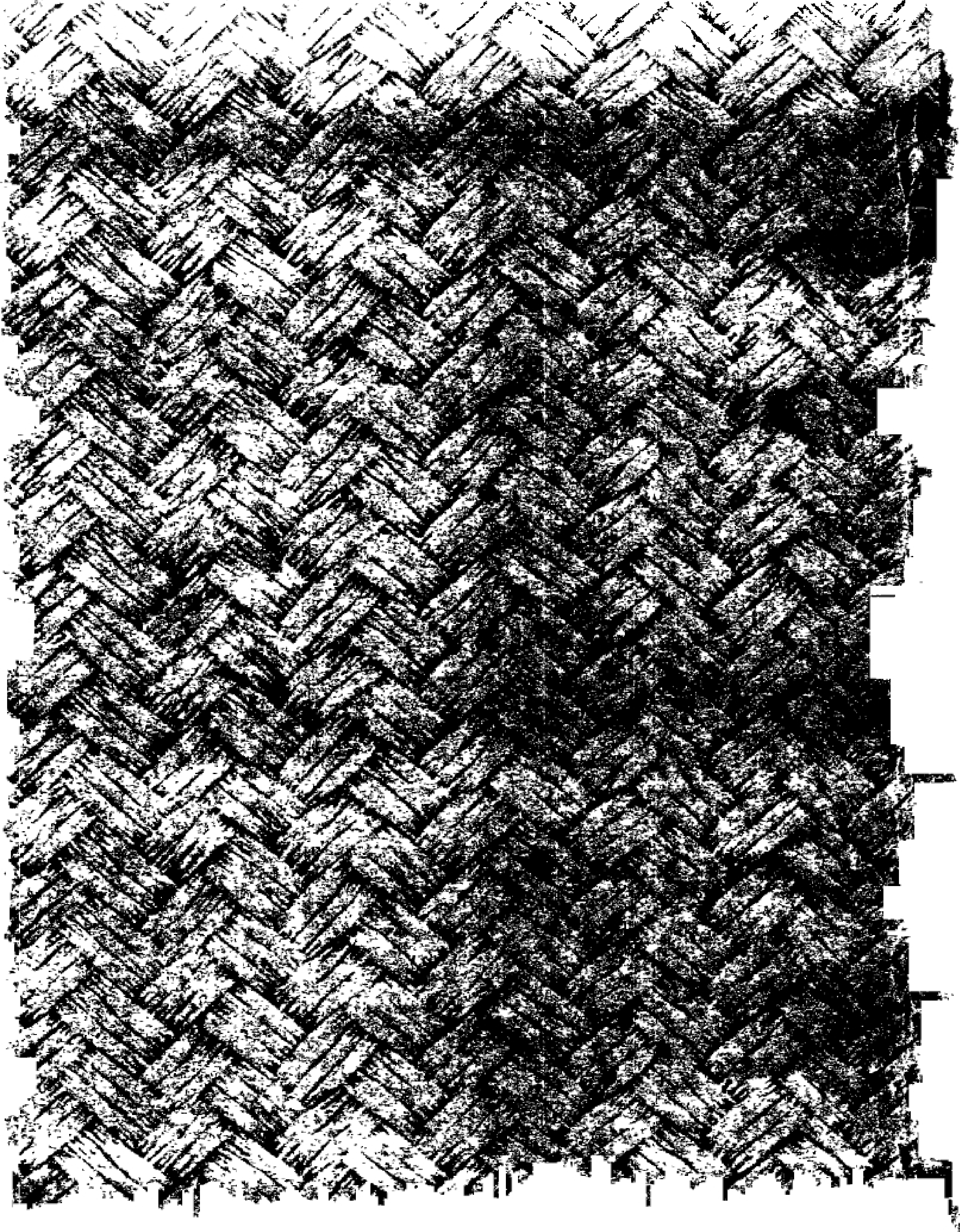

A Special Study

on

Problems and Remedial Measures of Slow Sand Filters - Operation and Maintenance in Thailand.

by

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I INTRODUCTION

A. General Introduction

Every living thing requires water. For human being, if water is used without treatment, it acts likewise a vehicle to transport disease into human body resulting in poor health and sometimes death.

In 1977-1978 WHO estimates that about 500 million people around the world are affected by water-borne diseases and morethan 10 million people die every year.

Recently, there is advanced technology for water supply treatment which can provide hygenic water for rural people in developing countries. Providing water supply for rural area is aroused because most of the country people are poor and illiterated resulting in ignorant care of sanitation. Those uneducated people silently suffer from water-borne diseases. May their silence be heard by all of us. It is our duty to think and find the way to help them.

In developing countries, low cost water supply treatment is needed. It requires:

1. Simple design and construction
2. Minimum maintenance
3. Easy Operation
4. Insured good quality and hygienic standard
5. Usage of local materials

From technical option, an excellent treatment method which can be used to advantage in quite a number of rural situation is slow sand filter. This filtration technique is an effective, low cost purification process that produces attractive and safe water for drinking. Its operation and maintenance is cheap and simple in comparison to other treatment system, then the slow sand filtration has an important role in water supply in rural areas as well as in small communities.

B. PWA and Rural Water Supply

The Provincial water Works Authority (PWA) was established in February, 1979 as a state enterprise to be in charge of supplying clean water to all municipalities, towns and rural communities across the country, except in Bangkok Metropolitan area. It was formed by the integration of the Provincial Water Supply Division of the Department of Public Works and the Rural Water Supply Division of the Department of Health. Its prime duty is to look for and develop appropriate sources of water, to set up treatment processes and to distribute the water to consumers as extensively and rapidly as possible. This task includes expanding existing waterworks, as the communities grow, as well as installing new ones.

At present, PWA owns and operates 175 town waterworks, serving a total population of 2.00 million. Even though the Rural Water Supply Division has been integrated within PWA. Their 660 rural waterworks are still operated and revenues collected by the local authorities. These waterworks serve approximately 2.15 million people.

Present Provincial Water Supply Program

Primarily, PWA provides piped water supplies in provincial municipalities sanitary districts and towns with population above 2,000. Its activities range from surveying, planning, designing, constructing, operating as well as maintaining water supply systems.

As mentioned earlier, services of PWA are divided into town and rural water supply programs. The former program is mow covering 88 municipalities and 137 large sanitary districts. Capacities of the treatment plants vary from 20 m^3/h. to 2,000 m^3/h. The total amount of water treated stands at around 758,160 m^3/per day. The rural water supply program covers 336 smaller sanitary districts and 324 villages, having a total production of 250,960 m^3 per day. While waiting for the local authorities to hand over these small waterworks, PWA also provides them with technical assistance as needed.

There are still 52 water supplies concessed by local municipalities and now are under control of the Department of Public Works. Total capacity amounts to approximately 208,000 m^3 per day and are serving a total population of about 500,000. Under the provincial Water Works Authority Act of 1979, these Waterworks will, too, be gradually transfered to PWA.

The rural water supply systems were using both surface and ground water. All systems included chlorination of water prior to distribution although a few of the communities have continued this practice. In general the systems are built to U.S. design eriterias established by th e American Water Works Association with minor modifications as necessary to fit local conditions.

