COWAP Field Paper 27

Report on The Performance of Afridev and Nira Handpumps on the Upper Regions Community Water Project (COWAP) Ghana

Report for the GWSC/CIDA
Community Water Project
Upper Regions, Ghana

Prepared by:

Raphael Nampusuor and Stein Mathisen

September 5, 2000

TABLE OF CONTENTS

List of Figures

List of Tables

List of Appendices

ACRONYMS AND ABBREVIATIONS

CIDA	Canadian International Development Agency
COWAP	Upper Regions Community Water Project
CWSA	Community Water and Sanitation Agency
NORRIP	Northern Region Rural Integrated Programme
Project Area	Upper East Region & Upper West Region of Ghana
PVC	Poly Vinyl Chloride
PWL	Pumping Water Level
RWST	Regional Water and Sanitation Team (of the CWSA)
SKAT	Swiss Centre for Development Cooperation in Technology and Management
SWL	Static Water Level
UNDP	United Nations Development Programme
VLOM	Village Level Operated and Maintained (handpump)

1 INTRODUCTION

This working paper was prepared by Raphael Nampusuor and Stein Mathisen of Cowater International Inc., under the Upper Regions Community Water Project (COWAP), funded by the Canadian International Development Agency and the Government of Ghana.

1.1 The Upper Regions Community Water Project

Between 1974 and 1981, approximately 2700 boreholes were constructed and installed with handpumps in what was at the time the Upper Region of Ghana, under bilateral agreements between the governments of Ghana and Canada (the Canadian International Development Agency). The handpumps installed during this period were the Moyno and Monarch pumps, which, while robust, required heavier tools and equipment and some specialized skills to maintain. Management and maintenance of these sites was under a centralized system, whereby communities paid a tariff to the national water agency then responsible (the then Ghana Water and Sewerage Company), which fielded repair technicians to perform the work. Problems of long waiting times for repairs were very common due to repair team logistical problems, lack of equipment and shortages of spares.

The Upper Regions Community Water Project (COWAP) was implemented in the Upper West and Upper East Regions of Ghana in the seven years between 1993 and 2000. Primary objectives of COWAP were:

- to stabilize or increase access to potable water in the 2700 rural communities (population approximately 800,000) where boreholes had been drilled and installed with the Moyno and Monarch pumps under previous CIDA support; and
- To enable these communities to assume ownership and maintenance of their water points.

Major activities to support these objectives included:

- borehole redevelopment;
- mobilization of communities;
- conversion of the older, centrally managed handpumps to new NIRA and the Afridev models – considered to be VLOM models (Village Level Operated and Maintained);
- training of pump management committees and pump caretakers; and
- drilling of replacement boreholes and construction of hand dug wells at sites where the original borehole was no longer functional.

COWAP was implemented through the two Regional Water and Sanitation Teams (RWST) of the Community Water and Sanitation Agency – the national body charged water supply and sanitation services in rural communities and small towns in Ghana. Throughout the Project, Cowater International Inc. provided advisory services to the two implementing Regional Water and Sanitation Teams.

1.2 Purpose of this Paper

Cowater has published a series of Field Papers during the implementation of COWAP, intended to extract and share some of the lessons learned in the course of the project.

The specific purpose of this paper is to summarize operational performance of the two types of VLOM handpumps utilized during the Project – the Nira and the Afridev handpumps. Through this paper we hope to provide feedback to the manufacturers for improvement of pump design and manufacture, and to offer supporting information to colleagues elsewhere in Ghana and the world who are installing or intend to install the these pumps.

2 PUMP SELECTION

VLOM handpumps are generally understood to be those that possess the following attributes:

- *Robustness:* The design and manufacture should be robust and reliable under field conditions.
- *High Discharge at Shallow Depth:* The pump should produce adequate discharge at low depths to ensure acceptability by the community.
- *Ease of Maintenance:* The pump should be easily maintained by a community caretaker, requiring minimum skills and few tools.
- *Local Manufacture:* Ideally, the pump and the required spare parts should be manufactured in-country, primarily to ensure availability of spare parts.
- *Cost Effectiveness:* The capital and maintenance costs for the pump should be reasonable

Ghana has standardized on the use of the following VLOM pumps at the national level:

- the Afridev;
- the Nira;
- the Ghana Modified India Mk II; and
- the Vergnet.

From these, the Nira and the Afridev pumps were selected as the VLOM pumps to be installed during the Project, primarily because an earlier CIDA-funded project, NORRIP, had installed these pumps in the Northern Region (immediately south of and adjacent to the Project area). Together, the Upper East Region, Upper West Region and Northern Region form the "Northern Regions" of Ghana, and the intent was to keep the focus narrowed to just two standardized pump types within the three regions.

The Afridev (Figure 1) is a lever operated pump and is most suitable for wells with pumping water levels between 10 and 45 meters.

