PART III SEWERAGE AND SANITATION

CHAPTER 10 CURRENT SANITATION SYSTEM IN THE STUDY AREA

CHAPTER 10 CURRENT SANITATION SYSTEM IN THE STUDY AREA

10.1 Kandy Municipal Council (KMC)

Sewage is discharged on-site throughout the Greater Kandy area (total population of 675,900) to:

1) septic tanks and/or soakage pits,
2) latrines, primarily in the rural but also in the urban areas, and
3) wastewater treatment plants at three small developments.

In the downtown area of Kandy, sewage is also discharged directly to the existing drainage system. Latrines are designed as either the pit type without a water seal (serving 42 percent of the population) or with a water seal unit (serving about 43 percent of the population), as reported in the Water Supply Master Plan for Greater Kandy in 1994. Latrines may also be connected to soakage pits or cesspools nearby. Septic tanks and soakage pits receive waste from water seal toilets or latrines and are of the single or double cell type. The remaining 15 percent of the population use temporary or public latrines or a sewage collection system connected to a wastewater treatment plant. Disposal of excreta from 99 percent of the households in Greater Kandy is on-site to latrines, septic tanks, or soakage pits. Grey water (from washing, bathing, etc.) is generally disposed of by direct connection to the soakage pits or local drains. Septic tanks and soakage pits are rarely maintained, often reducing the BOD and SS by less than 30 percent. Soil conditions are usually not optimum for percolation and the systems are generally overloaded after a short period.

The primary developed areas of downtown Kandy and along Peradeniya Road (including the University) rely on septic tanks and soakage pits; septic tanks and a connection to the local drainage network or a direct connection to the drainage system. In the dry season, sewage in the downtown area flows into the drainage system, which empties into the Meda Ela, which is heavily polluted and the source of odor problems. Sewage, mainly grey water from hotels, offices and residences around Kandy Lake flow into the lake causing heavy contamination and excessive algae blooms. However, some major hotels have individual sewage treatment plants and some are under construction, due to new regulations and greater concern on the degree of pollution by the higher ranked hotels.

Pumping of sludge from septic tanks and/or soakage pits is infrequent and usually only upon request. Kandy Municipal Council has two trucks for use within the KMC area and the adjoining Pradeshiya Sabha Divisions, which for a fee pump septic tanks and soakage pits. The trucks discharge at the Kandy trash dump into trenches, which are then covered with earth. No private septic tank pump operators exist in the Kandy area.

In the suburban areas surrounding the central area of Kandy however, the existing method of sanitation is quite satisfactory due to the low density of housing and shops.

The drainage system in the downtown area of Kandy is old, poorly maintained, and undersized by today's standards for runoff coefficients. The existing drainage system in the KMC carries both sewage and storm water from both the downtown area and from the spillway at Kandy Lake to the Meda Ela by underground culverts. There is apparently little problem from flooding during normal wet seasons. However, the system is old and those drains constructed with brick have deteriorated and several sections have collapsed when additional loads have been placed upon them by new buildings.

Statistics from the Provincial Director's Office of Health Services in Kandy reported that from 1989 to 1997, the incidence of Typhoid increased 44 percent, Bacillary Dysentery by 4 percent, and Hepatitis by 115 percent, in the Kandy District. These numbers indicate a serious health concern that needs to be addressed.

The three existing wastewater treatment facilities service particular developments, including a housing scheme and two hospitals.

(1) Hanthana Housing Scheme

The Hanthana National Housing Scheme for public sector employees has a piped sewage system collecting both excreta and gray water and transporting it to a sewage treatment plant on the slope of Hanthana Hill. Constructed in the early 1980's to accommodate 1200 houses, the plant consists of a bar screen, two horizontal grit removal units, two Imhoff tanks, two low rate trickling filters and three final sedimentation basins. Six sludge drying beds are provided for sludge from the Imhoff tanks and six for the final sedimentation basins.

Effluent from the final sedimentation basins is discharged to the nearby Hanthana Ela which connects with the Meda Ela which eventually connects to the Mahaweli River, just downstream of the intake for the Kandy Municipal Council's water treatment plant.

Chlorination of the wastewater effluent is not practiced. The nearby residents reportedly collect and use the dried sludge for fertilizer. At the time of visiting the plant, the grit chamber was full of grit and sludge, both trickling filters were inoperative and only two of the final sedimentation tanks were operating.

At present only 460 houses have been constructed and 364 homes connected resulting in a flow much less than design. The plant was never properly commissioned and the facility appears to be poorly maintained and in disrepair. No operator is stationed at the plant and sewage appears to be passing through the plant without treatment.

A water quality survey on the sewage treatment plant was carried our and the results are as follows:

Table 10.1 Water Quality of Sewage Treatment Plant in Hanthana

	Influent			Effluent		
	BOD (mg/l)	SS (mg/l)	Total Coliform	BOD (mg/l)	SS (mg/l)	Total Coliform
March 1998	91	136	> 10000	45	239	> 10000
August 1998	115	209	24×10^4	34	240	27×10^4
Average	103	173	-	40	240	-

The effluent quality is far from the requirements detailed in "General Standards for Discharge of Effluents into Inland Surface Waters" (BOD_5: 30 mg/l, SS: 50 mg/l) set by the Central Environment Agency, and total coliform which indicate the existence of pathogens is not treated at all.

(2) Hospital Treatment Plants

The General Hospital of Kandy and the Peradeniya Training Hospital both have similar secondary treatment systems, using the activated sludge method. Neither is operated correctly and is essentially primary treatment plants. The effluents are discharged into nearby drainage channels eventually connecting to the Mahaweli River, one upstream and one downstream of the KMC intake. Effluents are only minimally chlorinated using a solution of bleaching powder. Sludge, after digestion, is dried on sludge drying beds and used as fertilizer.

The treatment plant at the General Hospital is about 25 to 30 years old, but recently the mechanical and electrical equipment was replaced. The operation and maintenance is subcontracted to a private company with little knowledge of sewage treatment plant operations. The aerator is operated only six hours a day and the contents of the tank were anaerobic at the time of our visit. No sludge is returned to the aeration tank and the channel for return sludge is completely clogged. Disinfection by bleaching powder is only one drop per minute and inadequate.

Table 10.2 Water Quality of Sewage Treatment Plant in the Peradeniya Teaching Hospital

	Influent			Effluent		
	BOD (mg/l)	SS (mg/l)	Total Coliform	BOD (mg/l)	SS (mg/l)	Total Coliform
March 1998	49	203	> 10000	29	227	> 10000
August 1998	71	457	43×10^4	65	300	16×10^4
Average	60	330	-	47	264	-

The effluent quality does not meet effluent standards, and total coliform levels are very high. In general, over 100 different enteric pathogens such as viruses, parasites and bacteria together with the high total coliform level indicates that residents living downstream of the plant face serious health risks as a result of untreated sewage from the hospital.

(3) Hotel Treatment Plants

Some major hotels in Kandy, such as Suisse, Topaz, Mahaweli Reach hotels etc have their own sewage treatment plants to meet the requirements for higher ranked hotels. These plants are in operation, but not all operate effectively.

Water quality surveys on the sewage treatment plant were carried out and the results were as follows:

Table 10.3 Water Quality Survey Result of Hotel's Sewage Treatment Plant

	Influent			Effluent		
	BOD (mg/l)	SS (mg/l)	Total Coliform	BOD (mg/l)	SS (mg/l)	Total Coliform
March 1998	115	255	> 10000	9	116	> 10000
August 1998	152	147	66×10^2	48	150	32×10^2
Average	134	201	-	29	133	-

The Biochemical Oxygen Demand significantly improved but Suspended Solids and total Coliform are still high. This is due in part to improper design and operations and maintenance being carried out by inexperienced parties.

(4) Sanitation Facilities

Apart from the Sewage Treatment Facilities mentioned above, the KMC area lacks any other sewerage facilities apart from on-site treatment in the form of septic tanks and soakage pits.

Water quality surveys on septic tank effluent was conducted and the results are as follows:

Table 10.4 Water Quality of Septic Tank Effluent

Domestic Septic Tanks

Locations	March 1998		August 1998	
Housing Type	BOD (mg/l)	SS (mg/l)	BOD (mg/l)	SS (mg/l)
High Income House	-	-	124	2389
Middle Income House	188	3690	60	572
Low Income House	46	118	20	1716
Average	117	1904	68	1559

Non-Domestic Septic Tanks

Locations	March 1998		August 1998	
Non-domestic Type	BOD (mg/l)	SS (mg/l)	BOD (mg/l)	SS (mg/l)
Office	5	174	60	204
Office	-	-	43	289

Water quality analysis shows a relatively good BOD quality, but an extremely high SS concentration, which is higher than would be expected in properly maintained septic tanks. The reason for high SS is due to the overflowing of excessive septage or sludge settled at the bottom of the tank.

There are no sewage treatment plants in Kandy. The sludge generated in these areas is mainly from septic tanks and sewage/sludge from hotels and factories. The sewage/sludge is collected by gully suckers, which are operated by MC's and the private sector.

KMC has two gully suckers both with a capacity of 7.0 m^3. The Table 10.5 shows the present operation of gully suckers in the municipal council.

Removal of the septage should be carried out once every year or every other year, only minimum removal has been implemented at present in the KMC area. Only 35 houses, 13 institutes and 3 hotels had monthly removals during the six months from January to June 1998, the numbers of houses are however very small compared with the total of about twenty thousand houses in the KMC area.

Table 10.5 Operation of Gully Suckers

	Kandy
No. of Gully suckers	2
Average monthly operations	52.8 times (Jan to Jun 98)
Sludge volume (m^3)	370 m^3/month

At present, sludge collected in Kandy is disposed of in pits located at the Gohagoda dumping site.

A system for regular sludge collection to be implement in both areas is under consideration. With the introduction of the new facilities, the volume of sludge will be increased and the present disposal sites will not be adequate to accommodate such an increase in volume of sludge and leachate. If remedial measures are not taken the excess sludge and leachate will flow out to adjacent streams resulting in contamination of the streams and shallow aquifers.

(5) Planned/On-going Sewerage/Sanitation and Drainage Projects

No projects are planned or are on-going within the KMC area except for on-site systems such as septic tanks for schools or government buildings.

10.2 Other Town Areas in Greater Kandy

The towns of Akurana, Ampitiya, Katugastota, Kundasale New Town, Madawella, Talatu Oya, and Wattegama are included in this Sewerage/Sanitation Master Plan. Only on-site sewage disposal is presently practiced in each of these towns with effluent discharging to nearby streams used for water supply and/or irrigation of paddy fields. These communities are usually small, with populations less than 5,000, except for Akurana and Katugastota, which are close to 10,000. However, the town areas are dense and crowded, and in most cases situated along one major heavily traveled road. In the case of Katugastota, sewage is discharged directly to the Mahaweli River just upstream of the existing Polgolla water supply intake.

Removal of septic tank effluent is carried out using KMC's gully suckers but the number of operations is only three times a month on average.

The NWSDB has no planned or on-going projects for sewerage or sanitation other than on-site systems for other new improvements.

CHAPTER 11 PLANNING FUNDAMENTALS FOR WATER SUPPLY SYSTEM

CHAPTER 11 PLANNING FUNDAMENTALS FOR SEWERAGE SYSTEM

11.1 Service Area and Service Level

11.1.1 Policy for Sanitation/Sewerage Provision

The scope of work defines the area for which the Sewerage and Sanitation Improvement Master Plans are to be formulated as Kandy Municipality and Peradeniya (including the University area), as well as the surrounding towns of Akurana, Katugastota, Madawela, Wattegama, Kundasale New Town, Ampitiya and Talatu Oya. These areas are shown on Figure 11.1.

The Master Plans are to be developed for the target year of 2015 and are to include the most densely populated and commercial areas. The Policy for the Sanitation/Sewerage services also includes:

a. In areas of low density, the continued use of low cost sanitation facilities.
b. In areas of high population and commercial density and where pollution of the environment or public health is a major concern, collection of wastewater by a sewerage system and provision of adequate low cost treatment and disinfection and provision for the safe disposal of effluent and sludge.
c. The combination of sewerage systems with nearby population centers where practical, to reduce capital and operation and maintenance costs.
d. The improvement of community public health by the elimination of raw wastewater discharges upstream of existing or proposed water intakes.
e. The improvement of the environment for one of the major industries in the area, Tourism.
f. To meet the requirements of the National Environmental Regulations.

11.1.2 Selection Criteria for Sewerage Provision

Criteria to determine the target area for sewerage planning were established taking into account the above mentioned principal objectives, policies and the present conditions of the following:

- Large-scale commercial areas
- High population density

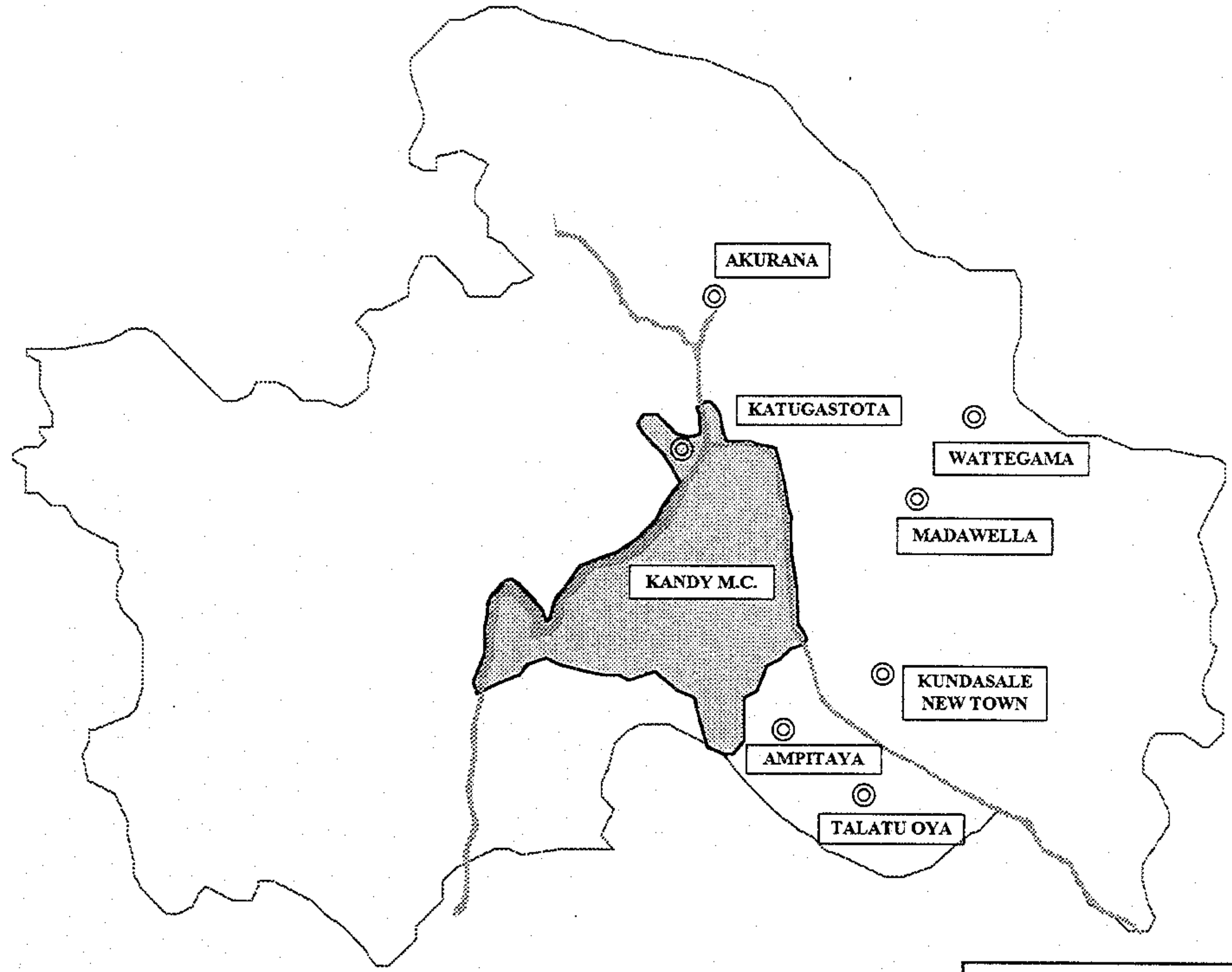


Figure 11.1

Study Area in Greater Kandy

- Large-scale facilities, such as schools, hotels, housing schemes, religious and institutional, both existing and proposed
- Conservation of the natural environment (tourist spots etc.)
- Reduction of pollutants from water sources.

1) Large-scale commercial areas

Most of the buildings and houses in urban areas of Sri Lanka have septic tanks and soakage pits, however these sanitary facilities are not properly operating, or maintained in overcrowded commercial areas. This is mainly because of the limitation of space. In urban areas, buildings and houses are often expanded using theexisting septic tanks and the resulting additional flow disturbs the treatment capability of the facilities. In commercial areas, some high-rise buildings also exist and sewage from these buildings can not be treated and disposed of within the site the buildings are located upon.

In an area of limited disposal sites, a sewerage system is the only option to provide the area with a safe sanitary environment.

2) High population density

In crowded residential areas, each house has only a small backyard where septic tanks and soakage pits exist. High-rise residential buildings are constructed where sewage can not be safely disposed within their property boundary.

In these high population areas, sewage overflows from septic tanks and or soakage pits to storm drains or small streams nearby pollute the environment, whereas a sewerage system could provide a safe and sanitary environment.

3) Large-scale facilities

Kandy Municipality is the second largest city in Sri Lanka, and the administrative, commercial and cultural center of the region. Many large-scale public and private facilities, as well as tourist facilities, are located in the municipality. These facilities discharge large amounts of sewage because of the large populations served.

4) Conservation of natural environment

Kandy is also one of the most famous tourist locations in the country, especially Kandy Lake located near the city center and religious center. The conservation of the natural environment of Kandy Lake and the surrounding area is key to further development of the tourist industry in this region.

5) Reduction in pollution at the water source
Mahaweli River crosses through the center of Greater Kandy and is the major water source of the area, particularly for Kandy Municipality. Wastes from the area are presently returned to this water source affecting downstream withdrawals for other public water supplies.

There are several implications for provision of a public sewerage service, including:

1) Cost and time requirement
Implementation of a sewerage system to achieve the proposed service coverage required by a master plan generally requires a considerable period and a large capital investment.

2) Accountability of executing agency
Sound accountability of the executing agency usually requires a thorough restructuring of its institutional and financial organization to accommodate the additional financial cash flow, debt service ratio, cost recovery, and human resource development for the new public service.

3) Affordability of beneficiaries
Beneficiaries (those who receive the sewerage system service) belong to different levels of income groups. Financial affordability in connection with per capita water consumption and payment for the new sewerage service charges must be recognized. These beneficiaries may also stay at more or less similar financial conditions during the master plan period which must be taken into account when determining the feasibility of providing a sewerage system.

