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INTEGRATED DEVELOPMENT FOR WATER SUPPLY AND SANITATION

Introduction of low cost borehole

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ACCESS TO POTABLE AND safe water is one of the basic needs, which is important for health, productivity and quality of life. Recognizing the importance of providing safe drinking water supply and improved sanitation, Concern Universal (CU) has been a leading NGO in Malawi in the water and sanitation sector, with an ambitious target of providing adequate domestic water and basic sanitation facilities to the rural communities of Malawi. CU promotes and advocates the need to introduce low cost and appropriate technology in the water and sanitation sector.

Given the present coverage and technologies available, Malawi urgently needs to find a means of accelerating its populations' access to clean safe water and adequate sanitation facilities. CU plays a role in identifying appropriate and low cost existing and new technologies in water and sanitation, such as alternative drilling methods.

Groundwater in Malawi

The occurrence of groundwater in Malawi is controlled largely by topography, and these are:

Plateau areas: - are extensively peneplained undulating surface with broad valleys and large level areas on the interfluves. A thick mantle of saprolite largely covers them; this forms an extensive and important aquifer, which is low yielding but generally adequate for domestic water supplies.

Upland areas: - there are several mountains or smaller uplands rising abruptly from the plateau where the underlying strata are more resistant to erosion. Slopes are steep and there is little potential for ground water supplies except very locally.

The rift valley escarpment: - falls steeply from the plateau areas and slopes are commonly very di-sected. There is considerable faulting in association with the development of the Malawi Rift Valley system. Again there is little scope for ground water development in these areas except very locally.

The alluvial plains: - these areas are the rift valley floors gently sloping and very low relief. They extend along the lakeshores around Lake Malawi, and along the Shire River Valley. These areas have considerable potential for groundwater development wherever suitable sedimentary sequences are found.

Geology and hydrogeology

The greater part of Malawi is underlain by crystalline metamorphic and igneous rocks of pre-Cambrian to Lower Paleozoic age referred to as the Malawi Basement Complex. Over most of the plateau area, except towards the escarpment edges, the bedrock is deeply weathered, and it is this saprolitic material (commonly 15 – 30m thick) which forms the principle aquifer. The fresh bedrock underlying the weathered zone is rarely a significant aquifer, even when fractured, as the available storage is negligible in the rock matrix and very low in the fractures.

On the uplands, the weathered zone is thin, and there is little potential for groundwater except where boreholes intersect a well-connected fractured system, however yields are likely to be unreliable because of low storage.

On the escarpment areas the weathering products have been largely stripped away by erosion. Aquifer is poor and discontinuous.

In the rift valley, Quaternary alluvial deposits comprising the unconsolidated and variable sequence of sands; silts and clays cover the areas. The alluvial deposits form very important aquifers wherever a sufficient thickness of sands is found in the sequence and adequate yield can be produced from boreholes. The required 0.5 l/sec yield for rural domestic water supplies (0.25 l/sec in Malawi) is likely to be sustained over most of the alluvial plains.

Background

Initially, CU's water program used hand-dug wells and the Vonder Rig (a hand operated, auguring technique) for shallow well/tube well construction and commercial contractors for deep wells. In 1995, the National Water Department, UNICEF and NGOs Program Plan of Action for Water and Environmental Sanitation (1997-2001) recognized the need for making low cost well drilling practice and technology available to Malawi. In light of this, objectives were set to identify appropriate low cost alternative drilling technologies. CU began investigations into the use of low cost drilling technology, and as a result, identified the Eureka Port-a-Rig as an appropriate technology drilling rig for providing deep (up to 50m) boreholes at a reduced cost that were suitable for Afridev Hand-pump installation.

The Eureka Port-a-rig was designed by Peter Ball of Eureka (UK) Limited. It is a rotary top drive, mud/air flush drilling rig. It is a very small and simple rig that is driven by a 4KW engine, but manually operated. The rig uses a 7 bar compressor as little as 175 CFM considered the minimum volume to sweep clean a 95mm diameter hole. The rig is low cost and portable, transported in component form using a pick up truck and then assembled on-site for drilling operations. In this regard, it has the additional advantage

of easy access to areas where communities live that has been in accessible to larger trailer and truck mounted rigs. The rig's drilling capacity lies between hand auguring and a heavy hydraulic rig. The capital cost of the rig plus accessories is about $30000. The basic rig weighs 500Kg and can be packed with other tools in a pick up truck – a small compressor mounted on 2 wheel trailer weighs 950Kg and is towed behind.

The designed construction methodology of the Eureka Port-a-Rig involves drilling at 150mm diameter in any unstable or soft formation to allow installation of 110mm PVC casings as per Malawi government standards. In a fractured basement, Eureka holes are designed to be partially cased (only the top unstable section is cased and grouted) and drilling at a smaller diameter of 95mm is undertaken. This, together with the low initial capital cost of the rig and low cost on spares contributes to the significant cost saving in borehole construction. The designed drilling depth is about 35m, but the rig is equipped to drill to a maximum depth of 51m and has done so.

