

**Borehole siting, borehole drilling, borehole
rehabilitation and borehole contract management**

**Evaluation of Best Practices in BSF Project Area,
Southern Sudan – Draft version**

Basic Services Fund (BSF) for Southern Sudan

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Glossary

BMB MM	BMB Mott MacDonald, BSF management consultant
BoQ	Bills of Quantities
BSF	Basic Services Fund
DFID	Department for International Development
DRWS	Directorate of Rural Water and Sanitation
E. coli	Escherichia coli
GoSS	Government of Southern Sudan
JDT	Joint Donor Team
MDTF	Multi Donor Trust Fund
NGO	Non Governmental Organisation
PHCU	Public Health Care Unit
RWSSP	Rural Water Supply and Sanitation Project (under Multi Donor Trust Fund)
SPLM	Sudan Peoples' Liberation Movement
WHO	World Health Organisation
WP	Water point

Executive Summary

BSF for Southern Sudan's Phase 1 Mid-Term Review recommended Lessons Learnt analysis for each Sector (Primary Education, Primary health and Drinking Water). This report covers the assignment of Lessons Learnt for drinking water. According to a baseline survey carried out in 2004, access to rural safe water and sanitation in Southern Sudan was 25-30 percent. Part of the joint GoSS Development's objective adopted for 2011 is to double these access figures. The Basic Services Fund (BSF) for Southern Sudan was developed within this framework and launched by DFID in January 2006.

Within the framework of Basic Services Fund's activities in water supply in Southern Sudan implemented during the first and second round through seven NGOs, Clarissa Mulders was contracted to analyse the approach to drilling and rehabilitation of boreholes and come up with Lessons Learned aimed at improvement of future projects similar in set up and nature as the one implemented by BSF. The assignment, with a time input of 18 days, started with signing of the contract in June 2008, whereas a debriefing workshop will be held in February 2009. The assignment included the collection and subsequent desk study of available information including available geophysical siting reports, borehole completion reports, borehole databases, hydrogeological map of Southern Sudan, and grant recipients' budgets. During the assignment discussions with most BSF partners as well as the BSF Secretariat in Juba were held, and a field trip was made to visit the new boreholes in the AMREF / Aquafund International's project area. The output of the assignment included a presentation / debriefing held on 12 February 2009 at the Government Accountancy Training Center in Juba, for which GoSS representatives, UNICEF as Sector Lead, grant recipients of the first two BSF proposal rounds as well as of the third round, Pact Sudan, USAID and consultants from RWSSP were invited.

In a relatively short time frame of 2.5 years, BSF has been able to install 169 and rehabilitate a total of 48 boreholes close to health centres in remote areas of Southern Sudan having hardly any infrastructure, combined with community mobilisation and training. This means that through the BSF fund, 65,100 people gained access to safe water, assuming one borehole covers 300 people (or 108,500 using the Sphere Standards of 500 people per borehole). This is an important achievement that is certainly due to the selected approach of contracting various NGOs already operational in the various areas at the same time. The water quality and quantity of the boreholes appears however questionable in cases, as deducted from sparsely available information from test-pumping and water quality records.

Only Medair and Oxfam GB issued separate siting contracts and could produce siting reports. Almost all boreholes drilled during the first two rounds were drilled in sedimentary formations, all of which were installed. These boreholes were drilled without any preceding siting. Dry / low yielding boreholes were those drilled in

Basement, or in the boundary zone between Basement and sedimentary formations, where Basement was found at shallow depth. The consultant tentatively concludes that geophysical siting is not required in most of the sedimentary formations in BSF's area of operation, but will increase the success-rate in the Basement formations, where 4 out of the five boreholes drilled by AMREF/Aquafund International were dry..

Oxfam and Medair employed their own drilling rig, whereas the other grant recipients subcontracted the drilling works. Apart from IRC, no grant recipient issued drilling contracts including technical specifications. Not a single grant recipient employed a fulltime drilling supervisor, and half of the grant recipients could not produce borehole completion reports. Water quality tests carried out varied among grant recipients from no tests done, to a maximum of 16 parameters. Grant recipients generally carried out handpump installation, regardless of sometimes occurring objectionable water quality in terms of turbidity, iron and salinity, or even borehole water posing health risks, in terms of nitrate, manganese and fluoride.

Overall direct drilling costs vary greatly from an average of 7,280 US\$ to 15,500 US\$ per borehole, which cannot be justified through degree of remoteness of the area or other logistical challenges, but rather through the different types of contract, with Bills of Quantities based contracts tendered out being more cost-efficient.

The selection criteria for rehabilitation of the 48 non-functional boreholes are not clear, whereas rehabilitation reports were not available, with greatly varying unit costs for rehabilitation per grant recipient.

Drilling supervision and contract management has been inadequate at the level of the BSF Secretariat, grant recipients and drilling contractors. The Consultant makes recommendations on how this can be overcome in a next round. The BSF Secretariat is to specify, in concert with DRWS, minimum standards for borehole water quality and quantity, and ensure contract quality of grant recipients with drilling contractors. A contract between the BSF Secretariat and the grant recipient is recommended, including payment terms, installation terms, reporting details, and the need for fulltime drilling supervision. In addition, contracts between grant recipients and drilling contractors need to be drawn up, including a financial section (type of contract, payment terms including retention, and advance payment securities and performance bonds), a terms of reference including hydrogeological information, designs, time schedule and technical specifications including water quality, test-pumping and development requirements, and responsibilities regarding completion reports and submission of data to the WES database. The Consultants recommends Bills of Quantities based contracts coupled with fulltime supervision by an independent supervisor as the most cost-efficient way of reaching JAM and MDG targets in Southern Sudan.

The available borehole database as well as the national hydrogeological map have not been used in the planning of new / rehabilitated boreholes. The Consultant recommends that grant recipients analyse these sources of information to optimise the effectivity of their borehole projects.

1 Introduction

Within the framework of the BSF Project, Clarissa Mulders was contracted to study the role of hydrogeological and geophysical surveys and set up of siting and drilling contracts in improving efficiency and effectiveness of the water implementation activities, in view of the number of low-yielding and saline boreholes constructed by March 2008. The Terms of Reference for the assignment is given in Annex 1. The Consultant started the assignment in June 2008. The NGOs/BSF partners with a drinking water component were requested to submit all relevant documentation of the drilled boreholes, the records of hydrogeological surveys, their geophysical siting contracts, drilling contracts and borehole rehabilitation contracts; and their activities for borehole rehabilitation. These data were analysed during a desk study. By end September 2008, the consultant visited Juba for a briefing meeting with the BSF Secretariat, met all NGOs with a drinking water component based in Juba, and made a field trip to the AMREF / Aquafund International area of implementation. Based on the results of the desk study, the discussions with the BSF partners as well as BSF secretariat, and the results of the field trip, this report on Lessons Learnt was prepared. A debriefing workshop will be held in February 2009.

The report commences with a background to the Project Basic Services Fund (BSF) for Southern Sudan, especially with regard to the prevailing water supply situation, in Section 2. In Section 3, the water sector in Southern Sudan is described. In Section 4, an analysis is given of the drinking water component results of all seven BSF partners. Section 5 describes the contracts currently applied by the BSF partners to set the framework for implementation or rehabilitation of boreholes by subcontractors. Section 6 concludes the report, by providing a description of best practices in the provision or rehabilitation of boreholes in the BSF project areas in Southern Sudan.

