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

MAIN REPORT

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.

PREFACE

In response to the request of the Government of the Democratic Socialist Republic of Sri Lanka, the Government of Japan decided to conduct a 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 and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Sadanobu Sawara of Nihon Suido Consultants Co., Ltd. to Sri Lanka, two times between January 2000 and January 2001.

The team held discussions with the officials concerned of the Government of Sri Lanka and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

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

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

March 2001

Kunihiko Saito
President
Japan International Cooperation Agency

March 15, 2001

Mr. Kunihiko Saito
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

Dear Sir,

We are pleased to submit the Final Report on 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 report incorporates the views and suggestions of the authorities concerned of the Government of Japan and your Agency. It also includes the comments made by the National Water Supply and Drainage Board on the Draft Final Report dated January 2001.

The Final Report comprises a total of twenty-one volumes as listed below.

1. Executive Summary
2. Main Report
3. Appendices to Main Report
4. Design Report on the Contract for Civil Works
5. Appendices to Design Report on the Contract for Civil Works
6. Design Report on the Contract for Leak Repair Works
7. Design Report on the Contract for Low Income Settlement Environmental Improvement
8. Prequalification of Contractors for Civil Works
9. Prequalification of Contractors for Leak Repair Works
10. Prequalification of Contractors for Low Income Settlement Environmental Improvement
11. Tender Documents for Civil Works (Volume 1)
12. Tender Documents for Civil Works (Volume 2)
13. Tender Documents for Civil Works (Volume 3, A3 size)
14. Tender Documents for Civil Works (Volume 3, A1 size)
15. Tender Documents for Leak Repair Works
16. Tender Documents for Low Income Settlement Environmental Improvement

17. Cost Estimate on Civil Works
18. Cost Estimate on Leak Repair Works
19. Cost Estimate on Low Income Settlement Environmental Work
20. Supplementary Data on Tender Documents for Civil Works
21. Quantity Survey Sheets for Civil Works

This Main Report, together with the appendices thereto, discusses the methodologies and approaches used in the study as well as the findings, conclusions and recommendations derived from the study.

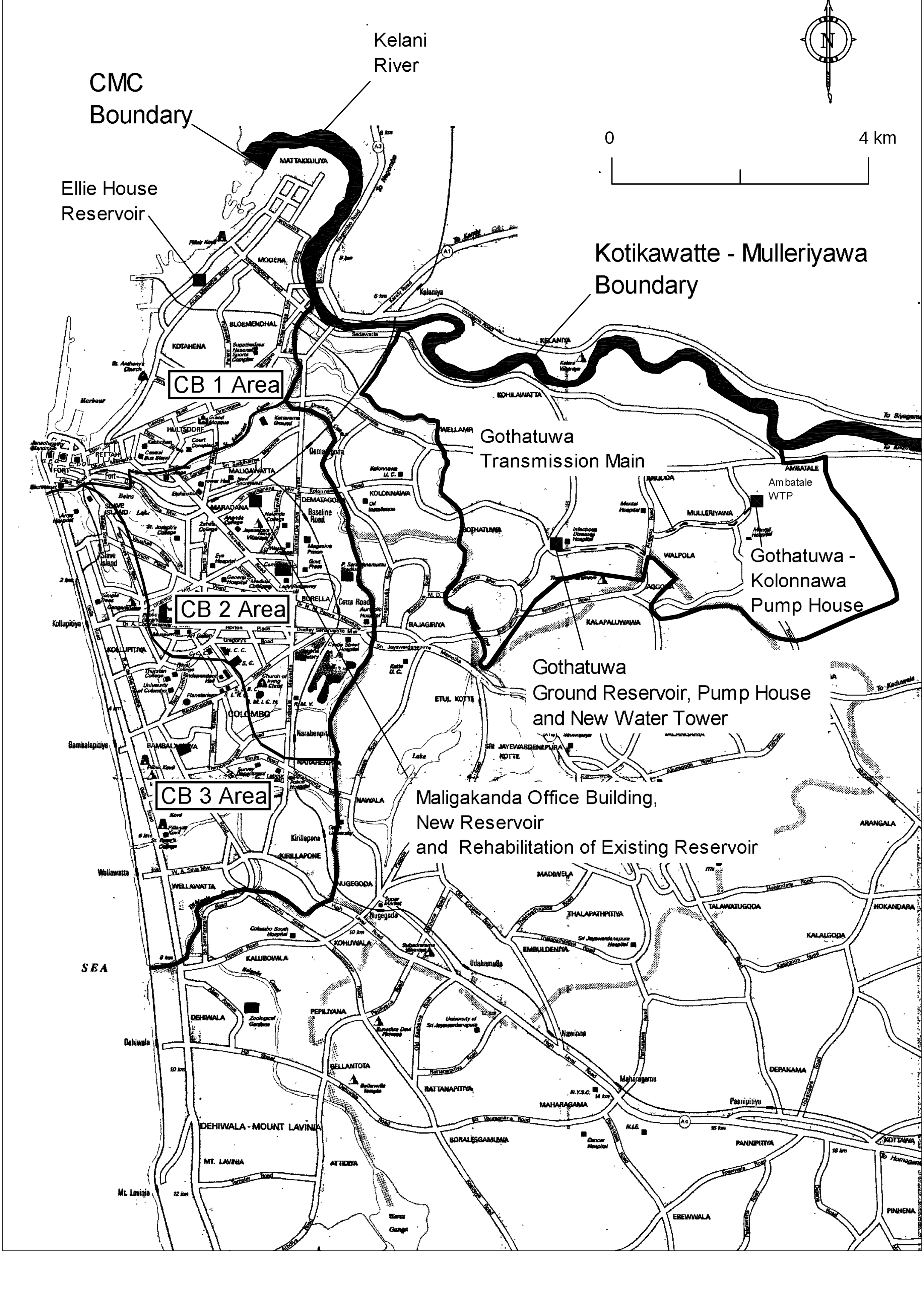
We wish to take this opportunity to express our sincere gratitude to your Agency and the Ministry of Foreign Affairs for their valuable suggestions and advice. We would also like to express our deep appreciation to the relevant officers of the National Water Supply and Drainage Board, Ministry of Urban Development, Construction and Public Utilities and other related agencies of the Government of the Democratic Socialist Republic of Sri Lanka for their cooperation and assistance extended to us during our study.

Very truly yours,

讃良貞信

Sadanobu SAWARA
Team Leader, 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

Project Location Map



EXECUTIVE SUMMARY

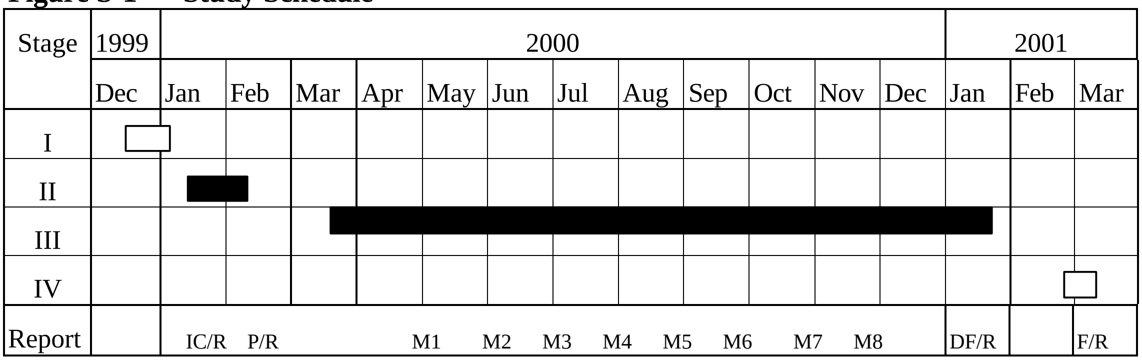
1. Background and Objective of the Study

On August 4, 1999, a Japanese ODA loan was signed between GOSL and JBIC for the implementation of the Project for Reduction of Non-Revenue Water (Loan Agreement No. SL-P66).

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

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

Figure S-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

2. Scope of the Project

During the course of the JICA detailed design study, several changes have been made to the scope of the JBIC loan project. The original scope of the JBIC loan project and that finally adopted in this JICA detailed design study are summarized in Table S-1

3. Project Cost

The project cost has been estimated as shown in Table S-2.

Table S-2 Project Cost

No.	Item	Cost (Yen)
A	Civil Works Contract	3,573,164,788
A1	Preliminary and General Works	539,584,706
A2	Rehabilitation of Maligakanda Reservoir and Ellie House Reservoir	1,318,680,956
A3	Water Supply Enhancement in Kotikawatte and Mulleriyawa Area	846,292,757
A4	Rehabilitation and Reinforcement of Medium and Large Diameter Pipe Network in CMC Area	470,188,753
A5	Rehabilitation of Small Diameter Distribution Mains in CB1 Area	274,924,852
A6	Supply of Materials and Equipment for Reduction of NRW	123,492,764
B	Leak Repair Works Contract	154,849,512
C	Low Income Settlement Environmental Improvement Contract	20,257,613
	Sub-Total for Three Contracts (A+B+C)	3,748,271,912
D	Consulting Service	389,177,139
E	Interest During Construction and Service Charge	177,049,549
	Sub-Total for JBIC Loan Part	**4,314,498,601**
F	Project Administration Cost	64,717,555
G	Land Acquisition Cost	27,400,358
H	Custom Duties	244,736,783
I	GST	446,646,072
	Sub-Total for NWSDB Part	**783,500,767**
	Total Project Cost	**5,097,999,368**

4. Project Implementation Schedule

The project is estimated to be implemented during the five years from early 2002 through late 2006 as shown in Figure S-2.

5. Disbursement of Project Cost

The project cost is estimated to be disbursed as shown in Table S-3.

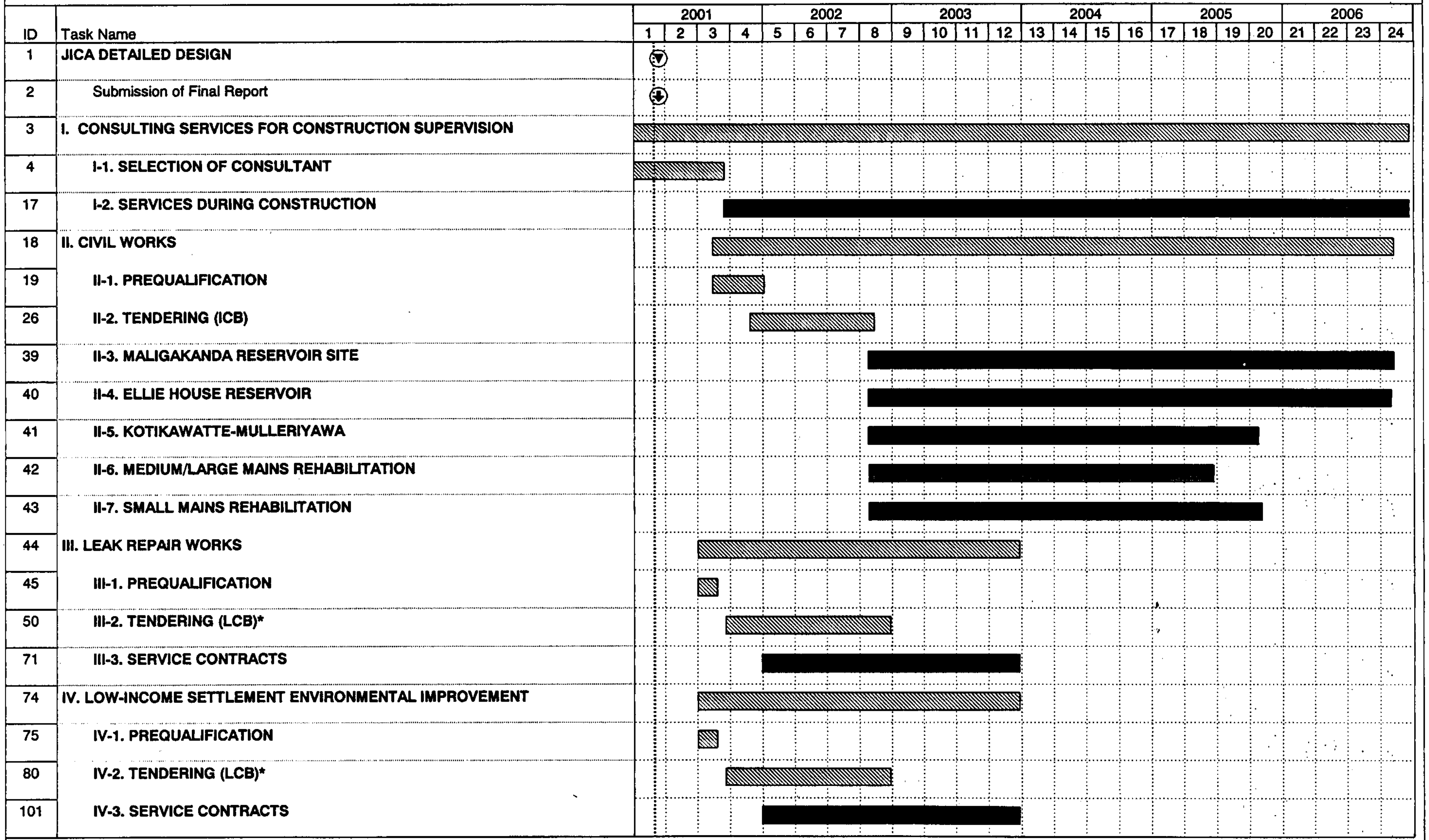
Table S-3 Disbursement of Project Cost (1,000 yen)

Project Cost	2001	2002	2003	2004	2005	2006	Total
JBIC Loan Part	7,850	514,358	1,182,019	1,415,647	724,322	470,303	4,314,499
NWSDB Part	33,872	74,298	198,853	276,100	193,906	6,472	783,501
Total	41,722	588,656	1,380,872	1,691,747	918,228	476,775	5,098,000

Table S-1 Scope of the Project

Project Component		Original Scope (JBIC Loan)	Final Scope (JICA Detailed Design)
A	**Civil Works Contract（ICB）**		
A1	Rehabilitation of Maligakanda Reservoir and Ellie House Reservoir	New Office Building at Battaramulla (3,000 m^2)	New Office Building at Maligakanda (3,100 m^2)
		Maligakanda New Reservoir (28,400 m^3)	Maligakanda New Reservoir (22,000 m^3)
		Rehabilitation of the Roof Structure of the Existing Maligakanda Reservoir	Same as left. (However, the final decision on whether or not the rehabilitation should actually be implemented will be made taking into account the results of the detailed structural assessment of the existing reservoir, which will be conducted by NWSDB after completion and commissioning of the Maligakanda New Reservoir.)
		Rehabilitation of the Roof Structure of the Existing Ellie House Reservoir（36,300 m^3）	Demolition of the Entire Existing Reservoir and Construction of A New Reservoir (36,600 m^3)
A2	Water Supply Enhancement in Kotikawatte and Mulleriyawa Area	Transmission Main 2.4 km（Dia.500 mm）	Transmission Main 4.36 km、(Dia.500 mm～800 mm)
		Distribution Main 4.71 km（Dia.75 mm～150 mm）	Distribution Main 39.7 km（Dia.100 mm～500 mm）
		Mulleriyawa Reservoir（2,000 m^3）	Gothatuwa Reservoir（4,400 m^3）
		Mulleriyawa Water Tower（1,500 m^3）	Gothatuwa Water Tower (1,500 m^3)
		Gothatuwa Pump Station（1.5 m^3/min. x 27 m）	Gothatuwa-Kolonnawa Transmission Pump House（14 m^3/min. x 50 m）
		Mulleriyawa Pump Station（9 m^3/min. x 40 m）	Gothatuwa Pump House（18 m^3/min. x 30 m）
A3	Rehabilitation and Reinforcement of Medium and Large Diameter Pipe Network in CMC	Pipe Rehabilitation 28.45 km (Dia.10”～30”)	Pipe Rehabilitation 27.9 km (Dia.250 mm～450 mm)
		Pipe Reinforcement 8.8 km (Dia.300 mm～500 mm)	Pipe Reinforcement 9.3 km (Dia.300 mm～500 mm)
		Rehabilitation/Replacement of Valves and Installation of Valve Covers	Replacement of Valves and Installation of Valve Covers
A4	Rehabilitation of Small Diameter Distribution Mains in CB1	Pipe Rehabilitation 33 km (Dia.50 mm～150 mm)	Pipe Rehabilitation 7.5 km (Dia.6”)
		Pipe Replacement 5.55 km	Pipe Replacement 32.6 km (Dia.3”～5”)
		Rehabilitation/Replacement of Valves and Installation of Valve Covers	Replacement of Valves and Installation of Valve Covers
		Rehabilitation/Replacement of Service Pipes	Replacement of Service Pipes
B	**Leak Repair Works Contract（LCB）**	Repair of 2,340 Leaks in Distribution Mains and 9,000 Leaks in Service Mains in CMC	Same as left.
C	**Low Income Settlement Environmental Improvement Contract（LCB）**	Provision of Individual Connections at 30 Low Income Settlements in CB1	Same as left.

Figure S-2 Project Implementation Schedule



JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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

MAIN REPORT

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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

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)

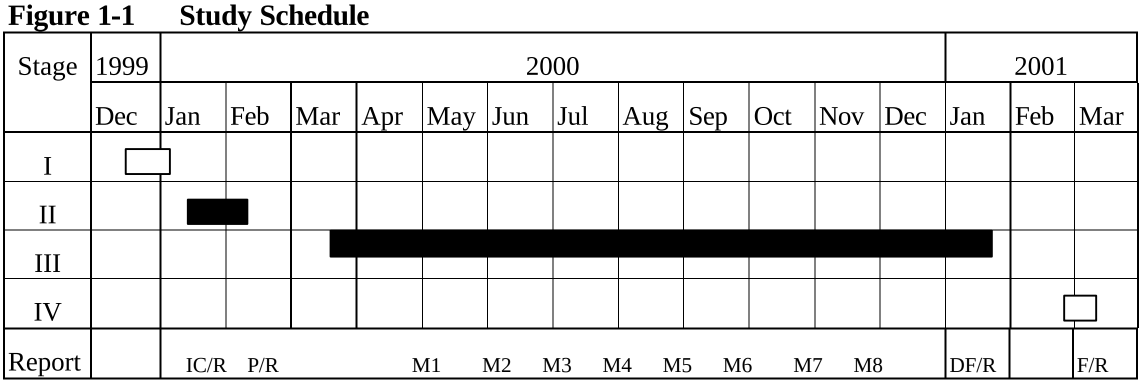
- Implementation of the component (b) of NRW Action Program

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 JBIC LOAN (LOAN AGREEMENT NO. SL-P66)

As mentioned earlier in Section 1.1, the JBIC loan for implementation of this project (Loan Agreement No. SL-P66) was signed on August 4, 1999 between GOSL and JBIC.

Details of the JBIC loan are summarized as follows:

(a) Loan Agreement No: SL-P66

(b) Date of Signing: August 4, 1999

(c) Project Title: The Project for Reduction of Non-revenue Water

(d) Loan Amount: Four Billion Two Hundred Seventeen Million Japanese Yen (¥4,217,000,000)

(e) Signed Between: The Japan Bank for International Cooperation ((JBIC) and The Government of Democratic Socialist Republic of Sri Lanka

(f) Executing Agency: National Water Supply and Drainage Board (NWSDB)

(g) Effective Date of Loan Agreement: December 1, 1999

(h) Effective Period of Loan Agreement: 7 years from December 1, 1999 through December 1, 2006 (Final disbursement shall be made not later than December 1, 2006)

(i) Percentage of Expenditure to be Financed:

Category		% of Expenditure to be Financed
(A)	Civil works	100
(B)	Leak Repair and Illegal Connection Reduction	100
(C)	Low Income Settlement Environmental Improvement	100
(D)	Consulting Services	100
(E)	Interest during Construction	
	(i) with respect to (A), (B), and (C)	-
	(ii) with respect to (D)	-
(F)	Contingencies	-

(j) Interest Rate and Method of Payment Thereof:

- 1.3 % per annum for Categories (A), (B), (C), and (E)-(i)
- 0.75 % per annum for Categories (D) and (E)-(ii)

To be paid semi-annually on August 20 (February 20 to August 19) and February 20 (August 20 to February 19)

(k) Grace Period for Repayment of Principal: 10 years

(l) Repayment Period of Principal:

- 20 years (from August 20, 2009 through August 20, 2029) for Categories (A), (B), (C), and (E)-(i), plus (F) if used with respect to (A), (B), (C), and (E)-(i)
- 30 years (from August 20, 2009 through August 20, 2039) for Categories (D) and (E)-(ii), plus (F) if used with respect to (D) and (E)-(ii)

(m) Items Not Eligible for Financing:

- General administration expenses
- Taxes and duties
- Purchase of land and other real property
- Compensation
- Other indirect items

(n) Eligible Source Countries:

- All countries and areas for procurement of all goods and services, except for consulting services
- Democratic Socialist Republic of Sri Lanka and Japan for procurement of consulting services

(o) Disbursement Procedure:

- Commitment Procedure for the Suppliers of Eligible Source Countries with respect to the portion of contract stated in the currency other than Sri Lankan Rupee, and with 0.1 % of the amount of the Letter of Commitment to be paid to JBIC by the Borrower on the issuing date of the Letter of Commitment as the Service Charge.
- Reimbursement Procedure for the Suppliers of Sri Lanka, and to the Suppliers of Eligible Source Countries with respect to the portion of contract stated in Sri Lankan Rupee, with 0.1 % of the amount disbursed to be paid to JBIC by the Borrower on each disbursement as the Service Charge.

1.3 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

2 CONSTRUCTION AND REHABILITATION OF RESERVOIRS

2.1 SCOPE OF JBIC LOAN

The JBIC loan includes the following budget allocations under rehabilitation of reservoirs:

Table 2-1 JBIC Loan Budget Allocation

III	Rehabilitation of Reservoirs	Total (Yen)
a.	Rehabilitation of Ellie House Reservoir	283,921,176
b.	Rehabilitation of Maligakanda Reservoir	283,921,176
c.	New reservoir at Maligakanda 28,400 m^3	444,262,336
d.	Office relocation 3,000 m^2	93,858,240
Sub-total		1,105,962,928

The scope of work and cost for Rehabilitation of Ellie House Reservoir and Maligakanda Reservoir was based on replacement of the roof structure in accordance with previous studies that were commissioned by NWSDB.

The scope and cost for relocation was based on constructing a simple 3,000 m^2 building at a unit cost of 16,000 Rs/m^2.

The original scope of work has changed as result of feasibility studies carried out by the study team and requests made by NWSDB. The following changes have been agreed:

Table 2-2 Changes to Scope of Work

Items Changed	Original Scope	Revised Scope
Rehabilitation of Ellie House Reservoir	Replacement of roof	New reservoir and valve house, 36,600 m3
Capacity of the new Maligakanda reservoir	28,400 m3	22,000 m3
Location of new office	2 storey building located in Battaramula	4 storey building with lift located at Maligakanda

2.2 DESIGN REQUIREMENTS FOR WATER RETAINING STRUCTURES

2.2.1 Design Standards

All water retaining structures are designed according to the limit states design philosophy in accordance with British Standard BS 8007: 1987 Design of concrete structures for retaining aqueous liquids and Specifications for protection of concrete against sulphate attack are taken from Table 17 of BS8004 – Foundations 1986.

Other standards referred to in the design and in the specification include:
BS 8110: Structural use of concrete Part 1 – Code of practice for design and construction
BS 8004 – Foundations
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

2.2.2 Design Approach

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:
   - 0.2 mm max
   - 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.
   - 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 pre-stressed elements are 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:
   - 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.

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

2.2.3 Protective Coatings Inside Reservoirs

(1) Historical context

A paper entitled "The History of Colombo Waterworks" published in 1931 by the Engineering Association of Ceylon" indicates that Colombo potable water had a disintegrating effect on concrete surfaces of reservoirs. The paper states that it was necessary to line the walls and floors of Ellie House reservoir with special cement rendering to protect the concrete.

A review of present day water quality data confirms that Colombo water has a tendency to dissolve any calcium carbonate from the concrete surface or in its absence to corrode steel thereby compromising the long-term durability of reservoir structures. The study team recommends a protective coating to all inside surfaces of the reservoir in contact with water.

(2) Langelier and Ryznar Indexes

The aggressiveness of water towards concrete can be characterized by the Langelier Saturation Index (LI) and pH. The LI index is used in Table 4.1 of the Australian Standard AS 3735-1991 Concrete structures for retaining liquids classification exposure levels and the measures required for protection.

LI= pH of water – pHs when in equilibrium with calcium carbonate

Langelier Saturation Index is a very useful tool to determine whether or not particular water is likely to dissolve calcium carbonate or to deposit. The pH of water when saturated with calcium carbonate is known as saturation pH (pH_S) and the difference between the original pH of the water and the saturation pH is the Langelier Index. A negative LI indicates that the water will tend to dissolve the lime in concrete, while a positive figure indicates that carbonates in the water may be deposited.

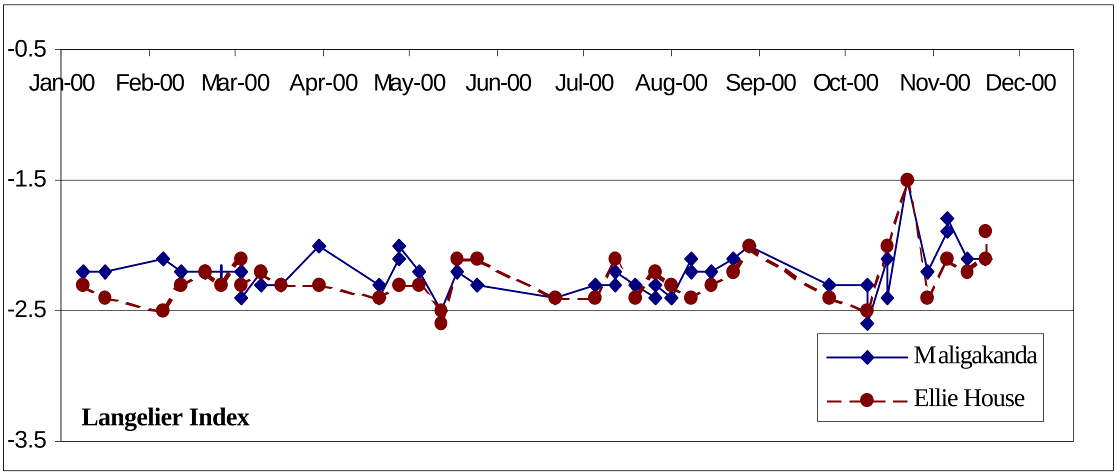
The Langelier equation has been slightly modified by other investigators. Ryznar has proposed the stability index, which is twice the saturation pH (pH_S) minus actual pH of water. Water with stability index 6 or 7 will be neither scaling nor corrosive. Water with stability index above 7 is corrosive. It should be noted that the Ryznar index is an alternative to using the Langelier Saturation Index. The study team has calculated both the Langelier Saturation Index and the Ryznar index to assess the whether or not potable water has corrosive tendencies.

(3) Colombo Water

Water quality data from tests carried out by NWSDB from January to November 2000 was collected and processed to calculate the Langelier Saturation Index (data is provided in Appendix 2A). The LI index, shown in Figure 2.1, is negative and fluctuates around –2.3 which indicates high corrosion potential. The pH value varies between 6.4 and 7.2 with an average of 6.8. The Ryznar index was also calculated and an average value of 11.3 confirms that the water is corrosive.

