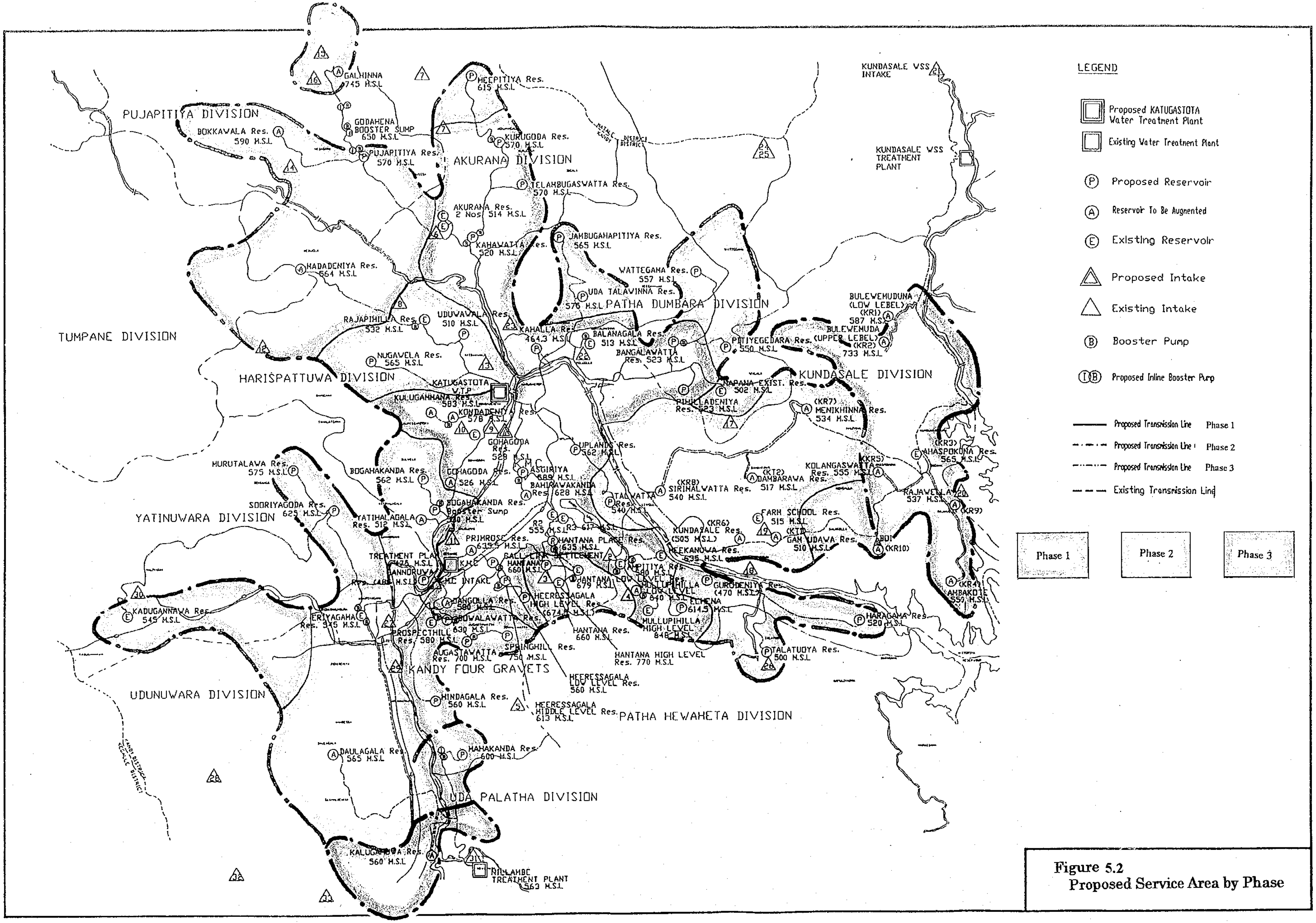


Figure 5.2
Proposed Service Area by Phase

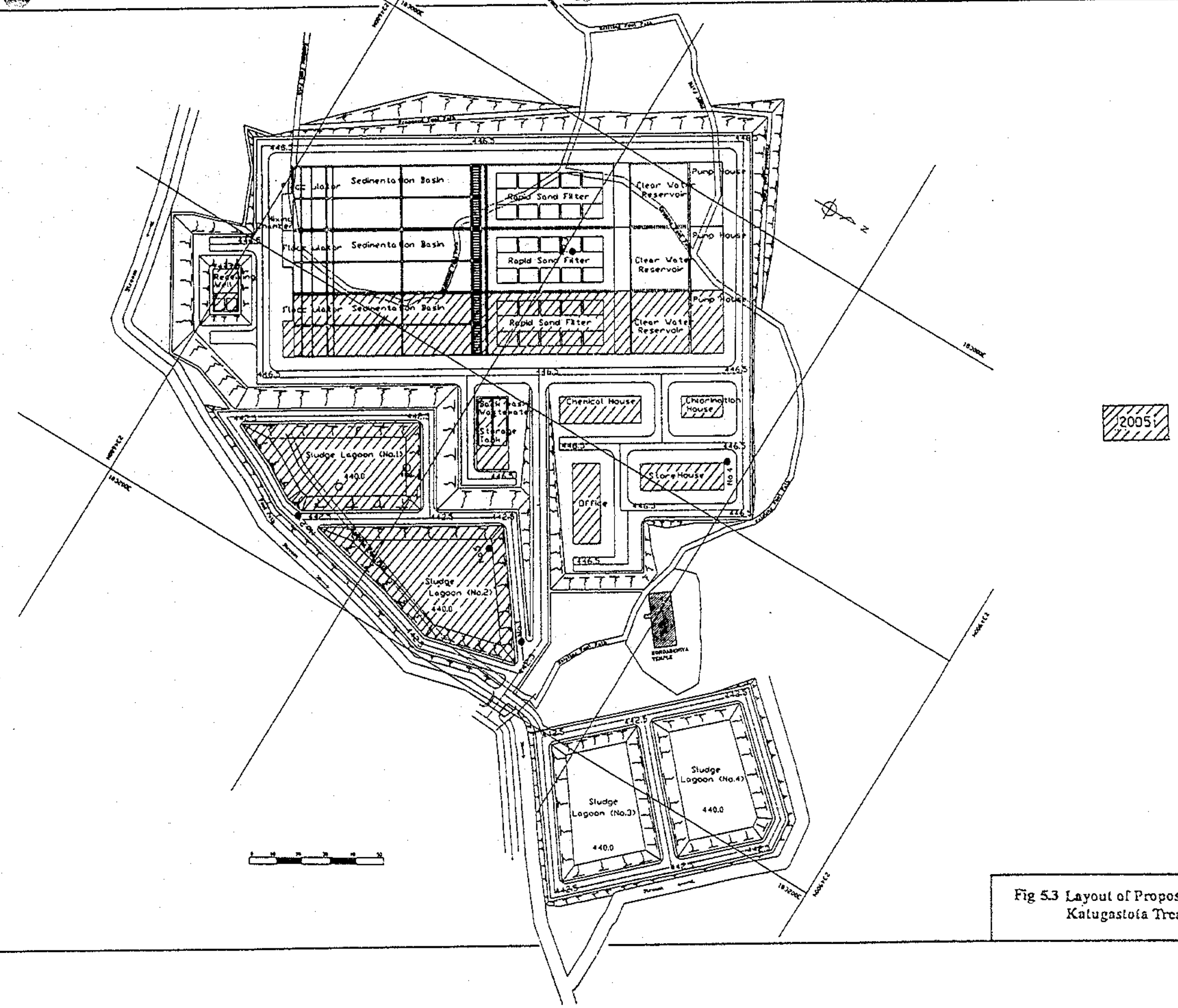


Fig 5.3 Layout of Proposed
Katugastota Treatment Plant

5.6 Project Cost

5.6.1 Composition of Project Cost

Composition of project cost is shown below:

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 %)

5.6.2 Conditions for Cost Estimate

Project cost is estimated on the basis of preliminary design of the Master Plan Study. Unit prices and lump sum prices are established considering local conditions, sub-contractors, hiring equipment, available construction equipment and materials as well as 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 Yen 1.8

5.6.3 Project Cost

Total cost of the proposed project is estimated at approximately Sri Lankan Rs 11,264 million as shown in Table 5.6.

Table 5.6 Estimated Total Project Cost

Unit: Thousand Sri Lankan Rs.

(1) Construction cost		
1) Intake Facilities		639,624
Weir / Grit Chamber		
Intake Pump / Conveyance Pipeline		
2) Water Treatment Plant		2,216,186
Civil Work	621,586	
Mechanical/Electrical Work	1,594,600	
3) Chlorination Facilities of Distribution Reservoir		81,900
4) Transmission Facilities		2,684,793
Pipe Facilities	2,178,167	
Pump Facilities	506,626	
5) Distribution Reservoir		995,208
6) Distribution Pipeline Rehabilitation		785,000
7) NRW reduction program (Leakage detection)		103,000
8) Administration cost		375,289
Sub-Total		**7,881,000**
(2) Procurement of maintenance equipment		**37,000**
(3) Engineering cost		
1) Detailed design	326,000	
2) Construction supervision	265,000	
Sub-Total		**591,000**
(4) Common expenses		
1) General and administration expenses	60,000	
2) Land acquisition	137,000	
Sub-Total		**197,000**
(5) Contingency (15%)		**1,306,000**
(6) GST (12.5%)		**1,252,000**
Total		**11,264,000**

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

5.7 Implementation Schedule

In connection with the target years for this Study (2005 and 2015), Phase 1 is an urgent and priority project and is expected to be completed by the end of 2004, while Phases 2 and 3 to complete the overall project are to be achieved by the end of 2008 and 2013, respectively.

Phase 1 (1999 to 2004) - Priority Project

1999-2000	Preparation of project
2001-02	Detailed design, bidding
2002	Commencement of construction & procurement of equipment
2002-04	Construction
2005	Commencement of operation

Phase 2 (2003 to 2008)

2003-04	Preparation of project
2005-06	Detailed design, bidding
2006	Commencement of construction & procurement of equipment
2006-08	Construction
2009	Commencement of operation

Phase 3 (2008 to 2013)

2008-09	Preparation of project
2010-11	Detailed design, bidding
2011	Commencement of construction & procurement of equipment
2011-13	Construction
2014	Commencement of operation

The project implementation and disbursement schedule with estimated annual disbursement of project cost is presented in Table 5.7.

