Cranfield UNIVERSITY
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Private Sector Participation in Low Cost Water Well Drilling

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Contractor Drilling with Pounder II

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- the four Cranfield MSc students whose findings informed the project at various stages,
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It is our hope that the work which we have started in this short project can continue and build on the foundation provided by the many partners and stakeholders involved.

2 BACKGROUND

This report contributes to the findings, implications, and future plans of a project, initiated by Cranfield University (Silsoe, UK) entitled "Private Sector Participation in Low Cost Water Well Drilling". The project was funded by DFID from July 1998 to June 2001, with additional funding partners (Government of Uganda, DANIDA, SIDA, UNICEF, Water Aid, and an anonymous donor) joining at various stages throughout this three-year period.

The three-year Project had two overall aims:

- to develop, and transfer to the private sector, technology suitable for affordable shallow well construction
- to research the process of technology transfer and the conditions necessary for its success, in the context of rural water source construction

The first aim of the project was addressed through three main objectives or outputs:

- the design, field testing, and evaluation of a new human-powered drilling rig (the "Pounder rig")
- the uptake of the technology by a small number of contractors, and their use of the rig in commercial contracts
- the establishment of a sustainable means by which the rig and subsequent spare parts will be made available in country

The research aspect of the project used the technology transfer and uptake process as a gateway to action research. The process of developing the technology and introducing it into the private sector, and the concurrent investigation and learning process, were intertwined in such a way that the project informed the research, and the research informed the project. Both benefited.
The overall research question was:

“what enabling conditions and external actions are necessary to stimulate and strengthen effective rural water supply service delivery by the private sector?”

3 Introduction

The Low Cost Drilling Project introduced the modified Pounder Rig into Uganda in December 2000. The rig has subsequently been hired out to private sector contractors, who have utilised it to drill wells for Mukono and Jinja District Local Governments under the Poverty Alleviation Fund Conditional Grants, and for Water Aid in Katakwi. This report provides a summary of the drilling operations undertaken between December 2000 and May 2001. The wells were drilled by two Mukono based private contractors.

The information in this report is a result of field observations by Kerstin Danert and John Okwi, as well as drill logs and Peter Ball's diary of his visit in December 2000. Further detail on the drilling technology can be found in the report “Technology of Pounder II and Pounder Wells”.

4 Summary of holes dug

Village	Sub-County	District	Comments
Gulapi 1	Ntunda	Mukono	Abandoned
Gulapi 2	Ntunda	Mukono	Completed and hand pump installed
Nakasajja	Kyampisi	Mukono	Abandoned
Lweza	Mukono Town Council	Mukono	Abandoned
Kasubi	Kitazi	Mukono	Completed well, incomplete head works
Kibundire (Buwanga 1)	Butagaya	Jinja	Abandoned
Kibundire (Buwanga 2)	Butagaya	Jinja	Abandoned
Kibundire (Buwanga 3)	Butagaya	Jinja	Completed, sufficient water for a hand pump
Makenke	Mafubira	Jinja	Completed, hand pump installed
Abelibuku 1	Katakwi	Katakwi	Abandoned
Abelibuku 2	Katakwi	Katakwi	Incpomplete
Osudan	Katakwi	Katakwi	Completed but not fitted with hand pump

5 Pounder Well Drilling Descriptions - Mukono & Jinja

5.1 Pounder Well: Gupali 1

Village: Gupali
Parish: Gupali
Sub-County: Ntunda
County: Nakifuma
District: Mukono
Dates: 9th - 11th December 2000

Gupali 1 was the first site to be drilled by the modified Pounder Rig. It was also the first hands on training of rig operation for the drill crew. Peter Ball, the LCDP Project Drilling consultant and principal Pounder Rig designer undertook the training. He was on site full time for the first three wells.

Siting

The siting work was undertaken by a hydrogeologist, using the siting methodology developed by the Project. The process involved a desk study, followed by field reconnaissance with the local community and augering of the formation with a 2" test hand auger. Note that the test hand auger is only capable of penetrating soft formations, unlike the Pounder which can drill through ferricrete (laterite) and marram. A review of the siting process is contained in the report "A Review of Siting Methods for the Pounder Rig in Uganda*" (yet to be written).*

Drill Log

Depth (m)	Notes & Description of Formation	Time (min)	Button Bit Dia. (mm)
0 - 1	1 m brown clay, hard clay and changing	15	82
1 - 2	Whitish stony formation. A marrum layer of 0.5m at 1.5m.	90	60
2 - 3	Clay with whitish formation	40	60
3 - 4	Light brown sandy formation	25	60
4 - 5	Soft sand mixed with clay blocking the drill pipe	120	60
5 - 6	Sandy formation with mica	10	60
6 - 7	Orange whitish stony clay	35	60
7 - 8	Drill pipe blocked, rain storm stopped the drilling. and hole clearing. Hard layer in the soft fine sandy formation	180	60
8 - 9	Very soft white sticky clay. Drill pipe cleaned with auger	20	60
9 - 10	Drilling pipe becomes blocked. Formation continues to be permeable. Used 70 jerry cans of water	140	60

Drilling Experience

Drilling on day one reached 7 m, for which 40 jerry cans (200 l) of water were used. The community members were paid 100 UShs to carry water to site for days one and two as there had been little community mobilisation.

The RWL. at the start of day two was 4.5m. The hole was progressed from 7m to 10 m on day two, with high water loss. 70 jerry cans (1400 l) were required.

An in-situ pump test utilising the Pounder Rig was undertaken on day 2, but the recovery was very slow.

On day three, the hole had collapsed to 6.6m, and the R.W.L. was at 5.5m. 1/2 sack of sawdust was added to 400 l of water over a period of time, but this was not able to reduce the water loss into the formation. A borehole camera survey was undertaken and revealed that the hole above the water table contained large caverns every 0.5m. As the crew were still learning to use the rig, it was decided not to temporary case the hole at this stage. Thus the hole was abandoned and the rig relocated to another site.

5.2 Pounder Well: Gupali 2

Village: Gupali
Parish: Gupali
Sub-County: Ntunda
County: Nakifuma
District: Mukono
Dates: 11th to 15th December 2000

Gupali 2 was located down slope of Gupali 1.

