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

Component 3 Report: Non-Revenue Water

April 2024

This report is made possible by the support of the American People through the United States Agency for International Development (USAID). The content of this report is the responsibility of Tetra Tech and does not necessarily reflect the views of USAID or the United States Government.

ACKNOWLEDGMENTS

This work was carried out by SEGURA Consulting on behalf of the Urban Resilience by Building and Applying New Evidence in Water, Sanitation, and Hygiene (URBAN WASH) project, with primary contributions from Paul Cumiskey and Cephas Oguah. Jorge Segura and Staci Schweizer contributed to various phases of the research including technical input, drafting, editing, and logistics. Liz Jordan, Miriam Otoo, and Tanvi Nagpal (Tetra Tech) as well as Kwabena Nyarko (Kwame Nkrumah University of Science and Technology) provided technical guidance. We also acknowledge the contributions of Faustina Boachie and the entire Ghana Water Company Limited (GWCL) teams in Accra and in the Ashanti South, Ashanti North, and Northern Regions for their collaboration and input.

Prepared for the United States Agency for International Development (USAID) by the Urban Resilience by Building Partnerships and Applying New Evidence in Water, Sanitation, and Hygiene (URBAN WASH) project, under the General Services Administration's (GSA's) One Acquisition Solicitation for Integrated Services (OASIS Unrestricted) Indefinite Delivery Indefinite Quantity (IDIQ), contract number GS00Q14OADU138 and order number 7200AA21M00012.

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ACRONYMS AND ABBREVIATIONS

AC	Asbestos-Cement
ATMA	Accra-Tema Metropolitan Area
AVRL	Aqua Vitens Rand Ltd.
BEWOP	Boosting Effectiveness of Water Operators Partnerships
CapEx	Capital Expenditure
CWSA	Community Water and Sanitation Agency
DMA	District Metering Area / District Metered Area
ECG	Electricity Company of Ghana
ESAWAS	Eastern and Southern Africa Water and Sanitation
EWASH	Effective Water, Sanitation, and Hygiene Services
GHS	Ghanaian Cedi
GIS	Geographic Information System
GUPI	Ghana Utility Performance Index
GWCL	Ghana Water Company Limited
HDPE	High-Density Polyethylene
HHC	Household Connection
HQ	Headquarters
IBNET	International Benchmarking Network
KII	Key Informant Interview
km	Kilometers
km^2	Square Kilometers
LICSD	Low-Income Customer Support Department
LiDAR	Light Detection and Ranging
m^3	Cubic Meters
MDA	Ministries, Departments, and Agencies
NGO	Nongovernmental Organization
NRW	Non-Revenue Water
O&M	Operations and Maintenance

PBC	Performance-Based Contract
PPIAF	Public-Private Infrastructure Advisory Facility
PURC	Public Utility Regulatory Commission
T&I	Technology and Innovation
UN	United Nations
uPVC	Unplasticized Polyvinyl Chloride
URBAN WASH	Urban Resilience by Building and Applying New Evidence in Water, Sanitation, and Hygiene
USAID	United States Agency for International Development
USD	United States Dollar
WASH	Water, Sanitation, and Hygiene
WASH-FIN	Water, Sanitation, and Hygiene Finance

EXECUTIVE SUMMARY

As Ghana Water Company Limited (GWCL) aims to become more financially sustainable, persistent high levels of non-revenue water (NRW) represent a clear challenge and an opportunity to increase operational efficiency, recover more revenue, and improve service delivery. Identifying sustainable solutions to address physical and commercial losses is particularly critical as GWCL works to expand and ensure adequate water supply for its rapidly growing population amid challenges with inflation, high depreciation costs, and continuing effects from the external shocks of COVID-19. As part of its work in Ghana, the USAID/Urban Resilience by Building and Applying New Evidence in Water, Sanitation, and Hygiene (URBAN WASH) project examined the causes of NRW in Ghana and recent planned efforts to combat NRW with the goal of prioritizing recommendations to assist GWCL as it works to carry out ambitious, far-reaching NRW Strategic Plans in each region.

In collaboration with GWCL, we selected two cities for this assessment: Kumasi and Tamale. Evaluation methods included interviews with GWCL at the national and regional levels, review of the regions' NRW Strategic Plans and commercial data, field visits to each region, and interviews with implementers of prepaid metering projects in Ghana.

A lack of bulk metering at key strategic points in the distribution systems in both Kumasi and Tamale, limited use of smart meters, and inadequate resources for robust leak and theft detection hamper the reliability of NRW estimates at the regional and district levels. These constraints complicate GWCL's efforts to fully understand, assess, and then address the biggest pain points in each district in terms of physical and commercial losses. Improved reliability of data—particularly through increased bulk metering—also enhances GWCL's ability to set up District Metering Areas (DMAs) in Kumasi and Tamale, which would enable GWCL to better target its NRW reduction activities. The regions' NRW Strategic Plans are ambitious and comprehensive, but they take more of a "shotgun" approach with a wide range of overlapping or simultaneous activities. A more focused prioritization of activities would help the regions better counteract the thorny commercial loss challenges in Tamale and address physical losses in Kumasi. This approach is particularly true given that resource constraints limit the ability to widely roll out new technologies or get approval for capital expenditure (CapEx)-intensive solutions like pipe replacement and rehabilitation. Performance-based contracting could be a means for GWCL to outsource efforts in each city to address specific NRW issues or implement initiatives that GWCL has been unable to sustain (e.g., DMAs), which would permit GWCL to focus its resources on key challenges and quick wins.

Prepaid metering for water supply is an attractive concept for GWCL to improve collections and revenue and offer customers greater visibility of their water usage and predictability of their costs. While GWCL, other Ghanaian government agencies, nongovernmental organization (NGOs), and private sector partners have explored prepaid metering through smaller-scale pilots, significant expansion has not occurred due to a combination of largely political and economic constraints. To consider whether GWCL can sustainably integrate prepaid metering into their range of revenue improvement activities, they must be able to be replicate and expand the concept outside of smaller, controlled environments and demonstrate economic viability.

URBAN WASH discussed these recommendations in detail with GWCL and the United States Agency for International Development (USAID)/Ghana and co-created detailed action plans to address and ameliorate NRW challenges in Kumasi and Tamale.

1.0 INTRODUCTION

1.1 BACKGROUND

Non-revenue water (NRW)[1] is an important indicator of a utility's commercial efficiency. A utility's success in reducing levels of NRW can have meaningful effects on its financial viability and abilities to provide service sustainably and effectively for its customers (Public-Private Infrastructure Advisory Facility [PPIAF] 2018). Ghana Water Company Limited's (GWCL's) national level NRW of 46 percent for the first half of 2023 represents a 7 percent decline over its highest recent value in 2017, but this level greatly exceeds the benchmark of 35 percent for developing country utilities (Kingdom 2006) and Ghana's Public Utilities Regulatory Commission's (PURC's) own internal benchmark of 45 percent. GWCL has struggled to meaningfully reduce its NRW below 40 percent since 2017 (GWCL 2022) despite implementing a range of potential solutions for addressing both physical and commercial losses, including performance-based contracting, smart metering, selective pipe replacement, and public campaigns.

A principal challenge is that Ghana's most populous regions, including the Accra-Tema Metropolitan Area (ATMA), the Ashanti Regions, and the Northern Region, perform poorest in terms of commercial efficiency (e.g., NRW, metering ratio, collection rate). In its first ever Ghana Utility Performance Index (GUPI), PURC assessed Ashanti North, Ashanti South, and the Northern Regions, along with Accra East, as three of the four "poor performers" for commercial efficiency (PURC GUPI 2023).[2]

GWCL's ability to carry out its ambitious plans to reduce NRW to 37.5 percent by 2027 is hampered by its poor financial viability. At the national level, GWCL cannot currently cover its operating costs through the revenue generated via tariffs and other fees (Component 2 Report, Ghana Buy-In), and its efforts to lobby PURC for cost-reflective tariffs are frequently stymied due to concerns about water equity and whether GWCL has been operating efficiently enough to justify its increased costs (PURC 2022). The reliability of data used to assess the components of NRW and formulate and carry out tailored strategies to address NRW challenges also limits GWCL. Due to a lack of bulk metering at the district level and at certain key points within GWCL's operating regions, GWCL must rely heavily on estimates for the various components of NRW. This lack of bulk metering also limits GWCL's efforts to implement District Metering Areas (DMAs) to more effectively manage NRW.

GWCL has committed to a comprehensive, broad-based approach to NRW reduction through its national-level NRW reduction strategy and the regions' individual NRW Strategic Plans. GWCL will share responsibility and accountability for the tall task of sustainably reducing NRW at the national, regional, and district levels. In addition to more traditional NRW reduction efforts, GWCL also has shown an openness and interest in piloting and testing NRW interventions or tools to be modeled or replicated in additional districts once successful.

Prepaid metering is an example of a more "experimental" means to increase revenue and collection by enabling customers on either standpipes or private connections to pay in advance for water via kiosks, tokens/cards, or even their mobile phones. GWCL has tried multiple times to introduce prepaid metering for water supply without broad success but has not yet abandoned the idea. Their challenges

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[1] NRW refers to the difference between the amount of water produced and the amount of water billed to customers, including unbilled authorized consumption (e.g., firefighting), physical losses (e.g., pipe bursts, leakages), and commercial losses (e.g., meter reading issues, theft).

[2] The initial GUPI was released in early 2023 as an effort by PURC to "name and shame" underperforming utilities. While PURC announced that they would release the GUPI on a quarterly basis, only the initial version covering calendar year 2021 appears to be publicly available as of the date of this report.

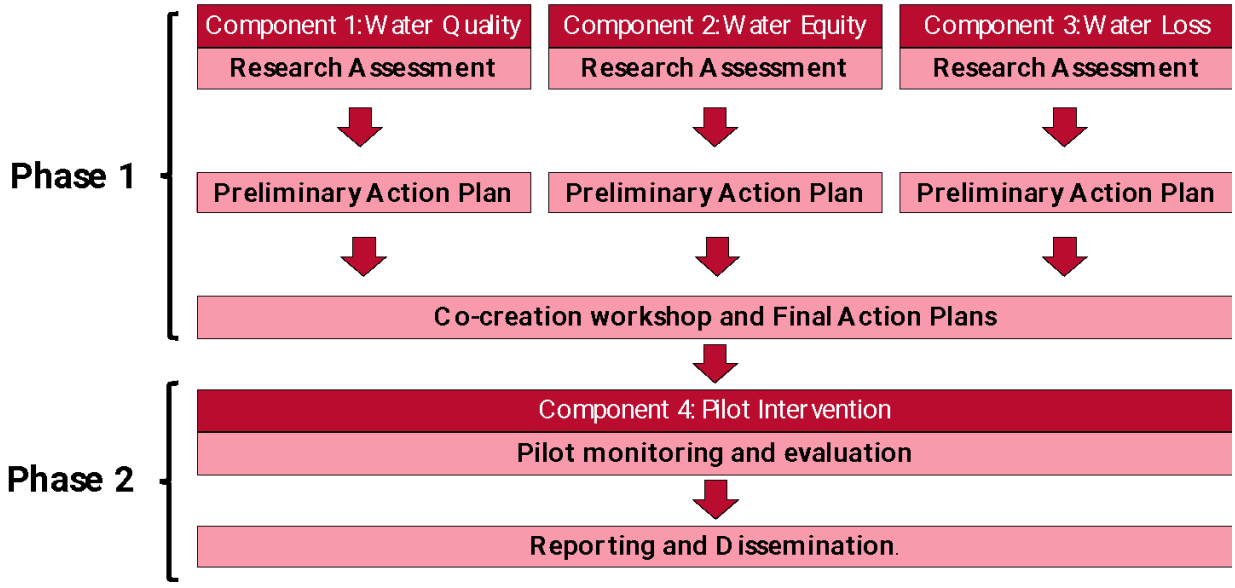
are principally twofold: 1) how to help customers understand the value of increased predictability and greater cost control, and 2) identification of solutions that balance cost and technological ease so that investment can be recouped without substantial delay through the increased revenues.

1.2 ACTIVITY PURPOSE

On July 5, 2022, the Urban Resilience by Building and Applying New Evidence in Water, Sanitation, and Hygiene (URBAN WASH) project, a centrally funded activity of the United States Agency for International Development's (USAID's) Bureau for Resilience and Food Security, received a request from USAID/Ghana to conduct research and pilot new interventions to help address **three core challenges faced by the urban water sector in Ghana: 1) improving water quality, 2) ensuring equity, and 3) reducing NRW**.

This study takes a phased approach in two cities, Kumasi and Tamale (Figure 1). Phase 1 consisted of initial assessments on water quality management, water equity, and NRW, leading to the co-development of action plans with GWCL. Findings from Phase 1 will inform Phase 2 of the activity, which includes a pilot of intervention(s) in collaboration with GWCL.

Figure 1: Study Framework Targeting Water Quality, Equity, and Losses



1.3 RESEARCH QUESTIONS

This report focuses on an assessment of NRW and prepaid metering and addresses the research questions listed in Table 1.

Table 1: Component 3 Research Questions Examining NRW and Potential for Prepaid Metering in Urban Ghana.

Topic	Research Questions
Non-revenue water	• 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?
Prepaid metering	• What is the extent of adoption, application, or acceptance of prepaid meters in the urban water supply space? • What have been the primary drivers and bottlenecks to adoption, application, or acceptance of prepaid meters in Ghana?

1.4 INTENDED AUDIENCE AND USES

The primary audiences for the research findings are GWCL and USAID/Ghana. The research team has engaged with GWCL staff in Tamale and Kumasi and at GWCL's national headquarters (HQ) as part of data collection and analysis. The assessment results and resulting action plans will provide GWCL with evidence to guide decisions regarding pilot interventions to improve urban water service delivery. USAID/Ghana and GWCL staff will identify these targeted, timebound pilot interventions to address NRW which were designed to support existing GWCL initiatives. Similarly, the outcomes of the pilots will inform USAID/Ghana's future investments in urban water programming. Secondary audiences include Ghana's Ministry of Sanitation and Water Resources; the local Metropolitan, Municipal, and District Assemblies (MMDAs); and other urban water project implementers in Ghana and other developing countries, particularly in sub-Saharan Africa.

2.0 NON-REVENUE WATER CONTEXT

2.1 NON-REVENUE WATER HISTORICAL BACKGROUND

The URBAN WASH team and GWCL selected two cities for this activity: Kumasi and Tamale. Initially, GWCL provided a list of priority cities with known challenges regarding water quality, equity, and/or NRW. Through a desk review and onsite visits, URBAN WASH then selected two cities that offered adequate geographical coverage (at least one northern Ghanaian city, in accordance with USAID/Ghana's Country Development Cooperation Strategy); sufficient population and water distribution system size; city-level GWCL representatives demonstrating interest in, and availability for the proposed activity; available data; and adequate personal safety for researchers.

