PART III SEWAGE AND SANITATION

CHAPTER 10 CURRENT SANITATION SYSTEM IN THE STUDY AREA

CHAPTER 10 CURRENT SANITATION SYSTEM IN THE STUDY AREA

Sewage is discharged, on-site, throughout Nuwara Eliya area (total population of 34,300) 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.

Wastewater collection, treatment, and disposal in Nuwara Eliya are similar to that experienced in Kandy. On-site disposal is practiced using septic tanks with or without soakage pits, pit latrines or temporary latrines as reported in the Nuwara Eliya Environmental Study of 1996. Of the estimated population of 34,300, some 63 percent use water sealed toilets and 24 percent use pit latrines. There are eight public toilets in the NEMC.

The General Hospital and the Ceylon Brewery both discharge without proper treatment, although treatment plants are provided, to adjacent streams which flow to the Barrack Plains Reservoir. The hospital plant originally consisted of a sedimentation tank and a disinfection basin with effluent discharged to a soakage pit. Presently, discharge from the hospital contains both sewage and biohazardous materials, which seriously jeopardizes the public health of the community.

The brewery has constructed a new treatment plant but it is still under testing, due to improper removal of color. The facility consists of coagulation, sedimentation, aeration and secondary sedimentation, as well as sludge drying. At the time of our visit, untreated wastewater was discharged from several pipelines.

Existing facilities include, besides the hospital and the brewery facilities, a treatment plant located at the Inter Fashion textile factory to treat wash water from its operations. The plant consists of coagulation, sedimentation and slow sand filtration. It appeared to be operated correctly and is treating wastewater from the factory satisfactorily. Sewage from the employees is discharged to septic tanks. Also some major hotels have their own secondary treatment system.

Contamination is high in both of the two catchment areas of Nuwara Eliya. The Nanu Oya, which runs through the downtown area and enters Lake Gregory, is used primarily for sewage collection and irrigation of home gardens. Lake Gregory is experiencing problems of eutrophication and siltation which causes significant growth of water plants. Although fishing was a major activity, Lake Gregory can no longer support fish in its waters. The Barrack Plains Reservoir is worse and is now no more than a mosquito breeding swamp fully covered with water plants.

(1) Hotel Treatment Plants

Some major hotels in Nuwara Eliya, such as Grand Hotel etc have their own sewage treatment plants to meet requirements for higher ranked hotels. These plants are in operation, but some of them were not properly designed.

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

Table 10.1 Water Quality of Sewage Treatment Plant in Hotel

	Influent			Effluent		
	BOD_5 (mg/l)	SS (mg/l)	Total Coliform	BOD_5 (mg/l)	SS (mg/l)	Total Coliform
March 1998	91	136	> 10000	45	239	> 10000
August 1998	115	23	87×10^2	72	20	6×10^2
Average	103	80	-	59	130	-

The effluent qualities of BOD and SS are the Central Environment Agency's standards (BOD_5: 30 mg/l, SS: 50 mg/l). The plan is improperly designed and the operation/maintenance suffers from inexperienced operators.

(2) Brewery

The brewery is the largest industry in Nuwara Eliya, and discharges large amounts of wastewater everyday. A new wastewater treatment plant was recently constructed and it is being commissioned. However, only some parts of the production lines discharge to the new treatment plant and others discharge to an adjacent stream.

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

Table 10.2 Water Quality of Brewery Effluent

	Effluent from Treatment Plant			Drain		
	BOD_5 (mg/l)	SS (mg/l)	Total Coliform	BOD_5 (mg/l)	SS (mg/l)	Total Coliform
March 1998	314	367	> 10000	298	374	> 10000
August 1998	259	2096	16×10^3	52	1289	22×10^2
Average	287	1232	-	175	832	-

The effluent qualities of BOD and SS are substantially higher than the Central Environment Agency's standards. It is recommended that the wastewater treatment plant be operated in a proper manner as soon as possible and that all drain lines are connected to the plant.

(3) Sanitation Facilities

All areas in the NEMC, except the above mentioned areas, have on-site treatment facilities, mainly septic tanks and soakage pits, in lieu of central sewerage collection and treatment systems.

Water quality surveys on septic tanks effluent were conducted and the result are as follows:

Table10.3 Water Quality of Septic Tank Effluent

Domestic Septic Tank

Housing Type	March 1998		August 1998	
	BOD_5 (mg/l)	SS (mg/l)	BOD_5 (mg/l)	SS (mg/l)
High Income House *	-	-	-	-
Middle Income House *	-	-	132	197
Low Income House *	-	-	130	182
Average	-	-	131	190

Non-Domestic Septic Tank

n-domestic Type	March 1998		August 1998	
	BOD_5 (mg/l)	SS (mg/l)	BOD_5 (mg/l)	SS (mg/l)
Office	-	-	218	102
Hotel - A	236	207	135	340

The analyses show high concentration of SS, which is due to excessive septage or sludge overflowing.

The sludge generated from septic tanks and hotels and factories are collected by a gully sucker, which is operated by the Municipal Council. The NEMC has one gully sucker with a capacity of 7.0 m^3. The gully sucker is shown in the following table:

Table 10.4 Operation of Gully Suckers

	Nuwara Eliya
No. of Gully sucker	1
Average monthly operations	7.0 times (Sep. 97 to Aug 98)
Sludge volume (m^3)	49 m^3/month

At present, sludge collected in Nuwara Eliya is disposed in pits located at the remote forest.

Septic tank sludge should be removed about every year. A system for regular collection of sludge should be implemented in both areas under consideration. With the introduction of the new facilities, the volume of sludge will increase and the present disposal sites will not be adequate to accommodate increased volumes 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.

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

The NEMC has no on-going or planned sewerage or sanitation projects other than on-site systems for disposal of sewage such as septic tanks for schools or government buildings.

In 1995, the ADB financed the Urban Development Sector Project in which the storm drainage system of Nuwara Eliya was improved and is now reported to be acceptable. However, urbanization and development of vegetable fields in the catchment area will require additional improvements in the future to control flooding in the town center.

CHAPTER 11 PLANNING FUNDAMENTALS FOR SEWERAGE SYTEM

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 the Nuwara Eliya Municipality. The Master Plan is to be developed for the target year of 2015 and is to include the most densely populated and commercial areas. The policy for sanitation/sewerage service also includes:

a. In areas of low density, continue the 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, collect wastewater by a sewerage system and provide adequate low cost treatment and disinfection and provide for the safe disposal of effluent and sludge.
c. To combine sewerage systems with adjacent population centers where practical, to reduce capital and operation and maintenance costs.
d. To improve the environment for one of the major industries in the area - Tourism.
e. 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, and policies and the following aspects:

- Large-scale commercial areas,
- High population density,
- Large-scale facilities, such as hospitals, brewery, schools, hotels, housing schemes, religious and institutional, both existing and proposed,
- Conservation of the natural environment (tourist spots etc.), and
- Topography

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 the existing septic tanks and the additional flow from the additional residents or fixtures disturbs the treatment capability of the facilities. In commercial areas, some high-rise buildings also exist and sewage from these buildings is not treated and disposed of within the site the property limits.

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, either each house has only a small backyard or frontyard where septic tanks and soakage pits exist, or, high-rise residential buildings are constructed where sewage can not be safely disposed within the property limits.

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

3) Large-scale facilities

Nuwara Eliya Municipality is one of the most well known cities in Sri Lanka, and the administrative, commercial and cultural center of the area. Some 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

Nuwara Eliya is also renowned as a premier tourist spot in the country, especially for the climate, golf courses, old British hotels, Victoria park, Lake Gregory, all of which are located near the city center. Conservation of the natural environment of the streams, lake and the surrounding areas are key to further development of the tourist industry in this region.

5) Topography

An important aspect in the development of any sewerage system is the topography of the area. Sewer systems rely on gravity to move the waste to a treatment facility. The logical location for the sewer is along the Nanu Oya. However, it is necessary to locate sewers in the nearby streets to service the properties along the streets and to avoid acquisition of lands to construct and maintain the sewer mains. These streets have both high and low places and require the use of pumps to lift sewage to the downstream gravity sewer.

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

a. 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.

b. 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.

c. 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.

d. Different states of urbanization by area
Although the Nuwara Eliya 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 to provide investment at different magnitudes in different fields of activity and at different locations.

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

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

This master plan has introduced categorization of target areas, namely;

- A core area for sewerage service,
- Transitional areas from on-site treatment to sewerage service, and
- On-site treatment areas.

11.1.3 Selection of Sewerage Service Areas in Nuwara Eliya

(1) Selection of Sewerage Service Area

1) Nanu Oya Catchment Area

The area is covers most of Nuwara Eliya Municipality and is surrounded by hills to heights of more than 1,900 m, including the city center, Lake Gregory etc. Nanu Oya originating in Bambarakele flows through the center.

Nuwara Eliya – City Center

2) Barrack Plain Catchment Area

This area is located to the northeast of the municipality where a hospital, a brewery and factories are located.

Nuwara Eliya – Barrack Plain

Among the above, two areas Nanu Oya catchment is considered important because it covers the most of municipality area and Lake Gregory. The Barrack Plain Catchment is also important due to the hospital and industries.

Taking the above selection criteria into consideration, the sewerage service area in Nuwara Eliya has been studied and the following table shows the need for a sewerage system in each study area.

Table 11.1 Selection of Sewerage Service Areas in Nuwara Eliya

Municipality / Town	Sewerage Necessity	Commercial Area	Density of Population	Sewage Flow	Tourist
- City Center	Yes	Middle	High	Middle	Large
- Hospital/Brewery	Yes	Middle	Middle	Large	Middle
- Other Areas	No	Small	Low	Small	Large

The service area for Nuwara Eliya is located around the city center commercial area, a portion of Lake Gregory and surrounding area, including the hotels, the Base hospital and the brewery. The service area covers some 314 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 were also considered taking into account the 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. As on-site treatment facilities cost approximately Rs 50,000, and sewer lateral installation per meter costs about Rs 5,250, the cost to provide a sewerage system to houses located more than 10 m away from the sewer network is more expensive than the construction cost of on-site treatment facilities. Therefore, residential areas removed from the core service area will continue with on-site treatment facilities.

2) Housing estates with sewer systems

For 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

Large-scale facilities, which discharge large amount of sewage, shall also be connected to sewer networks if within a reasonable distance. This is to avoid water-pollution and duplicate 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 Nuwara Eliya Municipality has been estimated. Population in the sewerage service area has been determined according to the criteria developed in a previous section. The population data are shown in Table 11.2.

Table 11.2 Population in Sewerage Service Area

ID GN	Name	Area(ha)	Population					
			1997	1998	2000	2005	2010	2015
No. 535	Nuwara Eliya	38.7	310	318	336	376	412	446
No. 535B	Kalukele	46.1	738	758	799	893	979	1,060
No. 535D	N'Eliya Central	78.4	2,117	2,174	2,293	2,563	2,809	3,041
No. 535F	Hewa Eliya West	49.0	980	1,006	1,062	1,187	1,301	1,408
No. 535I	Hewa Eliya East	31.1	622	639	674	753	825	893
No. 535L	N'Eliya East	70.9	1,276	1,310	1,382	1,545	1,693	1,833
Total		314.2	6,043	6,205	6,546	7,317	8,019	8,681

The service area is summarized as follows:

Table 11.3 Summary of Sewerage Service Area

	Area (ha)		Population	
Municipality	1,501	100 %	49,200	100 %
Service Area	314	21 %	8,680	17 %

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 for Nuwara Eliya is estimated as follows:

Table 11.4 Per Capita Water Consumption

Service	Present (1997)	2005	2015
Domestic	107 lpcd	107 lpcd	107 lpcd
Non-Domestic	44 lpcd	44 lpcd	44 lpcd

(2) Results of field survey

There is no sewerage system, and no data are available for reference in Nuwara Eliya.

