

HELP IS ON THE WAY MINISTRIES

P. O. BOX CE 12093

TEMA, GHANA

TOKORANU WATER SUPPLY

PROJECT

DESIGN REPORT

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| | |
|---|----|
| 1.0 INTRODUCTION | 3 |
| 2.0 OBJECTIVES | 4 |
| 3.0 DESCRIPTION OF THE SYSTEM..... | 4 |
| 3.1 Intake..... | 4 |
| 3.2 Delivery..... | 4 |
| 3.3 Reservoir..... | 4 |
| 3.4 Distribution | 4 |
| 3.5 Standpipes..... | 5 |
| 4.0 NATIONAL SMALL TOWNS DESIGN GUIDELINES..... | 5 |
| 4.1 Design Criteria..... | 5 |
| 5.0 METHODOLOGY | 5 |
| 5.1 Community meeting..... | 5 |
| 5.3 Design calculations | 6 |
| 5.3.1 Hydraulic Design..... | 6 |
| 5.3.2 Structural Design..... | 6 |
| 5.3.4 Preparation of draft contract..... | 7 |
| 6.0 ESTIMATED COST..... | 7 |
| ANNEX 1 – COMMUNITY MAP AND THE SYSTEM LAYOUT | 8 |
| ANNEX 2 – DETAIL DESIGN CALCULATIONS..... | 9 |
| 1.1 Basic Data | 9 |
| 1.3 Reservoir Size | 10 |
| 1.4 Number of Standpipes..... | 10 |
| 1.5 Design Flow Computation for standpipes..... | 11 |
| 1.6 Evaluation of Borehole | 11 |
| 1.7 Pump Selection | 12 |
| ANNEX 3 – DRAWINGS | 13 |

1.0 INTRODUCTION

Tokurano is VRA resettlement community in Krachi East District¹, located along the Asokawkaw- Dambai trunk road. During 2000 population census it was estimated that about 3271 people live in the community with 710 houses and 784 households.

One major problem facing the community is inadequate safe water supply to meet the community daily demand because there only 4 boreholes fitted with hand pumps when feasibility was conducted by AB-Serkoms in May 2004.

As a result of inadequate water supply to meet the community water demand, an NGO called 'Help Is On The Way Ministries' (HIOTWM) based in USA with local branch in Tema and Tokurano contracted AB-Serkoms Ltd. (a civil engineering firm in Ghana) in February 2004 to conduct a feasibility studies to recommend an economically reliable system that will help improve the water supply situation in the community.

AB-Serkoms in their report to HIOTWM gave 6 options with corresponding cost of each option for consideration. The options proposed by AB-Serkoms in their feasibility report were:

- Option 1 – Repair the existing Hand pumps which were not functioning properly and drilling additional boreholes to CWSA standard
- Option 2 - Taking Water from Volta Lake which is about 6 km from the community for treatment
- Option 3 – Mechanization of the high yielding borehole No. B14 to meet the CWSA standard
- Option 4 - Repair the existing Hand pumps which were not functioning properly and drilling additional borehole with a reduced service level
- Option 5 - Mechanization of the high yielding borehole no B14 with a reduced service level
- Option 6 - Repair the existing Hand pumps which were not functioning and Mechanization of the high yielding borehole No. B14 with a reduced service level

HIOTWM after studying the options chose option 3 from the 6 options and requested AB-Serkoms to give a detailed description of option 3 for further studies. The detailed description of option was sent to HIOTWM in April 2005.

Based on the detailed description of the option sent to HIOTWM, AB-Serkoms was requested to make a proposal detailing the scope of work and the cost involved for the design stage of the project. After negotiations a contract was signed between AB-Serkoms and HIOTWM for the detail design to commence.

¹formerly Krachi District before the district was divided into two Krachi East and West Districts

Consequently, this report details the methodology/activities carried out in the field, survey data, maps and design calculations used in order to have an installed reliable functioning water supply system that meets the water supply demand of the community.

