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REPORT NO. 1579 54TH ICHPB AUGUST-DECEMBER 1989

SUGGESTIONS FOR OPERATION AND MAINTENANCE ARRANGEMENT OF SANITATION FACILITIES FOR LOW INCOME HOUSING AREAS IN THAILAND

DIRECTED STUDY FOR WORKSHOP
LOW COST INFRASTRUCTURE
by
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MR. SOONTORN SROIMORA
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SOONTORN SROIMORA

DECEMBER, 1989

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ABBREVIATION

BMR	BANKOK METROPOLITAN REGION
BMA	BANKOK MUNICIPAL AUTHORITY
NHA	NATIONAL HOUSING AUTHORITY, THAILAND
IHS	INSTITUTE FOR HOUSING STUDIES
BOD	BIOLOGICAL OXIGEN DEMAND
COD	CHEMICAL OXIGEN DEMAND
D.O.	DISSOLVE OXIGEN
SS	SUSPENDED SOLID
M.O.	MICRO ORGANISMS.
O&M	OPERATION AND MAINTENANCE
TISTR	THAILAND INSTITUTE OF SCIENCTIFIC AND TECHNOLOGICAL RESEARCH.

PREFACE

I have been working for the National Housing Authority (NHA), Bankok Thailand, in the section of Community Sanitation Section about 13 years (1976 – 1989). I graduated with a Bachelor degree of Science (chemistry - biology) from Chulalongkorn University, Banghok in 1975. Then I worked 3 years as a chemist analysis in water & waste water treatment plants' laboratory. At that time NHA just start Huay Kwang Sewage treatment plants for Huay Kwang low-income housing project. So it was needed to follow up and to do a routine examination in laboratory.

During the year 1976-1982 NHA provided more and more housing projects for low-income, it means that NHA had to provide more and more water supply treatment plants and waste water treatment plants. The Community Sanitation Section was requested to take the responsibilities for the operation of treatment plants. After 1981 I graduated with a diploma in Sanitary Engineering from Chulalongkorn University and I have been appointed to be plant operator and manager and now I am chief of the

Community Sanitation Section.

Nowadays the economic situation in Thailand is going through a period of change and the Goverment has stipulated the policy of letting all state enterprises stand on their own feet and limiting foreign debts. The NHA has always recognized the Government's burden in national development and has tried to relieve as much as possible of this burden from the Government's back. One of the approaches adopted by the NHA is to introduce lower cost operation for running infrastructure in the community.

The main subject of my study is operation and maintenance arrangement of sanitation facilities for low-income housing areas in Thailand, because I am a field worker, and always working for NHA low-income areas that concern about sanitation.

So my objectives are as following

1. To assess operation and maintenance requirements of on-site and off-site sanitation systems in low-cost housing and upgrading

schemes.

2. To review the use and performance of sanitation systems that existing in urban of Thailand.

3. To review the role of agencies that are involved in operation and maintenance of sanitation systems.

4. To develop operational recommendations in respect of planning, design, construction and post construction management which would result in better operation and maintenance performance.

In order to deal with the different subjects, my study has the following structure:

In part I, I will deal with Thailand in general, urbanization and housing situation, sanitation situation in Thailand both on-site and off-site sanitation and then go to the problem encounter.

In part II, I will deal with requirements for management and operation and maintenance of sanitation system in general, specific requirements of sanitation systems in Thailand (in NHA schemes) both on-site and off-site systems, and then make a comparision the ideal requirements with the reality existing situation of sanitation systems give some suggestion from my experince.

Finally, go to conclusion and recommendation for improvement of sanitation system in low-income areas of Thailand.

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PART II :

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PART I

I.1 THAILAND

Thailand is a large country in South East Asia. It has land borders with Burma, Laos, Kampucha and Malaysia and it has a fairly long coastline with the South China Sea. It has an area of 513,115 square kilometres.

The population of Thailand in 1988 was 55 million, in 1986 the population grew at an annual rate of 1.7% There has been less urbanization than in other Asian countries and that which has occured has concentrat on the capital of Bangkok. The Bangkok metropolitance had a population of 5,700,000 in 1985

Thailand is a constitutional monarchy. There is a national Assembly, consisting of a Senate appointed by the King, and a House of Representatives elected by popular vote. Currently, a four party coalition is in power but there is a considerable military presence in the government.

GNP per capita was $ 820 in 1986. In the 1970s GNP grew by 8% a year. Inflatation reached 20% in 1980 before falling to 13% in 1981, to 4% in 1983, and to 2.9% early in 1986 [Summary the sixth national economic and social development plan, 1987-1991]

I.2 URBANIZATION AND HOUSING SITUATION

Urbanization in Thailand nowadays is a result of the changing economic structure of Thailand which is becoming a new industrializing country. The development of economic base in communities at the metropolitan level, in cities, in the regional areas and in the development of new economic zones, is considered importance for development in the future which must absorb the expansion of the urban population.

The area which have the most serious problems of housing in Thailand is Bangkok, the capital city. Since 1960, Bangkok has faced a rapid growth, the population increased from 1,622,000 in 1958 to 5,700,000 in 1985 (Tu Delf, Klong Settlement, 1987), the yearly growth rate exceeded 5% caused by natural increase, migration and annexation of adjoining areas where now considered as Bangkok Metropolitan Region.

Housing and services situation in Bangkok Metropolitan Region (BMR) can be summarized as show in TABLE I.

From TABLE 1. we can see that

ELECTRICITY : In 1970, only 66.9 percent of the households in BMR has access to electricity, while in 1980, electricity was generally available to virtually the whole area (99.8%).

WATER SUPPLY : In 1970, 43% of households had access to piped water in the house, compared with 57% in 1980. In 1970, 26% obtain water from sources of supply other than piped water, where as in 1980, 23% of household had to resort to wells or other sources as they were without piped water in the house.

SANITATION : With respect to toilet facilities, flush toilets have been increased by 9%, in 1970, 5% of all households had flush toilets compared with 14% in 1980. The majority of households use cesspit with water seal.

HOUSING STOCKS: expand dramatically from 743,971 in 1970 to 1,261,784 in 1980. This was the result of building activity within several sectors of community as follows:

1. Private individuals build their own houses.
2. Private developers who have provided a large number of houses and shop-houses for sale

to general public.

3. Public sector include the National Housing Authority (NHA), and other government agencies, who have constructed housing unit both for sale and for rental to public and government officials.

4. Slum and squatter settlement typically self-built to low standards and lack of infrastructures.

5. Other sectors which include dwelling within the compounds of religions building and temporary accommodation for building and construction workers.

In recent years, the growing demand of housing confront many problems.

First there is a current mis-match between private sector housing supply and popular demand. Evidence of this existing, is the large number of high quality houses and shop-houses remain unsold despite of the overall housing shortage problem.

The second problem is that regulations and planning standard are too high, so few units of house was provided for low-income and middle-income which is the main group of demand.

The third problem is the unavailability of low-cost, long-term financing for housing purchase.

The fourth problem is the severe shortage of land for development of low cost housing schemes. This shortage caused by land speculators And shortage has been further aggravated by un-co-ordinated infrastructure development and the absence of appropriate land control.

Moreover, the recent situation in housing has emerged as follows:

(1) Government Policy

The Government has taken the policy of the acceleration of housing project development both in the public and private sectors in order to improve economic and employment conditions, for instance, through the Bank of Thailand which urges commercial banks to provide loans for housing project development, 7,000 baht of interest paid as a result of housing loans to be decreased in calculation individual income tax, and easing of various regulations on real estate business which hinder housing project development.

(2) Housing Credits

During 1986 and 1987 various financial institutions have adopted the policy of providing more housing credits as a result of the viability of the financial system. Meanwhile during the two years the interest rate decreased from 16% to 11.5%. This has decreased the investment capital in housing development and the amount of money paid for hire-purchase installment payment.

According to the Bank of Thailand, the amount of unpaid debts in the first six months of 1987, at the end of June, was 42,792 million baht, compared to 38,049 million baht during the same period in 1986.

(3) Housing Demand and Affordability of the Public

Study results reveal that approximately 50,000-60,000 households needed residential quarters in 1987, about 80% or 48,000 units of which are standard housing units while the remaining 20% are made up of residential quarters in congested communities or temporary shelters.

The phenomena of domestic accumulation of capital for more investment in housing project development, more than 5% reduction of the interest rate during the period of 1985-1987, and the change in the design of housing units to be smaller and less expensive in the private sector, have evidently increased the affordability of the general public. In 1980 only about 15% of the people who needed housing units were able to buy them from the private sector; but currently over 55% can do so. A housing unit for the lower middle-income families costs about 200,000-370,000 Baht, and that for the upper middle-income group costs about 370,000-980,000 Baht.

The housing need and the affordability of the general public have brought about a great number of housing development projects in suburban areas for the upper middle income groups, for instance in Bangkapi, Prakhanong, Bangkhen, Phasi Charoen, Samutprakarn and Nonthaburi. As a result in 1987 the housing market has been genuinely for the buyers.

(4) Construction Material Situation

Construction material is the most important variable in housing development for its cost makes up more than 50% of the cost of a housing development project comprising land, management, taxes, labour and other expenditures. During the first 9 months of 1987 the atmosphere of investment in housing development was so satisfactory that the price of construction materials increased suddenly at the end of the year, beginning with an increase of over 30% in the price of steel wire, followes by an increase of the prices of lumber, pipes, electrical equipment, etc. As a result, the cost of housing production has been raised and marketing of housing has been affected, because currently after the housing units are completed they are sold in advance, Therefore so when the price of construction materials rises investors are directly affected.

NATIONAL HOUSING AUTHORITY (NHA)

The National Housing Authority (NHA) is a state enterprise established on February 12, 1973. in accordance with the National Executive Council Decree NO. 316 to be responsible for the solution of severe housing problem in Thailand. The agency was created through the combination of various governmental departments and agencies concerning public housing at that time.

According to the document mentioned, the NHA was created to materialize the following objectives.

1. Provide the public with housing for rent, hire-purchase or purchase.
2. Subsidize citizen who wish to own housing or individuals who wish to provide the public with housing for rent, hire-purchase or purchase.
3. Run building or housing estate businesses.
4. Slum improvement.

To achieve the stated objective, the NHA has managed the work performances and responsibilities which can be categoried as follows:

1. Construction of living quarters and land acquisitions.

2. Construction of living quarters for government employees as stipulated by the Cabinet.

3. Clearance or upgrading of slum areas.

4. Managing of housing construction loan programme.

5. Estate management and development of housing commitees.

NHA, in the respects of providing housing for low-income, had completed 70,000 units in BMR. It's market share has increase from 5% in 1974 to 9% in 1984. NHA also undertakes slum upgrading projects to improve the living condition of lowest income earners, for whom new housing was not affordable.

The following is the number of housing units constructed by the NHA as at September 30, 1987

Housing units for the general public	56,617
Housing units for government personnel	15,542
Upgraded housing units in squatter area	43,719
Special project and community services	309
TOTAL	116,189

NHA 'S ORGANIZATION AND STAFFING

NHA is one of state enterprises that under the Ministry of Interior, NHA administered by the Board Director, appointed by the Cabinet. The Governer of NHA is appointed by the Board, with approval from the Cabinet. The organization with assistance of 3 deputy governors and a group of technical staffs and director of 7 departments The 7 departments comprise of 39 divisions and 5 estate management zones. NHA has about 2400 employees in total, about 70% of permanent staff are administrative staff and multi disciplinary professionals.

The NHA Organization chart is shown in FIGURE 1

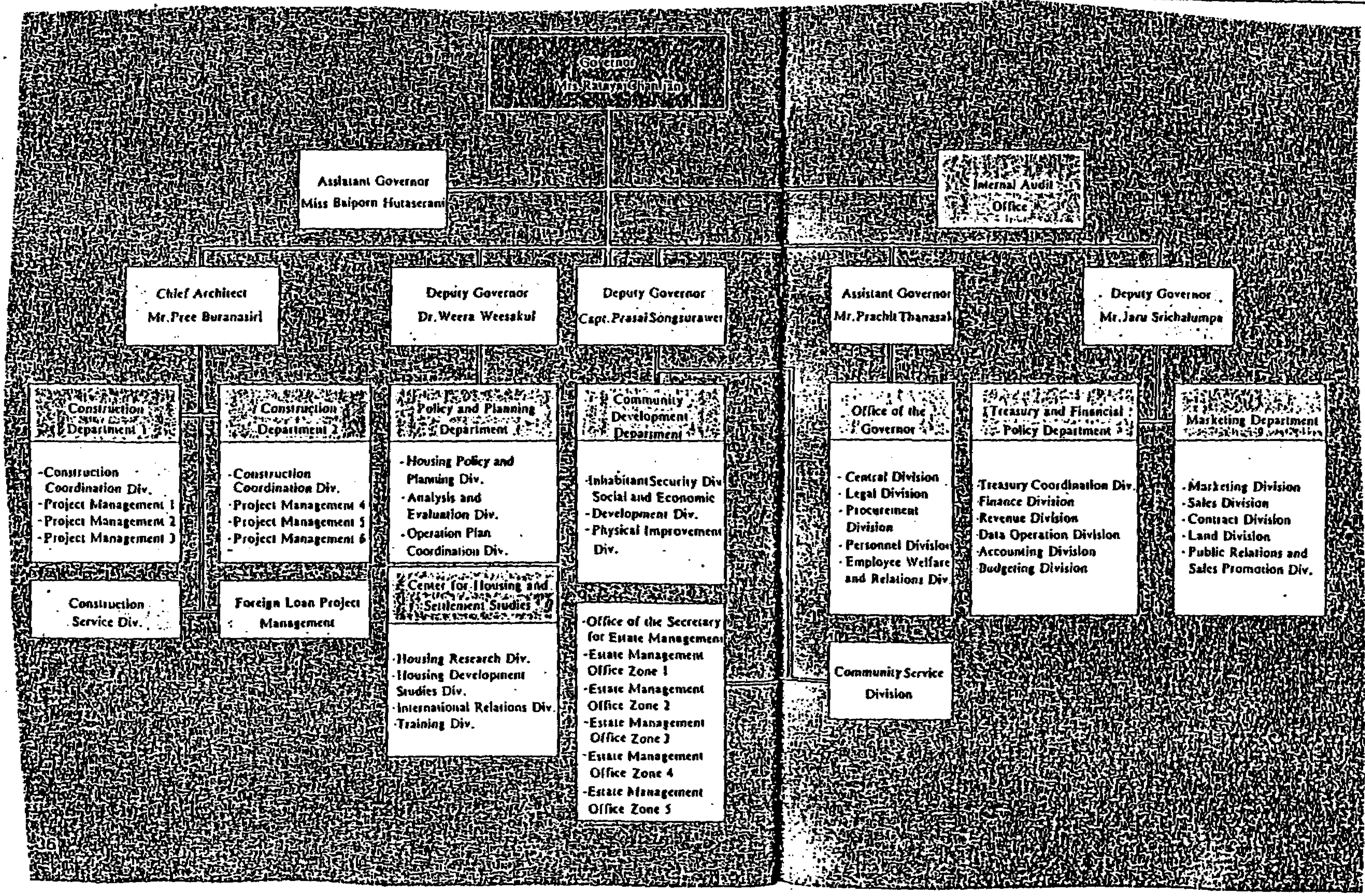

FIGURE 1: NATIONAL HOUSING AUTHORITY ORGANIZATION CHART, 1988

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I.3 SANITATION SITUATION IN THAILAND

Only about one thirds of the population in developing countries have adequate sanitation services. But about 79% are without excreta or sewage disposal facilities. Only 0.8% of the total population are serviced by sewage treatment facilities. [World Bank: Appropriate Technology for Water Supply and Sanitation, 1980] This figure show that sanitation situation in the World, especially in developing countries is a big problem.

As other developing countries, Thailand has the same situation, from my experience I found that few houses are serviced by sewage treatment facilities. Many houses use a cesspit or septic tank which very often contaminate the environment. Thus, people especially dense slum areas are living in unsanitary conditions.

Providing sanitation system in Bangkok has to overcome a number of specific constraints one of this constraints is that.

Bangkok is flat. The average natural ground water level is not much more than a metre above mean sea level.

This flatness is the controlling physical condition in any consideration of sewerage, drainage and flood protection. The extensive network of existing drains was constructed on the basis of carrying the runoff from rainstorms away from the land to the river and khlong (or canal) by means of gravity, but since the ground is flat, so the drain is hard. Under such conditions the drainage system does not and can not function adequately, resulting in occasional property damage and wide spread inconvenience during heavy rainstorms when the river level is high.

There is no waste-water collection system in BMR. Excreta disposal is generally by septic tank of cesspool and all other waste water are usually discharged into the nearest ditch or canals or into the storm-water drainage system. In as much as the BMR subsoil is impermeable clay, overflows from septic tanks usually find their way into the drainage system, either directly or indirectly. Those overflows together with the substantial amount of organic matter from kitchen laundry and bath wastes, have served to turn many of BMR.'s drains and khlongs into septic reservoirs of foul smelling pollution, a continuing assault on the aesthetic sensitivities of its citizens and a constant hazard to their health.

As said, at present there is no central sewerage collection and treatment system, except in some housing projects developed by NHA. In the 'Bangkok Sewerage System Project Masterplan' a system for sewerage is proposed to be implemented in future.

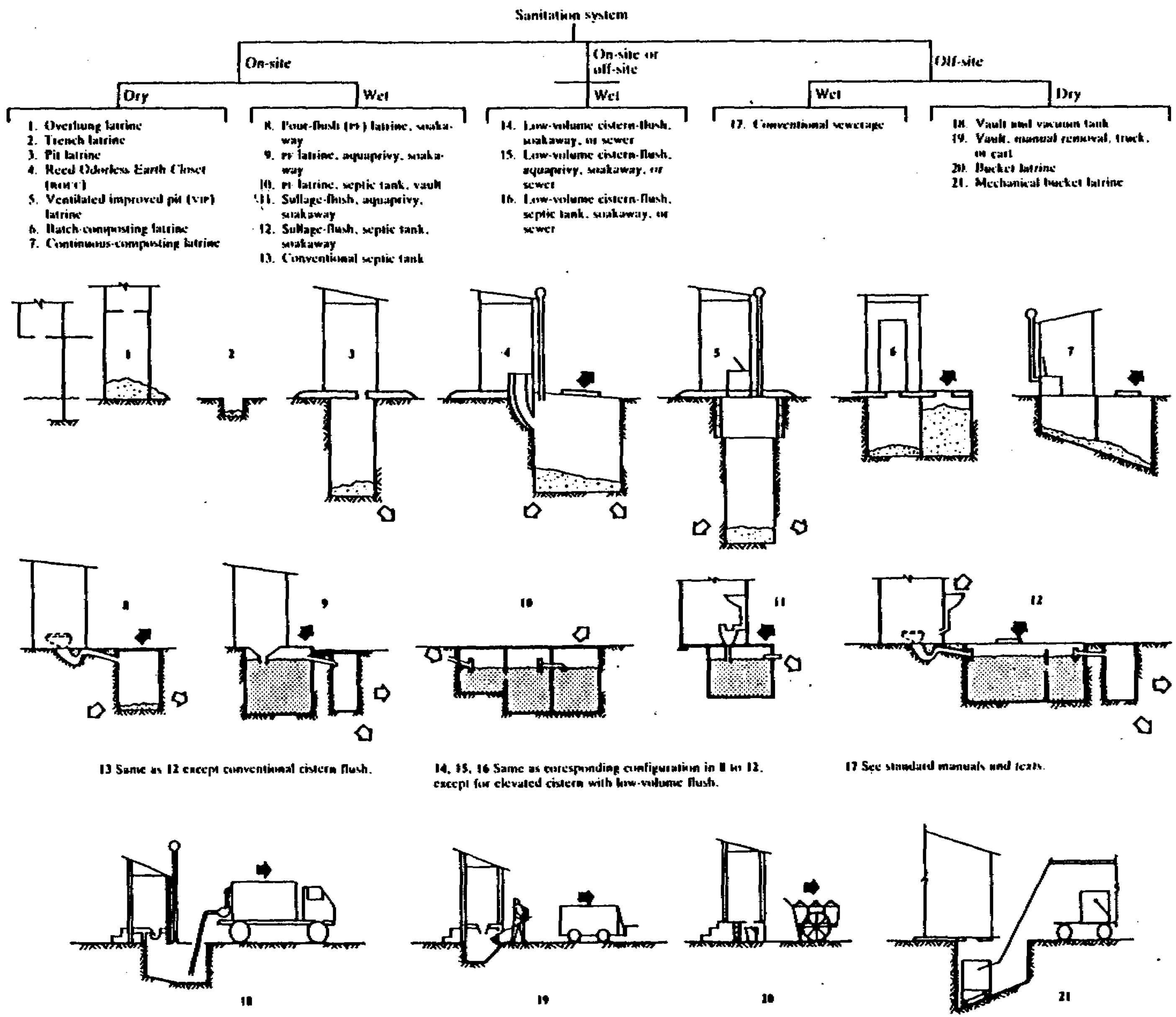
GENERAL DESCRIPTION OF ON-SITE AND OFF-SITE SANITATION SYSTEM IN THAILAND.

On-site disposal systems are human excreta disposal systems in which the sewage is discharged and as far as applicable treated on the plot. The include pit latrines, aqua privies, cesspool and septic tank with soakaways.

Off-site disposal systems are human excreta disposal systems that discharge and waste water are treated out of plot. The include water-borne sewerage, sewers, vacuum track system and waste water treatment plant.

[FOR TYPICAL ON-SITE AND OFF-SITE SYSTEM ARE SHOWN IN FIGURE 2]

Figure 2 *Generic Classification of Sanitation Systems*



⇧, Movement of liquids; ⬆, movement of solids.
Source: The World Bank, *Water Supply and Waste Disposal*, Poverty and Basic Needs Series (Washington, D.C.: September 1980).

Table 2 . *Descriptive Comparison of Sanitation Technologies*

Sanitation technology	*Rural application*	*Urban application*	*Construction cost*	*Operating cost*	*Ease of construction*	*Self-help potential*	*Water requirement*	*Required soil conditions*	*Complementary off-site investment*[a]	*Reuse potential*	*Health benefits*	*Institutional requirements*
Ventilated improved pit (VIP) latrines and Reed Odorless Earth Closets (ROECs)	Suitable	Suitable in L/M-density areas	L	L	Very easy except in wet or rocky ground	H	None	Stable permeable soil; groundwater at least 1 meter below surface[b]	None	L	Good	L
Pour-flush (PF) toilets	Suitable	Suitable in L/M-density areas	L	L	Easy	H	Water near toilet	Stable permeable soil; groundwater at least 1 meter below surface[b]	None	L	Very good	L
Double vault composting (DVC) toilets	Suitable	Suitable in L/M density areas	M	L	Very easy except in wet or rocky ground	H	None	None (can be built above ground)	None	H	Good	L
Self-topping aquaprivy	Suitable	Suitable in L/M-density areas	M	L	Requires some skilled labor	H	Water near toilet	Permeable soil; groundwater at least 1 meter below surface[b]	Treatment facilities for sludge	M	Very good	L
Septic tank	Suitable for rural institutions	Suitable in L/M-density areas	H	H	Requires some skilled labor	L	Water piped to house and toilet	Permeable soil; groundwater at least 1 meter below surface[b]	Off-site treatment facilities for sludge	M	Very good	L
Three-stage septic tanks	Suitable	Suitable in L/M-density areas	M	L	Requires some skilled labor	H	Water near toilet	Permeable soil; groundwater at least 1 meter below surface[b]	Treatment facilities for sludge	M	Very good	L
Vault toilets and cartage	Not suitable	Suitable	M	H	Requires some skilled labor	H (for vault construction)	Water near toilet	None (can be built above ground)	Treatment facilities for night soil	H	Very good	VH
Sewered PF toilets, septic tanks, aquaprivies	Not suitable	Suitable	H	M	Requires skilled engineer/builder	L	Water piped to house and toilet	None	Sewers and treatment facilities	H	Very good	H
Sewerage	Not suitable	Suitable	VH	H	Requires skilled engineer/builder	L	Water piped to house and toilet	None	Sewers and treatment facilities	H	Very good	H

Note: L, low; M, medium; H, high; VH, very high.

a. On- or off-site sullage disposal facilities are required for nonsewered technologies with water service levels in excess of 50 to 100 lcd, depending on population density.

b. If groundwater is less than 1 meter below the surface, a plinth can be built.

I.3.1 ON-SITE SANITATION SYSTEMS

Because Thailand is located in tropical zone, there is enough water resource. So most of excreta disposal methods and systems are wet-systems, most people use water for anal cleaning and flushing.

The most prevailent flushing wet on-site treatment systems in Thailand can be categorized into

1. cesspool
2. aqua pit with soakaway
3. septic tank

NHA has not much role on on-site sanitation. For design, construction of cesspool people do themself by the available typical knowledge and material resources in local areas. For desludge of septic solid in the tank, BMR operates vacuum trucks to empty the cesspools and septic tanks with the official charges about 200 Baht (US$ 8) per 1 cubic metre of waste by volume. Nevertheless, the poor quantities of effluent that contaminate to environment, NHA tries to promote cesspool with anaerobic upflow filter in Klong Toey Slum area, in order to assess the sanitation system for on-site congested area.

In Bangkok most houses are equipped with leaching cesspools while larger buildings such as municipal buildings, offices and schools have septic tanks. All waste waters other than toilet wastes are discharged into surface drains which discharge into canals. Since the subsoil is impervious clay, seepage from cesspool and overflow from septic tanks also flow into the canals since absorption into the soil for further treatment is precluded. Water pumps are used to augment the low mains pressure which causes polluted water to enter the water mains at leakage points. Thus, the insanitary waste disposal system presents a serious health hazard (Phanapavudhikul 1967; Camp, Dresser and McKee, 1968).

Very few houses in Bangkok lack a toilet facility. The sanitation compaigns have resulted in a very high acceptance of individual facilities - will over 90% of the slum households have one kind of toilet system or another.
Two important factors have played a role in the rapid acceptance of toilets in the Bangkok slums. The availability of an effective waterseal prevents the occurance unpleasant odours, the vicinity of a toilet is therefore no longer provoling strong negative reactions.

The second factor contribating to the general acceptance relates to the simple construction motheds developed for the system. The whole construction is readily available in prefabricated parts from a multitude of suppliers at a very low price. The system is so cheap,

However many households implementation the system by emptying the original one, because emptying is still cheaper than construction the new one.

In summary easy and economic supply and the elimination of pleasant sights and odours are the key factors behind the high implementation ratio of toilets systems in Thailand.

The successful introduction of the cesspool in Bangkok has achieved a very unified sanitation method which satisfies the people. The easy construction system and the widely available and cheap components brought this method within everybodies reach. The absence of offensive odours and the simple cleaning requirements give much satisfaction.
The result is that people feel that sanitation is adequate as it is. Public health and technical and environmental considerations are not felt to be questions within their control and do therefore fail to attract much interest.

CESSPOOL

THE ORIGINAL CESSPOOL DESIGN

The cesspool design as it was launched as the low cost solution for urban areas in Thailand in the early seventies consists of two interconnected tanks.

The first tank is for settling solids, while the partly purified efficient flows into a second tank: a soakage.
The first tank has a ventpipe, since most of the biogas is produced here and an inlet in the form of a squatting plate with a waterseal. Both tanks are made of concrete rings, the one has a tight bottom the second one has no floor. This design requires a regular removal of the sludge, while the system perculates a considerable quantity of unstabilized organic matter and pathogenes into the ground water. It is however very easily constructed and requires little maintenance.

The system works well in areas with a high ground water level, which keeps the second tank filled with fluids. As a result a secondary treatment takes place before the effluent soaks away. If there is a low ground water level however, the overflowing fluids from the first tank soak away into the ground before any secondary treatment takes place. The pollution effect will therefore be considerable.

The Simplified Cesspool

The actual installations that one finds in the slums are very different from the original cesspool desigh.
Instead of two tanks, there is only one - It consists of set of rings without a bottom plate and has a squatting plate with a water seal, but without ventpipe on top. The tank sometimes hardly enters into the soil, but rises through the surrounding surface water up to the floor of the house. The user still enjoys the same advantages as in the case of the correct double pit cesspool: cheap and easy installation and on effective waterseal keeping out all inpleasant edours.

The treatment process however has changed radically. Fluids leach directly without treatment into the surrounding surface water. There is no secondary treatment of effluents and the perculation of fresh feaqal matter into the water body is quite possible. There are many operational problems with this type of toilet, but from the users point of view it is satisfactory: it is cheap to construct and pleasant to use. The operational difficulties are not immediately appearant. The leaching effect constitutes a longterm health lazard and causes severe pollutions. [AS SHOW IN TABLE , page]

The direct soakage reduces the mineralisation process of the settling solids. The lack of a ventpipe results in a build up of biogas in the tank and causes blockages.
The adverse environmental conditions in the slums are partly related to this malpractice of building simplified cesspools.

The construction of the cesspool.

