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Appropriate Technology Transfer in Construction

Ninh Van Commune

Ha Nam Ninh Province

Water supply and sanitation

Technical report

April 1991

CERPAD - DW/GRET

Credits

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Summary of recommendations

Recommendations included in the text of this report are extracted below; together with the paragraph headings and numbers in which they are included.

4.1. Rain water tanks

4.1.1

Existing and new rain water tanks should be improved with a complete package including the following:
1) inlet filter;
2) close-fitting manhole cover;
3) overflow pipe fitted with mosquito netting;
4) offtake tap;
5) cleaning sump and drain.

4.1.2

Modular designs for enlargeable water tanks based on units of some 2m3 should be prepared for construction with conventional construction methods and materials.

4.1.3

Design and testing of non-conventional methods of tank construction should be undertaken aimed at using different materials and reducing costs. Cost comparisons and expected life of each design to be determined.

4.1.4

Water collection and storage should be incorporated into the design for the new market in Ninh Van, for the use of families living aroung the market or for public sale to market users.

4.2. Family wells

4.2.1.

Plans for improved design of new family wells should be prepared, tested, and if viable promoted, together with suggestions for upgrading existing wells.

4.3. Village wells

4.3.1

Plans for different methods for improving village wells should be outlined and accurately costed according to the local context.
Where village wells are improved the changes in quality should be monitored.
Where the improvements require regular maintenance, the responsibilities for this should be clearly agreed with the comune, and performance monitored.

4.5. Iron and sediment removal filters

4.5.1.

The efficiency of operation and cleaning of the two initial designs must be evaluated by running a series of parallel trials on filters already installed by the project. In partcular, this should examine the iron removal efficiency and the frequency and ease of cleaning.

4.5.2.

The upflow polystyrene iron filter should be further investigated and a simple design for household use produced. This should be tested according to the same criteria used to evaluate other project designs. development could be in collaboration with UNICEF.

4.5.3.

The disposal of high iron content cleaning waters from filters must be considered, for instance by means of a covered seepage pit away from the normal water supply.

4.5.4.

A cheap disposable iron removal filter should be developed and tested by the project in Hanoi. When a satisfactory design has been developed, its social acceptability should be tested in Ninh Van and other communes.

4.5.5.

A range of iron removal filters starting from cheap and disposable filters, through to permanent family filters and village well filters should be designed, accurately costed using different construction materials (and local material costs), and those which prove viable promoted. Promotional material showing construction and operational methods should be developed.

4.6. Slow sand filters

4.6.1

A design for slow sand filtration of waters with low iron contents should be prepared and costed for village well sizes. If iron contents are high, an iron filter should be fitted before the slow sand filter.

5.1. Survey and data collection

5.1.1.

For planning water supply in communes B2 and B3, a revised questionnaire should be prepared incorporating appropriate improvements especially those aimed at finding out opinions about the water supply.

5.5. Requirements for implementing improved water supply services in communes

5.5.1

CERPAD should develop the technology selection tools outlined in 5.3. - 5.4.

6.2. Field testing

6.2.1.

The project should acquire field test kits for bacterial and chemical analysis, plus sufficient spares to carry out these tests in at least five communes, and to test the effectiveness of various equipment.

6.2.2.

At least two project staff should receive training in the use of the test kits from the Institute of Hygiene, both in the laboratory and under supervision for at least two trips in the field. They should also be taught routine maintenance of the equipment.

6.2.3.

The project should prepare cost estimates for water testing services so that an economically sustainable service may be set up, and supplies purchased from abroad on a continuing basis.

7. Sanitation options for Ninh Van

7.1.

The project should prepare promotional material for both the construction and use of double pit latrines, easy to understand and attractively presented.

8. Biogas

8.1.

The economic viability of biogas plants needs to be thoroughly investigated using the installed biogas plants as case studies.

8.2.

Subject to the recommended investigation showing that biogas is viable, promotional materials for construction and operation should be prepared.

8.3.

Subject to the recommended investigation showing that biogas is viable, using the examples of the problems encountered and advice required from the families where biogas plants have been installed, an advisory service for biogas should be developed by the project.

1. GENERAL COMMENTS

This mission was carried out as part of the sub-contract to the project by the DW/GRET team. The consultant providing the specialist input on water supply and sanitation visited Vietnam between 2 and 23 March 1991. The first week was spent in visits to the Ninh Van Commune - the first of the group B communes - to study the existing situation in the commune, and in visits to Yen Bac, Dai Ang and Hy Cuong - the group A communes - to see work which had already been carried out by the project in water supply and sanitation. The second week was taken up with discussions both with the project staff and a variety of different organisations with interests and existing technology in rural water supply and sanitation. These included:-

- Water Supply and Sewerage Construction Company
- Design Company for Water Supply and Sanitation Systems
- National Institute of Occupational Health
- UNICEF Water Supply and Sanitation Project
- Hanoi Sanitation Company
- Institute for Research in Building Materials

At the beginning of the final week a half day seminar on water supply options for rural areas, especially in the Ninh Van commune was presented to project staff and to representatives from the first three organisations above. The remaining part of the mission was spent in discussions with project staff.

As a general comment, the consultant was encouraged by the approach taken by the project staff in addressing some of the urgent water supply problems. There are also a number of similar attempts in other institutions at developing rural water supply technologies which complement the activities of the project. In short, most of the technologies already exist in some form or another in Vietnam; there is little suitable technology which can be introduced from outside.[1]

However, it is the opinion of the consultant that most of the approaches and technologies developed do not really address the problem of making the technologies affordable for the poorest sectors of the rural population. They are not therefore accessible to the people who need them most.

The tasks of the project in rural water supply and sanitation are therefore seen as:-

- Reducing the costs of construction of existing water supply and sanitation technologies, either by identifying savings in conventional construction techniques, or by developing novel techniques.

1 *KEY POINT: Most technologies already exist in Vietnam. Adaptation to local conditions and needs, cost reduction, and promotion activities are more relevant than the introduction of new technologies.*

- Compiling a short list of recommended options suitable for different environmental conditions, available construction materials and price ranges suitable for both poorer and better-off families.
- Preparing promotional materials for these technologies, showing simple construction and operation techniques.
- Assisting communes in the choice of the most appropriate options for their particular situation, using surveys and water analysis.

The rest of this report concerns the detailed assessment of the situation and existing technologies, and suggestions for developing novel approaches to water treatment and water tank construction.

2. WATER SUPPLY SOURCES AND USES IN NINH VAN COMMUNE

In Ninh Van, as in many communes in the low-lying areas, there are four possible sources of water used by the people. These in order of increasing potential contamination are:-

- Rain water collected in rain water tanks from roofs.
- Family wells, 3 - 5 metres deep.
- Open ponds used exclusively as village 'wells'.
- River or canal water.

Essentially all the water, except the rain water, comes from surface water directly or from shallow infiltration and seepage through the thick clay soils. In addition to these sources there is also the possibility that underground water may be available using deep boreholes down to about 50 metres. This is not currently utilised because of difficulties in drilling through the stone outcrops underlying the clay, and the higher iron concentrations likely in such ground water.

Most of the villagers in the commune use water from more than one source, depending on the type of use. The quantities of water used based on assessments of water use by two better-off families in Ninh Van are:-

Drinking -	2 litres per person per day
Cooking -	20 litres per person per day
Washing -	34 litres per person per day
Bathing -	19 litres per person per day
Gardening -	25 litres per person per day
Animals-	6 litres per person per day
Others -	20 litres per person per day
TOTAL	126 litres per head per day

The water use by poorer families, i.e. those using village wells or river water only, calculated from the water survey data of the village, comes to about 1 bucket of water per person per day or 30 litres per person per day.

The results of the water survey for about 65% of the households in the commune (7 villages) are shown in Table 1 (overleaf).

Table 1. Results of water supply survey in Ninh Van - summary sheet

RESULTS OF SURVEY ABOUT NEEDS AND CAPACITIES OF HOUSEHOLDS

SUMMARY SHEET - NINH VAN COMMUNE persons: 4275
households: 960

THE WELL			
Number 0:	810	Rate:	87.50%
Number 1:	11	Rate:	1.15%
Number 2:	109	Rate:	11.35%
IMPROVE THE WELL			
Number 0:	691	Rate:	72.29%
Number 1:	66	Rate:	6.88%
Number 2:	200	Rate:	20.83%
THE TANKS			
Number 0:	694	Rate:	72.29%
Number 1:	18	Rate:	1.88%
Number 2:	248	Rate:	25.83%
THE HAND PUMPS			
Number 0:	0	Rate:	0.00%
Number 1:	6	Rate:	9.63%
Number 2:	104	Rate:	10.83%
THE POUR FLUSH LATRINES			
Number 0:	871	Rate:	90.73%
Number 1:	3	Rate:	0.31%
Number 2:	86	Rate:	8.96%
THE TWIN LATRINES			
Number 0:	675	Rate:	70.31%
Number 1:	81	Rate:	8.75%
Number 2:	201	Rate:	20.94%
IMPROVED STOVE			
Number 0:	596	Rate:	62.08%
Number 1:	81	Rate:	8.41%
Number 2:	283	Rate:	29.48%
PLAN GARDEN			
Number 0:	825	Rate:	85.91%
Number 1:	31	Rate:	3.23%
Number 2:	104	Rate:	10.83%

In summary this shows that 44% of the households have family wells, 15% use village wells, 16% use river water and 50% have a rain water tank and only 2% have installed a water filter. These figures confirm the previous assessment that about 30% of the families are poor using only village wells or rivers as their only water source. However, other figures given in the first report on Ninh Van based upon information given by commune leaders, are very different (compare Table 2 overleaf); this indicates the value of direct survey as well as the assessment of village leaders. [2]

The average size of the rain water tanks is only 0.88 cu.m per person, which is too small to provide enough water for drinking and some cooking needs (15 litres per day) throughout the dry season. Only 35% of the tanks are large enough for this need.

About 60% of the households have latrines, but 77% of these are simple pit latrines with the remainder being built of brick.

A visual assessment of the water quality in each of the villages in the commune has been made by the project team which has been backed up by chemical analysis on five samples of water from the commune. The results of these analyses are shown in Table 3.

The quality of water sources in the villages is as follows:-

Good quality well water in: Thuong, He, part of Van Le, Vu Xa, Phu Lang, and He Duong villages.

Bad quality well water in: Xuan Vu, Chan Lu, & half Dong Zuan

Bad quality Public wells in: Xuan Vu, Chan Lu, Phu Lang, Van Le Duong Thuong and Thuong.

Bad quality River water in: Van Le, Chan Vu, Xuan Vu, Dong Zuan and Duong Thuong.

The map of the commune prepared by CERPAD (Fig. 1) shows the sites of the main public wells and the quality of the water sources in different villages. In general the water from wells near the mountains is better quality than that elsewhere in the commune.[3]

2 *KEY POINT: Direct surveys at household level are essential in order to establish water supply availability and consumption.*

3 *KEY POINT: Water quality varies from one source to another in Ninh Van.*

Table 2. Water supply and sanitation in Ninh Van - previous assessment

Water supply and sanitation in Ninh Van

VILLAGE	HE DUONG	VAN LE	PHU LANG	XOM HE	XOM TH.	XUANG VU	CHAN VU	DONG QU.	AVERAGE
Families	176	107	169	242	88	338	279	68	1467
Population	642	486	713	786	264	1172	1403	365	5831
WELL	19%	19%	26%	33%	32%	32%	25%	29%	27%
good q.	100%		30%	40%	30%			20%	26%
medium q.		50%	70%	60%	70%	20%	90%	30%	50%
bad q.		50%				80%	10%	50%	24%
VILLAGE WELL			53%		45%	44%	64%		28%
good q.									0%
medium q.			100%		100%	80%	60%		83%
bad q.						20%	40%		17%
RAINY WATER TANK	26%	23%	23%	31%	26%	30%	28%	29%	26%
good q.	100%	95%	100%	100%	100%	90%	100%	100%	98%
medium q.		5%				10%			2%
bad q.									0%
RIVER	46%	71%		8%		6%	11%	29%	17%
good q.									0%
medium q.	50%	50%		50%		40%	65%	50%	51%
bad q.	50%	50%		50%		60%	35%	50%	49%
POND	31%	19%	41%	41%	51%	38%	54%	14%	36%
good q.									0%
medium q.	40%	40%	50%	45%	74%	35%	40%	60%	48%
bad q.	60%	60%	50%	55%	26%	65%	60%	40%	52%
WATER FILTER						13%	4%	30%	5%
good q.						100%			28%
medium q.							100%	100%	72%
bad q.									0%
LATRINE	28%	28%	30%	33%	46%	38%	36%	29%	31%
good q.	28%	33%	30%	33%	30%	30%	30%	25%	30%
medium q.	12%		10%	30%	25%		70%		20%
bad q.	60%	67%	60%	37%	45%	70%		75%	50%

Note : These data do not include the Workers Village (about 200 families)
Source : NCRPD-DW/GRET Dec 1990

Table 3. Vietnamese water quality standards and results of analysis of water samples from Ninh Van and filtered water samples from Yen Bac

	Rural drinking water standard	Xuan Vu Public well	Xuan Vu Public well filtered	Van Le River water	Phu Lang Village well	Xuan Thiop Village well nr mount.	Yen Private well bef.filt.	Bac Private well aft.filt.
Date	5/12/90	5/12/90	5/12/90	15/1/91	15/1/91	15/1/91	20/2/91	20/2/91
PH	6-7/8	6.95	7.33	7.23	6.75	7.05	6.8	6.8
Taste	Nil	-			Unsatis.	Unsatis.	Unsatis.	Accept.
Smell	Nil	Unsat.	Accept.	Accept.	Accept.	Accept.	Unsatis.	Accept.
Suspended solids	10	39	5	20	8	5	36	4
Disolved solids	1000							
SiO2	-	10	28	12	6.2	7.8	20	16
Disolved oxygen	4							
Acidity	-	13.5	8.5	11.3	9.36	6.4	2.4	2.2
Alkalinity	-	353.8	366	237.9	158.6	207.4	433.1	430.1
Total hardness	500	31.92	25.76	7.05	9.52	7.84	17.02	14.46
Hardness-Carbonate	-	15.68	8.96	0	2.24	0	0	0
Hydrogen Sulphid	0	0.03	0.01	0.056				
NaCl	-				134.4	105.9	125.57	122.6
CO3H	-	353.8	36.6	237.9	158.6	207.4	433.1	430.05
CO2	-	0	0	0	0	0	0	0
Cl	200-300	230.75	255.6	24.85	81.53	63.8	76.2	74.4
SO4	-	201.6	211.2	82.56	101.76	63.36	197.76	163.6
NO2	-	0.095	0.03	0.07	0.11	0.03	0.09	0.06
NO3	-	0	0	0	0	0	0	0
PO4	1.2-2.5	0.35	0.65	0.4	0.2	0.1	0.52	0.55
Ca	50-100	24	26.45	6.41	32.06	34.46	58.44	48.8
Mg	-	124.2	95.98	26.88	21.83	13.11	38.45	33.5
Fe	0.3-1.0	40	Trace	1.8	1.6	1.4	6	1.08
Al	-	0	0	0	0	0	0	0
Mn	0.1	0.8	0.03	0.05	0	0	1.05	0.25
NH4	-	1.2	0.5	1	0.8	0	0.15	0.15

Figure 1. Map of Ninh Van commune (prepared by CERPAD) showing water quality and well sites

3. PROBLEMS ASSOCIATED WITH THE WATER SUPPLY

3.1. Problems of access

In general there are very few problems of access to water in the commune. In most villages the village well or river is sited within 500 metres of all the houses, so that the time taken for water collection is not excessive. Some households with a family well may also let their neighbours use water from this more convenient source.

Water is collected from the village wells by descending the steps into the well, often knee high into the water, brushing aside any water weed and dipping the two 30 litre buckets below the surface. The necessity to wade into the water introduces the risk of bacterial contamination from the feet and buckets of collectors.

Water is collected from family wells by lowering a bucket into the water which may vary at between 2 and 5 metres below the surface depending on the season. No mechanical aids or lifts are used for this, and water lifting is not seen as a problem.

The drilling of deep boreholes to reach groundwater is reported to be difficult in this commune so near to the stone mountains. One 12 metre deep borehole is said to exist in the cement works, but the chemical quality is not good.

3.2. Availability Problems

During the dry season there can be serious problems of water shortage especially in the village wells. Apart from a natural tendency to use less water, the standard solution where rivers and canals are nearby is to channel water directly into the village well. Where this is not possible those using the village well have to make do with the poorer quality water left in the well.

Family wells do not appear to be critically affected by dry season shortages apart from a general lowering of the surface water table. Rivers and canals always have adequate water supply.