2.0 OBJECTIVES

The objective of the design assignment is to come out with a reliable and a sustainable system that meets the community's water requirement for the next ten years based on the national design guidelines.

3.0 DESCRIPTION OF THE SYSTEM

The design of the system is based on the Fill and Draw concept. The water from the borehole is to be pumped directly into the reservoir, which then flows under gravity into the standpipes from the reservoirs.

3.1 Intake

The intake shall consist of:

- A pump house with installed electric submersible pump, which will pump water from the borehole through a delivery line into reinforced concrete reservoir situated on high level ground.

3.2 Delivery

The delivery line shall consist of uPVC pressure pipes class "C" buried to ground at depth of between 600mm-900mm. Where road crossing are encountered the minimum depth will be 1.00 m.

Washouts, Air Release Valves, Pressure reducers, Flow controls and Water Meters (possibly uPVC Valves) will be installed at suitable points.

3.3 Reservoir

The reservoir shall be of a ground reinforced concrete for half a day demand.

3.4 Distribution

Generally, uPVC pressure pipes class "C" will be used. Galvanised pipes, connections and fittings will only be used in technically unsuitable areas

The distribution is consisted of a combination of various sizes of uPVC pipes.

3.5 Standpipes

The system will consist of public standpipes located at areas agreed upon with the community the number of standpipes will be based on the national guidelines.

4.0 NATIONAL SMALL TOWNS DESIGN GUIDELINES

4.1 Design Criteria

The design criteria used in the design based on the national design guidelines for small towns as outlined below:

- Basic per capita consumption (80% of P_p) = 20lpd
- Per capita consumption, house connection (20% P_p) = 60lpd

- Population Growth Rate (National Average) = (2.5%)
- Physical Losses = 20%
- Design Period = 10 years
- Pumping Time = 16 hours maximum
- Population per stand pipe = 600 persons
- Maximum distance to a stand pipe = 500m
- Minimum flow from a stand pipe = 0.4 l/sec
- Peak Hourly Factor = 1.0 -2.0
- Storage Reservoir Capacity = 50% daily demand
- Minimum Residual Pressure
 - Distribution System = 10m
 - Stand pipe at peak hourly factor = 6m
- Minimum Pipe Size
 - Distribution system = 50mm
 - House Connections = 19mm

Where

P_p = present population
lpd = litres per day

5.0 METHODOLOGY

Based on the data gathered in the feasibility studies and above design guidelines, AB-Serkoms carried out activities outlined in the following sections:

5.1 Community meeting

Initial community meeting was held in conjunction with HIOTWM directors to brief the community of the project and to determine the community's preference points for standpipes and other physical structures.

Also the passage of pipe line was determined during the determination of the location of the standpipes.

5.1 Engineering Survey and Mapping

A topographical survey was undertaken to produce the layout of the system. The spot heights and distances of the pipe lines were taken for hydraulic design. The data from the survey and the layout of the system is attached as ANNEX 1- Drawings 1

5.3 Design calculations

5.3.1 Hydraulic Design

All the variables picked from the survey; that is spot heights and distances picked during the survey were computer modelled using Epanet software. During the modelling appropriate pipe sizes were selected to get the required pressures in the distributions lines and at the standpipes

The output of the hydraulic modelling is attached as ANNEX 2 – Drawings 2

5.3.2 Structural Design

5.3.2.1 Reservoir

The proposed reservoir is ground one because a hill was identified near the community which has old reservoir sited on it. The proposed designed reservoir is reinforced concrete tank of 60 m³ capacity.

- **Soil Test**

Geotechnical investigation was conducted to estimated the soil bearing capacity

- **Foundation Design**

With the soil bearing information a foundation was designed

- **Tank Design**

The structural design of the tank was undertaken using pressures on the tank walls when the water is full.

