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Investigations Into and Development of a Training Guide and Model to Aid in the Training of Horizontal Roughing Filter Caretakers.

M.Sc. Thesis :
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MS.c. Community Water Supplies.

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Abstract.

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Horizontal roughing filters (HRF) are widely used across the world for the reduction of surface water turbidity prior to slow sand filtration. They employ appropriate technology for small scale rural treatment plants, and lend themselves to village level operation and maintenance, essential for the long-term reliable supply of safe water to remote communities. This can only realistically be achieved through the employment of trained village 'caretakers'.

Caretaker training should be based on the principles of adult learning, making particular use of participatory techniques. The use of a model as a training aid can also greatly enhance the value of training given, and increase the knowledge retained by trainees.

A working model HRF has been designed for use as a training aid. It is of simple design, made from materials readily available in developing countries, clearly demonstrates the principles of operation of a HRF, and allows 'hands-on' experimentation activities by the trainees. The model should be used in conjunction with the training course developed, which covers sufficient information and practical exercises for the trainees to know how to operate and maintain a HRF plant. The training course should be followed by a period of on-the-job training to reinforce the skills and knowledge acquired and to gain practical experience, prior to being allowed to look after the plant unsupervised.

Together these provide an appropriate and effective approach to the training of rural people as HRF caretakers. The thorough training of village caretakers in this way will help to reduce some of the problems associated with the poor performances occuring in village level operated and maintained treatment plants.

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1. Introduction.

1.i. Objectives.

The objectives of this research are :

1. To examine the background of horizontal roughing filter (HRF) application, operation and caretaking.
2. To examine the techniques used in training village level operators and caretakers.

And based on these :

3. To develop a training guide for instructors, for use in training village people as HRF caretakers.
4. To develop a working model of a HRF for use with the training guide, as a training aid to enhance the quality of training.

1.ii. Methodology.

The application of HRF as an appropriate method of rural water treatment in developing countries, and their suitability for village level operation and maintenance, are first examined. The issues involved in training HRF caretakers are examined in terms of who should be trained, and where and when training should be given. Techniques appropriate for the training of rural adults are then investigated, including the role of models as a training aid.

The design criteria for the model and training course are developed based on the findings of the above. The resulting working model and training course are 'field tested', and then redesigned to incorporate improvements. A summary of both the model design and the training course are presented, with the complete information on each being available in the Appendices.

2. The Application Of Horizontal Roughing Filters.

2.i. The Need For the Treatment of Turbid Waters.

Many areas of the developing world do not have access to water sources other than surface water. These are often polluted by faecal contaminants and a significant proportion are also troubled by high turbidity. Turbid surface waters are of two types (Galvis et al., 1992; Wegelin, 1992); highland rivers, which generally have low turbidities, but experience short, high peaks during the wet season, and lowland rivers, which have a higher mean turbidity, and increased levels for several months of the wet season. Rajapakse (1988) summarized the extent of monsoon turbidity data occuring around the world. See Table 2.1 below:

Table 2.1. Worldwide Monsoon Turbidity Values.

Country	River / Water Source	Turbidity / (S.S.C.)
Bolivia	R. Parapetti	15 500 NTU (30 000 mg/l)
India	R. Godavari	Av. 30 - 50 NTU Max. >3000 NTU
Iraq	R. Tigris	(9400 mg/l)
Kenya	R. Sabaki	(500 - 15000 mg/l)
Peru	Azpitiya	17 - 1000 NTU
Singapore	Bedoc Catchment	(Max. 14000 mg/l)
Sudan	Blue Nile	300 - 400 NTU
Tanzania	Iringa	40 - 200 NTU Max. 1000 NTU

Adapted from Rajapakse (1988).

Turbidity mainly reflects the amount of soilds and colloids present in the water. (Wegelin et al., 1991). It is well documented that turbid water has detrimental effects on the use of both slow sand filtration (SSF) and chlorination treatment processes, which may be essential to ensure bacteriologically safe drinking water for the communities using surface sources. High turbidity water rapidly clogs the SSF filter bed and interferes with the biological processes occuring in it. This leads to increased filter resistance, shorter filter runs, more frequent cleaning and decreased bacterial water quality output. (World Bank, 1991; Wegelin et al., 1991; Galvis et al., 1992). Micro-organisms attach to the surface of the solids, oxidising the disinfectant and reducing its efficiency (Wegelin et al., 1988). The W.H.O. (1984) specifies a maximum turbidity of 5 NTU as suitable for consumption, with < 1 NTU necessary for effective chlorination. These values can achieved using a SSF. However, the turbidity of influent water to a SSF required to produce this effluent quality is limited to an average value ranging from <10 NTU (Galvis et al., 1992) to 20 - 30 NTU (Hofkes, 1981; Wegelin and Schertenleib, 1993). Peak turbidities of 50 NTU can be coped with for 1 to 2 days without major increases in headloss (Galvis et al., 1992). As can be seen from Table 2.1, these values are far exceeded in many surface waters. Thus the initial surface source turbidities must be reduced to an acceptable level prior to input into the SSF. This is known as the 'multi-barrier concept', where reliance is placed on more than one stage of treatment to produce safe water; each stage removing progressively finer contaminants. (Wegelin, 1992; Galvis et al., 1992).

2.ii. Techniques for Turbidity Reduction.

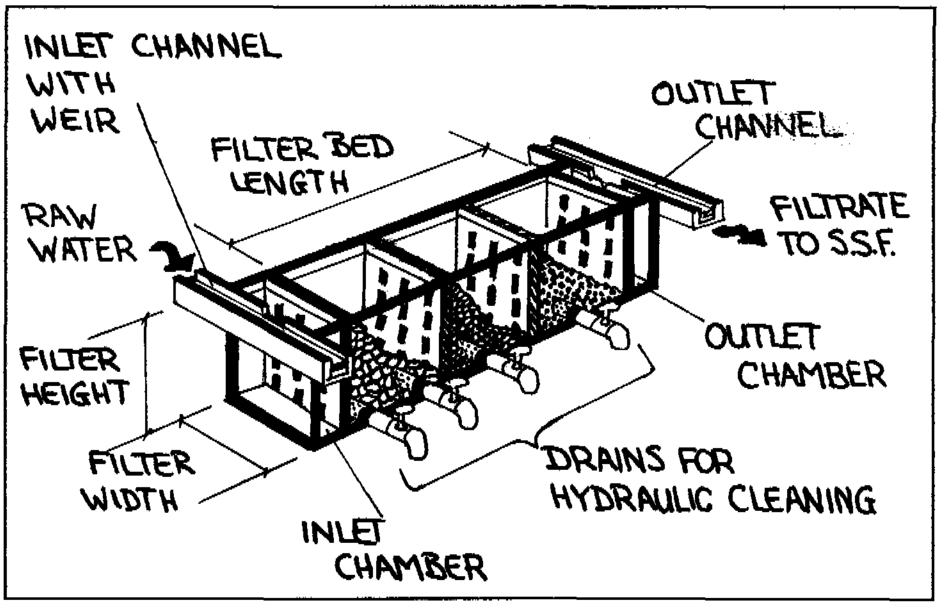
Three techniques are commonly used for turbidity reduction in developing countries: plain sedimentation, rapid gravity filtration, and coagulation and floculation. (Hofkes, 1981). However their applicability in the context of surface water turbidity reduction in rural communities in developing countries is questionable. Plain sedimentation is suitable for rural applications, being a low-cost and simple technique. It is relatively efficient for the removal of particles > 20 μm (Wegelin, 1992). However, solids smaller than this may form the bulk of the turbidity, and long settling times are required for finer particles (Wegelin et al., 1991). Coagulation and flocculation produce enhanced sedimentation of finer particles, but rely on the use of chemicals, the supply of which is likely to suffer from problems with distribution and transport in rural areas, and the recurrent costs of which are high (Wegelin and Schertenleib, 1993; Heslop, 1993, Pers.Com.) Their application also requires skilled personnel (Wegelin et al., 1988). Rapid gravity filtration has high capital costs of imported equipment, and relies on a high level of technical and institutional support (Wegelin, 1993, Pers.Com., Reitveld, 1994, Pers.Com.). Filter runs are often short in turbid waters, due to the small grain size, and cleaning is dependant on backwashing, often requiring additional pumping equipment and a reliable power source (Wegelin et al., 1988; Heslop, 1993, Pers.Com.) They are only really suited to use in larger treatment plants (Rudolph, 1994, Pers.Com.).

Although no technique is ever applicable in all situations, it can be seen that none of the above are satisfactory in this context. Roughing filters, however, provide a low-cost, appropriate technology solution for effective turbidity reduction in small scale rural water treatment plants.

2.iii. The Use of Horizontal Roughing Filters For Turbidity Reduction.

Horizontal roughing filters (HRF) consist of a long rectangular tank, divided along its length usually into three sections by perforated walls. (See Fig.2.1). Each individual section is filled with filter media of approximately uniform size, with the media in each section being of a decreasing size with increasing distance from the inlet. The first section contains the coarsest material, in the range 15mm - 30mm diameter, which removes the bulk of the suspensed solids (Mbwette and Wegelin, 1989; Wegelin and Schertenleib, 1993). The next two sections are finer, in the range 10mm - 15mm, and 5mm - 10mm respectively, and these perform a polishing function (Wegelin et al., 1992; World Bank, 1991). The filter media most commonly used is gravel, although any other inert, insoluble and mechanically resistant material of a suitable size can be used (Wegelin, 1986).

Fig. 2.1. A Horizontal Roughing Filter.



Source : Wegelin and Schertenleib (1993).

HRF are physical filters, with the main processes of solids removal being sedimentation in the pore spaces, and adhesion to the media particles (Schultz and Okun, 1984). They are designed to treat turbid surface water over prolonged periods of time, made possible by the deep penetration of suspended solids into the filter bed, which fully utilizes their large silt storage capacity. It is the small pore system and large surface area available for settling, created by the gravel, which makes roughing filtration an effective and efficient process of turbidity removal (Wegelin, 1992; Wegelin and Schertenleib, 1993).

The advantages of using HRF include :

- HRF silt storage capacity is very large, because of their long length.
- HRF can cope with higher turbidity peaks than other types of roughing filter : short peaks of 500 - 1000 NTU as compared with 50 - 150 in vertical flow roughing filters (Wegelin et al., 1991).
- HRF can be cleaned by rapid drainage, or by manual cleaning of the filter, so no backwashing is required (Wegelin, 1986).
- HRF have the simplest layout of roughing filter types, easing construction.

HRF have been adopted for use as a pretreatment stage prior to SSF in many developing countries. Table 2.2. gives some examples of their use in rural water treatment plants across the world.

2.iv. Conclusion.

In areas of the world where the only water available is from highly turbid and contaminated surface waters, the multi-barrier concept must be employed, the first stage to remove the turbidity, and the next to remove the pathogenic bacteria. HRF are widely used across the world for turbidity removal in these circumstances, in conjunction with SSF.

HRF employ appropriate technology for small scale rural treatment plants, and require no imported components or chemicals for operation. They therefore lend themselves to reliable village level operation and maintenance. They are of simple design, so can be constructed using local skills and labour, and are effective in removing solids which would otherwise prevent proper functioning of the SSF.

Table 2.2. Water Treatment Plants Involving HRF.

Country	No. Plants with HRF	Raw Water Source	Pre-Treatment Problems	Plant Details	Information Source
Bangladesh	50	Tube wells	- High iron content (24 mg/l) forcing villagers to use polluted sources. - High failure rates of iron removal plants.	- Aeration - Sedimentation tanks - Roughing filtration	World Bank (1991)
China	3	2 x Rivers 1 x Reservoir	- High turbidity and coliform counts. - Sources grossly polluted by small scale industry and heavy navigation.	- Sedimentation tank - 2 x HRF - 2 x SSF	Xiangkuan et al. (1992)
Colombia	-	Rivers	- High turbidity peaks in wet season - High levels of faecal coliforms	- Dynamic filter intake - 1 x HRF - 1 x SSF - Chlorination	Galvis et al. (1992a) Galvis et al. (1992b)
Ghana	-	Rivers Reservoirs	- SSF performance impaired by high turbidity. - High algal content.	- Aeration - 2 x HRF - 4 x SSF	Berkoh (1992)
Peru	19	Rivers Irrigation canals	- Very high turbidity levels - High faecal coliform counts	- Sedimentation tank - 2 x HRF - 2 x SSF	Pardon (1992) Wegelin and Schertenleib (1993)
Sudan	30	Rivers Irrigation canals	- Highly turbid water > 1000NTU in wet season. - High bacterial contamination with faecal coliforms. - High suspended sediment concentration unable to settle out in sedimentation tanks.	- 1 x HRF - 1 x SSF	Wegelin et al (1993) World Bank (1991)
Tanzania	3 operating & 1 pilot plant	Rivers	- Most SSF performing poorly due to lack of pre-treatment. - Chemical problems with treatment methods employed.	- Storage tank - 2 x HRF - 2 x SSF	Mbwette (1992)
Uganda	-	River	- Problems with SSF operation and run times.	- SWS intake unit - HRF - SSF	Heslop (1993) Pers.Com.

3. HRF Operation and Maintenance.

3.i. Operation and Maintenance Required.

Both adequate operation and maintenance are essential to ensure that there is a guarenteed regular supply of good quality water generated from the HRF (Ntupwa, 1990). Unless these tasks are dealt with satisfactorily, supplies will rapidly begin to fail, expected benefits will not occur, investments will be wasted, and the communities may return to using contaminated water sources (Cairncross et al., 1980; World Bank, 1991).

The exact operation schedule of each HRF is site-specific (Visscher et al., 1986), but the general operating principles of HRFs are the same for all installations. Table 3.1. details the basic tasks which must be performed for correct HRF operation.

Table 3.1. HRF Operation Tasks and Approximate Frequencies.

Action	Frequency
- Check filter flow rate, and adjust if necessary.	- Every 1 - 2 days
- Check filter overflow	- Daily
- Check the filter resistance.	- Once a week
- Check the turbidity of the raw water and effluent water.	- Twice a week, daily at periods of high turbidity.
- Hydraulically clean filter media, by rapid drainage.	- When max. filter resistance is reached. - If effluent water quality is below specified standard. - Prior to the start of the wet season. - Approx. once a month.
- Manually clean filter media, by excavation, washing and reinstalling.	- When filter resistance is high immediately after hydraulic cleaning. - Approx. once every 1 - 2 years

Source : Nyupwa (1990), Wegelin and Schertenleib (1991), W.H.O. and NORAD (1987), Mbwette and Wegelin (1989), Wegelin (1986).

HRF maintenance is not especially demanding because there are no mechanical parts, but is important in keeping the plant and surrounds in a good working and hygienic condition. (Wegelin, 1986; World Bank, 1991).

3.ii. The Role of Village Caretakers in Operation and Maintenance.

The widely documented reasons for failure of water supply projects, is testimony to the fact that the long-term sustainability of rural water supply schemes cannot occur without either some degree of community participation, or strong intitutional support. In many developing countries, the rural populations are so small and scattered that the cost of providing institutional backup for operation and maintenance of facilities would be prohibitive. This leaves community (managed) operation and maintenance as the only viable alternative to ensure that facilities continue to provide the required service.

