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IMPROVING WATER QUALITY MANAGEMENT, WATER EQUITY, AND NON-REVENUE WATER IN GHANA

Final Inception Report

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ACRONYMS

CapEx	Capital Expenditure
CapManEx	Capital Maintenance Expenditure
CDCS	Country Development Cooperation Strategy
CSIR	Council for Scientific and Industrial Research
CWSA	Community Water and Sanitation Agency
GKMA	Greater Kumasi Metropolitan Area
GLSS	Ghana Living Standards Survey
GPS	Geographic Positioning System
GWCL	Ghana Water Company Limited
IRB	Institutional Review Board
IWRM	Integrated Water Resources Management
JMP	Joint Monitoring Programme
KNUST	Kwame Nkrumah University of Science and Technology
LIA	Low-income Area
LICSD	Low-Income Customer Support Department
MDAs	Ministries, Departments and Agencies
MEL	Monitoring, Evaluation, and Learning
MMDA	Metropolitan, Municipal, and District Assembly
MoU	Memorandum of Understanding
NRW	Non-Revenue Water
OpEx	Operating Expenditure
PURC	Public Utility Regulatory Commission
QA/QC	Quality Assurance/Quality Control
RCM	Regional Chief Manager
SWN	Safe Water Network
UNICEF	United Nations Children's Fund
URBAN WASH	Urban Resilience by Building and Applying New Evidence in WASH
WaterCaRD	Water Capacity Rating Diagnostic

WASH	Water, Sanitation, and Hygiene
WHO	World Health Organization
WSP	Water Safety Plan
WTP	Willingness to Pay
WUA	Water User Association

1.0 INTRODUCTION

1.1 BACKGROUND

Rapid urbanization has strained Ghana's urban water systems. Ghana's urban population has more than tripled over the last three decades, rising from approximately five million (1990) to more than 18 million (2021), with over half (57 percent) of the country's population now living in urban areas (Ghana Water Company Limited [GWCL] 2022). This rapid rate of urbanization is outstripping expansion of urban water infrastructure. According to 2020 World Health Organization (WHO)/United Nations Children's Fund (UNICEF) Joint Monitoring Programme (JMP) data, approximately 40 percent of Ghana's urban population does not have access to "safely managed" water, i.e., water from an improved source on premises, available when needed, and free of contamination. The GWCL is the government-owned utility responsible for urban water supply and currently operates 88 urban water schemes across the country. On average, GWCL produces about 0.9 million cubic meters (m^3) per day, compared with the daily estimated potable water demand of 1.5 million m^3. Thus, GWCL's total production accounts for only 60% of water demand in urban areas, even before considering issues such as water losses estimated at 46% in 2021 (GWCL 2022). Due to this insufficient supply, consumers face issues of intermittent service delivery and water rationing, and must rely on other, non-regulated water sources such as informal vendors and boreholes (Twerefou et al. 2015).

Water quality issues are prevalent across the country and are caused by contamination at raw water sources, within GWCL's distribution systems and at points of use. GWCL's policies and procedures require that water quality meets standards for consumption set by the Ghana Standards Authority (Ghana Statistical Service 2019; Ghana Standards Authority, 2021). However, these standards are currently not met for either urban or rural areas. The 2018 Multi-Indicator Cluster Survey found that 48 percent of drinking water was microbially contaminated at the source, and 76 percent of Ghanaians risked drinking microbially contaminated water at the point of use (Ghana Statistical Service, 2019). These issues tend to be less prevalent in large urban systems, with 39% of urban water points exhibiting *E. coli* contamination compared to 57% of water points and locations in rural settings (Ghana Statistical Service, 2019). However, in addition to microbial contamination within the distribution system caused by aging infrastructure and poor sanitation practices, agricultural activities, housing development, small-scale illegal mining ("Galamsey"), sand winning (mining), and other commercial and industrial activities are degrading the quality of water resources and abstraction points. In addition to water quality challenges, GWCL's service is further impacted by supply and efficiency issues.

Aging infrastructure, commercial and industrial activities, and climate change threaten water supply and exacerbate system inefficiencies. A recent assessment (GWCL 2022) found that aging water supply infrastructure, including existing treatment facilities and piped networks, hampers GWCL's ability to produce potable water at full capacity and leads to high physical and commercial water losses. Many of the utility's water supply systems are over 50 years old and are operating largely without rehabilitation or upgrades, at least partially due to limited revenue and investment, causing efficiency issues and high non-revenue water (NRW). Exacerbating these conditions, climate change has led to longer periods of dry weather and heavier precipitation. Both compromise production - either via scarce supplies or flooding. NRW and supply shortages impede GWCL's ability to expand water services and implement programs targeting low-income communities.

Water inequity and poverty represent additional core challenges for urban water supply. GWCL's increasing block tariff structure is set by the Public Utility Regulatory Commission (PURC) and applies to all 88 urban systems (PURC 2022). Disaggregated water coverage data reveals persistent regional and wealth disparities across the country (Ghana Statistical Service 2019; Monney and Antwi-

Agyei 2018). The poorest households tend to have lower access to safe drinking water, in part due to the costs associated with piped water connections. The WHO/UNICEF JMP estimates that, in urban areas, 95 percent of households in the richest quintile have access to basic water services, compared to 85 percent among the poorest quintile (WHO/UNICEF JMP 2019). The Coronavirus Disease 2019 (COVID-19) pandemic and the associated economic shocks have made water access more difficult for consumers, particularly the poorest (USAID 2020a). In parallel, service providers such as GWCL face difficulties in setting tariffs to effectively balance cost recovery and affordability, which can lead to substantial inefficiencies and interruptions in service provision (GWCL 2022).[1] Such difficulties are amplified by the ongoing economic crisis in Ghana. With the inflation rate reaching 34% in September 2022 and a 45% depreciation in the cedi in 2022, the ongoing economic crisis is exacerbating these challenges and affecting both households and service providers (Hyde 2022).

1.2 ACTIVITY PURPOSE AND RESEARCH QUESTIONS

On July 5, 2022, the Urban Resilience by Building and Applying New Evidence in WASH (URBAN WASH) project, a centrally funded activity of USAID's Bureau for Resilience and Food Security, received a request from USAID's Ghana Mission (USAID/Ghana) to conduct research and pilot new interventions under the Ghana Field Support Buy-in.

The primary purpose of the Ghana Field Support Buy-in (Buy-in), which will take place in two cities, is **to conduct assessments of three core challenges faced by the urban water sector—water quality, equity, and NRW—with the goal of designing and piloting interventions for addressing these issues**.

The Buy-in's framework involves a phased implementation of activities in two cities. This inception report focuses on Phase 1, which consists of initial assessments, and the co-development of action plans with GWCL for three core components: (1) water quality management, (2) water equity, and (3) NRW.[2] Specifically, Phase I will address the research questions listed in Table 1 and URBAN WASH will implement Phase 1 based on the activity framework presented in Figure 1. URBAN WASH will share and utilize the findings from Phase I to inform Phase 2 of the activity, which includes a pilot of potential intervention(s) in collaboration with GWCL (Component 4).

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[1] According to GWCL 2022, the PURC has not been consistently applying the quarterly Automatic Tariff Adjustment Formula in recent years. In real terms the average tariff per cubic meter in 2016 was USD 1.49, but it fell to USD 1.13 in 2021 as a result of depreciation in the cedi over the period. The resulting loss in revenue has contributed to GWCL's inability to carry out repairs and replacement of aged and obsolete equipment and pipelines, and other critical assets, and led to even higher levels of NRW. In September 2022, GWCL requested a 334% tariff increase but was granted a 25% increase by PURC.

[2] Throughout this inception report, the term NRW will be used rather than "water loss," which was used in the technical response. Although these terms are sometimes used interchangeably, NRW is a more precise term frequently used in the development context, which encompasses physical/technical losses (e.g., from leakage), commercial losses (e.g., from poor billing practices), and unbilled, authorized and unauthorized consumption.

Figure 1: Phase 1 activity framework

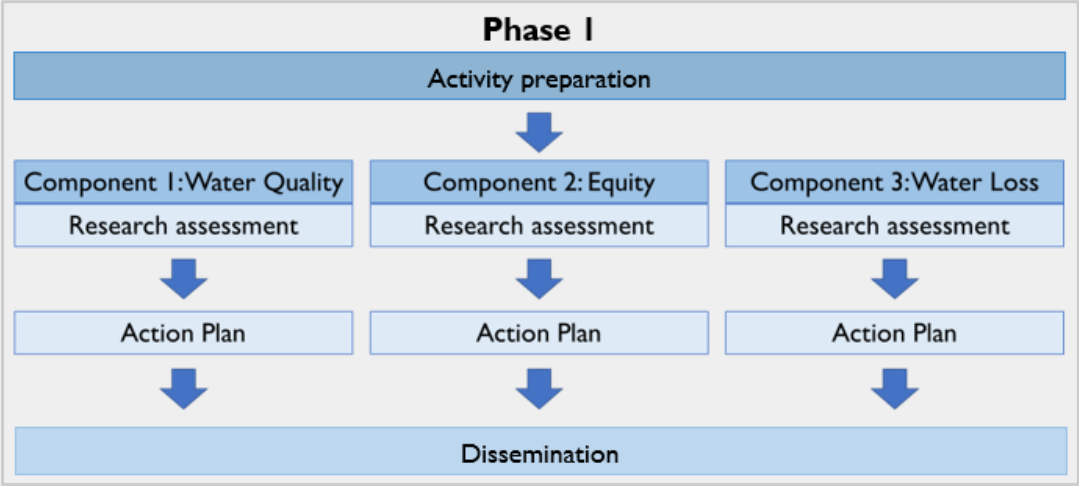


Table 1 presents the research questions developed to address the three main components of the study and the proposed data collection tools and analyses.

Table 1: Summary of research questions, data collection tools, and analyses

Component	Research Questions	Data Collection and Analytical Methods
Component 1: **Water Quality Management**	• What is the extent and complexity of GWCL's water quality monitoring activities for the distribution systems of the two target cities? • To what extent has GWCL prepared and implemented Water Safety Plans (WSPs) in its operations? • What is the quality of drinking water for GWCL consumers and non-consumers? What are the main sources of water contamination at the source and in the distribution network? • What measures or actions are being taken to reduce contamination risks both at the source and in the distribution network? • What are the best approaches and respective costs to improve water quality management?	*Needs assessment* • Desk review • Interviews of GWCL staff and water user associations (WUAs) leaders (Appendix A) • Water capacity rating diagnostic (WaterCaRD) – Interviews of GWCL staff (including the regional chief manager, water quality unit director, local district water quality officers, procurement managers, finance managers laboratory technicians), (Appendix B) – Water quality monitoring capacity rating tool (Appendix B) *Drinking water quality assessment* • Water quality sampling (implemented in conjunction with Component 2's household survey), testing, and analysis (Appendix C)
Component 2: **Water Equity and Tariffs**	• To what extent do GWCL's connection fees and tariff structures promote affordable[3] water	*Household-Level Assessment* • Desk review • Interviews with GWCL staff (Appendix D), and low-income community leaders (Appendix E)

[3] Affordability defined as condition in which a household's financial and economic costs for a type of service do not threaten the household's ability to meet other household needs, and fall below established affordability thresholds represented by a set proportion of household income (UNICEF and WHO 2021).

Component	Research Questions	Data Collection and Analytical Methods
	access for the poor[4] and vulnerable[5] in the target cities? • To what extent are underserved[6] populations able to pay for GWCL services? • What tariff/cross-subsidy arrangements for service connections and water tariffs are consistent with customers' willingness and ability to pay? • To what extent do GWCL's tariff structures support GWCL's financial sustainability in the target cities? • What tariff/cross-subsidy arrangements are most financially viable[7] given GWCL's financial performance? • What options for improving water equity[8] and affordability (e.g., revising tariff structures, cross-subsidy arrangements) support GWCL's financial viability and align with customers' willingness and ability to pay?	• Household survey (Appendix F) and focus group discussions in low-income areas with GWCL customers and non-customers (Appendix G) *Institutional-Level Assessment* • Regulatory framework review • Cost-revenue analysis • Financial viability models
Component 3: **Non-Revenue Water[9]**	• To what extent is NRW being reliably measured and estimated? • What are the primary drivers or sources of NRW? • To what extent have implemented NRW management measures been effective in reducing NRW? • What specific NRW management measures have been implemented or are planned to reduce water theft and uncollectable accounts?	• Desk review • Interviews with GWCL staff on NRW (Appendices H, I) and with GWCL and rural service providers on prepaid metering (Appendix J) • Onsite review of relevant data in conjunction with NRW-focused personnel • Site visits for ongoing/planned NRW reduction projects • Review and sampling of bulk and customer meters

4 Poverty is defined as a condition in which an individual or household is unable to meet their food and non-food needs. Based on the Ghana Living Standards Survey Round 6 (GLSS 6, conducted in 2016-2017), the national poverty line was estimated at 1,314 cedis (USD 280 at the time of the analysis) per adult per year in January 2013 prices (Ghana Statistical Service 2014).

5 Vulnerability is defined as conditions determined by inherent social, economic, environmental, physical and/or educational factors that place an individual or population at a disadvantage to access human rights, opportunities, and services relative to others (women-headed households, children, people living with disabilities, marginalized groups, unemployed, households with orphans, terminally ill persons, elderly persons, refugees and migrant populations, populations living in disaster-prone areas) (Ghana Ministry of Sanitation and Water Resources 2018, United Nations Development Programme 2018).

6 Underserved is defined as condition in which individuals or populations face barriers accessing basic services.

7 Financially viable is defined as a condition where an organization can generate sufficient revenues to maintain acceptable levels of service and to meet capital, operations and maintenance costs in the long-term, and maintain, replace, and expand infrastructure to maintain acceptable levels of service (Soppe, Janson, and Piantini 2018).

8 Water equity is defined as conditions where access to water services is affordable for all and where direct and indirect water expenditures do not disproportionally burden poor and vulnerable households when compared to middle- and high-income households.

9 URBAN WASH expanded and refined the research questions for Component 3 based on the team's initial understanding of NRW activities in the two selected cities.

Component	Research Questions	Data Collection and Analytical Methods
	• What is the extent of adoption, application, or acceptance of prepaid meters in the urban water supply space? • What have been primary drivers and bottlenecks to adoption, application, or acceptance of prepaid meters in Ghana?	
Component 4: Pilot Interventions	From the Action Plans in Components 1-3, which intervention(s) should be selected for piloting, to improve water quality, equity, and/or NRW?	• Design: co-creation workshop and protocol development • Implementation of pilot and data collection of selected indicators

1.3 INTENDED AUDIENCE AND USES

The primary audiences for the research findings are GWCL and USAID/Ghana. The findings will provide GWCL with evidence-based information for decision-making and opportunities to scale-up learnings that improve urban water services delivery. The assessments and pilot interventions will also inform USAID/Ghana's future water, sanitation, and hygiene (WASH) programming.

Secondary intended audiences include PURC and the Ministry of Sanitation and Water Resources, local Metropolitan, Municipal, and District Assemblies (MMDAs) in Tamale and Kumasi, NGOs in Urban Water Supply, and the WASH Sector Development Partners Group. PURC will be able to utilize the financial viability modeling alternatives to inform future tariff updates. The recommendation and piloting of strategies focused on improving water access for low-income households will help guide the Ministry of Sanitation and Water Resources in the development and update of pro-poor guidelines for urban water services.

Finally, this research will provide guidance to international donors and implementation partners to ensure that future urban water system expansions provide water in an equitable and efficient way. Table 2 describes how different stakeholders may use the findings to inform decisions.

Table 2: Intended audience and uses

Audience	Actor(s)	Key Use(s)
Primary	GWCL (two target cities)	Build on research findings to improve quality, equity, and efficiency of urban water services in the two target cities
	GWCL (nationally)	Adapt lessons learned from target cities to inform improvements nationally
	USAID/Ghana	Inform future WASH programming
Secondary	PURC	Integrate findings on affordability and cost-revenue modeling to inform future tariff revisions
	Ministry of Sanitation and Water Resources, Local MMDAs	Inform the potential development of pro-poor guidelines for urban water services (following the example of the existing pro-poor sanitation guidelines)
Tertiary	Local WASH project implementers	Provide evidence-based guidance and methodology to support implementation of projects that supply and expand safe, equitable and efficient water services in urban contexts in Ghana.
	Other WASH and WRM sector project implementers and researchers	Contribute to expanded sector knowledge base within Ghana and internationally.

1.4 ORGANIZATION OF REPORT

This inception report describes the selection process that led to the identification of the two target cities (Section 2), the research activities to be implemented to address the research questions under the three components (Section 3); data collection, quality assurance and management (Section 4); stakeholder engagement and dissemination (Section 5); activity management plan (Section 6); and monitoring, evaluation, and learning (MEL) (Section 7). The deliverables, travel plans, COVID-19 contingency plan, and timelines associated with the implementation of the research activities are included in Sections 8, 9, 10 and 11, respectively.

2.0 STUDY AREAS

2.1 CITY SELECTION

URBAN WASH collaborated with GWCL and USAID/Ghana to select the two study cities for the Buy-in activity. The initial intention was to select two Northern cities according to USAID/Ghana's current Country Development Cooperation Strategy (CDCS) Development Objective 3 (DO3), which is focused on the unique implementation challenges faced in the northern regions of Ghana. However, URBAN WASH considered priority concerns expressed by GWCL in the selection process and aimed to include at least one northern city as part of the Buy-in activity to balance USAID/Ghana's and GWCL's requests.

As a first step, GWCL provided a list of six priority cities with existing challenges in water quality, equity, and/or NRW: Koforidua, Takoradi, Kumasi, Wa, Tamale, and Bolgatanga, shown on Figure 2. While Kumasi, Koforidua, and Takoradi are not in the northern regions, GWCL shortlisted these cities because of a specific interest in their water quality issues caused by local surface mining activities, which have been increasing in scale over the past several years with the introduction of larger machinery. GWCL shared preliminary information via e-mail about each shortlisted city and provided contact information for the respective local Regional Chief Managers (RCMs). URBAN WASH applied the selection criteria in Table 3 to select the two target cities and exchanged phone calls and e-mails to gather information about the water quality, equity and NRW issues and relevant existing programs in each city considered, as shown in Table 4.

Figure 2: Map of priority cities[10]

[10] Map adapted from: https://www.aneki.com/map/map_Ghana.html

Table 3: City selection criteria

Selection Criteria	Description
Location – Focus on Four Northern Regions	USAID/Ghana's current CDCS DO3 focuses on addressing the unique implementation challenges faced in the northern regions of Ghana (Northern, North East, Upper East, and Upper West). This includes a particular focus on inequities in access to services including water, sanitation, and hygiene. Therefore, URBAN WASH aimed to include at least one northern city.
Motivation and availability of local GWCL leadership	Engagement and enthusiasm for the intervention from local GWCL staff was one of the most important selection criteria. The availability of GWCL staff to shape research activities, provide information, and discuss findings will be key to the activity's success. Through emails and phone calls to RCMs, URBAN WASH assessed whether local GWCL staff would be able to participate in regular meetings, contribute to agenda setting and partner with us in data collection, community engagement, and analysis.
Data availability	URBAN WASH inquired on the availability of information including engineering reports, financial statements, budgets, capital expenditure (CapEx) plans, service area maps, water quality reports, and databases containing information on water quality, NRW, and/or customer characteristics. These documents and datasets will provide a foundation for the team's understanding of existing challenges and guide our efforts to fill any gaps by collecting new data.
Network status and scale compatible with NRW reduction potential	To assess measurements of NRW, URBAN WASH inquired about the underground water network, including parameters such as length, materials, and age of pipes and the quality, functionality, age, and regular testing of water meters in the network. URBAN WASH gathered information on the type and number of water sources that supply the network. URBAN WASH assessed whether the distribution system was large enough to be conducive to NRW analysis.
Safety and security concerns	URBAN WASH took into consideration recent local events that could represent safety and security risks during field visits and interfere with data collection and stakeholder engagement.

Table 4 illustrates the extent to which the six shortlisted cities met the selection criteria.

- The team removed the city of **Wa** from consideration due to safety concerns associated with recent killings of security personnel in the area.
- Similarly, the team removed **Bolgatanga** from consideration due to its small population size (67,000, Ghana Statistical Service 2014), and small distribution system, which would limit the NRW analysis. The pipe network is limited to the center of the town and serves approximately 40% of the Bolgatanga township, while the rest of the population is served by rural water supply schemes including boreholes and hand-dug wells (Ghana Districts 2017). URBAN WASH determined that these factors would limit the scope of Component 3.
- **Tamale** was the only remaining city in the north after removing Wa and Bolgatanga.
- GWCL representatives in **Tamale and Kumasi** showed high interest in the project and level of engagement while representatives from **Koforidua and Takoradi** were slow to respond or provided limited information.

The URBAN WASH team conducted site visits to meet with GWCL representatives in Tamale and Kumasi to confirm that both cities are fitting candidates. URBAN WASH therefore recommends **Tamale and Kumasi** as the two cities for the implementation of the Ghana Field Support Buy-In.

Table 4: City selection matrix

City	Koforidua	Takoradi	Kumasi	Wa	Tamale	Bolgatanga
Region	Eastern	Western	Ashanti South	Upper West	Northern	Upper East
Total Population	281,000	445,000	3,630,000	201,000	701,000	67,000
Safety & logistics						
Recent safety issues	None noted [e]	None noted [e]	None noted [e]	Killings (Sep. 2022) [e]	None noted [e]	None noted [e]
Travel from Accra	2-hr drive	Direct flight	Direct flight	Flight to Tamale, 7 to 9-hr drive	Direct flight	Flight to Tamale, 3-hr drive
Level of engagement & interest	Engaged and interested in project, but limited initial reply to inquiry questions [a]	Limited engagement shown, slow to initially respond	Very enthusiastic and willing to assist [a]	NA (outreach was discontinued after safety concerns)	Engaged and willing to assist.	NA (outreach was discontinued due to small distribution system size and limitations for the NRW analysis)
Environment						
Water source(s) and supplies	From River Volta and River Densu [b]	Pra Basin [c]	Barakese and Owabi headworks [d]	Groundwater from 24 boreholes	Dalun system sourced from White Volta and BiWater project construction of an additional intake at Yapey [a]	Vea Dam, supplemented by four mechanized boreholes
Additional challenges	Poor source raw water quality due to industrial municipal waste and agricultural pollution etc. [e]	Limited available raw water supply (lack of inflow into Pra basin) leading to reduced pumping hours and intermittent service [c]	Increasing population and city expansion create challenges for gravity fed system. [a]	Poor source water due to industrial municipal waste and agricultural pollution etc. [e]	Increasing migrant population	Poor source raw water due to industrial and municipal waste and agricultural pollution etc. [e]
Existing issues on:						
Water quality	Raw water contamination, [a] aged water distribution network, limited implementation of integrated water resources management (IWRM) [e]	Illegal mining upstream, aged water distribution network, distribution water quality in some areas [e]	Raw water sources impacted by galamsey (mercury, lead and cyanide contamination), more alum needed to obtain clear color, old production equipment needs replacement, increasing price of imported treatment chemicals [a]	Poor source raw water quality (industrial and municipal waste and agricultural pollution) [e]	Source water pollution from sand winning, climate change (flooding of intake) [a]	Aged water distribution network, limited implementation of IWRM [e]

City	Koforidua	Takoradi	Kumasi	Wa	Tamale	Bolgatanga
Equity	Low water access to poor communities, existence of poor communities (Zongos), poor sanitation [e]	Low water access to poor communities, existence of poor communities, poor sanitation [e]	Lack of data and targeting methods for low-income communities [a], existence of poor communities, poor sanitation in communities, low water access to poor communities [e]	Low access to poor communities, existence of poor communities, poor sanitation in communities [e]	Low water access to poor communities, often in Zongo areas	Low access to poor communities, existence of poor communities, poor sanitation in communities [e]
Losses	Failure in distribution networks: bursts in distribution lines, illegal connections and lack of funds to expand and change the old pipe networks [b]	Aged water distribution network [e]	NRW at ~ 45%, water theft, pipe breakage, defective meters, inconsistent and not accurate data [a]	Aged water distribution network	NRW at ~ 35% (2022), unauthorized use of water (illegal connection, meter by-pass, meter tampering) malfunctioning customer meters, unmetered customers, pipe burst and leakage, leaking valves, pipeline damage by road contractors [a]	Aged water distribution network
Existing initiatives on:						
Water quality	None noted [a]	No data due to low level of engagement	Regional water quality laboratory based in Kumasi (30 to 40 staff), Regular water quality monitoring of raw, treated, and distributed water. Military brought to stop galamsey but this was ineffective [a]	No data due to discontinued outreach	Regional water quality laboratory based in Tamale (5 staff). Daily assessment of raw water quality before treatment, daily process flow monitoring, hourly monitoring of treated water quality, distribution water quality monitoring [a]	No data due to discontinued outreach
Equity	Ongoing demand management activities [a]	No data due to low level of engagement	Identified over 20 low-income communities in service area based on income, employment and education levels, housing structures and access to services, World Bank funded Greater Kumasi Metropolitan Area (GKMA) project to subsidize connections, UNICEF project constructing standpipes, regional Low-Income Customer Support Department (LICSD) officer stationed in Kumasi, LICSD sets up local WUAs to manage public standpipes to	No data due to discontinued outreach	Provided a list of 41 low-income communities, planned distribution system expansion under upcoming Biwater project	No data due to discontinued outreach

City	Koforidua	Takoradi	Kumasi	Wa	Tamale	Bolgatanga
			extend services to low-income communities [a]			
Losses	Program developed but not implemented due to lack of equipment (bidirectional flow meters and pressure loggers) [a]	No data due to low level of engagement	Checking pipe bursts check illegal connections, zonal metering, GIS mapping of all pipes [a]	No data due to discontinued outreach	Development of NRW strategic plan and data collection template, production & zonal metering, replacement of leaking valves, operation of illegal water use task force, replacement of faulty meters, removal of unauthorized connections, prompt repair of reported/visual leaks, servicing of bulk strainers, Biwater may be conducting analyses in preparation of their planned infrastructure improvements [a]	No data due to discontinued outreach
Data availability	Some data available, in need of processing [a]	Limited data provided	Some data available in all three focus areas	No data due to discontinued outreach	Extensive NRW data, available water quality data, but limited equity data, upcoming additional data from the Biwater project may be available	No data due to discontinued outreach

a. Indicates that this information was gathered from a phone call, email, or site visit with associated RCM.
b. (Joseph 2019)
c. https://www.gna.org.gh/1.21372509
d. (Kuma, Owusu, and Gawu 2010)
e. Information from GWCL LICSD head office

2.2 SAMPLING APPROACH

This section presents the sampling approach for the following data collection activities:

- The water quality sampling and testing at households' point-of-use in both cities that will be performed under Component 1, as described in Section 3.1
- The household survey deployed in both cities that will be conducted under Component 2, as described in Section 3.2. Note that URBAN WASH will apply the same sampling approach for the household survey (Component 2) and the primary water quality data collection (Component 1), and the same households will undergo water quality testing and respond to the household survey.
- The water meters within GWCL's distribution system that URBAN WASH will examine and test under Component 3, as described in Section 3.3.

