Technical brief

WaterAid

Hand-dug wells

Part of a series of WaterAid technology briefs.

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Introduction

The traditional method of obtaining groundwater in rural areas of the developing world, and still the most common, is by means of hand-dug wells. However, because they are dug by hand, their use is restricted to suitable types of ground such as clays, sands, gravels and mixed soils where only small boulders are encountered. Some communities use the skill and knowledge of local well-diggers, but often the excavation is carried out, under supervision, by the villagers themselves.

The volume of the water in the well below the standing water table acts as a reservoir which can meet demands on it during the day and should replenish itself during periods when there is no abstraction.

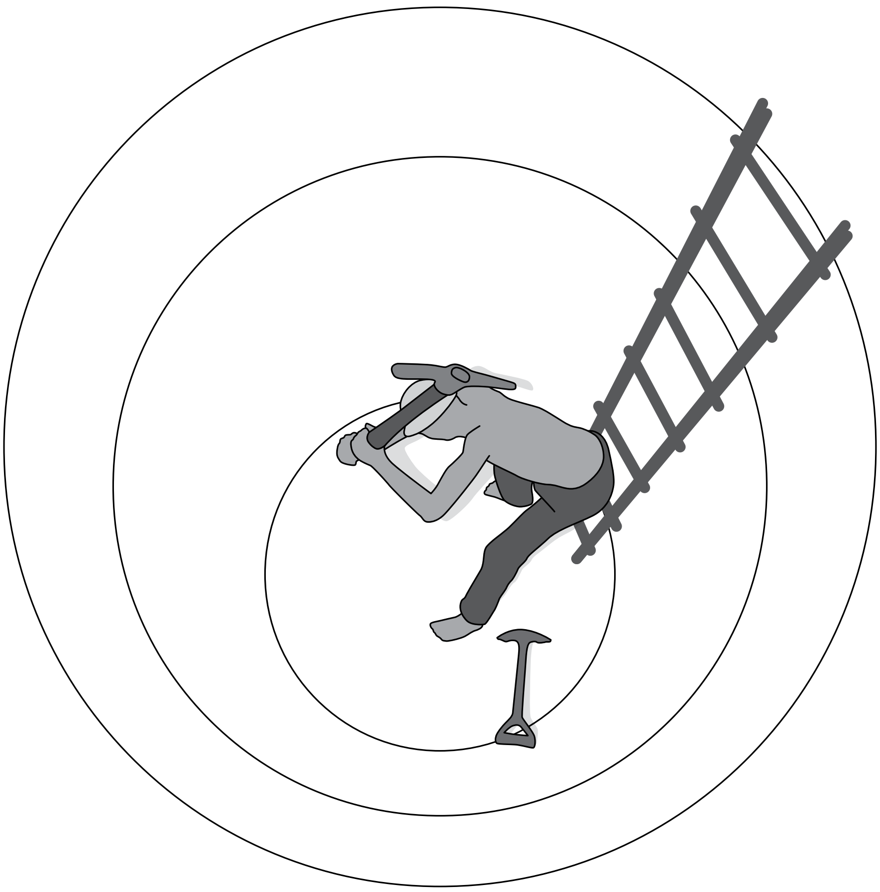
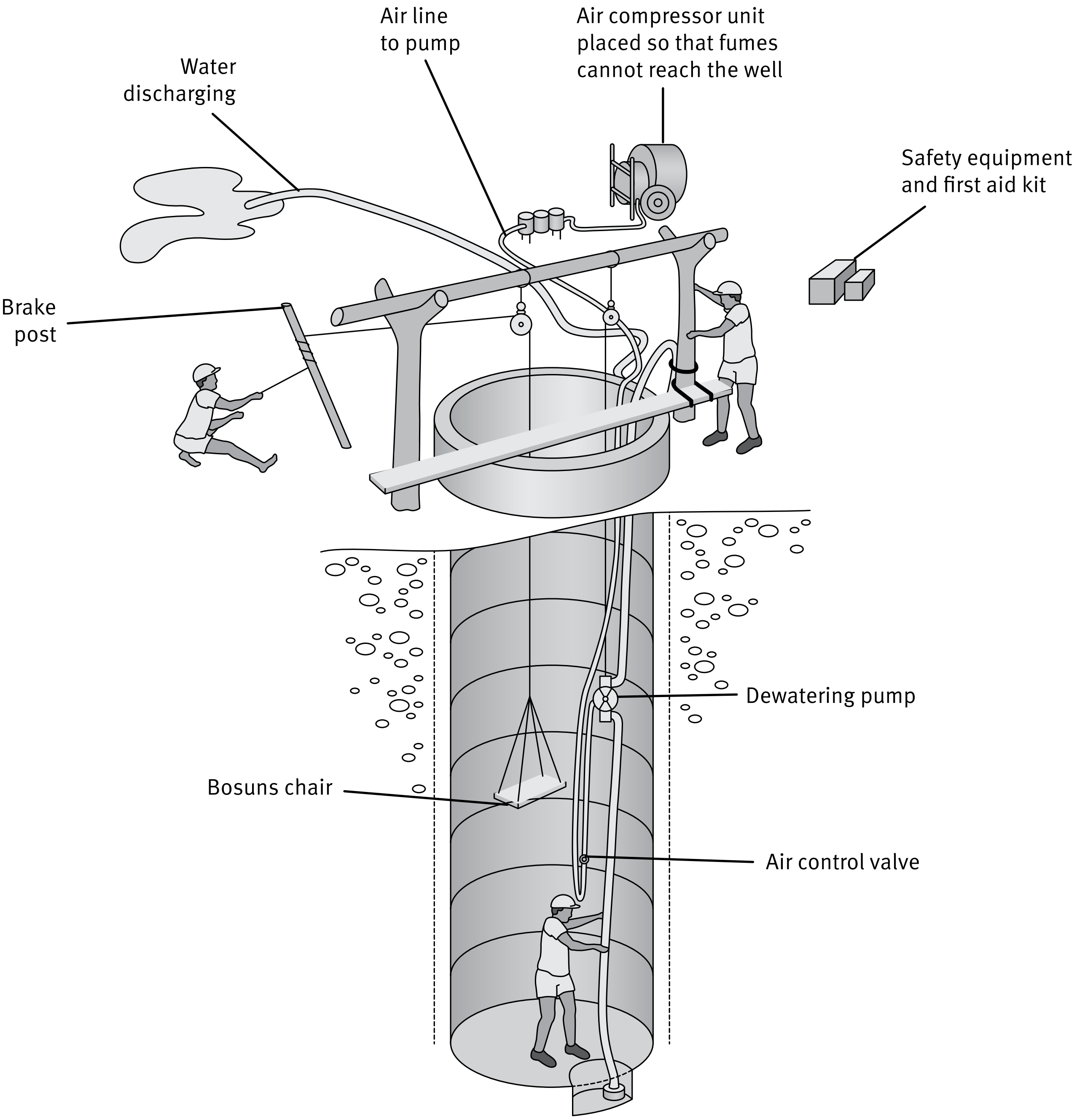


