GOVERNMENT OF GHANA

MINISTRY OF WATER RESOURCES, WORKS AND HOUSING

COMMUNITY WATER AND SANITATION AGENCY

SMALL COMMUNITIES SECTOR GUIDELINES
(Design Guidelines)

January, 2010

TABLE OF CONTENTS

1 GENERAL PRINCIPLES 1

1.1 INTRODUCTION 1
1.2 BASIC STANDARDS 1
1.3 WATER SUPPLY TECHNOLOGIES 1
1.4 WATER SOURCE SELECTION 1
1.5 ENERGY SOURCE SELECTION 2
1.6 PRINCIPAL TECHNOLOGICAL CHOICE 2

2 GUIDELINES - GROUND WATER BASED SCHEMES 2

2.1 BACKGROUND 2
2.2 GROUND WATER EXPLORATION 2
2.3 GUIDELINES FOR SITING 3
2.4 BOREHOLES 3
2.5 HAND DUG WELLS 4
2.6 HYDRO FRACTURING 4

3 GUIDELINES - SURFACE WATER BASED SCHEMES 5

3.1 BACKGROUND 5
3.2 PIPED SYSTEMS 5
3.3 GENERAL DESIGN PROCEDURE 5
3.4 BASIC DESIGN CRITERIA 5
3.5 POPULATION AND WATER DEMAND 6
3.6 PARTICIPATORY DESIGN 6
3.7 SURFACE WATER TREATMENT 7
3.7.1 Roughing Filters 7
3.7.2 Slow Sand Filters 7
3.7.3 Pressurised Filters 8
3.7.4 Packaged Treatment Plants 8

4 GUIDELINES - SANITATION 8

4.1 BACKGROUND 8
4.2 TECHNOLOGY CHOICE 8
4.3 BASIC DESIGN CRITERIA 8
4.4 GUIDELINES FOR SITING LATRINES 9
4.5 DESIGN 9
4.6 CONSTRUCTION 10
4.7 SANITATION PROMOTION 10
4.8 OPERATION AND MAINTENANCE OF LATRINES 10

5 SUPPLEMENTARY GUIDELINES 10

5.1 HAND PUMP MAINTENANCE 10
5.2 EXISTING WATER POINTS 10
5.3 WATER SOURCES 10
5.4 CONSTRUCTION OF HAND DUG WELLS 11
5.4.1 Construction Methods 11
5.4.2 Filter Pack 11
5.4.3 Well Head Works, Drainage Channel and Soakaway 11
5.5 DRILLING AND CONSTRUCTION OF BOREHOLES 11

5.5.1 Drilling of Boreholes 11
5.5.2 Construction of Boreholes 12
5.5.3 Construction of Well Head, Drainage Channel and Soakaway 12
5.6 PUMP DEPTH SETTING 12
5.7 BOREHOLE SOURCE MAINTENANCE 13
5.8 WATER QUALITY 13
5.8.1 Mwacafe Treatment Plants 13
5.9 STERILISATION OF TANKS AND PIPELINES 13
5.9.1 Tanks 13
5.9.2 Pipelines 14
5.10 CHLORINATION 14
6 SAFETY, EQUIPMENT AND MATERIALS STRENGTH 14
6.1 GENERAL 14
6.2 SAFETY PRECAUTIONS 14
6.3 PUMPING/YIELD TESTS 15
6.4 HAND PUMPS 15
6.5 SUBMERSIBLE PUMPS 15
6.6 PIPES 15
6.7 CONCRETE 16
6.8 STEEL REINFORCEMENT 16
6.9 VALVES 16
6.10 METERS 17
6.11 STORAGE TANK 17
6.12 CHAMBERS 18

1 GENERAL PRINCIPLES

1.1 Introduction

Design of **Small Communities** water supply schemes shall be in accordance with the following CWSA Design Criteria and Guidelines. Engineering designs shall be simple and design reports, including drawings, supporting calculations, computer printouts, etc., shall be made available to the CWSA and MMDAs.

Groundwater shall constitute the preferred source for small community water supplies, given that groundwater based technologies are appropriate and relatively inexpensive.