Table 5.7 Implementation and Disbursement Schedule of Greater Kandy Water Supply Project

Item \ Phase / Year		Phase 1						Phase 2				Phase 3				
		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	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 Intake Facilities																
3.2 Water Treatment Plant																
- Civil Work																
- Mechanical/Electrical Work																
3.3 Transmission Facilities																
3.4 Distribution Facilities																
4. Procurement of Equipment																
5. NRW Reduction Program																
Disbursement Schedule	**Total Cost (Million SL Rs)**					Phase 1	4,820			Phase 2	2,779				Phase 3	3,665
1. Land Acquisition	137.0			86				16					35			
2. Administration	60.0			2	6	6	6	2	6	6	6		2	6	6	6
3. Construction Work	7,778.0				807	1,076	1,346		491	655	819			646	861	1,077
4. Procurement of Equipment	37.0					37										
5. NRW Reduction Program	103.0			16	29	29	29									
6. Engineering Service	591.0			138	28	42	42	81	16	25	25		107	21	33	33
7. Contingency	1,306.0			36	131	179	213	15	77	103	128		22	101	135	166
8. GST(12.5%)	1,252.0			35	125	171	205	14	74	99	121		21	97	129	161
Total of Annual Disbursement	11,264.0			313	1,126	1,540	1,841	128	664	888	1,099		187	871	1,164	1,443

Table 5.8 Outline of Greater Kandy Water Supply Project

				Unit	Phase 1	Phase 2	Phase 3	Total
Frame Value	Study Area				Kandy Municipal Council,a part of Kandy Four Gravets,a part of Harispattuwa,a part of Akurana,a part of Pujapitaya,a part of Patha Dumbara,a part of Udunuwara,a part of Yatinuwara,a part of Udapalatha,a part of Kundasale,a small part of Patha Hewaheta			
	Target Year				2005	2010	2015	Figures in each phase show the total figure at the end of each phase.
	Population			person	717,600	762,900	810,100	
	Service Population			person	615,800	659,400	703,600	
	Service Ratio			%	86%	86%	87%	
Water Demand	Unit Water Demand	Domestic		lpcd	89	96	104	Figures in each phase show the total figure at the end of each phase.
		Non-Domestic		lpcd	39	43	48	
		NRW		lpcd	72	62	50	
		Total		lpcd	200	201	202	
	Daily Average	Domestic		m^3/d	54,680	63,396	72,944	
		Non-Domestic		m^3/d	24,022	28,495	33,430	
		NRW		m^3/d	44,154	41,474	35,273	
		Total		m^3/d	122,856	133,365	141,647	
		NRW %		%	36%	31%	25%	
	Daily Maximum	Total		m^3/d	147,430	160,000	169,980	
Proposed Facilities	Service Area	Including Service Area in Existig WTP (KMC, Kalugamuwa, Kundasale)			Study Area except a part of Pujapitaya, a part of Yatinuwara	Study Area except a part of Pujapitaya	Entire Study Area	Figures in each phase show the total figure at the end of each phase.
	Demand for Proposed WTP	Daily Average Water Demand		m^3/d	30,560	61,100	87,450	
		Daily Maximum Water Demand		m^3/d	36,670	73,330	104,940	
	Intake Facility	Location			Gohagoda			
		Capacity		m^3/d	38,500	77,000	115,000	
		Facility			Intake Mouth, Grit Chamber, Elec./Mech. Equipment			
	Conveyance Facility	Capacity		m^3/d	38,500	77,000	115,000	
		Conveyance Pipe	DI ϕ 800～900 (part. pararell)	m	2,200 (800mm)	600 (900mm)		
	Treatment Facility	Location			Katugastota			
		Treatment Capacity		m^3/d	38,500	77,000	115,000	
		Nominal Camacity		m^3/d	36,670	73,330	110,000	
		Treatment Method			Coagulation-Sedimentation-Rapid Sand Filter			
		Facility			Receiving Well, Sedimentation Basin, Rapid Sand Filter, Clear Water Reservoir, Wastewater Storage Tank, Sludge Lagoon, Chemical Dosing Equip., Elec./Mech. Equip., Buildings			
	Transmission Facility	Capacity		m^3/d	36,100	73,300	108,600	(Total)
		Transmission Pipe	PVC ϕ 75～225	m	23,745	26,610	52,050	102,405
			DIP ϕ 250～900	m	18,400	30,289	37,795	86,484
		Transmission Pump		stn.	9	9	15	33
	Distribution Facility	Reservoir		No.	20	12	27	59
		Distribution Pipe		L.S.	1	1	1	1
Project Cost	Project Cost	Construction Cost			3,332	1,965	2,584	7,881
		Procurement of Maintenance Equipment			37	0	0	37
		Engineering Cost			250	147	194	591
		Common Expenses			106	36	55	197
		Contingency			559	322	425	1,306
		GST	12.5%		536	309	407	1,252
		Total	Unit: Million Rs.		4,820	2,779	3,665	11,264
	O & M Cost	Personal Expenses			6,120	7,320	8,520	
		Electricity Cost			57,730	115,348	172,999	
		Chemical Cost			6,068	12,137	18,205	
		Repair Cost			11,371	20,306	29,326	
		others			1,200	1,200	1,200	
		Total	Unit: 1000 Rs./year		82,489	156,311	230,250	

CHAPTER 6 PRIORITY PROJECT OF WATER SUPPLY SYSTEM PLAN

6.1 Identification of the Priority Project

Priority areas were selected for the first phase project based on the prioritization of service areas and feasibility study was conducted thereto.

Augmentation of production capacity by new Katugastota Treatment Plant is taken up. In the first phase, one train, out of the total three trains of treatment facilities will be constructed. Augmentation work of a part of existing reservoirs will also be conducted together with provision of new reservoirs at the areas with large water demand, wherever necessary. In addition, a part of transmission pipelines shall also be constructed in the first phase. Diameters of pipes and sizes of reservoirs are decided based on the projected flow for 2015, in principle. However, an economic examination was conducted for final decision of pipe diameter to attain cost effectiveness of the investment.

Planning fundamentals of the priority project is as shown in Table 6.1.

Table 6.1 Major Planning Fundamentals for Priority Project

Fundamental Conditions	Overall System (Existing & New)	Priority Project (New)
Target Year	2005	2005
Population	717,600	256,400
Served Population	615,800	220,000
Total Water Demand in the Study Area (daily average, m^3/day)	122,900	-
Total Water Supply Capacity in the Study Area (m^3/day)	102,630	36,670
Peak Factor (maximum daily demand / average daily demand)	1.2	1.2
Peak Factor (hourly peak flow / average daily demand)	2.0	2.0
Capacity of New Katugastota Treatment Plant (m^3/day)	-	36,670

6.2 Preliminary Design of Water Supply System

6.2.1 Design Conditions

(1) Topographic condition

A new intake facility at Gohagoda along the Mahaweli River situates on the grassland at elevations ranging from 440.5 m to 442.5 m and gradually becomes gentle climbing slope from the riverside. Further upward, the area turns to rice field. The proposed site of water intake is currently unoccupied open land having approximately 40 m width and facing to precipice at both upstream side and downstream side. These proposed sites for water intake have enough space to accommodate grit chamber and pump house necessary facilities.

The proposed site for water treatment plant is located at 2.2 km downstream from the intake facility and on unused rice field with partial mountainous land with elevations ranging from 442 m to 448 m. Treatment facilities are designed to be located at elevated position, while sludge treatment facility is located at low elevation area near to the flood retention pond in the eastern direction.

Locations of distribution reservoirs are planned to have sufficient space to accommodate required facilities and enough elevations to allow water distribution by gravity flow.

(2) Geological condition

Geological conditions of the proposed site of intake facility are evaluated based on the boring test results and concluded that it will require rock excavation for about 5 m depth.

The geological conditions of the proposed site for water treatment plant require soil replacement or concrete piles for several meters depth.

Boring tests were also carried out at proposed sites of new reservoirs and at the existing reservoir sites for expansion. The test results revealed that soil replacement is required for about 1.5 m depth at the Kurugoda reservoir and about 1.0 m depth at Kahala reservoir and Kahawatta reservoir, while Heerassagala Upper reservoir requires 4 to 5 m depth of concrete pile foundation. Other sites for reservoirs will not require such foundation preparation.

Major transmission line routes, i.e. from the new Katugastota Water Treatment Plant to the Asgiriya reservoir in KMC Water Treatment Plant and to the Upland reservoir, cross the Mahaweli River by means of aqueduct. Piers of this aqueduct will also require concrete pile foundation.

(3) Reliability of power supply

A new water intake at Gohagoda and the new water treatment plant in Katugastota which will require a electricity supply of 900 kVA and 1800 kVA respectively will be constructed on the Phase 1 under the Greater Kandy Water Supply Project.

Under the electricity development project, a new gantry connected to two national grid stations will be constructed at Katugastota and an exclusive line can be provided for the new intake facility and treatment plant.

Therefore, no generator is planned at the intake pumping station and the water treatment plant. Nevertheless, a few trailer-mounted generators will be provided to supply electricity for pumping stations in Kandy MC and Greater Kandy area. Trailer-mounted generators will be transported to the areas where power failure occurs as back up to keep the pumps operating.

6.2.2 Intake Facility

(1) Water Intake Method

Open inlet method is adopted for water intake facility. Raw water will be led from water intake to grit chamber via conduit.

Water level in the Polgolla Dam varies between 440 m and 446.4 m depending on the river flow rate. The present elevation of riverbed at proposed intake point is 438 m with a water depth of about 2 m. There is a possibility to lower water level for flushing the accumulated deposit during the maintenance period of the dam. In this respect, the bottom plate of intake facility is designed at 2 m below the present level of the riverbed.

Water intake and conduit are designed to have the minimum width of 4 m to allow operation of bulldozer for dredging work.

(2) Grit chamber

The bottom plate of grit chamber is also designed to secure an effective water depth of 2 m, even during the maintenance period of the Polgolla Dam.

Cost effectiveness on capital investment to intake facility, square-shape conduit and raw water transmission pump was studied and concluded that the construction of such facilities required for the target year 2015 shall be undertaken by 2005.

(3) Intake pump

A vertical axial flow type pump is applied for raw water transmission.

(4) Raw water conveyance pipé

The raw water conveyance pipeline route has a total length of 2.2 km consisting of 1.6 km pressured pipe and 0.6 km of gravity flow pipe and a control tank is provided at junction point of these two pipelines.

Cost effectiveness on capital investment was reviewed and concluded that pressured pipe shall be dual lines (800mm dia. – Phase 1, and 900mm dia. – Phase 2), while gravity flow pipe shall be single line (800mm dia.) configuration.

Since the longitudinal cross-section of the conveyance pipeline route has the elevated area in its midway, a control tank is provided at the highest location as shown below.

Dimension, capacity, and number of respective facilities are summarized in Table 6.2.

Table 6.2 Dimensions of Water Intake Facilities

Name of Facility	Dimension
Grit Chamber	6.0 m W x 33.5 m L x 2.0 m Effective Depth x 2 units
Raw Water Transmission Pump	36,670 m^3/day x 50 m Pumping Head x 4 units
Conveyance Pipe	Pressured Pipe: 800 mm Dia. x 0.6 km x 1 line
	Gravity Flow Pipe: 800 mm Dia. x 1.6 km x 1 line
Control Tank	7.5 m Dia. x 3.0 m Effective Depth x 1 unit; Capacity - 132 m^3

6.2.3 Water Treatment Plant

The overall capacity of new water treatment plant is considered to have the daily maximum supply amount with a 5 % additional treatment capacity to cope with in-plant water consumption. The treatment plant is planned to be expanded by three phases and the first phase implementation is for 1/3 of the total capacity, though some of common facility is to be constructed at the first phase implementation.

Total capacity is (110,000 m^3/day daily maximum supply amount basis) and the priority project is designed to cater for 36,670 m^3/day as 1/3 of the total capacity. In view of water treatment amount, the total capacity is determined at 115,500 m^3/day, while the priority project has 38,500 m^3/day.

The treatment process is designed to be chemical coagulation-rapid filtration method. Design condition of water treatment facility is shown below. It shall be noted that layout of treatment facilities is prepared to meet with the full size of design capacity as shown in Table 6.3.

Table 6.3 Dimensions of Major Facilities of Water Treatment Plant

Name of Facility	Dimension	Implementation Scale
Receiving Well	3.9 m W x 3.9 m L x 4.0 m E.D. x 2 units	3/3
Mixing Chamber	6.0 m W x 33.5 m L x 2.0 m E.D. x 2 units	1/3
Flocculation Basin	Step 1: 1.2 m W x 11.0 m L x 3.5 m E.D. x 2 units Step 2: 1.6 m W x 11.0 m L x 3.5 m E.D. x 2 units Step 3: 2.4 m W x 11.0 m L x 3.5 m E.D. x 2 units	1/3
Sedimentation Basin	11.0 m W x 50.0 m L x 4.0 m E.D. x 2 units	1/3
Rapid Sand Filter	5.5 m W x 5.8 m L x 10 units	1/3
Clear Water Reservoir	10.5 m W x 22.5 m L x 3.5 m E.D. x 2 units	1/3
Back Wash Return Tank	8.0 m W x 11.0 m L x 3.0 m E.D. x 2 units	3/3
Back Wash Return Pump	3.5 cu.m/min x 20 m x 2 units (including 1 standby)	1/3
Sludge Lagoon	32.0 m W x 39.0 m L x 2.0 m E.D. x 2 units	1/3
Office	10.0 m W x 30.0 m L	3/3
Pump House	11.4 m W x 23.5 m L	3/3
Chemical House	10.0 m W x 30.0 m L	3/3
Chlorination House	8.0 m W x 15.0 m L	3/3
Store House	10.0 m W x 30.0 m L	3/3
Mechanical & Electrical Facility	Corresponding to staged expansion	1/3
Power Supply Facility	Corresponding to staged expansion	1/3

Note: E.D. - Effective Depth

6.2.4 Transmission Facility

(1) Transmission pump

Transmission pump will be installed at water treatment plant and reservoirs. At the treatment plant, electrical and mechanical facilities and pump house are commonly used with other facilities, while in reservoirs, pump house and electrical facility will be independently constructed. Transmission pump house is designed as a part of clear water reservoir and distribution reservoir. Design condition of transmission pump is summarized in Table 6.4.

