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Reena Chudgar Date

Water, Sanitation and Hygiene Practices in Dawa and Tugakope: A Multiple Methods Baseline Assessment of Two Rural Communities in Ghana

By

Reena Chudgar
Master of Public Health

Hubert Department of Global Health

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Christine Moe, PhD
Committee Chair

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By

Reena Chudgar

BS Chemistry
Emory University
2005

Thesis Committee Chair: Christine Moe, PhD

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Abstract

Water, Sanitation and Hygiene Practices in Dawa and Tugakope: A Multiple Methods Baseline Assessment of Two Rural Communities in Ghana
By Reena Chudgar

Background: An estimated 884 million people lack access to improved water and 2.6 billion people lack access to improved sanitation worldwide. In rural Ghana, 26% of the population does not have access to improved water and 93% to an improved latrine. Diarrheal diseases are the second leading cause of death worldwide; 90% of this burden is attributed to poor water, sanitation and hygiene (WASH) practices.

Objectives: This study performed a baseline WASH assessment of two rural communities in Ghana (Dawa and Tugakope) to understand access, use and practices.

Methods: Four data collection approaches were used: 1) GPS mapping of households, water sources and sanitation facilities, 2) household questionnaires on WASH knowledge, attitudes and practices, 3) microbiological water quality testing (Dawa), and 4) focus group discussions (not included in analysis). Inter- and intra- community comparisons were made.

Results: In total, 87 households in Dawa and 31 households in Tugakope participated. Ninety percent of households in Dawa and 3% in Tugakope used standpipe water as their primary drinking water source. Distance to primary drinking water source was significantly shorter in Dawa (286.8 meters) compared to Tugakope (802.7meters). Water quality testing indicated high concentrations of *E. coli* contamination in household drinking water. Open defecation was widely practiced in Dawa (79%) whereas most households in Tugakope reported using VIP latrines (74%). The presence of soap in the household was significantly less in Dawa (59%) compared to Tugakope (94%). Point prevalence of diarrhea among children under five years was 26% in Dawa and 17% in Tugakope, based on one week recall.

Discussion: Improved WASH practices are associated with reduced diarrheal prevalence. Uptake of interventions that increase access to improved WASH is related to community-specific factors such as distance, cost, habit, taste, and sense of ownership. Additionally, good quality source water does not ensure safe household drinking water. We measured high concentrations of *E. coli* in household stored water indicating post-source contamination that may be associated with source water quality, storage practices, household hygiene, and handling practices. Our assessment of these communities demonstrates that appropriate WASH interventions to reduce diarrheal disease require understanding community-specific factors that affect WASH.

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Introduction:

It is estimated that over 884 million people do not have access to safe drinking water and over 2.5 billion people lack improved sanitation facilities (UNICEF, 2009). These alarmingly high numbers have sparked movement among individuals and organizations across the world towards implementing programs and policies to reduce the number of people lacking access to these basic human needs. In 2001, the United Nations developed eight Millennium Development Goals (MDGs) in order to spur development and encourage growth, especially among the world's poorest nations. One target of the environmental sustainability MDG (Number Seven) aims to "halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation"(WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, 2010). With this specific focus on water and sanitation, development organizations have implemented programs to increase access to improved water sources, basic sanitation, and to improve hygiene practices. Increasing access to these basic human necessities also has an impact on many of the other MDG targets. Specifically, reaching this target can also beneficially affect child mortality, primary education, hygiene practices, gender equality, poverty, and disease. Women and children usually bear primary responsibility for water collection, and children are often late or absent from school because the water source is far.

Diarrheal diseases are the second leading cause of death worldwide among children under five years of age. Approximately 5,000 children die of water and sanitation-related diseases each day, but these deaths are largely preventable (Joint Monitoring Programme for Water Supply and Sanitation (JMP), 2008; Khan, 2008). An estimated 94% of the burden of diarrheal disease is attributable to the environment and linked with risk factors including unsafe drinking water (access to, availability of, and water quality), lack of adequate sanitation, and poor hygiene practices (Pruss-Ustun & Corvalan, 2006), which lead to exposures to fecal-oral pathogens in water, food and the environment. Approximately 40% of school age children suffer worm infections due to inadequate sanitation and hygiene practices (UNICEF, 2009). Therefore, increasing access to improved water and sanitation is not the only factor to consider if the overall goal is to reduce the burden of diarrheal diseases. Other factors such as hygiene practices and water quality also play a key role in transmission of pathogens. There is considerable evidence that improvements in water, sanitation and hygiene practices have substantial benefits in reducing the disease burden and child mortality (Fewtrell & 0Colford, 2005; UNICEF, 2009).

In 2008, the WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation, the official United Nations vehicle for monitoring progress towards the MDG targets and one of the principal platforms for data dissemination, reported the global, regional and national progress towards reaching the water and sanitation targets by 2015. The JMP reported that the world is on track to meet the drinking water target and that more than 90% of the global population will use improved drinking water sources by 2015. Currently, approximately 87% of the world's population uses improved drinking water sources, compared to only 77% in 1990(WHO/UNICEF Joint Monitoring

Programme for Water Supply and Sanitation, 2010). Improved water sources do not necessarily imply safe drinking water. Many boreholes and other “improved” water sources may not have treatment and therefore, if the aquifer is contaminated, then the source itself could be contaminated. Additionally, there could be contamination occurring in pipes, or post- collection. Therefore, the proportion of the global population with safe drinking water could be less when taking this into account.

The initiative to increase access to sanitation services is currently not on track to meet the MDG sanitation target. The JMP reported that between 1990 and 2006, the proportion of people without improved sanitation decreased by only 8% and currently about 39% of the global population still lack improved sanitation facilities (WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, 2010). To raise awareness and encourage progress towards the MDG sanitation target, the United Nations General Assembly declared 2008 the International Year of Sanitation. This specific emphasis aimed to generate more focus on sanitation in order to increase awareness and efforts towards reaching the sanitation target.

Currently, there are several limiting factors towards reaching the MDGs. Research has indicated that WASH interventions have resulted in reductions in diarrheal disease. However, there is a disconnect between research findings and actual implementation. Several factors influence the effectiveness of WASH interventions, such as uptake by community, personal behaviors, sustainability, and maintenance of systems. Each community will have different reasons that contribute to uptake. Therefore, to have the most effective intervention, understanding community-specific factors is essential, which can be accomplished by performing a comprehensive WASH baseline assessment. If we understand what community members want and what factors will influence use of improved WASH, then tailored interventions can be designed that will result in better implementation and effectiveness in reducing diarrheal disease in the communities.

Background:

Global burden of diarrheal disease:

The high disease burden attributable to poor water, sanitation and hygiene practices has been of concern to researchers throughout the years. Several studies have measured the average number of diarrheal episodes (typically defined as 3 or more loose stools in 24 hours) per child per year and morbidity and mortality due to diarrheal disease.

Snyder and Merson evaluated data from 25 published studies conducted in the 1950s, 1960s and 1970s to assess the annual morbidity and mortality from diarrheal diseases in developing countries (Snyder & Merson, 1982). The studies were selected if they contained an active surveillance component, where morbidity surveillance was carried out at least once every two weeks, and mortality surveillance at least once a month. From their analysis, the yearly morbidity and mortality from diarrheal disease for children in Africa, Asia (excluding China) and Latin America were 744 – 1000 million episodes of diarrhea and 4.6 million deaths. The average diarrheal incidence among children under 5 years old was 2.2 episodes per child per year for the studies analyzed and 3.0 for those with the smallest populations and more frequent surveillance (Snyder & Merson, 1982). In 1992, Bern *et al.* reevaluated these estimates based on studies published from 1980 through 1992 and found that the average incidence among children under 5 years old was 2.6 episodes per child per year. Compared to the older findings, the average incidence had increased very slightly. The authors found that the incidence varied greatly by region which could be attributed to the intensity of surveillance, the sample size, or regional risk factors. While the newer incidence estimate varied only slightly from the 1982 estimates, the estimated number of deaths per year from diarrhea was 3.3 million (range 1.5-5.1 million), significantly lower than the 1982 estimate (Bern, Martinez, Zoysa, & Glass, 1992). Because of differences in measurement techniques, definitions, surveillance frequency, and sample size, the 1982 and 1992 estimates are difficult to compare. This is true for most of the research that used episodes per year and deaths per year as a measure of burden of disease. There was a need for a standardized measure that relied on common methods to assess the burden of disease (Murray & Lopez, 1997).

As indicated above, for over 50 years, studies have assessed the disease burden due to diarrheal diseases in a number of ways, prior to the development of Disability Adjusted Life Years (DALYs) as a common measure. DALYs are used to assess overall disease burden (World Health Organization) and are expressed as number of healthy years of life lost due to illness, disability, or premature death. They are used to help measure the burden of disease and the effectiveness of health interventions. DALYs can be used to look at the total health burden from poor WASH practices (i.e., a way to add the diarrheal disease burden to the helminth burden). Furthermore, DALYs allow comparison of the disease burden due to WASH to the disease burden due to malaria, or HIV/AIDS, or schistosomiasis, etc. This is important for implementing organizations to be able to plan appropriate interventions based on the disease or risk factor with the greatest DALYs.

Pruss *et al.* (2002) estimate the diarrheal disease burden attributable to water, sanitation and hygiene exposures and diarrheal disease outcomes to be 4% of all deaths and 5.7% of all DALYs. The total DALYs are measured primarily from intervention studies, thus suggesting that the burden is largely preventable with improvements in water, sanitation and hygiene practices. Assessing the disease burden is important to develop and implement appropriate interventions that target specific risk factors which, if eliminated, can contribute to reducing the disease burden.

Strategies to reduce the diarrheal disease burden:

Researchers have investigated ways to reduce the burden of disease associated with lack of safe water, poor sanitation and hygiene for many years. Increasing access to water and sanitation, and improving water quality and hygiene practices were theorized and proven to be effective ways to prevent death (Jones, Steketee, Black, Bhutta, & Morris, 2003). Researchers have since been striving to perfect interventions that will result in the maximum reduction of the diarrheal disease burden. A common measure used to assess effectiveness is reduction in the risk of diarrheal disease as a result of a particular, or combinations of, intervention. Diarrheal diseases have a wide array of risk factors, and several of these can often contribute to an infection. Therefore, a single intervention, while important, may not necessarily result in a noticeable reduction in the overall burden of disease from diarrhea (Pruss-Ustun, Kay, Fewtrell, & Bartram, 2004; VanDerslice & Briscoe, 1995). Nevertheless, researchers have found ways to quantify the impact of

WASH interventions on health in order to shape future interventions and water, sanitation and hygiene policy.

Esrey *et al.* (1991) performed an influential systematic review of 144 studies to assess the impact of increased access to water supply and sanitation on diarrheal diseases. An analysis was performed to quantify differences in diarrheal disease, between those with access to safe water and sanitation, and those without. Using data from only the methodologically sound studies, the authors estimated the median reduction in diarrhea-specific mortality to be 65% and 55% in overall child mortality, attributable to one or more water, sanitation and hygiene interventions. Sanitation improvements alone were associated with the highest reduction in diarrheal disease morbidity (36%) (S. A. Esrey, Potash, Roberts, & Shiff, 1991).

Esrey (1996) conducted a follow-up study and analyzed data collected in the late 1980s from eight countries, including Ghana, to assess reductions in the diarrheal disease burden from interventions that improve water, sanitation and hygiene conditions. In addition to studying diarrheal disease morbidity, as in the 1991 study, Esrey also examined additional health outcome measures. Over rural and urban areas, Esrey determined that improvements in water and sanitation led to incremental health benefits such as reductions in the incidence of diarrhea and increases in weight and height of children. Health benefits associated with sanitation improvements were greater than those from water supply improvements, which was similar to the earlier assessment. Urban dwellers showed more pronounced health benefits from sanitation improvements than rural dwellers, and benefits from improvements in water only occurred when coupled with sanitation improvements (S. Esrey, 1996). In response to Esrey's analysis, Cairncross and Kolsky (1997) criticized the results as inconsistent and lacking a causal link between the interventions and the resulting outcomes (Cairncross & Kolsky, 1997).

More recently, Fewtrell *et al.* (2005) combined data from 46 WASH studies using meta-analysis and focused on less developed countries. All the interventions in this analysis were found to reduce the risk of diarrheal illness to a similar degree. Additionally, water quality interventions were found to be more effective than was previously reported. There was found to be a mean risk reduction of 37% associated with hygiene interventions, a mean risk reduction of 25% associated with water supply interventions, a mean risk reduction of 31% associated with water quality interventions, and a mean risk reduction of 33% associated with multiple, combined interventions. The authors noted the lack of rigorous studies focusing on sanitation interventions, and found only two that fit the meta-analysis criteria; these showed a mean risk reduction of 32%. The authors also observed that multiple interventions (i.e., improved water and sanitation) were not more effective at reducing the risk of diarrheal disease than interventions that had a single focus.

Fewtrell and Colford (2005) again performed a meta-analysis of 29 studies to estimate the effectiveness of different water, sanitation and hygiene interventions to reduce levels of diarrheal illness in developing countries and calculated the relative risk from each of the interventions. This differed from the previous study only on the number of studies that were included. Unlike the earlier analyses by Esrey and colleagues, Fewtrell and Colford found the greatest impact from the hygiene and household water treatment interventions. Excluding poor quality studies, hygiene interventions were associated with a 46% reduction in diarrheal disease risk, and household water quality treatment interventions were associated with a 34% decrease. Previous studies, as well as the MDGs, focus on increasing access to improve water, but this does not necessarily imply safe water or increased use (Gadgil, 1998). Fewtrell and Colford's analysis indicated that household water treatment is one of the most effective interventions for reducing the risk of diarrheal disease (Fewtrell & Colford, 2005).

As evidenced in Fewtrell and Colford's analysis, the effectiveness of water quality interventions is prominent. Many previous studies focused on quality of the water source and not at the household level (Esrey, Feachem, & Hughes, 1985; Esrey *et al.*, 1991). Targeting the water source for treatment is important to ensure safe water is being delivered to consumer. But, studies have found that water treatment at the household level, as well as intervention strategies such as safe storage of water in containers with narrow mouths, can contribute to keeping water potable (Gadgil, 1998; Jensen *et al.*, 2002) .

Recently, Clasen *et al.* (2007) performed a systematic review of 42 controlled trials to examine whether water quality interventions, especially household-based, are effective in reducing the diarrheal disease burden, even when not integrated with other common water, sanitation and hygiene interventions. The authors found that while the interventions to improve water quality are generally effective for reducing diarrheal disease occurrence among adults and children, the effectiveness of each type of intervention depends on a variety of conditions, such as uptake, sustainability, and access. The authors also found that household-based water quality interventions are more effective at preventing diarrhea than water source-based interventions. Water quality interventions were effective even in the absence of water supply or sanitation components, but did not seem to work synergistically when combined with other common interventions such as hygiene education, improved water supply, or improved sanitation facilities. The authors recognized the importance of other interventions types, however they emphasize the importance of cost-effectiveness and whether combined, integrated interventions are necessary given the effectiveness of household water quality interventions alone on health (Clasen *et al.*, 2007).

Baseline knowledge, practice, attitudes, and use surveys:

In order to estimate the diarrheal disease burden attributable to water, sanitation and hygiene, and help inform the MDG target of increasing access to improved water and sanitation, it is necessary to assess coverage, and to collect information about WASH knowledge, practices, and attitudes within the communities of interest. Monitoring changes in access to and use of improved water and sanitation systems, as well as improvements in hygiene behavior, are essential to track growth or decline in access and use. Baseline assessments are useful to identify the needs of a community, and to collect information to guide and shape future policy and interventions (Trykker, Simwambana, Kantu, & Eberhard, 1994). Additionally, baseline assessments provide preliminary information that can then be compared to future data collected. The WHO/UNICEF JMP compiles baseline data from communities in order to track progress towards the MDGs. The JMP has specific guidelines and definitions that are followed in order to make data comparable across districts, regions and countries. To measure increases or decreases in access, the JMP has specific definitions of what constitutes an "improved" water source or sanitation service. An "improved water source" is defined as piped water into a dwelling or public standpipe, borehole/tube well, protected dug well, protected spring, or rainwater. "Unimproved sources" include unprotected hand dug wells and springs, small carts with tank/drum, tanker truck, surface water, and bottled water. "Improved sanitation facilities" are defined as flush/pour-flush toilets that are connected to piped sewer systems or septic tanks, pit latrine, ventilated improved pit latrines, pit latrine with slab, or composting toilet. "Unimproved sanitation facilities" include other flush/pour flush latrines, open pit latrine, bucket latrine, hanging latrine, use of public facility, and open defecation. These definitions are used globally so that coverage can be evaluated accordingly (WHO & UNICEF Joint Monitoring Programme, 2008).

Children have an increased risk and susceptibility to many pathogens and diseases, such as diarrheal diseases, as their immune systems are still maturing. Therefore, much of the disease data collected focus on this group of the population. Mortality rates, especially infant and child, are measures of a country's health status, quality of life status, and socio-economic status, and are useful for informing health programs and policies (Ghana Statistical Service (GSS), Ghana Health Service (GHS), & IFC Macro, 2009). It is worth noting that, despite efforts to use common definitions, there are still inherent differences in data collected, which should be considered when performing meta-analyses.

Knowledge, attitudes and practice (KAP) surveys focus on measuring these indicators among the participants of a study. KAP studies tell us about the understanding of a topic, the feelings towards that topic and the actions or behaviors linked with that topic . A similar survey, the knowledge, practices and coverage (KPC) provides comparable information, but places an additional emphasis on coverage. These two data collection instruments are relevant to WASH because they allow for information to be collected on access, use, household water storage practices, water quality, and diarrheal disease prevalence, among other items. These surveys on the actual practices of households reveal information regarding potential exposures to pathogens through the various fecal-oral pathways.

The JMP estimates are based on compiling nationally representative data from household surveys and censuses collected by national statistics offices and international survey programs. One data source is The Demographic and Health Survey (DHS), funded by the United States Agency for International aid (USAID) and other donors, which is a program that collects and disseminates important data across the world. ICF Macro is the implementing company and works to continually improve data collection in order to provide useful, representative information for most countries (IFC Macro Measure DHS). Other surveys that are used by the JMP include the Multiple Indicator Cluster Surveys (MICS), World Health Surveys (WHS), and Living Standards Measurement Surveys (LSMS) (Joint Monitoring Programme for Water Supply and Sanitation, WHO, & UNICEF, 2010). All of these surveys collect a multitude of information from which the

JMP chooses the most relevant for tracking progress towards meeting the MDGs. For WASH, some of the specific indicators collected through the various surveys include: percentage of the population using improved water sources, type of water source used, time spent collecting water, persons responsible for water collection, percentage of the population using an improved sanitation facility, and type of sanitation facility. The JMP has recently pilot-tested a rapid assessment of drinking-water quality (RADWQ) project. While the results of this project varied greatly between countries, the RADWQ demonstrated that periodic water quality testing was not economically viable. The JMP provided the argument of opportunity cost, explaining that the resources used for performing water quality testing could instead be used to create additional water sources and sanitation facilities. They suggest incorporating a water quality component in new goals set after the current 2015 MDG target, as well as encouraging countries to develop their own frameworks for appraising water quality(WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, 2010).

In addition to the data sources used by the JMP to monitor progress towards the MDGs, there are other surveys that are used by different organizations for various purposes. These surveys may not follow the same definitions and methodologies as those used by the JMP, and therefore comparisons should be made with care. One example is the Food and Nutrition Technical Assistance (FANTA) guidelines, also funded by USAID, which includes their own water and sanitation indicators (Billig, Bendahmane, & Swindale, 1999). Some of the indicators are percentage of children under 36 months with diarrhea in the last 2 weeks, quantity of water used per capita per day, percentage of caregivers with appropriate handwashing behavior, percentage of population using hygienic sanitation facilities, percentage of households with year-round access to improved water, and percentage of households with access to a sanitation facility. It is clear that terminology between the JMP indicators and the ones listed in the FANTA guidelines is different. For example, FANTA defines the term “hygienic sanitation facility” as an excreta disposal facility where there are no feces on the floor or seat, and very few flies. This indicator takes the JMP indicator of access to an improved sanitation facility one step further, and assesses cleanliness. Another example is the definition of “access” used by FANTA, which is defined as either a direct connection or a public facility within 200 meters of the home. The JMP does not place distance restrictions on what is classified as an “improved” water source. FANTA also incorporates a hygiene component in their guidelines, indicating the importance of proper hygiene in reduction of fecal-oral pathogen transmission (Billig *et al.*, 1999).

Ultimately, the purpose of collecting this information, whether through baseline surveys performed by individual organizations for specific purposes, or through nationally representative surveys conducted every few years, is to provide information to inform policy, planning, monitoring and evaluation to improve the health and livelihood of individuals and the population as a whole.

Geographic Information Systems (GIS):

The use of GIS for spatial analysis is important for showing visual relationships between diseases and risk factors that may not be seen through other methods (Bessong, Odiyo, Musekene, & Tessema, 2009). Additionally, GIS allows investigations between demographic factors and environmental exposures, and their spatial distribution (Osei &

Duker, 2008). In the past, GIS has been used in surveillance of vector-borne diseases, water-borne diseases, environmental health, outbreak investigations, and analysis of disease planning and policy (by looking at spread of disease in a specific area) (Glass *et al.*, 1995). It is important and useful to examine the geographic distribution of disease when studying disease causation (Ali, Emch, Donnay, Yunus, & Sack, 2002). By capturing Global Position System (GPS) points of interest, datasets can be created and used to develop maps of disease distribution, water access points, distances to water source, spread of households throughout a community (i.e., location of one household in relation to another), sanitation facilities, etc, that can be distributed to interested parties. These maps are useful for analyzing spatial and temporal trends, determining geographic disease distributions, mapping vulnerable or at risk populations, planning interventions, monitoring trends over time, and informing appropriate allocation of resources (World Health Organization, 2010). One historical example that is referenced in many GIS conversations is John Snow's cholera map. By mapping the location of cholera victims in London in 1854, John Snow was able to visualize the clustering of victims in London. By visualizing the location of victims, Snow was able to identify the source of the outbreak (Goodchild, Haining, & Wise, 1992). The use of GIS to examine the spatial distribution of specific disease and risk factors is becoming widespread practice, especially since GPS devices have become affordable and easy to use. By mapping exposures and diseases, we may *see* relationships that are not obvious when looking at purely quantitative or qualitative data.

Water Quality Testing:

As Cairncross *et al.* (1996) wrote, there are two domains for pathogen transmission: "domestic domain" transmission and "public domain" transmission. Targeting the water source is important to ensure safe water is being delivered to the consumer. However, given the need to store water in the home, due to availability, distance and convenience, there has been evidence to show that the storage of water has been linked with increased contamination levels, even when collected from a clean source (Gadgil, 1998; Jensen *et al.*, 2002). Brick *et al.* (2004) studied water contamination levels and factors that may affect household water quality, such as container type and storage location. The authors found that 67% of the households had increased rates of contamination when the water was stored (between one and nine days). Several studies have investigated the association between reducing fecal contamination of household water and reducing diarrheal disease (Gundry, Wright, & Conroy, 2004; Mintz, Reiff, & Tauxe, 1995; Quick, Venezel, & Mintz, 1999).

Gundry *et al.* (2004) performed a systematic review of studies that investigated the relationship between diarrhea, cholera and the quality of drinking water at the point-of-use. The authors found a correlation between cholera and contaminated household water. But, the relationship between household water quality and diarrhea was not as prominent, although a small reduction in incidence of diarrhea was observed. The authors produce several explanations for the conflicting findings regarding diarrhea. The use of indicator bacteria measurements of water quality may not be a good measure of the risk from the wide variety of pathogens responsible for diarrhea and could explain the lack of a causal link between point-of-use water quality and diarrhea. Additionally, participant bias, a range of fecal-oral transmission pathways, and differing definitions of diarrhea were other plausible reasons listed as explanations for the discrepancy between better household water quality and reduction in the incidence of diarrhea.

Ghana:

Ghana is located on the coast of Western Africa and is bordered by Togo, Burkina Faso, and Cote d'Ivoire. In 2009, the population was estimated to be 23, 887,812 persons, and the country has a total land area of 238,533 square miles. Ghana has a tropical climate with two distinct rainy seasons from April to June and from September to November (Ghana Statistical Service (GSS), 2009). Half of Ghana's population lives in rural areas(WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, 2010). Several ethnic groups make up the population, with the Akans, Mole-Dagbon, Ewe, and Ga/Dangme being the largest groups. About 13% of Ghana's population is comprised of children less than five years of age, and the average household size is 3.7 persons per household. On average, approximately 21% of urban females have no education compared to 40% of rural females. In the Greater Accra Region, about 15% of women have no education, the lowest percent among any of the regions (Ghana Statistical Service (GSS), 2009).

Sanitation coverage still remains low in Ghana, where only 18% and 7% of the urban and rural populations, respectively, use an improved sanitation facility (13% total). Shared sanitation is extremely common in Ghana, and 54% of the population uses this type of sanitation facility. While a shared facility may have an improved structure, it is not considered an improved facility by the JMP because shared facilities have an increased likelihood of poor hygiene and un-sustainability. For rural areas specifically, 93% do not use an improved sanitation facility. Approximately 38% of the rural population uses a shared facility[1], 21% use an unimproved latrine, and 34% practice open defecation. The most common improved sanitation facilities used are flush/pour flush to septic tank/piped sewer system/pit latrine and VIP latrines for urban areas, and pit latrine with slabs, and VIP latrines for rural areas. The most common unimproved facilities used are pit latrines without slabs/open pit and no facility/bush/field for both urban and rural areas (Ghana Statistical Service (GSS), 2009).

For urban and rural areas of Ghana, the percent of the population with access to improved water is 90% and 74%, respectively (82% total) (WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, 2010). In Ghana, the most common sources of improved drinking water used are public tap/standpipe, piped water into dwelling/yard, tube well or borehole, and protected dug well for urban areas and tube well or borehole, public tap/standpipe, and protected dug wells for rural areas. Common unimproved sources include tanker trucks and bottled/sachet water in urban areas and unprotected dug wells, and surface water (such as dug-outs and streams) for rural areas (Ghana Statistical Service (GSS), 2009).

The overall under-five mortality rate in Ghana is 90 deaths for every 1000 live births. However, the mortality rates per region are markedly different and are affected by risk factors such as mother's education level and her age at birth. Diarrheal diseases are a major threat for this age group, as they are affected more than any other age group. In Ghana, 20% of children under five years of age experienced at least one episode of

[1] Shared sanitation facilities are defined as those of an otherwise acceptable type shared between two or more households. Public facilities fall into this category.

diarrhea during the two weeks preceding the DHS survey. Among these children, 3% experienced diarrhea with blood. The prevalence was lower among those using an improved drinking water source (19.8% for improved; 23.8% for not improved) as well as for those using improved latrines (12.8% for improved; 20.5% for not improved, including shared) (Ghana Statistical Service (GSS), 2009). In the Greater Accra Region, 12.4% of children under five years had diarrhea at least once in the two weeks prior to the DHS survey.

As the literature reveals, increasing safe water, improved sanitation and hygiene is not as simple as one may think. Exposure to fecal-oral pathogens causing diarrheal diseases can occur through several transmission routes including water availability, access, quality, fecal waste disposal, hygiene practices, and personal behaviors. Therefore, it is essential to collect data related to each of these exposure pathways in order to obtain a comprehensive overview of the WASH practices of a community. This research study used four methods to collect these data in order to compare practices both inter-community and intra-community.

Purpose and Aims:

One key objective in water and sanitation interventions is to improve the health of children less than five years of age, as they are vulnerable to the effects of poor water, sanitation and hygiene (WASH) practices. Individual factors, household factors, and community level factors all contribute to the health status of this population. Each community is different and therefore requires specific, tailored interventions targeted for that community. Therefore, it is essential to obtain a comprehensive overview and baseline assessment of the WASH use and practices for each community to allow implementing organizations to design programs to match the needs of the community. The objectives of this research study were to:

1. Evaluate what factors affect WASH practices at the community level by conducting a comprehensive baseline WASH assessment in two rural communities in Ghana using four different methods:

a. Perform GPS mapping of water sources, sanitation services, and households in each community

b. Perform door-to-door household questionnaires to assess knowledge, practice and coverage of WASH including

a. Source of water for household
b. Water storage and treatment methods used by household
c. Sanitation services used by household
d. Hygiene practices of household
e. Diarrheal prevalence among adults and children

c. Perform microbiological water quality analyses (i.e. testing for presence of *E. coli*) on water sources used by households, including public water sources such as standpipes and surface or groundwater, as well as stored water within each household

d. Conduct focus group discussions to understand community knowledge and perceptions of WASH and the interventions implemented

2. Compare water, sanitation and hygiene practices between and within communities using spatial, questionnaire and water quality data, to build a comprehensive description of WASH characteristics in these communities

Methods:

The study was conducted in two communities, Dawa and Tugakope, in June and July of 2009. With the aid of translators, the research team was able to perform a baseline water, sanitation and hygiene assessment of the communities. The assessment was conducted using four methods: 1) GPS mapping at the community and household level, 2) door-to-door in-depth questionnaires, 3) water quality testing in Dawa, and 4) focus group discussions. For this analysis, only the GPS mapping, door-to-door questionnaires and water quality testing results are included, and focus group discussions are omitted. All of the research and data collection methods were approved by Emory University's Institutional Review Board (see letter in Appendix A).

Community selection and entry:

With the guidance of The International Water Management Institute (IWMI) and the Community Water and Sanitation Agency (CWSA) Accra, two rural communities in the Greater Accra Region, Dawa and Tugakope, were chosen as feasible study sites. The sites were selected based on specific water and sanitation characteristics present within the community. The communities were selected because of the differences in water sources and sanitation practices between them. Dawa was a water source intervention community, while Tugakope was a sanitation facility intervention community. The researchers wished to compare the interventions in both communities and assess the effect on overall WASH practices. Additionally, the research team wished to assess the impact of the intervention within the communities themselves. The research team also chose communities based on willingness of the community leaders, and the availability of translators who spoke English.