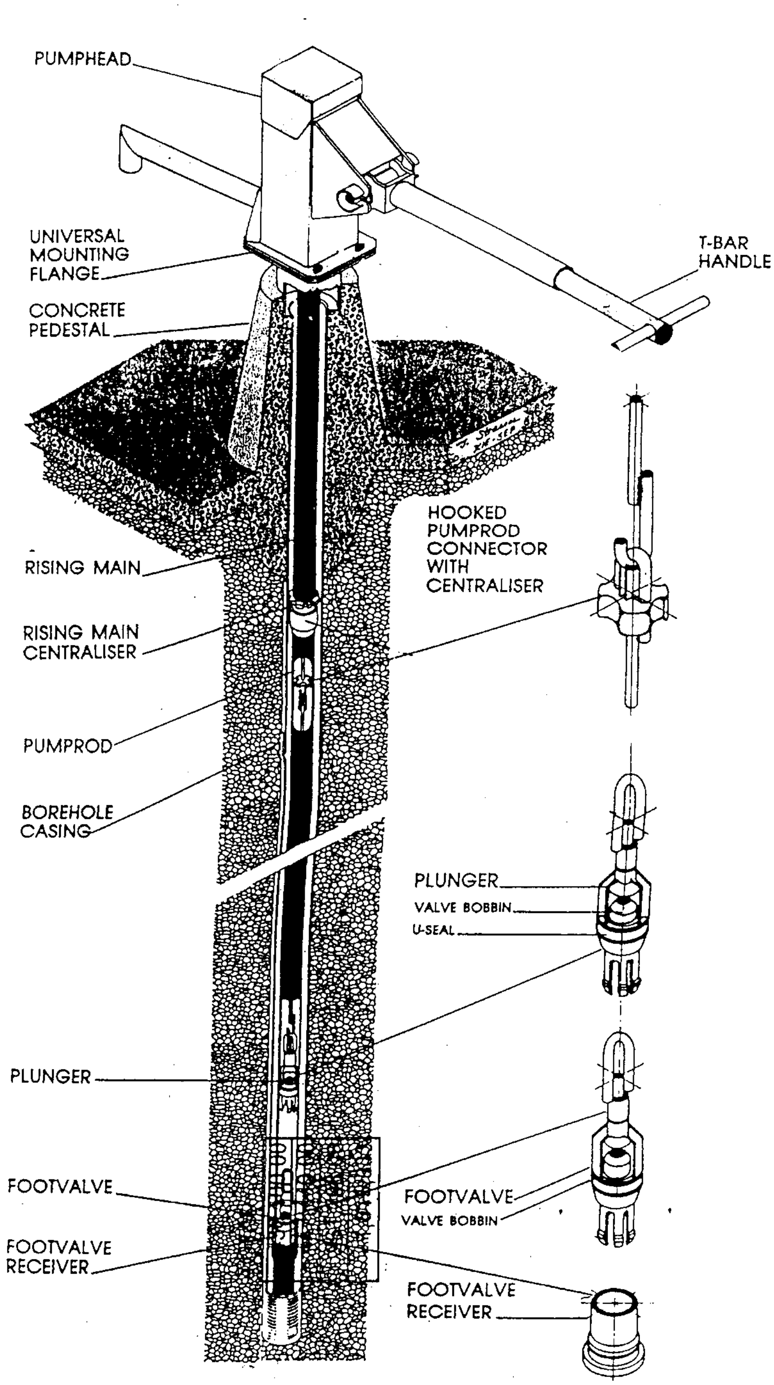

Figure 1. The Afridev Handpump (not to scale)

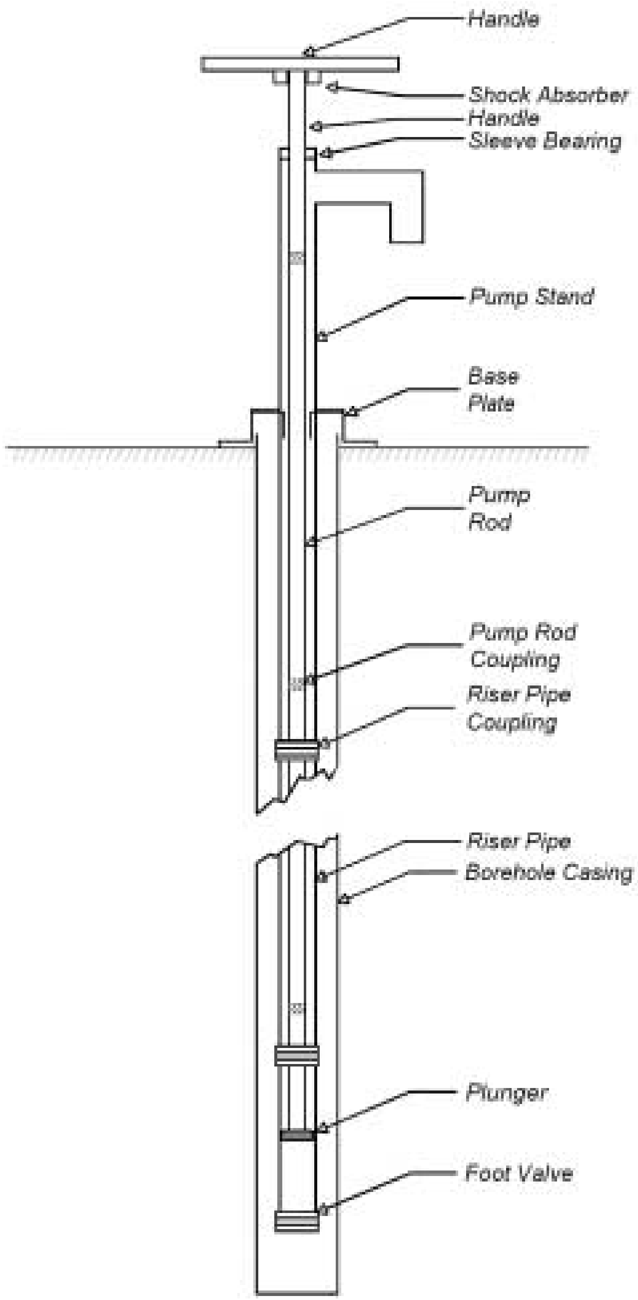

Figure 2. The Nira Handpump (not to scale)

Two versions of the Nira handpump – a direct action pump – were installed during the Project (Figure 2). The version most widely used is the AF 85, intended for use on boreholes with pumping water levels less than 12 meters. The second version – the AFD 85 – is designed for installations as deep as 21 meters.

For particular communities and boreholes, the choice between the Afridev and Nira (and their variations) was based primarily on borehole technical data including depth, static water level (SWL), yield pumping water level (PWL); and the preferred operating ranges for the Nira and Afridev as shown in Table 1. Community involvement in the choice of the type of pump was minimal.

Table 1. Yields in l/min for Nira and Afridev handpumps at various depths

	PUMPING WATER LEVEL (meters)					
PUMP TYPE	5 m	10 m	15 m	20 m	25 m	30 m
Afridev		26	***20***	***18***	***15***	***12***
Afridev (Handle extended)		18	***17***	***14***	***13***	***10***
Nira AF 85	***40***	***26***	20			
Nira AFD 85	***34***	***22***	17	15		

Source: Project field trials. Preferred operating ranges are shown in bold italic.

3 PUMP SUPPLY AND INSTALLATION

The Project entered into contracts with two private companies for the overall supply and installation of handpumps. Ghanira Ltd. - a Finnish / Ghanaian firm which is a subsidiary of the manufacturer of the Nira - supplied and installed the Nira pumps. Aquagro Ltd., a Ghanaian firm specializing in handpump procurement, installation and training, supplied and installed the Afridev pumps, manufactured in India.

Installation of the Afridev handpump requires two days to complete. On the first day, the PVC riser pipes are joined and installed in the borehole, then left overnight to ensure proper bonding of the joints. No hoist is required for the installation. The rods, the plunger and the foot valve can be pulled and re-installed in one hour.

The Nira pump installation requires just one day, and is less complex than the Afridev, requiring fewer persons and tools. Riser pipes are lightweight and no hoist is required to pull or install. Two installers can pull and install the pump within an hour.