Rain water tanks are solid structures built of brick or stone and plastered within and without. On average they are built too small to last the family for most drinking and cooking needs throughout the dry season. The average size is 0.88 cu. m. per person and twice that size is needed to provide 15 litres per head per day.[4]

Rain water can only be collected from houses with tile or flat concrete roofs. Poorer houses are often thatched, thus making them unsuitable for rain water collection, although some people with thatched houses will collect rain water from trees and by spreading out nylon sheets.

4 *KEY POINT: Access to water is only a minor problem. Dry season availability is a major problem. Rain water tanks are too small, and too expensive.*

3.3. Quality Problems

The most obvious water quality problem in Ninh Van is the high iron concentration found in both surface and ground waters. Even river water has been found to have concentrations of iron of 1.8 mg/l at Van Le. This is above the drinking water standard for rural areas of 0.3 mg/l although concentrations of up to 1.0 mg/l are often found to be acceptable. The Vietnamese drinking water standards and the results of water analysis from the commune are shown in Table 3. Where river water is led into public wells the iron concentration is similar to river water as at Phu Lang. The public well near a mountain at Xuan Thiop also has similar iron concentration.

However, well water from family wells and other public wells can have iron contents considerably higher, up to 40 mg/l as found at Xuan Vu. Iron content of water from boreholes sampled by the UNICEF project in Ha Nam Ninh province can also be as high if not higher than this.

The iron concentration tends to increase in the dry season, as the water resources have had greater contact with the iron bearing soil. Thus not only is water in short supply, it may also be increasingly unpalatable. High concentrations of iron in water impart a metallic taste, may have a characteristic brown colour which stains clothes and makes tea appear almost black. It is the main reason why people reject a specific water source in this area.

The other main aspect of chemical quality which affects the acceptability of water is salinity. The Vietnamese standard is up to 600 mg/l for rural areas and most of the well and river waters are below 100 mg/l. The public well at Xuan Vu has the highest concentration measured at 230 mg/l, so salinity does not appear as a problem in Ninh Van.

River water and public well water may have high turbidities and high suspended solids contents and be contaminated by organic matter. The public well at Xuan Vu and the River at Van Le have suspended solids contents above the standard of 10 mg/l. The presence of ammonia is also indicative of organic contamination, as is the presence of hydrogen sulphide. All samples except the well near the mountain showed raised levels of ammonia and hydrogen sulphide.[5]

Faecal contamination of water is indicated by the numbers of E.Coli and Faecal Coliforms. No bacteriological analysis has been carried out for water from Ninh Van but sampling of waters elsewhere by the Institute of Hygiene have showed that only 5 - 10% of family wells, 30% of rain water tanks and 60-80% of UNICEF's tubewells meet the drinking water standards of 20 E. Coli per litre. It can be assumed that most if not all public wells and river water will be bacteriologically contaminated, as well as the majority of the family wells.

The other possible concern over the quality of public well and river waters is contamination with agricultural chemicals. In the dry season when surface waters are led into the public wells, the channels often pass through paddy fields. It is more than likely that pesticides and inorganic fertilisers, the latter in common use, will be carried into the water supply. No samples have been tested for this, so the extent of the problem is not known as yet.

Even rain water tanks are not always free from contamination. Dust and dirt can be washed in from the roofs, even though the practice is to allow the first few rain storms to wash the roof down before water is collected. After collection, the manhole in the top of the tank is

5 *KEY POINT: High iron content of drinking water. Salinity may be an issue in other communes. Turbidity, suspended solids and organic contamination must be considered.*

often left open to the atmosphere and water will be taken by dipping containers which may be contaminated into the tank; both allow the water to be contaminated.

3.4. Socio-economic problems

People prefer surface waters to ground waters because the taste is better, even though the latter may be less contaminated. One good practice which is followed in the rural areas in the North of Vietnam is the boiling of drinking water. Whilst this is to be encouraged this practice does tend to hide the general unsatisfactory nature of the water supply.

The diseases which are commonest in the commune are diarrhoea, tapeworms, trachoma and eye infections and kidneystones. With the exception of the last, all common diseases are related to water. Diarrhoea is directly related to the quality of drinking water, tapeworms are passed on by consumption of contaminated food, especially unwashed vegetables, and trachoma becomes less prevalent where more water is available for washing and bathing.

All of the private water supplies, rain water tanks and family wells are owned by the better-off families in the commune. These and the families which make a small surplus each year can afford the significant costs of installing water tanks, wells and filters.[6]

The estimated costs in March 1991 (as indicated to the consultant) of the different items is as follows:-

Water tank (10 cu.m. for 6 persons):	800,000 dong
Digging wells to depth of 5 metres:	300,000 dong
Water filter for removing iron:	100,000 dong

The poorer families which make no surplus each year have no chance to improve the quality of their water supply. Improvement of the public water supplies offers the greatest possibilities for helping the poorer families. However, improvements which involve on-going operation and maintenance of a water treatment or pumping facility will often break down unless this is both simple and clearly organised. A badly operating or broken down water supply may be more dangerous than an unimproved supply. Management is thus a key issue to be addressed in any public system. For private systems the responsibility for good operation and maintenance is clear and in the obvious interest of the owner. This is not the case for public supplies only used by the poorer sections of the commune.[7]

6 *KEY POINT: Bacterial contamination*
Drinking water is usually boiled. Most common diseases associated with water quality and availability. Problems are accentuated by the high cost of water facilities.

7 *KEY POINT: Maintenance of water facilities is critical, but difficult to ensure for public water sources.*

4.WATER SUPPLY TECHNIQUES AVAILABLE, LIMITATIONS AND SUGGESTED IMPROVEMENTS

4.1. Rain water tanks

Rain water tanks are the preferred and safest source of drinking water in the Ninh Van situation. They are usually rectangular and solidly built of stone (or brick) with cement plaster.[8] There are three major limitations:-

- They tend to be too small to last the family through the dry season.

- They tend not to be protected so that they are often contaminated with dirt and dust.

- They are too expensive for many of the families to build.

The project team have designed a small filter system to attach to the inlet to the tank, Fig 2. This will remove any dirt being washed from the roof and enable all the rain water to be collected.

However, there is no point in filtering the inlet water if the manhole in the top is left uncovered all the time, nor if contaminated water containers are dipped into the tank.

RECOMMENDATION 4.1.1

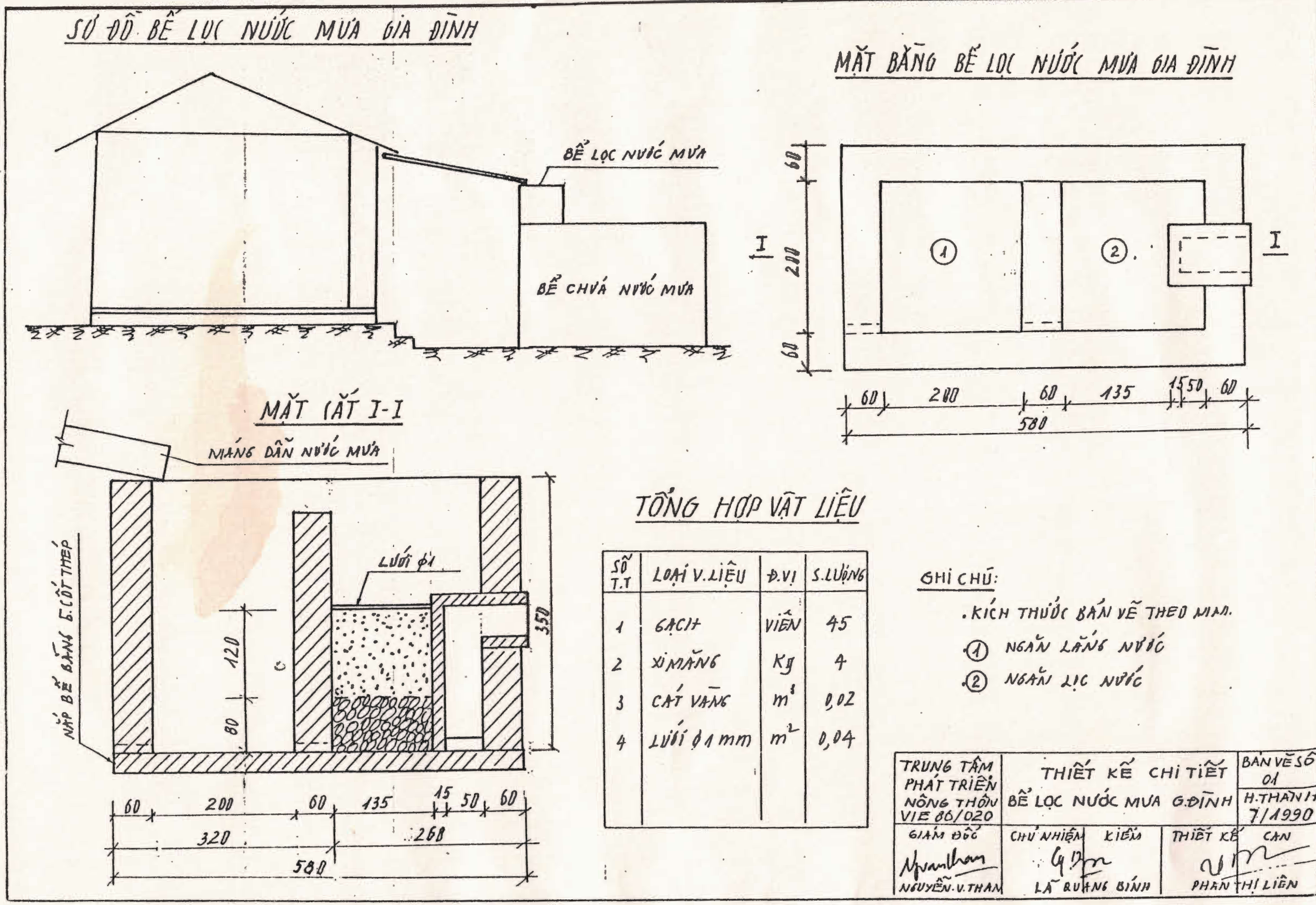
Existing and new rain water tanks should be improved with a complete package including the following:
1) inlet filter;
2) close-fitting manhole cover;
3) overflow pipe fitted with mosquito netting;
4) offtake tap;
5) cleaning sump and drain.

The small size may be related to both the cost or to the availability of land space inside the family compound. There are two approaches to reducing the cost:-

- Build or enlarge the tank in stages using conventional materials and methods.

- Build the tank out of non-conventional materials. All water technology depends on water tanks of different sizes and shapes, and the cost of the tank is the major part of the total cost of the technology. Savings in tank costs is the most direct way of reducing the overall cost and making it more accessible to less well-off families.

8 *KEY POINT: Rain water tanks are the preferred source of drinking water.*



TỔNG HỢP VẬT LIỆU

SỐ T.T	LOẠI V.LIỆU	Đ.VỊ	S.LƯỢNG
1	GẠCH	VIÊN	45
2	XI MĂNG	Kg	4
3	CÁT VÀNG	m^3	0,02
4	LƯỚI Φ1 mm	m^2	0,04

Figure 2. Rain water tank filter.

The Institute of Building Materials has recently imported the technology for making vibrated cement blocks which interlock in a curve to give a circular water tank (see description in Appendix 2). Although these are expensive even in comparison to the existing stone tanks (a 4.5 cu.m tank costs 850,000 d), they may be suitable in areas where stone and brick are not available or where raw materials for the blocks are cheaper. They can also be enlarged easily at a later date by adding on more layers of blocks. For Ninh Van, where sand is not easily available, such blocks are unlikely to be a viable solution.

The possibility of bamboo cement tanks should be investigated for some parts of the country, including their supply to Ninh Van. However, based on experiences from other countries (notably Thailand and Colombia) there are often difficulties over satisfactory keying of the cement with the bamboo, and with rotting of the bamboo, the latter encouraged by contact with chemicals in the cement. Coating the bamboo with bitumen, tar or oil-based paint is one way to overcome the problem.

A much cheaper, but less durable tank could be designed from nationally available nylon sheeting, heat-welded into the shape of an enclosed bag and housed in a simple woven bamboo and plastered mud circular structure. Research into the design, costs and durability tests should be carried out before any prototype could be promoted. (See Fig. 3.)

Another alternative is to design a system using a number of the traditional water storage jars, set up for ease of collection of the rain water. However it is likely that since traditional jars cost about 40,000 for 0.5 cu.m. the overall cost for a 10 cu.m storage system would be similar to a more durable conventional system. Nevertheless, it would have the advantage of being built up gradually, thus spreading the overall cost.

RECOMMENDATION 4.1.2

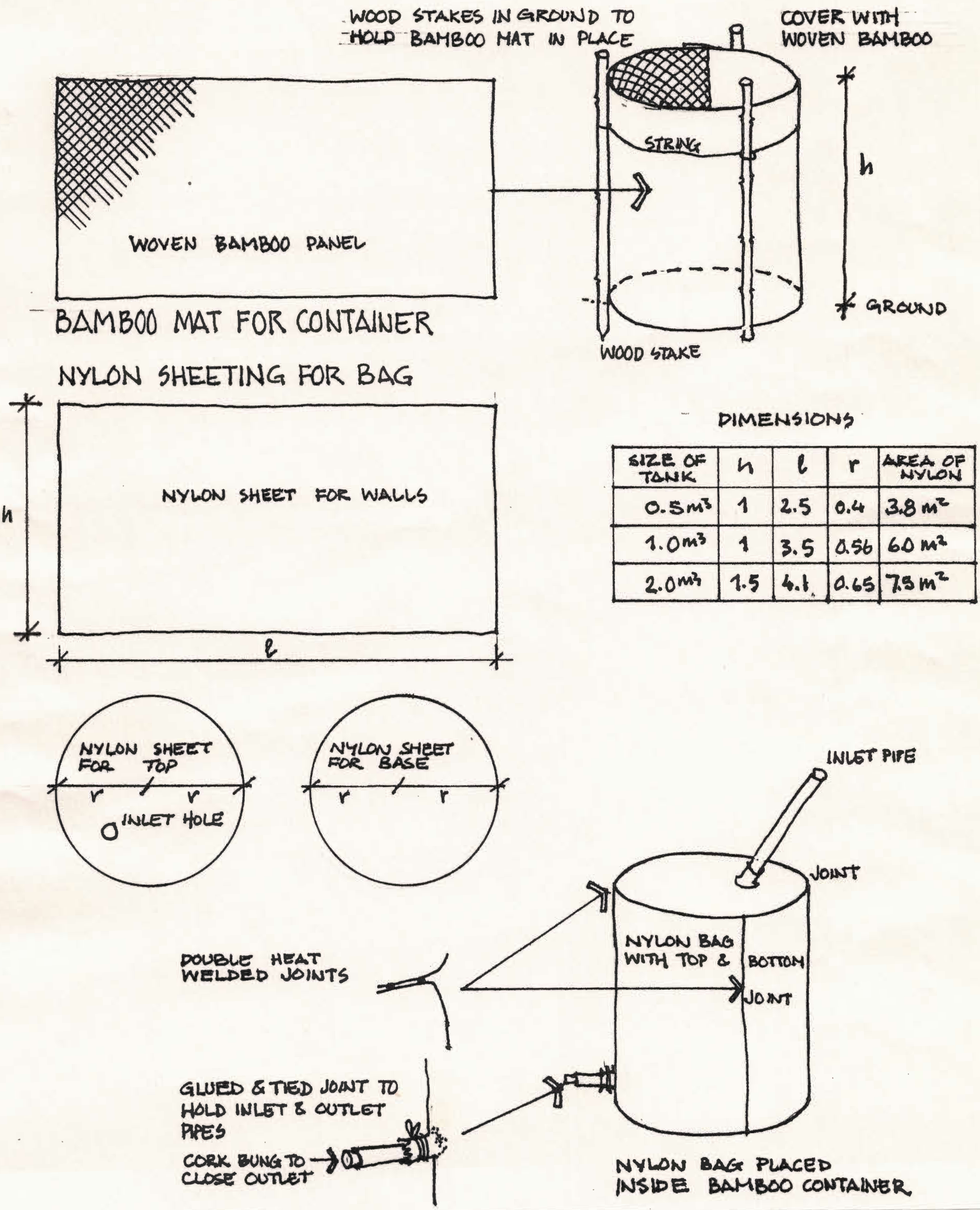
Modular designs for enlargeable water tanks based on units of some 2m3 should be prepared for construction with conventional construction methods and materials.

RECOMMENDATION 4.1.3

Design and testing of non-conventional methods of tank construction should be undertaken aimed at using different materials and reducing costs. Cost comparisons and expected life of each design to be determined.

In addition to family water tanks, there are possibilities of collecting water from public buildings, such as clinics, schools, churches and temples. The water could either be used for the institution or for controlled public use.

