Public Water Corporation

MIWR – GONU **MWRI - GOSS**

Technical Guidelines for the Construction and Management of Hand dug well Hand pumps

A Manual for Field Staff and Practitioners

April 2009

DEVELOPED IN PARTNERSHIP WITH

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Ministry of Irrigation and Water Resources – Government of National Unity

Foreword

Significant progress has been achieved in the provision of water and sanitation services in Sudan in the last few years. This is attributed to the increased access to many remote villages as a result of the three major peace agreements, the Comprehensive Peace Agreement (CPA) between north and south Sudan, the Darfur Peace Agreement (DPA) and the Eastern Sudan Peace Agreement (ESPA), that were signed in 2005 and 2006 respectively. This access has allowed the Ministries of Irrigation and Water Resource (MIWR) of the Government of National Unity (GoNU), state governments and sector partners (including NGOs and the private sector) to expand water and sanitation services in many areas. This prioritizing of the expansion of water and sanitation services in urban and rural areas throughout the county, including to the nomadic population has resulted in a steady annual increase in water and sanitation coverage for the citizens of Sudan.

With this expansion in implementation, the MIWR recognized the need to harmonize the various methodologies utilized by the various actors in the implementation of water and sanitation interventions. It was agreed that this could be best achieved through the development and distribution of Technical Guidelines, outlining best practices for the development of the 14 types of water supply and sanitation facilities in the Sudan. These Technical Guidelines, compiled in a systematic manner will undoubtedly set standards and provide guidance for all water and sanitation sector implementing partners.

The MIWR of the GoNU of the Sudan is grateful to UNICEF, Sudan for financial and technical support in the preparation of the Technical Guidelines.

I believe these Technical Guidelines will go a long way to improving WES sector programmes, allowing for scaling up implementation of activities towards achieving the MDG goal for water supply and sanitation in Sudan.

Minister
Ministry of Irrigation and Water Resources
Government of National Unity, Khartoum

Date ………………………………………

Foreword

The historic signing of the Comprehensive Peace Agreement (CPA) in January 2005, culminated in the establishment of an autonomous Government of Southern Sudan (GOSS) and its various ministries, including the Ministry of Water Resources and Irrigation (MWRI). The CPA has enabled the GOSS to focus on the rehabilitation and development of the basic services. The processing of the Southern Sudan Water Policy within the framework of the 2005 Interim Constitution of Southern Sudan (ICSS) and the Interim National Constitution (INC) was led by the MWRI. This Water Policy is expected to guide the sector in the planning and monitoring of water facilities during implementation. The Water Policy addresses issues like Rural Water Supply and Sanitation (RWSS) and Urban Water Supply and Sanitation (UWSS). The Southern Sudan Legislative Assembly (SSLA) of GOSS approved the Water Policy of Southern Sudan in November 2007.

The importance of developing effective water supply and sanitation services is universally recognized as a basis for improving the overall health and productivity of the population, and is particularly important for the welfare of women and children under five. Considering the current low coverage of safe drinking water supply and basic sanitation facilities as a result of the protracted civil war in the country during the last five decades, there are enormous challenges ahead. With the unrecorded number of IDPs and returnees that have resettled in their traditional homelands and the emergence of new settlements/towns in all ten states of SS, the demand for water and sanitation services is immense. There is need for implicit policies, strategies, guidelines and manuals to ensure provision of sustainable supply of quality and accessible water and sanitation services.

The preparation of these WES Technical Guidelines at this stage is very timely, as it enables us to further develop our strategies and prepare action plans for the implementation of the Water Policy. It will also allow us to strengthen existing best practices as well as to test new experiences that will create room for future development.

During the development and finalization of these Guidelines for water supply and sanitation facilities, we have consulted WASH sector partners at State level and partner non-government agencies through successive consultative meetings, and appreciate their contribution, which has assisted in finalizing these documents.

The MIWR of the GOSS is thankful to UNICEF, Juba for financial and technical support for the preparation of these Technical Guidelines.

We call upon our WASH sector partners to give us their continuous feedback from the field for the improvement of these Guidelines. We believe that successful implementation and future sustainable service provision will depend on effective coordination and close collaboration among all partners including government, non-government and beneficiary communities.

Mr. Joseph Duer Jakok,
Minister of Water Resources and Irrigation
Government of Southern Sudan, Juba

Date ……………………………………….

Acknowledgements

Special thanks go to Mr Mohammed Hassan Mahmud Amar, Mr Eisa Mohammed and Mr Mudawi Ibrahim, for their directions on GONU's sector policy; Engineer Isaac Liabwel, on GOSS's water policy; Mr Sampath Kumar and Dr. Maxwell Stephen Donkor, for their direction on the WASH sector from the UNICEF perspective, and for the provision of relevant documents & information, and facilitating & organizing a number of forums to discuss draft documents.

The author would also like to thank WES and UNICEF staff of North Darfur, North Kordofan, South Kordofan, Sinnar, Gedaref, Kassala, Red Sea and Blue Nile States; the staff of DRWSS, and UWC in Central Equatoria, Western Bahr el Ghazal, Warap and Upper Nile States; and the staff of UNICEF Zonal Offices responsible for the arrangement of meetings with sector partners and successful field trips to the various facilities.

Many thanks to Emmanuel Parmenas from MWRI, and Mr Mohammed Habib and Mr Jemal Al Amin from PWC, for their contribution in collecting documents and information at the national and state levels, facilitating field trips and contacting relevant persons at state level and to the latter two for their support in translating documents and information from Arabic to English.

The completion of this document would not have been possible without the contributions and comments of staff of SWC, PWC, MIWR, MCRD, MWRI, MOH in GONU, MAF, MARF, MOH MHLE, MWLCT and SSMO in GOSS, UNICEF, National and International NGOs like Oxfam GB, Pact Sudan, SNV, SC-UK, and Medair, and review workshop participants at state and national levels and members of technical working groups.

Acronyms

APO	Assistant Project Officer
BS	British Standard
CPA	Comprehensive Peace Agreement
DG	Director General
DPA	Darfur Peace Agreement
ES (Es)	Effective Size
ESPA	Eastern Sudan Peace Agreement
GONU	Government of National Unity
GOSS	Government of Southern Sudan
IRC	International Reference Center (International Water and Sanitation Center)
MCRD	Ministry of Cooperatives and Rural Development,GOSS
MIWR	Ministry of Irrigation and Water Resources, GONU
MPN	Most Probable Number (Faecal coliform counts per 100ml)
MWRI	Ministry of Water Resources and Irrigation, GOSS
NTU	Nephlometric Turbidity Unit
PM	Project Manager
PVC	Polyvinylchloride
PWC	Public Water Corporation
RPO	Resident Project Officer
RWD	Rural Water Department
SSMO	Sudanese Standard and Measurement Organization
SWC	State Water Corporation
SWL	Static water level
TCU	True Color Unit
TDS	Total Dissolved Solids
UC	Uniformity Coefficient
UNICEF	United Nations Children's Fund
WATSAN	Water and Sanitation
WES	Water and Environmental Sanitation
WHO	World Health Organization

Document Summary

This summary provides a brief overview of the document and is only meant as a quick reference to the main norms. Reference to the whole document is advised for accurate implementation.

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Norms

- Digging of a hand dug well should follow well established safety procedures, using local knowledge of hand dug well techniques wherever possible.
- Diameter of the well: 1.5 – 2.0m, depending on the type of lining material used. This could be plastic, concrete, brick or stone masonry.
- Maximum diameter of the well for plastic lining is 1.4m, for concrete lining 1.5m, for brick and stone masonry 2.0m. Where deepening of a well is anticipated due to drop down of groundwater level, all lining materials (except the plastic lining) can be used. The internal diameter of the current available plastic lining material is limited to 1.0m and does not allow deepening of the well for less than 1.0m diameter.
- Screen slot size of the lining material should range between 1 and 2mm.
- Maximum depth of the well should be 40m.
- Water quality should comply with Sudanese/WHO guidelines.
- Disinfection of the hand dug well is required prior to commissioning of the water supply system. Community's awareness of disinfection (chlorination of water) may be low, so information sessions are recommended.
- Where gravel packing is required, the packing material should be placed in two vertical layers (minimum) using round shaped gravel (whenever possible). One half of the vertical layers should be fine gravel of size 2 to 6mm placed closer to the lining material and the other half , medium gravel of size 6 to 20mm placed closer to the wall of the dug well.
- Types of hand pumps:
  a) For shallow wells up to 15m depth – Direct Action Pumps
  b) For wells up to 45m depth– IM2 or Afridev hand pumps. The latter are particularly appropriate for aggressive water. In this case, connecting rods and connecting nuts should be made of stainless steel.
  c) For wells more than 45m depth – Extra deep well IM2 or Dubba hand pumps such as those used in South Sudan are recommended.
- Hand pump specification should indicate appropriateness for the quality of water in the borehole.
- Number of people that can be served from one hand dug well at 20 l/p/d
  a) 250 people in North Sudan
  b) 250-500 people in South Sudan
  c) During emergencies at 15 l/p/d - 500 people

1. Introduction

1.1 The purpose of this document:

The Ministry of Irrigation and Water Resources (MIWR), GONU, and the Ministry of Water Resources and Irrigation, (MWRI), GOSS, are responsible for the policy and strategy development, coordination, planning, management, monitoring and evaluation of water supply and sanitation facilities in the country. In order to reduce disparities, improve standards, accelerate implementation and to standardise design and costs, the two ministries agreed to harmonize the methodologies utilised in the implementation of WATSAN interventions Currently, there is no standardised document providing Technical Guidelines for implementation by WES or other water and sanitation agencies and this is detrimental to the longevity of structures and the sustainability of interventions.

In 2006 MIWR and MWRI decided to develop Technical Guidelines for the construction and management of rural water supply and sanitation facilities. These Guidelines are a collection of global and national good practices in water and sanitation that have been collated. The process of the development of the Technical Guidelines is outlined in Annex 7.

These simple Guidelines are primarily intended as a reference for field staff and practitioners in the water and sanitation sector challenged by situations and conditions in the field.

Updating of the Guidelines is recommended biennially; to ensure newer and better practices are incorporated as they are developed/ introduced. Water and sanitation sector implementing partners should contribute in providing feedback to the MIWR and MWRI as necessary during the updating..

1.2 Mobilization of stakeholders

Identifying and mobilizing potential stakeholders is an important step in the realization and sustainability of a rural water supply system. Various stakeholders play various roles at different stages of a project cycle. Roles and responsibilities can be assigned using participatory techniques like participatory rural appraisal. Involvement of the community (including women) in decision making at all stages of the project will promote sustainability. For example in, site selection, technology choice, choice of preference design for the platform and drainage apron, community contribution for the construction, operation and maintenance of the water service, selection of the village health committee (for the management of water , sanitation and hygiene promotion activities in their villages) and village mechanics (that could be trained).

Local authorities also play a significant role in the facilitation of the implementation of the water supply system. Problems that may arise during the implementation of the water supply system such as for example, land ownership, can be more easily solved if the local authorities are brought on board and are involved in the decision making process.

Problems can only be identified by the active involvement of the stakeholders in the decision making process. The long process involved in getting community engagement will be decreased if the implementing agency uses a demand-driven approach.

In Southern Sudan, the roles and responsibilities of stakeholders in regard to operation and maintenance and hygiene promotion are outlined in separate guidelines which are available for reference.

1.3 Technology options

A number of global technology options are available for improved rural water supply systems. However, not all can be applied everywhere. In rural North Sudan, and Southern Sudan, the common choice is boreholes equipped with hand pumps or motorized pumps (water yards); hand dug wells (with hand pumps), Hafirs (with a combination of filtration systems and hand pumps), and from developed springs.

These Technical Guidelines focus only on hand dug wells with hand pumps. The following general design considerations are recommended for the application of this technology option.

2 Design considerations

2.1 General

In order to ensure the supply of improved and adequate water to communities within the design period of any water supply system, due consideration should be given by the designers and planners to the following parameters:

- **The population number**: A reliable forecast of the expected number of people utilizing this service is important. This can be extrapolated from the current population figure and the growth rate and/ or any other factors that might affect the numbers to be served.
- **The design period of components**: The design period of each component should be identified and their shelf-life discussed at the beginning of the planning stage as the life span of the different components varies. Components can be installed in phases depending on the availability of resources. Components like boreholes could initially be designed for 20 years more or less, and hand pumps should be designed for the same period with a regular replacement of components.
- **The per capita water demand**: The per capita daily water demand should be in line with the government development strategy. In Sudan, the current daily water demand is set at 20 liter per capita per day (l/c/d). The Government of Sudan aims to reach to 50 l/c/d by 2015. With the current budget allocation, it is realistic to

assume that the minimum per capita of 20 l/c/d will be maintained in the near future.

- **The quality of water**: The quality of water (in terms of physical, chemical and bacteriological content) has a significant impact on public health. Since this varies considerably from region to region in Sudan, the fluoride, sulphate and nitrate content in the groundwater sources needs to be examined as it may be higher than the rates allowed by the Sudanese Standards and Measurements Organization (SSMO).
- **Distance to improved water supply facilities**: To the extent possible, the distance of the water supply facility should not be greater than **500m** during emergencies and **1000m** during normal times from the village or dwellings.
- **Choice of various technology options:** Without compromising the quality, quantity and sustainability of the system, a low-cost option should be prioritized.
- **Hydro geological classification of aquifers**: The knowledge of hydrogeological classification of aquifers in the various parts of the country and the quantity and quality of the groundwater in the various aquifers is vital. This is detailed below.

2.2 Hydrogeological classification of the aquifers

The knowledge of the hydrogeological classification of aquifers in the various parts of the country and the quantity and quality of the groundwater in the various aquifers is vital, for an informed decision on the design of the water treatment system to be used. According to hydrogeological information from 1989, Sudan's hydrogeological units are divided into three main groups:

A) Porous rocks of relatively high to low hydrogeological importance
B) Fractured rocks of relatively medium to low hydrogeological importance, and
C) Porous or fractured rocks with very low hydrogeological importance.

A) Porous rocks of relatively high to low hydrogeological importance: This group is divided into three sub-groups:

1. **Continuous aquifers of sub-regional to regional extent which are confined or unconfined and consolidated or unconsolidated:** Nubian Sandstone and Gedarif Formations are categorized under this subgroup, whose saturated thickness is generally high; permeability varies but it is generally high; water quality is generally good and hydrogeological importance and potential is great.

   Areas under this subgroup are: South Kordofan, North Kordofan, Gedarif, Khartoum and Northern States, North Darfur, Baggara Basin of South and West Darfur, South Darfur, Western Bahir el Ghazal, Northern Bahir el Ghazal and Unity States (refer to map 1: Sudan Hydrogeological Map).

2. **Continuous and sub-continuous aquifers of local to regional extent:** Um Ruwaba, Gezira, El Atshan, Butana, Nawa and Undifferentiated Paleozoic Formations are categorized under this subgroup which are consolidated or unconsolidated; with saturated thickness medium to high; and permeability low to high. The water quality

varies though it is generally good and hydrogeological importance and potential is medium to great.

Areas under this subgroup are: All Southern Sudan except Western Bahr el Ghazal, West Equatoria and Central Equatoria.

3. **Continuous or sub-continuous aquifers of local to sub-regional extent**: Alluvium, Wadi fills and swamp deposits are categorized under this subgroup, which are unconsolidated and their saturated thickness generally small; permeability varies and the water quality is generally good; hydrogeological importance is generally great and the potential is variable.

   Areas under this subgroup are: In Southern Sudan, they are sub-continuous and are found in Lakes and Central Equatoria States.

B) Fractured rocks of relatively medium to low hydrogeological importance: This unit is characterized by local aquifers restricted to fractured zones. It could be unconfined or confined. The permeability varies and it is generally low. The water quality is generally good. Thermal saline waters may occur. Its relative importance is medium to low and the potential is generally low. Undifferentiated volcanics are categorized under this unit.

Areas under this hydrogeological unit are: Gedarif, Eastern part of Eastern Equatoria, Jebel Mara area in Darfur and some pocket areas in North Darfur, (refer to map 1: Sudan Hydrogeological Map)

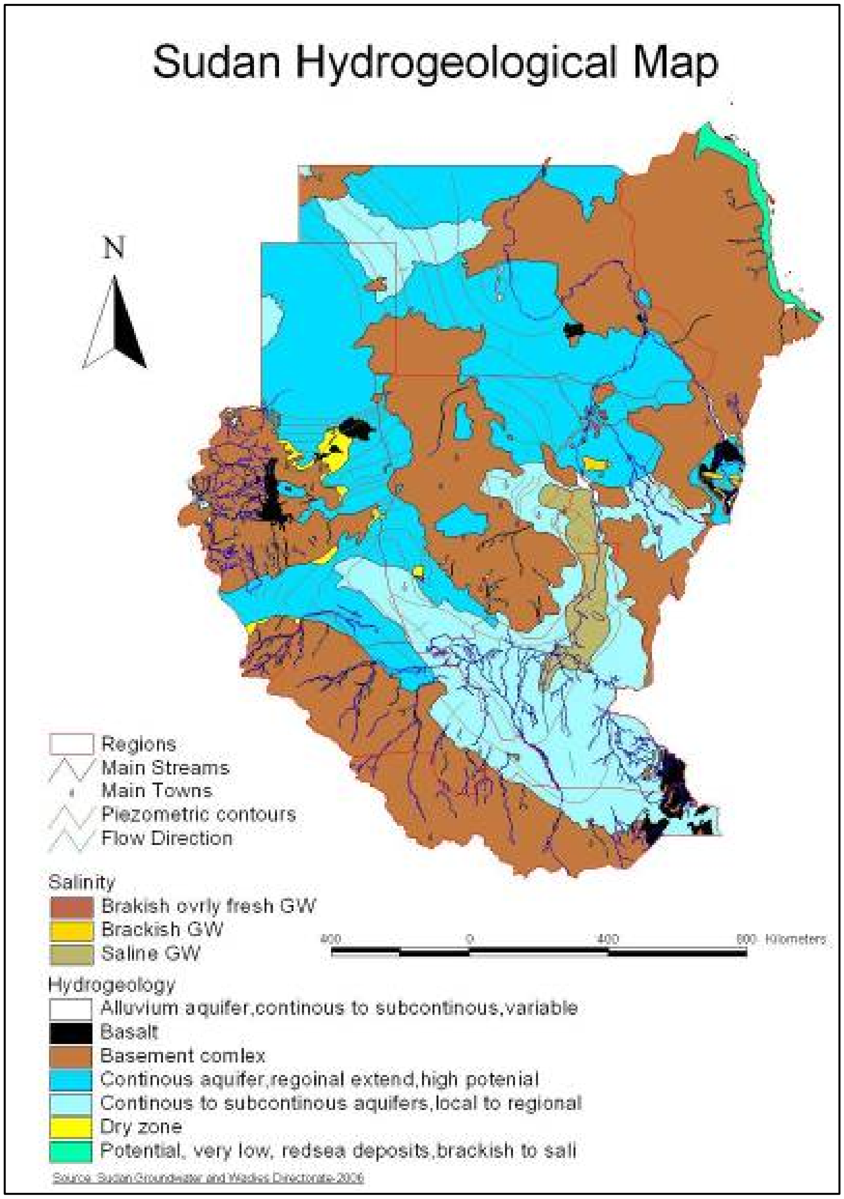
C) Porous or fractured rocks with very low hydrogeological importance: This unit is subdivided into two subgroups:

1. The Red Sea deposits are categorized under this subgroup, which are local aquifers that may be confined or unconfined. They are found in thin arentic beds or lenses consisting of consolidated or unconsolidated sediments. Their permeability is low to very low. The water quality varies and near the coast it is often brackish or saline. The relative hydrogeological importance is generally low and potential is low as well.

2. Undifferentiated Basement Complex and acid intrusions are categorized under this subgroup which are rocks that are generally non-water bearing. Water occurs in fractured or weathered zones. Local perched perennial or ephemeral aquifers may occur as well as thin saturated layers at depth and hydrogeological importance and potential is low.

   Areas under this unit are: Blue Nile, Nuba Mountatins, Western Equatoria, Central Equatoria, Eastern Equatoria, Western Bahr el Ghazal, West Darfur, Eastern States and some Northern part of Sudan (refer to map 1: Sudan Hydrogeological Map).

Practical problematic situations that are related to groundwater in different parts of Sudan are expressed in terms of high salinity, fine sand, loss of circulation, running sand & caving, thick mud-stone and other problems that will occur during drilling of boreholes like the presence of boulders. Areas affected with these problems are indicated in Table 2. The salinity zone has been indicated in map 1: Sudan Hydrogeological Map.



Map1: Sudan Hydrogeological Map

High Salinity	Fine sand	Loss of circulation	Running sand & caving	Thick mudstone	Others e.g. Boulders
-Sud Basin (Jonglei) (Some parts of Northern Upper Nile, Renk County) Latitude 8-13 Longitude3130-33 Umm Rawaba	-EnNhud Basin Nubian Sandstone, Northern Upper Nile	-Baggara Basin South Kordofan (Moo), South Darfur in Umm Rawaba Formation, West EnNhud Nubian Formation,	-Basement complex	-Nubian Sandstone Fula Depression Fula West Omdurman Arak and Debban North State	-Boulders Upstream and midstream of Red Sea Wadis emerging from escarpment (high mount) Sinkat

Formation, Unity State		Kapoyta area in Eastern Equatoria			Jabeit Port Sudan area
-East Kordofan Basin East Kordofan, White Nile, Latitude 13-14 Longitude 3130-3230 (Tendalti)	-Haskanita East Darfur, Umm Rawaba	-East Kordofan Basin Umm Rawaba Formation	-Umm Leuna Northern Darfur	-Gedarif Basin Mudstone below volcanic rock Darfur	-Nuba Mountain Waids Upstream
-Blue Nile Basin Jezira Formation, West Managil, Abuguta, North Central Gezira State, South of Khartoum 'between Niles', East of Nile Khartoum	-Baggara Basin	-Blue Nile Basin Sennar (North West) Nubian	-Nubian Formation Umm Hashaba Northern Darfur West Darfur Kulbus Wadi Sediment (100m)	-Malaha West Darfur Targmbout Nubian	-Jebal Marra Volcanic and upstream of wadis of Jebal Marra
-Gedarif Basin Southern part of the basin South of Gedarif	-Blue Nile Basin (Singa near river)	-Central Darfur Basin (Dabal) West Kordofan East Darfur	-Khartoum East Nile Um Dwit Nubian		-Basalt sills South of Khartoum and Omdurman
-Aroma	-South Darfur (Nubian)	-West Omdurman			-Basalt
-Delta Toker Downstream	-Khartoum East Nile, Kadarw (Nubian), Bageer (Nubian)	-Jezira State Umm El Gora (East of Blue Nile) (Nubian)			-Shagra Basin El fashir well field (180-250m)
-Red Sea Formation Red Sea at the shore line, downstream of alluvial in wadis in Red Sea m. system		-West Kordofan El Sederat Latitude 130858 Longitude 273488			-River Atbara (Boulders)
-Sinkat (Wadi sediment)					-Alluvium
-Basement (Dali & Mazamom) 6400ppm					

Table 2: Groundwater problematic Zones – Sudan[1]

3 Guideline for selection of hand pumps for hand dug wells

A hand dug well with a hand pump has the following main components: a hand dug well (the source of water), a platform with the drainage apron and a hand pump (the water lifting device). The method of hand dug well design and construction has been described in sections 5 and 6 respectively. It is of vital importance, however, to consider the following points during the selection of hand pumps:

3.1. Depths of static and dynamic water levels and discharge of the well: This knowledge is important to determine the appropriate type of the hand pump to be procured.