Fig 1: A hand-dug well

Dimensions of hand-dug wells

Hand-dug wells can range in depth from about five metres deep, to deep wells over 20 metres deep. Wells with depths of over 30 metres are sometimes constructed to exploit a known aquifer. It is impractical to excavate a well which is less than a metre in diameter; an excavation of about 1.5 metres in diameter provides adequate working space for the diggers and will allow a final internal diameter of about 1.2 metres after the well has been lined.

Fig 2: A safe well-digging operation



Digging with the sides of the excavation supported

There are several methods of supporting the sides of the excavation while digging proceeds:

Pre-cast concrete rings

The safest method is to excavate within pre-cast concrete rings which later become the permanent lining to the sides of the well. The first ring has a cutting edge, and additional rings are placed on it as excavation proceeds. As material is excavated within the ring, it sinks progressively under its own weight and that of the rings on top of it. This method should always be used in unstable ground. When construction has finished, the joints between the rings which are above the water table should be sealed with cement mortar.

In situ lining

In suitable ground, excavation may proceed for a short distance without support to the sides; these are then supported by means of concrete poured in situ from the top, between the sides of the excavation and temporary formwork, which becomes the permanent lining to the well. This process is repeated until the water table is reached.

Supported excavation (the 'Chicago' method)

In suitably stable ground, excavation may proceed within the protection of vertical close-fitting timber boards, supported by horizontal steel rings (the Chicago method). The timbers are hammered down as excavation proceeds and additional timbers are added progressively at ground level. The steel rings must be hinged, or in two parts bolted together, so that lower ones can be added as the excavation progresses. The vertical spacing between the rings will depend on the instability of the ground. The well is lined with bricks or concrete blocks, from the water table upwards, within the timbers as they are withdrawn.


WaterAid/Jim Holmes

A wide-diameter well being constructed in Uganda using the Chicago method of safe well construction. The photo illustrates the use of a temporary support system for safe digging in open holes. Steel rings, wedges and timber boards ensure the safety of workers at any depth.

Digging with the sides of the excavation unsupported

In stable ground, wells are often excavated down to water level without a lining, and are lined with in situ concrete, or with pre-cast concrete rings, from this level upwards.

Wells safely dug during the dry season may become unstable when the water level rises in the wet season and therefore must be lined before this occurs to prevent a collapse.

In firm and stable ground, wells may be safely excavated without support and may give satisfactory service, although it is strongly recommended that a permanent supporting lining be installed. This will support the sides of the excavation, preventing them from collapse and preventing pollution by surface water. Suitable lining materials have been shown in the following sketches and include concrete, pre-cast concrete, masonry and brickwork.

Fig3: Different ways of lining a well

Method 1

Sinking pre-cast concrete rings.

Method 2

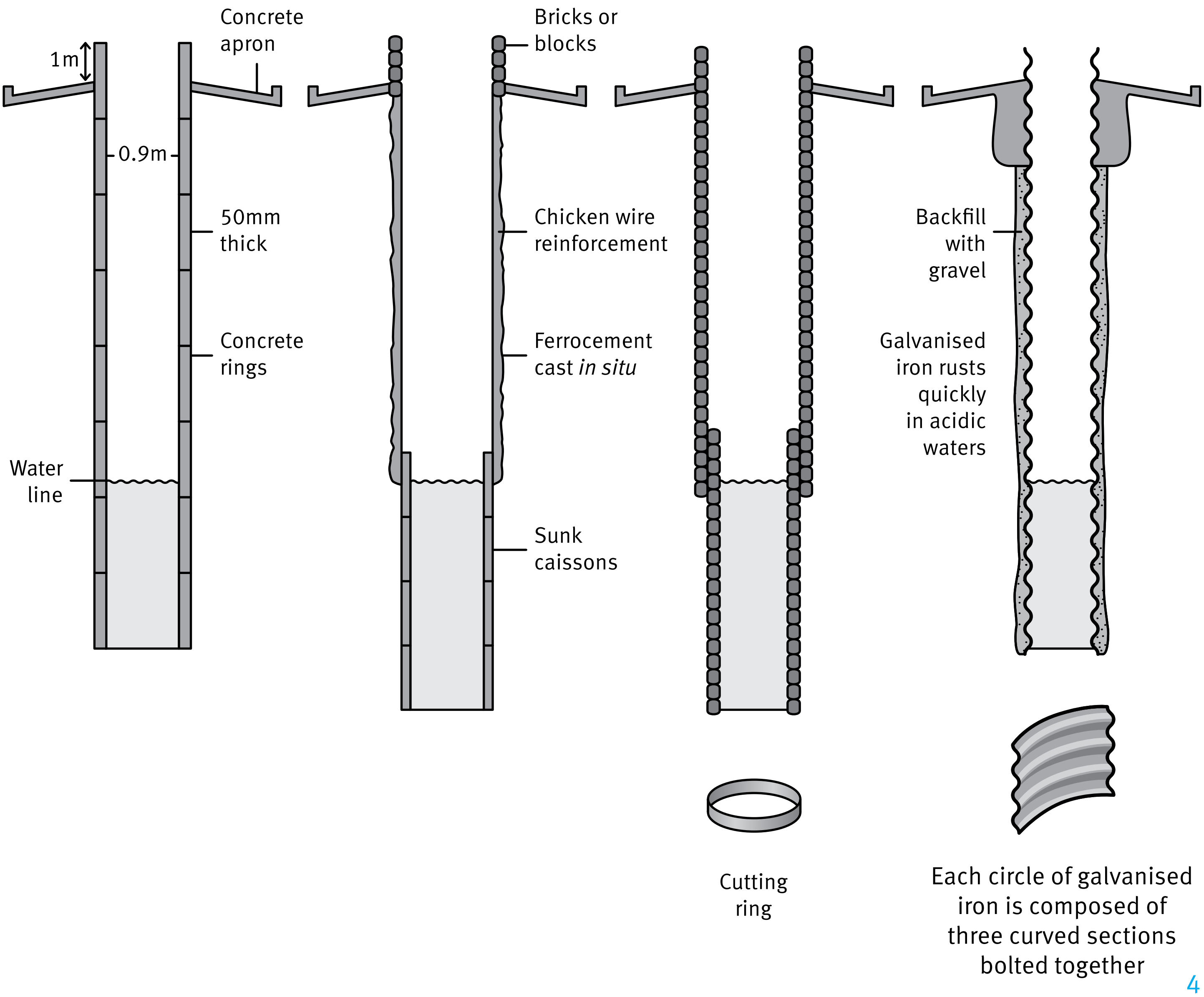
Reinforced concrete or ferrocement cast *in situ* above water line, concrete rings sunk below the water line.