Organisation chart of Thailand PWA is shown in appendices.

Installation of Rural Water Supply

The installation of a village pipe water system was planned to proceed as follow:

The initative for obtaining a pipe water system must start with the villagers themselves, often stimulated by the local public health sanitarian, or the community development officer. Sometimes, mainly in the case of security sensitive villages, the initative will start with the District Officer or perhaps even with the governor of the province. Specific requests for pipe water systems generated in this manner are submitted to the governor's office through the District Officer or Provincial Health Officer. The governor's office makes the final selection of villages and establishes priorities and sends the request with local contribution to PWA. Villages selected were to:

a. have an existing source of water;

b. be readily accessible by road;

c. have a high interest in obtaining a pipe water system as indicated by a willingness to assist in construction; and

d. be willing to develop a rate structure which will pay the operation

and maintenance costs, as well as provide for future expansion. One significant factor in the selection is the amount of local contribution or self-help the village can provide toward construction costs. The selection finally are reviewed by PWA, for engineering practicability.

- Once the village is selected, a reconnaissance report is made by the PWA field engineer, in regional office, including information such as source of water, population to be served, village contribution and power availability.

- A site survey is made by PWA regional office engineers.

- Based on the reconnaissance survey and site survey, standard plans and specifications developed by PWA regional office are assembled and sent to the PWA Head Office advertising for bids.

- Following receipt of bids and award of a construction contract to the lowest responsible bidder, the plant is constructed under supervision of a PWA construction technician. If part of the system, usually the laying of distribution main, is installed by the villagers, the PWA construction technician also supervises their work.

- When construction of a water treatment plant is completed, the plant and water system is turned over to the local government of the operation and maintenance. The local government, in turn, can and usually does delegate authority to the District Officer or village chief or, where applicable, to Sanitary District to operate and maintain the system.

- Meanwhile, training is provided for a water treatment plant operator who will be responsible for the proper operation of the system. One villager, selected by other villagers, is given two weeks training by PWA prior to completion of construction. Later he is given on-site training of sufficient duration to provide reasonable assurance of his competence to operate the plant correctly.

- Following completion and formal transfer of the system to the local government authorities, PWA engineers or technician visit the plant to give the operator follow-up instruction and to insure that the plant is operating properly.

- Further follow-up advice and inspection is given by PWA technicians as necessary and to the extent possible.

C. Statement of The Problems

It is the responsibility of village committee to manage the water supply system after a plant is established and given to the local.

The main problems of the operation and maintenance are listed below.

The Operation Problems.

1. Raw water rate control (which depends on the raw water characteristic)

2. Filtration rate control

   - constant rate filtration

   - declining rate filtration

3. Inefficiency of filter

4. Disinfection system

D. Objectives and Scope of the study

Objective of study.

1. To identify the operation and maintenance problems which are encountered in slow sand filtration in Thailand.

2. To propose some solution to overcome those problems.

3. To propose some training program.

Scope of study.

To achieve the mentioned objectives the following scope of work is planned.

1. Focus on the plants that receiving different raw water sources.

Plant's name	district	Province	raw water source
Thadindum	Chaibadan	Lopburi	Stream
Banglao	Muang	Singburi	Irrigation Cannal
Nongko	Kranuan	Khonkaen	Reservoir
Ubolrat	Ubolrat	Khonkaen	Dam
Kokphra	Kantrawichai	Mahasarakram	Swamp
Phanok-Kao	Phukradueng	Loei	Spring
Puan-pu	Phukradueng	Loei	Spring
Sritart	Sritart	Udornthani	Reservoir

2. The evaluation is mostly done by means of questionaires, field study at selected plants and interview operator and village committee.

II LITERATURE REVIEW

Problems of Operation and Maintenance in General

In-developing countries, slow sand filter is favourable as a water treatment process because it is simple, and cheap in operation and maintenance. To construct an effective water treatment work which can produce and deliver high quality water, is relatively simple in the case of Slow Sand Filter.

Organizing and managing to maintain this facility at the standard quantity and quality without interruption is by no means so straight forward. When problems is compounded by multiplication and dispersion of projects over a wide area and shortage of operation funds that precludes the engagement of adequate qualified staff, it becomes more necessary to pay attention at the initial stage for maintenance and operation.

Rural Water Supply usually is operated by the operator who has no experience, no knowledge about the Water Supply System. As a results, the quantity and quality of production does not meet the require standard and plant units like motors, engines, pump and filtration process do not function properly. The plant frequently breakdown which make it unreliable to the community. Within the field of maintenance, there are two types of maintenances, the two types are preventive maintenance is that which is conducted to prevent or to minimize breakdowns; corrective maintenance is that which is done after a breakdown occured. No preventive maintenance can hope to prevent all breakdowns; Some preventive maintenance may be costly than corrective maintenance; but it will also involve more and lengthier interuptions of service. The operator should have at least some knowledge of preventive maintenance of water supply system so as to keep the system continuos running. The system will run efficiently if the operator have a good knowledge about the operation and maintenance.

How to get an operator with good knowledge? The employment condition in the rural water supply is not very good. The salary is low and there is no career prospect. Therefore, the people who are working in the rural water supply, very often quit the job if they get a better one outside. So, we should think about some incentive for the rural water supply. How to improve the employment condition.

The administrator should bear in mind that good qualified operator will produce an attractive and Safe water to drink and will not be not harmful to the public health. Also the system will be reliable to the community.

Basic Elements of a Slow Sand Filter

From fig 2 shows, in diagramatic form of a slow sand filter consists of a box containing.

a) The supernatant (raw) water reservoir stand to a depth of 1-1.5 m. to provide a pressure or head of water, to drive the water through the fine spaces in the sand and to overcome resistance in other parts of the system and to provide a storage period to form "Schmutzdecks" or filter skin.

b) Scum Outlet

For the removal of scum which may float on the supernatant water this outlet always serves as an overflow for the raw water which drain the surplus water back to the raw water sources.

c) Filter-bed

The filter sand normally has as effective size of 0.15-0.35 mm. and uniformity coefficient of 2-3 is selected.

Huisman (1978). suggested that such sand can be obtained by mixing many types of sand, then screening out the too fine and too coarse fraction.

For a proper functioning of a purification process, the thickness of the filter-bed will be scraped out regulary during every cleaning of filter-bed. A new filter is to be provided with initial filter bed thickness of about one meter (range 1.0-1.2 m.) so that the bed will not have to be refilled more than once every few years.

