RURAL WATER SUPPLY AND SANITATION HANDBOOK

FOR EXTENSION WORKERS VOLUME 2

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Foreword

The Review of the Rural Water and Sanitation Handbook for Extension Workers (2000) in 2016, reaffirms the Government of Uganda's commitment towards ensuring availability and sustainable management of water and sanitation for all by 2030. This is in line with the Sustainable Development Goals (SDGs). The first handbook was developed in 2000 with the major aim of enabling Extension Workers to facilitate community action with regard to water and sanitation development, management, operation and maintenance of facilities, and eventually sustainability.

Prior to the review of the handbook, a study was undertaken in 2014, to assess the effectiveness of the participatory community management approaches highlighted in the handbook. The study findings indicated that the sector had made progress regarding the functionality and management of water facilities as indicated by 85% functionality of water sources and 72% functionality of water and sanitation management committees. The study further indicated a number of challenges affecting the sector including, poor access to spare-parts, unwillingness of water users to contribute towards the management of installed facilities, voluntary nature of water and sanitation committees and inadequate support to communities by extension staff. The study further revealed that a number of good management and technological innovations had emerged.

The Revised Rural Water and Sanitation Extension Workers Handbook (2016) has therefore taken stock of the challenges mentioned above and the emerging innovations. New innovations have been highlighted in the areas of communal fund management, Sub County management structures, Self- supply approaches, Rainwater Harvesting Technologies and Community Led Total Sanitation (CLTS) among others. Effort has been undertaken to ensure that the Handbook is well illustrated, user friendly and that it captures best practices and experiences for use by extension workers.

Special thanks and acknowledgements go to the staff of the Ministry of Water and Environment, Local Government staff, Sector Development Partners, more especially EU Water Facility and WaterAid Uganda. More thanks go to the selected communities that assisted and provided information in various ways during the review process.

It is my sincere hope that this handbook which contains well itemized procedures, processes and tools to use, guides Extension Workers to facilitate communities towards increased utilisation, sustainable operation and maintenance of water and sanitation facilities. I commend this handbook to Community Development Workers, Health Workers and Water Engineers who work in both public, Civil Society and private sectors within the communities.

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LIST OF ABBREVIATIONS AND ACRONYMS

ACDO	Assistant Community Development Officer
ADHO	Assistant District Health Officer
ADWO	Assistant District Water Officer
ATC	Appropriate Technology Centre
CAO	Chief Administrative Officer
CBO	Community-Based Organisation
CDO	Community Development Officer
CMP	Contract Management Plan
CWO	Community Water Officer
DE	District Engineer
DWO	District Water Officer
DWD	Directorate of Water Development
DWSSCC	District Water Supply and Sanitation Co-ordination Committee
GFS	Gravity Flow Scheme
GoU	Government of Uganda
HA	Health Assistant
IRP	Iron Removal Plant
LC	Local Council
MWE	Ministry of Water and Environment
NDP	National Development Plan
NGO	Non-Governmental Organisation
O&M	Operation and Maintenance
RGCs	Rural Growth Centres
RWH	Rainwater Harvesting
RWSS	Rural Water Supply and Sanitation
SanPlat	Sanitary Platform (a small latrine slab for sanitary improvement)
SCWSSB	Sub-county Water Supply and Sanitation Board
SDG(s)	Sustainable Development Goal(s)
SODIS	Solar Disinfection
UGX	Uganda Shilling
UV	Ultra Violet
VIP	Ventilated improved pit latrine
VTUC	Valley Tank User Committee
WSC	Water and Sanitation Committee
WSS	Water Supply and Sanitation

DEFINITION OF KEY TERMS

Term	Definition
Aquifer	Water bearing layer in the ground from where groundwater can be extracted
Capacity Building	An ongoing process of equipping individuals, communities and institutions with the understanding, knowledge, skills, and access to information, and training that enables them identify their needs, challenges, and make informed decisions on the best ways of addressing them. It can be achieved through a mix of training, coaching and learning-by-doing while implementing water and sanitation projects.
Community	A group of people living within the same geographical area sharing common resources and comprising of different categories of people with common but also different needs and interests
E-Coli	*Escherichia coli* – resistant bacteria in human excreta used as indicator for measuring faecal contamination in water.
Communication	A two-way process of sharing information
Evaluate	To look at the short and long term results of a piece of work
Facilitate	Guide, support and create a friendly environment to allow people do things for themselves.
Gravity flow scheme	Piped water supply with the source (usually protected spring) at a high elevation and water flows down to tap stands under gravity only.
Mobilise	To put in motion, organise for action
Monitor	Check or keep track of the progress of a piece of work, job or activity
Quality Assurance	Checking whether the work done is up to standard.
Resource	Available money, property or materials that can be drawn upon.
Self-Supply	Privately developed water source to serve one or more households.
Spring	Naturally occurring groundwater outflow on the ground surface
Sustainable	When a facility continues functioning or behaviour continues even if external intervention has ended.

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

The GOU aims to provide safe water and improved sanitation to 100% of the rural population by 2030 in line with Sustainable Development Goals (SDGs). The two areas of concern however are:

a) Ensuring a fast pace, efficiency, and quality of construction.

b) Ensuring effective long-term sustainability.

The key strategy in addressing these concerns is community participation and involvement in provision and maintenance of water and sanitation services. The main approaches applied in the rural sub-sector are therefore:

a) Demand responsive approach where the benefitting community is expected to demand for services they need and can afford.

b) Community contribution to capital cost of construction to strengthen ownership of the WASH facilities.

c) Community-based operation and maintenance (O&M) of facilities where the beneficiaries fully finance the O&M costs and local mechanics are trained to service and repair the equipment installed

To achieve sustainability of Water, Sanitation and Hygiene (WASH) services, it is important to ensure that the communities demand for the facilities that are suitable for their needs and are affordable especially in terms of operation and maintenance.

1.2 What This Handbook is all About

This is a 2nd edition of the Extension Workers Handbook which was produced in 2000. The main purpose of this Handbook is to enable extension workers or agents at the sub-county level facilitate communities in selection of water and sanitation services they need to ensure that these services are properly operated, maintained, and eventually sustained by the communities. Specifically the Handbook will assist extension agents perform their tasks in:

a) Identifying the potentials of the various WASH technologies in communities.

b) Highlighting the key technical requirements for the technologies.

c) Effectively promoting the adaptation and uptake of the WASH technologies.

d) Effectively monitoring the construction and performance of the WASH facilities

The Handbook is not intended to be a construction manual or guide to replace the design manuals and various technology development guidelines provided in the Revised District Implementation Manual (DIM) 2013.

1.3 Intended Users of the Handbook

This Handbook is intended for use by the extension staffs/workers of the Local Government and other development actors like Non-Governmental Organisations (NGOs) and Community Based Organisations (CBOs) providing services in communities. An extension staff/worker can be broadly defined as a person responsible for dissemination of new approaches and technologies, developing effective and efficient management systems, and community mobilisation. Extension workers link the community to the technical team at higher level to provide specific technical inputs.

The Local Government extension staffs engaged in the water and sanitation sector are deployed at district, sub-county, and county levels, while the development organisations' extension staffs are usually attached to projects in communities. The local government extension staffs include:

a) Public Health Workers.

b) Water Development Workers.

c) Community Development Workers.

d) NGO and CBO Extension Workers.

e) Individuals and staff from the private sector.

The development organisations' field staffs normally include: Community mobilisers; Hygiene and sanitation promoters, and Technical officers.

Community leaders and other individuals and staff from the Private Sector who are involved in rural water supply and sanitation development can also use the handbook as a reference.

1.4 How to Use this Handbook

The Technology Development Handbook Volume 2 shall be used together with the main Community Management Handbook Volume 1. In addition, the handbook should also be used together with the relevant supporting sector manuals and guides to provide more technical details on the various technologies highlighted. These sector manuals and guides include: the Community Resource Handbook, the District Implementation Manual (DIM), the Water Supply Design Manual, the Technical Water Supply Design Manual, the Community Training Guidelines, Handbook on Rainwater Harvesting Storage Options, and the O&M manual.

This handbook gives the overall description of the common water and sanitation technologies and their applications in the rural and small trading centres water supply and sanitation service delivery in Uganda. This will assist the extension workers to better advice community members in making the choice of WASH technology most suited for their situation.

1.5 Overview of the Chapters in the Handbook

Chapter One: Introduction: Presents the main concerns in the water and sanitation service delivery, the overall aim and purpose of the Handbook, and who the intended users are. The Chapter gives a quick summary of the main tasks of the Extension Workers – the primary users of the Handbook. It also provides a brief summary of the Handbook's content under each chapter.

Chapter Two: Legal, Policy, and Institutional framework: Provides information on the legal, policy and institutional framework for rural water supply, sanitation and hygiene development in Uganda. It highlights provisions in the various laws in support of WASH service provision, the guiding principles in the various sector policies, and also explains who the main actors are, their roles and responsibilities, and the institutional arrangements that help them work effectively together.

Chapter Three: WASH Facilities Design Principles: Presents the WASH services allocation principles as per the National Policy with regard to service level and subsidies, and gives general requirements for drinking water supply schemes and sanitation systems for communities and institutions. It also highlights the different commonly used technologies for delivery of WASH services and the levels of service they provide.

Chapter Four: Water Supply Technologies: Presents a general description of water supply technologies, their applications, design highlights, and key operation and maintenance issues. It also provides highlights of construction quality checks guidelines and reporting formats that can be used by Extension Workers/supervisors in charge of quality assurance. The technologies presented here are rainwater harvesting, spring protection, shallow wells, boreholes, and piped water supply and the pumps commonly used with the various technologies.

Chapter Five: Water Treatment Technologies: Presents highlights of water treatment technologies for piped water supplies and their applications. Included also are the low-cost water treatment technologies for household applications like ceramic filters, solar disinfection (SODIS), bio-sand filters, iron removal, boiling, and chlorination.

Chapter Six: Sanitation Technologies: Focuses mainly on review of technologies for human excreta disposal in rural Uganda and their applications in household, institutional, and communal settings. The main technology that is widely used, i.e. pit latrines designed, constructed, and managed in variety of ways. Other technologies are ecological sanitation (EcoSan) toilets, composting latrines, and water borne toilets. Other complementary practices like menstrual hygiene management (MHM) in schools, pit emptying, faecal sludge treatment and reuse are also reviewed in the chapter.

Chapter Seven: Hygiene Technologies: Presents brief highlights of the key hygiene technologies promoted and their applications at household and communal levels. The technologies covered are bath shelters, laundry platforms, hand-washing facilities, incinerators, compost pits, and drying racks.

Chapter Eight: Contract Administration and Management: Presents highlights of procurement process and contract management procedures for provision of consulting and construction services in local governments. It also identifies the key stakeholders and their roles in administering WASH services contracts in the lower local government and how they co-ordinate their roles. Construction supervision handled by the various stakeholders is also highlighted in the chapter.

Chapter Nine: Annexes: Presents the various reporting formats for extension workers, Water and Sanitation Committees (WSCs), and Hand Pump Mechanics (HPMs). It also provides sample service contract between WSCs and HPMs for maintaining hand pumps in communities. The chapter also has water sources verification forms that can be used by the Extension Workers to report the statuses of water sources they visit and also provide technical information on the water sources that can be used to update the database at the District Water Office.

CHAPTER 2 LEGAL, POLICY, AND INSTITUTIONAL FRAMEWORK

2.1 Introduction

This Chapter provides information on the legal, policy and institutional framework for rural water supply, sanitation and hygiene development in Uganda. It highlights provisions in the various laws in support of WASH service provision, the guiding principles in the various sector policies, and also explains who the main actors are, their roles and responsibilities, and the institutional arrangements that help them work effectively together.

2.2 Legal Framework

The Government of Uganda (GOU) has put in place rules and regulations to guide the key actors involved in the implementation of water and sanitation activities. In addition, the GOU has developed various economic reform policies and enacted a number of Acts of Parliament which have impacted on the water supply and sanitation sub-sector. These include:

The Constitution for the Republic of Uganda (1995): defines water supply and sanitation as fundamental right for all Ugandans.

The Local Government Act (2000): defines the roles and empowers different levels of Local Government in the provision and management of water and sanitation. These include planning and allocation of resources towards O&M support activities.

Land Act (1998): vests all land in the citizens of Uganda to be owned in accordance with customary, freehold, mailo and leasehold tenure systems. This implies that both Government and private owners of land can set up facilities on the land which they occupy and own. Land tenure issues are critical to the development of water infrastructure. Any location of a water supply project must respect the proprietary rights of the landowner or occupier, as protected by law.

The Public Health Act (2000): aims to consolidate the law regarding the preservation of public health. The Act is particularly relevant for the implementation and enforcement of hygiene and sanitation standards.

2.3 Policy Framework

The sector policies provide the principles of action to be followed in the implementation of water, sanitation and hygiene (WASH) activities, as well as the rules of practice. The key policies and planning frameworks include the following:

The National Water Policy (1999): provides the key principles as decentralisation, a demand-responsive approach, community management, appropriate technology and women's involvement.

The Health Policy (1999): provides guiding principles on cost effective interventions to be targeted with the most important priorities among which sanitation is included. More attention is paid to health promotion a collaboration with NGOs, inter-sectoral coordination, gender sensitive programming and sustainable financing.

The National Community Development Policy (2012): seeks to contribute to the attainment of socio-economic development goals and promote the participation of communities in the overall national development.

The Environmental Health Policy (2005): establishes the environmental health priorities of the GOU and provides a framework for the development of services and programmes at national and Local Government levels.

The National Gender Policy (2007): provides all stakeholders with guidance for mainstreaming gender in all development initiatives. Among the stated guiding principles for its implementation is "*sensitisation on gender issues at all levels and promoting community dialogue to address gender issues at household level*".

National Development Plan II (2015/16 – 2019/20): is the second in a series of six five-year plans aimed at achieving the Uganda Vision 2040. The goal of the NDP II is to propel the country towards a middle income status by 2020. In this planning period, the water and sanitation sub-sector will focus on increasing: access to safe water, sanitation and hygiene levels, functionality of water supply systems and promoting catchment based integrated water resources management. The Water for Production sub-sector will focus on increasing, provision of water for production facilities, their functionality and utilisation.

Uganda Vision 2040: operationalises the national vision of *"a transformed Ugandan Society from a peasant to a modern and prosperous country within 30 years"*. Water development is stated as one of the opportunities that can foster socio-economic transformation hence GoU is committed to strengthening the relevant fundamentals to facilitate optimal and sustainable utilisation. Provision of water will also improve health, sanitation and hygiene.

Sustainable Development Goals: The 2030 agenda for Sustainable Development envisions a world where we reaffirm our commitments regarding the human right to safe drinking water and sanitation and where there is improved hygiene. SDG number 6 is on clean Water and Sanitation and focuses on ensuring availability and sustainable management of water and sanitation for all.

2.4 Strategies

The Water and Sanitation Gender Strategy (2010): provides guidelines to sector players for appropriate planning and implementation of gender mainstreaming into water programmes and activities at national and Local Government levels.

The Community Mobilisation and Empowerment Strategy (2013): ensures effective community participation in the design and implementation of development programmes in various sectors and empowers communities to implement, manage and sustain such programmes over time.

The HIV/AIDS Mainstreaming Strategy (2004): provides Districts and Sub-Counties with guidelines on how to mainstream HIV/AIDS in the Sector.

The National Framework for Operation and Maintenance of Rural Water Supplies (2011): sets guidelines for all sector players in the use and maintenance of water facilities to rural communities.

The Pro-Poor Strategy for the Water and Sanitation Sector (2006): aims to improve the effectiveness of the WASH sector in providing services to the poor. It presents general and specific actions on how to provide services to the poor.

2.5 Institutional Framework

2.5.1 Actors and their Roles and Responsibilities

It is important for the Extension Worker to know all the various actors involved in planning, implementing, operating, maintaining and sustaining water and sanitation facilities, as well as their respective roles and responsibilities. Figure 1 highlights the roles and responsibilities of each of the actors.

Figure 1: WASH Actors and their Roles and Responsibilities

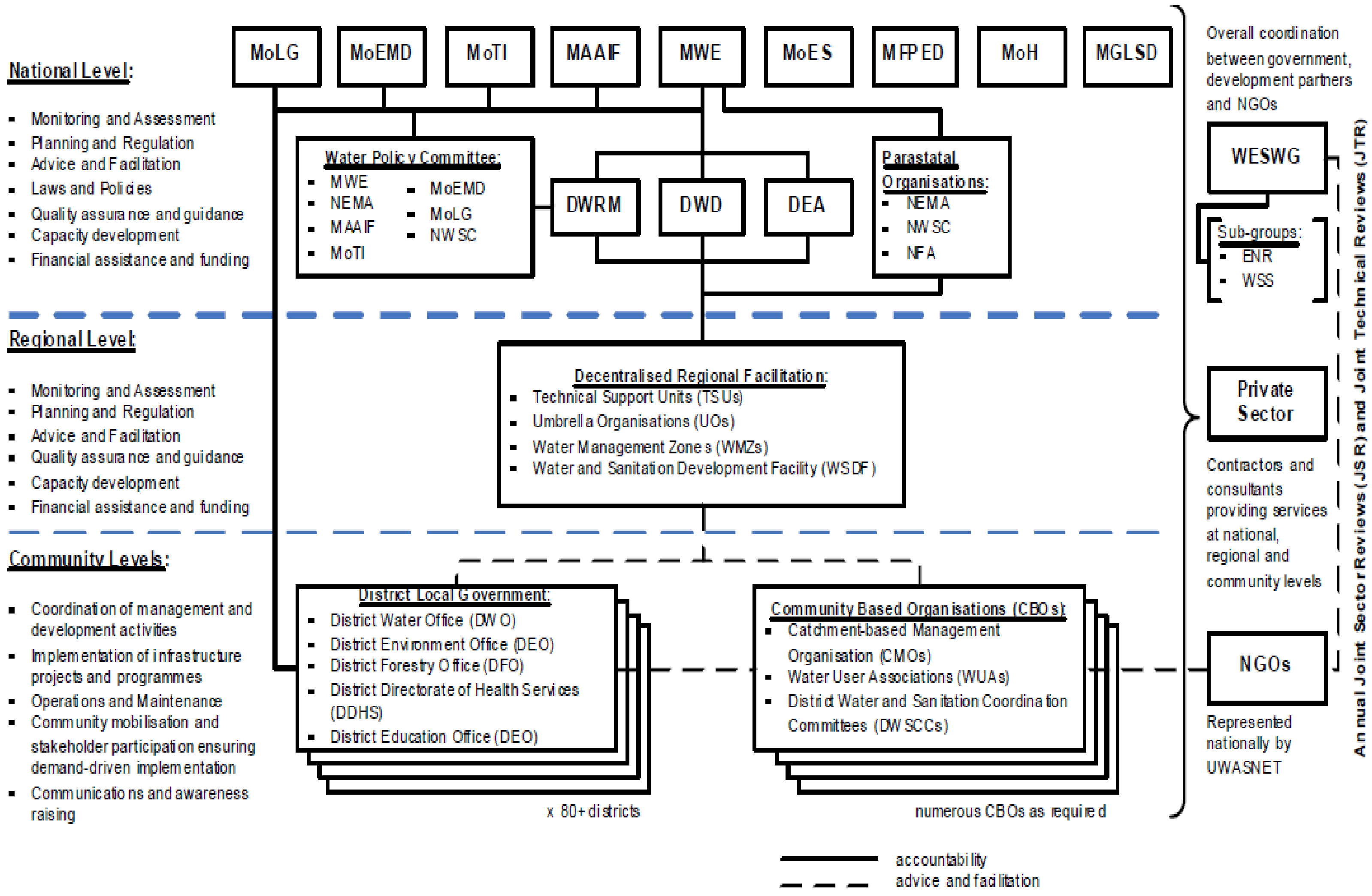


Figure 1: Actors and their Roles and Responsibilities

At all the key stages of WSS service delivery, it is important to ensure that the actors work in an organised way. While emphasis is placed on the use of existing community organisations and reactivation of old groups, formation of new ones may be recommended to facilitate management of facilities established and to promote hygiene and sanitation

2.5.2 Key Institutions at Local Government Level

Extension Workers should collaborate with the following institutions which are either established by the Local Government Act or set up by the water sector to enhance service delivery.

District level

District Council: The overall responsibility for the RWSS co-ordination and prioritisation in the district lies with the District Council i.e. the Works and Technical Services Sectoral Committee. The duties of the committee include, but not limited to, overseeing the allocation of water sources guided by a set criteria, and coordinating and monitoring activities in the district.

The District Water Office: The District Water Office in collaboration with the District Directorate of Health (Health Inspectorate Department) and the Community Development Department supervises and monitors activities undertaken by Extension Workers, Contractors and NGOs.

District Water Supply and Sanitation Coordination Committee (DWSSCC): In order to promote co-ordination amongst stakeholders in the implementation of WSS, District Local Governments **must** establish District Water Supply and Sanitation Coordination Committee (DWSSCC). The DWSSCC which is chaired by the Chief Administrative Officer (CAO) is a Technical Committee that reports to the Technical Planning Committee and meets on a quarterly basis. The DWSSCC comprises of district technocrats (i.e. DWO, District Planner, District Medical Officer, District Education Officer, District Community Development Officer, Town Clerk, Urban Development Officer), Secretary of District Committee responsible for Water, Secretary of District Committee responsible for Social Services, representatives from NGOs and Private Sector organisations involved in water and sanitation activities in the district.

Sub-county Level

Sub-county Sectoral Committee: At sub-county level, the sectoral committee of the council allocates water sources based on community demand criteria, monitors and co-ordinates activities at sub-county and lower levels. The district Extension Workers provide technical support to the sub-county administration and, together with staff from NGOs and private sector, carry out implementation of water and sanitation services.

Sub-county Water Supply and Sanitation Board (SCWSSB): It is an **optional** entity established at the sub-county level by the water sector. It mobilises and manages resources for all WSCs in its jurisdiction. The Main function of a SCWSSB is to take responsibility and oversight of rural water supply and sanitation services e.g. improving budgetary strategy, defining and realising benefits, and monitoring risks, quality, and timeliness in rural water and sanitation service delivery at the sub-county level.

Community Level

Water and Sanitation Committee/ Valley Tank User Committee: At source/water supply level, Water and Sanitation Committee (WSC) **OR** Valley Tank User Committee (VTUC) is elected by the community to manage the water or sanitation facility and promote improved hygiene and sanitation practices among users. The WSC/VTUC term of office should be two years at the end of which the water source users, with support from the Extension Workers and village leaders, should conduct re-election. Individual WSC/ VTUC members are eligible for re-election.

Private Operators (PO)

The Private Operator is appointed by the Water Authority (sub-county) to manage day-to-day operations and maintenance of the water supply system and all related operations. This system is mostly used in Gravity flow Schemes and small piped water systems. The Private Operator signs an agreement (Contract) with the Water Authority and is paid a management fee. Involvement of the private sector has seen private firms and individuals getting involved in the provision of management and operations services.

2.6 An Overview of the Wash Implementation Cycle

The key principle for implementation is putting people first. The Extension Worker should lead the mobilisation and hence inclusion of the entire community including children (boys and girls), women and the disadvantaged/marginalised groups, to examine their own problems, be involved in thinking their own solutions, join in making plans to take their own actions, contribute to monitoring/checking their own progress, taking part in evaluating their own work and taking responsibility for their own development. The main phases of implementation are:

a) **General Planning and Advocacy Phase:** Planning and advocacy is done at the sub-county level. Critical in this stage is the provision of information to sub-counties and communities to demand for services and to provide communities with information regarding behavioural change and the need to meet critical requirements before a water facility is provided.

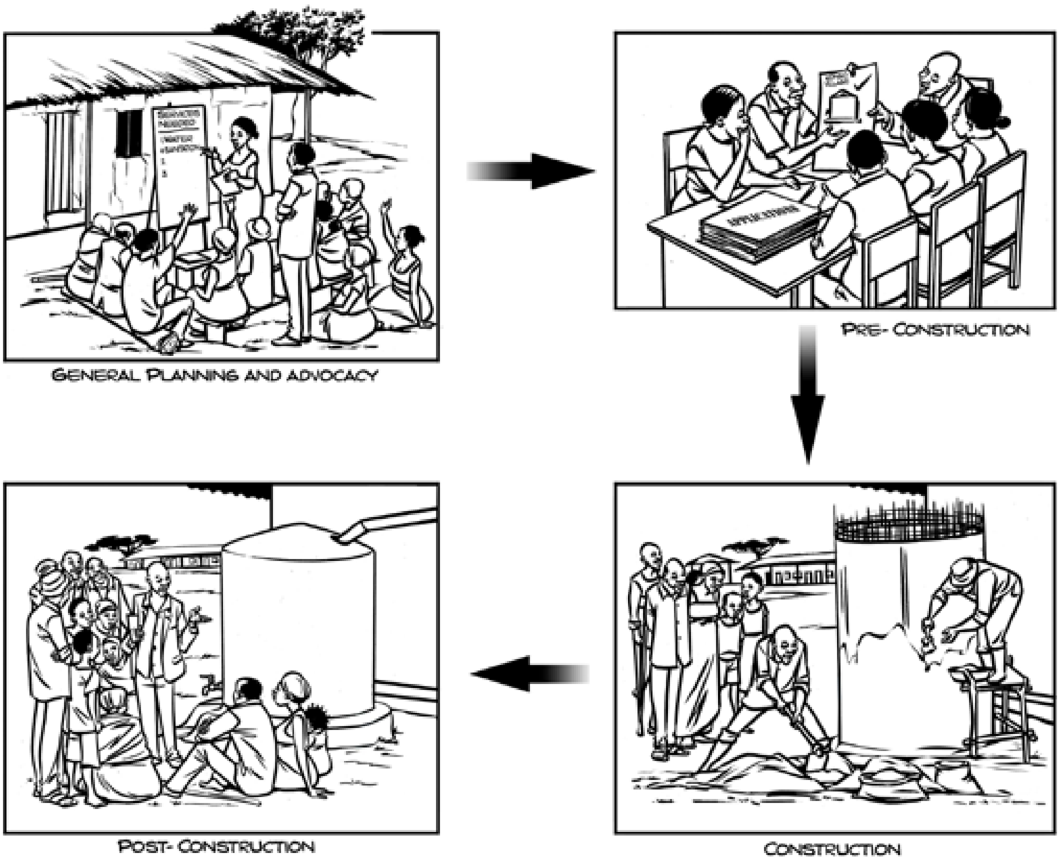
b) **Pre-construction Phase:** This phase focuses on screening and approval of community applications, feedback to communities on the status of their applications, formation and training of the WSC/VTUC, and follow up on compliance with the six critical requirements.

c) **Construction phase:** During this phase, construction of facilities is carried out by the private sector (Consultants and Contractors) co-ordinated by the Extension Worker with the community playing a monitoring role. It is also important to facilitate the communities during this stage of implementation for quality assurance, as well as prepare them for O&M.

d) **Post-Construction Phase:** During this phase the Extension Worker will further guide communities especially the WSCs/VTUCs and the source caretakers, and further develop their capacity to ensure effective O&M of the installed facilities.

e) **Crosscutting issues:** Some of the activities are mainstreamed in each phase. The Extension Worker should deliberately address HIV/AIDS, gender, human rights, governance, environment and climate change concerns in each phase of the implementation cycle.

Implementation cycle



Water and Sanitation activities during emergency situations: The handbook highlights mechanisms of provision of water supply and sanitation services during emergency and other special situations in order to protect public health. Even during emergencies it is important to put people at the centre of any action affecting their lives.

CHAPTER 3 DESIGN PRINCIPLES FOR WATER SUPPLY AND SANITATION

3.1 Introduction

The national policies and guidelines set out the desired service levels for communal facilities that are normally subsidised by Government. Individuals or communities can demand for higher levels of services than those targeted by government, but they must meet the additional costs of construction. The level of service is usually determined based on: the maximum walking distance to the facility and the maximum number of users of a facility. The level of service recommended depends on the type of technology used (see sections below).

The Rural Water Supply and Sanitation sub-sector prioritises the use of appropriate low-cost technologies adapted to the conditions in Uganda. This enables full community participation in selection, construction, and subsequently, Operation and Maintenance. Such technologies can also be upgraded to provide services to larger population like in rural growth centres and institutions that would require and can afford higher level of service.

3.2 Requirements for Water Supply System

Community water supply scheme should satisfy the following key requirements:

- Should supply water of acceptable quality.
- Should supply water in sufficient quantity.
- It should be easily accessible by majority of users.
- It should be reliable with minimal breakdowns.
- It should be affordable to the community in terms of construction, operation, and maintenance.

3.2.1 Water Quality

The quality of water is affected by existence of chemical and non-chemical substances or micro-organisms (collectively referred to as impurities) in the water that can be harmful to human health. Apart from the direct health risks, the impurities can also add colour, taste, smell (odour), and turbidity (cloudy appearance) in water, thereby making it unattractive for human consumption.

Some of the substances occur naturally in the ground and they dissolve in water as it seeps through. Some of the substances are, however, introduced into the water through human activities like manufacturing, construction, agriculture, transportation, and household subsistence. Some micro-organisms live in water bodies but others are washed from land into water bodies.

Water supply system should provide the community with water of good quality, which should be colourless, odourless, pleasant to taste, and free from disease causing organisms and substances. Quality guidelines for drinking water supply have been set up to help determine the health risks associated with each water source and also the possible remedial measures that can be taken to improve the quality of water supplied. Table 1 below shows the National Water Quality Guideline for untreated supply, which is more applicable to the rural water supply in Uganda.

Table 1: National Quality Guidelines for Drinking Water from Untreated Sources - 2007, MWE

Parameter	National G/line		WHO G/line	Remarks
	GV	MAV		
pH	5.5-8.5	5-9.5	-	Low pH – corrosion; high pH – taste & soapy
Turbidity (NTU)	10	30	5	Aesthetic problem i.e. unsightly
Total Dissolved Solids (TDS):mg/l	1,000	1,500	-	No known health effects but water can be objectionable at high concentrations
Hardness (mg/l as $CaCO_3$)	600	800	200	>200mg/l can result in scale deposition and <100mg/l can be corrosive to water pipes
Manganese (mg/l)	1	2	0.1	Black stains. Health problem at > 0.5mg/l
Tot. Iron (mg/l)	1	2	0.3	Brown stains – aesthetic problem
Nitrate (mg/l as N)	20	50	50	Acute health effect at 50mg/l (short term exposure)
Nitrite (mg/l as NO2)	0	3	3	Health effect at 3mg/l (short term exposure) and 0.2mg/l (long term exposure)
Chloride (mg/l)	250	500	-	No major health concern
Fluoride (mg/l)	2	4	1.5	Consider volume consumed & other sources
Sulphate (mg/l)	250	500	250	Taste problem at concentration >250mg/l
E-coli (per 100ml)	0	50	0	Up to 100 for surface water* sources
Arsenic (µg/l)	-	-	10	Acute health problems at high concentrations

** Surface water encompasses open water bodies, tanks, and shallow ground water less than 2m below ground (unprotected by an impermeable layer).*

Notes:

- *GV = guideline value; MAV = maximum acceptable Value.*
- *World Health Organisation (WHO, 2006) guideline values are used where national guidelines are not indicated or for piped/treated water supply.*

The measure of E. coli (faecal coliform) is a critical indicator of whether the water has been in contact with human excreta, which contains a lot of disease causing organism. Human excreta can seep from nearby sanitation facility or is washed from land into water bodies.

