KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF ENGINEERING

DEPARTMENT OF CIVIL ENGINEERING

WATER CONSUMPTION AND ITS VARIATIONS IN KOFORIDUA

BY

KWESI SANE BANAFO

SEPTEMBER, 2013

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in partial fulfilment of the requirements for the award of a Master of Science Degree in

Water Supply and Environmental Sanitation

By

KWESI SANE BANAFO, BSc. (Hons)

SEPTEMBER, 2013

CERTIFICATION

I hereby declare that this submission is my own work towards the MSc. and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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DEDICATION

This research is dedicated to my confidant, Frances Ohemaa Banafo, our three big boys, Daniel, David and Dennis and the many more big boys and girls to come whose inspiration keeps me stuck to my principle of hard work and self-discipline.

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I am most grateful to God for providing the funds and the thumb without which untying this knot of wisdom will not had been possible.

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The contribution of Mrs Agatha Agyemang of the Fort Worth Library, Texas, U.S.A and all the librarians of the KNUST library who gracefully assisted me in untying the proverbial knot of wisdom is highly appreciated.

Finally, to all those who assisted me in diverse ways especially the good people of Koforidua, I say "Nyame nhyira mo nyinaa" (God bless you all).

ABSTRACT

The study determined water consumption and its variations in Koforidua based on data from three hundred and eighty (380) metered domestic customers and seven (7) metered second cycle educational institutions out of the eight thousand three hundred (8300) customers of Ghana Water Company Limited (GWCL) in Koforidua, Ghana using data from 2008 to 2012.

The study found that consumption of water supplied by GWCL two years after an increase in production was 72 l/c/d which represented a changed of 48% when compared to what pertained two years before the increase in production. Those in the middle income groups consumed 37% more of the water than those in the low income groups. Some customers were found to rely on other sources of water to supplement their water demand.

January had the highest monthly demand with a peak factor of 1.07 while June had the lowest monthly demand with a peak factor of 0.91.

The study found some significant differences in the water bills of customers between periods when they had functioning water meters installed and periods when they were given flat (estimated) rates even after the new plant. Whereas the average consumption of the former was 76 l/c/d, the average consumption of the latter was 112 l/c/d, a difference of 49%.

Finally, the study recommended a regular review of the flat rates given to customers during periods when they do not have functioning water meters installed to measure their consumption so as to keep their estimated bills within reasonable range and further recommended the need for customers to be sensitized on water management and awareness practices as only few customers were found to engage in such practices.

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LIST OF ABBREVIATIONS

GSS	Ghana Statistical Service
GUWL	Ghana Urban Water Limited
GWCL	Ghana Water Company Limited
IWA	International Water Agency
NCDENR	North Carolina Department of Environment and Natural Resource
NJMA	New Juaben Municipal Assembly
UN	United Nations
WASH	Water and Sanitation Hygiene
WHO	World Health Organisation

1. INTRODUCTION

1.1 Background

Water is a very important natural resource. As Dr. Haldan Mahler, former director general of the World Health Organization (WHO), has said, "The number of water taps per 1000 persons is a better indicator of health than the number of hospital beds" (Gadgil, 1998).

The United Nations (UN) suggests that each person needs 20-50 litres of water a day to ensure their basic needs for drinking, cooking and cleaning. The importance of the need for water providers to know how much water their customers consume can therefore not be overemphasized as it helps them in their attempt to meet the water demand of customers.

The per capita water consumption as defined by Neto *et al*., (2005) is the daily water volume per inhabitant, usually expressed as litres/inhabitant/day (L/inhab/day). This value is used in the design of water supply systems, taking into account:

- domestic consumption
- commercial and industrial consumption;
- public consumption;
- water losses in the distribution network

Koforidua has over the years experienced perennial acute water shortage till the coming into operation of a 4.2 million gallons capacity new treatment plant at Bukunor in 2010 worth €35 million with its source from the Volta Lake. The new plant compliments the old 1.2 million gallons per day capacity plant constructed in 1960 which receives raw water from the Densu River, a source that was unable to meet demand especially in the dry season hence the perennial acute water shortages which compelled GWCL to ration water to its customers.

In a study on the, "Determination of the water consumption pattern in Accra'', Lamptey (2010) concluded that the average per capita consumption for high and low income dwellers in Accra were 138 l/c/d and 66 l/c/d respectively which were higher than the figures used for design by GWCL. Lamptey's study had been preceded by Gyeabour (2007), who had established that the water consumption in Kumasi was significantly different between water use by high income, middle income and low income households and concluded that the per capita consumption varied with income levels and varying conditions of supply.

The research works carried out by Gyeabour and Lamptey in Kumasi and Accra respectively though may provide a guide may not represent the water consumption in Koforidua adequately since the consumption depends on factors that change with space and time.

This research seeks to establish the variations in per capita water consumption with seasons, income groups and methods used in billing for domestic and second cycle educational institution customers of GWCL in the Koforidua municipality.

1.2 Problem statement

Data for planning, though very important may not be readily available as it requires research to establish hence planners rely on projected figures which in most cases do not represent the reality since the relevance of any data may be dependent on several factors.

The current actual water consumption pattern, a parameter that helps planners to plan for the future is not known two (2) years after the coming into operation of the new treatment plant that increased the water supplied to Koforidua by GWCL about 330% (1.2mgd-5.2mgd).

The outcome of the study will help GWCL to know the current actual water consumption pattern and help it to plan ahead of time to enable it achieve its vision of providing the urban

population of the Eastern Region with potable water twenty four (24) hours every day to the satisfaction of its customers.

1.3 Objectives

The main objective of the research is to establish the current water consumption pattern in Koforidua. To achieve this objective, the following sub-objectives have been set.

- Establish the water consumption of metered domestic and second cycle educational institutions in Koforidua supplied by GWCL.
- Establish the consumption of various domestic income groups in Koforidua.
- Assess water demand management awareness and practices among GWCL customers.
- Establish the percentage of GWCL customers who harvest rainwater to supplement their water requirement.
- Establish the variation in charges due to metered and estimated (unmetered) methods of billing.

1.4 Research hypothesis

- The consumption pattern of GWCL customers in Koforidua has not changed two years after the coming into operation of the new treatment plant.
- A significant number of GWCL customers use rain water to supplement their water requirement.
- Inhabitants understand the need for water management.

1.5 Justification of study

Ghana Water Company Limited (GWCL) has a vision to provide the urban population of the Eastern Region with potable water twenty four (24) hours every day to the satisfaction of its customers (GWCL, Koforidua). To achieve this vision, there is the need for GWCL to have a clear knowledge of the water consumption pattern to enable them make reasonable projections and plan ahead to ensure they do not only meet the current demand but are able to also sustain it into the future.

The research seeks to determine the per capita water consumption, an important parameter in water infrastructure planning, to help GWCL in planning and also establish the seasonal variations in water consumption two years after the water supply was increased.

1.6 Scope of study

The research focuses on determining water consumption pattern for selected domestic customers and second cycle educational institution customers of GWCL in Koforidua. Three hundred and eighty (380) domestic customers and seven (7) second cycle educational institution customers of GWCL in Koforidua were surveyed. The period under study spans from 2008 to 2012.

1.7 Flow chart for the report

Below is a flow chart of how the study was organized.

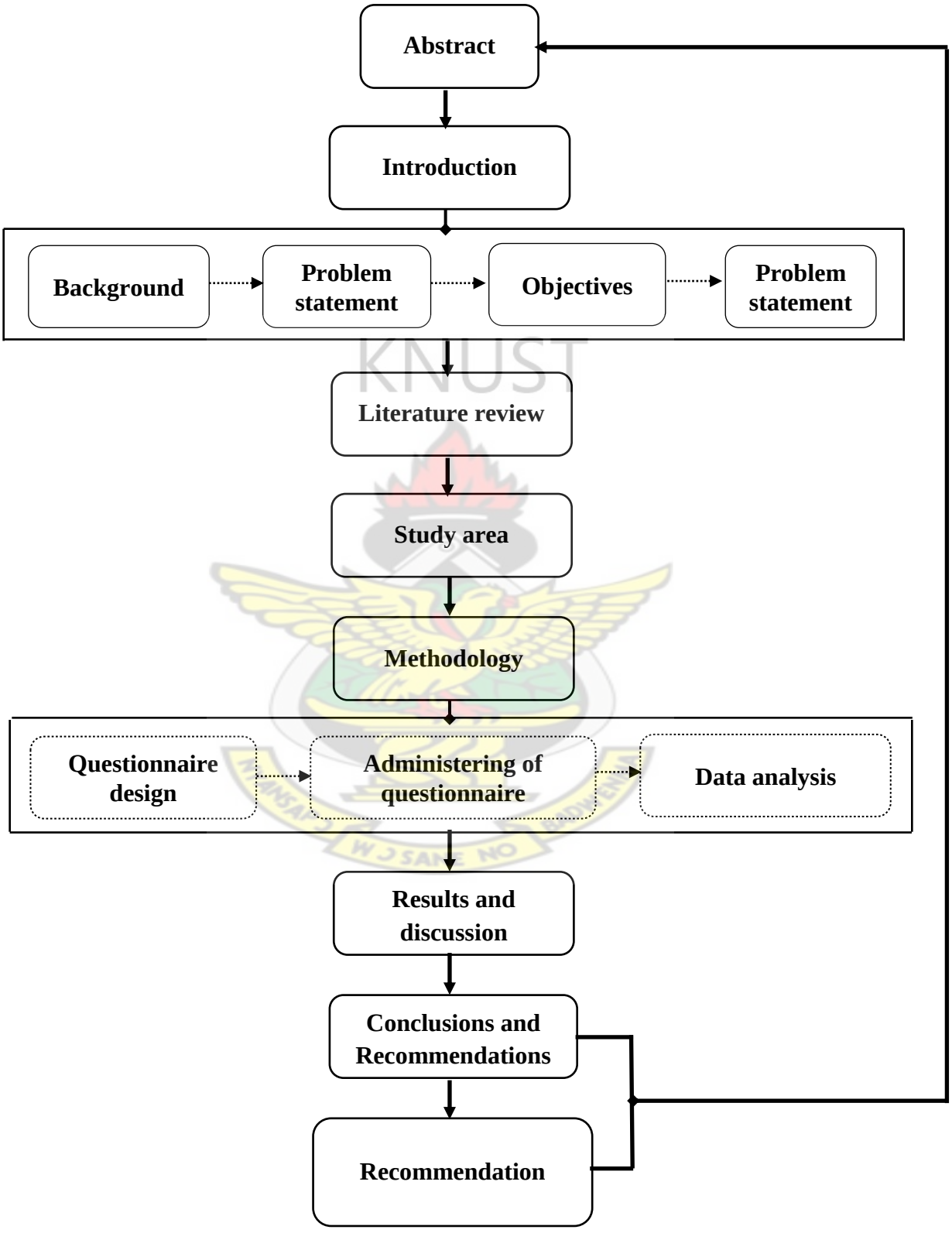


Figure 1.1: Flow chart for the study

2. LITERATURE REVIEW

2.1 Water consumption and demand

Water consumption is defined as the amount of water actually supplied (or estimated to be supplied) for some (legitimate) purpose whereas demand indicates the amount of water estimated to be required for the purpose (Andey and Kelkar, 2008).

According to Trifunovic, (2005), demand variations are commonly described by peak factors. These are ratios between the demand at particular moments and the average demand for the observed periods (hour, day, week, year, etc.).

2.2 Categories of customers

Beneficiaries of treated water may be categorized into various groups for effective operational purposes and monitoring. GWCL categorizes its customers by districts and customers numbers.

2.3 Factors influencing consumption pattern

Water consumption can be extremely variable due to a range of factors, including climate, culture, economy, individual demands, occupant attributes and appliance characteristics (Wong and Mui, 2005). The per capita consumption depends on a number of factors such as water price, income, household and housing characteristics, domestic appliances and rainfall and is considered a random variable (Nauges and Thomas 2003).

Andey and Kelkar, (2008) also mention that water consumption by a community is dependent on a number of factors like season, climate, cultural habits and local customs.

Wong, (1972) in a study concluded that both income and average summer temperatures had a significant impact on Chicago's water demand. Gamedze *et al*, (2012) in a study also

established that domestic water demand in Swaziland was determined by factors such as income, household size and distance from homestead to water sources.

2.3.1 Size of households

Gamedze *et al*., (2012) revealed that households in Swaziland with five or less people tend to collect small amount of water (0-100 l/day) whereas larger households (greater than five) are likely to fetch larger quantities of water (more than 100 l/day). The size of a household therefore influences the quantity of water it consumes.

2.3.2 Frequency of flow

The consumption pattern is influenced by the frequency of supply. According to Lamptey (2010), consumption in various income groups is influenced by flow conditions with consumers under continuous supply having higher per capita consumption than their counterparts in the intermittent supply conditions.

Furthermore, a study by Andey and Kelkar, (2008) indicated that domestic water consumption depends on adequacy of water supply, and concluded that even short duration of water supply with enough pressure than long duration with less pressure can satisfy the consumer demand.

2.3.3 Cheating by customers

Billed metered consumption may be affected by activities of some of the customers. According to Adombire, (2007, some customers in Ghana reverse their meters, make by-pass, and in some cases use magnets and sticks to prevent water meters from recording the correct amount of water consumed.

2.3.4 Income levels

The income of a people in particular and a country in general influences how water is consumed. According to UNESCO, industrial use of water increases with country income, going from 10% for low- and middle- income countries to 59% for high-income countries as shown in **Figure 2.1** (UNESCO, 2003).

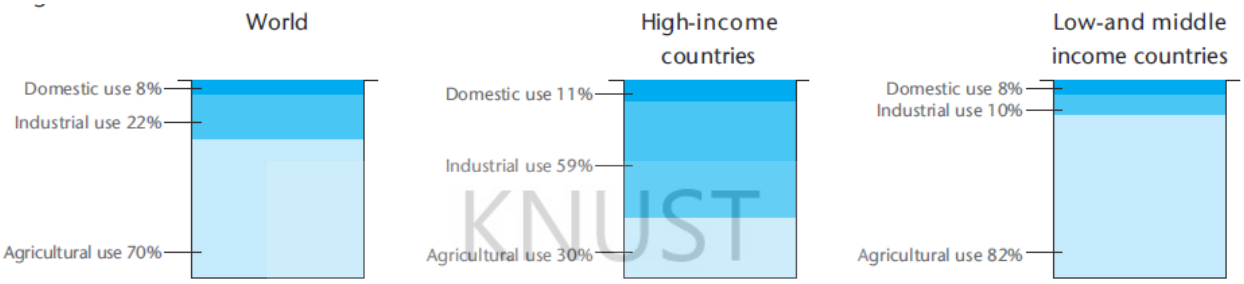


Figure 2.1: Variation in industrial use of water with country income

A research done by Shaban and Sharma, (2007) also revealed that the availability of water in Indian cities varies with socio-economic groups. Another research by Gyeabour, (2008) established that per capita water consumption in Kumasi ranges between 177 l/c/d for high income households to 70 l/c/d for low income households under continuous water supply. Furthermore, Rendwick and Archibald, (1998) in a study concluded that lower income households were more price responsive and that low income households were found to be more than five times more price responsive than relatively wealthy households; reflecting the fact that their water bill typically constitutes a larger share of the household budget.

2.3.5 Extent of usage of other sources of water

Parsons *et al.*, (2010) revealed that the collection and use of rainwater for water closet flushing could result in approximately one third reductions in the public water supply to the average household in UK.

2.3.6 Network pressure

The pressure levels in pipelines go a long way to influence the water consumption pattern. High pressures in pipelines are accompanied by high consumption. According to Nyende-Byakika *et al*., (2011) usually, most pipes have water which either fills or nearly fills their cross sectional areas but the pressure to push it out is absent.

Interestingly, Lee and Schwab, (2005), mentions that the hydraulic pressure, or water pressure in the pipeline may start off high but drop off rapidly, with those in the end zones experiencing very little pressure or water supply. Thus, those living closest to the treatment plant are at an advantage for receiving sufficient volumes of water than those who are located further away

2.3.7 Temperature

Gadgil (1998) disclosed that water need increases sharply as ambient temperature exceeds 25^{o}C. On the contrary, though Schleich and Hillenbrand, (2007) in a study concluded that, factors such as household size, the share of wells and summer rainfall had a negative impact on water demand, their work could not find an impact of temperature on residential water use.

2.3.8 Presence of water meters

The presence of water meters, shown in **Figure 2.2**, helps in regulating the water consumed by consumers. Batchelor, (1975) in a study on household technology and the domestic demand for water in United Kingdom concluded that not only will the level of consumption be lowered by metering, but its subsequent growth rate will also decrease.

Figure 2.2: Typical water meter

However, Staddon (2010) in a study on the best available current research on water metering around the world concluded that there is little evidence that compulsory universal metering can achieve either the water conservation or social equity goals articulated by the UK government.

2.3.9 Seasons

Domestic water consumption varies from season to season. Mahvi and Norouze, (2005) established that the maximum water consumption in Rural Pakistan occurred in summer, about 138 l/c/d and minimum of this occurred in winter with 89.6 l/c/d.

2.3.10 Presence of demand management policies

Demand Management Measures (DMM) is defined as "any regulatory, policy, technical, service or commercial interaction with customers or consumers that aims to minimise the overall demand for water" (Queensland Water Commission, 2007). DMMs go a long way to influence the water consumption pattern of consumers.

England, (2009) said a mix of regulatory, fiscal and educational initiatives encouraged Brisbane residents (in Australia) to reduce their water consumption by 57 per cent.

Kotwicki and Al-Otaibi, (2011), in a study on drinking water saving potential of dual networks in Kuwait concluded that with foresight and long-term planning it is feasible to implement a dual water supply network (one for potable water and the other for non-potable water) in a major city, on a scale which may lead to saving up to twenty five (25) per cent of drinking quality water on top of other traditional water conservation measures.

Dual systems in Hong Kong provides sea water in a separate system for toilet flushing in many government-built high rise blocks, while in Australia a few New South Wales towns give a non-potable supply for all uses of water outside the home, such as garden watering and car washing (Ress, 1976). In all these cases, potable water that would have otherwise been 'wasted' in activities such as 'toilet flushing, garden watering and car washing are conserved hence reducing the per capita water consumption from the treated water (potable) supply.

2.4 Water conservation and water efficiency

According to NCDENR, (2009) "Water efficiency" means using improved technologies and practices that deliver equal or better service with less water. For example, the use of low-flow faucet aerators can be more powerful than no aerators for washing hands. "Water conservation" is associated with curtailment of water use and doing "less" with less water, typically during a water shortage, such as drought; for example, minimizing lawn watering and automobile washing in order to conserve water.

Water conservation also includes day-to-day "demand management" to better manage how and when water is used, so it is common to hear the words "water conservation" used synonymously with "water efficiency."

2.4.1 Water conservation and consumption variation

Oliver and Brummer, (2007) in a study on factors influencing water consumption in South African schools revealed that water conservation in the form of reduced consumption will have varied impacts which include environmental benefits and direct and indirect cost savings.

The water consumed for domestic purpose depends largely on the type of facilities available in the house. A study on domestic water consumption in domestic and non-domestic properties in England and Wales concluded that the total volume of water consumed for domestic purposes in England and Wales accounts for 60% of water supplied out of which the use of water closets, baths and showers accounted for 51% of water for domestic purposes, thus, equivalent to 30% of all water supplied.

Hackett and Gray, (2009) found out that by using water-efficient appliances and the careful use of heated water, household water use in the UK could be reduced from 151 to 73 litres per capita per day (Hackett and Gray, 2009).

As cited by Campisano and Modia, (2009) a significant part (close to 30% of water in houses is actually used for toilet flushing and that values between 10 and 15% of the domestic total consumption are related to the use of bathroom washbasins for personal hygiene.

Moreover total domestic consumption percentages between 9.6 and 28.8% of water used in houses could be easily saved by the reuse of washbasin grey water (Campisano and Modia, 2009).

2.4.2 Water efficiency and consumption variations

The consumption pattern can be greatly altered depending on the level of usage of water saving devices. Hackett and Grey, (2009) revealed that by using water-efficient appliances and the careful use of heated water, household water use in the UK could be reduced from 151 to 73 litres per capita per day.

2.5 Water efficient devices

There are now modification in some traditional water appliances like showers, water closest, faucets and many others to ensure water consumers use less water to achieve the same results. This section elaborates on few of such devices.

2.5.1 Highly efficient toilets (HETs)

Before 1977, most water closet toilets manufactured required high quantity of water to flush. However, over the years, attempts have been made to reduce water consumption for toilets through the manufacturing of more water efficient toilets (NCDENR, 2009). The most efficient commercial toilet on the market is the high efficiency toilet (HETs). HETs use less than 1.28 gallons (4.84 litres) per flush.

Dual-flush toilets employ a dual-action flush valve or two-button system; one for a full flush (1.6 gallons per flush to eliminate solid waste) and the second button for a reduced flush (1.1 gallons per flush for liquid waste). An electronic sensor-activated dual-flush unit is also available, in which the sensor activates the appropriate flush, depending on the length of time the user remains seated.

2.5.2 Water efficient showerheads and timers

A survey by Oduro-Kwarteng *et al*., (2008) brought to light the potential for reducing annual water demand on a university campus in Ghana by 30.85% through water conservation measures such as retrofitting with water-efficient showerheads and water closets.

A study by Mui *et al*., (2007) in Hong Kong found that, for an estimated consumption of 61.2m^3 per capita per year, half of it is used at showerheads. The work by Oduro-Kwarteng *et al*., (2008) and Mui *et al*., (2007) gives a hint of the impact retrofitting with water efficient showerheads can have on water consumption in a typical case like what pertains in Hong Kong.

Showerhead replacement or modification represents effective water efficient area. According to NCDENR, (2009) most conventional showerheads use three to seven gallons (11.4 to 25.5 litres) per minute at 60 psi (4 bars) water pressure. Current standards require showerheads to use not more than 2.5 gallons (9.46 litres) per minute.

Efficient showerheads operate by mixing water flow with an air jet. These units provide satisfactory contact with water and achieve effective rinsing with much less water. Whereas a five minute shower with a normal shower head can use around 100 litres of water, a water efficient shower head consumes a modest 35 litres. **Figure 2.3** shows an example of an efficient shower head.

Simple and inexpensive timers shown in **Figure 2.3b** are available to alert users of the time spent in a shower. In an ordinary shower cycle, as much as 50% savings can be achieved by turning the water off while shampooing your hair or washing your body (Mirata and Emtairah, 2010).

(a)

(b)

Figure 2.3: Water efficient showerhead and shower timer

2.5.3 Efficient faucets

According to Mirata and Emtairah, (2010) faucets with automatic shut-off systems shown in **Figure 2.4a** cuts the flow of water once a predetermined amount of water has been discharged saving about 70% of water. On-demand faucet units shown in **Figure 2.4b** rely on infrared sensors to trigger water flow thus reducing water used in basins by about 80%.

(a) Automatic shut-off faucets (b) On-demand faucets

Figure 2.4: Faucet types

2.5.4 Water efficient urinals

Though typical water consumption for older urinals is 2 to 3 gallons per flush, a high efficiency urinal is now defined as a urinal fixture with a flush volume of 0.5 gallons per flush or less, including waterless units (NCDENR, 2009).

The use of waterless urinal shown in **Figure 2.5** involves a vitreous china or stainless steel fixture and a replaceable oil-filled cartridge that traps odours. These offers the savings of flush water and sewer charges though these operational savings are balanced with the cost of cartridges for the drain which typically are replaced every 7,000 uses.

