JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NATIONAL WATER SUPPLY AND DRAINAGE BOARD
MINISTRY OF URBAN DEVELOPMENT, CONSTRUCTION AND PUBLIC UTILITIES
DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

THE DETAILED DESIGN STUDY ON THE PROJECT FOR REDUCTION OF NON-REVENUE WATER IN THE GREATER COLOMBO AREA IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

FINAL REPORT

DESIGN REPORT ON THE CONTRACT FOR CIVIL WORKS

MARCH 2001

NIHON SUIDO CONSULTANTS CO., LTD.

CURRENCY EQUIVALENTS

(As of August, 2000)

Currency Unit = Sri Lankan Rupee (Rs.)

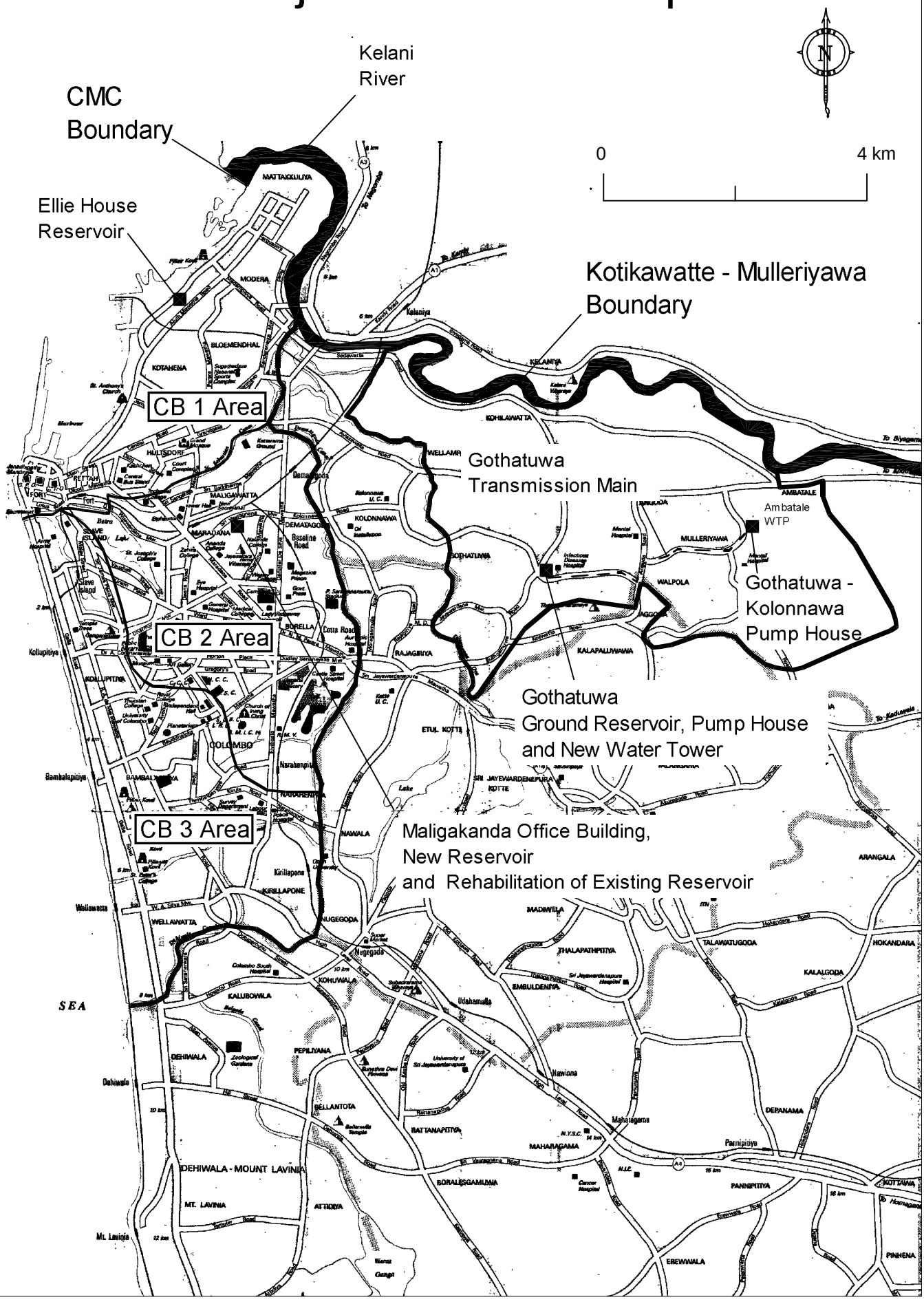
US$1.00 = 79.47 Rs.

US$1.00 = 109.288 Yen (Japanese Yen)

1.0 Rs. = 1.37522 Yen (Japanese Yen)

1.0 Yen (Japanese Yen) = 0.727 Rs.

Project Location Map



DESIGN REPORT
ON
THE CONTRACT FOR CIVIL WORKS

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ABBREVIATIONS

ABBREVIATIONS AND TERMINOLOGY

AC	-	Asbestos Cement
AGF	-	Above Ground Floor
AGM	-	Additional General Manager
AS	-	Australian Standards
AWWA	-	American Water Works Association
B/C	-	Benefit Cost Ratio
BOQ	-	Bill of Quantity
BS	-	British Standards
BWL	-	Bottom Water Level
CDC	-	Community Development Council
CEB	-	Ceylon Electricity Board
CI	-	Cast Iron
CMC	-	Colombo Municipal Council
CSPU	-	Clean Settlement Program Unit of the Ministry of Urban Development, Construction and Public Utilities
DG	-	Diesel Engine Generator
DGM	-	Deputy General Manager
DI	-	Ductile Iron
dia.	-	Diameter
E/N	-	Exchange Notes
GC	-	Greater Colombo
GI	-	Galvanized Mild Steel Pipe
GM	-	General Manager
GOJ	-	Government of Japan
GOSL	-	Government of Sri Lanka
GR	-	Ground Reservoir
GST	-	Goods and Services Tax
GWL	-	Ground Water Level
HP	-	Horsepower
HWL	-	High Water Level
I/O	-	Input-output
ICB	-	International Competitive Bidding
ICTAD	-	Institute for Construction Training and Development

IDA	-	International Development Agency
IEE	-	Institution of Electrical Engineers
IRR	-	Internal Rate of Return
ISO	-	International Organization for Standardization
JBIC	-	Japan Bank for International Cooperation
JICA	-	Japan International Cooperation Agency
JST	-	JICA Study Team
LCB	-	Local Competitive Bidding
LDB	-	Lighting Distribution Board
LECO	-	Lanka Electricity Corporation
LI	-	Langelier's Saturation Index
LV	-	Low Voltage
LWL	-	Low Water Level
M/D	-	Minutes of Discussion
MCCB	-	Molded Case Circuit Breaker
MDPE	-	Medium Density Polyethylene
MLD	-	Million Litre per Day
MS	-	Mild Steel
MSB	-	Main Switch Board
MSL	-	Mean Sea Level
MUDCP	-	Ministry of Urban Development, Construction and Public Utilities
NCCSL	-	National Construction Contractor Association
ND, DN	-	Nominal Diameter
NGO	-	Non-government Organization
NHDA	-	National Housing Development Authority
NPV	-	Nett Present Value
NRW	-	Non-revenue Water
NWSDB	-	Notional Water Supply and Drainage Board
O&M	-	Operation & Maintenance
ODA	-	Official Development Assistance
OPC	-	Ordinary Portland Cement
PDB	-	Power Distribution Board
PIU	-	Project Implementation Unit
PLC	-	Programmable Logic Controller
PQ	-	Prequalification
PRDA	-	Provincial Road Development Authority
PS	-	Polis Station
PVC, uPVC	-	(Unplasticized) Polyvinyl Chloride

R/C, RC	-	Reinforced Concrete
RDA	-	Road Development Authority
RSC	-	Regional Support Centre of the National Water Supply and Drainage Board
S/W	-	Scope of Work
SAPROF	-	Special Assistance for Project Formation
SAPS	-	Special Assistance for Project Sustainability
SDB	-	Socket Distribution Board
SLLRDC	-	Sri Lankan Land Reclamation and Development Corporation
SLS	-	Serviceability Limit State
SLT	-	Sri Lanka Telecom
SPSS	-	Statistical Package for Social Sciences
STP	-	Sustainable Township Programme of the Ministry of Urban Development, Construction and Public Utilities
TDH	-	Total Dynamic Head
TG	-	Tenement Garden
TM	-	Transmission Main
TOR	-	Terms of Reference
TP&N, TPN	-	Three Pole and Neutral
TWL	-	Top Water Level
UDA	-	Urban Development Authority
UFW	-	Unaccounted-for Water
ULS	-	Ultimate Limit State
UPDB	-	Utilities Power Distribution Board
VH	-	Valve House
WTP	-	Water Treatment Plant
XLPE	-	Cross-linked Polyethylene Insulated Vinyl Sheath

UNITS

A, amp, Amp	-	Ampere
^{o}C	-	Celsius
cm	-	Centimetre
d	-	Day
dB	-	Decibel
h, hr, Hr	-	Hour
ha	-	Hectare
Hz	-	Hertz

kg	-	Kilogram
km	-	kilometre
kN	-	kilonewton
kVA	-	Kilovolt-ampere
kW	-	Kilowatt
L, l, ltr	-	Litre
lpcd, lcd	-	Liter per Capita per Day
m, M	-	Metre, Million
m^2, sqm	-	Square Metre
m^3, cum	-	Cubic Metre
mg	-	Milligram
MG	-	Million Imperial Gallon
min	-	Minutes
mm	-	Millimetre
mm^2, sqmm	-	Square Millimetre
mph	-	Mile per Hour
N	-	Newton
pH	-	Potential of Hydrogen
ppm	-	Parts per Million
psi	-	Pounds per Square Inch
Rs.	-	Sri Lankan Rupee
s, sec	-	Second
V	-	Volt
W	-	Watt

CHAPTER 1

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND AND OBJECTIVE OF JICA STUDY

In January 1997, the implementation of the Towns East Colombo Water Project was completed with a financial assistance from the JBIC (Japan Bank for International Cooperation). The project included the construction of various distribution facilities such as water mains, service reservoirs and pump stations but did not include any production facility. The completion of this project was expected to increase the number of service population and improve water supply conditions in areas to the east of Colombo, once water was made available at the newly constructed distribution facilities.

Despite such expectation, however, there was serious concern over the availability of water for this project due to the limited water supply capacity and the considerable delay in the scheduled reduction of non-revenue water in the Greater Colombo area.

Against this background, the "Special Assistance for Project Sustainability for Towns East of Colombo Water Project (SAPS)" was conducted by the JBIC from September 1997 through January 1998 at the request of the Government of Sri Lanka (GOSL). The prime objective of the SAPS was to analyze the condition of Non-Revenue Water (NRW) in the Greater Colombo (GC) area with a view to formulating a comprehensive mid-term NRW reduction program and a program specially designed to improve the efficiency of the water distribution system in the Colombo Municipal Council (CMC) area.

The SAPS analyzed the condition of NRW in the Greater Colombo Area as follows.

- NRW is estimated at 47% in the entire GC area; 57% in CMC and 37% outside CMC.
- Leakage is estimated at 28% in the GC area with no significant difference between CMC and other parts of GC area
- Water consumed or wasted at low income settlements is estimated at 19% of the total NRW in the CMC area, constituting the major ground for the higher NRW ratio in CMC.
- If the current high NRW ratio in CMC continues, the GC area might have to face severe water shortages after the year 2003
- Such water shortages, however, could possibly be averted, if the NRW ratio in CMC is reduced from the present 57% to 30% by the year 2005 and thereafter maintained at 30% up to the year 2010

Based on the analysis, the SAPS proposed the following two sets of programs for implementation, each comprising several components as shown below.

(1) Rehabilitation Program

(a) Rehabilitation/Strengthening of Large and Medium Diameter Pipe Network in CMC Area
(b) Rehabilitation of Small Diameter Pipe Network in CB1 Area
(c) Rehabilitation of Maligakanda Reservoir and Ellie House Reservoir
(d) Rehabilitation/Strengthening of Water Transmission and Distribution Facilities in Kotikawatte and Mulleriyawa Area
(e) Improvement of NWSDB's Meter Workshop

(2) NRW Action Program

(a) Leakage Reduction
(b) NRW Reduction in Low Income Settlements
(c) Abatement of Illegal Connections
(d) NRW/Wastage Reduction at Wayside Public Standposts
(e) Abatement of Meter-related Losses
(f) NRW Reduction in Apartment Buildings

Following the completion of SAPS, GOSL requested the Government of Japan (GOJ) for a Japanese ODA loan for implementation of the above two improvement programs. In response, JBIC dispatched a project appraisal mission to Sri Lanka in January 1999, and the Minutes of Discussion (M/D) was signed between JBIC and GOSL on January 29, 2000. Following the signing of the Exchange of Notes (E/N) between the two governments on July 21, 1999, the "Loan Agreement (SL-P66) for the Project for Reduction of Non-Revenue Water" was signed on August 4, 1999, which subsequently became effective on December 1, 1999.

The loan agreement envisaged that the project would be implemented with one International Competitive Bidding (ICB) and two Local Competitive Bidding (LCB) contract packages as described below.

1) Civil Works (ICB)

- Implementation of all the components of Rehabilitation Program
- Procurement of materials and equipment for NRW reduction

2) Leak Repair Works (LCB)

- Implementation of the component (a) of NRW Action Program

3) Low Income Settlement Environmental Improvement (LCB)

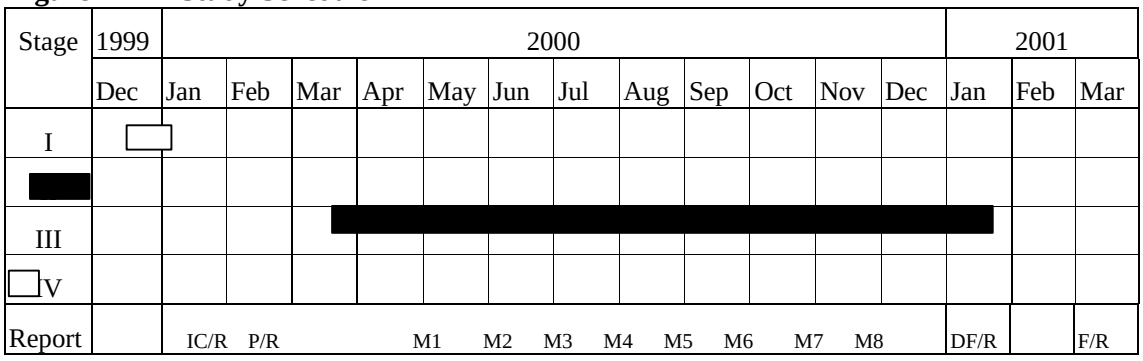
- Implementation of the component (b) of NRW Action Program

In December 1998, GOSL also requested GOJ to conduct a detailed design study on the project. In response, GOJ dispatched a Scope of Work (S/W) mission to Sri Lanka in June 1999 and decided to conduct a JICA (Japan International Cooperation Agency) Study, officially called "The Detailed Design Study on the Project for Reduction of Non-Revenue Water in the Greater Colombo Area in the Democratic Socialist Republic of Sri Lanka ".

The JICA detailed design study started in December 1999 and was conducted in four (4) stages as shown in Figure 1-1 below.

Stage I : Preparatory Work in Japan
Stage II : First Work in Sri Lanka
Stage III : Second Work in Sri Lanka
Stage IV : First Work in Japan

Figure 1-1 Study Schedule



Note: Work in Japan Work in Sri Lanka IC/R: Inception Report, P/R: Progress Report, M: Monthly Report, DF/R: Draft Final Report, F/R: Final Report

The study included the review of existing conditions and the scope of the project components included in the JBIC loan agreement with the prime objective of preparing detailed designs and tender documents necessary for the implementation of the Project for Reduction of Non-Revenue Water.

Another important objective of the JICA study was to enhance technology transfer from the study team to local counterpart staffs in the course of the study period. Throughout the tenure of the JICA Study, local counterpart staffs have always been encouraged to participate in field surveys, planning,

and design, and they responded quite positively. Towards the end of the Second Work in Sri Lanka, a technology dissemination seminar was held in Colombo by the study team. In this seminar, the study team presented an overview of the JICA study. The seminar was attended by a number of officials from NWSDB, CMC and other relevant local government agencies. A session on "Pilot Projects in Low-income Settlements" were attended by representatives from NGOs, donors and international agencies who are also involved or interested in the environmental improvement of low-income settlements in Sri Lanka. This session thus served as a forum for sharing experience and best practice.

1.2 FINAL OUTPUT OF JICA STUDY

As the final output of the JICA detailed design study, the following reports and documents have been produced.

(1) Executive Summary

This document provides an executive summary of the Main Report excerpting important outcome of the JICA detailed design study in a condensed form.

(2) Main Report

This report discusses about the original scope of the JBIC loan for each major project component and important changes made thereto with reasons why they became necessary or were recommended as a result of the JICA study. The report also intends to provide methodologies and approaches used by the study team to determine the final scope of work for each major project component. In addition, the report also provides construction plans and schedules for each project component, recommendations on project implementation, and project evaluation.

(3) Design Report

This report discusses, general design criteria and standards, design conditions, specific design criteria, design calculations, detailed design considerations, etc. used for the preparation of detailed designs and tender documents.

A separate design report has been prepared for each of the following three contracts.

i) Civil Works

ii) Leak Repair Works

iii) Low Income Settlement Environmental Improvement

(4) Tender Documents

A separate set of tender documents has been prepared for each of the following three contracts.

i) Civil Works

ii) Leak Repair Works

iii) Low Income Settlement Environmental Improvement

Each set of tender documents basically consists of Prequalification Documents, Tender Documents including drawings and Cost Estimates.

CHAPTER 2

CHAPTER 2

GENERAL DESIGN CRITERIA AND STANDARDS

2.1 STRUCTURAL

2.1.1 DESIGN STANDARDS

All structures are designed according to the limit states design philosophy in accordance with the following codes:

- The British Standard -BS 8110: 1985 -For Framed Building structures and
- BS 8007: 1987 for water retaining structures will be used mainly in the design.

Wherever necessary other internationally recognized standards and codes of practice are used for special requirements such as protection of concrete against corrosion and sulphate attack.

Other standards referred to in the design and in the specification include:
BS 5950 – Structural steel
BS 5400 – Bridges and related structures
BS 8004 – Foundations
BS 6399 Part 1 – Design loading for buildings-Live Loads
BS CP3 Chapter V part 2 - Basic data for the design of buildings – Wind loads
BS 6312 – Guide to selection of constructional sealants
BS 4449 – Hot rolled steel bars for the reinforced concrete
BS 4461 – Cold worked steel bars for the reinforced concrete
BS 5328 – Specification for concrete including ready-mixed concrete

2.1.2 ANALYSIS AND DESIGN PROCEDURES

The analysis and design is carried out in accordance with the limit state design philosophy of BS 8110 and BS8007. Depending on the type and complexity of structure analysis and part of the design have been carried out with the assistance of a computer software package.

(1) Structural design:

a) The partial safety factor for retained water; surcharge and earth pressure is 1.4 at ultimate limit state (ULS) and 1.0 at serviceability limit state (SLS).
b) The structures are designed with a factor of safety of at least 1.1 against flotation.
c) The maximum crack width for liquid retaining structures is:
    a. 0.2 mm max
    b. or where aesthetic appearance is critical is 0.1 mm max
    c. for Pre-stressed concrete as required by BS 8110; however, reference is made to Section 4.3 of BS 8007 for particular rules for cylindrical tanks.
    d. For Cylindrical pre-stressed structures (see section 4.3 of BS 8007), the Tensile stress in the concrete is limited in accordance with the recommendations of Section 2.2.3.4.2 of BS 8110 : Part 1 : 1985. However, it is recommended by code that pre-stressed, pre-cast elements be designed as class 1 (zero tensile stress).
d) Deflection is checked at SLS with consideration to deflection due to loading and rotation of base.
e) Loads :
    a. All structures required to retain liquids are designed for both the full and empty conditions and the assumptions regarding the arrangement of loading are such to cause the most critical effects. Particular attention is given to possible sliding and overturning.

b. At any given limit state the liquid level is taken to the top of the walls for design purposes assuming all outlets blocked.
c. No relief is given for beneficial soil pressures in designing walls subjected to internal water loading.
d. Expansion joints are provided to minimize thermal movement in roofs.
e. Earth covering the roof is treated as a dead load.

2.1.3 ENVIRONMENTAL AND LOADING CRITERIA

(1) Lateral Loads

The lateral loads considered in the design are due to wind forces and in the absence of a National Building Code for wind forces, the BS CP3 Chapter V in conjunction with the Report, "Design of buildings for high winds in Sri Lanka – Ministry of Local Government, Housing and Construction", will be followed in designing structures against forces due to wind.

According to this Report, the Project Area falls into Zone 3 where recommended basic wind speed is 75 mph. (34 m/s). This wind speed will therefore be used to calculate characteristic wind speed, which is dependent on factors such as topology, height of structure and life of structure. The buildings and components of buildings will be designed for pressures due to relevant characteristic wind speed.

Design wind speed (general):	Vs 34 m/s
Design wind speed for water towers:	Vs 40 m/s
Design temperature rise due to heat of hydration:	T_1 35 ^{0}C Min
Design temperature seasonal variation:	T_2 15 ^{0}C Min

(2) Live Load Criteria

Inaccessible roofs (general):	2.5 kN/m^2
Inaccessible roofs (office building)	1.0 kN/m^2
Roof with mechanical equipment:	actual weights plus provisions of BS 6399
Floor of mechanical rooms:	10.0 kN/m^2 minimum or actual weight of machinery whichever is higher.
Floors accessible to trucks:	BS 5400 - HA type loading
General public access:	5.0 kN/m^2
Offices:	3.0 kN/m2
Electrical rooms:	10.0kN/m2 minimum or actual weight of machinery whichever is higher.

(3) Earth Pressure Criteria

Compacted soil density	20.0 kN/m^3
Active lateral soil pressure coeff.	0.333 or as recommended in soils investigation reports
Passive earth pressure coeff.	3.0
Surcharge on walls:	0.9m of earth or HA–uniformly distributed load where the walls are subjected to lateral pressure due to vehicles.
Water head at bottom of walls	groundwater level, if present
Density of water	10 kN/m^3
Allowable bearing pressure	As per recommendations in soils investigation reports.

The above criteria for soil density and earth pressure generally conform to engineering properties of soil commonly occurring in the Project Area. However, where the soils investigations reveal values

that lead to structures with lesser factors of safety the designs for that particular site are modified accordingly.

(4) Seismic loading criteria

Normal design practice for structures in Sri Lanka involves little, if any, provision for resistance to seismic loading. The possibility of big earthquakes, such as those experienced in Japan is very rare in Sri Lanka. The structures are not specifically designed to resist earthquakes however as far as possible the detailing is carried out to provide some measure of safety against complete and sudden failure in the event of a large earthquake.

2.1.4 BUILDING MATERIALS

Reinforced cast in place concrete is the predominant building material with burnt clay brick, solid or hollow masonry block for perimeter and partition walls. In general steel platforms and stairs are galvanized mild steel however in areas where platforms must be lifted for access aluminium is specified to reduce weight. All steel ladders and accessories inside the reservoirs are stainless steel to resist corrosion from chlorine.

(1) Reinforced Concrete

The design of reinforced concrete structures is based on the following grades of concrete:

- cast in place: grade 35A (35 N/mm^2).
- pre-stressed or post-tensioned elements: shall be factory-controlled grade 50(50 N/mm^2).
- blinding concrete under footings and slabs: grade 15 (15 N/mm^2).

(2) Type of cement

In general the design is based on Ordinary Portland Cement (OPC). However, special design mixes shall be used foundations in locations where soil investigations confirm that soils are aggressive to concrete.

(3) Steel Reinforcement

Normal reinforcement will be high strength deformed bars with a specified characteristic strength of 460 N/mm2 or mild steel bars with a characteristic strength of 250 N/mm^2.

Pre-stressing or post-tensioning steel will be grade 270, low relaxation strands with an ultimate guaranteed tensile strength of 1860 N/mm^2.

(4) Metals

Structural steel will be grade 43 to BS with yield stress of 275 N/mm^2.

2.2 ARCHITECTURAL

2.2.1 DESIGN STANDARDS

The design of the new office building is based on the following criteria stipulated in the “Development Plan for the Colombo Municipal Council area Planning & building regulations1999”.

All buildings in the project are designed to meet as a minimum the specification for building works January 1988 issued by ICTAD (Institute for Construction Training and Development).

2.3 MECHANICAL

2.3.1 GENERAL

The mechanical components of the project are designed conforming to BS and ISO standards as appropriate.

The following ICTAD specifications are use as guidelines in the design of building systems:

- Electrical and Mechanical Works Associated with Buildings and Civil Works August 2000.
- Specifications for Building Works Volume II – Sanitary Installations July 1989.
- Specifications for Water Supply, Sewerage and Storm water Drainage Works

2.4 ELECTRICAL

2.4.1 STANDARDS AND REGULATIONS

Electrical installations are designed to comply with the latest requirements of the Ceylon Electricity Board and the latest edition of the Regulations for Electrical installations issued by the Institution of Electrical Engineers – London (IEE Wiring Regulations).

Specifications are based on ICTAD Specifications for Electrical and Mechanical Works Associated with Building and Civil Engineering August 2000.

2.4.2 ELECTRICITY SUPPLY

Electricity supply to all premises is 400 v, 3 phase, 4 wire at 50 Hz. The neutral of the incoming supply is solidly earthed at the source and connection of the neutral at any other point is not allowed.

The following objectives have guided the design of electrical power receiving and feeding systems:

- Minimize disruption to the existing electrical distribution system at the Ambatale Water Treatment Plant
- Provide safe and reliable operation and maintenance conditions by allocating enough space around electrical equipment safe operation and maintenance
- Conform with regulations of electric power supply companies CEB and LECO.
- Apply international standard ratings, class of insulation and other specifications to make it easier to obtain spare parts, modify, or repair equipment.

2.4.3 TYPE OF MOTOR WITH RATED VOLTAGE AND STARTING METHOD

All pump motors will be 3 phase, 400 V, squirrel cage, premium efficiency totally enclosed fan cooled type. Special motors for valve operators will be supplied to the manufacturers standard design.
Motor starters for pumps are reduced voltage to minimize inrush currents and voltage drops as well as reduce the capacity of emergency generators.

2.4.4 EMERGENCY STANDBY POWER GENERATING UNIT

Where required, emergency standby power generating units will be sized as follows:

- Capacity to operate 50% of the required water supply pumps and all essential electrical loads including all fire fighting pumps
- Capacity for starting the largest pump across the line

2.4.5 POWER FACTOR CORRECTION

Each pump motor exceeding 25 kW will be provided with dry type capacitors to correct the power factor to a minimum of 0.9 lagging. These capacitors will be located in the motor control centre.

2.4.6 LIGHTING

All lighting is designed in accordance with IES standards (Illuminating Engineering Society):

- Rough work (machining, assembly, pump floor) : 300 lux
- routine work (offices, control rooms) : 500 lux

2.5 INSTRUMENTATION AND CONTROL

NWSDB has no standard for instrumentation and control however the design has adopted the same approach used for the recent project in Towns North.

NWSDB has a telemeter system that links distribution facilities within Greater Colombo to the Ambatale treatment plant and the control centre at Maligakanda. Level sensing and flow metering at Maligakanda and Ellie House reservoirs will be integrated into the existing system since they are already connected. Facilities that are outside the scope of the existing system (e.g. Gothatuwa) have control and instrumentation systems with 4-20 ma contacts that can be telemetered in the future.

(1) Flow Measuring Devices

The type of flow measuring device is selected to match service conditions and balancing functionality with cost. Design considerations include:

- Purpose of Measuring and Accuracy required based on purpose
- Measuring Range
- Operation and Maintenance Condition
- Durability and Compatibility of Devices and Spare Parts

Electromagnetic flow meters are specified for transmission and distribution systems proposed under the project because they have no moving parts, provide reliable operation and require no maintenance. The inlet pipe at ground reservoirs will be equipped with a flow meter. In addition, flow meters will be installed on the outlet pipe of each reservoir/tower and on all distribution mains connected to outlet headers at reservoirs

New flow meters at Maligakanda and Ellie House must be compatible with the existing monitoring system therefore flow meters are external clamp on ultrasonic meters.

(2) Water Level Measuring Device

Water levels are measured for the purpose of pump control and indication of consumption patterns. Two types of water level measuring devices are specified: pressure type and capacitor type. Pressure devices are non-contacting devices used mainly for control of pumps and recording levels because they are more accurate. Capacitor type devices are installed in all reservoirs, and sumps as a redundant system in case the pressure devices fail.

2.6 WATER MAIN

2.6.1 HYDRAULIC DESIGN OF WATER MAINS

(1) Transmission System

The design parameters adopted are as follows:

- Day maximum demand: 1.1 times Day average demand
- Maximum flow velocity: 3.0 m/s
- Cover to the pipe; 1.0 m minimum
- C Factor in Hazen William Formula:
- For DI Pipes: 110

The above C factor takes into account minor losses in pipefittings and specials. However, in some specific cases, the values indicated in the Manufacturer's catalogues would be used.

(2) Distribution Systems

Criteria for design of distribution systems include:

- Hourly Peak factor: 1.6 (Peak Hour : Average Hour)
- Minimum diameter: 110 mm for distribution mains,
- Minimum residual head: 10 m at the peak flow conditions
- C Value for Hazen William Formula
  (i) for DI Pipes 120
  (ii) for uPVC pipes 130

Provision of Rider Mains and Feeder Mains:

- Rider mains are provided along RDA roads and major PRDA roads.
- Feeder mains are provided for the pipelines of diameter more than 300mm.

Waste districts, waste metering and valve arrangements:

- The demarcations of waste districts are made so that the disruption to the system operations during a waste study is minimum. Further, easily identifiable boundaries were selected as much as possible.

Fire Protection:

- The locations requiring the fire hydrants are determined in consultation with the Fire Brigade. Important and more vulnerable locations within the towns (such as fuel filling stations) and outside the towns (large industrial institutions, armed services camps, large government institutions) are given special considerations when selecting the locations.
- The hydraulic criteria shall conform to Fire Brigade requirements and shall include the following major parameters:
  (i) Condition of single outlet operation at a time was assumed.
  (ii) A flow of 2,000 L/min (33.3 L/s) at a residual pressure of 1.7 bar (approx. 17 m) was adopted as satisfactory.
  (iii) Under average flow conditions the system shall not develop negative pressures when the fire flow is applied.

2.6.2 TYPE OF PIPE AND JOINTS

(1) General

In the design of facilities for drinking water supply systems the selection of the most suitable pipe material and laying techniques for each application is a critical factor in the design process. This is particularly true in Sri Lanka where local availability and product durability are of great concern. In

this Section an evaluation is made of alternate pipe materials to determine the types of materials most suitable to the conditions in the Project Area. The pressure ratings for pipes will be decided with due consideration of such factors as maximum static head, surge effects, temperature, etc.