2 Background

Protected water points (WP) in Southern Sudan have been built since the beginning of the last century. UN-Operation Lifeline Sudan prepared an update of its WES database by January 2004, and reported that over the last 50 years more than 6,650 attempts have been made to construct WPs. Of these attempts, around 5,500 have been successful at the time. Bahr el Ghazal and Equatoria take the main share of these WP with 2,050 and 2,100 respectively. Upper Nile has 650 water points. Most active periods of construction were the early eighties and the late nineties. Borehole drilling in Upper Nile started only in recent years. In 2004, the water supply situation was schematised by Swiss Humanitarian Aid using UN's Operation Lifeline Sudan WES database, as depicted in Figure 1. Assuming that all water points are functioning and placed in an optimum location so that uniform coverage per Payam is guaranteed, it follows that only the counties coloured dark blue are appropriately covered.¹ The actual coverage is likely to be much worse, as many WP have broken down.

Restoring peace and harmony through access to basic services, including education, health and water and sanitation is one of the four key elements as laid out in Sudan's strategic framework for war-to-peace transition². According to a baseline survey carried out in 2004, access to rural safe water and sanitation in Southern Sudan was 25-30 percent. Part of the joint GoSS Development's objective adopted for 2011 is to double these access figures. New water systems should be sited as close as possible to schools and health facilities³.

¹ Sphere Standards assume that a borehole equipped with a hand pump can supply 500 people with drinking water, whereas national standards in Uganda use standards coverage figures of 300 people per borehole.

² SPLM Strategic Framework for War-to-Peace Transition, SPLM Economic Commission, New Site, August 2004.

³ Joint Assessment Mission South Sudan, Framework for Sustained Peace, Development and Poverty Eradication, Volume I Synthesis, March 2005

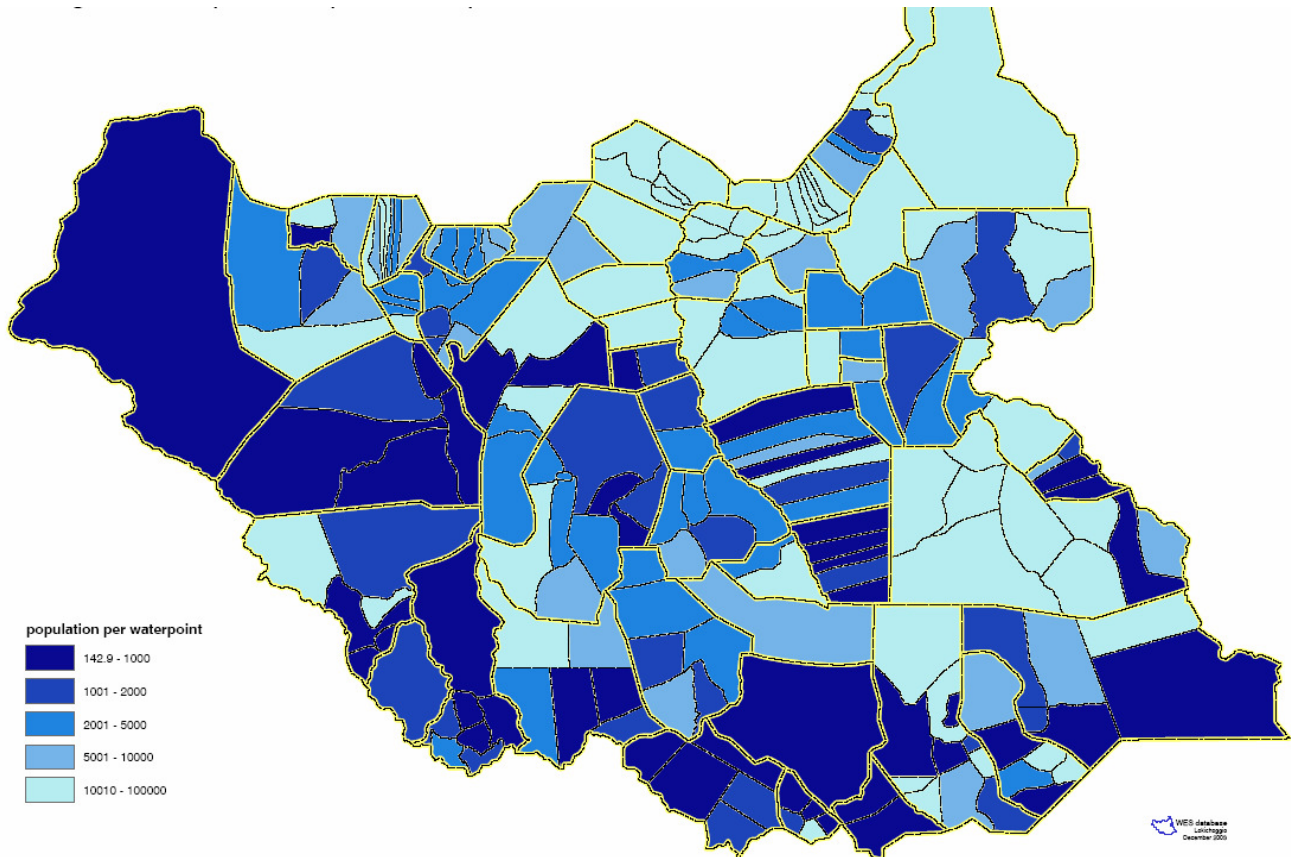


Figure 1 Population per water point in Southern Sudan by 2004

(Source: www.unjlc.org/ImportedObjects/19363/download).

The Basic Services Fund (BSF) for Southern Sudan was developed within this framework and launched by DFID in January 2006. The BSF Secretariat, operating from Juba aims to improve access to basic services for communities in Southern Sudan by management of the BSF Fund. The BSF is part of a combined package of support to Southern Sudan from the United Kingdom, Netherlands, Norway, Sweden and Denmark, managed through the Joint Donor Team (JDT) office in Juba.

The purpose of the project is to assist the Government of Southern Sudan with the provision of basic services, via non state actors, to the most under-served populations in Southern Sudan. Basic services are defined as primary education, primary health care and basic water, sanitation, and hygiene education. On 19 August 2006, DfID appointed BMB MM as BSF's management consultant.

A total of £15.6 million of funding has been awarded, through competitive selection, to 14 NGOs. The Steering Committee selected six NGOs in the 1st round starting January 2006, and eight in the 2nd round starting January 2007. In November 2007, DfID approved extensions of the NGO interventions,

whereas in July 2008, DfID in consultation with the Steering Committee announced BSF's extension to end August 2010.

Proposals with cross-sectoral synergies were encouraged. NGOs submitting proposals for a.o. water supply construction included five in the first round and two in the second round. The total number of planned boreholes varies depending on the source of information; the Terms of Reference for this assignment mentions 229 boreholes, the Review of the BSF (by Triple Line Consulting; February 2008) mentions 210 WPs (not specifying the type). According to BSF's approved budgets per partner, commitments were made for the drilling of in total 195 boreholes, rehabilitation of 65 boreholes, construction of 5 shallow wells and rehabilitation of 15 shallow wells. If all BSF's planned WPs will be implemented, BSF's contribution will be 5.5% of the Joint Assessment Mission's target of raising water coverage to 50-60% in 2011. According to the Terms of Reference for this assignment, between January 2006 and end March 2008, "a total of 70 boreholes were completed and from those probably half is successful"; whereas the earlier mentioned Review mentioned the completion of 116 WPs by 1 February 2008. Fact is, that only up to half of the commitment was met only months before the initial completion date.

The fund will evolve into the envisaged funding of basic services by the Multi Donor Trust Fund (MDTF), but through a different funding mechanism, called the Sudan's Recover Fund, as set up by development partners and GoSS..

Three so-called Lessons-Learned short-term missions have been planned; one for each relevant sector namely Primary Education, Primary Health and Drinking Water. This report presents the findings of the Lessons-Learned mission on Drinking Water.

3 The water sector in Southern Sudan

3.1 Historical background

The so-called second civil war that started in 1983, ended with the signing of a final peace treaty in January 2005. The civil war has displaced more than 4 million southerners. Some fled into southern cities, such as Juba; others trekked as far north as Khartoum and even into Ethiopia, Kenya, Uganda, Egypt, and other neighbouring countries. These people were unable to grow food or earn money to feed themselves, and malnutrition and starvation became widespread. The lack of investment in the south resulted as well in what international humanitarian organizations call a “lost generation” who lack educational opportunities, access to basic services, and little prospects for productive employment in the small and weak economies of the south or the north.

