implementation: mWater users and field testing

Within the first quarter of the project, mWater accomplished the registration of mWater Tanzania as a local NGO, with the registration number I-NGO/00006605. The project implementation began with a baseline assessment of water users and the water and health sectors in Mwanza, by interviewing several distinct stakeholder groups (see below). The aim of the assessment was to understand the local priorities for safe water, understand what problems are currently being addressed and what problems are perceived as beyond local capacity for resolving and to engage stakeholders as partners in this initiative. The assessment was carried out as a series of individual and small group interviews, using semi-structured interview questions. Over a two week period 112 water users, 30 health care providers and several individual stakeholders in government positions were surveyed.

Following the assessment, mWater obtained agreements with the Mwanza City Council Public Health Office and the Mwanza Urban Water and Sewerage Authority to implement the 9-month demonstration project.

Within the assessment, the Division of Water Quality Services expressed strong interest in field test methods that mWater was demonstrating, particularly for field microbiological and fluoride analysis. In response mWater further developed a field test kit for water quality testing. The kit contains a presence-absence test for E.Coli in 100ml samples, a quantitative test for E.Coli in 1ml samples, as well as test strips for Chlorine and Nitrate testing. The project's original strategy of compiling field test kits utilizing commercial distributors was not viable due to low volume of purchase orders required and the limited profit margin available to the distributors. Therefore mWater explored ordering supplies through the Lake Victoria Basin Water Lab and MWAUWASA Lab, but found that their supplies were all purchased through a central purchasing authority in the Ministry of Water. After several conversations with MWAUWASA and the Ministry of Water, the project settled on mWater acting as a non-profit distributor of supplies. Since mWater had registered for NGO status in Tanzania, it was possible to apply for tax exempt status from the Tanzania Revenue Authority (this process is ongoing as the paperwork is awaiting approval from the Revenue Authority). In May 2014, mWater staff in Tanzania assembled several hundred units of the testing kit, comprising components that had previously been delivered directly from manufacturers in India and Germany to mWater's Mwanza office.

During the purchase and assembly of test kits, mobile smartphones were also purchased and a local mWater staff member was hired. Initially 23 identified mWater users were trained on the use of the mWater app and water quality testing using the field test kit in order to gather information about water quality from municipal water points (hand dug wells, boreholes etc) and municipal water storage tanks. The trained users included 4 MWAUWASA (water utility) workers, 4 environmental health workers and 4 staff members from the Lake Victoria Basin Laboratory, alongside other participants involved in school WASH and the Health Office. Trained users were given a mobile phone and small data package, and were asked to undertake 15 tests and site

visits per month. This baseline phase of initial data collection lasted 6 months (September 2013 - February 2014) before an interim review was undertaken in March 2014.

Image 2: mWater User Training

The interim review marked the second phase of the project, the first having been the Baseline Phase, and the second the Incentivized Phase. The interim review involved qualitative interviews that directed the development of the second phase. From the interim evaluation, the project determined who among the originally trained mWater users was actively conducting apps and tests and we agreed to eliminate the non-active monitors from the stipend plan and to collect their phones.

The second phase undertook further data collection with an incentive structure. Users continued to provided with a smartphone and a travel stipend, but additionally were given a data bundle if tests were carried out; 30,000 TZS of data was added to their phone if 10 water tests had been carried out within the previous month.

During the final phases of the project, the team carried out refresher training with 23 participants from the MWAUWASA Head Office, Environmental Health Officers, Water Tank Operators, staff from the City Health Office and staff from the Lake Victoria Basin Laboratory. These participants were refreshed on the use of the app (including new features), the portal and water quality testing. New training materials in Swahili were also distributed.

In the final stage of the project, a handover to the local stakeholders was undertaken. Rather than holding one large workshop that would have been costly to run, individual transition meetings and

small focus groups were held with all available stakeholders, where further feedback on the app, portal and water quality testing kits was collected in order to further improve the technology and mWater process.

Implementation: Software development

Within the first half of the project the mWater app was rolled out from the Beta stage app to a fully public app, free of charge (version 3.0). The following improvements were made during the DIV project period, utilizing DIV and mWater investor funding:

- Surveys: the app now includes a flexible survey utility that can work in offline mode. The utility was created with health workers in mind as the end user. Its features include common survey question types, conditional questions, GPS capabilities, and voice dictation.
- Privacy: water sources and surveys can be labeled private to protect individuals when the information is sensitive. Sensitive information may include household water sources or water sources that have a stigma-inducing quality.
- Groups: users can now see and edit data that were created by other members of their group and surveys can be pushed to groups of users at a time.
- Offline performance: the app now keeps a list of nearby sources available when offline and synchronizes the list with the server once a data connection becomes available again.
- Multiple platform compatibility: the app now works on any model of smartphone or tablet. This has been achieved by re-writing the software in HTML5, which means the app now runs in the browser window at the URL http://app.mwater.co. mWater is still available as a native Android application, accessible through the Google Play Store.
- Database upgrade: mWater database has been upgraded to the latest modern database technology, a NoSQL database that makes it easier to add new fields to water sources for different groups without re-writing the app.
- Background software upgrade: users no longer need to visit the app store for upgrading the app. New generations of mWater are now seamlessly upgraded in the background on an ongoing basis. This usability feature makes it easier for individuals new to smartphone apps to continue using mWater as updates and upgrades become available.

Within the final stage of the project, the mWater team carried out software updates and bug tracking and released 10 new versions of the app (v3.0 to v3.10), incorporating 180 smaller updates and fixed. These included the following updates to the mWater app and platform:

- The native camera plugin was re-written in order to improve quality of photos taken and results determined from these, and to reduce crashes.
- Performance increases were updated on the mapping page.
- Upgrades were made to the mapping library.
- Bug fixes and workarounds for device-specific issues were undertaken, with special focus on fixes and workaround for the Intel Yolo, the handset utilised in the project.

- The smartphone database system was replaced with WebSQL for larger data sets on client.
- The app was localized into Swahili for ease of use by surveyors in Tanzania and other East African countries, which also allowed adding a framework for further easy localization into other languages at later dates.
- Fully offline maps capability was incorporated into the app.
- Surveys are now available with a WYSIWYG survey builder, full localization, multi-stage approval systems and complex conditions.
- Automatic data visualization with filtering was incorporated.
- Graphing of user activity by time frame, per survey has been added.
- Permissions system with multiple group memberships was incorporated.
- Quick functional status updating of sites was added.
- Data export and import via the portal was made possible.