(2) Recommended Pipe Materials

It is recommended to use cement lined Ductile Iron (DI) and Type 600 and Type 1000 Unplasticised Polyvinyl Chloride (uPVC) as pipe materials for the Project. These materials will be used for the following applications:

- All Pumping Mains and Gravity Transmission Pipelines — Cement Lined DI
- Distribution Pipelines up to the diameter of 160mm (150 DN) — Type 600 uPVC
- Distribution Pipelines of diameter 225mm (200 DN) — Type 1000 uPVC
- Distribution Pipelines of diameter greater than 225mm(200 DN) — Cement Lined DI

2.6.3 PIPE LAYING

The norms and criteria that will be used for pipe laying shall in general conform to manufacturer's recommendations. The clear cover for various diameters of pipeline are tabulated as follows:

Table 2-1 Cover to Pipelines

Nominal Pipe Diameter (mm)	**Minimum Cover (mm)**
110, 160, 225, 250	900
Above 250	1000

The nominal widths of trenches are taken as indicated in the following Table:

Table 2-2 Nominal Trench Widths

Nominal Pipe Dia. (mm)	**Nominal Trench Width (mm)**
63	450
90	450
110	500
160	550
225	600
250	600
300	650
350	700
400	750
450	800
500	900
600	1000
700	1100
800	1200
900	1400
1000	1500
1100	1600

2.6.4 PIPE APPURTENANCES

(1) Valves

For isolation valves to stop water flow, gate valve and butterfly valves are recommended. Large size gate valves require larger space and high procurement cost while dynamic water head loss at small butterfly valves is not negligible. Considering dynamic water head loss, space required for installation, cost and past practice in Sri Lanka, the following valves would be basically applied for transmission pipeline and distribution mains:

Table 2-3 Type of Valves

Diameter (mm)	Type of Valve	Type of Chamber
63 - 225 PVC	Gate Valve	Surface Box
250 - 400 DI	Gate Valve	Surface Box
450 - 1200 DI	Butterfly Valve	Valve Chamber

For the valves, which require the function of controlling water pressure or water, flow rate in distribution system, butterfly valves will be installed.

(2) Air Valve

Type of air valve shall be selected considering the amount of air to be released or inhaled in a certain period. Air release flow and inhale flow depend on water filling rate to pipes and water removing rate from pipes and these rates can be changed by several factors. Considering the past experience, following air valves are to be used basically:

Table 2-4 Type of Air Valves

Diameter (mm)	Type of Air Valve	Size of Air Valve
110 - 225 PVC	Single Orifice Type	13 - 25 mm
250 - 300 DI	Single Orifice Type	25 mm
350 - 1200 DI	Double Orifice Type	80 - 150 mm

Double orifice type air valves will be used when required even though pipe diameter is less than 300 mm.

(3) Wash Out Valves

Wash out valves are required to be provided at appropriate locations and chamber type suitable for individual site conditions will be selected from several typical chamber designs to be prepared. Gate valves are considered to be better than butterfly valves as washout valves since one side of valve will face to open air for a long period. The following size of vales will be used (Table 2-5).

Table 2-5 Size of Washout Valves

Diameter (mm)	Size of Gate Valve
110 - 225 PVC	80 mm
250 - 300 DI	80 mm
350 - 1200 DI	100 - 200 mm

(4) Fire Hydrant

Fire hydrants with the size of 80 mm will be provided at strategic locations of distribution mains.

(5) Flow Control Valves

For the purpose of maintaining constant flow in the transmission pipeline and inlet of receiving tank, flow control valves will be required. The size and type of valves are carefully determined based on the following hydraulic conditions:

- Flow condition: Minimum and Maximum design flow
- Differential Pressure condition: Minimum differential head under maximum design flow
- Energy Dissipation condition: The worst condition, maximum differential pressure under minimum design flow

2.7 STORAGE FACILITIES

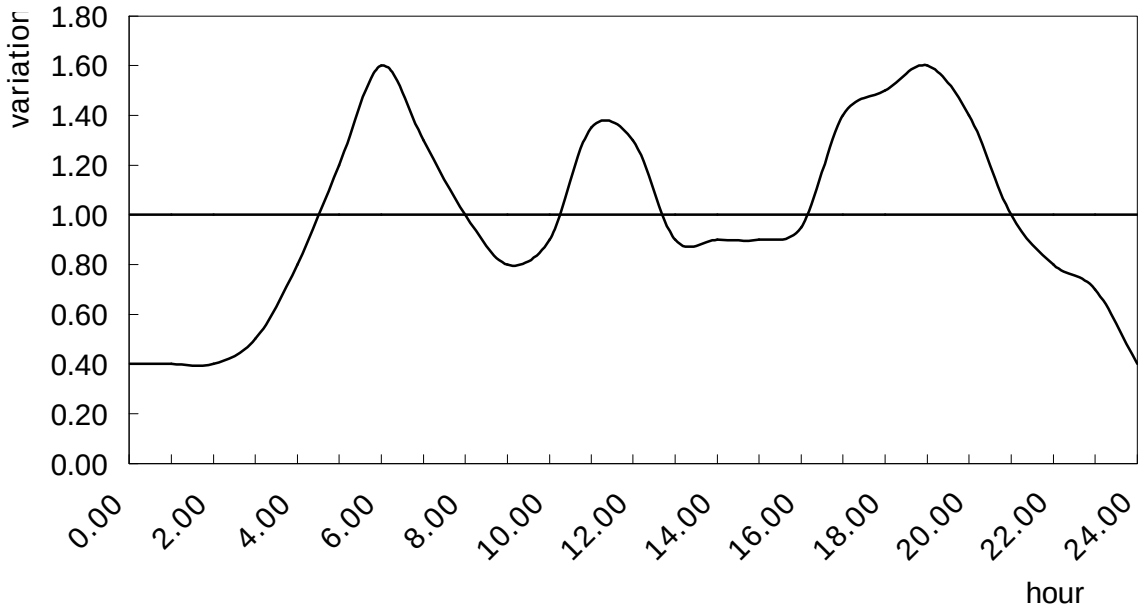
2.7.1 HOURLY DEMAND FLUCTUATION

The required storage is generally dependant on fluctuation of water demand with time. Based on previous studies in Greater Colombo Area, the pattern of hourly demand fluctuation accepted by the NWSDB is summarized below and graphically represented in Figure 2-1.

Table 2-6 Hourly Demand Fluctuation – Typical Pattern

TIME (Hrs)		Consumption pattern for peak factor 1.6
From	To	
0:00	1:00	0.40
1:00	2:00	0.40
2:00	3:00	0.40
3:00	4:00	0.50
4:00	5:00	0.80
5:00	6:00	1.20
6:00	7:00	1.60
7:00	8:00	1.30
8:00	9:00	1.00
9:00	10:00	0.80
10:00	11:00	0.90
11:00	12:00	1.35
12:00	13:00	1.30
13:00	14:00	0.90
14:00	15:00	0.90
15:00	16:00	0.90
16:00	17:00	0.95
17:00	18:00	1.40
18:00	19:00	1.50
19:00	20:00	1.60
20:00	21:00	1.40
21:00	22:00	1.00
22:00	23:00	0.80
23:00	24:00	0.70
24:00	25:00	

Figure 2-1 Hourly Demand Fluctuation



2.7.2 STORAGE CAPACITIES : GROUND RESERVOIR AND WATER TOWER

Generally, design standards adopted for storage at ground reservoir and at tower is 6 hours of the daily maximum demand. However NWSDB has used a standard capacity of 1,500 m3 in other similar projects (TNC Project) because of the practical limitations in construction and economic constraints.

2.8 DRAWINGS AND CONTRACT DOCUMENTS

2.8.1 DRAWING STANDARDS

Drawings are prepared for A1 format size and photo reduced to A3 size.

The drawings are prepared to the following scales:

- Key plans of the areas - 1: 10,000
- Site layout drawings - 1:200
- Detailed drawings - 1:100, 1:50,1:20,1:10 (as appropriate)
- LS drawings of pipe lines - 1:1,000 (Horizontal), 1:100 (Vertical)
- Junction details - Not to scale
- Bench Mark details - Not to scale

Drawings are organized into 3 contract packages:

Drawings for Low-income settlements Low	LIS
Drawings for Leakage repairs	LR
Drawings for Civil Works	CW

Drawing nomenclature is organized as follows:

CW / MK / GR / ST-01

where	CW	– Contract Package	: Civil Works
	MK	– Component	: Maligakanda
	GR	– Facility	: Ground reservoir
	ST-01	– Discipline – Sequential No.	: Structural -01

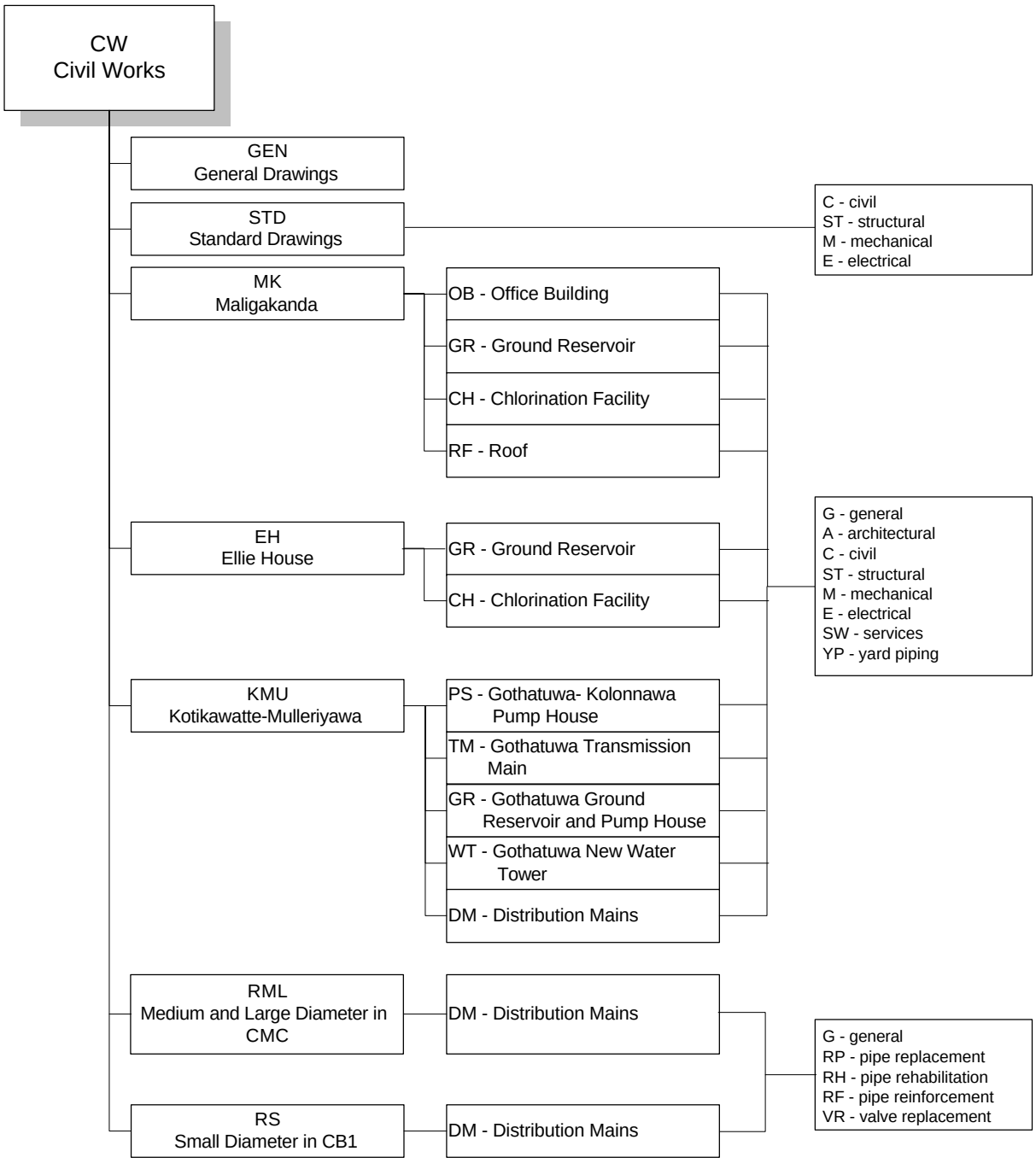


Figure 2-2 Drawing Organization for Contract for Civil Works

CHAPTER 3

CHAPTER 3

CONSTRUCTION AND REHABILITATION OF RESERVOIRS

3.1 CONSTRUCTION OF MALIGAKANDA OFFICE BUILDING

3.1.1 DESIGN CONDITIONS

3.1.1.1 Summary of Work

The CMC water works and drainage offices located at Maligakanda must be demolished to make space for the new 22,000 m^3 ground reservoir. Therefore the project includes construction of a new office building.

(a) Description of Building

Proposed building will accommodate the Water works office, CMC drainage section and CMC water supply divisions. The building will be located on the area situated in the direction of south east of the Maligakanda reservoir site. The extent of the land allocated for the building is 0.322 ha.

The building is rectangular in shape and covers an area of 44 m x 18 m and comprise of ground floor plus three upper floors with a total floor area of 3168 sqm. The building is oriented on horizontal plane along the bearings of Northeast and Southwest.

3.1.1.2 Site Location and Conditions

(a) Description of Site

The new office building will be located on 0.322 ha of land owned by CMC. CMC has agreed to the use of the site for the new office building but NWSDB will need to complete the necessary formalities to change land title before construction starts.

The site is just outside the boundary of the Maligakanda reservoir compound and is located directly South/East of the old CMC Water Works Office. The site is presently occupied by abandoned Municipal Courts buildings and overgrown by several trees. Some squatters have erected unauthorised housing at the edge of the road along the East boundary. The old buildings will need to be demolished and the trees removed as part of the contract for construction. The squatters will need to be relocated as well in order to reconstruct the boundary wall.

The back (South/East) of the proposed building site faces a public road where a boundary wall runs along the full length of the property line. This wall will be reconstructed. The building has been set back from the rear property boundary by 3.5m as required by regulations.

CMC has plans to widen the access road at the front of the building (N/W side) and has requested a 2 m road allowance from the edge of the existing road to the proposed property boundary for the new office-building site. This allowance has been provided in locating the front entrance of the building.

(b) Site Access

For security reasons main access to the building will be from the Maligakanda site access road on the Souh/West side of the building, which is controlled by a security station and gate. The site is easily accessible from Maradana Main Road through Ananda Mawatha adjoining Ananda College. The approach to the site is from the northwestern direction.

(c) Demolition of buildings and tree removal

All existing trees and building occupying the site will be removed. Buildings and trees that have a salvage value have been identified on the drawings. Demolition will include removal of the boundary wall along the South/East road.

(d) Land Acquisition

The question of land acquisition does not arise as the site belongs to the CMC. However NWSDB is required to fulfill the necessary formalities in order to get this land vested on the Board before commencement of construction.

3.1.1.3 Summary of Geotechnical Investigation and Assessment Results

(a) Geotechnical Assessment and Results

Three boreholes were executed within the plan area of the proposed building designated by OBH-1, OBH-2 and OBH-3. The logs of boreholes provide evidence of a near surface layer of crystal laterite with gravelly component having a high "N" value in the order of 18 to 34.

The borehole profile again shows a variegated laterite with variations in the contents of clay, sand and gravel. Based on the observed N values of the lateritic profile, it can be classified as moderately dense to dense with appreciable sand content.

Groundwater table varies from a depth of 3.80 m to 3.90 m. In terms of elevation, the GWL varies from 14.93 m to 15.29 m.

Soil sulphate content is the order of 0.6% SO_3 and is considered aggressive towards buried concrete structures.

(b) Recommendations

It has been indicated that column loads are of the order of 1500 to 2000 kN except in the machine room area where the loads would slightly exceed these limits. Strip footings are recommended for an allowable bearing capacity of 200 kN/sq m at a depth of 1 m.

Foundation concrete has the following specifications for protection against sulphate attack:

- grade 35 Ordinary Portland Cement (OPC),
- minimum cement content of 380 kg/m^3,
- water to cement ratio limited to 0.45
- 25% pulverized fly ash added.

3.1.2 SPECIFIC DESIGN CRITERIA

(a) Building and fire regulations

The design of the new office building is based on the criteria stipulated in the "Development Plan for the Colombo Municipal Council area Planning & building regulations1999". These regulations are considered as a minimum requirement only and have been supplemented in to meet specific requirements or concerns expressed by NWSDB. Building regulations issued by the Urban Development Authority & Provisions made for the proposed building are summarized in Table 3-1 as follows:

Table 3-1 Building and Fire Safety Regulations

Regulation	**Provisions made**
Minimum width of the road - 6m	6m existing, 9m proposed
Rear space required 3.5m	Provided
Lift and stand by generator	Provided
Minimum width of the building - 6m	18m
Height of the rooms on the ground floor shall be not less than 3m	provided
Upper floors 2.8m	provided
Natural light and ventilation	
15% of the floor space of the room shall be the area of the window with 50% opening for rooms	Area equivalent to 15% of the floor area with 100% openable windows has been provided.
10% of the floor space of the toilets, lobbies, stair cases shall be the area of the window with 50% openings.	Area equivalent to10% of the floor area with 100% openings has been provided as windows.
Sanitary facilities	
Water closet: one for every 200sqm of floor area	A total of 8 no toilets for each floor has been provided
Separate facilities for men and women to be suitably provided	
Urinals : 1 for every 200sqm	4 no has been provided for each floor
Wash basins: one for every 200 sqm	A total of 8 no of wash basins for each floor has been provided.
Parking: 1 for every 200 sqm	24no has been provided.
Commercial vehicle 1 for every 500	3 no has been provided , 3 no. to be parked out side the same premises.
Facilities for disabled person	
Entrances 80cm or more	Provided
Elevator	Provided
Corridors 120cm in width	Provided
Separate toilet stall	Provided
Slopeways	Provided

Regulation	Provisions made
Purpose group of the building –IV	
Occupant Load : Area of occupied floor space per person @ 10 sqm.	60 persons calculated on the usable area.
There shall be at least two no of door opening remote from each other and leading to exits.	Provided
There shall be at least two independent stair cases or other exits from every story of a building.	Provided
Smoke free lobby floor area not less than 6sqm	Provided
Minimum width of the stair case 1050 mm	Provided 1075mm
Minimum width of the internal stair case not less than 2 units width.	Provided 1325mm
Luminous exit and directional signs was requested by the Chief of the fire department.	Provided
Exit passageways, stair cases and exit of all buildings shall be provided with fail safe artificial lights.	Provided
Compartments between average pavement level and a height of 15m.	
Max floor area 3800sqm.	297sqm
Max cubical extent 14200 cubic meters	1188cubic meters
Fire resistance of element of structure Purpose group IV	
Minimum period of fire resistance 1/2 hours.	1 hour
Protected shaft for lift shall be ventilated with one or more permanent openings.	Provided
Ventilation ducts shall be fitted internally with automatic fire shutters.	Provided
Fire resisting doors	
Timber door not less than 45mm finished thickness for fire doors with door closures was requested by the chief fire officer of the fire department.	Provided
Fire resistance of the ceiling : class 1	Provided
Fire resistance of internal partitions	
Class 3 for small rooms	Provided
Class 1 for rooms other than small rooms	Provided

Regulation	Provisions made
Rising mains	
Any building in which the floor level of the highest story is higher than 15m above pavement or ground level shall be equipped with wet rising main.	Not applicable
Hydraulic hose reel	
At least one hydraulic hose reel shall be provided in every storied of the building	
Recommended by the chief fire officer of the fire department	2 no hose reels for each floor with sump pump and a stand by pump has been provided.
Fire Alarms	
Manual fire alarms for buildings with 4 storied	2 no manual fire alarms for each floor have been provided.
Portable Extinguishers	2 Nos. for each floor provided.

3.1.3 DETAILED DESIGN CONSIDERATIONS

3.1.3.1 Summary of Structural/Foundation Design

The structure is designed according to the limit state of serviceability and ultimate limit state design philosophy as outlined in the British Standard -BS 8110: 1985 -For Framed Building structures. The frame action of the beams and columns both in the longitudinal direction and in the transverse direction are used to support the direct loads created by dead loads, superimposed loads and lateral load due to wind effects.

Regulations do not require seismic design because of the low level of seismic activity in Sri Lanka. Details of the structural design are provided in the design report and drawings numbers MK/OB/ST-01 to 26.

Loading Criteria:
The following, loads as given in BS 6399 are used:

i) A wind speed of 34 m/s shall be adopted in designing the buildings.

ii) Live Load Criteria

Inaccessible roofs	1.0 kN/m^2
Roof with mechanical equipment	According to actual weights and provisions of BS 6399
Floor of mechanical rooms	Min.10.0k N/m^2 or according to actual weight of machinery which ever is higher.
General public access	5.0 kN/m^2
Offices	3.0 kN/m^2
Electrical rooms	Min. 10 kN/m^2 or according to actual weights of electrical equipment whichever is higher.

iii) Earth Pressure Criteria

Compacted soil density	20.0 kN/m^3
Active lateral soil pressure coeff	0.333
Passive earth pressure coeff.	3.0
At rest earth pressure coeff.	0.50

iv)Foundation design criteria

Allowable bearing pressure	200 kN/m^2
Coefficient of sub-grade reaction:	20,000 kN/m^2/m

(a) Foundations

The building is supported on strip footings 2.5 m wide forming a grid of ground beams having an inverted T cross section 450 mm x 1200 m deep. The ground floor slab is above finished grade and is cast on compacted fill placed between the beams. This method is preferred instead of column pad footings which would be very large and difficult to construct properly.

(b) Walls, Columns and Slabs

The perimeter walls are to be constructed using burnt clay bricks that are commonly available in the country. These walls are made to 225 mm thick and the main partition walls are made with 200 mm cement sand blocks as shown in the drawings. Partitions within the toilet area are made to 100 mm thick solid block walls to reduce the extra load on the floor slabs and also to increase the usable floor area.

All the columns are designed as reinforced concrete (rc) columns. The main columns are 400 x 400 mm square in section. Some of them are changed to 300 mm x 300 mm from third floor to the roof level. The columns at the lift shaft are made to 'L' shape. All slabs are suspended rc slabs of 175 mm thick with floor beams spanning between columns. The ground floor slab is directly supported on compacted soil. This slab was made to 125 mm thick with nominal reinforcement to cater for temperature and shrinkage stresses.

(c) Roof

The major portion of roof is long spanning Zinc-Aluminum sheets spanning on galvanized lipped C type purlings. The purlings in turn are supported on rc beams constructed to slope and supported on rc columns. There is heat insulation just under the roofing sheets. The area used for the water tanks and for the machine room of the lift is typically an rc slab.

(d) Machine Room and Hoist way

The hoist way is formed by brick infilling between RC columns and RC beams at each floor level. The machine room is a RC slab supported on RC beams.

(e) Stairs

There are two stairs for the building one serves as the main service stair and the other as the fire escape stair. Both stairs are designed as inclined slabs spanning between beams supported on RC columns.

3.1.3.2 Summary of Floor Plans

(a) General description

The building façade is in keeping with traditional Sri Lankan styles of architecture. The height of the building has been divided into two with a heavy bottom buttress replicating the appearance of massive stone foundation. The horizontal plane is emphasized by the window sills and horizontal plaster grooves. Roof drainage down pipes are arranged in pairs to resemble wooden roof brackets of the traditional Sri Lankan building.

The building is four-storeys (ground plus three upper floors) and will be used as office space for CMC Water Works and Drainage Offices as well as NWSDB metering staff working in the greater Colombo districts of CB1, CB2, and CB3. The public will have access to the building to settle accounts and complaints.

Table 3-2 Physical Characteristics of the Building

Site area	3220 m^2
Structural form	Reinforced concrete frame, slab on beams
Foundations	Strip footing with grade beams
No. of floors	4 (ground + three upper)
Building footprint area	863 m^2
Individual Floor area (gross)	792 m^2
Total floor area (gross)	3168 m^2
Top of roof (AFG)	17.68 m
Third floor slab (AFG)	11.60 m

Ground floor plan and front elevation and are shown in Drawings MK/OB/A-01 and A-08.

The building is 44 x 18 meters, provides 792 m2 (gross) per floor and a total area (Gross) of 3168 m2 excluding the machine room, roof slab and emergency staircase.

The building has eight 5.5 m bays in the longitudinal direction and three 6.0 m bays in the transverse direction. The width of the building is governed by the narrow shape of the site and by the need to satisfy building code regulations for natural ventilation. The site has sufficient space to provide vehicle parking on the south side and space for future expansion if required on the North side.

The floor-to-floor height is 4.0 m for the ground floor and 3.8 m for upper floors. The ceiling heights of individual floors is set at 3.0 m for the ground floor and 2.8 m for upper floors conforming with building regulations. The space above the ceiling is provided for ductwork in case a central air-conditioning system is installed in the future.

(b) Floor area, occupancy and function

Each floor provides 792 sq.m of gross floor area and the total floor area of the building is 3168sq.m. The total occupancy load according to regulations is 240 persons. The floor plans are designed for an occupancy level of 50 persons per floor (total 200 persons). Space allocation is tabulated in Table 3-3. Each floor is planned to meet the space requirements identified in consultations with CMC and NWSDB.

Table 3-3 Occupancy and Space Allocation

Description	Net Space Allocated (Sqm)	No. of People
Ground floor		
CB 1		
Area .Engineer.	12	1
Commercial Officer	12	1
Office EAA	16	2
CRA	8	1
CR Clerk	21	3
Acc Clerk	14	2
General Clerk	8	1
Computer Room	9	-
Total	100	11
CB 2		
Area .Engineer	12	1
C.O.	12	1
Office E.A.A (02)	16	2
C.R.A	8	1
C.R. Clerk (03)	21	3
A.C.C. Clerk (02)	14	2
General Clerk (01)	8	1
Computer Room	9	-
Total	100	11
CB3		
Area .Engineer .	12	1
C.O	12	1
Office E.A.A (02)	16	2
C.R.A	8	1
C.R. Clerk (03)	21	3
A.C.C Clerk (02)	14	2
General Clerk (01)	8	1
Computer Room	9	-
Total	100	11
Common Branches		
P.R.U	15.48	
Consumer Files	99.5	
Cashier	28	2
Waiting Area	40	
Photocopiers	9	
Tea & Lunch Room	25	
Total	217	2
Manager's (CC) Office		
Manager	15.5	1
Toilet	4.52	
Chief Engineer	12.8	1
Engineer(P&D)	9	1
Draughtsmen	16	2
Supply Assistant	9	1
Clerk	6	1
Computer Room	12.88	
Open Plan Office	63.92	8

Description	Net Space Allocated (Sqm)	No. of People
Toilets	34.81	
Total	225	13
Total Ground Floor	742	50
First Floor		
Eng. Cubicles	8 x 7.9 = 63.2	8
T.S.A	2 x 7.44 = 14.88	2
S.E	2 x 9.9 = 19.8	2
Director	27.9	1
Computer Room	20.36	
Conference	21	
Consumer Section	32	3
D.O.A	9.32	1
Drawing Office	40.3	4
Administration and Accounts	172.32	15
Acct.	6.19	1
A.S.	5.75	1
Lunch Room	20	
Technical Staff	103.74	10
Waiting	40	
Toilet	34.81	
Toilet	3.05	
Total First Floor	635	50
Second Floor		
Cubicals	6No. X 7.95 = 47.7	6
	4No. X 6.45 = 25.8	4
	2No. X 6.97 = 13.94	2
	4No. X 7.98 = 31.92	4
Director	29.0	1
Computer Room	18.36	
Conference	21	
Consumer Section	32.0	3
D.O.A	8.9	1
Drawing Office	40.3	4
Administration and Accounts	172.32	15
Acct	6.19	1
A.S	5.75	1
Lunch Room	20	
Technical Staff	64.8	10
Waiting Area	40.0	
Toilets	34.81	
Toilet	2.68	
Total Second Floor	615	52
Third Floor		
GC Sewerage Section		
A.G.M	23.5	1
Chief Engineer	12.47	1
Engineer	11.73	1
Computer Room	14.0	
Accountant	09.08	1
Acc. Clerk(02)	49.5	2

Description	Net Space Allocated (Sqm)	No. of People
Clerical Staff		5
Meter Readers	122	18
E.A (12Nos)	96 (Space Given In Open Plan Office)	12
E.A. (04Nos) M.Office	32 (Space Given In Open Plan Office)	4
Sociologist	09	1
Acct.	12	1
Acct. Clerk	06	1
Supply Assistant	09	1
Clerk	06	1
Chairman's Visiting R.	15.5	
DGM's Visiting Room	14.0	
Conference Room	30.0	
Lunch Room and Tea	30.0	
Future expansion	62	
Waiting Area	40	
Toilets	34.81	
Total Third Floor	640	50

(c) Circulation and internal partitioning

The Vertical circulation shall be via 8-person passenger lift and a staircase. All four levels of the building is linked together with a central lobby, strategically located to minimize the public circulation within the building. It also enables the multi use of space within the same floor, which is one of the main characters in the client's requirements list. Central lobby provides direct public access with minimum circulation. And Staff toilets, lunchrooms, electrical switchboards are also located centrally.

Horizontal circulation of each floor has been designed to accommodate the public up to the waiting area at each level. Public access to the office floor from the waiting area should be monitored for the smooth functioning of each office area. Except for the rooms needed by the client with the permanent partitions, rest of the partitions will be short partitions as requested by the client. This will give the flexibility to re-configure the internal arrangement and will allow proper air circulation within the building.

(d) Toilet Facilities

Each toilet facility consists of 6 water closets for both men and women, 6 wash hand basins for men and women, 4 urinals for men and necessary cloth hooks, soap trays, toilet paper holders and mirrors. Separate toilet facility for disabled persons has been provided with all the necessary specialized accessories. Separate toilet for managers /conference room has been provided.

(e) Lunch Rooms

Lunchroom has been provided for each floor with kitchen sink and a cupboard.

(e) Accessibility

Toilet facilities and lunchrooms are so located (in the central area) in order to gain access with minimum disturbance.

3.1.3.3 Building Materials and Finishes

(a) Building Materials

The basic building materials are reinforced concrete for the structure and concrete or clay blocks for interior partitions. A list of materials and finishes is presented in Table 3-4.

Table 3-4 Building Finishes

Exterior	
Roof	Zinc aluminum roofing with Insulation sandwich panels
	(M/S truss, Rafter, Purlin)
Gutters	Machine pressed zinc aluminum gutters/down pipes
Walls	Semi rough plaster painted with weather shield paint (Brick work)
	Columns & Beams : Fair-faced concrete
Plinths	Fair-faced rubble work (Rough ordinary rubble)
Sills	Fair-faced concrete
Windows	Bronze anodized aluminum
Glass	4mm thick clear glass or Heat absorbed glass
Front doors	Aluminum door with fixed glazed panels
Other doors	Aluminum door with fixed glazed panels

Interior							
Room		Floor	Skirting	Wall	Column	Ceiling	Others
Ground Floor	Lobby Waiting area	Terrazzo	Terrazzo	Smooth lime plaster painted	Smooth lime plaster painted	mineral fiber (600x600Suspended aluminum frame)	
Typical Floor 1 to 3	Lobby Waiting area	Terrazzo	Terrazzo	Smooth lime plaster painted	Smooth lime plaster painted	mineral fiber (600x600Suspended aluminum frame)	
	Office	300X300 Ceramic floor tiles.	Ceramic floor tiles.	Smooth lime plaster painted	Smooth lime plaster painted	mineral fiber (600x600Suspended aluminum frame)	

Interior							
Room		Floor	Skirting	Wall	Column	Ceiling	Others
	Toilet	300X300 Ceramic floor tiles.	---	200x200 Ceramic Tiles up to 2100	200x200 Ceramic Tiles up to 2100	Water proof cement board painted	Wall up to ceiling Semi rough water proofing plaster
	Stairs	terrazzo with 2no Carborundum strips inserted	terrazzo	Smooth lime plaster painted	Smooth lime plaster painted	Soffit plaster painted	3rd Floor Gypsum board (600x600Suspended aluminum frame)
	Machine room	R/C trowel	Cement Mortar	Semi rough plaster painted	---	Soffit plaster painted	
Typical Floor 1 to 3	Lift shaft	---	---	Fair-faced concrete washed & painted	---	Fair-faced concrete washed & painted	
	Riser shaft (sewer/water supply)	R/C trowel	Cement Mortar	Semi rough water proofing plaster	---	Fair-faced concrete washed & painted	
High Partition Low Partition		Block work plastered and painted h=1,200 Ready-made partition without door					

(b) Exterior Finishes

Semi rough cement plaster painted with two coats of filler and two coats of weather shield paint in two colors shall be used for exterior finishes. The engineer will select the exact colors after approval of color samples during the actual construction of the building. All the windows will have a windowsill cast with reinforced concrete.