(3) Design Per Capita Sewage Flow

In order to obtain design per capita sewage flow, an assumption that 80 percent 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, hospitals, hotels, offices etc. and by industries.

Because most commercial facilities are located in the downtown area of the municipality, it has been assumed that excluding industrial use, 80 percent of the non-domestic water is consumed in the sewerage service area in 2015 and 60 percent in 2005. A 100 percent of industrial wastewater is discharged at the area where the brewery and the garment factory are located.

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

Therefore, the daily average per capita sewage flow in the service area has been estimated as follows:

Table 11.5 Per Capita Sewage Flow

Flow	Present (1997)	2005	2015
Domestic	74 lpcd	74 lpcd	74 lpcd
Non-Domestic	36 lpcd	39 lpcd	51 lpcd
Infiltration	20 lpcd	20 lpcd	23 lpcd
Total	130 lpcd	133 lpcd	148 lpcd

(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.

The Maximum Daily / Average Daily ratio of 1.2 was applied because the same figure is used for water supply planning. As for Hourly Maximum / Average Daily, Babbit's M-Curve is often applied. In this study, sewage flow was measured at Hanthana Housing Scheme in Kandy and peak factors were obtained. Using actual peak factors, Babbit's M-Curve was modified.

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

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

Using this formula, a peak factor of 2.0 was established for this study. The peak factor of 2.0 was used for sewerage system where the served population is up to 20,000, and 1.8 was used for up to 100,000.

Therefore, the peak factors of Maximum Daily / Average Daily and Hourly Maximum / Average Daily for Nuwara Eliya Sewerage System are:

Maximum Daily / Average Daily: 1.2

Hourly Maximum / Average Daily: 2.0

The detailed data on the peak factor is shown in Appendix 11.2

Table 11.6 Design Sewage Flow

Planning Value	2005	2015
Area (ha)	314	314
Population	7,317	8,680
Average Daily Sewage Flow (m^3/day)	2,000	2,300
Maximum Daily Sewage Flow (m^3/day)	2,300	2,800
Hourly Maximum Sewage Flow (m^3/day)	3,800	4,500

The daily and hourly maximum flow shown above do not include infiltration, which is considered constant.

11.4 Design Sewage Quality

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

Two methods are commonly used to determine BOD of sewage. The first method is the estimation of BOD by use of the unit BOD pollution excreta load per capita per day and the unit water consumption. The second method is, of course, 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 carried out during the course of fieldwork for this Study. The results of this analysis are used to establish the proposed sewage quality.

(1) Examination of sewage quality

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

There are several reports on the study of unit BOD pollution load for domestic sewage based upon field investigation. Some 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	Gray Water	Total
BOD_5	18	39	57
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	Gray Water	Total
BOD_5	23	55	78

3) Tropical countries

Unit: g/capita/day

Water Quality Parameter	Nightsoil	Gray Water	Total
BOD_5	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 above, there are wide ranges of the unit BOD pollution load, reflecting differences in the standard of living life style, etc. In this study, 38 g/capita/day for tropical countries is used in the estimation of BOD_5 taking account living standard of the residence.

Using 38 g/capita/day as the unit BOD pollution load, the BOD for domestic sewage is calculated as follows:

- BOD_5 load: 38 g/capita/day
- Water consumption: 94 l/capita/day

- BOD_5 = (38 g-BOD_5/capita/day) / (94 l/capita/day) = 404 mg/l

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

- BOD_5 202 mg/l

The value of 94 1/capita/day is used instead of the 107 1/capita/day (previously reported) because about 12 percent of the water is used in irrigation of home gardens.

(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 two different housing types, namely middle-income and low-income houses where systems were available for sampling. The results of the sewage quality survey for domestic sewage are shown in Table 11.7.

Table 11.7 Domestic Sewage Quality

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 *	-	-	-	-
Middle Income House *	320	1059	227	200
Low Income House *	258	470	127	66
Average	289	765	177	133

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 *	-	-	-	-
Middle Income House *	-	-	132	197
Low Income House *	-	-	130	182
Average	-	-	131	190

2) Non-domestic sewage

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

Table 11.8 Non-Domestic Sewage Quality

Combined Sewage (Grey Water + Black Water)

Non-domestic Type	March 1998		August 1998	
	BOD_5 (mg/l)	SS (mg/l)	BOD_5 (mg/l)	SS (mg/l)
Hospital	-	-	15	127
Hotel	91	136	115	23
Brewery - Drain	298	374	52	1289
Brewery - Effluent	314	367	259	2096
Tea Factory	-	-	60	37
Garment	-	-	100	427

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

Non-domestic Type	March 1998		August 1998	
	BOD_5 (mg/l)	SS (mg/l)	BOD_5 (mg/l)	SS (mg/l)
Office	12	142	70	70
Hotel - A	30	450	103	83
Hotel - B	-	-	75	148
Local Restaurant	-	-	325	336

Septic Tank Sewage (Black Water - Toilet)

Non-domestic Type	March 1998		August 1998	
	BOD_5 (mg/l)	SS (mg/l)	BOD_5 (mg/l)	SS (mg/l)
Office	-	-	218	102
Hotel - A	236	207	135	340

(3) Planned sewage quality

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

a. Domestic sewage (642 m^3/day)

BOD_5 404 mg/l

b. Non-domestic sewage (1,496 m^3/day)

BOD_5 202 mg/l

c. Ground water Infiltration (200 m^3/day)

BOD_5 0 mg/l

d. Mixed sewage

BOD_5 = [(404 x 642) + (202 x 1,496)] / 2,358 = 240 mg/l

Therefore, BOD_5 of 240 mg/l and SS of 250 mg/l was applied in this 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 Dhaka 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 Nuwara Eliya

Planning Value	2005	2015
Area (ha)	314	314
Population	7,317	8,680
Average Daily Sewage Flow (m^3/day)	2,000	2,300
Maximum Daily Sewage Flow (m^3/day)	2,300	2,800
Hourly Maximum Sewage Flow (m^3/day)	3,800	4,500
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 used for calculation of flow velocity throughout the world, and is 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 achieved for each pipe diameter in order to obtain the self-cleansing velocity at full flow. The minimum velocity to be used in this study is 0.6 m/sec for separate sanitary sewer systems and 0.75 m/sec for the rest of the system except whereby use of a lower velocity a pump station can be avoided.

2) Maximum velocity

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

(3) Sewer capacity

The capacity of the pipelines was calculated using the full section of pipe for combined sewer and stormwater system.

For separate sanitary sewer systems, sewer capacity is selected on the following basis:

Diameter of 600mm or less	: Capacity exceeds the estimated flow by at least 200%
Diameter of more than 600mm	: Capacity exceeds the estimated flow by at least 150%

(4) Pipe Materials

Pipe materials are selected considering corrosion, local availability etc.

Diameter of 100 mm	: PVC - Type 600 (service connection)
Diameter of 150 to 600mm	: Vitrified Clay Pipe
Diameter of more than 600mm	: Concrete Pipe with corrosion-resistant lining
Force mains	: Coating is on the outside of pipe Lining is on the inside of pipe

12.2.2 Sewage Treatment Plant

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

(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.

Daily Average Flow		2,300 m^3/day
Daily Maximum Flow		2,800 m^3/day
Hourly Maximum Flow		190 m^3/hour (= 4,500 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 (Daily maximum sewage flow)

Phase 1 (in 2005)	1,400 m^3/day (700 x 2 trains)
Phase 2 (in 2015)	1,400 m^3/day (700 x 2 trains)
Total	2,800 m^3/day (700 x 4 trains)

12.3 Selection of Optimum Systems

12.3.1 Sewage Collection System

The planning 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 considered for Nuwara Eliya 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 in that it 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 completion of a sewage system. However, in this case, 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 pipe and is sent to a sewage treatment facility. In some tropical countries, black water is pre-treated by a septic tank system and gray water is discharged into storm drain channels which is finally discharged into receiving water bodies nearby without treatment.

Since the flow in stormwater drain channels during dry weather is occupied by gray 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 solid, which accumulates in these tanks, is 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 effected

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

Table 12.3 Comparison of Collection Systems

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

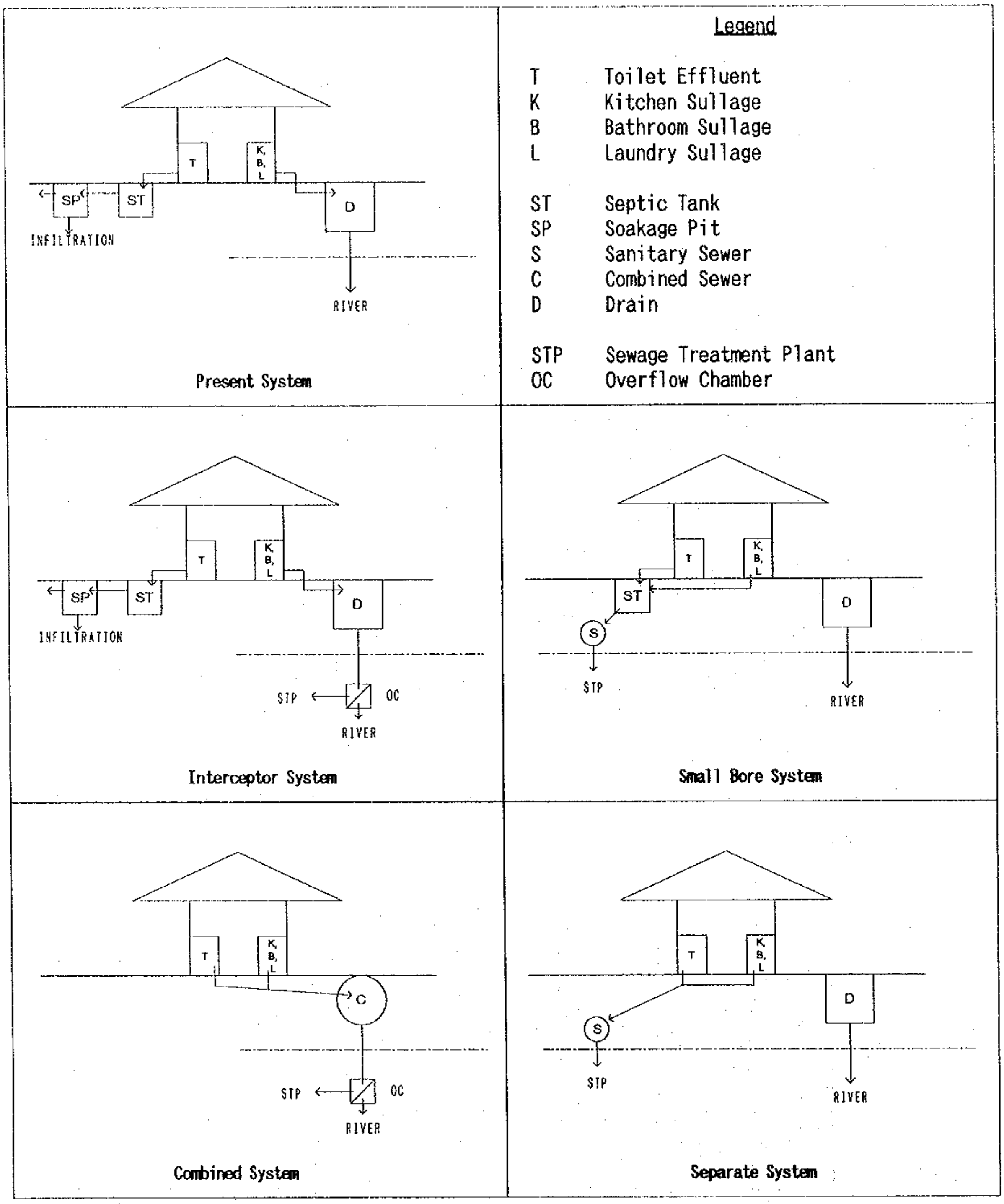


Figure 12.1 Collection/Drainage System Schematics

In the city center of Nuwara Eliya, an existing open drain system is available. In the remaining areas, only limited stormwater channels are available with major flows carried in natural streams. In new combined systems, new underground drainage piping and pumping stations should be constructed with three times more capacity than those in a separate system to accommodate stormwater.