Table 6.4 Specifications of Transmission Pumps

Location	Pump Capacity (m^3/day)	Pumping Head (m)	Power Requirement (kW)	Nr. of Units (Including standby)
Katugastota W.T.P.	48,700	150	1,416	5
	41,100	111	886	3
	5,100	120	118	3
	3,900	5	4	2
KMC W.T.P	2,000	172	66	3
Heerasagala Low Reservoir	2,000	115	44	3
Heerasagala Middle Reservoir	1,000	57	11	2
Ampitiya Reservoir	1,000	40	8	2
	700	70	10	2
	800	66	10	2
Kahawatta Reservoir	5,600	80	88	3
Kondadeniya Reservoir	3,900	153	116	2
Asgiriya Reservoir	6,700	64	84	2

(2) Transmission Line

Types of pipe material are designated to be PVC (Poly-vinyl-chloride) and DIP (Ductile Iron Pipe) with the minimum diameter of 75 mm as follows:

PVC: 75 to 225 mm Dia. 23,745m

DIP: 250 mm or larger 18,400m

For preparing staged implementation plan of transmission lines, cost effectiveness of the capital investment is evaluated, under several restrictive conditions. The evaluation result revealed that 23 sections out of the total 30 sections of the major transmission lines would be single line, while remaining 7 sections will be double lines.

6.2.5 Distribution Facility

Twenty (20) distribution reservoirs will be newly constructed or augmented in the priority project. With regard to distribution network, connection pipes between new distribution reservoirs and the existing distribution lines and augmentation of the existing distribution lines are considered as a part of the priority project.

6.3 NRW Reduction Program

In the priority project, costs for leakage detection survey for 70% of the total length of distribution network and for leakage repair at 5 % of the presumed current total construction cost of the existing distribution network. By these project inputs, the current 42 % of NRW are expected to be reduced to 34 % by the target year of 2005 and to 25 % by the master plan target year of 2015.

6.4 Project Cost

Total cost of the proposed project is estimated at approximately Sri Lankan Rs 4,820 million as shown in Table 6.5.

Table 6.5 Estimated Project Cost

Unit: Thousand Sri Lankan Rs.

(1) Construction Cost		
1) Intake Facility		416,929
Intake Mouse/Grit Chamber		
Conveyance Pump/Conveyance Pipeline		
2) Water Treatment Plant		777,043
Civil Work	242,243	
Mechanical/Electrical Work	534,800	
3) Chlorination Facility of Distribution Reservoir		21,000
4) Transmission Facility		1,062,291
Pipe Facility	805,103	
Pump Facility	257,188	
5) Distribution Reservoir		457,966
6) Distribution Pipeline Rehabilitation		335,000
7) NRW Reduction Program (Leakage Detection)		103,000
8) Administration Cost		158,771
Sub-Total		**3,332,000**
(2) Procurement of Maintenance Equipment		37,000
(3) Engineering Cost		
1) Detailed Design	138,000	
2) Construction Supervision	112,000	
Sub-Total		**250,000**
(4) Common Expenses		
1) General and Administration Expenses	20,000	
2) Land Acquisition	86,000	
Sub-Total		**106,000**
(5) Contingency (15%)		**559,000**
(6) GST (12.5%)		**536,000**
Total		**4,820,000**

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

6.5 Financial Evaluation of Priority Project

The results of the financial analysis on the priority project is as follows (refer to Chapter 17 for details):

Following conditions were assumed for the analysis.

(1) Costs

- Project cost presented in Table 6.5 (4,820 million Rs.).
- Operation and Maintenance cost presented in Table 7.4 (82,489 thousand Rs. per annum)
- Overhead equivalent to 10% of sales amount

(2) Income

- Water tariff is set at 90% of national average water tariff of NWSDB. (13.36 Rs./m^3 in 1998) Annual water tariff increase of 1% in real terms is assumed.
- Fifty percent of total project cost is covered by subsidy of the government. Remaining will be borrowed with a policy of 10% annual interest, 24 years payback including 2 years grace period.

(3) Depreciation period is considered as 50 years for civil structures, 15 years for mechanical and electrical equipment, and 15 years for vehicles. Salvage values at 20% of initial cost is considered for mech./elec. equipment, and vehicles.

Tables 6.6 and 6.7 show the results of computation.

Table 6.6 FIRRs by Different Tariff Increase Rate of Priority Project

Tariff Increase Rate	0.5%	**1.0%**	1.5%	2.0%	2.5%	3.0%	**3.5%**
FIRR for M/P	1.55%	**5.04%**	8.14%	11.10%	14.07%	17.17%	
FIRR for F/S					1.66%	2.71%	**3.69%**

Note: Bold Faces are the recommended Cases.

Table 6.7 Results of Sensitivity Analysis on Priority Projects

Case	Annual Tariff Increase	Variance of Capital Investment and O&M Cost			
		-5%	**0%**	+5%	+10%
FIRR of M/P	1.0%	6.47%	**5.04%**	3.74%	2.53%
FIRR of F/S	3.0%	3.13%	**2.71%**	2.31%	1.93%

As presented in the above tables, the priority project dose not show good performance, though annual water tariff increase of 3% in real terms is assumed, because of large initial investment. However, it is viable financially. Cash flow analysis on the priority project assuming 10% annual inflation rate shows that operating fund is in short by 2015. If required operating fund can be borrowed with 10% annual interest rate, cumulative deficit can be recovered in 2026. Comparing with the computation results for the master plan, it is recommendable that the project should be continued after the priority project, i.e. the Phase 1 project of the master plan.

6.6 Implementation Schedule

Phase 1 or priority project is expected to be completed by the end of 2004.

Phase 1 (1999 to 2004)	Priority Project
1999-2000	Preparation of project
2001-02	Detailed design, bidding
2002	Commencement of construction & procurement of equipment
2002-04	Construction
2005	Commencement of operation

CHAPTER 7 OPERATION AND MAINTENANCE PROGRAM FOR WATER SUPPLY SYSTEM

7.1 Work Program for Operation and Maintenance

7.1.1 Intake Facility and Water Treatment Plant

The Operation and Maintenance (O&M) activities for the intake facility and water treatment plant are normally classified into two categories, - daily and periodical functions. The work categories by O&M type are shown in Table 7.1.

Table 7.1 Work Categories for Intake and Treatment Facilities by O&M Types

O&M Category	Working Category
Daily Inspection	-Flow rate of water intake and distribution, -Water level at reservoirs, -Operating conditions of rapid sand filters and back washing, -Operating conditions of wastewater return pumps, -Operating conditions of chemical dosing/injection facility -Removal and transfer of sludge to the sludge lagoon -Operating conditions of mechanical/electrical facilities -Water quality examination
Periodical Work	-Removal of grit at grit chamber (monthly/seasonal) -Removal of dried sludge from sludge lagoon (monthly) -Inspection/repair of mechanical/electrical facilities (annually) -Overhaul of mechanical/electrical facilities (at 5 to 10 year interval)

The O&M activities for the intake facility and water treatment plant should be carried out in accordance with the program below:

(1) Daily work program

- Measurements of intake and treated water quantities, as well as water levels at reservoirs, are the principal activities in order to supply water to meet demand fluctuations.
- To insure that the required quality of water is produced and efficient operation of the treatment facilities, inspection of: operation conditions at rapid sand filters and back; removal and transfer of sludge to the sludge lagoon; as well as water quality examination at predetermined steps of water treatment are activities to be performed daily.
- The inspection of operating conditions of mechanical/electrical facilities is also important to determine any defects and to take immediate countermeasures to rectify such.

(2) Periodical work program

Periodical O&M items mainly focus on removal/disposal of accumulated sludge and grit and more detailed examination and overhaul of mechanical/electrical facilities. Grit stored in grit chambers and accumulated sludge in sludge lagoons will be disposed of to land fill on a regular basis commensurate with accumulation.

(3) Laboratory

Continual water quality examinations will be required to insure treated water quality is maintained within permissible levels of drinking water quality standards during the water treatment process. The water quality examination laboratory is planned, therefore, to be located at the treatment plant. The necessary staff will be assigned for within the water-works or hired from local contractors/laboratories. The water quality indices and examination frequency are determined based on the drinking water quality standards in Sri Lanka. Examinations for heavy metals and pesticide shall be contracted out to local contractors/laboratories to obviate the purchase of expensive equipment for infrequent use.

7.1.2 Transmission and Distribution Facilities

O&M activities include daily inspection, site investigation, rehabilitation of damaged pipes, etc. as shown in Table 7.2.

Table 7.2 Work Categories for Distribution Facilities by O&M Type

O&M Type	Working Items
Daily Inspection	-Operation of pumping facilities -Operation of electrical facilities
Site Investigation	-Confirmation of transmission/distribution facilities and their surrounding environment.
Rehabilitation	-Replacement/repair of damaged pipes
Water Quality Examination	-Periodical water quality examination of respective reservoirs and distribution lines.

The O&M for the transmission and distribution facilities should be conducted in accordance with program below:

(1) Daily inspection

Pumping facilities are designed to operate automatically based on change of water level in the reservoirs. Daily inspection of pump stations is required to monitor the operating conditions of pumps and associated electrical system.

(2) Site investigation

The transmission and distribution lines, reservoirs and surrounding environment should be surveyed regularly for damage caused by land-subsidence, erosion of slopes by rainfall, etc.

(3) Rehabilitation

Leakage repair of transmission/distribution lines and replacement of wearing parts for pumping equipment are the usual rehabilitation works.

(4) Water quality examination

Periodical sampling and water quality examination should be carried out at reservoirs, distribution lines and taps (end points of distribution lines) to confirm conformity to drinking water quality standards.

7.2 Organization for Operation and Maintenance

Proposed number of staffs for operation and maintenance is assumed at 23 persons for Phase 1, 28 persons for Phase 2, and 33 persons for Phase 3, as shown below.

Table 7.3 **Required Number of Staff for O&M of Water Supply System**

(Unit: persons)

Field & Position		Phase 1	Phase 2	Phase 3	Assignment
Manager		1	1	1	Responsible for overall management/ supervision of waterworks
Transmission/Distribution Facility					
Operation & Maintenance	Engineer	1	1	1	Responsible for work control/ supervision
	Forman	2	4	6	Responsible for site works
	Worker	6	8	10	Workers/team
	Driver	1	1	1	Workers/team
Vehicle Maintenance*	Mechanic	-	-	-	Maintenance of vehicles/equipment
Water Treatment Plant					
Operation	Engineer	1	1	1	Responsible for work control/ supervision
	Forman	2	2	2	Responsible for site works
	Operator	2	2	2	Responsible for plant operation
Maintenance	Technician	2	2	2	Responsible for site works
	Worker	4	5	6	Responsible for site works
Water Quality Examination	Chemist	1	1	1	Water quality examination and control
Total		**23**	**28**	**33**	

* Vehicle maintenance shall be done by the municipal workshop.

7.3 Operation and Maintenance Cost

The operation and maintenance program, as stipulated in the preceding sections, requires the following items and annual costs for transmission/distribution facilities and water treatment plant.

Table 7.4 Operation and Maintenance Cost

(Unit: Thousand Rs./year)

Item	Phase 1	Phase 2	Phase 3
Personal Expenses	6,120	7,320	8,520
Electricity Cost	57,730	115,348	172,999
Chemical Cost	6,068	12,137	18,205
Repair Cost	11,371	20,306	29,326
Removal of Sediments *	1,200	1,200	1,200
Total	82,489	156,311	230,250

* : Removal of sediments from Polgolla impoundment in front of intake facility at the time of dam maintenance. It will be conducted about once in every five years. Costs are divided to each year.

