JAPAN INTERNATIONAL COOPERATION AGENCY
NATIONAL WATER SUPPLY AND DRAINAGE BOARD
THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

# THE FEASIBILITY STUDY
# ON
# THE KALU GANGA WATER SUPPLY PROJECT
# FOR
# GREATER COLOMBO

## VOLUME II

## MAIN REPORT

NOVEMBER 1994

NIPPON JOGESUIDO SEKKEI CO., LTD.
NIPPON KOEI CO., LTD.

THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
THE FEASIBILITY STUDY ON THE KALU GANGA WATER SUPPLY PROJECT FOR GREATER COLOMBO
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# PREFACE

In response to a request from the Government of the Democratic Socialist Republic of Sri Lanka, the Government of Japan decided to conduct a feasibility study on the Kalu Ganga Water Supply Project for Greater Colombo and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Sri Lanka a study team headed by Mr. Ikuo Miwa, Nippon Jogesuido Sekkei, Co., Ltd. and composed of members from Nippon Jogesuido Sekkei, Co., Ltd. and Nippon Koei Co., Ltd., three times between December 1993 and October 1994.

The team held discussions with the officials concerned of the Government of Sri Lanka and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Sri Lanka for their close cooperation extended to the team.

November 1994

Kimio Fujita
President
Japan International Cooperation Agency

November 1994

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Japan

Dear Sir,

Letter of Transmittal

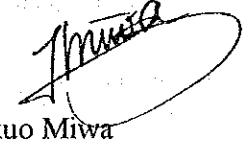
We are pleased to submit herewith the final report for the Feasibility Study on the Kalu Ganga Water Supply Project for Greater Colombo.

The Study was completed through the discussions with the Sri Lankan Government officials and the field investigation during three visits from December 1993 to October 1994 and the home work thereafter.

The Final Report consists of five volumes consolidating the progress report and the interim report: Volume I - Summary Report which succinctly describes the study and recommendations; Volume II - Main Report which covers the long-term development plan for the Greater Colombo Water Supply System, clarifies the position of the Kalu Ganga Water Supply System and describes the details of the first phase project through the Feasibility Study; Volume III - Supporting Report including detailed engineering analysis and relevant information; Volume IV - Data Report compiling collected data, and Volume V - Drawings showing the design of facilities involved in the proposed Project.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs and the Ministry of Health and Welfare. We also would like to show our appreciation to the officials of the National Water Supply and Drainage Board, the JICA Sri Lanka Office, and the Embassy of Japan in Sri Lanka for their kind cooperation and assistance throughout our field survey.

Very truly yours,



Ikuo Miwa
Team Leader
The Feasibility Study on
the Kalu Ganga Water Supply Project
for Greater Colombo

THE FEASIBILITY STUDY

ON THE KALU GANGA WATER SUPPLY PROJECT

FOR GREATER COLOMBO

**VOLUME II**

**MAIN REPORT**

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| | |
|---|---|
| ADB | Asian Development Bank |
| B.W.L. | Bottom Water Level |
| C.E.B. | Ceylon Electricity Board |
| C.M.C. | Colombo Municipal Council |
| DCS | Department of Census and Statistics |
| EPZ | Export Processing Zones |
| ES | Engineering-Science, Inc. |
| GS | Gramasevaka Division (local administrative unit) |
| IDA | International Development Association |
| JICA | Japan International Cooperation Agency |
| MHCUD | Ministry of Housing, Construction and Urban Development |
| MSL | Mean Sea Level |
| NHDA | National Housing Development Authority |
| NJS | Nippon Jogesuido Sekkei Co.,Ltd. |
| NK | Nippon Koei Co., Ltd. |
| NWSDB | National Water Supply and Drainage Board |
| OECF | Overseas Economic Cooperation Fund of Japan |
| OIC | Officers-in-Charge |
| PS | Pradeshiya Sabha (local administrative unit) |
| RDA | Road Development Authority |
| RSC | Regional Support Center, NWSDB |
| T.W.L | Top Water Level |
| UDA | Urban Development Council |
| UFW | Unaccounted for Water |

## LIST OF UNITS AND ABBREVIATIONS

| | |
|---|---|
| cm | centimeter |
| cu m, $m^3$ | cubic meter |
| cu m/d, $m^3/d$ | cubic meter per day |
| cu m/min, $m^3/min$ | cubic meter per minute |
| cu m/s, $m^3/s$ | cubic meter per second |
| dia. | diameter |
| ft | feet |
| gal | Imperial gallon (= 4.546 litters) |
| ha | hectare |
| hr | hour |
| Kg | kilogram |
| Km | kilometer |
| Kw | kilowatt |
| KwH | kilowatt Hours |
| L/cap/d | liter per capita per day |
| L/s | liter per second |
| m | meter |
| mgd | million gallons per day |
| mm | millimeter |
| MPa | megapascal |
| Rs. | Sri Lankan Rupee |
| sq km, $km^2$ | square kilometer |
| sq m, $m^2$ | square meter |
| V | volt |
| y | year |

## EXCHANGE RATE (As of June 1994)

US$1.0 = Rs.49.0 = Yen 106.0

# CHAPTER 1

# INTRODUCTION

# 1. INTRODUCTION

## 1.1 Authorization

On the basis of the Scope of Work agreed upon between the National Water Supply and Drainage Board (hereinafter referred to as the "NWSDB") and the Japan International Cooperation Agency (hereinafter referred to as "JICA") on 30 August 1993 in Colombo, JICA made a contract with the joint venture of Nippon Jogesuido Sekkei Co., Ltd. and Nippon Koei Co., Ltd. on 6 December 1993 to conduct a feasibility study on the Kalu Ganga Water Supply Project for Greater Colombo (hereinafter referred to as the "Study").

JICA, the official agency responsible for the implementation of technical cooperation programs of the Government of Japan, undertook the Study in accordance with the relevant laws and regulations in force in Japan and in close cooperation with the authorities of the Government of the Democratic Socialist Republic of Sri Lanka. The NWSDB acted as a counterpart agency to the Japanese Study Team and as a coordinating body in relation to other relevant organizations for the smooth implementation of the Study.

## 1.2 Background

The Greater Colombo area is located in the southwest quarter of the Island of Sri Lanka. The total population of this area is approximately 2,837,000 persons consisting of 1,616,000 persons living in the existing service area and 1,271,000 persons in an outlying area extending from Katunayake in the north to the Kalu Ganga in the south. The NWSDB currently provides service to the population residing in the existing service area which measures 194 $km^2$.

The existing water supply depends upon the impounding reservoirs at Kalatuwawa and Labugama, the river intake at Ambatale on Kelani Ganga, and a minor pumped supply from the Kalu Ganga providing a total supply capacity of about 136 mgd (618,800 $m^3$/day) after completion of the new Ambatale Water Treatment Plant on January 1994.

The first water supply master plan for Greater Colombo was prepared in 1972 by Howard Humphreys & Sons under the UNDP assistance. Since then, the implementation of the water supply development has been conducted in line with the recommendations in this master plan. In 1991, a study was undertaken to update the original master plan by Engineering-Science under USAID assistance to prepare "Greater Colombo Water Supply System Master Plan Update (hereinafter called as the Master Plan Update 1991)". This study was further updated in 1993 as Addendum for the Master Plan Update 1991 to incorporate the most recent development in the service area.

In accordance with the development plan presented in the Master Plan Update 1991 to meet the growing water demand for the expanding population in both the existing service area and in the outlying area by 1995, the Jubilee and Maharagama system and the "Towns East" scheme are in progress. The development of the Kalu Ganga Water Supply System as a new water source is one of the recommendations in the Master Plan Update 1991.

Sometime in between 2000 and 2005, it is necessary to serve the existing service areas of the towns south and the areas south of Dehiwala/Mt.Lavinia with a new water supply system from the Kalu Ganga due to the limited water supply from the Kelani Ganga. The number of population served by the new water supply from the Kalu Ganga will be 634,000 persons in the above area by the year 2010. This scheme will provide more flexibility to respond to the uncertain courses of future development in the area.

In light of this background, it was proposed to undertake the Feasibility Study for the Kalu Ganga Water Supply Project as a program of technical assistance by JICA.

### 1.3 Objective of the Study

The objective of the Study is to formulate a long-term plan for the expansion of the Greater Colombo Water Supply System with an intake from the Kalu Ganga to meet the water demand up to the year 2020 and to conduct the Feasibility Study for the Phase 1 Project of the long-term development plan.

### 1.4 Study Area

The Study shall cover the existing and proposed service areas of the Greater Colombo Water Supply System and the Kalu Ganga basin.

The areas proposed to be tentatively covered under the Study are Horana, Bandaragama, Panadura, Keselwatte, Kesbewa, Homagama, Moratuwa, and Dehiwala/Mt.Lavinia.

However, due consideration shall be given to the entire Greater Colombo area in order to realize the coordinated development of water supply in the area and to demarcate the service area in the most feasible way to be served by the two major sources, i.e. the Kelani Ganga and the Kalu Ganga.

### 1.5 Design Year

"Greater Colombo Water Supply System Master Plan Update" projected the water demand in the Greater Colombo area by 2020 and shows the facility plan by 2000. Taking into account the fact that the population projection is made on the basis of 1981 census data, it seems inappropriate in accuracy

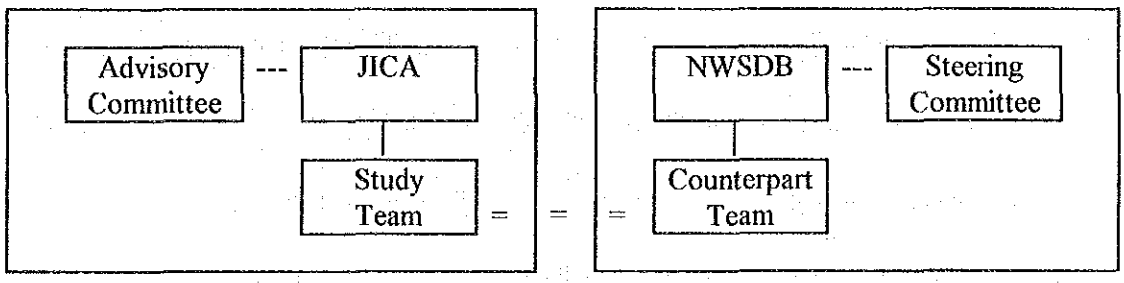
to extend the design year beyond 2020, hence a design year for the Master Plan in the Study shall be the same year of 2020 as that in the said Master Plan Update.

As for the design year for the Feasibility Study shall be set at the year 2010 in consideration of the construction period of the new water supply system including the time period needed for detailed design and project processing.

## 1.6 Study Organization

### 1.6.1 General

The general organization for the Study is as shown below




### 1.6.2 Japanese Organization

The Japanese organization consist of the Study Team under JICA headquarters and the Advisory Committee set up at the JICA headquarters.

The members of the Study Team are as follows:

| | |
|---|---|
| Mr. Ikuo Miwa | Team Leader/Water Supply Planning |
| Mr. Keisuke Okazaki | Facility Planning |
| Mr. Kuniaki Onishi | Distribution Planning and Water Demand |
| Mr. Masao Fujiwara | Water Intake Planning and Geology |
| Mr. Toshikatsu Imai | Hydrology and Water Source |
| Mr. Malcolm Patrick Hyde | Water Quality and Environment |
| Mr. Shin-ichi Osaka | Equipment Planning |
| Mr. Kiyohito Yamazaki | Implementation Planning and Cost Estimation |
| Mr. Kirthi Sri Senanayake | Organization and Operation |
| Mr. Shin-ichi Isoda | Financial Planning and Project Evaluation |

The members of the Advisory Committee are as follows:

| | |
|---|---|
| Mr. Katsuyoshi Tomono | Leader/Water Supply Planning<br>Senior Researcher, Japan Water Works Association |
| Ms. Keiko Yamamoto | Facility Planning |

| | |
|---|---|
| Mr. Tomio Iwamoto | Senior International Cooperation Specialist,<br>Japan Water Works Association<br>Finance<br>Assistant Manager, Engineering Department,<br>Osaka Municipal Waterworks Bureau |

### 1.6.3 Sri Lankan Organization

The Sri Lankan organization consists of the NWSDB Counterpart Team, and Steering Committee composed of the representatives of the organizations concerned with the Kalu Ganga Water Supply Project in coordination with the NWSDB.

The principal members of the NWSDB Counterpart Team and the NWSDB are as follows:

| | |
|---|---|
| Mr. T. B. Madugalle | Chairman |
| Mr. A. P. Chandraratne | General Manager |
| Mr. M. Wickramage | Addl. General Manager (Corporate Planning) |
| Mr. P. M. R. Pathiraja | Addl. General Manager (Operations) |
| Mr. P. U. Gunasinghe | Deputy General Manager (P&D) |
| Mr. S. K. H. Perera | Deputy General Manager (RSC-GC) |
| Mr. K. M. N. S. Fernando | Deputy General Manager (IDA) |
| Mr. T. M. M. Mediwaka | Deputy General Manager (Financial) |
| Mr. S. J. P. Wijegoonewardene | Assistant General Manager (P&D I) |
| Mr. D. N. J. Ferdinando | Assistant General Manager (RSC-GC) |
| Mr. A. H. C. Silva | Assistant General Manager (UFW) |
| Mr. L. S. P. J. de Silva | Assistant General Manager (Service) |
| Mr. R. H. Ruvinis | Chief Engineer (P&D) |
| Mr. Anura Jayasinghe | Chief Engineer (Corporate Planning) |
| Mr. Nimal Padamsiri | Chief Chemist |
| Mr. Asoka Perera | Geologist |
| Mr. G. B. N. Wimalasooriya | Senior Engineer (P&D) |
| Mr. W. A. Samarakoon | Engineering Assistant |
| Ms. P. Sangarapillai | Engineering Assistant |

The members of the Steering Committee are as follows:

| | |
|---|---|
| Mr. K. A. H. Ranaweera | Secretary to the Minister for Housing |
| Mr. T. B. Madugalle | Chairman, NWSDB |
| Ms. D. D. J. Kudaligama | Director, External Resources Department |
| Mr. P. Sumanapala | Deputy Director, National Planning Department |
| Mr. D. G. D. C. Wijeratne | Addl. General Manager (Planning), CEB |
| Mr. K. G. D. Bandaratilake | Deputy Director General (Technical), CEA |
| Mr. K. G. S. Lankatilake | Addl. Director (Technical), UDA |
| Mr. G. T. Dharmasena | Deputy Director(Hydrology), Irrigation Department |
| Mr. Lionel Wijendra | Addl. Director, Policy and Planning,<br>Ministry of Housing, Construction and<br>Public Utilities |

## 1.7 Organization of Report

The Study Reports prepared are as follows:

| | |
|---|---|
| Summary Report | (Volume I) |
| Main Report | (Volume II) |
| Supporting Report | (Volume III) |
| Data Report | (Volume IV) |
| Drawings | (Volume V) |

The Summary Report presents the essential results of the whole Study which is extracted from the Main Report. It consists of two parts ; Part I "Development Plan" and Part II "Feasibility Study".