3.2.2 Water Quantity and Accessibility

In rural areas, the recommended basic service level from a protected water source is 20 to 25 litres per person per day and should be accessed within 1km from the farthest household served. In built up areas like rural growth centres and peri-urban areas, the water service level is still 20 to 25 litres per person per day, but accessed within a maximum walking distance of 200 metres (for piped supply).

In order to reduce the waiting time at the point water source or tap stand, each water source should not serve more than 300 people. The recommended number of people per water source depends on the technology used as indicated below:

a) Springs protected should yield at least 600 litres per hour or 10 litres per minute and serve a population of about 200 within about 1km.

b) Shallow and deep boreholes installed with hand pumps should yield at least 500 litres per hour and serve a population of at least 300 within about 1.0km. A public tap stand should yield at least 10 litres per minute and serve a population of about 150 people but within 200 metres of the tap stand.

Hilly terrains where springs are common may necessitate a reduction in walking distance to the water source to reduce the effort spent fetching water.

3.2.3 Reliability

Protected water sources should function without much interruptions that are usually caused by breakdowns or insufficient water in the system. Possible causes of breakdown or interruption in water supply systems are:

- Poor quality of construction or installation leading to damage to structures and equipment.
- Inadequate designs of facilities that produce insufficient amount of water.
- Inability of the community to effectively Operate and Maintain the facility thereby resulting into underperformance and regular breakdowns.

Unreliable water supply source can force the community back into using unprotected sources thereby exposing them to risks of contracting water borne diseases.

3.2.4 Affordability

The community should select technologies that they can afford the capital cost contribution and the full Operation and Maintenance costs. Because of the high level of construction subsidy from Government, the community normally mobilise their contribution quite easily (Table 2). The main challenge is usually in meeting the O&M costs and organisation requirements.

Table 2: Community Capital Cost Contributions (MWE, sector schedules)

Type of Technology	Community Capital Cost Contribution (UGX)
Springs	
Small	50,000
Medium	50,000
Extra Large	75,000
Deep borehole	200,000
Shallow well (drilled or hand dug)	100,000
Rehabilitation of Shallow Well	50,000
Borehole rehabilitation	100,000
Gravity Flow Scheme	50,000 per tap stand
Valley Tanks and Dams	1% of investment cost
RWHT (Public)	1% of investment cost

**Subject to change depending on Government Subsidy Policy*

Some technologies like pumped or treated water supply require skilled personnel to operate and maintain some units, thereby increasing the costs of O&M for the community. In choosing a water supply system, due consideration should therefore be made to the capacity of the community to meet the operation and maintenance costs.

3.3 Requirements for Sanitation and Hygiene Services

Sanitation covers key areas of excreta disposal/management, personal and food hygiene, solid waste management, waste water disposal, and drainage. The main technical concerns with sanitation are the provision of facilities for safe disposal of human excreta. The sanitation sub-sector is divided into three main parts:

- Household sanitation – refers to private/domestic facilities that are installed and managed by the households. The common facilities used are pit latrines (traditional and improved) and EcoSan toilets; in urban areas, water borne toilets are also commonly used.

- School sanitation – refers to facilities in public primary and/or secondary schools installed by Government or NGOs and managed by the schools. The common facilities used are lined and unlined pits, VIP latrines and EcoSan toilets, and composting toilets. In a few cases; water borne toilets are also used in urban schools.

- Public sanitation – refers to communal facilities in public places like markets, health centres, town and urban centres, and other public facilities installed by Government. The common facilities used are water borne/flush toilets connected to sewerage systems for large towns and cities managed by National Water and Sewerage Corporation (NWSC), water borne toilets connected to septic tanks in urban areas with piped water supply managed by the local authority, and VIP latrines in rural growth centres managed by Private Operators or Community Based Associations accountable to the Local Authority.

Hygiene education and promotion of hand washing with soap and water is integral part of sanitation improvement interventions.

3.3.1 Sanitation Services

Household Sanitation: As a minimum for 100% coverage, every household should have an improved sanitation facility for safe disposal of human excreta. Shared facilities do not provide convenient and adequate access recommended for households.

School Sanitation: As a minimum target, one stance of latrine/toilet should be provided for every 40 pupils/students, The number of stances can be reduced for boys in favour of providing urinals. Boys and girls should have separate latrine/toilet facilities to provide adequate privacy especially for the girls, as well as separate latrine/toilet block for staff. In addition, facilities for the pupils with physical disability as well as washrooms for girls (with adequate water supply and wash water disposal system) should also be provided.

Public Sanitation: As a minimum requirement for health facilities, one stance of latrine/toilet should be provided for every 5 beds in addition to urinals for males. There should be separate access for females and males. Facilities for persons with disability should be fitted in at least 25% of the stances to cater for patients who are very weak.

3.3.2 Hygiene Services

Hand Washing with Soap: As a minimum, hand washing facilities with proper wash water disposal system and an adequate supply of water and soap should be provided at every latrine/toilet facility. In schools, hand washing facilities with multiple taps should be provided to reduce waiting time and ensure pupils/students wash hands properly.

In schools with feeding programmes, hand washing facilities with soap and adequate water supply should also be provided at food distribution points.

Menstrual Hygiene Management (MHM) in Schools: As a minimum, schools should have facilities for collection and safe disposal of sanitary pads/towels provided in the girls' latrines/toilets, Such facilities should include covered buckets for collecting the used pads and an incinerator for safe disposal of the pads. Washrooms/changing rooms with soap and water should also be provided within the latrine/toilet facilities to ensure privacy for the girls.

Other Hygiene Services: Other key hygiene services usually promoted in homes and institutions include: bathrooms with proper wastewater drainage system, drying racks and rubbish/composting pits.

CHAPTER 4 WATER SUPPLY TECHNOLOGIES

4.1 Introduction

The technologies promoted for rural water supply in Uganda are classified as 'appropriate' to mean that they are: low-cost, low-tech, adaptable to local conditions and managed at the lowest level (by the communities). Some of the technologies are only promoted under the self-supply initiative for households i.e. with no direct funding from government. But the majority are promoted as conventional water supply technologies for communal water sources.

This chapter provides general descriptions of the technologies, their applications, design highlights, and key O&M issues. The detailed descriptions of the technologies and their applications are provided in the Sector Design/Construction Manuals and the District Implementation Manual.

The common water supply technologies options in this handbook are:

1. Rainwater harvesting
2. Protected springs
3. Shallow wells
4. Deep boreholes
5. Piped water supply systems

4.2 Rainwater Harvesting

4.2.1 General Description

Rainwater harvesting refers to the collection and storage of rainwater. A rainwater harvesting system consists of three main components:

- The catchment surface where rainwater is collected. In general the catchment surface should be firm/hard, clean, and free from potentially harmful chemicals. The common surfaces used in RWH for domestic water supply are hard roofs (corrugated sheets or tiles) and solid rock outcrop (Figure 2).
- The collection/delivery system for transporting the water from the catchment to the storage reservoir. This consists basically of gutters (usually made from sheet metal, plastics, or concrete/brick work), and a first flush device (FFD) that pro-

vides storage for dirty water coming off the catchment when it begins to rain.

- The storage facility where the water is stored for future use especially during dry days/seasons. The common storage is tanks which are of different types: ferro-cement, cement mortar jars, brick or stone masonry, galvanised iron, plastic, stainless steel, tarpaulin, reinforced concrete and EMAS.

Figure 2: Roof catchment (left) and rock catchment rainwater harvesting system

4.2.2 Application of RWH

RWH is widely used in many homes and institutions like schools and health facilities in Uganda. There has been considerable experience in promoting rainwater harvesting for both communal/institutional and household water supply. Well designed and managed household RWH system normally supply adequate water year round but communal systems seldom supply adequate water because of the usually large number of users and weak system for regulating usage. With the steady improvement of homes in the country where households are constructing houses with iron roofs, the adoption of RWH technology for household water supply is only set to increase.

The government may cover full costs of the RWH facilities in institutions and public places especially in cases where the other conventional water supply technologies are not feasible. Private or household facilities are however fully funded by the beneficiaries as self-supply initiatives. Projects have trained Community Based Artisans to effectively install small to medium capacity RWH systems for households, but large capacity RWH systems in institutions and public places can be very complex and would require highly skilled construction team for proper installation.

<u>**Advantages of RWH**</u>

- It is affordable for low-income communities.
- Beneficiaries have improved water security, better quality of water and majority of the technologies are user friendly and have a long life span of over 10 years on average.
- It brings water closer to home, therefore time is saved from collection of water from other conventional sources (springs, boreholes, shallow wells). This is a key benefit for women and children especially the girl-child who bear the burden of collecting water for the family.

- Localising water facilities at household and institutional levels provides a better opportunity for proper operation, maintenance, and utilisation of water facilities by users themselves.
- During the wet seasons, the presence of rainwater storage within the compound would encourage the household and institutions to use more litres per person per day with the corresponding associated health benefits.
- Opportunity for skill development and income generation among individuals locally trained to construct facilities.
- Promotes agriculture production hence generating income for many households.
- Provides good quality water if properly harvested and managed.

Disadvantages of RWH

- Storage systems are expensive and not affordable by many households.
- Depends on the seasons – may not provide adequate water during the dry seasons of the year.
- The quality of rainwater is affected by cleanliness of the catchment surface.
- Domestic roof water harvesting is a house-by-house technology compared to communal sources and therefore benefits only a household.
- Communal rainwater harvesting is not usually adequate because the catchment surfaces i.e. roofs are normally too small for the number of the intended users (the primary advantage of convenience is therefore lost).
- Facilities installed are easily vandalised especially for the communal water supply systems that do not supply adequate water.

Materials Selection

Materials selection would determine the construction method to use and also the overall cost of the RWH system to be installed. The critical component of the RWH system, which accounts for most of the installation cost, is the water storage facility.

The common types of storage tanks promoted for RWH in Uganda are:

- Ferro-cement tanks with capacity ranging from 3,000 – 50,000 litres; larger capacity tanks up to 75,000 litres can also be constructed.
- Cement mortar jars with capacity ranging from 500 – 3,000 litres; smaller capacity jars are normally constructed for water storage in house.
- Plastic tanks manufactured in capacity ranging from 500 – 24,000 litres; smaller capacity vessels are available normally for in house water storage.
- Masonry tanks constructed from various materials like burnt bricks, concrete blocks/bricks, stones, and stabilised soil blocks. Tank capacity normally ranges from 4,000 to over 100,000 litres; the larger capacity tanks are usually constructed underground.
- Stainless steel tanks manufactured in capacity ranging from 500 – 7,000 litres; smaller capacity vessels are normally used for in house water storage.
- EMAS underground tanks (Figure 6) are recently introduced in Uganda and can

be constructed in capacity ranging from 3.000 – 15,000 litres.

- BOB water bags manufactured in capacity ranging from 1,000 – 1,500 litres.

The detailed description, designs, construction steps, and indicative construction costs are provided in 'The Handbook for Rainwater Harvesting Storage Option' (Ministry of Water and Environment, 2015).

Figure 3: Ferro-cement tank (left) and cement mortar jar

Figure 4: Above ground masonry tank (left) and below ground tank under construction

Figure 5: Plastic tank (left) and stainless steel tank (right)

Figure 6: the EMAS tank with EMAS pump installed (left) and BOB water bag

4.2.3 Design Highlights of RWH Systems

The overall aim for designing a RWH system is to provide an affordable facility that functions well with minimal O&M requirements and supplies adequate water for the intended purpose. The key design considerations for RWH system are: siting the main components (especially the storage facility), sizing the components, and selecting the construction materials to use.

Siting the RWH Facility

Some key considerations when siting RWH facilities are:

- The users should have easy and unrestricted access for fetching water.
- The facility should not undermine the normal use and functioning of the building on which it is installed.
- The facility should not cause structural damage to the building on which it is installed.
- The facility should not spoil the beauty of the building on which it is installed.

As a general guide therefore, a storage tank should be sited at least 1.5 metres from the wall of the building. For large capacity storage for household supply, underground tank is recommended because it will be largely out of sight.

Sizing the RWH Facility

This is mainly to do with determining the capacity of the storage tank necessary to meet the water demand or to store the available water from the catchment system. The capacity of the storage tank should be such that the catchment area is large enough to at least fill it up in the last month of rainfall to provide the maximum amount of water for the dry period.

Four critical parameters are used in sizing the storage capacity for a RWH system:

- The average amount of rainfall in the area (usually measured in mm) and how it is distributed over the year.
- The size of the catchment area that can or should be used (measured in m^2).
- The total daily water demand of the users (number of people x daily per capita consumption).
- The length of the (longest) dry period in the year.

The first two points will determine the amount of water that can be collected from the catchment area i.e. multiplying the amount of rainfall (**mm**) by the size of catchment area (**m^2**) gives the amount of water collected (**litres**). For example 10mm of rain falling on $10m^2$ of roof will produce 100 litres of water. The last two points will determine how much storage should be provided to meet the water demand of the target population.

To design for year round supply, the critical requirement is to have adequate storage at the start of the long dry period that would meet the dry period demand of the target population. The minimum storage capacity for a RWH system would therefore be: the total daily water demand (as determined above), multiplied by the number of days in the long dry period. Additional storage can be provided to meet other needs like vegetable farming, watering animals, or even for sale. The detailed steps in determining the storage capacity of a RWH system is presented in 'The Handbook for Rainwater Harvesting Storage Option' (Ministry of Water and Environment, 2015).

Table 3: Typical dimensions for cylindrical tanks of different capacities

<table>
<tr><th>Tank Capacity</th><th>Depth (Metre)</th><th>Diameter (Metre)</th><th>Comments</th></tr>
<tr><td>5,000 Litres</td><td>2</td><td>1.78</td><td rowspan="4">Deeper tanks can be constructed for masonry, concrete, stainless steel, and plastic materials.</td></tr>
<tr><td>8,000 Litres</td><td>2</td><td>2.25</td></tr>
<tr><td>10,000 Litres</td><td>2</td><td>2.5</td></tr>
<tr><td>15,000 Litres</td><td>2</td><td>3.1</td></tr>
<tr><td rowspan="2">20,000 Litres</td><td>2</td><td>3.56</td><td></td></tr>
<tr><td>2.5</td><td>3.2</td><td>Not for ferro-cement tanks</td></tr>
<tr><td rowspan="2">25,000 Litres</td><td>2</td><td>3.95</td><td></td></tr>
<tr><td>2.5</td><td>3.56</td><td>Not for ferro-cement tanks</td></tr>
<tr><td rowspan="2">30,000 Litres</td><td>2</td><td>4.36</td><td></td></tr>
<tr><td>3</td><td>3.56</td><td>Not for ferro-cement tanks</td></tr>
<tr><td rowspan="2">40,000 Litres</td><td>2</td><td>5.04</td><td></td></tr>
<tr><td>3</td><td>4.1</td><td>Not for ferro-cement tanks</td></tr>
<tr><td rowspan="3">50,000 Litres</td><td>2</td><td>5.63</td><td>Usually for ferro-cement tanks</td></tr>
<tr><td>3</td><td>4.6</td><td rowspan="2">For below/partially below ground masonry and concrete tanks</td></tr>
<tr><td>4</td><td>4</td></tr>
<tr><td rowspan="3">75,000 Litres</td><td>3</td><td>5.63</td><td rowspan="3">For below/partially below ground masonry and concrete tanks</td></tr>
<tr><td>4</td><td>4.47</td></tr>
<tr><td>5</td><td>4.36</td></tr>
<tr><td rowspan="3">100,000 Litres</td><td>3</td><td>6.5</td><td rowspan="3">For below/partially below ground masonry and concrete tanks</td></tr>
<tr><td>4</td><td>5.63</td></tr>
<tr><td>5</td><td>5.04</td></tr>
</table>

It is therefore important to determine the actual (or critical) daily water usage per person, as this will have a direct bearing on the storage capacity needed, and hence the cost of the facility. Wasteful water use (especially in the dry season) increases the cost and effectiveness of RWH systems but on the other hand, if there is alternative water source in the area then the rainwater is preserved for the critical potable use (i.e. drinking and cooking) only.

The first flush device/diverter (FFD) is very critical to ensure good quality water enters the storage tank (Figure 7). It is important that the FFD functions without rigorous O&M. A large capacity FFD with a small storage vessel and a washout valve would provide additional storage supplying water for non-potable use. Small capacity FFD would require constant operation for it to perform effectively.

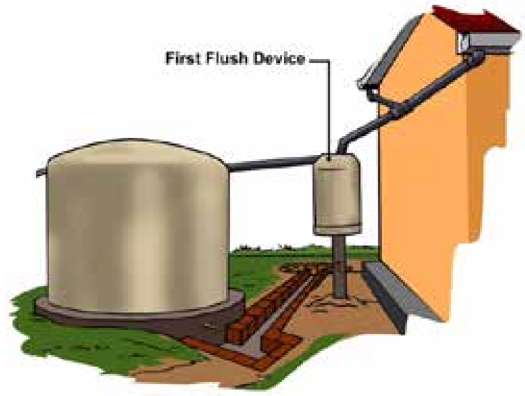


Figure 7: Small capacity FFD (left) and large capacity FFD with washout valve

4.2.4 Key Operation and Maintenance Issues

Some key O&M measures for RWH systems must be undertaken to maintain the quality of water collected, ensure efficient collection of water, reduce losses, and prevent major breakdown.

Catchment Area:

- Regularly clear all plant materials and dirt (especially for rock catchment system).
- Cut all tree branches hanging over the catchment area to reduce the amount of leaves and birds' droppings on the surface.
- Repair the fence that keeps out livestock (especially for rock catchment system).

Gutters:

- Regularly clear leaves and dirt accumulated in the gutters.
- Check the alignment of gutters and repair as necessary to remove all stagnant water.
- Check for any leakage and seal with recommended substance.
- Check for any weakness or damage to the gutter and repair or replace as necessary.

First Flush Device:

- Drain out all dirty water before the rain (especially after two or three dry days).
- Check for any leakage in the washout valve or plug and repair or replace as necessary.
- Check for any cracks or leakage in the storage vessel/column and repair or replace as recommended.

Storage Tank:

- Check for any leakage in the tank wall and repair immediately to avoid water loss.
- For underground tanks (or for leakage through the bottom), monitor any significant drop in water level to detect leakages in the tank.
- Regularly check for any cracks in the wall of the tank and seal them immediately.

- Wash the wall of the tank and clean out any rubbish from the bottom of the tank at least once a year (i.e. at the start of the rainy season).
- For above ground tank, regularly check the tap for any leakage or damage and repair or replace immediately to avoid water loss.

4.2.5 Roles of Stakeholders in Construction of Rainwater Facilities

District Water Officer

- Oversee, supervise and evaluate work in progress. Monitor contractor conduct testing procedures and schedules.
- Co-ordinate site meetings with contractor and consultants, and ensure that the decisions arrived at in the meeting are implemented.
- Provide oversight as required of contractor's compliance with schedule and technical performance.
- Procure all owner-related testing and reports including: environmental reports, design and other technical reports, training reports, and mobilisation and other necessary reports.
- Inspect completed works and prepare recommendations to the CAO/DE regarding the acceptability of the product including any inadequacies noted in the specifications and technical requirements.
- Develop District's prompt responses to contractor deliverables and provide recommendations to the CAO.
- Review contractor claims for payment. Make payment recommendations to the CAO/DE.
- Ensure that District meets its compliance obligations.
- Quantify and coordinate removal of all environmental concerns as recommended in the reports.

Contractor

- Ensure that designs and procedures are followed as per the specifications.
- Provide safe working conditions to the employees in relations to Acts and regulations (Health and safety regulations) by the rightful authority.
- Notify the client and consultant where the design may not be workable or has inadequacies. If the proposed procedures are not appropriate given the circumstances, the contractor should inform both the client and consultant.
- Ensure the testing of all materials used as may be specified in the contract/or in accordance with acceptable construction practice.
- Prepare and submit to the consultant the invoices for the works done.
- Attend all the site meetings and/or cause them to be held.

Consultant

- Ensure the contractor follows the designs and technical specifications.
- Ensure the workmanship of the contractor is acceptable.

- Prepare payment certificates for the Contract.
- Facilitate communication between the Client and the Contractor.
- Monitor systems performance during defects liability period, and get the contractor to correct any construction defects.

Extension Worker

- Plan with the community on their participation during construction (provision of labour, materials etc.)
- Monitor the contractor's work to ensure that it follows the terms of the contract.
- Report to the District Water Office on the work progress
- Facilitate communication between the Contractor, the Consultant and the community.
- Communicate to the community the work programme and the work progress.
- Monitor systems for defects, during the defects liability period, and report to the DWO.

4.2.6 Quality Check Guideline for Water Tank Construction

Concrete/Ferro-cement Tank – Materials Quality Check Form

District: ....Sub-county: ....

Parish:..Village: ....

Source Name: ....Source Number:....................................

Contracted Firm:..Contract Ref. No:..................................

Local Contact Person: ....

Date: ....

Materials Grading: Recommended: **1** Not recommended: **2**

Description of Material	Grade	Remark
1. **Lake sand:** Rough texture, water washed, and free of organic material and clay. 2. **Plaster sand:** Clean and free from inclusion like clay, organic matter, and soil. 3. **Aggregates:** Machine-crushed, 12mm (18mm maximum) size, no organic material, dust, and clay. 4. **Cement:** Ordinary Cement that is free of lumps. 5. **Blocks:** Should be 230mm (9") wide with firm edges. 6. **Hardcore:** Should be irregular in shape, clean and from fresh rock. 7. **Reinforcement mesh and bars:** Regular shape and free from too much rust. 8. **Chicken mesh:** Galvanised, strong gauge, and free from grease/oil		

Supervisor: Contractor:

Signed: ....Signed:...

Name:..Name: ....

Designation: ....Designation: ....

Date: ....Date: ....

Concrete/Ferro-cement Tank – Construction Quality Check Form

District: ....Sub-county:..

Parish: ....Village: ....

Contracted Firm: ....Contract Ref. No: ....

Date of Commencement: ....Date of this check: ....

Local Contact Person: ....

Rating Levels: Good: **1** Fair: **2** Poor: **3**

Component	Rating	Remark
Brick/stone masonry work: ▪ Damp proof course ▪ Bonding ▪ Plumb ▪ Rendering **Concrete/Ferro-cement:** ▪ Reinforcement bars/mesh – placement ▪ Mix ratio and placement (concrete/ mortar) ▪ Curing ▪ Finishing **Guttering:** ▪ Length and size ▪ Alignment (gentle and uniform slope) ▪ Firmly fixed on fascia board ▪ Joints tightness ▪ Drop pipe (size and tightness) **Valves and Fittings:** ▪ Well fitted/leak proof ▪ Accessible/easy to operate ▪ Protected ▪ Well drained apron		

General Remarks:...

....

Supervisor: Contractor:

Signed: ....Signed: ....

Name:...Name: ....

Designation: ....Designation: ....

Date: ....Date: ....

This form is to be filled at every site visit the Supervisor makes.

4.3 Spring Protection

4.3.1 General Description

A spring occurs naturally where the groundwater table intersects the ground surface and they mainly occur in steep valleys where the groundwater table is normally near the surface. Unprotected springs are usually exposed to contamination from runoff and human activities.

Springs are normally categorised as small, medium, or large depending mainly on the size of the structures to be constructed. Springs found in relatively flat terrains are usually large requiring long retaining walls and drainage channels while springs in hilly terrains tend to be smaller requiring short retaining walls and drainage channels. Very high yield springs requiring more than two delivery pipes can also be categorised as large because of the long retaining walls necessary to accommodate the delivery pipes.

Figure 8: Medium size unprotected spring (left) and large size spring (right)

Spring protection is one of the cheapest technologies of water supply and it involves four critical components:

- Spring development carried out to clear out the sediments accumulated around the spring 'eye(s)'. This normally improves the spring flow and removes the unstable soil around the spring eye(s).
- 'Capping' the spring involves constructing a water tight enclosure with an outlet around the spring eye to prevent contaminated surface water from mixing with the spring water.
- Constructing a retaining wall to hold back the soil and backfill around the spring eye to prevent soil collapse and erosion that would encourage flooding around the spring eye.
- Constructing drainage channels to divert runoff away from the immediate area upstream of the spring and carry wastewater into the natural drainage channel.

Figure 9: Medium size protected spring (left) and small size protected spring (right)

4.3.2 Application of Spring Protection

Spring protection has been widely applied in many parts of the country mainly to serve as community water sources. It is generally an improvement of existing water sources to supply water of potable quality. Communities easily identify with the springs.

High yield springs in hilly areas can be easily upgraded to supply piped water schemes that would provide safe water to large population and close to households. Well protected springs usually produce high quality water that can be directly consumed without treatment.

Advantages of Spring Protection:

- They are easy to construct.
- The cost of construction is low compared with most technologies.
- Construction materials are usually readily available in most areas.
- High level of community involvement in the construction.
- It supplies good quality water suitable for all potable use.
- Needs minimal maintenance after construction.

Disadvantages of Spring Protection:

- It does not reduce the walking distance to improved water source.
- Can easily get contaminated in densely populated areas.
- It is only applicable where springs occur naturally.

4.3.3 Design Highlights of Spring Protection

Four key considerations are made when designing a spring source protection to ensure that the spring source will function properly and the water supplied is of acceptable quality. The key considerations are:

- The location of the spring in relation to the nearby human settlements – spring should ideally be uphill from human settlements to reduce the risk of contamination from human activities and on site sanitation facilities.

- The (safe) yield of the spring normally measured at the end of the dry season (Figure 10) when the spring flow would be at the lowest level. The yield would determine whether the spring can satisfy the water demand of the target population and would inform the necessary classification of the spring i.e. low, medium, or high yield and therefore the type of protection to apply.
- The quality of the spring water to determine its suitability for human consumption or whether the water can be treated to make safe.
- The terrain of the area and soil type around the spring to determine whether adequate wastewater drainage can be conveniently provided or whether the spring structure can be constructed without affecting the water flow.

The yield can be measured by channelling water through a pipe into a container of known capacity or through a calibrated V-notch to read off the flow rate.

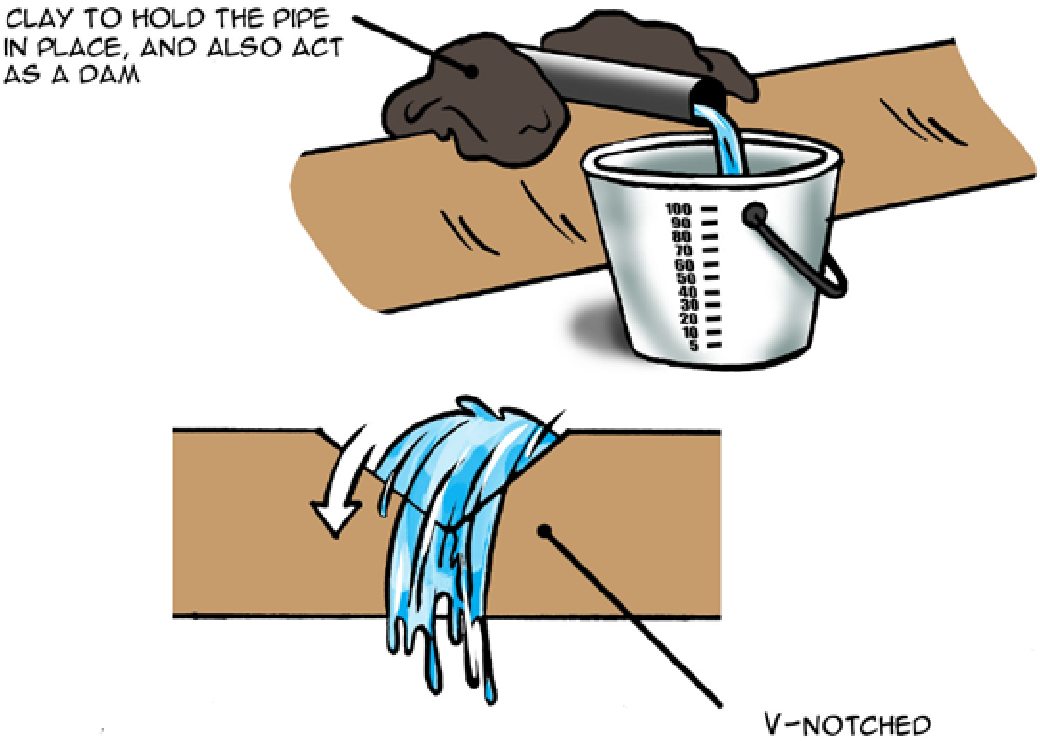


Figure 10: Measuring yield of a spring well

There are two main types of spring design/construction as a point source depending on the yield: ordinary spring construction for high yield springs and spring tank construction for low-yield spring.

<u>Ordinary Spring Construction:</u>

The ordinary spring construction with single or multiple pipes/spouts is for high yield spring i.e. with more than 8litres/minute of flow. The key features are highlighted in the schematic drawing in Figure 11 below:

- The retaining wall should be as near the spring eye as possible to reduce the amount of soil and hardcore backfill. The distance to the retaining wall is determined by the need to provide adequate wastewater drainage channel and the height to the delivery pipe enough to fit a jerrycan.

- A waterproof channel or a drain pipe should connect the capped spring eye to the retaining wall to minimise risk of contamination from runoff seeping into the ground behind the wall. Sub-surface drain through the hardcore bed behind the retaining wall and under the slab would remove any seepage water from behind the retaining wall.
- An overflow chamber behind the retaining wall would prevent damage to the spring eye capping in case the delivery pipe is blocked (by children or vandals).

