NO

BASIC DESIGN STUDY REPORT
ON
THE PROJECT
FOR
IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES
IN
THE KINGDOM OF NEPAL

OCTOBER 2001

JAPAN INTERNATIONAL COOPERATION AGENCY

JAPAN ENGINEERING CONSULTANTS CO., LTD.
NIPPON KOEI CO., LTD.

PREFACE

In response to a request from the Government of the Kingdom of Nepal, the Government of Japan decided to conduct a basic design study on the Project for Improvement of Kathmandu Water Supply Facilities and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Nepal a study team from November 6, 2000 to December 20, 2000.

The team held discussions with the officials concerned of the Government of Nepal, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Nepal in order to discuss a draft basic design, and as this result, the present report was finalised.

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

I wish to express my sincere appreciation to the officials concerned to the Government of the Kingdom of Nepal for their close cooperation extended to the teams.

October 2001

川上隆朗

Takao Kawakami
President
Japan International Cooperation Agency

October 2001

LETTER OF TRANSMITTAL

We are pleased to submit to you the basic design study report on the Project for Improvement of Katmandu Water Supply Facilities in the Kingdom of Nepal.

This study was conducted by Japan Engineering Consultants Co., Ltd. in association with Nippon Koei Co., Ltd., under a contract to JICA, during the period from November 6, 2000 to December 20, 2000. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Nepal and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

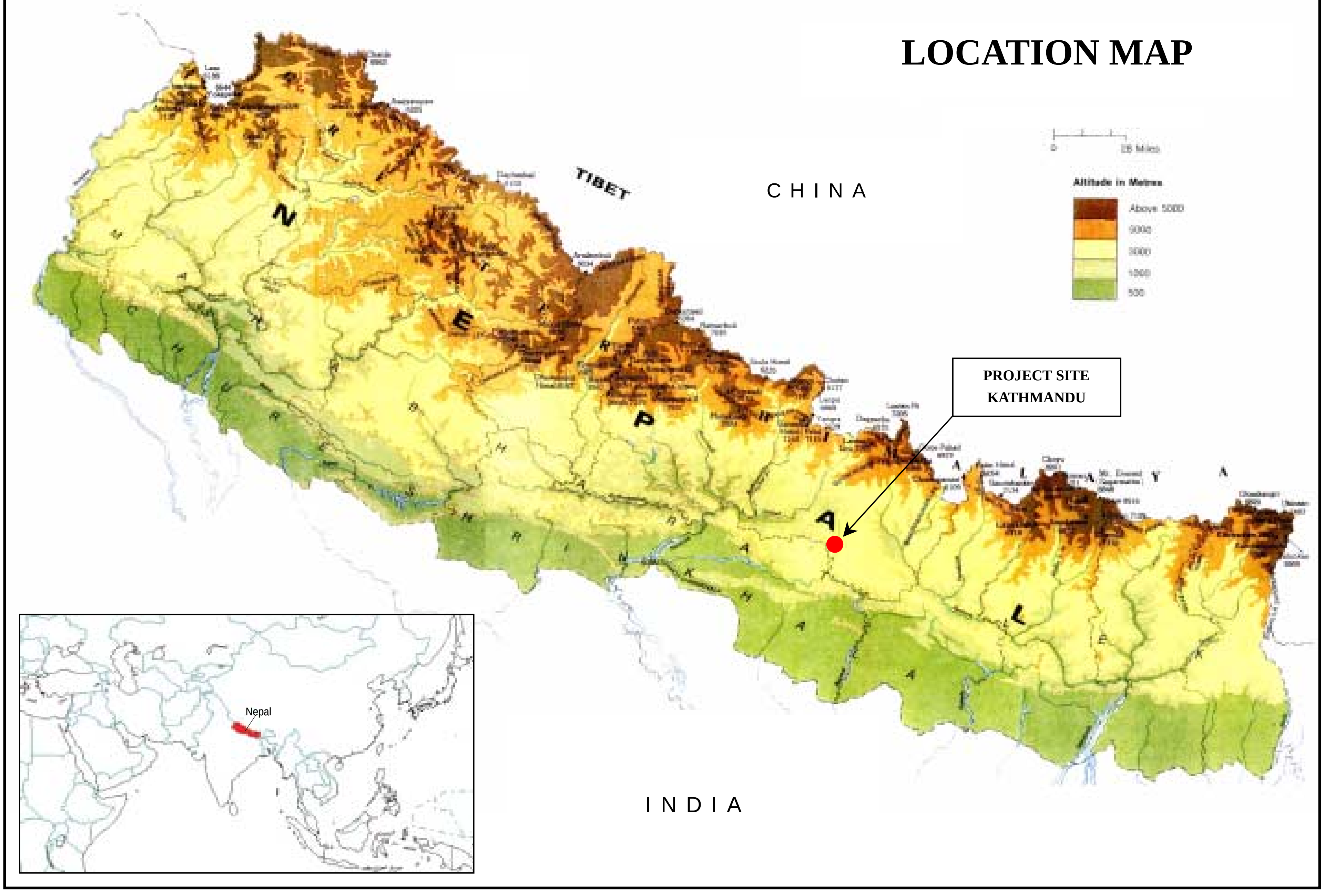
Very truly yours,

Munetaka Morio
Project Manager

Basic Design Study Team on the Project for Improvement of Kathmandu Water Supply Facilities

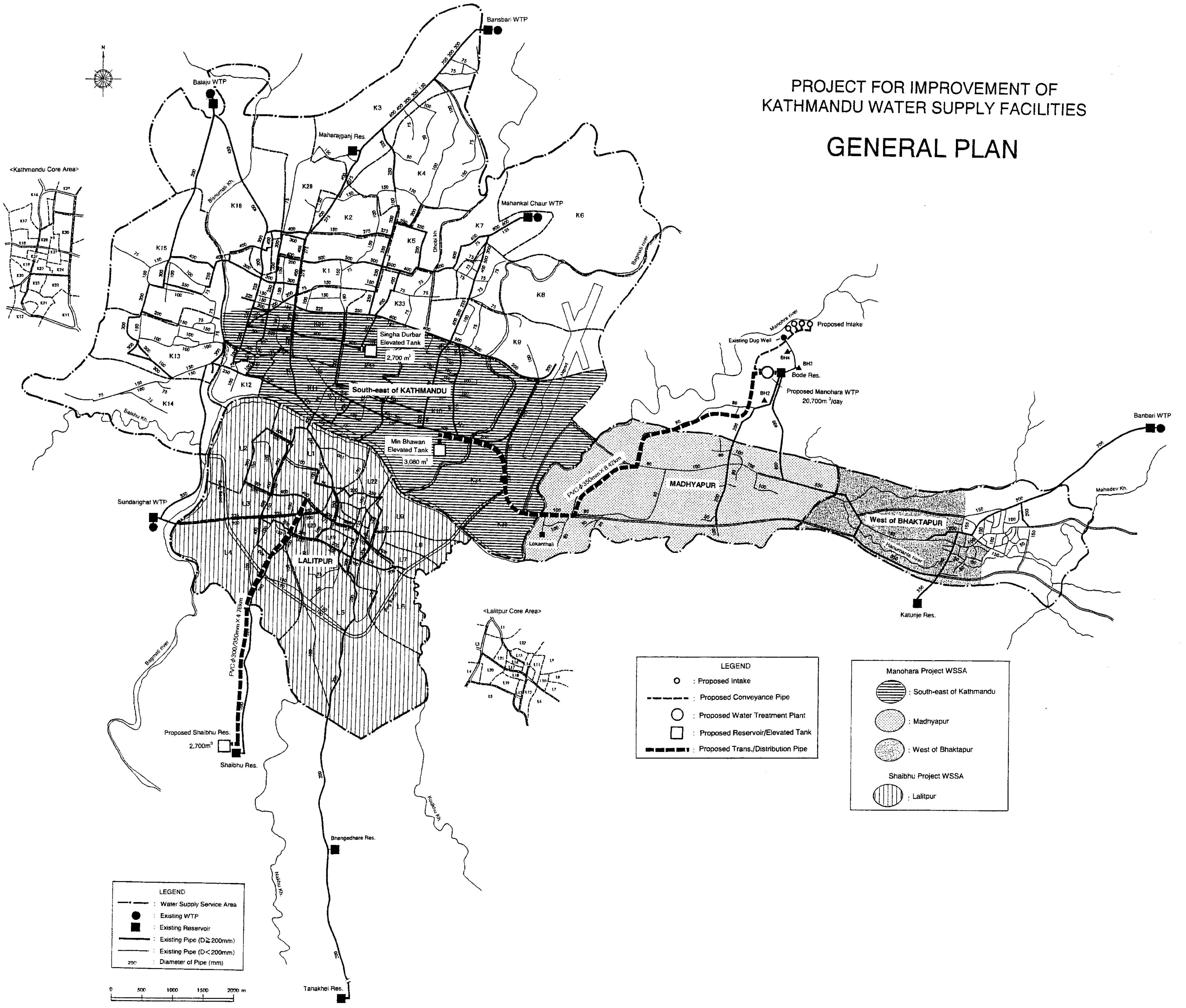
Japan Engineering Consultants Co., Ltd.
in association with Nippon Koei Co., Ltd.