Total number Afridev pumps and Nira pumps installed are as shown in the below Table.

Table 2. Handpumps Installed by the Project

PUMP TYPE	TOTAL INSTALLED
Afridev	1571
Nira AF85	1036
Nira AFD 85	2607

4 TRAINING

4.1 Training of Area Mechanics

The Project undertook two levels of technical training related to handpump installation, operation and maintenance. Firstly, Area Mechanics were recruited and trained to provide community-level technical services for the Project, including pump installation, and community training in handpump operation and maintenance. Area Mechanics were trained in:

- pump installation;
- all minor and major pump repairs (including the fishing of rods and pipes; replacement of cylinders; and repairs on the pump head).
- small business management, to assist them in their future role of providing technical services to communities, both during and after the Project;
- training of community pump caretakers who would be ultimately responsible for the regular maintenance of the handpumps;

4.2 Training of Community Pump Caretakers

The Area Mechanics were hired as private contractors by the Project to provide training to community pump caretakers (Figure 3). The training was delivered at two levels. In Level I caretaker training, caretakers were trained in:

- familiarization with pump components;
- explanation and demonstration of all component functions (including discussion of local names to the pump components where necessary);
- daily, weekly and monthly maintenance checks; and
- repair of common problems causing breakdown, such as U-seals, bearings and O-rings.

In Level II, caretakers were trained in:

- fault diagnosis;
- how to locate and liaise with Area Mechanics for further technical support in major repairs; and
- how to locate and deal with other service providers, including retailers of spare parts and commercial repair shops.

The handpumps, once installed, became the full responsibility of the community, under the care of community caretakers. The Project was responsible for all pump repair work resulting from faulty manufacture or installation for a period of one year from the date of pump installation. Following this period, communities contact an Area Mechanic, contracting directly for services on an as needed basis to provide support to the community caretakers in the above listed tasks, or to provide further training in operation and maintenance of their handpumps.

Figure 3. Caretaker Training

5 MONITORING METHODS

The first Nira and Afridev handpumps were installed on the Project in August 1994, and by June 2000, over 2600 pumps had been installed. Performance of these pumps was monitored very closely, and close communication was maintained with the manufacturers to ensure that operational or manufacturing defects were corrected as early as possible. Various sources were utilised by the Project to collect information on pump performance, as follows:

5.1 Warranty Inspection

Under the supply and install contracts entered into with private companies, both the Afridev and the Nira pumps were provided with a warranty of one year from date of installation. The pumps were inspected at 5 months and 11 months after installation. Defects in quality of manufacture and workmanship were flagged for rectification by the pump supply/install contractor. As well, a scoring system was developed to gauge pump performance, caretaker performance and general pump site condition during the warranty period.

The formats showing criteria used to rate pump performance and caretaker performance are provided in Appendix A and B respectively.

Low scores indicated a need for follow-up with the supplier, the community, or caretakers. Any weaknesses in caretaker performance noted during the 5-month inspection, which occured following Level I caretaker training, were flagged for follow-up in Level II caretaker training.

These regular warranty checks during the first year following installation provided one means of collecting data on pump performance discussed later in this section.

5.2 Internal Monitoring and Evaluation

Yearly, overall project progress was evaluated by independent consultants. The evaluations covered a wide range of project objectives, including handpump and borehole performance. Detailed interviews and focus groups were conducted with pump caretakers, community members, Area Mechanics, and private sector retailers of pump spares. During each such community visit, the pump and pump sites of selected communities were also inspected. Defects identified in quality of manufacture and workmanship were flagged for rectification by the pump supply/install contractor.

5.3 Reports from Communities

Breakdowns or other problems reported by communities were another source of information on pump performance. Defects identified in quality of manufacture and workmanship were flagged for rectification by the pump supply/install contractor.

5.4 Reports from Area Mechanics

In the course of their work with communities (whether contracted by the Project or the community itself), Area Mechanics were encouraged to report all abnormal problems with the pumps. Defects identified in quality of manufacture and workmanship were flagged for rectification by the pump supply/install contractor.

6 PERFORMANCE OF THE AFRIDEV HANDPUMP

This section describes the overall performance, discharge, and significant problems encountered with the Afridev handpump. Approximately 1571 Afridev pumps were installed on the Project, at depths ranging from 10 to 60 meters. This section discusses the performance, cost, ease of maintenance, and accessibility issues of the Afridev pump.

6.1 Overall Robustness

The pump stand and head are of steel fabrication and are generally robust. All portions that come into contact with water are made of stainless steel or plastic, and corrosion is therefore avoided if the pump is produced to specification. This general durability is demonstrated by the below pump operation scores recorded.

As mentioned, performance of the pump (as well as caretaker performance and general condition) were monitored for a one year period following installation of the pump, using criteria provided in Appendix A. Pump operation scores for Afridev pump sites are summarized in Table 3.

Table 3. Afridev Handpump Operation Scores

SCORE	PERCENTAGE OF SITES
Good	90%
Fair	7%
Poor	3%
Total	100%

The Pump Operation Score Card used by the Project is shown in Appendix A. Score ranges were defined as follows:

- *Good:* Pump is working, and there is no need for replacement or improvement
- *Fair:* Pump is working, but there is a need for replacement or improvement of a particular feature
- *Poor:* Immediate attention is required to replace or improve a feature.

The above Project-wide results are considered high, and are encouraging with regard to the future performance of the pumps.

6.2 Discharge

At installation depths at the low end of its operating range, the Afridev delivers acceptable flow (20 lpm at 15 m depth), and is popular with communities. Discharge decreases with increased depth, and is considered as adequate (to 10 lpm at 40 m depth).

6.3 Significant Performance Problems Encountered

6.3.1 Cylinder Corrosion and Other Cylinder Issues

Groundwater in the Project Area is not aggressive in terms of corrosion. Brass-lined cylinders were therefore originally selected for the Project over stainless steel cylinders, for cost reasons; stainless steel cylinders cost 30% more.

Early on, very severe corrosion of the cylinders was recorded with the brass lined cylinders. In some cases, brand new cylinders also showed very serious corrosion prior to installation. In others, the problem became apparent following installation of the pump, and the internal surface of the cylinder was found to be very rough and dark reddish/pink (Figures 4 and 5).

Figure 4. Corroded New Brass Cylinder Linings – Afridev

This problem was manifested in reduced U-seal life in general, and in some cases the U-seal was destroyed immediately upon pumping for the first time (in the first few strokes).