Installation consists of making a small excavation on the ground and putting a few rings on top of each other up to the floor level of the house. The joints between the rings are sealed and then the cover slab is masoned on top. This slab has an oval opening which allows -

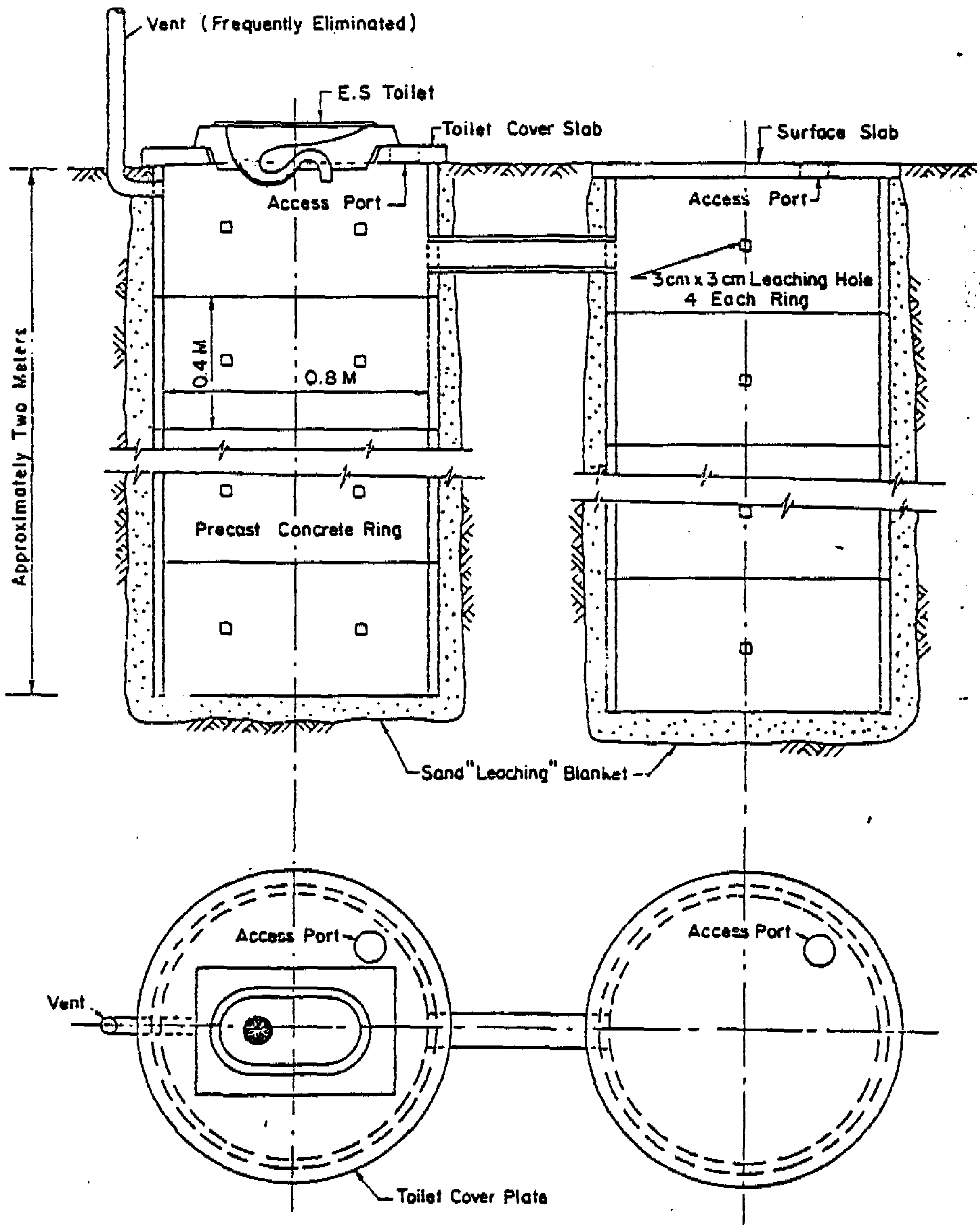


Fig. 3 Typical septic tank "leaching" cesspool for Bangkok area

(Camp, Dresser, and Mckee, 1968)

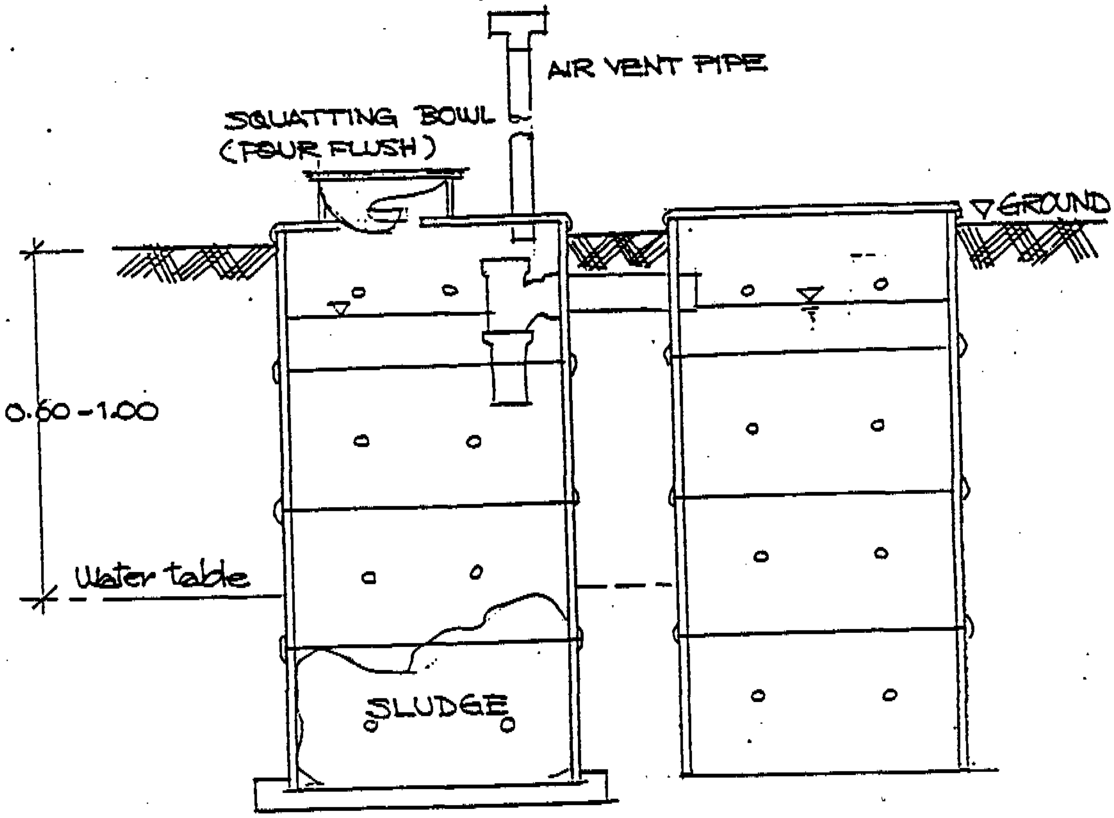


FIG. 4 ORIGINAL CESSPOOL DESIGN IN BANGKOK.

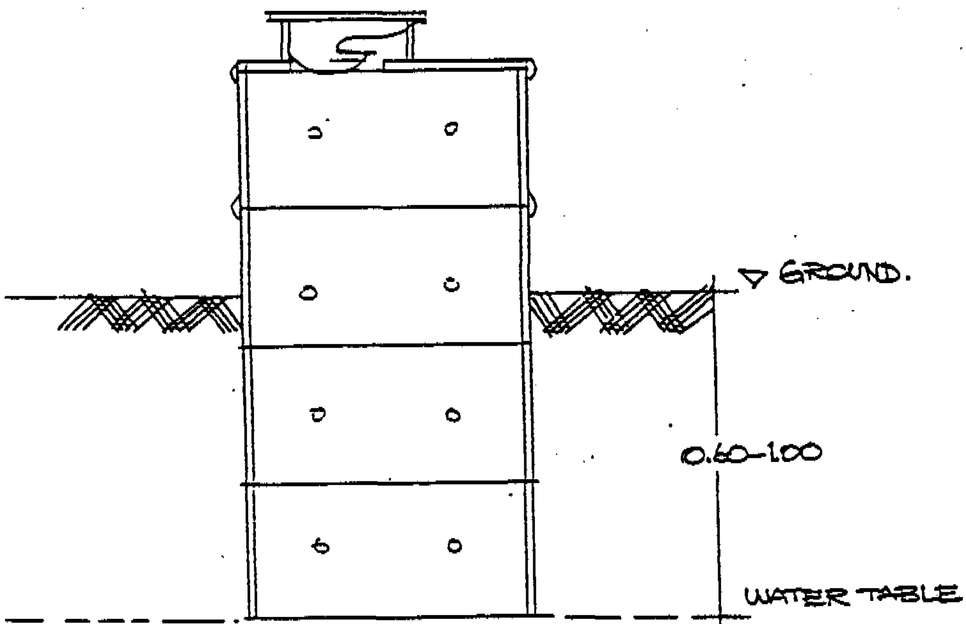


FIG. 5 SIMPLIFIED CESSPOOL USED IN SLUM

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the water seal of the squatting plate to enter the tank. In its simplest form this last element is made of concrete with a terrazzo facing, the more expensive model is made of China. Only the squatting plate protudes from the floor. The water seal is flushed with a small quantity of water either by hand or with an automatic flush.
This type of squatting plate is also used in public buildings which are linked with a septic tank system.
The rings have eight small dents in the sides which allow the rings to be punctured. This arrangement was made in the original cesspool design which allowed cesspool effluent to leach out of the tank.
The rings were therefore to be surrounded by a mantel of gravel so that the fluids through a soakage around the tank could perculate into the ground. The high water table of Bangkok and the clay do however prevent this from happening. The rings are usually left unpunctured, and the refill is the excevated soil from the pit.

The bottom of the pit is left open and the water level in the cess pool corresponds therefore with that of the groundwater. The volume of the cesspools are related to the number of rings used in the construction and this differs widely. Where the original design basically intended to be an underground, leaching tank, the present practice is often very different. Many houses are built on stilts, sometimes on flooded land and the floor of the house may be as much as 150 cm over the surrounding soil.
In these cases the tanks may have been build more above ground than underground. In some cases only half a meter of the tank penetrates the soil and the main volumes rises from that level to the floor of the house. As a result leaching effluent does nor perculate through a thick layer of soil but comes straight out in the surface water.

The cesspool design is suitable for the Thais because some water is needed to flush it. As little as two litres will do and the use of water for anal cleansing - as the population reports helps. Only few people are using toilet paper and this may cause blockages of the waterseal. It is fairly common to throw of this paper in a waste bin next to the toilet and dispose of it later with the garbage of the house this habit others still many possibilities for vector transmission and fly breeding

It is not unusual to throw waste water into the cesspool: do so. Garbage at the other hand is not flushed down,

The cess pool needs to be emptied periodically, when the solids have filled most of the tank. The normal procedure is to use a vacuum truck and insert the hose through a metal lid that has been mounted in a socket in the coverplate. It is however often difficult to unscrew this lid and the truck operators seldomly attempt to unscrew it. They find it easier to scissel away the mortar that holds the squatting plate, lift it off and seal it into place after completion the procedure.

The Municipality (BMA) operates vacuum trucks to empty the cesspools and septic tanks of Bangkok . The official charges seem to be about but it often takes some extra contribution to persuade the driver to come to the house; Higher income groups prefer this method.(

The sludge is dewatered and composted in two locations in Bangkok and then mainly used for landfill.

Table 3. Means of Emptying the Cesspit

Means	Percantage of Use
Pump-truck service	45
Draining into a new pit	12
Build new toilet (new pit)	8
Dump in the community	8
Dump in canals	3
Dump in public drains or sewers	2
Total	78

Note : 22% of the respondents never had to empty their cesspits

Table 4 Quality of Water Under Slum Houses

Slum No.	Bacterial count colonies/100 ml	MPN/100 ml	COD (mg/l)
1	5.1×10^4	100	40.0
13	1.0×10^5	100	31.0
	2.0×10^3	110	37.0
15	1.0×10^3	100	35.0
16	2.0×10^5	1,100	43.7

Research from Thailand Institute of Scientific and Technological Research (TISTR) in co-orporation with Mahidol Universisiervity, Thailand, 1981

AQUA - PRIVIES

DEFINITION AND DISTINCTIONS

The aqua-privy can be regarded as a simplified septic tank system – excreta are deposited directly into a tank, rather than being flushed along a short length of pipe before reaching it. The distinction between the two devices, and the simpler construction of the aqua-privy, is made clear by Figure . This distinction needs to be emphasized because in some countries, notably India, terminology is different, and the term 'septic tank' is consistently used to describe what this book calls an 'aqua-privy'. The two systems use the same principle – anaerobic fermentation or digestion of excreta in a tank of water – but an aqua-privy costs less than a septic tank, and requires less water for its operation.

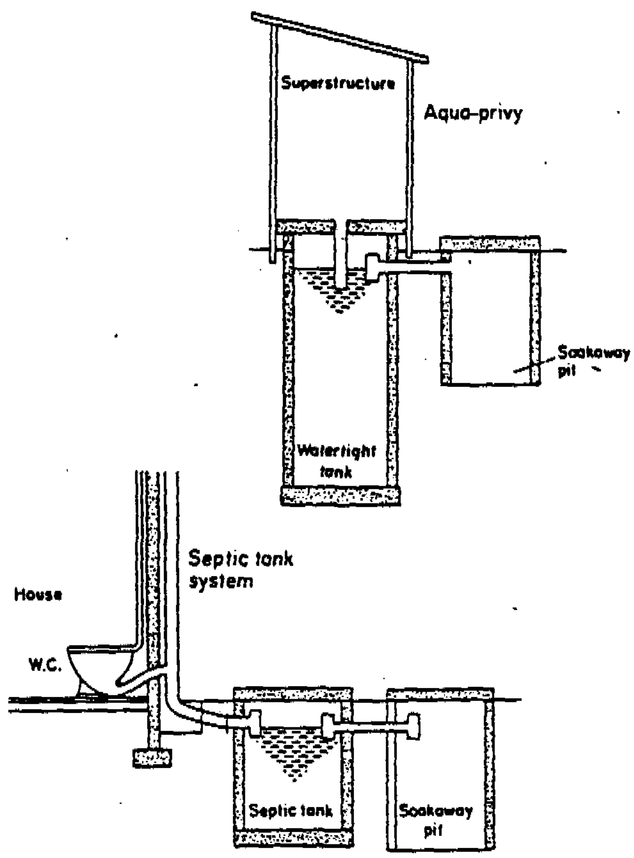
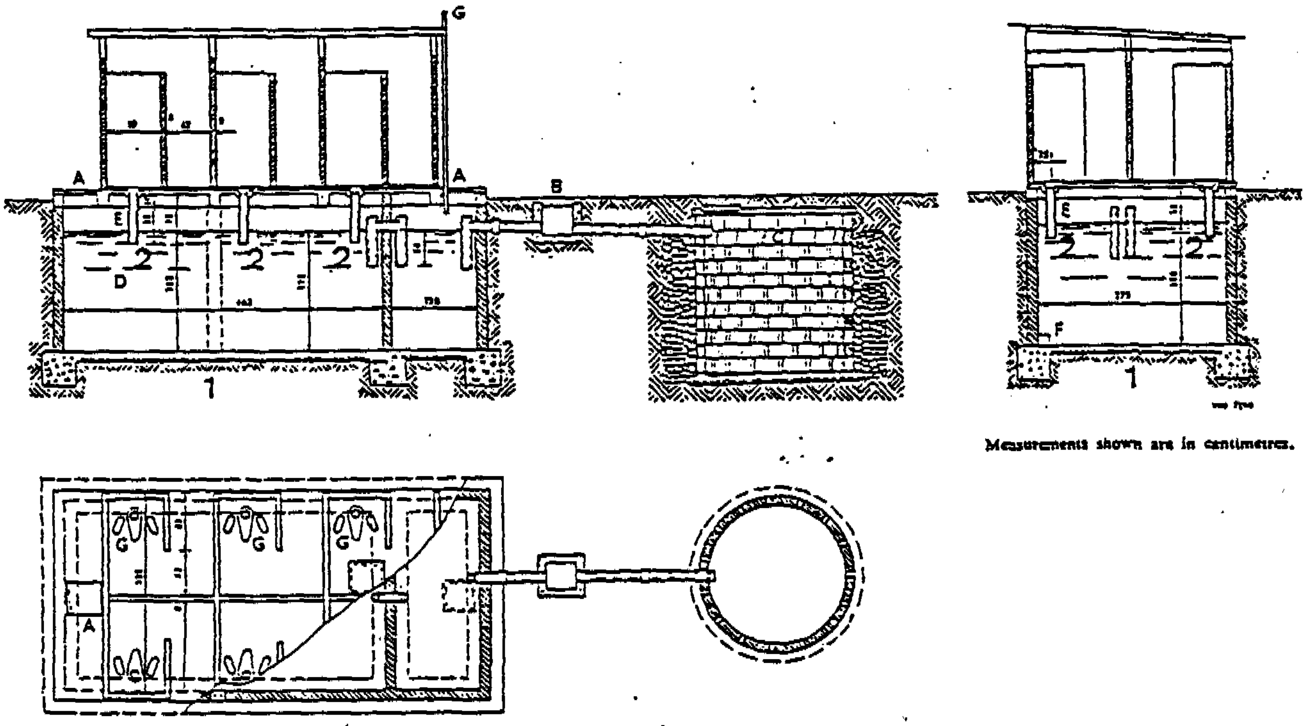


Figure 5. Comparison of the principle of the aqua-privy and the principle of the septic tank. The aqua-privy shown has a simple drop pipe as used in rural areas of Nigeria



Reproduced by permission of the United Nations Relief and Works Agency for Palestine Refugees in the Near East.

Check list

1. Is the concrete tank of watertight construction ?

A = Inspection manholes, 40 × 40 cm
B = Inspection box, 40 × 40 cm
C = Soakage pit or soakage trench
D = Capacity of tank : 22.3 m^3

2. Do the drop pipes extend below water outlet level ?

E = Drop pipe 10.5 cm in diameter
F = Opening 15 × 15 cm in partition wall
G = Ventilator pipe

Fig. 6. An aqua privy installation suitable for an institution. (From Rajagopalan & Shiffman).

General construction
The most common form of construction in developing countries is a concrete floor, rendered blockwork walls and a reinforced concrete cover slab. The floor is usually 100 mm thick unreinforced concrete, but some reinforcement may be provided in poor ground. The walls of a small tank can be made with 150–200 mm blocks, rendered with good cement mortar on the inside to make them completely watertight.

Prefabricated aqua-privies are produced from a variety of materials. Concrete units were built in large numbers in the West Indies from about 1947[11]. The design shown in Figure 13 was used in Calcutta's slum upgrading projects in the late

Aqua-privy chutes
Most aqua-privies are built under a squatting slab and a chute is formed by a vertical pipe. This is often 100 mm internal diameter. It is essential that the pipe extends at least 75 mm below the liquor level in the tank. The pipe may be integrally cast with the squatting plate.

There are two main variations to the usual chute;

a. Aqua-privies with seats are built where the local practice is to sit rather than squat, as in the West Indies and Botswana. (Figure 16).

b. Pour-flush water seals can be provided where the local practice is to use water for anal cleaning, as in the Calcutta type shown in Figure 13.

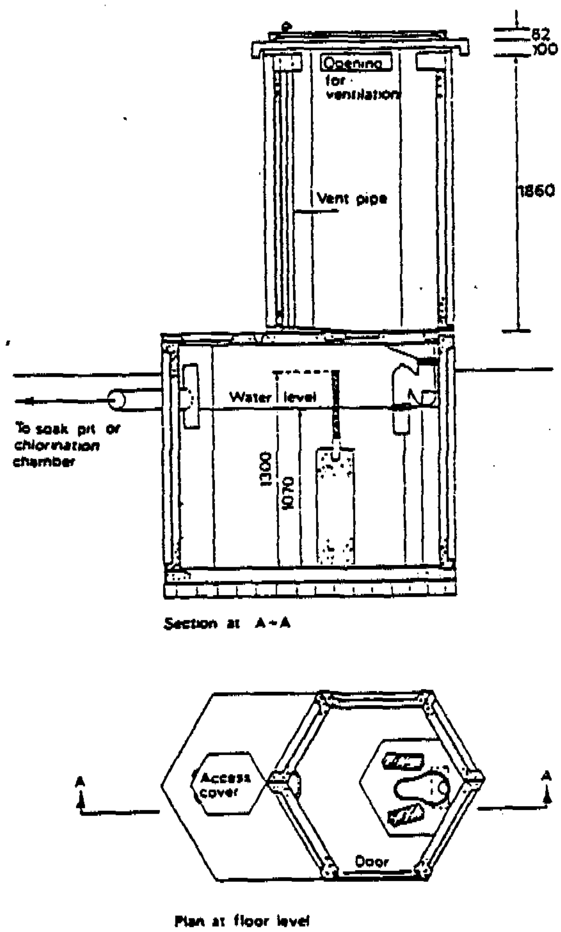


Figure 13 Aqua-privy for slum upgrading scheme in Calcutta

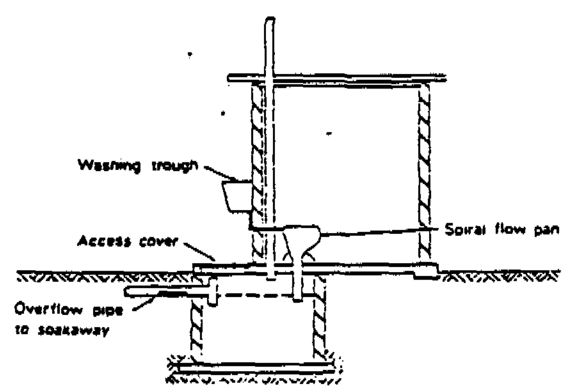


Figure 16 The type B aqua-privy used in Botswana

Outlets

Outlets for septic tanks and aqua-privies less than 1200 mm wide are usually made with a T-junction set so that the bottom of the horizontal leg is 50–75 mm below the level of the inlet pipe. The bottom of the pipe is called the invert, and the outlet invert fixes the water level in the tank. As with the inlet T-junction, the vertical leg must extend above the top and bottom of the scum layer. Liquor must be discharged from the liquor zone between the scum and the sludge.

Ventilation

Digestion of the sludge, and to a lesser extent the scum, results in the release of gases. These are mostly carbon dioxide and methane, but there are small amounts of other foul-smelling gases and some form of ventilation is therefore necessary for the tank. In household systems a screened outlet is often placed at the upper end of the drains and gases escape from the tank through the upper limb of the inlet T-junction. An alternative is to allow gases to escape through holes in the access covers. This does not avoid nuisance from bad smells, but prevents a build-up of pressure in the tank. A better method is to provide a ventilating pipe for the tank itself, and this is suitable both for aqua-privies .

Operation and starting-up

A newly-built aqua-privy should be tested for water-tightness by filling it with water and allowing the water to stand for a day. The water need not be piped drinking water if there is a stream, well or irrigation canal nearby. After testing, the tank should be left full of water. Digestion is helped by throwing in some well-digested material (such as sludge from an old tank).

Maintenance

The only maintenance necessary for well-constructed and properly-used . aqua-privies is the removal of surplus sludge and scum to leave a clear central zone for liquor. Proper use of an aqua-privy involves keeping the squatting plate clean and ensuring that the water level in the tank does not fall by adding enough water to make up for evaporation. If the chute becomes blocked it may be necessary to clear it with a stick.

Regular inspection of the tank is necessary to find out whether the sludge and scum levels are acceptable.

. If hard material is used for anal cleaning the sludge level in a small aqua-privy should be checked at monthly intervals.

The most satisfactory method of sludge removal is to use a tanker lorry equipped with a pump and flexible suction hose.

It is not uncommon for the suction pipe to be lowered down the chute of an aqua-privy, but this often results in damage to the chute. Therefore a removable access cover should be built in the top or side of the tank.

The bottom of the sludge is well-consolidated and a high proportion of the material may be sand cemented together by fine particles. Most of this material should be removed. Some tanker lorries are equipped with a hosepipe so that a jet of water can stir up the hard deposits. If a jet is not available the sludge should be disturbed with the end of the suction pipe or with a stick or long-handled spade.

When a tanker lorry is not available, it is usual to dig out the sludge with a long-handled shovel, and to remove it in buckets or tins. This is unpleasant work and can be a health hazard, as the sludge may still contain some pathogenic micro-organisms. An alternative used in some places is an animal-drawn tank fitted with a hand-operated suction pipe.

By whatever means it is collected, the material removed from the tank is a mixture of harmless matter (such as sand and well digested sludge) and potentially harmful fresh sewage and undigested sludge. It can only safely be used for agriculture or horticulture when persistent pathogens have been eliminated—for example by a long period of drying or by composting with vegetable waste. The provision of a sound collection and disposal service is essential for the health of the community.

It is particularly important to fill the tank of an aqua-privy so that the bottom of the inlet is covered.

Material and Labor Requirements

The aquaprivy vault may be constructed of brick, concrete, or concrete block and must be water-proofed with a stiff mortar. The smaller units may be prefabricated of plastic, if economically feasible.

Self-help labor is suitable for excavation work, but the vault construction requires skilled bricklayers.

Maintenance Requirements

Maintenance is simple. The aquaprivy should be kept clean and the vault desludged at 2-to-3-year intervals. An adequate supply of water is necessary for "flushing" and to maintain the water seal.

Water Requirements

Water required to maintain the water seal depends on local climatic conditions. In the sullage aquaprivy, the amount of sullage water discharged to the privy is sufficient to maintain the water seal, provided all sullage water is drained to the vault. In practice this means that wherever sullage water is used to irrigate a garden, self-topping aquaprivies are not recommended unless water is piped to the house or yard--or the users are educated well enough to maintain the water seal.

SEPTIC TANK

DESCRIPTION OF SEPTIC TANK

The septic tank is an on-site means of disposing of wastewaters from the household. Its construction, operation and maintenance is carried out solely within the confines of the private property, apart from infrequent desludging of the tank. As such it is often regarded as a panacea for sewage disposal by municipalities in that when operated properly the municipality need not be involved technically or financially; the system can be entirely supported by the individual house owner.

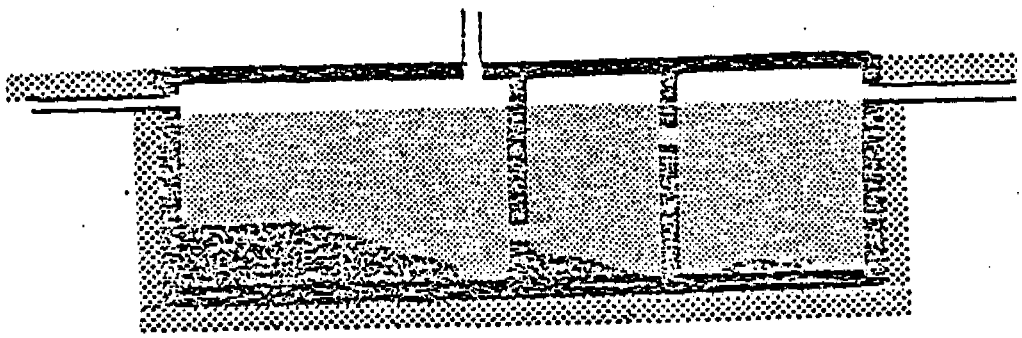
The septic tank consists of a large tank placed beneath the ground level in close proximity to the house from which it receives its influent of kitchen, cleansing and toilet wastewaters. Most of the solids in the waste settle in the tank as sludge and digest (ferment) on its bottom. The effluent leaves by overflow into a subterranean pipe or trench system which distributes it for percolation into the soil.

Unfortunately the septic tank has serious disadvantages. The first and most important one is that it is expensive, often costing more on a per household basis than separate sanitary sewers; its use is confined to the wealthier suburbs. The second is that it requires large areas of permeable subsoil through which it can distribute its effluent; where population densities are high the open spaces of land required for these purposes are too limited for its widespread use. Thirdly, in the majority of cases where cities have been built near rivers or in deltaic areas, the subsoil structure is too impermeable for the leaching of septic tank effluent; being unable to permeate the soil the effluent, still laden with pathogens, flows across the ground and, thereby hastening the spread of disease and not allaying it (Figure). Finally, and most insidious of all, the temptation of the municipality to rely upon privately owned systems during initial periods of urban growth may be too great and result in very costly reversions to other methods when population densities no longer allow septic tanks to function properly.

Other costs to be considered are those which affect the community as a whole. As often as not, vents on the septic tank are not effectively screened and the unit becomes an insect breeding ground. If a policy of endorsing septic tanks is followed in time by the installation of a municipal sewerage scheme there is a real danger of double costing, leading to public hostility if hook-up to the sewerage scheme is not offered entirely on a voluntary basis. Foresight is required to ensure that septic tanks are fully depreciated before sewerage schemes are imposed on the municipality.

Characteristic

Nimpuno gave a characteristic of septic tank that,



TYPE OF PROCESS:
Anaerobic digestion. Sedimentation in two or three chambers. Regular sludge removal required.

DECOMPOSITION:
Partial, sludge still instable and virulent, requires maturing.

PATHOGENE DESTRUCTION:
Partial, sludge and effluent still virulent.

HANDLING OPERATIONS:
Monthly sludge checks, annual sludge removal. Requires each time 15-25 l of flushing water. Sludge removal to be organized.

PERSONAL HYGIENE:
Good

ENVIRONMENTAL HYGIENE:
Ground water pollution likely. Overflow occurs if not maintained properly.

CAPACITY:
Large, usually one tank for each building.

CONSTRUCTION:
Concrete or masoned underground tanks, connected to soakage or trench drain.

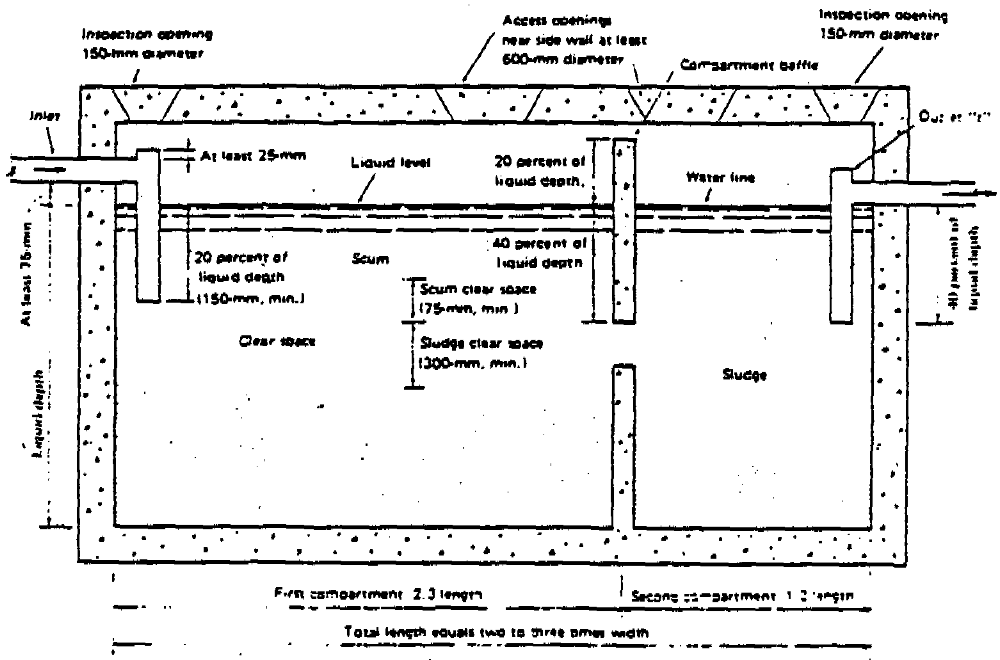
TRANSPORT:
Waterborne.

