

C FIELD EXAMPLES

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1 Planning a drilling programme

Creating a borehole involves siting the borehole, drilling and equipping the borehole, constructing the surface works, pumping tests and pump installation.

Depending on the context, more or less time will be devoted to groundwater prospecting and siting of the borehole, and the percentage of positive boreholes which may be equipped with hand-pumps will vary. A success rate of 75 to 80% is the optimum level to be reached in a bedrock context.

When higher yields are sought (more than 3 m³/h), the prospecting studies are more thorough and are complemented by drilling exploration boreholes (see Chapter 5).

The time required for drilling a borehole depends on several factors apart from its depth and diameter, such as the drilling technique and the rig used, geological conditions (ease of removal of cuttings, stability of the borehole sides), and technical problems with the drilling rig. Experience shows that on average about one week is necessary to complete a borehole.

The timetables of the exploration teams and the surface-works construction team are based on the progress of the drilling team. Likewise, the timetable of the drilling team must take account of the preparatory work carried out by the hygiene education team. A timetable similar to the one shown in Table 8XXVI, extrapolated to the duration of the programme, can be used to plan the activities involved.

During the rainy season, when access to sites is usually limited, and geo-electrical tests are difficult to carry out, it is advisable to stop drilling and make use of the time to repair and maintain the equipment.

Table 8 XXVI: Borehole-drilling plan.

Days	1	2	3	4	5	6	7	8	9	10	11	12	13
TEAM 1 (geophysical exploration)												
TEAM 2 (drilling and equipment, cleaning and development)												
TEAM 3 (pumping test, water analysis, test interpretation)												
TEAM 4 (surface works, pump installation)												

2 Resources to be mobilised

2.1 Human resources

Human resources required are listed in Table 8.XXVII.

Table 8.XXVII: Personnel necessary for drilling a borehole.

MANAGEMENT	
1 hydrogeologist project manager	Borehole siting, team management Contacts with the local partners
1 logistician	Supplies to the sites
PROSPECTION TEAM	
1 geophysics technician	Tests and their interpretation
3 assistants	Test preparation
DRILLING TEAM	
1 driller	Managing borehole drilling and equipping (casing plan), report writing
1 mechanic	Maintenance of drilling rig and compressor
4 labourers	Site installation, pit cleaning, drill-pipe changing, water supply, borehole equipping etc.
SURFACE-WORKS TEAM	
1 builder	Site manager, supervision of construction of apron
1 pump technician	Pump installation, borehole disinfection
3 labourers	Reinforcement, concrete mixing etc.

2.2 Drilling costs

The cost of a borehole depends on numerous factors: depth and diameter, type of drilling rig used, price of consumables etc., but also on the method used for calculating costs. The costs of consumables for a borehole in East Africa are listed in Tables 8.XXVIII A and B, and Table 8.XXIX shows the total cost of a borehole in South-East Asia. The cost of the work is clearly lower in Asia, because the consumables are less expensive, although the estimation methods are also different. When talking of drilling costs, especially to compare different areas or different agencies, it is necessary to know what is being assessed: only consumables, logistics, human resources, depreciation of the equipment etc.

**Table 8.XXVIII A: Example of cost of a borehole in Uganda (ACF, 1997).
Depth 50 m, rotary drilling 8”1/2 and then 6” DTH hammer (ACF-PAT 301).**

Items	Quantity	Unit cost (US\$)	Total cost (US\$)
<i>Borehole</i>			
PVC 103 x 113 mm (2.9 m) casing	13	12	156
PVC 103 x 113 mm (2.9 m) screen	6	18	108
PVC 167 x 180 mm (2 m) pre-casing	10	27	270
base plug	1	6	6
filter gravel (l)	600	0.05	30
diesel (l)	500	1	500
petrol (l)	150	1	150
polycol (kg)	10	10	100
drilling foam (l)	20	5	100
drilling oil (l)	5	5	25
grease (l)	10	5	50
<i>2.5 x 2.5 m apron</i>			
cement (50-kg bag)	12	12	144
sand (m ³)	0.6	12	7.2
gravel (m ³)	0.3	30	9
stone (m ³)	3	15	45
weld-mesh (m ²)	6	3.5	21
<i>3 x 3 m washing area</i>			
cement (50-kg bag)	14	12	168
sand (m ³)	2	12	24
gravel (m ³)	1	30	30
stone (m ³)	3	15	45
weld-mesh (m ²)	9	4	36
<i>Pumping test</i>			
petrol (l)	50	1	50
bacteriological water analysis	20	5	100
physicochemical analysis	10	10	100
<i>Pump</i>			
U2 (India Mark II) pump	1 000	1	1 000
<i>Depreciation of the equipment</i>			
ACF-PAT 301	1	800	800
TOTAL			4 074