4) Different states of urbanization by area
Although the Kandy Development Plan has been issued as an overall guideline of policy and strategy by the Urban Development Authority, it is still at the commencement stage and the actual implementation is subject to inter-agency coordination and approval of the Government. Meanwhile, private sectors continue providing investment at different magnitudes in different fields of activity at different locations.

Under the above mentioned circumstances and when the size of master plan target areas are taken into account, there appear different stages of urbanization with different population densities.

Although the provision of sewerage services to the whole of the urban area is idealistic, it is not realistic when the aforementioned implications are fully taken into account. An implementation of different service levels by area is therefore deemed as the most practical approach, which as an intermediate measure toward the realization and fulfillment of a complete public sewerage service in the future.

This Master Plan has introduced categorization of target areas, namely;

- A core area for Sewerage Service,
- A transitional area from on-site treatment to Sewerage Service, and
- An on-site treatment area.

11.1.3 Selection of Sewerage Service Area in Greater Kandy

(1) Selection of Sewerage Service Area

The Study Area in Greater Kandy is topographically categorized as follows:

1) Meda Ela Catchment Area

The area is surrounded by hills with height of more than 600 m, and the area covers the city center, Kandy Lake etc. Meda Ela originating in Kandy Lake flows at the center.

Kandy – City Center

2) Mahaweli River Catchment – Adjacent Area

These areas are located at both banks of the Mahaweli River.

Kandy-Katugestota, Peradeniya, Ampitiya and Other Area

3) Mahaweli River Catchment – Remote Area

These areas are within the Mahaweli River Catchment, but they are one to five kilometers from the river.

Greater Kandy – Akurana, Madawela, Wattagama, New Kundasale and Talatu Oya

Since sewage collection is mainly achieved using gravity flow, a sewerage system should be established in each catchment area. Among the above three areas, Meda Ela catchment is considered the most important which covers Kandy City Center. The Mahaweli River Cacthment-Adjacant area is also important because the river is a water source of water supply in Kandy MC and the adjacant area.

Taking the above selection criteria into consideration, the sewerage service area in Greater Kandy has been studied. Table 11.1 shows the need for a sewerage system in each study area.

Table 11.1 Selection of Sewerage Service Areas in Greater Kandy

Municipality / Town	Sewerage Necessity	Commercial Area	Density of Population	Sewage Flow	Tourist	Water Source
Kandy						
- City Center	Yes	Large	High	Large	Large	Yes
- Katugastota	Yes	Middle	High	Middle	Middle	Yes
- Ampitiya	No	Small	Middle	Middle	Small	No
- Peradeniya	No	Small	Low	Middle	Large	Yes
- Other Areas	No	Small	Low	Small	Middle	No
Greater Kandy						
- Akurana	No	Middle	Middle	Middle	Small	No
- Madawela	No	Middle	Middle	Middle	Small	No
- Wattegama	No	Small	Low	Small	Small	No
- New Kundasale	No	Small	Low	Small	Small	No
- Talatu Oya	No	Small	Low	Small	Small	No

The service area for Kandy is located around the city center commercial area, Kandy Lake and surrounding hotels, the General Hospital, the Hanthana Housing scheme, and the commercial, institutional and housing areas along the two principal transportation routes into Kandy Municipality of Sirimavo Bandaranayake Mawatha and William Gopallawa Mawatha. The area is also located below the 600 meter elevation. Above this elevation building construction is limited or prevented by regulation. The service area for Kandy also includes the nearby towns of Katugastota and a part of Ampitiya, and covers an area of 674 ha.

(2) Adjacent Areas which could be Provided with Sewerage Service

Criteria to determine if sewerage service should be provided to areas adjacent to the core area was also considered taking into account the above mentioned principal objectives, policies and the present conditions. The following basic reasons were considered:

1) Residential areas

Ordinary low density residential areas adjacent to the core area (mainly the commercial area) shall continue the use of on-site treatment, septic tanks, and soakage pits. On-site treatment facilities cost approximately Rs 50,000, where sewer installation requires Rs 21,800 for a service connection pipe (4 m, PVC 100 mm), Rs 5,098 for an inspection chamber and a sewer extension with a cost of Rs 7,188 per meter. The cost to provide a sewerage system to houses located more than 3.2 m away from the sewer network is much more expensive than the construction cost of on-site treatment facilities. Therefore, residential areas far from the core service area shall continue on-site treatment facilities.

2) Housing estates with existing sewer systems

As for housing schemes, such as the existing Hanthana development, where sewer network are presently provided, or new housing schemes where the sewer networks are to be provided by the developers, connection to the core sewerage system will be provided if the new systems are within a reasonable distance. This is to avoid duplicate costly treatment plants.

3) Large-scale facilities

Core sewer networks shall also be connected to large-scale facilities, which discharge large amount of sewage, if within a reasonable distance. This is to avoid heavy water-pollution and duplication of costly treatment plants.

11.2 Served Population

Based on the population data prepared by the Regional Rural Development Project in 1997, the population in 2005 and 2015 in Kandy Municipality has been estimated. The population in the sewerage service area has been determined according to the criteria developed in a previous section. This population data is shown in Table 11.2.

Table 11.2 Population in Sewerage Service Area

No.	ID GN	Name	Area (ha)	Population 1997	2000	2005	2010	2015
1	K 0220	Boowelikada	37.4	714	749	795	844	891
2	K 0222	Lewella	51.3	687	721	765	812	858
3	K 0229	Watapuluwa West	30.2	610	640	679	721	762
4	K 0233	Aniwatta West	13.1	434	455	483	513	542
5	K 0234	Aniwatta East	13.9	728	764	811	861	909
6	K 0235	Asgiriya	31.3	1,524	1,598	1,696	1,800	1,901
7	K 0236	Bahirawakanda	24.1	1,554	1,630	1,730	1,836	1,939
8	K 0239	Mahaiyawa	22.9	1,889	1,981	2,103	2,232	2,357
9	K 0240	Pumawatta	10.5	3,898	4,088	4,339	4,606	4,865
10	K 0243	Mulgampola	33.2	2,009	2,107	2,236	2,373	2,506
11	K 0245	Bowala	1.3	50	52	55	58	61
12	K 0251	Senkadagala	31.1	4,214	4,420	4,692	4,980	5,260
13	K 0252	Ampitiya North	6.2	706	740	785	833	880
14	K 0253	Ampitiya South	24.5	123	129	137	145	153
15	K 0254	Malwatta	47.3	1,183	1,241	1,317	1,398	1,477
16	K 0255	Katukele	40.4	2,784	2,920	3,099	3,289	3,474
17	K 0256	Katukele West	51	2,555	2,680	2,845	3,020	3,190
18	K 0257	Kandy	47.6	3,713	3,894	4,133	4,387	4,634
19	K 0258	Ihala Katukele	67.9	3,470	3,639	3,863	4,100	4,331
20	K 0260	Welata	18.5	862	904	960	1,019	1,076
21	K 0261	Deiyannewela	22.2	2,660	2,790	2,961	3,143	3,320
22	K 0262	Nagastenna	20.3	1,853	1,943	2,062	2,189	2,312
23	K 0263	Hantanapedesa	17.7	170	178	189	201	212
24	K 0264	Bogambara	30	633	664	705	748	790
25	K 0265	Suduhumpola East	15.6	1,560	1,636	1,737	1,844	1,948
26	K 0266	Suduhumpola West	15.1	2,404	2,521	2,676	2,840	3,000
27		Hanthana Housing S	-	1,069	1,121	1,190	1,263	1,334
Total			724.60	44,056	46,205	49,043	52,055	54,982

Annual population Increase Ratio (1997-2000) 1.016
(2000-2010) 1.012
(2010-2015) 1.011

The service area is summarized as follows:

Table 11.3 Sewerage Service Areas

	Area (ha)		Population	
Municipality	2,875	100 %	136,000	100 %
Service Area	724	25 %	54,982	40 %

The detailed data is shown in Appendix 11.1.

11.3 Design Sewage Flow

(1) Per Capita Water Consumption

In the water supply system evaluation, the per capita water consumption is estimated as follows:

Table 11.4 Per Capita Water Consumption

Service	Present (1997)	2005	2015
Domestic	94 lpcd	108 lpcd	121 lpcd
Non-Domestic	48 lpcd	61 lpcd	69 lpcd

(2) Results of field survey

On May 30 and July 30, 1998, sewage quantity surveys were carried out to examine the present status of the domestic sewage flow rate. The only available site for this survey was at the Hanthana Housing Scheme, where 314 houses are located in a high elevation zone and 53 houses in a low elevation zone, with population of 904 and 165 respectively.

Table 11.5 Sewage Flow in Hanthana Housing Scheme

Item	May 30	July 30
Water Supply (m^3/day)	256.9	212.1
Sewage Flow (m^3/day)	112.1	108.9
Sewage Flow/Water Supply	44 %	51 %
Per Capita Sewage Flow (lpcd)	106.0	101.9
Peak Factor (Hourly Max./Daily Ave.)	2.85	2.65

Although approximately 210 to 260 m3/day of water was supplied, only 110 m3/day of sewage was discharged to the existing sewerage system. This is about half of the water supplied. The per capita sewage flow is about 100 lpcd, based upon a total population of 1,069 in the housing scheme. This agrees with the domestic consumption reported in the above table. Some 50% of the water use was returned to the sewerage system.

The detailed data is shown in Appendix 11.2

(3) Design Per Capita Sewage Flow

In order to obtain a design per capita sewage flow, an assumption that 80 % of water consumption is discharged to the sewerage system is made for both domestic and non-domestic water supply. Non-domestic consumption consists of consumption by shops, restaurants, hotels, offices etc., but not much by industries because of the characteristics of the study area. In the Hanthana Housing Scheme, the per capita sewage flow was measured at only 50% of the water consumption. One of reasons why the sewage discharge rate is low is that there are no commercial developments.

Because most commercial facilities are located in the downtown area of the municipality, it has been assumed that 80% of non-domestic water is consumed in the sewerage service area in 2015 and 60% in 2005. Of these amounts, 50% is consumed in the downtown area, 10% at Katugastota and the remaining portion is in other service areas.

Groundwater infiltration to the sewer system is assumed to be equivalent to a flow of 15 % of daily maximum sewage flow (domestic and non-domestic sewage flow).

Consequently, daily average per capita sewage flow in the service area was estimated as follows:

Table 11.6 Per Capita Sewage Flow

Flow	Present (1997)	2005	2015
Domestic	78 lpcd	86 lpcd	97 lpcd
Non-Domestic	79 lpcd	92 lpcd	138 lpcd
Infiltration	28 lpcd	32 lpcd	42 lpcd
Total	185 lpcd	210 lpcd	277 lpcd

The above numbers are based on actual water billing records for the sewerage service area which are much higher than the average water consumption reported because of the high contribution of commercial wastewater flows as discussed above.

(4) Design Sewage Flow

In accordance with the above discussion, design average daily sewage flows were obtained for the sewerage service area for the years of 2005 and 2015. For sewerage facilities planning, the maximum daily and hourly maximum flows are necessary.

A peak factor of 1.2 for Maximum Daily / Average Daily was used. This is the same peak factor used for water supply planning. In this study, sewage flow was measured at Hanthana Housing Scheme and peak factors calculated by using a modified form of Babbit's M-Curve, were obtained thus:

Babbit's M-Curve: $M = 5 / P^{(0.2)}$

Hanthana: $M = 2.6 / P^{(0.115)}$

Using this formula, the peaking factors for this study were established. A peak factor of 2.0 will be applied for sewerage systems with a served population of up to 20,000, and 1.8 with a served population of 100,000.

Therefore, peak factors for the Kandy Sewerage System are:

Maximum Daily / Average Daily : 1.2

Hourly Maximum / Average Daily : 1.8

The Detailed data on the peaking factor is shown in Appendix 11.3.

Table 11.7 Design Sewage Flow

Year	2005	2015
Area (ha)	674	674
Population	49,000	55,000
Average Daily Sewage Flow	12,100	15,200
Maximum Daily Sewage Flow	14,100	17,800
Hourly Maximum Sewage Flow	20,300	25,500

The daily and hourly maximum values of flow shown above include infiltration, which is considered a constant flow, not subject to fluctuation.

The detailed data is shown in Appendix 11.4.

11.4 Design Sewage Quality

Among other characteristics, BOD (Biochemical Oxygen Demand) and SS (Suspended Solids) are important water quality parameters in the planning and design of sewage treatment plants. BOD, in particular, plays a role as a key parameter in the determination of the required capacity of the sewage treatment plant.

Two methods are commonly used to determine the BOD of the sewage. The first method is the estimation of BOD by use of the unit BOD pollution load per capita per day and the unit water consumption. The second method is the estimation of BOD based on the result of a comprehensive water quality examination of actual sewage sampled from the Study Area.

A series of water sampling and water quality examinations was repeatedly carried out during the course of fieldwork for the Study. The results of these analyses will be referred to in establishing the proposed sewage quality.

(1) Examination of sewage quality

The BOD value will be estimated with the use of actual data from other countries and compared to the analysis results of water samples collected during the fieldwork of this study.

There are several reports on the study of unit BOD pollution loads for domestic sewage based upon field investigations. The findings are reported below for Japan, the United States, Tropical Countries, and several other countries.

1) Japan (in 1990)

Unit: g/capita/day

Water Quality Parameter	Nightsoil	Grey Water	Total
BOD	18	39	57
COD_{Mn}	10	18	28
SS	20	23	43
T-N	9	3	12
T-P	0.9	0.3	1.2

2) United States

Unit: g/capita/day

Water Quality Parameter	Nightsoil	Grey Water	Total
BOD	23	55	78

3) Tropical countries

Unit: g/capita/day

Water Quality Parameter	Nightsoil	Grey Water	Total
BOD	22	18	40

4) Other countries

Unit: g/capita/day

Name of Country	BOD-Total
United Kingdom	50 - 59
France (rural area)	23 - 34
Brazil	44

Source: "Urban Drainage and Sewage Treatment in Developing Countries" by the Ministry of Construction of Japan.

As shown on the above table, there are wide ranges of the unit BOD pollution load, reflecting differences in the standard of living, life style, etc. In this Study, 40 g/capita/day for tropical countries is used in the estimation of BOD below.

Using 40 g/capita/day as the unit BOD pollution load, the BOD for domestic sewage is calculated as follows:

- BOD load: 40 g/capita/day
- Water consumption*: 106 l/capita/day
- BOD_5 = (40 g-BOD/capita/day) / (106 l/capita/day) = 377 mg/l

*: 12% of water consumption (121 lpcd x 0.12 = 15 lpcd) is asssumed to be used for gardening and is deducted.

For non-domestic BOD concentration, a half of the BOD concentration of domestic sewage is assumed and used as follows:

- BOD_5 189 mg/l

(2) Results of water quality examination

1) Domestic sewage

Sewage quality surveys were conducted to determine the status of domestic sewage during the dry season and the rainy season. The survey was carried out at three different housing types, namely high income, middle income, and low-income houses, and at the Hanthana Housing Scheme where an existing sewerage system is available for sampling. The results of the sewage quality survey for domestic sewage are shown in the following table.

Table 11.8 Domestic Sewage Quality

Combined Sewage (Grey Water + Black Water) – Hanthana Housing Scheme

Locations	March 1998		August 1998*	
Housing Type	BOD_5 (mg/l)	SS (mg/l)	BOD_5 (mg/l)	SS (mg/l)
Maximum	-	-	140	276
Minimum	-	-	70	140
Average	94	158	115	210

* Note: 12 samples were taken every 2 hours for a day.

Domestic Sewage (Grey Water – Cooking, Washing etc.)

Locations	March 1998		August 1998	
Housing Type	BOD_5 (mg/l)	SS (mg/l)	BOD_5 (mg/l)	SS (mg/l)
High Income House	-	-	222	1067
Middle Income House	158	178	210	221
Low Income House	154	757	140	437
Average	156	468	191	575

Septic Tank Sewage (Black Water - Toilet)

Locations	March 1998		August 1998	
Housing Type	BOD_5 (mg/l)	SS (mg/l)	BOD_5 (mg/l)	SS (mg/l)
High Income House	-	-	124	2389
Middle Income House	188	3690	60	572
Low Income House	46	118	20	1716
Average	117	1904	68	1559

2) Non-domestic sewage

The non-domestic use may be divided into commercial, institutional and industrial. A similar sewage quality survey was carried out for non-domestic sewage at two offices, two hotels, a hospital, and two factories. The results are as follows:

Table 11.9 Non-Domestic Sewage Quality

Combined Sewage (Grey Water + Black Water)

Locations	March 1998		August 1998	
Non-domestic Type	BOD_5 (mg/l)	SS (mg/l)	BOD_5 (mg/l)	SS (mg/l)
Hospital	49	203	71	457
Hotel	115	255	152	147
Food Processing	-	-	340	201
Groceries	3	500	290	175

Domestic Sewage (Grey Water – Cooking, Washing etc.)

Locations	March 1998		August 1998	
Non-domestic Type	BOD_5 (mg/l)	SS (mg/l)	BOD_5 (mg/l)	SS (mg/l)
Office	67	121	139	263
Hotel	204	179	108	97

Septic Tank Sewage (Black Water - Toilet)

Locations	March 1998		August 1998	
Non-domestic Type	BOD_5 (mg/l)	SS (mg/l)	BOD_5 (mg/l)	SS (mg/l)
Office	5	174	60	204
Office	-	-	43	289

(3) Planned sewage quality

There are differences in BOD concentrations for both domestic and non-domestic sewage between the above estimations and the results of the actual water analysis. These differences originate primarily from some samples that did not contain sewage from toilets. Therefore, the values obtained from the above estimations will be used for sewage quality assumptions.

a. Domestic sewage (5,334 m^3/day)

   BOD_5 371 mg/l

b. Non-domestic sewage (7,565 m^3/day)

   BOD_5 189 mg/l

c. Ground water Infiltration (2,318 m^3/day)

   BOD_5 0 mg/l

d. Mixed sewage

   $BOD_5 = (377 \times 5{,}334 + 189 \times 7{,}565) / 15{,}217 = 226$ mg/l say 240 mg/l

Therefore, BOD_5 level of 240 mg/l and SS level of 250 mg/l will be used in the Study.

As a comparison, "The Study on the Sewerage System in North Dhaka, Bangladesh" by JICA shows the BOD_5 at 213 mg/l and the SS at 276 mg/l measured at the influent of the Pagla Sewage Treatment Plant in 1994/95.

