Partners for Water and Sanitation

Note on project reports

The following report has been prepared by Partners for Water and Sanitation in response to a project Terms of Reference.

The content of the report is based on the opinion of the author(s) and does not necessarily represent the opinions of the wider PfWS partnership, or the project funders.

Partners for Water and Sanitation

Bauchi State Small Towns Water Supply and Sanitation Project, Bauchi State

TECHNICAL REPORT
on
Small Towns Water Supply Scheme Management Workshop and Assessment

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Contents

1 Executive Summary

Partners for Water and Sanitation (PAWS) is a collaboration of government, private sector and NGO organisations dedicated to solving problems associated with providing access to water and sanitation in developing countries. The initial focus of the partnership is Africa.

This report is a summary of the activities carried out, findings and recommendations from the visit to Bauchi State, Nigeria in April 2008. The purpose of the visit was primarily to provide technical training to partners associated with the WaterAid Nigeria (WANG) Small Towns project. WANG requested technical assistance from PAWS to provide technical training and also to assess one of the small town projects (Dass). A site visit was conducted with the Bauchi State Water Board to a small town water supply scheme (Dass). WANG have also installed a small solar scheme in this town, which was also inspected.

During a one week visit from the 6th to 10th of April 2008, we carried out a two-day training workshop with around 30 participants from Water Management Committees of the Towns of Jos (Plateau State), Kafin Madaki and Dass (Bauchi State), the State Water Board of Bauchi State, the Ministry of Water Resources (Bauchi State Office) and other partners.

The outputs of the visit are:

- A two-day training workshop, covering the areas of “Governance and Institutions”, “Introductory Accounting”, “Water Tariffs”, and “Technical aspects of Water Supply” was delivered and attended by around 30 participants. The feedback from the participants was unanimous in stating the usefulness of the workshop. The most popular modules were the modules on tariff reform and technical aspects of water supply. Non-water sector participants also appreciated having infrastructure and the water cycle explained to them.

- The site visit to Dass was at the request of the Bauchi State Water Board, who asked for an assessment of a proposed network extension and investment plan, which had been drawn up by local consultants in 2005. The time available for the assessment was insufficient to draw firm conclusions, but the preliminary findings are that the project does not represent the most effective way to increase the level of service in Dass. We consider that WANG and the Bauchi state water board should carry out a significant reform of the Dass water supply institutional arrangements, data and information gathering, and tariffs, as well as community mobilisation, before investing more funds on infrastructure and construction. The demand for treated water supply also remains to be demonstrated. We further consider that the network extension, based on our brief visit, does not appear to be the most efficient use of the available funds (₦22m).

The Main recommended action is that Senior representatives of the stakeholders (with the authority to take decisions on behalf of their organisations) should discuss, agree, sign and fully document in writing, a transition plan, complete with milestone dates for the handover of water supply schemes to the community. We suggest that the Project Team with support from WANG and PAWS acts as the coordinating body for the production of this plan.

This transition plan should clearly set out roles and responsibilities of all stakeholders at each stage of the plan; together with appropriate levels of service and a method of identifying and addressing any skills gaps that might be evident.

2 Introduction

Partners for Water and Sanitation works with developing countries providing unrivalled knowledge and expertise to help them supply clean water and adequate sanitation to their population. An innovative not-for-profit initiative, the partnership has members from three sectors: government, private enterprises ranging from water companies to engineering groups, and NGOs such as WaterAid, Tearfund and a trade union. This allows the partnership to draw from the widest possible range of expertise to rapidly respond to each unique challenge and to help local African partners develop and strengthen capacity and build truly sustainable solutions.

Each partner brings a unique set of skills and expertise. These are matched with a wide range of potential needs identified with partnering countries at a national or local level, working alongside their existing water and sanitation programmes. The emphasis of partner involvement is on-the-ground capacity building, such as knowledge transfer, to ensure the sustainability of each project and to encourage any lessons learned to be shared and used again throughout the region.

And it's not just about engineering: corporate, institutional and financial capacity building is also required. While the initiative does not itself provide funding, it often strengthens each locality's ability to identify and access available sources through the capacity building approach.[1]

2.1 Terms of Reference

The Terms of reference for the project stated the following Project Title, Justification Objectives, Deliverables and Impact for the PAWS intervention:

Project Title

Kafin Madaki, Bauchi State, Nigeria: Capacity Building Programme on Small Towns Water Supply Scheme Operations and Management.

Kafin Madaki Small town Water Supply and Sanitation Project is a WaterAid Nigeria supported project in Bauchi State. In December 2006, WaterAid requested for PAWS technical assistance in the rehabilitation of the water scheme in Kafin Madaki. A PAWS technical assessment mission was carried out in March 2007, with the support of South West Water of the UK. A technical report was submitted with key recommendations on the rehabilitation of the water supply scheme (Refer to technical report for 73-NIG).

The recommendations made by the PAWS team were applied by the project team made up of Bauchi State Water Board staff, and the scheme has been successfully rehabilitated

Justification

[1] From the Partners for Water and Sanitation website: http://www.partnersforwater.org/

WaterAid supported the development of a Water Consumers Association (WCA) in the community, working with the Bauchi State water board (BSWB). This terms of reference for PAWS support is to help in the capacity building of key actors in the management of the scheme, for sustainability.

The scheme is presently supplying water to a population of about 20,000. However, the key actors in the community, made up of Local Government officials, the WCA, and the BSWB will need some training for effective management of the scheme.

This project has been identified in the PAWS business plan 2007-08.

Objectives

To improve the capacity of key actors in the Kafin Madaki Water Supply Scheme, in the area of scheme Operation and Management.

Deliverables

1. A 1-day technical review of the status of the Water supply scheme

2. A 2-day training programme on; Operations and Maintenance procedures, required tools and human capacity, running and capital expenses, tariff setting and billing.

3. A technical report on the project status, the training programme carried out, and further support areas.

Impact

This support will;
- *Enhance the capacity of the team on ground, for effective operation and management of the small town scheme.*
- *Ensure sustainable use of the water supply scheme*
- *Increase the potential for replication in other small towns*

2.2 WaterAid Nigeria

WaterAid is a non-government organisation originating in the UK which has recently celebrated its 25th birthday. The organisation has been operating in Nigeria for over 10 years. WaterAid has a policy of not being an implementing agency but instead works with and through local partners, acting more as a local source of skills and finance than as a constructor or manager. The strategy is based on the premise that WaterAid projects should be above all sustainable in the (eventual) absence of WaterAid.

In Bauchi State, WaterAid Nigeria (WANG) have four local partners in urban and small towns work; the Bauchi State Water Board (BSWB), the local government areas of the towns of Kafin Madaki and Dass and an NGO in Dass called the Women's Development Association for Self Sustenance (WoDASS). While the organisation's roots lie within the UK water industry, WaterAid's core skills have evolved from primarily technical to the "soft" aspects of water and sanitation; capacity building and hygiene promotion.

The organisation has extensive experience in small scale rural water supply projects. However, in recognition of their stated goal of providing water and sanitation access for all and the rapid urbanisation of developing countries, the organisation has recently started a number of peri-urban water supply schemes. Their stated target is to increase urban work to 30% of expenditure.

The Bauchi projects are among the first such schemes in Nigeria.

2.3 Bauchi State Water Board (BSWB)

BSWB is one of the strategic partners for WANG in Bauchi State and, under state law, is responsible for all urban water supply. We were informed that the definition of urban in Bauchi is towns of more than 5,000 inhabitants. BRUWASSA is responsible for water supply in towns of less than 5,000 inhabitants. This urban / rural split into two actors is replicated in other states in Nigeria, and although various other organs of government have some responsibilities regarding water resources, the environment etc, these two organisations appear to shoulder most of the responsibility both of operating, owning, managing and regulating water supply. Although there is currently no state water policy, a federal policy was developed in 2000[2] which is currently in the process of being ratified. States may choose to adopt this policy or base their policies on it, and Bauchi appears to be generally inclined to follow the draft federal policy.

Among other things, this new policy suggests that water infrastructure management be devolved to *the lowest appropriate level*. Apart from this, the policy is not precise about ownership and management structures. In some places, state water agencies and local government areas are referred to articles 29 and 30, whereas other sections refer to community management of operations (article 35).

As in other states, the position of General Manager of BSWB is essentially a political appointment and as such is vulnerable to changes in elected government. Not only are the roles of operator and regulator combined in the State Water Board, it is closely linked to state government and the associated politics.