Part I describes the natural conditions, socio-economic conditions and land use of the Greater Colombo area as well as the Study area, the outline of the existing waterworks including the organization concerned, water supply system, population served, water use, and on-going and planned water supply projects. Based on the results of the review on the Master Plan Update prepared in 1991 and population and water demand projection, and the study on the water demand for the Kalu Ganga by other projects and the safe yield of the Kalu Ganga water source, the long-term development plan of the Kalu Ganga Water Supply System which is an integral part of the Greater Colombo Water Supply System is presented.

Part II defines first the scope of work for the Feasibility Study of the Kalu Ganga Water Supply System and describes the design of facilities, operation and maintenance program, implementation plan, project cost estimates, institutional and managerial considerations, financial performance of the NWSDB, project evaluation and the environmental protection considerations.

# CHAPTER 2

# GENERAL DESCRIPTION OF THE GREATER COLOMBO AREA

# 2. GENERAL DESCRIPTION OF THE GREATER COLOMBO AREA

## 2.1 Natural Conditions

### 2.1.1 Topography

(1) Nationwide Area

In general surface configuration, Sri Lanka comprises a high land massif situated in the south-center, which is surrounded by an intermediate zone of upland ridges and valleys. From a sea level, the relief appears to ascend in steps of three peneplanes to a maximum elevation of over 2,500 m at Pidurutalagala, nearly 300 m higher than the well known Adam's Peak (Samanalakanda) which is 2,243 m high.

On the basis of height and land forms, Sri Lanka will be divided roughly into five topographical regions: 1) central high lands, 2) south-west country, 3) east and south-east country, 4) northern lowlands, and 5) coastal fringes.

Among them the coastal fringe, where the Project Area is situated, consists of a series of lagoons, marshes, sand bars, peninsulas, dunes and other associated features.

(2) Greater Colombo Area

The Greater Colombo area comprises each parts of three Districts of Colombo, Gampaha and Kalutara. In general, there is no outstanding difference on relief features throughout the districts, namely constituting flat coastal plains, marshy lands and small scale of hills and dispersed forests.

The Colombo District located in the midst of the three Districts is bordered at the north end with the Gampaha District by the Kelani Ganga which roles as a major water source contributing to the Greater Colombo water supply scheme. At approximately 5 km east of the center of Colombo, marsh lands extend along the Heen Ela, Kolonnawa Ela and Diyawarna Oya. The Kaduwela Division in the east wards of the C.M.C., dispersed mountains of more than 100 m above MSL are seen, however, other areas are generally flat configurations. In the southern part of the Colombo District, the Bolgoda Lake and its tributaries are located giving fertile lands in the peripheral divisions of Moratuwa, Kesbewa and Panadura for agricultural use, unless otherwise the problem of saline intrusion.

In the Gampaha District, large scale of marsh land extends along the coastal line, however, there is no surface water source to be utilized for public water supply scheme. Major surface water sources other than the Kelani Ganga and its tributary giving fertile lands for agricultural use are the Attanagalu Oya, Dandugam Oya and some canals connecting these sources. In the eastwards, mountains with more than 100 m above MSL are seen as well as the Colombo District.

The Kalutara District having one of the largest rivers in the south-west of Sri Lanka has a potential of regional development in view of water related industries . The Kalu Ganga has a larger capacity than the Kelani Ganga in its annual runoff. However, due to the topographic configuration at the river mouth consisting of large sand dunes, flood control has become inevitably difficult bringing occasionally about large scale of flood to the catchment area. This sand dune resulting in the width of river mouth of approximately 15 to 20 m, on the contrary, contribute to the protection of the Kalutara City from sea waves and may mitigate saline intrusion to the upper reaches. In the eastwards of this district, mountains of more than 100 m above MSL can be seen, which will be proposed for the establishment of water supply facilities due to their locations and preferable altitudes.

(3) Project Area

The Project Area comprises seven divisions and four out of them are located in the Colombo District and three in the Kalutara District. The followings are the brief description on topographic configurations for each division in the Project Area:

The Dehiwala/Mt. Lavinia Division is situated in the southern part of the Greater Colombo area. The area is a low lying flat land with altitudes of approximately 5 to 10 m from MSL consistent of a soil mixed with rocks and sand containing salt due to sea erosion resulting in infertile lands.

The Moratuwa Division is situated in the outskirts of the Greater Colombo. The topography is generally flat surrounded by the Bolgoda Lake and its tributaries. The land use of this division is mainly for residential, commercial, industrial and public utilities and the potential land for cultivation is limited.

The Kesbewa Division is located in the coastal plain of below 30 m contour line. The major reservoir, the Bolgoda River reaches the Indian Ocean running through the boundary with the Moratuwa Division. The surrounding areas are suffered from salinity of the water .

The Homagama Division, except for the mountain called Kuragala Kanda which rises to approximately 100 m, is mainly a plain with heights from 30 to 70 m above MSL. The north and eastern parts of the regions are fed by the Kelani Ganga and its tributaries. This area is very rich as far as groundwater is concerned. There is no large scale natural forests in the area except reserved forest at Mattegoda along the Maha Oya basin. There are scattered plantations of economic crops such as coconut and rubber.

The Horana Division, hills, valleys and lowlands of the low country wet zone are the main geological features. Kurana, Kandanapitiya, Ingiriya, Nambapana and Urugala in the eastern part of this region have highlands ranging from 150 to 360 m above MSL. The Pinwara Ela, Mahawak Oya, Ingiriya Ela and Nambapana Ela are the main constituents of the drainage pattern along with the Kalu Ganga, which form a

part of the southern boundary. Southwest monsoon brings rain to this region with the highest rainfall in June and July, and amounts to 5000 mm annually.

The Maharagama division is located in the flat region, and where no major river or stream is found. Except for the Boralesgamuwa lake located in the south-west of the region no other important water resource can be found.

The Bandaragama Division is located in the north-west of the Kalutara District. This division is also located in the low lying flat plains with altitude of less than 60 m. In the southern part of this division, some hilly areas are scattered with altitudes of 60 m to 150 m.

### 2.1.2 Meteorology

Meteorological observation in Sri Lanka is conducted under the jurisdiction of the Department of Meteorology. In and around Greater Colombo and the basin of the Kalu Ganga, there are four meteorological observation stations. Locations of these stations are shown in Figure 2.1.

| | | |
|---|---|---|
| Colombo | 6° 54'N - 79° 52'E | + 7 m MSL |
| Agalawatta | 6° 32'N - 80° 09'E | +65 m MSL |
| Bombuwala | 6° 34'N - 80° 01'E | - |
| Ratnapura | 6° 41'N - 80° 23'E | +34 m MSL |

General meteorology of Greater Colombo and the basin of the Kalu Ganga is discussed below based on the meteorological data recorded in the recent ten years at the stations of Colombo and Ratnapura. (Source : Department of Meteorology).

(1) Temperature

Mean monthly temperature of daily mean temperature at Colombo varies from 26.8°C to 28.7°C. The highest temperature in a year appears in May and the lowest appears in November. Mean monthly temperature of daily mean temperature at Ratnapura varies from 27.1°C to 28.8°C. The highest temperature in a year appears in March and the lowest appears in July. The mean monthly temperature of daily mean temperature at Colombo is lower than that at Ratnapura in November to March and higher in May to September.

The range of daily temperature between maximum and minimum temperature at Ratnapura is wider than that at Colombo. The maximum at Ratnapura reaches at around 34°C in March and the minimum at around 22° C in January. Those at Colombo are around 32°C in April and 22°C in January, respectively.

(2) Relative Humidity

Mean relative humidity in day time at Colombo varies through a year from 69 percent in February to 80 percent in June. That in night time varies from 85 percent in January to 92 percent in November with a slight change through a year compared with that in day time.

Same tendency can be seen in those at Ratnapura. Mean relative humidity in day time at Ratnapura varies from 66 percent in February to 81 percent in June. That in night time varies from 90 percent in February to 95 percent in November. Humidity in day time through a year has a clear peak in June at Colombo and Ratnapura but that at night time through a year does not have a clear peak at Colombo and Ratnapura either.

The difference in humidity between day time and night time is rather wide in November to April and small in June to September.

(3) Wind

Mean monthly wind speed at Colombo varies from 1.7 m/s in June to 1.2 m/s in March. Wind speed has two peaks through a year in January and in June. That at Ratnapura varies from 0.9 m/s in June to 0.5 m/sec in December. Wind speed at Ratnapura has one peak through a year in June to August. Wind speed at Ratnapura is lower than that at Colombo by around 1 m/s.

Regarding the wind direction, south-west wind is dominant in April to October and north-east wind is dominant in November to February at Colombo. At Ratnapura, generally, west wind is dominant through a year.

(4) Sunshine Duration

Mean monthly sunshine duration at Colombo varies from 8.9 hours in March to 5.8 hours in August and October. That at Ratnapura varies from 7.6 hours in February to 4.8 hours in June. Sunshine duration at Colombo and Ratnapura has one peak through a year in February or March. Sunshine duration at Colombo is longer than that at Ratnapura by about one hour.

(5) Evaporation

Mean monthly evaporation at both stations varies from about 4.6 to 4.8 mm in March to 3.3 to 3.4 mm in December, respectively. The difference in evaporation between Colombo and Ratnapura is very small as well as the variation through a year.

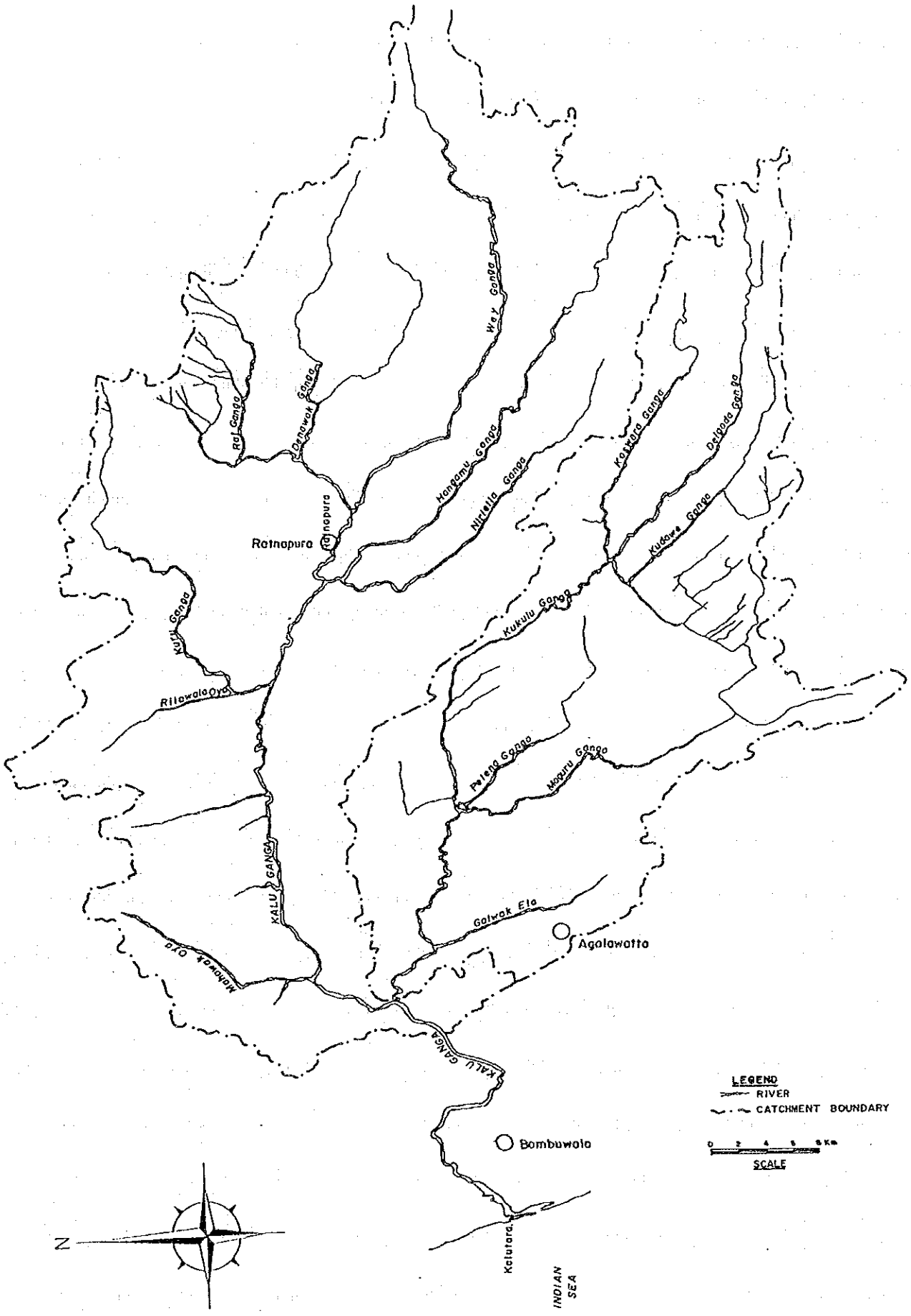



Figure 2.1 Location of Meteorological Stations

### 2.1.3 Hydrology

(1) Rainfall

Annual rainfall is shown in Table 2.1 and Figure 2.2. As seen in Figure 2.2, annual rainfall at Colombo that is located along the coast at the elevation of about 7 m above the mean sea level varies from around 1,500 mm to 2,500 mm in the last ten years and the average of annual rainfall in the last ten years is 2,153 mm. On the other hand, annual rainfall at Ratnapura varies from 3,000 mm to 4,500 mm and the average of annual rainfall in the last ten years is 3,685 mm. The difference is more than 1,500 mm.

Mean monthly rainfall at these two stations are also shown in Table 2.1 and in Figure 2.3. As seen in Figure 2.3, monthly rainfall at these two stations have two peaks through a year. Monthly rainfall at Colombo has peaks of 319 mm in May and 278 mm in November. Peaks at Ratnapura are 483 mm in June and 425 mm in October. Lowest rainfall are 57 mm in February and 106 mm in August at Colombo, and 141 mm in January and 286 mm in August at Ratnapura. (Source : Department of Meteorology).