Dawa (Figure 1) is located in the Dangbe East District and has approximately 200 households, according to CWSA. The community is primarily an agricultural community, whose residents have lived there for many generations. Community members rely on crops for food as well as a source of income. Dawa is located off of a major road connecting Accra, the capital of Ghana, to Togo. The community was the recipient of a piped-water system intervention from CWSA, the Danish International Development Agency (DANIDA) and the Ghanaian government. The construction was completed in 2007 with three functioning standpipes positioned in different areas of the community, the town standpipe, the school standpipe, and the Otengkope standpipe. Additionally, there is a sanitation market present in Dawa, as well as a mason who had been trained in the construction of the different types of latrines offered at the sanitation market.

Tugakope (Figure 2) is located in the Dangbe West District and has 31 households. The community is also primarily a farming community. In contrast to Dawa, Tugakope is located further off of the main Accra-Togo Road. However, Tugakope was the recipient of a household latrine intervention. CWSA and DANIDA provided materials and technical assistance to the community for building household Ventilated, Improved Pit (VIP) latrines. Each household, or group of households if clustered together, received latrines.

In June 2009, with the support of IWMI and CWSA, the research team visited Dawa and met with the Assemblyman. During this meeting, the research team discussed the goals and objectives of the research study and how Dawa would be participating. The

Assemblyman was able to identify two primary translators who would assist the team for the duration of the study. The translators were community members who were fluent in both Dangbe (the language spoken in Dawa), and English, and were trained on questionnaire administration prior to data collection. Additionally, the research team met with Dawa's Water and Sanitation Committee and conducted basic participatory community mapping with the committee members. This process allowed the researchers to visualize the community, and understand the views and perceptions of the committee members.

In July 2009, Tugakope was selected as the second study site. With the assistance of IWMI and CWSA, the research team met with the Water and Sanitation Committee Treasurer, the village Secretary, and other community members to discuss the goals and objectives of the research study. Two translators were selected by the community members to assist the team for the duration of the study, and they were trained on questionnaire administration prior to data collection.

GPS Mapping:

GPS mapping was performed using handheld GPS devices, Garmin 60CSX. GPS mapping consisted of two steps: initial community mapping and household mapping. The initial community mapping was conducted to produce a baseline map so that the research team could familiarize themselves with the community layout. As part of the door-to-door questionnaire, respondents were asked about the water sources and sanitation facilities for the household, and these coordinates were registered on the GPS device.

Initial Community mapping:

The research team collected GPS coordinates for major community landmarks, public water sources and latrines, and other relevant places in Dawa and Tugakope. The team walked around the community as the translators pointed out specific places. A community map, generated using the collected points, was created using ArcGIS Desktop Client v9.3, and subsequently given to the Assemblyman or leader of each village.

Household mapping:

The GPS coordinates of the front door of each participating household were marked and recorded. Additionally, the GPS coordinates of the sanitation facility used by the respondent and all of the children under five years of age within that household were marked. If two of the children under five years of age used the same spot, only one point was recorded. Last, if there was a private water source used by the household or another public source that was not previously marked, the respondent was asked to indicate the location and the GPS coordinates were marked.

Household Door-to-door questionnaires:

A questionnaire was administered to female heads of households over the age of 18, and took approximately 20 – 30 minutes to complete. The research team split into two groups, each with one translator. The female members of the team asked the questions to the respondents, and the males recorded observations. The research team and translators started at a random household, and then proceeded to the next closest household; therefore, this was a convenience sample. The final questionnaire was adapted from the U.S. Agency for International Development survey, “Assessing Hygiene Improvement: Guidelines for Household and Community Levels: Hygiene Improvement Household Survey Questions: Knowledge, Practice and Coverage of Water Supply, Sanitation and

Hygiene"(Environmental Health Project, 2004). The questionnaire was comprised of questions about basic demographic information, water and sanitation use and practices, hygiene behavior, and diarrhea experienced by the respondent and any children less than 60 months of age (five years). The questionnaire also contained an observation component which recorded specific information about the living quarters, hand washing items, water storage containers, and the sanitation facility used by the household (Appendix B).

Incentives:

Small sewing kits were given to each respondent who was interviewed upon completion of the questionnaire as a token of appreciation.

Water Quality Testing:

Public Water T esting: The research team collected 16 samples from public water sources in Dawa only. Two samples were taken from each of six public water sources including the town standpipe, two different stream collection areas, Worpa water reservoir (pond), a household rainwater collection point, and a broken standpipe collection area. Water samples were collected in the morning, between 6:00am-7:00am and again in the afternoon between 12:30pm - 2:30 pm of the same day. The sample was collected in a sterile plastic container by dipping directly into the water source for surface water sources and directly from the pipe for the standpipe source.

Household Water Testing: Two samples were taken from each of the selected households in Dawa only, resulting in 38 samples in total. The first sample from each house was taken between 6:30am-9:00am from the container in which the water was collected. The second sample was taken on the same day as the morning sample between 1:00pm-3:00pm from the container in which the water has been stored during the day. Samples were only taken from households that collected water that morning.

The pH, conductivity and temperature of the irrigation water sources were measured using pH/Cond 340i /SET (WTW Wissenschaftlich-Techniche Werkstatten, Germany).

Database:

All data were coded and uploaded or manually entered into a Microsoft Excel 2007 spreadsheet. Each household or waypoint had a unique identifier. Researchers re-entered data into a second spreadsheet to perform checks to ensure that the data was entered correctly.

Analysis:

Geospatial Analysis and Mapping: Using ArcGIS 9.3.1 and GPS coordinates collected by the research team, a geo-referenced dataset of interviewed households, water sources and sanitation services was created for both Dawa (N=87) and Tugakope (N=31) and linked to the questionnaire and water quality data. Shape files were created using this dataset. ArcMap 9.3.1 was used to generate maps of households, and water and sanitation data.

To create maps of households and their specific water source or sanitation facility, the geo-referenced dataset was used. Layers were created for each of the factors of interest, such as specific households, each water source, each sanitation facility used by households, public sanitation facilities, and *E. coli* contamination level per household water sample. Hawth's Tools was employed to find the Euclidean (straight line) distance between households and their respective water sources. Buffer rings of equal distances were created around the water sources. The distance categories depicted by these buffer rings were made consistent for all water sources and for both Dawa and Tugakope. The distances were imported into SAS v.9.2 to generate ANOVA and Kruskal-Wallis tests for difference in mean distance traveled.

Household and water source *E. coli* results were mapped, showing distance rings from the water sources and graduated symbols representing increasing levels of mean (*E. coli)* contamination.

The maps created were exported into JPEG format.

Descriptive and Univariate Analysis:

Using the dataset compiled from the GIS data, questionnaire data, and water quality data, a combined dataset was created and imported into SAS v9.2. Variables selected for analysis included water sources, distances to water sources, household water storage and use, microbiological water quality, sanitation facilities, anal cleansing practices, hygiene practices, and diarrheal prevalence. Frequencies, means and medians were generated for these variables and cross tabulated with other factors of interest, such as distance from water source, education level, and presence of children less than five years of age in the household. Student's t-tests, ANOVA, Kruskal-Wallis, and chi-square tests were performed in order to compare differences within groups of variables and between communities.

Microbiological A nalysis: (Adapted from personal communication with Dr. Philip Amoah, IWMI):

The *E. coli* populations in the water samples were analyzed by an IWMI lab technician using the spread plate technique. Ten-fold serial dilutions were made from each water sample by aseptically pipetting 1.0mL of each of the water samples into 9mL dilution water blanks, and the dilution tubes were thoroughly mixed by vortexing or vigorous shaking. Using a new pipette, 0.1 mL of each dilution was transferred onto Chromocult Coliform Agar (CCA) (Merch KGaA 64271 Darmstady, Germany) plate, which made another 10-fold dilution. Two replicate plates were prepared for each water sample. The inoculum was then spread over the surface of the agar plate using a sterile glass spreader and incubated at 37 degrees Celsius for 24 hours. After incubation the colonies were counted using a Quebec colony counter. Colonies on Chromocult coliform agar with dark blue to violet color were counted as *E. coli*. Presumptive colonies were confirmed on MacConkey No. 3 agar. *E. coli* concentration was reported as colony-forming units (CFU) per 100mL. Quantitative results from this microbiological analysis are a crude measure of contamination, as the technique used was not a standard method.

Results:

In total, 87 households were interviewed in Dawa (of 200 total households) and 31 in Tugakope (of 31 total households). The results of the GPS mapping, household questionnaires, and water quality testing are described below. Section One covers basic household demographics. Section Two describes the water use practices for both communities, including water sources, water storage and treatment, and water quality test results. Section Three describes the sanitation facilities and practices for the communities, including coverage and type of sanitation, as well as anal cleansing practices. Section Four describes hygiene practices for the two communities, and Section Five presents the data on diarrheal prevalence among adults and children less than five years of age in the study households.

Demographics:

The demographic characteristics of the interviewees and study households are shown in Tables 1 and 2. The mean age of the respondent (43 years) in Dawa was significantly higher than the mean age of 33 years in Tugakope (p=0.0063). The education level of the respondents was not significantly different between the two communities. The education level of female respondents was very low, 48% in Dawa and 49% in Tugakope had no education. Approximately 69% of respondents from Dawa could not read or write, and in Tugakope, 71% of respondents could not read or write.

Table 1: Demographics of Female Head of Study Households

Demographic Measure	Dawa N (%)	Tugakope N (%)
Age (in years)		
Mean (SD)	43 (19)	33 (14)
Range	18 - 100	19 - 75
Education Level		
No school	43 (49)	15 (48)
Primary, Incomplete	9 (10)	3 (10)
Primary, Complete	10 (11)	3 (10)
JSS†, Incomplete	4 (5)	1 (3)
JSS, Complete	18 (21)	9 (29)
SSS‡, Incomplete	0 (0)	0 (0)
SSS, Complete	1 (1)	0 (0)
College/University, Incomplete	1 (1)	0 (0)
College/University, Complete	1 (1)	0 (0)
Reading and Writing		
Can't Read or Write	60 (69)	22 (71)
Can Read	0 (0)	1 (3)
Can Write	1 (1)	2 (7)
Can Read and Write	26 (30)	6 (19)

†Junior Secondary School
‡Senior Secondary School

Table 2 describes the demographics and construction of the study households.

The mean household size was eight people in Dawa and seven people in Tugakope. Approximately 47% of households in Dawa had electricity compared to 81% in Tugakope. The construction materials used for houses in both communities was similar.

Table 2: Demographics and Construction of Study Households

Demographics of Household	Dawa N (%)	Tugakope N (%)
Number of People in HH		
Mean (SD)	8 (4)	7 (4)
Range	1 – 30	3 - 20
Households with At Least One Child Under Five Years	63 (72)	22 (71)
Number of Children Under Five Years	107	41
Households with Electricity	41 (47)	25 (81)
Construction of Household		
Wall		
Bricks/Blocks	22 (25)	12 (39)
Stone	0 (0)	1 (3)
Mud	65 (75)	16 (52)
Other	0 (0)	2 (6)
Floor		
Concrete	69 (80)	25 (81)
Earth	11 (13)	6 (19)
Other	1 (1)	0 (0)
Don’t Know	5 (6)	0 (0)
Roof		
Earth	1 (1)	0 (0)
Tin	62 (73)	14 (45)
Straw/Thatch	23 (27)	17 (55)

Water Sources:

Public Water Source Characteristics:

In Dawa, 90% of interviewed households reported piped water as their primary source of drinking water (Table 3). This was provided by the three standpipes located in different locations throughout Dawa. When asked if any other drinking water source was used, 42% of households reported using surface water as a secondary source of drinking water, while 23% reported that they stored enough water and did not need to rely on collecting water from another secondary source. This is in contrast to Tugakope, where 97% of households reported the use of surface water as their primary source of water, and 84% reported using piped water as a secondary source of water in addition to their primary source or when their primary source is unavailable. The piped water was available from a standpipe located in a neighboring community. This difference in usage of primary and secondary water source between the two communities was significantly different (Primary: Fisher's $p < 0.0001$; Secondary: Fisher's $p<0.0001$).

In Dawa, 90% of households use an improved primary drinking water source, compared to just 3% in Tugakope (Table 4). In contrast, for secondary drinking water sources 17% of households in Dawa use an improved drinking water source compared to 85% in Tugakope (Table 5).

Table 3: Reported Household Drinking Water Sources for Dawa and Tugakope

Water Source	Dawa N (%)	Tugakope N (%)
Main Source of Water		
Piped Water	78 (90)	1 (3)
Surface Water	7 (8)	30 (97)
Pure Water Sachets†	1 (1)	0 (0)
Rain Water	1 (1)	0 (0)
Secondary Source of Water‡		
Piped Water	9 (17)	21 (84)
Surface Water	22 (42)	1 (4)
Pure Water Sachets	7 (13)	0 (0)
Water Vendor	2 (4)	0 (0)
Rain Water	1 (2)	3 (12)
Stored Water	12 (23)	0 (0)
Water Source Used in Last Week		
Piped Water	69 (79)	2 (6)
Surface Water	11 (13)	4 (13)
Pure Water Sachets†	2 (2)	0 (0)
Rain Water	4 (5)	25 (81)
Stored Water	1 (1)	0 (0)

†A small water sachet filled with water from an unknown source, and therefore quality is unknown; these are purchased from a store or water vendor
‡34 households with no secondary source of water reported

Table 4: Households Using an Improved Primary Drinking Water Source

Primary Drinking Water Source	Dawa N (%)	Tugakope N (%)
Improved	78 (90)	1 (3)
Unimproved	9 (10)	30 (97)

Table 5: Households Using an Improved Secondary Drinking Water Source

Secondary Drinking Water Source	Dawa N (%)	Tugakope N (%)
Improved	9 (17)	21(84)
Unimproved	44 (83)	4 (16)

Spatial Analyses of Water Sources:

Maps:

For both Dawa and Tugakope, maps of primary, secondary and the water source used in the week prior to the interview ("last week") are shown below in Figures 3 through 8. Figure 3 displays the spatial relationships between the primary water sources and the households that use them in Dawa. The map illustrates that households appear to choose water sources that are close to them, and that there are clusters of households near the water sources. However, there are some anomalies. For example, the households using Worpa (pond) appear to be traveling farther to Worpa than they would if they had gone to one of the standpipe locations (Town Standpipe, School Standpipe).

Figure 4 shows the spatial relationship between households and their secondary water source in Dawa. It does not appear that households choose water sources that are closest to them for their secondary source. For example, some households that were using the Town Standpipe as their primary drinking water source reported using the Worpa as their secondary source, instead of another one of the public standpipes that were available and may be located closer to the household.

Figure 5 maps households in Dawa and their source of drinking water in the last week. Based on this map, it appears that the most common source of water in the last week was the Town Standpipe. No households reported using the Otengkope Standpipe in the last week, but households traveled to the School Standpipe in place of the Otengkope Standpipe.

Figures 6, 7 and 8 show the spatial relationships between households in Tugakope and their primary, secondary and last week sources of water, respectively. There are two primary drinking water sources for Tugakope, the Dam (surface water) and the Standpipe. From this map, we see that households appear to be closer to the Dam than the Standpipe (Figure 6). The households are also clustered together and would travel in the same direction to either of the two water sources.

Figure 7 shows that households reported using either the Standpipe or rain water as their secondary drinking water source. The households using the Standpipe are spread throughout the community and do not appear to be clustered.

Distances to water sources:

Figures 9 through 15 display the distances from specific water sources to the households that used them as either primary or secondary sources. The rings surrounding the water sources represent distance rings, as described in the key, and are the same throughout all the maps. In Dawa, all households were within 1040 meters of the water source they used. For Tugakope, additional rings are included to adjust for the longer distances from the water source, and all households were within 1384 meters of their water source. Dawa households were dispersed throughout the community more than the Tugakope households. The water sources for Dawa were all located within the community or in the immediate surrounding areas, whereas in Tugakope, the water sources were further away.

Households in Dawa who used the Worpa as a primary or secondary drinking water source traveled various distances to the Worpa to collect water (Figure 9). It is apparent from the map that households traveled from 173 meters to 1040 meters to the Worpa.

In Figure 10, most of the houses were dispersed within the first three distance rings, indicating that they travel up to 519 meters to the Town Standpipe. There were few houses that traveled further, as indicated in Figure 10.

Households in Dawa who used the School Standpipe traveled up to 519 meters to this source, with a few exceptions (Figure 11). The households who used this as a primary source and those who used this as a secondary source were equally dispersed in the community.

In Figure 12, the map indicates that households using the Otengkope Standpipe were within 500 meters of this source. All of the households that used this source were located to the south or east of the source.

Figure 13 illustrates the distance from the remaining four water sources in Dawa: the South Stream Collection Point #1, the South Stream Collection Point #2, the North Stream Collection Point, and the Rain Tank. There were fewer households using these sources compared to the previous four sources (Figures 9 – 12). These households traveled in the same direction to get to the water source.

Households in Tugakope who used the Dam as their primary drinking water source all traveled in the same direction to the source (Figure 14). Furthermore, they traveled between 519 meters and 1200 meters to the Dam. Based on the map, there is a road that could be used to travel towards the Dam, but once closer, the road disappears and there is a smaller pathway or unrecognized road that is probably used to arrive at the Dam.

In Figure 15, households in Tugakope who used the Standpipe as a drinking water source traveled between 1211 and 1384 meters to get to the Standpipe. On the map, there is a direct road from the community to the Standpipe.

The mean and median one-way Euclidean distances traveled from each study household to their specific primary water source were calculated (Table 6). In Dawa, households that traveled to South Stream Collection Point 2 had the greatest mean distance of 594.6 meters, followed by those who used the Worpa (530.8 meters). This does not include one household that used the public rain tank located on the household compound. Households that used the Otengkope Standpipe as their primary water source had the smallest mean distance to travel for water collection (243 meters). The surface water sources were all farther away from the households that used them than were the Standpipe water sources. There were significant differences between some of the distances traveled (ANOVA $p < 0.0001$; Kruskal-Wallis $p = 0.0017$). For example, the mean distance traveled by households using the South Stream Collection point #2 was significantly longer than the distance traveled by households using the Otengkope Standpipe. For Tugakope households, all but one of the households used the Dam as the primary water source and traveled an average of 786.4 meters to collect water (Table 7).

There was a significant difference in one-way distance traveled from household to primary water source between Dawa (mean= 286.8 meters) and Tugakope (802.7 meters), $p < 0.0001$.

The mean distances traveled from households to secondary water sources are shown in Tables 8 and 9. There was a significant difference in mean distance traveled from household to secondary water source between Dawa and Tugakope ($p < 0.0001$). Households in Tugakope traveled a mean of 2.6 times farther to their reported secondary water source than households in Dawa (1324.6 meters, 518.4 meters for Tugakope and Dawa, respectively).

Table 6: Mean Distances from Households in Dawa to Primary Drinking Water Source

Primary Water Source	Number of households (N)	Mean Distance traveled (meters)	Std. deviation	Median
Worpa	3	530.8	166.3	575.9
Town Standpipe	51	255.7	139.2	245.0
School Standpipe	18	327	82.7	306.4
Otengkope Standpipe	9	243	90.1	183.3
South Stream 2	2	594.6	24	594.6
North Stream	2	379.1	3.6	379.1
Public Rain Tank	1	6.5	--	--

Table 7: Mean Distances from Households in Tugakope to Primary Drinking Water Source

Primary Water Source	Number of households (N)	Mean Distance traveled (meters)	Std. deviation	Median
Dam	30	786.4	144.1	779
Standpipe	1	1290.2	--	--

Table 8: Mean Distances from Households in Dawa to Secondary Drinking Water Source

Secondary Water Source	Number of households (N)	Mean Distance traveled (meters)	Std. deviation	Median
Worpa	10	546.5	225.5	546.7
Town Standpipe	1	478.4	--	
School Standpipe	7	406.9	131.4	425.5
Otengkope Standpipe	1	202.8	--	--
South Stream 2	1	723.2	--	--
North Stream	5	442.3	132.7	391.1
Public Rain Tank	1	235.7	--	--
South Stream 1	6	737.2	99.3	756

†Households not listed reported no secondary water source, or using stored water, water sachets, or water vendors

Table 9: Mean Distances from Households in Tugakope to Secondary Drinking Water Source

Secondary Water Source	Number of households (N)	Mean Distance traveled (meters)	Std. deviation	Median
Dam	--	--	--	--
Standpipe	21	1324.6	29.8	1326.6

†Households not listed reported no secondary water source, or use stored or rain water

Microbiological Quality of Water Sources in Dawa:

E. coli concentrations for the six water sources tested in Dawa ranged from <1 to 17,000 CFU/100mL (Table 10). The Town Standpipe and Rain Tank samples both had <1 CFU/100mL, indicating that the water from these sources was safe. In contrast, each of the surface water sources tested had at least one sample (morning or afternoon) that had >1 *E. coli* CFU/100mL detected. The Broken Standpipe collection point had the highest concentrations of *E. coli* contamination compared to the other five sources. However, there was substantial variability between the two afternoon samples from the Broken Standpipe. It is unclear why this occurred since the two samples were collected immediately one right after the other. This variability in microbiological water quality was observed for some of the other water sources as well. For example, on the same day, water samples from the Worpa had concentrations of 2500 CFU/100mL in the morning and <1 in the afternoon. The variability between the two afternoon concentrations, and between morning and afternoon concentrations, may be due to the lab analysis methods used.

Table 10: *E. coli* Concentrations in the Morning and Afternoon Samples of Public Water Sources

	E. coli CFU per 100 mL		
Water Source	**Morning**	**Afternoon 1**	**Afternoon 2**
Town Standpipe	< 1	< 1	< 1
Worpa	2500	< 1	< 1
North Stream Point	< 1	500	< 1
South Stream 1	1000	< 1	< 1
Broken Standpipe	500	8500	17000
Rain Water Tank	< 1	< 1	< 1

Education Level and Presence of Children Under Five Effects on Choice of Water Source:

We examined the relationship between the education level of the female head of household and the primary water source used (Table 11). Among females in Dawa who had some education (having completed at least primary school), 91% used piped water as their primary water source. Among those with no education (not completing primary school or less), 88% used piped water as their primary water source. In Tugakope, 92% of those females with education used surface water as the primary source. Among those with no education, 100% used surface water.

Table 11: Comparison of Female Head of Household Education Level and Primary Water Source

	Primary Water Source			
Female Education†	**Piped Water**	**Surface Water**	**Pure Water Sachet**	**Rain Water**
	N (%)	**N (%)**	**N (%)**	**N (%)**
Dawa:				
Yes	32 (91)	2 (6)	1 (3)	0 (0)
No	46 (88)	5 (10)	0 (0)	1 (2)
Tugakope:				
Yes	1 (8)	12 (92)	0 (0)	0 (0)
No	0 (0)	18 (100)	0 (0)	0 (0)

† Having female education was defined as completion of primary school or higher

We also examined whether the presence of children under five in the household was associated with the primary drinking water source used (Table 12). Among households in Dawa with at least one child under five years of age, 92% used piped water as their primary water source, and 8% used surface water. Among those without children under five years, 84% used piped water as their primary water source. In Tugakope, 100% of those households with children under five years present used surface water as the primary source. Among those with no children less than five years of age, 11% used standpipe water and 89% surface water. The sample size was not large enough to detect the effect of having children under five years in the household on type of water source used if any.

Table 12: Comparison of Presence of Children Under 5 and Primary Water Source

	Primary Water Source			
Household with Child(ren) under 5 years	**Piped Water**	**Surface Water**	**Pure Water Sachet**	**Rain Water**
	N (%)	**N (%)**	**N (%)**	**N (%)**
Dawa:				
Yes	58 (92)	5 (8)	0 (0)	0 (0)
No	20 (84)	2 (8)	1 (4)	1 (4)
Tugakope:				
Yes	0 (0)	22 (100)	0 (0)	0 (0)
No	1 (11)	8 (89)	0 (0)	0 (0)

Household Drinking Water

Reported Household Drinking Water Storage and Treatment Practices:

We examined the water storage practices for both communities (Table 13).The majority of water storage containers in Dawa and Tugakope (94%) were wide mouth, defined as an opening greater than three centimeters. Additionally, most households in both communities covered their water storage containers (74% in Dawa and 87% in Tugakope). Fifty-eight percent of household storage containers in Tugakope were elevated above the floor compared to 3% in Dawa, representing a significant difference between the placement of containers between the two communities (*p* <0.0001). The majority of households in both Dawa and Tugakope removed water from the household storage container by dipping into the container (94% for Dawa and 97% for Tugakope).

Table 13: Household Water Storage Characteristics in Dawa and Tugakope

Container Characteristics	**Dawa N (%)**	**Tugakope N (%)**
Container Type		
Clay Pot	28 (33)	26 (84)
Bucket	2 (2)	0 (0)
Drum/Barrel	40 (47)	3 (10)
Jerry Can	5 (6)	1 (3)
Basin	3 (3)	0 (0)
Multiple Containers	8 (9)	1 (3)
Container Mouth		
Narrow Mouth	3 (4)	2 (6)
Wide Mouth	74 (94)	29 (94)
Both Types	2 (2)	0 (0)
Container Cover		
All Covered	59 (74)	27 (87)
Some Covered	4 (5)	2 (6)
None Covered	17 (21)	2 (6)
Container Placement		
On floor	76 (97)	13 (42)
Elevated above floor	2 (3)	18 (58)
Container Height (inches)		
Mean (SD)	27 (11)	30 (7)
Range	6 – 42	12 – 42
Water Removal Method		
Pouring	5 (6)	1 (3)
Dipping	81 (94)	31 (97)

In addition, the average number of loads of water (1 load = 1 jerry can) per household per day was 5 for Dawa and 3 for Tugakope.

A summary of household water treatment by water type for both communities is shown in Tables 14-18. For Dawa, the majority of households did not treat their drinking water from their primary source. Among the few households who did treat their drinking water in both communities, the main method of treatment was to sieve water with a cloth, which may have little biological efficacy (14% for Dawa and 77% for Tugakope) (Tables 14 and 15). The majority of households did not treat piped water. In Dawa, one household treated their water with mothballs, and in Tugakope, one household treated their water with kerosene. In Dawa and Tugakope, 76% and 72% of households, respectively, reported that they did not treat their household water from their secondary drinking water source (Tables 16 and 17). Furthermore, 94% of households in Tugakope reported that they had not treated their household drinking water in the past week (Table 18). There is no data from Dawa for water treatment in the past week because this question was added to the questionnaire after completion of sampling in Dawa.

Table 14: Method of Water Treatment by Primary Source in Dawa

Method of Treatment	Piped Water	Surface Water	Pure Water Sachet	Rain Water
	N (%)	N (%)	N (%)	N (%)
Boil	1 (1)	0 (0)	0 (0)	0 (0)
Sieve with Cloth	7 (9)	3 (43)	0 (0)	1 (100)
Boil and Sieve with Cloth	0 (0)	2 (30)	0 (0)	0 (0)
Mothballs	1 (1)	0 (0)	0 (0)	0 (0)
No treatment	69 (88)	2 (30)	1 (100)	0 (0)

Table 15: Method of Water Treatment by Primary Source in Tugakope

Method of Treatment	Piped Water	Surface Water
	N (%)	N (%)
Boil	0 (0)	1 (3)
Sieve with Cloth	0 (0)	24 (80)
Boil and Sieve with Cloth	0 (0)	0 (0)
Kerosene	0 (0)	0 (0)
No treatment	1 (100)	5 (17)

Table 16: Method of Water Treatment by Secondary Source in Dawa

Method of Treatment	Piped Water	Surface Water	Pure Water Sachet	Water Vendor	Rain Water
	N (%)	N (%)	N (%)	N (%)	N (%)
Boil	0 (0)	2 (9)	0 (0)	0 (0)	0 (0)
Sieve with Cloth	0 (0)	7 (32)	1 (14)	0 (0)	0 (0)
Boil and Sieve with Cloth	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Mothballs	0 (0)	1 (5)	0 (0)	0 (0)	0 (0)
No treatment	9 (100)	12 (55)	6 (86)	2 (100)	1 (100)

Table 17: Method of Water Treatment by Secondary Source in Tugakope

Method of Treatment	Piped Water	Surface Water	Rain Water
	N (%)	N (%)	N (%)
Boil	0 (0)	0 (0)	0 (0)
Sieve with Cloth	4 (19)	0 (0)	0 (0)
Boil and Sieve with Cloth	0 (0)	0 (0)	0 (0)
Kerosene	0 (0)	0 (0)	0 (0)
No treatment	17 (81)	1 (100)	3 (100)

Table 18: Method of Water Treatment by Water Source used in Past Week in Tugakope

Method of Treatment	Piped Water	Surface Water	Rain Water
	N (%)	N (%)	N (%)
Boil	0 (0)	0 (0)	0 (0)
Sieve with Cloth	0 (0)	1 (25)	10 (40)
Boil and Sieve with Cloth	0 (0)	0 (0)	0 (0)
Kerosene	0 (0)	0 (0)	1 (4)
No treatment	2 (100)	3 (75)	14 (56)

Education Level and Presence of Children Under Five Effects on Household Water Treatment:

We examined the relationship between the education level of the female head of household and if the water was treated at home (Table 19). In Dawa, 14% of educated women treated their household water from their primary source, and 19% of uneducated women treated their household water. In Tugakope, 85% of educated women and 78% of uneducated women treated their household water. The sample size was not large enough to detect the effect of education on type of water source used, or household water treatment, if any.