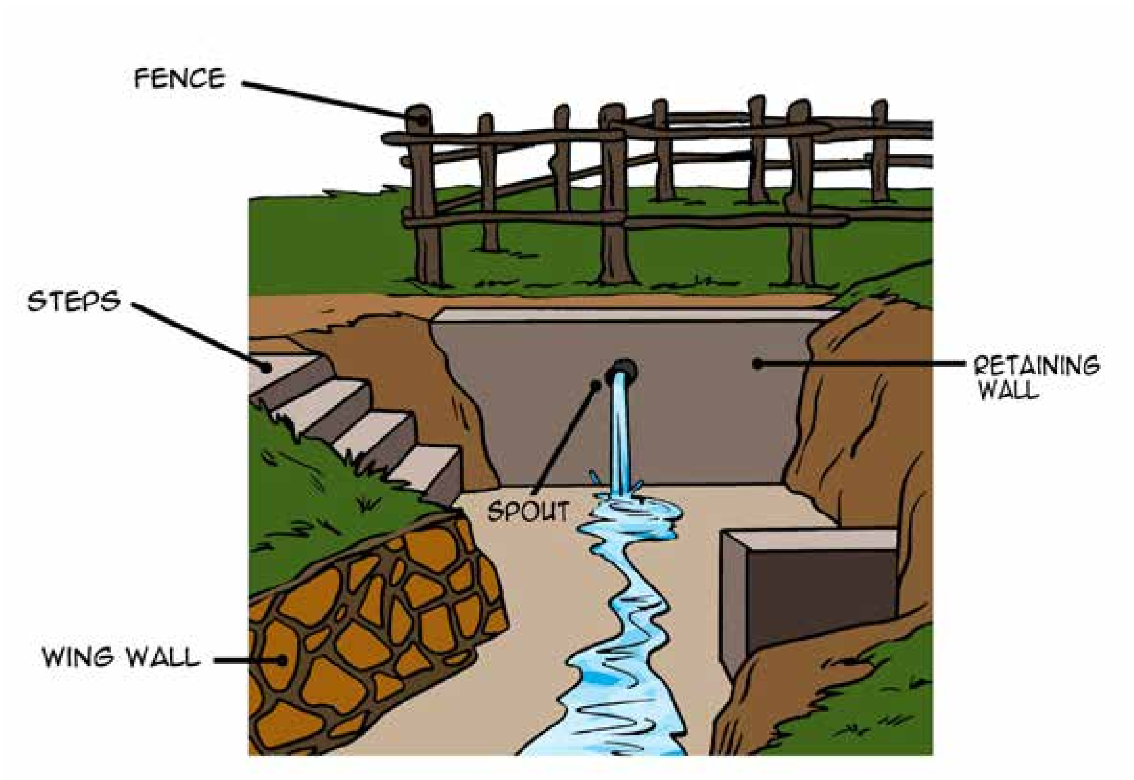


Figure 11: Ordinary Spring construction (for high-yield springs)

The number of spouts depends on the yield of the source. It is recommended to provide one spout for a flow of 8litres/minute.

Spring tank construction:

The spring tank construction is for low yield spring i.e. with flow of 4 – 8 litres/minute of flow. The key features are highlighted in the schematic drawing in Figure 12 below:

- Most of the design features are similar to the ordinary spring construction above but the overflow chamber behind the retaining wall is replaced by a storage tank to store off peak flows.
- The spring tank construction requires a fairly steep slope to accommodate the depth of the tank otherwise the retaining wall would have to be pushed farther down to create the necessary gap.

- The capacity of the tank should store about 10 hours of spring flow. A washout pipe is provided to facilitate cleaning. The overflow pipe empties into the sub-surface drain.

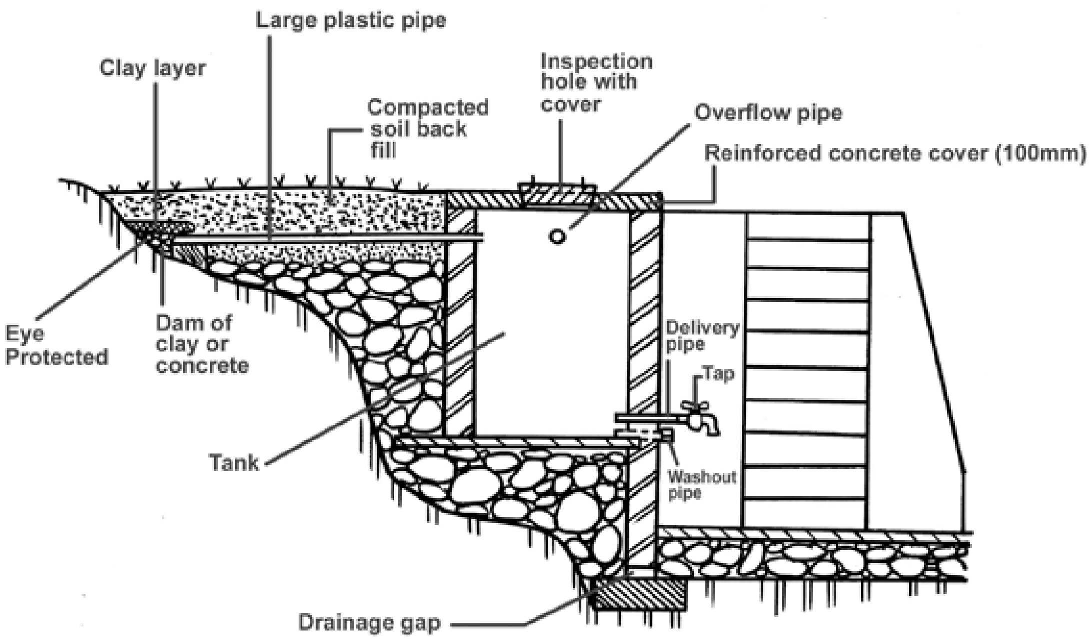


Figure 12: Spring Tank construction (for low-yield springs)

For yields below 4litres/minute, it is not economical to protect the spring for communal water supply.

(Detailed designs and construction steps are provided in the District Implementation Manual).

4.3.4 Operation and Maintenance of springs

Springs require minimal O&M since most of the construction/installations have no moving parts. Some of the key O&M undertakings are:

- Monitor any major reduction in the spring flow and check for signs of water escape, which should be stopped immediately.
- Regular clearing of the wastewater drain to ensure no stagnant water.
- Checking for any cracks in the retaining wall and the slab and carrying out necessary repairs immediately.
- Check for any damage to the steps and the slab and repair as necessary.
- Repairing the fence around the protected spring compound to keep animals out.
- Weeding and slashing the protective grass cover to ensure it is not overgrown.
- For spring tank, check for leakage in the tap and repair or replace as necessary.
- Check for any cracks or leakage in the tank and repair immediately.

4.3.5 Roles of Stakeholders in Construction of Rainwater Facilities

District Water Officer

- Oversee, supervise and evaluate work in progress. Monitor contractor conduct testing procedures and schedules.
- Co-ordinate site meetings with contractor and consultants and ensure that the decisions arrived at in the meeting are implemented.
- Provide oversight as required of contractor's compliance with schedule and technical performance.
- Procure all owner-related testing and reports including: geophysical reports, environmental reports, design and other technical reports, training reports, and mobilisation and other necessary reports.
- Inspect completed works and prepare recommendations to the CAO/DE regarding the acceptability of the product including any inadequacies noted in the specifications and technical requirements.
- Develop District's prompt responses to contractor deliverables and provide recommendations to the CAO.
- Review contractor claims for payment. Make payment recommendations to the CAO/DE.
- Ensure that District meets its compliance obligations.
- Quantify and coordinate removal of all environmental concerns as recommended in the reports.

Contractor

- Ensure that designs and procedures are followed as per the specifications.
- Provide safe working conditions to the employees in relations to Acts and regulations (Health and safety regulations) by the rightful authority.
- Notify the client and consultant where the design may not be workable or has inadequacies. If the proposed procedures are not appropriate given the circumstances, the contractor should inform both the client and consultant.
- Ensure the testing of all materials used as may be specified in the contract/or in accordance with acceptable construction practice.
- Prepare and submit to the consultant the invoices for the works done.
- Attend all the site meetings and/or cause them to be held.

Consultant

- Ensure the contractor follows the designs and technical specifications.
- Ensure the workmanship of the contractor is acceptable.
- Prepare payment certificates for the Contract.
- Facilitate communication between the Client and the Contractor.
- Monitor systems performance during defects liability period, and get the contractor to

correct any construction defects.

Extension Worker

- Plan with the community on their participation during construction (provision of labour, materials etc.)
- Monitor the contractor's work to ensure that it follows the terms of the contract.
- Report to the District Water Office on the work progress
- Facilitate communication between the Contractor, the Consultant and the community.
- Communicate to the community the work programme and the work progress.
- Monitor systems for defects during the defects liability period, and report to the DWO.

4.3.6 Quality Checks Guideline for Spring Protection

Spring Protection – Materials Quality Check Form

District:..Sub-county:..

Parish: ....Village:...

Source Name: ....Source Number: ....

Contracted Firm: ....Contract Ref. No:...................................

Local Contact Person:...

Date: ....

Materials Grading: Recommended: **1** Not recommended: **2**

Description of Material	Grade	Remark
1. **Lake sand:** Rough texture, water washed, and free of organic material and clay. 2. **Plaster sand:** Clean and free from inclusion like clay, organic matter, and soil. 3. **Aggregates:** Machine-crushed, 12mm (18mm maximum) size, no organic material, dust, and clay. 4. **Cement:** Ordinary Portland cement free of lumps. 5. **Blocks:** Should be 230mm (9") wide and with firm edges. 6. **Hardcore:** Should be irregular in shape, clean and from fresh rock. 7. **Clay:** Should be well kneaded to a homogeneous texture before placement. When rolled, it should not stick in the palm. 8. **PVC pipe:** To be 63mm (2 ½") nominal diameter and 3.5mm wall thickness		

Supervisor: Contractor:

Name: ....Name: ....

Designation: ....Designation:...

Date: ....Date: ....

Spring Protection – Construction Quality Check Form

District: ....Sub-county:..

Parish: ....Village: ....

Source Name: ....Source Number:..

Contracted Firm: ....Contract Ref. No:..

Local Contact Person: ....

Date: ....

Rating Levels: Good: **1** Fair: **2** Poor: **3**

Component	Construction	Rating	Remark
1. **Drainage:** Good slope to allow good flow; and wall inclined for stability			
2. **Floor and Base:** Thickness, slope and step between flow and channel as per design.			
3. **Steps:** ▪ Concrete well compacted ▪ Riser not more than 200mm ▪ Tread not less than 300mm			
4. **Retaining Wall:** Blocks well laid and wall is plumb.			
5. **Wing Wall:** Stones in the pitching well laid out and bonding well done			
6. **Finishing:** ▪ Clay layer (100mm) ▪ Sand layer (200mm) ▪ Back filling ▪ Grass planted ▪ Fence constructed			
7. **Cut – off Drain:** Constructed, depth conforms to design, etc.			

Supervisor: Contractor:

Signed: ....Signed: ....

Name: ....Name: ....

Designation: ....Designation: ....

Date: ....Date: ....

This form is to be filled at every site visit the Supervisor makes.

4.4 Shallow Wells

4.4.1 General Description

In Uganda, a shallow well refers to water well constructed to a depth of up to 30 metres to abstract shallow groundwater. Shallow wells are usually located in valleys where groundwater table is near the surface. There are two broad types of shallow wells: hand-dug wells and tube wells.

Hand-dug wells are no longer funded by government but are promoted as self-supply technology to provide water for both human consumption and production. They are usually large diameter wells (1.2 – 2 metres wide) excavated by hand with depths ranging from 5 – 20 metres. The wells are usually lined with block/brick masonry or concrete rings and installed with hand pumps.

Tube wells are drilled either manually (using auger) or using light motorised rig up to a depth of 15 – 30 metres and 180 – 200 mm in diameter. The wells are lined with plastic casing pipes and installed with hand pumps.

4.4.2 Application of Shallow wells

Shallow wells installed with hand pumps are widely used for rural water supply in Uganda. Well constructed shallow wells supply adequate good quality water for domestic use to communities.

Private shallow wells usually without hand pumps are also common in many parts of the country supplying households with fairly low quality water normally used for non-potable purposes including laundry, watering animals, and vegetable gardening.

Advantages of Shallow Wells

- Supplies good quality water for domestic use.
- Relatively easy to construct requiring less complex equipment than boreholes.
- Takes short time to construct (especially tube wells).
- Can be constructed near population centres to reduce walking distance (motorised tube wells).
- They are relatively easy to operate and maintain because of the shallow depth.

Disadvantages of Shallow Wells

- Can experience seasonal variation in yield (especially hand dug/drilled wells).
- Wells are usually located in valleys and are not likely to reduce walking distance.
- High safety risks during construction (hand dug wells).
- Water quality can be affected by surface water seepage and latrines constructed near water sources.

- Wells can silt up if drilled in very loose formations.
- Costs of motorised drilling can be high especially for hard to reach sites.

4.4.3 Design Highlights for Shallow Wells

Four key considerations are made when designing shallow wells to ensure that the well will function properly and the water supplied is of acceptable quality. The key considerations are:

- The location of the well in relation to the nearby human settlements – wells should ideally be uphill from human settlements to reduce the risk of contamination from human activities and at least 30 metres on level ground from on site sanitation facilities or potential source of contamination.
- The (safe) yield of the well normally measured at the end of the dry season when the groundwater table would be at the lowest level. The yield would determine whether the well can satisfy the water demand of the target population and would inform the design of the well.
- The quality of water to determine its suitability for human consumption or whether the water can be treated to make safe.
- The terrain of the area and soil type around the proposed site to determine whether adequate runoff and wastewater drainage can be conveniently provided or whether the well can be safely constructed without causing soil collapse.

A preliminary survey to assess the potential for shallow well is first carried out by:

- Reviewing the water resources map available at the district to see average depth to water table in the area.
- Investigating the risks of flooding around the proposed sites usually located close to valleys where the water level is near the surface.
- Assessing existence and seasonality of traditional sources, ponds, water holes and springs, and also the existence of vegetation common in wet areas, These are an indication of shallow water potential.
- Investigating whether there are records of pit latrines reaching groundwater in the area.
- Checking for any potential sources of contamination like graveyards, latrines (old or new), animal pens, and kraals near the proposed sites.

After successful preliminary surveys, a detail investigation by test drilling is carried out to confirm availability of shallow water table, estimate the yield, determine water quality, and assess the soil formation.

The Shallow Wells Manual (2007) and the District Implementation Manual (2013) give detailed technical designs and approaches to construction for shallow wells. Brief descriptions of each shallow well technology design construction are given below.

<u>Hand-Dug Well Construction</u>

Hand dug well construction poses very high safety risks and maximum precautions must be taken to avoid potentially fatal accidents usually caused by collapsing soil. As a minimum requirement therefore:

- Hand dug wells must only be constructed in areas with firm and stable soil formation to reduce the risk of soil collapse during excavation.
- All workers in the well must wear hard hats to protect the head from falling objects.
- Proper lifting equipment must be provided for removing excavated soil from the well.
- All excavation within the water bearing layer must be done within the protective concrete ring well lining that would be lowered progressively as excavation proceeds.

The design outline for hand dug well is shown in Figure 13 below and the key features are:

- Open jointed well lining with gravel and hardcore backfill in the water bearing zone for water to flow freely into the well.
- Clay seal at least 1 metre deep is provided above the gravel/hardcore backfill where the well lining is sealed to prevent surface contamination from entering the well. Where the water table is very high, the clay seal should be placed to start at least 3 metres below the ground surface and extend at least 1 metre above the water table.
- Compacted soil backfill should be placed on top of the clay seal up to about 1 metre from the ground surface then complete the backfill with clay sanitary seal to protect against inflow of wastewater. Where the water table is very high, the sanitary seal can merge with the clay seal to form a continuous layer of protection.
- The well lining should extend slightly above the ground level so that the cover is entirely above ground to allow for construction of the apron and the landscaping around the well to slope outwards to drain away the surface runoff.
- Because of the shallow groundwater, the wastewater should drain into the natural drainage course instead of the soak pit, which could instead become a source of contamination.
- Surface runoff diversion drain should be provided at least 5 metres from the well apron to channel water into the natural drainage course.

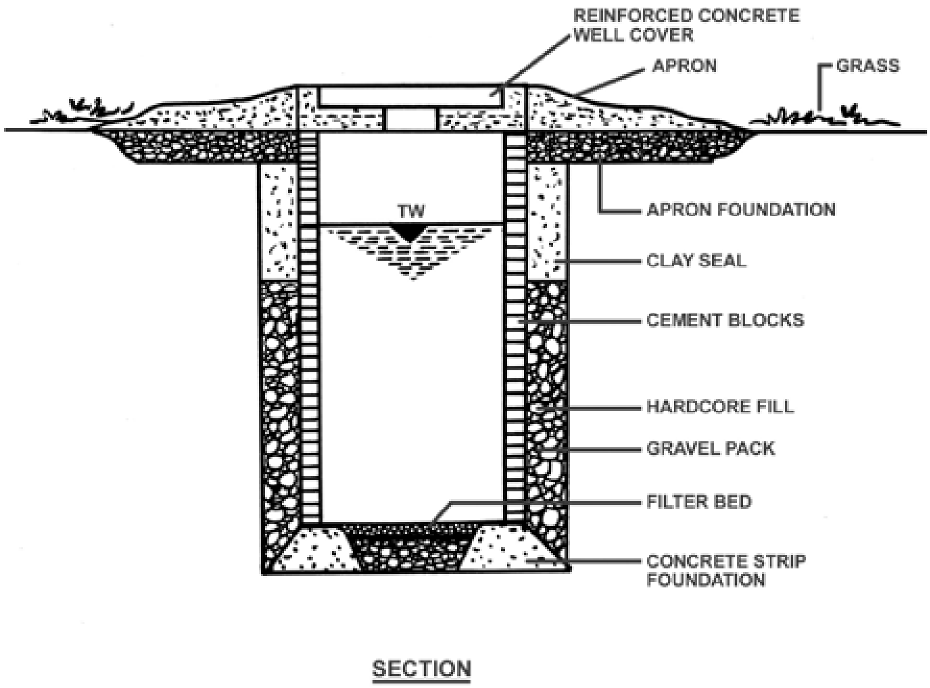


Figure 13: Section through a hand dug well

Tube well Construction

The design outline for tube well is shown in Figure 14 below and the key features are:

- Screened casing with well graded gravel pack in the water bearing zone for water to flow freely into the well. At least 1 metre length of plain casing plugged at the bottom is connected below the screen casing to provide storage for silt entering the well.
- Cement grout at least 1 metre deep is provided above the gravel pack where the plain well casing begins to prevent surface contamination from entering the well.
- Compacted soil backfill should be placed on top of the cement grout up to about 3 metres from the ground surface, then complete the backfill with cement grout sanitary seal to protect against inflow of wastewater. The sanitary seal should stop about 0.4 metre from the top for construction of the pump pedestal.
- The well casing should extend slightly above the ground level so that the apron is entirely above ground to allow for landscaping around the well to slope outwards to drain away the surface runoff.
- Because of the relatively shallow groundwater, the wastewater should drain into the natural drainage course instead of the soak pit, which could instead become a source of contamination.
- Surface runoff cut off drain should be provided at least 5 metres from the well apron to channel water into the natural drainage course.

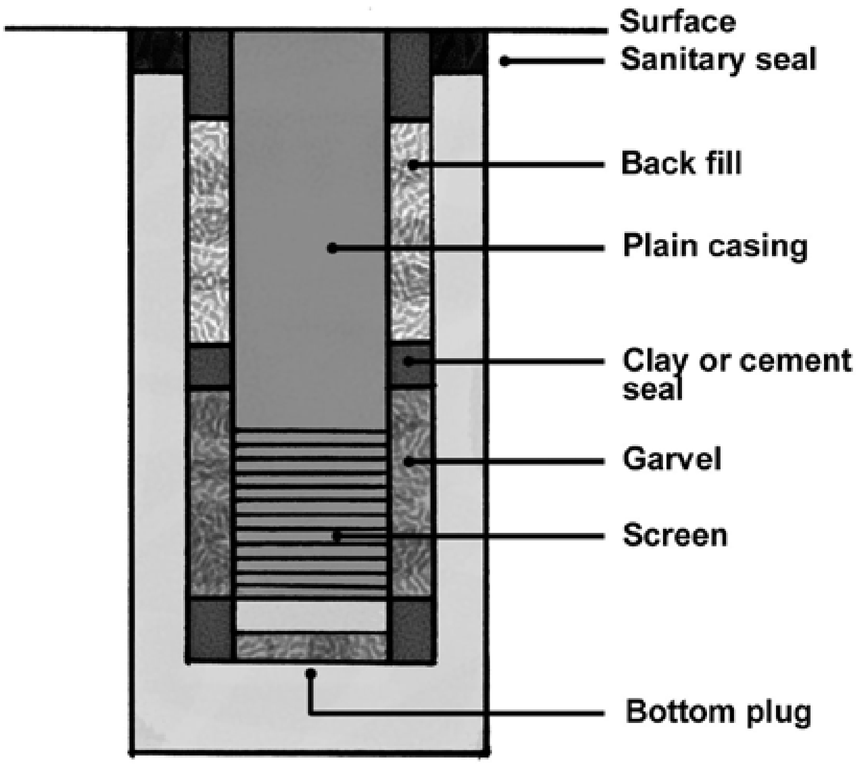


Figure 14: Tube well design and installation

4.4.4 Operation and Maintenance of Shallow Wells

The O&M for shallow wells are in two parts i.e. for the well construction and for the pump installation; the O&M for hand pump is covered under 'Hand Pumps' below. Some of the key O&M undertakings for shallow wells are:

- Checking for any cracks in the cover slab, apron, and drainage channel and carrying out necessary repairs immediately.
- Regular clearing of the wastewater drain to ensure no stagnant water.
- Repairing the fence around the protected well compound to keep animals out.
- Weeding and slashing the protective grass cover to ensure it is not overgrown.
- For tube wells, checking for soil particles in the pumped water to determine the level of siltation; accumulated silt should be pumped out immediately to preserve the water quality.

4.4.5 Roles of Stakeholders in Construction of Shallow wells

<u>**District Water Officer**</u>

- Oversee, supervise and evaluate work in progress. Monitor contractor conduct testing procedures and schedules.
- Co-ordinate site meetings with contractor and consultants and ensure that the decisions arrived at in the meeting are implemented.

- Provide oversight as required of contractor's compliance with schedule and technical performance.
- Procure all owner-related testing and reports including: geophysical survey reports; environmental reports; design and other technical reports; training reports; and mobilisation and other necessary reports.
- Inspect completed works and prepare recommendations to the CAO/DE regarding the acceptability of the product including any inadequacies noted in the specifications and technical requirements.
- Develop District's prompt responses to contractor deliverables and provide recommendations to the CAO.
- Review contractor claims for payment. Make payment recommendations to the CAO/DE.
- Ensure that District meets its compliance obligations.
- Quantify and coordinate removal of all environmental concerns as recommended in the reports.

Contractor

- Ensure that designs and procedures are followed as per the specifications.
- Provide safe working conditions to the employees in relations to Acts and regulations (Health and safety regulations) by the rightful authority.
- Notify the client and consultant where the design may not be workable or has inadequacies. If the proposed procedures are not appropriate given the circumstances, the contractor should inform both the client and consultant.
- Ensure that purchased equipment and materials/pipes have warranty that will assist the client after the liability period. Hand over warranty to the client at end of the contract.
- Ensure the testing of all materials used as may be specified in the contract/or in accordance with acceptable construction practice.
- Prepare and submit to the consultant the invoices for the works done.
- Attend all the site meetings and/or cause them to be held.

Consultant

- Ensure the contractor follows the designs and technical specifications.
- Ensure the workmanship of the contractor is acceptable.
- Prepare payment certificates for the Contract.
- Facilitate communication between the Client and the Contractor.
- Monitor systems performance during defects liability period, and get the contractor to correct any construction defects.

Extension Worker

- Plan with the community on their participation during construction (provision of labour, materials etc.)
- Monitor the contractor's work to ensure that it follows the terms of the contract.

- Report to the District Water Office on the work progress
- Facilitate communication between the Contractor, the Consultant and the community.
- Communicate to the community the work programme and the work progress.
- Monitor systems for defects during the defects liability period, and report to the DWO.

4.4.6 Quality Checks Guideline for Shallow Well Construction

Tube Well – Materials Quality Check Form

District: ....Sub-county:...

Parish: ....Village:..

Source Name: ....Source Number:..

Contracted Firm: ....Contract Ref. No: ....

Local Contact Person:...

Date: ....

Materials Grading: Recommended: **1** Not recommended: **2**

Description of Material	Grade	Remark
Temporary casing		
Plain casing (jointing, diameter, and thickness)		
Screen casing (jointing, diameter, thickness, machine slotted and size of slots)		
Cement		
Gravel pack (size grading and roundness)		
Membrane pump		
Hoisting rig		
Drill bits		
Other (specify):		
▪		
▪		

Supervisor: Contractor:

Signed: ....Signed: ....

Name: ....Name: ....

Designation: ....Designation: ....

Date: ....Date: ....

Tube Well – Construction Quality Check Form

District: ....Sub-county: ....

Parish: ....Village: ....

Source Name:....................................Source Number:...

Contracted Firm: ....Contract Ref. No:..

Date of Commencement: ....Date of this check: ....

Type of Drill:...

Depth attained: ....

Local Contact Person: ....

Rating Levels: Good: **1** Fair: **2** Poor: **3**

Component	Rating	Remark
1. Temporary Casing: Installation and Verticality		
2. Sampling drill cuttings		
3. Keeping of Driller's log		
4. Gravel Packing placement		
5. Permanent casing and plug installation		
6. Sanitary seal installation		
7. Well development		
8. Well capping and cleaning of site (at completion)		

General Remarks:

....
....
....

Supervisor: Contractor:

Signed: ....Signed: ....

Name: ....Name: ....

Designation:..Designation: ....

Date: ....Date: ....

This form is to be filled at every site visit the Supervisor makes.

Dug Well – Materials Quality Check Form

District: ....Sub-county: ....

Parish: ....Village: ....

Source Name: ....Source Number:...

Contracted Firm: ....Contract Ref. No: ....

Local Contact Person: ....

Date: ....

Materials Grading: Recommended: **1** Not recommended: **2**

Material	Grade	Remarks
1. Coarse aggregate (stone type, size)		
2. Gravel pack (size grading; roundness)		
3. Cement		
4. Blocks (strength, strong edges)		
5. Concrete rings (strength, uniformity)		
6. Porous rings (strength, uniformity)		
7. Sand (clean, rough, no clay content)		
8. Hard core (hard, sharp edges)		
9. Clay		
10. Others (specify)		
•		
•		

General Remarks:

....
....
....

Supervisor: Contractor:

Signed: ....Signed: ....

Name: ....Name: ....

Designation:..Designation: ....

Date: ....Date: ....

This form is to be filled at every site visit the Supervisor makes.

Dug Well – Construction Quality Check Form

District: ....Sub-county: ....

Parish: ....Village: ....

Source Name: ....Source Number:...

Contracted Firm: ....Contract Ref. No: ....

Date of Commencement:....................Date of this check: ....

Diameter of Well: ....Depth attained: ....

Rest Water Level (metres below ground):...

Local Contact Person: ....

Rating Levels: Good: **1** Fair: **2** Poor: **3**

Component	Rating	Remark
Open Hole: ▪ Stable/Collapsing ▪ Vertically straight **Well Lining:** ▪ Well aligned ▪ Well bonded ▪ Workmanship/finishing **Filter/Backfill:** ▪ Hardcore/gravel placing ▪ Water colour in the morning **Concrete Cover, Apron and drain:** ▪ Cracks ▪ Slope of drain ▪ Drainage around well		

General Remarks:

....
....
....

Supervisor: Contractor:

Signed: ....Signed: ....

Name: ....Name: ....

Designation:...Designation: ....

Date: ....Date: ....

This form is to be filled at every site visit the Supervisor makes.

4.5 Borehole Construction

4.5.1 General Description

Boreholes are similar to tube wells but are usually to depths ranging from 30 – 120 metres and 20 centimetre diameter thereby tapping into the deep and more reliable groundwater body. Boreholes can be sited in relatively higher grounds and also nearer to human settlements to reduce walking distances to the improved water source.

Boreholes are drilled using heavy duty rigs that can easily drill through the consolidated rock formation. The wells are lined with plastic casings backfilled with gravel pack and cement grout and are usually installed with hand pumps. However, they are considerably more expensive to construct than shallow wells but provide more reliable water supply nearer to the target population.

4.5.2 Application of Borehole

Boreholes are the main sources of water supply to rural communities in Uganda because of the abundant groundwater of relatively good quality in most parts of the country. An analysis of new water sources constructed in 2013/2014 in the sector indicated that 69% were from groundwater (boreholes, shallow boreholes, and protected springs).

Production boreholes are large capacity/high yield boreholes commonly used as water supply source for pumped pipe supplies in small towns and rural growth centres.

Advantages of Boreholes:

- Mechanised drilling is fast and water sources can be constructed quickly.
- Can be constructed in all formations and wells are much deeper thereby less susceptible to contamination by surface water or sanitation facilities.
- Can reliably supply large quantity of water throughout the year.
- It is widely used in most parts of the country. It is therefore easy to get supplies of spares for O&M.

Disadvantages of Boreholes:

- The cost of construction is very high and communities usually require external support to construct.
- All the investigation, design, construction, installation, and supervision works need skilled and experienced personnel and specialised equipment thereby limiting community participation and therefore ownership.
- The cost and also skills for O&M (especially for the installed hand pumps) is also very high compared with the other appropriate technologies.

- Some wells produce highly mineralised water, which may be objectionable to taste and not suitable for washing especially with soap.

4.5.3 Design Highlights for Borehole Construction

Most of the site investigations, designs, and construction of boreholes are carried out with highly specialised equipment and skills thereby limiting the roles of the community and the extension staffs. Some preliminary investigations usually carried out before detailed siting and design of boreholes are:

- Study of existing data/records of boreholes drilled in nearby communities.
- Review of the water resources map available at the district water office.
- Data from village identification and information gathering visits assessing physical features indicating presence of groundwater.

The key outline design and installation for a borehole is detailed in Figure 15 below. The apron and drainage construction is similar to that of tube wells though soak pit can be used for wastewater disposal without risking the quality of water in the borehole.

