WATER AND SANITATION CELL

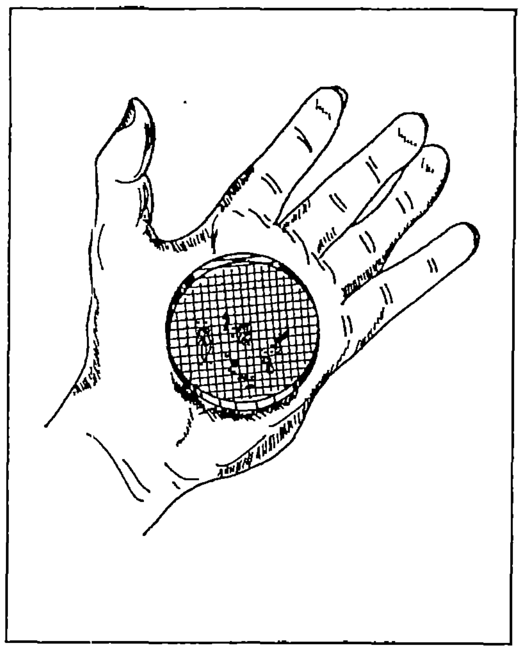
LOCAL GOVERNMENT AND RURAL DEVELOPMENT DEPARTMENT
QUETTA, BALOCHISTAN

TECHNICAL REPORT No. 1:

HAND DUG WELL IMPROVEMENT,

TRADITIONAL WATER STORAGE

AND BIOLOGICAL WATER QUALITY



ABSTRACT

Physical implementation of water supply and sanitation facilities by the Water and Sanitation Cell (W&S Cell), LGRDD has been on-going since late 1993. There have been a sufficient number of completed hand dug well improvement works to warrant the initial comparative testing of water quality. Testing of various parameters was carried out on a limited number of wells, both prior to well improvement and over a period of five months after handpump installation.

Changes in biological water quality from well sources was of primary interest in order to assess the impact of the sanitary sealing of unimproved wells. The impact of water storage using traditional goatskin containers on biological contamination was also examined.

Despite the limited number of well sites involved in this initial round of testing the results are quite encouraging. In both cases where baseline test data was available, results indicate that improvement of traditional hand dug wells leads to a significant reduction in faecal coliform contamination (without chemical disinfection) over the course of a four to five month period.

Results from the goatskin storage tests indicate that, even with a significantly improved biological quality of the water source, this form of storage presents a health risk in terms of faecal coliform contamination. However in improving biological water quality at source the absolute risk from traditional storage practices can be greatly reduced.

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ANNEXES:

1.0 Testing Procedures and Equipment

Every hand dug well proposed by the village community group for improvement and handpump installation is initially tested for physical and chemical water quality parameters. This first round of testing is used as an indicator as to the likelihood of significant biological contamination. If, as a result of this first round testing, biological contamination is suspected, the well source is further tested for the presence of faecal coliforms.

The guidelines used for physical and chemical test analysis are given in Annex I. Results of all physical testing are given in Annex V. If faecal contamination is indicated in the second round of testing, it is highly recommended that the source be disinfected immediately following handpump installation.

1.1 Physical Testing Parameters:

Testing of physical parameters include the following:

Parameter:	Equipment:	Unit:	Remarks:
Temperature	Field thermometer	°C	
Electrical Conductivity (EC)	Conductivity metre	μS/cm	Temperature coefficient of 2%
Total Dissolved Solids (TDS)	From E.C. result	mg/l	Multiplication factor of 0.65
Turbidity	Turbidity tubes	T.U.'s	
pH	Colour comparator	pH scale	
Taste and colour	n/a	n/a	Judged in field by technician

1.2 Chemical Testing Parameters:

Testing of chemical parameters includes the following:

Parameter:	Equipment:	Unit:	Remarks:
Nitrate	Colour disc	mg/l	Test equipment not yet available for initial testing
Free Chlorine	Colour comparator	mg/l	Test used only after disinfection

1.3 Biological Testing Parameters:

The most practical and widely accepted parameter in assessing biological quality is in testing for the presence of thermotolerant faecal coliforms. The method employed by the W&S Cell is the membrane filtration test, performed in the field using the Oxfam/DelAgua portable kit. This kit tests for the presence of Escherichia Coli (E-Coli) as the indicator organism for total (faecal) coliforms, incubated to the temperature range of 44°C +/- 0.5°C, for a period of 16 to 18 hours.