The main administrative structures across Ghana are national government Ministries, Departments and Agencies (MDAs) that work with the decentralized structures (Local Government Areas, i.e., MMDAs). Within the urban and peri-urban areas, metropolitan assemblies are the main governing bodies at the city level. Cities are further broken into communities. MMDAs and GWCL may use different delineations or naming systems for defining communities. In case of discrepancies, URBAN WASH will use the GWCL-defined communities, as most of our secondary data will come from GWCL. URBAN WASH will focus on the metropolitan districts (Sub-Metros) within Kumasi and Tamale, even though the distribution network may extend beyond this area.

For field data collection associated with Component 1 (primary water quality data collection) and Component 2 (household survey), URBAN WASH will implement a city-wide representative sampling approach in which geographic positioning system (GPS) sample points are identified to be proportionate with population density (Kumpel et al. 2016). In collaboration with local MMDAs and GWCL, the team will identify geographical units that will be considered as zones. These may include GWCL hydraulic zones or administrative areas managed by each MMDA (e.g., Kumasi Metropolitan District's nine administrative sub-metropolitan assemblies: Kwadaso, Bantama, Suame, Tafo, Manhyia, Oforikrom, Asokwa, Nhyiaeso, and Subin) (Kumasi Metropolitan Assembly 2017). URBAN WASH will calculate the number of sample points per zone based on the zonal population density obtained from high-resolution density maps (WorldPop 2023) or population data provided by MMDAs and the Ghana Statistical Service. In each zone, the team will use GIS to generate random spatial points (GPS locations) and will survey multiple households, which will be randomly selected at each location[11] (Kumpel et al. 2016).

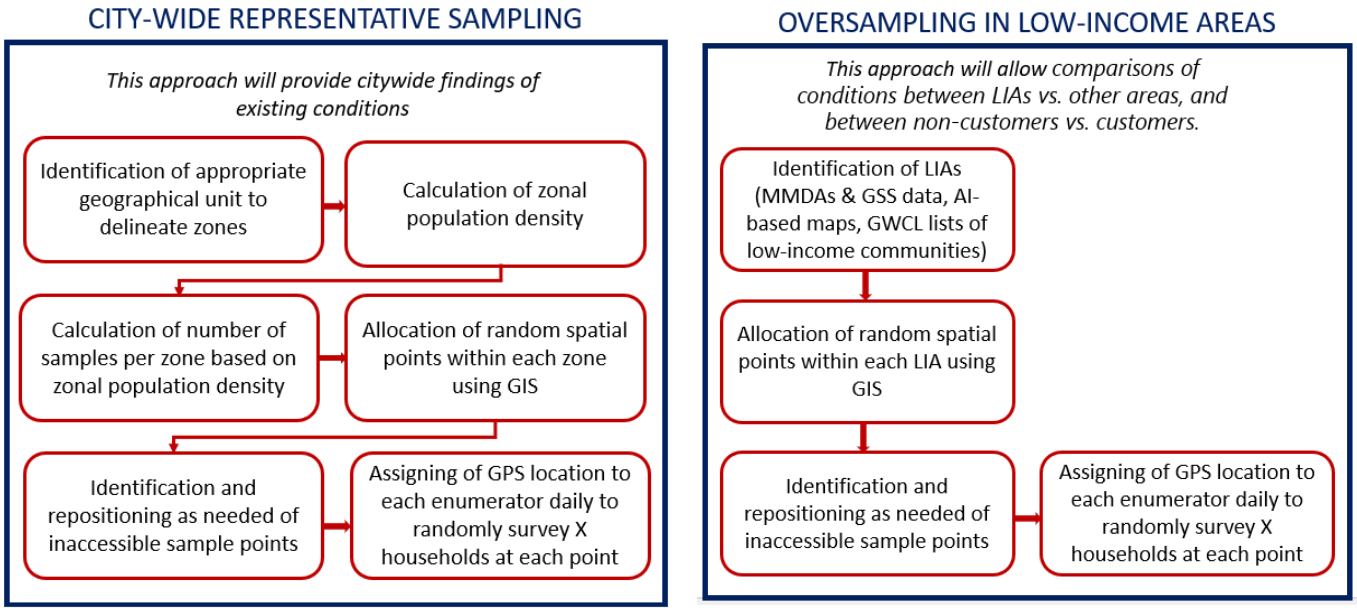
The city-wide representative sampling approach does not allow for any controls on the number of GWCL customers and non-customers, or the spread of income levels among the households surveyed. URBAN WASH will review the responses of the households surveyed during the city-wide representative sampling phase daily and identify the proportion of respondents that are GWCL customers and non-customers, and the split of low-income and middle-to-high income respondents. In the event that the city-wide representative sampling does not sufficiently capture respondents to enable comparisons between GWCL customers and non-customers, and between low-income and middle/high-income households, we will add points to oversample in specific areas or communities where more data points are needed.

[11] The survey software, CommCare, will provide a random direction and random household interval to guide enumerators in the random selection of households at their assigned GPS location.

For example, assuming the city-wide representative sampling does not sufficiently cover low-income households to allow the analysis planned under Component 2, the team would oversample low-income areas (LIAs) in each city, including those currently served by GWCL and those that are not currently served but are being considered for future planned expansion. The selection of LIAs will also take into consideration areas with predominantly migrant communities and other vulnerable populations. This approach will ensure that low-income households—both GWCL customers and non-customers—are adequately represented in the proposed activities, and enable us to compare these households with higher-income households. GWCL has provided lists of low-income communities in Tamale and Kumasi, and the URBAN WASH team will complement these community lists with demographic information from the Metropolitan Assemblies, demographic data from the Ghana Statistical Service, and potentially AI-based maps of low-income areas. GWCL maps of the distribution system and maps of LIAs in Kumasi, developed by Aquaya in 2019, are available as a starting point. Figure 3 presents a diagram of the process for the city-wide representative sampling approach supplemented by the purposive community sampling.

The team estimates surveying 250 households in each city's representative sample plus 50 additional households in purposive sampling within selected low-income communities. These numbers may change depending on the proportion of low-income households in the representative sample. The representative city-wide sample will provide a margin of error of 8% (at a 5% significance level). Assuming our entire sample includes at least 100 low-income households, we will be able to detect a 21-percentage point difference in access to safe water between low-income households and others, with a power of 80% and significance level of 5%. Power and significance calculations assume that sampling will involve 9 zones, consistent with Kumasi's number of sub-metropolitan assemblies. Additional assumptions include an intra-cluster coefficient of 0.02 (Yelland et al. 2011) between zones and outcome proportions close to 50% (conservative).

Figure 3: Diagram of sampling approach



For Component 3, URBAN WASH proposes to utilize a purposive sampling approach of bulk and customer meters for site visits. Since this Component focuses on GWCL efforts in Tamale and Kumasi to reduce water losses, a selective sampling approach will allow URBAN WASH to focus on the types of

meters that contribute to NRW due to a lack of functionality or poor accuracy. This approach will help investigate NRW sources of greater probative value for the required analysis and recommendations.

URBAN WASH will select water meters within GWCL's service area in each city with an emphasis on the following selection parameters:

- Newer, functional meters within each city, as these should be in good condition and providing more accurate data than older meters or those slated for phasing-out/replacement.
- Larger meters (e.g., commercial, industrial, compound housing) that have a greater incidental effect on NRW.
- Meters located within a subset of Kumasi and Tamale's sub-metropolitan districts, which may have a greater concentration of bulk meters or industrial customers, and/or are located within target zones or areas of interest to GWCL.
- Meters that report notably low, below-average metered use, which may be suggestive of defects, leakage, tampering, or miscalibration.

URBAN WASH will determine the criteria for sampling and sample size in close coordination with GWCL personnel in each city after having reviewed customer databases, information regarding the age and condition of meters, and other requested information. Examination of meters will include verification of existence of reported meters (including any reported upgrades), physical inspection of the condition of the meters, and review of meter readings against expected and reported results. In collaboration with GWCL, URBAN WASH will identify a smaller subset of water meters to be tested by GWCL, based on the findings from the data requests and site visits.

3.0 IMPLEMENTATION PLAN

This section details the implementation plan for the three research components for Phase I of the Buy-in. The implementation plan involves the research activities to be conducted for each component in Tamale and Kumasi:

- Component I - Water Quality Management: needs assessment and drinking water quality assessment.
- Component 2 - Water Equity: household-level assessment and institutional-level assessment.
- Component 3 - NRW: water system profiles, water balance and assessment of existing programs and financing needs to reduce NRW.

3.1 COMPONENT 1: WATER QUALITY MANAGEMENT

Information about drinking water quality is essential for guiding efforts to improve public health. For water service providers such as GWCL, accurate water quality data can help identify high-risk water sources, verify the effectiveness of treatment methods, and guide corrective actions.

Under Component I, URBAN WASH will conduct a **needs assessment** involving a desk review and key informant interviews to examine the status of GWCL's water quality monitoring activities, GWCL's capacity to meet water quality monitoring standards and best practices, the level of implementation of WSPs, and the mitigation measures in place to manage water contamination risks.

URBAN WASH will also conduct a **drinking water quality assessment** in Kumasi and Tamale. The team will review GWCL's existing water quality data and collect additional primary data from customers and non-customers across different areas of the cities to evaluate how water quality varies across different city areas, income levels, and water sources. Table 5 presents the research questions URBAN WASH will address as part of Component 1 and the activities and data collection methods that the team will use in the investigation.

Table 5: Component 1 water quality research questions

Component 1 Research Questions	Approach
• What is the extent and complexity of GWCL's water quality monitoring activities for the distribution systems of the two target cities? • To what extent has GWCL prepared and implemented WSPs in its operations as a risk-based approach? • What is the quality of drinking water for GWCL customers and non-customers? • What does GWCL identify as the main sources of water contamination at the source and in the distribution network? • What measures or actions are being taken to reduce the risk of contamination both at the source and in the distribution network?	*Needs assessment* • Desk review • Interviews of GWCL staff, PURC staff and WUA leaders (Appendix A) • Water quality monitoring capacity diagnostic (WaterCaRD) – Interviews with GWCL staff (including) regional chief manager, water quality unit director, local district water quality officers, procurement managers, finance managers laboratory technicians) (Appendix B) – Water quality monitoring capacity rating tool (Appendix B) *Drinking water quality assessment* • Existing water quality data review, primary water quality sampling (implemented in conjunction with Component 2's household survey), testing and analysis (Appendix C)

3.1.1 NEEDS ASSESSMENT

Approach

URBAN WASH will conduct a **desk review** to identify GWCL's water quality monitoring procedures, primary water quality issues and sources of contamination, and existing mitigation measures implemented to manage the water contamination risks in Tamale and Kumasi. The team will also conduct **key informant interviews** with GWCL staff and WUA leaders to assess the gaps between official standards and actual practice, the main barriers GWCL is facing in meeting the set standards, water quality regulatory targets and procedures as well as GWCL's experience with the implementation of WSPs.

Data Collection

- Desk review: URBAN WASH will initiate this task through an initial data request to the respective RCMs—John Eric Kwofie in Tamale and Dr. Edward Agyekum in Kumasi. The initial data request list includes WSPs, annual reports, guidance documents, water quality testing standard operating procedures, water quality collection and sampling plans, and other documents relevant to water quality monitoring and reporting. URBAN WASH will examine water sampling/collection and testing procedures, and the sampling and testing records to assess the implementation of the guidelines, , the frequency of testing, and the testing locations. URBAN WASH will also compile relevant national standards and guidance documents (e.g., the 2015 National Drinking Water Quality Management Framework for Ghana), which inform GWCL's performance goals and regulatory compliance targets for water quality testing and water safety planning.
- Key informant interviews with GWCL staff: URBAN WASH will conduct key informant interviews of GWCL staff using the WaterCaRD questionnaire and methodology, which was designed to evaluate institutional capacity for water quality monitoring. The WaterCaRD questionnaire (Appendix B) covers five dimensions of institutional capacity: accountability (e.g., standards, regulatory authorities, enforcement, vision), staffing (e.g., leadership, roles and responsibilities, training, recruitment, motivation), finances (e.g., resources, budgeting, accounting), equipment and services (e.g., suppliers, maintenance, procurement, infrastructure), and laboratory practices (e.g., methods, logistics, data management, quality control). Specific sections of the questionnaire will be directed to staff members who are most familiar with the respective topics, as described in the WaterCaRD methodology. The URBAN WASH team expects that respondents will include local RCMs, unit directors for water quality, local district water quality officers, procurement managers, finance managers, and laboratory staff. When warranted, multiple staff members will be asked the same questions to gain varied perspectives. (Aquaya 2016).
- Key informant interviews with PURC staff: URBAN WASH will conduct key informant interviews with PURC staff involved in overseeing GWCL operations. The interviews will help detail PURC's role as the regulatory entity overseeing GWCL's water quality performance, historical water quality reporting, and the enforcement and corrective action process.
- Key informant interviews with WUA leaders: In each study community, URBAN WASH will conduct semi-structured interviews with one to two community leaders in charge of managing WUAs (up to six interviews in each city). URBAN WASH will identify and contact these WUA leaders in collaboration with GWCL staff. LICSD Officer, Justin Navele, in Kumasi will be a focal point to liaise with WUA leaders. URBAN WASH will identify the appropriate point of contact to support the outreach to WUA leaders in Tamale.

The interviews will investigate the different sources of water used in the community and how they are used for different types of water usage (drinking, cooking, bathing, cleaning); the level of trust in the safety of the water; perception of water quality; water quality testing activities of GWCL water source and other water sources; type of water quality information received by community members; and main communication means available and used for reporting water quality complaints (See detailed questions in key informant guide included in Appendix A). The team will reassess the total number of interviews if we determine that saturation has been reached based on the responses collected.

Analysis Plan

URBAN WASH will utilize the data collected through the desk review and the interviews with GWCL staff to evaluate GWCL's water quality monitoring capacity using the **WaterCaRD tool**. Each of the five main elements (accountability, staffing, finances, equipment and services and program structure) includes sub-categories that are evaluated and assigned a score of 0 to 3, with 0 being the lowest or no capacity and 3 the highest score, indicating high capacity. The assessment will result in a total score, which will be calculated by dividing the sum of all sub-category scores by the maximum possible score. The resulting score will provide a baseline benchmark of the target cities' water quality monitoring performance and capacity and will inform the development of interventions (Aquaya, 2016). Two members of the research team will independently go through the scoring process, and a third will review and resolve any differences in scoring, which will help mitigate the impact of individual subjectivity on scoring. While research on water quality monitoring in low-resource settings tends to focus on hardware provision and staff training, the WaterCARD tool has shown the necessity of focusing on additional systemic conditions such as institutional commitment (e.g., motivation and leadership, knowledge, and staff retention) (Peletz et al. 2018).

URBAN WASH will analyze **the qualitative data from WUA leaders** in NVivo using a combination of inductive coding (i.e., searching the transcripts for information related to a predetermined list of themes), followed by deductive coding (allowing additional themes to emerge from the transcripts).

Assumptions and Limitations

GWCL staff are priority partners, and we count on their participation during the data collection period. URBAN WASH, however, realizes that they will have other priorities, especially considering the ongoing economic crisis. To address this, URBAN WASH will have several staff based in Ghana (including the Buy-in Program Manager) and will be flexible to plan interviews and other data collection activities around GWCL staff availability. Our Memorandum of Understanding (MoU) lays out expectations of GWCL support for this project, and we will leverage our connections with the LICSD head office, based in Accra, when presenting requests to the Tamale and Kumasi regional offices.

3.1.2 DRINKING WATER QUALITY ASSESSMENT

Approach

The water quality data assessment will provide a detailed understanding of water quality issues in Tamale and Kumasi. URBAN WASH will conduct a **water quality data review**, which will examine the water quality parameters monitored, their respective testing methods and frequencies and how they are adapted to local contamination risk considerations (e.g., mercury testing in Kumasi due to prevalence of galamsey activities). Following this initial evaluation, URBAN WASH will collect and analyze **household water quality data** to assess the overall water quality of both GWCL customers and non-customers

in Tamale and Kumasi and evaluate disparities in water quality based on income levels, city areas, and water sources.

Data Collection

- Water quality data review: URBAN WASH will request water quality testing data from all distribution system locations, raw water sources and other key locations including treatment plants and booster stations over the past five years (2017-2022) from GWCL's regional water quality laboratories in Tamale and Kumasi, supplemented as needed by information from the GWCL head office and/or PURC. Based on the team's current understanding of the water quality data collected by GWCL, the water quality dataset will include microbial parameters (e.g., *E. coli*, total coliform, salmonella), basic physical-chemical testing (e.g., pH, conductivity, free chlorine residual, turbidity, color), extended physico-chemical testing and specific contaminants (e.g., chloride, nitrate, calcium, magnesium, iron, manganese, aluminum, mercury, cyanide). The team anticipates that the water quality data review may involve cleaning and digitization of the existing data.
- Water quality primary data collection: URBAN WASH will collect water quality samples at the point of use (household tap and/or storage container) among the 300 households in each city that are included in the Component 2 household survey. The team will sample households as described in Section 2.2. The team plans to measure chlorine residual and *E. coli*. If existing water quality data does not cover specific local contaminants of concern identified in collaboration with GWCL, URBAN WASH will fill this data gap and consider testing 20 samples collected at key locations within the distribution system for up to three contaminants of concerns, for a total of 60 samples in each city. The team anticipates that the data gaps and contaminants of concern may vary between Tamale and Kumasi (e.g., mercury, cyanide, lead, fluoride, arsenic). Households within the selected communities will be randomly selected (e.g., starting from random GPS coordinates and sampling every X^{th} house in a random direction). Testing at the point of use will complement GWCL's existing data on water quality within the network. It will also provide a better understanding of the relationship between households' socioeconomic status and drinking water quality, as water supply intermittency and water storage behaviors may differ between lower- and higher-income communities.

Analysis Plan

- Based on the secondary water quality data available, URBAN WASH will assess temporal trends (seasonal and annual variations) and intra-city geographical disparities of the key water quality parameters monitored. We will also identify outliers and investigate any gaps or shortages in data. URBAN WASH will compare water quality between the two cities and examine disparities between environmental contaminants (e.g., fluoride and arsenic) and contaminants related to galamsey (e.g., cyanide, mercury, and lead) to understand regional water quality issues.
- The team will compare household-level water quality data with GWCL's data on water quality at distribution points and will examine trends.
- The team will disaggregate household-level water quality data by income levels, water source, and geographical locations within each city.[12] To determine income levels, URBAN WASH will rely on survey questions regarding income and wealth indices derived using the Equity Tool.

[12] Primary water quality data will be collected from the same households surveyed in Component 2 (see Section 3.2). This will allow us to pair water quality data with the data collected during the household survey (socio-economic status, water sources, level of service) to explore potential relationships.

- The analysis will also identify water quality differences between the types of GWCL water services (e.g., communal standpipe, private household connection, water kiosk).
- The results from the field water quality measurements may indicate that concentrations of tested contaminants exceed standards. URBAN WASH will share water quality testing results with local GWCL water quality teams and headquarters in Accra. We will highlight results that do not meet national drinking water quality standards for further investigation, reporting as appropriate, and corrective action.

Assumptions and Limitations

Parts of the above analyses rely on GWCL providing extensive data records. The extent and quality of the data shared with URBAN WASH is outside the team's control. Initial discussions suggest that GWCL should be able to provide existing water quality data, but the spatial/temporal extent of this dataset is currently unknown. Additionally, URBAN WASH expects that analyzing secondary data will require extensive data cleaning. In the case that local GWCL water quality staff share incomplete datasets, URBAN WASH will request data from the Accra head office or from PURC, although both would likely only have summary data.

3.1.3 COMPONENT 1 ACTION PLAN

URBAN WASH will identify opportunities to improve water quality management, ultimately improving water safety and public health, in collaboration with GWCL, USAID/Ghana, USAID/Washington, MMDAs, and other stakeholders. The Action Plan will include recommendations to improve GWCL's water quality monitoring activities and strengthen its capacity to mitigate contamination risks and meet water quality standards and regulations. These recommendations will be summarized in an Action Plan, including an options analysis with cost estimates for each recommendation and suggest decision support tools, if needed. These Action Plan recommendations will be considered for piloting as part of Component 4.

3.2 COMPONENT 2: WATER EQUITY

To be effective in promoting water access, a utility's tariff structure must balance affordability and financial sustainability (Franceys, Perry, and Fonseca 2006; Andres et al. 2019). If a tariff is set higher than customer ability to pay (or willingness to pay [WTP] for a given level of service), then customers will not pay bills punctually and/or may rely on alternate water sources. Conversely, if tariffs are too low to cover a utility's operating expenditure (OpEx), the utility will not be financially sustainable in the absence of other funding sources, and it will struggle to both maintain service levels and expand its geographical coverage. Accordingly, Component 2 will first examine tariff affordability (household-level assessment) and will then review strategies for GWCL to improve cost recovery without undermining equity (institutional-level assessment). The questions guiding Component 2 and the overall approach are summarized in Table 6.

Table 6: Component 2 water equity research questions

Component 2 Research Questions	Approach
• To what extent do GWCL's connection fees and tariff structures promote affordable water access for the poor and vulnerable in the target cities? • To what extent are underserved populations able to pay for GWCL services? • What tariff/cross-subsidy arrangements for service connections and water tariffs are consistent with customers' willingness and ability to pay? • To what extent does GWCL's tariff structures support GWCL's financial sustainability in the target cities? • What tariff/cross-subsidy arrangements are most financially viable given GWCL's financial performance?	*Household-Level Assessment* • Desk review • Interviews with GWCL staff (Appendix D), and low-income community leaders (Appendix E) • Household survey (Appendix F) and focus group discussions in low-income areas with GWCL customers and non-customers (Appendix G) *Institutional-Level Assessment* • Regulatory framework review • Cost-revenue analysis • Financial viability models

3.2.1 HOUSEHOLD-LEVEL ASSESSMENT

Approach

Following a desk review and key informant interviews, URBAN WASH will conduct a household survey and focus groups to assess households' ability to pay for piped water services. The goal of the **desk review** is to identify low-income and marginalized areas of each city, understand GWCL's past strategies to serve these areas, and estimate their level of access to piped water. **Key informant interviews** will further examine challenges for GWCL to serve poor and vulnerable groups (e.g., barriers to connecting to the network or paying water bills), existing pro-poor programs, and potential additional strategies for pro-poor support. **Focus group discussions** will further examine the barriers for low-income households to become (or remain) GWCL customers, including affordability, awareness of existing pro-poor programs, and perceptions of GWCL's service quality in comparison to alternate water sources. The open-ended discussion format will allow URBAN WASH to determine water access issues and their underlying causes in each city, which will inform the final design of the household survey questions. The **household survey** will assess i) income and wealth levels, ii) ability and WTP for piped water services, considering different payment modalities, iii) aspects of service delivery that households value most among accessibility, reliability, continuity, and quality. For each household, URBAN WASH will administer the household survey and then collect a water sample as described under Component 1.

Data Collection

- Desk review: The team plans to obtain statistics on water access among poor and vulnerable populations, maps of low-income communities in the cities of study as well as documentation about current and previous pro-poor activities.
- Key informant interviews: The team plans to interview three to five GWCL staff and one to two community leaders per additional low-income community covered in the LIA oversampling phase (up to 6) in each city.[13] Following best practice, URBAN WASH will interview new respondents until "saturation," i.e., when an additional interview doesn't provide new information. Interview guides are available in Appendices D and E. The key informant interviews

[13] Since LICSD is not operational in Tamale, URBAN WASH will conduct interviews with relevant GWCL staff that have been involved with measures to serve expand coverage low-income households and LIAs.

with GWCL will inquire about existing pro-poor programs, their costs, implementation barriers, performance monitoring, identification criteria for low-income communities and households, breakdown of the connection fees, and overall operations (Appendix E).