Siting

The initial siting was undertaken, as for Gupali 1. However, additional augering was undertaken by the crew. Three test holes were augered, of which two were very soft and sandy at the surface, with a water table of 1 - 1.15m. The third augered into red clay, and was chosen for Pounder Drilling.

Drill Log

Depth (m)	Notes & Description of Formation	Time (min)	Button Bit Dia. (mm)
	Investigative Hole (80 mm)		
0 - 1	Hard orange with stony sandy formation	160	60 or 80[C]
1 - 2	Sandy formation only	95	60 or 80
2 - 3	Loamy clay, whitish and sandy formation	15	60 or 80
3 - 4	Dark brown mixed with light grey formation, drill pipe blocked while clearing the hole. Changed the valve.	70	60 or 80
4 - 5	Hard dark brown formation	35	60 or 80
5 - 6	Sand mixed with clay. Tightening the valve and cleaning the hole (through sludging)	155	60 or 80
6 - 7	Soft orange clay mixed with white boulders which could not be easily penetrated.	70	60 or 80
7 - 8	Yellowish brown white sandy particles.	15	60 or 80
8 - 9	Very fine, brown sand with rocky particles.	20	60 or 80
9 - 10	As above.	15	60 or 80
10 - 11	Soft clay with big boulders coming out	25	60 or 80
11 - 12	Big boulders with wet grey clay formation	35	60 or 80
12 - 13	Moving, resetting up, re-installing the drilling pipes and cleaning the hole.	70	60 or 80
13 - 14	Yellowish brownish with sand.	10	60 or 80
14 - 15	Fine yellowish sand.	15	60 or 80
15 - 16	Course sand.	40	60 or 80
16 - 17	Mica silvered formation	45	60 or 80
17 - 18	Soft sand mixed with clay which could	75	60 or 80

[C] Conflicting information - Drill logs say 80, but crew claims that 60 was used

	block the drill pipe.		
18 - 19	Hard stony formation	50	60 or 80
19 - 20	Course sandy formation.	25	60 or 80
	Production Hole (100 mm)		60 or 80
0 - 17	Reaming hole.	530	100
16.5 - 20	Reaming hole.	365	100
	Installation of screen, cylinder and casing	160	-

Drilling Experience

The community involvement improved from the first site, after the arrival of the district community mobiliser. Water collection was subsequently undertaken for free and several villagers helped with the rig operation and other necessary tasks.

The first 2m were drilled on day one by direct pounding into the clay.

Drilling on day two progressed to 12 m, with the superstructure fitted and utilised during the day. The water loss was negligible.

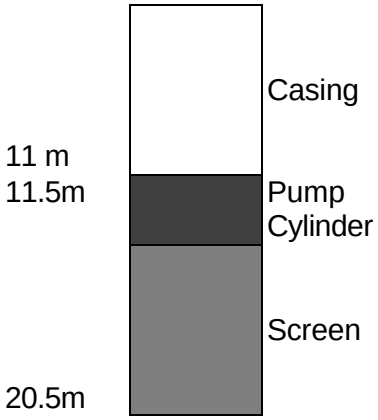
The RWL on day three was 0.3m, and the hole had filled in to 11.5m. Drilling progressed down to 20.5m, notably through some hard layers which caused the drill bit to ring.

The RWL on day four was 2.2 m, and the hole had filled up to 17m. A gentle in-situ pump test was undertaken on day four to draw the water down for about 1m. The recovery was low and there was uncertainty regarding if this would be sufficient for a hand pump. However, on the basis of the hydrogeological report, which recommended drilling as far as possible into the formation, the decision was taken to open the hole out to 100mm and install. The hole was reamed down to 17 m on day four.

The RWL on day five was 2.2 and the hole had collapsed back to 16.5m. The reaming proceeded slowly due to the hard layers at the bottom. Installation of the screen, pump cylinder and casing along with 1 1/2 bags of gravel pack was undertaken followed by a rough pump test using the drill pipe pump test arrangement. The drawdown was rapid and considerable fine sand was pumped out.

The crew left the site unsure of the success of the well as a hand pump water source.

Well Profile



Well Development & Completion

A return visit was made to Ntunda to undertake a pump test. The well was pumped to the suction limit with the treadle pump, after which a DC pump was used. The test indicated that, after one hour of pumping at a rate of 0.15 l/s, the water level was at 9.4m and still drawing down at a rate of approximately 4 cm in 5 minutes. However, the recovery was very rapid and recovered to 8m in 23 seconds, and to 7m in 54 seconds. It was estimated that a hand pump at this site was unlikely to be in constant use, due to the low population density, giving the well sufficient time for recovery. Thus, it was decided that this was a suitable hand pump site and the installation was completed.

The complete installation was undertaken without the full supervision of the Low Cost Drilling Project staff, and upon inspection, a number of changes had to be made to prevent long term problems with the pump. In particular, the centralises had to be replaced for those in the specification Annex 2 / 3 in the Final Report, the seal had to be adjusted and glued, the top rod altered, and the plunger and foot valve replaced (worn components had been utilised). In addition, the well was pumping significant quantities of sand causing high turbidity (NTU 2000).

Text Box 1: Pounder Well Development

Adequate development of a water well or borehole is paramount to a successful water source. The source is not completed until the development has been undertaken in order to yield a clear, plentiful source.

The *Pounder Well Development Method* was developed at Gupali 2. The well was particularly difficult to develop due to the presence of very fine material in the formation (mica/biotite), causing high turbitity in the water. Pumping the fines out with a treadle pump, with the inlet positioned at the base of the well had not been able to remove the fine material. Although the treadle pump would pump clean after some time, replacing the hand pump would once again result in very turbid water. The treadle pump was not able to suck at the formation hard enough to draw out the fines, whereas the hand pump was.

A well development method was undertaken which involved closing the valve on the U3 plunger (by threading the plunger to hold the valve shut) and utilising it as a surge block. The well was surged for say 20 minutes, and then, pumped using the normal U3 plunger and foot valve for several hours. In order to avoid abrasion of the brass liner, the pumping was undertaken inside the casing. This process was repeated several times in one day. The community was then left to pump the well for the whole of the following day. The cycle of surge - pump, surge - pump, surge - pump, then pump for a day, was repeated for one week. This improved the turbidity from the original 2000 to 20 NTU.