2.4 The Women's Development Association for Self Sustainance (WoDASS).

[2] National Water Supply Policy, Ministry of Federal Resources, Jan 2000

WoDASS are a small, local NGO in Dass with various funding sources, including WaterAid. They have a small office near the edge of town, in between the solar powered water scheme and the centre of town. In 2005, WoDASS commissioned a report from consultants Mazurah Engineering and Environmental to expand the town water supply scheme to an area near their office, on the other side of the road from the solar powered pump. The BSWB plans for expansion of the town water supply network are based on this consultants report and design.

3 Visit Programme

Day 1: (Sunday 6th April) Arrival, PAWS briefing

PAWS team arrives from UK, rests, meets country manager Gabriel Ekanem for briefing on week's activities and plans for workshop. Review of policy documents and Regulatory Handbook [3] . Review of participant list and participating organisations to ensure workshop suitability.

Day 2: (Monday 7th April) Meeting at WaterAid Country Office, Abuja, Travel to Bauchi, meeting with WaterAid team in Bauchi

Meeting with Jonathan Burton, WaterAid country representative. Travel by car to Bauchi and subsequent meeting with Christabel Omolade (WANG), Alfa Haruna Mohammed (Bauchi State Water Board / Project Coordinator for small town water and sanitation projects). Discussed and confirmed visit program. Quick overview of progress of Kafin Madaki and Dass schemes since previous PAWS intervention (March 2007).

Day 3: (Tuesday 8th April) Workshop day 1

First day of workshop covering the topics: Introductions, Participant Expectations, Objectives, WaterAid and PAWS presentations, Roles in Water and Sanitation in small towns, Incentives, Organisations in Bauchi and Plateau; Water Sector Policy in Nigeria (2000 document), Case Studies from other countries.

Day 4: (Wednesday 9th April) Workshop day 2

The second day of the workshop covered the topics: Re-cap of the water cycle and associated infrastructure; Introduction to Tariffs and "Why pay for water?", Introduction to accounting, Types of Tariffs, Tariff Tutorial, Financing Role play, Technical water supply modules (boreholes, groundwater, water quality etc)

[3] Regulatory Handbook, National Urban Water Sector Reform Project, Federal Ministry of Agriculture & Water Resources, August 2006.

Day 5: (Thursday 10th April) Site visit to Dass project

Meeting with Bauchi State Waterboard Small Towns project coordinator (Alfa Harun Moh'ed) and WaterAid Bauchi staff. Travel to Dass. Meeting with WoDASS. Meeting with LGA and accompanied visit to boreholes, booster station, generator stations, reservoirs and solar powered pump and reservoir. Travel to Jos (Plateau State).

End of period covered by this report

4 Review of Training Workshop

4.1 Participant Expectations

The participants were asked to list what they hoped to learn from the workshop. The following list was recorded during the workshop:

1. What will be the role of the community in any project executed by WaterAid or any NGO
2. How to manage sustainably (without failure) these projects
3. Sustainability of the project – how do we sustain it without any hitch?
4. How do we educate our people to know the importance of these schemes which are implemented for them?
5. How do we avoid political hijacking of projects?
6. Changing the attitude that “water should be free”
7. To acquire skills and knowledge on water and sanitation
8. The skills and knowledge acquired should be passed to the communities
9. To be able to understand palliative and safe water source
10. At the end of the workshop the community should be able to participate in providing potable water
11. How to mobilise the community to manage the water points
12. The community should be able to provide / source funds to maintain the project
13. To be able to find a way of selection the most needy communities for water and sanitation services
14. Proper management of available resources (financial)
15. How does WaterAid chose their project areas and target communities?
16. How do we avoid delays to projects?
17. How are the Water Management Committees formed?
18. Who is going to check the expenditure of the water management committees

List of Participating Organisations is contained in Appendix 1.

4.2 Workshop proceedings and objectives

4.2.1 Introductions and Expectations (Day 1)

The workshop began with introductions, and the participants were split into three groups to collectively determine their expectations of the workshop. Groups then presented their expectations to the room.

4.2.2 Governance module (Day 1)

The objectives of the Governance module, which essentially occupied all of the first day, was to familiarise the participants with the various roles typically associated with water and sanitation supply in an urban context. Attention was then paid to the Nigerian context by discussing the relevant implications of the 2000 Federal Water Supply and Sanitation Policy Document.

The "business" of water and sanitation service supply was broken up into various components in various ways; by thinking about water "from source to tap" (e.g. water abstraction, treatment, distribution) and by thinking about "people" (e.g. policy development, ownership, financing, management, monitoring). The financing components focussed on the difference between "capital" and "operational" expenditure, with the rough definition given as "capital" expenditure being on items which last for more than one year. The Water Policy capital expenditure suggestions were incorporated at this stage.

By considering these two angles of approach, a list of task and responsibilities was developed. Subsequently, existing organisations in the water sector were listed, as well as other potential bodies which could be involved in water and sanitation governance. Groups were asked to allocate tasks to various organisations in the sector and then present their reasons for doing so to the rest of the participants. The matrix used to facilitate this discussion is included in Appendix 2.

Note: the workshop was not intended to be used to agree a governance structure, merely to inform participants of the need and possible ways of organising the water sector.

A number of case studies in different countries were also presented to demonstrate the sort of structures which the participants might find useful when conceptualising how they might arrange their own water supply and sanitation services.

4.2.3 Water Infrastructure Module (Day 2)

It was realised during Day 1 that many participants were unfamiliar with the types of infrastructure required to supply water or sanitation services, something which the PAWS water engineers and the water board staff take as assumed knowledge.

The program was therefore modified to include a presentation on how water gets from sources to the doorstep, and is returned again to the environment. Participants were then asked to identify a series of photographs of supply equipment and place it correctly in the "cycle". When all participants were able to do this, the workshop proceeded as planned.

This module tied neatly into a discussion about why water should be paid for. By this stage, participants were aware of the cost implications of water. A persistent theme occurring in the group discussions was that "government" should pay for most, if not all, parts of the cycle. We asked the participants to consider the idea that government revenues are derived from taxes, which the consumers pay anyway as they consume taxed products, such as fuel and food. The suggestion was that current effective government expenditure in the sector was insufficient, that the taxes would have to be raised anyway, to pay for new infrastructure. If residents themselves were to pay for and manage services, a number of "middle men" could be removed from the financing cycle.

The idea of using business or commercial sector subsidies was also examined briefly. We suggested that some cross subsidy might be possible, and is often practiced. However, excessive taxes on businesses will eventually result in business failures and the financing problem will remain.

4.2.4 Introduction to Accounting Module (Day 2)

Before tariffs were discussed, we felt that participants would require some introduction to basic accounting concepts. The objective of the training was to get participants to understand three different ways of looking at a business' financial situation: The Cash Flow statement, The Balance Sheet, the Profit and Loss statement.

The discussion started with cash flow, as we felt this would be the most intuitive type of record that the participants would be able to readily grasp. The balance sheet was then discussed as a list of "stuff" which the business owns and "debts" that the business must pay.

Finally, the profit and loss statement was dealt with last, along with the concept of depreciation and the matching principle. Depreciation was tied in with the now familiar concept of capital expenses. A list of expenditure items was then read out and participants were asked to state whether the expense was capital or operational, and if capital over how many years it might be depreciated.

4.2.5 Introduction to Tariffs Module (Day 2)

We stated that a very useful, if detailed, tariff handbook had been produced by the urban water sector reform project, and that our presentation would be a much reduced and simplified version of that. The participants were asked to consider two questions when designing tariffs, those being;

Should the price of water change with the volume consumed and;

Should different types of customers pay different prices ?

Consideration was then given to the costs that the tariff was expected to cover – if capital costs were to be covered then depreciation would have to be entered as an expense that the tariff should cover.

Some discussions over the merits of different volumetric prices and customer differentiation was held. Flat rate tariffs were also discussed but we suggested strongly that, while these had been adopted in countries like Nigeria and the UK, the general trend was that such tariff structures are not useful in managing scarce water resources effectively.

The tariff module concluded with a group exercise (group sizes of 4-6 participants) where information regarding consumers, operational and capital expenses was given and the groups expected to come up with a price for water.

The exercise was then worked through as a group, comparing the different results obtained by the groups as we went.

4.2.6 Financing Role Play Module (Day 2)

As a way of bringing together the themes of tariffs and governance, and refreshing the group after a fairly dry mathematical exercise and accounting module, a role play was carried out after lunch on day 2. The tariff exercise groups were then given a role as either Water Management Committee, New Residents, Water Board, Bank, Governor and International NGO, and told jointly that some new infrastructure was required and that all of them had to work together to design a financing mechanism.

4.2.7 Technical Module (Day 2)

As a concluding module, a series of technical (engineering) presentations were given on the following subjects:

The theory and design of boreholes

Solar power applied to water supply schemes

Surface water quality risks and treatment methods

4.2.8 Review of Expectations (Day 2)

Finally, we reviewed the list of expectations collected on the first day and ensured any remaining unaddressed expectations were met with a question and answer session.