- Focus groups: The team plans to conduct two focus group discussions per city, one with men and one with women. Focus group discussions will use open-ended questions to gather in-depth information about existing pro-poor initiatives, the main barriers to accessing GWCL services and how GWCL's supply compares with other water source alternatives in each city. Single-gender focus groups will help create an environment that fosters open discussions and encourages participants to share their perspective. Each group will have approximately six participants from different low-income neighborhoods. Selected participants should be involved in financial decisions regarding the water supply in their households and include a mix of GWCL customers and non-customers. URBAN WASH will ask MMDAs and community leaders to assist the team with the recruitment of participants. URBAN WASH will utilize findings from the focus group discussions to refine the household survey questions. The focus group questionnaire is available in Appendix G.
- Household surveys: As discussed, the team plans to survey a total of 300 households in each city (assuming 250 households in each city's representative sample plus 50 additional households in selected low-income communities, although these numbers may change depending on the proportion of low-income households in the representative sample). These will be the same households surveyed in Component 1 as part of the water quality assessment. The household survey will assess the affordability of and WTP for water services (both connection fees and volumetric tariffs) using multiple complementary methods. First, the team will collect data on household income, along with current total and disaggregated water expenditures (Hutton 2012). The team will collect data on households' alternative water supplies, respective prices, and levels of service to provide an indication of revealed WTP for a certain level of service. The household survey will also integrate questions from the Household Water Insecurity Experiences Scale to investigate household water insecurity (Young et al. 2019). URBAN WASH will explore collecting data on disaggregated household expenditures (food, housing, education) to assess water expenses compared with those on other basic needs. Income data can be unreliable in settings where households have informal occupations and unstable income sources. URBAN WASH will complement this with data on stated WTP for tariff rates and connection fees (among households not currently connected to GWCL's system) using the double-bound dichotomous choice method (contingent valuation). Although stated WTP surveys can only approximate true WTP, they have been used in the past to document the gap between market prices and what poor urban residents are willing to pay , and to identify appropriate subsidy levels (Delaire 2021). Finally, WTP surveys can help identify households' preferences for different payment modalities associated with GWCL's connection fee (e.g., duration of installment payments for connection fee). URBAN WASH will employ a phased approach to refine the survey prior to its implementation, updating the survey tool based on the findings from the launch workshops and focus groups. The current version of the household survey tool is available in Appendix F. Enumerators will enter survey responses in the CommCare mobile application (Dimagi).

Analysis Plan

URBAN WASH will **analyze quantitative (survey) data using** R. The team will compute wealth indices using the standard method from the Equity Tool and will also estimate the proportion of the survey population living below the national poverty line using the Poverty Probability Index methodology. URBAN WASH will compute statistics on household demographic and socio-economic

characteristics, water supply behaviors and expenditures, alternative water sources, water services (private connection, share connection, communal standpipe) and priority water supply features (e.g., proximity, reliability, quality). The team will estimate GWCL's current penetration in low-income areas and assess access to the life-line tariff, considering communal standpipes, private connections and shared connections.

URBAN WASH will triangulate the different data collected on ability and WTP to identify adequate pro-poor pricing and payment modalities (both for connection fees and volumetric tariffs). In particular, URBAN WASH will anchor the stated WTP demand curves for the connection fee with the prevalence of and actual connection fee paid by current GWCL customers included in the household survey, as an indicator of revealed WTP. Additionally, the stated WTP results for monthly tariffs will be compared to households' reported monthly water expenditures (for GWCL and alternative water supplies used), which will provide an indicator of revealed WTP for different levels of service. The team will assess how households' WTP changes based on the level of service that they are currently receiving (non-GWCL water sources, GWCL standpipes, shared connections, and private connections), providing insight into households' perceptions of GWCL service in comparison to other sources. The analysis will also examine whether and how households use alternative water supplies for drinking and other applications (e.g., cooking, bathing, cleaning), to identify the main drivers behind households' selection of water supplies (price, convenience, perceived water quality, reliability, quantity). The team will disaggregate summary statistics by income level, wealth quintile, and neighborhood. Upon examining WTP responses from higher-income customers, the team will assess opportunities for these customers to cross-subsidize tariffs for lower-income households.

We will analyze **qualitative (interview and focus group) data** in NVivo using a combination of inductive coding (i.e., searching the transcripts for information related to a predetermined list of themes), followed by deductive coding (allowing additional themes to emerge from the transcripts).

Assumptions and Limitations

Collecting representative data on the two cities' low-income areas requires having comprehensive and reliable maps of these low-income areas. The team assumes that we will be able to obtain such maps from GWCL or MMDAs, but our experience is that these maps can be outdated. To address this potential limitation, URBAN WASH plans to complement available maps with satellite imagery.

3.2.2 INSTITUTIONAL-LEVEL ASSESSMENT

Approach

Under this sub-component, URBAN WASH will review the **regulatory framework** of water tariffs and conduct a **financial (cost-revenue) analysis** of the water services provided in Tamale and Kumasi to compare the local costs of service provision with revenues and recommend strategies for balancing equity and economic efficiency. This analysis will take into account water tariff levels and structure, connection charges and subsidies, the costs of providing services, and other relevant financial and commercial indicators as determined from responses to data requests and key informant interviews. URBAN WASH will present **financial viability models** and consider alternative revenue-generating and cost-saving measures –including changes to connection charges or subsidies, improvements in reducing NRW, changes to tariff structures (which would have to be made by PURC), government/donor transfers –that would allow the two utilities to move towards financial sustainability and reduce the financial barriers that low-income customers face to access service. The alternatives will take into consideration the current regulatory framework, the utilities' financial situations (current and

projected), connection charges/fees, and tariff structures and related subsidies for customers in need (including lifeline tariffs and their unavailability in the case of compound housing).

Data Collection

- Regulatory Framework Review: URBAN WASH will examine the current regulatory framework of water tariffs as dictated by PURC, including the current tariffs applied in Tamale and Kumasi and the Proposal for Tariff Review presented by GWCL to PURC in April 2022 (GWCL, 2022). URBAN WASH will also review data collected and activities undertaken by the GWCL Low-Income Distribution Extension Fund and GWCL's LICSD (if operational) to, respectively, identify low-income households and implement mechanisms to target financial aid for customers in need.
- Cost-Revenue Data Collection: URBAN WASH will examine the current financial situations of GWCL's Tamale and Kumasi operations. In the data collection stage, we will request the following detailed information:
  - Current coverage of water services
  - Number and type of customers
  - Volume of water consumed
  - Water produced
  - Bulk water bought
  - Billed and collected revenue
  - Financial statements
  - Details of operating costs and revenue components

Analysis Plan

The **cost-revenue analysis** will involve analyzing financial statements from the last three years. URBAN WASH will determine the components of revenues and costs, including operating costs, revenues, assets, liabilities, and cashflow, and estimate cost recovery ratios. Subsequently, the team will conduct a more detailed analysis to estimate the real costs of properly maintaining and operating the system including OpEx and capital maintenance expenditure (CapManEx), the revenue needed to cover these costs, and the revenue needed to also cover CapEx. The resulting cost per m^3 will be estimated per component (electricity, personnel, chemical, bulk water, etc.). We will estimate the gap between what is required (CapEx, CapManEx, and OpEx) and what is currently obtained by GWCL operations in Kumasi and Tamale. More specifically, URBAN WASH will determine the extent to which each utility's costs are covered by tariffs, government transfers, internal subsidy received from other GWCL operations, and/or external funding (disaggregated into grant funds and commercial finance/loans).

URBAN WASH will closely examine revenues from tariffs, including number of customers by category, which will likely include low-income, other residential, non-residential, and bulk water to other clients including government-funded and administered institutions (e.g., schools, hospitals, and other health facilities, etc.), or the rural water utility Community Water and Sanitation Agency (CWSA). The real cost of operating and maintaining the system will serve as the reference cost to be used both for the proposed tariffs and for estimating the subsidy that the utilities are receiving either from other regions served by GWCL or from the government, donors, etc.

URBAN WASH will build **financial viability models** to test alternatives for GWCL in the two cities to gradually achieve financial viability in a reasonable timeframe (typically the next five years but may be adjusted to the utilities' current financial situations). Using each utility's current financial situation as the starting point, the models will project the utilities' financial situations five years into the future, assuming

implementation of planned target investments in the short term and some additional, feasible efficiency gains from reductions in NRW, for example. The team will estimate the utilities' financial viability gaps for the five-year period. We will then present different scenarios to help cover these gaps, including a mix of tariffs and subsidies/transfers from the government or external funders. The team will discuss the scenarios with local personnel to validate their political and social feasibility, select the most feasible tariff and transfer scenario(s), and design a gradual application.

To ensure that URBAN WASH promotes financial arrangements that support more equitable access to water, we will pay special attention to the magnitude of transfers (subsidies) needed by low-income customers to access service at an affordable price (informed by Section 3.2.1 above), as well as how GWCL will fund this subsidy.

The team will estimate appropriate subsidy levels by applying affordability criteria primarily based on the household survey data, which will be supplemented by data from the Ghana Living Standards Survey (GLSS), if necessary, to estimate income levels and the real cost of providing the service (reference cost estimated in the cost-revenue analysis). The URBAN WASH team will also consider data on the utilities' current pro-poor strategies and customer characteristics collected for the household-level assessment. The team will explore a range of possible forms of subsidy, including subsidies through tariffs, cross-subsidy among customers, and direct transfers from government to low-income customers to alleviate the financial burden of water supply payments. Direct transfers may come in the form of rebates, bill forgiveness, or other social programs.

URBAN WASH will propose alternative tariff and transfer structures that aim to achieve the following objectives:

1. *Financial viability*: The tariff structure covers at least OpEx and CapManEx and additional financial obligations (e.g., loans, taxes, supplier commitments)
2. *Economic efficiency*: Tariffs are set using the real cost of providing the service, as reference.
3. *Water use efficiency:* Rational water use is incentivized among both domestic and non-domestic customers.
4. *Social equity*: Subsidies are awarded to low-income customers.
5. *Simplicity*: Tariffs are easily understandable to water users.

We will present different alternatives that comply with these objectives and propose a phased implementation approach. If the proposed tariff and transfer scenario(s) do not fit into the existing regulatory framework, URBAN WASH will highlight recommended adjustments.

Assumptions and Limitations

This analysis relies on availability of information including financial records, real cost of providing the service, market composition, and data on low-income customers. It also relies on the availability of relevant personnel to help answer questions about the data. In case some of the information is not available, URBAN WASH will make assumptions using secondary sources relevant to the situation in Tamale and Kumasi, which may provide less accurate results. Secondary sources include among others, knowledge from personnel based locally, international database of water utilities (World Bank, USAID, UNICEF, etc.), statistics produced by the Ghana Statistics Service, water engineers who are familiar with the water service provided by GWCL, other information collected by the team during preparation of the study.

3.2.3 COMPONENT 2 ACTION PLAN

URBAN WASH will summarize the two assessments in a report for project stakeholders. In collaboration with GWCL, USAID/Ghana, USAID/Washington, MMDAs, PURC, and other stakeholders, URBAN WASH will develop an action plan, which will consider the design for a new pilot tariff or subsidy regime that improves water equity and/or expands services to vulnerable populations. This collaborative development of the action plan will include (i) discussing the pros and cons of the alternatives proposed with stakeholders, and (ii) proposing a transition period for implementing the tariff/subsidy alternative that is most feasible.

3.3 COMPONENT 3: NON-REVENUE WATER

Although tariffs, subsidies, and transfers are important, they are not the only means for a utility to expand water access and achieve operational cost recovery. Cost-effective approaches to minimizing NRW are another pathway to promote equitable and affordable access while improving the utility's financial viability. Under Component 3, URBAN WASH will assess GWCL's NRW (i.e., physical water losses and administrative/commercial water losses) in the two selected cities. URBAN WASH will review GWCL's short-, medium-, and long-term NRW reduction plans in each city, analyze GWCL's human and institutional capacity (e.g., organizational structure, equipment, and data systems) to estimate and address NRW, and investigate the suitability of prepaid metering for urban water services based on the context in Tamale and Kumasi. Finally, the team will recommend short-, medium-, and long-term activities that are most feasible to reduce NRW given this context. Based on the team's initial understanding of NRW activities in Tamale and Kumasi, URBAN WASH refined the set of research questions for Component 3 as presented in Table 7.

Table 7: Component 3 NRW research questions

Component 3 Research Questions	Approach
• To what extent is NRW being reliably measured and estimated? • What are the primary drivers or sources of NRW? • To what extent have implemented NRW management measures been effective in reducing NRW? • What specific NRW management measures have been implemented or are planned to reduce water theft and uncollectable accounts? • What is the extent of adoption, application, or acceptance of prepaid meters in the urban water supply space? • What have been primary drivers and bottlenecks to adoption, application, or acceptance of prepaid meters in Ghana?	• Desk review • Interviews with GWCL staff on NRW (Appendices H, I) and with GWCL and rural service providers on prepaid metering (Appendix J) • Onsite review of relevant data in conjunction with NRW-focused personnel • Site visits for ongoing/planned NRW reduction projects • Review and sampling of bulk and customer meters

3.3.1 DETAILED NRW ANALYSIS

Approach

To obtain a baseline understanding of NRW, URBAN WASH will conduct a **desk review** of NRW measurements prepared by GWCL in Tamale and Kumasi. URBAN WASH will also obtain needed information regarding NRW through comprehensive **data requests** and **key informant interviews** with local GWCL personnel to understand the procedures used to estimate the components of their water balances. Based on the initial response to data requests and interviews, URBAN WASH may conduct follow-up interviews or request additional data.

URBAN WASH will also conduct interviews with GWCL to understand prior and planned efforts to use prepaid metering to reduce NRW, including drivers and impediments to adoption of prepaid metering technologies in Ghana in both urban and rural contexts. While an October 2022 PURC Regulatory Brief noted that prepaid water meters can suit the Ghanaian context, there has not been widespread uptake, particularly in urban areas of Ghana. (PURC 2022). In 2014 - 2015, GWCL efforts to introduce a prepaid meter pilot in the Accra-Tema Metropolitan Area, for example, were strongly opposed in part by a network of civil society organizations (GhanaWeb 2015). URBAN WASH will conduct interviews with Safe Water Network (SWN), the CWSA, and other rural stakeholders to learn more about their experiences and challenges with prepaid metering and understand how it may be relevant to more urban contexts of Tamale and Kumasi.

To understand the sources of physical and commercial NRW at a more detailed level and assess GWCL's human and institutional capacity to undertake NRW reduction activities, URBAN WASH will conduct **site visits** in each city utilizing local and international consultants. After preparing water system profiles and updated water balance plans for each city, URBAN WASH will propose feasible activities to reduce NRW in each city, including a qualitative assessment of whether and how prepaid metering may be effectively piloted in Tamale and Kumasi.

Data Collection

- Desk review: URBAN WASH will establish contacts and reporting relationships with GWCL utility managers in Tamale and Kumasi. Through data requests, the team will obtain GWCL's short-, medium-, and long-term NRW reduction plans in the two cities covering aspects such as bulk metering, establishment of district metering areas, meter reading practices, meter replacements, training, adoption and penetration rates of prepaid meters, factors affecting the roll-out of prepaid meters by GWCL, and periodic NRW measurement practices such as the use of minimum night flow measurements.[14] The team will also assess the frequency and extent of non-recovery from principal categories of customers, including individually-metered households, those in compound housing, commercial/industrial users, and institutions (e.g. schools, health facilities, both government-administered and private).
- Key informant interviews
  - *GWCL staff (Tamale/Kumasi):* The team will conduct interviews with GWCL staff in each city to discuss the main causes of NRW and planned reduction strategies, including the extent to which they have utilized or considered prepaid metering (Appendices H and I). Recognizing that most NRW reduction projects are implemented in a discrete section of a city's service area, the team will develop a sampling plan in collaboration with the two cities to determine the zones/districts in which URBAN WASH will conduct more detailed analysis. These districts/zones will be based on GWCL's preferences, as well as where NRW issues feature most prominently per desk review and interviews. In the interviews with Tamale GWCL staff, URBAN WASH will investigate the specific NRW challenges associated with the rural communities located along the lengthy transmission line from Nawuni (where the intake for the Tamale Water Supply is) to central Tamale.
  - *Prepaid Metering stakeholders:* These interviews will focus on prior and current examples of implementation of prepaid metering for either standpipes or individual meters in Ghana. URBAN WASH will conduct targeted interviews related to rural adoption of prepaid meters with representatives from SWN, CWSA, Water4 / Ward4 Development, while

[14] Noting the overlap in much of the core data needed in both Component 2 and Component 3, the team coordinated to develop a unified set of data requests that covered tariff- and NRW-related inquiries.

GWCL personnel in Accra would provide details regarding previous attempts to introduce prepaid meters in urban settings. These interviews would be conducted virtually and then supplemented as part of in-country visits as needed.

- Data and interview follow-up: After reviewing the responses received from the data request and key informant interviews, URBAN WASH will follow-up with GWCL managers responsible for monitoring physical and commercial water losses to obtain further information on NRW activities and reduction plans. This will involve meetings with the GWCL managers responsible for scheduling field service activities to obtain an estimate of the main activities and response times. Discussions with GWCL customer service staff will provide information on procedures for billing and collection, including procedures for enforcing payment.
- Site visits: URBAN WASH will hold meetings with GWCL's Technical, Commercial, GIS/Mapping/DMA/NRW department(s) in each city to review and evaluate the accuracy of collected data and analyses prepared by the city on the components of NRW. This will include discussions to identify gaps, understand and validate NRW reduction activities, and agree on a program of site visits. Site selection will reflect input from GWCL, USAID/Ghana, and discussions with Biwater regarding its planned activities, and will be conducted by local consultants in tandem with a visiting international NRW/Water Losses Specialist. URBAN WASH will survey the selected zones/districts with field maintenance staff and note the condition of above-ground assets; understand where bulk metering is occurring; review the condition of existing resources for maintenance activities (vehicles, equipment, and tools used by field staff), noting age and operability; discuss major reasons for water main breaks (e.g., electricity service interruptions, high pressure, etc.); and review current operating procedures for locating and repairing leaks. The team will analyze installed meters by type and age, determine the number of functional and read meters, note the quality of installation and absence of leaks, and inquire about leaks on service line connection points. URBAN WASH will also arrange for a sample of customer meters to be tested by GWCL and if possible, determine the number of unmetered connections. The sample of bulk and customer meters to be tested will be determined purposively, in order to better inform the accuracy of the NRW and apparent losses estimates, placing a heavier emphasis on newer, functional meters; larger meters (since their replacement will have a greater impact on revenue); and those with lower, below-average metered use. The team will also review and verify with GWCL network plans and customer information; review the baseline status of water system maps, GIS, and network models; and review current operating procedures for developing water supply network maps.

Analysis Plan

Based on analysis of documents collected during the desk review and interviews with GWCL management, URBAN WASH will prepare **brief water system profiles** for each city. The profiles will include population and other demographic data, population served by type of service, installed capacity of water sources, hours of service per day, annual water billed in GHS and m^3, annual operating costs, number of employees, and number of employees responsible for monitoring supply losses. URBAN WASH will also obtain or prepare a general map of the service areas that show the location of water sources, transmission mains, and major distribution zones.

Based on the above, the team will—in collaboration with the two cities—prepare or update and refine **water balance plans** using the International Water Association's methodology that identifies physical and commercial water losses and major causes of each (see Mastaller and Klingel 2017; Liemberger and Farley 2004). While some water balance information is available for Tamale and Kumasi, it is either outdated or regionally focused; URBAN WASH will therefore ensure that the team uses accurate,

updated plans at the appropriate level (city or district/zone). The team will also create an estimate of the costs and benefits of reducing NRW in short-, medium-, and long-term timeframes.

On the topic of prepaid metering, URBAN WASH will assess qualitative information gathered from key informant interviews and leverage insights on customer perceptions of prepaid metering obtained through the household surveys and focus groups conducted under Component 2. URBAN WASH will provide a high-level assessment of the drivers and barriers to adoption of prepaid metering, including how these may differ in rural and urban areas of Ghana.

During the team's surveys and site visits, URBAN WASH will identify programs at the local and national levels for reducing NRW to ensure that the Buy-in program appropriately complements rather than duplicates the efforts of other government and donor programs. For example, the city of Kumasi has some plans for checking pipe breaks and illegal connections, and installing flow meters and pressure loggers, while Biwater has been contracted to install new water supply infrastructure in Tamale.[15] Depending on the progress of implementation, such programs could present opportunities for URBAN WASH to provide further support through a pilot program URBAN WASH will seek to understand where NRW reduction activities are especially underfunded or communities undeserved by GWCL and donor initiatives.

Assumptions and Limitations

A key assumption of our research plan pertains to the complementarity of our proposed activities with GWCL's existing or prior NRW-related activities. In Tamale in particular, GWCL has conducted some level of NRW analysis and is in the process of developing a NRW strategic plan. The URBAN WASH team has taken this into consideration when refining the research questions and will continue to gather information to ensure complementarity of activities and adapt as needed.

Another limitation is the availability and reliability of the underlying data used to prepare our NRW analysis. The accuracy of NRW measurements and the components of a water balance depend on the availability and reliability of these data. For example, the reliability of the gross NRW percentage is dependent upon accurate bulk and customer meter readings and estimates of billed water from customers that do not have meters. We will rely on information from utility managers to develop estimates of the costs and benefits of NRW reduction strategies and projects. Further, NRW-related estimates can evolve over time as GWCL implements NRW reduction strategies and projects. URBAN WASH will take reasonable steps within the timeframe of the project to assess the reliability of the underlying data and will document the rationale for all assumptions made in projections or calculations, when necessary, in accordance with best practices and the team's expertise.

3.3.2 COMPONENT 3 ACTION PLAN

URBAN WASH will summarize the analyses of NRW root causes and reduction strategies in an Options Analysis for Improved Water Utilization/NRW Assessment Report. The team will prepare a high-level action plan identifying short-term, medium-term, and long-term activities to reduce NRW in Tamale and Kumasi, and their respective costs and benefits. The recommendations will consider each city's NRW management practices and plans and GWCL's human and institutional capacity (e.g., organizational structure, staffing levels, equipment, and data systems) to propose plans of action for GWCL in Tamale and Kumasi. These recommendations could include the introduction of prepaid

[15] The implementation timeline of the Biwater activities in Tamale has not been confirmed.

meters and will also consider the extent to which local private companies may have capacity to augment or supplement GWCL's NRW reduction activities.

3.4 COMPONENT 4: PILOT INTERVENTION

Phase 2 (Component 4) will take place following the development of action plans for Components 1–3 and will focus on the implementation of interventions that improve water quality and overall reliability of water services to low-income and underserved households. The pilot intervention programs will be tailored to GWCL's priorities and technical capacity building needs, with the aim of answering the following questions:

- Which intervention(s) should be selected for piloting, to improve water quality management, water equity, and/or NRW?
- To what extent do the selected intervention(s) improve water quality management, water equity, and/or NRW?
- How should the intervention(s) be adapted for future use among urban water systems in Ghana?

3.4.1 EVIDENCE-BASED CO-CREATION WORKSHOP

Drawing on the evidence from Components 1–3, URBAN WASH will convene workshops with USAID/Ghana, GWCL, USAID/Washington, Metropolitan, Municipal, and District Assemblies, and other stakeholders, to discuss and select intervention(s) for piloting. Potential examples include improvements in chlorination protocols (Component 1); new subsidies and service connection policies/fees to improve water equity or voucher experiments to test different payment modalities and levels of subsidies for connection fees (Component 2); and technology-driven NRW management system and prepaid metering models adapted to urban water services delivery for increased water revenues and water use efficiency (Component 3).

3.4.2 RESEARCH IMPLEMENTATION PROTOCOL AND INTERVENTION

URBAN WASH will develop research protocols, which will be presented to relevant stakeholders in the inception report for the Component 4 pilot interventions. The research implementation protocol will include learning questions specific to the selected intervention(s), methods to implement the intervention(s), key indicators, plans for data analysis, and plans for dissemination. In collaboration with GWCL, the team will implement the intervention(s), potentially through a comparative pilot study, if feasible. Throughout and following the intervention, URBAN WASH will collect and analyze data on key indicators, which will be defined in the Component 4 inception report.

4.0 DATA COLLECTION, QUALITY ASSURANCE AND MANAGEMENT

4.1 PREPARATORY STEPS

- The team will pre-test and refine all our data collection tools before enumerator training.
- During enumerator training, URBAN WASH will work in collaboration with the team supervisors and enumerators to establish standardized translations in local languages (Twi and Dagbanii) for all the household survey questions and response options. During the training, enumerators will practice delivering the questions and confirm the agreed-upon wording of the survey questions and responses.
- URBAN WASH will obtain ethical approval from the Council for Scientific and Industrial Research (CSIR) in Ghana.
- We will procure required water quality testing equipment and supplies internationally to conduct microbial and chlorine testing and will set up a "mini lab" in office spaces available in each study city. The team will rely on our local network to identify adequate space with reliable electricity.

URBAN WASH will contract the Kwame Nkrumah University of Science and Technology (KNUST) laboratory in Kumasi to conduct analytical water quality testing for the additional contaminants of concern identified during the desk review. The team may also partner with SGS Laboratory Services in Accra to conduct the analytical water quality testing, as needed.