Regional GWCL operating units handle GWCL operation in the cities of Kumasi and Tamale. The Ashanti Production, Ashanti North, and Ashanti South regions all contribute to water service delivery for the city of Kumasi, including the surrounding peri-urban areas. The Northern Region contains the city of Tamale and its nearby non-urban districts. While the decentralized nature of GWCL's operation is not new, the onus on its regions to assess and address NRW issues is relatively recent. To better understand the current governance and priorities for NRW at the national and regional levels, project teams must understand key points related to the historical and institutional context for NRW at GWCL:

- GWCL was established in 1999 as a state-owned enterprise with sole responsibility for urban water supply. By 2006, the World Bank had awarded a five-year contract to Aqua Vitens Rand Ltd. (AVRL),[3] which gave them full operational control of technical and commercial services and related administrative and financial functions. One of the stipulated service standards was reduction in NRW. Increasing dissatisfaction with the contract results and opposition from both the National Coalition Against the Privatization of Water and Ghana's Public Utility Workers ultimately torpedoed any chance of a contract extension, and AVRL's contract was terminated in 2011. By the end of AVRL's contract, NRW had only been marginally reduced from 53 percent in 2006 to 50 percent by 2011 (Luguterah 2017).
- In 2015, GWCL created a dedicated NRW Unit as part of its Corporate Planning and Monitoring Evaluation Department, and GWCL instituted a Performance Improvement Program as part of a larger effort to increase accountability.[4] The initiative was the first of a series of Performance Improvement Programs, which provided incentive payments for meeting or exceeding key performance indicators, including NRW reduction (PURC 2022). GWCL eventually deemed awarding incentives related to the NRW reduction target problematic because the metering systems or lack thereof were inadequate to reliably measure NRW. As a result, GWCL ignored the NRW performance indicator in the process of awarding incentive payments.
- In 2018, the NRW Unit was moved under the Department of Technology and Innovation (T&I), based in Accra followed by the hiring or identification of NRW Officers at the regional level. In 2021, each region worked with the NRW Officer and other Accra-based staff to begin

[3] AVRL was a local company established by a joint venture of the Dutch company VEI BV and the South African company Rand Water.

[4] Prior to the launch, all key positions such Regional Chief Managers and District Managers were declared vacant and advertised internally. Shortlisted applicants had to submit detailed business plans and set performance standards.

preparation of NRW Strategic Plans, which were completed in 2022 and are currently underway in each region.

- In 2023, GWCL awarded an NRW-focused performance-based contract (PBC) funded in part by the World Bank. The PBC is focused on the Accra East region, which is the third largest region by annual water sales but has the highest estimated NRW (approximately 70 percent). With a focus on the establishment of DMAs, leak detection and repair, training and knowledge transfer, and the provision of equipment, the goal is to reduce water loss in the region by 23,000 cubic meters (m^3)/day[5] (PPIAF Notice 2023).

In addition to the NRW-specific initiatives mentioned above, GWCL made the following strategic decisions, which bear on efforts to reduce physical and commercial losses:

- Starting in 2008, GWCL restricted the use of unplasticized polyvinyl chloride (uPVC) pipe in favor of high-density polyethylene (HDPE) pipe for new pipe extensions and replacement pipe projects. HDPE is superior to uPVC pipe because it is more durable, flexible, and resistant to shocks in water mains caused by power interruptions.
- Starting in 2019, GWCL required ultrasonic meters with smart reading technology to be installed on all new customer connections. Also in August 2019, GWCL launched a campaign to offer customers smart meter installation at no cost. Ultrasonic meters are more reliable and efficient than mechanical meters and can be a useful tool to better identify water theft by connected customers. The smart meter technology will also eventually be useful in monitoring NRW in established DMAs.
- Starting in 2017, GWCL began to overhaul its customer billing and payment system and eventually added mobile payment. They completed the transition in 2022 and will further enhance services with the expansion of smart meters to speed up bill processing and improve collection rates.
- In 2021, GWCL inaugurated its first meter testing laboratory and telemetry room in Accra. Establishing additional meter testing laboratories will help assess the reliability of meter measurements and refine estimates included in the biannual water balances prepared by each region. The planned upgraded facility in Kumasi is not yet fully rehabilitated, and a third meter testing laboratory contemplated for Tamale is currently undergoing procurement. (Interview with GWCL NRW Office 2023).

2.2 MANAGEMENT STRUCTURE

Responsibility for reducing NRW rests with GWCL's Department of T&I located in Accra, which includes a NRW Unit that was instrumental in overseeing the development of NRW Strategic Plans by each region. The department collaborates closely with the regions to implement planned NRW reduction efforts and monitors NRW reduction progress in the regions to assess GWCL's performance.

While GWCL decides the strategic direction of nationwide NRW reduction efforts at the HQ in Accra, on-the-ground efforts to reduce NRW occur at the regional level including the districts. Although the organizational charts for the regions differ slightly, similar departments carry out the work that most closely affects NRW.

District operations include activities to address both physical and commercial losses, such as efforts to respond to pipe bursts and leakage, maintain fire hydrants and operate valves, extend new mains to

[5] To add some context to this figure, the World Bank's goal for the NRW reduction activities in Accra East is a sustained decrease of 1.5 percent per year over three years, for a cumulative reduction of 4.5 percent (World Bank 2020).

connect new customers, read customer meters, deliver water bills, and search for unauthorized uses of water. Considering the fragile pipe network, much of the work apart from meter reading is related to responding to pipe bursts and leakage.

The T&I and NRW functions collaborate closely with their counterparts in Accra and monitor the NRW efforts performed by district operations. In addition to traditional internal audit activities, the Internal Audit Department checks the depth and quality of new pipe extensions and service lines. Employees involved in commercial operations maintain the customer cadasters, supervise and monitor meter reading activities, manage customer billing and collection activity, and approve new customer applications. They also look for unusual customer use trends to spot potential meter irregularities.

3.0 STUDY CITIES

3.1 KUMASI

The Ashanti South and Ashanti North Regions Water manage the distribution and customer service activities in Kumasi. The Ashanti Production Region is responsible for operations and maintenance (O&M) of water production and water booster stations. Two water treatment plants that have a combined average daily production of 129,500 m^3/day and over 1,000 kilometers (km) of water transmission and distribution mains service approximately 100,000 water customers in Kumasi. (Ashanti Strategic Plans 2022). In most areas of Kumasi, water service is available seven days a week but ranging anywhere from 12 to 24 hours per day (GWCL Response to Data Request 2023).

Two water treatment plants provide water service in Kumasi. The Barekese water treatment plant is the larger of the two plants with average daily production of 120,000 m^3/day. The Offin River water source and Barekese plants are 19 km from the Kumasi city limits. The Owabi water treatment plant draws water from the Owabi River and has an average daily production of 9,500 m^3/day. The Owabi water treatment plant is 10 km from the Kumasi city limits. Water from both plants flows to the 9,000 m^3 Suame water storage facility. As no bulk meter exists at the distribution point between the two Ashanti regions, roughly 55 percent of the flow is diverted to the Ashanti North Region and 45 percent to the Ashanti South Region based on sales volumes in each region. Water supply from both water treatment plants flows primarily via gravity, but some pumping is required from the Owabi River to the Owabi water treatment plant. Two booster stations serve as part of the transmission system and additional storage. Prior to 2023, water production at both treatment plants was estimated largely based on pump run time.[6] Bulk water meters were installed in 2022 and calibrated in early 2023.

Ashanti South, Ashanti North, and Ashanti Production regions have a total of roughly 700 employees of which approximately 58 percent are involved in district operations and nearly 30 percent focused on production. The remaining 12–13 percent of employees cover many of the departments whose activities affect NRW and all of the internal functions (e.g., communications, finance, human resources), including the Regional Chief Manager, support staff, and others.

Of the seven districts in the Ashanti South region, the five districts that are within the city limits of Kumasi are below:

Table 2: Kumasi Districts Served by Ashanti South Region

	Southeast	West 1	West 2	Central	South
1. Land area (square kilometers [km^2])	103	51	238	15	158
2. Number of customers	3,570	10,248	7,954	8,259	9,580
3. Density (customers/km^2)	35	201	33	551	61
4. Percentage of customers billed (%)	43%	71%	72%	69%	65%
5. Number of active standpipes	14	7	8	8	15
6. Bill collection percentage (%)	75%	93%	95%	95%	84%
7. Length of main (km)	65	130	105	87	106

[6] Water production estimates are based on the rated capacity of the pump to produce "x" m^3 per minute multiplied by the total number of minutes pumps are in operation.

	Southeast	West 1	West 2	Central	South
8. Main breaks and leaks/km	5.0	2.7	3.2	4.5	7.0
9. Average monthly m^3 billed	16,236	179,016	101,523	287,509	155,053[7]
10. Percentage government m^3 billed (%)	0%	26%	8%	48%	1%
11. Average monthly m^3/active customer	11	24	18	50	25
12. Estimated district NRW	66%[8]	50%	50%	50%	50%

Source: Compiled from the NRW Strategic Plan for Ashanti South and estimated district NRW.

Of the nine districts in the Ashanti North region, the six districts that are within the city limits of Kumasi are below:

Table 3: Kumasi Districts Served by Ashanti North Region

	East	North A	North B	North east	North west	Asokore Mampong
1. Land area (km^2)	19	162	21	129	257	17
2. Number of customers	10,216	14,454	12,881	9,207	10,997	4,243
3. Density (customers/km^2)	538	89	613	71	43	250
4. Percentage of customers billed (%)	75%	85%	74%	63%	70%	69%
5. Number of active standpipes	51	111	37	53	89	51
6. Bill collection percentage (%)	88%	84%	74%	63%	61%	73%
7. Length of main (km)	77	140	94	84	113	43
8. Main breaks and leaks/km	5.1	4.9	7.3	5.6	5.3	8.5
9. Average monthly m^3 billed	209,536	156,136	251,093	96,044[9]	148,400	52,071
10. Percentage government m^3 billed (%)	4%	2%	2%	4%	6%	10%
11. Average monthly m^3/active customer	27	13	26	17	19	18
12. Estimated district NRW	48%	56%	47%	58%	43%	39%

Source: Compiled from the NRW Strategic Plan for Ashanti North.

The 100,000-plus customers in the Kumasi urban districts represent approximately 82 percent of the total number of customers serviced by Ashanti North and Ashanti South, so reducing physical and commercial losses in these districts will have a greater effect on reducing regional NRW. The same is

7 This district includes a Guinness brewery that was opened in late 2022. In 2023, when the brewery is operating every month, the average monthly cubic meters of water billed should increase, and more revenues will be collected.

8 This district only receives water at night, which makes it harder to identify and address leaks and breaks.

9 This district is experiencing customer losses due to water supply challenges and the emergence of private borehole operations, so the average monthly cubic meters of water billed will likely decline, creating revenue loss.

The 100,000-plus customers in the Kumasi urban districts represent approximately 82 percent of the total number of customers serviced by Ashanti North and Ashanti South, so reducing physical and commercial losses in these districts will have a greater effect on reducing regional NRW. The same is true for the denser districts within these regions (e.g., Central, East, North B).[10] At the same time, reducing NRW in denser, urban areas where there is a preponderance of older mains is typically more expensive, and road congestion can interfere with efforts to identify and respond to leaks and bursts or to undertake more substantial efforts to rehabilitate the network via pipe replacement.

Other key features of Kumasi that are relevant to the discussion of NRW that follows include:

- A high level of leaks and breaks per kilometer is consistent with high proportion of physical losses;
- None of the districts have bulk water meters to measure the volume of water received. Instead, the NRW estimates by district are based on monthly desk reviews of projected versus actual water sales;
- The district has a relatively high percentage of non-billed customers (i.e., suspended or disconnected customers);
- Per the PURC's GUPI, Ashanti South and Ashanti North both rate as a "poor performer" for commercial efficiency (e.g., NRW, collections ratio, metering ratio). Ashanti North also rates as a poor performer—the only region to do so—for operational efficiency (capacity utilization, energy cost/m3, chemical cost/m3, operational cost/m3) (PURC GUPI 2022).

3.2 TAMALE

The Northern Region, the largest GWCL region by land area, manages water operations in Tamale. The Dalun water treatment plant, which has an average daily production of 33,000–35,000 m^3/day and about 500 km of water transmission and distribution mains,[11] exclusively serves nearly 47,000 customers in Tamale. Water service in Tamale is intermittent with a few days of water per week in each district.

Water from the Volta River is pumped to the Dalun water treatment plant, which is 39 km from the Tamale city limits. Treated water from the Dalun plant flows through several unmetered offtakes en route to the 20,000 m^3 Kukuo Yepalsi Reservoir. Most of the water from the Kukuo Yepalsi Reservoir flows by gravity to the districts in Tamale. GWCL has purchased but not yet installed a bulk water meter.

GWCL has 244 employees in the Northern Region. By way of comparison, the Northern Region has only 32 staff focused on district operations with another 6 at the regional level focused on distribution, physical losses, metering, etc. However, the Northern Region does have numbers of commercial staff commensurate with Ashanti South and numbers of T&I personnel commensurate with both Ashanti North and South.

Of the seven districts in the Northern region, the five districts that are within the city limits of Tamale are below:

Table 4: Tamale Districts Served by the Northern Region

	East	Northeast	West	Southwest	Dalun
1. Land area (km^2)	287	259	221	116	1,213

[10] Assuming five users per customer connection, the three densest districts are comparable to those of large American cities, while the West 1 District would be comparable to a small city in the United States.

[11] Notes from field visit meeting with Northern Region staff in September 2023.

	East	Northeast	West	Southwest	Dalun
2. Number of customers	14,297	8,608	6,742	13,803	3,393
3. Density (customers/km^2)	50	33	31	119	3
4. Percentage of customers billed (%)	77%	77%	59%	71%	76%
5. Number of active standpipes	74	42	98	49	268
6. Bill Collection percentage (%)	90%	91%	110%	77%	87%
7. Length of main (km)	102	71	89	115	120
8. Main breaks & leaks/km	2.8	3.4	1.3	2.3	1.9
9. Average monthly m^3 billed	156,778	87,951	47,808	144,112	102,068
10. Percentage government m^3 billed (%)	21%	27%	13%	9%	65%
11. Average monthly m^3/active customer	14	13	12	15	40
12. Estimated district NRW (2023 data)	45%	40%	44%	46%	43%

As would be expected given Tamale's smaller size and more rural nature, Tamale's districts are far less dense compared to Kumasi. In particular, the Dalun district is an outlier in terms of understanding Tamale due to low density, a very high proportion of government customers, and a high proportion of standpipes relative to population.

