CHAPTER 14 OPERATION AND MAINTENANCE PROGRAM FOR SEWERAGE SYSTEM

CHAPTER 14 OPERATION AND MAINTENANCE PROGRAM FOR SEWERAGE SYSTEM

14.1 General

The appropriate operation and maintenance (O & M) of the sewerage facilities is vital not only to maintain the performance of the system, but also to prolong its service life.

The O & M program contained in this chapter presents; scope of activities, institutional set-up, task descriptions and O & M procedures. It should be noted that the requirements described in this chapter should be considered as the minimum requirements necessary to attain satisfactory levels of O & M practice and that further development of O & M activities will be subject to the progress of human resource development in this particular field.

14.2 Work Program for Operation and Maintenance

14.2.1 Sewage Collection System

There are four major O & M procedures namely, daily inspection, site investigation, pipe cleaning and rehabilitation of damaged sewers. The work items by O & M procedure are presented in Table 14.1.

Table 14.1 Work Items by Type of O & M of Sewer

O & M Type	Work Items
Daily inspection	- Operation of pumping facilities - Operation of electrical facilities
Site investigation	- Identification of damage and blockage location - Identification of the percolation point of groundwater - Investigation of the overflow point at manhole - Measurement of the volume of settled soil at the sewer bottom
Pipe cleaning	- Removal of settled soil, silt and foreign matter
Rehabilitation	- Replacement/repair of damaged sewer

O & M activities for sewers should be conducted according to the working program outlined below.

(1) Daily inspection

Pumping facilities are operated automatically according to the water level in the pump pits. Daily visiting of the pumping station is required to observe the operation of the pumps and electrical control system.

(2) Site investigation

The site investigation plan by year should be prepared to cover the entire sewered area of the municipality. The actual site investigation should be implemented in accordance with this investigation plan. Safety procedures including "Permit to Work" entry into live manholes will be followed by all staff during the investigation.

This investigation plan will be performed repeatedly and periodically, and the investigation team will describe the site condition in a daily record.

(3) Pipe cleaning program

The pipe cleaning program by year should be prepared for the entire sewered area in the municipality. A priority action plan will be formulated based upon the results of the site investigation.

Generally, there are four types of pipe cleaning methods available: high pressure jet cleaning machine; vacuum machine; bucket machine; and manual cleaning. High pressure water jetting vacuum removal of waste is recommended.

In order to perform the above activities, it is proposed that the following vehicles and equipment be purchased:

Table 14.2 Vehicle /Equipment

Vehicle/Equipment	Q'ty	Purpose
High-pressure Cleaning Car	1	cleaning of sewers
Sludge Vacuum Car	1	cleaning of sewers
High-pressure Cleaning Device	1	cleaning of storm water inlets
Dump Truck	1	transportation of sediments
Pickup Truck	1	control of cleaning works

The pipe cleaning operation for a complete sewage collection system should be performed to a comprehensive maintenance schedule. The pipe cleaning crew should record the volume and quality of the removed sediment, the method of cleaning and cleaning time in order to make improvements in future O&M activities.

(4) Rehabilitation plan

An annual pipe rehabilitation schedule, based upon the results of the investigation survey should be prepared. The rehabilitation work should be prioritized such that the sewers in most urgent need of repair are rehabilitated first.

Generally there are two types of pipeline rehabilitation, namely the complete replacement of damaged sewers or the partial repair of damaged sewers. Damages to the pipes are caused by environmental or external factors. (damaged/deformed sewer resulting from ground subsidence, adjacent construction works, overweight vehicle, and corrosion by hydrogen sulfide etc.)

Pipe rehabilitation for damaged sewers should be contracted with local contractors according to the Rehabilitation Plan. The engineer responsible for sewer maintenance should instruct the contractors to prepare a report on the extent of damage, probable cause of damage, and suggested methods for pipeline in order to assist with future O & M.

14.2.2 Sewage Treatment Plant

The proposed method of sewage treatment to be used at the sewage treatment plant is the use of an oxidation ditch. This requires relatively simple technology and less manpower for operation and maintenance. Proper operation and maintenance is however indispensable in order to realize the full performance of the equipment and meet the design life of the equipment.

In the plant, there are two types of effluent to be treated namely, sewage, and sludge. Sewage is continuously treated by the oxidation ditches, sedimentation basins and by tertiary chlorination, while sludge is treated by seasonal natural drying and removal using a wheel loader and a dump truck.

The O & M for the pump station is classified into two items, daily and periodical working. The working items by O & M types are shown in Table 14.3.

Table 14.3 Work Items of Sewage Treatment Plant by O & M Types

O & M Work	Work Items
Daily work	- Measurement of sewage flow - Removal of screenings at screen - Inspection of operation of aerators - Inspection of operation of sludge collection - Inspection of operation of chlorination facilities - Inspection of operation of electrical facilities - Removal and transfer to the sludge drying beds - Removal of dried sludge
Periodical work	- Removal of grit and sediments at grit chamber (monthly) - Inspection/repair of mechanical/electrical facilities (annually) - Overhaul of mechanical/electrical facilities (every 5 to 10 years)

The O & M for the pump station should be conducted according to the working program outlined below.

(1) Daily work program

The measurement of sewage flow is a significant item for the proper operation of sewerage facilities into the future. The screenings, soil, silt, and other substances collected at the screen and grit chamber have to be removed every day. These substances should be collected at the plant and conveyed to solid waste dumping site for disposal.

The inspection of mechanical and electrical equipment during operation is necessary for the identification of operational problems. Early identification of any problems will help extend the life of the equipment well into the future.

(2) Periodical work program

Two types of maintenance staff are required for periodical working program. The first group is ordinary unskilled workers needed to clean the tanks and basins of the plant. The second are skilled technicians required for the maintenance of the mechanical and electrical establishments.

(3) Sludge disposal

The sludge from sedimentation basins will be thickened and digested at the plant from where it will be treated by natural drying and daily removal using a wheel loader and a dump truck.

In principle, the removed sludge will be disposed of in a solid waste dumping site or landfill site.

As the sludge may contain toxic substances that originate in industrial wastewater, special attention should be paid to the disposal of sludge in agriculture areas.

(4) Laboratory

The sewage treatment plant will discharge the treated water into Meda Ela, but the treated water will have to comply with strict effluent regulations. Because the quality of the treated water will need to be checked immediately on demand, a laboratory will be facilitated within the plant, staffed by a chemist. Complicated water quality analysis will, however, be conducted by a specialist outside company under contract to the treatment plant.

The items to be tested and the required frequency of testing are indicated in Table 14.4.

Table 14.4 Water Quality Examination

Items	Regulations	O&M	Trade effluent	Remarks
(Sewage)				
Air temperature		●		
Water temperature		●	×	
Color		●		
Odor		●		
Transparency by cylinder test		●		
pH		●	×	
DO		●		
BOD	⊙	○		
COD	⊙	●		
SS	⊙	●		
Settleable solids		●	×	
Chlorides		×		by contract
Total solids		×		
Fixed solids		×		
Volatile solids		×		by contract
Dissolved solids		×		by contract
Total nitrogen		×		by contract
Ammonia (Free)		×		by contract
Ammonia nitrogen		×		by contract
Nitrate		×		by contract
Nitrite		×		by contract
Organic nitrogen		×		by contract
Phosphorus (total as P)		×		by contract
Coliform count		●		
Total colonies		●		
Fats			×	by contract
Mineral oils			×	by contract
Organic solvents			×	by contract
Individual heavy metals			×	by contract
Calcium carbide			×	by contract
Bitumen			×	by contract
Cyanides			×	by contract
(Sludge)				
Temperature		●		
pH		⊙		
Moisture content		●		
Hazardous substance		×		by contract

Note: Examination frequency

● ; more than once a day

○ ; more than once a week

⊙ ; more than twice a month

× ; as required

14.3 Organization for Operation and Maintenance

The proposed staffing for operation and maintenance personnel is 12 persons for Phase 1 and 21 persons for Phase 2, as shown in Table 14.5.

Table 14.5 Required Number of Staff for O&M of Sewage System

(unit: persons)

Field & Position		Phase 1	Phase 2	Duty
Manager		1	1	Responsible for sewage system
Sewer and Pumping Station				
Sewer	Engineer	-	1	Responsible for cleaning of sewers
	Foreman	1	1	Responsible for site works
	Worker	1	2	2 workers/team
	Driver	1	2	2 workers/team
Vehicle Maintenance*	Mechanic	-	-	Maintenance of vehicles/equipment
Sewage Treatment Plant				
Operation	Engineer	1	1	Responsible for technical matters
	Foreman	1	3	Responsible for operation of each shift
	Operator	3	6	1 (2) operator/shift
Maintenance	Technician	1	1	Responsible for site works
	Worker	1	2	Cleaning
Water Analysis	Chemist	1	1	Water quality control
Total		12	21	

* Vehicle maintenance shall be done by the Municipality workshop.

14.4 Operation and Maintenance Cost

The operation and maintenance program, as stipulated in the preceding sections, requires the following items and annual funds for proper operation of the sewage collection system and the sewage treatment plant. The detailed cost estimate is shown in Appendix 14.1.

Table 14.6 Operation and Maintenance Cost

(Unit: Thousand Rs/year)

Item	Phase 1	Phase 2
- Personnel Expenses	1,176	1,980
- Electricity Cost	8,067	16,558
- Chemical Cost	161	334
- Repair Cost	3,323	6,915
Total	12,727	25,787

PART IV ENVIRONMENTAL, INSTITUTIONAL AND FINANCIAL ASPECTS, AND CONCLUSION

CHAPTER 15 ENVIRONMENTAL IMPACT ASSESSMENT

CHAPTER 15 ENVIRONMENTAL IMPACT ASSESSMENT

15.1 Project Presentation

15.1.1 Foreword

(1) Presentation of the EIA

The present Environmental Impact Assessment (EIA) is carried out as the second phase of the Environmental Studies proposed under the Greater Kandy and Nuwara Eliya Water Supply and Environmental Improvement Project.

The need for an EIA has been identified since the beginning by the preparatory mission team of the Japan International Cooperation Agency (JICA) who visited the area in October 1997, and has been confirmed by the Initial Environmental Examination (IEE) carried out during the first project phase (January - April, 1998). Conclusions of the IEE are briefly commented hereinafter in Section 15.2.

After reviewing the IEE, the Central Environmental Authority of Sri Lanka (CEA) had initially categorized this type of project as a *"Not-Prescribed"* project. Thus, a full Environmental Impact Assessment was not required. Nevertheless, CEA gave a certain number of recommendations, which imposed a requirement for a deeper environmental analysis. Furthermore, the environmental feasibility of the project is a pre-requisite for project implementation with financial assistance by international funding agencies.

To meet these requirements, a full-scale EIA representing a substantial part of the project was undertaken. The study has been carried out by a team of local consultants, and is presented as a separate report. This chapter concerns the Environmental Impact of the project in the Greater Kandy area, and has been prepared on the basis of information and data extracted from said report

(2) EIA objectives for the Greater Kandy Area

The Environmental Impact Assessment (EIA) for the Greater Kandy Water Supply and Environmental Improvement Plan, has the following objectives:

1) To assure that the works proposed under the "Greater Kandy Water Supply and Envi-

ronmental Improvement Plan" will respect the environment and will comply with the environmental standards required by the CEA, as well as by JICA;

2) To assure that each of the proposed works will be built and operated in compliance with the same standard and requirements of the above agencies;

3) To assess the major/critical environmental aspects emerging from the Environmental Analysis conducted during the IEE phase and propose adequate mitigation measures;

4) To identify and assess all other environmental impact which may arise during construction and/or during operation, as a consequence of the specific plant design and/or location;

5) To give guidelines for the implementation of an Environmental Monitoring and Auditing Plan.

The findings and conclusions of the IEE, carried out during the first project stage, are taken as a basis for the EIA and are reported in Appendix 15.1 (IEE – Executive Summary).

15.1.2 Water, Sewerage and Sludge Quality Analysis

A water quality examination has been conducted as an integral part of the present project, to collect data on raw water quality of water supply, raw sewage, surface water-bodies (rivers and lakes) and sludge quality.

The water quality examination covers both dry and wet/rainy seasons, including the following specific surveys:

- Water quality survey
- Sewage quality survey
- River quality survey
- Lake quality survey
- Sludge quality survey

The first investigation was carried out during the months of March and April 1998. The second investigation to collect samples during the rainy season was conducted during the months of July and August 1998. Collected data are reported in Appendices 15.2 and 15.3 (for both the Greater Kandy and Nuwara Eliya), while water quality for the Greater Kandy area and the balance of contamination is discussed in Section 15.5.

15.2 Critical Project Components/Activities Affecting the Environment

The proposed project consists of a number of components and activities. Major components are briefly described here to clarity, and to help in the identification of critical impacts arising from the project. (Refer to Figure 15.1)

15.2.1 Greater Kandy Water Supply

(1) Water sources

The projected demand for domestic water supply in the year 2015, is about 169,920 m^3 per day. Existing sources will continue to supply 65,040 m^3 per day. Therefore, there is a requirement for an additional supply of 104,880 m^3 per day. The Mahaweli river is the only source that can accommodate the projected demand. It has been estimated that the minimum flow in the Mahaweli river is approximately 180,000 m^3 per day, indicating therefore this source is adequate to supply the projected demand. In the event that the minimum flow falls below 180,000 m^3 per day, supplementary supplies will be required from the Kotmale Reservoir.

(2) Project components

The proposed Greater Kandy water supply project includes the following activities and/or project components:

- Construction of a water treatment plant at Katugastota
- Construction of a water intake structure in the Mahaweli river at Gohagoda
- Trenching and laying pipes for water transmission and distribution in served areas

(3) Intake facilities

The intake facility will be constructed approximately 2 km upstream of Polgolla Dam on the left bank of the Mahaweli river to avoid any contamination from the leachate entering the river from the Gohagoda dumping yard (Figure 15.2). The facilities to be developed at the intake site are; an intake mouth and grit chambers, intake pumps and a conveyance pipeline to the treatment plant.

PROJECT COMPONENTS - CENTRAL KANDY

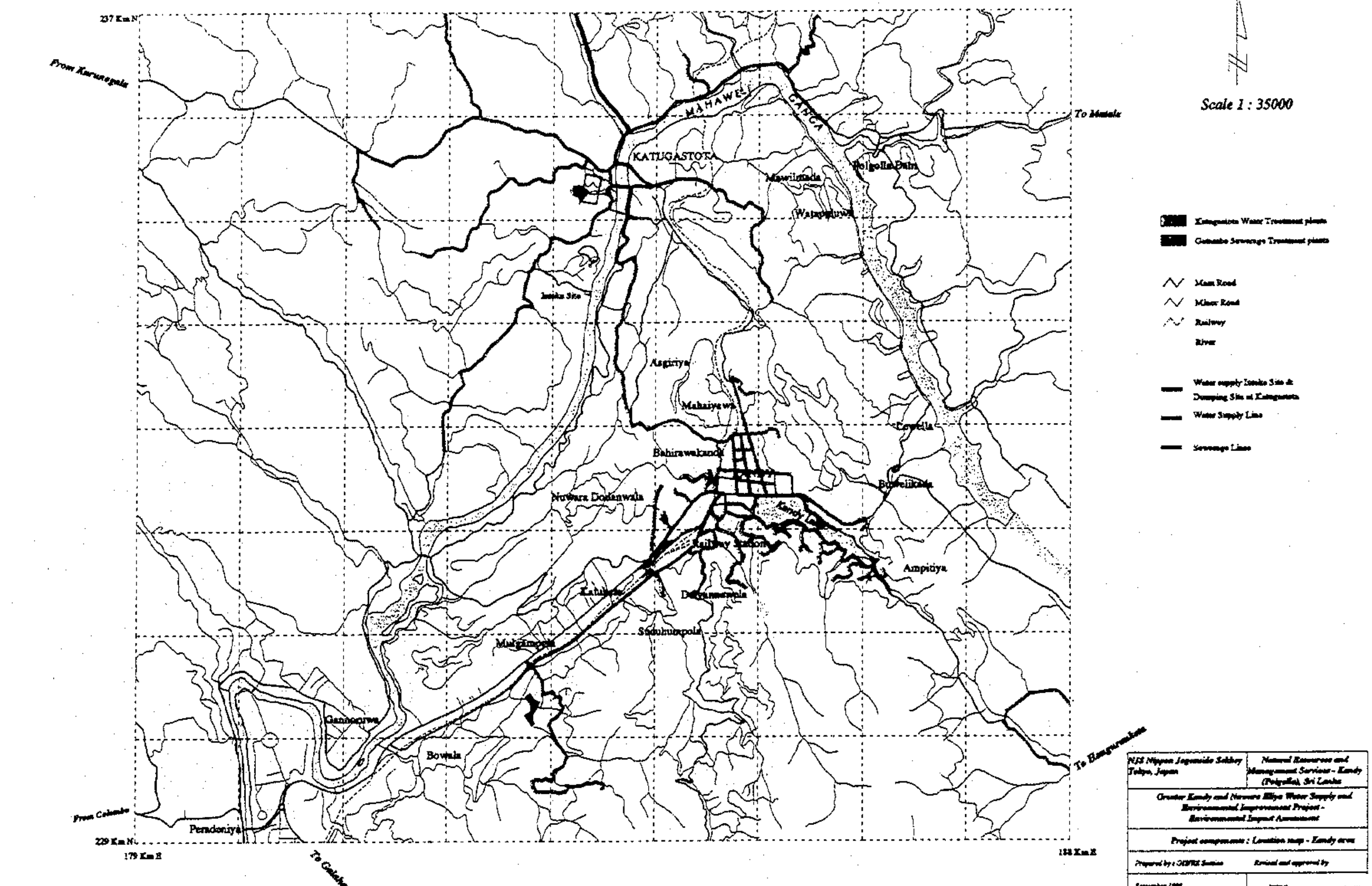


Figure 15.1

KATUGASTOTA WATER SUPPLY TREATMENT PLANT

PLANT SITE (AIR PHOTO - March 1987)

SCALE 1 : 2500

This air photo mosaic is based on the aerial photography of 1987 supplied by the Water Supply & Drainage Board, Kandy.