External plaster will have 20mm X 10mm Grooves along floor slab lines and beams. This would facilitate reducing the thermal cracks in the plaster. The Plinth shall be of Fair face random rubble masonry construction with a 75 mm deep continuous coping at the edge.

(c) Interior Finishes

The internal walls shall be finished with smooth lime plaster painted with 2 coats of primer & 2 coats of emulsion paint. Wall edges around the doors and windows shall be splayed 18.75mm.

Toilets: 200mm x 200mm Ceramic wall tiles will be used up to the height of 2100mm. Grooves will be

finished with the grout supplied by the tile manufacturer. All the walls will be water proofed according to specifications before tiling. 200mm x 200mm Ceramic floor tiles. All the floors will be water proofed before laying tiles.

All lobbies, waiting areas and internal staircase will be applied with terrazzo and shall be laid with 600mm x 600mm aluminum separation grid.

Office areas will be tiled with 300mm X 300mm Ceramic floor tiles

Skirting: 75mm High Terrazzo finish in terrazzo finished floor areas.

Porch: Pressed cement tiles will be used for the flooring of porch area.

Ceiling: Mineral fiber ceiling with 600mm x600mm panel edge type Sand finish panels with Class 1 fire rating will be used. The ceiling will be suspended with the 600mm x 600mm aluminum grid. The size of the main aluminum T section will be 38mm X 24 mm. Hanger rods will be used to suspend the aluminum grid. The installation of the ceiling will be done by a specialist contractor.

Soffit: Soffit plaster will be used under the Stair cases, Switch board rooms, Lift motor room and Pump room.

(d) Roof

The supporting structure for the roof will be constructed using reinforced cement concrete beams. C purlings of the roof will be fixed over the concrete beams. Zinc aluminum roofing sheets will be used with glass wool and aluminum foil insulation. There is 1800mm eve to protect the windows. A specialist contractor will carry out installation of aluminum roofing. Machine pressed Zinc Aluminum gutters with brackets at 900mm c/c shall be adopted for down pipes .

(e) Doors and Windows

Doors will be fabricated with Bronze anodized aluminium and will have infill panels varying from 5mm thick clear/frosted glass to acrylic infill panels. Fire doors will be made with 45 thick solid core timber with vision panels with wired glass. Toilet doors will be made of vinyl coated plywood ..All the fire doors and toilet entrance doors will have door closers. Stainless steel hinges will be used for all the doors.

Bronze anodized Aluminum casement windows with 5mm thick glazing panels shall be adopted. Window sashes will be side hung .Fanlights on top will be top hung type. All the hinges and fasteners will be stainless steel.

(f) Fixtures

All the toilet fittings, accessories, taps and kitchen sinks shall conform to British Standard or any other equivalent standard.

(g) Stairs

Internal Stair case: Terrazzo finish with 25mm x 25 mm nosing &two No, Carborandum strips inserted in to each step. Stainless steel handrail will be used for the staircase.

Rear Staircase (Fire Escape) : Cement rendered steps with two no Carborandum strips inserted in to each step. Tubular GI handrail will be used

(h) Partitions

Internal arrangements will be done with half height partitions with bronze anodized frames and gypsum board class I with class III fire rating. To make the internal partitioning more flexible, continuous windows at an each bay has been introduced.

3.1.3.4 Services and Safety Provisions

(a) Primary Power Supply and Metering

The following are taken into consideration:

The entire building is classified as a normal office. Only window type air conditioners will be installed in a few selected rooms -(not more than three in any floor. Natural ventilation will be assisted by ceiling fans. Exhaust fans are used in corridors and toilet areas to change inside air.

The estimated maximum demand for power supply to the building initially on the above premises, is 165 kVA. This is estimated to rise to 295 kVA, if the building is air-conditioned at a future date. The installed loads in the building are as follows:

Table 3-5 Maligakanda Office Building – Details of Installed Loads

Item of Load	kW (Now)	kW (Future)
Lighting, Internal	36.0	40.0
Lighting, External	3.5	4.0
Ventilation	24.0	4.0
Air – Conditioning	0.0	128.0
Mechanical Loads (Lift, Pumps etc)	30.0	35.0
Socket Load	61.0	76.5
Total	154.5	287.5

Power Supply will be obtained from Colombo City Distribution System. The Supply Authority (Ceylon Electricity Board, CEB) will construct an indoor consumer sub-station, for which the consumer is required to provide a room with floor space, ventilation and cableways, as stipulated by CEB, taking into consideration site conditions. A separate room for this sub-station is to be constructed beside the stand-by generator room.

CEB will have their own metering equipment inside this sub-station room. Armoured cables (2 x 240 sqmm. 4 -core XLPE, run underground in hard PVC conduits) are to be installed from CEB's meter terminals to consumer's Main Switch Board. This arrangement takes into account the increased power to be handled when the building is air-conditioned at a future date. A 500 Amp M.C.C.B (TP&N) consumer's isolating switch, housed in a lockable steel enclosure, installed on the outside of CEB's sub-station room wall, is provided to meet CEB’s requirements for control and isolation of the power supply.

(b) 415/220 Volt power distribution

The Main Switch Board (MSB) located in the power room of the Ground floor, controls the main feeders

to the Power Distribution Boards (PDB's) located in the power room of each floor, and to the Utilities Power Distribution Board (UPDB), located near the MSB.

The PDB on each floor controls the feeders to three single phase Lighting Distribution Boards (LDB's) and to three single phase Socket Distribution Boards (SDB's). All lights and fans are connected to the LDB's – and all sockets are connected to the SDB's.

The PDB on each floor also has space provision to install a 60 A MCCB TP&N for an additional feeder to the A/C Room of that floor. Empty conduits are laid between the Power Room and the A/C Room for installing this feeder at a later date.

For the above load requirement, the Ceylon Electricity Board will construct a dedicated 11kV/LV consumer sub-station in the premises.

The following factors are taken into consideration in designing the Power Distribution System:

1) The main cable (from CEB Isolating switch terminals to the Main Switch Board in the "Power Room" of the ground floor) is selected to be adequate to handle increased current, when the building may have more comprehensive air-conditioning arrangements, in the future.
2) The Main Switch Board (MSB) and the main feeder cables to the Power Distribution Boards on each floor will be designed to carry the estimated load required for air-conditioning in the future.
3) The Power Distribution Boards on each floor will have space provision for installing an additional 60 A MCCB TP&N in the future, when it is decided to air-condition the building. Empty conduits are to be laid at time of constructing the building, for taking a 60 A feeder from the PDB to the A/C Room in each floor.
4) The essential loads will be supplied through a "Utilities Power Distribution Board" (UPDB), located in the Power Room of the ground floor. This "UPDB" will receive its incoming supply either from the CEB system or from the DG set. The DG set will be operated automatically and the essential loads will be transferred by an automatic transfer switch, sensing mains failure.

(c) Emergency power distribution

Stand-by power, at times of CEB power Failure is provided by a 60 kVA D.G. set. This set is operated automatically by signals from an Automatic Load Transfer Switch in the MSB. A 35 sq mm 4 -core cable connects to the UPDB.

On each floor, the loads to be supplied from the DG set in case of CEB power failure are all connected to one separate single phase distribution board, which is fed from the UPDB.
The UPDB also feeds all essential loads such as the Lift, Water Pumps, Roadway Lighting etc.

The following essential loads can be supplied either from the normal supply or from the stand-by generator:

1) Essential utilities such as the Lift, Water Pumps, Fire Pumps etc.
2) Lighting in staircases and common areas, on each floor
3) Roadway lighting outside the building.

The estimated load on the DG set would be 60 kVA

(d) Lighting

In the general office areas, lighting is provided by recess mounted ceiling fittings having three 18W Fluorescent tubes, with mirror optic reflector system.. These fittings are specially desined for use on modular type false ceilings.

Local lighting in places such as staircases and in non-ceiling areas such as power room, A/C room etc will be by use of batton type fluorescent fittings with serrated opal diffuser covers.

Illumination levels will be as recommended in the Lighting Code of the Illumination Engineering Society and no less than 500 lux in office areas.

(e) Communication

Communications equipment (telephones and switching) is not provided under this contract. The design includes supply and installation of communication the required conduits and other accessories to receive internal telephone wires. In general, supply and installation of telephone facilities are carried out by the owner through a vendor specialized in telephone systems.

(f) Lightning Protection

Lightening protection is provided for the building by adopting "Early Streamer Emission" type air terminations (finials). This would provide a reliable and adequate level of protection with the use of one or two finials - as opposed to the use of several finials at roof-top, if the conventional passive finials are adopted.

Radio active heads will not be permitted. Copper tapes will connect the air terminations to copper plate earth electrodes buried 1.5 m below ground level.

(g) Water Supply

Water Supply to the premises will be obtained from the NWSDB distribution line lying adjacent to the site. Water will be stored in a ground sum where two (2) electrically driven submersible type pumps will lift the water to 3 overhead tanks placed on the roof top slab.

<u>Calculation of daily water consumption</u>

Average number of occupants (estimated)	=	240 + 10 = 250
Average individual consumption /day	=	35 ltr.
Total consumption per day	=	8750 ltr. (8.75 $m^{3)}$

<u>Fire fighting</u>

One hose reel	=	2000 litres
Required fire fighting water as per regulations	=	2 hose reels i.e. 4000 litres (4.0 $m^{3)}$

<u>Required storage volume:</u>

Volume of ground sump = peaking factor x daily consumption + fire fighting requirement
= 1.6 x 8.75 + 4
= 18 m^3

Volume of overhead storage = 1.0 x daily consumption
= 9 m^3

Two types of pumps were considered for transferring to water from ground sump to overhead storage tanks.

I Standard end suction centrifugal pumps 02 Nos. (01 duty, 01 side by) with starter panel housed in a pump room.

II Submersible type pump sets (02 Nos) installed in the sump and electrical panel installed in the pump room.

Due to limitation of available space, option II was selected.

Static head :

Depth of sump	:	2.5 m
Height from ground level of sump To overhead tank	:	16.9 m
Total	:	19.4 m …….. a.

Frictional head :
Frictional head for 1 ½ dia GI, at 1.5 m^3/hr

Hf	=	1.4 m /100 m
For 50 m length hf	=	0.7 m
Hf (fittings)	=	1.5 m
Total Hf	=	2.2 m …….. b.

Residual Pressure	=	0.5 bar
	=	5 m ……..c.
Total dynamic head		
(a) + (b) + (c)	=	19.4 +2.2+ 5
	=	26.6 m

Hence it is recommended to use pumps of capacity : 9.0 m^3/ hr @ 26.6 m head.

General Operation

One common starter panel installed inside the pump room will operate pumps.

Mode of operation will be manual or auto. In auto position the pumps will start & stop depending on the high & low water levels in the sump and overhead tank.

A set of gate valves and non - return valves are provided in order to facilitate manual change

over of the pumps alternately.

(h) Plumbing and Drainage

The plumbing and drainage installations are designed generally conforming to the basic requirements of ICTAD Specifications for building works Volume II Sanitary Installations July 1989 and the following British Standard Codes of Practice:

1. BSCP 3 - Basic Data for Building Design
2. BSCP 304 - Soil and Waste Pipes above ground
3. BSCP 305 - Sanitary Appliances
4. BSCP 310 - Water Supply

The details of plumbing and drainage are illustrated in drawings MK/OB/SW/01 to 10 (10 sheets). Water is pumped to three interconnected water tanks (placed on the roof) from a 18 m^3 capacity RC ground sump through a 63 mm PVC riser pipe. The distribution of water to the three floors is effected by three separate 50 mm dia PVC vertical delivery pipes laid within the service duct. At each of the floors, water is fed into a loop pipe, which in turn feeds all toilets and other appliances.

The sewerage system comprise 3 nr 90 mm vertical stacks for collection of wastewater from sinks and 2 nr 110 mm vertical stacks for collection of sewage from toilets, from each floor. The design provides for adequate venting through the stack itself, which extends up to roof level. The appliances shall be equipped with bottle traps as required in order to prevent emanation of odor. At the ground floor level, wastewater and sewerage stacks are led to the collecting manhole. The wastewater from sinks is disposed of through a grease trap and leaching field. The sanitary sewage is discharged to a sewerage manhole via 110 mm PVC pipe and connected to the City's sewerage network.

While maintaining the natural drainage pattern of the site, excess storm water run-off is collected into a network of 225 mm hume pipes through a number of gullies and manholes. The storm water is finally led to the city network through a main discharge hume pipe of diameter 275 mm.

(i) Fire Safety Systems

Fire sump, Hose reel and 9 HP pump

General

Fire fighting system is provided for the building consisting of a pressurized wet riser system. This complies with the Government regulations with regard to construction of buildings.

Design Approach

Fire fighting system standards and other regulations accepted by the local Fire Department were used for the design.

The office building's highest occupied floor is only 11.8 m above grade therefore fire regulations do not require automatic fire suppression system. The fire department has requested fire extinguishers and a wet riser system with 2 hose reels on each floor for fire fighting. In addition the fire department has requested an emergency exit staircase at the rear of the building.

Fire Water Storage

The 18 m^3 potable water ground sump includes a volume of 4.0 m^3 for fire fighting.

Firewater pumping system

The wet riser and hose reel system are served by (2) electrically driven centrifugal pumps and pressure is maintained by (1) jockey pump. A pressure tank installed on the main discharge header are used to operate the pumps and to maintain a set pressure in this wet riser main.

Two alternate sources of power are provided to operate the pumps in an event of a fire.

i.e.
Main power supply from CEB
Stand-by generator power.

The electrical control panel will be designed in such a way that the pumps will change over automatically to generate power, in the event of mains failure.

Hose Reels.

90 mm diameter of 6.0 m length and nozzle size of 4.8 mm of the hose reels have been designed in conformity with British standards and fire regulations.

(j) Elevator

General:

The proposed new building consists of four stories and it is proposed that both NWS&DB and Colombo Municipal Council will set up their offices within the building. The total number of occupants is estimated to be two hundred and fourty (240) within the building.

Further it is expected that movement of general public in and out of the premises will prevail on daily basis. However the density of traffic within the premises will vary depending on the type of offices, which are going to be set up by the NWS&DB and CMC.

Accordingly it is recommended to provide an electrically operated man elevator to facilitate the movements within the building. This is an extra facility in addition to the staircases provided.

Design:

The lifting capacity of the elevator has been based on following parameters.

- Number of floors,
- Area of each floor,
- Estimated number of occupants

Based on the above, it is recommended to provide an elevator with a maximum lifting capacity of 15 passengers. Lift specifications and installation will be in accordance with Part IV of ICTAD Specifications for Electrical and Mechanical Works Associated with Building and Civil Works August 2000.

Sizing of the lifting compartment, inner section of carriageway, machine room and the basement room

was based on the recommendations of reputed manufacturers such as MITSUBISHI – Japan, OTIS – France etc.

Type of necessary foundations, lifting hooks etc. for the lifting equipment was made to suit the typical models of elevators available with the manufacturers.

Necessary power supply will be made available for the lifting equipment at the machine room and the electrical control panel shall be installed.

The ventilation to the machine room will be provided by a ventilation fan, which will be installed on the wall. Capacity of the fan will be sufficient to make six air changes per hour.

(k) Ventilation and air-conditioning

The design is based on natural ventilation through windows that can be fully opened. Natural ventilation is assisted by use of ceiling fans on all floors. Exhaust fans are used to extract air and provide 6 air changes per hour in lobbies, waiting areas, common corridors and toilets. Exhaust air ducting system complete with fans of sufficient capacities was provided for ventilation of these areas. Fabricated ducting will be fixed within the gap between the ceiling and the ceiling slab on each floor. Fire dampers are provided at necessary locations inside the air ducting, in order to prevent spreading fire into protected areas, in such an event.

Window type air conditioners will be installed in only a few selected rooms -(not more than three in any floor. The building is designed with mechanical equipment room on each floor and ceiling space to install additional supply air ducts for a central air conditioning system if required at a later date. Central air-conditioning is taken into consideration in the electrical distribution design.

3.1.3.5 Landscaping, Grading, Drainage and Fencing

Grading around the building has been designed to ensure that the existing natural drainage patterns will be maintained as far as possible. Because of high elevation of the building site no major concerns were encountered in designing the drainage system. The storm water run-off shall be gravity fed into the main drain of the Colombo drainage network.

The landscaping for the entire site has been designed conforming to standards acceptable in Sri Lanka. The location, type and number of trees together with green areas have been designed to achieve the best blend with the surrounding environment. The proposed types of trees are pudding pipe, fern anf temple. For the paved areas, 600 x 600 concrete slabs shall be used. The proposed landscaping is depicted in the drawing nr MK/OB/G – 04.

3.1.3.6 Roads and Parking Area

The access to the site is designed to be a 5 m wide road with asphalt surface complete with paved walkway on both sides and pre-cast concrete curbs and side drains. The required parking areas have been provided in accordance with the requirements given in Chapter 2 of this report.

3.2 MALIGAKANDA NEW RESERVOIR

3.2.1 DESIGN CONDITIONS

3.2.1.1 Summary of Works

(a) Existing Reservoirs and Projected Flows for Maligakanda Reservoir Site

There are two reservoirs already in existence in Maligakanda. The old reservoir that was constructed in 1887 has a capacity of 36,300 (8 mgd) and operates at 29.00 TWL and 19.00 BWL. The roof of this reservoir and the pipe work are to be rehabilitated under this project

The second reservoir is circular in shape and made of post-tensioned concrete. It has a capacity of 13,600 m^3 (3mg) and maintains same TWL and BWL as the old reservoir.

The New Maligakanda Reservoir will have a capacity of 22,000 m^3, which resulted in the overall capacity of

Old Reservoir	36,300 m^3
Circular Reservoir	13,600 m^3
Proposed Reservoir	22,000 m^3
Total Capacity	71,900 m^3

The present storage capacity is not fully utilized due to inadequate supply to Maligakanda. This is expected to improve with the commissioning of Ellie House Transmission Main.

At present, the recorded average day supply to Maligakanda site is approximately 95,000 m^3/day. However, the New Maligakanda Reservoir and the related works are designed to meet the projected flow for the year 2010 as identified in SAPROF report:

Gravity Supply from Kalatuwawa	:	27,168 m^3/day
Pumped Supply from Ambatale	:	83,400 m^3/day
Maximum Daily Supply	:	110,208 m^3/day

(b) New Reservoir

A circular pre-stressed concrete reservoir with 53.0 meters internal diameter with a water height of 10.0 meters and a free board of 500 mm was adopted.

Because of the difficulties in shuttering, form work and concreting a domed structure was not considered for the roof and a beams and slab construction was used. To reduce the number of columns a column grid of 6.0 m x 6.0 m was used to support the beams. The perimeter post-tensioned wall was made to 500 mm thick and is designed to rest on a circular RC footing. The base slab of the reservoir, which supports the columns, is designed as an RC raft.

(c) New Valve House (function)

The outlet system of the two existing reservoirs is already complex and the outlet valves are located over a wide area. The addition of a third reservoir with a conventional outlet system will aggravate this situation.

To avoid this situation, it is proposed to direct all reservoir outlets as well as all distribution outlets via a properly designed valve house. Facilities are provided within the valve house to isolate the reservoirs and the distribution outlets.

(c) Rehabilitation of Re-Chlorination Facility

The function of this facility is to maintain the residual chlorine level in the distribution system at the desired level of around 0.1 mg/L. The existing facility has fallen into disrepair and is no longer used. It consisted of vacuum type gas chlorinators with pressure ejectors. The chlorine was drawn from 900 kg gas cylinders and injected on the supply side of the reservoirs.

The existing Chlorination Facility at Maligakanda Complex will be rehabilitated using the existing method of chlorination with the exception that chlorine cylinders will be smaller to reduce the health and safety impacts of a leak.

Three feed pumps took water from the transmission main to provide process water for mixing with chlorine gas. The feed pumps injected chlorine solution back into the inlet side of the two reservoirs. Considering the ease of operation and reliability of this system, it is recommended to continue

3.2.1.2 Site Location and Conditions

(a) Description of Site

The construction of Maligakanda New Reservoir will take place at the present Maligakanda Reservoir site, which houses the two existing reservoirs, CMC water works Department, the Maligakanda Telemetry Center and several other service buildings. Being the highest location (21 m above MSL) within the CMC area, Maligakanda site is a good site for service reservoirs.

The site plan with existing structures and other features are shown in the drawing nr MK/GR/C –01.

(b) Demolition of buildings and tree removal

The existing reservoirs and the office complex date back to more than 100 years. There are ten (9) existing buildings covering the Maligakanda reservoir site. These buildings have been identified and designated as follows:

Building No.	Description
2.	Waterworks Engineer's Office, Canteen and Toilet
3.	Drainage maintenance office and workers' rest room
4.	Security hut
5.	Overseers' equipment room and rest room
6.	Overseers' equipment room and garages
7.	Stores and transport office
8.	Carpentry room and drivers' rest room
9.	Meter room (abandoned)
10.	Water Board Stores

These buildings need to be demolished; services relocated and clear the site before commencement of construction. The drawing number MK/OB –3 illustrates the locations and number of buildings to be demolished.

Around thirty trees of medium girth are lying within the proposed site. Each of these trees have been identified and shown on the same drawing.

(c) Relocation of Services

Before demolition of buildings, it is necessary to relocate the existing utilities to continue the services to the remaining buildings and abandon the parts of utilities, which are no more required.

Drawing No.MK/OB-1 shows the relocation of electricity supply and other utilities, including water supply, sewerage and storm water. It is required to lay a new sewer line from the Telemetry Center to the Public Sewer on the access road, since the earlier route is affected by partial abandoning of the existing sewer system.

(d) CMC Stores buildings (maintaining access)

The stores building will remain intact and requires continuous access. The access shall be maintained (along the proposed road way) at all times.

(e) Land Acquisition

No land acquisition is required for reservoir construction. However, way-leave shall be obtained from the CMC Roads Department to lay the gravity washout/overflow drain through the existing mixing yard. Temporary easements are required during construction on land adjacent to the reservoir.

3.2.1.3 Summary of Geotechnical Investigation and Assessment Results

A typical under-ground profile of the site is as shown in Fig 1a and Fig 1b. of the geotechnical investigation report (refer to Supplementary Data to Tender Documents). According to the findings, there is an overburden of laterite to a depth in the order of 18.0 meters. This particular type of laterite is classified as hard laterite. The ground water level is located around 4.0 meters from the existing ground level.

Soil sulphate content is the order of 0.6% SO_3 and is considered aggressive towards buried concrete structures. Foundation concrete has the following specifications for protection against sulphate attack:

- grade 35 Ordinary Portland Cement (OPC),
- minimum cement content of 380 kg/m^3,
- water to cement ratio limited to 0.45
- 25% pulverized fly ash added.

Plate bearing tests indicate that settlements in the order of 110 mm can be expected for loading of 200 kN/m^2. This settlement is very rapid and almost instantaneous therefore it is recommended that:

- The tank be loaded with water before constructing the columns and roof slab
- Settlements be monitored during the 1st loading of the tank for the water test

Permanent pipe connections to the tank be made after these settlements are complete

A safe bearing pressure of 200 kN/m^2 is recommended in order to reduce initial settlement.

3.2.2 SPECIFIC DESIGN CRITERIA

3.2.2.1 Structural Design

a) Loading Criteria

The perimeter post-tensioned wall is analyzed and designed for segmental post-tensioning. The stresses in the wall are checked under no load (with no water pressure) condition and under full load condition (with full water pressure) considering all losses in post-tensioning cable ducts.

The concrete floor slab is designed for full water pressure and also the load transferred from columns. Roof live load is 2.5 kN/m^2 and dead load is 16.5 kN/m^2

(***b) Foundation design parameters***

The safe bearing pressure is taken as 150 kN/m^2 to minimize settlement.

The sub soil at this particular site can undergo instantaneous settlement in the order of 110 mm when loaded. Therefore, it is necessary to monitor the settlement of the structure at all stages of construction. It is also advised to fill the reservoir with water for a period of 30 days in order to obtain initial settlement prior to construction of the roof slab. The permanent pipe connections to and from the reservoir should be carried out only after this settlement takes place.

3.2.3 DETAILED DESIGN CONSIDERATIONS

3.2.3.1 Summary of New Reservoir

(a) Inlet and Outlet Arrangement

The inlet to the reservoir is taken from 30" by-pass main of the Old Reservoir. The size of inlet is 600mm DI and a valve is provided for flow control or isolation.

The part of the inlet inside the reservoir is placed vertically and ended with a bell mouth with its top level at 29.00 m MSL. The top of bell mouth coincides with TWL of the reservoir.

The size of the outlet is 800 mm DI and its entry bell mouth is kept slightly above BWL of the reservoir to avoid possible ingestion of silt. Outlet is provided with a flow-measuring device and connected to the main discharge header of the valve house.

(b) Overflow and Washout Arrangement

Overflow is 400 DI and extends vertically through the reservoir. The top of the overflow bell mouth coincides with the TWL of the reservoir.

Washout is 300 DI and the reservoir end of the washout is kept in a recess below the BWL of the reservoir. The flow of the reservoir is sloped towards this recess to ensure a complete drain of the reservoir through the washout.

The overflow and washout are connected to a manhole chamber from which the gravity drain starts.

(c) Circulation and internal partitioning

A series of baffle walls are arranged to the full height of the reservoir to ensure proper circulation of water between the inlet and outlet points.

(d) Access for maintenance

The access into the reservoir is maintained through 4 Nos. of access manholes and access ladders. A sufficient clearance had been maintained all around the reservoir for other maintenance purposes.

3.2.3.2 Summary of Valve House

(a) Layout

The valve house is located very close to old Maligakanda Reservoir and New Maligakanda Reservoir. It is positioned towards the edge of the property to save space and also to maintain some distance from the reservoirs and outlets for easy yard piping.

The valve house is designed to 'L' shape (two halves) to make yard piping simple and straightforward.

The location of the valve house is shown in Drawing No. MK/GR/YP-02 and the arrangement of the header are shown in Drawing No.MK/GR/YP/-03.

Due to the depth of the existing pipelines, the main header is kept at 17.50 m MSL. The formation of the ground level at this point is 22.50 m MSL. Due to this reason, the valve house is designed with a basement in which all valves and pipe works are installed.

The headstocks of all valves are installed at the ground floor level.

The access to the basement is obtained through two stairways located on both ends of the valve house.

Monorail cranes have been provided at the ceiling level of the ground floor. The access to the pipe work is obtained through, a wide and lengthy opening provided at the ground floor slab.

Two folding doors have been provided at the ground floor level for vehicles to reach the cranes.

(b) Discharge header (size and configuration)

The hydraulic calculation has been performed for the pipe work within the valve house and the discharge header has been sized at 1000mm diameter over the entire length.

One half of the valve house receives water from New Maligakanda Reservoir and existing Circular Reservoir. These inlets are provided with two isolating valves at the header. The other half receives water from Existing Maligakanda Reservoir and the existing by-pass. These inlets are also provided with two isolating valves.

The two halves of the valve house can be isolated by means of a line valve provided in the middle of the 'L' shaped header.

A provision has been made at one end of the valve house for another outlet in the future.

(c) Connection to the distribution mains

The following distribution mains are connected through the valve house via isolating valves. They are;

1.	Mount Mary	:	10"
2.	Old Borella	:	30"
3.	Kirulapone	:	20"
4.	St. Sebastian	:	27"
5.	Colombo Fort	:	20"
6.	Dematagoda	:	10"

In addition to the above six existing connections, the valve house caters for the new 300mm distribution main to Dematagoda.

(c) Access for maintenance

Two wide folding doors have been provided at both compartments of the 'L' shaped valve house at the ground floor level. The ground floor slabs are designed for vehicular loads that enable for vehicles to enter the valve house and do loading and unloading work. The movable cranes provided at both compartments of the valve house then can carry valves and fittings to the basement level. The operators' access into the basement is obtained through two stairways.

The valve house itself can be accessed through the proposed access road.

3.2.3.3 Summary of Re-Chlorination Facility

(a) Layout

The existing facility will be rehabilitated. The floor plan consists of two rooms separated by a masonry wall. One room is for storage of gas cylinders and vacuum regulators. The other room is for pumps and electrical equipment. The gas cylinder storage room has a monorail with chain block for moving cylinders

(b) Rehabilitation of Building

The existing building requires a number minor repairs:

- New doors
- Repair to windows
- New water proofing membrane to roof
- Removal of concrete saddles for 900 kg cylinders
- Construction of partition wall at entrance

(c) Mechanical and electrical systems

The chlorination system consists of vacuum type gas chlorinators with pressure ejectors. The chlorine is drawn from 68 kg gas cylinders and injected on the supply side of the reservoirs. Three feed pumps (2 duty and 1 standby) take water from the transmission main and pump through 2 ejectors where the water

is mixed with chlorine gas. The chlorine solution is pumped back into the transmission main on the inlet side of the reservoirs at two points

The following basis was adopted in designing the Chlorination equipment.

- The system shall have the capacity to handle water demand through to the year 2010 (110,000 m^3/day)
- Provision will be made for two injection points on the inlet headers to the reservoirs in order to cater for the worst operational scenario and to enhance flexibility of operation
- Based on the maximum supply figures for 2010, the maximum rate of consumption of chlorine has been estimated at 22 kg per day. Hence it is recommended to use the standard 68 kg cylinders in lieu of the present toners
- For maximum flow at a dosage rate of 0.2 mg/L a 68 kg cylinder will last for 3 days. It is therefore recommended to store 10 cylinders which provide a buffer stock for around 30 days
- Sizing of the booster pump and piping was based on the information supplied by reputed manufactures of chlorination equipment
- The intake water for the booster pumps shall be obtained by tapping in to the pumping main at the nearest location
- Twin type weighing scale with change-over facility shall be provided to facilitate day to day operation
- Sampling points are provided on the discharge header in the valve house and connected to a permanent residual chlorine analyzer.
- The quantity and quality of water supplied to the site from the transmission mains will not fluctuate much therefore the dosage rate will be controlled manually by the operator.