Other key features of Tamale that are relevant to the discussion of NRW that follows include:

- Compared to Kumasi, the lower level of leaks and breaks per kilometer is consistent with the higher proportion of commercial losses;
- The lower metering ratio is consistent with Tamale's challenges in reducing commercial losses;
- As with Kumasi, none of the districts have bulk water meters to measure the volume of water received. Instead, the NRW estimates by district are based on monthly desk reviews of projected versus actual water sales;
- Similar to Kumasi, Tamale has a relatively high percentage of non-billed customers (i.e., suspended or disconnected customers); and
- Per the PURC's GUPI, the Northern Region rates as the worst "poor performer" for commercial efficiency (e.g., NRW, collections ratio, metering ratio) (PURC GUPI 2022).

4. METHODS

To address the research questions, we used mixed methods to explore GWCL's NRW in the target cities and the opportunities and challenges for prepaid metering.

4.1 NON-REVENUE WATER ASSESSMENT

The team designed the NRW assessment to help answer the first four research questions focusing on: 1) the reliability of NRW data, 2) the causes of NRW, 3) the effectiveness of measures to address NRW, and 4) activities to reduce theft and uncollectable accounts.

Across all research questions, the team reviewed the NRW Strategic Plans produced by each region, which helped to understand the causes of NRW as well as the ongoing and planned management measures. The team also reviewed other material produced by each region or GWCL HQ in Accra, including water balances that help to understand the reliability of data, detailed monthly commercial reports that help to understand metering and collections, and presentations produced by some regions on their NRW progress. Based on these materials, the team developed questions and data requests that they sent to each region. They followed up with the Regional Chief Managers and NRW Managers to try to clarify responses or obtain additional data. The team also prepared profiles with key characteristics of the districts within the Ashanti South and Ashanti North regions that comprise Kumasi and the districts within the Northern Region that comprise Tamale.

URBAN WASH conducted field visits to the three regions in September 2023. In preparation for visits and to obtain additional information regarding GWCL's national strategies for NRW, we communicated via phone calls and email with Accra-based staff, including the NRW Manager; Chief Manager for Corporate Planning, Monitoring, and Evaluation; and Chief Manager for Operations. The team also developed a list of questions to discuss with GWCL staff and identified two districts per region to observe on-the-ground conditions: the Southwest and East districts of Tamale, the South and West 1 districts of Ashanti South, and the North A and North B districts of Ashanti South.

For the visits, we conducted an entry meeting with each Regional Chief Manager or his designee and then held a plenary session/focus group discussion with regional staff that included the NRW Managers, commercial and production staff, and in certain cases, district management and staff. This session focused on identifying the full range of causes of NRW and then drilling down via a ranking exercise on the NRW issues of primary importance to the assembled team members. The team was also able to review the availability of geographic information system (GIS)/mapping data to assess and address leaks and bursts. As part of discussions with the regional staff, we verified their view of whether the selected districts in fact were representative of the key NRW challenges in each region.

After the meetings, the team observed the existence and condition of equipment at the regional offices, including meters, vehicles, and pressure loggers. The team also viewed the Kumasi laboratory, which has been awaiting rehabilitation for several years to provide an option for meter testing. Along with the NRW Managers, the team then conducted visits to districts in each of the three regions, observing key installations (e.g., the Bagabaga Reservoir in Tamale), areas with exposed pipes or leakages, and customer meters.[12]

[12] Due in part to the ability to obtain data prior to the meetings via direct connection with regional staff and the information learned during the in-office meetings, the team did not conduct a systematic study in each of the six selected districts to view the same conditions. While the teams make recommendations at the regional level and co-creation also occurred at the regional level, this change in approach to visiting the districts is a deviation from the original plan and can be considered a limitation to the findings in this report.

Following the visit, the team continued to engage with GWCL staff at the national level to obtain additional information on GWCL's NRW activities prior to the NRW Strategic Plans and to get updated data (e.g., water balances, commercial data) from the regions to refine its analysis.

4.2 PREPAID METERING ASSESSMENT

The prepaid metering assessment sought to understand: 1) the history of prepaid metering for water supply in Ghana, 2) the experiences of ongoing pilots to introduce prepaid metering, and 3) the drivers and barriers to wider adoption of prepaid metering.

To obtain information related to the previous history of prepaid metering in Ghana, we reviewed desk materials including those prepared by GWCL and PURC as well as those prepared by civil society groups that have maintained opposition to prepaid metering. This topic was also covered via interviews with staff from GWCL and Community Water and Sanitation Agency (CWSA). The team also reviewed secondary research conducted in Ghana related to the success or lack of success for Ghana in introducing digital and mobile solutions including prepaid metering.

To understand more about the current prepaid metering pilots, the team conducted interviews with GWCL; CWSA; SafeWater Network, a nongovernmental organization (NGO) operating in Ghana and other countries; and Grundfos, a private equipment manufacturer. Review of available materials prepared by these implementers regarding their pilots complemented the interviews.

To understand the drivers and barriers for prepaid metering, we synthesized information from the interviews and reviewed secondary materials on the successes and failures of prepaid metering in other urban contexts and assessments of prepaid metering done by other USAID projects. This review allowed us to group the types of drivers and barriers into political, economic, sociocultural, and technological factors. We also reviewed and included relevant information from the household survey conducted in conjunction with Component 2, which offered insight into the specific views of residents of Tamale and Kumasi on their openness (or not) to prepaid metering for water supply and the primary reasons supporting those views.

4.3 LIMITATIONS

Assessing NRW at the city level has two principal limitations. First, in the case of Kumasi, two operating regions and one production region cover the city. Each of the regions has its own staff and maintains separate data. The NRW Strategic Plans were also developed at the regional level and not at the city level. In addition, each of the regions contains additional districts that are not included as part of the city, and based on the presentation of data, teams could not isolate and remove data for non-urban districts in all cases.

Another limitation is that data was not equally available across all three regions or was maintained in different formats or could not ultimately be obtained despite many requests, which made it hard to reconcile and compare. Ashanti South, for example, had more detailed, GIS-based burst and leakage info than Ashanti North or Tamale. The team tried as much as possible to use sources that were maintained in equivalent forms, including choosing timeframes that were consistent across all three regions (e.g., where commercial data was available through June in one region, April in another, and September in a third, the frame of reference would be April). In certain cases (e.g., the regional water balances) the most available data was for a half-year period, so the results needed to be extrapolated to a full year.

In terms of the prepaid metering assessment, observing the prepaid metering pilots being conducted by GWCL or CWSA in-person and engaging directly with customers who are utilizing prepaid meters for water supply would have been beneficial to understanding the positive and negative aspects to their experience. This approach would have provided additional context to the customer perspective beyond the more limited household survey results.

The recommendations are geared toward the respective cities, but the regions operate separately, which presents a potential limitation in developing the recommendations for NRW reduction activities, Ashanti South and Ashanti North share some NRW challenges, but they have their own plans and have made different levels of progress toward accomplishing planned activities. While the recommendations are geared toward the cities, GWCL HQ sets the national-level priorities to address NRW and controls what funding is available for NRW reduction efforts This includes how to prioritize and schedule capital expenditure (CapEx)-intensive solutions like installations and replacements for transmission and distribution, or construction and rehabilitation for plants, meter testing laboratories, and other facilities.

5.0 FINDINGS

5.1 TO WHAT EXTENT IS NON-REVENUE WATER BEING RELIABLY MEASURED AND ESTIMATED?

GWCL estimates NRW, sets its own targets, and monitors NRW at the national, regional, and district levels as a key performance indicator of effective utility management. PURC also evaluates GWCL against a benchmark of 45 percent as part of its assessment of whether GWCL is operating in a commercially efficient manner.[13] However, despite the importance of NRW as an indicator, significant limitations exist in the way that GWCL measures and estimates or calculates NRW. Many estimates, including the ones in Table 5 (below) are subject to significant margins of error, which is an explicit acknowledgement of the lack of reliability of the underlying data.[14] As a result, these estimates provide limited reliability for purposes of assessing and addressing physical and commercial losses.

Table 5 below compares annualized versions of the 2022 water balances included in the NRW Strategic Plans prepared by each region.[15]

Table 5: Regional Water Balances in Cubic Meters per Year

	Ashanti North	Ashanti South	Northern
System input (m^3/year)	23,372,836	21,624,790	11,206,180
Less billed use (m^3/year)	-12,627,668	-10,245,185	-7,270,210
= NRW (m^3/year)	10,745,168	11,379,905	3,935,970
NRW (%)	46%	54%	35%
• Authorized unbilled use[16]	1%	1%	29%
• Commercial losses	15%	17%	37%
• Physical losses	84%	82%	34%

The system input value in all cases is derived from estimates of water production, which are based on pump run time. The billed use is based on metered and estimated use from unmetered customers or customers with faulty meters. The latter accounts for approximately 29 percent in Ashanti North and

[13] PURC has used the 45 percent benchmark since at least 2005, which reflects regional and international benchmarks. For example, PURC cited Uganda (approximately 38 percent) and Kenya (approximately 47 percent) as relevant regional benchmarks (PURC 2005; 2022). As noted in the Component 2 Report, GWCL proposes tariff increases to PURC that it deemed necessary to cover its costs. In evaluating these requests, PURC considers—as part of balancing equity concerns—the extent to which GWCL has been operating efficiently. Customers should not bear the brunt of increased costs through higher tariffs as a result of poor performance and operating inefficiencies by GWCL.

[14] For example, a six-month water balance obtained for Ashanti South for January–June 2023 demonstrates continuing high error margins for water losses overall (49.7 percent), physical losses (68.4 percent), and ultimately NRW (49.3 percent).

[15] Because the water balances are prepared at the regional levels, they consider all districts in the region and not just the ones that constitute Tamale and Kumasi. Water balances are not currently prepared at the district level.

[16] This quantity indicates water used for firefighting and to flush hydrants and mains. The Northern Region Strategic Plan also includes water for schools, religious institutions, GWCL and government use, and special contract customers (in-kind payment).

22 percent in Ashanti South and the Northern Region.[17] The unmetered billed use is estimated based on factors, including the size of the customers dwelling, number of family members living in the house, and consumption history when available in the electronic billing system. Meter readers make these estimates, and the District Managers approve these estimates. NRW percentage equals NRW divided by system input.

The commercial loss percentage is based on estimates of unauthorized water use (i.e., theft from illegal water use) and meter inaccuracies and billing errors. Without bulk meters, it is difficult to reliably assess the extent of physical losses. Regions can determine physical losses either by subtracting commercial losses from total losses or by estimating physical losses (to some extent) based on data from mapped bursts and leakages. The latter method requires them to make significant assumptions related to water quality flushing and draining of transmission mains. In addition to the regional level concerns noted above, estimates made at the district level are also unreliable. While regions do make estimates of NRW at the district level, these are not based on system input as there are no bulk meters at points that water is delivered to the districts. The barriers to greater utilization of bulk meters at these important points are both financial and logistical. For example, distribution lines in both cities may run through several districts, complicating the placement of bulk meters in a way that most closely attributes the correct system input to each district. There must be effective mapping to understand where best to place the meters and having necessary time and resources to install them, test them after installation, and regularly monitor their readings to assess continuing reliability.

The methodology described above relies heavily on estimates due to several key factors that undermine NRW reliability:

- There were no bulk meters in place and operational in 2021 and 2022 to measure water production and thus no way to reliably measure system input volume at key distribution points. While production meters are now in place in water treatment plants in the Ashanti Region, there are still no bulk meters to measure the water flow to Ashanti North and Ashanti South. GWCL installed a bulk meter for the Northern Region in 2022, but the meter was not yet commissioned and operational by September 2023 during the field visit as part this report. Since the visit, production meters have been commissioned and are in operation.
- Commercial losses include an estimate of meter inaccuracies since no meter testing facility exists in either region.[18] Loss is compounded by the lack of comprehensive meter inventories to provide an accurate picture of age, condition, etc. An inventory exists for the Ashanti Region but only for those meters installed after 2016, but no inventory exists for the Northern Region. While the Ashanti Region was scheduled to complete an assessment of meter accuracy in November 2023, the Northern Region had not scheduled an assessment. For these reasons, commercial loss estimates in the Northern Region may be less reliable than anticipated.
- The lack of meter testing or inventory[19] would be less problematic from a reliability standpoint if smart meter utilization and replacement were more robust. Although ultrasonic smart meters are being installed in all regions, they are still a minimal part of the regions' overall meter

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[17] GWCL Strategic Plans 2022. Customers may be unmetered where GWCL lacks sufficient meters for installation or where a meter becomes defective or is tampered with and GWCL is either unaware or delayed in providing a replacement.

[18] GWCL has been trying to expand or upgrade its meter rehabilitation and testing capabilities past the facility completed in Accra in June 2021. Assessment for the Kumasi "Metershop" is complete, but the rehabilitation is part of the GAMA Project currently being implemented by the World Bank. While there are designs/procurement for a Tamale "Metershop," construction is not yet complete despite a target of October 2022.

[19] Meter inventory refers to the database of installed customer meters, and captures information such as meter size, type, serial number, date installed, and maintenance carried out.

coverage. For example, Ashanti South and North reported that only 1 percent and 4 percent of their total meters were smart meters even though GWCL started installing smart meters in 2018. According to PURC's 2022 Annual Report, the three regions had only about 1000 total smart meters installed (PURC Annual Report 2022).[20]

- As noted above, regions have limitations in how they develop physical loss estimates.[21] However, they also report having a lack of adequate leak detection equipment/personnel and a need to respond more quickly to known leaks, which exacerbate the risk of greater physical losses and suggest the regions may be underestimating the physical loss component of their NRW.

5.2 WHAT ARE THE PRIMARY DRIVERS OR SOURCES OF NON-REVENUE WATER?

As part of the process of developing their Strategic Plans, each region provided their assessments of the leading factors—in terms of both physical and commercial losses—that contributed to NRW (NRW Strategic Plans 2022). Given the time since the development of those plans began, based on review of documentation provided by each region and in-country feedback from the NRW staff in the two cities, the charts below highlight the most significant contributing factors to NRW from a common set of contributors to physical and commercial losses developed by the URBAN WASH team.