Each water source is tested with three sample counts to ensure against field error; furthermore every batch of samples is incubated together with a control sample in order to test equipment, sterilisation and operator processes. Test results are expressed in colony counts per 100 ml of water sample.

The acceptable level of faecal coliform contamination for rural water supply has been widely debated* in light of the costs and resources involved in protecting and treating sources effectively. These estimates vary from country to country but as a guideline for conditions in Balochistan the following levels of risk may be considered:

E-Coli count/100 ml	Risk
0	No risk
1-10	Low risk
11-50	Intermediate to high risk
51-100	High risk
> 100	Gross pollution; very high risk

[* For further details see "Surveillance of Drinking Water Quality in Rural Areas" Lloyd & Helmer, Longman Scientific & Technical, 1991]

2.0 Well Improvement and Design

The design developed for sanitary improvement of traditional hand dug wells by the W&S Cell is largely based on the existing UNICEF/LGRDD approach, but with several important changes (see Annex II). Commonly reported problems and field observations of the previous design approach have led to the adoption of the following changes in order to provide an improved sanitary seal of wells in preparation for handpump installation:

- Incorporating lining to 1.5 metres below ground level, and where possible providing puddled clay seal.

- Pre-casting of well cover slab in order to overcome the problems of in-situ casting (shuttering left in place, differential settlement).

- Tying in of pedestal frame to slab reinforcement in order to withstand stresses on pedestal/slab joint due to pumping action.

- Introduction of man-hole cover with integral sleeve shuttering which automatically sets cover above slab level and is manufactured with over-hung lid.

- Minimum apron diametre of no less than 1 metre greater than slab diametre; levelling system with set out pegs to ensure proper drainage off apron.

- Minimum drain length of 4 metres to ensure removal of waste water to safe distance.

- Introduction of soak-pit in cases where no adequate drainage outlet exists.

The improvements introduced were at little or no extra cost, and were developed in the context of both increased community participation and in the light of limited resources and skills available to LGRDD at district level.

A total of 7 hand dug well improvements have been carried out, in five Union Councils of Loralai District during the initial pilot phase since late 1993, all incorporating the above design changes. One purpose of the biological water quality testing was to monitor these improved wells in order to assess the impact of technical design modifications on water quality.

3.0 Well Testing Schedule and Results

Physical analysis of proposed well sites has been carried out since August 1993; the results of those well sources also involved in biological analysis are given in Annex V. Testing equipment for Nitrate analysis were not yet available at the time of writing this report, but will be included in all subsequent chemical analysis of water quality.

Biological analysis of well sites has been carried out since October 1993 when the testing kits arrived in country. Since project activities were still in the initial pilot phase it was decided to analyse as many of the well sites as possible. In this case two wells were tested in October 1993 and re-tested in February 1994 along with the 5 newly adopted sites; results are given in Annex III.

users, subsequent recharge from the aquifer has obviously been uncontaminated by any upstream source.

3.12 Dargi Shepelo Village, Mehktar Union Council

Physical test results taken in August 1993 on this proposed well indicated that biological contamination might be quite likely, with a high turbidity (25 T.U.'s) and strong taste and colour. This was made fairly obvious by the condition of the well which had been out of use for about 10 years.