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 borehole with hand pump or standpipe of a piped scheme serves no more than 300 persons, and that of a hand-dug well with hand pump no more than 150 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 in accordance with the following order of preference:

a. Borehole fitted with hand pump (for populations range 301 – 1,200);
b. Hand dug well fitted with hand pump (for population range 75 - 300);
c. Mechanised boreholes with simple piped schemes and PVC tanks (population range 1,201 – 2,000);
d. Spring or highland surface water with simple piped scheme (gravity or pumped scheme) with simple treatment;
e. Rain water harvesting with simple treatment;
f. Surface water (polluted) with simple treatment;
g. Other technologies to be adopted, where necessary.

1.4 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 abstraction (boreholes and hand pumps);
b. Springs ;
c. Rainwater harvesting (to augment inadequate sources);

d. Surface water sources;

1.5 Energy Source Selection

Selection of an energy source (where applicable) shall be in accordance with the following order of preference:
a. Grid Electricity;
b. Solar Energy;
c. Windmills;
d. Diesel Generator.

1.6 Principal Technological Choice

Groundwater based technologies (boreholes and hand dug wells fitted with hand pumps), which are appropriate and relatively inexpensive shall be the preferred technological choice for Small Communities, given that:

- There are little or no energy costs;
- Installation, O&M and repairs can be undertaken using local resources and expertise;
- Breakdown of one pump may not necessarily render a community without water, as other hand pumps may still be functional;
- Limited or no treatment is required. Simple Iron and Manganese removal systems may be provided where required.

Sound environmental management shall be practiced in beneficiary communities to avoid pollution of the groundwater especially in the case of hand dug wells as these are usually from shallow aquifers which are easily be contaminated.

2 GUIDELINES - GROUND WATER BASED SCHEMES

2.1 Background

Groundwater is the preferred source of providing potable water for small communities because it is generally of good quality and requires minimum treatment. Groundwater based schemes shall be designed in accordance with the CWSA design guidelines and standard drawings for boreholes and hand dug wells.

Water quality analyses shall be carried out on all groundwater sources to the water quality standards of the Ghana Standard Board (GSB).

2.2 Ground Water Exploration

Ground water exploration shall be carried out before any potential ground water source is sited. Hydrogeological studies including geophysical surveys shall be carried out depending on the geology of the area to determine the probability of success. In areas of favourable hydrogeological conditions,

interpretation of aerial photos shall be carried out and no geophysical investigations shall be undertaken. Consultants with the requisite expertise shall be engaged to provide siting and drilling supervision services.

2.3 Guidelines for Siting

Water points shall be sited only after the appropriate ground water investigations have been carried out by qualified professionals. The process for siting shall be as follows:

- Desk study of hydrogeological conditions;
- The use of aerial photos/satellite imagery;
- Field reconnaissance surveys/terrain evaluation;
- Geophysical investigations;
- Pollution risk assessment.

Selected sites shall not be close to the following:

- Infrastructure (roads, buildings etc);
- Latrines;
- Refuse dumps;
- Cemetery;
- Sacred groves;
- Utility lines (especially electricity lines).

All points sited shall be adequately located and marked using approved pillars. The WATSANs in the beneficiary community shall be informed of the location of all such pillars.

2.4 Boreholes

The verticality and alignment of boreholes shall be in accordance with good drilling practice. Unsuccessful boreholes shall be backfilled with drill cuttings.

Boreholes fitted with hand pumps

The minimum yield of a borehole to enable hand pump installation shall be 13.5 l/min. However, depending on a comprehensive assessment of existing hydrogeological conditions, and an adequate technical evaluation of the yield of available boreholes, lower yields of up to 10 l/min may be considered for hand pump installation. Boreholes with marginal yields (less than 10 l/min) may be capped, maintaining temporary casing in the well, for hydro-fracturing in the future.

Mechanised Boreholes

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 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
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. Inspection of borehole shall be carried out using a borehole camera to determine verticality.

2.5 Hydro fracturing

Hydro fracturing shall be carried out in boreholes in aquifers in which fractures were observed during drilling or during electrical resistivity logging. The pressure at which hydro fracturing shall be carried out will depend on the properties of the rock, the local stress field and the depth at which it is performed. Normally, pressures of between 25 and 150 bars shall be used. Stresses that are predominantly vertical in nature require less induced pressure than those which are horizontal.