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

A separate system is recommended as the optimum sewage collection system.

12.3.2 Sewage Treatment System

The number of existing sewerage systems in Sri Lanka is minimal and a few of them have only small sewage treatment plants. It is necessary when designing sewerage systems to take into account the technical ability of the personnel who will operate and maintain these sewerage systems as well as 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 because of lack of knowledge and experience of the operating personnel, lack of spare parts and budgetary constraints.

Design of sewage treatment plants must consider reliability, sustainability and operability, not only from the viewpoint of technical design and manpower capability, but also from the viewpoint of least cost for construction, operation and maintenance.

(1) Preliminary Selection of Sewage Treatment Method

There are many well-developed 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 applied in this study to select the most appropriate treatment method:

1) Reliability
2) Area requirement
3) Power Consumption
4) Construction cost
5) Operation & maintenance cost
6) Difficulty of operation & maintenance
7) Environment

(3) Design Calculation

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

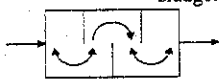
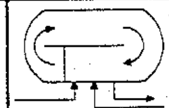
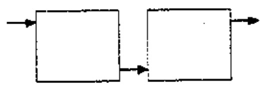
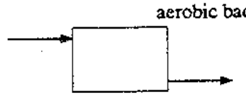
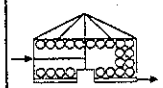
(4) Selection of Treatment System

1) Reliability of treatment

The oxidation ditch and the aerated lagoon systems can accept greater fluctuations in sewage flow and quality than stabilization ponds and the trickling filters.

Aerated lagoons, equipped only with aerators, have less mechanical/electrical equipment than oxidation ditches and the trickling filters that include sludge collectors and pumps. When equipment or power fails, sewage treatment will be affected in methods using more mechanical equipment.

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	P.S.T. → R.T. → F.S.T. → ; Sludge Treatment facility	Sewage flows down together with activated sludge 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	R.T. → F.S.T. → ; Sludge Treatment facility	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	R.T. → F.S.T. → ; Sludge Treatment facility	 Sewage is circulated together with activated sludge and contained organic substance is absorbed and assimilated by activated sludge.	ditto
Stabilization Pond	R.T.(1) → R.T.(2) → R.T.(3) →	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	R.T. → F.S.T. →	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	P.S.T. → R.T. → F.S.T. → ; Sludge Treatment facility	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	P.S.T. → R.T. → F.S.T. → ; Sludge Treatment facility	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.

2) 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 aerators in the lagoon and chlorination facilities. The trickling filter requires power for recirculation, sludge collection, and chlorination, and the oxidation ditch method requires power for aerators in the ditch, sludge collectors, sludge pumps and chlorinators.

An estimation of the power consumption (excluding power for offices and in-plant lighting) needed for the Nuwara Eliya plant is:

- Stabilization Pond approx. 0 kW
- Aerated Lagoon approx. 35 kW
- Trickling Filter approx. 39 kW
- Oxidation Ditch approx. 53 kW

The stabilization pond does not require any power because of the absence of mechanical equipment. The oxidation ditch consumes the largest amount of power.

3) Area requirement

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

Area requirements for each of these methods are:

- Stabilization Pond approx. 4.4 ha
- Aerated Lagoon approx. 0.8 ha
- Trickling Filter approx. 0.4 ha
- Oxidation Ditch approx. 0.4 ha

South of Lake Gregory, approximately 1.0 ha of land is available. Three of the treatment methods and stabilization ponds cannot be considered because of land constraints.

4) Construction Cost

A rough estimation of the construction cost is shown below:

Table 12.5 Cost Comparison between AL and OD Treatment Method

(unit: thousand SL Rs.)

Item	Aerated Lagoon	Oxidation Ditch
Construction Cost		
Civil Work	28,000	74,000
Mechanical/Electrical Work	89,000	139,000
Sub-Total	107,000	213,000
Land Acquisition Cost	(0.8 ha) 24,000	(0.4 ha) 12,000
Total	131,000	225,000

In the above cost comparison, it becomes apparent that the aerated lagoon method is far more economical than the oxidation ditch method, even when land acquisition costs are included.

5) Operation and maintenance cost

Since an oxidation ditch consumes much more power, the operation cost will be higher. Usually, about 5 percent of the construction cost for the mechanical/electrical facilities is required for annual maintenance and therefore the oxidation ditch requires a higher maintenance cost.

An oxidation ditch also requires sludge treatment, which means more personnel are necessary to operate the plant.

6) Difficulty of operation and maintenance

The oxidation ditch method is more difficult to operate and maintain than the aerated lagoon method because of the following reasons:

a. More mechanical/electrical equipment is required necessitating more maintenance for proper operation.

b. Sludge treatment is a daily operation, and which consists of sludge removal, thickening and drying and requires additional manpower for treatment.

7) Environment

Part of process for stabilization ponds and trickling filters are anaerobic which result in odors and the breeding of flies.

The following table shows the features of the various treatment methods.

Table 12.6 Comparison of Sewage Treatment Methods

Item	SP	AL	TF	OD
Water Quality	Fair	**Good**	Fair	Good
Area Requirement	4.4 ha	**0.8 ha**	0.4 ha	0.4 ha
Power Consumption	0 kW	**35 kW**	39 kW	59 kW
Construction Cost	Low	**Fair**	High	High
O & M Difficulty	Easy	**Easy**	Fair	Fair
Sludge Disposal	Less	**Less**	Often	Often
Environment	Fair	**Fair**	Poor	Fair
Evaluation	Fair	**Good**	Fair	Good

(5) Conclusion

The aerated lagoon method is recommended for this particular site because it is superior in power consumption, construction, and operation/maintenance cost as well as in the ease of operation and maintenance. While the oxidation ditch has an advantage in the size of the area required, the difference is not enough to impact the construction cost.

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 final 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 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.

Table 12.7 Typical Data of Sludge Produced from Various Sewage Treatment

Treatment	Specific Gravity		Produced Dry Solids ($kg/1000m^3$)	
Process	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

Sludge collected from septic tanks is discharged into sludge pits or plants. In the Nuwara Eliya sewage treatment plant, partials mixing aerated lagoons are regularly drained and settled sludge dried at the lagoons is transported to a dumping site.

(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. Selection of the processes and sequence is 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

Stabilization of solids occurs in aerated lagoons and natural drying of the lagooned sludge is recommended. The proposed sludge treatment/disposal method is shown in Figure 12.2.

(3) Composting facilities

Composting facilities at the municipality dumping site are under construction. Sludge from the proposed sewage treatment plants could be utilized for composting or disposed at dumping site. This matter will be studied in the implementation phase.

12.3.4 Integration/Separation of Sewerage Service Area

(1) Alternatives

As explained in Chapter 7, the sewerage service area in Nuwara Eliya Municipality includes the city center, the Lake Gregory area, and the Base Hospital/brewery area. Because the Base Hospital/brewery area is remote from the remaining service area, two alternatives (integration or separation) for these service areas are possible. Alternatives 1 and 2 respectively.

A preliminary design has been developed for the alternatives and the locations and summary of the major facilities are shown in Figure 12.3.

(2) Evaluation of Alternatives

The alternatives were evaluated in the following aspects;

1) Construction cost,
2) Operation and maintenance cost,
3) Man-power requirements for operation and maintenance, and
4) Difficulty of operation and maintenance.