SERVICE INPUT:
Water

ECONOMY:
Medium

ADAPTABILITY:
In rural and urban situations, where ground water can be accepted.

Figure . . Schematic of Conventional Septic Tank (millimeters)



Note: If vent is not placed as shown on figures 13-2, 3, and 4, septic tank must be provided with a vent.

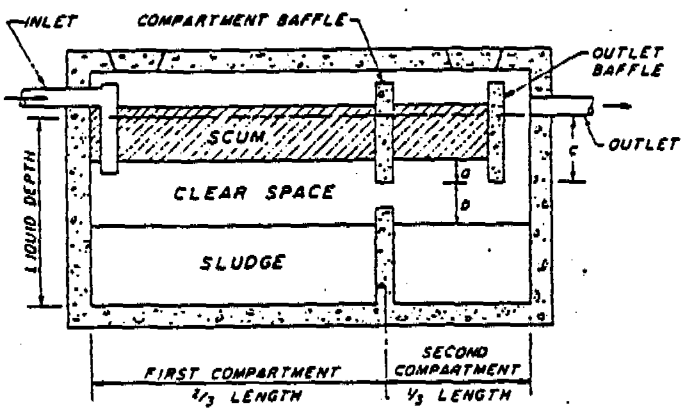
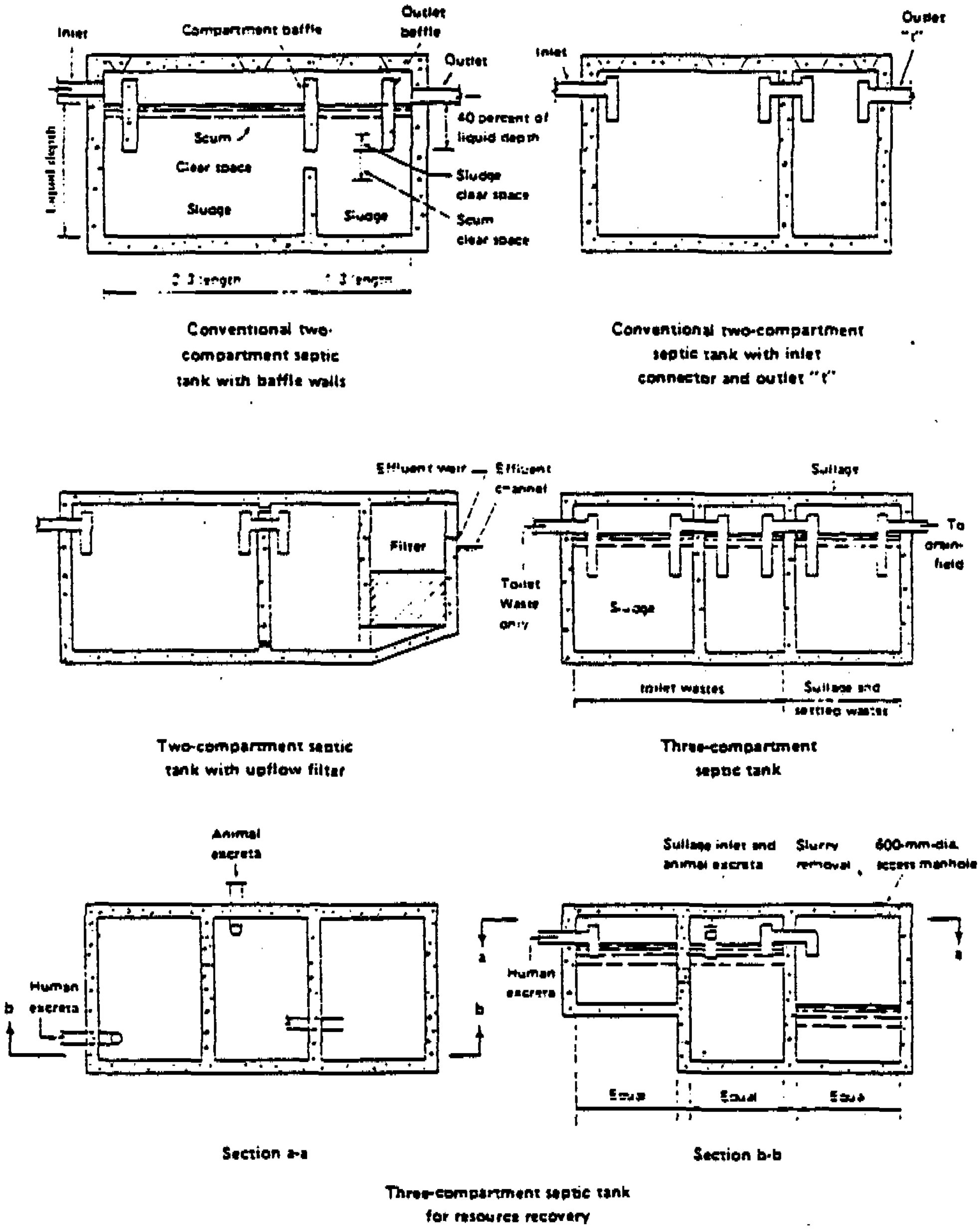


Figure . Two compartment septic tank: *a*, scum clear space (75 mm minimum); *b*, sludge clear space (300 mm minimum); *c* = 40 per cent of liquid depth [From Cotteral and Norris[3]]

Figure . Alternative Septic Tank Designs
(millimeters)



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OPERATION AND MAINTENANCE OF SEPTIC TANK

Ventilation
Digestion of the sludge, and to a lesser extent the scum, results in the release of gases. These are mostly carbon dioxide and methane, but there are small amounts of other foul-smelling gases and some form of ventilation is therefore necessary for the tank. In household systems a screened outlet is often placed at the upper end of the drains and gases escape from the tank through the upper limb of the inlet T-junction. An alternative is to allow gases to escape through holes in the access covers. This does not avoid nuisance from bad smells, but prevents a build-up of pressure in the tank. A better method is to provide a ventilating pipe for the tank itself, and this is suitable both for aqua-privies and for septic tanks.

Operation and starting-up
A newly-built septic tank or aqua-privy should be tested for water-tightness by filling it with water and allowing the water to stand for a day. The water need not be piped drinking water if there is a stream, well or irrigation canal nearby. After testing, the tank should be left full of water. Digestion is helped by throwing in some well-digested material (such as sludge from an old tank).

Maintenance
The only maintenance necessary for well-constructed and properly-used septic tanks and aqua-privies is the removal of surplus sludge and scum to leave a clear central zone for liquor.

Regular inspection of the tank is necessary to find out whether the sludge and scum levels are acceptable. A septic tank should be inspected at half the design time.

The most satisfactory method of sludge removal is to use a tanker lorry equipped with a pump and flexible suction hose. Removable covers should be provided for all compartments of septic tanks, and are best at the inlet ends, where sludge accumulation is greatest.

The bottom of the sludge is well-consolidated and a high proportion of the material may be sand cemented together by fine particles. Most of this material should be removed. Some tanker lorries are equipped with a hosepipe so that a jet of water can stir up the hard deposits. If a jet is not available the sludge should be disturbed with the end of the suction pipe or with a stick or long-handled spade.

When a tanker lorry is not available, it is usual to dig out the sludge with a long-handled shovel, and to remove it in buckets or tins. This is unpleasant work and can be a health hazard, as the sludge may still contain some pathogenic micro-organisms. An alternative used in some places is an animal-drawn tank fitted with a hand-operated suction pipe.

By whatever means it is collected, the material removed from the tank is a mixture of harmless matter (such as sand and well digested sludge) and potentially harmful fresh sewage and undigested sludge. It can only safely be used for agriculture or horticulture when persistent pathogens have been eliminated—for example by a long period of drying or by composting with vegetable waste. The provision of a sound collection and disposal service is essential for the health of the community.

A septic tank should never be completely emptied. Some old sludge should always be left at the bottom to ensure that digestion continues. (This is known as 'seeding'). After desludging, the tank should be filled with water. It is particularly important to fill the tank of an aqua-privy so that the bottom of the inlet is covered.

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I.3.2 OFF-SITE SANITATION SYSTEMS IN THAILAND

Safe human excreta disposal and treatment for communities is considered as, are of the basic physical infrastructure. Although on-site sanitation systems are most dominant in Thailand, off-site sanitation systems have become more popular. Especially BMA and provincial governments have been providing community treatment plants. The main reasons for choosing off-site sanitation systems are:

Criteria for sewage systems, the ideal system should satisfy all of the following criteria:

1. Health criteria. Pathogenic organisms should not be spread either by direct contact with the nightsoil or sewage or indirect via soil, water or flood or food. The treatment chosen should achieve a high degree of pathogen destruction.

2. Ecological criteria. The treatment process should yield a safe effluent into a surface water which should not exceed the self-purification capacity of the recipient water.

3. Nuisance criteria. The degree of odor, noise and eye-sight release must be below the nuisance

threshold. No part of the system should become aesthetically offensive.

4. Cultural criteria. The methods chosen for waste collection, treatment and disposal should be compatible with local habits and social (religious) practice.

5. Operational criteria. The skills required for the routine operation and maintenance of the system component must be available locally or are such that they can be acquired with only minimum training

6. Cost criteria. Capital and running cost must not exceed the community's ability to pay. The financial return from re-use schemes is an important factor in this regard.

Focusing on NHA schemes, the NHA has been a pioneer in domestic waste treatment plants, off-site sanitation system; in Thailand. He gains the experiences in this field for more than 10 years (since 1974). for choosing and designing an off-site treatment system the following consideration should be kept in mind:

Treatment plant design is one of the most challenging aspects of environmental engineering. Both theoretical knowledge and practical experience are necessary in the selection and analysis of the process flowsheet. Practical experience is especially important in the design and layout of the physical facilities and appurtenances and in the preparation of plans and specification. The detailed aspects of process analysis, physical unit operation, chemical unit processes operation and biological unit process operation are considered. The key steps to show how treatment plant designs are synthesized, the important terms are defined as follows:

1. Flowsheet. A flowsheet is the graphical representation of a particular combination of unit operations and processes used to achieve specific treatment objectives.

2. Process loading criteria. The process loading (or design) criteria are the key criteria used as the basis for sizing the individual unit operations and processes.

3. Solid balance. The solid balance is determined by identifying the quantities of solids entering and leaving each unit operation or process.

4. Hydraulic profile. The hydraulic profile is used to identify the elevation of the free surface of the wastewater as it flow through the various treatment units. Friction loss due to kind of pipe selected, head loss are considered.

5. Plant layout. The plant layout is the spatial arrangement of the physical facilities of the treatment plant indentified in the flowsheet.

6. Other important considerations.

CRITICAL INFORMATION ITEMS NEEDED FOR SELECTION AND DESIGN OF SANITATION SYSTEMS

Climatic conditions

Temperature ranges; precipitation, including drought or flood periods.

Site conditions

Topography.
Geology, including soil stability.
Hydrogeology, including seasonal water table fluctuations.
Vulnerability to flooding.

Population

Number, present and projected.
Density, including growth patterns.
Housing types, including occupancy rates and tenure patterns.
Health status of all age groups.
Income levels.
Locally available skills (managerial and technical)
Locally available materials and components.
Municipal services available, including roads, power.

Environmental sanitation

Existing water supply service levels, including accessability and reliability, and costs.
Marginal costs of improvements to water supply.
Existing excreta disposal, sullage removal and storm drainage facilities.
Other environmental problems such as garbage or animal wastes.

Socio-cultural factors

People's perceptions of present situation and interest in or susceptibility to change.
Reasons for acceptance/rejection of any previous attempts at upgrading.
Level of hygiene education.
Religious or cultural factors affecting hygiene practices and technology
Location or use of facilities by both sexes and all age groups.
Attitudes towards resource reclamation.
Attitudes towards communal or shared facilities.

Institutional framework

Allocation of responsibility, and effectiveness of state, local or municipal institutions, in providing the following services:
Water
Severage, Sanitation, Street cleansing, Drainage
Health
Education
Housing and urban upgrading

Note: The priority between various items will vary with the sanitation options being considered; the list above indicates typical areas which should be investigated by planners and designers.

OFF-SITE SANITATION TREATMENT PLANTS

At present, domestic waste treatment plants in Thailand are predominant in NHA scheme, which can be catagorized to 4 types:

1. Oxidation pond (waste stabilization ponds)
2. Aerated Lagoon.
3. Activated Sludge
4. Oxidation ditch.

My purposes do not intend to reproduce a text book on off-site treatment plants, so for more detail of each types can be found in the text book of Mara, 1980 [ref. no.]

However, for general overviews, the description and some details of each systems are shown below:

WASTE STABILIZATION PONDS

DESCRIPTION

Waste stabilization ponds are large shallow basins enclosed by earthen embankments in which raw sewage is treated by entirely natural processes involving both algae and bacteria. Since these processes are unaided by man (who merely allocates a place for their occurrence) the rate of oxidation is rather slow and as a result long hydraulic retention times are employed, 30–50 d not being uncommon. Ponds have considerable advantages (particularly as regarding costs and maintenance requirements and the removal of faecal bacteria) over all other methods of treating the sewage from communities of more than about 100 people. They are without doubt the most important method of sewage treatment in hot climates where sufficient land is normally available and where the temperature is most favourable for their operation.

Desludging frequency

The rate of sludge accumulation is approximately 0·03–0·04 m^3/hd year and desludging is required when the pond is half-full of sludge.[22] This occurs every n years where n is given by:

$$n = \frac{\frac{1}{2}\ (\text{pond volume, } m^3)}{(\text{sludge accumulation rate, } m^3/\text{hd yr}) \times (\text{population})}$$

For the purpose of design the rate of sludge accumulation may be estimated as 0·04 m^3/hd yr.

Odour release and control

The release of objectionable odours from anaerobic ponds occurs when the volumetric loading on the pond is > 400 g BOD_5/m^3d. Thus even for a very strong sewage (say, $BOD_5 = 1000$ mg/l) odour release is unlikely to be a problem when a retention time of 5 d is employed. The presence of industrial or agricultural wastes, particularly those with high concentrations of sulphate, may cause odour release. Odour control then becomes necessary and this may be achieved by:

(1) Raising the pH of the pond to about 8 so that most of the sulphide—formed by the bacterial reduction of sulphate—will exist as the odourless bisulphide ion (HS^-); under these conditions the release of the malodorous hydrogen sulphide gas (H_2S) is virtually non-existent.
(2) Recirculating the effluent from the facultative or maturation ponds to the anaerobic pond inlet in the ratio 1 to 6 (1 volume of effluent to 6 volumes of raw sewage).

There are three types of ponds: facultative, aerobic (maturation) and anaerobic pond.

Anaerobic pretreatment ponds, which function much as open septic tanks. In anaerobic processes, biological treatment process, occur in the absence of oxygen. Bacteria that can survive only in the absence of any dissolved oxygen are known as obligate anaerobes. The pond have retention times of one to five days and depth of 2–4 meters. Anaerobic ponds require periodic desludging and, if not properly designed and operated, will have strong odors.

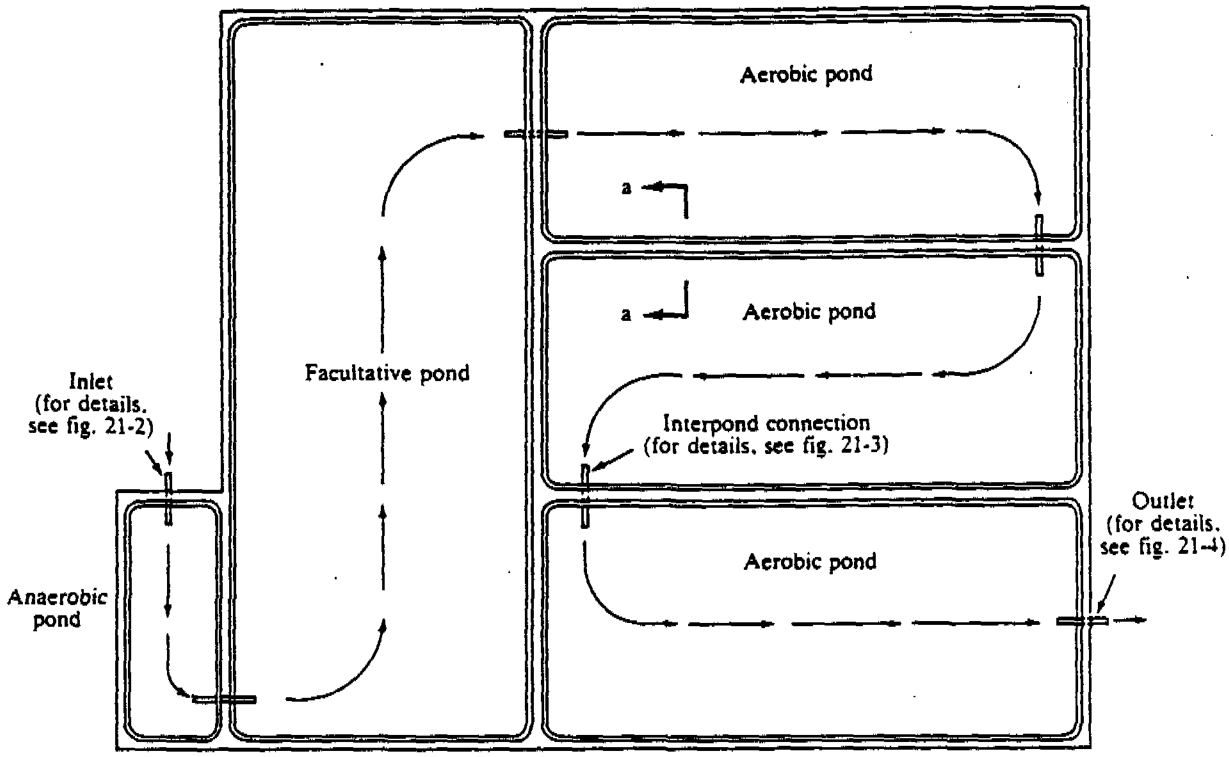
• Facultative ponds, in which the oxygen necessary for biooxidation of the organic material is supplied principally by photosynthetic algae that growth in them naturally and with great profusion. The organisms in the biological treatment process are indifferent to the presence of dissolved oxygen. These organisms are known as facultative micro-organisms. The pond require retention time of five to thirty days (sometime more) and depths of 1 to 1.5 meters. The lower layers of these ponds are usually anaerobic.

• Aerobic maturation ponds, are responsible for the qualities pond effluent. Biological treatments processes that occur in the presence of oxygen. by mean of photosynthesis reaction of algae, O_2 transfer from atmospheric wind. Certain bacteria that can servive only in the presence of dissolved oxygen are known as obligate aerobes (restricted to a specified condition in life). The aerobic maturation ponds have retention times of five to ten days and depth of about 1 to 1.5 meters. Each pond in a series of ponds will generally reduce the fecal coliform concentration by about an order of magnitude.

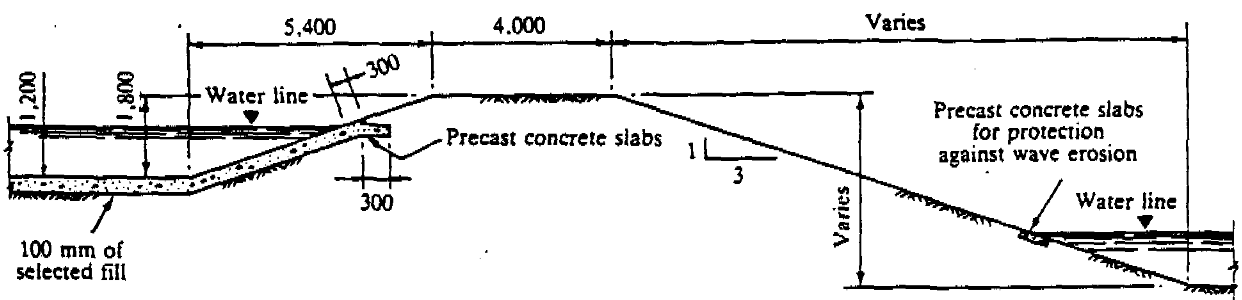
Anaerobic and facultative ponds are designed for BOD removal, whereas the function of maturation ponds is the destruction of excreted pathogens.

Thus, these three types of ponds should normally be used in conjunction to form a series of ponds, as show is figure

Figure . . *Stabilization Pond Layout and Details*
(millimeters)



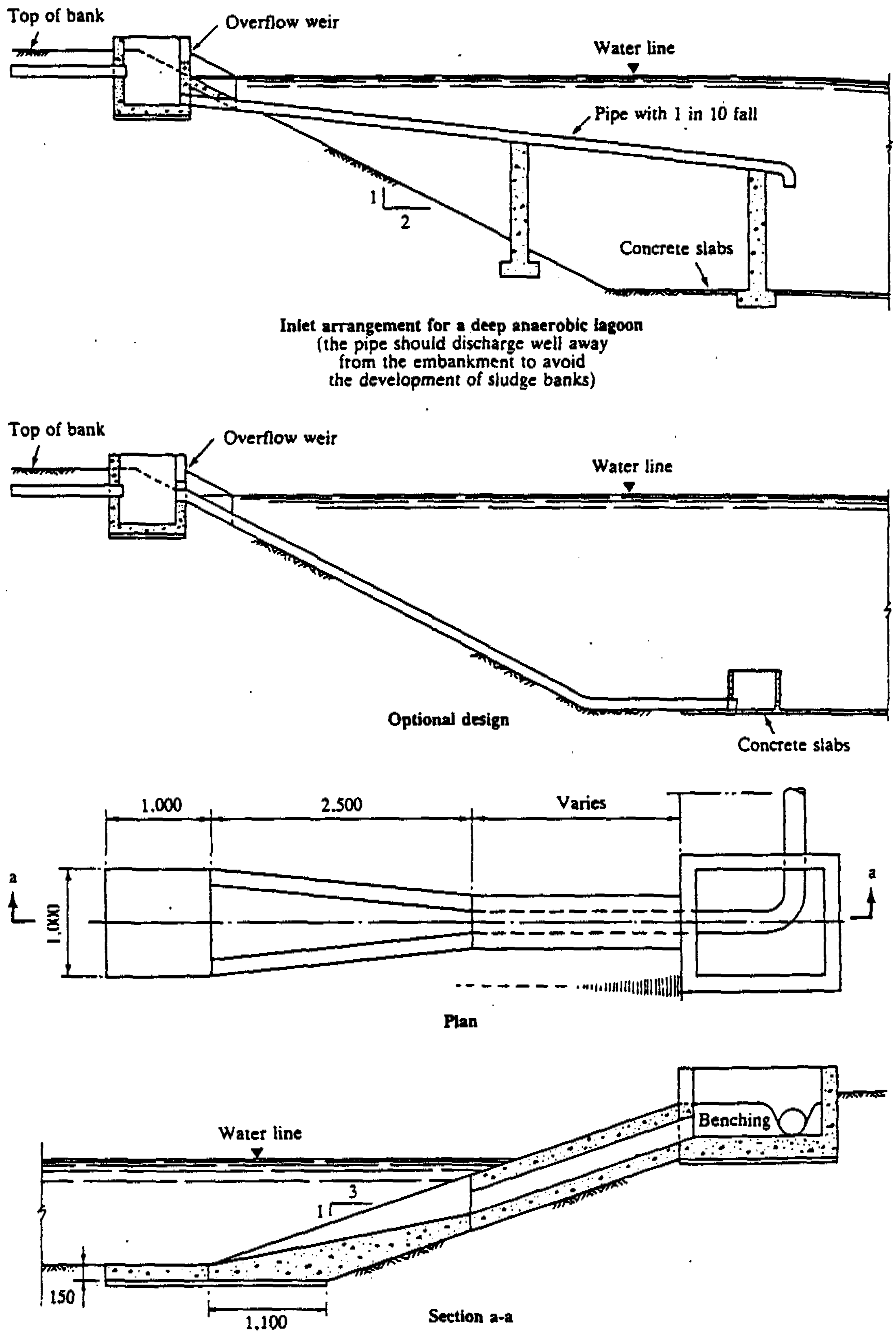
Plan layout
(not to scale)



Section a-a

Detail of a typical embankment

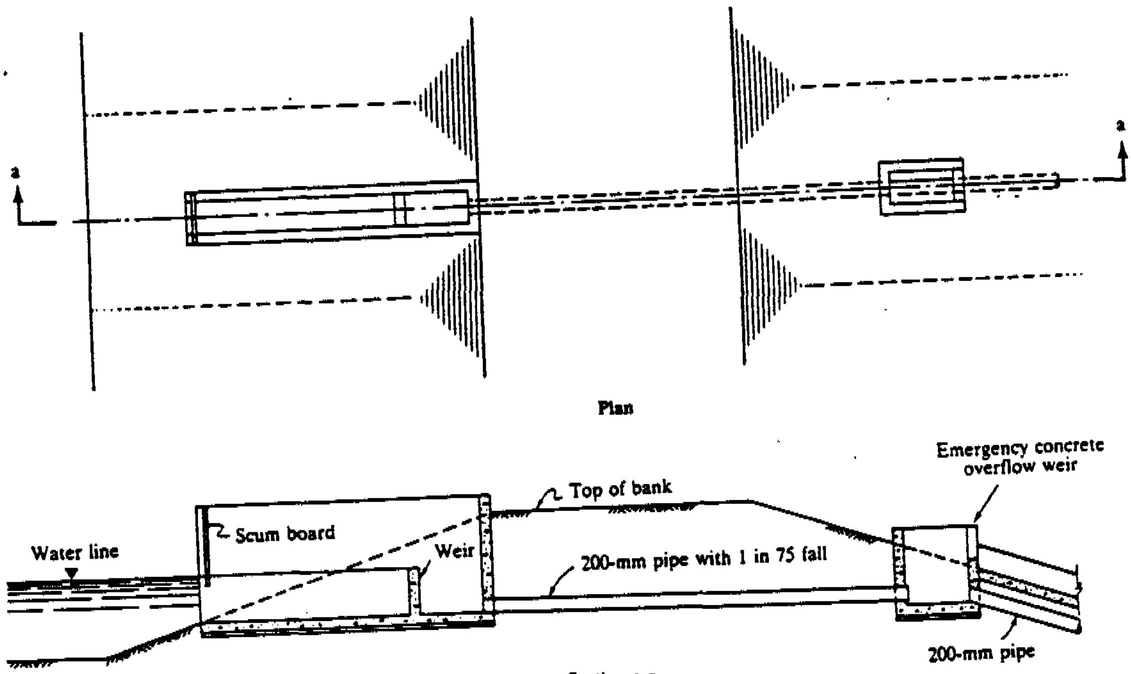
Figure .'' *Inlet Structures for Stabilization Ponds*
(millimeters)



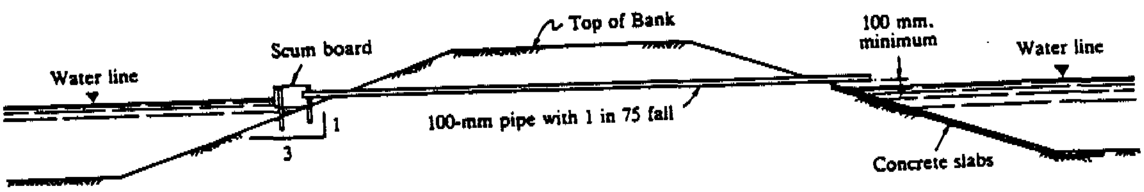
Inlet chute for a facultative or maturation lagoon

Source: Mara (1976). © John Wiley and Sons Ltd.; used by permission.

Figure . *Alternative Interpond Connections*
(millimeters)



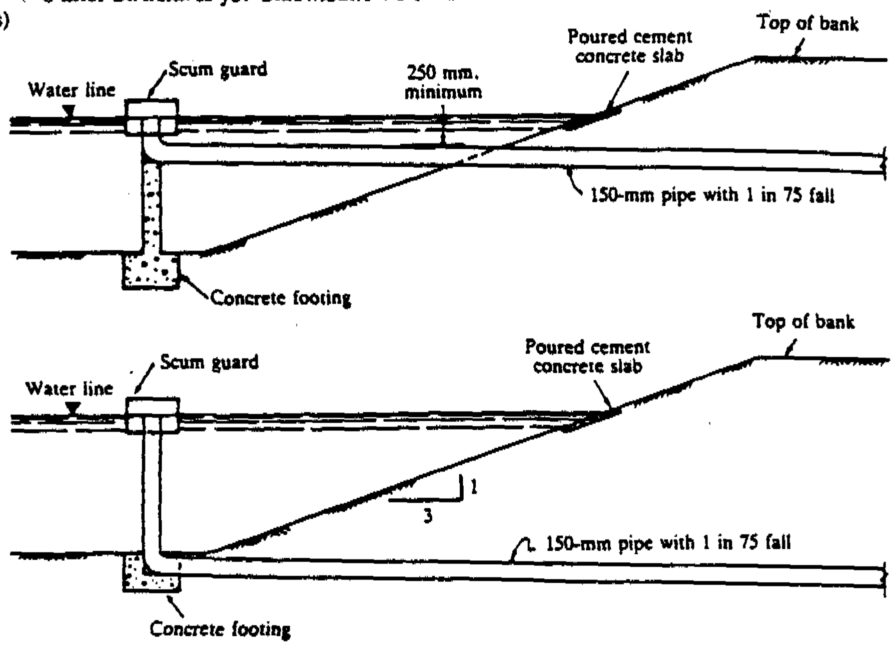
Interpond connection with concrete overflow weir



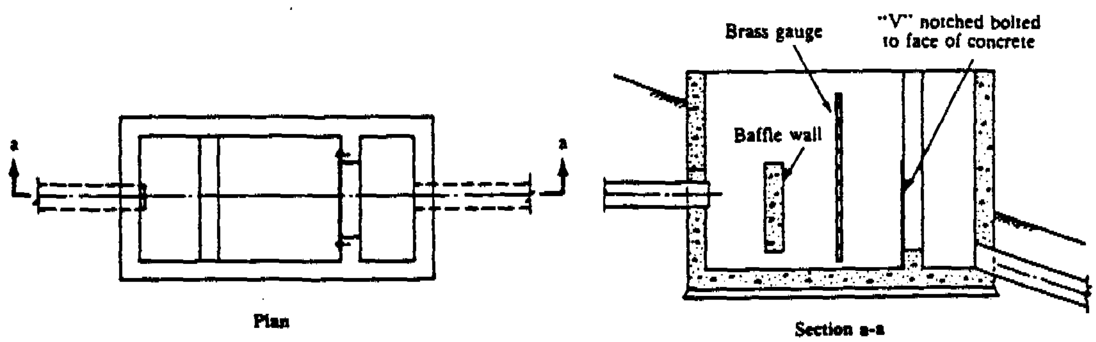
Simple interpond connection suitable for small lagoons

Note: Interpond connection, comprising a concrete overflow weir and a downstream junction chamber, would be connected to an inlet chute similar to that shown in figure 21-2.
Source: Mara (1976). ©John Wiley and Sons Ltd.; used by permission.