To carry out hydro fracturing, the following procedure shall be adopted:

- PVC working casings are properly sealed by grouting into the ground;
- Packer settings are then determined based on the drillers record and/or a geophysical borehole logging profile;
- The packers are expanded against the wall of the borehole using high pressures of up to three (3) times the expected water pressure;
- After the packer unit is firmly locked in position, the air in the pipe is released through the pressure release outlet;
- The pressure is increased when the air is up to the maximum pressure and held till there is a pressure drop. This is an indication that a fracture has been opened. The pressure is to be maintained for a minimum of three minutes. Longer periods and/or repetition of the process may lead to a more permanent transformation of the fracture.
- The process is repeated for every fracture zone identified.

2.6 Hand Dug Wells

Hand dug wells shall be constructed in formations in which the material is soft enough to be excavated by hand (i.e. unconsolidated aquifers in alluvial material, weathered zones, etc). Wells shall be excavated up to 3m below the water table. A minimum yield of 10l/min shall be achieved for hand pump installation. Compressors shall be used only in cases where a good yield of water has been achieved and further deepening is required to provide adequate storage capacity.

Construction of hand dug wells shall be carried out preferably in the dry season (i.e. between December and April) to take advantage of the low water table and ensure reliability in the dry season.

3 GUIDELINES - SURFACE WATER BASED SCHEMES

3.1 Background

Surface water sources shall be explored for small communities only if groundwater is unavailable or inadequate. Spring and highland streams shall be the preferred sources. Rainwater harvesting may also be considered to augment inadequate sources for schools and clinics. Generally, polluted surface water sources requiring major treatment efforts shall be used only as a last resort. Water quality analysis shall be carried out for all surface water sources at least once in the rainy season and once in the dry season. Appropriate treatment shall then be recommended. Final water quality shall meet the requirements of the Ghana Standards Board (GSB).

3.2 Piped Systems

Simple piped systems shall be provided in communities where feasible. Piped systems shall consist of:

- A protected intake at the water source/borehole
- Transmission main
- Simple treatment system
- Storage tank
- Distribution
- Standpipes/Distribution points

Categorisation

Present Population	**No. of Standpipes**	**Scheme**
Up to 1,200	2 No.	**Rural Piped**
1,201 – 2,000	3 - 4 No.	**Small Community Piped**

3.3 General Design Procedure

The design of a typical water supply system shall consist of:

a. Source selection;
b. Preliminary design of network;
c. Topographic surveys;
d. Design of treatment units and other ancillary structures;
e. Hydraulic and engineering design of storage tanks transmission and distribution networks;
f. Selection of electromechanical equipment.

3.4 Basic Design Criteria

The following criteria shall be used in the design of surface water based schemes:

• Storage Tank Volume	40 % of Average Daily Demand
• Peak Daily Factor (Transmission Mains)	1.05-1.2
• Peak Hourly Factor (Distribution Mains)	2.5 minimum
• Residual Pressures (Distribution System)	5m head minimum 30m head maximum 3 m head at outlets at peak hour flow 10m head max at outlets
• Design Period	15 years for pipe network 15 years for source
• Pumping Time	8 hours maximum
• Pipe Sizes (uPVC/HDPE)	50mm – min. for transmission mains 32mm – min. for distribution mains.
• 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.	

3.5 Population and Water Demand

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

• Population Growth Rate	Per District Average
• Per Capita Water Consumption	20 lcd
• Physical losses	10 %

3.6 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:

- 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.

3.7 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.

3.7.1 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

3.7.2 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 $m^3/m^2.h$	

3.7.3 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.

3.7.4 Packaged Treatment Plants

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

4 GUIDELINES - SANITATION

4.1 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.

4.2 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 life.

4.3 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

4.4 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.

4.5 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 about 1.2m diameter, 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 artisans 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.

4.6 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.

4.7 Sanitation Promotion

Sanitation shall be promoted through social marketing techniques. The 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.

4.8 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.