In 1989, Operation Lifeline Sudan (OLS), a tripartite agreement among the Government of Sudan, the UN, and the Sudan People’s Liberation Movement/Army (SPLM/A), was established as the main avenue for assisting the Sudanese population affected by war through a system of negotiated access. OLS has coordinated the work of most of the non-governmental organisations (NGOs) in Sudan. Each NGO has had responsibility for a particular area of the country and has worked closely with the local Sudanese authorities on either side of the conflict, conforming to strict codes of conduct or “ground rules”, based on neutrality. OLS has operated alongside UNICEF, the leading constituent agency, up to 2003, when OLS ended. By January 2004, rural safe water coverage in Southern Sudan was estimated at 25-30% (Southern Sudan WES Database Update, January 2004).

3.2 Available records for planning

Although OLS was ended in 2003, UNICEF is still regarded the leading agency in the water sector (the “sector lead”) in Southern Sudan. UNICEF, in concert with the Directorate of Rural Water and Sanitation (DRWS) has prepared standardised borehole completion logs that all organisations providing boreholes should complete and submit. These data are entered in the WES database at DRWS. Discussion with a representative of UNICEF in charge of safe water supply revealed that enforcement of submission of data by implementing agencies is an issue, as well as the submission of data on dry boreholes.

UNICEF is planning to do an inventory of water sources, as the actual coverage is unknown; a pilot survey is currently undertaken in Yei. A GIS mapping of the WES database has not been undertaken since 2004, and the selection of new borehole sites is ad hoc.

3.3 Supervision by rural water department

There is currently no properly functioning Rural Water Department at county level in Southern Sudan; usually there is one person working for the Department at County level who cannot physically oversee the implementation of water sources nor has the means to do this. Water supplies are implemented by the agencies operational in the regions. DRWS is currently undertaking the elementary training of drilling supervisors, so that there will be two trained supervisors per state.

3.4 Standardised contracts

Siting is usually done by the drilling contractor rather than by consultants. The DRWS does not stress the need for geophysical siting and provides no siting specifications, and siting results do not need to be submitted.

The implementation of standardised drilling contracts is another issue where the DRWS may need assistance. Currently each implementing agency has its own type of contract with greatly varying specifications, if any, on installation, development, test-pumping, and water quality testing. There are guidelines for drinking water standards as well as drilling contracts with DRWS.

3.5 Drilling challenges

The issue of incompetent and too few drilling contractors hampers the water development of Southern Sudan. Boreholes can be drilled only in the dry season 'window' of November to May.

3.6 Operation and maintenance

Operation and maintenance structures are overall very weak, and heavily dependent upon expensive agencies' logistical support. As a result, a large percentage of the existing boreholes is not functional, although exact figures are not known. According to UNICEF's representative, in many cases implementing agencies decide to completely replace boreholes, whereas it is just an operation and maintenance issue. UNICEF is currently providing spare parts, as a result of capacity gaps within GoSS.

4 Analysis of project results per BSF partner

This chapter is based on meetings held with all BSF partners that have an office in Juba, a desk study of available documentation and a field trip made to the area in which AMREF / Aquafund International has been drilling and rehabilitating boreholes for BSF. An overview of the drilling results is provided at the end of this Chapter.

4.1 AMREF / Aquafund International

4.1.1 Results of the field trip

AMREF subcontracted the NGO Aquafund International to drill a total of 20 boreholes, and rehabilitate a total of 10 boreholes (in Tali Payam), in Terekeka County, Central Equatoria. The consultant made a field trip to the project area together with Ms. Geerte van der Meijden of BMB Mott MacDonald, and Mr. Ben Odinga, director of Aquafund International, from 23 to 25 October 2008. The following boreholes were visited during the field trip:

Table 1 Boreholes drilled by AMREF, visited during the field trip

No.	Location	Functionality	Comments
1	Mokido Boma	Not functional	Not enough water in dry season
2	Mokido (replacement for Mokido Boma)	Partly functional	Leaking foot valve so lot of pumping required. This is a maintenance issue. Extra deep hand pump installed.
3	Pagara PHCU	Functional	No users seen, signs of high iron content
4	Triath (Roro)	Functional	Water tastes of iron
5	Mura	Functional	Extra deep hand pump, though not required. No fence
6	Dula Atiit	Functional	Replacement of dry borehole near Atiit PHCU
7	Dari	Functional	
8	Douran	Functional	Only successful borehole in Basement rocks
9	Mina PHCU	Partly functional	Low yield

The boreholes' superstructure including platform was well constructed. In most cases, the community had constructed a fence around the source.

4.1.2 Summary of achievements

Siting

No siting records were made available. Siting was not mentioned in the agreement, and therefore at the discretion of the contractor. Aquafund's director informed the consultant that Aquafund had carried out geophysical siting in Kajobu village and Mading PHCU, yet the boreholes were not successful. Siting included electrical profiling (also called Constant Distance Traversing) using an $\frac{1}{2}$ AB distance of 40 m and an interval of 10 m, a distance that is too short to measure hardrock variations. According to the hydrogeological map of Sudan, the project area is situated in the boundary zone between basement formations and sedimentary formations. This means that close to the basement unit, sediments are penetrated first until the basement hardrock is reached.

Drilling and installation

Aquafund International drilled a total of 26 boreholes in the project area, which include 7 unsuccessful attempts, resulting in a total of 19 successful boreholes⁴ installed with India Mark II hand pumps. Mr. Odinga informed the consultant that five boreholes had been drilled in Basement rock, of which four were dry (corresponding to a 20% success rate in Basement rocks). Only one borehole (in Loyukwe) out of 14 drilled in the sedimentary formation was dry (93% success rate). Drilling records of 9 of the 26 boreholes were made available. These 9 records do not indicate that development has been carried out,⁵ nor test-pumping⁶ to determine optimum pump intake depth and sustainable yield.

Test pumping

No test-pumping records were made available. According to Mr. Odinga, test-pumping was carried out. The Environmental Health Supervisor of AMREF supervised the drilling of eight boreholes since March 2008. He indicated that Aquafund could test-pump for up to one hour per borehole.

The agreement mentioned the water quality testing for chemical and bacteriological constituents for both drilled and rehabilitated boreholes. Four of the nine completion records mention that the water was tested for E. Coli (bacteriological test), whereas no other chemical quality testing has been carried out.

Rehabilitation

A total of 10 boreholes were rehabilitated. No details are available of exact works and actual BoQs of materials installed. The rehabilitation was not supervised. The status of the boreholes before rehabilitation is not known

⁴ One borehole was drilled at the AMREF headquarters in Juba. This borehole was not paid for under the BSF contract.

⁵ Development is the process of improving the yield and water quality of the borehole by removing the sand and silt particles from the screen and surrounding gravelpack and aquifer material.

⁶ Test-pumping is done to determine the yield that the borehole can sustain.

either. The boreholes were rehabilitated at a fixed cost regardless of the rehabilitation works. The contractor, Mr. Odinga informed the consultant that the rehabilitation involved works on the whole superstructure including the platform. The rehabilitation works did not include desilting (flushing) of the boreholes. Interestingly, a borehole in front of the AMREF compound in Tali was not-functional, whereas a new borehole was drilled in Tali centre under the BSF contract.

The consultant was informed that the earlier drilled boreholes are often bacteriologically contaminated as evidenced during rehabilitation works and subsequent sampling, as only the upper 6 m are cased off, and the rest of the hole is left open.

4.1.3 Available well documentation

A summary spreadsheet including location data, total depth, static water level, yield and pump depth was available with BSF. Mr. Odinga informed the consultant that all completion records had been submitted by Aquafund to the DRWS. He delivered a copy of nine borehole completion records to the consultant's office in Kampala. Water quality test results include tests for E. coli only.