CHAPTER 8 GROUNDWATER RESOURCES

Underlying the Greater Kandy Study Area are high-grade multi-phase metamorphic Precambrian rocks that are characterized by strong folding, shearing along the fold axes, and extensive regional faults.

A total of 30 single dimension electrical resistivity soundings were conducted in the Greater Kandy Study Area to identify the contact of the fresh rock and search for deep fractures. Sounding locations were decided based on proximity to Kandy MC, current water availability, and demonstrated need as discussed with NWSDB personnel.

Typically, a groundwater system of 2 to 4 zones (aquifers, aquitards) is defined by the hydrogeology within the first 200m. Overburden consists primarily of weathered gneisses, and commonly has a thickness of 2 to 35m. In areas of deep overburden, a 2-3m zone of clay and freshly weathered rock can be found just above the contact with hard rock. The clay particles tend to adsorb petroleum chemicals and contaminants, effectively creating an environmental filter and barrier. The hard rock typically has a shallow zone of fractures associated with weathering processes and is usually saturated. A series of faults and shears result in regional-scale deep fracture zones. The shear and fault zones typically extend from 10 to over 100km. These zones generally correspond to areas where more groundwater is available, with the fault zones having the most potential as a resource. Based on the feasibility study conducted in Nuwara Eliya, wells in the shear zones might produce up to 500 m^3/day and the fault zones might produce up to 1,200 m^3/day.

Several wells have been established as community and private water supplies and demonstrate that good groundwater resources occur in this area. However, in many areas problems were observed:

- Excessive drawdown due to overpumping,
- Seasonal wells due to shallow depth,
- Seasonal wells due to geologic properties,
- Contaminated water due to shallow depth,
- Contaminated or dirty water due to poor construction, and
- Lack of developed water supply.

In the course of this study, several areas were identified as having deficient water supplies, Bokkawala, Galhinna, Alawatugoda, and Talatuoya. Analyses of the data indicate that groundwater resources are probably available in these areas but may be somewhat limited, depending on the hydrogeological conditions and logistics. Generally, low lying areas intersecting with a fracture zone will have the highest potential for groundwater exploration and development.

The Figure 8.1 shows several areas identified for future groundwater exploration and development which correspond to the villages mentioned above. In the Bokkawala area, a fault zone to the west will be the best the best place to explore and could produce up to 1,000 m^3/day per well. In the Galhinna area, a shear zone to the northeast should be explored. If it can be located and developed, wells could produce up to 500 m^3/day. Further to the east, between Galhinna and Alawatugoda, there is a significant shear zone where some wells have already been drilled. These wells were a good water supply, but due to problems, production has been limited. However, the structure and hydrogeology of this area clearly this shear zone is rather extensive and would probably be a good source for additional wells, with potential yields of up to 400-500 m^3/day. The Alawatugoda area is situated in a valley that follows the axis of a syncline. There is a quartzite formation in the north that could also contribute significantly and should be explored. Wells drilled in this area should be capable of producing 300 to 500 m^3/day. Several features conducive to groundwater development characterize the Talatu Oya area. A shear zone passes through the area and a nappe also enters and terminates in this area, intersecting the shear zone. These two structural features, and especially the intersection, represent an area of high probability for groundwater development. Additionally, there are several strata of limestone/marble formations that are usually good water-bearing zones. It is almost certain that abundant groundwater resources are available in this area and wells should be capable of producing 500 m^3/day or more.

Generally, the most desirable fracture zone will have a substantial layer of solid rock above it. The nature of fracture zones usually make it necessary to put a screen and gravel pack in the water bearing zone to prevent fracture debris from entering and clogging the plumbing. Additionally, it will be necessary to develop the wells sufficiently to ensure maximum yield and clear, clean water. To correctly evaluate the well and aquifer, it is necessary to conduct a pumping test using one or more properly constructed and spaced observation wells.

However, more fundamental problems still exist which will certainly prevent the successful development of groundwater resources in the Greater Kandy Study Area. The correct construction materials are either in short supply or not available, such as blank steel casing, high quality PVC casing, commercially made screens. Drill bits are worn, size and type selections are inadequate, and there are not any portable mud pits. It is clear that fracture zone hydrology in Sri Lanka is poorly understood and that the NWSDB would benefit from assistance and training from experienced and qualified hydrogeologists and groundwater engineers.

It can be seen that there is a very high potential to locate and develop urgently needed groundwater resources in the Greater Kandy Study Area. However, this will be difficult, if not impossible, without international assistance. It is strongly recommended that the Sri Lankan government seek and utilize international assistance to resolve water supply problems in the Greater Kandy Study Area, as well as improve their ability and equipment resources for future groundwater projects.

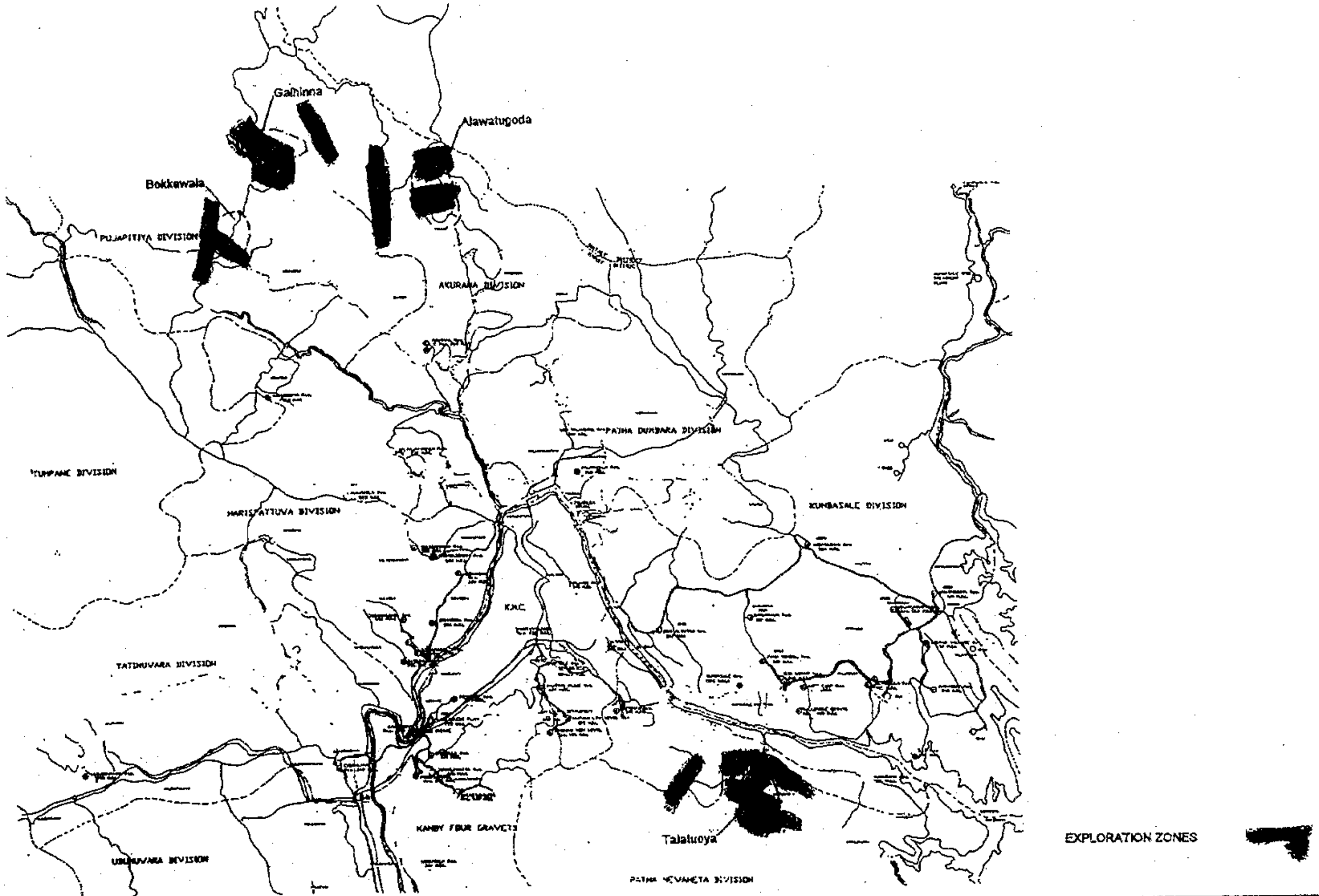


Figure 8.1

Areas for Future Exploration in Greater Kandy

CHAPTER 9 NON-REVENUE WATER REDUCTION PROGRAM

9.1 General

NRW is defined as the difference between the quantity of water produced and the quantity for which the water utility receives revenue. The difference between unaccounted-for water (UFW) and NRW consists of water use by legal connections that are provided with water at no charge. The average NRW for NWSDB managed systems is presently between 18 to 71 percent while for Greater Kandy it is 42 percent.

NRW can be due to a number of causes:

- Transmission main and distribution system leakage
- Reservoir leakage/overflow
- Unbilled legal connections
- Illegal connections
- Service connection meters
- Distribution system pressure
- Production metering
- Administrative errors

Water systems in the Greater Kandy area have been divided into three categories:

- NWSDB supplies 23,340 m^3/d and provides a full range of services from bulk supply to maintenance of water system and billing for 23 separate systems outside of the KMC with a total of 19,000 service connections and 500 standposts.
- Kandy Municipal Council (KMC) supplies 33,400 m^3/d and has 17,500 service connections and 470 standposts.
- Other Greater Kandy agencies supply 7,720 m^3/d and include those provided with bulk supplies by NWSDB and those who manage their own supply and distribution facilities.

9.2 Estimated NRW Components

9.2.1 Transmission Main and Distribution System Leakage

(1) NWSDB

NWSDB has only recently initiated a program to track leak repair activities and no data are available so far. However, the following comments can be made:

- Parts of the distribution systems operate at insufficient pressure to produce detectable leakage sounds, giving no practical method for measuring leakage.

- NWSDB has some 409 km of transmission/distribution pipelines and there are no rigid joint pipes, but there is about 42 km of asbestos cement pipe, which is believed by maintenance staff to be a source of leakage problems.
- Distribution pipelines are primarily confined to major roads and a significant portion of the service connections is long, small diameter lines. This has resulted in "bundles" of shallow, unprotected small diameter (mostly 12 to 25 mm) service connections in many secondary streets. NWSDB has determined an average of about five such service connections in every street, equivalent to about 750 km, or almost twice the distribution system.

(2) KMC

- The system has about 140 km of old, cast iron pipes out of a total of approximately 235 km. KMC estimates that there are approximately 50 km of streets with "bundled" service connections.
- KMC recently initiated a valve rehabilitation program, and estimates that many smaller valves need repair or replacement while most others are fully functional.
- Some 700 leaks are repaired monthly, nearly all on the service connections.

9.2.2 Reservoir Leakage/ Overflow

Two of the NWSDB reservoirs experience overflow problems on a regular basis representing wastage of about 1.3 percent of the water production. Interviews with KMC maintenance staff indicated no leakage or overflow problems.

9.2.3 Unbilled Legal Connections

Although it is common practice in many water utilities not to bill certain categories of legally connected water users, such as public parks/buildings, religious institutions, government institutions, schools or low-income groups such selective favoring of one group of customers over another affects the financial viability of the utility.

The NWSDB has no unbilled, legal consumer categories. In the KMC system, the total legally connected, but unbilled, consumption is estimated at 4.4 percent of total production.

9.2.4 Illegal Connections

Despite determined efforts NWSDB estimates that about 6 percent of total production is lost to illegal connections. KMC estimates that between 2 and 5 percent of all water use is illegal. A figure of 3 percent of production has been adopted for the purposes of this investigation.

9.2.5 Service Meters

(1) NWSDB

Some meters are subject to reversal of the meter registration and NWSDB staff estimates that about 10 percent of the service connections are subject to alternating periods of adequate and inadequate pressure. NWSDB staff estimate that 30 percent of the flow meters are not equipped with reverse flow prevention devices and that about 20 percent of service meters with non-reverse flow devices are affected by clogging with grit or sand. This indicates that a significant proportion of NRW is as a result of under registration. The NWSDB workshop repairs about 12 percent of the installed meters each year and on average meter tests read below 77 percent of the actual quantity. Based on the above factors a value of ten percent of total production has been taken for this NRW component.