Figure 2.5: Waterless urinal

According to Mirata and Emtairah, (2010) infrared sensor operated urinals work by detecting the presence of a user within the detection zone for more than a certain time threshold. The user's departure from the detection zone activates flushing. These units use no more than 1 to 1.5 litres of water per flush.

2.5.5 Greywater treatment device

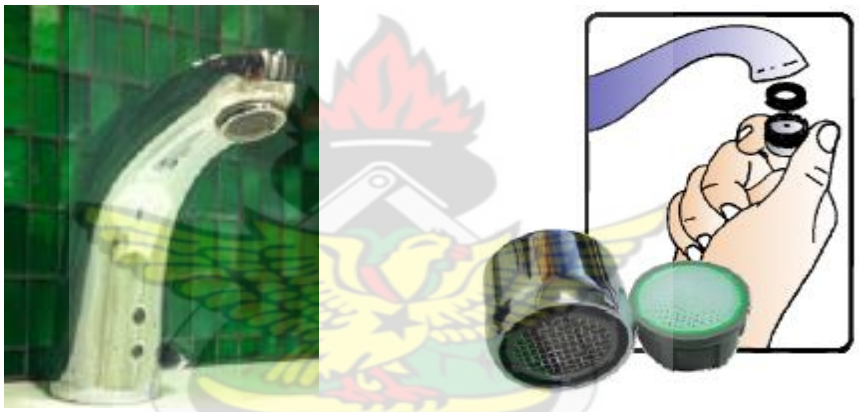
As cited by Campisano and Modia, (2009) about 30% of water in houses is used for toilet flushing and 10 to15% of the domestic total consumption are related to the use of bathroom washbasins. Water consumed in showers, wash basins, and laundry operations can be reused.

Campisano and Modia, (2009) revealed that total domestic consumption of between 9.6 and 28.8% of water used in houses could be easily saved by the reuse of washbasin grey water.

2.5.6 Water efficient faucets and tap adaptors

On-demand faucet units rely on infrared sensors to trigger water flow. With the use of such systems, water use in wash basins can be reduced considerably (Mirata and Emtairah, 2010).

Simple devices that mix water and air can reduce both water flow rates and splashing while increasing areas of coverage and wetting efficiency and can save up to 50% during hand washing. **Figure 2.6** is an example of water efficient faucets and tap adaptors.



(a) (b)

Figure 2.6: Water efficient infrared on-demand sensor tap and tap aerators

2.6 Unaccounted for water

Unaccounted-for water (UFW) in simple terms is known as water loss and sometimes also known as non-revenue water and it is defined as the difference between the quantity of water supplied to a city's distribution network and the metered quantity of water consumed by the customers (Sastry, 2006). The issue has emerged from the fact that not all water supplied by the water utilities reaches the consumer and not all water that reach them is properly measured and billed for payment (Thornton, 2002).

The constituent of annual water balance by the International Water Association (IWA) shown in **Figure 2.7** summarises the components of non-revenue water.

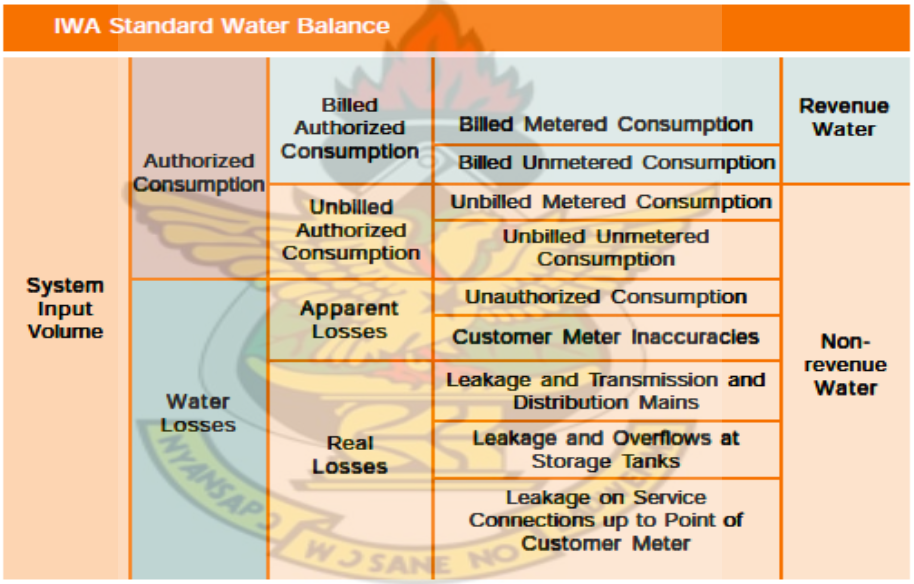


Figure 2.7: Constituents of annual water balance by IWA

According to the World Bank, the reduction of UFW is a crucial step to improve the financial health of water utilities and to save scarce water resources. UFW in well-run utilities is 15-20%, although the optimal level should vary depending on circumstances, such as particularly the cost of bulk water supply.

The percentage of physical losses is influenced not only by the deterioration of the piped network, but also by the total amount of water used, system pressure, and the degree of supply continuity. The percentage of administrative losses depends on the degree of effort exerted in identifying illegal connections and in repairing meters.

According to the GIPC (2012), with GWCL's unaccounted-for water at about 50% of total output, the volume of water that is effectively sold (280 000 m^3/day) is less than half of the daily demand (763 300 m^3).

2.7 Housing types

According to Ghana Statistical Service (2012), housing in Ghana can be classified into compound house, separate house, semi-detached house, huts, improvised house, living quarters attached to a shop, camps or tent, hotel, flats or apartments and others examples of which are shown in **Figure 2.8**.

Figure 2.8: Housing types in Koforidua

This work will be limited to water consumed by occupants of compound houses, separate (detached) house, semi-detached and flat or apartments.

2.8 Income group classification

Though the research was undertaken in the New Juaben Municipal Assembly, as a result of the unavailability of indicators for classifying various income groups in the municipality, the Accra Metropolitan Assembly (AMA) indicators for classifying various income groups was adopted as cited in Lamptey (2010). As shown in **Table 2.1**, the AMA classifies the various income groups based on indicators such as house type, access roads, solid waste management and type of sanitation.

Table 2.1 : Indicator for income class classification

Income group	House type	Access roads	Solid waste management	Type of sanitation
High income	Deluxe, exclusive, gated community with swimming pool, lawn and garden	All houses have access, with good drainage system in the area	Waste in the community is managed by waste management company which uses rear loading hydraulic compactor trucks	Water closet with septic tanks and underground sewerage systems
Middle income	Detached houses and semi-detached house with garden and flower beds	All houses have access, with poor drainage system in the area	Private individual cart waste by means of human pedal cart, human hand cart, tractor and trailer and dump into a secondary collection point in the community for a fee.	Water closet and KVIP
Low income	Compound houses, yards shanty houses and barracks	There are no access to most buildings in the area and there are no drains most of the time	Household members carry solid waste to secondary collection points or burn the rubbish or practice crude dumping of waste	KVIP, Pan latrine and the use of public toilets.

Source: (Lamptey, 2010)

3. STUDY AREA

3.1 Introduction

Koforidua is one of the ten administrative capitals in Ghana. Located in the Eastern Region of the country, the town doubles as both the regional capital of the Eastern Region of Ghana and the capital of the New Juaben Municipal Assembly.

3.2 Description of the study area

The Municipality, the location of which is shown in **Figure 3.1**, covers an estimated area of 110 square kilometres constituting 0.57% of the total land area of the Eastern Region and has an annual rainfall ranging from 50-120 inches and 20-32°C mean annual temperature.

The municipality shares boundaries with East-Akim district on the North-East, Akwapim North District on the East and South and Suhum-Kraboa-Coaltar District on the west.

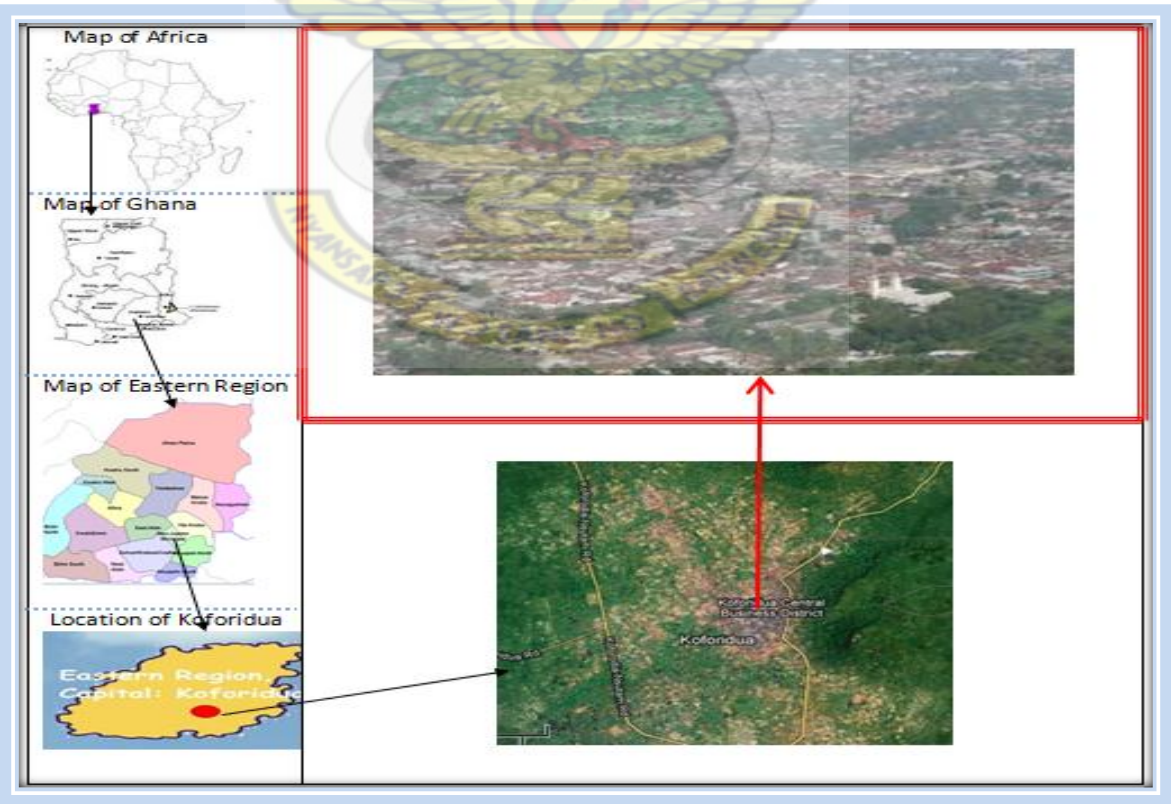


Figure 3.1: Location and aerial map of study area

The total population of the New Juaben Municipality is 183 227 of which 88 687 are males and 95 040 are females. 115 597 of this population are 18 years old and above. According to the 2010 housing and population census, there are 49476 households in the New Juaben Municipality with a total household population of 173 653 and a corresponding household size of 3.5 persons per household. 171 376 persons out of the total population dwell in the urban areas with the remaining 12 351 accounting for the rural population (GSS, 2012). **Figure 3.2** is a map of Koforidua indicating potable water supply pipe network.

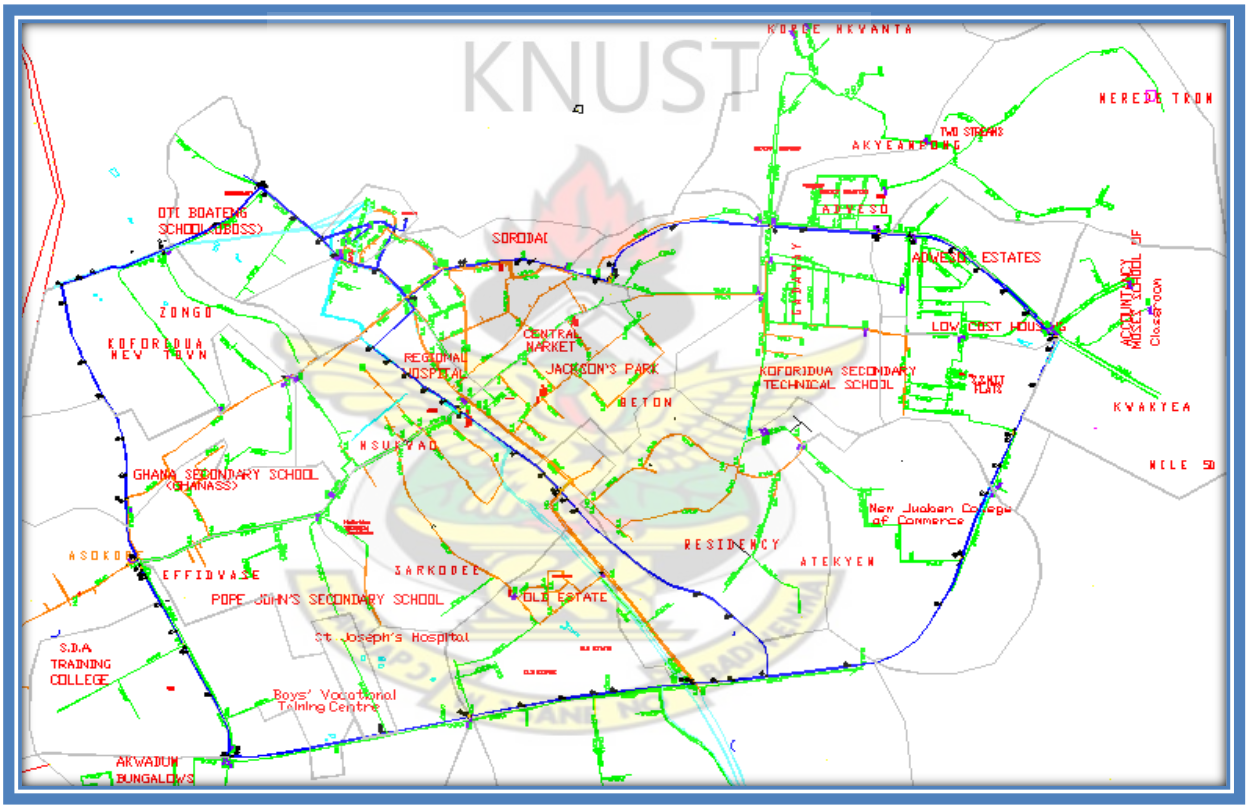


Figure 3.2: Map of study area indicating pipe networks

3.3 GWCL customers

The number of GWCL customers has been increasing over the years. **Table 3.1** gives the annual increases in GWCL customer numbers since 2008.

Table 3.1 : GWCL customer numbers since 2008

Year	No. of customers	% increase
2008	7 220	_
2009	7 399	2.48
2010	7 715	4.27
2011	8 066	4.55
2012	8 497	5.34

From **Table 3.1**, GWCL has seen an annual growth in customer strength of about 5% since the commissioning of the new plant in 2012.

3.3.1 Domestic customers

The domestic customers selected for the research included residents leaving in the predominantly low income areas. The housing type in these areas, though mixed, was mostly compound houses with few detached houses. Except in few cases, houses in these areas did not have water closets and showers and obtained their water supply from a single standpipe located in the house.

The other areas included the predominantly middle income areas where the housing type was mostly semi-detached, detached and flats with good access roads. These groups of houses usually had showers and water closet facilities and in some isolated cases owned washing machines.

3.3.2 Second cycle educational institutions customers

Koforidua boasts of several second cycle educational institutions among which are the Ghana Secondary School, New Juaben College of Commerce, Oti Boateng Secondary School, Pope John II Secondary School, Koforidua Secondary Technical and Kingsby Girl's High School.

The selected schools, though similar with regard to their level on the educational ladder, have different compositions. Pope John's Secondary School and Kingsby Girls' Secondary School are both single sex schools with the former composed of only males and the latter composed of only females. Koforidua Secondary School, though a mixed school (both male and female), only provides boarding facilities for the male population with the minority female population being day students. The three remaining schools are all mixed schools.

4. METHODOLOGY

4.1 Desk study

A desk study involving the acquisition of information about relevant institutions such as GWCL and relevant second cycle educational institutions was carried out. Journals and other publications which were relevant to the subject were also reviewed.

4.2 Questionnaire design

Due to the distinct nature of the two categories of GWCL customers under study, the questionnaires were structured to suit each of the categories to ensure that the data obtained from each of them will be relevant to the study (see **Appendix A** and **Appendix B**).

Face validity study to check whether the appropriate questions have been asked as well as the carrying out of a reliability test to ascertain whether the questionnaire is reliable in achieving the objectives of the research was undertaken.

4.3 Data collection

The income groups in Koforidua comprise of mainly low and middle income class hence the data used for the research was only from these two income groups. **Table 4.1** gives a list of the communities in Koforidua from which the data for the research was obtained.

Table 4.1: List of communities for the research

Low income communities	Middle income communities
Abogri	Adweso estate
Acheampong	Akwadum bungalow
Asokore	Low cost housing
Betom	Nursing quarters
Effiduase	Old estate
Kwaakyea	SSNIT flats
Nsukwao	
Sorodai	
Zongo	

Data relating to the monthly water consumption figures of customers (statement of billing) was obtained from the Data Processing Unit of GWCL, Koforidua using the various customer numbers of all the respondents and it is from this that the analysis was carried out.

4.4 Domestic category

To acquire the relevant data from domestic users, self-administered questionnaires were used to obtain socio-economic and demographic data of domestic customers of GWCL. In all, 380 questionnaires were administered for the domestic customers.

From the data obtained from the questionnaires administered, the domestic customers were grouped into medium and low income groups. The customer numbers (found on the water bills) were used to obtain the monthly water consumption (Statement of billing) of the all respondents from 2008 to 2012 from which the consumption variations were established based on comparative analysis.

4.4.1 Data sampling

To obtain the number of questionnaires that were to be administered, the Yamane (1967) formula was used. The formula is given as:

$$n = \frac{N}{1 + N(1 - \sigma)^2}$$

Therefore, for a sample frame of 8300 domestic customers of GWCL as of December, 2012;

Sample frame, N=8300 GWCL customers

Significance level, $\sigma = 0.95$

$$n = \frac{8300}{1 + 8300(1 - 0.95)^2}$$

$\Rightarrow$ Sample size, n =380

Hence, 380 questionnaires were administered.

The response rate was 100% because the researcher ensured that the questionnaires were self-administered and only customers who were willing to participate were sampled.

4.5 Second cycle educational institutions category

Seven (7) questionnaires were administered to the heads of all the seven second cycle educational institutions within Koforidua that were supplied by water from GWCL at the time of the research. The questionnaire sought to establish the student population of the various institutions and its variation with the various terms (sessions) within the academic calendars that fell within the study period.

4.6 Computation of consumption variations

This section explains how the various consumptions used for the research were computed.

4.6.1 Determination of per capita water consumption

The determination of the per capita water consumption for the domestic consumers of GWCL was done as follows:

- Questionnaires were used to obtain various data from 380 GWCL customers from various parts of Koforidua prominent among which were the customer numbers and population of the various households.
- The customer numbers that was obtained from a copy of the monthly water bills of the respondents were used to obtain the Statement of Billings of the all the 380 respondents from the Data Processing Unit of GWCL spanning the period of January 2008 to December 2012. These statements of billing provided detailed information on the respondents' consumption and served as the basis for the various consumption variations.
- The Statement of Billing of GWCL customers who had metered bills throughout the five year study period (2008-2012) were then selected for the computation of the consumption.
- The per capita water consumption of the relevant customers based on the monthly consumption of 170 out of the 380 respondents who had metered bills throughout the study period as provided in their statement of billing was then computed based on the relation:

$$Per\ capita\ consumption\ per\ day = \frac{Annual\ consumption}{Household\ population\ x\ number\ of\ days\ in\ the\ year}$$

4.6.2 Variation in consumption with modes of billing

The variation in the water consumption as consumed by customers (metered) and as estimated by GWCL (flat or estimated rates) shown in **Appendix G** was determined as follows:

- The category of GWCL customers who had enjoyed both metered billing (metered) and unmetered billing (estimated/flat rates) during the study period were identified for this computation.
- Thirty six (36) out of the 380 respondents who had metered bills for at least 5-months after the increase in production were selected for the analysis.
- For each of the 36 respondents that fell into this category:
  - The average consumption for n-months (n≥5) during the period when their consumption was metered after the increase in production was determined as C_m.
  - The average consumption for the last m-months before the n-months when their consumption was unmetered (n=m) was determined as C_u.
  - The percentage by which GWCL overestimate or underestimate the bills was then determined as :

$$P_o = \left(\frac{C_u - C_m}{C_m}\right) x100\%$$

$where$:

$P_o = Perceentage\ overestimate\ (overcharge)$

$C_u = Average\ unmetered\ consumption$

$C_m = Average\ metered\ consumption$

Note: Negative P_o values indicates undercharged consumption

and vice – versa

4.6.3 Estimation of change in consumption

The estimation was done using data from only the one hundred and seventy (170) respondents whose consumption was metered for the entire five year study period spanning 2008 to 2012. The estimation was done as follows:

- The average water consumption of the 170 respondents between January 2008 to December 2009 was determined;
- The average water consumption of the 170 respondents between January 2011 to December 2012 was also determined;
- The two categories water consumption values determined above were then compared to establish the percentage change in water consumption two years after the coming into operation of the new water treatment plant as shown in **Appendix F**.

4.6.4 Estimation of monthly consumption variations

The estimation of the variation in water consumption during different periods of the year was done using only data from the 170 respondents whose consumption was metered for the entire study period. This was done as follows:

- The total consumption of each respondents for the various months during the five year period was determined;
- The sum total of the consumptions of all the respondents for the various months for the five year study period was then determined.
- The monthly peak factors were then determined by dividing the total monthly consumption for each month by the average total monthly consumption (see **Appendix C** to **Appendix E**).

4.6.5 Estimation of consumption for different income groups

The water consumption for the two income groups (low and middle) identified was determined using data from only the 170 respondents who had metered bills spanning the entire study period. In all, data from one hundred and twenty nine (129) and forty one (41) middle and low income respondents respectively were used for the analysis. A summary of the analysis is provided in **Appendix F**.

5. RESULTS AND DISCUSSIONS

5.1 Introduction

This chapter presents a discussion of the results obtained from the three hundred and eighty (380) respondents using questionnaires as well as the determination of the water consumption from the statement of billing of customers from January 2008 to December 2012 for domestic and second cycle educational institutions customers of GWCL.

5.2 Domestic Category

This section presents the analysis of the results obtained from the distribution of the questionnaires as well as from the statement of billing of customers obtained from GWCL.

5.2.1 Reliability of service

From the questionnaires, 96% of the respondents acknowledged that there had been improvement in water supply since 2010 while the remaining 4% said it had remained the same over the years or had even deteriorated.

Table 5.1 shows respondents' assessment of the reliability of the service they receive from GWCL based on the frequency of water supply and the duration for which interruption in supply usually lasted.

Table 5.1: Respondents' assessment of current reliability of service

	Current frequency of supply				Current duration of supply interruption				
Number of days per week (days)	1	2 - 3	4 - 6	7	<1	1 - 2	3 - 4	5 - 7	>7
Number of Respondents	0	25	46	309	160	137	51	7	25
Percentage (%)	0	7	12	81	42	36	13	2	7

The reliability of water supply in Koforidua as presented in **Table 5.1** shows that 81% of the respondents enjoyed supply daily and none enjoyed supply just once a week. GWCL considers customers whose supply is between five to six days per week and lasting between twenty to twenty four hours per day as good intermittent flow and customers whose supply is between one to two days per week and lasting between six to twelve hours per day as poor intermittent flow (Lamptey, 2010).