NJS Nippon Jogesuido Sekkey Tokyo, Japan	Natural Resources and Management Services - Kandy (Polgolla), Sri Lanka
Greater Kandy and Nuwara Eliya Water Supply and Environmental Improvement Project - Environmental Impact Assessment	
Plant Site - Katugastota area	
Prepared by : GIS/RS Section	Revised and approved by
September 1998	Drawing No

Figure 15.2

(4) Water treatment plant

It is well established that the turbidity of the river water is high. Therefore, the treatment facility will use the coagulation-sedimentation and rapid sand filtration method. The treatment plant will be developed in an area of 3.2 ha at Katugastota. An aerial view of the plant site is shown in Figure 15.3. The entire facility will be above the high flood level of the Mahaweli river.

(5) Transmission facilities and water supply pipelines

Transmission facilities will be constructed to transmit water to all zones of the Greater Kandy area. Transmission by direct pumping to existing and new distribution reservoirs will be developed. The pipe layout for the water supply is an essential element for both the water supply and sewerage system, especially in central areas. The proposed layout is given in Chapter 5, and will not be discussed further in this chapter.

15.2.2 Sewage/Wastewater Treatment

(1) Project components/activities

The proposed sewage treatment includes the following:

- Construction of a sewage treatment plant at Uda Bowala (Getambe) or alternatively Gannoruwa, to serve the central Kandy area
- Construction of a sewage treatment plant at Katugastota, to serve Katugastota and additional areas in the Greater Kandy
- Trenching and laying pipes for transmission of sewage to the treatment plants
- Connecting households and commercial properties to the sewer system

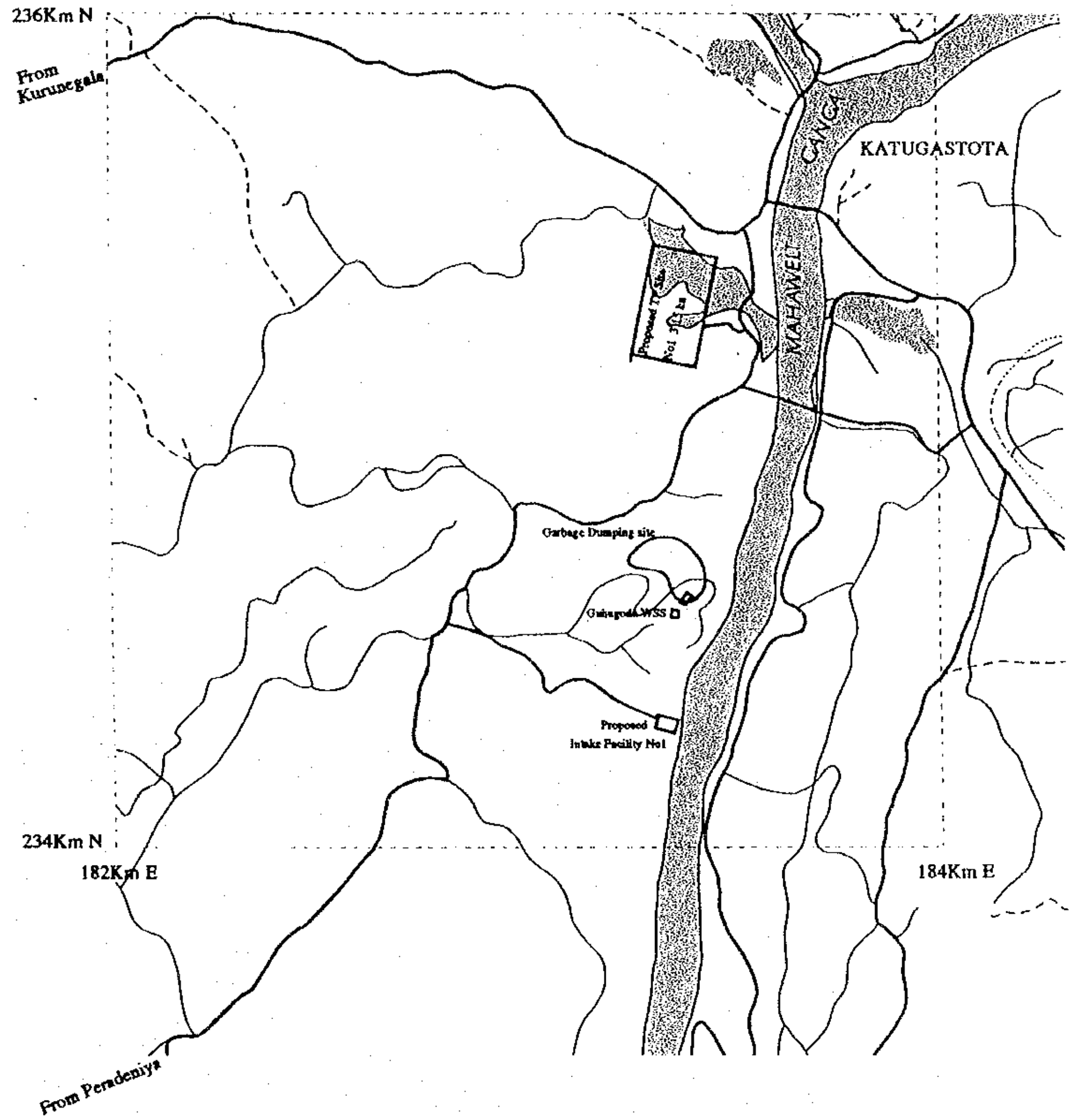
General system layout and preliminary plant design are given in Chapter 12.

An aerial view of the Uda Bowala area in Getambe is shown in Figure15.4.

The sewage treatment plant at Katugastota is in the same location as identified for the water supply treatment plant. However, it should be noted that the treatment plant to be located at Katugastota will be constructed in the Phase 2 of the project, because of the lower priority, according to the criteria used.

For the EIA purposes only the treatment plant at Uda Bowala (Getambe) was considered.

WATER SUPPLY INTAKE SITE & DUMPING SITE AT KATUGASTOTA



Main Road

Minor Road

Foot Path/Track

River

WS Intake & Dumping Sites

NJS Nippon Jogesuido Sekkey Tokyo, Japan	Natural Resources and Management Services - Kandy (Polgolla), Sri Lanka
Greater Kandy and Nuwara Eliya Water Supply and Environmental Improvement Project - Environmental Impact Assessment	
WS Intake site & Dumping site at Katugastota	
Prepared by : GIS/RS Section	Revised and approved by
September 1998	Drawing No **Figure 15.3**

WASTE WATER TREATMENT PLANT

PLANT SITE (AIR PHOTO - March 1987)

SCALE 1 : 2500

This air photo mosaic is based on the aerial photography of 1987 supplied by the Water Supply & Drainage Board, Kandy.

NJS Nippon Jogesuido Sekkey Tokyo, Japan	Natural Resources and Management Services - Kandy (Polgolla), Sri Lanka
Greater Kandy and Nuwara Eliya Water Supply and Environmental Improvement Project – Environmental Impact Assessment	
Plant Site – Gatambe area	
Prepared by : GIS/RS Section	Revised and approved by
September 1998	Drawing No

Figure 15.4

(2) Sewage treatment system

Descriptions of the sewage treatment plants are given below.

Table 15.1 Descriptions of the Sewage Treatment Plants

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

The proposed treatment process for Kandy (oxidation ditches) involves screening of the sewage to remove large objects and subsequent oxidation of the sewage. It is proposed to transport the sludge to sludge drying beds at Gohagoda garbage dumping site (the dumping site of solid waste collected from the KMC). Suitable drying beds will be constructed at this particular site as an alternative to development of drying facilities at Uda Bowala.

The aerated lagoon treatment process proposed for Katugastota includes a two-basin system and a disinfection tank designed to reduce bacteria, viruses and amoebic cysts from the effluent by the use of a chlorine solution.

15.2.3 Direct and Indirect Impact Areas (Water Supply and Sewerage)

The following direct and indirect impact areas are identified in the Greater Kandy study area.

The following can be considered as **Direct Impact Areas**:

- Water treatment plant site- 8.2 ha at Katugastota
- Water intake site, 2km upstream from Polgolla dam
- Sewage treatment plant site at Uda Bowala
- Water supply transmission pipelines and distribution reservoir locations
- Sewer pipeline and pumping stations

The following can be considered as **Indirect Impact Areas**:

- Resettlement sites (not determined)
- Municipal area
- Polgolla diversion/downstream power plants
- Downstream irrigation areas, such as Area H
- Mahaweli Ganga at the confluence of Meda Ela

- Kandy lake
- Meda Ela

15.3 Socio-Economic Impacts

15.3.1 Water Treatment Plant at Katugastota

(1) Major impacts

Major identified socio-economic impacts for the Kandy water treatment plant at Katugastota are the following:

1) Acquisition of land;
2) Loss of livelihood sources. Five parties; tenant farmers, private landowners, Kondadeniya temple, and Paththini Devalaya, servicemen of the temple and Paththini Devalaya, will be affected;
3) Aesthetic beauty of the village will be lost;
4) Grazing and open space will be lost;
5) Linkage between temple/devalaya and villagers will deteriorate.

(2) Acquisition of land

Nearly 3.5 ha of land developed for paddy cultivation and 0.3 ha of mixed crop lands need to be acquired. The cost of one hectare of land in this area is estimated at about **Rs. 6 million.**

(3) Loss of Livelihood Sources

Altogether 13 families will be affected, for which paddy cultivation is a direct source of employment, income, and food production. For seven families agriculture is the primary source of livelihood, for others it is a secondary source. This means that about 55 people, the total population of all 13 households will be directly and indirectly affected.

(4) Other Impacts

Other impacts will concern obstruction of aesthetic beauty, loss of traditional linkages between temples / devales and the villagers that have been established through land tenure, and the loss of opportunity to use these lands for animal grazing. Six families who claim their rights to land on their commitment to serve the temple/devale are reluctant to see the system changed.

(5) Compensations

The selected lands for construction of project components are private properties. For acquisition of these lands, payment of compensation to the owners / users is a necessary step prior to the commencement of any project implementation activity. The terms and conditions of compensation must be agreed by the acquisition officer after negotiation with the landowners and users.

1) Four families expect compensation in cash according to the present land price
2) Three families are prepared to accept either land or cash
3) Six families expect alternative land, either paddy or highland

The acquisition of all the required, totaling approximately six hectares, will cost a total of **Rs 36 million**, equivalent at about **US$ 600,000.**

15.3.2 Sewerage Treatment Plant - Bowala (Getambe)

(1) Population and land value

The proposed project area is located in the paddy tract between two traditional villages, Bowala and Siyambalapitiya. The paddy tract starts at the Ella-wala, the small waterfall, and extends down to Meda Ela.

The area is densely populated and both Siyambalapitiya and Bowala villages will be affected, involving **77 families and 350 persons.** The residential area will be disturbed by offensive odors and by the construction of the sewerage plant in the low-lying area.

Land value is extremely high in this area, ranging about **Rs. 16 million/ha** and the lowering of property values is a threat facing the people, and one of the strongest points of opposition.

(2) Major impacts

This is an area available for future residential expansion of Kandy city, and as such, it is undesirable to use this valuable land for utility construction.

1) Sewerage plant should not be constructed in densely populated areas such as the centers of traditional villages. Cultural concerns need to be taken into consideration.

2) Aesthetic beauty should not be destroyed. The area is more suitable for development as a place of cultural and natural beauty. Ella-wala is scenically beautiful and should be protected as part of the heritage of Kandy;

3) The opinions of local residents should not be ignored, but should be incorporated into the project concept.

4) The proposed area is too close to the heart of the municipality, which has been declared a heritage city in Sri Lanka.

(3) Public opposition

Public opposition to the project is a serious concern. Almost all the **350 residents** are involved in a ***"cold war"*** against its implementation. Posters are displayed all along the public roads, and women groups and community organizers are against the proposal.

(4) Conclusion about socio-economic feasibility

Considering the above, the socio-economic feasibility of Bowala sewage treatment plant appears to be critical. An alternative location should therefore be recommended, as discussed below.

(5) Alternative

A less problematic alternative can be identified in Gannoruwa. This is not a densely populated area and is closer to Gannoruwa Forest where air pollution is not considered a serious problem, and the land is not expensive. According to preliminary socio-economic investigations carried on during the project in this area, there will be almost no opposition to the project. Furthermore, considering the lower value of land, utilizing this location can save some Rs 15 to 20 millions for land acquisition. However, this site is located outside of the KMC, and hence there would be opposition by the residents.

This site is located across the Mahaweli river, and the sewage will need to be transmitted through a pumping station at Getambe or Bowala, and an aqueduct over the Mahaweli river will also be needed. A discharge pumping facility is also needed to transmit the treated sewage downstream of the existing intake facility of the Kandy municipal water treatment plant.

15.3.3 Land Acquisition and Compensations Procedures

(1) Legal assessment and responsibility for land acquisition in Kandy

Land acquisition and compensation to entitled persons and / or agencies are the primary impacts of the proposed project. However, the secondary impacts (socio-economic) that occur due to the project deserve major concerns, since they are much harder to mitigate. In fact, a deteriorated socio-economic environment nearly always adversely affects the physical environment.

The correct application of land acquisition procedures will help minimizing both the primary and secondary impacts of the project.

Land acquisitions for public purposes are based on the Land Acquisition Act of 1950. There are two procedures described for land acquisition for a public purpose, namely;

1) when the land acquisition to be undertake under normal conditions; and
2) when the land acquisition is urgently required.

These two procedures are described in detail in the Act and subsequent amendments (Appendix 15.1).

The final decision on land acquisition is based on the following[1]

1) Claimants eligible for compensation
2) The nature of their claim on the land identified for take over
3) The total amount of compensation for the entire land area to be taken over by the Ministry or its Agency.
4) According to Section VI of the Regulation under the Land Acquisition Ordinance, the final amount of compensation that should be paid for the claimants of the land to be taken over.
5) Share of compensation for each claimant.

Land acquisition for the water treatment plant in Kandy is the responsibility of the Divisional Secretary of Harispattuwa, while for the sewage treatment plant the necessary land acquisition is by the Divisional Secretary of Gangawata Korale. These two Divisional

[1] [1] *(Ref: Section 17 of the Chapter 460)*

Secretaries will take the necessary action to acquire the identified lands on the request of the NWSDB.

(2) Compensation for the acquisition of land

Compensation for any land acquired for a public purpose is paid as a measure to reduce socio-economic impacts, which are important factors that affect the immediate environment of the project sites.

Payment of compensation arises at two stages in the process of land acquisition namely; (i) At preliminary investigation stage, and (ii) at the stage of taking over of possession of the land by the State. Compensation is determined by the officer responsible for land acquisition in the district / Division. The second and the final compensation is determined after considering the claims made by affected persons, current market value, claimant's ownership relation to the land and any other factor that may be required for valuation under Section 17 of the Chapter 460 of the Land Acquisition Ordinance. The value of compensation determined by the acquisition officer is final.

The area of land to be acquired at the proposed water supply treatment plant site at Katugastota is about six ha. The land is presently used for agriculture. According to preliminary information, the Temple and Devale own the land, while 17 families work on the land. Part of the land is tenant cultivated, that is the real ownership of the land is with the Temple and Devale, while the user has the right to receive 75% of what is produced. The Paddy Land Act of 1958 determines this share. The other part of the land is given to the user as private ownership for Rajakariaya, therefore all rights are with the user, but he must ensure that the services assigned in return for land are provided to the Temple or Devale.