Method 3

Masonry lining of burnt bricks above water line, caisson made of blocks with cutting ring below water line.

Method 4

Galvanised iron rings bolted together as temporary measure for emergencies.



Excavation below the water table

Regardless of which method has been used to excavate the well to the water table, excavation below this level should never be attempted until the sides of the excavation have received the support of their permanent lining, from water table to ground level.

Excavation below the water table should be carried out within pre-cast concrete caisson rings of a smaller diameter than the rest of the well. To facilitate the ingress of water, these lower rings are often constructed with porous, or no-fines, concrete and their joints are left unpointed. See the diagram (right):

Fig 4: Example of excavation below water table using concrete caisson rings

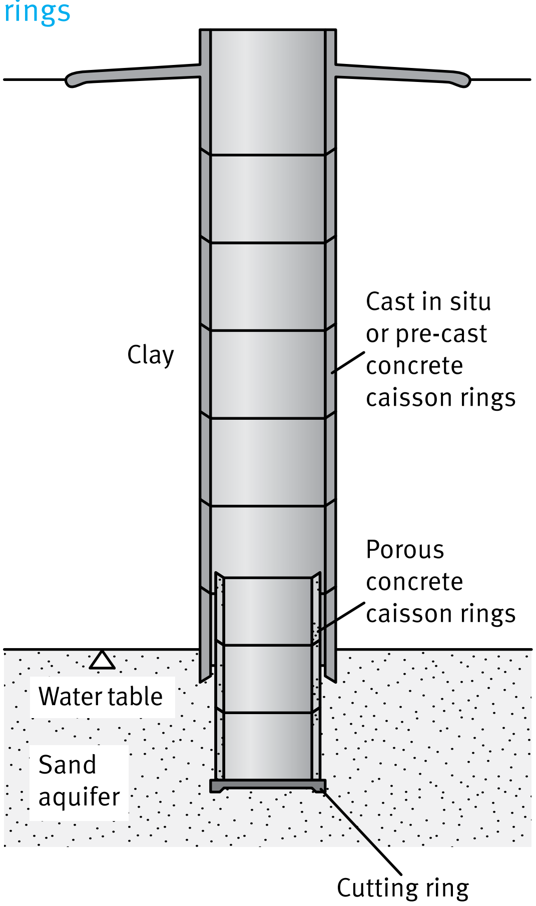
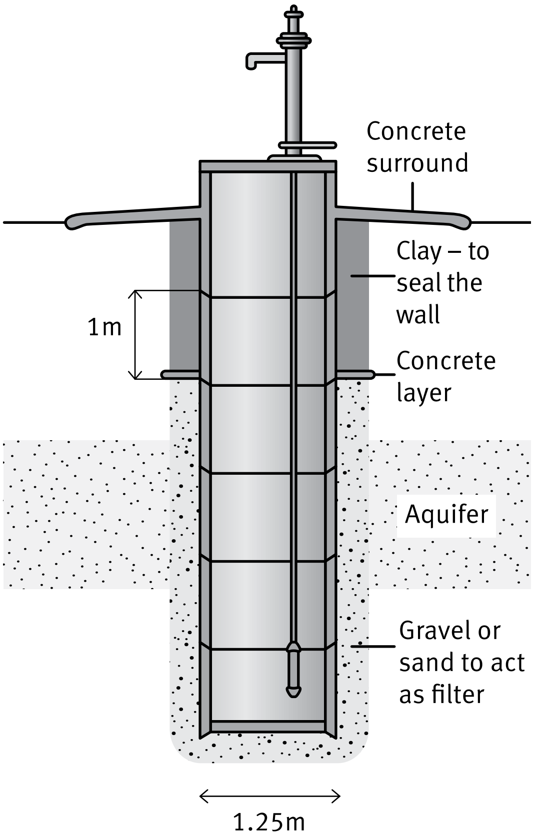