Figure 3. Cheap rain water tank design



SIZE OF TANK	h	l	r	AREA OF NYLON
$0.5 m^3$	1	2.5	0.4	$3.8 m^2$
$1.0 m^3$	1	3.5	0.56	$6.0 m^2$
$2.0 m^3$	1.5	4.1	0.65	$7.5 m^2$

RECOMMENDATION 4.1.4

Water collection and storage should be incorporated into the design for the new market in Ninh Van, for the use of families living aroung the market or for public sale to market users.[10]

4.2. Family Wells

Family wells are usually about 5 metres deep and 1 metre in diametre, lined with unplastered brick or stone, with a protecting wall to a height of about 1 metre. Water is raised by hand. Family wells are convenient and easy to maintain.

The limitations of family wells are:-

- Water can get into the well throughout its depth from the surface; as a result many wells are liable to direct contamination from surface waters.
- Chemical composition of well waters is variable, and a number of well waters have high iron contents.

Family wells can be protected better by lining the first 3 metres of the well with cement plaster. New family wells could be built with more extensive protection surrounding the well shaft with puddled clay, and making sure that the area around the well is concreted with a slope away from the well. For added protection the well could be covered and a hand-pump installed.

For those family wells which have high iron content, simple filters to remove the iron should be fitted, see later.

RECOMMENDATION 4.2.1.

Plans for improved design of new family wells should be prepared, tested, and if viable promoted, together with suggestions for upgrading existing wells.

4.3. Village wells

Village wells are usually open ponds, completely unprotected with steps leading into them for access. Some may be stone lined, but most are earth banked and often covered with

10 *KEY POINT: Options for cheaper construction of water tanks should be developed. Public buildings (churches, schools, etc.) should be used for rainwater collection.*

water weed. They are reasonably convenient and accessible to poorest families. The major limitations include:-

- High risk of contamination from faecal bacteria, organic matter and suspended solids.
- Possible contamination of agro-chemicals when water is brought in from fields during dry season.
- During the dry season some village wells dry out.[11]

The problem of dry season availability in village wells is a difficult problem. There are basically three alternatives:-

- To dig the well deeper: but this may not be effective since most of the water comes from the surface and may give rise to higher iron content in the water.
- To dig another well in a different part of the village, so that there is less pressure on the water resource. Similar proposals have been made to create a village washing area in a separate pond so that families only take water for drinking and cooking from the village well and not water for all their needs. Clearly cost is a factor.
- To allow water to pass from the river or canal into the village well. This is often the popular solution, but is not ideal. In this case the water should have some sort of treatment to protect it, typically, fitration.

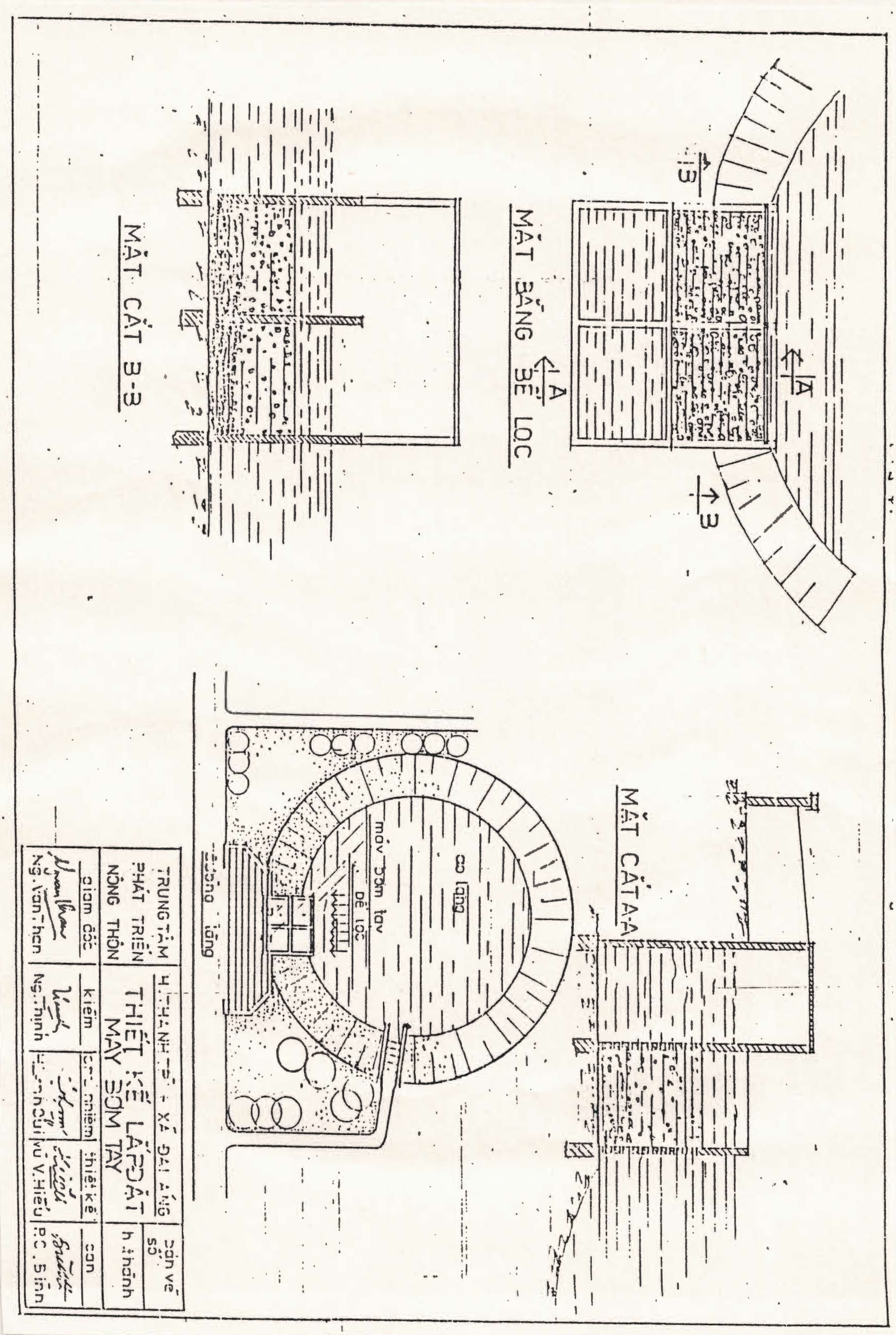
Village wells can be protected and upgraded by infilling the well with permeable layers of gravel and sand and leaving the central access point open, surrounded by a protecting wall. In essence it becomes an enlarged family well and can be protected further as already discussed. Infilling one village well has already been done in one of the villages (Vu Xa). Such measures will tend to filter out many impurities and bacteria. There are drawbacks, since eventually the gravel and sand will become clogged and increasingly less permeable. In this case considerable rehabilitation work will be required.

The second approach used elsewhere by the project has been to build a horizontal filter of gravel and sand through which the water passes before being hand pumped to road level (Fig.4). This both protects the water by minimising the need for people to wade in the well and filters the water of suspended solids and perhaps some bacteria. The limitations of this design are that:

- During the dry season the water level is too low for the filter to work, and so people still have to wade to collect water for at least two months of the year.

11 *KEY POINT: Family wells could be improved. Village wells have a high risk of contamination, and are liable to dry out.*

Figure 4. Horizontal filter for village well



- After some time the filters will become clogged and the sand will have to be replaced as there is no easy mechanism for back washing.

- There have also been difficulties with unreliable hand pumps.

- Critical to the above two points, the responsibility for maintenance of the pumps and filters needs to be clearly agreed with the commune.

A third alternative, particularly applicable when the public well contains high iron content, is to install a village scale iron filter, of similar design to the family scale iron filters. But clear responsibility for cleaning and maintenance is essential if such a system is to be effective.[12]

Similarly a slow sand filter system could be used for removing sediment and bacteria at a village well. However, although simple this may be too sophisticated to manage safely untill good working organization is in place. Slow sand filtration could be introduced at a later stage when a village has already gained some experience of managing and financing an improved village water supply system.

Another idea which may prove cheaper and easier to maintain than the others is also especially suitable where water is taken from the river to maintain the supplies in the village well. It consists in using the bulk of the well as a large sedimentation tank from which the water passes into a smaller collection chamber. Water plants, known to purify water such as Water Hyacinth and "Beo Ong" would be cultivated on the surface of the sedimentation zone. The water would pass from the sedimentation zone to the collection zone via a simple weir protected by a baffle to prevent water weeds from clogging or passing over it. (See Fig. 5). The collection zone could be improved with a simple lifting device or hand pump.

RECOMMENDATION 4.3.1

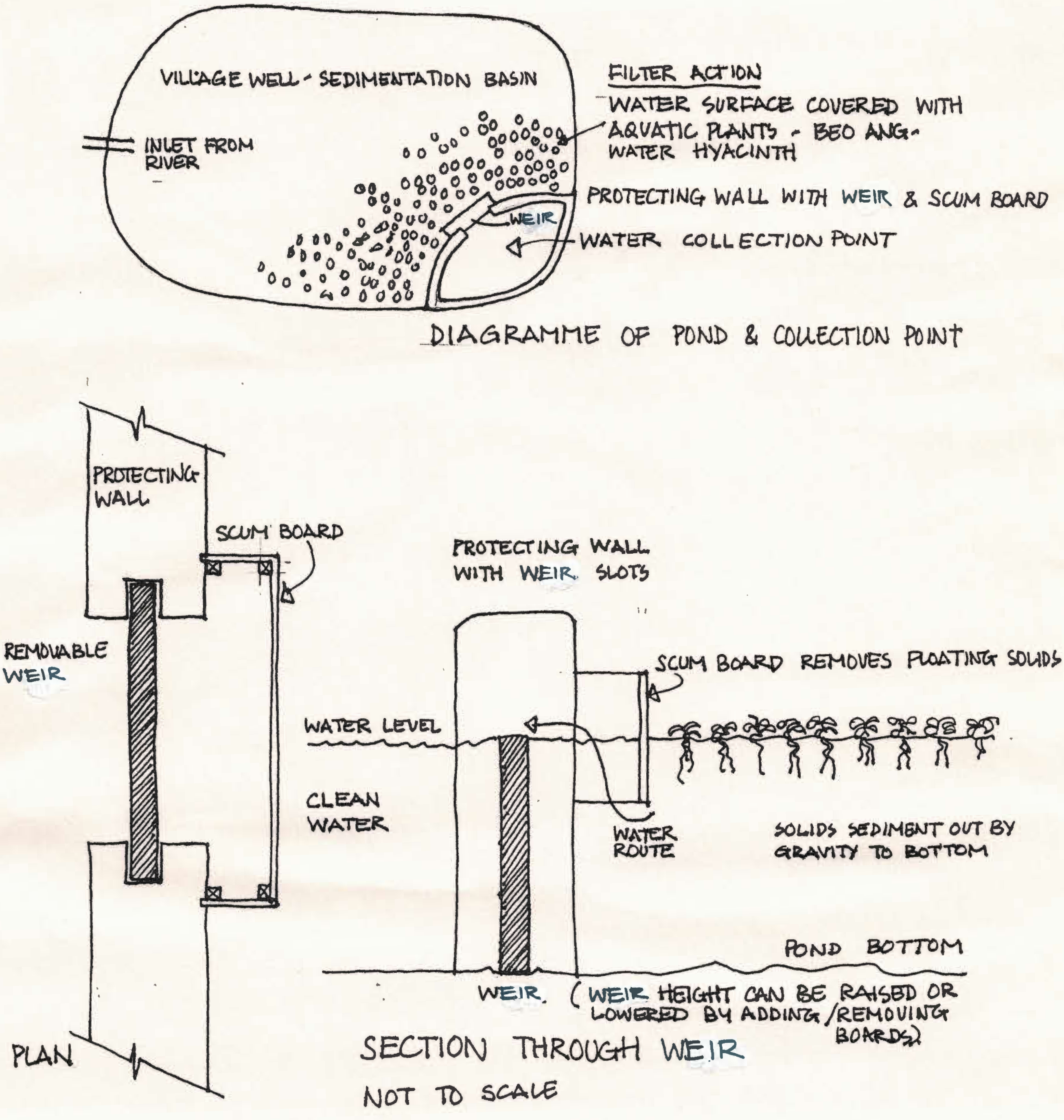
Plans for different methods for improving village wells should be outlined and accurately costed according to the local context.
Where village wells are improved the changes in quality should be monitored.
Where the improvements require regular maintenance, the responsibilities for this should be clearly agreed with the comune, and performance monitored.

4.4. River Water

River water tends to be organically and faecally contaminated, but to have lower iron content than ground or more static surface waters. Water is collected direct from the river, without any treatment.

12 *KEY POINT: Clogging of filters. There must be responsibility for maintenance. Sedimentation ponds and use of aquatic plants should be promoted.*

Figure 5. Protected village well using natural sedimentation with aqautic plants



Two options may be considered for improving river water supplies:-

- Filtering with slow sand filter on site or simple filter in the home.
- Offtake of river water into a settlement/collection tank as described above. This possibility will depend upon the availability of land and its topography.[13]

4.5. Iron & sediment removal filters

Several different models for iron removal filters have been produced in Vietnam. The project has produced two different designs in trying to improve the family filter. Both incorporate a perforated concrete tray through which the water passes to aerate it and so oxidise the ferrous ions to ferric. Ferric salts are insoluble in water and so these precipitate out and can be filtered.

The first design was a simple downflow filter through yellow sand, black sand and gravel (Fig 6). This has been installed in Dai Ang. The second design is an upflow filter through the same media which has been installed in Yen Bac (Fig.7). The results of analysis of water taken before and after filtration are shown in Table 3. In discussions with the Water Supply Design Company, it was pointed out that the first would be easier to clean, because one can stir the sand layer and so free any sediments during back washing. The upflow design is easier to back wash but the layers of fine sand are inaccessible and so cannot be stirred. Eventually all the media would have to be replaced; whilst this may be quite easy in the family filter, a larger filter for a village well might be more difficult to clean.

RECOMMENDATION 4.5.1.

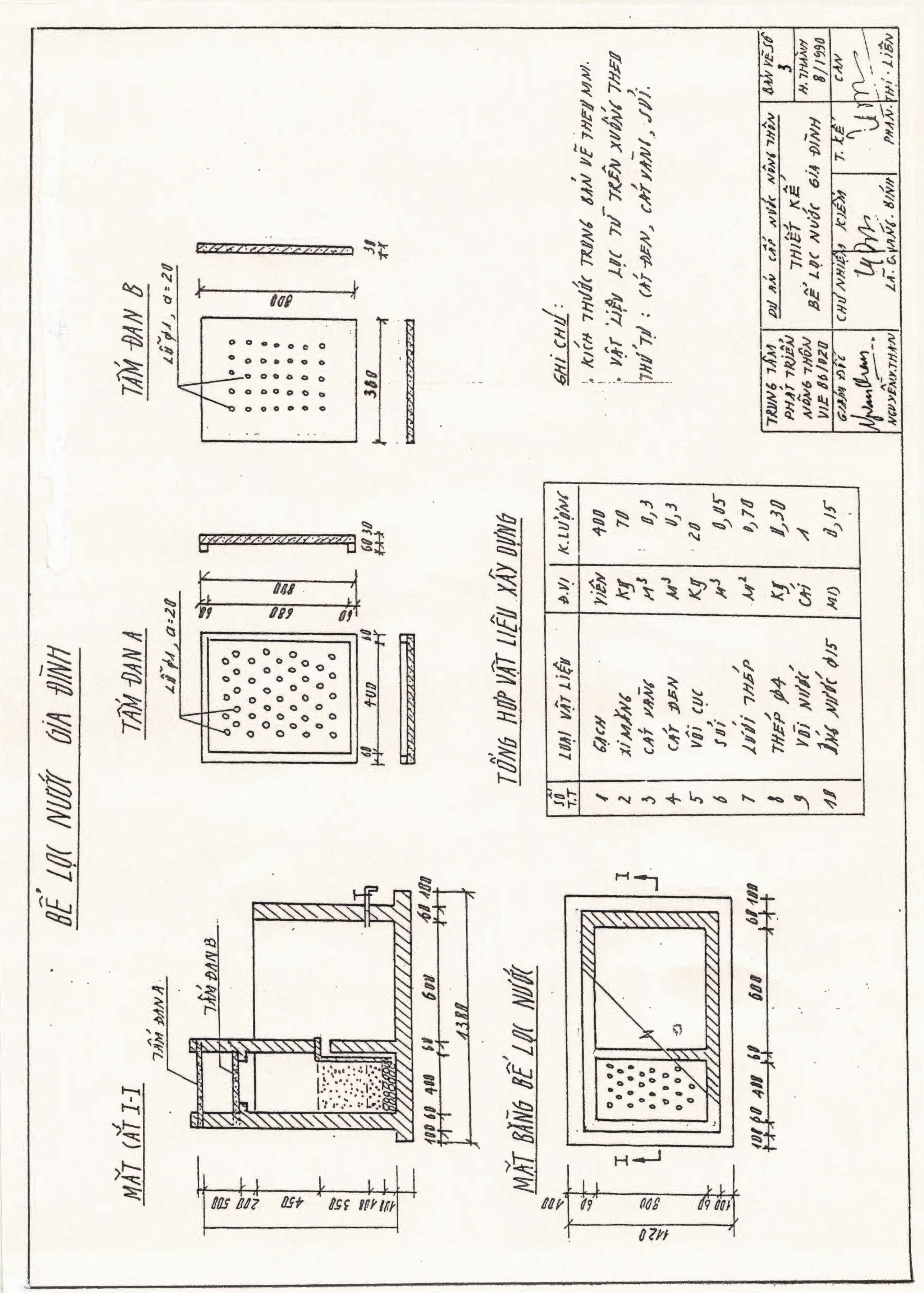
The efficiency of operation and cleaning of the two initial designs must be evaluated by running a series of parallel trials on filters already installed by the project. In partcular, this should examine the iron removal efficiency and the frequency and ease of cleaning.