Investigation by C&M Engineering of Canada [2] revealed that brass composition was not to specification and the corrosion was due to the zinc being washed out of the lining. Remaining copper was deposited on the surface of the lining, making the surface very rough. It was determined that the manufacturers had not used the right specification of brass for fabrication of the cylinders. The inspection agents had not carried out a detailed inspection of the pump components as recommended in SKAT Revision 2. [1]

Figure 5. Old Brass Cylinder Linings – Afridev

Following this experience with the brass-lined cylinders, the Project opted to switch to stainless steel lined cylinders, and all corrosion problems ceased. Typical U-seal lifespan with these stainless steel cylinders is the expected 6 to 12 months.

Other defects encountered periodically with the Afridev pump cylinder include:

- leakage of the foot valve;

- improper beveling of the cylinder liner; and
- roughness of cylinder liner.

As an example: In one lot of 150 pumps supplied, a random sampling of 1/3 of these pumps revealed that between 30% and 40% presented one or more of these above deficiencies. The entire lot was returned to the supplier for replacement.

6.3.2 U-Seals, Plunger and Foot Valve

The following specific issues regarding the U-seals, plunger and foot valve were identified during the project:

U-Seal Quality

Among the fast wearing parts of the Afridev handpump (these include U-seals, O-rings, plastic bearings and bobbin), the U-seal has a life span of 6 months to 1 year, depending on the amount of use. U-seals supplied from four different Indian manufacturers were not always to the specified dimensions, and tended to swell up when wet. These defects cause the following problems:

- leakage around the U-seal, and pumping inefficiency;
- stiffening of the plunger assembly, and therefore difficult operation of the pump; and
- rollover of U-seals during pumping.

The failure of U-seals from certain suppliers/manufacturers is attributed to use of non-specified rubber compound. This is a quality control problem that needs to be tackled by the manufacturers. Engineering drawings, specifications and the production of the U-seal, which cost less than USD 0.20, are quite complex. We believe that manufacturers often do not always follow drawings and specifications for this low cost component. It is felt that were the drawings and specifications of a simpler nature, manufactures might be more likely to comply with them.

Plunger and Foot Valve

Snap Leg Breakage on Plunger: Frequent cases of broken snap legs on the plunger were encountered during the Project, but this does not impede pump performance.

Similarity of Plunger and Foot Valve: Due to the similarity of the plunger components and foot valve components, the snap legs on both the plunger and the foot valve seem to confuse the caretakers who tend to interchange the components of the plunger with the components of the foot valve. When the components of the plunger are mistakenly fixed on the foot valve, the foot valve becomes locked in the plunger, and special tools and experience are required to rectify this.

Cracks on Plunger Body and Foot Valve Body: Another problem encountered with the plunger and foot valve was that cracks were detected on some plunger and foot valve bodies. Where these cracks were not detected before installation, the plunger and foot valve normally broke with use, and communities were forced to call on Area Mechanics to fish out the plunger or foot valve (Figure 6).

Figure 6. Broken Plunger Body – Afridev

Successful Trials of the New Brass-Body Plunger: The Project sent a number of reports to SKAT on the poor performance of the plunger assembly and U-seals. SKAT produced a new design for the plunger body [4], in which the plunger body is made of more sturdy brass. The U-seal is made of more durable nitrite rubber. The engineering drawings are simpler and should assist manufacture to specification. The new plunger body unit has been field tested by the Project, with satisfactory results. After 10 months of severe usage in conjunction with a stainless steel cylinder, the diameter of the U-seal had decreased somewhat, from 50.0 mm to 49.5 mm, however pump discharge had remained constant at 20 liters per minute.

6.3.3 Pump Rods

Quality of Welded Rod Connectors: Initially, pump rods with welded hook and eye connectors were supplied to the Project, but these did not perform very well. The rod usually broke at the hook portion of the rod, indicating poor weld quality. Also, the alignment of the hook and eye connectors with each rod was not consistently linear, sometimes resulting in bowing of the rods, bringing them into contact with the riser pipes. This abrasion would cause excessive wear to the rod centralizers and the riser pipes, resulting sometimes in rising pipe failure. These weld problems prompted the Project to order and test pump rods of forged stainless steel (see below).

Dimensional Inconsistency of Forged Rod Connectors: Though no breakage problems were encountered with the forged pump rods, the dimensional quality of some of the forgings were not consistent. Some of the hooks did not fit into the eye, and installers ended up filing these before installation. In some cases, the installer had used force to fix the hook into the eye, which could result in rod bending or damage. The same problem would result on subsequent dis-assembly and re-assembly of the pump, unless the rods were replaced in exactly the same order as originally installed.