Fig 5: Hand-dug well fitted with handpump



Completion

After construction of the well shaft has been completed, the bottom is plugged with gravel. This helps to prevent silty material from clay soils, or fines from sandy materials, being drawn into the well. Any annular space between the pre-cast caisson well rings and the side of the excavation should also be filled with gravel; such filling behind the rings which are below the water helps to increase water storage and to prevent the passage of fine silts and sands into the well.

The space behind the top three metres, or so, of the well rings should be backfilled to ground level with puddled clay, or concrete, and the well rings should project about one metre. An apron and a drain should then be constructed. This apron should be wide enough for people to stand on. It should be made of concrete that is between 75 and 100mm thick, preferably reinforced by steel rods or mesh. This apron provides a sanitary seal to prevent polluted water seeping into the well. It should have a smooth surface sloping down to the drain and a rim to prevent water going over the edge. The drain should be a cement-lined channel, at least four metres long, that takes spilled water to a soakage pit, an animal-watering trough or a vegetable garden.

Abstraction

Water is abstracted by means of either a bucket and windlass above an access hole, or a handpump, depending upon the yield of water available and the ability of the benefiting community to pay for ongoing maintenance for the handpump, spare parts, etc. A hand-dug well fitted with a handpump can serve the needs of about 300 people.

References

Watt S B and Wood W E (2007) *Hand-dug wells and their construction.* IT Publications

WaterAid (2000) *WaterAid's health and safety policy*

Advantages of hand-dug wells

- ✓ Cheap materials can be used
- ✓ Can be constructed by local artisans so communities can build themselves
- ✓ Generally good yields

Disadvantages of hand-dug wells

- ✗ Can be time-consuming to construct
- ✗ Risk of collapse if not supported properly
- ✗ Depth of well is limited
- ✗ Unless capped or protected, hand-dug wells can be open to contamination

An example of a handpump operated hand-dug well with an apron and drain surrounding the well head in Adi-awna-waza village in the Hintalo-Wajarat region of Ethiopia

Case study

Example of the hand-dug well method

WaterAid/Jon Spaull

The well being pumped out, Woriziehi, Tamale, Northern Region, Ghana

Hand-dug wells have been constructed for thousands of years but in the past this water supply often consisted of unlined holes (prone to collapse), that were unprotected from contamination, leading to health risks.