LOCATION MAP



PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES

GENERAL PLAN



LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

ADB	:	Asian Development Bank
BDS	:	Bulk Distribution System
BOD	:	Biochemical Oxygen Demand
COD	:	Chemical Oxygen Demand
DHM	:	Department of Hydrogeology and Meteorology
DO	:	Dissolved Oxygen
DWSS	:	Department of Water Supply and Sanitation
EIA	:	Environmental Impact Assessment
FY	:	Fiscal Year
GDP	:	Gross Domestic Product
HMGN	:	His Majesty's Kingdom of Nepal
IDA	:	International Development Agency
JBIC	:	Japan Bank for International Cooperation
JICA	:	Japan International Cooperation Agency
kV	:	kilo Volt
KVWA	:	Kathmandu Valley Water Authority
lcd	:	litres per capita(head) per day
MD	:	Minutes of Discussions
MHPP	:	Ministry of Housing and Physical Planning
MLD	:	million litres per day
MPN	:	Most Probable Number
MPPW	:	Ministry of Physical Planning and Works
MW	:	Mega watt
MWSDB	:	Melamchi Water Supply Development Board
NEA	:	Nepal Electricity Authority
NH_3, NH_4^-	:	Ammonia、 Ammonium
NWRB	:	National Water Supply Regulatory Board
NWSC	:	Nepal Water Supply Corporation
pcc	:	per capita consumption
pH	:	potential of Hydrogen (Acidity)
PO	:	Private Operator
UWSSRP	:	Urban Water Supply and Sanitation Rehabilitation Programme
VDC	:	Village Development Committee
WHO	:	World Health Organization
WTP	:	Water Treatment Plant

SUMMARY

Kathmandu, the capital of Nepal, lies in the Kathmandu Valley which occupies almost a circular area of 656 km^2 with north-south and east-west axes both of approximately 30 km. Central flat land in the Valley is of around 400 km^2 with elevation of 1,300 m to 1,400 m, surrounded by the mountainous region of elevation over 2,000 m. Kathmandu forms an urban area in the Valley, unified with the neighbouring Lalitpur, Madhyapur and Bhaktapur, showing recently population expansion as well as the industrial intensification as a political and economic centre of the nation. According to 1991 census, the urban area had population of 598 thousand, and it grew to 749 thousand in a survey in 1997. If the trend of population growth (average annual growth rate: 3.5%) maintained, it would reach almost 820 thousand in the year 2000.

The rapid population increase and progress in urbanisation like this have been hampering infrastructure provision and environmental conservation measures in the Kathmandu Valley, resulting in serious deterioration of the urban environment. Specifically waterworks, which is a key in maintaining the livelihood and human activities in the urban area at a stable level, have failed to secure the amount of safe and hygienic water as required owing to superannuated existing facilities coupled with construction delay of new facilities, afflicted with a chronic water shortage and several affections associated with water quality. In the 9th National Development Plan, 1997-2002, the Government of Nepal identified the needs of waterworks facilities provision in the Valley to cope with the long-range prospects of water demand, centring on the 2 major programmes: (1) implementation of new projects in the Valley for leakage reduction, adequate management of water resources and development of water source; and (2) the Melamchi Project seeking for water source outside of the Valley.

As concerned (1) above, the Government of Japan conducted in 1989 and 1990 "The Master Plan Study on Groundwater Management Project in the Kathmandu Valley", and identified 8 projects with the target year 2001. Out of the 8 projects, Mahankal Chaur and Bansbari Projects were judged to be the most urgent for quality improvement of the existing groundwater as well as for expansion of supply capacity through developing water source inside the Valley. Towards these 2 Projects, a Basic Design Study "The Project for Kathmandu Water Supply Facility Improvement" was conducted in 1991. Succeedingly in 1992 through 1995, in accordance with the Basic Design, 2 water treatment plants were constructed under a grant aid scheme of the Japanese Government; water supply situation was temporarily improved in the Valley. Notwithstanding, thereafter, affected by the suspension of the Urban Water Supply and Sanitation Rehabilitation Programme (UWSSRP), World Bank, for improvement of the existing waterworks facilities and a considerable delay of the commissioning of Melamchi Project facilities, the situation continues in which the existing water supply facilities might not have responded to rapidly increasing water demand, forcing the residents to live in an aggravated hygienic condition with inconvenience in the livelihood.

Under these circumstances, the Government of Nepal requested the implementation of 3 projects out of the remaining 6 projects identified in the Master Plan Study, under a grant aid scheme of the Japanese Government, aiming at urgently improving water supply service in the Kathmandu Valley. The requested 3 projects are: Manohara and Balkhu Projects, both for

setting-up new water supply system through developing water source inside the Valley; and Shaibhu Project, for augmenting the existing water supply system.

In response to the request, the Government of Japan commenced an examination of the requested contents towards implementation of the 3 Projects. In the examination, perceived were: more than 10 years have passed since the Master Plan Study conducted; in water source plan, etc., some items remain unclear; progress of the Melamchi Project implementation shall be monitored; and so forth. As these acknowledged, it was determined to conduct a Preparatory Study. Accordingly, JICA sent the Preparatory Study Team to Nepal from March 9 to April 5, 2000. Concluded in the Preparatory Study were: Manohara and Shaibhu Projects both will have a high feasibility in their implementation; however, Balkhu Project might not be justified of its implementation.