Table 2.1 Monthly Rainfall Records

**Colombo** unit: mm

| | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 4.1 | 0.2 | 311.8 | 108.8 | 323.7 | 195.0 | 160.9 | 123.6 | 104.9 | 186.6 | 434.9 | 51.0 | 2005.5 |
| 1983 | - | 43.0 | 60.3 | 83.0 | 336.5 | 118.6 | 163.1 | 94.0 | 291.5 | 94.8 | 241.7 | 223.6 | 1750.1 |
| 1984 | 211.5 | 179.6 | 162.5 | 254.0 | 491.0 | 176.8 | 127.8 | 4.9 | 339.3 | 161.3 | 360.2 | 24.2 | 2493.1 |
| 1985 | 83.5 | 160.8 | 116.1 | 76.3 | 253.1 | 316.9 | 19.6 | 111.2 | 343.4 | 275.7 | 244.9 | 230.9 | 2232.4 |
| 1986 | 144.9 | 78.4 | 81.4 | 216.8 | 230.9 | 63.8 | 10.5 | 76.2 | 128.4 | 163.0 | 58.9 | 203.4 | 1456.6 |
| 1987 | 98.4 | 0.0 | 73.2 | 179.3 | 198.4 | 116.3 | 12.0 | 404.8 | 508.9 | 506.5 | 217.4 | 136.0 | 2451.2 |
| 1988 | 3.0 | 63.6 | 206.4 | 185.0 | 146.2 | 325.7 | 101.5 | 122.4 | 374.3 | 117.9 | 266.9 | 96.0 | 2008.9 |
| 1989 | 35.8 | 6.9 | 146.3 | 332.9 | 399.1 | 217.2 | 138.2 | 49.1 | 174.5 | 450.4 | 284.7 | 31.5 | 2265.7 |
| 1990 | 182.7 | 36.9 | 184.0 | 366.9 | 324.3 | 184.1 | 206.3 | 17.9 | 29.6 | 374.1 | 255.8 | 178.8 | 2341.4 |
| 1991 | 78.8 | 55.2 | 146.4 | 142.1 | 317.4 | 309.9 | 121.0 | 88.8 | 112.4 | 353.1 | 292.7 | 79.1 | 2096.9 |
| 1992 | 19.8 | 3.5 | 0.8 | 151.5 | 488.7 | 602.3 | 218.1 | 70.9 | 323.0 | 216.7 | 401.5 | 78.4 | 2575.2 |
| Mean | 86.3 | 57.0 | 135.4 | 190.6 | 319.0 | 238.8 | 116.3 | 105.8 | 248.2 | 263.6 | 278.1 | 121.2 | 2152.5 |

**Ratnapura** unit: mm

| | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 55.5 | 24.4 | 318.1 | 455.4 | 545.3 | 892.5 | 307.2 | 267.2 | 237.5 | 628.2 | 638.8 | 129.4 | 4499.5 |
| 1983 | 93.1 | 78.8 | 150.1 | 128.0 | 495.1 | 367.6 | 276.1 | 284.4 | 450.5 | 146.0 | 344.6 | 537.8 | 3352.1 |
| 1984 | 274.7 | 407.1 | 356.7 | 529.2 | 564.0 | 343.5 | 515.9 | 48.2 | 312.1 | 255.4 | 343.7 | 264.5 | 4215.0 |
| 1985 | 214.2 | 174.1 | 273.7 | 133.2 | 504.2 | 746.2 | 249.8 | 183.4 | 252.9 | 646.1 | 251.7 | 346.4 | 3975.9 |
| 1986 | 159.6 | 319.0 | 131.3 | 358.7 | 287.5 | 201.8 | 121.3 | 270.3 | 700.2 | 435.0 | 277.8 | 284.5 | 3547.0 |
| 1987 | 138.7 | 11.2 | 157.9 | 239.2 | 302.7 | 233.1 | 18.8 | 660.4 | 320.0 | 475.3 | 381.4 | 72.6 | 3011.3 |
| 1988 | 94.7 | 324.4 | 228.2 | 252.3 | 13.3 | 662.4 | 331.7 | 557.6 | 694.3 | 224.5 | 378.8 | 139.3 | 3911.5 |
| 1989 | 47.5 | 7.8 | 123.3 | 257.1 | 405.9 | 632.2 | 610.9 | 282.7 | 448.5 | 500.4 | 320.0 | 97.4 | 3733.7 |
| 1990 | 74.8 | 134.1 | 251.2 | 352.1 | 493.6 | 298.8 | 327.4 | 73.6 | 107.2 | 446.5 | 511.4 | 209.4 | 3280.1 |
| 1991 | 257.4 | 106.5 | 175.5 | 325.1 | 412.6 | 450.2 | 282.7 | 233.9 | 175.9 | 488.7 | 259.8 | 152.9 | 3321.2 |
| 1992 | 83.4 | 41.0 | 44.8 | 335.4 | 489.0 | 408.3 | 426.0 | 265.3 | 434.0 | 400.2 | 513.5 | 95.3 | 3536.2 |
| Mean | 141.0 | 158.7 | 216.6 | 304.0 | 402.4 | 482.8 | 304.2 | 286.2 | 369.9 | 424.6 | 370.8 | 223.4 | 3684.7 |

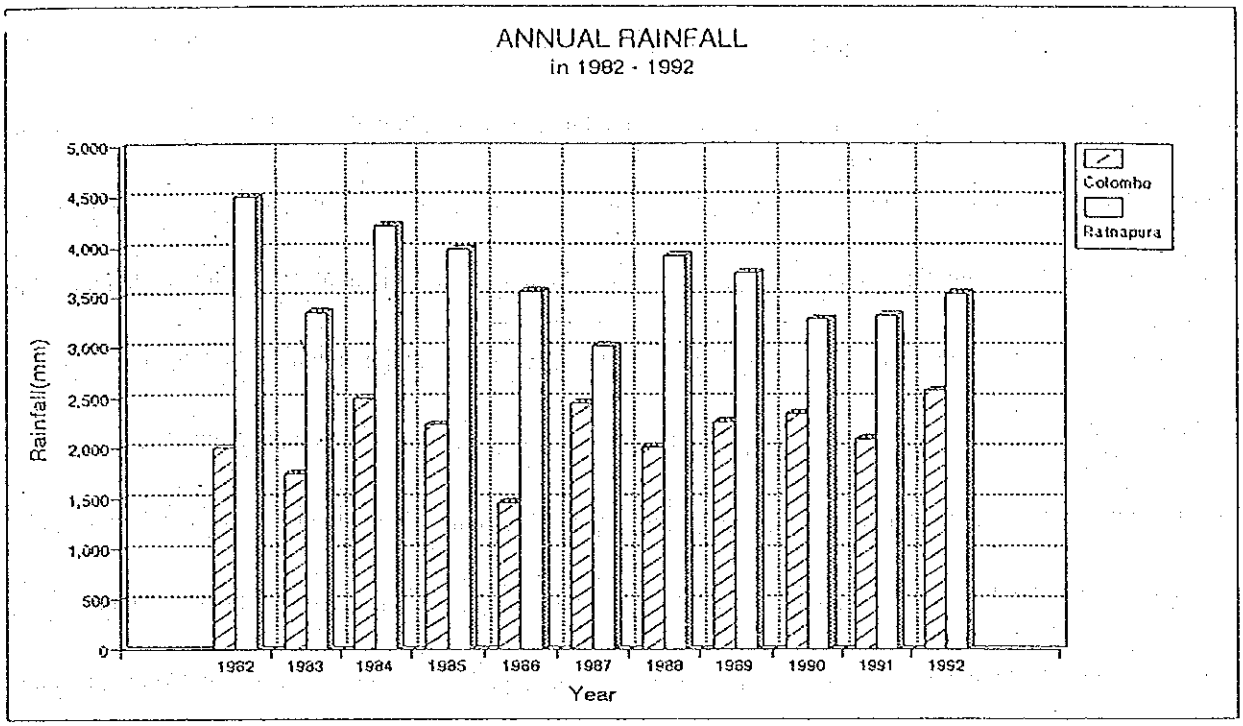



Figure 2.2 Annual Rainfall

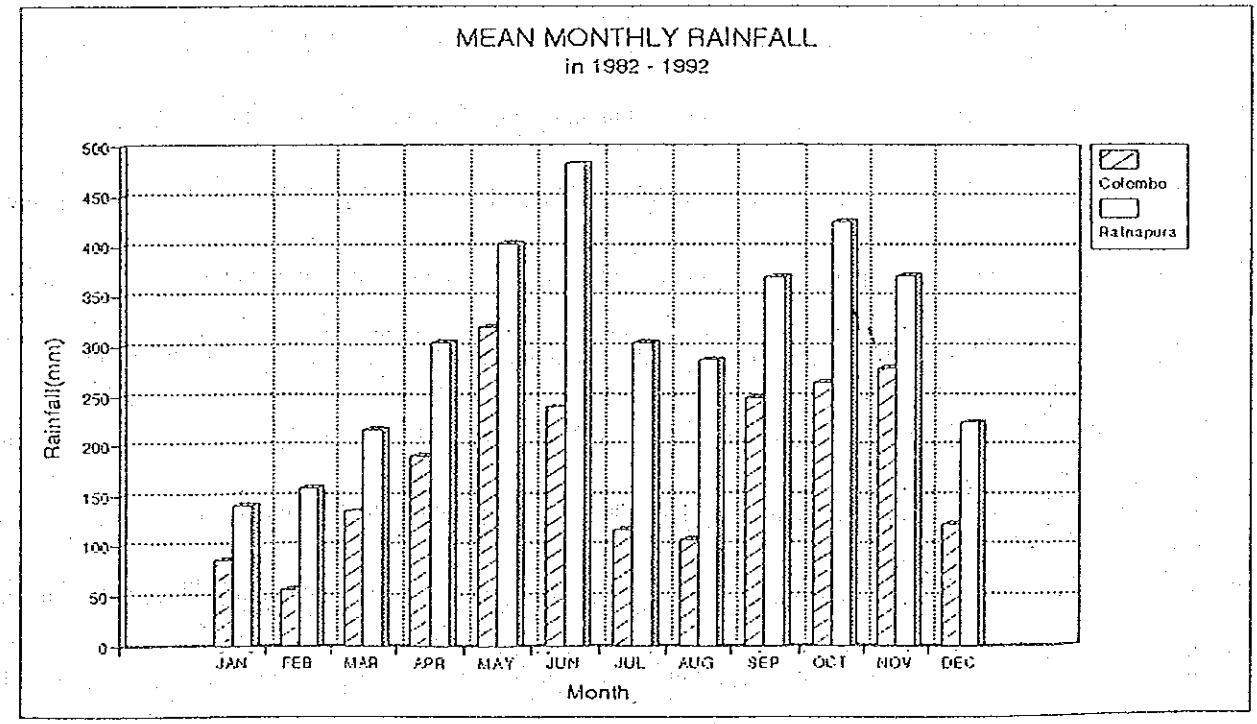



Figure 2.3 Mean Monthly Rainfall

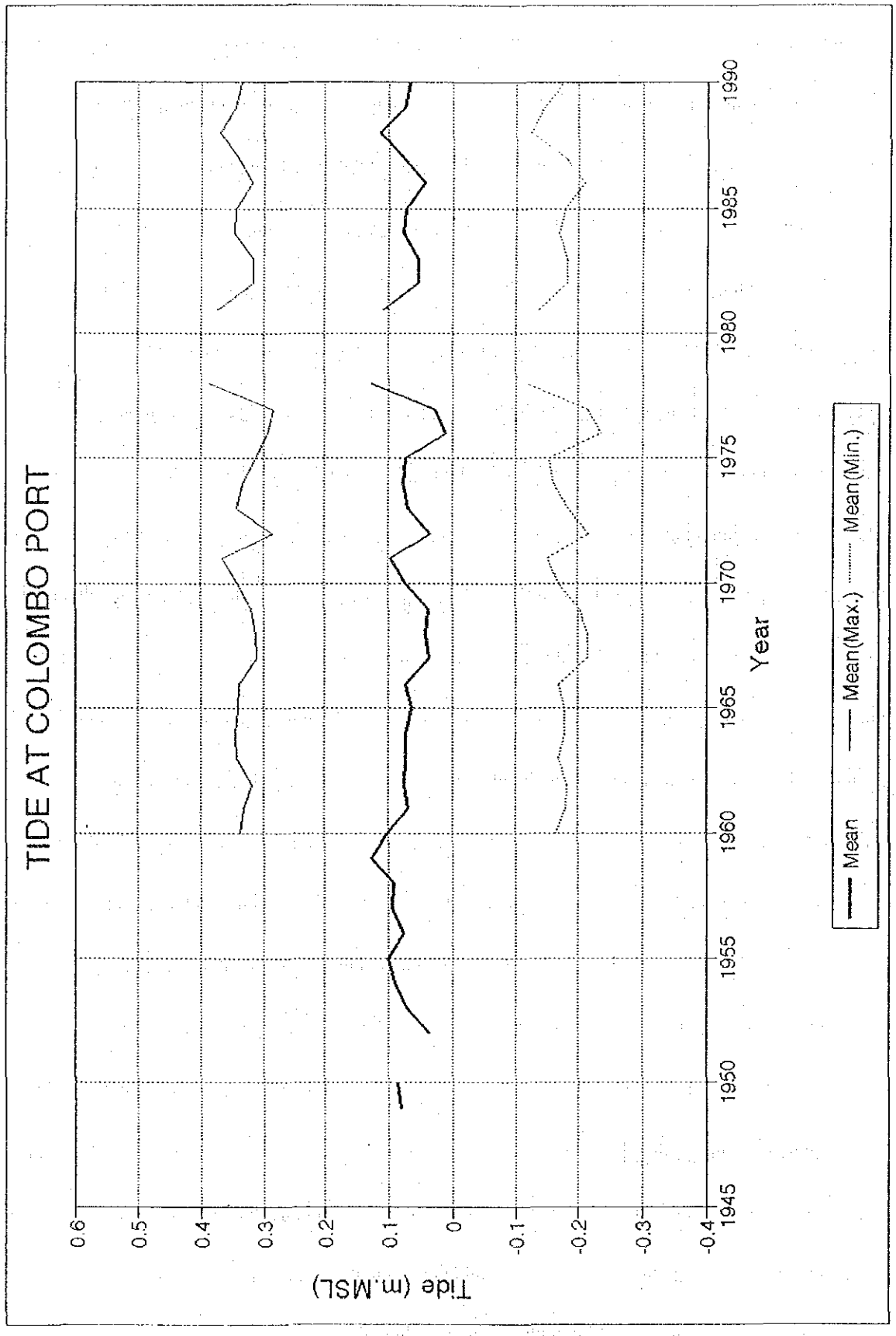



Figure 2.4 Annual Tide Level at Colombo Port

(2) Tide

There is one tide gauging station at the Colombo Port in and around Greater Colombo. Tide recording is under the management of the Ports Authority. Tide records are available since 1949.

At the Colombo port there are generally two high tides every day. Annual mean, mean daily maximum and mean daily minimum of tide in the period of 1949 to 1990 are shown in Figure 2.4. According to Figure 2.4, mean altitude of tide is +0.51 m in the reading of the staff gauge (0.08 m MSL) in this period (Source : the Ports Authority).