(2) KMC

About 90 percent of the meters are less than ten years old and approximately 60 percent have non-return devices built into them. Based on the above factors, the NRW component attributable to various service meter problems has been taken to be ten percent of total production.

9.2.6 Distribution System Pressure

NWSDB maintenance staff reports that distribution system pressures generally vary and, in some throughout the day and, in some cases, are negative during peak demand periods or when service is curtailed. Pressures vary widely throughout the service area, with about 10 percent of the service area experiencing negative pressures sometime during the day and about 10 percent reaching pressures up to 80 meters. Wide variations in system pressure can cause surges that damage pipes and appurtenances and can make leak detection difficult in low pressure areas.

Although no specific data were available on KMC system pressures, discussions with maintenance staff indicate that conditions are similar to those obtaining in the NWSDB distribution systems.

9.2.7 Production Metering

Production meters for NWSDB schemes are generally in poor condition and have not been calibrated for sometime. Based on maintenance staff comments an allowance of 2 percent of production has been adopted for this component of NRW.

Water production at the major KMC treatment facility is measured by an electromagnetic type of bulk meter that was installed in 1989 and the operation staff indicates that its accuracy is within normal operating parameters.

9.2.8 Administrative Errors

NWSDB, KMC and most of the other Greater Kandy water utility agencies all read meters on a monthly basis and estimate billing quantities for service connections with defective meters by comparison with the last three months metered consumption. Where no metered record is available, consumption is estimated by comparison with metered consumption for similar dwellings. Only six percent (6%) of the NWSDB service connections are estimated, but for KMC this figure is 25 percent. To allow for the higher risk of administrative error in the KMC system relative to the NWSDB systems, one percent (1%) was allowed for this component for KMC and zero for NWSDB.

9.2.9 Other Greater Kandy Water Supply System Management Agencies

Data for other Greater Kandy water system management agencies is limited, and only information on the Wattegama water system was available, a summary of which is presented below. Limited field observations of several other systems suggests that conditions are similar to those found in the Wattegama system.

- The Wattegama U.C. water system presently has no means to measure water production.
- The water utility has no meter readers.
- Inspection of the water supply facilities indicates that the problems causing such high NRW rates in other study area water utilities are also present in the Wattegama system.
- An inspection found a substantial number of leaking joints and connections.
- A considerable number of long, small diameter service connections are installed.

9.2.10 Summary of Estimated NRW Components

A summary of the estimated NRW components discussed above is therefore:

	(% of Production)	
	NWSDB	KMC
Transmission Main and Distribution System Leakage	8	15
Service Connection Line Leakage	14	9
Reservoir Leakage/Overflow	1	0
Unbilled Legal Connections	0	6
Illegal Connections	6	3
Low Service Connection Meter Registration	10	10
Production Metering	2	0
Administrative Errors	0	0
Total	41	42

As noted previously, estimates of most of the other NRW components are, in themselves, only general approximations and the resultant component estimates can only provide an approximate range within which the true leakage amount will fall.

9.3 Cost of Non-Revenue Water

Water saved due to implementation of a NRW reduction program is immediately reflected either in a reduction of projected demand or an increase in revenues. The net effect of a successful program is to increase water utility revenue and thus the ability-to-pay for water supply projects, and savings for projects that can be delayed or reduced in size. However, because existing supplies in Greater Kandy are inadequate, the question of project postponement does not arise. The cost of NRW can, therefore, be taken as equal to the present day costs to augment existing supplies to a given service area. The value of water saved due to NRW reduction efforts in Greater Kandy would be Rs 29.02/m^3 derived as follows:

Capacity		100,000 m^3/d
Capital cost	Rs	6,160,760,000
Annual O&M cost	Rs	244,375,000
Amortized capital cost	Rs	814,986,000
Average annual cost	Rs	1,059,361,000
Unit NRW cost	Rs	29.02 / m^3

9.4 Recommended NRW Reduction Program

The recommendations to reduce NRW are based on limited data available. The form and emphasis of the NRW reduction program should, therefore, be periodically reviewed to ensure that program efforts are cost effective.

9.4.1 Waste Management Districts

The location of areas where there are high concentrations of leaking pipes is best accomplished by dividing the distribution system into waste management districts that can be isolated from the rest of the system by means of appropriately placed valves. Water supply to the district can then be measured by specialized waste meters and the results compared to billing records.

Experience on NRW reduction programs in Colombo indicates that waste meters cannot be effectively employed where: (a) low distribution system pressures exist; (b) consumers have tanks that are filled at night; (c) high system connectivity; or (d) valves are in poor condition, insufficient in number or not properly located. Because all of these conditions exist to a significant degree in the study area, the classical leakage estimation by comparing minimum night flows to service meter records cannot be employed. Visual inspection and sounding methods are the only practical means of leak detection until conditions have been improved.

9.4.2 Leak Detection and Repair

With ADB assistance, NWSDB has an ongoing NRW reduction program concentrated on the Colombo area. The NWSDB is now considering shifting some of the focus of this program and has recently provided leak detection equipment to the Kandy area. The existing NWSDB leak detection equipment should be adequate for initiation of NRW reduction program activities but as implementation proceeds, additional equipment needs may be identified. Although some training in the use of this equipment has been given to NWSDB staff, additional training is required.

There are insufficient valves in any of the distribution systems to facilitate isolation of short sections for repair work. A valve rehabilitation program should be implemented and additional valves provided to facilitate the establishment of waste management districts which will, in turn, allow the isolation of suitably sized segments for water loss detection activities.

Increases in the number and severity of leaks that usually accompany the addition of new water supplies to an existing system can overwhelm the leak existing repair capacity and increase NRW. Implementation of the NRW reduction program should be carefully coordinated with the schedule of improvements to the water systems to allow maintenance staff time to deal with the higher leakage repair work load.

9.4.3 Reservoir Leakage/ Overflow

As part of the proposed NRW reduction program, all reservoirs should be tested for leakage and defects should be repaired.

9.4.4 Unbilled Legal Connections

Although most unbilled legal connections are for worthy social causes, the cost of such connections should not necessarily be borne by the water utility. Most of these uses are of benefit to the population at large and their costs should more appropriately be shouldered by some more broadly based financing mechanism (e.g. property tax). In most cases in the study area this is already being done or policy decisions have been made which will eventually result in shifting the burden of these costs away from the water utility.

9.4.5 Illegal Connections

All of the water utilities already have some procedures in place to detect illegal water users. However, the presence of numerous long service connection lines before the service meter provides ample opportunity for illegal connections to be made before the meter. These conditions should be corrected to minimize illegal connections.

9.4.6 Service Connections

Major causes of NRW in all of the water systems are related to the service connections. Although it is not clear whether the greatest impact is due to the extensive "bundles" of service connection pipes or under-registration of the meters, it is apparent that their collective impact is large. Over 98 percent of the repaired leaks are associated with service connection leakage and service meters brought in for repairs have major under-registration problems.

Although a single larger diameter extension line properly buried in the street would be preferable and possibly less expensive in the long run, the NWSDB finds it difficult to provide funding for all of the extensions required. The customer is required to pay for the service connection based on the length of line, thus solving the NWSDB's extension line funding problem but results in many more kilometers of pipelines that are prone to damage and illegal tapping.

Some alternative financing method could be employed that would not encourage the development of multiple service connection lines along individual streets and the proliferation of maintenance problems. A revolving fund that would be replenished by customer payments proportional to the cost of providing a connection to individual customers might be considered to finance distribution extension line. Another possibility would be to set up "improvement district contracts" where benefiting property owners would be required to pay a pro rata amount towards the cost of the extension facility upon receiving a service connection.

Correction of the service meter flow reversal problem requires: (a) adequate 24 hour pressures in the distribution system; (b) provide effective reserve flow prevention devices; (c) ensure that the reverse flow prevention devices on existing service meters are operational; and (d) install all new service connections in accordance with appropriate back flow prevention plumbing regulations.

9.4.7 Distribution System Pressure

Although some areas do exist in the Greater Kandy water systems where excessive pressures aggravate the leakage problem, these areas are not extensive and the proposed system improvements will ensure reasonable pressures.

9.4.8 Production Metering

Only NWSDB has any capability for bulk meter calibration in the study area but this does not include repairs. It is recommended that the Udu Yatinuwara facilities be expanded to provide all bulk meter service requirements, not only for the Kandy NWSDB systems, but also for other water systems in the study area.

9.4.9 Customer Leakage and Waste

Although leakage on the customer side of the service meter is generally not considered to be the problem of the water utility, excessive water use by customers ultimately increases the water supplies to be developed.

Given the high cost of new water supplies in the study area, it is a benefit to the water utility to minimize demand by raising public awareness of this problem and enlist their support in the conservation of water by public education programs using TV spots, newspaper articles, radio commercials, posters, leaflets, public meetings and school competitions.

A recommended adjunct to this is to provide assistance to the customer in identifying sources of leakage. One technique that has met with success elsewhere is to pinpoint customers that could potentially have a problem by computer searches of the billing records which identify customers where usage has increased dramatically from the same month the previous year, or even to a level more than some percentage above their average use for the last few months. Notification to customers with a potential problem can be included with their monthly bill. Assistance to the customer in identifying and repairing sources of leakage can be provided by the water utility in the form of lists of plumbers certified to posses the skills and equipment required for the detection and rectification of leakage and waste problems.

9.4.10 Technical Assistance and Training

The establishment of an effective NRW reduction capability will require upgrading of study area water utility staff capabilities in a number of areas:

- Leak detection methods and equipment
- Bulk meter repair and calibration
- Service meter calibration
- Service connection installation and repair
- Leak repair methods and equipment
- Pipe installation methods

9.4.11 Data Collection

One important observation as a result of this analysis is that there are areas where data, essential to planning and implementation of an effective NRW reduction program, are either not available or inadequate. The information that should be collected and recorded in support of the NRW reduction program is:

- Distribution system pressures
- Leak repairs (leakage rate, type of pipe, reason for leak)
- Valves (type, last date inspected, repaired, operated, condition)
- Bulk meter flow measurements
- Service meter records
- Waste meter flow measurements

9.5 Estimated costs

A number of defects in the existing study area water systems are either responsible for the excessive NRW rates or make it difficult to identify the causes of NRW, the most important of which have been discussed above. The corrective actions are:

- Replace "bundles" of connection lines with appropriately sized distribution mains
- Provide adequately calibrated bulk meters on all sources of supply
- Repair or replace gate valves to drop tight condition
- Repair or replace ball valves on reservoirs to prevent overflow losses
- Install air valves as required to minimize service meter reversal
- Replace old pipes with excessive leakage
- Relay pipes that have not been buried to an adequate depth
- Repair or replace leaking service connection valves
- Repair or replace under registering service meters
- Install meters on all service connections
- Provide additional leak detection equipment
- Provide adequate leak repair equipment and materials
- Provide additional meter repair and calibration equipment
- Provide waste metering equipment

The cost estimate given below is based on (a) leakage detection by sounding on 70 percent of existing distribution pipes by foreign specialist; and (b) repairs of leaks is 5 percent of the distribution pipeline cost.

9.6 Implementation

The estimated magnitude of the various components of NRW reduction program presented are necessarily approximate due to the limited amount of data currently available. The recommended NRW reduction program, based upon the current estimate, should be regarded as only a starting point for development of a more detailed program. Implementation of the NRW reduction program should proceed in stages. An initial data gathering stage should be carried out to provide an adequate basis for a refined estimate of NRW components and the costs to upgrade existing facilities to the point where conventional leakage and loss detection methods can be applied. NWSDB and KMC have initiated such an analysis, but it will be some time before sufficient information has been developed. Once this information is available, development of a detailed short term and long term action plan can proceed, followed by full-scale implementation of the recommended NRW reduction program. It is suggested that technical assistance in planning, coordination and implementation of the NRW reduction program be provided to study area water utilities.

