GOVERNMENT OF GHANA

MINISTRY OF WATER RESOURES, WORKS AND HOUSING

COMMUNITY WATER AND SANITATION AGENCY

SMALL TOWNS SECTOR GUIDELINES
(Design Guidelines)

(Volume III)

December, 2010

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1 GENERAL PRINCIPLES

1.1 Introduction

Design of **Small Towns** water supply schemes shall be in accordance with the following CWSA Design Criteria and Guidelines. Hydraulic designs shall be carried out by means of design software that is acceptable to the CWSA, and may allow hourly simulation of flows, pressures, etc. Engineering design reports, including drawings, supporting calculations, computer printouts, etc., shall be made available to the Client/CWSA. Engineering designs shall be simple with minimal automation.

1.2 Basic Standards

The design standards for community water supply and sanitation shall ensure that:

- Each person in a served community has access to a minimum of 20 litres of water per day;
- The walking distance to a water facility does not exceed 500 metres from the farthest house in the community;
- Each spout of a standpipe of a piped scheme serves no more than 300 persons;
- The facility provides all year round potable water to the community.

1.3 Water Supply Technologies

The main water supply technologies to be adopted shall include:

a. Groundwater based piped systems;
b. Spring or highland surface water with simple piped scheme (gravity or pumped scheme) with simple treatment;
c. Rain water harvesting with simple treatment;
d. Surface water (polluted) with simple treatment;
e. Other technologies to be adopted, where necessary.

1.4 Treatment Plants

The main treatment plant technologies to be adopted shall include:

a. Package Treatment Plants;
b. Small conventional treatment plants;
c. Biological Treatment Plants
d. Other CWSA approved treatment plant technologies to be adopted, where necessary.

1.5 Water Source Selection

Selection of water sources shall ensure minimum development costs, and shall be in accordance with the following order of preference:

a. Groundwater;
b. Springs;
c. Rainwater harvesting (to augment inadequate sources);
d. Surface water sources.

1.6 Energy Source Selection

Selection of energy sources shall be in accordance with the following order of preference:
a. Grid Electricity;
b. Solar Energy;
c. Windmill;
d. Diesel Generator;
e. Other approved sources of energy.

2 DESIGN GUIDELINES

2.1 Participatory Design

The design of water supply systems shall be done in close collaboration with the beneficiary communities. Meetings shall be held with the communities and relevant stakeholders. Stakeholders may include the following, among others:

- WSDBs
- WATSANs
- Traditional Authorities
- General Community
- MMDAs
  - Chief Executive
  - Co-ordinating Director
  - Planning Officer
  - DWD/DWST Officials
  - Unit Committees, Town Councils, Area Councils
- Opinion Leaders
  - Assembly Members
  - Leaders of Religious Bodies
  - Leaders of Youth Groups and Co-operatives
- Small Scale Commercial and Industrial Concerns
- Institutions.

2.2 General Design Procedure

The design of a typical water supply system shall consist of:
a. Source selection;

b. Design of boreholes, intakes, treatment units and other ancillary structures;
c. Hydraulic and engineering design of storage reservoirs/tanks transmission and distribution networks;
d. Selection of electromechanical equipment.

2.3 Ground Water Exploration

Hydrogeological and/or geophysical investigations shall be carried out to locate water-bearing aquifers and confirm siting of boreholes. The minimum yield of a borehole to enable mechanisation to be carried out shall be 85 l/min. However, depending on a comprehensive assessment of existing hydro geological conditions, and an adequate technical evaluation of the yield of available boreholes, boreholes with lower yields may be mechanised, particularly for Category I towns with the approval of CWSA.

Existing boreholes shall be developed and pump tested to obtain the safe yield before possible mechanisation. Existing boreholes/wells fitted with Hand Pumps and with adequate yield shall be integrated into the design of new water supply systems.