5 SUPPLEMENTARY GUIDELINES

5.1 Hand Pump Maintenance

Operation and maintenance of hand pumps shall be the responsibility of the WATSAN in each beneficiary community. Area Mechanics trained by the CWSA shall be contracted by communities to carry out periodic maintenance, and where necessary, repair of the pumps.

5.2 Existing Water Points

Existing water points shall be incorporated in the design of water supply system of each community, if the yield and quality meet the required guidelines.

5.3 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 also be monitored regularly (monthly) for at least one year and the results analysed. Available hydrological data (historical data for 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 for at least one year and the results analysed to enable provision of adequate treatment systems.

5.4 Construction of Hand Dug Wells

5.4.1 Construction Methods

Safety of workers is paramount in the construction of hand dug wells. The in-situ concrete lining and precast caissons method shall be the main construction methods employed. Construction shall be done in accordance with CWSA standard tender documents and drawings.

In stable formations, the in-situ concrete lining method shall be used. The pit is excavated and then lined upwards to the surface using internal moulds with an internal diameter of 1.5m.

Caissons are used in unstable conditions. Precast moulds with an internal diameter of 1.1m are employed. Care must be taken to ensure the well is vertical to within 10mm per metre depth of the well. Permeable caissons shall be provided in the water bearing formation.

Caissons may also be used to deepen wells constructed using the in-situ lining method into a formation which is unstable. Caissons in this case must be made to overlap fixed lining.

5.4.2 Filter Pack

A filter consisting of layers of graded sand and aggregate (6-19mm) shall be placed at the bottom of every hand dug well. The layer shall have a minimum thickness of 15cm.

5.4.3 Well Head Works, Drainage Channel and Soakaway

Well lining shall be extended a minimum of 200mm above ground level to form a head wall. Well cover slabs minimum 75mm shall be nominally reinforced to prevent collapse during usage. Well apron shall be provided. The apron shall be circular (minimum diameter 2.5m) or square/rectangular with a minimum length of 4.5m.

A drainage channel shall be provided from the apron to a soakaway to drain excess water.

5.5 Drilling and Construction of Boreholes

5.5.1 Drilling of Boreholes

Drilling rigs capable of drilling boreholes to a maximum depth of 120m and maximum internal diameter of 200mm shall be employed. Protection casings (PVC or steel) shall be installed in unstable overburden. The diameter of the

well shall be such as to enable drilling of the well, installation of permanent casing, screen and gravel pack. Successful boreholes shall be completed and capped 0.8m above the ground.

During drilling, samples of unwashed drill cuttings will be collected at 1m intervals and at every change in rock type or colour of weathered material and logged on CWSA standard log sheets. The standard log sheets shall be be obtained from CWSA regional offices. The records shall include:

- The lithology
- Degree of consolidation or hardness
- Nature of material if unconsolidated
- Penetration rate per meter

5.5.2 Construction of Boreholes

All boreholes shall be designed by the drilling consultant in accordance with CWSA standard designs and drawings and shall be constructed under supervision of the drilling consultant. The following shall be achieved:

- Boreholes shall be lined completely with high impact-resistant uPVC plastic casings and screens (both of inner diameter 126 - 200mm) manufactured for boreholes.
- Slot size for screens shall be between 0.5 - 1.0mm.
- Casings and screens shall have screwed flush joints with sturdy threads, either curved or angular with no eccentricity.
- Centralisers shall be fitted at 6m intervals.
- Gravel packs with clean well rounded quartz gravel of 1-3mm grading for sedimentary formation and 2-4mm grading for basement aquifer shall be installed.
- Bail plugs shall be fitted at the bottom of the boreholes.
- Grout seals shall be placed 1m thick above gravel pack and 4m thick above back filled material. The annulus between two grout seals shall be back filled with drilled cuttings or other suitable material.

5.5.3 Construction of Well Head, Drainage Channel and Soakaway

A superstructure, consisting of a concrete well pad with a platform shall be provided with a 200mm concrete dwarf wall. The surface of the well pad shall be sloped to ensure adequate drainage. The platform shall be circular (minimum diameter 2.5m) or square/rectangular with a minimum length of 4.5m.