Testing for faecal coliforms carried out in October 1993 confirmed this suspicion, giving an average E-Coli count of 33 per 100 ml. After improvement of the well head and installation of the pump a second test was carried out, five months later, in February 1994. The physical test results show a marked improvement in turbidity and also a very high reduction in the TDS level from 1,365 mg/l immediately after improvement works, down to 595 mg/l six months later. These improvements were reflected in the E-Coli count which, as in Mula Gagul, had been reduced to an average 0.33 per 100 ml. This represents an improvement of biological quality of 98.9% for users in Dargi Shepelo which is extremely encouraging.

It appears that the same immediate conclusions apply to the situation in Dargi Shepelo; namely that the well head design adopted by the W&S Cell is providing a good sanitary seal to the well.

3.2 Analysis of Initial Biological Test Results

3.21 Mula Gagul Village (cluster two), Mehktar Union Council

Physical test results indicated a fairly good source of water, except for a high turbidity count which was probably due to the fact that the well was newly constructed. However as in cluster one the average E-Coli count was relatively high at 47 per 100 ml. As the well has just been improved it will require careful monitoring to determine whether the same reduction in faecal coliform contamination will occur during the course of the next 3 to 6 months.

3.22 Shinglaz Rahkni Village (cluster one), Saddar Samalan Union Council

This well site which was improved in December of 1993 had good water quality except for a very high turbidity count, which was again explained by the fact that the well was new. Unfortunately the E-Coli count is still high (39 per 100 ml) even after almost 2 months of handpump installation. One reason for this may be the relatively high water table level and the quite dense population distribution of the village. This well will require disinfection if no substantial improvement is seen in biological water quality

over the next few months. Interestingly enough the adjacent kareze water tested at only 2.3 count per 100 ml, and therefore it can be hoped that the fairly high level of contamination in cluster one well was due to the direct introduction of faecal matter during construction.

3.23 Shinglaz Rahkni Village (cluster two), Saddar Samalan Union Council

This proposed well which is a few years old exhibits good physical parameters with TDS level of only 487.5 mg/l and turbidity of 7 T.U.'s. The E-Coli count was 18.3 per 100 ml on average which represents an intermediate risk to health. After improvement biological parameters will be monitored to assess any change in quality.

3.24 Lique Village, Union Council Poonga

This proposed site is a newly constructed well in a village which has a very wide population distribution. The physical test results were as expected with a fairly high turbidity and very high TDS level; local villagers said that their water always tasted slightly salty but was of "good quality" for drinking. The E-Coli count was on average 1.7 per 100 ml which is quite acceptable considering that this was a newly dug well.

3.25 Kharotabad Village, Union Council Sinjawi

This well was improved in December 1993 and the community was newly settled in the area. Physical results indicate a good quality source, except for the taste of the water which was slightly musty. Surprisingly the average E-Coli count was 0 per 100 ml, representing no risk to users. This was attributed to the fact that the area had no previous human settlements.

4.0 Traditional Water Storage Practices

In most of the villages where W&S Cell activities are carried out traditional goatskin bags are the primary method used for the collection and storage of drinking water. Hygiene education staff from the Cell were interested in finding out about the risks, in terms of biological contamination, inherent in the use of this type of container.

From discussions with village women the reasons for using goatskin bags were explained as follows:

- very low cost
- locally available
- "taste" of water remains good, even after several days of storage

- women are convinced that this is a "safe" storage practice because of the small opening
- large volume of water (30 - 40 litres) can be carried without being too heavy to manage

From observations by project staff the following risks seem to be associated with the use of goatskin containers:

- inside surface of container is very rough and can become dirty easily
- small opening makes proper cleaning of inside of container impossible
- women "clean" goatskin simply by pouring water in and shaking the bag a few times before pouring water away
- women pour out water from the bag with fingers over the opening
- goatskin is permeable, allowing for contaminated material to travel across the membrane when bag is placed on ground

In order to find out more about the risks associated with the use of goatskin bags technical staff from the Cell carried out a series of tests for faecal contamination of the stored water.