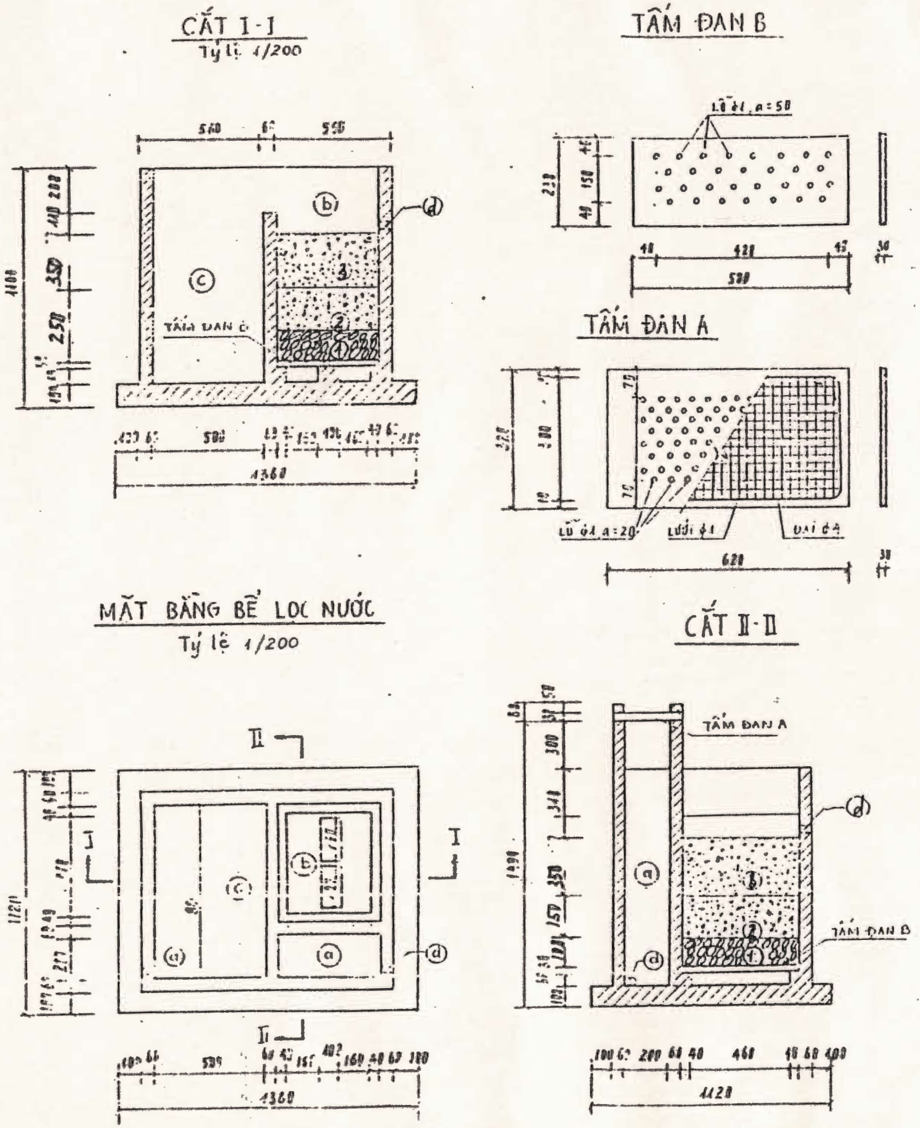
Of the other designs for filters the most promising would appear to be the upflow filter which uses ground-up particles of polystyrene as the filter medium. The big advantage this filter has is that the light filter medium is easily moved during backwashing, so that all the sediment is released quickly. Cleaning operations take up to 1 minute to complete and should be done once every day or two depending on the iron and sediment load.

The polystyrene is readily available in Hanoi (from imported waste packaging materials, and as a material used for moulding polystyrene objects).

13 *KEY POINT: River water treatment. Use of filters for iron removal.*

Figure 6. Downflow iron removal system





TỔNG HỢP V.L.X.D

SỐ T.T	TÊN V.L.X.D	ĐƠN VỊ	SỐ LƯỢNG	GHI CHÚ
1	GẠCH	VIÊN	400	
2	XI MĂNG	KG	70	
3	CÁT VÀNG	M^3	0,3	
4	CÁT ĐEN	M^3	0,3	
5	VÔI CỤC	KG	40	
6	SỎI	M^3	0,04	
7	LƯỚI THÉP	M^2	0,18	
8	THÉP φ6	KG	0,4	

GHI CHÚ:

① LỚP SỎI DÀY 10 CM.
② LỚP CÁT VÀNG DÀY 15 CM.
③ LỚP CÁT ĐEN DÀY 35 CM.
ⓐ NGĂN CHỨA NƯỚC THÔ.
ⓑ NGĂN LỌC NƯỚC.
ⓒ NGĂN CHỨA NƯỚC LỌC.
ⓓ LỖ THOÁT NƯỚC THAU RỬA.

TRUNG TÂM PHÁT TRIỂN NÔNG THÔN DỰ ÁN VIE 86/020	DỰ ÁN CẤP NƯỚC NÔNG THÔN THIẾT KẾ BỂ LỌC NƯỚC GIA ĐÌNH			BẢN VẼ SỐ: 03a HOÀN THÀNH: 10/12/1990
GIÁM ĐỐC	KIỂM	CHỦ NHIỆM	THIẾT KẾ	CÁN BỘ
NGUYỄN V. THÂN	LÃ. QUANG - BÌNH		PHAN THỊ LIÊN	

Figure 7. Upflow iron removal filter

RECOMMENDATION 4.5.2.

The upflow polystyrene iron filter should be further investigated and a simple design for household use produced. This should be tested according to the same criteria used to evaluate other project designs. development could be in collaboration with UNICEF.[14]

One of the problems which may arise as filters become more common is the regular discharge of cleansing waters which have a very high iron content and a rusty colour. Unless told otherwise the practice will be to discharge it on to the ground adajacent to the water supply, such as a well or village pond. Infilatration will then increase the localized pollution, and make the situation worse not better. Cleasing water should ideally be disposed of away from the normal water source, with the help of a pipe, to minimize this risk. A seepage pit located some distance away from the water supply point would also help control how this high iron content water is handled.

RECOMMENDATION 4.5.3.

The disposal of high iron content cleaning waters from filters must be considered, for instance by means of a covered seepage pit away from the normal water supply.

These iron filters are still not very cheap and so are not accessible to the poorer families. These families suffer considerably during the dry season when the iron content of well waters increases. If they had a simple iron removing filter, they would not be so obliged to consume contaminated waters.

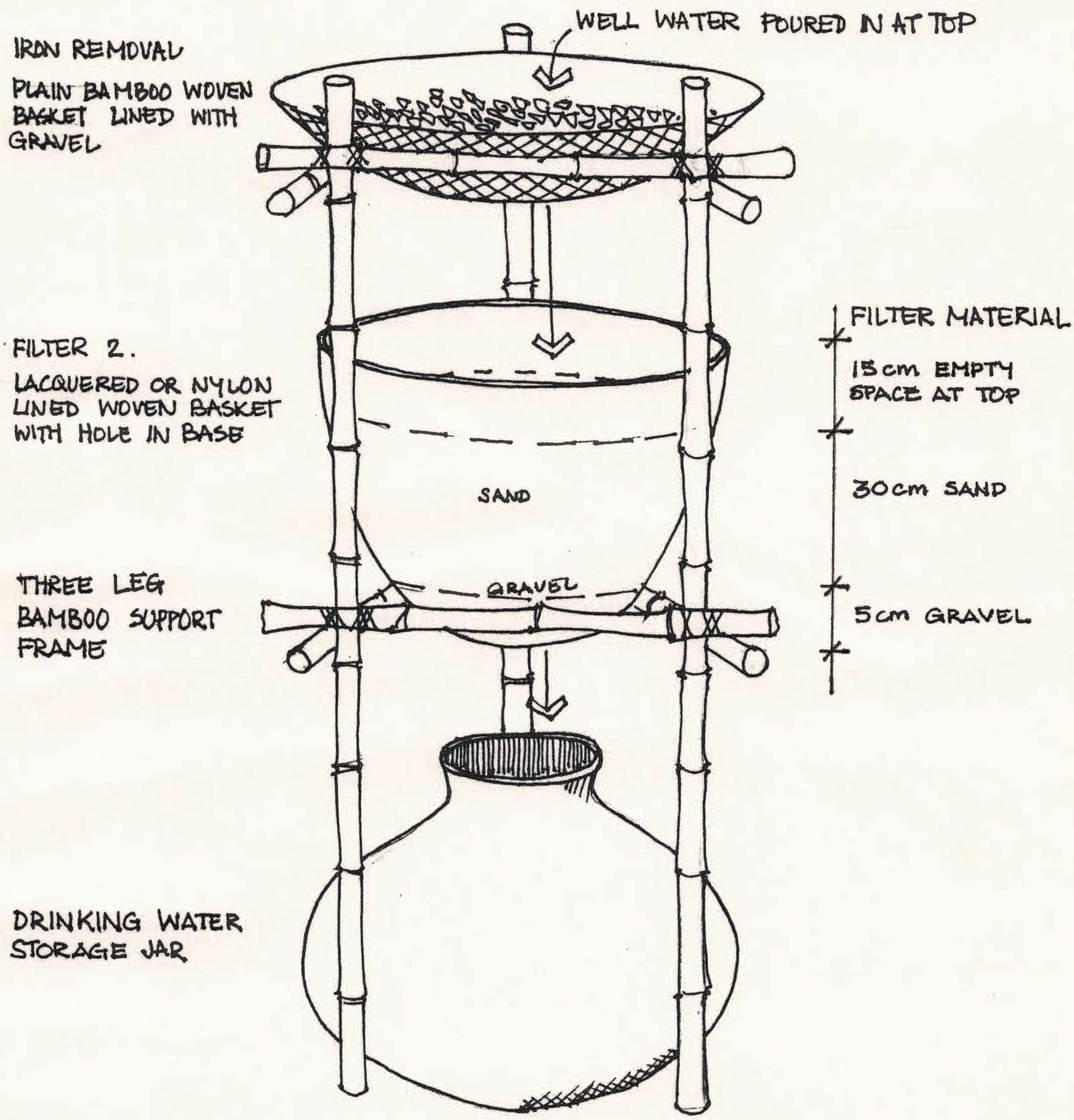
The project should examine the possibilities of designing a cheap disposable iron removal filter for single household use. If a filter tank could be produced involving cheaper materials, e.g. lacquered baskets or baskets lined with nylon in which the sand and charcoal filter was kept, and with a hole in the bottom from which water passes to the holding tank (or other receptacle), for under 10,000 dong, this would be a substantial improvement. The sand would need to be washed regularly and once the baskets became rotten, they would be thrown away. A possible design is shown on Fig.8. A more durable design might use plastic baskets and buckets. If sand is not readily available, other filter media such as burnt rice husks should also be tested.

RECOMMENDATION 4.5.4.

A cheap disposable iron removal filter should be developed and tested by the project in Hanoi. When a satisfactory design has been developed, its social acceptability should be tested in Ninh Van and other communes.

14 *KEY POINT: Testing of filters for iron removal must be done. People must be shown how to correctly dispose of water containing high amounts of iron as a result of washing the filter. Cheap disposable filters for iron removal should be developed for household use.*

Figure 8. Disposable iron filter



In addition to the brick or stone construction materials used for the more permanent types of filter, other materials should be investigated. The use of Natural Fibre Cement panels produced by the Institute of Building Materials might be more appropriate in some communes, although probably not in Ninh Van (due to the sand shortage). The Institute of Hygiene has already commissioned the IBM to build 8 prototype filters. The performance and accurate costs of these should be assessed in collaboration with the Institute of Hygiene, and compared to other filters being used or developed by CERPAD.

RECOMMENDATION 4.5.5.

A range of iron removal filters starting starting from cheap and disposable filters, through to permanent family filters and village well filters should be designed, accurately costed using different construction materials (and local material costs), and those which prove viable promoted. Promotional material showing construction and operational methods should be developed.

4.6. Slow sand filters

Iron and sediment removing filters will not be very effective at removing bacteria. The large upflow, polystyrene filter installed at a military hospital in Hanoi is said to achieve 70% removal of bacteria, but when water is severely contaminated that level will not be enough to produce a safe drinking water.

Slow sand filters are a more effective way of reducing the bacterial load of drinking water, particularly when the biolayer on top of the sand has been allowed to build up. It is not possible to combine slow sand filtration with iron filtration, because the sediment would quickly block up the filter, and iron reducing bacteria may grow in the bio-layer on top of the sand. These bacteria would tend to transform the iron back to the soluble ferrous state and so defeat the original purpose. Therefore the iron sediment would have to be removed first with a roughing filter using natural materials such as coconut husk fibres and burnt rice husks, followed by the slow sand filter.The original CERPAD slow sand filter design would have to be modified to give a larger filtration area, and in accordance with design criteria for the flow rates expected in a given public location: it is most probable that the filter size would cover too large an area to be applicable in a family situation, but might eventually be interesting in a public situation, should village finance permit. Slow sand filtration represents a slightly higher level of technology and preliminary designs should be costed and sizes and material quantities determined in order to see if they could be recommended for villages at this stage. If not, they should not be seen as a top priority for development.

RECOMMENDATION 4.6.1.