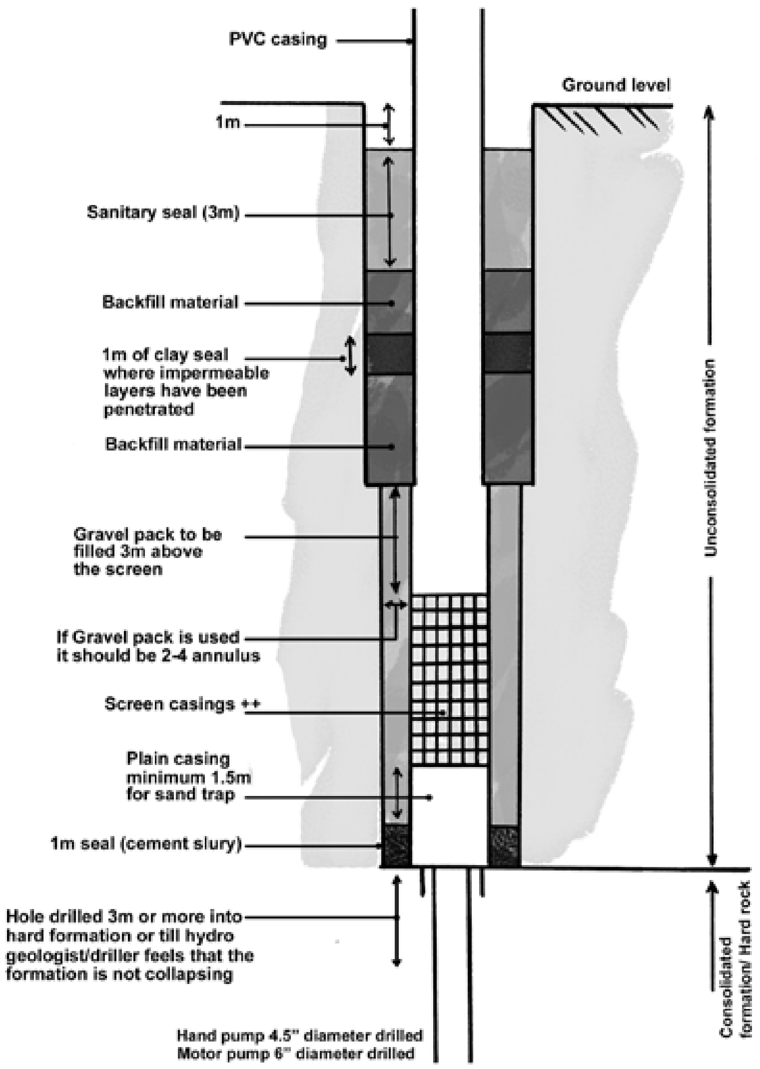


Figure 15: Detailed outline design and installation of borehole

4.5.4 Operation and Maintenance of Boreholes

The O&M for boreholes are in two parts i.e. for the construction works and for the pump installation. The O&M for hand pump is covered under 'Hand Pumps' below. Some of the key O&M undertakings for boreholes are:

- Checking for any cracks in the apron and drainage channel and carrying out necessary repairs immediately.
- Regular cleaning of the soak pit to ensure no stagnant water.
- Repairing the fence around the protected borehole compound to keep animals out.
- Weeding and slashing the protective grass cover to ensure it is not overgrown.
- For the long term, monitor the yield of the borehole to determine whether it is silted. De-silting can only be carried out using mechanised equipment.

Borehole rehabilitation is a major restoration work usually carried out on boreholes that are no longer in use. In most cases, it requires skills, equipment, and finances that are beyond the capacity of the community. Typical activities grouped under rehabilitation include:

- Re-alignment of casings in old boreholes
- Fishing out the fallen pump parts and
- Re-developing the borehole to restore the yield required for pump installation.

Sometimes poor routine maintenance and repairs of boreholes leads to major breakdowns that would require rehabilitation work.

4.5.5 Roles of Stakeholders in Construction of Borehole Facilities

District Water Officer

- Oversee, supervise and evaluate work in progress. Monitor contractor conduct testing procedures and schedules.
- Co-ordinate site meetings with contractor and consultants and ensure that the decisions arrived at in the meeting are implemented.
- Provide oversight as required of contractor's compliance with schedule and technical performance.
- Procure all owner-related testing and reports including: geophysical survey reports, environmental reports, design and other technical reports, training reports, mobilisation and other necessary reports.
- Inspect completed works and prepare recommendations to the CAO/DE regarding the acceptability of the product including any inadequacies noted in the specifications and technical requirements.
- Develop District's prompt responses to contractor deliverables and provide recommendations to the CAO.

- Review contractor claims for payment. Make payment recommendations to the CAO/ DE.
- Ensure that District meets its compliance obligations.
- Quantify and coordinate removal of all environmental concerns as recommended in the reports.

Contractor

- Ensure that designs and procedures are followed as per the specifications.
- Provide safe working conditions to the employees in relations to Acts and regulations (Health and safety regulations) by the rightful authority.
- Notify the client and consultant where the design may not be workable or has inadequacies. If the proposed procedures are not appropriate given the circumstances, the contractor should inform both the client and consultant.
- Ensure that purchased equipment and materials/pipes have warranty that will assist the client after the liability period. Hand over warranty to the client at end of the contract.
- Ensure the testing of all materials used as may be specified in the contract/or in accordance with acceptable construction practice.
- Prepare and submit to the consultant the invoices for the works done.
- Attend all the site meetings and/or cause them to be held.

Consultant

- Ensure the contractor follows the designs and technical specifications.
- Ensure the workmanship of the contractor is acceptable.
- Prepare payment certificates for the Contract.
- Facilitate communication between the Client and the Contractor.
- Monitor systems performance during defects liability period, and get the contractor to correct any construction defects.

Extension Worker

- Plan with the community on their participation during construction (provision of labour, materials etc.)
- Monitor the contractor's work to ensure that it follows the terms of the contract.
- Report to the District Water Office on the work progress
- Facilitate communication between the Contractor, the Consultant and the community.
- Communicate to the community the work programme and the work progress.
- Monitor systems for defects, during the defects liability period, and report to the

DWO.

4.5.5 Quality Checks Guideline for Borehole Construction

Borehole – Materials Quality Check Form

District: ....Sub-county: ....

Parish: ....Village: ....

Source Name: ....Source Number:..

Contracted Firm: ....Contract Ref. No: ....

Local Contact Person: ....

Date: ....

Materials Grading: Recommended: **1** Not recommended: **2**

Description of Material	Grade	Remark
1. Temporary casing 2. Plain casing (jointing, diameter, and thickness) 3. Screen casing (jointing, diameter, thickness, machine slotted and size of slots) 4. Cement 5. Gravel pack (size grading and roundness) 6. Type of Drilling rig 7. Drill bits 8. Other (specify): ▪ ▪		

Supervisor: Contractor:

Signed: ....Signed: ....

Name: ....Name: ....

Designation:..Designation: ....

Date: ....Date: ....

Borehole – Construction Quality Check Form

District: ....Sub-county: ....

Parish: ....Village: ....

Source Name: ....Source Number:...

Contracted Firm: ....Contract Ref. No: ....

Date of Commencement:...................Date of this check: ....

Type of Drill: ....

Depth attained: ....

Local Contact Person: ....

Rating Levels: Good: **1** Fair: **2** Poor: **3**

Component	Rating	Remark
1. Temporary Casing: Installation and Verticality		
2. Sampling drill cuttings		
3. Keeping of Driller's log		
4. Gravel Packing placement		
5. Permanent casing and plug installation		
6. Sanitary seal installation		
7. Well development		
8. Well capping and cleaning of site (at completion)		

General Remarks:

....
....
....

Supervisor: Contractor:

Signed: ....Signed: ....

Name: ....Name: ....

Designation:...Designation: ....

Date: ....Date: ....

This form is to be filled at every site visit the Supervisor makes.

4.6 Pumps

4.6.1 Introduction

Different types of pumps are used in the water supply sub-sector and can be broadly classified under hand pumps and motorised pumps. Hand pumps are widely used on shallow wells and boreholes for communal point water source supply and can be operated and maintained by communities using trained and equipped Hand Pump Mechanics (HPMs) in the communities. Motorised pumps are commonly used in piped water supply schemes drawing water from groundwater or surface water sources.

The Government approved commonly used hand pumps for Uganda are:

- The U2 hand pump for deep wells and boreholes.
- The U3 hand pump for deep wells and boreholes.
- The modified U2 and U3 (light handle) pump for shallow wells, The pumps for hand dug wells are provided with base plates for attaching on the cover slabs with anchor bolts.
- Rope pumps used mainly on hand-dug wells.

These pumps fit the global specifications for Village Level Operation and Maintenance (VLOM) technologies.

The motorised pumps commonly used in Uganda can be broadly classified as:

- Electric pumps; which can be powered by electricity from the grid or generators and solar power. They can either be submersible/lift pumps or surface/suction pumps.
- Combustion engine powered pumps that run on fuel (i.e. petrol, diesel, or gas).
- Windmill powered pumps

4.6.2 Key Design Features and Applications of Hand Pumps

U2 and U3 Hand Pumps:

The typical U2 and U3 pump head assembly is shown in Figure 16 below. The only key differences between the two hand pumps are the diameter of the rising main and the pump cylinder assembly.

The U2 hand pump uses 1¼" diameter riser pipes with a correspondingly smaller connector on the cylinder assembly, while the U3 hand pump uses 2½" diameter riser pipes with a larger diameter connector to the cylinder assembly (Figure 17). The cylinder for U3 is modified to facilitate extraction of the plunger and check/foot valve assemblies for repair or to reduce the weight of the riser pipe, which would be too heavy during lifting if it is holding water.

The common materials for below ground components are Galvanised Iron (GI) rising mains and stainless steel pump rods. In areas where the water is corrosive, the pumps are installed with stainless steel or fibre reinforced un-plasticised PVC (uPVC) riser pipes and stainless steel pump rods, The stainless steel pipes are much more expensive than the GI pipes but serve much longer.

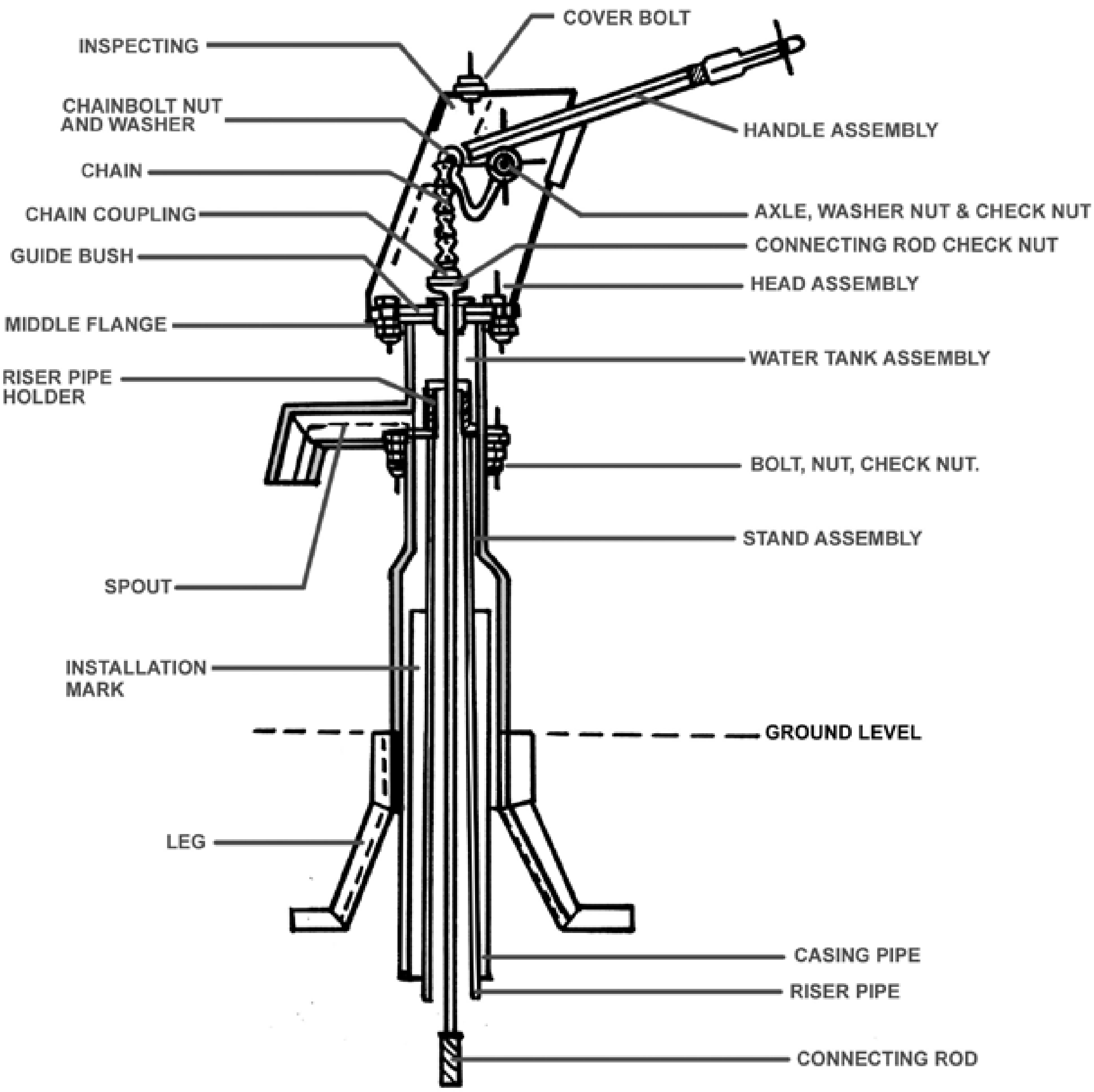


Figure 16: Pump head assembly

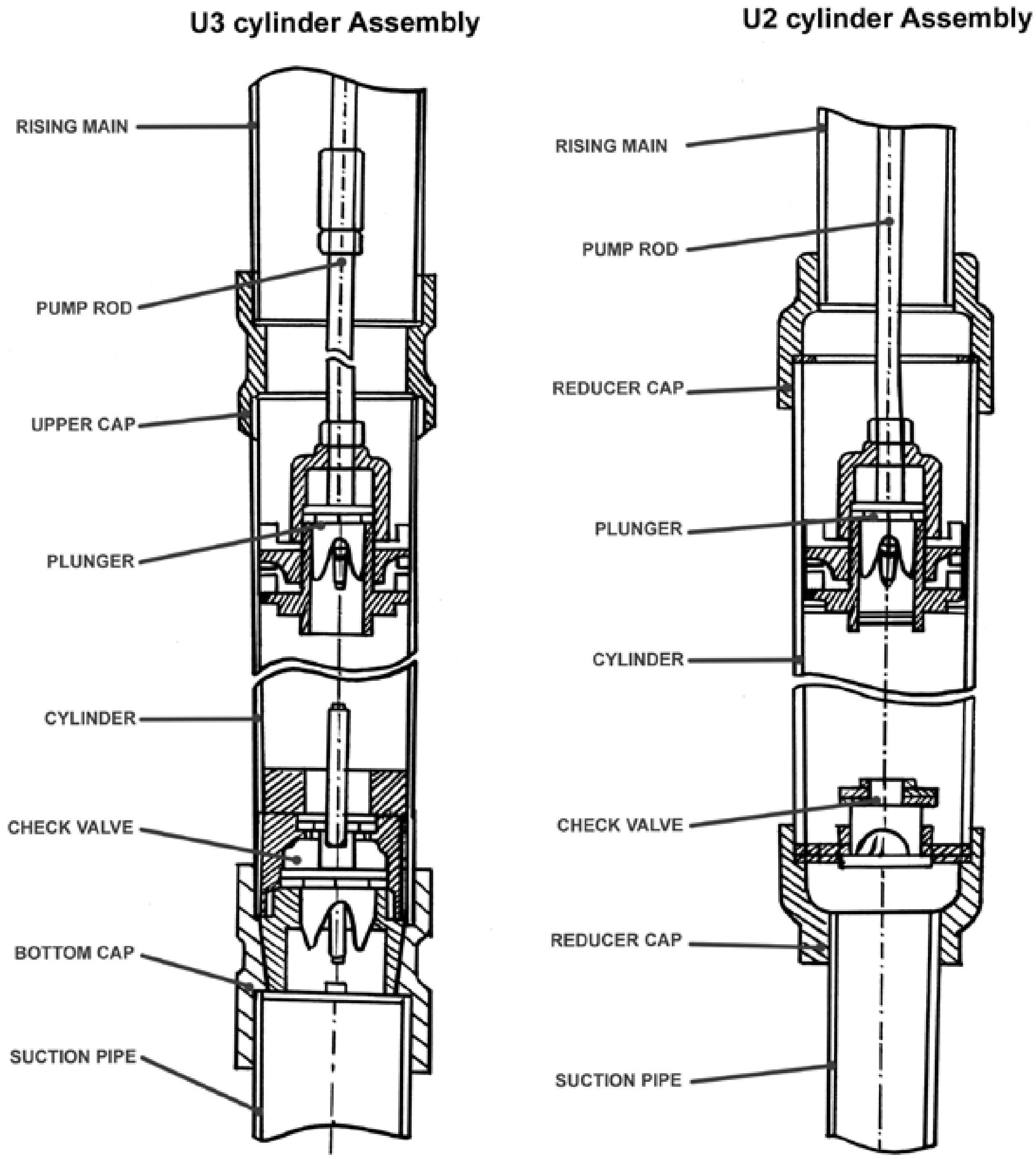


Figure 17: Cylinder assembly for U3 (left) and for U2 (right)

Rope Pump:

The rope pump (Figure 18) consists of small plastic pistons lined up on a rope and pulled through a plastic rising pipe over a crank operated drive wheel. A ceramic guide box leads the rope with the pistons through the rising pipe; the pump is generally corrosion resistant.

The pump is usually installed on dug wells or underground storage tanks and can supply an average of 15 litres of water per minute from depths of up to 30 metres (lower discharge at greater depths). The pump can be locally manufactured by trained artisans and installation does not require special tools or lifting equipment and can be done by trained community mechanics.

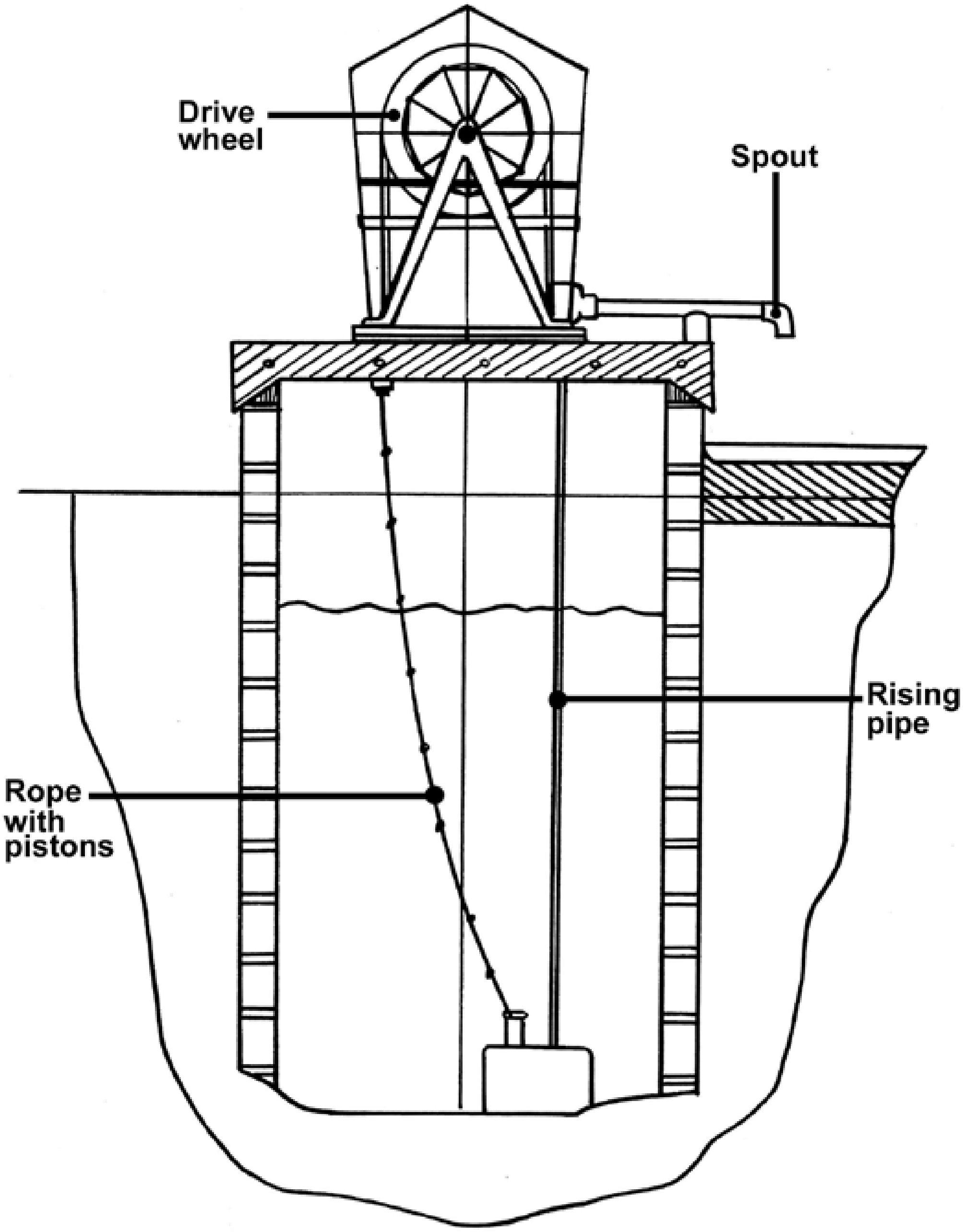


Figure 18: Rope pump installed on a dug well

<u>**Solar Pumps:**</u>

These are mainly submersible pumps running on Direct Current (DC) supplied by solar panels. There are three key components: the pump, the power regulator to stabilise the electricity generated, and the solar panels generating the electricity using the sunshine. The pumps can be installed on all water sources but they are commonly used on deep boreholes, wells, and underground storage tanks.

Pump selection and installation must be done by the design engineer to take into consideration the intended pumping rate, the operating head of the pump, and the power consumption. The power supply unit (solar panels and the regulator) should be properly balanced and must match the manufacturer's specifications for the pump to ensure proper operation.

Windmill:

This is basically a wind powered rotor comprising a set of wind vanes with a rudder mounted on a tower. The rotating vanes operate the pumping unit through a gearing or cam and shaft system converting the rotary motion into linear motion. The pumping unit can be the double action cylinder similar to the U2 and U3 cylinders or the membrane type. The wind mill can pump water from groundwater or surface water sources to elevated reservoirs for onward distribution to points of use.

Installation should be carried out by skilled personnel to ensure that the plumbing and gearing are properly done. The base as well as the assembly of the tower should be firm to carry the weight and withstand the force of the wind.

4.6.3 Operation and Maintenance

O&M for hand pumps is critical for the proper functioning of the wells/boreholes. Carrying out regular routine maintenance and minor repairs prolongs the service life of the pump and prevents major breakdowns that can be very costly or complex to handle by the community.

Some of the key O&M requirements for hand pumps are specified by the manufacturers and are highlighted below:

U2 and U3 Hand Pumps:

- Proper operation of the hand pump – avoid jerking and banging the handle when pumping water.
- Regular greasing of the chain (at least once a month) to reduce wear.
- Regular tightening of nuts in the pump head assembly to reduce play and wear.
- Periodically inspect the pump for worn out parts and replace as necessary to avoid breakdowns. Depending on the number of users, this could be done every three to four months.
- Monitor any changes in the water discharge rate and check the conditions of the rising main and the cylinder assembly if there is any significant drop in the rate.

The community should work closely with the HPMs to ensure that maintenance work is done in time and quality spare/replacement parts are used in repairs.

Rope Pump:

The rope pump can be entirely maintained at community level using materials locally available in shops. A torn or broken rope can be replaced without any special tools. A village caretaker can perform all maintenance operations.

Solar Pumps:

Maintenance and repairs of solar pumps should be done by qualified personnel according to manufacturer's specifications. For routine operation of the system, the pump attendant should regularly monitor the pumping rate of the pump and switch off the pump when the storage tank is full (and overflowing) to conserve the water.

Windmill:

Operation of the windmill basically involves setting the vanes to rotate or to stop by changing the alignment of the rudder. The vanes are usually stopped from rotating when the reservoir is full (to conserve water) or when the wind is too strong and is likely to cause damage to the windmill or the pumping unit.

Routine maintenance would involve regular greasing of bearings and gearings and tightening of bolts and nuts to minimise shaking and possible damage to the installation. Regular monitoring of the pumping rate would also determine how the pumping unit is performing.

During scheduled major maintenance, the technician should check the conditions of all moving parts (including the pumping unit and rods) for wear or damage and repair or replace worn out parts as necessary.

4.7 Piped Water Supply

4.7.1 Introduction

Piped water supply basically refers to piping water from the source (intake) to large number of consumers settled in wide areas often far away from the source. It is therefore a centralised water supply system where the entire target population rely on one source of water.

There are two main types of piped water supply: gravity flow scheme (GFS) and pumped scheme. For GFS, the water source is uphill from the target population and the water flows by gravity through the pipe networks to the various distribution points near the consumers. Pumped schemes normally draw water from any source but the water is pumped up into reservoir tank located above the target population; the water then flow by gravity to the distribution points near the consumers. Apart from the pumping station and the rising/pumping main in the pumped scheme, most of the installations for both systems are similar.

The key components of piped water supply are:

- The intake works at the source which can be: protected spring or river/stream diversion structures (for both schemes), deep borehole (production well) with a pump house, and other surface water bodies like dam or lake with pump house.
- Water treatment plants usually for surface water sources to improve the quality or prevent contamination of water supplied.
- Pumping main (for the pumped supply) or supply main (for GFS).
- Storage/service reservoir supplying the distribution network. This is necessary to store off peak flows if the yield of the source cannot meet the peak hourly demand of the population.
- Distribution pipe networks.
- Break pressure tanks (BPTs) especially in hilly areas, are provided where the water pressure in the pipeline is higher than the pressure rating of the pipe used <u>OR</u>

if the pressure in the pipeline is higher than the maximum pressure permitted at the tap stands.

- Tap stands.

Figure 19 shows a typical layout of a gravity flow scheme and Figure 20 shows the layout of a pumped scheme.

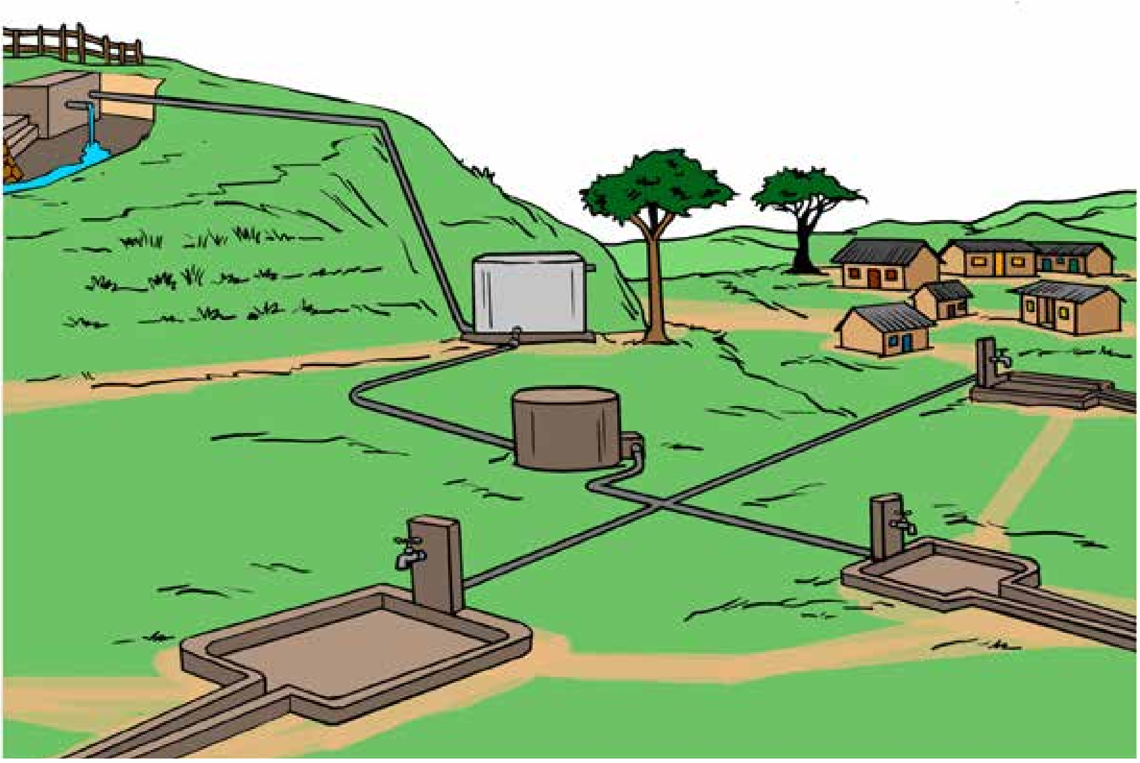


Figure 19: Schematic presentation a gravity flow scheme

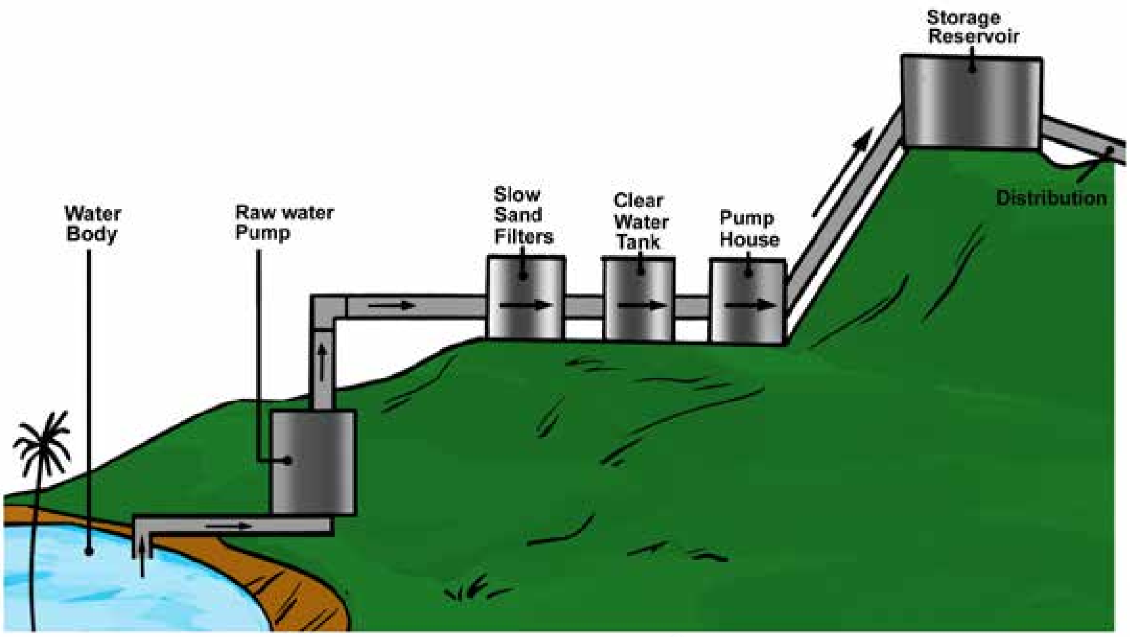


Figure 20: Diagrammatic representation of a piped water supply system

4.7.2 Application of Piped Supply Schemes

Piped supply schemes are widely used in the rural water supply sub-sector mainly to upgrade services that were otherwise provided through point water sources. GFS, the cheaper option, are common in rural areas where the terrains are hilly with many springs and streams uphill. Pumped schemes are common in rural growth centres where the population have more income to afford the water supply.