The study team asked an independent laboratory, the Industrial Technology Institute, to carry out tests on water samples taken from Ellie House and Maligakanda reservoirs on 13 November 2000 (refer to Appendix 2A). Although the results indicate higher pH values (more alkalinity) the Langelier Index remains negative confirming that the water is likely to dissolve calcium carbonate in the concrete surface.

Figure 2-1 Range of Langelier Index (Year 2000)



(4) Design for Durability

There is no question that treated water in Colombo will cause the concrete to degrade over time however the rate of concrete "corrosion" cannot be predicted.

Design practice identified in standards varies widely when it comes to design for durability. Protective measures generally fall into one of three categories:

- Increase the characteristic strength of concrete (denser concrete reduces the pore spaces)
- Increase cover to reinforcement (provides longer lasting protection for reinforcement steel)
- Provide a protective coating (prevents water from attacking the structural concrete)

The Australian Standard for concrete structures for retaining liquids AS 3735 considers the Langelier Index and pH as a simple indicator of the applicable exposure classification. The standard specifies that for a negative LI and pH less than 6.5 the cover to reinforcement should be increased from 45mm to 75mm for grade 32 concrete. (40mm to 50mm for grade 40 concrete).

Internal Surface Coating is an effective alternative to using higher density concrete and increased cover in water reservoirs. The coating acts as a seal to protect the concrete. A coating not only protects the structural concrete but also provides a smooth and non-porous surface that is easier to clean. This inner coating is also a wearing course, which can be replaced if necessary if the water is corrosive. Without this wearing course, corrosion occurs in the actual reinforced concrete structure, which soon leads to more serious damage, particularly if the steel reinforcement corrodes.

(5) Recommendations

All new reservoirs are designed in accordance with the BS 8007:1987 with a characteristic compressive cube strength of 35 N/mm^2 for reinforced concrete elements and a 40 mm concrete cover to limit crack width. Trying to meet the requirements of AS3735 has several disadvantages:

- Increasing the grade of concrete can be achieved by increasing the cement content however it increases the potential for quality control problems.
- Increased strength also has an impact on the amount of reinforcement steel provided.
- Increasing the cover to reinforcement as the amount of reinforcement needs to be increased to limit crack width.

The simplest and most cost effective way to protect the concrete structures from exposure to aggressive water is to provide a protective coating for the surface in contact with water.

Cementitious sealing mortar or epoxy resin coating systems are available. Epoxy is longer lasting but more expensive and difficult to apply correctly. The study team recommends using a Cementitious mortar. The approximate costs for providing protective a Cementitious coating to all reservoirs are indicated in Table 2-3:

Table 2-3 Approximate Costs of Protective Coatings

Reservoir	Surface Areas m^2	Rate Rs./m^2	Cost of Coating Rs.
Maligakanda New Reservoir			
Wall	1,602	2,000	3,204,000
Columns	1,018	2,000	2,036,000
Base	2,043	2,000	4,086,000
Total	4,663	2,000	9,326,000
Ellie House Reservoir			
Wall	3,385	2,000	6,770,000
Columns	1,246	2,000	2,492,000
Base	6,444	2,000	12,888,000
Total	11,075	2,000	22,150,000
Gothatuwa- Kolonnawa sump			
Wall	414	2,000	828,000
Base	64	2,000	128,000
Total	478	2,000	956,000
Gothatuwa Ground Reservoir			
Wall	1,165	2,000	2,330,000
Columns	135	2,000	270,000
Base	832	2,000	1,664,000
Total	2,132	2,000	4,264,000
Gothatuwa Tower	709	2,000	1,418,000

Note: cost are approximate budget estimates for evaluation purposes.

The cost of coating the reservoirs with Cementitious mortar will be roughly between 5% to 7% of the cost of the structure. The total cost of coating would be about Rs. 38 million, which is roughly 1.6% of the total civil works budget.

(6) Notes Regarding Inspection and Monitoring

NWSDB should inspect all reservoirs annually to monitor the rate of deterioration if any. Furthermore, water quality should be monitored and the Langelier index calculated periodically to identify trends or changing conditions.

2.3 MALIGAKANDA OFFICE BUILDING

2.3.1 Background

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. The budget allocated in the JBIC loan is based on providing a building equivalent in size and function to the buildings presently used by CMC.

At the end of the first work period in Sri Lanka (refer to Progress Report February) the NWSDB identified that the new office building would be used by both CMC and NWSDB. The site initially selected by NWSDB was located in Battaramula. Net office space requirements were identified by NWSDB totalling 2740 m^2 net. No other requirements were submitted.

In April (Monthly Report No.1), CMC objected to the Battaramula location because it was outside the municipal boundary and too far from their centre of operations. Instead, CMC proposed that the building be located at Maligakanda reservoir site on land owned by CMC and presently occupied by the abandoned municipal courts building.

The Study team was asked to prepare concept drawings for a 3,000 m^2, 4 storey building that would fit the selected site. Office and floor space requirements were provided by CMC and NWSDB with the idea that both organizations would share the space. NWSDB specified that the building should have a lift to service all floors and that the building should be designed with a central air-conditioning system or provisions for future central air conditioning if the cost exceeded the budget. Conceptual elevations and floor plans were submitted in Monthly Report No.2 end of May. The total floor area including utility rooms totalled 3,000 m^2

During the month of June the study team revised the floor plans trying to fit the changes in space allocation requested by NWSDB and CMC. At one stage the net requirement for office space grew to 3,600 m^2 but in discussions with NWSDB/CMC this was subsequently reduced to approx. 3,000 m^2.

The dimensions of the building and column grid spacing were adjusted to increase the total useful floor space. A final occupancy schedule was agreed resulting in 2,528 m^2 net useable space and 640 m^2 for corridors, stairs, lobbies and lift core. Pre-design drawings, occupancy schedule and list of proposed building finishes were presented at end of June (Monthly Report No.3) for approval before proceeding with detailed design.

The pre-design concept was approved and the study team was asked to proceed with detailed design. Code requirements, design criteria and structural calculations are presented in the Design Report. A design brief is given in the following paragraphs highlighting the main features of the building

2.3.2 Architectural

(1) 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.

A detailed description of the building is provided in the Design Report Section 3.1. The main points of interest are summarized as follows:

Table 2-4 Building Characteristics

Site area	3,220 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 (AGF)	17.68 m
Third floor slab (AGF)	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 m^2 (gross) per floor and a total area of 3,168 m^2 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.

(2) Code requirements and by-laws

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 to meet specific requirements or concerns expressed by NWSDB.

Regulations and restrictions pertaining to the proposed office buildings are summarized in Table 2-5.

Table 2-5 Summary of Building Code Requirements (1/3)

Regulation	**Provisions made**
Road allowances and floor heights	
Minimum width of the road – 6 m	6 m existing, 9 m proposed
Rear space required 3.5 m	Provided
Lift and stand by generator	Provided
Minimum width of the building – 6 m	18 m
Height of the rooms on the ground floor shall be not less than 3 m	provided
Upper floors 2.8 m	provided

Table 2-5 Summary of Building Code Requirements (2/3)

Regulation	Provisions made
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 200 sqm 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	provided
Urinals : 1 for every 200 sqm	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 80 cm or more	Provided
Elevator	Provided
Corridors 120 cm in width	Provided
Separate toilet stall	Provided
Access ramp	Provided
Use and occupancy classification - purpose group 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 6 sqm	Provided
Minimum width of the stair case 1050 mm	Provided 1075 mm
Minimum width of the internal stair case not less than 2 units width.	Provided 1325 mm
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
Max floor area 3800 sqm.	297 sqm
Max volume 14200 cubic meters	1188 cubic meters

Table 2-5 Summary of Building Code Requirements (3/3)

Regulation	Provisions made
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
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
Rising mains	
Any building in which the floor level of the highest storey is higher than 15 m 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 storey of the building	2 no hose reels for each floor with sump pump and a stand by pump has been provided.
Recommended by the chief fire officer of the fire department	
Fire Alarms	
Manual fire alarms for buildings with 4 storeys.	2 no manual fire alarms for each floor have been provided.
Portable Extinguishers	2 Nos. for each floor provided.

(3) Site Location and conditions

Site plan is presented on Drawing No. MK/OB/G-02.

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 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.

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 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 3.5 m 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.

(4) Floor plan

The central core of the building for front to back is used for utility function such as riser shafts, mechanical/electrical rooms, stairs, lift, lobby, reception, toilets and lunchrooms. Office space is located on either side of the core.

All four levels of the building linked together by the main staircase located at the front of the building. The main staircase provides access to the reception lobby on each floor and is strategically located to control the circulation of the public within the building. There is an 8-10 passenger lift next to the main staircase serving all floors. A second staircase is provided at the back of the building for fire emergencies in accordance with regulations.

Each floor has a toilet block located at the back of the building with separate facilities for men and women. One water closet and one hand washbasin is provided for every 200 sqm of floor. Separate washrooms are provided in the managers' offices and conference rooms.

Staff lunchroom is provided on each floor, with space for cupboards, sink and countertop.

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 area on each floor is controlled by a receptionist post located in the waiting lobby at each floor.

The office space is designed on the open floor concept using low partitions to maximise the use of space and maintain natural ventilation and lighting. NWSDB has requested that certain rooms (e.g. managers and conference rooms) have permanent floor to ceiling partitions. Most of these rooms are located along the perimeter wall but scattered in such a way to provide inner offices with a clear sightline to windows.

The building is designed to facilitate access and use by handicapped persons. The front entrance has an 800 mm wide ramp and corridors width of 1200 mm of for wheelchair access. In addition, a separate toilet for disabled persons has been provided on every floor with necessary accessories.

(5) Occupancy and space requirements

Occupancy schedules and space requirements were determined in consultation with the client and are provided in the design report. The building can be occupied by up to 250 persons. The space is planned for the client's requirement of approximately 50 persons per floor. The occupancy requirements are summarized in Table 2-6.

Table 2-6 Occupancy Schedule

Floor	Offices	Floor Space m^2 Required/(Available)	No. of people
Ground floor	NWSDB CB1, CB2 & CB3, metering/commercial Manager (Colombo City) Common Areas	688 / (792)	50
First Floor	CMC Water Works Office	603 / (792)	48
Second Floor	CMC Drainage Operations	615 / (792)	48
Third Floor	NWSDB Greater Colombo Sewerage Section	639 / (792)	50

(6) Materials interior and exterior

A list of building finishes is presented in the design report and summarized in Table 2-7

Table 2-7 Summary of 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

<table>
<tr><th colspan="2">Room</th><th>Floor</th><th>Skirting</th><th>Wall</th><th>Column</th><th>Ceiling</th><th>Others</th></tr>
<tr><td>Ground Floor</td><td>Lobby Waiting area</td><td>Terrazzo</td><td>Terrazzo</td><td>Smooth lime plaster painted</td><td>Smooth lime plaster painted</td><td colspan="2">mineral fiber (600x600Suspended aluminum frame)</td></tr>
<tr><td rowspan="7">Typical Floor 1 to 3</td><td>Lobby Waiting area</td><td>Terrazzo</td><td>Terrazzo</td><td>Smooth lime plaster painted</td><td>Smooth lime plaster painted</td><td colspan="2">mineral fiber (600x600Suspended aluminum frame)</td></tr>
<tr><td>Office</td><td>300X300 Ceramic floor tiles.</td><td>Ceramic floor tiles.</td><td>Smooth lime plaster painted</td><td>Smooth lime plaster painted</td><td colspan="2">mineral fiber (600x600Suspended aluminum frame)</td></tr>
<tr><td>Toilet</td><td>300X300 Ceramic floor tiles.</td><td>---</td><td>200x200 Ceramic Tiles up to 2100</td><td>200x200 Ceramic Tiles up to 2100</td><td>Water proof cement board painted</td><td>Wall up to ceiling Semi rough water proofing plaster</td></tr>
<tr><td>Stairs</td><td>terrazzo with 2no Carborundum strips inserted</td><td>terrazzo</td><td>Smooth lime plaster painted</td><td>Smooth lime plaster painted</td><td>Soffit plaster painted</td><td>3rd Floor Gypsum board (600x600 Suspended aluminum frame)</td></tr>
<tr><td>Machine room</td><td>R/C trowel</td><td>Cement Mortar</td><td>Semi rough plaster painted</td><td>---</td><td colspan="2">Soffit plaster painted</td></tr>
<tr><td>Lift shaft</td><td>---</td><td>---</td><td>Fair-faced concrete washed & painted</td><td>---</td><td colspan="2">Fair-faced concrete washed & painted</td></tr>
<tr><td>Riser shaft (sewer/ water supply)</td><td>R/C trowel</td><td>Cement Mortar</td><td>Semi rough water proofing plaster</td><td>---</td><td colspan="2">Fair-faced concrete washed & painted</td></tr>
<tr><td colspan="2">High Partition</td><td colspan="6">Block work plastered and painted</td></tr>
<tr><td colspan="2">Low Partition</td><td colspan="6">h=1,200 Ready-made partition without door</td></tr>
</table>

2.3.3 Building Services and Safety Systems

(1) Ventilation

The building elevation features a large expanse of windows. An area equivalent to 15% of the floor area has been allocated for window openings and all windows are 100% open able type. Fixed ventilation panels are not provided in order to make it possible to air-condition the whole building in the future. The windows are protected by sunshades to keep the inside of the building cool.

In addition to natural ventilation from the windows, all corridors, waiting areas and toilets are ventilated using exhaust fans. Cool air will be provided only to certain rooms such as manager's offices, and conference rooms using split type air conditioners.

(2) Lighting

In addition to natural lighting provided through the (glazed) window openings, artificial lighting consisting of fluorescent fixtures is provided on each floor. Lighting levels are 500 lux in accordance with guidelines provided by the Illuminating Engineering Society for office spaces.

(3) Water supply

The water supply to the building is taken from the water main running adjacent to the building premises. The total water demand is estimated at 8750 liters per day based on average number of 250 occupants and a per capita demand of 35 liters/day.

A total storage capacity of 27 m3 is provided: 9cum on the roof and 18 cum as ground level storage in a sump. Water is pumped to the overhead tank by submersible pumps located in the sump.

(4) Wastewater disposal

Grey water from sinks is discharged through grease traps to a soak away pit located at the back of the building. Sanitary waste from the toilets is discharged to a local wastewater drain.

(5) Fire Safety

Each floor is provided with two (2) manual fire alarm pull stations connected to an audible alarm system. Each floor has two points of egress in case of fire: the main staircase at the front of the building and the emergency exit staircase provided at the back of the building.

A fire fighting system is provided for each floor consisting of a wet riser system with 2 hose reels per floor: one for each office area outside the central core. In addition fire extinguishers (2) are provided on every floor.

The potable water ground sump is 18 m^3 and includes a 4 m^3 reserve for fire fighting. A hydro pneumatic pumping system consisting of 2 electrically driven centrifugal pumps and a pressure vessel is provided to maintain pressure in the wet riser. The fire safety system is designed in conformity with the standards and regulations set out by the local Fire Department.

Ventilation ducts are provided with automatic fire dampers to avoid spread of fire/smoke through ducts. Fire signage is provided as an evacuation aid.

(6) Emergency power

The building is equipped with a 60 kVA diesel generator for emergency power supply to critical loads such as the fire pump, water pump, lift and emergency lighting.

2.3.4 Structural

(1) General

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. Specific criteria used for design of the structure are presented in the design report. 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 general arrangement drawings numbers MK/OB/ST-01 to 06.

(2) Foundation design

A detailed geotechnical report describing soil conditions and recommended foundation design parameters is presented in the Supplementary Data to Tender Documents.

Three boreholes were drilled within the plan area of the proposed building designated by OBH-1, OBH-2 and OBH-3.

The borehole profile shows a variegated laterite with variations in the contents of clay, sand and gravel. Based on the observed N values in the order of 18 to 34 the soil is classified as moderately dense to dense with appreciable sand content. The groundwater table varies from a depth of 3.80 m to 3.90 m, which is lower than foundation formation 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/m3,
- water to cement ratio limited to 0.45
- 25% pulverized fly ash added.

The recommended safe bearing capacity for strip footings or individual column pads is 200 kN/m^2 at a depth of 1 m.

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.

(3) Superstructure

The main columns are 400 x 400 mm square reinforced concrete. The columns from third floor to roof level are 300 mm x 300 mm. Floor slabs are reinforced concrete 175 mm thick supported on floor beams spanning between columns. The ground floor slab is directly supported on compacted soil.. Structural concrete is grade 25.

The main partition and 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 partition walls within the toilet area are made to 150 mm thick to reduce the extra load on the floor slabs and also to increase the usable floor area.

The roof consists of Zinc-Aluminum sheets spanning on galvanized steel purlings that are supported on reinforced concrete (RC) beams. The roof beams are sloped and supported on RC columns. There is heat insulation just under the roofing sheets. A flat roof slab is provided for water tanks and future air-conditioning equipment. The machine room has an RC slab supported on RC beams and a monorail is provided for installing the hoist.

2.4 MALIGAKANDA NEW RESERVOIR

The details of the reservoir are provided in the Design Report. The purpose of the Main Report is to provide some background to describe how the pre-design concept for the reservoir was developed.

2.4.1 Background

(1) Previous studies and scope of work

The Water Supply Master Plan 1972 identified the requirement to increase storage capacity at Maligakanda. The concept drawing from the master plan identified 2 circular pre-stressed above ground structures to be constructed in separate phases to the east of the Old Maligakanda Reservoir.

- Phase 1: 3.0 MG tank (13,600 m^3)
- Phase 2: 6.25 MG tank (28,400 m^3)

The tank identified under Phase 1 was constructed in 1978 on vacant land. The second tank is now required in order to provide sufficient storage capacity for the old Maligakanda reservoir to be taken out of service and rehabilitated.

The budget allocated in the JBIC loan is 227.2 million rupees based on providing a new 28,400 m^3 reservoir at a unit cost of 8,000 rupees per m^3. Subsequent pre-design planning indicated that the site would only accommodate a 22,000 m^3 circular reservoir. The change in scope was agreed between NWSDB, JBIC and JICA on August 4, 2000.

The timing for construction of the new reservoir is related to the construction of new offices for CMC/NWSDB operating divisions and necessary for the rehabilitation of the old reservoir roof.

(2) Determining the Size and Shape of the New Reservoir

The proposed site for the new reservoir is located on flat and stable ground to the immediate South/East of the Old Reservoir in space occupied by CMC Waterworks and Drainage Offices. There are no other suitable areas within the existing Maligakanda site for water retaining structures.

The economic depth of a service reservoir varies for any given site. For rectangular reservoirs larger than 15,000 m3 the most economic depth of water usually varies between 5 and 7 meters. For circular pre-stressed concrete reservoirs depths can be increased to 10 or 12 meters thereby reducing land requirements.

At Maligakanda, the optimum depth and shape of the new reservoir depends mainly on the following factors:

- The shape and size of land available
- Geotechnical constraints and depth at which suitable foundation conditions are encountered
- Construction costs

Two structural options were considered at the pre-design stage:

- Circular post-tensioned tank
- Rectangular reinforced concrete tank

a) Option 1 – circular reservoir 28,400 m^3 capacity

A circular reservoir is geometrically the most economical shape, giving the least amount of wall surface for a given volume and depth. To obtain 28,400 m^3 the circular reservoir would need an internal diameter of 60 m and depth of 10 m. Top water level would be set at 29.9 m above MSL and the floor level at 19.9 m MSL to match operating levels in both existing reservoirs. In order to maintain sufficient clearance around the tank for vehicles and piping it would be necessary to acquire additional land from the CMC lands (residential bungalow) to the south.

b) Option 2 – rectangular reservoir 28,400 m^3 capacity

A rectangular reservoir is geometrically more practical for maintenance and operations because it can be divided into two compartments. Structural considerations would limit the water depth to 9 m therefore the floor level would be set 1 meter higher than existing reservoirs at 20.9 m. in order to keep the top water level at 29.9 m. The volume would require external dimensions of 45 x 80.5 m therefore the reservoir would also encroach on the adjoining residential property.

c) Cost comparisons

Comparison of costs for circular and rectangular options is summarized in Table 2-8.

Table 2-8 Cost Comparison of Reservoir Options (Rs.)

Cost Item	Rectangular	Circular
Structural materials and construction	209,000,000	120,000,000
Physical contingency (10%)	21,000,000	12,000,000
Total costs (Rs.)	230,000,000	132,000,000
Unit Cost (Rs./ m3)	8,215	4,725
ADDED INCREMENTAL COSTS FOR 2 CELLS IN A RECTANGULAR RESERVOIR		
Valves (700mm x 4)	1,450,000	0
Piping (760mm x 40m)	510,000	0
Flow meters (2)	220,000	0
Total Comparative Cost	**232,180,000**	**132,000,000**

Note: Costs shown are for the structure only and incremental costs. The costs of piping, valves, site works and relocation of water mains are approximately equal for both options.

The construction of a 28,400 m^3 rectangular reservoir would cost approximately 70% more than a circular reservoir. The difference in cost is mainly because a rectangular reservoir requires a larger wall surface and these walls must be heavily reinforced at the bottom section to withstand the required 9 m water depth.

d) Land acquisition

In both options a 28,400 m^3 reservoir will encroach on the adjoining residential property at the south west side. It would be necessary to acquire a strip of land approximately 180 m^2 to provide sufficient clearance around the tank. A survey plan was prepared for land acquisition but NWSDB was unable to negotiate and agree with CMC.

e) Conclusions

A circular tank is recommended because it is the least cost option by a significant margin.

There is insufficient space within the existing property boundary for a 28,400 m^3 tank therefore the decision has been taken to design a smaller tank with an internal diameter of 53 m and capacity of 22,000 m^3.

2.4.2 Process Design

2.4.2.1 Operating Characteristics

The service reservoirs at Maligakanda have four main functions:

- To balance the fluctuating demand from the distribution system allowing the source to give a steady output
- To provide a supply during failure or shutdown of the treatment plant
- To give suitable pressure for the distribution system and reduce pressure fluctuations therein.
- To provide a reserve of water to meet emergency demands (e.g. loss of water from burst main)

Characteristics of the existing structures:

<u>Old Reservoir</u>

Volume	:	36,368 m^3 (8 MG)
High water level	:	+28.64 m MSL (bell mouth removed)
Low Water Level	:	+19.9 m MSL
Floor level (avg.)	:	+18.5 m MSL
Depth of water	:	9.36 m
Ground elevation	:	+22.0 m MSL

<u>Existing circular tank</u>

Volume	:	13,638 m^3 (3 MG)
High water level	:	+29.9 m MSL
Low water level	:	+19.9 m MSL
Depth of water	:	10.0m

Design criteria for the new reservoir:

Volume	:	22,000 m3
High water level	:	+29.9 m MSL
Low water level	:	+19.9 m MSL
Depth of water	:	10.0 m

2.4.2.2 Supply Arrangement

A schematic diagram showing existing piping arrangement is presented in Figure 2-2.

Supply to the existing structures:		Average for Dec99
Old 20 inch main from Labugama WTP	:	12,500 m^3/day
New 30 inch main from Kalatuwawa WTP	:	37,550 m^3/day
Old 30 inch main pumped from Ambatale WTP: (with alternate supply from Lambugama WTP)		42,880 m^3/day
		92,930 m^3/day

The old reservoir supplied from the "Old' 20 inch main to the west and the "Old" 30 inch main to the north. The "New" 30 inch main from Kalatuwawa WTP supplies the new 3 MG circular tank however a branch connection provides the old reservoir with a separate inlet with the result that very little water reaches the circular tank.

Supply to all reservoir in the future (ultimate capacity 2010):		110,208 m^3/day
Old 20 inch main from Labugama WTP	:	0 m^3/day
New 30 inch main from Kalatuwawa WTP	:	27,168 m^3/day
Old 30 inch main pumped from Ambatale WTP	:	83,040 m^3/day

Projected demand for the year 2010 is 110,000 m^3/day (SAPS report). The design of inlet and outlet piping and re-chlorination facilities for the new reservoir configuration is based on the year 2010.

Sectional valves are arranged so the reservoirs can be fed from either source of supply. The reservoirs can also be completely by-passed via the old 27" by-pass main to the west and the new 30" by-pass main to the east.

The steel 30" presently does not have sufficient pressure to fill the 13,600 m^3 circular tank because most of the flow is going to the old reservoir. Flow meters on the supply side of the tank indicate zero flow because inlet and outlet pipes are not flowing full enough to activate the ultrasonic sensors. The depth of water in the tank varies between 1.5 and 2 m. NWSDB plans to increase flows into the reservoir by making changes in the transmission scheme before construction of the new reservoir begins.

The existing supply arrangement will be modified by removing the inlet connection from the new 30" supply to the old reservoir to provide more flow to the circular tank and the proposed new reservoir. The new reservoir will be connected to the 30” steel by-pass line. Inlet piping to the new reservoir (600 mm dia.) will be brought to the top water level to eliminate the need for non-return valves on the supply side.

The final configuration with the new reservoir is shown in Figure 2-3 with all three sources of supply contributing to inlet flows.

2.4.2.3 Outlet Arrangement

(1) Existing

		Typical day (Dec’99)
Distribution mains supplied from the existing reservoir:		
20” to Colombo/Fort	:	15,000 m^3/day
20” to Kirilapone	:	13,100 m^3/day
27” t San Sebastien	:	23,800 m^3/day
30” to Borella	:	20,875 m^3/day
12” to Mount Mary	:	1,450 m^3/day
10” top Dematagoda	:	4,050 m^3/day
Total	:	78,275 m^3/day

Outlet from the old reservoir originally consisted of a 20” and a 30”pipe located on midway along the South wall. These outlets have isolation valves located in a deep chamber that is now inaccessible because of overgrowth. At a later date a 40” outlet was added with a penstock gate located in side the South/East corner and a gate valve located at the toe of the embankment. The close proximity of inlet and outlet leads to short-circuiting of flow within the reservoir. The 30” outlet is no longer used because the valve is inoperative.

The 3 MG tank has a 30” outlet but the valve is throttled to limit flows because the tank cannot be filled. Outlet flow meter readings indicate zero because the pipe is not flowing full enough to activate the ultrasonic sensors.

Distribution mains are interconnected to the two active outlets and each distribution main has a gate valve located in a shallow chamber with an above ground operator stand. Supply is insufficient to meet demand therefore the outlet valves are throttled down every night around 9 pm to allow the old reservoir to fill. The outlet valves are opened every morning at 5am.

Gate valves are difficult to operate especially in large diameters and are well suited for throttling flows since only the last 10% of the gate’s travel towards closure has any significant effect on the flow rate. Throttling leads to high velocities under the gate that cause cavitation, which damages the pipe and valve seat. Butterfly valves are normally used in such flow control applications. Most of the gate valves are leaking and in need of maintenance.

(2) New yard piping and valve house

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. Yard piping at Maligakanda will be modified to simplify operations and provide greater flexibility in control of supply, by-pass and distribution.

The new reservoir will be provided with a 800 mm diameter outlet taken from a bottom sump located on the South side of the reservoir. The outlet of the new reservoir and outlets from the 3MG tank and the old reservoir will be connected to a common distribution header (1000 mm diameter) making it possible to float all three reservoirs at the same operating level.

The outlet header will be routed to a new valve house that will be constructed to organize and facilitate connection of distribution mains. Distribution mains that are presently connected to the outlets of the two existing reservoirs will be re-connected at the new valve house. The larger outlet capacity will improve pressure and flow conditions in the distribution system. The new valve house will also make it possible to isolate one or any combination of reservoirs without affecting the distribution system. In addition to the six existing connections, the valve house caters for the new 300mm distribution main to Dematagoda.

The new valve house arrangement is shown on drawing MK/GR/YP-03. 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.

A sectional valve is provided in case operators want to operate the two circular tanks separately from the old reservoir. All distribution mains will be provided with butterfly valves to facilitate operation, save space and provide improved flow control when throttled. The distribution header can be fed directly from any source of supply in order to by-pass the reservoirs.