A drainage channel shall be provided from the platform to a soakaway to drain excess water.

Standard drawings for borehole well heads, drainage channels and soakaways are available at CWSA regional offices.

5.6 Pump Depth Setting

The following shall be considered in pump depth (intake) setting:

Mechanised boreholes

- Safe yield of borehole;
- Maximum allowable drawdown;
- 1 m above main water zone screen.

Boreholes fitted with Hand Pumps

- 3 – 10m below DWL ;
- 6m above bottom ;
- 1m above or below screens.

5.7 Borehole Source Maintenance

The following shall be carried at the prescribed intervals to ensure boreholes are operated in a sustainable manner.

- 2-yearly pumping test to assess specific capacity variation
- 2-yearly camera inspection, checking of depth and siltation levels
- 4-5 yearly appropriate rehabilitation (redevelopment for clogged screens, brushing/acidisation for iron bacteria)

5.8 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.

5.8.1 Mwacafe Treatment Plants

The Mwacafe treatment plant may be used for Iron/Managanese removal from boreholes. It consists of a filter unit of carbon (crushed charcoal) and silica (sand) through which the water is passed to remove the iron and the manganese.

5.9 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:

5.9.1 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.

5.9.2 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.

5.10 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.

6 SAFETY, EQUIPMENT AND MATERIALS STRENGTH

6.1 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 cement, iron rods, etc. shall meet specifications in the relevant tender documents as well as the appropriate engineering standards.

6.2 Safety Precautions

1. Access to all excavations (hand dug wells, latrine pits, pipe line excavations) shall be protected to prevent injury to life and property.
2. 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.
3. First aid equipment shall be available at all construction sites at all times.
4. Rope ladders shall be provided for easy escape from hand dug wells.
5. Areas around excavations (especially hand dug wells) shall be kept free of equipment, material and debris.
6. All electrical works (where applicable) shall be carried out to the specifications of ECG and or VRA as applicable.

6.3 Pumping/Yield Tests

Pumping/yield tests shall be carried out for all boreholes to determine the yield. Appropriate pumping equipment shall be used.

Results from the pumping tests shall be used to determine the safe yield of the borehole.

6.4 Hand Pumps

Standardised hand pumps recommended by the CWSA shall be installed on boreholes and hand dug wells in beneficiary communities. These pumps are:

- For shallow wells
  - Nira AF-85
  - Nira AF-85D
- For deep wells
  - Ghana Modified India Mk 2 (GMIM2)
  - Afridev
  - Vergnet

Installation of hand pumps shall be done in the presence of Caretakers and/or Area Mechanics and in accordance with the manufacturers specification. The supplier of the hand pumps shall provide the relevant installation and O&M manuals.

6.5 Submersible 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.

6.6 Pipes

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

Pipe Material	Distribution	Transmission
	Min. Pressure	Min. Pressure

uPVC	9 bar	15 bar
HDPE	9 bar	15 bar
Galvanised (exposed)	10 bar	16 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 buried pipes shall be 1000mm

6.7 Concrete

Concrete used in civil works shall have the following strengths:

Classification/ Grade	Minimum Strength (N/mm2)		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, hand dug wells, well head, aprons etc.
III	20	14	40	Standpipes, building foundations, chambers, thrust blocks, drainage 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.

6.8 Steel Reinforcement

All steel reinforcement shall be to standards acceptable to the Ghana Institution of Engineers. Steel bars shall be to BS 4449 and bending of the bars to BS 4466.

6.9 Valves

The following valves shall be provided, where necessary:
- Air valves
- Washouts
- Stop valves
- Pressure reducing valves
- Non-return valves
- Axial 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.

6.10 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.

6.11 Storage Tank

Types of Storage Tanks

- Reinforced Concrete Tanks
- Pressed Steel Tanks
- Overhead Plastic Tanks (e.g. Polytank or Sintex)
- 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.
- 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.
- Rubber water bars at all joints (where there is a break in construction).
- 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.

6.12 Chambers

Chambers shall be provided to house appurtenances on networks. Chambers shall be covered and provided with a gravel base. Chambers shall be sized to provide adequate working space for maintenance.