The employment of one or two village 'caretakers' has become the solution adopted in an attempt to increase the reliablity of village water supply systems. The main task of the caretaker is to ensure the proper functioning of the system (Ntupwa, 1990). He/she is generally selected from amongst the villagers by the village water committee, given specific training by the responsible water supply agency in the duties expected of them, and is paid by the villagers, in money or in kind, for performing these duties (World Bank, 1991; Mbwette, 1994 Pers.Com.). Their work should be regularly checked and supported by the responsible institution, especially at the start of employment (Ntupwa, 1990; Visscher et al., 1986; Mbwette, 1992; Mzee, 1980), but in general the caretaker must be competent enough to carry out all duties expected of them accurately and unsupervised.

Village-level operation and maintenance does not always produce the desired results, due to a great variety of reasons. Table 3.2 details some examples of problems which have occurred with caretaker operation and maintenance of water supply systems, and the reasons for their failure. It can be seen that no one factor is to blame, and issues such as lack of institutional backup, or the *inability* of villagers to pay cannot be easily remedied. However, there is a strong relationship between the performance of a water project and training in the field of operation and maintenance (Mzee, 1980). The factors of training and motivation of the caretakers can also be influenced from the start of project operation.

3.iii. Conclusion.

The proper operation and maintenance of a HRF is essential for the long-term reliable supply of safe water to small rural communities. This can only realistically be achieved through the employment of village 'caretakers' for the plant, who must be adequately trained, motivated and compensated in order to perform his/her duties reliably.

Table 3.2. Problems With Village Level Operation and Maintenance of HRF.

Problem	Cause	Researcher
- Rapidly increasing coliform counts to very high levels after cleaning.	- Caretaker wore the same boots as used to clean out the septic tank. - Inadequate training.	Ellis (1985) cited by Ntupwa (1990).
- Discontinuous filter operation	- Inlet valve opened and closed at random	World Bank (1991)
- Inadequate control of flow through filter	- Inlet ball-valve deliberately set out of operation by caretaker, to maintain control of treatment plant and consequently their social influence.	World Bank (1991) Wegelin (1992)
- Intermittent operation of HRF (4 hours / day).	- Failure of village water committee to collect revenues for caretaker allowance, although villagers willing and able to pay.	Mbwette (1992)
- Villagers unwilling to pay for caretaker once agency involvement removed.	- General lack of knowledge about health education, so villagers did not realize the benefits of good water quality as well as quantity.	Bayaga (1991)
- Low caretaker morale / loss of interest.	- Lack of response from agency to repeated requests for routine maintenance funds.	Bayaga (1991)
- Caretakers stopped operating the HRF 2 years after training completed.	- Exemption from public duties was not a sufficient reward for their duties. - Failure of the water committee to collect the revenues for the caretaker allowances.	Awe (1990) Mbwette (1994) Pers.Com.
- Highly turbid water not adequately pre-treated by HRF.	- HRF operated at unstable or intermittent conditions.	Wegelin (1992)
- Lack of flow control of HRF.	- Inadequate training in operation and maintenance. - No supervisory support from responsible authorities. - No incentives for caretakers to produce a reliable water supply.	Wegelin (1992)
- Gravel stolen from HRF filter bed	- Remote siting of HRF from village meant that the caretaker was unable to properly look after and maintain it.	Wegelin (1992)

4. Caretaker Training.

4.i. Issues Concerning the Training of Caretakers.

The training of caretakers aims at developing the competence and capability necessary for the effective performance of the operation and maintenance activities entrusted to the individual (Shikwe, 1980). This broad objective generates many specific questions about the training of HRF caretakers, and Table 4.1 overleaf details some of these issues as addressed by different village level operation and maintenance training courses around the world. These issues, as relating to HRF caretaker training, are discussed in the following sections.

4.i.a. The Caretakers and Their Selection.

The trainees should be selected by the village council or water committee, so that they are accepted by the community in their position. It is advisable to train more than one HRF caretaker in case one person needs to leave the area for some time (Wegelin, 1994, Pers.Com.; van Wijk-Sijbesma, 1979).

Suggested suitable recruits for operation and maintenance functions include traditional well diggers, artisans, mechanics, village leaders, women and farmers (Hannan-Anderson, 1990; van Wijk-Sijbesma, 1979; Wegelin, 1994, Pers.Com.). The trainees should have an interest in water treatment for the village, must be likely to remain in the area for some time after being trained, and should not have so many other responsibilities that they are too busy to do the job, although it is not a full-time position (Wegelin, 1994, Pers.Com.; Mbwette, 1994, Pers.Com.). Formal education would be an advantage, but is not essential, with factors such as having the respect of the community and being likely to stay in the job being far more important (Visscher at al., 1986). The age and level of education of the trainees will also determine the teaching methods which are most appropriate and the readiness with which the trainees will adopt new ideas (F.A.O., 1970; F.A.O., 1992).

Table 4.1 Village Level Operation and Maintenance Training Courses Around the World.

Country	Subject of Training	Who Was Trained	Selection Criteria	Number Trainees/ Course	Location of Training	Duration of Training	Training Methods Used	Problems Encountered	Reference
Colombia	Village SSF operation and maintenance	Village SSF caretakers	- Trainees selected from village. - Likely to stay in job for reasonable length of time. - Have respect of the community.	-	At SSF plant site	-	- On-the-job practical training.	-	Visscher et al. (1986)
-	Village level operators / maintainers	Artisans and mechanics	-	5 - 6 per instructor	Training camps on site or at main training centre	1 week - 3 months (generally short courses)	- Highly practical training. - Very job specific.	- Mobility of trainees restricted at spceific times of year by other commitments. - Mixtures of ethnic / religious / sex / social background not always possible. - Diverse target group trainees.	F.A.O. (1992)
India	Handpump maintenance	Farmers, shopkeepers, artisans, etc. of the village	- Interested and capable volunteers. - People living close to handpumps.	-	-	2 day orientation course	- Theory of water supplies. - Practical training for repairs.	-	Hofkes (1981)

Kenya	Water operators	School leavers	Basic education certificates from secondary school	-	On site and at Ministry Training School.	Some time on site, followed by 2 month course	- On-the-job training under qualified water operator. - Office training - Theory of water treatment - Practical training.	-	Ichung'wa (1980)
-	HRF operation and maintenance	Plant caretakers	- Elected by village water committee from villagers. - Usually farmers with ties to area.	3 - 5 (best 1 - 2 selected for the job)	On site	1 - 3 days formal training	- Aid in construction of HRF. - Formal training in practical activities. - On-the-job training at HRF plant.	- Continued motivation, support and long-term guidance needed for sustainability.	Wegelin (1994) Pers.Com.
Tanzania	HRF and SSF plant operation and maintenance	Plant caretakers.	-	2	Existing and new plants	-	- On (existing) site practical training and testing on new plant once constructed.	-	Awe (1990)
Tanzania	HRF operation and maintenance	Plant caretakers.	Selected by village council from the villagers.	-	At regional centre and then village plant.	2 weeks + 1 week	- Theory and lab demonstrations. - Practical operation of HRF units (plant)	- Caretakers can only do simple routine testing and require backup from regional centres and labs.	Mbwette (1994) Pers.Com.
Zimbabwe	Handpump maintenance	Village women caretakers	Elected by handpump sub-committee	-	Ward level training centre.	Series of 1 day training sessions	- Dialogue and discussion by trainees. - Active involvement of trainees. - Posters.	Women do not have the money / time to work voluntarily.	Madsen (1990)

4.i.b. The Training Received.

The duration of the course and its location are important factors in determining the willingness of potential trainees to participate. The time available to farmers, women with family responsibilities, and other working adults for training, especially away from their local area, is limited as they already have a great deal of day-to-day tasks (Ralitte, 1981; Hannan-Anderson, 1990). These people are more willing to attend several half-day courses which do not take them too far from their everyday activities (F.A.O., 1970; F.A.O., 1992).

Although many caretaker training courses are organized with at least part of the training at a regional or national training centre, as can be seen from Table 4.1, it is sometimes better to carry out training at the villages, especially where scattered rural communities are involved. This can be done through the use of mobile training units, which can reach remote rural areas, making use of local buildings for any classroom sessions necessary within the practical training given (F.A.O., 1992; Rallite, 1981). Table 4.1 illustrates that these have been used in a number of training courses. It is generally accepted that rural training can be very effective when it is given in the place where people live, in this way (Ardent, 1982).

During the training, the caretakers must gain a full knowledge of the techniques employed, the time an operation is to take place and the tools to be used (F.A.O., 1970). However, it is rare that the people trained are simply performers of tasks (Ardent, 1982). The recognition of different conditions of the HRF system, and the taking of appropriate action, requires an understanding of why such actions must be taken (Turrell, 1987).

4.ii. Adult Training Techniques.

In the context of training adults as HRF caretakers, it is essential to take into account the way in which adults learn, and the teaching methods which will be most effective. Two key learning factors must be considered :

- how much of the knowledge imparted by the instructor will be retained by the trainee ?
- how can difficult, abstract, or technical elements which are new to the trainee best be assimilated ?

(F.A.O., 1970).

Table 4.2 below summarizes appropriate techniques in answer to these questions, as advocated by various researchers.

Table 4.2. Adult Training and Learning Theory.

Training Technique.	Advocated by...
- New learning must relate to and build on existing knowledge and experience.	- Carter and Marshall (1991) - Isley and Yohalem (1988)
- Adults learn best when they are actively involved, hence the use of participatory techniques including: - group discussions - group exercises - experimentation - problem solving - practical work involving 'learning by doing' - visual aids rather than passively listening to lectures or observing others.	- Carter (1986) - Carter and Marshall (1988) - F.A.O. (1970) - Geneva Research Centre (1972) - Hannan-Anderson (1990) - Isley and Rosensweig(1984) - Isley and Yohalem (1988) - McKone (1982) - Mwale (1980) - Richter (1978) - Rosensweig (1984) - Turrell (1987) - Ziliotto (1980)
- Activities should be varied to keep the trainees attention and interest.	- Carter (1986) - F.A.O. (1970) - Isley and Rosensweig(1984) - Isley and Yohalem (1988) - Williams (1977)
- The training message must be put across in a manner compatable with the trainees' language, education level, and abilities, if it is to be clearly understood.	- F.A.O. (1970) & (1992) - McKone (1982) - Mbwette (1994) Pers.Com. - Ralitte (1981)
- More emphasis should be placed on certain tasks than others, so the trainees can develop the skills most important for their work.	- Hofkes (1981) - Isley and Yohalem (1988) - Rosensweig (1981) - Turrell (1987)
- All adult trainees must be treated with respect, regardless of education level or ability.	- Carter and Marshall (1991)
- Motivation of adult trainees should be incorporated in training to keep trainees in their jobs and encourage them to be efficient, competent and productive, eg. by provision of an informal certificate at the end of the training course.	- F.A.O. (1992) - Glennie (1983) - Hofkes (1981) - Mbwette (1994) Pers.Com. - Mwale (1980) - Turrell (1987)
- Trainees should be given the opportunity to put into practice the skills and knowledge learnt during training as soon as possible afterwards, so as to reinforce them.	- Ardent (1982) - F.A.O. (1992) - Isley and Rosensweig(1984) - Turrell (1987) - Ziliotto (1987)

4.iii. The Role of Models in Training Caretakers.

Teaching methods which are used in regional or national educational institutions are not necessarily appropriate for the training of rural adults, because the education and literacy levels of trainees may prohibit the use of some techniques (Boot, 1990; Rallitte, 1981). Rural people may perceive the progress of an operation more easily if they see it in operation with their own eyes (Boot, 1990; Ardent, 1982). The use of visual aids in training can therefore be extremely effective, and usually form an important part of rural adult education programmes (van Wijk-Sijbesma, 1979). Table 4.3 below summarizes the advantages and disadvantages of the use of visual aids in adult training.

Table 4.3. Advantages and Disadvantages of the Use of Visual Aids.

Advantages.
- They can create a general awareness of a problem.
- They can acquire / recapture the attention of trainees, and bring variation to the training.
- They can illustrate points which are difficult or time-consuming to put into words.
- Their message can trigger group discussions.
- They can reinforce earlier messages.
Disadvantages.
- They are more suitable for providing illustrative and general information than for transferring technical skills to the trainee.
- They are passive.
- They are not always comprehensible by the trainees.
- Their credibility varies strongly.
- They are associated with entertainment.
- Their users may develop too great a dependance on them.
- People may get the wrong idea of the real size of the subject the model represents.

F.A.O. (1992), Boot (1990), van Wijk-Sijbesma (1979).

It can be seen that the advantages of visual aids include aspects which should be incorporated into adult training courses, based on the theories of adult learning. The disadvantages relate mostly to the quality of the visual aid itself, and the way in which it is used during training. An appropriate and well thought-out visual aid, which is used effectively, can overcome many of these disadvantages, and greatly enhance the instruction given to trainees. In this context, models can play a key role. They can take two forms:

- *Demonstration models:* where the key elements are represented to enable easier visualization of the subject.
- *Working models:* where in addition to illustrating the component parts, the model is able to actively perform functions in a similar way to those which the full-scale subject would do.

Demonstration models may be all that is necessary when trying to put across basic information. However, for HRF operational activities, this would not be sufficient for the trainees to learn the skills necessary to be able to carry out the tasks expected of them. Ardent (1982) advocates that a correctly conducted demonstration, followed by it's practical application repeated by all trainees, is by far the best method of teaching rural people how to perform a task correctly. With a working model this practice by the trainees can take place on the model during training, as well as later on the job.

The *way* in which the model is used is of equal importance in getting the intended message across. It is generally accepted that models can fail to have an impact when they are not used in or followed by open discussions, which draw attention to the salient aspects of the subject, or relate it to the everyday lives of the trainees (Boot, 1990; Sudad, 1979). It is also advocated that models are most effective when used in conjunction with other visual aids, such as blackboards, slides etc. which reinforce the message in different ways (F.A.O., 1970; Williams, 1977). When actually using a model during training, all activities must be carefully practiced beforehand, so that they appear realistic, and to ensure that no embarrassing breakdowns occur. A demonstration which leaves long delays between events, or with malfunctioning equipment, will leave a poor impression on trainees (F.A.O., 1992). Boot (1990) suggests several guideline for the successful use of visual aids in training, which are applicable to the use of models.

4.iv. Conclusions.

Ideally, more than one caretaker, selected by the village water (or similar) committee, should be trained. The selected caretakers should have long-term ties to the village area, sufficient spare time available to perform the duties required of them, be able to attend the training course, and be respected by the rest of the community. It would also be beneficial if they had helped in the construction of the village HRF system. It is also necessary that the caretakers have some literacy : a low level of basic reading, writing and counting skills are required for the record keeping of HRF activities. The caretaker training course should be of relatively short duration, with 2 - 3 days at approx. 4 - 5 hours / day required for HRF-related training. This should be carried out in the village where the plant and caretakers will work. The training course should be followed by a period of on-the-job training, further reinforcing the skills learnt.

The training itself should be based on the principles of adult learning, making particular use of participatory techniques, which have been shown to be very effective in training rural adults. The emphasis during training should be placed on practical tasks the caretakers will need to be able to do. The use of a model as a visual aid can greatly enhance the value of the training, and increase the knowledge retained by the adult trainees, especially if the trainees are able to practice the operations / activities which they will need to be able to perform on the village HRF. However, much depends on the creativity of the training course to use the model to its full potential.

5. HRF Model For Caretaker Training.

5.i. HRF Model Design Criteria.