Baffle walls are provided in the new tank to improve circulation within the reservoir. Details of the yard piping are shown on drawing MK/GR/YP-02 and inlet/outlet piping on MK/GR/YP-04.

Existing flow metering on distribution mains will be kept intact as far as possible however some modifications and relocations will be required to accommodate the new reservoir and the revised yard-piping scheme. An ultrasonic flow meter compatible with the recently installed system will be provided at the new reservoir outlet and on each distribution main. Modifications to the flow-metering scheme will include changes to the hardware and software of the existing computer monitoring system if necessary.

2.4.2.4 Overflow and Washout Arrangement

The old reservoir has a single 20" overflow line that runs to the south of the reservoir and discharges several kilometres away into a drainage canal. The condition of the pipe between the reservoir site and the outlet is uncertain and CMC is concerned about flooding residences that may have encroached and used the pipe for discharge of wastewater.

A separate drain was installed for the 3 MG tank but it discharges to a nearby road and is too small for the new tank.

The new reservoir has a 400 mm dia overflow and 300 wash out drain shown on drawing No. MK/GR/YP-05. Since neither of the two existing drains have sufficient capacity to deal with overflow from the new reservoir a new gravity drain will be required.

The design includes construction of a 600 mm diameter gravity drain running South/East along the road discharging to a natural storm water drain off Ketawalamulla Lane. The washout from the existing 3 MG tank will be re-connected to the new gravity drain since the existing arrangement is inadequate.

2.4.2.5 Re-chlorination

Water is chlorinated at the water treatment plants and transmitted to service reservoirs throughout Greater Colombo. NWSDB adds chlorine to the service reservoirs at Maligakanda to maintain water quality within the reservoir and boost free residual in the distribution system. At Maligakanda chlorine dosage is carried out continuously and set manually. One 900 kg cylinder normally lasts about 3 months.

A comparison of different chlorination options and costs is presented in previous monthly reports and provided again in Table 2-9 and Table 2-10. The NWSDB presently uses 900 kg containers because they are the cheapest form of chlorine available. However the lack of safe handling and storage practices and the absence of leakage control systems gives rise to serious concerns for public safety. In Monthly Report No.1 the study team recommended the use of sodium hypochlorite instead of chlorine, however, Sodium hypochlorite would be about 3.4 times more expensive than 900 kg cylinders.

Table 2-9 Comparison of Chlorination Alternatives (Q = 110 MLD, Cl dosage = 0.2 mg/L)

Comparison criteria	Chlorine gas		Sodium hypo-chlorite (liquid) 8.5% available Cl	Calcium hypo-chlorite (dry) 70% available Cl
	900 kg cylinder	68 kg cylinders		
Relative operating cost [(1)]	1	2.1 x	3.4 x	0.8 x
Duration	1 cylinder = 1.5 month	1 cylinder = 3 days 10 cylinders = 1 month	5.0 m3 every 3 weeks	200 kg per week
Public Safety	- Gas is 2.5 times heavier than air, Toxic and corrosive, fatal at 1000 ppm		- No risk of chlorine gas to nearby residents	- No risk of chlorine gas to nearby residents
	- 900 kg of liquid chlorine can produce 281 m3 of gas; high risk to nearby residents	- 68 kg of liquid chlorine can produce 21 m3 of gas; reduces the risk to nearby residents		
Required safety systems	- Ventilated room 60 air changes per hour with inlet at ceiling and outlet at floor level - Automatic chlorine gas leakage detection - Alkaline immersion tank to absorb chlorine in case of severe leakage		- Ventilated room 60 air changes per hour with inlet at ceiling and outlet at floor level - Emergency Eyewash system - Handling pre-cautions because it is corrosive	- Ventilated room 60 air changes per hour with inlet at ceiling and outlet at floor level - Emergency eye wash - Handling pre-cautions because it is corrosive
	- Requires automatic gas neutralization system - Requires 1160 kg of caustic soda mixed with 3680 liters of water to neutralize 1 cylinder	- Requires 90 kg of caustic soda mixed with 270 liters of water - Does not require automatic neutralization system		
Operation & maintenance	- Weigh scale needed to measure actual quantity of gas used - Chlorine injectors require careful maintenance and operation (1 duty + 1 standby)	- 2 cylinders must be connected in parallel to keep the draw off rate below 0.45 kg/hr - 3 injectors required (2 duty + 1 standby)	- Liquid metering pumps are easier to operate and maintain than chlorine injectors and weigh scales	- Used in liquid form; tends to crystallize therefore potential for clogging metering pumps and feed equipment - Normally only used at small installations
Storage & Handling	- Chlorine containers are heavy, and difficult to handle, - Cylinders should not be stored in direct sunlight - Require space for storing 3 x 375 kg drums of caustic soda to be replaced every 6 months	- Cylinders must be changed more frequently but easier to handle - Cylinders should not be stored in direct sunlight - Frequent bottle changes increase risk of leakage. - Require space for storing 2 x 50kg bags of caustic soda replaced every 6 months	- Hypo chlorite loses its available strength on storage (approx. 20% in 20 days) therefore bulk storage should not be larger than amount used in three weeks - Conveniently delivered in bulk liquid form - Stored in a pvc storage tank, within an air conditioned room	- Relatively stable but only under cool and dry conditions (not practical) - Handling dry chemicals and mixing to make solutions of the correct strength is messy and inconvenient for the quantities needed.

(1) Base cost = 1 is for liquid chlorine supplied in 900 kg cylinders. Operating costs are for chemicals only including the cost of caustic soda required to neutralize a leaking cylinder

The NWSDB has instructed the study team to design a gas chlorination system because there is no experience in Sri Lanka with sodium hypochlorite and because commercial availability of hypochlorite may be unreliable. Therefore in order to reduce the risk to the public, the study team recommends using smaller 68 kg chlorine gas cylinders and storing a smaller quantity of chlorine at the reservoir site.

The existing chlorination facility in the N/W corner of the old reservoir will be rehabilitated to house chlorine gas cylinders and dosing equipment. The general arrangement for the chlorination building is shown on drawing MK/CH/M-02. Chlorinated water solution will be injected into the supply mains before the reservoir.

Chlorination system design criteria:

- maximum day flow year 2010: 110,000 m3/day
- dosage: range of 0.1 mg/L to 0.3 mg/L, average dosage rate 0.2mg/L = 22 kg/day in 2010
- number of cylinders: 1 duty and 9 standby (68 kg each) = 31 days of supply
- chlorine ejectors: 2 vacuum type
- draw off rate: less than 0.45 kg/h to prevent freezing and malfunction
- water supply feed pumps: 3 x 0.075 m^3/min x 5m (2 duty + 1 standby)
- control: manual dosing
- alarm system for chlorine leak detection
- caustic soda neutralization tank: 2 x 50 kg drums of caustic soda, 300 litre sump pit to neutralize 68 kg of chlorine.
- Residual chlorine analyser located in valve house to monitor water quality in discharge header.

2.4.3 Structural Design

(1) Foundation design

A detailed geotechnical report describing soil conditions and recommended foundation design parameters is enclosed in Supplementary Data to Tender Documents.

Six boreholes were drilled within the plan area of the proposed reservoir designated by RBH-1 to RBH-5 and RBH-7. One shallow borehole RBH-6 was taken through the embankment of the old reservoir to assess slope stability characteristics.

The borehole profile shows a variegated laterite with variations in the contents of clay, sand and gravel. Based on the observed N values in the order of 12 to 20 the soil is classified as hard laterite. The recommended safe allowable bearing capacity is 200 kN/m^2 at depths of 1.0, 1.5, and 2.0 m.

The groundwater table varies from a depth of 4.0 m to 4.7 m, which is lower than foundation formation 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

(2) New Reservoir

Geotechnical investigations confirm that a circular reservoir is feasible.

The proposed structure is a circular ground reservoir with 22,000 m3 capacity, top water level of 29.9 m and bottom water level 19.9 m.

The internal diameter is 53.0 m and the wall height is 11.4 m. The perimeter wall is 500 mm thick reinforced concrete designed for horizontal segmental post-tensioning. There are four vertical pillars, at 90 degree positions, cast monolithically with the wall to anchor the post-tensioning wires.

The perimeter post tensioned wall rests on a ring beam foundation. The base slab inside the reservoir is a reinforced concrete raft foundation independent from the ring foundation. The roof is a reinforced concrete slab 250mm thick on beams supported on 600 mm diameter concrete columns.

Movement joints are introduced in the base slab and roof slab to cater to expansion and possible differential settlement between the ring beam and the floor slab during initial loading.

The structure is designed according to BS 8007: 1987 for water retaining structures which requires the design of reinforcement steel to limit maximum crack width to 0.2 mm or less. Reference is also made to Section 4.3 of BS 8007 for particular rules applicable to cylindrical pre-stressed tanks. 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. Pre-stressed elements are designed as class 1 (zero tensile stress).

Specific criteria used for design of the structure are presented in the design report. Details of the structural design are provided in the design report and drawings numbers MK/GR/ST-01 to ST-06.

Quality of drinking water in Colombo is considered slightly aggressive towards concrete therefore a Cementitious mortar coating is applied to protect all internal structural concrete surfaces (columns, walls and floor but not baffle walls).

2.4.4 Civil Works

(1) Access Roads

The existing entrance to the south east of the site will be abandoned. Access will be through a new gate located between administration building and the 3 MG tank.

A 5m 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.

Site lighting is provided by standard street lighting luminaire, with mercury vapour lamp, mounted on reinforced concrete lampposts or on external sides of the building wall.

(2) Grading and Drainage

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.

The new tank has a perimeter drain installed at the joint where the wall meets the footing. The perimeter drain connected to the new gravity drain that will be constructed for the overflow and wash out.

(3) Fencing and landscaping

Boundary walls to the south of the new tank will be demolished to provide space equipment access during construction. These walls will be reconstructed to match original height and appearance.

Landscaping will consist of re-grading and seeding around the reservoir and in construction staging areas. A raised berm is provided around the perimeter of the tank to prevent equipment from being accidentally rolled down the slope to the base of the wall. The berm will be planted with shrubs.

(4) Access for maintenance

Access into the reservoir is from 4 openings located on the roof. Stainless steel ladders are provided into the reservoir. An aluminium access ladder is provided on the outside of the tank to gain access to the roof.

2.5 REHABILITATION OF EXISTING RESERVOIR ROOF

2.5.1 History of the Reservoir

The Maligakanda reservoir has had a recurring history of leakage and failure, which is relevant to the rehabilitation of the reservoir roof. The following descriptions are taken from a number of old reports and engineering papers and provided here as reference.

When the water works were first designed for Colombo the two most suitable sites for service reservoirs were at Maligakanda and Ellie House. The central position of Maligakanda was recommended as being the better of the two. Although the ground at Ellie House was 25 feet higher than the ground at Maligakanda, the added distance of 2 miles in length to the main pipe and the Northerly position of this reservoir necessitated conveyance of bulk water 3 miles to the middle of town for distribution and therefore the Maligakanda site was considered more advantageous. Therefore the first service reservoir in Colombo was built at Maligakanda. The water level for the reservoir was fixed at 100 feet above mean sea level. The ground level at Maligakanda was 70 feet providing a difference of 30 feet.

Construction of the reservoir began in 1882 and was completed in 1885. The reservoir was excavated 10 to 12 feet into the ground. The reservoir, originally designed to hold 40 feet of water, was constructed of massive concrete lined with 10-inch concrete blocks on both sides. The top of the walls was covered with a double ventilating roof of thin concrete arches. The floor was lined with 12 inches of concrete. The height of the walls from foundation to the top of the parapet at the upper roof was 49 feet, the thickness varying from 5 feet 9 inches at the top to 19 feet 9 inches at the bottom.

The walls of the reservoir were not originally intended to be supported by the grassed embankment of earthwork that now covers up the original design. The reservoir was first filled in October 1885 and failed with 24 ½ feet of water when cracks appeared in the floor leading to a partial crack in the southeast corner of the walls. It was repaired by doubling the floor thickness thus reducing the water depth to 39 feet.

On second filling in December of 1886 the work failed again. With a depth of 29 ½ feet of water by developing a line of face crack horizontally along the inside of the four walls about the centre of the curved footing. These strains along the footing were lined with asphalt and the reservoir was tested again in February 1887 when it failed with 38 feet 2 inches of water by a break occurring in the north-east angle of the walls from the top downwards followed by a similar break in the south wall near the south-east angle and a partial break in the centre of the east wall.

The failure was attributed to expansion and contraction caused by exposure of the concrete walls to the daily effects of temperature variations. The walls were surrounded and covered by an earth embankment. Each wall was cut through into 6 distinct blocks so that each block would be free to move or contract and to take their bearings in any direction independently of each other. Each cut was made good by brickwork dove tailed into the original concrete but with an elastic joint of brick and asphalt in the centre of the wall to permit movement. The interior of the reservoir was lined with ¾ inch asphalt. The upper of the two roofs was removed to remove the weight and thrust of the roof arches off the walls. These works were completed in 1888. The reservoir was successfully put into operation providing watertight performance.

In 1920 it was found necessary to reline the reservoir because the old lining, having lost its adhesive properties, was delaminating. By removing the old lining it was possible to inspect the old cracks and expansion joints. It is reported that the cracks had expanded considerably since 1888 particularly at the southeast corner where a new crack was discovered and crossed the brick joint. The reservoir was relined using Trinidad asphalt. In 1935 the reservoir was relined again, this time with reinforced Gunite and it is assumed the asphalt was removed before hand. In 1950 there was an indication that the eastern wall had tilted slightly and superficial repairs were carried out to prevent leakage.

In November 1964 the eastern wall was found to be 3 inches (76 mm) out of plumb, and the reservoir was emptied completely. The State Engineering Company was consulted and major rehabilitation works were carried out between 1965 and 1967. Repairs included the construction of a grid of tie beams to prevent further outward movement and sealing of a crack in the floor and wall. Drawings for this repair have not yet been made available to the JICA Study Team. The reservoir was recommissioned in 1967 and to date these repairs appear to have been successful in reducing leakage to acceptable levels and in preventing further movement and cracking of the original structure.

The reservoir was last emptied in April 1970 for inspection. The Gunite on the walls was spalling in many areas but no new cracks were noted and the inspection report concluded that the reservoir was retaining water and could probably continue to provide satisfactory service for many years.

2.5.2 Scope of Work

The necessity for roof repairs has long been recognized by NWSDB which has commissioned three separate studies the status of the Maligakanda Reservoir Roof: Howard Humphreys & Sons in 1972, Watson Hawksley Asia (date unknown but probably 1987-88), and University of Moratuwa in 1989. According to previous reports and visual inspections, the roof is in a most unsatisfactory condition. Howard Humphreys & Sons have recommended to provide a new roof and the other two consultants have concluded that it was feasible to repair the existing roof.

The scope of work in the JBIC loan, based on previous studies, is to rehabilitate the roof (or replace it if necessary). The budget allocated in the JBIC loan is 283.9 million rupees derived by using a unit cost of 4,000 Rupees/m^3 (half the unit price assumed for a new reservoir) times

36,400 m3. This amount is sufficient to provide a new roof structure but not to rehabilitate the walls.

The JICA study team inspected the roof structure and determined that rehabilitation was no longer worthwhile because of the advanced stage of deterioration.

2.5.3 Operating Characteristics

(1) Hydraulics

Characteristics of the existing structure:

Old Reservoir

Volume	:	36,368 m^3 (8 M.Imp.Gal.)
High water level	:	+28.64 m MSL
Low Water Level	:	=19.9 m MSL
Floor level (avg.)	:	+18.5 m MSL
Depth of water	:	9.36 m
Ground elevation	:	+22.0 m MSL

(2) Inlets and outlets

The main inlet structure is to the west. A single cast iron riser pipe built into the mass concrete wall delivers water from two transmission mains to an inlet structure located at the top of the reservoir. Water comes out a bell mouth into a small cast iron stilling basin and flows by gravity over a discharge weir into the reservoir.

The stilling basin and the cast iron chequered floor inside the inlet structure are corroded and will be rehabilitated.

The reservoir has three outlet pipes:

- 30” and 20” located next to each other on the south side of the reservoir
- 40” located in the far South East corner of the reservoir

The 20” outlet is no longer used because the outlet valve is inoperable. The 40” outlet is controlled by a 40” gate valve located outside the reservoir and a penstock gate located inside the reservoir. The penstock gate is inoperable and will be rehabilitated by providing new a rising stem, floor stand and refurbishing the headstock, seals and guides. The 40” gate valve will be removed and replaced by a 1000 mm dia butterfly valve in located in the valve house.

(3) Overflow and Washout

The reservoir has a 20” washout line that is seldom used since the reservoir is rarely cleaned. The line runs some 2 km along small streets and outlets at a drainage canal. CMC operators have are reluctant to use the washout because they might flood residential settlements that have encroached on the pipe downstream of the reservoir.

Rehabilitating the washout is outside the scope of work for this project but CMC will need to find a way of draining the reservoir to carry out the repairs and future maintenance.

(4) Circulation and partitioning

The reservoir is a single cell with no internal partitions. The reservoir is prone to short-circuiting because of the proximity of the inlet to the outlet. The reservoir must be taken out of service for maintenance since there is no dividing wall.

When the new roof is constructed baffle walls will be provided to improve circulation. It is not possible to provide a partition wall within the reservoir because it would require a 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 integrity of the structure. In any case there will be no problem in taking the old reservoir out of service because two other reservoirs will be on-line.

2.5.4 Existing Roof Structure

(1) General arrangement

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 5.8 m and 7.1 m (approx.) from the level of the roof beam. These tie beams rest on a grid of 300 mm x 300 mm concrete columns.

(2) Visual Inspection by the study team

The study team inspected the reservoir on the 29th January 2000. The inspection of the reservoir roof was carried out from top of the roof and from inside the reservoir. Photographs M1 to M6, presented in Appendix 2B were taken during the inspection to show typical conditions of the roof structure, walls and tie beams. The water level at the time of inspection was about 7 meters below bottom of the roof beams. The following general observations were made during the inspection:

a) There are wide longitudinal cracks, in the direction right angles to the span of the vaults. These cracks appear at the crown as well as at the valley of the arch roof and extend from one end of the vault to the other end.
b) A large number of transverse cracks can be seen on the top surface of the roof. These cracks at 1.5 meters (approx) centres are in the direction of the span of the arches and extend to the entire span of barrel vault.
c) Most of the cracks appearing on top of the roof have been repaired but the repair material has failed to bond and is spalling off.
d) The concrete roof slab is not protected from exposure to sun and rain. As a result the cement sand mortar layer has been damaged leaving the coarse aggregate fully exposed.
e) The web and the top flange of the steel beams that support the vault roof are encased in concrete; hence the embedded surface of the steel beams is protected against corrosion. The exposed bottom flange of steel beam is very badly corroded and extensive scaling and de-lamination was observed.

f) Most of the tie-rods have are broken away. The few remaining tie-rods are badly corroded and cannot sustain the horizontal load exerted by the barrel arches. The roof load is at present extended to the perimeter walls.

g) The corrosion on the top 1.5 meters height of the cast iron stanchions columns is more compared to the rest of the height. This is due to less weathering of the immersed section.

On the basis of the above observations, a new roof structure is recommended. Reinforced concrete is selected for long-term durability. The roof to wall connection should be designed to prevent wall movement or rotation (if any) from transferring loads to the roof therefore a sliding joint is recommended. The roof to wall connection should also be designed to accommodate vertical wall movement.

2.5.5 Appraisal of Existing Walls

Before proceeding with the construction of the new roof it will be essential to carry out a thorough structural 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.

The inspection and appraisal of a structure must follow a systematic process outlined as follows:

<u>Stage 1 – before dewatering</u>
Geotechnical investigation
Leakage test

<u>Stage 2 – after dewatering</u>
Initial visual inspection and appraisal
Initial non-destructive testing
Preliminary structural/geotechnical analysis and modelling
Establish the cause of failure/deterioration
Further testing as identified by results of preliminary analysis, destructive testing if required
Identify remedial measures if required.
Report

The appraisal process is expected to take about 5 months. The proposed scope of work is as follows:

(1) Geotechnical Investigation and Assessment

- At least 8 boreholes around the existing reservoir
- At least 4 boreholes inside the reservoir
- Observation of ground water level in the boreholes in relation with the reservoir water level
- Allowable bearing pressure for the wall foundation
- Aggressiveness of the soil
- Other geotechnical parameters required for structural analysis
- Establish the cause/s of a foundation failure occurred in November 1964 and whether or not a similar failure could happen again in the future
- Recommend on geotechnical and foundation stability and any modifications to the foundation, if required

(2) Leakage Test

The water level should be measured at every 24 hours for minimum 20 days. (If the level of leakage found in this measurement exceeds the permissible level specified in BS 8007: 1987, step-by-step leakage tests should further be carried out to identify the areas of leakage.)

(3) Visual Inspection

- Visual inspection and assessment of walls, tie beams and floor slab to identify the signs of distress and cracking of concrete and the water proof membrane, as well as the amount and type of in-situ tests to be carried out.

(4) Testing

- Non-destructive tests to identify factors such as concrete strength, internal void, or corrosion (The types, number and location of non-destructive tests would depend on the nature and seriousness of the defects observed.)
- Hammer tapping, if durability is suspected.
- In post tension tie beams, some tests on carbonation depth, chloride content, thickness of concrete cover and quality of the cover

- Testing to detect corrosion of pre-stressing tendons by X-ray or ultrasonic pulse velocity testing or other suitable testing methods (This would depend on initial visual inspection and testing.)
- Laboratory tests on core samples to assess the quality of concrete in terms of strength, density, mix proportions and chemical contamination.

(5) Structural Analysis

- Structural integrity of the tie beams
- Stability of the walls against sliding, rotation and foundation failure for tank full and empty conditions
- Stability of the walls against rotation with and without tie beams by finite element modelling considering all possible loading condition

(6) Assessment of the Existing Structure and Recommendation

- Establish whether or not the existing structure complies with the level of safety in current design codes.
- Recommend remedial works (if any required)

2.5.6 New Roof

The general arrangement for the new roof is presented on drawings MK/RF/ST-03 and ST-04. Under the rehabilitation work the existing roof structure will be completely removed together with the supporting steel beams, mild steel tie rods and steel columns. The old columns are not re-used because cleaning and removing rust will be a costly and it will be difficult to achieve good results (i.e. complete removal of rust). To avoid potential problems with corrosion of steel and spalling of concrete the design provides new reinforced columns.

The new reinforced concrete roof is designed as a flat slab on column capitals. Roof beams are provide at expansion joints only. The roof is supported on 600 mm diameter columns spaced on a 4.83 m x 4.83 m grid. The outer panels of the roof is simply supported on top of the perimeter wall. The level of the new roof is almost same as the existing roof therefore it is necessary to lower the top level of the perimeter mass concrete wall by 1.6 m.

The new floor slab for the reservoir is designed as a raft slab supported on an elastic media. The design is checked for the direct water pressure and for the column loads. Expansion joints are introduced at regular intervals.

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. The roof slab is basically a flat slab with column capitals to take care of high shear at the supports.

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. The wall is planned to cut 50-100 mm below the required level with the help of a high pressure water jet or other acceptable means 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.

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.

2.6 ELLIE HOUSE RESERVOIR RECONSTRUCTION

2.6.1 History of the reservoir

About 20 years after Maligakanda, a second reservoir was constructed at the Ellie House site in 1905.

The reservoir was found to be leaking in 1909 and by 1913 it was being kept drawn down to 9 feet below top water level, this upper portion apparently being the source of leakage. A bituminous substance called Floatine was applied internally to the floor and walls in January 1918 but apparently had little effect. In July 1919, the reservoir walls and floor were relined with a special cement/Pudlo rendering. The reservoir was then thoroughly tested and reported watertight. An engineering paper written in 1931 indicates that leakage through the walls had eroded the soil under the step footing leaving parts of the wall unsupported. As a result, horizontal cracks appeared on the inside of the wall at a depth of 14 feet at the junction between the vertical and curved part of the wall. External buttresses were constructed to remedy this condition. The date when this intervention took place is unknown but is assumed to be 1919 when the cracks were also sealed. There are no drawings to show the details of the buttresses. In 1927 the steel joists in the roof were replaced where necessary, all ironwork was painted and the interior of the walls were cement washed.

In 1972 the western half of the reservoir was emptied and inspected. The inspection noted minor spalling of the lining and two large cracks about 20 feet long, one in the southern end of the West wall and one in the eastern end of the South wall, both running horizontally about 9 feet below top water level. Their location appears to correlate with the description of leakage difficulties that occurred in 1909 and which were apparently cured in 1919.

2.6.2 Scope of Work

The necessity for roof repairs has long been recognized by NWSDB which has commissioned three separate studies on the status of the Ellie House Reservoir Roof: University of Moratuwa in 1989, Watson Hawksley Asia (undated) and Godfrey, Heath & Spearing in 1993. The Godfrey, Heath & Spearing report, the most recent of the three, recommended a new roof. The other two reports have concluded that repairs were feasible.

The scope of work in the JBIC loan, based on previous studies, is to rehabilitate the roof (or replace it if necessary). The budget allocated in the JBIC loan is 283.9 million rupees derived by using a unit cost of 4,000 Rupees/m^3 (half the unit price assumed for a new reservoir) times 36,400 m^3. This amount is sufficient to provide a new roof structure but not to rehabilitate the walls.

Visual survey of the reservoir by the study team confirmed previous reports identifying the need to replace the roof but a lack of information on the walls made it impossible to comment on wall performance.

In accordance with the original scope of work the study team proposed a preliminary design for a new RC roof structure stipulating that the wall stability and conditions should be thoroughly investigated before proceeding with construction of the new roof.

Subsequent concerns over wall stability and uncertainty over the remaining service life of the 95-year-old walls resulted in a recommendation to reconstruct a new reservoir of the same capacity in the same location as the existing. The change in the scope of work was agreed between NWSDB, JBIC and JICA on August 4, 2000.

The rehabilitation of Ellie House Reservoir now includes the following components:

- Phased demolition of the existing reservoir
- Construction of a new reservoir with capacity equal to the existing
- Restoration of intake and outlet buildings

- Demolition of existing operations building
- Construction of new operations building: approximately 90 m^2, 1 storey
- Modification of inlet, outlet, washout and overflow piping with new valves where required
- Construction of a re-chlorination facility
- Improvements to access road and service road around the reservoir site and site lighting

The scope of work does not include:
- Analysis of the transmission system supplying the reservoir

2.6.3 Coordination with Other Related Projects

NWSDB is in the process of constructing a new 600 mm transmission main from Ambatale to augment the supply to Ellie House reservoir. The new transmission main and pump house has a capacity of 36,320 m^3/day

In the first stage the new transmission main will be connected several kilometres upstream of the reservoir to the old 20" steel TM. It is uncertain how much flow will reach Ellie House Reservoir since the transmission main also supplies several distribution mains before it reaches the reservoir.

If supply conditions at Ellie House do not improve sufficiently after the first stage, the NWSDB plans to extend the transmission main directly to Ellie House. Therefore the new reservoir will be provided with blank inlet piping as provision for this future connection.

2.6.4 Operating Characteristics

The service reservoir at Ellie House has four main functions:
- To balance the fluctuating demand from the distribution system allowing the source to give a steady output
- To provide a supply during failure or shutdown of the treatment plant
- To give suitable pressure for the distribution system and reduce pressure fluctuations therein.
- To provide a reserve of water to meet emergency demands (e.g. loss of water from burst main)

Characteristics of the existing structure:

Volume	:	36,400 m^3
High water level	:	+28.9 m MSL

Low water level	:	+22.9 m MSL
Depth of water	:	6.0 m
Ground elevation	:	+27.0 m MSL
Volume (1 cell empty)	:	8,800 m^3
High water level	:	+25.8 m MSL
Low water level	:	+22.9 m MSL
Depth of water	:	2.9 m

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

Volume (3 cells) 2 x 13,000 + 1 x 10,600 m^3	:	36,600 m^3
High water level (3 cells in parallel, normal condition)	:	+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 top water level will be slightly less than existing therefore there will be no additional head on the transmission mains supplying the reservoir.