Schemes utilising unprotected sources like streams, rivers, or lakes usually incorporate small and basic water treatment works to improve the quality of water to 'acceptable' levels before distribution.

Advantages of Piped Supply Schemes:

- Distribute water within short walking distances to save time for other productive work.
- Can supply large quantity of water to increase the associated health benefits.
- Usually supply good quality water for general domestic use.

Disadvantages of Piped Supply Schemes:

- Very high community organisational level required for proper O&M.
- For treated water source, the system will require high level skills and resources for operation and maintenance.
- Pumped supply requires additional funding for O&M to pay skilled personnel operating and maintaining the motorised pumps and also running costs of the pump. This could be too costly for communities who cannot afford to pay.

4.7.3 Design Highlights for Piped Supply Schemes

Most investigation and designs are usually contracted out to experienced and skilled personnel with minimal involvement of the community. Preliminary surveys however involve the community and the extension staff mainly to:

- Identify the water source and estimate the yield and water quality.
- Identify the possible routes of the pipeline and location of critical structures like reservoir tank(s), water treatment works, and proposed tap stands.
- Assess the ability and willingness of the intended beneficiaries to pay for the planned services.
- Estimate the current and projected water demand of the area over a period of time (usually 20 years).

The construction of protected water sources like springs and boreholes shall follow the procedures already outlined above.

Detailed designs will provide:

- Accurate location and installations of the intake works, treatment works, and pump house.
- Accurate pipeline routes and the profile.

- Final locations of the various installations like the BPTs, tap stands, valve boxes, and storage reservoirs.
- The type and capacity of the pump(s) to be used and the proposed source of energy.
- The capacity and type of the reservoir tank(s) to be constructed.
- The sizes, types, and length of pipes to be laid.
- The expected flow rates at every tap stand and the number of people to be served there.
- The estimated construction costs of the scheme and the breakdown.

The detailed design developed is then used to contract out the construction work. The supervision and monitoring teams would also use it as a reference for carrying out their duties.

4.7.4 Operation and Maintenance of Piped Supply Scheme

The O&M of piped scheme should look at the three main components:

- The operation and maintenance of the intake works and the pumping units up to the reservoir tank(s). This will ensure that good quality water is constantly supplied for distribution to the consumers.
- The operation, maintenance, and management of the distribution pipelines that will ensure that leakages and pipe bursts are repaired in time, and the water flows to all the tap stands are balanced to meet the water demands at all points.
- The operation and maintenance of the tap stands to ensure that water is not wasted, taps are repaired or replaced promptly as necessary, consumers pay the user fees in time, and proper disposal of wastewater.

It is important to determine how much money is required to run the three levels of operation and build it into the total user fees to be distributed to the consumers.

4.7.5 Roles of Stakeholders in Construction of piped water

<u>District Water Officer</u>

- Oversee, supervise and evaluate work in progress. Monitor contractor conduct testing procedures and schedules.
- Co-ordinate site meetings with contractor and consultants and ensure that the decisions arrived at in the meeting are implemented.
- Provide oversight as required of contractor’s compliance with schedule and technical performance.
- Procure all owner-related testing and reports including: geophysical survey reports; environmental reports; design and other technical reports; training reports; and mobilisation and other necessary reports.
- Inspect completed works and prepare recommendations to the CAO/DE regarding the acceptability of the product including any inadequacies noted in the specifications and

technical requirements.

- Develop District's prompt responses to contractor deliverables and provide recommendations to the CAO.
- Review contractor claims for payment. Make payment recommendations to the CAO/ DE.
- Ensure that District meets its compliance obligations.
- Quantify and coordinate removal of all environmental concerns as recommended in the reports.

Contractor

- Ensure that designs and procedures are followed as per the specifications.
- Provide safe working conditions to the employees in relations to Acts and regulations (Health and safety regulations) by the rightful authority.
- Notify the client and consultant where the design may not be workable or has inadequacies. If the proposed procedures are not appropriate given the circumstances, the contractor should inform both the client and consultant.
- Ensure that purchased equipment and materials/pipes have warranty that will assist the client after the liability period. Hand over warranty to the client at end of the contract.
- Ensure the testing of all materials used as may be specified in the contract/or in accordance with acceptable construction practice.
- Prepare and submit to the consultant the invoices for the works done.
- Attend all the site meetings and/or cause them to be held.

Consultant

- Ensure the contractor follows the designs and technical specifications.
- Ensure the workmanship of the contractor is acceptable.
- Prepare payment certificates for the Contract.
- Facilitate communication between the Client and the Contractor.
- Monitor systems performance during defects liability period, and get the contractor to correct any construction defects.

Extension Worker

- Plan with the community on their participation during construction (provision of labour, materials etc.)
- Monitor the contractor's work to ensure that it follows the terms of the contract.
- Report to the District Water Office on the work progress
- Facilitate communication between the Contractor, the Consultant and the community.

- Communicate to the community the work programme and the work progress.
- Monitor systems for defects, during the defects liability period, and report to the DWO.

4.7.6 Quality Checks Guideline for Piped Water Supply

Piped Supply – Materials Quality Check Form

District: ....Sub-county: ....

Parish: ....Village: ....

Source Name: ....Source Number:..

Contracted Firm: ....Contract Ref. No: ....

Local Contact Person: ....

Date: ....

Materials Grading: Recommended: **1** Not recommended: **2**

No. Materials	Grade	Remark
1. **Lake sand:** Rough texture, water washed, and free of organic material and clay		
2. **Plaster Sand:** Clean and free from clay, organic matter, soil		
3. **Aggregates:** Size 12mm, maximum allowance size is 18mm, free of organic material and dust		
4. **Hardcore:** Irregular in shape, clean, and from fresh rock.		
5. **Cement:** Ordinary Portland cement that is free of lumps.		
6. **Blocks/bricks:** Good quality and with firm edges.		
7. **GI pipe:** class "B", rust free, male threaded both ends with socket on one end.		
8. **Pipes (PVC and HDPE):** Specified class (PN rating) and free of cracks and other deformities.		
9. **Reinforcement bars:** Even dimension, NOT over rusted, and of visibly homogeneous material.		
10. **Fittings:** Specified class and PN rating		

General Remarks:

....

....

....

Supervisor: Contractor:

Signed: ....Signed: ....

Name: ....Name: ....

Designation:..Designation: ....

Date: ....Date: ....

This form is to be filled at every site visit the Supervisor makes.

Piped Supply – Construction Quality Check Form

District: ....Sub-county: ....

Parish: ....Village: ....

Source Name: ....Source Number:..

Contracted Firm: ....Contract Ref. No: ....

Local Contact Person: ....

Rating Levels: Good: **1** Fair: **2** Poor: **3**

Component	Rating	Remark
Brick/stone masonry work:		
▪ Damp proof course		
▪ Bonding		
▪ Plumpness		
▪ Cement slurry coating		
▪ Bituminous paint		
Concrete/Ferro-cement:		
▪ Reinforcement bars/mesh – placement		
▪ Mix ratio and placement (concrete/mortar)		
▪ Curing		
▪ Finishing		
Excavations & pipelines:		
▪ Dimensions of trench (500mm x 1000mm)		
▪ Pipe bedding		
▪ Joints tightness		
▪ Drainage of standpipes		
Valves and Fittings:		
▪ Well fitted/leak proof		
▪ Accessible/easy to operate		
▪ Protected		
▪ Well drained		

General Remarks:

....
....
....

Supervisor: Contractor:

Signed: ....Signed: ....

Name: ....Name: ....

Designation:..Designation: ....

Date: ....Date: ....

This form is to be filled at every site visit the Supervisor makes.

CHAPTER 5 WATER TREATMENT TECHNOLOGIES

5.1 Introduction

Water treatment is not usually considered appropriate for community managed rural water supplies due to the high costs of operation and because the water quality is dependent upon correct operation. Most communal water supply schemes exploit groundwater as the main source and in many cases the water quality meets the required standard for untreated supply.

With the expansion of piped water supply projects to the majority of RGCs, projects increasingly turn to surface water sources, which require treatment to supply water of acceptable quality. The common treatment methods used for surface water sources are sedimentation, sand filtration, and chlorination.

Some groundwater sources have high iron content, which has become increasingly objectionable to users due to bad taste and staining of clothes and utensils. Low-cost iron removal plants are currently under monitoring to study their usability and ability to accelerate the treatment process. For properly constructed groundwater sources, domestic treatment methods are usually adequate. Some of the household low-cost water treatment technologies like solar disinfection (SODIS), bio-sand filters, boiling, chlorination, and ceramic filters are also being used to improve the quality of water consumed in homes and institutions.

5.2 Water Treatment for Piped Water Supply

The treatment process is usually kept as simple as possible and is mainly applied to remove suspended solids from the water. The common treatment process consists of roughing sand filters followed by slow sand filters. The roughing filter provides pre-treatment by reducing the high turbidity level in raw water before treating in the slow sand filter. Slow sand filters are also effective in removing pathogens found in water to significantly improve the bacteriological quality as well. The effluent from a slow sand filter would only require chlorination to provide residual protection in the distribution system.

As much as possible, the treatment plants should be designed to operate by gravity with only one pumping stage required from the clear water well to the service reservoir. This will reduce the O&M cost and especially since the major inputs of labour and sand are usually locally available. The community is also less exposed to fluctuations in prices of spares and materials purchased from outside.

Slow sand filtration may not be necessary if the bacteriological contamination of the water to be treated is absent or small, particularly in surface waters draining an unpopulated catchment area, or where controlled sanitation prevents water contamination by human waste. For technical reasons, roughing filtration may therefore be used without slow sand filtration if the raw water originates from a well-protected catchment area and has minor bacteriological contamination i.e. in the order of 20 – 50 E. coli/100ml.

Figure 21 below shows the general layout and components of slow sand filter.

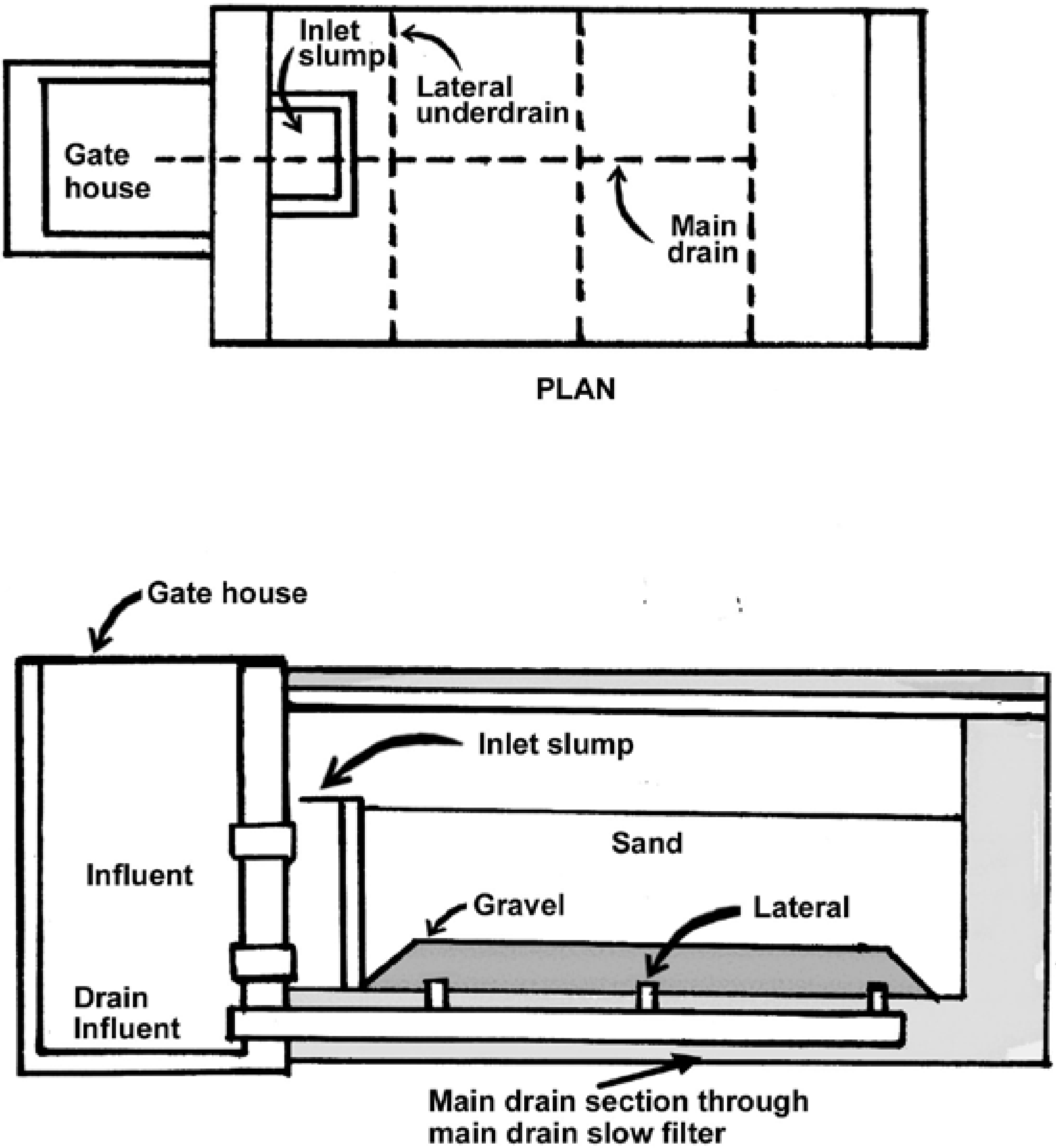


Figure 21: General layout and components of slow sand filter

5.3 Low Cost Water Treatment Technologies

5.3.1 Introduction

There are a number of low cost water treatment technologies in the world. These are commonly referred to as Point of Source (POS) treatment technologies. The advantage of these technologies is that, they are considered cheap, affordable and easy to use at a home set up. In Uganda, a number of these low cost water treatment technologies are under research specifically at the Appropriate Technology Centre (ATC) but also by other sector agencies like NGOs. Some of these technologies are briefly discussed below.

5.3.2 Solar Disinfection (SODIS)

SODIS is a simple technology that relies on the use of the sun's energy to inactivate and photo-oxidative destruction of disease causing organisms in water such that it is safe for drinking. SODIS destroys the most dangerous pathogens and greatly enhance the quality of drinking water. This is possible with oxidative effect of radials formed by Ultra Violet (UV) radiation. In simple terms, solar disinfection kills pathogens by the combined action of UV radiation and heat.

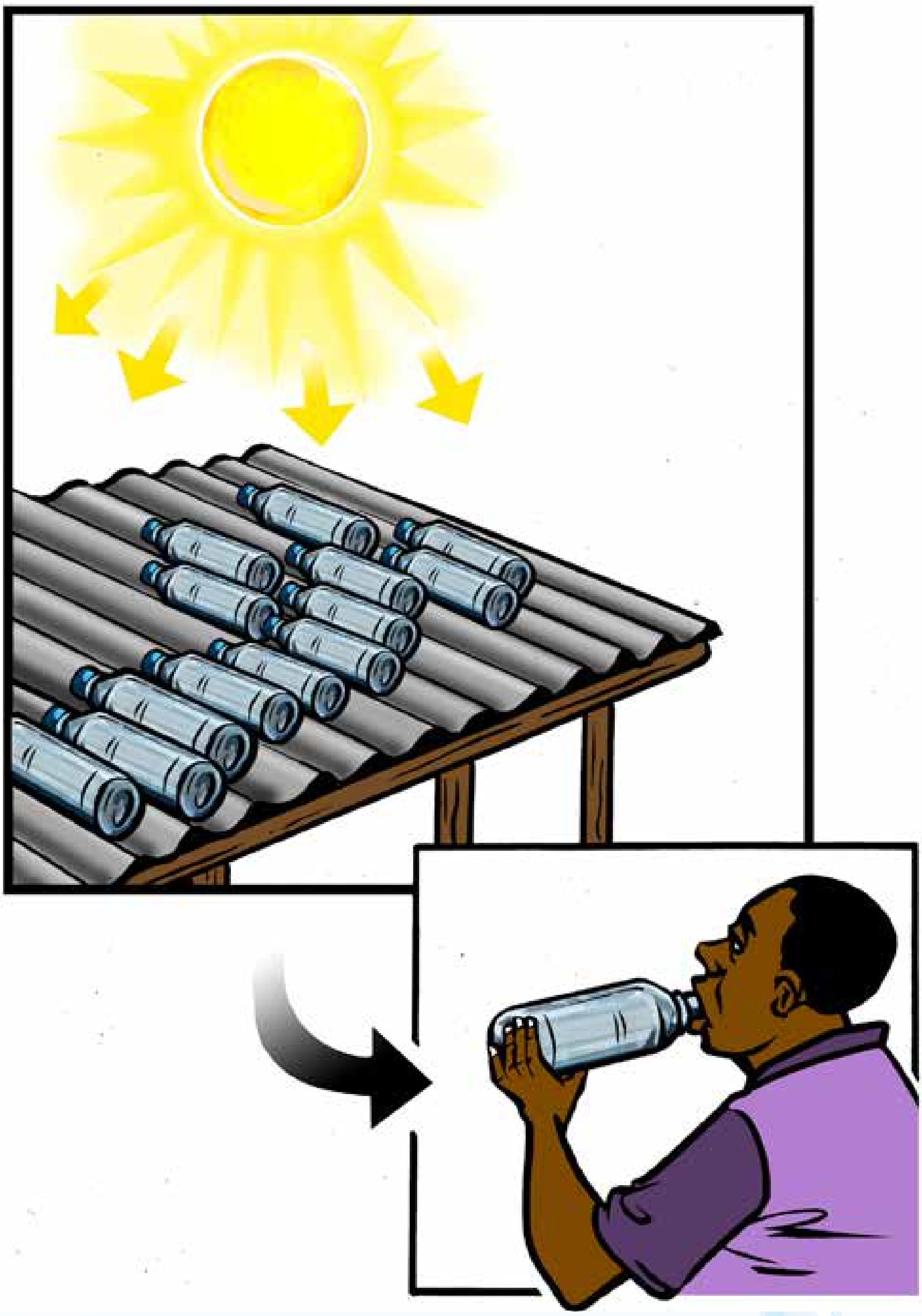


Figure 22: Typical SODIS with bottles arranged on the roof

The technology works by exposing plastic bottles filled with contaminated water under sun for a specified period of about 6hours. The following must be observed when using SODIS:

1. Fill the bottles with water, close and shake for about 20seconds for oxygenation
2. Place the bottles filled with water on a corrugated iron sheet, rack on the ground which reflects sun light.
3. Bottles should be placed horizontally in a flat angle towards the sun instead of upright.
4. The bottles water should be left in sunlight usually on the roof of your home for one day or two days if the sky is cloudy.
5. Ensure that no shadow falls on the bottles.
6. Aluminium bucket can be used to construct solar collector.
7. In the rainy season, paint one side of the bottle black. This will increase the water temperature. The painted side should be placed underneath.

The effectiveness of SODIS depends on the amount of sunlight available. Thus, fluctuation in the day's sunshine makes it hard for users to know when water put under the sun has reached a level safe enough for drinking. To solve this dilemma, WADI indicator helps visualise the progress of the treatment process in real time. When WADI indicator is connected to a bottle filled with water under treatment, the progress bar shows a sad face, which gradually changes to smiley when the water is finally ready for drinking.

However, it should be noted that SODIS does not provided residual disinfection and may be less effective for bacteria spores and cysts stage of some parasites; it does not improve water turbidity and needs constant supply of bottles. It only works well for water with turbidity of 30NTU or less.

5.3.3 Bio-sand Filter

A bio-sand filter (Figure 23) is a small; household sized adaptation of slow sand filters such that they can be run intermittently. The filter consists of a layer of gravel overlain with prepared sand media contained within a filter body or box, usually constructed in concrete. A shallow layer of water sits atop the sand, where a bio-film (schmutzdecke) is created that further filters the water of harmful micro-organisms.

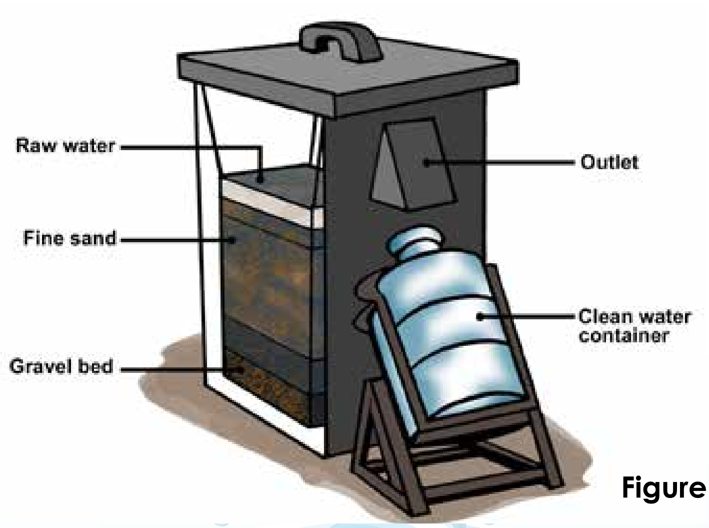


Figure 23: Bio-sand filter

Operating the filter is very simple. Remove the lid, pour a bucket of water into the filter, and immediately collect the treated water in a clean container. The operating guideline is usually provided by the manufacturers to make sure filter produce water of acceptable quality.

Household bio-sand filters can provide up to 30 litres of water per hour, which is sufficient for a family of five. The flow rate may decrease over time as the filter becomes clogged, but can be restored with cleaning.

Bio-sand filters have been shown to remove more than 90 percent of faecal coliform, and about 100 % of protozoa and metals like zinc, copper, cadmium, and lead, and all suspended sediments. However, these filters do not sufficiently remove dissolved compounds such as salt and fluoride or organic chemicals such as pesticides and fertilisers. Additionally, bio-sand filters are not able to handle water of high turbidity levels (should not exceed 50NTU) as they may become clogged and thus ineffective.

5.3.4 Ceramic Filters

Ceramic filters have micro-scale pores that are effective for removing bacteria from water. The filters are made from clay that is often mixed with materials such as sawdust or wheat husk to improve porosity after filtering. Colloidal silver, an antibacterial agent, can also be added to the filters. There are three main types of ceramic filters; disk, vessel and candle, with multiple variations of each. The commonly used ceramic filter is the vessel type, which comprises of a ceramic vessel/pot placed over a water storage container like bucket or pot fitted with a tap. The ceramic vessel is filled with untreated water, which is filtered into the storage container.

Figure 24: Placing the ceramic vessel into the receptacle

Disk and vessel filters typically have a flow rate of 1 – 11 litres per hour and candle filters have a flow rate of 0.3 – 0.8 litres/hour. Under ideal filter conditions and 12 hours of continuous refilling, a filter with a flow rate of 1.7 litres per hour would provide 20 litres per day, enough drinking water for a family of seven.

Ceramic filters are generally effective for removing turbidity, iron, faecal contaminants, and E. coli from water. In studies, disk filters with colloidal silver have exhibited a 93 to 100 percent bacterial removal rate, and those without silver have shown an 80 percent removal rate. Candle filters with colloidal silver generally exhibit 100 percent bacterial removal, and those without silver average at 85 percent removal. Disk filters range from 83 to 99 percent turbidity removal. Ceramic filters are generally not effective for removing organic contaminants.

Ceramic filters are easily assembled, and no component construction is required of the user other than placing the filter into the container. Scrubbing the filter with a toothbrush is required monthly as maintenance. Annual colloidal silver recoating is also recommended. Filters typically come with illustrated instructions. The fragility of ceramic filters can make their transport difficult. Some field studies have also indicated that heavy subsidisation or free distribution of filters may result in maintenance negligence. The production of ceramic filters is a lengthy process that requires skill and quality control. Quality can be affected by variations in clay composition across geographic regions. Variability in weather conditions also makes long-term production planning difficult, and lack of storage can complicate stockpiling of filters.

5.3.5 Iron Removal Plants

Groundwater usually has better bacteriological quality than surface water but it has higher mineral contents that can be objectionable in some cases. Boreholes in many areas of Uganda are found to contain unacceptable iron concentration levels. Even though iron is not harmful to human health, it causes bad tastes and stains clothes, containers, and the skin. Some boreholes have been reported abandoned due to iron content in water. It is therefore important to investigate the possibility of sustainable iron removal plant (IRP).

An Iron Removal Plant (IRP) is a simple chamber constructed to allow sufficient oxygen into water such that ferric iron (iron III) precipitates are formed. These are then filtered out using a sand filter media. Ion exists in water as dissolved ferrous (ion II) iron compounds such as ferrous sulphate and ferrous chloride. The formation of ferric ions is achieved through oxidation of ferrous ions by introducing oxygen, which is the cheapest oxidising agent readily available in the air. Mixing raw water with air will initiate a chemical reaction where ferric ions are formed and being insoluble will precipitate and can therefore be eliminated through mechanical filtration.

Iron removal plants can be based on different filtration media, depending on the iron concentration, the oxygen level, CO_2 content, and hardness of the water. There are challenges in operating and maintaining Iron removal plants and users should be properly trained in O&M.

At the time this manual was revised, a study at ATC had established that sieved coarse sand can work effectively as a filter material and that the flow rate can be increased by using sand filter with 2mm as the smallest grain size. This study showed that iron removal efficiency was at 95% for up to 10 mg/l of iron in the raw water. However this fell to less than 77% for water with higher iron content. Therefore, for now, the design of an IRP will remain based on characteristics of a specific borehole, up to when enough studies have been carried out in Uganda to categorise the specific prototype designs based on concentration of iron and hardness of water. The current study results have only shown efficiency for Iron concentration levels of up to 10 mg/l, and when a water source has similar conditions, this design can be adopted.

Figure 25: Iron Removal Plant at ATC, Mukono (built for research)

5.3.6 Boiling

Boiling water for drinking is widely used treatment method in homes and institutions. It targets mostly the destruction of microorganisms in water but it also reduces the concentration of some chemicals like iron and manganese thereby improving the chemical quality as well.

The process mainly involves boiling water in a covered, large vessel (e.g. drum or pot) or sauce pan over fire. Smaller quantities can also be boiled using electric kettle. When water has reached boiling point, it should continue boiling for at least five minutes before removing from the fire. The water is then allowed to cool before filling it in the drinking water storage vessel/container. It is advisable to strain the water through clean cloth material to remove any particles before storage.

It should be noted that boiled water can be re-contaminated if dirty cups are used to scoop the water from the storage vessel. Storage vessels should therefore be fitted with taps to prevent contamination of the water.

5.3.7 Chlorination

This is a widely used process both at household level and in water treatment works to destroy microorganism in potable water supply. The three common forms of chlorine used in water treatment are liquefied chlorine gas, sodium hypochlorite solution, and calcium hypochlorite granules. The last two forms are commercially available (i.e. 'Waterguard' and 'Aquasafe') for household use. Chlorine dispensers can be provided at point water sources to allow users to access the right quantity for the 'standard' 20 litre containers commonly used for fetching water. This is also convenient in that the water would be safe to drink by the time it is delivered at home.

Chlorinated water should be left to stand in a covered container for about 30 minutes before drinking to allow the chlorine to disinfect the water. Residual chlorine remains in water to safeguard against recontamination for up to 24 hours if the storage vessel is properly covered. Care should however be taken to follow instructions for use to avoid under dosage (making it ineffective) or over dosage (can be harmful or make water objectionable).

CHAPTER 6 SANITATION TECHNOLOGIES

6.1 Introduction

The main focus of this chapter is review of technologies for human excreta disposal in rural Uganda. The commonest sanitation technology used in both rural and urban Uganda for human excreta disposal is pit latrines designed, constructed, and managed in variety of ways. Other technologies also promoted in rural Uganda are EcoSan toilets, composting latrines, and water borne toilets being slowly taken up in RGCs where piped water supplies are provided.

Faecal sludge management (emptying, transportation, treatment, and reuse) is a very important support component of sanitation services. Faecal sludge emptied from most sanitation facilities is unstable and contains harmful micro-organisms and should be safely handled, stabilised, and sanitised before disposal or reuse.

The specific design options for the common sanitation technologies are:

- Trench latrine
- Traditional pit latrine
- Ventilated improved pit (VIP) latrine
- Alternating pit latrine
- EcoSan toilet
- Flush toilet

There are design variations within each category but the overall operating principles and practices are similar (if not the same). Overall, a sanitation system should be structurally safe, hygienic, offer privacy and easily accessible. A number of factors affect the choice of sanitation technology for households or institutions. These include:

- **Affordability:** This is the most important factor influencing the choice of technology and design standard. Capital investment and O&M costs should be considered in choosing technology.
- **Social Issues:** Social and cultural practices vary from area to area. These will affect the range of options acceptable to communities. However it is important to explain some cultural and social beliefs that promote unsafe disposal of human excreta.
- **Water supply levels:** In areas where water supply is limited or unreliable, water dependent sanitation systems would not be suitable.

- **<u>Site specific issues:</u>** The geology, hydrology, and topography of the area will influence the choice of technology and design.
- **<u>Availability of local materials and skills</u>** will also affect the choice of technology in order to reduce construction costs.

6.2 Trench Latrines

Trench latrines (Figure 26) are used as emergency excreta disposal facilities during the initial stages of emergencies. Emergencies can be divided into phases i.e. the impact/immediate phase is the first one to two weeks, the stabilisation phase is from the third week to three months, the recovery phase covers several months, and the settlement phase covers several years. During the first phase, defecation fields and defecation trenches (within the fields) are used for sanitation. Trench latrines are usually used during the recovery (second) phase and thereafter traditional family and communal VIP latrines are then used.

The trench latrine is basically a rectangular hole in the ground. The hole should be dug as deep as possible – about 2m and may be lined with timber where there is a risk of collapse. It may be of any convenient length, usually between 5 to 10m, and between 1 to 1.5m width. The trench is spanned by pairs of wooden boards on which the users squat. There is a gap between the boards through which the users excrete. Each pair of the boards is separated by a wooden screen to provide privacy.

The trench latrine is provided with a roof to prevent the trench from filling up with rain water. A drainage ditch should be built to divert surface water.

Each week, the contents of the trench are covered with 100 to 150mm deep layer of the excavated soil. This will reduce the smell and prevent flies from breeding. When the contents of the trench have risen to approximately 300mm of the surface, the trench is filled up with soil and the latrine is closed.