The following criteria are suggested by HUISMAN, THANH, and WHO with many other references supported:

Description	RANGE	OPTIMUM
Filtration rate (m/h)	0.1-0.4	0.1
Area of filter bed (sq.-meter)	10-100	
Height of supernatant water (m)	1.0-1.5	0.1
Depth of underdrain (m)	0.3-0.5	0.4
Effective size of media (mm)	0.15-0.3	
Uniformity coefficient of media	2.0-5.0	
Height of sand media (m)	0.6-1.2	1.0
Height of free board (m)	0.2-0.3	

Specification of filter support

Media	Size (mm)	Depth (m)
Coarse Sand	1.0-1.4	1.00
Graval	4.0-5.6	1.00
Gravel	16.0-23.0	1.0-2.0

d) Underdrainage system

The importance role of the underdrainage system is to provide unobstructed passage way for the treated water to leave the underside of the filter and to support the filter medium. The drainage system should be carfully designed bacause it usually can not be inspected, cleaned or repaired without completed removal of the filter bed material. There are a lot of underdrain system such as

- Unjoined bricks
- perforate pipes
- porous concrete covering drains
- etc.

e) A set of filter regulation and control devices to regulate the velocity of flow through the bed, to prevent the raw water level in reservoir from dropping below a predetermined minimum during operation, and to permit water level to be adjusted and back filling to take place when the filter is pushed back into the operation after cleaning.

Advantages of Slow Sand Filter

1. Quality of filtrated water

It is the only single process that can improve the physical, chemical and bacteriological quality of water. It can remove turbidity up to 200 JTU. when coupled with a pretreatment. The delivered water does not promote aftergrowth in the distribution system. It can remove 99.9% of coliform bacteria without chorination.

2. Construction

Usually the price of the land in rural area is low and local materials are available. Pipework and pumps are the only items required and as utilization of local workmen and skilled supervisors are not required which make the design simple and thus lower down the capital cost in comparison to the rapid sand filters.

3. Operation

The major cost of operation is for the cleaning of the surface layers which can be carried out manually by rural labours. The slow sand filter compared with rapid sand filter is less frequent of cleaning due to their low rate compressed air or high pressure water is no needed.

4. Sludge Disposal

The problem of sludge storage, dewatering and disposal are relatively less than the rapid sand filter since the latter uses chemical coagulants. Most of the organic and inorganic colloids in slow sand filter are metabolised by micro-organism, thus reducing the amount of sludge. The sludge can be handled when dried causing less problem of disposal.

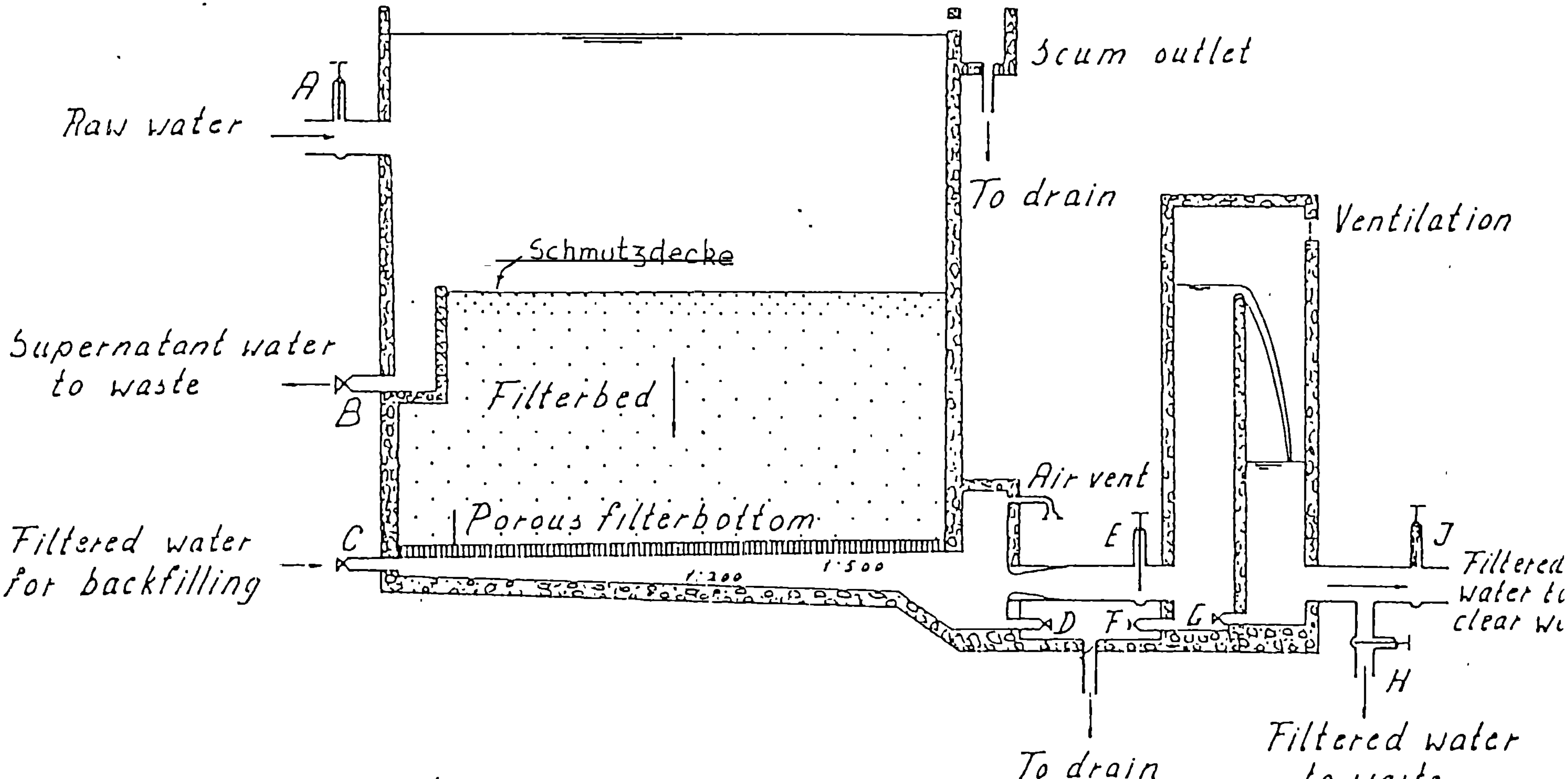


FIG. 1 DIAGRAMMATIC SECTION OF A SLOW FILTER

III OPERATION AND MAINTENANCE PROBLEMS IN SSF

From questionair and operator interview it can conclude that there are two types of problems. The first one is technical problem and the second one is management problems.

The Technical problems is an objective that would be discussed and emphasised here. The following main problems could be faced during the O & M of SSF:

- The unqualified operators
- The operators may have no knowledge about the formation of Schmutzdecke
- No control flow rate
- Incorrect sand scraping
- No sand Washing
- Inappropiate way of Re-sanding

The Unqualified Operators

In general SSF in Thailand is rural water supply which are in remote area. Almost most of the operators are low educated. Their routine works are only to start motor or engine in the morning to pump raw water into the filter box by fully open inlet and outlet valves and turn off them when the clear well or elevated tank is nearly full and the same function also in the evening.

The Operators may have no Knowledge about the formation of Schmutzdecke

When the filter sand is clogged, the operator stop the raw water pump and let the filter run until the sand surface become dry. The operator use shovel to scrap the sand surface and start to run the filter after finish surface scraping. As a result there is no ripenind period of micro-organism to perform Schmutzdecke or filter skin which is the most important activity to remove impurities from raw water.

No control flow rate

The operator always fully open inlet and outlet valves of filter box caused the overflow of raw water and the filtration rate is more than the design max rate which decreases filter efficiency.