4.1.4 Financial analysis

The contract between Aquafund and AMREF for the drilling and rehabilitation of boreholes is part of an agreement covering a much wider package, including primary health care and environmental health services in Terekeka County. Although the agreement mentions an accompanying project document and budget, this document was factually not there.

A financial analysis of borehole drilling and rehabilitation cannot be made in the absence of a drilling contract. A total of 26 drilling attempts were made, to arrive at a total of 19 installed boreholes, at a cost to the client of 294,500 US\$, or 15,500 US\$ per successful borehole. The factual payment per borehole, both successful and unsuccessful, amounts to 11,300 US\$. Rehabilitation was done at a fixed cost of 1,500 US\$ per borehole for a total of 10 boreholes.

4.1.5 Contractual issues

The agreement between AMREF and Aquafund International does not provide any detail on the requested assignment for drilling and rehabilitation of boreholes, e.g. locations, design of boreholes, type of water quality analyses, minimum yield, test-pumping requirements, development requirements, design of platform etc. In view of the total absence of any binding document, it is positive to note that the contractor has redrilled unsuccessful attempts, and has done a professional job on the platforms, which is the only item that the consultant may actually see on the ground.

AMREF paid out Aquafund International on a quarterly basis, based on successfully completed boreholes, at a lump sum rate of 15,500 US\$ per borehole.

AMREF hired an independent engineer to verify the success-rate of the boreholes, by interviewing the communities. The contractor has completed 19 of the 20 boreholes in Terekeka, and installed with hand pumps. He also has rehabilitated 10 boreholes as stipulated in the Agreement. There is an issue with the borehole in Mina; according to the community, the borehole dries up after abstracting some water. According to Aquafund, the borehole has no yield problem, but the situation is a result of lack of maintenance. The water quality testing results could not be made available, and may therefore be disputed until the evidence is provided. What was done according to the contractor is limited to bacteriological tests, chemical constituents as mentioned in the Agreement were not done.

Aquafund International did not hand out the tool kits and quick running spare parts for two years to the communities, apparently following delayed disbursement by AMREF of funds to Aquafund International. The delayed disbursement is related to the Auditor's report on manipulation of the award of contract to Aquafund International by AMREF's former country director, as well as transfers of funds without the required related quarterly reports. The current country director indicated that the described inappropriate activities were being verified, and that AMREF also insisted on a letter from Aquafund International's attorney indicating that they will withdraw from taking legal actions following the delayed payment.

4.1.6 Conclusions and recommendations

Appropriate siting, drilling and rehabilitation contracts need to be prepared and followed up. Copies of siting and borehole completion records, and copies of water quality analyses have to be submitted as was stipulated in the Agreement. Boreholes should only be installed when the sustainable yield and water quality is to the standards as set. It is recommended that the contract specifies that for every borehole a 3-hours constant rate test pumping is required at minimum rate of 0.7 m³/hr, followed by recovery. It is also recommended that a summary of required water sample tests should be included.

Geophysical siting of boreholes in Basement rocks increases the success-rates of boreholes. The profiling depth should be based on the depth to hardrock; as a rule of thumb the ½ AB distance should be 80 m or more. Geophysical siting in sedimentary formations in Southern Sudan is usually not required to obtain sufficient yields for hand pumps, as can also be seen from the drilling completion records.

Full-time drilling and rehabilitation supervision is necessary when having BoQ contracts, and developing and test-pumping supervision is necessary when lump sum contracts have been made where only successful boreholes are paid for.

Based on submitted records, it is concluded that water quality analyses were carried out for part of the boreholes only, and were restricted to E. coli analyses. 75% of reported analyses in the completion records handed to the consultant mention E. Coli presence, which is an indication for faecal pollution, and makes the water unfit for consumption, unless boiled. It is therefore recommended to re-sample these boreholes as it normally not occurs in new boreholes, and if found present, (shock) chlorinate the borehole. Furthermore, it is recommended to carry out additional tests specifically on elements that pose a health risk. These elements include nitrate, nitrite, copper, manganese, arsenic, fluoride, sulphate and chloride.

The Mina borehole needs to be test pumped to determine whether the yield and installation depth of the pump are appropriate. Otherwise, all drilling works for 19 boreholes have been completed and should be paid for.

4.2 Caritas

4.2.1 Summary of achievements

Caritas Suisse made a budget for the drilling of 36 boreholes, and rehabilitation of 30 boreholes, at a unit cost of 11,000 US\$, and 600 US\$, respectively. The contractually agreed budget sum was for the drilling of 20 boreholes, and rehabilitation of 30 boreholes. According to BSF's quarterly report, by end June 2008, 18 boreholes had been completed, and 8,665 US\$ was spent on rehabilitation (which using the unit costs would amount to some 14 boreholes). No records had yet been made available to BSF.

4.2.2 Available well documentation

The Consultant, upon her request for drilling and siting contracts and drilling records received rudimentary records for 17 successful boreholes, out of 19 drilling attempts. No contracts, and no water quality data were made available.

There is no evidence of geophysical siting of the boreholes, yet the well log data suggest basement rocks, where siting would increase the success rate.

The boreholes have been constructed using both the open hole and the shallow design. Both steel casing and uPVC casing are used, sometimes a combination of the two types of casing in one hole. There is no indication of on-site supervision by the Client

No test pumping data were made available though rudimentary information for some of the boreholes on 'yield test duration' is provided, varying from 30 minutes to 2 hours.

Caritas informed the Consultant that no contract was signed with the drilling contractor, and that the agreement was full payment after each successful borehole. Siting of the boreholes was the responsibility of the drilling contractor. According to Caritas Suisse, Caritas staff visited every borehole during the time of drilling and after finishing each borehole.

4.2.3 Financial analysis

A financial analysis is difficult to make in the absence of hard figures on number of boreholes, and contractual arrangements. A unit price of 11,000 US\$ per successful borehole is higher than the unit cost of 16,000,000 Ugandan Shillings (about 9,200 US\$) per borehole as drilled by Draco Ltd. for AVSI/Merlin, both projects in Eastern Equatoria. Total booked expenditures on the construction of boreholes by end May 2008 amount to 174,201 US\$, which would amount to 10,427 US\$ per borehole, assuming all 17 boreholes had been accounted for by that date.

4.2.4 Contractual issues

No contract was signed. It is not clear whether there are any outstanding issues.

4.2.5 Conclusions and recommendations

The limited available information supplied by Caritas Suisse suggests that record keeping has been weak, and supervision taken place has not been documented. It is unclear on what basis Caritas has paid out the Contractor. Pertinent information on sustainable yield or good water quality does not seem to be available.

4.3 IRC

4.3.1 Summary of achievements

Siting

No geophysical siting was carried out for this contract. This turned out to be a good decision as all boreholes had an aquifer in the sediments, although in a number of boreholes Basement rock was encountered at depth.

Drilling and installation

A total of 20 new boreholes and the rehabilitation or development of 15 wells was planned for in Northern Bahr-El-Ghazal according to IRC's budget. In reality, IRC completed 35 boreholes, whereas there were still funds available for

another 5 within the present BSF arrangement; 14 wells had been rehabilitated by end September 2008, whereas another five would be rehabilitated during the first extension. The boreholes were constructed by Geotechnical Drilling Company Ltd. IRC received the completion report and water quality reports of the first twenty boreholes.

Test pumping

(Constant rate) test-pumping was done for 3 – 6 hrs. This is a sufficient time span to determine whether the borehole may be installed with a hand pump.

4.3.2 Available well documentation

The well documentation including water quality reports of the first 20 boreholes is adequate, and provides the requested information.