4.3 Workshop Feedback

WHAT WENT WELL	WHAT DID NOT GO WELL
Very educative	Everything went well expect for the public address system
Today workshop is successful and interesting	But there is only one problem it started late
The presentation of the workshop is good	But timing of the workshop should be improved
	Public address system should be repaired

All well keep it up	You should service your public address system
Today seminar was interesting as I interacted with others from other communities. -being able to exercise my opinion about the roles govt and community should play. -Warm reception by WaterAid	The food was not that bad but the fried was not well cooked.
Today workshop is very great, you people should keep it up	You should improve on your microphone
I am happy to see people from other state	I am not happy for coming late
-The workshop was very interesting, the breakfast and the meal is good. -The presentation is fair. -The presentation should be well corrected	There should be more participation from participants
The workshop help me to understand the Water policy and how to improved the policy by involving the community	Most of the presentation have to be print for better understanding
This workshop is fantastic we look forward to same tomorrow God bless (Amen)	
The workshop generally is good	The public address system should be change
Generally the programme is enriching, the facilitators are very understanding being considerate of the participants need.	
Everything is good and move smoothly and I real enjoy the way each participant and everyone participate. I understand that the community have a big role to play not only the Govt or NGO	
The afternoon session is okay	
The presentations were interactive and interesting	But some aspect were a bit technical it should be tailored considering audience
The participation is good	-WaterAid meeting no water as now is a hot time - Lunch is not properly done -time should be strict
Good group presentation – starting time is not bad	
I enjoy the seminar things went well	
It is a nice workshop and I enjoy the level of commitment of senior colleagues from Water board	
The workshop is very nice, very interesting and we got more knowledge about Wateraid and other useful information. -We appreciate the entertainment you made for us. (i.e the food)	The Microphone should be in good operational state
Workshop ok	Lunch need to be improved
The workshop discussion was impressive and went beyond WaterAid	
The day is very interesting and very exciting with discussion	Only that the food need to be improved
I learn that my community can have suitable water supply	
The exercise was okay. The Resource persons really have the talent of impacting knowledge. The meal served was equally good so also is the venue	

Presentation of slides by the facilitators with graphic display. -entertainment of guest was splendid	Activities of group discussion was not well done
The Review:	
What went well	**What we could have done better**
Good facilitation on the following: Economic of Water Water quality test Cost sharing through the National policy Case study very informative Illustrating how water get to the door step done by participants	We should have started early Give more information about workshop to participants before the workshop
Impress with high level of participants and the calibre of participants from Bauchi	Courtesy call to the government took too long
The strategy from getting information from participants was very good	Poor timing
	Public address system need improvement
Level of participation impressive	Low participation from participants
Excellence turn out from members of the Bauchi State Water board	There was need to print agenda for participants to follow this was not done.
Participants have shown interest in taking the training forward	Explaining the water cycle would have been very important it will have enable participants to have a grip or foundation of all the process.
Participants show guinea interest in the training	Slides should have been printed and given to participants to follow
	Next there is training of this nature better timing will set for courtesy call to avoid facilitators missing training session.

5 Other Activities

5.1 Meeting with BSWB General Manager

Abubakar Adamu, the BSWB General Manager was very welcoming and indicated that he would be interested in contributing to the funding of PAWS technical assistance missions in future.

5.2 Meeting with Deputy Governor of Bauchi State

On the 8th of April, 2008, the PAWS team paid a courtesy call to the Deputy Governor of Bauchi state, Alhaji Garba Gadi, in his office. The visit was facilitated by the WaterAid Bauchi state programme officer, Mrs. Christabel Omolade, and the team was accompanied by Engr. Alfa Haruna and Dr. Tor of the University of Jos, Plateau state.

The deputy Governor expressed his appreciation for the PAWS and WaterAid support to the state in the area of water and sanitation. He reiterated the state Government's commitment to the improvement of water supply in the state, giving examples of ongoing and completed projects. He assured the team that the Government will meet all its requirements as regards counterpart funding for projects, and also requested that the PAWS and WaterAid partnership in the state be sustained.

5.3 Dass Scheme Site Visit

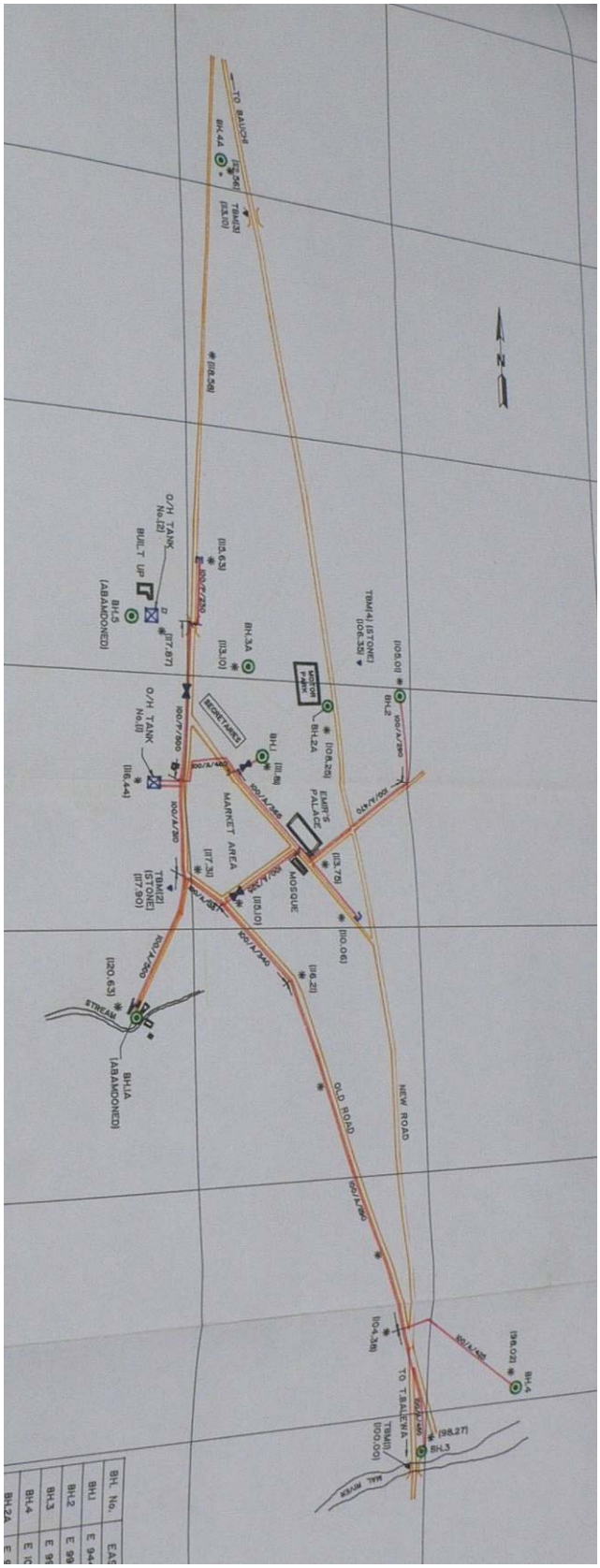
5.3.1 Description of Dass

Dass is a small town close to Bauchi which is spread along a tarred road running North East to South West from Bauchi (to the North East of the town). Estimates of Dass' population depend on who is asked, with figures ranging from 20,000 to 40,000. Previous PAWS reports refer to the population as being between 15 and 18 thousand.

The Dass water supply scheme consists of a number of boreholes, generators, a booster station and two reservoirs. These were rehabilitated in 1995 by a Chinese firm, and a report exists describing the situation prior to this rehabilitation (commissioned in 1995). There are a number of "private" or independently operated schemes (such as the hospital) and WaterAid has constructed a small solar powered scheme (2004) at the northern periphery of the town. In addition to these, there are a number of "political" boreholes and privately owned and managed boreholes. During our visit we observed a drilling rig preparing to construct another borehole. A number of public hand pumps also exist, some of which are operational.