Challenges

Several challenges arose during program implementation. Initially, the Project Implementation Plan included a small budget ($2500) reserved for experimenting with emerging low-cost sensors for measuring water levels in the remote municipal water tanks. However, a minimum purchase order of 50 units of the preferred sensor was required, which was outside of the budget range. Therefore mWater contacted a New-York based group of open-source hardware designers to develop a prototype sensor, integrating a commercially available ultrasonic level sensor with a mobile-enabled arduino microprocessor. Unfortunately, this approach failed during the initial planning phases before any money was exchanged due to lack of sufficient interest on the part of the hardware developers. In subsequent projects involving sensors, mWater has had success working with a professional electronics engineering firm, Sparx Engineering, in Houston, Texas. The lesson taken from this experience is that custom hardware and its integration with cloud-based platforms such as mWater is a complex task best taken on by experienced engineering firms. Toward the end of the project, mWater did discover an effective solution to tank level monitoring. During the Interim Review, mWater learned through on-site interviews that each of the tank operators was already keeping a written record of the tank level by counting the number of rungs visible on the ladder that they must use to descend into the tank to take their daily water sample. This data point was added to the Tank Operators survey form in mWater.

Challenges were also faced regarding water quality testing kits for the project. Since the prior UN Habitat project, the supplier of the preferred microbiological reagent changed. The new company's test kit utilizing the reagent was deemed to be too expensive and complex for the project's needs. However, mWater was able to negotiate the direct purchase of the reagent in order to utilize it directly in the mWater test kit, albeit at a more expensive price than budgeted. The unexpected price increase resulted in a 25% reduction in available water quality samples per month.

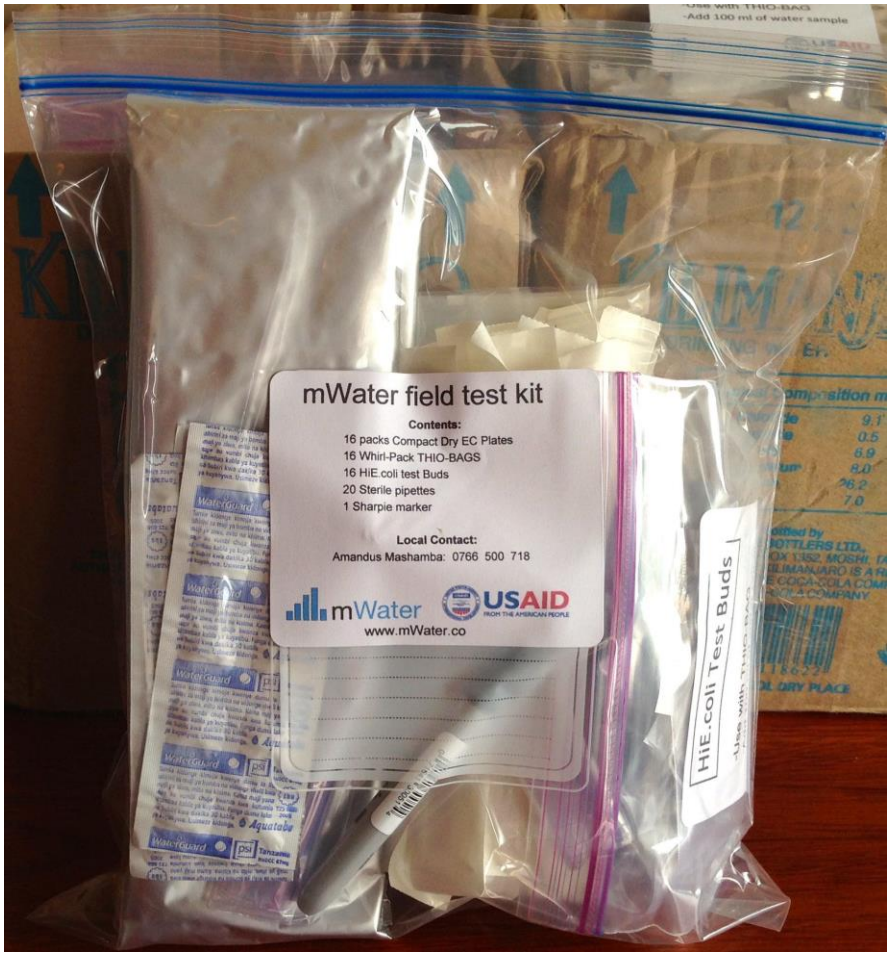


Image 3: mWater Field Test Kit

With regard to procuring mobile phones for data collection, mWater was unable to procure the preferred model, the Huawei Y300, in Mwanza, Dar Es Salaam or Nairobi. mWater then completed a second round of field testing with the Intel Yolo to verify its use for data collection. However the Yolo was difficult to source in Tanzania and had to be sourced in Nairobi. As such the phones had to be imported. This, alongside the purchase of the aforementioned reagents, brought another challenge related to import restrictions.

Delays were experienced related to customs restrictions (and exemptions) around equipment import of mobile phones and water test kit components. Initially the solution involved receiving supplies purchased by mWater at the Lake Victoria Basin Commission Water Laboratory, who enjoy an import duty exemption as a government entity. A minimum purchase of 1,000 units of the key reagent in the mWater test kit, HiEcoli test buds, was ordered from the manufacturer in India and delivered to this laboratory. However, upon arrival at the airport the shipment was confiscated by customs officials who maintained that the items should not have been ordered by another entity than the recipient. Despite several weeks of high level appeals within the Ministry of Water by the laboratory staff, this issue could not be overcome. Finally, mWater was forced to engage a customs agent to negotiate payment of the full duty plus storage fees incurred during

the lengthy appeal process. mWater recognized that even if this strategy had been more successful, the risk of these misunderstandings could put delivery of critical project supplies at risk in the future. Therefore, mWater Tanzania applied for an exemption from the Tanzania Revenue Authority for test kit supplies. This application is still in process, pending approval from the Revenue Authority.