The design criteria used for the model were:

Criteria for Training:

- *It must be representative in appearance of the full scale HRF plant*, so that trainees can easily identify the parts and procedures learnt on the model during training with those found on the HRF they are to operate.
- *It must be able to clearly demonstrate the principles of operation of a HRF*, so that the trainees gain a good understanding of how a HRF works, and how it should be operated.
- *It must be useable*, so that the salient points of operation can be demonstrated to and practiced by the trainees easily and with suficient access to parts for hands-on training.

Criteria for Replicability and Practicality:

- *It must be of simple design and construction*, so that it can be easily made by a village artisan, such as a blacksmith.
- *It must be constructed from materials readily available* in the rural areas of developing countries, or at least easily obtainable in main towns.
- *It must be low-cost*, so as to be affordable to be constructed in developing countries.
- *It must be portable*, carryable by one or two people, and able to be easily transported, eg. in the back of a landrover.

5.ii. Model Specifications.

Yalin (1971) states that 'a small scale reproduction of a physical phenomenon can be a scientifically valid model only if a certain set of its measurable characteristics are related to their counterparts in the actual phenomenon by certain constant proportions [scales] which satisfy definite mathematical conditions [criteria of similarity].' However, for the purposes of HRF caretaker training, it is not necessary that the model is scientifically valid, as long as it demonstrates the actions of and responses to operational activities carried out on the model in a sufficiently similar way to the full-scale plant, so as to convince the trainees that these factors occur and are the same.

It is preferable that, as far as possible, the model is a working model (see 4.iii.) as this will be more beneficial to the trainees. However, it is also important to consider the balance which must be struck between the principal factors which the model must be able to perform or demonstrate during training, and the practical criteria involved for simplicity and replicability of model design and construction. The model design will therefore have to compromise both of these aspects, in order to meet broadly all the design criteria.

5.iii. Model Design.

The training model design is based on the designs of full scale HRF plants which are in operation around the world. Table 5.1 details design values of existing HRF plants. The main physical dimensions are similarly reduced in the model, keeping, as far as possible, the proportions of the dimensions the same in the model as in the full-scale HRFs, both for visual and performance reasons. The exceptions are variables such as filtration rate (v_f) and drainage rate (v_d), which are kept at approximately the values used on a full-scale plant, so as to obviously demonstrate their values and effects.

The materials are selected so as to be relatively easily available and cheap in developing countries. Most materials and parts have alternatives which can be used if thoses specified are not available locally (see Appendix C). Some of the parts used on the model are different to the corresponding parts which would be found on the full-scale HRF, such as the inlet flow control 'valve', and the drain 'valves'. These are used as a compromise between cost / specialized equipment and representative action. Their relationship to the real parts can be demonstrated during training.

The component parts of the model are straightforward shapes to manufacture, and are simple to assemble by someone with limited workshop skills. This involves a combination of welding and the use of bolts and rubber seals to ensure that the model is relatively watertight. Welding may prove to be the only problem in construction.

Table 5.1. Design Variable Values in Use in HRF Plants Around the World.

Location	Filtration Rate (v_f) (m/hr)	Filter Media Sizes (mm)	Filter Section Lengths (m)	Filter Width (m)	Effective Filter Depth (m)	Filter Media	Reference
Jin Xing, CHINA	1.0	16 - 32 8 - 16 4 - 8	3 2 1	3.33	1.5	Gravel	Xiangkuan et al. (1992)
Chen Zhuang, CHINA	0.75	30 - 50 15 - 30 8 - 20	3 2 1	4.45	1.5	Gravel	Xiangkuan et al. (1992)
Guder, ETHIOPIA	2.0	Overall Range : 4 - 22	Total : 21 In 4 sections	-	-	Gravel	Wegelin and Schertenleib (1993).
Salaga, GHANA	0.75 - 1.5	3 Sizes Graded Media	Total : 5 In 5 sections	0.6	0.6	Graded Stone Chippings	Berkoh (1992).
Cocharcas, PERU	0.6	3 Sizes Graded Media	3 2 1	3.6	1.0	Gravel	Wegelin (1986)
Chacoma La Libertad, PERU	0.3 - 1.0	15 - 20 10 - 15 5 - 10 <5	3 2 2 1	2.7	1.75	Gravel	Pardon (1992)
Gezira / Managil, SUDAN	0.35 - 0.7	20 - 30 15 - 20 5 - 10	2.6 0.85 0.85	-	-	Pebbles and Broken Burnt Bricks	Wegelin et al. (1991), World Bank (1991).
Kasote, TANZANIA	1.0	16 - 32 8 - 16 4 - 8	6 4 2	3.7	1.1	Gravel	Mbwette (1992), Wegelin (1986).
Mlangali, TANZANIA	1.0	15 - 25 7 - 15 4 - 6	Total : 9 In 3 sections	1.65	1.2	Gravel	Ntupwa (1990), Mbwette (1992).
Kamonkoli, UGANDA	-	Hardcore 40 20 9 - 13	2 4 3 3	-	1.65	Hardcore and Gravel	Heslop (1993), Pers.Com.

5.iv. Testing The Model.

The model was tested to assess its performance and characteristics as a small scale HRF, in comparison with full scale HRF plants. It was also tested to investigate these characteristics as they relate to its use as a training aid. The optimum operating conditions for use during training, which most clearly demonstrate the aspects being portrayed, were than determined.

Kaolin powder mixed with tap water at different concentrations was used to generate influent turbid water with which to test the model. The turbidity of the effluent water was measured in turbidity units (TU) using a DelAgua turbidity tube. A range of turbidities was tested through the filter, at a range of filtration velocities (v_f) to explore the turbidity removal efficiency of the model. Filter resistance and total head loss were also examined for a range of v_f. The results of the testing of the initial model are given in Appendix E.

Use of the model for HRF caretaker training was tested on two groups of 'trainees', in an attempt to 'field test' the model during training sessions. The test 'trainees' subsequently evaluated the model design, appearance, performance and effect with respect to the model (training) design criteria, by completion of a questionnaire. This highlighted areas which needed improving, and the design was altered accordingly. A summary of the test 'trainee' responses is given in Appendix D.

5. v. The Training Model.

The complete set of model design drawings can be found in Appendix A. Fig. 5.1 details the overall model components and dimensions. The front length of the filter box and part of the inlet and outlet chambers are cut away and replaced by glass to enable the trainees to clearly see the interior of the filter and the reponse of the flow to various operations. See Fig. 5.2 overleaf.

Fig. 5.1. HRF Training Model Components and Dimensions.

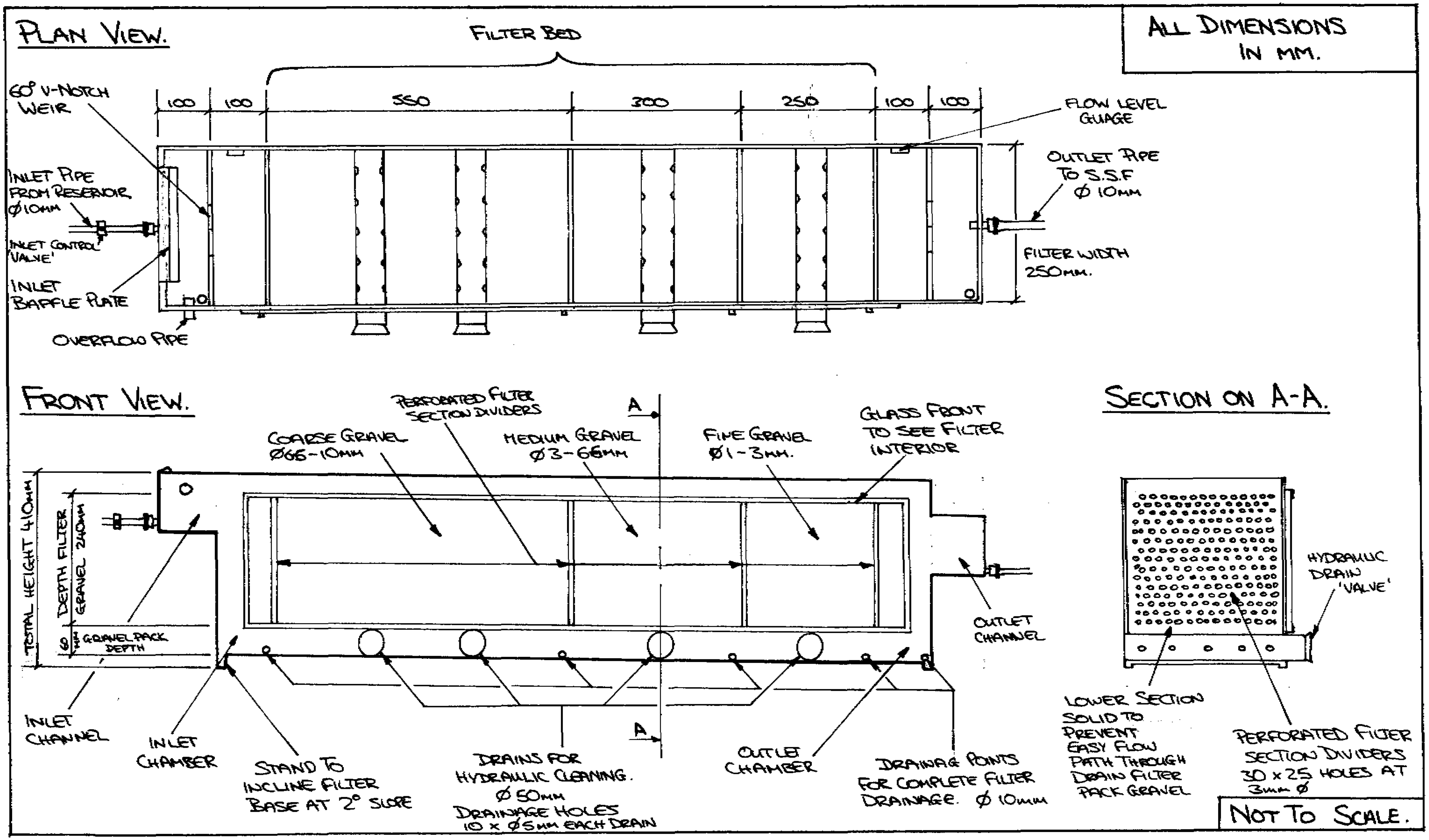
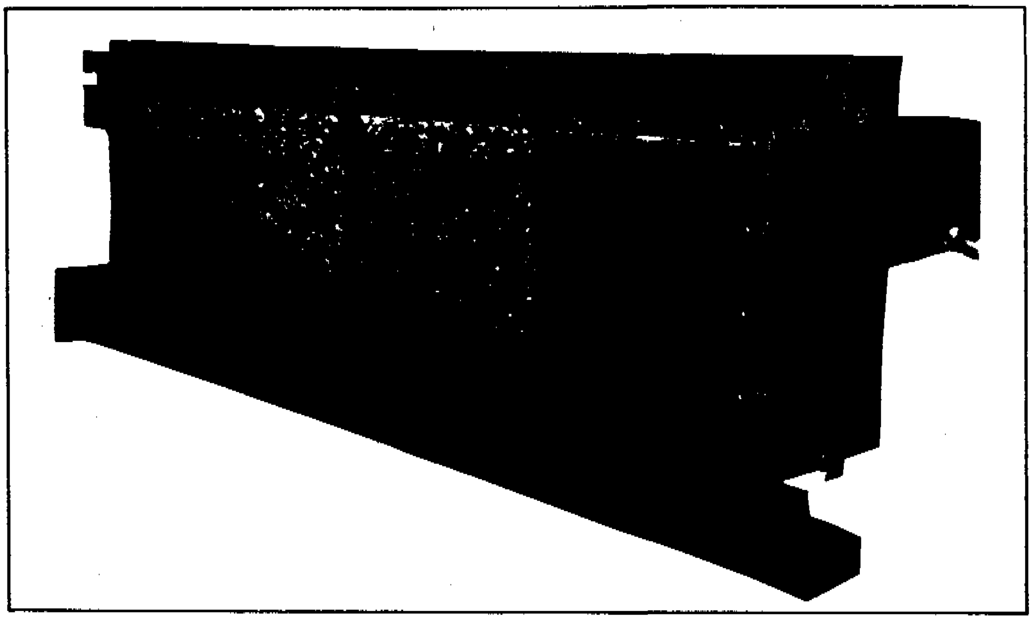


Fig. 5.2. HRF Training Model Filled With Gravel and Water.



5.v.a. The Filter.

The filter bed dimensions and gravel sizes are selected to :

- represent the proportions of and differences between the 3 gravel sections
- illustrate the perforated section dividers (see Fig. 5.4)
- demonstrate clearly the turbidity reduction along the filter length
- demonstrate clearly flow level changes occuring
- reduce filter filling and draining times
- facilitate access to the filter media

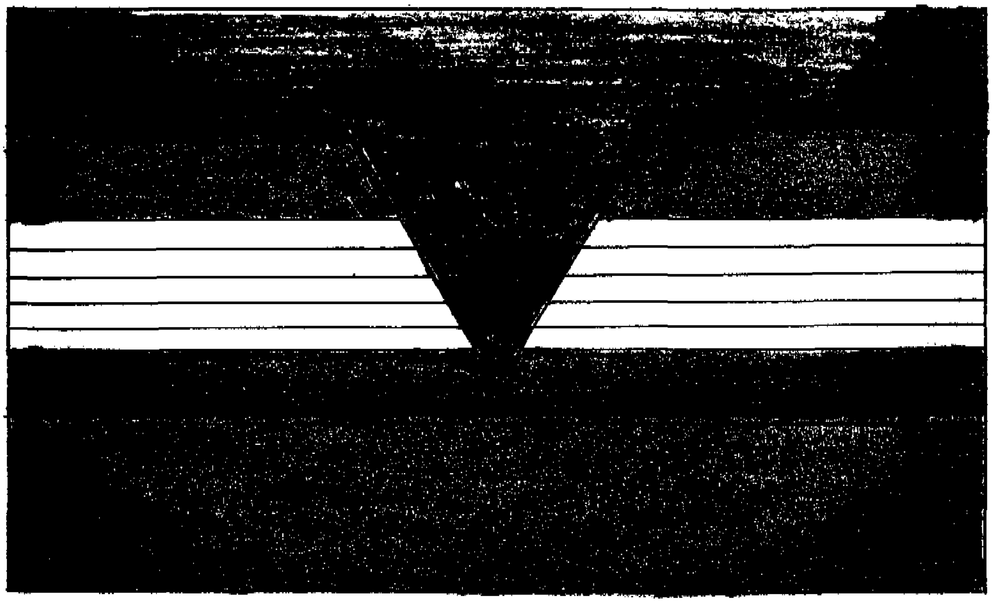
5.v.b. Inlet and Outlet Chambers and Channels.

The chambers show the quantity and quality of water entering and leaving the filter. The flow level guages enable the measurement of filter resistance across the HRF model.

The 60° V-notch weir measures the flow rate (v_f) into the inlet chamber. The maximum range of allowable v_f is indcated by a yellow band on the weir (see Fig. 5.3) which would be present in the same form on the full-scale HRF, so relating the model to the real plant.

The overflow pipe, also painted as it would be on the HRF plant, prevents flows greater than the max. allowable flow going through the model filter.

Fig. 5.3. Model V-Notch Weir Showing Band of Allowable Flows.



5.v.c. Reservoir and Inlet Control.