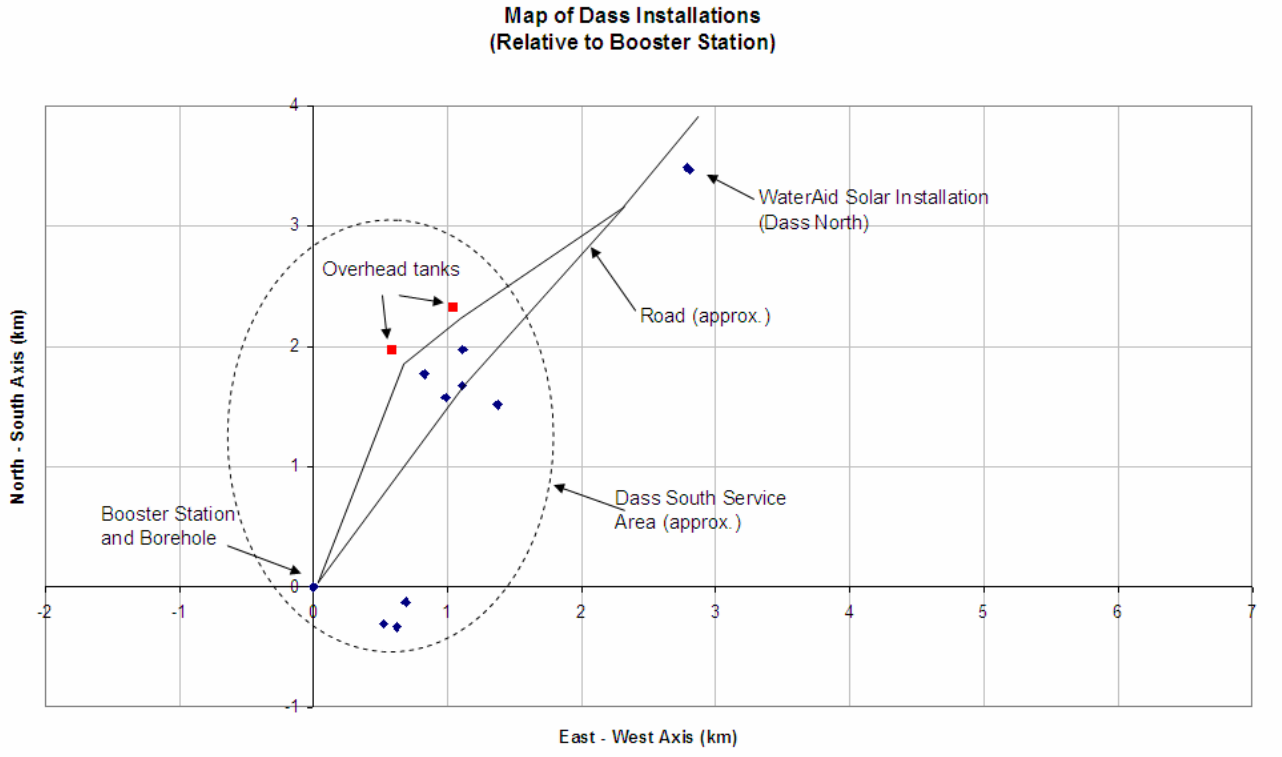
WaterAid's partner NGO in the town, WoDASS, commissioned a scheme expansion design by local consultants in 2005, after the installation of the WaterAid solar scheme. The report contains a design to connect the solar scheme to the original scheme at the south-west end of the town.

Figure 1 – Copy of Map of Dass in 1995 Rehabilitation Report



During the site visit we conducted a brief GPS survey (data included as Appendix 3.) of the installations and their position relative to the WaterAid Scheme in North of Dass. The blue diamonds in Figure 2 are boreholes.

Figure 2: Map of Dass Installations surveyed during site visit



5.3.2 Dass South Water Supply Scheme (original)

A report commissioned in 1995 prior to the refurbishment of the original Dass water supply scheme contains a list and map of 9 boreholes (BSWB staff informed us that two were missing, giving a total of 11). During the site visit, we visited 7 boreholes, the booster station, two generator installations, each containing two generators, and two overhead reservoirs (each of volume approx 100m^3). In addition to these above ground assets, the town contains a network linking the booster stations to the reservoirs, and boreholes to the booster stations. Some boreholes feed directly into the distribution network or to the reservoirs.

BSWB staff informed us that the network has some substantial leaks which prevent some of the boreholes from feeding the reservoirs.

We obtained conflicting information on the current state of operations of the water supply scheme. Operators informed us that the booster station was typically run 3 times per week, each time for 6 hours, yet the hour meters (two in number) on the generators stated that total operation time since installation (in 1998) was 400 and 600 hours. We were informed that the generators (at the booster station) were not currently running because of lack of fuel – the local government being responsible for its purchase. Staff were unclear if the hour meters actually worked, but we considered it unlikely that both hour meters would have failed at approximately the same time, and well before we would expect the asset to experience age related failures. It is also possible that the hour meters have been deliberately disconnected.

On the day of our visit, none of the infrastructure was in operation, although we did see two generators (at the second generator site) started to demonstrate that they did actually work. The voltmeter on one of the generators indicated that only one phase was working. On the other generator all three phases were working.

At a later meeting with residents and the town traditional ruler (Emir), WaterAid staff confirmed that the supply system had not been run for 5 years. This would appear to agree with the operating hours indicated on the generators at the booster station.

One of the boreholes had a flow meter installed, as did the outlet of the booster station. The booster station outlet indicated a total of 30,000 m3 and the one borehole indicated 12,000 m3. BSWB staff were unsure of the borehole yields, and the information given on pump power by the BSWB electrician conflicted with information in the 1998 rehabilitation report and also with the information written on the electrical panels.

5.3.3 Dass North Water Supply Scheme (WaterAid Solar Scheme)

About four years ago WaterAid Bauchi Programme installed a small solar powered submersible pump / borehole supply scheme to the north-west of the town centre. It is assumed that this scheme was installed when the main town scheme was running, and was designed to service the outlying part of town which did not have very good access to the existing network.

The scheme consists of three boreholes (one of which is actually exploited), one submersible pump powered by 32 x 55 W solar panels, and a small overhead tank (estimated at 8,000 litres volume). There are 4 taps nearby connected to the overhead tank, where residents can collect water – apparently for free.

The WoDASS commissioned report indicates the yield on the three boreholes as 0.8, 0.7 and 0.6 litres/s, with the most fruitful bore being the one in operation.

We were informed that the submersible pump was a 1.1 kW pump, which appears to correspond to the power provided by the solar panels. However we calculated that a 1.1 kW pump should be able to lift around 4 l/s to a height of 20m, assuming it is operating at 70% energy efficiency.

If the sustainable yield of the borehole is only 0.8 l/s, we would expect to see the pump "choked off", using a regulator valve on the outlet of the bore, to ensure that the pump did not empty the borehole and "run dry".

At the time of visit, 8 solar panels were not in place, apparently taken away for repair by a certain Musa after "storm damage", and when we climbed to the top of the overhead tank, only a small trickle of water could be heard entering the tank. Listening to the feed pipe also suggested no or very low flow – not the 0.8l/s reported and certainly not the theoretical 4l/s that the pump should deliver.

There was no valve on the top of the borehole, nor flow meter or pressure indicator. There were also no connecting flanges – the pipework having an elbow installed before direct connection to the mains feeding the overhead tank. Using flanges (a union join) at the top of the borehole facilitates borehole maintenance, flow testing, etc. This installation is therefore quite maintenance / operationally unfriendly, but would have been cheaper to install.

Further details of this scheme were reported in PAWS Project No: 73-NIG Review of Kafin Madaki and Dass Water Supply Projects dated March 2007.

5.3.4 Comments on the BSWB plans for Dass

BSWB provided us with a copy of the 2005 consultants report, commissioned by WoDASS and WaterAid. BSWB and WaterAid have asked for our technical opinion of the proposed scheme.

The scheme essentially proposes to connect the Dass South and Dass North water schemes, described above, as well as to expand the Dass North scheme to exploit the remaining 2 boreholes. The consultants carried out network deign and modelling – a copy of the proposed network is attached in Appendix 4.

Currently, BSWB has been allocated ₦22m into a project account which requires sign off from WaterAid, to spend on infrastructure in Dass.

Before commenting on the scheme, as should be apparent from the previous sections, we should state that we do not have enough precise information to be able to make definitive conclusions about what should or should not be done. The following recommendations are therefore tentative.

1. With the main town supply not functioning, there appears to be **no case to connect the two water schemes**. If the southern scheme were working, there could possibly be a case to supply water to the northern end of the town from the existing reservoirs (pressure losses permitting), however the northern scheme apparently does not produce enough water even to serve that end of town, and could hardly be expected to supply the rest of town as well. We could not find any rationale for connecting the two schemes in the report – it appeared to be a foregone conclusion that the schemes should be connected by a network.

2. There also appears to be **little reason to exploit the two remaining boreholes** in the northern scheme, if the flow rates as reported in the 2005 report are to be believed. 0.7 and 0.6 l/s are flows more typically associated with hand pump bores, and any submersible pump would most likely have to be choked off to prevent the bore from running dry. Choking off the pump represents a waste of the pump's capacity and the power supply. Under normal circumstances, it increases the cost in kWh per m3 pumped to uneconomic levels.