Though the tide at the river-mouth of the Kalu Ganga has not been measured in the past, discussion on the tide for the estimate of saline water intrusion in the Kalu Ganga is presented in the sub-section 6.4 "Extent of Saline Water Intrusion".

### 2.1.4 Geology

The Island of Sri Lanka is essentially an extension of Peninsular India which forms part of the Gondowana Shields from geologically remote times. The various geological formations are summarized below in order of geological times.

Geological Formation

Precambrian

This geological formation covers about 90 percent of the surface area of the Island.

a) Charnockite to Sedimentary Series (Highland Series)

Quartzites, quarz-schists, granulites, garnet-sillimanite graphite schists, sillimanite gneisses, cordierite gneisses, calc-gneisses, crystalline limestone, dolomites and charnockites

This series occupies the central portion of the Island extending in a broad sweep to the south and west, and north-eastwards to Trincomalee. Almost the entire hill country lies within this belt.

b) Vijayan Series

Granites, granitic gneisses, biotite gneisss, biotite-hornblends gneisses, pegmatites and charnockites.

This series of rocks are widespread in the lowlands which form the eastern and south-eastern sector of the Island.

Jurassic Sandstone, askoses, grits, shale and carbonaceous shale.

A few square kilometers of Jurassic deposits are found near Puttalam.

MioceneLimestone and arenaceous limestone.

These rocks which are mainly limestone are best developed in the Jaffna Peninsula

Pleistocene Red-earth, mottled gravel and laterite.

| | |
|---|---|
| | It is extensively developed in a strip about 50 km wide and extending parallel to the south-west coast from a few kilometers north of Colombo to as far south as Tangalle - over a distance of about 200 km. |
| Recent | Alluvium, wind brown sands, residual deposits, laterite and lateritic earth, gravel and coastal sandstone |

In the Greater Colombo area, hornblede gneisses, hornblende-biotite gneisses, biotite gneisses are developed around the Kelani Ganga northwards Charnockite covers in the south to beyond the Kalu Ganga. Horana lies within cordierite-garnet granulite or gneisses adjoining to garnet-biotite gneisses which is developed southwards.

## 2.2 Socio-Economic Conditions

### 2.2.1 Economic Condition

The data available for understanding the economic condition of the Greater Colombo area, especially the income level of the people is very limited. "Greater Colombo Water Supply System Master Plan Update" prepared in 1991 presents the 1989 Colombo household income developed with such limited data which is reproduced in Tables 2.2 and 2.3.

Table 2.2 Colombo Houschold Income (1989)

| Income Receiver Quintile | Household Income (Rs./month) |
|---|---|
| Lowest 20% | 630 |
| Second 20% | 2,090 |
| Third 20% | 3,677 |
| Fourth 20% | 5,326 |
| Highest 20% | 19,217 |

Table 2.3 Colombo Household Income Level (1989)

| Percent of Household | Receive Income (Rs./month) |
|---|---|
| 20% | 619 |
| 30% | 1,700 |
| 40% | 2,785 |
| 50% | 4,640 |

As for the seven southern divisions, the numbers of persons or families which received the food stamp which is one of the public welfare schemes in the poverty relief policy are reported as shown in Table 2.4. Although the administrative numbers of persons or families corresponding to those data are not available, the resource profile of Horana A.G.A. division stated that 43 percent of the entire population received the food stamp. It suggests that the people in the agriculture-based area have low income.

Table 2.4 No. of Food Stamp Recipients

| Division | No. of Food Stamp Received | |
|---|---|---|
| | person | Family |
| Dehiwala-Mt. Lavinia | | 6,324 |
| Moratuwa | | 12,504 |
| Kesbewa | | |
| Homagama | 12,707 | |
| Panadura | | |
| Bandaragama | 42,018 | 13,142 |
| Horana | 47,983 | 13,142 |

### 2.2.2 Education

All the schools are classified under the grade as shown in Table 2.5.

Table 2.5 Grade of School in Sri Lanka

| Grade | Description | Remarks |
|---|---|---|
| 1A | | |
| 1B | Schools w/ G.C.E. (A/L) Science Classes | Senior Secondary School |
| 1C | Schools w/ G.C.E. (A/L) Arts and Commerce Classes | Senior Secondary School |
| 2C | Schools w/ 6-10 Year Classes | Junior Secondary School |
| 3 | Schools w/ 0-5 Year Classes | Primary School |

G.C.E: General Certificate of Education, A/L : Advanced Level

The educational status of seven southern divisions is shown in Table 2.6.

Table 2.6 No. of Schools by Division

| | Teacher : Pupil | Primary School | Secondary School | Maha Vidyalayas | Madya Maha Vidyalayas | Total |
|---|---|---|---|---|---|---|
| Dehiwala-Mt. Lavinia | 1:24 | | | | | |
| Moratuwa | 1:29 | 15 | 23 | | | 38 |
| Kesbewa | 1:23 | 14 | 5 | 12 | 1 | 32 |
| Homagama | | 33 | | 11 | 1 | 45 |
| Panadura | 1:22 | 5 | 21 | 20 | | 46 |
| Bandaragama | 1:23 | 8 | 6 | 12 | | 45 |
| Horana | 1:25 | 20 | 21 | 14 | | 55 |

The ratio of pupils to teachers are in general satisfactory for each primary, secondary and maha vidyalayas level. The problems schools have been facing are the early school leavers and the lack of educational facilities.

As for the early school leavers, the following facts are reported:

1. In Moratuwa, the rate of early school leavers is rather high. The factors that contributed are as follows:

   - Moratuwa as an industrial and commercial town.
   - Opportunity available for petty jobs in business establishments and garages
   - Migration of the parents to seek employment abroad
   - Situations that compel to shoulder family responsibilities
   - Children who abandon schooling much earlier to join the parents in their traditional family occupations such as fishing and carpentry

2. In Horana, the total student population, according to 1989 statistics, is 24,090 and 46 percent of this number are year 1-5 students and 54 percent in years 6 to G.C.E. (A/L) classes. Only 5 percent of the student body is in A/L classes. It is therefore evident that a large number of students leave school or are drawn to some profession or another or else join the labor force.

The shortage of educational requirements includes the teachers, school furniture, school accessories (i.e. teachers' tables and chairs, black boards, cupboards, students' desks and chairs, science tables, home science unit, aesthetic unit, etc.), and other requirements (play grounds, buildings, floor space, science room, library, water, electricity, latrines, etc.). In Homagama, for example, 24 schools out of 45 schools need sufficient buildings, floor space and other requirements.

### 2.2.3 Public Hygiene

(1) Greater Colombo

The Provincial Director of Health Services (PDHS), the Deputy Provincial Director of Health Services (DPDHS) and the Medical Officers of Health (MOH) are responsible for sanitation, general preventive services, epidemiological and health education at each level of province, district and area of the Divisional Secretary (former Assistant Government Agent). The administrative area of the MOH almost coincide with that of the Divisional Secretary but not exactly.

Table 2.7 shows the incidence of the water and sanitation related/associated diseases for the Greater Colombo area in 1990 by division. The population to calculate the incidence on a rate per 100,000 persons were those developed for the Greater Colombo Water Supply System Master Plan Update in 1991.

Per 100,000 persons morbidity of the water and sanitation related/associated diseases are 17,215 in ill defined intestinal infection, 3,303 in shigellosis and 2,596 in malaria, respectively, in order of magnitude. Ill defined intestinal infections and shigellosis are attributable to poor sanitation and undesirable health behavior, while malaria is mainly due to poor drainage leaving stagnant pools of water and indiscriminate disposal of water containing materials in which vectors breed.

Table 2.7 Water and Sanitation Related/Associated Morbidity (1990)

| Name of Disease | DPDHS Colombo | | DPDHS Gampaha | | DPDHS Kalutara | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No. of Cases | Per 100,000 | No. of Cases | Per 100,000 | No. of Cases | Per 100,000 | No. of Cases | Per 100,000 |
| Typhoid/Para Typhoid Fever | 531 | 28.0 | 70 | 9.0 | 5 | 2.2 | 606 | 21.0 |
| Shigellosis | 2,046 | 08.2 | 559 | 73.3 | 697 | 309.2 | 3,303 | 114.7 |
| Food Poisoning | 316 | 16.7 | 520 | 68.1 | 21 | 9.3 | 857 | 29.7 |
| Amoebiasis | 346 | 18.3 | 153 | 20.0 | 10 | 4.4 | 509 | 17.7 |
| Ill-defined Intestinal Infections | 13,065 | 691.1 | 2,916 | 382.2 | 1,234 | 547.5 | 17,215 | 598.0 |
| Subtotal | 16,304 | 862.3 | 4,218 | 552.6 | 1,967 | 872.6 | 22,490 | 781.1 |
| Viral Hepatitis | 905 | 47.8 | 501 | 65.6 | 153 | 67.9 | 1,559 | 54.1 |
| Dengue Fever | 27 | 1.4 | 4 | 0.5 | 0 | 0.0 | 31 | 1.0 |
| Japanese Encephalitis | 19 | 1.0 | 64 | 8.4 | 9 | 4.0 | 92 | 3.2 |
| Leptospirosis | 109 | 5.9 | 37 | 4.8 | 0 | 0.0 | 146 | 5.0 |
| Malaria | 1,699 | 89.9 | 758 | 99.3 | 139 | 61.6 | 2,596 | 90.2 |
| Filalia | 345 | 18.2 | 125 | 16.4 | 32 | 14.1 | 502 | 17.4 |
| Cholera | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Total | 35,712 | 1,888.8 | 9,925 | 1,300.2 | 4,267 | 1,892.8 | 49,906 | 1,733.1 |

Source: Greater Colombo Wastewater and Sanitation Master Plan - Volume 1: Final Report", Engineering-Science, Inc. (April 1993)

(2) Seven Southern Divisions

In the southern divisions, the following diseases are reported as the common diseases:

| | |
|---|---|
| Dehiwala- Mt. Lavinia | scabies, diarrhea, dental diseases and influenza |
| Moratuwa | dysentery, vomiting, worm diseases, tuberculosis, leprosy, venereal diseases, filaria, enteric fever, hepatitis, contagious diseases (measles, chicken pox), dental diseases, asthma |
| Panadura | jaundice, dysentery, malaria, typhoid and dengue fever. |
| Kesbewa | basilary diarrhea, tuberculosis, fever |
| Bandaragama | tuberculosis, diarrhea diseases, typhoid and rabies |

Population congestion, living in houses not suitable to live in, lack of toilet facilities, mosquito breeding grounds such as not cleared refuse and stagnation of water and so on are identified to have contributed to spread of those diseases.

It should be noted that a number of people in those divisions suffer from malnutrition, for example, 35 percent of the population in Dehiwala-Mt. Lavinia, 50 percent of the children and 65 percent of the school children in Moratuwa and 62 percent of the less than 5 year children in Bandaragama. Major reasons for the malnutrition is the low income of the people.

### 2.2.4 Garbage Disposal

The local authorities are responsible for refuse collection and disposal including the sludge in the septic tank and pit latrine.

The storage of household refuse before collection is done with the following methods:

1) Providing polythene bags
2) Placing of track trailers or bin carts near institutions, market places and bus stands
3) Construction of three-sided masonry community bins
4) Construction of masonry enclosures with metal door

The collection and transportation to the disposal site are done with the following methods:

1) Open tipping trucks
2) Side-loaded non-compaction lorries
3) Tractor pulling open trailers or close trailers
4) Rear-loading compaction Trucks
5) Push carts
6) Two-wheel tractors with carts

The disposal sites are in most cases located in the low-lying land, flood plain or marsh areas. When dumping the solid waste, tractor type dozers are used for pushing, spreading and compacting the waste. There are some people to make a living by scavenging near such sites.

The disposal sites are operated in an unsanitary manner creating a potential health hazard and nuisance to residents close to such disposal sites. In addition some wastes often flow out of the disposal sites into the watercourses causing the deterioration of water quality of watercourses and the flood by blocking such watercourses.

About 1,200 tons of solid waste were generated in C.M.C. daily in 1990 in which the per capita generation of solid waste increased from 0.75 kg/capita/day to 0.98 kg/capita/day from 1986 to 1990, and is expected to increase by another 21 percent by 2010. About 90 percent of solid waste in C.M.C. is collected or brought by households to temporary collection sites.

The smaller urban local authorities collect as little as 5 percent of solid waste.

### 2.2.5 Sanitation and Sewerage

In the Greater Colombo area, the sanitation and sewerage facilities are used for excreta and wastewater management as of 1992 as listed in Table 2.8.

The existing sewerage system covers only the C.M.C. area as shown in Figure 2.5. Although sanitary sewers have been constructed in a northern coastal part of Dehiwala-Mt.Lavinia M.C., no house connection has been provided due to no operation of two pumping stations to convey sewage within the area.

Apart from the public sewerage system mentioned above, several independent sewerage systems are in use at such industrial estates and export processing zones as Ekala IE, Katunayake EPZ and Biyagama EPZ, as shown in Figure 2.6. Industries discharging process wastewater in Katunayake and Biyagama EPZ's are

required to meet the Greater Colombo Economic Commission (GCEC, now Sri Lanka Board of Investment : BOI) pretreatment standards. Individual discharges are monitored to ensure compliance with these standards.

Table 2.8 Sanitation Facilities in Greater Colombo

| | Population | % |
|---|---|---|
| Served by sewers | 550,000 | 19 |
| Served by on-site facilities | 1,700,000 | 59 |
| No service or service grossly inadequate | 650,000 | 22 |
| Total | 2,900,000 | 100 |

Treatment records at the Katunayake and Biyagama EPZ's are presented in Table 2.9.

The major part of the existing public sewerage system was constructed between 1906 and 1916 in the British colonial era to function as two independent systems - a northern system and a southern system, each with its own treatment plant. The northern plant discharged to the Kelani Ganga; the southern plant through a short outlet to the sea at Wellawatta. Although the original sewerage system was designed as a combined system, it is now functioning as a separate system by separating surface water from sewage.

The both treatment plants were inoperative for five years after installation. Rehabilitated in 1956, the Madampitiya Treatment Plant in a northern system broke down again soon after the commissioning and raw sewage was discharged to the Kelani River. The Wellawatta Treatment Plant in a southern system was abandoned due to the objections raised by the residents in the area over the nuisance caused by flies and smells. Thereafter, sewage was discharged through the short outfall (80 m long) into the sea.

At the Katunayake EPZ, a combined industrial and sanitary wastewater sewerage system has been constructed to collect wastewater for treatment in aerated/facultative lagoons after screening and grit removal. Excess sludge generated in aerated/facultative lagoons are dried at the sludge drying beds.