2.4 Topographic Surveys

Topographic Surveys shall be carried out to enable hydraulic design of the networks. All topographic surveys shall be done in accordance with standards and guidelines prescribed by the Ghana Institution of Surveyors.

2.5 Basic Design Criteria

The following criteria shall be used in the design process.

• Storage Reservoir Volume	35 - 40 % of Average Daily Demand
• Peak Daily Factor (Transmission Mains)	1.05 - 1.2
• Peak Hourly Factor (Distribution Mains)	2.5 minimum
(Design software simulating hourly flows may be used for hourly factors.)	
• Residual Pressures (Distribution System)	10m head minimum 60m head maximum 5 m head at outlets at peak hour flow 20m head max at outlets
• Basic Design Period	10 years (from the completion of the system)
• Pumping Time	16 hours maximum (Boreholes) 20 hours maximum (Treatment Plant)
• Pipe Sizes	75mm - minimum for transmission mains
	50mm - minimum for distribution mains.
	19mm - minimum for house connections.
	uPVC/HDPE pipes to be provided for transmission and distribution networks .

	uPVC/HDPE pipes to be provided as minimum diameter pipes leading to standpipes.
• Galvanised Steel/Ductile Iron/HDPE to be provided for exposed piping.	
• 600 people per standpipe with two outlets.	
• Maximum Walking Distance to a Standpipe shall be 500m.	
• Isolating valves shall be placed at all major branches and on transmission and distribution mains at minimum distance of 500m.	
• Fire fighting draw-off points/hydrants shall be strategically located for each system in collaboration with the Ghana National Fire Service.	

2.6 Design Periods

The general design period for construction of Small Towns Water Supply Systems shall be 10 years from the expected time of commissioning. Individual components of the system may have varying design periods determined from the expected time of commissioning as follows:

• Storage /Tanks	
- Volume (sizing)	- 10 years
• Transmission Mains	- 15 years
• Distribution	
- Mains	- 15 years
- Branches	- 10 years
• Public Standpipes	- 10 years
• Pumps	- 10 years
• Transformers	- 15 years
• Source	- 15 years

2.7 Population and Water Demand

The following criteria shall be used to determine design population and water demand.

• Population Growth Rate	Per Regional Average
• Per Capita Water Consumption	
- Standpipes SP	20 lcd
- Private Connections (PC)	60 lcd
• Small Scale Industrial and Commercial Demand	10 - 20 % of the Domestic Demand
(To be determined based on actual socio-economic surveys)	
• Physical losses	10 - 15 %
(Losses of 15 - 20% shall be applied where existing pipelines are to be rehabilitated. Adequate engineering studies need to be carried out to enable rehabilitation to be effected.)	
• The share of population having access to standpipes to house connections shall be determined based on socio economic studies, and in accordance with the following:	

Category	Category I	Category II	Category III	Category IV
Population	2,000 – 5,000	5,001 – 15,000	15,001 – 30,000	30,001 – 50,000
% SP	80 – 90	75 – 85	70 – 80	60 – 75
% PC	10 – 20	15 – 25	20 – 30	25 – 40

2.8 Socio-Economic Factors for Design

Each design should be based on socio-economic data obtained through surveys and desk studies. The relevant socio-economic data shall include, among others:

- Pattern and growth of the community;
- Relative role of community in metropolitan/municipal/district/regional economy;
- Main occupation of inhabitants;
- Existing infrastructure (hospitals, markets, schools, etc.);
- Existing small scale industrial/commercial activities;
- Previous provision of WSS facilities.

3 SANITATION GUIDELINES

3.1 Background

Individual household latrines shall form an integral part of interventions in all communities to maximise health benefits in beneficiary communities. Institutional latrines may be constructed for schools and clinics.

The design of latrines shall be in accordance with acceptable design criteria and the level of affordability established through feasibility studies. Appropriate Hygiene and Sanitation Promotion shall be carried out in all communities in accordance with the Framework for Hygiene and Sanitation for Small Towns Water and Sanitation Projects.