Table 6: Primary Causes of NRW in the Target Cities

	Main Causes	Kumasi	Tamale
Physical losses	Old, deteriorating, and inadequate infrastructure	• Old asbestos-cement (AC) pipe (50+ years old) subject to burst • Long uPVC service lines with visible leaks • Exposed pipe due to erosion	• Old AC pipe (50+ years old) subject to burst • Long uPVC service lines with visible leaks
	Uncontrollable factors	• Road contractors causing leaks or pipe breaks	• Road contractors causing leaks or pipe breaks
Commercial losses	Meter reading issues	• Lack of production and district bulk metering • Old and malfunctioning customer meters • Unmetered customers • Unread meters	• Lack of production and district bulk metering • Unmetered customers • Unread meters

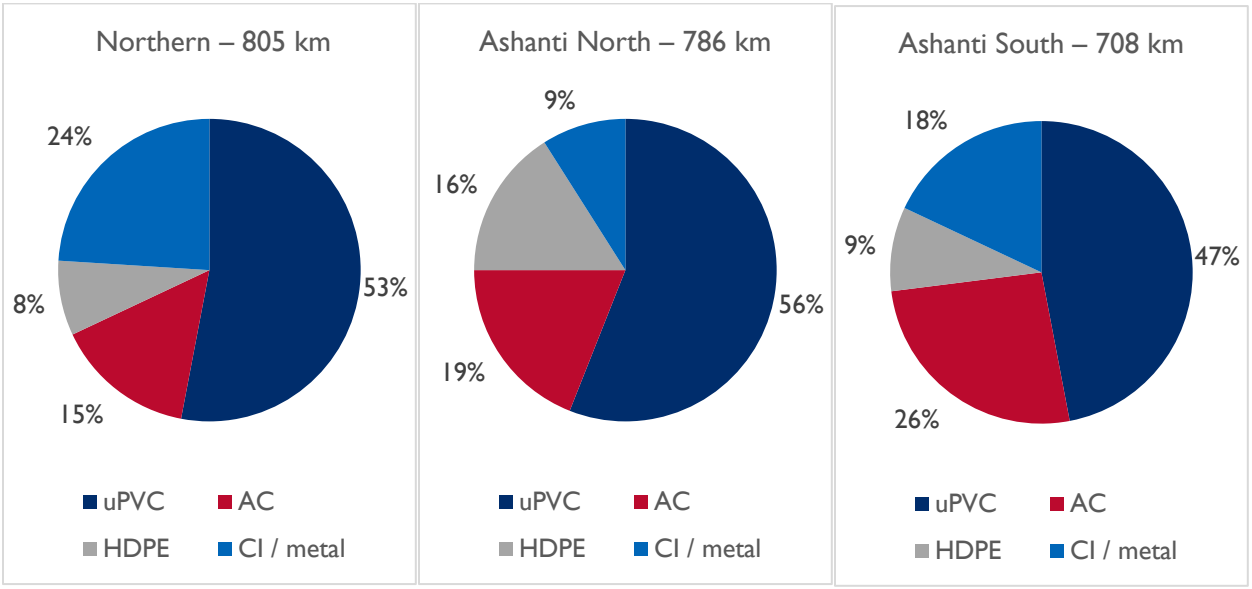
[20] As flagged by GWCL management at the January 2024 co-creation workshops, the slow uptake in smart meter installation is due to the interplay between their comparatively higher per-unit costs and the significant constraints on GWCL's financial resources.

[21] In the absence of DMAs and robust bulk metering, the best practice for calculating physical losses for the water balance is to use both a top-down approach (to subtract the estimated commercial loss from the System Input Volume to calculate leakage) and a bottom-up approach (measure leakage and subtract from the System Input Volume to calculate commercial loss). Currently, GWCL cannot use the bottom-up method for each of the cities as they cannot adequately measure leakage.

	Main Causes	Kumasi	Tamale
	Unauthorized consumption	• Unknown and untraceable customers • Disconnected customers/meter tampering[22] • Water theft on transmission mains/illegal connections	• Water theft on transmission mains/illegal connections

In terms of pipe installation, replacement, and maintenance, AC pipe and long uPVC pipe are primary culprits for leaks and breakages. As presented in Figure 2 below, AC and uPVC pipes account for over 70 percent of the total kilometers of pipe across Ashanti South, Ashanti North, and the Northern Region.

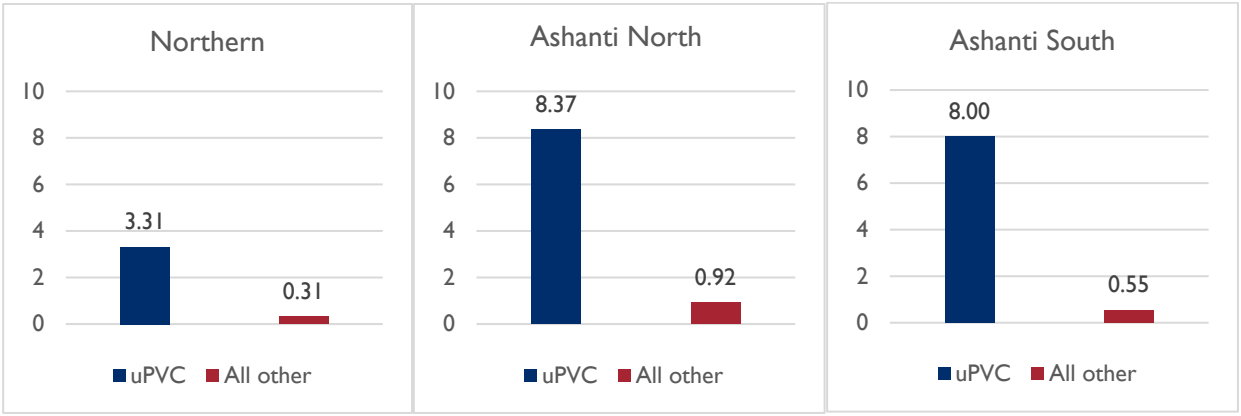
Figure 2: Water Pipe by Type of Material



The AC, cast iron (CI), and metal pipes are more than 50 years old and known to burst and leak, while uPVC pipes are also very old and mostly used for service lines that are very long and not buried at sufficient depth. As a result, uPVC pipe has a history of breaks due to soil erosion that exposes the pipe and is further exacerbated when heavy vehicles being utilized by road contractors travel over the pipe during construction projects. As shown below, on a per kilometer basis, uPVC accounts for a far higher number of breaks.

22 Disconnected customers can often find ways to reconnect to the network either through a still-present meter or other means to maintain their consumption.

Figure 3: Water Breaks and Leaks per Kilometer



About 15 years ago the use of uPVC pipe was discontinued in favor of HDPE pipe, which is more durable, flexible, and resistant to shocks in water systems with intermittent service. As GWCL extends and replaces pipes due to bursts and known leakage, the percentage of HDPE pipe will increase, which should result in fewer pipe bursts and less leakage. In Ashanti South, for example, the rate of replacement over the last 10 years has been less than 1 percent (GWCL KII – Ashanti South 2023), which is true even though up to 50 percent of the water network is more than 50 years old (GWCL Ashanti South Strategic Plan 2022). While on the field visit, the team visited a pipe burst in the West 1 District, which was promptly reported and crews were repairing.

In addition to pipe leakage concerns, Tamale also reports leakages at two of its service reservoirs: Bagabaga and Kaladan. The team observed the leakage at Bagabaga during this field visit. Due to leakages, GWCL is maintaining Bagabaga at one-third of its capacity, and Kaladan is not in use (GWCL KII – Northern 2023).

Although the infrastructure challenges are considerable, additional contributing factors affect physical losses: the identification and repair of visible leaks and active leak detection. While the regions map bursts and leakages to varying degrees,[23] none of the regions currently has dedicated active leak detection teams or the equipment to help assess invisible leaks (GWCL KII – All, 2023).[24] As observed as part of the field visit, NRW personnel in Tamale did not have access to their own vehicle and needed to utilize available vehicles in the motor pool,[25] whereas one pickup truck was available in each of Ashanti South and Ashanti North, both observed to be in good condition. While GWCL reported leak detection equipment was available, but teams did not observe the equipment at the regional offices or in the districts.

The lack of comprehensive meter inventories and the current inability of any of the three regions to test its meters without relying on the Accra facility both contribute to commercial losses. As noted above, regional offices and districts rarely utilize smart meters and continue to rely on older mechanical meters, which are more error-prone and under-register water consumption.

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23 In terms of general GIS capabilities, the team noted from a review of the systems at the regional offices that Ashanti North and South had largely complete data except for the age of the pipes, whereas the Northern Region had incomplete mapping and data gaps, including the age of the pipes.

24 Leakage may either be visible (showing above ground) or invisible (not apparent above aground). Regional offices have not used leak detection equipment and other technologies to locate invisible leaks.

25 After the field visit and prior to finalization of this report, GWCL assigned a dedicated vehicle to the NRW Unit in the Northern Region.

From the metering perspective, commercial data from the three regions for 2023 shows a significant difference between the regions. Monthly metering coverage ratios ranged from 73 percent to 83 percent (Northern), 79 percent to 84 percent (Ashanti North), and 88 percent to 92 percent for Ashanti South.[26] For July 2023, the three regions reported consistent high percentages of unbilled customers (25 percent to 32 percent).[27] Of these percentages, disconnected customers represented the largest portion (compared to suspended/other customers) ranging from 64 percent in the Northern Region to 87 percent in Ashanti South (GWCL Regional Commercial Reports 2023). GWCL provided this high rate of disconnected or untraceable customers as a reason that 54 percent of meters showed no use in the Ashanti South NRW Strategic Plan. The low use and zero use meters that teams observed as part of the field visit were operable.

Water theft covers meter tampering, unauthorized consumption from hydrants, and illegal connections. Based on discussions, the regions cited water theft as a key driver for commercial losses in Tamale, where they discover an estimated 20 new illegal connections per month, and Ashanti North. Tamale also noted theft from fire hydrants. (GWCL KII – All, September 2023). While the regions have planned field surveys to better understand the extent of illegal connections, the surveys are challenging to implement comprehensively due to evasion of detection and hostility toward GWCL employees engaged in these tasks, particularly in the Northern Region.

5.3 TO WHAT EXTENT HAVE IMPLEMENTED MANAGEMENT MEASURES BEEN EFFECTIVE IN REDUCING NON-REVENUE WATER?

5.3.1 NON-REVENUE WATER MANAGEMENT MEASURES PRIOR TO STRATEGIC PLANS

As noted above in the contextual background section, GWCL did not establish a dedicated NRW Unit at the national level until 2016. Despite intentions to staff NRW Units in each region and district, by December 2018, GWCL still focused on introducing NRW reduction measures in the regions with the greatest contributions to nationwide NRW, the three regions of the ATMA and the two Ashanti Regions. Their focus reflected an increasing trend of NRW at the national level above 50 percent from 2015 to 2018 following four years of consecutive decreases between 2010 and 2013 below 50 percent (GWCL, 2018). GWCL planned specific initiatives for Ashanti, including efforts to deploy dedicated NRW staff, institute annual meter calibration, upgrade the Kumasi meter testing laboratory, and meter Ashanti's regional and district boundaries. (GWCL Tariff Proposal 2018). By comparison, specific NRW plans for the Northern Region in December 2018 included only a mention to "revive 10 DMAs."[28] Likewise, capital projects were geared more heavily toward the Ashanti Regions and several others than the Northern Region.[29] Prior to 2018, GWCL completed the Kumasi Water Supply Project to establish the water treatment plant at Barekese and improvements to transmission and distribution lines.

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26 GWCL Regional Commercial Reports 2023. GWCL's benchmark and target for metering coverage is 100 percent. (NRW Strategic Plans 2022).

27 As of the drafting of the report, July was the most recent month in 2023 for which data in the regional commercial reports was available for all three regions.

28 Ibid. A joint effort between GWCL and Biwater to expand Tamale's water system established but did not sustain DMAs in Tamale in 2008. (Hansen 2014). They designed 86 DMAs and installed meters for roughly 18 of the DMAs, but the devices are nonfunctional or have been taken out of the network. Shapefiles are still available and may be of use for future attempts to provide DMAs (Interview with Tamale staff September 2023).

29 Capital investments to reduce NRW have historically been weighted toward ATMA and Kumasi given their larger sizes and customer bases but also because of their heavy contribution to NRW. As noted by GWCL in its 2022 Tariff Proposal, "the three ATMA regions and the two Ashanti regions contribute 80 percent of the reported water loss of the company. More resources will therefore be allocated to these regions to manage NRW" (PURC 2022).

From 2019 to 2021, GWCL invested more heavily to improve water coverage and production but geared efforts far more heavily to other regions, including pipeline extension efforts of nearly 52 km in the Northern Region, 74 km in Ashanti North, and just 2 km in Ashanti South (GWCL 2022). By April 2022, with the completed appointment of NRW Officers in each of the three regions, NRW Strategic Plans were already supposed to be set in motion for Ashanti North, Ashanti South, and the Northern Regions. Instead, GWCL initiated other more substantial efforts geared toward NRW reduction (e.g., zonal metering, creation of DMAs for other GWCL operating regions. Additionally, COVID caused procurement issues that stymied efforts to replace mechanical meters and introduce smart meters. Despite noting the challenges of COVID-based procurement, GWCL provided Ashanti Production with portable flow meters, digital pressure loggers, thickness loggers, and a metal detector to help the regions conduct basic measurements of distribution and assess water loss. While GWCL did not target the Northern Region for any specific NRW measures, they did note planned replacement of 3 km of its pipeline and the provision of 3 automatic voltage regulators and 3 soft starters for water pumps to increase the stability of power supply and reduce energy consumption and costs, respectively (GWCL 2022).

5.3.2 CURRENT OR RECENTLY COMPLETED NON-REVENUE WATER MANAGEMENT MEASURES

The NRW Strategic Plans prepared by the regions set four-year targets for ambitious NRW reduction. The Ashanti North plan indicated a goal to reduce NRW from a baseline percentage of 50 percent to 36 percent by the end of 2026, while Ashanti South aims for a decrease from 52 percent to 40 percent and the Northern Region from 42 percent to 30 percent over the same period.[30]

The NRW plans developed by the regions are comprehensive, multi-faceted, and include the appropriate types of interventions for their specific NRW needs. Having a dedicated NRW Officer for each region helps with organization and accountability to both the HQ NRW Unit and the Regional Chief Manager. Providing training and capacity-building at the regional and district levels as demonstrated in the charts below evinces the necessary recognition of the complexity and interrelatedness of holistically addressing NRW.

But the regions lack the needed staff capacity, equipment, vehicles, and financing to implement the physical NRW reduction activities. Thus, the regions focus more on commercial NRW reduction activities related to metering. The lack of information about the age and condition of existing customer meters and meter reader integrity limits the opportunity for significant reduction in commercial losses. An accelerated commitment to smart meter installation would ameliorate these challenges, but as noted above, there have been significant delays in rolling out smart meters in both cities.[31] The NRW Strategic plans do not include cost estimates or project justifications in terms of potential NRW reduction or impact on revenues and O&M expenses.