4.3.3 Financial analysis

IRC budgeted the drilling of 20 boreholes for an average unit rate of 7,280 US\$, which is a competitive price. The price was obtained following competitive bidding for a BoQ-based contract, which turns out to be cost-efficient.

4.3.4 Contractual issues

IRC is the only NGO contracted by BSF that implemented a Bills of Quantities⁷ drilling Contract in which the terms of reference, obligations of all parties, quality control and payments terms were clearly stipulated; this means that the boreholes were paid according to actual quantities consumed rather than lump sum per completed borehole. Finally, the contractor was paid for completed boreholes, rather than for successful boreholes only. Provided there is competent drilling supervision on site, this type of contract is favourable for both the Client and the Contractor.

In addition, the contractor had to provide a bank guarantee for the amount of the advance payment (20% of the contract sum), and a performance security of 20% issued by a bank. This provided to be a challenge, as smaller companies cannot set such amounts aside for the duration of a contract, especially when there is a retention period. However, still four drilling companies submitted a bid, which proves that performance securities are feasible.

The Terms of Reference given in the Contract are very strict, and not always required. It is interesting that the contract was all the same signed and payments made, as strict implementation would have led to unnecessary high costs. Examples are in the first place the stipulated duration of the test pumping of 24 hours, which is not required, and therefore not cost-efficient. Secondly the installation of gravel pack from the bottom until 6 m below the ground surface, which is also usually not required unless the screens cannot adequately be

⁷ The priced Bills of Quantities could not be made available

placed opposite the aquifer zone. Both requirements were not implemented by the contractor.

4.3.5 Conclusions and recommendations

Siting is not necessary in the sediments of Northern Bahr-EI-Ghazal. Half of the surface area is in Basement rocks; in Basement rocks siting is still deemed necessary to increase success-rates.

IRC managed to implement a BoQ drilling contract, including also a performance security. This turned out to be efficient, and made money available for another five boreholes.

4.4 Merlin / AVSI

Merlin partnered with the NGO AVSI to carry out the drilling works. AVSI employed Draco (S) Ltd. to do the siting and drilling of the boreholes.

4.4.1 Summary of achievements

Siting

Siting was carried out by execution of one Vertical Electrical Sounding (VES) per location. Nine out of ten VESes show a rise of 45 degrees at depth, indicating fresh bedrock rather than sediments. This bedrock was confirmed through drilling.

Drilling and installation

A total of ten boreholes were drilled as per contract, all installed with India Mark II hand pumps. The boreholes were tested for selected parameters against threshold values for potable water in the NWSC laboratory in Uganda, and all 10 boreholes have potable water (meaning without any health risk), whereas 8 are of good chemical quality.

No independent supervision was carried out on the implementation of the drilling works. Merlin's country director assumed that BSF submits the records to the database of DRWS.

Test pumping

The boreholes were test-pumped for three hours at a constant rate, followed by measurement of recovery. This is a good practice for testing boreholes to be equipped with hand pumps. A stabilising water level indicates a sustainable yield at a particular pumping rate. However, six out of the ten tested boreholes did not stabilise and therefore have a lesser sustainable yield than the tested yield. One of these boreholes, Guniuro did not sustain 400 litres/hour, and is therefore low yielding (a hand pump typically pumps up 700 litres per hour); this

borehole was installed, which makes sense as this village was confirmed to have 93 inhabitants only.

Rehabilitation

No rehabilitation was carried out by Merlin / AVSI. The Country Director asserted however that many boreholes constructed by Unicef that were initially drilled in Southern Sudan have collapsed, and rehabilitation of existing boreholes should be prioritised, if the rehabilitation would be cost-effective.

4.4.2 Available well documentation

The information on the boreholes is well documented.

4.4.3 Financial analysis

The completion report mentions a lump sum payment of 16.5 M Ugandan Shillings per borehole (some 9,200 US\$), for a total of ten boreholes. It is not clear whether the lump sum payment is for successful boreholes only, as all drilled boreholes were regarded as successful.

4.4.4 Contractual issues

Apart from the one-page partnership agreement between Merlin and AVSI, no contract was submitted to the consultant. The borehole completion report mentions “contractual obligations”, suggesting some form of contract.

4.4.5 Conclusions and recommendations

The country director of Merlin acknowledged that water and sanitation is not a speciality of the NGO. He suggested that for a next phase, the BSF partners together with the government institutions should decide on how to divide the work according to specialization.

4.5 Medair

4.5.1 Summary of achievements

Siting

Geophysical site investigations were carried out for only 5 of the 10 boreholes (Groundwater Survey Kenya Ltd, 2004). The report did not mention the possibility of penetrating saline aquifers, though the soundings are characterised by significant layers with specific resistivities below 5Ωm, which is an indication for either saline water or clay⁸.

Drilling and installation

⁸ It should be noted that extremely low resistivities are not by default pinpointing saline aquifers; Oxfam's boreholes in Upper Nile were only partly saline, whereas measured apparent resistivities of less than 2 Ohm were measured (see also Section 4.6.1)

Drilling was done using Medair's own PAT 301 rig at all 10 sites. Nine out of 10 boreholes were installed, though nine of the 10 are saline. No completion report was made available to the consultant. According to Medair, notwithstanding their saline water, 60% of the boreholes are still used demonstrating the great need for drinking water in that area.

Test-pumping

No test-pumping records were made available.

Rehabilitation

No boreholes were rehabilitated, as there were no boreholes found suitable for rehabilitation.

4.5.2 Available well documentation

Geophysical data could all be made available, apart from a contract made with one contractor. These reports are well prepared and clear. However, the first report on which the BSF drilling works were based, did not mention the option of saline water.

4.5.3 Financial analysis

The rig was paid fully from BSF funds. On actual water supply implementation costs for 10 boreholes and five shallow wells, Medair booked 62,357 GBP. Assuming that the shallow wells jointly did not cost more than 2,357 GBP, it follows that some 6,000 GBP, or 9,000 USD was booked per borehole.

4.5.4 Contractual issues

There have been no contractual issues.

4.5.5 Conclusions and recommendations

Nine out of 10 boreholes, though installed with hand pump, have water with chloride, sodium and total dissolved solids far exceeding WHO guidelines. Although this water is fit for human consumption, it is excessively hard and salty, and therefore objectionable to the population. In this respect the following lessons can be learnt: drilling should have been supervised by a competent hydrogeologist, with conductivity readings taking every 2-3 m, so that drilling can stop once the water becomes too salty. After the first wells, drilling would have stopped pending an evaluation of the siting results. Since end 2006, a hydrogeological map has become available indicating the extent of a saline groundwater zone cover a.o. Melut County. This map should from now on be consulted before planning for boreholes. In Melut County, alternative types of water sources need to be sought.

The consultancy company SWEX did another, more extensive water resources assessment in the area in August 2008, covering the whole of Melut County. In the report it is concluded that the area is characterised by two aquifers. The

upper aquifer has hard and saline water, whereas the second aquifer is very hard, but not saline, and therefore potable. Therefore, the first aquifer should be sealed and cased off, and the deeper aquifer penetrated. This would need boreholes drilled down to on average 140 m deep, with an associated cost of 18,500 US\$ per borehole. It may be concluded that this groundwater development option is too costly, and alternative options should be further explored, including e.g. household filtration of water from surface water sources.

4.6 OXFAM

4.6.1 Summary of achievements

Siting

Siting was done for twelve sites only, of which three could be found in the database of drilled boreholes (siting was carried out by Geolink Associates, Nairobi, November 2006). These three sites have fresh groundwater, though their apparent resistivities measured through VES have extremely low resistivity values.

Drilling and installation

A total of 80 boreholes was planned for. By the time of visiting the Oxfam office in Juba for the lessons learnt mission (22 September 2008), a total of 74 boreholes had been drilled with mud-drilling using the two PAT301T rigs owned by Oxfam, all of which have reportedly a sufficient yield for hand pump installation⁹.