In accordance with the conclusion of the Preparatory Study, the Government of Japan determined to conduct a Basic Design Study of the above 2 Projects with high feasibility judged thereof. Accordingly, JICA sent the Study Team to Nepal from Nov. 7 to Dec. 19, 2000. The Study Team conducted, in Nepal, confirmation of the requested contents, field investigation on the site, investigation of operation and maintenance system, examination of facilities plan, and so forth, through discussion meeting with the Ministry of Physical Planning and Works (MPPW) and Nepal Water Supply Corporation (NWSC). After returning to Japan, the Study Team undertook the basic design, and compiled the results into a draft Report. Thereafter, JICA sent again the Study Team to Nepal, July 30 to August 8 2001, for explaining the draft Report as well as for deliberation on the contents of Basic Plan with the counterpart officials concerned. The results are all embodied in this Report.

The target year of the Project has been set at 2006, considering the commissioning of Melamchi Project facilities being scheduled in the year 2007. From the field investigation and the subsequent analysis, it is revealed that the effective supply amount (consumption) is 63,900 m^3/day in the urban area of the Kathmandu Valley in the current situation (in 2000) and that it might be estimated to increase to 101,400 m^3/day in the target year 2006. On the other hand, the implementation of Balkhu Project initially requested by the Nepalese Government has been suspended, due to the problems of water quality in the source. Like this, in the recent years, new water source development has become difficult, qualitatively as well as quantitatively, in the Kathmandu Valley; the augmentation of supply capacity, as previous, through construction of new water supply facilities has been drawing to its limit.

The water supply capacity augmentation in the Project, from the cooperation direction that it should be minimal in facility scale and contents until the Melamchi Project materialised as well as from the situation of water source in the Valley as discussed above, would be 20,600 m^3/day. For fulfilling the augmented effective supply amount of 37,500 m^3/day, a measure is required in which the currently high leakage ratio (almost 43.5%) be reduced and water currently lost in the leakage made into effective water the users might use actually (effective supply amount), in parallel with the water supply capacity augmentation.

In the consequence, in the Project, a basic concept applied in the planning of water supply, shall be: the current water supply service area be sub-divided, coinciding with the existing water supply facilities provided, supply capacity of facilities to be newly constructed in the Project, and distribution of water demand, to reduce the current high leakage ratio through making supply pressure distribution even as well as through reducing the average supply pressure.

Also, in the water supply facilities plan, for the purpose of sub-dividing the water supply service areas on the basis of the basic concept; 2 elevated tanks shall be constructed in the southeast of Kathmandu, in Manohara Project, and direct distribution pipe to the northeast of Lalitpur installed, in Shaibhu Project.

The Study Team has determined the contents of the Project as under, based on the initially requested contents, in consideration of the results of field investigation, examination as above, and others.

Basic Plan of the Project

[Manohara Project]

Facilities	Content (Amount, Specifications, etc.)
1. Water Intake Facilities	
(1) Intake well	8 wells (ϕ4 m x 6.4 m depth)
(2) Intake pump	2.70 m^3/min. x 23.5 m x 15 KW x 2 nos. 2.20 m^3/min. x 23.5 m x 15 KW x 2 nos. 2.13 m^3/min. x 21.0 m x 15 KW x 2 nos. 1.67 m^3/min. x 21.0 m x 11 KW x 2 nos.
(3) Electrical equipment	Transformer: 200 KV
2. Water Conveyance Facilities	
(1) Conveyance pipe	PVCϕ125-400 mm x 1.48 km
3. Water Treatment Plant	
(1) Coagulation-Sedimentation basin	920 m^3/basin x 3 basins (detention time: 3 hrs.)
(2) Rapid sand filtration basin	22.68 m^2/basin x 8 basins
(3) Clear water reservoir	561 m^3/basin x 2 basins (detention time: 1 hr.)
(4) Sludge and discharge basin	202 m^3/basin x 2 basins
(5) Sludge drying bed	280 m^3/bed x 4 beds
(6) Chemicals feeding equipment	1 set each for PAC, sodium hydroxide, and bleaching powder
(7) Electrical equipment	Transformer: 750 KVA
(8) Constructions	Office, electrical room, warehouse
4. Water Transmission Facilities	
(1) WTP – Bode reservoir	2.63 m^3/min. x 52 m x 45 KW x 3 nos. DCIPϕ250 mm x 0.38 km
(2) WTP – Min Bhawan elevated tank	2.79 m^3/min. x 68 m x 55 KW x 5 nos. PVCϕ350 mm x 8.42 km
5. Elevated Tank	
(1) Min Bhawan elevated tank	3,080 m^3 (RC structure, 15 m height)
(2) Singha Durbar elevated tank	2,700 m^3 (RC structure, 15 m height)

[Shaibhu Project]

Facilities	Content (Amount, Specifications, etc.)
1. Service Reservoir	2,700 m^3 (RC structure)
2. Sterilising Agent Feeding Equipment	1 set for bleaching powder
3. Distribution Pipe	PVC φ350 mm x 1.26 km φ300 mm x 3.50 km

The Project will be implemented as a 2-phase grant aid scheme. In phase-I, undertaken will be the construction of water intake and conveyance facilities and water treatment plant in the Manohara Project, and plumbing work of transmission pipes to Bode reservoir. Through this, water will be able to supply to Madhyapur and west of Bhaktapur. In phase-II, through plumbing work of transmission pipes to southeast of Kathmandu and construction of 2 elevated tanks, treated water will be able to supply to Kathmandu and Lalitpur. The construction periods required are, about 6 months for the detailed design/tendering work in the both Phases; for water supply facilities construction, 9.5 months in Phase I, and 12 months in Phase II; totalling to approximately 19.5 months.

The direct-benefited area of the Project will be southeast of Kathmandu, Madhyapur and west of Bhaktapur in the Manohara Project, and Lalitpur in the Shaibhu Project. Beneficiary population will be 267,000 and 160,000, respectively, totalling to 427,000 (estimated for the target year 2006). In addition, when these areas be supplied water with Project facilities, the supply amount hitherto supplied to these areas with the existing facilities might be applied to other service areas. In consequence, water supply situation in the whole urban areas will be equally improved. The benefiting effects of the Project would cover the whole urban population in the Kathmandu Valley, that is, 1,007,000 in the target year 2006.

With the implementation of the Project, the following effects might directly be expected:

- Through constructing water treatment plant and augmenting service reservoir, supply capacity will be augmented to 133,700 m^3/day from the current 113,100 m^3/day (augmentation: 20,600 m^3/day).

- Through constructing elevated tanks as well as plumbing work of the distribution main, aiming at sub-division of service areas, an even distribution of pressure and the reduced average pressure level will be effected, leading to leakage reduction. The leakage ratio will be reduced to 32.8% from the current 43.5% (improvement: 10.7%).

- Through the supply capacity augmentation and the leakage reduction, effective supply amount (consumption) will be enhanced with 25,900 m^3/day. Per capita consumption for domestic use will be increased to 65.5 litre/capita/day from the current 46.6 litre/capita/day (increase: 18.9 litre/capita/day).

- In Madhyapur and west of Bhaktapur currently served with unfavourable-quality groundwater, safe and hygienic water will be supplied, and affections associated with water quality of approximately 45,000 residents will be eliminated.