[1] Source: Information Center (Kilo 10) Groundwater and Wadis Directorate, Ministry of Irrigation and Water Resources, August 2007

3.2. Quality of water: Appropriate riser pipes and connecting rods should be identified, based on whether the water is corrosive or non-corrosive In case the corrosivity cannot be determined, knowledge of the quality of water will help to establish an informed, appropriate and time-bound maintenance procedure for procurement of the GI riser pipes and connecting rods. In Sudan, the groundwater quality parameters[2] are generally as follows:

Water temperature:	30 – 40^{0}C
pH:	6.5 – 8.5
Total hardness:	200 – 300 mg/l
Total dissolved solids:	500-1000mg/l and at some places >1500 mg/l
Sand content:	The water is moderately charged with sand particles

3.3. Ease of operation and maintenance: The pump design should allow for easy village level operation and maintenance.

3.4. Local capacity for operation and maintenance: The building or strengthening of community capacity to manage, operate and maintain their water supply systems is important..

3.5. Availability of spare parts: Spare parts should be available locally at affordable prices..

3.6. Government policy on standardization of hand pumps. Standard hand pumps recommended by the GONU through the MIWR/PWC are IM2 including deep well IM2 pumps. In Southern Sudan IM2 and Afridev have been adopted for shallow wells and Dubba for deep wells. This might change through time, however, as and when new pumps are introduced, tested and proven to be more appropriate.

4 Hand dug well design

The design of the hand dug well aims to achieve the following:

- **Well siting**: The use of local knowledge in addition to cientific methods is advised in the siting of dug wells. Areas that are likely to be flooded must be avoided to the extent possible. The site of the hand dug well should be at least 30 to 50m away from latrines and from grave yards and other sanitary land fills (the latter to be determined by the community).
- **Wall lining extension above ground level as a parapet or wall**: The provision of 75 to 80cm extended wall lining will protect from the possibility of flooding from surface water during the wet seasons. The height of wall lining extension depends on the flood level. If the wall lining extension height is more than 50 cm, a step must be constructed for the users to access the hand pump.

[2] Source: NWC, Water Supply Design Criteria and Equipment Standardization

- **Cover slab on top of the well:** If fixed properly on the lining of the well, this will protect from pollution by blocking contact with the well water. The space between the spout and the cover slab should sufficient to allow easy water collection by the community with their water fetching container.
- **Hand pump to withdraw water:** Water should be withdrawn from the well only through the hand pump. A rope and bucket method should be prohibited in order to avoid pollution of water in the well.
- **Extend apron/platform around the well (preferably at least 1.5 m to 2.0m from the wall (parapet) of the well:** This enables the users to properly operate the hand pump and protect the area from getting muddy and at the same time facilitates the diversion of spilt water away from the well through the drainage ditch.
- **Good drainage of wasted water :** A proper drainage ditch that extends from the platform up to animal trough or soak away should be provided to allow proper drainage of wasted water from the well. Animal trough has to be constructed at an appropriate location and fencing of the hand pump surrounding should be done to avoid contamination related improper usage and gathering of animals around the water source. In some locations, the wasted water from the well could be diverted to small gardens, nurseries etc. This has to be decided by the communities.
- **Well head area protected:** The well head including the apron and the immediate surrounding should be protected with a fence to keep animals off the platform and apron and prevent pollution of the water with animal dung. Local material can be used for fencing, as per community choice.
- **Diversion of surface water:** Surface water diversion ditches should be dug upstream of the well at a reasonable distance from the well, to divert surface water away from flowing to the well site.
- **Well diameter:** This should be large enough to allow well diggers and their equipment into the well for future deepening of the well in case the water table level drops and sufficient water cannot be drawn. The recommended diameter for a concrete ring lined well is 1.50m, whilst the minimum diameter recommended for a brick lined well is 2.0m

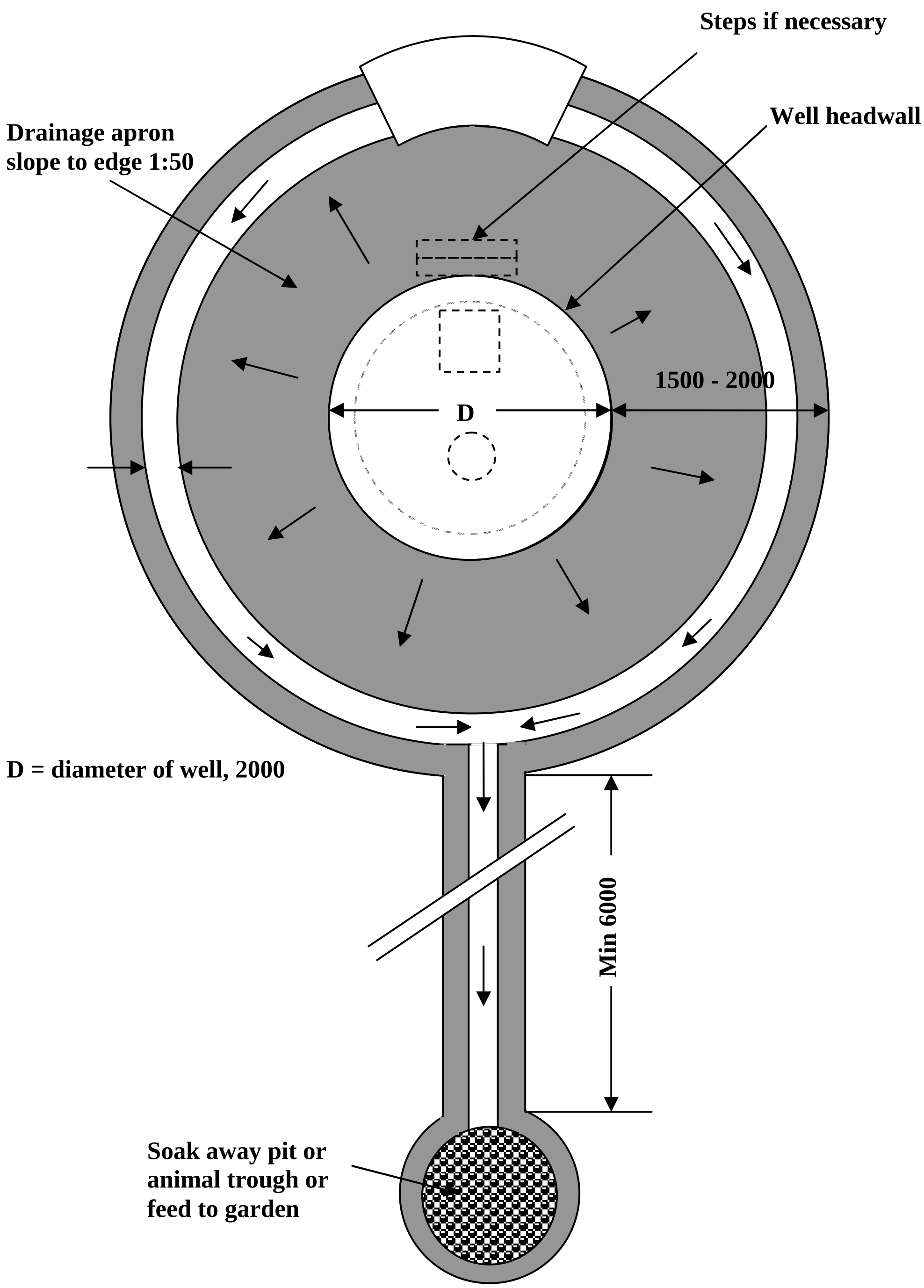


Figure 1: Layout of a hand dug well, adapted from Tearfund

5 Digging of a hand dug well and installation process

The following steps are recommended for digging a hand dug well and installing a pump:

Establishing safety procedures, digging of the well, water quality testing, lining of the well, completion of the hand dug well, disinfection of the well and hand pump installation.

Establishing safety procedure
Before any work is begun, it is important to ensure that safety measures are in place. Careful preparation of the well diggers, their equipment and the environment is of primary importance to avoid accidents as a result of: lack of experienced supervision, careless workers and work methods, tiredness and lack of concentration, faulty equipment, collapsing soil, poisonous gases from pump engines, explosives and naturally occurring gases, incoming water, excessive dust, interference by casual onlookers, animals and children playing on unattended well sites.

Proper safety measures to minimize possible accidents include:

- Ensuring that the construction is supervised by experienced and competent staff
- Proper signal arrangements must be in place between the diggers and the surface to alert in case of danger
- Ensuring that there are no solo diggers: the requirement is a minimum of four people on a well at any one time.
- Ensuring safe and easy access to the well,
- Ensuring an additional entry and exit into the well, in case of emergency
- Protecting the hole during digging and securing the site during non-working periods, when workers are not on site, and especially at night to prevent people, animals and materials from falling in
- Ensuring all equipment including ropes, ladders, tripods, lifting gear, buckets, pick-axe and hammer handles and heads are in good working order.
- Ensuring the provision and use of essential safety equipment such as: safety helmets, protective footwear, gloves, and goggles (this especially when breaking rock)
- Ensuring first aid training and equipment is provided as part of the overall safety measures
- Ensuring the use of safe and suitable de-watering equipment;
- Ensuring no combustion engine, petrol or diesel-powered pumps are lowered into the well for de-watering as exhaust gases are heavier than air and will sink to the well lower levels. They can cause suffocation for the well diggers.
- Ensuring petrol or diesel engines are positioned downwind of the well site at ground level
- Ensuring onlookers are kept a safe distance from the excavation.
- Additional safety measures may be necessary depending on the situation.

Digging of the Well

Points to note:

Use local knowledge and expertise to the extent possible. In availing basic tools and equipment such as buckets, pick axes, crow bars, rope, ladder, tripod, pulley, dewatering pump etc, pick traditional, locally made. For example, shop-bought buckets are often not strong enough and can be unsafe. Make sure the handles are firmly attached and not likely to slide off a hook. A bucket full of soil falling into the well could easily kill someone.

If poles made from tree branches are available locally, a tripod and winch can be made for excavation of dug materials. And for critical operations such as getting in and out of the well. A 24mm diameter nylon rope is recommended.

In unstable soil, it is advisable to line the well as the excavation proceeds. In some cases, only a temporary lining may be necessary to support loose soil at the surface.

For efficiency and safety when digging in difficult soils and hot conditions, it may be necessary to change diggers every 15-30 minutes.

Use de-watering pumps to extract water and thus allow digging to a greater depth. An air-operated pump is appropriate where compressed air tools are already being used.

Ideally digging should be started in the dry season. However, if that was not possible, and the well is not deep enough at the end of the dry season, it can be deepened using the caissoning method. This method is suitable for digging in an unstable sand layer, or for deepening a well if the water table drops (refer to **Figs 3**).

If the well has to be dug in hard formation and the use of explosives is unavoidable, safety procedures outlined below must be put in place before and after the blast.

- Know and follow the national law of Sudan on handling of explosives for civilian purposes.
- Know and apply the purchase and transport procedures.
- Carefully store the explosives. Do not store explosives and detonators together.
- Carefully control the flow and use of explosives from stores. Only competent and trained persons should handle them.

The well yield depends on several factors, but in particular the aquifer type, the depth of the well and the time of the year. The diameter of the well has little effect on yield, but will increase the amount of storage

Digging of the well
Once all necessary safety measures are in place, it is possible to start the digging after marking the diameter of the well on the ground. Based on the lining material to be used, dig a 1.5m diameter well for concrete lining or a 2.0m diameter well for brick lining, refer to **Fig 1 & 2**.

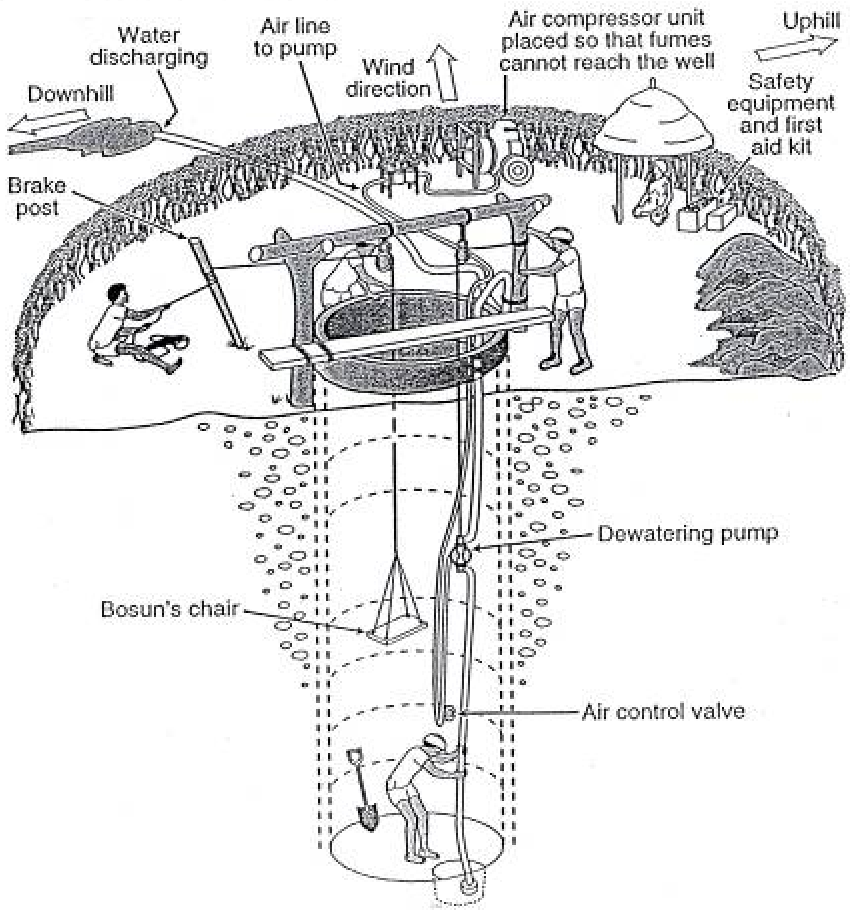


Figure 2: A safe well digging operation (adapted from Engineering in Emergencies)

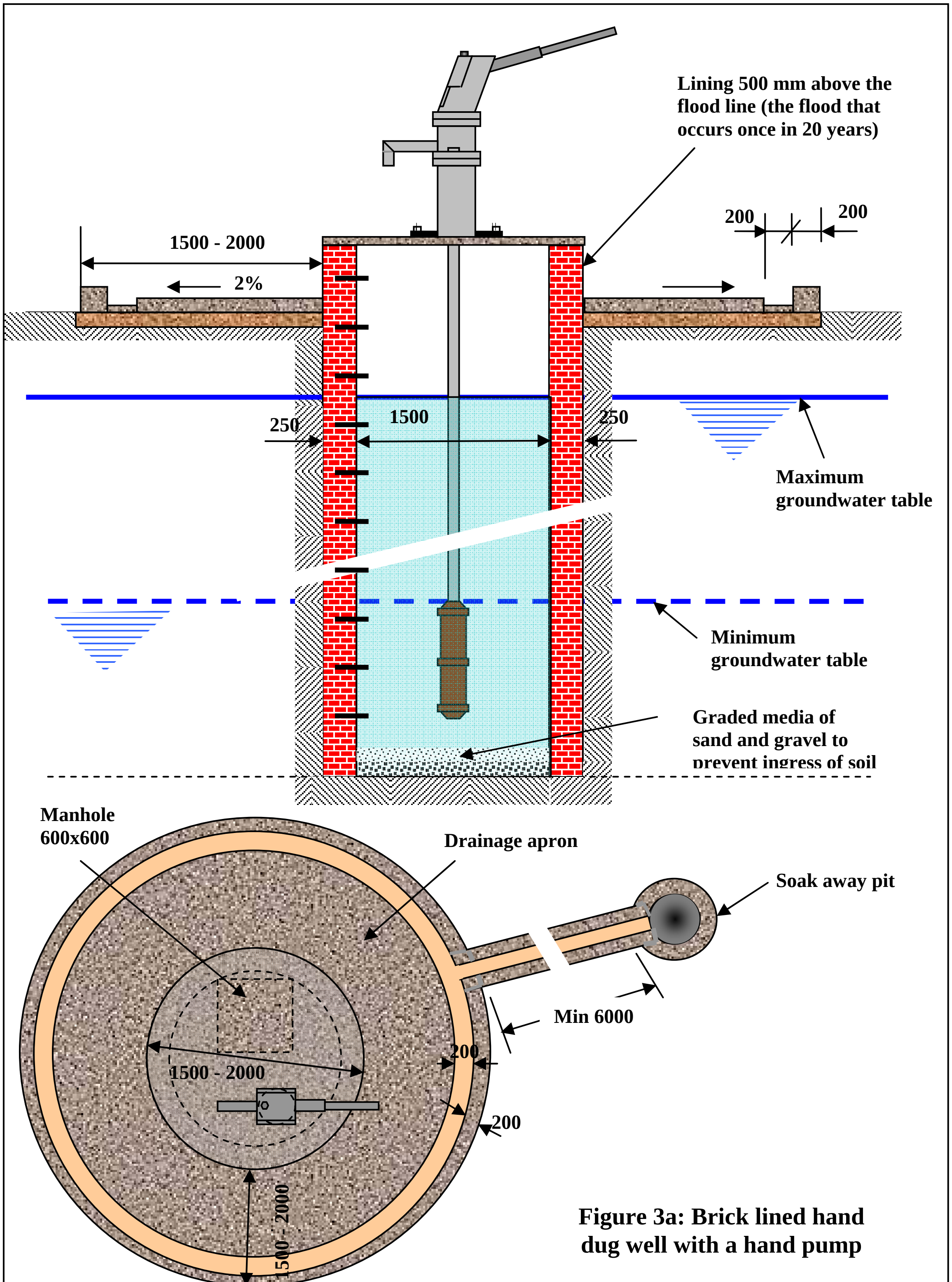


Figure 3a: Brick lined hand dug well with a hand pump

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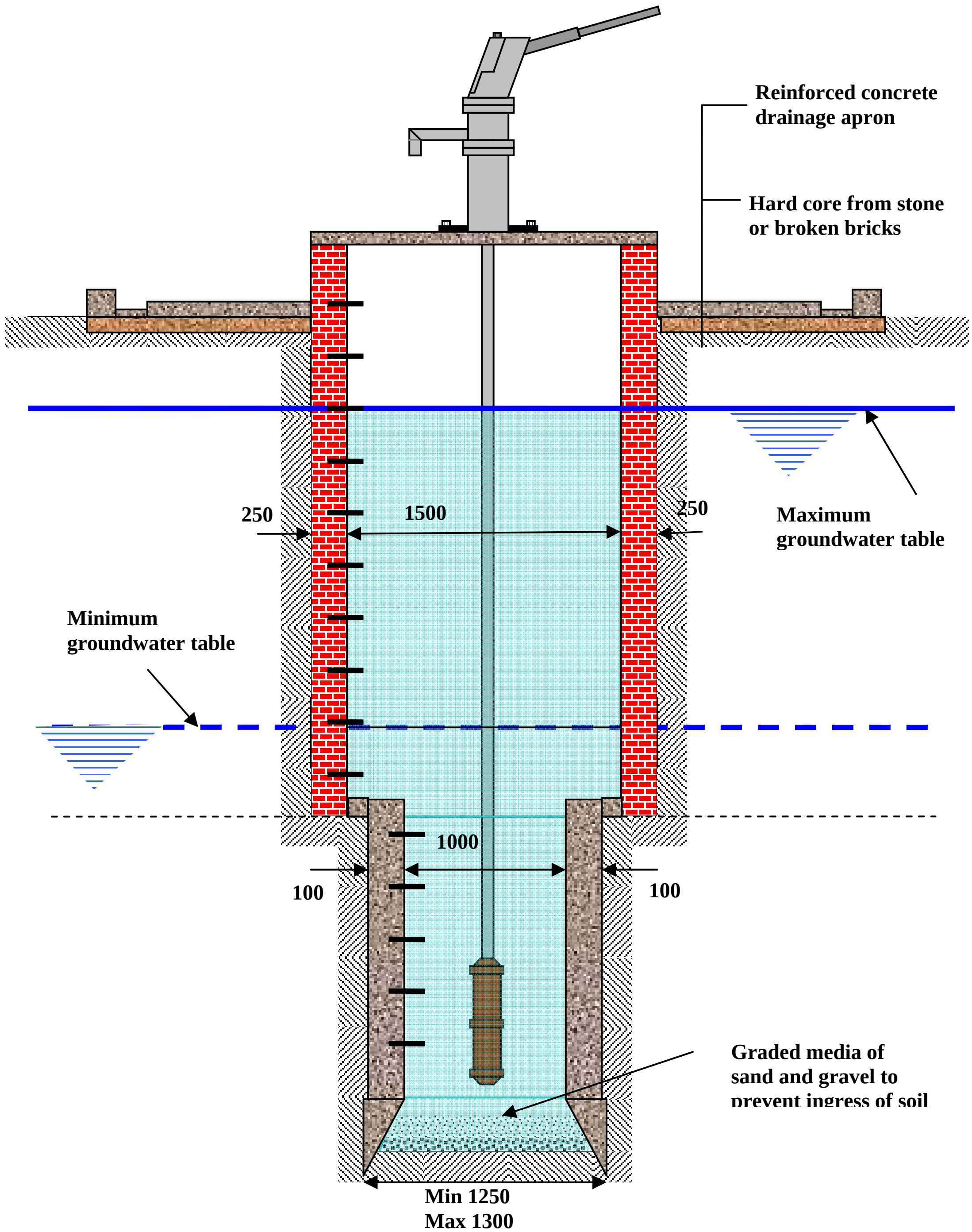