Table 19: Comparison of Female Head of Household Education Level and Primary Water Source Treatment Method

Female Education†	Primary Water Source Treatment‡ Yes N (%)	Primary Water Source Treatment‡ No N (%)
Dawa		
Yes	5 (14)	30 (86)
No	10 (19)	42 (81)
Tugakope		
Yes	11 (85)	2 (15)
No	14 (78)	4 (22)

† Having female education was defined as completion of primary school or higher
‡Treatment included sieving through cloth, boiling, filtering, chlorine treatment, mothballs, or kerosene

We also examined whether the presence of children under five in the household was associated with household water being treated (Table 20). In Dawa, 14% of households with children under five years treated their household water, and 25% of households without children under five treated their household water. In Tugakope, 91% of households with children under five years of age and 56% of households without children under five years treated their household water. For Dawa, there is not sufficient evidence to conclude that the presence of children less than five years of age in the household had an impact on household water treatment. However, in Tugakope, households with young children were significantly more likely to treat their water (p=0.0434). These results should be interpreted with caution because of the small sample size.

Table 20: Comparison of Presence of Children Under 5 and Primary Water Source Treatment Method

Household with Child(ren) under 5 years	Primary Water Source Treatment Yes N (%)	No N (%)
Dawa:		
Yes	9 (14)	54 (86)
No	6 (25)	18 (75)
Tugakope:		
Yes	**20 (91)** †	2 (9)
No	**5 (56)** †	4 (44)

† *$p < 0.05$*

Household Water Quality in Dawa:

We assessed *E. coli* concentrations in household water, from morning and afternoon samples, that were collected from the sources above. *E. coli* was detected in 68% of the morning household water samples and 58% of the afternoon samples. The morning and afternoon water samples were collected on the same day from the same households. As with the water source results, we observed that fewer households had contaminated water in the afternoon - this also may be due to sampling methods. Among households with *E. coli* contamination, the mean morning *E. coli* concentration among households was 1000 CFU/100mL, and the mean afternoon concentration was 1455 CFU/100mL (Table 21). These results seem to indicate that, although the number of households that tested positive for *E. coli* in the afternoon was less than the morning, the average concentration increased from morning to afternoon among only households with contamination >1 CFU/100mL.

Table 21: Mean *E. coli* Concentration of Household Morning and Afternoon samples

Households with *E. coli* contamination	**N (total=19)**	**%**	**Mean of All Household Samples (CFU per 100mL)**	**Mean of Positive Samples (CFU per 100mL)**
E. coli levels AM	13	68	8421†	1000†
E. coli levels PM	11	58	842	1455

† Excludes one household sample with a morning *E. coli* contamination of 148,000 CFU/100mL

Households that used a wide-mouth container to store drinking water had a higher proportion of *E.coli*-positive water samples than households that used a narrow-mouthed container (Table 22). Compared to other storage containers, households using a drum/barrel, which had a wide-mouth, to store water had the highest number of positive water samples (71% had *E. coli* contamination in the morning and 67% in the afternoon). However, households using a narrow mouth container had *E. coli* contamination in 60% of the morning samples and 6 % of the afternoon samples. It was also surprising to find that households that dipped into the water storage container to retrieve water and households that poured water from the water storage container had similar proportions of *E. coli*-contaminated samples.

Table 22: Comparison of Household Storage Container Characteristics and *E. coli* Contamination

Container Characteristics	Households with *E. coli* detected in the morning sample		Households with *E. coli* detected in the afternoon sample*	
	N total using source	N (% positive)	N total using source	N (% positive)
Container Type				
Clay Pot	3	2 (67)	5	2 (40)
Bucket	1	1 (100)	1	0 (0)
Drum/Barrel	7	5 (71)	6	4 (67)
Jerry Can	5	3 (60)	6	4 (67)
Basin	3	2 (67)	1	1 (100)
Container Mouth				
Narrow Mouth	5	3 (60)	8	4(50)
Wide Mouth	14	10 (71)	11	7 (63)
Container Cover				
Covered	8	5 (63)	7	4 (57)
Not Covered	5	3 (60)	5	2 (40)
Water removal				
Pouring	4	3 (75)	7	4 (57)
Dipping	14	10 (71)	12	7 (58)
Pouring and Dipping	1	0 (0)	0	0 (0)
Water removed by				
Adults only	3	2 (67)	3	1 (33)
Everyone (4)	4	4 (100)	3	3 (100)
Adults and school age children only	11	6 (55)	11	5 (45)

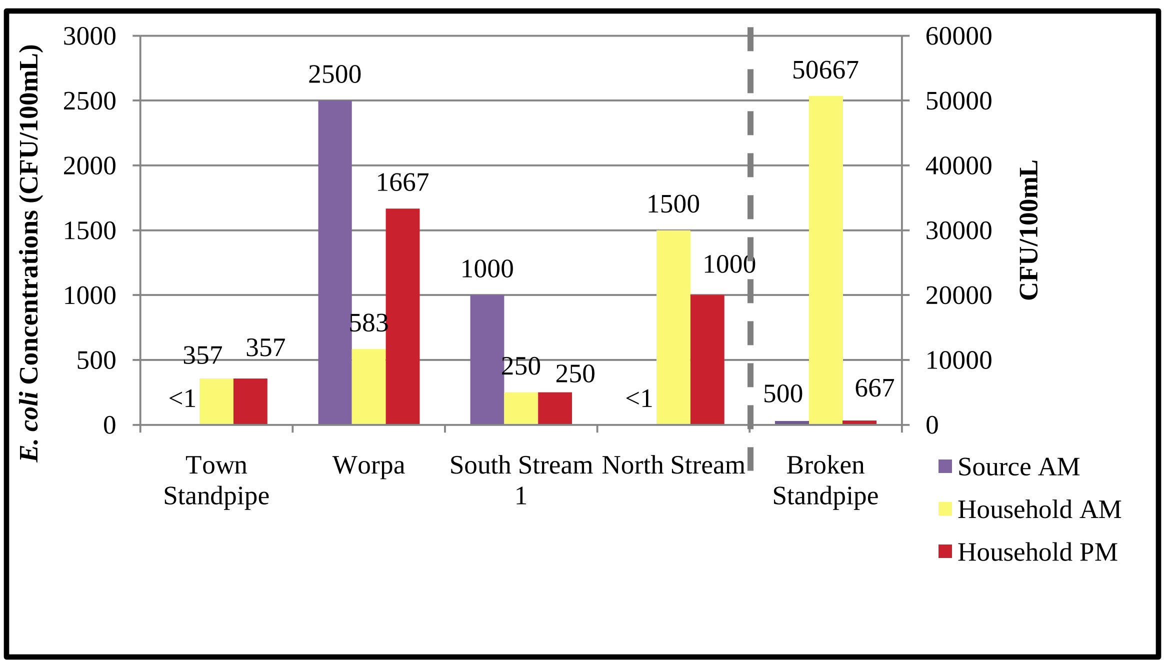
Comparison of Water Source and Household Water Contamination Levels:

Household water quality is dependent on the source water quality, time since collection, recontamination, and household treatment, if any. To assess this, we compared water source quality to household water quality. Table 23 shows *E. coli* detection in household water samples stratified by water source used. *E. coli* was detected in at least one household from each of the water source categories. Households using the Town Standpipe had the fewest positive water samples, both in the morning and afternoon, compared to households that used the Broken Standpipe or Surface Water. There was a significant association between water source used and presence of *E.coli* in the household water sample in the afternoon (Fishers p=0.0169).

Table 23: Comparison of Container and Water Source Characteristics and Households with *E. coli* Present in Water

	Households with *E. coli* detected in the morning sample		Households with *E. coli* detected in the afternoon sample*	
Container Characteristics	**N total using source**	**N (% positive)**	**N total using source**	**N (% positive)**
Source of water				
Broken Standpipe	3	3 (100)	3	3 (100)
Standpipe	7	3 (43)	7	1 (14)
Surface Water total	9	7 (78)	9	7 (78)
Worpa	6	5 (83)	6	5 (83)
N. Stream	1	1 (100)	1	1 (100)
S. Stream 1	2	1 (50)	2	1 (50)

Figure 16: *E. coli* Concentrations for Households and the Water Source Used



We also compared mean *E. coli* concentrations from household samples and the concentration from the morning water source (Figure 16). While the morning water sample from the Town Standpipe had < 1 CFU/100mL *E. coli* detected, the mean household *E. coli* concentration for the morning and afternoon were both 357 CFU/100mL. This indicates that even though no *E. coli* were detected in the source water sample, the household water samples were contaminated, which may indicate that post-source contamination occurred. There is also great variability between *E. coli* concentration in the morning water samples from the source, and the mean *E. coli* concentration in the morning water sample from the households. This could be due to the analytical methods used. It's surprising to see some household samples have much lower contamination than the water source that was used (e.g., Worpa) and some household samples have much higher contamination than the source (e.g., Broken Standpipe, North Stream). This variability may indicate that the method used for analysis was good for assessing presence or absence of *E. coli*, but not accurate in quantifying how much was present. However, this information shows that regardless of the concentrations at the water source, there was *E. coli* contamination at the household level.

Spatial Analysis of Microbiological Quality of Water Source and Household:

Figures 17 - 21 show the spatial relationships between households and water quality testing results in Dawa. Six of the water sources and 19 households selected from the questionnaire participants are shown. The distance from the water source is also shown using the rings buffers around each of the water sources. Therefore, the spatial relationship between distance from water source and household water contamination level can be examined (Figure 17). The map indicates that the households that were sampled were all within about 200 meters of the Town Standpipe. The *E. coli* concentration for most of the household water samples was <1 CFU/mL; however there are some households with high *E. coli* concentrations in the water. It is interesting that two households where *E. coli* was detected in the morning water samples did not have any detectable *E. coli* in the sample in the afternoon. This decrease could be due to household water treatment, or to natural microbial die off, or to the lab analysis method used.

The households included in the water quality testing that used Worpa were farther away from the source than the Standpipe users, ranging from about 173 meters to 1040 meters (Figure 18). This map shows that the *E. coli* concentrations detected are very high, and *E. coli* were detected in the morning, the afternoon, or both samples for every household. Four of the six houses showed an increase in concentration from morning to afternoon.

Water quality was assessed for three households using the Broken Standpipe Collection Point (Figure 19). These households were located within 520 meters of the collection point. In the morning, all of the household water samples had very high concentrations of *E. coli*, from 2000 CFU/100mL to 148,000 CFU/100mL. However, water collected at the source in the morning had <1 CFU/100mL *E. coli*, suggesting that post-source contamination had occurred. The household afternoon samples showed decreased concentrations of *E. coli*, which may be due to natural die-off or limitations of the analysis technique used.

The two households using the South Stream 1 that participated in the water quality testing are displayed in Figure 20. These households were between 700 and 1040 meters from the South Stream 1 collection point. For both the morning and afternoon household samples, the same concentrations of *E. coli* were detected. One household that used the North Stream Point was included in the water quality testing (Figure 21). In this household water, *E. coli* concentration appeared to decrease from 1500 CFU/100mL in the morning to 1000 CFU/100mL in the afternoon. This may be due to the lab analysis technique used, or because the household treated their water, or due to natural die-off.

The mean distance traveled by interviewed households to their water source on the day that sampling occurred ranged from 148.9 meters to 872.1 meters (Table 24). Households that used the South Stream 1 water collection point traveled the farthest, on average, compared to households that used other water sources. There were significant differences between some of the distances traveled by the households to these water sources (ANOVA $p < 0.0001$; Kruskal-Wallis $p = 0.0045$)

Table 24: Mean One-way Distance Traveled to Water Source by Study Households in Dawa

Water Source Used	N Households	Mean distance (meters)	Median (meters)
Town Standpipe	7	148.9	150.4
Worpa	6	653.6	642.0
North Stream Point	1	382.7	--
South Stream 1	2	872.1	872.1
Broken Standpipe	3	351.4	387.8

Sanitation:

Household Sanitation Practices:

We examined the sanitation and anal cleansing practices for adults in the two communities (Table 25). Seventy-nine percent of households in Dawa practiced open defecation compared to only 26% of households in Tugakope. The main defecation point for households in Tugakope was reported to be household Ventilated Improved Pit (VIP) latrines however, the proportion of households practicing open defecation in Tugakope was still high. This difference between the two communities in defecation points was statistically significant (Fisher's p=7.79*10^{-19}). Most households in both communities reported using paper (toilet paper or other paper) for anal cleansing. About 69% of households in Dawa reported leaving the anal cleansing item at the defecation site, in contrast to Tugakope, where 19% reported leaving it at the defecation site. In Tugakope, 39% of households reported dropping it in the pit of the latrine, whereas just 3% report doing so in Dawa. We then examined whether a higher proportion of children's feces was disposed of in a pit latrine when there was increased access to household VIP latrines.

Children under five years defecated in a variety of areas (Table 26). In Dawa, 36% of children under five defecated in the house/yard area compared to 49% in Tugakope. In Tugakope, no children under five defecated in a sanitation facility. The caretakers of these children reported seven different ways of disposing the feces of the children under five (Table 26). In Dawa, the area for feces disposal varied. However, for Tugakope, 44% of caretakers reported disposing the feces of their children under five in a toilet facility. These toilet facilities are most likely the household VIP latrines that are accessible to them.

Table 25: Adult Latrine Type and Anal Cleansing Practice

Sanitation Variable	Dawa N (%)	Tugakope N (%)
Latrine Type		
Pour-Flush to Pit	1 (1)	0 (0)
VIP	0 (0)	23 (74)
KVIP	12 (14)	0 (0)
Pit Latrine without floor/slab	5 (6)	0 (0)
Bush (open defecation)		
	69 (79)	8(26)
Method of Anal Cleansing		
Toilet Paper	40 (46)	9 (29)
Water	2 (2)	0 (0)
Other Paper	37 (43)	22 (71)
Cloth	6 (7)	0 (0)
Other	2 (2)	0 (0)
Disposal of Anal Cleansing Item		
Leave it there		
Bury	60 (69)	6 (19)
Drop in Pit	9 (10)	1 (3)
Drop in Container Next to	3 (3)	12 (39)
Pit	2 (2)	5 (16)
Burn it		
	13 (15)	7 (23)

Table 26: Children Under Five Years: Place of Defecation and Feces Disposal

Sanitation Variable	Dawa(N=107) N (%)	Tugakope (N=41) N (%)
Defecation Area		
Used sanitation facility	3 (3)	0 (0)
Used potty	19 (18)	9 (22)
Used washable diapers	19 (18)	7 (17)
Used disposable diapers	2 (2)	0 (0)
Went in house/yard	39 (36)	20 (49)
Went outside the premises	25 (23)	5 (12)
Feces Disposal Area		
Dropped into toilet facility	11 (10)	18 (44)
Water rinsed/washed and discarded outside premises	18 (17)	6 (15)
Disposed of somewhere in yard	2 (2)	0 (0)
Disposed outside premises	29 (27)	6 (15)
Buried	27 (25)	8 (19)
Did nothing/left there	19 (18)	3 (7)
Other	1 (1)	0 (0)

We assessed differences in sanitation practices by education among the female heads of household (Table 27). Among female heads of household from Dawa, 77% who reported having some education practiced open defecation compared to 81% who had no education. Among female heads of households in Tugakope who reported some education, 69% used VIP latrines compared to 78% with no education who used VIP latrines. We also assessed whether presence of at least once child under five living in the household affected sanitation practices (Table 28). Regardless of whether or not there was a child under five living in the household, 79% of households practiced open defecation. In Tugakope, among households with children less than five, 68% use VIP latrines (Table 28). Among households without children less than five, 89% used VIP latrines. There was no evidence that there was a significant difference in sanitation practices due to education level or presence of children less than five years of age in the households in either Dawa or in Tugakope.

Table 27: Comparison of Sanitation Practices by Education Level

	Sanitation facility used				
Female Education†	**Pour-flush to Pit**	**VIP**	**KVIP**	**Pit latrine without slab**	**Open defecation**
	N (%)	**N (%)**	**N (%)**	**N (%)**	**N (%)**
Dawa:					
Yes	0 (0)	0 (0)	5 (14)	3 (9)	27 (77)
No	1 (2)	0 (0)	7 (13)	2 (4)	42 (81)
Tugakope:					
Yes	0 (0)	9 (69)	0 (0)	0 (0)	4 (31)
No	0 (0)	14 (78)	0 (0)	0 (0)	4 (22)

† Having female education is defined as those who have completed primary school or higher

Table 28: Comparison of Sanitation Practices Stratified by Presence of Children Under 5

	Sanitation facility used				
Presence of child(ren) under 5 years	**Pour-flush to pit**	**VIP**	**KVIP**	**Pit latrine without slab**	**Open defecation**
	N (%)	**N (%)**	**N (%)**	**N (%)**	**N (%)**
Yes	1 (2)	0 (0)	7 (11)	5 (8)	50 (79)
No	0 (0)	0 (0)	5 (21)	0 (0)	19 (79)
Tugakope:					
Yes	0 (0)	15 (68)	0 (0)	0 (0)	7 (32)
No	0 (0)	8 (89)	0 (0)	0 (0)	1 (11)

Spatial Analyses of Defecation Practices:

Figures 22 and 23 show the adult latrine locations and the households for both Dawa and Tugakope. The different sanitation facilities in Dawa included open defecation areas, Kumasi Ventilated Improved Latrines, Simple pit latrine without slab, and pour-flush to pit latrines (Figure 22). There did not appear to be a clustering or trend for defecation location and household. The households that reported practicing open defecation are spread throughout the community. Households that used the public latrines were the ones located closest to the latrine. For Tugakope (Figure 23), the sanitation facilities were Ventilated Improved Latrines, Simple pit latrines with slabs and open defecation areas. In Tugakope, the households that practiced open defecation were located on the outskirts of the community.

Figure 24 shows the feces disposal points for all children less than five years in households in Dawa. The defecation or disposal areas include outside of the house premises, in the house/yard, disposable diapers, washable diapers, potty/chamber pot, and in a sanitation facility. In Tugakope, the defecation or disposal areas used were outside of the house premises, in the house/yard, washable diapers, and potty/chamber pots (Figure

25). For both communities, there did not seem to be any one area where feces are disposed of but rather, they were disposed close to the location of the house.

Hygiene:

Hygiene P ractice: A significantly higher proportion of households had no soap on the premises in Dawa compared to Tugakope (Table 29, p=0.0002). However, the two communities had approximately the same proportion of households with soap found in the household's reported handwashing station, (37% and 36% for Dawa and Tugakope respectively). Tugakope had a higher percentage of households that did not have soap located in the hand washing station, but were able to produce soap to the researchers within one minute.

Table 29: Observation of Soap in Dawa and Tugakope Households

Presence of Soap	Dawa N (%)	Tugakope N (%)
Found in Hand washing Place	30 (37)	11 (36)
Brought within One Minute	18 (22)	18 (58)
No Soap	33 (41)	2 (6)

Diarrhea:

Diarrheal Prevalence: Of the 87 adults interviewed in Dawa, six adults in Dawa reported having diarrhea (defined as three or more loose or watery stools within 24 hours) in the past week (Table 30). Of those, two adults reported having diarrhea in the past 24 hours. In Tugakope, one adult reported experiencing diarrhea in the past 24 hours.

The diarrheal prevalence among children under five years of age in Dawa was reported to be 26% in the past week and 6% in the past 24 hours (Table 31). This is a higher prevalence than Tugakope, where it was reported that 17% of children under five years had diarrhea in the past week and 12% had diarrhea in the past 24 hours. For both communities, a variety of medications were reportedly used to treat diarrhea, as well as range of locations where treatment was purchased or sought (Table 31). In Dawa, 90% reported seeking treatment for children under 5 with diarrhea, compared to 73% in Tugakope. Among those in Dawa who sought treatment, 79% reported seeking treatment for diarrhea for children under five at the private pharmacy located in the community.

Table 30: Diarrheal Prevalence and Characteristics of Diarrhea and Treatment in Adults

	Dawa N (%)	Tugakope N (%)
Diarrhea		
Past 24 Hours	2 (2)	1 (3)
Past One Week†	6 (7)	1 (3)
Stool		
Blood	0 (0)	0 (0)
Mucus	1 (17)	1 (100)
Don’t Know	1 (17)	0 (0)
Vomit	1 (17)	
How treated		
Pills (NOS‡)	2 (33)	0 (0)
Pills (antibiotics)	2 (33)	1 (100)
Pills and Syrup	1 (17)	0 (0)
IV	1 (17)	0 (0)
No medication taken	0 (0)	0 (0)
Where treatment sought		
Government Health Center	2 (33)	0 (0)
Private Pharmacy	3 (50)	1 (100)
Did not seek treatment	1 (17)	0 (0)

†Adults with diarrhea in past 24 hours are included in adults with diarrhea in the past one week
‡NOS: Not Otherwise Specified

Table 31: Diarrheal Prevalence and Characteristics of Diarrhea and Treatment in Children Under Five Years

	Dawa†	Tugakope‡
	N (%)	**N (%)**
Diarrhea		
Past 24 Hours	7 (6)	5 (12)
Past One Week*	28 (26)	7 (17)
Stool		
Blood	0 (0)	0 (0)
Mucus	9 (32)	3 (43)
Both	1 (4)	0 (0)
Neither	18 (64)	4 (57)
Vomit		
Yes	7 (25)	0 (0)
No	21 (75)	7 (100)
How treated		
Pills (NOS**)	2 (7)	1 (14)
Pills (antibiotics)	6 (21)	2 (29)
Syrup (NOS)	13 (46)	2 (29)
Pills and Syrup	1 (4)	0 (0)
ORS and Antibiotic syrup	1 (4)	0 (0)
Antibiotic syrup and traditional medicine	1 (4)	0 (0)
No treatment	3 (10)	2 (29)
Don't Know	1 (4)	0 (0)
Where treatment sought		
Government Hospital	1 (4)	1 (14)
Government Health Center	1 (4)	0 (0)
Private Pharmacy	22 (79)	1 (14)
Private Pharmacy and Family Member	1 (4)	0 (0)
Market/Shop	0 (0)	1 (14)
Drug Peddler/ Hawker	0 (0)	2 (29)
Did not seek treatment	3 (11)	2 (29)

†Total number of children in Dawa = 108
‡ Total number of children in Tugakope = 41
*Children with diarrhea in past 24 hours are included in children with diarrhea in the past one week
**NOS: Not Otherwise Specified;

Discussion:

One of the main goals of a baseline assessment is to understand community specific practices in order to better inform intervention design and policy development, both of which contribute to improving health. Diarrheal diseases are the second leading cause of death among children under five years of age. A large part of the burden of diarrheal diseases is attributable to poor WASH practices (Joint Monitoring Programme for Water Supply and Sanitation (JMP), 2008). The purpose of this study was to conduct a baseline assessment of the water, sanitation and hygiene practices in Dawa and Tugakope in order to compare these practices between and within the communities. This was accomplished using multiple methods, including collecting GIS information, household Knowledge, Practice and Coverage questionnaires, water quality testing (Dawa), and focus group/key informant interviews (which were not included in this analysis), each providing a unique perspective on the assessment. Differences were found both inter- and intra- community, particularly in water source used, proximity to water source, water quality, sanitation services, and hygiene practices, and are described below.

Diarrheal Prevalence for Children Under Five Years:

The prevalence of diarrhea for children under five years was 26% in Dawa and 17% in Tugakope. Although the small sample size for this study was not large enough to detect the effect of WASH practices as potential risk factors for diarrheal disease, we are able to hypothesize what factors among those included in the baseline assessment contribute to the prevalence. It is likely that the prevalence for both communities is due to a mixture of WASH practices that occur at the household level and the public domain that lead to an exposure of children under five to enteric pathogens. According to DHS surveys for

2008, the prevalence of diarrhea among children under five living in rural areas was 21.3% (ICF Macro Measure DHS, 2008). For just the Greater Accra Region, the DHS surveys report diarrheal prevalence for children under five to be 12.4%. Compared to Ghana as whole, Dawa's diarrheal prevalence for this age group is a little higher, while Tugakope's is a little lower. However, when comparing to just the Greater Accra Region, both Dawa's and Tugakope's diarrheal prevalence are higher.

Previous research indicates that there is not one single risk factor for diarrheal disease. Dawa and Tugakope each have specific risk factors that contribute to the diarrheal prevalence. Some factors that influence the high diarrheal prevalence for children under five years seen in these communities include drinking water quality, distance to drinking source, defecation practices, and handwashing with soap (Gasana, Morin, Ndikuyeze, & Kamoso, 2002). All of these factors affect exposure to enteric pathogens that can cause a diarrheal episode. Previous studies indicate that these factors do contribute to diarrheal disease; however the effect of each factor, as well as which factor is most responsible, varies greatly by community. Wang and Hunter, in a meta-analysis of studies from Tanzania, Democratic Republic of Congo (Zaire), and other countries, found that distance from water source is an important risk factor for diarrheal disease in children under five, possibly because distance to source is associated with availability, and lower availability leads to reduced personal hygiene (Wang & Hunter, 2010). Garrett *et al.* (2008) conducted a quantitative review in Kenya of diarrheal disease risk factors and concluded that water quality, defecation practice, and water source used were predictors of diarrheal illness. All of these factors are potential causes of the high diarrheal prevalence in both

Dawa and Tugakope, and further studies should focus on these specific factors to validate these hypotheses. Other studies have also indicated that knowledge of diarrhea transmission is not enough to encourage behavior change of habits, preferences and cultural traditions (Halvorson, 2004; Westaway & Viljoen, 2000; Williams, Halvorson, Ba, & Dunkel).

Water Source Access and Use:

This study examined what primary and secondary water sources households in Dawa and Tugakope chose, and what factors influenced this choice. Primary drinking water sources were significantly different between Dawa and Tugakope, where 90% used piped water in Dawa compared to just 3% in Tugakope. However, 42% of households in Dawa reported using surface water as their secondary water source, in contrast to 84% of households in Tugakope who reported using water from a standpipe as their secondary source. According to DHS surveys, average access to improved water in Ghana is 76% for rural areas (Ghana Statistical Service (GSS), *et al.*, 2009). While this country estimate measures **access**, and this study measures **use**, we will assume they serve as proxies for each other to allow for comparison (WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, 2010). The choice of primary water sources between Dawa and Tugakope is different. Additionally, the proportion of households in Dawa that used an improved primary water source is greater than the DHS estimates whereas the proportion of households in Tugakope is much less than the DHS estimates. The most likely explanation for this difference between the two communities is the piped-water scheme intervention that Dawa received (from CWSA and DANIDA) that resulted in piped water being more accessible for households. Tugakope has not been the recipient of a piped water intervention, and households still rely on a traditional surface water source for drinking water. It is important to note, however, that increasing access to and use of piped water does not necessarily mean that the water is safe for drinking as evidenced by the results of the household water quality testing in Dawa, where 68% of the morning samples and 58% of the afternoon samples exceeded the WHO guidelines of <1 *E. coli* CFU per 100mL.

Another explanation for the difference in primary water source choice between the two communities is the distance traveled from household to water source. The mean Euclidean distance traveled from primary drinking water source to household in Dawa (286.8 m) is significantly different than that in Tugakope (802.7m). Additionally, the Standpipe used by households in Tugakope mainly as a secondary source was even farther away (1290m) than the Dam (786.5m). The distance between secondary sources was also found to be significantly different. There were more public water sources, both improved and unimproved, in Dawa, available for use. In Tugakope, the closest option for water was the Dam, which may explain why households primarily used this source instead of the Standpipe.

Other studies conducted in different rural communities throughout Africa indicate that households that have increased access to an improved water supply will be more likely to use this water source compared to a surface water source (Simon Lewin, Norman, Nannan, Thomas, & Bradshaw, 2007; Whittington, *et al.*, 1990). Typically, households tend to use water sources that are closest to them (Arouna & Dabbert, 2010) as evidenced by Tugakope households' choice of Dam water.

Factors that influenced choice of water source within the communities

Some variation also exists when examining intra-community water source choice. Within Dawa, there were four different primary drinking water sources, and six different secondary sources. The only improved water source in Dawa was the standpipe water; surface water, rain water, and water vendors are all considered unimproved water sources. Despite increased access to piped water in Dawa, some households continued to use other water sources. Our spatial analysis indicated that households who used water sources other than the standpipes traveled farther, on average, than those who used the public standpipes. This could be due to where the households are located within the community (e.g., if they are located on the outskirts of Dawa, or closer to another water source than to the standpipe locations). However, this was not always the case as some households traveled farther for surface water from the Worpa, for example, rather than going to the standpipe that was closer.

Although we did not specifically collect data on factors that influence the choice of water source, this choice may be due to habit, taste, or cost, among other reasons (Ahmad *et al.*, 2007). Additionally, according to the implementing agency (CWSA), the piped-water system in Dawa was implemented by outside contractors and required only financial contribution from Dawa. Therefore, community members may not feel a sense of ownership about the standpipe system which may contribute to lack of use, as seen in other studies (Altman, 1995; Whittington, *et al.*, 1990). Although piped water interventions increase access to safe water, the process by which an intervention is implemented may contribute significantly to uptake by the community. Gleitsmann *et al.* (2007)found, in three rural communities in Mali, that while water supply interventions are extremely important, if they are implemented without participation and involvement of the community, sustainability may be an issue. Instead, a "platform" approach that mobilizes assets and different community members in the decision making process is advocated for. This could be an explanation for why some households in Dawa still choose surface water sources despite having access to the Standpipes (Gleitsmann, *et al.*, 2007; J. Thompson *et al.*, 2001; Whittington, *et al.*, 1990).

Other studies conducted in rural Kenya and Uganda support our findings that important determinants of water use include distance to water source and reliable access to the water source (Arouna & Dabbert, 2010; J. Thompson, *et al.*, 2001). These studies also found that ability and willingness to pay, taste preferences, household size, and composition are important factors in choice of water source; however, we did not examine these factors in this study of Dawa and Tugakope. Further focused research may improve our understanding of the reasons why individuals choose certain water sources as well as what actions would be necessary to encourage behavior change (2008).