The filter is fed from a reservior of turbid water held in a large water vessel, eg. 220 l drum, which is raised just above the filter level. This allows the model to be continuously used during training with turbid water, and can represent a stilling or settling tank at the plant, or the water source. The flow into the filter is controlled by the inlet control 'valve'.

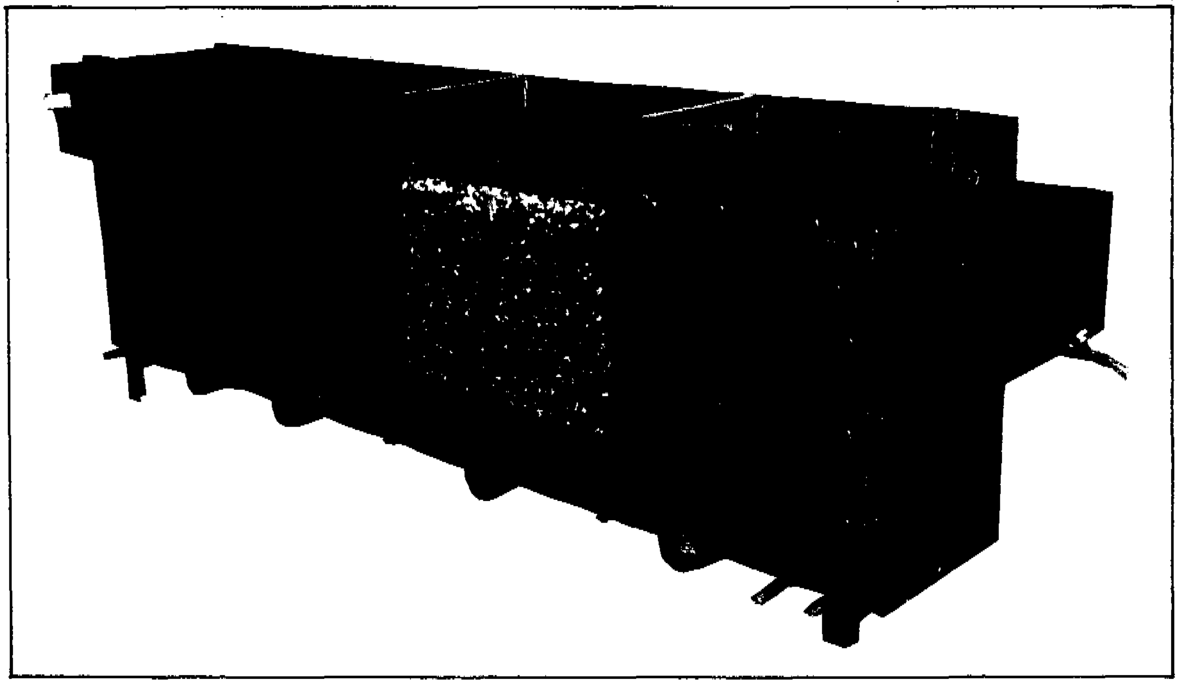
5.v.d. The Drainage System.

The hydraulic drains are designed to be:

- simple in design
- effective in demonstrating the action of filter cleaning by hydraulic drainage

They are painted the same colour as the full-scale HRF drainage pipes. See Fig. 5.4 overleaf :

Fig. 5.4. HRF Training Model Showing Hydraulic Drainage System.



All the drains empty out into an open drainage channel to facilitate the inspection and collection of drainage water. The water is collected in a large water vessel such as a 220 l drum. There are also small drainage points at the base of each section of the model, to allow it to be fully drained of water prior to transportation or storage.

5.vi. Limitations of the Model.

The model is quite large in size, in order to convey the long length of the HRF and illustrate its turbidity removing performance, while maintaining sufficient access space to the model for reading the weir and water levels and excavating the filter media. This results in relatively large volumes of both gravel and water being used during training, and makes the model non-portable once the gravel is installed. However, the model would not be transported full of gravel or water, and the separated gravel sizes and filter can be moved individually relatively easily.

The main body of the filter is constructed from sheet steel, which rusts on contact with water. It would prove too costly to coat it with anything except paint, which will easily scratch with the gravel and general wear and tear. Therefore the model must always be emptied of gravel and water, and dried, prior to transportation or storage, especially the insides of the pipes, to maintain it in a good condition.

The influent water turbidity producing the best turbidity removal results from the model may not always be available when training in the field, when local turbid water must be used. This may not give such convincing results of turbidity reduction by the HRF if the initial turbidity value is too high.

5.vii. Conclusions.

The model developed for use as a training aid with HRF caretakers is of simple design, made from materials readily available in developing countries, low cost and portable. It also fulfills the training design criteria set, being representative in appearance of a full-scale plant, accessable for use, and clearly demonstrates the principles of operation of a HRF.

6. HRF Caretaker Training Course.

6.i. Training Course Design Criteria.

The design of training courses must be carried out in relation to the specific needs of the target group, in terms of both their requirements and capabilities (F.A.O., 1992). These are encompassed in the broad objectives, or design criteria, of the training course itself. They are :

- *It must create an awareness and interest in the trainees of the benefits and problems of water quality and treatment.*
- *It must impart sufficient specific knowledge and practical skills for the trainees to be able to competently:*
  - *operate and maintain a HRF plant*
  - *carry out basic water quality testing*
  - *keep the HRF plant records up to date.*
- *It must motivate the trainees to perform their duties effectively.*
- *It must be pitched at a level and pace comensurate with the level of education and ability of the potential trainees.*
- *It must use a variety and type of training methods appropriate for use with rural adults.*

6.ii. Specific Learning Objectives of the Training.

It is important to define specific objectives which address exactly what the trainees need to be able to do, so that the training is focused and does not simply create knowledgeable trainees who cannot put into practice the theory learnt (Mzee, 1980; Rosenseweig, 1984; Carter and Marshall, 1991). The learning objectives are based on the detailed operational activities which the caretakers need to be able to perform (See 3.i.). The trainee caretakers will be able to :

- Understand their role as a caretaker and the duties and reponsibilities expected of them.
- Know the name and funtion of the main HRF components.
- Be aware of the flow through the HRF and its effect on reducing the turbidity of water.
- Take influent and effluent water samples correctly, and measure their turbidity using a DelAgua turbidity tube.

- Check and adjust the flow rate through the HRF to maintain it at the required level.
- Measure, calculate and check the filter resistance.
- Know what action to take on finding the turbidity, flow rate or resistance measurements different from the specified levels for the plant.
- Hydraulically clean the HRF by rapid drainage, following the correct procedure for draining and refilling of the filter.
- Manually clean the HRF by excavation, washing and replacing the filter media, observing all necessary precautions for hygiene and effectiveness of operation.
- Know the frequency with which all operations and checks should be carried out.
- Accurately record the necessary measurements and actions in the log book for the plant.
- Understand the importance of routine maintenance of the plant and surrounds, and be able to carry out the necessary tasks / inspections.

6.iii. Training Course Specifications.

A balance must be struck between the time and resources available, and the facts which are most important for the trainees to know. For the purposes of this project, the training course developed will be subject to the following specifications :

- The training course will follow the recommendations made in 4.iv.(caretaker training conclusions), as to the people to be trained and their preferred qualities, and also the location, duration and techniques of training.
- The course will give an overview of all subjects which should be included in caretaker training, but will only focus on the units concerned with HRF operation activities involving the use of the model developed.

6.iv. Testing the Training Course.

It is widely accepted that it is essential to carry out an evaluation once the training has been completed (Carter and Marshall, 1991; Mzee, 1980; Rosenweig, 1984; Mwale, 1980; F.A.O., 1992). This can take two forms: an evaluation of the trainees, to ascertain whether they have understood suficiently what has been taught, and an evaluation of the training course itself; its content, activities and teaching methods, to investigate their strengths and weaknesses as percieved by the trainees.

The original course devised was tested on two groups of 'trainees' in an attempt to 'field test' the training. The test 'trainees' subsequently evaluated the course presentation, content and training techniques with respect ot the design criteria, by completion of a questionnaire. This highlighted aspects requiring improvement, which were altered accordingly. A summary of the test 'trainee' responses is given in Appendix D.

6.v. The Training Course.

6.v.a. The Training Guide.

The full Training Guide can be found in Appendix B. It details for each relevant unit :

- The specific learning objectives to be accomplished.
- An overview of the purpose of the unit.
- Pre-unit preparations necessary by the instructor.
- A list of materials required.
- A description of procedures / activities to be followed.
- The time allocated for the unit and activities.
- Instructors notes providing additional information, as necessary

6.v.b. Training Course Summary.

The training course is divided into individual units, each covering a specific subject, or group of related subjects. This makes it easier for trainees to take in new information as it is presented in small, easily assimilable 'packages', and enables greater flexibility and replicability of the course in different areas.

Day 1.

Introduction and the Role of the Caretaker.

Unit 1 : Health and Hygiene.

Day 2.

Unit 2 : Water Treatment

Includes visit to existing similar treatment plant.

Days 3 - 5.

Units 3 - 6 : Slow Sand Filtration.

Day 6.

Unit 7 : Introduction to the HRF System. 1 hr. 5 mins.

7.i. Introduction to Unit 7. (5 mins)

7.ii. The need for HRF with turbid water sources prior to SSF. (20 mins)

- *Case study* : illustrating the problems occuring in SSF with turbid waters.
- *Group discussion* : turbid water is bad for SSF (revision Units 3 - 6), and must be prevented from getting into it.
- Introduce HRF (revision Unit 2).

7.iii. HRF components. (20 mins)

- *Demonstration* : use of model to explain components of HRF, and relate them to village plant.

7.iv. Direction and path of water flow. (15 mins)

- *Demonstration* : use of model to illustrate water flow in HRF.

7.v. Consolidation. (5 mins)

- Review main points covered in unit.

Unit 8. Turbidity Removal, Sampling and Measurement. 1 hr. 35 mins.

8.i. Introduction (5 mins)

- Review of Unit 7 and introduction to Unit 8.

8.ii. HRF action in removing turbidity from water. (15 mins)

- *Demonstration* : use of model to show turbidity reduction by HRF.

8.iii. Water quality sampling and measurements. (45 mins)

- *Demonstration* : correct water sampling procedure and measurement of turbidity using a turbidity tube.
- Max. turbidity values allowable into and out of HRF.
- Frequency of measurements.
- *Practical exercise* : water sampling and turbidity measurements.

8.iv. Recording of measurements in plant logbook. (15 mins)

- *Group Discussion* : what records must be kept and why.
- How and when measurements are recorded.

8.v. Consolidation. (5 mins)

- Review of main points covered in unit.

<u>Unit 9 : HRF Flow control and Filter Resistance.</u> <u>1 hr. 10 mins.</u>

9.i. Introduction. (5 mins)

- Review of Unit 8 and introduction to Unit 9.

9.ii. HRF flow rate control at inlet. (20 mins)

- *Demonstration :* alteration of inlet control and corresponding weir water level changes, including effect of the overflow.
- Max. range of flow levels allowable.
- Frequency of checking / adjusting flow.
- *Practical exercise :* alteration of flow rates.

9.iii. Filter resistance measurement and calculation. (30 mins)

- *Active participation :* change in and measurement of water levels in HRF as flow rate changes. Calculation of filter resistance.
- Max. range of filter resistance allowable.
- Frequency of checking / calculating.
- *Practical exercise :* measurement and calculation of filter resistance.

9.iv. Recording of measurements in plant logbook. (10 mins)

- What, how and when measurements are recorded.

9.v. Consolidation. (5 mins)

- Review of main points covered in unit.

Day 7.

<u>Unit 10 : Hydraulic Cleaning of HRF.</u> <u>1 hr. 40mins.</u>

10.i. Introduction. (10 mins)

- Review of Units 7, 8 and 9, and introduction to Unit 10.

10.ii. Clogging of HRF. (25 mins)

- *Case study :* illustrating that HRFs wil clog over time.
- *Demonstration :* use of model to show effects of clogging on effluent water turbidity and filter resistance.
- *Group discussion :* remedy a clogged HRF by cleaning.
- HRF conditions indicating cleaning is needed.

10.iii. Hydraulic draining and refilling procedures. (50 mins)

- *Active participation :* open first drain and sample and measure turbidity to show the effect of hydraulic cleaning.
- *Group Discussion :* effect of this and further cleaning on HRF.
- Procedure for refilling and draining HRF.
- Frequency of hydraulic cleaning.
- *Practical exercise :* refilling and draining the HRF.

10.iv. Recording of HRF cleaning details. (10 mins)

- What, how and when information is recorded.

10.v. Consolidation. (5 mins)

- Review of main points covered in unit.

Unit 11 : Manual Cleaning of HRF. 1 hr. 35 mins.

11.i. Introduction. (5 mins)

- Review of Unit 10 and introduction to Unit 11.

11.ii. Manual cleaning procedures. (1 hr)

- *Group discussion :* hydraulic cleaning is ineffective after a long time, so gravel must be cleaned by hand.
- HRF conditions indicating manual cleaning is needed.
- Procedure and method of manual cleaning.
- *Practical exercise :* manual cleaning of first filter section gravel.

11.iii. Practical aspects of manual cleaning. (15 mins)

- *Group discussion :* organization of villagers for manual cleaning.
- The importance of sound hygiene practices.
- Tools to be used.

11.iv. Recording of HRF cleaning details. (10 mins)

- What, how and when information is recorded.

11.v. Consolidation. (5 mins)

- Review of main points covered in unit.

Day 8.

Unit 12 : Revision of SSF operational activities.

Unit 13 : Revision of HRF oprational activities. 2hrs.30mins.

- *Group discussion :* activities for HRF operation and frequencies.
- *Practical exercise :* perform operation activities of HRF for given operational conditions.

Day 9.

Unit 14 : Maintenance of the Treatment Plant.

Day 10.

Course and Trainee Evaluation. 8hrs.30mins.

Total : 10 day course, with 4 - 5 hours training per day.

Note :

- A 15 - 20 minute break is allowed between each unit, or within any unit over 1hour 30 minutes long.
- The activities of *group discussion* and *consolidation* include the use of a blackboard or flip-chart, so as to be able to note down and emphasize the key points.
- The activities of *demonstration, active participation* and *practical exercise* include discussions of the main points occuring as part of these activities.

6.vi. Training Course Limitations.

The course is designed as an appropriate and effective method of teaching caretakers the principles and operations of a HRF, and as such constitutes *only one part* of the training required. It is not sufficient on its own to impart operational experience. It should therefore be preceeded by visits to existing treatment plants, and followed by a period of on-the-job training at the village plant once constructed.

6. vii. Conclusions.

The training course designed for caretaker training can be used effectively to meet the design criteria set, with the specific learning objectives being brought out by the design and content of the course. The course details one way in which HRF caretaker training can be implemented, and allows scope for aspects to be altered to suit the specific circumstances and characteristics of the trainees. The highly participatory nature of the training enables the adult trainees to become actively involved, following the principles of adult learning, so as to make the training more effective.

7. Conclusions, Recommendations and Discussion.

7.i. Conclusions.

The model designed as a training aid and the training course developed using it, together provide an appropriate and effective approach to the training of rural people as HRF caretakers.

The model functions well as a working model for training purposes, enabling trainees to carry out operations and activities on it in a similar way to the way they would on a full-scale HRF, with the model responding in a similar manner. Thus the lack of and consequences of operational activities can be experimented with, and a better understanding gained.