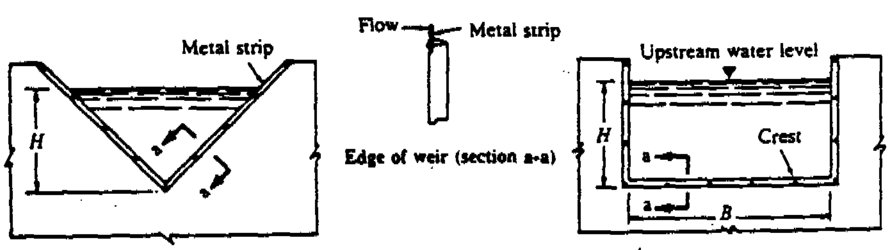
Figure ' . . *Outlet Structures for Stabilization Ponds*
(millimeters)



Alternative interpond connections made from standard pipe fittings



Flow-measuring chamber for final effluent



90° triangular weir (Q, m³/sec = $1.38H^{5/2}$)

Rectangular weir (Q, m³/sec = $1.84BH^{3/2}$)

Note: Q, quantity; m³/sec, cubic meters per second; H, heights; B, breadth.
Sources: For flow-measuring chamber, Mara (1976; ©John Wiley and sons Ltd.; used by permission). For weirs, Okun and Ponghis (1975).

FOR TYPICAL BIOLOGICAL PROCESS OPERATION OF OXIDATION POND ARE SHOWN AS BELOW:

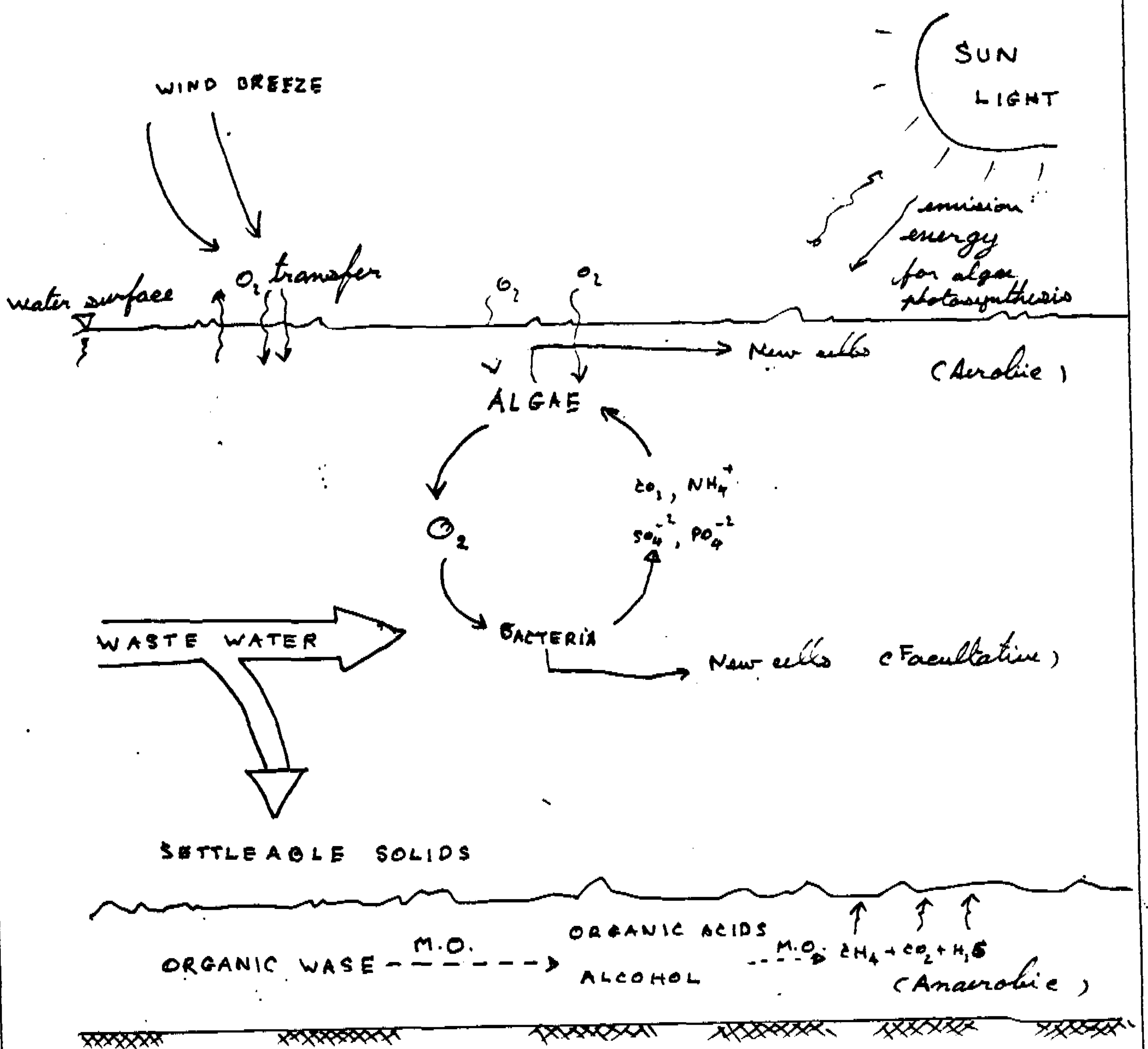


FIGURE BIOLOGICAL PROCESS OPERATION OF OXIDATION POND

AERATED LAGOON

DESCRIPTION

Aerated lagoons are activated sludge units operated *without* sludge return. Historically they were developed from waste stabilization ponds in temperate climates where mechanical aeration was used to supplement the algal oxygen supply in winter. It was found, however, that soon after the aerators were put into operation the algae disappeared and the microbial flora resembled that of activated sludge. Aerated lagoons (Figure 8.1) are now usually designed as completely mixed non-return activated sludge units. Floating aerators are most commonly used to supply the necessary oxygen and mixing power.

Aerated lagoons achieve BOD_5 removals > 90 per cent at comparatively long retention times (2–6 d); retention times < 2 d are not recommended as they are too short to permit the development of a healthy flocculent sludge (even so the activated sludge concentration is only 200–400 mg/l, in contrast to the 2000–6000 mg/l found in conventional systems and oxidation ditches). They are often useful as pretreatment units before a series of ponds; particularly when used as a second stage of development to extend the pond capacity. In common with all activated sludge systems,

Figure 8.1 An aerated lagoon [Courtesy of Peabody Welles]

ACTIVATED SLUDGE

For conventional sewage treatment in temperate climate, normally comprises of four stages of treatment

1. Preliminary treatment, usually to removal of large floating objects and heavy settleable mineral particle eg sand, grit.

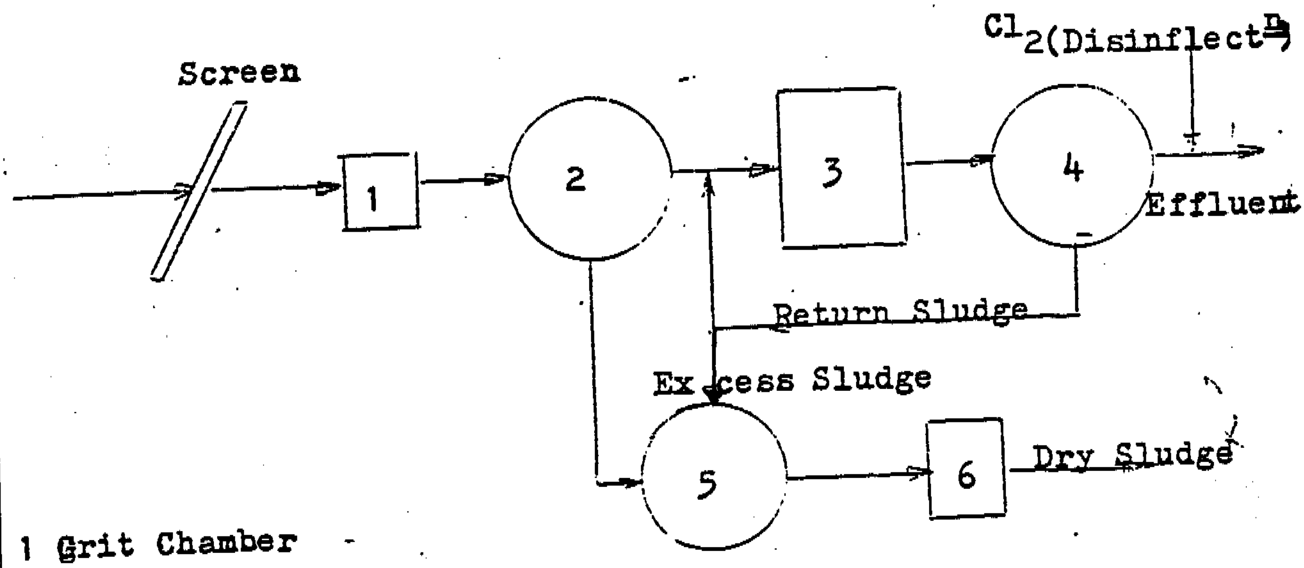
2 Primary or physical treatment (sedimentation) by mean of gravity or sometime flocculant agents are applied in order to enlarge capacity of tank by reducing detention settling solid time.

3. Secondary or biological treatment, here waste water that contain organic matter will be complete aerobic digestion by bacteria and microorganisms in sequence of actions.

4 Sludge treatment. The fresh sludge will be treated in anaerobic digestion tank or aerobic tank after complete digestion, sludge are disposal by landfill or being use as humus material for plantation.

For the typical flow diagram is show in FIGURE

FIGURE . TYPICAL FLOW DIAGRAM OF WASTE WATER TREATMENT PLANTS



1 Grit Chamber

2 Primary Sedimentation Tank

3 Aeration Tank

4 Final Sedimentation Tank

5 Digestion Tank

6 Sludge Pressed Machine/Drying Bed

DESCRIPTION OF ACTIVATED SLUDGE:

Activated sludge is the conventional alternative to biofiltration. Settled sewage is led to an aeration tank where oxygen is supplied either by mechanical agitation , or by diffused aeration . The bacteria which grow on the settled sewage are removed in a high-rate secondary sedimentation tank. In order to maintain a high cell concentration (2000–8000 mg/l) in the aeration tank, most of the sludge is recycled from the sedimentation tank to the aeration tank inlet. The sludge contains some inert solids but the main components making up its loose, flocculent structure are living or 'active' bacteria and protozoa—hence the name 'activated sludge'.

Mechanism of BOD removal

In settled domestic sewage much of the BOD is associated with the small suspended and colloidal solids; very little (< 5 per cent) of the BOD is due to organic compounds present in true solution. There are two phases of BOD removal by activated sludge. First there is a rapid initial removal by the entanglement of suspended solids within the gross sludge matrix and absorption of colloidal material on to the floc surfaces. This phase is followed by a slow progressive solubilization and oxidation of these waste compounds by the bacteria present within the sludge flocs.

Activated sludge systems

The conventional system (Figure 6.14 (a)) is a plug flow reactor operated with cell recycle. Oxygen is supplied at a uniform rate throughout the aeration tank, even though the oxygen demand decreases along the length of the tank. To overcome this waste, either the oxygen supply is progressively reduced along the tank (this modification is termed *tapered aeration*) or the influent is added in several stages, a process known as *stepped aeration* (Figure 6.14 (b)). In all of these systems the usual hydraulic retention time is 8–12 h at mean flow. In the *contact-stabilization* process (Figure 6.14 (c)) the two phases of BOD removal are separated. In the contact aeration tank a short time (0·5–1 h) is provided for solids entanglement and adsorption; the solids are settled out with the activated sludge flows in the secondary sedimentation tank and then aerated for 2–4 h to permit their solubilization and oxidation and so re-activate the sludge. This modification is only suitable for wastes with most of their BOD associated with suspended and colloidal solids, but in such cases considerable reductions in both capital and running costs results as the total aeration volume is much smaller.

If the aeration period in the conventional plant process is extended to *18–48h* the rate of sludge autolysis increases and substantially less sludge is produced. This principle of *extended aeration* is the basis of the oxidation ditch

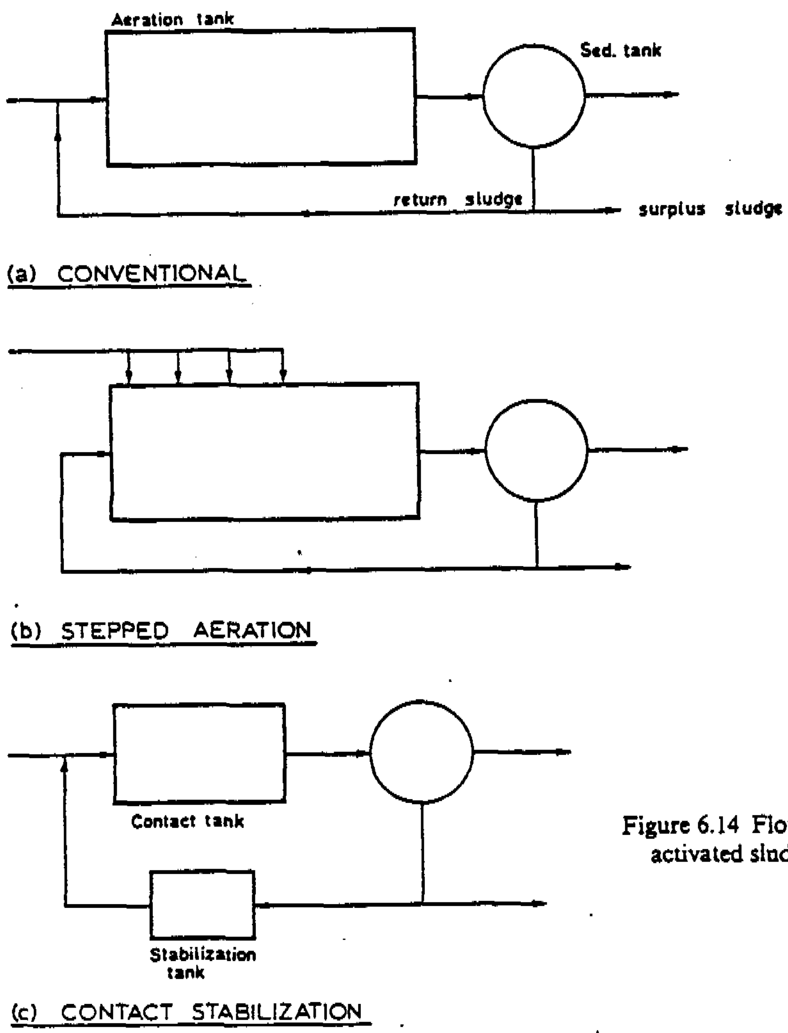


Figure 6.14 Flow diagrams for activated sludge processes

OPERATION AND MAINTENANCE OF ACTIVATED SLUDGE

Conventional sewage treatment relies heavily on electrical machinery—pumps, sludge scrapers, aerators—which requires considerable skill in installation, operation and maintenance. This skill, particularly in maintenance, is not

readily available in many of the tropical developing countries; for example a survey conducted in Kenya revealed that, outside Nairobi, none of the existing conventional works was working satisfactorily, the most common failure being associated with pumps and trickling filters

Odour

In hot climate sewage can soon become malodorous ('septic') if sufficient oxygen is not made available to prevent the onset of anaerobic conditions. A higher level of odour can thus be expected in hot climates to come from primary sedimentation tanks which are by their nature designed for quiescent settling and not turbulent oxygenation. This odour is however almost always masked by the even higher odour release from the biofilters. Indeed so intense is the odour from low-rate biofilters that in many hot climates, for example California, activated sludge plants are used simply to overcome the biofilter odour problem.

Insect nuisance

The microbial film in biofilters is used as a breeding ground by various flies and midges. This is beneficial in that the larvae feed on the film and thus help to prevent ponding. However, although none of the species found in filters actually bites humans, their sheer numbers can be a severe nuisance in hot climates: clouds of *Psychoda* flies can effectively stop all human activity in and near a sewage treatment works.

OXIDATION DITCH

DESCRIPTION

The oxidation (Pasveer) ditch is a modification of the conventional activated sludge process. Its essential operational features are that it receives screened or comminuted raw sewage and provides long retention times: the hydraulic retention time is commonly 0·5–1·5 d and that for the solids 20–30 d. The

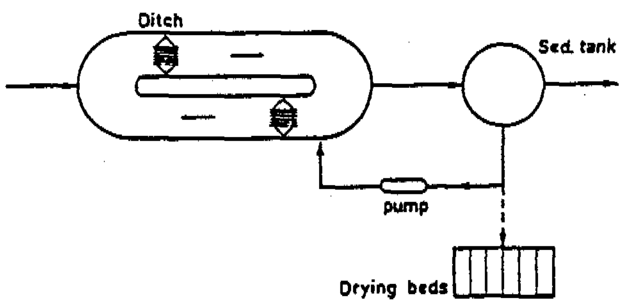


Figure Flow diagram for oxidation ditch

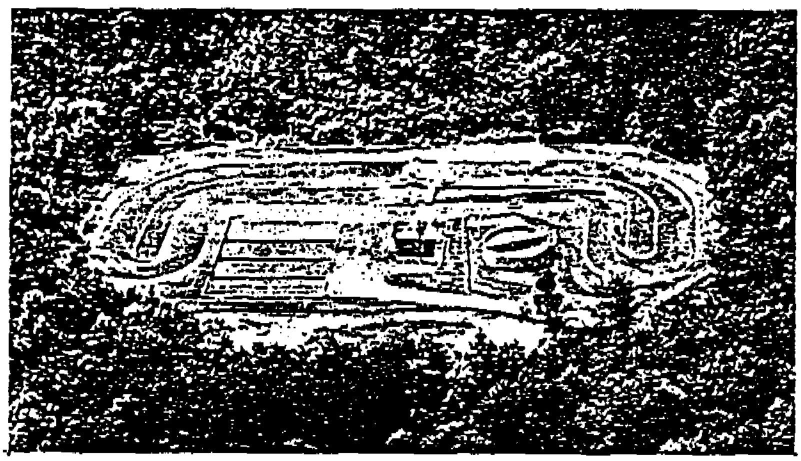


Figure Typical oxidation ditch installation [Courtesy of Lakeside Equipment Corporation]

The concentration of total SS in the ditch is 3000–5000 mg/l; in order to prevent the concentration much exceeding this range the return sludge flow is diverted to the drying beds for a short period each day; this period is best determined by operational experience (a simple field check on the ditch SS concentration is to fill a 1000 ml graduated cylinder to the mark with the ditch liquor; if the solids concentration is 3500–4500 mg/l the volume of sludge which settles in 30 minutes should be about 200 ml). Alternatively the sludge wastage rate may be estimated by considering the solids retention time (Section 9.2). BOD_5 removals are consistently > 95 per cent.

The oxidation ditch was developed in Holland to provide small communities of 200–15 000 people with sewage treatment facilities at the same per capita cost as conventional works serving much larger populations. At present there are few oxidation ditches in hot climates since waste stabilization ponds are usually more favourable both in terms of cost and the removal of faecal bacteria although where there is a reliable electricity supply but insufficient land for pond they are being increasingly used (but unfortunately seldom with provision for improving the bacteriological quality of the effluent).

(In Europe for populations < 1000 the ditch usually serves the dual purpose of aeration tank and sedimentation tank; one to three times each day the sewage inlet is closed and the rotor switched off for a period of about 1 h to permit the bioflocs to settle and so produce a high quality supernatant (during this time the influent sewage is stored in the sewer). After settlement some of the supernatant is discharged to the receiving watercourse; the inlet is then opened and the aerator switched on. Excess sludge is accumulated in a sludge trap adjacent to the ditch and is removed at regular intervals (normally once a day) and spread on drying beds. For populations > 1000 it is more economic to have continuous operation by providing a sedimentation tank and a sludge return pump. In tropical developing countries oxidation ditches are unlikely to be used for populations < 1000 for which waste stabilization ponds are usually more suitable. The type of ditch shown in Figure 9.1 can therefore be expected to be the one most frequently used in hot climates.)

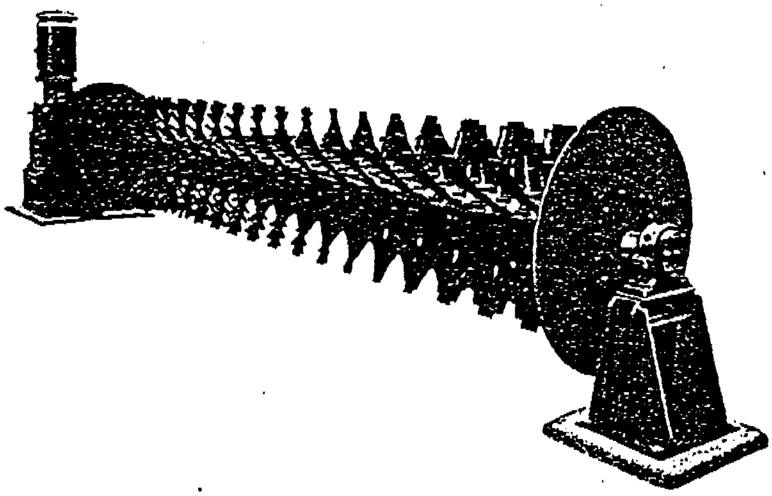


Figure 9.4 Mammoth rotor [Courtesy of Whitehead and Poole Ltd]

latter, achieved by recycling > 95 per cent of the sludge, ensures minimal excess sludge production and a high degree of mineralization in the sludge that is produced. Sludge handling and treatment is almost negligible since the small amounts of waste sludge can be readily dewatered without odour on drying beds. The two other major differences from the conventional process lie in shape and type of aerator. The oxidation ditch is a long continuous channel, usually oval in plan and 1·0–1·5 m deep (Figures 9.1 and 9.2). The ditch liquor is aerated by one or more cage rotors (Figure 9.3) placed across the channel; for large flows it is usually more economic to provide the more powerful mammoth rotors[2] (Figure 9.4). The rotors also impart a velocity of 0·3–0·4 m/s to the ditch contents, sufficient to maintain the active solids in suspension.

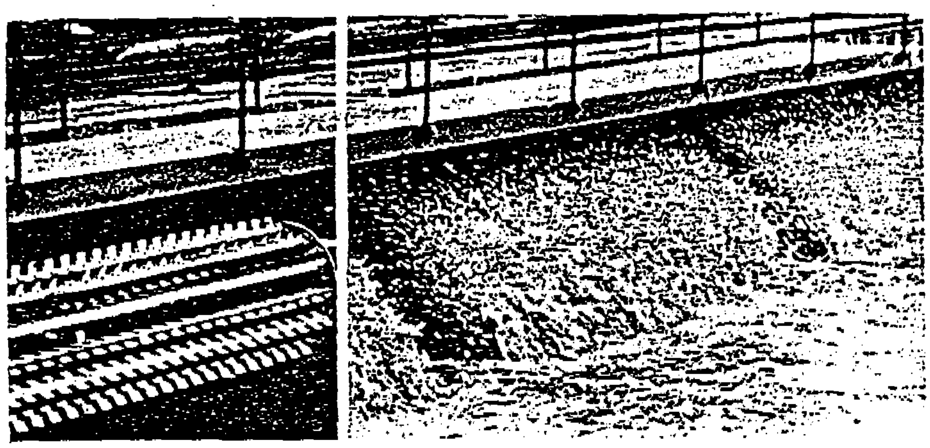


Figure 9.3 Cage rotors [Courtesy of Whitehead & Poole Ltd]

NHA ROLE IN O&M OF OFF-SITE SANITATION SCHEMES

For the existing waste water treatment plants on NHA schemes can be grouped in four categories:

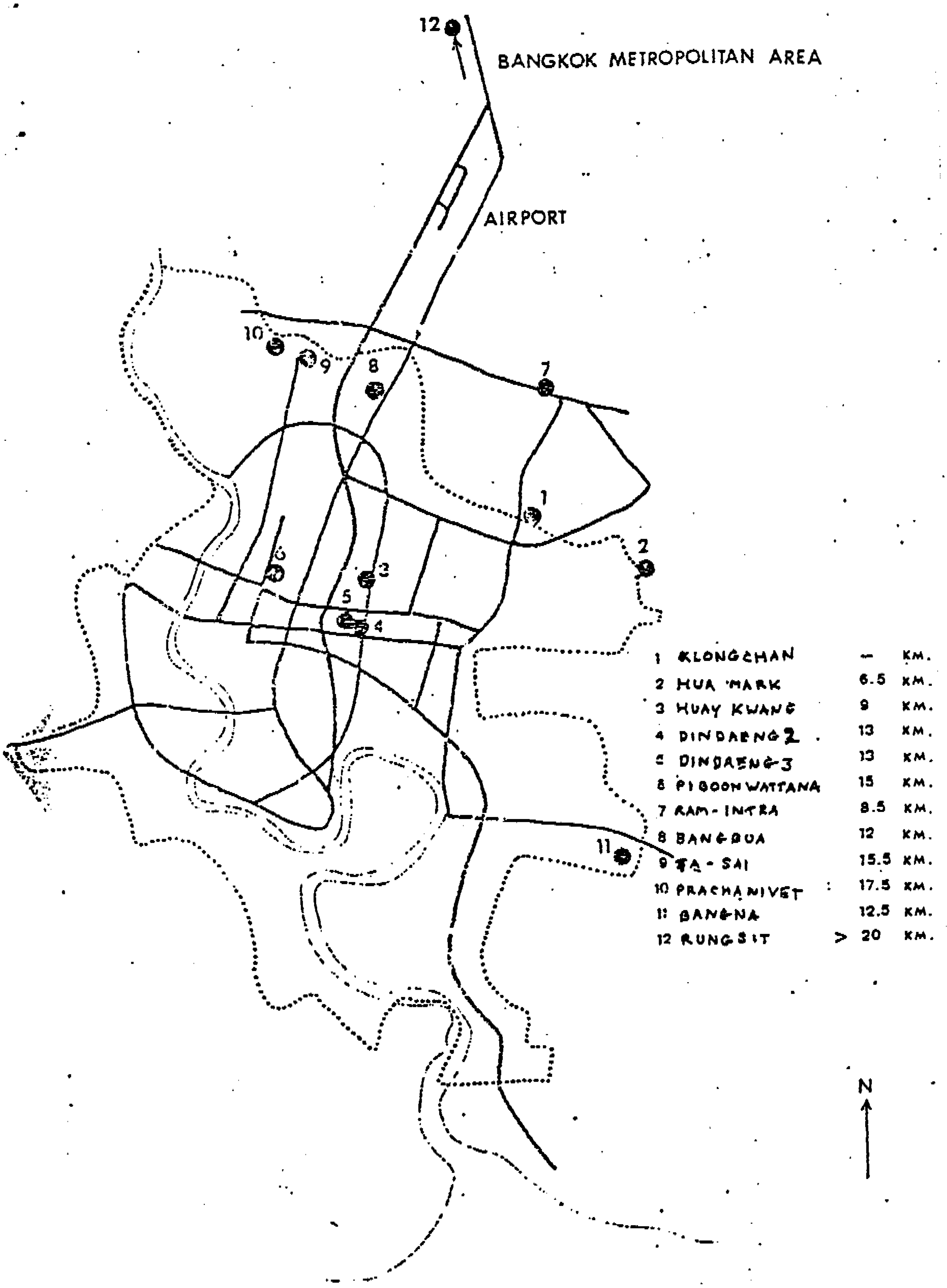
1. OXIDATION POND : the existing plants are Hua Mark treatment plant and incrementation of Rangsit aerated lagoon
2. AERATED LAGOON : the existing plants are Rangsit, Tung-Song-Hong phase II (site and services)
3. ACTIVATED SLUDGE : the existing plants are Huay Kwang, Romintra, Dindaeng, Piboonwattana, Klongchan, Tawai Bangplee, Klongtoey, Boanhai, Tung-Song-Hong phase I (flat) Romklao treatment plants.
4. Oxidation ditch : the existing plants are Pracharnivet, Bangbua, Bangna.

Most of them are designed by NHA, only Huay Kwang by John Taylor & Sons, British company, and Piboonwattana that contract out to private engineer consultance.

Types and main characteristics of some waste treatment plants are summarized in TABLE

TYPES	NAMES OF PLANTS	FLOW (m^3/day)	BOD LOAD. (Kg/day)	VOLUME OF AERATOR	NUMBER OF HOUSEHOLDS
1. OXIDATION POND	HUAMARK	416	42.4	6460	588
2. AERATED LAGOON	RUNGSIT	1040	105	1155	1429
3. ACTIVATED -	HUAYKWANG	3087	429	460	3360
- SLUDGE	RAMINTHRA	798	30.7	1017	812
	KLONGCHAN	4791	130.8	5000	6438
	TASAI	1330	106.4	1313	1419
	PIBOONWATTANA	172	7.4	220	410
	DINDAENG	863	170	780	1020
4. OXIDATION DITCH	PRACHANIVET	2563	93	4003	4584
	BANGBUA	584	62	1613	1214
	BANGNA	562	61	2980	1656
				TOTAL	22930

TABLE SUMMARIZED OF SOME MAIN CHARACTERISTICS OF SOME TREATMENT PLANTS IN NHA.



LOCATION OF OFF SITE SANITATION
IN NHA AREA OFFICES IN BMR.