Furthermore, indirectly, satisfaction degree of the residents towards NWSC waterworks undertaking would be raised through quantitative as well as qualitative improvement of water supply service and securing evenness of water supply service level in the Valley. These will contribute considerably in obtaining the cooperation and understandings of the residents towards the aimed waterworks facilities provision to come and smooth undertaking of waterworks (such as in water tariff lifting-up). Moreover, the planned facilities in the Project will be able to utilise as the facilities having an important role in fulfilling the long-range water demand in the Kathmandu Valley, even after the Melamchi Project materialised.

As above delineated, considerable effects might be expected in the Project implementation. At the same time, as the Project will extensively contribute to the improvement of basic human needs of the residents as well as stabilisation of the livelihood, the appropriateness of the Project implementation under the grant aid scheme of the Japanese Government might be confirmed. On the other hand, it might be considered that human resources and financial resources of the Government of Nepal be adequate without problems in undertaking the operation and maintenance practices in the Project.

Nevertheless, now that the following be improved or provided, the Project is to be implemented more smoothly and efficiently:

- In Nepal, ministries, agencies and related offices having a development project proposal are obligated with an environmental impact assessment (EIA) under the Environment Protection Act, 1997. Accordingly, it is desirable for the counterpart agency, NWSC, to complete the required procedures in EIA, without any delay, for obtaining a permit of construction commencement.

- In the Project, the water treatment equipment made in Japan will be used in view of simplicity and durability. NWSC has already laid down the rules and regulation for the procurement of spare-parts, etc. required in maintenance of foreign-made equipment. These rules and regulation are expected to apply in practice to make the procurement certain.

- At the moment, the waterworks undertaking in the Kathmandu Valley is ready to be entrusted to the private operator in operation and management. Even after the entrustment brought into effect, however, staff force and manpower quality of the O/M personnel shall be maintained.

- The fundamental concept in the Project is to provide waterworks facilities aiming at enhancement of effective supply amount through leakage reduction in the sub-divided service areas. Parallelly, if the existing distribution network be rehabilitated under the programme of World Bank and others, the Project effects would be further raised, which will be much desirable.

CONTENTS

Appendices

Chapter 1 Background of the Project

In the 9th National Development Plan, 1997-2002, the Government of Nepal identified the needs of waterworks facilities provision in the Valley to cope with the long-range prospects of water demand, centring on the 2 major programmes: (1) implementation of new projects in the Valley for leakage reduction, adequate management of water resources and development of water source; and (2) the Melamchi Project seeking for water source outside of the Valley.

As concerned (1) above, the Government of Japan conducted in 1989 and 1990 “The Master Plan Study on Groundwater Management Project in the Kathmandu Valley”, and identified 8 projects with the target year 2001. Out of the 8 projects, Mahankal Chaur and Bansbari Projects were judged to be the most urgent for quality improvement of the existing groundwater as well as for expansion of supply capacity through developing water source inside the Valley. Towards these 2 Projects, a Basic Design Study “The Project for Kathmandu Water Supply Facility Improvement” was conducted in 1991.

Succeedingly in 1992 through 1995, in accordance with the Basic Design, 2 water treatment plants were constructed under a grant aid scheme of the Japanese Government; water supply situation was temporarily improved in the Valley. Notwithstanding, thereafter, affected by the suspension of the Urban Water Supply and Sanitation Rehabilitation Programme (UWSSRP), World Bank, for improvement of the existing waterworks facilities and a considerable delay of the commissioning of Melamchi Project facilities, the situation continues in which the existing water supply facilities might not have responded to rapidly increasing water demand, forcing the residents to live in an aggravated hygienic condition with inconvenience in the livelihood.

Under these circumstances, the Government of Nepal requested the implementation of 3 projects out of the remaining 6 projects identified in the Master Plan Study, under a grant aid scheme of the Japanese Government, aiming at urgently improving water supply service in the Kathmandu Valley. The requested 3 projects are: Manohara and Balkhu Projects, both for setting-up new water supply system through developing water source inside the Valley; and Shaibhu Project, for augmenting the existing water supply system.

In response to the request, the Government of Japan commenced an examination of the requested contents towards implementation of the 3 Projects. In the examination, perceived were: more than 10 years have passed since the Master Plan Study conducted; in water source plan, etc., some items remain unclear; progress of the Melamchi Project implementation shall be monitored; and so forth. As these acknowledged, it was determined to conduct a Preliminary Study. Accordingly, JICA sent the Preliminary Study Team to Nepal from March 9 to April 5, 2000. Concluded in the Preliminary Study were: Manohara and Shaibhu Projects both will have a high feasibility in their implementation; however, Balkhu Project might not be justified of its implementation due to deteriorated water quality in the source.

The following are the requested contents of the Project:

(1) Manohara Project

(a) Surface water intake facilities
(b) Conveyance facilities (23,000 m^3/day)
(c) Water treatment plant (23,000 m^3/day)
- Bio-filter
- Flocculation basin
- Sedimentation basin
- Rapid sand filter
- Sludge removal facilities
- Clear water reservoir
- Chemicals feeding equipment
- Disinfection equipment

(d) Service reservoir (3,000 m^3)
(e) ϕ350 mm distribution main (7,500 m)

(2) Shaibhu Project

(a) Service reservoir (4,500 m^3)
(b) ϕ350 mm distribution main (3,500 m)
(c) Disinfection equipment for bleaching powder and sodium hypochlorite
(d) Water quality monitoring equipment and instruments

(3) Balkhu Project

(a) Surface water intake facilities
(b) Conveyance facilities (13,000 m^3/day)
(c) Water treatment plant (13,000 m^3/day)
- Flocculation basin
- Sedimentation basin
- Rapid sand filter
- Sludge removal facilities
- Clear water reservoir
- Chemicals feeding equipment
- Disinfection equipment

(d) 2 service reservoirs (1,850 m^3/day each)
(e) Transmission main
- ϕ350 mm (1,800 m)
- ϕ250 mm (2,300 m)

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

(1) Overall Goal and Project Purpose

Recently in Kathmandu infrastructure provision and environmental conservation have been hampered by rapid population growth and increasing urbanisation, resulting in serious deterioration of the urban environment. In particular, water supply service that is a key in ensuring the stable livelihood and in maintaining human activity level in the urban environment, has failed to supply the required quantity of safe and sanitary water, due to superannuated existing facilities as well as construction delay of new facilities, which have brought about a chronic water shortage and several affections associated with water quality.

The Government of Nepal, in the 9th 5-year National Development Plan (1997-2002), identified the need to provide water supply facilities in the Kathmandu Valley, through implementation of a programme with 2 major constituents: (1) newly-framed project implementation, reduction of water leakage, and an appropriate management as well as development of water resources in the Valley; and (2) Melamchi Project for water supply development program which divert water from outside the Valley, in response to the water demand overviewed in the long run.

The Project envisages the improvement of current water supply situation in the Valley, as a contribution to the latest National Development Plan, through putting in operation water resources development in the Valley, construction of a water treatment plant, and extension of the existing water supply facilities. The planned facilities in the Project shall be effectively and sustainedly utilised, even after the Melamchi Project materialised, as water supply facilities to play an important role in meeting long-range water demand in the Valley.

The Overall Goal and Project Purpose might be summarised as follows:

[Overall Goal]

To improve the livelihood conditions, through upgrading water supply service in the NWSC service area (Target Area) in the Kathmandu Valley.