Figure 3b: Deepening of brick lined hand dug well using caisson method (adapted from Oxfam and Engineering in Emergencies)

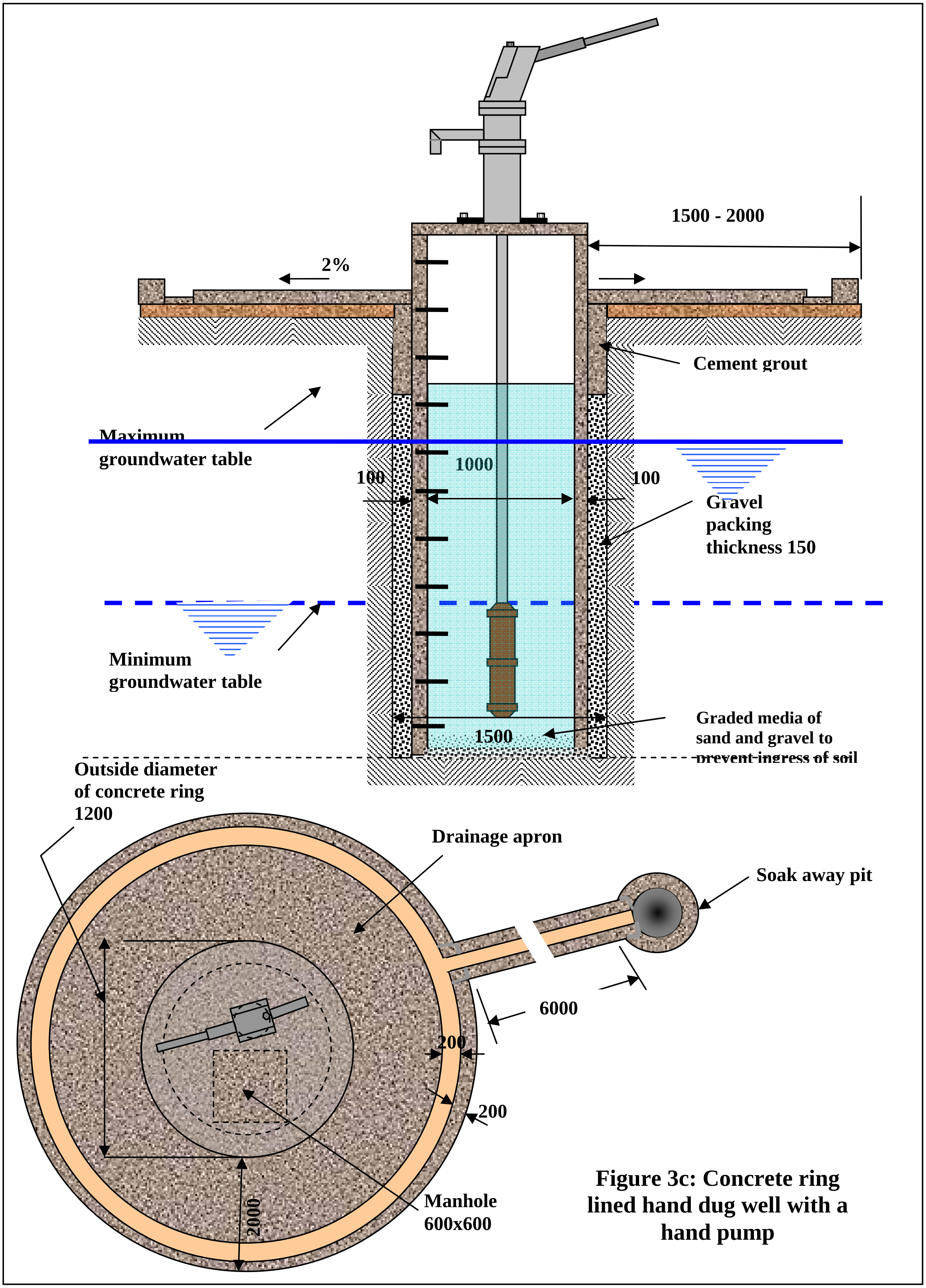


Figure 3c: Concrete ring lined hand dug well with a hand pump

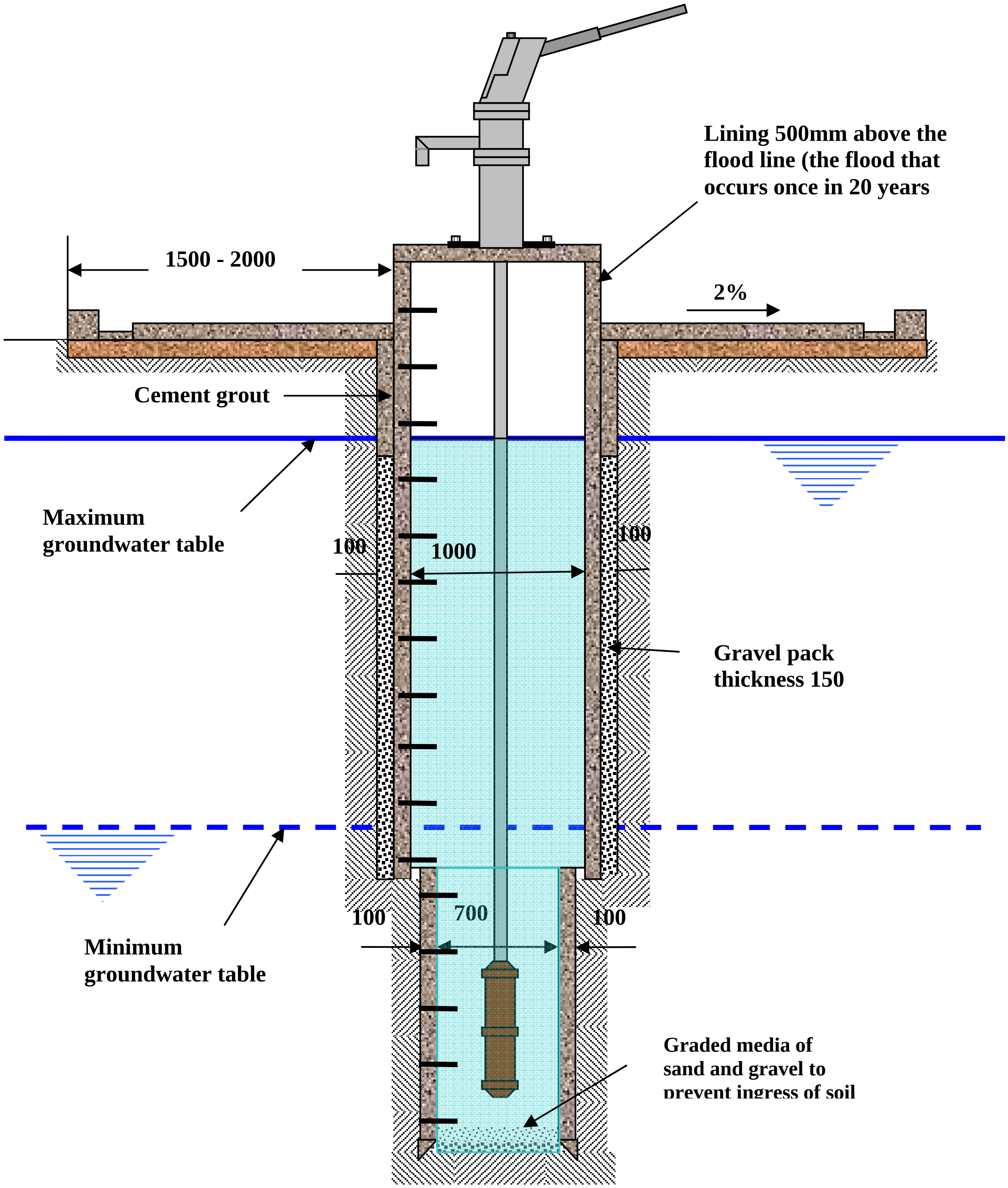


Figure 3d: Deepening of a hand dug well lined with concrete rings using caisson method (adapted from Oxfam and Engineering in Emergencies)

Water quality testing
The quality of the water from the hand dug well should be tested for bacteriological, chemical, and radiological contamination before commissioning for public consumption. Water from a hand dug well will most likely have been bacteriologically contaminated during the digging and lining of the well, so it needs to be disinfected. Once this has been done, the bacteriological contamination must be checked field level with portable equipment like, H_2S vials, or an Oxfam/Delagua Water Testing Kit. Chemical and radiological contamination should be verified by the Sudanese institute authorized to do this at state or national level. The quality of water should be checked against Sudanese/WHO guidelines for Drinking Water Quality Standard For chemical tests, two samples from each hand dug well should be sent to the authorized institute in 5 liter clean and sealed water containers The guideline values for drinking water quality standard are attached in the annex.

Lining of the well
There are many ways of lining a hand dug well, however if a local method is available this is preferred. The two basic methods are in-situ lining (from the top-down or the bottom-up) and caissoning. In stable soils, wells are sometimes dug unlined down to the water table and then lined in situ from the bottom up. This is the simpler of many processes and has the advantage that lining can be done after water has been struck, avoiding the extra work in case the well is dry. The principal disadvantage in this method is the danger of collapse. In situ lining from the top down is a safer although technically more difficult option.

Caissoning is the sinking of a lining column as excavation proceeds. This method is used when dealing with collapsing soil and below the water table, to protect diggers as they work and to increase the well yield when groundwater table level drops. It is important to use a cutting edge with a slightly larger diameter than the lining column to ease and control the downward passage of the column. If a column moves out of the vertical, correct it immediately as straightening will be difficult at a later stage..

Lining materials can be selected from concrete, bricks, stone, corrugated steel culvert or plastic.

There are several methods of lining in concrete; using pre-cast rings, fixed in situ lining or caissoned in situ lining. Reinforcement may be needed for concrete rings which have to be transported but is not essential for concrete rings which are simply placed in position and are not going to be used for caissoning.

In situ concrete lining avoids the handling of heavy concrete rings on site. A concrete ring column can be caissoned by casting a stage at a time in situ as the column descends. This avoids the need to maneuver concrete rings into position.

According to British Standard 5328, the appropriate mixing ratio of concrete for $1m^3$ of concrete, is 6 bags of cement (each 50kg), 490 liters of sand, and 800 liters of aggregate for 1:2:6 mix ratio for reinforced concrete in mild conditions. For a 1:3:6 ratio and unreinforced concrete the quantities would be 5.4 bags of cement, 510 liters of sand and 800 liters of aggregate for $1m^3$ concrete. For uniform measurement of sand and aggregate use a gauge box of size 367mm (length) x 300mm (width) x 300mm (depth) that gives a box of volume $0.033m^3$ which is the volume of a 50kg bag of cement. The amount of water in a mix is critical to the strength of concrete. For hand mixing, a water : cement ratio of about 0.55 by weight gives a strong concrete, so a 50 kg bag of cement will need 27.5kg (27.5 liters) of water. This ratio is for aggregates that are not absolutely dry. Where very dry aggregates are used, for instance in hot arid climates like in Sudan, a little extra water is needed or the mix will be too stiff for good compaction. Use 20mm size of aggregate and sand from naturally occurring deposits such as river beds. If using damp sand, increase the volume by 25%. Water should be as clean as possible.

Moulds can be used for pre-cast concrete (as shown on **Figure 4**) and formwork (shuttering) for in situ placement of concrete. Sufficient water is essential for the concrete to harden through hydration. The concrete must be kept moist or cured to ensure that it does not dry out. Poorly cured concrete will not attain its full strength and may shrink and crack. Particular attention is needed to curing in a hot, dry or windy climate when evaporation rates can be high. Curing can be done by covering or wrapping with plastic sheet, covering with wet cement bag papers which are kept damp and regular spraying with water. Curing must be started as soon as the concrete has set, or immediately in hot and dry weather.

Lining with bricks or stones, unlike concrete rings, can be done with the minimum of equipment. Locally developed knowledge in brick lining is quite established in Sudan priority should be given to the use of this methodology. Use a lower reinforcement beam to avoid deferential settlement and cracking of the brick wall resulting in contamination of the water. There is no need to perforate the lining material in fine granular aquifers; graded gravel can be placed in the bottom of the well

Ready made plastic lining material for shallow wells (diameter 1m and height 1m) is available, mostly, into two semicircular halves. These can be perforated or blind. The two halves can be fixed with bolts & nuts. When using plastic lining materials, it is important to check the specification of the plastic material which should comply with food grade polyethylene standards. The disadvantage of this lining material is its relative high cost.

Water quality must be tested before lining, and where digging is continued simultaneously with lining, the test must be done once water is struck. This is to avoid resource and material wastage in case the quality of water is unacceptable for human consumption.

Completion of a hand dug well

A completed hand dug well should have the following components/parts:

- A sanitary seal at the surface to prevent pollution from surface water seepage into the well.

- A concrete apron and effective drainage system to carry waste water away and not allow collection of water around the well.
- A concrete cover slab cast with a pump stand and a manhole sealed with a cover.

A hand dug well constructed in soft formation, especially loose fine sand, will need a permeable concrete plug or graded media at the bottom of the well to prevent the entrance of the aquifer's fine sands to the well with the incoming water.

The above-ground design of the well must be discussed with the end users to increase their ownership of it, encourage hygienic maintenance and promote sustainability.

Disinfection of the well

Disinfection is necessary initially during pump installation and if and when the well gets polluted. The well should be disinfected or sterilized with a chlorine solution yielding at least 50mg/l of active chlorine in all parts of the well. The chlorine solution may be prepared from calcium hypochlorite or sodium hypochlorite. In case bleaching powder is used for disinfection, 300g of bleaching powder should be mixed thoroughly in 15 liters of water and poured into the well.

The disinfectant should stay in the well for at least four hours at the specified concentration, after which water should be pumped out and discarded until the water smells strongly of chlorine. At this point, no more water should be pumped out for at least 24 hours, after which water should be pumped out and discarded until the taste of chlorine is just noticeable in the water. A sample of water should be collected in a sterile bottle and sent for bacterial analysis. Once the hand dug well is disinfected, it should be sealed to avoid any possible external pollution.

When a functional hand dug well needs disinfecting, communities must be informed ahead of time and given adequate time to collect enough water to last the family for the disinfection period which ranges from 24 to 48 hours.

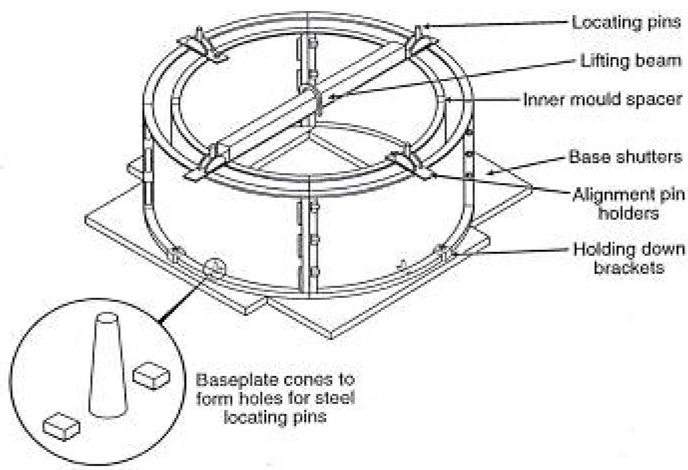


Figure 4: Formwork for pre-cast concrete well rings (adapted from Oxfam)

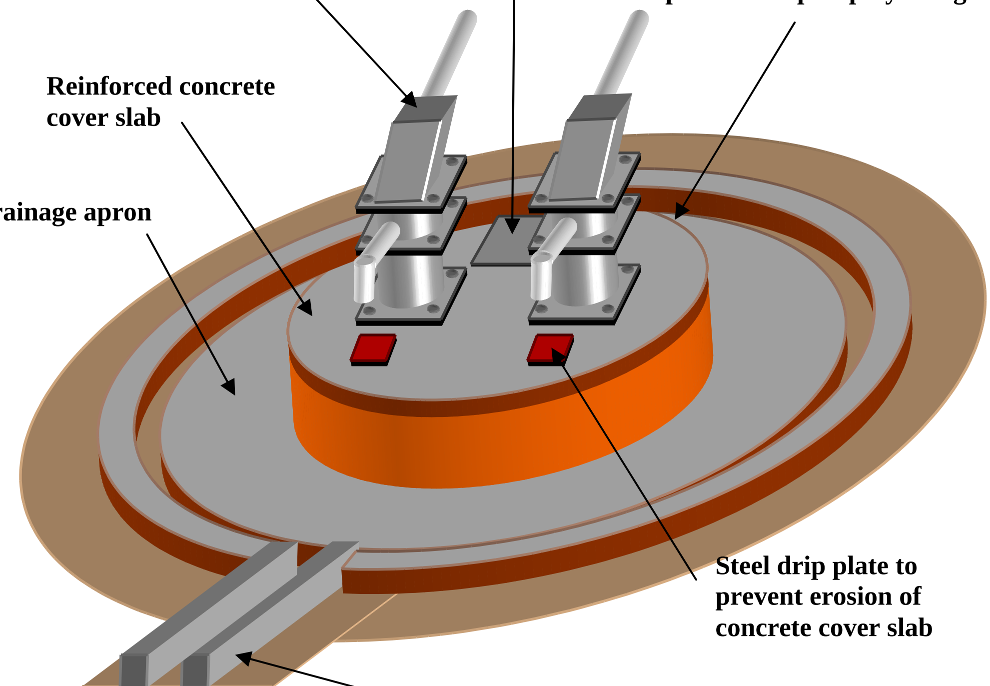


Figure 5: Twin hand pumps installed in a completed hand dug well, adapted from Tearfund

Hand pump installation

An installation manual must be ordered with the hand pump. Installation, as per the guidelines of the manufacturer, can begin when the quality of the water in the borehole is found to comply with the Sudanese/WHO standard. It is important to ensure that all standard hand tools are available with the team that is installing the pump.

6 Hand dug wells with hand pumps

6.1 Types of hand pumps

Hand pumps used worldwide can be categorized in to two major classes:

- Hand pumps for shallow wells, and
- Hand pumps for deep wells.

Figures 6 & 7 illustrate the components typical of deep well hand pumps.

6.2 National standard hand pumps for Sudan

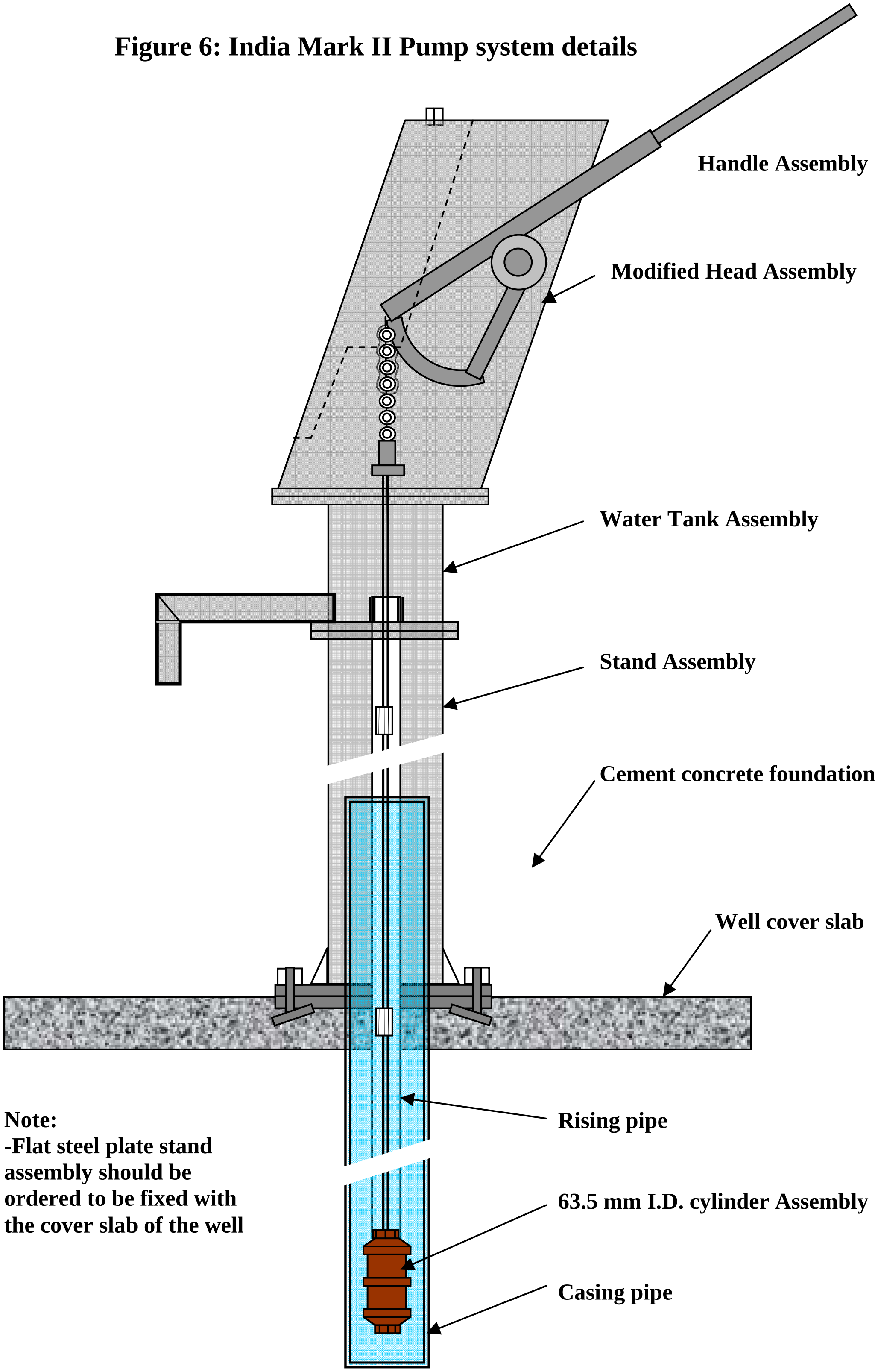
The nationally accepted standard hand pumps for North Sudan are Indian Mark II standard and extra deep well hand pumps. India Mark II has been used in Sudan since the mid seventies. Its technical standard specifications have been improved from time to time and the latest version conforms to Indian Standard (IS) 15500, 2004.