2.6.5 Supply Arrangement

Schematic diagrams showing existing piping arrangement and future development of the reservoir are presented in Figures 2-4 and 2-5.

Supply to the existing structure:	Average for dec99
Old 20” steel pumped from Ambatale :	0 m^3/day
Duplicate 20” fed by gravity from Lambugama :	6,100 m^3/day
Triplicate 20” pumped from Ambatale :	25,200 m^3/day
	31,300 m^3/day

Supply to the new reservoir: ultimate capacity (2010):	93,650 m^3/day
Duplicate 20” fed by gravity from Lambugama:	59,100 m^3/day
Old 20” steel pumped from Ambatale } Triplicate 20” pumped from Ambatale }	34,550 m^3/day
Ellie House TM:	Unknown

The amount delivered to reservoir from the 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 m^3/day (SAPS report). The design of inlet and outlet piping for the new reservoir assumes 110,000 m^3/day.

The inlet to the 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 the reservoir can be fed from either source of supply . The reservoir can also be completely by-passed, diverting supply directly to distribution lines. The existing supply header will be maintained.

The two main inlets to the reservoir are located in identical buildings on either side of the centre wall. At present the northerly intake structure is closed since water pressure from Labugama is insufficient to rise above the bell mouth. The southerly inlet structure is fed from the triplicate 20". Inside the inlet building one can observe the water flowing up through a submerged bell mouth into a stilling basin. From the stilling basin water spills over a rectangular sharp crested weir 2.16m wide and into 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 flows into the reservoir. When flows improve the water will be supplied to the reservoir through the northerly 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 will be required to allow supply from triplicate 20".

2.6.6 Outlet Arrangement

Distribution mains supplied from the existing reservoir:

		Average for dec99
Old 18" to Fort	:	18,380 m^3/day
Old 18" to Walls Lane	:	

New 900mm supplying Walls Lane junction	:	
New 500 mm supplying Mattakkuliya:	installed Oct'2000, no meter	

Distribution mains supplied directly from the triplicate 20 TM	:	11,761 m^3/day
Old 10" to Kotahena	:	
Old 14" to Mutwal	:	

Outlet from the existing reservoir consists of a single 20" pipe located between the two inlet structures. The close proximity of inlet and outlet leads to short-circuiting of flow within the reservoir. The outlet is too small to meet the needs of a 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 1,000 mm diameter outlet header located on the west side, at opposite the inlets to improve circulation. Baffle walls are also provided to improve circulation within the reservoir. Details of the reservoir outlet and overflow are shown on drawing EH/GR/C-07 and C-08.

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 re-connected at the new valve house to the outlet of the reservoir. The larger outlet capacity will improve pressure and flow conditions in the distribution system.

The 3 cells will each have an outlet connected to the common discharge header. Each cell can also be connected with a neighbouring 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 floating on the system at approximately the same water level.

The arrangement for the new valve house is shown on drawing EH/GR/C-10. Pipe centreline is set at +22.5 m MSL whereas ground elevation is +27.0 m MSL. A new building will be constructed over the valve house for storage, the OIC office and maintenance staff rest room. All new connections will be provided with butterfly valves to facilitate operation and flow control. A connection from the valve house to the supply header is provided to bypass the reservoir if necessary.

2.6.7 Overflow and Washout Arrangement

The existing reservoir has a single 20” overflow line to that runs to the south of the reservoir. The pipe has insufficient capacity for ultimate flows and must be increased in size to 600 mm ND.

Overflow from each cell is provided by an overflow weir and chamber. The chamber also serves as an inspection gallery. Details of the reservoir outlet and overflow are shown on drawing EH/GR/C-07 and C-08.

During demolition, the wash out pipe in the south cell will serve as a temporary overflow for the north cell.

2.6.8 Re-chlorination

Water is chlorinated at the water treatment plants and transmitted to service reservoirs throughout Greater Colombo. NWSDB adds chlorine to the service reservoirs at Ellie House and Maligakanda to maintain water quality within the reservoir and boost free residual in the distribution system. At Ellie House chlorine dosage is carried out intermittently and set manually. One 900 kg cylinder normally lasts about 5 months.

In order to minimize the risk to the public, the chlorination facility is designed to use smaller 68 kg cylinders and to store a smaller quantity of chlorine at the reservoir site.

A new building approximately 15 m^2 will be located in the southeast corner next to the inlet structure. The general arrangement for the new chlorination building is shown on drawing EH/GR/M-02. Chlorinated water solution will be injected into the supply main on each side of the inlet structures. Piping will be run in a reinforced concrete pipe trench covered with removable pre-cast concrete covers.

Chlorination system design criteria:

- maximum day flow year 2010: 110,000 m^3/day
- dosage: range of 0.1 mg/L to 0.3 mg/L, average dosage rate 0.2mg/L = 22 kg/day in 2010
- number of cylinders: 1 duty and 9 standby (68 kg each) = 31 days of supply
- chlorine injectors: 2 vacuum type (1 duty + 1 standby)
- draw off rate: less than 0.45 kg/h to prevent freezing and malfunction (therefore 2 duty chlorinators will be required at ultimate design flow)
- water supply feed pumps: 3 x 0.075 m^3/min x 5m (2 duty + 1 standby)
- control: manual dosing

- alarm system for chlorine leak detection and caustic soda neutralization tank: 2 x 50 kg drums of caustic soda, 300 litre sump pit to neutralize 68 kg of chlorine.

2.6.9 Existing Reservoir Structure

(1) General Arrangement

Since part of the reservoir must be kept operational during demolition it is essential to understand the existing structure in order to plan for a controlled demolition sequence.

The reservoir is 360 feet by 195 feet by 20 feet deep and is divided across its width by a half wall 10 feet high for the purpose of facilitating maintenance without interrupting service.

There are no record drawings to describe the structure or how it was constructed. A historical paper published in 1907 and 1931 by the Engineering Association of Ceylon provides the only description of the wall structure. In addition to these two papers, recent studies commissioned by NWSDB have indicated the details of the roof structure and column. Drawings EH/GR/C-02 and EH/GR/C-03 were developed mainly based on these two papers and site measurements.

<u>Floor</u>

The 18” floor is constructed in two layers of 7” of cement concrete and finished with a layers of 2” of cement concrete laid in-situ between iron screeds, dividing the floor into rectangular divisions 10 feet x 5 feet. The space formed on removing the screed was run with a mixture of tar, cement and pitch, forming a watertight joint.

<u>Roof Structure</u>

There are 128 Rolled Steel Stanchions 18”x 7” supported by cast iron base plates resting on footing of concrete upon the floor. Eight of these piers rest upon the dividing wall.

The Stanchions are spaced 30 feet apart and supported 18”x 7” H iron joists, on the top of which are the cross girders 15 feet span of 7”x$3^{3}/_{4}$” Rolled steel joists spaced 6 feet apart. Placed between these 7”x$3^{3}/_{4}$” joists are curved corrugated sheet No. 20 B.W.G. having a rise of 6” in the centre. Over this corrugated iron arch sheeting, cement concrete is laid, being 4” thick at crown of the arch and 7” thick at haunches. Upon this concrete a layer of earth 12’ thick is laid and finished off with turf, which complete the cover of the reservoir.

<u>Wall structure</u>

The depth of this reservoir is 20 feet. The walls are of concrete with concrete brick facing on the inner surface, from the top to a depth of 14 feet the walls are three feet in thickness, below this depth to floor level the wall is curved inwards to a 10 foot radius. The back of the wall however is not carried vertically to the foundation but is stepped also inwards the concrete resting on cabook ground. Owing to leakage through the walls, it was found that the cabook at several places had been washed away with the result that the walls were left unsupported and horizontal cracks appeared at a depth of 14 feet at the junction with the vertical and the curved portion of the walls. To remedy this external buttresses were constructed. The locations and details of the buttresses are unknown.

(2) Visual Inspection by the study team

The study team inspected the reservoir on the 27th January 2000. The inspection of the reservoir roof was carried out from top of the roof and from inside the reservoir. Photographs E1 to E4, presented in Appendix 2C were taken during the inspection to show typical conditions of the roof structure, walls and beams. The water level at the time of inspection was about 2 meters below bottom of the roof beams. The following general observations were made during the inspection:

a) Evidence of water dripping from the reservoir roof was clearly observed during the inspection.

b) A horizontal crack or joint on the perimeter wall under water at about 2.8 m below the secondary beams of the roof was observed with the help of the divers.

c) The corrugated galvanized iron sheets at roof level are extensively corroded and some parts are partially or fully detached from the concrete.

d) The corrosion of the expanded metal in the secondary beams is widespread. Due to the fact that rusted steel reinforcement occupies a bigger volume, the expansive forces exerted on the concrete cover have resulted in spalling off of concrete in many locations, exposing the rusted steel reinforcement.

e) The steel main beams that support the roof are badly corroded, particularly at the soffit. The extensive de-lamination has resulted in a significant reduction in the cross section. The flange thickness measured in certain areas varies from 50mm to 80mm.

f) Some of the main beams are in very bad condition. In the report prepared by Godfrey, Heath & Spearing, they have reported that from any structural calculations they cannot justify how the roof exists with out collapse. It is the membrane action of some of the roof members that prevents the roof from collapsing.

g) The top portion of each steel stanchion is also badly corroded with considerable sectional reduction due to corrosion de-lamination. The bottom portion of the steel stanchions, although corroded have not been laminated with rust scales.

(3) Conclusions about the roof structure

The main conclusions from the inspection and previous documentation are as follows:

a) The steel beams are corroded beyond repair and must be replaced
b) The roof may be providing some stability to the concrete walls.
c) Replacement of the roof may disturb the stability of the walls.

A new roof structure is recommended. The long-term performance of the walls cannot be predicted with any certainty and the ability of the walls to remain stable and leak free for the life span of a new roof is doubtful. Therefore the study team recommends reconstruction of the walls as well as the roof.

2.6.10 Geotechnical Assessment

The results of the Geotechnical investigations are presented in Supplementary Data to Tender Documents and the assessment is summarized as follows:

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.

In the case of boreholes EBH-01, EBH-02 and EBH-03 (South side):

- The sub-surface consists of a strong lateritic overburden with high SPT values.
- The ground water level at EBH –01 is at a depth of 7.6m, i.e. at an elevation of 20.3m MSL. The water level at EBH –02 is at a depth of 9.8m, i.e. at an elevation of 18.65m MSL. The water table was not encountered at EBH-03. (i.e. below 22.2m MSL).

In the case of boreholes EBH-04, EBH-05 and EBH-06 (North side):

- The surface horizon consists of a 2 to 4 m thick layer of loose fine to medium sand with gravel.
- There is a strong possibility that a part or whole of it consists of a poorly compacted fill formed during the levelling of a lateritic hillock.
- The surface horizon is followed by a stronger layer of lateritic origin located at elevation 22.5 m MSL (EBH-04); at 23.70 m MSL (EBH-05) and at 25.25 m MSL (EBH-06). It

would appear that the foundation of the existing reservoir was taken down to this stronger layer.

- The ground water level at EBH –04 is at a depth of 7.8 m, i.e. at an elevation of 18.5 m MSL. The water table was not encountered at EBH-05. (i.e. below 22.8 m MSL).The ground water level at EBH-06 is much closer to the surface, (2.3 m from the surface) and further observations would be required at this location to determine if this is the actual water table and not a perched water table or water from a leak in the reservoir.

The recommended allowable bearing capacity for foundations placed at a depth around 22 m 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 $\phi = 28^o$ or C' = 0 kN/m^2 and $\phi = 30^o$.
- 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 $\phi = 27^o$.
- Soil pH value s in the order of 5.0 which is acidic and considered corrosive to concrete.

2.6.11 New Reservoir Structure

It is feasible to construct a three-cell reservoir with 36,600 m^3 of storage on the existing site as shown in drawings EH/GR/C-04 and EH/GR/C-05.

Construction can be phased to reduce disruption in service. Half the reservoir could be kept in service while building the first of three new cells. Once the first new cell is ready, the other half of the reservoir can be demolished and remaining cells built in sequence.

The top water level is at 28.64 m above MSL and the floor level is +22.7 m MSL. To obtain 36,600 m^3 the reservoir will have two cells with 13,000 m^3 each and the middle cell with 10,600 m^3. The reservoir can be constructed with reinforced concrete walls and reinforced concrete beam slab supported on columns for the roof. The structure is shown in drawings EH/GR/ST-01 to ST-03. The walls are 700 mm thick at the base and the footings protrude 750 mm beyond the outside face of the wall. The wall footing is to be constructed with 750mm thick reinforced concrete base slab after removing the existing 450mm unreinforced concrete base slab. The existing base slab is removed and a new 500mm base slab will act as the foundation for the new circular columns.

This reservoir will be designed as a continuous structure with full expansion joints at regular intervals to cater for stresses due to temperature variations and long-term creep and shrinkage of concrete. The roof slab will be properly insulated with a pebble layer and proper drainage will be provided. There will be a sliding joint between the walls and the roof slab.

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

- grade 35 Ordinary Portland Cement (OPC),
- minimum cement content of 360 kg/m^3,
- water to cement ratio limited to 0.45

2.6.12 Modification to Existing Dividing Wall and Demolition

Because there is a dividing wall, one half of the reservoir can be kept in operation during the reservoir reconstruction. However since the wall is only 2.9 m high the effective capacity of the reservoir will be 8,800 m^3.

The dividing wall height could be increased by 800mm but this would only increase the effective capacity to 10,300 m^3. Instead of raising the dividing wall, a temporary bypass from the steel 20” (which will be fed by the new Ellie House TM) to the outlet header will be provided.

A temporary overflow for the north cell will be required during the demolition of south cell. A overflow weir will be created along an 8 m length at the east end of the dividing wall. The rest of the middle wall will be raised by 225mm masonry to create sufficient freeboard for the overflow weir.

When demolishing the existing roof slabs there should be adequate support to prevent total collapse of the roof structure. The contractor will be asked to provide a temporary supporting system with props and bracings, which shall be reviewed by the Engineer at the construction stage. The controlled demolition of the roof slab is important and should be carried out by a competent contractor.

Wall demolition work to be started from eastern wall 8 m away from the inlet structure by using non vibratory equipment or methods giving special attention to the existing inlet and outlet structures. The method selected to cut the east wall should not cause damage to these existing inlet and outlet structures.

2.6.13 Inlet Structure Channel Extensions

Two new concrete channels will be constructed to supply water to mid Cell NR2 from the existing Inlet structure. Width of the channel will be slightly more than the existing inlet weir width. The channel base top level to be set at 28.64m MSL which is same as the top water level of the new reservoir. When these channel extensions are carried out, it is almost impossible to seal connection joint between old and new sections with conventional water bars. This problem can be overcome by using a proprietary Swelleable water stop system such as SikaSwell-Profile with SikaSwell S and Sikadur-Combiflex system.

2.6.14 New Office Building / Valve House

The proposed office building and valve house is shown on Drawing EH/GR/ST-19 and ST-20:

- Ground floor office: 7x14 m footprint = 98m^2
- First basement: valve operators and maintenance from stairs or hatchway on the west side of the building.
- Second basement: valves and piping gallery
- The valve chamber will be constructed of reinforced concrete with monolithic raft foundation and walls
- The building will be R/C frame and roof beams with masonry walls covered with an exterior grade cement mortar finish,
- The roof will be corrugated asbestos sheeting covered with half round clay tiles, supported on steel purlins
- Septic tank system for 15 people

2.6.15 Chlorination Building

The proposed chlorination building is shown on drawing EH/GR/ST-27:

- 4 x 5 m footprint, x 1 storeys = 20m^2
- R/C frame and roof beams
- Masonry walls with exterior cement mortar finish
- Corrugated Asbestos roof covered with half round tiles, supported on steel purlins
- Chlorine storage room separated from pump room and electrical panels
- Electrical equipment will include breakers for site lighting and feeder to service new office and valve house.

2.6.16 Repairs to Inlet and Outlet Structures

The 95-year old buildings have a heritage value and the NWSDB has requested that they be protected during demolition and repaired under the scope of reconstruction. Photographs depicting the appearance and condition of the structures are presented in Appendix A.

The inlet chambers occupy central positions along the East wall of each cell. The outlet structure is located between the inlet structures on top of the dividing wall and is an ornamental building with a concrete dome as shown in drawing EH/GR/A-02. The inlet structures are surmounted by towers of similar appearance and construction to the outlet structure as shown in drawing EH/GR/A-01.

The concrete dome roof of these structures is cracked as shown in photographs and these are to be rehabilitated. These cracks rarely affect the structural integrity of the roof dome provided the structure is not subjected to dynamic loading or earthquake. However, cracks are unsightly, permit intrusion of water, which can lead to additional problems. Crack injection repair system can be used to sealing of the cracks in the structure. Waterproof coating (water-based elastic) should be applied to the roof. This waterproof coating system should ensure slight movements are catered for without compromising the protective layer.

Architectural repairs included in the design will consist of:
- repairing cracks in dome
- providing waterproofing to dome
- new floor grates and steel beams in outlet structure,
- lightning protection
- Replacing all doors and windows
- Repairing ornamental plaster work on the exterior

2.6.17 Access Roads

Site restoration and improvements to miscellaneous civil works are presented on Drawing EH/GR/C-12 and described in the following sections.

The existing entrance to the north of the site presents a narrow, steep, uphill climb with a sharp bend. It is unsuitable for large construction and maintenance vehicles therefore the study team proposes providing an alternate access route through the park (east side) that can be used to accommodate larger maintenance vehicle. The gate at the park entrance (Aluthmawatta road) and the gate next to the OIC office will be made wider following a plan that was previously proposed by NWSDB.

The service road around the west side of the reservoir will be moved to accommodate the slightly wider reservoir structure. The road around the reservoir will be gravel, properly graded to provide positive drainage towards the toe drain. The road in front of the reservoir (east side) and around the new valve house/office will be paved and curbed using pre-cast concrete curb stone.

Roadway lighting will be provided around the reservoir consisting of mercury vapour lamps in cobra head luminaries mounted on 8-meter high concrete posts.

2.6.18 Drainage

A new drain will be constructed around the toe of the embankment to the south, north and west sides. The drain will be half round 375 mm wide, 225 mm deep and will be connected to the existing toe drain at the front of the reservoir. The toe drain will carry rainwater from reservoir roof drains and road runoff.

The paved roadway in front of the reservoir will be sloped to a reinforced concrete (grade 20) 300 x 300 mm drain running along the east boundary wall. The drain will discharge near the chlorination building to a natural drain.

2.6.19 Fencing and Landscaping

Boundary walls along the construction staging areas to the south and east of the site will be demolished to provide equipment access during construction. These walls will be reconstructed to match original height and appearance. The wall will be 225 mm brick, minimum 2 m high with support columns 450 x 450 mm at 3 m intervals and finished with 1:5 cement sand mortar and weatherproof colourwash.

Landscaping will consist of re-grading and seeding around the reservoir and in construction staging areas. Mature trees to the west of the reservoir will be protected during construction.

2.6.20 Miscellaneous Metal Works

- Outlet tunnel: Gratings covering the tunnel access openings will be replaced with galvanized iron gratings.

- Old Inlet structures: corroded manhole covers and frames in front of the intake structure will be replaced with 750 mm x 750 mm ductile manhole cover and frame. Corroded railings and ladders inside the inlet chambers will be replaced with aluminium ladder and railings.

- Old Outlet structure: the corroded floor gratings, beams and ladders will be replaced with galvanized iron.

- Reservoir access ladders: each cell will be provided with two aluminium access ladders. Outlet and overflow chambers for the new reservoir will be provided with aluminium floor gratings and ladders.

Table 2-10 Cost Comparison of Chlorination Options

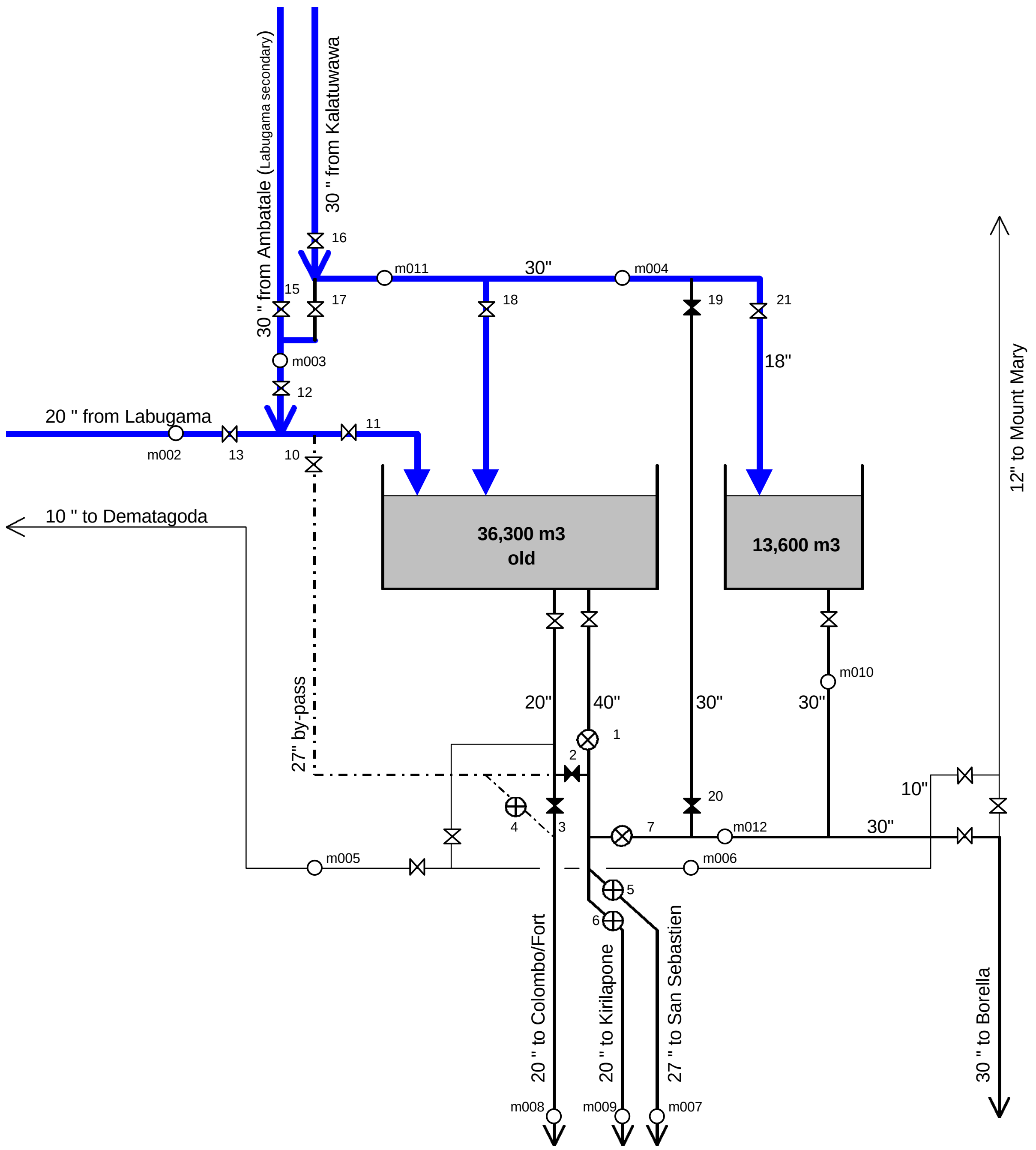
Flow and chlorine dosage applied				
	Malligakanda		Ellie House	
Units	Existing	2010	Existing	2010
flow MLD	86	110	30	93.6
Cl cylinder size (kg)	900		900	
duration (days)	90		150	
dosage (mg/l)	0.12	0.20	0.2	0.2

Unit costs					
Chlorine gas		Sodium hypochlorite		Calcium hypochlorite	
		8.5% solution		70 % powder	
900 kg cylinder	56000				
68 kg cylinder	9552				
Caustic Soda (kg)	28.25	cost per m3	20000	cost per Kg	40

Chemical consumption and cost comparison

		Chlorine gas						Sodium hypochlorite 8.5% solution			Calcium hypochlorite 70 % powder		
				900 kg cylinder		68 kg cylinder							
Q (MLD)	Cl dosage rate mg/l	kg Cl /day	kg Cl /hr	days per cylinder	annual cost (.Rp)	days per cylinder	annual cost (.Rp)	Litre / hour	Storage required for 3 weeks m3	annual cost (.Rp)	kg/day	no. of 25 kg bags per week	annual cost (.Rp)
30	0.2	6.0	0.3	150	199,829	11	317,872	2.9	1.5	515,294	8.6	2.4	125,143
35	0.2	7.0	0.3	129	222,540	10	369,909	3.4	1.7	601,176	10.0	2.8	146,000
40	0.2	8.0	0.3	113	245,251	8	421,946	3.9	2.0	687,059	11.4	3.2	166,857
45	0.2	9.0	0.4	100	267,963	7	473,983	4.4	2.2	772,941	12.9	3.6	187,714
50	0.2	10.0	0.4	90	290,674	7	526,020	4.9	2.5	858,824	14.3	4.0	208,571
55	0.2	11.0	0.5	82	313,385	6	578,057	5.4	2.7	944,706	15.7	4.4	229,429
60	0.2	12.0	0.5	75	336,096	6	630,094	5.9	3.0	1,030,588	17.1	4.8	250,286
65	0.2	13.0	0.5	69	358,807	5	682,131	6.4	3.2	1,116,471	18.6	5.2	271,143
70	0.2	14.0	0.6	64	381,518	5	734,168	6.9	3.5	1,202,353	20.0	5.6	292,000
75	0.2	15.0	0.6	60	404,229	4	786,205	7.4	3.7	1,288,235	21.4	6.0	312,857
80	0.2	16.0	0.7	56	426,940	4	838,242	7.8	4.0	1,374,118	22.9	6.4	333,714
85	0.2	17.0	0.7	53	449,651	4	890,279	8.3	4.2	1,460,000	24.3	6.8	354,571
90	0.2	18.0	0.8	50	472,363	4	942,316	8.8	4.4	1,545,882	25.7	7.2	375,429
95	0.2	19.0	0.8	47	495,074	4	994,353	9.3	4.7	1,631,765	27.1	7.6	396,286
100	0.2	20.0	0.8	45	517,785	3	1,046,390	9.8	4.9	1,717,647	28.6	8.0	417,143
105	0.2	21.0	0.9	43	540,496	3	1,098,427	10.3	5.2	1,803,529	30.0	8.4	438,000
110	0.2	22.0	0.9	41	563,207	3	1,150,464	10.8	5.4	1,889,412	31.4	8.8	458,857
115	0.2	23.0	1.0	39	585,918	3	1,202,501	11.3	5.7	1,975,294	32.9	9.2	479,714
120	0.2	24.0	1.0	38	608,629	3	1,254,538	11.8	5.9	2,061,176	34.3	9.6	500,571
Incremental cost factor				Chlorine Gas				Sodium hypochlorite			Calcium hypochlorite		
				900 kg cylinder		68 kg cylinder		8.5% solution			70% powder		
					1		**2.1**			**3.4**			**0.8**

Note: the cost of chlorine includes caustic soda required to neutralize 1 leaking cylinder