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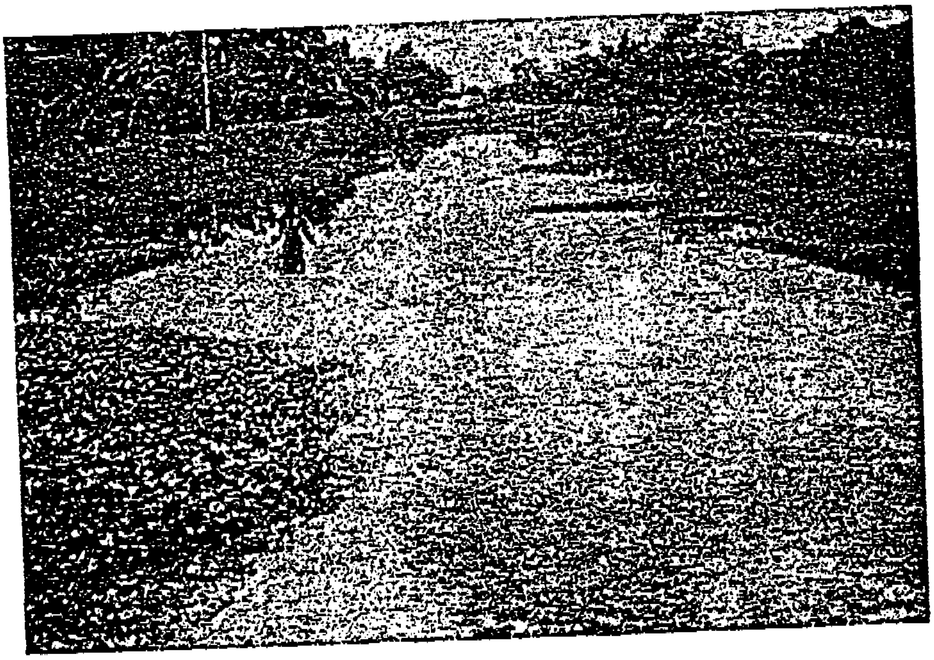
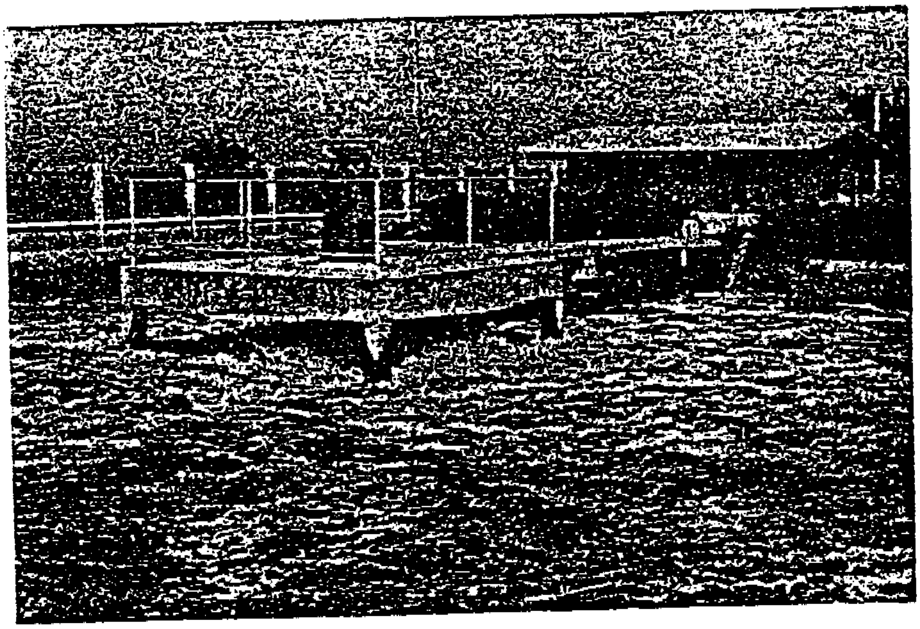


OXIDATION POND AT HUA MARK COMMUNITY



AERATED LAGOON AT RUNGSIT COMMUNITY

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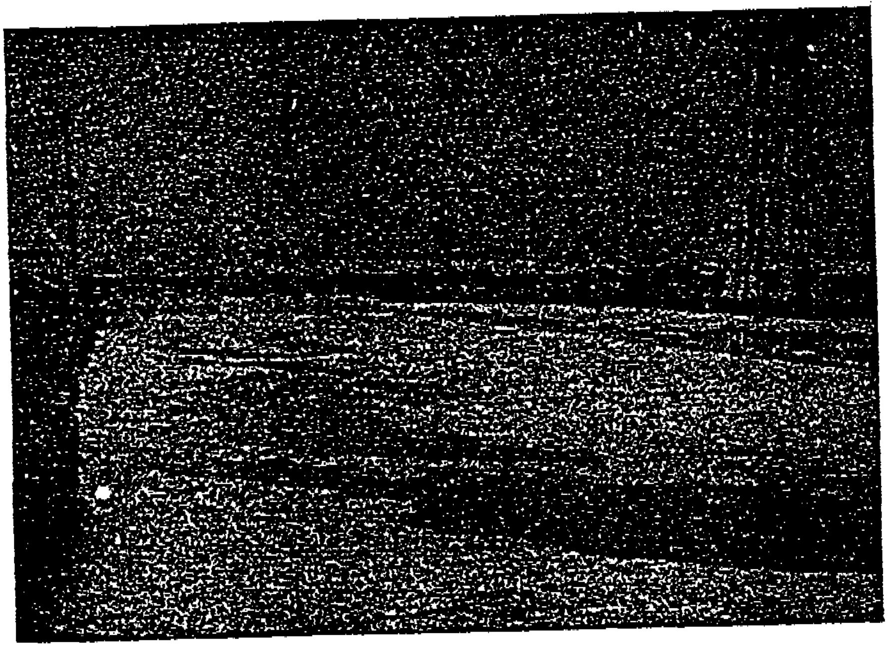
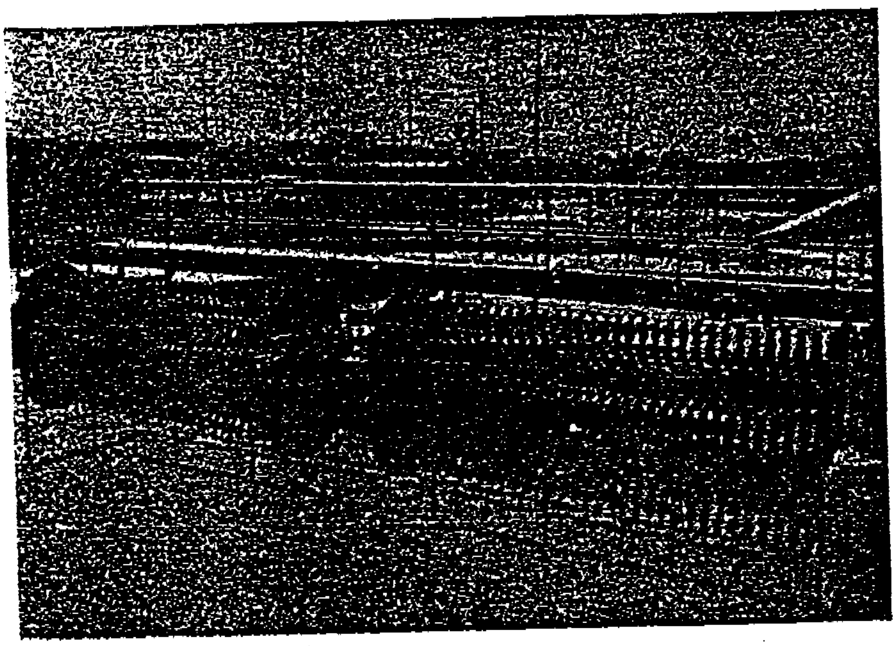


OXIDATION DITCH AT PRACHANIVET COMMUNITY



MAMMOTH ROTOR AT PRACHANIVET COMMUNITY

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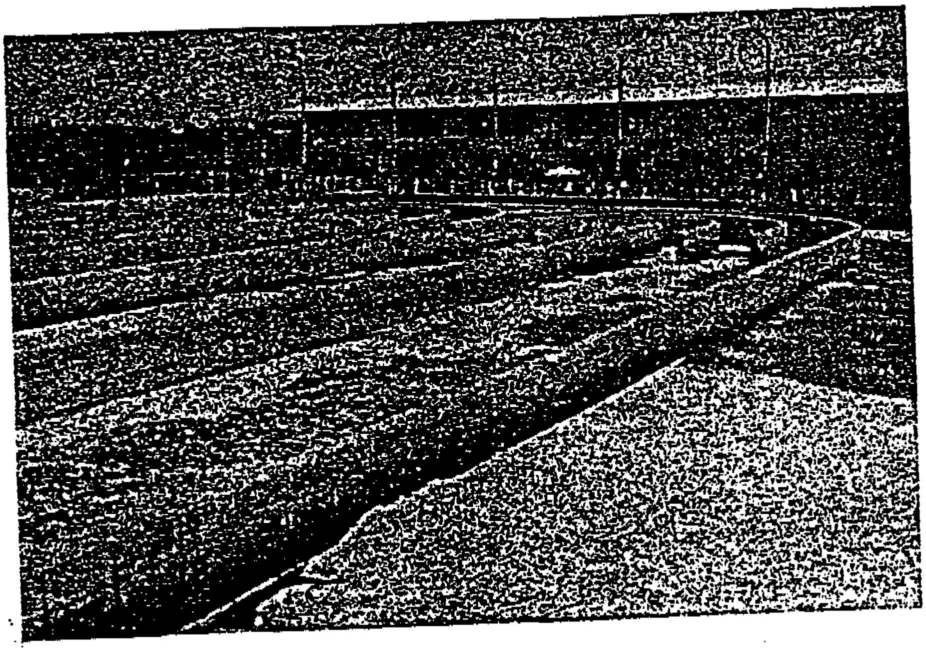
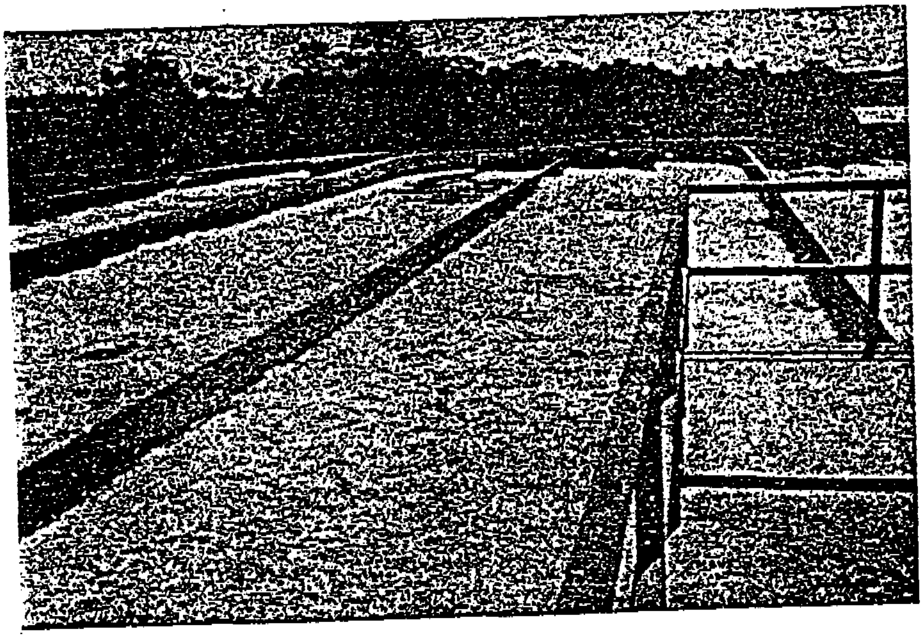


OXIDATION DITCH AT BANGBUA COMMUNITY



OXIDATION DITCH AT BANGNA COMMUNITY

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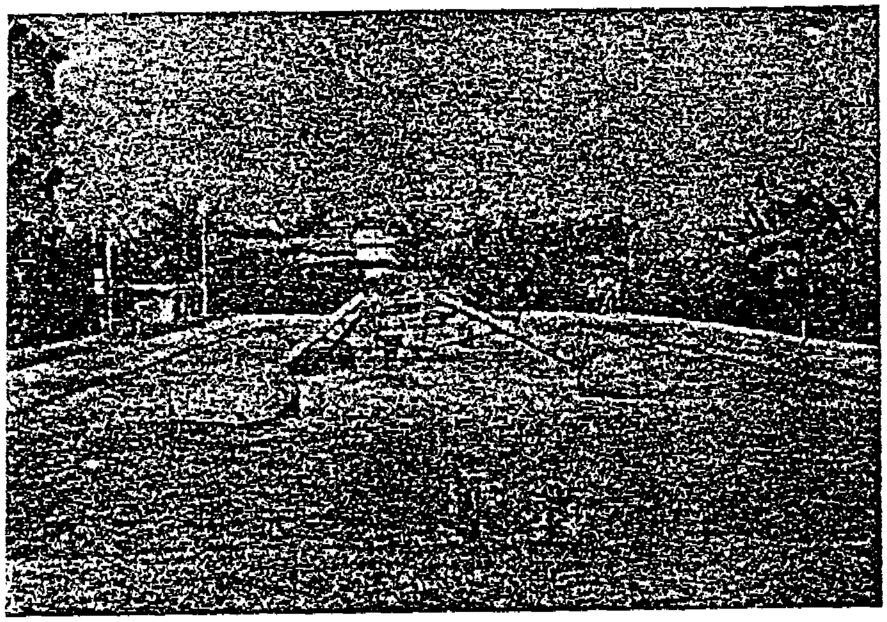
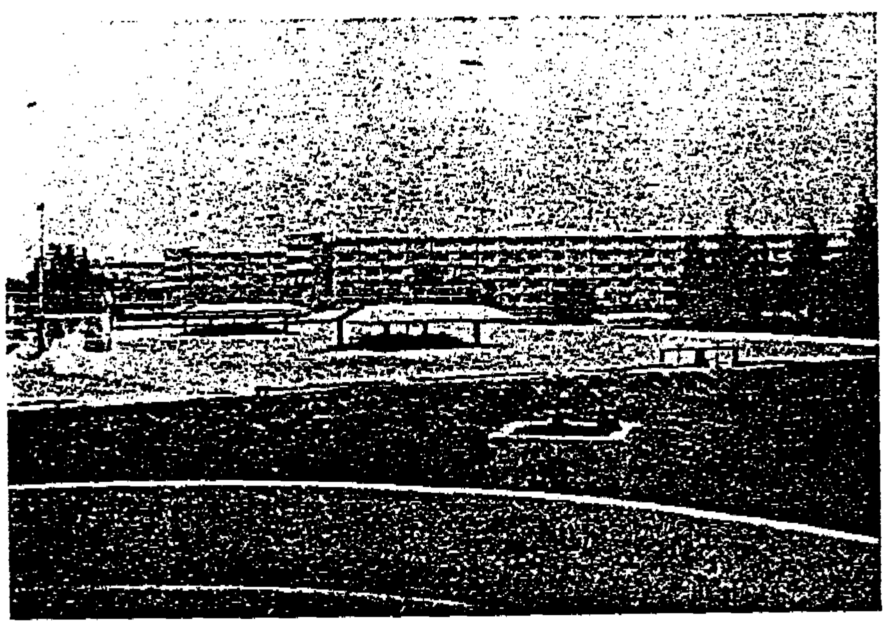
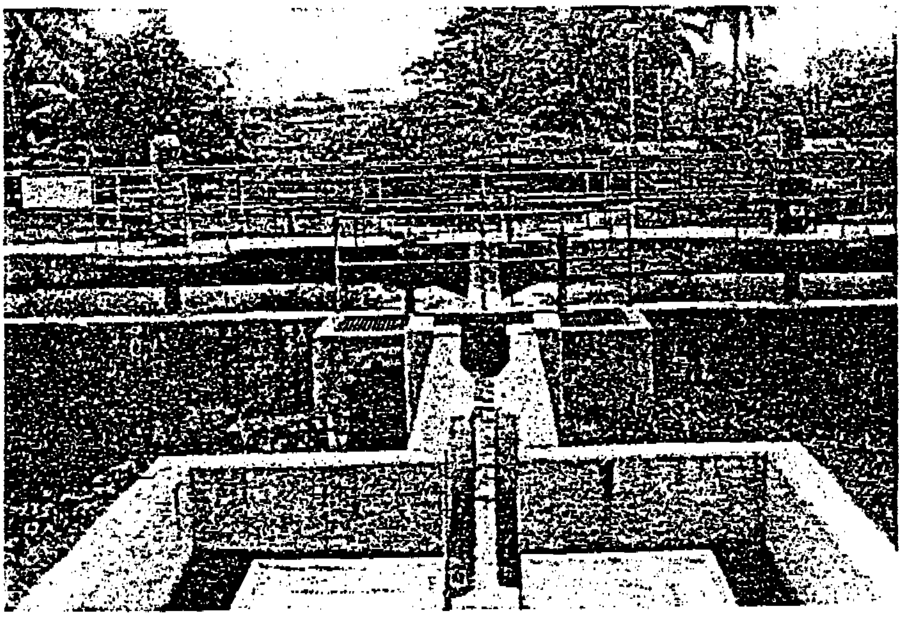


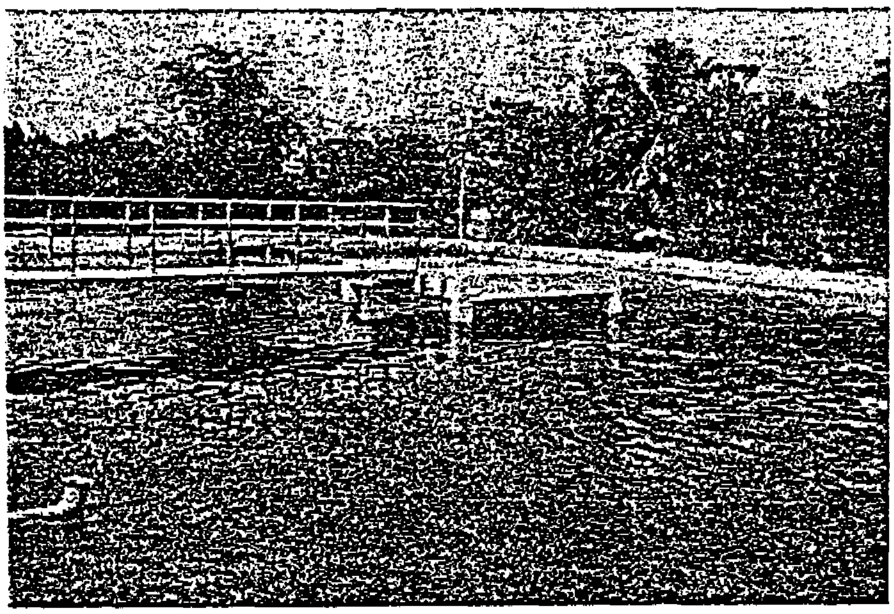
FLOATING AERATOR TYPE IN
EXTENDED ACTIVATED SLUDGE AT
RAM-INTHRA COMMUNITY



ACTIVATED SLUDGE AT KLONGCHAN
COMMUNITY

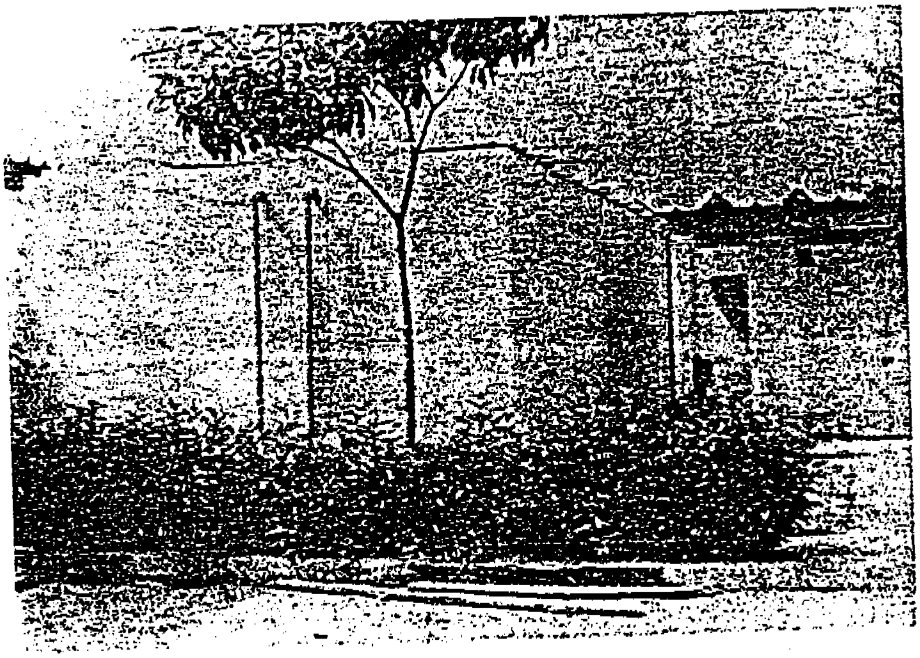


CONVENTIONAL PLUG FLOW
ACTIVATED SLUDGE AT HUAY KWANG
COMMUNITY



ACTIVATED SLUDGE AT TASAI
COMMUNITY

PACKAGE ACTIVATED SLUDGE WITH AIR DIFFUSER
AT DINDAENG COMMUNITY



PACKAGE ACTIVATED SLUDGE WITH AIR DIFFUSER
AT PIBOONWATTANA COMMUNITY

MANAGEMENT OF OFF-SITE SANITATION IN NHA SCHEMES

The NHA is responsible for construction low-income housing, which it does by building various forms of housing, including detached, semi-detached and terraced housing, four storey walk up and multi-story apartments. NHA also provides infrastructure eg. roads, drainage, water suply distribution net-works, water treatment plants and waste water treatment plants. It means that NHA has to manage, operate and maintain all infrastructure himself.

The management, operation and maintenance of infrastructure and sanitation in communities will fall under the Estate Management Office Zone in the organization chart as shown in FIGURE ...

NHA has set up Area Offices in eachs of its housing estates to look after their affairs in the communities. At present there are about 24 Area Offices under the supervision of 5 Estate Management Office Zones.

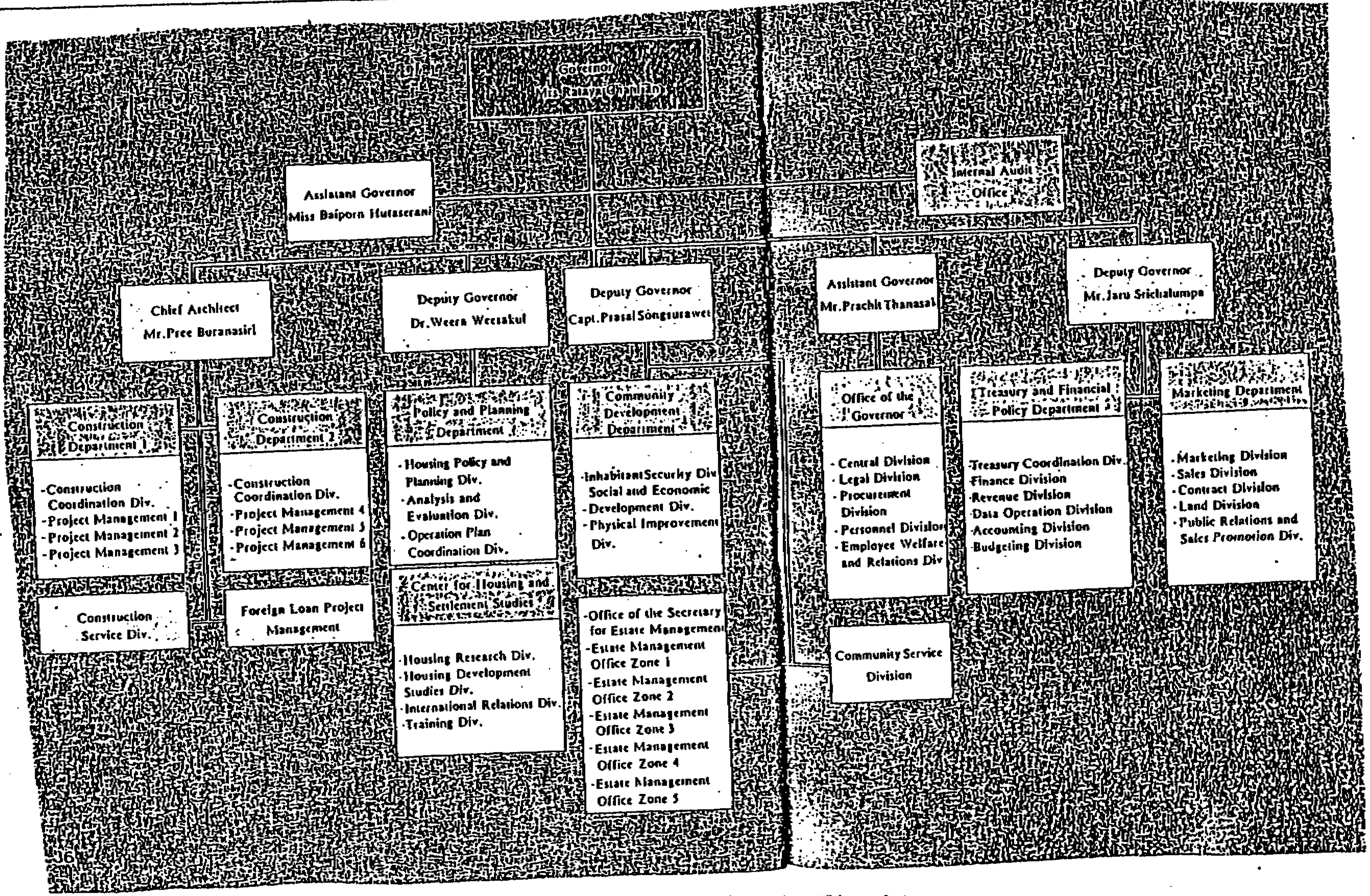
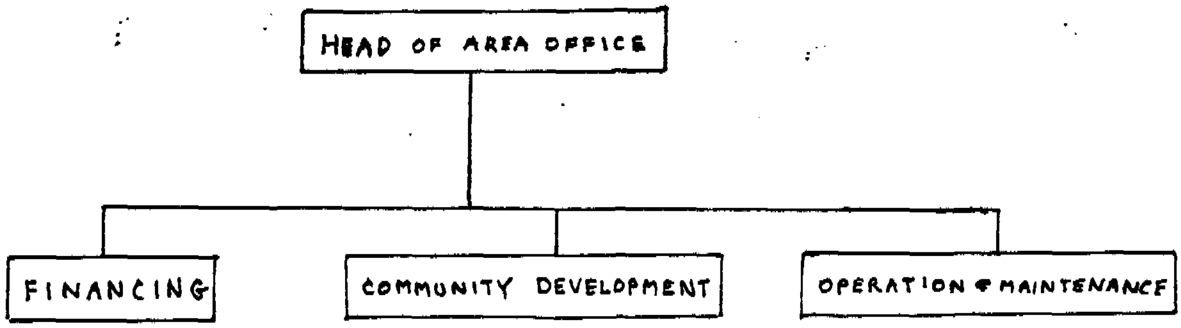
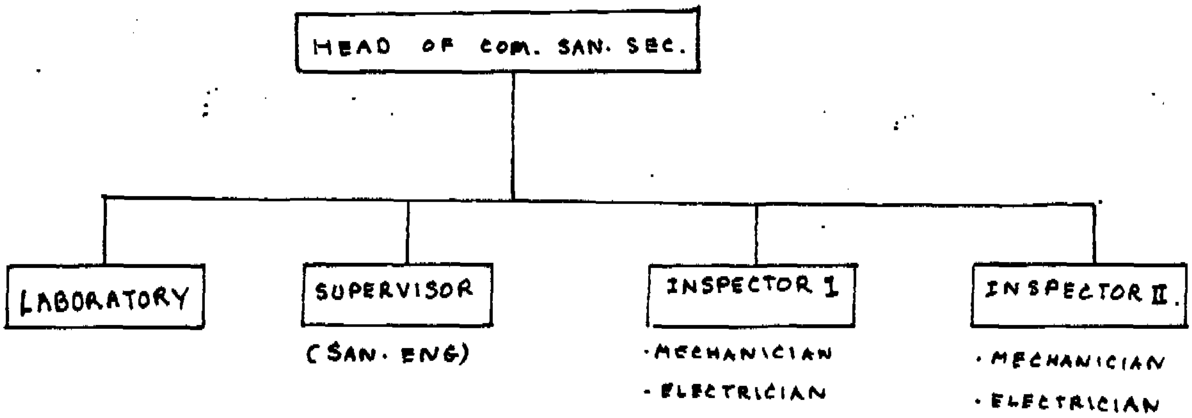


FIGURE : NATIONAL HOUSING AUTHORITY ORGANIZATION CHART, 1988



TYPICAL ORGANIZATION CHART OF AREA OFFICE.

Area Offices directly take responsibility for operation and maintenance of infrastructure; building and public facilities eg. public sewer, public pumps both clean water pumps and waste water pumps and waste water treatment plants in its areas. Area Offices have many duties, for instance collecting rent and long-term purchase payments, claim and prompt payments of all debts, develop and up-grading the co-operation of community, develop community committee. Numbers of staff in Offices vary from 3 - 40 depends on size of community and how much contract out the activities, he does.



TYPICAL ORGANIZATION CHART OF COMMUNITY SANITATION SECTION

For the monitoring of O&M of waste treatment plants, there is Community Sanitation Section under the Community Service Division, to check the quantities of water and waste water, to check the condition of electrical and mechanical equipment, used in the plants, give suggestion to O&M if requested. Community Sanitation Section make a monthly report and suggestions to the Area Offices. Area Office will justify, normally by mean of budget remain or budget balance from the incomes of community activities, to repair, rehabilitation or not.

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The operation of waste water treatment plants in NHA schemes had to face an increasing number of problems:

1. There is no sound financial basis for operation. Local community income are very lows and are just enough to run normal routine essential activities eg. lighting, keep surrounding clean, security of community, pumping, repairing of water supply pumps. Thus additional budgets have to be created to operate & maintain the treatment system. These come from general resource of NHA, that have been provided to subsidy for running sanitation performances.