Many groups define the distance a water source should be from a house in order to be considered an "improved source". The Food and Nutritional Technical Assistance (FANTA) guidelines define this distance as no more than 200 meters (Billig, *et al.*, 1999). By this definition, almost all of the water sources in both Dawa and Tugakope would be considered unimproved, as on average they are located farther than 200 meters from households. This is important because distance traveled is time taken away from other activities and may allow additional time and opportunity for water contamination during the trip (Jagals, 2006; S Lewin, Stephens, & Cairncross, 1997). It should be noted that this does not imply that no other water source exists within 200 meters for each household, but rather the distance to the water source preferred by households.

Water Quality:

The study also assessed the microbiological water quality at the water source and in the household and examined what factors affected water quality. Water quality measurements are extremely important to assess if and where contamination occurs. This information can be used to design specific interventions, especially with the growing body of evidence indicating that point of use treatment of water is an effective intervention (Fewtrell & Colford, 2005; Fewtrell *et al.*, 2005). Microbiological water quality testing for Dawa included source and household water samples that were collected both in the morning and in the afternoon of the same day. We were interested in examining what factors affect household water quality, and the association between source water quality and household water quality.

Source Water Quality:

No *E. coli* was detected in the water samples from the Town Standpipe and rain water tank; however varying levels of contamination (> 1 CFU/100mL) were detected for the surface water sources. The Town Standpipe and Rain Tank were covered and had spouts that were used to retrieve the water. The surface water sources were located in exposed areas accessible to animals, insects and debris, and individuals dipped their buckets or containers directly into the water for collection.

Household Water Quality:

When assessing impacts on household water quality, there are numerous factors that should be considered including source water quality, how the water was collected, what container it was collected in (were hands used to wipe it down), how it was transported, where it was stored, if it was elevated above the ground, if it was covered, how water was retrieved from the container, who retrieved water from the containers, if the water was treated, and personal hygiene behaviors, all of which have been shown to be contributors to water quality in previous studies (Gundry *et al.*, 2004; Quick *et al.*, 1999; Roberts *et al.*, 2001; T. Thompson, Sobsey, & Bartram, 2003; Trevett, Carter, & Tyrrel, 2005).

In Dawa, 68% of household water samples collected in the morning and 58% of samples collected in the afternoon had *E. coli* contamination. For the households that used the standpipe, even though samples collected at the standpipe showed no detectable *E. coli* present, 43% of samples from households using this source showed contamination greater than the maximum acceptable level of less than 1 organism per 100mL (Gadgil, 1998). This implies that post-source contamination occurred during transport and storage in the home. For surface water users, 78% of household water samples were contaminated. The broken standpipe, a point where the pipe that feeds into the standpipe had a hole in it and had formed a pool of water, was used by households on the day of the water sampling, as well as a few days before, when the leak had appeared. Samples from this source had high levels of contamination, and all the samples from households that used this source also had high levels of *E. coli*.

Household storage container type may also be associated with water contamination levels. For those households that used a wide-mouth container, such as basins or barrels, *E. coli* was detected in 71% of the morning and 94% of the afternoon samples. Water samples from narrow-mouthed water storage containers had *E. coli* detected in 60% of the morning samples and 50% of the afternoon samples.

For Dawa, the household water was always contaminated, regardless of the source quality. This may be due to the effects of the source quality, to household transport, storage and handling practices, or all of these. We did not find an association between the education level of the female head of household and the presence of *E. coli* in the household water, nor did we find an association between the presence of any children under five years in the household, which we hypothesized may be associated with water quality based on previous research (Desai & Alva, 1998; Andrew F. Trevett, Richard C. Carter, & Sean F. Tyrrel, 2005; Williams, *et al.*). Although we did not collect data on water treatment practices of households that participated in the water quality testing, we can hypothesize that treatment of water would reduce the concentrations of *E. coli* in the water, thus improving the quality.

Gundry *et al.* (2004) emphasize the importance of, and distinction between, source water quality and household water quality and the potential for microbial contamination at the source, during collection, and post-collection, all of which have an impact on health. For Dawa, this is particularly important as our data show that post-source contamination occurred. Our findings for Dawa were similar to other studies that assessed factors that contribute to post-source water contamination. Several studies in South Africa, Zimbabwe, Malawi, Mali, and Rwanda have examined microbiological water quality at the source and post-source (Dawa and Tugakope community members, 2009; Gasana *et* *al.*, 2002; Gundry *et al.*, 2006; Roberts *et al.*, 2001; Williams *et al.*). These studies indicate that generally, improved water sources had less *E. coli* contamination than unimproved sources. At the household level, water from both improved and unimproved sources had significant deterioration of microbiological quality post-source possibly from utensils used during transport, storage of water, and unhygienic water handling. The proportion of households with *E. coli* contamination detected in household drinking water ranged from 40% to 97%, and our study results for Dawa fall within this range. These studies indicate that the proportion of households with contaminated water varies by community. However, the reasons for post-source contamination occurring are often similar and inter-connected. Because there are many factors that could contribute to the household contamination level, further research in Dawa may be required to delineate specific reasons and causes. However, regardless of cause, previous studies have shown that household water quality interventions, such as point of use treatment and safe storage containers, are effective in improving household water quality and health (Clasen *et al.*, 2007; Gundry *et al.*, 2004; Makutsa *et al.*, 2001) and could be appropriate for Dawa.

Household Water treatment:

As another component of the baseline assessment, this study examined what, if any, water treatment was practiced, and what factors were associated with household water treatment. Treatment of drinking water was not common in either community, and among those who did treat, most households treated water from a surface water source only, and by sieving through a cloth, a method which has little biological efficacy. We did not find an association between educational level of the respondent and whether household water treatment was practiced, or between presence of any children under five and household water treatment, which we hypothesized to be associated with water treatment practices based on previous research (Desai & Alva, 1998; Williams, *et al.*). Other explanations for the low treatment of household water could be the perception that water from a public standpipe source is always safe to drink or general lack of education on household water treatment. Of particular concern, one respondent in Dawa stated that her household used moth balls to treat drinking water, and one respondent in Tugakope reported using kerosene to treat drinking water. Both of these women believed that the use of these items would kill off harmful organisms in the water, as well as improve the taste (Dawa and Tugakope community members, 2009). This observation further supports the fact that taste may play an important role in water source choice. Additionally, these women believed that treatment of water with these items would not provide any harmful effects. Education about household water treatment may be necessary in order to improve household water quality as well as discourage unsafe treatment practices.

In a study comparing the extent of household water treatment in low and middle income countries around the world, 33% of households reported treating their drinking water (Rosa & Clasen, 2010). However, for African countries, the proportion is only 18.2%. Our study reported 17% of households in Dawa and 81% of households in Tugakope treat their primary drinking water source, and 29% and 16% treat their secondary water source, respectively. For the primary drinking water source, the proportion for Dawa is similar to that reported for other parts of Africa, but is much lower than the global estimates. For Tugakope, the proportion of households who reported treating their primary water source is much higher than the Africa and global estimates; however this is inverted for secondary source. Although further research should be conducted to assess specific reasons why a higher proportion of households in Tugakope treat their primary drinking water (from the Dam), it is likely due to taste and turbidity. Similar findings have been documented elsewhere in Africa (Williams *et al.*). Williams *et al.* conducted a quantitative and qualitative assessment of WASH practices in rural Mali, and found that respondents did not perceive of their household drinking water as a source of diseases (80%) (Williams *et al.*). This suggests that respondents believe water quality is not associated with illness, so the need for water treatment is not realized.

Sanitation:

This study also examined household sanitation practices and determinants for these practices. There was a significant difference in sanitation services used between Dawa and Tugakope. The majority of households in Dawa (79%) practiced open defecation, whereas the majority in Tugakope used household VIP latrines (74%). For children under five years, 44% of caretakers in Tugakope disposed of feces in the pit of a latrine. Tugakope was the recipient of a sanitation intervention (from CWSA and DANIDA), and each household, or group of households, was given materials and taught how to build a VIP latrine. Because of increased access, convenience, and proximity to the VIP latrines, it is likely that this intervention led to increased use of these latrines (Taha, Sebai, Shahidullah, Hanif, & Ahmed, 2000). Previous research has indicated that community involvement in the planning and implementation stages is key to fostering a sense of ownership in the intervention (Altman, 1995; Gleitsmann *et al.*, 2007; Thompson *et al.*, 2001; T. Thompson *et al.*, 2003; Whittington *et al.*, 1990). We hypothesize that Tugakope felt a sense of ownership in the latrines, as they were involved in the construction. However, a motivation factor may have been lacking as part of the intervention, as evidenced by the 26% of households in Tugakope who still practiced open defecation. This study did not find an association between education level of the respondent and sanitation practices (Desai & Alva, 1998; Williams *et al.*). We did not collect data on unused latrines in Tugakope. Despite the presence of the Sanitation Market in Dawa, where households could purchase different types of latrines, open defecation was very common. This intervention strategy was not as effective as the household latrine intervention in Tugakope. According to a community leader in Dawa, the sanitation market had only sold a handful of latrines (Dawa and Tugakope community members, 2009). It is likely that cost was a prohibitive factor for Dawa households.

Latrine use among children under five was not common. About 27% of caretakers in Dawa reported that they disposed of their children's feces somewhere outside of the house premises, and 25% reported burying them. In Tugakope, 44% of caretakers reported disposing of their children's feces in the pit of a latrine. This difference may be due to the presence of household latrines in Tugakope where respondents would be more inclined to dispose of anal cleansing materials or children's feces in the pit. In Dawa, the majority of respondents practiced open defecation and were thus more inclined to leave the children's feces and anal cleansing materials on the ground, where they defecated.

When comparing our results to other sanitation studies in Africa, we noted a few differences. In Burkina Faso, after implementation of a sanitation and hygiene intervention, no evidence of a change in disposal practices of children's feces was found (Curtis, Kanki, Cousens, & Diallo, 2001). In our study, we found that 44% respondents in

Tugakope reported disposing of children's feces in a pit latrine. While we do not have pre-intervention information to compare this to, it is likely that this increase in fecal disposal in a pit latrine is associated with increased access to a pit latrine. In another study assessing sanitation and hygiene in Tanzania, Uganda, and Kenya, our results also differed slightly (Tumwine *et al.*, 2003). For rural households within these three countries that had received sanitation interventions, latrine possession was very high: 73.5% in Uganda, 90.5% in Tanzania and 95% in Kenya. Dawa had a very low proportion of households who have a latrine. Tugakope also falls in the lower end of this spectrum, which is notable considering that Tugakope was an intervention community. This may be because the Tugakope intervention was a one-time intervention, and households that were built after completion of the intervention did not receive a latrine.

While latrine access seems to vary across different communities, reasons or motivating factors for using a latrine are consistent with our results. Previous studies have shown that owning a latrine inherently increases use of that latrine (Taha *et al.*, 2000). However, reasons for owning a latrine often have very little to do with concern for health, but rather with prestige, convenience and status (Mara, Lane, Scott, & Trouba, 2010). These studies indicate that interventions often lack an educational or motivational component that encourages all community members to change defecation practices, not just those who receive the intervention (Jenkins & Curtis, 2005; Kravitz, Nyaphisi, Mandel, & Petersen, 1999). These results may explain why uptake of latrines from the sanitation market in Dawa was very low, and why some households in Tugakope continued to practice open defecation, despite having access to VIP latrines.

Hygiene:

There was a significant difference in presence of soap between Dawa (59%) and Tugakope (94%). Although this study did not examine specific reasons for the presence of soap in a household, it is likely that a contributing factor was the higher percentage of households with latrines in Tugakope. Better hygiene practices have been observed in households that have sanitation facilities, independent of the presence of piped water (Strina, Cairncross, Barreto, Larrea, & Prado, 2003). However, among our study households who did have soap present, there was still a high proportion of households where the soap was not found in the handwashing station. This is likely an indication that soap may not be used predominantly for handwashing purposes, but rather for other chores around the household. According to DHS estimates from 2003, soap was found in 10.5% of rural households (ICF Macro Measure DHS, 2008). For the Greater Accra Region, soap was found in 24.2% of households. Thus, a greater proportion of the study households in Dawa and Tugakope had soap compared to DHS estimates for rural Ghana and for the Greater Accra Region.

Hygiene is not only important for personal cleanliness, but is also a contributing factor to household water quality (Luby *et al.*, 2009). As described above, many community members in both Dawa and Tugakope used wide-mouth water storage containers and dipped into the containers to retrieve water. Where personal hygiene behaviors are poor, this practice can lead to contamination of the water. Thus hygiene may be another determinant of household water quality. Luby *et al.* (2009) reported that the presence of a regular handwashing station, or the materials required to wash hands, was associated with increase handwashing with soap after fecal contact, regardless of proximity to defecation.

For Dawa and Tugakope, improvements in handwashing behaviors may be achieved by setting up household handwashing stations. Regardless of the presence of a latrine, households become accustomed to washing their hands with soap, which in turn will affect personal hygiene and household water quality.

Our results are supported by other studies in sub-Saharan Africa (Aunger *et al.*, 2010; Pickering, Boehm, Mwanjali, & Davis, 2010). A study conducted in Kenya found that 97% of Kenyan households had soap present, close to the percentage in Tugakope. However the proportion of households that used soap for handwashing was not as high and the authors stated that this occurred because soap was used for other household chores (such as cleaning, laundry). The authors concluded that the determinants of soap were related to reactive factors (such as habit), motivational factors (such as hygiene, cleanliness), and cognitive factors (such as health education and economic constraints). In contrast to our results, Pickering *et al.* (2010) found, in a field study in Dar es Salaam, Tanzania, that proximity to and quantity of water was correlated with frequency of handwashing. In our study, fewer households in Dawa had soap compared to Tugakope, despite the fact that standpipe water was readily available in Dawa, and the average distance to the water source was about 3 times shorter than the distance to the water source in Tugakope.

Strengths and Limitations:

Strengths:

This research study was conducted using multiple methods to perform a comprehensive baseline assessment of the two communities. Previous studies have typically focused on one specific risk factor or method related to water and sanitation, such as geospatial factors, water and sanitation coverage, household factors, community-level factors, water quality, or hygiene, and have examined the association between this factor and diarrheal disease. While assessing these relationships is important, many of these previous studies fail to recognize the multivariate effects of a combination of factors on disease (Pande *et al.*, 2008). Many studies have assessed the impact of different interventions on reduction of the diarrheal disease burden (Fewtrell & Colford, 2005; Fewtrell *et al.*, 2005), but do not recognize that interventions should be community specific, as each community has different needs. For example, one community may have different reasons for not choosing an improved water source, or for practicing open defecation even with access to latrines. This research study takes both of these factors, i.e., the relationships that affect diarrheal prevalence, as well as community-specific factors that contribute to access or use, into consideration by using multiple methods to develop a comprehensive overview of water, sanitation and hygiene factors in these two rural communities. As a result of this multi-faceted approach, the results can then be used to design specific interventions appropriate for the needs and practices in these communities, thus increasing the likelihood that they will be effective for reduction of diarrheal disease.

Spatial analysis was another strength of this study. By looking at spatial relationships between different WASH factors, we were able to observe relationships that may not have been apparent by traditional quantitative or qualitative data analyses.

Moreover, conducting research as a multi-disciplinary team enhanced the research efforts. The collaborative effort and approach with multiple perspectives was extremely beneficial. Each person was able to contribute ideas from their respective disciplines and past experiences, and combining these diverse approaches greatly strengthened the assessment process. In order to obtain a comprehensive overview of WASH practices, we had to take a multi-disciplinary approach by collecting different types of data. Each person was able to use their strengths and work on a particular aspect or aspects of the comprehensive assessment.

Limitations:

Inherent to any study design and implementation are limitations that may restrict the extent to which inferences can be drawn from the data. For this study, the sample size was small and thus limited the analyses that could be performed. To examine more robust measures and predictors, a larger sample size would be necessary. This would also allow for further inter- and intra- community analyses. Another limitation was the time frame of the research. Ideally, the water samples should have been taken simultaneously with the household questionnaires, thus allowing for comparisons between all of the questionnaire data and the water quality results, but due to logistical constraints, this did not occur. In addition, the study design could have been improved by including a series of household interviews over time, and not just a single point in time observation. This would allow us to measure diarrheal incidence or period prevalence.

Interviewer bias may have also influenced the study results. Although the translators were trained beforehand, there may have been leading when asking the questions. Additionally, the two translators may have translated the questions differently and therefore elicited different responses from the interviewees. Social desirability bias may also have been a limitation to this study. Respondents may have replied in a way that they perceived as favorable (e.g., using soap for handwashing), instead of answering truthfully. The household questionnaires relied heavily on recall, albeit short-term recall. Recall bias is another limitation to this study. Respondents may not have recalled diarrheal episodes, or other answers, correctly, therefore affecting the reliability (or accuracy) of the data.

Because of the convenience sampling method used, the generalizability of these data is not known. The two communities were chosen based on the type of intervention implemented, as well as willingness of the community leaders to work with us. Therefore, these communities may not be representative of other rural communities in Ghana. However, the purpose of this study was to obtain a comprehensive assessment for Dawa and Tugakope in order to better inform future interventions for these communities, and therefore generalizability was not expected.

The cross-sectional study design is another limitation of this study. Because we are looking at various factors at one point in time, cross-sectional study designs do not allow for causation to be established. We were only able to study the associations between water, sanitation, hygiene, and diarrhea. This study design is not suited to study causal links between specific WASH factors or combinations of factors and diarrheal disease.

In addition to these limitations, the research team also reflected on other data that may have enhanced our understanding of WASH practices in Dawa and Tugakope. Data on unused latrines, latrine sales at the Sanitation Market, water sources during rainy season versus dry season, water taste preferences, willingness to pay for standpipe water, perceived quality of the different water sources, and microbiological water quality data for each household in both communities would have strengthened our assessment. Additionally, collecting GPS data for all household locations, and not just those that were interviewed would have been helpful to map the layout of the entire community and the relationship between the houses that participated and those that did not.

Last, the lab analytical technique used to measure *E. coli* was not a standard method and was not accurate for quantitative assessment of *E. coli* concentration in water.

Summary and Conclusions

This study gives a comprehensive overview of the water, sanitation and hygiene practices for these two communities. There are many factors that contribute to the burden of disease related to water, sanitation and hygiene including water source or sanitation service, use of these services, water storage and treatment practices, waste disposal practices, geo-spatial factors, and personal hygiene behaviors. This assessment collected information related to each of these factors in order to determine which are most relevant for the two communities studied. Future investigators can use this information to develop follow up studies that focus on specific aspects of the results of this study. Specific areas for follow up include

1. Further understanding of community water, sanitation and health related beliefs, customs, and habits
2. Further educational training for community members with emphasis on household water storage and treatment practices, hygiene and safe feces disposal

3. Further disease prevalence information from the communities including mapping of all households and diarrheal cases
4. Eventual design of community-specific interventions using the results of this study and follow-up studies to maximize uptake by the community members

References

Ahmad, S. A., Sayed, M. H. S., Khan, M. H., Karim, M. N., Haque, M. A., Bhuiyan, M. S. A., et al. (2007). Sociocultural aspects of arsenicosis in Bangladesh: Community perspective. [Article]. *Journal of Environmental Science & Health, Part A: Toxic/Hazardous Substances & Environmental Engineering, 42*(12), 1945-1958. doi: 10.1080/10934520701567247

Ali, M., Emch, M., Donnay, J. P., Yunus, M., & Sack, R. B. (2002). Identifying environmental risk factors for endemic cholera: a raster GIS approach. *Health & Place, 8*(3), 201-210.

Altman, D. (1995). Sustaining Interventions in Community Systems: On the Relationship Between Researchers and Communities. *Health Psychology, 14*(6), 526-536.

Arouna, A., & Dabbert, S. (2010). Determinants of domestic water use by rural households without access to private improved water sources in Benin: A seemingly unrelated tobit approach. *Water Resources Mangement, 24*, 1381-1398.

Aunger, R., Schmidt, W.-P., Ranpura, A., Coombes, Y., Maina, P. M., Matiko, C. N., et al. (2010). Three kinds of psychological determinants for hand-washing behaviour in Kenya. *Social Science & Medicine, 70*(3), 383-391. doi: DOI: 10.1016/j.socscimed.2009.10.038

Bern, C., Martinez, J., Zoysa, I. d., & Glass, R. I. (1992). The magnitude of the global problem of diarrhoeal disease: a ten-year update. *Bulletin of the World Health Organization, 70*(6), 705-714.

Bessong, P. O., Odiyo, J. O., Musekene, J. N., & Tessema, A. (2009). Spatial distribution of diarrhoea and microbial quality of domestic water during an outbreak of diarrhoea in the Tshikuwi community in Venda, South Africa. *Journal of health, population, and nutrition, 27*(5), 652 - 659.

Billig, P., Bendahmane, D., & Swindale, A. (1999). Food and Nutrition Technical Assistance (FANTA) Water and Sanitation Indicators Measurement Guide.

Cairncross, S., & Kolsky, P. (1997). Water, Waste and well-being: a multicountry study. *American Journal of Epidemiology, 146*(4), 359-361.

Cairncross, S., Blumenthal, U., Kolsky, P., Moraes, L., & Tayeh, A. (1996). The public and domestic domains in the transmission of disease. *Tropical Medicine & International Health, 1*, 27-34.

Clasen, T., Schmidt, W.-P., Rabie, T., Roberts, I., & Cairncross, S. (2007). Interventions to improve water quality for preventing diarrhoea: systematic review and meta-analysis. *BMJ, 334*(7597), 782. doi: 10.1136/bmj.39118.489931.BE

Curtis, V., Kanki, B., Cousens, S., & Diallo, I. (2001). Evidence of behavior change following a hygiene promotion programme in Burkina Faso. In World Health Organization & Bulletin of the WHO (Eds.), (Vol. 79, pp. 518-528).

Dawa and Tugakope community members (2009). [Personal Communication about water treatment practices].

Desai, S., & Alva, S. (1998). Maternal Education and Child Health: Is there a strong causal relationship. *Demography, 35*(1), 71-81.

Environmental Health Project. (2004). Strategic Report 8: Assessing Hygiene Improvement , Guidelines for Household and Community Levels. In USAID (Ed.), *Hygiene Improvement Household Survey Questions: Knowledge, Practice and Coverage of Water Supply, Sanitaion and Hygiene* (pp. 121-151). Washington, DC.

Esrey, S. (1996). Water, Waste and Well-Being: A Multicountry Study. *American Journal of Epidemiology, 143*(6), 608-623.

Esrey, S. A., Feachem, R. G., & Hughes, J. M. (1985). Interventions for the control of diarrhoeal diseases among young children: improving water supplies and excreta disposal facilities. *Bulletin of the World Health Organization, 63*(4), 757-772.

Esrey, S. A., Potash, J. B., Roberts, L., & Shiff, C. (1991). Effects of improved water supply and sanitation on ascariasis, diarrhoea, dracunculiasis, hookworm infection, schistosomiasis, and trachoma. *Bulletin of the World Health Organization, 69*(5), 609-621.

Fewtrell, L., & J.M. Colford, J. (2005). Water, sanitation and hygiene in developing countries: interventions and diarrhoea-a review. *Water Science & Technology, 52*(8), 133-142.

Fewtrell, L., Kaufmann, R. B., Kay, D., Enanoria, W., Haller, L., & Colford, J. J. M. (2005). Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta-analysis. *The Lancet Infectious Diseases, 5*(1), 42-52.

Gadgil, A. (1998). DRINKING WATER IN DEVELOPING COUNTRIES. *Annual Review of Energy and the Environment, 23*(1), 253-286. doi: 10.1146/annurev.energy.23.1.253

Garrett, V., Ogutu, P., Mabonga, P., Ombeki, S., Mwaki, A., Aluoch, G., et al. (2008). Diarrhoea prevention in a high-risk rural Kenyan population through point-of-use chlorination, safe water storage, sanitation, and rain water harvesting. *Epidemiology of Infectious Diseases, 136*, 1463-1471.

Gasana, J., Morin, J., Ndikuyeze, A., & Kamoso, P. (2002). Impact of Water Supply and Sanitation on Diarrheal Morbidity among Young Children in the Socioeconomic and Cultural Context of Rwanda (Africa). *Environmental Research, 90*(2), 76-88. doi: DOI: 10.1006/enrs.2002.4394

Ghana Statistical Service (GSS), Ghana Health Service (GHS), & IFC Macro. (2009). Ghana Demographic and Health Survey, 2008. In G. GSS, ICF Macro, (Ed.). Accra.

Glass, G., Schwartz, B., Morgan, J., Johnson, D., Nov, P., & Israel, E. (1995). Environmental risk factors for Lyme disease identified with GIS.

Gleitsmann, B. A., Kroma, M. M., & Steenhuis, T. (2007). Analysis of a rural water supply project in three communities in Mali: Participation and sustainability. *Natural Resources Forum, 31*(2), 142-150. doi: 10.1111/j.1477-8947.2007.00144.x

Goodchild, M., Haining, R., & Wise, S. (1992). Integrating GIS and spatial data anlysis: problems and possibilities. *International Journal of Geographical Information Systems, 6*(5), 407-423.

Gundry, S., Wright, J., & Conroy, R. (2004). A systematic review of the health outcomes related to household water quality in developing countries. *Journal for Water and Health, 2*(1), 1-13.

Gundry, S., Wright, J., Conroy, R., Preez, M. D., Genthe, B., Moyo, S., et al. (2006). Contamination of drinking water between source and point-of-use in rural households of South Africa and Zimbabwe: implications for monitoring the Millennium Development Goal for water. *Water Practice & Technology*.

Halvorson, S. J. (2004). Women's management of the household health environment: responding to childhood diarrhea in the Northern Areas, Pakistan. *Health & Place, 10*(1), 43-58. doi: Doi: 10.1016/s1353-8292(03)00018-2

Jagals, P. (2006). Does improved access to water supply by rural households enhance the concept of safe water at the point of use? A case study from deep rural South Africa. *Water Science & Technology, 54*(3), 9-16.

Jenkins, M. W., & Curtis, V. (2005). Achieving the 'good life': Why some people want latrines in rural Benin. *Social Science & Medicine, 61*(11), 2446-2459. doi: DOI: 10.1016/j.socscimed.2005.04.036

Jensen, P. K., Ensink, J. H. J., Jayasinghe, G., Hoek, W. v. d., Cairncross, S., & Dalsgaard, A. (2002). Domestic transmission routes of pathogens: the problem of in-house contamination of drinking water during storage in developing countries. *Tropical Medicine & International Health, 7*(7), 604-609.

Joint Monitoring Programme for Water Supply and Sanitation, WHO, & UNICEF. (2010) Retrieved 11-10, 2010, from http://www.wssinfo.org/definitions-methods/data-sources/

Joint Monitoring Programme for Water Supply and Sanitation (JMP). (2008). Progress on drinking water and sanitation:special focus on sanitation. In UNICEF & WHO (Eds.).

Jones, G., Steketee, R. W., Black, R. E., Bhutta, Z. A., & Morris, S. (2003). How many child deaths can we prevent this year? *The Lancet, 362*(9377), 65-71.

Khan, S. S. (2008). In the fight to save children's lives, washing hands takes centre stage.

Kravitz, J., Nyaphisi, M., Mandel, R., & Petersen, E. (1999). Quantitative bacterial examination of domestic water supplies in the Lesotho Highlands: water quality, sanitation and village health. In W. H. O. Bulletin (Ed.), (Vol. 77, pp. 829-836).

Lewin, S., Norman, R., Nannan, N., Thomas, E., & Bradshaw, D. (2007). Estimating the burden of disease attributable to unsafe water and lack of sanitation and hygiene in South AFrica in 2000. *South African Medical Journal, 97*(755-762).

Lewin, S., Stephens, C., & Cairncross, S. (1997). Reviewing the health impacts of improvements in water supply. *Urban Health Newsletter, 32*, 34-47.

Luby, S. P., Halder, A. K., Tronchet, C., Akhter, S., Bhuiya, A., & Johnston, R. B. (2009). Household Characteristics Associated with Handwashing with Soap in Rural Bangladesh. *Am J Trop Med Hyg, 81*(5), 882-887. doi: 10.4269/ajtmh.2009.09-0031

Makutsa, P., Nzaku, K., Ogutu, P., Barasa, P., Ombeki, S., Mwaki, A., et al. (2001). Challenges in Implementing a Point-of-Use Water Quality Intervention in Rural Kenya. [Article]. *American Journal of Public Health, 91*(10), 1571-1573.

Mara, D., Lane, J., Scott, B., & Trouba, D. (2010). Sanitation and Health. *PLoS Med, 7*(11), e1000363.

Measure DHS, I. M. Demographic and Health Surveys: About Retrieved January 2010, from http://www.measuredhs.com/aboutdhs/

Measure DHS, I. M. (2008). Demographic and Health Surveys Stat Compiler. Retrieved 11-1-2010 http://www.measuredhs.com/accesssurveys/

Mintz, E. D., Reiff, F. M., & Tauxe, R. V. (1995). Safe Water Treatment and Storage In the Home: A Practical New Strategy to Prevent Waterborne Disease. *JAMA, 273*(12), 948-953.

Murray, C. J. L., & Lopez, A. D. (1997). Global mortality, disability, and the contribution of risk factors: Global Burden of Disease Study. *The Lancet, 349*(9063), 1436-1442.

Osei, F., & Duker, A. (2008). Spatial and demographic patterns of Cholera in Ashanti region- Ghana. *International Journal of Health Geographics, 7*(44).