In order to remove fines which may have settled to the bottom of the hole, the treadle pump could be used, with the inlet placed at the base of the well. In order to pass the inlet through the cylinder, it is recommended that a perforated point be fixed to the end.

A combination of surging, hand pumping and treadle pump were able to reduce the turbidity from 2000 to 20 NTU, and the hand pump at Gupali 2 is now being successfully utilised by the community.

5.3 Pounder Well: Nakasajja

Site name: Nakasajja
Village: Nakasajja
Parish: Ndundu
Sub-County: Kyampisi
County: Mukono
District: Mukono
Dates: 16th to 19th December 2000

Siting

As with Gupali village, the siting was undertaken by a hydrogeologist utilising the siting methodology developed by the Project, as with Gupali 1 and 2.

Drill Log

Depth (m)	Notes & Description of Formation	Time (min)	Button Bit Dia. (mm)
	Transport rig from Gupali 2 to the Nakasaja, offloading, setting the machine & drilling 1 m.	300	60
0 - 1	Dark grey clay formation		
1 - 2	Soft dark grey formation	10	60
2 - 3	As above	24	60
3 - 4	Dark sandy orange clay formation	25	60
4 - 5	Whitish clay mixed with orange clay sandy formation.	30	60
5 - 6	Dark brown sandy formation	25	60
6 - 7	Course sand.	30	60
7 - 8	Fine dark brown sandy formation	20	60
8 - 9	Silvered, orange, grey clay formation	30	60
9 - 10	Very fine, orange, sandy formation	25	60
10 - 11	As above	25	60
11 - 12	Grey orange with black formation	21	60
12 - 13	Brown, fine, soft sandy formation	30	60
13 - 14	Dark brown sandy with orange, soft sandy material.	45	60
14 - 15	Hard dark grey stony , with dark grey sandy formation	35	60
15 - 16	Due to the hardness above, changed the drill bit, drilled through hard rocky formation.	140	60
16 - 17	as above	73	60
17 - 17.5	Very hard, with little penetration made	240	60
7 - 17	Cleaning out collapsed material (day 3)	240	60

Drilling Experience

Day one involved transporting the rig from Gupali, seting up the machine and drilling to 3m. The community labour at the site was very high, with members operating the machine as well as carrying water to the site.

The second day saw the hole progress down to 17m, but the formation comprised very fine grained material, with likely low permeability.

The hole had collapsed back to 7m by day three, and had a RWL of 1.5m. Very fine silt was removed when cleaning out the hole. The hole was progressed to 17.5m, in very hard material.

The crew undertook some direct Pounding (i.e. without the frame), and one of the aluminium handles broke.

Due to the fact that the formation was considered to be too fine for a productive hand pump source, and that there would be no payment for the dry wells, the decision was taken with Mukono District water office to suspend drilling until the new year, allowing time for reflection and discussion.

Subsequently a hand dug well to 6m has been dug at Nakasaja and installed with a handpump. It is a successful water source.

5.4 Pounder Well: Lweza

Village: Lweza
Parish: Nsumbe
Sub-County: Mukono Town Council
District: Mukono
Dates: 8th to 10th February 2001

Siting

The siting was undertaken by a hydrogeologist known to the district. The process involved visiting the site and undertaking some hand augering. Full details of the method are given in the report "*A Review of Siting Methods for the Ponder Rig in Uganda".*

Drill Log

Depth (m)	**Notes & Description of Formation**	**Time (min)**	**Button Bit Dia. (mm)**
0 - 1	Topsoil	360[E]	60
2 - 3	Clay loam		60
3 - 3.5	Clayey sand with silt		60
3.5 - 4	Mica (silt)		60
4 - 5	Lost circulation at 3.5, RWL = 3.2, Sand with stones and gravel		60
5 - 6	Sand - slow due to loss of circulation	360	60
6	Very hard material	5 cm in 120[E] min	60

Drilling Experience

The crew reached 5 m in the first day, but lost circulation slowed the drilling down considerably. Sawdust mixed with water failed to plug the hole and 2 x 200 l drums were used in 50 minutes. However, a mixture of saw dust, guar gum and water, managed to plug the hole for some time, enabling the crew to reach 6m, and penetrate 5 cm into the hard formation.

An in-situ pump test with the treadle pump was undertaken, and the recovery was 10 cm in two to three minutes. The site would probably be more suitable for a hand dug well, as the slow recovery could be compensated by the storage. In light of this, the contractor decided that he would provide a hand dug well at this site, and moved the rig on to another location.

[E] Estimated time, one day of drilling, comprising 6 hours.
[E] Estimated time, one day of drilling comprising 6 hours.

5.5 Pounder Well: Kasubi

Village:
Parish:
Sub-County: Mukono
County:
District: Mukono
Dates: 22nd February - 4th March 2001 (including 2 days where the rig was not in use)

Drill Log

Depth (m)	Notes & Description of Formation	Time (min)	Button Bit Dia. (mm)
	Investigative Hole		
0 - 1	clay		60
1 - 2	clay	23	60
2 - 3	clay	27	60
3 - 4	clay	27	60
4 - 5	clay	13	60
5 - 6	clay with gravel and some sand	33	60
6 - 7	clay with gravel and some sand	23	60
7 - 8	clay with gravel and some sand (lost circulation between 7 and 8 meters) formation becoming harder with depth	35	60
8 - 8.5	as above	30	
8.5 - 9	clay, more gravel and stones	270	60
9 - 10	clay with some stones		60
10 - 11	clay, large quartz pebbles and fine gravel		60
11 - 12	clay, mica (extremely fine sand) and some gravel		60
12 - 13	clay, sand and gravel		60
13 - 14	clay and black gravel		60
14 - 15	clay and mica	120	60
15 - 16	clay, mica and gravel		60
16 - 17	course sand		60
	Production Hole		
1 - 3	Reaming	80	100
3 - 8.5	As above	120	100
8.5 - 11	Medium to hard formation	300[E]	100
11 - 16	Very fast reaming - very soft		100
16 - 17	Reaming	20	100
11.75 - 17	re-ream collapsed formation	120	100
17 - 18	drilled with 100 mm (not reaming only) sand and mica (mica was perhaps from the collapse). The sand became courser with depth.	120	100

[E] Estimated time, one day of drilling comprising 6 hours.