2. Due to this weak financial basis, the budgets for O&M have been under pressure for many years and in fact, have been cut drastically.

3. This has caused various problems, such as

- the plants is not properly staffed by technicians & operators

- casual and permanent labours could not be employed.

- routines O&M had to be aboned or done less frequently and out of minimum requirements.

- replacement or purchase of equipment & materials can not be done immediatly

- purchase of chemical used in the plan's has short down, so the process can not be continuing

I.4 PROBLEM ENCOUNTER

Excreta disposal systems in high density, low-income communities where adequate sanitation has not been provided, largely due to the absence of an acceptable system which the community could afford to pay for in it rates. Recent WHO. statistics have shown that only 28 %. of urban population of developing countries are served by waterborne sewerage and that 29 %. have no sanitation facility whatsoever.

One of the fundamental problems in any attempt to provide the necessary sanitation services is their costs. General estimates base on existing per capita costs indicate that around $150 to $650 is need to investment costs for sewage per capita. (WORLD BANK, 1982). In industrialized countries, the standard solution for the sanitary disposal of human excreta is water borne sewerage. In fact, conventional sewerage is the is the result of slow development over decades, even centuries, from the pit latrine to the flush toilet, and the present standard of convenience has been achieved at substantial economic and environmental costs.

Advantages and Disadvantages of Onsite Wastewater Disposal

Advantages

The economic advantage is the low cost to governments because the cost is borne by the user. A single-system failure constitutes a low hazard to the environment and, as will be shown, the system fails gradually, thus providing advance warning. The low hazard level stems from the fact that family sewage never contains pathogenic organisms unless one or more of the family or their guests excrete pathogens.

City sewage usually contains pathogens because of the probability that out of about 100,000 people, one person may be ill. Properly functioning onsite disposal systems do not discharge an effluent to surface waters, and few treatment plant operators are required because of limited accompanying sampling and chemical laboratory analysis, laboratory equipment and toxic chemicals for analytical work. Onsite systems have lower energy consumption and water use, and produce less sludge. This sludge is also more suitable for soil conditioning.

Disadvantages

The greatest disadvantage has been the land area required to dispose of the wastewater generated. How much land area is really required and what soil conditions are suitable has been studied for over 100 years. The approximate land area required is shown in Table 1-1.

The second disadvantage is that the homeowner does not always look after the system. Problems may arise if repairs are not carried out economically and promptly. In some cases groundwater has been polluted by improper location and installation of onsite systems.

The onsite system suffers more from technological development than large sewage treatment plants. The improvements developed by researchers and industry are difficult to implement because onsite systems need local approval. Onsite systems are controlled like plumbing and electrical installations, i.e., regulations are written in such detail that few innovative ideas or designs can readily be accepted. The incentive to improve is minimal because no cost advantages are allowed through smaller land area requirements and better designs. The local codes are the design and are widely accepted as the best available or workable technology.

The modern notion developed around the priciple that a few large treatment plants are desirable, because control over wastewater can be achieved with the least cost, and manpower and additional treatment can be readily added later when ecological effects show the need.

For Thailand, facing the main problems in the development of infrastructures are:

1. Professional planner and designer were graduated with the idea of high technology and standard from western country, normally lack of local experience, get used to conventional design and high standard of regulations so the investment cost expensive and not appropriat to local condition, poor people can not afford and run post construction.

2. No institutional arrangement in order to co-operate planning, designing and management of O&M, no training or seminar in the relevant field.

3. Limited of budget and no financial aspect to support for long term O&M.

4. Lack of community participation.

PART II

II.1 REQUIREMENTS FOR MANAGEMENT AND OPERATION AND MAINTENANCE OF SANITATION SYSTEM

Within the framework of an urban plan, it is often found that planning and execution of projects for physical infrastructure are the beginning and the end of the provision process. Too often it happens that infrastructure and sanitation systems run-down. Beyond the serious existing social and physical crisis, physical deterioration of sanitation system, is being faced now. One of the main causes are inadequate management and operation and maintenance.

The problems result in the state of Management and O&M of sanitation system, and can be distinguished into the following fields:

1. Technology selection
2. Institutional - organizational - Management
3. Personnel - Training
4. Financial
5. Economic - Social
6. Technical
7. Political decision-making level
8. External Support Agency Policy and Practices.

In Thailand, the choice of sanitation technology depends on the criteria used for comparing one method with another, and on the availability of knowledge about each method.

Over the last number of years a number of decision making aids have been developed.

An algorithm, which can be used as a step-by-step guide to the selection of the most appropriate sanitation technology for any given community in the developing countries, is presented (in stages) throughout figures 9-1 through 9-3. The algorithm is intended only as a guide to the decisionmaking process. Its main virtue is that it can stimulate engineers and planners to ask the right kinds of questions, the sort they may not ask otherwise. Some of the answers to these questions can only be obtained from the intended beneficiaries

Although it is believed that the algorithm is directly applicable to most situations encountered in developing countries, there will always be the occasional combination of circumstances for which the most appropriate option is not the one the algorithm suggests. This analytical device should not, therefore, be used blindly in the place of engineering judgment but, rather, as a tool for facilitating the critical appraisal of various sanitation options, especially those for the urban and rural poor.

The selection process starts, in figure 9-1, by asking if there is, or soon will be, water supply service to the houses under consideration. This is a critical question, since its answer immediately determines whether conventional sewerage is a possible option or not. If the water supply service is through house connections, if there are no social or environmental reasons for excluding sewerage, and if it can be afforded—then conventional sewerage is chosen (unless there is sufficient land and less cost for septic tanks with soakaways). Septic tanks with drainage fields would be the technology of preference where water-saving appliances—such as cistern-flush toilets using less than 1 gallon (3.8 liters) of water—can be installed to make them feasible.

If a community does not have, and is not likely to have, house water connections, then cistern-flush toilets and conventional sewerage cannot be used. If sullage generated on site is sufficient (>50 liters per capita daily) to enable a sewered pour-flush (PF) system to function satisfactorily, a sewered PF system can be used provided that: it is cheaper than alternative systems with separate sullage disposal facilities or the users, or the municipality are willing to pay the extra cost, and there is no overriding social preference for night soil to be collected separately for subsequent use. If the sewered PF system is not appropriate, the choice lies among the various on-site excreta disposal technologies with appropriate facilities for the disposal of sullage (see the selection process for these in figure 9-2).

If double-vault composting (DVC) toilets and three-stage septic tank systems cannot be used, the choice lies between ventilated improved pit (VIP) latrines, Reed Odorless Earth Closets (ROECs), PF toilets, vault toilets, and communal sanitation blocks as determined by the algorithm in figure 9-3.

Figure 9-1. *First-stage Algorithm for Selection of Sanitation Technology*

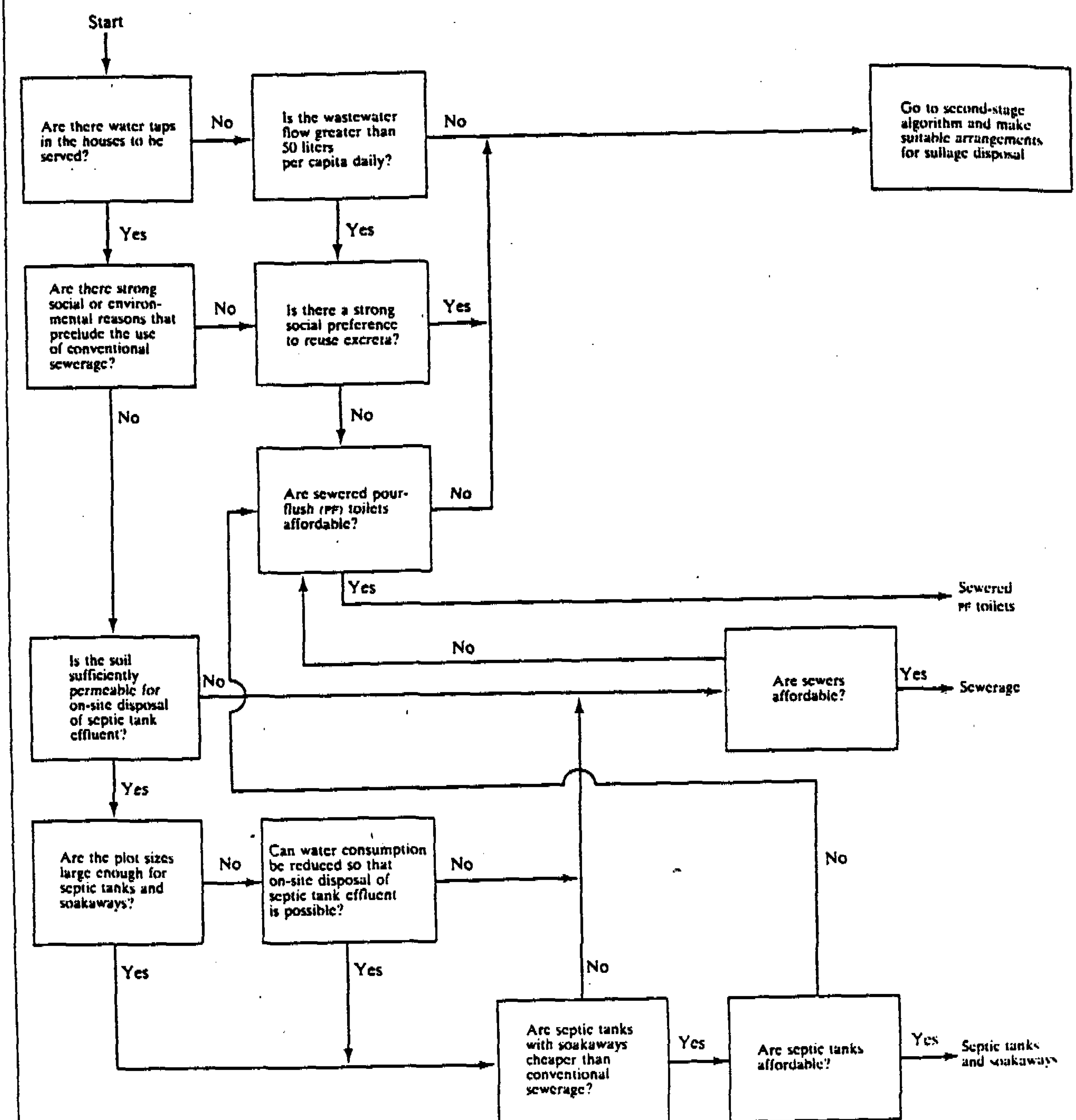


Figure 9-2. *Second-stage Algorithm for Selection of Sanitation Technology*

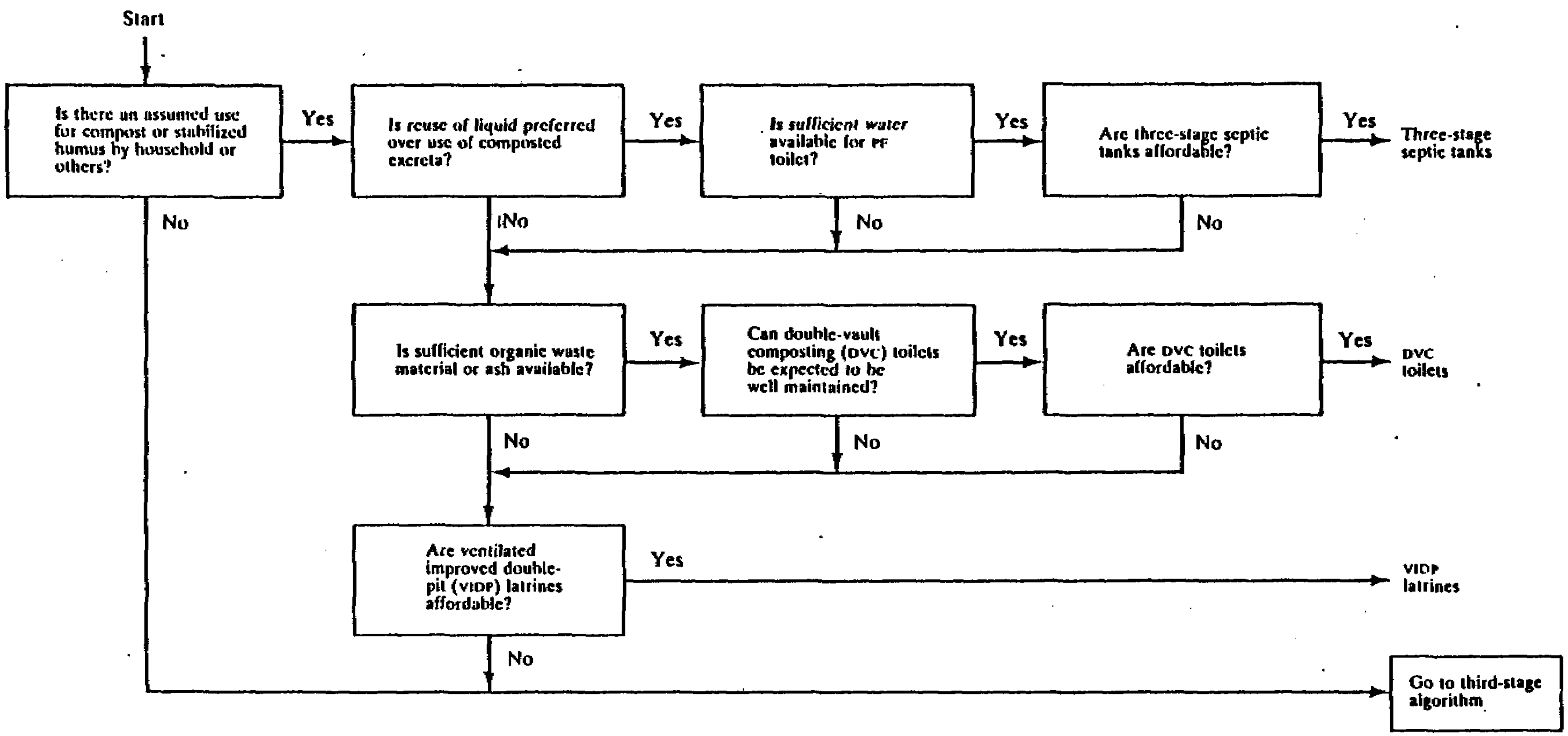
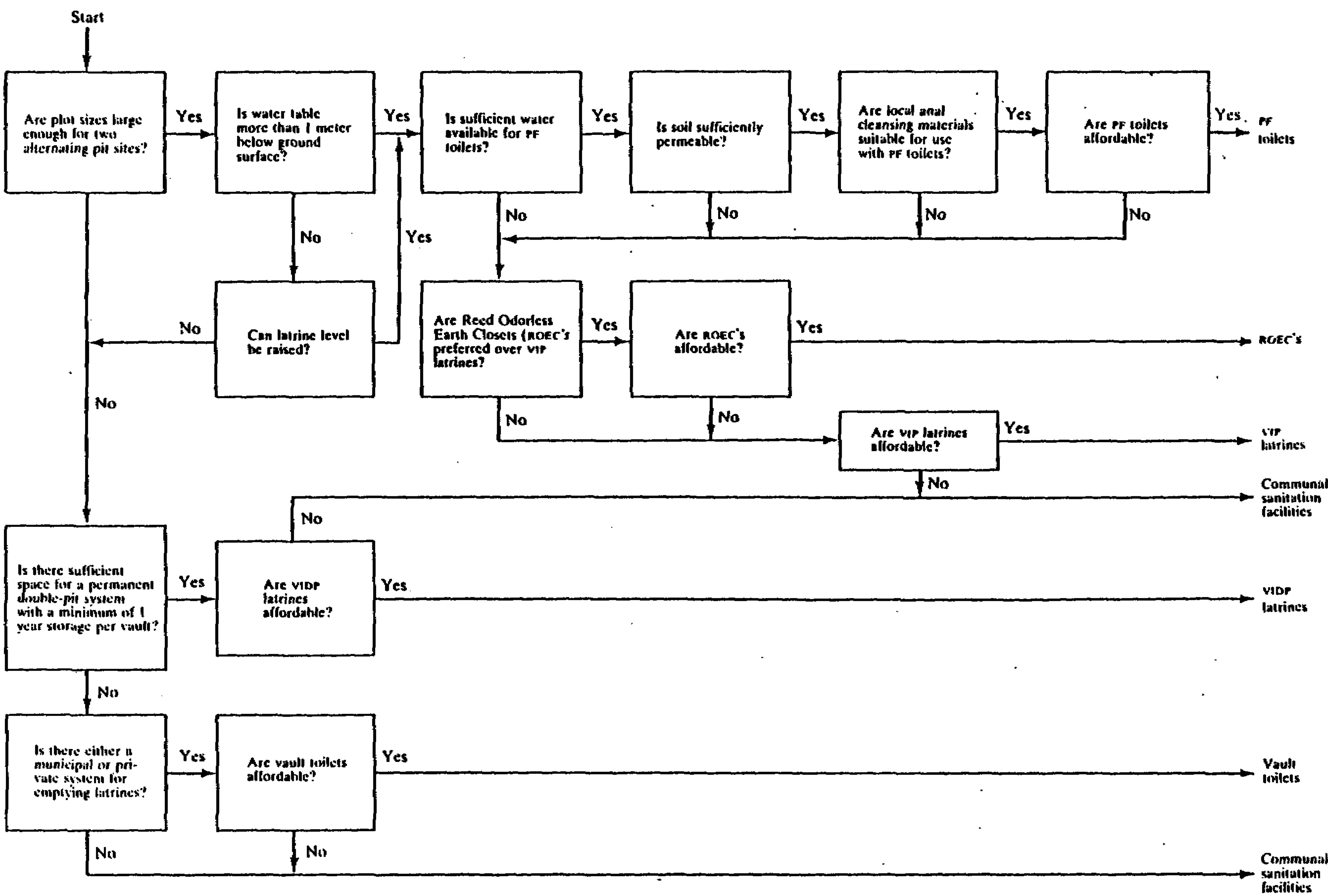


Figure 9-3. *Third-stage Algorithm for Selection of Sanitation Technology*



1.2 INSTITUTIONAL - ORGANIZATIONAL - MANAGEMENT REQUIREMENTS.

There is very often a lack of clearly delegated responsibilities and accountability for operations and, particularly, for maintenance activities;

In many authorities responsible for O&M, a "management by crisis" situation exists. Basic information on assets and their condition is not available, and systematic strategies and plans for management of operations and maintenance rarely exist. More often than not, inadequate management is the fundamental cause of deficiencies in O&M;

Central-local government relations play important roles in two areas: (i) ad-hoc mechanisms for grant allocation hamper systematic planning and budgeting of O&M at the local level; O&M financial resources clearly need to be generated at the local level to a much higher degree, particularly through improved cost recovery; and (ii) national or regional government decision makers are often isolated from the operational realities of local authorities; therefore, maintenance at the local level often gets little too consideration in the planning and budgeting cycle;

Institutional arrangements whereby one authority is responsible for planning, design and construction of assets and another (usually local), for O&M are often unsatisfactory. Problems arise when local authorities are insufficiently involved in the design process, and are unprepared to assume the O&M responsibility, because their institutional strength was not adequately assessed and because maintainability and ease of operations were not adequately considered in design and specifications;

Inefficiency and low productivity in operations and maintenance work carried out by direct labor, suggest that depending on the degree to which the private sector is able and willing, there may be substantial scope and potential for contracting out activities to the private sector or privatizing suitable infrastructure service functions;

1.3 PERSONNEL - TRAINING REQUIREMENTS

Low pay scales and lack of incentives make it difficult for local governments and even parastatals to retain qualified and motivated staff, and very low productivity very often is the result. There is frequently over-staffing in the lowest echelons, while vacancies exist in critical managerial and supervisory posts. There are pronounced needs for training of local staff at all levels in local authorities, particularly those engaged in O&M activities, because this is an area where educational institutions have very often failed to provide adequate pre-service training;

The field of maintenance is a professional backwater in many countries and does not attract a high caliber of staff;

1.4 FINANCIAL REQUIREMENTS

Local resource mobilization is generally highly inadequate; cost recovery through taxes, fees and user charges does not sustain adequate levels of expenditure, particularly in the area of maintenance. Available resources are often fully committed to payroll and essential operating expenses like power supply which have to be met to avoid disconnection and complete halt of operations;

However, in many instances, the problem is not so much insufficient outlays on O&M as it is the inefficient utilization of the funds which do get allocated for these purposes;

Inadequate budgeting and cost accounting systems lead to a situation where funds are not sufficiently earmarked for specific O&M functions and where actual resource requirements for specific O&M tasks cannot be isolated to facilitate effective management and monitoring;

In case of water supply, this for an example is observed in India by P.S.A Sundaram, paper presented to AIDHA policy seminar, Sept. 1986
[REFERENCE No. .]

It was forcibly brought out in a study of the management of services in 9 towns in three states undertaken by the National Institute of Urban Affairs (2) that the local bodies were not effective even in the delivery of the available services. The water available for distribution was not put to efficient use and the installed capacities were uniformly underutilised. The utilisation ratio of raw water ranged from 52 to 86%. This was partly due to the irregular supply of electricity, non-availability of spare pumpsets and absence of repair facilities for pumps. The unserved parts of the city ranged from 54 to 9%. The per capita water supply ranged between 42.9 litres per day to 138.5 litres, and the average supply was lower than the technical norms. Proper treatment facilities for raw water were not available in many of the towns, and water was insufficiently treated due to shortage of chemicals, filters etc., and periodic maintenance. There were considerable disparities in terms of water supplied in different zones of each city, ranging from 25 to 90% of the population in the zone. The principal victims of the quantitative and qualitative inadequacies and spatial disparities were the poorer sections of the population. About 6 to 28% of the water was supplied through unmetered standposts for which the local body received no revenues. Apart from this leakage of revenue, there were significant losses of water at the stage of pumping, distribution and storage, and this can go upto as much as 30% even in a city like Bombay. There is also no sensitivity on the part of the local bodies to market the water services by securing data on the type of consumers, their income profile, requirement of water price and demand elasticities, tariff threshold etc., and the costs often bore no relation to the revenue realised.

For an example of inadequate financial basis was observed in India by P.S.A. Sundaram, paper presented to AIDHA policy seminar, Sept, 1986, [REFERENCE NO..]

The other side of the picture is the phantom distinction between capital and maintenance expenditure, leading to inadequate provision for maintenance of assets. In 1979-80, the total ordinary income of all the municipal bodies was about $654 million while total expenditure was just under $585 million. The surplus is more indicative of the statutory requirement to keep a show of surplus in the budget thanof affluence. There are definite indications of weakening of the municipal resource structure over the past two decades, as well as their insensitivity to rising urban incomes. A study made by the NIUA in 1982[3] showed that even in terms of tolerable norms for basic services, the municipalities are simply not providing an adequate level of services in terms of expenditure or coverage of population. It was estimated that the total replacement value of existing urban infrastructure excluding transport was in the range of $10,000 million in 1981, while the average maintenance liability at the assumed cost of 10% for maintenance is around $1000 million, as compared with the total resources of $654 million all of which is certainly not available for maintenance. The NIUA[3] estimated that the local bodies require a sum of $615 million to the planning and execution of new servics to specialised agencies; b) the failure to build in urban development plans a committed provision for the effective maintenance of assets created by Plan investment; c) failure to link cost recovery for services not only with the total question of resource mobilisation, but with systems of design and provision of shelter and basic services that facilitate involvement of beneficiaries at all levels of execution, and d) failure to strengthen the fiscal and managerial capability of the agencies in charge of basic services, arising partly from the political and bureaucratic perception of maintenance as an unglamorous function. Some cities have, however, shown their realisation that maintenance is a development priority and has to be seen in the broad context of urban management. The projects in these cities seek to find a balance between financing new public works and providing resources to ensure that existing services function. At the national level, the Task Force on Financing Urban Development[1] recognised that the two problems to be tackled were: a) the separation of responsibility for urban development and maintenance to be resolved by integrating the municipal and state planning process for allocating plan funds for urban development, and (b) to harmonise in a fiscal sense the municipal budgets with the plan and non-plan budgets of the state, to be resolved by undertaking exercises to determine the pattern of systematic and predictable devolution of state funds for local bodies, along with greater resource mobilisation by the local bodies themselves.

1.5 ECONOMIC - SOCIAL REQUIREMENTS

Poorly maintained and unreliable urban infrastructure and service delivery systems hamper public and private sector productivity. They thereby affect cities' capacity to act as driving forces in their regional economies and, in turn, in the national economy of the countries concerned;

Lack of maintenance has direct and sizeable effects on the balance-of-payments. Inefficient operations and maintenance result in waste of scarce imports, e.g., energy and chemicals, premature needs for replacement of imported spares, and in rehabilitation works, which often have substantial foreign currency components.

The O&M problem has an important dimension of equity because the urban poor are the most vulnerable to deficiencies in O&M. They often live in urban fringe areas or marginal lands with poor access conditions and with infrastructure and utility services not in place, or at best, provided in a haphazard manner which adversely affects systematic O&M efforts; also, because of their low income, they (in contrast to more affluent population groups who can afford private sector-provided alternative services) have no alternative than to rely on these inadequate public services;

Community participation in the area of O&M works well in a number of cases and has a further potential in many countries, but it requires planning and monitoring efforts by the responsible public authorities, and will only succeed where there is political will and systematic follow-up; its success depends very much on local demand, the required community inputs and participation of the design stage (very often areas such as health education are a first step towards promotion of community participation).

1.6 TECHNICAL REQUIREMENTS

Equipment for operations and maintenance is frequently inappropriate for developing countries, and decision-makers often have a low level of appreciation of the importance of appropriate technology in O&M. Specified equipment is often not suitable for use in environments characterized by labour intensive work methods; in many cases, unco-ordinated development efforts by different donors have resulted in the proliferation of a wide range of unstandardized equipment systems. Spare parts are frequently unobtainable; consequently costly vehicles and equipment are cannibalized to obtain parts for other units; For example: Solid waste collection vehicles are mostly not designed to enter narrow alleys in urban centres or poorly accessible areas in the urban fringe; mechanical street sweeping vehicles are inappropriate in areas where manual street sweeping and drain cleaning are much more effective because of low labour costs and the current state of road and drain maintenance; mechanical compactor trucks are inappropriate where solid waste has high percentages of organic matter and moisture content; lastly, the worst situation for a cash - and foreign exchange - stripped local authority is to have many different makes of vehicles and equipment for which spares have to be imported from many different countries - often following tedious customs and foreign exchange regulations in each case;

Materials for maintenance are often inappropriate because requisite standard specifications, laboratories and testing facilities are not available, the required construction/O&M supervision

is inadequate, and because foreign exchange to procure even simple imported materials is not available;

Urban services are strongly interdependent at technical/functional levels, and require coherent, coordinated O&M efforts across several service sectors, e.g., road maintenance and traffic management are severely affected by un-coordinated diggings for water mains and by pipe trenches which are not properly reinstated; efforts to improve public health may be jeopardized by stagnant water caused by failure to properly maintain drainage systems; drains do not function properly without a proper street sweeping and garbage collection system, etc. There are many such interlinkages which underscores the need to address O&M problems in a broader urban management context; many interventions in the past to improve O&M have not succeeded because they were too narrowly focussed on individual service sectors;

1.7 POLITICAL REQUIREMENTS

Particularly maintenance often has a low priority on the agenda of political decision makers and other executives of local authorities because it is not perceived as being as politically "visible" and "glamorous" as new capital works;

The fact that maintenance is frequently under-funded, may in part be the result of a lack of understanding of the costly downstream consequences, both in financial and economic terms, of neglecting maintenance;

One of the principal reasons for inattention to O&M is the pervasive informal "commission" system at work in many countries which on the one hand often favors attention to major contracts for new capital investments and on the other hand sometimes lead to situations where allocation for O&M become "slush funds" for inappropriate uses.

1.8 EXTERNAL SUPPORT AGENCY POLICY AND PRACTISES REQUIREMENTS.

International development agencies may in some cases, have biased borrowers/recipient countries against maintenance, because of their policy to lend for capital investments with little support for recurrent costs; the response may be in strategic sector adjustment landing rather than lending for recurrent costs which, ultimately, are a recipient country obligation.

There is rather limited expertise on O&M available in the consulting profession; twinning arrangements (i.e., a professional relationship between a local authority in a developing country and a similar but more experienced organization in a different part of the world), sometimes assisted by consultants, have in a number of cases proven to be a successful mechanism for technical assistance delivery in the area of O&M.

II.2 SPECIFIC REQUIREMENTS OF SANITATION SYSTEM IN THAILAND

It is of considerable value to have a checklist of criteria by which to evaluate sanitation systems, but it will be found that many items in that list have to be define in terms of local conditions and needs and have to be interpreted in the light of what people want. Choices about technology can not therefore be made in generals terms for all developing countries, but must be made seperately and locally by each community or nation.

More specifically the requirements of sanitation systems in Thailand, and more particular in NHA schemes should comply with the following:

1. Awareness among key political decision-makers and adequate priority of sanitation system given by policy-making.

2. Availability of Capital Funds. Capital funds for investement of the sanitation systems should not be a problem

3. Proper design in technology & construction. The planning team have to select and design a reliable, long term, system which will accommodate

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increasing flows of water as living standards rise. The design must be safe in all soils and accommodate variations of construction methods or quality, which necessitates a longer term design commitment than a brief, close ended, planning and design project.

4. Consideration of designer for the operation and maintenance implication of services.

5 Adequate financial basis & commitments for managment, operation and maintenance of sanitation systems

6. Institutional arrangement that has distinctive responsible to do O&M. how related to others. Inter-agency is also a major, common issue as evidence, for example BMA, NHA, and Public Health Ministry do design, construct facilities in slum area without co-ordination.

7. Good on-site management and organization

8. Proper number & trained staff for Administration. Adequate number and qualifications of staff in each unit are require eg. staff on payroll but not reporting for work.

9. Adequate equipment, materials, standards and procedures for construction, operation and maintenance.

10. Records and Inventories of Assets. The important informations must be recorded before those old employees retire and the information is lost. eg. plan, tabular form, as build drawings.

11. Training of operator and maintenant worker to perform the waste treatment plants and equipments.

12. Community participation eg. community understanding of use and maintenance regime of sanitation facilities, communities sensitivities and taboos (religion restriction), communities affordabilities for cost recovery, and involvement own.