Pump details of Indian mark II, including the head, handle, cylinder and valve assemblies are shown in Figures 10, 11, 12, 13, 14, 15, 16, 17, 18 & 19 in Annex 3.

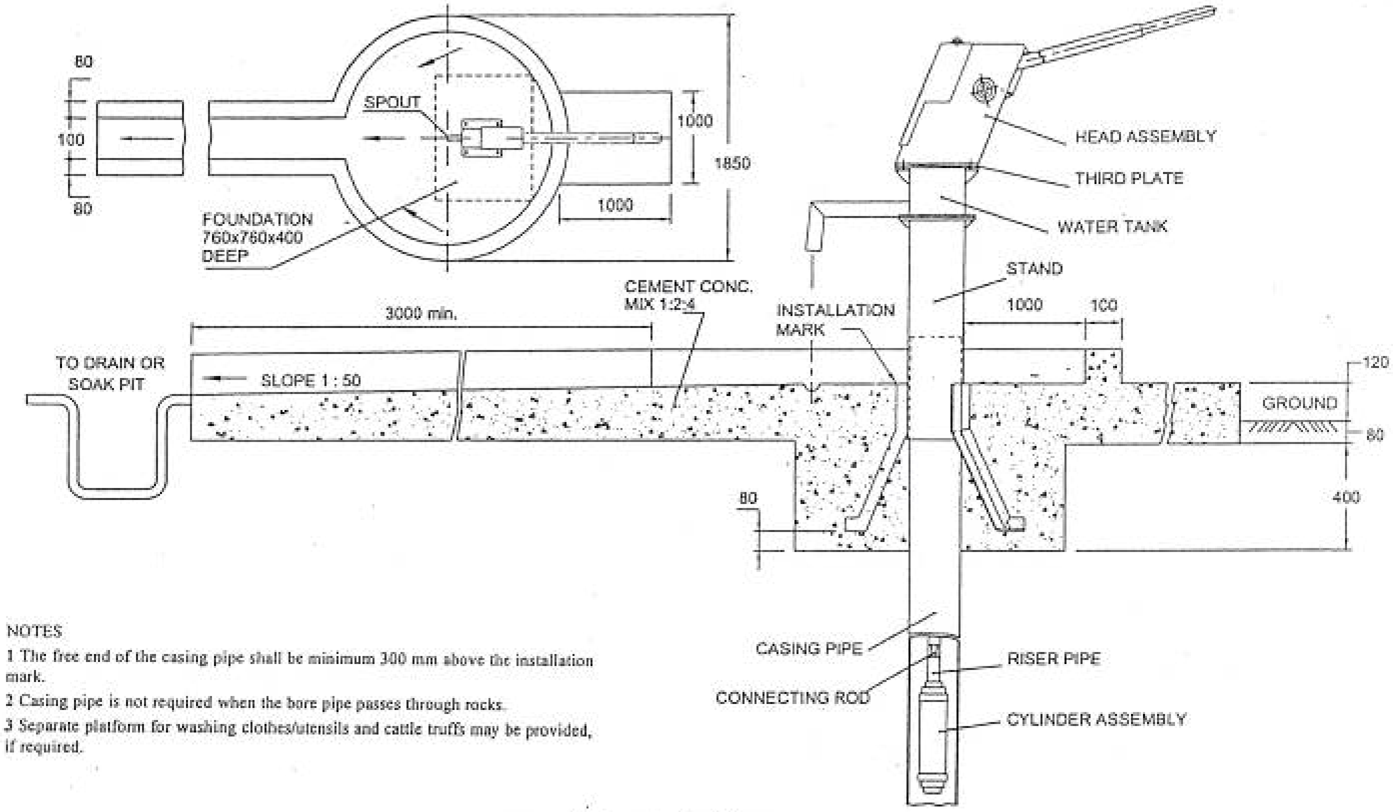
Minimum delivery of a hand pump is estimated to be 20 l/minute (from 15-70m depth) for operational time of about 8-10 hours per day. One hand pump will serve 500 people during emergency and 250 people in normal times.

In Southern Sudan, the hand pumps of choice are India Mark II standard hand pumps and Afridev hand pumps (Figure 25 in the annex) for depth of wells up to 45m and Dubba deep well hand pumps for depth of wells over 45m. Direct Action Hand Pumps (Figure 24 in the annex) are used for shallow wells of depth less than 15m.

Figure 6: India Mark II Pump system details



Note:
-Flat steel plate stand assembly should be ordered to be fixed with the cover slab of the well



NOTES

1 The free end of the casing pipe shall be minimum 300 mm above the installation mark.

2 Casing pipe is not required when the bore pipe passes through rocks.

3 Separate platform for washing clothes/utensils and cattle truffs may be provided, if required.

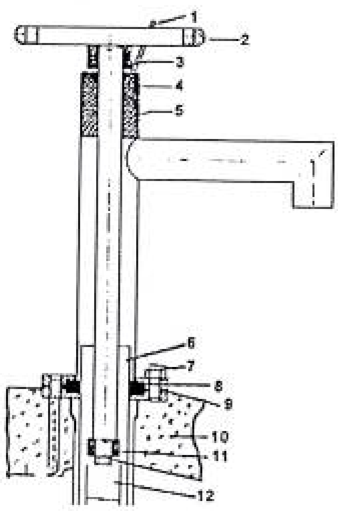
All dimensions in millimetres.

Figure 7 Typical Set-Up for Deepwell Handpump

Pump Head Assembly: The above ground mechanism operating the plunger.

- Cylinder Assembly: Contains plunger, check valve, etc which is lifting water upward in each stroke.
- Connecting Rod: Provides linkage between the pump head and cylinder.
- Riser pipe: Carries water from the cylinder to the water tank

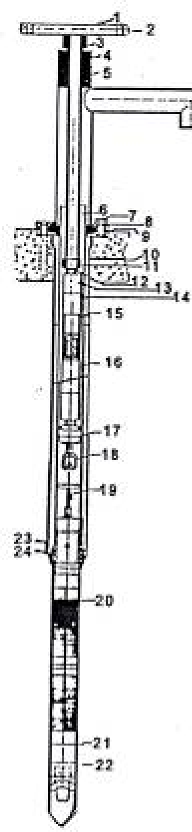
Hand pumps for shallow wells are those hand pumps to be used up to 12-15m depth of a well. Under this category, direct action pumps like Tara, Niara, etc hand pumps are known as technology options. These kinds of pumps are good for aggressive soil and water as below-ground mechanism is constructed from corrosion resistant components. These pumps can also withdraw water up to 2100 liters per hour. Typical pump head and cylinder assemblies of such kinds of pumps are shown in [illegible] **Figure 8**.



Sectional Details of Pumphead Assembly

1. HANDLE RETAINER
2. HANDLE
3. HANDLE CUSHION TOP
4. TOP GUIDE BUSH
5. PUMP HEAD
6. RISING MAIN
7. HEX BOLT M 12 X 25
8. GROMMET
9. BOTTOM FLANGE
10. UPPER WALL CASING
11. HANDLE CUSHION BOTTOM
12. CHECK NUT

TOP CONNECTOR
PUMP ROD



Sectional Details of Cylinder Assembly

1. HANDLE RETAINER
2. HANDLE
3. HANDLE CUSHION TOP
4. TOP GUIDE BUSH
5. PUMP HEAD
6. RISING MAIN
7. HEX BOLT M 12 X 25
8. GROMMET
9. BOTTOM FLANGE
10. UPPER WELL CASING
11. HANDLE CUSHION BOTTOM
12. CHECK NUT
13. TOP CONNECTOR
14. PUMP ROD
15. THREADED ADAPTOR
16. PIPE CENTRALISER
17. PISTON SUB ASSEMBLY
18. GRAPPLE SUB ASSEMBLY
19. FOOT VALVE GUIDE ASSEMBLY
20. WELL SCREEN
21. SAND TRAP
22. C.I.CUTTER PLUG ASSEMBLY
23. REDUCING SOCKET
24. RUBBER SEAT

Figure 8

Hand pumps for deep wells are further categorized into standard and extra deep well hand pumps. These hand pumps are being installed into 45m and 60m-90m deep wells respectively.

Hand pumps could also be categorized into village level operated and maintained (VLOM) and non-VLOM types. India Mark III, Afridev (**Figure 9**), Aquadev, Tara, Niara etc are categorized in VLOM hand pumps while pumps like India Mark II are categorized in non-VLOM hand pumps. The main difference between VLOM (eg. India Mark III) and non-VLOM hand pumps (eg India Mark II) is that in VLOM hand pumps it is possible to withdraw the cylinder components without the disassembly of the rising mains.

The difference between India Mark III and other VLOM hand pumps (like Afridev and Aquadev) is in the type of riser pipe. India Mark III has galvanized iron pipes while the others have PVC pipes with solvent cement joints.

India Mark II & III are good for non corrosive water while the other types of VLOM pumps are good for corrosive waters (except the galvanized connecting rods).

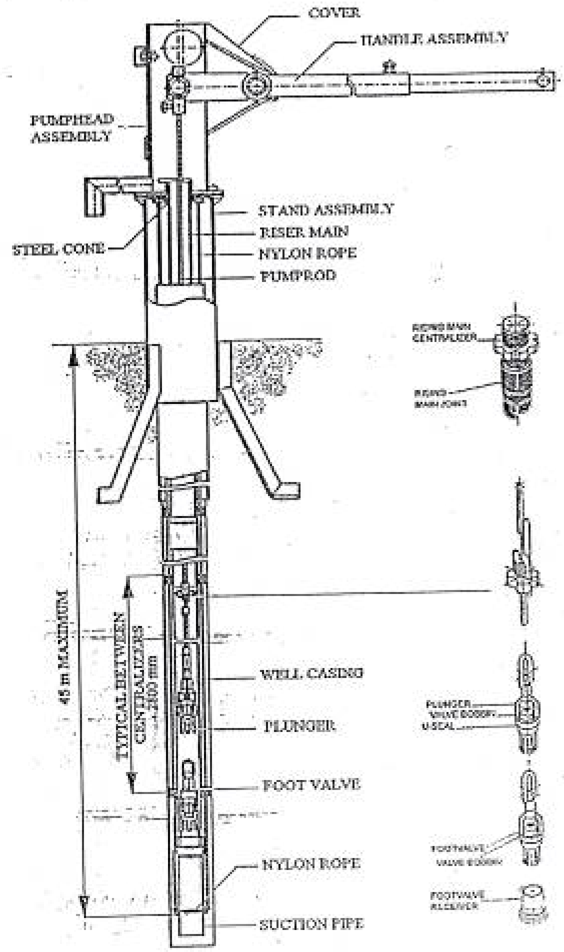


Figure 9: Afridev Hand Pump

In order to understand the differences between non-VLOM (India Mark II) and VLOM (Afridev) hand pumps refer to the following table.

Comparison between the India Mark II and Afridev[3]

Criteria	India Mark II	Afridev
International Specification	Specified through Indian Standards. The pump is produced in several countries to these standards. The design is in the public domain and the specifications are available to everybody.	Specified through an International Standard. The pump is produced in several countries to these standards. The specifications are in the public domain and the specifications are available to everybody.
Ease of installation	19 different tools are required for installation. Skilled crew is needed.	8 different tools are needed for installation. Skilled crew is needed.
Ease of repair (routine repairs)	The cylinder components can not be withdrawn without the disassembly of the rising main and pump rods. A trained village mechanic equipped with special tools is required.	All routine repairs can be performed by the community with a single spanner and a fishing tool
Ease of repair (major repairs)	A trained village mechanic equipped with special tools is required. For fishing dropped components special equipment is needed.	A skilled mechanic is required for the replacement of perforated riser pipe and fishing of dropped rods. Retrieval of PVC pipes and rejoining them in the field needs proficiency and special equipment.
Reliability	Reliable in non-corrosive water with few breakdown interventions.	Reliable, but frequency of maintenance interventions will be comparatively higher due to preventive maintenance requirements. Reliability can suffer badly if used in unlined borewells. When breakdowns occur, in most cases, it can be repaired quickly by the village mechanic. However results from the field indicate that the PVC rising main can fail if they are in contact with the rods.
Corrosion resistance	Galvanized rising mains and carbon steel galvanized rods are not corrosion resistant in water with pH values below 6.5. Stainless steel pipes are available but at a very high cost and are not standard to the specification. Corrosion resistant stainless steel rod option available is standard to the specification.	All below ground components including rising main are corrosion resistant with the exception of galvanized pump rods. Corrosion resistant stainless steel rod option available is standard to the specification.
Abrasion resistance	Riser main and rods have shown excellent abrasion resistance in non-corrosive water. The ball bearings generally last for 3-4 years. The introductions of nitrile rubber cup seal in place of leather cup seals reduce the frequency of below ground repairs by over 50%.	The bearings and the seal have a service life of about one year, but they are less expensive and easy to replace. Rubber centralizers prevent the rods coming in contact with the PVC pipes. They need regular replacement. Hook and eye connectors on the rods are subject to wear and frequent replacement of rods may be expected. Riser main perforation can reach unacceptable levels when used in unlined borewells.
Suitability for unlined borewells	Can be installed in unlined borewells.	Should not be installed in unlined borewells.
User preference	Acceptable discharge and ergonomics.	Acceptable discharge and ergonomics. Acceptable discharge and ergonomics.
Cost of pump	For 36m setting ,in 1996, (with galvanized pump rods): USD 200 FOB Bombay, plus packing and frieght	For 36m setting (with galvanized pump rods): USD 250, FOB Bombay, plus packing and freight.
Cost of spares	Spare parts are affordable.	Spare parts are affordable.
Suitability for local manufacture	It is manufactured in several countries in Africa and Asia. Can be produced in a country where industrial infrastructure for steel fabrication, hot dip galvanizing, electro-galvanizing, ferrous and non-ferrous foundry and galvanized steel pipes and familiarity with quality control practices and mass production techniques exist. A substantial investment has to be made in tooling.	It is manufactured in Africa and Asia. Can be produced in a country where industrial infrastructure for steel fabrication, hot dip galvanizing, electro-galvanizing, extrusion of uPVC pipes and moulding of nylon/polyacetal components and familiarity with quality control practices and mass production techniques exist. A substantial investment has to be made in tooling. The production of the plastic components requires special skills and extensive tooling.
Pumping lift	Can be used up to 45m, extra deep well version for over 45m available.	Can be used up to 45m.

[3] Sudan Hand pump Mission Report (January 1996)

7 Management, operation and maintenance of the hand dug well with a hand pump

7.1 Management of the water supply system

The Village Health Committee (VHC) in North Sudan and Water Committee (WC) in Southern Sudan are responsible for the management of their water supply system with the technical support of a village mechanic. The WC in Southern Sudan states, counties and payams is guided by the recently developed operation and maintenance guideline, which was developed to address problems related to operation and maintenance of the water supply system..

VHCs and WCs are elected by community members through the facilitation of WES Rural Council Unit in North Sudan and DRWSS at county/payam level in Southern Sudan. VHCs comprise equal representation by men and women from the village. Community leaders and representative from local administration could be included in the committee. VHCs comprise 10 members while WCs have at least 5. The committees' roles include: operation and maintenance of the water supply system at village level, mobilizing the community at village level and raising awareness of important issues, encouraging positive participation and effective contribution, managing the caretaker (guard) and purchasing all necessary spare parts. In cases where a fee is charged for the water the committee is responsible for collecting revenues and managing the accounting, salary/ incentive payments etc. They also report back to the WES Rural Council Unit or Payam Water Supply and Sanitation Committee for follow-up and to the community as well on all aspects of the water supply system.

A caretaker/guard should be employed to overlook the system, carry out routine maintenance and report the need of major works to the VHC or WC, and secure the safety of the system during day time.

7.2 Operation and maintenance

An India Mark II hand pump is easy to operate and can even be done by children. It involves raising and lowering the handle attached to the pump.

The pump and the site around it must always be kept clean. This is part of preventive maintenance which also involves a daily function check. The pump should be greased weekly and all parts of the pump stand must be checked monthly. Pump rods that have corroded must be replaced; under normal conditions, a galvanized steel pump rod needs to be replaced every five to six years. Rising mains consisting of galvanized iron should be dismantled and checked, and pipes with badly corroded threads must be replaced. Small repairs include replacement of bearings, cup seals and washers, straightening bent pumping rod etc. Major repairs may involve the replacement of the plunger, foot valve, cylinder, pump rods, rising main, pump handle, fulcrum etc.

Hand pumps should generally be maintained according to the factory's operation and maintenance manual. Trained village mechanics should be responsible for routine and regular maintenance of the hand pumps and should have the necessary standard and special tools for maintenance. External support should be sought for any major repairs.

Hand dug wells are operated with hand pumps. As the wells are shallow they are likely to get flooded, and consequently polluted, particularly during the rainy season. Particular attention should be given on protecting them against flooding, depending on their location. Regular water quality monitoring is recommended so timely action can be taken in case of pollution. If the water in the hand dug well is found to be polluted with bacteria, the first step is to halt the water supply, dewater the well with a dewatering pump and disinfect the well. Once this is done, Re-check for the presence of pathogens and restart the supply of water if no substances harmful to public health are found. Inspection of the well head for any signs of cracks and any potential pollutant should be part of the regular operational procedure.

In case the static water level in the well drops, deepen the well using the telescopic deepening procedure or caissoning as described earlier.

7.3 Capacity building

For proper operation, maintenance and sustainability of any water supply system, capacity building of the village mechanics and the communities (through their VHC or WC) is vital. Capacity building should training, provision of spare parts and tools etc. To ensure that appropriate training is provided, a capacity building needs assessment at community, locality, state and national levels, is advised, at the first instance.

The VHC or WC members need to be trained in basic management of the water and sanitation facilities and hygiene promotion activities so that they can operate and maintain the pump in good working condition. Based on community needs, training may include: pump care taker on basic maintenance, village mechanics on operation and maintenance and the supporting agency like WES or Department of Rural Water Supply and Sanitation (DRWSS) on microbial analysis and extension work. Availability of spare parts is one of the determining factors for the sustainability of the water supply system. The spare part supply chain that includes the responsibility, location and current price also needs to be worked out.

8. Recommendations

- A tender document is appropriate only when large number of hand dug wells are going to be implemented..

- It has been observed that in many cases hand dug wells are used with out a hand pump and since the wells are open, they are very susceptible to pollution and can often be a source for outbreak of waterborne diseases. It is important to make users aware of the importance of installing a hand pump in a hand dug well. In North Darfur some pastoral communities were against the installation of hand pumps as they found the wells are too crowded during the watering of their livestock.

- In most cases the hand dug wells are located along wadis that make them vulnerable to flooding as well as pollution. Particular attention should be given for flood protection and a water quality testing should be planned after each rainy season.

- A reinforced concrete drainage apron and platform should be standard practice (picture below). Platforms made from bricks or stones are easily damaged when not regularly maintained.

- 

- The picture below demonstrates a protection mechanism against injury (e.g a child's finger could get caught in the pump head assembly without the protective shield)

It should be common practice for all partners to guarantee and make available spare parts for every hand pump they have assisted in installing for two at least years, and establish a sustainable system of access to spare parts for the users.

It has been demonstrated that the spout of the hand pump is not compatible with the containers used by the community to collect water, resulting in the unnecessary wastage of water. UNICEF is in discussion with the manufacturers to get the spout modified.