Drilling Experience & Installation

The crew reached the site and set up on day one. The drilling of the first 7m on day 2 was very fast, but when the crew stopped for lunch there were significant water losses. Immediately prior to this, the sludging water had been becoming cleaner, so that the crew thought that they had reached water. Course sawdust was added, which abated the loss but could not reduce it completely. There were insufficient people at the site to enable sufficient water collection (poor community mobilisation/ no paid unskilled labour). Finally, a mix of sawdust, guar and water were put into the hole and left overnight. The rig remained on site for the following seven days, with the drilling progress slow due to water loss combined with a lack of labour to fetch water.

The RWL varied from 8.2 to 9m. This was too low to use the treadle pump for pump test, and with concern of collapse of the formation onto the drill pipe by carrying out an in-situ pump test, the crew decided to risk opening the hole to 100 mm without being sure of the formation. The behaviour of the water in the hole was interesting. In general, 100 to 200 litres of water would be added to the hole in order to commence the drilling. The circulation would be maintained, with the addition of very little water. However, as soon as the drilling stopped in order to add a pipe, the water circulation would be lost. Lack of labour to collect water thus considerably slowed the drilling down.

The reamed hole was left overnight, and had collapsed back to 11.75m. Due to sufficient labour to collect water (it was a Sunday, so there were plenty of children around), opening the hole was fairly quick.

2 lengths of screen (6 m), the cylinder and 4 (12m) of casing were installed. Three bags of gravel pack filled the hole.

Well Development and Completion

The well was developed once the rig had moved on to undertake work in Jinja District. The crew surged for half a day, and tried to use the treadle pump to remove cuttings but failed due to the low water level. The crew then pumped with the handpump for three hours but the source has failed to clear. Due to other commitments, the contractor has not to date returned to complete the site, and the source is remaining without completed headworks to date (15 May 2001).

5.6 Pounder Well: Mywangi-Bulumba

Following the well drilled in Nakasaja, and the decision was taken to hold off the drilling in Mukono for some time to enable discussions to be taken with respect to the possible payment of dry wells. In the mean time, at the end of December, the contractor and the drilling consultant were keen to take the rig to try and drill shallow wells in Jinja District.

Two attempts were made to drill in Buwenge Sub county, but both ran into hard rock, with the first striking the material at 1.5m, and the second at 4m. The drilling in Jinja was subsequently stopped to enable the contractor to commission a small hydrogeological study.

5.7 Pounder Well: Buwanga 1

Site: Buwanga LC1
Village: Kibundire
Parish: Lubange
Sub-County: Butagaya
District: Jinja
Dates: 20th March 2001

The village of an estimated 450 people have access to one borehole for their drinking water supplies. A water committee had already set up, and there was a high level of community participation during the source construction. This involved working the rig, collecting water as well as dancing, drumming and singing.

Siting
Electrical resistivity readings had been taken for the contractor by a consultant hydrogeologist. The drilling was undertaken following their recommendations. In addition, the crew hand augered at the site, immediately prior to drilling. However, following the experiences at Buwanga 1 which failed to be a successful hole, the contractor decided that it would be better to undertake their own siting (with the test hand auger) as the resistivity readings did not provide them with a sufficient indication of drilling conditions and expected water strike.

The contractor was to drill five sites for Jinja District Government, and had paid for the hydrogeological study at these sites. However, after returning to the sites with the test hand auger, he decided not to drill at three of them due to hard formation.

Drill Log

Depth (m)	**Notes & Description of Formation**	**Time (min)**	**Button Bit Dia. (mm)**
0 - 1	top soil and fine sand	480	60
1 -2	course sand, little clay and gravel		60
2 - 3	gravel and little clay, then hard rock		60

Drilling Experience
The crew reached hard rock at 3m, abandoned the hole and moved 2m away to the next site.

5.8 Pounder Well: Buwanga 2

Site: Buwanga LC1
Village: Kibundire
Parish: Lubange
Sub-County: Butagaya
District: Jinja
Dates: 21st to 26th March 2001

The crew moved 2 m along to this site after reaching hard rock at 3 m at Buwanga 1.

Siting
As with Buwanga 1.

Depth (m)	Notes & Description of Formation	Time (min)	Button Bit Dia. (mm)
0 - 1	medium to fine sand with the occasional pink and white angular stones (3mm diam.)	300	60
1 - 2	RWL = 1.2m, fine to medium sand with small (2mm and less) stones like those found above and some hard black particles.		60
2 - 3	Fine sand but more stones (gravel) - red, black and red/white mixed		60
3 - 3.8	course sand mixed with fine gravel		60
3.8 - 4	as above	240	60
4 - 4.2	gravel from 1mm to 1cm. Opaque & white, pink, red and orange. The gravel came up with clay.		60
4.2 - 4.4	gravel from 1mm to 1cm. Opaque & white, pink, red and orange. The gravel came up with clay.	180	60
4.5 - 5	Progress was extremely slow and tiring, with 200 strokes (5mins) giving a progress of 1.9cm. Cuttings looked like crushed bedrock as they were smaller than the gravel found above and had the tendency to be one coloured particles, suggesting fracturing at the week joints.	180	60
5 - 6	As above. The 60 mm bit broke, and the drilling stopped.		60

Drilling Experience

Threads had to be tightened between 4 and 5 m. The endless rope sling was not being used to turn the drill pipe. Due to the broken pin which holds the drill pipe, the crew were not able to attach the lever, and decided to hand sludge. Initial hand sludging techniques were poor, but have subsequently improved, to the point where the crew prefer to hand sludge in course sand as they find the performance better than that of the flap valve.

Pump testing was undertaken with the treadle pump, although the pump was not operating well due to damaged valves. The well took 2 1/2 minutes to recover 1.2 m, which was not promising. The crew continued to drill but the recovery was 0.5m in 8 minutes. The crew penetrated into the hard rock, and the drilling indicated that they were simply pushing a boulder down into softer material, as the penetration of each stroke was reasonable but the material sounded very hard. The crew abandoned this site when the 60 mm button bit broke, and it was apparent that there was tungsten carbide residue in the hole.