4.1 Goatskin Water Storage Testing Schedule and Results

Two sets of tests for biological parameters were carried out in Mula Gagul village (cluster one); the first in October 1993 just after handpump installation and the second in February 1994. In both cases village women were requested to let the technician test water from a household goatskin container used for collection and storage of drinking water.

In the first round of testing E-Coli counts were taken after 30 minutes, 5 hours and 24 hours; in the second test a count was only taken after 24 hours. These results were then compared with the E-Coli count results from the water source taken on the same day as testing for the goatskin water. All test results are shown in Annex IV.

4.2 Analysis of Goatskin Water Storage Test Results

The average E-Coli count for the well source at the time of the first testing was 49 per 100 ml. After 30 minutes of storage in a goatskin bag this had increased to an average of 153.3 per 100 ml; after 5 hours the average was up to 176.6 per 100 ml and 24 hours of storage produced an average E-Coli count of 183.3 per 100 ml. This represents an increase of almost 4 times the contamination from source to storage after a 24 hour duration.

The results of the second round of testing were more encouraging; as stated earlier, due to well improvement work, the source E-coli count was only 0.33 per 100 ml. After 24 hours of storage

in a goatskin the average count was 33 per 100 ml; although this still represents an intermediate to high risk to health, the positive impact of an improved source meant a reduction of faecal contamination by 82% in water stored by traditional methods over a period of 24 hours.

5.0 Conclusions

It is important to stress that the results of testing so far are limited in scope and therefore it is not advisable to draw any (statistically based) conclusions with regard to the success of the approach of this programme. Nonetheless the test results have shown, at least in a small number of cases, that the design of the headworks and providing a handpump at source can achieve encouraging results in terms of biological water quality.

It appears, through the sampling and control process, that the testing procedure and practices are yielding reliable results and that on this basis a perspective emerges with regard to the rural water supply situation in North East Balochistan. Before these are discussed in detail, it is preferable to view the results in light of the guidelines and objectives of rural water supply implementation in general.

The World Health Organisation (WHO) has laid down a series of guidelines for potable water, which are periodically up-dated*. These guidelines are developed in the light of what is practicable for a given social and economic context, and as such stress the need for flexibility, particularly for contaminates which are extremely difficult and/or costly to eliminate. Because of the more immediate, acute and (at times) widespread effects of micro-biological contamination this is given a higher priority than chemical contaminates which cause adverse health effects over a much more prolonged period.

Therefore in terms of the W&S Cell efforts in providing improved water quality to rural communities in Balochistan the two main criteria for potable water are :

- As free from pathogenic organisms as possible
- Having taste, smell and colour which is acceptable to the users

Clearly village users know more about the acceptability of their own source in terms of the latter criteria, and will continue to drink water from this source regardless of outside intervention. Because the elimination of chemical contamination is beyond the means of the W&S Cell, it is ensuring against biological contamination which is the most important challenge in this case.

[* For further details see "Guidelines for Drinking-water Quality" Second Edition, WHO Publications, 1993]

It is virtually impossible for community-based rural schemes, such as those implemented by the W&S Cell, to eliminate this type of contamination completely in light of the financial and human resource costs involved. Consequently any approach to the improvement of water quality should be seen as one of reducing the "order of magnitude"; more simply put it is more realistic to aim for the goal of reducing the presence of E-Coli from a count of 150 to 30 per 100 ml, than from 10 to 0 per 100 ml under this type of project.

Setting of rigid and unattainable goals will only lead to the perceived failure of project efforts and a loss of motivation to continue towards the important target of improved water supply.