PART III SEWAGE AND SANITATION

CHAPTER 10 CURRENT SANITATION SYSTEM IN THE STUDY AREA

Sewage is discharged on-site throughout the Greater Kandy area (total population of 675,900) to 1) septic tanks and/or soakage pits, 2) latrines, primarily in the rural but also in the urban areas, and 3) wastewater treatment plants at three small developments.

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

Pumping of sludge from septic tanks and/or soakage pits is infrequent and usually only upon request. Kandy Municipal Council has two trucks for use within the KMC area and the adjoining Pradeshiya Sabha Divisions, which for a fee pump septic tanks and soakage pits. The trucks discharge at the Kandy trash dump into trenches which are then covered with earth.

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

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

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

The Hantana National Housing Scheme for public sector employees has a piped sewage system collecting both excreta and gray water and transporting it to a sewage treatment plant on the slope of Hantana Hill. At present only 460 houses have been constructed and 364 homes connected resulting in a flow much less than design. The plant was never properly commissioned and the facility appears to be poorly maintained and in disrepair. No operator is stationed at the plant and sewage appears to be passing through the plant without treatment.

The General Hospital of Kandy and the Peradeniya Training Hospital both have similar secondary treatment systems, using the activated sludge method. Neither is operated correctly and are essentially primary treatment plants. Some major hotels in Kandy, such as Suisse, Topaz, Mahaweli Reach hotels etc have their own sewage treatment plants to meet the requirements for higher ranked hotels. These plants are in operation, but not all operate effectively.

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

Only on-site sewage disposal is presently practiced in the towns of Akurana, Ampitiya, Katugastota, Kundasale New Town, Madawella, Talatu Oya, and Wattegama with effluent discharging to nearby streams used for water supply and/or irrigation of paddy fields. Removal of septic tank effluent is carried out using KMC's gully suckers but the number of operations is only three times a month on average.

Water quality analysis shows a relatively good BOD quality, but an extremely high SS concentration, which is higher than would be expected in properly maintained septic tanks. The reason for high SS is due to the overflowing of excessive septage or sludge settled at the bottom of the tank.The sewage/sludge is collected by gully suckers, which are operated by MC's and the private sector. Removal of the septage should be carried out once every year or every other year, only minimum removal has been implemented at present in the KMC area. At present, sludge collected in Kandy is disposed of in pits located at the Gohagoda dumping site.

CHAPTER 11 PLANNING FUNDAMENTALS FOR SEWERAGE SYSTEM

11.1 Service Area and Service Level

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

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

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

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

a. Large-scale commercial areas
b. High population density
c. Large-scale facilities, such as schools, hotels, housing schemes, religious and institutional, both existing and proposed
d. Conservation of the natural environment (tourist spots etc.)
e. Reduction of pollutants from water sources.

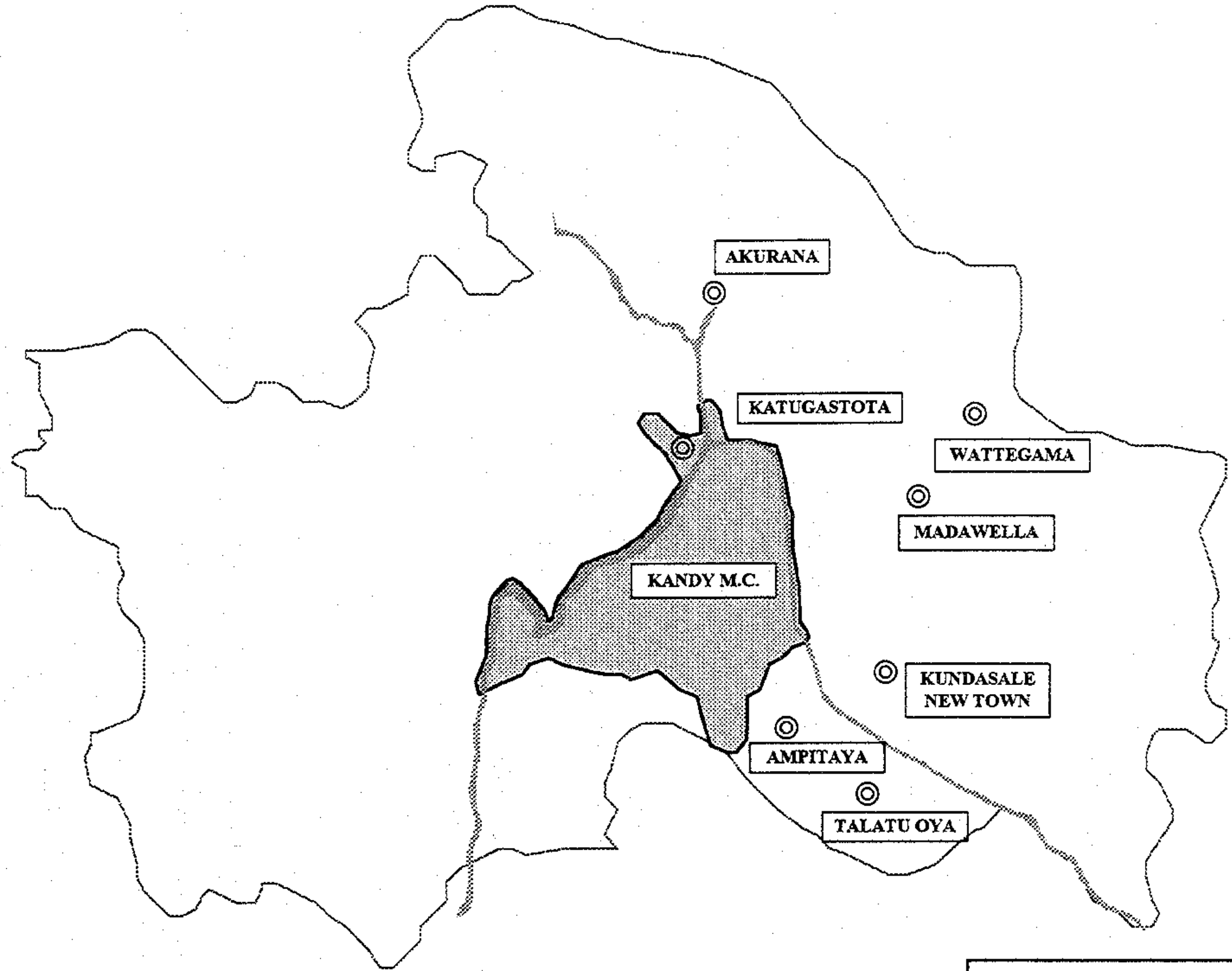


Figure 11.1

Study Area in Greater Kandy

There are several implications for provision of a public sewerage service, including 1) Cost and time requirement, 2) Accountability of executing agency, 3) Affordability of beneficiaries, and 4) Different states of urbanization by area.

The selected sewerage service area for Kandy is located around the city center commercial area, the Kandy Lake and surrounding hotels, the General Hospital, the Hanthana Housing scheme, and the commercial, institutional and housing areas along the two principal transportation routes into Kandy Municipality of Sirimavo Bandaranayake Mawatha and William Gopallawa Mawatha. The area is also located below the 600 meter elevation. Above this elevation building construction is limited or prevented by regulation. The service area for Kandy also includes the nearby towns of Katugastota and a part of Ampitiya, and covers an area of 724 ha.

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 the Kandy municipality has been estimated. The population in the sewerage service area has been determined according to the criteria developed in a previous section. The population in the service area is 54,982, or 40 percents of total projected population data in 2015, covering the area of 724 ha which is 25 percents of whole municipality area.

11.3 Design Sewage Flow

In order to obtain a design per capita sewage flow, an assumption that 80 % of water consumption is discharged to the sewerage system is made for both domestic and non-domestic water supply. Non-domestic consumption consists of consumption by shops, restaurants, hotels, offices etc., but not much by industries because of the characteristics of the study area. Because most commercial facilities are located in the downtown area of the municipality, it has been assumed that 80% of non-domestic water is consumed in the sewerage service area in 2015 and 60% in 2005. Of these amounts, 50% is consumed in the downtown area, 10% at Katugastota and the remaining portion is in other service areas.

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

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

Table 11.1 Per Capita Sewage Flow

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

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

Therefore, peak factors adopted for the Kandy Sewerage System are:

Maximum Daily / Average Daily: 1.2

Hourly Maximum / Average Daily: 1.8

Table 11.2 Design Sewage Flow

Year	2005	2015
Area (ha)	724	724
Population	49,000	55,000
Average daily Sewage Flow	12,100	15,200
Maximum daily Sewage Flow	14,100	17,800
Hourly Maximum Sewage Flow	20,300	25,500

Note: The daily and hourly maximum values of flow shown above include groundwater infiltration, which is considered to be constant.

11.4 Design Sewage Quality

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

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

Using 40 g/capita/day as the unit BOD_5 pollution load, the BOD_5 for domestic sewage was calculated at 377 mg/l, while for non-domestic BOD_5 concentration, a half of the domestic sewage, i.e. 189 mg/l, was assumed.

Sewage quality surveys were conducted to determine the status of domestic sewage during the dry season and the rainy season. The survey was carried out at three different housing types, namely high income, middle income, and low income houses, and at the Hanthana Housing Scheme where an existing sewerage system is available for sampling. The results of the sewage quality survey for domestic sewage , combined sewage at Hanthana H.S. are BOD_5: 94 mg/l, SS: 158 mg/l in March 1998 and BOD_5: 115 mg/l, SS: 210 mg/l in August 1998.

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

a. Domestic sewage (5,334 m^3/day)
   BOD_5 377 mg/l
b. Non-domestic sewage (7,565 m^3/day)
   BOD_5 189 mg/l
c. Groundwater Infiltration (2,318 m^3/day)
   BOD_5 0 mg/l
d. Mixed sewage
   BOD_5 = (377 x 5,334 + 189 x 7,565) / 15,217 = 226 mg/l say 240 mg/l

Therefore, BOD_5 of 240 mg/l and SS of 250 mg/l were adopted in this study.

CHAPTER 12 SEWERAGE AND SANITATION SYSTEM LONG-TERM DEVELOPMENT PLAN

12.1 Population and Sewage Flow

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

Table 12.1 Planning Fundamentals in Kandy

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

12.2 Conditions and Design Criteria for Facility Planning

For sewerage collection system, Manning's formula is used for the calculation of flow velocity and sewers is designed to convey peak flows. The size of the main sewer must be determined the minimum flow velocity of 0.75 m/sec to ensure the self-cleansing velocity at full flow and maximum velocity of 3.0 m/sec to protect the pipe against sewer erosion.

Sewer diameter is selected with at least 200% of the estimated flow for the diameter of 600 mm or less, while at least 150% of the estimated flow for the diameter of more than 600 mm.

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

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

Diameter of 150 to 600mm : Vitrified Clay Pipe

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

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

Planned design flow

Average Daily Flow 15,200 m^3/day

Maximum Daily Flow 17,800 m^3/day

Hourly Maximum Flow 1,063 m^3/hour (= 25,550 m^3/day)

Planned water quality

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

Phased construction (maximum daily sewage flow)

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

12.3 Selection of Optimum System

12.3.1 Sewage Collection System

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

Selection of the optimum collection system is consider 1) Construction cost, 2) Operation and maintenance cost, 3) Septage disposal, 4) Sanitation Improvement, and 5) Environmental improvement.

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

12.3.2 Sewage Treatment System

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

Among many well-developed and popular sewage treatment 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.

The select of the most appropriate treatment method is done with the consideration of such items as 1) Quality of treated water, 2) Area requirement, 3) Construction cost, 4) Operation & maintenance cost, and 5) Difficulty of operation & maintenance.

Limited land is available in Bowala, downstream along the Meda Ela, and the oxidation ditch method only is applicable for this size of land. Therefore, the adoption of the Oxidation Ditch method is recommended.

Because of serious public opposition to the construction of STP at Bowala, the KMC and the NWSDB proposed a new alternative site at Gannoruwa (refer to Chapter 15, 15.3.1). The study team conducted the examination at the new site in response to the request of the NWSDB. The results are presented in Chapter 18, and the final decision on the selection of the site should be made under the judgement of concerned authority. In this chapter, examination was conducted for the Bowala site.

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 the sludge.

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, and 3) to process the sludge for reuse (or disposal)

Considering the environmental and other conditions in Kandy MC, digestion, thickening and drying or same system followed by composting is recommended.