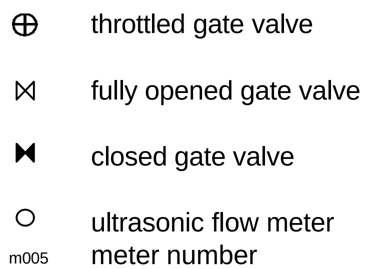


FIG. 2-2	**Pipe Schematic for Maligakanda Reservoirs (Existing Condition)**
SCALE	Not to scale

JICA STUDY TEAM

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

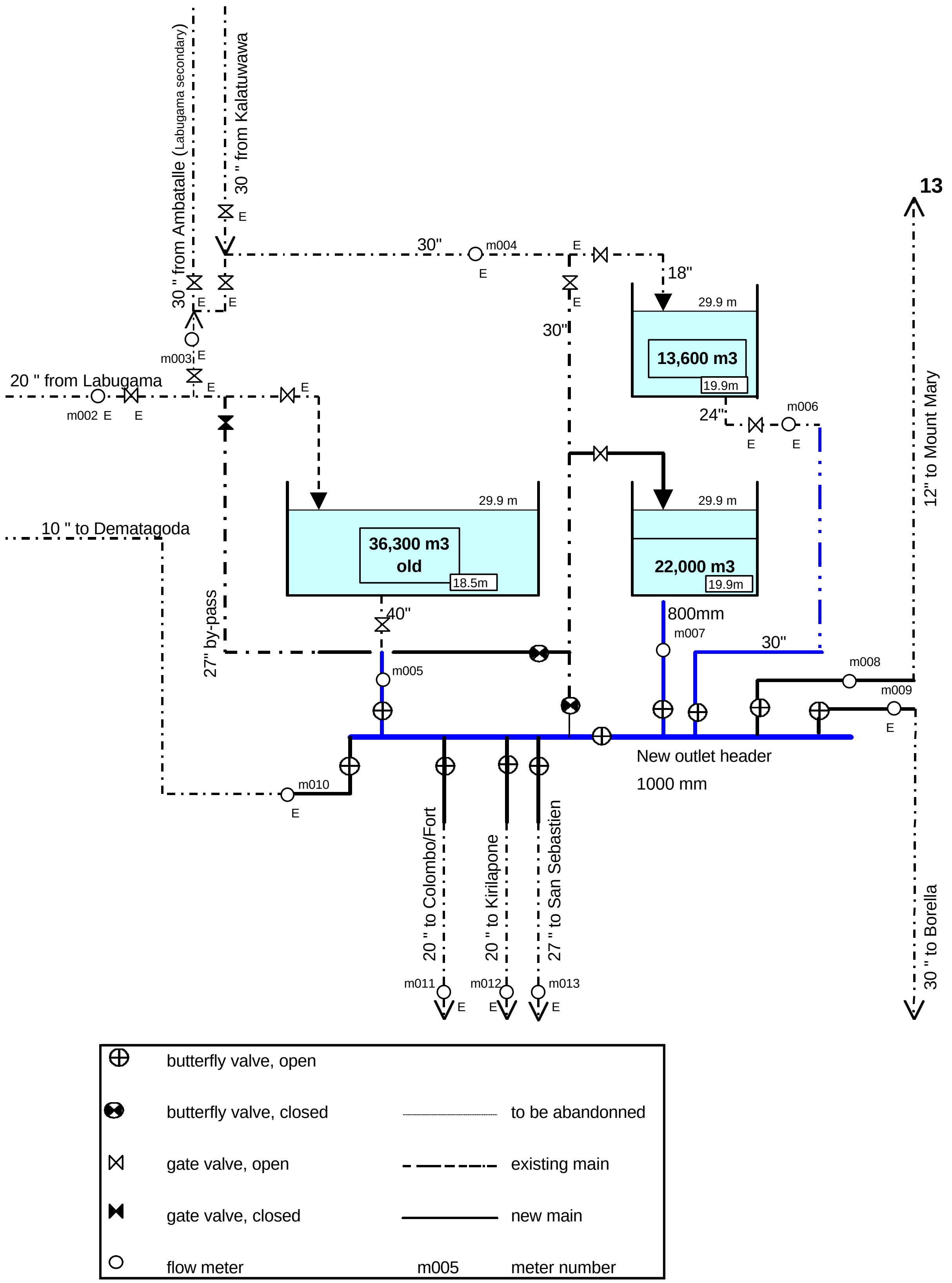


FIG. 2-3	**Pipe Schematic for Maligakanda Reservoirs (Proposed)**
SCALE	Not to scale

JICA STUDY TEAM

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

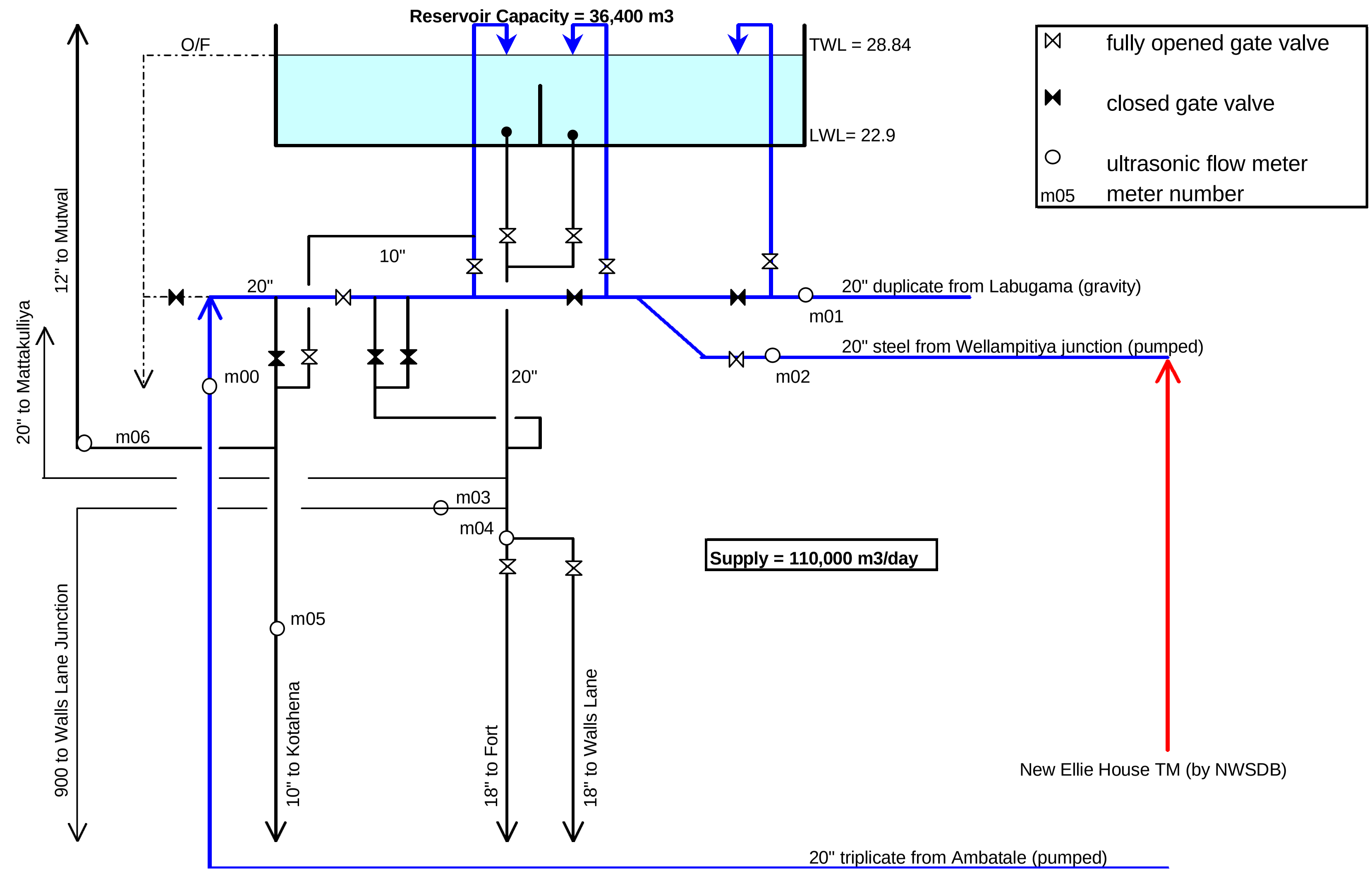


FIG. 2-4	**Pipe Schematic for Ellie House Reservoir (Existing Condition)**
SCALE	Not to scale

JICA STUDY TEAM

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

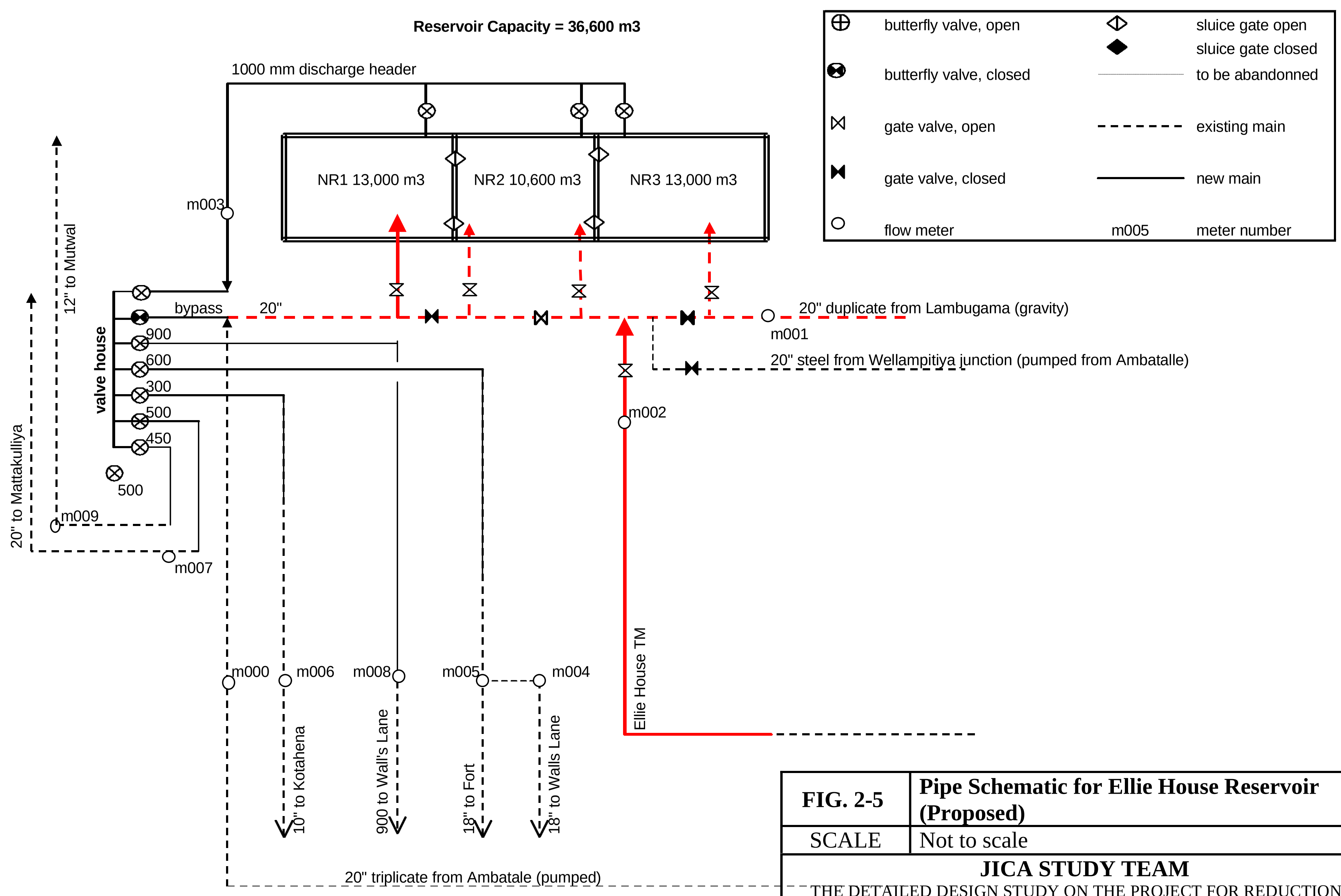
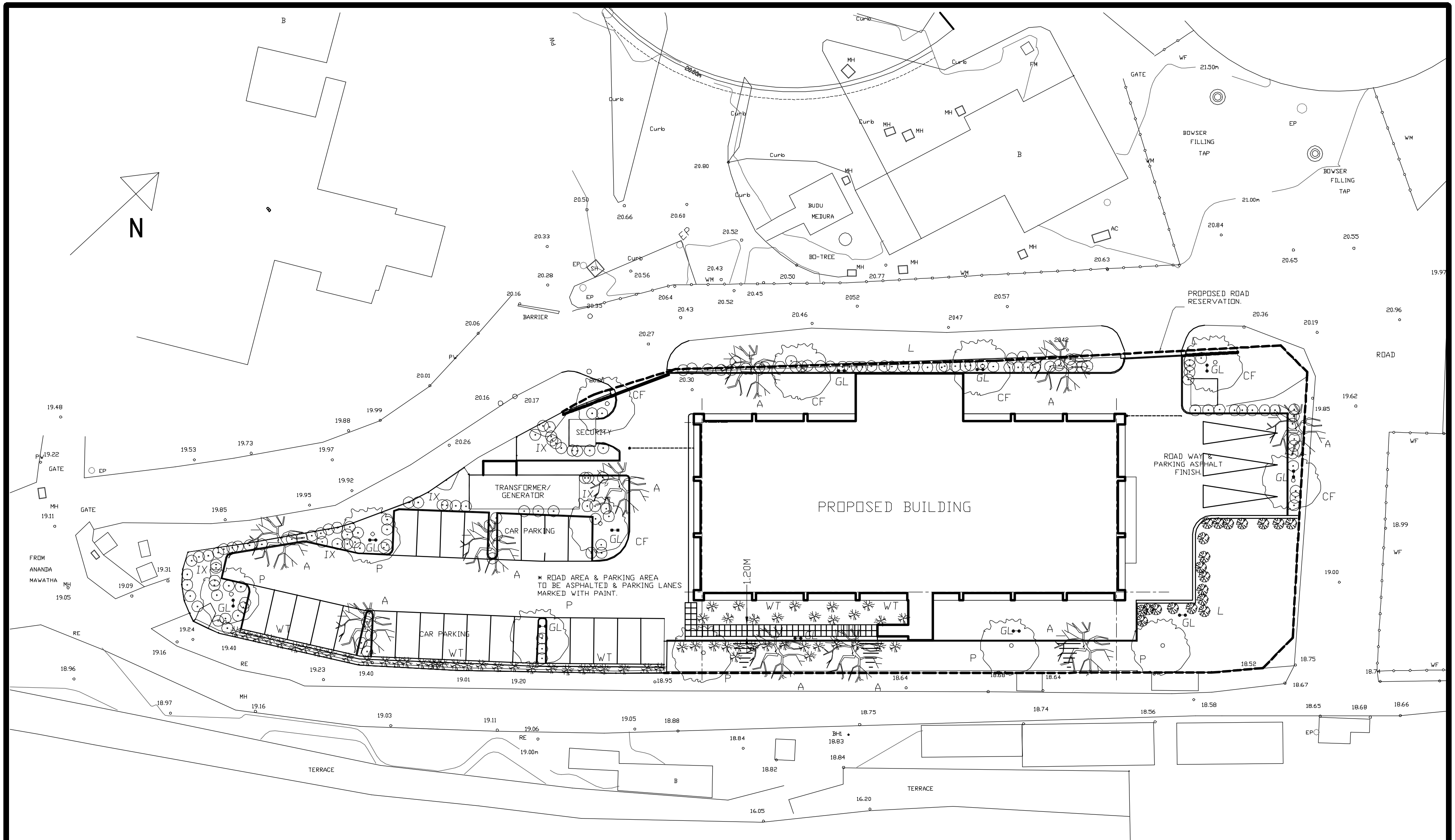


FIG. 2-5	Pipe Schematic for Ellie House Reservoir (Proposed)
SCALE	Not to scale

JICA STUDY TEAM

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



KEY

TYPE	COMMON NAME	ENGLISH NAME	SCIENTIFIC NAME AND FAMILY
CF	EHELA	PUDDING PIPE.	CASIA ESTULA. (LEGUMINOSAE)
p	PIHIMBIA	FERN TREE	ILICIUM DECIPIENS. (SAPINDACEA)
A	ARALIYA	TEMPLE TREE	PLUMERIA ACUMINATE. (APOCYNACEAE)
L	Lantana camara Variety flava (yellow flower), Variety nivea(white flower)	-	Lantana camara Variety flava(yellow flower), Variety nivea(white flower)
IX	Ixora coccinea (red and yellow varieties)	-	Ixora coccinea
WT	Wedella trilobata	-	Wedella trilobata

•• GL GARDEN LAMP (REFER DRAWING No. MK/OB/A-23.

SCALE:- 1:200

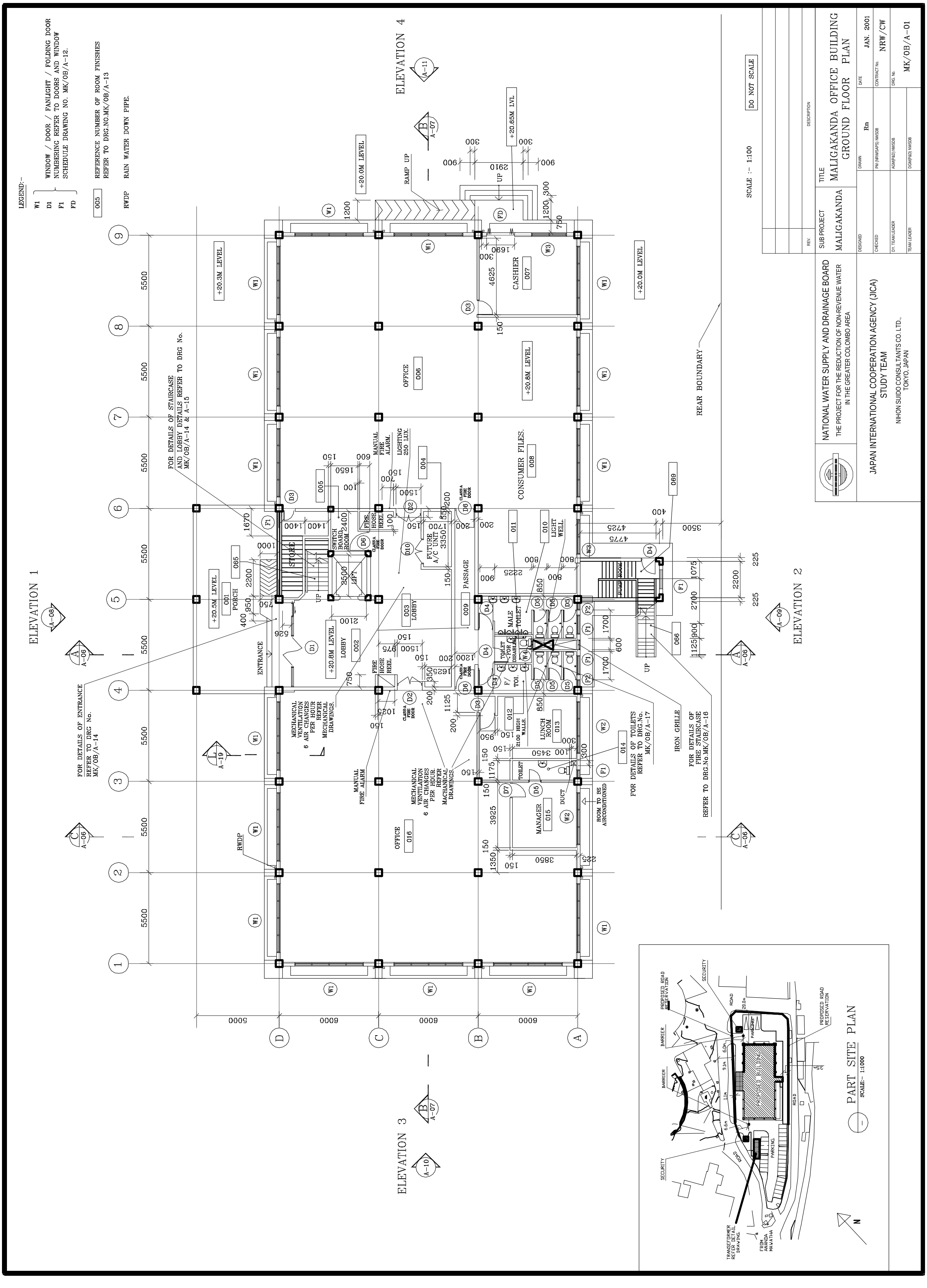
REV. DESCRIPTION

NATIONAL WATER SUPPLY AND DRAINAGE BOARD
THE PROJECT FOR THE REDUCTION OF NON-REVENUE WATER IN THE GREATER COLOMBO AREA

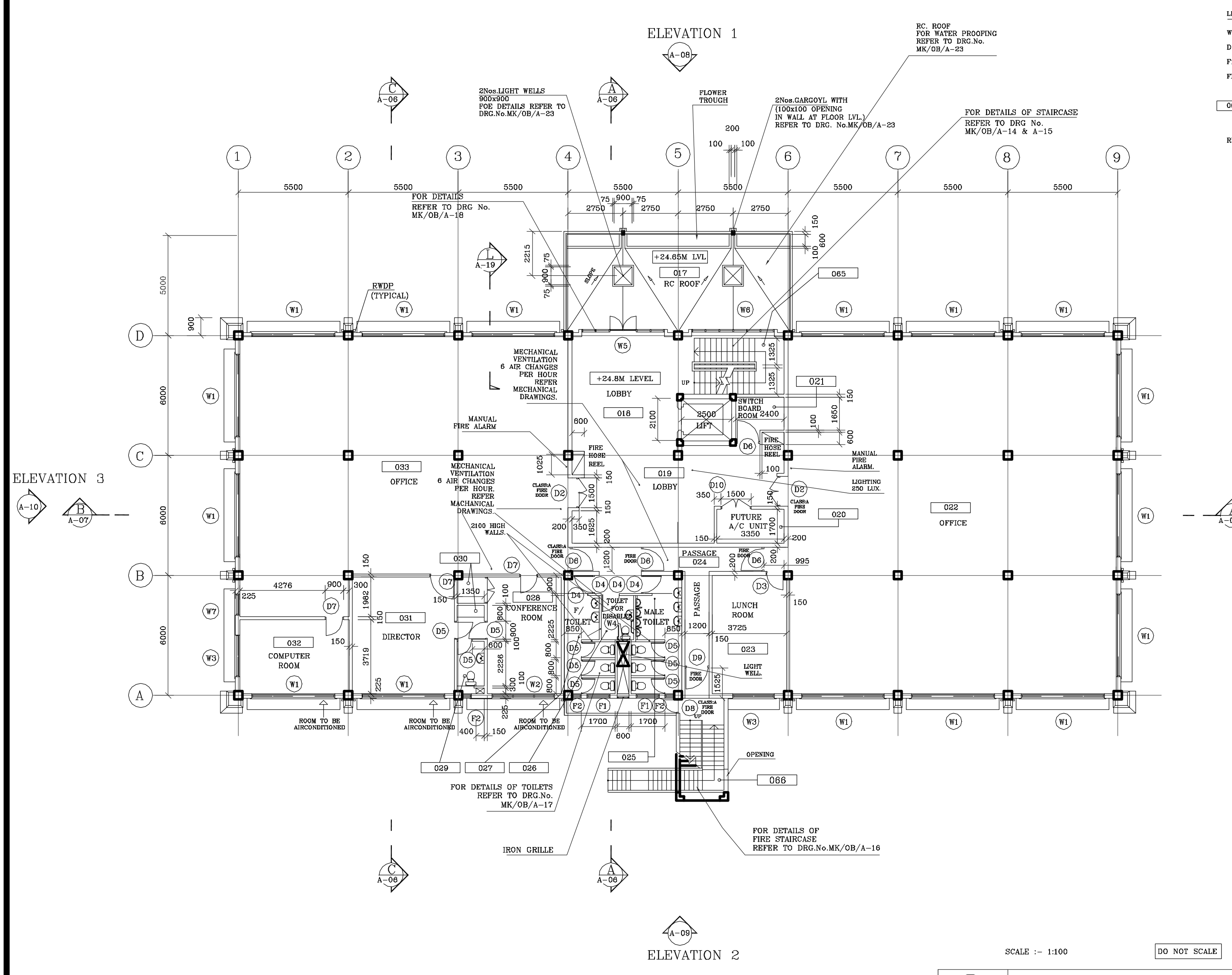
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) STUDY TEAM
NIHON SUIDO CONSULTANTS CO. LTD., TOKYO, JAPAN

SUB PROJECT: MALIGAKANDA
TITLE: MALIGAKANDA OFFICE BUILDING LANDSCAPING LAYOUT

DESIGNED	DRAWN Rn	DATE
CHECKED	PM(NRW/SAPS) NWSDB	CONTRACT No. NRW/CW
DY. TEAM LEADER	AGM(P&D) NWSDB	DRG. No.
TEAM LEADER	DGM(P&D) NWSDB	MK/OB/G-4



NATIONAL WATER SUPPLY AND DRAINAGE BOARD
THE PROJECT FOR THE REDUCTION OF NON-REVENUE WATER IN THE GREATER COLOMBO AREA
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) STUDY TEAM
NIHON SUIDO CONSULTANTS CO. LTD., TOKYO, JAPAN
SUB PROJECT
MALIGAKANDA
TITLE
MALIGAKANDA OFFICE BUILDING GROUND FLOOR PLAN
DATE JAN. 2001
CONTRACT No. NRW/CW
DRG. No. MK/OB/A-01
SCALE :- 1:100
DO NOT SCALE
LEGEND:-
W1 D1 F1 FD WINDOW / DOOR / FANLIGHT / FOLDING DOOR NUMBERING REFER TO DOORS AND WINDOW SCHEDULE DRAWING NO. MK/OB/A-12.
005 REFERENCE NUMBER OF ROOM FINISHES REFER TO DRG.NO.MK/OB/A-13
RWDP RAIN WATER DOWN PIPE.
ELEVATION 1
ELEVATION 2
ELEVATION 3
ELEVATION 4
REAR BOUNDARY
PART SITE PLAN
SCALE:- 1:1000
PROPOSED BUILDING
PARKING
SECURITY
BARRIER
ROAD
PROPOSED ROAD RESERVATION
TRANSFORMER REFER DETAIL DRAWING
FROM ANANDA MAWATHA
OFFICE 016
MANAGER 015
LUNCH ROOM 013
LOBBY 002
LOBBY 003
PORCH 001
STORE
SWITCH BOARD ROOM
LIFT
PASSAGE
CASHIER 007
OFFICE 006
CONSUMER FILES. 008
LIGHT WELL
MALE TOILET
TOILET
ENTRANCE
RAMP UP
FOR DETAILS OF ENTRANCE REFER TO DRG No. MK/OB/A-14
FOR DETAILS OF STAIRCASE AND LOBBY DETAILS REFER TO DRG No. MK/OB/A-14 & A-15
FOR DETAILS OF TOILETS REFER TO DRG.No. MK/OB/A-17
FOR DETAILS OF FIRE STAIRCASE REFER TO DRG.No.MK/OB/A-16
IRON GRILLE
MECHANICAL VENTILATION 6 AIR CHANGES PER HOUR REFER MECHANICAL DRAWINGS.
MANUAL FIRE ALARM
FIRE HOSE REEL
FUTURE A/C UNIT
+20.8M LEVEL
+20.5M LEVEL
+20.3M LEVEL
+20.0M LEVEL
+20.65M LVL



LEGEND:-

W1, D1, F1, FD — WINDOW / DOOR / FANLIGHT / FOLDING DOOR NUMBERING REFER TO DOORS AND WINDOW SCHEDULE DRAWING NO. MK/OB/A-12.