According to present information, the Temple and Devale trustees do not object to the planned acquisition. However, it is necessary to obtain the cooperation of the current land users. The land users will be socio-economically affected if the lands are taken over by the State. They will not be physically affected as resettlement does not arise, except for one or two families on the highland area. The best and most acceptable form of compensation would be alternative agricultural land of similar production potential, in the absence of which monetary compensation is needed. Considering an average cost of **Rs. 6 million per ha,** the total cost for the acquisition of land will be **Rs. 36 million,** equivalent to US$ 600,000. In addition to that, some compensation to tenants for the lost period of employment income, house moving, etc, needs to be considered. A rough estimation, adding up acquisition of land and compensation, leads to a **total amount to be paid of some Rs. 50 million.**

The sewage treatment plant site is located entirely on private land with an area to be acquired of about **1.25 ha.** The number of families likely to be affected by the treatment plant is 77[2] The number of families likely to be involved in involuntary / or voluntary resettlement is about the same. Even if resettlement can be avoided, these families will be socio-economically affected due to loss of agricultural lands. Alternative agricultural lands of similar agricultural potential within a reasonable distance of their existing land would be the best forms of compensation.

At the Uda Bowala sewage treatment plant site the amount of compensation owed to the 77 families for voluntary relocation has been estimated at between **Rs. 150-160 million.**

The overall amount to be paid for land acquisition and compensation in Kandy, including both the water supply and the sewage plant sites, is therefore estimated close to **Rs. 200 millions (US$ 3.3 millions).** This payment will be substantially reduced if an alternative site can be found for the sewage treatment plant (Gannoruwa).

15.4 Impact of Water Abstraction from the Mahaweli River

15.4.1 Availability of Water for Abstraction

The new intake site for water supply is located on the Mahaweli river, about 1 km upstream of Gohagoda, and some 4.5 km upstream of Polgolla dam. The total anticipated water abstraction rate is about 150,000 m^3/d, and this will have a direct influence on the overall water availability at Polgolla reservoir and over alternative water uses for power generation and agriculture.

The analysis of monthly inflow data at Polgolla indicates however that there is an adequate volume of water for abstraction, and impacts will be minor. As shown in Figure 15.5-1, all the monthly inflows are higher than the monthly abstractions. On average, the percentage of abstraction is about 2.85% of the total inflow; assuming that 50% of abstractions return back to the river, the actual water loss to the system will not exceed 1.43% of available water, and

[2] *77 families in the two villages objected to plant construction during the socio-economic survey.*

is therefore negligible considering the uncertainties of the analysis.

However, there may be operational problems during the dry periods, since daily flows at the time of year can be less than the abstraction requirements. According to statistical analysis of available data, daily inflows are less than the required abstraction rate with a probability ranging from 5 percent (daily low flows) to 13percent (average monthly flows at Peradeniya (Figure 15.5-2 and 15.6-1). This is not a serious problem since the flow can be regulated from the upstream reservoir at Kotmale. However, formal working arrangements must be made by the NWSDB with the Mahaweli Authority of Sri Lanka (MASL) to deal with these situations since the frequencies of such requirements are going to increase with the higher extraction rates after completion of the project.

15.4.2 Impact on Energy Generation and Agriculture

(1) Energy

A total of 150,000 m^3/d of water is to be abstracted from the Mahaweli River between the Peradeniya and Polgolla barrage. It is assumed that half of this water will return to the river because of urban drainage and that this water will not be used for irrigated agriculture. Therefore, the net amount of water unavailable (or lost) for diversion from Polgolla for power generation and irrigation is about 75,000 m^3/d.

The anticipated power generation capacity after the water supply project is completed, and the loss of energy generated for a six year period is given in Figure 15.6-2. The average annual power reduction is expected to be about 6.06 GWh/year, equivalent to an economic loss of about **Rs. 24 million/year,** considering the unit cost of energy at **4.99 Rs./kWh.**

(2) Agriculture

The water diverted from Polgolla finds its way to the irrigation schemes in the North Central Province (NCP). Inadequate water availability for irrigation is a major concern, since, even at present, water is not sufficient to cope with the design capacity of 2,000 m^3/day of diversion. MASL has agreed to provide 875 MCM annually (about 1,700 m^3/min) to the irrigation systems in the NCP through the diversion tunnel. Therefore, any reduction in this diverted water from Polgolla will have a direct impact on irrigated agriculture.

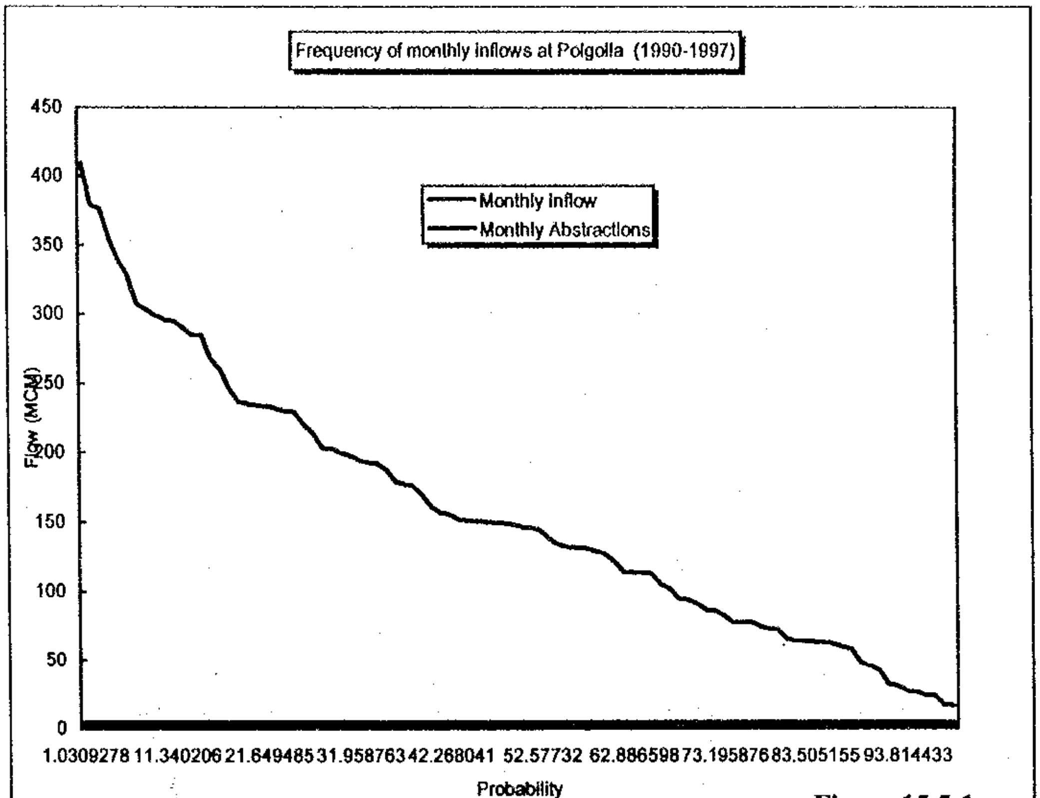


Figure 15.5-1

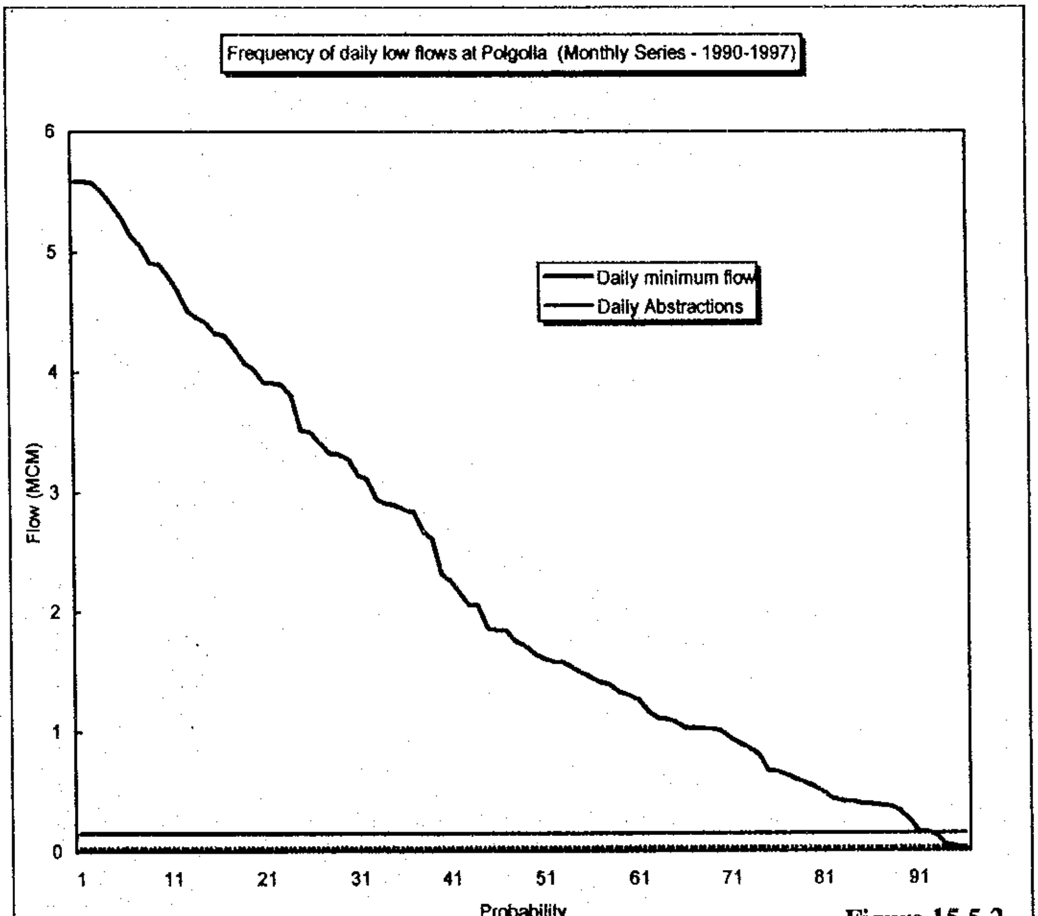


Figure 15.5-2

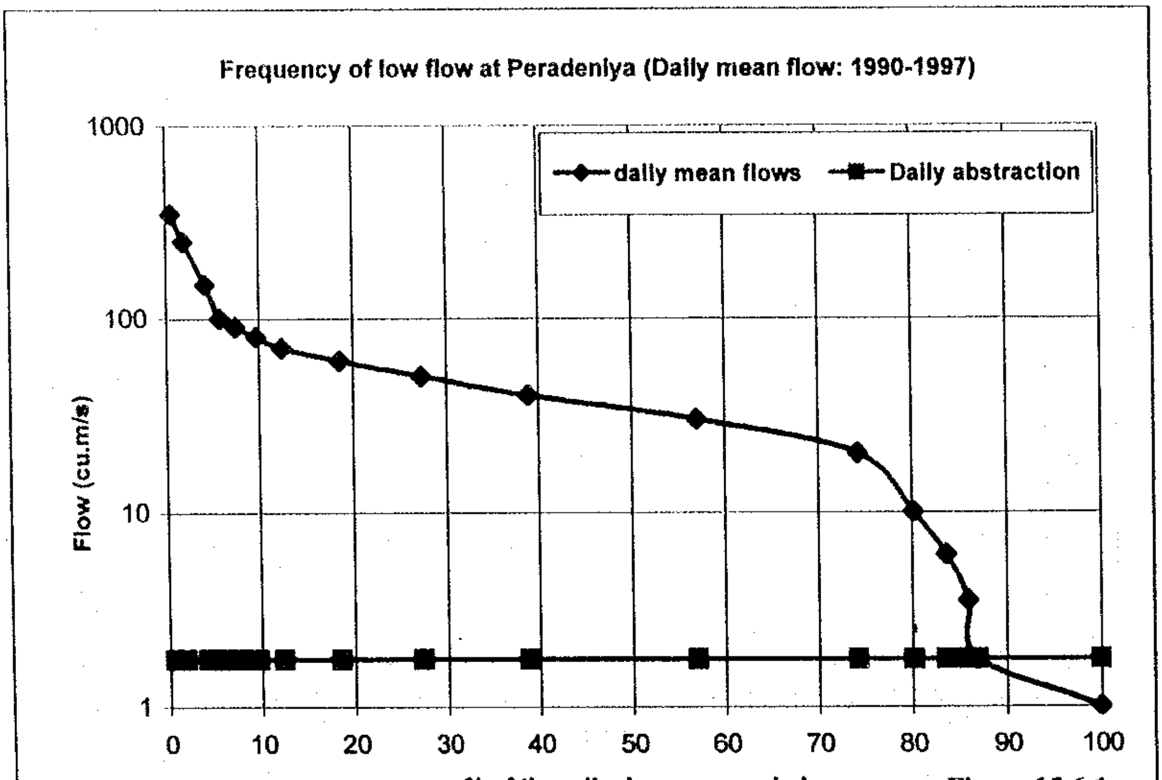


Figure 15.6-1

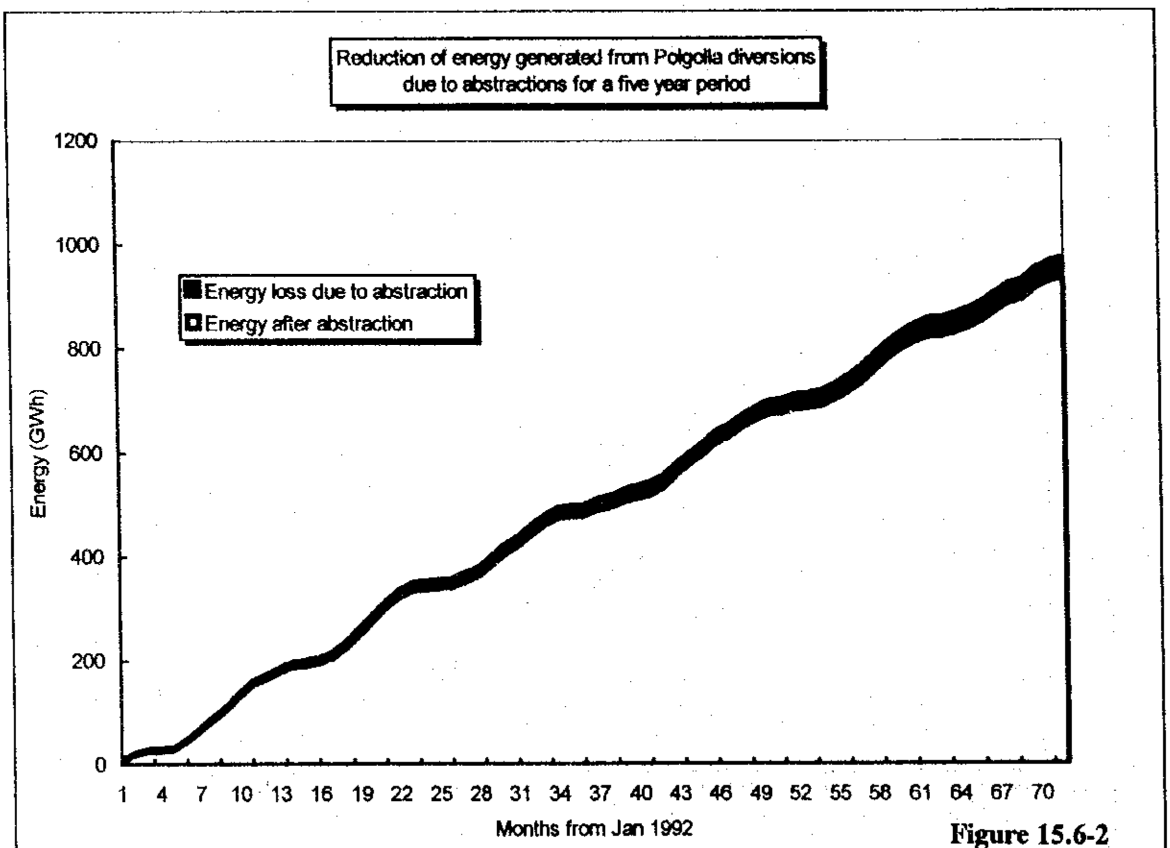


Figure 15.6-2

Assuming that the discharges from Polgolla to the downstream areas will not change in the future, the expected reduction of total diversion from Polgolla (through Ukuwela) is about 27 MCM/year, i.e. 3% of the present diversion.

As a result, some 700 ha of irrigated paddy lands could go out of production, assuming a conveyance efficiency of 75 percent and a water requirement of 3 m/ha/year. This will cost farmers about Rs. 14 million, assuming that the farmers can realize a net yearly income of Rs 20,000 from one hectare of land.

This impact can be minimized by improving water management practices in irrigation schemes (reducing water losses of say 5 percent is relatively easy).

15.4.3 Water Level Regulation at Polgolla Dam during Construction

Lowering of water level in the pool at Polgolla for a minimum period of one month is anticipated for the construction of the water intake at Gohagoda. However, during a series of meeting between the officials of the NWSDB and the MASL, the MASL would not agreed to empty the pool under any circumstance, as the impact would be detrimental in downstream areas. The construction work will therefore have to be carried out without changing the existing flow regulation procedures. A change in the design of the intake structure solves this problem.

15.4.4 Conclusions

(1) The total abstraction for water supply to the Greater Kandy area is a very small percentage of the total flow to Polgolla. Therefore, plant operation will not significantly affect water availability;

(2) It will be, however, necessary to maintain a minimum flow in the river to facilitate water abstraction during the dry period. Therefore **deliberate water releases from the Kotmale reservoir will be required** for this purpose.