12.3.4 Integration/Separation of Sewage Service Area

Preliminary design for both alternatives, i.e. integration or separation is suggested for this service area has been carried out, and the locations of major facilities are shown in Figure

12.1. An outline of facilities and the construction costs for both alternatives are summarized in the same figure.

The considerations in the evaluation of two proposed alternatives are 1) Construction cost, 2) Operation and maintenance cost, 3) Man-power requirement for operation and maintenance , 4) Difficulty of operation and maintenance, 5) Influence to water sources.
Construction and operation & maintenance costs of Alternative 2 are slightly cheaper. From the viewpoint of operation and maintenance, Alternative 2 is less advantageous due to the requirement for two treatment plants, while Alternative 1 has more pumping station with a high pumping head. With regard to the influence of the to water source, Alternative 2 is more advantageous because the discharge point of the Katugastota STP is located downstream of the intake tower of the new Kandy water treatment plant. Taking into account the above considerations, it is recommended that the separate sewerage system described in alternative 2 be adopted.

12.4 Preliminary Design of Sewerage System

Layout of sewerage system in Kandy is shown in Figure 12.2.

Sewage Collection System

The summary of sewer and pumping stations are shown in the following tables.

1) Sewer

Table 12.2 Summary of Sewer Plan

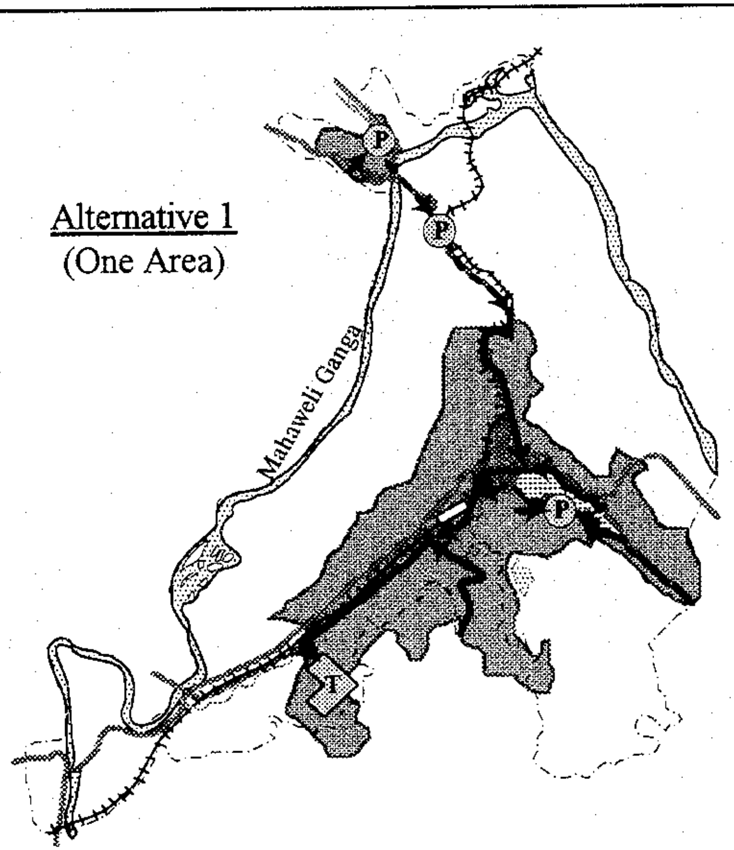
Item	Diameter (mm)	Length (m)
Clay Pipe - Lateral	150	9,300
Clay Pipe – Sewer Main	150 to 600	16,540
Concrete Pipe	675 to 825	2,870
DI Pipe	100	650
Service Connection	units	12,400

2) Pumping Station

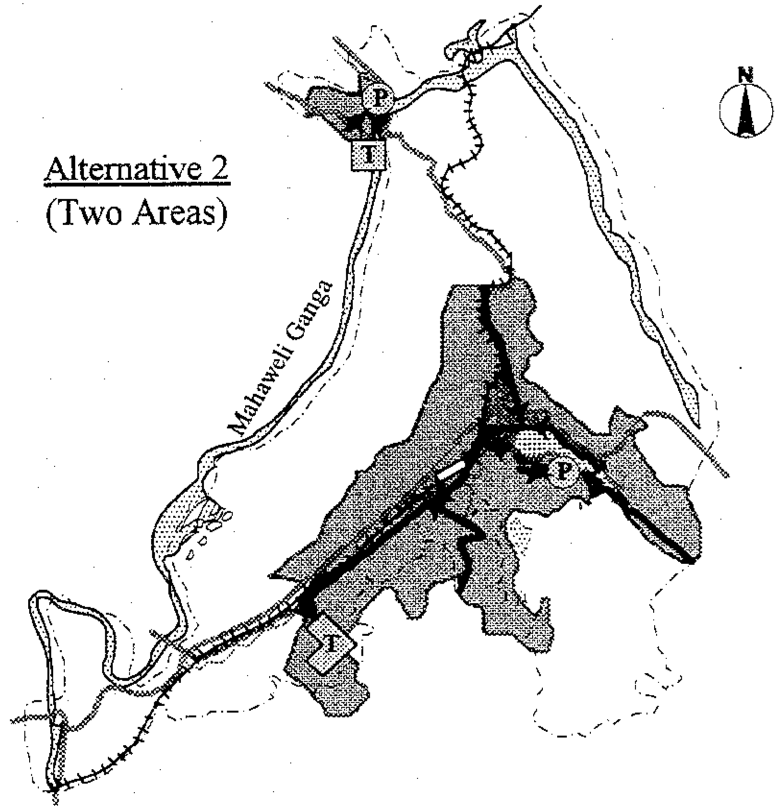
Table 12.3 Summary of Pumping Station Plan

Location	Specification
Katugastota	Submersible Pump, 1.74 m3/min, 24 m, 15 kW, 2 sets
Kandy Lake	Submersible Pump, 0.42 m3/min, 27 m, 7.5 kW, 2 sets
Kandy STP	Submersible Pump, 8.2 m3/min, 14 m, 37 kW, 4 sets Submersible Pump, 4.1 m3/min, 14 m, 18.5 kW, 4 sets

Alternative 1
(One Area)



Alternative 2
(Two Areas)



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

Figure 12.1

Alternative of Service Area

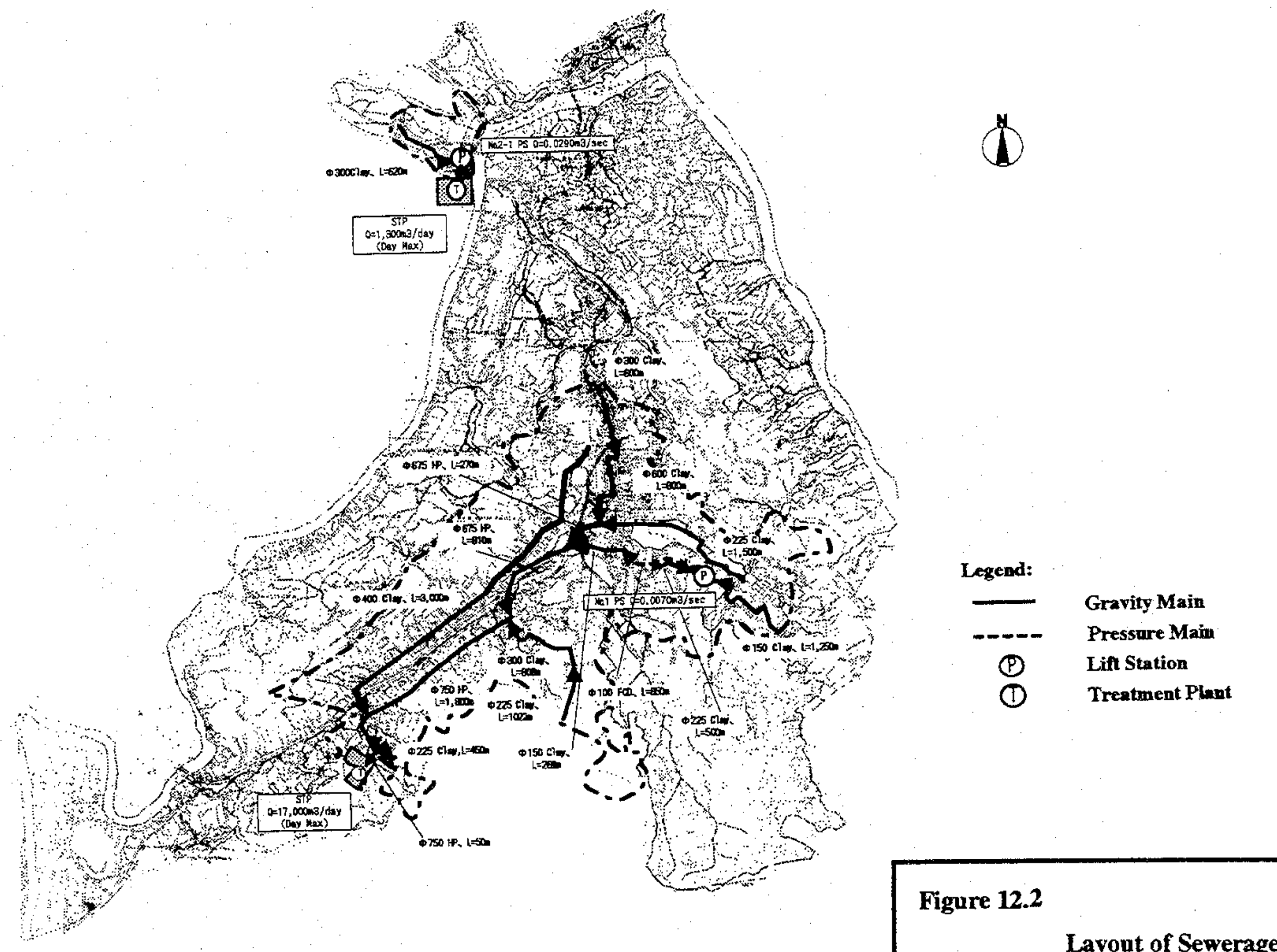


Figure 12.2

Layout of Sewerage System

Sewage Treatment System

The preliminary design for the sewage treatment plant was prepared with the following capacity.

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

(1) Layout

Since the area for the treatment plant is small and secluded by the main road and hills, the entire land can not be fully utilized. A tentative layout for the sewage treatment plant is shown in Figures 12.3 and 12.4.

(2) Specifications of Facilities

Specifications for each facility of the sewage treatment plant together with numbers, dimensions and design parameters are given in Table 12.4.