Test-pumping

No test-pumping of the boreholes has been done.

Borehole rehabilitation

There are no details on what rehabilitation works have been carried out on each borehole.

4.6.2 Available well documentation

Oxfam only records successful drilling attempts in its database. All borehole attempts are successful, with a high recorded average airlift yield of 13.6 m³/hr. Records were available for 73 boreholes. The boreholes were not test-pumped, and actual sustainable yields have therefore not been established. According to Oxfam's database, water quality records were available for 47 of the first 48

⁹ The drilling was done with a diameter of 6.5", whereas the installed casing had a diameter of 4". The borehole installation follows the shallow well design, which means that the casing is installed down to the bottom of the hole. The boreholes were all drilled in sedimentary formations.

boreholes¹⁰, whereas hand pumps had been installed in the first 60 boreholes. Out of the 47 boreholes sampled, 22 boreholes have water that is not fit for human consumption (having adverse health effects), based on values for nitrite, copper, manganese and/or fluoride exceeding maximum allowable WHO guidelines; this corresponds to 47% of the sampled boreholes. Other boreholes have an objectionable water quality due to high salt content or turbidity (5, and 20 boreholes, respectively). All in all, a total of 36 of the 47 boreholes that were subjected to water analysis have water that is not fit for human consumption and/or objectionable though without health risks. However, all boreholes were installed with hand pumps.

The BSF drilling works, as carried out by the Oxfam drilling team were not supervised by an independent supervisor. The Consultant was informed that drilling works subcontracted to drilling contractors is also not supervised¹¹.

4.6.3 Financial analysis

Oxfam uses their own drilling equipment, and apart from overhead costs, only charges for rig maintenance, consumables, and costs for logistics including fuel, freight costs, truck hire and (off)loading (the latter four items for both water and sanitation works). In general, the actual expenditures on budget lines for the water project appear to have been adequately followed. Exceptions including overshooting of individual budget lines are the reported expenses for India MKII Pumps, which could equip 211 boreholes with hand pumps instead of the 80 planned boreholes, and water quality testing consumables. Summing costs for direct consumables, rig maintenance and logistics for the construction of a maximum of 80 boreholes plus rehabilitation of 24 boreholes, it follows that the average cost per borehole, both new and rehabilitated, excluding remuneration package of the drilling team (covered under the budget heading Human Resources) amounts to 9,850 US\$. As rehabilitation costs are generally much lower than construction costs, the costs for constructing a borehole will be higher, but less than 12,850 US\$ (which would be the total expenditure divided by 80 rather than 104).

4.6.4 Contractual issues

There are no contractual issues, as Oxfam has not subcontracted the drilling works. Up to June 2008, the direct costs for the water supply component exceeded the total budget grant including additional grant for these budget lines by 3%.

¹⁰ The boreholes were tested for the following contents: thermotolerant coliform, turbidity, total dissolved solids, nitrate, nitrite, ammonia, aluminium, sulphate, iron, copper, manganese, fluoride, chloride and arsenic

¹¹ Oxfam's approach when subcontracting private drilling contractors is to subcontract the siting and drilling to one company. In a low potential area, as indicated by the siting results, the contractor will not drill; if the contractor drills and it is dry, then Oxfam only pays part of the borehole.

4.6.5 Conclusions and recommendations

In view of the assumed 100% success-rate, geophysical siting is not required in this part of Southern Sudan.

No test-pumping data are available, and it is therefore assumed that this is not done. This is unfortunate, as test-pumping is required to determine the optimum location of the intake of the hand pump, and will determine whether the yield is enough for installation of a hand pump. It is therefore recommended that test-pumping will be specified as a requirement in future drilling contracts of BSF.

Oxfam makes use of a tailor-made database which is kept up to date as much as possible, containing a lot of useful information. Water quality testing is done after hand pump installation. As a result, 77% of the installed boreholes have water quality problems¹². It is therefore recommended to only install the hand pump after the water quality has been found fit for human consumption. This is possible, as a portable testing kit is used so that results can be obtained relatively quickly.

Twenty out of the 47 sampled boreholes are turbid. This turbidity is highly likely related to an improper completion of the boreholes. Possibilities are that:

- the boreholes are not developed properly,
- the screens are partly placed opposite clayey sections,
- the thickness of the installed gravel pack is not adequate, or
- the slot size of the screens is too large for the type of aquifer material.

It is therefore important that a competent independent hydrogeologist is attached to the drilling team, who can ensure that completion is done appropriately.

No records on rehabilitation were available. It is recommended that rehabilitation works are described in a report, and that a budget for rehabilitation is made based on actual needs. Rehabilitation always needs to include the cleaning of the borehole by flushing it.

¹² Oxfam's project proposal states that " water supplied by Oxfam in all project areas is potable in terms of both physico-chemical and bacteriological water quality. This commitment to accountability to beneficiaries and adhering to internationally recognised standards¹² is in line with Oxfam GB's three-year Public Health Strategy".

Table 2 overview of all boreholes drilled within the BSF contracts

	Organisation	Area of operation (States)	Through / drilling company	PLANNED water sources				ACTUAL water sources				
				New boreholes	Rehabilitated boreholes	New shallow wells	Rehabilitated shallow wells	New boreholes	Attempts	Rehabilitated boreholes	Shallow wells	Rehabilitated shallow wells
1	Oxfam	Upper Nile, Unity	own rig	80	20	0	0	74	74	24	0	0
2	Medair	Upper Nile	own rig	10	5	5	0	10	10	0	5	0
3	AMREF/Aquafund	Central Equatoria	Aquafund International	20	10	0	0	19	26	10	0	0
4	Caritas-Switzerland	Eastern Equatoria	New Sudan Service & Delivery; Mango Camp	20	30	0	0	17	19	no data	0	0
5	Merlin/AVSI	Eastern Equatoria	AVSI / Draco Ltd.	10	0	0	0	10	10	0	0	0
6	IRC	N. Bahr el Ghazal	Geotechnical Drilling Company Ltd.	35	19	0	19	35	35	14	0	0
7	Save The Children - US	Upper Nile	no data	20	0	0	0	4	0	0	0	0
				195	84	5	15	169	171	48	5	0

	Organisation	No. of boreholes drilled	Of which dry/low yielding	unfit for human consumption [No.]*	high mineral content (salty)	turbid	Boreholes installed		
1	Oxfam	74	0	25	5	20	74		
2	Medair	10	0	no data	9	no data	9		
3	AMREF/Aquafund	26	7	3	0	no data	19		
4	Caritas	19	2	no data	no data	no data	no data		
5	Merlin/AVSI	10	1	0	0	0	10		
6	IRC***	20	0	0	0	1	20		
7	Save The Children - US	4	no data	no data	no data	no data	no data		
		163							
*Oxfam: based on test results of first 47 boreholes									
**AMREF: Aquafund carried out E.coli tests. Of the 9 submitted well reports, four E.coli tests were reported, of which 1 had 2 cfu/100 ml., and 2 had more than 10 cfu/100 ml									
*** No. of boreholes drilled based on report of 1st 20 boreholes, and water quality based on records 2nd of 10 boreholes sampled.									

5 Discussion of BSF water supply contracts

Currently, DRWS has not yet made standard drilling contracts including standard specifications. Similarly no national standards for water quality have been set, necessitating the selection of internationally accepted standards, like WHO standards for drinking water.

Contracts between BSF and the individual partners, as well as between BSF partners and their subcontractors are also not standardised with regard to the construction of water points. Few BSF partners could actually produce a siting or drilling contract; some BSF partners only made an Agreement / Memorandum of Understanding with the subcontractor, giving no specifications on how the boreholes were to be drilled, designed and completed, installed, developed, test pumped, no details on hand pump installation, water quality requirements, reporting to the client etc. This makes a comparison of prices and success-rates of boreholes practically impossible.