The tables below represent the recent status of NRW measures undertaken by the regions pursuant to their Strategic Plans:

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30 The NRW Strategic Plans include a wide range of both commercial and physical loss reduction activities. Customer meter replacements and upgrades and identifying and deterring unauthorized customer use will help reduce commercial losses, however capital financing to replace aging pipes is a priority.

31 One option may be to make 100 percent smart metering a part of new DMAs to assess their impact in terms of costs and benefits.

Table 7: Status of NRW Measures (Ashanti Regions)

Ashanti South	Objective	Ashanti North
Ongoing	**NRW awareness campaign**	**80% completed**, 135 staff trained
Pending	**NRW management team**	Formed and trained **18 district NRW staff**
Completed, with **16 staff trained on e-billing** and **40 staff trained on mapping of bursts and leaks**	**Training and capacity building**	Completed, with **20 staff trained on e-billing** and **40 staff trained on mapping of bursts and leaks**
14 electromagnetic meters installed and activated on pipelines at production centers; pending installation of magnetic meters at Booster Station and Boadi Junction	**Production metering**	**33 electromagnetic meters installed and 32 activated** on pipelines at production centers; pending installation of magnetic meters at boundaries in Offinso district and Booster Stations
93% metering ratio with compiled details of mechanical meters to be replaced with smart meters	**Customer metering**	**92% metering ratio** with compiled details of mechanical meters to be replaced with smart meters
Consumer survey ongoing in all districts (completed in West 1); amnesty for staff involved in illegal connections	**Reduce unauthorized consumption**	**Proposal to conduct consumer survey submitted** to regional management; amnesty for staff involved in illegal connections
195 fire hydrants validated and awaiting metering	**Unbilled authorized consumption**	**133 fire hydrants validated** and awaiting metering
Conducted field validation of city boundaries with district representatives; proposal to modify city boundaries with **one DMA in place**	**Network zoning**	Conducted field validation of city boundaries with district representatives; proposal to modify city boundaries but **no DMAs implemented yet**
Routine surveillance on weak pipelines more than once per week for early detection of bursts/leakages; **replacement of portions of 400-millimeter (mm) ring main**	**Leakage management**	Procuring 9 motorcycles for leakage detection; **replacement of 7 of 22 km AC mains with HDPE pipes**; contractor awarded to replace **3 of 10 km AC line**
Approximately 633 km and 1000 valves mapped and validated; dashboard in place for real-time monitoring	**Asset management**	**Approximately 670 km and 1260 valves mapped and validated**; dashboard in place for monitoring of bursts and leakage repair

Table 8: Status of NRW Measures (Northern Region)

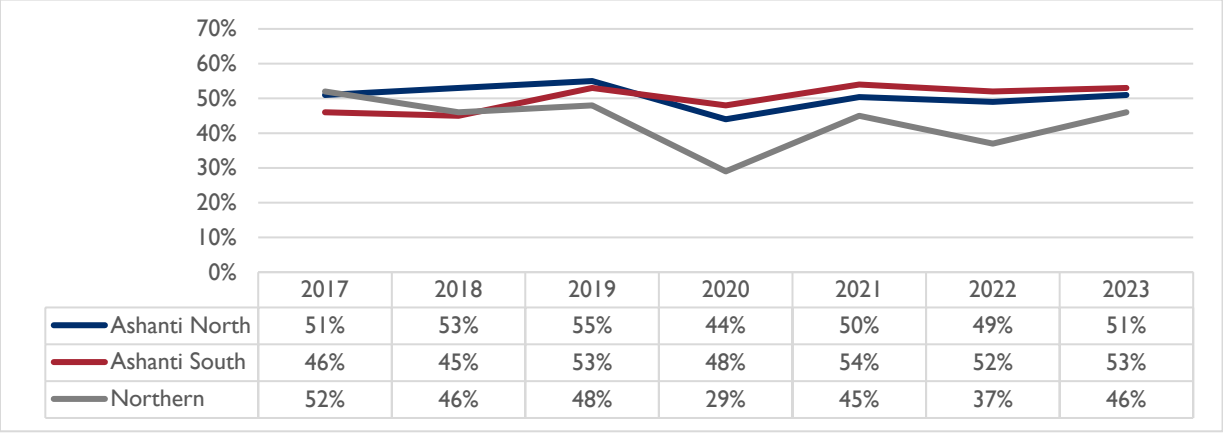
Objective	Northern Region
NRW awareness campaign	Not yet started
Training and capacity building	All Customer Care Assistants trained on e-billing; 71% of distribution staff trained on mapping bursts/leakages
Zoning and system input	Not yet started designing DMAs
Hydraulic network modelling	Memo submitted to regional management for procurement of materials to start pressure tapping
Customer meter installations and replacement	In progress with over 1300 replacements of faulty meters
Prompt repair of reported and visible leaks	In progress and daily; distribution teams responding to reported leaks and bursts

5.3.3 EFFECTIVENESS OF IMPLEMENTED NON-REVENUE WATER MANAGEMENT MEASURES

Given GWCL's many priorities, some planned NRW reduction initiatives have not begun or have not progressed on the intended schedule. For example, GWCL took longer to finalize the NRW Strategic Plans and gave regions a year to revise their initial plans by December 2022, with implementation to begin in 2023 GWCL 2022).). The Kumasi meter testing laboratory upgrade announced in 2018 is still not yet complete, and as noted above, despite ambitious plans for smart meter installation and replacement, GWCL has installed very few smart meters in the target regions. These examples are not meant to minimize the considerable work that goes into strategic planning over both shorter and longer-term time horizons or GWCL's efforts to reduce NRW at the national and regional levels, but only to illustrate that the completion of any single activity cannot "solve" NRW, just as the failure of any single activity does not by itself derail efforts to reduce water losses. Effective, sustained NRW reduction over several years relies on a constellation of activities proceeding largely as planned due to the presence of continuing political will and sufficient economic resources and the absence of extenuating factors (e.g., a pandemic, natural disaster, sustained armed conflict).

Nevertheless, URBAN WASH must determine if regional NRW data demonstrates significant trends that may suggest either the effectiveness or lack of implemented NRW management measures.

Figure 4: Regional NRW Trends (2017 through July 2023)



	2017	2018	2019	2020	2021	2022	2023
Ashanti North	51%	53%	55%	44%	50%	49%	51%
Ashanti South	46%	45%	53%	48%	54%	52%	53%
Northern	52%	46%	48%	29%	45%	37%	46%

Source: NRW Strategic Plans (2017–2021), Regional Commercial Reports for 2022 and 2023

The chart above does not clearly indicate if meaningful improvement in NRW has been made. All regions experienced a significant drop in 2020, the first year of COVID, which is consistent with national-level trends as GWCL's overall NRW dropped from 50 percent in 2019 to 37 percent in 2020 and back to roughly 46 percent in 2021 (GWCL 2022).[32] After the 2020 drop, Ashanti North and Ashanti South have been nearly flat, neither progressing nor significantly backsliding. Even with COVID as an outlier, the Northern Region shows the most consistent decrease since 2017, which is surprising to some extent because the ATMA and Ashanti regions have historically received more attention and funding to address NRW.

5.4 WHAT NON-REVENUE WATER MANAGEMENT MEASURES HAVE BEEN IMPLEMENTED OR ARE PLANNED TO REDUCE WATER THEFT AND UNCOLLECTABLE ACCOUNTS?

Efforts to reduce water theft (unauthorized consumption) include: 1) outreach to customers and community leaders to form committees to look for and report potential illegal use, such as tampering with fire hydrants or customer water meters; 2) recurring efforts for meter readers to check zero meter reads for meter tampering; and 3) encouraging customers to report on illegal connections/water theft activities by GWCL employees.[33] URBAN WASH was unable to assess the effectiveness of these activities because of limited data. However, the Strengths, Weaknesses, Opportunities, and Threats (SWOT) matrix included in the NRW Strategic Plans suggests that meter reader conduct and a lack of meter reading supervision contribute to unauthorized water use. This finding is not unique to GWCL or any of the regions of study. Corrupt practices of meter readers that collude with customers to record lower readings in exchange for money may significantly impact a water company's billed consumption (Boosting Effectiveness of Water Operators Partnerships [BEWOP] 2020).

As presented below, the collection percentages from Ministries, Departments, and Agencies (MDAs) and government customers increased dramatically in many districts in 2022.

Table 9: Bill Collection Rates by District

	Tamale			Ashanti North			Ashanti South		
	District	2021	2022	District	2021	2022	District	2021	2022
Private	West	76%	95%	North A	82%	85%	Central	94%	93%
	Northeast	82%	94%	East	93%	95%	West 1	90%	98%
	East	76%	85%	Northwest	70%	63%	South	80%	84%
	Southwest	71%	78%	Northeast	89%	96%	Southeast	83%	74%
	Dalun	60%	64%	North B	83%	81%	West 2	83%	97%
MDA/ government	West	7%	192%	North A	2%	64%	Central	4%	98%
	Northeast	15%	81%	East	3%	99%	West 1	1%	80%
	East	1%	120%	Northwest	6%	34%	South	8%	92%

[32] In fact, given the extent to which NRW in 2020 differed from the expected level, GWCL adjusted it to 48.9 percent, the anticipated level, for purposes of its proposal to PURC for the last major tariff adjustment (GWCL 2022).

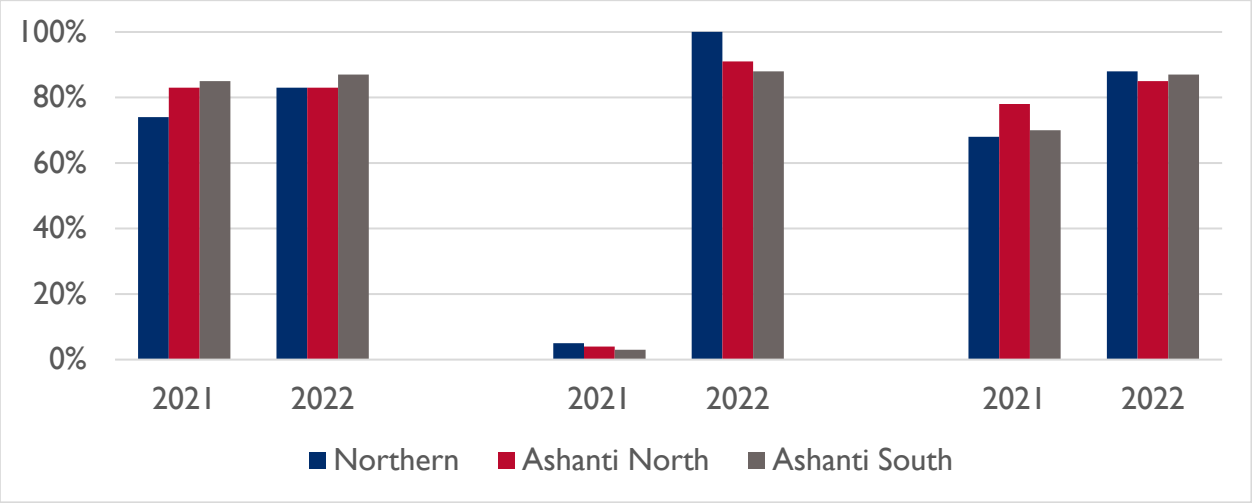
[33] GWCL has repeatedly requested reporting on illegal conduct by its staff members including recently. (Ghana News Agency 2023). Although not in the water sector, interestingly the Electricity Company of Ghana (ECG) will provide citizens with "6 percent of the total debt of any illicit connections they expose" (ECG 2023).

	Tamale			Ashanti North			Ashanti South		
Total	Southwest	10%	86%	Northeast	1%	117%	Southeast	8%	92%
	Dalun	16%	91%	North B	20%	136%	West 2	0%	77%
	West	72%	110%	North A	81%	84%	Central	59%	85%
	Northeast	80%	91%	East	70%	97%	West 1	74%	93%
	East	66%	90%	Northwest	68%	61%	South	79%	84%
	Southwest	67%	77%	Northeast	87%	98%	Southeast	79%	75%
	Dalun	56%	87%	North B	83%	82%	West 2	79%	95%

The Ministry of Finance offsets government customers' water bills against government services charges incurred by GWCL, which was a practice that occurred annually through a "Cross Debt Clearing House" but was abolished in 2014 (PURC 2022). While the practice has been reintroduced, the discretion to do so and the timing of these offsets is solely in the hands of the Ministry of Finance.

The total average collection percentages in the districts in Tamale, Kumasi North, and Kumasi South in 2022 were 91 percent, 84 percent, and 86 percent respectively. The higher average percent in the Tamale Districts was due to collecting more than 100 percent of current billings from MDAs and government customers.[34] Thus, some unpaid bills from prior years were collected in addition to 2022 water bills.

Figure 5: Bill Collection (%) by Region



By comparison, the average reported collection rates in the World Bank-funded International Benchmarking Network (IBNET) for the 10 African water utilities in IBNET is 81 percent, the lowest was 35 percent in Nigeria, and the highest was 94 percent in Uganda. If the two lowest reported collection rates are excluded, the average reported collection rate in IBNET is 90 percent. Although continued improvement by GWCL is possible, the average collection rates compare favorably with

[34] This outcome occurs in situations where unpaid bills from prior years are paid in arrears or through one of the cross-agency debt arrangements discussed above. They are therefore closer to accounting quirks rather than a demonstration of improved collections practices, which is demonstrated by the fact that MDA collection rates declined precipitously in the first half of 2023.

IBNET benchmarks[35] due in part to implementation of a unified customer billing system in all GWCL regions and a robust effort to monitor billings and collections monthly for all districts (GWCL Commercial Reports 2023). Periodic revenue mobilization campaigns organized by GWCL also support efforts to collect unpaid water bills, which have typically been conducted once or twice a year.

5.5 PREPAID METERING

As the sections above have noted in detail, utilities like GWCL face a range of challenges and several avenues of opportunity to reduce NRW and contribute to the financial health of their organizations. Addressing illegal connections and improving metering, billing, and collections practices can contribute to reducing commercial losses and increasing commercial efficiency.[36]

GWCL has made significant strides to modernize and digitalize metering, billings, and collections practices through a range of solutions, including e-billing and smart metering. As noted earlier, GWCL should install only smart meters with the ability to read meters more efficiently via "drive by" rather than manual reading. However, accurate readings do not address the issue of recurrent customer non-payment or underpayment. Utilities have sought to address issues of non-payment and underpayment by introducing prepaid metering, which takes the modality of pre-payment (e.g., debit cards, phone cards) and adapts to the utility context to control and monitor overconsumption and provide greater reliability for the utility. Historically and for reasons discussed below, prepayment for electricity is far more common and has been received better than efforts to introduce prepaid metering for water service delivery.

Although there has not been significant success in establishing prepaid metering for water supply in Ghana, GWCL and PURC are interested in understanding the conditions under which prepaid metering may be more feasible or successful in the future. As part of this inquiry, URBAN WASH posed two questions.

