GOVERNMENT OF GHANA

MINISTRY OF WATER RESOURES, WORKS AND HOUSING

COMMUNITY WATER AND SANITATION AGENCY

WATER SAFETY FRAMEWORK

March, 2010

Table of Content

ACRONYMS

BH	-	Borehole
CWSA	-	Community Water and Sanitation Agency
DA	-	District Assembly
GSB	-	Ghana Standards Board
GSBS	-	Ghana Standards Board Standards
GSI	-	Groundwater Safety Index
GPI	-	Groundwater Pollution Index
GWCL	-	Ghana Water Company Ltd
HDW	-	Hand dug well
NCWSP	-	National Community Water and Sanitation Programme
NGO	-	Non Governmental Organization
RWH	-	Rainwater Harvesting
WATSAN	-	Water and Sanitation
WHO	-	World Health Organization
WSDBs	-	Water and Sanitation Development Boards
WSF	-	Water Safety Framework
WSPs	-	Water Safety Plans

1 Background

The Community Water and Sanitation Agency (CWSA) was established by an Act of Parliament of the Republic of Ghana, 1998 (Act 564). The Agency is mandated to facilitate the provision of safe water and related sanitation services to rural communities and small towns. As part of government policy to achieve a rapid water and sanitation coverage nation wide, the National Community Water and Sanitation Programme (NCWSP) was developed, and launched in 1994. The CWSA facilitates the implementation of the NCWSP whiles Ghana Water Company Ltd (GWCL) manages urban water supply. Provision of safe drinking water and related sanitation services are some of the key outputs expected to significantly contribute to public health protection, improvements in the livelihoods of communities and poverty reduction. Monitoring of water systems forms an integral part of the role of the Agency towards ensuring that water safety targets are achieved.

Under the NCWSP, a high proportion of communities are supplied from groundwater sources. This choice result from the availability of groundwater compared with the other water sources, and the high cost implications associated with purification of surface water sources. Groundwater although abundant in many of the rock formations in Ghana also has challenges related to water quality and low yield, depending on the rock formations. Ghana is underlain by different geological formations. The most widely spread across the land mass of the country are the Birrimian, Tarkwaian, Dahomeyan, Togo Series, Buem, Voltaian and the coastal sedimentary Basins. The rock types associated with these formations and the development activities undertaken within the environmental setting present varying water quality challenges. It is also recognized that levels of water quality parameters differ within the regions depending on types of formations and rocks, economic, industrial or other related development activities that impact on the environment and water resources.

One of the measures taken by the Agency to ensure that the objectives of the NCWSP is achieved is to develop a Water Safety Framework (WSF), which provides broad guidelines on issues related to the provision of safe water in accordance with water safety targets set by the Ghana Standards Board for domestic water supply. The standards set out for water quality parameters, methods for measuring and monitoring referred to in the Water Safety Framework is that approved by the Ghana Standards Board (GSB). However in order to achieve consistency in a wider risk management during monitoring within the sub-sector, acceptable water safety targets are defined to cover GSBS, with reference to World Health Organization (WHO) Drinking Water Quality Guidelines.

The safety of drinking water provided to communities can be controlled through a combination of measures namely protection of the water source, control of treatment processes (when required), management of distribution and handling at the consumer points. Education, health and hygiene promotion play an important role in preventing recontamination during handling and storage between delivery and consumption points.

Many chemical components of water when present at unacceptable levels have significant adverse health impacts on water users. In the past, water safety was restricted to occasional water quality tests. The results of these tests most often are not applied to impact and risk assessments on the user communities, or the cost of improvement required when available, both in the short and long term. Whereas provision of water infrastructure may increase coverage, improved health and poverty reduction impacts expected can only be achieved if sufficient attention is paid to water safety management for all water facilities.

This framework provides information on how water supplies and their immediate environments should be monitored within the rural water and sanitation sub-sector. The goal is to ensure that water supplies are always safe for domestic use. It is therefore mandatory that all stakeholders delivering water to communities conform to provisions set out by this water safety framework

2 Water Supply Technologies

Water supply technologies implemented in small communities and towns under the National Community Water and Sanitation Programme shall be monitored within the provisions of the WSF. These technologies are classified as follows;

2.1 Point Water Systems

These are water systems defined by a single source of supply and fetching point. Examples are;

(1) Borehole fitted with hand pump
(2) Hand dug well fitted with hand pump
(3) Rainwater harvesting facility

2.2 Small Community and Small Town Water Systems

These fall under relatively small to large water systems. Water supplies are transported through pipelines from a mechanized (pumps) source (surface or groundwater) into storage reservoirs for distribution to the community. These systems may require some level of treatment. The water sources normally associated with small communities and small towns water systems can be classified under the following;

(1) Mechanized borehole
(2) Mechanized surface water source
(3) Mechanized springs/gravity spring systems

3 Water Safety Framework

3.1 Definition

Water Safety Framework is a management tool which provides the strategy of keeping water supplies safe for use. It gives guidelines on measures to be taken by all stakeholders involved in facilitation, provision and management of small community and small town water systems.