Industries discharging their process wastewater in the Katunayake and Biyagama EPZs are required to meet the Greater Colombo Economic Commission (GCEC, now Sri Lanka Board of Investment: BOI) pretreatment standards. Individual discharges are monitored to ensure compliance with these standards.

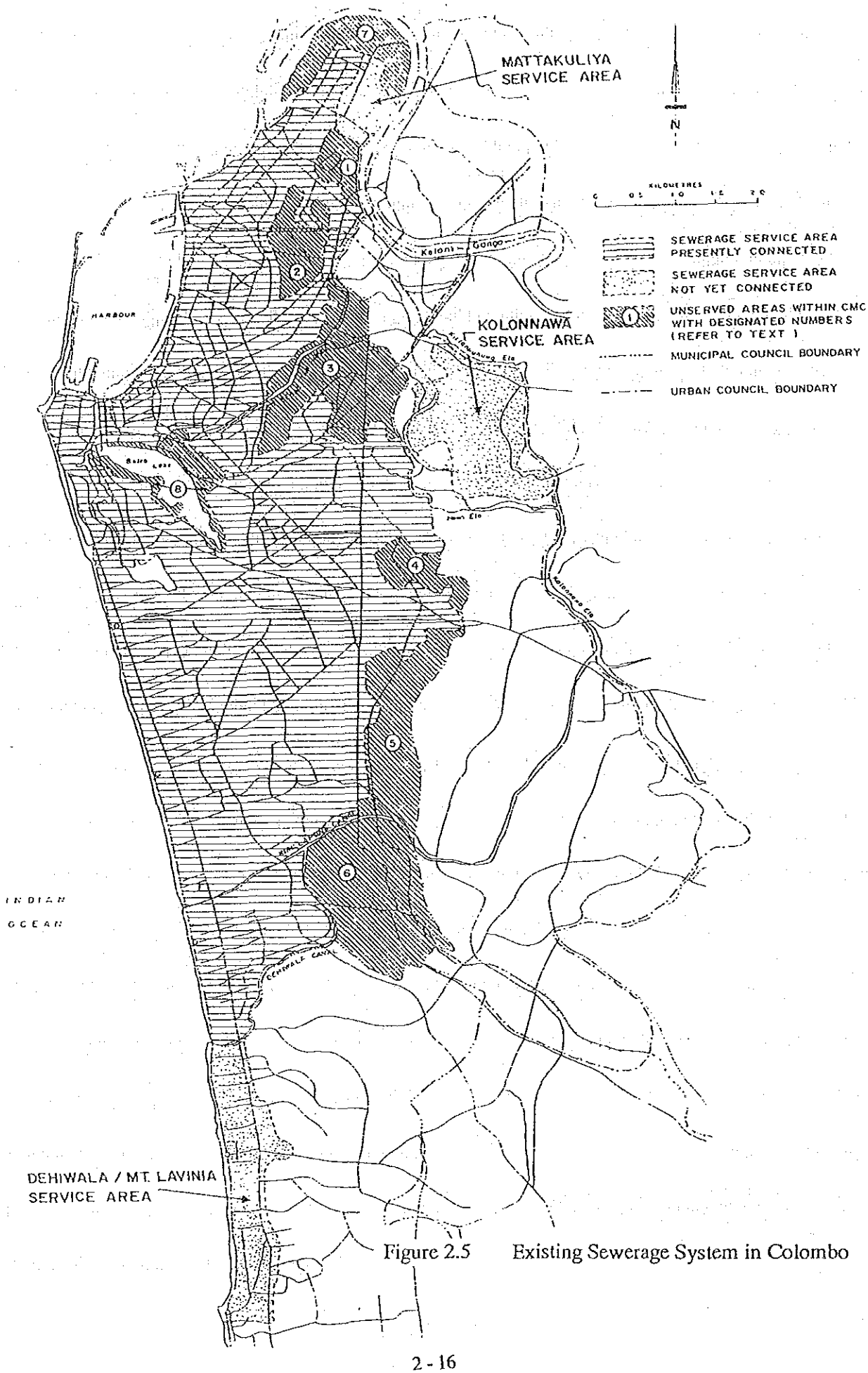



Figure 2.5 Existing Sewerage System in Colombo

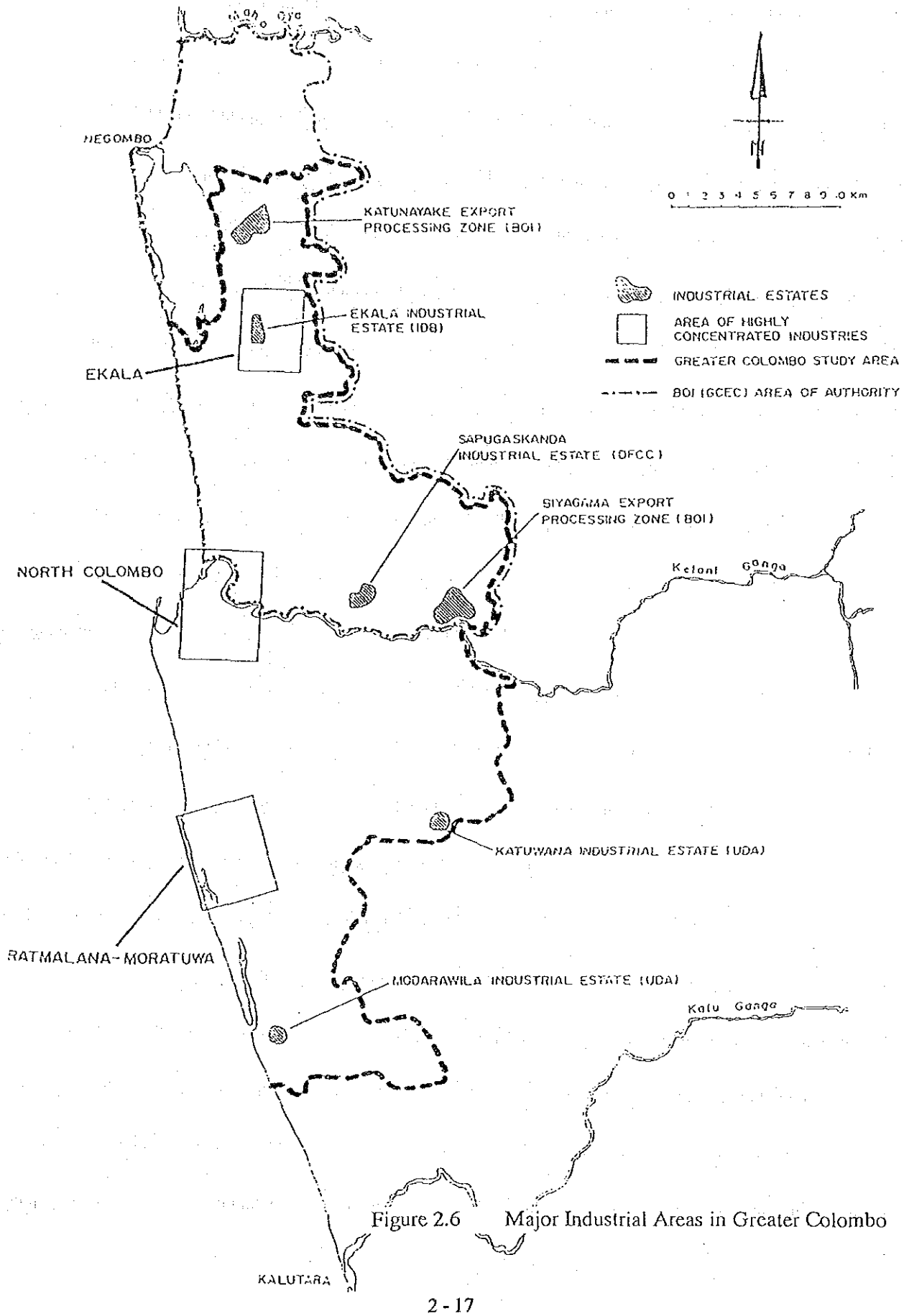



Figure 2.6 Major Industrial Areas in Greater Colombo

Table 2.9 Treatment Records at the Katunayake and Biyagama EPZ's

Katunayake EPZ

Process: screening; grit chamber; aeration/facultative lagoon

| Item | | Influent min. | Influent max. | Influent ave. | Effluent min. | Effluent max. | Effluent ave. |
|---|---|---|---|---|---|---|---|
| pH | | 5.6 | 8.0 | 6.5 | 4.3 | 7.7 | 6.5 |
| Conductivity | S/cm | 401 | 1004 | 630 | 307 | 657 | 521 |
| BOD | mg/l | 140 | 528 | 246 | 16 | 108 | 37.5 |
| Ammonia | mg/l | 18 | 36 | 25.6 | 4.5 | 7.6 | 4.1 |

Biyagama EPZ

Process: screening; grit chamber; aeration/facultative lagoon; dilution & polishing

| Item | | Influent min. | Influent max. | Influent ave. | Effluent min. | Effluent max. | Effluent ave. |
|---|---|---|---|---|---|---|---|
| pH | | 6.3 | 8.9 | 7.6 | 6.5 | 8.5 | 7.5 |
| Conductivity | S/cm | 724 | 2010 | 1371 | 333 | 1335 | 845 |
| BOD | mg/l | 120 | 440 | 253 | 2 | 40 | 22 |
| COD | mg/l | 186 | 672 | 433 | 86 | 96 | 92 |
| TSS | mg/l | 52 | 415 | 159 | 12 | 48 | 23 |
| Ammonia | mg/l | 0.7 | 24 | 12.8 | 2 | 9 | 4.8 |

Outside the municipal area, the number of households and percentages in each category are summarized in Table 2.10.

Table 2.10 Individual Toilet Facilities

| | No. of Households | Percent (%) |
|---|---|---|
| Water-seal | 263,287 | 83.30 |
| Pit latrine | 41,709 | 13.30 |
| Bucket | 210 | 0.07 |
| other | 7,286 | 2.33 |
| Total | 312,493 | 100.00 |

The Government grants subsidy of Rs.700 for a family for the purpose of construction of a latrine.

As for the development of sewerage and sanitation "Greater Colombo Wastewater and Sanitation Master Plan" in 1993 presents the two-phased plan; the first phase from 1993 to 2001 and the second phase from 2001 to 2020, with notes that the recommendations for the first phase are considered valid but those for the second phase will remain relevant of which the needs for scheduling and location of new infrastructures will depend on the future development trends toward the end of this decade.

The plans are developed for different levels of sewerage service to the year 2020 as shown in Table 2.11 under the assumptions that 1) there will be a gradual increase in the number of persons connected to conventional systems over the period, 2) progress will be made to provide sanitary facilities to the 650,000 persons now having no sanitary facilities or ones which are grossly inadequate and that 3) this group will be at least have access to communal toilets by 2010.

Table 2.11 Distribution of Population by Category

| Category | 1992 | 2000 | 2010 | | | 2020 | | |
|---|---|---|---|---|---|---|---|---|
| Development Scenario | | | Low | Medi. | High | Low | Medi. | High |
| Connected to Sewers | 550 | 700 | 830 | 1,020 | 1,300 | 960 | 1,360 | 1,800 |
| On-site Facilities | 1,700 | 2,600 | 3,120 | 2,930 | 2,650 | 3,440 | 3,040 | 2,600 |
| No facilities or Facilities Grossly inadequate | 650 | 200 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 2,900 | 3,500 | 3,950 | 3,950 | 3,950 | 4,400 | 4,400 | 4,400 |

The projected service areas in high development scenario are shown in Figure 2.7

Of the seven southern divisions, Dehiwala-Mt. Lavinia M.C. and part of Moratuwa U.C. are included in the service area by 2000 but beyond 2001 only the reminder of Moratuwa U.C. and Panadura U.C. are added to the service area in the scenario of high development.

### 2.2.6 Commerce and Industry

(1) Greater Colombo

As shown in Figure 2.6, there are several industrial areas which have been spontaneously developed or intentionally established. Ekala, North Colombo and Ratmalana-Moratuwa industrial areas belong to the former category.

The Ekala area is located 20 km north of Colombo with an extent of some 8 $km^2$ including the Ekala Industrial Estate. The types of industries located include the garment making, textiles processing, metal fabricating and finishing, plastic molding, and food and beverages processing. According to the survey conducted in "Greater Colombo Wastewater and Sanitation Master Plan", 10 factories out of 91 factories with a total workforce of 15,544 surveyed employ more than 500 workers, 22 factories 100 to 500 workers and 59 factories less than 100 workers.

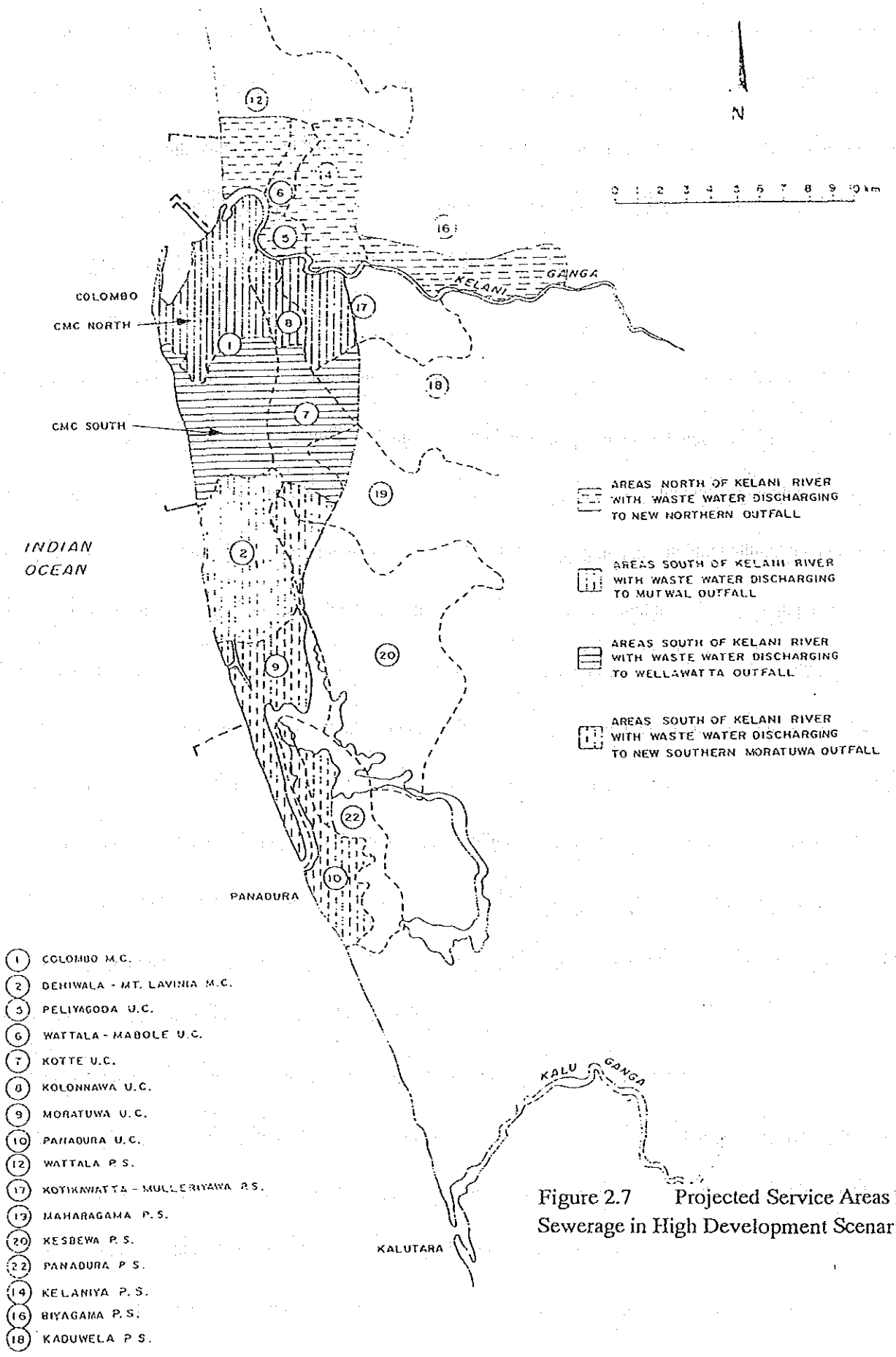



Figure 2.7 Projected Service Areas for Sewerage in High Development Scenario

The North Colombo area covers all Kolonnawa U.C., Periyagoda U.C. and the northern and northeastern part of C.M.C. with an extent of approximately 20 $km^2$. The transport-related stores, warehouses and depots, vehicle repair and maintenance facilities, metal fabricating and equipment manufacture, garment making, and chemicals, pharmaceuticals and allied products are prevalent in this area. The factory size distribution of 121 factories with a total employee number of 28,171 is composed of 11 large-, 39 medium- and 71 small-scale factories.