[Project Purpose]

1) To eliminate the shortage of supply quantity (effective water) in Target Area.
2) To improve quality of the water supplied in Target Area.

(2) Outline of the Project

In the Project, for the attainment of above Project Purpose, to be carried out are the construction of the planned facilities in the Manohara Project and the Shaibhu Project, out of 3 Projects requested by the Government of Nepal for improvement of water supply facilities in the Kathmandu Valley; and the study, design, and construction supervision, relevant to the facility construction.

2-2 Basic Design of the Requested Japanese Assistance

2-2-1 Design Policy

In the Project to be carried out are the design of the Manohara Project and the Shaibhu Project out of three Projects requested by Nepalese Government, since the Bulk Project was not justified of its implementation by the JICA Preliminary Study in 2000 because of deteriorated water quality.

The facility design shall be done according to the following fundamentals.

(1) Fundamentals

1) Target Year of the Project

The target year of the Project is set at 2006, considering that water supply operation in the Melamchi Project is scheduled to commence in 2007.

2) Planned Service Area (Target Area) of the Project

While the Project aims at improving overall water supply situation in the entire NWSC service area in the Kathmandu Valley, the Manohara Project and the Shaibhu Project have the direct-benefited areas, respectively, as follows:

- Manohara Project: Kathmandu Southeast, Madhyapur and Bhaktapur West
- Shaibhu Project: Lalitpur

3) Service Population

(a) Population

The population in target area is projected based on the results of national census being conducted every 10 years and the results of a consumer survey conducted by NWSC in 1997, through the following procedures:

- Urban and suburban population is projected by logistic curve formula technique based on national census results and saturated population in target area (density of saturated population is set at 250 persons/ha). Refer to Fig. 2.2.1
- Rural population is projected based on population growth trends in urban and rural areas (share of population growth rates between urban and rural areas) from 1991 to 1997.

(b) Service Ratio

Target service ratio is determined, based on the service ratio of 75.5% in urban areas and 47.2% in rural areas indicated in the NWSC consumer survey in 1997, taking into consideration an annual increase rate of 0.5%.

(c) Service Population

The estimated service population, on the basis of population projection and target service ratio described above, is shown in Table 2.1.1.

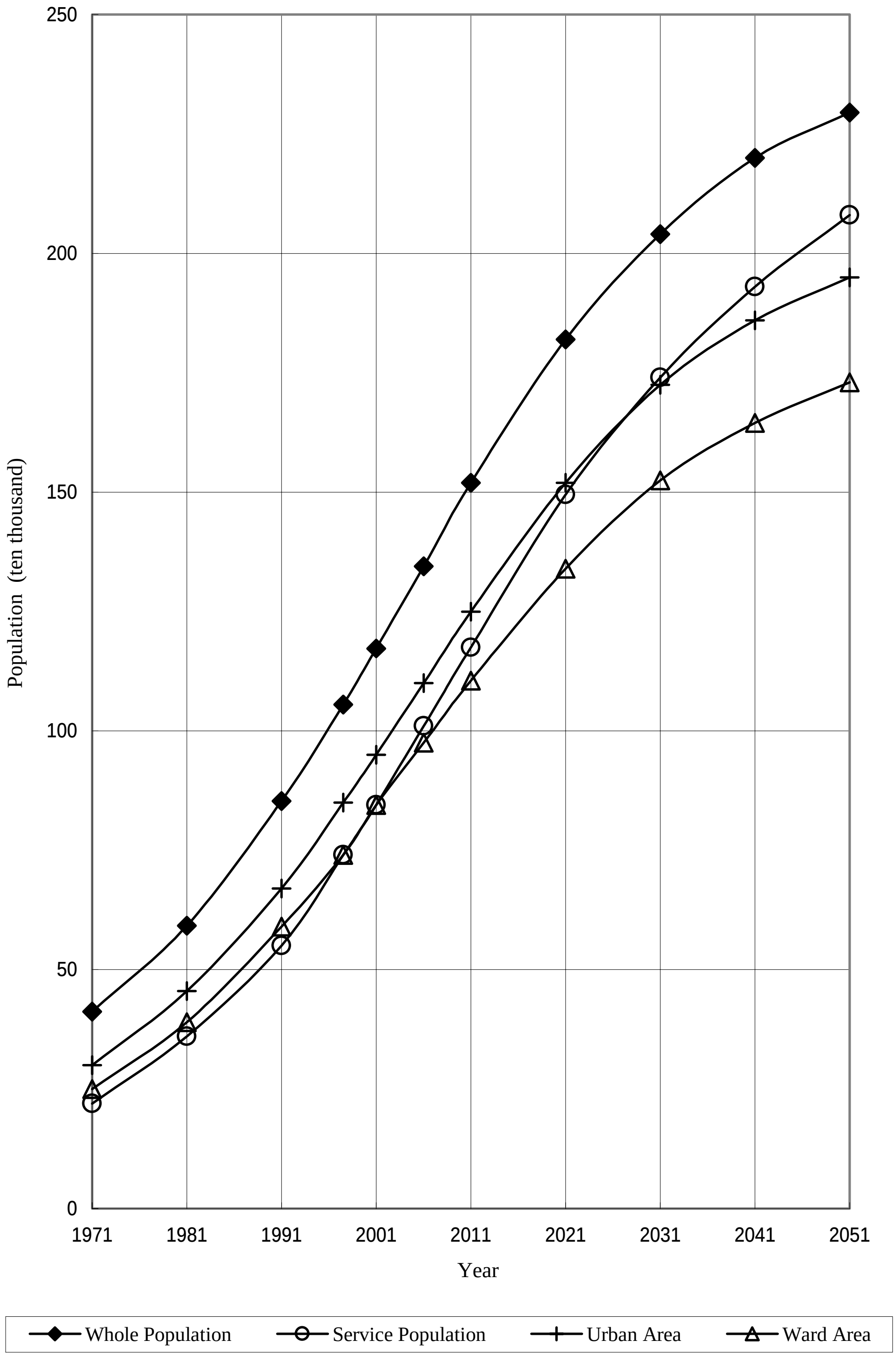


Fig. 2.2.1 Population Projection (By Logistic Curve Formula Method)

Table 2.2.1 Service Population

(Unit: 1,000 persons)

		2001			2006		
		Population	Service Ratio	Served Population	Population	Service Ratio	Served Population
Kathmandu	Urban	697.8	77.5%	540.8	819.6	80.0%	655.7
	Rural	116.3	49.0%	57.0	127.4	51.5%	65.6
	Total	814.1	73.4%	597.8	947.0	76.2%	721.3
Lalitpur	Urban	177.3	77.5%	137.4	200.1	80.0%	160.1
	Rural	61.5	49.0%	30.1	67.4	51.5%	34.7
	Total	238.8	70.1%	167.5	267.5	72.8%	194.8
Bhaktapur	Urban	77.5	77.5%	60.1	83.2	80.0%	66.6
	Rural	43.3	49.0%	21.2	47.4	51.5%	24.4
	Total	120.8	67.3%	81.3	130.6	69.7%	91.0
Total (Entire Area)	Urban	952.6	77.5%	738.3	1,102.9	80.0%	882.4
	Rural	221.1	49.0%	108.3	242.2	51.5%	124.7
	Grand Total	1,173.7	72.1%	846.6	1,345.1	74.9%	1,007.1

Note: The figures for urban areas are the total of urban and suburban areas.