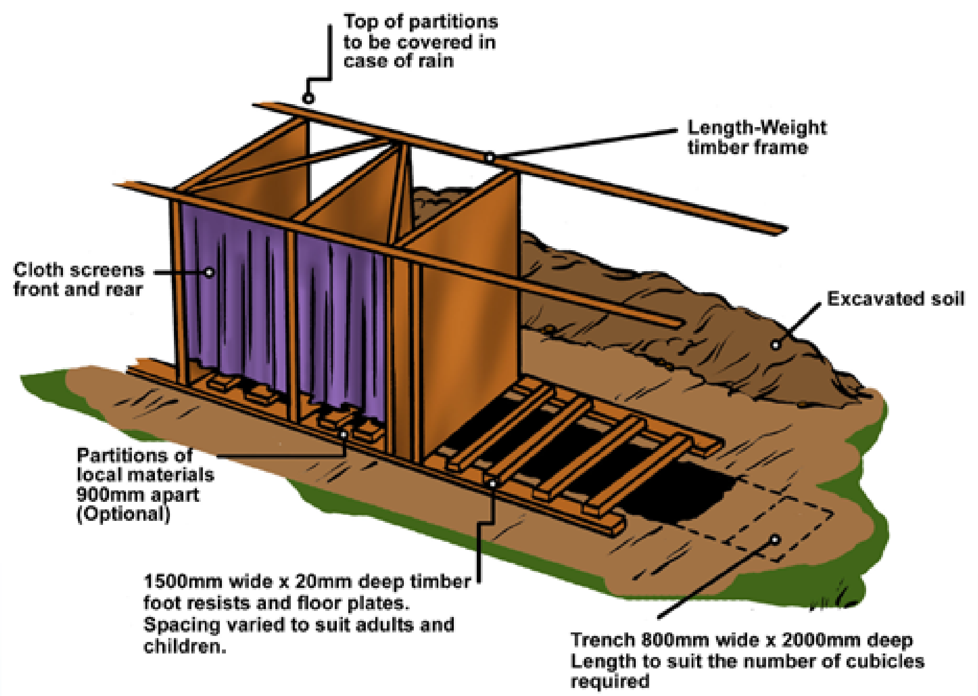


Figure 26: Typical design and layout of a trench latrine

6.3 Pit Latrines

6.3.1 Traditional Pit Latrines:

This is a simple pit latrine design popular in rural areas because it is low-cost and easy to construct. The latrine is usually demolished when the pit is full and a new one is constructed. The key features of the latrine are: unlined pit 4 – 10 metres deep, logs and soil pit cover, mud and wattle or adobe brick wall, thatched or sheet roof, and a door shutter or mat screen. The latrine can be improved with SanPlat for easy cleaning and safety during use (Figure 27).

This technology has the advantage of being low cost and needs no water for operation and maintenance. The pit latrine can have considerable odour and fly nuisance and can easily pollute shallow groundwater. The life of the latrine is limited to the size and stability of the pit or strength of the cover slab.

Figure 27: Typical traditional pit latrine improved with SanPlat

6.3.2 Ventilated Improved Pit (VIP) Latrines:

A VIP latrine is a variation of the traditional latrine but with many crucial improvements: ventilation of the pit to attract and trap flies as well as channel foul air above the roof through the vent pipe, concrete floor slab for easy cleaning and safety during use; and well-fitting door with a gap underneath to allow air circulation but maintain darkness in the stance. In theory, the VIP is simple to construct and should provide effective fly and odour control (Figure 28).

Some VIP Latrines are constructed with lined pits to allow for safe emptying when full thus making it suitable for congested urban areas where land for sanitation facilities is limited or for institutions where rate of pit filling is high. The high initial cost is offset by the much cheaper cost of emptying as compared with the cost of constructing new replacement latrine when the old one fills up. Pits are usually lined using bricks or stone masonry walls, concrete rings, or factory made plastic lining.

A lined pit VIP Latrine can also be upgraded to pour flush toilet just by installing the pans and providing soak pit thereby completely eliminating flies and smell.

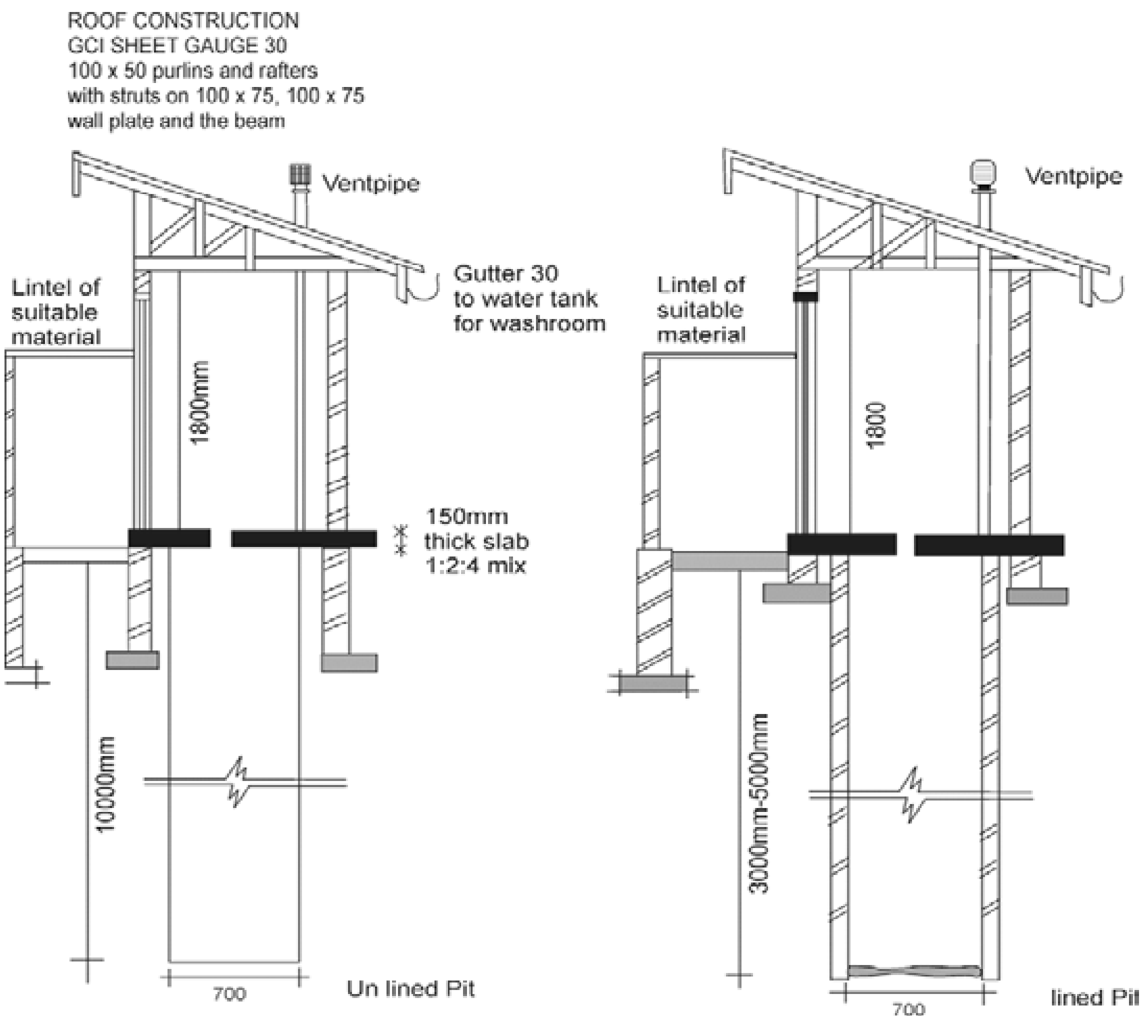


Figure 28: Ventilated improved pit (VIP) latrine with unlined pit (left) and lined pit (right)

6.3.3 General Operation and Maintenance of Pit Latrines

Properly operated and maintained latrines provide the intended health benefits otherwise they can become serious health risks to the community. Some of the key O&M activities to carry out to ensure proper functioning of the facilities are:

- Regularly applying ash around the squat holes and into the pit to control smell and breeding of flies. The act of 'smoking' the pit also has the same effect.
- Sweeping the floor every day or washing with water and soap if it is cemented.
- Covering the squat hole after use if latrine is not a VIP.
- If the (unlined) pit is nearly full i.e. about 1.2 metres to the top, the pit should be filled up with soil and the superstructure demolished to prevent infestation by vermin; a replacement latrine will then have to be constructed.
- Avoid dumping non-biodegradable materials in the lined VIP Latrine to prevent quick filling up and to ease emptying
- Sludge emptied from lined pits should be treated in a sewage treatment plant or safely buried in a shallow pit for it to compost over time and later used as soil conditioner.

6.3.4 Quality Checks Guideline for Pit Latrine Construction

Pit Latrine Construction – Materials Quality Check Form

District: ....Sub-county: ....

Parish: ....Village: ....

Source Name: ....Source Number:...

Contracted Firm: ....Contract Ref. No: ....

Local Contact Person: ....

Materials Grading: Recommended: **1** Not recommended: **2**

Description of Material	Grade	Remark
1. **Lake sand:** Rough texture, water washed, and free of organic material and clay. 2. **Plaster sand:** Clean and free from inclusion like clay, organic matter, and soil. 3. **Aggregates:** Machine-crushed, 12mm (18mm maximum) size, no organic material, dust, and clay. 4. **Cement:** Ordinary cement that is free of lumps. 5. **Blocks/bricks:** Well fired and with firm edges. 6. **Hardcore:** Should be irregular in shape, clean and from fresh rock. 7. **Reinforcement mesh and bars:** Regular shape and free from too much rust. 8. **Roofing sheets:** Galvanised of pre-painted, G30 minimum. 9. **PVC vent pipes:** At least 125mm diameter, grey or black colour, and of strong gauge 10. **Moulds for key holes:** Right size and shape with smooth surface		

Supervisor: Contractor:

Signed: ....Signed: ....

Name: ....Name: ....

Designation:...Designation: ....

Date: ....Date: ....

Pit Latrine Construction – Construction Quality Check Form

District: ....Sub-county: ....

Parish: ....Village: ....

Source Name: ....Source Number:...

Contracted Firm: ....Contract Ref. No: ....

Local Contact Person: ....

Rating Levels: Good: **1** Fair: **2** Poor: **3**

Component	Rating	Remark
Masonry walls: ▪ Bonding ▪ Plumb ▪ Rendering **Concrete slab:** ▪ Reinforcement bars/mesh – placement ▪ Mix ratio (1:2:4) and placement (vibrated) ▪ Curing ▪ Floor finishing (smooth, drain into the pit) ▪ Apron finishing (mortar screed, drain out of the latrine) **Doors:** ▪ Not obstructing users ▪ Alignment ▪ Firmly fixed ▪ 50mm Gap underneath ▪ Latches inside and outside (at good height) **Vent pipes:** ▪ One for every stance ▪ Protruding 30cm below the slab ▪ Projecting 60cm above the roof line ▪ With fly screen on top		

General Remarks:

....
....

Supervisor: Contractor:

Signed: ....Signed: ....

Name: ....Name: ....

Designation:...Designation: ....

Date: ....Date: ....

This form is to be filled at every site visit the Supervisor makes.

6.4 EcoSan Toilets

Ecological sanitation (EcoSan) is based on three main principles:

- Offers safe sanitation – prevents disease and promotes health by successfully and hygienically removing pathogen-rich excreta from the immediate environment.
- Environmentally sound – doesn't contaminate groundwater or use scarce water resources.
- Creates a valuable resource from what is usually regarded as a waste product.

EcoSan toilets work on the principle that when soil and ash are added to faeces, it rapidly breaks down to produce compost that is an asset to any farm or garden. The mixture is odourless, as long as it is not too wet. EcoSan toilets are permanent, cheap and easy to build, and over time generate an easy to handle, rich compost. There are three main types: the Arborloo; the Fossa Alterna; and the Skyloo.

6.4.1 The Arborloo:

This is the simplest type of latrine (Figure 29) and the one that involves the least amount of behaviour change from the conventional pit latrine. Anybody who has planted a tree in a full latrine pit can be said to be practising EcoSan.

A shallow pit (1.2 m recommended) is dug and a ring beam placed around the pit to protect it from collapse. A slab and easily movable superstructure placed on top of the ring beam for privacy. The family uses the latrine, adding a mixture of soil and ash after each use, until it is three quarters full (usually between 4 and 9 months). Dry leaves/grass are placed at the bottom of the pit before use and then added from time to time during use. When the pit is full, the slab and the superstructure are moved to another pit. A layer of soil is added to the full pit and a seedling placed into the soil. The tree grows and utilises the compost to produce large, succulent fruit. After a few years of latrine movement the result is an orchard that is producing fruit with a real economic value.

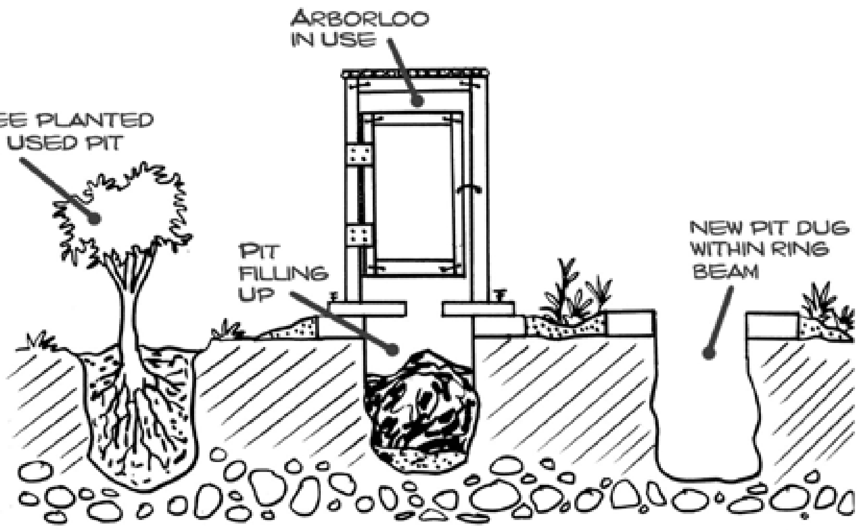


Figure 29: Schematic Diagram of an Arborloo

6.4.2 The Fossa Alterna

Fossa Alterna is similar to the Arborloo but it has two shallow pits (about 1.5m deep) that are used alternately. The pits are lined with ring beams at the top to prevent collapse, a single concrete cover slab and toilet superstructure for privacy are placed over one pit which would be put to use. Dry leaves or grass are placed at the bottom of the pit before use and a mix of soil and ash is added after every use. Dry leaves are also added from time to time during use.

When the first pit is full, the slab and superstructure are move onto the second pit and top soil is placed over the contents of the first pit, which is the left to compost and mature. When the second pit is full, the first pit is emptied and then used again. The compost is placed on the garden to improve the soil fertility. Some crops like tomato or pepper can be planted on the maturing pit while the other pit is being used, Watering the plants helps the composting process.

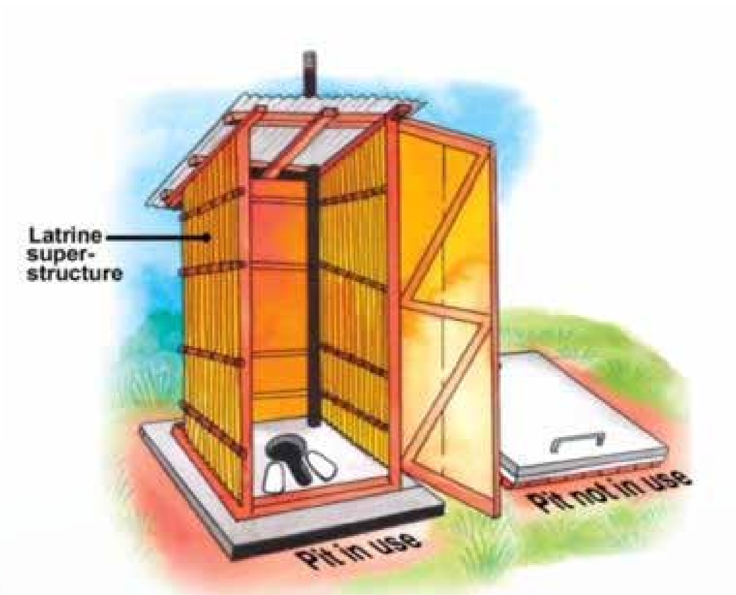


Figure 31: A typical layout of the Fossa Alterna toilet

Safe Handling of By Products from Composting Toilets

Safe handling, using multi-barrier approaches which involve treatment of the faeces, risk reduction during handling and in agricultural practices as well as the individual behaviour (hygiene) aspects minimises the risks associated with reuse of excreta. Safe handling of EcoSan by products aims at maximising the protection of human health and the beneficial use of important resources.

The faeces are sanitised on the principle of predation and ample storage time that allow composting and soil composting. Composting faeces requires the addition of materials that provide structure and balance the nutrients.

Primary processing of excreta from a fossa alterna toilet:	
What to do	**Reason**
User interface at the toilet	
Place a sack of leaves to the bottom of the pit before using it.	To minimise faecal matter from sticking on the floor.
Stockpile carbon- rich materials such as leaves, straw, twigs, branches, paper (avoid glossy prints), cardboard and wood. Chop them to pieces not thicker and longer than our fingers for adding to excreta.	These materials are the energy source for compost microbes and provide structure to the compost. A good structure allows air to circulate through the compost and lets the microbes' breath (aerobic process).
Gather green materials. Fresh leafy green plant material, food waste (but not meat), peelings, garden refuse and rotten fruit for adding to excreta.	They are easy to digest and a nitrogen source for microbes. Sufficient green material is important in order to achieve initial high microbial activity and elevated temperatures.
Add a good amount of soil/ and or wood ash after each defecation. This is in addition to green and carbon-rich material. Adding ash and leaves helps make better compost 	To increase the pH and reduce moisture of the contents of the pit/vault. This will enable the presence of a variety of organisms that break down the solid into humus. Different types of organisms affect each other by predation, releasing antagonistic substances or competition for nutrients. The more soil added the better, but this must be offset against filling the pit too fast

Primary storage and treatment	
A period of 12 months of composting in shallow pits [without addition of fresh excreta] is recommended before application to gardens.	To allow further pathogen die-off due to UV radiation, dryness and competition with other soil organisms.
Most pathogenic bacteria are destroyed within 3-4 months due to competition with soil based organisms and unfavourable environmental conditions (very dry climate). In composting, several processes kill pathogens. These include competition between indigenous microorganisms and pathogens, antagonistic relationships between organisms, the action of some antibiotics produced by certain fungi and natural die-off in the compost environment.	Bacteria adapted to living in the gut are not always capable of competing with other organisms in the general environment for scarce nutrients. This may limit the ability of faecal bacteria to reproduce and survive in the environment.
Secondary processing	
To render human excreta safe for agricultural use, secondary treatment is recommended, regardless of the time the human excreta has been kept in the pits of a Fossa Alterna. Some pathogens (e.g. ascaris) may still be infective after six months of primary processing because it may not be adequate time to sanitise human faeces. In areas where ambient [surrounding] temperatures reach up to 20 °C, a total storage time of 1.5 to 2 years (including the time stored during primary treatment) will eliminate most bacterial pathogens. In areas where the ambient temperatures reach up to 35 °C, a total storage period of 1 year is adequate. In areas with higher temperatures, the storage time is further reduced. The compost product is usually free of pathogens.	
What to do during secondary processing	**Reason**
Secondary treatment site should be fenced off.	To ensure no access for children, who can pick up pathogen infections.
Insulate large heaps of compost [garden compost pile or manure pile] using materials such as tarpaulin or heavy duty polyethylene to cover the heap. Alternatively, application of a layer of soil or old compost will also act as an insulator. Grass can also be used for insulation though it allows heat loss through its voids via convection and radiation.	The high temperatures in the compost heap will kill pathogens because all pathogens have threshold temperatures beyond which their viability ceases.
Add more urea or lime.	To increase the pH (alkaline treatment).
Compost should be about as moist as a wrung out sponge. Squeeze a handful of compost to get a good indication of its water content.	To have optimum moisture and temperature. A dry compost pile will decompose slowly as all organisms need water for growth. If the pile is too wet, the air supply will be limited, and a bad odour will result, causing anaerobic decomposition

Turn the compost inside out every ten days.	To make sure that all materials get exposed to the high temperatures in the centre. The more often you turn the compost, the quicker the compost will be ready because the material gets air. If the compost does not contain a sufficient amount of good quality structure material, turning improves aeration too.
Check the temperature inside the pile. Between the first and second turning, the inside of the pile should be too hot to keep your hand in the core for a prolonged time.	Optimum temperature will promote quick decomposition. High temperatures during the 2^{nd} and 3^{rd} week are usually sufficient to deactivate most pathogens and kill weed seeds.
In urban homesteads, transfer the faecal material into a cement jar or container.	This is done because of lack of space in urban homesteads and prevent ground water pollution.
Application Techniques	
After 12 months, the material can be directly spread in gardens and ploughed/ dug into existing soil in the family garden.	To reduce contact in the garden especially with the edible parts of plants.
Treated faeces should be incorporated in the soil before crop establishment.	A safety barrier to protect workers.
General safe handling practices of EcoSan byproducts from a Fossa Alterna: Safe handling of EcoSan byproducts operates on the principle of reducing contact with the material	
Wear gloves, rubber boots (shoes), and overalls when emptying processing chambers or pits. Careful hand washing with clean water and soap should be done after handling the EcoSan by products.	This is to avoid contact between people and the EcoSan by-product. To block the feacal-oral route.
Only adults and not children should empty the chambers/pits.	Children may fail to adhere to the hygiene rules.
Use proper handling tools.	Reduce contact with the EcoSan by-product.
 **The farmer digs or ploughs the treated faecal material in to the soil immediately upon application**	Reduce contact in the garden.

Clean the used equipment well afterwards.	Reduce contact with the EcoSan by-product.
Handling and transport systems should involve minimal contact with the EcoSan by-product.	This is to avoid contact between people and the EcoSan by-product thus limiting the secondary spread of pathogens through equipment.
Clean the used equipment well afterwards especially if they are to be used for other purposes.	
Hygienic food handling and food preparation practices e.g. washing and peeling (if possible) or cooking the harvested crops before consumption.	For disease vector intermediate control.
Processing of excreta from an arborloo toilet The faeces in an arborloo are sanitised on the principle of predation, storage time and avoiding contact	
What to do	**Reason**
User interface at the toilet	
The pits should have a maximum depth of 1.5m.	To reduce the risk of contamination of underground water supplies.
Urine and faeces are deposited in the pit and covered with equal amounts of soil, ash and leaves after each defecation.	To encourage the presence of other microorganisms to destroy pathogens by predation. To aid efficient composting. To increase the pH of the contents of the pit/vault. Sufficient green material helps to achieve initial high microbial activity and elevated temperatures.
Measures at the site	
When the pit is almost full, top up with soil, and plant a tree or bananas directly in a shallow pit.	No further contact is made with the composted human excreta, so it is safe.
Wear gloves and rubber boots (shoes), when planting a tree/ banana in the pit. Careful hand washing with clean water and soap should be done afterwards.	This is to avoid contact between people and the EcoSan by-product. To block the faecal-oral route.
Clean the used equipment well afterwards.	Reduce contact with the EcoSan by-product.
Only adults and not children should plant the tree/ banana in the pit.	Children may fail to adhere to the hygiene rules.

6.4.3 The Skyloo

This is a Urine Diversion Dry Toilet (UDDT) in which urine is separated from faecal matter, It consists of two processing chambers each with a volume of about 0.3 cubic metres. It is built entirely above ground with the processing chambers placed on a solid floor of concrete, bricks or clay. The floor is built up to at least 10cm above ground so that heavy rains do not flood it. The processing chambers are covered with a squatting slab that has two drop holes, foot rests and a groove for urine. At the back are two openings 50cm x 50cm for the removal of the dehydrated material.

The vaults are rotated in a similar manner to the Fossa Alterna. After a suitable retention time, the contents of the vaults are placed on to the garden or farm. The Skyloo/UDDT can be safely used in urban areas where land is scarce. The compost can be used for vegetable gardens or for greening the compound.

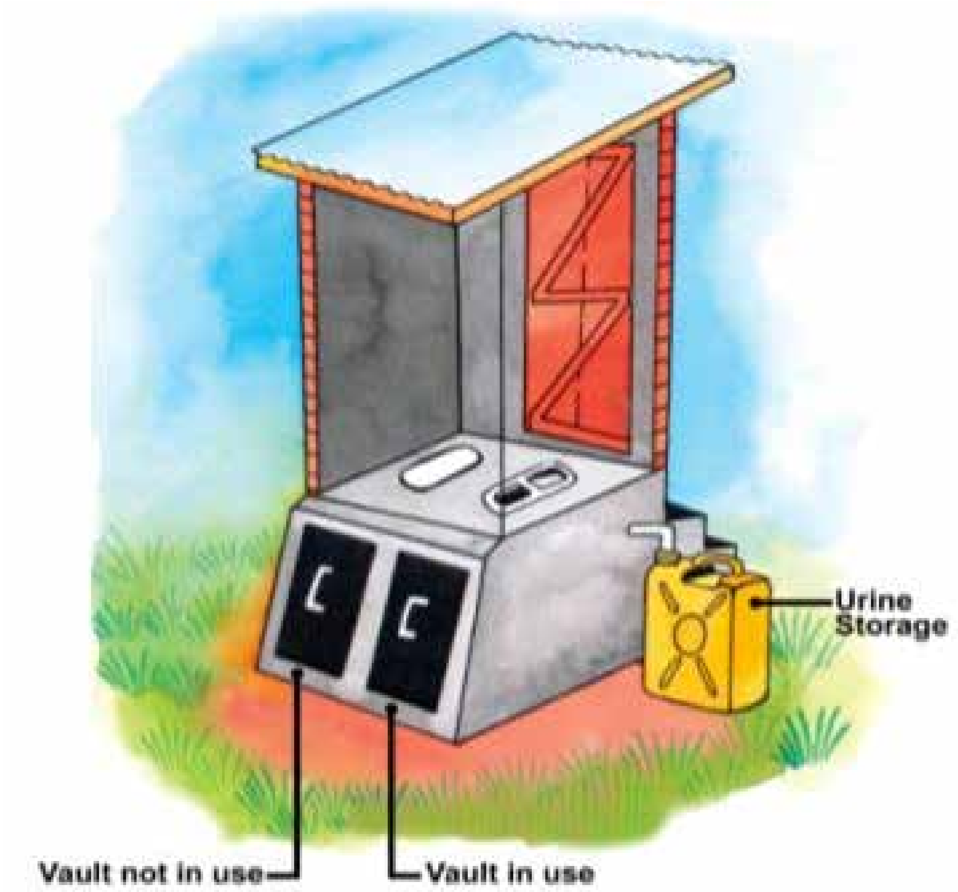


Figure 32: The Typical Skyloo/Urine Diversion Dry Toilet (UDDT)

Safe Handling of Compost from a Skyloo/UDDT

Safe handling using multi-barrier approaches which involve treatment of the faeces, risk reduction during handling and in agricultural practices as well as the individual behavioural (hygiene) aspects, minimise the risks associated with reuse of excreta. Safe handling of EcoSan by products aims at maximising the protection of human health and the beneficial use of important resources.

The faeces in the UDDT are sanitised on the principle of dehydration and elevated pH due to ash or lime addition. Dehydration deprives the pathogens of the moisture they need to survive. The long storage period and increased pH further reduces the pathogen content.

Primary processing of excreta from a UDDT	
What to do	**Reason**
User interface at the toilet	
The faecal vaults should be above ground.	To avoid leaking into the groundwater or the surrounding environment.
Divert the urine and do not add water to faeces.	To keep the volume of the faeces low and less moist.
Add dry material (ash, sawdust, husks, dry soil) after each defecation. It is wise to premix the dry soil and ash at a ratio of 4 parts of soil to 1 part of ash, put in a container and store in the toilet for use	To lower the moisture content of the faeces in the processing vault to less than 25%. To eliminate bad odour. To make faeces less attractive to fly breeding. To raise the pH (acidity/alkalinity) of the contents of the pit/vault to 9 or higher, which also enhance the die-off of pathogens. To make it easier to handle and transfer the material.
 **Children's faeces should also be put in to the faecal compartment**	The faeces of babies and young children are often dangerous because they may have a high concentration of pathogens.
More addition of ash, lime or sawdust is needed when diarrhoea is prevalent.	To increase absorption of moisture and facilitate pathogen die-off.
The paper/ leaves used for anal cleaning may be directly dropped into the faecal vault or put in a box for burning, and the remains put in the faecal vault.	They are biodegradable.

Broken bottles, condoms, sanitary pads, plastic bags, stones and any other non-biodegradable material should never be put into the faecal vault.  **Do not throw broken bottles, condoms, stones into the toilet**	So that they don't interfere with the dehydration/ decomposition process and be a nuisance in the reuse practices. To maximise the volume of the vault. They should be disposed off elsewhere, incinerated or recycled.
The chamber/ vault cover should be made of dark colours (blackened).	To allow for solar heating in order to increase the temperature in vault, which will facilitate pathogen die-off.
Primary storage and treatment on-site	
When the chamber is full, keep the faeces contained and well stored in the chambers for 6-12 months.	To provide ample time for pathogen to die off. The containment prevents the dispersal of material containing pathogens until safe for recycling.
During excreta storage there should be no additions of fresh faecal material. This ensures a secure die-off period without later contamination. The process of drying starts after the last input of fresh faeces.	To avoid re-hydrating the dehydrated excreta because this will make dormant bacteria become viable again and multiply under the more favourable conditions.
Secondary processing	
To render human faeces safe for agricultural use, secondary treatment is recommended, regardless of the time the human faeces have been kept in the vaults of the UDDT. Some pathogens (e.g. ascaris) may still be infective after six months of primary processing because it may not be adequate time to dehydrate and thus sanitise human faeces.	