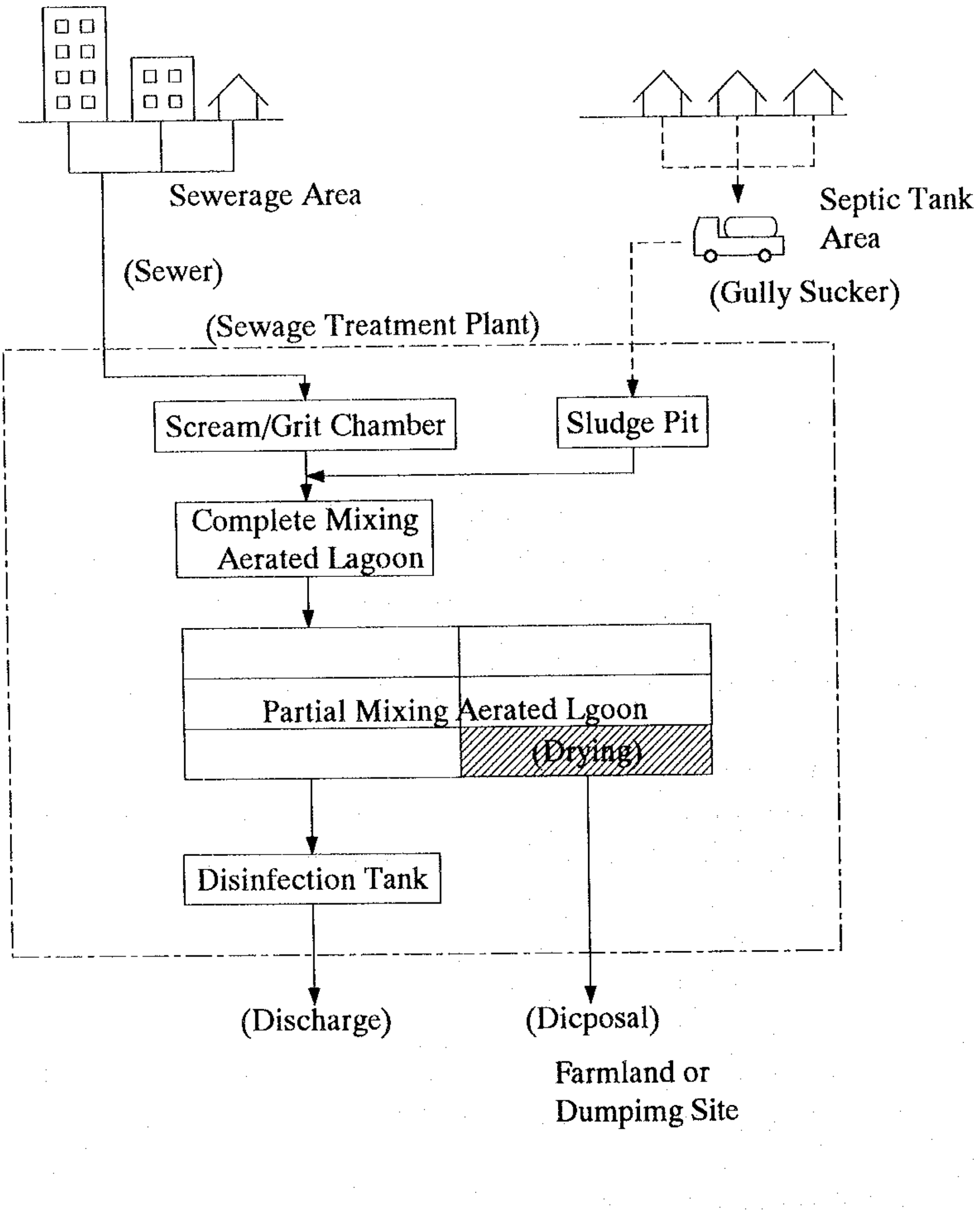
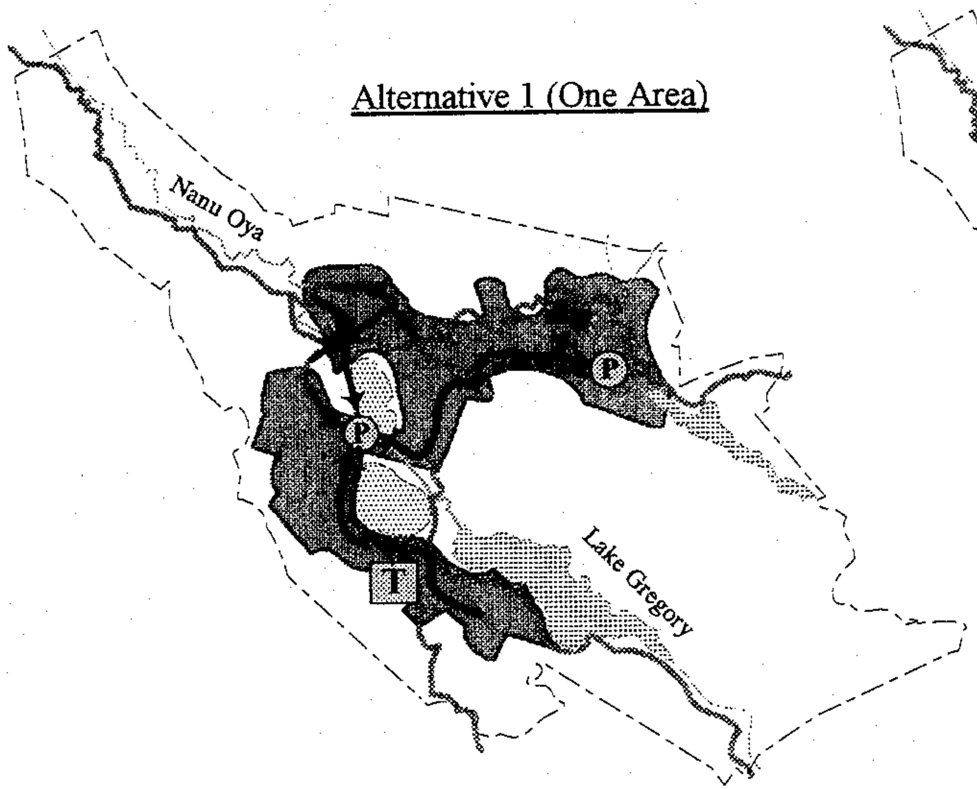
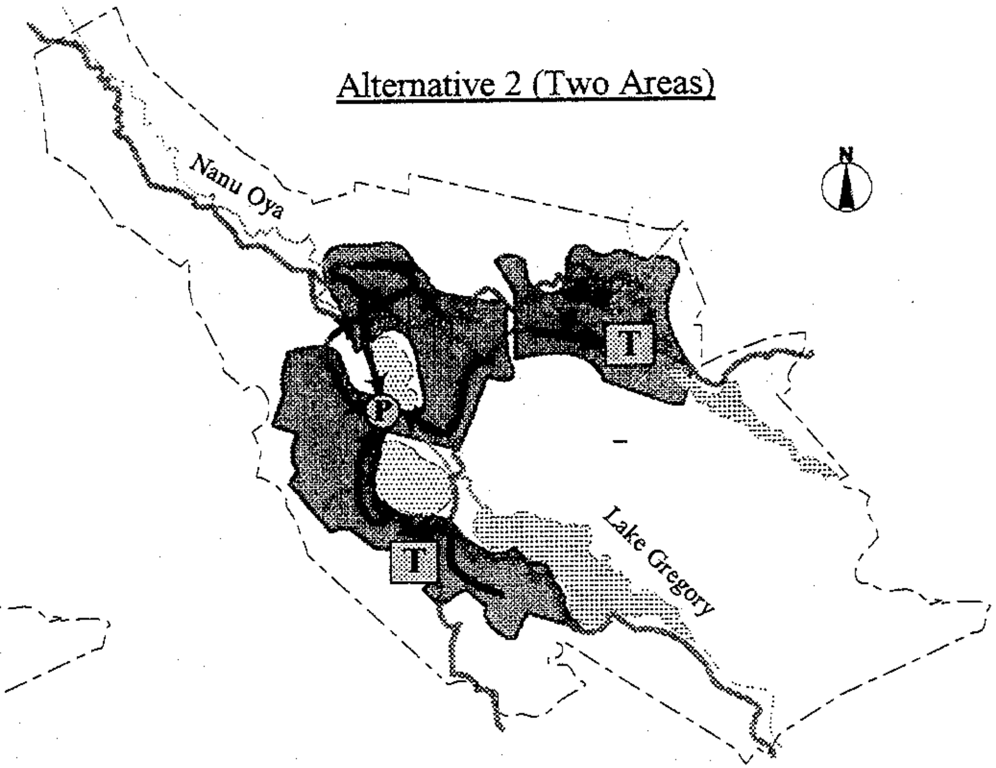


Figure 12.2 Sludge Disposal





Item		Alternative 1 (One Area)	Alternative 2 (Two Areas)	
			Nuwara Eliya	N'Eliya Central
Area		314ha	172ha	142ha
Population		8,700	5,800	2,900
Sewerage Treatment Plant		2,800 m3/d	2,000m3/d	800m3/d
Pumping Station		No1 PS : 0.0148m3/sec	No1 PS : 0.0148m3/sec	—
		No2 PS : 0.0470m3/sec	No2 PS : 0.0322m3/sec	—
Pipe	Gravity Line	ϕ150～400mm , L=16,764m	ϕ150～400mm , L=10,897m	ϕ150, 225mm , L=5,687m
	Pressure Line	ϕ150, 200mmFCD , L=2,020m	ϕ200mmFCD , L=620m	—

Figure 12.3

Alternative of Service Area

Features of the alternatives are summarized in Table 12.8.

Table 12.8 Evaluation of Alternatives

Feature	Alternative 1	Alternative 2
Construction Cost (thousand Rs.)	398,917	416,572
Annual O&M Cost (thousand Rs.)	4,603	4,912
Man-power Requirement	12	15
Difficulty of O & M	Less	More

(3) Conclusion

Alternative 1 is superior to Alternative 2 in all aspects of evaluation. Alternative 1, an integrated sewerage system, is recommended.

12.4 Preliminary Design of Sewerage System

12.4.1 Layout of Sewerage System

Layout of sewerage system in Nuwara Eliya is shown in Figure 12.4.

12.4.2 Sewage Collection System

(1) Sewage collection method

A separate system is recommended

(2) Piping Materials

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

Diameters of 150 to 600mm : Vitrified Clay Pipe

Diameters of more than 600mm : Reinforced Concrete Pipe with corrosion-resistant lining

(3) Summary of Sewage Collection System

The preliminary design for the sewage collection system is shown in Appendix 12.2 and 12.3, and the summary of sewer and pumping stations are shown in Tables 12.9 and 12.10.

Figure 12.4

Layout of Sewerage System

1) Sewer

Table 12.9 Summary of Sewer Plan

Item	Diameter (mm)	Length (m)
Clay – Lateral	150	5,200
Clay Pipe	150 to 400	11,560
DCI Pipe	150 to 200	2,920
Service Connection	units	2,690

2) Pumping Station

Table 12.10 Summary of Pumping Station Plan

Location	Specification
Nuwara Eliya - 1	Submersible Pump, 0.89 m^3/min, 39 m, 11 kW, 2 sets
Nuwara Eliya - 2	Submersible Pump, 2.82 m^3/min, 24 m, 22 kW, 2 sets

12.4.3 Sewage Treatment System

The preliminary design for the sewage treatment plant was prepared using the, flow of 2,800 m^3/day for the target year of 2010. A total of two treatment trains with a capacity of 1,400 m^3/day each are proposed and each train consists of four aerated lagoons; one complete mix aerated lagoon and three cells of partial mix aerated lagoons. Details of the sewage treatment plant are shown in Appendix 12.4.

(1) Layout

Original land for the treatment plant is nearly square and located on a sloping area at the edge of a tea plantation. Because the land must be leveled, the entire land cannot be fully utilized as a portion will be a cut or fill slope.

However, as a result of the Steering Committee Meeting, held on November 27th, 1998, the proposed site was changed due to the difficulty of acquiring the land and an alternative site was proposed at the nearest agricultural land. The proposed land is currently used as a private agricultural land on a sloping area with sufficient for the setting of a sewage treatment plant of 2,800 m^3/day.

Tentative layout of the sewage treatment plant is shown in Figure 12.5.