Pande, S., Keyzer, M. A., Arouna, A., & Sonneveld, B. (2008). Addressing diarrhea prevalence in the West African Middle Belt: social and geographic dimensions in a case study for Benin (S. Pande, M. A. Keyzer, A. Arouna & B. G. J. S. Sonneveld, Trans.) (Vol. 7, pp. 1-17): BioMed Central.

Pickering, A. J., Boehm, A. B., Mwanjali, M., & Davis, J. (2010). Efficacy of Waterless Hand Hygiene Compared with Handwashing with Soap: A Field Study in Dar es Salaam, Tanzania. *Am J Trop Med Hyg, 82*(2), 270-278. doi: 10.4269/ajtmh.2010.09-0220

Pruss-Ustun, A., & Corvalan, C. (2006). Preventing Disease Through Healthy Environments: Towards an estimate of the environmental burden of disease. In WHO (Ed.). Geneva.

Pruss-Ustun, A., Kay, D., Fewtrell, L., & Bartram, J. (2004). Unsafe water, sanitation and hygiene. In M. Ezzati, A. D. Rogers, A. D. Lopez & C. J. L. Murray (Eds.), *Comparative Quantification of Health Risks: Global and Regional Burden of Disease due to Selected Major Risk Factors* (Vol. 2). Geneva, USA: The World Health Organizations.

Pruss, A., Kay, D., Fewtrell, L., & Bartram, J. (2002). Estimating the Burden of Disease from Water, Sanitation, and Hygiene at a Global Level. *Environmental Health Perspectivies, 110*(5), 537-542.

Quick, R., Venezel, L., & Mintz, E. (1999). Diarrhea prevention in Bolivia through point-of-use water treatment and safe strorage: a promising new strategy. *Epidemiology and Infection, 122*, 83-90.

Roberts, L., Chartier, Y., Chartier, O., Malenga, G., Toole, M., & Rodka, H. (2001). Keeping clean water in a Malawi refugee camp: a randomised intervention trial. *Bulletin of the World Health Organization, 79*, 280-287.

Rosa, G., & Clasen, T. (2010). Estimating the Scope of Household Water Treatment in Low- and Medium-Income Countries. *Am J Trop Med Hyg, 82*(2), 289-300. doi: 10.4269/ajtmh.2010.09-0382

Snyder, J. D., & Merson, M. (1982). The magnitude of the global problem of acute diarrhoeal disease: a review of active surveillance data. *Bulletin of the World Health Organization, 60*(4), 605-613.

Strina, A., Cairncross, S., Barreto, M. L., Larrea, C., & Prado, M. S. (2003). Childhood Diarrhea and Observed Hygiene Behavior in Salvador, Brazil. *American Journal of Epidemiology, 157*(11), 1032-1038. doi: 10.1093/aje/kwg075

Taha, A. Z., Sebai, Z. A., Shahidullah, M., Hanif, M., & Ahmed, H. O. (2000). Assessment of Water Use and Sanitation Behavior in a Rural Area of Bangladesh. [Article]. *Archives of Environmental Health, 55*(1), 51-57.

Thompson, J., Porras, I. T., Tumwine, J., Mujwahuzi, M., Katui-Katua, M., Johnstone, N., et al. (2001). *Drawers of Water II*. London.

Thompson, T., Sobsey, M., & Bartram, J. (2003). Providing clean water, keeping water clean: an integrated approach. [Article]. *International Journal of Environmental Health Research, 13*, S89-S94.

Trevett, A. F., Carter, R. C., & Tyrrel, S. F. (2005). The importance of domestic water quality management in the context of faecal-oral disease transmission. *Journal of Water & Health, 3*(3), 259-270.

Trevett, A. F., Carter, R. C., & Tyrrel, S. F. (2005). Mechanisms leading to post - supply water quality deterioration in rural Honduran communities. *International Journal of Hygiene and Environmental Health, 208*(3), 153-161. doi: DOI: 10.1016/j.ijheh.2005.01.024

Trykker, H., Simwambana, A., Kantu, K., & Eberhard, M. (1994). A primary health care baseline survey in a rural district in Zambia. *African journal of medicine and medical sciences, 23*, 147-151.

Tumwine, J., Thompson, J., Katui-Katua, M., Mujwahuzi, M., Johnstone, N., & Porras, I. N. A. (2003). Sanitation and hygiene in urban and rural households in East Africa. [Article]. *International Journal of Environmental Health Research, 13*(2), 107.

UNICEF. (2009). Soap, toilets and taps: How UNICEF supports water, sanitation and hygiene.

VanDerslice, J., & Briscoe, J. (1995). Environmental Interventions in developing countries: interactions and their implications. *American Journal of Epidemiology, 41*, 135-144.

Wang, X., & Hunter, P. R. (2010). A Systematic Review and Meta-Analysis of the Association between Self-Reported Diarrheal Disease and Distance from Home to Water Source. *Am J Trop Med Hyg, 83*(3), 582-584. doi: 10.4269/ajtmh.2010.10-0215

Westaway, M. S., & Viljoen, E. (2000). Health and hygiene knowledge, attitudes and behaviour. *Health & Place, 6*(1), 25-32. doi: Doi: 10.1016/s1353-8292(99)00027-1

Whittington, D., Briscoe, J., Mu, X., & Barron, W. (1990). Estimating the Willingness to Pay for Water services in Developing Countries: A case study of the use of contingent valuation surveys in southern Haiti. *Economic Development and Cultural Change, 38*(2), 293-311.

WHO/UNICEF Joint Monitoring Programme. (2008). The Joint Monitoring Programme: definitions.

WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation. (2010). Progress on Sanitation and Drinking Water.

Williams, A. L., Halvorson, S. J., Ba, S., & Dunkel, F. V. Water quality and waterborne disease in the Niger River inland delta, Mali: A study of local knowledge and response. *Health & Place, In Press, Accepted Manuscript*. doi: DOI: 10.1016/j.healthplace.2010.10.002

World Health Organization. Global Burden of Disease Retrieved 12/1, 2010, from http://www.who.int/healthinfo/global_burden_disease/en/index.html

World Health Organization. (2010). GIS and public health mapping Retrieved 11-10, 2010, from http://www.who.int/health_mapping/gisandphm/en/index.html

Figures:

Figure 1: Study Households and Water Sources in Dawa, Greater Accra, Ghana

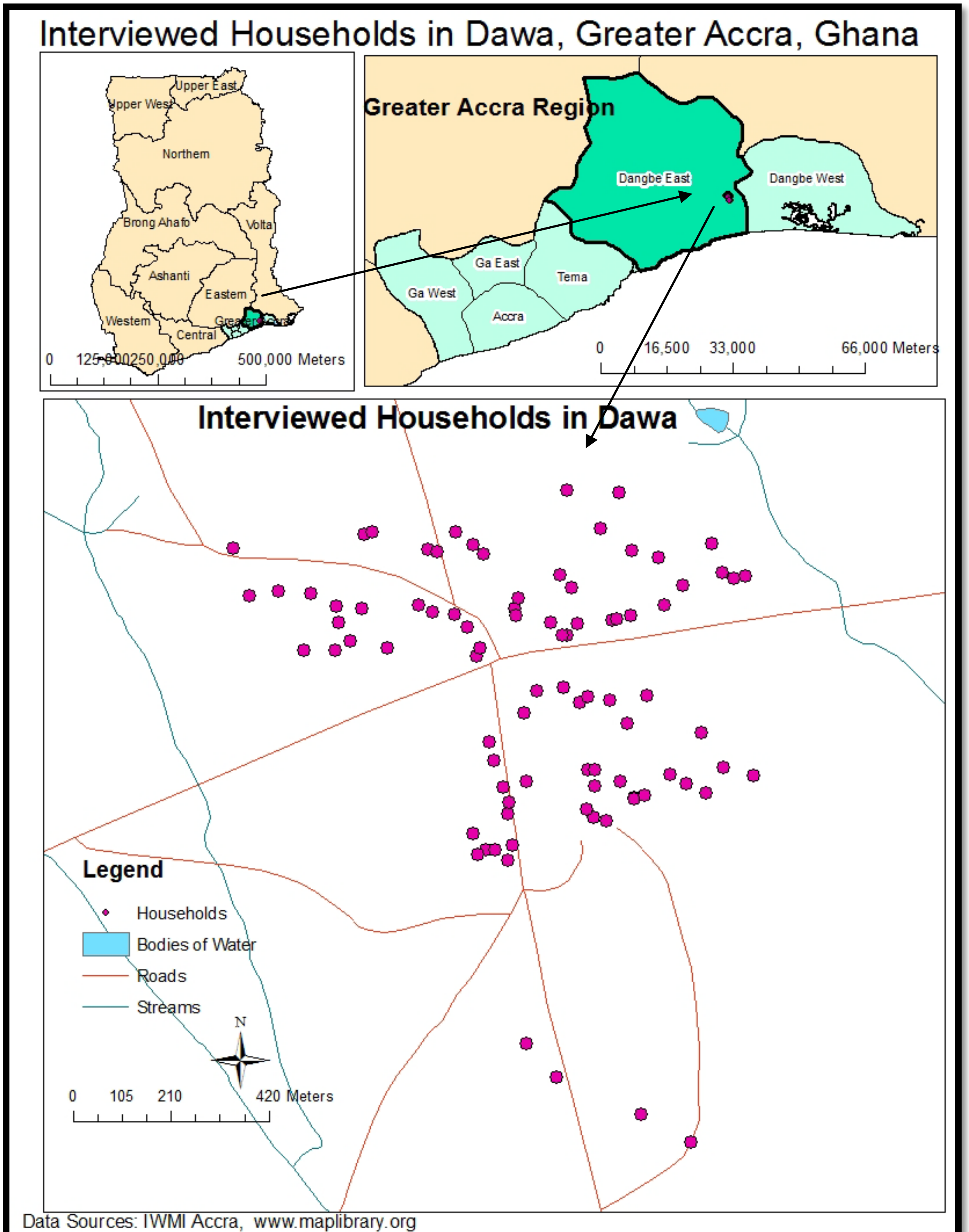


Figure 2: Study Households and Water Sources in Tugakope, Greater Accra, Ghana

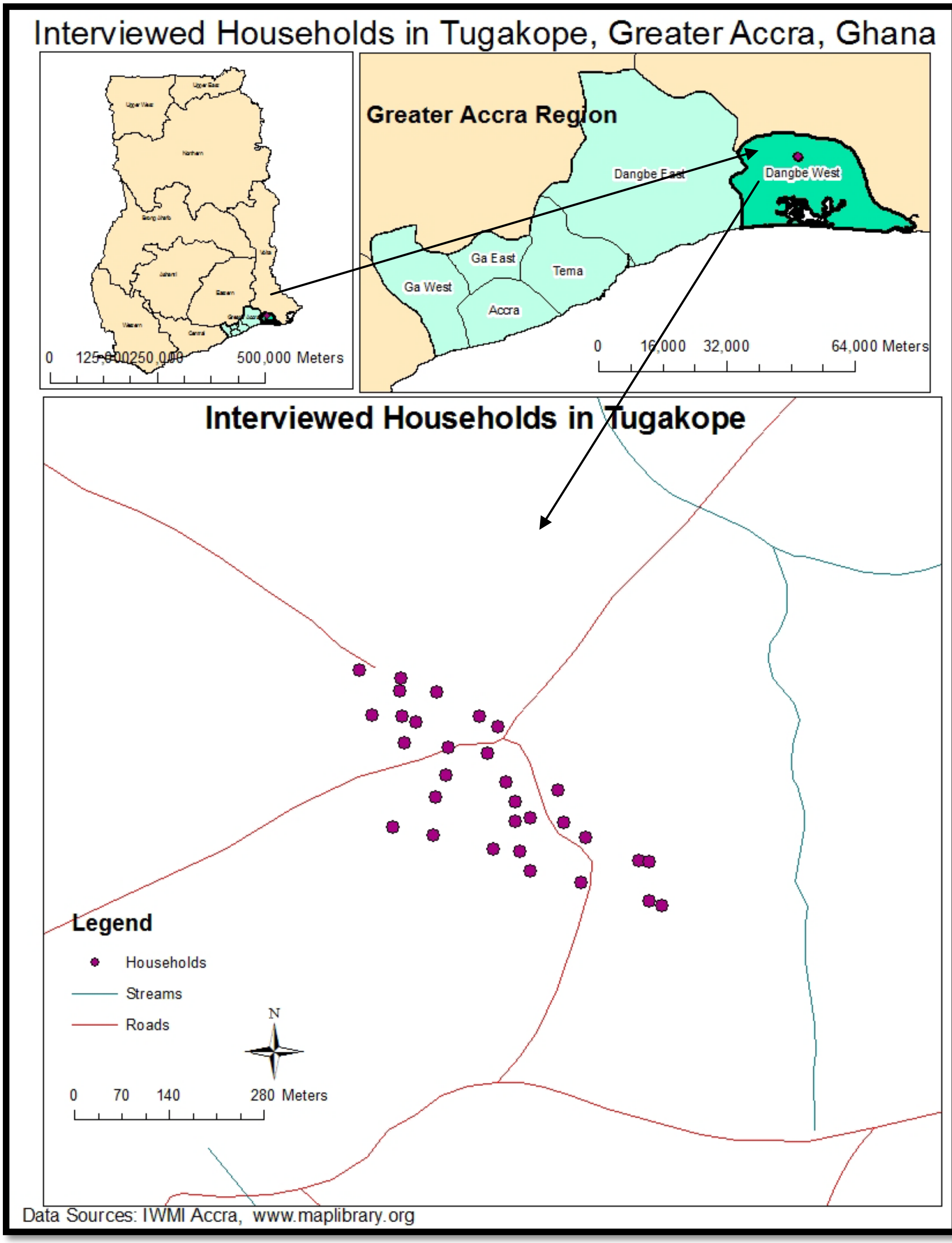


Figure 3: Study Households in Dawa and Their Primary Drinking Water Sources

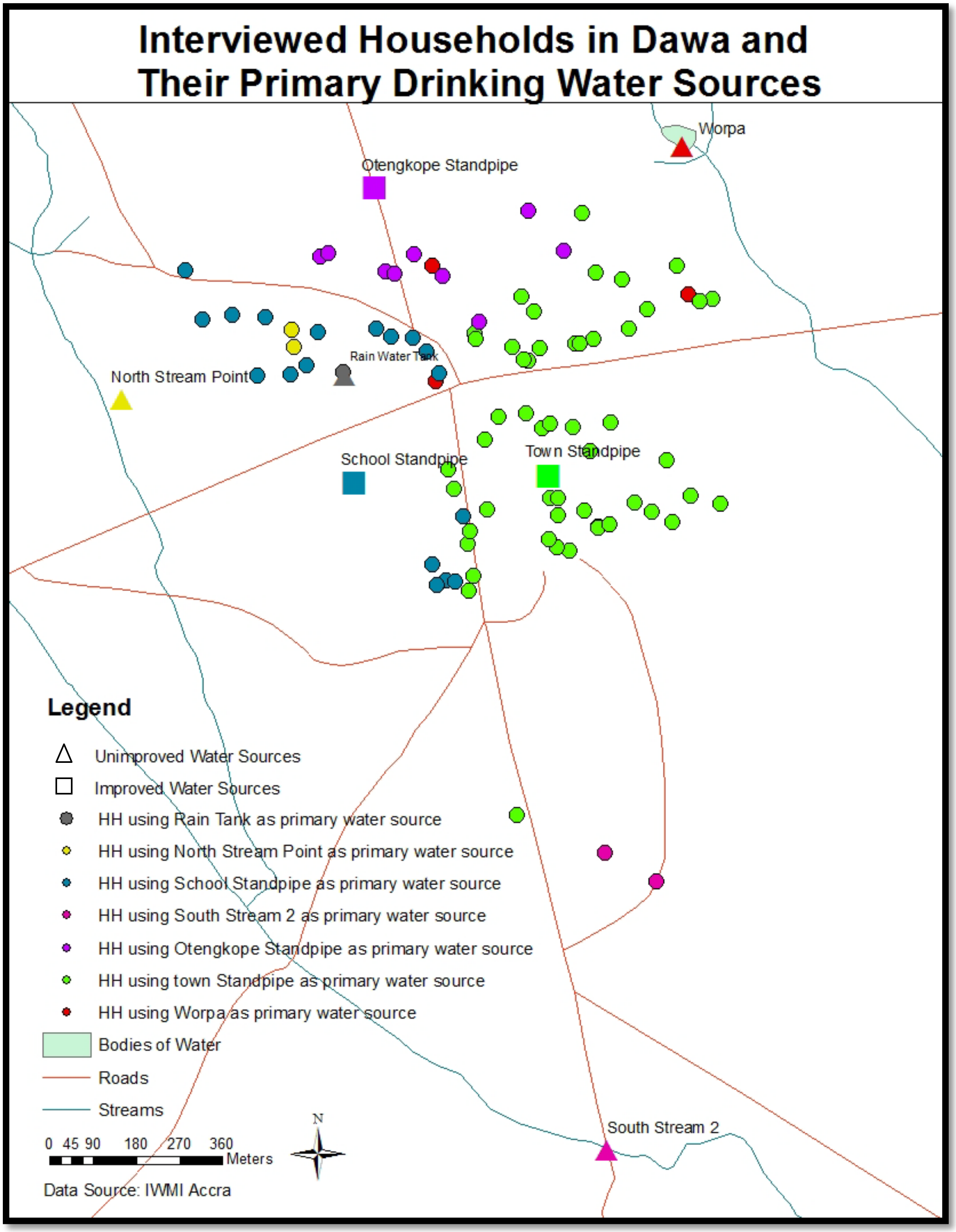


Figure 4: Study Households in Dawa and Their Secondary Drinking Water Sources

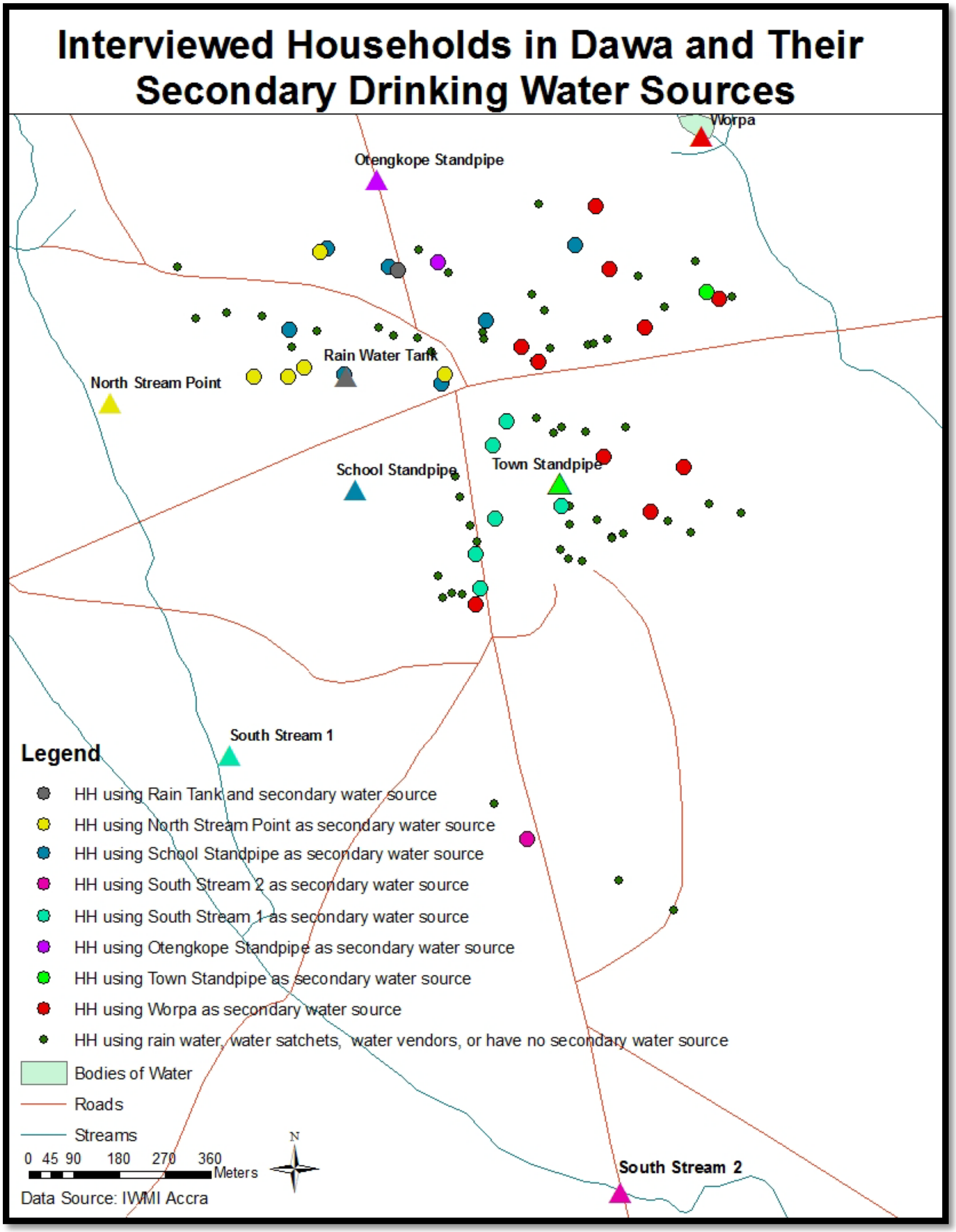


Figure 5: Study Households in Dawa and Their Sources of Drinking Water in the Last Week

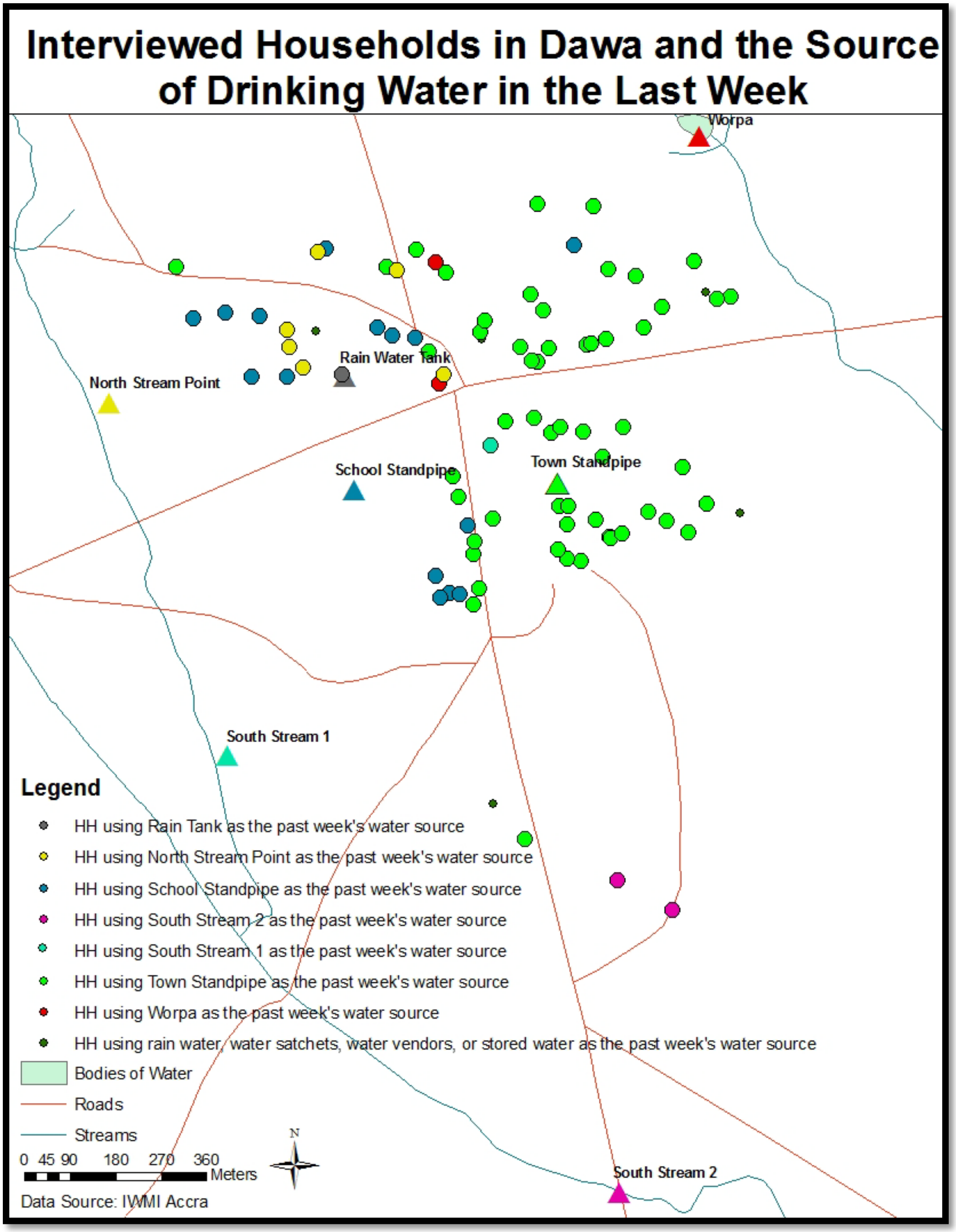


Figure 6: Study Households in Tugkaope and Their Primary Drinking Water Sources

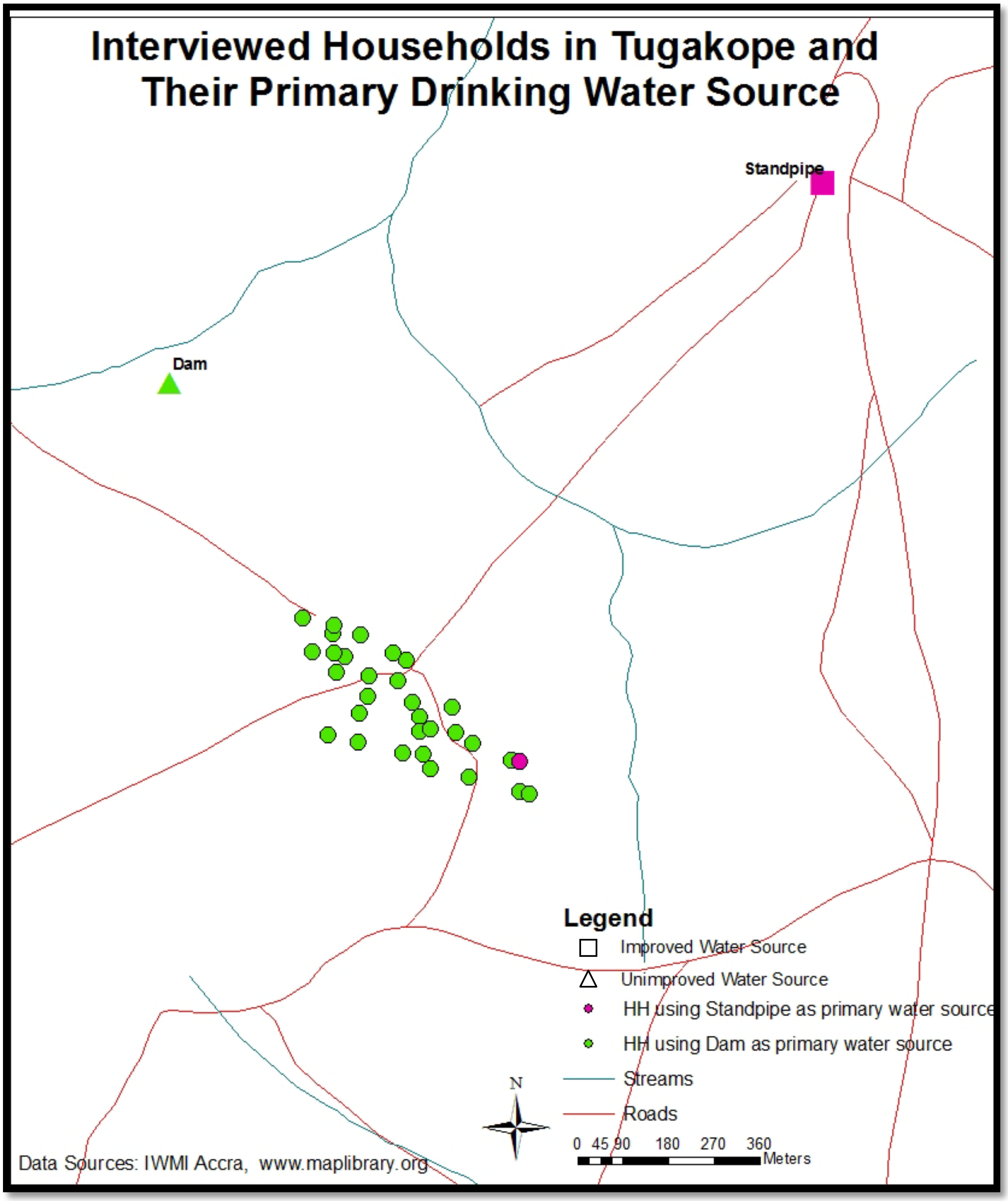


Figure 7: Study Households in Tugakope and Their Secondary Drinking Water Sources