005 — REFERENCE NUMBER OF ROOM FINISHES REFER TO DRG.NO.MK/OB/A-13

RWDP — RAIN WATER DOWN PIPE.

SCHEDULE OF DOORS & WINDOWS

TYPE	DIMENSIONS WIDTH x HEIGHT	DESCRIPTION
D1	5100 x 2650	ALUMINIUM 1620 WIDE DOOR WITH OPENABLE WINDOW PANEL.
D2	1500 x 2100	CLASS A FIRE DOOR WITH DOOR CLOSERS AND VISION PANEL (TIMBER SOLID CORE 45mm THICK)
D3	900 x 2100	ALUMINIUM PANELLED DOOR.
D4	900 x 2100	-DO-
D5	800 x 2100	-DO-
D6	1200 x 2100	CLASS A FIRE DOOR WITH DOOR CLOSERS AND VISION PANEL (TIMBER SOLID CORE 45mm THICK)
D7	900 x 2100	ALUMINIUM PANELLED DOOR.
D8	800 x 2100	CLASS A FIRE DOOR WITH DOOR CLOSERS AND VISION PANEL (TIMBER SOLID CORE 45mm THICK)
D9	1200 x 2100	ALUMINIUM PANELLED DOOR.
D10	1500 x 2100	ALUMINIUM LOUVERED DOOR.
		-DO-
W1	4000 x 1650	GLAZED ALUMINIUM WINDOW WITH 100% OPENABLE SASHES.
W1a	4000 x 1650 + 1333 x 1000	GLAZED ALUMINIUM WINDOW WITH 100% OPENABLE SASHES.
W2	2667 x 1650	GLAZED ALUMINIUM WINDOW WITH 100% OPENABLE SASHES.
W3	2000 x 1650	-DO-
W4	450 x 1750	GLAZED ALUMINIUM WINDOW WITH OPENABLE SASH & FIXED VENTILATION PANEL.
W5	4000 x 2650	GLAZED ALUMINIUM WINDOW WITH OPENABLE SASHES & FIXED VENTILATION PANELS.
W6	4000 x 2650	-DO-
W7	690 x 1650	GLAZED ALUMINIUM WINDOW WITH 100% OPENABLE SASHES.
W8	690 x 975	ALUMINIUM FIXED VENTILATION PANEL.
F1	1400 x 950	GLAZED ALUMINUM FANLIGHT WITH 100% OPEN ABLE SASHES.
F2	450 x 2650	GLAZED ALUMINUM FANLIGHT WITH EXHAUST FAN ON TOP AND OPENABLE SASH IN MIDDLE AND FIXED VENTILATION PANEL IN BOTTOM.
GRILLE	600 x 2650	IRON GRILLE.

REV. DESCRIPTION

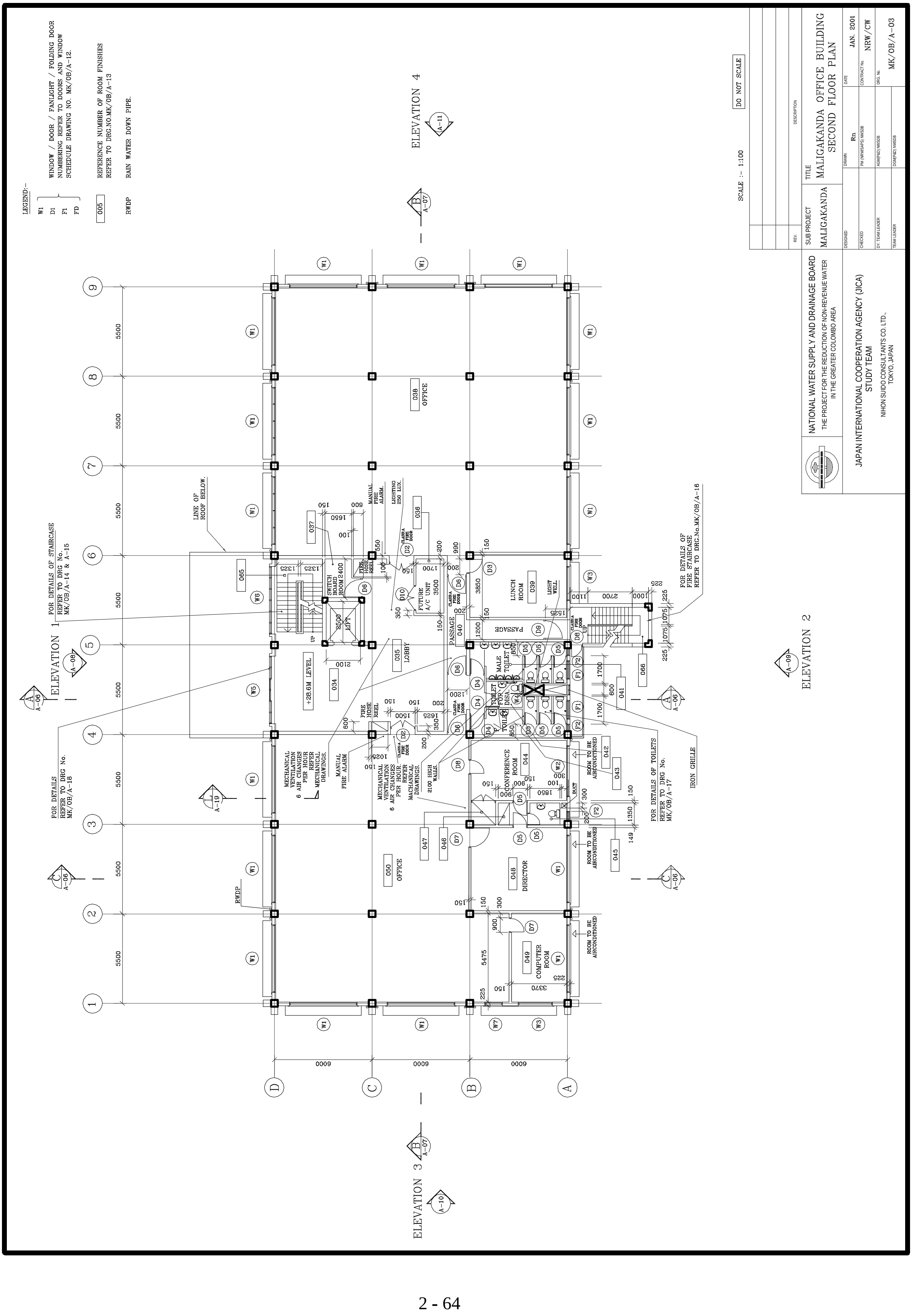
NATIONAL WATER SUPPLY AND DRAINAGE BOARD
THE PROJECT FOR THE REDUCTION OF NON-REVENUE WATER IN THE GREATER COLOMBO AREA

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
STUDY TEAM
NIHON SUIDO CONSULTANTS CO. LTD., TOKYO, JAPAN

SUB PROJECT: MALIGAKANDA

TITLE: MALIGAKANDA OFFICE BUILDING FIRST FLOOR PLAN

DESIGNED	DRAWN	DATE
	Rn	JAN. 2001
CHECKED	PM (NRW/SAPS) NWSDB	CONTRACT No. NRW/CW
DY. TEAM LEADER	AGM(P&D) NWSDB	DRG. No.
TEAM LEADER	DGM(P&D) NWSDB	MK/OB/A-02


LEGEND:-
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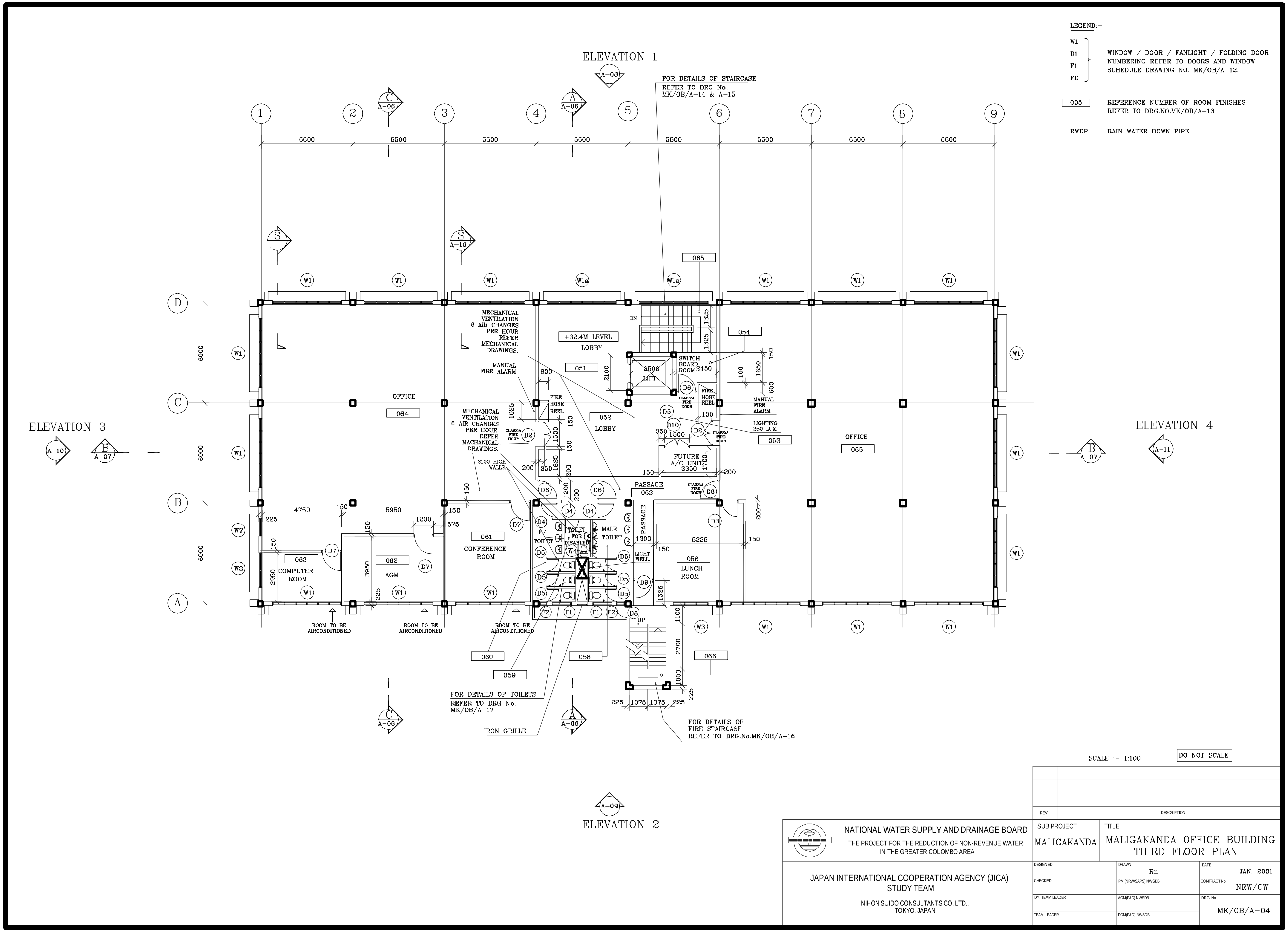
005 REFERENCE NUMBER OF ROOM FINISHES REFER TO DRG.NO.MK/OB/A-13
RWDP RAIN WATER DOWN PIPE.
ELEVATION 1
ELEVATION 2
ELEVATION 3
ELEVATION 4
038 OFFICE
050 OFFICE
035 LOBBY
034 +28.6M LEVEL
048 DIRECTOR
049 COMPUTER ROOM
044 CONFERENCE ROOM
039 LUNCH ROOM
040 PASSAGE
MALE TOILET
TOILET FOR DISA.
SWITCH BOARD ROOM
LIFT
FUTURE A/C UNIT
LIGHT WELL
IRON GRILLE
LINE OF ROOF BELOW.
FOR DETAILS OF STAIRCASE REFER TO DRG No. MK/OB/A-14 & A-15
FOR DETAILS OF FIRE STAIRCASE REFER TO DRG.No.MK/OB/A-16
FOR DETAILS OF TOILETS REFER TO DRG No. MK/OB/A-17
FOR DETAILS REFER TO DRG No. MK/OB/A-18
MECHANICAL VENTILATION 6 AIR CHANGES PER HOUR REFER MECHANICAL DRAWINGS.
MANUAL FIRE ALARM
ROOM TO BE AIRCONDITIONED
SCALE :- 1:100
DO NOT SCALE
NATIONAL WATER SUPPLY AND DRAINAGE BOARD
THE PROJECT FOR THE REDUCTION OF NON-REVENUE WATER IN THE GREATER COLOMBO AREA
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) STUDY TEAM
NIHON SUIDO CONSULTANTS CO. LTD., TOKYO, JAPAN
SUB PROJECT MALIGAKANDA
TITLE MALIGAKANDA OFFICE BUILDING SECOND FLOOR PLAN
DATE JAN. 2001
CONTRACT No. NRW/CW
DRG. No. MK/OB/A-03


LEGEND:-
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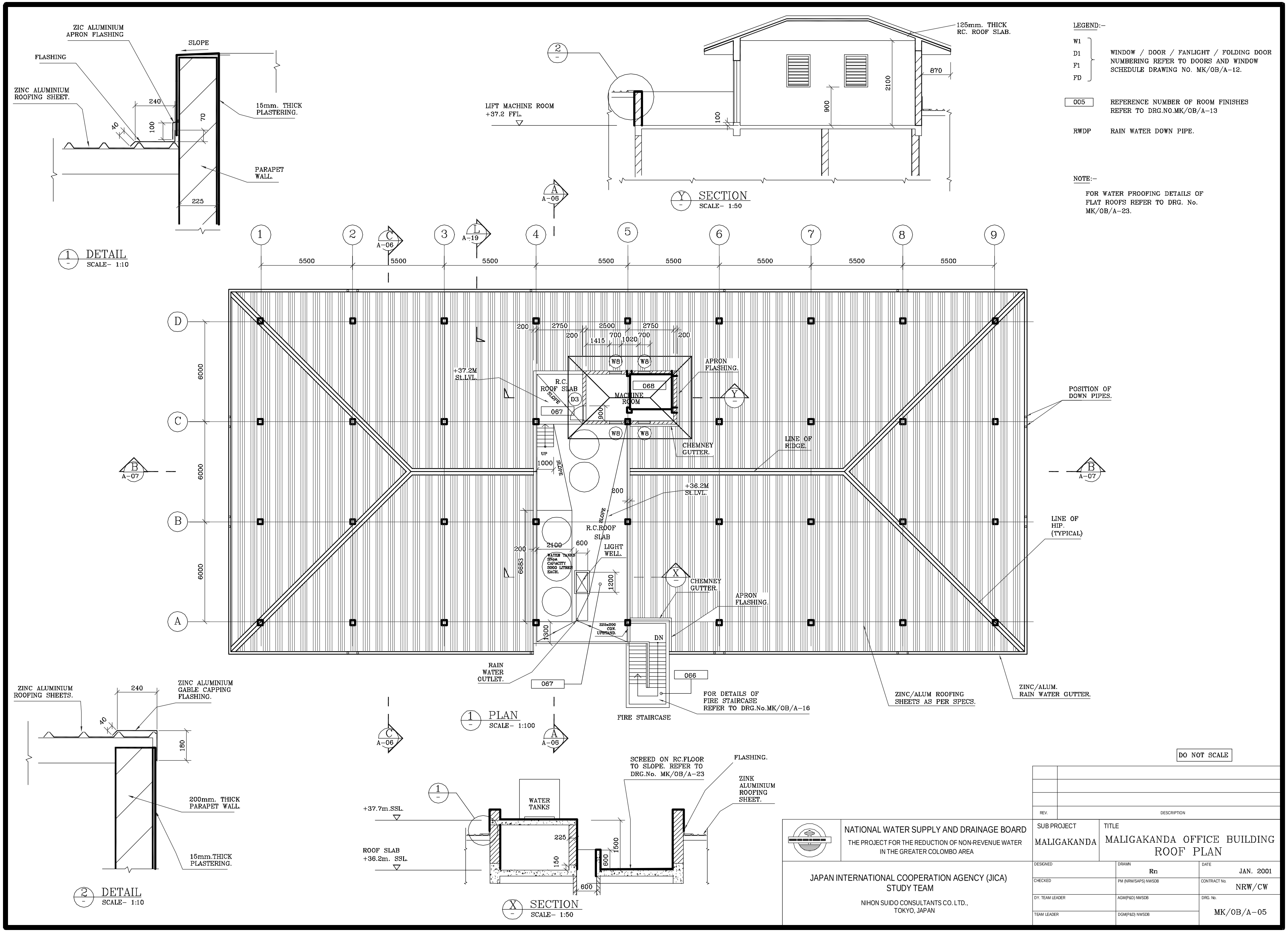
WINDOW / DOOR / FANLIGHT / FOLDING DOOR NUMBERING REFER TO DOORS AND WINDOW SCHEDULE DRAWING NO. MK/OB/A-12.
005 REFERENCE NUMBER OF ROOM FINISHES REFER TO DRG.NO.MK/OB/A-13
RWDP RAIN WATER DOWN PIPE.
ELEVATION 1
ELEVATION 2
ELEVATION 3
ELEVATION 4
FOR DETAILS OF STAIRCASE REFER TO DRG No. MK/OB/A-14 & A-15
FOR DETAILS OF TOILETS REFER TO DRG No. MK/OB/A-17
FOR DETAILS OF FIRE STAIRCASE REFER TO DRG.No.MK/OB/A-16
IRON GRILLE
OFFICE 064
OFFICE 055
+32.4M LEVEL LOBBY 051
LOBBY 052
PASSAGE 052
SWITCH BOARD ROOM
LIFT
FUTURE A/C UNIT
CONFERENCE ROOM 061
AGM 062
COMPUTER ROOM 063
LUNCH ROOM 056
MALE TOILET
F. TOILET
TOILET FOR DISABLED
LIGHT WELL
MECHANICAL VENTILATION 6 AIR CHANGES PER HOUR REFER MECHANICAL DRAWINGS.
MANUAL FIRE ALARM
FIRE HOSE REEL
2100 HIGH WALLS.
LIGHTING 250 LUX.
ROOM TO BE AIRCONDITIONED
SCALE :- 1:100
DO NOT SCALE
REV.
DESCRIPTION
NATIONAL WATER SUPPLY AND DRAINAGE BOARD
THE PROJECT FOR THE REDUCTION OF NON-REVENUE WATER IN THE GREATER COLOMBO AREA
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) STUDY TEAM
NIHON SUIDO CONSULTANTS CO. LTD., TOKYO, JAPAN
SUB PROJECT
MALIGAKANDA
TITLE
MALIGAKANDA OFFICE BUILDING THIRD FLOOR PLAN
DESIGNED
DRAWN Rn
DATE JAN. 2001
CHECKED
CONTRACT No. NRW/CW
DRG. No. MK/OB/A-04



ZIC ALUMINIUM APRON FLASHING
SLOPE
FLASHING
ZINC ALUMINIUM ROOFING SHEET.
15mm. THICK PLASTERING.
PARAPET WALL.
1 DETAIL
SCALE- 1:10
125mm. THICK RC. ROOF SLAB.
LIFT MACHINE ROOM
+37.2 FFL.
Y SECTION
SCALE- 1:50
LEGEND:-
W1
D1
F1
FD
WINDOW / DOOR / FANLIGHT / FOLDING DOOR NUMBERING REFER TO DOORS AND WINDOW SCHEDULE DRAWING NO. MK/OB/A-12.
005
REFERENCE NUMBER OF ROOM FINISHES REFER TO DRG.NO.MK/OB/A-13
RWDP
RAIN WATER DOWN PIPE.
NOTE:-
FOR WATER PROOFING DETAILS OF FLAT ROOFS REFER TO DRG. No. MK/OB/A-23.
+37.2M St.LVL.
R.C. ROOF SLAB
MACHINE ROOM
APRON FLASHING.
CHEMNEY GUTTER.
POSITION OF DOWN PIPES.
LINE OF RIDGE.
+36.2M St.LVL.
R.C.ROOF SLAB
LIGHT WELL.
WATER TANKS 3Nos CAPACITY 5000 LITRES EACH.
LINE OF HIP. (TYPICAL)
RAIN WATER OUTLET.
FOR DETAILS OF FIRE STAIRCASE REFER TO DRG.No.MK/OB/A-16
FIRE STAIRCASE
ZINC/ALUM ROOFING SHEETS AS PER SPECS.
ZINC/ALUM. RAIN WATER GUTTER.
1 PLAN
SCALE- 1:100
ZINC ALUMINIUM ROOFING SHEETS.
ZINC ALUMINIUM GABLE CAPPING FLASHING.
200mm. THICK PARAPET WALL.
15mm.THICK PLASTERING.
2 DETAIL
SCALE- 1:10
SCREED ON RC.FLOOR TO SLOPE. REFER TO DRG.No. MK/OB/A-23
FLASHING.
ZINK ALUMINIUM ROOFING SHEET.
WATER TANKS
+37.7m.SSL.
ROOF SLAB +36.2m. SSL.
X SECTION
SCALE- 1:50
DO NOT SCALE
NATIONAL WATER SUPPLY AND DRAINAGE BOARD
THE PROJECT FOR THE REDUCTION OF NON-REVENUE WATER IN THE GREATER COLOMBO AREA
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) STUDY TEAM
NIHON SUIDO CONSULTANTS CO. LTD., TOKYO, JAPAN
SUB PROJECT
MALIGAKANDA
TITLE
MALIGAKANDA OFFICE BUILDING ROOF PLAN
DRAWN
Rn
DATE
JAN. 2001
CONTRACT No.
NRW/CW
DRG. No.
MK/OB/A-05

SCALE:– 1:100

DO NOT SCALE

REV.	DESCRIPTION

NATIONAL WATER SUPPLY AND DRAINAGE BOARD
THE PROJECT FOR THE REDUCTION OF NON-REVENUE WATER IN THE GREATER COLOMBO AREA

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
STUDY TEAM
NIHON SUIDO CONSULTANTS CO. LTD., TOKYO, JAPAN

SUB PROJECT	TITLE	
MALIGAKANDA	MALIGAKANDA OFFICE BUILDING ELEVATION NORTH–WEST	
DESIGNED	DRAWN Rn	DATE JAN. 2001
CHECKED	PM (NRW/SAPS) NWSDB	CONTRACT No. NRW/CW
DY. TEAM LEADER	AGM(P&D) NWSDB	DRG. No. MK/OB/A–08
TEAM LEADER	DGM(P&D) NWSDB	

DO NOT SCALE

REV.	DESCRIPTION

NATIONAL WATER SUPPLY AND DRAINAGE BOARD
THE PROJECT FOR THE REDUCTION OF NON-REVENUE WATER IN THE GREATER COLOMBO AREA

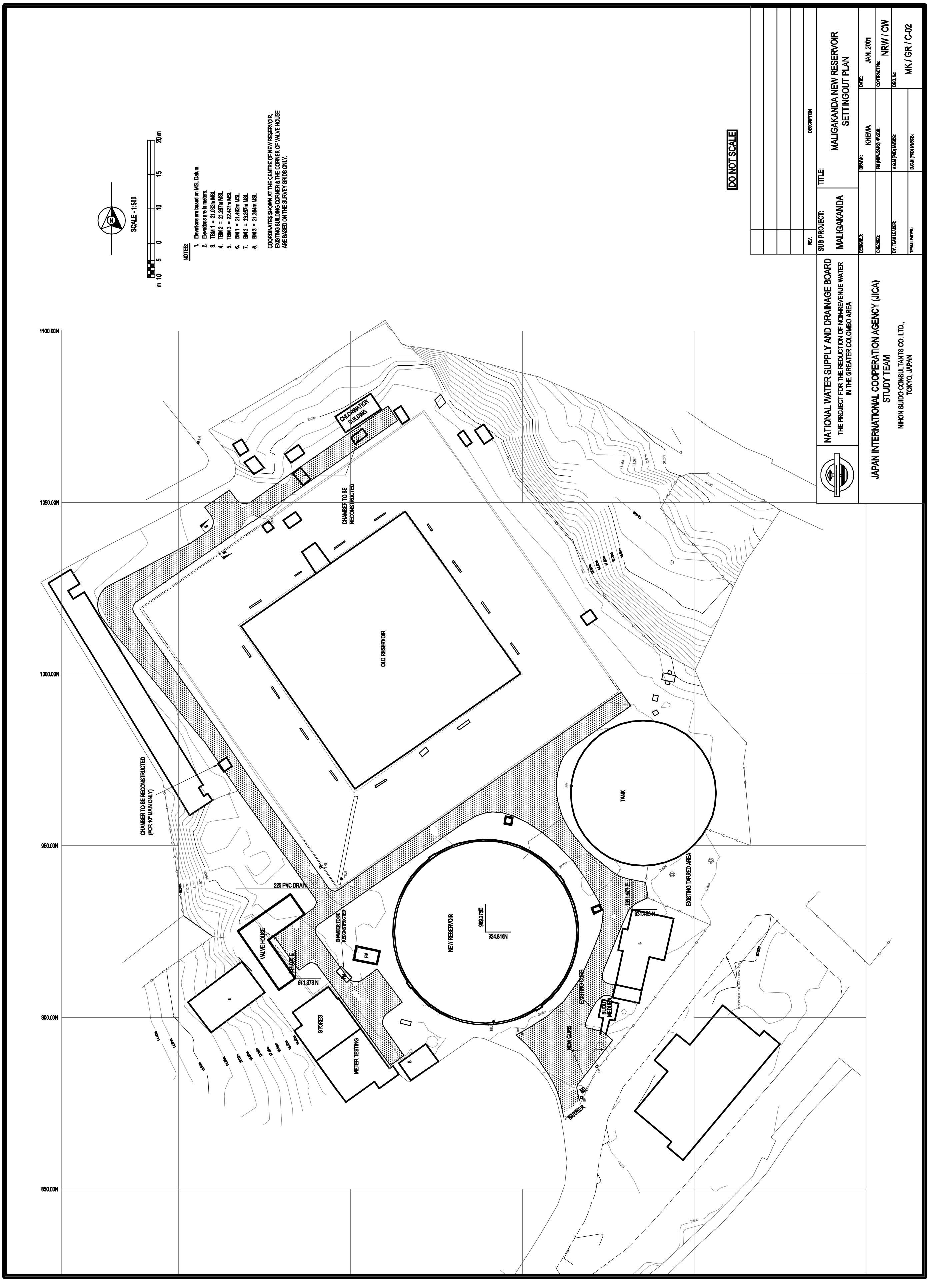
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
STUDY TEAM