CHAPTER 12 SEWERAGE AND SANITATION SYTEM LONG-TERM DEVELOPMENT PLAN

CHAPTER 12 SEWERAGE AND SANITATION SYSTEM LONG-TERM DEVELOPMENT PLAN

12.1 Population and Sewage Flow

Planning fundamentals were established in a previous section, and the major values developed therein for sewerage system planning are summarized as follows:

Table 12.1 Planning Fundamentals in Kandy

Planning value	2005	2015
Area (ha)	724	724
Population	49,000	55,000
Average Daily Sewage Flow (m^3/day)	12,100	15,200
Maximum Daily Sewage Flow (m^3/day)	14,100	17,800
Hourly Maximum Sewage Flow (m^3/day)	20,300	25,500
BOD_5 (mg/l)	240	
SS (mg/l)	250	

12.2 Conditions and Design Criteria for Facility Planning

12.2.1 Sewage Collection System

(1) Hydraulic calculation

Manning's formula is commonly used for the calculation of flow velocity throughout the world, and maybe written as follows:

$$Q = A \times V, \qquad V = 1/n \times R^{2/3} \times I^{1/2}$$

where, V = velocity of flow (m/sec)

n = roughness coefficient

R = hydraulic radius (m)

I = gradient in decimal (m/m)

A = cross section area (m^2)

Standard roughness coefficients (n) to be used for various types of pipe materials are as follows:

Table 12.2 Roughness Coefficients (n) in Manning's Formula

Type of Pipe	Roughness Coefficient
Asbestos Cement Pipe	0.013
Vitrified Clay Pipe	0.013
Plastic Pipe	0.013
Concrete Pipe/Conduit	0.013
Coated Steel Pipe	0.008

(2) Flow velocity

1) Minimum velocity

Sewers must be designed to convey peak flows. In addition, the gradient of the sewer must be determined to ensure that the minimum flow velocity is determined for each pipe diameter in order to obtain the self-cleansing velocity at full flow. The minimum velocities that will be used in this Study is 0.6 m/sec for separate sanitary sewer systems, and 0.75 m/sec for most of the system except for critical sewers in order to minimize pumping stations.

2) Maximum velocity

The maximum velocity within a sewer main should not exceed 3.0 m/sec to protect the pipe against sewer erosion.

(3) Sewer capacity

The flow capacity of the pipelines was calculated to convey sewage using the full section of pipe for a combined sewer and stormwater system. For a separate sanitary sewer system, sewer capacity is selected on the following basis:

Diameter of 600 mm or less : Capacity exceeds the estimated flow by at least 200%

Diameter of more than 600 mm : Capacity exceeds the estimated flow by at least 150%

(4) Piping Materials

Following materials are selected considering corrosion resistance, local availability etc.

Diameter of 100 mm: PVC - Type 600 (service connection)

Diameter of 150 to 600mm: Vitrified Clay Pipe

Diameter of more than 600 mm: Reinforced Concrete Pipe with Anti-corrosion Coating

12.2.2 Sewage Treatment Plant

The following fundamentals and criteria are used in the study of the sewage treatment plants.

(1) Planned design flow

Planned design flow for a sewage treatment plant is established as shown below taking into consideration the treatment capacity in each train and the number of trains.

Average Daily Flow	15,200 m^3/day	
Maximum Daily Flow	17,800 m^3/day	
Hourly Maximum Flow	1,063 m^3/hour	(= 25,550 m^3/day)

(2) Planned water quality

Influent:	BOD_5	240 mg/l
	SS	250 mg/l
Effluent:	BOD_5	30 mg/l
	SS	50 mg/l

Note: The quality of effluent shall meet the Central Environment Agency's "General standards for Discharge of Effluents into Inland Surface Waters"

(3) Phased construction (Maximum daily sewage flow)

Phase 1 (in 2005)	9,000 m^3/day
Phase 2 (in 2015)	9,000 m^3/day
Total	18,000 m^3/day

12.3 Selection of Optimum System

12.3.1 Sewage Collection System

The plan and design of sewage collection systems are different depending on the collection method. The characteristics of four alternative collection systems (separate, combined, interceptor and small bore) which could be used in Kandy are summarized as follows:

(1) Separate System

A separate system has parallel collection systems for sanitary sewage and stormwater run-off, respectively. This system is advantageous to the surrounding environment and reduces water pollution. It is also recommended in areas where existing conventional drainage facilities are maintained in relatively good condition and only the collection and treatment of sanitary sewage is required for the completion of a sewage system. However, the collection of sanitary sewage requires the construction of house connections and lateral sewers.

(2) Combined System

A combined system refers to a system to collect sanitary sewage and stormwater run-off by means of a single pipeline. This system may also be employed to provide sewerage service as a low cost investment under the following conditions:

1) Discharge of sewage into a public water body is acceptable during the rainy season.
2) Existing drainage/channels presently collecting stormwater and sludge can also be used as combined sewers and/or receiving watercourses for overflow water from diversion chambers.

The design and construction of combined sewer systems today has been virtually abandoned, and such systems are only used in special circumstances. In old, densely built-up cities, for example, the limited space available in streets may favor a combined system.

(3) Interceptor System

This system consists of stormwater overflow chambers and interceptor pipelines. The stormwater overflow chamber contains overflow weirs to discharge stormwater during wet weather. During dry weather, incoming sewage flows into interceptor pipes and is sent to a sewage treatment facility. In some tropical countries, black water is pre-treated by a septic tank system and grey water is discharged into storm drain channels which is finally discharged into nearby receiving water bodies without treatment.

Since the flow in stormwater drain channels during dry weather is occupied by grey water, this system contributes to pollution of public water bodies.

(4) Small Bore System

Small bore sewer systems are designed to receive only the liquid portion of household sewage for off-site treatment and disposal. Grit, grease and other troublesome solids which might cause obstruction in the small bore sewers are separated from the sewage inflow using interceptor tanks installed upstream of every connection to the sewers. The solids that accumulate in these tanks are removed periodically for safe disposal in landfills.

Collecting only the liquid portion of sewage in this manner has four principal advantages:

1) Reduced pipe size requirements
2) Reduced excavation costs
3) Reduced material costs
4) Reduced treatment requirements

Thus, small bore sewer systems provide an economical way to upgrade existing sanitation facilities to a level of service comparable to conventional sewers.

The principal disadvantage of the small bore sewer system is the need for periodic removal and disposal of solids from each interceptor tank in the system.

Schematics of these collection systems are shown in Figure 12.1

(5) Selection of Collection System

Selection of the optimum collection system must consider the following items.

1) Construction cost
2) Operation and maintenance cost
3) Septage disposal

   In the small bore system, existing septic tanks are used for settlement and septage, grease, sludge and grit need to be removed regularly.
4) Sanitation Improvement

   Since septic tanks remain at each house, improvement in sanitation is not available under the small bore system.
5) Environmental improvement

   The combined system uses the existing drainage system, and improvement of the environmental conditions where open drainage systems are applied, is likewise not available.

A summary of the comparison between the various collection systems is shown in the following Table 12.3.

In the city center of Kandy, an existing drain system is available. The system was constructed late in the last century and some of the drains are considered to be in a deteriorated condition. In new combined systems, pumping stations should have three times more capacity than that in a separate system to accommodate stormwater.

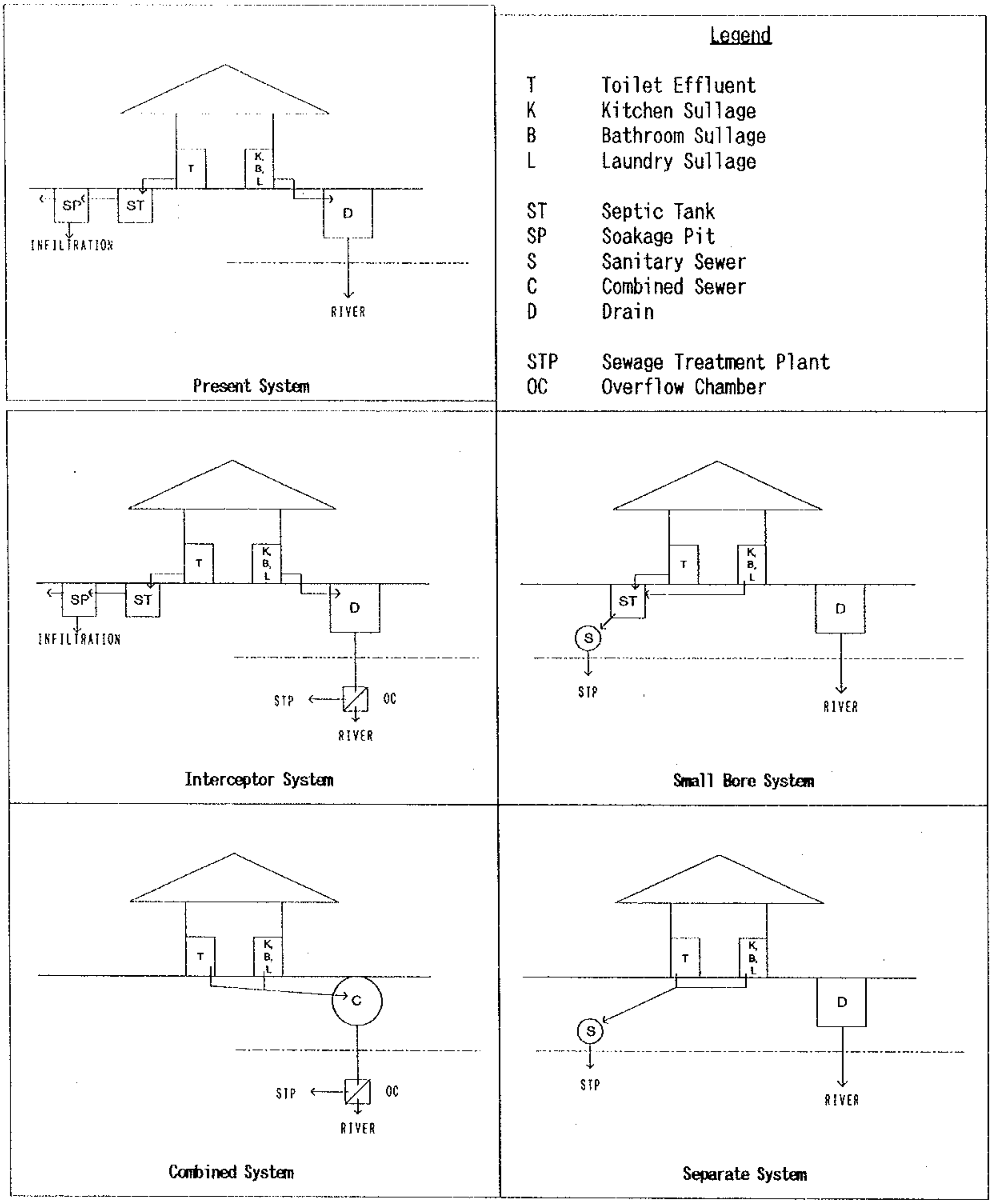


Figure 12.1 Collection/Drainage System Schematics

Table 12.3 Comparison of Collection System

Item		Combined	Separate	Small Bore
Cost	Pipe	Lowest	Fair	Low
	Pumping Station	High	Fair	Fair
	Treatment Plant	High	Fair	Fair
O & M Cost		High	Fair	Fair
Septage Disposal		Not Needed	Not Needed	Needed
Sanitation		Fair	Good	Fair
Environment		Poor	Good	Good
Evaluation		Fair	Good	Fair

For small bore systems, improvement in sanitation at individual houses is not satisfactory as residents must still maintain septic tanks to use the sewerage system.

(6) Conclusion

Therefore, a separate system is recommended as the optimum sewage collection system.

12.3.2 Sewage Treatment System

The number of the existing sewerage systems in Sri Lanka is minimal and a few of them have only small sewage treatment plants. It is indispensable when designing a sewerage system to take into account the technical ability of the personnel who will operate and maintain these sewerage systems as well as the capability of the operating organizations.

In some treatment plants, it is often observed that the effluent from the treatment plant looks the same as raw sewage due to several reasons such as the lack of knowledge and experience of the operating personnel, lack of spare parts and budgetary constraints.

The design of a sewage treatment plant must attain reliability, sustainability, and operability not only from the viewpoint of technical design and manpower capability but also from the viewpoint of least cost for operation and maintenance.

(1) Preliminary Selection of Sewage Treatment Method

There are many well-developed and popular sewage treatment methods, such as:

1) Conventional Activated Sludge,
2) Extended Aeration,
3) High Rate Trickling Filter,
4) Rotating Bio-Reactor,
5) Oxidation Ditch,

6) Aerated Lagoon, and

7) Stabilization Pond.

Features of these treatment methods are summarized in Table 12.4. Among these methods, the Trickling Filter (TF), Oxidation Ditch (OD), Aerated Lagoon (AL) and Stabilization Pond (SP) were further reviewed. In general, these methods are suitable for tropical developing countries.

(2) Comparative Study of Sewage Treatment Method

The following criteria are used in this Study to select the most appropriate treatment method:

1) Quality of treated water
2) Area requirement
3) Construction cost
4) Operation & maintenance cost
5) Difficulty of operation & maintenance

(3) Design calculations

Preliminary design calculations were performed. An outline of the facilities required, site size requirements and power consumption of these four treatment methods are shown in Appendix 12.1.

(4) Selection of Treatment System

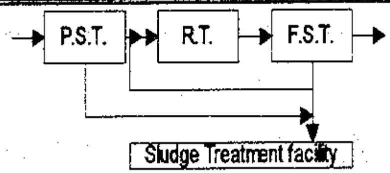
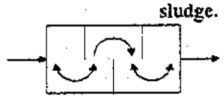
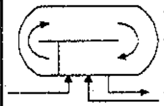
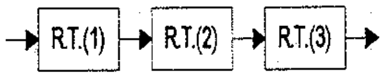
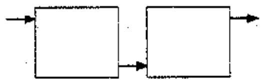
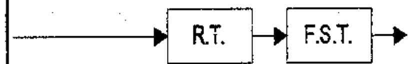
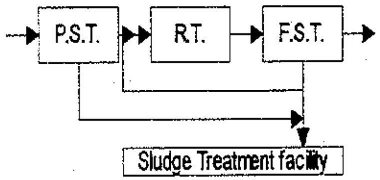
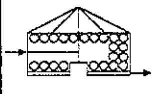
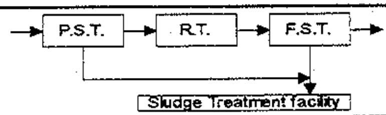
1) Power consumption

Among the four methods, the stabilization pond does not require any electric power for treatment. However, the aerated lagoon method needs power for the aerators in the lagoon and chlorination in the disinfection tank; trickling filter requires power for recirculation, sludge collection and chlorinators; oxidation ditch method needs powers for the aerators in the ditch, sludge collectors, sludge pumps and chlorinators.

An estimation of the power consumption requirements (excluding power for offices and in-plant lighting) are:

- Stabilization Pond	approx.	0 kW
- Aerated Lagoon	approx.	250 kW
- Trickling Filter	approx.	210 kW
- Oxidation Ditch	approx.	280 kW

Table 12.4-1 Major Sawage Treatment Method and Characteristics

Treatment Method	Composition of Treatment Process	Theory of Reactor for Tank	Features of Treatment Process
Conventional Activated Sludge		Sewage flows down together with activated sludgc organic substance is absorbed and assimilated by activated sludge. 	Retention time in reactor tank is relatively short and load is high. Thus, primary sedimentation tank is needed to cope with the fluctuation in sewage flow and quality and to equalize/mitigate the load. Sludge treatment facility is necessary as well.
Extended Aeration		ditto	This process is flexible to the fluctuation of sewage flow and quality by its long retention time in reactor tank. Primary sedimentation tank is not necessary, however, sludge treatment facility is needed.
Oxidation Ditch		 Sewage is circulated together with activated sludge and contained organic substance is absorbed and assimilated by activated sludge.	ditto
Stabilization Pond		Sewage is purified by oxidation of aerobic bacteria activated by oxygen supply through algae or anaerobic bacteria. 	Since oxygen supply in reactor tank is conducted by natural oxidation and photosynthesis of algae. Retention time is extremely long. Sludge treatment facility is not needed . Anaerobic pond, maturation pond and aerobic pond are allocated individually or combined.
Aerated Lagoon		Sewage is purified by oxidation of aerobic bacteria. 	Since supply in reactor tank will be done by compulsive oxidation, retention time is shorter than that of flowing stabilization pond. Sludge treatment facility will not be needed.
High Rate Trickling Filter		Section  Sewage is sprinkled on bio-filter by rotating distributor. Contained organic substance is absorbed/assimilated by bacteria attaching on bio-filter. Enlarged bacteria membrane falls out and are removed.	Primary sedimentation tank must be installed to prevent clogging in bio filter and distributor's nozzle. Sludge treatment facility is needed as well.
Rotating Biological Contactor		Section  Sewage flows through rotating bio disk on to organic substance is absorbed/assimilated by bacteria attaching on bio disk.	Primary sedimentation tank is needed to mitigate the load in reactor tank. Sludge treatment facility is needed as well.

Legend P.S.T. : Primary Sedimentation Tank, R.T. : Reactor Tank, F.S.T. : Final Sedimentation Tank

Table 12.4-2 Major Sewage Treatment Method and Characteristics

Treatment Method	General Features	Operation and Maintenance
Conventional Activated Sludge	* BOD removal rate is superior, 85-95%. * Transparency of treated effluent is high. * Stability in sewage temperature fluctuation is inferior in comparison with other methods. * Generated sludge volume is larger than other method.	* The system has many maintenance and inspection points. Thus, advanced/complicated operational technique is needed.
Extended Aeration	* BOD removal rate is worse than conventional method. * Transparency of treated effluent is high. * Stability in sewage temperature fluctuation is good. * Nitrification is expected. * Generated sludge volume is less than conventional method.	* Operational technique is easier than Conventional Activated Sludge Method but difficult compared with Oxidation Ditch.
Oxidation Ditch	* Same as Extended Aeration Method. * Denitrification is possible by operational condition.	* Operation and Maintenance is easy since no advanced/complicated operational technique is needed.
Stabilization pond	* Although BOD removal rate is affected by sewage temperature and retention time, approximately 70-90% BOD removal can be expected. * Stability in sewage flow and temperature fluctuation is relatively good but once deteriorated, recovery takes a long time. * Odours and harmful insects are generated:	* Easiest in O&M due to "Non-equipped" process. * Algae control is important for stable treatment efficency. * Ponds should be drained periodically, once in 1 to 5 years. Sludge should be hauled off site/disposed of after drying by sun light.
Aerated Lagoon	* BOD removal rate is affected by sewage temperature and retention time as well as stabilization pond, the rate will be 75-90% approximately. * Stability in load fluctuation is superior. * Less odour generation.	* O&M is easy since there's simple equipment like aerators.
Trickling Filter	* BOD removal rate is 65-75%. * Transparency of treated effluent is worse than Activated Sludge Method. * Less affected by sewage temperature fluctuation compared with Activated Sludge Method. * Flies and Odours are generated.	* O&M is easy since no advanced/complicated operational technique is needed. * Attention must be paid to fly/odour generation.
Rotating Biological Contactor	* BOD removal rate is same as Conventional Activated Sludge Method. * Transparency of treated effluent is inferior. * Nitrification is expected.	* The system has little maintenance and inspection points and no advanced operational technic is needed. But, O&M is difficult in comparison with Oxidation Ditch and Trickling Filter.