5.1 Hand Dug Well Improvement and Water Quality

Bearing in mind the limited scope of the testing carried out to date, it is possible to arrive at some general positions regarding water quality and well improvement:

- It can be assumed, that in general, unimproved hand dug wells within project areas are likely to contain faecal coliform contamination levels expressed as an E-Coli count in the range of approximately 30 - 50 per 100 ml.
- Higher population density rural villages, in combination with relatively high water tables (10 metres or less), are likely to exhibit an increased level of faecal contamination in unimproved wells.
- The design approach, providing for a sound sanitary seal and adequate drainage can reduce faecal contamination significantly.
- The introduction of a raised man-hole appears to be a significant improvement and may be the single most important factor in reducing contamination.

Clearly further testing, both of the baseline wells and wells previously up-graded by LGRDD, will be necessary to confirm any of these observations. The baseline data collected so far will be integral to long-term monitoring efforts of biological water quality as W&S Cell activities expand in the Province.

5.2 Traditional Water Storage and Well Improvement

In light of the very limited faecal coliform test results from traditional goatskin containers, the following observations can be put forward:

- Collection and storage of water in goatskin containers poses an increased health risk in terms of subsequent contamination of source water (regardless of quality) by

faecal coliform growth; the factor of risk is unclear, but it represents at least a fourfold increase in contamination.

- Very significant improvements in the biological quality of the water source still does not mitigate the health risks associated with use of goatskin containers at the same source; however such improvements can lead to considerable reduction of risks in absolute terms over a storage duration of 24 hours.

- Despite the inherent risks of using goatskin bags it is questionable whether it would be feasible for outside intervention in persuading village women to adopt any other container due to the factors of low cost and easy availability.

The goal of water quality improvement within the W&S Cell approach is not, and cannot be, the complete eradication of faecal coliform contamination from rural sources. However the early results are very positive, and efforts should be focused on the up-grading of source wells and provision of handpumps.

In providing these sanitary protection measures, greatly improved biological quality of water can be provided at source, and have secondary positive impacts in the health risks associated with existing traditional water storage practices at household level.

ANNEX I: GUIDELINES FOR PHYSICAL AND CHEMICAL FIELD TESTING

Testing procedures:

1. Indicator Tests:

Every proposed well should have a first round of testing which includes the following:

- Temperature
- Turbidity
- Nitrate
- Total dissolved solids
- ph
- Taste and colour

2. Analysis of Indicator Test Results:

Following the first round of testing the results should be analysed for key indicators which can suggest further testing and or treatment of the particular well.

The most important indicator of possible contamination is a high **nitrate** level; if nitrate level exceeds 50 mg/l this should act as a warning of potential contamination. However be careful nitrates have three main sources:

- Human or animal sewage
- Agricultural fertilisers
- Leguminous plants and soil in which they are growing