The new chlorination equipment proposed are summarized as follows:

- 3 Nr booster pumps and associated pipe work (1 duty/2 standby), capacity of each: 2.1 cum per hour at 30 m TDH.
- 2 Nr vacuum type gas chlorinator, manifold mounted with automatic switchover of capacity 0 – 2 kg /Hr (1 duty/1 standby)
- 2 Nr gas ejectors and piping
- 2 Nr chlorine solution injectors and piping
- cylinder weigh scale and changeover facility
- Storage for 10 Nr 68 kg cylinders
- Exhaust fans etc.

Power supply, is 3 phase, 4 wire, 400 volts obtained from existing power supply to buildings that remain on site.

(d) Injection Points

Provision will be made for two injector points in order to cater for the worst operational scenario and to enhance flexibility of operation

(e) Monitoring total and residual chlorine

The total and residual chlorine is monitored at the valve house manually using a simple device such as comparator. It is recommended to monitor chlorine level within the reservoir and furthest points in the

distribution system as a routine function of the operation staff. Chlorine dosage needs to be periodically adjusted to maintain a residual chlorine level of 0.1 to 0.2 ppm in the distribution system.

(f) Safety features

Adequate safety measures shall be provided to protect the operation staff in the event of a chlorine leakage. The safety features proposed include:

1) chlorine gas masks
2) eye wash
3) Chlorine gas detectors, audible alarm and signal light
4) Sump where a leaking cylinder can be quickly immersed in caustic soda solution
5) Slaked lime dispensers for neutralizing small leaks

3.2.3.4 Summary of Yard Piping Design

(a) Connection to the existing supply scheme

Maligakanda Reservoir sit receives water from three transmission mains namely, old 30" New 30"from Ambatale pump house and old 20" from Labugama. The old Maligakanda Reservoir has two inlets, one on the western side and the other on the eastern side. The existing circular reservoir receives water from 30" by-pass, which is connected to Borella 30". The 27" by-pass on the other side is connected to 20" outlet of the old reservoir. The other by-pass system of the Labugama inlet side is connected to 20" washout and Borella 30". The inlet and by-pass system will be changed in the following manner to improve supply to existing circular reservoir and new Maligakanda reservoir.

- Remove existing inlet on the eastern side of the Old Maligakanda Reservoir and end cap.
- Provide inlet to the New Maligakanda Reservoir from 30" by-pass on the southern side.
- Continue 27" by-pass on the western side of the Old Maligakanda Reservoir and join it to 30" by-pass on the southern side in order to complete the by-pass arrangement around Old Maligakanda Reservoir and connect the joint by-pass to valve house.
- Disconnect the other by-pass arrangement taken off from Labugama inlet.

(b) Modification to the existing outlet scheme

Old Maligakanda Reservoir has three outlets of 30", 20" and 40". Out of these three, only 40" outlet will be connected to the valve house, while 30" and 20" will be end capped inside the reservoir.

A tee will be fixed on 30" outlet of the circular reservoir to divert flow through the valve house. A 30" valve will be installed immediately downstream of the tee. This valve will be kept permanently closed to ensure that the flow from this circular reservoir is sent through the valve house.

The outlet of New Maligakanda Reservoir will be connected to the valve house.

(c) Reservoir bypass

The by-pass around the old Maligakanda Reservoir will be completed and connected to the valve house discharge header in order to directly connect the transmission system to the outlet system. This enables

to by-pass any one of the three reservoirs, any two of the three reservoirs or all three reservoirs at any given time.

(d) Flow metering and level sensing

All existing flow meters will be retained at their current locations except the meter on Mount Mary 10". This outlet lies under New Maligakanda Reservoir and needs removal. This 10" main will be reconnected to the valve house and the flow measuring arrangement will be shifted to the new location. New flow meters will be installed on800 DI outlets of the New Maligakanda Reservoir and 300 DI proposed main to Dematagoda.

The level sensing arrangement for the two existing reservoirs will remain. New level sensing arrangement will be installed in New Maligakanda Reservoir.

3.2.3.5 Summary of Structural/Foundation Design for Reservoir

(a) Foundations

The perimeter wall is supported on a continuous RC ring foundation. The base slab inside the reservoir support the columns and is designed as a raft slab supported on elastic media. Expansion joints are introduced at regular intervals and treated with proper water bars, joint filler and a joint sealant.

(b) Post-Tensioned Walls

This wall is designed to be horizontal post-tensioned to support water pressure. Nominal reinforcement is provided to cater for temperature, shrinkage and secondary stresses that arise at the stage of post-tensioning. Actual process of post-tensioning is defined as starting from bottom most cable duct and finishing with the topmost duct. To minimize secondary effects alternate cables are planned to post-tension to the required tension. The analysis and design is carried out for the commonly available system and sufficient parameters are given in the drawings for the contractor to give an alternative proposal to suit his expertise and equipment.

(c) Columns and roof slab

The columns are 600 mm dia reinforced concrete columns spaced on a regular grid of 6.0m x 6.0m and spanning from base level to the roof beams without any bracing at intermediate levels.

The roof is a beam slab design with beams on same grid as columns (6.0 m x 6.0 m). The slab panels are designed as continuous over supporting beams. The slab is 250 mm thick and a concrete benching of 200 mm was considered in the design in addition to the 300 mm pebble layer, which acts as an insulation.

(d) Baffle walls

The baffle walls are 200 mm thick RC walls with nominal reinforcement to cater for temperature and shrinkage stresses. They span from column to column with continuity at base slab and to a free height of to the top water level of the reservoir.

3.2.3.6 Summary of Structural/Foundation Design for Valve House

The valve house is an L shaped building with plan area of approx. 225 m^2. The valve house is approx. 3.0 meters deep and is formed below the formation ground level. The ground floor is typically for all services like valve controls and electrical panels. A monorail is provided at roof level and in line with the main pipeline to facilitate installation and maintenance work. The basement floor or the valve pit is served with a staircase from the ground floor. The perimeter cladding is 225 mm burnt clay bricks with windows for proper ventilation. There is an access door for a loading truck and a man access door for maintenance purposes.

a) Foundation

The 400 mm thick basement floor is designed as a raft slab is acting as the foundation for the entire valve house.

b) Walls

The basement walls are 400 mm thick reinforce concrete and are designed to take earth pressure and external water pressure. The perimeter walls above ground level are typically 225 mm burnt clay brick, which is very commonly available in the country.

c) Floors

The Basement floor is a reinforced concrete raft slab and the ground floor is a suspended RC floor slab supported on the perimeter RC wall and a set of RC beams. He beams are supported on RC columns where the load is directly transferred to basement floor, which act as a raft.

d) Roof

The roof is typically long spanning Zinc-Aluminum sheets spanning on galvanized lipped C type purlins. A heat insulation is under the roofing sheets.

3.2.3.7 Building Materials and Finishes (Reservoir, Valve House)

a) Post-tensioned concrete

The concrete grade for post-tensioned work is grade 40 with characteristic strength of 40 N/mm^2. The concrete face will be fair face with shutter finish according to specifications.

b) Reinforced concrete

All reinforced concrete work is designed with grade 35A concrete. All exposed concrete faces and faces that get covered due to benching concrete is as specified.

Soil sulphate content is the order of 0.6% SO_3 and is considered aggressive towards buried concrete structures. Foundation concrete has the following specifications for protection against sulphate attack:

- grade 35 Ordinary Portland Cement (OPC),
- minimum cement content of 380 kg/m^3,
- water to cement ratio limited to 0.45
- 25% pulverized fly ash added.

c) Masonry

All masonry work will be plastered with cement-lime-sand mix and painted as per specification.

d) Metals

All metal works within the reservoir are stainless steel. Ladders outside the reservoir are aluminum. Metal works for cleats and handrails etc. are hot dip galvanized mild steel sections.

e) Exterior/Interior finishes

All exterior faces of concrete surfaces will have fair face with no extra painting applied.

The interior surfaces of the reservoir (except partition walls and underside of roof slab) will be coated with a Cementitious mortar lining to protect the structural concrete from corrosion caused by soft water.

f) Roofing

The roof of the reservoir is finished with a bituminous membrane for waterproofing and a 300 mm pebble layer, which acts as an insulation

The roof of the valve house is typically long spanning Zinc-Aluminum sheets layed on galvanized lipped C type purlins. A heat insulation is provided under the roofing sheets..

g) Doors and windows

All doors are steel and windows are anodized aluminum.

3.2.3.8 Grading and Drainage

(a) Grading around the new reservoir

Grading around the reservoir has been done to ensure that the existing natural drainage patterns will remain even after the construction of the new reservoir and valve house has been completed.

(b) Reservoir perimeter drains and under-drains

There is a perimeter drain resting on the perimeter ring foundation and rainwater on to the roof of the reservoir and also a part of the rainwater on the graded ground level is diverted to this drain. An under drainage is provided under the base slab of the reservoir. The perimeter surface drain and the under drain are connected to a manhole from which the flow is discharged through a gravity drain.

(c) New gravity drain

The overflow and washout of the existing circular reservoir is connected to a manhole chamber. A 12" CI lead-away pipe is connected to the chamber at a higher level. A valve outlet has been provided at a lower level to release overflow and washout water into a nearby property. No pipeline or drain has been

constructed to dispose the water safely. With more water coming into this reservoir when the old Maligakanda Reservoir is isolated for rehabilitation work, it is extremely important to see that the overflow/washout water from this reservoir is disposed safely.

Due to this reason, a properly sized drainage system has been designed to carry away overflow and washout water from New Maligakanda Reservoir and Existing Circular Reservoir to a natural storm water drain off Ketawalamulla Lane. Drawing No. MK/GR/C-05 provides the details of pipes, manholes and outfall arrangement.

(d) Site grading

The site has been graded to preserve the existing drainage pattern.

3.2.3.9 Roadways and Landscaping

A 5 m wide roadway has been provided within the site to provide vehicular access to chlorination building, NWSDB stores buildings and the valve house. Three existing manholes will be reconstructed to the same size to withstand the vehicular loads.

Except for the area surrounding the new office building, no specific landscaping is allowed for the reservoir area.

3.2.3.10 Site Lighting

Site lighting is provided by cobra head street roadway fixtures, using 250 watt mercury vapor lamps These are to be mounted on RC lamp posts or on external sides of the building wall.

Cabling is installed underground in rigid PVC conduits buried at depths between 500mm and 750mm according to site conditions. Surface mounted cables (running on walls) will be installed in rigid PVC conduits.

3.3 REHABILITATION OF THE ROOF STRUCTURE OF THE EXISTING MALIGAKANDA RESERVOIR

3.3.1 DESIGN CONDITIONS

3.3.1.1 Summary of Works

(a) Existing Roof structure

The general arrangement of the existing old reservoir as provided by previous studies and historical documents is shown in MK/RF/ST-01.

The old ground reservoir is 190 x 191 x 36 feet deep and has no dividing walls. The perimeter mass concrete gravity type retaining wall is getting subjected to a maximum water depth of 11.7 m (38'-5"). The top level of the earth embankment, which covers the gravity wall, is slightly higher than the top water level.

The roof consists of 225mm (9") thick un-reinforced multi-span barrel vaults spanning on to steel beams and the perimeter retaining wall. The roof vaults and steel beams run in the direction of north to south. The steel beams are in turn supported by a grid of circular hollow section cast iron stanchions columns of 225mm (9") external dia.

The horizontal reaction of the barrel vault roof is taken by steel tie-rods located at the level of the spring of the barrel vault. Two tie rods each, 1.2m (approx) apart have been provided on either side of the columns. The two end spans of the vaults roof have closer ties.

In the year 1965 to 1967 a set of post-tensioned concrete tie beams 300 mm x 600 mm were constructed to strengthen the perimeter retaining wall. The beams are located at depth of 5.8m and 7.1m (approx.) from the level of the roof beam. These tie beams rest on a grid of 300 mm x 300 mm concrete columns.

The barrel vault roof section is cracked at several places and the mild steel tie rods are completely corroded and at some places have fallen away. The existing roof is monolithically connected to the perimeter mass concrete wall and there is no room for expansion due to exposure to direct heat due to exposure to sun.

The perimeter mass concrete wall is projecting around 1600 mm above the top level of the existing roof.

(b) Replacement of roof structure

Under the rehabilitation work the existing roof structure including supporting columns and beams will be completely removed and replaced with reinforced concrete columns and roof slab.

(c) Rehabilitation of Inlet Structure

The inlet building is damaged and cast iron components of the inlet structure such as floor, bell mouth and inlet weir are heavily corroded. The inlet structure will be rehabilitated as follows:

- Provide a ground floor slab, which will directly rest on the sub grade.
- Replace the existing cast iron checkered plate floor around the inlet weir with open grated aluminum floor
- Remove corrosion on cast iron inlet bell mouth structure by sand blasting and finish with two part epoxy coating.

(d) Rehabilitation of overflow pipe and penstock gates

The 20" washout and 40" outlet have penstock gates with non-rising stems. The gates are inoperative and must be rehabilitated. The extension spindles are brought up to roof levels and these spindles are bracketed to the existing vertical overflow pipe and to the wall respectively. The extension spindles are heavily corroded and will be replaced. New floor stands will be provided at roof level and the gate seals, and guides will be refurbished.

3.3.1.2 Site Location and Conditions

(a) Description of site (access and space constraints)

The site for the existing reservoir is located within the security perimeter of the Maligakanda Reservoir.

The site has limited space and will be actively used by CMC during construction. The contractor will need to closely coordinate construction activities with CMC to minimize disruption to operations. Access to CMC stores will not be possible during demolition and re-construction of the new roof. CMC will need to temporarily relocate their stores operations.

Space for construction equipment and stockpiling materials is limited. A narrow staging area is available around the perimeter of the old reservoir for loading demolition debris and construction materials. The contractor will need to remove all construction and demolition waste to a suitable location off-site on a daily basis.

(b) Demolition of existing roof

The contractor shall erect a temporary platform under the existing steel girders of the “barrel vault” roof as a precautionary measure to safeguard the existing post-tensioned concrete beams and rc column that support them. Since the steel tie rods, which normally would provide horizontal support for the “barrel vaults”, are severely corroded/or damaged it is necessary to provide temporary horizontal ties prior to removing the roof. It is suggested that demolition proceed as follows:

- Existing reinforced concrete (rc) “barrel vault” roof structure should be cut into pieces with the help of a high pressure water jet, electrically or mechanically operated diamond tipped circular saw or an approved equivalent, and be carefully removed part by part.
- The existing steel girders which support the barrel vault roof, should be cut into pieces with the help of an oxy-acetylene flame or an electric saw or any approved equivalent and carefully removed part by part. It is necessary to provide lateral supports to the existing cast iron columns when removing the existing steel girders.
- The existing cast iron columns and bases, which support the roof structure, should be carefully removed.
- The perimeter concrete wall should be cut with the help of a high pressure water jet or a diamond tipped circular saw, to 50-75 mm below the bottom level of the proposed new rc roof

slab and carefully be removed roughened the exposed surface and finished with topping concrete with approved bonding agent.

- Since there are post-tensioned beams and their supports within the reservoir, the contractor shall be careful when erecting tower cranes or using heavy equipment within the reservoir to facilitate demolition or construction work.
- The contractor may erect a motorized gantry to span between existing reservoir walls with center support on the existing base of the reservoir and the cut pieces may be brought to a place reachable to a tower crane erected outside the perimeter earth fill.
- The earth fill around the existing perimeter mass concrete wall of the reservoir should be made to a constant slope by filling in local depressions with fresh soil. The filling should be carried out manually and tamping should be done with the help of a manual tamper, so that there will be no vibrations passed on to the existing structure. Prior to filling operation, the topsoil should be removed. The filled area should be finished with turfing with approved grass.
- The existing toe drain along the perimeter of the reservoir should be cleaned, and repaired where necessary, to have a constant gradient for the water to flow into the nearest manhole.
- Heavy constructions equipment is not allowed on the existing embankment, especially when the reservoir is empty and the roof structure is removed.
- The possible location for a tower crane to facilitate removal of debris is as shown on the layout plan. This can be changed to suit the contractor's proposal for rehabilitation works.

3.3.1.3 Assumption on Stability of Walls

It is assumed that the perimeter mass concrete wall with the soil backing and supported by post-tensioned beams at regular intervals is fully stable without any lateral support from the existing roof slab. It is not possible to calculate stability of the wall because the following information is not available:

- soils investigations within the reservoir and embankment
- exact profile of the existing mass concrete perimeter wall
- as built details of the post-tensioned tie beams.

Before proceeding with the construction of the new roof it will be essential to carry out a thorough structural and geotechnical appraisal of the reservoir to determine if the reservoir can in fact provide another 40 to 50 years of trouble free, water tight service. If the reservoir is deemed unsound or near the end of its service life then there will be no financial benefit for replacing the roof and the reservoir should be replaced entirely or abandoned.

3.3.2 SPECIFIC DESIGN CRITERIA

3.3.2.1 Structural Design

(a) Loading Criteria

The roof slab is designed to support the RC slab, benching concrete necessary to form the slopes necessary for storm water. The dead load is 16.5 kN/m^2 including 250 mm pebble layer. A superimposed live load of 2.5 kN/m^2 is considered adequate for manual cleaning operations.

3.3.3 DETAILED DESIGN CONSIDERATIONS

3.3.3.1 Summary of Rehabilitation

(a) General Arrangement

The General Arrangement is as shown in drawing number MK/RF/ST-01.

(b) Circulation and internal partitioning

New baffle walls are introduced to have proper circulation of water. No partitioning is carried out within the reservoir because it may lead to heavy foundation within the existing structure. Any type of heavy foundation within the structure can disturb the existing post-tensioned beams and can jeopardize the structural integrity of the structure.

(c) Ventilation

Natural ventilation is maintained by providing 600 mm x 600 mm vent openings through new roof slab on a regular grid as shown in drawings The openings are capped with RC cover slabs and the sides covered with stainless steel mosquito proof wire meshes to prevent mosquito breeding and insects get into the reservoir.

(d) Access for maintenance

Five numbers of Access openings of 900 x 900 with lockable devices are provided on the roof for maintenance purposes.

(e) Removal of secondary inlet pipe

The old Maligakanda reservoir receives water mainly from the 20" outlet via northern side of the reservoir. This inlet structure will be refurbished under this contract. The 30" inlet on the eastern side will be disconnected and the branch tee on 30" by-pass main will be blank flanged thus, permanently de-commissioning this inlet.

3.3.3.2 Summary of Structural Design

(a) Reservoir floor slab

The new floor slab for the reservoir is designed as a raft slab supported on an elastic media. It will be cast against the existing floor slab. The design is checked for the direct water pressure and for the column loads. Expansion joints are introduced at regular intervals to cater to any movements. The new RC base slab will be properly sloped towards the wash outlets with benching concrete.

(b) Columns and Roof Slab

A new rc roof –flat slab type design with column capitals is provided. This new roof is supported along the perimeter wall and on a grid of columns of 4.83 m x 4.83 m. The 600 mm dia. Rc columns and 200 mm thick baffle walls are supported on newly added rc base slab.

The columns are designed to support the roof slab with no intermediate level bracing. The column grid is so chosen to match with the existing column grid so that new construction will not disturb the existing post-tensioned beams.

(c) Modification to top of existing wall

The top level of the existing mass concrete wall is higher than the newly introduced roof. To arrange a simple support for the roof slab and also to arrange roof drainage the existing wall should be lowered by about 1.6 m. It should be cut to 50-75 mm below the bottom level of the new RC roof and carefully removed. This cutting operation should be done carefully with the help of a water jet, diamond tipped circular saw or an approved equivalent so that no appreciable vibration is introduced to the existing structure. A capping concrete is added with a bonding agent to bring the top level to the final required level.

(d) Movement joints

Movement joints are introduced at regular intervals to look after expansion and any differential settlement that may occur between the walls and the roof. A sliding joint is provided between the roof slab and the perimeter wall.

(e) Baffle walls

Reinforced concrete baffle walls are designed to span between newly added columns with monolithic construction with the newly added RC base slab. They are made to 200 mm thick and nominally reinforced.

(f) Structural modifications to Inlet building

The concrete floor slab at the lower entrance (at grade along the embankment) will be replaced with a reinforced concrete floor slab on compacted granular fill.

The cast iron checkered plate floor at bell mouth level will be replaced with open grate mild steel (galvanized) floor resting on mild steel (galvanized) beams bearing on the perimeter wall of the inlet building.

The existing barrel-vault roof will be removed and a new roof constructed of reinforced and waterproofed.

The existing ladders from reservoir roof and inside the structure ar ereplaced with aluminum ladders. The entire

3.3.3.3 Building Materials and Finishes

a) Reinforced concrete

The structural concrete for the inlet building sub-structure and super structure should be grade 25 with characteristic strength of 25 N/mm^2.

The grade of concrete for the potable water storage sump should be grade 35 A with characteristic strength of 35 N/mm^2.

b) Masonry

Masonry shall be constructed from approved hard durable rubble stone laid to bond. The joints shall be 16 mm thick on average and completely filled with cement sand mortar (1:6 mix). The faces of works shall be true to profile and joints shall be neatly pointed in mortar. All masonry works above grade shall be rendered with cement sand plaster (1 : 6 mix) and the rendering shall be started at least 200 mm below the formation ground level.

c) Metals

All metal works within the reservoir shall be constructed with stainless steel. The floor grate and structural sections inside the inlet building will be aluminum. The ladders and hand rails outside the reservoir which will be exposed to weather shall be constructed with aluminum sections.

d) Finishes (removing rust and applying protective coating)

The existing inlet weir is constructed out of mild steel plates. It is necessary to clean the weir by sand blasting or by applying approved equivalent method. After cleaning and repairs the surfaces of the steel inlet structure will be finished inside and out with two stage epoxy treatment suitable for potable water.

The inlet riser pipe is cast iron and exposed. It too will be cleaned and coated with epoxy.

e) Roof

The roof of the new reservoir is finished with a bituminous water proofing membrane and a 250 mm thick pebble layer that acts as heat insulation.

3.3.3.4 Grading and Drainage

a) Grading around the existing reservoir

The existing grading pattern around the old reservoir will be maintained. The access road will be constructed to match the existing grade.

b) Reservoir roof drains and perimeter drains

The storm water collected on the new roof will be brought down to the peripheral drain through down pipes placed at regular intervals. The existing toe drain along the perimeter of the reservoir should be cleaned, and repaired where necessary to have a constant gradient for the water to flow in to the nearest manhole.

3.3.3.5 Roadways and Landscaping

A new roadway will be constructed to cover the two existing reservoirs and the new reservoir as shown on drawing nr MK/GR/C – 04. The width of the proposed road is 5 m and its construction comprise a

type 1 sub-base material of compacted thickness 200 mm, a dense graded aggregate base course of compacted thickness of 150 mm and 30 mm thick bitumen surface treatment using 20 and 12.5 mm aggregate.

3.4 ELLIE HOUSE RESERVOIR

3.4.1 DESIGN CONDITIONS

3.4.1.1 Summary of Works

(a) Existing Reservoir and Flows for Ellie House Reservoir Site

The characteristics of the Existing Ellie House Reservoir are:

Volume	:	36,400 m3
High Water Level	:	+28.9 m MSL
Low Water Level	:	+22.9 m MSL
Depth of Water	:	6.0 m
Ground Elevation	:	+27.5 m MSL
Volume (1 cell empty)	:	8,800 m3
High Water Level	:	+25.8 m MSL
Low Water Level	:	+22.9 m MSL

The new reservoir will provide approximately the same storage capacity and will occupy approximately the same space as the old reservoir.

The supply of water to the existing reservoir (Average flow for December 1999) is:

Old 20" steel pumping main from Ambatale	:	0 m3/day
Duplicate 20" fed by gravity from Labugama	:	6,100 m3/day
Triplicate 20" pumping main from Ambatale	:	25,200 m3/day
Total	:	31,300 m3/day

(b) New Reservoir

The characteristics of the New Ellie House Reservoir will be:

Volume (3 cells) 2x13,000 +1x10,600 m3	:	36,600 m3
High Water Level (3 cells in parallel, normal operation)	:	+28.45 m MSL
High Water Level (3 cells in series)	:	+28.64 m MSL
Low Water Level	:	+23.2 m MSL
Depth of Water	:	5.25 m

The High water Level will be slightly less than the existing and there will be no additional head on the transmission system.

The projected flows to the new reservoir (ultimate capacity in 2010) will be;

Duplicate 20" fed by gravity from Labugama	:	59,100 m3/day
Old 20" steel and Triplicate 20" pumping main from Ambatale	:	34,550 m3/day
Ellie House Transmission Main	:	unknown
Total	:	93,650 m3/day +

The quantity delivered to the Ellie House Reservoir from New Ellie House Transmission main is unknown because there are many distribution mains fed by the TM upstream of the reservoir.

Projected demand for the year 2010 is 93,600 m3/day (SAPS Report). The design of inlet and outlet piping for the new reservoir will be for 110,000 m3/day.

(c) New Valve House (function)

There are five outlets from the existing reservoir. The main outlet of the new reservoir will be diverted into the new valve house and all five existing outlets will be connected through the same via isolating valves for individual flow controls. Two new outlets will be provided for future connections. The existing by-pass header will also connected into the valve house to enable to by-pass the reservoir completely, if necessity arises.

(d) Chlorination Facility for Ellie House Reservoir

The NWSDB has requested a Chlorination Facility at Ellie House Complex. The function of this facility is to maintain the residual chlorine level in the distribution system at the desired level of around 0.1 ppm-0.2 ppm.

The proposed system comprises of vacuum type gas chlorinators with pressure or vertical multistage ejectors. The chlorine is drawn from 65 kg standard gas cylinders. The rider pumps consist of end suction type centrifugal booster pumps complete with all necessary piping and accessories.

The following basis was adopted in designing the Chlorination equipment.

- The system shall have the capacity to handle water demand through to the year 2020
- Provision will be made for two injector points in order to cater for the worst operational scenario and to enhance flexibility of operation
- Based on the maximum day demand figures, the maximum rate of consumption of chlorine has been estimated at 17.2 kg per day. Hence it is recommended to use the standard 65 kg cylinders.
- At the maximum dosage rate, a 65 kg cylinder will last for 3.8 days. It is therefore recommended to store 10 cylinders which provide a buffer stock for around 38 days
- Sizing of the booster pump and piping was based on the information supplied by reputed manufactures of chlorination equipment
- The intake water for the booster pumps shall be obtained by tapping in to the pumping main at the nearest location
- Twin type weighing scale with change-over facility shall be provided to facilitate day to day operation

3.4.1.2 Site Location and Conditions

(a) Description of Site

The construction of New Ellie House Reservoir will take place at the same location as the existing reservoir. This is the highest location in the northern part of the CMC area with a ground elevation of around 27 meters above mean sea level. The main access to the site is obtained through Aluthmawatha Road. It also can be accessed through Muthuwella Road from the rear side.

The site plan with the existing structures is shown in Drg No EH/GR/C-01.

(b) Land Acquisition

No land acquisition is required for the reservoir construction as the land is owned by NWSDB. However, way leave shall be obtained from CMC to lay the outlet pipes, the overflow/washout pipe and to construct the manhole chambers within the Ellie House Park surrounding the reservoir.

3.4.1.3 Summary of Geotechnical Investigation and Assessment Results

A typical underground profile of the site is as shown in Fig. 2a and Fig. 2b of the geotechnical investigation report.

Six deep boreholes (EBH-01 TO EBH-06) to bedrock were taken surrounding the existing reservoir. In addition to this two shallow (2m deep) boreholes (BH-A1 and BH-A2) were taken through the upper level of the embankment. Locations are indicated on site plan drawing EH/GR/C-01.

The recommended allowable bearing capacity for foundations placed at a depth around 22m MSL is 250 kN/m^2. Recommended values for the coefficient of sub grade reaction (k_s) for flexible foundations design varying between 4 kn/m^2 per cm and 20 kn/m^2 per cm.

The lateral earth pressure on the walls could be determined using following shear strength parameters:

- The Geotechnical design parameters of lateritic overburden on the south side (EBH-01 to EBH-03) are recommended as C' = 10 kN/ m^2 and $\emptyset = 28^o$ or C' = 0 kN/ m^2 and $\emptyset = 30^o$.
- The Geotechnical design parameters of the loose, fine to medium sand at the surface horizon on the north side (EBH –04 to EBH-06) are recommended as C' =0 kN/ m^2 and $\emptyset = 27^o$.

Soil pH value s in the order of 5.0, which is acidic and considered corrosive to concrete.

3.4.2 SPECIFIC DESIGN CRITERIA

3.4.2.1 Structural Design

(a) Loading Criteria

The perimeter RC walls and the base sections are analyzed and designed as a retaining wall to support Internal water pressure, External pressure due to surcharge and earth pressure. A shear key at the base guards the lateral thrust.

The roof is a beam slab construction with beams at a approximate grid of 6 meters. The roof slab supported on RC beams is 200mm thick concrete. It is designed to support a live load of 2.5 kN/m^2. The base slab for the center area is designed as raft slab to support the column loads. This raft slab is designed for full water pressure from inside. An under drainage is provided to guard against any ground water.

(b) Foundation Design Parameters.

The perimeter RC retaining wall foundation is designed with safe bearing pressure of soil as 250 kN/m^2 and the center area base slab is designed as a raft slab on elastic media.

(c) Circulation and internal partitioning.

A series of baffle walls are designed to the full water height of the reservoir to ensure proper circulation of water between the inlet and outlet points.

(d) Access for maintenance

The access in to the three cells of the reservoirs is as follows.

- Four numbers of access manholes and access ladders each to serve the two outer cells
- 6 numbers of access manholes and access ladders to serve the center cell.

3.4.3 DETAILED DESIGN CONSIDERATIONS

3.4.3.1 Summary of New Reservoir

(a) Inlet and Outlet arrangement

Inlet Arrangement

The inlet to the existing reservoir consists of a common supply header running along the east side with three supply lines arranged in a double ended configuration, duplicate and steel 20" mains at the north end and triplicate 20" at the south end. Sectional valves are arranged so that the reservoir can be fed from each source of supply. The reservoir can also be completely by-passed diverting the supply directly to distribution lines. The existing supply header will be maintained.

The two main inlets to the existing reservoir are located in identical buildings on either side of the center wall. At present the northerly intake is closed since water pressure from Labugama is insufficient to rise above the bell mouth. The southerly inlet is fed from the triplicate 20". In the inlet building, the water flows through a submerged bell mouth into a stilling basin. From there water spills over a rectangular sharp crested weir in to the reservoir. The existing inlet structures will be repaired and kept operational. They will feed the middle cell of the new reservoir NR2 and will both be supplied from the steel 20" when it is connected with the new Ellie House TM.

The steel 20" is presently not used because it has insufficient pressure to feed the reservoir. NWSDB plans to connect the new Ellie House TM to this line to increase the flow in to the reservoir. When the flow improves, the water will be supplied to the reservoir thoroughly inlet structure.

From the common supply header a supplemental inlet is taken into the north cell from the duplicate 20"(gravity fed from Labugama). This inlet will remain connected to the new reservoir (NR3) to supplement the supply from Ambatale.

The south cell of the new reservoir (NR1) will be supplied by a new connection made to the supply header. A new sectional valve is provided to allow supply from triplicate 20". A further provision has been made in the supply header in case NWSDB decides to extend the new Ellie House transmission main up to the reservoir.