5.5.1 WHAT IS THE EXTENT OF ADOPTION, APPLICATION, OR ACCEPTANCE OF PREPAID METERS IN THE URBAN SUPPLY SPACE?

The earliest cited efforts to introduce prepaid metering for water supply in Ghana was a 2004 pilot in the Tema region completed as a pseudo-PBC whereby GWCL contracted Aquamet to help reduce collection issues and retain part of the collected revenue as payment (Shang-Quartey 2017). Aquamet installed prepaid meters to improve collections. After roughly five unsuccessful months, GWCL shelved the pilot, replaced all the prepaid meters with traditional meters, and suied for an injunction to forestall Aquamet from collecting additional revenue (GhanaWeb 2004).

Citizen distrust from the 2004 Aquamet contract was still present ten years later when GWCL announced plans to re-introduce prepaid water meters that utilized smart cards to address non-payment challenges. Opposition from civil society and members of the Ghanaian legislature quieted GWCL on the issue until summer 2015 when GWCL revived the idea of prepaid metering to reduce the incidence of violence against bill collectors. Renewed opposition from the public and civil society led GWCL to first scale back its intentions, including to focus on gated communities rather than low-income neighborhoods, and ultimately to shelve the plan less than a year later (Shang-Quartey 2017).

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[35] Although not full-year estimates, an average of the 2023 monthly collection rates from GWCL regional commercial reports show a decrease in total collections in all three regions below 80 percent with precipitous decreases in the Government/MDA collections rate (GWCL Regional Commercial Reports 2023).

[36] Improved metering, billing, and collections practices are valuable because of their positive effects on the bottom line for the respective regions and GWCL but also because GWCL's ability to demonstrate efficient operation is part of what PURC considers and assesses when responding to GWCL's requests for tariff increases.

Despite the previous unsuccessful attempts to launch prepaid water metering in earnest, PURC forecast continued interest in the topic through the release of a 2019 regulatory brief, which was re-released with similar content in 2022. In addition to describing the potential types of prepaid meters (e.g., standpipe, private, card, token, Radio-Frequency Identification [RFID]), the briefs lay out potential opportunities for prepaid water metering and acknowledge that further study is needed to determine whether it is a tenable solution from a political and economic perspective (PURC 2019; 2022).

While PURC was reinvigorating the idea of prepaid metering, GWCL launched a small-scale pilot with initial funding from the Austrian government in the Accra East district. Borrowing from some of the lessons of the previous attempts, the pilot focused on a gated community as a model area that offers the advantages of a closed system for better containment with an installed bulk meter at the closest inlet. GWCL regional management chose this community because it already had smart meters and the community residents expressed interest in being the pilot location. The chosen prepaid meters for the pilot were all-digital and utilized long range radio wireless technology with the ability to split between prepaid and postpaid operation (GWCL KII – HQ, 2022). Due to technological issues with the placement of aggregators and concentrators for the wireless network, GWCL could not launch the pilot prior to the expiration of donor funding. As a result, GWCL picked up the mantle of carrying the pilot forward and reported in December 2021 that it had installed 820 of 1000 meters (GWCL 2022). However, as of June 2023, installed meters were still operating via postpaid functionality and GWCL had yet to operationalize an app to provide mobile access for customers to make payments, recharge, or view consumption data. The most recent version of GWCL's NRW Reduction Plan notes that GWCL suspended the prepaid metering pilot and is awaiting GWCL's Board of Directors to "direct on the way forward." (GWCL 2022)

While GWCL hoped to eventually complete the pilot with existing technology and scale up to other gated communities or metered areas, evidence suggested GWCL was rethinking its approach to prepaid metering. In April 2023, GWCL's Chief Manager for Public Relations noted that "GWCL has not abandoned the idea of replacing the postpaid system with prepaid; but for now, we are on the lookout for robust metering equipment [with sensors to detect tampering]," (GhanaWeb 2023). This information is consistent with the NRW Strategic Plans for Ashanti North, Ashanti South, and the Northern regions, which highlight the continued implementation of smart meters and efforts to reduce illegal theft and tampering without specific reference to prepaid technologies.[37]

While prepaid water metering has a limited GWCL footprint, several groups are implementing small-scale pilots or initiatives as follows (more detail for each follows the table):

Table 10: Prepaid Water Metering Initiatives by Group

	GWCL	Safe Water Network	Grundfos	CWSA
1. Objective	To pilot concept in limited community	To reduce NRW and lay groundwork for extension to household connections (HHCs)	To counteract increasing NRW in brownfield community water system	Objective to mitigate revenue issues of water loss

[37] GWCL's lack of enthusiasm to reconsider prepaid water metering may also be tempered by recent challenges with electricity prepaid metering. In fall 2022, the ECG's prepaid systems went down, preventing customers from purchasing additional electricity. As a short-term solution, GWCL provided third party vending options, but the prepaid issue lingered for several days including in Kumasi. A year prior to this incident in August 2021, the ECG indicated they would abandon 59 million Ghanaian cedis (GHS; roughly $5 million United States dollars [USD]) in faulty prepaid electricity meters procured in 2014–2016.

	GWCL	Safe Water Network	Grundfos	CWSA
2. Geographies	Accra East	Southern Ghana with largest presence in Ashanti	Eastern Region (Nsawam)	Greater Accra, Oti, Bono East
3. Technology	Postpaid meters with prepaid switch using long range radio	Converted water ATMs to communal prepaid, minimal HHCs	TechMeter (from Netherlands) using Light Detection and Ranging Radio (LiDAR) signal	Card Meters using SkyLink software; prepaid standpipes (Lorenz)
4. Customer Segment	Gated residential community	Domestic customers in peri-urban and small communities (less than 3,000 people)	Primarily commercial and domestic customers located near radio signal	Domestic and some small commercial enterprises in rural communities
5. Business Model	Initially funded by Austrian government and now GWCL-funded	Optimized pipe connections funded by philanthropic contributions and considering private capital	Funded by Grundfos' experimental/philanthropic arm (Grundfos Safe Water)	Government of Ghana-funded; some funding from development partners

- **Community Water and Sanitation Agency:** CWSA is the other principal government-led prepaid pilot but operates primarily in rural areas given its mandate. From an initial 1,400 planned prepaid meters, they installed only 200 between Greater Accra, Oti, and Bono East by June 2023.
  - **Type:** Primarily card meters, which community members purchase at a central office and then load into their meters, with some prepaid standpipes. The estimated cost is $150–$200/unit.
  - **Key Aspects:** Due to the previous opposition to prepaid water metering, CWSA spent several months on the ground prior to the launch gaining the confidence and trust of the communities, first at the village elder level and then followed by continuous outreach and "boots on the ground" in the months leading up to launch, during launch, and after launch. Residential customers and small commercial enterprises were interested initially, so CWSA prioritized these customers.
  - **Challenges:** The primary limitations to the planned rollout were two-fold. First, the SkyLink software used for purchase could only process whole Ghanaian cedis (GHS) values. For example, if a customer wanted 3 m^3, which cost GHS 2.40, they would need to pay 3 GHS to receive the required amount. The other challenge was how to get the software to integrate both the consumption rate and monthly service charge and then reconcile against the final consumption if there was unused water. While CWSA saw these issues as surmountable, the challenges did cause them to slow their rollout and limit their ambitions to not endanger the initial trust gained from their constituent communities.

- **Safe Water Network:** This NGO operates stations that provide community standpipe access and undertakes HHCs with the majority of their systems in and around Kumasi and several other regions in the South of Ghana. They focus on more peri-urban communities and small towns (approximately 3,000 people):
  - **Type:** For HHCs, Safe Water Network (SWN) provides a digitally enabled LAISON Multi-Jet STS prepaid meter that permits individuals with mobile phones to utilize an app to prepay for service with an estimated cost of $100 per meter. They also operate community water standpipes that operate 24 hours a day and 7 days a week based on cards purchased from vendors, which can be topped up via a mobile app.
  - **Key Aspects:** In piloting the conversion from post-paid to prepaid meters, SWN found increased revenue and decreased arrears for household connections, but currently the costs of optimized piped connections are being covered by SWN's donors (e.g., Hilton Foundation, Stone Foundation) and not carried by the households themselves. SWN sees HHCs as the primary avenue for expansion and is looking to secure funding for expanding to a 100-station footprint of which 30 percent would be HHC stations with an aim to increase the number of HHCs in these communities from 50–60 households to 400 households.
  - **Challenges:** Based on where they work, customers have low digital literacy and thus considerable distrust of new technology from both the community members who felt they were getting less than they paid for and vendors who felt their commissions were reduced. It also took significant time and investment to integrate the separate technology platforms/providers for household prepaid meters, automatic water dispensers, sales tracking, and mobile money with their own data management.
- **Grundfos:** Grundfos is a private company that produces pumps and other technologies and has a strategic business unit called Grundfos Safe Water, which aims to benefit communities with an eye toward commercially viable solutions. Through their Ghana Water Initiative, Grundfos operates a brownfield site for CWSA through a Build-Own-Operate-Transfer (BOOT) that covers roughly 8,000 people in the Eastern Region. After installing the first 200 connections at the brownfield site, they introduced prepaid metering at 25 percent of those sites to reduce NRW.
  - **Type:** The prepaid meters are from TechMeter and utilize LiDAR radio transmission to an antenna placed on a storage tank for increased reach. The cost per unit is $80 but is a separate subscription cost of roughly $15/unit/year to cover radio/internet transmission costs and management costs. Grundfos also utilizes AQTap, a self-service water automated teller machine (ATM).
  - **Key Aspects:** Unlike SWN or GWCL, Grundfos prioritized commercial customers for prepaid meters because they have comparatively greater consumption. They also include self-selecting residential customers. Similar to the Low-Income Customer Support Department (LICSD) connection fee program, Grundfos subsidizes connection fees (GHS 500, similar to GWCL) but permits customers to pay GHS 50 GHS "down" for the connection and then spread the remaining GHS 450 over 9 months.
  - **Challenges:** Grundfos did not observe any change in consumption habits with prepaid meters. While it helped reduce arrears, the $2–6/month they received in payments would take too long to justify the costs of the unit and subscription. Therefore, they are choosing

to focus on drilling boreholes and increasing connections rather than expanding prepaid metering at their brownfield site.[38]

Although these initiatives will be discussed further in the next section, the primary takeaways and commonalities between the initiatives described above and GWCL's own recent efforts to re-introduce prepaid metering for water supply include:

- **Limited scope/self-selection of communities and customers:** In all cases, groups were committed to selecting communities that were small, contained in scope, and stated interest or where staff operating in the region regarded the communities as open to being included. A controlled environment is designed for greater success but may not be easily replicable under "real world" conditions.
- **Technological challenges slowing or frustrating progress:** Technology issues, particularly related to prepaid meters' interoperability with the greater prepaid ecosystem (e.g., connectivity, software, Application Programming Interface [APIs]) has tempered early enthusiasm. Increased or unanticipated installation, maintenance, replacement, and/or management costs limit the potential return on investment.
- **Economic realism:** High costs of meters, associated technologies, and implementation make the cost recovery horizon too long or non-existent to justify introducing prepaid for water. This makes it less attractive relative to other ways to increase revenue and reduce NRW, particularly in cost-constrained environments like that faced currently by GWCL.[39]
- **Cautious pragmatism regarding potential for expansion:** Even where there has been limited success in introducing prepaid for water, there are no significant stated plans to dramatically expand or replicate current efforts absent donor funding or outside capital.

5.5.2 WHAT HAVE BEEN THE PRIMARY DRIVERS AND BOTTLENECKS TO ADOPTION, APPLICATION, OR ACCEPTANCE OF PREPAID METERS IN GHANA?

Bottlenecks or Impediments

Given the limited uptake or acceptance of prepaid metering for water in Ghana, URBAN WASH must first understand the types of bottlenecks or impediments to wider adoption or application before focusing on opportunities and recommendations for introduction or expansion.

Despite the comparative success of prepayment for electricity, there are key differences that limit the applicability of prepaid for electricity to the urban water service delivery context. These include:

- Water is viewed as an intrinsic human right and cannot be replaced with less powerful, safe, or efficient alternatives as electricity can be (e.g., candle, solar power) (PURC 2019, citing Heymans 2014).

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[38] Grundfos is developing and testing its own prepaid meter, which would work with both cards and mobile payment, but indicated they have no intention to expand the brownfield prepaid pilot.

[39] This finding accords with a 2022 Zambia Country Brief prepared by USAID's Water, Sanitation, and Hygiene Finance (WASH-FIN) project, which compared postpaid and prepaid metering options through a cost-benefit analysis that concluded that "the benefits of prepaid meters did not justify the higher purchasing costs" and that "[higher returns on investment could be achieved through improvements in operational efficiencies, prioritized debt management, and increased efforts to sensitize customers around timely payment." (WASH-FIN Zambia 2023). See also USAID/Nigeria Effective WASH (EWASH) Final Report, which highlighted interventions in multiple states to install prepaid domestic water meters but cited reduced NRW in those same states would instead come from "novel DMA management" and "pipe replacements." (EWASH 2021).

- Relatedly, access to electricity is lower in Ghana and comparatively much newer, so prepaid for electricity can be seen as facilitating valuable service provision by NEDCo compared to GWCL carrying out a fundamental, historical responsibility of the government to provide a basic service.
- Prepaid meters for water have more moving parts and are prone to greater physical stress, which combine to make them more susceptible to wear and damage. They also require their own independent electricity source, which may pose limitations for how effectively they can be set up (PURC 2019).
- The greater complexity and relative newness of technology for prepaid water meters creates several other issues. There are fewer suppliers or customizable options than with prepaid electric meters, which limits competition and facilitates higher prices. Additionally, this complexity frustrates the development of robust local markets for repair and replacement, which forces continued reliance on international vendors and has both financial and temporal ramifications when units stop working properly (PURC 2022).

Primary impediments and opportunities for prepaid water delivery will be grouped into four types: 1) sociocultural, 2) political, 3) economic, and 4) technological. In practice, these features are clearly interrelated and exist as more of a constellation of push and pull factors. For example, there would be greater political will for introducing prepaid metering on a broader scale if GWCL could effectively advocate for its expansion in a way that assuaged customers' hesitancy and negative perceptions. Similarly, identification and "proof of concept" of a reliable, lower-cost prepaid metering system could alter the economic calculus about whether prepaid metering would provide sufficient return on investment vis-à-vis other modalities to increase interest in additional pilots or expand existing ones.