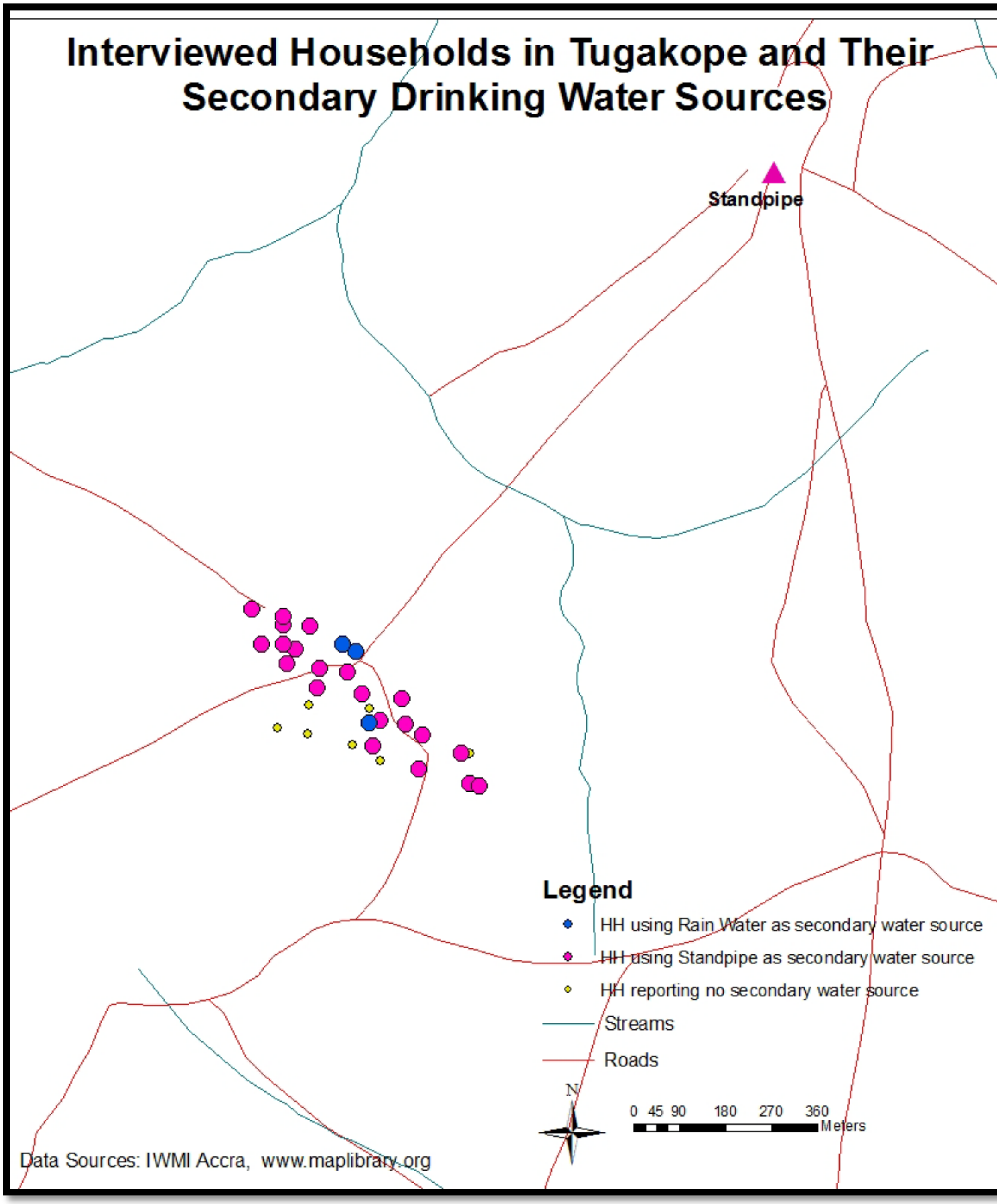
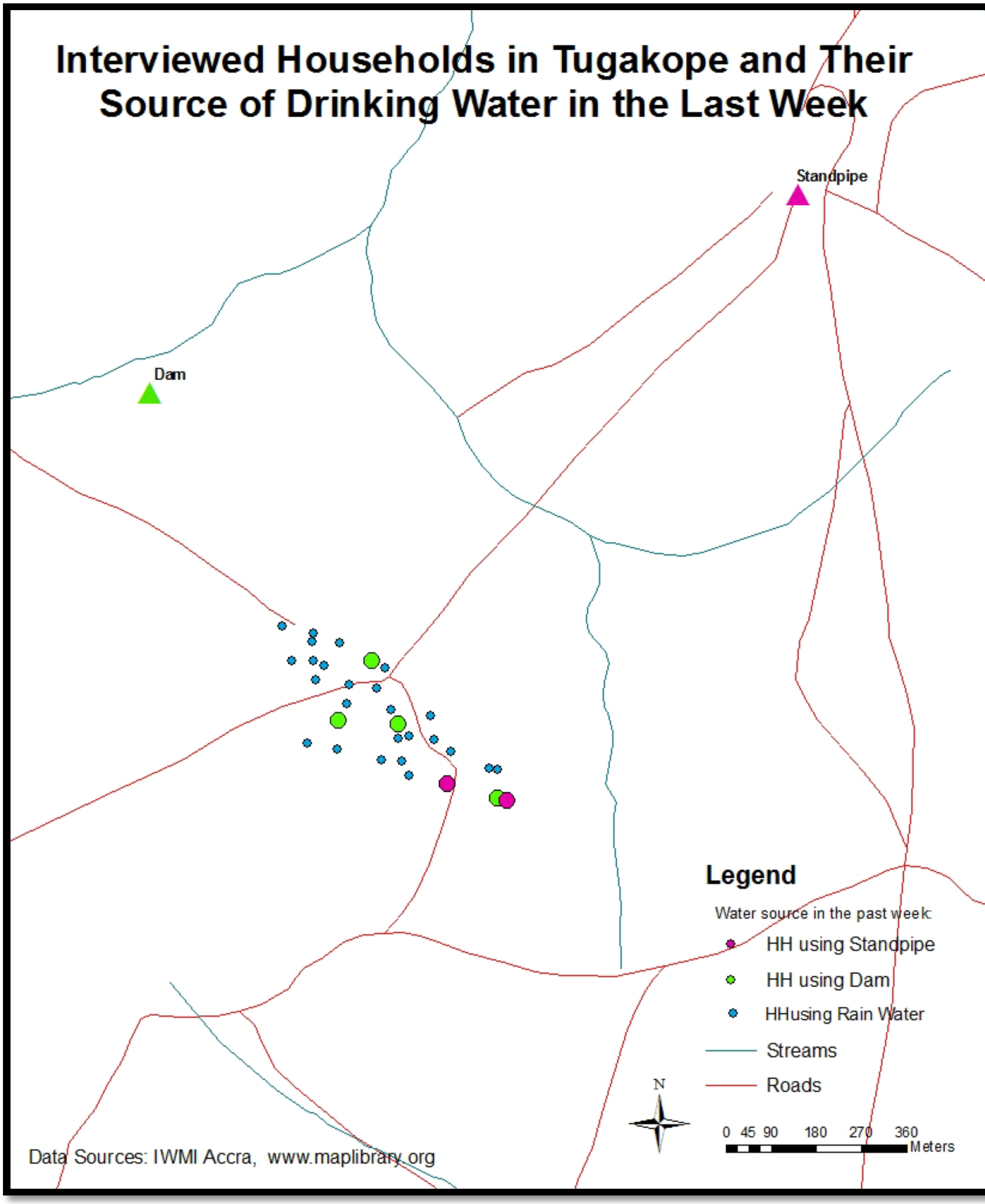


Figure 8: Study Households in Tugakope and Their Source of Drinking Water in the Last Week



Distances to water sources:

Figure 9: Distances from Worpa to Study Households Using Worpa in Dawa

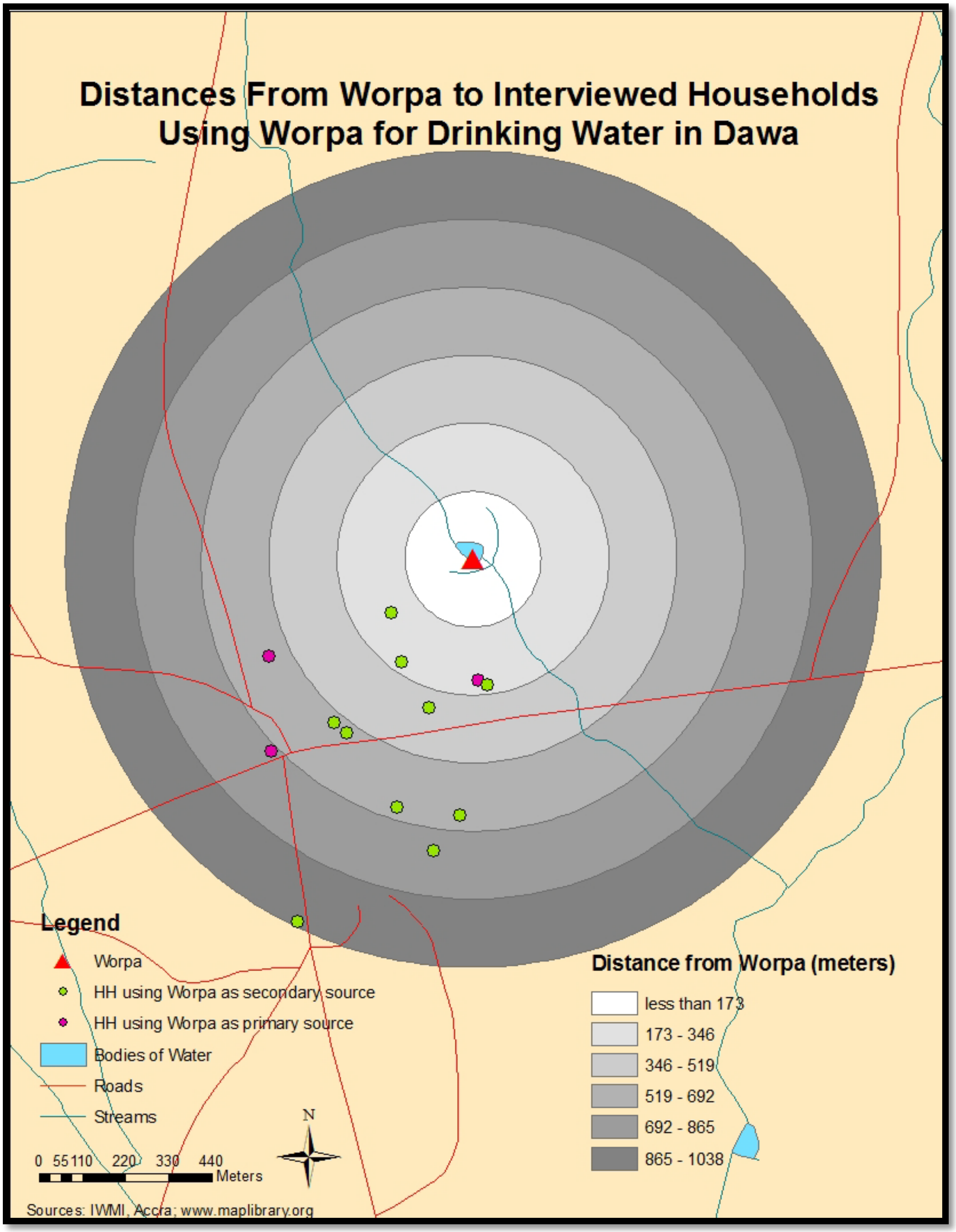


Figure 10: Distances from Town Standpipe to Study Households Using Town Standpipe in Dawa

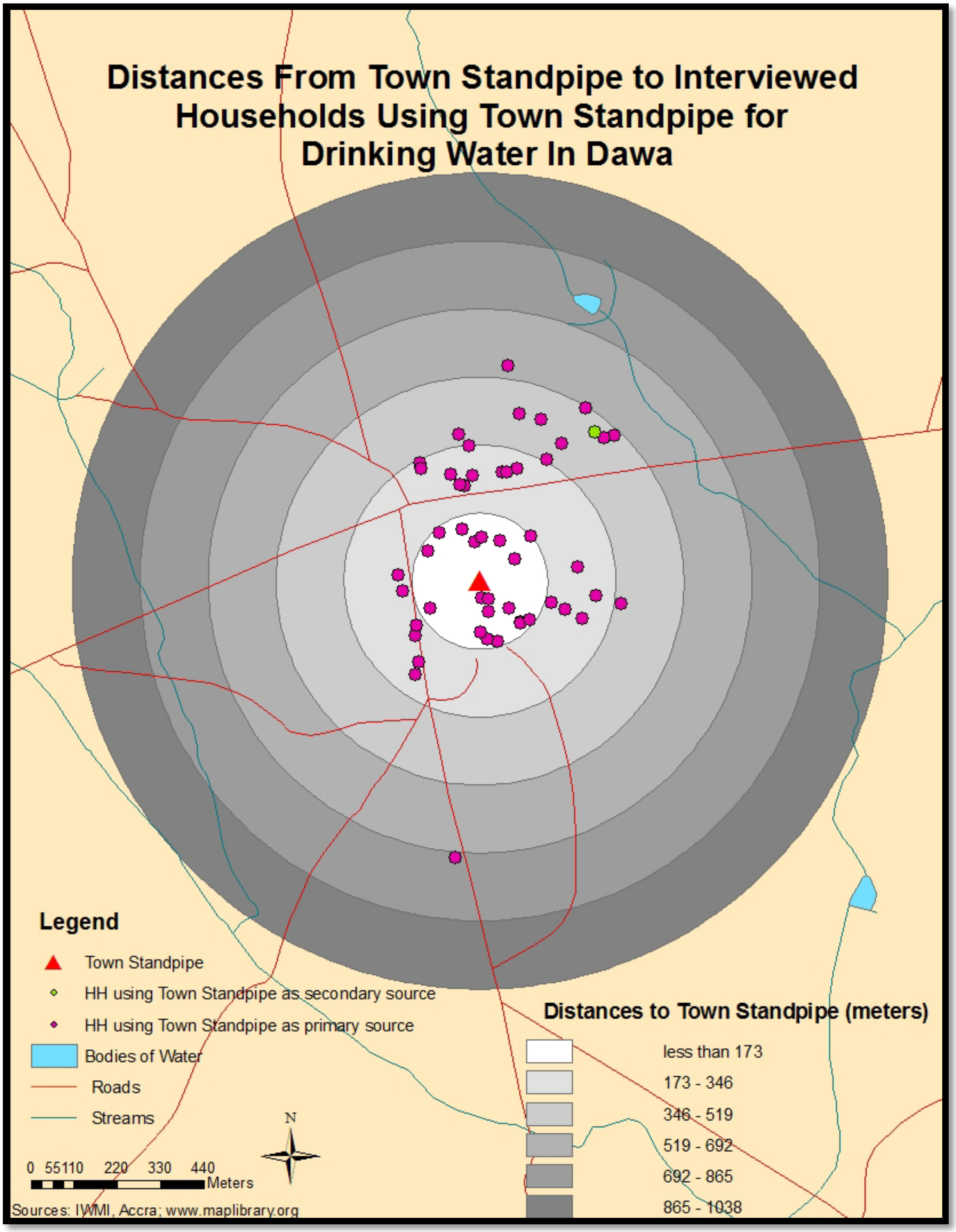


Figure 11: Distances from School Standpipe to Study Households Using School Standpipe for Drinking Water in Dawa

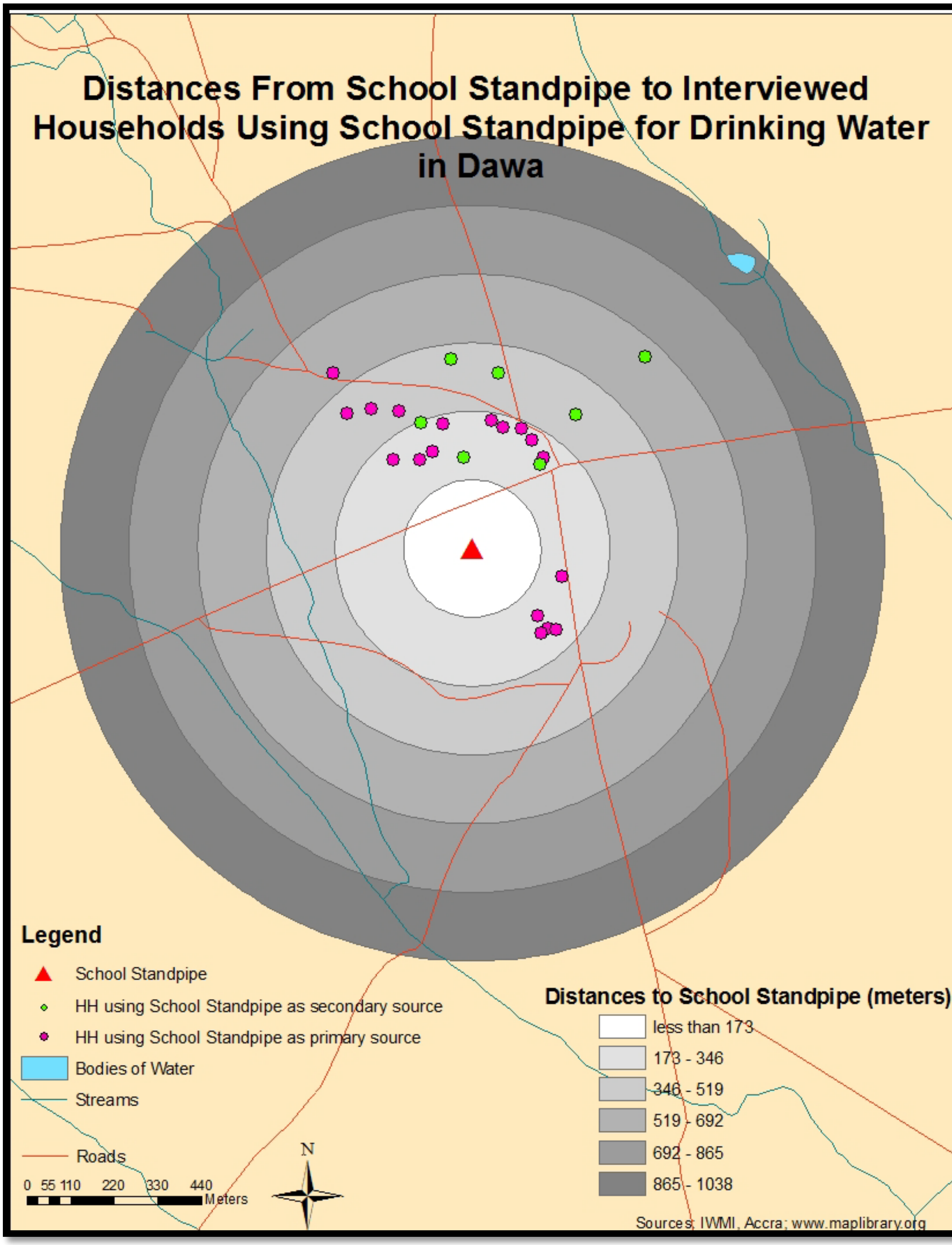


Figure 12: Distances from Otengkope Standpipe to Study Households Using Otengkope Standpipe for Drinking Water in Dawa

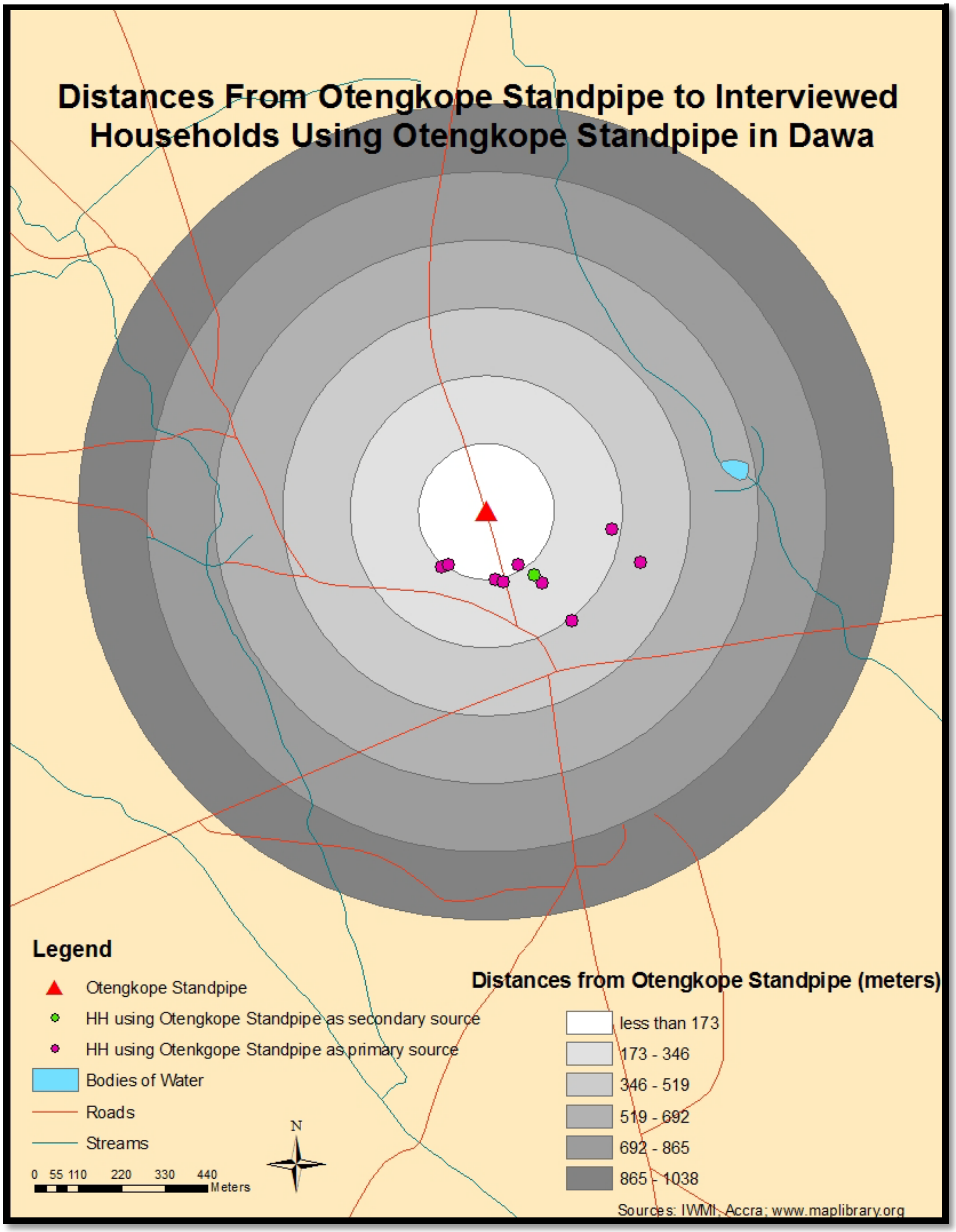


Figure 13: Distances from Specified Water Source to Study Households Using that Source for Drinking Water in Dawa

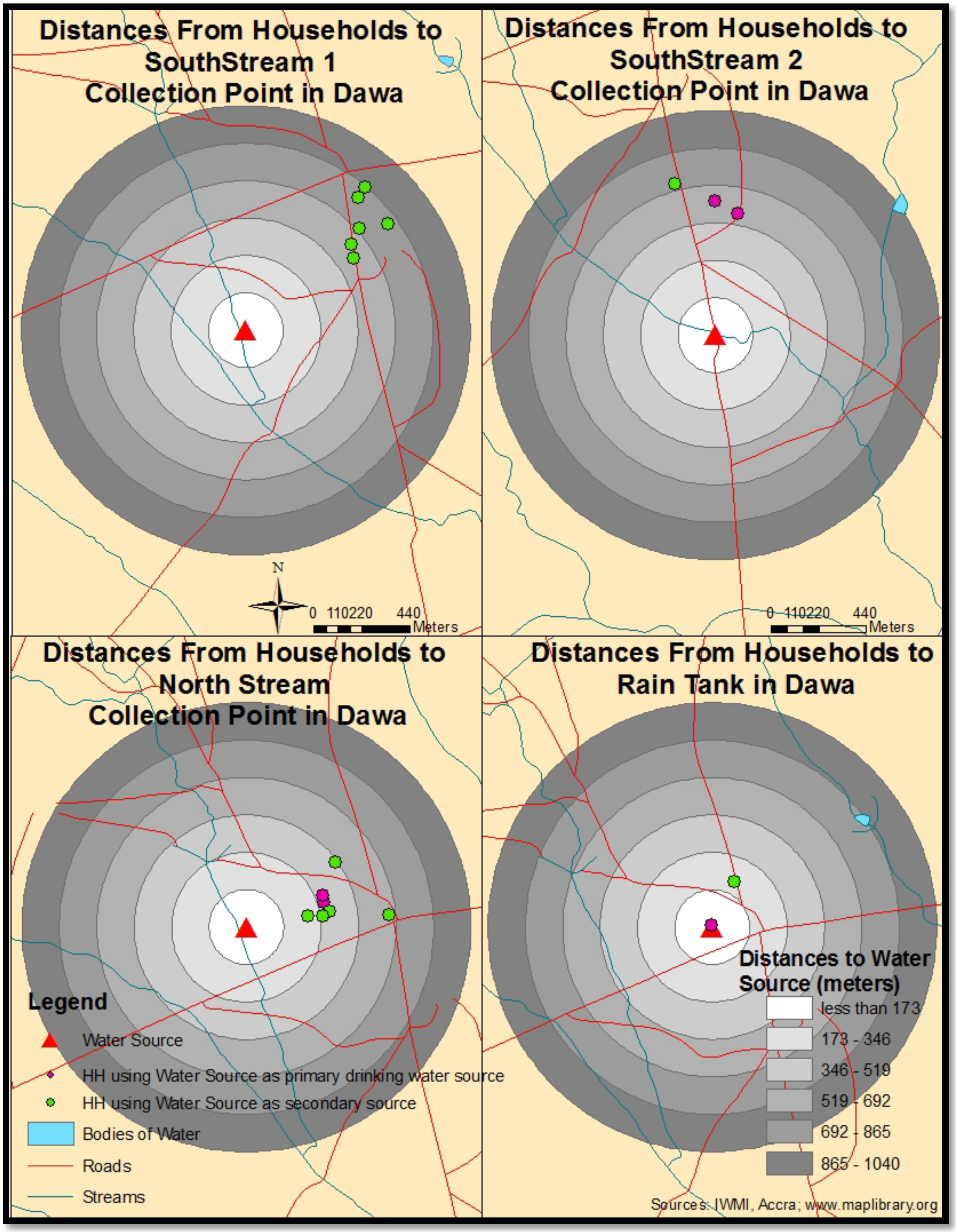


Figure 14: Distances from Dam to Study Households Using Dam for Drinking Water in Tugakope

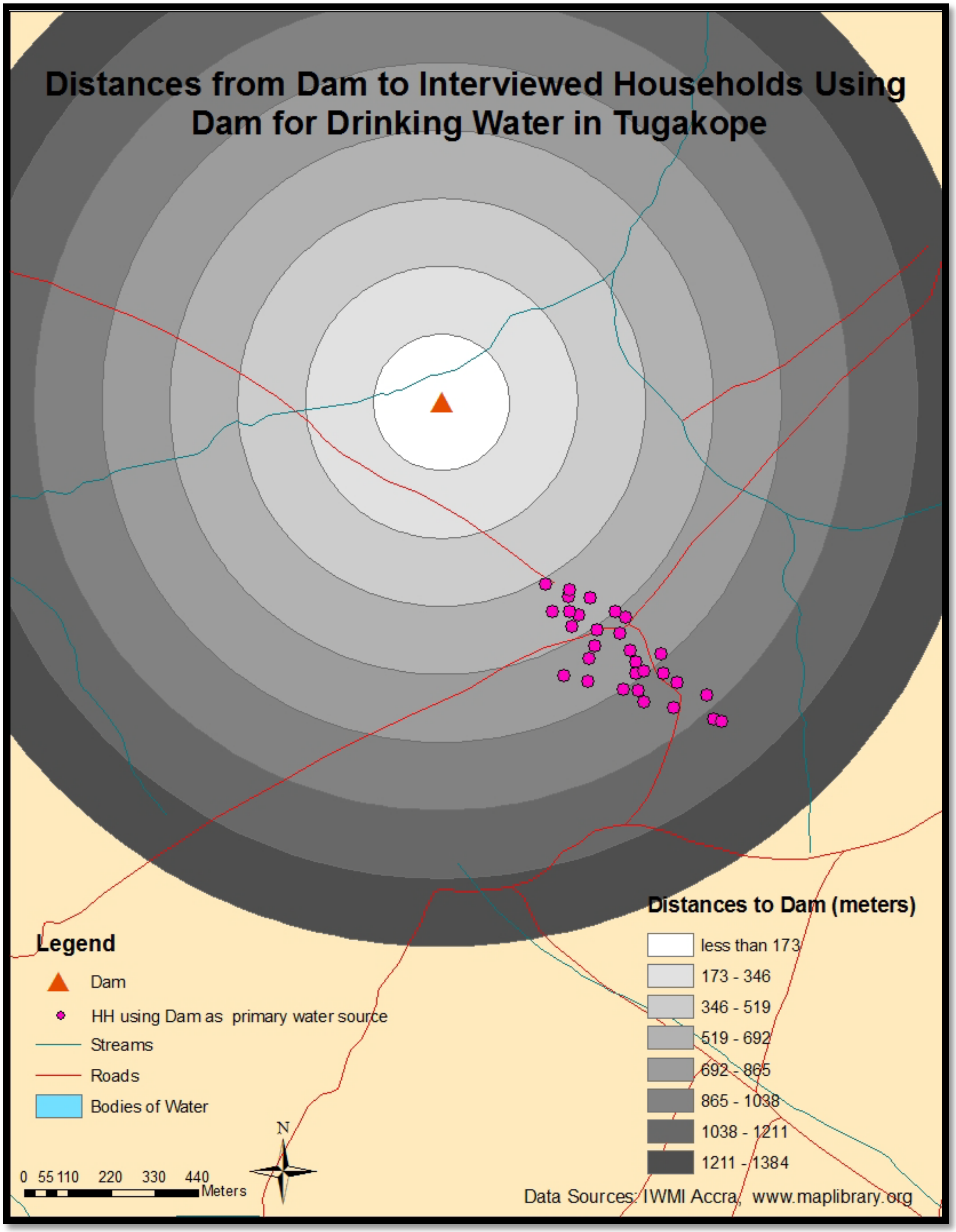


Figure 15: Distances from Standpipe to Study Households Using Standpipe for Drinking Water in Tugakope