5.9 Pounder Well: Buwanga 3

Site: Buwanga LC1
Village: Kibundire
Parish: Lubange
Sub-County: Butagaya
District: Jinja
Dates: Tue. 27th to Thu. 29th March 2001

The crew moved 500m to try and drill at a new site in the same village as Buwanga 2

Siting

The crew augered some 3m above the base of the valley, and 9 - 10 m away from a pond (which the community claim never dries). A hole was augered to a depth of 5m and found water at 2 m. The profile of the augered hole is given below.

Auger Hole Profile

0 - 1		Little topsoil, then red clay
1 - 2	RWL at 2m	clay
2 - 3		red clay with little gravel (red stones/marram)
3 - 4		white clay with some fine red gravel, very little glittery mica
4 - 5		clay

Drill Log

Note that the drill site was situated approximately 4m from the augered hole (up-slope) as it was deemed to be too close to the traditional source, the RWL was thought to be a little too high, and there was concern that during there was a chance that a hand pump source at this site might flood. Note the differences in the formation over such a short distance.

Depth (m)	Notes & Description of Formation	Time (min)	Button Bit Dia. (mm)
	Investigative Hole	360[E]	69
0 - 1	Little topsoil, then red clay		69
1 - 2	sand, RWL at 2m		69
2 - 3	sand		69
3 - 4	sand		69
4 - 5	sand		69
5 - 6	course sand + gravel, little clay and fine mica		69
6 - 7	course sand + gravel, little clay and fine mica		69
7 - 8	course sand + very big gravel particles (medium hardness)	360[E]	69
	Production Hole		
0 - 8	Reaming	360[E]	100

[E] Estimated time, one day of drilling comprising 6 hours.

Drilling Experience & Installation

The crew set up and started to drill on the 27th March. They drilled down to a depth of 6.8m in the first day. The second day's drilling took them down to a depth of 8m as the formation was harder. Day three was spent reaming the hole to 7.8 and installing the pump. The reaming was gradual to 3m, with no resistance from 3m to 7m (suggesting caving or collapse of the formation). The final 0.8 m yielded a lot of sand and gravel. A pump test undertaken during the drilling showed a recovery of 1m per minute.

The screen, cylinder and gravel pack were installed on day three. Five and a quarter bags of gravel pack were used in total, with the bottom 2.8m of the hole taking three bags. As only three bags were available on site, the gravel packing was not completed for several days while more supplies were collected from Entebbe. Finally, the hole was gravel packed to within 0.5m from ground level.

Well Development & Completion

The crew developed the well using the treadle pump on Tue. 3rd April for two days. It was claimed that the source yielded clean water. However, samples taken on the 12th April (during installation) indicate that the water was not so clean. Levelling, brickwork, casting of apron and pedestal were undertaken in one day. A 20 minute continuous pump test utilising the treadle pump indicated that there was sufficient water for a hand pump source.

5.10 Pounder Well: Makenke

Village: Makenke
Parish: Mafubira
Sub-County: Mafubira
District: Jinja
Dates: 8th to 11th May 2001

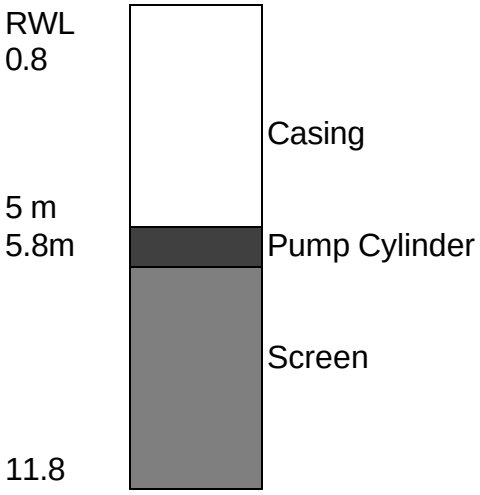
Siting

A consultant hydrogeologist to the contractor had undertaken resistivity measurements to site the well (along with three other sites). The contractor subsequently followed on by test hand augering the site.

Drill Log

Depth (m)	**Notes & Description of Formation**	**Time (min)**	**Button Bit Dia. (mm)**
	Investigative Hole	360[E]	69
0 - 1	top soil - mix of top soil and sand, porous RWL = 0.8m		69
1 - 2	clay		69
2 - 3	clay and fine sand		69
3 - 4	fine clay		69
4 - 5	clay and gravel		69
5 - 6	murram	360[E]	69
6 - 7	murram and clay		69
7 - 7.5	boulders and clay (no water added)		69
7.5 - 8	clay and gravel		69
8 - 9	hard fine clay		69
9 - 11	soft clay and a little mica		69
	Production Hole		
0 - 11	Reaming	360[E]	100

Well Profile



[E] Estimated time, one day of drilling comprising 6 hours.

Well Development & Completion

According to the drilling crew (Nereko), an attempt was made to pump all the water out of the hole (which had a static water table of 0.8m), out of the ground. Due to the suction limit of the pump, this was not possible. The water level remained constant at 6m. Within 3 minutes of stopping pumping, the water level rose to 1.2m. A further four minutes were required before the water level rose to 0.8m.

Well development took one day, with the water reasonably clean.