The stabilization pond does not require any power owing to absence of electrical/mechanical equipment. The oxidation ditch consumes the largest amount of power.

2) Area requirement

Since stabilization ponds use the natural activity of bacteria, the treatment efficiency is relatively low and large areas are required. Aerated lagoons, trickling filters, and oxidation ditch require less area because aerators or filters are used to accelerate the activity of aerobic bacteria or sludge.

Area requirements of these methods are:

- Stabilization Pond approx. 21.2 ha
- Aerated Lagoon approx. 5.4 ha
- Trickling Filter approx. 3.0 ha
- Oxidation Ditch approx. 2.1 ha

An area of only 2.6 ha is available downstream along the Meda Ela, and the oxidation ditch method is applicable for this size of land.

Other features of each treatment methods are summarized in Table 12.5

Table 12.5 Comparison of Sewage Treatment Methods

Item	SP	AL	TF	OD
Water Quality	Fair	Good	Fair	Good
Area Requirement	21.2 ha	5.4 ha	3.0 ha	2.1 ha
Construction Cost	Low	Fair	High	High
Power Consumption	0 kW	250 kW	210 kW	280 kW
O & M Difficulty	Easy	Easy	Fair	Fair
Sludge Disposal	Less	Less	Often	Often
Environment	Fair	Fair	Poor	Fair
N-Removal (Future)	Fair	Fair	Fair	Good
Evaluation	Fair	Good	Fair	Good

(4) Conclusion

Due to the limited availability of land for the treatment plant, the adoption of the Oxidation Ditch method is recommended.

(5) Gannoruwa Site

Because of serious public opposition to the construction of STP at Bowala, the KMC and the NWSDB proposed a new alternative site at Gannoruwa (refer to Chapter 15, 15.3.2). The study team examined the new site in response to the request of the NWSDB. Though the results are presented in Chapter 18, the final decision on the selection of the site should be made under the judgement of concerned authority. In this chapter, examination was conducted for the Bowala site.

12.3.3 Sludge Treatment/ Disposal

A continuous and stable sludge treatment/disposal method is one of the most essential components of a sewage and sanitary plan. In modern technology, the outcome of sewage treatment is sludge. Even on-site treatment facilities such as septic tanks and soakage pits etc. produce sludge. Generally, sludge consists of water, inorganic and organic substances. Productive usage of the sludge will result in the optimum disposal of the sludge.

(1) Characteristics of sludge

To treat and dispose of the sludge produced from sewage treatment plants and septic tanks, it is important to know the characteristics of the sludge that is going to be processed. The characteristics vary depending on the origin of the sludge, the detention time and the type of processing done. Some of the physical characteristics of sludge are as follows:

1) Activated sludge

Activated sludge generally has a brownish, flocculent appearance. If the color is dark, the sludge may be approaching a septic condition. If the color is lighter than usual, there may have been under-aeration with a tendency for the solids to settle slowly. Sludge in good condition has an inoffensive "earthy" odor. The sludge tends to become septic rapidly and develops a disagreeable odor of putrefaction. Activated sludge digests readily by itself or when mixed with primary sludge.

2) Composted sludge

Composted sludge is usually dark brown to black, but the color may vary if bulking agents such as recycled compost or wood chips have been used in the composting process. The odor of well-composed sludge is inoffensive and resembles that of commercial garden-type soil conditioners.

3) Septage

Sludge from septic tanks is black. Unless the sludge is well digested by long detention periods, it is offensive because of hydrogen sulfide and other gases that it produces. The sludge can be dried on porous beds if spread out in thin layers. However, objectionable odors can be expected while it is draining unless it is well digested.

Sludge collected from septic tanks is transported to sewage treatment plants and discharged into sludge pits or plants. In the Kandy sewage treatment plant, surplus activated sludge generated in sedimentation basins is transported to dumping site for drying after thickening at the plant.

Table 12.6 Typical Data of Sludge Produced from Various Sewage Treatment

Treatment Process	Specific Gravity		Produced Dry Solids (kg / 1000m^3)	
	Sludge Solid	Sludge	Range	Typical
Activated Sludge	1.25	1.005	72 to 96	84
Aerated Lagoon	1.30	1.01	84 to 120	96

(2) Sludge Treatment

The objectives of sludge treatment are:

1) To separate solids in the sludge and reduce the volume
2) To stabilize the nature of the sludge
3) To process the sludge for reuse (or disposal)

Standard sludge treatment methods include thickening, digestion, dewatering, and incineration as shown in the following figures. Selection of the processes and sequence should be done considering the final usage and disposal.

Method A

Thickening → Digestion → Thickening → Drying → (Use) (Disposal)

Method B

Thickening → Digestion → Thickening → Drying → Composting → (Use)

Method C

Thickening → Digestion → Conditioning → Dewatering → Incineration → (Disposal)

Considering the environmental and other conditions in Kandy MC, Method A or Method B is recommended. The proposed sludge treatment/disposal method is shown in Figure 12.2.

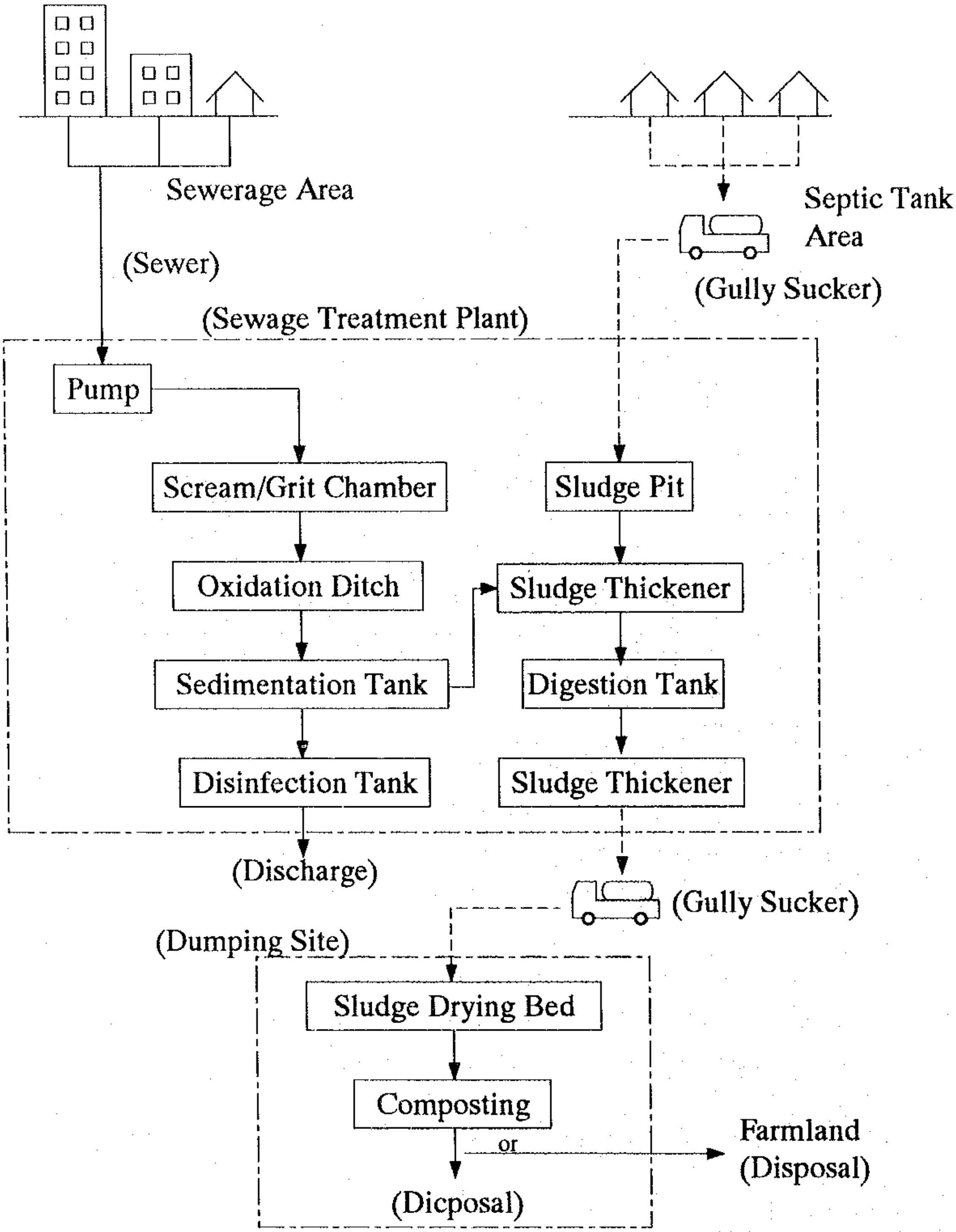


Figure 12.2 Sludge disposal

(3) Composting facilities

Many plans have been developed for the Kandy MC dumping site at Gohagoda; they are;

a. Feasibility Study to Design, Construct and Operate a Composting Facility for the City of Kandy by PEC International Ltd., July 1996
b. Pre-proposal for the Kandy Municipal Council Composting of Municipal Organic Waste by Bio-Engineering Service Technologies Ltd., June 1997

Although the above plans still have not been implemented, the KMC gave a commitment to provide 1250 m^2 of land for Bio-Engineering Service Technologies Ltd. in March 1998. At present, the KMC is not certain of the prospects for implementation of this project.

Sludge from the proposed sewage treatment plants can be utilized for composting and this matter will be studied in the implementation phase.

12.3.4 Integration/Separation of Sewage Service Area

(1) Alternatives

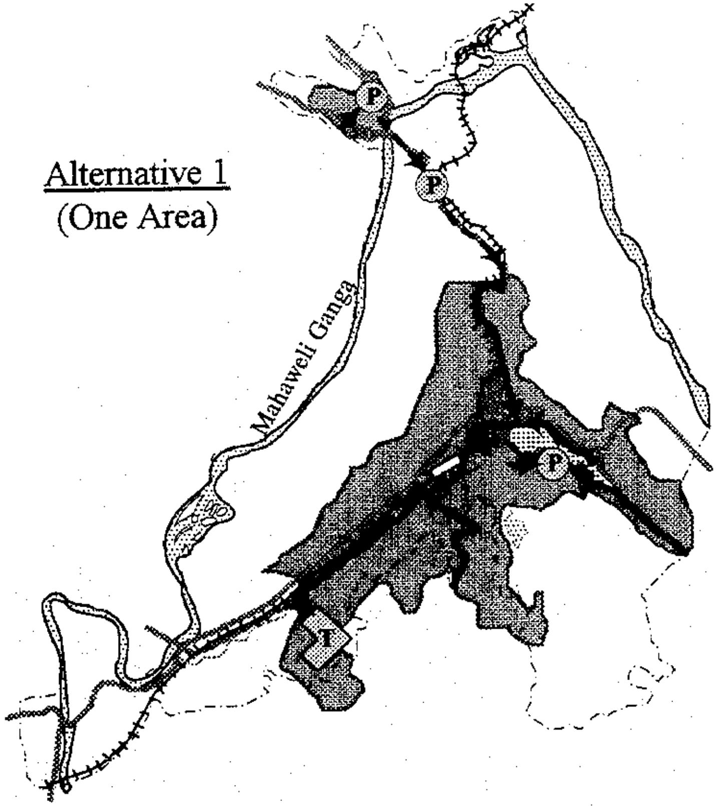
As explained in Chapter 11, the sewerage service area in Greater Kandy is in the Kandy Municipality boundary, encompassing the city center, Kandy Lake area, and a part of Ampitiya and Katugastota. Since Katugastota is remote from the other service areas, two alternative possibilities i.e. integration or separation is suggested for this service area.

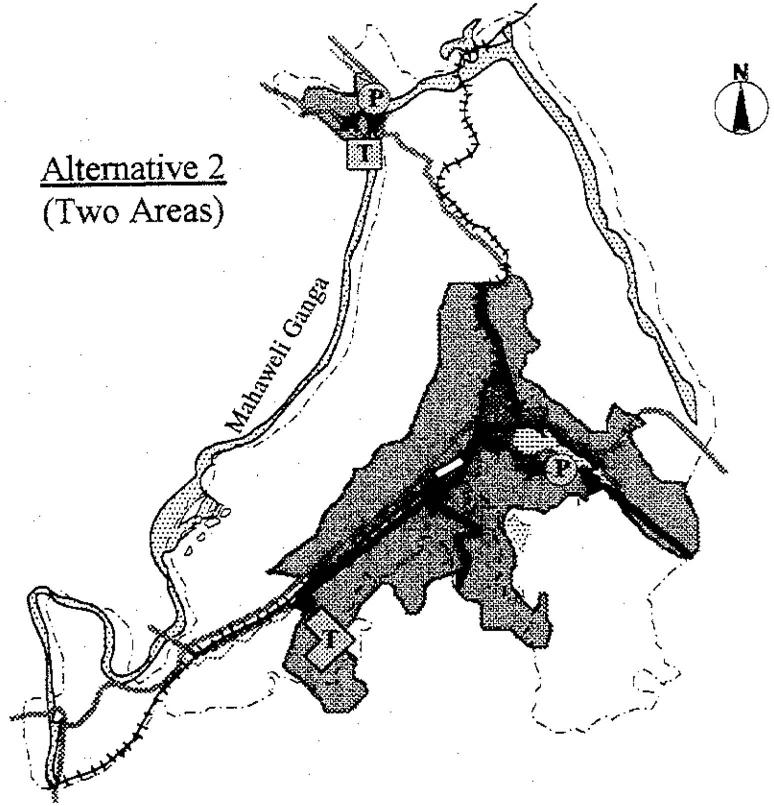
Preliminary design for both alternatives has been carried out, and the locations of major facilities are shown in Figure 12.3. An outline of facilities and the construction costs for both alternatives are summarized in the same figure.

(2) Evaluation of Alternatives

The following considerations are evaluated for the two proposed alternatives.

1) Construction cost
2) Operation and maintenance cost
3) Man-power requirement for operation and maintenance
4) Difficulty of operation and maintenance
5) Influence to water sources





Item		Alternative 1 (One Area)	Alternative 2 (Two Areas)	
			Kandy	Katugastota
Area		674ha	643ha	31ha
Population		55,000	49,700	5,300
Sewerage Treatment Plant		18,000 m3/d	17,000m3/d	1,800m3/d
Pumping Station		No.1 PS : 0.0070m3/sec	No.1 PS : 0.0070m3/sec	—
		No.2-1 PS : 0.0290m3/sec	—	No.2-1 PS : 0.0290m3/sec
		No.2-2 PS : 0.0290m3/sec	—	—
		No.3 PS : 0.3022m3/sec	No.3 PS : 0.2732m3/sec	—
Pipe	Gravity Line	φ150~825mm , L=28,711m	φ150~825mm , L=28,091m	φ300mm , L= 620m
	Pressure Line	φ100,150mmFCD , L=3,250m	φ100mmFCD , L= 650m	φ150mmFCD , L= 50m

Figure 12.3

Alternative of Service Area

The features of two alternatives are summarized in Table 12.7.

Table 12.7 Comparison of Alternatives

	Alternative 1	Alternative 2
Construction Cost (thousand Rs.)	1,840,349	1,838,128
Annual O&M Cost (thousand Rs.)	26,130	25,787
Man-power Requirement (persons)	19	21
Difficulty of O & M	Fair	More
Influence to Water Source	Fair	Good

(3) Conclusions

Construction and operation & maintenance costs of Alternative 2 are slightly cheaper. From the viewpoint of operation and maintenance, Alternative 2 is less advantageous due to the requirement for two treatment plants, while Alternative 1 has more pumping station with a high pumping head. With regard to the influence of the to water source, Alternative 2 is more advantageous because the discharge point of the Katugastota STP is located downstream of the intake tower of the new Kandy water treatment plant. Taking into account the above considerations, it is recommended that the separate sewerage system described in alternative 2 be adopted.

12.4 Preliminary Design of Sewerage System

12.4.1 Layout of Sewerage System

Layout of sewerage system in Kandy is shown in Figure 12.4.

12.4.2 Sewage Collection System

(1) Sewage collection method

Separate system

(2) Piping Materials

Diameter of 100 mm : PVC - Type 600 (service connection)

Diameter of 150 to 600mm : Vitrified Clay Pipe

Diameter of more than 600 mm : Concrete Pipe with Anti-corrosion Coating

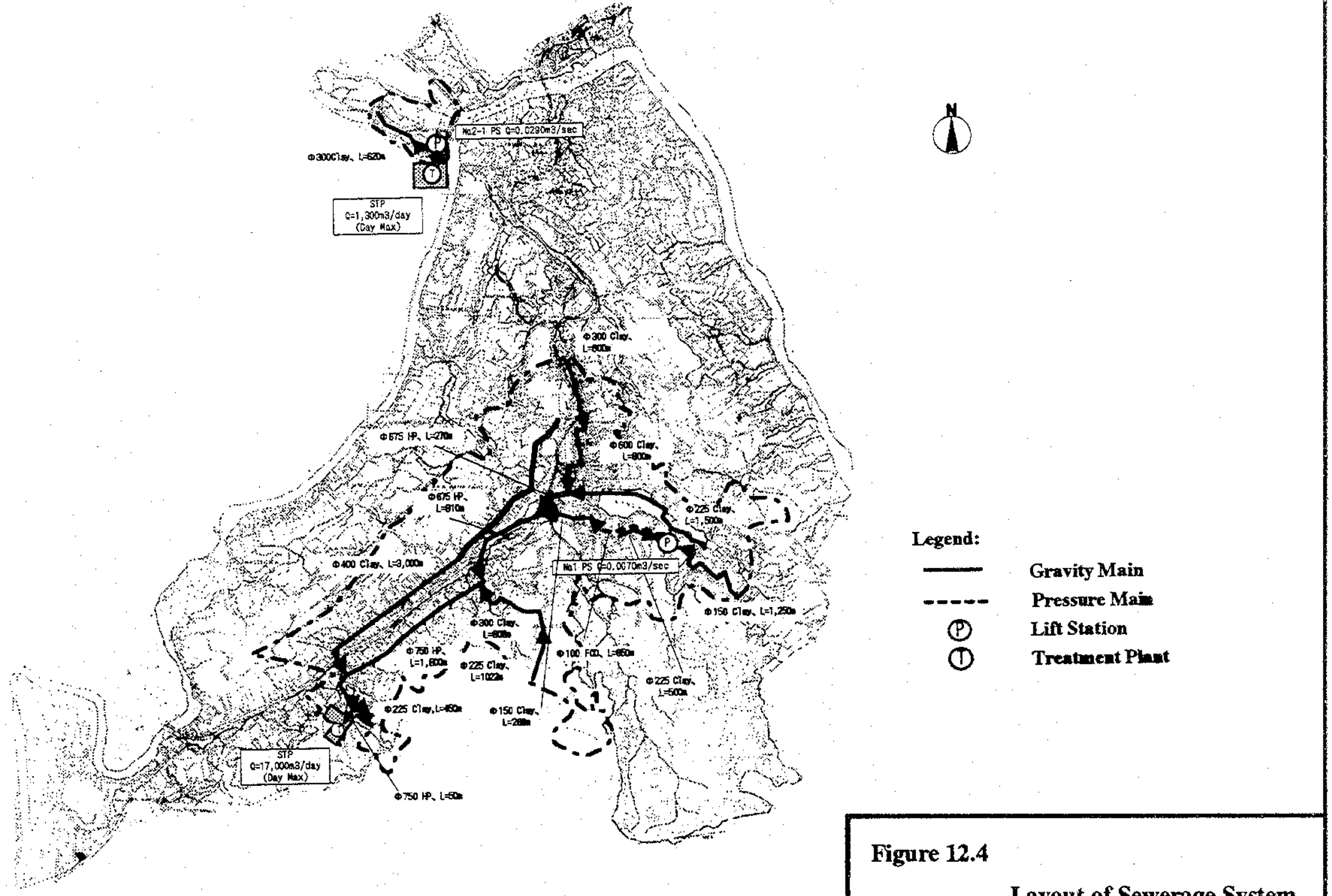


Figure 12.4

Layout of Sewerage System

(3) Summary of Sewage Collection System

The preliminary design for the sewage collection system was shown in Appendix 12.2 and 12.3, and the summary of sewer and pumping stations are shown in the following tables.