The Ratmalana-Moratuwa area with an extent of 19.25 $km^2$ is bounded on the west by the sea and on the east by the Weras Ganga and the Bolgoda Lake. The types of industries prevalent in this area are the garment making, textiles manufacture and processing, metal fabricating and equipment manufacture, and chemical, pharmaceuticals and allied products in order of the factory number. Of 224 factories surveyed, 34 factories are categorized into a large-scale, 79 factories into a medium-scale and 111 factories into a small-scale. A total number of employees is 56,094.

Other than the above, there are several medium and small industrial areas such as the Negombo Road area and Kandy Road area north of the Kelani Ganga, and Pallidora Road area in Dehiwala, Nawara area in Kotte, Narahenpita area in Colombo, Wellawatta area, etc. south of the Kelani Ganga, which have been spontaneously developed.

The intentionally-established industrial area is summarized in Table 2.12.

Table 2.12 Industrial Estate in the Greater Colombo Area

| IE/EPZ | Established | Area (ha) | Type of Industry |
|---|---|---|---|
| Ekala IE | 1963 | | see the above |
| Katunayake EPZ | 1978 | 190 | ready-to-wear garment, leather goods, gemstone processing, jewelry making, plastics, rubber goods, electronics assembly |
| Biyagama EPZ | 1986 | 104 | soft toy, garment, towel, injection or blow molded plastic items, finished leather goods, polished stone slab |
| Sapugaskanda IE | Under planning | 50 | medium/large-scale textile processing<br>10 to 15 factories |
| Katuwana IE | | 24 | small/medium-scale low-pollution industries<br>100 factories |
| Modarawila IE | 1992 | 9.6 | small/medium-scale low-pollution industries<br>25 to 30 factories |

(2) Seven Southern Divisions

As stated in relation to the Ratmalana-Moratuwa area, Dehiwala-Mt. Lavinia M.C. and Moratuwa U.C. are the urbanized industrial area as represented by garment and timber-based industry, respectively. Kesbewa U.C.

and Panadura U.C. have the high potential of industrialization due to their superiority of location but now still remains in a rural state, while Homagama P.S., Panadura P.S., Bandaragama P.S., Horana U.C. and Horana P.S. are considered to be the agriculture-based areas.

Dehiwala-Mt. Lavinia

Dehiwala-Mt. Lavinia is considered as an industrial area which has a number of well-run, large scale, successful industries. The industries that were started first in this area are manufacturing of biscuits, sweets, jelly, dairy products, canned fruits, etc. The footwear industry and the shirt and garment industry developed subsequently. Finished products are distributed throughout the Island. The main factor of economic development in this area is the garment industry. It is recorded that this industry bring 90 percent of the earning within this division. Thousands of people in and around this area have found employment by way of such contracts by these garment industries. This was brought a great economic development among small and medium scale industrialists.

Moratuwa

Moratuwa is widely known as an area for timber and timber-based industries which amount to 1,102 factories registered. Such industries are located in areas in close proximity to the river of Moratumulla, Willorawatta and Indebedda. Timber in the form of logs brought from far off places are sawn and treated. The furniture made out of these treated timber once again taken out of Moratuwa to distant places for disposal.

In addition, as a result of the spill over of the industries that had originated in C.M.C. beyond its limit, has made a large number of industries based on other raw material to spring up in the this area.

A good majority of the factories in this division are privately owned.

Kesbewa

There are 76 large- and medium-scale factories for rubber paint, ornaments, cement products, timber products, polythene industry, ceramic industry, plastic and metal products, drugs, garments, etc. Ceramic is the most important industry in this area followed by ready-made garments. Apart from these, there are about 120 rural small industries, of which most are service and food production industries.

Homagama

There are 105 large- medium- and small-scale factories which are categorized into domestic accessories (3), building materials (3), iron works/garages (11), leather products (3), granite industries (30), food products (7), timber mills and timber halls (10), miscellaneous (19), and not categorized (19).

Panadura

There are about 224 small industrial units. A major portion of these industries are those associated with the production of food items, and with the manufacture of building materials, small-scale technical equipment and garments.

Bandaragama

There are 264 small-scale factories. Among others the self-employment rice grinding mills count up to 60 and in this connection a vast number of people are engaged in paddy transportation, rice-production and marketing of rice. In addition there are a large number of various self-employment industries such as saw mills, welding works, garment products, metal crushing and the production of furniture.

Horana

There are 353 established small industries of which most common are the milling of rice and other cereals, production of sweet meats or confectionery, stone quarrying, preparation of rubber including smoking and bicycle repairs.

### 2.2.7 Transportation

The daily transportation of the people mainly depend on a bus transportation system.

Three major roads start from Sedawatta near the estuary of the Kelani Ganga and go northwards (Negombo Road:A3), southwards (Galle Road:A2) and north-eastwards (Kandy Road:A1).

Galle Road (A2) penetrates the core of the Greater Colombo Area including C.M.C., Dehiwala-Mt. Lavinia M.C., Moratuwa U.C. and Panadura U.C. from the north to south in parallel with the coast. Road A4 branching from Galle Road at Fort Pettah goes southwards for a while in parallel with Galle Road and then eastwards through Maharagama P.S. and Homagama P.S. Road B5 branching from Road A4 at near the fork of Kirillopon Canal and Dehiwala Canal goes south-eastwards through Kesbewa P.S. and Homagama P.S. to join Road A8 at west of Horana U.C. Road A8 branching from Galle Road at near the north estuary of the Bolgoda Lake runs eastwards to Horana U.C. through Bandaragama P.S. Road B6 running east of the Bolgoda Lake connects Road B5 with Road A8.

Road B1 runs south of and along the Kelani Ganga and passes through Kolonnawa U.C., Kotikawatta-Mulleriyawa P.S. and near the Ambatale Water Treatment Plant. Road B25 branching from Kandy Road runs north of the Kelani Ganga eastwards and then northwards through Periyagoda U.C., Kelania P.S. and Biyagama P.S. to join again Kandy Road. Kandy Road goes to Kandy through Periyagoda U.C., Kelania P.S. and Mahara P.S.

Negombo Road passes through Periyagoda P.S., Wattala-Mabole U.C., Wattala P.S., Ja-Ela U.C., Ja-Ela P.S. and Seeduwa-Katunayake northwards. Road B13 as well as Road A33 connect Negombo Road with Kandy Road.

Three railways start from Marrana and run southwards along the coast to Matara most south of the Island, eastwards along Roads A4 and B2 to Avissawella north of the Kalatuwawa impounding reservoir and northwards along Negombo Road to Puttalam. Another railway branching from the north line at Ragama goes north-eastwards to Kurunegala and Kandy.

The Katunayake International Airport is located in Katana P.S. near Negombo Road most north of the Greater Colombo area.

### 2.2.8 Environmental Problems

Investigations into the overall environmental problems of the Greater Colombo area seem to be few. The most comprehensive assessments produced to date appear to be contained in the following:

- Environmental Study of Sri Lanka. Status Assessment and Programme for Environmental Cooperation. Main Report, NORAD/COLOMBO 1989.
- Conservation of Luwana Lagoon - a preliminary stud, University of Moratuwa, November 1993.
- World Bank Assisted Water Supply and Sanitation - Project IV, Project Proposals, Vol. 1, Main Report July 1993.
- Water Supply and Sanitation Sector Report, data Base Report January 1991.
- Greater Colombo Wastewater and Sanitation Master Plan, Executive summary April 1993, Engineering Science Inc.

The following overview of the Greater Colombo environmental problems has been divided into four categories:

- Water Pollution
- Air Pollution
- Solid Waste Pollution
- Noise Pollution

Point sources for pollution frequently contribute to two or more of the above categories, with industries often contributing to all four.

(1) Water Pollution

The water resources of Greater Colombo consist of rivers, lakes, ponds, canals, lagoons, streams and the sea. All suffer from pollution to a greater or lesser extent.

The major river and main source of portable water for Colombo is the Kelani Ganga which flows into the sea just North of the harbor. In its lower reaches the river receives pollution from industrial discharges, saline intrusion and domestic sewage.

Oil refineries, tanneries, food and vegetable oil processing, tire factories, fertilizer factories, steel works and breweries all discharge untreated effluents to the river. In the lower reaches alone it is estimated that about 3,500 kg per day of $BOD_5$ are discharged to the Kelani Ganga.

Uncontrolled sand excavation is steadily lowering the river bed level causing saline intrusion to proceed further upstream with each succeeding year.

On occasions the salinity wedge now extends as far as the Ambatale Intake Station.

Sewage pollution has been reduced since completion of a sea outfall pipe at Mutwal in 1987. Previously some 90,000 $m^3$ of untreated sewage was pumped into the river from the northern sewerage zone each day. A second outfall was constructed at the same time to serve the Southern sewerage zone, discharging untreated sewage at a point 1.4 km from the coast at Wellawatta. In theory the northern outfall is some 2.0 km in length but unofficial sources suggest the pipeline has been severed about 1.0 km from the shore. High levels of sewage pollution are frequently found in the harbor area and it is quite likely that significant pollution drifts inshore from both outfalls. No coastal pollution monitoring has been carried out to quantify this danger. Figure 2.8 gives the location of the two sewage outfalls.

Colombo city has the only piped sewerage system in the Greater Colombo area. It is very old, most of it installed between 1906 to 1916 and in very bad condition. Frequent collapses, blockages, reduced capacity due to siltation and tree root intrusion, plus failures of the pumping station make overflows a common occurrence. Raw sewage in large quantities then pollutes the open water courses of the city.

No definitive data exists as to the number of people served by the limited piped sewerage system, self contained systems, or no system at all. An informed estimate was made for the 1992 population of Greater Colombo based on municipal and health department records as shown in Table 2.8. It shows that only 19 percent of the population are connected to the conventional sewerage system.

More than 50 percent of the population live in poor housing and discharge their sewage directly or indirectly to surface waters. Septic tanks and pit latrines are used extensively but are often constructed without any

regard to location or ground conditions. In consequence significant groundwater contamination occurs. This is cause for great concern as many areas of Greater Colombo rely on wells for their potable water supplies. A survey of an area in the Ratmalana/Moratuwa district showed 95 percent of the well waters to have faecal contamination.

Unfortunately the situation regarding piped water supplies is also cause for concern. Pollution of drinking water by faecal coliforms was found in 9 percent of samples taken from the distribution system in 1989 and 1990. Poor treatment, low mains pressure, leaking distribution systems and inadequate chlorination are considered to be the main factors. Contamination of consumers ground and overhead tanks add to the problem.

Storm waters and industrial effluents flow into the streams and canal networks in the Colombo area, most finally entering the Kelani Ganga at the St. Sebastian Canal North Lock. At high water the effluent flows are diverted South and West to be discharged to sea at Dehiwatta and Wellawatta. Combined with domestic sewage, these inflows have caused the vast majority of such watercourses to become open sewers. The results of a sampling program at selected surface water sites are given in Table 2.13. The location of the sites is given Figure 2.13.

Large industrial estates are not numerous in Sri Lanka but four exist within the Greater Colombo area, Biyagama, Katunayake, Ratmalana and Lady Catherine. The first two have effluent treatment plants but it is unclear if they are currently in use. Numerous medium and small industries are scattered over the area and discharge their untreated liquid effluents directly into the nearest surface waters. In the Ratnapura District alone it is estimated that up to 28,300 tons of $BOD_5$ are discharged annually.

A 1989 survey indicated that 80 percent of Sri Lanka's manufacturing industries were located in the Colombo and Gampaha districts. Some 60 percent of the 7,610 large and medium scale industries identified by the survey were considered to be potential polluters.

It should be mentioned that future industrial development is to be moved away from the Colombo City area with the establishment of industrial estates near the Kalu Ganga. It is intended that effluent treatment plants shall be installed as part of the infrastructure of these estates.

As previously mentioned, no detailed information is currently available for the whole of the Greater Colombo area. Discussions with the NWSDB, CEA, BOI etc. articles in the local press and data from study reports have identified various surface waters as suffering from significant pollution. Examples being parts of Bolgoda Lake, Weras Ganga, and the canal systems within Colombo itself. Mattakkuliya Lake which lies close to the mouth of the Kelani Ganga is heavily polluted by untreated sewage, storm water runoff, industrial

effluents and solid waste. Heavy weed growth and debris at the point of discharge to the river limit the outflow causing severe flooding of the surrounding area at times of heavy rainfall.

The Beira Lakes in the heart of Colombo represent one of the most serious cases of a polluted inland water. They have been the subject of a number of investigations since 1989 with an ongoing project to try and improve their water quality. Although an extreme case, the results never-the-less must be representative of similar situations that exist throughout the more densely populated areas of Greater Colombo.