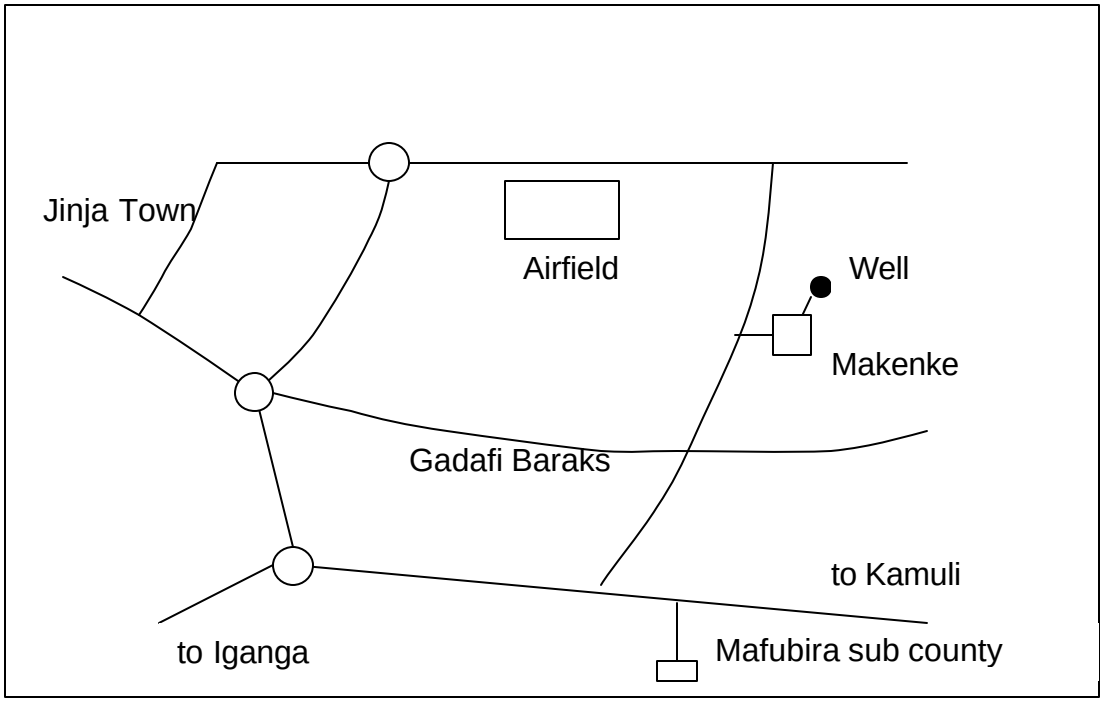
Note that as the pump has been positioned above the maximum drawdown achieved with the treadle pump, the well may suffer from water shortage problems.

Other comments

The community is slightly urbanised with most of the population operating as small traders or working in factories around Jinja town. There is a mixture of tribes with most people not being permanent residents of the area. Community participation was thus poor, with five or six men helping. Water for drilling was collected with the treadle pump.

The community complains that the water is salty, although they say that is better than the water from another well constructed in the area earlier. The other well was vandalised by thieves who were interested in the pipes. As the Pounder well components plastic and are fixed in the ground, the pump is not likely to be vandalised.

Map of Site



6 Pounder Well Drilling Description - Katakwi

The purpose of the drilling in Katakwi was to utilise the rig to find appropriate sites for hand dug wells. Several hand dug wells had been attempted in this area, but they had failed to find water. The contractor was contracted to Water Aid to undertake this siting work. In the area where the Pounder rig was being operated, water is generally scarce, and people have to walk 2 to 3 km in search of water. Once the pond water near the site had been used up, water for drilling was trucked in from a source 1 km away.

Community Mobilisation

Community mobilisation was undertaken by VRM, a local NGO, in conjunction with the LCI officials. Water committees had not been established, and the response from the community was rather poor for a number of reasons:

1. the drilling was undertaken during the planting season, so the gardens and fields were the community priority at that time of year. The community members would participate in the drilling once they had completed their work in the fields at 10 or 11 am.
2. two wells had been previously dug in the community, the first of which collapsed, while the second reached hard rock at shallow depth. Subsequently, the first Pounder hole did not succeed due to the hard formation, combined with poor recovery. These events managed to almost kill off the moral in the community.

However, as a result of constant pressure from the community mobilisers, the drill crew were able to drill for 6 -7 hours per day.

Once the rain-fed ponds had been utilised, water for drilling was brought to the site by lorry. This slowed down the drilling operation from half way through the second hole.

6.1 Pounder Well: Abelibuku 1

Village: Abelibuku
Parish: Alyakamer
Sub-County: Katakwi
District: Katakwi
Dates: Fri 20th to Mon 23rd April 2001

A hand dug well was situated approximately 20m from Abelibuku 1 (5 m up-slope). The well had been abandoned after hard rock was struck at 2 m. Although the rest water level in the well was 1m, the recovery was so slow that the well would not have been able to supply the demands of the village. The community could not be persuaded to deepen the well by another meter to provide storage, as the formation was extremely hard.

Pounder Well Drill Log

Depth (m)	Notes & Description of Formation	Time (min)	Button Bit Dia. (mm)
	Investigative Hole		
0 - 1.8	Sand	180	69
1.8 - 2	Sand	360	69
2 - 3	Sand		69
3 - 4.2	Sand (RWL = 3.5)		69
4.2 - 4.5	Hard Formation - reddish sand, thought to be laterite	180	69
4.5	Very hard Formation, thought to be bedrock		69

Drilling Experience

Half a day's drilling on day one enabled 1.8 m to be drilled. The hole was progressed to 4.2m on day two, and day three saw the hole depth reach 4.5m, before striking a very hard surface, thought to be bedrock. A pump test emptied the hole, and the recovery was extremely low. However, it has recovered to the RWL by the following morning. The well was subsequently abandoned and the crew started to drill another hole situated 1 km away but in the same village.

6.2 Pounder Well: Abelibuku 2

Village: Abelibuku
Parish: Alyakamer
Sub-County: Katakwi
District: Katakwi
Dates: 24th April to 28th April 2001

This site was situated 1 km from Abelibuku 1, between two 2m deep ponds, 100m apart. The ponds were seasonal, with the water comprising a mixture of groundwater and surface water.

Drill Log

Depth (m)	Notes & Description of Formation	Time (min)	Button Bit Dia. (mm)
0 - 1	Sandy top soil	12	69
1 - 1.5	Sandy top soil	38	69
1.5 - 1.85	Clay and Course Sand & some gravel (marram)	15	69
1.85 - 2.12	Laterite	18	69
2.12 - 2.7	Laterite	375	69
2.7 -3.22	Laterite	235	69
3.22 - 3.33	Course white-ish Sand	34	60 no.2
3.33 - 4	Course white-ish Sand	60[E]	60 no.2
4 - 5	Gravel and sand	360[E]	60 no.2
5 - 6	Broken white gravel and sand - bigger pieces of gravel broken by the drilling	360[E]	60 no.2
6 - 6.3	Mica and sand	360[E]	60 no.2

Drilling Experience

On the first day, the crew drilled to a depth of 2.12m in approximately 3 1/2 hours. Day two of the drilling progressed somewhat slower, with the crew drilling into laterite, reaching a depth of 2.7 m. Drilling on day three continued through the laterite and into course sand to a depth of 4m. Another meter was drilled on day four to a depth 5m. Drilling stopped at 6.3m on day six due to the fact that it was very difficult to progress in the gravel (stones).