4) Water Demand

(a) Per Capita Consumption

Water demand varies dependent upon the livelihood level, local customs and others. Per capita consumption for domestic use in Kathmandu is estimated as shown in Table 2.2.2, based on a survey on water consumption by water use purpose in large cities of Japan, with the correction meeting local conditions in Kathmandu.

Table 2.2.2 Per Capita Consumption by Water Use Purpose

(Unit: litres/capita/day)

Water Use Purpose	Large Cities in Japan		Kathmandu (Estimate for 2001)	
	Per capita consumption by Purpose (1)	Per capita consumption by Purpose (2)	Full-plumbing	Yard Tap
Bath Tub	42	22	22	10
Bathing	40	40		
Flush Toilet	40	40	12	4
Washing	63	32	11	10
Kitchen	42	22	22	10
Hand Washing	17	17	17	10
Others	11	6	6	6
Total	255	179	90	50

Notes:

(1) Per capita consumption for domestic use with 3.54 family members (survey results in the Explanatory Notes on Design Criteria for Waterworks Facilities).

(2) Corrected figures for domestic use with an average family size of 6.95 in Kathmandu.

The average per capita consumption for domestic use in Kathmandu is 64 litres/capita/day in 2001, based on the above estimated figures, assuming a service ratio of 34.5% for full plumbing and 65.5% for yard taps. Target per capita consumption for domestic use in the Project is set as shown in Table 2.2.3, considering the increase in consumption derived from the increasing flush toilet use and the enhancement of livelihood level based on the average per capita consumption of 64 litres/capita/day in the base year 2001.

Table 2.2.3 Target Per Capita Consumption

(Unit: litres/capita/day)

2001	2002	2003	2004	2005	2006
64.0	66.0	68.0	70.0	72.0	74.0

Consumption for public, commercial and industrial use is assumed as 22.5% of the domestic consumption for domestic use, as a result of the Study.

(b) Load Factor

The load factor concerning the seasonal fluctuation of water demand, is determined through analysis of the existing data, as shown in Table 2.2.4.

Table 2.2.4 Load Factor

Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
0.945	0.939	0.921	0.928	0.918	1.031	1.102	1.111	1.096	1.068	1.024	0.919

(c) Leakage Ratio

The current leakage ratio is 43.5%, according to a demand and supply balance estimation based on the consumption with metered connections and supply amount from the service reservoir, the data of which is collected in the Study. Under such a circumstance that the facility capacity strengthening might be limited constrained by the exploitable water from the source, in order to meet water demand, a measure is required, in which the amount currently lost in the leakage might be converted to the amount actually usable by the consumers (effective water), through improving the leakage ratio. In the Project, whereas the strengthening of facility capacity will be kept minimal, the following shall be undertaken for the improvement of leakage ratio:

- Sub-division of the existing service areas;
- Appropriate allocation of supply amount in conformity with the water demand in the respective areas revised; and
- (through above 2 actions), reduction of leakage by attaining an even distribution pressure and reducing an average pressure level in the distribution network.

In the Project, in order to attain the target effective amount in the target year 2006, a measure with the above-mentioned concept will be undertaken, aiming at improvement of the leakage ratio.

(d) Consumption

Based on the previous indicators, the total consumption is estimated as shown in Table 2.2.5.

Table 2.2.5 Total Daily Consumption by Area

(Unit: 1,000 m^3/day)

	2001	2002	2003	2004	2005	2006
Kathmandu	52.1	55.8	59.6	63.7	68.1	72.6
Lalitpur	14.6	15.5	16.5	17.5	18.5	19.6
Bhaktapur	7.1	7.5	7.9	8.3	8.7	9.2
Total (Entire Areas)	73.8	78.8	84.0	89.5	95.3	101.4

5) Planned Effective Water

(a) Current Water Supply Situation

Current water supply situation in the entire NWSC service area is shown in Table 2.2.6, which was estimated basically from the demand and supply survey by the Study Team. Among 3 kinds of estimated figures, (b) is used for the planning base in the Project.

Table 2.2.6 Water Supply in 2000

(Unit: 1,000 m^3/day)

Area		(a) Estimation upon Demand and Supply Survey by the Study Team	(b) *1 Estimation on Maximum Demand and Supply	(c) Estimation Based on Data Published by NWSC
Kathmandu	Effective Water	42.5	44.6	48.5
	Supply Amount	66.4	74.0	82.0
	Leakage Ratio	36.0%	39.7%	40.9%
Lalitpur	Effective Water	12.1	13.0	12.7
	Supply Amount	25.1	28.0	32.6
	Leakage Ratio	51.8%	53.6%	61.0%
Bhaktapur	Effective Water	5.9	6.3	6.4
	Supply Amount	10.0	11.1	11.3
	Leakage Ratio	41.0%	43.2%	43.4%
Total (Entire Area)	Effective Water	60.5	63.9	67.6
	Supply Amount	101.5	113.1	125.9
	Leakage Ratio	40.4%	43.5%	46.3%

Notes

(1) Figures in brackets indicate the per capita consumption (litres/capita/day)

(2) *1: Based on maximum demand and supply by applying load factor of 1.111 to (a)

(b) Planned Effective Supply

From estimated consumption in the target year (Table 2.2.5) and current water supply situation as above, the Project shall accommodate the incremental effective water of 37,500 m^3/day additionally required in the target year 2006.

Table 2.2.7 shows the effective water additionally required in the respective service areas in the target year 2006.

Table 2.2.7 Required Effective Water

(Unit: 1,000 m^3/day)

	Effective Water in 2006 (Target) (a)	Effective Water in 2000 (Current) (b)	Additional Effective Water (a) - (b)
Kathmandu	72.6	44.6	28.0
Lalitpur	19.6	13.0	6.6
Bhaktapur	9.2	6.3	2.9
Total (Entire Area)	101.4	63.9	37.5

(2) Supply Quantity Improvement Plan

The 2 Projects, consisting the Project, will have the water supply capacity strengthened with 20,600m^3/day after the Project implementation, according to the cooperation direction that the minimum required facility scale and contents be set in before the Melamchi Project materialised. For this reason, the only increasing supply amount in the Project, might not fulfill the augmentation of effective supply amount required in the target year, 37,500m^3/day.

Under the circumstance that the strengthening of supply capacity by the newly-constructed facilities be limited due to the relevance with the Melamchi Project as well as the difficulty of new water source development in the Kathmandu Valley, in order to respond to the increasing water demand of the residents, the measure is required in which the currently-high leakage ratio be reduced and the amount currently-lost in the leakage be converted to the effective supply amount the residents might actully use.

In the consequence, in the Project, the basic concept for the formulation of water supply plan has been set forth; the existing water supply service area shown in Fig.2.2.2 shall be sub-divided in accordance with the existing water supply facilities, supply capacity of the planned facilities, and the areal water demand distribution (refer to Fig.2.2.3); effective supply amount would be augmented through reducing the leakage ratio, by making supply pressure level even as well as by reducing the average supply pressure.

Appendix 7 summarises the examination on leakage reduction, according to the basic concept above. The water supply plans in the respective water supply service areas, formulated from the examination, are as under.