Table 8.XXVIII B: Example of cost of a borehole in Liberia (ACF, 2003).**Depth 35 m, rotary drilling 8”1/2 and then 6” DTH hammer (ACF-PAT 301). Duration of task: 1 week including development and handpump installation.**

Items	Quantity	Unit cost (US\$)	Total cost (US\$)
<i>Borehole</i>			
PVC screen 2 m x 125 mm slot 1 mm	3	20	60
PVC casing 125 mm x 2 m	10	15	150
PVC casing 125 mm x 1 m	2	8	16
PVC pre-casing 6m x 150 mm	3	33	99
base plug	1	5	5
PVC glue (can 500 ml)	1	30	30
filter gravel (50 kg)	23	1	23
polycol (50 kg)	1	50	50
diesel for compressor (gallon)	40	3	120
petrol (gallon)	15	3	45
<i>Apron</i>			
cement (50 kg-bag)	14	7	98
sand (ton)	2	10	20
gravel (m ³)	0.3	30	9
stone (m ³)	3	15	45
reinforcement bars 3 m x 6 mm	10	2	20
<i>Pump</i>			
Afridev (15 m depth)	1	500	500
<i>Depreciation of the equipment</i>			
ACF-PAT 301	1	500	500
<i>Drilling team</i>			
(a drilling coordinator supervises the different machines)			
drilling supervisor	1	70*	70
mechanical drilling assistant	1	40	40
drilling technician	3	30	90
labourers	3	20	60
<i>Apron construction</i>			
supervisor	1	70	70
mason	2	30	60
TOTAL			2 110

* Cost per borehole for 1 week of work.

**Table 8.XXIX: Example of cost of a borehole in Cambodia (ACF, 2003).
Depth 56 m, 6”1/2 (ACF-PAT 301).**

	Unit cost (US\$)
56 m borehole, fully equipped	590
Apron	238
Afridev pump	390
ACF-PAT 301spares	300
Depreciation of the ACF-PAT 301 drilling rig	120
Sub-total	1 638
Drilling team	90
Surface-works team	62
Hygiene-education team	180
Supervisor	48
Sub-total	380
ACF expatriate	212
Sub-total	212
4x4 vehicle	350
Truck rental	50
Sub-total	400
8% administrative charges	216
TOTAL	2 846

3 Overview of selected programmes

3.1 Non-consolidated sedimentary area

The programme summarised in the following tables deals with a non-consolidated sedimentary area (sand and clay) in Central Africa. In this inaccessible context, light rotary drilling with an ACF-PAT 201 machine was chosen. The objective was to complete 40 boreholes of 40 m average depth using two rigs over a total period of 12 months:

- 1 month for purchase and transport of material;
- 1 month for organisation and training of teams;
- 8 months for drilling;
- 2 months for follow-up of water committees in charge of pump maintenance.

Table 8.XXX presents the total budget for the operation.

Table 8.XXX: Total budget for an ACF-PAT 201 drilling programme (ACF, 1996).