Smaller challenges were experienced in terms of user interaction with the mobile phones. mWater staff noted variation in participant capacity to operate the phone, use email addresses and remember login details, meaning that mWater staff had to be attentive to users who struggled more and spend more time training and reviewing with them. Additionally, activation of data bundles undertaken by third parties (cell service providers) caused delays to the app use, and data upload and analysis. mWater noted that where possible, future data plans should be agreed and activated prior to cell phone distribution to avoid users negative feedback around inactive data plans.

Finally mWater identified some challenges experienced by health workers and mWater users who required further tools to explain water quality results, especially negative ones, to community members. mWater staff supported mWater users with additional training in order to assist them in explaining these results to interested community members.

Evaluation Design

Considering the goals of the project, there were several measurements of progress made in order to determine how each were met.

The project measured the ability to *demonstrate that local ward health officers can perform effective water quality monitoring using low-cost tests* through a baseline assessment and interim review where Environmental Health Officers were interviewed on their skills and knowledge related to water quality and testing, among other themes. After the initial 6 month Baseline Phase, the trained Environmental Health Officers had undertaken 290 water quality tests using the mWater test kit and app, and had mapped 53 water points[3]. The project was able to monitor and review incoming tests from the Health Officers (and other mWater users) on a daily basis using the mWater Portal, and so could measure in real time the ability of the Health Officers to undertake valid tests.

The project also held the goal to *Implement a mobile phone-based system for monitoring drinking water service and quality at the scale of a large city within a developing country*. To this end, the mWater App was translated into Swahili and the mWater Portal was also developed. The use of these by the City Health office and the water utility was the first stage in the implementation of the system.

[3] mWater Platform Data, 2013

Regarding the goal *Evaluate the effectiveness of providing quantitative water quality data to motivate behavior changes in households who have a choice of water sources*; the project found that data collection and analysis had a greater impact in motivating change at the city management level, than at the individual household level. mWater are currently developing further grant proposals to work on the development of a wider range of channels for dissemination of water quality and access data to household users.

The goal to *transition water quality monitoring to local authorities using local equipment distributors* was monitored by the mWater team through documenting progress in project Milestone reports. This goal was partially met by mWater acting as a local distributor after assessing options for the Lake Victoria Basin Lab, MWAUWASA Lab and other commercial suppliers in Tanzania were all deemed to be unsuitable under the project needs and timeframe.

The development of the mWater Portal included features including approval chains and Permission Levels for Enumerators, Viewers and Managers, in order to allow for quality checks to be run on data, and improve overall data quality. Feedback from the “power users” of the Lake Victoria Basin Water Lab included the need for a simple spreadsheet export for their data, as well as custom forms, and forms that can measure additional parameters such as Fluoride. These requests were incorporated into the software development. Future work would likely use a similar evaluation design, based in semi-structured qualitative interviews and focus groups to gather the most detailed information and feedback possible from mWater users and other relevant stakeholders. Additionally, plans are to develop tools within the mWater Portal for monitoring user statistics on the use of the mWater platform.

Findings

Data collection results with mWater

At the conclusion of the baseline phase 20 of the 25 originally trained users could be considered active users. In total, 919 water quality tests were conducted by this group and 211 mWater sites were created. The rate of testing was not uniform over time, with most of the tests being completed in the two months following the initial training (Figure 1). Increases in the number of tests per month also occurred in May 2014 following the introduction of incentives and again in August 2014, possibly due to the arrival of mWater personnel for the final evaluation.