Annexes

1. Sudanese/WHO Drinking water standards
2. Three dimensional and various other construction drawings
3. Detailed diagrams of India Mark II Hand Pumps
4. Technical Specifications for Hand Pumps
5. Standard tools required for installation/maintenance of a hand pump
6. Recommended spare parts for a hand pump
7. The process of development and finalization of the technical guidelines and manuals
8. List of contacted people
9. Technical working group members
10. Some selected bibliography and references
11. Unit conversion tables

Annex 1: Drinking Water Standards

No	Dissolved substances in water	Sudanese maximum permissible (mg/l) by SSMO, 2008	WHO guideline value (mg/l), 2006
1	Antimony	**0.013**	0.02
2	Arsenic	**0.007**	0.01 (P)
3	Barium	**0.5**	0.7
4	Boron	**0.33**	0.5 (T)
5	Cadmium	0.002	0.003
6	Chromium (total)	**0.033**	0.05 (P)
7	Copper	**1.5**	2
8	Cyanide	**0.05**	0.07
9	Fluoride	1.5	1.5
10	Lead	**0.007**	0.01
11	Manganese	0.27	0.4 (C)
12	Mercury (for inorganic Mercury)	**0.004**	0.006
13	Molybdenum	**0.05**	0.07
14	Nickel	**0.05**	0.07 (P)
15	Nitrate as NO3	50	50 Short term exposure
16	Nitrite as NO2	**2**	3 Short term exposure
17	Selenium	**0.007**	0.01
18	Uranium	0.01	0.015 (P,T)

Microbiological contents			
No	Organisms	Sudanese guideline value by SSMO	WHO guideline value
1	All water intended for drinking a) E-coli or thermotolerant coliform bacteria b) Pathogenic intestinal protozoa	Must not be detectable in any 100ml sample	Must not be detectable in 100ml sample
2	Treated water entering the distribution system a) E-coli or thermotolerant coliform bacteria b) Total coliform bacteria c) Pathogenic intestinal protozoa	Must not be detectable in any 100ml sample	Must not be detectable in 100ml sample
3	Treated water in the distribution system a) E-coli or thermotolerant coliform bacteria b) Total coliform bacteria c) Pathogenic intestinal protozoa	Must not be detectable in any 100ml sample Must not be detectable in any 100ml sample. In the case of large supplies where sufficient samples are examined, must not be detectable in 95% of samples examined through out any consecutive 12 months period. Must not be detectable in any 100ml sample.	Must not be detectable in 100ml sample

Maximum permissible limit for other parameters which affect the acceptability of water			
	Parameter	Levels likely to give rise to consumer complaints by SSMO, 2008	
1	Physical parameters		
	Colour	15 TCU	
	Taste & odour	Acceptable	
	Temperature	Acceptable	
	Turbidity	5 NTU	
	pH	6.5 – 8.5	
2	Inorganic constituents		
	Aluminum	0.13 mg/l	
	Ammonia	1.5 mg/l	
	Chloride	250 mg/l	
	Hydrogen sulfide	0.05 mg/l	
	Iron (total)	0.3 mg/l	
	Manganese	0.27 mg/l	0.4 mg/l
	Sodium	250 mg/l	
	Sulfate	250 mg/l	
	Total dissolved solids (TDS)	1000 mg/l	
	Zinc	3 mg/l	
3	Organic constituents		
	2-Chlorophenol	5 µg/l	
	2,4-Dichlorophenol	2 µg/l	

Parameter	Permissible level in µg/l by SSMO, 2008	WHO guideline value in mg/l, 2006
Carbontetrachloride	2.7	0.004
Dichloromethane	14	0.02
1,2-Dichloroethane	20	0.03
1,2-Dichloroethene	33	0.05
Trichloroethene	13	0.02 (P)
Tetrachloroethene	27	0.04
Benzene	7	0.01
Toluene	470	0.7(C)
Xylenes	330	0.5 (C)
Ethylbenzene	200	0.3 (C)
Styrene	13	0.02 (C)
1,2-Dichlorobenzene	700	1 (C)
1,4-Dichlorobenzene	200	0.3 (C)
Di(2-ehylhexyl) phthalate	5.4	0.008
Acrylamide	0.3	0.0005
Epichlorohydrin	0.3	0.004 (P)
Edetic acid (EDTA)	400	0.6 Applies to the free acid
Nitrilotriacetic acid (NTA)	130	0.2
Hexachlorobutadiene	0.4	0.0006
Dioxane	33	0.05
Pentachlorophenol	7	0.009 (P)

Parameter	**Maximum Permissible level in µg/l**	WHO guideline value in mg/l, 2006
Pesticides		
Alachlor	15	0.02
Aldrin/Dieldrin	0.02	0.00003 For combined Aldrin and Dieldrin
Aldicarb	7.5	0.01 Applies to Aldicarb Sulfonide and Aldicard Sulfone
Atrazine	1.5	0.002
Carbofuran	4.5	0.007
Chlordane	0.15	0.0002
Chlorotoluron	20	0.03
1,2-Dibromo-3-Chloropane	0.7	0.001
DDT	0.7	0.001
2,4-Dichlorophenoxy acitic acid	20	0.03
1,2-Dichloropropane (1,2 DCP)	26	0.04 (C)
1,3-Dichloropropene	13	0.02
Isoproturon	6	0.009
Lindane	1.3	0.002
MCPA	1.3	0.002
Methoxychlor	13.5	0.02
Metholachlor	7	0.01
Molinate	4	0.006
Pendimethalin	13.5	0.02
Pentachlorophenol	7	0.009 (P)
Permethrin	200	0.3
Simazine	1.3	0.002
Trifluralin	13.5	0.02
2,4-DB	60	0.09
Dichlorprop	66	0.1
Fenoprop	6	0.009
Mecoprop	7	0.01
2,4,5-T	6	0.009
Cyanazine	0.4	0.0006
1,2 Dibromoethane	0.27	0.0004 (P)
Dimethoate	4	0.006
Edin	0.4	0.0006
Terbuthylazine	5	0.007
Chlorpyrifos	20	0.03
Pyriproxyfer	200	0.3
Disinfectants and disinfectants' byproducts		
Chlorine	3	5
Monochloroacetate	13	0.02

Bromate	6.6	0.01 (A,T)
Chlorate	470	0.7 (D)
2,4,6-Trichlorophenol	135	0.2 (C)
Bromoform	70	0.1
Dibromochloromethane	70	0.1
Bromodichloromethane	66	0.06
Chloroform	200	0.3
Dichloroacetate	33	0.05 (T,D)
Trichloroacetate	133	0.2
Dichloroacetonitrile	13	0.02 (P)
Dibromacetonitrile	50	0.07
Cyanogen Chlorides (CN)	50	0.07
Chlorote	470	0.7 (D)
Disinfectants byproducts		
Gross alpha activity	0.07	
Gross beta activity	0.7	

P= Provisional guideline value as there is evidence of a hazard, but the available information on health effects is limited.

T= Provisional guideline value because calculated guideline value is below the level that can be achieved through practical treatment methods, source protection etc.

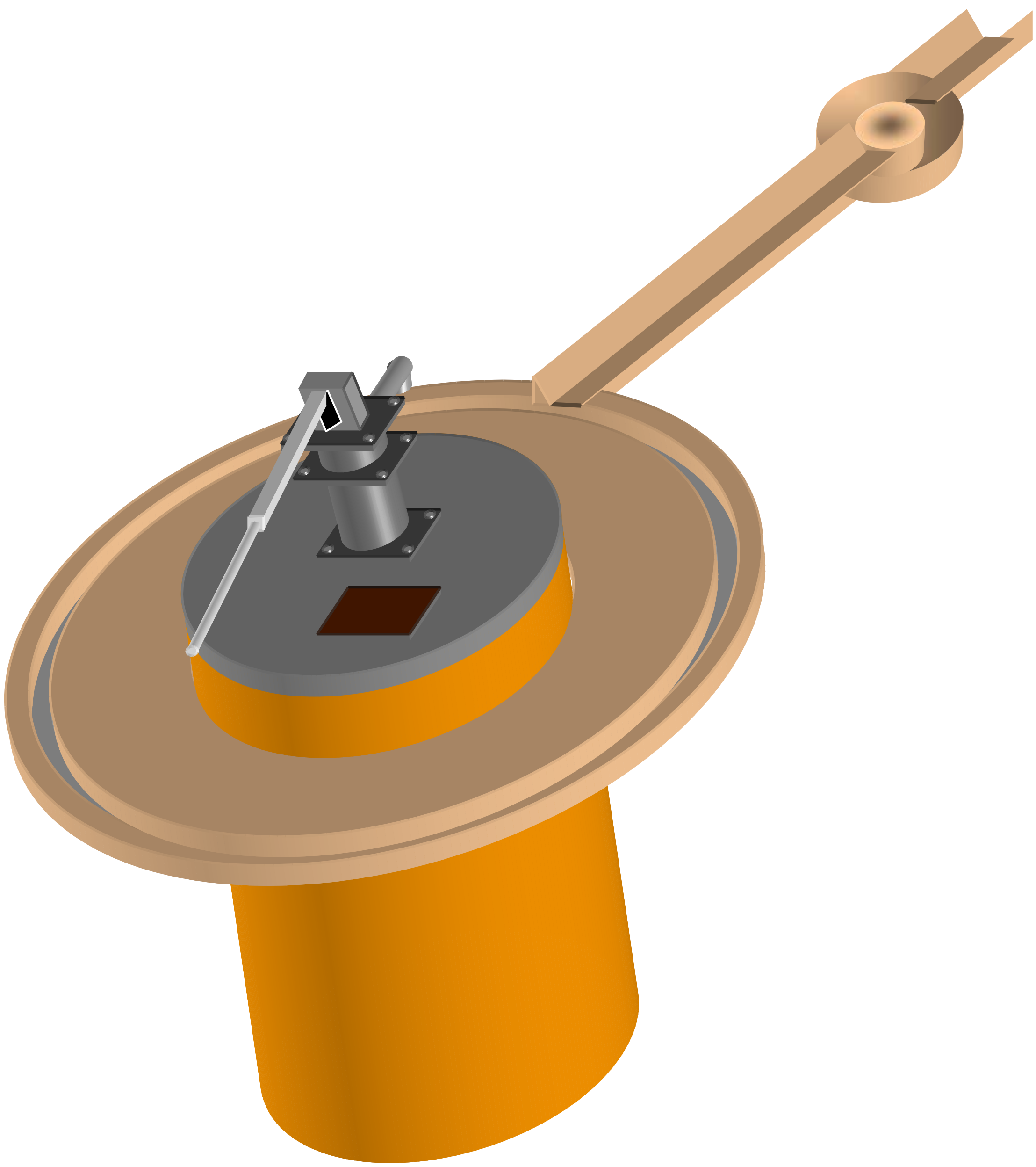
C= Concentration of the substance at or below the health-based guideline value may affect the appearance taste or odor of the water, leading to consumer complaints.

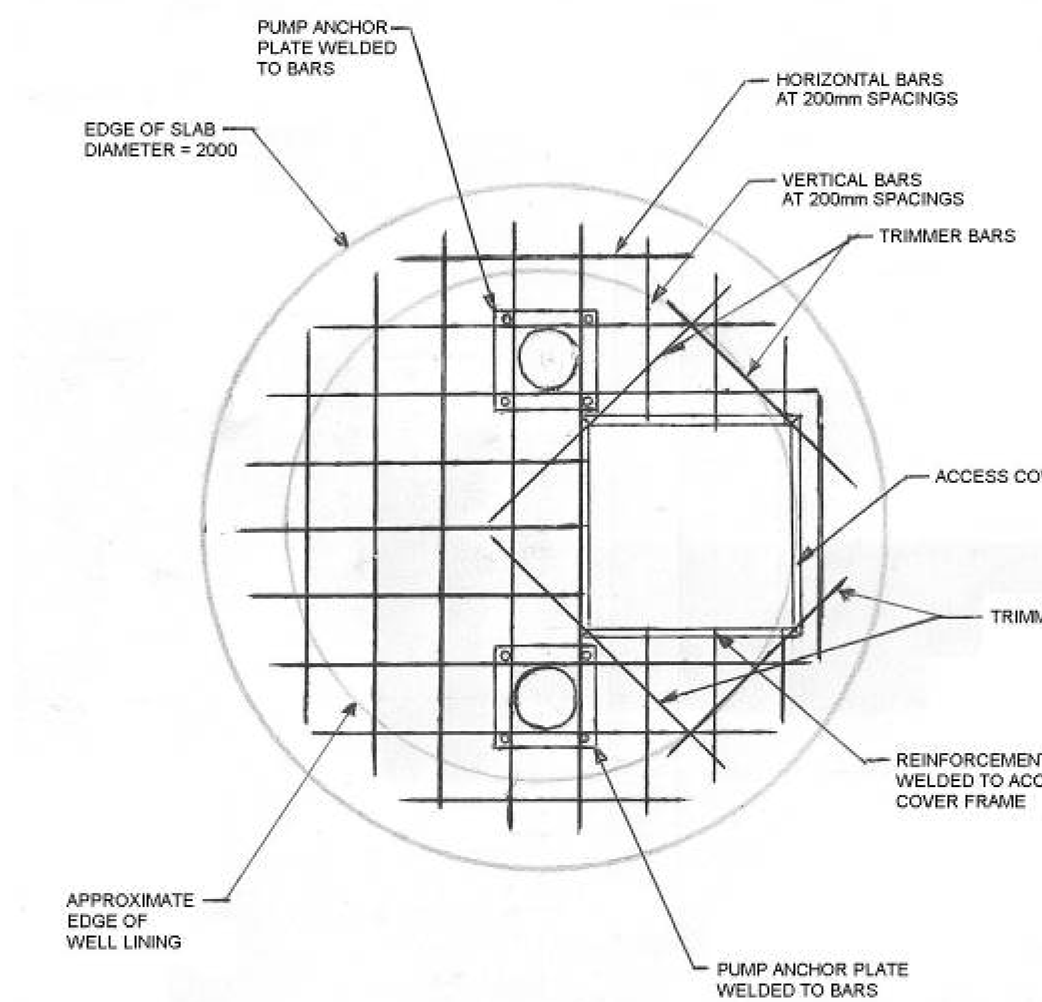
A= Provisional guideline value because calculated guideline value is below the achievable quantification level.

D= Provisional value because disinfection is likely to result in the guideline value being exceeded.

TCU = True Colour Unit

NTU = Nephlometric Turbidity Unit





PLAN VIEW OF COVER SLAB REINFORCEMENT

Reinforcement bar lengths (mm)

- All bars are single 10mm diameter bars.
- Horizontal and vertical bars shall be spaced at 200mm centres.
- Bars shall be positioned 25mm from the base of the cover slab.
- Minimum edge cover to reinforcement shall be 100mm.
- Bars are referred to as they appear on the drawing (horizontal bars from top to bottom, vertical bars from left to right).

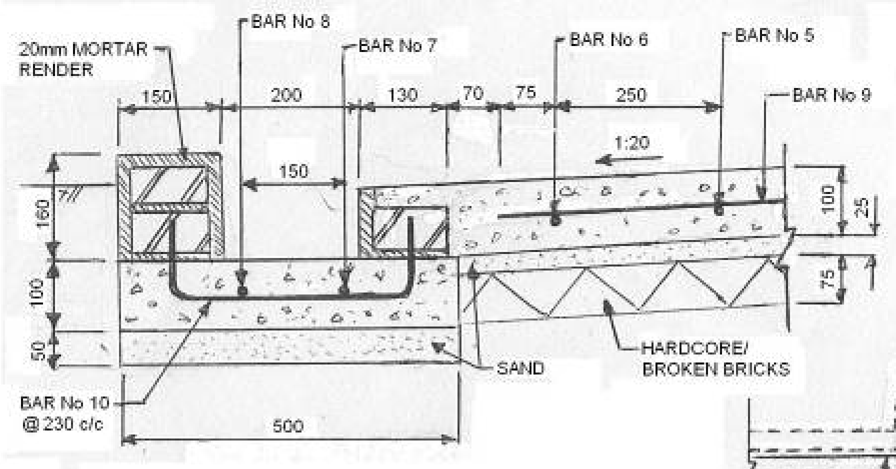
Horizontal bars	Vertical bars
900	1,200
1,400	1,500
1,650	1,700
1,000	1,800
1,050	1,800
1,000	2 x 550
1,650	2 x 400
1,400	2 x 250
900	800
Trimmer bars	
2 x 1,000	
2 x 750	

Notes:

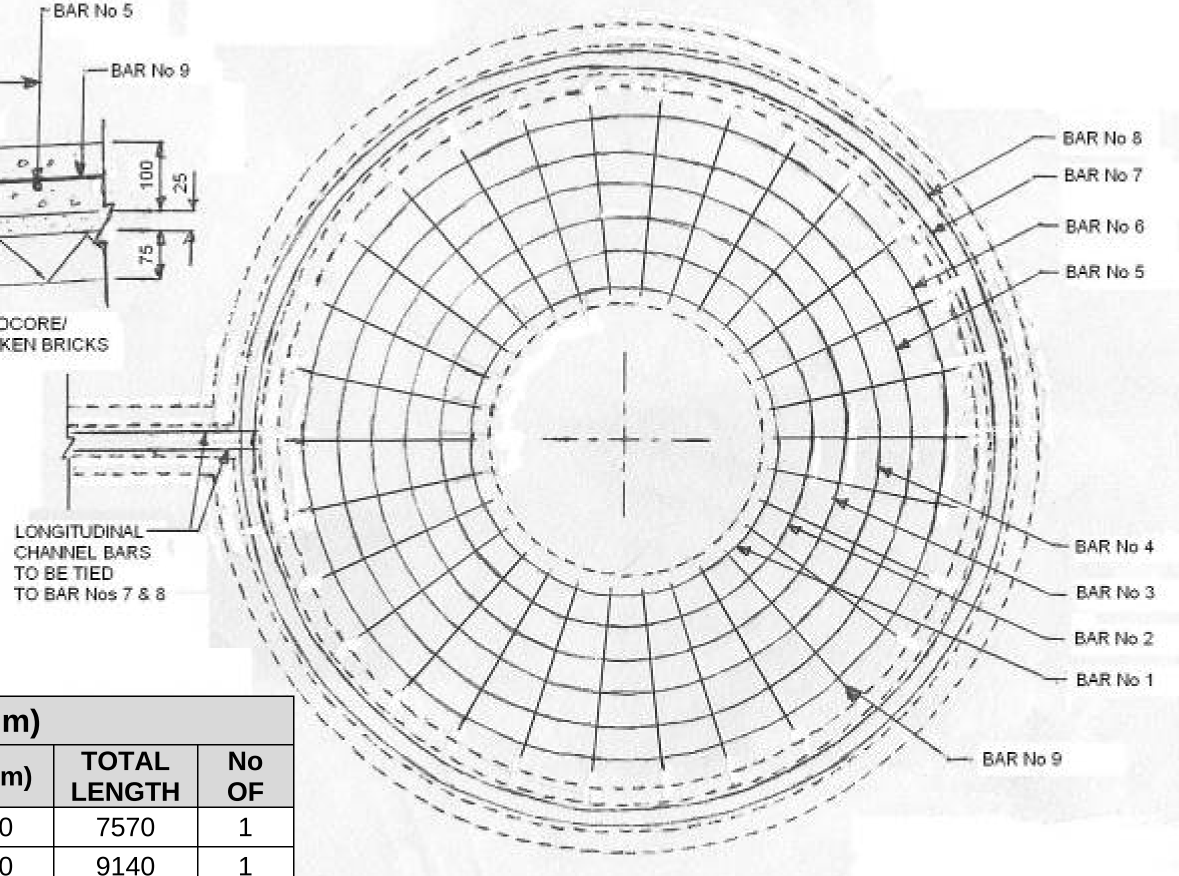
1. All dimensions are in mm unless noted otherwise
2. All reinforcement bars are 10mm diameter at 200mm spacing
3. All concrete is mix ratio of 1:2:4 (cement: sand: aggregate)

Adapted from Tearfund's Sudan Humanitarian Programme

Not to scale



SECTION THROUGH EDGE CHANNEL



PLAN ON APRON

(BAR No 10s OMITTED FOR CLARITY)

Reinforcement bar lengths (mm)

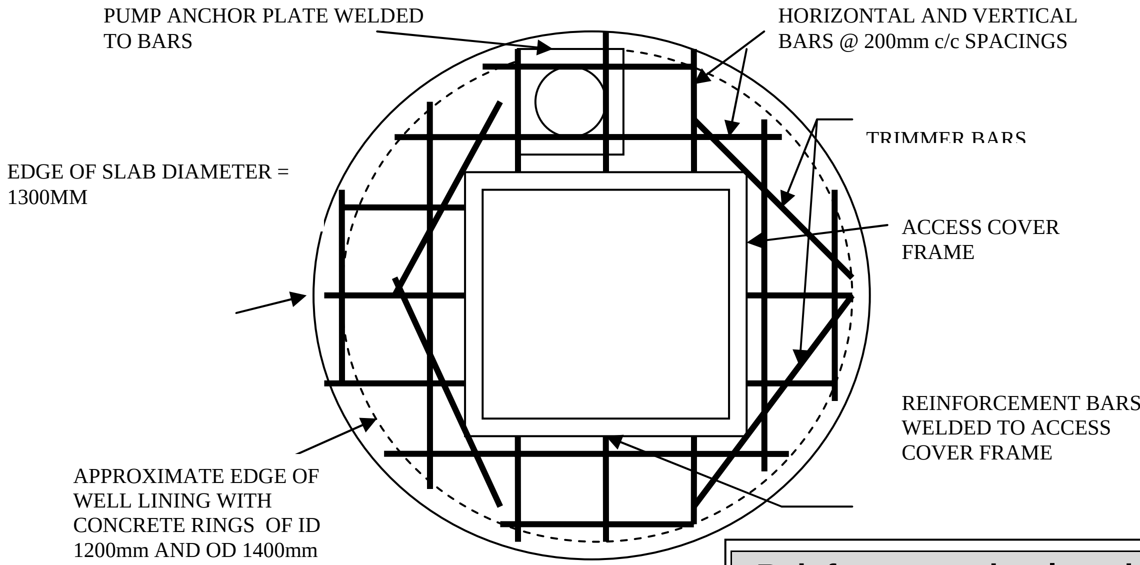
BAR No	SHAPE	DIA (mm)	LENGTH (mm)	LAP (mm)	TOTAL LENGTH	No OF
1	CIRCLE	2250	7070	2 x 250	7570	1
2	CIRCLE	2750	8640	2 x 250	9140	1
3	CIRCLE	3250	10210	2 x 250	10710	1
4	CIRCLE	3750	11780	2 x 250	12280	1
5	CIRCLE	4250	13350	3 x 250	14100	1
6	CIRCLE	4750	14930	3 x 250	15680	1
7	CIRCLE	5350	16810	3 x 250	17560	1
8	CIRCLE	5650	17750	3 x 250	18500	1
9	STRAIGHT	-	1400	-	1400	31
10	‘U’	-	550	-	550	70

Drawing not to scale

Adapted from Tearfund’s Darfur, Sudan Humanitarian Programme

For brick lining D of the well is 2000mm
For concrete lining D of the well is 1500mm

Notes:
1. All dimensions are in millimetres unless noted otherwise.
2. All reinforcement is 6mm diameter steel bars
3. Cover to reinforcement shall be 25mm minimum.
4. All concrete is mix 1:2:4 (cement:samd:aggregate)



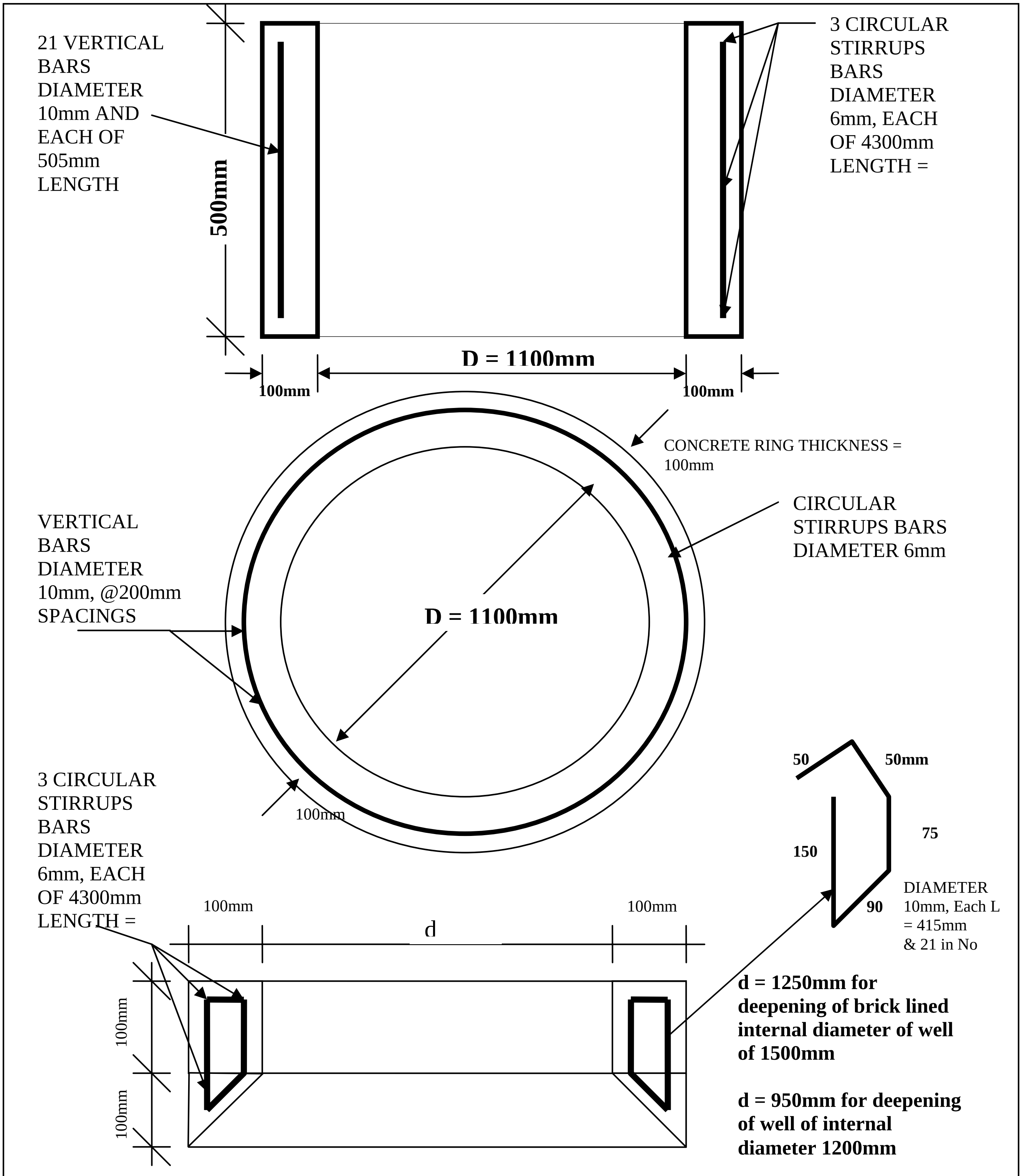
Reinforcement bar lengths (mm)

- All bars are single 10mm diameter bars.
- Horizontal and vertical bars shall be spaced at 200mm centres.
- Bars shall be positioned 25mm from the base of the cover slab.
- Minimum edge cover to reinforcement shall be 25mm.
- Bars are referred to as they appear on the drawing (horizontal bars from top to bottom, vertical bars from left to right).