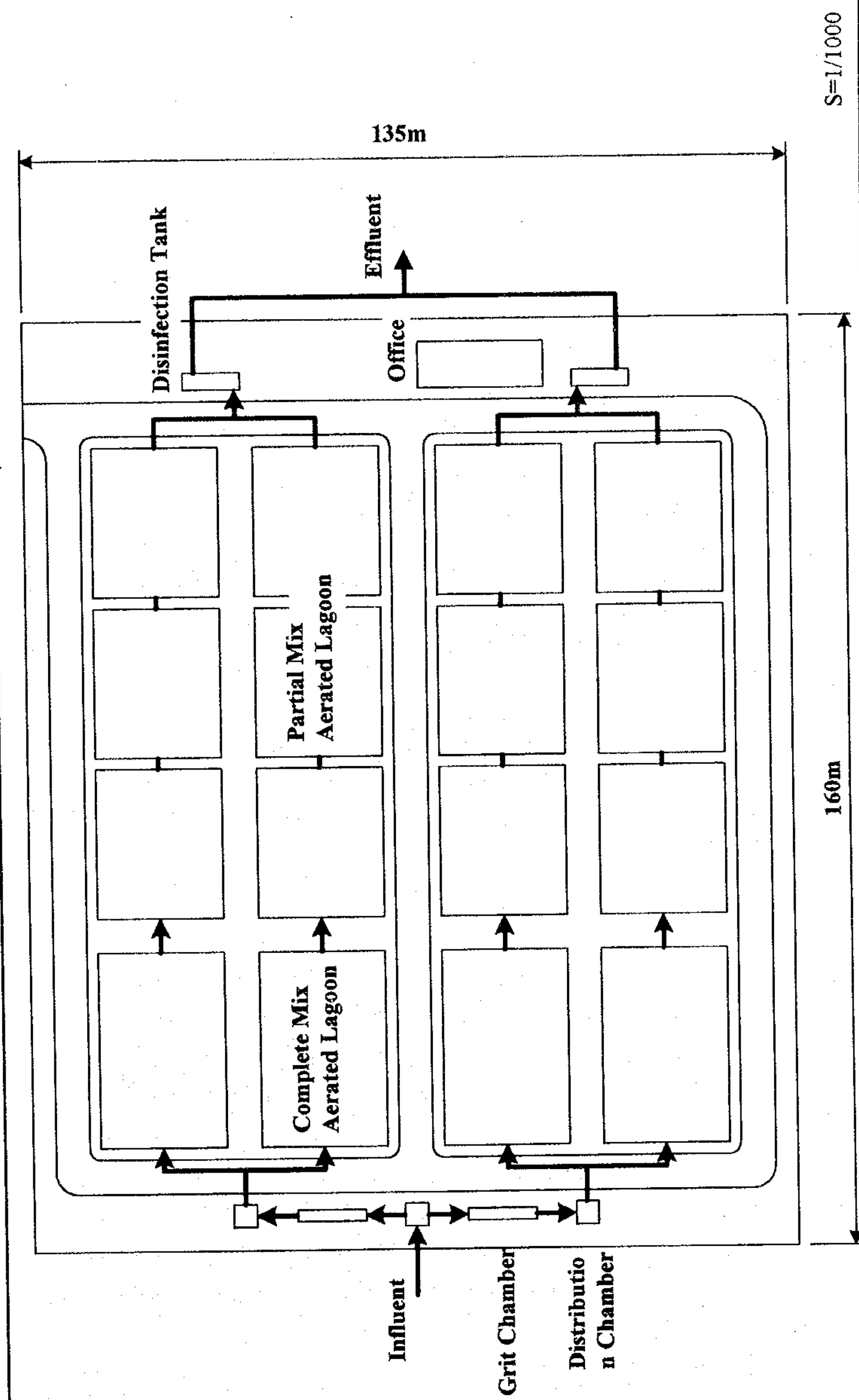


Figure 12.5 Layout of Sewage Treatment Plant

(2) Specifications of Facilities

Specifications for the sewage treatment plant are shown in Table 12.11, with numbers, dimensions, and design parameters for each facility.

Table 12.11 Specifications of Sewage Treatment Plant

Facilities	Specifications
1. Grit Chamber and Screen	
Type	Parallel Flow Type
Dimension	0.5 m W x 2.7 m L x 0.3 m D
Water Surface Load	1,778 $m^3/m^2/day$
Average Velocity	0.15m/sec
Number of Basin	3 basins (including 1 stand-by)
2. Complete Mixing Aerated Lagoon	
Type	Rectangular Type
Dimension	14.0 m W x 25.0 m L x 3.0 m D
Aeration Power Level	13 kW
Retention Time	1.5 days
Number of Basin	4 basins
3. Partial Mixing Aerated Lagoon	
Type	Rectangular Type
Dimension (Cell)	12.0 m W x 16.0 m L x 4.0 m D
Aeration Power Level	6 kW
Retention Time	2.0 days
Number of Basin	3 cells x 4 basins
4. Disinfection Tank	
Type	Rectangular Type
Dimension	1.0 m W x 15.0 m L x 1.0 m D
Retention Time	15.4 min
Number of Basin	2 basins

(3) Treatment Process

1) Grit chamber

The grit chamber removes inorganic sediment and eliminates the 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.

2) Complete mixing aerated lagoon

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

3) Partial mixing aerated lagoon

3) Partial mixing aerated lagoon

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 disinfects the effluent by use of chlorine solution.

12.4.4 Sanitation Facilities

(1) Objectives of the Study

On-site sewage treatment/disposal is an important treatment method not only for small rural communities, but also for urban/semi-urban households unserved by the public sewerage system. The study of on-site treatment/disposal methods was done to offer alternatives from low-cost sanitation and technical aspects, corresponding to the differences among the beneficiaries, such as a clusters of households, apartments and independent households.

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

A brief discussion of the data available is presented hereunder. The study results indicate the above outcomes as well as recommendations on associated problems to help maintain public hygiene and living environment at desirable level and were incorporated in the F/S on the Priority Project.

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

Water quality surveys of effluents were conducted from existing septic tanks and percolation tests were undertaken at three different locations in NEMC.

1) Effluents from septic tanks

Quality of effluents from septic tanks is shown in Table 12.12, which indicates that BOD is reduced while SS has a high concentration.

Table 12.12 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	-	-	-	-
Middle Income House	-	132	-	197
Low Income House	-	130	-	182
Office	-	218	-	102
Hotel-A	236	135	207	340
General Performance	140-200		50-90	

The high SS is a result of overflowing of septage or sludge and will cause clogging of soakage pits and shorten the operation life of soakage pits.

2) Percolation tests

Percolation tests were conducted during the rainy season in August 1998 at two locations in NEMC, namely Barrows Road and Bonavista. Barrows Road is located in a valley and Bonavista is located in a hilly area.

Sri Lanka Standard SLS 745, 1986 "Code of Practice for Design and Construction of Septic Tanks" is applied for this test.

Table 12.13 Percolation Test

Location	Depth (m)	Percolation Rate (min)
Barrows Road	2.0	62.5
Bonavista	2.0	62.5

The recommended method of disposal of septic tank effluent is shown in Sri Lanka Standard SLS 745, 1986, and it indicates the following disposal method for these locations.

Barrows Road and Bonavista:

a. Dispersion trench, or

b. Sub-surface biological filter with under drains and the effluent led into a drain or used for gardening.

Table 12.14 Recommended Method for Disposal of Effluent from Septic Tank

Water Level of Groundwater	Soil and Subsoil Conditions		
	Porous soil with percolation rate		Dense and clay soil with percolation rate exceeding 60 min.
	Not exceeding 30 min.	Exceeding 30mm. But not exceeding 60 min.	
Within GL-1.8 m	Dispersion trench located 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 GL-1.8 m	See page pit or dispersion trench.	Dispersion 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 populations expected to be served by this sewerage system and on-site treatment are as follows:

Table 12.15 Sewerage and Septic Tank Area

	Total		Sewerage		Septic Tank	
	Population	House	Population	House	Population	House
1997	34,235	7,073	0	0	27,388	5,659
2005	39,113	8,081	1,826	377	29,829	6,163
2015	42,867	8,857	8,681	1,794	27,349	5,651

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

The results of the water quality survey carried out during the dry season indicate this process of pollution as shown in Table 12.16.

Table 12.16 River Water Pollution

(unit: mg/l)

Nanu Oya	BOD_5	COD
Upstream of city center	1.4	21.3
Downstream of city center	7.2	28.0

To improve this situation, it is recommended that sludge from septic tanks and soakage pits be regularly removed, at least once in every five years. On the basis, the following table gives the expected sludge that will be generated daily:

Table 12.17 Discharged Sludge Volume from Septic Tanks

2005	9.9 m^3
2015	9.0 m^3
STP Capacity (2005)	1,400 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 sludge collected could be treated at the sewage treatment plants.

(4) Typical Septic Tank with Infiltration System for Effluent Disposal

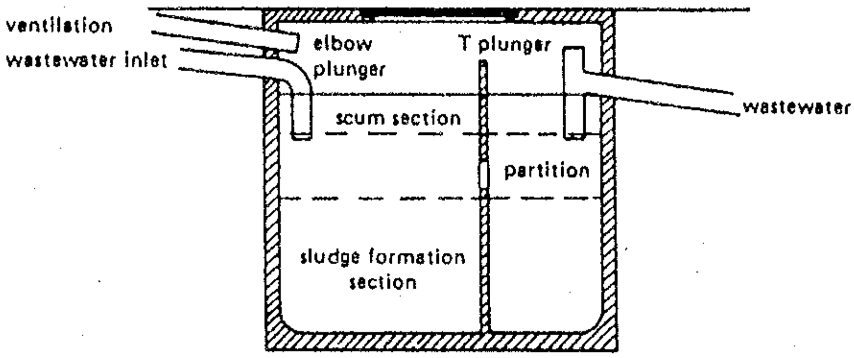
This method is practically suitable for treatment of domestic sewage from single households, institutions and small communities (or apartment type housing accommodating more than 5 households).

1) Design of septic tank

Septic tanks should be constructed using watertight materials and composed of two compartments as shown in Figure 12.6.

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 to surface water body or an aquifer



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

Figure 12.6 Typical Design of Septic Tank

The sizing of septic tanks depends on the following conditions:

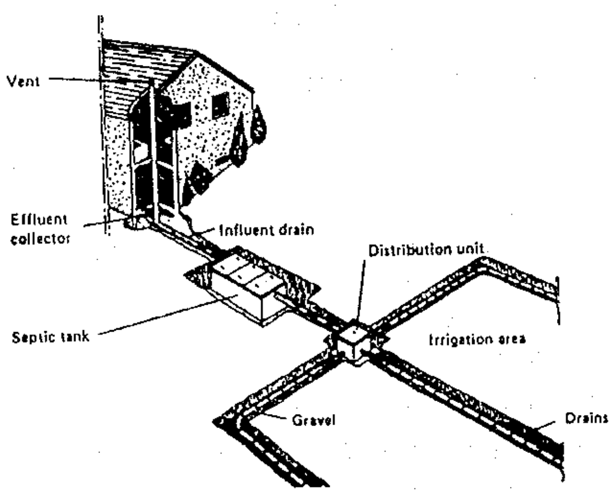
a. Influent sewage flow
   Attention should be paid to reduce water consumption such as replacement of conventional flush toilets by water-saving designs (pour flush, etc.), for economical sizing of septic tank.
b. The required retention time for solid sedimentation depends on the number of users.
c. 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 land availability and the volume of treated effluent. However, septic tanks with irrigation systems are being used 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 12.7.



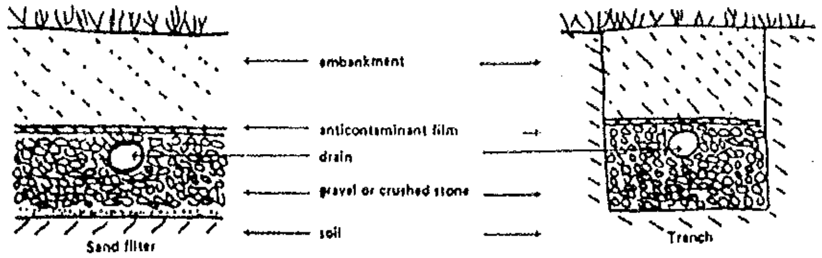
Source: *L'assainissement individuel-principles et techniques actuelles.* Paris, Ministère de l'Environnement et du Cadre de Vie et Agence de Bassin Loire-Bretagne. 1980

Figure 12.7 Principal Design of Shallow Subsurface Irrigation System

Additional options to this system include:

- 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.



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.

Figure 12.8 Subsurface Filtration System (Trench & Sand Filter)

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.