Sewage and industrial effluents have caused drastic pollution of increasing magnitude to the Beira Lakes. With a catchment area of 757 hectares, many surface and submerged outfalls feed the two main water bodies. Varying in size, these inlets have COD levels measured between 29 and 1080 mg/l and suspended solids between 31 and 570 mg/l. Water flows out of the lakes on an intermittent basis via a system of locks and the St. Sebastian canal into the Kelani Ganga.

Pollutants entering the lakes come from a wide variety of sources, the main ones identified in the 1993 Environmental Monitoring Report by Japan Port Consultants Ltd. were as follows:

- Untreated sewage from 587 shanties fringing the lakes;
- Untreated sewage overflows from the sewerage system;
- Untreated industrial effluents, oily water from workshops, Laundry waste from hotels etc.;
- Solids wastes dumped around the edges;
- Storm water flows.

The Consultants estimated that just the domestic effluents contributed one million $m^3$ per year containing 488 tons of $BOD_5$.

Despite dredging and considerable efforts to circulate fresh water through the Beira lake system, the lakes remain highly eutrophic and algae laden. Resettlement of squatters and attempts to enforce effluent controls are ongoing, along with renovation of the canal network.

The Lunawa Lagoon has also been studied, with at least four reports prepared since 1991. Located in the Moratuwa district, the lagoon used to support a fishing industry, recreational facilities and served as a tourist attraction. Now it has deteriorated into a heavily polluted body of water devoid of any aquatic life due to indiscriminate dumping of solid wastes, sewage and industrial effluents.

From these results it can be seen that nitrate and phosphate levels are very high causing severely eutrophic conditions. Dissolved oxygen levels are generally nil.

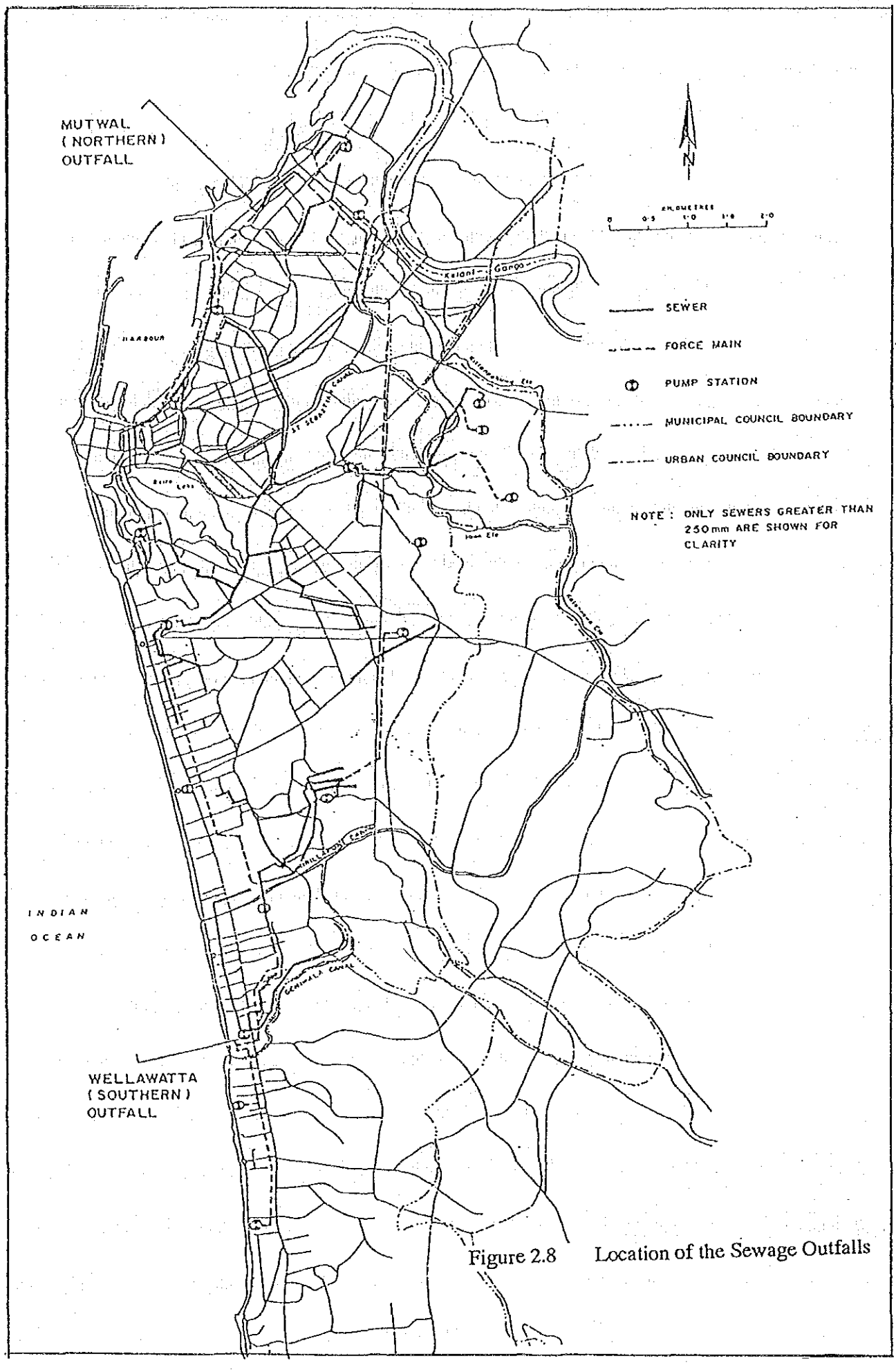



Figure 2.8 Location of the Sewage Outfalls

Table 2.13 Surface Water Quality at Selected Locations in Greater Colombo

| Item | 1<br>San Sebastian Canal at Prince of Wales Ave. | 2<br>Dematagoda Canal at Baseline Road | 3<br>San Sebastian Canal at Maradana Road | 4<br>Wanattamulla Ela near Pump Station (Sarnapala Himi) | 5<br>Kirimandala Ela at Narahenpita (near Mild Board) | 6<br>Kirillapona Canal at Galle Road (Wellawatta) |
|---|---|---|---|---|---|---|
| pH | 6.3 | 6.3 | 6.5 | 6.6 | 6.3 | 6.4 |
| Alkalinity )total, mg/l as $CaCO_3$) | 68 | 56 | 96 | 132 | 72 | 48 |
| Conductivity, µmhos/cm | 400 | 350 | 450 | 550 | 350 | 250 |
| Total dissolved solids, mg/l | 144 | 106 | 110 | 214 | 82 | 126 |
| Total suspended solids, mg/l | 32 | 8 | 66 | 60 | 34 | 14 |
| Volatile suspended solids. mg/l | 26 | 2 | 8 | 14 | 12 | 4 |
| BOD (3-day, 30°C), mg/l | 125 | 60 | 125 | 75 | 109 | 54 |
| Total COD (unfiltered), mg/l | 229 | 100 | 162 | 262 | 221 | 333 |
| Soluble COD (filtered), mg/l | 158 | 46 | 117 | 108 | 162 | 117 |
| Ammonia Nitrogen, mg/l | 2.6 | 1.7 | 4.4 | 8.6 | 2.1 | ND |
| Kjeldahl Nitrogen, mg/l | 3.2 | 2.0 | 5.8 | 9.4 | 2.4 | 0.4 |
| Sulphide, mg/l | 3.2 | 5.6 | 2.4 | 3.2 | 4.0 | 2.4 |
| Oil & Greaase, mg/l | ND | ND | ND | 0.2 | ND | ND |
| Cadmium, mg/l | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Chromium (Total), mg/l | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Lead, mg/l | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |

ND : not detected (detectionlimits not reported)

Samples were collected by project team members. Laboratory analysis were conducted by Envirnmental Laboratories Ltd.

Table 2.13 Surface Water Quality at Selected Locations in Greater Colombo (Cont'd)

| Item | 7<br>Dehiwala Canal at Galle Road (Wellawatta) | 8<br>Bolgoda Canal at Pallidora Road | 9<br>Main Drain from Katukarunduwwatta & Attidiya Areas | 10<br>East Drain from Lady Cathrine (Telewala Road) | 11<br>North Drain into Lunawa Lagoon (Along Railroad) | 12<br>East Drain into Lunawa Lagoon (after Velona) |
|---|---|---|---|---|---|---|
| pH | 6.68 | 6.7 | 6.9 | 8.94 | 6.4 | 7.06 |
| Alkalinity )total, mg/l as $CaCO_3$) | 122 | 106 | 195 | 100 | 148 | 200 |
| Conductivity, µmhos/cm | 600 | 600 | 1200 | 1500 | 600 | 1050 |
| Total dissolved solids, mg/l | 246 | 206 | 500 | 940 | 200 | 430 |
| Total suspended solids, mg/l | 10 | 110 | 32 | 200 | 34 | 26 |
| Volatile suspended solids. mg/l | 2 | 80 | 16 | 106 | 6 | 8 |
| BOD (3-day, 30°C), mg/l | 44 | 39 | 140 | 165 | 70 | 170 |
| Total COD (unfiltered), mg/l | 216 | 291 | 175 | 562 | 329 | 225 |
| Soluble COD (filtered), mg/l | 133 | 92 | 121 | 383 | 162 | 108 |
| Ammonia Nitrogen, mg/l | 3.1 | 0.7 | 7.0 | 13.7 | 4.1 | 8.6 |
| Kjeldahl Nitrogen, mg/l | 3.2 | 0.9 | 9.0 | 20.4 | 5.8 | 16.9 |
| Sulphide, mg/l | 4.0 | ND | ND | 1.6 | 4.0 | ND |
| Oil & Greaase, mg/l | ND | ND | ND | 2.0 | ND | ND |
| Cadmium, mg/l | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Chromium (Total), mg/l | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Lead, mg/l | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |

ND : not detected (detectionlimits not reported)

Samples were collected by project team members. Laboratory analysis were conducted by Envirnmental Laboratories Ltd.

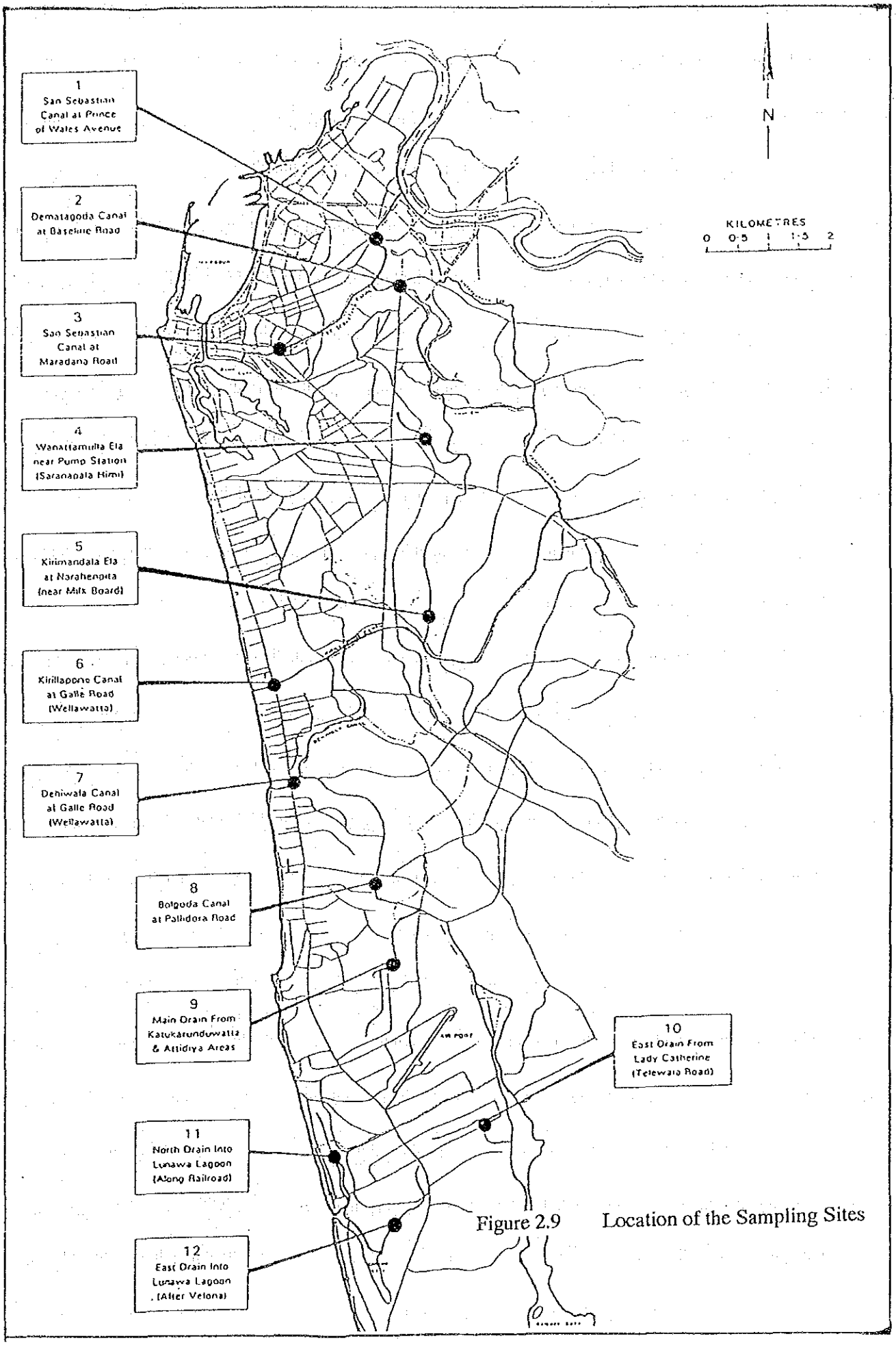



Figure 2.9 Location of the Sampling Sites

Water pollution from agricultural sources occurs mostly in the form of nitrates from fertilizers, some phosphates and pesticides. Both fertilizer and phosphate use have risen steadily in recent years with a tendency for farmers to apply more than the recommended amount. Agricultural based industries have also been on the increase with attendant increases in pollution of the surrounding areas. The severity of the problems from agriculture are hard to asses as, for example, little if any pesticide analyses have apparently been carried out.

In recent years concern has grown over the fate of the Muthurajawela wetlands and the Negombo Lagoon in the North of the Greater Colombo area. Once an agricultural area, Muthurajawela has long since ceased to be productive due to saline intrusion causing abandonment of the rice paddies. It now forms an ideal habitat for a wide variety of birds and wetlands flora.