- **Sociocultural:** Previous efforts by GWCL to introduce prepaid metering were stymied largely on sociocultural grounds due to the belief in water as a fundamental human right and related distrust regarding GWCL's true intentions (Shang-Quartey 2017). As Ghanaian citizens have warmed to prepaid electricity meters or paying for other types of services (e.g., calling cards, SIM cards for mobile data), but the same is not true for water, which suggests these concerns linger. This perspective was confirmed by the household survey conducted by URBAN WASH for roughly 600 respondents in Tamale and Kumasi. Overall, 91 percent of survey respondents had used a prepaid payment method in the past year, and of those, more than 75 percent were either "somewhat satisfied" or "very satisfied" with these methods. Yet, of the same 91 percent, only one-third were willing to prepay for their water bill with this proportion roughly equal in Kumasi and Tamale. A majority of respondents in Kumasi (59 percent) and a plurality in Tamale (39 percent) noted the primary reason they did not want to prepay their water bill is that "I like how I pay my water bill now and don't want to change," which evinces a failure on the part of GWCL to convince the citizens of the benefits for them of switching to prepaid.
- **Political:** Because of the general apprehension and reluctance of citizens to prepay for water, promoting a more robust introduction or expansion of prepaid metering is not politically expedient. PURC has been the entity of late, albeit in a more balanced way, to explain and make the case for prepaid metering through its regulatory briefs. (PURC 2019; 2022). Moreover, prioritizing prepaid metering is an even harder political sell considering it is one of many options to facilitate, requires far less political capital, and courts far less controversy to champion easier options. For example, GWCL recently announced that it would mitigate non-payment by introducing more flexible payment options for consumers and also that its efforts to improve service delivery would focus on better billing systems and investment in smart meters. (Business Ghana 2023)
- **Economic:** As noted in the Component 2 Report and echoed earlier in this report, GWCL faces serious financial constraints and thus must continually prioritize and promote those activities that have a more immediate and significant effect on the bottom line. Advocating for prepaid metering seems challenging given the significant time and effort to lay the groundwork

and the lack of clear evidence that resulting revenue increase would exceed or even offset the related material and labor costs. The effects trickle down to GWCL's operating regions, which receive funding directly from GWCL HQ and thus will face similar constraints in their ability to implement current planned initiatives including their NRW Strategic Plans. Moreover, it does not appear that prepaid metering would even necessarily help address the current NRW needs of each of the target regions. For example, the Ashanti Regions' struggle nearly equally with physical losses and commercial losses and thus need to devote resources, which tend to be costlier, to address leaks and bursts. The Northern Region's commercial loss challenges relate more to addressing low metering and illegal consumption, which can be addressed in a less costly manner via smart postpaid metering.

- **Technological:** Technological issues, including interoperability concerns, slowed or limited rollout of smaller pilots. The technological complexity of prepaid metering increases the overall costs, including installation and maintenance. Additionally, as noted above, providers must ensure sufficient field presence to help communities address technological hiccups that occurred during and after installation. This support requires labor resources which are already needed to implement GWCL's ongoing activities, including replacing mechanical meters, adding smart meters, and installing bulk meters. Additionally, it is not clear how prepaid meters would work in the case of shared private connections, which are typical for many households in both Tamale and Kumasi. Also, to work effectively, prepaid meters must be able to effectively charge based on GWCL's tariff structure, which includes consumption charges per cubic meter, a flat monthly service charge, and applicable fees.

Opportunities and Drivers

- **Sociocultural:** Especially in uncertain times, prepaid metering offers a degree of predictability and control over costs that can be attractive, particularly where multiple households share a connection. Through the household survey, respondents indicated that the primary reason they would want to prepay their water bill was for easier control of water expenses (51 percent), with convenience as the next closest option (18 percent). Since part of the hesitation around prepaid metering is that it exists as a tool only to benefit the utility, doing a better job of reframing the technology around control and visibility for the user counteracts that opinion. Especially in communities with issues of non-payment or water theft, having a prepaid meter may appeal to those who want to be seen as respected or above reproach. Given how comparatively rare prepaid metering for water supply is within Ghana, it may convey a certain status for those who want to be seen as in the vanguard or who relish a role as an early adopter of technology.
- **Political:** Utilities can more easily point at or highlight theft or tampering as a cause of NRW than to acknowledge the contributions of persistent failure to maintain, inspect, or upgrade aging infrastructure. As tariffs increase to address rising operational costs, emphasizing prepaid metering to forestall scofflaws and require each to pay their part fits GWCL's larger narrative around vigilance and reporting illegal connections. This perspective may be particularly true in Tamale, which has only intermittent water supply.
- **Economic:** From the perspective of the utility, prepaid meters can help increase revenue that would otherwise fall into arrears. Prepaid metering also provides a greater degree of predictability or reliability regarding future revenue. Wider adoption of prepaid metering would also reduce the need for meter readers, which would reduce labor costs for GWCL. For customers, particularly those who have lower income and do not have significant affordability concerns, prepaid metering via a HHC or a commercial standpipe offers increased visibility into consumption and thus augments the ability to limit or control costs. For commercial or industrial customers, prepaid meters offer greater predictability and as set up, may help identify

site or department inefficiencies that lead to higher water costs. While the higher material costs for prepaid metering hinder current efforts to demonstrate timely return on investment, a shift in the supply landscape that reflects cost-efficient technical advances and/or introduces new market entrants could improve the cost-benefit needed for sufficient political will on the part of GWCL and the greater Government of Ghana.

- **Technological:** The widespread adoption of prepaid for electricity and other payments and more frequent use of mobile or digital technologies in more urban areas should help allay familiarity concerns. Denser urban areas also typically have stronger network connectivity to avoid communication interruptions and increased proximity, which would benefit prepaid meters based on radio frequency technologies. As GWCL works to enhance its mobile app and provide greater visibility into consumption data and other metrics, it will better appeal to those Ghanaians who value predictability and cost control.

6.0 RECOMMENDATIONS AND NEXT STEPS

Based on its assessment, URBAN WASH developed and discussed recommendations with GWCL as part of co-creation workshops that took place in January 2024. The team captured GWCL's input and alternative ideas as part of action plans developed after the meetings and present the feedback in parallel to this report.

To support the URBAN WASH team's recommendations given the financial viability of GWCL and its role in financing regional NRW activities, the team summarizes the financial situation of the regions below.

6.1 FINANCIAL SITUATIONS OF REGIONS

Table 11 below presents a summary of the revenues and O&M expenses of the Ashanti regions (North, South, and Production) and the Northern Region.

Table 11. Ashanti Regions' and Northern Region 2022 Revenues and Expenses (in Millions of Ghanaian Cedis)

	Ashanti Regions	Northern Region
Revenues		
Operating revenue	156.8	48.1
Other revenues	1.2	.5
Total revenues	**158.0**	**48.6**
Operating Expenses		
Personnel cost	52.0	15.9
Chemicals	9.7	6.3
Electricity	41.0	9.6
Repairs and maintenance	17.5	3.9
Overheads	14.5	5.8
Fuel and lubricants	3.8	1.7
Other	4.4	.7
Total operating expenses	**142.9**	**43.9**
Net Revenue	***15.1***	***4.7***

The above amounts are based on accrual accounting, but the expenses exclude depreciation and provision for uncollectable accounts. Costs related to water production account for more than half of total operating expenses in the regions. Based on information obtained as part of the Component 2 assessment (Water Equity), URBAN WASH has made no provision for uncollectable accounts, which range from 10 percent to 20 percent in most districts. Assuming 10 percent of operating revenues are not collected, the net revenue amount would be wiped out in the Ashanti Regions because the uncollected revenue would be at least GHS 15.6 million (156.8 x 10 percent) = 15.6), which is more than the net revenues of GHS 15.1 million. The same conditions apply to the Northern Region where 10 percent of operating revenues is equal to GHS 4.8 million, which is more than net revenue of GHS 4.7 million. This calculation means the Ashanti Regions and Northern Region are at best working at a break-even level on a cash basis with very limited internally generated funds to cover increases in operating expenses, especially for repairs and maintenance that will be needed for NRW reduction.

Personnel costs in the Ashanti Regions' are for payroll related expenses for 280 employees in Ashanti North, 223 employees in Ashanti South, and 201 employees in Ashanti Production. The combined employee per 1,000 customers ratio is 6.5 for the Ashanti Regions.[40] If the ratio is based on the number of billed customers, the ratio would be closer to 9.0, which is very high by water sector benchmarks and would suggest that the Ashanti regions are overstaffed.[41] This situation is likely due to the responsibilities of meter readers to distribute customer bills and read meters located in customer dwelling units as well as the high level of pipe bursts and leaks that district staff need to repair. By contrast, the ratio for the Northern Region is just 4.9 employees per 1,000 customers,[42] which may owe to the fewer employees needed for water production activities.

GWCL's financial management system is highly centralized. GWCL moves collected revenues in the regions from depository bank accounts into operating bank accounts where they pay almost all regional operating expenses. Annual operating budgets are developed by the regions but approved by GWCL HQ. URBAN WASH understands that operating budgets are often limited to the amount of cash-based revenue. The regions have discretion on how to employ budgeted funds, but GWCL HQ expects them to stay within budget. As part of the annual budget process, the regions can suggest capital projects but GWCL HQ is in full control of awarding and monitoring capital projects.

6.2 RECOMMENDATIONS

URBAN WASH suggests seven recommendations to improve the reliability of NRW estimates and to reduce NRW. The recommendations are as follows:

1. Expand bulk metering to include bulk meters at all water production locations and major above ground assets along the transmission system and at the points water is delivered to districts;
2. Establish, train, and equip dedicated district level NRW Teams (three to four people) led by a District NRW Officer (reporting to a District Manager) to supervise and monitor NRW reduction activity in the districts**;**
3. Accelerate efforts to reduce unauthorized water use, including potentially with short-term PBCs with local contractors;
4. Enhance the capabilities of visible leak detection teams to search for visible leaks within each district and make timely repairs and/or replacements of pipes and valves as needed;
5. Identify locations for DMAs in one district in each region studied and at least one pilot DMA within the selected districts;
6. Bid and award a NRW reduction contract similar to the PBC recently awarded in the Accra East region; and
7. Conduct a cost-benefit analysis to understand how prepaid metering for water supply can demonstrate an economic return on investment.

Although these recommendations are presented separately, several crosscutting aspects are important to all of them:

- First, each recommendation takes place within the wider context of GWCL's modernization efforts and should reflect a commitment to data and digitalization as levers for greater

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40 704 employees divided by 107,817 customers and multiplied by 1000.

41 As a measure of cost-effectiveness, the World Bank's Turnaround Utility Framework rates staff per thousand connections as "good" for a ratio between 5.0 and 6.5 and "basic" for a ratio between 6.5 and 10 (Soppe 2018). Eastern and Southern Africa Water and Sanitation's (ESAWAS') regional benchmarking cited 5–8 staff per 1,000 connections as "acceptable boundaries." (ESAWAS 2022).

42 244 employees divided by 49,636 customers and multiplied by 1000.

operational efficiency and improved service delivery. This improvement does not need to be—and ideally is not principally—new software or technology but rather technical assistance to increase awareness of available tools, increase or better utilize existing systems and functionalities, improve data integration, and expand methodologies and techniques for data collection and analysis.

- Similarly, the efficacy of these recommendations will be greatly enhanced by robust knowledge-sharing between GWCL HQ and regions. Interventions like PBCs for NRW or the setup of DMAs are ongoing or have been previously completed in other regions. Important lessons learned can guide future efforts.
- Capacity-building is also a fundamental aspect to each recommendation. While training or mentorship through technical assistance is one contribution that URBAN WASH can provide, developing and facilitating NRW robust training programs—and standardizing them across regions for consistency and wider uptake—remains a core responsibility of GWCL HQ.

Each recommendation is further explained below, along with an illustrative business case analysis for Recommendation #6.

Recommendation # 1 – Expand bulk metering to include bulk meters at all water production locations and major above ground assets along the transmission system and at the points water is delivered to districts.

While all three regions have bulk meter installation as part of their Strategic Plans, URBAN WASH recommends that the regions accelerate the installation and periodic calibration of bulk water meters at all production facilities, above-ground assets along the transmission systems, and at all points where water is delivered to the districts. Financial and resource constraints have limited how widely and quickly bulk meters have been installed, but they are fundamental to increasing the reliability of NRW estimates at the regional and district levels. Without reliable NRW measurements, GWCL staff at the regional and district levels cannot properly evaluate the effectiveness of their NRW reduction efforts. This is similar to what occurred with the introduction of Performance Improvement Programs in 2015. These programs provided for incentive payments to the districts for improved performance, including reduced NRW. Because NRW could not be reliably measured, GWCL ultimately eliminated incentive payments based on NRW reductions. When GWCL in all three regions install and calibrate all needed bulk meters and there is greater reliability to NRW measurements, URBAN WASH recommends that GWCL develops an appropriate incentive plan in the Northern Region and Ashanti Regions that provides sufficient motivation to the regional and district employees involved in NRW reduction efforts. These could function like internal PBCs.[43]

Recommendation # 2 – Establish, train, and equip dedicated district level NRW Teams (three to four people) led by a District NRW Officer (reporting to a District Manager) to supervise and monitor NRW reduction activity in the districts.

The two Ashanti Regions and Northern Region first hired NRW Officers in the 2019–2020, which led to more focus on NRW and the development of the Regional NRW Strategic Plans. Implementing the NRW reduction plans will require planning, collaboration with district managers, procurement of technical equipment, training, and monitoring and evaluation of NRW project results. Coordination with GWCL's HQ NRW Officer will also be essential in efforts to evaluate the cost effectiveness of NRW capital projects and to search for financing. This work is beyond the role of district managers and the current one-person regional NRW sub-department that is part of the regional departments of T&I.

[43] As part of the World Bank's ongoing PBC in Accra East, the PBC Contractor is implementing NRW reduction efforts in three of four districts while GWCL is concurrently running the remaining district under a PBC approach.

URBAN WASH recommends that each district nominate one of its current employees or hires a new employee to take on the role of a District NRW Officer. Once in place, each district could also assign a team of district employees, perhaps one each from the commercial, distribution, and production teams, to report directly to the District NRW Officer. The District NRW Officer would work directly for the District Manager but also collaborate closely with the Regional NRW Officer. This deliberate organizational change should bring even more focus to NRW at the district level and more hands-on supervision for efforts to plan and execute NRW reduction activities.

The selection of a district-level NRW Officer would not place main accountability for NRW reduction with these individuals. Accountability would remain with the NRW Regional Officers, Regional Chief Managers, and NRW Officer in Accra. GWCL HQ needs to provide the policies, direction, and financing for NRW improvement and facilitate knowledge transfer and important learnings between the regions. The RCMs need to reinforce HQ direction on NRW priorities; provide motivation, advocate for, and facilitate needed training and equipment; and monitor progress for adaptive management.[44]

Since most of the day-to-day activities of addressing NRW happen at the district level, these NRW Officers would help with downstream accountability and provide a localized "champion," even if a dedicated team was deemed unnecessary. Because of how interrelated the departments are to addressing NRW, this officer would be a conduit between them and almost like an "air traffic controller" providing direction and guidance to avoid duplication of effort or working at cross-purposes.