A design for slow sand filtration of waters with low iron contents should be prepared and costed for village well sizes. If iron contents are high, an iron filter should be fitted before the slow sand filter. [15]

4.7. Washing and bathing ponds

As has already been mentioned, a proposal has been made in Ninh Van to create a special washing/bathing area in one village where the village well capacity comes under pressure during the dry season. This is an excellent suggestion and a plan has already been prepared, (see Fig.9). Two comments can be made:-

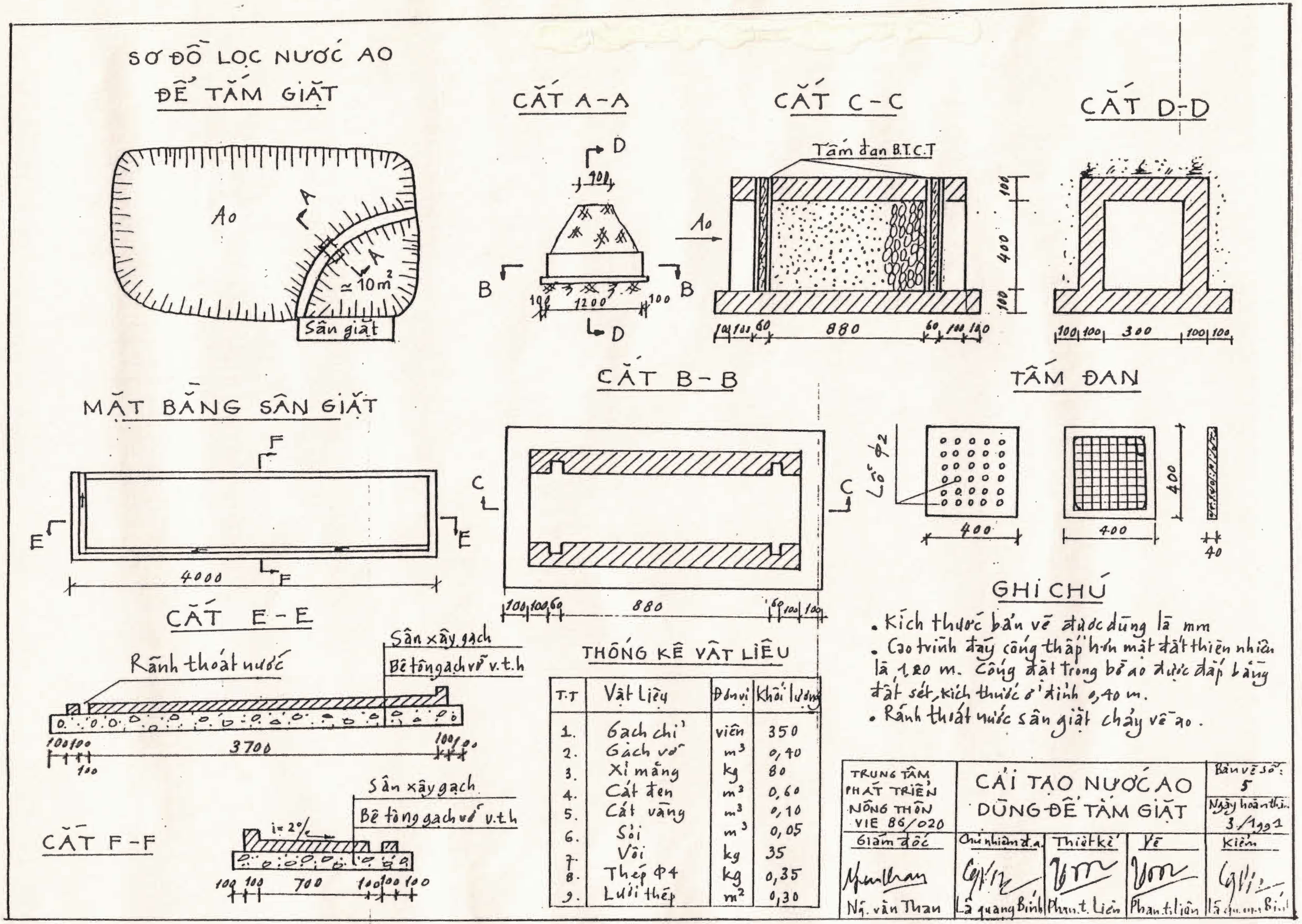
- The waste wash waters from washing plinth should not be allowed to drain back directly into the pond, which will quickly become contaminated with soap etc. The waters should be drained to a seepage pit and only thence back to the pond.
- The layout of the washing plinth should take into account the suggestions of the women who will use the washing area, and should be designed to accommodate different types of washing, with, as needed, appropriate privacy.

4.8. Boreholes and hand-pumps

Although boreholes and hand pumps as promoted by the UNICEF project would appear not to be so suitable for the Ninh Van area, they do have definite application in many other plains villages. This option will have to be considered along with the technologies already discussed for improving water supply in other communes, but if so, the pump mechanism should be re-evaluated and probably re-designed to ensure relaibility and potential for local maintenance and repair.

UNICEF have indicated that they have had problems with the siting of village wells, which have led to poor social distribution of the benefits. They have attempted to provide coverage of 1 well per 400 persons and in some districts have achieved 1 well per 120 persons. At least two wells should be provided in every village with a maximum collection distance of 500 metres. Maintenance is the responsibility of the main user on whose property the pump is sited, but the organization and financing of this should be collectively considered, otherwise after some time the pump sometimes becomes taken over by the main user. In order to get over poor site selection and some main users denying access to others, a system of self-selecting user groups based upon family links might be more successful than has been the case for sites selected by commune leaders.

15 *KEY POINT: Slow sand filtration is not seen as a priority for development.*
User should be involved in washing pond design. Research should be done to overcome the poor reliability of hand pumps.



THỐNG KÊ VẬT LIỆU

T.T	Vật Liệu	Đơn vị	Khối lượng
1.	Gạch chỉ	viên	350
2.	Gạch vỡ	m^3	0,40
3.	Xi măng	kg	80
4.	Cát đen	m^3	0,60
5.	Cát vàng	m^3	0,10
6.	Sỏi	m^3	0,05
7.	Vôi	kg	35
8.	Thép Φ4	kg	0,35
9.	Lưới thép	m^2	0,30

Figure 9. Village washing/bathing pond

However, in addition to this problem, the UNICEF boreholes and pumps do not have a high reputation for reliability. The Water Supply and Sewerage Construction Company consider that their wells are better. No comment can be made on claim or counter- claim, since this consultancy has not addressed the issue of boreholes and pumps in detail.

5. RURAL WATER SUPPLY PLANNING AND ADVICE

The VIE/86/020 project has a stated aim to improve the capabilities in rural planning for communes; water supply and sanitation forms an important detail of this. Water supply planing involves the survey of water sources, analysis of the problems and identification of the priorities, leading to the choice of appropriate solutions. One aspect of the CERPAD role should be to provide such advice, to help communes make the best choice given the resources they have. CERPAD need to strengthen this role. It should involve a number of clear steps indicated below.

5.1. Survey and data collection

a) Water supply data

Collection of reliable and relevant data about the situation is critical. Without this the planning process cannot work. The information required includes:-

- The current sources of supply
- How many people use each source
- How much water they use from each source
- The status of each source - (i) availability throughout the year; and (ii) quality of the water throughout the year.
- Problems with each source - (i) as observed by the planning team; (ii) as reported by users; and (iii) as shown by water analysis - both chemical and bacteriological.
- Potential yield of each source - how much water can be extracted without significantly reducing the availability or quality.

In the case of Ninh Van Commune CERPAD has collected two estimates of water supply in Ninh van. The first during the initial needs assessment based on discussions with commune leaders and the second through a detailed house-to-house questionnaire. We have already noted the differences betwen commune leader assessments and the questionnaire results. The latter should be considered more reliable.

The questions asked in the questionnaire included:-

1. Number of house.
2. Name of family.
3. Number in family.
4. Do you have a rain water tank? What is its size and construction materials?
5. Do you have a family well? What is its depth and construction materials?
6. Do you have a water filter? What is its size and construction material?
7. Do you collect water from the village well? If yes, how many visits with 2 x 30 litre buckets do you make per day?

8. Do you collect water from the river? If so, how many visits with 2 x 30 litre buckets do you make per day?

9. Do you have a latrine? If so is it a simple pit latrine or twin pit latrine?

10. Do you have a drilled well less than 10m?

11. Do you want a family well?

12. Do you want an improved family well?

13. Do you want a filter tank?

14. Do you want a hand pump?

15. Do you want a latrine - pour flush or twin pit?

16. Do you want an improved stove

17. Do you want improved gardening?

Questions 11 - 17 were answered by the following code:

0 = People do not want/need improvements.

1 = People want the improvements and have capacity to build/afford.

2 = People want improvements but have no money.

The survey was carried out for CERPAD in each village by questionners from the Peoples' Committee and the responses seemed variable, especially in answer to the needs and wants of the people, which were sometimes omitted. Numbers are relatively easy to collect, but opinions less so, especially when the people may be unclear what the improvements might be, and this should be taken into consideration in the design.

Questionnaires have to be carefully designed to get enough information quickly without boring the householder or making the task of the questionner so long he cannot cover the whole village. Although this questionnaire is quite a good first attempt, it is obvious that the way some of the questions are put will result in 'yes' or 'no' as an almost automatic answer - (do you want a filter tank - ... Yes; can you afford it?... No). A questionnaire should try to avoid putting questions in such a way that one can almost forecast the answer.

This present questionnaire could also be improved to yield more useful information.[16] Suggestions for improvement include the following:-

- Does the family receive rice supplements? Each year? Occasionally? Never?
- What roofing materials are used on the house? (and other buildings). (to check-suitability for rainwater collection.)
- Does the water in your rainwater tank last through the dry season?

16 *KEY POINT: Improvements to the water supply questionnaire.*

- Is a pump fitted to the family well? What energy supply does it use?
- Does your family well run dry in the dry season?
- How far is it to the public water source you most often use (metres or minutes per trip)?
- If there is more than one public water source in the village? Which one do you use? Why?
- How does the water look and taste from each source? Good? Satisfactory ? Bad?
- What problems do you experience with your water sources?

  Too far/ Too deep/ Bad taste/ Too cloudy/ Too coloured/
  Not enough in the dry season/ Other.
- Are you satisfied with your present water source?
- Would you be able / prepared to contibute towards improvements? Labour/ money/ both? How much?

b) Sanitation

The questionnaire is very short on sanitation questions, finding out only how many latrines there are. Additional questions should include:-

- If you have no latrine, do you use your neighbour's latrine?
- How far is your latrine from the nearest source of drinking water (own well, neighbours well, village well)? Less than 5 m 5 - 10 metres/ over 10 metres.
- To fertilise gardens/ fields or fishponds, do you use (i) urine; (ii) solids from your latrine?
- Are you aware of the need to store solids for several months before applying to the fields to reduce the risk of infections?[17]

c) Health

Health is closely connected with water supply and sanitation and the questionnaire may be an opportunity to identify possible problems. For instance, questions might be asked as:

- Does any member of your household suffer from:

  Diarrhoea - Once a week/Once a month/ Few times a year/Never ?

17 *KEY POINT: Improvements can be made to the sanitation questionnaire. It should include health questions and use local clinic records. Direct observation in the household is important.*

Worms ?

Eye Problems ?

Skin problems ?

Indications of water related health problems may also be obtained by checking the records of the local clinic(s) over the past year or two. These may show what the commonest diseases are, and whether there are any differences of occurence between different villages in the commune, e.g. if one particular village has more incidence of diarrhoea than others indicating that the water supply needs urgent attention.

d) Observations by the planning team and water analysis

The data collected by the questionnaire must be backed up by direct observation by the planning team, including visiting:

- All public water sources - village wells, rivers, village pumps.
- A sample of family wells in different part of the village from both better-off and poorer families.
- Direct discussions with users of public water sources.

The observations are aimed at identifying technical issues connected with improving the water supply, as well as some of the social constraints. They also serve to verify questionnaire gathered information

At the same time as observing the water sources, tasting and smelling the water, samples may be taken for analysis on the spot or in the laboratory. This will be discussed in the next section.

RECOMMENDATION 5.1.1.

For planning water supply in communes B2 and B3, a revised questionnaire should be prepared incorporating appropriate improvements especially those aimed at finding out opinions about the water supply.

Questionnaires of this kind should be continually revised and adapted to the situation, i.e. include (or leave out) questions which are more (or less) relevant.

5.2. Analysis of the data

Once collected and entered into the data base, the data from the survey can be analysed. This has been done for Ninh Van. However, as well as analysing the straight data, e.g. by finding percentages etc.; it would also be useful to make cross comparisons e.g. numbers of households with rain water tanks and family wells; numbers with rain water tanks using public water supplies; what percentage of the users feel about the water source; does the water analysis bear out the majority feelings about the water source?

In order to identify the priorities for action in the commune, the survey data, observations and water analysis should be combined by summarising:

- The different water sources, the technical issues associated with each and the degree of severity of the problem.
- The numbers of people using each water source.
- The ability of the people to help themselves, e.g. as a general rule the richer families may be able to finance improvements to their own water supplies and need technical advice only, the poorer families dependent upon the village water supplies may need financial and technical assistance to upgrade those supplies.

Thus if In a commune, one village well is more contaminated, more likely to dry up and used by larger numbers of people than others, this is the one which should be considered first. It would be helpful to prepare a Water Source Assessment Matrix for each water source as shown (Fig. 10). Within each commune, the planning team grades each water source according to its accessability, availability, and chemical and microbiogical quality. Scores are assigned from 0 - 3 by giving the highest scores to those sources with the greatest problems. (It does not matter that these scores will be rather subjective , provided that a constant standard is applied by the whole team, and for all the water sources within the commune.) The matrix is one aid to choosing priorities.[18] The scores for each source are then added together and multiplied by the number of households served. Thus in the example village wells A1 and A2 would have high priority as well as Village Tube well D2. The river sources in village E also require attention. The families in villages A and D also require advice on improving their family wells. Thus we get a rational profile of action that could be taken.

18 *KEY POINT: Use data to identify priorities. Use the Water source assessment matrix.*

Figure 10. Water source assessment matrix - hypothetical worked example

Water source	Numb.of household using source	Access	Issues Water availa-bility	Water Chemical	quality Bacterial	Total issues score	Score x househ.no	Priority
Village wells								
A1	30	2	2	3	1	8	240	5
A2	50	3	3	1	3	10	500	1
B3	10	0	2	2	3	7	70	
C4	5	0	1	1	1	3	15	
Village tubewells								
D5	20	2	0	2	0	4	80	
D6	50	3	1	2	1	7	350	2
River water								
B7	17	2	0	1	2	5	85	
C8	15	1	0	2	3	6	90	
E9	25	2	0	2	3	7	175	6
E10	35	2	0	1	2	5	175	6
Family wells								
Village A	45	0	1	3	3	7	315	3
B	25	0	0	2	1	3	75	
C	17	0	1	3	2	5	85	
D	40	0	2	2	3	7	280	4
E	10	0	0	1	0	1	10	

Assessment severity score
0 = no problems
1 = few problems
2 = some problems
3 = severe problems

5.3. Choosing the appropriate technologies

Looking again at the Assessment Matrix, we see that even within the priority sources there are different problems. Village well A2 has both an access problem (it is too far for some of the users) and a water availability problem (it runs dry in the dry season) and it is heavily contaminated bacterially, whereas Village well A1 has less of an access and availability problem (it may be deeper) but is heavily contaminated with iron.

Different problems require different solutions. Sometimes there is no easy technical answer to a problem, e.g. if the water is too saline, or the technical solution may be socially unacceptable or beyond the financial means of the people.

A simple flow diagram or alogrithm has been designed to assist in technology choice based upon the experience to date in Ninh Van (Fig. 11). The priority water sources are considered in turn, starting as indicated. Simple questions requiring YES/NO answers lead one through the diagram to the possible technical solutions in the square boxes. These are then subjected to social, management and affordability questions. If a blockage is reached, one has to start again and look at alternative sources of water. Thus the alogrithm first of all helps you choose the type of technology required and then the appropriate level of cost and complexity. [19]

5.4. Choosing the level of technology

If sufficient water is available, the most important criterion for improving water supplies is the chemical and bacteriological quality. WHO and the Vietnamese Government have issued reccommended standards for microbiological purity for drinking water of 20 coliforms per litre. In many rural situations where contamination may reach several thousand times higher than this, such standards will be realistically unobtainable.

So what quality should we be looking for in the rural areas? It is not possible to set absolute standards, but it is better to look for a small improvement which can be consistently maintained over a long period of time, than to reach very high standards for only short periods. Thus it would be better to introduce a simple technique which reduces the bacterial load by 70%, (e.g. from 10,000 cells per litre to 3,000 cells per litre) all the time, compared to one which achieves 99% reduction to 100 cells per litre for only one week a month. We are looking for a combination of EFFECTIVENESS and CONSISTENCY.