Currently, there is no rationing of water in Koforidua and it is expected that except during occasional power failure and maintenance works, water supply will be regular. It was therefore surprising that about 7% of respondents still received less than three (3) days of continuous supply.

Moreover, the duration of water supply interruptions presented in **Table 5.1** shows that over two-third (70%) of the respondents were found to experience interruptions that lasted two days or less while 7% experienced interruptions that lasted more than a week. These results buttress the need for GWCL to find out why some of its customers do not get regular supply notwithstanding the increase in production.

Pressure ratings by respondents presented in **Table 5.2**, though subjective, gives an idea of how the respondents perceived the pressure with which water flowed through their water taps.

Table 5.2: Respondents' rating of pressure levels

	Pressure			
Rating	**Very low**	**Low**	**High**	**Very high**
Number of respondents	18	41	294	27
Percentage (%)	5	11	77	7

It is clear from **Table 5.2** that over 80% of the respondents were satisfied with the pressure with which water flowed through their taps as they perceived the pressure to be either high or very high.

5.2.2 Impact of water efficient appliances on consumption

The link between water consumption and the type of appliances used by the consumers based on other researches reviewed cannot be overemphasized. To this end, data on the type of water appliances (devices) used by respondents including their knowledge on water efficient devices were taking. The results, presented in **Table 5.3**, indicated that about a quarter (26%) of the respondents had knowledge of the existence of water saving devices and this meant most of the respondents had no knowledge of the existence of water saving devices.

Table 5.3: Appliance used and water efficiency

Parameter	Water appliance used			Water saving device		
	Shower	Water closet	Washing machine	Knowledge	Usage	Will to invest
Number of respondents	265	291	21	99	14	273
Percentage (%)	70	77	6	26	4	72

There is therefore the need for increased sensitization on the long term benefits of water saving devices (notwithstanding the seemingly initial high cost) to be carried out for customers to appreciate the need to be water efficient conscious especially when purchasing water appliances. This is feasible as a high percentage (72%) of the respondents expressed their willingness to invest in water saving devices when the researcher enlightened them on their initial costs which tend to be higher than the conventional (non-water saving) devices as well as their long term benefits.

5.2.3 Alternate source of water

In the event of interruption in supply, most respondents relied on water they store while others depended on other sources such as wells and boreholes. **Table 5.4** presents the other sources of water customers depended on to supplement their water needs.

Table 5.4: Respondents' use of alternative sources

Source	No. of Respondents	Percentage (%)
Borehole	11	3
Well	42	11
Tanker service	4	1
Rainfall harvesting	136	36
Stored water	323	85

The results presented in **Table 5.4** indicates that more than one-third (36%) of the respondents harvest rainwater during raining seasons to supplement the supply they get from GWCL. The results are however not mutually exclusive as some respondents rely on multiple sources of water as their alternative source of water.

5.3 Consumption variation for domestic customers

Analysis for some of the sub-sections under this section has been done for:

- the two years before the commissioning of the new plant (2008-2009)
- the two years after the commissioning of the new plant (2011-2012)
- the entire five year study period (2008-2012)

5.3.1 Estimation of consumption pattern

The water consumption for Koforidua shown in **Figure 5.1** varied from month to month throughout the period preceding the construction of the new water treatment plant and the period that followed the commissioning of the new treatment plant. It shows a consistent increase in consumption for every month after the increase in supply.

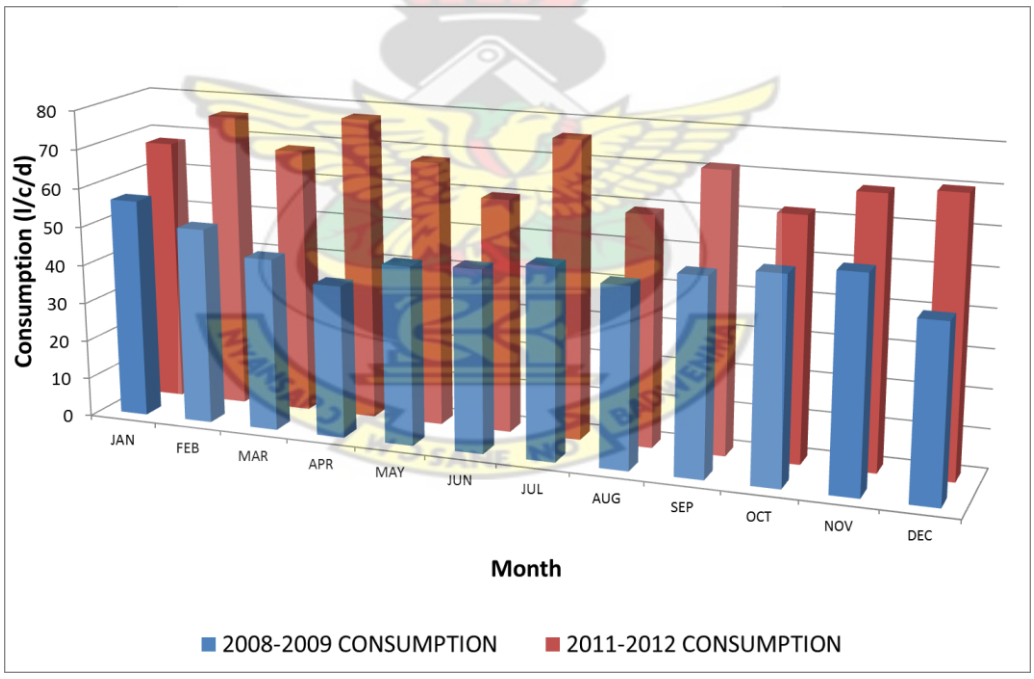


Figure 5.1: Monthly consumption pattern before and after treatment plant

It is worth noting that even the highest water consumption that was recorded in January before the coming into operation of the new plant is lower than the lowest water consumption that was recorded in August after the construction of the new plant.

5.3.2 Seasonal variation before the new treatment plant (2008-2009)

As shown in **Figure 5.2**, before the coming into operation of the new treatment plant, April had the lowest monthly demand with a peak factor of 0.85 followed by March and December with peak factors of 0.91 and 0.93 respectively. In effect, these were the months that customers consumed the least water. However, due to the intermittent nature of water supply within that period, it is possible that these were the months that GWCL supplied the least volumes of water to their customers as demand then was higher than supply.

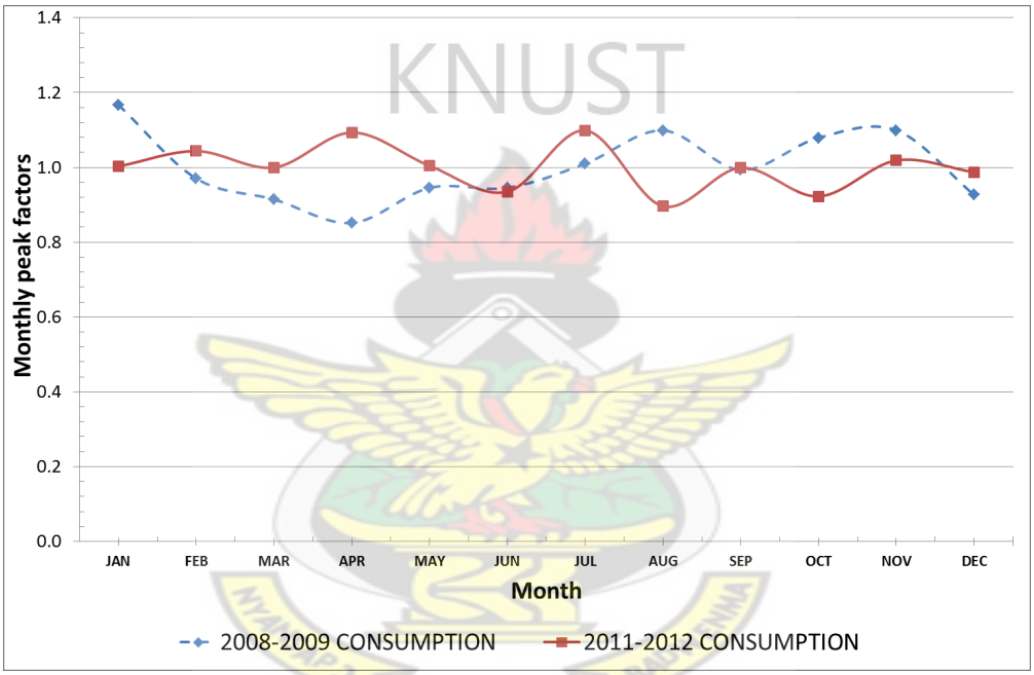


Figure 5.2: Seasonal consumption variations before and after 2010

However, the highest monthly demand occurred in January with a peak factor of 1.17 followed by August and November both with a peak factor of 1.10 before 2010.

5.3.3 Seasonal variation after the new treatment plant (2011-2012)

The gradual decline in monthly demand between April and June as well as between September to October after the commissioning of the new plant depicted in **Figure 5.2** cannot be solely attributed to the onset of the rains though the months of May and June are usually

associated with high rainfall. In spite of December and February falling within the dry season, they did not record high monthly demands. Though there is some indication of drops in dependency on GWCL water during raining season, other factors must be responsible for the variation because July (usually associated with rains) had the highest monthly demand with a peak factor of 1.1 whiles August had the lowest monthly demand with a peak factor of 0.90.

5.3.4 Seasonal variation for the study period (2008-2012)

Interestingly, for the entire study period, January (usually associated with little or no rains) and June (usually associated with heavy rains) had the highest and lowest monthly demands with peak factors of 1.07 and 0.91 respectively as shown in **Figure 5.3**. Though these values may have a connection to the 37% of customers who from the survey used rainwater to supplement their water needs, this cannot be entirely true as July which is also associated with heavy rains has one of the highest monthly demand with a peak factor of 1.04.

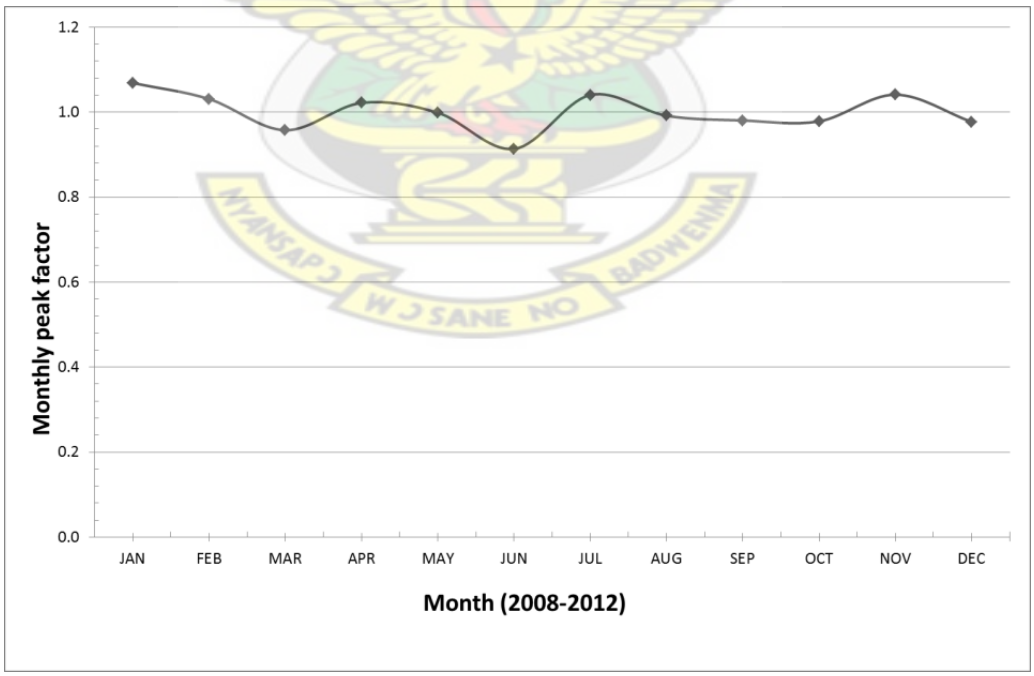


Figure 5.3: Seasonal variation in water consumption

5.3.5 Estimation of annual variations in water consumption

Based on the statement of billing of 170 metered consumers of GWCL water, the annual consumption which stood at 50 l/c/d in 2008 declined by 6% to 47 l/c/d in 2009 but increased by 35% to 63 l/c/d in 2010 as shown in **Figure 5.4**.

It is worth mentioning that the decline in water consumption in 2009 is was to be expected because that was the year most of the interconnections between the new and old distribution system was undertaken which required high frequency of interruption in water supply to enable the interconnections to be carried out.

Furthermore, the high increase in water consumption of 35% in 2010 over the previous year's (2009) value reflects the instant impact the commissioning of the new plant in 2010 had on the water consumption of GWCL customers in Koforidua.

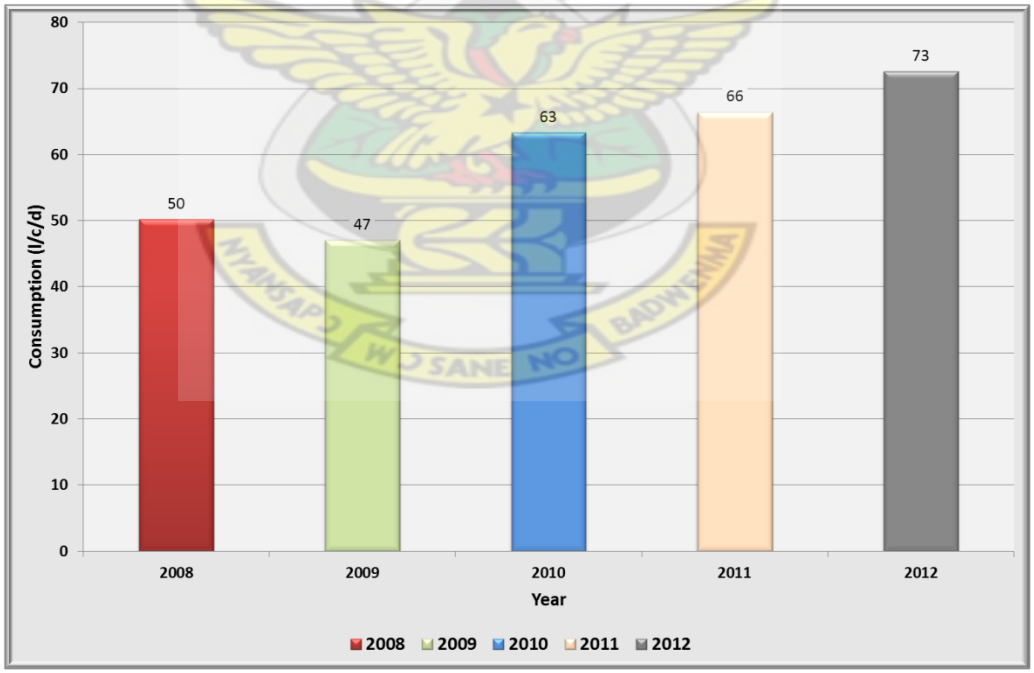


Figure 5.4: Annual variations in water consumption

Finally, the water consumption increased by 5% to 66 l/c/d in 2011 and then by 9% to 73 l/c/d in 2012. The consistent increases in consumption from 2010 is understandable as water supply was boosted by 19200 m^3/d in that year (2010) thus marking the end of the era of water rationing in Koforidua. These supports the conclusions from other reviewed researches like Andey and Kelkar (2008) that the water consumption is affected by adequacy of supply.

5.3.6 Estimation of consumption of different income groups

The monthly variations in water consumption before and after the commissioning of the new treatment plant in 2010 are as shown in **Figure 5.5** and it shows the changing trends in water consumption for all the two income groups considered in the research before and after the commissioning of the new treatment plant.

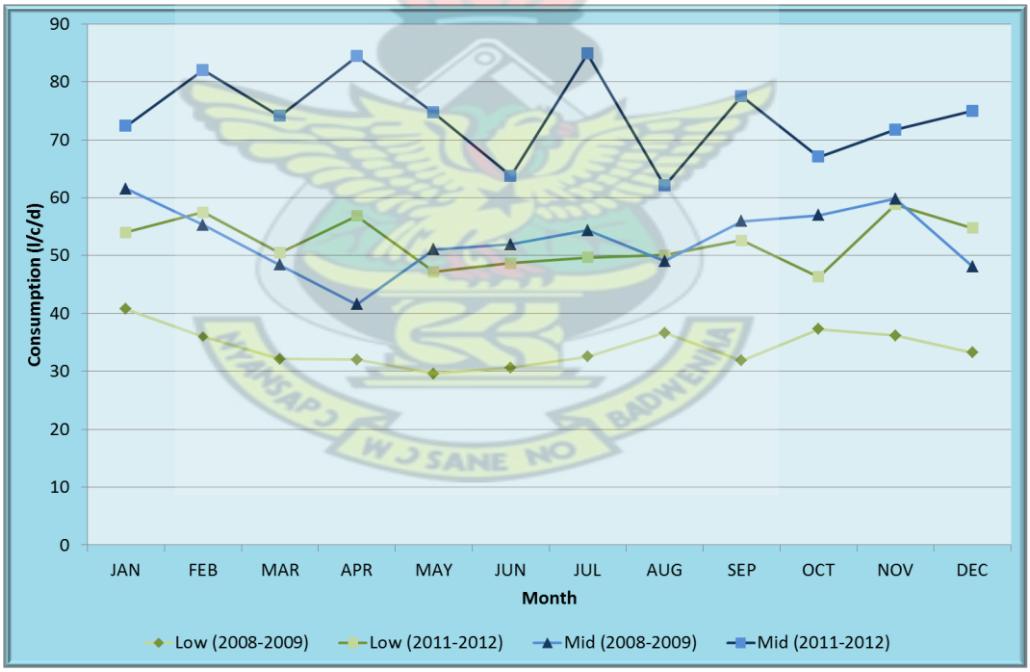


Figure 5.5: Monthly variation in consumption with income groups

It also shows a complete departure in water consumption trends for all the two income groups after there was an increase in water production in 2010.

Moreover, as shown in **Figure 5.6**, based on the water bills from 2011-2012 of 170 respondents who had metered bills for the first two years after the increase in production, consumptions of 56 and 77 l/c/d for the low and middle income groups respectively was estimated which represented 37% difference in water consumption between the two income groups.

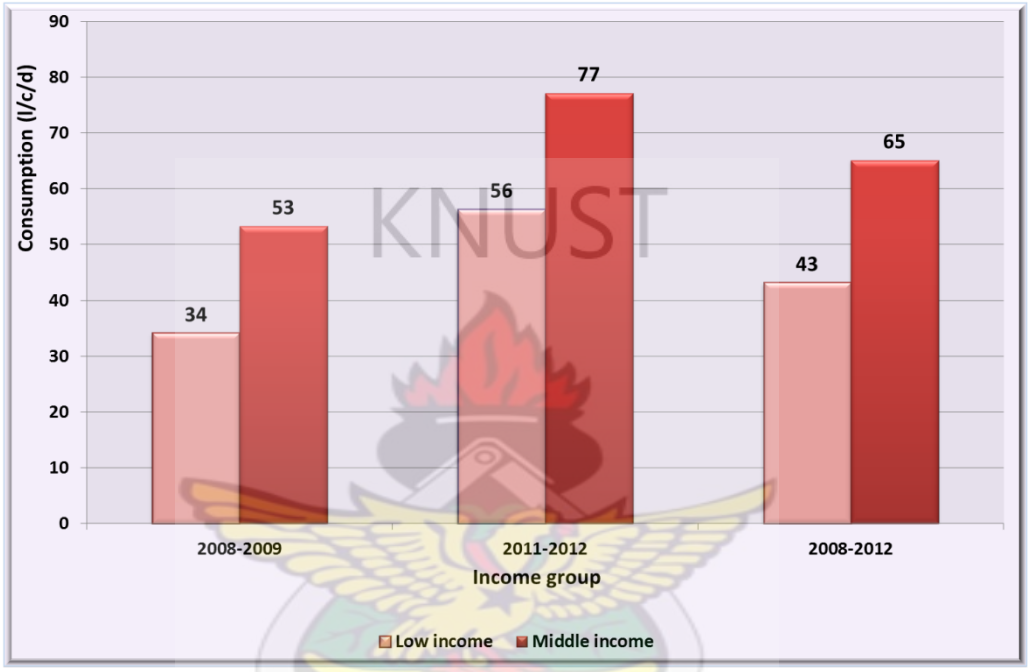


Figure 5.6: Water consumption for income groups

A careful analysis of these figures however shows that compared to the figures for the period 2008-2009, the values obtained for the five years are higher for both income groups. The five year figures are however lower than the figures obtained for the period 2010-2012 thus attesting to the change in water consumption for both income groups after the increase in supply in 2010.

5.3.7 Determination of current water consumption

The determination of the water consumption of Koforidua before and after the new plant provided some interesting revelations and this sub-section presents analysis for the current water consumption of Koforidua.

Out of the 380 customers sampled, only 170 had metered (regulated) bills that spanned the entire five (5) year study period (2008 to 2012). As shown in **Figure 5.7**, the average water consumption for the last two years before the commissioning of the new water treatment plant stood at 49 l/c/d but the value for the first two years after the commissioning of the plant rose to 72 l/c/d, a change of 48%. This indicates a significant change in the water consumption as a result of the availability of water from GWCL.

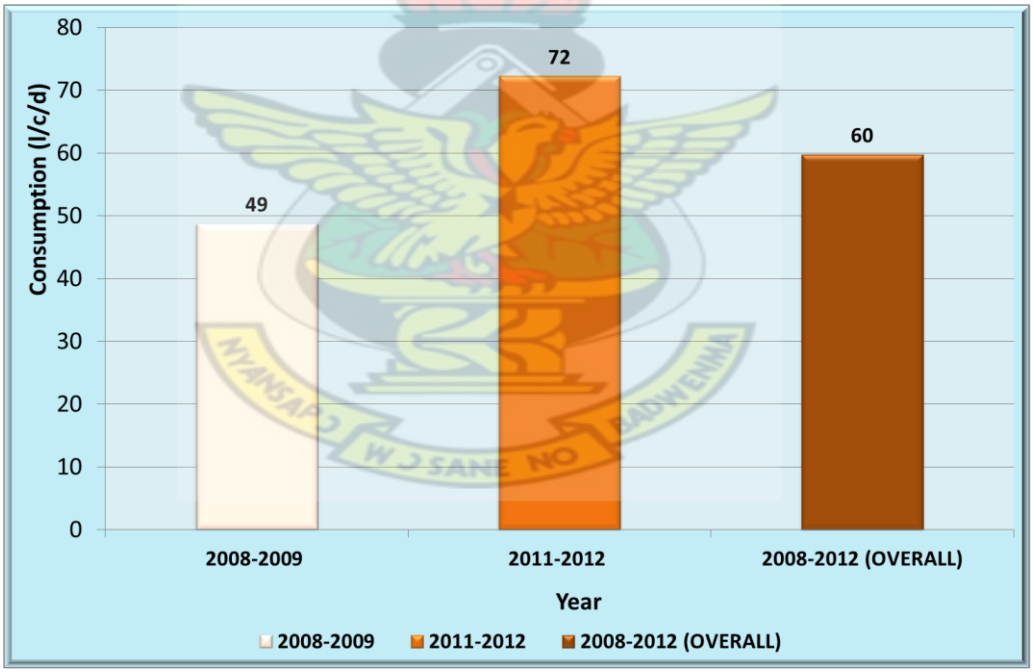


Figure 5.7: Consumption before and after the new plant

The water consumption for GWCL customers as of 2012 was estimated at 60 l/c/d based on only data from GWCL for the entire five year study period which represents a 23% change in consumption when compared to the figure of 49 l/c/d for the last two years (2008-2009)

before the commissioning of the new treatment plant in 2010 when water was rationed. This value is however not a true representation of the current consumption Koforidua since the flow conditions has changed from intermittent to continuous. The value of 72 l/c/d determined for the first two years after the increase in production is therefore a better representation of the current water consumption value for Koforidua.