Population pressures in urban Colombo, the international airport and industrial expansion requirements have led to plans for extensive reclamation of the wetlands. The significant environmental value of such areas has been recognized and in January 1989 the Government decided to halt all development proposals for the Muthurajawela marshes. At the same time the Greater Colombo Economic Commission (GCEC) were requested to prepare a master plan for the area to ensure development of the marshes on an environmentally sound and sustainable basis. This led to the publication of the "Master Plan of Muthurajawela and Negombo Lagoon" Greater Colombo Economic Commission - Euroconsult May 1991 and "Environmental Profile of Muthurajawela and Negombo Lagoon" Greater Colombo Economic Commission - Euroconsult March 1991.

These studies found some 3,366 people living in the Marsh proper in 1989 with 90 percent of them living in temporary housing with no available drinking water or toilet facilities. Infectious and endemic diseases are present with Leptospirosis the most common health problem. The general poor health of the mash people is mainly caused by their insanitary living conditions.

Frequent dumping of household and industrial waste takes place in the marsh area causing ever increasing pollution. The Euroconsult reports have highlighted the urgent need for a sewerage system to be provided in the area to "avoid drastic deterioration of surface and groundwater". The prime cause of the deterioration will be the greatly increased provision of piped drinking water to the region.

(2) Air Pollution

Air pollution problems in the Greater Colombo area are relatively few compared with industrialized regions in other countries. However it is believed to have the highest air pollution levels of Sri Lanka as it accounts for 60 percent of manufacturing industries, 60 percent of registered vehicles and both diesel driven power stations.

Vehicles account for nearly all the pollution from hydrocarbon consumption, with buses and trucks responsible for more than two thirds.

A three year air quality monitoring program was begun in 1989 by the National Building Research Organization at 52 locations in Colombo City. Initial results showed sulphonation rates between 0.04 and 0.45 mg per 100 $cm^2$. Dustfall measurements ranged from 139.7 $mg/m^2$ per day to 1,472.5 $mg/m^2$ per day.

Unsatisfactory results (more than 300 mg of dustfall and more than 0.2 mg of sulphonation) were found at 9 of the monitoring points, all of which were in commercial/industrial areas or at major road junctions.

The only other significant sources of air pollution are smoke from chena fires and refuse burning. This is considered to be a nuisance rather than a health concern.

(3) Solid Waste Pollution

Solid waste in the Greater Colombo area has a number of different impacts on the environment. Heaps of domestic refuse are a common site in both urban and rural areas, attracting scavengers and flies etc. to form a significant health hazard.

An estimated 1,200 tons per day of domestic refuse were produced in the Colombo urban area in 1990, a figure which is set to rise by another 21 percent by the year 2010. About 90 percent of this solid waste in the C.M.C. is brought to temporary collection sites where it remains for unacceptably long periods of time. In some of the smaller Urban Local Authorities only 5 percent is collected.

The net result is that very large quantities are dumped in low lying areas, much of which eventually finds its way into the drains, watercourses, lakes and lagoons. This causes severe water pollution, blockage of channels promoting flooding and offensive odors.

Solid waste from industry is small compared to their discharge of liquid effluents.

(4) Noise Pollution

Noise pollution is minimal in the Greater Colombo area with the exception of traffic generated noise in the main population centers. No heavy industries such as ship building, metal forging etc. are carried out which could cause disturbance to nearby residents.

(5) Future Problems

Industrial pollution of surface waters will increase in future years unless all new industrial units and factories are located in purpose built industrial areas with adequate waste treatment facilities. A concentrated effort

must also be made to compel the current polluting industries to clean up their effluents before discharge to the environment.

An inevitable consequence of providing more water for the Greater Colombo area will be an increase in the quantity of sewage produced. With the present inadequate sewerage facilities, increased ground and surface water pollution must be expected.

In the broad sense, the anticipated increase in traffic in the urban areas will constitute a degradation of the social environment. Traffic jams and exhaust gasses will have a detrimental impact on the quality of life with their attendant noise and fumes.

Fertilizer and pesticide use in agriculture has steadily increased and is likely to continue to do so in the short to medium term. Careful monitoring and control of the use of these substances must be implemented if pollution from agriculture is to be prevented from becoming a more serious threat to the environment.

## 2.3 Land Use

### 2.3.1 Existing Land Use

(1) Colombo, Gampaha and Kalutara Districts

The existing general configuration of land use of Colombo, Gampaha and Kalutara districts as of 1981 is summarized as given in Tables 2.14 to 2.16. In Colombo district, the entire land extent amounts to 69,790 hectares consisting of: urban land 12.2 percent, agricultural land 78.8 percent, forest land 2.2 percent, grass land 1.8 percent, wet land 1.6 percent, water 3.3 percent and barren land 0.1 percent. The figures implicate that this central district of the nation, although having its capital city, consists mainly of agricultural land. In Kalutara district, the entire land amounts to 159,760 hectares consisting of: urban land 0.9 percent, agricultural land 86.3 percent, forest land 10.4 percent, grass land 0.4 percent, wet land 0.4 percent, water 1.4 percent and barren land 0.2 percent. In Gampaha district, the entire land amounts to 139,870 hectares consisting of: urban land 1.6 percent, agricultural land 90.5 percent, forest land 1.0 percent, grass land 0.7 percent, wet land 2.5 percent, water 3.3 percent and barren land 0.4 percent. It is manifest that the latter two districts are predominantly covered by agricultural lands.

(2) Master Plan Area

The existing land use of the Master Plan Area has been identified in compliance with the Resources Profile of the Division compiled in 1990 by the Ministry of Policy Planning. On the basis of these reports, current configuration of detail land uses together with population constitution, general topography, economic conditions and social and educational aspects have been manifested

As is described above, almost all the divisions are predominant in agricultural activities over other land uses and less potential in developing into urban areas is anticipated. In this regard, there is no reason for estimating great increase of water consumption in the future except in and around the central part of the City of Colombo and in some divisions where industrial estates are currently being promoted.

(3) Project Area

The Project Area comprises seven Divisional Secretary's Divisions. The followings are the brief summaries of current configurations of land use presented in the Resources Profile of each A.G.A. Division in June 1990 by Ministry of Policy Planning except for Panadura Divisional Secretary's Division.

1) Moratuwa Divisional Secretary's Division

This division is located at the western and southern end of the boundaries of the Colombo district with demarcated boundaries on the west by sea coast line of approximately 10 km, on the east and south by the Bolgoda river and on the north by Ratmalana division in Colombo district.

The total land of this division is 23.6 $km^2$, and of them 90 percent is occupied by houses, industrial and commercial buildings, roads and other public facilities.

Table 2.14 Land Use of Colombo District

| Category of Land Use | | | Area (ha) | % |
|---|---|---|---|---|
| Urban Land | Built-up Land | | 7,880.0 | 11.3 |
| | Associated Non-agricultural Land | | 600.0 | 0.9 |
| Agricultural Land | Homesteads | | 14,840.0 | 21.2 |
| | Tree and Other Perennial Crops | Tea | 210.0 | 0.3 |
| | | Rubber | 20,670.0 | 29.6 |
| | | Coconut | 5,490.0 | 7.9 |
| | | Cinnamon | - | - |
| | | Mixed tree and other | 2,410.0 | 3.4 |
| | | Perennial crops | - | - |
| | Crop Land | Paddy | 10,590.0 | 15.2 |
| | | Sparsely used crop land | 750.0 | 1.1 |
| | | Other crop land | 40.0 | 0.1 |
| Forest Land | Natural Forest | Dense Forest | 1,310.0 | 1.9 |
| | | Open Forest | 210.0 | 0.3 |
| | Forest Plantations | | - | - |
| Range Land | Scrub Land | | 570.0 | 0.8 |
| | Grass Land | | 700.0 | 1.0 |
| Wet Land | Forested | Mangroves | 200.0 | 0.3 |
| | Non-forested | Marsh | 930.0 | 1.3 |
| Water | | | 2,320.0 | 3.3 |
| Barren Land | | | 40.0 | 0.1 |
| Total | | | 69,790.0 | 100.0 |

Source: Land use map, Survey Department, 1981

Table 2.15 Land Use of Kalutara District

| Category of Land Use | | | Area (ha) | % |
|---|---|---|---|---|
| Urban Land | Built-up Land | | 1,360.0 | 0.9 |
| | Associated Non-agricultural Land | | 10.0 | 0.0 |
| Agricultural Land | Homesteads | | 35,230.0 | 22.0 |
| | Tree and Other Perennial Crops | Tea | 3,380.0 | 2.1 |
| | | Rubber | 51,210.0 | 1.4 |
| | | Coconut | 2,170.0 | 1.4 |
| | | Cinnamon | 250.0 | 0.2 |
| | | Mixed tree and other | 2,840.0 | 1.8 |
| | | Perennial crops | - | - |
| | Crop Land | Paddy | 27,870.0 | 17.4 |
| | | Sparsely used crop land | 14,840.0 | 9.0 |
| | | Other crop land | 60.0 | 0.0 |
| Forest Land | Natural Forest | Dense Forest | 14,430.0 | 9.0 |
| | | Open Forest | 1,410.0 | 0.9 |
| | Forest Plantations | | 770.0 | 0.5 |
| Range Land | Scrub Land | | 650.0 | 0.4 |
| | Grass Land | | 80.0 | 0.0 |
| Wet Land | Forested | Mangroves | 220.0 | 0.1 |
| | Non-forested | Marsh | 460.0 | 0.3 |
| Water | | | 2,210.0 | 1.4 |
| Barren Land | | | 310.0 | 0.2 |
| Total | | | 159,760.0 | 100.0 |

Table 2.16 Land Use of Gampaha District

| Category of Land Use | | | Area (ha) | % |
|---|---|---|---|---|
| Urban Land | Built-up Land | | 1,950.0 | 1.4 |
| | Associated Non-agricultural Land | | 270.0 | 0.2 |
| Agricultural Land | Homesteads | | 69,670.0 | 49.8 |
| | Tree and Other Perennial Crops | Tea | 10.0 | 0.0 |
| | | Rubber | 5,190.0 | 3.7 |
| | | Coconut | 25,000.0 | 17.9 |
| | | Cinnamon | - | - |
| | | Mixed tree and other | 1,920.0 | 1.4 |
| | | Perennial crops | - | - |
| | Crop Land | Paddy | 22,550.0 | 16.1 |
| | | Sparsely used crop land | 120.0 | 1.5 |
| | | Other crop land | 2,140.0 | 0.4 |
| Forest Land | Natural Forest | Dense Forest | 600.0 | 0.3 |
| | | Open Forest | 450.0 | 0.3 |
| | Forest Plantations | | 340.0 | 0.5 |
| Range Land | Scrub Land | | 740.0 | 0.2 |
| | Grass Land | | 200.0 | 0.4 |
| Wet Land | Forested | Mangroves | 610.0 | 2.1 |
| | Non-forested | Marsh | 2,880.0 | 3.3 |
| Water | | | 4,620.0 | 0.4 |
| Barren Land | | | 610.0 | 0.2 |
| Total | | | 139,870.0 | 100.0 |

Source: Land use map, Survey Department, 1981

Table 2.17 Existing Land Uses Pattern of Moratuwa

| Type of Land Use | Area($km^2$) | % |
|---|---|---|
| Residential, industrial, commercial and roads | 21.3 | 90.2 |
| Cultivated land | 1.6 | 6.8 |
| Potential area to be cultivated | 0.3 | 1.3 |
| Land that cannot be cultivated | 0.4 | 1.7 |
| Total | 23.6 | 100 |

2) Bandaragama Divisional Secretary's Division

The map prepared by the Survey Department on land use in Colombo and Kalutara districts during 1981-1984 reveals that the extent of Bandaragama division is 84.8 $km^2$. Out of that 0.1 $km^2$ is developed land, 83.3 $km^2$ which corresponds to 98 percent is agricultural land, 1.3 $km^2$ is swamps and 0.1 $km^2$ is barren land.

Table 2.18 Existing Land Use Pattern of Bandaragama

| Type of Land Use | Area($km^2$) | % |
|---|---|---|
| Urban land | 0.1 | 0.4 |
| Agricultural land | 83.3 | 95.6 |
| Swamps | 0.3 | 2.2 |
| Inland water | 1.0 | 0.7 |
| Barren land | 0.1 | 0.3 |
| Total | 84.8 | 100 |

3) Horana Divisional Secretary's Division

Horana division is situated in Kalutara district and bordered on Colombo district to the north, Madurawala and Bulathsinhala divisions to the south, Ratunapula district to the east and Bandaragama division to the west. Horana is the second largest Divisional Secretary's Division in the district.

Table 2.19 Existing Land Use Pattern of Horana

| Type of Land Use | Area ($km^2$) | % |
|---|---|---|
| Urban land | 1.1 | 0.4 |
| Agriculture land | 254.9 | 95.6 |
| Forests | 5.9 | 2.2 |
| Grassland | 1.9 | 0.7 |
| Reservoirs | 2.1 | 0.8 |
| Vacant land | 0.7 | 0.3 |
| Total | 266.6 | 100 |

4) Ratmalana Divisional Secretaries Division (Dehiwala/Mt. Lavinia M.C)

The land extent of this division is approximately 20 $km^2$. Approximately 90 percent of the land is utilized for the urban facilities and utilities. The land for agricultural use occupies only 1.1 percent and the remaining potential land for cultivation is very less. This division is currently functioning as a sort of satellite town of the city of Colombo.

Table 2.20 Existing Land Use Pattern of Ratmalana

| Type of Land Use | Area ($km^2$) | % |
|---|---|---|
| Housing, roads, playgrounds, parks and cemeteries | 18.4 | 89 |
| Land under cultivation | 1.1 | 5 |
| Uncultivated land | 1.0 | 5 |
| Land unsuitable for cultivation | 0.2 | 1 |
| Total | 20.7 | 100 |

5) Kesbewa (Piliyandala) Divisional Secretary's Division

This division is located in the coastal plain with the extent of approximately 60 $km^2$. According to the data obtained, the land use pattern indicates that an approximately half of the land is home gardens and the main crop is coconut. These characteristics of home gardens spread from urban to rural areas.

Table 2.21 Existing Land Use Pattern of Piliyandala

| Type of Land Use | Area($km^2$) | % |
|---|---|---|
| Homeland with mixed crops | 32.0 | 53.3 |
| Agricultural land | 21.2 | 35.3 |
| Housing | 1.9 | 3.1 |
| Reservoirs | 1.6 | 2.6 |
| Roads | 2.4 | 4.0 |
| Swamps and barren land | 1.4 | 0.7 |
| Total | 60.0 | 100 |

6) Homagama Divisional Secretary's Division

Except for the mountain called Kuragala Kanda which rises to a height of 350 feet, this region is mainly a plain, 30 to 75 m above the sea level. The north and eastern parts of the region are fed Kelani Ganga and its tributaries, while the western and southern parts are by Maha-Oya and its tributaries.

According to above table 80 percent of the total extent of lands is highlands and 20 percent are paddy lands. Out of 125.8 $km^2$ of arable lands 1.6 $km^2$ are still to be cultivated.