(3) There is an indirect cost resulting from reduced power generation capacity and irrigation supply. However, these impacts are not very significant and can be easily mitigated.

(4) There should be no change in flow regulation at Polgolla dam during intake construction works. A careful considered construction schedule will therefore be necessary;

(5) A formal working relationship should be formulated between the officials of the NWSDB in Kandy and the head works division of MASL in Digana during construction particularly during dry periods, to avoid possible conflicts.

15.5 Water Quality Assessment and Balance of Contamination in the Major Surface Water Bodies

15.5.1 Water Quality Criteria

Remarks on water quality criteria for surface and groundwater, which are important in water quality assessment, are reported in Table 15.2.

Table 15.2 Surface and Groundwater Criteria in Water Quality Assessment

Water Quality Index	Description
pH	The pH of most natural surface water is between 6.0-8.5 although low values can occur in dilute water high in organic content, and higher values in eutrophic waters and ground water
Dissolved Oxygen	In freshwater DO at sea level ranges from 15 mg/l 0 °C to 8 mg/l at 25 °C; concentrations in unpolluted waters are usually close to, but less than 10.00 mg/l.
Free Ammonia	Unpolluted water contains about 0.1 mg/l, total ammonia is less than 0.2 mg/l; concentrations of 2 - 3 mg/l indicate high organic pollution
Nitrate	Natural levels of NO_3 seldom exceed 0.1 mg/l; polluted water contains up to 5 mg/l but often less than 1 mg/l; more than 0.2 mg/l promotes algal blooms; in groundwater it should be around 500 mg/l; concentrations in ground water is extremely high in areas subjected to intensive agriculture and livestock
Nitrite	Usually less than 0.001 mg/l, rarely reach about 1 mg/l
Phosphorus	Range in natural surface water 0.005-0.020 mg/l; average in ground water is 0.02 mg/l
BOD_5	2 mg/l in unpolluted surface water; 10 mg/l in surface water receiving wastewater; average in raw sewage is 600 mg/l and industrial waste may contain 25,000 mg/l
COD	Less than 20 mg/l in less polluted surface waters; exceed 200 mg/l in surface water receiving effluent; range in industrial effluent is 100 – 60,000 mg/l
Total coliform	Counts in rivers and lakes vary from <1 to 3,00 organisms per 100 ml ; counts in water bodies in areas of high population densities may increase up to 10 million organisms per 100 ml; natural ground waters should contain no fecal bacteria unless contaminated
Metals	Eight trace elements (viz., Cu , Cd, As, Cr, Pb, Hg, Ni, and Zn are considered as high priority; Be, Tl, V, Sb and Mo are highly toxic; concentrations of different metals in waters varies from 0.001 to 0.1 μg/l
Pesticides	Most pesticides are compounds which do not occur naturally in the environment and therefore detectable concentrations indicate pollution.

(Source: Water Quality Assessment 1992)

15.5.2 Water Quality in the Greater Kandy (Historical Data)

(1) Mahaweli River

Historical water quality data of the Mahaweli river at Peradeniya and Tennekumbura collected during 1993 show no significant organic or inorganic pollution. However, fecal contamination of the river water has been shown in recent studies. In addition, the Mahaweli river at immediate downstream of the confluence of Meda Ela has been polluted to a considerable extent due to contaminant discharge from the Meda Ela.

(2) Meda Ela

Several studies have shown significant deterioration of Meda Ela with respect to organic and inorganic pollution. There are no aquatic organisms in certain stretches except chironomids and sewage fungus which are adapted to highly polluted water. It has been shown that high concentrations of some trace elements (e.g., Pb, Cd, and V) exist in the Meda Ela and adjacent dug wells. The magnitude of pollution of the Meda Ela varies from headwaters to downstream. Concentrations of pollutants are extremely high during the dry season when it receives poorly treated hospital wastes.

(3) Kandy Lake

Several studies have shown extremely high organic and inorganic pollution in Kandy Lake (Table 15.3). Further, high concentrations of trace elements have been reported.

Table 15.3 Water Quality of the Kandy Lake (Historical Data)

Parameter	1979	1986 (NWSDB)	1991 (NWSDB)	1991 (CEA)
pH	7.14 ± 0.11	8.3 ± 0.7	6.9 ± 0.02	8-37*
EC (us/cm)	153 ± 2.16	220 ± 34	225 ± 0	6.5-7.9*
Turbidity (NTU)		13 ± 2.6	6.5 ± 1.73	
Alkalinity (mg/l)	0.2 ± 0.005	93 ± 7.5		
DO (mg/l)	7.8 ± 0.14			
Chloride (mg/l)	14.8 ± 6.75	19.6 ± 1.5		
Sulfate (mg/l)	3.86 ± 0.27	1.0 ± 0.86	6.75 ± 0.5	
Ammonia (mg/l)		0.7 ± 0.14	0.09 - 0.06	
Nitrite (mg/l)		0.19 ± 0.15		
Nitrate (mg/l)		7.76 ± 8.54	2.89 ± 0.25	0.28-0.62*
T-P (mg/l)	9.19± 4.51	0.33 ± 0.18	0.32 ± 0.18	0.37-2.1
T-Iron (mg/l)		0.11 ±.0.07	0.20 ± 0.9	
T-Coliform (MPN/100 ml)		1000 ± 408		
E-Coli. (MPN/10 ml)		833 ± 288		
BOD_5 (mg/l)				1.5 – 5.0*
T-Iron (mg/l)		100 – 420*		
Cd (mg/l)		100 - 190*		
Pb (mg/l)		100 - 390*		
V (mg/l)		6 - 32*		

*(mean ± standard deviation or * - range in 1979 (after De Silva & De Silva, 1984) and as reported by the NWSDB (1986 & 1991) and CEA (1991). Results on trace elements are modified from Dissanayake et al. 1986*

Although it is eutrophic, extremely high organic and trace metal pollution in Kandy Lake is very unlikely. Recent studies carried out on limnological aspects of Kandy Lake show stable equilibrium in biotic and abiotic characteristics of the water body. Further, aquatic biodiversity in this water body is fairly high[3].

15.5.3 Water Quality Survey Conducted in the Study

(1) Sampling sites and water quality parameters

A comprehensive survey on surface and ground water quality was carried out by the Study Team to comply with the proposed project activities. During this survey the quality of surface and ground water (e.g., raw water, river water, water from bore holes and lake water) was determined during dry weather (February – March 1998), and during wet weather (July – August 1998), at several pre-selected sites (Figure 15.7 and 15.8).

The type of water analyzed and sites where samples were collected from are shown in the following Table 15.4.

Table 15.4 WQ Survey: Type of Water and Sampling Sites

Type of Water	Sampling area
Raw Water	Kandy municipal plant's intake Apologia Dam Proposed Gohagoda Intake
River Water	Mahaweli River - University - Getambe - Polgolla - Kundasale - Gohagoda Pinga Oya Meda Ela Tributary near Polgolla
Lake Water	Kandy Lake* - Dry season two point - Wet season eight point

The following parameters have been determined for different sites during this survey using standard methods:

[3] *The high concentrations of pollution indicative parameters (e.g., T-N, T-P, BOD_5) reported in previous studies may be attributed to analytical errors.*

WATER QUALITY SAMPLING
DRY SEASON - KANDY AREA

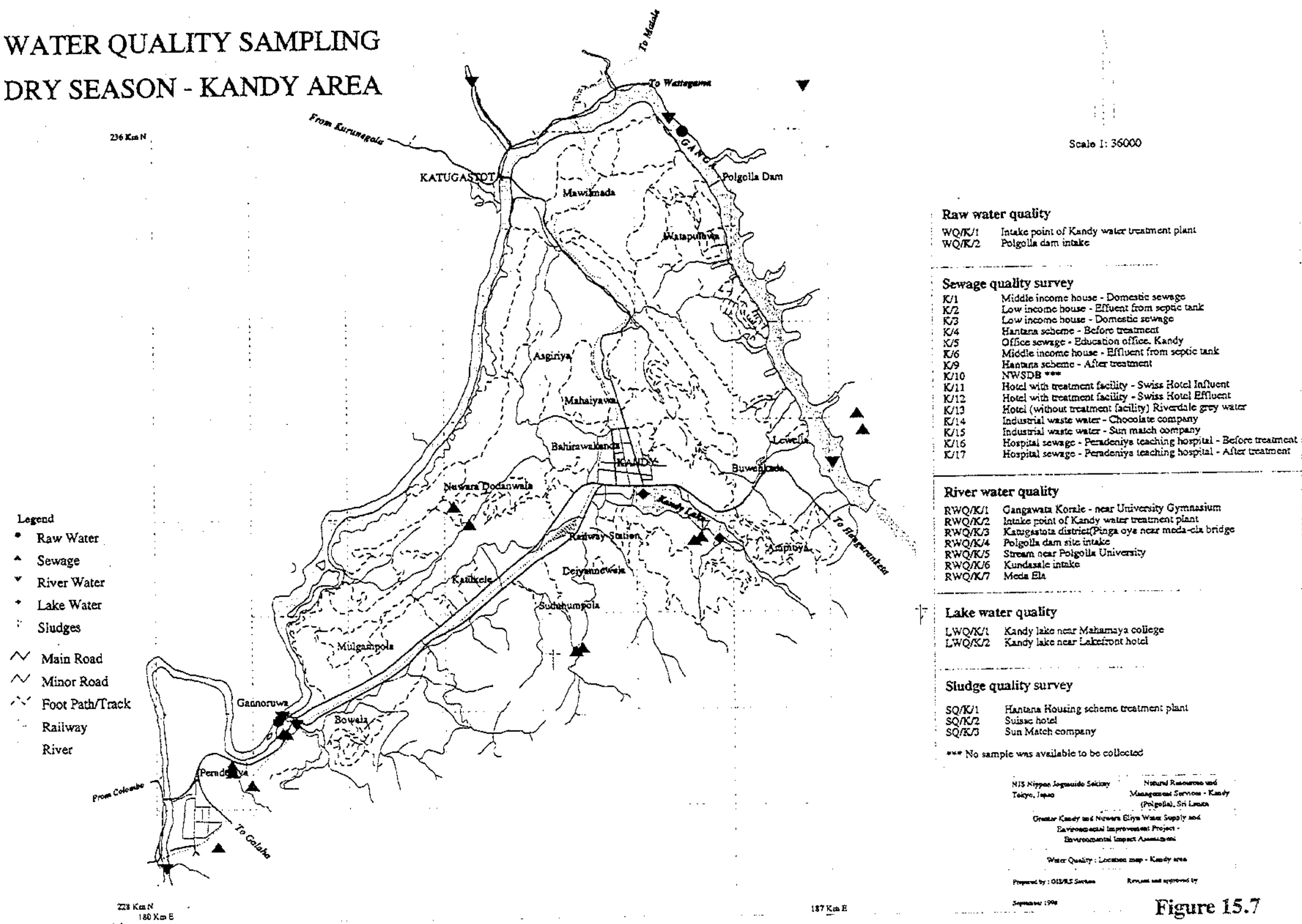
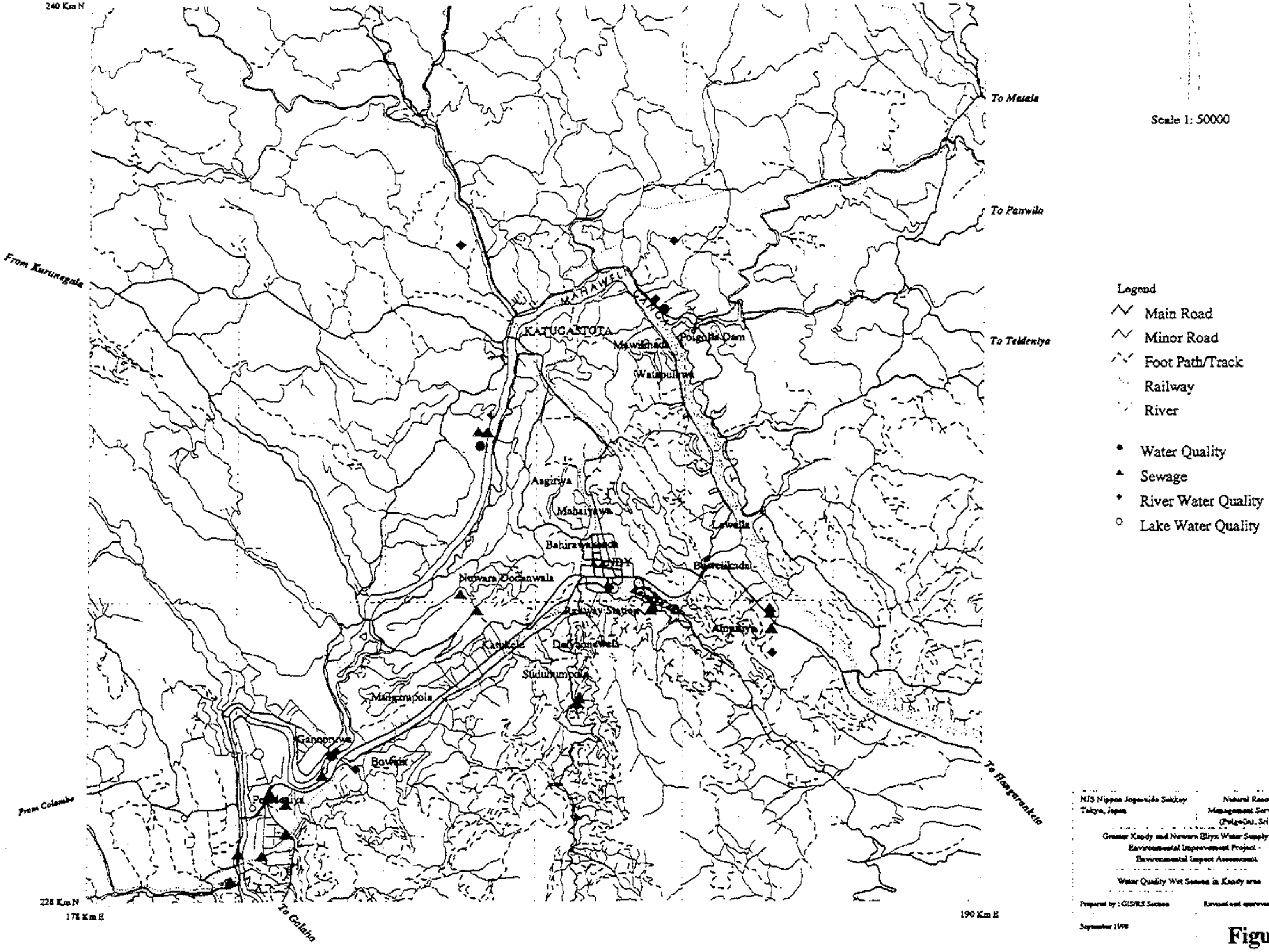


Figure 15.7

WATER QUALITY SAMPLING WET SEASON - KANDY AREA



NJS Nippon Jogesuido Sekkey Tokyo, Japan

Natural Resources and Management Services - Kandy (Polgolla), Sri Lanka

Greater Kandy and Nuwara Eliya Water Supply and Environmental Improvement Project - Environmental Impact Assessment

Water Quality Wet Season in Kandy area

Prepared by : GIS/RS Section

Revised and approved by

September 1998

Figure 15.8

- **Physicochemical:** Temperature, pH (Acidity), Alkalinity, EC (Electrical conductivity), Chloride, Sulfate, Kjeldhal Nitrogen, total Nitrogen, total Phosphorus, Nitrate, Nitrite, SS, TDS, DO, COD and BOD_5
- **Trace Metals:** Cd, Fe, Pb, Mn, Co, Zn, Cu, As, and Hg
- **Bacteriological:** Total Coliform and *E.coli*
- **Pesticides:** Thirty-four types of commonly used different pesticides in 20 water samples.

(2) Raw water quality

The Mahaweli water at Getambe and Polgolla intakes have shown acidic nature during the rainy season with extremely high concentrations of total phosphorus. Nitrate concentration was also fairly high at the proposed intake at Gohagoda. The river water shows fecal contamination and high concentrations of Mn and Fe ions within the Greater Kandy (Table 15.5).