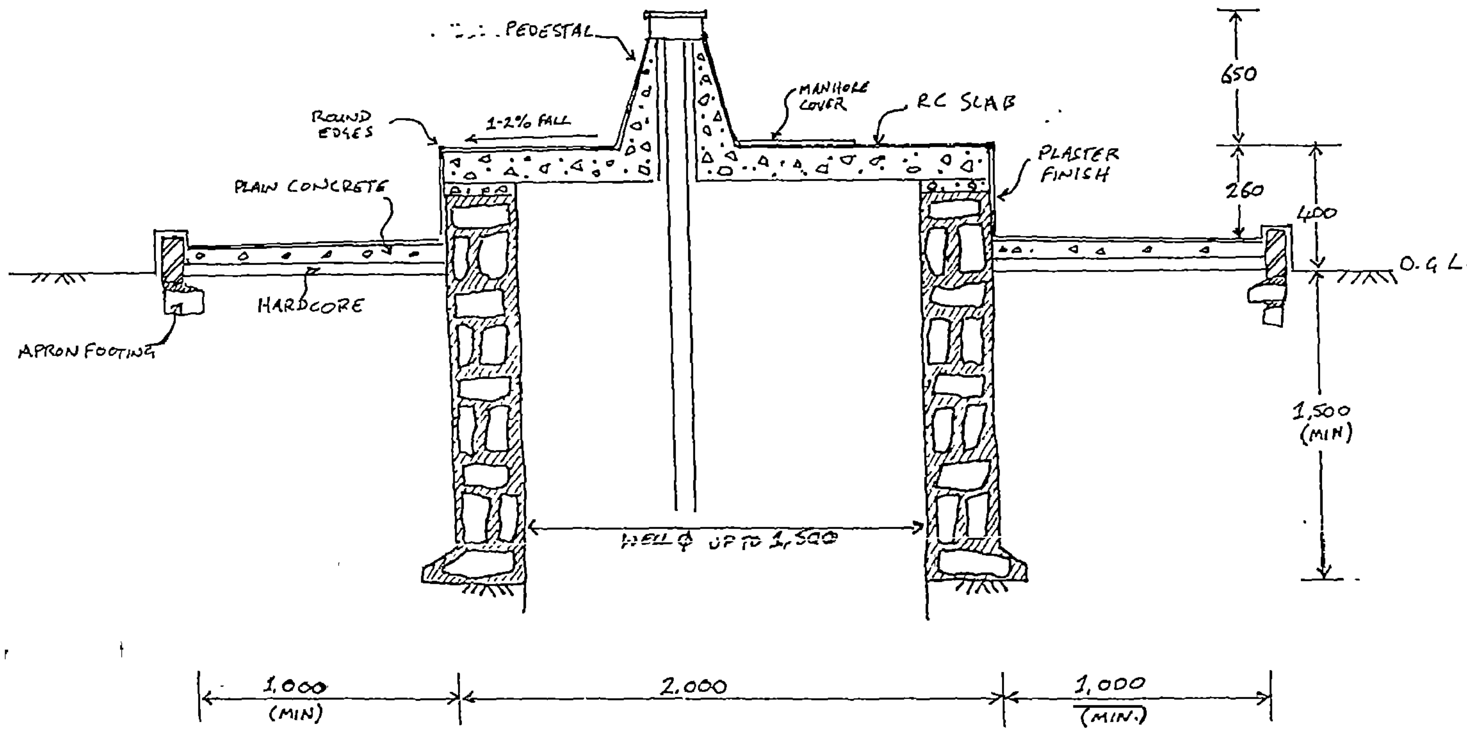
Use common sense; if farmers have recently used large quantities of fertilisers in the village then this is probably the cause.

Use of common sense is important; if there has been recent heavy rainfall then the nitrate probably is the result of surface run-off and infiltration. If high levels of nitrate cannot be explained by local conditions as above, look at the other indicators tested:

- If the turbidity count is greater than 25, and
- If the water temperature is high (ie: 25 - 30°) and
- If there is significant taste (musty) and colour (brown/green)

Then the high nitrate level could very well be the result of human sewage or animal faeces. If this is the case the well should be checked for E-coli under the second round of testing before going ahead with the well improvement.

ANNEX II: W&S CELL STANDARD WELL IMPROVEMENT DESIGN



Note: Not to scale
All dimensions in millimetres

ANNEX III: BIOLOGICAL WATER TESTING SURVEY RESULTS: SELECTED PROJECT WELLS, LORALAI DISTRICT

VILLAGE (CLUSTER):	TEST DATE:	NEW OR EXISTING WELL:	WELL IMPROVED (Y/N/DATE):	E-COLI COUNT RESULTS (100 ML SAMPLE):			CONTROL (100 ML SAMPLE):
				A	B	C	
U.C. MEHKTAR							
Mula Gagul (one)	27-10-94	Existing	Yes/09-09-93	50	48	48	0
Dargi Shepelo	27-10-93	Existing	Yes/10-09-93	40	32	28	0
Mula Gagul (one)	16-02-94	Existing	Yes/09-09-93	0	0	1	0
Mula Gagul (two); proposed site	16-02-94	New	No	42	39	53	0
Dargi Shepelo	18-02-94	Existing	Yes/10-09-93	1	0	0	0
U.C. SADDAR SAMALAN							
Shinglaz Rahkni (one)	15-02-94	New	Yes/22-12-93	43	45	30	0
Shinglaz Rahkni (two); proposed site	15-02-94	Existing	No	18	19	18	0
Shinglaz Rahkni (Kareze water)	15-02-94	Not applicable	Not applicable	2	2	3	0
U.C. POONGA							
Lique; proposed site	18-02-94	New	No	4	1	0	0
U.C. SINJAWI							
Kharotabad	18-02-94	Existing	Yes/21-12-93	0	0	0	0

