

Introduction of Low Cost Rotary Drilling to Malawi: Specifically the Eureka Port-a-Rig

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Outline

From 1989 onwards, Concern Universal (Malawi) was involved in drilling boreholes through sub contracting, use of the Vonder rig (hand-operated auger) and Shallow well construction. In 1995, Concern Universal began its investigations into the use of the Eureka Port-a-Rig. This was as a result of Concern Universal's own experience in the water sector in Malawi and a recognition of the high cost of engaging commercial contractors. The Water Department and UNICEF was also developing its programme plan of action for the period 1997-2001 and also recognised the need for alternative technologies, and stated:

'Given the present coverage and technologies available, Malawi urgently needs to find a means of accelerating its population's access to clean water and adequate sanitation facilities. Investigations are necessary to find the technologies that are quickest and most cost-effective for installing both water and sanitation facilities.'

And specifically, *'(I) To identify appropriate and low cost existing and new technologies in water and sanitation, such as alternative drilling methods.'*

Concern Universal experience in the sector concurred with the Water department/UNICEF. The Eureka Port-a-rig was identified as one such possible appropriate technology. The Port-a-rig is a rotary, diesel-operated, compressed air/fluid flush rig that is assembled on site and is carried from site to site in a 4WD Pick-up truck.

As a result, Concern Universal approached the British Government for funding to pilot test the Eureka Port-a-Rig in Malawi. This proposal was supported and pilot testing of the rig began in November 1995 in Central Malawi, with an initial 30 holes.

The test period was successful with a variety of geological conditions encountered requiring mud and air drilling. All of these holes remain within areas where Concern Universal are operating and a check of all pumps in April 1997 (on average 18 months after construction) found them working effectively. A further eight holes had their pumps removed for more detailed inspection and depth measurements.

Having initially tested the rig with good results, it was promoted as an appropriate drilling technology that could be used more widely. Therefore, operation of the rig continued and specifically on a Ministry of Education Primary Community Schools Project, since this project covered the whole country.

There are now three rigs in operation in Malawi, two by Concern Universal and one by Action Aid.

Construction methodology adopted with the Eureka Port-a-Rig

In fractured basement, holes are not fully cased (only the top unstable or weathered section is cased) and drilling at a smaller diameter of 95mm is undertaken, sufficient to allow installation of

the Afridev and Malda handpumps. This is what contributes to the significant cost saving in borehole construction, since the Port-a-Rig is a rotary diesel operated compressed air/fluid flush rig with the other associated running costs (although on a smaller scale and with a 12bar, 275cfm compressor), but of a much lower capital cost and drilling capacity. In any unstable or soft formation, drilling occurs at 150mm to allow installation of 110mm PVC casing as per current Malawi standards (i.e. borehole construction standards set in the early 1980's with support from British Geological Survey). It is worth noting that drilling technology and construction methods since then have improved and, hence, current advice from British Geological Survey indicate that the methodology adopted for the Port-a-Rig is sound.

Successes

- **Operation.** Drilling operations are entirely operated and managed by National staff after a six-week training period. To date over 100 new boreholes drilled and operational.
- **Maintenance.** Effective operation and maintenance established and maintained.
- **Low cost.** The nominal cost per hole using the Port-a-Rig currently stands at approximately £1,200 or MK36, 000. This is a very considerable saving over the use of commercial contractors, where total construction costs exceed MK100, 000. The Port-a-Rig can replace a good number of holes traditionally drilled by commercial contractors.
- **Effective communication and support.** Peter Ball of Eureka UK Ltd has been efficient in the supply of spare parts and in providing ongoing technical support as drilling experience was developed.
- **Integration.** The Port-a-Rig allows for a good deal of community participation in terms of its transport and erection on site, as well as during the construction period. It is able to access those areas where communities live but cannot be reached by larger rigs.
- **Flexibility.** The rig can be flexibly operated by CU to take into account community aspects (e.g. waiting for community to mobilise, ensuring participation, delays for funerals). This ties in well with community-based management and the need for maximum participation and ownership.
- **Complimentarity.** The rig is operated in conjunction with a number of Vonder rigs and use of commercial contractors. This allows most appropriate technology choice for differing circumstances.
- **Construction methodology.** Low-cost, alternative construction methodology re-introduced to Malawi, which can be monitored for its appropriateness.
- **NGO "Friendly".** The rig and its operation have shown itself to be within the management capacity of a small NGO with relatively little prior direct experience of borehole drilling.
- **Drilling rates.** Completion of drilling takes approximately two days, competitive with larger rigs. Further low-cost technology at present in Malawi is in the form of the Vonder Rig, which has a limited application as far as geology is concerned and can take in excess of two weeks to complete a hole.
- **Rig performance.** The rig exceeded its expected performance criteria, with many holes going beyond 35m in basement complexes.
- **Larger diameter drilling.** Current compressed air drilling in basement at 150mm diameter is proving effective against expectations.

Constraints

- **Acceptance.** Despite regular communication, government is not willing to accept any modification to borehole construction methodologies. This has necessitated the development of upgrades to the rig (see *Lessons learned*).