1) Kathmandu Service Area

At the moment, the Kathmandu service area is served by 4 water supply systems; Mahancal Chaur, Bansbari, Balaju and Sundarighat. After the Project implementation, in addition to these existing systems, water be supplied, with 14,800 m^3/day from the Manohara Project and with 2,000 m^3/day from the Shaibhu Project to southeast of Kathmandu. The current Kathmandu Service area shall be, with 2 elevated tanks constructed, sub-divided into 7 new service areas, in accordance with the supply capacity of facilities as well as distribution of water demand.

It is anticipated that 19,900 m^3/day of effective supply amount be increased, with supply amount increase in the Project (16,800 m^3/day) and through reducing the leakage ratio (28.9%) from the current 39.7%) derived from the service area sub-division. Besides, fill-up ratio towards the domestic water comsumption target of 74 liters/capita/day in 2006, would be 88.8%.

2) Bhaktapur Service Area

At present, in operation in Bhaktapur Service area, are a system to supply to Madhyapur and west of Bhaktapur after storing the groundwater of the deep- and shallow-wells in Bhode reservoir, and Bansbari water treatment plant (the same name, but the different plant from that in Kathmandu) to supply water to east of Bhaktapur.

The quality of groundwater of the deep-wells is not favourable, causing several affections, associated with water quality in the Bhaktapur Service area. After the Project implementation, including the substitution of groundwater (4,200 m^3/day), 5,900 m^3/day of water be supplied to the area. By utilizing the existing Bhode reservoir and Katunje reservoir, the area shall be sub-divide into 3 new service areas, coinciding to the supply capacity of the facilities and distribution of water demand.

1,800 m^3/day of effective supply amount would be increased, with the augmented 1,700 m^3/day of supply amount in the Project, and through leakage reduction (36.7% from the current 43.2%) derived from service area sub-division. The fill-up ratio of domestic water consumption target, 74 liters/capita/day in 2006, would be 88.0%.

The distribution system has not been provided in Madhyapur, and the water demand there being confined accordingly. It is foreseen that the water supply service ratio be improved as in urban built-up areas, and the water demand rapidly increase. For this reason, in the Manohara Project, the water supply facility capacity shall be set at 7,200 m^3/day, in anticipation of the demand increase as above.

3) Lalitpur Service Area

Lalitpur Service Area is supplied water from Shaibhu reservoir and Tahakel reservoirs, source of both are from spring in the southern Kathmandu Valley. Of these, the Shaibhu reservoir has a small reservoir capacity compared to the available amount in the source. (maximum 24,700 m^3/day), not capable of supplying water by fully utilizing the source capacity.

In the Project, in the Shaibhu Project, a reservoir be newly constructed to augment the reservoir capacity to 24,500 m^3/day from the current 20,400 m^3/day. Distribution pipes be installed from the reservoir to central Lalitpur, and the area served by Shaibhu reservoir shall be sub-divided into 4 new service areas. Tahakel reservoir shall supply water only to village areas, after the Project implementation.

4,200 m^3/day of effective supply amount be increased, with 2,100 m^3/day of augmented amount of water supply (of the augmented 4,100 m^3/day, 2,000 m^3/day for the supply to Kathmandu) and the leakage reduction (42.9% from the current 53.6%) derived from the sub-division of service area. The fill-up ratio of the domestic water consumption target, 74 liters/capita/day in 2006, would be 87.8%.