3. The case for investing in Dass itself was not very clear to us. Clearly, the inhabitants have apparently been coping with the total dysfunction of the existing system for 5 years now. During our visit, we did not observe long queues for the northern supply point – in fact no-one was collecting water at all. If supply quality or quantity was a serious issue, we would expect some attendance at the borehole, as is commonly witnessed in other urban areas. It appears that there are many independent supply points operating in Dass. There are extensive irrigation activities with private bores (often temporary) sunk into the sand bed of the river. With the water table reported to be at 2.6 m depth, we would also expect many hand dug wells. While the quality of this water might be uncertain, the existing schemes have no chlorination capacity and would therefore offer the residents no incentive to purchase or even collect this water. While the rehabilitation of the main town scheme might increase the convenience of water supply, serious thought should be given to ensuring that the demand is really there to pay for the operation of the scheme. Where water is freely available from hand wells, of identical quality, demand could be expected to be reasonably price elastic.

4. Serious attention must be given to the sustainability of any investment carried out. Given that the government has approved ₦22m for investment, it appears likely that "something will be done" with this money. It should be recalled that the previous rehabilitation scheme carried out in Dass in 1998 appears to have resulted in about 500 hours of operation in the first 5 years, and subsequently complete failure. WaterAid's approach of community mobilisation and engagement is clearly an essential component, however some thought must also be given to the willingness to pay for the considerable O&M costs of running the scheme, and the ability of the water management committees to oversee the activities of the eventual operator (BSWB being the most likely candidate).

5. We were made aware of a nitrate quality problem, which is potentially a subset of a wider water quality problem in the town of Dass. High levels of nitrates have the potential to cause methemoglobinemia ("blue baby syndrome") in babies under six months old, although the health risk of faecal contaminated water or poor hygiene would appear to be much greater. Nitrate treatment processes are exceptionally expensive and complicated, and probably beyond the means / capacity of the Dass residents. The good news is that as their aquifer is unconfined and close to the surface, it is reasonable to assume that steps taken to reduce nitrate releasing fertiliser use might have a positive impact on nitrate levels in groundwater in the short to medium term. Obviously, this action would have to take place in the entire river catchment area upstream of Dass, and would necessitate considerable community and local government mobilisation and engagement. In the first instance, we would suggest the collection of medical data in Dass to determine if there is any incidence of methemoglobinemia and also a survey of nitrate levels in drinking water (i.e. domestic wells), rather than just water from the river. Domestic sources may also be additionally contaminated from latrines and septic tanks, regardless of the bacteriological quality of the water. If some residents appear to have the symptoms described above, then consideration should be given to taking blood samples to test for the condition prior to initiating any large scale response to the problem.

5.3.5 Recommended immediate steps for the Dass Scheme

1. Establish which of the Dass south boreholes actually have working pumps. To do this it may be necessary to bring a portable 2 (to 5) kW generator and engage an electrician to connect the power supply to the portable generator for the pump test.

2. Confirm sustainable (i.e. dry season) yields of all operational boreholes in Dass. Write these down, ensure BSWB keeps a safe record of these yields. Record GPS coordinates of bore with yield information, as well as date of pumping test.

3. Locate and reinstall the missing solar panels from the Northern scheme.

4. Establish the sustainable yield of the Northern solar powered borehole.

5. Bring fuel, test all generators. Test all phases. Ensure hour meters on generators are working.

5.3.6 Recommended medium term actions for Dass investment program

1. Conduct a survey of water demand and ability / willingness to pay for various levels of improved services, such as borehole to domestic tap (untreated) water, and also chlorinated water (delivered to domestic tap). Investigate current water borne disease morbidity levels. Try to collect information from dispensaries on medication sales and local clinics on diarrhoea morbidity (and mortality).

2. Provide training and capacity building for the water management committee – consider investment in a computer and power supply (solar?) which will allow the committee to manage their water assets, billing and monitor the activities of the operator (BSWB or other)[4].

3. Metering: Sustainable management of the system in Dass will require metering. Dass is a semi-rural area with many residents irrigating their fields. Without 100% metering, residents may use potable water for irrigation. In addition to this, metering will be essential to monitor system losses and unaccounted for water, to ensure the operator is looking after the community assets.

4. Protection from NEPA: The mains electricity supply appears to have been responsible for numerous fires and destruction of equipment, both in Dass and in other sites we have visited (Jos). It is therefore essential that all electrical installations should have adequate protection (automatic trips) from mains power surges and voltage fluctuations. The failure to install such (functioning) protection should be regarded as negligence and the asset should not be accepted (or paid for).

5. Chlorination: As mentioned in point 1 above, consider chlorination of water supplies. Currently the scheme offers little advantage over hand dug wells and will have very limited effect on public health. Sustainable sources of chlorine should be investigated – chlorination could be carried out as a batch job in the reservoirs or booster station break-pressure tank. Where boreholes feed directly into supply, a more sophisticated method of in-line chlorination would have to be devised. PAWS could advise on simple dosing systems using sodium hypochlorite.

6. Nitrates: As mentioned above, the reported[5] high levels of nitrates will present a difficult problem for the community to overcome. Given the relatively low risk[6] the community may wish to bear the risk but be informed of the symptoms and be prepared to take appropriate action should any infants (or adults) develop methemoglobinemia. If, however, it is felt that something should be done – a possible sustainable mechanism would be to source alternative drinking water supplies for young children (and women in late pregnancy), either by water tanker or purchasing bottled / bagged water. *We emphasise that care should be taken to ensure residents do not interpret the advice as to give water to babies, which should be exclusively breastfed for the first 6 months*[7]. The cost of this could be factored into the overall tariff, and would certainly be cheaper than attempting to treat the Dass water supplies for nitrates. The alternative water could be dispensed centrally to all residents with young babies (and pregnant women), with a recorded weekly allocation.

[4] PAWS could assist in this area.
[5] PAWS did not confirm the reported nitrate problem by carrying out any water quality tests, however PAWS could possibly provide some support in this area, including interpretation of results.
[6] Refer to Appendix 5 for a discussion on the risks of Nitrate contaminated water
[7] WHO guidelines

7. Record keeping: The current borehole / generator set up is unsustainable and open to predatory exploitation by the operator. All boreholes should have flanges, valves and meters at the wellhead to facilitate easy maintenance, monitoring of flow and yield measurements. All generators should have functioning hour meters. The meter readings should systematically be recorded daily (at every shift change over) in logbooks kept in the pump houses / generator buildings. Depth sounders (dippers) should also be used to systematically record static and dynamic water levels (daily). Where mains electricity supply is used, meters should be installed. The power obtained from NEPA should be evaluated and a long term decision made to see if the connection is worth the standing charge paid (it may be more cost effective for the water scheme to be entirely fuel powered).

8. Dass Mutli-Utility: Some consideration could also be given to using the generators to provide power to the town when not required for pumping, or to balance the generator loads when pumping. Balancing the load will optimise generator performance and also value for money from the fuel consumed, and could provide an additional revenue stream for the water supply operation. We note it may be beyond the capacities of the water management committee to become both a water and power utility, but it is an interesting prospect that could be investigated. We note that it is also likely that the generators will be used for this purpose anyway (with illegal connections to the pump power supply lines), so formalising the processes might result in a win-win situation.

5.4 Water Management Capacity in the Bauchi Water Consumers Associations (WCA)

5.4.1 The skills required

Following the workshop and site visit to Dass, it is possible both to gain some idea of the existing skills in the local partners (BSWB and WCAs) and also of the sort of skills required to run a sustainable small town operation.

Of the 30 or more participants at the workshop, two claimed to have some knowledge of accounting practices, and none claimed to have any experience running a small business. Some participants did own farms, and it is also possible that some run small businesses in addition to their regular jobs in the civil service, but were unwilling to confess to this.

We would like to stress, drawing on experience of both working for large utilities and also running a small water scheme, that the business of supplying water to people is exactly that – a small business.

The vast majority of the Water Consumers Association's time will not be taken fixing pumps or repairing leaky pipes, but supervising the work of others (the operators). While some technical knowledge about how to do this is essential, far more important to the committee will be skills in:

- Bookkeeping and Accounting
- Billing and Revenue collection
- Operating bank accounts
- Performance monitoring
- Procuring services
- Contract writing and negotiation
- Prevention of Fraud

These are the skills typically associated with running a small business, and small business owners should therefore be essential team members for the committee (which is not to exclude other community representatives). While the poorest and most vulnerable consumers should have a voice on the committee, it is likely that these members will also be the least educated and have few or none of the business skills (or possibly self confidence) required to deal with the relatively educated operators.