The calculation and drawings of the reservoir design attached as ANNEX 3- Drawings 2

5.3.2.2 Pump House

The pump house is made of masonry works of sandcrete blocks. The drawings attached in ANNEX 3 – Drawings 3

5.3.2.3 Standpipes

The standpipes are public ones located at place accessible to households. It made of reinforced concrete platforms and plinth with 2 No. taps serving 600 people

The Drawings attached in ANNEX 3 – Drawings 4

5.3.4 Preparation of draft contract

After the design a draft contract was prepared for the consideration of the client. The contract dossier contains the following:

- Contract Agreement form
- Scope of works
- Conditions of the contract
- Specifications
- Drawings
- Bill of Quantities

The draft contract is prepared as separate volume.

6.0 ESTIMATED COST

The estimated cost of the system was done by preparing the bill of quantities of each component and pricing the unit cost of each quantity. The table below summarizes the cost of the system

| Ref | Component | Estimated Amount |
|-----|--------------------------------|---------------------|
| 0 | General Items & Mobilization | ¢ 40,000,000 |
| 1 | Water Tank | 162,947,800 |
| 2 | Pump House & Pump Installation | 143,441,500 |
| 3 | Transmission Line | 92,672,000 |
| 4 | Distribution Lines | 377,630,000 |
| 5 | Standpipes | 82,786,500 |
| | Total | ¢899,477,800 |

ANNEX 1 – COMMUNITY MAP AND THE SYSTEM LAYOUT

ANNEX 2 – DETAIL DESIGN CALCULATIONS

1.1 Basic Data

| | |
|--|------------------|
| 2000 Census Population | 3271 |
| Community Specific Population Growth Rate | 2.1 % |
| Estimated Population (2005) | 3629 |
| Projected Population for 10 years (2015) | 4468 |
| Number of institutions (schools) | 4 |
| Existing functioning boreholes with hand pumps | 3 |
| Basic per capita consumption (80% of P _p) | 20 lpd |
| Per capita consumption, house connection (20% P _p) | 80 lpd |
| Physical Losses | 20% |
| Design Period | 10 years |
| Minimum flow rate from the taps | 0.4 l/sec |
| Number of people per standpipe | 600 |
| Peak Hourly Factor | 2.5 |
| Reservoir capacity | 50% Daily Demand |
| | |
| | |

1.2 Daily Water Demand Estimation

The demand for basic consumption, house connection or leakages can deduced as follows;

$$\begin{aligned}
 Q_1 &= P_p (0.8 * 1.025^{10} * 20) &= 16 P_p (1.025^{10}) &- \text{Demand for basic consumption} \\
 Q_2 &= P_p (0.2 * 1.025^{10} * 60) &= 12 P_p (1.025^{10}) &- \text{Demand for house connections} \\
 Q_3 &= 0.2(Q_1 + Q_2) &= 5.6 P_p (1.025^{10}) &- \text{Allowance for Physical Losses}
 \end{aligned}$$

$$Q_{\text{total}} = (Q_1 + Q_2 + Q_3) = \{16 P_p (1.025^{10}) + 12 P_p (1.025^{10}) + 5.6 P_p (1.025^{10})\}$$

$$Q_{10 \text{ years}} = 34 P_p (1.025^{10})$$

where:

$$\begin{aligned}
 P_p &= \text{Present Population} \\
 Q_{\text{total}} &= \text{Total community daily water demand} \\
 Q_{10 \text{ years}} &= \text{Total community daily water demand in 10 year time} \\
 Q_{\text{presen}} &= \text{Total community daily water demand at present}
 \end{aligned}$$

1.2.1 Community Population Growth Rate

From Table 1 the average community population growth is calculated as 2.1%

Table 1: Community Population Figures from 1970 – 2000 Census and Project to 2015

| | | | | | |
|------------|------|------|-------|-------|-------|
| Year | 1970 | 1984 | 2000 | 2005 | 2015 |
| Population | 2006 | 2358 | 3,271 | 3,629 | 4,468 |

Sources\: Ghana Statistical Service

1.2.2 Water Demand Calculation

Table 2 shows the present daily water demand and daily water demand from the mechanised borehole in ten years time.