13. Health Aspects and Personnel Hygiene requirements, Sanitation system has to prevent transmission of disease by various pathogen eg. viruses, bacteria, protozoa, helminths, present in excreta. Any kind of latrine which contains or remove excreta does not permit the contamination of the floor, yard or fields.

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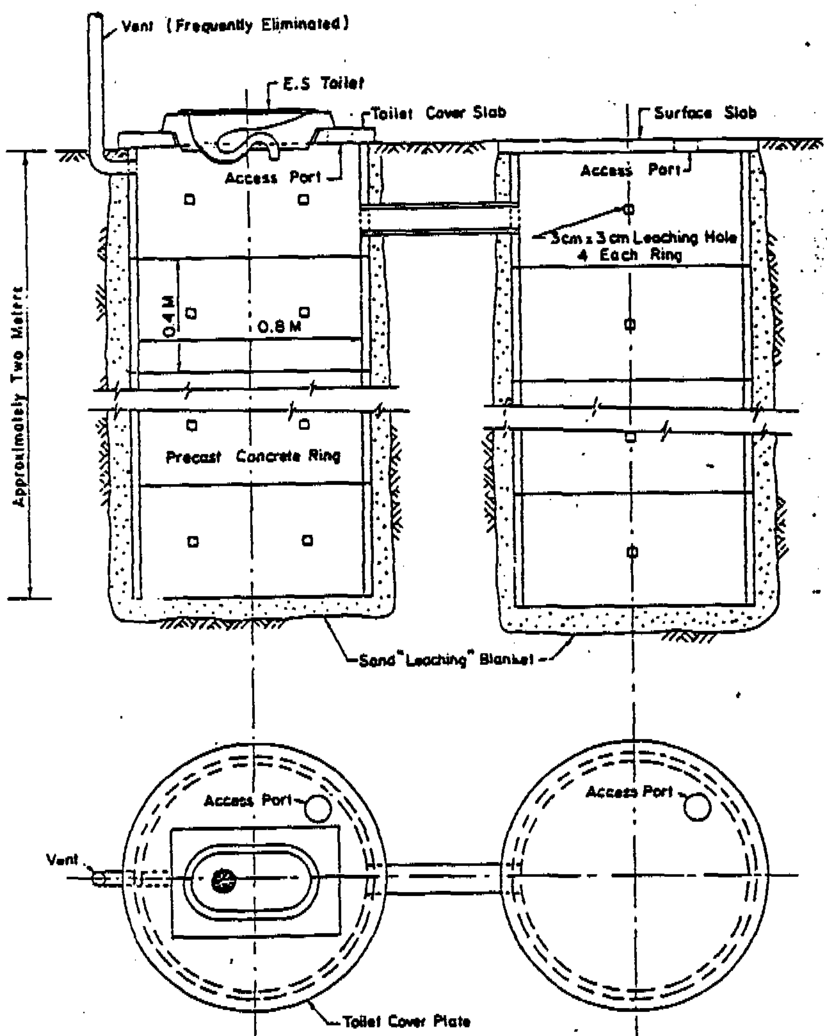
IDEAL PRELIMINARY CHECKLIST DESIGN, CONSTRUCTION, OPERATION AND MAINTENANCE OF SANITATION SYSTEMS.

Let's focus on some prevalent sanitation systems both on-site and off-site systems in Thailand that are applied in NHA scheme as following.

CESSPOOL LATRINE

In general, the latrine has four basic compartments: the pits the slab or squatting plate, the superstructure and the vent pipe.



TYPICAL CESSPOOL FOR THAILAND

DESIGN AND CONSTRUCTION REQUIREMENTS

- soil condition for percolation/infiltration is suitable (recommend at least 10 litre/m² per day)
- low ground water table, if not it necessary to construct elevated above ground for squatting plate inorder to prevent flooding, or emflushing of feace.
- joints between the rings are sealed
- ring are puncture
- Ventpipe is required inorder to easy flush (PVC = 250mm)
- removable lit are placed on second cover plate inorder to desludge
- cesspool should free from smell and unsightly condition
- Footstep, plate, bowl is Well construction and installation.
- Floor is sloping towards drainage point.
- reinforced concrete for the cover slab.
- cover slab should be 40 cm longer in diameter than the pit and about 75 mm. thick
- pit lining requirement. if the soil is stable, only the top part of the pit will need lining. For loose soil, or where the groundwater surface is above the bottom of the pit for all or part of the year, the entire pit of first tank will need linging with light concret, second cesspool pit lining with sand or gravel as a blanket.
- superstructure provides sufficient privacy, light, safety and air ventilation
- proper position of container, tap for easy use

- Doors are sufficient quality
- Door can be locked from inside
- Superstructure should provide hanger for cloth.
- Design for easy construction, consideration of concrete rings or other local materials
- Easy for self-building by community.
- Coordinate between designer, constructors, users and services people inorder to get the exact practical informations in the field inorder to overcome the existing problem of user and service people.
- bowl color selection should satisfy to the user taste.

OPERATION REQUIREMENTS

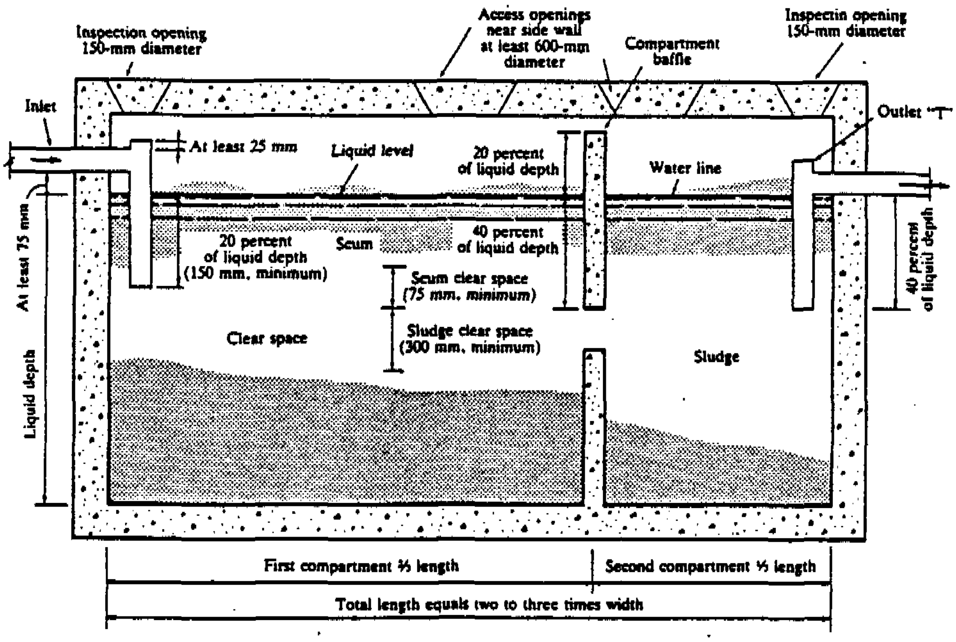
- Bowl is wetted before using
- four litres of water is used for pour-flush.
- eighteen litres of water is used for cistern flush
- water tap with container and can are require for pour flush latrine.
- no solid enter the bowl
- correct squatting position is practised; children are assisted when required
- other water is not emptied into pan. sullage, rainwater
- water tap inside latrine (if present) is closed properly after use
- coordination between user and designer and service people.

MAINTENANCE REQUIREMENTS

- regular removal of the sludge
- inspectation of full sludge in the tank periodically
- Superstructure must be kept in good condition
- Floor and bowl are cleaned regularly and properly, no excessive water, no aggressive chemicals, no abrassive materials are used for cleaning
- cover plate not be broken
- cover lit on the plate is replace tighly after desludging
- the removal is disposed of in an environmental safe area
- the contact faces of cover and pit are cleaned and a small layer of plaster is applied to restore an air-tight pit.
- After removal of sludge equipment, workers and environment is cleaned thoroughly to avoid any health risks.

SEPTIC TANK

Figure 14-1. *Schematic of Conventional Septic Tank*
(millimeters)



DESIGN AND CONSTRUCTION REQUIREMENTS

- latrine does not cause any inconveniences (smell, noise)
- Entrance to latrine is without difficulty (high steps, narrow space, wrong opening door etc.)
- pan is well bedded in floor
- footsteps of pan are well positioned for use by men, women and children
- sufficient space is created for woman and child,
- water container location is suitable not far
- floor has smooth finishing
- tank is well-connected, well-located accessible

do not affect foundation of wall and beam
- tank cover is well constructed, tight, removable
cover lid for desludging
- tank is well design complies with number of
users, compartments, level of inlet and outlet,
sufficient volume for influent loading.
- tank walls are constructed properly (erect, thickness
depth, width and materials)
- outlet of tank connects to sewerage.
- Septic tank does not overflow into road side
or footpath.
- Superstructure provides sufficiency privacy, safety
ventilation with fresh air.
- Door can be closed from inside
- Inside superstructure provide hanger for cloth,
water tap
- Sufficient space is created for water container
- coordination between designer, constructor, material
supplier, user and department of sludge removal
inorder to achieve the field problem.

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OPERATION REQUIREMENTS

- Pan is wetted before using
- sufficient water is used for flushing of human excreta
- water seal in shiphon pipe of bowl is always kept full in order to prevent bad odor from biological gasses in the septic tank.
- Discharge just right into the squatting hole so as not to dirty the seat.
- correct squatting position is practiced, children are assisted when required.
- If septic tank is not designed for other than latrine influence, sullage, rainwater, bathing and washing water are not implied into pit.
- Water tap inside latrine is closed properly after every use.
- No solid enter the pan or seat (rags, sand earth, leaves, sticks)
- Loads on pan or seat are avoided (by stepping)
- Water for handwashing is not discharged into pan
- strong chemical, detergent are not used for cleaning pan (no chlorine, bleaching powder, soap)
- people who operate should made aware of the requirements in accordance with the plan or drawing made by the designer.

MAINTENANCE REQUIREMENTS

- Roof, walls and door of superstructure are kept in good condition and repairs are executed.
- Floor and pan or seat (inside, outside) is cleaned regularly and properly.
- No excess water is used for cleaning floor, pan and seat.
- Leaking water taps inside the latrines are repaired immediatly
- No abrasive material are used for cleaning of pan
- junction box is not overflowing, no back-flow in junction box or discharge pipes.
- cover lid of septic tank and junction box are removed and placed with care, without damaging if incase of damaging should be repair immediatly with air tight condition.
- Record is kept for starting and emptying dates of septic tank
- Remove the sludge when the level of the sludge exceeds 3/4 of the liquid level.
- During sludge removal not contact with the liquid and solid
- After removal of the sludge, equipment, workers and environment are cleaned thoroughly to avoid any health risks.
- the sludge is discharged, disposed of in an environmental safe manor.

WASTE STABILIZATION PONDS

DESIGN AND CONSTRUCTION REQUIREMANTS

- pond landscape should be looked attractive (eg. by introducing permanent adiquate long life tree planting around the embankment)
- setting paving slabs at top water level on pond embankment (consideration of stopping veget-ation growing down the bank, prevent the breeding of mosquitoes, erosion of the embank-ment)
- long thin pond is advisable, series of ponds.
- rectangular pond geometry. length to width ratio of 2:1 or 3:1)
- minimize earthworks by balancing the volume of cut and fill (introducing parallel units of pond)
- the bottom of the pond should be impermeable.
- slop of embankment of 1:3 is usually satisfy in most soil conditions.
- main sump provides screening, suitable space for removing dispose solid
- rust proved steel bar screenings are prefered
- inlet chut and final outflow should provide for measuring of hydraulic flow.
- distribution of inlet flow pipeline are properly display

- clear zone of algae growth are required if discharge to natural water body inorder to prevent algae bloom and dislike odor.
- storm water by pass system should provided.
- electrode or floating are equipped to control level of water in main sump for automatically pumping
- circuit and control are kept simple clear and safety
- water supply distribution net work
- plant building
- truck to carry the deslndge waste.
- coordination between designer, constructure, operator and maintenance worker.
- financial basis
- spacings for walkway or for convenience to renew, redig the pond are provided.

OPERATION REQUIREMENTS.

- remove floating objects at inlet screen frequency, at least twice a day
- continuous flow in and flow out of waste water
- for the plant of 3000 cu. metre. require 3 semi-skilled labour to lookafter the plant equipment, pump.

- check the efficiency of treatability of each pond in laboratory at least once a week
- appropriate policies and organizational arrangements for dealing with its operation function
- submersible pump
- financial basis = 3 - 5 % of investment cost.
- on the job training of operators
- health aspects of operator who contact with sewage.
- safety regulations, eg wearing boot, handglove special uniform
- manual for operator to perform the stabilization ponds step by step., state what is the importance part.
- co-ordination between operator, designer.
- people who operate should made aware of the requirements in accordance with the plan or drawing made by the designer.

MAINTENANCE REQUIREMENTS

- Redig / desludge from the bottom of the pond. frequency 5-8 years/time depend on the decreasing available depth in the pond (1.5 m for facultative pond.)
- roaring boats are required inorder to remove vegetation in the pond
- inspectation of mechanical, electrical equipment

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by technician
- Record and inventory of equipment, instrument that used in the plant
- periodically check the performance of equipment and process performance
- During sludge removal by manually, or by mechanical hawl tractor, contact with liquid or sludge is avoided.
- Sludge should be proper dry.
: no chemical peticide application inorder to get rid of floating vegetation.

ACTIVATED SLUDGE

DESIGN AND CONSTRUCTION REQUIREMENTS

- all metals used in the process have to be perfectly rust proved
- surface of metals have to be coating, painting with rust-proved agent (eg. epoxy painting, anti rust painting)
- concrete surface that contact with waste water must be polished type.
- out let pipe should be bell-mouth type
- flexible joint, flexible union of pipe are required
- installation of inlet flow meter
- installation of return sludge flow meter
- installation of grease trap in the channel before aeration tank
- slop of bar screen is 60° to horizontal are suggestion
- storm water by pass system should be provided
- inlet pipe to each tank should be vertical up flow and located in centre of tank
- baffle board is required in order to destroy the turbulence of hydraulic flow
- hydraulic flow in the settling tank must be completely radial flow off.
- labour and material used for construction should specific requirement eg skilled labour, specificated materials

- tanks and walls are constructed properly correct, thickness, depth, width, and material and water tight.
- qualified and financial basis contractors for construction.
- supervision of a resident engineer during construction.
- commissioning period for at least 12 months after handling over the plants from constructor.
- water distribution net work to the proper point in the plant
- high pressure pump (eg booster pump) are required to installation for cleaning tank, pump, building.
- office building, resident room for shift caretakers,
- proper fencing around the plant.
- truck to carry the disposal waste
- financial basis
- coordination between designers, contractors, operators and maintainors.
- emergency electric generation for electrical supply to aerators incase of long time electricity shortage in order to keep activated sludge bacteria availability.
- sump pits in each tank are required in order to install removable submersible pump for cleaning the tank periodically.
- circuit and control are kept simple clear and safety.

OPERATION REQUIREMENTS

- all day and all night (24 hours) and continuous process operation.
- for a small plant about 2500 cubic meters of waste water required at least 3 skilled labour to keep the process (eg. tank, weirs, channel, building, equipments) and the surrounding clean everyday, required at least 2 skilled technician (1 electrician, 1 mechanician) to run equipment and do routine maintenance
- required process supervisor
- laboratory to check and control of processing
- record of operating data everyday
- channels, flumes edges of tanks that contact with waste are cleaned up by soft brush long arm type everyday
- antiseptic agent to clean part of body after contact the waste
- emergency dispensary package for shift caretakers
- periodical clean up settling tanks, digestion tank, (each compartments are considered to be clean periodically.)
- weekly summary report for physical, process, mechanical and electrical condition, variation, deterioration to supervision.
- remove of scum layer in flow meter chamber everyday.

- operation manual for process running, start up equipment as guideline step by step.
- water spray nozzle to get rid of the foam formation in aeration tank.
- result of process check lists (eg. sludge volume index (SVI), pH, floating of sludge, bulking, denitrification) should be properly solved immediatly
- water supply, water tank, water pipe distribution and high pressure clean water pump are required to clean the compartments.
- adequate equipment for labours (eg. sweeper, digging tools), mechanical tools (set of tools), electrical equipment (eg clipped ampmeter, screw drivers), are supplied.
- coordination between operator, designer, constructor and maintainers.
- financial basis.
- people who operate should made aware of the requirements in accordance with the plan or drawing made by the designer.

MAINTENANCE REQUIREMENTS

- regularly remove off floating objects at bar screen at least 2-3 time a day
- greasing, lubricating, oil refill for mechanical equipment periodically.
- routine check the performance of electrical and mechanical equipments by providing check list table.
- dispose solid waste accummulation on the bar sreen chute - one or two day per time.
- remove and disposal of grit from the grit chamber every 1 or 2 week or after inspect the depth of grit chamber is reduce to ½ of total hight.
- painting all metal surfaces with epoxy painting every 3 years
- leaking pipe are repaired immediatly.
- leaking of water into landyard has to be found out and solve immediatly.
- routine maintenance, preventive maintenance and overhall maintenance of equipment are required and should be done regularly and properly
- to keep radial flow of waste water from each tank are recommended (for balancing in every direction of flow, keep completely settling of settleable solid in waste water, to prevent short

circuit of hydraulic flow, keep retention time as design, if inspect that tank can not provide balancing of radial flow to every direction, solve by baffle weir adjustment or installation of baffle weir are suggestion.

- Organization arrangement for maintenance.
- Submersible pump are provided in order to desludge or cleaning out the tank.
- maintenance manual of instruments and equipments
- check the operational report and solve the defect problem properly and immediatly.
- adequate budget to maintain the physical condition eg. painting, repair mechanical and electrical equipments.
- Cooperation between designers, operators, constructors, and maintainors

II.3 SUGGESTIONS FOR SANITATION SYSTEMS IN LOW-INCOME AREA OF THAILAND

Part II.2 states the ideal sets of requirements for designing, construction, management and O&M of sanitation systems both on-site and off-site sanitation systems that are prevalent in Thailand and are applied generally in NHA schemes. So this chapter will review the requirements described in part II.2 in respect of the existing reality both on-site and off-site system and give some suggestions from my observation and experiences.

II.3.1 ON-SITE SANITATION SYSTEMS

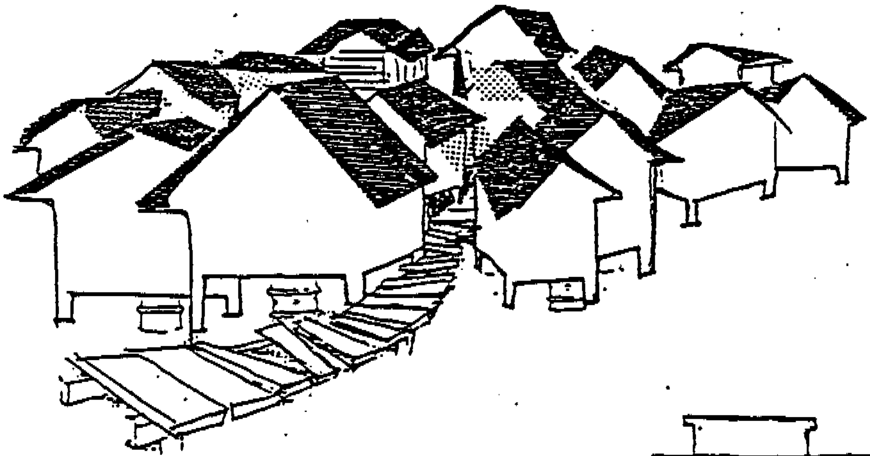
The prevalent sanitation systems for on-site treatment in urban area of Thailand are cesspool and septic tank with pour flush type of latrines.

For those existing system, from my experience I observed that:

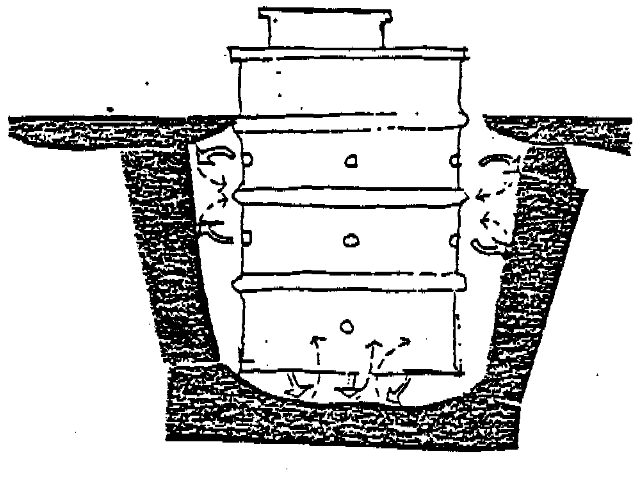
1. This systems may spread diseases especially during flooding periods, because effluent quality

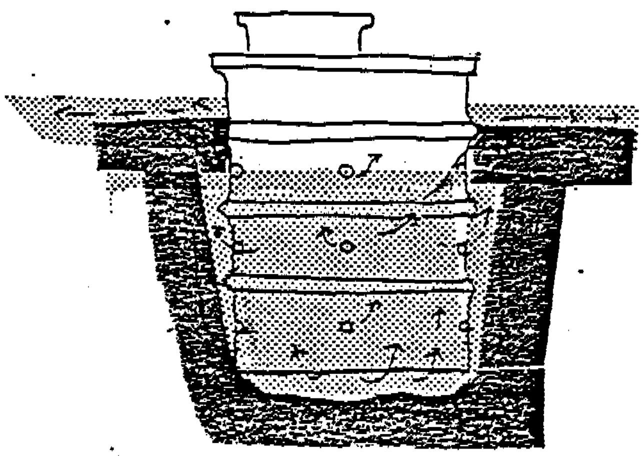
WHY DOES THE CESSPOOL FAIL?

1. HIGH DENSITY
   - EXCEED PURIFICATION CAPACITY OF SOIL



2. POOR SOIL CONDITION
   - CLAY SOIL SLOWLY PERMEABLE





3. HIGH GROUNDWATER TABLE AND FLOODING
   - CONTAMINATE ENVIROMENT

is still polluted. The earlier mentioned regard on the research done by TISTR and Mahidol University in TABLE , page has confirmed this.

2. Urban area in generally is pretty flat and is flood prone due to local rainfall and bad drainage system

3. Soil is clay and groundwater in Bangkok at about 1 metre below surface, other region soil condition can permit percolation but only in loose density of houses, can applied cesspool type which function well.

4. Soil condition in Bangkok and dense urban area are not suitable for permeability of waste water from soak pit, some places need very frequently to remove of accummulation sludge in cesspool. but from my observation I found that the most of disposal sludge are liquid content than digested solid sludge content.

5. Vent pipe from the pit is not suitable in size or sometime dissapear, it causes uneasy to flush down the faces into the bowl

6. Clogging in the bowl, because of the disposal of ladies' sanitary materials in the bowl.

7. When people (user) get difficulty of flushing the toilet. The way the cope with the problem is connecting a small pipe from the chamber directly to the public drainage system.

8. The underground water is rather high (about 1 metre) and periodically flooded in the rainy season, so the effluent is hard to soakaway.

9. Design criteria for cesspool and septic tank are still so empirical at the present time. For the volume of pit or tank may be calculate as

= (waste flow, m^3/hd.d) x (population) x (1 or 3 days retention)

by assuming - hydraulic retention time = 1 or 3 day
- waste flow as sludge accumulation
= 0.03 - 0.04 m^3/hd-year.

For desludge interval (years) is therefore given by

$$\frac{(\text{1/2 or 2/3 of tank volume, } m^3)}{(\text{sludge accumulation, } m^3/\text{hd-yr.}) \times (\text{population})}$$

Soak way pit design. by assuming
- soil infiltration rate = 10 litres/m²-day.

For the above design criteria, the efficiency to remove BOD is not exactly known and applied. In my opinion, I think that it need to do a research for other parameters that directly effect on design for better effiency of BOD removal.

10. Superstructure and overground facility, I observed that:

- it usually has bad odor in the toilet room due to bad ventilation, no free space between the wall and the roof.

- water container inside the toilet is located so far from the user, which cause inconvenient for leaching process.

- desludge removal interval time can not be known inadvance by the user, he will know when the sludge floating to the squatting plate or when it cause uneasy to leaching into the squatting plate.

- On the floor often found that water is locked due to uncare of slope floor to the drainage point.

- water tap is not tightly closed after used

- uncare to repair the leakage water trap inside the toilet

- No awareness of people on hygiene eg. after anal cleaning by hand and water, they do not use soap to clean their hand again. sometime they prepare food, drinking water on the cover of the pit.

- standard model designs are not influent. known by user, constructors

- no financial issue to support low-income people
- emptying service sometime asked for extra payment from the user.
- rarely advice or assistance from local government.

SOME SUGGESTIONS FOR ON-SITE SANITATION SYSTEMS

1. Squatting pan : horizontal length of the pan should be at least 425 mm long and at most 200 millimeter wide, so that children will not fall into the pit

: Ceramic or fibre glass pan have many advantages over the concret one, they are smooth, require less water for flushing and are more aesthetic. Fibre glass pan is cheaper, lighter and easier to transport than the ceramic one. The concret pans are heavy, difficulty to transport and get roughened and unattractive after sometime due to the action of uric acid.

: The squatting plate should have no sharp edges or rough surface that would make its cleaning difficult and unpleasant.

2. Leaching pits or ~~cesspool~~ or septic tank, the size depend on a number of factor such as, number of users, cleaning interval, soil composition including its permeability, water table condition.

: for sludge accumulation rate suggestion for effective value is 0.03-0.04 m^3/hd-years
∴ Hydraulic retention time = 1 day.
: desludge interval time = 3-5 years in order to have complete digestion in septic tank
: shape of pit can be circular or rectangular with concrete seal for water tight; but prefab concrete rings - diameter 800mm or 1000mm and hight for each of 350mm or 400mm are available in local market.

3. Location of pits: pit should be located within the premise of the house.
4. Pit covers should be reinforcement and install removable lit for emptying by vacuum trucks.
5. Superstructure should provide sufficience privacy, light, ventilation, safety. hight of roof should be a minimum of 1.8 metres.
6. Institutional arrangement. It is necessary to set up a suitable institution for planning, implementation, maintenance, advising people
7. Orientation and training of user
8. Awareness of personnel and public hygiene should be in practice.
9. Methodology for construction of household latrine for constructures.
10. communication support eg. promotion of toilet material, propaganda activity to make people awareness to toilet; commissioning period of toilet after complete construction (if done by constructors)

II.3.2 OFF-SITE SANITATION SYSTEMS

Thailand does not have a sewerage system for collection and treatment of domestic sewage. Most households in the urban and rural areas are entirely equipped with septic tanks or cesspools, sometimes combined with soakage pit, as mean of excreta disposal. Only for a few newly-constructed housing projects, off-site sanitation system have been introduced by NHA and private sector housing projects.

In the off-site sanitation systems in NHA scheme I gained longterm experience. I found that there are many problem concerning on designing, construction, management, operation and maintenance. In respect of the earlier requirements the following constraints and problem can be observed:

1. Investment cost (capital cost) for waste water treatment plants is about 1.48 - 2.9% of total housing project cost. It is reasonable.

2. Electricity consumption is about 25.8 - 72.5% of total running cost. It is too high in proportion.

3. operation cost in 1982 for 11 treatment plants is 739,263.2 ; capital cost = 54.9 million baht

so operation cost in 1982 = 1.34% of capital cost

in the same way, in 1987

operation cost reduce to 329962.7 ฿

= 0.60%

operation cost in 1982 = 1.34%

operation cost in 1987 = 0.60%

But for the suggestion operation cost should be 3-5% of total captital cost

these may be lack of financial basis or the operators and maintainors donot know how to perform the plant in satisfaction management and O&M.

But reality it cause severe deteriorat-ion.

4. Some treatment plants creat noise due to mechanical air blowers, surface aerators

5 when start up the operation process/ when process fail and start it up again aeration tank creat detergent sud that causes nuisance to people (residents)

6. In main sump and in septic condition creat bad odor.

7. Contractor, constructure have not adequate experience not keen for perfect

construction eg. difficult to make a big round tank for instance, in Tasai treatment plants

8 Overdesign for some compartment eg. return sludge tank in Bangplee plants retention time now is more than 10 hours but designer designs for next expansion for full scale settlement. So it cause septic condition.

9. No inventories and records of sewer, as build drawing only old worker know the exact location.

10. Lack of coordination between designer, operator and maintainors.

11. Operation and maintenance is not in good performance which can show by the following figure [FIGURE 123(A.) AND TABLE 124(A.)]

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SOME QUANTITIES OF WASTE WATER, FROM 11 SELECTED PLANTS

CHARACTERISTIC OF WASTE WATER	HUAMARK	RUNGSIT	HUAYKWANG	RAMINTHRA	KLONGCHAN	PIBOONWATTANA	BANGBUA	BANGNA
COD, mg/l.								
- influent	159	139	317	145	192	121	265	284
- effluent	144	96	26.5	66.8	53.5	59	96.2	119
% removal	33.3	29.4	91.4	53.9	72.1	51.2	63.7	58.1
BOD, mg/l								
- influent	30	73	139	38.5	27.3	43	105	107
- effluent	18.7	35	10.4	13.4	8	13	26.6	52.7
⇒ % removal	62.3	52.1	92.5	65.2	70.7	69.8	74.7	50.7
S.S., mg/l								
- influent	27.3	43.3	135.7	53.4	27.3	28	172	69.5
- effluent	12.8	25.29	5.72	9.8	16.7	17	26.7	9.25
% removal	66.1	41.7	95.8	81.6	38.8	39.3	84.8	86.7
MPN/100ml.								
- influent	1100×10^5	87×10^5	398×10^5	45×10^5	110×10^5	40×10^5	42.7×10^5	30.5×10^6
- effluent	23×10^4	17.9×10^5	12×10^5	119×10^5	0.4×10^5	0	4.5×10^5	9.3×10^6
% removal	99.8	43.4	96.8	73.6	99.6	100	99.5	79.3

DATA FROM RESEARCH OF THAILAND INSTITUTION OF SCIENTIFIC AND TECHNOLOGY RESEARCH, 1981

OPERATION COST AND QUANTITIES OF EFFLUENT FROM 11 SELECTED PLANTS.