Incorrect Sand Scraping

Because of poor knowledge, when the supply is not enough, the operator try to make a hole on the sand filter surface which make the pathogens passes into clear water tank.

No Sand Washing

Almost sand washing machines are not used because the surface scraping is disposed by the operators although in that area where sand is expensive or difficult to obtain.

Inappropriate Way of Re-Sanding

After several years of operations and more than thirty scrapings the depth of sand filter is dropped nearly supporting gravel. Then operator report to the Village committee on the one who is responsible for the plant. The filter sand is not classified (natural sand) and usually filled at the top instead of the below of the remaining sand.

A foresaid problems is the usual cause of plant failure which results in unpopularity of slow sand filtration in Thailand which is in fact due to the wrong operation and maintenance techniques.

IV REMEDIAL MEASURES

The following process should be practice to solve the technical problems:

The Problem of Unqualified Operator:

As most of the Rural Water Supply Plants do not work properly and the collected data indicates that the failure of a plant is mostly caused by the inability of caretakers, So caretakers or operators should be acknowledged or trained to increase their ability in operation and maintenance, It is suggested that the training program should be offered by PWA for it has skilled mechanics and training staff. For this training program, it is expected that the trained caretakers would be able to produce adequate qualified water for the community.

The Problem of the "Schmutzdecke" or "Filter Skin"

Slow sand filters are usually built in the open. Photosynthetic algal growth may occur. This has some disadvantages but it also promotes the filter efficiency and helps achieve a greater removal of organic matter and bacteria. This is brought about by the thin slimy (Schmutzdecke) matting on top of the filter bed, consisting of threadlike algae and numerous other forms of aquatic life such as plankton, diatoma, protozoa, and rotifers. The filter matting is intensely active with the various organisms entrapping, digesting and breaking down organic matter from water passing through. Dead algae from the supernatant water and living bacteria from the raw water are similarly consumed in the filter matting; inert suspended matter is strained out.

The Problem of Filter rate control (Fig. 2)

In order to obtain good filter per formance, basic operation must be followed.

1. deliver pretreated water into the supernatant water reservoir. Volve A controls the flow rate of influent to the filter, and the constant level of the supernatant water is maintained by overflow pipe. (The influent should not destroy the filter Skin)

2. Flow rate control

The rate of filtration should be controlled of the rate 0.15 m^3/m^2-h by adjusting the effluent outlet volve.

The rate of flow in the filters is measured at the weir outlet by means of manometers and stop watch. (Fig.)

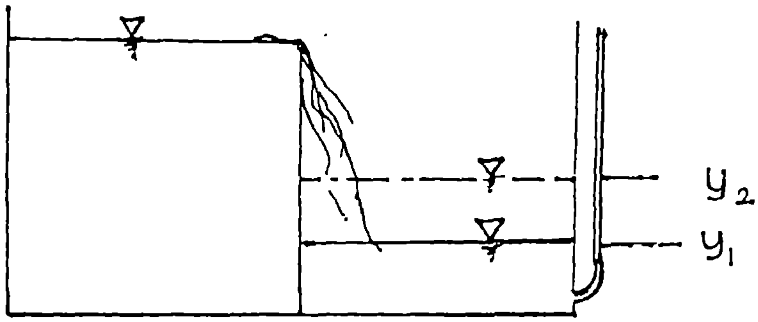
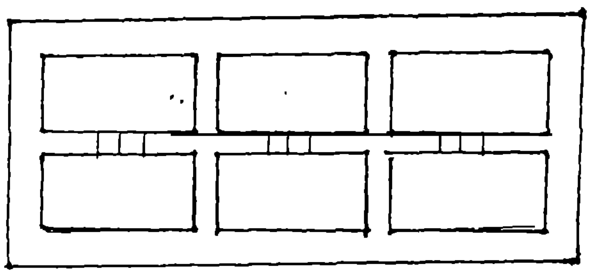
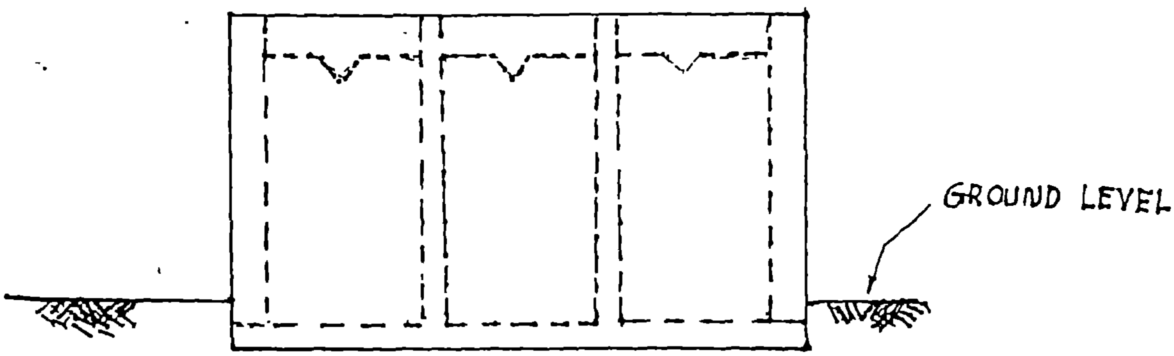


Fig. 2.



Weir Chambers



Suppose

Surface area of filter	=	$X\ m^2$
Infiltration rate	=	$0.15\ m^3/m^2\text{-}h$
Flow	=	$0.15\ X\ m^3/h$
Cross sectional area of Weir Chamber	=	$Y\ m^2$

Let Z be the increasing Water level (in cm) in the manometer in one minute, then

$$Y\ m^2 \times Z\ cm/min = 0.15 \times X\ m^3/h \times \frac{h}{60\ min} \times$$

$$Z\ cm/min = \frac{0.15\ X\ m^3}{Y\ m^2} \times \frac{1}{60\ min} \times \frac{m}{m^1} \times cm \times 100$$

$$= \frac{15\ X}{Y \times 60}$$

$$\therefore Z = \frac{1}{4}\frac{X}{Y}\ cm/min$$

Therefore the rate of Z_3 cm/4 min in Weir Chamber to corresponds to the flow rate of $0.15\ m^3/m^2\text{-}h$.

Problem of - Sand - Scraping

Decide on the thickness of sand to be removed. This will be something between 1 and 3 cm. and will depend on how far the silt has penetrated. It can be decided by observing the colour of the sand, as this will usually be stained by the silt.

Mark out the bed in squares about 3 m x 3 m by scraping narrow strips (the width of the shovel) and dumping the scrapings in the middle of the squares. Lay boards on these cleaned strips. Then complete the scraping carefully to the planned thickness for each square, dumping the scrapings in the middle of the square.

Removal of the scrapings

Lay down a row of boards in the bed adjacent to a row of he heaps so that the barrow can the brought up to clear each heap in turn. The area covered by the heaps will not have been scraped. So when the heap is removed this area has to be carefully scraped. Erect a ramp with boards and supports so that the barrow with its load of dirt and dirty sand can be carried out or pushed out of the filter easily.

When one row of heaps has been cleared, move the boards if necessary to reach the next row of heaps and so on until all heaps have been removed.