Outlet Arrangement

Distribution Mains supplied from the existing reservoir;

900 Steel to Walls Lane
20” CI to Fort
400 DI to Mattakkuliya

Distribution Mains supplied directly from triplicate 20”

10” CI to Kotahena
12” CI to Muthuwella

The Outlet from the existing reservoir consists of a single 20” pipe located between the two inlet structures. The close proximity of the inlets and the outlet leads to short-circuiting of flow within the reservoir. The outlet is too small to meet the needs of the growing distribution system. Over the years several distribution mains have been connected add-hoc to the 20” outlet, but the outlet capacity remains inadequate.

The new reservoir will be provided with a 1000 mm diameter outlet header located on the west side opposite the inlets to improve circulation. Baffle walls are also provided to improve circulation within the reservoir.

The outlet header will be routed to a new valve house that will be constructed to organize and facilitate connection of distribution mains. Mains that are presently connected to the inlet will be reconnected at the valve house to the outlet of the reservoir. The larger outlet capacity will improve pressure and flow conditions in the distribution system.

All three cells of the reservoir will have outlets connected to the common discharge header. Each cell can also be connected with a neighboring cell through penstock gates in the separation wall. Thus the cells can be operated in parallel or series or any combination. There are no check valves on the outlet so all cells will be operating at the same level.

(b) Overflow and Washout Arrangement

The Overflow from each cell is provided by an overflow weir and chamber. The over flow and wash water are taken away through a 600 pipeline and connected to the existing 20” overflow/washout pipe which finally discharges the water at the sea.

3.4.3.2 Summary of Valve House

(a) Layout

The valve house is located very close to the Ellie House Reservoir. It is positioned at the edge of the property to save space and also to maintain some distance from the reservoir and outlets to make yard piping easy. The location of the valve house is shown in Drg. No. EH/GR/C-01 and the arrangement of valve house and the supply header are shown on Drg. No. EH/GR/YP –04.

The LWL of the Ellie House Reservoir is kept at 23.20 MSL. Therefore the top level of the main header within the valve house is kept at 23.00 MSL (Pipe Center line at 22.50 m MSL) so that the header is kept slightly below the bottom level of the reservoir. The formation level of the ground at the valve house is 29.00 m MSL. This makes the Ellie House Valve House much deeper than the Maligakanda Valve House. Due to these excessive depths, the main supply header is kept in a second level basement while the

operating headstocks are kept in a first level basement. A part of the valve house at the ground level will be used as the site office.

(b) Discharge Header (Size and Configuration)

The hydraulic calculation has been performed for the pipe work within the valve house and the discharge header has been sized at 1000 mm diameter. The layout of the discharge header and the associated valves and fittings are shown in Drg No. EH/GR/YP – 04. Provisions have been made for 600 and 500 mm additional outlets in the valve house.

(c) Connection to the Distribution Mains

The following existing distribution mains are connected through the valve house via isolating valves. They are:

1.	Walls Lane	:	900 Steel
2.	Fort & Walls Lane	:	20” CI
3.	Kotahena	:	10” CI
4.	Muthuwela	:	12” CI
5.	Mattakkuliya	:	400 DI

In addition to the above five distribution mains, the valve house has provisions for 600 and 500 future distribution mains.

(d) Access for Maintenance

Access for Pipes and Fittings

The access to the first level basement is obtained through an opening at the ground level. An overhead crane will be provided below the ground level floor slab and the access to the second level basement is obtained through a recess provided at the first level floor slab.

Access for workers

The workmen’s access to the basements are obtained through a stair way and a caged ladder.

3.4.3.3 Summary of Re-Chlorination Facility

The proposed chlorination equipment proposed are summarized as follows:

- 3 Nr booster pumps and associated pipe work (1 duty/2 standby), capacity of each: 2.1 cum per hour at 30 m TDH.
- 2 Nr vacuum type gas chlorinator, manifold mounted with automatic switchover of capacity 0 – 2 kg /Hr (1 duty/1 standby)
- 2 Nr gas ejectors and piping
- 2 Nr gas injectors and piping
- Cl2 gas weighing scale and changeover facility
- Storage facility for 10 Nr 65 kg cylinders
- Exhaust fans etc.

3.4.3.4 Summary of Yard Piping Design

(a) Connection to the Existing Supply Scheme

This is described in details in Section 3.4.3.1

(b) Modification to the Existing Outlet Scheme

The existing outlets of 900 steel to walls Lane, 20" CI to fort & walls Lane. 12" CI to Muthuwella and 400 DI to Mattakkuliya are taken from the 20" CI single outlet from the Ellie House Reservoir.

10" to Kotahena is taken from the reservoir by-pass. These arrangement are far from satisfactory and the 20" CI outlet has been identified as a bottleneck , which obstructs the free flow of water into the distribution system.

All these outlets will be connected through separate distribution outlet pipes laid through the valve house.

The valve house will receive water from the rear of the reservoir through a 1000 outlet. The existing 20" by-pass is also connected to the valve house via a control valve for emergency use.

(c) Reservoir By-pass

Arrangements have been made to connect the existing 20" by-pass to the 1000-mm main supply header for emergency use.

(d) Flow Measuring and Level Sensing

Flow meters will be provided on the following pipelines:

1. 1000 DI main outlet from the reservoir
2. 900 DI to walls Lane, 600 DI to Fort and Walls Lane, 300 DI to Kotahena and 500 DI Future Main in a common Flow Meter Chamber.
3. 450 DI to Muthuwela and 500 DI to Mattakkuliya in a Common Flow Meter Chamber

The Existing flow meters will be relocated where possible.

A new level sensing arrangement similar to existing will be installed in the new reservoir.

(e) Overflow and Washout Pipeline

A 500-mm dia DI overflow/washout pipeline has been provided between manhole No.1 and manhole No.2. The size of the pipe has been increased to 600 DI between manhole No.2 and the existing 20" overflow/washout pipeline, which runs up to its final discharge point at the sea.

A part of the under-drainage system is also connected to this overflow/washout system.

3.4.3.5 Summary of Structural/Foundation Design of Reservoir

(a) Foundations

The perimeter RC retaining wall foundation is designed with safe bearing pressure of soil as 250 kN/m2

and the center area base slab is designed as a raft slab on elastic media. The expansion joints at regular intervals are provided. These joints have water bars, joint fillers and joint sealant.

(b) Perimeter walls

The perimeter walls are designed as reinforced concrete retaining walls stability being provided by the base slab and the shear key at bottom.

(c) Columns and roof beams and roof slab

The columns are 500 mm dia reinforced concrete columns spaced on a approximate regular grid of 6.0m x 6.0m and are spanning from base level to the roof beams without any bracing at intermediate levels.

The 200 mm thick roof slab is designed as supported on a grid of beams spanning on to the columns of the same grid (6.0 m x 6.0 m). The slab panels are designed as continuous over supporting beams.

(d) Baffle walls

The baffle walls are 200 mm thick RC walls with nominal reinforcement to cater for temperature and shrinkage stresses. They span from column to column with continuity at base slab and to a free height of to the top water level of the reservoir.

3.4.3.6 Summary of Structural/Foundation Design for Valve House

The base slab is designed as a raft foundation to support the entire new office building/valve house. The walls are designed for side thrust and the direct load.

(a) Foundation

The 600 mm thick basement floor is designed as a raft slab is acting as the foundation for the office building/valve house. It is designed for a safe bearing pressure of 200 kN/m^2. The side walls are designed for lateral earth pressure and pressure due to surcharge and possible water pressure due to ground water rising.

(b) Walls

The RC walls below the formation ground level are 600 mm thick reinforce concrete and are designed to take earth pressure and external water pressure. The perimeter walls above ground level are typically 225 mm burnt clay brick, which is very commonly available in the country.

(c) Floors

The Basement floor is a reinforced concrete raft slab and the ground floor is a suspended RC floor slab supported on the perimeter RC wall and a set of RC beams. He beams are supported on RC columns where the load is directly transferred to basement floor, which act as a raft.

(d) Roof

The roof is typically long spanning Zinc-Aluminum sheets spanning on galvanized lipped C type purlins. A heat insulation is under the roofing sheets.

3.4.3.7 Building Materials and Finishes (Reservoir, Valve House)

(a) Reinforced concrete

All reinforced concrete work for water retaining structures, RC walls, columns slabs and beams of the new office building/valve house up to the formation ground level and is designed with grade 35A concrete. Concrete for normal RC works is designed with grade 25 concrete. All exposed concrete faces and faces that get covered due to benching concrete are as specified on relevant drawings.

Foundation concrete has the following specifications for protection against acidic soil:

- grade 35 Ordinary Portland Cement (OPC),
- minimum cement content of 360 kg/m3,
- water to cement ratio limited to 0.45

(b) Masonry

All masonry work will be plastered with cement-lime-sand mix and painted as per specification.

(c) Metals

All metal works within the reservoir will be out of stainless steel. Ladders outside the reservoir will be out of aluminum. Metal works for cleats and handrails etc. will be hot dip galvanized mild steel sections.

(d) Exterior Finishes

All exterior faces of concrete surfaces will have fair face with no extra painting applied.

(e) Roofing

The roof of the reservoir is designed as a RC slab resting on RC columns. The slab is supported on a grid of RC beams. The roof of the new office building/valve house is typically long spanning Zinc-Aluminum sheets spanning on galvanized lipped C type purlins. A heat insulation is provided under the roofing sheets..

(f) Doors and Windows.

The doors and windows shall be provided conforming to specifications and as shown on relevant drawings.

3.4.3.8 Grading and Drainage

(a) Grading around the New Reservoir

Grading around the new reservoir has been done to ensure that the existing natural drainage pattern will remain after the construction of the new reservoir and the valve house.

(b) Drainage

A new drain will be constructed around the toe of the embankment to the south, north and west sides. The new drain will be connected to the existing toe drain at the front of the reservoir. The toe drain will carry rainwater from reservoir roof drain and road runoff.

The paved roadway in front of the reservoir will be sloped to a reinforced concrete drain running along the east boundary wall. The drain will discharge near the chlorination building to a natural drain

3.4.3.9 Fencing and Landscaping

Boundary walls along the south and east of the site will be demolished to provide equipment access during construction. These walls will be reinstated to their original shape.
Landscaping will consisting of re-grading and seeding around the reservoir and construction staging areas.

3.4.3.10 Electrical Installations

(a) Power Supply

A 60-Amp 3-phase LT supply is to be obtained from CEB - which will be terminated in the "CEB Room" indicated on drawing No: EH/GR/E.01. The metering equipment of the CEB will be wall mounted inside this CEB room.

The CEB supply will be taken to a Main Distribution Board having provision for six out-going feeders (vide drg: EH/GR/E.01) - three of them are single-phase feeders and the other three would be three phase feeders.

The three single-phase outgoing feeders will be used as follows:

Feeders 1 & 2	for the Yard /Street lighting system.
Feeder 3	to provide lighting in the OUT-LET & IN-LET buildings.

The three phase feeders are used as follows:

Feeder No 4	to provide supply to the Chlorination House
Feeder No 5	to provide supply to the Valve house and Office
Feeder No 6	spare.

(b) Yard/Street Lighting:

A photoelectric control switch controls each street lamp feeder. Standard type street lamps with mercury vapor lamps are used(specification type 22). These are mounted on standard RC posts.

The cables will be run underground in hard PVC pipes. At each lamppost a weather proof connection box is used, which houses a fused tee connection to the lamp.

(c) Electrical Equipment in Chlorination House:

The distribution Panel in the chlorination house will have a watertight enclosure (IP 65 or better) and shall be protected against corrosion in a chlorine-contaminated atmosphere.

All wiring shall be in hard PVC conduits - fully sealed against ingress of any liquid.

Lighting Fittings will be of the fully enclosed type protected against corrosion in a chlorine-contaminated atmosphere (specification type 21)

(d) Valve House and Office

The equipment and their installation in this building are all of the standard used in other Valve houses and Offices.

CHAPTER 4

CHAPTER 4

WATER SUPPLY ENHANCEMENT IN KOTIKAWATTE MULLERIYAWA AREA

4.1 GOTHATUWA – KOLONNAWA PUMP HOUSE

4.1.1 DESIGN CONDITIONS

4.1.1.1 Summary of Work

(a) Water source and projected flows to Gotathuta and Kolonnawa Reservoirs

Water for the proposed Goththatuwa – Kolonnawa Pump house located at Ambatale will be supplied from the clear water reservoir of the water treatment plant. It has been projected that during the year 2020, 60,485 cum of water per day needs to be pumped from the Ambatale WTP to Gothatuwa and Kolonnawa reservoirs.

a) Number and Capacity of transmission pumps

Three 165 kW pumps each having 11.85 m^3/min x 42m (TDH) shall be installed to pump water to Goththatuwa and Kolonnawa reservoirs with trimmed impellers. Nominal capacity of each pump is 14 m^3/min x 50 m (TDH) with normal impellers. Provision for an additional pump will be allowed for future requirement.

b) Pump house (size, shape, operating levels, construction type, and formation levels)

Reinforced concrete rectangular structure having clear dimension of 20.0m x 9.0m used for pump house. Pump house base level of 8.0 m MSL and a staging area of 4.0m wide L- shaped at 11.25 m MSL available for loading and unloading purposes. Also the same staging area used to install the electric panel boards.

A rectangular shaped sump of 15.0m x 4.0 clear dimension having base level of 7.30 m MSL and roof top of 14.50 m MSL used to receive water to the pump house and the pumps suction connected to the same sump. Made up ground around the pump house & sump is 11.00 m MSL.

Roof structure of the pump house made of RC portal frame & Aluminium sheeting on steel purlins.

4.1.1.2 Site Location and Conditions

a) Description of site

Proposed site for the Pump house & sump is located near the existing Ellie House pump house & the New Amabtale Water Treatment Plant. 1200mm Diameter water main running adjacent to the pump house will be connected to the sump for required supply of water to the pump house.

4.1.1.3 Summary of Geo-technical Investigation and Assessment Results

Geo-technical investigation using bore hole tests shows fairly good ground condition. Allowable soil bearing pressure of 250 kN/m^2 recommended for the design of foundation.

4.1.2 SPECIFIC DESIGN CRITERIA

4.1.2.1 Structural Design

a) Loading Criteria:

Dead loads:

200mm thick staging area slab	= 4.80 kN/m^2
Screed & Terrazzo finish	= 1.80 kN/m^2
100mm benching concrete on roof	= 2.40 kN/m^2
200mm thick Pebble layer on roof	= 4.00 kN/m^2
Zinc Aluminum Roofing with Purlin etc.	= 0.50 kN/m^2
200mm thick Block wall & Plaster	= 3.30 kN/m^2
Density of concrete	= 24.0 kN/m^3
Density of water	= 10.0 kN/m^3

Live loads:

Inaccessible Roof	= 1.00 kN/m^2
On staging area slab	= 10.0 kN/m^2
On Sump Roof	= 2.50 kN/m^2
Maximum water level	= 14.25 m MSL
Minimum water level	= 7.30 m MSL

Wind Forces & Environmental:

Basic wind speed of 34.0 m/s used to determine the wind pressure on the pump house roof sheet & RC frame.

Design temperature rise due to heat of hydration T1 = 35 °C
Design temperature seasonal variation T2 = 15 °C

b) Foundation design parameters:

Compacted soil density	= 20.0 kN/m^2
Active lateral soil pressure coeff.	= 0.333
Passive earth pressure coeff.	= 3.0
Allowable soil bearing pressure	= 250.0 kN/m^2
Concrete strength - fcu	= 35.0 N/mm^2
Reinforcement strength – fy	= 460.0 N/mm^2
Design surface crack width	= 0.20 mm

4.1.3 DETAILED DESIGN CONSIDERATIONS

4.1.3.1 Summary of Pump House

a) Water inlet and outlet arrangement, layout of sump

Water inlet to the sump using 1200 mm diameter pipe connected to existing water main feeding at 8.00 m MSL pipe centre line. Three pumps on duty arranged parallel at 4.0 m interval inside the pump house having pipe centre line at 8.80 m MSL connected to a common header of 600 mm diameter with provision for connecting a 4th pump for the future requirement. Discharge through an outlet pipe of 800mm diameter.

b) Pump house floor

Pump house floor arranged to have four pumps, control valves, discharge header & flow meter. Two sump pumps for cleaning & maintenance of the pump house area.

c) Pump operation and control area

Electric panels are mounted at the staging area and the cables are running through cable ducts on the walls & on the base floor near to the pumps that will supply power for pump operation.

d) Space for surge control equipment

Two surge tanks are arranged along the discharge pipe outside the pump house next to the sump.

e) Access for operation and maintenance

Access through staircase leading to base floor from staging area provided. MS platform at the end of staircase across the pipes arranged to have access to the pumps and valves.

f) Power supply

Electric Power to the pump house through the Government mains. Proposed Electric substation at the existing Ellie House pump house to supply power the new pump house.

g) Drainage

Pump house and the surge tank area drainage through gutter drains leading to the sumps and the sump pumps will discharge the drainage water to the surface on the back of the pump house.

4.1.3.2 Operation and Control

a) Operation and Control Concepts

The operation of transmission system to pump water from Ambatale WTP up to Gothatuwa and Kolonnawa ground reservoirs was studied and designed to provide adequate quantity of water to meet the maximum day demand of the years 2005 through to 2020. Due to the fact that pre-determined quantity of water needs to be delivered to each of the two reservoirs, it is inevitable that precise flow control is required at both Gothatuwa and Kolonnawa. The system has been designed to operate with two parallel pumps on duty under normal flow conditions, i.e. when there is simultaneous pumping to Gothatuwa and

Kolonnawa reservoirs. In addition, different operating scenarios were considered in designing and selection of the most appropriate pumping set.

In a system of this nature, it would be extremely difficult to achieve precise hydraulic balance while satisfying the desired flow distribution. Hence the system needs to be controlled by some external means if the required flow distribution is to be maintained. There are two options available for system operation:

1) Energy dissipation pump discharge flow control method using a control valve and a flow meter.
2) Adoption of variable speed pumps

The second method, which is technically superior, involves high capital investment and careful maintenance. Although it consumes little more energy, the method one is simple, reliable and easy in operation. Therefore, it is recommended to use the energy dissipation method.

The basic control system is described in the following:

(1) Equipment

- Two (2) duty pumps and one (1) standby pump, 165 kW each pump providing 11.85 m^3/min x 42 m TDH
- Pump volute is sized for the ultimate design flow (year 2020) but impellers are sized to meet flow and head requirements for the year 2005. Impellers will be replaced for larger ones when demand exceeds pump capacity around year 2010.
- A third duty pump will be added when demand exceeds pump capacity (around the year 2010). Provision for the future pump is provided in the piping design and floor layout of the pump house
- Discharge valves with motorized operator -three(3)
- Pump low suction pressure switch - three(3)
- Level sensing transmitter – one (1)
- Level sensing electrode - one(1)
- Pressure transmitter on transmission main - one(1)

(2) Flow Regulation

The transmission pumps are sized to match the projected maximum day demand (Kolonnawa and Gothatuwa) until the year 2010. Pump selection is made with the intention to provide continuous pumping operation with as few stop start cycles as possible.

Flow control at the transmission end (Ambatale) is not possible since the transmission main branches into two sections with different operating requirements and head loss characteristics. Therefore flow control is placed at each reservoir to control the amount of water received.

(3) Pump Control System

The pumps are controlled automatically by a local a programmable logic controller (PLC) or manually by the operator in charge. The control program is resident in the PLC and control set-points can be adjusted at the PLC.

a) Control Modes (pumps):

There are 3 control modes available for the pumps:

- (AUTO) automatic PLC control,
    - (LINK-UP) manual control of the pumps linked with the discharge valve
    - (INDIVIDUAL) manual control of the pump only without opening the discharge valve.
    - Each pump has two control switches located at the motor control panel providing "ON-OFF" and "RUN-STOP" positions
    - Each pump has one selector switch located at the Motor Control Panel providing "INDIVIDUAL-LINK UP-AUTO" positions
    - When the selector switch is in the "AUTO" position, the pump is controlled automatically by the PLC
    - There are two manual control modes: "LINK UP" and "INDIVIDUAL".
    - When the selector switch is in the "LINK UP" position manual control of the pump is linked to the operation of the discharge valves. The pump is activated manually by setting the control switch to the "RUN" position and de-activated by selecting "STOP"
    - With the selector switch in the "INDIVIDUAL" position the pump can be started with the discharge valve closed. This feature is required for pump maintenance when the operators want to test the correct operation of the pump or motor without having the discharge valve open automatically. The pump is activated manually by setting the control switch to "ON" and deactivated by selecting "OFF".
    - The "ON-OFF" switch has a handle that can be removed for safety during maintenance. When in the "OFF" position the pump is deactivated and cannot be turned on by any other means.
    - Most interlocks are contained in the PLC software. However, critical interlocks (mainly related to safety) are hardwired into the control circuit.

b) Control mode (discharge valves)

There are 3 control modes available for each discharge valve:

- AUTOMATIC (linked to pump operation),
- REMOTE manual control at the motor control panel (upper station level) and
- LOCAL manual control at the valve (pump level).
- Each discharge valve has a selector switch with "REMOTE-LOCAL" positions and a control switch with "OPEN-CLOSE" positions located at the valve. A control switch providing "OPEN-CLOSE" positions is also mounted on the motor control panel (upper station level)
- The discharge valve operates automatically (linked to pump operation) when the pump selector switch is in the "AUTO" position or in the "LINK-UP" position.
- The valve can be operated manually at pump level by placing the selector switch at the local control panel in the "LOCAL" position and activating the "OPEN-CLOSE" control switch at the valve.
- The valve can be operated manually from the motor control panel at the upper station level by placing the selector switch at the local control panel to the "REMOTE" position and activating the "OPEN-CLOSE" control switch on the motor control panel.

c) I/O Listing

- level sensing in the suction sump
    - digital level indicator
    - high level alarm
    - low level alarm

- motor protection
    - low voltage, phase failure
    - over current
    - stator coil high temperature
    - motor bearing temperature
    - ground fault
- Pump protection
    - Failed to start
    - Failed to stop
    - Low suction pressure
    - Pump Bearing temperature
    - Low discharge pressure
- Motor operated Valves
    - Position indicator
    - Over torque alarm
    - Failed to open
    - Failed to close
- Flow metering
    - Instantaneous flow
    - Totalized flow
    - Analogue recorder

(4) Control Logic

(a) Starting pumps

- With the control switch in "AUTO" the pumps operate automatically according to a 24-hour schedule that is programmed into the PLC by the operator. The schedule will determine the number of pumps that should be in operation at a given time of day.
- The pumps can also be brought on line manually either at the PLC or by turning the control switch to "LINK UP" position.
- If the PLC fails for any reason, the pumps shut down and the operator must restart the pumps by turning the switch to "LINK UP" position.
- Each pump will start automatically against a closed discharge valve. After an adjustable time delay the PLC will modulate the butterfly valve to open.
- Before starting a pump the following conditions must be maintained:
    - The Motor operated discharge valve must be closed
    - The water level in the clear well must be above LWL
    - No pump or transmission main faults
- The pump starters are interlocked so not more than one pump can be started at the same time

(b) Stopping Pumps

- High pressures will occur in the transmission main when the flow control valve at the ground reservoir(s) is closed or throttled to reduce inlet flows to the reservoir, or when the inlet valve(s) at the ground reservoir are closed.
- When a high-pressure condition occurs the number of pumps in operation at Ambatale will automatically be reduced. A pressure transducer located on the common discharge header will provide a signal to the PLC to shutdown one pump. If two pumps are in operation the second pump will be shutdown after a suitable time delay if high pressures continue.
- The pressure transducer on the discharge header will also signal all pumps to stop if it detects a low operating pressure on the transmission main (typically caused by a transmission main break). This will prevent the pump from reaching run-out conditions

- After pump shutdown the discharge valves will be returned to their normal position i.e. fully closed after a suitable time delay (adjustable automatic slow closure of discharge valves)
- All motor operated discharge valves are equipped with limit switches to indicate fully open and fully closed positions.
- If the level of water on the suction side of the pumps drops below an adjustable set-point (9.28m) the pumps will be shutdown or prevented from starting.
- Should a pump stop for whatever reason while it is energized (including low liquid level), an integral pump relay will send a pump general alarm signal to the PLC.
- The low level switch in the treated water well will provide a low level alarm for the PLC. In this way the operator will be able to distinguish between a general pump fault and a low liquid level.
- A pressure switch located on the suction side of the pump will shutdown the pump if low suction pressure is detected (e.g. suction valve is accidentally closed). The set-points are independently adjustable at the pressure switch. This switch is wired into the pump control circuit and operates independent of the PLC. The appropriate alarm (low pressure) is activated whenever the switch is activated.

b) Instrumentation Equipment for Operation and Control (summary of equipment for operation and control with their functions and specifications)

Considering the control philosophy outlined in a) above, the instrumentation equipment have been designed. The single line diagram of the proposed instrumentation is given in Dwg. KMU/PS/E – 06.

4.1.3.3 Summary of Foundation / Structural Design

a) Foundation and Thrust blocks

Foundation slab designed using the most unfavourable loading condition. All the dead & live load on the floor combined with the subjected bearing pressure on the ground & water load inside the sump considered in designing the base slab.

Thrust blocks are designed using the loads created by a test pressure of 10 Bar.

b) Walls, columns and slabs

Walls designed as retaining wall subjected to most unfavourable loading due to earth pressure and water pressure. Water full & empty condition checked.

Cracks due to thermal & serviceability limit state flexural checked.

Columns designed using the most unfavourable loading arrangement due to dead, live & wind loads. Columns and roof frames analysed as portal frames.

Slabs of staging area and the sump roof designed using the ultimate loading due to dead & Live loads.

c) Roof

Roof frame analysed as portal frames and the loads due to dead, Live & wind considered in the analysis.

4.1.3.4 Summary of Yard Piping Design

a) Connection to exiting 1200 mm treated water main

The clear water sump of the proposed pump house is fed directly from the existing 1200 mm transmission main that runs close to the sump. The connection shall be done by installing tee and an isolating butterfly valve. The proposed inlet piping arrangement is shown on Dwg. No. KMU/PS/YP – 02.

b) Piping within pump house

Design of pipe work within the pump house has been based on following criteria.

* The total number of pumping units for Kotikawatte – Mulleriyawa pump house shall be three (03) where two pumps will be on duty, and one pump will be stand-by. Further, provision shall be made to install one (01) pump in the future.

* In order to achieve the above operation, the individual pumping unit shall be connected in parallel and the individual deliver lines shall be connected to one common header pipe.

* Spacing between each pumping unit shall be equal and shall be sufficient to carry out maintenance work.

* Due to compactness and particular design of piping layout, the material of piping within the pump house has been recommended to be steel. This will facilitate the fabrication of various non-standard fittings, etc., at the site and will avoid excessive number of standard flanged joints.

c) Connection to surge control vessels

A possible surge, which may occur inside the delivery piping has been analysed and it has been recommended to connect surge vessels with total volume of $30m^3$ to the pumping main in order to avoid the effect of surge. A standard software package has been used to analyse the surge on the pumping main.

Accordingly, two (02) Nos. surge vessels with a volume of $15m^3$ each shall be connected to the pumping main, immediately outside the pump house.

Sufficient spacing shall be provided to install the two surge vessels immediately outside the pump house, in vertical position.

These vessels shall be connected to the pumping main in parallel through DI pipe of 200mm diameter.

Viking Johnson type removable couplings shall be provided on the connection piping for easy removal.

It is recommended to avoid using isolation valves on each of the connection pipe, to avoid the risk of operating the pumps with closed valves.

Compressed air shall be provided to the surge vessels by an air-compressor installed on the pump operating floor. The compressed air connection shall be made in parallel and hence the operation of the two vessels shall be uniform.

4.1.3.5 Summary of Mechanical Design

a) Pump Intake and Discharge

Diameter of suction and discharge pipes of individual pumping unit shall be 500 mm and the diameter of common header pipe shall be 600 mm.

The diameters of the piping has been decided in such a way that;

- frictional losses shall be minimum,
- maximum velocity of flow shall be nelow 2 –3 m/s, which is acceptable to international standards,
- capital investments shall be most economical.

* Butterfly valves shall be provided on the individual pump suction and discharge pipes in order to facilitate throttling, easy operation and providing limit switches to sense the position of each valve.

* The butterfly valve on the individual delivery pipe shall be of motor operated type. This is to achieve the control of the flow automatically by means of electrical signal.

(b) Overhead Crane

Overhead gantry cranes are designed conforming to the British Standards. A factor of safety of 1.5 is applied in determining the design loading.

(c) Ventilation and Drainage

The ventilation for the upper flow of the pump house is provided using two exhaust fans installed at the two gable walls of the building. The ventilation for the low level floor is affected through ducts with their outlets fixed to the walls and incorporated with an exhaust fan.

4.1.3.6 Summary of Electrical Design

a) Power Supply

Power supply for the building is taken from the main switch board.

A 60-amp MCCB (TPN) on the main switch board will control the supply for the building services. Lighting and small power sockets in the pump house building and the external site lighting are supplied from a "Building Services Panel", located as shown on the drawings. A 16 sqmm, 4-core cable, will connect this "Building Services Panel to the Main switch board . The supply & installation of the building services panel and the connecting cable will be part of the building contract. Three single phase distribution boards are used for controlling the sub-circuits in the building and the site lighting circuits.

b) Site Lighting and Cabling

Site lighting is provided by standard type mercury vapour street lamps. These are fixed externally on the building walls or mounted on RC posts along roadways. The minimum height of lamps from ground level is to be 4.0 m.

XLPE or PVC cables are run in hard PVC conduits. These conduits are run of the surface of walls - or buried underground along roadways.

The location of these lamps, the route of cabling and the size of cables to be used are indicated in the relevant drawings.

c) Lightning protection

Lightening protection is provided for the building by adopting "Early Streamer Emission" type air terminations (finials). This would provide a reliable and adequate level of protection with the use of one or two finials - as opposed to the use of several finials at roof-top, if the conventional passive finials are adopted.
Radio active heads will not be permitted.
Copper tapes will connect the air terminations to copper plate earth electrodes buried 1.5 m below ground level.

4.1.3.7 Building Material and Finishes

a) Reinforced concrete

All concrete surfaces shall be fair faced.

b) Metals

All the metal surfaces shall be protected using anticorrosive paints.

c) Exterior finishes

Semi rough plaster painted with two coats of filler and two coats of weather shield paint in two colours shall be applied on exterior walls..

d) Roofing

Zinc aluminium roofing sheets on steel purlin considered for roofing works.

e) Doors and Windows

Bronze anodised aluminium doors & windows shall be used.

4.1.3.8 Grading and Drainage

a) Site Grading

Existing sloping ground shall be filled in layers & compacted unto 11.00 MSL as per the detailed drawing and finished with asphalt on the roadway.

b) Drainage

No special drainage facilities are considered.