4.2 FIELDWORK PROCEDURES

Component 1 and Component 2 (household-level assessment)

- URBAN WASH will recruit two data collection teams, one in each study city, for the combined household water quality testing (Component 1) and household survey (Component 2). Each team will be comprised of five local enumerators and one supervisor. URBAN WASH estimates that each enumerator will be able to complete four to five household surveys per day, which means that completing the 600 surveys across the two cities survey is expected to last for a period of approximately 20 working days in each city, including six days of training. The team expects that the start of the survey collection will be staggered by 1-2 weeks to ensure dedicated training for each city's team, and then data collection activities will overlap in the two cities. Based on the staggered start of the field operations in each city and anticipated rest days, the data collection will take approximately one month.
- URBAN WASH will train data collection teams for at least six days: three days in the classroom and three days in the field to pilot household selection procedures and the household survey tool. An important aspect of the training will be to ensure that enumerators are using consistent wording when translating the household survey in local languages. Supervisors will play a key part in this.
- Enumerators will collect data on Android phones using the survey app CommCare.
- Supervisors will oversee team logistics, community entry, quality control, and centralizing consent forms.
- Additionally, URBAN WASH will recruit two qualitative data collectors in each city. They will take turns in conducting interviews/focus groups and taking detailed notes. They will audio-record all interviews and will also be responsible for transcribing recordings into English.

- URBAN WASH staff will conduct interviews with GWCL staff.

Component 3

- URBAN WASH will conduct examinations of a sample of installed bulk and customer meters to assess NRW data. This will be carried out by an international specialist, who may work in tandem with local consultants as needed.

4.3 DATA QUALITY ASSURANCE

URBAN WASH will take the following steps to ensure quality of household survey and qualitative data:

- Embed data consistency checks and non-falsifiable questions (e.g., GPS) within the household survey data collection platform (CommCare).
- Review incoming data daily and follow-up with data collection teams on inconsistencies.
- Have supervisors conduct back-checks or spot checks on 20% of surveys.
- Require qualitative data collectors to finalize notes on the day of an interview and to transcribe audio-recordings within three days, to avoid loss of information.
- Review qualitative transcripts as soon as they are ready and follow up with qualitative data collectors for clarifications when needed.
- When collecting primary water quality data, URBAN WASH will ensure that enumerators calibrate their instruments (e.g., digital chlorine colorimeters) daily and follow best practices for microbial water quality measurements, such as the analysis of blanks, positive controls, and duplicates.

4.4 HUMAN SUBJECTS PROTECTION AND DATA MANAGEMENT PLAN

URBAN WASH will submit data collection protocols to the CSIR, an Institutional Review Board (IRB) in Ghana. The team will also collect written informed consent from all study participants. All quantitative and qualitative data will be loaded daily on password-protected computers and backed on password-protected Dropbox account. URBAN WASH will not communicate any personally identifiable information to local stakeholders and will only present summary statistics and statements, and the team will remove all personal identifiers (names and GPS coordinates) before uploading data on USAID's Development Data Library.

5.0 STAKEHOLDER ENGAGEMENT AND DISSEMINATION

URBAN WASH proposes the following engagement events and will attempt to combine these with existing sector-wide events and existing active national-level platforms (or groups) whenever possible. The proposed stakeholder engagement and dissemination activities are summarized in Table 8.

5.1 ENGAGEMENT AND DISSEMINATION STRATEGY

Engagement with local stakeholders will include:

1. **Project launch:** The project will formally commence with a launch workshop/meeting, held in Accra, with GWCL, USAID/Ghana, and other key stakeholders, as well as two subsequent local launch workshops/meetings (one in each city) with local GWCL staff and other key stakeholders.
    a. National launch workshop/meeting with GWCL, USAID/Ghana, and other key stakeholders
    b. Two local launch workshops/meetings with GWCL and other key stakeholders (one in each city)
2. **Technical working group:** A Technical Working Group will involve key stakeholders at national and/or city-level and meet at least quarterly throughout the project. This working group will inform the research process and the selection of pilot interventions, ensuring that the Buy-in activity addresses relevant local and national issues. The working group will also aid in identifying effective ways to share and disseminate the findings and will influence the dissemination workshops. The team will explore opportunities to leverage the existing Technical Working Group under URBAN WASH's Focus Area 1 Core Activity.
3. **Evidence-based co-creation workshop:** Drawing on the evidence from Components 1-3, URBAN WASH will work with USAID/Ghana, GWCL, USAID/Washington, MMDAs, and other stakeholders, to select intervention(s) for piloting. Potential examples include improvements in water quality management capacity, chlorination protocols (Component 1) and new subsidies and service connection policies/fees to improve water equity (Component 2), and technology-driven NRW management system for increased water revenues and water use efficiency (Component 3).

Dissemination activities will include:

1. **Dissemination of Components 1–3** to share findings and co-creation of potential interventions:
    a. Two local workshops (one in each city)
    b. National workshop/meeting
2. **Dissemination of Component 4**
    a. Two local workshops (one in each city)
    b. National workshop/meeting

URBAN WASH will also work with the Global Waters Communications and Knowledge Management II activity to disseminate communications and learning products, as appropriate, from the assessments and pilots.

5.2 ENGAGEMENT WITH RELATED INITIATIVES IN TARGET CITIES

URBAN WASH has identified two related projects led by other organizations and operating in Tamale and Kumasi:

- In Kumasi, pro-poor projects include the World Bank-funded GKMA project, which targeted households for water connections subsidies and installed 1,200 new connections in low-income communities at the periphery of the city, and a UNICEF-funded project installing standpipes, which reached 1,350 customers. URBAN WASH will contact UNICEF and World Bank representatives involved in these project and compile information about the poor-households targeting tools used and the results of the connection subsidies program. Lessons learned from these projects will provide insights for the selection of communities in Kumasi, the implementation of the Buy-in's research plan and the development of pilot interventions. The Buy-in's findings will provide evidence-based information that has the potential to support the scaling of the pilot to additional communities.
- In Tamale, Biwater has been contracted to expand the system's supply capacity, infrastructure and GWCL's service coverage area, which will involve the construction of new source intake structures, storage tanks, and distribution system pipelines, with the aim to meet the city's projected demand by 2040. It is not yet clear when Biwater will begin implementation. URBAN WASH will access the data collected and analyses conducted by Biwater as part of their project, if available. Assuming that the Biwater activities in Tamale are concurrent with the Buy-In's timeline, URBAN WASH team believes that the Buy-In Activity could offer a useful complement to Biwater's planned expansion of services by identifying opportunities to work in low-income communities and provide them with high quality, equitable, and efficient services (e.g., specific data on WTP and affordability).

URBAN WASH will coordinate with local GWCL contacts and engage with Biwater, the World Bank and UNICEF to gain a better understanding of the respective projects, identify any cross-cutting activities, ensure complementarity, and promote collaboration. The Buy-in's activities and findings will serve organizations implementing projects in Tamale and Kumasi in providing tailored evidence-based processes and best practices for high-quality, equitable, and efficient service provision as the systems become larger and more complex.

The URBAN WASH team will propose bi-monthly check-in meetings, which will ensure that we build on existing and planned projects and facilitate the exchange of relevant information throughout the project. Table 8 summarizes stakeholder engagement and dissemination activities for the Buy-in. The estimated timeline presented in Table 8 below includes updated dates for stakeholder engagement milestones due to the delay caused by the revisions and signing of the MoU with GWCL.

Specific stakeholder engagement activities for Component 4 will be determined based on the nature of the pilot interventions selected for implementation.

Table 8: Stakeholder engagement and dissemination activities

Project Stage	Stakeholders	Engagement Activities	Estimated Timeline
Introduction to national stakeholders	• GWCL head office, Accra team • USAID/Ghana • Technical Working Group • WASH Sector Working Group	• Launch workshops with national stakeholders	March 2023

Project Stage	Stakeholders	Engagement Activities	Estimated Timeline
Introduction to local stakeholders	• Tamale GWCL team • Kumasi GWCL team • Local MMDAs • USAID/Ghana • Technical Working Group	• Two launch workshops, one in each city, with local stakeholders	March 2023
Engagement with related initiatives	• Local Biwater team in Tamale • World Bank team in Kumasi	• Two introductory meetings, one with each stakeholder identified • Bi-monthly check-in meetings	March 2023–July 2023
GWCL engagement	• Tamale GWCL team • Kumasi GWCL team • Local MMDAs	• Key informant interviews • Field visits	March–June 2023
Community engagement	• WUAs, and households in Kumasi and Tamale	• Key informant interviews • Household survey • Focus groups	March–May 2023
Action plans co-development	• National GWCL team • Tamale GWCL team • Kumasi GWCL team • USAID/Ghana • Local MMDAs • PURC • Local project implementers	• Technical working group meetings • In-person meetings, calls and email communications as needed	July–August 2023
Dissemination and feedback – Components 1-3	• Tamale GWCL team • Kumasi GWCL team • GWCL head office, Accra team	• One dissemination workshop in each city • One dissemination workshop with head office. • Co-creation workshop	September 2023
Dissemination and feedback – Component 4	• Tamale GWCL team • Kumasi GWCL team • GWCL head office, Accra team	• One dissemination workshop in each city • One dissemination workshop with head office	August 2024

6.0 ACTIVITY MANAGEMENT PLAN

Tetra Tech/URBAN WASH will have overall management, financial, and quality assurance/quality control (QA/QC) responsibilities for the Buy-in activity. Deputy Chief of Party Miriam Otoo will provide technical oversight of the research activities, have bi-weekly check in calls with the Research Leads throughout the research activity, and provide QA/QC of all deliverables. Aquaya and SEGURA will report to Dr. Otoo and be responsible for the technical research activities, with support from the wider URBAN WASH team and inputs from stakeholder groups such as USAID/Washington and USAID/Ghana.

Aquaya will lead the implementation of Component 1 and the household-level assessment of Component 2, while Segura will lead the institutional assessment of Component 2 and Component 3. Aquaya will coordinate the implementation of the research activities and will integrate Segura's inputs into deliverables. For the respective components, Aquaya and Segura will design the research activity and lead the data collection, analysis, reporting, stakeholder engagement, preparation of deliverables, dissemination of findings, and design and implementation of pilot interventions as part of Component 4. Aquaya will be the focal point of contact for local stakeholders including GWCL, MMDAs, PURC, and other local stakeholders. Additional details on roles and responsibilities are included in Table 9 below.

Table 9: Summary of buy-in team roles and responsibilities

Team Member	Role	Responsibilities
Dr. Miriam Otoo	Deputy Chief of Party	Miriam will oversee the management of the Buy-in activity, coordinate with relevant external stakeholders and support the review and quality control process for deliverables.
Dr. John Trimmer	Research Lead	Based in Kenya, John will provide guidance on overall program design, preparation, troubleshooting, data analysis, and outputs of Components 1, 2, and 4. He will support co-creation activities and oversee the program team and review all program outputs.
Dr. Caroline Delaire	Quality Control & Research Advisor	Caroline will provide advice and guidance for the activity design and the implementation of Components 1, 2, and 4. She will support co-creation activities and provide guidance on overall program design, preparation, troubleshooting, data analysis, and outputs. Caroline will support the review and quality control process for all deliverables.
Dr. Kwabena Nyarko	Ghanaian Co-Research Lead	Dr. Kwabena Nyarko, a professor in Civil and Environmental Engineering from Kwame Nkrumah University of Science and Technology university in Ghana, will be a co-Research Lead for this research. He will provide guidance on the design and implementation of the research activities, will review the deliverables, and support in-country engagement.
Lara Egbeola-Martial	Program Manager	Based in Ghana, Lara will oversee all research activities under Components 1, 2, 3, and 4, including planning field research, managing timelines, data collection activities, troubleshooting, coordinating with various stakeholders, and liaising with staff across the team for any support. The Program Manager will be the main point person for GWCL throughout the life of the Buy-in. The PM will also lead engagement activities with GWCL and other relevant stakeholders on the URBAN WASH core funded activities (under Focus Area 1) to ensure streamlining communication across URBAN WASH. Under

Team Member	Role	Responsibilities
		Components 1, 2 and 4, the Program Manager will recruit and oversee a local team of supervisors and enumerators for data collection.
Miles Osprey Schelling	Research & Planning Officer	Based in Ghana, Miles will support project initiation activities, provide support to the implementation of the research activities under Components 1, 2, 3, and 4, including field research, coordination with key stakeholders, data collection activities under Components 1, 2, 3 and 4, and preparation of deliverables.
Dr. Chloé Poulin	Data Analyst	Chloe will set up an electronic data collection platform, set up quality control data checks, and develop a data analysis plan for Components 1, 2, and 4. For Component 1, she will manage and analyze water quality data. For Component 2, she will manage and analyze household survey data. For Component 4, Chloe will manage and analyze pilot data.
Afua Ampomah	Engagement Support	Based in Ghana, Afua will support project initiation activities, including coordination with key stakeholders, and will support data collection activities under Components 1 and 2. For Components 4, she will support co-creation activities and coordination with GWCL for the intervention.
Tom Mahin	Water Quality Expert	Tom will support the implementation of Component 1 by providing expert guidance and participating in the WaterCaRD analysis. He will also contribute to the design and implementation of pilot interventions related to water quality as part of Component 1.
Haleemah Qureshi	Core URBAN WASH Communications	Haleemah will coordinate with the Ghana Buy-in Program Manager to streamline communications with the GWCL team in Accra and liaise with the relevant stakeholders on the URBAN WASH core funded activities as needed.
Luz Maria Gonzalez	Tariff Specialist	Luz Maria will lead SEGURA's Component 2 contributions. Luz Maria will lead the desk review of available institutional data on revenue and operating costs, develop alternative tariff/cross-subsidy scenarios, and contribute to the design and implementation of pilot interventions related to tariffs as part of Component 4
Paul Cumiskey	Accounting & Financial Specialist	Paul will lead the implementation of Component 3 including review and analysis of available data on commercial losses. He will contribute to the development of recommendations to inform the action plan and will contribute to the design and implementation of pilot interventions related to NRW as part of Component 4.
Eldin Suljagic	NRW/Metering Specialist	Eldin will support Component 3 by reviewing available data on utility practices and physical losses, working with a local consultant to fill knowledge gaps on losses, including through sampling of metering processes as part of field-based work. He will also contribute to the action plan with recommendations to reduce NRW and will contribute to the design and implementation of pilot interventions related to NRW as part of Component 4.

7.0 MONITORING AND EVALUATION

The activity will employ rigorous and consistent MEL efforts and reporting as required by the URBAN WASH contract and Activity MEL Plan. Quarterly and annual reporting will include progress on this buy-in activity. While URBAN WASH will be able to use five of the Activity's custom indicators (see Table 10) to measure the results of the first three Components and their dissemination, we propose waiting to select indicators for Component 4 until the Component 4 implementation research protocol is developed.

Table 10: URBAN WASH performance indicators relevant to the Ghana field support buy-in

N°	Performance Indicator [and Type]	Disaggregation
Cross-cutting		
C.1	Number of partners (GWCL, USAID/Ghana) and stakeholders[16] (to be confirmed based on stakeholders' application of Buy-in's findings) applying URBAN WASH-generated learning [Custom, Outcome]	Type of partners/stakeholders; Learning topic area; Geographic area
C.2	Number of institutional tools (reports, policies, laws, agreements, action plans, regulations, strategies, or investment agreements) influenced by URBAN WASH [Custom, Outcome]	Type of Guidance; Topic area; Type of institution; Stage (proposed/draft, adopted/final); Influence level (strong, medium, weak); Geographic area
C.3	Number of technical publications/communications materials developed to share information and learning [Custom, Output]	Type of products; Topic area; Type of institution; Geographic area
C.4	Number of individuals exposed to WASH and WRM approaches/tools through attendance at URBAN WASH presentations/ events, communication materials and knowledge products [Custom; Output]	Sex (Male/Female/Undisclosed); Age (15–29, 30+); Type of exposure (events, knowledge, and communication products); Topic area; Affiliated institution; Geographic area
Component 3: Provide Short-Term and On-Demand Technical Assistance Supporting Mission WASH and WRM Research, Learning, Evaluation, and Analytics		
3.1	Level of Operating Unit/partner satisfaction with the responsiveness and quality of technical assistance [Custom, Output]	Topic area; Type of technical assistance; Geographic area

URBAN WASH will develop the pilot interventions for Component 4 in consultation with GWCL, USAID/Ghana, and other key stakeholders based on the evidence from Components 1–3 during the co-creation workshop. The workshop will include a discussion of the most suitable indicators to measure the results of the success and achievement of the pilot interventions. At that time, URBAN WASH will review the standard USAID WASH indicators and consider if additional custom indicators are necessary and will select the indicators that are most appropriate for measuring the outcomes of the selected interventions.

[16] This indicator tracks partners' and stakeholders' application of WASH/WRM learning products, approaches, and tools developed and/or documented as a result of URBAN WASH interventions. Partners and stakeholders include, but are not limited to, USAID Missions and operating units, implementing partners, local governments, private sector, and community-based organizations. For the purposes of this indicator, "applying" learning may include evidence of new or revised policies, procedures, strategy documents, training materials, or solicitation design (in the case of missions) used by the target stakeholder audiences related to the URBAN WASH three focus areas.

8.0 DELIVERABLES

URBAN WASH will develop the following deliverables for each component, which will present the analysis conducted and the findings. The timelines for the following deliverables have been updated to reflect the delays resulting from the MoU revisions with GWCL:

- Ghana Field Buy-in Draft Inception Report *(December 2022)*
- Ghana Field Buy-in Final Inception Report *(March* 2023)
- IRB submission to CSIR in Accra, Ghana (Submission by March 2023, with an anticipated timeline of 2 to 4 weeks for approval)
- Component 1:
  - Water Quality Assessment Report *(August 2023)*
  - Water Quality Assessment Two-Pager *(August 2023)*
  - Water Quality Management Action Plan / Options Paper *(August 2023)*
- Component 2:
  - Tariff Structure and Water Equity Assessment Report; including Action Plan *(August 2023)*
  - Tariff/Subsidy Assessment Two-Pager *(August 2023)*
- Component 3:
  - Options Analysis for Improved Water Utilization / NRW Assessment Report; including Action Plan *(August 2023)*
  - NRW Assessment Two-Pager *(August 2023)*
- Component 4:
  - Implementation Research Pilot Study Inception Report *(September 2023)*
  - Pilot Study Report or Draft Publication (Tentatively September 2024)
  - Summary Slide Deck (Tentatively September 2024)
  - Findings and Recommendations Two-Pager (Tentatively September 2024)

URBAN WASH will develop recommendations in collaboration with GWCL, USAID/Ghana, MMDAs, and other stakeholders, taking into consideration the financial, operational, and political implications of potential solutions. URBAN WASH will summarize the recommendations in an Action Plan for each component, which will inform the design of interventions considered for piloting as part of Component 4. URBAN WASH proposes to combine the Assessment Reports for Component 1, 2, and 3 into one assessment report, if these are being prepared simultaneously.

Following the development of the Phase 1 Action Plan(s), URBAN WASH will develop research protocols, which will be presented to relevant stakeholders in the inception report of the Component 4 pilot interventions. The research implementation protocol will include learning questions specific to the selected intervention(s), methods to implement the intervention(s), key indicators, plans for data analysis, and plans for dissemination.

9.0 TRAVEL PLAN

URBAN WASH anticipates both international and local travel for the Buy-in, which will focus on Tamale and Kumasi. Two full-time staff based in Accra will lead the implementation of the research activities and will plan visits to each city approximately every two months, depending on the stage of the project. Details on local travel will be provided to USAID/Ghana and GWCL according to the needs of the project. Different constellations of the core team, apart from the locally based staff, will make trips to Ghana (from their individual home bases) for different stages of the activity, as proposed by the partners below. The timelines provided here are estimates to account for the availability of government officials, other stakeholders, and response times for data requests. Actual timelines and team members for each trip may differ from the estimates below. Additionally, though in-person events have advantages, URBAN WASH will also consider virtual meetings in view of any COVID-19 restrictions. Related implications are discussed in the next section.

Aquaya - Aquaya has had full-time staff in Ghana since 2017, and currently has staff based in Accra, Tamale, Kumasi, and Kenyasi. Two of Aquaya's staff based in Ghana are full-time, and will be working on this project, including the Buy-in Program Manager. Aquaya has planned for two international trips for each of three team members (two Kenya-based staff, and one US-based consultant), totaling six trips.

- Lara Egbeola-Martial, the Program Manager, has relocated to Ghana from the US to lead the Buy-in activities.
- John Trimmer, the Research Lead, will travel to Ghana to support the implementation of research activities and key stakeholder engagement efforts for Components 1, 2, and 4.
- Tom Mahin (US-based Water Quality Expert) will travel to Ghana to support data collection activities under Component 1.

International travel will coincide with key activities, such as stakeholder engagement and program launch, enumerator training, (Components 1, 2 and 4), fieldwork initiation, and co-creation activities (Component 4).

SEGURA - SEGURA has planned for up to five international trips for its team members based in the United States over the course of the activity. It is currently anticipated that Luz Maria Gonzalez (Tariff Specialist) will carry out trips for Component 2 and Eldin Suljagic (NRW/Metering Specialist) for Component 3. The majority of international travel will be focused on data collection (supported by local consultants) and follow-up support for activities under Components 2 and 3. A trip is also anticipated to support the co-creation activities under Component 4, to be carried out by the expert whose technical focus most closely aligns with the anticipated pilot activities.

10.0 COVID-19 CONTINGENCY PLAN

The URBAN WASH team will take the necessary steps to adhere to the national COVID-19 guidance in Ghana and ensure to adopt all recommended or required COVID-19 mitigation measures. For the field activities, the team will also use WHO's Mass Gathering Risk Assessment Tool that Tetra Tech recommends as complementary guidance when planning events and activities requiring physical participation (WHO 2022).

When collecting primary data through in-person surveys and interviews, URBAN WASH will take all necessary precautions to protect the health of the evaluation team and those with whom they interact. These measures may include wearing masks, offering masks to interview and survey participants, conducting interviews or surveys outdoors and/or at a safe distance, and testing the team regularly for COVID-19. The team will explain risks to interview and survey subjects, offer options for mitigating risks, and proceed with the interview or survey only if the participant agrees.

In the event that COVID-19 restrictions prevent travel or in-person data collection, or URBAN WASH believes in-person data collection poses an unacceptable risk to our team or those with whom they interact, URBAN WASH will pivot to remote methods, e.g., methods that rely on information and communication technologies such as telephone, email, or internet, as needed.

11.0 TIMELINES

The overall schedule for conducting the Ghana Field Support Buy-in on Improving Water Quality Management, Water Equity, and NRW is provided in Table 11. Ongoing discussions to revise the MoU with GWCL have delayed the launch workshops and the initial data requests, and will likely push back the start of field data collection, impacting the feasibility of the Phase 1 timeline. Depending on progress with the MoU, we anticipate completion of Components 1-3 action plans by August 2023. In addition, considering the time anticipated to set up potential interventions (e.g., installation of equipment, implementation of pilot pro-poor program), the seven-month duration proposed for implementation under Component 4 may limit the extent to which pilot interventions can be rigorously evaluated. Given our estimation of the work involved, we expect that the pilot interventions will require an extended timeline and we will provide an estimate of a realistic timeline for execution once we have identified potential pilot interventions (Component 4). WASH will discuss this timeline with USAID/Ghana after discussion with GWCL and will make the necessary adjustments.

Table 11: Initial implementation schedule

	Oct 22	Nov 22	Dec 22	Jan 23	Feb 23	Mar 23	Apr 23	May 23	Jun 23	Jul 23	Aug 23	Sep 23	Oct 23	Nov 23	Dec 23	Jan 24	Feb 24	Mar 24	Apr 24	May 24	Jun 24	Jul 24	Aug 24	Sep 24
1. Activity Preparation			x																					
2. Launch workshops																								
3. Working Group meetings																								
4. IRB submission and review						x																		
5. Component 1: Needs assessment																								
6. Component 1: Water quality data collection																								
7. Component 1: Analysis and action plan											x													
8. Component 2: Initial assessment																								
9. Component 2: Household-surveys																								

	Oct 22	Nov 22	Dec 22	Jan 23	Feb 23	Mar 23	Apr 23	May 23	Jun 23	Jul 23	Aug 23	Sep 23	Oct 23	Nov 23	Dec 23	Jan 24	Feb 24	Mar 24	Apr 24	May 24	Jun 24	Jul 24	Aug 24	Sep 24
10. Component 2: Analysis and action plan											X													
11. Component 3: Baseline analysis																								
12. Component 3: Detailed analysis											X													
13. Component 4: Co-creation workshop and dissemination of 1-3																								
14. Component 4: Protocol development												X												
15. Component 4: Intervention implementation																								
16. Component 4: Analysis and write-up																								
17. Component 4: Deliverables and dissemination																								X

Notes/Key

X = Final Deliverables, Meeting, or Discrete Event

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APPENDIX A: COMPONENT 1 KEY INFORMANT INTERVIEWS WITH WATER USER ASSOCIATIONS LEADERS

A. Introduction and informed consent

Hello, my name is _____. I am a staff member at the Aquaya Institute based in Accra. I would like to invite you to participate in our research study. The purpose of our research is to understand the perceptions and challenges with respect to drinking water quality in [CITY]. The study will be conducted over X months. You are being asked to participate in this study because you are part of a Water User Association in one of the communities selected for the present study.

The discussion will involve questions about water quality of the different water sources used in [CITY], satisfaction with water quality, and access to information about it. The discussion should last no longer than 1 hour or until you feel you have told me everything you want me to know. If you agree to participate in this research, I will conduct an interview with you now.