The new 60 mm button bit wore very quickly, with deeper scratches in the body material than on the previous button bit.5.3

[E] Estimate

6.3 Pounder Well: Osudan

Village: Osudan
Parish: Osudan
Sub-County: Katakwi
District: Katakwi
Dates: Mon 28th to Tue 29th April 2001

Drill Log

Depth (m)	Notes & Description of Formation	Time (min)	Button Bit Dia. (mm)
	Investigative Hole		
0 - 0.5	Fine Sand	360[E]	69
0.5 - 0.75	Large gravel - white-ish		69
0.75 - 1	murram - red but not solid		69
1 - 1.74	Laterite and some gravel		69
1.74 - 2	White stones and sand	360[E]	69
2 - 2.5	Course sand and broken white stones		69
2.5 - 2.7	Course sand and broken white stones	(reamed)	69
	Production Hole		
0 - 2.7	Hole reamed open to 100 mm	360[E]	100

Drilling stopped as it was very difficult to progress the hole. This was believed to be due to the gravel rather than solid rock. The main problem with this hole was driving the 1 m length into the ground. The crew request that the casing length be slightly shortened to enable installation in such formations.

The hole was not installed with a handpump. Although the yield appeared to be sufficient, with a drawdown to 1.6m after three hours of pumping at a rate of 0.8l/s, the depth of well was shallow for the installation of a U3 direct install. The client chose to follow the original plan and utilise the site for a hand dug well source.

[E] Estimate

7 Obervations And Comments Regarding The Rig And Its Use

7.1 Swivel Block

The pin holding the swivel block broke on Thursday 22nd March, and was replaced the following day. The first two chain links showed approximately 2 mm of wear on the 23rd March. The latter can be attributed to the jerking action on the upstroke. The material which surrounds the chain around the pin on the swivel block has also worn as a result of rub from the second chain link. The wear has caused the edges to be pushed in so that the removal and reinsertion of the chain is difficult.

During the Katakwi well, there was considerable play resulting on considerable noise between the sludging valve and the plate. The crew had a spare M16 bolt which they were going to fit in tightly enough to reduce the gap.

The swivel block was replaced on the 23d March as the threads on the original block had been damaged when the remainder of the broken aluminium handle had been removed on the lathe following the first breakage at Nakasaja.

7.2 Valve & Hand Sludging

In order to prevent the leather valve from denting while it dries out, it is necessary to insert a leaf between the flap and pipe when idle overnight.

The crew stopped using the flap valve and switched to using the hand at Buwanga 2 and 3. By Buwanga 3, they were utilising the hand in the manner used by the Indian Mistries. The reasons given for this change were as follows:

- that the valve needs to be cleaned very often with water when drilling course sand as it does not close properly;
- that the valves were getting torn (although it is suspected that this point is a actually an excuse);
- that utilising the hand delivers more cuttings out of the hole in sandy formations than the flap valve.

A pattern seems to be developing in that the crew use the flap valve in clayey formation and the hand for course sandy material.

At a depth of 5 m, the crew used three men to hand sludge, i.e. two to lift and one to provide the hand to hand sludge.

7.3 Pulley Bearing

The pulley bearing on the wet side of the rig was replaced on Friday 23rd March as it had gone, due to leakage. The specified part was bought in Kampala. Replacing the pulley into the housing was not easy due to the tight tolerances.

7.4 Aluminium Handles

The aluminium handle on one side has broken twice; once at Nakasaja, and the second time at Buwanga 2. The breakage is occurring at the neck of the handle, which does not seem to have any particular design purpose. In addition, considering the shock loading to which the handles are subjected, the thread design may not be appropriate. Another arrangement may ne more suitable, such as stronger threads or a "grub screw" arrangement.

7.5 Drill Pipe

The drill pipe threads are not standard, and are thus not available ex-stock, but must be machined specifically for the Pounder rig. Surely this limits the suppliers of the equipment, as well as increasing the cost of the components as they are likely to be manufactured in such small quantities.

7.6 Button Bit

The 60 mm button bit broke at Buwanga 2. An estimation of the use of the bit is given in appendix 2. From observations of the bit prior to breakage, as well as other bits, it is the material around the buttons which wears before the buttons. This wear, seems to ultimately enable the button to fall out of it's socket. The breakage of the other buttons at Buwanga 2 is likely to have been caused by the button which had fallen out. It is of particular note that of the vertical buttons, one had worn and three had broken, but they had all remained in place. All of the outward pointing buttons had broken, while of the inward facing buttons, three had fallen out and one had broken.

A visual inspection indicated that the outside surface had worn more than the inside. Considerable attention needs to be paid to the hardness of the material to enable the bits to have a satisfactory life.

The 60 mm button bit that wore out at Buwanga 2, was being used in very hard formation. Immediately prior to use, the rig was being utilized with the lever, but not the handles (one of them was broken). There was nothing particular about the use of the rig which appeared to have caused the button bit to fail. The Ugandan team attributes the broken bit to wear from the hard formation.

The 69mm had worn considerably when it was returned from Katawi. An inspection of the button bit taken on Monday 23rd April showed the following: the outer diameter of the button bit was 67.7 mm (at the join to the drill pipe). The button end looks corrugated as the buttons stick out of the bit. The outer diameter, behind a straight button was 66.2 mm. The inner diameter from a straight button was 45.9mm. The wear is greater around the buttons than on the rest of the bit. The straight button bits were almost flat.

The 69mm diameter drill bit being used for much of the drilling is so worn that it would be advisable to use it only on soft formations. A replacement 60mm diameter bit came from Silsoe, and was still in a good state of repair when John left Katakwi at the end of the first week of drilling there. It was used in place of the worn 69mm bit.

The replacement 60 mm bit (brought out from Silsoe) seemed to be wearing faster than the previous bit. Deep scars were visible along the body, which were not there on the first 60mm button bit. Is it possible that the heat treatment given to this button was less than given to the previous bit?

The button bit life seems to be lower than expected of a low cost rig. There may be lessons which we have not yet learnt from the manufacture of other button bits used in the industry. This is an area which may be worth following up in more detail.

The crew seem to prefer to use the 60 mm bit, followed by the 100mm bit. The 69 mm bit was used only when the 60 mm had broke and the 80 mm bit has not been used at all (perhaps Gupali 2).