Table 15.5 Raw Water Quality of Greater Kandy

Parameter	Site					
	Getambe Intake		Polgolla Intake		Gohagoda Proposed Intake	
	Min	Max	Min	Max	Min	Max
Turbidity (NTU)	**4.4** 11.5	**46.3** 47.1	**2.7** 11.7	**50** 54.3	10	15
PH	**6.2** 5.5	**7.5** 7.2	**6.5** 5.2	**8.2** 7.2	6.8	6.9
EC (μs/cm)	**61.4** 43.3	**81.7** 57.1	**59.8** 50.7	**84.5** 59.2	52	63
Alkalinity (mg/l)	**24.2** 8	**39.3** 22	**26.6** 16	**39.9** 35	20	21
Chloride (mg/l)	**4.2** 2.1	**7.8** 4.2	**5** 2.7	**9.3** 5.0	1.99	2.55
Free NH_3 (mg/l)	**0** 0.08	**0.2** 1.00	**0** 0.06	**0.19** 0.29	ND	0.46
Nitrite (mg/l)	**0** 0.08	**0.27** 0.27	**0** 0.08	**0.96** 0.13	0.13	0.19
Nitrate (mg/l)	**1.28** 0.17	**3.02** 4.19	**1.52** 1.32	**4.97** 2.53	3.52	4.79
Fluoride (mg/l)	**0.05** 0.02	**0.2** 0.10	**0.04** 0.02	**1** 0.33	0.15	0.16
Phosphate (mg/l)	**0.32** 0.91	**1.1** 4.04	**0.64** 1.58	**1** 6.85	1.51	2.15
Sulfate (mg/l)	**1.13** 1.3	**3.41** 2.4	**1.21** 0.7	**2.68** 5.8		0.7
T-Coliform /100 ml	**400** 100	**>1000** >1000	**160** 200	**960** >1000	100	1100
E.coli /10 ml	**70** 20	**>1000** >1000	**40** 60	**340** 480	32	260
Mn (mg/l)	**0.06** 0	**0.22** 0	**0.06** 0	**0.25** 0	0	0
T-Iron (mg/l)	**0.4** 0	**0.6** 3.42	**0.2** 1.8	**1** 1.94	0	0

(3) Surface water quality

In general, suspended solids content in river water and streams draining into the Mahaweli river was high during the rainy season. In contrast, water analyzed from the Polgolla dam site has shown high concentration of SS during the dry season compared to the rainy season (Table 15.6). Extremely high concentrations of total nitrogen have been reported for the Mahaweli river and its tributaries within the Greater Kandy. Analytical results also show high concentration of zinc and iron in water samples analyzed from the Mahaweli river, Meda Ela, and Kandy Lake. With respect to the reported values of BOD_5 during this study it has to be considered that the Mahaweli river, Meda Ela and Kandy Lake have been highly polluted by organic matter.

Table 15.6 Surface Water Quality - Greater Kandy

Parameter	Site								
	PN	GT	PD	KI	TR	PO	ME	G	KL
pH	**6.4 - 7.1** 5.4 - 5.7	**6.2 - 7.1** 5.0 - 5.5	**6.4 – 6.8** 5.4 – 5.6	**6.5 - 7.2** 5.0	**6.7 - 6.8** 5.0 – 5.2	**6.5 - 6.7** 5.2 - 6.2	**6.5 – 6.6** 5.6 – 6.4	7.4	**7.3 - 8.9** 7.8 - 8.6
EC (µS/cm)	**63 - 64** 49 - 68	**61 - 64** 51 - 57	**69 – 200** 260	**82 – 92** 54 – 56	**69 – 280** 58	**184 – 200** 116 – 145	**404 – 500** 400 – 540	111	**230 - 260** 230 - 276
COD (mg/l)	**24 - 32** 8	**24 - 32** 8 - 32	**24 – 48** 8 – 32	**24 – 44** 8	**24 – 32** 8 – 16	**28 – 40** 4 – 32	**40 – 52** 24 – 49	17	**5 - 7** 30 - 76
BOD_5(mg/l)	**3.0 - 3.2** 3.2 - 4.2	**2.0 - 5.7** 1.2 - 1.7	**3.4 – 5.5** 3.2 – 6.4	**1.7 - 3.2** 3.2 - 4.2	**2.2 - 4.7** 3.2 – 4.7	**4.2 - 4.7** 4.2 - 4.7	**6.0 – 8.2** 7.7 – 8.2	1.2	**8.0 - 28** 0.2 - 6.8
DO (mg/l)	**5.3 - 7.5** 7.3 - 7.5	**2.2 - 5.8** 7.2 - 7.9	**1.0 – 4.9** 3.4 – 4.5	**5.3 - 6.3** 7.3 - 7.6	**1.4 - 3.6** 6.4 – 7.0	**1.0 - 2.2** 4.2 - 4.8	**0.3 – 3.6** 0.3 – 8.0	7.6	**6.5-11.8** 6.3-12.8
SS (mg/l)	**130 - 142** 10 - 60	**130 - 175** 10 - 110	**143 – 188** 20 – 30	**110 – 123** 150 – 120	**121 – 145** 20	**172 – 201** 70	**258 – 273** 20 – 30	113	**62 - 76** 9 – 78
Chloride (mg/l)	**4.1 - 5.5** 3.2 - 4.3	**4.0 - 4.6** 3.5 - 4.2	**4.0 – 4.9** 17.9 - 7.1	**5.1 - 6.0** 3.1 - 2.8	**19.9 - 21.3** 13.5 - 3.2	**21.3 - 22.9** 7.1 - 6.3	**50.1 - 93.3** 17.8 - 44.7	6.9	**38.9 - 43.7** 10.2 - 14.8
Sulfate (mg/l)	**1.9 - 2.3** 1.2 - 2.1	**2.1 - 3.3** 1.6 - 1.8	**2.1 – 2.6** 1.4 – 1.6	**2.9 - 3.4** 2.4 - 6.2	**1.3 - 1.4** 1.9 – 5.5	**1.6 - 4.1** 2.3 - 1.5	**6.8 – 10.4** 13.0 - 6.4	1.5	**5.0 - 7.7** 2.2 - 12.8
T-Nitrogen (mg/l)	**3.7 - 4.3** 3.6 - 9.9	**2.2 - 5.3** 5.1 - 11.0	**4.5 – 4.9** 12.3 - 2.5	**3.9 - 4.2** 7.1 - 2.8	**6.9 - 7.6** 1.5 – 16.4	**6.1 - 6.6** 2.6 - 9.2	**15.4 - 16.2** 12.0 - 5.6	6.27	**20.0 – 35.0** 8.9 - 16.4
T-Phosphorus (mg/l)	**1.3 - 1.5** 0.2 - 0.7	**0.8 - 0.8** 0.6 - 0.9	**1.4 – 1.7** 0.7 – 1.1	**1.2 - 2.4** 0.8 - 1.6	**1.7 - 1.9** 0.9 – 0.7	**1.6 - 1.8** 0.9 - 0.5	**1.3 – 1.8** 0.4 – 0.9	1.19	**0.9 - 1.4** 1.2 - 2.6
T-coliform /100ml	**2.5 - 10** 17 - 24	**1 – 8** 13 – 22	**1 – 10** 22 – 17.5	**2.2 - 2.5** 8 – 19	**6 – 10** 20 – 13	**>10** 7 – 14.5	**2 – 10** 14 – 30	26	**2 - 5** 30 – 350
E.coli /100 ml	**10 – 50** 60 - 120	**7 – 15** 80 – 110	**2 – 100** 100 – 120	**8 – 10** 100 – 135	**25 – 100** 20 – 110	**>100** 9 – 120	**4 – 100** 100 – 120	120	**1.2 – 5** 100-1400
Zn (mg/l)	**0.02** 0.02	**0.01** 0.02	**0.01 - 0.02** 0.01 - 0.02	**0.01** 0.13	**0.01** 0.14	**0.01 - 0.06** 0.02	**0.02 - 0.06** 0.21		**0.06 - 0.10** 0-1.96

(Mahaweli River at PN-Peradeniya, GT- Getambe, PD-Polgolla Dam, KI-Kundasale Intake, and GH-Gohagoda,) TR-Tributary of Mahaweli, PO-Pinga Oya, ME-Meda Ela, KL-Kandy Lake)

A Synthesis of water quality examination carried out by the Study Team and NWSDB in the Greater Kandy area is shown in the following Table 15.7.

Table 15.7 Synthesis of Water Quality Examination carried out in the Greater Kandy Area by the Study Team and NWSDB

Type of Water	Parameter								
	pH	DO	Free NH_3	T-N	T-P	BOD_5	COD	Coliform	Metals
Raw Water									
Getambe	min. low		Normal	High	High			High	ND
Polgolla	min. low		Normal	High	High			High	ND
Gohagoda	min. low		Normal	High	High			High	ND
Surface Water									
Mahaweli River									
Peradeniya	min. low	Normal		High	High	Mod.	Mod.	Normal	High*
Getambe	min. low	min. low		High	High	Mod.	Mod.	Normal	High*
Polgolla	min. low	min. low		High	High	Mod.	Mod.	Normal	High*
Kundasale	min. low	Normal		High	High	Mod.	Mod.	Normal	High*
Gohagoda	Normal	Normal		High	High	Mod.	Mod.	Normal	High*
Tributary	min. low	min. low		High	High	Mod.	Mod.	Normal	High*
Pinga Oya	min. low	min. low		High	High	Mod.	Mod.	Normal	High*
Meda Ela	min. low	min. low		High	High	Mod.	Mod.	Normal	High*
Kandy Lake	Normal	Normal		High	High	Mod.	Mod.	High	High*

15.5.4 Sewage, Industrial Effluent and Sludge Quality

The Study Team also examined the quality of various type of sewage (i.e., different socio-economic classes), effluents from septic tanks, hospitals, the brewery and some industries located in the Greater Kandy and the Nuwara Eliya areas. Irrespective of the category, raw sewage contains a large amount of BOD_5, SS, T-N and T-P (Table 15.8). The effluent from different septic tanks also contained usual amounts of the above mentioned, organic wastes. However, BOD_5, SS, T-N, and T-P values of effluent released from both the Kandy and the Nuwara Eliya hospitals and several industries were relatively low compared to standard values. This may be attributed to specific conditions registered at the date and time of analysis, and cannot be considered as indicative of a permanent situation. Therefore, standard values are used for the computation of contaminant loads in this environmental assessment.

Table 15.8 Sewage and Industrial Effluent Quality in Greater Kandy Area

Type	Parameter			
	BOD_5	TSS	T-N	T-P
Sewage Quality				
Lower income	111	333	86.7	16.6
Middle income	220	239	165	1.62
High income	222	1,067	207	178
Office sewage	103	192	50.3	4.40
Hotel sewage	156	136	54.5	12.4
Effluent/Septic Tanks				
Lower income	39.5	118	93	2.7
Middle income	141	1,990	172	10.4
High income	124	2,140	95.0	6.8
Office	43.0	289	16.9	2.28
Hospital Effluent				
Hospital Effluent	50.0	34.7	54.0	4.10
Industrial Effluent				
Sun Match Factory	109	196	113.6	4.85
Chocolate Factory	345	681	31.0	5.40
Gohagoda Landfill	3.2	2.73	2.23	8.15
Gohagoda Landfill	3.1	201	174.4	8.00

The quality of sludge analyzed from different sources varies within a wide range is shown in Table 15.9. The highest content of total SS (385.1 mg kg^{-1}) was found at Peradeniya Hospital. Similar trends could be seen with respect to T-N and T-P in sludge.

Table 15.9 Sludge Quality of Greater Kandy

Site	Parameter					
	Water Content (mg/g)	TSS (mg/g)	VSS (mg/kg)	T-P (mg/kg)	T-N (g/kg)	Zn (mg/kg)
Hantana scheme	5.84	52.82	5.18	14.35	24.1	
Swiss Hotel	60.38	24.01	2.27	12.56	38.4	
Match Company	3.32	2.28	2.2	19.3	1.96	
Univ. Senate	462.1	369.2	20.2	6.0	8.3	0.19
Peradeniya Hospital	172.2	385.1	30.7	13.0	5.38	0.67
Meewatura*	517.3	174.3	8.6	2.35	5.95	0.01

**Meewatura-University Treatment Plant*

The efficiency of treatment facilities presently operating in the Greater Kandy is shown in the following Table 15.10

Table 15.10 Efficiency of Treatment Facilities Presently Operating in the Greater Kandy

Site	Parameter			
	BOD_5	SS	T-N	T-P
Hantana Scheme				
Before Treatment	119	199	53.4	10.8
After Treatment	30.6	168	61.3	6.46
% Efficiency	73	15.5	--	--
Hotel Swiss			70.2	8.33
Before Treatment	134	128	48.9	9.88
After Treatment	29	133	--	--
% Efficiency	78.3	Negative		
Peradeniya Hospital				
Before Treatment	70.9	457	32.7	8.83
After Treatment	65.1	300	20.5	9.37
% Efficiency	8.2	34.3	--	--

15.5.5 Contaminant Balance and Impact Assessment

(1) Water quality modeling

The impacts of the implementation of the proposed project on major surface water resources in the Greater Kandy have been quantified using water quality modeling. Contaminant concentration (BOD_5, DO, T-N and T-P) in the Meda Ela in the Greater Kandy were computed for above different phases using a one-dimensional (linear) modeling approach. The concentrations in Kandy Lake were computed using the complete mixed system approach.

The general mass balance equation under steady condition together with the single first order kinetic equation for the decay process of the constituents are the governing equations of the models. The saturated dissolved oxygen in water is based on the Henry's equation. Details of the models and the validations are given in the main EIA report prepared by the local consultants.

(2) Water bodies considered in the present analysis

The following water bodies have been considered for the Greater Kandy in the present analysis:

- **Meda Ela:** a 4.0 km stretch, from its beginning at the outflow of Kandy Lake, to the confluence with the Mahaweli River at Getambe.
- **Kandy Lake:** Kandy Lake, as well as Lake Gregory in Nuwara Eliya, is considered as "complete mixing". That means that the level of contaminants is supposed to be

the same all over the lake's surface. Contaminant loads and water quality modeling are therefore computed for the whole water body.

(3) Computations of contaminants load

A comprehensive survey was conducted in both the Greater Kandy and Nuwara Eliya, during the month of September, 1998, to identify the various sources of contaminants with respective location and type, and the quantity of contributing wastewater and drainage flows[1] into the water bodies directly or through infiltration. For the streams, the contaminant loading rates and water flows rates were considered as continuous point sources at 30m intervals. For lakes, the contaminant loads from the streams flowing into them and from the direct and infiltration flows from the perimeter were used.

The following information was collected during this survey:

- Type of building: house, office, school, hospital, and hotel, restaurant public latrine
- Type of disposal: septic tank, pit latrine, direct, treatment plant
- Number of inhabitants: only during the daytime and permanent (day and night);
- Type of water used: municipal pipeline system, dug well, stand-posts.

Quantification of contaminant discharge flow rates into respective water bodies was based on the standard rates and the proportion given in the Table 15.11

Table 15.11 Pollution Load Evaluation

Type	Flow Rate (l/capita/day)	Quantity of Contaminant (g/capita/day)		
	Q	N	P	BOD_5
Day time occupant Day & night occupant	60 120	2.5 7.0	0.5 1.0	15 40
% infiltration from pits within 0 – 15 m within 15 – 30 m	% 90 60	% 20 05	% 20 05	% 10 00
Public latrine Excretion (g/capita/day) Urination (g/capita/day)	 30 15	 2.0 0.4	 0.2 0.005	 20 05
Wastewater drains (mg/l) Stream drainage (mg/l)	- -	04 0.5	01 0.1	30 02

(4) Simulated scenarios

The following scenarios are considered to explain the impact of the implementation of the proposed project on surface water resources in the Greater Kandy and Nuwara Eliya.

Phase 0: present status of water quality;

Phase 1: **30%** of the population and all sewage inflows, public latrines and the other direct connections are connected to the sewer system;

Phase 2: another **60%** of the population (i.e., **90%** of the total population) is connected to the sewer system;

Predictions are based on the above-specified Water Quality Modeling. Concentrations of BOD_5, DO, T-N and T-P were computed for the Meda Ela using one-dimensional modeling approach, and for the Kandy Lake was computed using the complete mixed system approach.

(5) Modeling results and prediction of water quality improvement

1) Meda Ela in Kandy

As shown in Figure 15.9 and 15.10, the organic and inorganic pollution will be reduced progressively with implementation of phase 1 and the phase 2 of the project. This will enhance colonization of aquatic communities along the course of the Meda Ela and perhaps riverine fish may also re-colonize. In addition to Meda Ela the water quality of the Hali Ela will also improve to a greater extent. The improvement of the water quality and river ecosystem will enhance both aesthetic and socio-economic values of this running water system.

2) Kandy Lake

It has been shown that the organic load will be decreased only slightly in Kandy Lake since it is a well mixing water body. Table 15.12 shows computed values for T-N, T-P and DO at present and with the implementation of phase 2 during wet and dry weather condition. This will ensure ecological stability and equilibrium for Kandy Lake.