CU, funded by DFID began, in November 1995, a pilot project where the Eureka rig was used for drilling of 30 boreholes in the Bwanje Valley. Bwanje valley is in Ntcheu district, located to the south east of Lilongwe district in the central region of Malawi. It is part of the Lake Malawi rift valley. The testing was carried out in this area as CU had a borehole drilling programme and a well established field office was already operational. On these boreholes depth ranged from 9m to 41m, through different formations and geology. PVC screen varied from 3m to 15m depending on potential borehole aquifers and depth. Sand from the lakeshore was used as a raw material for gravel pack. This was sieved twice to remove the fine materials <1mm and coarse >4mm. The gravel pack is rounded as a result of weathering and easily rotates during development. Borehole development is carried out for a minimum period of 4 hours via- compressed air surging – inserting a small hose to base of hole and then surging water in the hole up and down, violently and thoroughly washing fines from the screened section of the hole until water is clear and free of any silt.

This pilot project was seen as positive with more than 70 per cent success (a rate comparable to with commercial drilling contracts in Malawi). This success is measured with respect to wet against dry holes rather than against performance in differing geological conditions, which were limited within the pilot project area. The Bwanje valley has a river alluvium, lacustrine deposits type of geology, but a few holes were drilled in colluvium residual soils and charnockitic granulite and gneiss. There was a danger of rapid siltation problems and/or collapse with partially cased holes if casing was inserted before solid basement was hit or if grouting was not properly done at the casing bottom.

Although the testing of the rig in Bwanje showed good results, CU recognized that the testing was of limited value given the specific geology the rig had encountered. It was necessary to test the rig over a larger geographical/geological area and over a long period of time. In this regard, it was necessary to broaden as mush as possible the area of operation, before concluding its suitability in Malawi.

Utilisation and experience

CU is currently operating two Eureka rigs. As at 30th April 1999, the two rigs had drilled more than 210 holes with a combined success rate of 69 per cent. Despite the rigs drilling through complex geology over a wider geographical area all over Malawi after the test period, they have maintained a -good overall success rate.

The approach at village level is to adopt the lowest possible cost technology for each particular water point. In the first instance this may be a shallow well upgrading / protection or a Vonder rig tubewell. Should these attempts fail, then the Eureka Port-a-rig is used. In a few cases / projects there is then the option to engage a large commercial rig, should the other technologies fail.

When the Eureka rig is drilling on a concentrated project area, logistical and operations management is very easy and utilization effective. The construction team can camp at one central point, and moving to the subsequent drilling sites is time efficient and effective with community participation in advance of the rig arrival easily arranged as project staff are within the area. For widely dispersed sites, obviously movement takes significantly more time. In such cases every week the construction team finds itself in a new set up with respect to the environment/community. Since drilling with the Eureka rig demands and facilitates significant community involvement relative to larger rigs, community participation in drilling operations rig is affected, as it takes time for the drill crew and community to understand and work effectively with each other.

The Eureka Port-a-rig has some limitations due to its capacity. These are - (i) an inability to drill in conditions where geology varies from hard rock back to softer sand/ clay deposits. This is due to the fact that the rig is not equipped to drill with temporary casing. Therefore, hole collapse is common and prevents further drilling. (ii) It has struggled to penetrate through pegmatite zones and other very hard rock zones as it has a low weight and no hydraulic load. (iii) On several occasions, it has been problematic to hold coarse pebbles with foam during drilling, (particularly after hitting water, when the foam is diluted/liquefies). In this case drilling usually stops, and if an adequate yield is found, the hole is cased. Coarse pebbles have at times led to the "Down The Hole Hammer" getting jammed and on occasion lost in the hole. It should be noted that other rigs would also face these difficulties to greater or lesser extent.

It is also useful to point out a few of the important considerations to be taken into account in any developments, which may not be technical but might prove more problematic. While we had a good deal of operating success with the Port-a-rigs, we have met significant resistance from the Ministry of Water Development with regard to them accepting the construction methodology used with the Port-a-rig. Despite rational discussion and demon-

strated success of the boreholes drilled, there appears to remain a powerful lobby against them. This position could prove the sticking point in introducing new drilling technologies rather than the technological / manufacturing aspects. Possible factors to consider would be:

- Existing commercial contractors threatened by lower cost options - will lobby against this due to their large current capital investment.

Large donor programmes (e.g. World Bank) fund the majority of drilling carried out currently in Malawi, who are willing to pay up to $ 15000 per hole. Since Government is not paying for drilling, it is not necessarily a strong interest of theirs to reduce drilling costs. Eureka borehole cost about $3000.