4.2 GOTHATUWA TRANSMISSION MAIN

4.2.1 DESIGN CONDITIONS

4.2.1.1 Summary of Work

Gothatuwa Transmission main is to pump water from Gothatuwa-Kolonnawa Pump House located within Ambatale Water Treatment Plant premises to the Gothatuwa Ground Reservoir to be constructed next to the existing Gothatuwa water tower along the Fever Hospital Road (refer Figure 3-16 Main Report). Gothatuwa Transmission Main will exit thorough the gate of Ambatale New Water Treatment Plant and will be along Himbutana Road, Angoda Hospital Road and along Fever Hospital Road. It is also designed to convey water to New Kolonnawa Ground Reservoir in the future through a T-branch to be provided at the Hospital Junction of Himbutana Road and Angoda Hospital Road. The diameters and lengths of Gothatuwa Transmission Main and Kolonnawa Transmission Main are as follows:

Length of 800 mm transmission main, from Gothatuwa-Kolonnawa Pump house to Hospital Junction = 2,541 m

Length of 500 mm transmission main, from Hospital Junction to Gothatuwa Ground Reservoir = 1,821 m

Length of 600 mm transmission main, from Hospital Junction to Kolonnawa New reservoir = 6,207 m

Schematic of the transmission system is shown in Figure 3-11 of Main Report.

Variation of the quantity of water to be conveyed in the transmission main between year 2005 to year 2000 is shown in Table 4-1.

Table 4-1 Flow rate, Velocity and Friction Gradient in the Transmission Mains

Transmission Main	Parameter	2005	2010	2015	2020
800 mm section from Pump House to Hospital Junction	Flow rate, Q, L/s	371.0	501.5	662.3	700.1
	Velocity, V, m/s	0.74	1.00	1.32	1.39
	Friction Gradient, m/km	0.84	1.48	2.47	2.73
500 mm section from Hospital Junction to Gothatuwa GR	Flow rate, Q, L/s	255.0	285.5	320.0	357.8
	Velocity, V, m/s	1.30	1.45	1.63	1.82
	Friction Gradient, m/km	4.16	5.13	6.34	7.79
600 mm section from Hospital Junction to Kolonnawa New Reservoir	Flow rate, Q, L/s	116.0	216.0	342.3	342.3
	Velocity, V, m/s	0.41	0.76	1.21	1.21
	Friction Gradient, m/km	0.40	1.26	2.95	2.95

Note: The above values are when pumping to both Gothatuwa and Kolonnawa simultaneously.

Maximum velocity in the transmission, which would occur when pumping to Gothatuwa only and when flow control is not used is below the maximum permissible velocity of 3 m/s. During normal operation, flow control will be used and the velocities will vary in the range shown in Table 4-1.

Drawing No. KMU/TM/G-1 shows the hydraulic grade line along the transmission main in the year 2020. Maximum pressure in the transmission main during normal operation is 6.3 bars.

4.2.1.2 Existing Conditions of Pipeline Route

(1) Existing Pipelines and Other Utilities

Stretches of Udumulla Road, Himbutana Road and Fever Hospital Road are narrow with a width of approximately six meters. There are two transmission mains along part of the stretches, originating from Ambatale WTP, namely Dehiwela transmission main (CI Pipe, 1000 mm diameter) and Kolonnawa Transmission Main (DI pipe, 600 mm). Both mains are laid on left and right sides of Himbutana Road approximately between Ch-300 and Ch-625 (Bank Junction). Gothatuwa Transmission Main will cross the existing Kolonnawa Transmission Main around Ch-300 and will be laid in between these two mains along this stretch. After the Bank Junction along Himbutana Road, existing Kolonnawa Transmission Main is on the right side of the road and the Gothatuwa Transmission Main will be laid on the left side of the road. There are also underground telecom cables with manholes marked on the plan and existing PVC water distribution mains throughout these routes. As-built drawings of the existing water mains are not available and are not shown on the drawings.

4.2.1.3 Summary of Geotechnical Investigation and Assessment Results

Geotechnical investigations consisting of boreholes, Macintosh tests and resistively tests were carried out along the transmission main route and the details of investigation are presented in Geotechnical Report in Supplementary Data to Tender Documents. Following is the summary of assessment results.

Table 4-2 Summary of Geotechnical Assessment (Transmission Main)

Description	Chainage m	Ground water table m below Ground level	N valve at 2 m below ground level	Bearing Pressure
BH1	50	11.8	17-21	250
BH4	2285	7.2	24 - 27	250
BH5	2575	3.1	3-7	100
M2	2800	0.6	16	-
M3	3200	1.5	9	-

4.2.2 SPECIFIC DESIGN CRITERIA

4.2.2.1 Test Pressure

Working pressure in the transmission main is 6.3 bar. Test pressure is specified according to Section 4.1 of AWWA C600 which shall not be less than 1.5 times the maximum working pressure. Therefore, pipeline shall be tested for 10 bar which is approximately above 1.5 times the operating pressure.

4.2.2.2 Surge Protection

Surge analysis of the Gothatuwa Transmission Main was carried out considering the worst possible scenario when operated together with future Kolonnawa Main when transmitting maximum design flow. Data on the route and profile of future Kolonnawa Main provided by the NWSDB is used for the analysis.

Schematic of transmission system used for the surge analysis is shown in Figure 3-12 of Main Report.

Detailed analysis is presented in Appendix to Design Report. It is evident from the results that in the event of the pump stoppage negative pressures quickly reach the sub-atmospheric conditions and might pose danger to the pumps and as well to the pipeline. With the introduction of a surge tank of capacity 30 m^3 negative pressures will be nullified and will not reach the limiting value of –10.2 m where cavitation occurs.

4.2.2.3 Corrosion Protection

Since, transmission main passes through low-lying areas and the pH of soil is low, polyethylene sleeving will be provided except where restrained pipe is used.

4.2.3 DETAILED DESIGN CONSIDERATIONS

4.2.3.1 Types of Pipe and Fittings

Ductile iron pipe with cement-mortar lining will be used. Types of pipe and fittings are as follows:

- All pipes except flange pipes shall be Class-K9.
- Flange pipes and all fittings except tees shall be Class-K12.
- All tees shall be Class-K14.
- All flanges shall be of PN16.

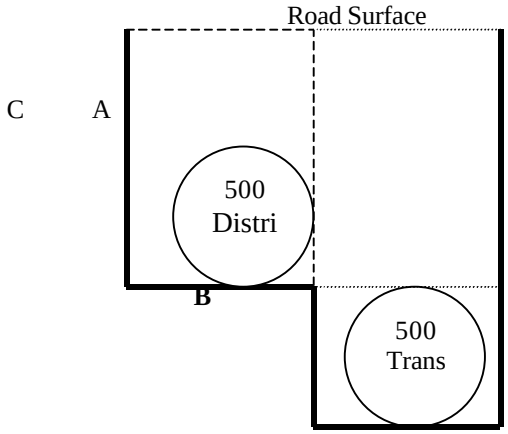
4.2.3.2 Pipe Trench, Pipe Bedding, Backfilling and Compaction

Between Ch-566 and Ch-4,042, distribution main will also be laid along the same route as transmission main and a common trench is proposed for laying both mains to avoid inconvenience. Pipelines will be staggered both vertically and horizontally with distribution main at a shallower depth than transmission main. Minimum cover to the finished ground level will be maintained for both pipes. Lengths included are as follows.

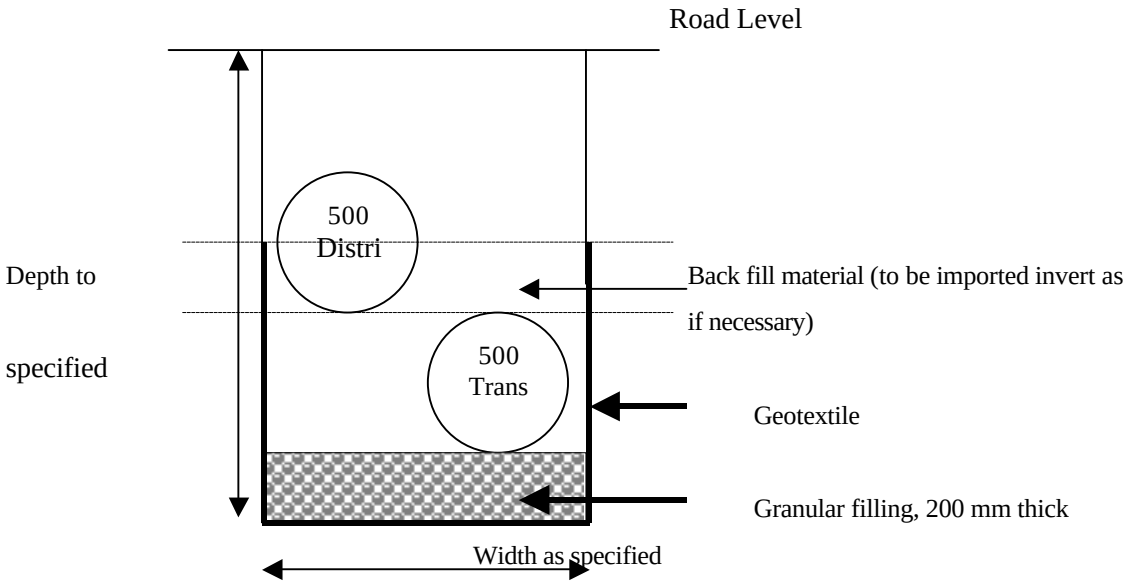
- 300 mm dia DI pipeline, L=1,719 m, Ch-566 to Ch-2285 with 800 mm dia transmission main
- 500 mm dia DI pipeline, L=1,757 m, Ch-2285 to Ch-4042 with 500 mm dia transmission main

The procedure to be followed when laying pipelines in common trench are as follows:

- Excavate areas A and B
- Lay Transmission main
- Backfill B (up to crown of pipe)
- Excavate C
- Lay distribution pipe
- Back fill A and C
- Reinstate Road



Soft ground is expected between Ch-2,700 and Ch-3,360 (660 m long stretch) along Fever Hospital Road, where invert level of the transmission main will be below 3.00 m MSL. The pipeline shall be provided with modified type of Class C bedding over some parts of this stretch as shown in the drawings.



Allowance has been made in the BOQ for this type of bedding.

Back-filling shall be by imported material if necessary and compaction shall be similar to other pipe trench.

4.2.3.3 Air Valves and Section Valves

Air vales are provided at all humps. Type of air valve is double orifice.
Line valve is provided at the exit of the pump house, after the T-branch to Kolonnawa and at the inlet to Gothatuwa Ground Reservoir.

Air valves provided for both transmission and distribution mains in the common trench are staggered and their arrangement is shown in Drg. KMU/TM/C-08

4.2.3.4 Culvert Crossings and Washouts

The trench becomes deeper when pipes cross the existing culverts. The pipes cannot be placed above the opening, as the depth of the culvert is not sufficient to provide the minimum earth cover required for the pipes. Therefore, the pipes have to be laid under the culvert which require deeper excavation. Safety of the culvert shall be ensured in the process of construction and any damage done shall be made good.

Washouts are provided at all troughs, generally near existing culverts. A washout chamber will be provided which will drain to nearby canal identified at site.

Washouts provided for both transmission and distribution mains in the common trench are staggered and their arrangement is shown in Drg. KMU/TM/C-08

4.2.3.5 Pipe Anchorages and Thrust Blocks

As shown in the yard piping Drg KMU/PS/YP-02, transmission main from pump house up to the gate of Ambatale New WTP (Ch-220 – Ch-0) consists of several bends spaced close to each other around the water treatment facilities. Due to space restrictions and due to soil conditions (filled soil) this section of pipeline is designed with restrained joints. The restrained length is continued up to Ch-90 in the transmission main drawing No. KMU/TM/C-1. However, as the bends are located close to each other, it is not possible to keep the required length of pipeline on each side of every bend. Therefore it has become necessary to supplement this restrained section of pipelines with additional nominal thrust blocks at the bends. Thrust blocks for this length are designed to withstand additional forces 3 bar of pressure. Polyethylene sleeving shall not be provided for the entire restrained length.
Thrust blocks are provided at other sections of pipeline where standard bends are used to counter unbalanced forces. Standard bend sizes used are 11.25^{o}, 22.5^{o}, 45^{o} and 90^{o}.

4.2.3.6 Disinfection and Testing

Pipeline have to disinfected and tested for leakage as set out in the design criteria for pipelines. Test pressure for transmission main shall be 10 bars.

4.3 GOTHATUWA GROUND RESERVOIR AND PUMP HOUSE

4.3.1 DESIGN CONDITIONS

4.3.1.1 Summary of Work

a) Location, purpose, capacity and shape of reservoir, operating water levels

Proposed site for the reservoir and pump house is near the existing water tower at Goththatuwa neighborhood adjoining Fever Hospital boundary.

Rectangular shaped reservoir of capacity to hold 4400 m^3 of water and to lift to the nearby existing water tower and to the new water tower there by distributing to the Goththatuwa area.

High water level at the reservoir is 26.25 m MSL and the low water level 21.00 m MSL. Sump bottom level 19.15 m MSL and the pump house base level 20.00 m MSL.

b) Purpose of pump house, number of pumps and their capacity

Pump house is located next to the reservoir having two numbers of duty pumps. Provision for an additional future pump is also considered. These pumps will deliver water to the two water towers. Capacity of the pumps 130 kW, 18 m^3/min x 30m (TDH)

4.3.1.2 Site Location and Conditions

a) Description of site (topography, related facilities i.e. existing water tower)

Proposed site for the reservoir and pump house is near the existing water tower at Goththatuwa neighborhood adjoining Fever Hospital boundary. Natural ground level varies between 23.00 m MSL and 25.00 m MSL.

b) Demolition of existing buildings and tree removal

Small building and a boundary wall exist at the site of the reservoir and to be demolished and carted away.

c) Land Acquisition

Land to be acquired by the water board for the proposed site of reservoir, pump house and the water tower.

4.3.1.3 Summary of Geo-technical Investigation and Assessment Results (including assumptions)

Geo-technical investigation using bore hole tests near to the site shows fairly good ground condition. Allowable soil bearing pressure of 250 kN/m^2 recommended for the design of foundation. However, additional three bore holes to be carried out within the reservoir area once the site access available to further confirm the results of the previous tests.

4.3.2 SPECIFIC DESIGN CRITERIA

4.3.2.1 Structural Design

a) Loading Criteria

Dead loads:

200mm thick staging area slab	= 4.80 kN/m^2
Screed & Terrazzo finish	= 1.80 kN/m^2
250mm thick Reservoir roof slab	= 6.00 kN/m^2
100mm benching concrete on roof	= 2.40 kN/m^2
200mm thick Pebble layer on roof	= 4.00 kN/m^2
Zinc Aluminum Roofing with Purlin etc.	= 0.50 kN/m^2
200mm thick Block wall & Plaster	= 3.30 kN/m^2
Density of concrete	= 24.0 kN/m^3
Density of water	= 10.0 kN/m^3

Live loads:

Inaccessible Roof	= 1.00 kN/m^2
On staging area slab	= 10.0 kN/m^2
On Sump Roof	= 2.50 kN/m^2
Maximum water level	= 26.25 m MSL
Minimum water level at the reservoir.	= 21.00 m MSL
Minimum water level at the sump	= 19.15 m MSL

Wind Forces & Environmental:

Basic wind speed of 34.0 m/s used to determine the wind force on the pump house Roof & RC frame.

Design temperature rise due to heat of hydration T1 = 42 °C
Design temperature seasonal variation T2 = 15 °C

b) Foundation design parameters

Compacted soil density	= 20.0 kN/m^2
Active lateral earth pressure coeff.	= 0.333
Passive earth pressure coeff.	= 3.0
Allowable soil bearing pressure	= 250.0 kN/m^2
Concrete strength - fcu	= 35.0 N/mm^2
Reinforcement strength – fy	= 460.0 N/mm^2
Design surface crack width	= 0.20 mm

4.3.3 DETAILED DESIGN CONSIDERATIONS

4.3.3.1 Summary of Gothatuwa Ground Reservoir

a) Partition

Ground reservoir divided into two parts from the middle as cell 1 & cell 2. A sump common to both cells with separate sluice gates to discharge water to the sump area.

b) Inlet arrangement

Two inlet pipes arranged to supply water to each cell and the baffle walls so arranged to smoothly direct the flows to the sump area.

c) Sump

A sump area having clear dimension of 10.234m x 4.58m provided within the reservoir area near to the pump house. Base level of the sump is 19.15 m MSL

d) Overflow and washout arrangement

One over flow and one washout provided for each cell. All the outlets from overflow and washout connected to a common header at the outside drain and discharge to the drain at the near by road.

e) Access for maintenance

Five numbers of access manholes considered on the roof of reservoir & the sump area. And one RC staircase arranged within the pump house to provide access to the base floor where the pumps are installed. MS platform at the end of staircase provided for access across the pumps & pipes.

4.3.3.2 Summary of Gothatuwa Pump House

a) Sump/inlet and outlet arrangement

Two sluice gates provided on the bottom of the wall divides the sump and the reservoir as inlet to the sump and the suction pipes of the pumps are connected to the sump as outlet from the sump.

b) Pump floor

Pump house floor arranged to have two duty pumps and provision for a future pump.

c) Pump operation and control area

Staging area within the pump house at 26.25 m MSL considered to allow loading, unloading and to fix all the electric panel boards. Pumps are connected to these panel boards through wall & floor mounted cable trays next to the pumps.

d) Power Supply and Emergency Power Supply (generator area)

Electric power supply to the pump house will be through the Government mains.

A generator house to install 375 kVA generator to provide emergency power to the pump house also considered in the design.

e) Access for operation and maintenance

Access for operation and maintenance of the pumps & valves using the staircase and MS platform at the end of the staircase above the pump across the pipes to reach the pumps and valves.

f) Drainage

Gutter drain inside the pump house to discharge water to a sump inside the pump house and the sump pumps in the sump will lift the water and discharge to a surface drain outside.

Under drain provided within the reservoir area that will discharge water to a nearby manhole. This manhole connected to another manhole located at the road drain that takes water from the overflow & washout drains.

4.3.3.3 Summary of Operation and Control System

a) Operation and Control Concepts

(1) Equipment

- one(1) duty pumps and one(1) standby pump, 130 kW each pump providing 18 m^3/min x 30 m TDH
- a second duty pump will be added when demand exceeds pump capacity (around the year 2010)
- discharge valves with motorized operator
- magnetic flow meter inlet to reservoir
- magnetic flow meter outlet to reservoir
- pump low suction pressure switch
- level sensing transmitter
- level sensing electrodes
- motor operated flow control valve

(2) Flow Regulation

General

- pumping from Ambatale will be a continuous operation with as few stop start cycles as possible
- a motor operated flow control valve on the inlet side will be modulated by a flow meter to keep flow into the reservoir constant and match demand as closely as possible

Control mode (flow control valve)

- There are 3 control modes available for each discharge valve:
- AUTOMATIC (linked to pump operation),
- REMOTE manual control from the control panel (inside the pump house) and
- LOCAL manual control at the valve (outside the pump house).
- The flow control valve can be operated remotely from the pump house or locally at the valve
- Control at the valve consists of a selector switch with “REMOTE-LOCAL” positions and a control switch with “OPEN-CLOSE” positions.
- The valve modulates automatically when the selector switch in the pump house is placed in “AUTO” position and the selector switch at the valve is placed in “REMOTE” position.
- The valve can be operated manually from the pump house by selecting “MANUAL” position and activating the “OPEN-CLOSE” control switch on the control panel.
- The valve can be operated manually at the valve by selecting “LOCAL” and activating the “OPEN-CLOSE” control switch at the valve.

List of I/O Points (flow control valve)

- Motor operated Valves
    - Position indicator
    - Overtorque alarm

    - Failed to open
    - Failed to close
- Flow metering
    - Instantaneous flow
    - Totalized flow
    - Analogue recorder

Control logic (flow control valve)

- The valve modulates open or close to match the desired inlet flow set-point
- Flow is monitored continuously by an electro-magnetic flow meter
- The flow meter, located just ahead of the flow control valve, will send a signal to the PLC to modulate the valve to the desired set-point programmed into the PLC
- If the level in the reservoir reaches overflow level and remains there for more than 5 minutes (adjustable) then the motor operated control valve will close and send an alarm signal to the PLC.
- Following an overflow alarm the motor operated flow control valve will remain closed for a suitable period of time (adjustable) then modulate to the fully open position. In this way the station attendant will have sufficient time to investigate the reason for the overflow condition and communicate with operators at Ambatalle to shutdown pumps at Gothatuwa-Kolonnawa Pump House if necessary.

(3) Pump Control System

- the pumps will be controlled automatically by a local programmable logic controller (PLC) or manually by the station attendant
- the control program is resident in the PLC and control set-points can be adjusted at the PLC
- the control panel is located in the pump house.

d) Control Modes (pumps):

- There are 3 control modes available for the pumps:
- (AUTO) automatic PLC control,
- (LINK-UP) manual control that links the pump with the discharge valve
- (INDIVIDUAL) manual control of the pump only without opening the discharge valve.
- Each pump has two control switches providing “ON-OFF” and “RUN-STOP” positions and one selector switch providing “INDIVIDUAL-LINK UP-AUTO” positions located at the Motor Control Panel.
- When the selector switch is in the “AUTO” position, the pump is controlled directly by the PLC and can also be activated manually via the PLC keypad or it can be operated automatically using the control program
- There are two manual control modes: “LINK UP” and “INDIVIDUAL”.
- When the selector switch is in the “LINK UP” position manual control of the pump is linked to the operation of the discharge valves. The pump is activated manually by setting the control switch to the “RUN” position and de-activated by selecting “STOP”
- With the selector switch in the “INDIVIDUAL” position the pump can be started with the discharge valve closed. This feature is required for pump maintenance when the operators want to test the correct operation of the pump or motor without having the discharge valve open automatically. The pump is activated manually by setting the control switch to “ON” and deactivated by selecting “OFF”.
- The “ON-OFF” switch has a handle that can be removed for safety during maintenance. When in the “OFF” position the pump is deactivated and cannot be turned on by any other means.
- Most interlocks are contained in the PLC software. However, critical interlocks (mainly related to safety) are hardwired into the control circuit.

e) Control mode (discharge valves)

- There are 3 control modes available for each discharge valve:
- AUTOMATIC (linked to pump operation),
- REMOTE manual control at the motor control panel (upper station level) and
- LOCAL manual control at the valve (pump level).
- Each discharge valve has a selector switch with “REMOTE-LOCAL” positions and a control switch with “OPEN-CLOSE” positions located at the valve. A control switch providing “OPEN-CLOSE” positions is also mounted on the motor control panel (upper station level)
- The discharge valve operates automatically (linked to pump operation) when the pump selector switch is in the “AUTO” position or in the “LINK-UP” position.
- The valve can be operated manually at pump level by placing the selector switch at the local control panel in the “LOCAL” position and activating the “OPEN-CLOSE” control switch at the valve.
- The valve can be operated manually from the motor control panel at the upper station level by placing the selector switch at the local control panel to the “REMOTE” position and activating the “OPEN-CLOSE” control switch on the motor control panel.

- level sensing in the reservoir
    - digital level indicator
    - high level alarm
    - low level alarm
- level sensing in the 1500 m^3 water tower
    - digital level indicator
    - low level alarm
    - high level alarm
    - pump start level
- level sensing in the 227 m^3 water tower
    - digital level indicator
    - low level alarm
    - high level alarm
    - pump stop level
- motor protection
    - low voltage, phase failure
    - over current
    - stator coil high temperature
    - motor bearing temperature
    - ground fault
- Pump protection
    - Failed to start
    - Failed to stop
    - Low suction pressure
    - Pump Bearing temperature
    - Low discharge pressure
- Motor operated Valves
    - Position indicator
    - Over torque alarm
    - Failed to open
    - Failed to close

(4) Control Logic

(a) Starting pumps

- With the control switch in "AUTO" the pumps operate automatically according to the level sensors in the elevated tanks.
- The pumps are automatically activated when water levels in the new 1500 m^3 tank drops below an adjustable set-point (+43.0 m MSL)
- If the PLC fails for any reason, the pumps shut down
- Pumps will start against a closed discharge valve. After an adjustable time delay the PLC will modulate the butterfly valve to open.
- Before starting a pump the following conditions must be maintained:
    - The Motor operated discharge valve must be closed
    - The water level in the reservoir must be above LWL (+21.0 m MSL)
    - No motor or pump faults detected
- The pump starters are interlocked so not more than one pump can be started at the same time

(b) Stopping Pumps

- The pump will shutdown when water level in the 227 m^3 tank reach top water level (+46m MSL).
- After pump shutdown the discharge valve will be returned to the normal position i.e. fully closed after a suitable time delay (adjustable automatic slow closure of discharge valves)
- Motor operated discharge valves are equipped with limit switches to indicate fully open and fully closed positions
- If the level of water on the suction side of the pumps drops below an adjustable set-point (19 m) the pump will be shutdown
- Should a pump stop for whatever reason while it is energized (including low liquid level), an integral pump relay will send a pump general alarm signal to the PLC.
- The low level switch in the reservoir will provide a low level alarm for the PLC. In this way the operator will be able to distinguish between a general pump fault and a low liquid level.
- A pressure switch located on the suction side of the pump will protect the pump against low suction pressure if the suction valve is accidentally closed. The set-points are independently adjustable at the pressure switch. This switch is wired into the pump control circuit and operates independent of the PLC. The appropriate alarm (low pressure) is activated whenever the switch is activated.
- A limit switch on the check valve (pump delivery side) will signal the PLC to shutdown the pump if the check valve does not open after a suitable time delay (this is to indicate a broken coupling or a failure of the motor operated discharge valve)
- A limit switch on the check valve (outlet of 227 m^3 elevated tank) will signal the PLC to shutdown the pump if overflow levels are reached and the check valve is not open after a suitable time delay (this is to prevent pumping to a full tank if the check valve fails to open)

f) Operating sequence (automatic control)

- The pump will start automatically verifying the start conditions when the control panel receives a low water signal from the 1500 m^3 elevated tank.
- When the motor is started the control panel will signal the discharge valve to open after a suitable time delay
- The pump will run continuously until receiving a signal from the control panel that top water level has been reached in the 227 m^3 elevated tank.
- If power failure occurs the generator will start after a suitable time delay. The pumps will restart automatically (one at a time) after verifying that power of correct voltage and frequency is available.

b) Instrumentation Equipment for Operation and Control (summary of equipment for operation and control with their functions/specifications)

The instrumentation equipment has been designed to satisfy the proposed control concept and the instrumentation diagram is given on drawing No.KMU/PS/E-06

4.3.3.4 Summary of Foundation / Structural Design for Ground Reservoir

a) Foundation

Foundation for retaining walls designed using most unfavourable loading condition due to water & earth pressure. Water at full level and empty condition also considered.

Also cracks due to thermal condition & serviceability flexural cracks checked.

b) Base slab

Base slab designed as a raft mat subjected to most unfavourable loading condition due to dead load, live load, loads due to water & earth pressure underside.

Also cracks due to thermal condition checked.

c) Walls

Retaining walls deigned for earth pressure and water pressure. Reservoir full and empty cases considered.

Also cracks due to thermal condition & serviceability limit state flexural checked.

d) Columns

Columns inside the reservoir area designed for loading due to roof slab. Ultimate limit state method used in designing columns.

e) Roof

Roof slab designed as flat slab framing with the columns. 1.0m x 1.0m column capital considered. Most unfavourable loads due to dead & live loads considered in the analysis.

4.3.3.5 Summary of Foundation / Structural Design for Pump House

a) Foundation

Pump house column foundation is designed as a raft foundation with the base slab. Most unfavourable combination of loads due to dead, live & earth pressure.

Also cracks due to thermal condition checked.

b) Base slab and floor slab

Base slab and floor slab designed as the raft foundation. Also cracks due to thermal condition checked.

c) Walls

Walls below ground level designed as retaining wall due to earth pressure. Wall facing the new water tower designed with surcharge loads due to existing water tower & the future access road.
Also cracks due to thermal condition & serviceability limit state flexural cracks checked.

d) Columns

Columns at the pump house and generator house analysed as portal frames with the roof beams and designed with most unfavourable loads due to dead, live & wind loads.

e) Roof

Roof structure analysed as portal frame with the most unfavourable loads due to dead, live & wind loads.

4.3.3.6 Summary of Mechanical Design

a) Pump intake and discharge

Diameter of suction and discharge pipes of individual pumping unit shall be 500 mm and the diameter of common header pipe shall be 600 mm.

The diameters of the piping has been decided in such a way that;

- frictional losses shall be minimum,
- maximum velocity of flow shall be below 2 –3 m/s, which is acceptable to international standards,
- capital investments shall be most economical.

* Butterfly valves shall be provided on the individual pump suction and discharge pipes in order to facilitate throttling, easy operation and providing limit switches to sense the position of each valve.
* The butterfly valve on the individual delivery pipe shall be of motor operated type. This is to achieve the control of the flow automatically by means of electrical signal.

(a) Overhead Crane

Overhead gantry cranes are designed conforming to the British Standards. A factor of safety of 1.5 is applied in determining the design loading.

(c) Ventilation and Drainage

The ventilation for the upper flow of the pump house is provided using two exhaust fans installed at the two gable walls of the building. The ventilation for the low level floor is affected through ducts with their outlets fixed to the walls and incorporated with an exhaust fan.

4.3.3.7 Summary of Electrical Design

a) Power Supply

Power supply for the building is taken from the main switch board (to be supplied and installed under the electromechanical contract).

A 60-amp MCCB (TPN) on the main switch board will control the supply for the building services. Lighting and small power sockets in the pump house building and the external site lighting are supplied from a "Building Services Panel", located as shown on the drawings. A 16 sqmm, 4-core cable, will connect this "Building Services Panel to the Main switch board . The supply & installation of the building services panel and the connecting cable will be part of the building contract. Three single phase distribution boards are used for controlling the sub-circuits in the building and the site lighting circuits.

Stand-by power supply is provided by Diesel generating set operated manually at times of mains failure. In addition, emergency lighting for the generator area is provided by battery operated emergency lamps which switch on automatically on mains failure. The batteries will have sufficient capacity for one hour operation of the lamps.

b) Internal and Site Lighting

Internal Lighting is provided by high bay type wide dispersive luminaires fixed to roof members, in conjunction with standard fluorescent lamps fixed to walls and under concrete slabs.

Site lighting is provided by standard type mercury vapour street lamps. These are fixed externally on the building walls or mounted on RC posts along roadways. The minimum height of lamps from ground level is to be 4.0 m.

XLPE or PVC cables are run in hard PVC conduits. These conduits are run of the surface of walls - or buried underground along roadways.

The location of these lamps, the route of cabling and the size of cables to be used are indicated in the relevant drawings.

c) Emergency Power Supply

Stand-by power supply is provided by Diesel generating set operated manually at times of mains failure. In addition, emergency lighting for the generator area is provided by battery operated emergency lamps, which switch on automatically on mains failure. The batteries will have sufficient capacity for one hour operation of the lamps.

d) Battery System for Control Equipment

This is included in the electro-mechanical equipment contract.

e) Lightning Protection

Lightening protection is provided for the building by adopting "Early Streamer Emission" type air terminations (finials). This would provide a reliable and adequate level of protection with the use of one or two finials - as opposed to the use of several finials at roof-top, if the conventional passive finials are adopted.
Radio active heads will not be permitted.
Copper tapes will connect the air terminations to copper plate earth electrodes buried 1.5 m below ground level.