Smoothing of the sand surface

When all the dirty sand has been wheeled or carried away, remove all the

boards, barrows etc. and smooth the surface of the sand level using a smoothing tool.

Problems of Sand - Washing

In Thailand, Sand Washing machinics are not used because they are difficult to operate then sand-washing by hose which is very simple and cheap. The following step should be followed:

Sand - washing has to be carried out to clean new sand before it is placed in the filter or to separate the dirt from the sand in the scrapings, directly after their removal to prevent odor problems. Usually it is cheaper to wash and store the scraped sand, than to use fresh sand for re-sanding purposes. A simple sand - washing operation includes:

1. Carrying scrapings or new sand to the washer

The new sand or the scrapings is carried to the washer which consists of a platform with a pitch lengthwise of 15-20 cm (Figure 3). The platform is surrounded by a wall rising from 30 cm at the end of the pitch to 60 cm at the head.

The lower end is closed by a removable plank weir 15-18 cm high. From 1.5-3 m^3 of the sand are placed upon this platform.

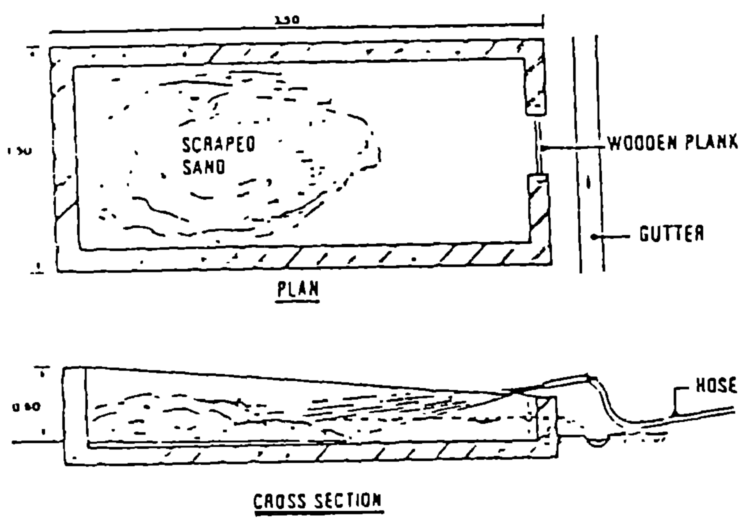


Figure 3 Sand-washing platform.

2. Sand - Washing

A stream of water from a hose with a nozzle is directed upon it, moving it about from place to place. The sand itself is always kept towards the upper end of the platform, while the water with the impurities flows into the pond made by the weir. There the sand settles and the water with the impurities flows removed from the sand overflows the weir. It is absolutely necessary to stir the sand during the washing to make sure tha+ all the dirt is washed out.

In general, filtered water is used for sand - washing, although this seems quite unnecessary as ordinary river water may be used if its quality is not too bad. Often however it is cheaper, especially in small works to use the clear water from the plant, rather than to provide a separate supply for the washers.

If average amount of water required is approximately 5-10 times the amount of soiled sand. The amount of clean sand produced is approximately 70-80% of the amount of soiled sand. For instance sand - washing from a filter of 100 m^2 in area. With a depth of scraping of 2 cm produces an amount of 2.5 m^3 of scrapings (including dirt) and requires 10-20 m^3 of water.

If there is a shortage of quantity and pressure of the water used in the sand - washing, sand - cleaning efficiency will decrease. On the other hand, if the washing process is not carefully supervised, the fine material may be removed and the average size of the sand increased, causing a deeper penetration of impurities into the sandbed.

Sometimes this is done on purpose to remove the finest particles from a new fresh sand, before it is placed in the filter-basin.

The dirt with the water can be carried to waste or to a sedimentation pit, where the dirt and the water can be separated. Afterwards the cleaned water can be carried to waste. The dirt must be periodically removed from the sedimentation pit and can be spread out over the land.

3. Check if the sand is properly washed

To check whether the sand is clean, take a handful an d rub it between the hands; if there is any sign of dirt on the hand, the sand is not yet clean enough.

Another method is to put a small quantity of the sand into a graduated glass cylinder, add water and shake well, allowing to settle. There will be practically no sediment on the sand is suitable clean.

4. Drying the sand

When the sand is properly washed, which is usually after an hour, the weir is removed and after draining the sand is removed. The washed sand should be spread out and dried in the sun. As the drying process is completed, the sand should be passed through a sieve of about 6 mm mesh width to remove gravel or wooden chips often mixed with the sand.

5. Storage

The storage place must be safe from contamination and located conveniently for transport of sand. It may consist of a concrete platform, some 15 cm above ground-level, constructed under a little slope.

6. Cleaning of the washing equipment

When the sand - washing operation is finished, the drainage piping and washing platform must be cleaned thoroughly.

7. Washing before use

Sand - washing rarely removes the strong adherent coating from the grains. This coating is of organic nature and may disintegrate during storage. In addition dirt and dust may enter the stored sand. Therefore it is recommended to wash the sand again before it is placed on the filter - bed during the re-sanding operation.

Problem of Re-Sanding

The decision to re-sand should be made well in advance as it takes rather a long time before the bed will be put back into service. The carrying out of the work must be planned, if possible, in a period of low demand for water. It follows that some flexibility may be needed and so re-sanding may take place even before the minimum thickness has been reached.

The re-sanding procedure should be executed as follows:

A. Scraping of the top layer

The dirty top layer has to be removed in th e usual way as described in Note 1. "Sand Scraping". Clean the side walls of the filter basin with closer attention than in scraping.

B. Adjustment of the water level

Arrange for the water level in the sand to be lowered to asmost the gravel level by operating the emptying valve (D).

C. Remove the sand

Remove the remaining sand. If the filter drainage system is covered by a gravel layer 10 cm of sand should remain as not to disturb this layer of gravel. This sand layer should be smoothed. Usually in smaller filters the old sand is removed from the filters and stocked nearly.

D. Refill the sand bed

Place washed sand in the bed to the required thickness.

Make sure that the surface of the new sand is levelled.

E. Replace the old sand

Replace the old sand which has been removed on top of the new sand.

F. Smooth the sand surface

Smooth the sand surface with a smoothing tool.

G. Re-start the filter

Put the filter back into service as quickly as possible following the procedure described in "The starting-up of a new filter".

H. Ripening period

The ripening period for a re-sanded filter will be 3-7 days under tropical conditions and up to two weeks or more in cooler areas.

V PROPOSED OPERATION AND MAINTENANCE PROGRAM

Training and Refreshment training are Considered to be essential for an effective O & M Program.

The following items should be incoorporates in designing training Program.

a) Ripening process

b) Constant and declining rate control

c) Cleaning of a slow sand filter

d) Resanding process

e) Cleaning of a horizontal filter

In rural area, at least one permanent official should be intensively trained, so he/she can do the expected job and able job. To transfer his/her Knowledge if he/she has to leave the job for better prospect. The proposed O & M for SSF which should be practiced in phased as depicted as below:-

Operation of filter box

1) Water level of filter basin should be kept mostly up to the designed level, at least upwards of 90 cm above the sand surface.