The training course employs the principles of adult training by the use of various participatory techniques, including the use of the model, so as to impart the greatest amount of knowledge and skills to the trainees possible in a non-on-the-job training course.

7.ii. Recommendations for Caretaker Training.

The training of village caretakers should take place in their own village, or near the site of the HRF, whichever is most convenient. A 'mobile training vehicle', for example a landrover, can be used to transport the training materials required and the instructor to rural areas. They are unlikely to be so remote that a landrover (and therefore also the materials necessary for HRF construction) cannot reach the village in question. Training in the place where the trainees live has been shown to be an effective technique, it limits the amount of disruption to the lives of the trainees, and makes the whole village aware of the caretakers being trained.

The training should be for only 4 - 5 hours per day, so as to leave the working trainees sufficient time to carry out their other daily activities as necessary. The time(s) of day for training which are most acceptable to the trainees should be established prior to the start of the course.

The training should ideally occur when the construction of the HRF has almost been completed. This allows time for the trainees to have participated in construction prior to the training course, so gaining background knowledge of HRF components, design and appearance. It will also mean that following the training course, the new caretakers will be able to put into practice what they have learnt within a short space of time, so reinforcing the knowledge and skills acquired.

A short summary leaflet of all activities to be carried out, how and when should be produced for the caretakers to take away with them on completion of the training course. This will to serve as a basic reference for future use, to ensure that key activities are not forgotten. It should be of simple design, and include no more than the key points, with photographs to illustrate them as carried out on the full-scale HRF.

Any training course, however thorough, can never be more than initial training (Glennie, 1983). The training course designed *must* be followed by a period of supervised on-the-job training, in order for the trainees to gain experience of operating the full-scale HRF. No matter how good the working model is, it is not a full-scale HRF, and training *cannot* replace direct experience (Geneva Research Centre, 1972).

7.iii. Discussion : Wider Issues.

The health and hygiene education of the villagers should be carried out at the same time as, or before the caretakers are trained, in order to generate the essential demand for safe drinking water by the village. It should also ensure that the safe water produced is not recontaminated by poor collection, use or storage practices.

Sufficient time must be incorporated into the treatment plant project plans to enable both the initial and on-th-job training to be carried out properly. The funding and resources available for training will also have a significant impact on its effectiveness. Much of the money is likely to come from the government or responsible institution. The amount available often depends on the success of the training given, and the success of the training depends on the resources available...(F.A.O., 1992).

The training of caretakers will not alone solve all of the problems associated with the failures of village level operation and maintenance, seen in 3.ii. Some deficiencies can be addressed by training, but others are related to shortcomings within the responsible organization / institution, or to external factors, which no amount of training can solve (Carter and Marshall, 1991). However, the thorough training of caretakers is essential if the treatment plant is to produce a safe and reliable water supply for the village community.

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Appendix A.

Training Model Detailed Design Drawings.

Appendix B.

HRF Caretaker Training Guide.

Appendix B : Training Guide for HRF Caretakers.

B.i. Introduction.

This Training Guide is designed as an appropriate method of teaching potential rural treatment plant caretakers the principles and operations of a HRF. It illustrates one way in which the HRF model developed can be used effectively as an aid in caretaker training. It constitutes only one part of such training, and is not sufficient on its own to impart operational experience to the trainee. It must therefore be preceeded by visits to an existing treatment plant, and followed by a period of on-the-job training at the village plant once constructed, so as to reinforce the skills and knowledge learnt, and to gain experience.

The Training Guide is divided into individual units, each covering a specific subject, or group of related subjects. The Guide focuses on those units concerned with the training of HRF caretakers, but sets these in the context of a complete training course for treatment plant operators. For each HRF / training model related unit, the following are detailed :

- The specific learning objectives of the unit.
- An overview of the purpose of the unit.
- Pre-unit preparation activities which the instructor should organize prior to the trainees arriving.
- A list of training materials required.
- The subjects covered and approx. time allocated.
- A description of procedures / activities to be followed.
- Instructors notes, *written in italic*, providing additional information as necessary.
- Example case studies, discussions etc. which may be used or adapted to the local situation as appropriate.

B.ii.Training Course Overview / Timetable.

This provides an example of how the timing of training can be allocated. Breaks of 15 - 20 minutes have been allowed between each unit, or within any unit over 1.5 hours. The training should not be rushed to fit in with this timetable, and if the pace needs to be slower additional days, rather than hours per day, should be added.

Day 1 : — 2.5 hrs.
- Introduction and the role of the caretaker
- Unit 1 : Health and hygiene

Day 2 : — 4 hrs.
- Unit 2 : Water treatment (includes visit to existing plant)

Day 3 : — 3.5 hrs.
- Unit 3 : The need for SSF for safe drinking water
- Unit 4 : SSF components and filter action

Day 4 : — 5 hrs.
- Unit 5 : SSF operational activities

Day 5 : — 4 hrs.
- Unit 6 : SSF cleaning and resanding

Day 6 : — 4.25 hrs.
- Unit 7 : Introduction to the HRF system
- Unit 8 : Turbidity removal, sampling and measurement
- Unit 9 : HRF flow control and filter resistance

Day 7 : — 3.5 hrs.
- Unit 9 : Hydraulic cleaning of the HRF
- Unit 10 : Manual cleaning of the HRF

Day 8 : — 5 hrs.
- Unit 12 : Revision of SSF operational activities
- Unit 13 : Revision of HRF operational activities

Day 9 : — 4hrs.
- Unit 14 : Maintenance of the treatment plant

Day 10 : — 8.5 hrs.
- Course and trainee evaluation.

B.iii. Training Course Guide.

Introduction.	**30 mins.**

- The role of the caretaker.
- Subjects to be covered during the training course, when and how.

Unit 1 : Health and Hygiene.	**2 hrs.**

- Why the river water is not safe to drink
- Why clean, safe water is good
- The need for water treatment.

Unit 2 : Water Treatment.	**4 hrs**

- General principles of water treatment, as they relate to the specific village circumstances.
- Visit to an existing similar treatment plant.

Unit 3 : The Need for SSF.	**1.5 hrs**
Unit 4 : SSF Components and Filter Action.	**2 hrs**
Unit 5 : SSF Operational Activities.	**5hrs.**
Unit 6 : SSF Cleaning and Resanding.	**4 hrs.**

Unit 7 : Introduction to the HRF System. 1 hr. 5 mins.

Learning Objectives.

At the end of this unit, the trainees will be able to :

- Know the name and function of the main HRF components.
- Be aware of the flow through the HRF.

Overview.

The purpose of this unit is to familiarize the trainees with the components of the HRF. An important part is to get across the fact that the model is a small version of the village HRF, which will act in the same way even though some parts of it may look diferent. The following units will depend on the trainees understanding and accepting this, and being able to relate parts to the full-scale plant being constructed in the village. The unit also introduces HRF operation and the way water passes through the filter.

Pre-Unit Preparation.

- Assemble the HRF model, reservoir and collection vessel in a suitable place.
- Fill the two smaller HRF sections with gravel.
- Fill the reservoir with turbid water.
- Fill a glass jar with water and add 1/8 - 1/4 teaspoon potassium permanganate crystals to form a purple dye.
- Assemble other equipment necessary for the unit.

Materials Required.

- Dry HRF model with the two smaller gravel sections filled, and the largest empty.
- Reservoir full of turbid water
- Collecting vessel for water output from HRF (220 l drum)
- Blackboard and chalk / flipchart etc.
- Container of largest size model filter gravel
- Small scoop (x 2) (500ml)
- Bucket (x 2) (10 l)
- Full- scale gate valve (x 2)
- Small container of each of the three real sizes of gravel used in HRF (x 3)
- Clear glass / plastic sampling jar (x 2) (250 ml)
- Potassium permanganate crystals (1/8 - 1/4 teaspoon)
- Teaspoon

Note : the sizes of items given are those used in the training sessions given during testing, and can be replaced by any other suitably-sized container etc.

7.i. Introduction. 5 mins.

- Present the purpose of the unit and the learning objectives to the trainees.
- Review where the HRF component comes in the village treatment plant *(Revision Unit 2).*

7.ii. The Need For HRF With Turbid Water Sources Prior to SSF. 20 mins.

Case Study : Illustrating the problems occurring in SSF with turbid waters.

Two villages each have a SSF, and both get their water from the river nearest their village. In one village the river is muddy, and the other village, a long way away, has a clear river for its water source. The village with the muddy water has a lot of problems with its SSF : it clogs quickly and gives unsafe water, and so need to be cleaned often to keep the village water supply safe. The village with the clear river has no problems with its SSF : it runs for a long time producing safe water to drink before it needs to be cleaned.

Group Discussion : Guide the discussion of the case study.

- What can be concluded from the story ?
- Encourage trainees to suggest why the muddy water village has problems with its SSF and the clear water village does not, and how the muddy water effects the SSF.*(Revision Units 3 - 6).*
- What can be done to prevent the muddy water from entering the SSF ?
- Summarize the key points of the discussion and introduce the role of the HRF.

Note : Write main points on blackboard as they are made, for all to see.

7.iii. HRF Components. 20 mins.

Demonstration : Use of semi-filled HRF model to explain components of the HRF, and relate them to the village plant.

- Allow trainees a few minutes to examine the model.
- Draw attention to the salient components, compare them with the parts on the HRF being built in the village, and emphasize the similarities to ensure that the trainees can relate the model parts to those on the HRFs seen previously:
  - inflow weir (yellow)
  - overflow pipe (white)
  - inlet chamber
  - perforated filter dividing walls

- 3 main filter gravel chambers
- outflow chamber
- filter drains (black)
- connections to other parts of the treatment system

- Draw attention to the parts of the model which are different from those found on a full-scale HRF, so that the trainees realise that they are different, and what they are meant to represent:

- inlet flow control and drain 'valves'

Present the trainees with the actual parts used for inspection, and emphasize the fact that the devices used on the model they have equivalent actions to the real parts.

- filter gravel sizes

Present the trainees with samples of the actual sizes which will be used in the village HRF, and compare tham with the sizes used in the model. Conclude that the model uses smaller sizes because it is smaller.

- materials of construction

Compare the differences in materials used in the model and in the village HRF, and conclude that the model is only a model of the real thing, so it doesn't matter.

- Flow into HRF from reservoir

Liken the reservoir to either the settling tank used prior to the HRF in the village plant, or those visited, or to the river etc. where the water source is connected straight into the HRF.

- Flow out to SSF.

7.iii. Direction and Path of Water Flow. 15 mins.

Active Participation : Get the trainees to fill the empty chamber with gravel.

Demonstration : Open the inlet valve to maximum flow *(for speed of filling the HRF)* and allow trainees to observe the direction of water flow as the filter fills.

- Discuss the way water moves through the filter ; through both the gravel and the perforated section dividers.
- Draw attention to the fact that the water which initially comes out of the HRF is not clean *(See Note 1).*
- Conclude that the first water coming out of the HRF when it is started up must not be allowed to flow into the SSF, until the diry water has cleared.

Demonstration : Add a little of the potassium permanganate dye to the inlet chamber of the model, and allow trainees to follow the path of the purple dye through the HRF until it washes through. *(see Note 2).*

Note 1 : The water initially output will be coloured by any dirt loosened from the gravel during installation, and will wash through after a few minutes at max. flow.

Note 2 : only a small amount of dye should be added at the sied of the inlet chamber nearest the glass front, so that the trainees can follow its path, but it does not take too long to wash through the filter. The dye path will become hard to follow in the smallest gravel section, but will be immediately obvious once it emerges in the outlet chamber.)

7.iv. Consolidation. 5 mins.

Group Discussion : Review the main points covered in the unit, encouraging the trainees to bring out the key issues.

Note : List all key points on the blackboard for all to see.

Unit 8 : Turbidity Removal, Sampling and Measurement. **1 hr. 25 mins.**

Learning Objectives.

At the end of this unit the trainees will be able to :

- Be aware of the effect of the HRF on reducing the turbidity of water.
- Take influent and effluent water samples correctly.
- Measure the turbidity of samples using a DelAgua turbidity tube.
- Know the max. influent and effluent turbidity levels allowable.
- Know the frequency at which turbidity measurements must be made.
- Accurately record the necessary measurements in a logbook.

Overview.

The purpose of this unit is to demonstrate the turbidity removing ability of the HRF. The trainees will be taught how to sample, measure and record the turbidity values and informed of the maximum turbidity values which can be allowed into the HRF and into the SSF, for their proper operation. It is important that these points are clearly got across, as the proper operation of both the SSF and HRF depend on the correct turbidity values being applied.

Pre-Unit Preparation.

- Stop HRF flow
- Refill the reservoir with turbid water of approx. 125 TU *(see Note 1)*.
- Fill two glass jars with water samples : one of 30 TU, and one of 350 TU *(see Note 2)*.
- Clean jar with potassium permanganate dye in, and the blackboard.
- Assemble other equipment necessary for the unit.

Note 1: Try to get the turbidity of the water as near to 125 TU as possible, as this will give the best results. If the turbidity of water available is below this, collect or stir up some bottom sediments to increase the turbidity of the water, but ensure that they remain in suspension during the unit and do not settle out.

Note 2 : The water sample with the larger turbidity should have a value which is the max. allowable turbidity of influent water into the village HRF being constructed, so as to demonstrate what this looks like to the trainees. 350 TU is taken as an example.

Materials Required.

- HRF model filled with gravel and water
- Reservoir full of turbid water

- Collecting vessel for water output from HRF
- Blackboard and chalk
- DelAgua turbidity tube (x 2)
- Clear glass / plastic sampling jar (x 4)
- Sample logbook sheet

8.i. Introduction. 5 mins

- Review the key points of unit 7
- Present the purpose of unit 8 and the learning objectives to the trainees.

Emphasize that the trainees will need to know how to carry out the activities and measurements covered in this unit to be able to look after the HRF properly, thus focusing their attention on learning how to do the activities.

8.ii. HRF Action in Removing Turbidity From Water. 15 mins.

Demonstration : Open the inlet control to the second line up on the weir level.

- Draw attention to the colour of the turbid water input into the HRF, and compare it to the water from the river when it is muddy (turbid).
- Ask the trainees what they notice about the colour of the water coming out of the HRF *(see Note 1)*.
- Take a sample of the influent and effluent waters in separate glass jars, and place them against a plain background *(see Note 2)* to emphasize their difference. Allow the trainees to examine the samples if they wish.
- Discuss the effect the HRF has had on the turbid water input and emphasize its ability to make the water clear.

Note 1 : the influent and effluent waters may not look that different while they are in the HRF, but on taking a sample of each in a glass jar, the difference will be immediately obvious.

Note 2 : Eg. a plain piece of paper, or the blackboard.

8.iii. Water Quality Sampling and Measurement. 45 mins

Demonstration : Show the trainees the correct method for taking a sample from both the influent water and effluent water of the HRF for turbidity measurement.

- Discuss the important points, such as not contaminating the sample by putting muddy fingers into it etc.

Demonstration : once the samples have been taken, illustrate the way in which the amount (degree) of muddiness (turbidity) in the water is measured for each sample, using a turbidity tube.

- Explain the details of the turbidity tube and allow trainees to examine one, drawing attention to the base circle, and the log. scale up the side.

- Explain the procedure for turbidity measurement using the tube, and demonstrate this for one of the samples.

- Allow the trainees to examine the sample in the tube, to see for themselves when to take a reading, just being able to see the circle. Get them to read off the value and write it on the blackboard.

- Repeat with the second sample.