What to do during secondary processing (these are options)	Reason
The secondary treatment site should be fenced off. Secondary processing can take place either on site (in the garden) or off site (at an eco-station).	To ensure no access for children.
(1) Incineration/ burning of faeces in locally manufactured incinerators. The ash from incineration of faeces contains large proportions of phosphorous and potassium which can fertilise the soil for agricultural purposes. However the nitrogen and sulphur are lost in the atmosphere.	Incineration/burning is used if a completely sterile end product is needed.
(2) Bury faeces at shallow depth in such a way that the plant can utilise the nutrients. However faeces should not be buried in areas with shallow ground water.	It is expected that additional sanitisation takes place in the fields due to natural die-off and out-competition by the more resistant soil organisms.
(3) High temperature composting by insulating large heaps of compost [in a garden compost pile or manure pile] using materials such as tarpaulin or heavy duty polyethylene to cover the heap. They are good cover to the compost and decrease both heat and water losses. Alternatively application of a layer of soil or old compost will also act as an insulator. You can use grass for insulation though it allows heat loss through its voids via convection and radiation. Continuously turn the compost so that the outer compost also gets exposed to the internal sanitising temperatures by insulation from heat loss. Turn 4-6 times in 2 weeks at 50°C. Add more urea or lime.	In composting, several processes kill pathogens. These include competition between indigenous microorganisms and pathogens, antagonistic relationships between organisms, the action of some antibiotics produced by certain fungi and natural die-off in the compost environment. In addition, all pathogens have threshold temperatures beyond which their viability ceases. The compost product is usually free of pathogens. To increase the pH (alkaline treatment) If secondary offsite treatment is not feasible due to limited logistics, deploy some health protection measures e.g. suitable crop restriction such as planting crops, which are not eaten raw. In areas where ambient [surrounding] temperatures reach up to 20 °C, a total storage time of 1.5 to 2 years (including the time stored during primary treatment) will eliminate most bacterial pathogens In areas where the ambient temperatures reach up to 35 °C, a total storage period of 1 year is ok. In areas with higher temperatures, the storage time is further reduced.
In urban homesteads, the faecal material can be transferred into a cement jar or container that doesn't allow see page of the faecal matter into the ground. This is done because of lack of space in urban homesteads.	

Application techniques	
Avoid putting fresh excreta on crops.	Crop fertilisation with raw excreta causes excess infection with intestinal nematodes, in both field workers and consumers of the crops.
Treated faeces should be incorporated in the soil before crop establishment.	A safety barrier to protect workers. To reduce contact in the garden especially with the edible parts of plants.
General safe handling practices of EcoSan byproducts: Safe handling of **EcoSan** byproducts operates on the principle of reducing contact with the material	
What to do	**Reason**
Wear gloves, rubber boots (shoes), and overalls when emptying processing chambers or pits. Careful hand washing with clean water and soap should be done after handling the EcoSan by products.  **Harvesting from UDDT**	This is to avoid contact between people and excreta. To block the faecal-oral route.
Only adults and not children should empty the chambers/pits.	Children may fail to adhere to the hygiene rules.
Use proper handling tools.	Reduce contact with excreta.
Dig or plough the treated faecal material into the soil immediately upon application.	Reduce contact in the garden.
Handling and transport systems should involve minimal contact with the faeces.	This is to avoid contact between people and excreta thus limiting the secondary spread of pathogens through equipment
Clean the used equipment well afterwards especially if they are to be used for other purposes.	
Hygienic food handling and food preparation practices e.g. washing and peeling (if possible) or cooking the harvested crops before consumption.	For disease vector intermediate control

SAFE HANDLING OF URINE AND ITS APPLICATION IN THE GARDEN Untreated urine is dangerous to human life and should be handled with care. Urine is sanitised on the principle of storage time, the elevated pH (around 8.8) that will result when urea is converted to ammonia in undiluted urine, the ammonia concentration itself and higher temperatures.	
What to do	**Reason**
Source separation	
The urine collection container should be designed with an overflow device with local soil infiltration.	To avoid the putrid smell of overflowed urine that could be a local nuisance
Collect urine separately from faeces. Source separation of urine is a strong barrier against pathogen transmission since most pathogens are excreted with faecal matter. Also, most nutrients required by pathogens are in urine.	To allow its availability for use as a liquid fertiliser, to reduce smell, avoid fly breeding and reduce faecal cross contamination.
Storage & Treatment	
Prior to application, urine should be treated. Storage at ambient [same temperature like surroundings] temperature is considered a viable treatment option. As a rule: The longer storage, the better. Store un-diluted urine for 1 – 2 weeks in single households and at least six months for multiple households.	In order to sanitise it and reduce microbial health risks. If storage is not possible, then the fresh urine should be applied to tall standing crops, crops with a long crop cycle, grain crops and root crops processed and cooked. Examples of such crops are: banana, papaya, oranges, avocado, mango, cassava, millet etc.
The jerrycans or any other urine collection devices should be kept in a sun location where the sun hits all four walls of the jerrycan- days to weeks' storage. Solar heating should only be applied on collection devices that are air tight.	High temperature is beneficial for pathogen inactivation. High temperature will enhance the loss of ammonia to the air if the collection device is not air tight.
Urine should be stored in sealed containers. Jerrycans are the most common way of collecting urine, and a very good way for short-term storage.	In order to prevent direct contact with the urine. Urine has a distinctive smell/ odour. However, this is rarely a problem if urine is stored in closed containers. The smell is a signal that urine contains nutrients since ammonia smells strongly.
Dilution of the urine should be avoided during the treatment phase.	Undiluted urine provides a harsher environment for microorganisms, increases the die off rate of pathogens, and prevents breeding of mosquitoes.

Application Techniques	
Urine should always be applied close to the ground. Do not apply urine on the edible or foliar (leafy) parts of vegetables as this can cause foliar burning.	This reduces direct contact with the edible parts of the plants.
Urine can be applied neat [un-diluted] or diluted with water. There is no standard recommendation for dilution/non-dilution and the existing recommendations vary depending on the local conditions. Levels of dilution can vary between 1:1 (1 part urine to 1 part water) and 1:15. Most common dilution ratios are 1:3 or 1:5. However urine should always be applied at the rate corresponding to the desired application rate of Nitrogen, while additional water should be applied according to the water needs of the plants.	Dilution has the advantage of decreasing, or eliminating, the risk of applying urine at such high rates that it becomes toxic to the crop.
 **Urine should be applied in furrows and mixed with or watered in to the soil immediately**	It minimises the formation of aerosols, minimises the exposure. Decreases ammonia loss through evaporation Minimises smell/ odour. For best fertilising effect. It limits potential health risks of direct exposure.
Application of fresh urine on arable land should not be done close to surface water sources in endemic areas.	To prevent further spread of pathogens
Spraying urine in the air should also be avoided. Use drip irrigation or a watering can.	To avoid nitrogen loss through gaseous emissions of ammonia and the hygiene risk through aerosols
Urine should be applied before or during sowing/planting In areas where there is heavy rainfall during the cropping season, repeated applications of urine is an insurance against losing all the nutrients in one rainfall event.	To give adequate time for a further die-off of potential remaining pathogens and thereby risk reduction.

<table>
<tr><th colspan="2">Crop restriction</th></tr>
<tr><td>When treated urine is used no particular crop restrictions need to be applied. However as an additional safety feature, the urine use may be restricted to non-food crops (e.g. cotton), crops that are processed (e.g. wheat) or cooked before consumption (e.g. potato) as well as crops/trees that allow for a minimum distance between soil and harvested part of the crop (banana).</td><td>To prevent spread of pathogens and further reduce risk.</td></tr>
<tr><td>Note that urine should not be applied to nitrogen fixing crops, like groundnuts, peas and beans.</td><td>This may reduce the nitrogen fixing capacity and thereby the yield</td></tr>
<tr><th colspan="2">Withholding period</th></tr>
<tr><td>There should be one month between urine application on crops and harvesting. Don’t apply urine less than a month before harvest on vegetables, fruits (except fruit trees) and root crops that are consumed raw.</td><td>To allow pathogen die off.</td></tr>
<tr><td colspan="2">General safe handling practices of urine:

Safe handling of EcoSan byproducts operates on the principle of reducing contact with the material</td></tr>
<tr><td>Although there is no high risk associated with treated urine it is recommended that agricultural fieldworkers wear appropriate protective clothing (shoes & gloves).</td><td rowspan="2">To reduce potential health risks.</td></tr>
<tr><td>Careful hand washing with clean water and soap should be done after handling the urine.</td></tr>
<tr><td>Only adults and not children should empty the chambers.</td><td>Children may fail to adhere to the hygiene rules.</td></tr>
<tr><td>Use proper handling tools.</td><td rowspan="3">This is to avoid contact between people and urine and further reduce the spread of pathogens.</td></tr>
<tr><td>Handling and transport systems should involve minimal contact with the urine.</td></tr>
<tr><td>
Clean the used materials well afterwards</td></tr>
<tr><td>Hygienic food handling and food preparation practices e.g. washing and peeling (if possible) or cooking the harvested crops before consumption.</td><td>For disease vector intermediate control.</td></tr>
</table>

6.4.4 Operation and Maintenance of EcoSan Toilets

It is critical that the toilet facilities are properly used to avoid any serious health risks that may be caused by malfunctioned toilets. Key O&M actions required are:

- Always add ash and soil into the pit after every use to keep the content as dry as possible.
- For the Skyloo (with constructed vaults), divert the urine away from the vault to ensure the content remains dry. Urine can be used directly as fertiliser or soaked away in the soil.
- Do not use water for washing/cleaning the toilet. People using water for anal cleansing should provide separate facilities for washing.

6.5 Composting Latrines

As indicated in Figure 33 below, the pit is constructed with two chambers separated by a wall. The pits are lined with brick or stone. One pit is used until it is full. It is then closed and the second pit is used until it is also full, by which time the contents of the first pit are completely composted and can be dug out or emptied and the first pit then used again.

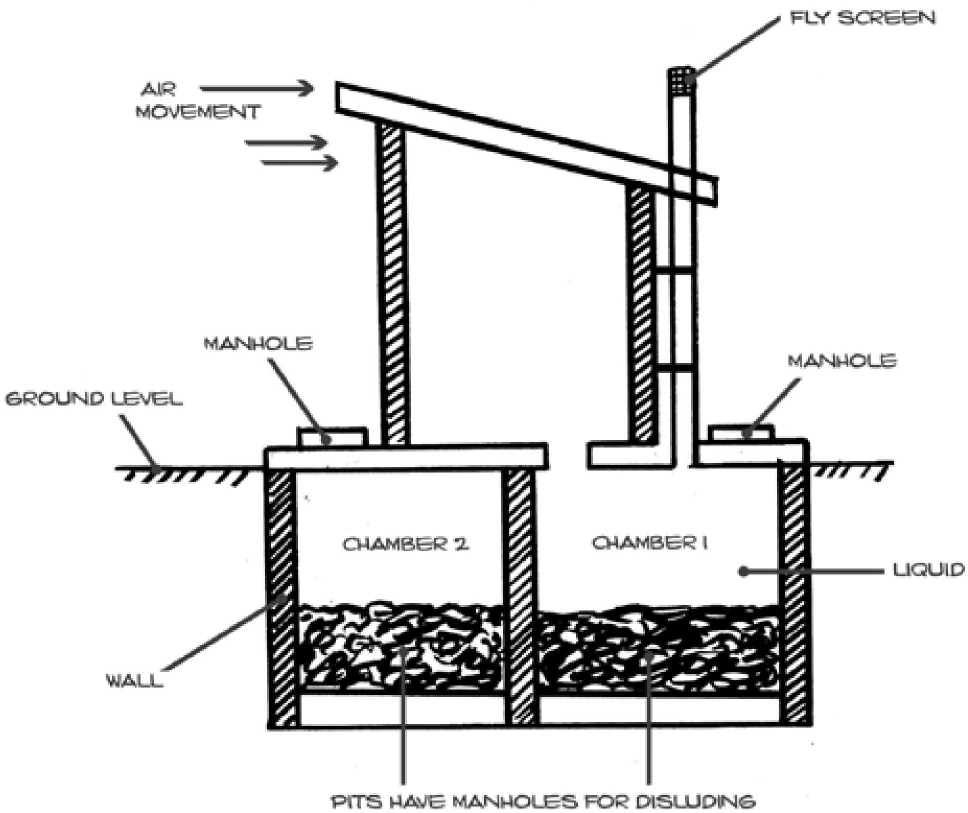


Figure 33: Alternating pit with two chambers

6.5.1 Operation and Maintenance of Composting Latrine

It is critical that the latrine is properly used to avoid health risks that may be caused by malfunctioned facility. Key O&M actions required are:

- Always add ash, soil, and organic matters like banana peelings and dry leaves into the pit after every use to keep the content as dry as possible.
- Bury the emptied compost in the soil for further composting to ensure that all organic matters are stabilised and sanitised before application in the gardens.

6.6 Flush Toilets

With the introduction of piped water supply systems in rural areas, some communities have adopted water borne excreta disposal methods, especially in rural growth centres and rural towns. The common designs that would be suitable for rural areas are:

- Septic tank based system.
- Tiger toilet (still under adaptation at the ATC).

The construction cost of flash toilets would be comparable to that of a lined pit VIP Latrine but the operational costs are a lot higher because of the cost of water supply. Operation of flush toilets depends on reliable water supply without which repeated blockage of the sewer line would cause inconveniences and unhygienic conditions.

6.6.1 Septic Tank Based Disposal System

A septic tank is an underground watertight settling chamber into which urine, faeces and wash water is delivered from a building. The sewage is partially treated in the tank by separation of solids to form sludge and scum. The effluent from the tank infiltrates into the ground from a soak away pit (Figure 34). This system is very expensive and needs a reliable supply of piped water. The system also requires regular de-sludging, which makes the system very expensive to operate and maintain.

Septic tanks can be built of mortar and bricks, blocks or concrete. They can also be manufactured out of plastic and placed in a dug hole of pre-determined size. The principle is that they must be watertight.

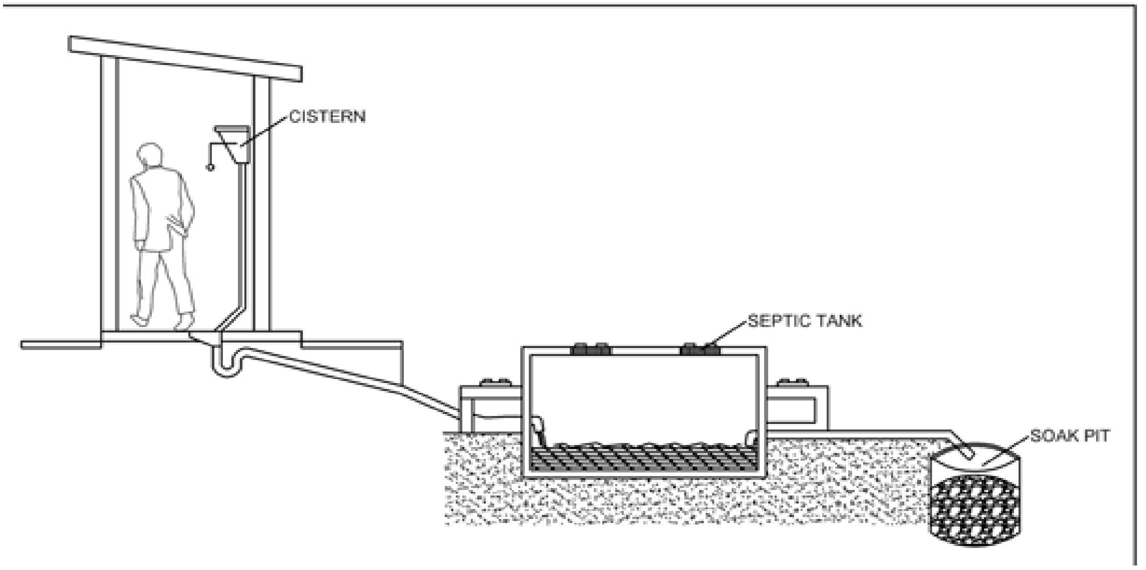


Figure 34: Diagrammatic representation of a septic tank system

6.6.2 The Tiger Toilet

This toilet is similar to the septic tank based toilet but uses low-volume pour flush ecological toilet. It uses a type of earthworm (the 'Tiger Worm', Eisinia Fetida) to digest faecal solids, combined with a filtration layer to treat the liquid effluent which then infiltrates safely into the soil. The biofilter is linked to a low-volume, pour-flush toilet. We refer to the complete unit as the Tiger system. The Tiger system is not a traditional composting toilet. It is designed to maximise solids digestion and minimise compost build-up which is in line with the best way of managing waste that is 'reduce and reuse'.

Figure 35: Tiger Toilet in Mukono

A surface area of 5 sq.m and a depth of just over 1m is the space required for a unit capable of processing the faecal waste of 10 people. The Tiger system therefore offers a very efficient and complete form of on-site sanitation which is much more compact than a septic tank.We believe that through the use of local materials we can achieve a purchase price for the Tiger system of around $150. This would bring the benefits of a septic tank (eg permanence, dignity, safety, lack of smells) within reach of the majority of pit-latrine users. The cost of installation would be similar to the VIP latrine but it completely eliminates flies and odour and treats effluent to higher quality than septic tank, It is therefore more environmentally safe.

Globally (and in Uganda, Water for People in partnership with the Appropriate technology centre) the technology is still being piloted and no reliable full scale trial performance record is available to inform choice as a viable sanitation technology.

b. DuraSan Latrine

The DuraSan is modular latrine assembled from precast concrete blocks. It has a flexible design, allowing customers to choose the number of latrine stances as well as latrine options. By minimising the skill level required for latrine construction, the DuraSan is a complete pour-flush latrine package that is assembled much like a ‘‘lego’’ kit. No longer reliant on the long-exhausted mason led supply chain, this innovation is comprised of interlocking, precast concrete components, resulting in a quick, simple assembly process, in which the final quality is guaranteed. The standardised manufacturing process guarantees the customers a clean, affordable and durable latrine facility. The facility can be assembled in 2-5 days, including digging for a pit or septic tank, assembly of blocks, and painting.

The substructure can take on various forms like using concrete rings which are also prefabricated or barrel septic tank system depending on the prevailing ground conditions.

Figure 36: DuraSan toilet with ring liners

This barrel septic tank system seeks to address the fast filling rates of pits during the rainy seasons. The substructure is affected most and as such, an innovative solution was created in form of inclusion of barrels as septic tanks on pour flush latrines. The septic tanks are tough plastic tanks connected in series by PVC pipes as illustrated in Figure 37 below. Water for People is promoting this technology in Uganda

Figure 37: Pour flush latrine with barrels as septic tanks

6.7 Sludge Management System

6.7.1 Pit Emptying

Faecal sludge from water borne toilets and VIP latrines contain high levels of micro organisms and other pollutants that can be harmful to humans and the environment. Emptying therefore requires proper equipment to reduce contacts with the handlers and the environment. Three main types of pit emptying technologies are used in Uganda: the conventional cesspool trucks, the motorised small scale vacuum emptier (Vacutug), and the manually operated suction emptier (the 'Gulper') being promoted by Water for People.

Cesspool Trucks:

These are large capacity emptiers commonly used in areas with good access like well planned urban settlements. The services are generally based in urban centres and their environs with easy access to sewage treatment works where the sludge is discharged for further treatment. Using cesspool trucks in rural areas far from urban centres is very costly because of the additional charges for the round trip to the site. Some initiatives are however being considered to provide access to cesspool trucks and treatment facilities for a cluster of districts in order to reduce the distances and hence the costs for faecal sludge management in rural areas.

The Vacutug

This is small scale emptying equipment comprising basically of a motorised vacuum pump and a sludge storage vessel (about 500 litre capacity) mounted on a wheel base. The motor is also used to provide traction to move the equipment from place to place. The Vacutug is usually used for emptying latrines or septic tanks in congested areas without road access. It delivers the sludge to a trailer mounted tank stationed within the operation area from where it is transported to the sewage treatment works.

Figure 38: Pit emptying techologies

<u>The ‘Gulper’:</u>

The ‘Gulper’ is small scale, low-cost, manually operated cesspool emptying equipment, which can suck out thick sludge and reasonably sized non-soluble materials like polythene bags or sanitary towels. Very little or no water is therefore needed for diluting the sludge before emptying. The gulper is easily transported even in areas with poor road networks thereby reducing costs for emptying services even in remote places.

The sludge can be collected in large buckets of drums, which are then carted away to treatment sites.

Figure 38: The Gulper I in use (left) and the Gulper II (Rammer Model)

Figure 39: Components of the Gulper II (as assembled above)

6.7.2 Faecal Sludge Treatment

Faecal sludge from latrines and septic tanks require treatment before disposal or reuse but sludge from well managed EcoSan toilets can be reused without further treatment. In large towns with sewage treatment works, faecal sludge is usually treated together with the sewage from the sewerage system either in waste stabilisation ponds or sludge digesters. Many rural district towns without sewage treatment works have sludge drying beds to stabilise and sanitise the faecal sludge. The dry sludge can be co-composted with other organic wastes to treat it further and produce rich compost for application to the soil.

In areas without faecal sludge treatment facilities, the sludge should be buried in shallow pits (up to 1 metre deep) to compost for not less than four months after which it can be dug out and applied to the gardens for crop production.

Water For People is currently promoting a low cost decentralised faecal sludge treatment (DEFAST) system, that aims at treatment and reuse of products. The DEFAST was first piloted in Kampala since May 2014 and after satisfactory performance, its being scaled up in Lira and Kitgum where Sanitation as a Business is being promoted.

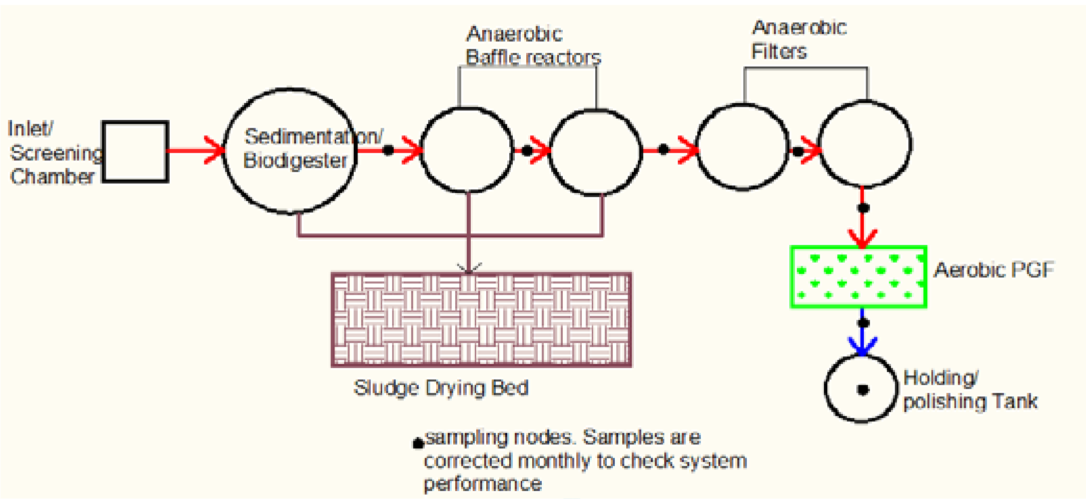


Figure 40: Schematic layout of the DEFAST

6.7.3 Faecal Sludge Reuse

Treated faecal sludge is usually reused as fertiliser or soil conditioner for crop production or gardening. In EcoSan toilet systems, urine is also used as fertiliser with minimal treatment/conditioning. Faecal sludge can also be mixed with other organic waste and used for making fuel briquettes to serve as a 'green' substitute for charcoal.

Application of faecal sludge in crop production should be handled carefully because some resistant micro organisms in the sludge can survive the treatment process and still enter the food chain in the process especially through the leafy vegetables. The sludge should be completely buried in the planting pits. The garden should also be properly mulched to prevent rain drops from splashing the faecal materials onto the crops. Harvested vegetables and fruits like tomatoes should be properly washed before cooking or consumption to remove any possible contamination from the sludge.

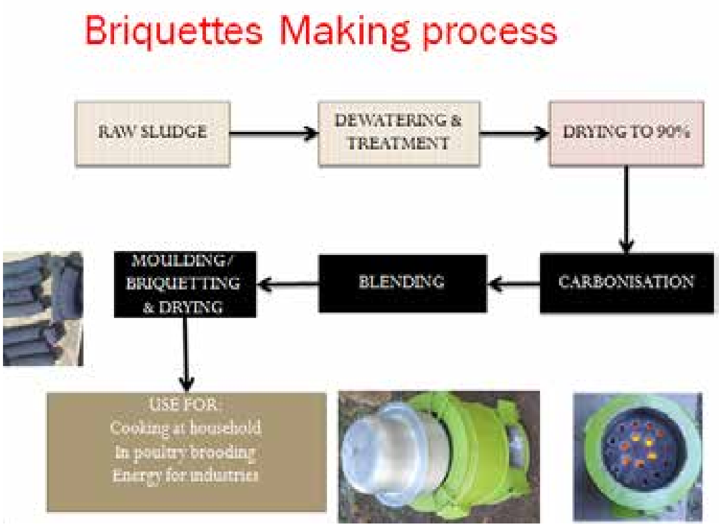


Figure 41: Processes of making faecal reuse products (Water For People Uganda, 2016).

CHAPTER 7 Hygiene Technologies

7.1 Introduction

Various types of hygiene technologies are promoted to facilitate safe hygiene practices. The common ones are:

- Bath shelters that provide privacy and proper drainage of wastewater.
- Laundry platforms especially in institutions and schools to allow for better and hygienic management of waste water.
- Hand-washing facilities like tippy taps, vessels with taps, and water fountains near sanitation facilities.
- Incinerators especially in schools and health facilities for disposal of hazardous materials.
- Compost pits in homes and institutions for disposal of biodegradable solid wastes.
- Drying racks for keeping washed utensils while they dry.

7.2 Bath Shelters

These are enclosures (usually open roof) about 1.5m x 1.5m x 1.8m high constructed from a range of materials like: reeds or grass and poles, corrugated (roofing) sheets, or masonry. The floor can be cemented with wastewater drainage into covered soak pits or covered by a bed of hardcore in a shallow pit that also serves as soak away for wastewater

Figure 42: A typical bath shelter

7.3 Laundry Platform

This is basically a slab (with receptacles) raised about 90cm above ground with paved apron around. The wash water drains in well constructed soak pit and the runoff from the apron drains into the compound around the facility. The platform can be connected to piped water supply or individuals carry water for their laundry. The size of the platform depends on the expected number of users but typically it would have 4 to 10 receptacles arranged in two rows (see below).

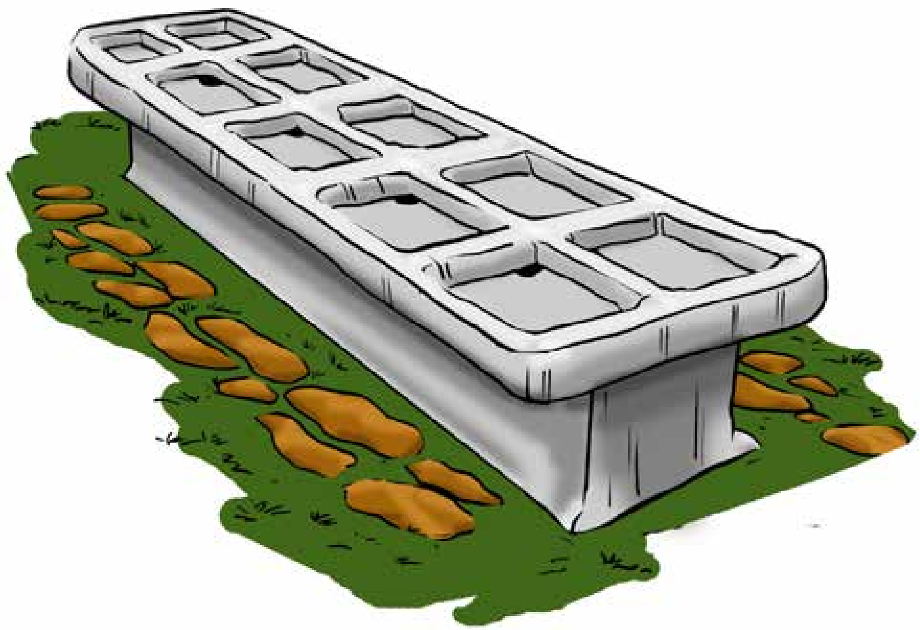


Figure 43: Laundry platform

7.4 Hand-washing Facilities

These are facilities for dispensing water used for washing hands especially after using latrines or before eating. There are various types but the main ones are: tippy taps; storage vessels with taps, and water fountains.

7.4.1 Tippy Tap

These are small scale facilities normally for household use but a series of them can be installed for medium size population. It basically consists of a 3 to 10 litre jerrycan (Figure 44) filled with water and hanged on a string about 1 metre above the ground. The jerrycan has a hole near the top and a string tied at the top used for tipping the jerrycan so that water flows out of the hole into the hands. The string is usually attached to a 'foot pedal' which is used to operate the tippy tap without handling the container.

The tippy tap should be placed over a bed of hardcore inside a shallow pit serving as soak away for the wash water. Users should ensure that the facility contains enough water at all times and soap or ash is provided at the facility for proper hand-wash.

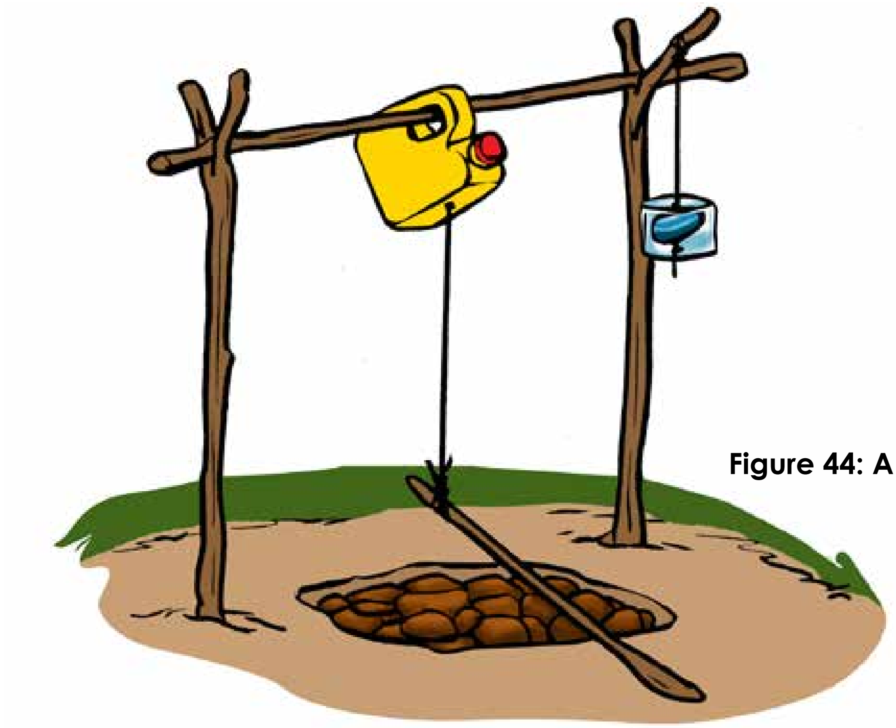


Figure 44: A tippy tap model

7.4.2 Storage Vessels with Tap

These are medium to large capacity facilities usually comprising a storage vessel 20 to 200litre capacity with single or multiple taps. The vessels are placed on stands or platforms about 60cm high to afford easy access to the various age groups. The facilities can be moveable or fixed and can be connected to rainwater collection system to supplement the water supply. (Figure 45).