3.2 Technology Choice

Technology choice shall be based on the Sanitation Ladder. The Sanitation Ladder involves the broad range of technology options ranging from basic pit latrines to Water Closet facilities. All trained and certified artisans shall be equipped with knowledge on the Sanitation Ladder approach. Technical designs based on the Sanitation Ladder shall be available at CWSA Offices.

All latrines shall have hand washing facilities. All sanitation facilities shall be designed and constructed according to the following:

- Shall be relatively free from flies and odours
- Shall safely dispose of human excreta

- Shall be structurally stable to prevent collapse during its design life.

3.3 Basic Design Criteria

• Sludge Accumulation Rate (R)	0.06 m3/person/year (for dry latrines. 0.04 m3/person/year (for wet latrines)
• Minimum retention time (T)	2 years
• Population (P) per pit	25 persons for household latrines and 50 persons for institutional.
• Maximum depth of pit (d) (excavation shall not be below water table)	1.8 – 2m for KVIP 2 – 3m for VIP etc.
• Free board (space for evolving gases)	0.5 m

3.4 Guidelines for Siting Latrines

The following guidelines shall be used for the siting of latrines:

- Latrines shall be sited a minimum of 50m from borehole (in the case of dry latrines), hand dug well or spring source. For wet latrines hydrogeological expertise should be sought.
- Latrines shall be sited downstream of water sources.
- Public latrines shall be at least 50m from nearest residence and as far as practicable.
- Latrines shall be sited away from trees to prevent obstruction of vent pipes.

3.5 Design

General

All latrines shall be designed in a manner that is girl child friendly. Latrines shall also be designed to meet the needs of the physically challenged. Appropriate modifications shall be made to standard latrines designs to cater for areas with high water table, rocky or unstable soil.

Pits

Pits should be at least 1.2m x 1.2m, square or rectangular. Ideally pits should be above the water table. If necessary, the floor level of the superstructure shall be raised above ground level to increase the volume of the pit. In unstable soils, the pit walls should be supported.

Slabs

Slabs shall be made of concrete. The required structural strength can be achieved by making the slab slightly dome shaped (Mozambique) or by using steel reinforcement. Slab design shall ensure ease of use and convenience for users and the surface shall be smooth for ease of cleaning. Surface of slab

should slope towards the squat hole for drainage purposes. Slabs shall be cast under the supervision of a trained and certified artisan or professional.

Superstructure
The superstructure should provide adequate privacy and can be built of any appropriate local materials. A vent pipe may be included to help with fly and odour control. The roof of superstructure shall drain away from the front of the superstructure.

3.6 Construction

Construction of latrines shall be assigned to artisans or small-scale contractors who have the requisite qualification experience, training and certification.

Designs for both household and institutional latrines shall be provided by the CWSA.

3.7 Sanitation Promotion

Sanitation shall be promoted through social marketing techniques. The general principles of Community Led Total Sanitation (CLTS) shall be adopted for communities to attain an Open Defecation Free (ODF) status. A revolving fund shall be established for construction of sanitation facilities for interested and pre qualified households in communities where poverty levels are high.

3.8 Operation and Maintenance of Latrines

Pits shall be closed when the free board is reduced to 0.5m.
Disinfectants shall not be put in pits.
Appropriate anal cleansing materials shall be used and shall be put in the pit.

4 SUPPLEMENTARY GUIDELINES

4.1 Electromechanical

Surge vessels shall be provided where necessary for protection against excessive back pressure including water hammer.

Pump houses/Control Panel houses shall be provided to house all electro-mechanical and related appliances excluding the borehole head.

All Generator Sets shall be housed separately.

Suppliers of all electromechanical equipment shall provide three (3) copies each of relevant operational manuals (in English) to enable adequate operation and maintenance of such equipment.

4.2 Point Source(s)

Piped schemes shall be combined with point source(s) for optimal coverage, where necessary. In such instance, the point source(s) shall have adequate yield and shall contribute to the overall coverage of the water supply system.