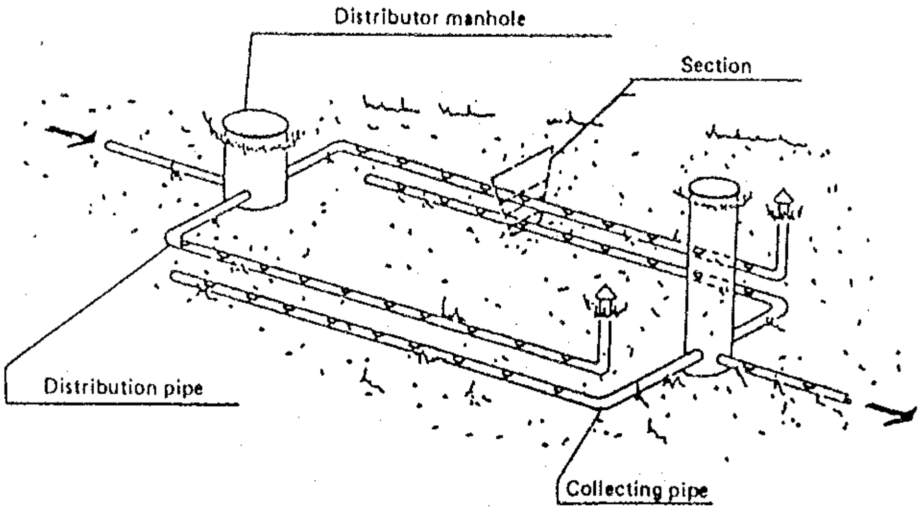
b. Alternative measures for subsurface filtration

More costly alternative measures are available for subsurface filtration, when the environmental conditions restrict the application of the above methods. This is particularly when unprotected groundwater is located near the surface and/or when the soil stratum is not sufficiently thick.

Three alternative measures are:

i. Drained sand filter

This method is useful when the permeability of soil is poor or when groundwater table is shallow (0.5 to 1 m). This method should be used only in cases where the effluent can be discharged into a surface environment, as shown in Figure 12.9.



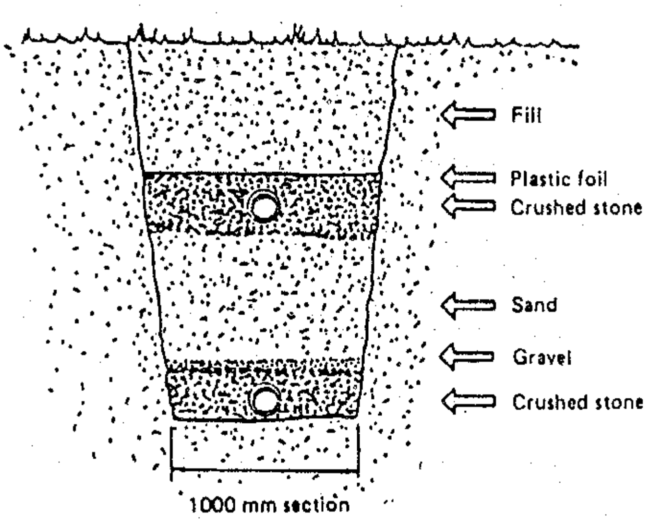
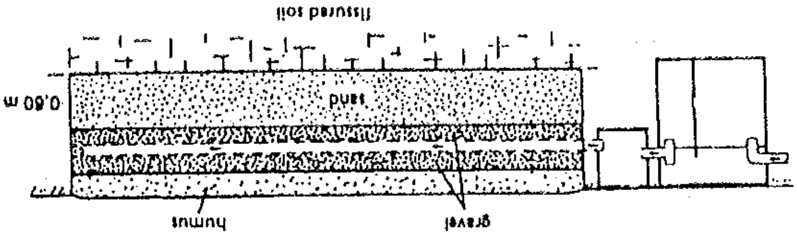


Figure 12.9 Drained Sand Filter for Single Household

ii. Undrained sand filter

This is a modified method of the drained sand filter and is applicable when the soil stratum is not sufficiently thick, but does allow infiltration of effluent after treatment (fissured substratum), as shown in Figure 12.10.

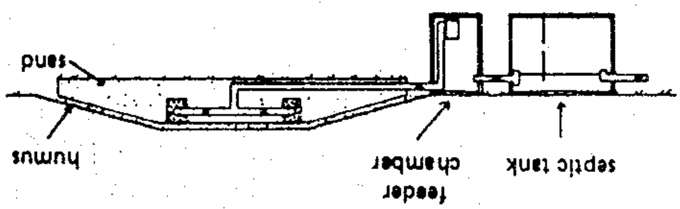


Source: L'assainissement individuel-principles et techniques actuelles. Paris, Ministère de l'Environnement et du Cadre de Vie et Agence de Bassin Loire-Bretagne. 1980

Figure 12.10 Undrained Sand Filter

iii. Raised sand filter

The sand filter is installed in a mound (approximately 1 m) 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. For this method, the soil must be sufficiently permeable, as shown in Figure 12.11.



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

Figure 12.11 Raised Sand Filter

(5) Compact Aerobic Domestic Sewage Treatment Module

Septic tanks with infiltration systems have several limitations on use:

- It is applicable to rural and suburban areas where the necessary open space is available to construct the infiltration system,
- It is applicable to areas where soil conditions are favorable for infiltration of effluent.

In other words, in densely populated areas where houses are located close together and there is insufficient open space to construct infiltration system or soil conditions are impermeable, the use of septic tanks and infiltration systems is not suitable. However to meet these restrictions, there is a technical option among the on-site treatment/disposal methods – the so-called compact aerobic domestic sewage treatment module.

This compact treatment module employs a biological contact treatment method with diffused air. The required space is more or less equivalent to the equivalent septic tank by increased treatment efficiency but does not require an infiltration system.

The compact treatment module has two different applications; one for only nightsoil treatment and the other for both nightsoil and domestic sewage. Generally, this compact module achieves treatment efficiency of at least 30 mg/l of BOD in the treated effluent. However, it requires twice yearly intervals removal of excess sludge.

Different treatment capacities are available corresponding to different household sized. The provision of an equalization tank is recommended for facilities having service populations of more than 200 persons, to offset flow rate fluctuation of raw sewage. A typical design of a compact aerobic domestic sewage treatment module is shown in Figure 12.12

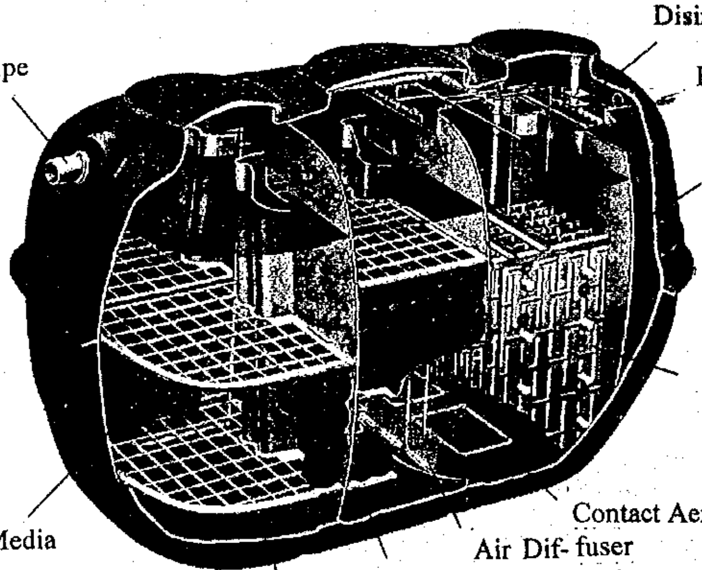


Figure 12.12 Typical Design of Compact Aerobic Domestic Sewage Treatment Module

When the future urban development in the Study Area is taken into account, this compact treatment module could be considered for that apartment-type housing to be constructed in the suburban area where the public sewerage system is not available.

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

In applying on-site treatment methods to individual households and larger scale facilities such, as commercial establishments and apartment type buildings, certain technical standardization and legislative arrangement are indispensable to achieve better sanitation practices, easier O&M, and environmental soundness.

1) Technical standardization

The majority of existing septic tanks installations has following characteristics:

- The capacity of septic tanks is not based on sound technical criteria.
- Septic tanks are constructed with the use of bricks and mortar and have effluent outlet with regardless to surrounding environmental conditions.
- Septic tanks are usually located at the back of houses away from the streets.
- No allowances are made for future conversion from septic tank to sewerage system.
- Inappropriate desludging results in a considerable number of septic tanks discharging untreated sewage.
- Septage is dumped into rivers, ponds, canals, and sewer manholes, resulting in further deterioration of environment.

To attain environmentally acceptable installations, the following must be implemented:

- Soak pit should be provided where effluent disposal to a nearby drainage system is not available and/or surrounding environment does not allow such disposal, such as densely populated area.
- Combined treatment of excreta and grey water should be introduced for apartment-type housing and other large scale facilities, i.e. commercial establishments, public facilities.

2) Legislative arrangement

Deficiencies and/or inappropriateness of the existing on-site treatment facilities are largely due to lack of implementation of proper legislative arrangements. In this

Master Plan, septage removed from respective septic tanks is planned to be treated at the sewage treatment plant.

The following legislative and administrative arrangements should be enacted to improve on-site treatment:

- Building permission for either new house/building or renovation/improvement of existing one should only be granted to applicants when the appropriate septic tank or equivalent facility including location and plumbing schedule for disposal of effluent is submitted and approved by the authorized technical standards.
- NWSDB or Municipality should be able to remove the water supply and acceptance of septage for treatment from any applicant when the house/building owner violates the above mentioned building permission.
- House/building owner should be obliged to enter into a contract for septic tank desludging with public corporation or private entity registered with NWSDB or Municipality, and subject to approval of pertinent authority.
- Penalty clause should be included in the pertinent regulations to prohibit building without appropriate domestic sewage treatment facility and inadequate removal of septage. Negligence to remove septage may be subject to penalty in a form of holding tax or other measure, such as closure of business or termination of water supply.
- Financial assistance, i.e. soft loan facility, partial subsidy, should be considered for smooth and accelerated implementation of proper sanitation measures.
- Accreditation, by the pertinent authority, of developments conforming to sanitation requirements is another option to advise the purchasing public. By this means, private developers will be encouraged to follow appropriate sanitation practices.
- Public health and hygiene education should also be initiated by to instill the importance of public hygiene practice and community participation in the general populace.

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 Basis for Cost Estimate

(1) Conditions

1) Basic conditions

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

Assumptions and conditions applied 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 Project etc. are compared and established as unit costs as of November 1998. Details are presented 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 cost for the sewage treatment plant and pump stations is estimated for 2.2 ha for Phases 1 and 2. The required land should be secured prior to the commencement of the construction work.

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

Nuwara Eliya = Rs. 24 million

4) Contingencies

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

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

The following works are deemed to be implemented under the 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 following preliminary project cost estimate.

(3) Scope of work to be implemented by the local counterpart fund

The following indigenous works are deemed to be implemented by the local counterpart fund 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, pump stations and along the proposed route of the trunk sewers.

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

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

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

12.5.3 Project Cost

Total cost of the project is estimated in Table 12.18. Detailed cost is presented in Appendices 12.5 to 12.7.

Table 12.18 Project Cost of Nuwara Eliya Sewerage Project

Unit: Thousand Sri Lankan Rs.

(1) Construction cost		
1) Collection System		236,022
Trunk/Main Sewers		
Sewer Laterals		
2) Pumping Station		10.617
Civil Work	2,462	
Mechanical/Electrical Work	8,155	
3) Sewage Treatment Plant		152,278
Civil Work	73,321	
Mechanical/Electrical Work	78,957	
4) Administration cost		21,083
Sub-Total		**420,000**
(2) Procurement of maintenance equipment		25,000
(3) Engineering cost		
1) Detailed design	19,000	
2) Construction supervision	16,000	
Sub-Total		**35,000**
(4) Common expenses		
1) General and administration expenses	8,000	
2) Land acquisition	24,000	
Sub-Total		**32,000**
(5) Contingency		77,000
(6) GST (12.5%)		74,000
Total		**663,000**

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

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, the imported materials for civil work are to be procured through sales agents and suppliers in Sri Lanka.