The facility should be provided with wash water disposal system like hardcore bed in shallow pit (for the moveable facility) or an apron with covered soak pit for the fixed facility.

Figure 45: HWF with multiple taps (left) and with a single tap (right)

7.4.3 Water Fountains

These are large capacity HWFs with multiple taps normally fitted at different heights to cater for the various age groups targeted like primary school population. The facilities are usually connected to piped water supply and an elaborate wastewater disposal system provided.

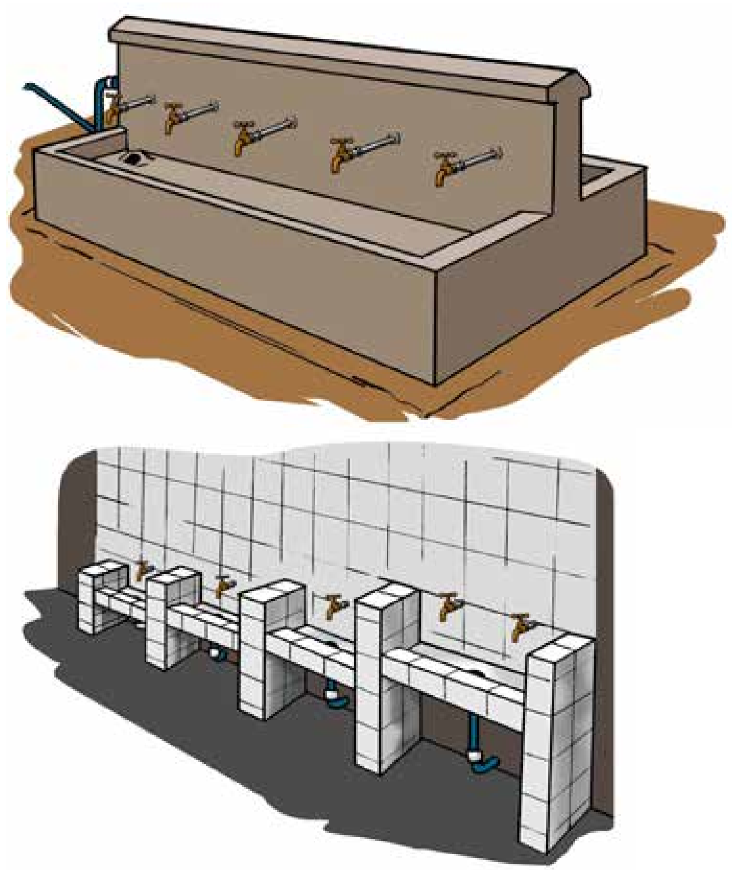


Figure 46: Water fountains with multiple taps for primary school HWFs

7.5 Incinerators

Incinerators (Figure 47&48) are very effective for burning or sanitising hazardous wastes before final disposal. Two types are commonly used: single combustion chamber and double combustion chamber incinerators.

The single combustion chamber incinerators burn wastes at relatively low temperatures (about 500 – 600^{0}C) and are suitable for low risks wastes like sanitary pads and non-biodegradable wastes from sewage treatment works. The main disadvantage of this type of incinerators is the high emissions of smoke and fumes that can be a nuisance to neighbouring communities.

The double combustion chamber incinerators are capable of reaching temperatures in the range of 800 – 1000^{0}C and are suitable for treating highly hazardous wastes like medical wastes. If well operated, the level of emissions from these incinerators is very low. They are therefore safe to operate near dwelling places.

Residues from incinerators are usually safe to dispose in landfills but sharps like needles, blades, and broken glasses from medical wastes are usually buried in separate pits.

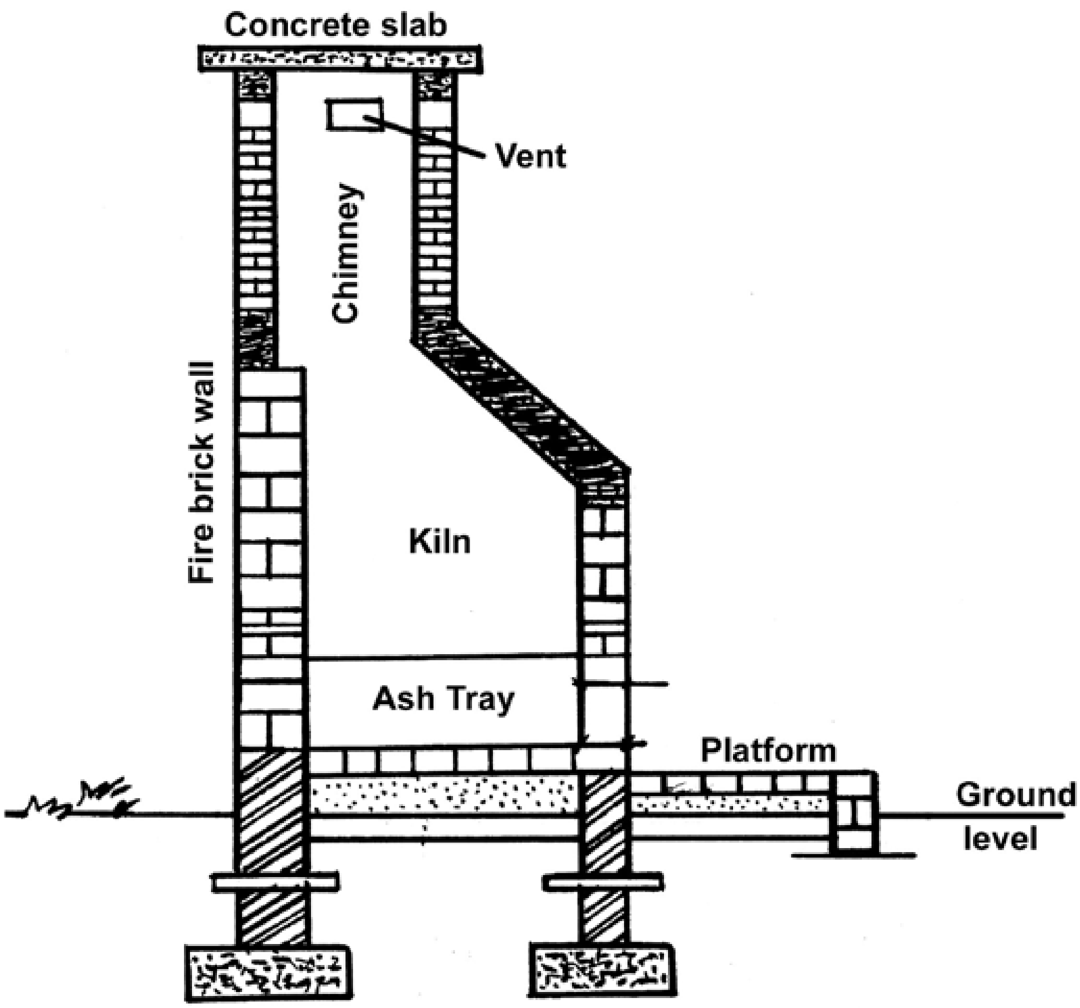


Figure 47: Typical single combustion chamber incinerator

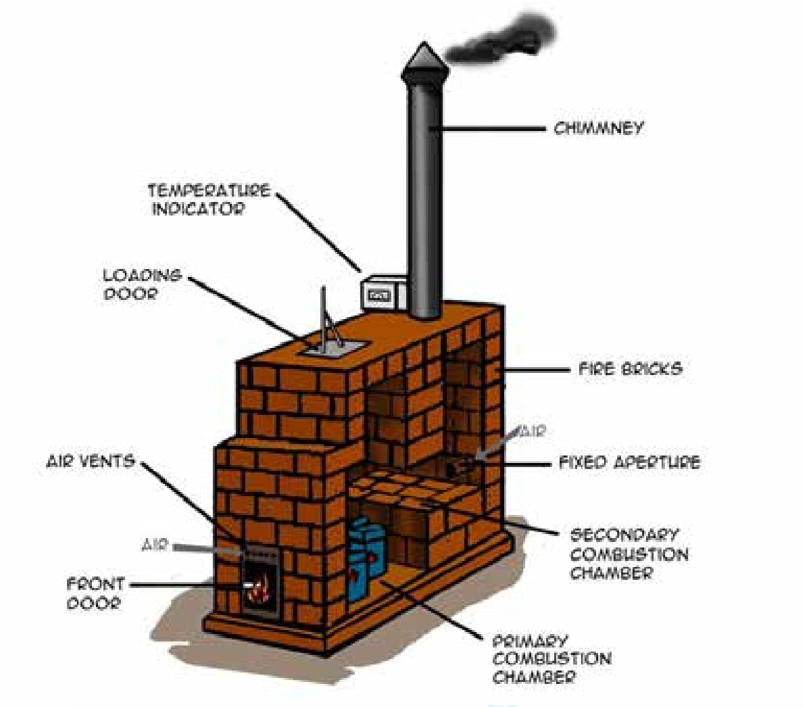


Figure 48: Typical layout of double combustion chamber incinerator

7.6 Compost Pits

Compost pits are commonly used for disposing household (solid) wastes more especially the biodegradable kitchen wastes comprising of food wastes and ash. They are generally pits in the ground about 1 metre deep and 1 – 1.2metre diameter. The wastes are dumped in the pit and covered regularly (preferably weekly) with about 10cm layer of soil to prevent breeding of vermin and infestation by flies.

When the pit is full, it is finally covered with a layer of soil and left for about 4 months for the wastes to compost completely while another pit is being used. The pit is then emptied (and reused) and the compost applied to the garden as fertiliser. The un-composted materials like plastics and paper are separated from the compost, dried, and burnt.

7.7 Drying Rack

Drying racks support the washing and drying of utensils in hygienic manner (Figure 49). They are usually constructed from wooden poles or metal frames with mesh placed on the decks for holding utensils while allowing the water to drip through. They vary in sizes depending on the expected number of utensils that would be washed at a time. On average they are about 1.5 metres x 1.5 metres with the upper deck about 1.8 metres above ground, and the smaller lower deck about 60cm above ground.

Dirty utensils are stored on the lower deck and washing also done on the lower deck. The clean utensils are then dried on the upper deck away from chicken and ducks. A hardcore bed is provided underneath the deck to soak away water dripping from the utensils.

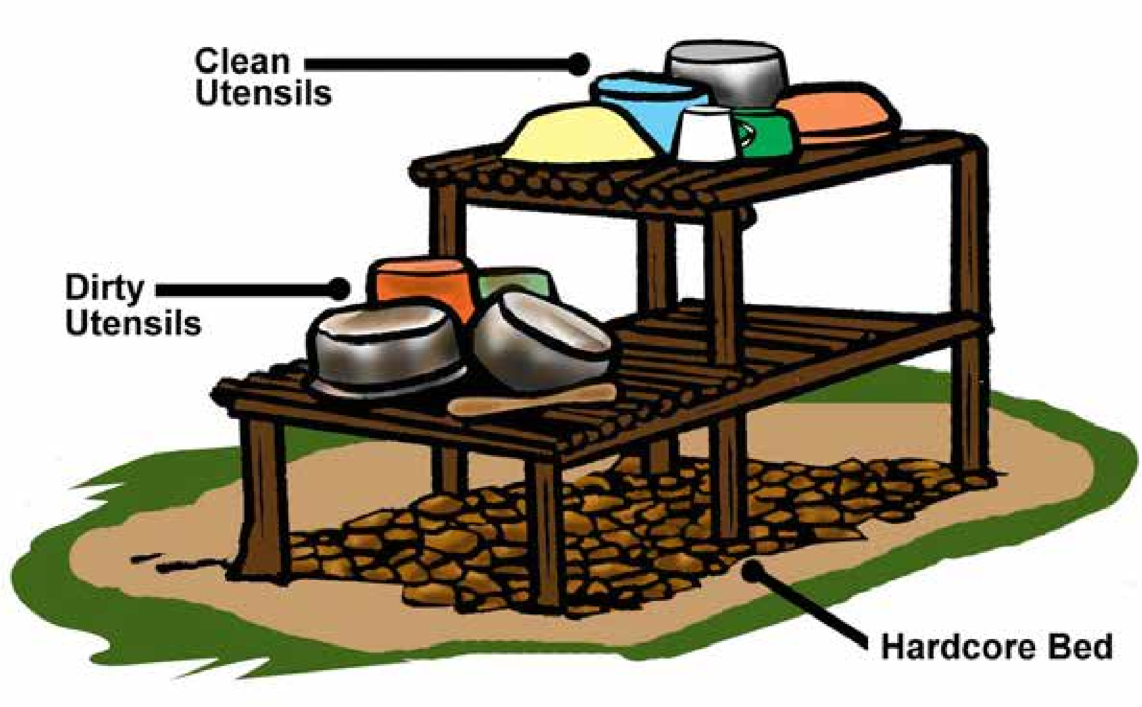


Figure 49: A typical drying rack

CHAPTER 8 CONTRACT ADMINISTRATION AND MANAGEMENT

8.1 Introduction

There are different types of Contracts; those run by the district and those run directly by an NGO or CBO. This Chapter refers to the Contracts executed using conditional grant funds to the district. The same principles still apply in the case of funding by donors and NGOs.

Under the National Water Policy, one of strategies is institutional development, including private sector involvement. Under the RWSS, the study, design, documentation, and construction of WASH facilities is carried out by consultants or contractors under the supervision of the District Water Officer (DWO) who is the main technical officer representing the Client (i.e. The District Local Government). The district can employ a consultant to supervise the construction work, but the district water office will be responsible for the supervision of the consultant for quality assurance.

8.2 Procurement

The National water policy and the Local Government Act require that all construction work be tendered out to private contractors. Once sources for protection or new sanitation systems to be constructed have been identified and designed, the district prepares tender documents and invites bids from contractors for the works. The procurement process is executed under the following stages:

1. Preparation of Tender Documents which normally include:
   - Invitation to tender
   - Instructions to bidders
   - Form of Tender
   - Articles of Agreement
   - Amendments to Conditions of Contract
   - Design drawings
   - Technical specifications on materials and methods of construction
   - Bill of quantities
   - Location where work is to be carried out as well as number of facilities to be constructed.
2. Advertisement in the press inviting eligible contractors to tender for the construction

works. The District Procurement and Disposal Unit through the Chief Administrative Officer (CAO) is responsible for placing the advertisement.

3. A site visit with a pre-bid meeting is usually arranged before bids are submitted. The District Water Officer briefs the Contractors on technical matters. The Contractors then visit the site(s) where the works are to be carried out to help them fully appreciate the extent of the works to be done and the distances to be covered.

4. Submission of Bids is done on or before the appointed date and time. On the close of submission, Bids are opened in the presence of the Contractors who submitted to verify the completeness of the Bids.

5. The evaluation of the bids is then carried out by a Contract Committee, appointed by the CAO. This committee makes a recommendation to the District Procurement and Disposal Unit for the award of contract based on the evaluation.

   The criteria for the evaluation of the bids are laid down under Instructions to Bidders in the Bid Document and are summarised below:

   a) Accuracy of bids
   b) Project Experience (company and personnel)
   c) Financial status
   d) Personnel Capability
   e) Equipment Capability
   f) Work Programme
   g) The bid amount

   Each criterion is evaluated and scores awarded accordingly and the bidder with the highest score is recommended for the contract.

6. Contract negotiation and signing; negotiating the terms and conditions of the contract is necessary to maximise financial and operational performance of the project, ensuring compliance with the terms and conditions of the contract between the clients (in this case DLG) and contractors in order to ensure a successful quality output.

   The Contract Document guides how the contract is conducted and supervised. It is important that both the supervisor and the Contractor understand all the clauses or terms of the contract. Contract documents vary for different contracts, with some much simpler than others.

This section explains some of the common conditions of execution of work.

8.3 Contract Management

Contract management focuses on what happens after a contract is formed. Contract management involves deciding what human, financial and technical resources the DWO will devote to various activities of the project from planning to conclusion. The availability of accurate information on the contractor's plan of performance and actual progress is fundamental in enabling the client to monitor and supervise the contractor's performance. Although the contract is the legal and binding document, a Contract Management Plan (CMP) assists in the management and administration of the contract and provides a snapshot of the roles and responsibilities of the contracting parties. If the roles and responsibilities are closely adhered to, the contract can be successfully managed. The CMP is flexible and can adapt to changing circumstances. It does not include every action that the district must take to make the contract successful. Instead, it summarises the higher-level requirements, deliverables, and tasks necessary and describes the overall process with which the tasks are performed.

Contract management runs for as long as the project is running, and will normally extend to defect's liability period. The DWO does not necessarily have to be the contract manager of every water supply and sanitation project in the district, he can delegate this duty to one of his officers. But he remains collectively responsible for the output. Even when the district contracts out supervision of a project to a consultant, the consultant works on behalf of the contract administrator/manager implying, DWO remains responsible. In any case, the consultant only comes at implementation stage, implying that the terms of reference and technical specifications would have been derived already and embedded in the contract.

8.4 Stakeholders and Roles in Contract Management

8.4.1 Stakeholders in Contract Management

The stakeholders directly involved in contract management of water and sanitation programmes at district level include the District Water Officer (DWO), the Contractor, the Consultant, the Chief Administrative Officer (CAO) and the District Engineer (DE) provide the oversight functions. The Extension Workers from the district water office and at the sub-county also participate in the contract management process.

The Extension Worker is in close contact with the work sites compared to the DWO. In addition, he/she is always with the community during construction to further sensitise them on their responsibilities. As such, it is important for the Extension Worker to know the roles of the other stakeholders. The Extension Worker is advised to monitor progress, listen to community comments and complaints, and update the DWO on progress. If any of the stakeholders mentioned deviates from their contract roles according to the Extension Worker, he/she should notify the DWO immediately, who in turn should take action immediately. The Extension Worker has no authority to stop progress of works nor issue instructions or alterations to designs.

8.4.2 Key Roles of Stakeholders in Contract Management

<u>District Water Officer</u>

- Oversee, supervise and evaluate work in process. Monitor contractor conduct testing procedures and schedules. Request warranty information (especially electro-mechanical equipment).
- Co-ordinate site meetings with contractor and consultants and ensure that the decisions arrived at in the meeting are implemented.
- Review the Contractor's monthly status reports and Critical Quarterly Analysis. Report to the CAO any schedule delays or progress problems. Provide oversight as required of contractor's compliance with schedule and technical performance.

- Procure all owner-related testing and reports including: geophysical survey reports; geotechnical report (soils report); environmental reports; design and other technical reports; training reports; and mobilisation and other necessary reports.
- Review for quality and timeliness, the Contractor's submission of required contract deliverables. Inspect completed works and prepare recommendations to the CAO/DE regarding the acceptability of the product including any inadequacies noted in the specifications and technical requirements.
- Develop District's prompt responses to contractor deliverables and provide recommendations to the CAO.
- Review contractor claims for payment. Make payment recommendations to the CAO/DE.
- Ensure that Government-furnished property is delivered to the Contractor and monitor the Contractor's use of the property.
- Ensure that District meets its compliance obligations.
- Quantify and coordinate removal of all environmental concerns as recommended in the reports.

Contractor

- Ensure that measures and procedures described in the specifications are adhered to.
- Provide safe working conditions to the employees in relations to Acts and regulations (Health and safety regulations) by the rightful authority.
- Construct facilities in accordance with design approved but apply professional discretion.
- Notify the client and consultant where the design may not be workable or has inadequacies. If the proposed procedures are not appropriate given the circumstances, the contractor should inform both the client and consultant.
- Ensure the testing of all materials used as may be specified in the contract/or in accordance with the construction practice
- Ensure that purchased equipment and materials/pipes have warranty that will assist the client after the liability period. Hand over warranty to the client at end of the contract.
- Prepare and submit to the consultant the invoices for the works done.
- Attend all the site meetings and/or cause them to be held.

Consultant

- Ensure the contractor follows the contract
- Ensure the contractor follows the designs
- Ensure the contractor uses the proper materials
- Ensure the workmanship of the contractor is acceptable
- Prepare payment certificates for the Contract
- Facilitate communication between the Client and the Contractor

- Facilitate communication between the Contractor and the community
- Monitor systems during defects liability period, and get the contractor to correct any construction defects.

Extension Worker

- Plan with the community on their participation during construction (provision of labour, materials etc.)
- Monitor both the Consultant's and contractor's work to ensure that they both follow the terms of their contracts.
- Report to the Water Engineer on the work progress
- Facilitate communication between the Contractor, the Consultant and the community.
- Communicate to the community the work programme and the work progress.
- Monitor systems for defects, during the defects liability period, and report to the DWO.

8.5 Construction Supervision

8.5.1 Introduction

Overall, two aspects contribute to the attainment of good quality work:

- Quality of materials
- Workmanship

It is important for the supervisor to ensure that the contractor follows the terms of agreement. This is done by periodic visiting of the site to ascertain the quality of the materials and of the work produced by the contractor.

In principle the contractor is aware of the materials needed for the job from the technical specifications, but it is important that the supervisor checks all materials before they are used. The contractor will still be held responsible for the use of poor quality material whether it is checked by the supervisor or not.

At the end of each technology chapter, there is a materials check form, which should be used at each site in checking the quality of materials to be used for construction.

8.5.2 Roles of the Supervisor

A Supervisor is assigned to a particular Contract on behalf of the client (DLG, CSO, NGO, etc) to ensure that the Contractor upholds the standards and guidelines. Depending on the type of work contracted, the supervisor can be a consultant employed by the district or local government district staff (represented by the extension worker).

Before going to site, the supervisor should:

- Confirm locations, check against Contractor's Work Programme and inform community of future construction activities.

- Review survey results and produce photocopies for the Contractor in case there are issues (e.g. land disagreements, site location, etc) with some of the selected sites
- Obtain and review a copy of the Contract and become familiar with all aspects of the Contract, most importantly the Technical Guidelines/specifications.

On-site, the supervisor should:

- Establish who is in charge on the Contractor's side.
- Confirm Work Programme and proposed construction method with the Contractor.
- Check equipment and materials on site. Provide written instructions to the Contractor specifying the exact location where the facilities are to be constructed. Instructions must be signed by both parties prior to construction work.
- Record details of the construction activities on the Daily Record sheets (details of what to record are usually included in the Technical Specifications of the Contract).

It is important that the supervisor checks on all stages of construction. There are however key stages for different technologies, which should not be missed. These are outlined in the construction quality check forms included under the chapters on different technologies.

CHAPTER 9 ANNEXES

9.1 Reporting Formats

9.1.1 Extension Worker Reporting Format (Protected Spring)

District: ....Sub-county: ....

Parish: ....Village: ....

Source Name: ....Source Number:...

Date: ....

STATUS:

Functioning fully: ☐ Functioning partly: ☐ Not Functioning: ☐

CONDITION:

	GOOD	NOT GOOD
Wall		
Floor		
Pipe		
Steps		

	GOOD	NOT GOOD
Fence		
Grass		
Drain		
Catchment		

PROBLEMS IDENTIFIED*

....

....

....

....

....

ADVICE GIVEN

....

....

....

....

....

Signature:..Designation:..

Date: ....

9.1.2 Extension Worker Reporting Format (Boreholes and Shallow Wells)

District: ....Sub-county: ....

Parish: ....Village: ....

Source Name: ....Source Number:..

Date: ....

STATUS:

Functioning fully: ☐ Functioning partly: ☐ Not Functioning: ☐

CONDITION WATER SOURCE:

Pump Condition:	Good:	☐	Not Good:	☐
Chain:	Oiled:	☐	Not Oiled:	☐
Condition of Platform:	Good:	☐	Not Good:	☐
Condition of Fence:	Good:	☐	Not Good:	☐
Grass:	Cut:	☐	Not Cut:	☐
Surroundings:	Clean:	☐	Not Clean:	☐
Soak Away Pit:	Clear:	☐	Not Clear:	☐

Preventive Maintenance in last 3 months: Done: ☐ Not Done: ☐

PROBLEMS IDENTIFIED*

....

....

....

....

ADVICE GIVEN

....

....

....

....

Signature:...Designation:...

Date: ....

9.1.3 Hand Pump Mechanic Quarterly Report

Sub-county: ....

District: ....

Quarter (1, 2, 3 or 4); Months (list the months):..

Year:..

Name: ....

Location	Major/Minor	Person Seen	Date	Payment received	Available spares

Received by: ....

Designation: ....

Date: ....

Action Taken (if any)

....

....

Distribution: Sub County, District

9.1.4 Water and Sanitation Committee (WSC) Reporting Format

District: ....Sub-county: ....

Parish: ....Village: ....

Source Name: ....Source Number:..

Date: ....

Report for Month: ....Year: ....

WSC: ....Number of Users: ....

Condition of Water Source:

Functioning: Fully ☐ Partly ☐ Out of Order* ☐

*Nature of Problem: ....

....

Action Taken: ....

....

Date last Service carried out:...

Cost: ....

General Environment:

Clean/soak away clear
Fairly clean/soak away clear
Fairly clean/soak away partly cleared
Not clean/soak away clogged

Date last WSC Meeting: ....

Dues collected during month: Payments made during month:

Item	Amount		Item	Amount

Total Income: ....Total Expenditure: ....

Balance at Hand: ....

Signed: ....(Chairperson WSC)

Date: ....

Distribution copies to: Community, Sub County, and District

9.1.5 Hand Pump Caretaker Diary

DATE	ACTION	TAKEN	BY WHOM	COST	SIGNATURE

9.1.6 Hand Pump Mechanic Diary

Date	Village & Pump No.	Action Taken and Spare Parts Used	Cost	Signature of WSC Member(s)

9.2 Water Source Information

9.2.1 Borehole Verification Form

LOCATION

District: ....Sub-county: ....

Parish: ....Village: ....

Source Name: ....Source Number:..

Date of Construction: ....Grid: North:..

South: ....

CONDITION OF BOREHOLE

Status: Operational ☐ Non-Operational ☐

When started functioning: ....

Estimated yield: ....

Presence of backfill material: ....

Water quality: ....

Other remarks: (History of known problems (siltation, others)

....

CONDITION IN THE SURROUNDING:

Any sources of contamination:...

Accessibility of site: ....

WATER QUALITY AS REPORTED BY USERS

Good ☐ Fair ☐ Poor ☐ Acceptable ☐ Not Acceptable ☐

Remarks:..

....

Was the Source Reliable: Yes ☐ No information ☐

Any alternative water source:...

What type and how far:..

STATUS DATA:

Casing depth: ....

Last Service date: ....Services carried out:.................................

Condition of pump: ....No. and condition of pipes: ....

Condition of pedestal & tank: ....

Condition of Chain: ....Missing bolts: ....

Condition of pump cover bolt: ....Condition of foot valve: ....

Condition of platform: ....Condition of the drain: ....

Condition of soak away: ....

Date of Inspection: ....Inspection by: ....

9.2.2 Hand Pump Equipped Water Source Information Sheet

A copy of this form should be kept by the LC1 and the C/P WSC. The LC1 and the WSC should keep it safely, and shall be filed in the water source file comprising a list of water source users, maintenance cards, etc.

HAND PUMP EQUIPPED WATER SOURCE INFORMATION SHEET

LOCATION

District: ....Sub-county: ....

Parish: ....Village: ....

Source Name: ....Source Number:...

Type of Source: ....Date Completed: ....

Date: ....

CONSTRUCTION DETAILS

Depth of Well: ....(m)

Final Water Level: .... (m)

Yield of the Well: ....(L/hr)

Quality of Structures (Apron and Drain): ....

Condition of Fence: ....

Condition of Soak Away Pit: ....

EQUIPMENT INSTALLED

Type of Hand Pump: ....

No. of Riser Pipes: ....

Date Installed: ....

Status of Hand Pump: ....

COMMENTS

....

....

For: District

Name and Title: ....

Signature:..

Date Received:..

Water and Sanitation Committee

Name and Title: ....

Signature: ....

Date Received: ....

9.3 Agreement

9.3.1 Hand Pump Preventive Maintenance Agreement

This Contract Agreement is Between the **Water and Sanitation Committee** of:

Water Source No: ....of ....Village;

....Parish; ....Sub-county;

....District.

(Hereinafter referred to as WSC)

And

The Hand Pump Mechanic of ....Sub-county;

....District.

(Hereinafter referred to as HPM);

Whereby the HPM will provide preventive maintenance service for hand pump at water source referred to above according to the schedules in ***The Hand Pump Installation and Maintenance Manual***. This Contract Agreement will take effect on the .... day of the ..... month of year .... and will remain in force for a period of **Two Years.**

1. **Work Programme**

The yearly preventive maintenance will be as follows:-

Date	Type of Service
a)	....
a)	....
a)	....
a)	....
a)	....
a)	....

2. **Fee:**

The HPM will be paid a fee of:-

USH..for minor service (see below); and

USH ....for major service (see below)

The fee will be reviewed after every one year of service.

The above fee does not include costs of spare parts.

3. **Payment:**

Payment will be made upon the HPMs completion of each half yearly service. The HPM shall provide the WSC with a detailed invoice together with any spare parts removed.

4. **Minor Service:**

The following schedule of maintenance is drawn out and recommended for the HPM to carry out with caretakers once in a year.

Examine the pump carefully and check:

- If the hand pump and the surrounding area are clean.
- If the hand pump drainage is working properly
- For insufficient lubrication
- For loose bolts, nuts, etc.
- That all nuts, bolts and washers are in position.
- That water discharge is satisfactory.
- If handle is shaky.
- If guide bush has excessively worn out.
- If chain has worn out.
- If chain guide has worn out.

Any faults found should be reported to the WSC and repair carried out or recommended to be carried out on the next visit.

5. **Major Service:**

The following schedule of maintenance is drawn out and recommended for the HPM to carry out once a year:

a) Pull out rods and insides of pump cylinder.

- Check condition of rods and centralisers
- Check condition of water tank and riser pipe holder
- Pull out plunger, check valve assemblies and replace pump buckets, upper and lower rubber seating and 'O' ring.
- Reinstall the plunger and rods.

Examine platform and Soak away.

- Check for cracks in platform and, if present, recommend repairs.
- Check that Soak away is working and, if not, recommend repairs.

The full schedule of minor maintenance (see no. 4 above).

7. Other Conditions:

....

....

If both parties agree with the terms of this agreement please fill in three copies (WSC, HPM, and District) and sign

Name: .... Name: ....

Signature: .... Signature: ....

Date: .... Date: ....

Chairperson, WSC **Hand Pump Mechanic**

NB:

1. *Communities are free to contract any other HPM outside the sub-county in case of breach of contract by overcharging.*

2. *Similarly the HPM may not continue to abide by the terms of the agreement in case the WSC has failed to pay him as was agreed in the contract.*