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AFFORDABLE WATER SUPPLY AND SANITATION

Low technology drilling

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IN MANY PARTS of the world groundwater is the only source of clean water available to rural populations. Hand-dug wells are the traditional means of accessing water but they require considerable investment in terms of time and effort to construct. Allied to this is the uncertainty in locating groundwater which means that a dry well is very frustrating for those involved. Even with successful wells care is needed to preserve sanitary integrity.

An alternative to well sinking is to drill boreholes and these are quicker to produce as well as being easier to protect from pollution. However the downside is the considerable financial investment to purchase and operate a technologically complex drilling rig. Boreholes therefore are usually associated with major assistance programmes and have been beyond the control of most communities. This situation is slowly changing with the availability of low technology drilling methods and equipment that can be used by most people to drill boreholes suitable for handpumps after only a short period of training. A review of these methods and their applicability constitutes the remainder of this paper.

Basics of drilling

No matter what drilling technique is used there are constraints on the process that must be addressed, these including :-

- The strength and degree of consolidation of the rock being drilled governs the energy required to make the hole (weak unconsolidated rocks are much easier to drill than hard consolidated rocks).
- As the hole is deepened debris or cuttings need to be removed (otherwise the tools will become fast in the hole).
- Unconsolidated rocks may need a means of preventing them from collapsing as the borehole is deepened (using either drilling mud or casing).
- For stronger rocks the cutting tools will require cooling and lubrication.

On the basis of these points it is clear that each drilling method must fulfil several functions and that some methods will only work for specific types of aquifer. Because the use of handpumps in most cases there is only the need for shallow boreholes and it is only the weaker uppermost rock layers that are being penetrated; so energy input requirements are modest.

Percussion drilling

Perhaps the oldest method of borehole drilling is by the repetitive lifting and dropping of a heavy cutting tool which will chip or break rock and thus make a hole. Tools can be of heavy wood with metal cutting edges, iron bars or girders or specially made steel tools all of which are suspended on a rope or cable to enable them to be lifted and dropped quickly. The lifting can be by hand via levers or pulleys or a small internal combustion engine can power a winch or "cathead" (Figure 1). (McJunkin 1967 [i])

This method works reasonably well in moderate strength rocks but weak rocks or clays absorb and dissipate the impact energy. In hard rocks progress can be very slow. In practice the cutting tools only break the rock and a means of removing debris is required. A "bailer "(a metal tube open at the top and with one way valve at base) is usually used but in dry boreholes water needs to be added to produce a cuttings slurry that will easily flow past the valve. Depths are only limited by the size of equipment and time available.

Augers

An auger is a tool that is rotated and pushed into the ground to create a hole. The material cut is retained by the tool which has to be removed from the hole periodically for emptying before further progress. It works well in

Figure 1. Percussion drilling methods and tools

weak unconsolidated to slightly consolidated rocks coping with clays through sands to fine gravel. The main types of cutting head are the bucket auger, the flight auger (archimedean screw thread) Fig 2. but special tools have been devised to cut clays, gravels and to remove small stones. (Brush 1979, DHV 1979, Naugle 1991)

Rotation is by hand and down to about 5 metres depth the tools and connecting rods can be removed by hand. Beyond this depth a tripod and winch are used to lower and recover the cutting head and drill rods. Fig 3 (Von Elling 1988)

The method works well in soft rocks but below about 15 to 20 metres depth the rock consolidation is such that progress is slow and the rotation effort needed is excessive. Wear and tear on the equipment also becomes high beyond these depths. (Mutwalib 1994) Large rocks or stones at any depth can prematurely stop progress. If the sides of the borehole start collapsing casing tubes must be inserted.

Jetting

In the vicinity of rivers or deltas thick layers of sand and silt can be found. The water table is often only a few metres below the surface and conditions suitable for jetting are found. This method requires water to be pumped down a hollow tube and where it emerges at the base the surrounding sediments are fluidised and then flushed to the surface allowing the tube to descend into the cavity created. Fig 4 The tubes or drill pipe can be made of metal or hollowed out bamboo and the water pump can be hand or foot propelled. In order to assist with the loosening and fluidising of the sediment a metal cutting edge or bit can be used. An up and down and rotary motion of the drill pipe will help in making the borehole. (US AID 1982, McJunkin 1967[ii]) If the formations are liable to be unstable then the hydrostatic pressure exerted by the water will tend to prevent collapse of the borehole sides.

Drilling depths achieved depend on the thickness and nature of the unconsolidated sediment but 20 metres is common and 80 metres has been achieved. A tripod lifting mechanism is needed for deeper boreholes.

Sludging

This is a variation on jetting and will work in similar circumstances where unconsolidated alluvial sediments are found. Only an up and down motion of a metal or bamboo drill pipe is required usually powered by a hand controlled beam. The drill pipe needs a one way valve often in the form of a hand over the top of the drill pipe (Figure 5).