3.2 Objectives of the water safety framework

The objectives set out for ensuring water safety under the WSF are as follows,

(1) Establish targets for physico-chemical and microbial quality of water supply
(2) Establish the modalities for Water quality testing, monitoring and assessment needed to ensure the safety of drinking water supply.
(3) Develop Public health protection mechanism through water system monitoring, risk assessment and management, surveillance, health and hygiene education.
(4) Determine the level of investment required for ensuring water safety.

3.3 Components of the Water Safety Framework

The major components of the Water Safety Framework are;

(1) Water Quality Testing.
(2) Water Safety Risk Assessment.
(3) Water Safety Risk Management
(4) Environmental and Social Surveillance
(5) Development of Water Safety Plans for Water Systems
(6) Capacity Building for Stakeholders

3.4 Water Quality Testing

Water quality testing during installation of new water facilities as well as monitoring during operation, form an essential component of the water safety framework. Even though testing was used extensively as the only control measure for determining water safety in the past, it is viewed now as one of many steps needed to ensure that the water is safe at point of abstraction and within the water system network.

The quality of water provided for domestic use has significant socio-economic and health impact on users. Socio-economic impacts are related to taste, staining of food, laundry and utensils and significantly determine the level of patronage of the water provided to the community. Health impacts are pronounced in children and may result into debilitating effects some of which are irreversible.

Testing allows determination of the levels of the various chemical components as well as physical and bacteriological characteristics of the water supply. Water quality parameters to be tested are categorized into two groups;

(1) Water quality parameters to be tested immediately the water system is completed (referred to as Baseline Water Quality Parameters).
(2) Water quality parameters to be tested during monitoring (referred to as Water quality parameters to be monitored).

3.5 Baseline Water Quality Parameters

All water quality parameters prescribed by the Ghana Standards Board to determine the safety of drinking water supplies must be tested at the initial stage that the water system is being installed. These are referred to as Baseline Water Quality Parameters. The baseline parameters shall serve as the basis for comparison during future monitoring. For water systems that do not have data on baseline parameters, testing shall be carried out to establish them. The baseline parameters must conform to and be within acceptable limits of all parameters prescribed by the latest Ghana Standards Board Standard for drinking water supplies before the water facility is approved for use. It is mandatory that all water systems to be commissioned by any organization or individuals for private or commercial use, must meet the requirements of the baseline water quality parameter.

3.6 Baseline Water Quality Parameters

3.6.1 Physical Parameters

No	Parameter	Unit of measurement	Ghana Standards Boards Standard
1	pH	N/A	6.5-8.5
2	Colour (true)	Hz	15
3	Turbidity	NTU	5
4	Total Dissolved Solids	mg/l	1000
5	Electrical Conductivity	µS/cm	2000
6	Temperature	^{O}C	25-30

3.6.2 Chemical Parameters of Health Significance

No	Parameter	Unit of measurement	Ghana Standards Boards Standard
7	Antimony	mg/l	0.005
8	Arsenic	mg/l	0.05
9	Barium	mg/l	1.0
10	Borate	mg/l	5.0
11	Cadmium	mg/l	0.003

12	Copper	mg/l	1.0
13	Chromium	mg/l	0.05
14	Cyanide	mg/l	0.07
15	Fluoride	mg/l	1.5
16	Lead	mg/l	0.01
17	Manganese	mg/l	0.1
18	Total iron	mg/l	0.3
19	Mercury	mg/l	0.001
20	Nickel	mg/l	0.02
21	Nitrate	mg/l	50.0
22	Nitrite	mg/l	0.02
23	Selenium	mg/l	0.05

3.6.3 Other Chemical Substances

No	Parameter	Unit of measurement	Ghana Standards Boards Standard
24	Calcium	mg/l	50.0
25	Magnesium	mg/l	50.0
26	Sodium	mg/l	100.0
27	Potassium	mg/l	30.0
28	Chloride	mg/l	250.0
29	Sulphate	mg/l	200.0
30	Total Alkalinity	mg/l	400.0
31	Bicarbonate	mg/l	
32	Hardness	mg/l	
33	Carbon dioxide	mg/l	
34	Oxygen	mg/l	
35	Ammonia	mg/l	