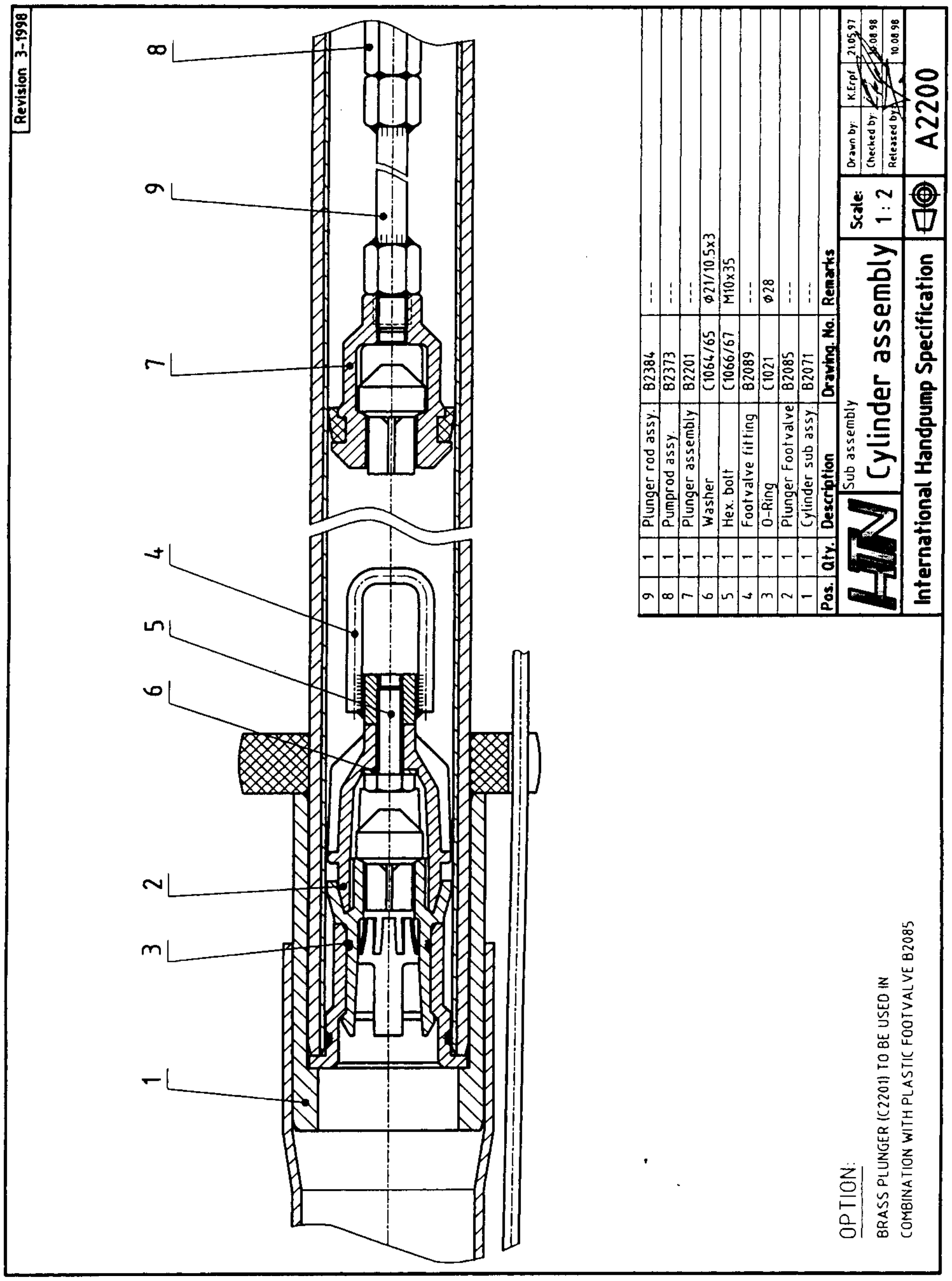

Figure 7. SKAT Improved Plunger Body and U-Seal

6.3.4 Tools and Equipment

Fishing Tools: The single fishing tool provided with the Afridev handpump is of good design and worked very well during the Project. But standardized tools have not yet been developed for fishing broken rods, pipes, plungers and foot valves. The Project developed a set of these tools (Figure 8) which have worked well. Three different tool heads can be screwed onto threads welded to a section of pump rod from which the hook connector has been removed.

Foldable Spanners: One batch of foldable spanners did not work very well, as the socket was not thick enough, and the spanners often cracked along the corners of the socket. This problem was attributed to a case of poor quality in manufacture.

Installation Support Rope: The installation support rope rots after 3 to 4 years in water and cannot be used to pull the pump in cases where the riser pipes break.

Figure 8. Project-Fabricated Fishing Tools – Afridev

6.4 Capital and Operating Costs

For installations to 30 meters in depth, the initial capital cost of the Afridev pump is approximately USD 400.00.

Project experience with the Afridev handpump, while broad in terms of the number of pumps installed, is limited to six years (1996-2000) during which more than 1500 Afridev pumps were installed. Nevertheless, based on these six years of experience, manufacturers' recommendations, and the projections of Project technical staff regarding future pump performance and needs, the schedule of replacement of Nira parts shown in Table 4 was developed, with associated costs. Table 4 attempts to illustrate the situation of those communities that participated in the Project, in that:

- the initial capital cost of the pump is assumed by the Project (zero or near-zero capital cost to the community). For this reason, the capital cost of the pump is shown for reference, but is not reflected in the Year O cost to the community;
- 100% community responsibility for all future operation and maintenance costs, purchasing needed spares at retail rates;
- an assumed pump body lifespan of 15 years; and
- replacement of the Afridev stand, head and handle at the cost of the community, at the end of the 15^{th} year.

Without allowance for a discount rate, the total cost to the community over 15 years would be USD 1244, or an average of USD 83 per year. When a discount rate of 3% is used, the present value of the total cost over time is USD 941, for an average cost per year of USD 63.

Table 4. Estimated Replacement Schedule and Costs – Afridev Handpump

PUMP LIFE BY YEAR	PART DESCRIPTION AND COST (USD)														TOTAL COST (USD)	PRESENT VALUE OF TOTAL COST AT DISCOUNT RATE (USD)
	Initial Capital Cost	U-seal	O-ring	Bobbin x 2	Bearing x 2	Rod centralizers	Pump rods	Pipes	Cylinders	Hanger pin	Fulcrum pin	Foot Valve	Rope	Stand, Head & Handle		
	$ 600.00	$ 0.27	$ 0.15	$ 0.47	$ 2.43	$ 6.00	$ 198.00	$ 90.00	$ 85.50	$ 5.84	$ 8.64	$ 3.90	$ 7.50	$ 139.50		
0.0															0.00	0.00
0.5		✓													0.27	0.27
1.0		✓	✓	✓	✓	✓									9.32	9.04
1.5		✓													0.27	0.26
2.0		✓	✓	✓	✓	✓				✓	✓				23.79	22.42
2.5		✓													0.27	0.25
3.0		✓	✓	✓	✓	✓									9.32	8.52
3.5		✓													0.27	0.24
4.0		✓	✓	✓	✓	✓				✓	✓		✓		31.29	27.80
4.5		✓													0.27	0.24
5.0		✓	✓	✓	✓	✓			✓						94.82	81.79
5.5		✓													0.27	0.23
6.0		✓	✓	✓	✓	✓	✓	✓		✓	✓				311.79	261.12
6.5		✓													0.27	0.22
7.0		✓	✓	✓	✓	✓									9.32	7.57
7.5		✓													0.27	0.22
8.0		✓	✓	✓	✓	✓				✓	✓	✓	✓		35.19	27.78
8.5		✓													0.27	0.21
9.0		✓	✓	✓	✓	✓									9.32	7.14
9.5		✓													0.27	0.20
10.0		✓	✓	✓	✓	✓			✓	✓	✓				109.29	81.32
10.5		✓													0.27	0.20
11.0		✓	✓	✓	✓	✓									9.32	6.73
11.5		✓													0.27	0.19
12.0		✓	✓	✓	✓	✓	✓	✓		✓	✓		✓		319.29	223.94
12.5		✓													0.27	0.19
13.0		✓	✓	✓	✓	✓									9.32	6.34
13.5		✓													0.27	0.18
14.0		✓	✓	✓	✓	✓				✓	✓				23.79	15.73
14.5		✓													0.27	0.18
15.0		✓	✓	✓	✓	✓			✓					✓	234.32	150.40
TOTAL COST (USD)															1,243.50	940.93
TOTAL YEARS															15.00	15.00
COST PER YEAR (USD)															82.90	62.73

DISCOUNT RATE: 3.00%

6.5 Ease of Maintenance and Caretaker Performance

Pump caretakers trained by the Project in general are capable of carrying out most routine maintenance tasks and can diagnose and repair most breakdowns of the Afridev. These include the following:

- replacement of U-seals, O-rings and bobbins (Figure 9);
- replacement of plastic bearings;
- replacement of pump rods; and
- replacement of hanger and fulcrum pins.