SUMMARY	Total amount (US\$)			
1. Local staff	65 600			
2. Equipment	96 282			
3. Logistics	95 064			
4. Administrative costs	4 000			
Grand total	260 946			

1. LOCAL STAFF	Number	Salary (US\$)	Duration (months)	Total (US\$)
Supervisor	1	800	12	9 600
Drilling team (2 groups)	10	200	10	20 000
Builder/pump technician (2 groups)	6	150	12	10 800
Geophysical team	4	150	10	6 000
Logistics	1	300	12	3 600
Community workers	5	100	12	6 000
Labourers	6	50	12	3 600
Others	5	100	12	6 000
Total	38			65 600

2. EQUIPMENT	Number	Total cost (US\$)	
Water equipment	1	45 400	
Tools and consumables	1	11 882	
Equipment for 40 boreholes	1	39 000	
Total		96 282	

3. LOGISTICS	Quantity /month	Unit cost (US\$)	Total (US\$)
Warehouse	2	3 000	6 000
Vehicle	24	2 400	57 600
Motor-cycle	3	1 938	5 814
Bicycle	3	100	300
Fuel and maintenance	24	400	9 600
International transport (tons)	3.5	4 500	15 750
Total			95 064

4. ADMINISTRATIVE COSTS	Duration (months)	Unit cost (US\$)	Total (US\$)
Educational materials	10	300	3 000
Communications costs	10	100	1 000
Total			4 000

Table 8.XXXI shows costs of drilling equipment.

Table 8.XXXII shows costs of consumables for 40 boreholes.

Table 8.XXXI: Cost of drilling equipment.

Description	Quantity	Unit cost (US\$)	Total (US\$)
Complete kit ACF-PAT201	2	10 500	21 000
Pumping-test kit	1	3 000	3 000
50 m water-level dipper	2	600	1 200
Water-analysis kit	1	1 000	1 000
Bacteriological-analysis kit	1	3 000	3 000
Conductivity meter	1	700	700
Ωmega+ resistivity meter	1	5 500	5 500
Computer	1	2 000	2 000
Motor-pump & accessories	1	3 000	3 000
Spares	1	5 000	5 000
TOTAL			45 400

Table 8.XXXII: Costs of consumables for 40 boreholes.

Description	Quantity	Unit cost (US\$)	Cost (US\$)
<i>Borehole</i>			
103x113 mm casing (10/borehole)	400	12	4 800
103x113 mm screen (4/borehole)	160	18	2 880
167x180 mm pre-casing (2/borehole)	80	27	2 160
filter gravel (600 l/borehole)	24 000	0.05	1 200
diesel (20 l/borehole)	800	0.85	680
petrol (30 l/borehole)	1 200	1	1 200
<i>Apron</i>			
cement (8 bags/borehole)	320	12	3 840
sand (0.5 m ³ /borehole)	20	12	240
bricks (500/borehole)	20 000	1	20 000
weld-mesh (1 sheet/borehole)	40	20	800
stone (2 m ³ /borehole)	80	15	1 200
handpump	40	donation	
TOTAL			39 000

3.2 Bedrock area

This example of a programme deals with the purchase of an ACF-PAT 301 drilling rig capable of drilling in rotary and in DTH-hammer mode in an African bedrock area. The 6-month project includes drilling 10 boreholes of an average depth of 50 m (Table 8.XXXIII to Table 8.XXXVI).

Table 8.XXXIII: Total budget for an ACF-PAT 301 drilling programme.

Summary	Total amount (US\$)			
1. Local staff	11 100			
3. Equipment	106 306			
4. Logistics	83 521			
5. Administrative costs	2 400			
GRAND TOTAL	203 327			

1. LOCAL STAFF	Number	Salary (US\$)	Duration (months)	Total (US\$)
Supervisor	1	300	6	1 800
Driller	1	50	6	300
Driller assistant	5	30	6	900
Builder	1	40	6	240
Builder assistant	4	30	6	720
Geophysics technician	3	30	6	540
Driver	3	200	6	3 600
Labourer	5	50	6	1 500
Others	5	50	6	1 500
Total	23			11 100

2. EQUIPMENT	Quantity	Total cost (US\$)
Drilling rig and equipment	1	88 050
Drilling tools and consumables	1	7 391
Equipment for 10 boreholes	1	10 865
Total		106 306

3. LOGISTICS	Quantity /month	Unit cost (US\$)	Total (US\$)
4x4 vehicle	1		30 000
Drilling truck	1		15 000
Truck maintenance & fuel (month)	6	778.5	4 671
Light vehicle maintenance & fuel (month)	6	1 100	6 600
Road transport (month)	2	3 500	7 000
International transport (t)	4.5	4 500	20 250
Total			83 521

4. ADMINISTRATIVE COSTS	Duration (month)	Unit cost (US\$)	Total (US\$)
Stationery	6	200	1 200
Communications costs	6	200	1 200
Total			2 400

Table 8.XXXIV: Cost of equipment.