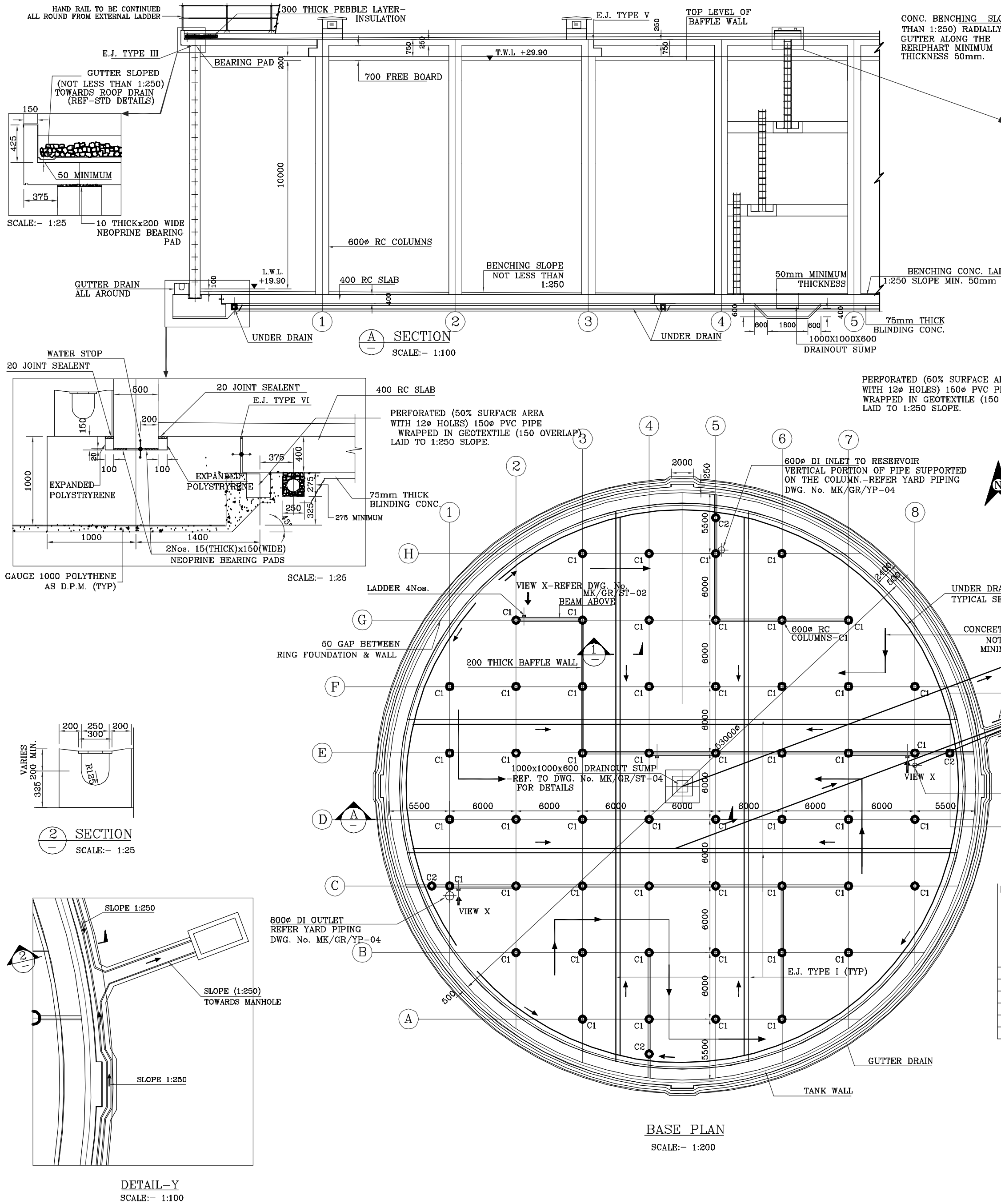
NIHON SUIDO CONSULTANTS CO. LTD.,
TOKYO, JAPAN

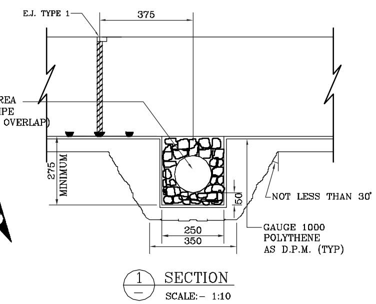
SUB PROJECT: MALIGAKANDA

TITLE: MALIGAKANDA OFFICE BUILDING ELEVATION 4 NORTH-EAST

DESIGNED	DRAWN Rn	DATE JAN. 2001
CHECKED	PM (NRW/SAPS) NWSDB	CONTRACT No. NRW/CW
DY. TEAM LEADER	AGM(P&D) NWSDB	DRG. No. MK/OB/A-11
TEAM LEADER	DGM(P&D) NWSDB	


NATIONAL WATER SUPPLY AND DRAINAGE BOARD
THE PROJECT FOR THE REDUCTION OF NON-REVENUE WATER IN THE GREATER COLOMBO AREA
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) STUDY TEAM
NIHON SUIDO CONSULTANTS CO. LTD., TOKYO, JAPAN
SUB PROJECT: MALIGAKANDA
TITLE: MALIGAKANDA NEW RESERVOIR SETTINGOUT PLAN
DRAWN: KHEMA
DATE: JAN. 2001
CONTRACT No: NRW / CW
DRG. No: MK / GR / C-02
DO NOT SCALE
SCALE - 1:500
NOTES:
1. Elevations are based on MSL Datum.
2. Elevations are in meters.
3. TBM 1 = 21.032m MSL
4. TBM 2 = 21.267m MSL
5. TBM 3 = 22.427m MSL
6. BM 1 = 21.462m MSL
8. BM 3 = 21.384m MSL
COORDINATES SHOWN AT THE CENTRE OF NEW RESERVOIR, EXISTING BUILDING CORNER & THE CORNER OF VALVE HOUSE ARE BASED ON THE SURVEY GRIDS ONLY.
1100.00N
1050.00N
1000.00N
950.00N
900.00N
850.00N
CHLORINATION BUILDING
CHAMBER TO BE RECONSTRUCTED
OLD RESERVOIR
CHAMBER TO BE RECONSTRUCTED (FOR 10" MAIN ONLY)
TANK
NEW RESERVOIR
989.276E
924.816N
225 PVC DRAIN
VALVE HOUSE
911.373 N
STORES
METER TESTING
EXISTING TARRED AREA
EXISTING CURB
NEW CURB
BARRIER





Notes:-

1 The drawings to be read in conjunction with Standard Drawings, Structural and other relevant drawings.

2 All exposed concrete corners shall be chamfered 20 mm unless otherwise stated on the drawings.

3 The blinding concrete shall be grade 15 having Characteristic strength of 15 N/mm^2.

4 The structural concrete of the perimeter post-tensioned circular wall shall be grade 40 having a Characteristic strength of 40. N/mm^2 and for all other structural members the concrete shall be grade 35A having a Characteristic strength of 35. N/mm^2 unless otherwise noted on the drawings.

5 All laps in reinforcing steel (48 x bar diameter) shall be staggered.

6 All reinforcing steel in the perimeter wall shall be arranged so that there is a minimum of 40 mm between any bar and the nearest cable duct and clear cover to reinforcing steel shall be 50. mm.

7 The proprietary post-tensioning wires, ducts and anchorages shall be approved by the Engineer prior to start with construction.

8 The contractor shall provide adequate steel supports for the cable ducts and reinforcing steel in addition to the designed reinforcement shown on drawings and the details shall be approved by the Engineer.

9 Wires shall be placed in the ducts before concreting commences.

10 All cable ducts shall be grouted and grout vents shall be provided at all points necessary at not more than 10.m centres. The grout mix shall be approved by the Engineer and shall contain approved expanding agent.

11 The cables shall be stressed in the order shown. The wires in the cables shall not be cropped until all wires have been stressed.

12 The wires shall not be cropped closer than 25. mm from the grips and cropping of wires shall not commence until the stressing records have been approved by the Engineer.

13 Each pre-stressing wire shall be 7.0 mm dia high tensile low relaxation steel conforming to BS 5896-1980 with ultimate guaranteed tensile strength not less than 1860 N/mm^2 and shall be stressed as shown in Table 1.

14 The pre-stressing wires shall be stressed only after the complete wall is cast and the entire wall concrete attains 28 day strength and after a minimum period of 28 days.

15 Anchorage recesses shall be dimensioned by the contractor to suit type of anchor used and the details shall be approved by the Engineer. All anchor recesses shall be covered with non-shrink cement sand mortar after stressing all wires and grouting the ducts are completed and approved by the Engineer.

16 All exposed concrete surfaces shall be in accordance with the specifications.

17 The wires in the cable ducts shall be stressed in two operations, first with 50% of the force on all cables and second to complete the balance 50% of the forces and in the following order of ducts.
1, 4, 7, 10, 13, 16, 19, 22, 25, 28, 31, 34, 37, 40, 43, 46, 49, 52, 55, 58, 61
2, 5, 8, 11, 14, 17, 20, 23, 26, 29, 32, 35, 38, 41, 44, 47, 50, 53, 56, 59,
3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, 39, 42, 45, 48, 51, 54, and 57.

18 The notation used in labeling the cable ducts (and wires) is as shown in example table 1 of dwg. No MK/GR/ST-06

19. The cement used to produce concrete for the foundation structure such as the perimeter rc ring foundation and the base slab of the reservoir shall be Portland Cement complying to BS 12 mixed with 25 % pulverized fuel ash (pfa). The cement content of the concrete shall be not less than 380 kg/m^3 and the maximum free water cement ratio shall be 0.45.

loads (unfactored)

super imposed load on roof	2.5kN/m^2
250 mm pebble layer on roof	5.0 kN/m^2
benching concrete (250 mm average)g on roof	5.5 kN/m^2
Density of water	10.0 Kn/M^3

Parameters assumed -post tensioning

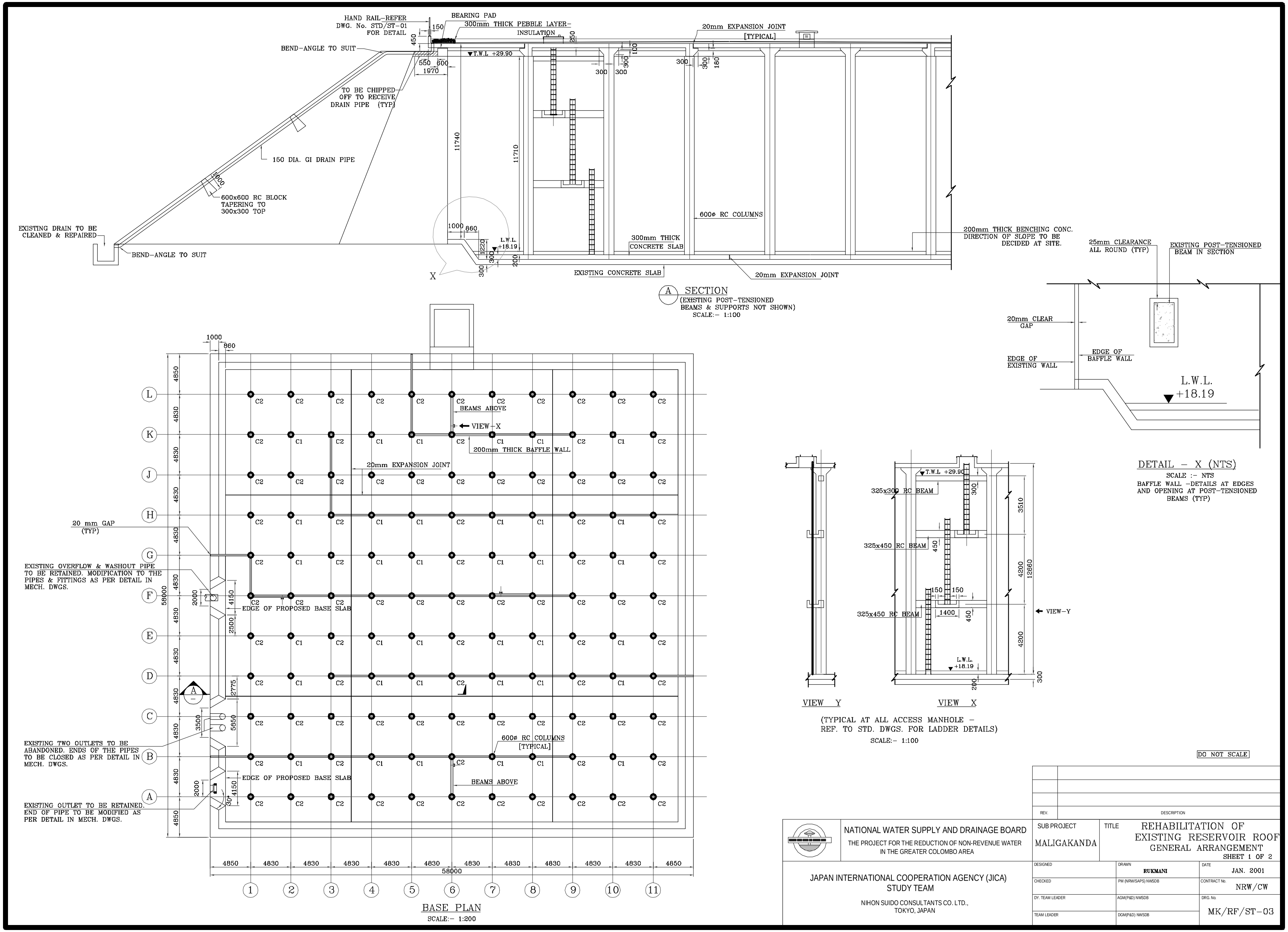
Coeiff. of friction	0.3
Profile Coeiff.	0.0025 /m

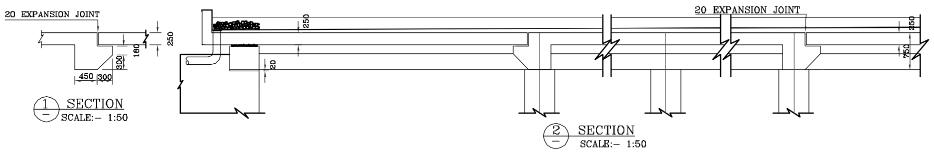
Allowable bearing capacity of founding material = 200 kN/m^2

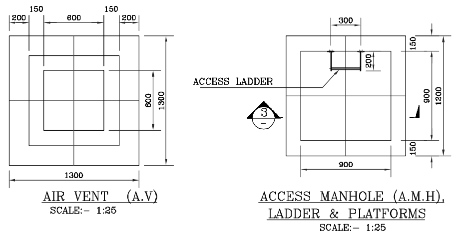
Table 1

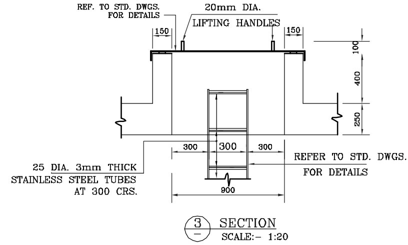
Height of wall measured from bottom of wall (m)	Force that should be applied by prestressing –after all losses (kN/m height)	No of 7.0 mm Wires in a single cable (nos.)	Cable spacing used (mm c/c)	Jacking force per Cable allowance for slip at anchors is not considered (kN)	Actual stress that should get transferred on to the wall due to pre-stressing (after all losses) (N/mm^2)
10.0-11.4	892.0	12	400	443.0	1.78
8.0-10.0	1177.0	12	300	443.0	2.35
6.0-8.0	1547.0	12	225	443.0	3.09
4.0-6.0	2254.0	12	150	443.0	4.51
2.0-4.0	2756.0	12	120	443.0	5.51
0.0-2.0	3233.0	12	100	443.0	6.47

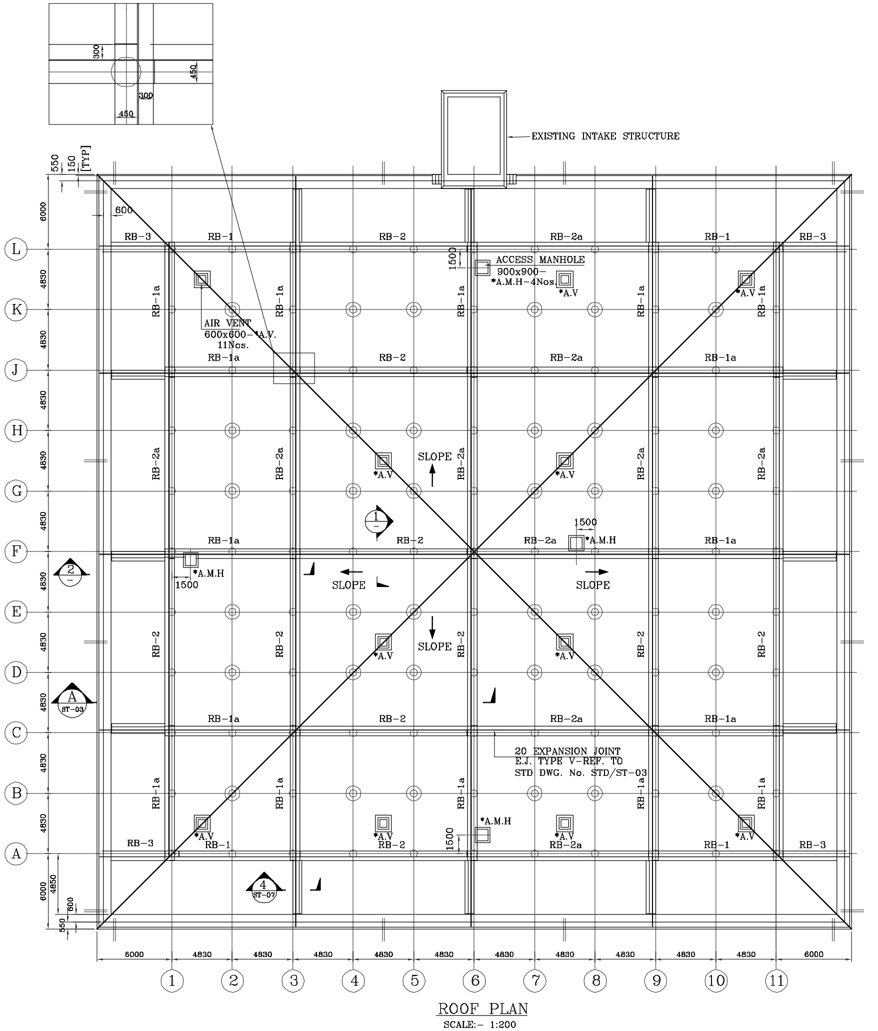
NATIONAL WATER SUPPLY AND DRAINAGE BOARD THE PROJECT FOR THE REDUCTION OF NON-REVENUE WATER IN THE GREATER COLOMBO AREA	SUB PROJECT: MALIGAKANDA	TITLE: NEW RESERVOIR GENERAL ARRANGEMENT SHEET 1 OF 3
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) STUDY TEAM NIHON SUIDO CONSULTANTS CO. LTD., TOKYO, JAPAN	DESIGNED / CHECKED / DY. TEAM LEADER / TEAM LEADER	DRAWN: RUKMANI PM (NRW/SAPS) NWSDB AGM(P&D) NWSDB DGM(P&D) NWSDB CONTRACT No. NRW/CW DRG. No. MK/GR/ST-01


HAND RAIL–REFER DWG. No. STD/ST–01 FOR DETAIL
BEARING PAD
300mm THICK PEBBLE LAYER–
INSULATION
20mm EXPANSION JOINT [TYPICAL]
BEND–ANGLE TO SUIT
T.W.L +29.90
TO BE CHIPPED–OFF TO RECEIVE DRAIN PIPE (TYP)
150 DIA. GI DRAIN PIPE
600x600 RC BLOCK TAPERING TO 300x300 TOP
EXISTING DRAIN TO BE CLEANED & REPAIRED
BEND–ANGLE TO SUIT
600φ RC COLUMNS
300mm THICK CONCRETE SLAB
200mm THICK BENCHING CONC. DIRECTION OF SLOPE TO BE DECIDED AT SITE.
L.W.L. +18.19
EXISTING CONCRETE SLAB
20mm EXPANSION JOINT
A SECTION
(EXISTING POST–TENSIONED BEAMS & SUPPORTS NOT SHOWN)
SCALE:– 1:100
25mm CLEARANCE ALL ROUND (TYP)
EXISTING POST–TENSIONED BEAM IN SECTION
20mm CLEAR GAP
EDGE OF BAFFLE WALL
EDGE OF EXISTING WALL
L.W.L. +18.19
DETAIL – X (NTS)
SCALE :– NTS
BAFFLE WALL –DETAILS AT EDGES AND OPENING AT POST–TENSIONED BEAMS (TYP)
BEAMS ABOVE
VIEW–X
200mm THICK BAFFLE WALL
20mm EXPANSION JOINT
20 mm GAP (TYP)
EXISTING OVERFLOW & WASHOUT PIPE TO BE RETAINED. MODIFICATION TO THE PIPES & FITTINGS AS PER DETAIL IN MECH. DWGS.
EDGE OF PROPOSED BASE SLAB
EXISTING TWO OUTLETS TO BE ABANDONED. ENDS OF THE PIPES TO BE CLOSED AS PER DETAIL IN MECH. DWGS.
600φ RC COLUMNS [TYPICAL]
EXISTING OUTLET TO BE RETAINED. END OF PIPE TO BE MODIFIED AS PER DETAIL IN MECH. DWGS.
BASE PLAN
SCALE:– 1:200
325x300 RC BEAM
325x450 RC BEAM
325x450 RC BEAM
VIEW–Y
VIEW Y
VIEW X
(TYPICAL AT ALL ACCESS MANHOLE – REF. TO STD. DWGS. FOR LADDER DETAILS)
SCALE:– 1:100
DO NOT SCALE
NATIONAL WATER SUPPLY AND DRAINAGE BOARD
THE PROJECT FOR THE REDUCTION OF NON-REVENUE WATER IN THE GREATER COLOMBO AREA
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) STUDY TEAM
NIHON SUIDO CONSULTANTS CO. LTD., TOKYO, JAPAN
SUB PROJECT: MALIGAKANDA
TITLE: REHABILITATION OF EXISTING RESERVOIR ROOF GENERAL ARRANGEMENT
SHEET 1 OF 2
DRAWN: RUKMANI
DATE: JAN. 2001
CONTRACT No.: NRW/CW
DRG. No.: MK/RF/ST–03









DO NOT SCALE

REV.	DESCRIPTION

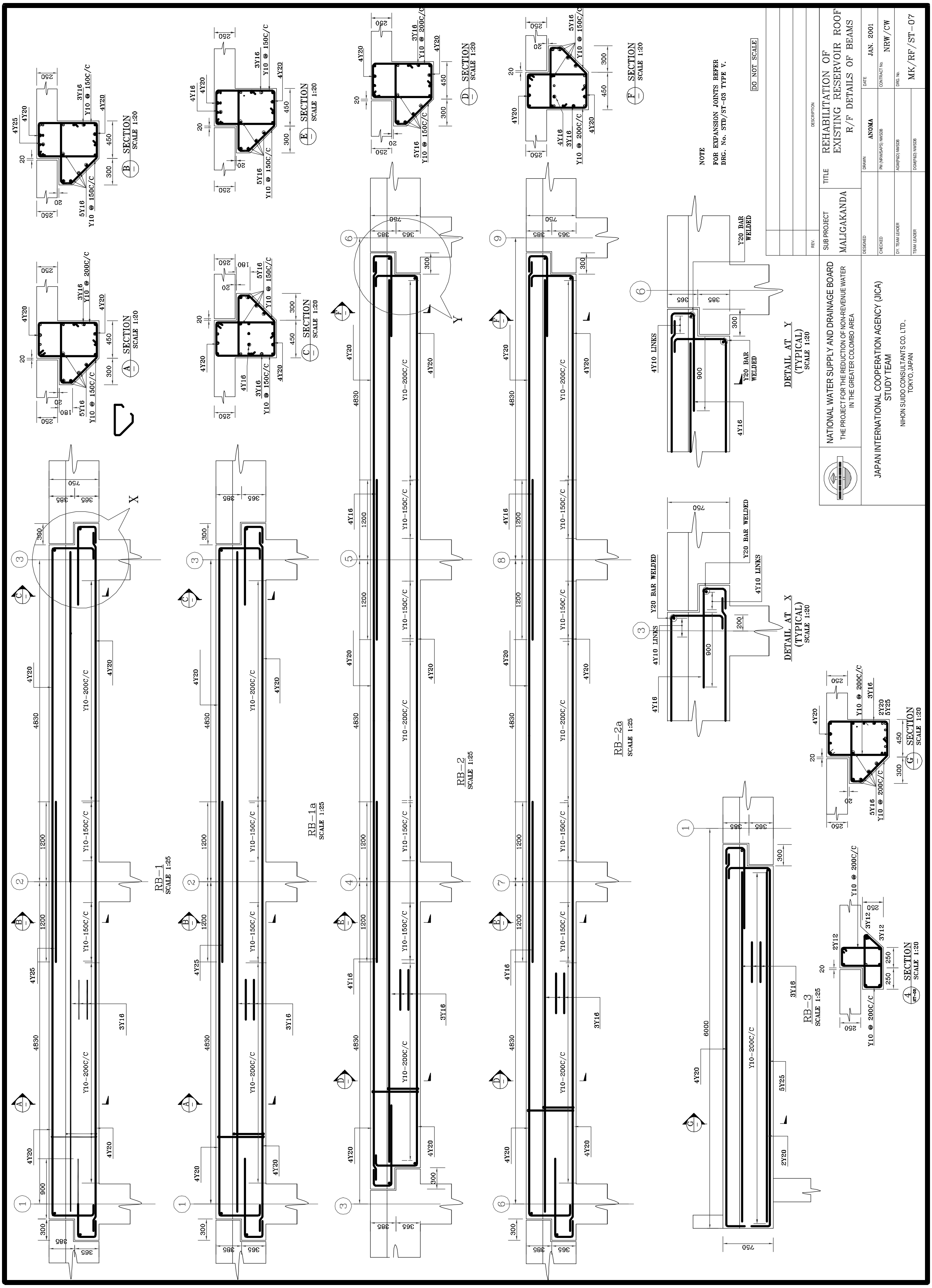
NATIONAL WATER SUPPLY AND DRAINAGE BOARD
THE PROJECT FOR THE REDUCTION OF NON-REVENUE WATER IN THE GREATER COLOMBO AREA

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
STUDY TEAM
NIHON SUIDO CONSULTANTS CO. LTD., TOKYO, JAPAN

SUB PROJECT: MALIGAKANDA

TITLE: REHABILITATION OF EXISTING RESERVOIR ROOF
GENERAL ARRANGEMENT
SHEET 2 OF 2

DESIGNED	DRAWN RUKMANI	DATE JAN. 2001
CHECKED	PM (NRW/SAPS) NWSDB	CONTRACT No. NRW/CW
DY. TEAM LEADER	AGM(P&D) NWSDB	DRG. No. MK/RF/ST-04
TEAM LEADER	DGM(P&D) NWSDB	


NATIONAL WATER SUPPLY AND DRAINAGE BOARD
THE PROJECT FOR THE REDUCTION OF NON-REVENUE WATER IN THE GREATER COLOMBO AREA
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) STUDY TEAM
NIHON SUIDO CONSULTANTS CO. LTD., TOKYO, JAPAN
SUB PROJECT
MALIGAKANDA
TITLE
REHABILITATION OF EXISTING RESERVOIR ROOF R/F DETAILS OF BEAMS
DRAWN ANOMA
DATE JAN. 2001
CONTRACT No. NRW/CW
DRG. No. MK/RF/ST-07
DO NOT SCALE
NOTE
FOR EXPANSION JOINTS REFER DRG. No. STD/ST-03 TYPE V.
RB-1 SCALE 1:25
RB-1a SCALE 1:25
RB-2 SCALE 1:25
RB-2a SCALE 1:25
RB-3 SCALE 1:25
SECTION A SCALE 1:20
SECTION B SCALE 1:20
SECTION C SCALE 1:20
SECTION D SCALE 1:20
SECTION E SCALE 1:20
SECTION F SCALE 1:20
SECTION G SCALE 1:20
SECTION 4 SCALE 1:20
DETAIL AT X (TYPICAL) SCALE 1:20
DETAIL AT Y (TYPICAL) SCALE 1:20
Y20 BAR WELDED
4Y10 LINKS
Y10-200C/C
Y10-150C/C