In spite of the average water consumption of 72 l/c/d comprising of 53 and 77 l/c/d for the low and middle income groups respectively being lower than those determined by Gyeabour (2007) and Lamptey (2010) in their respective research works in Kumasi and Accra, it was to be expected because of the differences in socio-economic status of the cities involved.

Moreover, as already shown in **Table 5.4**, some of the inhabitants still rely on other sources of water to supplement the supply they receive from GWCL. The attitude of storing water all the time are common among inhabitants of Koforidua mainly due to the long period of perennial water shortages that the town experienced before the coming into operation of the new plant. It is therefore not surprising that Koforidua, a town that has just migrated from intermittent supply to continuous supply, will have such lower values than similar towns where other sources of water like wells and boreholes may not be common.

5.4 Consumption variations with modes of billing

This section compares the water consumption of customers who had metered and unmetered (flat rates) water bills for at least five (5) months during the study period.

The need for the analysis in this section arises from the sharp difference between consumption figures obtained for customers who were metered throughout the study period and those who had both metered and unmetered (estimated) bills during the study period.

Interestingly, while the average water consumption from the research based on only the 170 respondents who had metered bills throughout the study period stood at 60 l/c/d, the water consumption of all the 380 respondents (including customers on flat rates) resulted in a higher value of 78 l/c/d mainly due to comparatively higher consumption values recorded for some of the customers who were on flat rates. The analysis in this section is therefore intended to bring to the fore the extent to which flat rates impacts on the water consumption figures determined from the research.

Furthermore, of the 380 respondents, one hundred and eleven (111) had both metered and unmetered bills between 2008 and 2012 out of which about 5% had the estimated bill after the commissioning of the new plant while 43% had the estimated bills before the commissioning of the new plant as presented in **Table 5.5**.

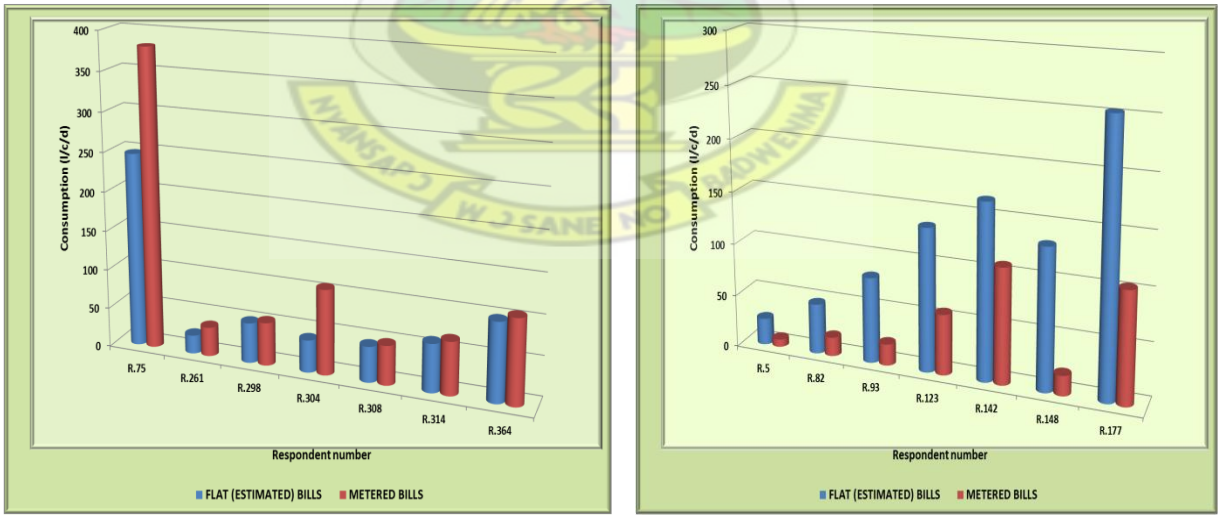
Table 5.5: Period during which respondents had flat rates

Parameter	Before					Both			After			Total
Period	2008	2010	08-09	08-10	09-10	11-12	10-11	08-11	09-12	2011	2012	
No. of respondents	7	2	14	24	1	6	6	45	2	1	3	111
Percentage (%)	6.31	1.80	12.61	21.62	0.90	5.41	5.41	40.54	1.80	0.90	2.70	100
	43.24					51.35			5.41			100

5.4.1 Consumption variations with modes of billing before 2010

A customer who is given flat rates during periods when water supply is intermittent may be at a disadvantage as that customer will have to pay a predetermined bill at the end of the month whether water is supplied or not.

It was therefore not surprising that a comparison of typical average metered and unmetered water consumption of fourteen (14) selected respondents (seven in each category) out of the 111 respondents who had been given water bills by GWCL that were based on both flat rates and meter readings between 2008 and 2009 for at least a period of five (5) months as provided in **Figure 5.8** showed some differences in the average consumption of each respondent during periods when the respondent (represented with the letter R and a number) was given flat rates and metered bill. However, it was the extent of the variations especially in cases when the flat rates bills were higher than the metered bills as shown in **Figure 5.8b** that raised some concerns.



(a) Underestimation (b) Overestimation

Figure 5.8: Typical cases of differences in water bills before 2010

Between 2008 and 2009, metered and estimated water consumptions of 75 and 117 l/c/d respectively were recorded for twenty four (24) of the respondents as shown in **Figure 5.9**.

The difference between the figures resulted in a 55% difference between the consumption values recorded for the respondents when they were on flat rates and when they were metered and this occurred before the commissioning of the new water treatment plant in 2010.

Though the difference could partly be attributed to possible change in customers' water consumption during period when there were meters installed or due to the intermittent supply before 2010, there was possibility that other factors could be responsible for the difference.

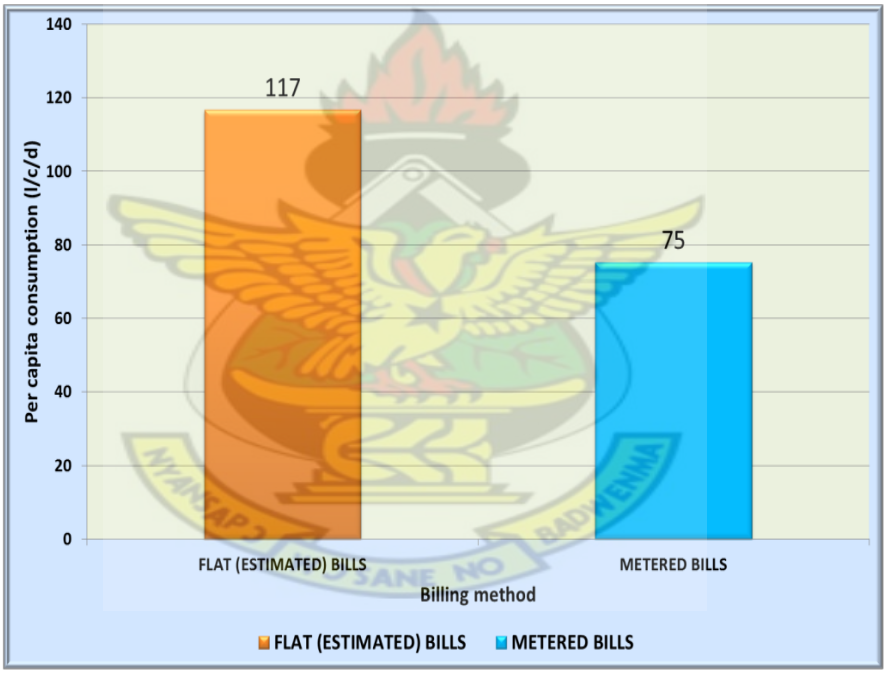
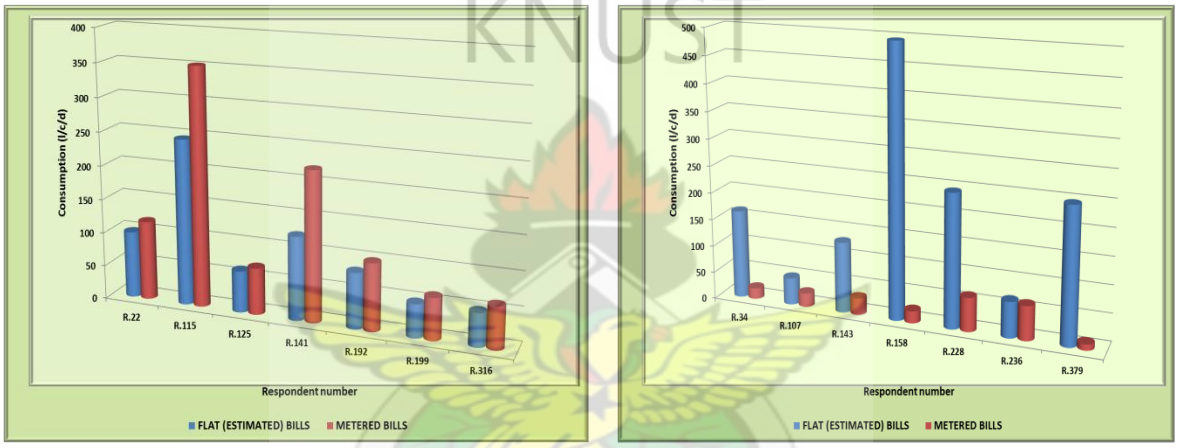


Figure 5.9: Domestic metered and unmetered consumptions before 2010

5.4.2 Consumption variations with modes of billing after 2010

On commissioning of the new treatment plant in 2010 the problem of intermittent supply of water was ended but the problem of customers having to live with flat rates determined by GWCL still continued for some of the respondents.

Figure 5.10 compares typical average metered and unmetered water consumption of fourteen (14) selected respondents (seven in each category) out of the 111 respondents who had water bills from GWCL that were based on both flat rates and meter readings from 2011 to 2012.



(a) Underestimation (b) Overestimation

Figure 5.10: Typical cases of disparities in water bills after 2010

The sharp difference in water consumption figures shown in **Figure 5.10b** for periods during which the respondents had functioning water meters installed and periods when they were on flat rates raise some concern. Though this could partly be attributed to possible change in customers' water consumption when there are meters installed, it cannot be due to intermittent supply as water supply in Koforidua was continuous during this period. Other factors such as the method used in determining the flat rates might be a possible reason for the differences between the two categories of water bills after 2010.

A further analysis of the water bills of thirty six (36) out of the one hundred and eleven (111) respondents who were given metered and unmetered bills for at least five (5) months after the increase in production resulted in a consumption of 76 l/c/d during the period when they were metered and 112 l/c/d (49% difference) during the period when they were on flat rates as shown in **Figure 5.11**.

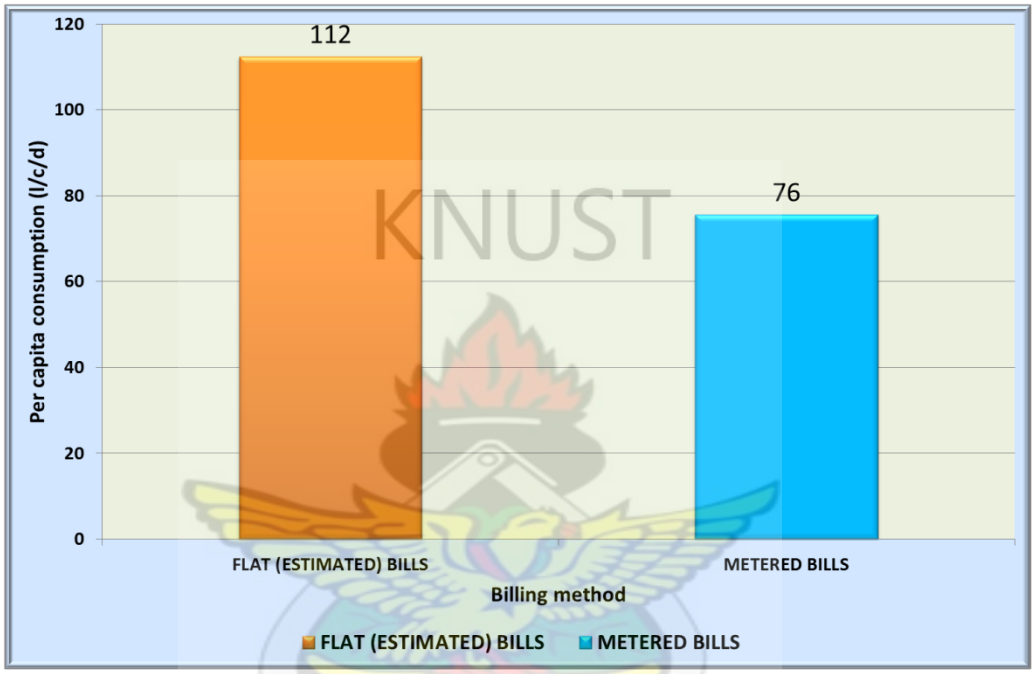


Figure 5.11: Domestic metered and unmetered consumptions after 2010

The 49% difference in estimated and metered bills arises from either the absence of water meters or non-functioning of water meters installed for some of the respondents which makes it imperative for GWCL to estimate the consumption of such customers based on indicators that may not reflect the actual consumption of the customer.

Despite the fact that the 49% difference in metered and unmetered water bills recorded after the increase in production represented a six (6) percentage decrease when compared to the 55% value that pertained before 2010, it is still too significant to be ignored.

Obviously, the relatively higher consumption values for flat rate (estimated) bills than metered bills in this scenario unlike the previous case before 2010 cannot be attributed to intermittent flows as supply was adequate within this period.

Regardless of the justification that may be attributed for such high flat rate bills such as a change in customers' water consumption behaviour during periods when there are meters installed, the possibility of it being connected to the procedure GWCL uses to estimate water bills cannot be overlooked. There is therefore the need for the causes to be addressed as this will go a long way to enhance customer satisfaction with the services from the utility company.

5.5 Consumption variation for second cycle schools

5.5.1 Determination of consumption

The average water consumption per student for second cycle educational institutions in Koforidua based on data for five of the institutions for the period when they were metered was estimated at 23 l/c/d.

However, the analysis of the statement of billing from 2008 to 2010 was limited by the lack of bulk meters in most of the schools in Koforidua during that period which meant such schools did not have any record of metered readings from 2008 to 2010. Most of the meters were only installed in 2012 and hence not much could be deduced from the data.

The results, depicted in **Figure 5.12**, shows that only one of the schools (Kingsby) had meter from 2008-2012 while another school (Pope Johns) did not have any meter reading for the entire study period.

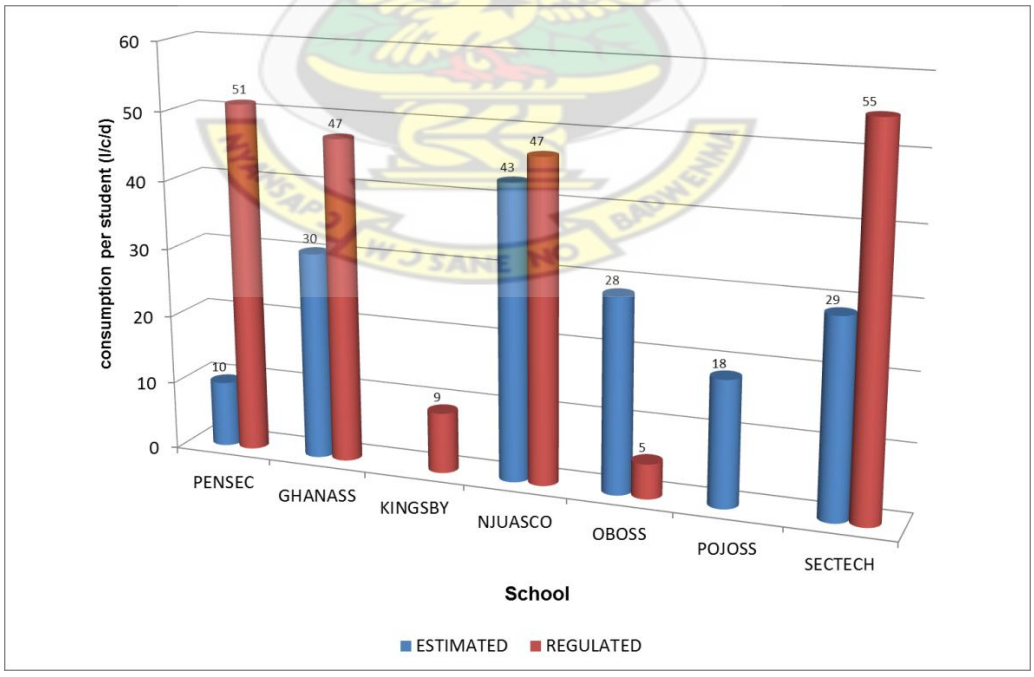


Figure 5.12: Schools metered and unmetered consumption

5.5.2 Variation in consumption of schools with method of billing

The absence of bulk meters in most of the schools during the period under study (2008-2012) was a major hindrance to effort to analyze the data from the schools. However, averaging the consumption for seven months (March –September 2012) during which some of the schools were metered shows that the volume of water consumed by some of these schools ranged from 173 m^3 to 3183 m^3 per month.

A comparison of the average water consumption per student during periods when five of the schools were on flat rates and during periods when the schools were on metered rates is as shown in **Figure 5.13**. It indicates that the average consumption when the schools were not metered (flat rates) was 28 l/c/d compared to the 40 l/c/d when the schools were metered hence GWCL 'underestimates' the water consumed by some second cycle educational institutions by about 32%.

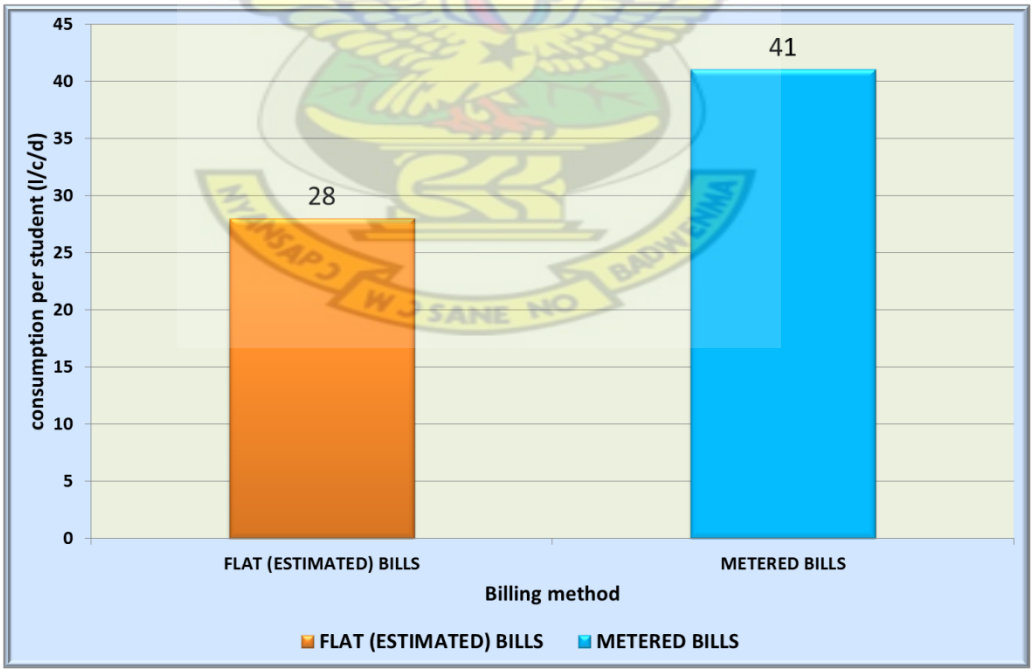


Figure 5.13: Metered and unmetered water bills for schools

A further breakdown of these figures for five (5) out of the seven (7) schools that had a combination of flat rates and metered bills during the study period however indicates that four (4) of the five schools recorded higher consumption per student during periods when they were given metered bills than period when they were on flat rates while the remaining school had higher consumption per student during periods when it was given flat rates than during periods when it was given metered bills. Details of the analysis are provided in **Appendix H**.

All the five schools were only metered in 2012 that is after the increase in supply hence their low water consumption during the period when they were metered cannot be attributed to unavailability of water.

Suffice it to say that the results is an indication that while some schools benefitted during periods when there was no functioning bulk-meter installed, others were at a disadvantage.

Considering the volume of water involved and the variations, it is in the interest of GWCL to install bulk meters in all second cycle educational institutions as underestimated water bills adds up to GWCL's already high unaccounted for water (UFW) which stood at about 50% as of the end of 2012.

5.6 Summary of Results

This section presents a summary of the results from the research. The summary, as presented in **Table 5.6**, includes the overall water consumption for Koforidua based on data from GWCL for the five year study period, the consumption figures for Koforidua before and after the commissioning of the 19200m^3/d capacity plant, as well as results for low and middle income domestic consumers (LI and MI).

It further presents results on water consumption per student for second cycle institutions and results showing variations in water consumption with method used in determining the water bills of customers (metered or estimated) before and after the commissioning of the new plant.

Table 5.6: Summary of results

No.	Parameter	Sample Space	Mean (l/c/d)	Quartiles (l/c/d)			Standard error	StD	% Diff. in P.C.C
				Q_1	Q_2	Q_3			
1	Consumption (2008-2012)	170	59.79	44.06	54.07	69.72	± 2.03	26.42	
2	Consumption (2008-2009)	170	48.78	31.88	44.32	62.61	± 1.99	25.98	48.11
3	Consumption (2011-2012)	170	72.25	49.28	65.79	86.14	± 2.71	35.38	
4	Domestic_LI	41	43.12	33.75	44.04	49.97	± 2.30	14.75	
	(2008-2009)	41	34.07	23.24	35.18	42.73	± 2.31	14.80	65.19
	(2011-2012)	41	56.28	41.86	53.39	66.72	± 3.80	24.33	
5	Domestic_MI	129	65.09	49.15	59.43	76.67	± 2.39	27.13	
	(2008-2009)	129	53.26	33.85	48.49	67.19	± 2.39	27.15	44.80
	(2011-2012)	129	77.12	50.29	69.30	96.16	± 3.25	36.91	
6	Metered bills before 2010	24	75.24	35.04	54.83	104.04	± 15.63	76.57	55.09
7	Estimated bills before 2010	24	116.69	50.10	82.18	143.15	± 20.38	99.84	
8	Metered bills after 2010	36	75.59	35.32	59.68	83.68	± 10.75	64.48	48.70
9	Estimated bills after 2010	36	112.40	65.23	98.86	123.89	± 10.13	60.80	
10	2nd Cycle Schools	7	23.22	10.21	18.37	34.00	± 5.71	15.10	

Standard error at 95% confidence level.

StD: Standard deviation

6. CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the conclusions and recommendations from the research that was carried out.

6.1 Conclusions

This section presents the conclusions drawn from the research work based on the specific objectives set for the research.