Group Discussion : Get the trainees to associate the turbidity measurements just taken using the turbidity tube, with what the samples look like in the glass jars.

- Ask them if they think the output turbidity is an acceptable quality for input into the SSF, and if not, what value they think the water should be to be allowed into the SSF. *Write any suggestions on the blackboard.*

- Repeat for the input turbidity; what value is the max. which can be input into the full-scale HRF, so that acceptable water quality is produced output. *Write suggestions on the blackboard.*

- Explain to the trainees the max. turbidity values allowed into the HRF (350 TU) and out from it into the SSF (30 TU). Show the trainees the prepared samples of these values to enable them to visualise them.

- Discuss the fact that if these values are exceeded then the water must not be allowed to flow into the HRF / SSF (as appropriate) or they will be damaged.

- Discuss the frequency (2 x week) with which the trainees, as HRF caretakers responsible for the functioning of the plant, must take water samples and measure their turbidity. Get the trainees to suggest frequencies, and point out that it needs to be done so regularly to ensure that the plant remains in proper working condition.

Practical Exercise : Alter the flow rate into the model to the 4th weir water level, and allow the filter to adjust to this.*(see Note 1).*

- Get the trainees to each take a sample from the input and output of the HRF, and measure their turbidity values using the turbidity tubes.*(see Note 2).*

- Once the trainees have done this, take a sample the input and output water, measure their turbidity, and write the results on the blackboard.

- Discuss the differences and similarities in the results of the trainees and those of the instructor. Point out mistakes which may have been made in readings which are too high or too low by a large amount.

- Repeat the exercise at a different flow rate, to provide the trainees with more guided practice at sampling and measurement *(see Note 3).*

Note 1 : this increased flow rate through the filter will reduce the amount of turbidity removed by the model, so that the trainees have a different output value to *measure, and cannot cheat!*

Note 2 : This gives each trainee a chance to take two samples and two turbidity measurements. The instructor should watch the trainees as they carry out the exercise, correcting any errors in technique which are spotted, so that the trainees realise how to do it correctly. Write the results for input and output turbidity for each trainee on the blackboard.

Note 3 : This is especially important in the reading of the turbidity tube, as it is a fairly subjective technique, and the trainees should gain a visual understanding of when a reading should be taken, with respect to the degree to which the circle can be seen.

8.iv. Recording of Measurements in Plant Logbook. 15 mins.

Group Discussion : Get trainees to suggest why measurements should be recorded in the plant logbook, and what information needs to be recorded.

- Detail what, how and when measurements must be recorded, and emphasize the importance that they are kept up to date.
- Show the triainees an example of a plant logbook, to familiarize them with the general format / layout.

8.v. Consolidation.

Group Discussion : Bring out the key points made in unit 8, and discuss their importance for the HRF caretakers.

Write all main points on the blackboard.

Unit 9 : HRF Flow Control and Filter Resistance. **1 hr. 10 mins.**

Learning Objectives.

At the end of this unit the trainees will be able to :

- Check and adjust the flow rate through the HRF to maintain it at the required level.
- Measure the flow levels in the HRF using the level guages.
- Calculate the filter resistance from the flow levels measured.
- Know the max. filter resistance allowable across the HRF.
- Know the frequency at which the filter resistance must be checked.
- Accurately record the necessary measurements in the logbook.

Overview.

This unit covers the rest of the frequent operational activities which the caretakers need to be able to perform in order to ensure the proper functioning of the HRF. The importance of these tasks must be emphasized, along with their frequencies, so that the trainees are certain of what they have to do and how often.

Pre-Unit Preparation.

- Stop HRF flow.
- Refill reservoir with turbid water of approx. 125 TU.
- Remove unwanted equipment from unit 8.
- Assemble other equipment necessary for this unit.
- Clean the blackboard.

Materials Required.

- HRF model filled with gravel and water
- Reservoir full of turbid water
- Collecting vessel for water output from HRF
- Blackboard and chalk
- Non-permanent fine marker pens (x 2 colours)

9.i. Introduction. 5 mins.

- Review key points of unit 8.
- Present the purpose of unit 9, and the learning objectives to the trainees.

Emphasize that the trainees will need ot know how to carry out the activities and measurements covered in this unit to be able to look after the HRF properly, thus focusing their attention on learning how to do the activities.

9.ii. HRF Flow Rate Control at Inlet. 20 mins.

Demonstration : Get the trainees to observe that when there is no flow through the HRF, the water level is at the very base of the inlet weir, outside the yellow band.

- Open the inlet control and demonstrate how the water level at the weir increases as the 'valve' is opened by increasing amounts.

- Draw attention to the increase in flow rate (speed of water inflowing) as the inlet is opened more.

- Guide the trainees to associate the 'valve' being opened, with the weir water level increasing, and the flow into (and through) the HRF also increasing.

- Point out the yellow band on the weir, and explain that this indicates the max. and min. limits of where the water level should be for the HRF to operate properly; no lower or the flow is too slow, and no higher or the flow is too high.

- Draw attention to the white overflow pipe, and demonstrat its use when the flow is increased over the max. value indicated by the yellow weir band. Explain that this limits the max. flow into the HRF.

- Get trainees to suggest how often the caretakers must check the overflow and the flow rate into the HRF, and bring out the fact that it must be adjusted so that it is within the yellow band, if it is initially not when checked. *(see Note 1).*

Practical Exercise : Allow each trainee to practice adjusting the inlet control, and get a feel for the response of the weir water level and the speed of flow. Specify certain weir water levels which the trainees then try to attain by controling the inlet.

Note 1 : Emphasize that these are very important aspects of the filter operation, and so must be checked every day, in order for the HRF to function properly and produce water acceptable for input into the SSF.

9.iii. Filter Resistance Measurement and Calculation. 30 mins.

Active Participation : Get one trainee to close the inlet control so that the flow of water through the HRF ceases. Get another trainee to draw a line along the glass of the model at the level the water rests in the filter once the flow has stopped. *(see Note 1).*

- Get the trainees to read off the water level just drawn, on the water level guages at the inlet and outlet chambers.*(see note 2). Write these on the blackboard.*

- Get a trainee to open the inlet control so that the weir water level is on the

3rd line up, allow the flow level in the filter to adjust, and get a trainee to mark on the new flow level at the inlet and outlet chambers, using a different coloured pen.

- Draw attention to the difference in level changes at the inlet and outlet chambers, and get the trainees to read off each value, and write them on the blackboard. *(see Note 3)*.

Analogy : use to explain why the level change is greater at the inlet than at the outlet in the filter :

If the village streets are empty, a group of people can run through the streets in a line following each other, as fast as they want to. But if the village is full of crowds of people, the group of people can't run so fast and have to slow down. When the first person slows down, the person behind him slows down etc., and they have to queue up to get through the crowded streets in a line. This is what happens in the HRF. The water wants to flow through the filter at the speed it enters it at the inlet, but the gravel (equivalent to the crowds of people in the streets) slows down the water as it tries to get through. But it is still entering the filter at the same speed, so it has to 'queue up' or backs up at the inlet to the gravel. *(see Note 4)*.

Group Discussion : Discuss the above analogy and the way it relates to the changes seen in the filter.

- Explain that the amount by which the inlet level is greater than the outlet level is called the filter resistance, and is calculated by subtracting the outlet value from the inlet value. Do this for the values measured, and write the result on the blackboard.

Practical Exercise : Alter the inlet control so the weir water level is at its max. value. Get the trainees to repeat the above exercise as a group, measure the flow levels and calculate the filter resistance. Write the results on the blackboard.

Group Discussion : Examine the results obtained, and compare them with those at the lower (slower) flow rate.

- Conclude that as the flow rate is increased, the filter resistance increases also.

- Get the trainees to suggest what the max. filter resistance allowable could be, and bring out the fact that it must be below 30cm.for the HRF to function properly.

- Discuss the frequency at which the HRF caretakers must check the filter resistance (2 x week), with suggestions from the trainees.

Note 1 : It may be difficult to follow the level of the water through the fine gravel, but this is no problem, as only an approximate level is required. The levels drawn at the inlet and outlet chambers are the important ones.

Note 2 : These should both be zero.

Note 3 : The inlet value should be greater than the outlet value.

Note 4 : Be careful in the use of this or a similar analogy, first ensuring that it will not be misunderstood, or its 'story' unassociated with the point which is attempting to be made.

9.iv. Recording of Measurements in Plant Logbook. 10 mins.

Group Discussion : Review why measurements must be recorded in the logbook

- Get trainees to suggest what information needs to be recorded
- Explain how and when it must be recorded.
- Show the trainees an example of a plant logbook with inflow and outflow levels, and filter resistance recorded.

9.v. Consolidation. 5 mins.

Group Discussion : Bring out the key points made in unit 9, and discuss their importance to the HRF caretakers.

Write all main points on the blackboard.

Unit 10 : Hydraulic Cleaning of HRF. **1hr. 40 mins.**

Learning Objectives.

At the end of this unit the trainees will be able to :

- Understand the effects of clogging on the HRF.
- Recognise the HRF conditions indicating hydraulic cleaning is necessary.
- Hydraulically clean the HRF by rapid drainage, following the correct procedures for draining and refilling the filter.
- Accurately record the relevant details in the plant logbook.

Overview.

The purpose of this unit is to demonstrate the fact that the HRF will clog up after a period of time, which impairs its performance, and that it must be regularly hydraulically cleaned to ensure the continued output of water acceptable to the SSF. The importance of this task must be emphasized, as it is not so regular as the operational activities so far covered, and its neglect will result in the SSF producing unsafe water for the village supply.

Pre-Unit Preparation.

Prior to this unit being carried out, the model must be run at a low flow rate (eg. 2nd weir water level), with very turbid water (1000 - 1500 TU, or more if possible), for approx. two reservoirs full. This will take a couple of hours, and so must be done either the night before, or in the morning prior to the start of training. This is ***essential****, in order to demonstrate the clogging of the HRF.*

Other preparations necessary include:

- Stop HRF flow.
- Refill the reservoir with turbid water of approx. 125 TU.
- Assemble other equipment necessary for the unit.

Materials Required.

- HRF model filled with gravel and water, and clogged as much as possible
- Reservoir full of turbid water
- Collecting vessel for water output from HRF
- Blackboard and chalk
- watch or stopwatch
- clear glass / plastic sampling jar (x 4)
- DelAgua turbidity tube (x 2)
- Sample logbook sheet

10.i. Introduction. 10 mins.

Group Discussion : Review the key points made in units 7, 8 and 9 covered yesterday.

- Present the purpose of unit 10 and the learning objectives to the trainees.

Emphasize that the trainees will need ot know how to carry out the activities and measurements covered in this unit to be able to look after the HRF properly, thus focusing their attention on learning how to do the activities.

10 .ii. Clogging of the HRF. 25 mins.

Case Study : Illustrating the fact that HRF clog rapidly if highly turbid waters are allowed into it, and over a longer time when used with acceptable turbidity waters.

Two villages each have a HRF to remove the muddiness of their river water before it enters the village SSF. One of the villages is in an area where the rainy season is very short, and the rains are very heavy. Therfore during the rainy season, the river water is very muddy, has a greater turbidity than the max. allowed for the plant, and so should not be allowed into the HRF. However, the caretakers do not do their job properly, and let the very turbid water into the HRF, which then quickly produces poor quality water, with a turbidity greater than the max. allowed , and which cannot be put into the SSF. The second village is in a different part of the country, where the rainy season is longer, and the rains are lighter. The river water is therefore a little bit turbid for much of the year. The caretakers at this second HRF are very consciencious, and ensure that the flow rate and turbidity of the HRF are always acceptable, and the plant functions properly, with the water being OK for input to the SSF. However, once the HRF has been operating for some time, the water quality output begins to get worse, and eventually it is greater than the maximum which can be allowed into the SSF.

Group Discussion : Guide the discussion of the case study.

- What can be concluded about the performance of the HRF at each of these villages ?
- Encourage the trainees to suggest what is happening to the filter in each case.
- Bring out the idea that the HRF removes the muddy sediments making the river turbid (and so making the water clearer) by trapping these sediments in the gravel filter bed : the mud goes in in the turbid water input, but does not come out, so it must be left behind in the gravel.
- Direct the trainees to see that the HRF can become clogged quickly when extremely turbid water is allowed through it, and also after some time when it is operated properly.

Demonstration : Describe to the trainees that since the last training session, the HRF has bee run with very, very turbid water (100 - 1500 TU), which is much more than should be allowed into it. Draw attention to the obvious accumulations of sediments on the gravel, visible through the glass front.

- Open the inlet control to the 2nd weir water level. Draw attention to the flow levels marked on the glass front the previous day, and state that the HRF is now running at the same flow rate as the first flow level measurement taken yesterday.

- Draw attention to the increase in flow level at the inlet chamber for the same low rate as previously, and the increase the turbidity of the water output.

Active Participation : Get the trainees to sample the water input and output, and measure their turbidities, and to measure the flow levels and calculate the filter resistance across the filter *(see Note 1).* Write all results on the blackboard.

- Stop the HRF flow once completed.

Group Discussion : Discuss the results, how they differ from those of the previous day, whether they are acceptable for HRF operation *(see Note 2).*

- Indicate that the increase in filter resistance and turbidity output is caused by the clogging of the filter by the sediments.

Analogy : used to explain the way clogging of the filter leads to an increase in filter resistance :

Return to running through the village streets. When there are crowds of people in the streets, it is difficult to run through very fast, and as the group of people slow down, they must queue up to get through. This is equivalent to the normal filter resistance of the HRF. But when it is a market day every person in the street has with them their goods to sell. If the streets are crowded with people, it is even more difficult to run through the village, as there are not only people, but market stalls in the way as well. Therefore, the group have to go even slower, and have to queue up even more to get through in a line. This is equivalent to what happens in the HRF gravel; the gravel collects the muddy sediments, and this makes it even harder for the water to get through at the speed it wants to, so it must slow down even more, and so the filter resistance is higher, as it backs up more.*(see Note 3).*

Group Discussion : Discuss the analogy above and relate it to what has been seen in the filter.

- Encourage suggestions on how the clogged filter can be remedied to function properly again, and bring out the fact that the gravel must be cleaned of sediments.

- Review the conditions of the HRF which indicate that the filter must be cleaned (turbidity > 30 TU, or filter resistance > 30 cm).

Note 1 : This acts as revision of the activiteis learnt previously, and will aid in demonstrating the effects of filter clogging.

Note 2 : Filter resistance should be > 30 on the water level guage scales, and the output turbidity should be > 30 TU. Ensure that the filter is sufficiently clogged prior to the training session to produce these results.

Note 3 : Again be careful in the use of this or a similar analogy, first ensuring that it will not be misunderstood, or its 'story' unassociated with the point which is attempting to be made.

10.iii. Hydraulic Draining and Refilling Procedures. 50 mins.

Active Participation : Explain that the regular cleaning of the HRF is done by rapid drainage of the water, which flushes out the sediments.

- Get a trainee to open the hydraulic drain nearest the inlet chamber, and another to start timing on the watch or stopwatch.
- Allow the trainees to observe the lowering of the water level in the filter and the consequent draining down of the accumulated sediments in the filter.
- Get the trainees to sample the drainage water coming out at intervals of 1, 2 and 3 minutes following the opening of the drain.
- The trainees can then measure the turbidities of each of the samples. *Write the results on the blackboard, underneath the influent and effluent turbidity measurements taken earlier.*

Group Discussion : Discuss what has been seen in the demonstration.