PIPING SCHEDULE - From Existing Reservoir

Pipe No.	ND mm	Description	Length mm	Qty.
A1	1000	Coupling		1
A2	1000	P/E Pipe Piece with Puddle Flange	2840	1
A3	1000	Flange Adapter		11
A4	1000-1000	Flanged Tee		7
A5	1000	F/PE Pipe piece	800	2
A5a	1000	F/PE Pipe piece	810	2
A5b	1000	F/PE Pipe piece	715	1
A5c	1000	F/PE Pipe piece	740	2
A6	1000-300	Flanged Tee		3
A7	1000	90º Flanged Bend		1
A8	1000-300	Flanged Tee		1
A9	300-150	Flanged Taper		1
A10	1000	P/E Pipe Piece	2430	1
A11	1000	F/PE Pipe Piece	1065	1
A12	1000	D/F Pipe Piece	3600	1
A13	1000	Blank Flange		1

PIPING SCHEDULE - From 27" / 30" By Pass

B1	1000-800	Flanged Taper		1
B2	800	Flange Adapter		1
B3	800	P/E Pipe Piece with Puddle Flange	2760	1
B4	800	Coupling		1

PIPING SCHEDULE - To 10" Old Dematagoda

C1	300-250	Flanged Taper		1
C2	250	D / F Pipe Piece	1125	1
C3	250	Flange Adapter		1
C4	250	P/E Pipe Piece with Puddle Flange	2270	1
C5	250	Coupling		1

PIPING SCHEDULE - To New Dematagoda

D1	300	D / F Pipe Piece	1550	1
D2	300	Flange Adapter		1
D3	300	P/E Pipe Piece with Puddle Flange	1950	1
D4	300	Coupling		1

PIPING SCHEDULE - To 20" Existing Colombo Fort

E1	1000-500	Flanged Taper		1
E2	500	Flange Adapter		1
E3	500	P/E Pipe Piece with Puddle Flange	2080	1
E4	500	Coupling		1

PIPING SCHEDULE - To 27" Existing St. Sabastian

F1	700	D / F Pipe Piece	500	1
F2	1000-700	Flanged Taper		1
F3	700	Flange Adapter		1
F4	700	P/E Pipe Piece with Puddle Flange	2030	1
F5	700	Coupling		1

PIPING SCHEDULE - To 20" Existing Kirilapone

G1	1000-500	Flanged Taper		1
G2	500	Flange Adapter		1
G3	500	P/E Pipe Piece with Puddle Flange	2240	1
G4	500	Coupling		1

PIPING SCHEDULE - From New Circular Tank

H1	1000-800	Flanged Taper		1
H2	800	D / F Pipe Piece	1200	1
H3	800	Flange Adapter		1
H4	800	P/E Pipe Piece with Puddle Flange	2237	1
H5	800	Coupling		1

PIPING SCHEDULE - From New Circular Tank

I1	1000-800	Flanged Taper		1
I2	800	D / F Pipe Piece	1200	1
I3	800	Flange Adapter		1
I4	800	P/E Pipe Piece with Puddle Flange	2200	1
I5	800	Coupling		1

PIPING SCHEDULE - To Mount Mary

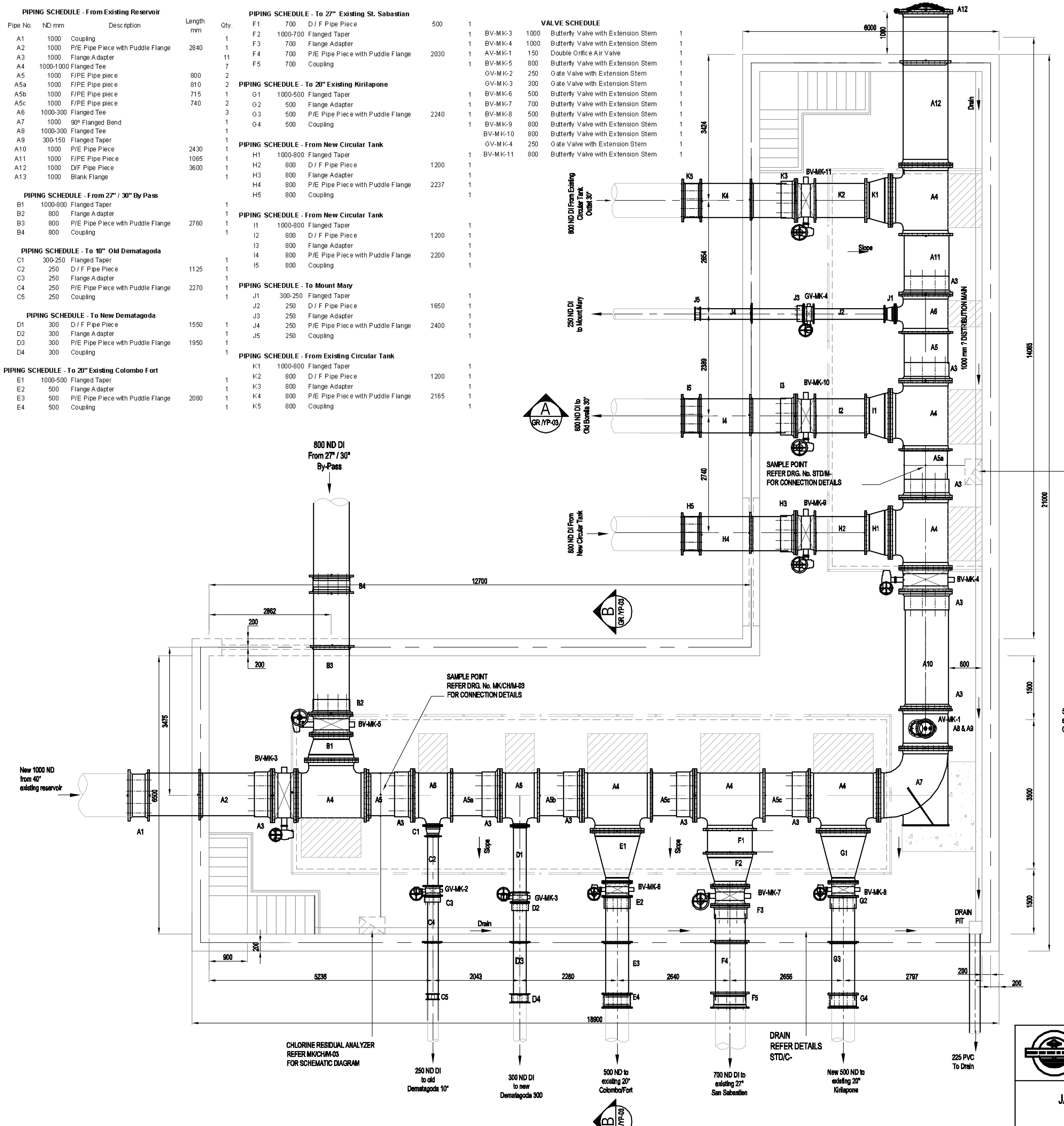
J1	300-250	Flanged Taper		1
J2	250	D / F Pipe Piece	1650	1
J3	250	Flange Adapter		1
J4	250	P/E Pipe Piece with Puddle Flange	2400	1
J5	250	Coupling		1

PIPING SCHEDULE - From Existing Circular Tank

K1	1000-800	Flanged Taper		1
K2	800	D / F Pipe Piece	1200	1
K3	800	Flange Adapter		1
K4	800	P/E Pipe Piece with Puddle Flange	2165	1
K5	800	Coupling		1

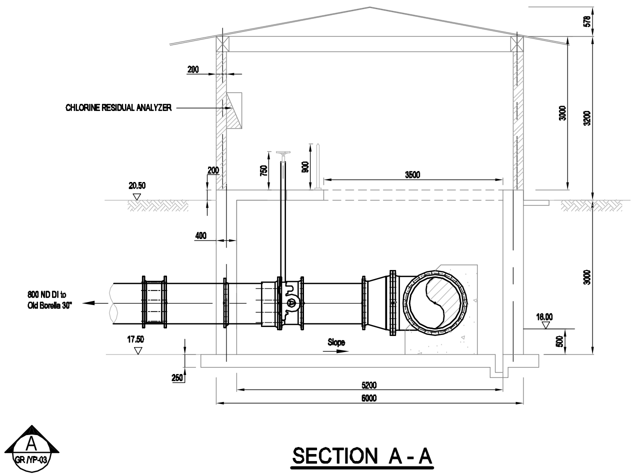
VALVE SCHEDULE

BV-MK-3	1000	Butterfly Valve with Extension Stem	1
BV-MK-4	1000	Butterfly Valve with Extension Stem	1
AV-MK-1	150	Double Orifice Air Valve	1
BV-MK-5	800	Butterfly Valve with Extension Stem	1
GV-MK-2	250	Gate Valve with Extension Stem	1
GV-MK-3	300	Gate Valve with Extension Stem	1
BV-MK-6	500	Butterfly Valve with Extension Stem	1
BV-MK-7	700	Butterfly Valve with Extension Stem	1
BV-MK-8	500	Butterfly Valve with Extension Stem	1
BV-MK-9	800	Butterfly Valve with Extension Stem	1
BV-MK-10	800	Butterfly Valve with Extension Stem	1
GV-MK-4	250	Gate Valve with Extension Stem	1
BV-MK-11	800	Butterfly Valve with Extension Stem	1



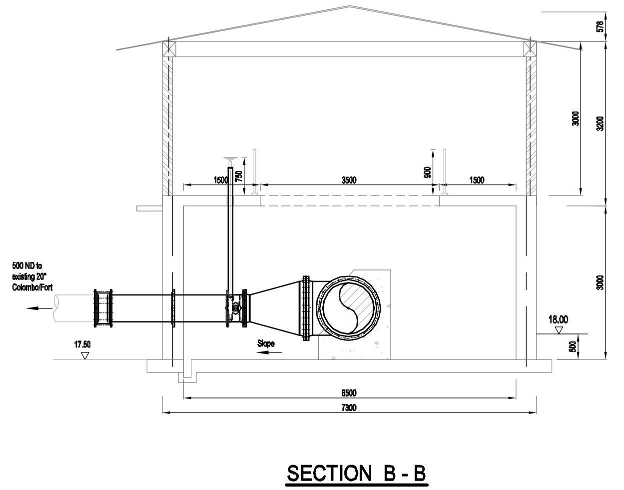
PLAN VIEW

Scale - 1 : 50



SECTION A - A

SCALE - 1 : 50



SECTION B - B

SCALE - 1 : 50

Reduced Drawing
Do Not Scale

REV.	DESCRIPTION

NATIONAL WATER SUPPLY AND DRAINAGE BOARD
THE PROJECT FOR REDUCTION OF NON-REVENUE WATER IN THE GREATER COLOMBO AREA

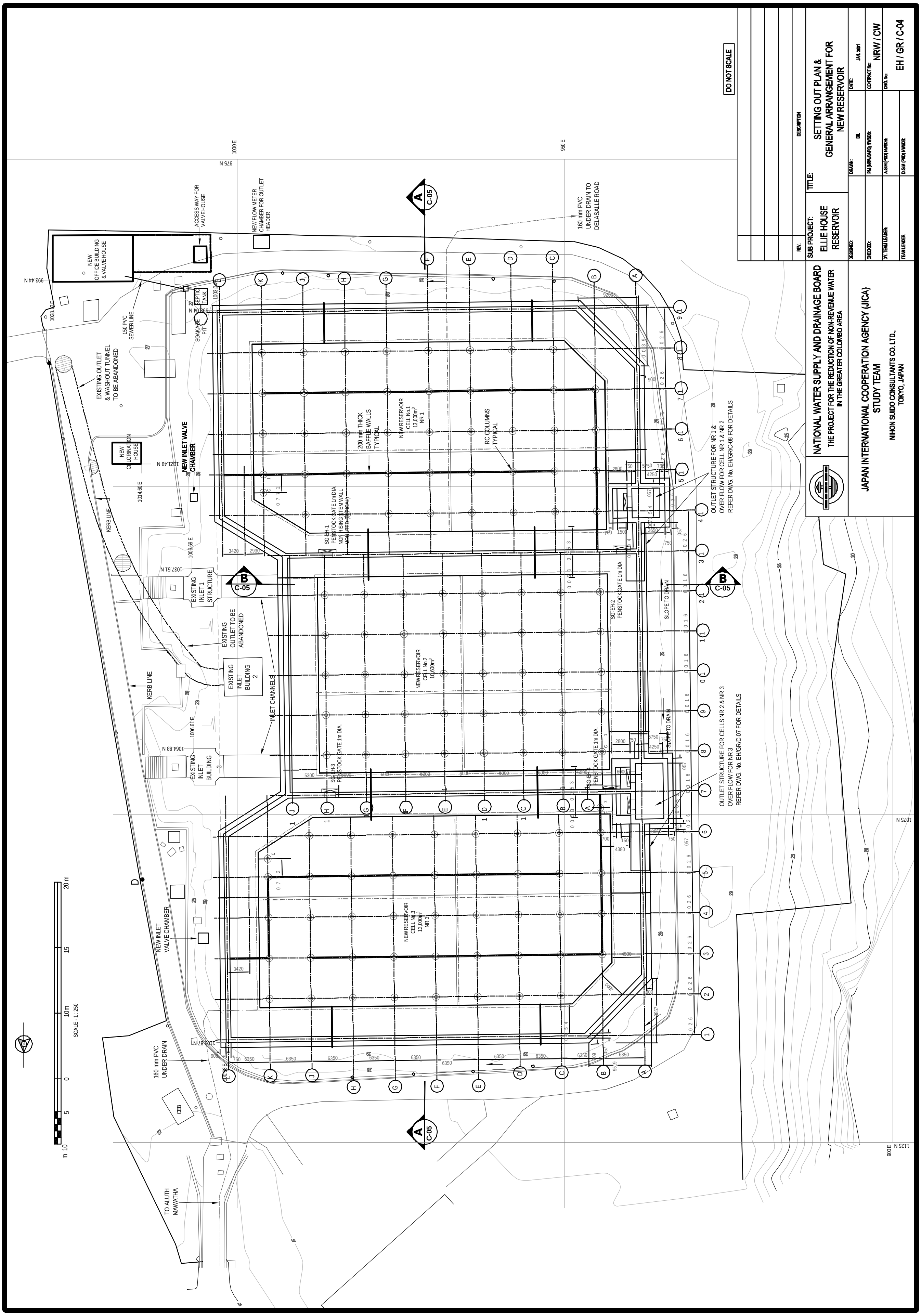
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
STUDY TEAM

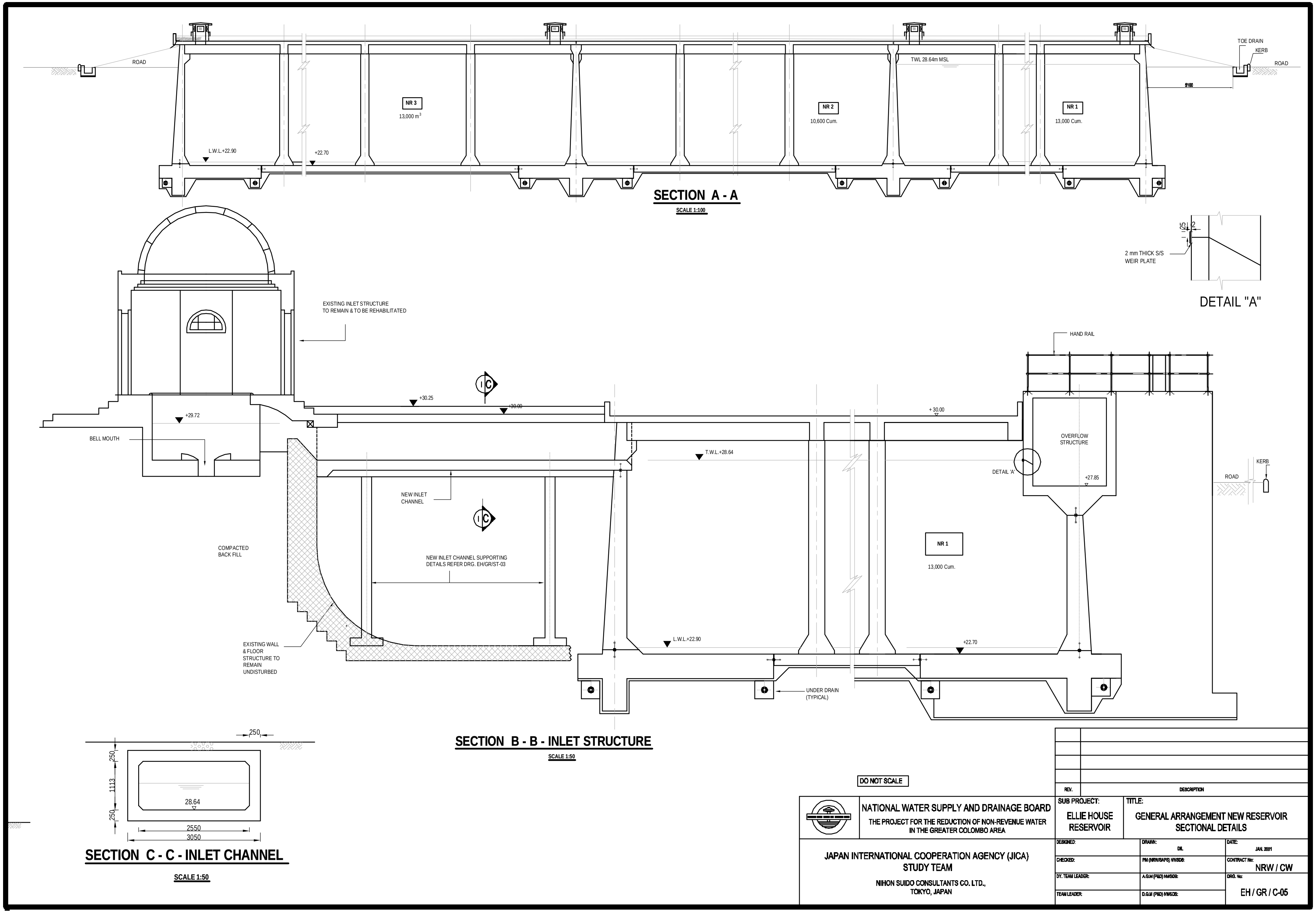
NIHON SUIDO CONSULTANTS CO. LTD., TOKYO, JAPAN

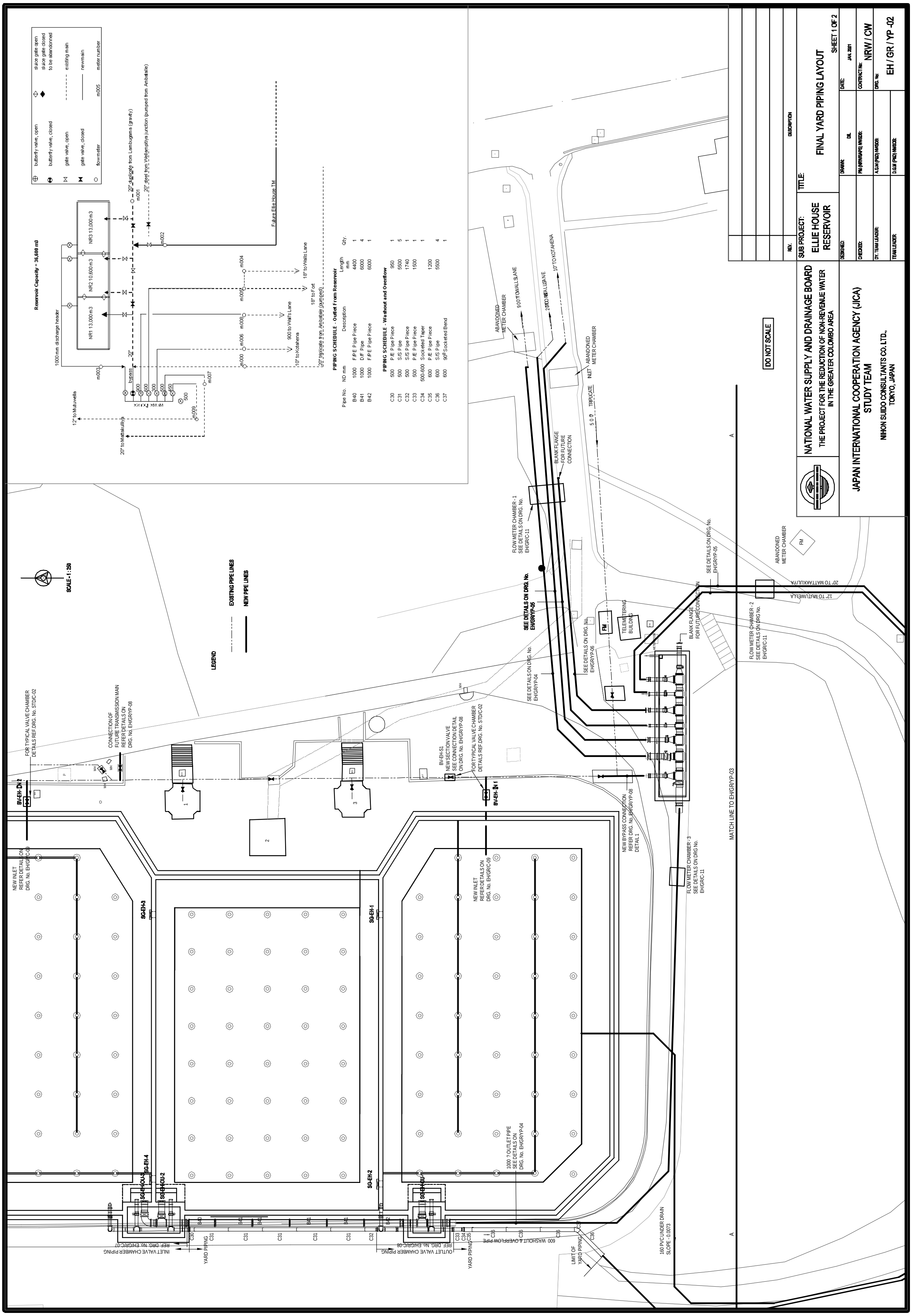
SUB PROJECT: MALIGAKANDA

TITLE: MALIGAKANDA NEW RESERVIOR ARRANGEMENT OF VALVE HOUSE

DESIGNED:	DRAWN:	DATE:
CHECKED:	PM (NRW/SAPS) NWSDB:	CONTRACT No: NRW / CW
DY. TEAM LEADER:	A.G.M (P&D) NWSDB:	DRG. No: MK / GR / YP-03
TEAM LEADER:	D.G.M (P&D) NWSDB:	


DO NOT SCALE
NATIONAL WATER SUPPLY AND DRAINAGE BOARD
THE PROJECT FOR THE REDUCTION OF NON-REVENUE WATER IN THE GREATER COLOMBO AREA
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
STUDY TEAM
NIHON SUIDO CONSULTANTS CO., LTD., TOKYO, JAPAN
SUB PROJECT:
ELLIE HOUSE RESERVOIR
TITLE:
SETTING OUT PLAN & GENERAL ARRANGEMENT FOR NEW RESERVOIR
DATE: JAN. 2001
CONTRACT No: NRW / CW
DWG. No: EH / GR / C-04
NEW OFFICE BUILDING & VALVE HOUSE
ACCESS WAY FOR VALVE HOUSE
NEW FLOW METER CHAMBER FOR OUTLET HEADER
160 mm PVC UNDER DRAIN TO DELASALLE ROAD
150 PVC SEWER LINE
SEPTIC TANK
SOAKAGE PIT
EXISTING OUTLET & WASHOUT TUNNEL TO BE ABANDONED
NEW CHLORINATION HOUSE
NEW INLET VALVE CHAMBER
KERB LINE
EXISTING INLET 1 STRUCTURE
EXISTING OUTLET TO BE ABANDONED
EXISTING INLET BUILDING 2
EXISTING INLET BUILDING 3
INLET CHANNELS
200 mm THICK BAFFLE WALLS TYPICAL
NEW RESERVOIR CELL No.1 13,000m³ NR 1
RC COLUMNS TYPICAL
NEW RESERVOIR CELL No.2 12,600m³
NEW RESERVOIR CELL No.3 13,000m³ NR 3
SG-EH-1 PENSTOCK GATE 1m DIA. NON RISING STEM WALL MOUNTED (TYPICAL)
SG-EH-2 PENSTOCK GATE 1m DIA.
SG-EH-3 PENSTOCK GATE 1m DIA.
SG-EH-4 PENSTOCK GATE 1m DIA.
SLOPE TO DRAIN
OUTLET STRUCTURE FOR NR 1 & OVER FLOW FOR CELL NR 1 & NR 2 REFER DWG. No. EH/GR/C-08 FOR DETAILS
OUTLET STRUCTURE FOR CELLS NR 2 & NR 3 OVER FLOW FOR NR 3 REFER DWG. No. EH/GR/C-07 FOR DETAILS
160 mm PVC UNDER DRAIN
CEB
TO ALUTH MAWATHA
NEW INLET VALVE CHAMBER
SCALE - 1 : 250
A C-05
B C-05


SECTION A - A
SCALE 1:100
ROAD
TOE DRAIN
KERB
9100
TWL 28.64m MSL
NR 3
13,000 m3
NR 2
10,600 Cum.
NR 1
13,000 Cum.
L.W.L.+22.90
+22.70
DETAIL "A"
2 mm THICK S/S WEIR PLATE
HAND RAIL
EXISTING INLET STRUCTURE TO REMAIN & TO BE REHABILITATED
+30.25
+30.00
+ 30.00
+29.72
BELL MOUTH
OVERFLOW STRUCTURE
DETAIL 'A'
+27.85
T.W.L.+28.64
NEW INLET CHANNEL
NEW INLET CHANNEL SUPPORTING DETAILS REFER DRG. EH/GR/ST-03
COMPACTED BACK FILL
EXISTING WALL & FLOOR STRUCTURE TO REMAIN UNDISTURBED
L.W.L.+22.90
+22.70
UNDER DRAIN (TYPICAL)
SECTION B - B - INLET STRUCTURE
SCALE 1:50
250
1113
28.64
2550
3050
SECTION C - C - INLET CHANNEL
SCALE 1:50
DO NOT SCALE
REV.
DESCRIPTION
NATIONAL WATER SUPPLY AND DRAINAGE BOARD
THE PROJECT FOR THE REDUCTION OF NON-REVENUE WATER IN THE GREATER COLOMBO AREA
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) STUDY TEAM
NIHON SUIDO CONSULTANTS CO. LTD., TOKYO, JAPAN
SUB PROJECT:
ELLIE HOUSE RESERVOIR
TITLE:
GENERAL ARRANGEMENT NEW RESERVOIR SECTIONAL DETAILS
DESIGNED:
DRAWN: DIL
DATE: JAN. 2001
CHECKED:
PM (NRW/BAPS) NWSDB:
CONTRACT No: NRW / CW
DY. TEAM LEADER:
A.G.M (P&D) NWSDB:
DRG. No: EH / GR / C-05
TEAM LEADER:
D.G.M (P&D) NWSDB:



NATIONAL WATER SUPPLY AND DRAINAGE BOARD
THE PROJECT FOR THE REDUCTION OF NON-REVENUE WATER
IN THE GREATER COLOMBO AREA
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
STUDY TEAM
NIHON SUIDO CONSULTANTS CO. LTD.,
TOKYO, JAPAN
SUB PROJECT:
ELLIE HOUSE
RESERVOIR
TITLE:
FINAL YARD PIPING LAYOUT
SHEET 1 OF 2
NRW / CW
EH / GR / YP -02
DO NOT SCALE
LEGEND
EXISTING PIPE LINES
NEW PIPE LINES
SCALE - 1 : 250
MATCH LINE TO EH/GR/YP-03