2) Filtering rate, according to the quality of raw water, should be within the designed max. rate. Also, what should be kept in mind is that changing the filtration rate suddenly will have had effect upon the filtration efficiency; 10-20% increase in the rate of filtration will have no significant influence upon it, but sudden 50% rise will impair the filtration effect extremely.

3) Outlet level of the filter basin should not be lower than the sand layer surface so that no negative water head be produced in the filter layer to reduce filtering efficiency.

4) Filtration head loss is an index of the filter conditions, which claims constant checking; sudden rise or fall of it means an accident in the filter film or in the bed so instant stop of operation and check and repairs are needed.

5) Duration of filtration days, so long as the quality of filtrate is good and the necessary quality secured, will be so much the better as it is longer. But since filtration rate, raw water quality and condition of the filter bed will exert an influence upon it, extremely short or long duration calls for our survey.

6) Headloss, quantity of the filtrate and water level of the distribution reservoir must be periodically observed, recorded and utilized for delivery control. In addition, for the same purpose, operation diary should be prepared and kept in which days of filtration duration headloss at a definite hour of the day filtration rate, etc., are to be entered.

7) Filtration controlling device and headloss gauge must be so arranged as to be able to grasp the flow and headloss correctly. For checking, repairing and adjustment of these instruments, the idle hours of the filter as in scraping and replenishing of sand should be employed. Further, by use of such hours, inspection, repairs or repainting of the fitting pipes, valves and other acces sories would be conveniently made.

Maintenance of Filter Beds

1) No act of stirring the filter film with such tools as rake and rod should be allowed for fear of the film being damaged and partial filtration ensuing. Also watch out for up-floating of the film due to the growth of algae and damage by fishes, shells and earth worms. In case the film has actually been damaged or is feared to be, thicker than usual scraping of the sand layer must be done as early as possible.

2) The conditions of the beds must be always checked and making use of the aforesaid idle hours of the filter, subsidence, sludge accumulation inside the filter and growth of microorganism should be periodically inspected. On detecting these faults, proper steps mentioned earlier should be taken as early as practicable. The materials or samples for filter layer survey can be taken by thrusting the sand-collector into the sand layer.

3) When the water level at the outlet has dropped to the sand layer surface of the basin, scraping of the sand must be conducted. However, the headloss of the basin, when the water level at the outlet come down near the surface height of the sand layer, tends to increase suddenly, and several basins get clogged simultaneously, causing shortage of the filtered water, thus early scraping will be needed to avoid such situation.

4) At each scraping time, depth of the remaining sand layer is measured, and when the depth has lowerted to around 70 cm, sand must be replenished; as regards sand replenishment, the number of filters to be sand-replenished per year should be determined on the basis of the remaining sand depth of each filter, and replenishing must be performed in turn during the months when water demand is comparatively low. (Note 2)

5) As regards sand-replenishment, use of sand insufficiently washed will affect filtration effect, so the work of sand-washing must be done with minute care. (Note 3)

6) For uncovered filters in the cold district, on freezing of the water surface, ambient ice-cutting is necessary in order to check the rise of ice pressure.

Note 1. Sand-scraping

1) Sand-scraping is generally conducted in the following order:

a) suspension of inlet and outlet operations

b) cleaning of sidewalls of filter-basin

c) draining on and under the sand surface

d) scraping of the sand surface

e) carrying out of the scraped sand

f) levelling of the sand surface

g) returning of the filtrate

h) introducing of the raw water

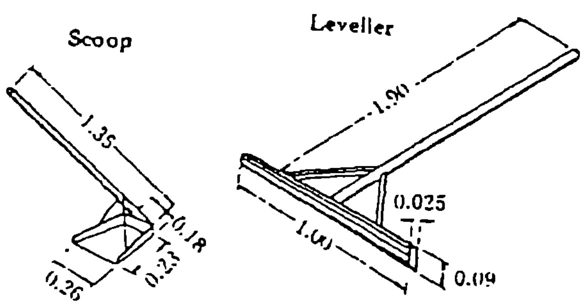
i) draining of initial filtrate

j) starting of operation

2) On draining of the sand surface, the sludge and organisms sticking on the filter walls should be swept off by long-stemed brush or bamboo-broom.

3) Draining of the sand surface should be done at the drain, while draining of the bottom, at the drain of the outlet by degrees after the above work has completed. Sudden and abrupt draining might damage the filter layer, draining under the sand surface would be adequate when done around 20 cm under the surface.

4) For scraping, the sand surface of about 1 cm in thickness will be scraped off by use of such tool as "joren" or a kind of scoop (sketch - 1) evenly and uniformly; for this purpose, number and direction of scraping ridges must be changed from time to time; ridge intervals of 2.0 - 2.5 m will suit the purpose, and the scraped sand will be carried out by use of basket, carrier bicycle.



5) After the scraped sand had been carried away , the surface must be levelled by use of wooden leveller.

6) Prior to introduction of raw water, the filtrated water must be sent back from the outlet for the purpose of deaeration of the sand layer and surface protection, at the rate of less than 2m/d, and water to be introduced into the filter up to the height of 10-20 cm above the sand surface.

7) Raw water must be led in gradually after the sending back of the filtrate and up to the specified level. For preventing the turbulence and scouring of the sand layer, concrete slabs or bricks must be spread at the inlet for raw water.

8) Draining of initial filtrated water must be continued within the limits of 3m/d, with gradual raise of filtration rate the filtrate to be discharged, until filtering effect is perceived.

9) Resumed filtration function is to be confirmed through the process of quality tests on the filtered water. However, when time intervals from the initial filtration to this confirmation is determined on the basis of the quality of raw water, filtering function may be regarded as resumed after that period elapsed. The items for water quality test in this case should at least include: turbidity, color, bacteria and E. coli.

Note 2. Sand-replenishing

1) Sand-replenishing should be conducted in the following order:

   a) draining on and under the sand surface

   b) scraping of the sand surface

   c) replenishing of sand and relocating of the old sand

   d) levelling of the sand surface

   e) draining of the initial filtrate

   f) starting of operation

2) Cleaning of the filter walls should be conducted in a manner similar to that in scraping, only with closer attention.

3) Draining under the sand surface should be extended to the bottom of the collecting gallery.

4) In replenishing sand, the amount or depth - of the sand to be removed will better be determined by examining vertical pervasion of the sludge in the sand layer.

5) In replenishing sand, see that the old sand will not be thrust into the lower layer by force of the new sand; for this purpose, first scrape the old sand up to the coarse sand layer at proper width, then introduce the clean sand over which the old sand must be relocated. This process will be repeated until the whole bed is renewed. During the work, sheeting will serve to prevent the old sand from mixing with the new.

6) Sending-back of the filtered water, introduction of the raw water, draining of the initial filtrate and starting of operation will be done in a manner similar to that in the case of scraping of sand; draining of the filtrate, as it will take time before the normal function is resumed, should be done at nearly 50% of the specified filtration rate, with strict water analysis conducted the while.

7) When entry into the filter is necessary for sand-replenishing, scraping or repairing purposes wear clean footwears and take care that the filter bed will not be soiled. Pollution by wild life must be also watched.