Additional technical training for the new District NRW Managers and the employees reporting to the District NRW Managers will be critical. URBAN WASH believes such training should be delivered by GWCL's Head Office to ensure consistency among all regions. Past initial technical training, some form of internal accreditation will be useful to ensure the nominated employees are up to the tasks expected of the District NRW Officers.

Recommendation # 3 – Accelerate efforts to reduce unauthorized water use, including through short-term PBCs with local contractors.

URBAN WASH believes NRW can decrease significantly as a region implements NRW reduction plans, especially those related to reducing commercial losses, including by replacing old and defective water meters, checking customers' meters to determine if they have been tampered with or bypassed, and verifying if meters showing zero use is accurate.

Some aspects of this work may be dangerous because it involves interacting with customers invested in maintaining illegal connections and/or meter readers who may have collaborated with customers to deliberately under-record metered use. For these reasons, districts could consider a short-term PBC with a local company able to deal with these issues.[45] Such a contract should include efforts to 1) search billing records for suspicious looking use trends or low use rates, 2) visit customer locations with zero usage and customers who have been disconnected to determine if they have tampered with or bypassed the water meter, and 3) estimate the age[46] and observe the condition of customer meters with recorded low consumption. The contract should include a fixed fee component and a performance bonus for the value of unauthorized water use found and under-registered water from old and defective water meters.

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[44] Each region has initiatives related to increasing NRW awareness and staff training on NRW issues as part of its Strategic Plans but without the designation of a specific NRW Manager or team at the district levels.

[45] While all three regions Strategic Plans include multi-faceted plans to reduce unauthorized water use, none contemplates using local contractors or short-term PBC to do so.

[46] Meter age can be determined by looking at the first two digits on the water meter serial number.

Hiring an external contractor for this work is not without risks or complications. Where sensitivity and even hostility to GWCL related to illegal connections exists, as in Tamale, working with contractors could have the opposite effect, inflaming tensions and increasing resentment within those communities. It could also damage future efforts where GWCL might consider bringing in external contractors to address NRW issues, even those unrelated to unauthorized use. Use of an external contractor would not address the extent that illegal connections, habitual non-payment, or other sources of commercial losses reflect frustrations with GWCL service, a sense of entitlement, or another sociocultural factor. Accelerated or expanded internal efforts to address unauthorized water use with existing staff resources or by hiring additional dedicated personnel for these purposes could be a more attractive avenue to address these challenges.

Recommendations # 4 – Enhance the capabilities of visible leak detection teams to search for visible leaks within each district and make timely repairs and/or replacements of pipes and valves as needed.

Most repairs to pipe burst and leaks are conducted on a reactive basis following reports by customers or field crews working in a district. A large amount of water can be lost by the time the burst or leak is reported, compounded by slow response time due to limited availability of vehicles, motor bikes, and materials.

Districts could become more proactive in reducing lost water from visible leaks by purchasing additional equipment, tools, and motor bikes.[47] The visible leak detection teams should make scheduled visits in areas of the district to look for visible leaks. The teams should have tool kits with them to repair small leaks on pipes and valves when located and schedule follow-up work on visible leaks requiring additional equipment and materials to repair. The teams should also make scheduled visits to check for overflows at reservoirs and storage tanks and leaks at booster stations.

Recommendation # 5 – Identify locations for DMAs in one district in each region studied and at least one pilot DMA within the selected districts.

The establishment of DMAs will be a key component of medium- and long-term efforts to reduce NRW. URBAN WASH suggests efforts to establish DMAs start after the district NRW teams have been formed and fully trained per Recommendations #2 and #4. Before NRW teams can select DMAs, they will need to conduct a hydraulic analysis to identify the number and location of DMAs within the districts selected for piloting DMAs.[48] Generally, the preferred size of a DMA ranges from 500 to 3,000 connections. (BEWOP 2020). Most of the districts in the two Ashanti Regions and the Northern Region have between 8,000 to 12,000 customers. Assuming an average of 1,500 connections per DMA, there each district will have 5–8 DMAs. The selected DMA should be based on clearly visible topographical points that can serve as boundaries for the DMAs such as rivers, roads, and drainage channels.

Once NRW teams establish the number and location of DMAs, they can select the pilot DMAs. URBAN WASH suggests that the pilots include DMAs in both high-density and low-density areas to provide a range of lessons learned. Isolating the selected DMAs will require installing meters to measure water entering the DMA, verification of customers and customer meters within the DMA, and valves to allow

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[47] Improving leak detection, including through the purchase of equipment and vehicles to facilitate more regular and frequent visits, is a part of all three regions' Strategic Plans. Accelerating the progress of these activities as a means to mitigate physical losses is what is recommended here. For instance, at the co-creation meeting in January 2024, the Northern Region indicated that only since the fall had a vehicle been assigned to its NRW Unit.

[48] Zoning and hydraulic modeling is undergoing in all three regions as part of the Strategic Plans, with plans for the regions to be fully zoned and hydraulically modeled by 2026. Ashanti North has plans to pilot DMAs in the North A region in 2024-2026. Ashanti South's Strategic Plan noted a goal to implement DMAs in the South, Southeast, and Konongo districts (outside of urban Kumasi) by 2023 but had just one DMA that had been zoned in the entire region by the co-creation workshops in January 2024.

for study of hydraulic conditions after the DMA is successfully isolated. Intermittent water supply service will complicate the efforts to isolate the DMAs and determine the causes of NRW.

The selected districts will likely need to alter normal supply schedules to ensure a minimum of 24 hours of a pressurized pipe network within the selected DMA. They will need to make special arrangements to periodically read customer meters more than just one per month to measure and monitor NRW within the DMAs if the minimum night flow method is used. Alternatively, installation of smart meters within the selected DMAs that can be read daily would be very useful in efforts to measure and monitor NRW in the selected DMAs.

After isolating DMAs, the NRW Teams can effectively prepare a water balance, identify the causes of NRW, and begin discrete efforts to reduce NRW starting with the district-specific recommendations in the Strategic Plans. GWCL could incentivize strong performance by providing bonuses and/or imposing penalties for success or sustained failure in reducing NRW, respectively. Once the NRW Team has sustained progress towards NRW goals, they can move on isolate and study the next DMA. They will need to continuously measure NRW in all created DMAs to ensure that NRW remains at an acceptable level.

Recommendation # 6 – Bid and award a NRW reduction contract similar to the PBC recently awarded in the Accra East region.

While DMAs have been successful in the ATMA Region, they have not had sustained success in setting and maintaining DMAs in Ashanti South, Ashanti North, and the Northern regions.[49] For this reason, URBAN WASH suggests that districts consider a short-term NRW performance contract. This type of contract can bring the needed technical resources and know-how to the regions to jump start the efforts to reduce NRW, especially physical losses, and provide practical hands-on training to the regions and districts.

To provide a very preliminary business case analysis of the cost effectiveness of a PBC, URBAN WASH used information from the NRW performance contract in Accra East and applied it to the Ashanti Regions.

The Accra East contract calls for the establishment and management of water loss reduction activities within several DMAs, combined with knowledge transfer and supply of materials and equipment needed for water loss reduction. The estimated contract cost is $20.5 million with a target to reduce NRW by 23,000 m^3/day within 2 years (PPIAF 2023), which calculates to roughly $891 to reducing water loss by one m^3/day.[50]

Using this same $891 metric and assuming NRW in the Ashanti regions can be reduced from approximately 50 percent to 40 percent within two years, (the payback[51] and annual rate of return clearly justifies the capital investment needed as shown below in Table 12.

Table 12: Business Case for NRW Reduction in Ashanti Regions

	Baseline (Current)	After PBC (2 years)
1. Annual system input (m3)	48,000,000	48,000,000
2. Annual billed use (m3)	-24,000,000	-28,800,000
3. Annual water loss (m3)	24,000,000	19,200,000

[49] The three regions' NRW Strategic Plans did not consider performance-based contracting for NRW reduction.

[50] This quantity is calculated as $20.5 million divided by 23,000.

[51] Payback is the time it takes to recover the cost of a capital investment project from the benefits derived by the capital investment project.

	Baseline (Current)	After PBC (2 years)
4. NRW (%)	50%	40%
5. Increase in annual billed use (line 4 – line 1)	-	4,800,000
6. Average billed tariff per m^3	-	GHS 10
7. Increased revenues (line 5 x line 6)	-	GHS 48 million
8. Cost to reduce water loss by 4,800,00052	-	GHS 140 million
9. Pay back (line 8 / line 7)	-	2.9 years
10. Annual return after PBC (line 7 / line 8)	-	34%

In this hypothetical case, the benefit is additional annual revenues that should last as long as the investment in new pipes, meters, and equipment last, which is typically around 20 to 30 years. Some of the investment will be related to employee training and some recurring costs will be incurred to monitor the DMAs and other activities each year. The recurring costs should be able to be performed by existing employees without the need to hire additional employees. For utility capital investments in assets that have useful lives of 20 or more years, a payback of five years is within normal ranges to justify the investment. The above annual rate of return calculation is very simplistic but does show how the hypothetical water loss reduction could be a good investment in today's economic environment.

Recommendation #7 – Conduct a cost-benefit analysis to better understand the economic conditions under which prepaid metering for residential and non-residential customers could be financially viable.

Since a principal finding of this report was that there is not yet an economic case to justify GWCL to shift its limited resources toward prepaid metering for water supply, [53] this intervention would utilize available commercial and financial data from GWCL along with cost information for various models of prepaid metering technology to understand the scenarios under which prepaid metering for water supply in various types and sizes of communities could justify the economic return on investment. This would build on a similar analysis conducted by USAID's WASH-FIN project in Zambia.

Table 13 below provides a summary of all seven recommendations, including URBAN WASH's view of which cities the recommendations are most appropriate for; whether recommendations are short-term, medium-term, or long-term in duration; how cost/resource-intensive recommendation seem and what drives the cost/resources; and how the interventions should be prioritized.

[52] 4,800,000 annual water loss reduction/365 days in a year = 13,151 m^3/day x $891 cost to reduce a m^3/day of water (per Accra East PBC) x 11.95 conversion of USD to GHS.

[53] Introducing prepaid metering is not included as a part of any of the NRW Strategic Plans.

Table 13: Summary of NRW Reduction Recommendations

Recommendation	City Application	Duration[54]	Cost/Resource Intensive	Priority Level
1. Expand bulk metering to include bulk meters at all major above-ground assets along the transmission system and at the points water is delivered to districts.	This has application for **both**, but a bulk meter must also be put where water is diverted to Ashanti South and Ashanti North.	***Short-term (0–1 years)***	This is a **medium-cost** intervention since it requires a hydraulic survey, bulk meters, and the costs for installation and calibration.	This is the **highest priority**.
2. Hire, train, and equip dedicated district level NRW Teams (3–4 people) (reporting to District Manager) to supervise and monitor NRW reduction activity in the districts.	This has application for **both** as there are no NRW teams at the district level.	***Short-term (0–1 years)***	This is a **medium-cost** intervention since it requires hiring or reassignment of staff, pressure loggers, vehicles, and other equipment.	This is a **high priority** since it needs to occur for Recommendations #4 and #5 to be effective.
3. Accelerate efforts to reduce unauthorized water use through the use of PBCs with local contractors.	This applies more to **Tamale** because it has identified water theft as a key driver of commercial losses	***Medium-term (1–3 years)***	This could be a **lower-cost** intervention if it is handled internally through existing staff or via an external contractor where any contract would be structured as incentive-based with payment for hitting targets.	Addressing unauthorized water use is a **high priority** for Tamale but may be only **medium priority** for Kumasi.
4. Enhance the capabilities of visible leak detection teams to search for and reduce visible leaks.	This applies more to **Kumasi** because it has a higher proportion of physical losses.	***Medium-term (1–3 years)***	This is a **medium-cost** intervention because it requires more employees, vehicles, and leak detection equipment. Also, repair and maintenance expenses will increase as more repairs occur.	This is **medium** priority since visible leak repairs are only being done on a reactive basis due to lack of resources.
5. Identify locations for DMAs in one district in	This should be prioritized in **Kumasi** because it has	***Medium-term (1–3 years)***: Identifying,	This is a **higher-cost** intervention since it will require	This is **lower** priority because it can only occur after the training

[54] Duration refers to the length of time it would take to complete the intervention assuming that all needed funding was in place and there were not significant delays. The interval for short-term (less than a year) accords with the length of time from the date of this report through the potential end of URBAN WASH's Phase 2 pilots. A medium-term recommendation (1–3 years) could be feasibly started and ended prior to the expiration of the current NRW Strategic Plans, and a long-term recommendation (3+ years) could be started but not completed prior to the expiration of the current NRW Strategic Plans.

Recommendation	City Application	Duration[54]	Cost/Resource Intensive	Priority Level
each region studied and at least one pilot DMA within the selected districts.55	higher physical losses but could apply to both.	isolating, and studying the DMA **Long-term (3+ years):** Implementing sustainable NRW reduction efforts in the DMA	hydrological analysis to determine location of and isolate DMAs, study the measurements, and then implement needed reduction efforts, which may be a combination of employees and outside contractors.	that is part of Recommendations #2 and #4.
6. Bid, award, and implement a NRW reduction contract similar to the PBC recently awarded in the Accra East region.	This should be prioritized in **Kumasi** because it has higher physical losses but could apply to both.	**Long-term *(3+ years)***	This is a very **high-cost** intervention. The Accra East PBC is $20.5 million. Kumasi is about half the size of Accra East in terms of billed consumption.	This is **lower** priority, since it may be advisable to wait to see how other less costly interventions proceed so that any PBC is limited in scope. It also allows a chance to gauge and learn from the success of the Accra East PBC.
7. Using available commercial and financial data and updated cost information for prepaid meters, conduct a cost-benefit analysis to better understand the economic conditions under which prepaid metering for residential and non-residential customers could be financially viable.	This has application to **both.**	***Short-term (0–1 years)***	This is a relatively **low-cost** intervention.	This is **low** priority, especially given that GWCL has suspended its own prepaid metering pilot.

55 Depending on the selected district, size of DMA, and customer profile, a small-scale prepaid metering pilot could be considered as part of the DMA.

6.3 NEXT STEPS

Drawing on the evidence from Components 1–3, URBAN WASH will collaborate with GWCL to select interventions for implementation under the Phase 2 of the program and identification of appropriate performance indicators to measure the achievements of the intervention(s).

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