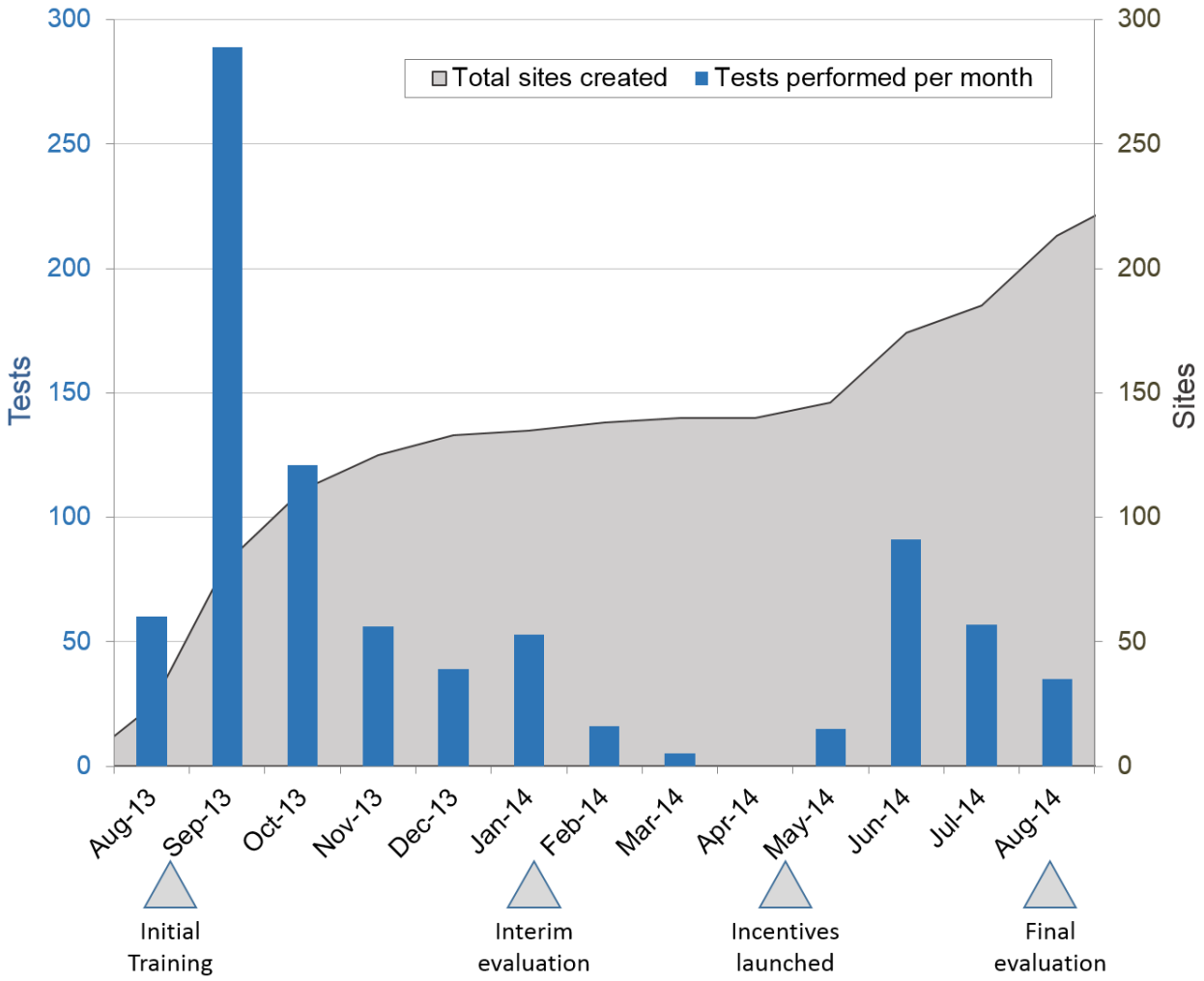


Figure 1. Tests performed and water point sites created each month by Mwanza participants

Factors affecting participation rates

Within the baselines data collection, basic information on the trainee mWater users was gathered, including their age, gender, education, literacy and information on their job roles, and experiences with technology and water issues. From this the users were scored on three criteria to assess if their previous experiences were related to their experience with mWater data collection; (1) Technical experience with smartphones and technology, (2) Professional experience and literacy level, and (3) Personal motivation (experience with water quality, including water related illness). A breakdown of the scoring structure can be found in **Table 4** in Annex 1.

From the data collection results several basic analyses and regressions were run, to determine if independent variables could predict user participation rates (dependent variables). The dependent variables were defined as total water quality test results entered into mWater per user,

total mWater sites created per user and the rate of incentive response (change in tests during the period after incentive introduction). Independent variables examined were defined as two groups: attributes (role, gender, age and position as a manager vs technician), and scores (Technical, Professional, Motivation). A summary table of this data is given below in **Table 1. Table 3** in Annex 1 shows a summary of results by user.

Table 1: Summary of users by role and average participation factors and participation rates

Role	No. of users	Avg. Tech Score (Max. 9)	Avg. Prof. Score (Max. 8)	Avg. Motiv. Score (Max. 4)	Avg. no. tests	Avg. Incentive response	Avg. no. sites
Community Development	2	5.0	8.0	2.0	41	0.1	19
Public Health	6	5.1	6.4	2.5	38	0.8	14
Utility	8	6.4	6.8	2.3	17	0.1	3
Utility Tank Operator	4	4.1	2.8	3.3	59	0.4	6
Water Quality Lab	4	7.0	6.6	2.9	75	0.2	9

From this analysis, the only regression that showed significant coefficients was Sites ~ Attributes. With respect to role, this showed that those in Utility Tank Operator and Utility worker roles were likely to create a lower number of sites. This may be explained by the geographic limitations of these workers; Tank Operators remain at their tank stations, whilst Utility Workers are largely based at the Water Treatment plant in Capri point and limited by transportation arrangements. Manager roles were also significantly less likely to create sites, which can be explained by the office-based (rather than field-based) nature of their roles. It could not be seen that age, position as manager and gender as factors affecting participation rates had any significant effect on the likelihood of users to undertake tests or create sites, given the small sample sizes involved.

Data for decision making

The project demonstrated a significant need for improved data collection and reporting of water supply-related data in Mwanza, both in terms of quality and quantity of data recorded.

The initial data gathered in this project identified the need for safe water sources; the Baseline Assessment of Water Users (112 users) found that people in the peri-urban areas of the Mwanza study generally choose from 2 to 3 water sources for their daily needs and consider contaminated water to be a significant health concern. Water users also identified economic impacts from missed work due to illness or caring for a sick child to be major concerns. Availability and reliability

of water from both the piped network and point sources were major problems encountered by people, forcing them to use less safe sources at times. Participants are also aware of the environmental risks to maintaining safe water sources. When asked what makes water unsafe, the most frequently raised answer was bacteria. Within the Baseline Assessment of Health Care professionals, a shared concern was expressed that diarrheal disease and safe water are significant priorities in the communities surveyed. The participants were accurate with their assessments of risks to health from waterborne disease but did not have unified responses regarding how diarrheal disease should be reported and were unclear on the current reporting mechanisms in their district. This suggested that a more standardized reporting system would benefit these health professionals representing different sectors. Additionally, there was a lack of uniformity among health care providers related to symptoms they associate with diarrheal disease identification; the participants provided a range of 24 symptoms. This finding is significant because it indicates that although health professionals understand basic links between water quality and illness, more work is needed to educate them about diarrhea; and large-scale population surveys querying the incidence of diarrheal disease may not be accurately defining diarrhea in local terminology. This was not however the focus of this project but may be incorporated into future mWater work in Mwanza.

After the initial phase of data collection, further findings were defined in the interim review. Environmental Health Workers reported that ‘high risk’ water sources are those which are most remote, and most difficult to access. Additionally they reported a high public demand for testing water, commonly posing the question “What will you do to help?” to the health workers. This is significant as it displays a demand from the community for improved water services.

The overarching response from MWAUWASA and the City Health Department following the official close of the project was that after reviewing the data from the water quality tests undertaken, the City does not wish to continue supporting outside development (mainly INGO) of hand-dug wells that showed high levels of contamination. Rather the City now aims to direct outside investment towards expansion of piped-chlorinated supply, to ensure that safe drinking water is delivered in underserved areas.

Key Partnerships

Several key stakeholders were engaged during the project. In particular Engineer Gogadi Mgwatu, Assistant Manager Quality Control MWAUWASA and Mr. Danford Kamenya, Mwanza City Health Officer gave significant support to the training of mWater users and their participation in data collection. MWAUWASA Tank Operators and Lake Victoria Laboratory workers were found to be mWater ‘power users’, users that were generally more active in undertaking higher numbers of surveys and water quality tests. One common attribute that unites these groups is that they deal with water quality testing on a daily basis. Tank operators perform free chlorine tests every morning and the water lab technicians work with water samples throughout their daily routine. This information is useful in targeting mWater subgroups of users in the future, and may

also infer that users that are not as familiar with water quality training may need higher levels of initial training and/or refresher training with the mWater field test kit.