- Discuss the turbidities of the samples taken, in relation to each other, and with respect to the influent water turbidity previously measured.
- Encourage the trainees to reason that the turbidity of the drainage water is always greater than that of the influent water, because the sediments trapped in the filter, as well as those entering it, are being brought out.
- Also that the drainage samples are increasingly more turbid as the length of time of drainage increases, because the sediments are pulled downwards by the lowering water level, and so as the water level lowers further, more and more sediments accumulate towards the bottom of the filter, and come out of the drain.

Group Discussion : Ask the trainees if they think that this has cleaned the HRF enough for it to return to proper functioning or not.

- Discuss the fact that the filter must be refilled, and drained again, and the procedures for doing this : through the drain nearest the inlet again first, with the filter being refilled in between, as this is where the most turbid water enters the HRF, and so it is where most of the muddy sediments accumulate. The second drain from the inlet, still in the coarsest gravel section, is next to be drained,and then the second and third filter sections, to ensure that as many muddy sediments as possible are cleaned out of the filter.

- Detail the way in which the HRF must be refilled between drainages, with the first 1/3 of the depth being filled at a rate of 1/2 the normal operational flow rate, so as to not disturb and raise upwards the sediments which have accumulated at the filter base, the next 1/3 at the operational flow rate, and the final 1/3 of the depth at 1.5 times the operational flow rate, to speed up the filling.

See Note 1.

Practical Exercise : Get the trainees to fully clean the HRF by hydraulic draining, following the procedures for refilling and draining just discussed. Samples should be taken from each drain, at the same time intervals as previously, their turbidities measured, and the results all written on the blackboard.

Active Participation : once the HRF has been fully cleaned, refill it and allow it to operate at the flow rate previously used (2nd weir water level). Get the trainees to sample the influent and effluent water turbidities and measure and calculate the filter resistance again. Write all results on the blackboard.

Group Discussion : Use the results obtained in the practical and active participation session to discuss and emphasize further the effect of hydraulic cleaning of the HRF, and the necessity of checking the output turbidity and filter resistance before the HRF is reconnected to the SSF.

*Note 1 : It is essential to emphasize that the HRF **must** be drained and refilled in this way or cleaning of it by draining will not work.*

10.iv. Recording of Measurements in Plant Logbook. 10 mins.

Group Discussion : Review why measurements must be recorded in the logbook

- Get trainees to suggest what information needs to be recorded
- Explain how and when it must be recorded.
- Show the trainees an example of a plant logbook with hydraulic cleaining details recorded.

10.v. Consolidation. 5 mins.

Group Discussion : Bring out the key points made in unit 10, and discuss their importance to the HRF caretakers.

Write all main points on the blackboard.

Unit 11 : Manual Cleaning of HRF. 1 hr. 35 mins.

Learning Objectives.

At the end of this unit, the trainees will be able to :

- Know that the HRF will clog over a long time period, even with regular hydraulic cleaning.
- Recognise the HRF conditions indicating that manual cleaning is necessary.
- Manually clean the HRF by excavation, washing and replacing the filter media, observing all necessary precautions for hygienic operation.
- Organize the villagers to aid in the cleaning.
- Accurately record the relevant details in the plant logbook.

Overview.

The purpose of this unit is to illustrate the fact that the HRF will still clog up after a long period of time, even with regular hydraulic cleaning, and that the filter can then only be cleaned by manually washing the filter medis. The importance of this task must be emphasized, as it is not a very regular activity, and its neglect will result in the SSF producing unsafe water for the village supply.

Pre-Unit Preparation.

- Stop HRF flow
- Refill the reservoir with turbid water of approx. 125 TU.
- Clean the blackboard, except for the effluent turbidities and filter resistances measured in unit 10, prior to and after hydraulic cleaning.

Materials Required.

- HRF model filled with gravel and water
- Reservoir full of turbid water
- Collecting vessel for water output from HRF, filled with turbid (natural) river water
- Blackboard and chalk
- Container for the temporary storage of the largest section of filter gravel (as used previously in unit 7), or plastic sheet
- Small scoop (x 2)
- Bucket (x 2)
- Clear / glass sampling jar (x 2)
- DelAgua Turbidity tube (x 2)

Introduction. <u>5 mins.</u>

- Review the key points made in unit 10
- Present the purpose of unit 11 and the learning objectives to the trainees.

Emphasize that the trainees will need ot know how to carry out the activities and measurements covered in this unit to be able to look after the HRF properly, thus focusing their attention on learning how to do the activities.

11.i. Manual Cleaning of the HRF. <u>1 hr</u>

<u>Group Discussion</u> : Guide the trainees to reason that although hydraulic cleaning removes the majority of the muddy sediments from the HRF, so that it can be operated again as normal, it does not remove all of them, and that the sediments which are left gradually accumulate over a very long time (1 - 2 years), and clog the filter.

- Explain that when this clogging happens, the HRF is hydraulically cleaned as usual, but afterwards the output turbidity and the filter resistance are not reduced to within the acceptable limits, and the filter still cannot be operated or connected to the SSF.
- Get the trainees to suggest what can be done to remedy this situation, and conclude that the gravel must be washed by hand.

<u>Group Discussion</u> : Encourage the trainees to suggest the conditions of the HRF which indicate that it requires manual cleaning. *Write these points on the blackboard.*

- Ask for suggestions on the method which should be employed to manually clean the gravel in the filter.
- Bring out the procedure for manual cleaning as the draining of the HRF, the excavation of the gravel from one section of the filter bed, its transportation to the washing site, its aggitation in the washing tank by means of a shovel, its transportation to a temporary storage site near the filter after washing, and its reinstallation as the filter section becomes empty enough to begin filling the cleaned area of it. Then repeat the same for the next gravel filter section.
- Stress the importance of washing all the gravel as soon as possible once the filter has been drained, or the muddy sediments will stick to the gravel as it dries, and will be very difficult to remove.
- Also emphasize the fact that the different sizes of gravel must be kept separate during the cleaning procedure, and some parts, especially around the gravel drain filter packs will need to be seived to separate the gravel sizes prior to reinstallation in the HRF.

<u>Practical Exercise</u> : Explain to the trainees that although the model HRF has just been cleaned by hydraulic draining and does not need to be manually cleaned, the

manual cleaning of the first (coarsest) section of filter gravel will show the trainees the amount of muddy sediments which are left behind after hydraulic cleaning, and allow them to understand the way in whcih the gravel should be removed, washed and reinstated.

- Allow the trainees to organize themselves to carry out the manual cleaning of the largest filter section gravel, guiding them on the exact methods involved as necessary *(see Note 1)*.

Active Participation : Once the first filter section has been cleaned and reinstalled, get a trainee to refill the HRF with water following the usual procedure for flow rate control as this is done.

- When full, adjust the flow rate to the 2nd weir water level, and get the trainees to sample and measure the output turbidity and filter resistance. Write the results on the blackboard, and stop the HRF flow.

Group Discussion : draw attention to the differences in the readings taken with the HRF clogged, after hydraulic cleaning and after manual cleaning, and emphasize the effects of the cleaning methods.

Note 1 : This will enable the trainees to learn the exact method for gravel excavation, transport, washing, storage and reinstallation. The small scoops and buckets are used to excavate and transport the gravel to the collecting vessel full of river water, which represents the washing site. The gravel should be washed in a bucket using water from the collecting vessel, and agitated with e small scoop. It can then be transported back to near the HRF, and temporarily stored in the second container, or on a plastic sheet laid on the ground, until it can be reinstated in the filter.

11.iii. Practical Aspects of Manual Cleaning. 15 mins.

Group Discussion : With reference to the practical exercise, get the trainees to reason that the manual cleaning of the full-scale HRF is an enormous task, and will require the involvement of the whole village.

- Discuss the importance of the effective organization of the villagers into teams of workers doing the different jobs involved.

- Review the tools which will be required for such work. *List them on the blackboard.*

- Get the trainees to consider the importance of employing sound hygiene practices during the manual cleaning of the HRF, such as the wearing of clean boots or shoes by anyone who gets into the HRF, andthe cleaning of wheelbarrows, buckets and shovels etc. prior to being used in the operation, so as to ensure that extra mud, dirt and germs are not put into the filter.

Write the main points on the blackboard for emphasis.

11.iv. Recording of Measurements in Plant Logbook. 10 mins.

Group Discussion : Review why measurements must be recorded in the logbook

- Get trainees to suggest what information needs to be recorded
- Explain how and when it must be recorded.
- Show the trainees an example of a plant logbook with manual cleaining details recorded.

11.v. Consolidation. 5 mins.

Group Discussion : Bring out the key points made in unit 11, and discuss their importance to the HRF caretakers.

Write all main points on the blackboard.

Unit 12 : Revision of SSF Operational Activities. **2.25 hrs.**

Unit 13 : Revision of HRF Operational Activities. **2.25 hrs.**

Learning Objectives.

- Revision of all activities for HRF operation, and their frequency.

Overview.

The purpose of this unit is to revise all the knowledge and skills which the trainees need to know as HRF caretakers, and to set them a relativley complex practical exercise to enable them to repeat the most important operational activities under the supervision of the instructor, so reinforcing the aspects they need to know for proper HRF operation.

Pre-Unit Preparation.

- Refill the reservior with turbid water of approx. 125 TU
- Assemble all other equipment.

Note : it will may be necessary to refill the reservoir with additional turbid water part way through the practical, in order to have sufficient to last the whole unit.

Materials Required.

- HRF model filled with gravel and water
- Reservoir full of turbid water
- Collecting vessel for water output from HRF
- Blackboard and chalk
- Clear glass / plastic sampling jar (x 4)
- DelAgua turbidity tube (x 2)

13.i. Group Discussion. 30 mins.

- Review of key points in HRF operation.

13.ii. Practical Exercise. 1.5 hrs.

- Group practical exercise set carried out by trainees under the supervision of the instructor.
- Write all recorded measurements on the blackboard.

13.iii. Consolidation. 15 mins.

- Discussion of key points and questions arising frmo the practical exercise.

Unit 14 : Maintenance of the Treatment Plant. **4 hrs.**

Course and Trainee Evaluation. **8 hrs.**

Note 1: Trainee Evaluation. 7 hrs.

The trainee caretakers should be tested to ensure that the level of their knowledge and skills in all aspects of the whole treatment plant operation and maintence are adequate. This should be undertaken individually, with each trainee undergoing approx. a 1.5 hour practical and verbal test, based on the learning objectives of each training unit. The total time allocated is greater than the max. of 5 hours specified for each days training, but each trainee will only participate for a short time.

Note 2 : Course Evaluation. 1hr.

This should take the form of a group discussion, once the trainee evaluation has been completed. The results of the trainee testing can be presented, and the trainees have the opportunity to tell the instructor what they thought of the training given, pointing out any particular strengths and weaknesses. These should then be taken into account by the instructor, ready for the next training course.

Appendix C.

Model Materials : Used and Alternatives.

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C. i. Materials Used.

Material	Specification
Sheet steel	16 guage (1.6mm thick)
Car exhaust pipe	50mm diam.
Steel pipe	10mm diam.
Sheet glass	4mm thick
Angle iron	20 x 20 x 2 mm
Hose / Jubilee clip	12 mm diam.
Tube clamp	-
PVC flexible tubing	12.5 mm diam.
Rubber bung	45 mm diam. (small end)
Rubber bung	9 mm diam. (small end)
Nut	6 mm diam.
Bolt	6 mm diam.
Welding iron	-
Mastic	-

C. ii. Alternative Materials.

The materials used above were used as they were the most convenient for constructing the model at Silsoe College. However, they are not the only materials possible, and alternatives can be used if they are unobtainable. Some examples are given below :

- Any of the specified sizes can be changed (within reasonable limits) if alternative material thicknesses, diameter pipes, bolts, nuts etc. are available.
- Bungs carved from wood can be used in place of the rubber bungs to seal the drains.
- A variable tube-clamp can be manufactured from pieces of metal.
- Wire or string can be used in place of a hose clip to attach and seal the flexible pipe to the model.
- Washers and flanges cut from neoprine bonded cork, sheet rubber, car tyres etc. and used under bolted-on cross pieces of sheet metal can be used to seal the joints if welding equipment is unavailable.
- Any other type of sealant can be used instead of mastic.

Appendix D.

Summary of Test
'Trainee' Questionnaire Responses.

HRF Model / Training Questionnaire.

The purposes of this questionnaire is to get an impression of your feelings about both the model and the training course, having used / experienced both from a trainees point of view. Circle the most appropriate number, tick the box, or add comments as applicable. Please complete it in black ink. Thanks.

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1. The Model.

1.i. How easy is the model to use in terms of access to its various parts for activities?

	Very Awkard ... Very Accessible	Range
- Use of inlet control 'valve'.	1 2 3 4 5 6 7 8 (9) 10	7-10
- Sight and use of inlet weir levels.	1 2 3 4 5 6 (7) 8 9 10	5-10
- Sample taking at inlet.	1 2 3 4 5 6 7 (8 9) 10	4-10
- Sample taking at outlet.	1 2 3 4 5 6 7 8 (9 10)	7-10
- Opening of hydraulic drains.	1 2 3 4 5 (6) 7 8 9 10	4-9
- Filling the filter section with gravel.	1 2 3 4 5 6 7 (8 9) 10	5.5-10
- Other (please specify):	1 2 3 4 5 6 7 8 9 10	

Any other comments about access:

1.ii. How well did the model demonstrate the actions of the parts of the HRF ?

	Not Visible ... Immediately Obvious	Range
- Inlet control 'valve' action.	1 2 3 4 5 6 (7) 8 9 10	4-10
- Variation of inlet weir water level as inlet control is altered.	1 2 3 4 5 6 7 (8 9) 10	7-10
- Variation in water levels through filter as inlet control is altered.	1 2 3 4 5 6 (7) 8 9 10	5-9
- Variation of outlet water levels as inlet control is altered.	1 2 3 4 5 6 (7) 8 9 10	4-9
- Direction of water flow through HRF.	1 2 3 4 5 6 7 8 (9 10)	7-10
- Cleaning action of gravel of turbid water (difference between water input and output).	1 2 3 4 5 6 7 8 (9) 10	8-10
* - Clogging of the HRF.	1 2 3 (4) 5 6 7 8 9 10	1-6
- *Action* of the drains in hydraulic cleaning (rapid draining of HRF).	1 2 3 4 5 6 7 (8) 9 10	3-10
- *Effect* of hydraulic cleaning on HRF gravel (sediments washed out of HRF).	1 2 3 4 5 6 (7) 8 9 10	3-10
- Other (please specify):	1 2 3 4 5 6 7 8 9 10	

Any other comments about the models quality of demonstration / visual impression of HRF actions:

- THE DIFFERENCE BETWEEN NO FLOW + FLOW LEVELS FOR FILTER RESISTANCE CALCULATION IS QUITE SMALL. ③
- ADD NUMBERS TO THE WATER LEVEL GUAGES ③
- THE CONCEPT OF SCALE MAY BE DIFFICULT TO GRASP. ①
- REAL VALVES SHOULD BE USED, IT WOULD BE WORTH THE EXTRA COST. ①
- SOME DEMONSTRATIONS SHOULD BE MADE QUICKER IF POSSIBLE, SUCH AS DRAINING THE FILTER. ①

1.iii. What do you think about the model dimensions, in terms of its practical use in training ?