Contracts documents are required to be able to verify whether the subcontractor has properly completed the job, and can be paid. In the absence of a clear contract document, supervision of works becomes arbitrary. IRC is the only BSF partner that implemented a detailed drilling contract with detailed Terms of Reference and specifications. The other BSF partners operated without a drilling contract, and based their agreement on a lump sum payment based on successfully completed boreholes.

It is recommended to use a standard siting contract and drilling contract. These contracts need to be specific on time schedule of works, payment schedule, advance payment and performance securities, standard designs of boreholes and platforms, standards for development and test-pumping, and minimum water quality standards for installation. Bills of Quantity contracts are favourable in terms of cost-efficiency, but require an independent fulltime supervisor on site.

6 Lessons learnt

1. First of all, in the relatively short time frame of 2.5 years, BSF has been able to construct 169 and rehabilitate a total of 48 boreholes close to health centres in remote areas of Southern Sudan having hardly any infrastructure, meaning 65,100 people gained excess to safe water, assuming one borehole covers 300 people. This is an important achievement that is certainly due to the selected approach of contracting various NGOs already operational in the various areas at the same time.
2. Geophysical siting has hardly been done. In sedimentary formations in Southern Sudan, all boreholes appear successful, and therefore no siting is required to increase success-rates. In Basement formations, geophysical siting will increase success-rates; however, these formations were only struck in few cases, and only resulted in dry boreholes in the AMREF/ Aquafund International project area (Eastern Equatoria, Terekeka County). Based on the limited geophysical siting data, it is concluded that saline aquifers do not show up as distinctly different resistivities, and therefore siting in these formations in Southern Sudan is also not warranted to discern saline aquifers from fresh aquifers.
3. Direct drilling costs, i.e. costs excluding sizeable NGO overheads vary widely from 7,280 US\$ (by IRC in Northern Bahr-EI-Ghazal) to 15,500 US\$ (by AMREF / Aquafund International in Central Equatoria) per successful borehole. Costs logically vary depending on the type of drilling contract, depth and installation details of boreholes, and mobilisation costs as a result of remoteness of an area. However, interestingly IRC drilled its relatively lower cost boreholes in a far more remote area (Northern Bahr el Ghazal) than AMREF / Aquafund International's boreholes (Central Equatoria).
4. Many boreholes have been declared successful whereas their water is of low quality. The biggest challenges are turbidity, iron, hardness, manganese and high mineralization (saltiness). In addition, sustainable yields have often not been determined.
5. Stakeholders in the Sector in Southern Sudan are of the opinion that there are many non-functional and abandoned boreholes in Southern Sudan, yet none of the NGOs appears to have used the information from the WES Database update.

6. Grant recipients should use Southern Sudan's hydrogeological map, and new borehole data from DRWS to delineate areas with saline aquifers, where alternative water supply technologies need to be exploited.
7. Contracts between BSF grant recipients and subcontractors should be based on a standardised contract provided by BSF through DRWS. Payment terms should not be based on completed boreholes, but rather include an advance payment to be able to mobilise and purchase all required materials in one go, to avoid backlogs as a result of the rainy season, as well as a retention period of half a year. The contract should also stipulate the need for a performance bond.
8. Drilling should always be supervised by an experienced drilling supervisor. Even if the contract is a lump sum contract for successful boreholes only, the client still has to have proof that the borehole has sufficient water with the pump intake placed at the correct depth (so has been test-pumped appropriately), and that the water is of good quality (water analyses of relevant constituents carried out).
9. In sediments, borehole water levels may vary significantly over the seasons. Care should be taken that the boreholes are drilled to a sufficient depth so that they do not dry up in the dry season. Minimum depths for boreholes, and corresponding hand pump intakes will depend on the area, and should be analysed before drilling commences.
10. Development should always be carried out until the water is completely clear. This is specifically important in sediments, where silt, clay and proper coarse sandy aquifer material may be encountered at short intervals.
11. Test pumping should be standard, and always be carried out for at least three hours at $0.7 - 1.0 \text{ m}^3/\text{hr}$, followed by recovery measurements, to determine whether the aquifer can sustain hand pumping, and the pump is installed at the optimum depth.
12. All records should be made available to the Client and to DRWS, and this should be mentioned as such in the drilling contract.
13. Ideally, a borehole water quality analysis should also include all major ions, but the consultant recommends to at least include conductivity, pH and temperature (measured at the end of the test pumping exercise), and nitrate, nitrite, turbidity, iron, copper, manganese, arsenic, fluoride, sulphate and chloride (in the laboratory). These will assist to determine whether the water does not pose a health risk, or is objectionable to the users. Bacteriological analysis is normally not necessary in properly installed boreholes, but is useful for existing boreholes that will be

rehabilitated, as these may have installation flaws, and can thus be polluted from surface water entering through the superstructure.

14. Using the WES database, a more cost-efficient approach to increasing safe water coverage can be envisaged, whereby abandoned sources in the denser populated areas can be rehabilitated first where feasible, before drilling new boreholes.

Annex 1 Terms of Reference

Terms of Reference :

Basic Project Data

Project name	Basic Services Fund (BSF) for South Sudan
Launched	January 2006
Project authority	GOSS Steering Committee chaired by Ministry of Finance
DFID Contribution of which:	UK £ 17,216,100
NGO component	UK £ 15,904,600
Technical Assistance component	UK £ 1,311,500
Location	South Sudan
Management contract BMB MM	19 August 2006-31 December 2008

Borehole records, Site selection, Standards (Hydro-geological surveys)

Date: 23 April 2008

BSF has a target of 229 boreholes providing 200,000 peoples with sustainable safe drinking water (this number also one gravity scheme) By the end of March 2008 a total of 70 were completed and from those probably half is successful (by the end of the 2007/08 dry season targets to be completed though). The successful ones include those boreholes that have salt water but with concentrations within WHO's norms of WHO.

Typical issues for evaluations are:

1. Formation and Training of Water Point Committees
2. Female participation
3. O&M in particular use fees
4. Pump mechanic training
5. Spare parts supply chain
6. Suitability pump type
7. Quality water
8. Quantity water

These issues and their lessons learned, are well documented and available in so called grey literature (not officially published but recorded in print nonetheless). For example the JAM records the desirability for O&M and WPC and the fact that in nomadic communities this is always works yet.

Other issues that play an important role in the efficiency and effectiveness of water implementation activities are hardly addressed and include:

1. type and quality of hydrogeological surveys
2. type of borehole siting (water prospecting) and borehole drilling contracts

Hydro-geological surveys are far less prominent in the review. On the one hand this is surprising because good surveys, meeting minimum standards, increase the success rate dramatically. This applies in particular to areas with underlying hard rock. In sediment subsoil the surveys are probably less useful although salt water aquifers may show up in the readings through very low resistivity values. These surveys, that should meet minimum standards, also are in line with DFID's Recovery Principles (see attachment)-away from the emergency (relief the immediate need) to drill for sustainable access to drinking water.

Recent government data show that Less than half (48%) of people in South Sudan use improved drinking water, and that 1,200 new safe water points need to be dug and another 700 rehabilitated per year to meet the projected need. Compare this dismal reality on the ground with Target 10 (halve by 2015 the proportion of people without sustainable access to safe drinking water) of MDG 7 (ensure environmental sustainability). Assuming a population of South Sudan of 8 million, 4 million are without access to safe drinking water.

The estimated cost for a borehole is about \$12,000, but it appears that the technology currently being utilized is far from state-of-the-art. "Donors are reluctant to invest in costly water exploration, so we are left to drill according to trial and error, sometimes drilling as many as 10 holes before we strike water," one humanitarian official told Refugee International (<http://www.refugeesinternational.org/content/article/detail/10144/> accessed on 9 April,2008)

On the other hand these surveys require specialist input and are as such an extra cost. Depending on the underlying geology, (sediment or hard rock) and related depth of the aquifers the boreholes costs in the area of interest vary between twenty and forty thousand dollars. There is a need to evaluate whether the comparatively small additional costs of the hydrogeological surveys usually leading to increased success rates are warranted.