There are no right or wrong answers, so please be honest and tell us what is true for you. Information from this study may help increase understanding and awareness of what it is like to live in [CITY] especially with regard to quality and access of drinking water sources. There are no personal risks or benefits to your participation. Everything that you say will be confidential, and we will not use your real name or any identifying information in any of our reports or papers. Our team may sometimes look at your record for research purposes. The results will be used to inform GWCL and other institutions in developing improved water quality and communication strategies.

With your permission, I will record our discussion and my colleague will take notes during the interview. The recording is to accurately capture the information you provide and will be used for transcription purposes only. You have the right to review, edit, or erase any information from the interview that you do not want documented or written down. Excerpts from the recordings/transcripts may be used to illustrate the research findings. This will always be done in a way to protect your identity (e.g., your name will not be used). Any other material or information generated by you, such as ideas written down on paper, will be subject to the same strict controls.

Your participation in this research is completely voluntary. You can decline to answer any questions, and if you do not wish to continue, you can withdraw from the study at any time for any reason. You will not receive any monetary payment for your participation. An alternative is not to participate in this study.

If you have any questions or concerns about the research, please feel free to contact me. I can be reached at +_____ or _____@aquaya.org or [hand over business card].

If you agree to participate, please say so.

[ALL QUESTIONNAIRES WILL BE SAVED BY THE INTERVIEWER REGARDLESS OF THE RESPONDENT'S DECISION TO PARTICIPATE OR NOT TO PARTICIPATE.]

B. Interview details

Target City:
Name of interviewer:
Name of respondent(s):
Date:

[ASK FOR PERMISSION TO RECORD AND START RECORDING]

C. Focus on the respondent and the community details

- Please tell me about yourself.
  - Which neighborhood/community do you live in?
  - How long have you lived at your current residence?
  - What is your role within your community?
- Please tell me about your community.
  - What is the average number of people in a household?
  - How would you describe the average socio-economic status of the community/area?
  - How do most people earn a living and what is the average monthly income for most households?

D. Current water sources

- **Tell me about where people in your community get their water from.**
  - How do most community members access GWCL water supply (private GWCL water connection, property compound yard tap, communal public standpipe managed by GWCL)?
  - What are other sources of water that community members use often?
  - Where do people get their water for drinking, cooking, bathing, cleaning? Do people typically use different water sources for different uses?

E. Perception of water quality and water quality testing

- What are the preferred sources of drinking water?
  - Which available sources of water are perceived to have the best water quality?
- What is the community's opinion of the water quality supplied by GWCL (color, smell, taste, etc.)?
  - Do community members trust the quality of the water provided by GWCL?
  - Do household members conduct any level of treatment of the water supplied by GWCL before using (boiling, filter, etc.)?
  - Have you ever contacted GWCL to submit a complaint about water quality?
- How does water quality impact households' decision to get a private GWCL water connection?

F. Transparency – Water Quality Information

- How do community members receive information regarding water quality from GWCL? If yes, how do you most often receive this information?
- What type of water quality information do customers receive?
- Do community members feel like you receive an appropriate amount of information regarding water quality testing activities and the overall quality of the water supplied?

Would you like to tell me anything else about your community, about sanitation or any other topic?

Thanks so much. Do you have a question for me?

APPENDIX B: COMPONENT 1 WATERCARD QUESTIONNAIRE

WaterCaRD Questionnaires

Thank you once again for taking the time to participate in the Water Capacity Rating Diagnostic (or WaterCaRD) assessment exercise. This tool assesses institutional strengths and weaknesses with respect to water quality monitoring in order to accurately assess your water quality monitoring program. It focuses on five overarching categories determined to be key to successful monitoring:

1. Accountability
2. Staffing
3. Program Structure
4. Finance
5. Equipment and Services

The assessment will take 1-2 days and will attempt to ask those questions specific to your role with regards to water quality monitoring. Relevant supporting documents will be requested. If sampling and testing is taking place, we would like to observe these processes. [ASK FOR PERMISSION TO RECORD AND START RECORDING]

Regional Chief Manager

- Please provide a brief overview (<10 min) of your institution in terms of the following: (1) overall scope and responsibilities, (2) size/jurisdiction, (3) organizational structure (i.e., independent, semi-autonomous, sub-unit of a larger institution).
- This background will be helpful in addressing certain sections such as Procurement, Staff Recruitment, and Resources, as certain areas might be under the control of another larger body (e.g., a Regional Health Department under the Ministry of Health).

Sample Collection *Water Quality Manager* *Technical Staff*	How often does your institution collect water samples for testing? Can you walk me through, in detail, your sample collection process (who, what, when, how)?	Do you have established institutional testing targets for sampling frequency (e.g., x samples per month)? If so, what are the targets? Do you generally meet these testing targets? Do samples ever arrive too late to the lab/analysis location for processing?
Sampling Logistics *Water Quality Manager* *Technical Staff*	What form of transport is used to collect samples (e.g., walking, public transport, bicycle, motorbike, vehicle)?	Is this transport available when needed? Is transport funding provided if needed? Or does staff have to use personal funds for transport? To what extent is staff able to collect samples from remote locations? Is this seasonal?
Sampling Plans *Water Quality Manager* *Technical Staff*	How do you determine the number of samples to be collected?	Do you have an established sampling plan? Does this reflect testing targets? Was the local context considered when developing targets? Were national standards (or WHO Guidelines) considered when developing targets?

Methods *Water Quality Manager* *Technical Staff*	What water quality parameters do you test for? Discuss the water quality testing method your institution uses for microbial testing (or another parameter listed) and how this was selected. If you wanted to test for a new parameter, how would you go about determining what method to use?	How does the staff know how to select the methods, equipment, and consumables needed to meet their testing needs? How comfortable are staff performing and interpreting the selected methods? (Also OBSERVE) OBSERVE: Are procedures performed correctly? Do mistakes potentially compromise results? Provide details.
Quality Control *Water Quality Manager* *Technical Staff*	Discuss any quality control your institution conducts with regards to water quality monitoring. Note: Use checklist to evaluate QAQC.	Do you test blanks/negative samples? Do you test replicates? If so, how often? What is done if unusual test results are found? Are there procedures to verify results?
Data Management *Water Quality Manager* *Technical Staff*	Where, when and how do you compile and organize your test results?	Are results recorded in paper logbooks, scrap paper, digital files, in multiple formats, etc.? Is record keeping ad-hoc or systematic? Can we see your testing results? OBSERVE: Can they readily access up-to-date information? Is data shared with senior institutional managers? Is this regular?
Actions *Water Quality Manager* *Technical Staff*	Describe an instance when a contaminated sample was discovered. What actions were taken? Is this generally what happens when a contaminated sample is found?	Who conducts these follow up actions? To what extent is all relevant staff familiar with these procedures? When contamination is found, are these actions on an ad-hoc or regular basis? Are follow up actions documented? OBSERVE
Results *Water Quality Manager* *Technical Staff*	How often do you find that the water samples are contaminated (or exceed standards)? Do you believe that your results provide sufficient information about water quality? Explain.	Are most of your samples either all positive or all negative? If so, what are you able to do with this information? Are you able to use results to guide water safety management (as discussion above under 'Actions')? Are your results sufficient for reporting to relevant authorities? If not, explain. (For example, authorities may specify specific testing methods or indicators, such as E.coli/100mL?
2. Equipment and Infrastructure		
Equipment and Supplies *Regional Chief Manager* *Water Quality Manager*	1. What type of equipment and consumables do you use for testing? 2. Which distributor did you use to purchase? Where are they based? How did you find this distributor?	1. Does the institution have easy access to distributors? 2. Can institutions obtain what they need, or is this inhibited (by a limited product range, poor roads, long distances, etc.)?

Maintenance *Water Quality Manager* *Technical Staff*	1. Has there been a situation where an equipment item broke down or needed maintenance? Can you discuss what happens when equipment requires maintenance? 2. Discuss how and when consumables are reordered.	1. Is equipment maintenance ad-hoc or consistent? 2. Is the tracking of consumables ad-hoc consistent? Does staff order consumables in advance or do they sometimes run out?
Procurement *Water Quality Manager* *Procurement Department*	Can you talk about the procurement process for ordering monitoring equipment your institution uses? When was the last time you ordered something – take me through that process.	1. Note: Does the water quality manager understand the procurement process? 2. Note: Do things like multiple bids, multiple internal approvals, and other bureaucracies make the process slow and time consuming? 3. Are there different procedures for large pieces of equipment vs. smaller repeat purchases (such as consumables/reagents)? 4. Are there options for sole sourcing for smaller, repeat purchases?
Infrastructure *Water Quality Manager* *Technical Staff*	Observe the space used for testing	1. Is there dedicated space for water quality testing? 2. Is there electricity? When did it last go off? For how long? 3. Is there running water? How often is there water here?
3. Staffing		
Roles and Responsibilities *Water Quality Manager* *Regional Chief Manager*	Can you tell me everyone who is involved in the water quality monitoring program and what their specific responsibilities are (Note: will ask this question for both MD and WQ Manager to ensure all roles are covered)?	1. Including all departments: sampling, testing, leadership, procurement, finance 2. Are roles well defined? 3. Does staff have other responsibilities outside of water quality monitoring? Do other responsibilities hinder their performance? 4. Are staffing levels sufficient?
Knowledge and Experience *Water Quality Manager*	How did the technical staff learn about water quality sampling and testing?	1. What practical experience have they had? 2. What education or qualifications did they receive? 3. How comprehensive is their theoretical knowledge (i.e., dilutions, multiple testing methods, data management, etc.)?
Water Quality Leadership *Regional Chief Manager* *Water Quality Manager*	1. Who at your institution manages your water quality monitoring activities? 2. Please tell me about their responsibilities.	1. What do they do besides water quality monitoring? 2. How does water quality fit into their other priorities? How much time do they spend on other activities compared to water quality monitoring?
Training *Water Quality Manager*	What types of training activities are available to the staff?	1. Do you have staff within your institution that act as trainers? If so, do they lead internal trainings? How often?

		2. Have they attended outside/external trainings? When/how often? 3. Are there trainings procedures set in place? 4. Are there training resources in place (such as funding, venue, trainers, etc.), for either internal or external trainings?
Motivation *Regional Chief Manager* *Water Quality Manager*	1. Can you explain the overall mission of the organization and how it relates to water quality monitoring? 2. Can you discuss any situations where technical staff had other priorities besides water quality monitoring and how they handled it? 3. Can you discuss any strategies your institution has adopted for incentivizing staff or recognizing their work?	1. OBSERVE - Does staff seem proud and positive about their work? 2. OBSERVE - Has staff internalized the responsibility for water quality monitoring?
Staff Stability *Regional Chief Manager* *Water Quality Manager*	1. Can you discuss the last time a staff member involved in water quality monitoring left the institution? Do you know why did they left? 2. What happened to water quality monitoring activities when this person left? 3. How common is staff turnover?	1. Discuss staff turnover in general – Is it high, moderate, or low (some or minimal). Provide examples of why staff leave. 2. Does staff turnover interrupt monitoring activities? 3. Are there any procedures set in place for ensuring water quality monitoring activities are not affected by staff transitions? Explain.
Staff Recruitment *Regional Chief Manager* *Water Quality Manager*	Can you describe the last time you recruited a staff for your water quality monitoring program?	1. Is this in-line with your general process for recruitment? Explain. 2. Do you have any difficulties managing staff transitions? Explain. 3. Does your institution have on-the-job training procedures for new staff?
Risk Management *Regional Chief Manager* *Water Quality Manager*	Describe the last major challenge your institution faced to adequate water quality testing (e.g., staff turnover, vehicle breakdowns, supply shortages, government changes). How was this situation managed?	1. What are the most common risks or challenges to water quality testing? 2. How does your institution prevent these challenges / risks? What procedures are in place? OBSERVE any written procedures. 3. To what extent have these challenges/risks interrupted water quality testing?
4. Finance		
Resources *Finance Department* *Regional Chief Manager*	How are your monitoring activities funded?	1. If you need to buy equipment or supplies, is there internal funding to do so? 2. Is this funding consistent or sporadic? 3. Is this funding sufficient to support regulatory requirements for monitoring (note: might have already been covered earlier)?

		4. Are there any difficulties accessing internal funds?
Budgeting *Finance Department* *Water Quality Manager*	Describe any budget for water quality monitoring your institutions has established.	1. Is there a specific budget for water quality monitoring? Or it this integrated into a larger budget (such as Operations & Maintenance or Water Management)? 2. If there is a specific budget, does it include distinct water quality monitoring activities (i.e., itemized budget)?
Accounting *Finance Department* *Water Quality Manager*	Describe any methods of bookkeeping/ accounting your institution employs to manage funds for water quality monitoring.	1. Are bookkeeping systems in place? 2. Are actuals to budgeted monitored? 3. How long is the process to make payments? 4. Are there internal controls to verify that payments are accurate and timely?
5. Accountability		
Consumers *Regional Chief Manager* *Water Quality Manager*	1. Have you shared water quality information with consumers or the community (or other relevant stakeholders)? 2. Under what circumstances do you do so? How often/ when did this last happen and why?	1. Are data shared regularly or on an ad-hoc basis? Is this only when consumers request data/lodge complaints? 2. What type of information is shared? (Data for both passing and failing tests?)
Regulatory Authorities *Regional Chief Manager*	Has your institution ever submitted water quality data to regulatory authorities? If so, who? How often, and when was the last time you did so?	1. Is data submitted regularly (such as monthly or quarterly), or more of an ad-hoc basis? 2. Do you have a standard submission format for submitting water quality data? Do you always use this format?
Enforcement *Regional Chief Manager*	Do you receive any feedback from the regulatory authority (e.g., regulator, ministry of water or health) on your water quality monitoring activities?	1. If so, can you tell me about the last time you received feedback? 2. How often do you receive feedback? 3. Are you penalized if you do not report or do not meet guidelines? What incentive does the regulatory authority give you to perform water quality monitoring? Are these consequences (incentives/penalties) regular or ad-hoc? 4. Scoring/benchmarking: Do you know if you are scored/benchmarked based on your water quality monitoring activities (such as compared to other water utilities or districts)? How much does this affect your overall score?
Standards *Regional Chief Manager*	Does your country have national standards for drinking water quality?	1. If standards exist, do these include • Approved testing methods • Contamination limits • Frequency of testing and sampling numbers 2. If no standards exist, is there a government (or other) agency that is responsible for setting drinking water quality standards?

WaterCaRD Scoring Criteria

1. Accountability

Score	1.1 Standards	1.2 Regulatory Authorities	1.3 Consumers	1.4 Enforcement	1.5 Vision
0	There are no government agencies responsible for setting drinking water quality standards.	Institution does not submit water quality data to regulatory authorities.	Institution does not share water quality test results with consumers.	Regulatory authorities do not incentivize water quality data reporting nor penalize poor reporting. They do not provide feedback on reported data.	Institution does not have a vision or goals for using water quality data to improve water safety (i.e., guide water safety management).
1	Government agencies are designated for setting water quality standards, but they have not issued standards.	Institution submits water quality data to regulatory authorities on an ad-hoc basis, usually when regulatory authorities request data.	Institution shares water quality test results with consumers on an ad-hoc basis, usually when consumers request data or when consumers lodge complaints.	Regulatory authorities have procedures in place for incentivizing water quality data reporting or for penalizing poor reporting, but these procedures are rarely executed. Regulatory authorities provide little to no feedback on reported data.	Institution has vision and goals for water safety management but plans for using water quality data to guide water safety management have not been implemented.
2	Government agencies have issued drinking water quality standards, though they are not comprehensive.	Institution submits water quality data to regulatory authorities on a regular basis.	Institution consistently shares test results for passing or failing tests, but not both.	Regulatory authorities have procedures in place for incentivizing water quality data reporting or for penalizing poor reporting, but these procedures are executed on an ad-hoc basis. Regulatory authorities provide occasional feedback on reported data.	Institution has vision, goals and plans for water safety management, but has faced challenges implementing the management plan.
3	Government agencies have issued comprehensive drinking water quality standards that specify contamination limits, frequency of testing and sample numbers, and approved testing methods.	Institution submits water quality data to regulatory authorities on a regular basis. Additionally, institution consistently uses standard submission formats (i.e., who reports, what is reported, and when it is reported).	Institution consistently shares test results for both passing and failing tests.	Regulatory authorities have procedures in place for incentivizing water quality data reporting or for penalizing poor reporting, and these procedures are regularly executed. Regulatory authorities provide consistent feedback on reported data.	Institutional has vision, goals and plans for water safety management, and ensures resources for and use of water quality data to guide water safety management.

2. Capacity

Score	2.1 Water Quality Leadership	2.2 Roles and Responsibilities	2.3 Knowledge and Experience	2.4 Training	2.5 Motivation	2.6 Staff Stability	2.7 Staff Recruitment	2.8 Risk Management
0	Institution is unclear on who is responsible for water quality management within the institution.	Institution has not assigned water quality monitoring activities to specific staff.	Institution does not have staff with water quality monitoring experience.	Institution does not engage in training activities for water quality monitoring.	Institution does not acknowledge the importance of monitoring water quality.	Institution has high staff turnover.	Institution has no procedures for recruiting competent water quality personnel and for managing transitions.	Institution does not anticipate challenges (e.g., staff turnover, vehicle breakdowns, supply shortages, power disruptions, government changes) that interrupt water quality testing, and it does not respond to challenges when they occur.
1	Institution's water quality manager does not prioritize water quality monitoring.	Institution has assigned water quality monitoring tasks to staff, though competing priorities or insufficient staffing levels hinder their ability to conduct testing. Their roles and responsibilities for water quality monitoring are poorly defined.	Water quality manager and junior staff have participated in practical trainings, but they have not had theoretical training in water quality monitoring, data analysis, and data management.	Institution only engages in external training activities funded by sporadic donor programs.	Institution acknowledges the importance of water quality monitoring, but most monitoring or management staff does not internalize this responsibility.	Institution has moderate staff turnover.	Institution has procedures for recruiting competent water quality personnel. It does not have procedures for managing transitions, including on-the-job training in systems and responsibilities.	Challenges have interrupted water quality monitoring, but institution attempts to respond to challenges when they occur.
2	Institution's water quality manager prioritizes water quality monitoring, but has faced challenges with consistent monitoring.	Institution has assigned water quality monitoring tasks to staff, though competing priorities or insufficient staffing levels hinder their ability to conduct testing. Their roles, responsibilities,	Water quality manager has had theoretical training in water quality monitoring, data analysis, and data management. Junior staff is limited to practical trainings	Institution has some internal training procedures and resources in place.	Institution acknowledges the importance of water quality monitoring and, but this responsibility is only internalized by some monitoring or management staff.	Institution has some staff turnover.	Institution has procedures for recruiting competent water quality personnel and for managing transitions, though on-the-job training in systems and	Institution has identified some risks to regular monitoring and has procedures for mitigating these risks. Therefore, there have been minimal interruptions to water quality monitoring.

Score	2.1 Water Quality Leadership	2.2 Roles and Responsibilities	2.3 Knowledge and Experience	2.4 Training	2.5 Motivation	2.6 Staff Stability	2.7 Staff Recruitment	2.8 Risk Management
		and team structure are adequately defined.	and onsite experience.				responsibilities may be limited.	
3	Institution's water quality manager prioritizes water quality monitoring, and the institution is able to consistently conduct monitoring.	Institution has assigned water quality monitoring tasks to staff and staffing levels are sufficient to conduct testing. Roles, responsibilities, and team structure are well defined.	Water quality manager and at least some junior staff have practical and theoretical training in water quality monitoring, data analysis, and data management. They also have significant onsite experience.	Institution has established internal training procedures and has training resources in place.	Institution acknowledges the importance of water quality monitoring, and most monitoring and management staff internalizes this responsibility.	Institution has minimal staff turnover.	Institution has procedures for recruiting competent water quality personnel and for managing transitions, including sufficient on-the-job training in systems and responsibilities.	Institution has identified all key risks to regular monitoring and has procedures for mitigating these risks. Therefore, there have been almost no interruptions to water quality monitoring.

3. Program Structure

Score	3.1 Methods	3.2 Results	3.3 Sampling Plans	3.4 Sample Collection	3.5 Sampling Logistics	3.6 Quality Control	3.7 Data Management	3.8 Actions
0	Institution does not know how to select appropriate testing methods: selected methods are well beyond the ability of testing staff to reliably perform and interpret, or impossible to perform given the space or equipment available.	Institution does not test water quality regularly enough to maintain or use testing results.	Institution does not have a sampling plan.	Institution does not collect water samples for testing on a regular basis.	Institution does not have the means/transportation to collect samples.	Institution is not aware of water testing quality control procedures.	Institution does not record water quality test results, or records results on paper on an ad-hoc, unorganized basis.	Institution does not use water quality data to guide water safety management.
1	Institution had some knowledge of appropriate testing methods: selected methods are generally within the abilities of most of the staff to perform and understand, though procedures are often performed incorrectly, potentially compromising test results.	Testing methods do not give sufficient information based on contamination levels or sample volume (e.g., sample volume <100ml, presence/absence used when most sources are positive, etc.) to either guide local water safety management or to report to relevant authorities.	Institution developed a sampling plan but not based on knowledge of standards or guidelines.	Institution does not consistently coordinate water sample collection with water testing requirements. For example, samples arrive too late for timely processing, or sample collection usually falls short of target numbers.	Institution can only collect samples from locations near the testing center.	Institution is aware of water testing quality control procedures but does not implement them in their testing program.	Institution records water quality test results in paper logbooks, in a standard format, in the place where testing occurs. Institution can readily locate up-to-date logbooks.	Institution responds to water quality tests that "Fail" on an ad-hoc basis. Follow-up procedures are not well understood by all staff.

Score	3.1 Methods	3.2 Results	3.3 Sampling Plans	3.4 Sample Collection	3.5 Sampling Logistics	3.6 Quality Control	3.7 Data Management	3.8 Actions
2	Institution has good knowledge of appropriate testing methods and equipment: selected methods are generally within the abilities of most of the staff to perform and understand, and procedures are usually performed correctly.	Testing methods give sufficient information based on contamination levels or sample volume (e.g., sample volume <100ml, presence/absence used when most sources are positive, etc.) to either guide local water safety management or to report to relevant authorities, but not both.	Institution developed a sampling plan based on standards or guidelines.	Institution generally coordinates water sample collection with water testing requirements: a sufficient number of samples generally arrives for timely processing.	Institution has the means to collect samples from nearby locations regularly and collect samples from distant locations sporadically.	Institution implements some form of quality control on an ad-hoc basis such as occasional sample replicates or blank controls.	Institution records water quality test results in paper logbooks and regularly transcribes results to digital files (or records digitally directly). Institution can readily locate digital files as needed.	Institution responds to water quality tests that "Fail" on a regular basis. Follow-up procedures are understood by all staff but are rarely documented.
3	Institution has good knowledge of appropriate testing methods and equipment: selected methods are within the abilities of all staff and are consistently performed correctly.	Testing methods give sufficient information based on contamination levels or sample volume (e.g., sample volume <100ml, presence/absence used when most sources are positive, etc.) to either guide local water safety management and to report to relevant authorities.	Institution developed a sampling plan based on standards or guidelines, with consideration of local context.	Institution always coordinates water sample collection with water testing requirements: a sufficient number of samples always arrives for timely processing.	Institution has the means to collect samples from all planned locations on a regular basis.	Institution consistently implements robust quality control procedures and has procedures to always verify unusual test results.	Institution can readily locate paper logbooks and digital files as needed. Water quality analysis is regularly shared with senior institutional managers.	Institution responds to water quality tests that "Fail" on a regular basis. Follow-up procedures are in place and understood by all staff. Follow-up actions are documented.

4. Program Finances

Score	4.1 Resources	4.2 Budgeting	4.3 Accounting
0	Institution does not allocate internal funding for water quality monitoring. Monitoring only occurs when external resources (i.e., limited-term donor program) are available.	Institution does not have a budget for water quality monitoring.	Institution does not have bookkeeping systems. A lack of timely payments severely hinders activities. Records are primarily handwritten or do not exist.
1	Institutional allocations for water quality monitoring are sporadic and are not sufficient to support regulatory requirements for monitoring.	Institution has a water quality monitoring budget as part of a broader budget (such as O&M).	Institution has paper-based bookkeeping systems but does not monitor budget to actuals and does not have internal controls to verify that payments are accurate and timely.
2	Institutional allocations for water quality monitoring are consistent but are not sufficient to support regulatory requirements for monitoring.	Institution has a specific budget for water quality monitoring but not itemized.	Institution has electronic bookkeeping systems but does not monitor budget to actuals and does not have internal controls to verify that payments are accurate and timely.
3	Institutional allocations for water quality monitoring are consistent and sufficient to support regulatory requirements for monitoring.	Institution has a specific budget for water quality monitoring and is itemized.	Institution has electronic bookkeeping systems, monitors budget to actuals, and maintains internal controls to verify that payments are accurate and timely.