3.6.4 Bacteriological Parameters

No	Parameter	Unit of measurement	Ghana Standards Boards Standard
36	E. Coli	No. per 100ml sample	0.00
37	Total Coliform	No. per 100ml sample	0.00
38	Faecal Streptococci	No. per 100ml sample	0.00

3.7 Water Quality Monitoring

After the baseline water quality parameters have been established, the quality of the water supply must be monitored regularly to ensure its continuous safety. The frequency of monitoring must be at least two (2) times in a year for all water sources. Testing should be dispersed within the year in accordance with seasonal variations

3.8 Water Quality Parameters to be Monitored

The water quality parameters to be monitored are selected based on their health significance. Testing during monitoring would provide sufficient information on general safety of the water supply to consumers. The parameters to be monitored are listed below.

3.8.1 Physical Parameters

No	Parameter	Unit of measurement	GSBS	WHO Guidelines
1	pH	N/A	6.5-8.5	6.5-8.0 [Dn]
2	Colour	Hz	15	15[Dn]
3	Turbidity	NTU	5	5 [Dn]
4	Total Dissolved Solids	mg/l	1000	1000 [Dn]
5	Electrical Conductivity			

3.8.2 Chemical Parameters of Health Significance

No	Parameter	Unit of measurement	GSBS	WHO Guidelines
6	Antimony	mg/l	0.005	0.02
7	Arsenic	mg/l	0.05	0.01
8	Barium	mg/l	1	0.7
9	Boron	mg/l	5	0.5
10	Cadmium	mg/l	0.003	0.003
11	Copper	mg/l	1	2
12	Chromium	mg/l	0.05	0.05
13	Cyanide	mg/l	0.07	0.07
14	Fluoride	mg/l	1.5	1.5
15	Lead	mg/l	0.01	0.01
16	Manganese	mg/l	0.1	0.4
17	Total iron	mg/l	0.3	0.3^{Dn}
18	Mercury	mg/l	0.001	0.001
19	Nickel	mg/l	0.02	0.02
20	Nitrate (as NO_3^-)	mg/l	50.0	50
21	Nitrite (as NO_2^-)	mg/l	0.02	$3^S/(0.2^L)$
22	Selenium	mg/l	0.05	0.01

S= health based guideline for short term exposure of parameter, L= health based guideline for long term exposure of parameter, Dn=Discussed but no health based guideline given

3.8.3 Other Chemical Substances

No	Parameter	Unit of measurement	GSBS	WHO Guidelines
23	Calcium	mg/l	50	N/A
24	Magnesium	mg/l	50	N/A
25	Sodium	mg/l	100	200^{Dn}
26	Potassium	mg/l	30	N/A
27	Chloride	mg/l	250	250^{Dn}
28	Sulphate	mg/l	200	500^{Dn}
29	Total Alkalinity	mg/l	400	N/A
30	Hardness	mg/l		500^{Dn}

3.8.4 Bacteriological Parameters

No	Parameter	Unit of measurement	GSBS	WHO Guidelines
31	Total Coliform	No. per 100ml sample	0.00	0.0

3.8.5 Disinfection

No	Parameter	Unit of	GSBS	WHO

		measurement		Guidelines
32	Residual chlorine	Mg/l	0.5	Check

The parameters selected for monitoring are based on available historical, environmental and health information that impact negatively on water consumers. In the future continuous assessment needs to be made to ascertain the relationships between the levels of these parameters and the health impacts they have on water users. Conclusions reached on any such study may be relevant in varying the parameters to be monitored.

3.9 Assessment of Water Quality Parameters

Results of the water quality parameters monitored shall be compared with those determined for the baseline (Ghana Standards Board Standards) and the World Health Organization (WHO) drinking water quality guidelines. The WHO has not prescribed guidelines for a number of parameters that have been determined to have no health based impacts on water consumers. This may generally imply that the GSBS is more stringent than the guidelines of the WHO. Only the GSBS will be used for comparison in the case of those parameters, and in extreme cases of water scarcity those of WHO may be considered.

The following decisions shall be made to determine the safety of the water supply and the Water Safety Risk Management Methods to be applied as solution. (Refer to Water Safety Risk Assessment/Management).