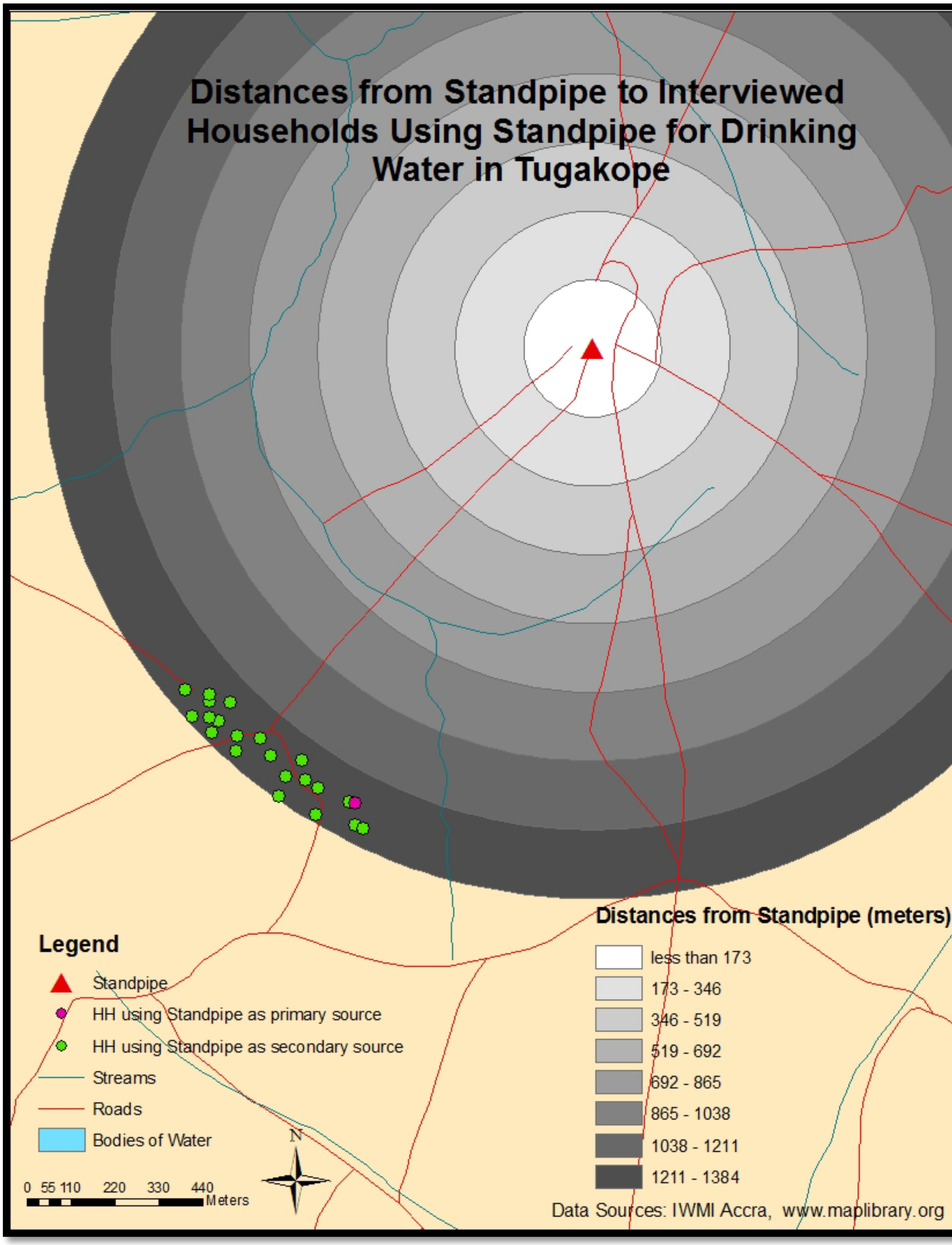


Figure 17: Drinking Water Contamination with *E. Coli* Among a Subset of Town Standpipe Users in Dawa

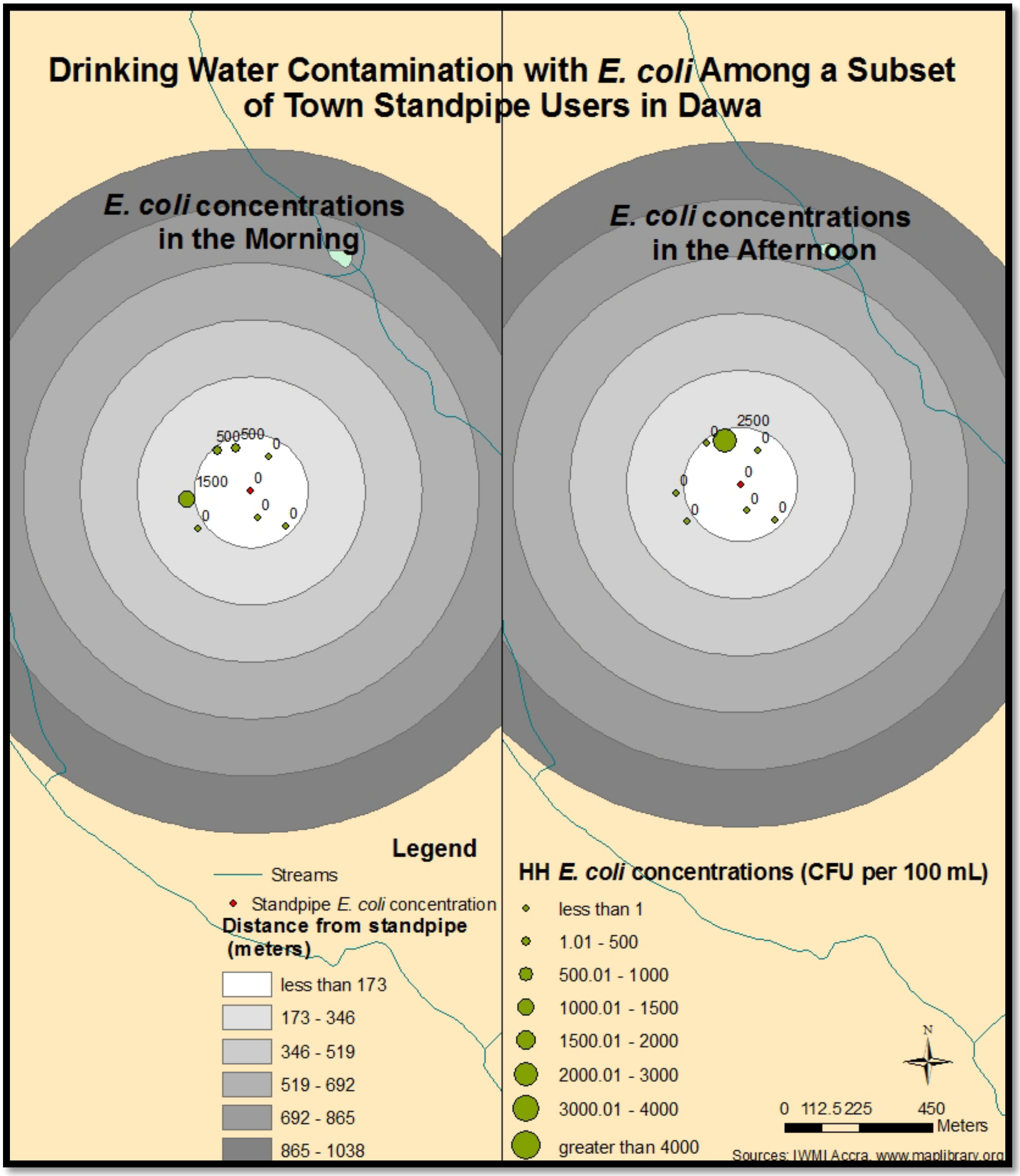


Figure 18: Drinking Water Contamination with *E. Coli* Among a Subset of Worpa Users in Dawa

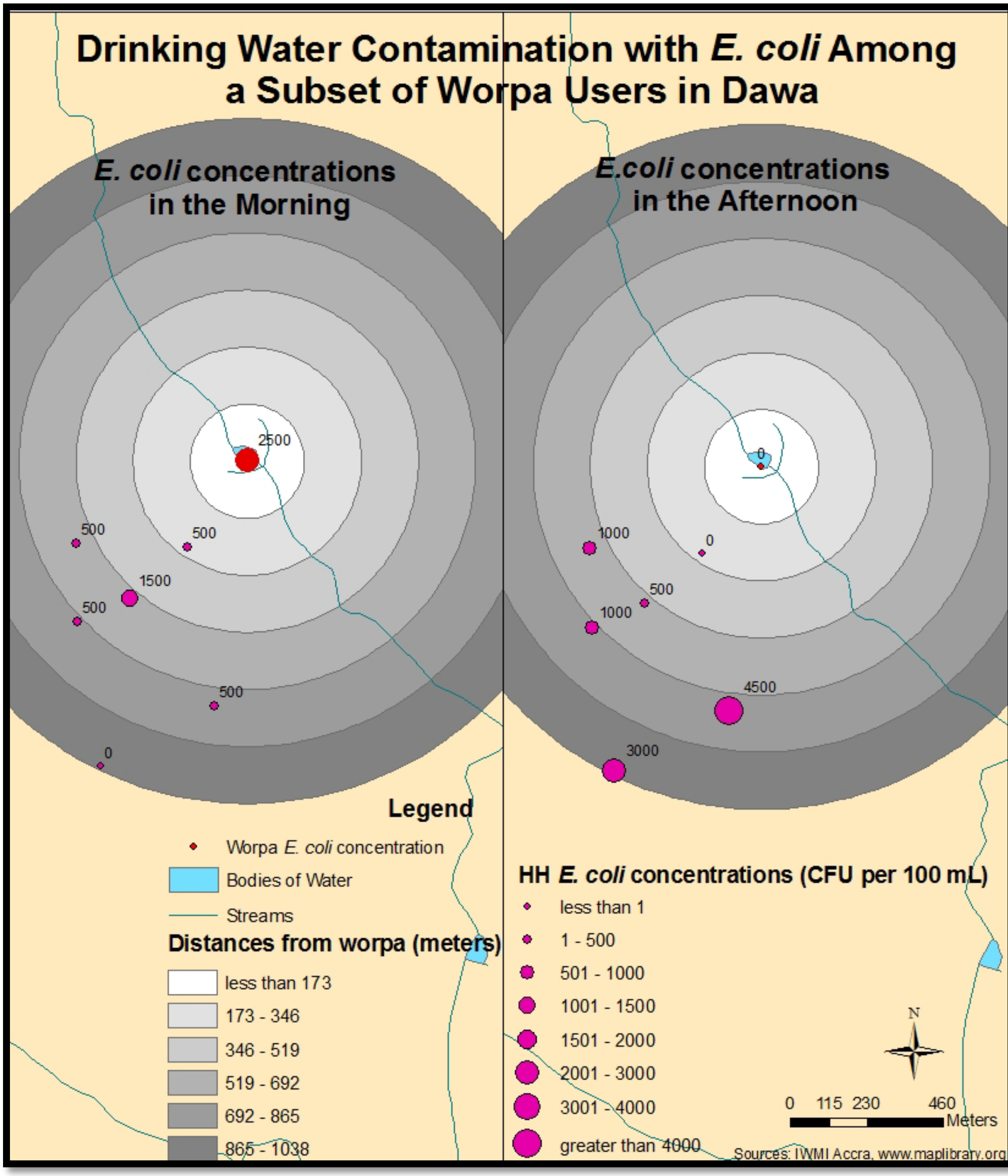


Figure 19: Drinking Water Contamination with *E. Coli* Among a Subset of Broken Standpipe Users in Dawa

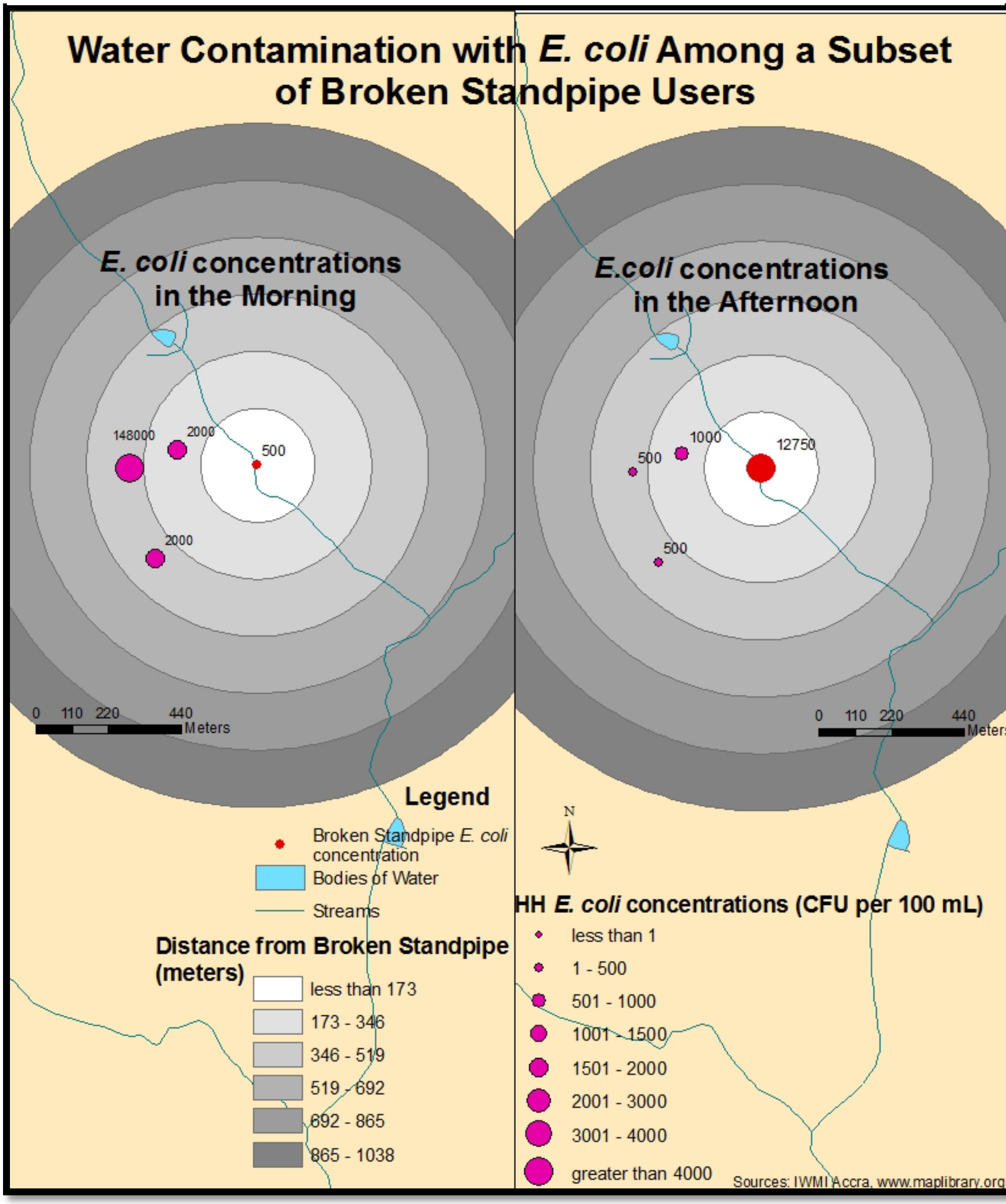


Figure 20: Drinking Water Contamination with *E. Coli* Among a Subset of South Stream 1 Users in Dawa

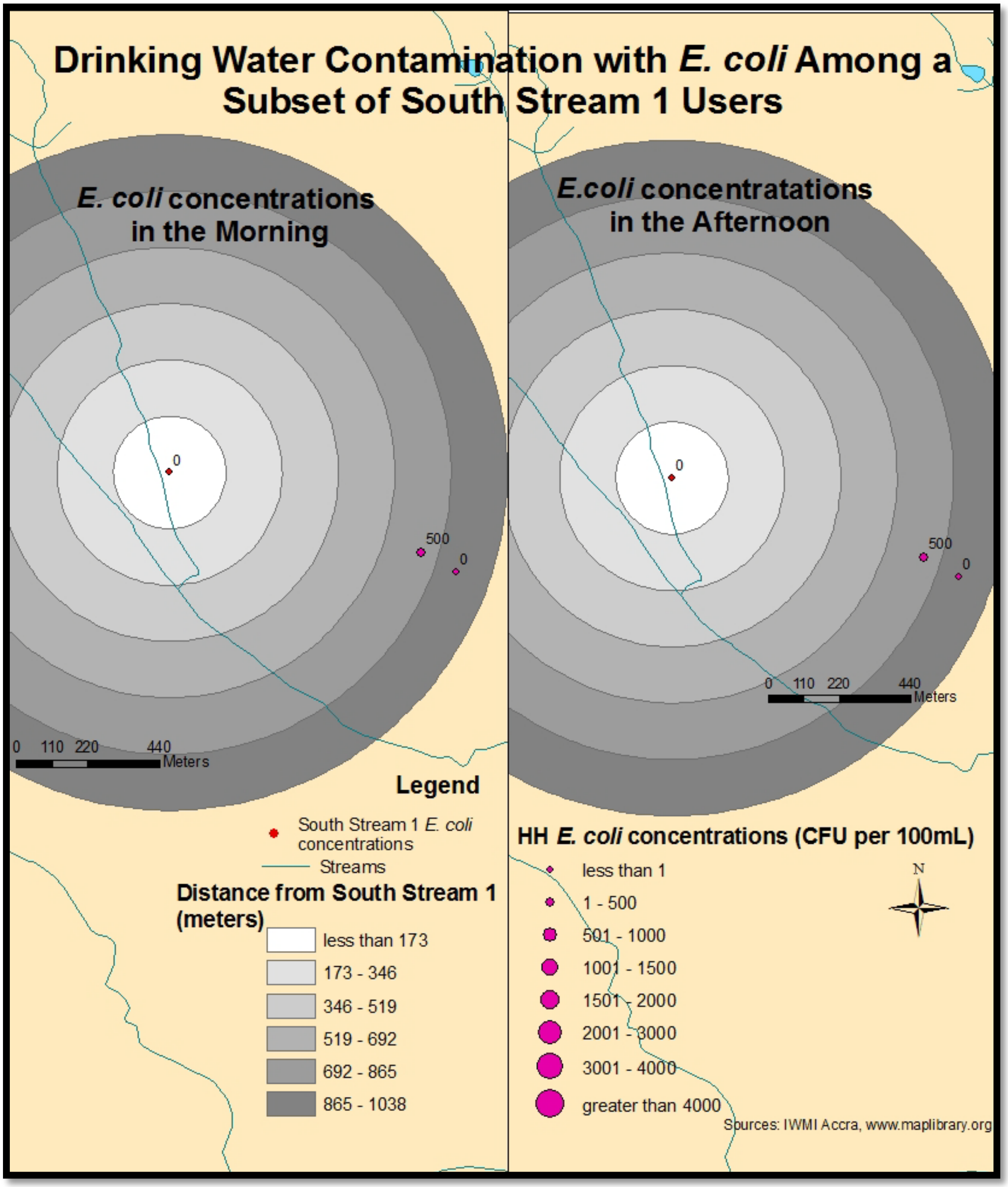


Figure 21: Drinking Water Contamination with *E. Coli* Among a Subset of North Stream Users in Dawa