Table 15.12 Changes in T-N, T-P and DO in Kandy Lake with Implementation of the Project (Average Values)

Parameter	Wet Weather		Dry Weather	
	Present	Phase 2	Present	Phase 2
T-N	2.31	2.30	2.6	2.3
T-P	0.01	0.007	0.003	$1x10^{-5}$
DO	6.5	6.6	6.9	7.0

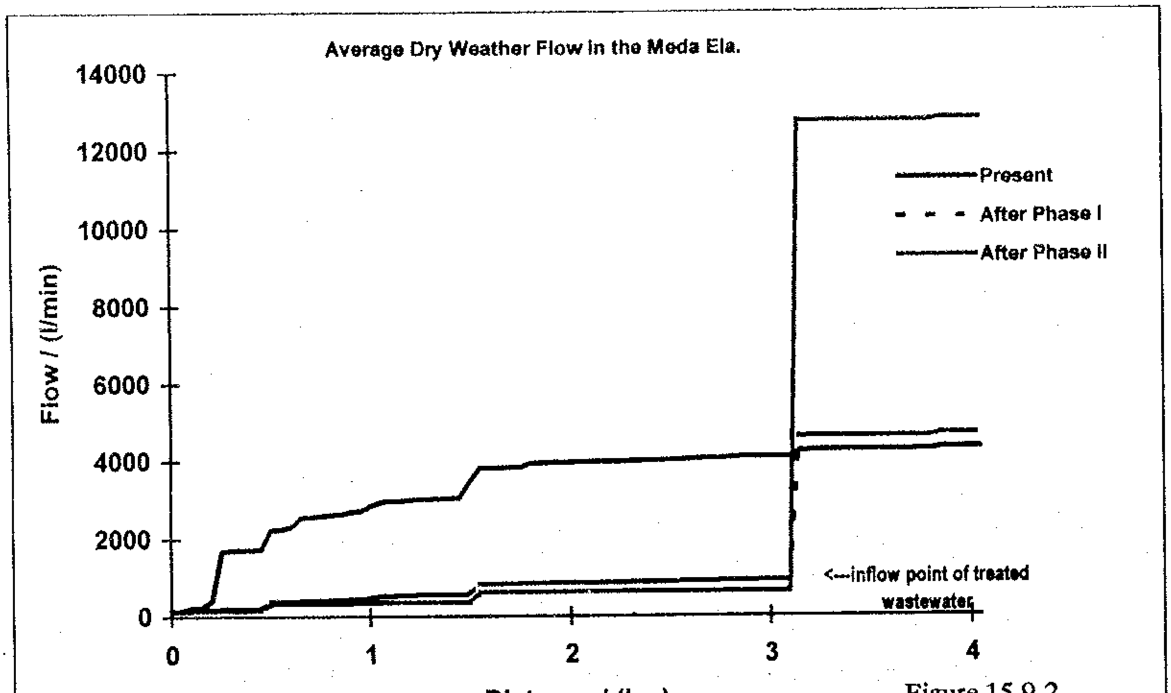


Figure 15.9-2

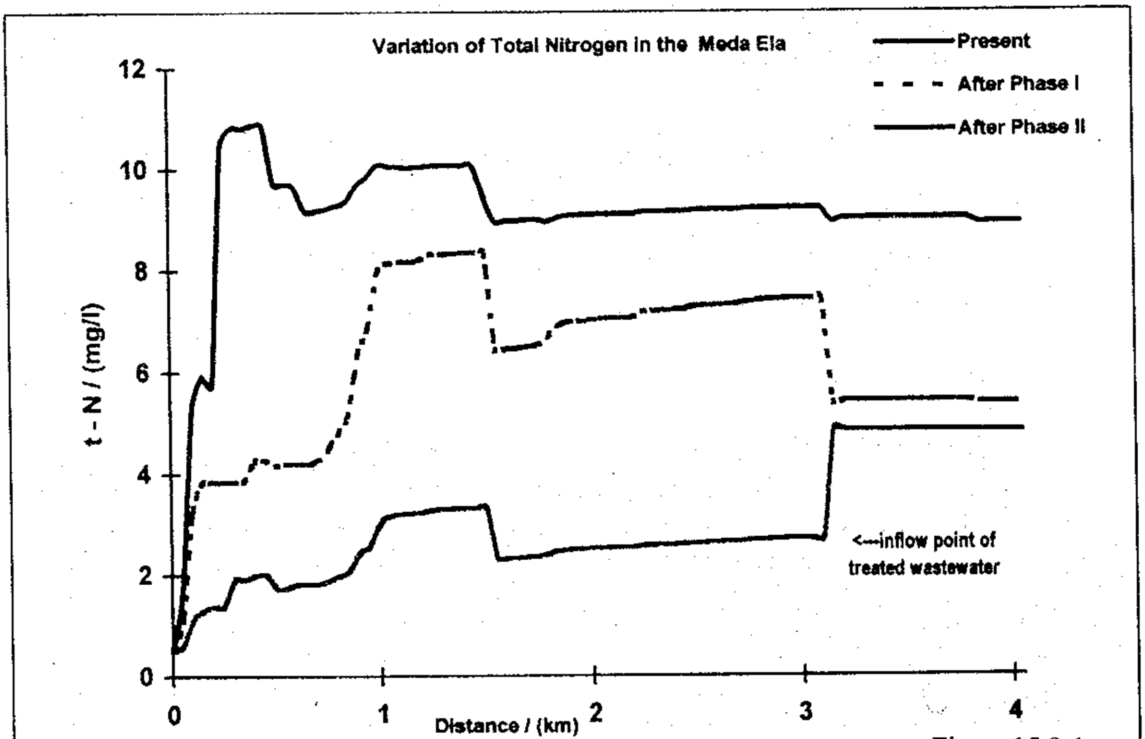


Figure 15.9-1

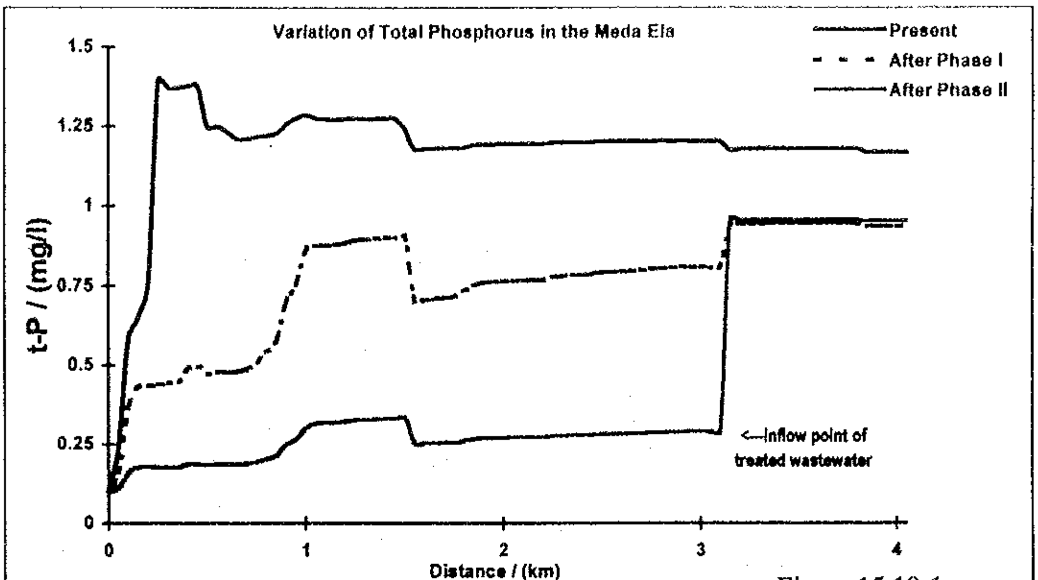
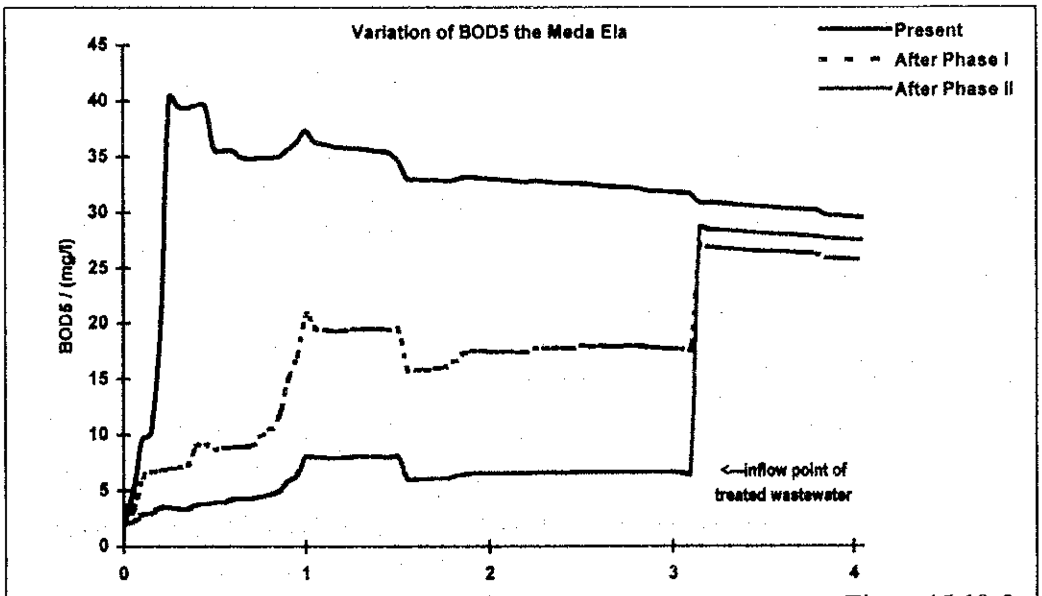


Figure 15.10-1



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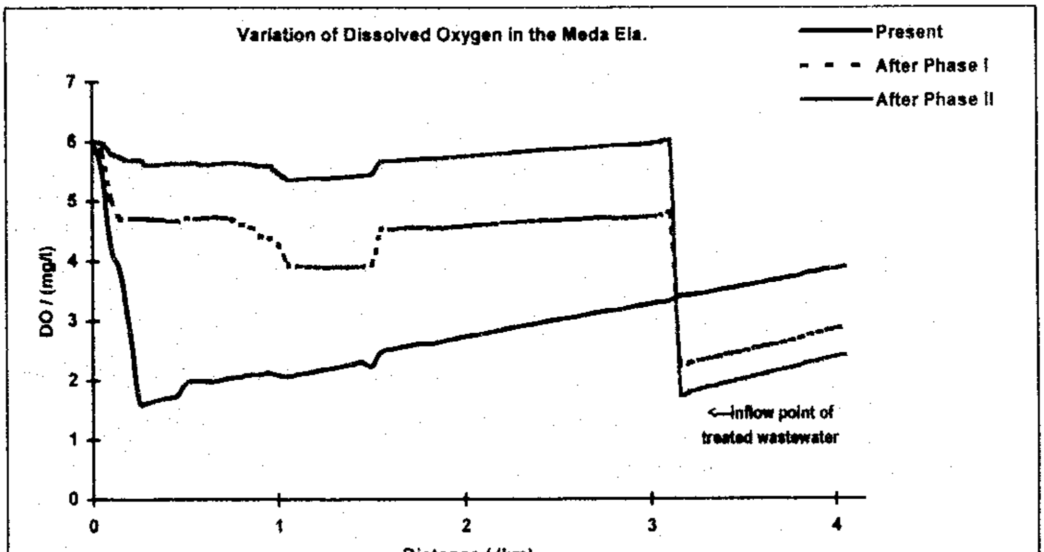

Figure 15.10-3

As it can be appreciated, visible improvement is minimal, due to the size of the lake compared with amount of in-flowing contaminants, the consequent dilution effect, and the "complete mixing" criteria applied by the model. A more sophisticated approach would have most probably shown important water quality improvements locally at the discharge points, with a consequent remarkable benefit for the whole lake. However, even under the simplified hypothesis applied for this study, reduction of both T-N and T-P, with a slight increase of DO, will be clearly beneficial, reducing the risk of algal blooms, although maintaining the eutrophic state of the lake.

2) Mahaweli river

The model shows no appreciable water quality changes in the Mahaweli river, due to inflow of treated sewage. Results are therefore not reported here.

15.5.6 Prediction and Mitigation of Negative Impacts

Negative impacts of the project on water quality in Kandy will be minimal or none. The following can be mentioned:

(1) Discharge of effluent from sewage treatment plants

The sewage treatment plant will produce an effluent which contains 30 mg/l BOD_5 and 50 mg/l SS. The effluent will be discharged into the Meda Ela at a constant flow-rate throughout the day after disinfecting with chlorine. The Meda Ela has to transport the effluent about 1.5 km up to the Mahaweli river. This will result in severe organic pollution from the effluent out fall to the confluence of the Meda Ela and the Mahaweli river. Further, organic matter may also accumulate along the right bank of the Mahaweli river for a certain distance due to variations in the flow pattern.

Continuous discharge of organic wastes into the river may result in a marked decline in dissolved oxygen and the release of ammonia and nitrite downstream of the effluent outfall. The magnitude of the effect on the river is directly linked to the ratio of effluent load to river water discharge. The most obvious effect of the discharge of organic matter with a high BOD will be the development of an oxygen sag-curve which may be observed from a few km to 100 km downstream of the input. The establishment of an oxygen sag-curve may be critical during dry weather.

Therefore it is necessary to monitor the zone of degradation (critical limits or distance) and time of recovery in both Meda Ela and the Mahaweli river. During the impact monitoring, stations should be located in the middle part of the oxygen sag-curve or at the beginning of the recovery zone. During preliminary surveys a complete longitudinal profile incorporating various hydrological features is necessary in order to choose the location for permanent monitoring stations.

(2) Effects of residual chlorine from sewage treatment plant

Since it is the objective to eliminate most of coliform bacteria by chlorination before the effluent is discharged into the receiving water body, the effluent will be free from harmful bacteria. However, the rate of decomposition of organic matter along the Meda Ela as well as in the Mahaweli river will be decreased. On the other hand, if residual chlorine is increased in the organic matter rich water, dissolved organic compounds may react with residual chlorine forming organo-chlorines, which could be carcinogenic. The rate of biodegradation of organic chlorine along tropical rivers is unknown. Therefore, there is a possibility that the organo-chlorine compounds may reach up to the proposed Gohagoda water intake. This indicates the importance of determining what complex organic compounds exist intermittently in raw water. High concentrations of residual chorine may also affect planktonic and benthic organism of the Mahaweli river. Therefore, continuous monitoring of the water quality of the Mahaweli river is indispensable. Though the disinfection by chlorination method is planned to be adopted in the Study, other methods such as ozone, or ultra violet lay are worth to consider to avoid use of chlorine.

15.6 Impact on Traffic and Transportation during Construction

15.6.1 General Impacts

The proposed project involves additional vehicle movements to the construction sites, the possible closure of at least one traffic lane due to trenching for pipeline laying activities and stationing of equipment and machinery at the work sites. All these will obstruct traffic movement, and heavy traffic delays can be expected during the construction phase due to the restriction of space on roads.

This can be due to two reasons. One is due to the disturbance caused to moving traffic and the other is due to the roadside parking of vehicles. Within the Kandy municipal limits nearly 90 percent of the roads are used for traffic movement and parking by the side of the road. Hence during construction suitable routes for traffic diversion and some space to move roadside parking of vehicles will be required. In addition to that, re-arrangement of traffic moving directions along some of the roads will be required.

Some of the routes selected for traffic diversion are not experiencing heavy traffic loads under normal conditions. Hence, improvement of some sections along those roads will be important. The Figure 15.11 shows the recommended alternative roads for traffic diversion within the Kandy municipality. It must be stressed that not all selected roads are presently in good enough physical condition to absorb the new traffic load, and should therefore be improved for best results.

With the above modifications for traffic movement, restriction of unnecessary traffic flowing into the town should be controlled.

According to the traffic count carried out during the initial report at five locations in the Kandy municipal limits, three busy periods with respect to traffic movements are clearly identified. Busy periods for traffic are 7:00 to 8:00 AM, 1:00PM to 2:00 PM and 5:00 PM to 6:00 PM. Therefore, the public should be informed about the possible traffic congestion and delays during those hours. Methods should be adopted to discourage heavy vehicles entering into the traffic system during those hours.

In addition to the traffic study, a survey was carried out to identify the number of vehicles parked on the sides of roads. Alternative parking space must be found during the construction work.

15.6.2 Control of Vehicles Entering the Construction Zones

Three main areas can be identified in the Kandy municipal limits with respect to construction:

Zone A: William Gopallawa Mawatha and Sirimavo Bandaranayake Mawatha up to Police Station;

Zone B: Kandy municipality central Business department area;

Zone C: Kandy Lake round.