Note 3. Sand-washing

1) The washed, clean sand should be in conformity with the standards specified in the "Standards for waterworks facilities" editted by the Japan Waterworks Association.

2) In case there is shortage of quantity and pressure in the water used with the sand-washer sand-cleaning effect will decrease because of reduced washing efficiency. Also there is fear of the sand flowing away when the water quantity and pressure are too great. Though the optimum quantity and pressure will vary dependent upon the type and capacity of individual sand-washer, the average figures are: Amount of water required, approx. 10 times the amount of soiled sand clean sand produced, approx. 70-80% of the amount of soiled sand.

3) The washed, clean sand should be stored in a chamber for this special use, safe from contamination and flying, located convenient for transport of sand and equipped with perfect drainage at the bottom.

4) The soiled sand should be placed on a concrete floor separated from the clean sand and be washed before getting dry. Also, the settling chamber for the sludge from sand-washing and drain pipe system should advisably be dredged periodically.

5) The sand-washer must be equiped with metal net of about 6 mm mesh for removing gravels or wood chips often mixed with the soiled sand.

6) Since the nozzle, jet pipe and metal net of the washer are liable to damage, spares should be stocked for ready replacement.

VI CONCLUSION

All problems of rural water supply can be solved if the government agency responsible (especially PWA), will pay much more attention to these problems. PWA obtains a lot of skilled mechanics and specialists which experienced in water supply. Besides it attains fiscal and authority to monitor old water supplies and establish a new one if a community is in need of. In case of establishing, PWA can manage it if the local people would share 30% of investment cost, and in sensitive area the local people does not have to pay at all.

At present, PWA is developing new internal administration struction (a chart shown in appendix 2). It's policy is to decrease expense and increase income. According to the policy, the division of rural water supply is reduced to a smaller unit in order to convert its budget to spend in PWA business. So what PWA should do to help the rural water supply is offerring:

- free corrective maintenance
- designing water supply system
- training program on operation and maintenance
- installation of new water supply in remote areas

PWA also needs to propose the government to change the status from government agency to state enterprise in order to aviod red tape in working system.

As rural water supply is a public utility that PWA is authorized and supported by the government, if the water supply's enterprise does not profit it does not mean that it's administrative system is inefficient because it is not the government policy to gain benefit from public utility. If PWA can not be attentive to rural water supply, it is better to return the responsibility to the government to reconsider of another agency to promote it. The objective of this suggestion is to bring good health and happiness to rural community.

REFERENCES

Huisman, L., Wood, W.E., F.I.C.E. (1974), Slow sand Filtration, World Health Organization, Geneva, pp. 73-97.

Huisman, L., J.M. DE AZEVEDO XETTO, B.B. SUNDARESAN, J.M. LANOIX, E.H. Hofkes (1981), Small community Water supply, pp. 247-250.

Huisman, L. (1982), Slow sand filtration, Research and demonstration Project, reprint for the AIDIS congrese held in PANAMA, August 1-6, IRC-Water and sanitation centre.

IRC Water and Sanitation Centre (1982), Basic Guidlines for operation and maintenance of slow sand filter plants in Bural Areas of Developing Countries, SSF Research and Demonstration Project, Occational Poper Devised Draft 01/07/82.

Thanh, N.C., Samorn Muttamara, Sompol Boonthanon, Sunantha Buaseemuang (1981), Monitoring and Evoluation of villedge Demonstration Plants, Slow sand Filtration Project, Final Report to PWWA, AIT, Bangk ok, Thailand.

Thanh, N.C., J.P.A. HETTIRATCHI (1982), Surface Water filtrati on for dural Area, Guideline for Design, Construction and Maintenance, ENSIC, Bangkok, Thailand, p. 14.

Thanh, N.C. (1976), Slow Sand Filtration as a low cost water S upply Systme for small village, Slow Sand Filtration Project, AIT, Bangkok , Thailand.

Thanh, N.C., Muttamara, S. (1979), New Filtration System to treat surface Water in the Tropics, Proc. and Reg. Conf. Water Supply Eastern Asia, pp. 180-210.

Thanh, N.C., OUANO, E. AR (1977), Flow Coacse-Material Prefiltration, AIT-IRC Research conducted for WHO International Reference Centre for community water supply, Environmental Engineering Division, AIT, Bangkok, Thailand.

Thanh, N.C., Muttamara, S. (1983), Pre-Treatment of High turbidity Waters Prior to slow sand filter. For Present at Regional Seminar or Burul Water Supply and Sanitation for Developing countries, Chulalongkorn University, Bangkok, Thailand, (18-25 July, 1983).

Thanh, N.C. (1978), Functional Design of Water Supply for Rural Communities, IDRC Research Award Report, AIT, Bangkok, Thailand.

Wilairat Wangcharoenwong (1983), Rational Design of Water Supply System for small communities in Thailand with Emphasis on Slow sand Filtration AIT Master's Thesis, Bangkok, Thailand, pp. 19-21.

Thanh, N.C. (1982), Guidelines for Design, Construction and Maintenance, Surface Water Filtration for Rural Area, Environmental Sanitation Information Center, Bangkok, Thailand.

Chenboonthai, S. (1978), Functional Design of Rural Water Supply Systems, Master's Thesis. Asian Institute of Technology, Bangkok, Thailand, pp. 6-8.

JWA (1975), Guidelines for Waterworks Technical Management.

IRC Research and Demonstration Project on Slow Sand Filtration (1983), Guidelines for operation and Maintenance of Slow Sand Filtration Plants in Rural Areas of Developing Countries, Rijswijk, The Netherlands, p. 83.

Thai, Yazaki (1978), Technical Data and Specification for Electric Wires and Cables, Thai Yazaki Electric Wire Company Limited, Thailand, p. 24.

Huisman, L. ( ), Slow Sand Filtration, Delft University of Technology, Netherlands, p. 12.