Horizontal bars	Vertical bars
2 x 347	2 x 347
2 x 884	2 x 884
2 x 359	2 x 269
2 x 160	2 x 250
400	309
199	290
Trimmer bars	
4 x 550	

Notes:
1. All dimensions are in millimetres unless noted otherwise.
2. All reinforcement is 10mm diameter steel bars at 200mm spacings.
3. All concrete is mix 1:2:4 (cement:samd:aggregate)

Not to scale

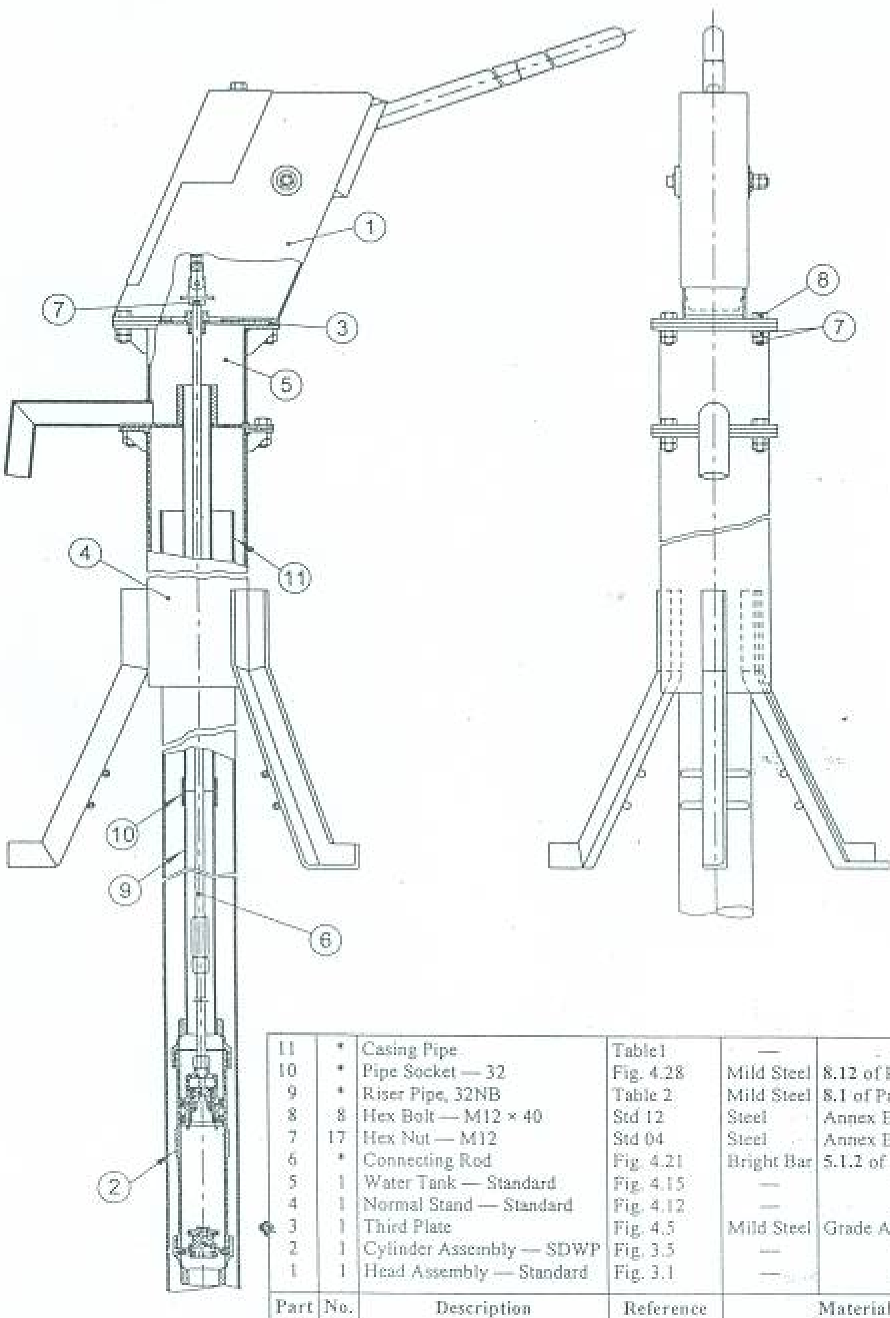


REINFORCEMENT SCHEDULE FOR A CONCRTE RING THAT WILL BE PRODUCED AT SITE. AND A CUTTING EDGE RING TO BE USED AT THE TIME OF DEEPINING IN SOFT AND LOOSE FORMATIONS

Drawing not to scale

Annex 3: Detail diagrams of India Mark II Hand Pumps

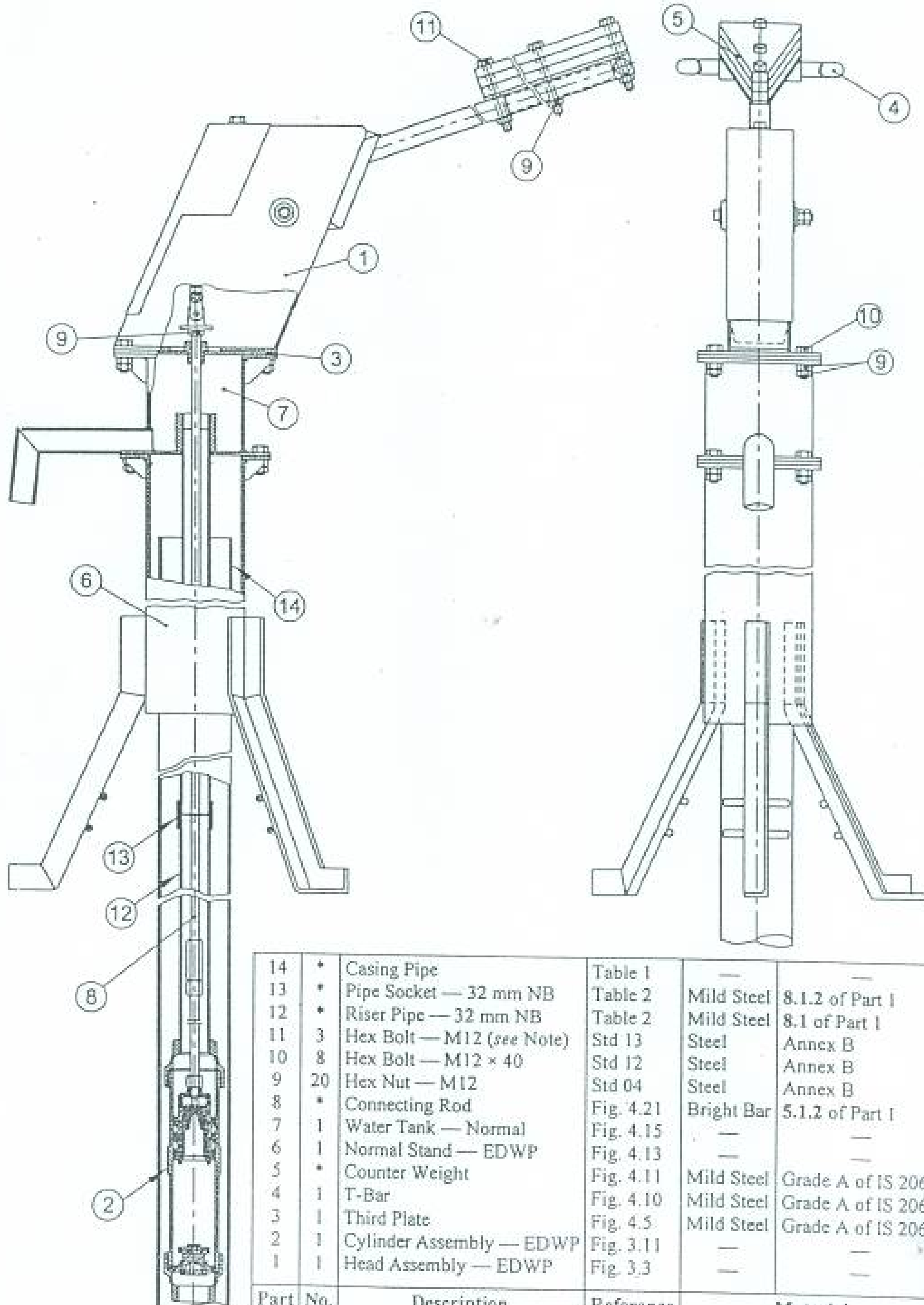
IS 15500 (Part 2) : 2004



Part No.	No. Off	Description	Reference	Material	
11	*	Casing Pipe	Table1	—	—
10	*	Pipe Socket — 32	Fig. 4.28	Mild Steel	8.12 of Part 1
9	*	Riser Pipe, 32NB	Table 2	Mild Steel	8.1 of Part 1
8	8	Hex Bolt — M12 × 40	Std 12	Steel	Annex B
7	17	Hex Nut — M12	Std 04	Steel	Annex B
6	*	Connecting Rod	Fig. 4.21	Bright Bar	5.1.2 of Part 1
5	1	Water Tank — Standard	Fig. 4.15	—	—
4	1	Normal Stand — Standard	Fig. 4.12	—	—
3	1	Third Plate	Fig. 4.5	Mild Steel	Grade A of IS 2062
2	1	Cylinder Assembly — SDWP	Fig. 3.5	—	—
1	1	Head Assembly — Standard	Fig. 3.1	—	—

* Depending on the field conditions/pump settings.

Figure 10: DEEPWELL HANDPUMP — STANDARD (SDWP)

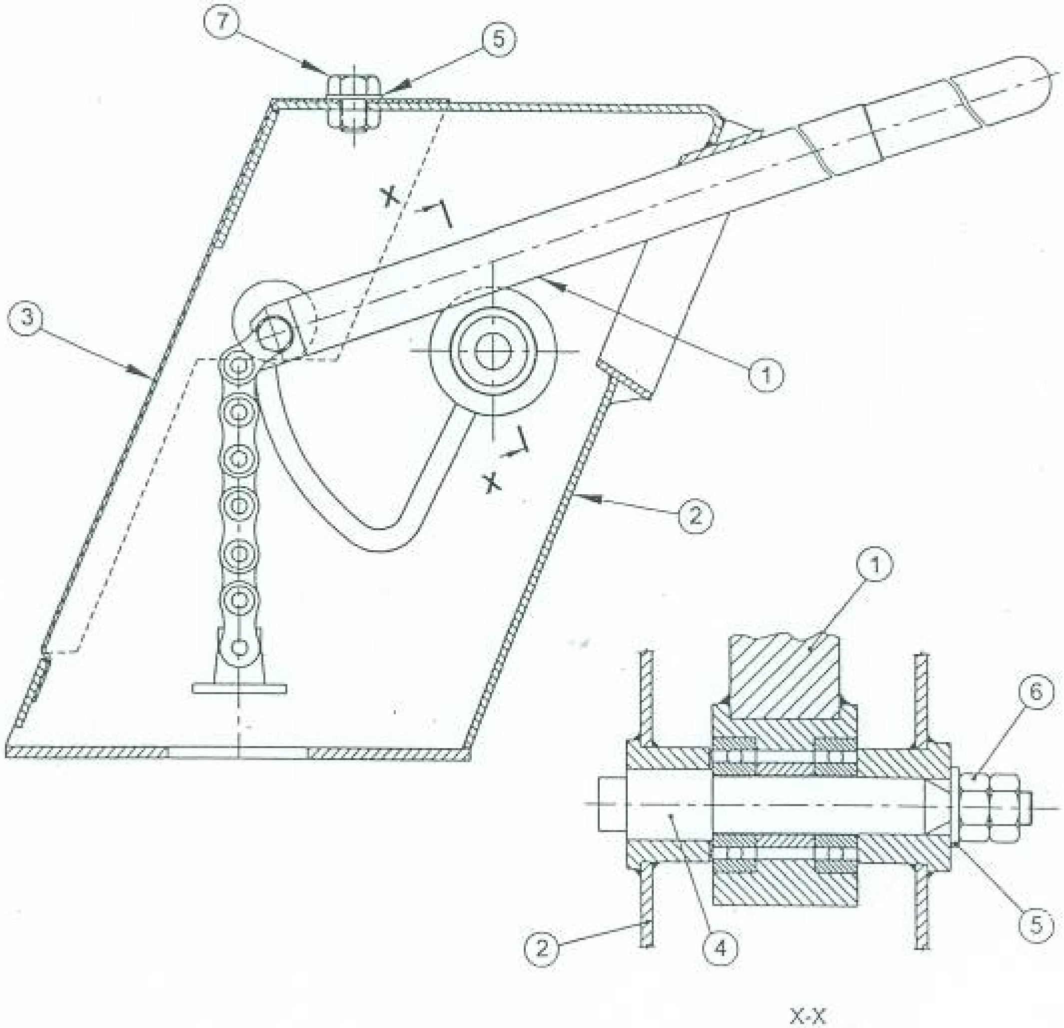


Part No.	No. Off	Description	Reference	Material	
14	*	Casing Pipe	Table 1	—	—
13	*	Pipe Socket — 32 mm NB	Table 2	Mild Steel	**8.1.2** of Part 1
12	*	Riser Pipe — 32 mm NB	Table 2	Mild Steel	**8.1** of Part 1
11	3	Hex Bolt — M12 (*see* Note)	Std 13	Steel	Annex B
10	8	Hex Bolt — M12 × 40	Std 12	Steel	Annex B
9	20	Hex Nut — M12	Std 04	Steel	Annex B
8	*	Connecting Rod	Fig. 4.21	Bright Bar	**5.1.2** of Part 1
7	1	Water Tank — Normal	Fig. 4.15	—	—
6	1	Normal Stand — EDWP	Fig. 4.13	—	—
5	*	Counter Weight	Fig. 4.11	Mild Steel	Grade A of IS 2062
4	1	T-Bar	Fig. 4.10	Mild Steel	Grade A of IS 2062
3	1	Third Plate	Fig. 4.5	Mild Steel	Grade A of IS 2062
2	1	Cylinder Assembly — EDWP	Fig. 3.11	—	—
1	1	Head Assembly — EDWP	Fig. 3.3	—	—

* Depending on field conditions/pump settings.

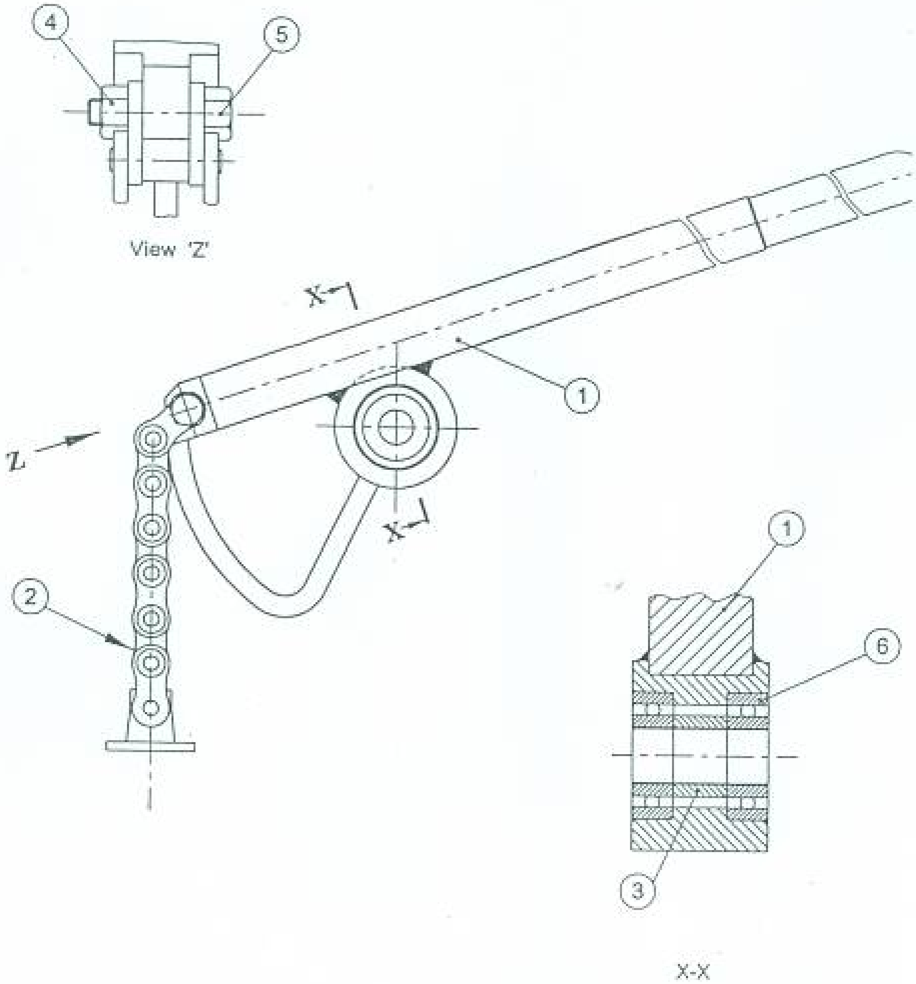
NOTE — In case of item 11, the bolt length will depend upon the number of counter weight.