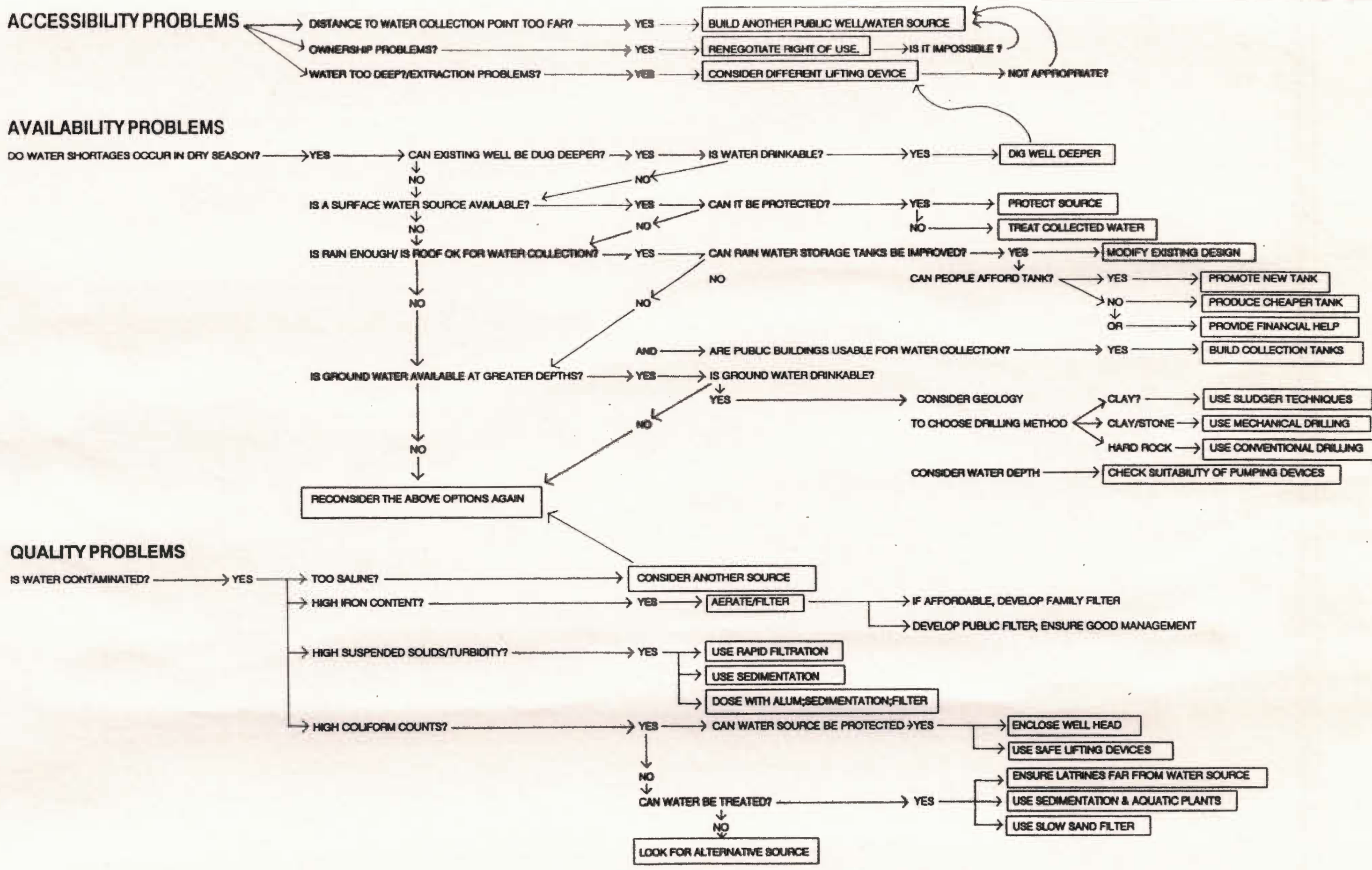
These two criteria are usually affected by the cost and the ability to manage/operate the technology. Thus the more expensive and sophisticated, the higher the effectiveness, but the higher the demands of management required to achieve consistency.

Improvements in rural water supply should be seen as a continuing, step by step process. Once small but consistent improvements have been mastered both technically and in management, other more sophisticated options can be introduced.

19 *KEY POINT: Use the algorithm for water supply technology choice. High water standards may not be realistic in some areas. More important is to ensure a constant improved quality of water.*

Figure 11. Algorithm for water supply technology choice in Ninh Van

SELECT WHICH WATER SUPPLY PROBLEM YOU HAVE ENCOUNTERED



IS THE SELECTED TECHNOLOGY VIABLE?

TECHNICALLY?	CAN USERS INSTALL AND OPERATE IT 1) WITHOUT DIFICULTY? 2) ONLY WITH TRAINING? PROVIDE TRAINING 3) ONLY WITH TECHNICAL HELP? TRAIN HELPERS
FINANCIALLY?	CAN PEOPLE AFFORD TO INSTALL IT? CAN THEY AFFORD TO OPERATE IT ?

IF THE ANSWER IS NO, LOWER CAPITAL OR OPERATING COST OR CHANGE TECHNOLOGY

SOCIALLY?	WILL OPERATION AND MAINTENANCE BE UNDERSTOOD ? AND WILL IT BE ACCEPTABLE ?

IF ANSWER IS NO, RECONSIDER CHOICE.

ENVIRONMENTALLY?	WILL TECHNOLOGY CAUSE ENVIRONMENTAL HARM? WILL IT LOWER THE WATER TABLE? WILL IT CAUSE UNACCEPTABLE WASTE DISCHARGE?

IF ANSWER IS NO, RECONSIDER YOUR CHOICE.

AFFORDABILITY is perhaps the most important constraint on the level of technology. A public planning service should not develop a splendid technology which can only be afforded by 5% of the population. It should be aware of it, but leave its development to a company which markets its product specifically at that 5%. The public planning service needs to develop a range of technology options at different costs so that it can advise which is the most affordable for poor and better-off sectors of the population.

Costs should be considered as (1) Initial or capital costs and (2) Operating costs (time, spares, fuel, supplies, replacement costs). Do not just compare the straight costs, but divide the total cost by the numbers of people served, or quantity of water treated, since different techniques may have varying capacities. This is especially important when comparing different solutions for village wells/public water supplies.

DURABILITY should also be considered as part of the cost and affordability calculation. If a piece of equipment - for example, a filter - lasts for 20 years, but is expensive (say 800,000 dong) it may not be as realistic and appropriate as equipment which costs 80,000 dong but only lasts for 2 years, (i.e. which has low durability), even though the total cost over 20 years would be the same. One must consider which technology is better - a family which makes a surplus of under 300,000 dong per year might be able to afford one cheap filter every two years, and thus have better water, whereas they would have to save for at least three years in order to install the more expensive long lasting equipment, and in the meantime go on using contaminated water.

MANAGEMENT SKILLS required is another criterion. When comparing technologies assess the level of technical skill required to install and operate the equipment, and consider whether this is available in the village. If it is not, consider whether training will provide that skill adequately. If this is not possible or appropriate, then a simpler level of technology may be needed.

Management skills also refer to the organisation of the operating and maintaining of the water supply. In a family situation it may be clear who has the responsibility for making sure that the equipment keeps on working. For a public water supply, this may not be obvious, so an assessment of the management skills required will consider whether the village organisations are capable of doing this, who will be responsible for maintaining the equipment and how will spares be obtained.[20]

In order to be able to compare different technology options for any one problem using these criteria, a form (Fig.12) has been prepared which includes assessments of capital and operating costs, durability, effectiveness and affordability. The degree of management skills required would be reflected in the capital and operating costs so has not been included in this form. However a separate comparison of management skills would be useful.

20 *KEY POINT: Undertake a 'level of technology' assessment. Affordability - consider both capital and running costs and Durability. Consider what management skills are needed.*

Figure 12. Total annual affordable cost effectiveness assessment matrix for water supply technologies - hypothetical worked example

Technical Option	1 Numb. of people served	2 Capital Total Dgsx1000	3 costs Cost/h. (2)/(1) Dx1000	4 Lifetime Years	5 Operating Total annual cost Dx1000	6 costs Annual cost/h. (5)/(1) Dx1000	7 Total annual capital+ op. costs /head (3)/(4)+(5) Dx1000	8 Effec- -tiveness Grade 1-3	9 Total annual effect. /head (7)/(8) Dx1000	10 Affordab. Capital cost as % of surplus (3)/su. %	11 Total annual afford. cost effectiv. (9)x(10) %
A	100	1000	10	10	200	2	3	1	3	17%	0.51
B	100	2000	20	20	100	1	2	3	0.66	33%	0.22
C	100	750	7.5	5	150	1.5	3	2	1.5	13%	0.19

* Effectiveness grade
1 = least effective
2 = average effectiveness
3 = most effective

* Surplus = estimate of surpluses achieved per head of population served each year

For each technical solution work through the form as shown, to come up with a final column for a measure of the Total Annual Affordable Cost Effectiveness. This is rather an artificial figure, but by comparing the final column figures, the lowest figure represents the most effective and affordable option. In the example figures given, Option C comes out with the lowest Affordable Cost Effectiveness, even though it has by far the shortest life, medium effectiveness and lowest affordability. However, B is quite close behind with the highest capital cost and affordability, but with the longest life and greatest effectiveness.

This sort of approach helps the planner make a rational choice of technology option. However, the final decision must be made bearing in mind the real situation. Check out the decision by asking the following questions:-

- Will the people accept the technology easily?
- Will they be able to manage and operate it continuously, and to sustain it over a long period?
- Does it do the job effectively enough to be worth the effort and cost?
- Will the people really be able to afford it?
- Will it cause any other problems - social or environmental?[21]

5.5. Requirements for implementing an improved water supply service to communes

In order to be able to offer a regular service to communes to help them improve their water supplies, CERPAD needs to develop the tools outlined in 5.1. - 5.4. above. This involves the following:-

1) Improve data collection questionnaires and provide training in filling out the questionaires for village surveyors.

2) Become technically proficient in on-site water sampling and analysis for chemical and bacterial contents.

3) Improve techniques for analysing rural water supply conditions and choosing appropriate technology types.

4) Develop and test or acquire from other institutions a range of technologies of different construction materials/techniques and different cost ranges.

5) Prepare a data base/spread sheet for cost analysis for each of the technology ranges, so that up-to-date costs may be quickly prepared depending upon local costs and availability.

6) Improve the tools for comparing different technologies/methods of construction according to criteria of effectiveness, durability, management skills required and affordability.

21 *KEY POINT: Tools for planners to make rational choices of technology.*

7) Prepare simple promotional literature and media, and construction/operational manuals for each technology.

8) Work out rates of charges for these services, realistic in terms of what communes can afford and what it actually costs to provide the service.

9) Promote these services amongst the communes.

RECOMMENDATION 5.5.1.

CERPAD should develop the data collection and analysis, and technology selection tools outlined in 5.1. - 5.4.

6. WATER TESTING SERVICES

As will be seen in the previous section, water sampling and analysis are integral to the planning process. Without knowing the content of certain key chemicals and the number of indicator bacteria per litre, the planning team would only be guessing about the need for treatment; and they would be unable to test the effectiveness of treatment of different types of technology that can be applied.

6.1. Key chemical and bacteriological tests

For the purposes of routine drinking water analysis, relatively few tests are required. These are:-

- ***pH*** - standard test of how acid or alkaline the water is; normally water is around neutral, pH 7 +/- 1. Can be measured by pH meter and colorimetrically.
- ***Conductivity*** - measure of the quantity of disolved solids in the water, especially for more saline waters. Measured with conductivity meter.
- ***Turbidity*** - measure of the clarity of the water which will be affected by the suspended solids content and the colloidal matter in the water. Useful for surface water sources. Measure with turbidimeter.
- ***Colour*** - water should be colourless, so any coloration is undesirable as it indicates the presence of dissolved salts, e.g. iron. Measure by comparing colour against distilled water.
- ***Taste & Smell*** - water should be tasteless and odourless. Taste and smell can only be tested organoleptically, i.e. by human senses and noting particular smells or tastes e.g. ammonia, hydrogen sulphide, iron.
- ***Salinity*** - measures the salt content of the water. Measured colourimetrically and indicated by conductivity. Maximum chloride content of rural water supplies in Vietnam is 600 mg/l.
- ***Hardness*** - measures the concentration of Calcium and Magnesium salts, carbonate/bicarbonate/sulphate in water which tend to be deposited on boiling. Maximum total hardness in rural water supplies is 500 mg/l. Measured colourimetrically.
- ***Ammonia /Nitrite/Nitrate*** - measure of the free forms of nitrogen and the degree of oxidation. The presence of ammonia usually indicates recent organic pollution of water and with Nitrite may indicate lowered oxygen content. Nitrates indicate the fertility of water. High levels may be toxic. Measured colourimetrically.
- ***Iron*** -high iron content will give both a metallic taste to the water and an unacceptable yelow colour. The ferrous reduced salts are soluble and the oxidised ferric salts are insoluble. Can be measured colourimetrically. Maximum iron content in water is 1.00 mg/l for rural areas.
- ***Bacteria*** - coliform bacteria are present in the gut and faeces of humans and animals and also in the soil. E.Coli are faecal coliforms and though not necessarily pathogenic they are used as indicators of faecal contamination. The Vietnamese standard for drinking water is 20 cells per 100 mg. Measured by filtering the water and growing the colonies on special media.

6.2. Rationale for Field testing

There are two approaches to water analysis:-

1) Take samples of the water and transport to the laboratory for analysis.

2) Take samples of the water and analyse in the field.

There are pros and cons to both approaches:-

Laboratory analysis is potentially more accurate since the analysis can be done under standard conditions, but delays in transporting the samples and variations in ambient conditions, particularly if the water is heated or shaken, will alter some of the constituents. What is measured may not reflect the actual composition of the water; in particular bacterial content may be very different. The laboratories in Vietnam are very short of equipment and some of the analytical chemicals are of dubious age and quality. The test results will not become available for up to a week or two after collection.

Field Testing is done on the spot using direct reading meters and colourimetric tests, so that the measurement is more realistic of the actual content of the water. Field measurements will not give the degree of accuracy of laboratory analysis, but with this sort of analysis one is looking for relative quantities rather than absolute concentrations. The degree of accuracy provided by the field test is usually that required for comparison to drinking water standards. Field testing gives more or less immediate results upon which judgements about the suitability for drinking, the need for treatment and the efficiency of treatment can be made.

With some training in the application of the field tests kits, any of the planning team should be able to use them consistently, whereas laboratory analysis can only be carried out by trained technicians. Some of the electronic measuring equipment in the field kits are quite delicate, even though designed for field conditions. To reduce the risk of costly and time consuming breakdown, simpler colourimetric analysis can be used instead for a number of tests.

The cost per test is probably higher for the field test kits, but this is more than compensated for by the immediacy of the results, no need for permanent laboratory facilities and no need to transport sample containers with minimum delay.

In short it is considered that field testing kits for the tests mentioned in 6.1. are entirely justified for this project. If other tests are required on occasion, or if the accuracy of the field tests needs to be checked from time to time, then additional laboratory analysis can be carried out.

RECOMMENDATION 6.2.1.

The project should acquire field test kits for bacterial and chemical analysis, plus sufficient spares to carry out these tests in at least five communes, and to test the effectiveness of various equipment.

RECOMMENDATION 6.2.2.

At least two project staff should receive training in the use of the test kits from the Institute of Hygiene, both in the laboratory and under supervision for at least two trips in the field. They should also be taught routine maintenance of the equipment.

RECOMMENDATION 6.2.3.

The project should prepare cost estimates for water testing services so that an economically sustainable service may be set up, and supplies purchased from abroad on a continuing basis.

6.3. Supplies required

For routine water supply testing in the five communes of Dai Ang, Yen Bac, Hy Cuong, Ninh Van and the remaining two group B communes to be selected, it is estimated that the following tests will be required:-

		tests	total	
10 village wells 2 times a year (dry/wet season)		20		
4 river samples 2 times per year		8		
4 tube wells 2 times per year		8		
32 family wells 2 times per year (2 per village)		64		
TOTAL for full range of tests per commune	100			
x 5 communes		500		
Additional tests for communes as yet undefined			100	
OVERALL TOTAL				600

For testing equipment:-

1) Iron filtration

4 models (upflow, downflow, polystyrene and disposable filters);
10 comparative samples per run, iron content only before and after treatment:

10 samples x 4 models x 2 tests	80	

2) For improved village wells

Tests for coliforms, turbidity, and iron content:
2 village wells per commune, before and after improvement or at inlet to well and at collection point; one sample taken per month for 12 months:

2 wells x 5 communes x 2 tests x 12 months	240	
Total		320

3) For improved rainwater tanks and filters

3 improved tanks compared to 2 unimproved, control tanks, tested for coliforms only once a month for 12 months:

5 tanks x 12 months	60	
x 5 communes		300

Summary

TOTAL FULL TESTS	*600*
IRON TESTS EXTRA	*320*
COLIFORMS TESTS EXTRA	*300*

6.4. Cost estimates

1 Paqualab standard 50 incl. 200 tests

400 extra tests

1 irrigation water test kit incl. 200 tests

400 extra tests

supplies for 320 extra iron tests

supplies for 300 extra coliform tests

TOTAL COST INCL. SHIPPING GBP £ 2,984.00

7. SANITATION OPTIONS FOR NINH VAN

Whilst the focus of this consultancy was on water supply, sanitation is obviously an important consideration in water supply. The survey data shows that 60% of the population have some sort of latrine, of which three quarters are simple pit latrines. Whilst no figures on the use of faecal material as fertiliser are available, it is assumed that this almost universal in the rural areas of Vietnam. Two sorts of improved latrine are being promoted in Vetnam:

1) The double pit composting latrine.

2) The pour-flush latrine with soak-away.

Recently the Ministry of Health has been trying to discourage the use of untreated faecal material as a fertiliser, including that from double pit latrines, due to observations that these have not been used properly, e.g. inadequate sealing, too short time-periods before use of composted material, shortage of ash/earth for mixing with solids. The point has also been made that much of the nitrogenous material is in the urine not the solids and that much of the valuable fraction of the waste is lost. According to Ministry of Health calculations the savings in not having to treat the farm family for worms twice a year would more than balance the fertiliser value of the waste. Whilst these calculations cannot be verified, the fact that the fertility of Vietnamese soils have been maintained for hundreds of years through the application of human wastes should not be overlooked.

Despite this negative attitude towards the double pit latrine, the project feels that given the situation in Ninh Van of high water tables and liability to flooding, and the relative impermability of soils making soakaways less practicable, the pour-flush latrines are not really appropriate. CERPAD consider that the double pit latrine is more suitable and staff have agreed this with the Ministry of Health. Thus for latrine improvement in Ninh Van, CERPAD will be promoting the double pit latrine.