Table 12.4 Specifications of Sewage Treatment Plant

1. Kandy

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

5. Sludge Thickening Tank	
Type	Circular Type
Dimension	5.0 m Dia. x 4.0 m D
Solid Load	65 $kg/m^2/day$
Number of Basin	4 basins
6. Aerobic Sludge Digestion Tank	
Type	Circular Type
Dimension	13.0 m Dia. x 4.0 m D
Solid Load	2.4 $kg/m^3/day$
Number of Basin	2 basins
7. Sludge Drying Bed	
Type	Rectangular Type
Dimension	6.0 m W x 14.5 m L x 0.3 m D
Retention Time	10.2 days
Number of Basin	10 basins

2. Katugastota

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

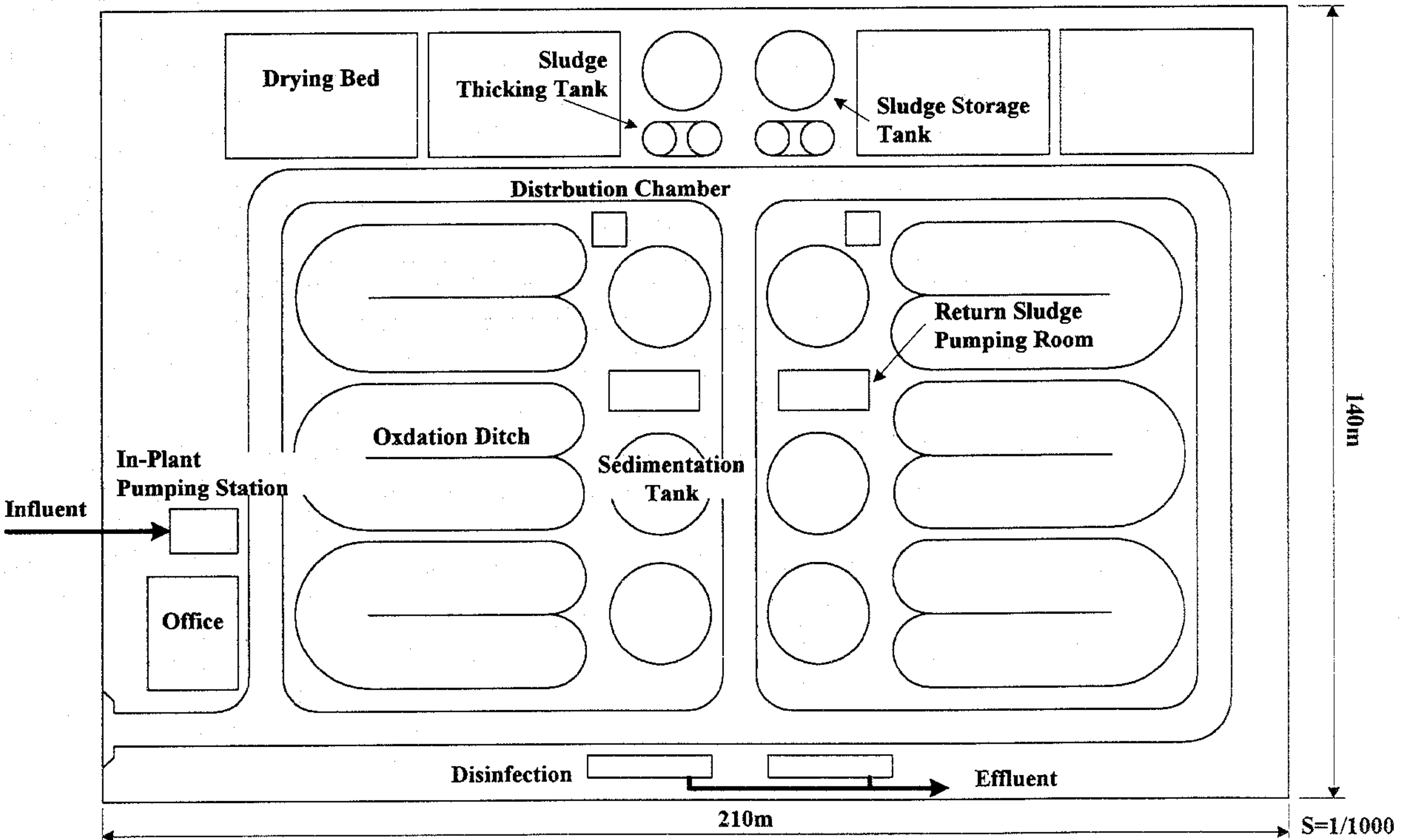


Figure 12.3
Layout of Kandy Sewage Treatment Plant

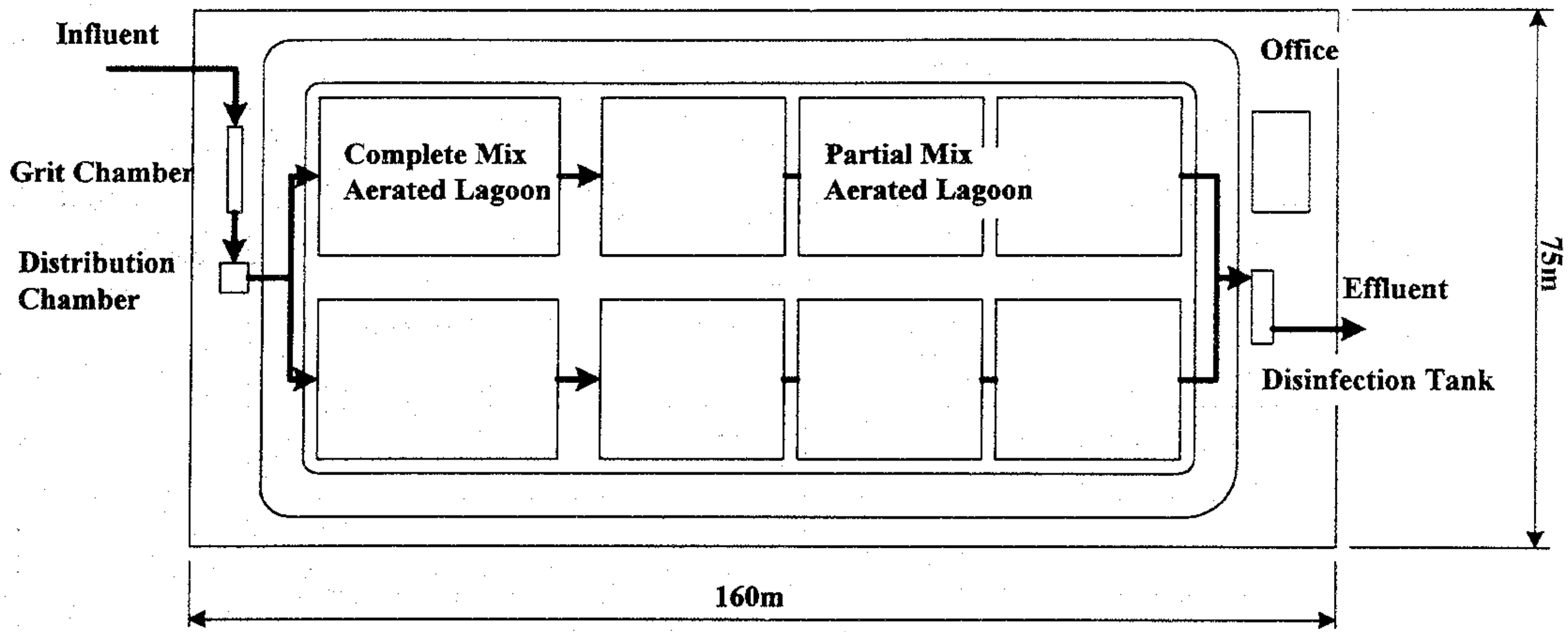


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Figure 12.4

Layout of Katugastota Sewage Treatment Plant

12.5 Sanitation Facilities

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

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

Percolation tests were conducted in August 1998 (rainy season) at three locations in KMC, namely Getambe, Hanthana and Mahayyawa.

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

Getambe and Hanthana:

Seepage pit or dispersion trench

Mahayyawa:

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

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

The population and houses which is expected to be served by on-site treatment are 106,990 in 2005 and 92,812 in 2015, also numbers of houses are 16,089 in 2005 and 13,957 in 2015, respectively.

To improve this situation, it is proposed that sludge from septic tanks and soakage pits be regularly removed, at least once in every five years. The expected sludge that will be generated daily for five years if regularly removed is 25.7 m^3 in 2005and 22.3 m^3 in 2015. 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 sewage treatment plants.

12.6 Project Cost

Composition of project cost is shown below:

<u>Project Cost</u>

- 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 %)

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

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

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

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

Table 12.5 Project Cost of Kandy Sewerage Project

Unit: Thousand Sri Lankan Rs.

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

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

12.7 Implementation Schedule

In connection with the target years of this Study (2005 and 2015), Phase 1 is an urgent and priority project which is expected to be completed by the end of 2003, while the overall project, Phase 2, will be completed by the end of 2013 (refer to Table 12.6).

Phase 1 (1999 to 2003) - Priority Project

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

Phase 2 (2009 to 2013)

2009 - 11	Preparation of project
2011 - 12	Detailed design, bidding
2012	Commencement of construction
2012 - 13	Construction
2014	Commencement of operation

Table 12.6 Project Implementation and Disbursement Schedule of Kandy Sewerage Project

Item / Phase, Year	Phase 1					Phase 2				
	1999	2000	2001	2002	2003	2009	2010	2011	2012	2013
Implementation Schedule										
1. Preparation of Project										
2. Pre-Construction Stage										
2.1 Detailed Design										
2.2 Bidding										
3. Construction										
3.1 Collection System										
- Trunk Mains										
- Sewer Laterals										
3.2 Sewage Treatment Plant										
- Civil Work										
- Mechanical/Electrical Work										
4. Procurement of Equipment										

Disbursement Schedule	**Total Cost (Million SL Rs)**	1999	2000	2001	2002	2003	2009	2010	2011	2012	2013
		Phase 1	1710.0				Phase 2	1270.0			
1. Land Acquisition	180.0			160.0					20.0		
2. Administration	20.0			2.0	4.0	4.0			2.0	4.0	4.0
3. Construction Work	1,932.0				345.0	700.0				287.0	600.0
4. Procurement of Equipment	25.0					25.0					
5. Engineering Service	146.0			45.0	15.0	22.0			36.0	10.0	18.0
6. Contingency	346.0			31.0	54.0	113.0			9.0	45.0	94.0
7. GST (12.5 %)	331.0			30.0	53.0	107.0			9.0	38.0	94.0
Total of Annual Disbursement	2,980.0			268.0	471.0	971.0			76.0	384.0	810.0

Table 12.7 Outline of Kandy Sewerage Project

Phase			Unit	Phase 1	Phase 2	Remarks
Frame Values	Service Area			City center commercial area, Kandy Lake, surrounding hotels, hospital, Hantana housing scheme , housing area along the two principal transpotation routes and Katugastota..		The values in phase 2 column shows these for the whole project.
	Target Year			2005	2015	
	Service Area		ha	271	724	
	Population		Pop	153,000	171,000	
	Service Population		Pop	19,300	55,000	
	Percentage of Service Population		%	13%	32%	
Sewage Flow	Per Capita Sewage Flow	Domestic	lpcd	86	97	The values in phase 2 column shows these for the whole project.
		Non-Domestic	lpcd	92	138	
		Infiltration	lpcd	32	42	
		Total	lpcd	210	277	
	Design Sewage Flow	Daily Average Sewage Flow	m3/d	7,300	15,200	
		Daily Maximum Sewage Flow	m3/d	8,500	17,800	
		Hourly Maximum Sewage Flow	m3/d	12,200	25,500	

Phase			Unit	Phase 1	Phase 2	Total
Facility	Planning Area			Kandy-city center commercial area , the area around the Kandy Lake ,hospital, Hantana housing scheme.	Excluding Phase 1 column in Sevice area.	—
	Sewage Treatment Plant (Kandy)	Treatment Method		Oxidation Ditch		
		Capacity	m3/d	8,500	8,500	17,000
		Facilities		Grit Chamber, Oxidation Ditch, Sedimentation Basin,		
	Sewage Treatment Plant (Katugastota)	Treatment Method		Arerated Lagoon		
		Capacity	m3/d	—	1,700	1,700
		Facilities		Grit Chamber, Complete Mixing Aerated Lagoon, Partial Mixing Aerated Lagoon, Disinfection Tank		
	Pumping Station	Submersible Pump	Nr	2	1	3
	Sewer Pipe	Lateral Sewer Clay φ150mm	m	4,500	4,800	9,300
		Trunk Sewer Clay φ150~600mm	m	13,940	2,600	16,540
		Concrete φ675~825mm	m	2,870	0	2,870
		Puressure Pipe DI φ100mm	m	650	0	650
		Service Connection	Nr	5,800	6,600	12,400
Project Cost	Construction	Direct Construction Cost	Milli. Rs.	1,045	887	1,932
		Procurement of Maintenance Equipment	Milli. Rs.	25	0	25
		Engineering Cost	Milli. Rs.	82	64	146
		Administration and Land Acquisition	Milli. Rs.	170	30	200
		Contingency	Milli. Rs.	198	148	346
		GST 12.5%	Milli. Rs.	190	141	331
		Total	Milli. Rs.	1,710	1,270	2,980
	Operation and Maintenance	Personnel Expense	Thou. Rs.	1,176	1,980	—
		Electricity Cost	Thou. Rs.	8,067	16,558	—
		Chemical Cost	Thou. Rs.	161	334	—
		Repair Cost	Thou. Rs.	3,323	6,915	—
		Tatal	Thou. Rs.	12,727	25,787	—