If no one on the water management committee has any of these skills, failure of the scheme is guaranteed. The operators will have no effective supervision, and fraud, incompetence or indifference can be expected to ruin the scheme within a few years, as we have witnessed with the spectacular failure of the 1998 refurbishment.

5.4.2 The existing skills (as assessed from the workshop)

The dearth of accounting skills and small business experience aside, we were encouraged by the ability of the teams during the tariff setting exercise. It should be noted that BSWB or ministry staff took the lead in most of the groups for this activity, and that when these participants were deliberately excluded, many groups struggled with the tasks.

By the end of the workshop all participants were able to grasp the difference between capital and operational expenditure, and understood the concept of depreciation.

5.4.3 Conclusions

1. For the successful hand over of supply schemes to the community it is essential that the roles and responsibilities of the various stakeholders is fully understood. This applies not only to the long term vision of how the schemes will operate, but also to any transition phases.

2. A project plan and 'road map' is required to document the transition from the existing method of operation to the desired future state. This plan will take into account the roles and responsibilities of the stakeholders.

3. Any plan and allocation of roles and responsibilities must be fully documented in writing and checked for compliance with various State and federal policies and legislation, to ensure that all stakeholders are acting within the law. Formal contracts or MoUs may be required.

4. Any plan for allocation of roles and responsibilities will also need to address any skills gaps that might be present that would prevent or hinder full delivery of the allocated responsibilities. These skills gaps need to be addressed by a suitable training provider or partner. PAWS can assist and support this process but would not be able to act as a formal training provider.

5. Any plan should also consider the appropriate levels of service associated with each role and how such levels of service will be monitored, reported and how remedial action will be taken to rectify shortcomings in service.

5.4.4 Recommended action

The Main recommended action is that Senior representatives of the stakeholders (with the authority to take decisions on behalf of their organisations) should discuss, agree, sign and fully document in writing, a transition plan, complete with milestone dates for the handover of water supply schemes to the community. We suggest that the Project Team with support from WANG and PAWS acts as the coordinating body for the production of this plan.

Appendix 1 – List of attendees

1. Members of the WCA in Kafin Madaki
2. 3 members of Dass WCA for the Dass Urban Project.
3. Members of the BSWB Project team.
4. 2 members of the Bauchi State Water Board
5. 2 members from Ministry of Water Resources
6. 2 members from Ministry of Rural Development.
7. 10 participants from Jos.
8. WaterAid State Coordinator

Appendix 2 – Roles and Responsibilities

Roles and Responsibilities			Government					Community					Other
Where are we talking about ?	What are we talking about ?	Doing what exactly ? (remember if you're doing it, you're paying for it)	Federal Government (Ministry of Water Resources)	Environmental Protection Agency	Public Health Authorities	State Government / Water Board	LGA	Water Management Committees	Private Individuals / Entrepreneurs	Traditional Leaders	Religious Leaders	Local NGOs	Big NGOs (e.g. WaterAid)
Whole country	All water resources	Policy											
Groundwater	Boreholes	Ownership / Replacement											
		Maintenance											
		Operation											
River	River Abstraction	Ownership / Replacement											
		Maintenance											
		Operation											
River / Borehole	Water Treatment	Ownership / Replacement											
		Maintenance											
		Operation											
Treatment plant --> Town	Tranmission in Pipe (using pump or gravity)	Ownership / Replacement											
		Maintenance											
		Operation											
Distribution to the door in the town	Smaller Pipes / pumps or water trucks or porters or kiosks	Ownership / Replacement											
		Maintenance											
		Operation											
In the town	Collection of Revenues	Operation											
In the town	Check Water Quality	Operation											
In the town	Check price and service	Operation											
In the town	Collection of wastewater by sewers	Ownership / Replacement											
		Maintenance											
		Operation											
	Collection of wastewater by trucks	Ownership / Replacement											
		Maintenance											
		Operation											
	Pit latrines	Ownership / Replacement											
		Maintenance											
		Operation											
Out of town	Treatment of wastewater before discharge to river	Ownership / Replacement											
		Maintenance											
		Operation											
In the town	Check wastewater quality	Operation											
In the town	Hygiene Promotion	Operation											
In the town	Community Mobilisation	Operation											
In the town	Capacity building and training	Maintenance											
		Operation											

Appendix 3 - GPS data from site surveys in Dass and methodology used for mapping

Point	Northings	Eastings	Notes	Alt.
0	09 Deg 59.106 Min	009 Deg 30.643 Min	Booster Station and Generators	592
1	09 Deg 58.941 Min	009 Deg 30.926 Min	New BH 3	594
2	09 Deg 58.927 Min	009 Deg 30.980 Min	New BH 4	601
3	09 Deg 59.038 Min	009 Deg 31.20 Min	New BH 2	600
4	09 Deg 59.927 Min	009 Deg 31.423 Min	BH 2	611
5	10 Deg 00.176 Min	009 Deg 31.287 Min	BH 3a	618
6	09 Deg 59.961 Min	009 Deg 31.211 Min	BH 2a	617
7	10 Deg 00.172 Min	009 Deg 30.998 Min	Reservoir 5x4x3	623
8	10 Deg 00.367 Min	009 Deg 31.252 Min	Reservoir 8x4x2	625
9	10 Deg 00.985 Min	009 Deg 32.241 Min	Solar System BH	618
10	10 Deg 00.014 Min	009 Deg 31.280 Min	Road	616
11	10 Deg 00.65 Min	009 Deg 31.126 Min	Generator (2)	618

Distance between points was determined from the northings and eastings in three steps. Both steps use triangles and did not take the curvature of the earth into account. R is the radius of the earth from the core.

Step 1: Determine distance from equator: 2 x R x SIN(northings / 2)

Step 2: Determine the radius of the earth from it's axis to circle on the surface traced by the latitude of the northings reading: r' = COS(nothings) x R

Step 3: Determine the distance of the point from the meridian at the latitude described by the northings (because this distance is a function of latitude):

2 x r' x SIN(eastings / 2).

Once the relative positions of all the points to the intersection of the meridian and equator was determined, the distance between each point could be calculated.

REPORT OF DASS WATER SCHEME

FOR

DASS WOMEN MULTIPURPOSE COOPERATIVE UNION

SUBMITTED BY

MAZURAH ENGINEERING AND ENVIRONMENTAL SERVICES LIMITED

DECEMBER 2005

REPORT OF DASS WATER SCHEME

1.0 BRIEF INTRODUCTION

The first part of this report presents the servicing of boreholes and the second part presents the pipe network modeling and analysis for water supply.

2.0 BACKGROUND

DASS Women Multi- purpose Cooperation Union (DWMCU) an NGO based in DASS Local Government Area of Bauchi State, in partnership with the support of WaterAid in Nigeria is implementing Urban Water Sanitation and Hygiene (WASH) scheme in DASS.

DWMCU has a water scheme with an overhead tank, fed by one borehole fitted with submersible pump powered by solar. However, two other new boreholes are not yet put into use.

Recently, the solar panel has been vandalized and the program is at halt temporarily. This has led DWMCU as an organization to want to reassess the Urban/ Small Town Scheme, along side the existing water supply scheme in DASS.

3.0 REPORT OF SERVICING OF THREE NUMBER BOREHOLES ON THURSDAY, THE 3RD OF NOVEMBER, 2005.

3.1 PREAMBLE

Three (3) No boreholes located in the eastern ~~cities~~ part of Dass in Bauchi State have been serviced first time after their construction. One of them is already installed with a solar-powered GRUNDFOS submersible pump and channeled to an elevated pressed steel tank while others are not.

3.2 HYDROGEOLOGY

Dass is completely underlain by rocks of the crystalline basement complex, where ground water occurs in the weathered overburden (saprolite zone) and fractures and joints in the fresh/partially weathered bedrock. Granific iselbergs can be clearly seen inside the town at the point of entry and are located just behind the places of human settlements. Such places where Dass is situated have been found to be hydro geologically favoured for occurrences of ground water.

3.3 FIELD OPERATIONS

For the benefit of easy of description, each of the boreholes have been coded as below.

(i) Borehole 1: The borehole that is installed with solar powered submersible pump.

(ii) Borehole 2: The borehole nearest to the installed one.

(iii) Borehole 3: The borehole farthest from the installed one.

Below therefore is full but summarized information on each borehole.

3.4 BOREHOLE 1:

The borehole is 27m deep with a 2.4m static water level (depth to water). The pump installed is of GRUNDFOS make and 1.5 HP capacity yield estimate of water flow from the 0.80 liters/second. The installed pump and other accessories were dismantled and the borehole serviced with compressed air by airlifting and surging. Incrustrations were minimal; indicating that and the well is well constructed. After the services, the installations were returned into the borehole and remarkable improvement in yield was observed when energized to operate. The present pump selected for the borehole is quite okay.