4.3 Physical Losses

Physical Losses shall be estimated based on the size and complexity of the water supply system. For all population categories, losses of 15- 20 % shall be applied where systems are to be rehabilitated. Detailed engineering studies including cost benefit analyses shall be carried out to establish the feasibility and economic viability of rehabilitation of existing pipelines.

4.4 Fire Hydrants

Fire hydrants shall be provided in all district capitals and in other towns with population of over 15,000 (category III & IV). For towns with population below 15,000, provision shall be made for a fire fighting draw-off point. Where necessary the National Fire Service should be contacted for further information. Fire hydrants shall be approved by the Regional Fire Service.

Small Scale Industries or premises presenting high fire hazards and requiring flows in excess, shall construct storage tanks on their premises and provide necessary fire fighting facilities in accordance with their needs.

4.5 Water Sources

Water sources shall be protected by prohibiting human activities within 100 meters radius of the source in case of surface water, and 50 meters in case of ground water.

The quantity and quality of surface water sources including springs shall be monitored regularly for at least one year and the results analysed. Available hydrological data (historical data for at least 10 years) including community information on quality and quantity of the sources, shall be collected and analysed to ensure adequate design.

Contaminated ground water sources shall be monitored regularly (monthly) for at least one year and the results analysed to enable provision of adequate treatment systems.

4.6 Water Quality

Water Quality shall meet the relevant Ghana Standards Board (GSB) criteria for drinking water. Safety chlorination shall be provided for all water supply systems. Periodic water safety monitoring shall be undertaken for all piped schemes and boreholes/hand dug wells fitted with hand pumps in accordance with the Water Safety Framework.

As much as possible, no treatment systems shall be required for ground water. Where necessary, simple Iron (Fe), Manganese (Mn), Fluoride (F), Turbidity and Odour removal systems may be provided. Such systems shall have minimal operation and maintenance requirements.

4.7 Surface Water Treatment

Simple, robust and easy to operate treatment units shall be provided to treat water from surface source(s). These units shall include Roughing (pre-treatment) and/or Slow Sand Filtration Systems to improve the physico-chemical and biological quality of the water. Package Treatment Plants or Small Conventional Treatment Plants may be adopted where necessary.

4.7.1 Roughing Filters

Roughing filters for pre-treatment shall be up flow or horizontal flow depending on the turbidity. The following shall be adopted for selection of the filter media:

Upflow Roughing Filters

Turbidity : Up to 150 NTU		Filtration Rate : 0.3 – 1 $m^3/m^2.h$	
Filter Material Characteristics	Size of Filter Material (mm)		
	1st fraction	2nd fraction	3rd fraction
Coarse RF (<20 NTU)	18 – 24	12 – 18	8 - 12
Medium RF (20-50 NTU)	12 – 18	8 – 12	4 - 8
Fine RF (50-150 NTU)	8 – 12	4 – 8	2 - 4
Depth (mm)	750 -1250	400 - 700	300 – 600

Horizontal Roughing Filters

Turbidity : Above 150 NTU		Filtration Rate : 0.3 – 1.5 $m^3/m^2.h$	
Filter Material Characteristics	Size of Filter Material (mm)		
	1st fraction	2nd fraction	3rd fraction
Medium RF (150-250 NTU)	12 - 18	8 – 12	4 - 8
Fine RF (250-1000 NTU)	8 - 12	4 – 8	2 - 4
Length (m)	2.5 – 3.5	1.5 – 2.5	0.75 – 1.25

4.7.2 Slow Sand Filters

Slow sand filters may be preceded by roughing filters. The filter media shall be selected based on the following:

Gravel fraction	Diameter (mm)	Depth (mm)
1st	5 - 8	100 - 150
2nd	1.5 - 2	75 - 125
3rd	0.4 – 0.6	40 - 75
Filter sand	0.15 – 0.35	750 - 1500
Supernatant		750 - 1200
Freeboard		200 - 300
Filtration Rate	0.1 – 0.3 $m^3/m^2.h$	

4.7.3 Pressurised Filters

Pressurised filters may be used, where necessary. These shall consist of two layers of crushed silica in pressurised containers with semi automatic cleaning system. The use of such filters shall be in accordance with the manufacturers' specifications.