Despite the identification of key partnerships, the field visits and man-hours required to carry out monitoring with mWater do imply a budget requirement from respective city departments. Within this grant, mWater was able to provide travel and mobile data stipends to support data collection efforts. For ongoing data collection, assignment of in-house budget is required. Within future work mWater could work to support the relevant city departments in the development of these budgets.

Service delivery

Several findings were made regarding service delivery aspects of the project. Training of mWater users was important in the delivery of the technology to the City. A small, dedicated group of data collectors were trained, and given refresher training at a later date in the project. mWater staff observed that some participants who were not as familiar with the use of smartphones and/or computers required more support throughout the project. In future work it will remain important for the implementing staff (mWater or Mwanza City) to carefully observe which users may need more help learning how to use a smartphone and/or the app. Additionally it was found that users did show a slight increase after a stipend was given, but that this fell after time and rose again when mWater staff were present. More regular spot-checks by stakeholder managers may help to maintain higher levels of data collection.

In terms of delivery of water quality supply kits, the project encountered several hurdles, finding that there was not a viable local supplier or business that could act as a local distributor, nor was it possible for government groups to import the test kits. This implies that for water quality field testing to continue, mWater will have to continue act as the distributor in Mwanza, and that other options may have to be reviewed for the longer term.

Product development

Feedback from mWater users and other stakeholders was incorporated into mWater software development throughout the project (see **Implementation: Software development**, above). Important Product Development aspects that emerged from this project were:

- Translation of the app to Swahili
- Flexible survey utility
- Privacy settings
- Creation and management of Groups of users
- Offline performance of the app
- Multiple platform compatibility across all smart phones, tablets and computers through a browser window or the native android app
- Database upgrade to NoSQL
- Background software upgrades

Additionally, other feedback that may be addressed in later development of mWater included the ability to take notes in a local language and incorporate this into the mWater report of the survey, and to improve the count feature for microbiological tests that utilizes a smart phone camera. Future software support is needed to overcome the focus problems that are common with various smartphone cameras.

MWAUWASA's feedback centered on the outputs of the app; a request for a results view in the app was made, alongside a request for the app to provide health workers with suggestions and best practices based on the results from the survey(s) conducted. MWAUWASA also expressed interest in water meter reading applications, in order for their staff to more easily be able to incorporate this information into a digital form. These requests were not addressed as they fell outside the scope of the project and implied larger time and budget requirements than the project was capable of.

Other feedback that was not addressed in software development, due to time and budget restrictions and other prioritized development included a request from Environmental Health Workers. In order to assist their reporting, this stakeholder group suggested that the app produce reports in a format such that water safety information can be posted on local boards.

Cost-effectiveness & Competitive Landscape

There are two main aspects to be considered relative to the competitive landscape where the project is developing solutions; (1) water quality testing and (2) reporting systems and/or tools.

In Mwanza the standard practice for water quality testing (prior to this project) is an expensive and lengthy procedure carried out by the Lake Victoria Basin Lab. Samples are taken at the source and brought to the laboratory for testing. Each test costs around US$ 100 to complete, and as such few tests are carried out, especially with regard to water points that are not fed by the municipal piped water system. Additionally, the tests require trained laboratory technicians to carry them out; Lake Victoria Lab only has 5 trained technicians, and so test numbers are also limited by human resources.

The field test kit that mWater has developed allows test to be carried out by trained Health Workers and MWAUWASA staff, on site or at their offices, in order to give red flag indications of where further laboratory testing may be required. Each test kit costs $5-10 and can be completed within 24 hours. However, import challenges must be overcome in order for this to become effective and mWater is awaiting approval for import tax exemption from the Tanzania Revenue Authority.

With regards to reporting systems and tools, there are several other solutions that are operating within the competitive landscape. A short analysis is given in the **Table 2** below.

Table 2: Analysis of products within the mWater competitive landscape

Reporting system / tool	Comments
Paper- and excel-based reporting	+ Can be developed in local language(s) + Does not rely on internet/mobile connection + Associated cost: Relatively low – printing costs, human resources and transport costs. − Requires power supply for computer for excel data entry − Mapping requires hand-held GPS and enumerators competent in GPS use − High risk of loss of paper surveys, excel files − Data review for quality control difficult in excel form − GPS data often misreported giving incorrect mapping points − Version control very difficult with multiple excel files − Data privacy and security issues high risk with large enumerator teams, risk of survey loss and version control − High level of management and coordination required, which increases dramatically with survey size increasing − Mapping software required if mapping is to be undertaken with data – this may require internet connection
Online & mobile survey tools e.g. Survey Monkey, Magpi	+ Digital tools that can improve efficiency in terms of time to develop, complete and analyze surveys − Not specialized to the Development or Municipal Utilities sectors − Most require a smart phone − Requires internet / mobile data connection and power supply (offline functionality often not possible) − Most tools operate on a Freemium model, requiring purchase of monthly subscriptions or packages for access to feature − Mapping features often not available in these models and would require separate software − Local language translations can be difficult or not possible
Specialized monitoring tools e.g. ODK, Akvo Flow	+ Specialized tools for monitoring in Development work that can improve efficiency in terms of time to develop, complete and analyze surveys and mapping exercises + Several that offer mapping and survey functionality + Some can operate on standard mobile phones (“dumb” phones) (e.g. ODK) − Some require smart phones (e.g. Akvo Flow) − Some require an IT expert (e.g. ODK requires a server set-up)

Reporting system / tool	Comments
	− Cost: Many follow Freemium models whilst others may have expensive yearly subscriptions (up to US$15,000 per project/organization) − Offline functionality often poor − Feature development can be slow due to product development question in an established product
mWater	+ Specialized tool for monitoring WASH in Development work that can improve efficiency in terms of time to develop, complete and analyze surveys and mapping exercises + Free app and portal + Free training manuals available online + Free remote support for queries / issues + Offline functionality outside of internet / mobile data connection + Surveying and mapping features + Viewer and approval levels may be set for data privacy and security + Demand driven feature development − Requires smart phone − Requires power supply for mobile phone charging − Requires internet/mobile data connection for initial connection to app / portal

Similarly to our closest competitors, mWater requires the use of a smartphone or mobile device. However, mWater always aims to advise the most appropriate locally available device around the US$100 – US$150 range. A large competitive advantage of mWater over our competitors is our investor model, which allows mWater users to access the App and Portal for free, rather than paying for subscriptions or access features through Freemium models. The associated costs of running and developing mWater are covered by larger organizations who wish to invest in a free, public platform that they may also use for their own monitoring and evaluation needs.