The pump caretakers generally call on area mechanics to help them carry out the following repairs:

- fishing of broken rods and pipes;
- fishing of broken plunger and foot valve bodies;
- replacement of cylinders; and
- repair of damaged pump head.

Performance of the community pump caretakers were monitored for a one year period following installation of the pump using criteria provided in Appendix B. Pump caretaker scores for Afridev pump sites are summarized in Table 5.

Table 5.Afridev Pump Caretaker Scores

CARETAKER SCORE	PERCENTAGE OF SITES
Good	60%
Fair	23%
Poor	17%
Total	100%

The above scores are satisfactory only. The ability to carry out these tasks does not always mean that the tasks are performed in a timely fashion. A regimen of proper preventative maintenance is lacking in many Project communities, where there is a tendency is to await an obvious problem and then repair it, rather than performing regular maintenance and checks. Fast moving parts are often not changed at the appropriate time, and bolts and nuts are often not regularly checked and tightened. This lack of routine maintenance can result in major problems on rather costly items, such as the pump

Figure 9. Pump Repairs – Afridev

head, which must be completely replaced if destroyed if the fulcrum pin bolts are allowed stay loose for some time.

6.6 Local Manufacture and Local Availability of Parts

The pump stand and head of the Afridev were in fact manufactured in Ghana on a trial basis for the Project. The exercise required a high degree of supervision of the manufacturer, and many pieces were returned due to non-compliance with specifications. Eventually, a total of 50 compliant sets (stand & head) were produced which are still in use today, however the final cost per set was not competitive with those of Indian manufacture. Were production attempted on a larger scale, it could possibly become economically viable.

All rubber components of the pump have at one time or another been manufactured by various companies in Ghana. And quite likely, the plastic components could be made in Ghana as well. Close monitoring of the quality and cost are essential for sustainable manufacture of these and all other components.

While Ghana-based production of the Afridev or some of its parts would be desirable from the standpoint of ensuring constant supply and also creating a local economy around this production, this is not seen as necessarily essential to the Afridev's success as a VLOM pump in Ghana, as long as an imported supply is adequate and affordable. The government of Ghana has included the Afridev among four "standard" pumps within the country. While Ghanaian suppliers of the Afridev exist, these are few, and the reliable supply and distribution of pumps and parts is still a challenge facing the country, and most critically the north. Also, there is a definite weakness in the system where the retail sale of fast-wearing spares is concerned. Project efforts to encourage the private sector to fill this gap in Northern Ghana have not been successful. To answer this need, a national initiative is now beginning, for the provision of central supply and warehousing of pumps and parts at three points in the Country (Accra, Kumasi, Tamale). The private sector has been invited to submit bids for this multi-year "middle-man" role which, it is hoped, will "kick-start" larger scale private sector involvement in both the wholesale and retail areas.

If successful, these efforts may be sufficient to guarantee the Afridev's continued service as an economically viable and readily accessible technology in Ghana, whether in-country production occurs or not.

7 PERFORMANCE OF THE NIRA HANDPUMP

This section describes the overall performance, discharge, and significant problems encountered with the Nira handpump. Approximately 1036 Nira handpumps were installed on the Project, at depths ranging from 3 to 18 meters.

7.1 Overall Robustness

The pump stand and head are of robust steel fabrication and all portions that come into contact with water are made of stainless steel or plastic. Corrosion is therefore not an issue. This general durability is demonstrated by the below pump operation scores recorded.

Performance of the pump (as well as caretaker performance and general condition) were monitored for a one year period following installation of the pump using criteria provided in Appendix A. Pump operation scores for Nira pump sites are summarized in Table 6.

Table 6. Nira Pump Operation Scores

SCORE	PERCENTAGE OF SITES
Good	80%
Fair	18%
Poor	2%
Total	100%

The Pump Operation Score Card used the by Project is shown in Appendix A. Score ranges were defined as follows:

- *Good:* Pump is working, and there is no need for replacement or improvement
- *Fair:* Pump is working, but there is a need for replacement of improvement of a particular feature
- *Poor:* Immediate attention is required to replace or improve a feature.

7.2 Discharge

At installations down to 10 meters, discharge is 28 liters/min. This discharge is considered very good, and the pump is in general popular with the communities, in part for this reason.

7.3 Significant Performance Problems Encountered

7.3.1 Operating Difficulty / Ergonomics

Difficulty Below 12 Meters: Operation of both versions of the Nira is comfortable for installations down to 12 meters. For deeper installations, pumping progressively more difficult, given the direct action design of the pump.

Figure 10. Difficult Operation for Small Children – Nira

Ergonomics for Children: Also, the pump handle was found to be relatively high for small persons; children find that they must hold their hands at chest level, a position that requires significant effort to pump water (Figure 10).

7.3.2 Bending of Pump Rods

The Nira's riser pipes and rods are flexible, and will easily bend if exposed to sunshine or if not laid on a flat surface. If pipes and rods are not straight, abrasion between the pipes and the rods will result, causing difficulty of operation and potential failure of the rods and/or pipes.

7.3.3 Entry of Water into Pump Rods

Each Nira pump rod section has a rubber plug at each end, preventing water from entering the rods. The air entrapped in the pump rods provides buoyancy that assists the user on the upstroke of pumping. In over 300 cases on the Project, the pump rods were found to have been filled with water, making them very heavy and resulting in great difficulty to the user. The cause was found to be faulty rod plugs, which had allowed entry of water into the rods. At the request of the Project, the manufacturer returned to the affected pumps to remove and replace the plugs. It appears that this problem was due to a faulty batch of rod plugs, since other Nira pumps installed by the Project have had no such problem. Nevertheless, it is an issue to be monitored in the first year following pump installation.