1) Sewer

Table 12.8 Summary of Sewer Plan

Item	Diameter (mm)	Length (m)
Clay Pipe - Lateral	150	9,300
Clay Pipe – Sewer Main	150 to 600	16,540
Concrete Pipe	675 to 825	2,870
DI Pipe	100	650
Service Connection	units	12,400

2) Pumping Station

Table 12.9 Summary of Pumping Station Plan

Location	Specification
Katugastota	Submersible Pump, 1.74 m^3/min, 24 m, 15 kW, 2 sets
Kandy Lake	Submersible Pump, 0.42 m^3/min, 27 m, 7.5 kW, 2 sets
Kandy STP	Submersible Pump, 8.2 m^3/min, 14 m, 37 kW, 4 sets Submersible Pump, 4.1 m^3/min, 14 m, 18.5 kW, 4 sets

12.4.3 Sewage Treatment System

The preliminary design for the sewage treatment plant was prepared with the following capacity. Details of the sewage treatment plant are shown in Appendix 12.4.

Location	Treatment Method	2005	2015
Kandy	Oxidation Ditch	8,500 m^3/day	17,000 m^3/day
Katugastota	Aerated Lagoon	-	1,700 m^3/day

(1) Layout

Kandy sewage treatment plant was originally designed to be located at Bowala. However, as stated previously, the alternative site at Gannoruwa was proposed in the Steering Committee Meeting, held on November 27, 1998. A sewage treatment plant at the original site is preliminarily designed in this chapter, while an alternative design is shown in Chapter 18.

Since the area for the treatment plant is small and secluded by the main road and hills, the entire land can not be fully utilized. A tentative layout for the sewage treatment plant is shown in Figure 12.5 and 12.6.

(2) Specifications of Facilities

Specifications for each facility of the sewage treatment plant together with numbers, dimensions and design parameters are given in Table 12.10.

Table 12.10 Specifications of Sewage Treatment Plant

1. Kandy

Facilities	Specifications
1. Grit Chamber and Screen	
Type	Grit Pit Type
Dimension	1.0 m W x 1.5 m L x 0.5 m D
Average Velocity	0.16 m/sec
Number of Basin	1 basin
2. Oxidation Ditch	
Type	Oval-shape Type
Dimension	6.0 m W x 190 m L x 3.0 m D
Aeration Power Level	180 kW
Retention Time	29.0 hours
Number of Basin	6 basins
3. Sedimentation Basin	
Type	Circular Type
Dimension	16.0 m Dia. x 3.0 m D
Water Surface Load	14.1 m3/m2/day
Retention Time	3.4 hours
Number of Basin	6 basins
4. Disinfection Tank	
Type	Rectangular Type
Dimension	1.5 m W x 40.0 m L x 1.5 m D
Required Chlorine	1.42 kg/hour
Retention Time	15.2 min.
Number of Basin	2 basins
5. Sludge Thickening Tank	
Type	Circular Type
Dimension	5.0 m Dia. x 4.0 m D
Solid Load	65 kg/m^2/day
Number of Basin	4 basins
6. Aerobic Sludge Digestion Tank	
Type	Circular Type
Dimension	13.0 m Dia. x 4.0 m D
Solid Load	2.4 kg/m^3/day
Number of Basin	2 basins

7. Sludge Drying Bed	
Type	Rectangular Type
Dimension	6.0 m W x 14.5 m L x 0.3 m D
Retention Time	10.2 days
Number of Basin	10 basins

2. Katugastota

Facilities	Specifications
1. Grit Chamber and Screen	
Type	Parallel Flow Type
Dimension	0.5 m W x 3.0 m L x 0.3 m D
Water Surface Load	1,667 $m^3/m^2/day$
Average Velocity	0.29m/sec
Number of Basin	3 basins (including 1 stand-by)
2. Complete Mixing Aerated Lagoon	
Type	Rectangular Type
Dimension	30.0 m W x 15.0 m L x 3.0 m D
Aeration Power Level	16 kW
Retention Time	1.56 days
Number of Basin	2 basins
3. Partial Mixing Aerated Lagoon	
Type	Rectangular Type
Dimension (Cell)	30.0 m W x 8.0 m L x 4.0 m D
Aeration Power Level	4 kW
Retention Time	2.0 days
Number of Basin	3 cells x 2 basins
4. Disinfection Tank	
Type	Rectangular Type
Dimension	1.0 m W x 18.0 m L x 1.0 m D
Required Chlorine	0.21 kg/hour
Retention Time	15.2 min.

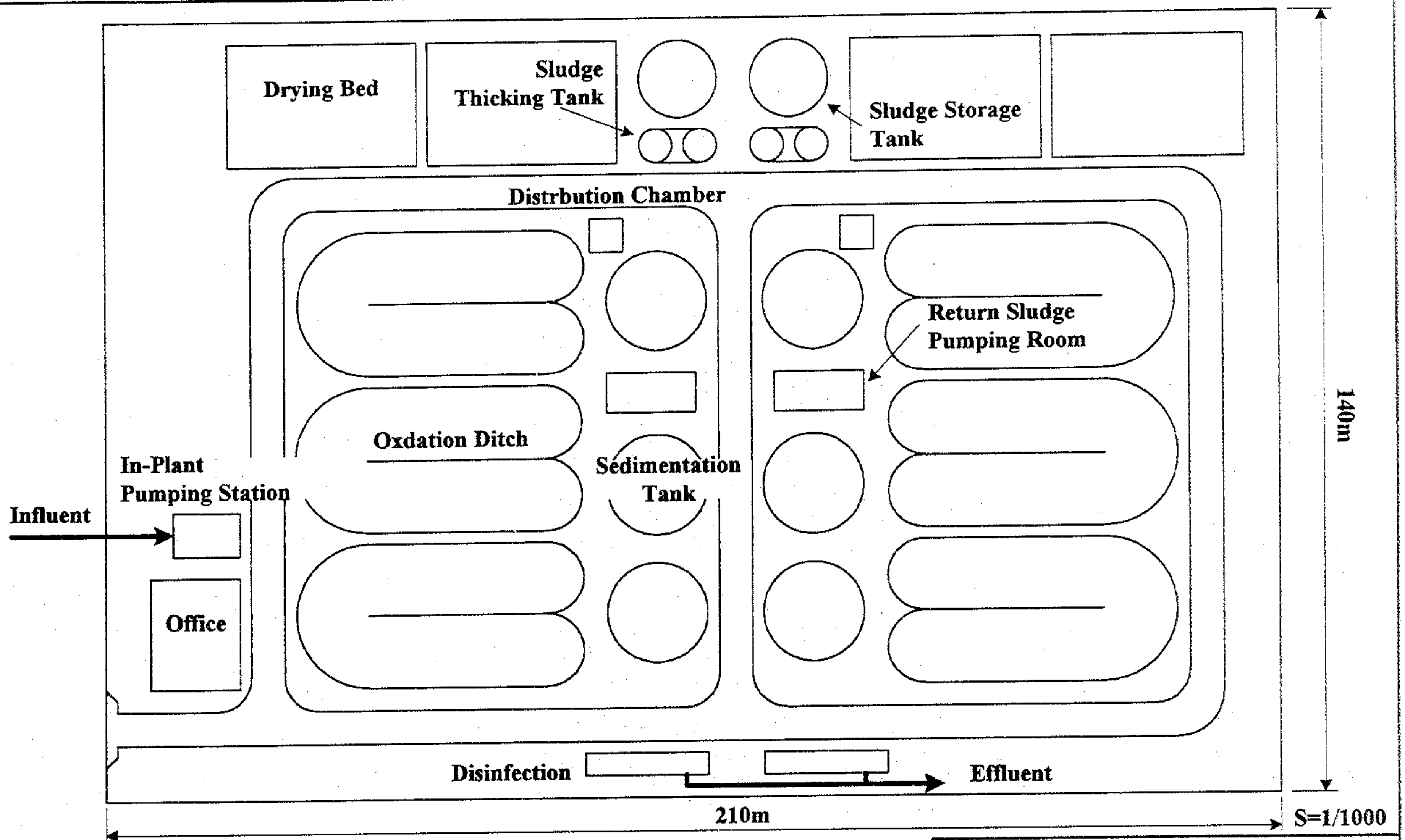


Figure 12.5
Layout of Kandy Sewage Treatment Plant

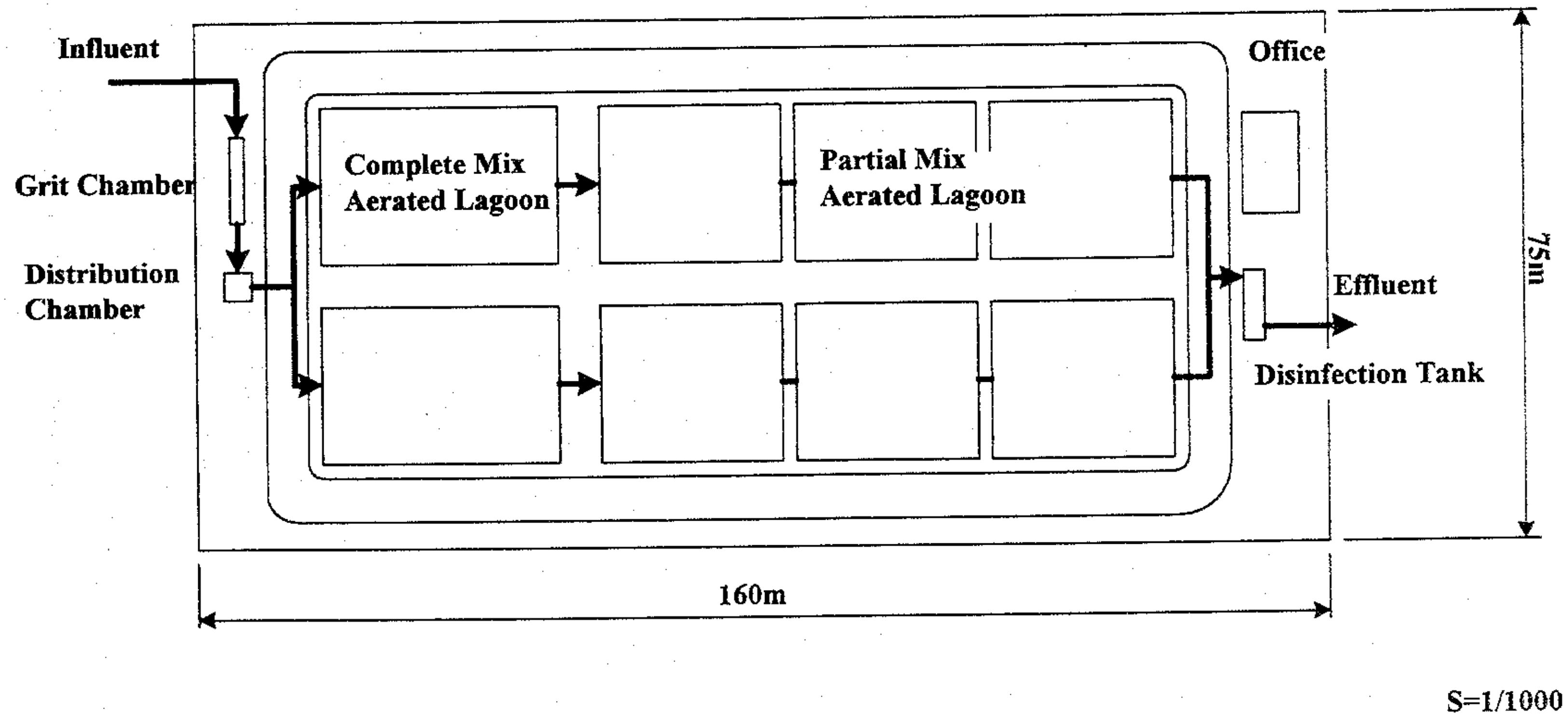


Figure 12.6 Layout of Katugastota Sewage Treatment Plant

(3) Treatment Process

1) Grit chamber

The grit chamber is used to remove inorganic solids and to eliminate grit contained in sewage. As sewage also contains large items such as trash, garbage, cloth, sticks etc., it is necessary to remove such materials by providing a screen in the grit chamber. By removing this material, treatment equipment downstream will be protected against and the treatment process can function effectively.

2) Oxidation Ditch and Sedimentation Basin (Kandy)

The Oxidation Ditch consists of an oval-shaped channel and is equipped with mechanical aeration devices. Screened sewage entering the ditch is aerated and circulated. Oxidation ditches operate in an extended aeration mode with long detention and solids retention periods.

The Sedimentation Basin is for removal of solids and sludge storage. Circular-shaped clarifiers are required to collect settled sludge, which is returned to the oxidation ditches as return sludge, and small portions of sludge to the sludge thickener as surplus sludge for thickening.

3) Aerated Lagoon (Katugastota)

The configuration of the aerated lagoon is a two-basin system. The first basin will reduce the biodegradable materials in the sewage in a complete mixing aerated lagoon. Aerators are provided to maintain all solids in suspension and to supply oxygen for the BOD removal.

This lagoon allows gravity settlement of the solids, biological stabilization of the settled solids and sludge storage. Aerators, which are smaller than ones in the complete mixing aerated lagoon, are required to maintain dissolved oxygen for stabilization of settled sludge and to prevent odors.

4) Disinfection tank

This facility is designed to remove microorganisms from the effluent by use of a chlorine solution.

12.4.4 Sanitation Facilities

(1) Objectives of the Study

On-site sewage treatment/disposal is important, not only for small rural communities, but also for urban/semi-urban households which are not served by the public sewerage system. The study of on-site treatment/disposal was undertaken to offer alternatives from the viewpoints of low-cost sanitation and technical aspects, corresponding to the differences among the locations such as a cluster of households, apartments, and individual households. The study also looked into technical options as an intermediate countermeasure for those unsewered households situated in the transitional areas for on-site treatment.

Field inspections of the existing facilities, such as individual septic tanks and small bore community sewerage systems were carried out during the Stage 1 Field Work and the Stage 2 Field Work. Water sampling from various points in the Study Area and laboratory examination were also carried out.

Reference is made to the "Appropriate Technology for Treatment of Sewage for Small Rural Communities" (Lyon, 1982, EURO Reports and Studies, WHO Regional Office for Europe).

(2) Evaluation of Existing System

A water quality survey of effluents from existing septic tanks and percolation tests at three different locations in KMC were conducted.

1) Effluents from septic tanks

Water quality of effluents from septic tanks is shown in Table 12.11 and it indicates that BOD is removed in some septic tanks while SS is high.

The high SS is a result of overflowing of septage or sludge from the bottom of septic tanks. This will cause clogging of the seepage pits and shorten the operation life of the pits.

Table 12.11 Water Quality of Septic Tank Effluent

	BOD_5(mg/l)		SS(mg/l)	
Locations	March 1998	August 1998	March 1998	August 1998
High Income House	-	124	-	2,389
Middle Income House	188	60	3,690	572
Low Income House	46	20	118	1,716
Office	5	60	174	204
Office	-	43	-	289
General Performance	140-200		50-90	

2) Percolation test

Percolation tests were conducted in August 1998 (rainy season) at three locations in KMC, namely Getambe, Hanthana and Mahayyawa. Getambe is located on the right bank of Mahaweli River, Hanthana is located in the hilly area, and Mahayyawa is located in the valley. The results are presented in Table 12.12.

Table 12.12 Percolation Test Results

Location	Depth (m)	Percolation Rate (min)
Getambe	2.0	25.0
Hanthana	2.0	7.35
Mahayyawa	1.2 *	125.0

* : Depth of test hole is limited to 1.2m due to ground water level.

The recommended method of disposal of septic tank effluent are shown in Sri Lanka Standard SLS 745, 1986, "Code of Practice for Design and Construction of Septic Tanks" (presented in Table 12.13) and these indicate the following disposal methods for the three locations

Getambe and Hanthana:

Seepage pit or dispersion trench

Mahayyawa:

Biological filter party or fully above ground level with under drains and the effluent led into a surface drain.

Table 12.13 Recommended Method of Disposal of Septic Tank Effluent

Depth of the highest position of the water table below ground level	Soil and subsoil conditions		
	Porous soil with percolation rate :		Dense and clay soil with percolation rate exceeding 60 min.
	Not exceeding 30 min.	Exceeding 30min. But not exceeding 60	
Within 1.8 m	Dispersion trench locate partly or fully above ground level in a mound.	Dispersion trench located partly or fully above ground level in a mound.	Biological filter partly or fully above ground level with under drains and the effluent led into a surface drain or used for gardening.
Below 1.8 m	See page pit or dispersion trench.	Dipersion trench	Subsurface biological filter with under-drains and the effluent led into a drain or used for gardening.

Note- Where the above mentioned methods are not feasible and where the effluent has to be discharged into an open drain, it should be disinfected.

Detailed methods of effluent disposal are shown in the following section.

(3) Expected Septic Tank Sludge Generation

After the new sewerage system is introduced in Kandy and Nuwara Eliya MCs, the system will only cover the central area of the Municipal Councils, mainly commercial areas. Residential areas surrounding these central areas will continue to use on-site facilities such as septic tanks and soakage pits for sometime.