Through the US$100,000 grant from the USAID DIV Fund, mWater was able to assess water quality in two wards of Mwanza, where the 500 water points surveyed provide water to collective populations of over 88,000 people. The influence of this project within MWAUWASA and City Government decision making will impact over 635,730 people living in the Mwanza City District[4].

Since the inception of this project, mWater has grown to include 3,000 free users in 56 countries, and a portfolio of over 10 large clients and investors operating in the INGO WASH sector. Major new investors, including Water.org, WaterAid, and The World Bank have collectively contributed funding that exceeds the initial USAID investment. This has allowed mWater to expand into a full

[4] Mwanza City Council. http://www.mwanzacity.go.tz/Population.php

featured mobile survey and data management platform, including the ability to manage users and data, visualize results, and download data for offline analysis.

Through the work undertaken during this USAID DIV project, the app has been translated into Swahili, allowing easier reach to over 50 million people in East Africa[5]. mWater aims to release the mWater Surveyor App in French, Spanish, Arabic and Hindi soon, with translations of the Portal later, in order to reach larger numbers of beneficiaries. Currently, free training manuals for the app and portal are available for download on the mWater website, and mWater plans to develop training videos to accompany them, allowing free users to learn by themselves or train their own enumerator teams, rather than incurring training costs. Finally, mWater participates in the Open Source community by posting our public code on GitHub, allowing other users to develop their own software where they prefer. This is important as much of the code is applicable to monitoring of any project or issue, and is not constrained to only monitoring WASH matters, giving endless possibilities for the impact of the use of the code by other groups.

Scaling Plan

Future scaling of this project may take several paths given its initial success. Aside from the monitoring of water points, MWAUWASA expressed interest in water meter reading applications, in order for their staff to more easily be able to incorporate this information into a digital form. According to the most recent MWAUWASA Business Plan, the most pressing business challenge for the utility is the high level of non-revenue water, which is estimated to be as high as approximately 40% of overall production. The causes of non-revenue water include physical losses due to leaks and commercial losses caused by failed metering systems, meter-tampering and illegal connections. This paper-to-digital move may involve similar development of the mWater App's ability to read photographs taken of meters, as was developed for the microbiological test kits. Training of MWAUWASA meter readers and other technicians would be required. Additionally integrating task management systems that would be utilized with recorded meter readings would also be necessary. These would both require the continued engagement of MWAUWASA management, and would necessitate a dedicated one-off training budget, that could be provided by a grant such as DIV. A possible increase to the existing metering operations budget may also be required, and sustainable sources for this would have to be identified during the project if required, ideally coming from metering payments.

Aside from the metering improvements that could be made the Project would plan to expand the current monitoring framework alongside an additional mapping component in order to support MWAUWASA's decision to invest in chlorinated piped supply over shallow wells, informed by the findings of this work.

[5] Swahili Language, Stanford. http://swahililanguage.stanford.edu/

From the existing mapping of water points undertaken in this Phase I work, mWater will support MWAUWASA to undertake digital mapping of the existing piped water supply system. In addition to this, socio-economic mapping and data collection will be undertaken, including Progress out of Poverty Indices, using the mWater platform. By combining this information to build a market-gradient map, mWater will support MWAUWASA to identify areas for network expansion using tax collection and metering, whilst also identifying vulnerable areas that may not be able to afford piped-water under tax schemes. This areas could be provided with kiosks from the piped supply, where extensions to the network can be funded through taxes from more affluent areas.

This extension of the Phase I work would require the continued engagement of the Ministry of Water, MWAUASA, Lake Victoria Laboratory and the City Health Department, as well as more stakeholder involvement from communities, existing kiosk owners and relevant engineering services that would be capable of extending the piped network. This Phase II extension would aim to extend piped services in order to rehabilitate existing or install new up to 20 water kiosks in vulnerable areas of Mwanza, reaching an estimated 50,000 citizens with safe water. In order to implement a pilot in four wards, a two year implementation would be planned, with the first year being focused on data-driven decision making, and the second with network expansion and kiosk construction.

Finally, there may also be opportunity for mWater to begin working with a second mWater application in Mwanza, BroadStreet. BroadStreet is an application to support health worker reporting of diarrheal diseases and associated needs. Given the findings that Health Care professionals shared concern that diarrheal disease and safe water are significant priorities in the communities surveyed but did not have unified responses regarding how diarrheal disease should be reported and were unclear on the current reporting mechanisms in their district, suggests that a more standardized reporting system would benefit the health professionals. This could be coordinated with the expansion of safe, piped water supply, or may be developed as a stand alone intervention.

Annex 1 – Data collection results and analysis

Table 3: Summary table of data from trained mWater users in Mwanza (USAID 2013-2014).