- **Drilling.** Limited to maximum depth of 50m with air and 36m with current mud pump (not a problem in Malawi as few boreholes exceed 45m and average depth is 35m). Cannot cope with complex or difficult geological/drilling conditions.
- **Construction methodology.** Due to lightweight, mechanical nature of the rig, sometimes difficult to ensure fractured basement has been reached and there is therefore a danger of leaving unstable sections of the hole uncased.
- **Spares.** Many spares have to be supplied by Eureka UK Ltd Despite efforts to source locally or in the region, these often turn out to be more expensive than Eureka supply. UK supply means it is necessary to carry a comprehensive spares stock to ensure rig is not held on stop awaiting spares.
- **Operation and maintenance.** Despite the simple technology, Local NGO partners would probably still have difficulty in effectively running the rig. This is more a reflection of the relatively weak local NGO sector than complexity of operations.

Lessons learned

- **Operation and management.** As with all drilling operations, good logistics support and efficient field management is essential for success. Project Field Engineer required on site frequently.
- **Borehole Monitoring Requirement.** Due to refusal of government to accept partially cased holes and lack of proper documentation of their performance in Malawi's geological conditions, it has been necessary to develop a monitoring programme and also upgrade the rig for the interim period. As a result, a Borehole Camera and VCR has been procured which will allow recording and viewing of boreholes constructed. Any indications that the boreholes are not performing and/or siting/collapsing will result in revision of the construction methodology or a reduction in terms of the areas of effective operation of the rig. This will allow for comprehensive testing and reporting.
- **Currently Proposed Upgrades to the Rig.** In light of current experience with the rig and also in response to some of the concerns raised by the Water Department with respect to construction methodology, Concern Universal with Eureka UK Ltd has undertaken efforts to consider improvements to the rig in order to try to enhance its capacity and performance. Some of these are outlined below and constitute part of the ongoing testing of the technology and it's adaptation to the Malawi conditions. These upgrades will be developed within the context of the monitoring programme.

Rig modifications/upgrades

150mm compressed air button bit combined with a high pressure foam pump

The variable rock hardness found in some areas had resulted in the need to abandon some sites as a result of drilling with compressed air (at 95mm diameter) through hard laterite layers and less weathered basement into softer formations below, which subsequently collapse and cannot be cased.

Since the 150mm dragblade bits used with a mud flush does not have the capacity to penetrate these harder laterite layers or less weathered basement complexes, it was deemed necessary 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 110m.

In order to enable air drilling to be carried out without casing the top section of the hole (to prevent hole collapse and probable loss of the down-the-hole hammer), it was necessary to be able to

inject stable foam into the hole while drilling with the button bits. The rig was equipped with a manual foam pump, which limited the potential for creating the stable foam required. Therefore, provision of a high-pressure (100 bar) foam pump, together with a 150mm button bit, would allow drilling with compressed air and stable foam without fear of collapse of the hole. It would also increase the penetration capacity of the rig at larger diameter.

It was hoped that this additional capacity and facility on the rig would improve the application of the rig and ensure that all potentially unstable formations can be fully cased with 110mm PVC casing. This would reduce the number of sites that have to be abandoned due to drilling difficulties.

Field testing of this technique began in September 1997 and to date results have been very successful, although only seven holes have been drilled so far and further testing is required.

Hydraulic feed/hoist to drilling operations

The manual operation of the hoist and light weight of rig limits the speed of drilling operations and also the available load applied to the dragblade bit during drilling operations. Therefore, addition of hydraulics to the rig would serve two functions:

- 1) Provide a feed weight during drilling therefore potentially increasing the penetration potential during mud/dragblade drilling.
- 2) Make drilling operations quicker and less labour intensive on the drill crew since the hydraulic hoist would be used to lift the drill stem from the hole - particularly relevant on the deeper holes.

New drilling rig – upgraded/up-sized Port-a-Rig

Eureka UK Ltd, having designed two appropriate technology drilling rigs (the 'Port-a-Rig' and the larger 'drill system'), is proposing to combine elements of both rigs in the design of a new intermediate rig which will be an up-sized Port-a-Rig costing approximately £12,000. The new rig would be fitted with hydraulics and deliver more power to drilling operations. Key improvements/differences to the Port-a-Rig would include:

- trailer mounted rig as opposed to loading rig components onto a pick-up
- hydraulic hoist/feed fitted as standard
- larger drill mast, gearboxes, components etc.
- 11Hp engine versus the current 5Hp engine on the Port-a-Rig.

It is expected that this rig would be able to demonstrate a clear improvement in performance and drilling capacity over the port-a-rig. It would also fit into the existing infrastructure of the project and Concern Universal. It would remain a low-cost drilling option, with drilling parameters established during design but likely to be very appropriate to Malawi conditions.

- **Government.** High personnel turnover has resulted in a change in level of co-operation at Ministry level. There is limited commitment to develop appropriate drilling technologies and research capacity at the Ministry is weak. Government drilling programmes are donor-funded and cost-effectiveness is not a key issue. Possible strong lobby from commercial contractors against introduction of low-cost alternatives.