In order to avoid these problems it is advisable to use the method outlined below:

Materials required for construction:

- Shovel and pickaxe
- Concrete rings, the first one with a cutting edge and smaller diameter ones to continue past the water table depth
- Cement mortar
- Cement and reinforced steel rods or mesh to create apron and drain
- Gravel

Construction methodology:

- Excavate to depth of first pre-cast concrete ring and to diameter of approximately 1.5metres
- Add additional concrete rings as excavation deepens – de-watering will need to take place to keep excavating after water table depth is reached
- Use smaller diameter rings to continue excavating from water table to desired depth
- Plug bottom of well with gravel after construction
- Fill any annular space between concrete rings and outer excavation with gravel to create a gravel pack (preventing silts and sands passing into well)
- When construction is finished, fill the joints between the concrete rings above the water table with a cement mortar
- Top three metres of rings should be grouted with concrete to create a sanitary seal
- Create apron or install concrete slab and drain to prevent ponding of water at well

Water source options: See how hand-dug wells compare to other water source options

	Water source	Capital cost	Running cost	Yield	Bacteriological water quality	Situation in which technology is most applicable
	Spring protection	Low or medium if piped to community	Low	High	Good if spring catchment is adequately protected	Reliable spring flow required throughout the year
	Sand dams	Low – local labour and materials used	Low	Medium/high – depending on method used to abstract water. Water can be abstracted from the sand and gravel upstream of the sand dam via a well or tubewell	Good if area upstream of dam is protected	Can be constructed across seasonal river beds on impermeable bedrock
	Sub surface dams	Low – local labour and materials used	Low	Medium/high – depending on method used to abstract water. Water can be abstracted from the sand, gravel or soil upstream of the sub-surface dam via a well or tubewell	Good if area upstream of dam is protected	Can be constructed in sediments across seasonal river beds on impermeable bedrock
	Infiltration galleries	Low – a basic infiltration gallery can be constructed using local labour and materials	Low	Medium/high – depending on method used to abstract water	Good if filtration medium is well maintained	Should be constructed next to lake or river
	Rainwater harvesting	Low – low cost materials can be used to build storage tanks and catchment surfaces	Low	Medium – dependent on size of collection surface and frequency of rainfall	Good if collection surfaces are kept clean and storage containers are well maintained	In areas where there are one or two wet seasons per year
	Hand-dug well capped with a rope pump	Low	Medium – spare parts required for pump	Medium	Good if rope and pump mechanisms are sealed and protected from dust. Area around well must be protected	Where the water table is not lower than six metres – although certain rope pumps can lift water from depths of up to 40 metres
	Hand-dug well capped with a hand pump	Medium	Medium – spare parts required for pump	Medium	Good if area around well is protected	Where the water table is not lower than six metres
	Tube well or borehole capped with a hand pump	Medium – well drilling equipment needed. Borehole must be lined	Medium – hand pumps need spare parts	Medium	Good if area around borehole/tubewell is protected	Where a deep aquifer must be accessed
	Gravity supply	High – pipelines and storage/flow balance tanks required	Low	High	Good if protected spring used as source	Stream or spring at higher elevation – communities served via tap stands close to the home
	Borehole capped with electrical/ diesel/solar pump	High – pump and storage expensive	High – fuel or power required to run pump. Fragile solar cells need to be replaced if damaged	High	Good if source is protected	In a small town with a large enough population to pay for running costs
	Direct river/lake abstraction with treatment	High – intake must be designed and constructed	High – treatment and pumping often required. Power required for operation	High	Good following treatment	Where large urban population must be served
	Reverse osmosis	High – sophisticated plant and membranes required	High – power required for operation. Replacement membranes required	High	Good	Where large urban population must be served
	Household filters	High – certain filters can be expensive to purchase/produce	Filters can be fragile. Replacement filters can be expensive or difficult to source	Low	Good as long as regular maintainance is assured	In situations where inorganic contaminants are present in groundwater sources or protected sources are not available
	SODIS (solar disinfection)	Low – although clear bottles can be difficult to source in remote areas	Low	Low	Good	In areas where there is adequate sunlight – water needs to be filtered to remove particulate matter that may harbour pathogens before SODIS can be carried out effectively. SODIS is not appropriate for use with turbid water

= most preferable   = preferable   = least preferable

WaterAid

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