Figure 11: Deepwell Handpump — Extra Deep (EDWP)



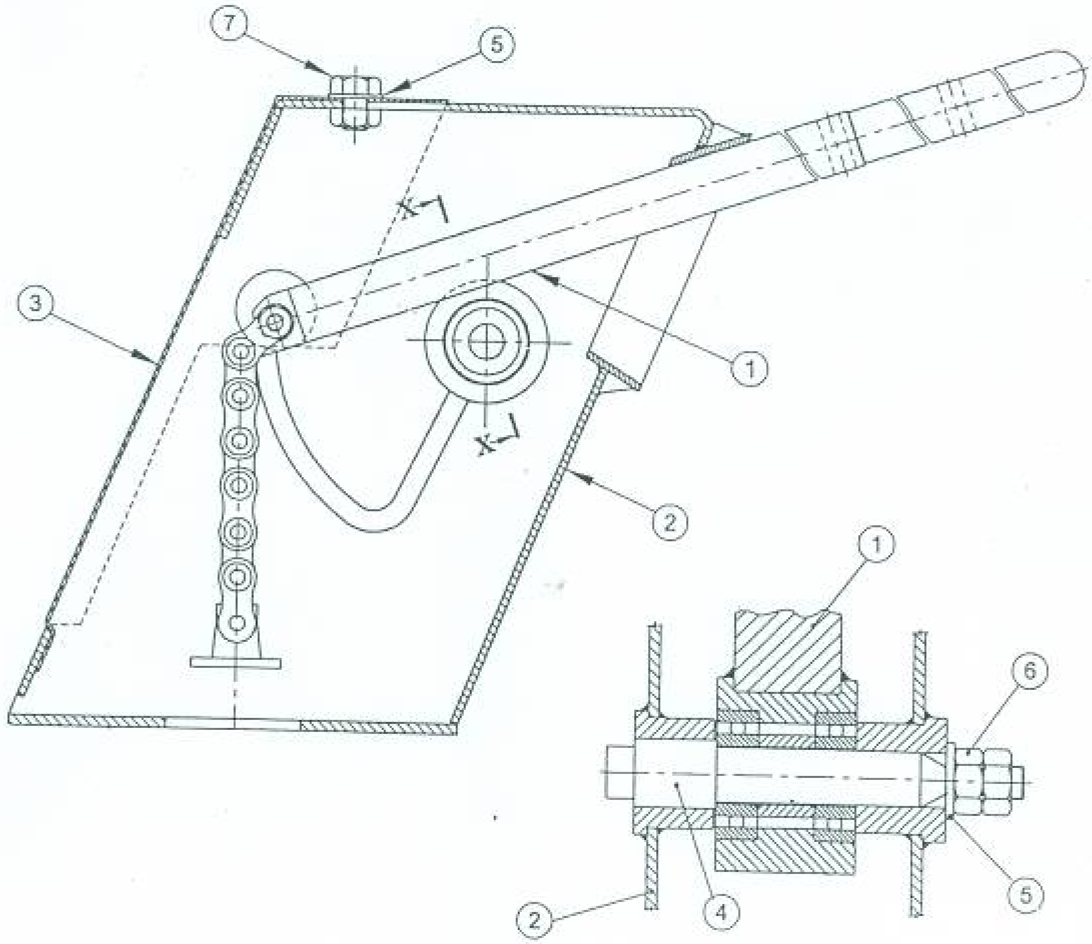
7	1	Hexagonal Bolt — M12 × 20	Std 10	Steel	Annex B
6	1	Hexagonal Nut — M12	Std 04	Steel	Annex B
5	1	Washer	Fig. 4.27	Mild Steel	Grade A of IS 2062
4	1	Handle Axle	Fig. 4.24	Stainless Steel	5.2 of Part 1
3	1	Front Cover	Fig. 4.4	CRS Sheet	Ord. Grade of IS 513
2	1	Head — Standard	Fig. 4.1	—	—
1	1	Handle Assembly — Standard	Fig. 3.2	—	—
Part No.	No. Off	Description	Reference	Material	

Figure 12: Head Assembly Standard
For SDWP,



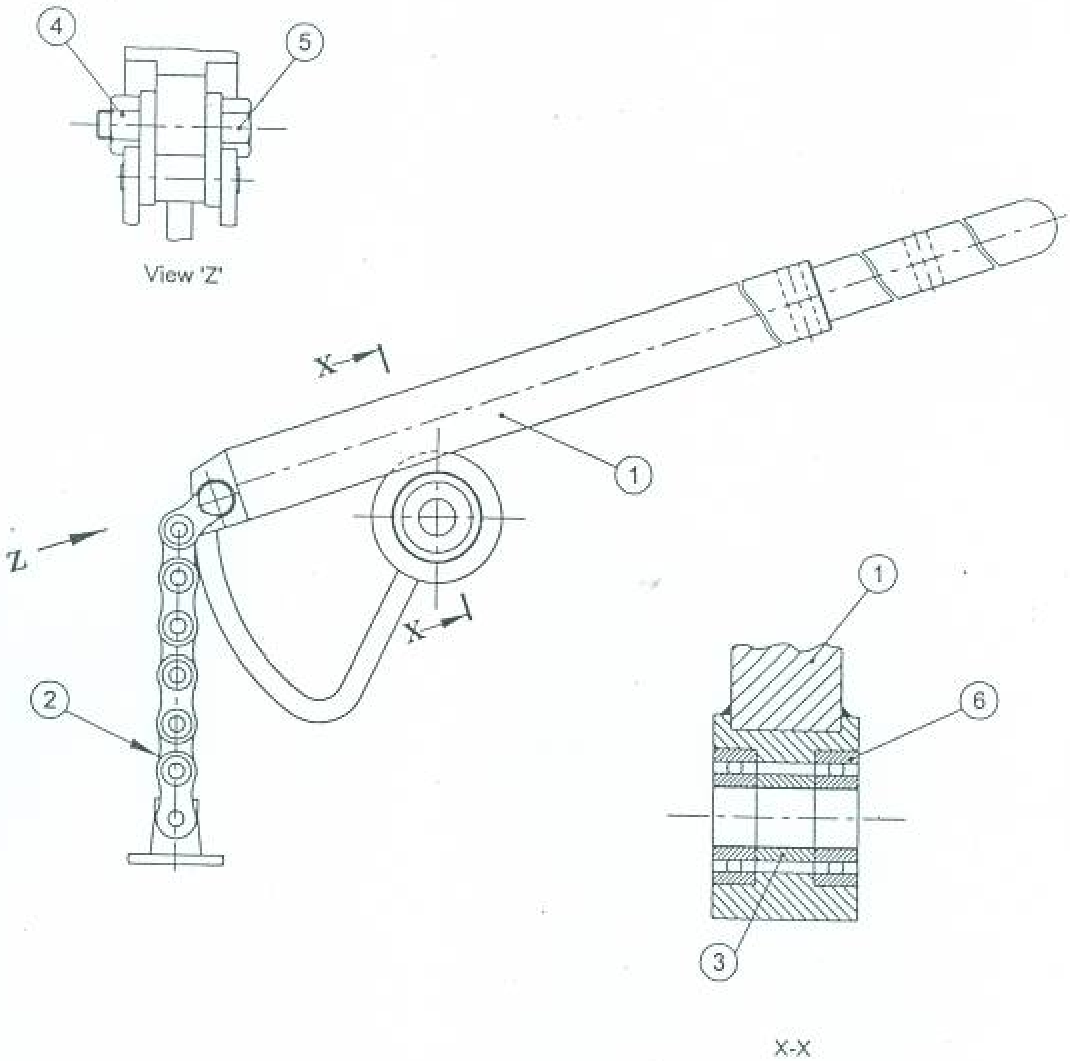
Part No.	No. Off	Description	Reference	Material	
6	2	Bearing, Single Side Shielded	Std 15	Designation 20 BC 02 PP of IS 6455	
5	1	Hex. Bolt — M10 × 40 (Gr 8.8)	Std 09	HT Bold	Annex B
4	1	Prevailing Torque Type Hex. Nut, M10	Std 03	Steel	Annex B
3	1	Bearing Spacer	Fig. 4.26	Mild Steel	Grade A of IS 2062
2	1	Chain with Coupling	Fig. 4.9	—	—
1	1	Handle — Standard	Fig. 4.6	—	—

Figure 13: HANDLE ASSEMBLY — STANDARD
For SDWP



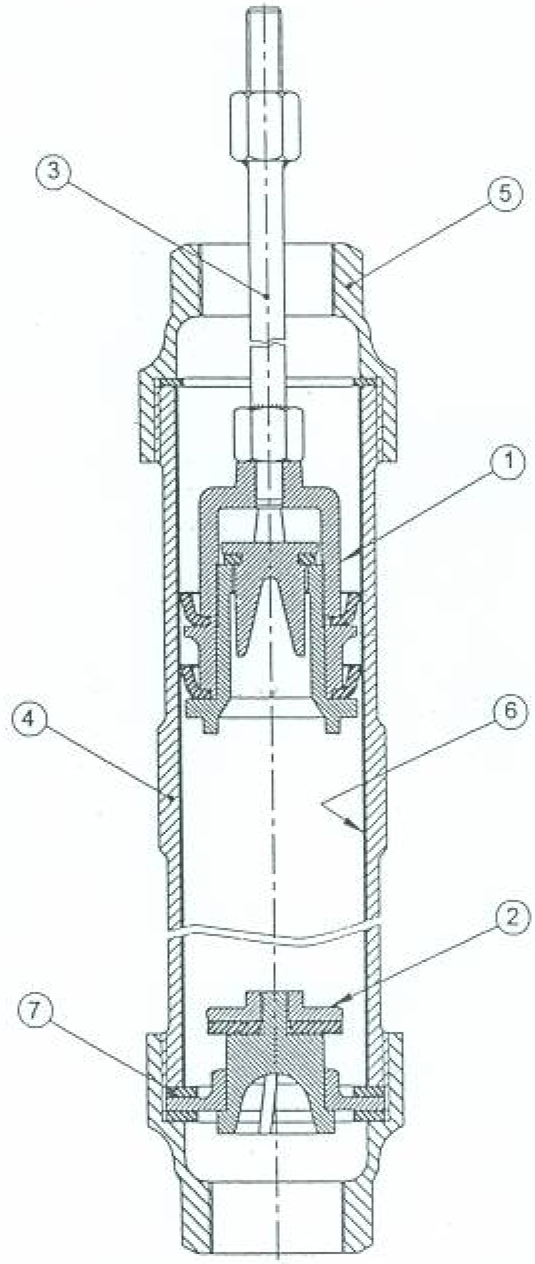
Part No.	No. Off	Description	Reference	Material	
7	1	Hexagonal Bolt — M12 × 20	Std 10	Steel	Annex B
6	1	Hexagonal Nut — M12	Std 04	Steel	Annex B
5	1	Washer	Fig. 4.27	Mild Steel	Grade A of IS 2062
4	1	Handle Axle	Fig. 4.24	Stainless Steel	5.2 of Part 1
3	1	Front Cover	Fig. 4.4	CRS Sheet	Ord. Grade of IS 513
2	1	Head — EDWP	Fig. 4.2	—	—
1	1	Handle Assembly — EDWP	Fig. 3.4	—	—

Figure 14: Head Assembly — EDWP



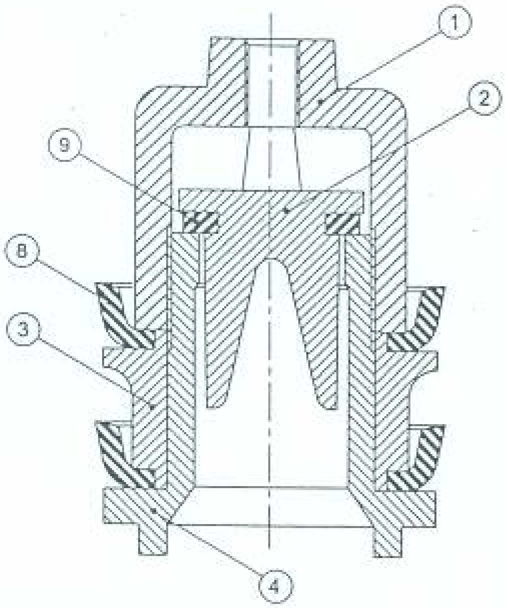
Part No.	No. Off	Description	Reference	Material	
6	2	Bearing, Single Side Shielded	Std 15	Designation 20 BC 02 PP of IS 6455	
5	1	Hex. Bolt — M10 × 40 (8.8)	Std 09	HT Bolt	Annex B
4	1	Prevailing Torque Type Hex. Nut, M10	Std 03	Steel	Annex B
3	1	Bearing Spacer	Fig. 4.26	Mild Steel	Grade A of IS 2062
2	1	Chain with Coupling	Fig. 4.9	—	—
1	1	Handle — EDWP	Fig. 4.7	—	—

Figure 15: Handle Assembly — EDWP

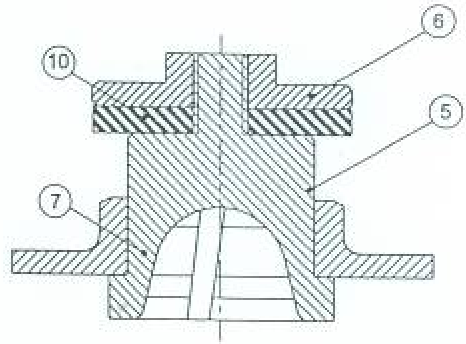


7	3	Sealing Ring — Standard	Fig. 7.3	Nitrile Rubber	5.6 of Part 1
6	1	Brass Line — Standard	Fig. 6.1A	Brass Tube	CuZn30 As of IS 407
5	2	Reducer Cap	Fig. 5.4	Cast Iron	FG 200 of IS 210
4	1	Cylinder Body — Standard	Fig. 5.1	Cast Iron	FG 200 of IS 210
3	1	Plunger Rod — Standard	Fig. 4.22	Stainless Steel	04Cr18Ni10 of IS 6603
2	1	Check Valve Assembly — Standard	Fig. 3.6B	—	—
1	1	Plunger Valve Assembly — Standard	Fig. 3.6A	—	—
Part No.	No. Off	Description	Reference	Material	

Figure 16: Cylinder Assembly — SDWP



3.6A Plunger Valve Assembly — SWDP

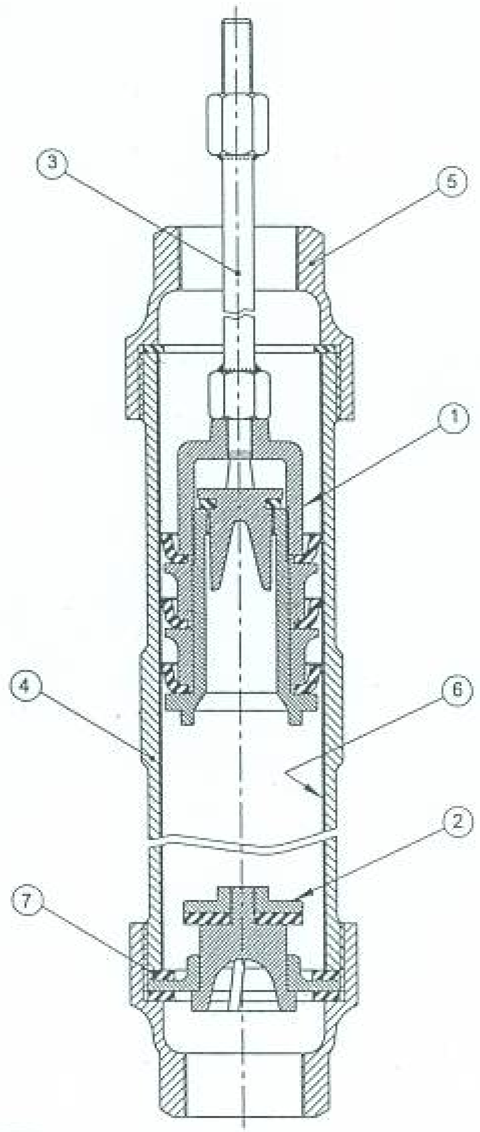


3.6B Check Valve Assembly — SDWP

Part No.	No. Off	Description	Reference	Material	
10	1	Check Valve Seating — Standard	Fig. 7.7	Nitrile Rubber	5.6 of Part 1
9	1	Upper Valve Seating	Fig. 7.6	Nitrile Rubber	5.6 of Part 1
8	2	Pump Bucket — Standard	Fig. 7.1	Nitrile Rubber	5.6 of Part 1
7	1	Check Valve Seat — Standard	Fig. 6.12	Bronze	Grade LTB2 of IS 318
6	1	Rubber Seat Retainer	Fig. 6.11	Bronze	Grade LTB2 of IS 318
5	1	Check Valve — Standard	Fig. 6.9	Bronze	Grade LTB2 of IS 318
4	1	Follower — SDWP	Fig. 6.6	Bronze	Grade LTB2 of IS 318
3	1	Bucket Spacer — Standard	Fig. 6.4	Bronze	Grade LTB2 of IS 318
2	1	Upper Valve	Fig. 6.3	Bronze	Grade LTB2 of IS 318
1	1	Plunger Yoke Body	Fig. 6.2	Bronze	Grade LTB2 of IS 318

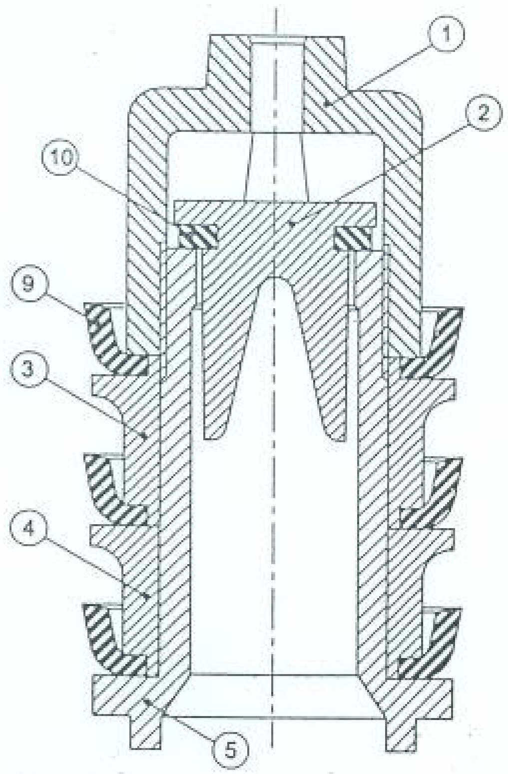
NOTE — Check valve assembly to be punch locked on top at M10 joint at diametrically opposite two points after filing the two surfaces even.

Figure 17: Valve Assemblies — SDWP

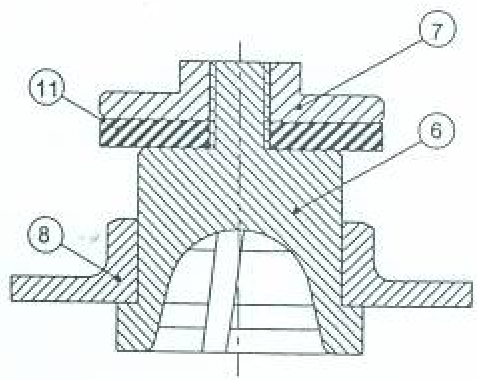


7	3	Sealing Ring — Standard	Fig. 7.3	Nitrile Rubber	5.6 of Part 1
6	1	Brass Liner — Long	Fig. 6.1B	Brass Tube	CuZn30 As of IS 407
5	2	Reducer Cap	Fig. 5.4	Cast Iron	FG 200 of IS 210
4	1	Cylinder Body — Long	Fig. 5.2	Cast Iron	FG 200 of IS 210
3	1	Plunger Rod — Long	Fig. 4.23	Stainless Steel	04Cr18Ni10 of IS 6603
2	1	Check Valve Assembly — EDWP	Fig. 3.12B	—	—
1	1	Plunger Valve Assembly — EDWP	Fig. 3.12A	—	—
Part No.	No. Off	Description	Reference	Material	

Figure 18: Cylinder Assembly — EDWP



3.12A Plunger Valve Assembly — EDWP



3.12B Check Valve Assembly — EDWP

Part No.	No. Off	Description	Reference	Material	
11	1	Lower Valve Seating — Standard	Fig. 7.7	Nitrile Rubber	5.6 of Part 1
10	1	Upper Valve Seating	Fig. 7.6	Nitrile Rubber	5.6 of Part 1
9	3	Pump Bucket — Standard	Fig. 7.1	Nitrile Rubber	5.6 of Part 1
8	1	Check Valve Seat — Standard	Fig. 6.13	Bronze	Grade LTB2 of IS 318
7	1	Rubber Seat Retainer	Fig. 6.11	Bronze	Grade LTB2 of IS 318
6	1	Check Valve — Standard	Fig. 6.9	Bronze	Grade LTB2 of IS 318
5	1	Follower — EDWP	Fig. 6.7	Bronze	Grade LTB2 of IS 318
4	1	Bucket Spacer — Lower	Fig. 6.5	Bronze	Grade LTB2 of IS 318
3	1	Bucket Spacer — Standard	Fig. 6.4	Bronze	Grade LTB2 of IS 318
2	1	.Upper Valve	Fig. 6.3	Bronze	Grade LTB2 of IS 318
1	1	Plunger Yoke Body	Fig. 6.2	Bronze	Grade LTB2 of IS 318

NOTE — Lower valve assembly to be punch locked on top at M10 joint at diametrically opposite two points after filing the two surfaces even.

Figure 19: VALVE ASSEMBLIES — EDWP

Annex 4: Technical Specifications for Hand Pumps:

Technical Specifications for India Mark II Standard and Extra Deep Well Hand Pumps conforming to Indian Standard (IS) 15500, 2004 are outlined below. Every India Mark II hand pump imported into Sudan must have an Inspection Seal. It is important to ensure this when purchasing this type of hand pump.

Dimensions and tolerances

- The material, dimensions and tolerances for different components/assemblies must comply with the specifications provided in respective figures given in Parts 2 to 8 of IS 15500, 2004.
- Unless otherwise specified, the tolerance on the un-machined dimensions relating to the following items used in the pump production, should be governed by their respective Indian Standards:
  Hot/cold rolled carbon steel plates, sheets, flat and bars.
  Steel sections
  Brass tube, and
  Cast iron/bronze castings
- For all other linear and angular dimensions where tolerances are not specified, the tolerance as per Class C (coarse) of IS 2102 (Part 1) should be followed for the manufacturing of the components.
- The tolerance of metric thread should conform to IS 14962 (Part 3), Class 6g for bolts and 6H for nuts.
- Standard parts like fasteners, ball bearings, etc used in the hand pump assembly and sub-assemblies should match specifications in Annex B of IS 15500
- All bolts, nuts and washers except high tensile bolts should be electro-galvanized to conform to IS 1367 (Part 11)

Raw materials

- All raw materials for use in the manufacturing of the pump parts like steel, stainless steel, cast iron, brass, rubber should conform to specifications in point 5 of IS 15500 (Part 1).

Anti-corrosive treatment

- Connecting rod (mild steel), bearing spacer, and washer should be electro-galvanized and passivated conforming to service condition No 4 of IS 1573.
- The stand, water tank, head, cover, handle, third plate, T-bar (for extra deep well), counter weight (for extra deep well), and socket for riser pipe should be hot dip galvanized according to IS 4759.
- Galvanized assemblies should be chromate conversion coated according to point 5.9 of IS 2629.
- Exterior surfaces of cast iron components should treated with
  -One coat of red oxide primer, conforming to IS 2074.
  -Two coats of synthetic enamel paint conforming to IS 2932
- Chain coupling should be coated with epoxy primer and paint.
- Chain assembly should be boiled in graphite grease for better anti-corrosion

Workmanship

- All components should be free from rough edges, burrs and other surface defects. Sharp machined edges should be filed smooth.
- Casting should not be repaired or welded and should conform to Grade PG 200 or higher grade of IS 210.
- Welding of mild steel components should be done in accordance with IS 9595.
- Welding for stainless steel components should conform to IS 2811.
- All welding should be free from blow holes, pin holes, cracks, etc.
- All other workmanship must be carried out in accordance with point 7 of IS 15500 (Part 1)

Riser pipes

- Riser pipes shall be hot dipped galvanized, screwed and socketed conforming to IS 1239 (Part 1) medium class with special emphasis on the instructions in point 6.4. Pipe ends should have a smooth finish and should be free of burrs or sharp machining chip. The internal surface of pipes should not have any lump of zinc. One end of each riser pipe should be fitted with a hot dipped galvanized socket and the other end with a thread protector. The nominal bore and length of each pipe for both Standard and Extra Deep Well Hand pumps should be 32mm and 3000mm. respectively.
- The socket for the riser pipe should be manufactured from a seamless pipe according to IS 1239 (Part 2), or machined from a solid bar conforming to Grade A of IS 2062 and should be hot dipped galvanized. The dimensions of the socket should conform to Fig 4.28 of IS 15500. Sockets should be tightly screwed into the rising main thread to avoid disconnection during transportation.
- Poly-tetra-flouro-ethylene (PTFE) tape or similar shall be used on the riser pipe joints before installation.