- Domestic water demand is 72 l/c/d based on data on consumption of GWCL water alone representing a 48% change in consumption since 2010. The consumption of middle income groups is 37% higher than those in the low income groups.
- There are significant differences between monthly water bills of domestic and second cycle educational institutions customers of GWCL during periods when they have functioning water meters and periods when they are given estimated (flat) bills.
- Knowledge on the availability of water efficient devices as well as their use is low among customers in Koforidua.
- Significant numbers of customers harvest rains to supplement the supply they get from GWCL especially when there is interruption in water supply.

6.2 Recommendations

This section presents the recommendations made based on the conclusions drawn from the research work carried out.

After carrying out the research, it is recommended that:

- The increases in consumption must be taking into consideration when planning.
- There is the need for a periodically review of flat rates to reflect the consumption of unmetered domestic and institutional customers in other to minimize or eliminate the situation where customers cheat or are cheated by a GWCL due to absence of meters.
- A cost-benefit analysis on the feasibility of installing bulk meters for all the second cycle educational institutions to reduce the revenue that is lost as a result of underestimation of water consumed by some second cycle institutions is needed.
- There is the need to take advantage of the high interest shown by respondents regarding their willingness to invest in water efficient devices to educate customers on water management awareness and practices.
- Rainfall harvesting as an alternate source of water is practiced by one-third of the customers.
- Further work must be carried out on the other categories of GWCL customers.

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Appendix A: Questionnaire for domestic customers

Location……..... Date……..……

Housing type…….. Questionnaire no…….

I will be very grateful if you could help me to conduct a survey aimed at establishing water consumption pattern in your neighbourhood as part of my MSc. thesis by helping me to complete this questionnaire. The survey will help GWCL improve its services to you in the near future. Please be assured that the information you provide will be treated as confidential.

For household connections only

1. Do you use water from GWCL?
   YES ☐ NO ☐
a. If YES, how do you get access to water from GWCL?
   i. ☐ Household connection ii. ☐ Public Stand Pipe
2. How often do you get water from GWCL?
   a. Once a week b. 2-3 days a week c. 4-6 days a week d. Everyday
3. How long does it usually take for supply to be restored when there is interruption?
   a. Less than 24hours b. 2 days c. 3-4days d. 5-7days e. more than a week
4. How will you classify the pressure with which water flows through your tap?
   a. Very Low b. Low c. High d. Very High
5. What alternative source of water do you depend when there is interruption in supply?
   a. Well b. Borehole c. Tanker service d. Other (specify)_____
6. Have you seen an improvement in water supply in the last two years?
   YES ☐ NO ☐
7. Do you use rain water to supplement your water needs during the raining season?
   YES ☐ NO ☐

7a. If YES, what are some of the activities you use the rain water for?

i. ☐ Washing
ii. ☐ Cooking
iii. ☐ Cleaning
iv. ☐ Watering lawns/garden
v. ☐ Bathing
vi. ☐ Other (Specify)_____

8. Do you use any of the following in your house?

i. ☐ Showers _____ iii. ☐ Dish washers _____

ii. ☐ Water closet _____ iv. ☐ Washing machine _____

9. Do you know about water saving devices?

YES ☐ NO ☐

a. If YES, do you use any?

YES ☐ NO ☐

b. If NO, will you be willing to invest in any of them if you knew of their benefits?

YES ☐ NO ☐

10. Does anyone own a car in your household?

YES ☐ NO ☐

10a. If YES, how many?

i. ☐ Private_____ ii. ☐ Commercial_____

11. If you answered YES to Q. 9, where do you wash your car?

a. Home b. Car washing bay c. Both means

12. What is the average population of this house?_____

13. How many households are there in this house?_____

14. Can I have a look at your monthly water bill?

House number	
Billing date	
Customer number	
Quantity used	

15. Any other relevant information

……

……

……

……

……

THANK YOU

Appendix B: Questionnaire for schools

Location…… Date…….

Name of institution……...……..

I will be very grateful if you could help me to conduct a survey aimed at establishing water consumption pattern in your neighbourhood as part of my MSc. thesis by helping me to complete this questionnaire. The survey will help GWCL improve its services to you in the near future. Please be assured that the information you provide will be treated as confidential.

For institutions only

1. Do you use water from GWCL?
   YES ☐ NO ☐
2. How often do you get water from GWCL?
   b. Once a week b. 2-3 days a week c. 4-6 days a week d. Everyday
3. How long does it usually take for supply to be restored when there is interruption?
   b. Less than 24 hours b. 2 days c. 3-4 days d. 5-7 days e. more than a week
4. Have you seen an improvement in water supply in the last two years?
   YES ☐ NO ☐
5. Can I have a look at your monthly water bill?

School name	
Billing date	
Meter number	
Quantity used	

6. What has been the school's population since 2008?

Term	**Population**				
	2008	2009	2010	2011	2012
1st Term					
2nd Term					
3rd Term					

THANK YOU

Appendix C: Monthly variations from 2008-2012

MONTHLY CONSUMPTION FROM 2008-2012												
RPDNT. No.	JAN. (m^3)	FEB. (m^3)	MAR. (m^3)	APRIL (m^3)	MAY (m^3)	JUN. (m^3)	JUL. (m^3)	AUG. (m^3)	SEP. (m^3)	OCT. (m^3)	NOV. (m^3)	DEC. (m^3)
1	81.00	77.00	77.00	86.00	71.00	58.00	65.00	63.00	63.00	74.00	78.00	76.00
4	125.00	109.00	119.00	135.00	132.00	86.00	125.00	161.00	164.00	129.00	163.00	99.00
7	154.00	137.00	177.00	191.00	122.00	87.00	165.00	211.00	112.00	87.00	182.00	163.00
11	220.00	173.00	202.00	199.00	182.00	181.00	208.00	191.00	198.00	177.00	242.00	217.00
13	88.00	79.00	92.00	92.00	87.00	66.00	87.00	78.00	89.00	91.00	101.00	118.00
14	82.00	75.00	93.00	84.00	74.00	76.00	96.00	61.00	72.00	76.00	76.00	51.00
15	116.00	95.00	105.00	100.00	103.00	86.00	101.00	107.00	112.00	93.00	116.00	80.00
19	24.00	31.00	25.00	28.00	35.00	22.00	31.00	21.00	22.00	29.00	33.00	31.00
25	54.00	84.00	56.00	41.00	94.00	119.00	66.00	51.00	66.00	39.00	49.00	40.00
27	53.00	47.00	36.00	46.00	46.00	51.00	44.00	42.00	45.00	39.00	50.00	51.00
28	41.00	44.00	32.00	40.00	43.00	27.00	52.00	35.00	41.00	30.00	41.00	33.00
30	21.00	16.00	19.00	16.00	11.00	15.00	14.00	25.00	16.00	39.00	14.00	13.00
31	40.00	28.00	23.00	33.00	30.00	19.00	40.00	25.00	30.00	32.00	34.00	45.00
32	51.00	36.00	35.00	39.00	36.00	26.00	33.00	38.00	37.00	33.00	40.00	37.00
35	6.00	6.00	7.00	8.00	6.00	5.00	4.00	8.00	3.00	4.00	4.00	3.00
36	83.87	92.80	70.97	140.00	98.39	78.33	129.03	108.06	96.67	85.48	91.67	100.00
38	37.00	35.00	31.00	31.00	32.00	33.00	37.00	27.00	38.00	26.00	32.00	25.00
39	30.00	34.00	31.00	29.00	28.00	32.00	27.00	29.00	28.00	30.00	32.00	35.00
40	24.00	22.00	15.00	20.00	30.00	14.00	16.00	20.00	20.00	22.00	16.00	23.00
41	47.00	45.00	36.00	47.00	51.00	43.00	45.00	49.00	51.00	51.00	56.00	55.00
42	17.00	16.00	23.00	17.00	20.00	25.00	36.00	20.00	24.00	22.00	23.00	23.00
43	36.00	63.00	41.00	40.00	46.00	37.00	38.00	34.00	47.00	38.00	42.00	35.00
44	37.00	78.00	87.00	30.00	35.00	32.00	39.00	31.00	28.00	24.00	38.00	45.00
47	94.00	85.00	73.00	114.00	76.00	71.00	100.00	60.00	61.00	96.00	74.00	64.00
55	72.00	88.00	83.00	70.00	57.00	58.00	83.00	57.00	55.00	66.00	73.00	60.00
56	79.00	99.00	111.00	101.00	89.00	74.00	91.00	84.00	102.00	91.00	90.00	72.00
72	86.00	91.00	88.00	93.00	88.00	61.00	80.00	75.00	75.00	71.00	96.00	62.00
73	137.00	112.00	122.00	113.00	105.00	111.00	117.00	110.00	118.00	107.00	115.00	76.00
74	84.00	67.00	92.00	85.00	60.00	57.00	65.00	63.00	78.00	72.00	74.00	57.00
78	51.00	38.00	31.00	38.00	30.00	23.00	45.00	34.00	38.00	37.00	37.00	32.00
79	15.00	12.00	14.00	16.00	18.00	6.00	17.00	17.00	11.00	18.00	14.00	13.00
80	36.00	32.00	20.00	32.00	23.00	17.00	13.00	32.00	14.00	31.00	18.00	22.00
81	86.00	68.00	51.00	56.00	72.00	59.00	79.00	53.00	47.00	68.00	47.00	36.00
83	31.00	27.00	24.00	25.00	27.00	24.00	33.00	20.00	45.00	27.00	32.00	24.00
84	23.00	20.00	16.00	20.00	20.00	15.00	18.00	11.00	13.00	17.00	17.00	22.00
85	34.00	26.00	27.00	22.00	21.00	17.00	27.00	17.00	23.00	21.00	22.00	21.00
86	110.00	102.00	105.00	78.00	106.00	105.00	115.00	85.00	107.00	110.00	105.00	116.00
87	88.00	103.00	89.00	66.00	79.00	74.00	68.00	55.00	82.00	96.00	72.00	93.00
88	35.00	21.00	25.00	34.00	24.00	21.00	23.00	17.00	25.00	28.00	27.00	26.00
89	63.00	51.00	40.00	58.00	63.00	47.00	39.00	36.00	44.00	44.00	36.00	42.00
90	43.00	20.00	14.00	31.00	27.00	17.00	26.00	18.00	24.00	23.00	24.00	20.00
96	12.00	17.00	15.00	16.00	15.00	14.00	13.00	12.00	17.00	13.00	22.00	14.00
97	38.00	54.00	62.00	48.00	42.00	62.00	48.00	78.00	68.00	53.00	61.00	50.00
98	95.00	87.00	75.00	66.00	75.00	72.00	99.00	98.00	83.00	69.00	64.00	55.00
99	74.00	81.00	74.00	74.00	66.00	56.00	58.00	53.00	65.00	61.00	74.00	62.00

NB: Missing respondent numbers represent customers who did **not** have **metered** bills **throughout** 2008-2012

MONTHLY CONSUMPTION FROM 2008-2012 (cont'd)												
RSPDNT. No.	JAN. (m^3)	FEB. (m^3)	MAR. (m^3)	APRIL (m^3)	MAY (m^3)	JUN. (m^3)	JUL. (m^3)	AUG. (m^3)	SEP. (m^3)	OCT. (m^3)	NOV. (m^3)	DEC. (m^3)
100	53.00	50.00	31.00	32.00	38.00	34.00	39.00	41.00	59.00	52.00	53.00	39.00
101	81.00	56.00	70.00	73.00	60.00	58.00	58.00	76.00	66.00	76.00	64.00	67.00
102	52.00	68.00	55.00	59.00	41.00	44.00	56.00	51.00	40.00	48.00	46.00	53.00
104	30.00	27.00	24.00	25.00	55.00	24.00	23.00	13.00	19.00	19.00	18.00	12.00
105	100.0	75.00	73.00	75.00	70.00	165.00	81.00	90.00	73.00	88.00	99.00	78.00
106	145.0	94.00	114.00	98.00	115.00	99.00	122.00	115.00	112.00	116.00	121.00	98.00
108	38.71	66.19	61.29	75.00	79.03	68.33	74.19	53.23	45.00	20.97	58.33	53.23
109	39.00	42.00	32.00	29.00	43.00	26.00	35.00	30.00	30.00	32.00	40.00	38.00
110	103.0	72.00	92.00	83.00	71.00	78.00	70.00	68.00	70.00	80.00	75.00	71.00
111	66.00	54.00	44.00	50.00	48.00	23.00	52.00	42.00	25.00	55.00	39.00	38.00
112	53.00	50.00	55.00	27.00	45.00	32.00	94.00	42.00	26.00	41.00	30.00	35.00
113	168.0	154.00	209.00	186.00	302.00	281.00	190.00	159.00	161.00	165.00	181.00	172.0
114	29.00	34.00	41.00	35.00	40.00	18.00	19.00	36.00	27.00	30.00	36.00	25.00
121	66.00	38.00	61.00	54.00	74.00	47.00	82.00	73.00	66.00	83.00	98.00	81.00
122	27.00	22.00	25.00	17.00	42.00	16.00	17.00	19.00	16.00	24.00	25.00	13.00
124	28.00	19.00	15.00	18.00	16.00	15.00	14.00	24.00	20.00	21.00	21.00	19.00
126	40.00	55.00	45.00	38.00	44.00	22.00	46.00	34.00	29.00	39.00	37.00	38.00
127	55.00	87.00	46.00	59.00	66.00	36.00	61.00	43.00	47.00	54.00	34.00	37.00
128	189.0	148.00	133.00	240.00	131.00	179.00	204.00	153.00	165.00	179.00	157.00	169.0
129	48.00	50.00	49.00	53.00	47.00	53.00	52.00	42.00	48.00	49.00	49.00	49.00
130	30.00	27.00	25.00	25.00	25.00	16.00	27.00	28.00	34.00	24.00	32.00	35.00
131	56.00	59.00	47.00	58.00	62.00	50.00	60.00	53.00	56.00	39.00	51.00	49.00
132	40.00	39.00	35.00	32.00	36.00	32.00	40.00	33.00	40.00	42.00	41.00	39.00
134	69.00	87.00	67.00	83.00	80.00	77.00	78.00	76.00	77.00	54.00	74.00	74.00
135	40.00	40.00	25.00	40.00	44.00	51.00	42.00	33.00	37.00	46.00	37.00	59.00
144	63.00	40.00	36.00	40.00	88.00	30.00	37.00	27.00	44.00	43.00	50.00	49.00
167	18.00	30.00	30.00	32.00	37.00	20.00	29.00	25.00	23.00	23.00	52.00	62.00
168	51.00	57.00	53.00	82.00	64.00	62.00	60.00	59.00	58.00	51.00	62.00	64.00
169	111.0	109.00	103.00	97.00	105.00	96.00	112.00	111.00	126.00	99.00	104.00	88.00
170	52.00	62.00	51.00	59.00	63.00	48.00	59.00	56.00	55.00	59.00	63.00	54.00
171	26.00	24.00	22.00	21.00	23.00	24.00	35.00	26.00	29.00	21.00	17.00	22.00
172	109.0	127.00	42.00	106.00	54.00	41.00	62.00	32.00	30.00	56.00	73.00	42.00
173	100.0	100.00	98.00	91.00	67.00	72.00	55.00	58.00	71.00	124.00	101.00	76.00
176	64.00	87.00	57.00	64.00	79.00	55.00	82.00	64.00	83.00	70.00	56.00	76.00
179	60.00	64.00	56.00	63.00	68.00	62.00	70.00	60.00	62.00	51.00	76.00	65.00
181	30.00	46.00	51.00	57.00	60.00	46.00	55.00	51.00	69.00	43.00	42.00	41.00
182	39.00	34.00	25.00	32.00	27.00	27.00	28.00	26.00	20.00	14.00	29.00	40.00
183	47.00	66.00	71.00	68.00	57.00	62.00	67.00	57.00	59.00	58.00	93.00	54.00
193	34.00	45.00	33.00	39.00	42.00	45.00	42.00	38.00	36.00	29.00	32.00	33.00
201	36.00	52.00	47.00	42.00	42.00	27.00	34.00	26.00	34.00	29.00	37.00	38.00
202	36.00	51.00	44.00	34.00	38.00	37.00	43.00	34.00	44.00	36.00	36.00	33.00
203	9.00	9.00	10.00	11.00	9.00	8.00	15.00	11.00	8.00	7.00	11.00	10.00
204	21.00	16.00	16.00	18.00	18.00	22.00	52.00	15.00	22.00	17.00	19.00	25.00
205	18.00	26.00	14.00	12.00	14.00	13.00	16.00	13.00	14.00	12.00	18.00	11.00
207	11.00	4.00	8.00	5.00	9.00	6.00	9.00	5.00	10.00	6.00	8.00	5.00
209	7.00	5.00	4.00	18.00	4.00	4.00	6.00	6.00	7.00	4.00	11.00	4.00

NB: Missing respondent numbers represent customers who did **not** have **metered** bills **throughout** 2008-2012

MONTHLY CONSUMPTION FROM 2008-2012 (cont'd)												
RSPDNT. No.	JAN. (m^3)	FEB. (m^3)	MAR. (m^3)	APRIL (m^3)	MAY (m^3)	JUN. (m^3)	JUL. (m^3)	AUG. (m^3)	SEP. (m^3)	OCT. (m^3)	NOV. (m^3)	DEC. (m^3)
210	26.00	22.00	29.00	24.00	25.00	24.00	29.00	20.00	25.00	20.00	28.00	28.00
211	15.00	11.00	11.00	12.00	11.00	16.00	13.00	9.00	11.00	13.00	11.00	14.00
213	23.00	31.00	28.00	24.00	21.00	22.00	29.00	17.00	18.00	24.00	22.00	18.00
214	7.00	16.00	14.00	12.00	14.00	11.00	35.00	58.00	81.00	39.00	16.00	12.00
215	19.00	9.00	15.00	15.00	10.00	11.00	19.00	20.00	26.00	15.00	21.00	11.00
217	30.00	32.00	19.00	12.00	16.00	15.00	25.00	20.00	25.00	24.00	24.00	23.00
218	11.00	10.00	10.00	12.00	9.00	12.00	12.00	9.00	9.00	10.00	12.00	11.00
219	41.00	47.00	43.00	61.00	56.00	49.00	49.00	41.00	46.00	45.00	48.00	52.00
220	34.00	44.00	32.00	31.00	26.00	31.00	34.00	18.00	33.00	36.00	40.00	29.00
221	16.00	19.00	20.00	17.00	20.00	19.00	23.00	13.00	18.00	15.00	21.00	15.00
222	10.00	16.00	13.00	7.00	19.00	14.00	11.00	12.00	18.00	15.00	23.00	17.00
224	26.00	21.00	26.00	20.00	30.00	17.00	30.00	20.00	34.00	20.00	23.00	25.00
225	31.00	24.00	26.00	26.00	24.00	19.00	29.00	22.00	25.00	15.00	30.00	22.00
226	72.00	65.00	59.00	47.00	59.00	45.00	68.00	33.00	61.00	51.00	54.00	45.00
227	20.00	31.00	26.00	29.00	29.00	22.00	32.00	23.00	28.00	23.00	27.00	21.00
233	106.00	75.00	58.00	123.00	109.00	83.00	103.0	83.00	93.00	100.0	90.00	101.00
234	110.00	130.00	88.00	112.00	93.00	65.00	94.00	83.00	92.00	93.00	100.00	140.00
238	69.00	65.00	132.00	82.00	123.00	221.00	125.0	122.00	119.00	112.0	97.00	55.00
239	311.00	342.00	297.00	277.00	281.00	386.00	295.0	762.00	294.00	286.0	420.00	314.00
241	37.00	30.00	31.00	34.00	24.00	35.00	47.00	31.00	48.00	30.00	40.00	36.00
242	111.00	102.00	137.00	129.00	116.00	109.00	135.0	105.00	116.00	111.0	119.00	130.00
243	37.00	32.00	38.00	38.00	47.00	15.00	24.00	27.00	32.00	30.00	36.00	28.00
244	117.00	57.00	72.00	68.00	91.00	75.00	70.00	76.00	81.00	79.00	92.00	113.00
245	70.00	52.00	40.00	59.00	101.00	49.00	57.00	72.00	47.00	70.00	60.00	42.00
247	78.00	43.00	65.00	94.00	100.00	40.00	60.00	55.00	51.00	52.00	40.00	56.00
248	93.00	78.00	89.00	78.00	125.00	84.00	92.00	88.00	96.00	104.0	84.00	108.00
249	127.00	94.00	99.00	89.00	139.00	70.00	96.00	106.00	149.00	134.0	104.00	133.00
250	35.00	35.00	34.00	24.00	35.00	29.00	33.00	31.00	34.00	26.00	26.00	28.00
251	36.00	22.00	24.00	25.00	29.00	23.00	38.00	28.00	30.00	33.00	30.00	38.00
252	46.00	35.00	14.00	24.00	28.00	40.00	35.00	51.00	56.00	68.00	33.00	48.00
253	18.00	16.00	14.00	12.00	21.00	10.00	17.00	14.00	16.00	15.00	20.00	22.00
254	44.00	37.00	32.00	29.00	49.00	36.00	26.00	27.00	32.00	35.00	31.00	42.00
255	21.00	15.00	14.00	13.00	23.00	12.00	26.00	15.00	17.00	25.00	12.00	24.00
256	38.00	35.00	31.00	36.00	48.00	37.00	41.00	37.00	45.00	40.00	38.00	43.00
257	14.00	24.00	26.00	48.00	26.00	10.00	41.00	17.00	18.00	13.00	22.00	21.00
258	91.00	61.00	75.00	76.00	107.00	71.00	72.00	70.00	125.00	88.00	80.00	91.00
262	48.00	40.00	37.00	35.00	51.00	38.00	40.00	35.00	41.00	45.00	39.00	52.00
264	48.00	40.00	37.00	35.00	51.00	38.00	40.00	35.00	41.00	45.00	39.00	52.00
268	48.00	37.00	46.00	36.00	29.00	25.00	29.00	40.00	37.00	53.00	54.00	63.00
272	67.00	51.00	53.00	57.00	45.00	50.00	48.00	51.00	30.00	63.00	94.00	37.00
274	35.00	23.00	30.00	42.00	25.00	8.00	21.00	19.00	23.00	45.00	38.00	37.00
276	49.00	45.00	63.00	52.00	51.00	38.00	34.00	54.00	43.00	62.00	48.00	58.00
278	60.00	60.00	63.00	52.00	53.00	54.00	47.00	70.00	54.00	53.00	49.00	49.00
282	116.00	152.00	105.00	149.00	117.00	148.00	149.0	105.00	122.00	161.0	154.00	133.00
284	116.00	107.00	86.00	97.00	55.00	38.00	46.00	74.00	77.00	33.00	59.00	63.00
290	100.00	102.00	90.00	99.00	90.00	88.00	84.00	78.00	74.00	118.00	96.00	102.00
299	53.00	62.00	46.00	45.00	31.00	60.00	72.00	59.00	44.00	59.00	37.00	48.00

NB: Missing respondent numbers represent customers who did **not** have **metered** bills **throughout** 2008-2012