4.3.3.8 Summary of Yard Piping Design

a) Interconnecting pipe of New and Old Towers

An outlet pipe of 150 mm in diameter has been provided to interconnect the new tower and the existing tower. The inlet of this pipe is placed at the TWL of the new water tower and is connected to the inletpipe of the existing tower at the floor level.

b) Connection to distribution mains

The 450 mm outlet of the tower first reduces to 300 mm at the meter chamber and then enlarges to 500mm before joining with the 500 mm distribution main. Provision has been made on both sides of the tee for flow measurement.

c) Piping within pump house/reservoir

All pipes within the pump house shall be of flanged and welded steel construction to facilitate fabrication of non-standard fittings flexibility of negotiating change of direction within restricted spaces.

d) By-pass line

A by-pass arrangement has been provided by interconnecting the inlet and outlet pipes below the floor level of the water tower via an isolating valve. The tower can be by-passed by opening this isolating valve and closing the inlet valve provided on the inlet riser pipe.

4.3.3.9 Roadways, Grading and Drainage

a) Roadways

6.0 m wide roadway with curves having sufficient turning radius of large trucks planned in the landscaping plan. Asphalt finishes considered in the road area.

b) Site Grading

Proper filling and compaction allowed in the grading of the sites that is indicated in the grading plan.

c) Under drains

Under drains provided under the reservoir area to discharge any ground water collected due to high water table. This under drain connected to a manhole near the reservoir that will be connected to the road drain.

d) Washout Drain

Washout drain at the reservoir (one in each cell) provided and connected to the common header under the proposed roadway and that will be connected to the road drain.

4.4 GOTHATUWA NEW WATER TOWER

4.4.1 DESIGN CONDITIONS

4.4.1.1 Summary of Work

a). ***Location, Purpose, capacity and shape of tower, operating water levels***

The New Tower will be constructed next to the existing tower. The capacity of the New Tower will be 1,500 m^3. The Intz-type tower has its top water level at 47.5 m and low water level at 41.5 meters above main sea level. The foundation level is set at 22.25 m MSL. The combined capacity of the new water tower and the existing water tower is sufficient to cater for the hourly peak demands in the distribution system in the year 2020.

The tower will be of reinforced concrete. It consists of a doomed roof. The cylindrical tank has a conical bottom that will be supported on a circular reinforced concrete shaft bearing into a raft foundation. The inlet, outlet and washout / overflow pipes will be accommodated within the shaft. Access stairs and landings will be provided to the bottom of the tank. A thin wall shaft will be provided in the center of the tank or service access.

4.4.1.2 Site Location and Conditions

a). Description of site

The new water tower will be constructed next to the existing water tower. This site is located in Gothatuwa New Town and bordered by IDH Road and Halgahadeniya Road. The site is located on a high ground with ground elevation vary from 24.38m MSL to 23.38m MSL. The ground is firm and suitable for this type of construction.

The site of the existing tower is owned by NWSDB. However, the adjoining land that is owned by the Ministry of Health, needs to be acquired to construct the new tower, ground sump, pump house and the associated pipe work.

b). Demolition of existing buildings and tree removal

An existing residential building owned by the Ministry of Health will be demolished and removed**.** Trees shall also be removed as shown on the Drawing.

c). Land Acquisition

The land next to the existing tower will be acquired for the construction of the new water tower, ground pump, pump house and laying of yard piping. This land is presently owned by the Ministry of Health.. NWSDB will follow the land acquisition procedure to make sure that ht eland will be available in time for construction.

4.4.1.3 Summary of Geotechnical Investigation and Assessment Results

Two boreholes were taken at the tower site. The material existing at the proposed foundation level is classified as hard laterite. Very high SPT values were recorded in the overburden. Ground water table is

at an elevation of 19.02 m MSL, which is more than 3m below the foundation level. The allowable bearing capacity is greater than 250 kN/m^2.

4.4.2 SPECIFIC DESIGN CRITERIA

4.4.2.1 Structural Design

a). Loading Criteria

The general loading criteria is as given in Chapter 2 of this report. The Water Tower with its supporting RC circular shaft is considered under different load combinations. The dead load due to self weight, Super load mainly due to water and lateral load due to wind was considered in the design.

The main loading criteria is as described in the Chapter 2.1 of this report.
The following basic loads are applied in the design
Density of water = 10 kN/m^3
Density of concrete = 24 kN/m^3

b). Foundation design parameters

The circular raft type foundation which is connected with the circular rc shaft is designed for a safe (unfactored) bearing pressure of 250 kN/m^2. The foundation depth was so chosen not to load the existing foundation of the existing tower.

4.4.3 DETAILED DESIGN CONSIDERATIONS

4.4.3.1 Summary of Foundation/ Structural Design

a) Foundation

The design of the foundation is based on simple theory as a circular slab resting on a circular shaft with a constant cantilever right round.

b) Shaft

The rc shaft which carries the tower is in compression under all combinations of loads and the capacity of the concrete section as sufficient to carry the worst possible loads and nominal reinforcement is provided.

c). Platform

The centre area of the rc shaft is used as the pipe gallery and there is a service stairs which are supported on concrete platforms. These rc platforms at different levels are formed by projecting radial reinforcement from the shaft.

d). Tank and roof

The tank is designed as a monolithic structure with a conical and hemispherical bottom. He perimeter wall and the ring beam is under tension. The roof is a rc dome with supports along the perimeter and at the centre as well.

4.4.3.2 Summary of Electrical Design

(a) Internal Lighting

Internal lighting is provided at each of the platform levels within the cylindrical wall and also unside the shaft up to the lantern level. Inner space of the tank compartment is illuminated by the lamps fixed on to the external surface of the shaft below crown of the spherical dome.

(b) Lightning Protection

Lightening protection is provided for the tower by adopting "Early Streamer Emission" type air terminations (finials). This would provide a reliable and adequate level of protection with the use of one or two finials - as opposed to the use of several finials at roof-top, if the conventional passive finials are adopted.

Radio active heads will not be permitted. Copper tapes will connect the air terminations to copper plate earth electrodes buried 1.5 m below ground level.

(c) Air Craft obstruction warning light

The aircraft warning light is installed on a mast fixed to the lantern roof conforming to International Standards.

4.4.3.3 Summary of Yard Piping Design

(a) Interconnecting pipes of new and old towers

A 150 mm dia. pipe has been provided to interconnect the new tower and the existing tower.

A 150 mm outlet pipe taken off at the TWL of the new tower is connected to the 150mm inlet to the existing tower at the floor level.

(b) Connection to distribution mains

The 450 mm outlet of the reservoir is reduced to 300mm at the meter chamber. Then it is enlarged to 500 mm to join with 500 mm distribution main. Provision has been made on the distribution main on both sides of the tee for flow measurements.

(c) Piping within new water tower

As discussed in 4.4.3.1, all piping work has been accommodated within the reservoir. The piping work consists of inlet, outlet, overflow and washout.

(d) By Pass Line

The inlet and outlet has been connected below the floor via a by-pass valve. The tower can be by-passed by opening the by-pass valve and closing the inlet valve provided on the inlet riser pipe within the shaft.

4.4.3.4 Roadways, Grading and Drainage

(a) Roadways

There are no roadways proposed for the water tower site. Direct access to the tower will be provided from the Fever Hospital Road.

(b) Site Grading

The existing grading pattern of the site will be maintained after construction of the water tower.

(c) Washout Drain

The scour and overflow pipe of the two water towers and the two compartments of the ground reservoir (300 mm in dia) joins with the main washout drain pipe of 400 mm in diameter. Overflow and washout water is finally discharged to the main drain along Halgahadeniya road.

4.5 DISTRIBUTION MAINS

4.5.1 DESIGN CONDITIONS

4.5.1.1 Summary of Work

(1) Pipeline Route

Drawing KMU/DM/G-02 shows the routes of pipeline to be laid under this project to supply water from Gothatuwa Water Tower and Gothatuwa New Water Tower.

(2) Diameter and material

Diameters of pipes to be laid range from 100 mm to 500 mm. PVC pipes will be used for diameters equal to or below 200 mm and ductile iron pipe with cement mortar lining will be used for pipes with diameter 250 , 300, 400 and 500 mm keeping with NWSDB standards.

Pipeline routes, length, ground levels at nodes and diameters of pipe are summarised in Table 4-3.

(3) Maximum Working Pressure

High water level in the Gothatuwa New Water Tower is 47.5 m MSL and therefore maximum working pressure is approximately 5 bars.

(4) Interconnections

Interconnections between the distribution mains to be laid under this project and the existing pipe network are required to supply water from the water tower and to abandon the existing tappings on various transmission mains. Forty two locations are identified mainly on the junction nodes and at the ends of distribution mains to be laid. Locations where interconnection to the existing pipelines will be made are also shown on Drawing KMU/DM/G-02.

Table 4-3 Summary of Priority Pipelines for Strengthening (1/2)

Name of Road	Node No.	Road Authority	Elevation, m MSL	Distance, m	Diameter / Material
1. I. D. H. Road	N98	RDA	22.95		
	N312B		18.42	187	500 mm DI
2. Kotikawatta Road	N312A	RDA	2.82		
	N354		2.75		
	N368		3.95		
	N601		3.60	1,689	400 mm DI
3. Kohilawatta Road	N601	RDA	3.60	75	400 mm DI
	N532		2.67		
	N679		3.70	1,188	300 mm DI
4. Angoda Road /	N888	PRDA	15.00		
	N892		17.50		
Siri Sumana Mawatha	N1137	PRDA	4.35	1,370	300 mm DI
	N1166		3.65		
	N1215		3.65	804	110 mm PVC
5. Meegoda Kolonnawa	N312A	RDA	2.82		
Road /	N265	PRDA	7.10	1,282	300 mm DI
	N86		6.60		
Katupelella Road	N407	PRDA	3.00		
	N397		1.46		
	N500		3.06	2,900	225 mm PVC
6. Delgahawatta Road	N354	PRDA	2.75		
	N931				
	N892		17.50	1,328	300 mm DI
7. Bandaranayakapura Road	N98	PRDA	22.95		
	N177		22.05	135	500 mm DI
	N137		2.57	1,007	300 mm DI
8. Buthgamuwa Road /	N137	RDA	2.57		
Koswatta Road /	N133	PRDA	2.31		
	N834		6.67		
Angoda Road	N837	PRDA	3.58		
	N823		2.57	2,653	300 mm DI
9. Halgahasdeniya Road	N22	PS	21.56		
	N199		3.58	400	160 mm PVC
	N177		3.58	295	225 mm PVC
	N199	PS	3.58		
	N170		2.57	474	225 mm PVC
10. Thapowanaya Road	N834		5.87		
	N846		21.00	213	250 mm DI
11. Sri Perakum Mawatha /	N892	PS	17.50		
Ranabiru Mawatha	N984	PS	5.80	381	300 mm DI
	N1127		5.08	984	225 mm PVC
	N1227		5.54	846	110 mm PVC
12. Old Avissawela Road	N1227	RDA	4.35		
	N679		3.12	2,362	110 mm PVC
	N500		3.06		
	N373		2.38	2,338	225 mm PVC
	N750		1.90	627	160 mm PVC
13. Gothatuwa Road	N265	PRDA	7.10		
	N389		3.15	804	225 mm PVC
SUB-TOTAL				24,342	

Table 4-3 Summary of Priority Pipelines for Strengthening (2/2)

Name of Road	Node No.	Road Authority	Elevation, m MSL	Distance, m	Diameter / Material
14. Brandiyawatta Road	N712	PRDA	3.50		
	N387		2.20	1,424	225 mm PVC
15. Nagahawela Road	N368	PRDA	3.95		
	N1145		4.60		
	N631		4.75	1,061	110 mm PVC
16. Abeysiri Perera Mawatha	N1145	PS	5.46		
	N1151		4.96	426	110 mm PVC
17. Malpura Road	N1313	PS	2.00		
	N1314		19.50	658	110 mm PVC
18. Dahamwila Mawatha	N532	PS	2.67		
	N655		2.42	270	110 mm PVC
19. Buthgamuwa Road	N312A	RDA	16.01		
	N168		4.15	365	160 mm PVC
	N128		2.36	571	110 mm PVC
20. Buthgamuwa Road	N128	RDA	2.36		
	N137		2.57	303	110 mm PVC
21. M. D. H. Jayawardena	N128	PRDA	2.36		
Mawatha &	N130A		2.82		
Elhena Road	N130B		3.57		
	N142		14.20	334	110 mm PVC
22. M. D. H. Jayawardena	N130B	PRDA	3.57		
Mawatha	N153		14.20		
	N63		4.10	1,263	110 mm PVC
23. Moravitiya Road	N168	PS	4.15		
	N130A		2.82	553	110 mm PVC
24. Pethiyagoda Road	N1315	PS	12.65		
	N984		5.80	885	160 mm PVC
25. Shanthi Mawatha	N1071	PS	18.15		
	N768		12.25	569	160 mm PVC
26. Udumulla Road	N1096	PRDA	16.65		
	N1003		15.85		
	N1015		12.54	1,406	300 mm DI
	N1014		7.00	333	225 mm PVC
27. Pansala Road /	N1085	PS	16.50		
Jayanthi Mawatha /	N1080	PS	18.35	352	225 mm PVC
Batahena Road	N1004	PS	16.30		
	N1003		15.30	615	160 mm PVC
28. Galwalahena Road	N1016	PRDA	16.45		
	N1019		21.50	471	160 mm PVC
29. Fever Hospital Road	N98	RDA	22.95		
	N22		6.50		
	N823		8.46	1,520	500 mm DI
30. Angoda Road	N823	PRDA	8.46		
	N888		15.00	282	500 mm DI
31. Himbutana Road	N888	PRDA	15.00		
	N1096		16.65		
	N1071		18.15	1,710	300 mm DI
SUB-TOTAL				15,371	
TOTAL				39,713	

Table 4-4 Summary of Priority Pipeline

Diameter and Material	Required Length, m
500 mm DI	2,124
400 mm DI	1,764
300 mm DI	12,290
250 mm DI	213
Sub-total	16,391
225 mm PVC	9,904
160 mm PVC	3,932
110 mm PVC	9,486
Sub-total	23,322
Total	39,713

4.5.1.2 Existing Conditions of Pipeline Route

(1) Existing Pipelines and Other Utilities

There are existing water distribution pipelines, underground telecom lines on all of the pipeline routes. There are also transmission mains from Labugama, Kalatuwawa and Ambatale WTP's passing through Kotikawatte and Mulleriyawa areas. They are,

- Jubilee Transmission Main (1,100 mm DI) from Ambatale WTP along Udumulla Road
- Dehiwela Transmission Main (1,000 mm CI) from Ambatale WTP along Himbutana Road / Udumulla Road
- Kolonnawa Transmission Main (600 mm DI) from Ambatale WTP along Himbutana Road / Pethiagoda Road / Kumara Mawatha and Delgahawatta Road
- Four transmission mains from Labugama WTP / Kalatuwawa WTP, Old 30" CI, Old 20" CI, Duplicate 20" CI and New 30" along Low Level Road
- 20" Transmission main from Ambatale WTP along Old Avissawella Road
- Ellie House Transmission main (600 mm DI) from Ambatale WTP along Old Avissawella Road

Approximate locations of these transmission mains are identified from the as-built drawings and other landmarks such as valve chamber etc.

As-built drawings of existing distribution pipelines are not available with NWSDB and the information of their diameter and side of the road along which they were laid are obtained from the NWSDB.

Existing telecom manholes are shown on the plan. There is an on-going project to lay underground telecom cables, the plan of which was obtained from SLT (Sri Lanka Telecom).

Kotikawatte-Mulleriyawa PS is improving roadside drains in this area during the time of study.

Roads along the pipeline routes belong to RDA, PRDA and PS as shown in Table 4-3. Most of the RDA roads are ashpalt-paved while PRDA and PS roads are tar macadam roads. NWSDB has informed RDA,

PRDA and PS of the proposed pipelaying work and obtained cost estimate of road reinstatement work which will be carried out by respective authorities.

Pipeline routes passes through low-lying areas close to 2.0 m MSL and some of which are permanently water logged.

There are two crossings of canals along Delgahawatta Road and along Angoda Road. Existing bridges at these locations cannot support the 300 mm DI pipes and pipe supports will have to be designed independently.

4.5.1.3 Summary of Geotechnical Investigation and Assessment Results

Geotechnical investigations consisting of boreholes and MacIntosh tests and were carried out along the distribution main routes. Testing of boreholes were carried out at the two bridge locations for canal crossings and the details of investigation are presented Geotechnical Report as Supplementary Data to Tender Documents . Following is the summary of assessment results.

At Bridge Locations

- At Delgahawatta Bridge location,
  Two alternatives were recommended, (1) RC piles end bearing in rock core was recommended with the piles having a safe carrying capacity of 5 N/mm^2 and (2) Shallow foundations at a depth of 2-3 m where the net allowable bearing capacity at foundation depth can be taken as 250 kN/mm^2. Groundwater level has to be lowered for construction in case of latter alternative.

- At Angoda Bridge Location, it was recommended that bored and cast in-situ RC piles end bearing in rock be used. They shall be socketed in to the rock and designed for a safe carrying capacity of 5 N/mm^2.

Along Distribution Main routes

Table 4-5 Summary of Geotechnical Investigation along Distribution Main Routes

Bore Hole No.	Location	Depth of Ground water table below ground level	N value at 2 m below ground level
M1	Pethiyagoda Road	1.5	9
M2	Fever Hospital Road	0.6	16
M3	Fever Hospital Road	1.5	9
M4	Kotikawatta Road	1.2	6
M5	Kotikawatta Road	1.3	8
M6	Gothatuwa Road	1.0	11
M7	Gothatuwa Road	1.15	9
M8	Brandiyawatta Road	0.45	10
M9	Katupelella Road	0.5	11
M10	Meegoda Kolonnawa Road	0.5	8
M11	Meegoda Kolonnawa Road	0.6	3
M12	Meegoda Kolonnawa Road	0.8	4

4.5.2 SPECIFIC DESIGN CRITERIA

4.5.2.1 Test Pressure

Working pressure in the distribution main is 4.75 bar. Test pressure is specified according to Section 4.1 of AWWA C600 which shall not be less than 1.5 times the maximum working pressure. Therefore, pipeline shall be tested for 7.5 bar which is approximately above 1.5 times the operating pressure.

4.5.2.2 Canal Crossings

Following the assessment results of geotechnical investigations at bridge locations, canal crossings are designed with the following criteria.

- At Delgahawatta Bridge location,
- At Angoda Bridge Location,
  Bored and cast in-situ RC piles end bearing in rock socketed in to the rock with safe carrying capacity of 5 N/mm^2.

4.5.2.3 Corrosion Protection

Corrosion protection will be provided for DI pipes with polyethylene sleeving as they will be laid in low lying area.

4.5.3 DETAILED DESIGN CONSIDERATIONS

4.5.3.1 Types of Pipe and Fittings

Types of ductile iron pipe and fittings are as follows:

- All pipes except flange pipes shall be Class-K9.
- Flange pipes and all fittings except tees shall be Class-K12.
- All tees shall be Class-K14.
- All flanges shall be of PN-16.

Types of PVC pipes and fittings are as follows:

- All pipes shall be Type 1000.
- All fittings except flanges shall be Type 1000.
- All flanges shall be of PN-16.

4.5.3.2 Pipe Trench, Pipe Bedding, Back-filling and Compaction

A common trench will be used as described in Section 4.2.3.1 of Design Report as part of the distribution main runs along the route of transmission main in Fever Hospital Road, Angoda Road and Himbutana Road. For all other sections, standard trenches as outlined in Section 2.6 will be utilised.

For low-lying areas pipe-bedding with selected material will be provided and is shown in the drawings for pipe invert levels below 1.0 m MSL.
Back-filled materials shall be compacted to 90% of the dry density.

4.5.3.3 Section Valves

Section valve arrangement is as shown in Drawing KMU/DM/G-02. Valves are provided such that sections of proposed pipelines can be isolated and independently to the existing pipeline network.

4.5.3.4 Air Valves

Air vales are provided at all humps. Double-orifice or single orifice air valve is provided generally according pipe diameter.
Air valves provided for both transmission and distribution mains in the common trench are staggered and their arrangement is shown in Drg. KMU/TM/C-08

4.5.3.5 Fire Hydrants

Fire hydrants are provided after consultation with Fire Brigade and NWSDB. Fire Brigade requirements are for providing fire hydrants every 90 m in urban areas. However it was agreed to limit the numbers by providing them at major junctions and facilities. Fire hydrants will be provided at twelve locations as shown in Drg. KMU/TM/G-02.

4.5.3.6 Canal Crossings

Existing bridges at two canal crossings belong to PRDA (Provincial Road Development Authority) and was consulted on the restrictions when providing pipes on independent supports next to the bridges. PRDA indicated no restrictions and independent structures are designed with piles which will be capped to provide platform for steel truss on which pipe will be supported.

4.5.3.7 Culvert Crossings

Three types of culvert crossings are used. Type A is when pipe is laid underneath the culvert and Type B is when pipe is laid through the culvert depending on the type of culvert, cover to the pipe and clearance to waterway. Type C is crossing is used when pipe can be laid without modifying the culvert structure when there is sufficient depth between top of the road and culvert structure. Safety of the culvert shall be ensured in the process of construction and any damage done shall be made good.

4.5.3.8 Washouts

Washouts are provided at all troughs, generally near existing culverts. A washout chamber will be provided which will drain to nearby canal identified at site.

4.5.3.9 Pipe Anchorages and Thrust Blocks

Thrust blocks are to be provided at all sections of pipeline where standard bends are used to counter unbalanced forces. Standard bend sizes used are 11.25^{o}, 22.5^{o}, 45^{o} and 90^{o}.

4.5.3.10 Provisions for District Metering

Provisions are made for district metering at both in which chambers will be provided for insertion meters.

4.5.3.11 Disinfection and Testing

Pipeline have to disinfected and tested for leakage as set out in the design criteria for pipelines. Test pressure for distribution main shall be 7.5 bars.

4.5.3.12 Interconnection to Existing Distribution System

All interconnection to existing distribution system are identified with the node number of the network. Sketch of the plan view of existing and proposed pipelines are shown and included as Supplementary Data to Tender Documents for reference. Junction detail showing the required fittings for the interconnections and pipe junctions are shown in the distribution main drawings. It should be noted that most of the existing pipelines are at a depth of 0.75 m according to NWSDB field staff. However, pipelines to be laid under this project will be provided with soil cover as described in the Chapter 2 General Design Criteria depending on the pipe diameter.

4.5.3.13 Closure of Existing Transmission Tappings

Basic concept of enhancement of Kotikawatte and Mulleriyawa water supply is to limit the water supply to Kotikawatte and Mulleriyawa areas from the water tower and to relieve existing transmission mains to their intended purpose. Therefore, all the existing transmission main tappings shall be closed when the new system is commissioned. Existing transmission main tappings identified are as follows:

1. Dehiwela Transmission Main, at the washout along Udumulla Road near Bank Junction
   - 160 mm transmission/distribution main to supply along Himbutana Road and to fill the existing sump opposite Fever Hospital
   - 160 mm distribution main to supply along Himbutana Road up to Maligagodella Road
   - 90 mm distribution main to supply along Udumulla Road
2. Dehiwela Transmission Main, at the exit of S-tower
   - 225 mm distribution main to supply along Old Avissawela Road
   - 160 mm distribution main to supply along Low Level Road
3. Kolonnawa Transmission Main, at the junction of Kotikawatte Road and Delgahawatta Road through the tee
   - 160 mm distribution main to supply towards south along Kotikawatte Road,
4. Transmission Main from Labugama, at the Kohilawatta Junction through the washout
   - 90 mm distribution main to supply along Low Level road and along Kotikawatte Road,
5. Transmission Main Kolonnawa Tower to Weragoda Water Tower (250 mm CI) near Wellampitiya Bridge, through a tee
   - 160 mm distribution main to supply along Low Level road and along Katupelella Road
6. Distribution Main from Moragasmulla Water Tower through Madinnagoda Bridge
   - 90 mm distribution main to supply along M.D.H. Jayawardena Mawatha
7. Distribution Main from Towns East Project
   - through southern part of Udumulla Road
   - through Galwalahena Road
   - through Angoda Road at Aggona Junction
   - along Koswatta Road
8. Transmission Main from Labugama near Angoda Junction
   - 200 mm CI main to supply Angoda Mental Hospital
9. Transmission Main from Kolonnawa Tower to Harbour, through a tee
   - 90 mm distribution main to supply parts of Sedawatta area

Procedure to be followed when closing the existing tappings are discussed in sub-section 4.5.3.15

Commissioning of New Supply.

4.5.3.14 Disconnection of Existing Sump and Pump House

Existing sump and pump house need to be disconnected and abandoned. Schematic of existing pipe connection and after disconnection is shown in Figure 3-17 of Main Report. Existing 160 mm PVC from Dehiwela Transmission Main washout will be connected to 500 mm DI distribution main and to the existing pumped main (110 mm PVC). Existing pumped main shall be encapped prior to existing tower and will be used as distribution main.

Disconnection of sump can only be made after tapping on Dehiwela Transmission Main and existing Kolonnawa Transmission mains are closed and the new tower is successfully put on service. Time when this can be carried out in the overall program of commissioning as described in sub-section 4.5.3.15 Commissioning of New Supply. Once disconnected, existing tower shall also be isolated to facilitate the alteration of piping and shall be put on service on completion.

4.5.3.15 Commissioning of New Supply

Commissioning of new supply can be done once the proposed pipe network is completed and tested and Gothatuwa-Kolonnawa Pump House, Gothatuwa Transmission Main, Gothatuwa Ground Reservoir and Pump House and Gothatuwa New Water Tower are ready for commissioning. Closure of the existing transmission tappings shall be done one by one while commissioning the supply from the new system based on the following rule.

- ***As much as possible current pressures and direction of flow shall be maintained***
  - Interconnection to the existing system shall be opened near the location where the existing transmission tapping is closed.
  - Interconnection around areas where there is insufficient pressure shall be opened to the required pressure.
  - Wherever pressure is insufficient opening of interconnection shall be carried out for example at N297 and at N846
  - Opening of other interconnection shall be carried out in the course of time when increase of pressure is required for a particular area

Following major steps shall be adopted for closing of transmission main tappings and commissioning the new system.

(1) Conduct leakage and pressure testing all facilities and disinfect.
(2) Inform public in affected areas on the transition.
(3) Test and operate transmission system.
(4) Test and operate Gothatuwa Pump House
(5) Fill Gothatuwa Ground Reservoir and Gothatuwa New Water Tower.
(6) Stop pumping to the existing Tower from the existing pump station in front of Fever Hospital.
(7) Isolate the existing tower by closing valves on the outlet to the existing distribution main and by keeping the isolation valve between existing and new tower closed.

Proceed to (8)

(Disconnection of sump and existing pump house and alteration of pipelines as outlined in sub-section 4.5.3.14 can be carried out after this step)

(8) Close the existing tapping at Dehiwela Transmission Main and at existing Kolonnawa Main.
(9) Gradually open interconnections at N1071, N1003 and at N354 until supply is satisfactory.

Proceed to closure of next transmission main tapping

(10) Close the valve at the exit of S-tower (Dehiwela Transmission Main) on 225mm distribution main supplying Old Avissawela Road and 160 mm distribution main supplying Low Level

Road and gradually open interconnections at N768, N1127 and N1227. If necessary, open N892, N1137 and N750 until supply is satisfactory. Before opening N892, close tapping on Labugama Transmission Main supplying Angoda Mental Hospital. Similarly, close tapping on pipeline on Kolonnawa Tower to harbour before opening N750.

Proceed to closure of next transmission main tapping

(11) Close valve at washout from Labugama Main at Kohilawatta Junction and gradually open the interconnection at N601.

Proceed to closure of next transmission main tapping

(12) Close valve at the tapping on pipeline from Kolonnawa Tower to Weragoda Tower (250 mm CI) and gradually open the interconnection at N407.

Proceed to closure of next transmission main tapping

(13) Close valve of pipeline at Bridge along M. D. H. Jayawardena Mawatha from Weragoda Tower and gradually open interconnection at N63.

Proceed to closure of next transmission main tapping

(14) Isolate Towns East water supply by closing valves on
- Udumulla Road and gradually opening interconnection at N 1014
- Galwalahena Road and gradually opening interconnection at N1019
- Angoda Road at Aggona Junction and gradually opening interconnection at N837

(15) Open interconnections at N297 and at N846 to increase pressure, if necessary.

4.5.3.16 Provision for Future Extensions

For roads which are not covered under this Project, provision has been made to install blind flanges on the pipelines for laying pipelines on those roads as provisional sum in the BOQ.

CHAPTER 5

CHAPTER 5

REHABILITATION & REINFORCEMENT OF MEDIUM AND LARGE DIAMETER PIPE NETWORK IN CMC

5.1 REHABILITATION OF MEDIUM AND LARGE DIAMETER PIPE NETWORK IN CMC

5.1.1 DESIGN CONDITIONS

5.1.1.1 Summary of Works

Table 5-1 below shows the road-wise details of the existing cast iron water mains to be rehabilitated by means of scraping and cement mortar lining.

Table 5-1 Existing CI Mains to be Rehabilitated

Rehabilitation of Medium & Large Dia. Pipe Network in CMC		Diameter (inch) & Length (m)				
Drawing No.	**Road Name**	**10"**	**12"**	**15"**	**18”**	**Total**
RML/DM/RH/01	Mattakkuliya Centre Road	660				660
RML/DM/RH/02	Aluthmawatha Road		510			510
RML/DM/RH/03	Aluthmawatha Road		570			570
RML/DM/RH/04	Aluthmawatha Road		120			120
RML/DM/RH/05	St. Andrew's Road		457			457
RML/DM/RH/06	Muthuwella Mawatha		630			630
RML/DM/RH/07	Muthuwella Mawatha		60			60
RML/DM/RH/08	Ellie House Road	310				310
RML/DM/RH/09	Lawer St. Andrew's Place		330			330
RML/DM/RH/10	Collage Street	1,100				1,100
RML/DM/RH/11	Kotahena Street	480				480
RML/DM/RH/12	George R. De Silva Mawatha		640			640
RML/DM/RH/13	George R. De Silva Mawatha		496			496
RML/DM/RH/14	Sumanatissa Mawatha			385		385
RML/DM/RH/15	Sangaraja Mawatha		649			649
RML/DM/RH/16	Panchikawatta Road		675			675
RML/DM/RH/17	Grandpass Road	650				650
RML/DM/RH/18	Grandpass Road	280				280
RML/DM/RH/19	Galle Road	280	360			640
RML/DM/RH/20	Galle Road	660				660
RML/DM/RH/21	Galle Road	650				650
RML/DM/RH/22	Galle Road	650				650
RML/DM/RH/23	Galle Road	335	165			500
RML/DM/RH/24	Galle Road	650				650
RML/DM/RH/25	Galle Road	439				439
RML/DM/RH/26	Quarry Road		396			396
RML/DM/RH/27	Allan Mawatha		340			340
RML/DM/RH/28	Union Place		650			650

Rehabilitation of Medium & Large Dia. Pipe Network in CMC		Diameter (inch) & Length (m)				
Drawing No.	**Road Name**	**10"**	**12"**	**15"**	**18”**	**Total**
RML/DM/RH/29	Union Place	171	464			635
RML/DM/RH/30	Foster Lane		285			285
RML/DM/RH/31	Bridge Street	206	305			511
RML/DM/RH/32	Sir Macan Marker Street	280				280
RML/DM/RH/33	Dharmapala Mawatha	600		650		1,250
RML/DM/RH/34	Dharmapala Mawatha	650		650		1,300
RML/DM/RH/35	Dharmapala Mawatha	530	38	303		877
RML/DM/RH/36	Elvitigala Mawatha			650		650
RML/DM/RH/37	Elvitigala Mawatha			625		625
RML/DM/RH/38	Kirillapone Avenue			650		650
RML/DM/RH/39	Kirillapone Avenue			115		115
RML/DM/RH/40	High Level Road			503		503
RML/DM/RH/41	Dickman's Road	600				600
RML/DM/RH/42	Dickman's Road	133				133
RML/DM/RH/43	Kumarathunga Munidasa Mawatha	555				555
RML/DM/RH/44	Serpentine Road	190				190
RML/DM/RH/45	Havelock Road	650				650
RML/DM/RH/46	Havelock Road	485				485
RML/DM/RH/47	Havelock Road	600				600
RML/DM/RH/48	Havelock Road	600				600
RML/DM/RH/49	Havelock Road	249				249
RML/DM/RH/50	Sea Street				607	607
RML/DM/RH/51	St. Anthony's Mawatha				301	301
RML/DM/RH/52	Sri Ramanathan Mawatha				643	643
Total		**13,643**	**8,140**	**4,531**	**1,551**	**27,865**

5.1.1.2 Existing Condition of Water Mains and Pipeline Routes

The water mains selected for rehabilitation are 50 to 100 years old. As verified at the site, these water mains are laid at a depth from 0.55 m to 1.35 m and with the system pressure ranging from 0.25 to 2 bars. Random cut samples exhibited heavy internal encrustation greatly impairing the flow capacity.