5. Equipment and Infrastructure

Score	5.1 Resources	5.2 Maintenance	5.3 Procurement	5.4 Infrastructure
0	Institution has not tried to contact any equipment distributors.	Institution does not maintain equipment and does not track consumables.	Water quality managers are not familiar with institutional procurement procedures.	Institution does not have dedicated space or equipment for water quality testing.
1	Institution has tried to contact equipment distributors but has had limited success.	Institution maintains either equipment or tracks consumables, but not both.	Water quality managers understand procurement procedures, but the procedures are not appropriate for small, repeat purchases. For example, every repeat purchase requires multiple bids and multiple internal approvals.	Institution has dedicated space and equipment for water quality testing, but the space does not have reliable electricity or running water.
2	Institution has access to distributors, though they have a limited product range that does not always include the best options.	Institution maintains equipment and tracks consumables, but this is not always consistent.	Water quality managers understand procurement procedures. The procedures for small, repeat purchases are improved: for example, justifications for sole sourcing are straightforward.	Institution has dedicated space and equipment for water quality testing, which includes reliable electricity and running water but not Internet access.
3	Institution has access to distributors, and they carry a broad product range that usually includes the best options.	Institution consistently maintains equipment and tracks consumables.	Water quality managers understand procurement procedures. The procedures for small, repeat purchases are optimized: for example, repeat purchases do not require justifications for sole sourcing or multiple approvals.	Institution has dedicated space and equipment for water quality testing, which includes reliable electricity, running water, and Internet access.

APPENDIX C: WATER QUALITY DATA COLLECTION PLAN

The water quality data collection plan presents the preliminary methodology to collect water quality data from a selection of households in the two target cities. The water quality sampling and testing will be conducted in conjunction with the household survey included in Appendix F.

The households will be randomly selected within GWCL's service areas in the two target cities. Household selection will cover a set number of areas, which will be determined in collaboration with the local GWCL teams.

1. Parameters Tested

The following water quality parameters will be tested:

- Microbial testing: *E. coli*
- Free chlorine residual
- Priority chemical testing that will be defined based on relevant contamination risks
  - Lead
  - Mercury
  - Cyanide
  - Fluoride
  - Arsenic

E. coli will be tested from a point-of-use sample in all households, and in a point-of-collection sample if there is an on-plot improved water point. Free chlorine residual will be tested on-site from household samples that are reported to be chlorinated in the home, or if the source is a piped system.

Other priority chemicals will be tested at the KNUST laboratory in Kumasi.

2. Household Survey and Sample Collection

The enumerators will visit the randomly selected households to conduct a survey and test water quality at the point-of-use. The household survey respondent will be an adult household member over the age of 18 who is willing to participate in the survey, is knowledgeable about household drinking water habits, and provides written informed consent.

As part of the household survey, enumerators will make observations about the household storage container (if there is one), and method of extracting water from the storage container. Enumerators will ask questions pertaining to the source of the sample, time since collection, and whether it was treated. The data collection teams will ask household respondents about their primary drinking water point, and their current available drinking water sources. Enumerators will ask household respondents to identify the specific source of their current water from a photo list of water points commonly used within the area and will record the water point so that it can be matched within the set of water point surveys completed.

<u>Microbial Testing</u>

Enumerators will ask households to serve some water the way they normally would for drinking – typically in a cup or other vessel. Enumerators will aseptically collect >100mL of this water by pouring it from the vessel into a Whirl-pak sample collection bag with sodium thiosulfate.

If households do not have water in the home on the day of the visit, then the sample will not be collected. If household respondents are not available on the day of the visit, it should be re-visited up to three times, or replaced with a backup selected household (if unable to return on a different day).

Samples will be stored on ice in a cooler and delivered to a field laboratory within 8 hours of collection. URBAN WASH will set up a field temporary water quality testing to conduct microbial testing. Laboratory assistants will use the membrane filtration method and the CompactDry plates will be read after incubating for 24 hours at 37°C in accordance with the detailed laboratory test procedures described in a document titled "Procedure for Microbial Testing Using the Compact Dry Method".

Free Chlorine Testing

Additionally, free chlorine residual will be tested on site in point-of-use samples with handheld calibrated meters if: 1) respondents report chlorinating their water, or 2) the sample originated from a piped system.

For the physical-chemical testing parameters, samples will be collected directly from the primary drinking water point and tested on site with calibrated meters or test kits for the following physical-chemical parameters: pH, electrical conductivity, turbidity, and FCR. Additional priority chemical tests will be performed either on-site or in a laboratory, following appropriate protocols for testing the specified chemicals.

Priority Chemical Testing

KNUST laboratory technicians will conduct water quality testing for mercury, lead, arsenic, and cyanide of the samples collected in a laboratory setting, following appropriate protocols for testing the specified chemicals according to the methods in the table below.

Table C.1: Laboratory Testing Methods

Constituent	Method
Arsenic	Atomic absorption spectrophotometry (AAS) with hybride generator
Lead	AAS
Mercury	AAS with cold vapor technique
Fluoride	Fluoride selective electrode with HACH HQ 4200 Meter
Cyanide	Spectrophotometric (HACH DR 6000)

3. Quality Assurance / Quality Control

For approximately 20% of samples, or at a minimum of once per week per enumerator, enumerators will collect one field blank and one "field duplicate" sample. The field blank sample will consist of a sample taken from a new, unopened, packaged water bottle. The field duplicate sample will be collected as a second sample in a separate sample bag of the same of water from the same source.

For the field blank and duplicate samples, enumerators will collect a sample will be collected for microbial and chlorine testing.

For laboratory microbial testing, lab assistants will run one laboratory blank sample (sample of de-ionized water or boiled tap water) each day.

APPENDIX D: COMPONENT 2 KEY INFORMANT INTERVIEWS WITH LOW-INCOME COMMUNITY LEADERS

A. Introduction and Informed Consent

Hello, my name is _____. I am a staff member at the Aquaya Institute based in Accra. I would like to invite you to participate in our research study. The purpose of our research is to understand the practices, perceptions, and challenges with respect to access to GWCL water service in [CITY]. The study will be conducted over X months. You are being asked to participate in this study because you live in one of the areas selected for the present study

The discussion will involve questions about water equity in [CITY], main barriers to water access, and existing programs facilitate access to water services for low-income households. The discussion should last no longer than 1 hour or until you feel you have told me everything you want me to know. If you agree to participate in this research, I will conduct an interview with you now.

There are no right or wrong answers, so please be honest and tell us what is true for you. Information from this study may help increase understanding and awareness of what it is like to live in [CITY] especially with regard to quality and access of drinking water sources. There are no personal risks or benefits to your participation. Everything that you say will be confidential, and we will not use your real name or any identifying information in any of our reports or papers. Our team may sometimes look at your record for research purposes. The results will be used to inform GWCL and other institutions in improving water quality and communication strategies.

With your permission, I will record our conversation and my colleague will take notes during the interview. The recording is to accurately capture the information you provide and will be used for transcription purposes only. You have the right to review, edit, or erase any information from the interview that you do not want documented or written down. Excerpts from the recordings/transcripts may be used to illustrate the research findings. This will always be done in a way to protect your identity (e.g., your name will not be used). Any other material or information generated by you, such as ideas written down on paper, will be subject to the same strict controls.

Your participation in this research is completely voluntary. You can decline to answer any questions, and if you do not wish to continue, you can withdraw from the study at any time for any reason. You will not receive any monetary payment for your participation. An alternative is not to participate in this study.

If you have any questions or concerns about the research, please feel free to contact me. I can be reached at +_____ or _____@aquaya.org or [hand over the business card].

If you agree to participate, please say so.

[ALL QUESTIONNAIRES WILL BE SAVED BY THE INTERVIEWER REGARDLESS OF THE RESPONDENT'S DECISION TO PARTICIPATE OR NOT TO PARTICIPATE.]

B. Interview Details

Target City:
Name of interviewer:
Name of respondent(s):
Date:

ASK FOR PERMISSION TO RECORD AND START RECORDING

C. Focus on the Respondent and the Community Details

- Please tell me about yourself.
  - How long have you lived at your current residence?
  - Which neighborhood/community do you live in?
  - What is your role within your community?
- Please tell me about your community.
  - What is the average number of people in a household?
  - How would you describe the average socio-economic status of the community/area?
  - How do most people earn a living and what is the average monthly income for most households?

D. Current Water Sources

- Tell me about where people in your community get their water from.
  - How do most community members access GWCL water supply (private GWCL water connection, property compound yard tap, communal public standpipe managed by GWCL)?
  - What are other sources of water that community members use often?
  - Where do people get their water for drinking, cooking, bathing, cleaning? Do people typically use different water sources for different uses?

E. Water Bill Payment Schemes and Barriers

- What are the main barriers to community members getting a private GWCL connection (financial, administrative, capacity, etc.)?
- What are the main barriers to community members being able to pay monthly water tariffs (financial, logistical, payment modalities, etc.)?
- What household/building arrangements have facilitated access to a private GWCL water connection (shared fees within property compound, etc.)?
- What payment methods would make it easiest for households to connect to the network? (payments in installments for connection fees, micro-credit loans for connection fees, shorter payment intervals for tariffs, seasonal payment intervals, pre-paid schemes, etc.)
- What changes in service (e.g., reliability, water quality data availability) would most encourage households to connect to the network or pay their water bills?

F. Existing Pro-poor/Equity Programs

- What programs (if any) have been successful in encouraging connections or allowing current customers to pay their bills?
- How would you recommend identifying low-income households?
- How do communities learn about existing pro-poor/equity programs?

- What are the main barriers to low-income households to access benefits from existing equity programs?

Would you like to tell me anything else about your community, about sanitation or any other topic?

Thanks so much. Do you have a question for me?

APPENDIX E: COMPONENT 2 KEY INFORMANT INTERVIEWS WITH GWCL STAFF

A. Introduction and Informed Consent

Hello, my name is _____. I am a staff member at the Aquaya Institute based in Accra. I would like to invite you to participate in our research study. The purpose of our research is to understand GWCL measures and programs to facilitate expansion of water services to low-income communities and households in [CITY]. The study will be conducted over X months. You are being asked to participate in this study because you are part of the GWCL team working on water equity.

The discussion will involve questions about water equity in [CITY], main barriers to water access, and existing programs facilitate access to water services for low-income households. The discussion should last no longer than 1 hour or until you feel you have told me everything you want me to know. If you agree to participate in this research, I will conduct an interview with you now.

There are no right or wrong answers, so please be honest and tell us what is true for you. Information from this study may help increase understanding and awareness of what it is like to live in [CITY] especially with regard to quality and access of drinking water sources. There are no personal risks or benefits to your participation. Everything that you say will be confidential, and we will not use your real name or any identifying information in any of our reports or papers. Our team may sometimes look at your record for research purposes. The results will be used to inform GWCL and other institutions in improving water quality and communication strategies.

With your permission, I will record our conversation and my colleague will take notes during the interview. The recording is to accurately capture the information you provide and will be used for transcription purposes only. You have the right to review, edit, or erase any information from the interview that you do not want documented or written down. Excerpts from the recordings/transcripts may be used to illustrate the research findings. This will always be done in a way to protect your identity (e.g., your name will not be used). Any other material or information generated by you, such as ideas written down on paper, will be subject to the same strict controls.

Your participation in this research is completely voluntary. You can decline to answer any questions, and if you do not wish to continue, you can withdraw from the study at any time for any reason. You will not receive any monetary payment for your participation. An alternative is not to participate in this study.

If you have any questions or concerns about the research, please feel free to contact me. I can be reached at +_____ or _____@aquaya.org or [hand over the business card].

If you agree to participate, please say so.

[ALL QUESTIONNAIRES WILL BE SAVED BY THE INTERVIEWER REGARDLESS OF THE RESPONDENT'S DECISION TO PARTICIPATE OR NOT TO PARTICIPATE.]

B. Interview Details

Target City:
Name of interviewer:
Name of respondent(s):
Date:

ASK FOR PERMISSION TO RECORD AND START RECORDING

Provide introduction and obtain informed consent. Then ask the questions below.

C. Respondent Introduction

- Please tell me about GWCL's organization and your role.
  - What is your title and role at GWCL?

D. Existing Pro-poor/Equity Programs

- What are existing pro-poor programs implemented within your service area?
- If existing, how are pro-poor programs funded?
- How do you currently handle household accounts that are not able to pay monthly water tariffs?
- How do you identify low-income households and how to you determine eligibility to existing pro-poor/water equity program, if any?
- What is the cost of the existing pro-poor program per connection?
- How do you disseminate information about pro-poor programs to the targeted audience?
- What are the main barriers to low-income households to access benefits from existing equity programs?
- If no existing program, what is the main barrier to the implementation of a local pro-poor program? e.g., Financial, lack of time and resources,
- How do you monitor the performance of existing pro-poor programs (e.g., number of connections served as part of the program)?

Thank you for your responses. This is the end of our interview. Is there anything else you would like to share with me about water service delivery in low-income communities?

APPENDIX F: COMPONENT 2 HOUSEHOLD SURVEY

The **consumer** survey questions will be asked to willing adults of 18 years involved in the financial decisions of the household.

A. Informed Consent

Hello, my name is _____. I am a staff member at the Aquaya Institute based in Accra. I would like to invite you to participate in our research study in [CITY]. The purpose of our research is to understand the practices, perceptions, and challenges with respect to access to GWCL water service in [CITY]. You are being asked to participate in this study because you live in one of the areas selected for the present study.

The discussion will involve questions about water equity in [CITY], main barriers to water access, and existing programs facilitate access to water services for low-income households. The discussion should last no longer than 1 hour or until you feel you have told me everything you want me to know. If you agree to participate in this research, I will conduct an interview with you now.

There are no right or wrong answers, so please be honest and tell us what is true for you. There are no personal risks or benefits to your participation. Everything that you say will be confidential, and we will not use your real name or any identifying information in any of our reports or papers. Our team may sometimes look at your record for research purposes. The results will be used to inform GWCL and other institutions in improving the quality and overall reliability of water services throughout the city.

Your participation in this research is completely voluntary. You can decline to answer any questions, and if you do not wish to continue, you can withdraw from the study at any time for any reason. You will not receive any monetary payment for your participation. An alternative is not to participate in this study.

If you have any questions or concerns about the research, please feel free to contact me. I can be reached at +_____ or _____@aquaya.org or [hand over the business card].

If you agree to participate, please say so.

[ALL QUESTIONNAIRES WILL BE SAVED BY THE INTERVIEWER REGARDLESS OF THE RESPONDENT'S DECISION TO PARTICIPATE OR NOT TO PARTICIPATE.]

B. Interview Details

Target City:
Respondent's Household area/neighborhood:
Name of interviewer:
Name of respondent(s):
Date:

No.	SECTION A: Consent and Identifiers	Answer Choices	Code	Logic
Z0	Enumerator:	Enumerator 1 Enumerator 2 Enumerator 3 Enumerator 4 Enumerator 5 Supervisor	1 2 3 4 5 6	
Z1	City	Kumasi Tamale	1 2	
Z2	Zone	DROP-DOWN MENU		
Z3	What number is this COMPOUND of those you have visited today?	1st compound 2nd compound 3rd compound 4th compound 5th compound	1 2 3 4 5	
Z4	What number is this household of those who have visited today?	1st household 2nd household 3rd household 4th household 5th household 6th household 7th household 8th household 9th household 10th household	1 2 3 4 5 6 7 8 9 10	
Z5	*CommCare to generate unique household ID.*			
A1	Does this household have at least one member above 18 years old?	Yes No	1 0	 >>Note 2
A2	Is an adult (above 18 years old) involved in financial decisions home and available to be interviewed?	Yes No	1 0	 >>A3
A3a	READ CONSENT FORM Are you willing to participate in the study?	Yes, available now Yes, though at a later time No	1 2 0	>>A6 >>A3 >>Note2
A3b	Write household ID on consent form			
A4	How many times have you visited this household?	This is the first time This is the second time This is the third time	1 2 3	>>A4 >>A4 >>Note2
A5	May a household member who is 18 years old or above be available at a later time?	Yes, later today Yes, on another day No	1 2 0	>>Note1 >>Note2 >>Note2
Note1	Save this form as incomplete and return later today.			

A6	Why was the household ineligible? (automated calculation)	Not available today Not willing to participate. No household member > 18 years old.		>> End >> End >> End
Note2	This household is ineligible because [A5].			
A7	Respondent family name/last name:	_____		
A8	Respondent first name:	_____		
A9	Popular name: *Optional*	_____		
A10	Respondent gender:	Female Male	2 1	
No.	**SECTION B: Demographics**	**Answer Choices**	**Code**	**Logic**
Note3	Now I would like to ask you questions about the composition of your household.			
B1	Are you the head of household? *We are asking about head of HOUSEHOLD, not head of FAMILY*	Yes No	1 0	
B2	What is your age? *(Ask birth year if doesn't know)*	_____ Years		>>End if <18
B3	What is your marital status?	Married Living together Separated Divorced Never married/single Widowed	1 2 3 4 5 6	
B4	What is the highest level of school you <u>completed</u>?	None Primary school JHS/JHS SSS/SHS Diploma/HND Bachelors Masters Don't know	0 1 2 3 4 5 6 99	
B5	What is your main occupation? *In the last 12 months*	Agriculture, fishing, forestry Selling produce or goods (market or kiosk) Cooperatives Private sector: self-employed Private sector: employed Government sector NGOs (local & International) Student No occupation, stay home Don't know	1 2 3 4 5 6 7 8 0 99	
B6	First name of head of household			

B7	What is the gender of the head of household?	Female Male	2 1	
B8	What is the age of the head of household? *(Ask birth year if doesn't know)*	_____ Years		
B9	What is the highest level of school the head of household completed?	None Primary school JHS/JHS SSS/SHS Diploma/HND Bachelors Masters Don't know	0 1 2 3 4 5 6 99	
B10	What is the marital status of the head of household?	Married Living together Separated Divorced Never married/single Widowed	1 2 3 4 5 6	
B11	What is the main occupation of the head of household? *In the last 12 months*	Agriculture, fishing, forestry Selling produce or goods (market or kiosk) Cooperatives Private sector: self-employed Private sector: employed Government sector NGOs (local & International) No occupation, stay home Student Don't know	1 2 3 4 5 6 7 0 8 99	
B12	How many people are in your household, including yourself? *People who eat and sleep here more than 50% of the time or 6 months in the year.* *(Probe for children and elders. 99 if doesn't know)*	_____		
No.	**SECTION C: Socioeconomic Indicators**	**Answer Choices**	**Code**	**Logic**
Note4	Now I will ask you questions about your household dwelling and assets.			
C1	How many rooms in this household are used for sleeping?	_____		

C2	What is the main construction material used for the dwelling's outer walls? *Observe.*	No walls Cane/palm/trunks Mud/landcrete Bamboo with mud Stone with mud Uncovered adobe/mud bricks Plywood Cardboard Reused wood Cement Stone with lime/cement Kiln-fired bricks Cement blocks Covered adobe/mud bricks (plastered) Wood planks/shingles Other:_____ Don't know	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 96 99	
C2b	Other wall material			
C3	What is the main construction material used for the dwelling's roof? *Observe*	No roof Thatch/palm leaf Mud/sod Rustic mat Palm/bamboo Wood planks (rudimentary roofing) Cardboard Zinc/Aluminium Wood (finished roofing) Ceramic/brick tiles Cement Roofing shingles Asbestos/slate roofing sheets Other:_____ Don't know	0 1 2 3 4 5 6 7 8 9 10 11 12 96 99	
C4	What is the main construction material used for the dwelling's floor? *Observe*	Earth/sand Dung Wood planks Palm/bamboo Parquet or polished wood Vinyl or asphalt strips Tiles (ceramic, marble, porcelain, terrazo) Cement Carpet (woolen or synthetic) Linoleum/rubber carpet Other:_____ Don't know	1 2 3 4 5 6 7 8 9 10 96 99	
C4b	Other floor material			

C5	What type of fuel does your household mainly use for cooking?	Electricity LPG Natural gas Biogas Kerosene Cooking gel Charcoal Wood Straw, shrubs, grass Agricultural crop residue Animal dung Other: _____ None, no cooking Don't know	1 2 3 4 5 6 7 8 9 10 11 96 0 99	 >>C8
C6	What type of cookstove is mainly used for cooking?	Electric stove Solar cooker Liquefied petroleum gas (LPG)/cooking gas stove Piped natural gas stove Biogas stove Liquid fuel stove Manufactured solid fuel stove Traditional solid fuel stove Three stone stove/open fire Other: No food cooked in household Don't know	1 2 3 4 5 6 7 8 9 96 0 99	>>C8 >>C8 >>C10
C7	Does the stove have a chimney?	Yes No Don't know	1 0 99	
C8	Is the cooking usually done in the house, in a separate building, or outdoors?	In the house In a separate building Outdoors Other: _____	1 2 3 96	 >>C10
C9	Do you have a separate room which is used as a kitchen?	Yes No	1 0	
C10	In the past month, have you purchased any chicken eggs (fresh or single)?	Yes No	1 0	
C11	In the past month, have you purchased any raw or corned beef?	Yes No	1 0	

C12	At night, what does your household mainly use to light the home?	Electricity Solar lantern Rechargeable flashlight, torch, or lantern Battery-powered flashlight, torch, or lantern Biogas lamp Gasoline lamp Kerosene or paraffin lamp Charcoal Wood Straw/shrub/grass Agricultural crop Animal dung/waste Oil lamp Candle No lighting in household Other: _____	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 96	
C13	What kind of sanitation facility does your household usually use?	Flush or pour flush toilet Ventilated improved pit latrine Pit latrine with slab Composting toilet Pit latrine without slab/Open pit Bucket toilet Hanging latrine Other	1 2 3 4 5 6 7 96	 >>C15 >>C15 >>C15 >>C15 >>C15 >>C15 >>C15
C14	If flush or pour flush toilet: Where does it flush to?	Piped sewer system Septic tank Pit latrine Somewhere else Biodigester Don't know	1 2 3 4 5 99	
C15	Is the main sanitation facility available to household members shared with other households?	Yes No Don't know	0 1 99	 >>C17 >>C17
C16	If sanitation facility is shared – Including your own household, how many households share this sanitation facility?	_____		
C17	Where is this sanitation facility located?	In own dwelling In own yard/plot Other	1 2 96	

C18	Does your household have any of the following items? *Choose for each.* *Check yes if the household owns the item, even if it is broken or non-functional.*	Electricity Radio Television Non-mobile telephone Computer/tablet Refrigerator Freezer Electric generator/invertor Washing machine Photo camera (not on phone) Video deck/DVD/VCD Sewing machine Bed Table Chair *(Stools don't count as chairs.)* Cabinet/cupboard	Y/N/dk Y/N/dk Y/N/dk Y/N/dk Y/N/dk Y/N/dk Y/N/dk Y/N/dk Y/N/dk Y/N/dk Y/N/dk Y/N/dk Y/N/dk Y/N/dk Y/N/dk Y/N/dk	
C19	Does any member of your household own any of the following items? *Choose for each.* *Check yes if the household owns the item, even if it is broken or non-functional.*	Wristwatch Mobile phone Bicycle Motorcycle Animal-drawn cart Car or truck Boat with motor Boat without motor	Y/N/dk Y/N/dk Y/N/dk Y/N/dk Y/N/dk Y/N/dk Y/N/dk Y/N/dk	
C20	Does any member of your household own any agricultural land? *(Including land outside this area)*	Yes No Refuse to answer Don't know	1 0 98 99	 >>C22 >>C22 >>C22
C21	How many acres of agricultural land do members of this household own?	_____		
C22	Does this household own any livestock, herds, other farm animals or poultry?	Yes No Don't know	1 0 99	 >>C24 >>C24
C23	How many of the following animals does this household own?	Milk cows or bulls: _____ Other cattle: _____ Horses, donkeys, mules: _____ Goats: _____ Sheep: _____ Chickens or other poultry: _____ Pigs: _____ Rabbits: _____ Grasscutter: _____		
C24	Does any member of this household have a bank account? *This does not include a mobile money account.*	Yes No Don't know	1 0 99	

C25	Does any member of this household use a mobile phone to make financial transactions such as sending or receiving money, paying bills, purchasing goods or services, or receiving wages?	Yes No Don't know	1 0 99	
C26	Is your household able to feed itself all year round without help from neighbors or relatives?	Yes No Don't know	1 0 99	
C27	In the last 4 weeks, what was your household's total income?	*Appropriate ranges will be included here* Refuse to answer Don't know	1 2 3 4 5 6 98 99	
C28	In the last 12 months, what was your household's total income?	0 – It is free 0 – I am the owner <500 GHS 500 – 1,500 GHS 1,500 – 3,000 GHS 3,000 – 5,000 GHS 5,000 – 10,000 GHS >10,000 GHS Don't know Other	1 2 3 4 5 6 6 7 99 96	
C29	In the last month, how much did your household spend on housing?	*Appropriate ranges will be included here* Refuse to answer Don't know	1 2 3 4 5 6 98 99	
C30	Does your household housing spending amount include other charges (water, electricity)?	Yes – water Yes- electricity Yes – water & electricity No Other Don't know	1 2 3 0 96 99	
C31	In the last month, how much did your household spend on food? *Foods and non-alcoholic beverages*	*Appropriate ranges will be included here* Don't know Other	1 2 3 4 5 96 99	