Names of Plants	Capital Cost (M.Baht)	1982 Operation cost (Baht/Unit/Month)	Efficiency (BOD)	1987 Oeration cost (Baht/Unit/Month)	Efficiency (BOD)
Hua Mark	0.4	17.17	20	6.07	40
Rung Sit	1.4	32.95	18	5.73	30
Huay Kwang	26.0	29.39	10	20.16	25
Klongchan	11.4	29.55	15	19.56	40
Ta-Sai	0.4	7.46	20	6.96	60
Piboonwatana	1.1	70.63	15	24.12	40
Dindaeng	3.0	57.10	15	20.28	60
Prachanivet	2.5	9.60	20	4.66	40
Bangbua	3.2	26.47	12	11.96	50
Bangna	3.2	22.66	12	16.10	50
Ram-inthra	2.3	51.73	12	22.70	40
TOTAL SUM	54.9	AVERAGE 32.24	15.36	14.39	43.18

Operation cost in 1982 = 8,871,158.4 Baht.

Operation cost in 1987 = 3,959,552.4 Baht.

Therefore it can safe about = 4,911,606 Baht.

But efficiency decrease about = 2.81 times and suffer more.

DATA FROM COMMUNITY SANITATION SECTION, 1988

From TABLE 123 we can compare the value of BOD, COD, SS and MPN of waste water before influent, and after treated (effluent) in the process performance. The percentage of removal can be use as an index to indicate the efficiency of waste treatment plants in comparision with the ideal and reality one.

For the standard criteria of off-site treatment plants performance should have efficiency to remove BOD. more than 85%, due to the original design. [Mara, 1980] but from Table 124 in the year 1981 only Huay Kwang sewage treatment plant can satisfy this performance, it can remove 92.5% BOD while the other plants can remove only 50.7 – 74.7%. And from TABLE comparing the effluent BOD from 11 plants in the years 1982 with the year 1987 the efficiency to remove BOD is decrease about 2.81 times.

From my observation I found that there are many problems for instance:

1. Oxidation pond of Hua Mark and Aerated Lagoon of Rungsit is under design, the capacity of the tank is too small to treat all quantity of waste from their communities, The retention time is 3-days for oxidation pond and less than 12 hrs. for aerated lagoon so aerobic digestion condition will never be completely done.

2. Turbulence and percentage of dissolve oxygen missing in the aeration tank is too low,

eg. Bangna and Bangbaua have dissolve oxygen in aration tank below than 1 milligram/litre and some area has dead stream.

3. Mechanical equipment defects, normally found that aerator and longshaft sewage pump are run down in spite of in between the commissioning period eg. Bangna, Raachaniwet then because they used normal type instead of heavy duty type that have to operate for 24 hours, serviced factor is understandard. O_2 transfer efficiency of aerator is not as the specification. Sometime found that they installed the horizontal aerator instead of vertical type eg. Bangna.

4. Operators do not turn on the return sludge pump. So there is no activated sludge from the bottom of the final settling tank to balance F/M ratio in aration tank, this cause severe failure of aerobic process performance.

5. No control of surplus activated sludge, sometime sludge age is too old and not active for digestion of organic waste

6. Shortage of chemical used in the plants eg. chlorine, polyelectrolyte for dewatering

7 sometime they pump out directly the sewage to the caunal, so bacteria in aration tank are lack of organic nutrients and die.

8. It is often found that the plant is operated only during office time due to no man-power to look after hence there is stop running

SOME SUGGESTIONS ON OFF-SITE SANITATION ARRANGEMENTS

From the existing situation as said earlier, in my opinion I give suggestion that:

1. It is necessary to set up maintenance policy which describe how satisfactorily the system is functioning, major attention will be given to the arrangements for operation and maintaining system in good working order.

2. It is necessary to prepare a manual for operation and maintenance of the plants

3. It is necessary to set up a routine checklist for O&M of process, mechanical and electrical equipment

4. It is necessary to set up adequate finance basis, because maintenance budgets are the easiest to cut when money is scarce.

5. It is necessary to train the staff and operators to perform the treatment plant with great awareness of their responsibility and also train about health hygiene and security regulations in the plants.

6. There should be a feedback of information on performance in use from previous projects to the designer, planner in order to avoid repeating the same error.

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7. The designer needs the participation of users and maintenace managers to obtain effective feedback; they must be regarded as an integral part of extended design team.

8. Operators and maintainors should made aware of the requirements in accordance with the plan or drawing made by the designer.

9. Operation and maintenance cost should be shown seperately, year by year, so that the probable trends in unit costs can be indicat. And try to make an alternative technic which have differing O&M cost implication.

10. Area Office should give greater attention to waste water quality and quantity produce by the residents in community, thereby improving clogging condition in sewer.

11. Simplifying the design of treatment plants to reduce the operation and maintenance problems (eg. use waste stabilization pond instead of an complicate activated sludge plants)

12. It is necessary to assess the efficiency of management and O&M of the treatment plant.

13. In opting for an alternative to management of wastewater treatment plant of NHA eg. official-time operation, mediation number of operators, handling the plants over to other agencies or communities, these trade-offs need to be considered and detailed comparision made before

conclusions can be drawn. These require research to be set up to test such aspects (as social acceptance, cost effectiveness, continued maintenance and financial viability)

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CONCLUSIONS AND RECCOMMENDATIONS

number:

CONCLUSIONS AND RECOMMENDATIONS

Thailand does not have a sewerage system for collection and treatment of domestic sewage. Most households in the urban low-income areas are entirely equipped with septic tank or cesspools, sometime combined with soakage pits, as means of excreta disposal. Only for a few newly constructed housing projects have off-site sanitation systems which have been introduced by NHA and some private sector housing projects.

On-site disposal systems are human excreta disposal systems in which the sewage is discharged and as far as applicable treated on the plot. In Thailand, the prevalent on-site sanitation systems are cesspool, aquaprivies (in refugee camps) and septic tank the toilet in used is pour flush type. The major causes of failure of these system are:

1. Poor soil condition, clay soil allow slowly permeable of waste water

2. High ground water table and flooding that effect contamination to environment.

3. High density of households in urban area exceed the purification capacity of soil.

4. improper installation of these systems
5. Poor operation and poor maintenance by individual house-holders

RECOMMENDATIONS ON ON-SITE SANITATION SYSTEMS.

1. It is necessary to develop an organization for undertaking proper operation, maintenance and management of such systems. The utility would undertake engineering studies consisting of site survey, design of on-site units, installation of new units, demonstration , emptying the full units and replacement of failed units. The utility would also assume responsibility for monitoring, inspection, hygiene education on sanitation, promotion of on-site adequate systems, maintenance and management of these systems.

2. Some basic criteria should be considered:
- the surface soil should not be contaminated
- there should not be contamination of ground water that may enter wells.
- there should be no contamination of surface water
: excreta should not be accessible to flies or animals
: there should be no handling of fresh excreta,

- there should be freedom from odors or unsightly conditions.
- the method used should be simple and inexpensive in construction and operation.
- the system should be as similar as possible to the use of the present cesspool/septic system.
- it should be incrementary improvable.

OFF-SITE SANITATION SYSTEMS are the excreta disposal systems that discharge and treat waste water out of plots. They include water-borne sewerage, sewers, vacuum truck system, waste water treatment plants. More particularly, this report shows in respect of waste water treatment plants in NHA schemes, which can be catagorized to 4 types: waste stabilization ponds (oxidation pond), aerated logoon, oxidation ditches and conventional activated sludge. For the existing situation, the main contraints & problems can be observed:

1. Investment cost for waste water treatment plants is about 1.48-2.9% of total housing project cost. This is reasonable.

2. Electricity consumpsion is about 25.8-72.5% of total running cost. It is too high

3. operation cost & maintenance cost } in 1992 = 1.34% of investment cost
in 1987 = 0.60% of investment cost
both of them are below suggestion o&m cost (3-5%)

4. Waste water treatment plants create many problems, they are run-down beyond the point of economic repair. A complete solutions for this problems has not been find out but it seems that three main failings are at the root of most of the problems: inadequate financial basis, bad management - bad operation and bad maintenance, poor design.

RECOMMENDATIONS ON OFF-SITE SANITATION

1. It is necessary to set up maintenance policy which describe how satisfactorily the system is functioning, major attention will be given to the arrangements for management and operation and maintenance of the system in good working order.

2. It is necessary to establish long-term institution for undertaking proper operation, maintenance and management of such systems. The utility would undertake engineering studies consist of site survey, design of off-site treatment plants, co-ordination with the related unit to get feed back information as to avoid repetitive mistakes in the use of materials or design of inappropriate facilities that create a problem for maintenance.

3. It is necessary to do a reseach to improve the existing condition of off-site sanitation as an

incremental part of the old one.

2. It is necessary to look for alternative appropriate options that can achieve most of the problems and requirements, this require a more precise analysis and research.

OTHER RECCOMMENDATIONS BOTH FOR ON-SITE AND OFF-SITE SANITATION

The O&M situation of sanitation in Thailand has continued to deteriorate. Available data on O&M are very limited, often outdated and generally not very accurate. More often, deficiencies in O&M are the result of a failure to recognize the importance of O&M and the linkages which exist between the various servic sectors. O&M issues should be seen as a part of an urban management system, and interventions should not be too narrowly focused on technical issues in the individual service sectors as it has too often been the case in the past, it should also associated with practical realities.

Recommendations for improve O&M by:

1. Establish appropriate inventories and records of assets to be operated and maintained as a basis for systematic planning, budgeting and monitoring of O&M works.

2. Develop performance indicator for O&M activities and establish appropriate management information

systems and sound principles for cost-effective O&M management.

4. Identify staff training needs in the field of operation and maintenance at managerial, professional, supervisory and operational levels as well as for policy-decision makers and set up training strategies and programs to meet these needs.

5. Mobilize community groups and private voluntary groups for increasing participation in O&M

6. Ensure that sanitation are planned and designed with maintainability and ease of operations. the constructions are very closely supervised.

7. Ensure that people who operate and maintain sanitation system made aware of the requirements inaccordance with the plan or drawing made by the designer.

From the existing situation as said earlier, it is strongly necessary to do a systematic research, look into the factors and quauntify those factors which determine the adequacy of operation and maintenance of the various sanitation options for low income housing areas in Thailand. The main objective of research should achieve to formulate operational recommendations for the planning, design and implementation of future low cost sanitation scheme including site specific conditions, and establishment various long term requirements including investment requirements for the operation and maintenance of these services and facilities.

At present, there is co-operation between National Housing Authority (NHA), University of Chiengmai (UCM), Thailand and Institute for Housing Studies (IHS), Netherlands to carry out the reseach.
The selection of the reseach project areas take place in 8 provinces in Thailand to conduct a technical and environmental field survey of 20% of these site, analyse the collected data, conduct review seminar

For more details of this reseach can be seen in ANNEX.

RESEARCH PROPOSAL

OPERATION AND MAINTENANCE ASPECTS OF SANITATION SYSTEMS IN LOW INCOME SHELTER AREAS.

prepared by

Netherlands

Institute for Housing Studies, IHS
International Reference Centre for Community Water Supply and Sanitation. IRC

India

Housing and Urban Development Corporation, HUDCO
Human Settlement Management Institute, HSMI

Thailand

National Housing Authority, NHA
Centre for Housing and Human Settlement Studies, CHHSS
University of Chiang Mai, UCM

#11 (10/6/88)

PROJECT DATA SHEET

1. Project Title:

   OPERATION AND MAINTENANCE ASPECTS OF SANITATION SYSTEMS IN LOW INCOME SHELTER AREAS.

2. Location: India and Thailand
3. Duration: 24 months
4. Sector: Infrastructure, appropriate technology
5. Total costs : Dfl
6. Req. contribution : Dfl
7. Own. contribution : Dfl

8. Third parties : HUDCO/HSMI, India
   NHA/CHHSS, Thailand
   CMU, Thailand

---

9. Summary of project:
   More and more developing countries faced with severe resource constraints have opted for low cost sanitation solutions to abate insanitary conditions in low income shelter areas (in which 30-50% of the population lives). As such during the last ten years an increasing amount of investment has been made in this sector. Lately it has beome increasingly clear, however, that due to inadequate attention devoted to issues of operation and maintenance (which was thought to be of no significance or simply as an individual household problem) valuable assests created are becoming inoperable and often damaged beyond repair.
   Therefore, unless these operation and maintenance issues are addressed adequately the entire basic urban sanitation programme will be put in jeopardy (thus leading to the continued bad environmental conditions for the urban poor) when third world institutions would opt again for the installation of conventional high cost solutions only. This would result in a much lower coverage and- whenever undertaken - would generally only be installed in affluent areas which can afford them.

   This research will systematically look into the factors and quantify those factors which determine the adequacy of operation and maintenance of the various sanitation options for low income shelter areas in the Asian region. Due to the variety of climate, soil conditions and sanitation technologies used, India and Thailand have been selected as representative study countries for the Asian region.

10. Project Objectives:
    * To review operation and maintenance aspects of on-plot and off-plot sanitation systems in low-cost housing and slum upgrading schemes within the overall context of the complete physical housing related infrastructure package.
    * To review the use and performance of these systems.
    * To obtain observations on operation and maintenance of the sanitation systems from various user groups, including men, women and children.
    * To establish long term requirements including investment requirements for the operation and maintenance of these services and facilities.
    * To formulate operational recommendations for the planning, design and implementation of future low cost sanitation schemes including site specific conditions.

11. Direct results to be expected.

* Status report on operation and maintenance requirements of different sanitation systems.
* Status report on the performance of different sanitation systems.
* Design recommendations and guidelines with its related operation and maintenance requirements of sanitation systems for low-income shelter areas.

12. Summary of main activities:
The selection of the research project areas (app. 15 in India and 8 in Thailand). To conduct a technical and environmental field survey for 20% of these sites, analyse the collected data, conduct an in-house review seminar. Based on the experience, execute the main survey based on the review seminar, establish the performance and operation and maintenance requirements of the different schemes. The production of an interim report for seminar submission. After review a final report with guidelines and recommendations will be submitted.

13. Finances:
Total finances required (DGIS) Dfl. (see attached budget sheet).

14. Relevant documents:
HSMI, ISHP brochures
IHS, IRC brochures
HUDCO/HSMI letter of intent
CMU letter of intent
NHA letter of intent
Sulabh International article from Habitat
The Urban Edge, December 1987, World Bank, Washington D.C.

15. Responsible institutions and project cordinators:

Principal Investigator
Institute for Housing Studies (IHS), Rotterdam.

Coordination: G.J.W. de Kruijff
M. Jansen
H. Mengers

Supporting Investigator
International Reference Centre for Community Water Supply and Sanitation, (IRC), The Hague.

Coordination: J.T. Visscher
J. Wilson
M. Boot

India- HUDCO/ HSMI Indian Human Settlements Programme.
Sanjib Sarma
Suresh Dave

Thailand- National Housing Authority (NHA)
To be appointed
To be appointed
University of Chiang Mai (CMU)
Thanintorn Sankhasilapin

Research Title:

OPERATION AND MAINTENANCE ASPECTS OF SANITATION SYSTEMS IN LOW INCOME SHELTER AREAS.

Introduction:

The issue of operation and maintenance of basic infrastructure in developing countries is of global significance. The role of operation and maintenance of urban infrastructure (roads, water supplies, electricity, sanitation, drainage, telecommunications) becomes apparent when it is understood that in almost all countries, more than 50 percent of gross domestic product is produced in urban areas and is steadily increasing. Inspite of this and the obvious need to maintain urban productivity and its contribution to the Gross Domestic Product of the country, the operation and maintenance responsiblities for the efficient functioning of the aforementioned public infrastructure regularly has not been taken seriously enough.

Also in many developing countries national ministries are the prime decision makers in the investment planning, programming and the implementation process, whereas local governments are left with the responsibility for the operation and maintenance of infrastructure networks and facilities, in the development of which they often had hardly any say or contribution.

Further governments often cannot keep up with the growing demand for the provision of infrastructure services. This is partly on account of rapidly rising population densities and partly due to a vastly proliferating urban sprawl.

The result of these developments is an all around detoriation in the quality and the adequacy of the urban basic services supply. This in turn on the one hand creates socio-political pressure on authorities to service the mushrooming urban settlements and on the other a rapid depletion of investible resources- thus leading to the unescapable situation that low cost solutions have to be arrived at. In this dual challenge however the issue of adequate operation and maintenance is often delegated to a less important position with generally inadequate or even nil resource allocation and/or institutional responsibility. The people which are then ultimately worst affected by these conditions are those who live in the low income shelter areas.

This has led many experts to conclude that it may be easier to support high unit-cost investments rather than to enter the unknown subject of lower cost technologies with unquantified operation and maintenance requirements. On the economic and financial side this has led to greater attention to the methods of life cycle costing and attempts to understand the long term financial implications of technology and investment choice. These exercises, however, in absence of relevant field data have been largely academic in nature.

The particular operation and maintenance problems suggest that technology design must reflect an appreciation of the need for operation and maintenance from the outset both by the users and the responsible agencies. While it is unreasonable to expect for example that sewage treatment plants would be maintained by community workers, it may be possible as a result of technology selection that the operation and maintenance problems can be shifted from public to private responsiblity.

The investment process in developing countries during the 70's assumed that better project selection, more careful appraisal criteria, and better supervision of project execution could all contribute to the full economic benefits of investment. However, other conditions also have to be met for reaping the full benefits of development efforts. Indeed, investment in inappropriate technologies without users involvement and operation and maintenance may in fact be worse than no investment at all. It raises expectations of a higher quality of life and higher productivity. In the absence of proper use and operation and maintenance, however, those expectations may be shortlived. This in turn leads to frustration and can become counterproductive. Inadequate operation and maintenance may also hamper hygienic use of sanitation facilities and add new health risks.

For example in the case of pour- flush on-site sanitation provision with double leaching pits the users were not made aware of the specific requirements of the system. Users disposed all waste water into the pit which could not absorb these amounts and started to overflow. Connections were made to the second pit, which also started to fill up rapidly. The principle of alternating pits was therefore disbanded. As a result of the flooding the population was brought in direct contact with pathogenic material. In the interim, the inhabitants own immune system had weakened and became less able to resist infectious diseases. Instead of health improvement with its related benefits, the opposite was achieved.

Specific Relevance:

Increasingly over the last decade it has been the experience that sanitation services in Low Income Shelter areas have not been operated and maintained adequately. On the contrary, many services have fallen into disuse for reason of early failure and /or misuse. This generally resulted into a (much) lower service level to the target population than anticipated in project plans. At the same time this caused serious scepsis amongst policy makers, executing agencies and beneficiairies as regards the systems applied.

This research will systematically look into the factors which determine the adequacy of operation and maintenance of the various sanitation options for Low Income Urban Shelter areas with the main objective to provide better design criteria and assessments of long term operation and maintenance requirements.

A main principle of any low cost sanitation system - besides being technically sound - is to provide a system that can be operated, maintained and managed by the community and/or local government organisation. There is however not a good track record in this respect. Generally emphasis has been placed on the construction of services rather than establishing well-operating self- sufficient systems. Often too little attention has been given to arrangements for operation and maintenance, to user and agency training and to the availability of the required equipment.

Problems of this kind often surface only after several years (such as when the time has come to desludge the leaching pits) but then become serious enough to jeopardize the functioning of entire schemes. Hence the need of including sanitation schemes of both recent and older date in the study.

During the last decade an increasing number of Low Income Shelter projects in India and Thailand have been provided with low cost on-site sanitation schemes, such as Pour-flush toilets.

India.

India has made a real pioneering effort both through Government agencies and Non Government Organisations. During the years 1983 - 1984 the Indian Government adopted on-site sanitation technology as the prime alternative for sanitation in Low Income Shelter areas. All towns below the size of 100.000 people qualify for on-site sanitation only in order to both increase coverage and remain within the affordability ranges of local governments and beneficiairies alike. (See Urban Edge, December 1987 article)

In line with this policy the main financer of Low Income Housing in India, The Housing and Urban Development Corporation, (HUDCO) adopted this technology as the first choice for its shelter programmes. Another major motive behind the development of on-site sanitation schemes in India is the national programme for Liberating the Scavengers, i.e. to abolish the manually cleaned toilet systems (bucket latrines) and the creation of meaningful alternative employment for the job loosing scavengers. The NGO Sulabh International is a main pioneer in this respect. The work of Sulabh and the technologies and arrangements applied have found nationwide acceptance. (see Low Cost Sanitation Project in Bihar in India).

Since then a large number of schemes have been planned and implemented based on this technology all over India. This nationwide application in such a vast and varied country naturally is faced with a large variety of circumstances and conditions under which such schemes are implemented. As such a large body of experience both positive and negative is being gained which urgently awaits compilation and evaluation for subsequent feed-back into the planning, design and implementation of new schemes. To date relatively little monitoring has been done of the schemes thusfar implemented. When monitoring takes place this is mainly restricted to the first two years of use of the services. This may have to do with the fact that sanitation schemes once constructed rarely remain the responsibility of the agencies responsible for planning and construction.

Lately HUDCO with its expanding project financing in low cost sanitation is now devoting increasing attention to generate feed-back for policy reformulation as well as to identify fully the technical and socio-economic implications of adopting these alternative basic sanitation technologies in projects financially assisted by it. This research proposal is a result of this concern and will upgrade its capacity to pursue policies which help maintain the assets once created.

Just recently HUDCO through HSMI has undertaken some modest research in the field of user response towards Low Cost Sanitation Conversion schemes. It is felt that the proposed research would complement and corroborate the findings of the said research. It would also help in further strengthening HSMI's capacity of conducting such larger scale research in future.

It is foreseen that the conduct of this mentioned in-house research would form a very good reference in establishing the proposed larger programme of research.

Thailand.

In Thailand the National Housing Authority (NHA) is involved with physical improvements of over 100 slum upgrading projects, for a substantial part financed by World Bank loans. Furthermore it constructed over 100.000 low cost housing in Bangkok and in the smaller cities of the country. Its annual production volume is targeted to average some 10.000 units for the coming five years. On-site sanitation has also gained in importance. The National Housing Authority has been applying a variety of technology choices often quite challenging for example in flood-prone conditions. In the course of time the NHA has been shifting from centralised sewer schemes to on-site or partly on-site solutions, all of which have now been in place for four or more years. As such they offer an interesting agency of field situations for observation and evaluation.

It is the policy of NHA that housing and infrastructure schemes after 5 years are *entirely* taken over by local government. So far this has not taken place smoothly. Local governments are unwilling to take over these schemes due to unknown and unquantified operation and maintenance requirements. A study on the aspects of these requirements for urban infrastructure items is urgently required.

At the moment the NHA is reviewing and updating its planning and design criteria in the light of the experiences gained over the years since they were last formulated (for most standards this is more than 8 years ago). The main challenge remains to offer sound, well-working systems which are both affordable and functional on the immediate and the longer term. Furthermore they should offer the possibility of upgrading over time in line with rising densities and service demand.

The Engineering Faculty of the University of Chiang Mai has recently decided to incorporate a Low Cost Infrastructure (LCI)component in its civil engineering curriculum. It plans to develop its teaching capacity and material on real field experience and therefore included issues of LCI in its regular research programme. The University is also involved in so-called service to the community, in which factual help is offered to communities in better understanding and tackling developmental problems. The Engineering Faculty will include the applied research activity as an optional practical field research for the 4th year engineering studies. The University of Chiang Mai largely caters to the regions outside Bangkok, notably the Northern provinces of Thailand. It is these provinces which largely feature medium and smaller townships which of late have become targets of national development in order to help contain migration to the principal city of Bangkok.

General considerations.

Sofar selection of sanitation technologies have primarilly been made based on the direct investment costs and far less on long(er) term operation and maintenance considerations. At present a lot of schemes are still developed based on the initial assumptions regarding technical functioning and user response, which in actual practice not rarely have proven to be different, hence calling for users involvement, design modifications and different arrangements for operation and maintenance.

Systematic research in these areas is deemed to provide most valuable information for future planning of sanitation schemes within the larger context of housing related infrastructure. While earlier research projects have primarily adressed sanitation design and technology aspects, this project will provide a logical follow up of these earlier research activities. The research will evaluate operation and maintenance requirements of sanitation technologies as used in India and Thailand. These technologies are primarily based on wet disposal techniques such as, sewerage, septic tanks and pour-flush toilets on single and double leaching pits which are widely used in Asia. The information obtained will also be relevant for other countries in the region.

Relevance for Dutch bilateral technical cooperation programmes:

The Netherlands through its bilateral technical cooperation programmes is involved in a large number of Water Supply and Sanitation projects in India and other "programme" countries (Indonesia, Pakistan, Tanzania, Kenya etc). In these projects the concern of both the receiving country and the donor agency has gradually shifted from intitial construction to long term viability, functioning and use of these infrastructure services. It is also in this context that sanitation is seen as an indispensable complement of water supply and housing improvement schemes, now receiving due recognition. Both elements together now enjoy increasing attention both within bi-and multilateral programmes in respect of their long term operation and maintenance aspects.

As regards the technology selection and operation and maintenance (O&M) activities the realisation has grown that this should be undertaken - where possible - through cooperation and participation of the direct beneficiairies in order to enhance correct usage and prevent disuse, misuse and overburdening of the government budgets with recurrent expenditure. Users involvement has proven to be essential to enhance feelings of responsibility as regards the functioning and use of the facilities. It further helps to develop community awareness and receptivity to wider health and social programmes (Mother-and Child care, alphabetisation programmes etc).

Research Objectives:

The general objective of the research is to define improved design criteria and assess long term operation and maintenance requirements of various sanitation options for low income shelter areas in the Asian region. The immediate objectives are:

* To review operation and maintenance aspects of on-plot and off-plot sanitation systems in low-cost housing and slum upgrading schemes within the overall context of the complete physical housing related infrastructure package.
* To review the use and performance of these systems.
* To obtain observations on the operation and maintenance of the sanitation systems from various user groups, including men, women and children.
* To obtain observations on operation and maintenance of the sanitation systems from local agencies and staff responsible for on-plot and off-plot sanitation and community health.
* To establish long term requirements, including investment requirements for the operation and maintenance of these services and facilities.
* To formulate operational recommendations for the planning, design and implementation of future low cost sanitation schemes including site specific conditions.

Research Methodology:

A large part of the research will be undertaken in India. Due to the sheer size of the country, the diversity of climate and conditions and the good availability of documentation on past projects it is felt that India can provide a rather broad and varied experience. Thailand at the same time would offer a largely different set of socio-economic characteristics and physical context. Both country studies together would offer most interesting pointers valid for the whole of the South and South-east region, though it is felt that adding further country cases would certainly enrich the overall research findings.

In India a not yet defined number (say 15) of low cost housing and slum upgarding schemes will be selected. In Thailand app. 6-8 of these areas are considered as a representative sample for the different sanitation technologies in use under a variety of circumstances. The age of these schemes will be in the range of 5-10 years although some older and younger schemes may be included.

A technical and environmental evaluation will be carried out on the present condition of the sanitation systems with due reference to historic developments and the condition of related facilities (s.a. water supply). Users of the different sanitation systems will be interviewed. Emphasis will be put to involve users groups (men, women and youth), community leaders, community level workers and responsible agencies in the longer term evaluation process.

The main structure and specific objectives of the research will be further defined, whereby suitable categories of sanitation schemes will be established for which representative cases will be selected for the longer term evaluation process. During a period of approximately two years (but preferably continued for a longer term beyond this research) the operation and maintenance performance will be monitored.

Phasing and organisation of the research:

For further information is attached a planning and manpower barchart. In the first phase formal agreements will be established with HUDCO and NHA and a detailed workplan will be formulated. A review of relevant literature and detailed discussions in the two countries will form the bases to refine the specific objectives and to establish suitable categories of sanitation schemes for which representative cases will be identified. A workshop will be organised to discuss and agree upon the the survey methodology and possible checklist. Likely variables will include city size, scheme size, topography, geology, community and economic characteristics, type of scheme (Agency built, Sites & Services, Core Housing, Slum Upgrading), type(s) of facilities (Individual, Communal etc). After a review of these sites a sample will be drawn of 3-4 sites in India and 2 sites in Thailand for a further pilot investigation. (Month 1-4).

In the second phase the field work will be conducted for the pilot survey areas, the data compiled and analysed. Training will be provided to the surveyers at the start of this phase. (Month 5-7).

In the third phase the results will be compared for the pilot areas. Based on the pilot survey a review seminar. will be conducted, which will function as the starting point for the remaining survey areas. (Month 8)

In the fourth phase the field work will be conducted in the remaining survey areas, data compiled and analysed. (Month 9-16)

In the fifth phase the results will be compared, the conclusions written and draft recommendations made. (Month 17-20)

In the sixth phase the results will be discussed in national seminars with a wide audience of agencies and individuals involved and final recommendations drawn up. A final report, with the combined findings of the two countries, suitable for international distribution will be published. This report will be presented in an international meeting. (Month 21-24)

Interim conclusions and recommendations - where possible - will be communicated in an early a stage as possible to implementing agencies (notably HUDCO and NHA) for early incorporation in the planning and design process. Recommendations will be developed for long and-longer term monitoring of the schemes to enable future planning design and organisational adjustments in the light of future findings and technological and social developments.

Executive Framework:

The Institute for Housing Studies will act as the principal investigator and coordinator of the research project. It will assist the National research organisations in their research programme and ensure sufficient coordination between the national organisations of the countries.

The International Reference Centre for Community Water Supply and Sanitation will assist in the coordination and in the training aspects of this research project. Experiences obtained with the IRC research and demonstration projects will be fully utilised.

The research project is structured in such a way that intensive participation and guidance by above mentioned organisations is only foreseen for phases one, two ,three and six. For the other phases IHS and IRC will function primarily in a facilitating and coordinating role.

India

In India the research work will be conducted under the aegis of the Housing and Urban Development Corporation (HUDCO) of India. This is a subsidiary organisation of the Ministry of Urban Development of the Republic of India. HUDCO recently established a high level Low Cost Sanitation Committee with the purpose of critically reviewing and promoting Low Cost Sanitation technology in all her Low Income Shelter programmes. This research proposal therefore strongly supports local interests.

For the day-to-day follow-through the research will be managed by the HSMI (the HUDCO promoted Human Settlements Management Institute), with which the IHS has a long standing cooperative agreement. (training and research since early 1985 through the Indian Human Settlements Programme - IHSP).

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