Testing

- The procedure given in IS 2500 (Part 1) should be followed for sampling inspection.
- The single sampling plan with general inspection level1 and AQL of one percent as given in Table I and II-A of IS 2500 (Part 1) should be followed for the characteristics given in testing clause 9 of IS 15500 (Part 1) of all the parts.
- Stroke length and discharge of pumps should be as follows:
    - For Standard Deep Well, stroke length :125±4mm and minimum discharge: 15 liters per minute or 40 strokes.
    - For Extra Deep Well, stroke length: 100±4mm and minimum discharge:12 liters per minute or 40 strokes.

Criteria for Conformity

- A lot shall be considered conforming to the requirements of the standard, if the batch selected according to 9.3 of IS 15500 (Part 1) satisfy the criteria for conformity given in the corresponding part (Part 2 to Part 7) of IS 15500 depending on the assembly, sub-assembly or component it is comprised of .

Guarantee

- All pumps and accessories should have a guarantee for 12 months from the date of installation or 18 months from the date of supply whichever is earlier against bad workmanship/material.

Marking

- The pump head assembly should have a name plate incorporating the name and address of the manufacturer, date of manufacturing and a serial number correlating it with the production records.
- A code/serial number should be punched on the raised portion of the cylinder body, correlating it with the production records.
- The connecting rod should have a steel punch impression indicating rhe manufacturer's identification mark, month and year of manufacture on the 50mm long hexagonal coupler.
- For Standard and Extra Deep Well Hand pumps, a number '32' shall be marked on the upper side of bottom flange of the water tank in minimum 10mm size ensuring that it is legible after galvanizing.
- All other markings should be done according to clause of 11 of IS 15500 (Part 1)

Packing

- The packing procedure in Annex C of IS 15500 should be followed.
- External threads of all the threaded components should be fitted with suitable thread protectors to avoid transit damage.
- The riser pipe should be packed as per instructions in IS 4740.
- In addition to the requirements given in 12.1 and 12.2 of IS 15500 (Part 1), the following conditions apply for the head assembly:
    - The handle should be locked in position with some suitable arrangement before packing the head assembly.
    - An extra hexagonal nut (Std 04 in Annex B of IS 15500) should be attached to the chain to lock the last connecting rod with the chain coupling.
    - The chain should be smeared with graphite grease and covered with a polyethylene bag prior to dispatch.

Annex 5 Standard tools required for installation/maintenance of a hand pump

The various kinds of tools required for maintenance and repair are categorized under standard tools for routine maintenance and special tools for major repair work. Village mechanics should always have a set of standard tools available.

The following table shows the list of items required under the standard tools category for both Standard and Extra Deep Well Hand Pumps.

No	Description of the standard tools	Unit	Quantity
1	Button Die to suit M12x1.75 threads	No	1
2	Die set for 32/40mm NB pipe	set	1
3	600mm pipe wrench (stilson type)	No	2

4	450mm pipe wrench (stilson type)	No	1
5	M 17 x M19 double ended spanners (10mm x 12mm)	No	2
6	Screw Driver 300mm long	No	1
7	1 kg (approx) ball pein hammer with handle	No	1
8	Hacksaw frame with spare blade 300mm	No	1
9	Pressure type oil can with oil	No	1
10	Wire brush	No	1
11	250mm half round file with handle	No	1
12	250mm flat file with handle	No	1
13	Lithium base/multipurpose grease	Kg	1
14	Graphite grease	Kg	1
15	0-9 number punch (6mm)	set	1
16	Nylon rope (3mm thick)	M	75
17	Adjustable spanner	No	1
18	Pipe stands	set	1

The following items are required as part of special tools.

No	Description of the special tools	Unit	Quantity
1	Self locking clamp	No	1
2	Water tank (or Tank pipe) lifter	No	1
3	Rod coupler (or Coupling) spanner	No	2
4	Axle (or Handle axle) punch	No	1
5	Connecting rod lifter	No	1
6	Crank spanner	No	2
7	Pipe lifting (or Lifting) spanner	No	3
8	Connecting (or Connections) rod vice	No	1
9	Chain coupling (or coupler) supporting tool	No	1
10	Bearing pressing tool	No	1
11	Tool box	No	1

- Self-locking clamp is required for clamping of the riser pipe. It grips the pipe as soon as the handle is released.
- Water tank lifter handles the water tank during assembly and dismantling of the pump.
- Rod coupler spanner is required for easy fitting of the connecting rods.
- Axle punch helps in driving the handle axle out of the head assembly.
- Connecting rod lifter facilitate in lowering or lifting of the connecting rods.
- Crank spanner is required for fastening of M12 and M10 bolts and nuts specially the chain bolt.
- Pipe lifting spanner helps in lifting or lowering riser pipes.
- Connecting rod vice is required to clamp the connecting rod.
- Chain coupling supporting tool facilitates the disconnection of the chain from the handle.
- Bearing pressing tool is required for pressing the bearings in the bearing housing

- Tool box to keep all above tools except water tank lifter, pipe lifting spanner and self-locking clamp

Annex 6: Recommended spare parts for a hand pump

The following spare parts are recommended for two years as per the current Indian Mark II Technical Standard (IS 15500) Technical Specification.

No	Description of the spare part	Unit	Quantity
	Spares for pump head		
1	Hexagonal bolts M12 x 20mm long	No	8
2	Hexagonal nuts M12	No	18
3	Washers M12	No	10
4	Hexagonal bolt M10 x 40	No	1
5	Prevailing Torque Type Hexagonal nuts M10	No	2
6	Handle axle (stainless steel)	No	1
7	Washer (4mm thick) for handle axle	No	1
8	Bearing single side shielded	No	2
9	Bearing Spacer	No	1
10	Chain with coupling	No	1
	Spare for cylinder		
1	Pump bucket (Nitrile rubber)	No	4
2	sealing ring (Nitrile rubber)	No	6
3	Check valve seating	No	2
4	Upper valve seating	No	2
	Spares for connecting rods and G.I. riser pipe		
1	Hexagonal coupling M12 x 1.75 x 50mm	No	2
2	Pipe sockets (32mm NB medium grade hot dip galvanized	No	4

Annex 7: The Development of the Technical Guidelines

The Technical Guidelines development process was completed in two stages: preparation and finalization.

A. The Preparation Stage

The preparation stage began in April 2006 with the agreement to select eight WASH facilities. At the request of the GONU, 3 additional water supply facilities were added, making the total eleven. The preparation stage that included information collection and analysis was completed in December 2006.

Collection of Information:
Technical and managerial information related to the development of the 14 Technical Guidelines was collected from the following sources:

- PWC/WES, SWCs and GWWD
- UNICEF, WHO, World bank and NGOs
- National institutions like SSMO
- International institutions like IRC and WEDC
- Donors like DFID.
- Different countries' standards like BS, IS, DIN, etc.
- Field trips to 14 states in the northern and southern states of Sudan to visit the different existing facilities and to have live discussion with the sector professionals and community members.

Analysis of collected information:
The Steering Committee, which comprised senior staff from PWC, WES and UNICEF together with the consultant, analyzed the collected information, which led to the development of the outlines of the documents in a zero draft. The draft documents were shared with the Steering Committee. The committee met to discuss the drafts, and provided comments, which were incorporated, resulting in the first draft. .

The first draft was widely circulated to PWC, UNICEF, various SWCs, INGOs and GoSS for information and feedback. All relevant feedback from the sector actors were incorporated into the documents and the second draft prepared and presented to the first national review workshop in December 2006. The relevant recommendations and comments of the national review workshop were incorporated into the documents resulting in a third draft. The first National Review Workshop recommended that this draft of the Technical Guidelines be shared with a wider range of stakeholders, including specific technical working groups.

B. The Finalization Stage

The finalization of the 14 Technical Guidelines involved wider consultation with WASH sector partners through technical working group discussions, 3 regional review workshops, wider consultation and revision by GoSS and a national review workshop at the final stage.

Technical Working Group Discussions:
Professionals from various ministries participated in these technical working group discussions. MIWR, MOH, University of Khartoum, Sudan Academy of Science, private sector, NGOs, PWC/WES, UNICEF and Khartoum Water Corporation were also represented in these groups. This technical consultation process started in July 2007 and continued up to December 2007 resulting in the fourth draft of Technical Guidelines.

Regional Review Workshops:
Three Regional Review Workshops were conducted in Nyala, Wad Medani and Juba in November-December 2007 for GoSS and state level inputs into the documents. The Juba workshop recommended that the need for wider consultation within Southern Sudan to review the documents and to incorporate Southern Sudan specific contexts into the documents such as information relating to the location and different hydrogeological situations. These 3 workshops, resulted in the fifth draft.

Wider Consultation by GoSS:
Based on the recommendation of the Juba Review Workshop, a wider consultation process was started in July 2008 and completed in October 2008. The process included state level consultation with sector actors, technical working group discussions and a final consultation workshop in Juba. The process was concluded by the finalization and the approval of the final draft documents which were reviewed at a final National Workshop.

Final National Workshop:
The final National Workshop was conducted in April 2009 in Khartoum under the guidance and the presence of H.E. Eng. Kamal Ali Mohamed, Minister of Irrigation and Water Resources of GONU, Eng. Isaac Liabwel, Undersecretary, Ministry of Water Resources and Irrigation of GoSS, Eng. Mohammed Hassan Mahmud Amar, DG of PWC and Eng. Adam Ibrahim, Minister of Physical Planning and Public Utilities of South Darfur State.

The workshop was attended by ninety two participants representing MIWR, MWRI, MOH, PWC, WES, GWWD, Engineering Council, SWCs, SMoH, University of Khartoum, UNICEF, WHO, IOM, ICRC, NGOs, USAID and private sector.

The National Workshop reviewed the 14 WASH Technical Guidelines and approved them as the national WASH Technical Guidelines.

The workshop recommendations included:

- Publication and wide distribution of the Guidelines;
- Translation of the Guidelines into Arabic and other major Sudanese languages;
- Organization of training and advocacy courses/workshops related to the Guidelines;
- Adoption of supportive policies, strategies, laws and regulations to ensure best utilization of the Guidelines;

- Development of a system for further feedback from implementing partners for inclusion in future updates of the Guidelines. MIWR/PWC, MWRI and SWCs were selected as focal points for that purpose.

Annex 8: People contacted

At Khartoum level

1. Mr Mohammed Hassan Mahmoud Amar, Director General, PWC
2. Mr Eisa Mohammed, National WES Coordinator, WES/NWC
3. Mr Mohammed Habib, National Project Coordinator, PWC
4. Mr Sampath Kumar, Chief WES Section, UNICEF
5. Mr Vishwas Joshi, PO, UNICEF
6. Mr Zaid Jurji, PO, UNICEF
7. Mr Stanely Hall, SPO, UNICEF
8. Mr Fouad Yassa, PO, UNICEF
9. Mrs Awatif Khalil, APO, UNICEF
10. Mr Samuel Riak, PO, UNICEF
11. Mr. Mohammed El Hassan Eldori, Director of Department of Groundwater, MOIWR
12. Mr Mohammed Ahmed Bukab, Mechanical Engineering Department, PWC
13. Mr Mohammed Salih Mahmoud, Mechanical Consultant, PWC
14. Mr. Yassir Ismael, WES/PWC
15. Mr Al Amin Ahmed Ibrahim, PWC
16. Mr Mohy El Deen Kabeer, Groundwater and Wadis, MOIWR

North Darfur, El Fashier

1. Osman Bukhari Ibrahim	SMOH	DG Envoronmental Health
2. Abdul Azim Ahmed	SWC	Mechanical Engineer
3. Abdella M. Adam	WES	Drilling Engineer
4. Mohammed Mohammedein	WES	Mechanical Engineer
5. Omer Abdurahman Adam	GWWD	Hydrogeologist
6.Nour Eldin Adam	WES	Surveying Engineer
7. Abdella Adam Ibrahim	WES	Geologist
8. Tayalla El Medomi	UNICEF	Water Engineer
9. Mohammed Mohammedein Subi	SWC	Acting DG & Manager of RW
10. Salma Hassan	WES	Social Mobilzer
11. Ahmed Abu Elgasim	WES	Acting GM
12. Hassan Sheik Nur	Oxfam GB	Public Health Engineering Coord.
13. Jaka Magoma	IRC	Environmental Health Manager

North Kordofan, El Obeid

1. Hassan Adam Suleiman	ACU WES	Monitoring Officer
2. Ahmed El Abeid	RWD	Surface Water Section
3.Alehmin Ahmed	WES	Mechanical Engineer
4. Saeed Elmahdi	WES	Programme Manager
5. Asia Mahmoud Mohmed	ACU WES	W Coord. Kordofan Section
6. Yassin Abbas	PWC, NK	RWD Manager
7. Mahgoup Dahia	WES, NK	Mini Water Yard Officer
8. Abeer Ali Elnour	WES, NK	Civil Engineer

9. Mutasim Hamad	WES, NK	Monitoring Officer
10. Makin Mohammed Toto	WES, NK	Drilling Engineer
11. Salah Mohammed	GWWD	Director General

South Kordofan

1. Adil Awad Farog	SWC	Geologist
2. Jakob Jebbrel	SWC	Engineer
3. Haidar Ariah Abdel Bari	SWC	Geologist
4. Mohammed Morgan Yhya	SWC	WES PA
5. Gamaa Aziz	UNICEF	APO
6. Fatima Toto	SWC	Urban Water Management
7. Sunaya Zroog	SWC	Urban Water Management
8. Mymona Taha	SWC	Urban Water Management
9. Adam Mohammed Ibrahim	SWC	Urban Water Management
10. Ali Gabaur Ahmad	SWC	Urban Water Management
11. Elzaki Eisa	WES	Drilling Engineer
12. Kamal Bashir	SC/USA	Watsan
13. Osman Elnour	SWC	DG
14. Dr Abdel Rahim Ahmed	UNICEF	APO
15. Hassaballa Hamad	SWC	Rural Water Management
16. Absaida	SWC	Mechanic
17. Awatif Elhag	WFP	Field Monitor
18. Al Amin Shawish	Sudan Aid	Coordination Officer

People Contacted in Southern Sudan, July 2008

1. Juma Chisto, Operator of Kator Emergency Water Supply, Juba
2. Habib Dolas, Member of Watsan committee, Hai Jebel
3. Andew Wan Stephen, Member of Watsan committee, Hai Jebel
4. Francis Yokwe, Member of Watsan committee, Hai Jebel
5. William Ali Jakob, Member of Watsan committee, Hai Jebel
6. William Nadow Simon, Member of Watsan committee, Hai Jebel
7. Ali Sama, Director General, Rural Water Department, Central Equatoria State (CES)
8. Engineer Samuel Toban Longa, Deputy Area Manager, UWC, CES
9. Sabil Sabrino, Director General UWC, WBeG
10. James Morter, Technician, UWC, Wau
11. Carmen Garrigos, RPO, Unicef Wau
12. Sevit Veterino, Director General, RWC, WBeG
13. Stephen Alek, Director General, Ministry of Physical Infrastructure (MPI), Warap
14. John Marie, Director of Finance, MPI, Warap State
15. Angelo Okol, Deputy Director of O&M, Warap State
16. Santino Ohak Yomon, Director, RWSS, Upper Nile State
17. Abdulkadir Musse, RPO, Unicef Malakal
18. Dok Jok Dok, Governor, Upper Nile State
19. Yoanes Agawis, Acting Minister, MPI, Upper Nile State

20. Bruce Pagedud, Watsan Manager, Solidarites, Malakal
21. Garang William Woul, SRCS, Malakal
22. Peter Onak, WVI, Malakal
23. Gailda Kwenda, ACF, Malakal
24. Amardine Atsain, ACF, Malakal
25. Peter Mumo Gathwu, Care, Malakal
26. Engineer John Kangatini, MPI, Upper Nile State
27. Wilson Ajwek Ayik, MoH, Upper Nile State
28. James Deng Akurkuac, Department of RWSS, Upper Nile State
29. Oman Clement Anei, SIM
30. Abuk N. Manyok, Unicef, Malakal
31. Jakob A. Mathiong, Unicef, Malakal
32. Emmanuel Badang, UNMIS/RRR
33. Emmanuel Parmenas, DG of O&M, MCRD GOSS
34. Cosmos Andruga, APO, Unicef Juba

Annex 9. Technical Working Group Members

A) At Khartoum level

1) For Slow Sand Filters

Dr Mohammed Adam Khadam, University of Khartoum
Dr V. Haraprasad, UNICEF
Mr. Ibrahim Adam, PWC
Mr Eshetu Abate, UNICEF - Consultant

2) For Borehole Hand pumps, Hand dug well Hand pumps, Hand dug well Water yards, Mini Water yards and Water yards

Mr. Mohamed Hassan Ibrahim, GWW
Mr. Mohy Al Deen Mohamed Kabeer, GWW
Mr. Abd el Raziq Mukhtar, Private Consultant
Mr. Mohamed Salih Mahmoud, PWC
Mr. Mohamed Ahmed Bukab, PWC
Mr. Mudawi Ibrahim, PWC/WES
Mr. Yasir Ismail, PWC/WES
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3) For Improved Small Dams

Dr. Mohamed Osman Akoud, University of Khartoum
Professor Saif el Deen Hamad, MIWR
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4) For Improved Haffirs

Mr. Mohamed Hassan Al Tayeb, Private Consultant
Mr. Hisham Al Amir Yousif, PWC
Mr. Hamad Abdulla Zayed, PWC
Mr Eshetu Abate, UNICEF - Consultant

5) For Drinking Water Treatment Plants, Drinking Water Distribution Networks and Protected Springs & Roof Water Harvesting

Dr Mohamed Adam Khadam, University of Khartoum
Mr. Burhan Ahmed Al Mustafa, Khartoum State Water Corporation (KSWC)
Mr Eshetu Abate, UNICEF - Consultant

6) For Household Latrines, School Latrines and Rural Health Institution Latrines

Mr. Sampath Kumar, UNICEF
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B) At Juba level:

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Mr. Nyasigin Deng, MWRI-GOSS
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Mr. Philip Ayliel, MHLPU
Mr. James Adam, MWRI

Annex 10: Selected bibliography and references

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11. Technical Design Manual, Ethiopian Social Rehabilitation and Development Fund (ESRDF), April 1997
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Annex 11: Unit conversion tables

Length

	m	ft	in
1 m	1	3.281	39.37
1 ft	0.3048	1	12
1 in	0.0254	0.0833	1

Area

	m^2	ft^2
1 m^2	1	10.76
1 ft^2	9.29×10^{-2}	1

Volume

	m^3	litre	ft^3
1 m^3	1	1.0×10^{3}	35.32
1 litre	1.0×10^{-3}	1	3.532×10^{-2}
1 ft^3	2.832×10^{-2}	28.32	1

Discharge

	l/s	m^3/s	m^3/d	ft^3/s
1 l/s	1	1.0×10^{-3}	86.40	3.531×10^{-2}
1 m^3/s	1.0×10^{3}	1	8.640×10^{4}	35.313
1 m^3/d	1.157×10^{-2}	1.157×10^{-5}	1	4.087×10^{-4}
1 ft^3/s	28.32	2.832×10^{-2}	2.447×10^{3}	1

Velocity

	m/s	ft/s
1 m/s	1	3.281
1 ft/s	0.3048	1

Mass

	kg	lb	t
1 kg	1	2.205	1×10^{-3}
1 lb	0.454	1	4.536×10^{-4}
1 metric ton (t)	1000	2205	1

Density

	g/m^3	kg/m^3	lb/in^3	lb/ft^3
1 g/cm^3	1	1000	0.0361	62.43
1 kg/m^3	1×10^{-3}	1	3.61×10^{-5}	0.0624

1 lb/in^3	27.68	27.68 x 10^3	1	1728
1 lb/ft^3	0.016	16.02	5.787 x 10^{-4}	1

Pressure

	kgf/cm^2	bar	kN/m^2	lbf/in^2 (psi)
1 kgf/cm^2	1	0.981	98.1	14.223
1 bar	1.02	1	100	14.504
1 kN/m^2	0.01	0.0098	1	0.145
1 lbf/in^2 (psi)	0.07	0.0689	6.89	1

1 Pa (pascal) = 1 N/m^2
1 N/mm^2 = 1 MN/m^2 = 1 MPa
101325 Pa = 1 standard atmosphere (atm) = 1.01325 bar
100 kPa = 1 bar
10.33 m head of water = 1 atm
2989 Pa = 1 ft head of water = 22.42 mm of mercury (mmHg)
1 mmHg = 0.0394 inch of mercury (inHg)
1 MPa = 145 lbf/in^2 (psi)

Force

	N	kgf	lbf	pdl
1 N	1	0.1019	0.2248	7.2330
1 kgf	9.8066	1	2.2046	70.9316
1 lbf	4.4482	0.4536	1	32.1740
1 poundal (pdl)	0.1382	0.0141	0.0311	1

1 N = 1 kg m/s^2
1 pdl = 1 lb ft/s^2

Power

	kW	CV	bhp
1 kilowatt (kW)	1	1.3596	1.3410
1 metric horsepower (CV)	0.7355	1	0.9863
1 brake horsepower (bhp)	0.7457	1.0139	1

The metric horsepower, Chavel Vapeur, is variously denoted as CV, ch and PS.

Contact Addresses for Feedback by WASH Sector Partners

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