The population, which is expected to be served by this sewerage system or on-site treatment, is as follows:

Table 12.14 Sewerage and Septic Tank Area

	Total		Sewerage		Septic Tank	
	Population	House	Population	House	Population	House
1997	136,000	20,451	0	0	108,800	16,361
2005	153,000	23,008	19,262	2,897	106,990	16,089
2015	171,000	25,714	54,985	8,268	92,812	13,957

The demand for septage collection service depends solely on requests by residents. Requests are made generally when septic tanks and soakage pits are full, when leakage is detected from sewage tanks/pits, or when odors are detected. However, it is observed that sewage or leachate from the tanks is merely emptied, and it contaminates adjacent streams.

To improve this situation, it is proposed that sludge from septic tanks and soakage pits be regularly removed, at least once in every five years.

The following table gives the expected sludge that will be discharged daily if regularly removed.

Table 12.15 Discharged Sludge Volume from Septic Tanks

2005	25.7 m^3
2015	22.3 m^3
STP (2005)	18,000 m^3/day

The volume of sludge collected from septic tanks will be comparatively small when compared with the capacities of the plants and therefore collected sludge could be treated at sewage treatment plants.

(4) Proposed Design for Septic Tank with Infiltration as Typical Method

Systems with septic tanks are the most commonly applied method for sewage treatment in unsewered areas. Effluent from the tank is usually disposed into the soil. However, the design and size of the infiltration units/facilities play an important role in the satisfactory performance of the unit.

This method is practically suitable for the treatment of domestic sewage of single households, institutions and small communities (or apartment type housing accommodating comprising up to about 5 households).

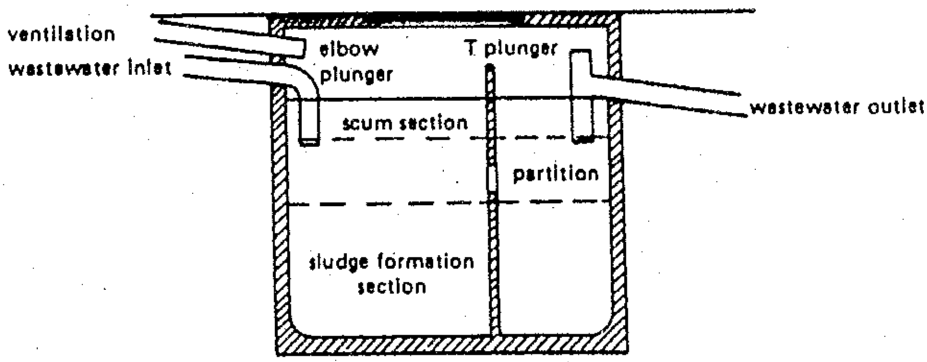
1) Design of septic tank

Septic tanks shall be constructed with the use of watertight materials and composed of two compartments as shown in Figure 12.5

Domestic sewage (both sullage and fecal sewage) is carried into the first compartment of the septic tank. In this compartment, solid wastes settle to form a sludge layer and are anaerobically digested. Further sedimentation, as well as sedimentation of the sludge that has been re-suspended by peak flow, takes place in the second compartment, which is generally half the size of the first compartment.

The treatment performance largely depends on climatic conditions (particularly temperature). BOD may be reduced by 30-50 percent while the total suspended solids (TSS) by 50-70 percent. The physico-chemical characteristics of treated effluent generally restrict direct disposal of surface water body or an aquifer (cesspool, fissured subsoil, etc.).

Figure 12.7 Typical Design of Septic Tank



Source: L'assainissement individuel - principes et techniques actuelles. Paris. Ministère de l'Environnement et de Cadre de Vie et Agence de Bassin Loire-Bretagne. 1980.

The required size of septic tank depends on the following design conditions:

a. Influent sewage flow
   Attention shall be paid to reduce water consumption by economically designed septic tanks; such as replacement of conventional flush toilets by water saving designs (pour flush, etc.).

b. Retention time required for effective sedimentation of solid wastes
   The required retention time for solid sedimentation depends on the number of users.

c. Sludge accumulation rate
   The sludge accumulation rate varies considerably depending on climatic conditions, ranging from 30 liters/person/year in southern Europe to 70 liters/person/year in the north.

d. Frequency of desludging

The frequency of desludging depends on the rate of sludge accumulation and the cost of its removal. In different European countries, the desludging frequency varies from twice a year to once every four years, although yearly or twice-yearly intervals are usually recommended.

2) Disposal of treated effluent

There are several technical options for the disposal of treated effluent, such as soak pits, subsurface irrigation systems, and sand filters. The selection of the technical option largely depends on availability of land and the volume of treated effluent. However, septic tanks with irrigation systems are becoming popular for both individual households and community sanitation (for up to 1,000 people in some European countries).

a. Subsurface irrigation system

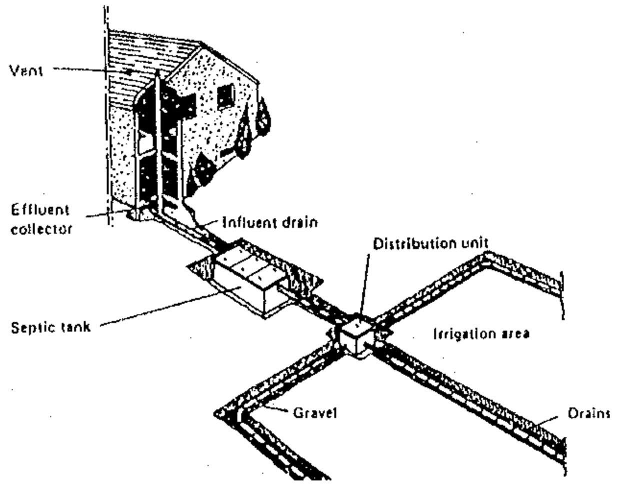
This system disposes of the treated effluent from the septic tank by infiltration into the soil through drains embedded in filtering media. The principal design of this system is exhibited in Figure 12.8.

Additional options to this system are:

- Pre-filter upstream of the distribution unit to serve as a precaution against silting of the drains as it is an indicator of the functioning of the septic tank.
- Flushing cistern to ensure better distribution of sewage in the treatment unit.

A subsurface filtration system consists of a series of narrow (0.5 to 1 m) leaching trenches or one or more sand filters. The choice between trenches or filters depends on the nature of the soil and the land immediately surrounding the system, as shown in Figure 12.8.

Figure 12.8 Principal Design of Shallow Subsurface Irrigation System



Source: L'assainissement individuel-principles et techniques actuelles. Paris, Ministère de l'Environnement et du Cadre de Vie et Agence de Bassin Loire-Bretagne. 1980

i. Trenches

Trenches are suitable for the locality where the soil is not permeable enough and is difficult to work on. Trenches can accommodate certain storage of the effluent, since the walls of trench play a useful role in the infiltration process.

ii. Sand filters

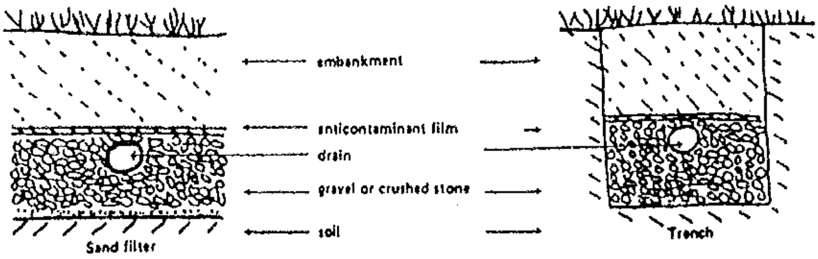
Sand filters are more compact and are particularly suitable when the soil is permeable, and when the site does not present any topographical problems or difficulties due to the presence of impermeable strata.

b. Alternative measures of subsurface filtration

More costly alternative measures are available for subsurface filtration, when the environmental conditions restrict the application of the above mentioned methods, particularly:

- when unprotected groundwater is located near the surface; and
- when the soil stratum is not sufficiently thick.

Figure 12.9 Subsurface Filtration System (Trench & Sand Filter)



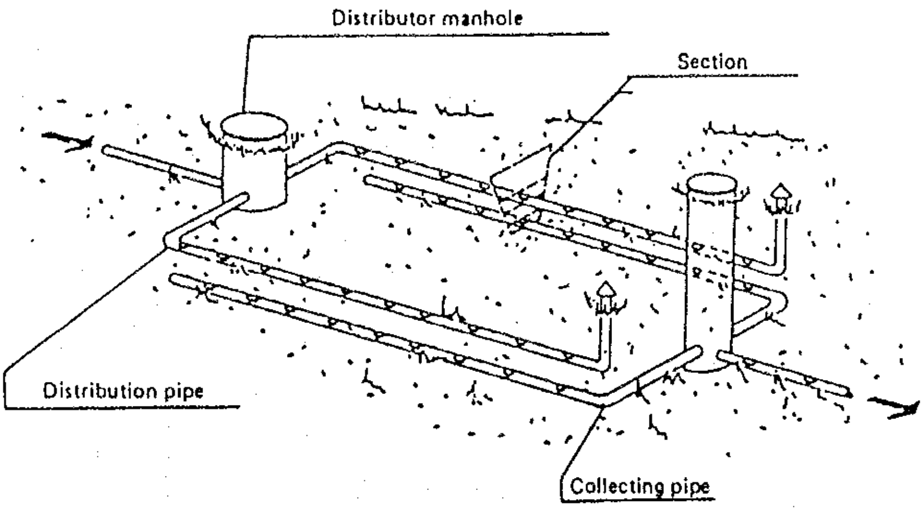
Source: L'èpandage des eaux usèes domestiques. Tude prèalable de l'aptitude des sols et règles de dimensionnement des installations. Paris, CTGRF. Etude No. 50, 1980.

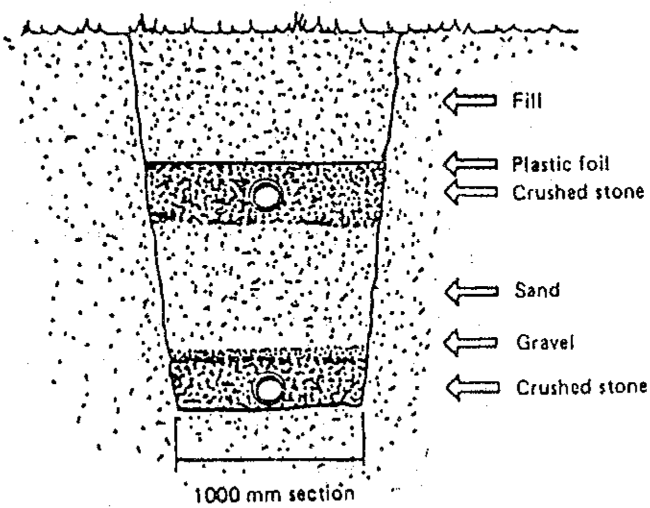
Three alternative measures are considered as follows:

i. Drained sand filter

This method is useful when the permeability of the soil is too poor or when the groundwater table is too shallow (0.5 to 1 m). This method will be used only where the effluent can be discharged into a surface environment, as shown in Figure 12.10.

Figure 12.10 Drained Sand Filter for a Single Household

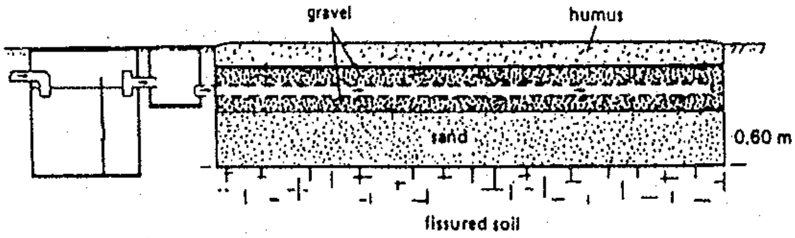




ii. Undrained sand filter

This is a modified method of the above mentioned drained sand filter and applicable when the soil stratum is not sufficiently hick, but does allow infiltration of effluent after treatment (fissured substratum), as shown in Figure 12.11.

Figure 12.11 Undrained Sand Filter

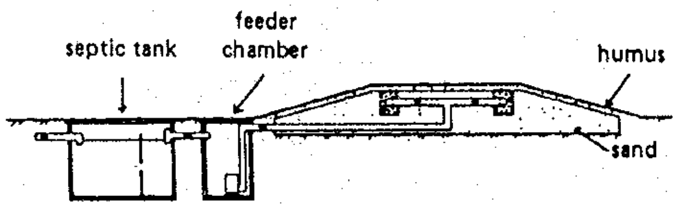


Source: L'assainissement individuel-principles et techniques actuelles. Paris, Ministère de l'Environnement et du Cadre de Vie et Agence de Bassin Loire-Bretagne. 1980

iii. Raised sand filter

This sand filter is installed in a mound (approximately 1 m high) of sand placed on the natural ground surface after leveling. This method is applicable if an aquifer is close to the surface (0.5 to 1 m depth) and if the effluent cannot be discharged into the environment. In the application of this method, the soil must be sufficiently permeable, as shown in Figure 12.12.

Figure 12.12 Raised Sand Filter



Source: L'assainissement individuel-principles et techniques actuelles. Paris, Ministère de l'Environnement et du Cadre de Vie et Agence de Bassin Loire-Bretagne. 1980

(5) Compact Aerobic Domestic Sewage Treatment Module

Septic tanks associated with the infiltration system have several limitations on these application viz.:

- They are applicable to rural and suburban areas where the necessary open space is available to construct infiltration systems.
- They are applicable to areas where the soil conditions are favorable for infiltrating effluent from septic tanks.

In other words, when houses are located in densely populated areas and sufficient open space to construct infiltration systems is not available, and/or soil conditions are impermeable, the said treatment/disposal method of domestic sewage is not suitable.

To comply with the above-mentioned restrictions on locality, there is a further technical option belonging to the among the on-site treatment/disposal method which is the so called compact aerobic domestic sewage treatment module.

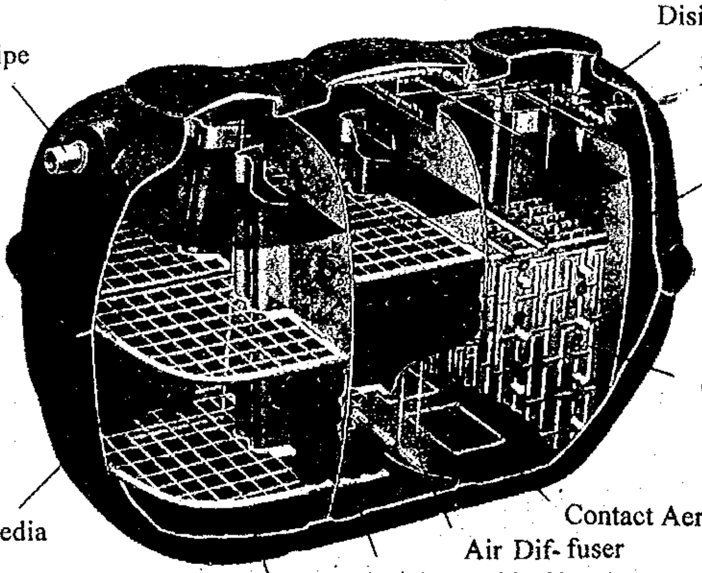
This compact treatment module employs a biological contact treatment method with diffuser of compressed air. It enables a reduction of required space to more or less the equivalent of a septic tank by increased treatment efficiency and does not require an infiltration system.

This compact treatment module has two different types in its application; one for only nightsoil treatment and the other for both nightsoil and other domestic sewage. Generally, this compact module achieves a treatment efficiency level of at least 30 mg/l of BOD in its treated effluent. It requires, however, removal of excess sludge that accumulates in the module at intervals of at least twice a year.

Different treatment capacities are available corresponding to the volume of households or apartments. The provision of an equalization tank is recommended for facilities having service populations of more than 200 persons, to offset the flow rate fluctuations of raw sewage. A typical design of a compact aerobic domestic sewage treatment module is shown in Figure 12.13

Taking the future urban development in the Study Area into account, this compact treatment module will be given consideration for those apartment type housing schemes to be constructed in suburban areas where the public implementation of sewerage system are not planned.

Figure 12.13 Typical Design of Compact Aerobic Domestic Sewage Treatment Module



(6) Standardization of On-Site Treatment and its Application

In the application of the on-site treatment method to individual households and other large scale facilities such as commercial establishments and apartment type buildings, particular technical standardization and legislative arrangements are deemed indispensable in order to achieve better sanitation practices, efficiency in operations and maintenance, and environmental soundness.

1) Technical standardization

The majority of existing septic tanks have the following characteristics:

- The size/capacity of the septic tanks is not determined based on sound technical criteria.
- Septic tanks are simply constructed with the use of bricks and mortar and have effluent outlet regardless of the surrounding environmental conditions.
- Septic tanks are usually located at the backs of houses away from the streets.
- Future conversion from septic tanks to sewerage systems is not considered.

- Due to the lack of inappropriate timing of desludging a considerable number of septic tanks seem to be full of septage and are therefore discharging untreated sewage.
- Removed septage is dumped into rivers, ponds, canals, and sewer manholes, causing further deterioration of the environment.

To attain environmental soundness both for residents and the surrounding environment, the following technical set ups are necessary:

- Soak pits will be attached to the septic tank where effluent disposal to nearby drainage facility is not available and/or the surrounding environment does not permit such disposal methods such as in densely populated areas.
- Combined treatment of nightsoil and grey water will be introduced for apartment type housing and other large scale facilities, i.e. commercial establishments, public facilities et al.

2) Legislative arrangements

Deficiencies in and/or the inappropriateness of the existing on-site treatment facilities are largely due to a lack of proper legislative controls and their implementation. In this Master Plan, septage removed from septic tanks is planned to be treated together with the excess sludge from the STP at the sludge drying facility in the STP.

The following legislative and administrative arrangements are required:

- Permission to either build new houses or buildings or to carry out renovations/ improvements to existing buildings will be granted to applicants when an appropriate installation plan for a septic tank or equivalent facility (including location and plumbing schedule for disposal of an effluent) is submitted and approved by the relevant authority.

- The NWSDB or Municipality shall have the option to reject an application for water supply services and the acceptance of septage for treatment against any applicant when the house/building violates the above requirement.

- The house/building owner will be obliged to enter into a contract for a septic tank with a public corporation or private entity that is registered with the

NWSDB or Municipality and which is subject to the approval of the relevant authority.

- Penalty clauses shall be included in the regulations to restrict building without appropriate domestic sewage treatment facilities and inadequate removal of septage. Negligence to remove septage may be subject to a penalty in the form of a holding tax or any other measure, such as the closure of a business or the termination of water supply facilities.

- Financial assistance, i.e. the facility for a soft loan or partial subsidy, shall be considered for the efficient implementation of proper sanitation measures.

- Accreditation of houses or buildings conforming to the required sanitation standards should be issued by the relevant authority. This is a further option to bring to the attention of the public the importance of an adequate sanitation facilities. This will also ensure enforcement of sanitation standard by private developers.

- Health and hygiene education of the public shall also be initiated by authorities, in order enhance the importance of public hygiene practices and community participation.