4.7.4 Packaged Treatment Plants

Packaged treatment plants shall be installed and operated in accordance with the manufacturers' specification.

4.8 Sterilisation of Tanks and Pipelines

All storage tanks and pipelines shall be sterilised before commissioning. The following procedure shall be complied with to ensure adequate sterilisation:

4.8.1 Tanks

After testing for leakages, the tank is filled with potable water containing free chlorine (at least 50mg/l concentration) and left to stand for at least 24 hours, after which samples are taken to measure the residual chlorine. The measured concentration of the residual chlorine should not be less than 10mg/l.

4.8.2 Pipelines

After pressure testing, water shall be made to run out of the pipes until clear. The pipes shall then be refilled with potable water containing free chlorine (at least 50mg/l concentration) and left to stand for at least 24 hours. All outlets shall be opened at least once in this period. The residual chlorine at the point farthest from the point of injection shall be measured and it should not be less than 10mg/l. If the measured concentration of the residual chlorine is less than 10mg/l the process shall be repeated till it is achieved.

4.9 Chlorination

During normal operation of the water supply system, water in the storage tanks and distribution network shall be chlorinated (disinfected) to maintain a measured concentration of residual chlorine of not less than 0.2mg/l after 10 minutes of injection.

4.10 Standard Drawings and Tender Documents

Standard drawings and tender documents are available for adaptation and use at CWSA Head Office.

5 SAFETY, EQUIPMENT AND MATERIALS STRENGTH

5.1 General

Generally, equipment and material specifications shall be in accordance with internationally accepted codes and standards, notably, the British or ISO codes and standards. Where necessary, codes and standards accepted by the Ghana Institution of Engineers shall be adopted.

The strength of general construction materials such as concrete, timber, steel and iron rods, etc. shall meet specified engineering standards.

5.2 Safety Precautions

- Access to all excavations (pipe line excavations, tank foundations, chamber bases, latrine pits, etc) shall be protected to prevent injury to life and property.
- Personnel working in pits and doing all construction works shall wear the appropriate protective gear including boots, safety helmets, gloves, goggles, dust masks and ear protectors.
- First aid equipment shall be available at all construction sites at all times.
- Rope ladders shall be provided for easy escape from hand dug wells.
- Areas around excavations (especially hand dug wells) shall be kept free of equipment, material and debris.
- All electrical works (where applicable) shall be carried out to the specifications of ECG and or VRA as applicable.

5.3 Pumps

Pumps from reputable manufacturers shall be used in all systems where pumps are required. All pumps shall be provided with the following protection:

- Protection against lightning strike;

- Protection against dry running;
- Protection against pump motor stalling;
- Protection against high pressures in transmission pipe;
- Protection against voltage fluctuations;
- Protection against phase failure;
- Protection against corrosion;
- Provision of sleeving where necessary.

All electrical connections to pumps shall be to the specification of the Ghana Grid Company Limited, Electricity Company of Ghana and/or the Volta River Authority.

5.4 Pipes

Pipes to be used in construction shall meet the following requirements.

Pipe Material	Distribution	Transmission
	Min. Pressure	Min. Pressure
uPVC	9 bar	9 bar
HDPE	10 bar	10 bar
Galvanised (exposed)	10 bar	10 bar
Galvanised Steel/Ductile Iron (High pressure areas)	To be specified to meet requirements.	

Pipes used should be generally available on the local market.
Minimum depth of cover for buried pipes shall be 600mm
Minimum depth of cover for pipes in road crossing shall be 1,200mm and encased or sleeved.