The consultant agrees with this decision and considers that attention should be given to the promotion of good use of double pit latrines as well as their construction.

Construction materials are available, but these would appear to be aimed technically high, and may be inaccessible to many rural builders. No operation manuals or advice on how to use double-pit latrines appears to be available for rural families. The technology of the double pit latrine is well established in Vietnam, but its application and use requires good promotional material.

RECOMMENDATION 7.1.

The project should prepare promotional material for both the construction and use of double pit latrines, easy to understand and attractively presented.

8. BIOGAS

Although biogas is not being promoted in Ninh Van, plants have been installed by the project in Yen Bac, Dai Ang and Hy Cuong. The plant in Dai Ang was seen to be working, whilst the others are still under construction. The consultant has various comments on the biogas programme.

1) The plants are relatively expensive. No estimates have been worked out for the value of the fuel and other benefits, and it may take a very long time for the family to pay back the capital costs. The basic question of whether it is worthwhile investing in such technology has not been answered adequately.

2) One of the main reasons for failure of biogas plants all over the world is lack of maintenance; this leads to deacreasing gas yields, loss of interest and then complete failure. Any programme promoting biogas must provide a 'post-installation' advice service. There is no evidence that the project has paid much attention to this aspect. If biogas is to become a regular part of the project's range of technologies, and if biogas is to become widely established, such a back-up service must be built up.

3) The working plant at Dai Ang had encountered problems of disposing of the digested liquid produced during the harvest seasons, when the only outlet for the liquid manure is on the vegetable garden. There is insufficient storage space for the liquid; and this factor needs to be taken into account when designing other biogas plants. A simple pit store would be sufficient.

RECOMENDATION 8.1.

The economic viability of biogas plants needs to be thoroughly investigated using the installed biogas plants as case studies.

This investigation should take account of actors such as time required for operation, time saved in collection of wood/fuel, costs of other fuels saved, use of rice straw saved as animal feed, fertiliser value and improvements in health/hygiene of the family should be included.

RECOMMENDATION 8.2.

Subject to the recommended investigation showing that biogas is viable, promotional materials for construction and operation should be prepared.

RECOMMENDATION 8.3.

Subject to the recommended investigation showing that biogas is viable, using the examples of the problems encountered and advice required from the families where biogas plants have been installed, an advisory service for biogas should be developed by the project.

9. PROTOTYPE DEVELOPMENT AND TESTING PROGRAMME.

The following series of tests are suggested for the different prototypes being developed:

9.1. Iron Filters

There are a number of iron filter units which should be compared technically and economically. These include:

- Project down-flow filter
- Project up-flow filter
- Polystyrene filter with UNICEF
- Disposable filter
- Ministry of Health units built by IBM.

Technically these should be tested by analysing samples of water for iron content and turbidity before and after passing through the iron removal filter, progressively as the volume of water treated is increased. As the volume treated increases so the efficiency of iron removal will decrease until the filter needs cleaning. (See Fig. 13a).

Similarly the rate of flow will decrease as the filter becomes clogged. At the same time as the iron contents are measured, time how long it takes for one litre of water to pass through the filter. This could be done say at the beginning, after 50 litres, 100 litres, 200 litres etc. The actual volumes chosen will vary depending on the size/capacity of the filter. (See Fig. 13b).

The third technical characteristic to test is the cleaning of the filter. Assess the quantity of water used for backwashing. How much time is required to clean, how easy it is to do and how often cleaning will be required under normal patterns of use. This information will be useful both for comparing the different filters and for preparing operational advice.

Financially the designs need to be costed for the different materials from which they might be constructed. It is suggested that a standard data base be set up for each design with full quantities required so that the exact costs may be applied for a particular situation. Costs may be maintained up to date and the most appropriate design and materials chosen.

With all this information, the project will be in a position to compare the different filters and concentrate on those designs which appear most effective.

Figure 13a. Efficiency of iron removal by iron filters - hypothetical example

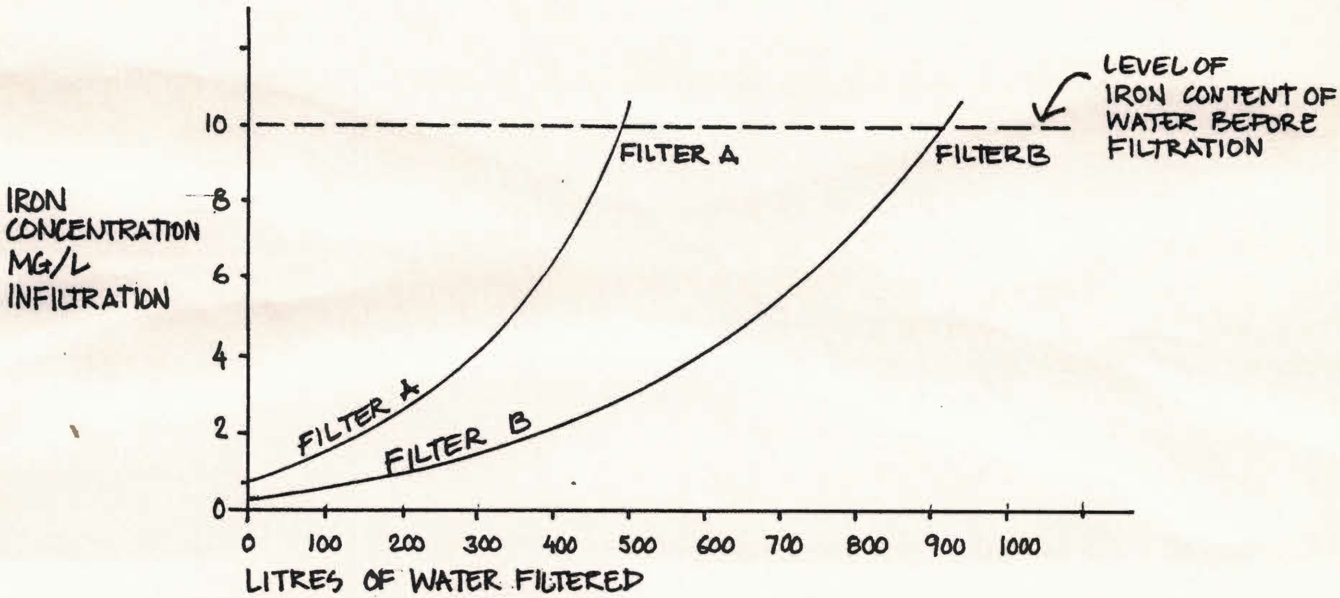
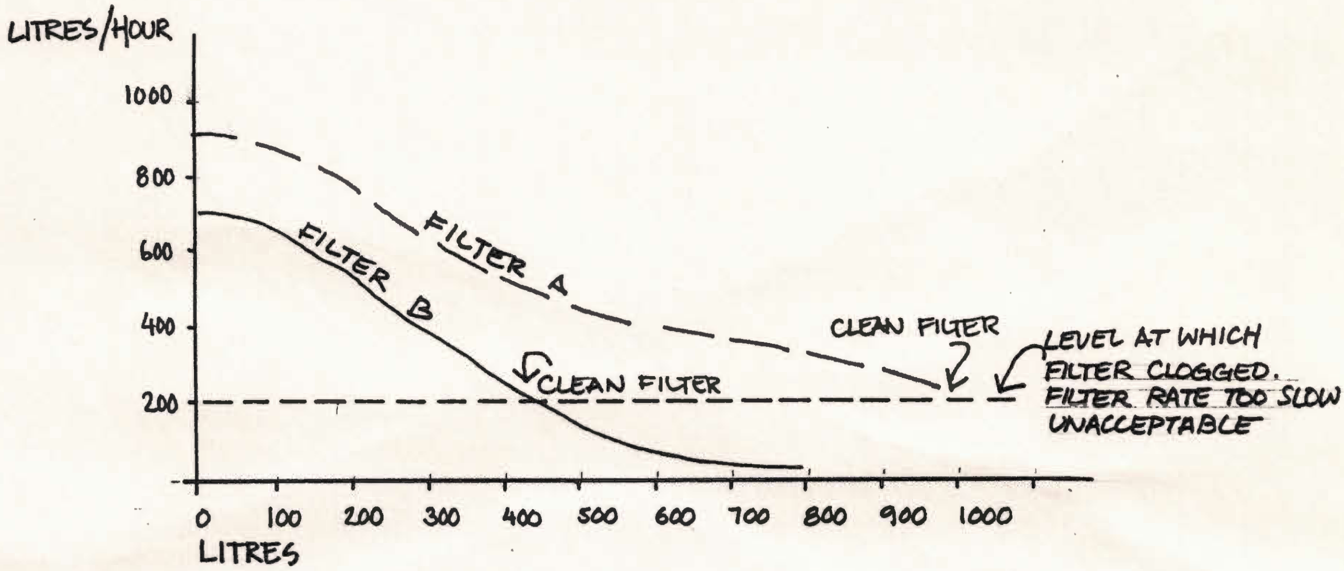


Figure 13b. Changes of rate of flow through iron filters - hypothetical example



9.2. Water Tanks

An improved design for conventional rain water tanks is required. It should include the following features:-

- Inlet filter
- Tight fitting cover for access hole
- Outlet tap
- Overflow covered with fly netting
- Drain sump/outlet
- Facility for extension of tank.

The design for extending the water tank, to add capacity in stages could be by building on to the existing end of the tank and connecting the new tank with the old by holes or pipes at the bottom. An alternative extendible water tank is the circular model of vibrated concrete blocks being produced by IBM.

The nylon and bamboo tanks require development and testing. A possible design is shown in Fig. 3. However, this should be developed in conjunction with the nylon factory which may have suggestions for the most suitable materials and the best methods for heat welding. This design needs to be tested for its water tightness, durability, maintenance requirements and costs before being promoted in the villages.

9.3. Village well with sedimentation zone

A design for a village well with a sedimentation zone is shown in Fig.5. This depends on an overflow weir protected by a scum guard. An alternative to this is a simple roughing filter through which the water can pass at all levels. Such a filter might be made of coconut fibre packed between a double bamboo fence set in the bottom of the village well. When clogged the coconut fibre could be easily replaced.

The village well needs to be tested by comparing the water coming in from the river and in the sedimentation zone, with the water collected for drinking. It should be analysed bacteriologically for coliforms and for turbidity. Such before and after tests should be carried out monthly throughout the year. If it is possible an unimproved village well using the same source of water could be tested as a control.

Another series of tests should be aimed at testing the effectiveness of the aquatic plants and their management. Ideally such a test would compare two identical wells using the same water source, one with aquatic plants and one without. Since such a situation is unlikely to be available, the project should build up information on a series of village wells, noting whether plants are present or not.

Management of the plants, e.g. how much to remove and how often, also needs working out. Different management regimes such as:-

- Removing 10% of the plants every month
- Removing 25% of the plants every 3 months
- Removing 50% of the plants every 6 months

should be tested, taking sets of samples before and after removing the plants. There may also be seasonal differences to be considered, so that less plant material would be removed in the cooler months.

As more information is gathered on this simple technique, promotional and operational material should be prepared.

Appendix 1. Average annual and monthly rainfall data

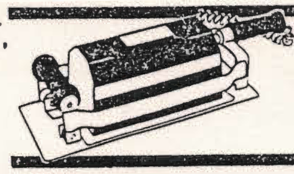
Table : Rain falling (mm)

Month	1	2	3	4	5	6	7	8	9	10	11	12	Total
Hanoi	24	36	47	90	210	268	321	255	261	105	48	28	1809
Than Hoa	33	36	40	78	178	182	297	261	275	265	74	31	1751
Ninh Binh	29	36	44	84	194	225	309	258	268	185	61	30	1780

Ninh Binh, Ninh Van commune, is located between Hanoi and Thanh Hoa. No rainfall data is available specifically for Ninh Binh: the table above shows the average rainfall of Hanoi and Thanh Hoa as indicative of rainfall in Ninh Binh.

Appendix 2. Note on "Multivibe" rain tanks

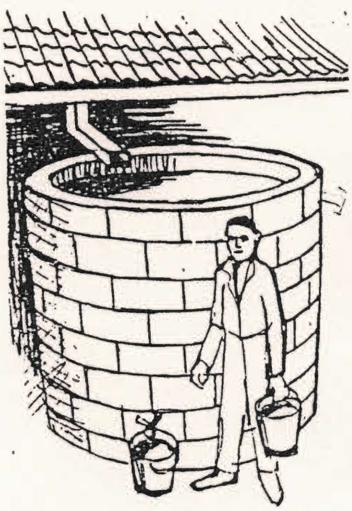
(See paragraph 4.1., page 18.)

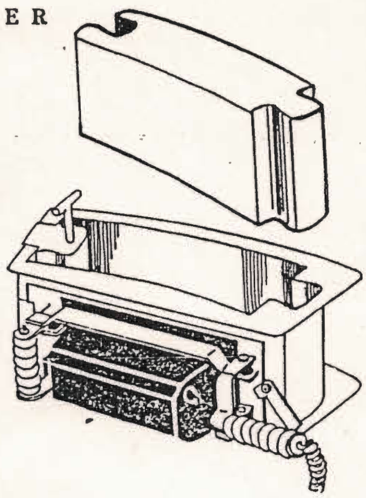


MULTIVIBE ACCESSORY PACKS

115

SELF BUILD WATER STORAGE TANKS





CURVED BLOCK MOULDS FOR MAKING INTER-LOCKING BLOCKS

The precious rainwater which pours from the wide catchment area of a roof can be caught and stored in large capacity tanks built with the aid of MULTIVIBE and our BLP60W Accessory Pack.

The pack consists of equipment to produce a new design of CURVED INTERLOCKING CONCRETE BLOCKS which when laid with ordinary masonry skills in 2 metre diameter circles makes a tubular shell of a strong permanent masonry. After internal plastering this becomes a watertight tank capable of holding over 6 cubic metres or 1,300 gallons of drinking water. No steel reinforcement is needed in the construction of these tanks - nothing to rust, simplicity itself!

It requires 2-3 day production with the BLP60W to produce the blocks to make a full size tank. This again can be built in 2-3 days by an experienced team.

CONTENTS of the BLP60W Watertank Block Pack include

- Two part mould with MULTIVIBE mounting for forming the interlocking curved blocks
- Production accessories, washing tank, hand tools etc
- Setting out templates for tank building
- Instruction manual
- 1 MULTIVIBE demountable vibrator

CALCULATIONS

For 1 cubic metres of water contained, the following quantity of materials are needed to make the blocks

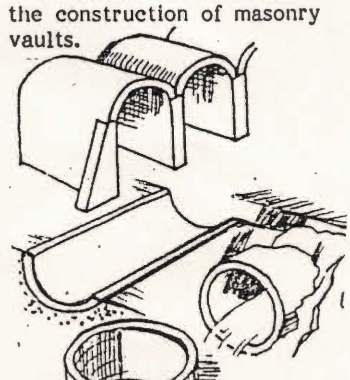
1 bags cement]
250 kg sand] = 25
300 kg aggregate] blocks
Add 10% for finishes

To make a tank 2 metres high, 2 metres diameter, containing 6 cubic metres or 1,300 gallons of water, requires 150 blocks using 6 bags cement etc. Typical developing country costs - under US $60

In most countries these costs will work out lower than those for any other means of constructing above ground water storage.

OTHER FEATURES

In addition to water tanks, the interlocking blocks can be adapted for use to build cattle troughs, well linings, road culverts, loadbearing arches for bridges, linings of stormwater drains and in the construction of masonry vaults.



PARRY ASSOCIATES

INTERMEDIATE TECHNOLOGY WORKSHOPS

JPM Parry & Associates Ltd.,
Overend Road, Cradley Heath,
West Midlands B64 7DD, U.K.
Tel: (0384) 69171 (3 lines). Telex: 334132 ITPARR-G

Appendix 3. Water Source Assessment Matrix

See worked example in Figure 10, page 39.

Water source	Numb.of household using source	Issues				Total issues score	Score x househ.no	Priority
		Access	Water availa-bility	Water quality				
				Chemical	Bacterial			

Assessment severity score

0 = no problems

1 = few problems

2 = some problems

3 = severe problems

Appendix 4. Total annual affordable cost effectiveness assessment matrix for water supply techniques

See worked example in Figure 12, page 43.