MONTHLY CONSUMPTION FROM 2008-2012 (cont'd)												
RSPDNT. No.	JAN. (m^3)	FEB. (m^3)	MAR. (m^3)	APRIL (m^3)	MAY (m^3)	JUN. (m^3)	JUL. (m^3)	AUG. (m^3)	SEP. (m^3)	OCT. (m^3)	NOV. (m^3)	DEC. (m^3)
302	51.00	36.00	30.00	25.00	30.00	27.00	47.00	25.00	23.00	36.00	34.00	38.00
307	61.00	53.00	44.00	45.00	44.00	30.00	36.00	40.00	34.00	33.00	35.00	38.00
310	71.00	67.00	51.00	74.00	49.00	44.00	72.00	69.00	65.00	70.00	54.00	43.00
312	41.00	31.00	31.00	24.00	20.00	12.00	21.00	27.00	49.00	20.00	18.00	27.00
315	72.00	53.00	70.00	72.00	60.00	51.00	68.00	59.00	65.00	55.00	39.00	73.00
318	37.00	117.00	23.00	68.00	20.00	29.00	37.00	46.00	52.00	45.00	57.00	54.00
319	37.00	41.00	25.00	60.00	41.00	38.00	34.00	54.00	23.00	51.00	52.00	47.00
327	50.00	53.00	53.00	52.00	44.00	44.00	45.00	50.00	48.00	67.00	55.00	46.00
333	21.00	28.00	20.00	27.00	39.00	29.00	29.00	34.00	26.00	27.00	20.00	32.00
338	51.00	52.00	42.00	47.00	36.00	30.00	51.00	48.00	53.00	55.00	52.00	46.00
339	57.00	49.00	26.00	40.00	35.00	67.00	45.00	51.00	46.00	47.00	39.00	45.00
344	72.00	54.00	44.00	64.00	52.00	48.00	58.00	46.00	58.00	75.00	55.00	52.00
345	84.00	57.00	80.00	37.00	30.00	14.00	206.00	99.00	52.00	109.00	73.00	40.00
349	96.00	85.00	78.00	72.00	72.00	71.00	78.00	71.00	70.00	78.00	79.00	73.00
350	74.00	23.00	55.00	47.00	37.00	37.00	34.00	35.00	59.00	59.00	59.00	54.00
353	85.00	82.00	85.00	59.00	53.00	49.00	55.00	42.00	43.00	61.00	64.00	61.00
357	41.00	36.00	39.00	34.00	30.00	27.00	26.00	36.00	34.00	34.00	33.00	38.00
359	55.00	48.00	48.00	63.00	59.00	65.00	82.00	57.00	61.00	45.00	85.00	50.00
365	41.00	57.00	37.00	47.00	39.00	43.00	39.00	40.00	46.00	58.00	57.00	49.00
369	69.00	59.00	67.00	62.00	53.00	42.00	78.00	62.00	70.00	45.00	59.00	100.0
370	36.00	37.00	23.00	31.00	29.00	26.00	26.00	31.00	27.00	31.00	24.00	51.00
373	51.00	52.00	33.00	79.00	38.00	33.00	44.00	56.00	55.00	47.00	39.00	49.00
374	63.00	67.00	42.00	51.00	60.00	47.00	68.00	54.00	50.00	50.00	43.00	53.00
375	29.00	32.00	37.00	33.00	37.00	31.00	20.00	23.00	43.00	40.00	32.00	34.00
376	36.00	48.00	54.00	52.00	45.00	41.00	37.00	33.00	46.00	45.00	32.00	33.00
377	50.00	43.00	54.00	42.00	41.00	34.00	55.00	35.00	29.00	75.00	93.00	21.00
378	95.00	76.00	73.00	78.00	73.00	89.00	69.00	63.00	74.00	49.00	44.00	51.00
SUMMARY												
Total (m^3/y)	**10038**	**9684**	**8994**	**9598**	**9380**	**8580**	**9772**	**9314**	**9210**	**9190**	**9779**	**9179**
Av. of total	**9393.23**											
Peak factors	**1.07**	**1.03**	**0.96**	**1.02**	**1.00**	**0.91**	**1.04**	**0.99**	**0.98**	**0.98**	**1.04**	**0.98**

NB: Missing respondent numbers represent customers who did **not** have **metered** bills **throughout** 2008-2012

Appendix D: Monthly variations before increase in supply

MONTHLY VARIATION CONSUMPTION BEFORE INCREASE IN WATER SUPPLY												
RSPDNT No.	JAN. 2008-2009	FEB. 2008-2009	MAR. 2008-2009	APRIL 2008-2009	MAY 2008-2009	JUNE 2008-2009	JULY 2008-2009	AUG. 2008-2009	SEPT. 2008-2009	OCT. 2008-2009	NOV. 2008-2009	DEC. 2008-2009
1	39.00	35.00	34.00	33.00	36.00	26.00	29.00	28.00	20.00	33.00	28.00	27.00
4	8.00	15.00	8.00	9.00	7.00	17.00	16.00	23.00	26.00	31.00	32.00	31.00
7	45.00	35.00	26.00	30.00	33.00	34.00	43.00	41.00	34.00	39.00	31.00	35.00
11	66.00	49.00	53.00	45.00	50.00	55.00	62.00	66.00	49.00	53.00	77.00	65.00
13	19.00	24.00	29.00	24.00	32.00	18.00	29.00	18.00	30.00	31.00	33.00	57.00
14	30.00	29.00	26.00	22.00	16.00	14.00	27.00	12.00	22.00	28.00	27.00	24.00
15	34.00	29.00	14.00	17.00	34.00	27.00	35.00	41.00	33.00	45.00	37.00	32.00
19	3.00	2.00	5.00	0.00	12.00	6.00	7.00	5.00	7.00	6.00	10.00	6.00
25	22.00	18.00	11.00	13.00	15.00	21.00	20.00	28.00	24.00	25.00	21.00	15.00
27	18.00	18.00	13.00	13.00	14.00	17.00	20.00	19.00	20.00	17.00	21.00	18.00
28	16.00	19.00	13.00	13.00	17.00	8.00	26.00	18.00	21.00	14.00	18.00	14.00
30	10.00	9.00	10.00	4.00	5.00	7.00	9.00	17.00	9.00	33.00	6.00	5.00
31	12.00	9.00	6.00	6.00	5.00	2.00	6.00	7.00	12.00	10.00	11.00	13.00
32	18.00	13.00	15.00	15.00	12.00	11.00	16.00	11.00	14.00	14.00	22.00	13.00
35	4.00	3.00	3.00	3.00	0.00	3.00	2.00	3.00	1.00	2.00	3.00	2.00
36	10.00	20.00	25.00	25.00	25.00	25.00	18.00	23.00	20.00	13.00	7.00	24.00
38	14.00	19.00	13.00	11.00	14.00	15.00	17.00	15.00	16.00	14.00	18.00	15.00
39	5.00	8.00	7.00	2.00	2.00	5.00	4.00	5.00	8.00	11.00	11.00	7.00
40	10.00	7.00	7.00	4.00	13.00	7.00	7.00	4.00	7.00	7.00	7.00	8.00
41	7.00	5.00	8.00	9.00	13.00	9.00	16.00	11.00	17.00	14.00	20.00	11.00
42	8.00	5.00	8.00	8.00	6.00	7.00	10.00	7.00	10.00	7.00	7.00	4.00
43	12.00	7.00	8.00	10.00	6.00	9.00	10.00	9.00	10.00	8.00	13.00	10.00
44	8.00	7.00	7.00	10.00	10.00	8.00	13.00	12.00	7.00	5.00	12.00	11.00
47	39.00	19.00	28.00	17.00	16.00	47.00	25.00	14.00	11.00	30.00	30.00	20.00
55	23.00	49.00	34.00	31.00	20.00	23.00	24.00	26.00	22.00	28.00	30.00	28.00
56	32.00	27.00	32.00	27.00	31.00	26.00	31.00	32.00	34.00	38.00	29.00	31.00
72	33.00	37.00	33.00	35.00	34.00	23.00	33.00	28.00	28.00	33.00	32.00	31.00
73	48.00	45.00	46.00	40.00	44.00	40.00	47.00	46.00	38.00	46.00	40.00	45.00
74	32.00	27.00	24.00	33.00	21.00	22.00	23.00	25.00	23.00	31.00	26.00	31.00
78	20.00	8.00	15.00	7.00	7.00	14.00	13.00	11.00	13.00	1.00	14.00	13.00
79	5.00	4.00	5.00	2.00	8.00	4.00	4.00	3.00	3.00	5.00	6.00	4.00
80	13.00	9.00	9.00	7.00	7.00	8.00	4.00	17.00	2.00	10.00	5.00	10.00
81	29.00	19.00	26.00	17.00	17.00	22.00	34.00	19.00	24.00	19.00	18.00	20.00
83	8.00	6.00	6.00	7.00	4.00	4.00	7.00	7.00	8.00	7.00	9.00	6.00
84	4.00	6.00	5.00	6.00	3.00	3.00	6.00	3.00	8.00	4.00	7.00	4.00
85	23.00	11.00	12.00	8.00	5.00	4.00	9.00	6.00	9.00	7.00	8.00	7.00
86	31.00	34.00	32.00	27.00	32.00	29.00	29.00	27.00	39.00	47.00	32.00	42.00
87	40.00	48.00	38.00	29.00	34.00	34.00	36.00	30.00	42.00	46.00	30.00	40.00
88	8.00	7.00	7.00	10.00	8.00	4.00	14.00	8.00	11.00	11.00	11.00	9.00
89	11.00	10.00	10.00	14.00	8.00	11.00	13.00	13.00	13.00	14.00	16.00	17.00
90	4.00	2.00	3.00	12.00	5.00	3.00	8.00	6.00	9.00	8.00	9.00	7.00
96	6.00	9.00	6.00	6.00	5.00	7.00	5.00	6.00	7.00	7.00	9.00	7.00
97	17.00	13.00	13.00	7.00	6.00	20.00	12.00	13.00	13.00	15.00	20.00	12.00
98	35.00	34.00	29.00	20.00	26.00	26.00	33.00	40.00	38.00	30.00	34.00	28.00
99	28.00	44.00	39.00	35.00	26.00	28.00	28.00	25.00	33.00	29.00	37.00	27.00

NB: Missing respondent numbers represent customers who did **not** have **metered** bills **throughout** 2008-2012

MONTHLY VARIATION IN PER CAPITA CONSUMPTION BEFORE INCREASE IN WATER SUPPLY (cont'd)												
RSPDNT. No.	JAN. 2008-2009	FEB. 2008-2009	MAR. 2008-2009	APRIL 2008-2009	MAY 2008-2009	JUNE 2008-2009	JULY 2008-2009	AUG. 2008-2009	SEPT. 2008-2009	OCT. 2008-2009	NOV. 2008-2009	DEC. 2008-2009
100	12.00	1.00	15.00	8.00	7.00	5.00	8.00	7.00	19.00	10.00	10.00	2.00
101	18.00	11.00	13.00	21.00	12.00	17.00	17.00	13.00	22.00	22.00	13.00	3.00
102	9.00	8.00	5.00	18.00	8.00	5.00	6.00	4.00	6.00	7.00	8.00	4.00
104	22.00	20.00	19.00	22.00	18.00	6.00	10.00	7.00	8.00	9.00	9.00	4.00
105	28.00	16.00	11.00	10.00	20.00	95.00	24.00	30.00	31.00	35.00	45.00	20.00
106	49.00	25.00	42.00	31.00	29.00	35.00	38.00	30.00	39.00	39.00	45.00	21.00
108	7.00	13.00	15.00	14.00	16.00	9.00	13.00	14.00	6.00	5.00	14.00	13.00
109	18.00	12.00	17.00	6.00	21.00	12.00	16.00	16.00	17.00	10.00	14.00	12.00
110	41.00	20.00	40.00	31.00	26.00	32.00	29.00	25.00	35.00	34.00	36.00	20.00
111	18.00	12.00	17.00	7.00	23.00	7.00	14.00	10.00	7.00	13.00	12.00	10.00
112	31.00	21.00	27.00	8.00	21.00	17.00	13.00	11.00	10.00	12.00	12.00	13.00
113	59.00	29.00	48.00	40.00	35.00	41.00	46.00	35.00	45.00	42.00	52.00	26.00
114	11.00	10.00	6.00	5.00	15.00	7.00	7.00	9.00	8.00	15.00	12.00	7.00
121	14.00	5.00	28.00	8.00	19.00	20.00	26.00	28.00	28.00	33.00	42.00	17.00
122	13.00	8.00	7.00	8.00	23.00	5.00	6.00	7.00	5.00	8.00	5.00	5.00
124	7.00	4.00	2.00	3.00	4.00	5.00	5.00	4.00	7.00	5.00	6.00	5.00
126	17.00	12.00	19.00	6.00	21.00	12.00	14.00	11.00	10.00	14.00	12.00	12.00
127	30.00	23.00	14.00	16.00	29.00	22.00	20.00	12.00	17.00	22.00	15.00	16.00
128	84.00	51.00	14.00	122.0	49.00	56.00	76.00	39.00	68.00	55.00	60.00	45.00
129	20.00	21.00	21.00	14.00	15.00	25.00	19.00	17.00	17.00	20.00	23.00	22.00
130	10.00	12.00	19.00	5.00	8.00	2.00	10.00	15.00	18.00	11.00	14.00	16.00
131	17.00	17.00	8.00	11.00	13.00	12.00	15.00	17.00	15.00	18.00	25.00	22.00
132	4.00	6.00	10.00	5.00	7.00	7.00	6.00	6.00	4.00	4.00	5.00	3.00
134	22.00	26.00	17.00	20.00	20.00	24.00	23.00	28.00	29.00	16.00	22.00	20.00
135	33.00	28.00	12.00	21.00	25.00	31.00	18.00	18.00	17.00	25.00	18.00	24.00
144	20.00	15.00	11.00	11.00	9.00	7.00	19.00	13.00	13.00	22.00	14.00	17.00
167	6.00	13.00	8.00	10.00	15.00	10.00	9.00	6.00	8.00	11.00	12.00	11.00
168	17.00	20.00	15.00	16.00	19.00	22.00	17.00	19.00	21.00	19.00	24.00	17.00
169	45.00	50.00	37.00	38.00	37.00	44.00	48.00	50.00	56.00	41.00	38.00	34.00
170	17.00	26.00	17.00	18.00	18.00	19.00	19.00	19.00	14.00	22.00	26.00	22.00
171	6.00	9.00	4.00	4.00	8.00	8.00	9.00	8.00	7.00	7.00	4.00	5.00
172	11.00	10.00	6.00	8.00	10.00	9.00	8.00	8.00	7.00	7.00	15.00	10.00
173	28.00	34.00	23.00	26.00	25.00	26.00	27.00	27.00	35.00	24.00	33.00	30.00
176	24.00	27.00	24.00	21.00	27.00	26.00	23.00	19.00	32.00	33.00	37.00	27.00
179	18.00	19.00	11.00	13.00	15.00	18.00	13.00	15.00	17.00	13.00	23.00	21.00
181	6.00	23.00	34.00	23.00	31.00	30.00	28.00	30.00	33.00	28.00	26.00	25.00
182	22.00	21.00	10.00	13.00	11.00	16.00	28.00	15.00	6.00	6.00	12.00	15.00
183	19.00	26.00	26.00	24.00	21.00	28.00	28.00	21.00	23.00	22.00	47.00	10.00
193	12.00	16.00	13.00	10.00	19.00	17.00	14.00	15.00	16.00	17.00	13.00	11.00
201	10.00	10.00	6.00	9.00	7.00	6.00	8.00	9.00	8.00	4.00	9.00	9.00
202	16.00	11.00	10.00	10.00	5.00	9.00	14.00	14.00	17.00	13.00	14.00	11.00
203	5.00	4.00	4.00	6.00	4.00	5.00	6.00	5.00	6.00	5.00	6.00	6.00
204	8.00	5.00	5.00	7.00	5.00	5.00	8.00	5.00	8.00	7.00	7.00	6.00
205	3.00	13.00	4.00	3.00	3.00	3.00	3.00	4.00	5.00	3.00	3.00	4.00
207	3.00	2.00	3.00	2.00	3.00	3.00	4.00	3.00	4.00	2.00	4.00	2.00
209	3.00	2.00	2.00	4.00	2.00	2.00	2.00	4.00	4.00	2.00	4.00	2.00

NB: Missing respondent numbers represent customers who did **not** have **metered** bills **throughout** 2008-2012

MONTHLY VARIATION IN CONSUMPTION BEFORE INCREASE IN WATER SUPPLY (cont'd)												
RSPDNT No.	JAN. 2008-2009	FEB. 2008-2009	MAR. 2008-2009	APRIL 2008-2009	MAY 2008-2009	JUNE 2008-2009	JULY 2008-2009	AUG. 2008-2009	SEPT. 2008-2009	OCT. 2008-2009	NOV. 2008-2009	DEC. 2008-2009
210	10.00	6.00	9.00	7.00	5.00	7.00	6.00	8.00	7.00	5.00	9.00	6.00
211	4.00	3.00	3.00	4.00	3.00	4.00	3.00	3.00	5.00	6.00	6.00	6.00
213	12.00	11.00	11.00	12.00	5.00	7.00	8.00	9.00	9.00	9.00	11.00	8.00
214	4.00	3.00	3.00	3.00	2.00	2.00	3.00	7.00	2.00	2.00	0.00	0.00
215	10.00	6.00	9.00	9.00	6.00	6.00	8.00	10.00	10.00	8.00	14.00	8.00
217	6.00	5.00	6.00	5.00	4.00	4.00	4.00	0.00	5.00	5.00	7.00	6.00
218	5.00	3.00	4.00	5.00	3.00	5.00	6.00	5.00	5.00	3.00	5.00	4.00
219	12.00	10.00	10.00	11.00	9.00	10.00	13.00	11.00	10.00	12.00	13.00	12.00
220	11.00	10.00	9.00	11.00	7.00	8.00	13.00	7.00	9.00	12.00	13.00	8.00
221	5.00	3.00	3.00	3.00	3.00	4.00	5.00	5.00	5.00	3.00	6.00	2.00
222	6.00	8.00	5.00	4.00	3.00	3.00	3.00	5.00	8.00	7.00	14.00	8.00
224	9.00	7.00	8.00	7.00	7.00	6.00	9.00	7.00	8.00	8.00	9.00	7.00
225	7.00	5.00	6.00	6.00	5.00	4.00	8.00	5.00	6.00	5.00	6.00	7.00
226	18.00	17.00	13.00	18.00	11.00	15.00	17.00	14.00	18.00	17.00	18.00	14.00
227	7.00	5.00	7.00	8.00	7.00	7.00	9.00	8.00	8.00	9.00	9.00	7.00
233	40.00	37.00	38.00	41.00	48.00	32.00	40.00	33.00	34.00	42.00	37.00	40.00
234	31.00	35.00	22.00	49.00	48.00	25.00	40.00	33.00	34.00	40.00	43.00	44.00
238	7.00	5.00	5.00	6.00	3.00	14.00	27.00	22.00	9.00	3.00	2.00	9.00
239	78.00	78.00	77.00	72.00	124.0	76.00	82.00	562.0	79.00	93.00	199.0	77.00
241	14.00	6.00	9.00	9.00	9.00	9.00	10.00	11.00	12.00	6.00	15.00	9.00
242	48.00	46.00	34.00	39.00	40.00	36.00	45.00	39.00	42.00	40.00	47.00	43.00
243	16.00	13.00	19.00	16.00	20.00	3.00	6.00	9.00	8.00	12.00	13.00	12.00
244	56.00	20.00	20.00	12.00	51.00	34.00	25.00	31.00	37.00	42.00	39.00	48.00
245	27.00	13.00	13.00	15.00	31.00	26.00	19.00	32.00	8.00	29.00	14.00	9.00
247	31.00	10.00	18.00	11.00	21.00	6.00	26.00	18.00	14.00	21.00	17.00	13.00
248	38.00	22.00	22.00	4.00	38.00	25.00	22.00	21.00	29.00	30.00	20.00	23.00
249	38.00	30.00	26.00	7.00	55.00	22.00	35.00	19.00	49.00	38.00	33.00	37.00
250	17.00	10.00	11.00	4.00	14.00	10.00	11.00	7.00	7.00	11.00	11.00	6.00
251	20.00	9.00	7.00	3.00	11.00	9.00	14.00	8.00	15.00	9.00	9.00	11.00
252	15.00	10.00	9.00	5.00	6.00	28.00	15.00	6.00	20.00	26.00	12.00	16.00
253	7.00	4.00	3.00	2.00	6.00	4.00	6.00	3.00	7.00	7.00	7.00	6.00
254	19.00	18.00	11.00	4.00	16.00	12.00	8.00	6.00	9.00	12.00	8.00	10.00
255	13.00	8.00	9.00	1.00	12.00	5.00	17.00	6.00	7.00	14.00	3.00	9.00
256	12.00	14.00	8.00	3.00	14.00	13.00	14.00	10.00	13.00	14.00	11.00	11.00
257	7.00	5.00	5.00	2.00	4.00	2.00	32.00	6.00	10.00	10.00	12.00	10.00
258	36.00	21.00	20.00	10.00	32.00	22.00	22.00	21.00	32.00	28.00	20.00	20.00
259	7.00	7.00	8.00	2.00	27.00	15.00	14.00	9.00	13.00	13.00	8.00	8.00
262	21.00	15.00	11.00	4.00	23.00	15.00	16.00	12.00	12.00	16.00	9.00	14.00
264	30.00	16.00	22.00	15.00	15.00	23.00	15.00	13.00	11.00	20.00	49.00	4.00
268	13.00	8.00	7.00	7.00	4.00	5.00	7.00	5.00	4.00	11.00	4.00	4.00
272	30.00	16.00	22.00	15.00	15.00	23.00	15.00	13.00	11.00	20.00	49.00	4.00
274	5.00	3.00	5.00	6.00	6.00	2.00	3.00	2.00	7.00	10.00	3.00	7.00
276	4.00	2.00	2.00	6.00	4.00	2.00	2.00	7.00	3.00	8.00	3.00	4.00
278	26.00	20.00	26.00	21.00	23.00	25.00	24.00	25.00	18.00	32.00	20.00	20.00
282	48.00	61.00	32.00	61.00	42.00	55.00	52.00	39.00	52.00	52.00	61.00	51.00
284	20.00	11.00	10.00	11.00	4.00	6.00	15.00	21.00	10.00	11.00	8.00	2.00
287	36.00	29.00	13.00	42.00	18.00	41.00	13.00	40.00	22.00	22.00	29.00	44.00
290	34.00	34.00	34.00	29.00	27.00	34.00	27.00	24.00	26.00	42.00	19.00	25.00
299	22.00	19.00	27.00	16.00	18.00	25.00	23.00	26.00	23.00	26.00	14.00	24.00

NB: Missing respondent numbers represent customers who did **not** have **metered** bills **throughout** 2008-2012