The existing pipes in CMC have generally been installed in close proximity to other utilities, such as power cables, telephone cables, etc. The detailed layout plans of existing telecom cables have been collected by the study team and they are kept at the project office for future reference.

The traffic condition in the roads shown on Drawing Nos. 1-18, 28-32, 50-52 in Table 5-1 is quite heavy during daytime and adequate precautions therefore need to be taken during the construction to divert the traffic through possible alternative routes with the permission of the concerned authorities.

The routes of the medium and large diameter water mains selected for rehabilitation are given in Drawing No.RML/DM/G-01.

5.1.2 SPECIFIC DESIGN CRITERIA

5.1.2.1 Scraping

In order to provide a clean internal surface to receive the lining, it is important to scrape and clean thoroughly the encrusted surface before commencement of the lining operation. Generally the process of cleaning can go up to a 50-200 m stretch of the pipeline in one single operation. However the length should be decided at site to suit the configuration of the distribution system. A minimum length of 50m is recommended for a single operation of cleaning.

The access pits will therefore be required at a minimum interval of 50 m in distance where the pipe configuration permits. They should be located at convenient points to minimize the traffic diversion. Once the access pits are established, the cleaning is performed using "drag" cleaning method or any other similar method acceptable to the Engineer. This is followed by a plunging operation with rubber disk to ensure that the main is free from fine residues.

5.1.2.2 Lining

The cement mortar lining comprises carefully graded fine sand and Portland cement mixture. The mixture is pumped through a flexible hose to the lining machine, which is gradually dragged inside the pipeline as application of the lining proceeds. The lining machine sprays cement mortar evenly on to the internal surface of the pipe creating an "orange peel" finish coating to the pipe wall. The surface finish is further improved by pulling a conical trowel behind the lining machine.

Materials

Cement
The cement used for the lining shall confirm to BS 4072 or other equivalent internationally accepted specification.

Sand
Sand shall be clean, well graded with no organic impurities and shall meet the requirement of BS 882 Part 2 for graded sand in accordance with Table 2, Zone 4. The sand shall contain no aggregate of size greater than one third of the minimum lining thickness. The sand shall be washed by the application of clean water during the final sieving process. Field mixing of sand shall not be permitted.

Water
Water used for the entire operation shall be of potable quality.

Cement Mortar
The cement mortar mix for lining pipes and fittings shall contain not less than one part of cement to one and a half to two parts of sand by weight.

The cement and sand should be thoroughly mixed with water to form a dense and homogenous mix. No mortar which has attained its initial set or has been mixed for more than one hour shall be used.

The cement mortar shall be uniformly applied to the interior surface of the pipe to create a lining concentric with the pipe section and should be of specified thickness and finish without variation in quality.

Lining shall be placed by centrifugal method and the lining machine shall be of such design as to provide for the projection of the mortar against the walls of the pipe at appropriate velocity. The machine shall be provided with trawling arrangement for smoothing the surface finish of the applied mortar.

Thickness of the Lining

The completed lining shall have an even finish complying with the following requirements.

Trawled to finish with the following mean thickness

150mm to 300 mm	= 5.0 mm
300 above and up to 600 mm	= 6.0 mm
Permitted deviation from the mean thickness	= ±1.5 mm

Special attention shall be given to ensure smoothness and coverage at pipe joints.

Sections of pipe removed for access purposes and all fittings not lined during main operation shall be separately lined with cement-mortar to the thickness prescribed above.

Lining through valves

Valve locations and tight bends should be used as far as possible as entry and exit points for lining.

Piecing-up and curing

As soon as practicable following completion of the lining of a section of pipe line or of a days' run of the lining machine, the completed section shall be pieced-up to prevent circulation of air. A sufficient amount of water shall be introduced into the section to create a moist atmosphere and keep the lining damp.

5.1.2.3 Testing of Lining

After the main has been cleaned and cement mortar lined, tests should be carried out to determine the coefficient "C" in the Hazen Williams formula for frictional head loss. The following C-Values shall be guaranteed by the contractor.

Nominal Pipe Diameter	Guaranteed Coefficient ("C" Hazen-Williams)
350-500 mm	125
300 mm	120
250 mm	115
200 mm	110
150 mm	100

5.1.2.4 Test Pressure

The test pressure of the main after rehabilitation is normally taken as 1.5 times the operating pressure. Since the maximum operating pressure is 2.0 bars, the test pressure to be applied shall be 3.0 bars.

5.1.3 DETAILED DESIGN CONSIDERATIONS

5.1.3.1 Isolation and Reconnection

Wherever possible, it is necessary to make available an isolated length or lengths of main between valves for reconditioning. However if the distance between the valves is found to be excessive or unsuitable, it is necessary to cut and cap the main to achieve the desired operating length.

Temporary caps should be properly anchored to resist the thrust applied and must have facility for draining down and charging of the mains.

If it appears that the water service will be interrupted for an extended period of time, adequate measures, (such as temporary interconnection between distribution main/or service mains and laying temporary by-pass or water tank to feed the consumers) should be provided to maintain an uninterrupted water supply to consumers.

5.1.3.2 Accessories

All the accessories on the proposed pipeline and valves immediately on the branch lines connected to the proposed main to be scraping and lining to be replaced with new accessories and valves.

5.2 REINFORCING MAINS

5.2.1 DESIGN CONDITIONS

5.2.1.1 Summary of works

The locations of the proposed reinforcing mains are shown in Drawing No. RMC/DM/G-2 and their diameters and lengths are given in Table 5-2 below.

Table 5-2 Proposed Reinforcing Mains

Reinforcement of Medium & Large Dia. Pipe Network in CMC area							
Drawing No.	**Road Name**	**300**	**350**	**400**	**450**	**500**	**Total**
RML/DM/RF/01	Dematagoda Road	650					650
RML/DM/RF/02	Dematagoda Road/Reservoir road				336		336
RML/DM/RF/03	School Lane	207					207
RML/DM/RF/04	Prince Of Wales Avenue				650		650
RML/DM/RF/05	Prince Of Wales Avenue				550		550
RML/DM/RF/06	Sir James Peiris Mawatha/Nawam Mawatha	632					632
RML/DM/RF/07	R.A. De Mell Mawatha/ Perahara Mawatha	510					510
RML/DM/RF/08	Alwis Place	176					176
RML/DM/RF/09	Mart Road/Sri Nigrodharama Mawatha	248					248
RML/DM/RF/10	Saranapala Himi Mawatha	650					650
RML/DM/RF/11	Saranapala Himi Mawatha	253					253
RML/DM/RF/12	Stace Road		650				650
RML/DM/RF/13	Stace Road		160				160
RML/DM/RF/14	Ward Place			650			650
RML/DM/RF/15	Ward Place			650			650
RML/DM/RF/16	Ward Place			146			146
RML/DM/RF/17	Bloemendhal Road					237	237
RML/DM/RF/18	Port Access Road					600	600
RML/DM/RF/19	Port Access Road					401	401
RML/DM/RF/20	Thimbirigasyaya Road	290					290
RML/DM/RF/21	Mahakumarage Mawatha				627		627
Total		**3,616**	**810**	**1,446**	**2,163**	**1,238**	**9,273**

5.2.2 SPECIFIC DESIGN CRITERIA

5.2.2.1 Types of Pipes and Fittings

In order to provide safety against the internal pressure and external load conditions and to suit the underground environment and traffic conditions ductile Iron pipes and fittings shall be used for the reinforcing mains.

5.2.2.2 Pipe Trench Bedding, Backfilling and Compaction

It is recommended to use the standard pipe trench wherever possible except for the Main Road crossings, Railway Crossings and Bridge crossings. The specified clear cover shall be maintained right along the pipeline line.

Bedding Material

Bedding material shall be as specified and as shown on drawings. Excavated material could be used as bedding material provided it conforms to the specifications. However if any soil material available at site is found to be unsuitable, proper material should be imported from burrow areas that need to be identified in consultation with the Engineer.

Backfilling and Compaction

Backfilling and compaction shall be carried out as per the specifications. The required degree of compaction should be achieved and tested at site.

5.2.3 DETAILED DESIGN CONSIDERATIONS

5.2.3.1 Types of Pipes and Fittings

Class K9 Ductile Iron Pipes and Fittings shall be used for the reinforcing mains and Steel pipes shall be used at bridge crossings at Stace Road and Navam Mawatha.

Because of weak subsurface conditions prevailing along the Port Access road, it is recommended to use restrained type of joints for the pipeline along this road.

5.2.3.2 Pipe Laying along Port Access Road

The Ports Authority has requested to exercise special care and attention while laying the pipeline along the maintenance road running parallel to the port access road. The following points should be taken into consideration during pipe laying operations:

- Because of very weak subsoil conditions, the road has been designed to sit on a sand mat 1 m in thickness
- Hence trench excavation should be carried out with minimum disturbance to the sand mat.
- Once excavated, the pipe should be laid and trench backfilled within the shortest possible time to avoid seepage of water through the sand mat that would result in washing down the material.

Due to reasons indicated above, it is recommended to perform pipe laying in stretches of a short length in that one section should totally be completed before proceeding with the excavation in the other section.

5.2.3.3 Section Valve Arrangement

The positioning of valves shall be arranged to facilitate the operation and maintenance of the distribution system. Generally section valves will be located at branches and on the main itself at an interval of 500 m in order to isolate the section when required.

5.2.3.4 Connection to Existing System

At present, the low pressure areas identified for improvement are fed directly from the transmission mains bypassing service reservoirs. Once all the proposed reinforcing mains have been connected to the existing distribution system and reservoir rehabilitation has been completed, tapings from the transmission mains should disconnected.

5.2.3.5 Air Valves

Air valves shall be provided at Station 710 in Dematagoda road, Station 335 in Prince of Wales Avenue , Station 622 in Navam Mawatha, Station 425 in Stace road, Station 71 in Bluemendhal Road and Station 590 and 1000 in Port Access Road. The type of the proposed air valves shall be double orifice Type B as given in Standard Drawing No. STD/C-03.

5.2.3.6 Fire Hydrants

Fire hydrants will be positioned at a distance of every 300 m mainly near the road junctions for flushing and fire fighting purposes. The details of the fire hydrant is given in Standard Drawing No STD/C-06.

5.2.3.7 Canal Crossing

There are two canal crossings at Stace Road and Navam Mawatha. The existing road bridge at Stace Road is owned by the Road Development Authority. A permission has already been granted from the Road Development Authority for laying the proposed main on the existing bridge. Navam Mawatha Bridge is owned by the Port Authority and for this too a permission has already been granted for constructing the proposed main on the existing bridge.

5.2.3.8 Railway Crossing

There are four railway crossings at the following locations:

1. At Station 185 along Dematagoda road
2. At Station 575 along Prince of Wales Avenue
3. At Station 143 along Sri Nigrodarama Mawatha(Base Line Mawatha)
4. At Station 80 along Bluemendhal Road.

For all these crossings, estimates were given by the Railway Authority for laying the casing as per Standard Drawing No. STD/C-07.

5.2.3.9 Culvert Crossings

There are three main drainage culvert crossings at Saranapala Himi Mawatha, School lane, and Jayantha Weerasekara Mawatha Junction. The details of the culvert crossing is given in Type “A” of Standard Drawing No. STD/C-01.

5.2.3.10 Washouts

Washouts shall be provided at major Troughs along the pipeline. The particular locations are as follows:

- School lane at the distance of 165 m,
- Prince of Wales Avenue at the distance of 1,187 m,
- R.A. D. Mel Mawatha at the distance of 10 m
- Port Access Road at the distance of 175 m & 700 m

Washout chambers will be provided which will drain to nearby drainage facility identified at site.

5.2.3.11 Pipe Anchorage and Thrust Blocks

Thrust blocks should be provided at all bends and tees along the pipeline in accordance with the requirements given in Standard Drawing No. STD/C-08.

5.2.3.12Testing and Disinfection

All pipelines shall be pressure-tested section by section followed by disinfection using calcium hypochlorite solution as specified. Test pressures for reinforcing mains shall be 7.5 bars.

5.3 REPLACEMENT OF VALVES

5.3.1 DESIGN CONDITIONS

5.3.1.1 Summary of works

All the existing valves attached to the water mains listed in Table 5-1 above will be replaced for a smooth execution of scraping and cement mortar lining operations. There are a total of 199 existing valves with diameter ranging from 7” to 30” as shown in Table 5-3 below.

In addition, 35 existing valves have been identified as being seriously undermining the operation and maintenance of the distribution system by CMC. The locations of those problematic valves are given in Drawing No. RML/DM/G-03. Their details are given in Table 5-4 below. They will be replaced as per the details shown in Standard Drawing No. STD/C-02.

Table 5-3 Existing Valves on Rehabilitation Mains

Diameter		Valves on Rehabilitation Mains
mm	Inch	
750	30	0
675	27	0
500	20	5
450	18	6
375	15	13
300	12	50
250	10	93
225	9	8
200	8	21
173	7	3
Total		199

Table 5-4 Problematic Valves

Serial No	Detail No	Road Junction	Diameter (inch)						Total
			10	12	15	20	27	30	
1	02	Prince of Wales Avenue/ St.Joseph's Street	1						1
2	04	Chatham Street / Hospital Street	1						1
3	05	Chatham Street / York Street (1) Along York Street (2) Along Chatham Street	2						2
4	03	Justice Akbar Mawatha/ Masjidul Jamia Road	1						1
5	03	Wekanda Road / Vithanage Road	1						1
6	01	Maradana Road/ Vajiragnana Mawatha	1						1
7	03	Muhandiramge Mawatha/ Hudson Road	1						1
8	01	W.A.Silva Mawatha / Havelock Road	1						1
9	04	Mahavidyala Mawatha / Central Road		1					1
10	03	Old Moor Street/ Hultsdorf Street		1					1
11	02	Maligakanda Road / Maradana Road		1					1
12	06	Anada Mawatha / Maradana Road		1					1
13	05	Temple Road / Maradana Road		2					2
14	01	Punchiborella Junction		1					1
15	02	Deans Road/ Dharmapala Mawatha		1					1
16	01	Leyards Road/ Lorenze Road		1					1
17	01	Thimbirigasyaya Road/ E.D.Dabare Mawatha		1					1
18	01	Olcott Mawatha/Saunders Place		1					1
19	03	Justice Akbar Mawatha/ Masjidul Jamia Road		1					1
20	03	Dharmapala Mawatha/ Union Place		1					1
21	02	Lauris Road / Galle Road			1				1
22	04	Bagathale Road / Galle Road			1				1

23	01	Walukarama Road / Galle Road			1				1
24	01	Collpity Lane / Galle Road			1				1
25	01	W.A.Silva Mawatha / Havelock Road			2				2
26	02	W.A.Silva Mawatha/ Galle Road			1				1
27	02	Aluthmawatha Road/ St. James Street				2			2
28	04	St .Sebestian Hill / Hultsdorf Street					1		1
29	02	Panchikawatta Road / Darly Road					1		1
30	02	C.W.W.Kannangara Mawatha/ Independence Avenue						1	1
31	04	Lipton Roundabout						1	1
Total			**9**	**13**	**7**	**2**	**2**	**2**	**35**

CHAPTER 6

CHAPTER 6

REPLACEMENT & REHABILITATION OF SMALL DIAMETER DISTRIBUTION MAINS IN CB1 AREA

6.1 REPLACEMENT OF SMALL DIAMETER MAINS AND VALVES

6.1.1 DESIGN CONDITIONS

6.1.1.1 Summary of Works

The existing 3", 4" and 5"cast iron mains proposed to be replaced are listed in Table 6-1 below. The locations of these existing mains are shown in Drawing No. RS/DM/G-01.

Table 6-1 Existing CI Mains to be Replaced

Serial No	Drawing No	Road Name	Length of the Pipe (m)			Total
			3"	4"	5"	
1	RS/DM/RP/01	1 st Cross Street			405	405
2	RS/DM/RP/02	2 nd Cross street			440	440
3	RS/DM/RP/03	3 rd Cross street	220			220
4	RS/DM/RP/04	4 th Cross street			425	425
5	RS/DM/RP/05	5 th Cross street		450		450
6	RS/DM/RP/06	Keysor street	145			145
7	RS/DM/RP/07	Main street	570	305		875
8	RS/DM/RP/08	Recalamation/Sea Beach Rd			475	475
9	RS/DM/RP/09	Malwatta Road		320		320
10	RS/DM/RP/10	Olcott Mawatha	420			420
11	RS/DM/RP/11	Maliban Street	400			400
12	RS/DM/RP/12	Prince Street	98	190	128	416
13	RS/DM/RP/13	Sameera's lane , Market St.China Lane,	278	94		372
14	RS/DM/RP/14	Butcher's St., China Lane				
15	RS/DM/RP/15	Gabos Lane	85			85
16	RS/DM/RP/16	Kadiration Road			510	510
17	RS/DM/RP/17	1 st Rohini Lane	90			90
18	RS/DM/RP/18	2 nd Rohini Lane	95			95
19	RS/DM/RP/19	Mayuri Lane	100			100
20	RS/DM/RP/20	Cafferman's Lane	65	145		210
21	RS/DM/RP/21	Lotus Road		490		490
22	RS/DM/RP/22	Sri Wickrema Mawatha	665		190	855
23	RS/DM/RP/23	Francewatta Road	400			400
24	RS/DM/RP/24	Mattakkuliya Farm Road		400	400	800
25	RS/DM/RP/25	Muthuwella Mawatha		690		690
26	RS/DM/RP/26	Muthuwella Mawatha				
27	RS/DM/RP/27	Sea Street		295	300	595
28	RS/DM/RP/28	Aluthmawatha Road		1,200		1,200

Serial No	Drawing No	Road Name	Length of the Pipe (m)			Total
			3"	4"	5"	
29	RS/DM/RP/29	Aluthmawatha Road				
30	RS/DM/RP/30	Modara Street		840		840
31	RS/DM/RP/31	Modara Street				
32	RS/DM/RP/32	Vivekananda Hill		544		544
33	RS/DM/RP/33	Madampitiya Road		240		240
34	RS/DM/RP/34	Bloemendhal Road	340	1,745		2,085
35	RS/DM/RP/35	Bloemendhal Road				
36	RS/DM/RP/36	Bloemendhal Road				
37	RS/DM/RP/37	Bloemendhal Road				
38	RS/DM/RP/38	Messenger Street		1,120		1,120
39	RS/DM/RP/39	Messenger Street				
40	RS/DM/RP/40	Quarry Road		455		455
41	RS/DM/RP/41	Hospital Road	220			220
42	RS/DM/RP/42	College Street		510		510
43	RS/DM/RP/43	Mattakkuliya Centre Road		265	400	665
44	RS/DM/RP/44	Upper St.Andrew's Place	330			330
45	RS/DM/RP/45	Ferguson Road			170	170
46	RS/DM/RP/46	Mayfield Lane	114	350		464
47	RS/DM/RP/47	Paramananda Mawatha	105	386		491
48	RS/DM/RP/48	Paramananda Mawatha				
49	RS/DM/RP/49	Bloemendhal Lane			160	160
50	RS/DM/RP/50	Arthur De Silva Mawatha		230		230
51	RS/DM/RP/51	Mattakkuliya Church Road		650		650
52	RS/DM/RP/52	Prince of Wales Avenue		1,117		1,117
53	RS/DM/RP/53	Prince of Wales Avenue				
54	RS/DM/RP/54	Prince of Wales Avenue				
55	RS/DM/RP/55	Prince of Wales Avenue				
56	RS/DM/RP/56	Nagalagam Street		785		785
57	RS/DM/RP/57	Nagalagam Street				
58	RS/DM/RP/58	Rajamalwatta Road		230		230
59	RS/DM/RP/59	St.Wilfred's Lane	270			270
60	RS/DM/RP/60	St.James Lane	145			145
61	RS/DM/RP/61	George R.de Silva Mawatha	450	1,270		1,720
62	RS/DM/RP/62	George R.de Silva Mawatha				
63	RS/DM/RP/63	Central Road		780		780
64	RS/DM/RP/64	New Moor Street			549	549
65	RS/DM/RP/65	Dam Street	215	641		856
66	RS/DM/RP/66	Dam Street				
67	RS/DM/RP/67	Hultsdorf Street		300	285	585
68	RS/DM/RP/68	Silversmith Street		560		560
69	RS/DM/RP/69	Mirania Street		350	215	565
70	RS/DM/RP/70	Sri Sangaraja Mawatha		855		855
71	RS/DM/RP/71	Sri Sangaraja Mawatha				
72	RS/DM/RP/72	Abdul Jabbar Mawatha	187			187
73	RS/DM/RP/73	Kelaniganga Mill Road		300		300
74	RS/DM/RP/74	Saunder's Place		250		250

Serial No	Drawing No	Road Name	Length of the Pipe (m)			Total
			3"	4"	5"	
75	RS/DM/RP/75	Lower St. Andrew's Place		320		320
76	RS/DM/RP/76	St. Anthony Street		637		637
77	RS/DM/RP/77	Mayfield Road		534		534
78	RS/DM/RP/78	Mayfield Road		144		144
79	RS/DM/RP/79	St. Josep's Street		570		570
Total			**6,007**	**21,557**	**5,052**	**32,616**

6.1.1.2 Replacement Plan

Table 6-2 shows the proposed replacement plan of the existing cast iron mains.

Table 6-2 Replacement Plan

Road Name	Existing CI Mains to be Replaced				Proposed PVC Mains			
	Diameter (inch) & Length (m)				Diameter (mm) & Length (m)			
	3"	4"	5"	Total	110	160	225	Total
1 st Cross Street			405	405		405		405
2 nd Cross street			440	440		440		440
3 rd Cross street	220			220	220			220
4 th Cross street			425	425		425		425
5 th Cross street		450		450		450		450
Keysor street	145			145	145			145
Main street	570	305		875		875		875
Recalamation/Sea Beach Rd			475	475		475		475
Malwatta Road		320		320		320		320
Olcott Mawatha	420			420			420	420
Maliban Street	400			400		400		400
Prince Street	98	190	128	416	288	128		416
St.China Lane, Butcher's St., China Lane	278	94		372	372			372
Gabos Lane	85			85		85		85
Kadiration Road			510	510		510		510
1 st Rohini Lane	90			90	90			90
2 nd Rohini Lane	95			95	95			95
Mayuri Lane	100			100	100			100
Cafferman's Lane	65	145		210	210			210
Lotus Road		490		490		490		490
Sri Wickrema Mawatha	665		190	855	665	190		855
Francewatta Road	400			400	400			400
Mattakkuliya Farm Road		400	400	800	400	400		800
Muthuwella Mawatha		690		690	690			690
Sea Street		295	300	595	295	300		595
Aluthmawatha Road		1,200		1,200		1,200		1,200
Modara Street		840		840	840			840
Vivekananda Hill		544		544	544			544
Madampitiya Road		240		240	240			240
Bloemendhal Road	340	1,745		2,085	2,085			2,085
Messenger Street		1,120		1,120	1,120			1,120
Quarry Road		455		455	455			455
Hospital Road	220			220	220			220
College Street		510		510	510			510
Mattakkuliya Centre Road		265	400	665	265	400		665
Upper St.Andrew's Place	330			330	330			330
Ferguson Road			170	170		170		170
Mayfield Lane	114	350		464	464			464
Paramananda Mawatha	105	386		491	491			491
Bloemendhal Lane			160	160		160		160
Arthur De Silva Mawatha		230		230	230			230
Mattakkuliya Church Road		650		650		650		650
Prince of Wales Avenue		1,117		1,117	1,117			1,117
Nagalagam Street		785		785	785			785
Rajamalwatta Road		230		230	230			230
St.Wilfred's Lane	270			270	270			270
St.James Lane	145			145	145			145
George R.de Silva Mawatha	450	1,270		1,720	1,720			1,720
Central Road		780		780	780			780
New Moor Street			549	549		549		549
Dam Street	215	641		856	856			856
Hultsdorf Street		300	285	585	300	285		585
Silversmith Street		560		560		560		560
Mirania Street		350	215	565	350	215		565
Sri Sangaraja Mawatha		855		855	855			855
Abdul Jabbar Mawatha	187			187	187			187
Kelaniganga Mill Road		300		300	300			300
Saunder's Place		250		250	250			250
Lower St. Andrew''s Place		320		320	320			320
St. Anthony Street		637		637	637			637
Mayfield Road		534		534	534			534
Mayfield Road		144		144	144			144
St. Josep's Street		570		570	570			570
Total	6,007	21,557	5,052	32,616	22,114	10,082	420	32,616

6.1.2 SPECIFIC DESIGN CRITERIA

6.1.2.1 Types of Pipes and Fittings

It is proposed that Type 600 PVC pipes be used for replacement. In designing the "laying" details of the pipelines, particular attention shall be paid to the safety against internal and external pressure conditions, the underground environment and traffic loading. The system pressure in the small diameter pipe network varies from 1 to 2 bars in the respective areas of the distribution system.

In general, the existing water mains listed in Table 6-1 shall be replaced with PVC mains with rubber ring joints. The proposed mode of replacement is:

3" ⟶ PVC 110 mm (Rubber Ring Joint)
4" ⟶ PVC 110 mm (Rubber Ring Joint)
5" ⟶ PVC 160 mm (Rubber Ring Joint)

However, in some low pressure areas, a larger diameter PVC main will be used for replacement as shown in the table below.

Road Name	Diameter of Existing CI Pipe (inch)	Diameter of Proposed PVC Pipe (mm)
5 th Cross street	4	160
Main Street	3 & 4	160
Malwatta Road	4	160
Olcott Mawatha	3	225
Maliban Street	3	160
Gabos Lane	3	160
Lotus Road	4	160
Aluth Mawatha	4	160

6.1.2.2 Bedding, Backfilling and Compaction of Pipe Trench

It is recommended that bedding, backfilling and compaction shall conform to the requirements specified in Standard Drawing No. STD/C-08.

Bedding Material

If the material available at the site is not in sound condition, borrow areas shall be identified for importation of suitable backfilling material conforming to Specifications.

Backfilling and Compaction

Backfilling and compaction should be carried out as per the specifications using suitable backfilling material that conforms to the Specifications.

6.1.3 DETAILED DESIGN CONSIDERATIONS

6.1.3.1 Sectional Valve Arrangement

The valves on the proposed mains will be arranged to facilitate operation and maintenance similar to the existing distribution system. In general, valves will be located at branches and on the main at an interval of 300 m in order to isolate the section as and when required.

6.1.3.2 Connection to the Existing Mains

The survey conducted by the study team revealed that approximately 80% of the existing pipes are laid at a shallow depth. Connecting new mains to existing mains shall be carried out as shown in Standard Drawing No.STD/C-10.

6.1.3.3 Air Valves

Air valves will be provided at all humps and shall be single orifice type. They shall be installed as shown "Type A" given in Standard Drawing No. STD/C-03.

6.1.3.4 Fire Hydrants

Fire Hydrants will be located every 300m distance mainly near the road junctions for flushing and fire fighting purposes as per Standard Drawing No.STD/C-06.

6.1.3.5 Canal Crossing

If any canal crossing, pipe will be laid along the pavement of the bridge adopting the same arrangement as for the existing small diameter pipeline.

6.1.3.6 Culvert Crossing

Culvert crossings, if any, shall be carried out conforming to the guidelines shown in Standard Drawing No. STD/C-01

6.1.3.7 Washouts

Washouts will be provided at all troughs generally near existing drainage facility. Washout chambers will be provided which will drain to nearby drainage facility as shown in Standard Drawing No. STD/C-04.

6.1.3.8 Pipe Anchorage and Thrust Blocks

Thrust blocks will be provided at all sections of pipeline where standard bends are used to counter the unbalanced forces. The details of thrust blocks are shown in Standard Drawing No. STD/C-08.

6.1.3.9 Disinfection and Testing

Before completing backfilling, all new mains shall be pressure tested and disinfected in segments. The test pressure to be applied for testing shall be 3 bars.

6.1.3.10 Service Connections

All the existing service connections on the cast iron mains to be replaced shall be removed and new service connections with MDPE pipes shall be provided from the new PVC mains as per Standard Drawing No. TD/C-09.

6.2 REHABILITATION OF SMALL DIAMETER MAINS

6.2.1 DESIGN CONDITIONS

6.2.1.1 Summary of Works

Table 6-3 below shows the road-wise details of the existing 6" cast iron mains, which will be reconditioned by means of scraping and cement mortar lining. The locations of these mains are given in Drawing No. RML/DM/G-02.

Table 6-3 Existing CI Mains to be Rehabilitated

Existing 6"Mains to be Reconditioned		
Drawing No.	**Road Name**	**Pipe Length (m)**
RS/DM/RH/1	Sri Wickrema Mawatha	340
RS/DM/RH/2	Vystwyke Road	650
RS/DM/RH/3	Bloemendhal Road	2,240
RS/DM/RH/4	Bloemendhal Road	
RS/DM/RH/5	Bloemendhal Road	
RS/DM/RH/6	Walls lane	365
RS/DM/RH/7	Upper St.Andrew's Place	165
RS/DM/RH/8	Paramananda Mawatha	130
RS/DM/RH/9	Bloemendhal Lane	160
RS/DM/RH/10	Prince of Wales Avenue	1,588
RS/DM/RH/11	Prince of Wales Avenue	
RS/DM/RH/12	Prince of Wales Avenue	
RS/DM/RH/13	Hultsdorf Street	460
RS/DM/RH/14	Silversmith Street	30
RS/DM/RH/15	Elie House Lane	185
RS/DM/RH/16	Mayfield Road	210
RS/DM/RH/17	Mayfield Road	308
RS/DM/RH/18	Mattakkuliya Church Road	650
Total		**7,481**

6.2.2 SPECIFIC DESIGN CRITERIA

(Specific design criteria given in Section 5.1.2 of Chapter 5 shall apply.)

6.2.3 DETAILED DESIGN CONSIDERATIONS

(Section 5.1.3 of Chapter 5 shall apply.)