7.3.4 Leakage of Foot Valve

In most cases, slight leakage of the Nira's foot valve was encountered, resulting in loss of the water column. As this was not found to be progressive (it did not increase over time), and because water flow is obtained after 4 to 6 strokes, the issue is not seen as a very serious performance problem.

7.3.5 Wear of Handle Sleeve

The life span of the Nira's handle sleeve is 3 to 4 years, which can be considered satisfactory for a major handpump part.

Wear of the handle sleeve can however be accelerated with exposure to abrasives such as fine sand (common in arid climates). Handle sleeve wear can also vary depending on the way the pump is operated. Many users will not normally pull or push the handle up and down in a straight line, but will rather tend to pull the handle towards oneself during the up stroke and pushing it away during the down stroke. Pressure is therefore exerted at the opposite sides of the handle sleeve at different heights, resulting in uneven wear on the sleeve material (Figure 11).

Figure 11. Perforated Handle Sleeve – Nira

As with Nira parts in general, the replacement cost of the component is relatively high – USD22.00 - and may be a significant consideration if the part is to be replaced every 3 years under worst case conditions in communities with very limited financial resources.

7.3.6 Potential for Borehole Contamination

Because there is no breather hole on the Nira's base plate nor on the pump stand, a vacuum is induced within the borehole when the pump is used. Furthermore, there is no gasket between the base plate and the pump stand. Under these conditions, if no alteration is made to the pump to allow entry of air to the borehole, potentially non-potable spillage water and dirt present on the base plate can be sucked into the borehole via the baseplate. Figure 12 shows such a case, where the entry of surface water is evidenced by the dirty riser pipes, down which sediment-laden surface water has trickled.

At the special request of the Project, the supplier in Ghana drilled breather holes beneath the base plate flange, and provides gaskets for use between the base plate and pump stand flanges.

Figure 12. Evidence of Surface Water Entry – Nira

7.4 Capital & Operation Costs

For installations down to 12 meters, the installation cost of the Nira pump is about USD700.00.

Project experience with the pump only spans six years (1996-2000) and approximately 1036 pumps. Based on this experience, manufacturers' recommendations, and the projections of Project technical staff regarding future pump performance and needs, the schedule of replacement of Nira parts shown in Table 7 was developed, with associated costs. Table 7 attempts to illustrate the situation of those communities that participated in the Project, in that:

- the initial capital cost of the pump is assumed by the Project (zero or near-zero capital cost to the community). For this reason, the capital cost of the pump is shown for reference, but is not reflected in the Year O cost to the community;
- 100% community responsibility for all future operation and maintenance costs, purchasing needed spares at retail rates;
- an assumed pump body lifespan of 15 years; and
- replacement of the pump body at the cost of the community, at the end of the 15th year.

Without allowance for a discount rate, the total cost to the community over 15 years would be USD 1340, or an average of USD 89 per year. When a discount rate of 3% is used, the present value of the total cost over time is USD 1025, for an average cost per year of USD 68.

Nira spare parts tend to be somewhat more expensive than the Afridev's, however in the analysis presented in Table 7, the lower frequency of replacement of parts results in the Nira operation and maintenance cost being only marginally greater than that of the Afridev shown in Table 4.

Table 7. Estimated Replacement Schedule and Costs – Nira Handpump

PUMP LIFE BY YEAR	PART DESCRIPTION AND COST (USD)										TOTAL COST (USD)	PRESENT VALUE OF TOTAL COST AT DISCOUNT RATE (USD)
	Capital Cost	Bobbin x 2	Sleeve Bearing	Bumper Sleeve	Handle Sleeve	Pump Rods	Riser Pipes	Cylinder	Plunger Ring	Replace Handpump		
	$ 910.00	$ 15.60	$ 44.20	$ 15.60	$ 31.20	$ 156.00	$ 208.00	$ 104.00	$ 15.60	$ 321.10		
0.0											0.00	0.00
0.5											0.00	0.00
1.0											0.00	0.00
1.5											0.00	0.00
2.0											0.00	0.00
2.5											0.00	0.00
3.0		✓		✓	✓						62.40	57.10
3.5			✓						✓		59.80	53.92
4.0											0.00	0.00
4.5											0.00	0.00
5.0											0.00	0.00
5.5											0.00	0.00
6.0		✓		✓	✓	✓	✓	✓			530.40	444.20
6.5											0.00	0.00
7.0			✓						✓		59.80	48.62
7.5											0.00	0.00
8.0											0.00	0.00
8.5											0.00	0.00
9.0		✓		✓	✓						62.40	47.82
9.5											0.00	0.00
10.0											0.00	0.00
10.5			✓						✓		59.80	43.84
11.0											0.00	0.00
11.5											0.00	0.00
12.0		✓		✓	✓						62.40	43.77
12.5											0.00	0.00
13.0											0.00	0.00
13.5											0.00	0.00
14.0			✓						✓		59.80	39.53
14.5											0.00	0.00
15.0		✓		✓	✓					✓	383.50	246.15
										TOTAL COST (USD)	1,340.30	1,024.98
										TOTAL YEARS	15.00	15.00
										COST PER YEAR (USD)	89.35	68.33

DISCOUNT RATE USED : 3.00%

7.5 Ease of Maintenance and Caretaker Performance

The community pump caretakers trained by the Project can carry out maintenance and repair on almost all components of the pump. These include:

- replacement of pipes and rods;
- replacement of plunger ring and bobbin; and
- replacement of plastic guide bearings.

The caretakers may call an area mechanic to assist in fishing out a dropped or broken rods or riser pipe.

Performance of the community pump caretakers was monitored for a one year period following installation of the pump using criteria provided in Appendix B. Pump caretaker scores for Nira pump sites are presented in Table 8.

Table 8. Pump Caretaker Scores at Nira Locations

CARETAKER SCORE	PERCENTAGE OF SITES
Good	52%
Fair	27%
Poor	21%
Total	100%

As in the case of the Afridev, the practice of proper preventative maintenance is lacking in many Project communities, where there is a tendency for repair upon breakdown, rather than preventative maintenance. This lack of routine maintenance can result in major problems on rather costly items, such as the base plate.

Caretaker performance scores for the Nira pump, in general, are lower than for the Afridev. This is thought to be the case because of the relatively “hands off” nature of the Nira. It is not as complex as the Afridev, and requires less day to day maintenance. This capacity to function for a long period without preventative maintenance, especially early in the life of the pump, may cause some community pump caretakers to become rather lackadaisical in their approach to caring for the pump.