Dimension.	Too small	About Right	Too Large
- Model length		7	
- Model width		6	1
- Model height		7	
- Volume of gravel used		5	2
- Volume of water used		5	2
- Variation in weir water levels	1	6	

If you feel that any dimension needs to be altered, why? and by how much ?

- THERE ARE LONG LAG TIMES INVOLVED, DUE TO THE VOLUME OF THE FILTER. POSSIBLE SOLUTIONS INCLUDE: ②
  - USE LARGER GRAVEL (SO FLOW IS FASTER)
  - USE LESS GRAVEL
  - REDUCE FILTER WIDTH.

Any other comments on the model dimensions:

- OUTLET NOZZLE TO S.S.F. COULD BE LARGER, TO STOP BACKING UP OF WATER OVER THE OUTLET WEIR DUE TO AIR LOCKS. ①
- THE MODEL MAY WEIGH TOO MUCH, BUT ITS HARD TO GUAGE. ①

1.iv. Do you think that the use of certain alternative parts on the model, which differ from those found on a full-scale HRF, affects the interpretation of their role on the HRF ?

	Feature.	No	Yes	Don't Know
	- Inlet control 'valve'	5	2	
*	- Perspex front (GLASS)	3	4	
	- Bung drain 'valves'	5	2	
	- Smaller gravel sizes used	5	2	
	- Presence of reservoir	5	2	
	- Outflow pipe not connected to SSF	7		
	- Drainage channel leading 'nowhere'	5	2	
	- Other (Please specify):			

Does the inspection of the actual parts used (valves, gravel sizes etc.) help in interpretation of the what the full-scale HRF is like?

- YES FOR GRAVEL SIZE COMPARISON ②
- YES ③
- A BIT ①
- NOT REALLY ①

Any other comments on alternative parts used :

- IT WOULD BE USEFUL TO GIVE INFORMATION ON ACTUAL SIZES, FLOW RATES ETC. - MORE DETAIL ①

1.v. Overall, how well do you think the model meets the design criteria given below?

	Not at All									Very Well	Range
- The model must be representative in appearance of a full-scale HRF plant.	1	2	3	4	5	6	(7	8)	9	10	5-9
- It must be able to clearly demonstrate the principles of operation of a HRF.	1	2	3	4	5	6	7	8	(9)	10	6-10
- It must be useable (so that salient points of operation can be demonstrated and practiced).	1	2	3	4	5	6	7	8	(9)	10	7-10
- It must be of simple design and construction	1	2	3	4	5	6	7	(8)	9	10	5-10

1.vi. What changes, if any, do you feel the model needs, in order to meet the above design criteria ?

- THE SCALE OF THE MODEL WITH RESPECT TO THE FULL SIZE HRF IS DIFFICULT TO VISUALIZE. POSSIBLY HELPFUL IF: (4)
  - USE SCALE DRAWINGS RELATING MODEL SIZE TO ACTUAL SIZE
  - USE A PHOTO TO GET AN IDEA OF REAL SCALE
  - TAKE CARETAKERS TO SEE AN OPERATING HRF
  - USE PICTURES/PHOTOS OF CORRESPONDING PARTS OF HRF + MODEL.
- USE NON-CORRODIBLE DRAINS (1)
- THE MODEL IS NOT SO REPRESENTATIVE OF APPEARANCE, OR EASY TO CONSTRUCT DUE TO THE GLASS FRONT. COULD BE MISLEADING IF PEOPLE DO NOT UNDERSTAND THAT THE HRF PLANT WILL BE SELF-CONTAINED. HOWEVER, THE GLASS IS NECESSARY TO DEMONSTRATE THE PRINCIPLES OF OPERATION (1)
- NEED TO CONCENTRATE ON FUNDAMENTAL PRINCIPLES, NOT MINOR DESIGN ALTERATIONS, EG BUNGS/TUBE CLAMPS ARE NOT FUNDAMENTAL PRINCIPLES AND THEREFORE SERVE THEIR PURPOSE WELL. BUT THE EXTRA HEAD LOSS DUE TO CLOGGING IS FUNDAMENTAL AND THEREFORE NEEDS TO BE DEMONSTRATED MORE OBVIOUSLY. (1)
- THE NEED FOR AVAILABILITY OF MATERIALS + CONSTRUCTION SKILLS IS IMPORTANT TO CONSIDER. POSSIBLY MAY BE DIFFICULT TO CONSTRUCT IN RURAL AREAS. (2)
- HOW EASY WOULD IT BE TO REPLACE THE GLASS IF IT BROKE? (1)
- THE CHANGES IN FLOW LEVELS + FILTER RESISTANCE SHOULD BE MADE CLEARER (3)

1.vii. Any other comments on the model design ?

- TRY TO CUT OUT FILLING/DRAINING WAITING TIMES ①
- AN INJECTION SYSTEM SHOULD BE USED SO ALL THE WATER DOES NOT NEED TO BE CHANGED TO REMOVE THE DYE. ①
- USE REAL VALVES ①
- IT MAY BE TOO HEAVY TO USE IN SOME CIRCUMSTANCES, IE. DIFFICULT TRANSPORT AREAS ①
- THE DESIGN COULD INCORPORATE A 'PORTCULLIS' SECTION WITHIN WHICH A METAL SHEET COULD BE LOWERED. THIS WOULD EQUATE TO INCREASED FILTER RESISTANCE + SHOW HOW THE LEVELS CHANGE.

2. The Training Course.

2.i. Did the units covered follow a progressive and logical path through the training ?

6 (Yes): Easy to follow : one unit lead to the next logically.

1 (O.K): The order of units made sense once all the topics had been covered.

- No : The order of units made no sense at all.

Any other comments on the order of units :

- A UNIT ON THE CONCEPT OF FILTRATION 1ST MIGHT BE USEFUL. (1)
- A FACILITY SHOULD BE MADE TO ANSWER PROMPTIVE QUESTIONS WHEN THEY ARE POSED - REPEATING SUCH POINTS LATER ONLY SERVES TO RE-EMPHASIZE + REINFORCE SUCH ANSWERS. (1)

2.ii. What did you think of the presentation of the units in terms of the following ?

		1. Introduction & HRF components and action.	2. HRF operation activities.	3. Filter clogging and cleaning.	4. Revision & frequency of operations.
Duration	Too short				
	About right	7	6	6	7
	Too long		1	1	
Pace	Too slow			1 *	
	About right	7	5	6	7
	Too fast		2		
Amount of information covered	Too little		2		
	About right	7	5	7	7
	Too much				

* DUE TO SLOWNESS OF PROCESS

Any other comments about subject presentation within the units :

- OVERALL GOOD (1)
- BE PREPARED TO GIVE SLIGHTLY MORE TECHNICAL EXPLANATIONS (1)
- USE OF ANALOGIES (VILLAGE, MARKET ETC) IS TO BE GREATLY ENCOURAGED (1)

- A WRITTEN BOOKLET ON THE OPERATIONS INVOLVED HANDED OUT AT THE TRAINING, TO BE KEPT BY THE CARETAKERS FOR REFERANCE WOULD BE USEFULL. ①

- ALLOW SUFFICIENT TIME FOR QUESTIONS/ANSWERS WITHIN EACH MODULE. ①

2.iii. How useful were the training methods / techniques used in terms of the trainees gaining a clear understanding of the HRF ?

	No Use At All ... Very Beneficial	Range
- Group discussions	1 2 3 4 5 6 7 8 (9) 10	7 - 10
- Case studies	1 2 3 4 5 6 (7) 8 9 10	6 - 9
- Use of the model as a demonstration aid by instructor (trainees watching).	1 2 3 4 5 6 7 (8) 9 10	7 - 10
- Use of the model as a working practical tool in trainee exercises.	1 2 3 4 5 6 7 8 (9 10)	8 - 10
- Practical exercises / activities (general).	1 2 3 4 5 6 7 8 (9 10)	8 - 10
- Other (Please specify):		

Any other comments about training techniques / activiities used :

- ANALOGIES WITH VILLAGE / MARKET ARE VERY BENEFICIAL BUT PEOPLE MIGHT NOT GO WITH THE CONCEPT OF AN ANALOGY. ②

- THE TRAINER SHOULD ADOPT THE ROLE OF A FACILITATOR AS WELL AS A TEACHER ①

2.iv. What did you think about the breaks between units ?

Parameter.	Characteristic	Tick
Frequency	Not often enough	
	About right	7
	Too often	
Duration	Too short	
	About Right	6
	Too long	1
Timing with respect to breaks in subjects covered.	Good timing	7
	Poor timing	

Any other comments about the breaks :

- BREAKS ARE ALWAYS IMPORTANT AS THEY ALLOW INFORMAL DISCUSSION OF THE SUBJECT BETWEEN PARTICIPANTS. THIS FREQUENTLY GIVES OPPORTUNITY FOR AREAS OF UNCERTAINTY TO BE EXPLORED AND CLARIFIED, AND QUERIES RAISED. ①

2.v. Are the course contents / subjects covered useful / relevant to the training of HRF caretakers ?

	Irrelevant ... Essential	Range
Unit 1:		
- The need for HRF with turbid water (pre- SSF).	1 2 3 4 5 6 7 8 (9 10)	8 - 10
- HRF components	1 2 3 4 5 6 7 8 (9) 10	7 - 10
- HRF water flow	1 2 3 4 5 6 7 8 (9) 10	8 - 10
- HRF removal of turbidity (mud) from water	1 2 3 4 5 6 7 8 (9 10)	8 - 10
Unit 2:		
- Water quality sampling and measurements	1 2 3 4 5 6 7 8 9 (10)	9 - 10
- Filter flow control at inlet	1 2 3 4 5 6 7 8 9 (10)	9 - 10
- Filter resistance measurement	1 2 3 4 5 6 7 8 (9 10)	7 - 10
- Recording of measurements in logbook	1 2 3 4 5 6 7 8 (9 10)	7 - 10
Unit 3:		
- HRF clogging and increased resistance when dirty.	1 2 3 4 5 6 7 8 9 (10)	10
- Hydraulic cleaning of filter	1 2 3 4 5 6 7 8 9 (10)	10
- Restart and filling of filter	1 2 3 4 5 6 7 8 (9) 10	7 - 10
Unit 4:		
- Revision of activities / operations	1 2 3 4 5 6 7 8 (9 10)	8 - 10
- Frequency of activities / operations	1 2 3 4 5 6 7 8 (9) 10	6 - 10

Any other comments about the relevance of subjects covered / not covered :

- THE ACTUAL USE, MEASUREMENT + RECORDING IS CRUCIAL TO THE UNDERSTANDING OF THE HRF AND HOW IT MAY BE USED EFFECTIVELY. WITHOUT IT THE S.S.F. WILL GET CLOGGED BECAUSE PEOPLE WON'T BOTHER WITH THE HRF. (1)
- CONSTRUCTION (1)
- MAINTENANCE OF THE CONSTRUCTED FILTER, AND GENERAL CLEANLINESS OF THE SITE (1)

2.vi. Overall, how well do you think the training course meets the design criteria given below ?

	Not At All ... Very Well.	Range
- The training course must create an awareness of the general problems of water quality and water treatment.	1 2 3 4 5 6 7 (8) 9 10	4 - 10
- It must impart sufficient specific information and practical skills for the trainees to be able to competently:		

- operate and maintain a HRF plant	1 2 3 4 5 6 7 8 (9) 10	8 - 10
- carry out basic water quality testing	1 2 3 4 5 6 7 (8) 9 10	7 - 10
- keep the HRF records up to date	1 2 3 4 5 6 (7 8) 9 10	6 - 9
- It must motivate the trainees to perform thier duties effectively.	1 2 3 4 5 6 (7 8) 9 10	5 - 10
- It must be pitched at a level and pace comnsurate with the level of education and ability of potential trainees	1 2 3 4 5 6 7 (8) 9 10	4 - 10
- It must use a variety and type of training methods appropriate for use with rural adults.	1 2 3 4 5 6 7 8 (9) 10	8 - 10

2.vii. What changes, if any, do you feel the training course needs, in order to meet the above design criteria ?

- WEAKNESSES ARE DUE TO NOT HAVING THE FULL TIME TO TRAIN THE 'TRAINEES' WITH, THEREFORE MORE TIME IS NEEDED TO BE ABLE TO MEET THEM. (1)
- ENSURE THE MODEL OPERATES AS WELL AS IT CAN - WATER LEVELS, DYE FOR FLOW PATH, CLEAN GRAVEL ETC., SO POINTS COME ACROSS WELL. (1)
- THE ILLUSTRATION OF A CLOGGED HRF MIGHT MAKE THE TRAINEES REALIZE THE IMPORTANCE OF CLEANING IT A BIT MORE. THE WATER APPEARED DIRTY ON DRAINING, BUT IT WAS OF NO REAL CONSEQUENCE TO THE FILTER (1)
- IMPRESS THE NEED FOR RECORD-KEEPING MORE (1)

2.viii. Any other comments on the training course content / application ?

- IT MIGHT BE WORTH CONSIDERING EVALUATION WHEN THE CARETAKERS ARE STARTING ACTUAL WORK, BY MEANS OF A REFRESHER COURSE.

Appendix E.

Initial Model Performance
Test Results.

Appendix E : Model Testing Results.

E.i. Turbidity Removal Efficiency.

The results of the turbidity removal tests are given in Table E.1, and can be compared with the values in Table E.2 for full size HRF plants. It can be seen that the removal efficiency compares favourably with those in operation around the world, although not all of the effluent turbidities resulting are suitable for input into a slow sand filter.

Table E.1. Turbidity Removal Efficiency of the HRF Model.

Mean v_f (m/hr)	Influent Turbidity (TU)	Range Effluent Turbidity (TU)	Mean % Turbidity Removal
0.35	50	<5	90%
	125	6 - 7.5	95%
	300	30 - 40	88%
1.0	50	6	88%
	125	12 - 15	90%
	300	60 - 65*	79%
2.0**	50	7 - 8	85%
	125	25 - 30	79%
	300	75*	75%
3.0**	50	15	70%
	125	30 - 35*	75%
	300	75 - 100*	72%

* : These effluent qualities not suitable for input into a slow sand filter.

** : These values are greater than the recommended v_f values.

Table E.2. Full Scale HRF Plant Performances.

HRF Plant	Raw Water Turbidity (NTU)	Effluent Turbidity (NTU)	Mean % Turbidity Removal	Researcher
Chen Zhuang, CHINA	15 - 180	< 10	80%	Xiangkuan et al. (1992).
Guider, ETHIOPIA	30 - 1000	<10 - 30	67% - 97%	Wegelin and Schertenleib (1993)
Blue Nile Health Project, SUDAN	90 - 1500	20 - 300	78% - 80%	World Bank (1991). Wegelin et al. (1991)
Mlangali, TANZANIA	43 - 780	85	55%	J.A.D. Ntupwa (1990).
Tagamenda, TANZANIA	25 - 78	26.9	40.7%	T.S.A. Mbwette (1992)

E.ii. Other Performance Characteristics.

Table E.3. HRF Model Variable Values.

Variable	Value on Model
Filter resistance at $v_f = 0.35$ m/hr	0.1cm
Filter resistance at $v_f = 3.0$ m/hr	0.9cm
Total headloss across filter	5.5cm (mean)
Drainage velocity (v_d)	m/hr (mean)

All of these variables are acceptable for the size of the model, when compared with the design criteria recommended in the literature.