MONTHLY VARIATION IN CONSUMPTION BEFORE INCREASE IN WATER SUPPLY (cont'd)												
RSPDNT. No.	JAN. 2008-2009	FEB. 2008-2009	MAR. 2008-2009	APRIL 2008-2009	MAY 2008-2009	JUNE 2008-2009	JULY 2008-2009	AUG. 2008-2009	SEPT. 2008-2009	OCT. 2008-2009	NOV. 2008-2009	DEC. 2008-2009
302	21.00	16.00	17.00	7.00	13.00	13.00	23.00	8.00	12.00	12.00	14.00	14.00
307	23.00	16.00	13.00	15.00	14.00	6.00	15.00	17.00	10.00	15.00	12.00	14.00
310	42.00	15.00	25.00	25.00	15.00	28.00	23.00	25.00	26.00	20.00	13.00	1.00
312	14.00	8.00	9.00	3.00	2.00	5.00	6.00	9.00	12.00	6.00	4.00	7.00
315	26.00	14.00	33.00	14.00	17.00	23.00	17.00	19.00	24.00	24.00	18.00	21.00
318	23.00	82.00	10.00	16.00	8.00	0.00	18.00	13.00	25.00	28.00	23.00	22.00
319	7.00	8.00	4.00	6.00	5.00	5.00	7.00	3.00	5.00	6.00	5.00	8.00
327	14.00	12.00	10.00	12.00	9.00	15.00	12.00	11.00	12.00	18.00	8.00	11.00
333	10.00	10.00	8.00	9.00	11.00	15.00	13.00	13.00	9.00	6.00	6.00	15.00
338	12.00	13.00	10.00	11.00	16.00	13.00	15.00	19.00	16.00	22.00	20.00	13.00
339	15.00	12.00	11.00	13.00	11.00	22.00	15.00	18.00	15.00	17.00	13.00	16.00
344	15.00	9.00	12.00	9.00	8.00	12.00	10.00	9.00	12.00	11.00	13.00	11.00
345	20.00	15.00	12.00	14.00	10.00	14.00	20.00	18.00	19.00	24.00	12.00	16.00
349	38.00	31.00	32.00	27.00	27.00	29.00	30.00	31.00	28.00	33.00	33.00	30.00
350	47.00	11.00	41.00	21.00	16.00	15.00	10.00	32.00	32.00	41.00	25.00	40.00
353	37.00	36.00	33.00	21.00	16.00	17.00	18.00	12.00	12.00	20.00	21.00	23.00
357	16.00	9.00	11.00	10.00	9.00	9.00	10.00	12.00	10.00	13.00	7.00	6.00
359	16.00	13.00	3.00	7.00	7.00	10.00	14.00	9.00	8.00	9.00	8.00	5.00
365	18.00	14.00	14.00	16.00	13.00	16.00	17.00	15.00	18.00	27.00	10.00	18.00
368	18.00	11.00	11.00	11.00	10.00	14.00	10.00	13.00	15.00	18.00	17.00	19.00
369	23.00	19.00	21.00	13.00	13.00	8.00	14.00	19.00	12.00	14.00	19.00	20.00
370	17.00	20.00	7.00	9.00	6.00	9.00	9.00	9.00	8.00	10.00	5.00	28.00
372	37.00	13.00	9.00	24.00	7.00	25.00	22.00	28.00	27.00	39.00	5.00	0.00
373	31.00	11.00	17.00	16.00	14.00	19.00	7.00	16.00	22.00	18.00	11.00	9.00
374	19.00	19.00	13.00	19.00	16.00	22.00	18.00	14.00	15.00	25.00	14.00	16.00
375	6.00	4.00	7.00	7.00	8.00	10.00	5.00	3.00	3.00	10.00	5.00	2.00
376	16.00	11.00	14.00	11.00	9.00	15.00	5.00	11.00	16.00	16.00	7.00	6.00
377	28.00	14.00	30.00	10.00	19.00	23.00	12.00	17.00	14.00	24.00	68.00	8.00
378	41.00	19.00	28.00	17.00	25.00	25.00	32.00	24.00	24.00	22.00	13.00	14.00
SUMMARY												
Total (m^3/y)	3456	2873	2707	2521	2799	2799	2990	3253	2941	3195	3254	2743
Av. of total	**2960.92**											
Peak factors	**1.17**	**0.97**	**0.91**	**0.85**	**0.95**	**0.95**	**1.01**	**1.10**	**0.99**	**1.08**	**1.10**	**0.93**

NB: Missing respondent numbers represent customers who did **not** have **metered** bills **throughout** 2008-2012

Appendix E: Monthly variations after increase in supply

MONTHLY VARIATION CONSUMPTION AFTER INCREASE IN WATER SUPPLY												
RSPDNT No.	JAN. 2011-2012	FEB. 2011-2012	MAR. 2011-2012	APRIL 2011-2012	MAY 2011-2012	JUNE 2011-2012	JULY 2011-2012	AUG. 2011-2012	SEPT. 2011-2012	OCT. 2011-2012	NOV. 2011-2012	DEC. 2011-2012
1	29.00	29.00	28.00	37.00	28.00	23.00	26.00	26.00	29.00	31.00	36.00	36.00
4	90.00	77.00	83.00	97.00	112.0	62.00	72.00	100.0	103.0	72.00	99.00	41.00
7	77.00	80.00	105.0	115.0	73.00	30.00	77.00	147.0	46.00	15.00	120.0	106.0
11	108.0	81.00	100.0	104.0	107.0	91.00	102.0	77.00	104.0	88.00	120.0	117.0
13	48.00	39.00	41.00	48.00	40.00	32.00	41.00	38.00	39.00	45.00	49.00	50.00
14	32.00	32.00	40.00	42.00	37.00	31.00	30.00	32.00	34.00	28.00	36.00	16.00
15	64.00	47.00	61.00	56.00	53.00	37.00	40.00	45.00	53.00	34.00	56.00	26.00
19	14.00	17.00	14.00	19.00	13.00	10.00	16.00	9.00	11.00	16.00	14.00	18.00
25	19.00	23.00	24.00	13.00	23.00	35.00	14.00	15.00	28.00	14.00	16.00	13.00
27	21.00	21.00	16.00	19.00	19.00	28.00	15.00	15.00	19.00	18.00	25.00	28.00
28	14.00	16.00	11.00	15.00	14.00	14.00	15.00	10.00	14.00	11.00	15.00	13.00
30	8.00	5.00	6.00	9.00	4.00	6.00	3.00	5.00	5.00	4.00	6.00	4.00
31	18.00	12.00	12.00	14.00	17.00	14.00	20.00	14.00	11.00	15.00	17.00	20.00
32	15.00	13.00	13.00	16.00	18.00	10.00	10.00	17.00	17.00	11.00	13.00	17.00
35	2.00	2.00	4.00	5.00	5.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00
36	125.0	86.21	52.42	208.3	92.74	45.83	157.2	80.65	112.5	120.9	158.3	108.8
38	15.00	12.00	13.00	12.00	13.00	13.00	16.00	11.00	18.00	11.00	14.00	9.00
39	18.00	22.00	21.00	21.00	20.00	23.00	19.00	15.00	17.00	18.00	20.00	21.00
40	10.00	9.00	5.00	11.00	12.00	3.00	3.00	8.00	8.00	10.00	5.00	11.00
41	27.00	27.00	26.00	29.00	32.00	26.00	22.00	28.00	26.00	27.00	27.00	35.00
42	8.00	10.00	12.00	9.00	13.00	17.00	25.00	8.00	12.00	10.00	16.00	19.00
43	13.00	46.00	27.00	18.00	30.00	22.00	27.00	14.00	24.00	24.00	17.00	15.00
44	22.00	61.00	74.00	9.00	19.00	16.00	22.00	12.00	17.00	14.00	20.00	28.00
47	40.00	43.00	33.00	80.00	46.00	11.00	50.00	29.00	36.00	45.00	29.00	21.00
55	37.00	30.00	32.00	28.00	32.00	24.00	24.00	28.00	29.00	26.00	29.00	19.00
56	26.00	55.00	53.00	48.00	36.00	28.00	41.00	34.00	45.00	38.00	43.00	26.00
72	34.00	31.00	33.00	36.00	41.00	24.00	29.00	27.00	30.00	24.00	33.00	17.00
73	63.00	48.00	52.00	49.00	47.00	50.00	46.00	43.00	54.00	43.00	53.00	14.00
74	36.00	25.00	53.00	37.00	24.00	27.00	29.00	25.00	42.00	27.00	32.00	16.00
78	24.00	20.00	12.00	24.00	19.00	4.00	23.00	15.00	18.00	25.00	16.00	10.00
79	8.00	7.00	6.00	11.00	8.00	1.00	8.00	4.00	6.00	9.00	5.00	5.00
80	18.00	14.00	8.00	20.00	12.00	6.00	4.00	9.00	9.00	13.00	9.00	6.00
81	46.00	26.00	15.00	28.00	42.00	25.00	33.00	19.00	14.00	30.00	17.00	0.00
83	16.00	14.00	14.00	9.00	16.00	15.00	24.00	13.00	27.00	15.00	16.00	14.00
84	16.00	12.00	11.00	11.00	16.00	10.00	12.00	5.00	5.00	9.00	9.00	17.00
85	8.00	11.00	13.00	9.00	12.00	10.00	17.00	7.00	11.00	11.00	10.00	11.00
86	58.00	47.00	54.00	32.00	58.00	60.00	56.00	36.00	50.00	46.00	53.00	53.00
87	35.00	31.00	34.00	18.00	36.00	32.00	23.00	13.00	29.00	48.00	41.00	40.00
88	19.00	9.00	15.00	14.00	11.00	14.00	8.00	7.00	14.00	14.00	16.00	17.00
89	40.00	26.00	26.00	20.00	33.00	19.00	25.00	14.00	27.00	22.00	20.00	25.00
90	33.00	14.00	7.00	13.00	17.00	10.00	17.00	5.00	12.00	10.00	15.00	13.00
96	4.00	4.00	7.00	6.00	6.00	6.00	5.00	4.00	7.00	4.00	9.00	5.00
97	0.00	20.00	28.00	25.00	24.00	20.00	16.00	50.00	29.00	32.00	34.00	20.00
98	31.00	41.00	34.00	26.00	27.00	31.00	46.00	36.00	32.00	27.00	23.00	20.00
99	25.00	25.00	24.00	24.00	23.00	21.00	21.00	16.00	21.00	19.00	22.00	21.00

NB: Missing respondent numbers represent customers who did **not** have **metered** bills **throughout** 2008-2012

MONTHLY VARIATION CONSUMPTION AFTER INCREASE IN WATER SUPPLY (cont'd)												
RSPDNT No.	JAN. 2011-2012	FEB. 2011-2012	MAR. 2011-2012	APRIL 2011-2012	MAY 2011-2012	JUNE 2011-2012	JULY 2011-2012	AUG. 2011-2012	SEPT. 2011-2012	OCT. 2011-2012	NOV. 2011-2012	DEC. 2011-2012
100	40.00	48.00	15.00	22.00	20.00	21.00	22.00	21.00	27.00	25.00	25.00	24.00
101	38.00	31.00	46.00	45.00	35.00	31.00	37.00	44.00	32.00	35.00	36.00	44.00
102	28.00	38.00	39.00	32.00	25.00	29.00	37.00	29.00	25.00	29.00	27.00	33.00
104	4.00	7.00	5.00	3.00	4.00	16.00	10.00	4.00	8.00	5.00	4.00	5.00
105	43.00	34.00	45.00	40.00	33.00	47.00	43.00	42.00	26.00	36.00	43.00	42.00
106	56.00	42.00	52.00	42.00	68.00	37.00	63.00	58.00	45.00	49.00	56.00	44.00
108	40.32	64.66	52.42	54.17	60.48	70.83	52.42	44.35	54.17	32.26	45.83	44.35
109	11.00	17.00	9.00	14.00	13.00	8.00	10.00	5.00	7.00	12.00	11.00	16.00
110	29.00	26.00	33.00	34.00	31.00	28.00	29.00	29.00	25.00	28.00	29.00	34.00
111	34.00	22.00	16.00	31.00	18.00	9.00	28.00	14.00	10.00	32.00	17.00	28.00
112	14.00	19.00	19.00	19.00	24.00	8.00	28.00	14.00	11.00	21.00	11.00	17.00
113	72.00	86.00	132.0	110.0	253.0	218.0	127.0	98.00	97.00	96.00	112.0	119.0
114	9.00	16.00	28.00	22.00	15.00	6.00	5.00	21.00	13.00	10.00	14.00	8.00
121	15.00	15.00	15.00	36.00	34.00	5.00	40.00	17.00	22.00	29.00	25.00	33.00
122	10.00	7.00	13.00	4.00	9.00	8.00	8.00	9.00	7.00	12.00	15.00	3.00
124	18.00	14.00	12.00	12.00	8.00	8.00	6.00	18.00	11.00	14.00	11.00	9.00
126	17.00	20.00	18.00	23.00	15.00	4.00	22.00	14.00	14.00	15.00	15.00	18.00
127	10.00	45.00	21.00	25.00	20.00	6.00	26.00	18.00	19.00	16.00	9.00	12.00
128	64.00	62.00	80.00	76.00	48.00	79.00	82.00	53.00	66.00	84.00	71.00	88.00
129	18.00	21.00	22.00	27.00	18.00	20.00	23.00	16.00	23.00	21.00	19.00	20.00
130	13.00	11.00	11.00	14.00	9.00	10.00	11.00	8.00	11.00	9.00	13.00	13.00
131	21.00	30.00	18.00	23.00	21.00	25.00	24.00	27.00	30.00	14.00	18.00	18.00
132	32.00	31.00	25.00	26.00	29.00	24.00	34.00	27.00	36.00	29.00	25.00	28.00
134	36.00	51.00	41.00	46.00	42.00	43.00	39.00	32.00	37.00	28.00	33.00	37.00
135	7.00	12.00	13.00	14.00	15.00	12.00	20.00	10.00	16.00	15.00	14.00	26.00
144	33.00	14.00	16.00	18.00	25.00	23.00	18.00	14.00	24.00	21.00	24.00	21.00
167	8.00	14.00	18.00	16.00	10.00	5.00	16.00	17.00	12.00	7.00	26.00	48.00
168	23.00	30.00	28.00	41.00	25.00	28.00	30.00	27.00	26.00	23.00	28.00	39.00
169	38.00	42.00	43.00	35.00	41.00	40.00	48.00	40.00	52.00	43.00	46.00	38.00
170	20.00	26.00	24.00	27.00	27.00	20.00	27.00	23.00	30.00	25.00	23.00	20.00
171	12.00	13.00	16.00	12.00	9.00	13.00	21.00	13.00	17.00	11.00	10.00	13.00
172	89.00	103.0	36.00	83.00	29.00	23.00	44.00	19.00	0.00	44.00	31.00	24.00
173	31.00	30.00	25.00	29.00	26.00	33.00	26.00	22.00	23.00	88.00	53.00	34.00
176	21.00	47.00	18.00	23.00	33.00	19.00	44.00	26.00	26.00	19.00	9.00	38.00
179	27.00	33.00	31.00	32.00	30.00	31.00	36.00	27.00	28.00	24.00	31.00	31.00
181	18.00	18.00	15.00	21.00	19.00	13.00	22.00	15.00	30.00	10.00	9.00	10.00
182	11.00	9.00	12.00	12.00	11.00	8.00	9.00	8.00	11.00	6.00	15.00	21.00
183	22.00	30.00	33.00	29.00	21.00	26.00	27.00	23.00	26.00	25.00	31.00	33.00
193	15.00	19.00	12.00	17.00	15.00	23.00	19.00	15.00	14.00	12.00	12.00	13.00
201	20.00	33.00	34.00	17.00	23.00	17.00	22.00	9.00	18.00	17.00	16.00	20.00
202	13.00	29.00	27.00	16.00	27.00	20.00	25.00	12.00	19.00	17.00	13.00	15.00
203	2.00	3.00	4.00	3.00	3.00	3.00	7.00	2.00	1.00	1.00	3.00	2.00
204	10.00	9.00	9.00	6.00	9.00	13.00	40.00	7.00	8.00	7.00	7.00	14.00
205	14.00	9.00	8.00	6.00	9.00	8.00	11.00	4.00	6.00	6.00	8.00	3.00
207	7.00	2.00	2.00	1.00	4.00	2.00	3.00	1.00	5.00	2.00	2.00	2.00
209	2.00	2.00	1.00	2.00	1.00	1.00	3.00	2.00	1.00	1.00	6.00	1.00

NB: Missing respondent numbers represent customers who did **not** have **metered** bills **throughout** 2008-2012

MONTHLY VARIATION CONSUMPTION AFTER INCREASE IN WATER SUPPLY (cont'd)												
RSPDNT. No.	JAN. 2011-2012	FEB. 2011-2012	MAR. 2011-2012	APRIL 2011-2012	MAY 2011-2012	JUNE 2011-2012	JULY 2011-2012	AUG. 2011-2012	SEPT. 2011-2012	OCT. 2011-2012	NOV. 2011-2012	DEC. 2011-2012
210	13.00	12.00	17.00	11.00	16.00	16.00	20.00	10.00	14.00	12.00	14.00	18.00
211	9.00	4.00	5.00	4.00	6.00	10.00	10.00	6.00	6.00	5.00	5.00	8.00
213	4.00	12.00	13.00	5.00	11.00	11.00	17.00	2.00	6.00	9.00	4.00	3.00
214	3.00	6.00	10.00	6.00	10.00	7.00	31.00	49.00	77.00	5.00	16.00	12.00
215	3.00	0.00	1.00	0.00	1.00	4.00	9.00	4.00	11.00	6.00	4.00	1.00
217	11.00	11.00	13.00	7.00	12.00	10.00	18.00	8.00	16.00	14.00	11.00	12.00
218	4.00	5.00	5.00	4.00	5.00	5.00	6.00	4.00	4.00	5.00	4.00	4.00
219	22.00	25.00	30.00	26.00	37.00	27.00	36.00	20.00	28.00	26.00	24.00	33.00
220	13.00	24.00	18.00	11.00	18.00	17.00	21.00	11.00	24.00	16.00	17.00	17.00
221	9.00	13.00	14.00	8.00	14.00	13.00	15.00	7.00	13.00	9.00	11.00	11.00
222	2.00	6.00	6.00	3.00	12.00	11.00	8.00	5.00	9.00	6.00	4.00	4.00
224	14.00	13.00	16.00	9.00	19.00	9.00	18.00	8.00	20.00	8.00	10.00	14.00
225	17.00	14.00	16.00	11.00	14.00	12.00	16.00	10.00	14.00	10.00	13.00	15.00
226	41.00	38.00	35.00	16.00	32.00	23.00	40.00	10.00	29.00	19.00	20.00	26.00
227	6.00	18.00	13.00	9.00	16.00	10.00	18.00	7.00	11.00	9.00	10.00	9.00
233	35.00	19.00	15.00	38.00	34.00	36.00	37.00	30.00	37.00	30.00	34.00	35.00
234	47.00	75.00	45.00	46.00	29.00	32.00	37.00	31.00	43.00	38.00	39.00	68.00
238	50.00	60.00	83.00	62.00	120.0	207.0	98.00	100.0	110.0	109.0	95.00	46.00
239	178.0	186.0	154.0	138.0	107.0	281.0	147.0	144.0	170.0	146.0	163.0	192.0
241	17.00	18.00	16.00	19.00	11.00	20.00	22.00	15.00	20.00	18.00	18.00	21.00
242	34.00	30.00	74.00	62.00	46.00	53.00	54.00	41.00	50.00	47.00	49.00	56.00
243	16.00	14.00	14.00	15.00	22.00	7.00	10.00	11.00	15.00	12.00	15.00	11.00
244	35.00	21.00	30.00	32.00	34.00	33.00	32.00	26.00	32.00	24.00	41.00	48.00
245	22.00	20.00	25.00	36.00	24.00	22.00	22.00	23.00	23.00	21.00	31.00	12.00
247	32.00	31.00	39.00	55.00	49.00	27.00	26.00	21.00	25.00	17.00	17.00	24.00
248	30.00	40.00	46.00	50.00	41.00	46.00	45.00	37.00	47.00	45.00	45.00	55.00
249	54.00	45.00	55.00	66.00	45.00	39.00	48.00	49.00	70.00	57.00	46.00	50.00
250	11.00	16.00	17.00	14.00	11.00	15.00	17.00	17.00	20.00	9.00	9.00	18.00
251	10.00	9.00	12.00	16.00	11.00	13.00	19.00	16.00	11.00	19.00	18.00	21.00
252	21.00	15.00	13.00	18.00	11.00	10.00	15.00	24.00	29.00	24.00	12.00	11.00
253	5.00	8.00	8.00	10.00	8.00	6.00	10.00	11.00	9.00	8.00	13.00	9.00
254	13.00	14.00	16.00	21.00	16.00	21.00	11.00	13.00	18.00	17.00	18.00	21.00
255	5.00	5.00	4.00	8.00	6.00	5.00	6.00	7.00	6.00	7.00	7.00	9.00
256	14.00	14.00	18.00	26.00	19.00	19.00	18.00	15.00	21.00	17.00	19.00	20.00
257	4.00	16.00	18.00	43.00	5.00	5.00	7.00	4.00	5.00	1.00	8.00	8.00
258	31.00	28.00	37.00	44.00	39.00	45.00	40.00	39.00	48.00	38.00	42.00	42.00
259	13.00	11.00	14.00	15.00	13.00	12.00	15.00	12.00	15.00	15.00	13.00	12.00
262	15.00	17.00	18.00	22.00	16.00	19.00	19.00	15.00	20.00	19.00	22.00	27.00
264	34.00	29.00	16.00	32.00	22.00	17.00	31.00	32.00	16.00	37.00	25.00	25.00
268	29.00	24.00	33.00	23.00	14.00	16.00	16.00	28.00	28.00	29.00	35.00	45.00
272	34.00	29.00	16.00	32.00	22.00	17.00	31.00	32.00	16.00	37.00	25.00	25.00
274	29.00	14.00	19.00	23.00	12.00	6.00	8.00	9.00	10.00	16.00	27.00	12.00
276	29.00	27.00	52.00	38.00	39.00	25.00	23.00	33.00	30.00	36.00	35.00	31.00
278	22.00	26.00	25.00	18.00	22.00	19.00	13.00	33.00	25.00	8.00	19.00	15.00
282	52.00	58.00	47.00	49.00	60.00	72.00	67.00	51.00	53.00	74.00	70.00	56.00
284	91.00	61.00	61.00	66.00	30.00	22.00	21.00	44.00	61.00	19.00	46.00	55.00
287	30.00	32.00	31.00	36.00	41.00	32.00	34.00	32.00	38.00	45.00	40.00	40.00
290	42.00	41.00	40.00	52.00	46.00	34.00	47.00	43.00	39.00	46.00	51.00	45.00
299	24.00	29.00	11.00	17.00	7.00	25.00	37.00	20.00	10.00	21.00	13.00	14.00

NB: Missing respondent numbers represent customers who did **not** have **metered** bills **throughout** 2008-2012