C32	In the last month, how much did your household spend on transportation? *Fuel, trotros, taxis, bus, car maintenance*	*Appropriate ranges will be included here* Don't know Other	1 2 3 4 5 96 99	
C33	In the last month, how much did your household spend on education?	*Appropriate ranges will be included here* Don't know Other	1 2 3 4 5 96 99	
No.	**SECTION D: Water Sources**	**Answer Choices**	**Code**	**Logic**
Note5	Now I will ask you questions about your sources of water.			
D1	Does this household use the GWCL piped water for drinking or cooking? *Doesn't have to be their primary source, as long as they use it sometimes.*	Yes No Don't know	1 0 99	
D2	Does your household use the same water source for drinking and other uses such as cooking, cleaning, washing etc.?	Yes No Don't know	1 0 99	
D3	*[If D1=0]* What is the main source of drinking water for members of your household? *[If D1=1]* What is the main source of water for members of your household?	Piped water inside dwelling Piped water to yard/plot Piped water to neighbor Piped water to public tap/standpipe Tube-well or borehole Protected dug well Unprotected dug well Protected spring Unprotected spring Rainwater Tanker truck Cart with small tank Surface water (river, dam, lake, pond, stream, canal) Bottled water Sachet water Other: _____ Don't know	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 96 99	 >>D5 >>D5 >>D5 >>D5 >>D5 >>D5 >>D5 >>D5 >>D5 >>D5 >>D5
D4	Is this the GWCL piped water?	Yes No Don't know	1 0 99	>>D6 >>D6

D5	*[If D1=0]* For what reason(s) does your household not use the GWCL piped water as the primary source of drinking water? *Select all that apply.* *[If D1=1]* For what reason(s) does your household not use GWCL piped water as the primary source of water? *Select all that apply.*	Don't like the smell and/or taste Don't like the color of water The water is not safe to drink The water supply is not reliable/Supply interruptions Too far from my house - GWCL does not serve my area Too far from my house – Mainline extension/infrastructure needed Connection Fee too expensive Monthly Tariffs too expensive Other: _____ Don't know	1 2 3 4 5 6 7 8 96 99	
D6	*[If D1=0]* Does your household ever use the GWCL piped water as a source of drinking water? *[If D1=1]* Does your household ever use the GWCL piped water as a source of water?	Yes No Don't know	1 0 99	
D6	What is the main reason (price, convenience, water quality, reliability) you chose to use this primary water source?	Price Convenience Water Quality Reliability Other Don't know	1 2 3 4 96 99	
D7	*[If D1=0]* Where is that water source located?	In own dwelling In own yard/plot Other	1 2 96	>>D10
D8	How many households share the piped water source?	1-2 3-5 5-10 >10 Communal standpipe Other Don't know	1 2 3 4 5 96 99	
D9	*[If D1=0]* How long does it take to go there, get water, and come back? (in minutes)	_____		

D10	*[If D1=0]* What is the main source of water used by your household for other purposes such as cooking, cleaning, washing, etc.?	Piped water inside dwelling Piped water to yard/plot Piped water to neighbor Piped water to public tap/standpipe Tube-well or borehole Protected dug well Unprotected dug well Protected spring Unprotected spring Rainwater Tanker truck Cart with small tank Surface water (river, dam, lake, pond, stream, canal) Bottled water Sachet water Other: _____ Don't know	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 96 99	>>D12 >>D12 >>D12 >>D12 >>D12 >>D12 >>D12 >>D12 >>D12 >>D12 >>D12
D10	Is this the GWCL piped water?	Yes No Don't know	1 0 99	
D11	For what reason(s) does your household not use GWCL piped water for these other uses?	Don't like the smell and/or taste Don't like the color of water The water is not safe to drink The water supply is not reliable Too far from my house - GWCL does not serve my area Too far from my house – Mainline extension/infrastructure needed Connection Fee too expensive Monthly Tariffs too expensive Other: _____ Don't know	1 2 3 4 5 6 7 8 96 99	
D12	Which of the following water sources do you use every week? *Select all that apply.*	Piped water inside dwelling Piped water to yard/plot Piped water to neighbor Piped water to public tap/standpipe Tube-well or borehole Protected dug well Unprotected dug well Protected spring Unprotected spring Rainwater Tanker truck Cart with small tank Surface water (river, dam, lake, pond, stream, canal) Bottled water Sachet water	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	

D13	What is the main reason (price, convenience, water quality, reliability) you use each water source you use on a weekly basis?	Piped water inside dwelling Piped water to yard/plot Piped water to neighbor Piped water to public tap/standpipe Tube-well or borehole Protected dug well Unprotected dug well Protected spring Unprotected spring Rainwater Tanker truck Cart with small tank Surface water (river, dam, lake, pond, stream, canal) Bottled water Sachet water	P/C/Q/R P/C/Q/R P/C/Q/R P/C/Q/R P/C/Q/R P/C/Q/R P/C/Q/R P/C/Q/R P/C/Q/R P/C/Q/R P/C/Q/R P/C/Q/R P/C/Q/R P/C/Q/R P/C/Q/R	
No.	**SECTION F: Satisfaction and Awareness**	**Answer Choices**	**Code**	**Logic**
Note6	I am now going to ask you questions about your experience with the GWCL piped water			
F1	Please rate your level of satisfaction with the GWCL water *Use Liekert scale on flashcard.*	Very satisfied Somewhat satisfied Somewhat not satisfied Very not satisfied Don't know	1 2 3 4 99	
F2	What do you dislike about the GWCL water? *Select all that apply*	Bad taste, smell Bad color Unsafe for health Too far from my house Long waiting time, queuing Too expensive Unreliable water supply Other: _____ Don't know	1 2 3 4 5 6 7 96 99	
F3	Has your level of satisfaction changed in the past year?	No, unchanged. Yes, my level of satisfaction has increased. Yes, my level of satisfaction has decreased. Don't know	0 1 2 99	>>F6a >>F5 >>F6a
F4	Why has your level of satisfaction decreased?	Worse taste and/or smell Worse color Water is less safe to drink Longer queuing time More service interruptions More expensive Other: _____ Don't know	1 2 3 4 5 6 96 99	>>F6a >>F6a >>F6a >>F6a >>F6a >>F6a >>F6a >>F6a

F5	Why has your level of satisfaction increased?	Better taste and/or smell Better color Water is safer to drink Shorter queuing time Fewer service interruptions Less expensive Other: _____ Don't know	1 3 2 4 5 6 96 99	
F6a	Is the GWCL water treated?	No Yes Don't know	0 1 99	>>F8 >>F8
F6b	What type of treatment are you aware of is performed by GWCL before you receive the water? *Select all that apply.*	Periodic tank cleanings Occasional chlorination Ongoing chlorination Treated at the water treatment plant Other treatment: _____ Don't know	1 2 3 4 96 99	
F7	How did you know the water is treated? *Select all that apply*	Told by the GWCL Told by a friend Told by community leader Changes in the taste or smell of water More precipitates (black or orange particles) in the water Community center or radio Other:_____ Don't know	1 2 3 4 5 6 96 99	
F8	Do you feel safe for you and your household to consume water from your GWCL connection?	No Yes Don't know	0 1 99	
F9	Do you conduct any level of treatment before consuming water supplied by the GWCL?	No Yes Don't know	0 1 99	>>F11 >>F11
F10	What water treatment method do you use before consuming water supplied by GWCL?	Boiling Point-of-use filter (biosand, ceramic, other filter) Point-of-use chlorination Straining through a cloth Alum or coagulant Solar disinfection Settling Other (please specify) Don't know	0 1 2 3 4 5 6 96 99	
F11	Is the GWCL water tested?	No Yes Don't know	0 1 99	>>F14 >>F14

F12	Are you aware of the test results?	No Yes: water is safe Yes: water is unsafe	0 1 2	
F13	How did you know the water is tested? *Select all that apply*	Told by the GWCL Told by a friend Told by community leader Told by GWCL staff Community center or radio Saw the operator sample water Other:_____ Don't know	0 1 2 3 4 5 96 99	
F14	*[Don't ask if selected 0 for F4 or F12]* Did your household receive any information from the GWCL about water safety? *Select all that apply*	No Yes: about tank cleanings Yes: about chlorination/treatment Yes: about water testing Yes: about safe storage practices Yes: other:_____ Don't know	0 1 2 3 4 5 99	
F15	Did your household listen to any radio or community center program about water safety?	Yes No Don't know	1 0 99	
F16	*[Private connection user]* On how many hours each day is water usually available at your private tap? *[Standpipe user]* On how many hours each day is water usually available at your standpipe?	1-4 hours per day 4-8 hours per day 8-12 hours per day More than 12 hours per day 24 hours per day Don't know	1 2 3 4 99	
F17	How many days per week do you have water available from your main GWCL connection?	1 – 3 days per week 4 – 6 days per week 7 days per week Don't know	1 2 3 99	
F18	In the past two weeks, has there been a FULL DAY when water was not available?	Yes No Don't know	1 0 99	
F19	In the past two weeks, has there been a day when water was not available WHEN YOU NEEDED IT?	Yes No Don't know	1 0 99	
F20	In the past 12 months, were there periods when service interruptions were more frequent? *Select all that apply*	January – March April – May May- August September – October October - December Don't know	1 2 3 4 5 99	

No.	SECTION E: Water Security	Answer Choices	Code	Logic
E1	In the last 4 weeks, how frequently did you or anyone in your household worry you would not have enough water for all of your household needs?	Never Rarely Sometimes Often Always Don't know	1 2 3 4 5 99	
E2	In the last 4 weeks, how frequently has your main water source been interrupted or limited?	Never Rarely Sometimes Often Always Don't know	1 2 3 4 5 99	
E3	In the last 4 weeks, how frequently have you or anyone in your household had to change what was being eaten because there were problems with water (e.g. for washing foods, cooking, etc.)?	Never Rarely Sometimes Often Always Don't know	1 2 3 4 5 99	
E4	In the last 4 weeks, how frequently have you or anyone in your household had to go without washing hands after dirty activities (e.g., defecating or changing diapers, cleaning animal) because of problems with water?	Never Rarely Sometimes Often Always Don't know	1 2 3 4 5 99	
E5	In the last 4 weeks, how frequently has there not been as much water to drink as you would like for you or anyone in your household?	Never Rarely Sometimes Often Always Don't know	1 2 3 4 5 99	
E6	In the last 4 weeks, how frequently has there been no useable or drinkable water whatsoever in your household?	Never Rarely Sometimes Often Always Don't know	1 2 3 4 5 99	
No.	**SECTION G: Water Payments**	**Answer Choices**	**Code**	**Logic**
Note7	*[If household uses the GWCL standpipe]* I am now going to ask you questions about the GWCL standpipe.			
G1	Does your household ever pay user fees or a tariff to collect water from the GWCL stand pipe?	Yes No Don't know	1 0 99	>>G3 >>G7 >>G7

G2	Why does your household never pay to collect water from the GWCL standpipe? *Select all that apply.*	Water from this source is free for all My household is exempt from paying Too expensive GWCL doesn't enforce payments Other: _____ Don't know	0 1 2 3 96 99	>>G7 >>G7 >>G7 >>G7 >>G7 >>G7
G3	How much did your household pay the last time? *Record unit appropriately (GHS, pesawas)* *Type -99 if don't know*	_____		
G4	What volume of water did this cover? *Type -99 if don't know*	Liter: _____ Bucket or gallon (18-20L) _____ Basin (30-40L) _____		
G5	In a typical week, how much does your household pay to collect water from the GWCL standpipe? *Type -99 if don't know*	_____ GHS		
Note8	Based on these answers, it seems that this household pays [CALCULATE] pesawas/GHS per bucket/basin on average. If this is very different from the official tariff, please explain the reason here: _____			
G6	What is the payment method that your household uses most often to pay for water from the GWCL standpipe?	Cash Mobile money Bank transfer Bank card Mobile application Other: _____	1 2 3 4 5 96	
G7	What is the payment method that your household uses most often to pay for other sources of water?	Cash Mobile money Bank transfer Bank card Mobile application Other: _____	1 2 3 4 5 96	
G8	In a typical week, how much does your household pay to get water from the following sources? *Fill out all that apply.* *Fill out 0 if the household does not use the water source listed.*	Tanker truck: Cart with small tank: Bottled water: Sachet water: Other: _____ Don't know		
G9	What would be your preferred payment approach to pay water usage tariff?	Monthly pre-paid bill Monthly post-paid bill Weekly payments Pay-as-you-fetch Other	1 2 3 4 96	

G10	Have you used a prepaid payment method in the past year? *Example: electricity bill, phone bill, water bill*	Yes No Don't know	1 0 99	 >>Next section >>Next section
G11	If you have used a prepaid payment method, to what extent do you agree with the following statement: *My experience prepaying for services has been positive.*	Strongly agree Somewhat agree Neutral Somewhat disagree Strongly disagree	1 2 3 4 5	
G12	Would you be willing to prepay for your water bill?	Yes No Don't know	1 0 99	 >>G13 >>Next section
G13	What is the main reason for wanting to prepay your water bill?	Convenience Flexibility of payment (amount and timing) Easier control of water expenses Visibility of real-time water use Other Don't know	1 2 3 4 96 99	
G14	What is the main reason for not wanting to prepay your water bill?	I like how I pay my water bill now and don't want to change. I don't know what prepaying my water bill would involve. I don't want to have to use a phone application to pay. I think it will be more complicated to pay my water bill. I think it will make my water bill more expensive I think it will limit the amount of water I can access through my water connection Other Don't know	1 2 3 4 5 6 96 99	
[If household uses a GWCL private connection] I am now going to ask you questions about your GWCL private connection.				
G1pc	Does your household ever pay for water coming out of your private connection?	Yes No Don't know	1 0 99	>>G3pc

G2pc	Why does your household never pay for the GWCL water? *Select all that apply.*	Water from this source is free for all My household is exempt from paying Too expensive GWCL doesn't enforce payments Other: _____ Don't know	0 1 2 3 96 99	>>G15pc >>G15pc >>G15pc >>G15pc >>G15pc >>G15pc
G3pc	How much did your household pay the last time? *Type -99 if don't know*	_____ GHS		
G4pc	What period of time did this cover? *In months* *(How long was it since your previous payment?)*	_____months		
G5pc	How much did your household pay the time before last? *Type -99 if don't know*	_____ GHS		
G6pc	What period of time did this cover? *(How long was it since your previous payment?)*	_____months		
G7pc	Do you know about the GWCL monthly lifeline tariff?	Yes No Don't know	1 0 99	 >>G9pc >>G9pc
G8pc	Does your household pay the GWCL monthly lifeline tariff?	Yes No Don't know	1 0 99	
Note9	If available, take a picture of the household's latest water bill.			
G9pc	Hidden calculation of the average monthly payment			
Note10	Based on these answers, this household has paid an average of ${E10pc} GHS per month over the past two payments. Or Based on these answers, it seems that this household cannot provide enough information to estimate monthly payments.			
G10pc	Did you pay for the one-time connection fee for the shared GWCL connection?	Yes No Don't know	1 0 99	 >>G12pc >>G12pc
G11pc	How much did you pay for the one-time connection fee? *Type 99 if don't know*	_____ GHS		
G12pc	Did you encounter difficulties when you connected and got a private GWCL water connection?	Yes No Don't know	1 0 99	 >>G14pc >>G14pc

G13pc	What difficulties did you encounter when connecting and getting a private GWCL water connection?	GWCL application process was complicated/confusing GWCL took a long time to process the application Connection required a mainline extension Delays with installation of the equipment Negotiations with neighbors Other	1 2 3 4 5 96	
G14pc	What is the payment method that your household uses most often to pay for water from your private GWCL connection?	Cash Mobile money Bank transfer Bank card Mobile application Other: _____	1 2 3 4 5 96	
G15pc	What is the payment method that your household uses most often to pay for other sources of water?	Cash Mobile money Bank transfer Bank card Mobile application Other: _____	1 2 3 4 5 96	
G16pc	In a typical week, how much does your household pay to get water from the following sources? *Fill out all that apply.* *Fill out 0 if the household does not use the water source listed.*	Tanker truck:_____ Cart with small tank: _____ Bottled water: _____ Sachet water: _____ Other: _____ Don't know		
G17pc	What would be your preferred payment approach to pay water usage tariff?	Monthly pre-paid bill Monthly post-paid bill Weekly payments Other	1 2 396	
Note11	*[If household uses a shared connection from the GWCL]* I am now going to ask you questions about your shared connection.			
G1sc	Does your household ever pay for water coming out of your shared connection?	Yes No Don't know	1 0 99	>>G3sc
G2sc	Why does your household never pay for the water from your shared connection? *Select all that apply.*	Water from this source is free for all My household is exempt from paying Too expensive GWCL doesn't enforce payments The owner pays the water bill Other: _____ Don't know	0 1 2 3 4 96 99	>>G15sc >>G15sc >>G15sc >>G15sc >>G15sc >>G15sc >>G15sc

G3sc	How much did your household pay the last time? *Type -99 if don't know*	_____ GHS		
G4sc	What period of time did this cover? *In months* *(How long was it since your previous payment?)*	_____months		
G5sc	How much did your household pay the time before last? *Type -99 if don't know*	_____ GHS		
G6sc	What period of time did this cover? *(How long was it since your previous payment?)*	_____months		
G7sc	Do you know about the GWCL monthly lifeline tariff?	Yes No Don't know	1 0 99	 >>G9sc >>G9sc
G8sc	Does your household pay the GWCL monthly lifeline tariff?	Yes No Don't know	1 0 99	
Note12	If available, take a picture of the household's latest water bill.			
G9sc	Hidden calculation of the average monthly payment			
Note13	Based on these answers, this household has paid an average of ${E10pc} GHS per month over the past two payments. Or Based on these answers, it seems that this household cannot provide enough information to estimate monthly payments.			
G10sc	Did you pay for the one-time connection fee for the shared GWCL connection?	Yes No Don't know	1 0 99	 >>G12sc >>G12sc
G11sc	How much did you pay for the one-time connection fee? *Type 99 if don't know*	_____ GHS		
G12sc	Did you encounter difficulties when you connected and got a water connection?	Yes No Don't know	1 0 99	 >>G14sc >>G14sc

G13sc	What difficulties did you encounter when connecting to the GWCL system and getting a water connection?	GWCL application process was complicated/confusing GWCL took a long time to process the application Connection required a mainline extension Delays with installation of the equipment Negotiations with neighbors Other	1 2 3 4 5 96	
G14sc	What is the payment method that your household uses most often to pay for water from GWCL shared connection?	Cash Mobile money Bank transfer Bank card Mobile application Other: _____	1 2 3 4 5 96	
G15sc	What is the payment method that your household uses most often to pay for other sources of water?	Cash Mobile money Bank transfer Bank card Mobile application Other: _____	1 2 3 4 5 96	
G16sc	In a typical week, how much does your household pay to get water from the following sources? *Fill out all that apply.*	Tanker truck: Cart with small tank: Bottled water: Sachet water: Other: _____ Don't know	1 2 3 4 96 99	
G17sc	What would be your preferred payment approach to pay water usage tariff?	Monthly pre-paid bill Monthly post-paid bill Weekly payments Other	1 2 3 96	
No.	**SECTION H: WTP with Double-bounded Dichotomous Choice**	**Answer Choices**	**Code**	**Logic**
Customer Type_2	*Automated calculation based on previous answers*	Standpipe user: bucket (18-20L) Standpipe user: basin (30-40L) Private connection user		
	Following questions for private connection users			
Note for private connection user	There are several things that the GWCL in your community can do to improve reliability and quality of water services. For example, improvements could involve enhanced metering and piping replacements to maximize supply and minimize service disruptions. There are also ways to treat the water to make it safer to drink. All of this costs money and I would like to understand whether your household would be willing to pay more than currently to help support these improvements.			
H0	Have you read the script and answered any questions from the respondent?	Yes No	1 0	

Note14	Your household currently pays [*automated calculation*] pesawas per bucket (18-20L) on average. or Your household currently pays [*automated calculation*] pesawas per basin (30-40L) on average. or Your household currently pays [E3pc/E6pc] GHS per month on average.			
CommCare will randomly assign the first price point X. Y is higher than X; and Z is lower than X. CommCare will calculate X, Y and Z based on set percentages of current payments and will display monetary amounts as shown below.				
H1	Would your household be willing to pay X GHS/pesawas per bucket/basin/month more (on top of what you are currently paying) to ensure (or keep) adequate water service?	Yes No Don't know	1 0 99	 >>G3 >>G4
H2	Would your household be willing to pay Y GHS/pesawas per bucket/basin/month more (on top of what you are currently paying) to ensure (or keep) adequate water service?	Yes No Don't know	1 0 99	>>H4 >>H4
H3	Would your household be willing to pay Z GHS/pesawas per bucket/basing/month more (on top of what you are currently paying) to ensure (or keep) adequate water service?	Yes No Don't know	1 0 99	
H4	What is the maximum amount that your household would be willing to pay (on top of what you are currently paying) to ensure t (or keep) piped water is tested and chlorinated?	_____ GHS/month _____pesawas/bucket _____pesawas/basin		
H5	Are you certain that you would be willing to pay this amount next time?	Yes No Don't know	1 0 99	
I will now present different payment scenarios for the connection fee and ask you which one you prefer.				
CommCare will use the maximum amount that the household is willing to pay and assign it to the following scenarios.				
H6	Which of the following two options would your household prefer to pay the connection fee for a private water connection from the GWCL? *Insert the 2 description of payment scenarios here*	Option 1: One-time payment of full fee amount (equal to maximum WTP) Option 2: Monthly installments of fee amount at 5% annual interest over 6 months Don't know	1 2 99	

H7	Which of the following two options would your household prefer to pay the connection fee for a private water connection from the GWCL? *Insert the 2 description of payment scenarios here*	Option 1: One-time payment of full fee amount (equal to maximum WTP) Option 3: Monthly installments of fee amount at 10% annual interest over 12 months Don't know	1 2 99	
H8	Which of the following two options would your household prefer to pay the connection fee for a private water connection from the GWCL? *Insert the 2 description of payment scenarios here*	Option 2: Monthly installments of fee amount at 5% annual interest over 6 months Option 3: Monthly installments of fee amount at 10% annual interest over 12 months Don't know	1 2 99	
	Following questions are for standpipe users and non-customers			
Note for non-customers and standpipe connection user	There are several things that the GWCL in your community can do to improve reliability and quality of water services. For example, you could have a private water connection in your household that would eliminate time to collect water at the standpipe and provide a tap for your household use. All of this costs money and I would like to understand whether your household would be willing to pay more than currently to get a private water connection from the GWCL, including the monthly tariff and the connection fee.			
H0nc	Have you read the script and answered any questions from the respondent?	Yes No	1 0	
I will now ask you about how much your household would be willing to pay every month for the monthly tariff to maintain water supply through a private water connection in your household.				
Note15	Your household currently pays [*automated calculation*] pesawas per bucket (18-20L) on average. or Your household currently pays [*automated calculation*] pesawas per basin (30-40L) on average.			
CommCare will randomly assign the first price point X. Y is higher than X; and Z is lower than X.				
H1nc	Would your household be willing to pay X GHS/pesawas per bucket/basin/month more (on top of what you are currently paying) to get a private water connection?	Yes No Don't know	1 0 99	 >>H3 >>H4
H2nc	Would your household be willing to pay Y GHS/pesawas per bucket/basin/month more (on top of what you are currently paying) to get a private water connection?	Yes No Don't know	1 0 99	>>H4 >>H4
H3nc	Would your household be willing to pay Z GHS/pesawas per bucket/basing/month more (on top of what you are currently paying) to get a private water connection?	Yes No Don't know	1 0 99	

H4nc	What is the maximum amount that your household would be willing to pay (on top of what you are currently paying) to get a private water connection?	_____ GHS/month _____pesawas/bucket _____pesawas/basin		
H5nc	Are you certain that you would be willing to pay this amount next time?	Yes No Don't know	1 0 99	
I will now ask you about how much your household would be willing to pay for the one-time connection fee required to connect to the system and install a private water connection in your household.				
H6nc	Would your household be willing to pay X GHS for the one-time connection fee for a private water connection?	Yes No Don't know	1 0 99	 >>H8nc >>H9nc
H7nc	Would your household be willing to pay Y GHS for the one-time connection fee for a private water connection?	Yes No Don't know	1 0 99	>>H9nc >>H9nc
G8nc	Would your household be willing to pay Z GHS for the one-time connection fee for a private water connection?	Yes No Don't know	1 0 99	
H9nc	What is the maximum amount that your household would be willing to pay for the one-time connection fee for a private water connection?	_____ GHS		
H10nc	Are you certain that you would be willing to pay this amount next time?	Yes No Don't know	1 0 99	
I will now present different payment scenarios for the connection fee and ask you which one you prefer.				
CommCare will use the maximum amount that the household is willing to pay and assign it to the following scenarios.				
H11nc	Which of the following two options would your household prefer to pay the connection fee for a private water connection from the GWCL? *Insert the 2 description of payment scenarios here*	Option 1: One-time payment of full fee amount (equal to maximum WTP) Option 2: Monthly installments of fee amount at 5% annual interest over 6 months Don't know	1 2 99	
GH12nc	Which of the following two options would your household prefer to pay the connection fee for a private water connection from the GWCL? *Insert the 2 description of payment scenarios here*	Option 1: One-time payment of full fee amount (equal to maximum WTP) Option 3: Monthly installments of fee amount at 10% annual interest over 12 months Don't know	1 2 99	

H13nc	Which of the following two options would your household prefer to pay the connection fee for a private water connection from the GWCL? *Insert the 2 description of payment scenarios here*	Option 2: Monthly installments of fee amount at 5% annual interest over 6 months Option 3: Monthly installments of fee amount at 10% annual interest over 12 months Don't know	1 2 99	
No.	**SECTION I: Chlorine Measurements**	**Answer Choices**	**Code**	**Logic**
I1	Can you point me to the most recent water that your household collected from the GWCL piped water?	Yes No (no GWCL piped water in the house at this moment, or refuses to answer)	1 0	
I2	Was this water mixed with water from another source?	Yes No Don't know	1 0 99	
I3	When was this water collected?	Less than 4 hours ago Today, but more than 4 hours ago Yesterday (after the current time) Yesterday (before the current time) The day before yesterday (after the current time) The day before yesterday (before the current time) More than 2 days ago Don't know	1 2 3 4 5 99	
I3b	When your household collected this water, had there been a service interruption in the previous 24 hours?	Yes No Don't know	1 0 99	
I4	Does the storage container have a lid, cap, or cover? *Observe.*	Covered Uncovered Cannot observe	1 0 99	
I5	Does the storage container have a wide mouth where a child can dip his/her hand? *Observe.*	Narrow mouth Wide mouth Cannot observe	1 0 99	
I6	Is the inside of the storage container visibly dirty (visible dirt or biofilms)? *Observe.*	Visibly dirty Clean Cannot observe	1 0 99	
I7	Is the water turbid or slightly orange? *Observe.*	Yes No Cannot observe	1 0 99	

I8	Was the water collected in the same container as the one used for storage?	Yes, same container for fetching and storage No, water changed container after collection Don't know	1 0 99	
I9	Did someone in your household treat this water after collecting it?	Yes, boiling Yes, added chlorine Yes, other treatment method Yes, point-of-use filter (biosand, ceramic, other filter) Yes, straining through a cloth Yes, added alum or coagulant Yes, solar disinfection Yes, Settling Yes, other treatment method No Don't know	1 2 3 4 5 6 7 8 9 0 99	
I10	Can you give me a glass of water from this container?	Yes No	1 0	>>End
	How was water removed from the container or the source? *Observe.*	Dispensing from tap in storage container Pouring from container Dipping or scooping with cup or bowl Scooping with ladle Dispensing directly from the water point Don't know	1 2 3 4 5 99	
I11a	Measure free chlorine residual	_____ mg/L		
I11b	Measure total chlorine residual	_____ mg/L		
Note16	For respondents who have a private connection on plot, ask permission to take a sample directly from the tap. Run the water for 1 minute before collecting the sample.			
I13	Can I take a sample of water directly from your tap?	Yes No: permission not granted No: water not flowing at that time	1 0 2	 >>End >>End
I12a	Measure free chlorine residual	_____ mg/L		
I12b	Measure total chlorine residual	_____ mg/L		
I12c (note)	Fill a Whirlpack bag for microbial analysis and write [HOUSEHOLD ID] on the bag.			
Note17	This concludes our survey, thank you very much for your time.			
K1	Any comments or notes from enumerator. *Indicate if you have any reason to believe the respondent was not truthful.*			
K2	Record GPS			

APPENDIX G: COMPONENT 2 FOCUS GROUP GUIDE

VERBAL CONSENT SCRIPT TO PARTICIPATE IN RESEARCH (FOCUS GROUP)

My name is _____. I am a staff member at Aquaya Institute based in Accra. I would like to invite you as the head of household or a knowledgeable family member to participate in to take part in our research study. The purpose of our research is to understand satisfaction with current water supply service [name of city].