(1) The monitored test result is acceptable (Water supply is safe for use. No further action to be taken)
(2) The monitored test value is outside the GSBS but within the WHO guidelines (water source to be further monitored).
(3) The monitored test result is outside both GSBS and WHO guidelines.
    (i) Facility to be further monitored and treatment provided if available.
    (ii) Facility to be decommissioned and replaced if no treatment solution is available).

3.10 Water Safety Risk Assessment

The results of all water quality tests shall be studied and developed further into a risk assessment report for each of the regions. The reports shall highlight on the levels of water quality parameters that have significant health impact, the number of facilities with such quality challenges and the location (district, community and geological formations if possible). The assessment shall also highlight on water systems that have safe supplies. Risk assessment shall also cover the cost of risk management methods proposed for mitigation.

During the risk assessment stage, one of the following decisions listed below may be made based on the quality of the water source as compared with the baseline parameter, GSBS, WHO guidelines or the report on environmental and social surveillance. The cost implications of the decisions made shall be established under the Risk Management. Water sources, which have acceptable quality test results (GSBS/WHO guidelines) within five (5) years shall not be monitored further, unless new development activities have started within the immediate environment that are likely to affect the water quality in the future, for instance mining, waste disposal or petroleum related activities.

(1) A water sources has been monitored over five (5) years and the test results are within GSBS/WHO guidelines. There is no need for further monitoring.
(2) A water sources has levels of water quality parameters outside GSBS but within WHO guidelines. The sources require further monitoring.
(3) A water sources has levels of water quality parameters outside the GSBS and WHO guidelines within the five year monitoring period.
    (i) If there are solutions for treatment, risk management is required.
    (ii) If there are no water treatment solutions, the sources should be decommissioned and replaced with a new facility.

3.11 Water Safety Risk Assessment Form

The results of the water quality test carried out during monitoring can be displayed on the Water Safety Risk Assessment Form and classified under any of the four (4) decisions listed above. The cost of actions to be taken based on the test results can then be estimated so that overall cost implications for risk management can be determined.

Water Quality Risk Assessment Form									
Region:						**Date:**			
No. of Water Sources monitored:				**No. of Water Sources unacceptable:**			**No. of Water Sources acceptable:**		
No.	**Community**	**District**	**Water Source BH/HDW/RWH ID**	**Levels of Chemical/Bacteriological/Physical Parameters of Health Significance/GSBS/WHO Guidelines**				**Measures Proposed**	**Cost of Measures (GH¢)**
				GSBS ()	**GSBS (2)**	**GSBS (3)**	**GSBS (n)**		
				WHO ()	**WHO (2)**	**WHO (3)**	**WHO (n)**		
				Parameter 1	**Parameter 2**	**Parameter 3**	**Parameter 4**		

Only water quality parameters noted to occur in significant levels are to be reported on. This would give a general outlook of the water quality situation in a specific region. Where several parameters are noted to occur in unacceptable levels, they are to be added to the table. Cost of measures proposed for risk management to be added. Units of parameters should be indicated.

4 Water Safety Risk Management

Water supplied to communities must be safe and acceptable to users. Water quality parameters of water provided for domestic use should be within permissible limits determined by the Ghana Standards Board. During monitoring, detailed water quality assessment is necessary after testing. The assessment should be based on comparison of the water quality results with baseline data, the GSBS and the WHO guidelines. Several measures may be taken to correct the water quality situation. These measures are referred to as Risk Management Measures.

4.1 Point Water Systems

The type of risk management measures to be taken on point water systems such as boreholes, hand-dug wells and rainwater facilities depend on the type of risk associated with the water source.

4.1.1 High Levels of Chemical/Bacteriological Parameters (general)

If a water source contains high levels of chemical compounds that have significant health impacts, any of the following measures can be taken.

(1) The water source should be further monitored.
(2) A water treatment solution should be provided if available. The cost of treatment should be included in the water safety assessment report defined as cost of measures.
(3) The water source should be replaced if no water treatment solution for the specific chemical compound is available. The cost of replacement should be included in the water safety assessment report.
(4) Water source should be decommissioned if water treatment solution is unavailable.
(5) Health education should precede all the actions to be taken. The cost of health education should be included in the water safety assessment report.

4.1.2 Point source with unacceptable physical parameters

If a point water source has unacceptable physical parameters, any of the following measures can be taken.

(1) The water source should be reengineered (cleaned or redeveloped). The cost of reengineering should be included in the water safety assessment report as cost of measures applied to solve the problem.
(2) A water treatment plant should be provided where applicable. Additional cost of treatment should be included in the water safety assessment report.
(3) The water source should be replaced if the problem persists after reengineering. The cost of replacement should be included in the water safety assessment report.