5.5 Concrete

Concrete used in civil works shall have the following strengths:

Classification/ Grade	Minimum Strength (N/mm^2)		Maximum aggregate size (mm)	Use
	28 days	7 days		
I	30	20	20	Water tight reinforced structure
II	25	17	20	Support tower, tank foundation, chamber covers, pipe line markers
III	20	14	40	Standpipes, building foundations, chambers, thrust blocks etc.
IV	15	10	40	Blinding

Cement used shall be Ordinary Portland Cement to BS 12. CWSA Engineers shall ensure that consultants provide adequate supervision of all civil works contracts.

5.6 Valves

The following valves shall be provided, where necessary:

- Air valves
- Washouts valves
- Isolating valves
- Pressure reducing valves
- Non-return valves
- Float valves

Other valves may be provided as specified in the design. All valves shall be robust, simple and easy to operate, and shall be provided with adequate anchorage.

Valves provided shall conform to the respective pipe diameters.

5.7 Meters

Flow meters shall be provided on all water supply networks. At least one bulk flow meter shall be provided on the pump head. Water meters shall be provided for each draw-off point (i.e. standpipes or private/institutional connections).

Manometers shall be provided on pump heads and at other relevant locations, and shall have a face of 75 mm diameter minimum.

All meters shall be calibrated in S. I. or metric units.

5.8 Storage Tanks

Types of Storage Tanks

- Reinforced Concrete Tanks
- Pressed Steel Tanks
- Overhead Plastic Tanks
- Other approved by CWSA

Design of Reinforced Concrete Tanks

- Method of analysis (elastic method)
- Method of design (BS8110 or other approved)
- Foundation design to be based on geotechnical investigation
- Structural designs shall be undertaken and checked by structural engineers certified by the Ghana Institution of Engineers or equivalent.

Steel and concrete storage tanks shall be provided with the following:

- Shut off valve.
- Inlet, outlet, washout and overflow pipes.
- Aluminium access ladder in the tank.

- External ladder.
- Safety cage and valve/rest platform on external ladder for high level tanks.
- Protective handrails (at least 1.2m high) at the top of tanks.
- Water level gauge (calibration in meters).
- Internal waterproof coating.
- Lightning protection.
- Ventilation on tank covers (mosquito proof).

All concrete storage tanks shall be tested for water tightness by filling with water for a minimum of three days, during which period drop in water level shall not exceed 3mm/day. Standard designs for tanks shall be obtained from CWSA.

5.9 Chambers

Chambers shall be provided to house appurtenances on networks. Chambers shall be covered and provided with a gravel base. Covers shall be made of galvanised steel or concrete and shall be lockable. Chambers shall be sized to provide adequate working space for maintenance.

ANNEX A SAMPLE CONSUMPTION CALCULATION

EXAMPLE

Kojo-Krom requires a water supply system. A socio-economist/demographer has undertaken feasibility studies and provided the following information. What is the water demand of the community ten years from today?

Current Population: 10,000
Growth Rate: 2.5%
Industrial and Commercial Demand: 15% of Average Domestic Daily Demand
From the level of urbanisation in the town, 80% of the population are expected to use water from standpipes and 20% from house connections.

SOLUTION

Population = 10,000 (category II)
Domestic Demand = 10,000 x [(60 x 0.2) + (20 x 0.8)] = 10,000 x 28 = 280,000 lpd
Demand = Domestic Demand x Commercial/Industrial Demand fraction
= 280,000 x 1.15
= 322,000 lpd
Total Daily Demand = Demand x losses
= 322,000 x 1.1
= 354,200 lpd
Peak Daily Demand = 354,200 x 1.2 (peak factor) = 425,040 lpd
Projected Peak Daily Demand = $425,040 \times (1 + 0.025)^{10}$.
= 544,087.13 lpd
= 544.1 m^3/day
= 545 m^3/day