3.5 BOREHOLE 2:

The borehole is the deepest amongst the three and is 34m deep. It equally has the highest depth to water (SWL), which was measured as 3.5m. Sustainable yield is about 0.70 liters per second and is capable of recovering fast after excessive flush. Incrustrations were minimal as water from the well became clear after about 8 minutes of flush. This means that the construction is okay. The servicing will continued for about 1 hr to ensure all incratrants were expelled.

3.6 BOREHOLE 3:

This borehole exists without installations. It was serviced with compressed air for about 1 hr. After 11 minutes of flush incrustrations

from the borehole were substantially reduced leading to clearance in the appearances of its water. Total depth is measured to be 32m while depth to water is 3.1m. A sustainable yield of about 0.60 liters per second was measured. (The boreholes were not cased to the bottom, but to be rock was encountered).

3.7 CONCLUSIONS AND RECOMMENDATION

All the three (3) boreholes were completed with 5" (ID) FINAL PVC and screen to the point where hard rock was encountered. This means the boreholes are open holes with the stable bedrock left open on its own. This is evidenced from the presence of mica that (although of minimal quantity) observed freely from the air flush. With this design it is advisable that these boreholes be serviced every 12 months for sustained efficiency.

The same capacity of pump installed in the solar powered borehole (Borehole 1) is recommended for Boreholes 2 and 3 especially as their hydraulic parameters are very similar. However the location of the storage tank to which these boreholes are to deliver water is an important factor for pump selection as long distances of tank location with respect to the boreholes will lead to selection of longer capacity pump to overcome frictional losses.

Well heads are recommended for installation at each of the boreholes. Concrete seal of mixture 1:2:4 should be made to hold the wellheads in place to protect the boreholes from surface pollution by unwanted water.

4.0 REPORT OF PIPE NETWORK MODELING FOR WATER DISTRIBUTION

It was considered that the three existing boreholes would be yielding into the system a total of 6.48m3/hr (1.8l/sec) with 1 HP submersible pump at each borehole. Also a new storage tank of capacity 50m3 with a 7m high tower and 2m maximum depth of water in the tank would be needed. The existing small tank was only considered for feeding locally the watering point at the location.

The system was modeled using Watercad computer programme for the distribution until the pipe sizes selected ensured that these was at least 6m pressure head at the location of the community watering points of four (4) stand pipes each.

Because of the low pressures anticipated, the analysis was carried out using UPVC pipes for the distribution. The results of the selected pipe sizes together with the flows, pressure heads and velocities are represented in the tables of Pipe Report and Junction. (Attached to the report).

5.0 RECOMMENDATION

For water from the existing boreholes to be distributed to the various parts of the settlement, the following are recommended:

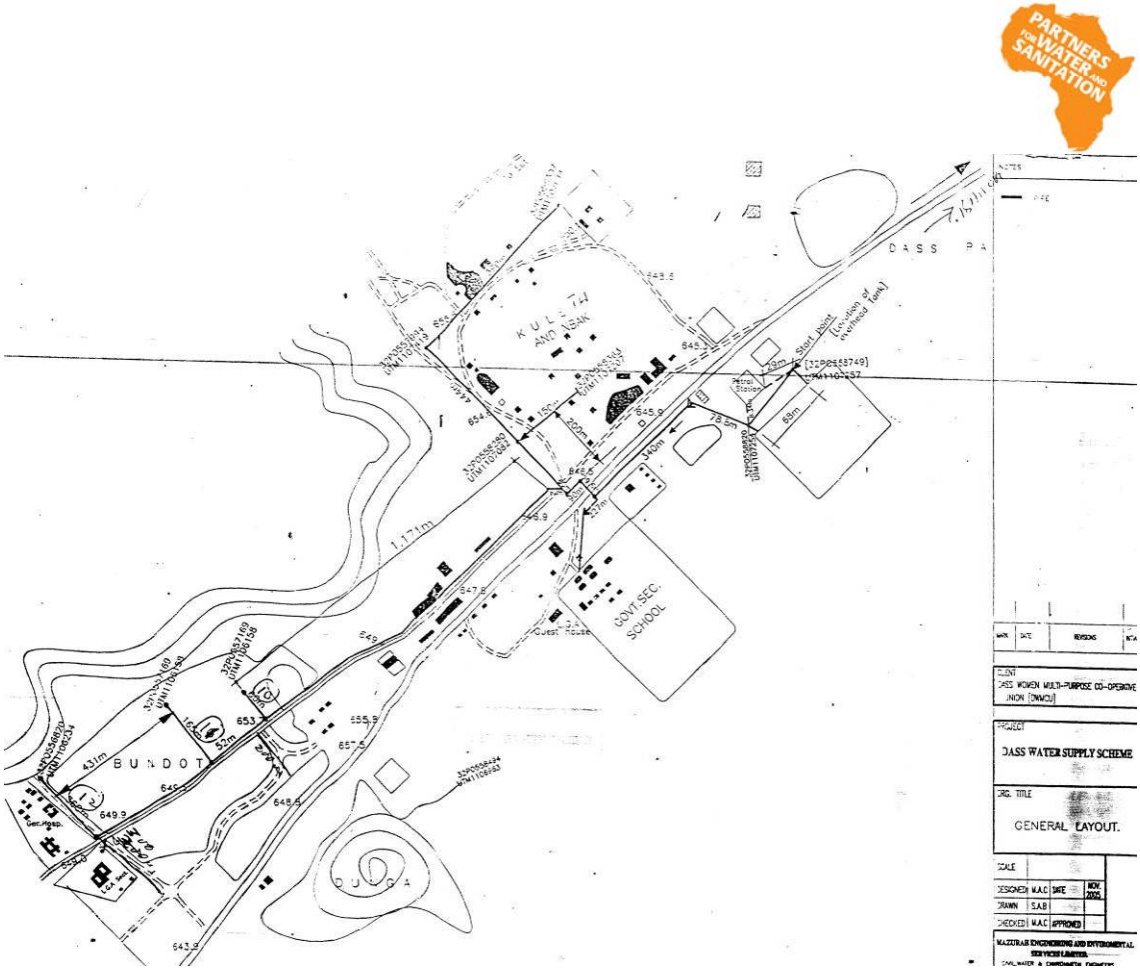
1. Laying of the following UPVC pipes with associated fittings and valves.
   - i. 150mm diameter for 590m
   - ii. 100mm diameter for 2550m
   - iii. 75mm diameter for 600m
   - iv. 50mm diameter for 1150m
2. Construction of a 50m3 capacity elevated steel tank on a 7m tower.
3. For more water to be delivered, additional two (2) boreholes would need to be constructed near the 50m3 tank and pumped directly into it for distribution.

Scenario: Base
Steady State Analysis
Junction Report

Label	Elevation (m)	Base Flow (m³/min)	Pressure (kPa)	Pressure Head (m)	Calculated Hydraulic Grade (m)
N-4	610.79	0.00635	161.14	16.47	627.26
N-5	612.69	0.00635	168.10	17.18	629.87
N-6	615.52	0.00635	147.28	15.05	630.57
N-7	622.86	0.00635	91.15	9.31	632.17
N-8	612.97	0.00635	139.70	14.27	627.24
N-9	611.44	0.00635	154.66	15.80	627.24
N-10	618.06	0.00635	113.56	11.60	629.66
N-11	620.01	0.00635	94.37	9.64	629.65
N-12	617.46	0.00635	119.18	12.18	629.64
N-13	615.25	0.00635	140.71	14.38	629.63
N-14	618.50	0.00635	109.19	11.16	629.66
N-15	620.17	0.00635	92.75	9.48	629.65
N-16	618.89	0.00635	105.03	10.73	629.62
N-17	622.45	0.00635	69.91	7.14	629.59
N-18	615.00	0.00635	143.06	14.62	629.62
N-19	617.81	0.00635	140.22	14.33	632.14
N-20	615.58	0.00635	146.55	14.97	630.55
N-1	611.00	0.00635	60.27	6.16	617.16