The following recommendations are given:

ALTERNATIVE TRAFFIC DIVERSION FOR KANDY WATER SUPPLY & SEWERAGE PROJECT

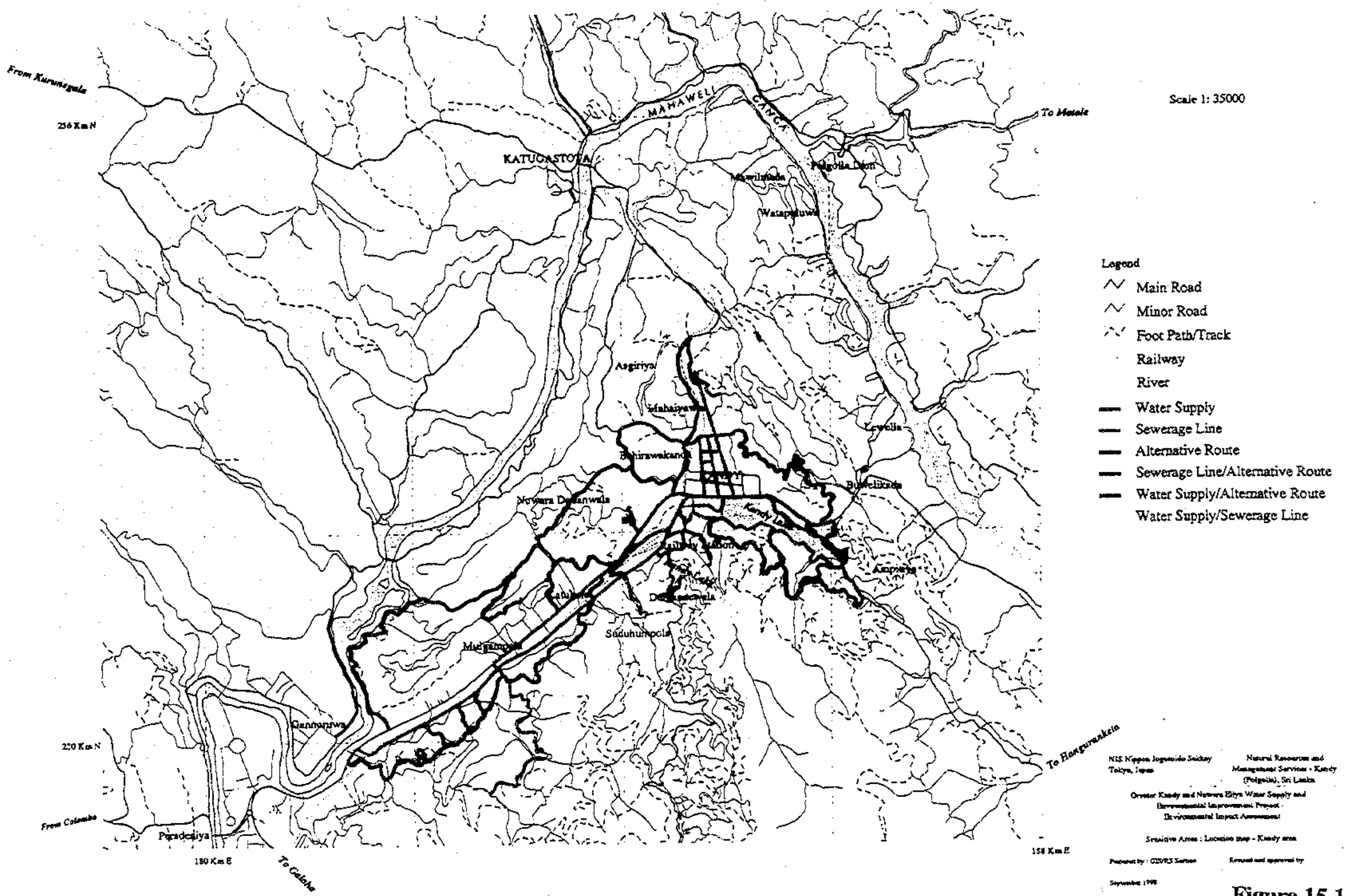

Figure 15.11

(1) People living in those zones can be advised to seek permission to allow entry of their private vehicles during the construction period. Relevant authorities (KMC or NWSDB) can inform the public about the project and call for applications to seek permission.

(2) Permission should be granted only after verifying the ownership of the vehicle and permanent address. Specially designed identification card can be issued to those vehicles clearly indicating the vehicle number and the zone number.

(3) During the construction period, the greater part of the carriageway will be closed. Hence, parallel roads will experience higher traffic loads. Therefore, during normal rush hours only passenger transport vehicles (private coaches, "peopolized" transport service buses, school service vans, office service vans) and vehicles with more than 10 passengers should be allowed along normal routes. All the other vehicles should be diverted along alternative routes.

(4) Delivery vans, heavy vehicles and lorries transporting goods should be allowed only from 7:00 PM to next day 5:00AM within the construction areas. Vehicles arriving outside this time should be denied access.

(5) Carefully prepared signboards giving all the information related to project traffic delays and congestion during the construction period should be displayed at all the entrances to Kandy municipality (Ex. Williamgopallawa Mawatha junction, Katugastota town, Ampitiya Junction in lake round and Lewella Junction may be good for this purpose).

(6) Signboards should be started about 6 months in advance of construction and should be maintained properly and updated for public information. Parallel to this process, leaflets giving relevant information about the project can be distributed to the public. They should be advised to avoid peak hours (especially 7:00AM to 9:00 AM) coming to town.

(7) Discourage using private vehicles during peak hours and give rewards those who are using the public transport system. Maps of the project area and possible alternative routes can be included in the same leaflet.

(8) Roadside parking in affected areas should be totally banned and if possible rules and regulations should be revised to charge high penalties against those who are violating those rules. During the construction period, even in other areas within the municipal

limits, long parking hours (more than one and a half hours) should be banned. According to a study carried out by the Faculty of Engineering of the University of Peradeniya, 30 ~ 50 percent of roadside parked vehicles are owned by shop owners in the town and those vehicles are parked for 3 ~ 8 hours per day. While banning roadside parking, a suitable place should be identified to relocate those vehicles. Possible places for that purpose may be,

- Free space in the Bogambara ground
- Boy's scout head quarters building site
- Mahaiyawa ground,
- Asgiriya police ground
- Wewsiripitiya ground

(9) In addition to those places, the KMC is planning to construct some multistoried parking places. If that project goes forward, most of the roadside parking problems will be solved.

(10) Due to congestion, construction at some areas should be carried out only at night and certain areas only during school vacations. Details of those are given in coming sections. In no event should construction be carried out during the Kandy Perehera season.

(11) During the construction, Deveni Rajasinghe Mawatha, George R. de Silva Mawatha, Piasso Gardens Road, Anniewatte road, Sri Pushpadana road, and Asgiriya bypass will have to be used for traffic diversion. On the other side of the town, Sri Amarawansa Mawatha, Dangolla Road, Bodhiangana Mawatha, and Vihara Mawatha will have to be used for traffic diversion. Most of these roads are suitable for light traffic in normal situation. To divert traffic during the construction periods, some roads need improvements. Dangolla Road, Bodhiangana Road, and Vihara Mawatha can be widened at some locations and at other locations can be improved by covering the drainage trenches with concrete slabs. The bridge across the Ellewela ela should be improved or reconstructed.

(12) Traffic going towards Katugastota and Digana should be diverted along the Gohagoda road.

15.6.3 Specific Recommendations for Traffic Control during Construction

All critical town areas have been analyzed during the study. Sensitive areas in the town center, where specific traffic management will be needed, are reported hereinafter. Detailed recommendations and sketch diagrams are given in Chapter 7 of the main EIA report.

- Yatinuwara Vidiya: 500 m one way bus route. Sensitive locations are School, DS office, PC Office, Bank, and Roadside parking.
- Kotugodella Vidiya: 600 m one way road. Sensitive locations are two banks, two religious places, and Insurance Corporation.
- DS Senanayake Vidiya – KM junction to old Matale road: two-way road, bus route. Sensitive locations are three schools. Roadside parked vehicles.
- DS Senanayake Vidiya – KM junction to Queens Hotel: one way bus route. Commercial area.
- Sri Wrickrama Rajasinghe Mawata: one way bus route. Sensitive locations are: private bus stand at Torrington, filling station for a people transport service.
- SWRD Bandaranayake Mawata: Sensitive locations are: good shed bus stand, railway station, general Post Office, Telecom office, and RCDC office.
- Colombo street: 420 m one way road. Sensitive location is Bank of Ceylon.
- Internal roads in the Kandy municipality: most of roads are one way, commercial areas and parking. Night construction is highly recommended. Ban all roadside parking.
- Sri Dalada Thapavona Road: Road to a temple. Sensitive locations are the KMC, School, and Presidential Palace entrance.
- Lake round: average daily traffic along this road is 8460 towards the town and 8300 away from town. From 6:45 AM to 8:00AM the total number of school vans identified were 200 out of a total number of vehicles of 990 towards town and 119 schools vans out of a total number of vehicles of 1030 away from town. During the lake round construction, the following roads are suggested for traffic diversion: Rajapihilla Mawatha, Mahamaya Mawatha, Luvy Peiris Mawatha, and Sangaraja Mawatha.
- Lake round: Maligawa side: presently closed for traffic; no significance effects are expected.
- Sirimavo Bandaranayake Mawata (stage II). Sensitive locations are schools, channeling centers, private hospital and the supermarket.
- Nittawela road (Stage II): residential area. It is recommended that all access roads be closed.

15.6.4 Safety during Construction

Safety should be the primary concern of any kind of construction site. If safety conditions are improved, this will have an automatic effect on the easing of traffic movement. Safety during construction can be improved in the following ways.

- Properly barricading the construction sites
- Proper fencing along trenches. These should be illuminating to ensure safety during night.
- Night bulbs, lights at all barricades and safety fences
- Direction signs for vehicle movement as well as pedestrian movement
- Flagmen at construction sites to warn drivers and pedestrians

Details of service lines along the construction sites should be made available for contractors to avoid possible damage. The work force should be informed about the importance of their own safety as well as the safety of other road users. Suitable methods of punishing those who are violating the minimum safety conditions should be implemented.

15.7 Other Environmental Impacts

15.7.1 General

Other than major impacts, already discussed in the previous part of the EIA, the construction and operation of works planned under the present project will involve the following:

- Offensive odors, mainly due to emissions of hydrogen sulfide (H_2S) and the presence in the sewage of organic rotten compounds.
- High noise levels during construction due to engine operation, power generators, pumps, etc.
- Impacts on air quality due to plant emissions during operation, or emissions of equipment during construction.
- Additional production of solid wastes, collected in grit chambers at inlet of sewage treatment plant, and to be properly collected and disposed.
- Security and hygiene of workers and the public, especially during construction.
- Accident risks for workers and the public, especially during construction;

All negative effects associated with these impacts can be effectively mitigated by including in the Project Specifications an Environmental Action and Management plan. This should include specific environmental control and mitigation measures to be adopted, and limits to be observed by the contractor(s) and the Plant operator(s)[4].

Odor, noise impacts, and disposal of contaminant materials are of major importance and will be briefly discussed in this section.

15.7.2 Odors

(1) General concepts

Offensive odors are either the consequence of decomposition of organic matter, or may be produced by other organic substances usually present in the sewage. Raw sewage present a characteristic displeasing odor, sometime irritating, which is not as offensive as the odor of sewage after anaerobic decomposition processes have taken place.

The most penetrating odor is generally due to Hydrogen Sulfide (H_2S), produced as a result of bacterial reduction of sulfur anhydrides SO_2 and SO_3. Other offensive or disturbing odors may also result from the presence of different chemical substances originated from hospitals or industrial sources (as is the case of the brewery in Nuwara Eliya).

Offensive odors coming from sewage treatment plants, represent one of the most important concerns of public opinion, and are usually the principal cause of public nuisance. This aspect is especially important in the case of Kandy, where the sewage treatment plant, whichever alternative is adopted, will be located within or close to the urban environment.

The important point to reduce or possibly avoid public complains, is to perform a periodic monitoring of offensive odors, involving representatives of the potentially affected communities.

(2) Characterization of odors

The following four parameters are suggested to characterize offensive odors:

[4] *This document should not be confused with the Environmental Monitoring and Auditing Program, which will be discussed in Section 15.8.*

Table 15.13 Characterization of Odors

◆ Character	It is relevant to the mental association of the subject who perceives the odor. It is therefore a subjective parameter, which may vary from individual to individual.
◆ Perceptibility	It is the number of dilutions necessary to reduce an odor to the minimum detectable level.
◆ Hedonic	Relating to, or marked by pleasure: it is relative level of pleasure or repulsion of an individual perceiving a certain odor. It is also a subjective parameter.
◆ Intensity	It is the most objective parameter. It is normally measured with an olfactometer, or it may be measured through "perceptibility", once the basic relation (number of dilutions up to the lower limit of perceptivity) has been established.

(3) Evaluation of odor intensity

Odor can be measured using odor-sensitive instruments, which provide "objective" values, or through the "sensorial method" (organoleptic), which leads to subjective values.

The sensorial method, based on the human capacity of detecting offensive odors, is usually preferred. According to this method, groups of persons are exposed to odors which have been diluted with non contaminated air, taking note of the number of dilutions necessary for the odor not to be perceived by the majority of exposed persons. This value is called *" Minimum Detectable Threshold of Odor Concentration - MDTOC".*

An alternative accepted terminology for the sensorial method is *ED50*, which measures the number of dilutions necessary for an odor to be detected with difficulty by an "average person" (50^{th} percentile). That means that if the *ED50* is increased one point the odor is no longer detectable. To avoid inevitable errors direct touch *olfactometers* have been developed permitting sensorial measurement of odors at the same site where odors are generated.

For the detection of Hydrogen Sulfide gas diffused portable meters are available capable of detecting concentrations of less than 1 ppb/volume.

(4) Specific recommendations

Mitigation

Offensive odor, as already mentioned, represent a major problem for the Greater Kandy sewerage project, considering the location of the plant. Monitoring will be important, but by planting a double row of trees around the perimeter of the treatment plant, further mitigation of the negative effects of odor can be realized. This will have the triple effect of; a) hiding the plant from public view, thus limiting or avoid complains from neighboring people, b) reduce the perceptibility of odors out of the plant area; and c) improve visual impact.

Monitoring

The recommendation is to monitor the odors using the "sensorial" method. An evaluation group composed by say seven persons should be formed, including 3 representatives of public institutions (NWSDB, Municipality Health Office, local CEA representative), and four representatives of potentially affected families or communities. This group will be requested to detect offensive odor at different distances from the plant (or from the point where odor is more detectable), determining the minimum distance, in the different geographical directions, where the majority of people do not detect the odor any more.

15.7.3 Noise and Vibrations

(1) General

Noise is usually defined as an unwanted sound that affects everyone in the environment. People's reaction to offensive noises is similar to their reaction to odors. Most people express an opinion about offensive noises, the threshold of sensitivity is different for different persons, and continuous noises may have negative effects on physiological, psychological, communication, performance and social behavior, not only upon human beings, but also upon animals.

Sounds are measured by Decibel scale (dB)[5], i.e. by use of sound-level meters. This is an objective measure of sound pressure levels, and not a measure of "loudness", which describes the pressure amplitude of sound vibration in the air, and is related to the stress imposed to the ear.

An essential parameter to be considered is the length of time a person is exposed to an offensive noise. This will be of particular concern during construction activities, when highly noisy equipment will be working simultaneously. Table 15.14 reports the criteria adopted by the US Environmental Protection Agency and the State of California concerning the maximum exposure time to offensive (high level) noises, and Table 15.15 reports the average noise emission level for some construction equipment.

Table 15.14 Maximum Admissible Time of Exposure to Offensive (High Level) Noises

Noise Levels (dB)	Maximum Time of Exposure (Residential Areas) (hours)	Maximum Time of Exposure (Industrial or Commercial Areas) (hours)
70	16-24 (hours)	
75	8 (hours)	
80	4 (hours)	
85	2 (hours)	
90	1 (hours)	8
95	0.5 (hours)	4
100	15 minutes	2 (hours)
105	8 minutes	1 (hours)
110	4 minutes	30 minutes
115	2 minutes	15 minutes or less

Table 15.15 Average Noise Emissions of Most Common Construction Equipment[6]

Construction equipment	Noise Level at 16.5 m (dB)
Tracked excavator	88
Water Truck	87
Compactor	82
Bulldozers	86
Road roller	74
Asphalt spreader	91
Cement lorry	85

(2) Sri Lanka regulations

Sri Lanka regulations about Noise control have been established by the Ministry of Transport, Environment and Women's affairs, under Section 23P, 23Q and 23R of the National Environmental Act-No. 47 of 1980, read with section 32 of that act.[7]

These regulations include VIII "Schedules", each one of them fixing specific limits to be respected. Maximum permissible noise levels at boundaries of $L_{Acq}T$[8] are established under Schedule I, as reported in the following Table 15.16.

[5] *The "dB" is a non-dimensional unit defined as 10 times the logarithm of the rate between two selected values (dB=10log*q1/q2).*
[6] *Noise emission of specific construction equipment must be indicated by the contractor.*
[7] *See Extraordinary gazette 924/12, 1996, 05, 23*
[8] *L_{Acq}'T means the equivalent continuous, A-weighted sound pressure determined over a time interval T (dB).*

Table 15.16 Sri Lankan Regulations: Maximum Permissible Noise Level at Boundaries L_{Aeq}'T

Area	Day Time (dB)	Night Time (dB)
Low noise	55	45
Medium noise	63	50
High noise	70	60
Silent zone	50	45

Where:

- **Low noise area**: means an area located within any Pradeshiya Sabha area;
- **Medium noise area**: means an area located within any municipal Council or Council Urban Area;
- **High noise area**: means any export processing zone established by the board of Investment or industrial estate approved under part IV of the National Environmental Act;
- **Noise sensitive area**: includes any area in which a courthouse, hospital, public library, school, zoo, sacred areas set a part for recreational or environmental purposes are depicted in a noise zone map (see Figure 15.12 for the Central Kandy area)

For construction activities, the maximum permissible noise levels at boundaries of the land in which the source of noise is located in L_{Aeq}T, is fixed at 75 dB during day time, and 50 dB during night time (Schedule III, Regulation 4).