MONTHLY VARIATION CONSUMPTION AFTER INCREASE IN WATER SUPPLY (cont'd)												
RSPDNT. No.	JAN. 2011-2012	FEB. 2011-2012	MAR. 2011-2012	APRIL 2011-2012	MAY 2011-2012	JUNE 2011-2012	JULY 2011-2012	AUG. 2011-2012	SEPT. 2011-2012	OCT. 2011-2012	NOV. 2011-2012	DEC. 2011-2012
302	19.00	13.00	10.00	10.00	12.00	10.00	16.00	10.00	8.00	15.00	12.00	17.00
307	25.00	20.00	22.00	17.00	19.00	16.00	13.00	16.00	17.00	15.00	17.00	18.00
310	18.00	43.00	19.00	36.00	26.00	5.00	38.00	33.00	29.00	36.00	32.00	33.00
312	17.00	15.00	16.00	6.00	7.00	4.00	10.00	9.00	30.00	7.00	9.00	10.00
315	32.00	27.00	28.00	42.00	36.00	16.00	38.00	28.00	33.00	16.00	16.00	42.00
318	3.00	17.00	13.00	35.00	0.00	11.00	12.00	23.00	16.00	5.00	15.00	32.00
319	21.00	23.00	15.00	37.00	25.00	23.00	19.00	35.00	13.00	31.00	32.00	27.00
327	25.00	24.00	34.00	28.00	25.00	17.00	24.00	23.00	23.00	29.00	33.00	16.00
333	9.00	8.00	7.00	11.00	23.00	10.00	16.00	13.00	13.00	13.00	10.00	12.00
338	27.00	29.00	25.00	25.00	11.00	13.00	25.00	23.00	25.00	23.00	25.00	27.00
339	33.00	21.00	5.00	13.00	11.00	37.00	19.00	21.00	19.00	15.00	15.00	17.00
344	48.00	33.00	25.00	43.00	37.00	20.00	38.00	23.00	34.00	46.00	32.00	28.00
345	48.00	11.00	14.00	23.00	20.00	0.00	186.00	6.00	18.00	10.00	14.00	5.00
349	45.00	41.00	31.00	35.00	29.00	33.00	33.00	33.00	31.00	35.00	35.00	35.00
350	11.00	7.00	9.00	9.00	8.00	4.00	22.00	3.00	17.00	18.00	15.00	8.00
353	35.00	33.00	43.00	31.00	31.00	27.00	29.00	25.00	25.00	37.00	39.00	35.00
357	19.00	19.00	22.00	18.00	15.00	14.00	10.00	18.00	19.00	8.00	19.00	23.00
359	31.00	20.00	38.00	28.00	40.00	36.00	55.00	26.00	36.00	27.00	30.00	21.00
365	15.00	27.00	15.00	20.00	19.00	16.00	15.00	10.00	15.00	15.00	19.00	20.00
368	58.00	73.00	69.00	65.00	66.00	49.00	40.00	28.00	58.00	42.00	49.00	58.00
369	32.00	28.00	32.00	34.00	28.00	24.00	44.00	30.00	40.00	22.00	28.00	26.00
370	19.00	17.00	14.00	16.00	17.00	10.00	12.00	13.00	12.00	9.00	12.00	12.00
372	35.00	148.00	49.00	104.00	24.00	137.00	110.00	127.00	95.00	68.00	155.00	121.00
373	15.00	32.00	9.00	47.00	18.00	9.00	31.00	33.00	27.00	24.00	22.00	32.00
374	33.00	26.00	19.00	21.00	35.00	19.00	31.00	21.00	17.00	19.00	22.00	22.00
375	17.00	20.00	23.00	19.00	21.00	14.00	12.00	12.00	33.00	11.00	17.00	21.00
376	12.00	24.00	28.00	23.00	24.00	14.00	20.00	16.00	19.00	13.00	22.00	18.00
377	12.00	15.00	11.00	16.00	6.00	1.00	31.00	7.00	5.00	25.00	12.00	10.00
378	38.00	47.00	33.00	48.00	38.00	45.00	26.00	27.00	31.00	20.00	18.00	24.00
SUMMARY												
Total (m^3/y)	4577	4764	4564	4991	4584	4268	5016	4091	4561	4211	4650	4506
Av. of total	**4565.20**											
Peak factors	**1.00**	**1.04**	**1.00**	**1.09**	**1.00**	**0.93**	**1.10**	**0.90**	**1.00**	**0.92**	**1.02**	**0.99**

NB: Missing respondent numbers represent customers who did **not** have **metered** bills **throughout** 2008-2012

Appendix F: Variation with income groups and period

VARIATION IN PER CAPITA CONSUMPTION (l/c/d)										
RSPDT No.	AVERAGE CONSU-MPTION	INCOME GROUPS		PERIODIC VARIATION						
		LOW INCOM	MIDDLE INCOME	BEFORE AND AFTER		YEARLY VARIATION				
				2008-09	2011/12	2008	2009	2010	2011	2012
1	31.72	31.72		31.11	37.48	40.03	27.10	26.19	27.86	37.48
4	53.78	53.78		30.72	98.58	9.90	28.28	53.97	81.91	98.58
7	69.81	69.81		51.91	78.19	45.07	38.11	72.53	119.7	78.19
11	46.69	46.69		38.82	61.47	35.79	31.58	49.10	54.11	61.47
13	44.91	44.91		39.13	56.54	41.29	30.99	45.12	49.97	56.54
14	50.97	50.97		47.97	65.14	48.42	27.44	68.06	47.00	65.14
15	61.41	61.41		53.24	80.73	44.66	49.26	65.81	68.22	80.73
19	36.36		36.36	47.68	44.74	7.15	30.45	50.66	47.15	44.74
25	83.43		83.43	95.74	73.49	58.06	69.44	159.7	58.25	73.49
27	60.24		60.24	55.87	79.65	48.78	65.13	53.69	55.74	79.65
28	50.28		50.28	54.22	41.91	53.74	54.07	54.84	47.63	41.91
30	59.74		59.74	69.91	44.98	129.2	39.44	41.01	45.08	44.98
31	51.77		51.77	44.45	61.81	33.64	34.06	65.67	62.09	61.81
32	60.32		60.32	61.83	61.79	71.88	47.18	66.45	55.43	61.79
35	35.03		35.03	34.72	20.83	35.68	43.84	24.66	51.89	20.83
36	97.94		97.94	88.28	130.95	68.45	92.39	104.0	98.09	130.9
38	42.07		42.07	41.49	44.80	51.02	48.20	25.27	42.66	44.80
39	39.96		39.96	23.73	61.60	20.83	20.29	30.05	67.85	61.60
40	44.12		44.12	44.71	40.87	42.81	37.33	53.98	43.65	40.87
41	105.05		105.05	74.28	159.17	64.74	62.66	95.45	143.9	159.1
42	48.42		48.42	32.47	79.72	43.73	35.56	18.11	68.94	79.72
43	68.20		68.20	50.29	91.93	38.31	38.30	74.26	105.8	91.93
44	55.28		55.28	34.74	69.30	21.87	38.26	44.11	102.7	69.30
47	89.83		89.83	76.85	118.60	71.75	63.17	95.62	102.3	118.6
55	22.89	22.89		22.12	27.05	24.77	21.65	19.93	21.41	27.05
56	17.74	17.74		16.36	21.20	15.66	14.08	19.35	18.70	21.20
72	48.95	48.95		50.47	48.37	51.86	42.78	56.76	44.92	48.37
73	37.38	37.38		35.63	48.86	39.99	31.80	35.10	32.12	48.86
74	22.64	22.64		20.92	25.34	20.44	21.02	21.29	25.33	25.34
78	60.37		60.37	51.13	80.64	54.62	38.33	60.44	69.52	80.64
79	94.87		94.87	84.46	107.25	65.69	79.07	108.6	114.7	107.2
80	32.31		32.31	29.58	38.85	27.73	27.42	33.58	34.51	38.85
81	80.35		80.35	78.00	90.92	74.76	69.49	89.75	77.73	90.92
84	29.00		29.00	18.09	49.30	20.57	19.97	13.72	35.45	49.30
85	38.04		38.04	33.82	47.05	26.68	47.93	26.83	42.28	47.05
86	30.93	30.93		26.59	39.79	22.14	27.74	29.90	34.98	39.79
87	20.34	20.34		20.60	23.69	25.54	21.59	14.67	15.93	23.69
88	27.90		27.90	22.52	50.27	24.15	25.06	18.36	21.82	50.27
89	102.76		102.76	81.17	134.57	76.63	60.15	106.7	137.0	134.5
90	39.22		39.22	27.59	49.37	25.31	26.64	30.82	64.04	49.37
96	49.38		49.38	51.74	53.82	55.04	54.72	45.47	41.00	53.82
97	51.98		51.98	47.84	51.85	20.41	42.62	80.50	64.60	51.85
98	73.30		73.30	73.44	77.29	68.90	76.88	74.55	72.23	77.29
100	71.30		71.30	47.93	104.70	49.87	21.04	72.90	111.3	104.7
101	43.99		43.99	32.02	63.19	25.47	24.36	46.23	60.61	63.19
102	22.40		22.40	14.79	30.86	10.64	5.47	28.25	37.37	30.86
104	78.99		78.99	97.37	63.01	152.1	58.85	81.09	42.39	63.01
105	97.44		97.44	90.49	113.28	77.97	89.03	104.4	106.0	113.2
106	49.15		49.15	44.83	60.56	37.16	39.94	57.39	53.78	60.56
108	57.79		57.79	62.08	34.76	60.84	34.17	91.24	42.60	59.72
109	56.96		56.96	64.58	59.72	53.91	62.82	77.01	48.09	38.82
110	102.11		102.11	105.55	38.82	100.4	101.3	114.8	99.41	94.29

NB: Missing numbers represent customers who did **not** have **metered** bills **throughout** 2008-2012

VARIATION IN PER CAPITA CONSUMPTION (l/c/d) (cont'd)										
RSPDNT No.	AVERAGE CONSU-MPTION	INCOME GROUPS		PERIODIC VARIATION						
		LOW INCOM	MIDDLE INCOME	BEFORE AND AFTER		YEARLY VARIATION				
				2008-09	2011/12	2008	2009	2010	2011	2012
111	36.65		36.65	31.65	41.99	31.06	20.06	43.81	44.42	41.99
112	72.32		72.32	73.96	77.87	69.71	64.32	87.84	64.33	77.87
113	50.92		50.92	29.53	117.44	26.35	28.10	34.12	50.71	117.4
114	101.27		101.27	92.64	102.44	96.88	56.28	124.7	123.7	102.4
116	22.73		22.73	20.29	25.19	20.68	18.18	22.00	24.03	25.19
121	224.50		224.50	244.25	235.83	198.7	166.3	367.6	149.3	235.8
122	28.76		28.76	28.82	24.28	22.94	31.63	31.89	33.45	24.28
124	62.87		62.87	40.56	122.45	46.47	31.56	43.65	68.35	122.4
126	64.00		64.00	62.25	68.69	49.07	60.09	77.60	66.23	68.69
127	49.00		49.00	51.96	45.36	44.28	48.00	63.60	47.15	45.36
128	86.19		86.19	83.89	96.16	81.76	71.37	98.54	82.87	96.16
129	161.24		161.24	155.65	173.50	150.5	167.1	149.2	169.4	173.5
130	89.73		89.73	88.91	85.50	80.66	95.89	90.18	95.49	85.50
131	70.10		70.10	67.68	75.65	53.19	52.46	97.39	75.42	75.65
132	49.10		49.10	18.78	97.86	22.96	13.68	19.70	93.54	97.86
134	98.19		98.19	78.73	144.94	73.55	72.87	89.77	113.8	144.9
135	90.07		90.07	97.33	82.99	158.6	87.89	45.46	69.71	82.99
144	59.77		59.77	53.93	68.55	43.74	49.68	68.38	67.77	68.55
167	69.45		69.45	56.03	62.64	57.67	51.06	59.37	110.9	62.64
168	79.16		79.16	68.47	104.27	56.52	67.33	81.55	85.70	104.2
169	62.75		62.75	62.65	67.14	73.02	55.98	58.97	61.29	67.14
170	62.15		62.15	59.20	56.77	56.27	52.03	69.30	77.05	56.77
171	52.83		52.83	39.48	79.65	33.95	38.12	46.37	68.23	79.65
172	85.13		85.13	42.93	157.98	32.36	27.38	69.07	148.2	157.9
173	92.55		92.55	90.52	115.71	82.28	72.16	117.1	78.37	115.7
176	65.48		65.48	67.04	70.36	57.11	68.14	75.87	58.70	70.36
179	103.62		103.62	90.40	115.18	54.90	79.47	136.8	131.8	115.1
181	80.94		80.94	89.28	66.44	74.89	142.2	50.74	73.96	66.44
182	62.24		62.24	63.37	47.84	90.47	57.60	42.05	74.56	47.84
183	59.43		59.43	56.57	72.21	44.73	70.96	54.02	55.85	72.21
193	61.40		61.40	59.87	53.80	55.53	62.89	61.20	72.66	53.80
201	60.86		60.86	45.31	75.56	28.10	37.08	70.76	95.08	75.56
202	42.57		42.57	35.67	50.29	36.51	29.16	41.34	58.41	50.29
203	32.27		32.27	38.31	19.46	41.00	43.84	30.08	27.25	19.46
204	71.22		71.22	55.65	74.75	50.59	53.33	63.01	108.5	74.75
205	49.80		49.80	41.09	53.72	31.50	39.44	52.32	73.81	53.72
207	46.93		46.93	48.22	44.48	46.42	49.30	48.92	46.52	44.48
210	54.69		54.69	38.68	95.62	40.06	37.47	38.50	61.69	95.62
211	40.23		40.23	31.61	64.13	31.50	36.94	26.38	40.82	64.13
213	50.65		50.65	54.93	17.86	46.45	56.02	62.33	70.27	17.86
214	56.68		56.68	25.22	208.81	20.94	7.23	47.48	10.98	208.8
215	52.23		52.23	67.05	20.92	77.88	64.37	58.90	39.47	20.92
217	48.46		48.46	37.40	66.78	31.94	24.62	55.63	63.54	66.78
218	34.77		34.77	32.90	38.77	35.44	37.07	26.18	38.27	38.77
219	52.75		52.75	37.25	89.18	32.38	28.24	51.13	63.51	89.18
220	53.24		53.24	41.47	63.67	41.09	39.69	43.62	76.01	63.67
221	39.42		39.42	24.06	68.83	22.82	19.15	30.22	59.12	68.83
222	47.95		47.95	45.27	65.65	61.66	39.99	34.16	41.05	65.65
224	53.18		53.18	40.69	65.94	43.77	40.10	38.21	80.69	65.94
225	53.45		53.45	39.91	77.73	31.88	31.88	55.98	69.10	77.73
226	51.54		51.54	43.08	47.16	35.99	38.42	54.81	82.17	47.16
227	42.62		42.62	39.99	40.61	28.00	34.18	57.79	54.56	40.61
233	51.24	51.24		56.57	50.17	49.37	55.96	64.37	36.93	50.17
234	46.96	46.96		43.67	52.21	42.56	44.29	44.18	50.55	52.21

NB: Missing numbers represent customers who did **not** have **metered** bills **throughout** 2008-2012

VARIATION IN PER CAPITA CONSUMPTION (l/c/d) (cont'd)										
RSPDT No.	AVERAGE CONSU-MPTION	INCOME GROUPS		PERIODIC VARIATION						
		LOW INCOME	MIDDLE INCOME	BEFORE AND AFTER		YEARLY VARIATION				
				2008-09	2011/12	2008	2009	2010	2011	2012
238	28.90	28.90		6.59	81.37	5.79	6.40	7.58	45.84	81.37
239	53.02	53.02		46.74	68.32	72.19	26.67	41.36	56.50	68.32
241	33.08	33.08		27.12	41.86	23.40	23.08	34.87	41.43	41.86
242	48.55	48.55		47.02	49.27	41.17	44.29	55.60	52.65	49.27
243	13.16	13.16		12.71	15.31	14.49	10.63	13.02	12.63	15.31
244	108.24		108.24	109.78	110.74	94.24	132.12	103.00	97.44	110.74
245	98.21		98.21	99.60	85.99	95.33	65.44	138.02	105.39	85.99
247	133.46		133.46	112.13	123.55	96.25	90.53	149.62	207.78	123.55
249	91.52		91.52	81.46	108.50	55.15	77.79	111.46	107.02	108.50
250	67.50		67.50	59.63	81.83	61.96	46.38	70.55	74.66	81.83
251	64.78		64.78	54.93	79.68	59.98	53.83	50.98	76.20	79.68
252	88.54		88.54	85.94	88.81	78.15	75.09	104.57	100.79	88.81
253	53.30		53.30	40.97	49.33	39.52	45.18	38.21	94.33	49.33
256	128.25		128.25	113.47	148.17	87.66	99.82	152.93	151.54	148.17
259	70.08		70.08	68.24	76.75	65.33	53.80	85.59	70.86	76.75
262	91.30		91.30	82.58	108.82	89.05	63.84	94.85	96.43	108.82
264	91.30		91.30	82.58	108.82	89.05	63.84	94.85	96.43	108.82
268	67.88		67.88	40.32	134.46	26.62	27.45	66.89	79.74	134.46
272	32.14	32.14		27.43	39.33	26.89	31.18	24.21	38.97	39.33
274	47.25		47.25	36.60	52.53	22.54	17.68	69.59	72.25	52.53
276	54.37		54.37	30.26	105.59	16.34	4.99	69.45	75.76	105.59
278	45.43	45.43		47.78	45.90	44.34	51.29	47.70	40.08	45.90
284	42.46	42.46		22.90	66.96	16.89	15.12	36.69	76.87	66.96
287	41.06	41.06		38.24	60.95	41.67	31.91	41.13	28.93	60.95
290	51.13	51.13		45.29	71.55	48.39	32.54	54.96	48.15	71.55
299	56.22		56.22	59.02	46.62	58.25	61.50	57.32	60.84	46.62
302	43.93	43.93		45.57	50.12	66.70	26.20	43.83	32.68	50.12
307	33.75	33.75		31.77	39.64	32.46	25.57	37.28	35.11	39.64
310	41.31	41.31		52.03	41.03	43.87	37.93	44.30	60.53	41.03
312	58.59		58.59	55.03	76.32	49.30	28.11	87.69	53.40	76.32
318	64.90		64.90	74.87	59.18	72.75	77.08	74.78	31.63	59.18
319	34.41	34.41		23.07	53.39	14.06	9.57	45.58	49.20	53.39
327	55.39		55.39	46.61	72.36	37.84	27.84	74.16	65.85	72.36
333	45.41		45.41	42.75	55.82	49.87	35.57	42.81	42.93	55.82
338	44.04	44.04		37.18	55.96	41.68	28.69	41.17	51.98	55.96
339	49.97	49.97		48.90	54.85	43.15	38.05	65.51	48.85	54.85
344	37.09	37.09		24.76	66.72	16.70	19.15	38.43	44.91	66.72
345	47.97		47.97	47.92	49.87	34.65	18.40	90.70	50.41	49.87
349	38.87	38.87		35.60	45.06	40.09	37.60	29.11	42.50	45.06
350	44.69	44.69		57.46	35.67	60.29	68.43	43.65	15.69	35.67
353	80.99	80.99		63.95	109.25	83.58	62.51	45.77	103.26	109.25
357	44.65	44.65		37.20	60.44	29.56	37.09	44.94	50.32	60.44
365	37.91		37.91	39.64	32.63	30.13	36.78	52.02	37.69	32.63
368	40.66	40.66		25.06	71.41	12.32	20.27	42.58	58.46	71.41
369	39.55	39.55		32.39	54.33	28.38	24.95	43.85	47.01	54.33
370	67.80		67.80	63.47	87.98	65.98	59.11	65.32	60.79	87.98
371										
372	80.54	80.54		51.55	145.67	33.85	15.74	105.06	104.60	145.67
373	63.11		63.11	50.58	109.69	45.96	58.44	47.35	60.58	109.69
374	59.16		59.16	55.38	81.61	43.77	52.14	70.23	49.93	81.61
376	68.79		68.79	61.50	86.19	40.37	53.51	90.63	75.73	86.19
377	78.27		78.27	96.14	52.83	119.34	63.47	105.60	51.15	52.83
378	57.09		57.09	50.02	82.74	39.19	60.49	50.38	56.54	82.74
AVRGG	59.77	40.01	62.77	48.72	72.25	50.21	47.03	63.37	66.51	72.49

NB: Missing numbers represent customers who did **not** have **metered** bills **throughout** 2008-2012

Appendix G: Metered and unmetered consumption comparison

RSPDNT No.	LOCATION	TYPE	PPLTN	COMPARISON		% DIFFERENCE IN CONSUMPTION CHARGED	NO. OF CUSTOMERS	
				AVERAGE (ESTIMATED)	AVERAGE (REGULATED)		UNDER CHARGED	OVER CHARGED
22	Adweso Est.	Detached	5	98.96	117.20	-15.56	1	0
34	Adweso Est.	Semi-det.	1	163.44	20.01	716.60	0	1
61	Nurses' Qtrs	Semi-det.	2	247.50	77.06	221.17	0	1
67	Nurses' Qtrs	Semi-det.	6	82.50	10.99	650.56	0	1
77	Adweso Est.	Semi-det.	8	74.07	49.76	48.83	0	1
107	A. New Town	Semi-det.	12	49.62	25.09	97.79	0	1
115	Adweso	Detached	2	245.58	352.03	-30.24	1	0
123	L. C. H.	Semi-det.	3	135.55	56.51	139.84	0	1
125	L. C. H.	Semi-det.	8	61.40	69.04	-11.07	1	0
140	AK'dum	Detached	2	246.89	91.72	169.17	0	1
141	AK'dum	Detached	4	123.36	220.86	-44.14	1	0
143	AK'dum	Detached	6	130.30	30.67	324.89	0	1
185	AK'dum	Detached	3	82.30	78.67	4.60	0	1
186	AK'dum	Detached	5	164.59	137.71	19.52	0	1
187	AK'dum	Detached	10	131.67	40.73	223.27	0	1
188	AK'dum	Detached	3	49.10	34.89	40.73	0	1
189	AK'dum	Detached	5	164.59	146.31	12.50	0	1
190	AK'dum	Detached	5	131.67	127.05	3.64	0	1
192	AK'dum	Detached	6	82.30	99.21	-17.05	1	0
194	AK'dum	Detached	5	98.75	65.59	50.56	0	1
195	AK'dum	Detached	4	123.44	52.04	137.19	0	1
197	AK'dum	Detached	7	98.96	55.30	78.94	0	1
199	AK'dum	Detached	5	49.22	61.69	-20.22	1	0
228	SSNIT Flat	Flat	2	244.62	62.08	294.05	0	1
236	Effiduase	Cmpd Hse	10	65.84	62.82	4.81	0	1
237	Effiduase	Cmpd Hse	9	65.23	42.60	53.11	0	1
246	Densu Estate	Detached	4	164.59	130.38	26.24	0	1
288	Adweso	Cmpd Hse	16	44.13	35.46	24.44	0	1
294	Kwaakyea	Cmpd Hse	5	132.00	81.00	62.95	0	1
303				98.26	20.46	380.18	0	1
309	Betom	Cmpd Hse	15	36.58	20.41	79.28	0	1
313	Adweso	Detached	5	99.00	30.47	224.95	0	1
316	Kwaakyea	Cmpd Hse	16	40.42	71.73	-43.65	1	0
320				61.24	31.81	92.50	0	1
332	Adweso	Detached	7	93.58	54.29	72.38	0	1
340	Kwaakyea	Detached	8	65.23	57.67	13.12	0	1
Average (total)				**112.40**	**75.59**		**(7)**	**(29)**

NB: Missing numbers represent respondents who **had metered** bills **throughout** 2008-2012

Appendix H: Summary of analysis for second cycle educational institutions

SCH. No.	SCHOOL	AVRGE POPLTN	CUSTOMER NUMBER	AV. CNSPTN (l/c/d)	COMPARISON		% DIFFERENCE IN IN CONSUMPTION CHARGED	NO. OF CUSTOMERS	
					AVERAGE (ESTIMATED)	AVERAGE (REGULATED)		UNDER CHARGED	OVER CHARGED
1	PENSEC	723	614-10-3060	8.85	9.61	51.14	-87.00	1	0
2	GHANASS	2177	624-10-4020	32.82	30.37	47.21	-35.66	1	0
3	KINGSBY	245	624-10-9010	8.86	-	8.86	-	-	-
4	NJUASCO	1504	624-10-6030	46.90	42.91	46.76	-8.24	1	0
5	OBOSS	2269	624-10-4020	11.56	28.46	5.07	461.15	0	1
6	POJOSS	2088	624-10-9050	18.37	18.37	-	-	-	-
7	KSTS	2214	624-10-6030	35.19	28.68	54.97	47.82	1	0
	Average (total)			**23.22**	**28.01**	**41.03**		**(4)**	**(1)**