12.5 Project Cost

12.5.1 Composition of Project Cost

Project cost is composed of the following items

Project Cost

- Construction Costs — Direct Cost
  - Civil Work
  - Mech./Elec. Work
  - (Site Expenses)
  - (Packing/Transportation Cost)
  - (Import Tax)
  - (Administration Cost, partial)
- Equipment Procurement — Equipment
  - (Packing/Transportation Cost)
  - (Import Tax)
  - (Administration Cost, partial)
- Engineering Services
  - Detailed Design
  - Construction Supervision
- Common Costs
  - General/Administration Expenses
  - Land Acquisition
- Contingencies
- GST (12.5 %)

12.5.2 Conditions for Cost Estimate

(1) Conditions

1) Basic conditions

The project cost is estimated on the basis of the preliminary design for the Master Plan facilities. Unit prices and lump sum prices were determined considering local conditions, sub-contractors, equipment, available construction equipment and materials as well as suitability of the proposed construction method.

Assumptions and conditions used for the cost estimate are as follows:

Price level	:	as of November 1998
Foreign exchange rate	:	Sri Lankan Rs. 1.00 = Japanese ¥ 1.80

2) Direct cost

a. Unit prices obtained from the NWSDB and actual international contract prices from the Towns South of Colombo Water Supply Project, etc. are compared and established as unit costs as of November 1998. Details are shown in Appendix 12.7.

b. Administration costs mainly cover mobilization/demobilization for the construction works. The magnitude of the project is too large for local contractors.

3) Common expenses

Land acquisition costs for the sewage treatment plant are estimated for a total of 4.2 ha for Phase 1 and 2. The required land for the treatment plant and pump stations should be secured prior to the commencement of the construction activities.

Land acquisition costs for the sewage treatment plants are estimated as follows:

Kandy (3.0 ha) = Rs. 160 million, Katugastota (1.2 ha) = Rs. 20 million

4) Contingencies

A total contingency fund of 15 percent of the project cost, for the physical contingency and price escalation, is included in the project cost.

(2) Scope of work to be implemented using foreign financing

The following works are deemed to be implemented under foreign financial assistance.

1) Procurement of engineering services for detailed engineering design and construction supervision.

2) Construction, including the procurement of equipment and materials as identified in the preliminary design and project cost estimate.

(3) Scope of work to be implemented using local counterpart funds

The following indigenous works are deemed to be implemented using counterpart funds of the Sri Lankan Government:

1) Construction of house connections in the proposed sewerage service area.

2) Land acquisition and relocation of local residents from the proposed site for the sewage treatment plant, pumping station sites and along the proposed route of the trunk mains.

3) Construction of a perimeter fence around the proposed site of the sewage treatment plant.

4) Provision of water quality examination equipment and apparatuses for BOD, COD, Phosphorus, Nitrogen, etc., for other testing (Subletting of analysis work is applicable as a substitute measure.)

5) Cost of electricity, fuel, and chemicals during the testing activity for the sewage treatment plant, except for individual testing of the electrical equipment.

12.5.3 Project Cost

Total cost of the proposed project is estimated in Sri Lankan Rs. as follows:

Table 12.16 Project Cost of Kandy Sewerage Project

Unit: Thousand Sri Lankan Rs.

(1) Construction cost		
1) Collection System		747,251
Trunk/MainSewer		
Sewer Lateral		
2) Pumping Station		28,690
Civil Work	9,339	
Mechanical/Electrical Work	19,351	
3) Sewage Treatment Plant		1,062,378
Civil Work	390,237	
Mechanical/Electrical Work	672,141	
4) Administration cost		93,872
Sub-Total		**1,932,000**
(2) Procurement of maintenance equipment		**25,000**
(3) Engineering cost		
1) Detailed design	81,000	
2) Construction supervision	65,000	
Sub-Total		**146,000**
(4) Common expenses		
1) General and administration expenses	20,000	
2) Land acquisition	180,000	
Sub-Total		**200,000**
(5) Contingency		**346,000**
(6) GST (12.5%)		**331,000**
Total		**2,980,000**

Note: Exchange rate: SL Rs. 1.00 = Japanese Yen 1.80 (as of November, 1998)

Detailed Costs are shown in Appendix 12.5 to 12.7.

12.5.4 Construction Equipment and Materials

Most of the construction materials are imported from adjacent countries except cement, sand, gravel, concrete pipe etc. The imported materials, however, are available in the local market in Sri Lanka since the requirement for quality and quantity is not extraordinary. Mechanical and electrical facilities, and equipment for sewer maintenance must be imported from foreign countries.

Local products and imported materials and equipment are listed below. However, it is assumed that the imported materials for the civil work are procured through sales agents and suppliers in Sri Lanka.

(1) Local material

Cement, stone, aggregate, sand, water, timber, plywood, steel reinforcement, structural steel, concrete pipe, small steel pipe, road curb, concrete blocks, bricks, AC roof and tiles, pre-cast built wall, fence, road/pedestrian gates, wire nails, gabion mesh, gasoline, diesel, lubricants, concrete admixture, waterstop, scaffolding, metal forms, guardrail, asphalt, emulsion and other small miscellaneous items.

(2) Imported material and equipment

Construction equipment, truck cranes, vehicles, motorcycles, computers, pumps, motors, transformers, switchgears, aerators, disinfection facilities, laboratory equipment, flow meters, sluice gates, hoists, clarifier and thickening mechanisms, and other similar items.

12.6 Implementation Schedule

In connection with the target years of this Study (2005 and 2015), Phase 1 is an urgent and priority project which is expected to be completed by the end of 2003, while the overall project, Phase 2, will be completed by the end of 2013.

Phase 1 (1999 to 2003) - Priority Project

1999 -2001	Preparation of project
2001 - 02	Detailed design and bidding
2002	Commencement of construction
2002 - 03	Construction
2004	Commencement of operation

Phase 2	(2009 to 2013)	
	2009 - 11	Preparation of project
	2011 - 12	Detailed design, bidding
	2012	Commencement of construction
	2012 - 13	Construction
	2014	Commencement of operation

The project implementation and disbursement schedule with estimated annual disbursements of project cost is presented in Table 12.17.

Table 12.18 Project Implementation and Disbursement Schedule of Kandy Sewerage Project

Item \ Phase / Year		Phase 1					Phase 2				
		1999	2000	2001	2002	2003	2009	2010	2011	2012	2013
Implementation Schedule											
1. Preparation of Project											
2. Pre-Construction Stage											
2.1 Detailed Design											
2.2 Bidding											
3. Construction											
3.1 Collection System											
- Trunk Mains											
- Sewer Laterals											
3.2 Sewage Treatment Plant											
- Civil Work											
- Mechanical/Electrical Work											
4. Procurement of Equipment											
Disbursement Schedule	**Total Cost (Million SL Rs)**	Phase 1	1710.0				Phase 2	1270.0			
1. Land Acquisition	180.0			160.0					20.0		
2. Administration	20.0			2.0	4.0	4.0			2.0	4.0	4.0
3. Construction Work	1,932.0				345.0	700.0				287.0	600.0
4. Procurement of Equipment	25.0					25.0					
5. Engineering Service	146.0			45.0	15.0	22.0			36.0	10.0	18.0
6. Contingency	346.0			31.0	54.0	113.0			9.0	45.0	94.0
7. GST (12.5 %)	331.0			30.0	53.0	107.0			9.0	38.0	94.0
Total of Annual Disbursement	2,980.0			268.0	471.0	971.0			76.0	384.0	810.0

Table 12.19 Outline of Kandy Sewerage Project

Phase			Unit	Phase 1	Phase 2	Remarks
Frame Values	Service Area			City center commercial area, Kandy Lake, surrounding hotels, hospital, Hantana housing scheme , housing area along the two principal transpotation routes and Katugastota..		The values in phase 2 column shows these for the whole project
	Target Year			2005	2015	
	Service Area		ha	271	724	
	Population		Pop	153,000	171,000	
	Service Population		Pop	19,300	55,000	
	Percentage of Service Population		%	13%	32%	
Sewage Flow	Per Capita Sewage Flow	Domestic	lpcd	86	97	The values in phase 2 column shows these for the whole project
		Non-Domestic	lpcd	92	138	
		Infiltration	lpcd	32	42	
		Total	lpcd	210	277	
	Design Sewage Flow	Daily Average Sewage Flow	m3/d	7,300	15,200	
		Daily Maximum Sewage Flow	m3/d	8,500	17,800	
		Hourly Maximum Sewage Flow	m3/d	12,200	25,500	
Phase			**Unit**	**Phase 1**	**Phase 2**	**Total**
Facility	Planning Area			Kandy-city center commercial area , the area around the Kandy Lake ,hospital, Hantana housing scheme.	Excluding Phase 1 column in Sevice area.	–
	Sewage Treatment Plant (Kandy)	Treatment Method		Oxidation Ditch		
		Capacity	m3/d	8,500	8,500	17,000
		Facilities		Grit Chamber, Oxidation Ditch, Sedimentation Basin,		
	Sewage Treatment Plant (Katugastota)	Treatment Method		Arerated Lagoon		
		Capacity	m3/d	–	1,700	1,700
		Facilities		Grit Chamber, Complete Mixing Aerated Lagoon, Partial Mixing Aerated Lagoon, Disinfection Tank		
	Pumping Station	Submersible Pump	Nr	2	1	3
	Sewer Pipe	Lateral Sewer Clay ϕ 150mm	m	4,500	4,800	9,300
		Trunk Sewer Clay ϕ 150～600mm	m	13,940	2,600	16,540
		Concrete ϕ 675～825mm	m	2,870	0	2,870
		Puressure Pipe DI ϕ 100mm	m	650	0	650
		Service Connection	Nr	5,800	6,600	12,400
Project Cost	Construction	Direct Construction Cost	Milli. Rs.	1,045	887	1,932
		Procurement of Maintenance Equipment	Milli. Rs.	25	0	25
		Engineering Cost	Milli. Rs.	82	64	146
		Administration and Land Acquisition	Milli. Rs.	170	30	200
		Contingency	Milli. Rs.	198	148	346
		GST 12.5%	Milli. Rs.	190	141	331
		Total	Milli. Rs.	1,710	1,270	2,980
	Operation and Maintenance	Personnel Expense	Thou. Rs.	1,176	1,980	–
		Electricity Cost	Thou. Rs.	8,067	16,558	–
		Chemical Cost	Thou. Rs.	161	334	–
		Repair Cost	Thou. Rs.	3,323	6,915	–
		Tatal	Thou. Rs.	12,727	25,787	–

CHAPTER 13

PRIORITY PROJECT OF SEWERAGE SYSTEM PLAN

CHAPTER 13 PRIORITY PROJECT OF SEWERAGE SYSTEM PLAN

13.1 Identification of the Priority Project

The Master Plan Area consists of Kandy-city center and Katugastota. From the viewpoint of topography and urban development the area is also divided into the following six sub-areas, namely Kandy city center, Kandy Lake, Peradeniya Road-North Peradeniya Road-South, Hanthana and Katugastota.

Detailed data on population, commercial activities, etc by these sub-areas are not available, and evaluation was mode by a series of discussions and field observations.

Table 13.1 Evaluation for Priority Project Area

Sub-Area	Priority	Catchment	Population Density	Commercial Activity	Environmental Conservation
Kandy-City Center	High	Meda Ela	High	High	Low
Kandy Lake	High	Meda Ela	Middle	Low	High
Peradeniya Road-North	Middle	Meda Ela	Middle	Middle	Low
Peradeniya Road-South	Middle	Meda Ela	Low	Low	Low
Hanthana	Middle	Meda Ela	Low	Low	Low
Katugastota	Middle	Mahaweli	Middle	Middle	Middle

Kandy-City Center and Kandy Lake Sub-areas are identified as priority project area. Priority of Hanthana is middle, but the sewerage system exists and only a single sewer main is required to connect the existing system to priority project. Therefore, Hanthana is also identified as priority project area.

13.2 Planing Fundamentals

The priority project area for Kandy includes the city center commercial area, the area around the Kandy Lake containing many hotels, schools, institutional and religious buildings, small hospitals, the Hanthana Housing Scheme, which is presently served by a sewer system, the General Hospital, the railroad station, the central market, the prison and the soccer stadium. Figure 2.1 shows this area and a summary of the important characteristics. Although the trunk sewer from the priority project area continues along William Gopallawa Mawatha to the treatment plant site as described elsewhere above, any additional area back of this major street, along side streets, will not be served. However, the trunk sewer will be sized and designed to receive the additional flows from these areas in the future. Any large-scale developments such as schools fronting the major streets would be served.

Table 13.2 Priority Project Area in Kandy

Planning Value	2005
Area (ha)	271
Population	19,300
Daily Average Sewage Flow (m^3/day)	7,300
Daily Maximum Sewage Flow (m^3/day)	8,500
Hourly Maximum Sewage Flow (m^3/day)	12,200

The priority project area is shown on Figure 13.1.

As stated in Chapter 12, the KMC and the NWSDB proposed a new alternative site at Gannoruwa. The study team conducted the examination at the new site in response to the request of the NWSDB. The results are presented in Chapter 18, and the final decision on the selection of the site should be made under the judgement of concerned authority. In this chapter, examination was conducted for the Bowala site.

13.3 Preliminary Design of Sewerage System

13.3.1 Design Consideration

(1) Topographic Conditions

Proposed pumping station site is located at south of Kandy Lake along Lake Road. The site is now a drain pool with about 15 m squire wide. The elevation is 510.8 m, while Lake Road is 512.2 m. The land shall be filled up to 513 m to avoid gathering of storm water.

Proposed sewerage treatment plant site is in valley area partly cultivated by paddy and located at Bowala along William Gopallawa Road and Meda Ela. The shape of the site is distorted with 100m long and 40 to 130m long, and area of 1.1 ha. The elevation is varied 470m along Meda Ela and 473m at the other side. Considering elevation of William Gopallawa Road, 473.6 to 474 m, and Water level of 25-year re-occurrent flood at Peradeniya Gauge Station, 473.44 m the final ground level at the plant site shall be 474.0m

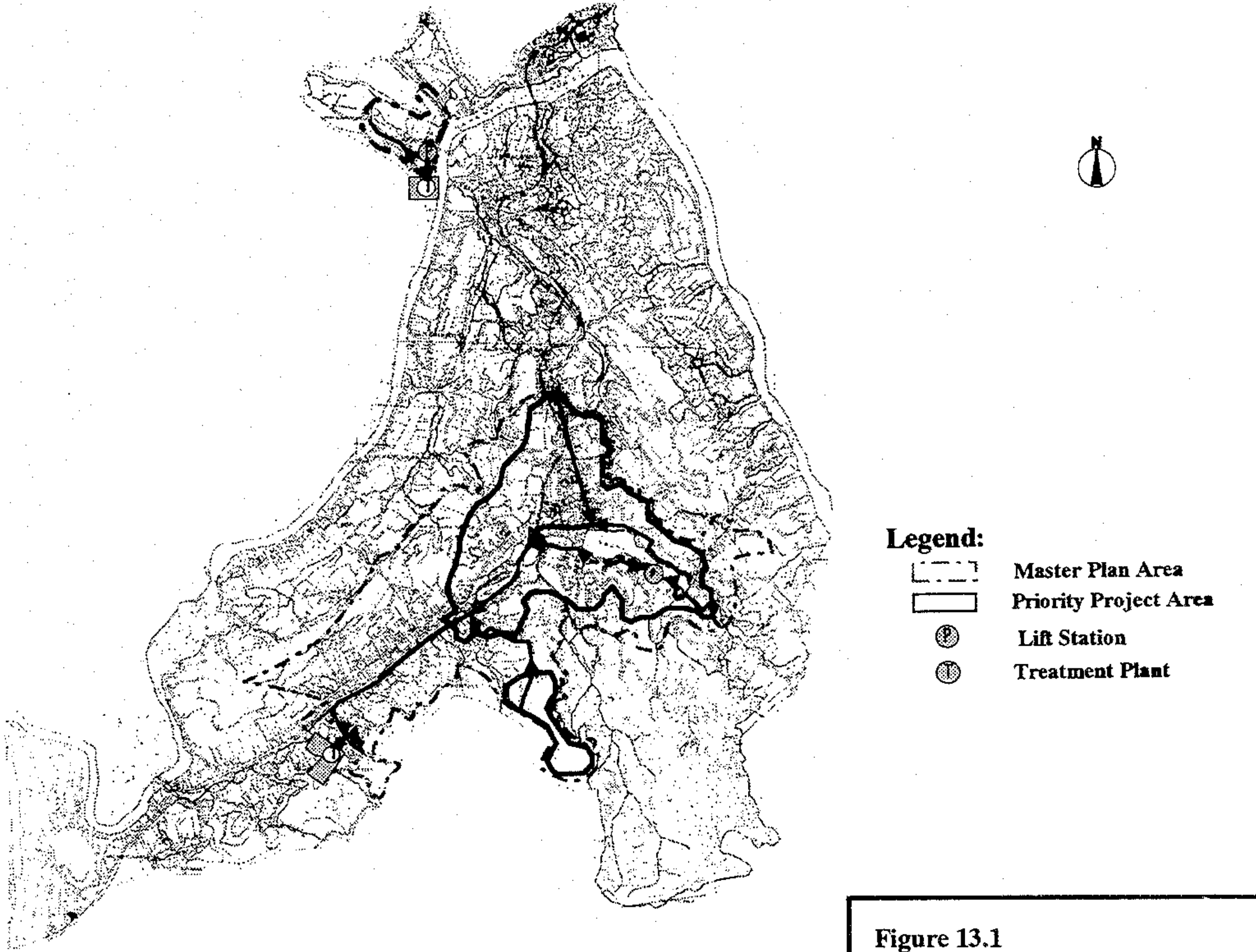


Figure 13.1

Priority Project Area

(2) Geological conditions

The survey result for proposed pumping station site shows a very thick alluvial profile. The horizons consist of soft clays, stiff clays, and clayey sands to a depth of 7.10m. Below 7.10m is a thick bed of loose alluvial gravel. The S.P.T. N-values are variable in the alluvium of clays, sands, and gravel which terminates at a depth of 11.80m.

At 11.80m depth is a boulder of quartzo - Feldspathic Gneiss down to 13.10m depth. Below 13.10m is dense weathered rock disintegrating to dense medium sands. The in-situ bedrock terminates in Fresh Charnockitic Biotite Gneiss rock at depth of 16.20m. The bedrock is dense and continuous with good evaluation for CR% and RQD% (See Borehole Logs).

The overburden horizons are clayey sands, and stiff clays. In the clay horizon very low S.P.T. N-values are recorded (N = 1). Settlements will occur in these clays for shallow seated foundations. The groundwater table is also very shallow at a depth of 0.30m. Therefore deep-seated independent footing is mot practical. Driven R.C. piles can be recommended, which should be driven within the weathered rock zone (N-value>100). The required set will be achieved below 13.50m.