4.1.3 Piped Systems

Risk assessment on piped systems must cover assessment of the entire water system components so that remedial management actions can be identified and restricted when applicable.

4.1.4 Water System Components

The water system components include the following:

(a) Water source
(b) Water treatment plant
(c) Transmission pipeline.
(d) Distribution pipeline.
(e) Storage reservoirs
(f) Standpipes
(g) Valves/Inspection chambers
(h) Wash outs, hydrants etc

4.1.5 Risk Assessment on Water System Components

4.1.5.1 Water Source

The format for monitoring, and risk assessment of the water source for pipe systems is the same as that for point sources. The following measures shall be taken when the water quality of the source deteriorates.

(1) The quality of treated water fall outside the GSBS, but within WHO guidelines, water should be further monitored.
(2) The water source is contaminated and no treatment is currently provided. Water treatment solution should be provided, and the cost of treatment included in the water safety assessment report.
(3) If the water source is contaminated and no treatment is available immediately, the water system should be decommissioned. An urgent arrangement should be made for a packaged treatment plant if the facility is a piped system.
(4) Health education should precede all the actions to be taken. The cost of health education should be included in the water safety assessment report.

4.1.5.2 Other Water System Components

The performance of other water system components may be measured by the water quality at locations selected as control points. The choice of control points within the water production and distribution system should be based on the characteristics of the distribution network (example size of the network, low/high pressure points, locations of standpipes, hydrants, water treatment plant, wash out valves etc). It is generally believed that once the quality of the water supplies is acceptable at the standpipes then the safety situation is acceptable within the water production and distribution networks. However it is important that other control points are created to determine possible pipe bursts or non-functioning of some components.

4.1.6 Control Points

Control points need to be determined and created within the water system network during the design and construction stages. The number of control points selected shall depend on the size of the water system network. However, a minimum of four (4) control points is advised, excluding the water source(s). The location and distribution should be based on the water system components listed above, pressure distribution in the pipeline and nodes as well as materials used for pipelines.

If some water quality parameters fall outside the permissible limits at the control points, Environmental and social surveillance of the water system should be intensified, and remedial actions taken by the WSDB or the private operator when the problem is identified. The cost of remedial action shall be borne by the WSDB or the private operator.

4.1.7 Risk Assessment Form for Water System Components

Risk assessment should be carried out on the system components based on the results of water quality tests carried out on samples from the control points. The approach is to identify any problem associated with the water quality. Measures should be designed and taken to correct the defects. The Risk Assessment Form must be completed for the water system components where control points are located. The frequency of the testing (monitoring of water quality) should be at least once every quarter for the pipe systems.

4.1.8 Risk Assessment Form for Water System Components

Water Quality Risk Assessment Form for Piped System Components								
Region:			**District:**			**Community:**		
No.	**Control Point ID**	**Levels of Chemical/Bacteriological/Physical Parameters of Health Significance**					**Measures Proposed**	**Cost of Measures (GH¢)**
		GSBS (1)	**GSBS (2)**	**GSBS (3)**	**GSBS (4)**	**GSBS (n)**		
		WHO (1)	**WHO (2)**	**WHO (3)**	**WHO (4)**	**WHO (n)**		
		Parameter (1)	**Parameter (2)**	**Parameter (3)**	**Parameter (4)**	**Parameter (n)**		
1								
2								
3								
n								

Only water quality parameters noted to occur in significant levels are to be reported on. This would give a general outlook of the water quality situation within the water system component. Where several parameters are noted to occur in unacceptable levels, they are to be added to the table. Cost of measures proposed for risk management to be added.

5 Water Safety Plans for Water Systems at the District Level

In order to make monitoring much easier on the small community and small town water system, a Water Safety Plan (WSP) will be prepared by the district assemblies for each water system. The WSP is a risk management tool designed for a specific system to ensure that safe drinking water is delivered to the consumer according to the approved water quality standards (GSBS). The WSP must be included in the updated District Water and Sanitation Plan prepared by the district assembly. The forms to use in data collection during implementation of the WSP are same as those included in the WSF. However, specific decisions on control points and how monitoring will be undertaken should be detailed in the plan.

5.1 Components of the Water Safety Plan

The following issues must be properly documented in detail in the WSP.

(a) Identify and document control points to be monitored for piped systems.
(b) Identify and document hazards the water supply is or would be exposed to. This can be determined through environmental and social surveillance.
(c) Determine how each of the hazards identified would be controlled in the short and long term.
(d) Determine how the control measures will be monitored.
(e) Establish how the water system manager, WATSAN Committee or WSDB, or any other operator will determine that control has been successful or lost.
(f) Identify what activities are to be undertaken to restore control when lost.
(g) Develop indicators to verify how efficient the WSP is being implemented.