It should also be appreciated that the comparison of actual drilling costs does not take into account the need for community participation at all stages from site selection, drilling, and pump installation through to utilization. All of these phases demand skills in community mobilisation and training which CU provide.

Manufacturing costs in Malawi are likely to be high - nearly all raw materials would have to be imported and transport costs are high. However, manufacturing workshops do exist and have relevant experience e.g. the Afridev pump prototype was developed in Malawi.

Reluctance from Government bodies to adopt a variety of construction methodologies, depending on geology and technology used. This acts as a way of protecting against poor construction of water points by private sector contractors, as the Water Department does not have the capacity to adequately supervise work carried out in the field.

These are some of the issues involved and in particular the need to obtain full government support and involvement in any country of implementation.

Rig improvements

In view of current Malawi Government standard construction of boreholes, Eureka partially cased boreholes were considered sub standard. CU in collaboration with the manufacturer of the rig, investigated ways of improving the rig, to try to establish a method of penetrating the harder formations at 150mm diameter through air drilling and use of button bits that would subsequently allow for casing at 110mm. As a result a 150mm-button bit combined with high-pressure foam pump were purchased in 1998. So far, field tests have been good. This allows full casing of all boreholes drilled as per standards. However, penetration rate has decreased since 2.5 times as much material has to be drilled, and so drilling costs per meter have subsequently increased. On average a 40m hole drilled at 95mm costs about $900, while a 150mm hole costs about $1700. The 150mm bit has so far drilled more than 50 holes to a maximum depth of 48 meters in consolidated basement. For the vast majority of Malawi hydrogeology, this is a more than adequate drilling depth.

The concerns raised over the stability of partially cased holes resulted in the need to monitor some of the test boreholes in Bwanje Valley. A preliminary monitoring exercise was done in April 1997 with Water Development on eight boreholes. The main focus was borehole depth and visual water quality. Refer to the table below:

Another set of 20 partially cased holes and 5 Fully cased holes taken at random from different geographical/geological areas will be monitored in detail with a borehole camera in order to determine their long-term stability. In the meantime, and until government policy with regard to borehole construction standards is reviewed, all holes will be fully cased, irrespective of geology. At this stage it is not possible to draw firm conclusions with regard to the longer term stability (life/cost) of partially cased holes but at

Table 1. Preliminary borehole monitoring results

Site Name	Type of Hole	DEPTH (m) 95 –initial	1997	Diff. (m)	Possible cause of depth change.	Visual water Quality
Phumula	PC	15.0	15.0	0	-	Very clear
Kalilombe	PC	22.7	18.2	4.5	Hole collapsed before installation. Incorrect initial depth measurement. Siltation over time.	Clear but with Some Mica.
Nkungumbe	PC	21.0	21.0	0	-	Very clear
Lobi	PC	24.5	24.4	0.1	Incorrect initial depth measurement.	Very clear
Chimalira	PC	18.0	18.0	0	-	Clear
Akubilira	FC	32.0	31.9	0.1	Siltation	Clear -Mica
Ndembo	PC	21.7	21.7	0	-	Clear
Thondoya	FC	35.0	35.0	0	-	Clear

Note: PC –Partially Cased.
FC –Fully Cased

present (recognising the short time scale and need for ongoing monitoring) there are no negative indications

Conclusion

As a result of our experience, I would encourage development of further low cost drilling technologies and / or rigs since a wider choice of technologies would hopefully result in most appropriate technology choice being made for any particular area or site.

Considering the original drilling capacity of the rig against the geology and depth it has been required to drill, the Eureka rig has indeed proved to be an appropriate drilling technology, and it has performed beyond its design criteria. It has successfully sunk boreholes in alluvial/ valley, weathered and fractured zone geological formations, which constitute the Plateau and the alluvial plains. Maximizing the use of the rig in this way will effectively increase coverage of safe water supply in a more cost effective manner.

The Eureka is identified as a possible additional drilling technology for Malawi and is not intended to replace any existing technologies or larger contractor rigs. It is able to fit in a gap in cost, technology and drilling capacity between hand auguring techniques and larger trailer/truck mounted rotary rigs.

The essence of the rig's philosophy is to use a level of mechanism and technology which can be clearly understood by operators with little formal education, can be maintained and repaired without much expense and, delay or the need for expert technicians. It also provides for active participation of the local community, significantly enhancing community ownership of the construction process. All this has been achieved.

The fact that the Port-a-rig also allows for full community participation in terms of its transportation and erection on site as well as during the construction period, it can be flexibly operated taking into account community aspects. This ties in well with the Malawi Government policy on Community Based Management and the need for maximum participation and ownership.

Note: The views expressed in this paper are of the writer and not necessarily of Concern Universal.

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