7.6 Local Manufacture and Local Availability of Parts

The Nira pump is assembled in Ghana by Ghanira, a subsidiary of the Finnish company. Certain parts for the Nira are supplied or manufactured here in the country. Pumps and spares are available in Ghana on 4 weeks delivery time. This setup makes it fairly easy for procurement to be done on a large basis, with advance planning. The presence of a direct Nira subsidiary in the country is extremely positive in terms of the pump’s viability as a VLOM technology; the company is generally quite interested in maintaining its good relationship and performance record in the Ghana water sector. Ghanira also has representatives at the regional level in northern Ghana, though they primarily sell whole pumps, not running spares.

Distribution of the Nira and its parts still suffers from the same problem as the Afridev: distribution and retail sale to all parts of the country is far from being a reality, and is most problematic in the northern part of the country, far from the capital and the shipping ports. As with the Afridev, the Nira pump is expected to be included in the upcoming national scheme to establish three major warehouses for the wholesale and retail distribution of handpumps and their spares.

8 SUMMARY AND CONCLUSION

8.1 The Afridev Handpump

The Afridev pump generally fulfils the requirements of VLOM. The pump is robust, generally resistant to corrosion, and discharge is acceptable over a wide range of depths between 0 and 60 meters.

The regular maintenance required by the Afridev is easily mastered by rural communities, with some training. Some more involved tasks (these include the fishing of rods, pipes, plunger, and foot valve, as well as the replacement or repair of the cylinder and pump head) are best done by an area mechanic with more specialized training. The components that wear rapidly and need replacement are cheap and easy to replace. Other main pump components have long life.

Some potential exists for confusion (on the part of the pump caretaker) between the foot valve and the plunger bodies, due to their similar appearance. A simple design change is recommended to make apparent the difference between these two pieces. Secondly, a more complete fishing tool set - allowing removal of broken pipes, rods, plungers and foot valves - would complement the Afridev package nicely.

If produced to specification, the Afridev performs well, however numerous cases of manufacture non-compliance with the SKAT specifications were encountered. These include problems with the cylinder lining; U-seal dimensions and quality; cracking of the plunger and foot valve bodies; poor welding and forging of pump rod connectors; and the quality of the tool kit. Inspection of the pumps during production and by the consignee is highly recommended with the Afridev, to ensure user satisfaction, to provide feedback on quality to the manufacturers, and to reduce “return” costs.

The potential for the manufacture of the Afridev and its spares in Ghana does exist, but the low prices of imported items, and the difficulties in local quality control make it unlikely that the pump in its entirety will be produced in Ghana in the near future. As long as the supply and price of imported items are considered acceptable, however, the Afridev seems well placed to enjoy many years of use by rural communities in Ghana.

The initial capital cost of the Afridev is USD 400 excluding labour. Projecting the parts replacement schedule over 15 years results in an estimated total cost of USD 941, or USD 63 per year (present value figures discounted at 3% per annum).

8.2 The Nira Handpump

The Nira handpump in Ghana also fulfils most requirements of a VLOM technology. The pump is durable and resistant to corrosion. Discharge is best and pumping most convenient at depths less than 12 meters, however the pump (model AFD85) will perform to 20 meters depth. Pumping is increasingly difficult at depths over 12 meters. Small children can encounter some difficulty in pumping, due to the relative height of the bar. Some research into ameliorating this problem is recommended.

Community pump caretakers can perform maintenance and repair on virtually the entire pump, with some training. Only the fishing of a dropped or broken rod or riser pipe may require the community to contract the assistance of an Area Mechanic with more specialized training. Performance of Nira caretakers was noted to be markedly lower than their Afridev counterparts. This may be due to Nira's low level of mandatory maintenance in the first few years of operation, allowing the caretaker to lose interest in the job.

Pump components in general are longer lasting as compared to the Afridev, though more expensive to replace.

Problems with the Nira pump include the possible bending of pump rods prior to installation; faulty pump rod plugs (limited cases); slight leakage of the foot valve; quick wearing of the handle sleeve when subjected to abrasives and non-linear force during pumping; and entry of surface water into via the baseplate (if a gasket and air hole are not used).

The Nira, a Finnish pump, is assembled in Ghana by Ghanira. The regional representation of Ghanira in the Project Area is a positive aspect, yet distribution and retail of Nira spare parts is not adequate. Communities in need of Nira spares may often encounter difficulty in locating them. As with the Afridev, the Nira pump is expected to be included in the upcoming national scheme to establish three major warehouses for the wholesale and retail distribution of handpumps and their spares.

The initial capital cost of the Nira is USD 700. Projecting the replacement schedule over 15 years results in an estimated total cost of USD 1025, or USD 68 per year (present value figures discounted at 3% per annum). Thus, the Nira is slightly more costly to install and maintain than the Afridev.

8.3 Maintenance Culture

Communities are easily capable of mastering the necessary training to adequately care for both the Nira and the Afridev, however Project experience indicates a general tendency towards lax maintenance practices. Response to a breakdown or change in pump performance, instead of preventative maintenance, is the norm in many communities.

This is not a new revelation. In 1998, the Project commissioned a study of the UNDP 50 Wells Project [3], which constructed 50 VLOM water points in the late 1980's in northern Ghana. The study assessed the performance of both the pump management groups and the pumps themselves, almost a decade after project completion. The study concludes that, in spite of this maintenance culture, and in spite of turnover of pump caretakers, all 50 water points (almost 40% of which were either Afridev or Nira pumps), were functioning satisfactorily. And in all cases, a community group still existed which was managing the pump for the community.

This is encouraging in the context of the Community Water Project upon its completion in June 2000. In the decade since the UNDP 50 Wells Project ended, community mobilization, training, and the working relationships between the communities, Districts, and the private sector have probably improved, if anything. These are seen to be important factors in the sustainability of investments in the water sector, and thus our hopes for similar evidence of success, 10 or 20 years from now, are high.

9 REFERENCES

1. Baumann, Erich and Keen. 1994. “Afridev Handpump Specification, Revision 2.” Swiss Centre for Development Cooperation in Technology and Management (SKAT). St. Gallen, Switzerland.

2. Duncan, Colin. 1996. “Afridev Shallow Water Well Handpump Cylinder Liner Damage. “ C&M Engineering Ltd. Calgary, Alberta, Canada.

3. Pragmatic Outcomes. 1998. “Community Water Project; Report on UNDP 50 Well Survey”. Tamale, Ghana.

4. Handpump Technology Network (HTN) Drawing No. B2201. 1998. “Sub Assembly; Plunger Assembly; International Handpump Specification.”