Appendix 1

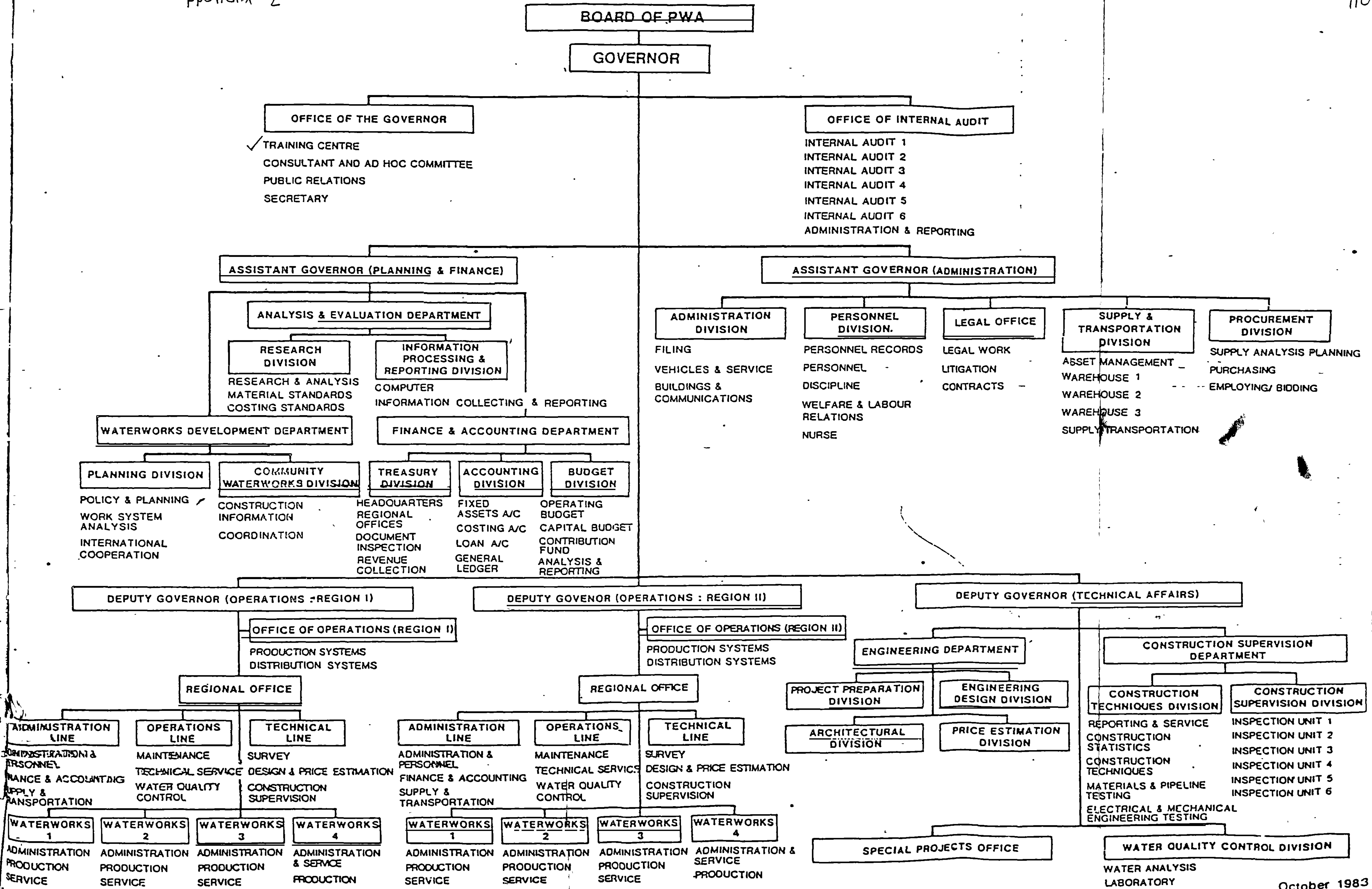
Fig. 10
MAP OF THAILAND
Showing the Locations of Slow Sand Filtration Plants

- ▫ Capacity 10 m^3/h
- ○ 20 m^3/h
- △ 30 m^3/h
- ◆ 40 m^3/h
- • 50 m^3/h

Appendix 2

ORGANISATION CHART FOR THE PROVINCIAL WATERWORKS AUTHORITY OF THAILAND

Figure 1



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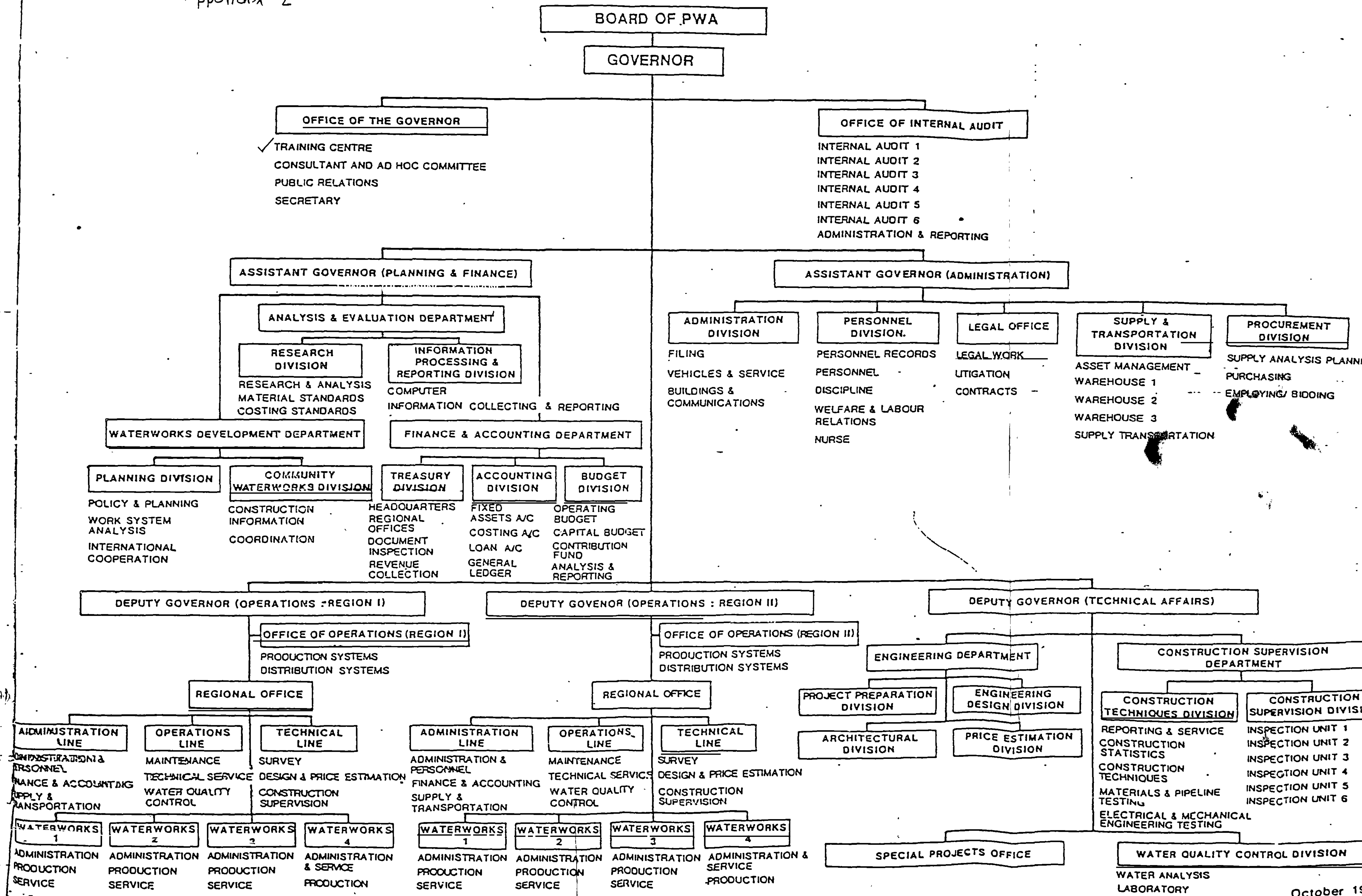
Appendix 2

ORGANISATION CHART FOR THE PROVINCIAL WATERWORKS AUTHORITY OF THAILAND

Figure 1



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