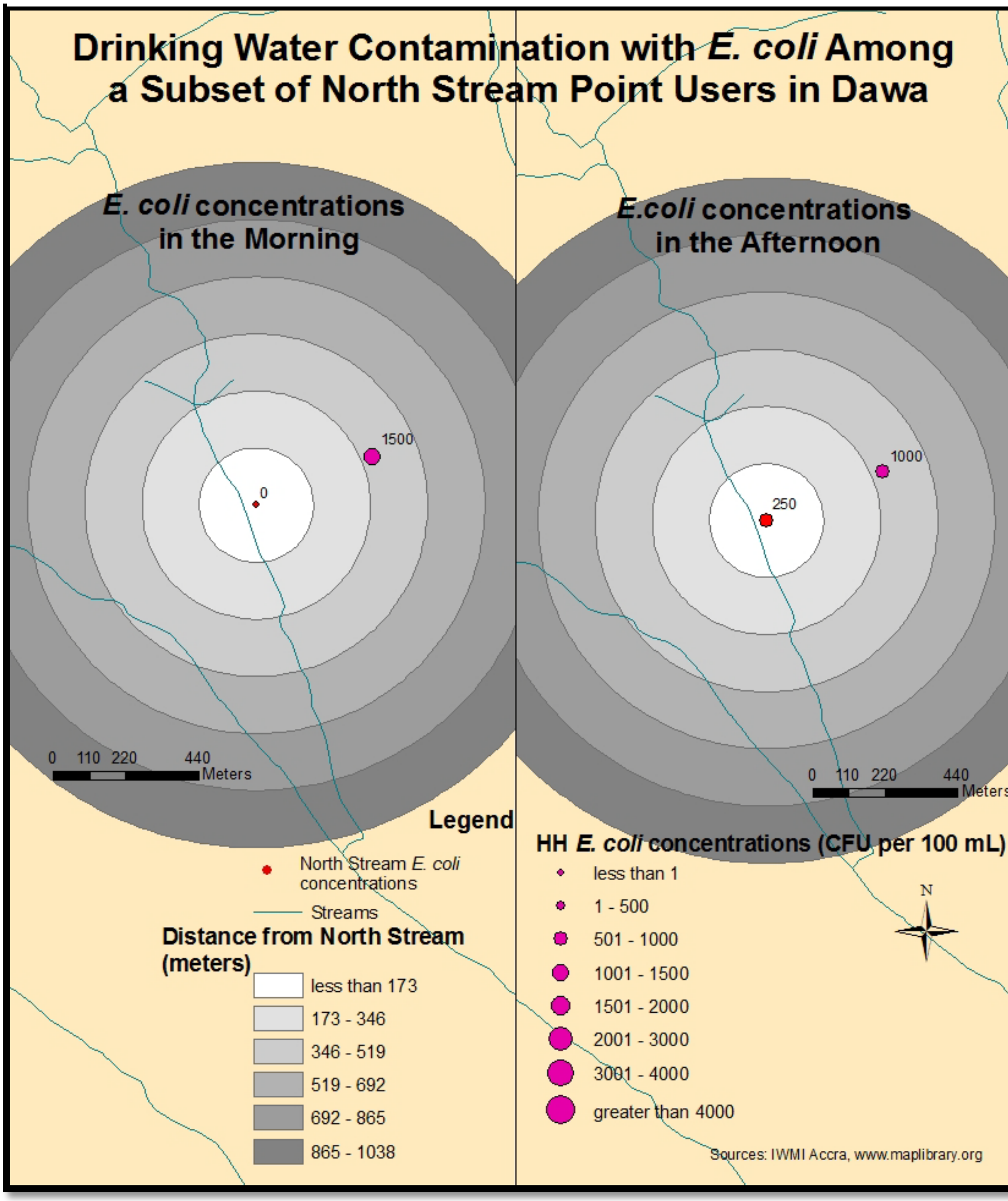


Figure 22: Study Households and Adult Defecation Locations in Dawa

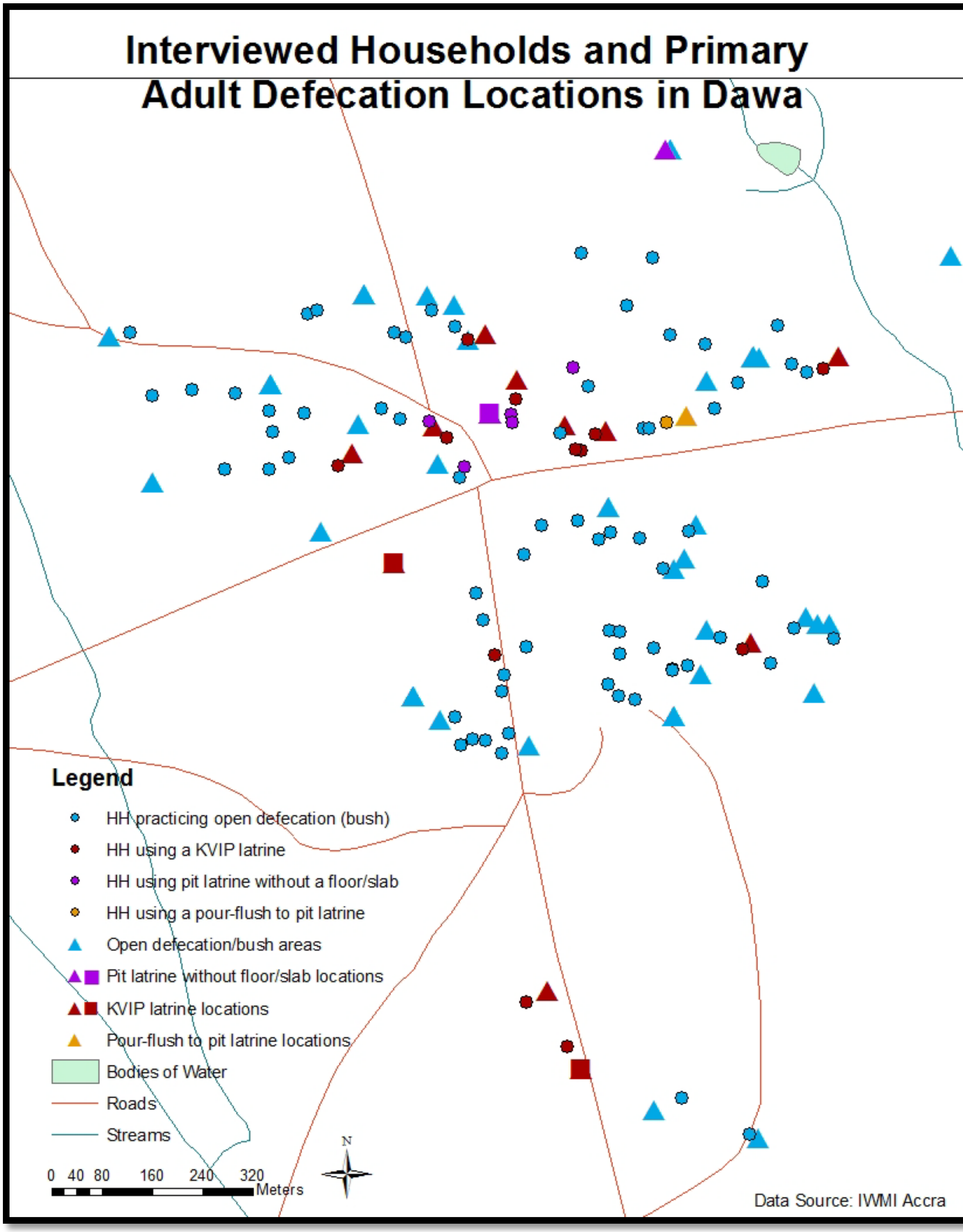


Figure 23: Study Households and Adult Defecation Locations in Tugakope

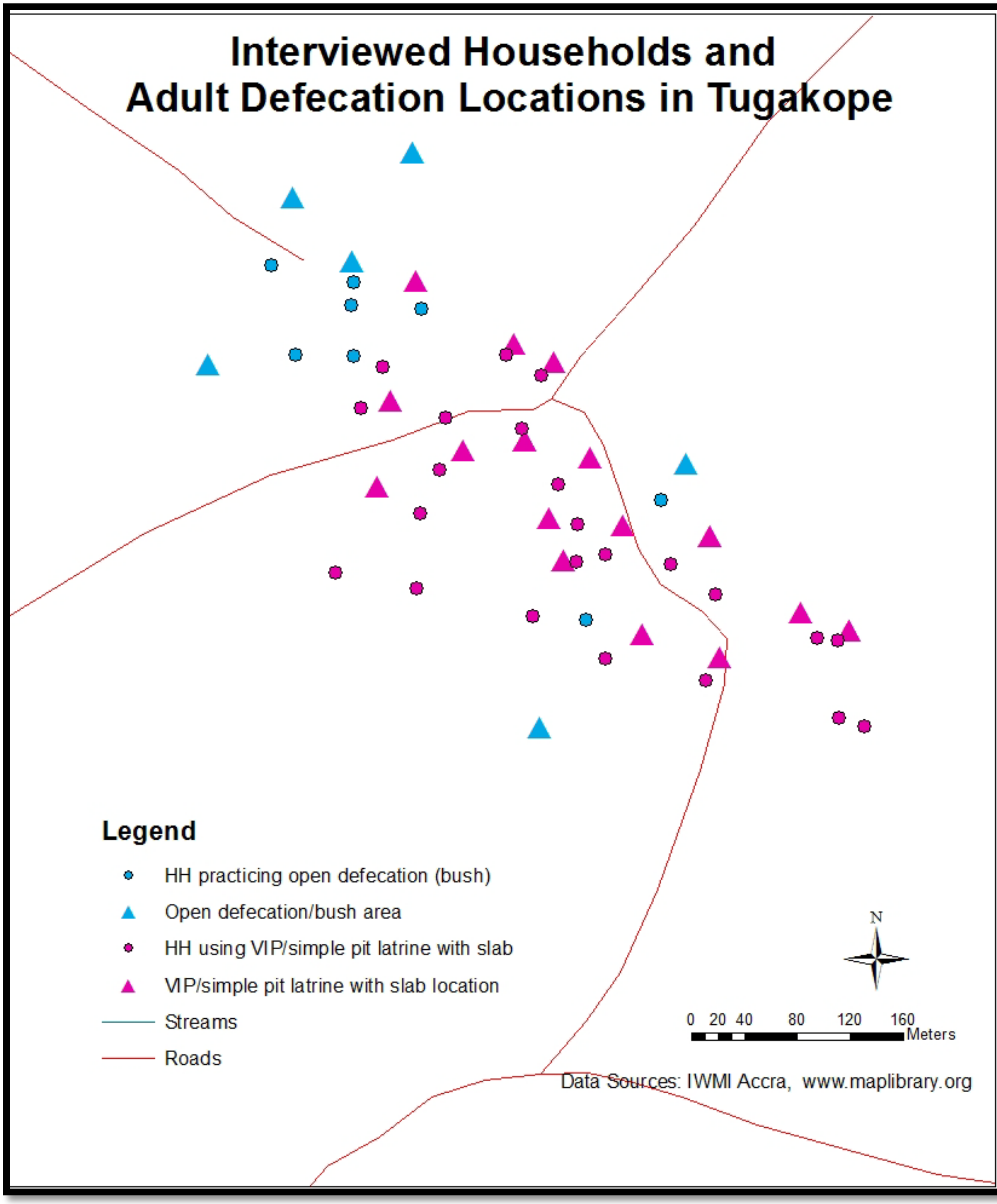


Figure 24: Feces Disposal Locations for Children Under Five in Dawa

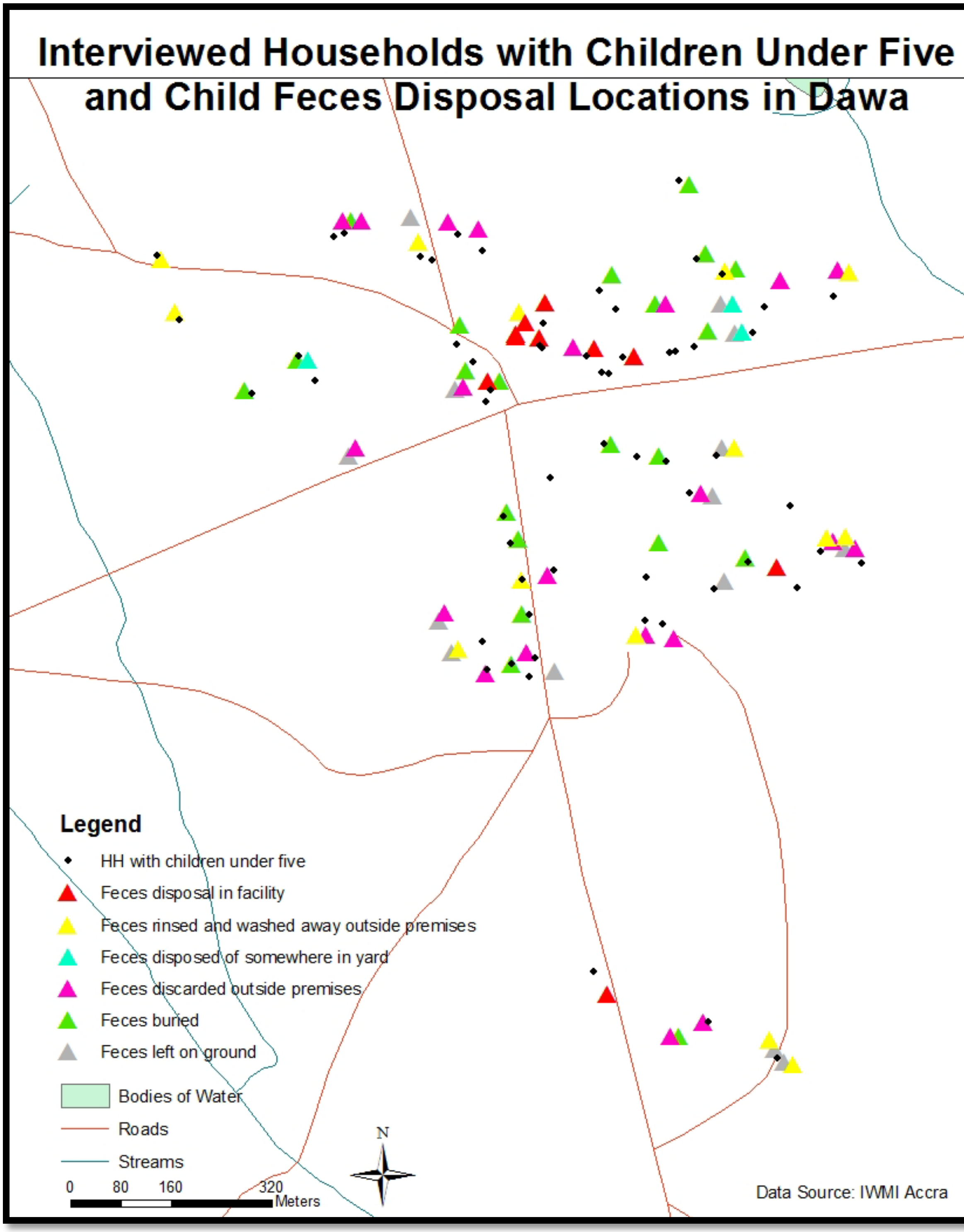
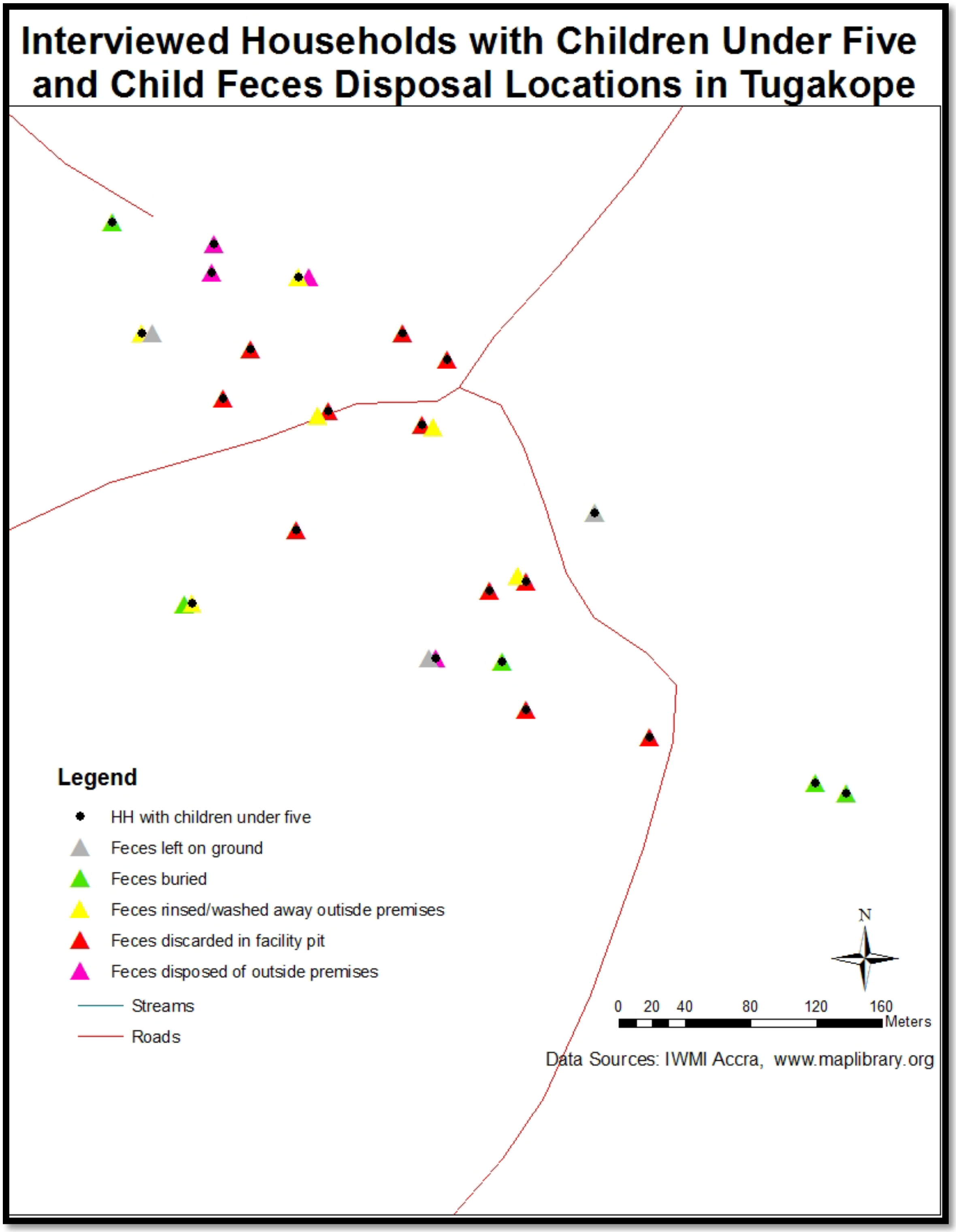


Figure 25: Feces Disposal Locations for Children Under Five in Tugakope



Appendices

APPENDIX A: IRB Study Exemption Letter

EMORY UNIVERSITY | Institutional Review Board

FROM: Donna Dent, MISM, MS
Lead, Research Protocol Analyst

TO: Reena Chudgar
Principal Investigator

CC:	Foote	Andrew	Emory College
	Khosropour	Christine	Public Health
	Prater	Adam	Medical School

DATE: June 18, 2009

RE: **Notification of Exempt Determination**
IRB00019695
Identification and Assessment of Water and Sanitation Practices by Use of GPS Mapping and Door-to-Door Questionnaires in Urban, Peri-Urban and Rural Communities in Accra and the Volta Region of Southeastern Ghana

Thank you for submitting an application in eIRB. We reviewed the application and determined on 6/2/2009 that it meets the criteria for exemption under 45 CFR 46.101(b)(2) and thus is exempt from further IRB review.

This determination is good indefinitely unless something changes substantively in the project that affects our analysis. The PI is responsible for contacting the IRB for clarification about any substantive changes in the project. Therefore, please do notify us if you plan to:

• Add a cohort of children to a survey or interview project, or to a study involving the observation of public behavior in which the investigators are participating.
• Change the study design so that the project no longer meets the exempt categories (e.g., adding a medical intervention or accessing identifiable and

potentially damaging data)
• Make any other kind of change that does not appear in the list below.

Please do not notify us of the following kinds of changes:
• Change in personnel, except for the PI
• Change in location
• Change in number of subjects to be enrolled or age range for adults
• Changes in wording or formatting of data collection instruments that have no substantive impact on the study design

For more information about the exemption categories, please see our Policies & Procedures at www.irb.emory.edu. In future correspondence about this study, please refer to the IRB file number, the name of the Principal Investigator, and the study title. Thank you.

Sincerely,

Donna Dent, MISM, MS
Lead, Research Protocol Analyst
This letter has been digitally signed

Emory University
1599 Clifton Road, 5th Floor - Atlanta, Georgia 30322
Tel: 404.712.0720 - Fax: 404.727.1358 - Email: irb@emory.edu - Web: http://www.irb.emory.edu/
An equal opportunity, affirmative action university

APPENDIX B: Household Questionnaire

Data Entry Completed by: ___________________
Entry Date: ___________________

WATER, SANITATION AND HYGIENE ASSESSMENT OF HOUSEHOLDS IN GREATER ACCRA, GHANA

SECTION A- Location and Logistics (For Interviewer)

1. Name of Interviewer: ____
2. Date of Interview: ___ ___ / ___ ___ / ___ ___
3. District Name ____
4. Community/ Village /Town ____
5. Household ID Number ____
6. GPS reading for position of house: Serial number: _________________________
   Waypoint number: ______________________
7. Name of Female Head of Household: ____
8. Birth date/Age ___ ___ / ___ ___ / ___ ___ /Age:________

SECTION B- Household Questionnaire

9.	What is your education level?	No Formal Schooling ________11 Primary, Incomplete ________ 12 Primary Completed _________13 Junior Secondary, Incomplete ___________________________14 Junior Secondary, Completed ___________________________15 Senior Secondary, Incomplete ___________________________16 Senior Secondary, Completed ___________________________17 College/University, Incomplete ___________________________18 College/University, Completed ___________________________19 Professional Level __________ 20 Don’t Know ______________ 98

		Other ______________________
10.	Can the interviewee read, write, or both?	Can Read _________________A Can Write _________________ B
11.	Do you have Electricity in your home?	No __________________________0 Yes ________________________ 1

12.	How many people live in this household? *List in Table D all children 0-59 months*	__________ ____

Table D: List of All Children 0-59 Months

ID#	Name	Sex	Age	Relationship of Primary Caretaker to This Child
	List of primary caretakers, followed by all her/his children 0-59 months and the oldest child attending elementary school. (No Visitors)		In months	Mother ____________1 Grandmother ______2 Sister______________3 Aunt ______________4 Father ____________5 Brother____________6 Grandfather________7 Other family (F)____8 Other family (M)___9 Not family (F)____10 Not family (M)____11
Caretaker				
A				
B				
C				
D				
E				

	What is the main source of water for:	Stand-pipe	Surface Water	Hand dug well	Bore -hole	Bottled Water	Water Vendor	Rain Water	Piped Water
13.	Drinking								
14.	Bathing								
15.	Cleaning								
16.	Washing clothes								
17.	Cooking								
18.	Hand-washing								

19. May I take GPS coordinates for source? Yes/No
GPS reading for position of water source: Waypoint number: ___________________

20.	How long does it take you to go to your main water source, get water, and come back?	Minutes __________ On premises ______ Don't Know ______
21.	Who usually collects water? (Check all that apply)	Adult Woman __A School age female children __B Adult Men __C School age male children __D Young, pre-school age children __E
22.	Is water usually available during the following times?	Morning __A During the day __B Evening __C At night __D Varies, no regular times __E Don't Know __Z
23.	Do you always use the main water source for drinking water?	No __0 Yes __1
24.	During other times what is the main source of drinking water for members of this household?	Standpipe __ 11 Surface Water __12 Hand dug well __13 Borehole __14 Bottled Water __15 Water vendor __16 Rain water __17 Piped water __18
25.	May I take GPS coordinates for this sources?	Yes/No Waypoint Number_______________

26.	How long does it take you to go to this water source, get water, and come back?	Minutes ____________________ On premises _________________ Don't know ___________________
27.	In the past week, where did you collect water from?	Standpipe __ 11 Surface Water __12 Hand dug well __13 Borehole __14 Bottled Water __15 Water vendor __16 Rain water __17 Piped water __18
28.	If different than main source, may I take GPS coordinates of this source?	Yes/No Waypoint Number______________
29.	Do you pay for water?	No __0 Yes __1
30.	How much do you pay per load or volume unit?	_________________ Pesewas/Cedis
31.	In what type of container is the water carried from your main source?	Gallon(plastic or metal) __1 Bucket __2 Drum/Barrel __3 Jerry Can __4 Jerkin __5 Other __6 Don't Know __8
32.	How many loads do you fetch per day?	____________________________

Water Storage, Handling, Treatment, and Cost

33.	Do you store water for drinking in the household?	No __0 Yes __1 Don't know __8
34.	If yes, what do you store it in?	Clay water pot __1 Bucket __2 Drum/Barrel __3 Jerry Can __4 Aluminum Basin __5 Other __6 Don't Know __8
35.	May I see the containers please?	No/Yes
36.	Who takes water from these containers? (Check all that apply)	Adults __A School age children __B Children under 5 __C Everyone __D
37.	How do you remove water from the drinking water container?	Pouring __1 Dipping __2 Both pouring and dipping __3 Container has a spigot or tap __4 Other __6 Don't Know __8
38.	Are the water containers cleaned?	No __0 Yes __1 Don't know___________________8
39.	If Yes, how are they cleaned?	
40.	When were they cleaned last?	Today or yesterday_______11 Less than one week ago_____12 Several weeks ago___________13 Never______________16 Other_____________96 ___________________ Don't remember ______________98
41.	Do you treat your drinking water? *Probe: Do you drink it right from the source, or do you do something to it before you use it?*	No_______0 Yes_______1 Don't know_________8
42.	Do you _____ your water before you drink it?	Boil _____A Add bleach/chlorine ______B Sieve it through cloth _____C Water filter(ceramic, sand composite)_____D Solar disinfection _____E Sedimentation ______F Other ________X Don't know ________Z

43.	When did you treat your water the last time using this method?	Today___________11 Yesterday________12 Over one day ago/less one week__13 One week ago or more/ less than a month ago________14 One month ago or more______15 Don't remember_________98

Hygiene Behaviors and Knowledge

44.	When do you wash your hands? *Probe: For what? Anything else?*	Washing my children's hand__A Washing hands after defecating__B Washing hands after cleaning child__C Washing hands after feeding child__D Washing hands before preparing food__E Washing hands before eating__F Wahing hands after eating__G Other____X Don't remember __Z
45.	Where do you usually wash your hands?(Check all that apply)	In or near toilet facility__1 In or near kitchen __2 Elsewhere on premises ____3 Outside premises ___4 No specific place ___5
46.	Can you show me everything you use to wash your hands?	No/Yes Yes ____1

Excreta Disposal

47.	What kind of toilet facility does this household use? *(Probe until all choices are exhausted)*	Flush to piped sewer system___11 Flush to septic system___12 Pour-flush to pit____13 Flush or pour-flush elsewhere__14 VIP/simple pit latrine with floor/slab__15 KVIP latrine__16 Pit latrine without floor/slab__17 Composting/dry latrine__18 Service or bucket latrine__19 Hanging latrine__20 No facility, field, bush, plastic bag__21
48.	Where is the toilet facility located?	Inside or attached to dwelling___1 Elsewhere on premises____2 Outside premises___3

49.	Do children under 5 use this toilet facility?	No_______0 Yes______1 Don't know___________8
50.	Is the toilet facility used every time you need to defecate when you are home?	No___________0 Yes ___________1
51.	How many households share this toilet facility?	Not shared______00 More than 20 ________21 Don't know ________98
52.	If shared, can anybody in the neighborhood use this toilet facility or is it shared between a few households only?	Anybody in the neighborhood can use it ________1 Shared between few households only ______21 Don't know ________98
53.	How much do you pay to use the toilet facility?	Nothing _____________000 Don't know ___________998
54.	Is there anyone who does not have to pay to use the toilet?	No ___________0 Yes ___________1 Don't know ____8
55.	Is the facility cleaned?	No __________0 Yes _________1 Don't know _____8
56.	When was the facility cleaned last?	Today______1 Yesterday____2 Less than one week ago____3 Several weeks ago_______4 Never___________5 Other__________6 Don't remember________8
57.	May I see the toilet facility?	No___________0 Yes___________1
58.	May I take GPS coordinates for the facility? *(If different facilities, take all locations)*	No/Yes Waypoint number (Adult): ______________________ Waypoint number (Child): ______________________
59.	What do use for anal cleansing?	Nothing__1 Toilet paper__2 Tree leaves__3 Water__4 Other Paper__5 Other __6
60.	How is it disposed of?	Leave it there__1 Bury it__2 Drop in Pit__3 Drop in container next to latrine__4 Other__6

Caretaker questionnaire about child less than 60 months (5 years old) (Refer to list)
Name of Child:

61.	Is ________breastfed and is it exclusively?	No___________0 Yes, exclusively ________1 Yes, with supplements _______2 Don't know ____________8
62.	The last time _________ passed stool, where did he/she defecate?	Used sanitation facility__11 Used potty_____12 Used washable diapers____13 Used disposable diapers___14 Went in house/yard__15 Went outside the premises__16 Went in his/her clothes___17 Other_____________96 Don't know___________98
63.	The last time ___________passed stool, where were the feces disposed of? *(If "washed" or "rinsed away", probe where the waste water was disposed of, If "disposed, probe where it was disposed of specifically)*	Dropped into toilet facility ____11 Rinsed/washed away -Water discarded in toilet facility_21 -Water discarded in sink/tub connected to drainage system__22 - Water discarded outside __23 Disposed - Into solid waste/trash___31 - Somewhere in yard___32 - Outside premises ___33 Buried_____________41 Did nothing/left it there ___51 Other ___96 ______________________ Don't know ____________98
64.	Has ___________had diarrhea during the past 24 hours (today and yesterday)? Diarrhea: 3 or more liquid stools in 24 hours	No _____________0 Yes_____________1 Don't know_______8
65.	Has ____________had diarrhea in the last one week?	No____________0 Yes___________1 Don't know _____8
66.	Did __________vomit while he/she had diarrhea?	No____________0 Yes___________1 Don't know __________8
67.	Did the stool contain: (check all mentioned)	Blood____________A Mucus ___________B Don't know __________Z
68.	Was he/she given any of the following to	A fluid from a special packet called

	drink to treat the diarrhea?	___________________A A government or NGO recommended homemade fluid ____B Pill or syrup ___________C Injection _____________D Intravenous fluid (IV)________E Home or traditional medicine ___F None of these fluids _____G Other __________X Don't know _________Z
69.	Where did you seek advice or treatment? If source is hospital, health center or clinic, write the nameo f the place. Probe to identify the type of source and circle the appropriate code. ____________________________(name)	Public Sector - Gov. hospital______A - Gov health center_____B - Gov health post______C - Gov mobile clinic________D - Gov field worker________E - Other gov ___________F Private medical sector - Pvt hospital _G - Pvt health center/clinic __H - Pvt pharmacy ___I Pvt doctor _____J - Pvt mobile clinic ___K - Pvt field worker ____L - Other Pvt medical _________M Other source - Market/shop_____________N - Drug peddler/hawker ____O - Traditional practitioner ___P - Family member ____Q - Other __________R _____________________ Don't know ___________________Z
70.	If not, why did you not seek treatment? (Don't read answers- ask if there is anything else and check all mentioned)	No money ______A Too far __________B Child not seriously ill ______C Nobody to go to _________D Place has no drugs _____E Other __________X __________________ Don't know ________________Z

Caretaker questionnaire

71.	The last time you passed stool, where did you defecate?	Used sanitation facility__11 Went in house/yard__12 Went outside the premises__13 Other_____________96 _____________________ Don't know___________98
72.	The last time you passed stool, where were the feces disposed of? *(If "washed" or "rinsed away", probe where the waste water was disposed of, If "disposed, probe where it was disposed of specifically)*	In toilet facility ____11 Rinsed/washed away -Water discarded in toilet facility_21 -Water discarded in sink/tub connected to drainage system__22 - Water discarded outside __23 Disposed - Into solid waste/trash___31 - Somewhere in yard___32 - Outside premises ___33 Buried_____________41 Did nothing/left it there ___51 Other ___96 ______________________ Don't know ____________98
73.	Have you had diarrhea during the past 24 hours (today and yesterday)? Diarrhea: 3 or more liquid stools in 24 hours	No _____________0 Yes_____________1 Don't know_______8
74.	Have you had diarrhea in the last one week?	No____________0 Yes___________1 Don't know _____8
75.	Did you vomit while you had diarrhea?	No____________0 Yes___________1 Don't know __________8
76.	Did the stool contain: (check all mentioned)	Blood____________A Mucus ___________B Don't know __________Z
77.	Did you drink any of the following to treat the diarrhea?	A fluid from a special packet called __________________A A government or NGO recommended homemade fluid ____B Pill or syrup __________C Injection ____________D Intravenous fluid (IV)_______E Home or traditional medicine ___F None of these fluids _____G

		Other _________X _____________________ Don't know ________Z
78.	Where did you seek advice or treatment? If source is hospital, health center or clinic, write the name of the place. Probe to identify the type of source and circle the appropriate code. _________________________(name)	Public Sector - Gov. hospital______A - Gov health center_____B - Gov health post______C - Gov mobile clinic_______D - Gov field worker_______E - Other gov __________F Private medical sector - Pvt hospital _G - Pvt health center/clinic __H - Pvt pharmacy ___I Pvt doctor _____J - Pvt mobile clinic ___K - Pvt field worker ____L - Other Pvt medical ________M Other source - Market/shop____________N - Drug peddler/hawker ____O - Traditional practitioner ___P - Family member ____Q - Other _________R ___________________ Don't know _________________Z
79.	If not, why did you not seek treatment? (Don't read answers- ask if there is anything else and check all mentioned)	No money ______A Too far _________B Not seriously ill ______C Nobody to go to ________D Place has no drugs _____E Other _________X ________________ Don't know ______________Z

OBSERVATION SHEET
WATER, SANITATION AND HYGIENE ASSESSMENT OF HOUSEHOLDS IN GREATER ACCRA, GHANA

1	House wall construction: **[WALL]**	Brick or cement blocks __1 Stone __2 Mud __3 Raffia __4 Other ________________________________6 Don't know __8
2	Floor construction: **[FLOOR]**	Tile __1 Concrete __2 Earth __3 Other ________________________________6 Don't know __8
3	Roof construction: **[ROOF]**	Cement __1 Earth __2 Tin __3 Straw/Thatch __4 Other ________________________________6 Don't know __8

Household Environment:

4.	Is livestock (poultry, goats, pigs, etc) present inside living quarters? **[LIVSTK]**	No __0 Yes __1 Don't know __8
5.	Are animal feces visible in the house or in the yard? **[AMLFECES]**	No __0 Yes __1
6.	Is there garbage lying in the open in the house or in the yard? **[GRBGEYD]**	No __0 Yes __1
7.	Is there sewage in the yard? **[SWAGE]**	No __0 Yes __1
8.	Is there sewage or are there open sewers outside the premises or in the streets within 10 meters of the dwelling? **[SWAGEOUT]**	No __0 Yes __1
9.	Does the smoke come from burning garbage in the area? **[SMKGBGE]**	No __0 Yes __1
10.	Are there any graves present around the compound? **[GRAVES]**	No __0 Yes __1

Water Storage, handling, treatment, and cost

11	If there is a well on compound, is it: **[WELLCNST]**	Covered __A Lined with cement __B Open __C
12	What is used to fetch water from the wells? **[WATWELL]**	____
13	What is surrounding the well? **[ARNDWELL]**	____
14	What type of storage containers are present? (Observe and check all that apply) **[CONTTOP]** Narrow mouthed: opening is 3 cm or less	Narrow mouthed __1 Wide mouthed __2 Of both types __3
15	Are the containers covered? **[CONTCOV]**	All are __1 Some are __2 None are __3
16	Where are the water containers placed? **[CONTWHR]** **[CONTHGT]**	On the floor __1 Elevated above the floor __2 Approximate height ___________________________________
17	If water is treated by a method other than boiling, check for presence of: **[TYPETRT]**	Bleach/chlorine present __A Bleach/chlorine containers are empty __B Cloth filter present __C Water filter present __D Solar disinfection present __E Other __F ____ None available __G

Excreta Disposal

18	Verify that the type of latrine indicated is correct.	Yes, is correct __1 No, correction made __2 Did not verify __8
19	Toilet facility observation: observe access to the facility- are there obstacles in the path, are there signs of regular use? **[TOILREG]**	Dense vegetation __A Waste or debris in its path __B Major crevices or potholes __C Mud __D Entrance is obstructed __E Path is clear __F Path well worn as sign of regular use __G Other observation ______________________X

20	Toilet facility observation: Observe the superstructure of walls, roof and door **[TOILSTCT]**	Has walls __A Has a roof __B Has doors __C Superstructure damaged __D No superstructure __E Don’t know __Y
21	Toilet facility observation: If doors are present, can they be closed? **[TOILDOOR]**	No __0 Yes, are unlocked __1 Yes, are locked __2 Impossible to determine __8
22	If any type of pit latrine, are the holes covered? **[TOILHOLE]**	No __0 Yes __1 Not a pit latrine __2 Don’t know __Y
23	Are there separate facilities for men and women? **[TOILGEND]**	No __0 Yes __1 Cannot identify __8
24	Does it have any of the following child-friendly features? (may be separate or in the same compartment as an adult facility.) **[TOILKIDS]**	Pit latrine with smaller hole __A Lower seat __B Potty available __C None of the above __D Cannot identify __Y Not a pit latrine __Z
25	Is there fecal matter present inside the facility on floor or walls (human or animal) **[FECESFLR]**	No __0 Yes __1 Cannot assess __8
26	Is there fecal matter clearly visible in the pit at less than 30 centimeters depth (as a sign that the pit is full) **[FECESPIT]**	No __0 Yes __1 Cannot assess __8
27	Is there a place for handwashing in the toilet facility or within 10 meters? **[TOILHAND]**	No __0 Yes __1 Don’t know __8
28	Are the following items present at the place for handwashing? **[HANDITEM]**	Water from tap or container __A Soap or detergent __B Ash __C Towel or cloth __D Basin or sink __E None of the above __F

Handwashing Place

29.	Is there water? (Turn on tap and/or check container and note if water is present) **[HANDWAT]**	No __ 0 Yes, found in handwashing place __1 Brought by caretaker within 1 min __2
30.	Is there soap, detergent or ash? **[HANDSOAP]**	No __0 Yes, found in handwashing place __1 Brought by caretaker within 1 min __2
31.	If there is soap, detergent or ash mark all that are present. **[TYPESOAP]**	Soap ___A Detergent __B Ash __C
32.	Is there a handwashing device such as a tap, basin, bucket, sink, or tippy tap? **[HANDBUCK]**	No __0 Yes, found in handwashing place __1 Brought by caretaker within 1 min __2
33.	Does the washing device allow unassisted washing and rinsing of both hands, for example, a tap, a basin, bucket, a sink, or a tippy tap? **[HANDUNAS]**	No __0 Yes __1
34.	What method is used to dispense water? **[HANDISP]**	Tap or spigot __A Tippy tap or similar device __B Pipe without tap __C Pour water into a basin or bucket __D Pour water from container onto hands assisted by another person __E Pour water from container onto hands without assistance __F Other __X ________________________________ Don't know __Z
35.	Is there a towel or cloth to dry hands? **[HANDTWL]**	No __0 Yes, found in handwashing place __1 Brought by caretaker within 1 min __2
36.	Does the towel or cloth appear to be clean? **[CLTWL]**	No __0 Yes __1