Two boreholes were made in the proposed sewage treatment plant. The western sector indicates near surface alluvial clayey sands, sands, and gravel beds. A boulder of quartzite was encountered from 3.40m to 5.50m depth. The alluvial horizon due to high sand contents is moderately dense in compaction down to the depth of weathered rock at around 5m depth, which is very dense. The dense weathered rock is a thin horizon, followed by bedrock between 6.60m and 7.10m depth, in the two borings. The bedrock is fresh Charnockitic gneiss, which is competent rock as seen from the engineering evaluation.

In the area of a borehole, clay with organic matter is present to a depth of 2.00m, which is not a load bearing material. Therefor foundations can be proposed at a depth of 2.00m, because in both boreholes granular compact material is present down to the level of dense weathered rock. Based on the S.P.T. N-values below 2.00m depth an average N-value in overburden sands and gravel was 26. In the weathered rock profile below, N-value more than 100 have been recorded. Therefor a safe load bearing capacity at a depth of 2.00m will be around 200 kN/m^2. The water tables recorded in the two boring were 0.35m, and

0.70m, and hence dewatering with stuttering will be required for foundations on independent footings.

(3) Reliability of Electricity Supply

The Ceylon Electricity Board (CEB) operates and maintains electricity supply in Sri Lanka. The available electricity supply in Greater Kandy is 400V, 11 kV and 33 kV. In Kandy MC area, 400V with general distribution line and 400V with bulk supply are available. The bulk supply is usually applied for more than 42 kVA demand and is supplied by "Link Supply" which is a more reliable source than the general distribution. There is also 11kV supply for large demand. All power supply connections in Kandy MC area are done by underground cables. 33kV power supply is available only for connections beyond Kandy MC limits such as those supplied by overhead cables. Present electricity supply is not reliable and CEB's records show frequent power failures.

Table 13.3 Current Power Supply Status in KMC

	Low-Tension		High-Tension	
	Frequency (time/month	Total Duration (hour/month	Frequency (time/month)	Total Duration (hour/month
March 1998	158	186	26	62
July 1998	180	170	16	21

Low-tension supply shows comparatively frequent and prolonged power failures than the high-tension supply.

CEB is implementing a project to improve the electricity supply in Kandy MC and the suburb areas, outlined as follows:

Kandy Electricity Distribution Development Project

Financing Agency : World Bank loan and local funds

Project cost : Rs. 700 million

Project Area : Kandy MC and suburbs

Completion of the project

Kandy MC : April 2000

Suburb : End of 2000

Components

Replacement of entire underground cables in KMC

Rehabilitation of overhead cables in KMC

Strengthening of 33 kVA supply

Electrical Engineers of CEB are confident that the electricity supply in Kandy MC will be significantly improved after completion of this project.

Storage capacities of inflow sewers to each pump station are examined during power failure as follows:

Pump Station	Storage Capacity
Kandy Lake	102 min.
Sewage Treatment Plant	21 min.

Detailed calculation is presented in Appendix 13.7.

Kandy Lake Pumping Station has enough storage capacity of inflow sewers, but not the pumping station in STP. Therefore, a generator set for STP is provided to operate pumps. Since treatment facilities will not be damaged by short power failure, any generator will not be provided for operating treatment facilities. .

13.3.2 Sewage Collection System

(1) Sewage collection method

Separate system

(2) Piping Materials

Diameter of 100 mm : PVC - Type 600 (service connection)

Diameter of 150 to 600mm : Vitrified Clay Pipe

Diameter of more than 600mm : Reinforced Concrete Pipe with Anti-corrosion Coating

(3) Sewer pipe construction method

1) General conditions for sewer pipe installation

Excavation for the proposed sewer facilities extends from the ground surface to a depth of approximately 2 to 4 m below.

2) Principle of construction method for large sewer pipe at deep position

The following comparison table shows the principal construction method, which is applied for large and deep sewer pipe. Among the construction methods, open cut

method likewise pipe jacking method, shall be the most suitable method for the target sewer pipes. Additionally, the open cut with temporally embankment or sheet piles for encasement at halfway in the river may be utilized for river crossing point.
In this connection, it is very important that the construction method must be studied more deeply in the detailed design, taking into account the soil conditions, groundwater levels, traffic condition and riverbed conditions in order to select the most suitable construction method for a smooth and economical construction.

Table 13.4 Comparison of the Sewer Pipe Construction Method

Construction Method	Typical Features
Open Cut Method	1) This is the most popular and economical method, but protection work is needed for safeguard of works. 2) Waterproof is not always perfect, but this method can keep the continuous work against the earth pressure.
Pipe Jacking Method	1) This method is suitable for the self-support soil and the excavation is performed by manpower or mechanical equipment. 2) Excavated soil is transported to where it can be raised to the surface by a muck car or automatically using conveyor belts..
Earth Pressure Type Shield Method	1) The face is held by excavated material filled in the chamber. 2) Excavated material is removed by screw conveyer and then transported outside by a muck car.

(4) Summary of Sewer System

The diameters and lengths of the sewer system to be constructed are summarized in the following tables. The detailed data is shown in Appendices 13.1 and 13.2.

Table 13.5 Summary of Sewer Plan

Item	Diameter (mm)	Length (m)
Clay Pipe – Lateral	150	4,500
Clay Pipe – Sewer Main	150 to 600	13,940
Concrete Pipe	675 to 825	2,870
DI Pipe	100	650
Service Connection	units	5,800

Table 13.6 Summary of Special Sewer

Item	Sewer No.	Diameter (mm)	Length (m)	Location
Railway Crossing	42	300	20	Near the Police Office (Open Cut)
	48	675	20	Near the Kandy Station (Open Cut)
	50	675	-	Near the Playground closed to the Kandy Station (in Meda Ela Culvert)
Road Crossing	30	675	30	Near the Underground Passage (Jacking)
River Crossing (Inverted Siphon)	48-1	450×2	20	Near the Kandy Station (Meda Ela)
	52-1	450×2	20	About 700m south-west from the Kandy Station (Meda Ela)

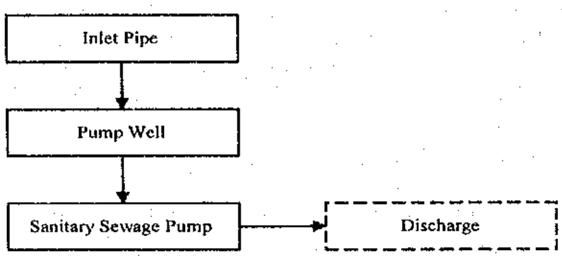
13.3.3 Pumping Station

(1) Type of Pumping Station

Rectangular or Circular Manhole Type Pumping Station

a. Design Flow: Less than 3.0 m^3/min

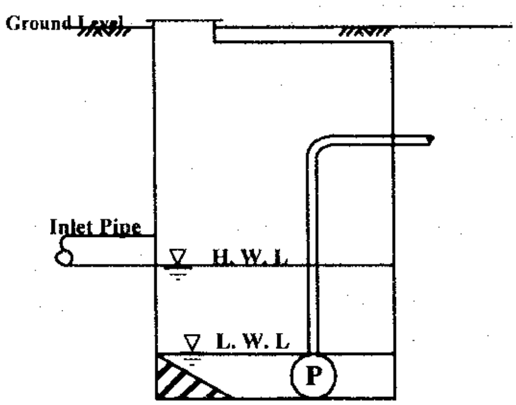
b. Standard Flow



c. Condition

The pumps are installed inside a manhole.

d. Schematic Diagram



(2) Design sewage flow

Design hourly maximum sewage flow is used for designing the pumping station.

(3) Pump type

The submersible pump should be used for the pump.

(4) Number of pumps

More than two pumps should be installed including the standby pump.

(5) Pump size

The suction diameter of the pump is given by the following equation:

$$D = 146\sqrt{\frac{Q}{V}}$$

where, D : suction diameter (mm)

Q : discharge quantity (m^3 / min)

V : velocity at sunction (m/ sec)

V value is in the range of 1.5 to 3.0 m/sec.

The minimum suction diameter of the pump is 80 mm considering the operation and maintenance.

(6) Total pump head

The total pump head is calculated by the following equation:

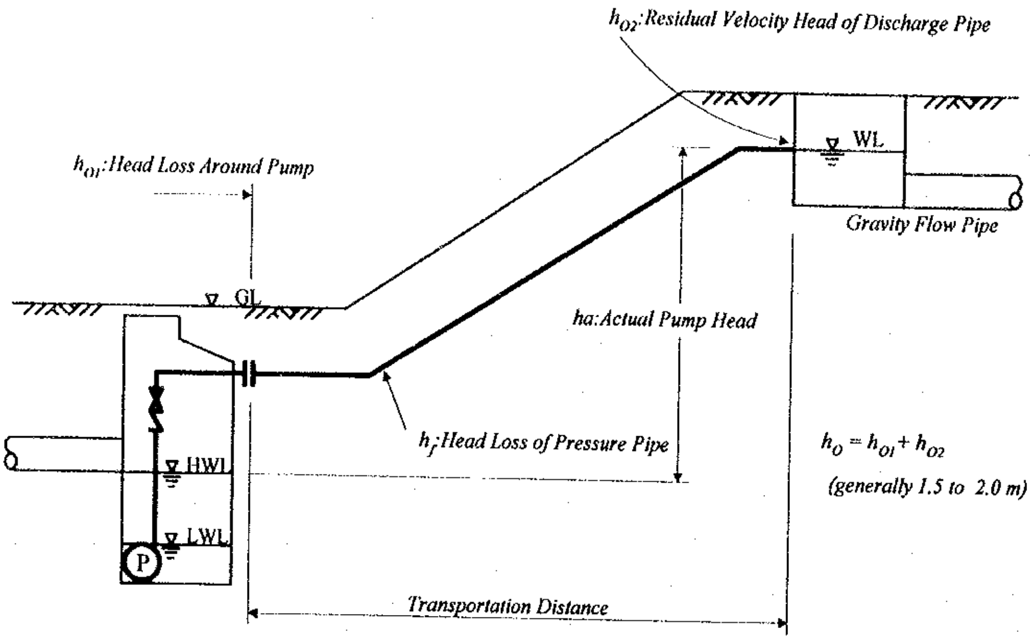
$$H = h_a + h_f + h_o$$

where, H : total pump head

h_a : actual pump head

h_f : head loss of pressure pipe

h_o : residual velocity head of discharge pipe and head loss around pump



(7) Shaft power

The shaft power of a pump is calculated by the following equation:

$$L = \frac{k \cdot \gamma \cdot Q \cdot H}{\eta}$$

where, L : shaft power of pump (kw or PS)

k : constant (0.163 for kw and 0.222 for PS)

Q : discharge quantity (m^3 / min)

H : total head of pump (m)

γ : bulk density of wastewater ($\gamma = 1$)

η : efficiency of pump

(8) Summary of Pumping Station Plan

The tentative requirement and specifications are summarized in the following tables. The detailed data is presented in Appendices 13.3.

Table 13.7 Summary of Pumping Station Plan

Location	Specification
Kandy Lake	Submersible Pump, 0.42 m^3/min, 27 m, 7.5 kW, 2 sets
Kandy STP	Submersible Pump, 8.2 m^3/min, 14 m, 37 kW, 2 sets Submersible Pump, 4.1 m^3/min, 14 m, 18.5 kW, 2 sets

Considering the results of topographical survey, these specifications will be finalized.

13.3.4 Sewage Treatment System

The preliminary design for the sewage treatment plant was prepared with the following capacity. Details of the sewage treatment plant are presented in Appendices 13.4 and 13.5. In this study, the plant is designed the capacity of 8,500 m^3/day at this phase, considering the final capacity of 17,000 m^3/day.

Location	Treatment Method	2005	2015
Kandy	Oxidation Ditch	8,500 m^3/day	17,000 m^3/day

(1) Layout

Since the area for the treatment plant is small and secluded by the main road and hills, the entire land can not be fully utilized. The layout of the sewage treatment plant will be designed with careful examination on the results of topographical and soil investigations.

(2) Specifications of Facilities

Specifications of the sewage treatment plant with numbers, dimensions and design parameters for each facility are given in Table 13.8. The detailed data is presented in Appendices 13.4 and 13.5.

Table 13.8 Specifications of Sewage Treatment Plant

1. Kandy

Facilities	Specifications
1. Grit Chamber and Screen	
Type	Grit Pit Type
Dimension	1.0 m W x 1.5 m L x 0.5 m D
Average Velocity	0.16 m/sec
Number of Basin	1 basin
2. Oxidation Ditch	
Type	Oval-shape Type
Dimension	6.0 m W x 190 m L x 3.0 m D
Aeration Power Level	90 kW
Retention Time	29.0 hours
Number of Basin	3 basins
3. Sedimentation Basin	
Type	Circular Type
Dimension	16.0 m Dia. x 3.0 m D
Water Surface Load	14.1 m3/m2/day
Retention Time	3.4 hours
Number of Basin	3 basins

4. Disinfection Tank	
Type	Rectangular Type
Dimension	1.5 m W x 40.0 m L x 1.5 m D
Required Chlorine	1.42 kg/hour
Retention Time	15.2 min.
Number of Basin	1 basin
5. Sludge Thickening Tank	
Type	Circular Type
Dimension	5.0 m Dia. x 4.0 m D
Solid Load	65 kg/m^2/day
Number of Basin	2 basins
6. Aerobic Sludge Digestion Tank	
Type	Circular Type
Dimension	13.0 m Dia. x 4.0 m D
Solid Load	2.4 kg/m^3/day
Number of Basin	1 basins

2. Gohagoda

Facilities	Specifications
1. Sludge Drying Bed	
Type	Rectangular Type
Dimension	6.0 m W x 14.5 m L x 0.3 m D
Retention Time	10.2 days
Number of Basin	10 basins

13.4 Project Cost

Total cost of the proposed project is estimated in Sri Lankan Rs. as follows:

Table 13.9 Project Cost of Priority Project

Unit: Thousand Sri Lankan Rs.

(1) Construction cost		
1) Collection System		463,191
Trunk/MainSewer		
Sewer Lateral		
2) Pumping Station		20,178
Civil Work	8,129	
Mechanical/Electrical Work	12,049	
3) Sewage Treatment Plant		510,953
Civil Work	190,707	
Mechanical/Electrical Work	320,246	
4) Administration cost		50,678
Sub-Total		**1,045,000**
(2) Procurement of maintenance equipment		**25,000**
(3) Engineering cost		
1) Detailed design	78,000	
2) Construction supervision	45,000	
Sub-Total		**82,000**

(4) Common expenses		
1) General and administration expenses	10,000	
2) Land acquisition	160,000	
Sub-Total		**170,000**
(5) Contingency		**198,000**
(6) GST (12.5%)		**190,000**
Total		**1,710,000**

Note: Exchange rate: SL Rs. 1.00 = Japanese Yen 1.80 (as of November, 1998)

Detail Cost is shown in Appendix 12.5 to 12.7.

13.5 Implementation Program

13.5.1 Implementation Schedule

In connection with the target years of this Study (2005 and 2015), Phase 1 is an urgent and priority project which is expected to be completed by the end of 2003, while the overall project, Phase 2, will be completed by the end of 2013.

Phase 1	(1999 to 2003)	- Priority Project
	1999 -2001	Preparation of project
	2001 - 02	Detailed design and bidding
	2002	Commencement of construction
	2002 - 03	Construction
	2004	Commencement of operation

The project implementation and disbursement schedule with estimated annual disbursements of project cost is presented in Table 13.10. The required project activities are described below:

13.5.2 Activities in Project Implementation

(1) Preparation of Project

Preparatory work for project implementation includes:

- Budgetary arrangements within the Sri Lankan Government for land acquisition and institutional development,
- Negotiation of grant/loan with foreign lending institution/s, and
- Selection of consultants in accordance with the agreement executed between the foreign lending institution and the executing agency of the Sri Lankan Government

Table 13.10 Project Implementation and Disbursement Schedule of Priority Project

Item \ Phase / Year		Phase 1 1999	Phase 1 2000	Phase 1 2001	Phase 1 2002	Phase 1 2003
Implementation Schedule						
1. Preparation of Project						
2. Pre-Construction Stage						
2.1 Detailed Design						
2.2 Bidding						
3. Construction						
3.1 Collection System						
- Trunk Mains						
- Sewer Laterals						
3.2 Sewage Treatment Plant						
- Civil Work						
- Mechanical/Electrical Work						
4. Procurement of Equipment						
Disbursement Schedule	**Total Cost (Million SL Rs)**	Phase 1	1710.0			
1. Land Acquisition	160.0			160.0		
2. Administration	10.0			2.0	4.0	4.0
3. Construction Work	1,045.0				345.0	700.0
4. Procurement of Equipment	25.0					25.0
5. Engineering Service	82.0			45.0	15.0	22.0
6. Contingency	198.0			31.0	54.0	113.0
7. GST (12.5 %)	190.0			30.0	53.0	107.0
Total of Annual Disbursement	1,710.0			268.0	471.0	971.0

This preparatory work shall be commenced by the middle of 1999 and completed by the middle of 2001.

It should be noted that the institutional development of the executing agency and staffing as required for project implementation are prerequisite not only to ensure the successful achievement of the project objectives, but also to secure the firm commitment of financial assistance from the foreign lending institution/s. Appraisal missions by the institution will focus on the preparedness and maturity of the proposed project as well as the implementing capability of the executing agency both financially and institutionally.

(2) Pre-construction stage

The consultants hired by the executing agency will undertake the majority of project activities. Those activities to be carried out by the consultants include, but are not limited to, detailed field investigations, detailed engineering design, and preparation of tender documents for bidding. These activities will be carried out in the year 2001 and 2002.

After preparation of the tender documents, bidding for construction of the proposed project will be executed by the middle of 2002.

In parallel to the above project activities, the Sri Lankan executing agency shall, in accordance with the detailed design, negotiate with respective landowners and acquire the required land for construction. Other important subjects, such as a tariff system for sewerage service for the cost recovery, shall be carried out by the executing agency as recommended elsewhere in this Study.

(3) Construction

The major scope of construction work is as follows:

1) Collection System
   - Trunk mains
   - Sewers
   - Sewer Laterals
2) Sewage treatment plant
   - Civil work
   - Mechanical/electrical work

Construction periods for the major works are estimated in months as follows:

1) Collection System

- Mobilization	1.0
- Trunk mains	15.0
- Sewer laterals	12.0

2) Sewage treatment plant

- Mobilization	2.0
- Civil work	9.0
- Mechanical/electrical work	6.0
- Trial Operation	1.0
- Training	2.0

3) Total 20 months

(4) Procurement of maintenance equipment

Preparation of specifications and bid documents for maintenance equipment, such as jet-cleaners, vacuum trucks, dump trucks, etc. will be prepared by the consultant during the detailed design of the sewerage facilities and procured within the year 2003 by international bidding.

Table 13.11 Construction Schedule of Priority Project