If you agree to participate in this research, I will conduct a group interview with you now. The interview will involve questions about the kind of household you live in, access to and satisfaction with water and sanitation services. The discussion should last no longer than 2 hours or until you feel that you have told me everything you want me to know.

There is no direct benefit to you from taking part in this study. It is hoped that the research will provide you with an opportunity for you to talk about some of your experiences and concerns with water services. Information from this study may help increase understanding and awareness of what it is like to live in [name of city].

With your permission, I will audiotape and take notes during the interview. The recording is to accurately record the information you provide and will be used for transcription purposes only. You have the right to review, edit, or erase any information from the interview that you do not want recorded or written down. We will not use your real name or any identifying information in any of our reports or papers. Excerpts from the recordings/transcripts may be used to illustrate the research findings. This will always be done in a way to protect your identity (e.g., comments will not be attributed). Any other material or information generated by you, such as ideas written down on paper, will be subject to the same strict controls.

Your participation in this research is completely voluntary. You can decline to answer any questions and if you do not wish to continue, you can withdraw from the interview discussion at any time for any reason.

Because focus groups include discussion of personal opinions, it is important to keep information discussed in the focus group confidential. By agreeing to participate, you agree to keep everything discussed in the room confidential.

You will not receive any monetary payment for this group discussion.

I can be reached using the contact information on the sheet that I am about to give to you [Distribute business card or flyer with Aquaya contact information]. If you agree to participate, please say so.

TOPICS FOR FOCUS GROUPS DISCUSSIONS

Topic Area	Primary Question	Secondary Question	Tertiary Question
Satisfaction	How satisfied are you with your current water service provided by GWCL?	What issues do you face with your current water supply?	Are there benefits to the GWCL piped connections?
Service reliability	Is this water service reliable. Do you trust GWCL to provide reliable service consistently and to address any issues promptly?	How often do you experience shortages of water?	Do you know the reason for rationing or intermittency of supply?
Transparency	Is there transparency and communication from GWCL about water quality and supply?	If water supply is cut, will you be notified and how will you be notified?	Are you informed about the quality of water provided? Is there additional information you would like to receive?
Existing Tariffs & Types of Payment	Do you think the amount GWCL is asking you to pay is appropriate?	Is the current method of payment simple and understandable?	Would there be a more preferable method of payment?
Alternate Vendors	Are you aware of alternate vendors and households which purchase water from sources other than GWCL?	What are the pros/cons of using alternate vendors?	Under what circumstances would you purchase water from an alternate vendor?
Existing pro-poor programs	Are you aware of existing pro-poor programs?	Do you support these programs?	Do you think these programs are effective in assuring water supply to low-income households? Why or why not?
Prepaid Metering	How have you used prepaid payment methods for your bills in the past?	Do you face any issues or have concerns about prepaid metering?	Do you think it would be convenient to prepay your water bill (in the same way electricity bills are prepaid)?

APPENDIX H: COMPONENT 3 KEY INFORMANT INTERVIEWS - TAMALE

A. Introduction and Informed Consent

Hello, my name is _____. I am a consultant working with SEGURA Consulting on a USAID project implemented by Tetra Tech ARD in connection with Aquaya. The purpose of our research is to understand the practices, perceptions, and challenges with respect to water losses in Tamale. You are being asked to participate in this interview because you work on issues related to water losses or non-revenue water and supply in Tamale.

We will try to be efficient with your time, but there is a chance that it could last more than an hour or until you feel you have told me everything you want me to know. If you agree to participate in this research, I will conduct an interview with you now.

There are no right or wrong answers, so please be honest and tell us what is true based on your experience, including if you do not know an answer or would need to consult other information in order to be able to answer. There are no personal risks or benefits to your participation. Everything that you say will be confidential, and we will not use your real name or any identifying information in any of our reports or papers. Our team may sometimes look at your record for research purposes. The results will be used to inform GWCL and other institutions in identifying, diagnosing, and addressing challenges with water losses in Tamale.

With your permission, I will record our conversation and a colleague may take notes during the interview during the interview. The recording is to accurately capture the information you provide and will be used for transcription purposes only. You have the right to review, edit, or erase any information from the interview that you do not want documented or written down. Excerpts from the recordings/transcripts may be used to illustrate the research findings. This will always be done in a way to protect your identity (e.g., your name will not be used). Any other material or information generated by you, such as ideas written down on paper, will be subject to the same strict controls.

Your participation in this research is completely voluntary. You can decline to answer any questions, and if you do not wish to continue, you can withdraw from the study at any time for any reason. You will not receive any monetary payment for your participation. An alternative is not to participate in this study.

If you have any questions or concerns about the research, please feel free to contact me. I can be reached at +___or __@ or [hand over the business card].

If you agree to participate, please say so.

[ALL QUESTIONNAIRES WILL BE SAVED BY THE INTERVIEWER REGARDLESS OF THE RESPONDENT'S DECISION TO PARTICIPATE OR NOT TO PARTICIPATE.]

B. Interview Details

Target City: Tamale
Name of interviewer:
Name of respondent(s):
Date:

ASK FOR PERMISSION TO RECORD AND START RECORDING

C. Respondent Identification

- Please tell me about yourself.
  - What is your current role?
  - How long have you been in that role? If you had other roles at this organization, what were they?
  - How much does your current role involve consideration water losses or non-revenue water?
  - Are there specific aspects of water losses (i.e. physical, commercial) on which you focus? If so, which?

D. Monthly NRW Review Meetings/Related Documents

- We have been provided with a Power Point Presentation entitled *Monthly Non-Revenue Water Meeting* from January 2022 as well as a water balance document. [Share the documents.] We would like to ask you about them.
  - Are you familiar with these documents? Did you attend the January 2022 meeting?
  - Who prepared the water balance and estimated the water loss components?
  - What 365-day time period was used to prepare the water balance?
  - If the water balance was prepared by a consulting firm, was training provide to Tamale technical employees?
  - If so which employees? Did you participate in that training?
  - Can, or have, Tamale employees periodically updated the water balance?
  - Does the Tamale utility have updated data on critical performance indicators (water production, water sales, collection efficiency, operating ratio, number of water connections and hours of service)?
  - Is the water balance for the entire Northern Region or just the City of Tamale?
  - Have any water balances been prepared for some of the districts within the city?
  - If so, which ones?

E. Demand and Consumption

- We would now like to ask some questions about the Tamale utility, how demand is calculated, and about your measurement of consumption.
  - Has the Tamale utility established District Metered Areas (DMAs)? If yes, how many and has the utility performed following activities: (i) readings in network including at the source(s), (ii) zone mapping, (iii) visible leaks assessment?
  - Can the Tamale utility calculate and forecast water demand?
  - Regarding the system input volume of 10,847,751 m3, is this measured at the water treatment plants or at the reservoirs or some other location?
  - How old are the bulk meters and are they periodically calibrated?
  - Are there bulk meters to measure system inputs into different districts of the city?
  - Regarding billed metered consumption of 4,714,213 m3, is this based on meter data or data from the customer billing files? Who provides this input?
  - How many customers make-up the billed metered consumption?

- Regarding billed unmetered consumption of 1,301,756 m3, what procedures are used to make this estimate?
- Unbilled metered consumption of 1,084,775 m3 is equal to 23% of billed meter consumption. That seems high. Why are customers with meters not being billed?
- Unauthorized consumption of 952,650 m3 is equivalent to 13% of authorized consumption. What are main reasons for unauthorized consumption and why is the margin of error (48%) so high. Please explain the methodology to make this estimate.
- Regarding customer meter inaccuracies and data handling errors of 831,920 m3, how much is due to bad meters and how much is due to data handling errors.
- Have you experience a reduction in this component of NRW as new meters were installed?
- It seems unusual to have a 0% error rate on the estimate of customer meter inaccuracies. Can you explain why this rate is 0%?

F. Prepaid Metering

- Does Tamale currently use prepaid metering?
- If so, can you describe the technology? Was it for community standpipes, individual customer meters, or both? How many prepaid meters are being used? How long have they been in use?
    - In your view, has it been helpful in reducing NRW? If so, how successful? What evidence of that success have you observed?
- If not, has Tamale ever previously attempted to utilize prepaid metering? If it did attempt prepaid metering, can you describe more about the attempt, including any successes and challenges?
- What do you see as the primary obstacles to either introduction or more widespread adoption of prepaid metering in Tamale?
- What do you see as the primary factors that could positively contribute to either introduction or more widespread adoption of prepaid metering in Tamale?
- If prepaid meters are not currently being utilized, do you see their introduction as achievable in 2-3 years? Why or why not?
- Is there someone else associated with either current or previous prepaid metering efforts in Tamale that you recommend we speak with?
- Are you aware of other cities or communities where prepaid metering has been successful? If so, can you tell us more what you know? Can you recommend someone that we talk to learn more?

G. NRW/Water Losses

- Overall, it looks like the components of NRW is 60% commercial and 40% physical. Do you have any estimates of the amount of capital expenditure that will be needed to reduce each component?
- Are physical losses calculated by components (leakage on transmission mains, leakage on distribution mains, leakage from reservoirs and overflows and leakage on customer service connections)?
- Does the Tamale utility have historic burst/leaks data?
- Does the Tamale utility calculate the International Leakage Index?
- How many leaks detection teams does the Tamale utility have and what equipment do they use?

- How many leaks repairing teams does the Tamale utility have? Please describe the procedure for service, maintenance and repair of network failures/bursts and water supply facilities.
- Slide 5 of the Power Point presentations presents water loss per district. This causes us to think the water balance presented on Slide 3 is just for the City of Tamale. Can you confirm that this is correct?
- If available, please send the water balance for each of seven districts presented on Slide 5.
- Are one or more of the districts considered a priority for NRW reduction?
- Are distribution teams and metering teams organized around these seven districts?
- Please tell us a little more about the current situation in these districts. For example, population, how water is obtained by the population in percentage terms, number of domestic and commercial customers, length, average diameter and age of the distribution main within the different districts.
- Slide 7 mentions a completed NRW Reduction Strategic Plan. Please send a copy. Slide 7 also mentions the formation of regional and district level NRW teams. Please send whatever is available about these teams.

H. Other Questions

- What is the average billing cycle?
- Has the Tamale utility performed a quality of existing household connections survey recently?
- Does the Tamale utility have defined standards for material quality and water meter accuracy?
- Does the Tamale utility outsource any tasks related to reconstruction of water supply network or maintenance?
- Does the Tamale utility supervise any construction activities on water supply network and facilities?
- Does the Tamale utility have an asset management plan?

Would you like to tell share anything else about water losses or NRW in Tamale or any other topic?

Thanks so much. Do you have any questions for me?

APPENDIX I: COMPONENT 3 KEY INFORMANT INTERVIEWS - KUMASI

A. Introduction and Informed Consent

Hello, my name is _____. I am a consultant working with SEGURA Consulting on a USAID project implemented by Tetra Tech ARD in connection with Aquaya. The purpose of our research is to understand the practices, perceptions, and challenges with respect to water losses in Kumasi. You are being asked to participate in this interview because you work on issues related to water losses or non-revenue water and supply in Kumasi.

We will try to be efficient with your time, but there is a chance that it could last more than an hour or until you feel you have told me everything you want me to know. If you agree to participate in this research, I will conduct an interview with you now.

There are no right or wrong answers, so please be honest and tell us what is true based on your experience, including if you do not know an answer or would need to consult other information in order to be able to answer. There are no personal risks or benefits to your participation. Everything that you say will be confidential, and we will not use your real name or any identifying information in any of our reports or papers. Our team may sometimes look at your record for research purposes. The results will be used to inform GWCL and other institutions in identifying, diagnosing, and addressing challenges with water losses in Kumasi.

With your permission, I will record our conversation and a colleague may take notes during the interview. The recording is to accurately capture the information you provide and will be used for transcription purposes only. You have the right to review, edit, or erase any information from the interview that you do not want documented or written down. Excerpts from the recordings/transcripts may be used to illustrate the research findings. This will always be done in a way to protect your identity (e.g., your name will not be used). Any other material or information generated by you, such as ideas written down on paper, will be subject to the same strict controls.

Your participation in this research is completely voluntary. You can decline to answer any questions, and if you do not wish to continue, you can withdraw from the study at any time for any reason. You will not receive any monetary payment for your participation. An alternative is not to participate in this study.

If you have any questions or concerns about the research, please feel free to contact me. I can be reached at +___or __@ or [hand over the business card].

If you agree to participate, please say so.

[ALL QUESTIONNAIRES WILL BE SAVED BY THE INTERVIEWER REGARDLESS OF THE RESPONDENT'S DECISION TO PARTICIPATE OR NOT TO PARTICIPATE.]

B. Interview Details

Target City: Kumasi
Name of interviewer:
Name of respondent(s):
Date:

ASK FOR PERMISSION TO RECORD AND START RECORDING

C. Respondent Identification

- Please tell me about yourself.
  - What is your current role?
  - How long have you been in that role? If you had other roles at this organization, what were they?
  - How much does your current role involve consideration water losses or non-revenue water?
  - Are there specific aspects of water losses (i.e., physical, commercial) on which you focus? If so, which?

D. Water Balance and Related Documents

- We have been provided with a water balance document for Kumasi as well as a study from the internet from roughly 10 years ago that included basic information about the Kumasi water system. [Share the documents.] We would like to ask you about them.
  - Are you familiar with these documents?
  - Who prepared the water balance and when?
  - What 365-day time period was used to prepare the water balance?
  - If the water balance was prepared by a consulting firm, was training provide to Kumasi technical employees?
  - If so what employees? Were you a part of this training?
  - Does the Kumasi utility have an NRW team/department to work on NRW reduction? If yes, could you please provide details on the NRW team (number of employees, education and position/responsibility).
  - Can Kumasi employees periodically update the water balance?
  - Does the Kumasi utility have updated data on critical performance indicators (water production, water sales, collection efficiency, operating ratio, number of water connections and hours of service)?
  - Does the Kumasi utility have a strategy to reduce NRW?
  - Is the water balance for the entire city?
  - Have any water balances been prepared for some of the districts within the city?
  - If so, which ones?

E. Demand and Consumption

- We would now like to ask some questions about the Kumasi utility, how demand is calculated, and about your measurement of consumption.
  - Has the Kumasi utility established District Metered Areas (DMAs)? If yes, how many and has the utility performed following activities: (i) readings in network including at the source(s), (ii) zone mapping, (iii) visible leaks assessment?
  - Can the Kumasi utility calculate and forecast water demand?
  - Regarding the system input volume of 32,500,763 m3, is this measured at the water treatment plant or at the reservoirs or some other location?
  - How old are the bulk meters and are they periodically calibrated?
  - Are there bulk meters to measure system inputs into different districts of the city?

- Regarding billed metered consumption of 10,350,20 m3, is this based meter data or data from the customer billing files? Who provides this input?
- How many customers make-up the billed metered consumption?
- Regarding billed unmetered consumption of 2,783,352 m3, what procedures are used to make this estimate?
- Looks like unbilled unmetered consumption of 36,000 m3 is mostly illegal connections. This seems low based on background information received so far. Please explain the methodology used to make this estimate.
- Customer meter inaccuracies and data handling errors of 2,577,198 m3 looks to be based evenly between billed meter consumption (without supply) and corrupted meter reading practices. Does the term billed meter consumption (without supply) refer to water that flows through a customer meter but is not registered on the meter?
- We note an 8.8% error rate on the estimate of customer meter inaccuracies. Please explain the methodology used to make these estimates.

F. Prepaid Metering

- Does Kumasi currently use prepaid metering?
- If so, can you describe the technology? Was it for community standpipes, individual customer meters, or both? How many prepaid meters are being used? How long have they been in use?
    - In your view, has it been helpful in reducing NRW? If so, how successful? What evidence of that success have you observed?
- If not, has Kumasi ever previously attempted to utilize prepaid metering? If it did attempt prepaid metering, can you describe more about the attempt, including any successes and challenges?
- What do you see as the primary obstacles to either introduction or more widespread adoption of prepaid metering in Kumasi?
- What do you see as the primary factors that could positively contribute to either introduction or more widespread adoption of prepaid metering in Kumasi?
- If prepaid meters are not currently being utilized, do you see their introduction as achievable in 2-3 years? Why or why not?
- Is there someone else associated with either current or previous prepaid metering efforts in Kumasi that you recommend we speak with?
- Are you aware of other cities or communities where prepaid metering has been successful? If so, can you tell us more what you know? Can you recommend someone that we talk to learn more?

G. NRW/Water Losses

- Clearly, physical losses of 16,503,986 m3 is the largest component of NRW at 85% of NRW. We will need some help to follow the logic used to make this estimate. For now, please let us know how much of the physical losses are due to pressure issues.
- Are physical losses calculated by components (leakage on transmission mains, leakage on distribution mains, leakage from reservoirs and overflows and leakage on customer service connections)?
- Does the Kumasi utility have historic burst/leaks data?
- Does the Kumasi utility calculate the International Leakage Index?

- How many leaks detection teams the Kumasi utility have and what equipment they use?
- How many leaks repairing teams the Kumasi utility have? Please describe the procedure for service, maintenance and repair of network failures/bursts and water supply facilities?
- Are the metering districts presented on Figure 5 on page 16 of the attached study still in place? If so, please update the tables by the different districts? If not, please provide similar information for any restructured district metering areas.
- Are distribution teams organized around these same districts?
- Please tell us a little more about the current situation in these districts. For example, population, how water is obtained by the population in percentage terms, number of domestic and commercial customers, length, average diameter and age of the distribution main within the different districts.

H. Other Questions

- What is the average billing cycle?
- Has the Kumasi utility performed a quality of existing household connections survey recently?
- Does the Kumasi utility have defined standards for material quality and water meter accuracy?
- Does the Kumasi utility outsource any tasks related to reconstruction of water supply network or maintenance?
- Does the Kumasi utility supervise any construction activities on water supply network and facilities?
- Does the Kumasi utility have an asset management plan?

Would you like to tell share anything else about water losses or NRW in Kumasi or any other topic?

Thanks so much. Do you have any questions for me?

APPENDIX J: COMPONENT 3 KEY INFORMANT INTERVIEWS – PREPAID METERING

A. Introduction and Informed Consent

Hello, my name is _____. I am a consultant working with SEGURA Consulting on a USAID project implemented by Tetra Tech ARD in connection with Aquaya. The purpose of our research is to understand the practices, perceptions, and challenges with respect to water losses in Kumasi and Tamale. As part of this research, one of the tasks we have been asked to explore relates to the drivers and barriers to adoption of prepaid meter technology in Ghana. You are being asked to participate in this interview because your organization is part of the ecosystem related to water service delivery in Ghana and we believe you may have knowledge and experience to share regarding prepaid metering.

We will try to be efficient with your time. We anticipate this interview will take around an hour or until you feel you have told me everything you want me to know. If you agree to participate in this research, I will conduct an interview with you now.

There are no right or wrong answers, so please be honest and tell us what is true based on your experience, including if you do not know an answer or would need to consult other information in order to be able to answer. There are no personal risks or benefits to your participation. Everything that you say will be confidential, and we will not use your real name or any identifying information in any of our reports or papers. Our team may sometimes look at your record for research purposes.

With your permission, I will record our conversation and a colleague may take notes during the interview. The recording is to accurately capture the information you provide and will be used for transcription purposes only. You have the right to review, edit, or erase any information from the interview that you do not want documented or written down. Excerpts from the recordings/transcripts may be used to illustrate the research findings. This will always be done in a way to protect your identity (e.g., your name will not be used). Any other material or information generated by you, such as ideas written down on paper, will be subject to the same strict controls.

Your participation in this research is completely voluntary. You can decline to answer any questions, and if you do not wish to continue, you can withdraw from the study at any time for any reason. You will not receive any monetary payment for your participation. An alternative is not to participate in this study.

If you have any questions or concerns about the research, please feel free to contact me. I can be reached at +___or __@ or [hand over the business card].

If you agree to participate, please say so.

[ALL QUESTIONNAIRES WILL BE SAVED BY THE INTERVIEWER REGARDLESS OF THE RESPONDENT'S DECISION TO PARTICIPATE OR NOT TO PARTICIPATE.]

B. Interview Details

Name of interviewer:
Name of respondent(s):
Date:

ASK FOR PERMISSION TO RECORD AND START RECORDING

C. Respondent Identification

- Please tell me about yourself.
  - What organization do you work for or with?
  - What is your current role at that organization?
  - How long have you been in that role? If you had other roles at this organization, what were they?

D. Prepaid Metering – Primary Information

- Can you describe your organization's experience/role in the adoption of prepaid water meters in Ghana?
  - When did it begin? Is it still continuing as of this interview?
  - In what regions or MMDAs of Ghana does/did it occur?
  - Would you characterize the specific area where prepaid meters were contemplated or adopted as urban, peri-urban, or rural?
  - Can you describe more about the communities in this specific area in terms of their cultural, occupational, and socioeconomic aspects?
  - How did or how do communities in this area primarily obtain water?
  - In your view, what were the specific challenges in these areas that led to the contemplation of prepaid meters?
  - How was the concept of prepaid meters introduced?
  - How did the community/ies receive the idea of prepaid metering?
- Can you describe the prepaid meters that were contemplated?
  - Were the meters to be used for communal standpipes, individual customers, or both?
  - What was the specific prepaid technology proposed?
  - Were alternate technologies considered and rejected?
  - Was a vendor ultimately selected? If so, which?
  - Were any vendors rejected? If so, which and for what reason?
  - Are there other features of the prepaid meters that it would be good for us to understand?
  - Are there any vendors that you recommend that we speak to?
- Was prepaid metering ultimately introduced?
  - If so, would you say it was successful? Why or why not? Can you describe more about what occurred?
  - If not, what were the primary obstacles to adoption?
    - In your view, could these obstacles have been overcome? If so, how? If not, why not?
    - Were there any subsequent attempts to reintroduce the concept of prepaid metering? If so, can you tell me about those?
- Based on your experience, what are the types of communities where you feel that prepaid metering would have the greatest chance of being successful?

- What other features that would need to be present to increase the chance of success of adoption of these technologies?
- Based on your experience, what is the single greatest obstacle to adoption of more widespread prepaid metering? Can it be overcome or worked around? If so, how?

E. Prepaid Metering – Secondary Information

- Apart from your organization's own experience, are you aware of other efforts – successful or otherwise – to implement prepaid water metering in Ghana?
- Can you share what you know about these efforts?
- Is there someone that you recommend that we speak to in order to learn more?

Would you like to tell share anything else about prepaid metering for water in Ghana?

Thanks so much. Do you have any questions for me?