The CWSA will develop a generic WSP to be adapted by the districts assemblies and facilitate the capacity building of the WSDBs in preparation of their WSPs.

6 Environmental and Social Surveillance

Surveillance on the water sources and the water system components entails monitoring of the immediate environment in which the water source(s) and other water system components are located and beyond. It provides opportunities for the detection of possible hazards that the water source or other system components may be subjected to. These hazards when detected may lead to interventions that can improve water safety.

Environmental and Social Surveillance activities include the following.

(a) Environmental survey within the immediate environment of the water source or other water system component to determine;
- Interference of possible hazards such as pollution sources (refuse dumps, unprotected toilets, etc), seepage of industrial waste into water sources.
- Leaking pipelines.
- Non-functioning equipment or components.

(b) Monitoring the response of water users to water quality and safety issues.

(c) Public health impacts/status.

6.1 Environmental Surveys

The results of environmental surveillance should impact positively on the provision of safe water supply to the community. The water system management shall on regular basis take inventory of all activities taking place within the immediate water system environment. Possible pollution sources such as unlined latrines and refuse dumps should be removed from areas within close proximity (30 metres) of water sources and water system components. Inappropriate practices such as improper use of agro-chemicals and illegal mining (galamsey) should be monitored to avoid adverse impact on the water sources. Where it becomes impossible to remove the pollution source the water system component should be decommissioned or relocated. In areas where regular pipe burst exist, pipe materials and pressures should be assessed and remedial actions taken to protect the water supply.

6.2 Monitoring the Response of the Community to Water Safety

Water users normally respond quickly to changes in the quality of water supplies. The responses reflect patronage. Physical parameters such as odour, colour, turbidity and taste are easily noticed when significant changes occur. Where water testing is carried out only occasionally, reports on surveillance are useful in keeping the water reasonably safe. Surveillance shall also cover monitoring trends in consumption pattern and patronage of the water system and the response of water users to water quality issues.

6.3 Public Health Impacts/Status

The levels of many chemical compounds in water significantly affect the health of water users when consumed at levels higher than recommended by water quality regulatory institutions. Public health impacts (positive and adverse) shall be monitored using available public health data at health institutions such as clinics, polyclinics or hospitals. The frequency of outbreaks of water related health problems or epidemics shall be accurately documented. This activity should be coordinated by the Ghana Health Service and reported during the sector wide collaboration meetings.

6.4 Sector Wide Collaboration

Many aspects of water safety management fall outside the control of the Community Water and Sanitation Agency and the District Assemblies. It is also noted that protection of water bodies which serve as water sources for all water systems fall under the jurisdiction of agencies other than the CWSA. It is essential that a collaborative multi-sectoral approach be adopted to involve all institutions that have responsibilities for specific areas within the management of water resources and the environment, and in consonance with the mandates of Water Resources Commission and Environmental Protection Agency. The CWSA will collaborate with Ghana Health Service and Water Resources Commission to hold annual meetings to discuss health impacts and water resource management issues. . This collaboration is expected to create a platform for assessing linkages of water safety, health impacts and poverty reduction.

6.5 Hydrogeology of Ghana and Impacts on Water Quality

Ghana is underlain by different geological formations. Most widely spread across the land mass of the country are the Birrimian, Tarkwaian, Dahomeyan, Togo Series, Buem, Voltaian and the Coastal Sedimentary Basins.

The Birrimian (classified into Upper Birrimian and Lower Birrimian) extends from the north through the mid-west to the southwestern parts of the country. Major rock types identified with this formation are metamorphosed lavas, pyroclastic rocks, phyllites, greywacke, schist and quartzites. The Tarkwaian formation is concentrated at the southeastern part of Ghana comprising rocks such as phyllites, quartzites, sandstones, grit, schist and conglomerates. The Dahomeyan System, Togo Series and Buem formation extend across eastern and southeastern Ghana. Gneisses, migmatites, granulites and schist are common rock types of these formations. The Voltaian formation covers almost one-third of the land area of Ghana. It consists of sandstones, shales, mudstones and conglomerates, and rests unconformably on the Birrimian. The coastal sedimentary Basins occur mostly along the extreme southeast and southwest sections of Ghana. The rock types are clays interbedded with limestone, shale, sandstone, siltstone and mudstone.