Starting the borehole from the bottom of a small water filled pit will ensure that the hole is always full of fluid. As the drill pipe is moved it loosens, agitates and fluidises sediment which enlarges the borehole. On every up stroke of the drill pipe the one way valve is closed (hand placed over top) and water and sediment are lifted from the hole. Fig 5 This simple action produces a borehole so that casing and screen can be installed prior to installation of a handpump. The method has been pioneered in places such as Bangladesh where depths approaching 80 metres have occasionally been achieved. (Gibson 1969, McJunkin 1967 [ii])

Rotary

Normally rotary drilling methods are associated with large technologically complex drilling rigs but in the past few years small, simple, portable machines have been developed that can drill boreholes suitable for handpump installation in a wide range of rock types.

The cutting action is by the rotation of a drill bit and this is transferred via the drill rods from a small economical internal combustion engine. A hand winch can be used to lift and lower the rods and bit in the borehole. Fig 6 The means of power transfer is a simple robust mechanical linkage that can easily be maintained and repaired without specialised equipment.

For rotary drilling to work the borehole needs to be flushed with air, foam, water or mud. The flush has several functions including removing rock debris, cooling, lubricating and stabilising weak horizons. Each type of flush has its own particular application but water or drilling mud are the common choice and these are pumped down the hollow drill rods emerging at the drill bit and returning up the annulus between drill rod and borehole. The flush needs to have sufficient velocity to carry cuttings to the surface and this can be provided by a small centrifugal pump driven by an internal combustion engine. Ideally the same model of engine as that on the drill rig. A reservoir for the flushing fluid is needed, this being a pit dug in the ground or tank incorporated into the base of the drilling rig. (Ball 1993)

The important features of these small rotary rigs is that they should be robust, simple to operate and maintain, easy for non-specialists to use, portable and of relatively low cost. A depth capability of between 30 and 40 metres, in most rock types, is also necessary.

Rotary percussion

In situations where strong rocks such as sandstones, limestones, granites and quartzites are present none of the previous techniques will work or be cost effective. However, the use of a “down the hole hammer” (DTH) will enable boreholes to be drilled quite quickly. This tool is compressed air driven and impacts on the bottom of the borehole very rapidly, whilst being rotated slowly at between 10 and 30 rpm. - hence the name rotary-percussion. Rock is not cut but crushed to very fine debris.

The disadvantage is the need for air compressor but small DTH tools can work with air volumes of 5-7 m3/min (175-250 cfm) and at pressures in the order of 6 bar (100 psi) with the air also being used as a flush. Some of the new portable rotary rigs can easily use a DTH but a simpler alternative is to suspend the drill pipe and DTH

Figure 2. Auger heads

Figure 3. A Vonder Rig

Figure 4. Jetting

Figure 5. Sludging

Table 1. Advantages and disadvantages

from a tripod, use a hand winch for lifting and lowering and provide the rotation by 3 rig operatives who turn the drilling tools by means of a 'T' bar. Fig 7 This has been quite effective on trials in Uganda. (Allen 1993)

Summary

There are now several low cost, low technology methods for drilling handpump boreholes but each has a particular geological environment where it works best. However the small rotary and DTH rigs are much more adaptable and their relative low cost makes them an attractive purchase for an NGO or a co-operative of communities.

In some circumstances a borehole is not adequate or traditions require a large diameter well. The risk associated with the siting and construction of wells can be considerable and one way of reducing this is to utilise several quickly drilled small diameter boreholes to prove the location of the water and the highest yields.

Progress with this affordable and appropriate technology is one way in which communities can have control over finding their own water resources.

Figure 7. Rotary percussion – hand rotated

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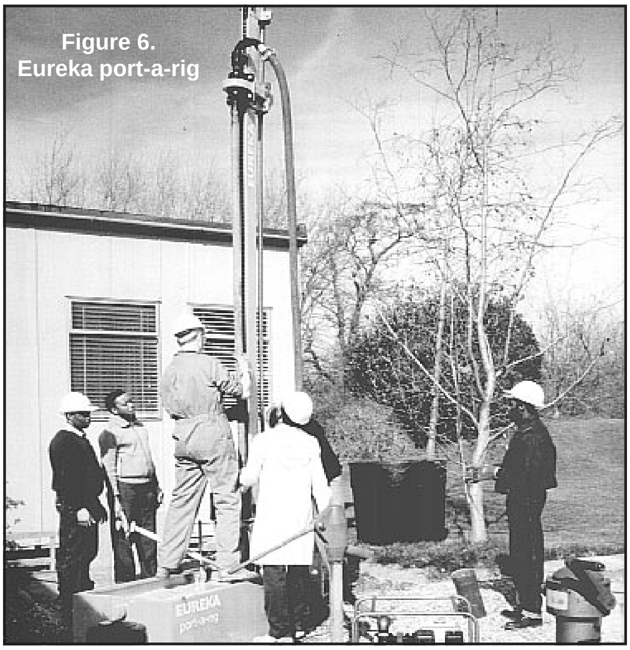

Figure 6. Eureka port-a-rig

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