	1	2	3	4	5	6	7	* 8	9	** 10	11
Technical Option	Numb. of people served	Capital	costs	Lifetime	Operating	costs	Total annual capital+ op. costs /head	Effec- -tiveness Grade 1-3	Total annual effect. /head	Affordab. Capital cost as % of surplus	Total annual afford. cost effectiv.
		Total	Cost/h.	Years	Total annual cost	Annual cost/h.					
			(2)/(1)			(5)/(1)	(3)/(4)+(5)		(7)/(8)	(3)/su. %	(9)x(10) %

* Effectiveness grade
1 = least effective
2 = average effectiveness
3 = most effective

** Surplus = estimate of surpluses achieved per head of population served each year

Appendix 5. "Paqualab" water quality testing equipment data from ELE

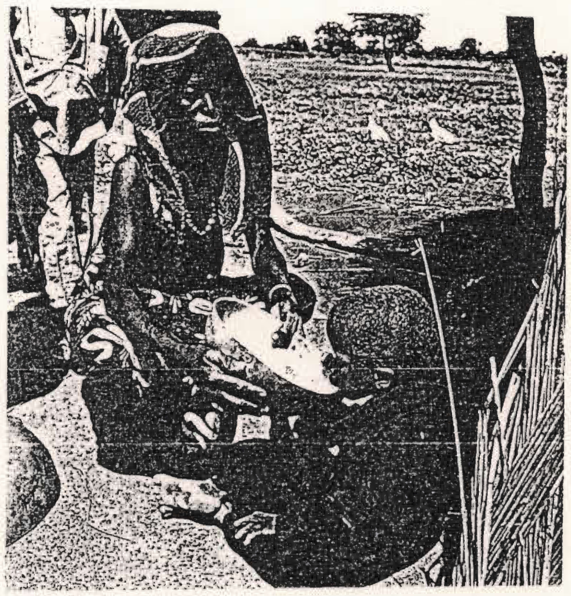
See cost estimates in paragraph 6.4., page 49.

The portable approach to effective water quality testing, giving you results where they matter – in the field.

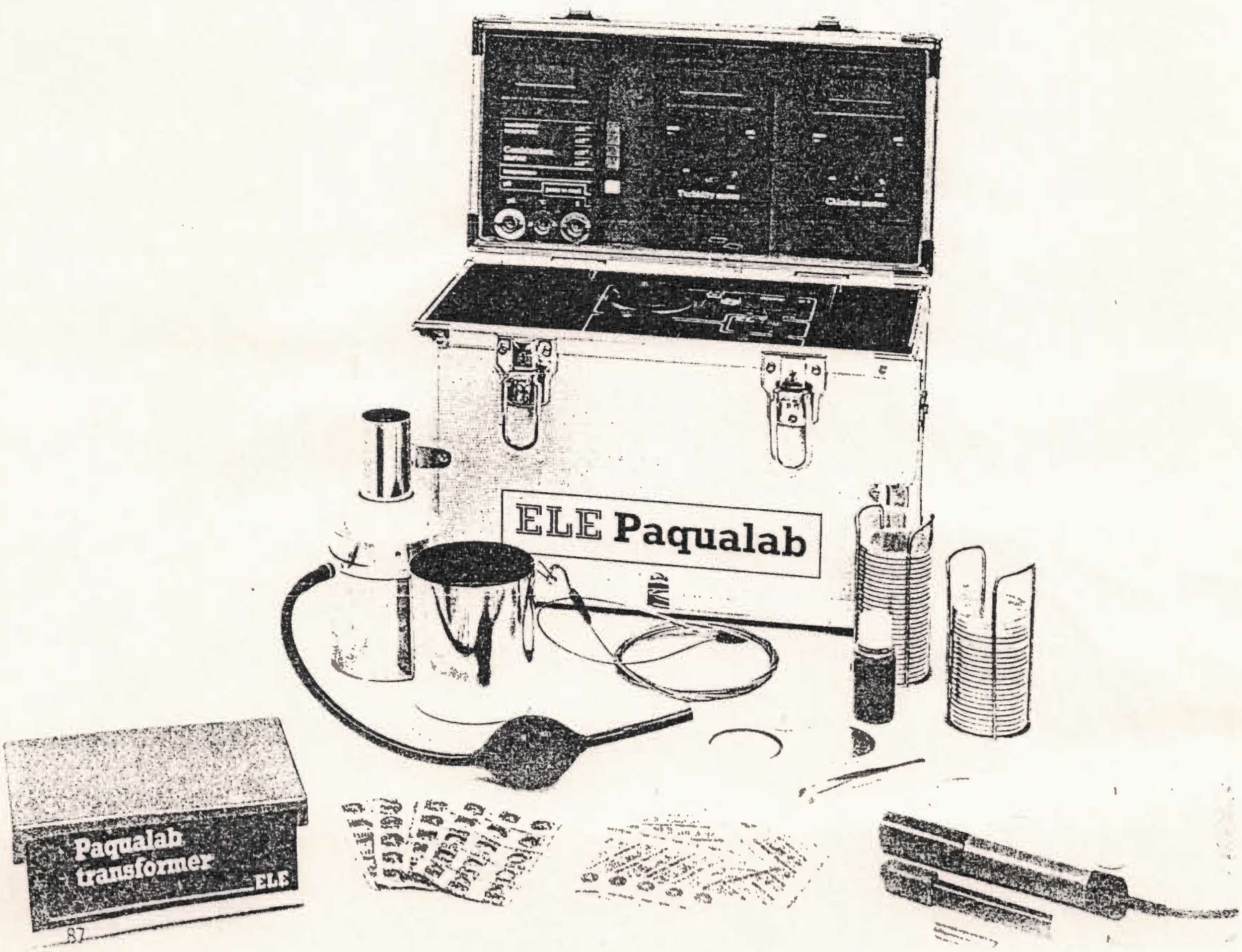
In this, the International Water and Sanitation Decade (1980 – 90), awareness of the importance of water hygiene has never been greater; but still the number of fatalaties around the world, as a result of water-borne diseases, continues to rise.

Into this decade of concern, ELE Agronomics Division is pleased to introduce the Paqualab, a unique and flexible solution to the problems of monitoring and controlling water quality from source to supply.

The Paqualab kit is fully comprehensive, containing all the necessary equipment required to monitor the key microbiological and physico-chemical indicators of water quality, as specified by the World Health Organisation (WHO). The kit is fully portable and allows the user to measure water contamination and take remedial action where it counts – in the field.



EL420-100



Paqualab – water quality testing, continued

Microbiological testing

Incubation unit for faecal and total coliform analysis

The Paqualab incubator system provides the facility to analyse directly the key microbiological indicators of water quality in the field, without laboratory support.

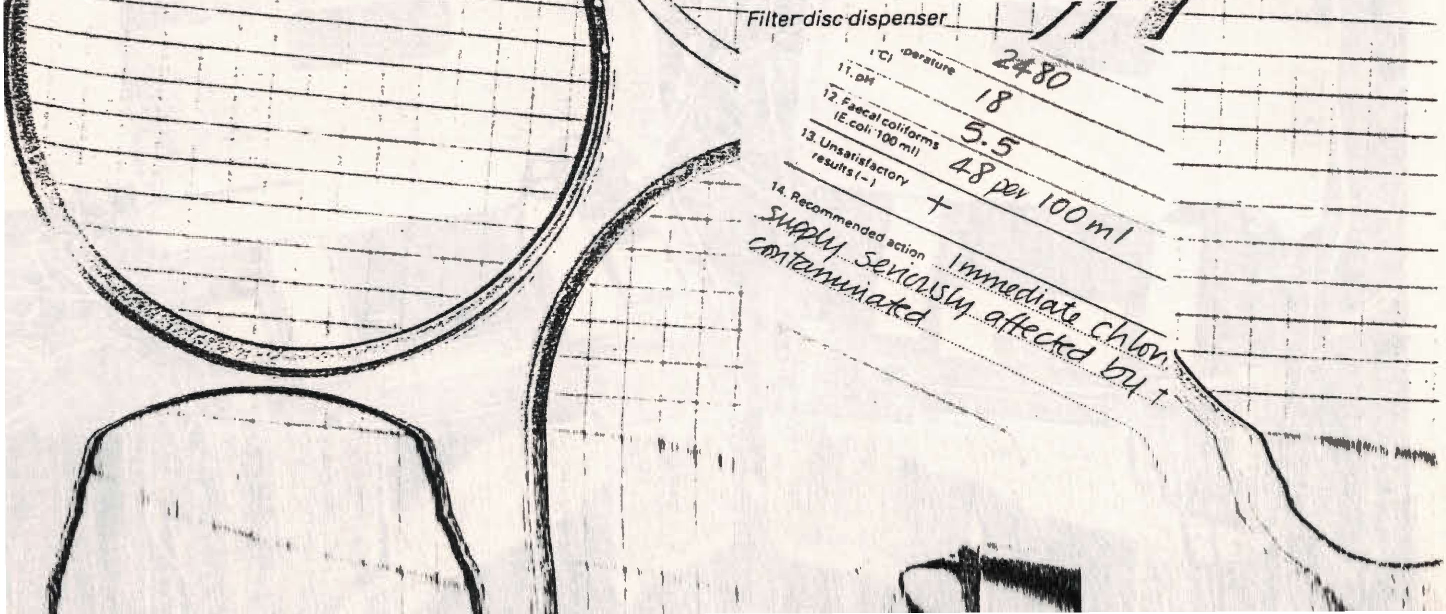
Each incubator may be run independently at either 37°C for total coliform incubation or 44°C for faecal coliform incubation. This allows the operator to measure both parameters simultaneously or to double the capacity of either test. ELE technicians will adjust incubator temperatures on request to suit selective incubation of other organisms of hygienic significance when specified.

Each column can accommodate 25 reusable aluminium petri dishes, which stack easily into compact racks. This configuration allows a full days testing to be carried out and also simplifies labelling.

The Paqualab can be powered from an internal rechargeable 12 V DC battery, or external AC/DC supplies using its own transformer for 110 or 240 V. During mains operation the internal battery is automatically charged.

By employing reusable components, the cost of individual microbiological tests has been reduced to a fraction of that of other systems. The Paqualab is supplied with full instructions, a report sheet pad and a comprehensive starter kit for 200 tests which includes sterile filter membranes and growth pads with dispenser, powdered lauryl sulphate growth medium and DPD1 and DPD3 tablets.

Total coliform growths found using the Paqualab

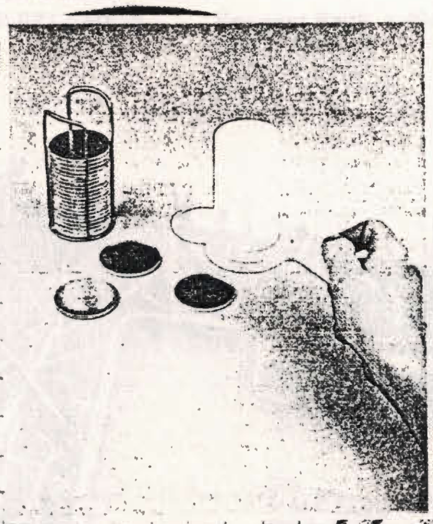


Sterilisable field filtration unit

A lightweight and compact filtration unit complete with stainless steel sampling cup.

Designed to be sterilised in the field using methanol, the filtration unit allows water samples to be vacuum filtered through a sterile membrane filter using a simple handpump. This membrane is then placed on the growth pad in the petri dish and incubated.

Field filtration unit



Filter disc dispenser

Paqualab – water quality testing, continued

Specification for microbiological testing

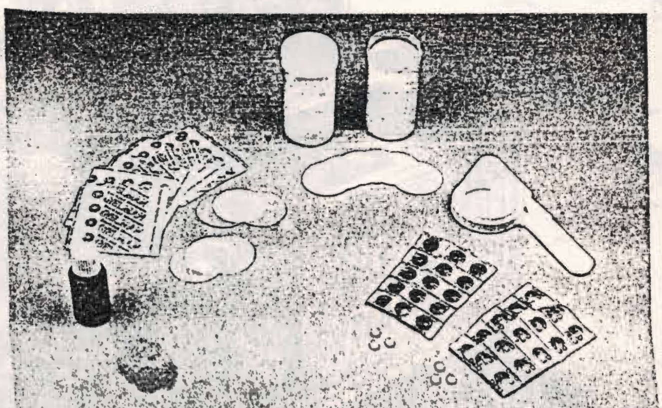
Dual incubator unit	
Temperature, switchable setting	37 or 44°C, ±0.5°C
Reusable aluminium petri dishes	55 x 4 mm (dia x depth)
Incubator capacity	25 dishes per incubator
Power rating per incubator	12 V DC at 220 mA amps
Power	
AC supply with voltage selectable transformer	220 – 240 V, 50 Hz, 1 ph or 110 – 120 V, 60 Hz, 1 ph
DC supply	12 V external or 12 V internal rechargeable battery (9.5 A/hr)

Specification for physico-chemical testing

Turbidimeter	
Nephelometric (low range)	0 – 50 NTU
Accuracy	±1 NTU at 0 – 10 NTU ±5% at 10 – 50 NTU
Residual chlorine photometer (DPD method)	
Range	0 – 3 mg/L (linear)
Accuracy	±5% at 1 mg/L
Conductivity meter	
Range (4 preset)	0 – 10,000 µs/cm
Accuracy	±5% at 1407 µs/cm at 25°C
Cell	K = 1.0 dip cell type
pH	
Ranges	0 – 14
Accuracy	±0.1 pH
Electrode	Combination, gel filled
Temperature	
Range	0 – 100°C
Accuracy	±5% at 20°C

General specification

Power supply of each meter	9 V DC alkaline battery, PP3 size
Dimensions of each meter	175 x 100 x 40 mm (length x width x height)
Weight of each meter	400 g
Overall dimensions of Paqualab in carrying case	280 x 400 x 210 mm (height x width x depth)
Overall weight of Paqualab	13 kg



Starter kit

EL420-100
Paqualab, Portable Water and Hygiene Testing Laboratory, complete with starter kit for 200 tests, full instructions and report sheet pad, AC transformer for AC 110 – 240 V to 12 V DC, 12 V DC extension cables.

Spare parts for EL420-100

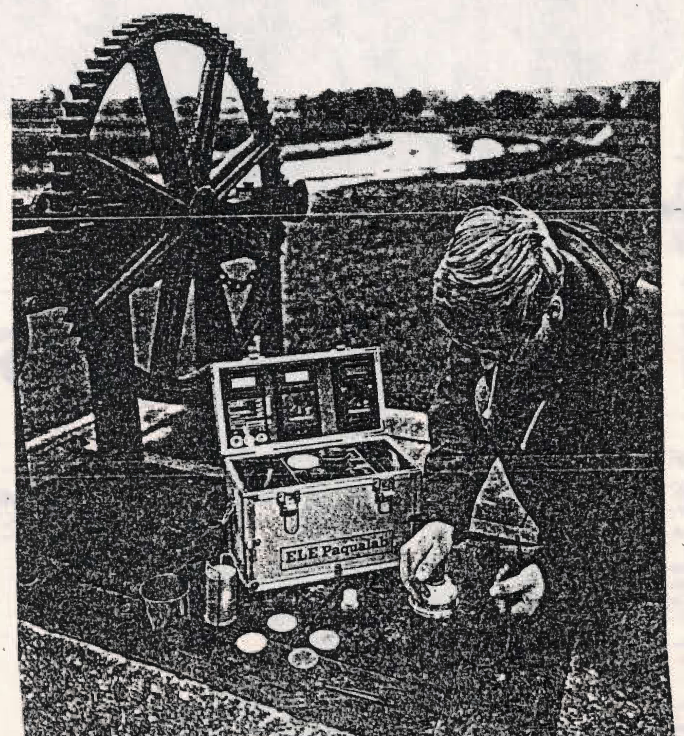
EL420-100/10	**Disposable Plastic Cuvette,** pack of 150
EL420-100/12	**DPD1 and DPD3 Tablets,** pack of 250 each
EL420-100/14	**pH Electrode,** gel filled
EL420-100/16	**Media Pack,** Lauryl Sulphate Medium 100 g of powder, makes approximately 1300 ml.
EL420-100/18	**Sterile Filter Membrane and Filter Disc,** set of 200 each
EL420-100/20	**Filter Disc Dispenser**
EL420-100/22	**Aluminium Petri Dish,** set of 25

Recommended spares kits for EL420-100

EL420-100/90	Bronze filter disc, gasket kit, O-ring
EL420-100/95	Disposable plastic cuvette, pack of 150. DPD1 and DPD3 tablets, pack of 250 each. Media pack, lauryl sulphate medium 38 g of powder, makes 500 ml, suitable for 250 tests. Sterile filter membrane and filter disc, set of 200 each.

Accessories for EL420-100

EL420-118	**Turbidimeter 0 – 200 NTU,** for extinction method. Accuracy ±5% at 0 – 200 NTU. Uses 9 V DC alkaline battery (not supplied). Dimensions: 175 x 100 x 40 mm *Weight 400 g*



Microbiological testing on site