Most of the rocks associated with these formations, especially Birrimian and Tarkwaian are rich in mineral deposit such as gold, diamond, bauxite, manganese and iron. As a result of difference in the mineral composition and concentration in the various rock types as well as varying climatic conditions, groundwater quality and quantity remain non uniform across the country. Similarly, varying levels of economic and industrial activities within the regions also provide non uniform water pollution challenges. In particular, mining of gold, diamond, bauxite and manganese pose one of the worst threats to surface and groundwater quality. It is envisaged that future oil extraction and refinement may create a more serious environmental problems in relation to water quality management.

As a result of the varying geological conditions and industrial waste generation potential in the regions, it is recognized that specific water quality parameters may require monitoring depending on location. In particular, fluoride, arsenic, iron, manganese and some heavy metals pose new challenges to both surface and groundwater quality. The CWSA at the regional level will study and identify such specific parameters that require short to long term monitoring.

7 Capacity Building for Sector Players

7.1 Training in Water Safety

Capacity building is critical in ensuring that operators and managers of water facilities understand and appreciate clearly issues related to water safety, risk assessment and measurement as well as risk mitigation. The major stakeholders responsible for the implementation of the NCWSP (project facilitation, implementation, operation and maintenance of facilities, and monitoring) are the CWSA, the District Assemblies, The WSDBs, the Private Sector Operators, the Community, External Support Agencies (including Non Governmental Organizations, NGOs).

Different levels of capacity building are required for all the different stakeholders. Capacity of the programme facilitator (CWSA) needs to be strengthened in order that it can provide the support needed by other stakeholders. Generally the training of stakeholders needs to be built based on the specific role they play in the overall NCWSP implementation and follow up monitoring programmes.

Key areas of training required for stakeholders are

(1) water quality targets, testing and interpretation of results
(2) water quality impacts on health of users
(3) environmental and social surveillance
(4) water pollution/safety risk assessment and management
(5) development of water safety plan

The CWSA shall facilitate the training of WATSAN Committees and WSDBs to undertake sanitary survey. The District Assemblies will supervise the conduct of the sanitary surveys at the community level and capture the relevant data in the DiMES. The sanitary survey module shall be included in the overall training plan for WATSAN Committees/WSDBs

7.2 Accreditation of Laboratories

CWSA will request the GSB to carry out accreditation of laboratories in the country for water quality testing. Water quality sampling and analysis services shall be performed by only the accredited institutions. The cost of testing shall be paid for by the owners of the water supply system.

7.3 Water Quality Test kits for Monitoring

Water quality test kits should be provided as part of tools for WSDBs before commissioning. The physical parameters indicated to be monitored during operation are pH, colour, turbidity, total dissolved solids and electrical conductivity, and will be undertaken at the plant level. The CWSA at the regional level should also have water quality test kits to periodically monitor the physical parameters. This activity by CWSA will provide assurance for water safety and also serve as mechanism for emergency testing when there is a complaint from the community on water quality.

7.4 Frequency of Monitoring Water System Components

The frequency of monitoring water sources depends on several factors including the following;

(1) Quality of the water sources.
(2) Presence of industrial activities within the catchment of the water source.
(3) Potential pollution envisaged in the future.
(4) Mineralogy of the rock mass of the geological formation underlying the catchment.

All water point sources fitted with hand pumps need to be monitored over a period not less than five (5) years. Water system components of pipe systems are to be monitored as long as they function and provide water supplies according to the standard required. The number of water sources to be monitored at a particular time nation wide depends on the following factors.

(i) Total number of water sources available and functioning.
(ii) Information available on water quality challenges for existing water systems
(iii) Resources available for monitoring and risk management

It has been estimated that a total of 20,000 (CWSA, 2008 Annual Report) point water sources consisting of boreholes, hand dug wells and rainwater harvesting facility exist nation wide. There are also 300 pipe systems that depend on groundwater (boreholes) and 50 small town systems that depend on surface water sources or springs. It is planned that annually, 500 point sources and 5 pipe systems would be added to existing water facilities (CWSA, 2008 SIP).

Studies within the CWSA (2008) indicated that 20-30% of point water sources have water quality challenges ranging from high levels of arsenic, fluoride, iron, manganese and other heavy metals, organic and inorganic substances (resulting from chemicals used in mechanized agriculture), hardness, colour, turbidity, and occasionally low or high pH. It is proposed that 5-10% of point water sources should be monitored whiles 100% of water sources for pipe systems are monitored annually. The lower 5% monitoring is proposed to be started in the first year for point water sources. As data on monitoring accumulates, new water sources can be added while others can be discontinued after the five year minimum period.