It is not clear what the standards are of the Ministry of Cooperatives and Rural Development. Does MCRD have standard formats for the borehole data collection and processing?

BSF partners are of the view that the quality of the surveys and the records of the surveys vary widely. It is advisable that an evaluation of borehole siting activities and siting and drilling/rehabilitation contracts be carried out based on the outputs of recent water development projects implemented by NGOs and other partners:

The plan is therefore for BSF to:

- 1) Request all partners with a drinking water component to submit for:
 - a. Supervision arrangements of driller,
 - b. Drilling contract,
 - c. Drilling Log (one per borehole),
 - d. Borehole Completion Certificate,
 - e. Lithological log.
 - f. Coordinates of each borehole
- 2) Request all partners with a drinking water component to submit the records of hydro-geological surveys (in case there is no survey, the NGO records how the site was selected (secretariat)
- 3) Request all partners with a drinking water component to submit their geophysical siting contracts, drilling contracts and borehole rehabilitation contracts
- 4) Request all partners with a drinking water component to submit their activities for borehole rehabilitation (what is, and what is not included in the rehabilitation works)
- 5) Create a file per NGO with these documents (secretariat)
- 6) These records will be submitted to a specialist for analysis.
- 7) A briefing and debriefing workshop is part of the assignment
- 8) Secretariat conveys the workshop and the specialist will be the facilitator

- 9) Specialist drafts report on lessons learned on site selection, borehole data processing, borehole designs and minimum required measures to rehabilitate boreholes. This report should also include MCRD¹³ standards (existing and recommended).

¹³ MCRD (Ministry of Cooperatives and Rural Development) with the mandate in rural water supply

Annex 2 Itinerary / People met

1 July 2008 – Meeting with Ms. Klaziena Louwes of BSF in Kampala, Uganda

3 September 2008 - Meeting with Ms. Klaziena Louwes of BSF in Kampala, Uganda

22 September 2008 – Travel from Kampala by air to BSF Secretariat in Juba, Southern Sudan.

Meeting at **Oxfam** – Mr. Sylvain Bertrand, Mr. Zedek Maline

Informal meeting with Klaziena Louwes, Geerte van der Meijden of **BSF**; Mike Wood, consultant for BSF

23 – 25 September 2008 – Field visit to BSF Project Area:

23 September 2008 – Travel from Juba to **AMREF / Aquafund International** Project area in Tali. Stay overnight at AMREF compound in Tali. Visit boreholes constructed for AMREF by Aquafund International. Meeting with Mr. Letro Moses Isaiah, Environmental Health Supervisor of AMREF acting as Water Technician

24 September 2008 – Visit boreholes constructed for AMREF by Aquafund. Stay overnight at AMREF compound in Tali. Meeting with Mr. Ben Odinga, MD of Aquafund

25 September 2008 – Visit boreholes constructed for AMREF by Aquafund. Travel from Tali to Juba. Debriefing at BSF Secretariat on field trip, initial findings and consultations.

26 September 2008 – Meetings with NGO representatives involved in water supply contracts with BSF:

Meeting at **AMREF** office in Juba – Mr. Steve Gikunda.

Meeting at **Merlin** office with Mr. Manohar Shenoy.

Meeting with **UNICEF**'s Mr. Elicad Nyabeeya.

Meeting at **Medair** office with Mr. Kees van Bemmelen and Mr. John Primrose.

27 September 2008 – Meeting with Ms. Kate Foster of **IRC**. Travel back to Kampala, Uganda.

28 September – 20 December – Further communication with BSF partners on missing documents; writing of Lessons Learnt report

10 February 2009 – Travel from Kampala by air to BSF Secretariat in Juba, Southern Sudan.

10-11 February - Discussion and finalisation of presentation material for debriefing

12 February – Debriefing at the Government Accountancy Training Center

13 February – Discussion of outcome of the debriefing and implications for the third round, travel back by air to Kampala, Uganda

Annex 3 Overall recommendations

It is recommended that the construction of new water sources is based on a preliminary needs assessment, or assessment of current coverage. Counties that are best covered in the 2004 update should not be targeted. DRWS should be contacted for the latest coverage details.

Siting is not useful in the sedimentary areas in Southern Sudan. The boreholes appear to almost all yield sufficient water, and salty and hard water cannot be detected as superficial clay layers often mask salt aquifers at depth. Analysis of available borehole records and the hydrogeological map will give a better indication of the presence of salty aquifers. In sedimentary areas that may be salty, the water needs to be tested at intervals of 2 m, so that increasing salt content is noticed in time and drilling can stop. Telescopic drilling to depths exceeding 120 m (drilling through the salty aquifer followed by cementing the hole and continue drilling down into a fresh aquifer) is very costly and therefore not recommended.

In Basement rock, geophysical siting using a combination of geo-electrical profiling and vertical electrical soundings (VES) may increase the success rate substantially. In case of doubt, the results of a VES will demonstrate whether the area is in basement rock (granites, gneisses) or in sediments, because of their distinctly different shape and apparent resistivity values¹⁴.

Test pumping should always be carried out for at least three hours at 0.7 – 1.0 m³/hr, followed by recovery, to determine whether the aquifer can sustain hand pumping, and the pump is installed at the optimum depth.

Development should always be carried out until the water is completely clear. This is specifically important in sediments, where coarse and fine material may be encountered at short intervals.

All records should be made available to the Client and to the ministry of water, as mentioned in the contract.

Contracts between BSP Partners and subcontractors should be based on a standardised contract provided by BSF. Payments should not be based on completed boreholes, but rather include an advance payment to be able to mobilise and purchase

¹⁴ Sedimentary formations are characterised by low resistivity readings, whereas the curve may drop steeply at larger 1/2AB values. On the other hand, basement rocks are characterised by a 45° rise at larger 1/2AB values.

all required materials in one go, to avoid backlogs as a result of the rainy season. The contract should also include a performance bond.

Drilling should always be supervised by an experienced drilling supervisor. Even if the contract is a lump sum contract for successful boreholes only, the client still has to have proof that the borehole has sufficient water with the pump intake placed at the correct depth (so has been test-pumped appropriately), and that the water is of good quality (water analyses of relevant constituents carried out).

In sediments, borehole water levels may vary significantly over the year. Care should be taken that the boreholes are drilled to a sufficient depth so that they do not dry up in the dry season. Minimum depths will depend on the area, and should be analysed before drilling commences.

A borehole water quality analysis should ideally include all major ions, but are recommended to at least include conductivity, pH and temperature (measured at the end of the test pumping exercise), and nitrate, nitrite, turbidity, iron, copper, manganese, arsenic, fluoride, sulphate and chloride (in the laboratory). These will assist to determine whether the water does not pose a health risk, or is objectionable to the users. Bacteriological analysis is normally not necessary in properly installed boreholes, but is useful for existing boreholes that will be rehabilitated, as these may have installation flaws, and can thus be polluted the top end.

Stakeholders in the Sector in Southern Sudan are of the opinion that there are many non-functional boreholes and abandoned in Southern Sudan, yet none of the NGOs appears to have used the information from the WES Database update. In 2002, the information from the WES database on functionality was updated and all existing safe water sources in 12 counties were mapped, whereas for 12 more counties the updates were in process by January 2004 (www.unjlc.org/ImportedObjects/19363/download). In that way a more cost-efficient approach to increasing safe water coverage can be envisaged, whereby abandoned sources in the denser populated areas can be rehabilitated first where feasible, before drilling new boreholes.

Annex 4 Pictures made during the AMREF site visit

Lessons Learnt from borehole projects in BSF Project area, Southern Sudan



Lessons Learnt from borehole projects in BSF Project area, Southern Sudan