Role	Gender	Age	Manager?	Tech Score	Prof Score	Motiv. Score	Language	Total tests	Incentive response	Tests by month	Total Sites	Sites by month
Community Development	F	30 - 39	N	5	8	2	English	26	0.0		18	
Community Development	M	30 - 39	N	5	8	2	English	56	0.2		19	
Public Health	M	40 - 49	Y	7	8	4	English	0	0.0		0	
Public Health	M	20 - 29	N	4	6	2	Swahili	51	0.2		11	
Public Health	F	40 - 49	N	5	6	2	Swahili	44	4.5		29	
Public Health	M	30 - 39	N	6	7	3	English	31	0.0		15	
Public Health	M	50 - 59	N	4	7	2	English	57	0.3		22	
Public Health	F	30 - 39	Y	6	6	2	Swahili	47	0.0		9	
Utility	M	30 - 39	Y	7	8	3	English	5	0.0		2	
Utility	M	50 - 59	N	4	2	2	Swahili	0	0.0		0	
Utility	F	30 - 39	Y	6	8	2	English	15	0.1		7	
Utility	F	30 - 39	N	7	7	1	English	16	0.0		2	
Utility	M	30 - 39	Y	7	7	1	English	2	0.0		0	
Utility	M	30 - 39	N	7	8	4	English	97	0.5		15	
Utility	M	40 - 49	Y	6	7	4	English	0	0.0		0	
Utility	M	40 - 49	Y	7	8	3	English	0	0.0		0	
Utility Tank Operator	M	40 - 49	N	4	2	4	Swahili	52	0.0		5	
Utility Tank Operator	F	50 - 59	N	5	4	3	Swahili	42	0.9		11	
Utility Tank Operator	F	50 - 59	N	4	3	3	Swahili	50	0.3		5	
Utility Tank Operator	F	40 - 49	N	4	2	4	Swahili	28	0.4		4	
Water Quality Lab	M	40 - 49	N	7	7	3	English	258	0.4		20	
Water Quality Lab	M	20 - 29	N	7	8	4	English	0	0.0		0	
Water Quality Lab	F	40 - 49	N	8	6	3	Swahili	42	0.4		17	
Water Quality Lab	M	30 - 39	Y	6	7	2	English	0	0.0		0	

Table 4: Scoring structure for baseline experience of mWater users

Criteria	Question	Answer & related score
Technical experience with smartphones and technology (Maximum score of 9)	Do you own a mobile phone?	Yes =1 No =0
	How many mobile phones do you own?	None =0 One =1 Two =2
	Do you have an Android phone?	Yes =1 No =0
	Have you used a smartphone before?	Yes =1 No =0
	Have you used a phone application with maps before?	Yes =1 No =0
	Do you use your mobile phone for SMS messages?	Yes, every day =1 Sometimes =0.5 No =0
	Do you have a Facebook account?	Yes =1 No =0
	Do you have a mobile banking account?	Yes =1 No =0
Professional experience and literacy level (Maximum score of 8)	Do you have a managerial role or a technician/field worker role in your job?	Manager =1 Technician =0.5
	What is your highest educational level?	Primary only =1 Some secondary school =2 Graduated secondary school =3 Certificate of training =4 Some university =5 Graduated university =6
	In which language do you prefer reading?	English =1 Swahili =0.5
Motivation score (Maximum score of 4)	Have you ever performed a water test?	Yes =1 No =0
	Have you or anyone in your family suffered a waterborne disease or illness recently?	Yes =1 No =0
	Is water contamination a problem for your community?	Yes, very much =1 Sometimes =0.75 Not very much =0.5 No, not at all =0
	If you observe a case of diarrheal disease or a contaminated water source, where or to whom would you report it?	Reports to health office =1 Reports to a government office that is not health office =0.5 Doesn't report to any office =0