7.5 Responsibility for Monitoring

Monitoring of water sources and water system components is classified under the following categories.

(i) Monitoring of point water sources, boreholes, hand dug wells (fitted with hand pumps) and rainwater facilities
(ii) Monitoring of mechanized boreholes/surface water sources on piped systems.
(iii) Monitoring of pipe system components

The estimated number of facilities required for monitoring and corresponding annual cost is shown in the Table 1 below.

7.6 Cost of Monitoring Water Systems

The average cost of monitoring water supply systems could be estimated using the following linear mathematical relationships based on the agreed at least two times monitoring per year

7.6.1 Point Sources

Definitions
N = Total number of point sources available
Frequency of monitoring = 2
C = Unit cost of monitoring

Then the total cost of monitoring Tp is given as,

Tp = 0.1NC

7.6.2 Mechanised Systems

Definitions
M = Total number of mechanized systems available
Frequency of monitoring = 2
C = Unit cost of monitoring

Then the total cost of monitoring Tm is given as,
Tm = 2MC

7.6.3 Piped System Components

Definitions

Y = Total number of mechanized systems available
Frequency of monitoring = 4
Number of control points = 4

C = Unit cost of monitoring
Then the total cost of monitoring Tm is given as,

Ty = 16YC

7.7 Model for groundwater safety and pollution indices

The Water Safety and Pollution Indices model has been developed to estimate the level of water safety or pollution risk associated with groundwater resources exploited for use within small communities and small towns. The model is simple and will measure two indices namely;

(1) Groundwater Safety Index (GSI).
(2) Groundwater Pollution Index (GPI).

The data needed for the computation of the indices are derivatives of monitoring results collated on groundwater sources (boreholes or hand dug wells) during field monitoring using the water safety framework. The indices may be estimated but actual results will require application of all water quality data so that a country wide perspective can be achieved. Groundwater safety index gives the proportion of groundwater sources that are safe for drinking, whilst groundwater pollution index gives the proportion of groundwater not safe for drinking. A maximum GSI value of one (1) implies that all the groundwater source facilities provided have no water quality problem and a value of zero (0) implies that all the groundwater source facilities provided have water quality problems. The GSI and GPI can be estimated as follows;

$$GPI = (N+M)/2 \quad \text{(Estimated)}$$
$$= T \quad \text{(Actual)}$$

$$GSI = (1-GPI)$$

$$N = \frac{\sum GNq}{\sum GN}$$

$$M = \frac{\sum GMq}{\sum GM}$$

$$T = \frac{\sum GTq}{\sum GT}$$

Definitions

N = The proportion of new facilities with water quality challenges.

M = The proportion of existing water facilities monitored in a particular year with water quality challenges.

T = The proportion of facilities which have water quality challenges.

$\sum GNq$ = Total number of new groundwater facilities (boreholes and hand dug wells provided in that year, which have water quality problems.

$\sum GN$ = Total number of new groundwater facilities (boreholes and hand dug wells provided in that year.

$\sum GMq$ = Total number of existing groundwater facilities (boreholes and hand dug wells monitored in that year, which have water quality problem.

$\sum GM$ = Total number of existing groundwater facilities (boreholes and hand dug wells monitored in that year.

$\sum GTq$ = Total number of groundwater facilities (boreholes and hand dug wells, which have water quality problem in the national database.

$\sum GT$ = Total number of groundwater facilities (boreholes and hand dug wells in the national database.

8 Implementation Arrangements for Water Safety Framework

It is recognized that all water systems provided under the NCWSP are owned by the District Assemblies. Generally rural communities using point systems are unable to generate enough funds for maintenance, and therefore to ensure sustainability of the monitoring programme, the District Assemblies shall be responsible for the funding of this activity at that level. However in view of the fact that the WSDBs have the financial capacity, monitoring of small town water systems shall be funded as part of normal operation cost. Reports generated during monitoring shall be submitted through the Districts for input into the DiMES database. The CWSA at the regional and national levels shall quality assure the reports and ensure that they are properly captured into the Dimes database. The reports generated through the monitoring shall be analyzed by the CWSA and further action recommended for risk mitigation.

The CWSA shall be responsible for facilitating the implementation of the WSF at all levels. Orientation is required immediately after approval by the sector ministry for all stakeholders on the broad objectives of the WSF. Training for the Districts, WSDBs, WATSAN Committees and key staff of CWSA is necessary to ensure that the WSF is implemented as desired.

The line of reporting on water safety issues is indicated in chart below