(1) Local material

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

(2) Imported material

Construction equipment, truck cranes, vehicles, motorcycles, computers, pumps, motor, transformer, switchgears, aerators, disinfection facilities, laboratory equipment, flow meters, and so on.

12.6 Implementation Schedule

As the target year of this Study are 2005 and 2015, Phase 1 is an urgent, priority project and is expected to be completed by the end of 2002, while the overall project (Phase 2) will be completed by the end of 2010.

Phase 1	(1999 to 2002)	- Priority Project
	1999	Preparation of project
	2000 - 01	Detailed design and bidding
	2001	Commencement of construction
	2001 - 02	Construction
	2003	Commencement of operation
Phase 2	(2009 to 2012)	
	2009	Preparation of project

2010 - 11	Detailed design, bidding
2011	Commencement of construction
2011 - 12	Construction
2013	Commencement of operation

The project implementation and disbursement schedule with estimated annual disbursements of project cost are presented in Table 12.16.

Table 12.19 Project Implementation and Disbursement Schedule of Nuwara Eliya 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	418.0				Phase 2	245.0			
1. Land Acquisition	24.0			24.0							
2. Administration	8.0			1.0	1.5	1.5			1.0	1.5	1.5
3. Construction Work	420.0				70.0	180.0				40.0	130.0
4. Procurement of Equipment	25.0					25.0					
5. Engineering Service	35.0			11.0	3.5	6.0			8.0	2.0	4.5
6. Contingency	77.0			5.5	11.0	32.0			1.5	6.5	20.5
7. GST (12.5 %)	74.0			5.5	10.0	30.5			1.5	6.0	20.5
Total of Annual Disbursement	663.0			47.0	96.0	275.0			12.0	56.0	177.0

Table 12.20 Outline of Nuwara Eliya Sewerage Project

			Unit	Phase 1	Phase 2	Remarks
Frame Values	Service Area			City center commercial area, a potion of Lake Gregory, including the hotels, hosipital and brewery.		The values in phase 2 column shows these for the whole project .
	Target Year			2005	2015	
	Service Area		ha	84	314	
	Population		Pop	33,800	44,300	
	Service Population		Pop	1,830	8,680	
	Percentage of Service Population		%	5%	20%	
Sewage Flow	Per Capita Sewage Flow	Domestic	lpcd	74	74	The values in phase 2 column shows these for the whole project .
		Non-Domestic	lpcd	39	51	
		Infiltration	lpcd	20	23	
		Total	lpcd	133	148	
	Design Sewage Flow	Daily Average Sewage Flow	m3/d	1,200	2,300	
		Daily Maximum Sewage Flow	m3/d	1,400	2,800	
		Hourly Maximum Sewage Flow	m3/d	2,400	4,500	
Phase			**Unit**	**Phase 1**	**Phase 2**	**Total**
Facility	Planning Area			Northern area of city center, including the hotels, hospital and brewery.	Excluding Phase 1 column in Sevice area.	—
	Sewage Treatment Plant	Treatment Method		Arerated Lagoon		
		Capacity	m3/d	1,400	1,400	2,800
		Facilities		Grit Chamber, Complete Mixing Aerated Lagoon, Partial Mixing Aerated Lagoon, Disinfection Tank		
	Pumping Station	Submersible Pump	Nr	2	0	2
	Sewer Pipe	Lateral Sewer Clay ϕ 150mm	m	4,000	1,200	5,200
		Trunk Sewer Clay ϕ 150-400mm	m	8,190	3,370	11,560
		Puressure Pipe DCI ϕ 150、200mm	m	2,020	0	2,020
		Service Connection	Nr	750	1,940	2,690
Project Cost	Construction Cost	Direct Construction Cost	Milli. Rs.	250	170	420
		Procurement of Maintenance Equipment	Milli. Rs.	25	0	25
		Engineering Cost	Milli. Rs.	20.5	14.5	35
		Administration and Land Acquisition	Milli. Rs.	28	4	32
		Contingency	Milli. Rs.	48.5	28.5	77
		GST 12.5%	Milli. Rs.	46	28	74
		Total	Milli. Rs.	418	245	663
	Annual Operation and Maintenance Cost	Personnel Expense	Thou. Rs.	840	1,176	—
		Electricity Cost	Thou. Rs.	1,947	2,504	—
		Chemical Cost	Thou. Rs.	27	51	—
		Repair Cost	Thou. Rs.	483	871	—
		Tatal	Thou. Rs.	3,297	4,602	—

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 the Nuwara Eliya-city center in Nanu Oya catchment and the hospital/brewery area in Barrack Plains catchment. From the viewpoint of the following considerations, which are the same as the Master Plan, the priority area was determined.

- Large-scale commercial areas
- High population density
- Large-scale facilities, such as hospitals, breweries, schools, hotels, housing schemes, religious and institutional, both existing and proposed
- Conservation of the natural environment (tourist spots etc.)
- Topography

Detailed data on population, commercial activities, etc. by these sub-areas are not available, and the evaluation was made by a series of discussions with the Municipality officers concerned and from field observations.

13.2 Planing Fundamentals

The priority project area for the Feasibility Study for Nuwara Eliya includes the city center and the surrounding commercial and residential areas as far north as the Saint Andrews Hotel and along the Nanu Oya as far south as the south end of the Victoria Park. The project area also includes a separate area around the Base Hospital and the Brewery and along Uda Pussellawa Road in front of these vicinities. Although the trunk sewers will continue further to the south to the proposed treatment plant site as described in Chapter 12, additional areas along this section will not be served in principle. However, Large-scale developments such as the Grand Hotel will be served. The trunk sewers were designed to receive this additional flow in the future under the Phase 2.

The planning values for the priority project area is shown in Table 13.1.

Table 13.1 Priority Project Area in Nuwara Eliya

Planning Value	2005
Area (ha)	84
Population	1,830
Average Daily Sewage Flow (m^3/day)	1,200
Maximum Daily Sewage Flow (m^3/day)	1,400
Hourly Maximum Sewage Flow (m^3/day)	2,400

The priority project area is shown on Figure 13.1.

13.3 Preliminary Design of Sewerage System

13.3.1 Design Consideration

(1) Topographic Conditions

One of the proposed pumping station sites is located at the northeast of the municipality along Uda Pussellawa Road. The site is now used to accommodate Municipality employees. The elevation is 1,863m with dimensions of 35 m long and 10 to 25 m wide. Another proposed pumping station site is located at the Victoria Park is at an elevation of 1,877 m and is 20 m square. The proposed original site of the sewage treatment plant in the valley area cultivated for tea plantation along London Road. The elevation varies from 1,852 m at the bottom of valley to 1,871 m at the road. The finished ground level for the sewage treatment plant will be at an elevation of 1,855 m and 1,884 m for the complete mixing aeration lagoons.

Since an alternative site was proposed at the nearest agricultural land on the Steering Committee Meeting on November 27th, no topographic survey was carried out due to time limitation. The survey is required at the next stage.

(2) Geological conditions

Two locations were investigated for the siting of the pumping stations.

One of the proposed locations for the pumping station site is at Victoria Children's Park, close to Nuwara Eliya Town. Just below the surface is a peat bed down to a depth of 0.45m, followed by peaty clay to a depth of 1.85m. These are very soft strata.

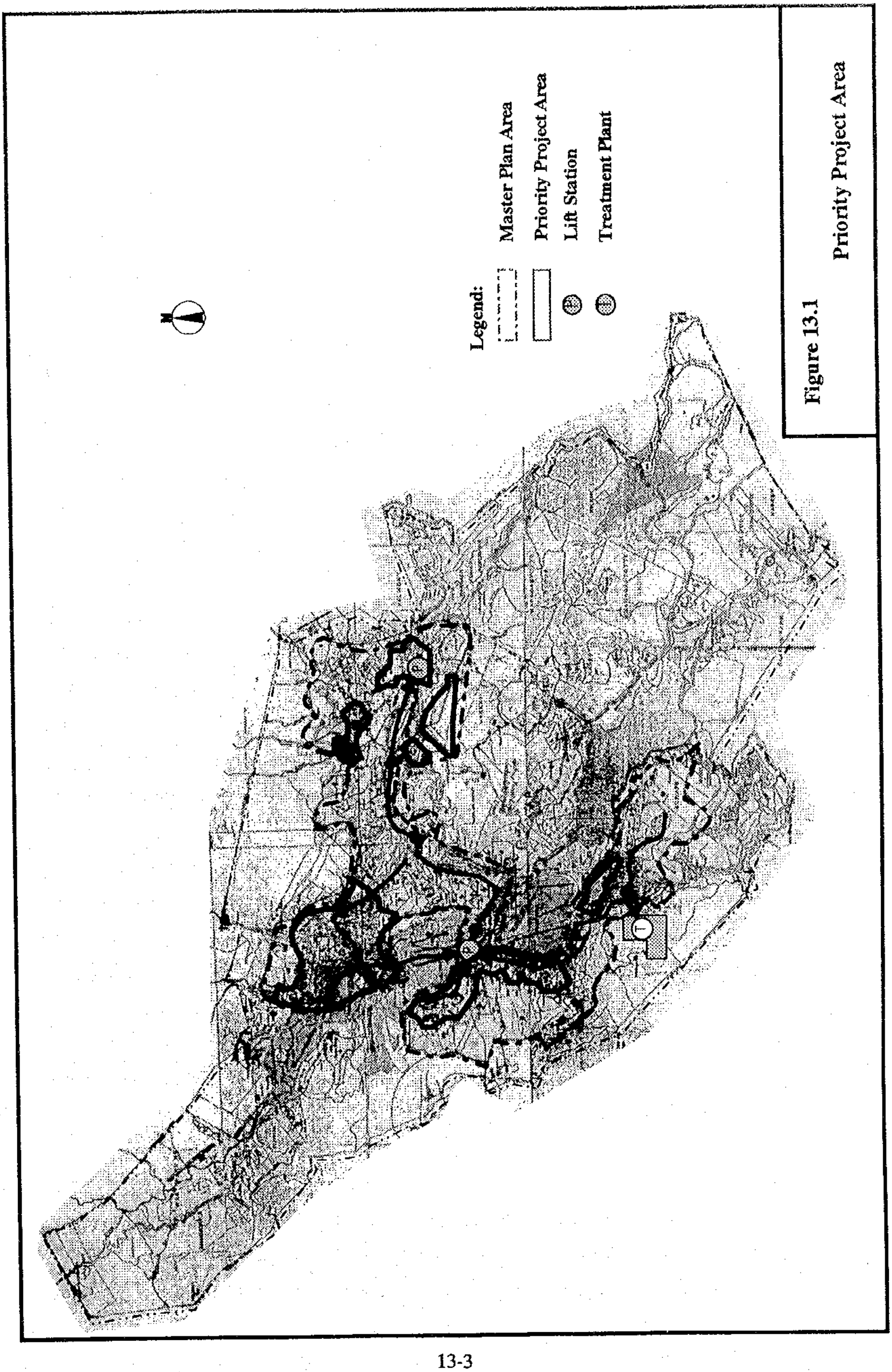


Figure 13.1 Priority Project Area

The stratum from 1.85m to 3.20m is a moderately dense layer of fine sand, followed by a gravel bed to a depth of 4.10m. From 5.40m to 11.60m, moderately dense granular weathered rock disintegrating to medium coarse sands with rock pieces exists. At 11.60m the bedrock encountered is Biotite Gneiss, which is medium grained, yielding fresh continuous cores. The rock is of satisfactory quality as indicated by CR = 75% and RQD = 40%.