Maximum permissible noise levels at boundaries in L_{Aeq}T, for industrial activities, are established as follows (Schedule IV, and V, Regulations 7(a) and 7(b):

Table 15.17 Sri Lankan Regulations: Industrial Activities: Maximum Permissible Noise Level at Boundaries L_{Aeq}'T

Areas	Day Time (dB) (Sched. IV)	Night Time (dB) (Sched. IV)	If Background Noise Exceed Given Levels (Sched. V)
Rural residential areas	55	45	+ 3 dB
Urban residential areas	60	50	+ 3 dB
Noise sensitive areas	50	45	+ 3 dB
Mixed residential	63	55	+ 3 dB
Commercial areas	65	55	+ 3 dB
Industrial areas	70	60	+ 3 dB night + 5 dB day

SENSITIVE AREAS IN CENTRAL KANDY

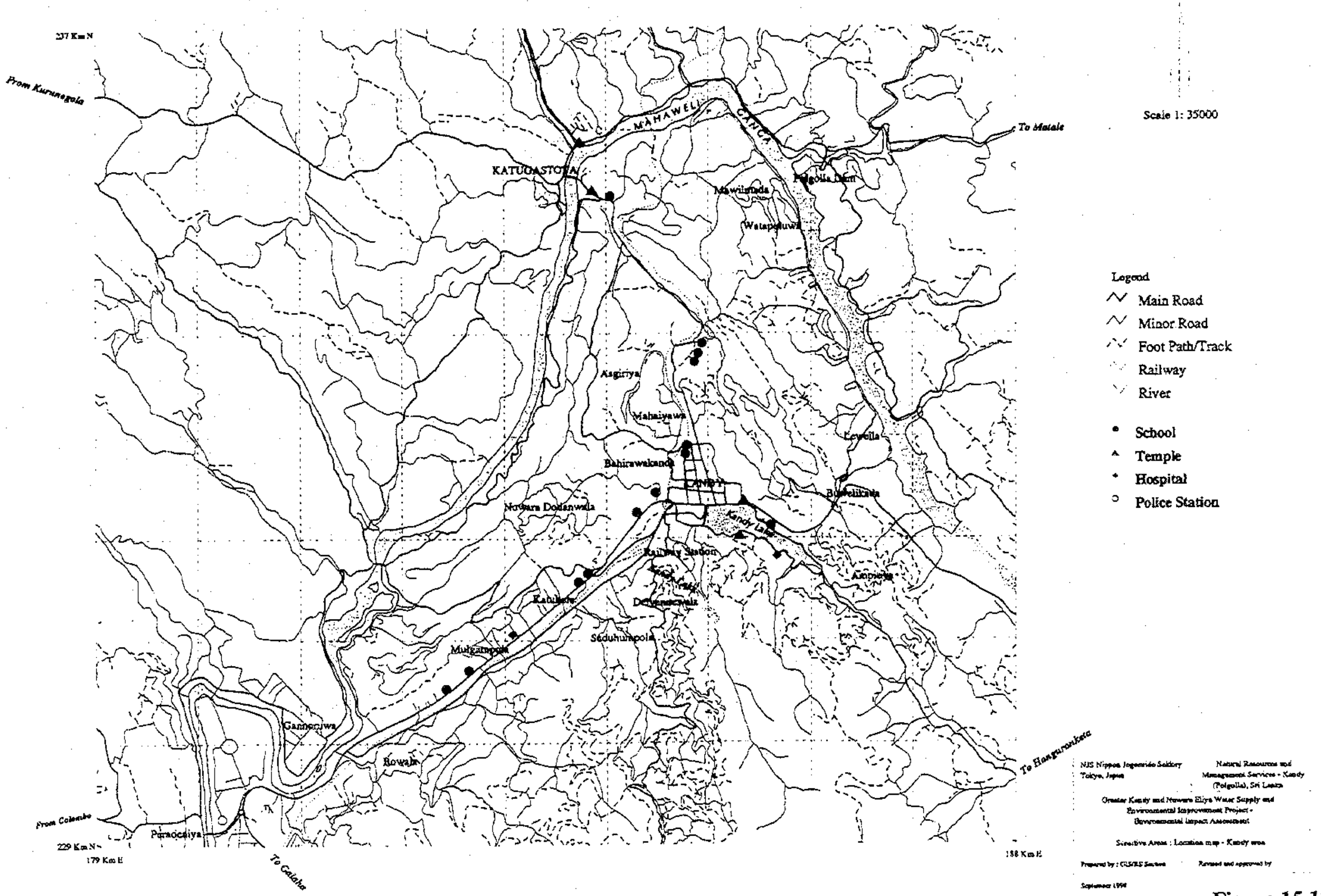

Figure 15.12

Schedule VI concerns Industrial/Commercial and Urban/Rural/Mixed residential areas, and reads as follows:

Table 15.18 Sri Lankan Regulations: Mixed Areas: Maximum Permissible Noise Level at Boundaries L_{Acq}'T

Areas	Day Time (dB)	Night Time (dB)
Industrial/Commercial	75	60
Urban/Rural/ Mixed Residential	65	50

(3) Unavoidable environmental impacts

During operation

During normal plant operation, noise is minimal and will not be detectable outside the plant area. The only exception will be during periods when the emergency power plant is operated, because of power failure or low voltage from the public power supply. In this case, especially if the power plant is not located underground, noise in the immediate vicinity of the plant can easily pass the threshold of 70 dB, and will be audible outside the plant up to a distance ranging from 50 to 100 m, depending on wind direction and obstacles to noise transmission.

Considering the relatively isolated location of the plant and the exceptional nature of this impact, noise during plant operation is not expected to represent a problem either for plant workers or for neighboring communities. The following specific recommendations are anyhow given to minimize this impact:

During construction

Noise impacts will be relatively important and unavoidable only during the construction period, both at plant sites and for the layout of main transmission lines.

Noise levels to be respected will depend upon the classification of the area where the specific work is carried out. Considering the location of the works, the following classification is given:

Table 15.19 Noise Levels to be Respected at the Different Work Sites

Site	Classification	Noise Levels to be Respected Day/Night
Kandy WT Plant	Low noise / Rural residential /Sensitive ❑ Operation ❑ Construction	 55/45 75/50
Kandy ST Plant	Medium noise / Urban/ Rural/ Mixed residential ❑ Operation ❑ Construction	 63/50 75/50
Kandy Central Area	Medium noise / Urban / Residential Sensitive (see map) ❑ During construction	60/50 50/45 75/50
Kandy Peripheral	Medium noise Urban/Rural/Mixed residential ❑ Construction	65/50 75/50*
Katugastota Central Area ❑ During construction	Medium noise (Urban/Rural/Mixed residential)	65/50 75/50*

The following actions are important to avoid public nuisance and repeated interruption to work:

- Thoroughly inform the local population and surrounding communities about the works to be done, period of execution, and noise inconvenience which will be suffered;
- Avoid operation of highly noisy equipment (like jack hammers) in particularly sensitive areas during specific hours (i.e. during school hours if works are close to a school, or during religious functions if works are close to a temple or cult site);
- In any case avoid the use of highly noisy equipment in hospital zones, even for short periods of time, employing alternative low-noise techniques;
- In any event avoid the use of highly noisy equipment in residential areas at night;
- In any case limit the period of time during which highly noisy works are carried out, considering the limits given in Table 15.19 above;
- Ensure that the contractor employs the use of as much low noise emission equipment as possible.

15.7.4 Removal, Transport and Disposal of Contaminant Materials

Removal, transport and disposal of contaminant material mainly concern:

- Materials generated during construction (temporary impact);
- Sludge produced at the sewage treatment plant site (permanent impact).

(1) Excavation and construction material

Solid waste generated during construction depends on the site characteristic, such as surface cover or vegetative cover, slope of the land, land use, depth to rock as well as the structures that would be built and land leveling required for construction and foundation excavations needed. Therefore, the volume and content of the waste materials will differ from place to place and the method of disposal varies accordingly.

At this level of design, it is not possible to predict the amount of excavation materials generated, but it will be in the order of magnitude of a few hundred thousand cubic meters both for trenching and plant sites excavation.

In some places the materials generated may be used at the site itself for filling and landscaping, and it will not be necessary to transport it to a disposal site elsewhere. This is the case for either the water treatment plant site at Katugastota, or Uda Bowala Sewage Treatment Site, where most of the excavation material may be used on site for filling the lower slopes and depressions and for leveling the site for construction (cut and filling), hence the necessity for transport and disposal of solid material will be minimal.

Otherwise, all this material should be collected and disposed of in the public dumping area, or in areas which are suitable to receive it with no negative environmental consequences. It is strongly recommended that construction / excavation material is not allowed to accumulate in public areas (as is the case of trenching in town), provoking disturbances to the population and causing a public nuisance.

(2) Sludge

Produced sludge will be treated as follows:

- Excess sludge → Thickening → Aerobic digestion → Thickening → Sludge drying bed → Disposal.

As a means to overcome the opposition of the residents around Uda Bowala sewage treatment plant site, sludge will be removed to drying beds at Gohagoda Municipal dumping site. The transport process has some inherent risks such as spilling during loading, breakdown of the transport vehicles, and poor maintenance of the transport vehicles etc.

Estimates of quantities of sludge to be transported range between 22 and 26 m^3/day. Considering the use of four cubic meter load capacity trucks to collect and dispose of the sludge, a minimum of six runs per day will be required. These operations are certainly annoying for the neighboring populations. It is therefore recommended that peak traffic times and night times are avoided in order to mitigate any nuisance due to noise. A negative impact is anyhow unavoidable, and compensations to affected people should be taken into account.

15.8 Environmental Auditing and Monitoring

15.8.1 Responsibilities

In the case of WS or WW treatment plants, environmental auditing and monitoring will be necessary both during construction and operation stages. Responsibilities will be as follows:

- Environmental monitoring and reporting: NWSDB / WWTP;
- Environmental auditing: CEA, or the entitled Project Approving Agency.

15.8.2 Environmental Auditing and Monitoring during Construction

The main components of the project are designed to improve the quality of the environment and the well being of the population in the Greater Kandy and Nuwara Eliya. Specific monitoring is required as an environmental control measure in situations where the environmental impacts of the project appear as critical and adverse. After the review of the IEE and the comments received from the CEA the following areas are critical:

(1) Disposal of solid material generated during construction,
(2) Solid waste associated with the work force should be collected and disposed,
(3) Routes for the transport of material and transport to be carried out in consultation with the local authorities,
(4) Action to be taken to minimize dust,
(5) During construction measures to be taken to reduce disturbance due to noise,
(6) Proper surface drainage systems to be maintained during construction,
(7) Restore or rehabilitate the temporarily used areas to initial state.

Of these specific recommendations of the CEA, the last is the most important item that needs regular monitoring and auditing on a long-term basis. The other recommendations are valid for the construction period. Nevertheless, all of them should be monitored and corrective measures adopted where necessary.

The other specific areas to be monitored are:
(1) Mahaweli river water quality after the discharge point of the treated sewage,
(2) Health hazards in the vicinity of the treated sewage discharge area,
(3) Health hazards due to toxic gases at the treatment plants soil erosion during construction,
(4) Public health hazards from sewer outflows,
(5) Air pollution/ odors and noise,
(6) Traffic disturbance during construction,
(7) Groundwater contamination and water disease vector at dumping area.

15.8.3 Environmental Auditing and Monitoring during Operation

As already mentioned, environmental auditing and monitoring during operation is a routinely activity, to be performed by the Environmental Section active at the Plant. The target is to ensure, through periodic sampling, analysis, and reporting, that in no case will the environmental quality parameters established by the CEA and accepted by the NWSDB be exceeded.

The NWSDB apply for the Environmental Protection License for the sewage treatment plant in accordance with the requirements of the National Environmental (protection and quality) Regulation No. 1 of 1990 published in the Gazette Extra Ordinary No. 595/16 of 2nd February 1990.

Environmental auditing and monitoring is expected to be of particular importance for the sewage treatment plant, because of the nature of the plant itself, and because of the lack of experience existing in the country. The treated sewage from the treatment plant should meet the relevant CEA standards as stipulated in Gazette Extra Ordinary No. 595/ 16 of 2nd February 1990.

A general monitoring and reporting program should be agreed between the NSWDB and the CEA. It will concern:
(1) General monitoring and reporting provisions
- Procedures for collection of samples and measurements;

- Procedures for flow measurement, devices and methods to be applied;
- Analyses to be performed, detection methods, list of certified laboratories (including a quality assurance (QA) plan for laboratory analyses).
- Frequency of monitoring;
- Reporting of monitoring results;
- Frequency of reporting.

(2) Influent sampling and analysis required

Parameter, units, sample type, sample frequency, report frequency);

(3) Sludge monitoring requirements

1) General requirements;
   - Sludge removal;
   - Sludge handling, storage, use or disposal;
   - Sludge management practices;
   - Sludge operation and maintenance facilities;
2) Monitoring: sampling, testing for pollutants, sludge quality analysis.
3) Notification and reporting.

(4) Effluent monitoring

- Location of effluent sampling stations;
- Periods of monitoring;
- Effluent sampling and analysis requirements.

A proposal for a "Sewage Treatment Plant Monitoring and Reporting Program" suitable for application to the NWSDB for the Kandy sewerage project, is given in Appendix 15.5.

15.9 Institutional Setting

15.9.1 Specific Project Requirements

The NWSDB does not have, at this time, an internal environmental organization, able to perform all environmental activities usually requested to correctly engineer, build and operate all owned production, transmission and distribution structures.

For the accomplishment of the environmental tasks requested under the present project, the NWSDB is asked to set up the following environmental units:

- A **Project Environmental Unit (PEU),** in charge for environmental management, monitoring and reporting, as above specified;

- An **Environmental Auditing Commission (EAC),** in charge of the Environmental Auditing, i.e. exerting a direct control over the PEUs activities and environmental impacts of the project, either during construction or during operation.

These units, to operate correctly, need to be inserted in an organized institutional scheme, where tasks, responsibilities and hierarchical dependencies are clearly defined. Even if it is not a task of the present project to discuss in any detail the institutional arrangement of the NWSDB, is necessary to draft a full environmental organization for the Water Board, as a recommendation to the General Management.

15.9.2 Proposed Environmental Setting for the NWSDB

The proposed environmental setting for the NWSDB includes the following structures:

(1) A **Central Environmental Division (CED),** to be created in Colombo, as an additional staff function of the General Management office. This Division is responsible for:

- Setting the general environmental policies and regulation, to be applied by the NWSDB at National level;
- Coordination of environmental activities at National level;
- Preparation of all required environmental studies (Initial Environmental Examination, Environmental Impact Assessment, Environmental Management and Monitoring Plan), in collaboration with Regional Offices and project units.

(2) A **Regional Environmental Unit (REU),** to be established in the regional NWSDB office in Kandy, in charge of the general coordination of all environmental activities directly or indirectly concerning the NWSDB RSC Office in Getambe. This office will operate a laboratory for non-routine analysis, to be performed quarterly or yearly, or for special analysis which may be requested if particular problems occur.

(3) Two **Project Environmental Units (PEUs),** to be established in Kandy and Nuwara Eliya, in charge for the Environmental Management and Monitoring of the specific projects. These Units will operate local laboratories for routine water quality and sludge quality analysis.

- The **PEUs** will be hierarchically dependent to the **REU** in Kandy, even if physically located within the plant areas. Each PEU will be composed of at least two specialists, as described hereinafter. These Units will prepare reports on environmental quality, to be forwarded to the Regional Environmental Office in Getambe, and through this, after approval, channeled to the Environmental Auditing Commission.

- The **REU** will, on its turn, formally report to the Environmental Division in Colombo, but will operate in strict coordination and under the direct control of the General Manager of the Central Region in Kandy.

- The **Environmental Auditing Commission** does not formally belong to the NWSDB. It will be created as an independent institution, or, as recommended by the CEA, within the Kandy municipality, and will be tentatively composed of five members, namely: 1) Municipal Council; 2) NWSDB; 3) Mahaweli Authority; 4) CEA - Local Office or Central Office; 5) CEA nominated independent consultant.

- The **EAC** will decide a schedule of site inspections and meetings (say quarterly), to assess the state of the environment and audit the job performed by the Project Environmental Units. The Commission, if needed, will report directly to the CEA, for the necessary environmental permits.

- Figure 15.13 shows the Environmental Organization recommended for the NWSDB, applicable to all projects and plants developed and/or operated by the Board.

Figure 15.13

NWSDB RECOMMENDED ENVIRONMENTAL ORGANIZATION CHART