	Quantity	Unit cost (US\$)	Total (US\$)
Complete ACF-PAT 301 RT kit	1	26 000	26 000
Atlas Copco XAHS 175 compressor	1	40 000	40 000
Rotary drilling tools	1	1 900	1 900
8"1/2 three-bladed bit (216 mm)	2		
6"1/2 three-bladed bit (165 mm)	2		
3"7/8 three-bladed bit (99 mm)	2		
F 2"3/8 PAI REG x F 2"3/8 API REG adaptor	2		
F 2"3/8 API REG x F 3"1/2 adaptor	2		
DTH hammer tools	1	6 800	6 800
Stenuick Challenger 4 hammer	1		
150-mm drilling bit	4		
105-mm drilling bit	2		
assembly spanners for 150 & 105-mm drilling bits			
Pumping-test kit	1	2 500	2 500
Resistivity meter	1	5 000	5 000
Water-level dipper 50 m	1	1 000	1 000
Water-analysis kit	1	500	500
iron (ref. 11136C)	1	150	150
manganese (ref. 14768)	1	200	200
Computer and printer for report and monitoring of drilling	1	3 000	3 000
GPS	1	1 000	1 000
TOTAL			88 050

Table 8.XXXV: Cost of drilling consumables.

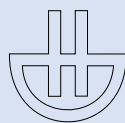
Item	Quantity	Unit cost (US\$)	Total (US\$)
<i>Borehole</i>			
103 x 113 mm casing (10/borehole)	100	12	1 200
103 x 113 mm screen (6/borehole)	60	18	1 080
167 x 180 mm pre-casing (4/borehole)	40	27	1 080
plug	10	5	50
filter gravel (600 l/borehole)	6 000	0.05	300
diesel (500 l/borehole)	5 000	0.85	4 250
petrol (150 l/borehole)	1 500	1	1 500
<i>Washing area</i>			
cement (11 bags/washing area)	55	12	660
sand (1 m ³ /washing area)	5	12	60
gravel (2 m ³ /washing area)	10	30	300
weld-mesh (1.5 sheets/washing area)	8	20	160
stone (3 m ³ /washing area)	15	15	225
TOTAL			10 865

Table 8.XXXVI: Costs of tools and minor consumables.

Item	Quantity	Unit cost (US\$)	Total (US\$)
Water tank	1	1 500	1 500
Metal shuttering mould	1	1 000	1 000
Toolkit	1	1 200	1 200
Bolt cutter for reinforcement bars	1	480	480
Measuring tape (100 m)	4	30	120
Pickaxe	10	3	30
Shovel	10	3	30
Hoe	10	3	30
Spirit level	2	30	60
Measuring tape (5 m)	10	6	60
Bucket	10	5	50
Wheelbarrow	2	20	40
Wood saw	2	10	20
Hammer	5	5	25
Sledgehammer (5 kg)	2	8	16
Hydraulic oil (l)	50	3	150
Drilling oil (Azolla) (l)	50	5	250
Motor oil (l)	50	2.5	125
Grease (kg)	30	5	150
Polycol (kg)	50	10	500
Drilling foam (l)	100	3	300
PVC 2" dia. screwed pipe (3 m)	20	15	300
PVC 2" dia. screwed pipe (1 m)	3	15	45
PVC screwed elbow for 2" PVC pipes	2	10	20
Rubber boots	15	10	150
Gloves	20	8	160
Waterproof coats	10	30	300
TOTAL			7 391

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HERMANN  ÉDITEURS DES SCIENCES ET DES ARTS

The illustration on the cover is from Souffles du monde–BKK, Erik Sampers, ACF Liberia.

ISBN 2 7056 6499 8

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