The subsurface peat bed down to 1.85m depth is soft and not load bearing material. However the sand bed, and gravel bed below 1.85m depth is moderately dense. Independent footings or a raft type foundation can be considered at a depth of 1.85m. Below this depth are sands and granular bedrock with an average S.P.T. N value is 17. The safe load bearing capacity will be 150 kN/m^2 at 1.85m depth. No long-term settlements are expected in granular sands below 1.85m depth. Dewatering and shuttering will be required during construction because of the shallow ground water table at 1.00m depth.

At the other site at the Municipal Quarters, just below the surface is a bed of peat, which is very soft down to a depth of 1.40m. The peat bed is followed by soft plastic clays down to a depth of 3.80m. From 3.80m to 4.20m is a rock boulder of Charnockitic Gneiss. From 4.20m to 8.90m, a thick zone of dense granular weathered rock exists. The bedrock at 8.90 m is Garnet Biotite Gneiss with patches of Charnockite. Continuous fresh cores are recorded with good rock quality as seen in CR = 90% and RQD = 80%.

The near surface soft peat bed is present down to a depth of 1.40 m. Below the peat bed are soft clays and plastic clays giving low S.P.T. N-values. If shallow foundations are considered long-term settlements can be expected, Foundations below 3.00 m depth may not be practical with a ground water table at 1.90m. Therefore shallow R.C. driven piles can be considered which will achieve the set within the dense weathered rock. The boulder recorded from 3.80 m to 4.20 m may be considered an isolated occurrence. The required pile load set can be achieved at a depth of around 8.00 m within the granular dense weathered rock.

(3) Reliability of Electricity Supply

No generator is planned at the pumping stations and the sewage treatment plant. Nevertheless, a few trailer-mounted generators will be provided to supply electricity for the pumping stations in the Nuwara Eliya sewerage system. Trailer-mounted generators will be transported to the areas where power failure occurs as back up to keep the pumps operating.

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	: 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.

2) Construction method for large sewer pipes at depth

The following comparison table shows the principal construction methods, which are used for large and deep sewer pipes. Among the construction methods, open cut and pipe jacking are the most suitable construction method. Additionally, open cut with temporally embankments or sheet piles for encasement at halfway in the river may be utilized at river crossing points.

In this regard, it is important that the construction method be studied in detail during the design stage, taking into account the soil conditions, groundwater levels, traffic condition and riverbed conditions in order to select the most suitable construction method for construction.

Table 13.2 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 to safeguard the Works. 2) Water-Proof 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 tentative diameters and lengths for the sewer system to be designed are summarized in the following tables.

Table 13.3 Summary of Sewer Plan

Item	Diameter (mm)	Length (m)
Clay Pipe – Lateral	150	4,000
Clay Pipe – Sewer Main	150 to 600	8,190
DCI Pipe	100	2,020
Service Connection	units	750

The detailed data is presented in Appendices 13.1 and 13.2.

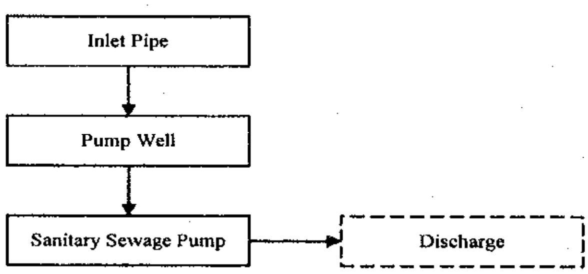
13.3.3 Pumping Station

(1) Type of Pumping Station

Rectangular or Circular Manhole Type Pumping Station

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

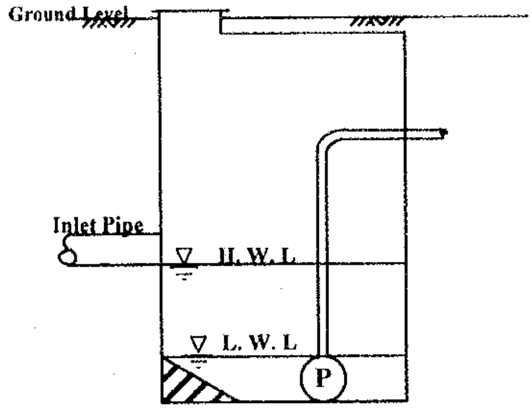
b. Standard Flow-Sheet



c. Condition

The pumps are installed inside a manhole.

d. Schematic Diagram



(2) Design sewage flow

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

(3) Pump type

A submersible pump should be selected.

(4) Number of pumps

A minimum of two pumps with one standby should installed.

(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 suction (m/sec)

V shall be in the range of 1.5 to 3.0 m/sec

The minimum suction diameter of the pump should not be less than 80 mm in order to assist in operation and maintenance.

(6) Total pump head

The total pump head is calculated from the following equation:

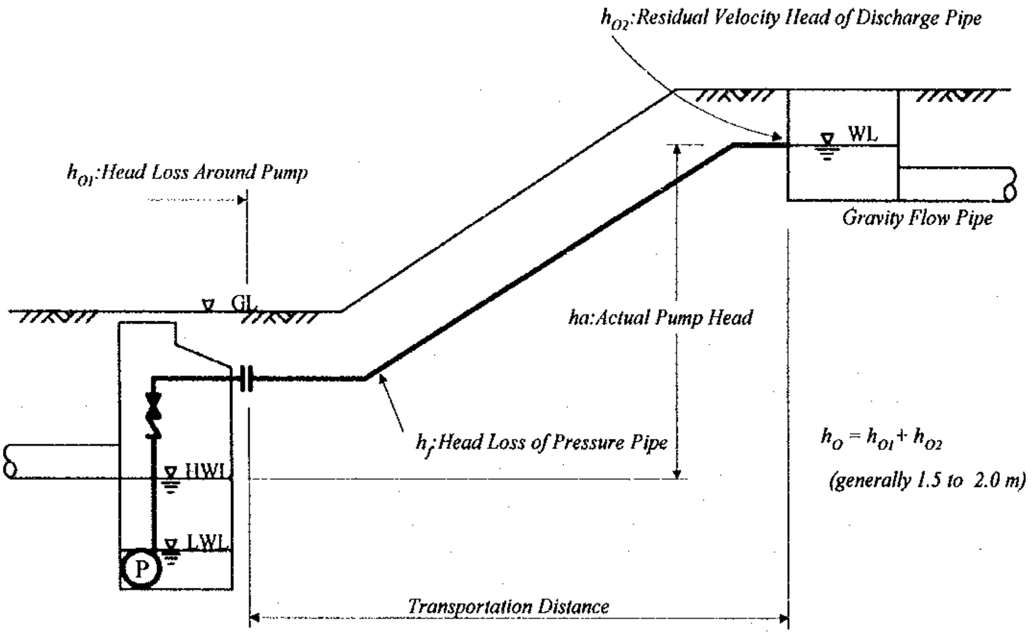
$$H = h_a + h_f + h_o$$

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 from 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 requirements and specifications for the pumping facilities are summarized in the following tables. The detailed data is presented in Appendix 13.3.

Table 13.4 Summary of Pumping Station Plan

Location	Specification
Nuwara Eliya - 1	Submersible Pump, 0.89 m^3/min, 39 m, 11 kW, 2 sets
Nuwara Eliya - 2	Submersible Pump, 2.82 m^3/min, 24 m, 22 kW, 2 sets

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 Appendix 13.4. In this study, the plant is designed with a capacity of 1,400 m^3/day at this stage, with a final capacity of 2,800 m^3/day, being borne in mind.

Location	Treatment Method	2005	2015
Kandy	Aerated Lagoon	1,400 m^3/day	2,800 m^3/day

(1) Layout

Since the area for the treatment plant is in a valley, the entire land can not be fully utilized. The layout of the sewage treatment plant will be designed with careful consideration given to the result of the topographical and soil investigations.

(2) Specifications of Facilities

Specifications for the sewage treatment plant with numbers, dimensions and design parameters for each facility are given in Table 13.5.

Table 13.5 Specifications of Sewage Treatment Plant

Facilities	Specifications
1. Grit Chamber and Screen	
Type	Parallel Flow Type
Dimension	0.5 m W x 2.7 m L x 0.3 m D
Water Surface Load	1,778 m^3/m^2/day
Average Velocity	0.15m/sec
Number of Basin	2 basins (including 1 stand-by)
2. Complete Mixing Aerated Lagoon	
Type	Rectangular Type
Dimension	14.0 m W x 25.0 m L x 3.0 m D
Aeration Power Level	13 kW
Retention Time	1.5 days
Number of Basin	2 basins

3. Partial Mixing Aerated Lagoon	
Type	Rectangular Type
Dimension (Cell)	12.0 m W x 16.0 m L x 4.0 m D
Aeration Power Level	6 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 15.0 m L x 1.0 m D
Retention Time	15.4 min
Number of Basin	1 basins

13.4 Project Cost

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

Table 13.6 Cost of Priority Project

Unit: Thousand Sri Lankan Rs.

(1) Construction cost		
1) Collection System		145,085
Trunk/MainSewer		
Sewer Lateral		
2) Pumping Station		10,617
Civil Work	2,462	
Mechanical/Electrical Work	8,155	
3) Sewage Treatment Plant		82,026
Civil Work	41,910	
Mechanical/Electrical Work	40,116	
4) Administration cost		12,272
Sub-Total		**247,000**
(2) Procurement of maintenance equipment		**25,000**
(3) Engineering cost		
1) Detailed design	18,525	
2) Construction supervision	9,500	
Sub-Total		**20,500**
(4) Common expenses		
1) General and administration expenses	4,000	
2) Land acquisition	24,000	
Sub-Total		**28,000**
(5) Contingency		**48,500**
(6) GST (12.5%)		**46,000**
Total		**418,000**

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

13.5 Implementation Program

13.5.1 Implementation Schedule

With regard to 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 12.12. 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

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 matters of importance, such as the proposed tariff system for the cost recovery, will be performed 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	12.0
- Sewer laterals	6.0
2) Sewage treatment plant	
- Mobilization	2.0
- Civil work	10.0
- Mechanical/electrical work	10.0
- Trial Operation	1.0

-	Training	2.0
3)	Total	18.0 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 13.7 Project Implementation and Disbursement Schedule of Priority Project

Item \ Phase / Year		Phase 1				
		1999	2000	2001	2002	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	418.0			
1. Land Acquisition	24.0			24.0		
2. Administration	4.0			1.0	1.5	1.5
3. Construction Work	250.0				70.0	180.0
4. Procurement of Equipment	25.0					25.0
5. Engineering Service	20.5			11.0	3.5	6.0
6. Contingency	48.5			5.5	11.0	32.0
7. GST (12.5 %)	46.0			5.5	10.0	30.5
Total of Annual Disbursement	418.0			47.0	96.0	275.0

Table 13.8 Construction Schedule