ANNEX IV: BIOLOGICAL WATER TESTING SURVEY RESULTS: GOATSKIN WATER STORAGE; CLUSTER ONE WELL, MULA GAGUL, U.C. MEHKTAR, LORALAI DISTRICT

STATUS OF WELL SOURCE:	TEST DATE:	WATER SOURCE E-COLI COUNT (100 ML SAMPLE):			DURATION OF WATER STORAGE:	GOATSKIN E-COLI COUNT (PER 100 ML SAMPLE):			CONTROL:
		A	B	C		A	B	C	
Cluster one well; tested 7 weeks after improvement	27-10-93	50	48	48	30 mins.	160	150	150	0
					5 hours	170	180	180	0
					24 hours	180	190	180	0
Cluster one well; tested 24 weeks after improvement	18-02-94	0	0	1	24 hours	28	43	28	0

ANNEX V: PHYSICAL WATER QUALITY TESTING SURVEY RESULTS: SELECTED PROJECT WELLS, LORALAI DISTRICT

VILLAGE (CLUSTER):	TEST DATE:	EXIST. OR NEW WELL:	W.T. LEVEL (M)	TOTAL DEPTH (M)	SOIL TYPE	TEMP. (°C)	T.D.S. (mg/l)	TURBIDITY (T.U.'s)	pH	COLOUR /TASTE
U.C. MEKHTAR										
Mula Gagul (one)	16-08-93	Existing	17.6	18.3	sandy loam	20.0	853.0	5	7.4	clear/sweet
Dargi Shepelo	16-08-93	Existing	18.5	27.0	sandy gravel	21.0	1,365	35	7.4	brown/musty
Mula Gagul (one)	17-02-94	Existing	17.6	18.3	sandy loam	20.0	825.5	5	7.6	clear/sweet (lime)
Mula Gagul (two)	17-02-94	New	13.5	14.3	silty loam	17.0	364.0	20	8.2	clear/sweet
Dargi Shepelo	18-02-94	Existing	18.5	27.0	sandy gravel	20.0	595.0	5	7.4	clear/sweet
U.C. SADDAR SAMALAN										
Shinglaz Rahkni (one)	09-12-93	New	5.0	7.0	silty clay	20.0	384.8	80	8.2	murky/sweet
Shinglaz Rahkni (one)	15-02-94	New	5.0	7.0	silty clay	20.0	365.0	20	8.2	clear/sweet
Shinglaz Rahkni (two)	15-02-94	Existing	10.35	11.8	silty clay	17.0	487.5	7 - 8	7.4	clear/sweet

ANNEX V (cont.):

VILLAGE (CLUSTER):	TEST DATE:	EXIST. OR NEW WELL:	W.T. LEVEL (M)	TOTAL DEPTH (M)	SOIL TYPE	TEMP. (°C)	T.D.S. (mg/l)	TURBIDITY (T.U.'s)	pH	COLOUR /TASTE
U.C. POONGA										
Lique	17-02-94	New	5.75	6.7	silty clay	13.0	1,495.0	20	8.2	clear/ saline
U.C. SINJAWI										
Kharotabad	18-02-94	New	7.9	8.3	sandy clay, gravel	18.0	477.1	18	7.6	clear/ slightly musty