Table 5: R-Analysis of mWater user data, determining factors for participation

```
> str(mwanza)
'data.frame':   24 obs. of  13 variables:
 $ Role             : Factor w/ 5 levels "Community Development",..: 1 1 2 2 2 2 2 2 3 3 ...
 $ Gender           : Factor w/ 2 levels "F","M": 1 2 2 2 1 2 2 1 2 2 ...
 $ Age              : Factor w/ 5 levels "20 - 29","30 - 39",..: 2 2 3 1 4 2 5 2 2 5 ...
 $ Manager          : Factor w/ 2 levels "N","Y": 1 1 2 1 1 1 1 2 2 1 ...
 $ TechScore        : int  5 5 7 4 5 6 4 6 7 4 ...
 $ ProfScore        : int  8 8 8 6 6 7 7 6 8 2 ...
 $ MotivScore       : int  2 2 4 2 2 3 2 2 3 2 ...
 $ Language         : Factor w/ 2 levels "English","Swahili": 1 1 1 2 2 1 1 2 1 2 ...
 $ Tests            : int  26 56 0 51 44 31 57 47 5 0 ...
 $ IncentiveResponse: num  0 0.2 0 0.2 4.5 0 0.3 0 0 0 ...
 $ Sites            : int  18 19 0 11 29 15 22 9 2 0 ...
 $ username         : Factor w/ 23 levels "-","adilimrema",..: 2 20 3 8 9 14 15 22 6 7 ...
 $ Name             : Factor w/ 24 levels "Adili Mrema",..: 1 9 4 12 3 18 6 23 8 11 ...
>
>
tests.attributes <- lm(Tests ~ Role + Gender + Age + Manager, data=mwanza)
sites.attributes <- lm(Sites ~ Role + Gender + Age + Manager, data=mwanza)
incen.attributes <- lm(Sites ~ Role + Gender + Age + Manager, data=mwanza)
incen.attributes <- lm(IncentiveResponse ~ Role + Gender + Age + Manager, data=mwanza)
tests.scores <- lm(Tests ~ TechScore + ProfScore + MotivScore, data=mwanza)
sites.scores <- lm(Sites ~ TechScore + ProfScore + MotivScore, data=mwanza)
incen.scores <- lm(IncentiveResponse ~ TechScore + ProfScore + MotivScore, data=mwanza)
summary(tests.attributes)

Call:
lm(formula = Tests ~ Role + Gender + Age + Manager, data = mwanza)

Residuals:
    Min      1Q  Median      3Q     Max
-51.827 -23.528  -5.231  18.140 144.296

Coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)                -37.267     67.676  -0.551   0.5905
RolePublic Health           27.008     50.530   0.534   0.6014
RoleUtility                  9.088     49.039   0.185   0.8556
RoleUtility Tank Operator   15.145     57.176   0.265   0.7950
RoleWater Quality Lab       58.770     53.450   1.100   0.2901
GenderM                     19.877     25.774   0.771   0.4534
Age30 - 39                  68.328     50.767   1.346   0.1997
Age40 - 49                  72.323     47.188   1.533   0.1476
Age50 - 59                  47.981     53.014   0.905   0.3807
ManagerY                   -58.621     30.064  -1.950   0.0715 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 54.32 on 14 degrees of freedom
Multiple R-squared: 0.3701,     Adjusted R-squared: -0.03488
F-statistic: 0.9139 on 9 and 14 DF,  p-value: 0.5402

> summary(sites.attributes)

Call:
lm(formula = Sites ~ Role + Gender + Age + Manager, data = mwanza)

Residuals:
    Min      1Q  Median      3Q     Max
-9.8533 -2.5539  0.2036  3.8168  6.6335

Coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)                  9.277      7.523   1.233  0.23782
RolePublic Health            1.427      5.617   0.254  0.80320
```

```
RoleUtility                 -7.939      5.451  -1.456  0.16733
RoleUtility Tank Operator  -13.045      6.356  -2.053  0.05930 .
RoleWater Quality Lab       -3.810      5.941  -0.641  0.53167
GenderM                     -2.585      2.865  -0.902  0.38217
Age30 - 39                  10.516      5.643   1.863  0.08352 .
Age40 - 49                  11.663      5.245   2.223  0.04316 *
Age50 - 59                   9.666      5.893   1.640  0.12321
ManagerY                   -10.952      3.342  -3.277  0.00551 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 6.038 on 14 degrees of freedom
Multiple R-squared: 0.7066,      Adjusted R-squared: 0.5181
F-statistic: 3.747 on 9 and 14 DF,  p-value: 0.01355

> summary(incen.attributes)

Call:
lm(formula = IncentiveResponse ~ Role + Gender + Age + Manager,
    data = mwanza)

Residuals:
    Min      1Q  Median      3Q     Max
-0.8175 -0.4355 -0.1639  0.4016  2.5738

Coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)                 0.2876     1.1376   0.253    0.804
RolePublic Health           0.8323     0.8494   0.980    0.344
RoleUtility                 0.3415     0.8243   0.414    0.685
RoleUtility Tank Operator  -0.2503     0.9611  -0.260    0.798
RoleWater Quality Lab       0.1236     0.8985   0.138    0.893
GenderM                    -0.6655     0.4332  -1.536    0.147
Age30 - 39                  0.1452     0.8534   0.170    0.867
Age40 - 49                  0.8064     0.7932   1.017    0.327
Age50 - 59                  0.2519     0.8911   0.283    0.782
ManagerY                   -0.6060     0.5054  -1.199    0.250

Residual standard error: 0.9131 on 14 degrees of freedom
Multiple R-squared: 0.3939,      Adjusted R-squared: 0.004277
F-statistic: 1.011 on 9 and 14 DF,  p-value: 0.4753

> summary(tests.scores)

Call:
lm(formula = Tests ~ TechScore + ProfScore + MotivScore, data = mwanza)

Residuals:
    Min      1Q  Median      3Q     Max
-45.884 -34.189  -7.873  11.438 216.811

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  19.1330    62.5007   0.306    0.763
TechScore     1.3727    12.5815   0.109    0.914
ProfScore    -0.4095     7.9429  -0.052    0.959
MotivScore    5.1046    13.0124   0.392    0.699

Residual standard error: 56.98 on 20 degrees of freedom
Multiple R-squared: 0.009935,    Adjusted R-squared: -0.1386
F-statistic: 0.0669 on 3 and 20 DF,  p-value: 0.9768

> summary(sites.scores)

Call:
lm(formula = Sites ~ TechScore + ProfScore + MotivScore, data = mwanza)
```

```
Residuals:
   Min     1Q Median     3Q    Max 
-9.831 -7.145 -2.374  4.838 17.944 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)  
(Intercept)  16.8263     9.4637   1.778   0.0906 .
TechScore    -2.9471     1.9050  -1.547   0.1375  
ProfScore     1.7223     1.2027   1.432   0.1676  
MotivScore   -0.6842     1.9703  -0.347   0.7320  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 8.627 on 20 degrees of freedom
Multiple R-squared: 0.1445,	Adjusted R-squared: 0.01616 
F-statistic: 1.126 on 3 and 20 DF,  p-value: 0.3623

> summary(incen.scores)

Call:
lm(formula = IncentiveResponse ~ TechScore + ProfScore + MotivScore, 
    data = mwanza)

Residuals:
    Min      1Q  Median      3Q     Max 
-0.6065 -0.3671 -0.2373 -0.0775  4.0212 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.186752   1.058938   1.121    0.276
TechScore   -0.097234   0.213165  -0.456    0.653
ProfScore   -0.007616   0.134574  -0.057    0.955
MotivScore  -0.088021   0.220466  -0.399    0.694

Residual standard error: 0.9653 on 20 degrees of freedom
Multiple R-squared: 0.03224,	Adjusted R-squared: -0.1129 
F-statistic: 0.2221 on 3 and 20 DF,  p-value: 0.8799

> summary(incen.scores)
> summary(lm(Tests ~ Age, data=mwanza))

Call:
lm(formula = Tests ~ Age, data = mwanza)

Residuals:
   Min     1Q Median     3Q    Max 
-60.57 -26.00 -11.04  13.94 197.43 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)    25.50      39.58   0.644    0.527
Age30 - 39      4.00      43.36   0.092    0.927
Age36 - 50    -25.50      68.56  -0.372    0.714
Age40 - 49     35.07      44.88   0.781    0.444
Age50 - 59     11.75      48.48   0.242    0.811

Residual standard error: 55.98 on 19 degrees of freedom
Multiple R-squared: 0.09219,	Adjusted R-squared: -0.09893 
F-statistic: 0.4824 on 4 and 19 DF,  p-value: 0.7484

> summary(lm(Sites ~ Age, data=mwanza))

Call:
lm(formula = Sites ~ Age, data = mwanza)

Residuals:
    Min      1Q  Median      3Q     Max 
```

```
-10.714  -6.704  -0.850   6.300  18.286

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)    5.500      6.515   0.844    0.409
Age30 - 39     3.200      7.137   0.448    0.659
Age36 - 50    -5.500     11.285  -0.487    0.632
Age40 - 49     5.214      7.388   0.706    0.489
Age50 - 59     4.000      7.979   0.501    0.622

Residual standard error: 9.214 on 19 degrees of freedom
Multiple R-squared: 0.07295,     Adjusted R-squared: -0.1222
F-statistic: 0.3738 on 4 and 19 DF,  p-value: 0.8244

>
```