7.7 Drill Pipe Lift and Stroke

As the crew are using their hand for course formations, they remove the bucket and lever arrangement and lift the drill pipe directly by hand. They are holding onto the casing driver to lift the pipe and complain that this provides them with little space to hold on to.

When the crew first started to use the hand sludging method, they lifted the drill pipe 0.6 - 0.7m into the air, and could manage seven strokes in 15 s before pausing to rest for about 2 minutes. However, subsequently the drill stroke is actually between 0.3 and 0.4m in length, but usually 0.3m. In Katakwi, the crew were averaging at a speed of 13 strokes in 20 seconds.

7.8 Drilling Technique

The crew initially ignored the superstructure completely and utilised the T-bar to drive the rig as far as possible into the ground. Considerable training and explanation was required to illustrate that the use of the lever was beneficial in terms of reducing the necessary physical input by the crew. Further explanations were required to persuade the crew to use the counterbalance as a ballast, in order to reduce the number of operators required. However, the attitude of the crew which has continued to prevail is that the counterbalance slows the descent of the drill pipe, this reducing the impact of the button bit, and thus the efficiency of the drilling. The crew thus do not fill the barrel to balance the weight of the drill pipes.

7.9 Operators Required

At least three operators are required in order to enable the rig to operate effectively. There needs to be one operator on each end of the lever, as well as another to ensure that the flap valve is operating properly, and to clean it. If the flap valve sticks, and the lever operator needs to run round to check it each time, the down time goes up considerably. In addition, there must be a very good supply of water, as experience has illustrated that lost circulation can occur at almost any time, and lack of water can stop the drilling process. The water can be supplied by community, or hired labour, or, in the case of dry areas may need to be brought by vehicle.

As the lever operation is tiresome, it is recommended to have a pool of labourers/community members to alternate the work with. The well will take considerably longer to complete if two crew members are required to undertake all of the rig operation, as they require frequent and regular rest.

7.10 Formation

Drilling pure gravel is slow, in fact, almost as slow as drilling laterite. The penetration itself is higher than laterite, but the granules which prevent the valve from sealing, slow the process down considerably.

7.11 Reaming

The crew ream with the 1m x 98 mm pipe on the bottom of the drill string they find that the additional weight improves the penetration. At times, the reaming is so fast that is suggests that the drilling has opened more that the diameter it is designed for.

7.12 Rig Transport to Site

Despite the fact that the rig has wheels which can be attached to the base frame, the preferred method of transport is to hand carry the frame to the site rather than use the wheels. However, when moving the rig for 1 km between sites in Katakwi, the wheels were used.

When the rig is being transported by pick-up, the wheels do enable the rig to be held off the cabin. However, if a pickup has a welded guard rail, that the wheels cannot be used and the rig must be lifted on. For this type of puck-up, the rig is able to rest on the guard rail, thus protecting the cabin. Wheeling the rig on and off the pickup has implications for safety as planks can easily slip and the process of ensuring that the rig is perfectly aligned to the planks is tricky.

7.13 Steel Quadrants Bang Pivot

When the rig is not used carefully, the steel quadrant on the arc bang the pivot. Initially, this was addressed by fixing a shock absorber to the arc, and rope to contain the impact. However, subsequently, careful rig operation prevents the bang from occurring.

7.14 Lost Circulation

Drilling has revealed that sawdust on its own is not always capable of preventing lost circulation. However, the situation can sometimes be improved by adding guar to the mixture. Temporary casing has not been used to date to determine it's lost circulation capabilities.

7.15 Rig Settling

The fact that the drill fluid spills over the edge of the frame means that the supports are eroded by the flow and the rig tends to settle. Placing planks of 1.5 m length under the rig have helped to spread the weight of the machine, thus reducing the settle and drilling of bent hole. Lengthening the plate by an inch or two over the supports may further help to prevent erosion of the material beneath at the edge of the settling pit. Alternatively, the drill fluid could spill over the side of the machine rather than the back.

7.16 Rig Set-up

Levelling the machine properly can take considerable time. As the contractor is trying to complete the operation as quickly as possible it is unlikely that the rig will be set up level. Bent holes are likely to be common amongst Pounder Wells unless the set-up strategy can be improved and simplified.

8 APPENDIX 1 - DRILL BIT USE

Formation classification:

Soft = clay and sand
Medium = gravel without clay, marram & ferricrete (laterite)
Hard = bedrock

	Distance (m)			Time [1] (hours)		
Formation	Soft	Medium	Hard	Soft	Medium	Hard
Gupali 1						
60 mm	9			11		
80 mm	1			0.25		
Gupali 2						
80 mm	17	3		16.35	3.95	
100 mm	17	3		10	7	
Nakasaja						
60 mm	22			19.7	3.5	
Jinja						
60 mm						
80 mm						
Mukono Town						
? 60 mm	5	1		11	1	
Kasubi						
? 69 mm	17	1		10.5	1	
100 mm	23.25			12.5		
Buwanga 1						
60 mm	3			6		
Buwanga 2						
60 mm	3	2	1	5	4	5+6+6+5
	60 broke					
Buwanga 3						
(no 60) 69 mm	7.5	0.5		6.8	1.5	
100 mm	3	0.8		0.5	4	
Katakwi 1						
(no 60) 69 mm	4.2	0.3		9	3	
Katakwi 2						
new 60 mm	need info			need info		
old 69 mm	1.85	1.4		2.25	10	
100 mm						

	s	m	h	s	m	h	
old 60 mm	20	3	1	52.7	7.5	2 2	
new 60							
old 69	30.55	3.2		28.5 5	15. 5		
80	18	3					
100 mm	43.25	3.8		23	11		

[1] Drilling Time per day varied. Unless stated otherwise in the drilling logs, it is assumed that days on which Peter Ball was on site contained 8 to 10 hours of drilling time. In general, the hours of drilling per day were less on other days. The time has been calculated for days on which there was on-site observation, with estimations made for other days.



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Contractor Drilling with Pounder II

Danert, Kerstin; Carter, Richard C.

2001-06
Cranfield University
http://hdl.handle.net/1826/2791
Danert K and Carter R C; Contractor Drilling with Pounder II, Knowledge and Research (KAR) Project R7126 "Private Sector Participation in Low Cost Water Well Drilling" Cranfield University, 2001

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