Scenario: Base
Steady State Analysis
Pipe Report

Label	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Discharge (m³/min)	Pressure Pipe Headloss (m)	Headloss Gradient (m/km)	Velocity (m/s)
P-4	120.00	100	PVC	150.0	0.74362	2.61	21.75	1.58
P-5	200.00	150	PVC	150.0	-0.80712	0.70	3.51	0.76
P-6	444.00	150	PVC	150.0	-0.81982	1.61	3.62	0.77
P-7	227.00	75	PVC	150.0	0.01270	0.01	0.05	0.05
P-8	100.00	75	PVC	150.0	0.00635	0.00	0.01	0.02
P-10	50.00	100	PVC	150.0	0.04445	0.01	0.12	0.09
P-11	232.00	100	PVC	150.0	0.03175	0.01	0.06	0.07
P-12	430.00	100	PVC	150.0	0.01905	0.01	0.02	0.04
P-13	60.00	50	PVC	150.0	0.00635	0.01	0.09	0.05
P-14	60.00	50	PVC	150.0	0.00635	0.01	0.09	0.05
P-15	165.00	50	PVC	150.0	0.00635	0.02	0.09	0.05
P-16	360.00	50	PVC	150.0	0.00635	0.03	0.09	0.05
P-17	100.00	50	PVC	150.0	0.00635	0.01	0.09	0.05
P-18	50.00	150	PVC	150.0	-0.83252	0.19	3.72	0.79
P-20	150.00	50	PVC	150.0	0.00635	0.01	0.09	0.05
P-9	1,080.00	100	PVC	150.0	0.05715	0.20	0.19	0.12
P-21	32.00	50	Ductile Iron	130.0	0.03000	0.07	2.17	0.25
P-1	31.00	50	Ductile Iron	130.0	0.04200	0.13	4.05	0.36
P-25	27.00	50	Ductile Iron	130.0	0.03599	0.08	3.04	0.31
P-19	390.00	50	PVC	150.0	0.00635	0.04	0.09	0.05
P-22	100.00	75	PVC	150.0	0.03000	0.02	0.23	0.11
P-24	100.00	75	PVC	150.0	0.03599	0.03	0.32	0.14
P-2	100.00	75	PVC	150.0	0.04200	0.04	0.43	0.16
P-3	487.00	100	PVC	150.0	-0.72457	10.10	20.73	1.54
P-23	5.00	100	PVC	150.0	0.82622	0.16	26.44	1.75



Proposed network extensions from “start point” in top right to bottom left.

Appendix 5 – Technical Note on Methemoglobinemia[8]

Nitrate (NO3–) and nitrite (NO2–) are naturally occurring inorganic ions that are part of the nitrogen cycle. Microbial action in soil or water decomposes wastes containing organic nitrogen into ammonia, which is then oxidized to nitrite and nitrate. Because nitrite is easily oxidized to nitrate, nitrate is the compound predominantly found in groundwater and surface waters. Contamination with nitrogen-containing fertilizers (e.g. potassium nitrate and ammonium nitrate), or animal or human organic wastes, can raise the concentration of nitrate in water. Nitrate-containing compounds in the soil are generally soluble and readily migrate with groundwater.

Water Contamination

Shallow, rural domestic wells are those most likely to be contaminated with nitrates, especially in areas where nitrogen-based fertilizers are in widespread use. Approximately 13 million households in the United States use private wells to supply their drinking water. In agricultural areas, nitrogen-based fertilizers are a major source of contamination for shallow groundwater aquifers that provide drinking water. A recent United States Geological Survey study showed that more than 8,200 wells nationwide were contaminated with nitrate levels above the U.S. Environmental Protection Agency (EPA) drinking water standard of 10 parts per million (ppm). EPA has estimated that approximately 1.2% of community water wells and 2.4% of private wells exceed the nitrate standard.

Other sources of nitrate contamination are organic animal wastes and contamination from septic sewer systems, especially in wells less than 100 feet deep. During spring melt or drought conditions, both domestic wells and public water systems using surface water can show increased nitrate levels. Drinking water contaminated by boiler fluid additives may also contain increased levels of nitrites.

Health Risks

Infants younger than 4 months of age who are fed formula diluted with water from rural domestic wells are especially prone to developing health effects from nitrate exposure. The high pH of the infant gastrointestinal system favours the growth of nitrate-reducing bacteria, particularly in the stomach and especially after ingestion of contaminated water. The stomach of adults is typically too acidic to allow for significant bacterial growth and the resulting conversion of nitrate to nitrite.

A proportion of haemoglobin in young infants is still in the form of fetal hemoglobin. Fetal haemoglobin is more readily oxidized to methemoglobin (MHg) by nitrites than is adult hemoglobin. Therefore, infants, and especially premature infants, are particularly susceptible.

In addition, NADH-dependent methemoglobin reductase, the enzyme responsible for reduction of induced MHg back to normal hemoglobin, has only about half the activity in infants as in adults.

[8] This note draws on material provided by the Agency for Toxic Substances and Disease Registry, Case Studies in Environmental Medicine, Nitrate/Nitrite Toxicity, Course: WB 1107, Original Date: September 24, 2007, Expiration Date: September 24, 2010

Infection and inflammatory reactions can increase endogenous synthesis of nitrate in both infants and adults. Gastroenteritis with vomiting and diarrhoea can exacerbate nitrite formation in infants. It has been reported to be a major contributor to MHg risk in infants independent of nitrate/nitrite ingestion. These factors combine to place young infants with diarrhoea, who are fed formula diluted with nitrate-contaminated well water, at the greatest risk for toxicity.

Methemoglobinemia is a well-recognized hazard of ingestion of nitrates and nitrites. The first reported case of fatal acquired methemoglobinemia in an infant due to ingestion of nitrate-contaminated well water occurred in 1945. In the following 25 years, about 2,000 similar cases of acquired methemoglobinemia in young infants were reported worldwide; about 10% of such cases resulted in death. Sporadic cases and occasional fatalities occurred through the 1980s and 1990s, most often resulting from ingestion of nitrate-contaminated well water by infants.

Pregnancy

The pregnant woman and her foetus represent another high-risk group. Reproductive outcome studies done at sites with high nitrate levels in the water supply provide some evidence of maternal transfer of nitrate and nitrite. The pregnant woman and her foetus might be more sensitive to toxicity from nitrites or nitrates at or near the 30th week of pregnancy.

Maternal exposure to environmental nitrates and nitrites may increase the risk of pregnancy complications such as anaemia, threatened abortion/premature labour, or preeclampsia. Recent epidemiologic data have suggested an association between developmental effects in offspring and the maternal ingestion of nitrate from drinking water; however, a definite conclusion on the cause-and-effect relationship cannot be drawn. The maternal transfer of nitrate, nitrite, and N-nitroso compounds, and the potential effect on foetal death and malformation have been described. A few studies have hinted at a role for nitrate intake in the risk for developing diabetes mellitus in childhood. All of these reproductive and developmental effects require further study.

Symptoms of Methemoglobinemia

Signs and Symptoms of Methemoglobinemia	
Methemoglobin Concentration (%) in blood	Clinical Findings
10–20	Central cyanosis[9] of limbs/trunk; often asymptomatic but may have weakness, tachycardia
20–35	Central nervous system depression (headache, dizziness, fatigue), dyspnea, nausea
35–55	Lethargy, syncope, coma, arrhythmias,
> 70	High risk of mortality

[9] Cyanonsis is a blue coloration of the skin and mucous membranes due to the presence of deoxygenated haemoglobin in blood vessels near the skin surface.

PAWS Comments

The most important comment we have on the risks of nitrates to infants in Dass is that some care should be taken when sensitising the population to this risk. As can be seen from the reported figures world-wide, despite a large fraction of the US population being exposed to the risk, the number of fatalities (and even cases) is relatively low, with 2,000 cases in 25 years from 1945-70. However, the increased use of fertilizers may result in an increased incidence in coming years.

Nitrates pose some risk to unborn children during pregnancy. There is however a strong risk posed to infants from drinking water containing nitrates. Conveying this message implies that children under 6 months should be drinking water in some form. This strongly underscores the conventional wisdom that infants under 6 months should be exclusively breastfed (which will offer protection from nitrates, in addition to pathogens and other risks).

The detection of Methemoglobinemia may be harder in black populations, because the blue skin symptom (cyanosis) will be harder to detect.

Appendix 6 – Selected Images

Dass booster station and break pressure tank

Booster pump at Dass

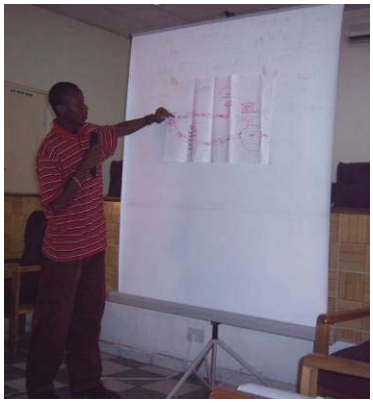
Borehole 4

Generator

Borehole 2

Borehole 3

Group exercise (role play)



Presentation of group exercise (water cycle)

Workshop attendees and PAWS