Table 2: Present and ten years daily water demand

| Year | Population | Total Demand (m ³ /day) |
|------|------------|------------------------------------|
| 2005 | 3629 | 123 |
| 2015 | 4468 | 152 |

$$\text{Total daily water demand} = 152 \text{ m}^3$$

$$\begin{aligned} \text{Residual daily water demand} &= \text{Total demand} - \text{quantity served by 3 boreholes} \\ &= 34 \times 4468 - 34 \times 900 \\ &= 121 \text{ m}^3 \text{ per day} \end{aligned}$$

1.3 Reservoir Size

Based on the CWSA criteria the reservoir capacity is found as follows:

$$\text{Ten years daily water demand} = 121 \text{ m}^3$$

$$\begin{aligned} \text{50\% per storage capacity} &= 50\% \times 121 \text{ m}^3 \\ &= 61 \text{ m}^3 \end{aligned}$$

Therefore half-day storage of 60 cubic metres.

1.4 Number of Standpipes

The number standpipes to be provided is calculated as follows:

$$\text{Present population (a)} = 3629$$

| | |
|---|--------------------------------|
| 10-year design population (b) | = 4468 |
| Maximum users per standpipe (c) | = 600 |
| Number of standpipes to be provided (d) | = (b)/(c) =4468/600 =7 |
| Additional pumps for institutions (e) | = 4 |
| Existing number of handpumps (f) | =3 |
| Total number of standpipes to be provided | = (d)+(e)-(f) = 7+4-3 =8 |

Agreed on 9 stand pipes to be constructed

1.5 Design Flow Computation for standpipes

The design flow per tap is defined as average flow for 24 hours multiplied by the peak factor of the community

Design flow per tap = (n*q)/duration of collection period

Where

| | | |
|---|--------------------------------|------------|
| n | = number of users per tap | = 600 |
| q | = per capita daily consumption | = 34 litre |

$$\begin{aligned} \text{Average flow for 24 hours per standpipe} &= \frac{600 * 34}{24 * 60 * 60} \\ &= 0.24 \text{ litres/sec} = 0.85 \text{ m}^3/\text{hr} \end{aligned}$$

The peak hour factor is determined by the number standpipes in the community.

| | | |
|----------------------------------|---|--|
| The number of standpipes | = | 12 |
| The peak factor for 9 standpipes | = | 2.0 |
| Therefore flow per standpipe | = | 0.24*2.0 = 0.48 l/s = 1.73m ³ /hr |
| Total flow from reservoir | = | 1.73*12 = 20.76 m ³ /hr |

1.6 Evaluation of Borehole

From the evaluation of the pump test report of the borehole, the following data is obtained.

- Internal diameter of borehole = 126mm
- Depth to static Water Level (S.W.L) = 10.65m
- Total Depth of Borehole = 31m
- 24 hours pumping rate = 300 l/min = 18.0 m³/hr.
- Draw Down (pumping test result) = 6.79 m
- 12 hours recovery residual draw down = 1.07
- Specific Capacity of Borehole [24 hours][12.0/8.79] = 1.37 m³/hour/m
= 32.76 m³/day/m

- Maximum Allowable Draw Down (MADD) is taken to the top of the first screen
MADD = 23 - 10.65 = 12.35 m
- Allowable Dynamic Water level = 23 m

Pump installation is put at 25 m below ground level

1.7 Pump Selection

The calculation for the selection of the suitable pump is shown in the attached Annex 2.1

The summary of the specifications of the selected pump are as follows:

- Make: Grundfos
- Type: SP17-8
- Power: 5.5 kW
- Pumping Head: 72 m
- Pumping Rate: 12.1 m³/hr
- Efficiency: 72.5%
- Weight: 13 kg

The calculations for the pump selection, specifications and characteristic curves is presented overleaf

ANNEX 3 – DRAWINGS