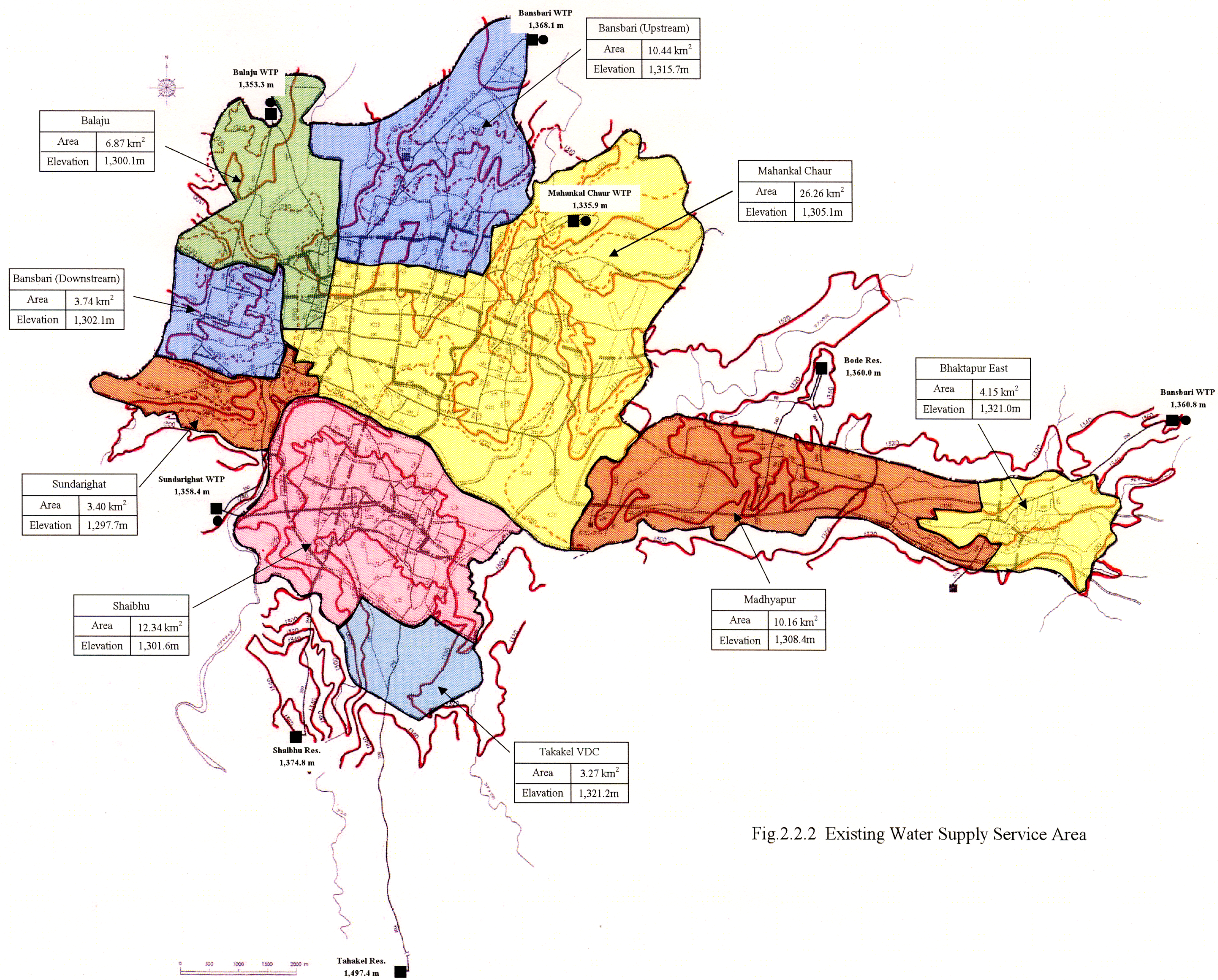


Fig.2.2.2 Existing Water Supply Service Area

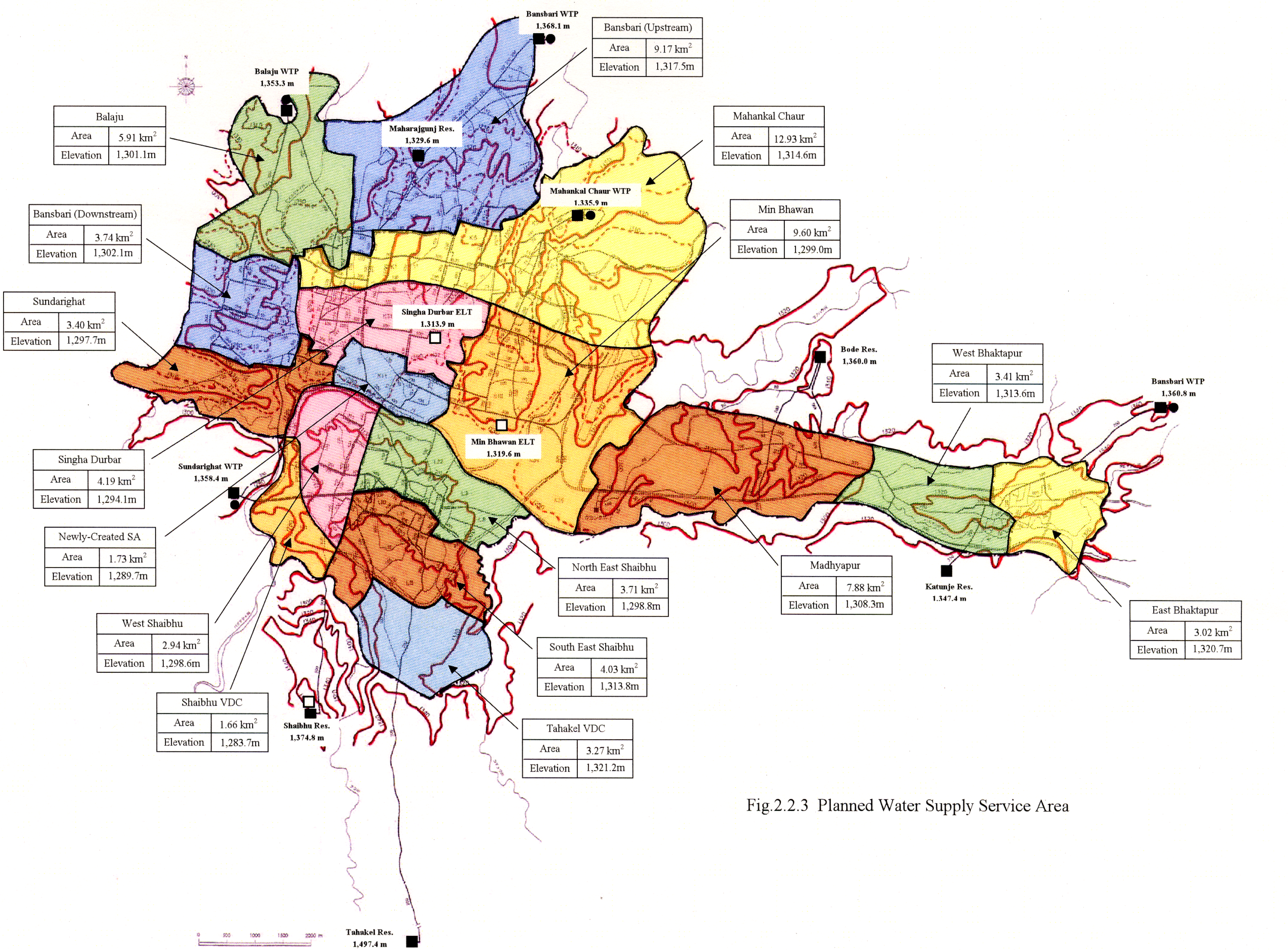


Fig.2.2.3 Planned Water Supply Service Area

(3) Water Quality Improvement Plan

1) Objective of Water Quality Improvement

In the Katmandu Valley, water resources development was undertaken in the 70's and the 80's to cope with the rapidly increasing water demand, focusing on spring water in the south and groundwater in the north. While the southern spring water is of extremely favourable quality due to location at limestone plateau, the groundwater exploited from the northern aquifer contains a high concentration of iron, manganese and ammonium nitrogen, and has low pH values and acutely corrosive nature towards water supply facilities and materials.

The problems associated with water quality might primarily be found in the rust-coloured water caused by iron and manganese. Secondarily, as chlorine fed for sterilisation is consumed by these ions, water inside the distribution pipes become non-resistant to the contamination with disease germs, etc. Furthermore, bacteria proliferating in the pipe might cause turbidity increase, red water and others.

The quality of surface water is also declining with the progress of urbanisation in the Valley, calling for precise management of water treatment with an adequate system. However, the existing water treatment plants constructed in the 1960's, are in such a condition that an appropriate water treatment might not be undertaken, causing the problems associated with water quality, similarly to groundwater.

The objectives of waterworks consist in supplying safe and clean water extensively to the residents, thereby contributing to the improvement of hygienic conditions and the living environment. For this purpose, required are prevention of contamination in the source, selection of an appropriate treatment system meeting water quality in the source, a precise water quality control in the treatment plant, and further the protection of internal and outside contamination in the distribution pipe, service connections and so on. Unless the operation management centring around water quality control is properly undertaken in water treatment, not only waterworks objectives would be lost, but, adversely, water-born contagious disease might be spread.

Consequently, the Project aims at the following quality improvement, to fulfill the fundamental objective of waterworks:

- To secure safe and hygienic quality of the water supplied, through precise water treatment in an appropriate manner.
- To secure sterilisability in the distribution pipe, to prevent the contamination from outside.
- To remove matters probable of causing secondary problems inside the distribution pipe.

2) Water Quality Improvement Plan

Table 2.2.8 shows the quality of river water and river bed water at the planned intake point in the Manohara Project, and that of river water at the point 2.5 km upstream.

The emphasized are water quality at the planned intake point measured by the Study Team. Since there is almost none of polluting source upstream, it is concluded upstream water quality might be approximated with that of the planned intake point.

Table 2.2.8 Quality of Manohara River Water

Water Quality Indicator		River Water			River Bed Water
	Unit:	June 1999*	Nov. 1999*	Nov. 2000	Nov. 2000
pH		6.8	6.8	6.8	6.8
Chemical oxygen demand (COD)	mg/l	5.0	3.5	3.5	2.5
Biochemical oxygen demand (BOD)	mg/l	2.9	1.7	2.2	2.0
Dissolved oxygen mg/l (temperature: ℃)		6.1 (25)	7.2 (18)	8.2 (20)	7.0 (19)
Potassium permanganate consumed	mg/l	-	-	5.5	4.8
Turbidity (NTU)	degree	13	25	36	19
Chloride	mg/l	4.5	3.0	3.0	3.3
Ammonium nitrogen	mg/l	<0.01	<0.01	<0.01	<0.01
Nitrate nitrogen	mg/l	1.6	1.0	2.0	2.0
Total Iron	mg/l	0.97	1.25	1.35	0.91
Total Manganese	mg/l	-	0.04	0.05	0.17

Remarks *: Melamchi PMC Report; water taken 2.5 km upstream of the planned intake point in the Project.
-: Not mentioned in PMC Report.

From these, it is apparent the turbidity of river water is not so high, while the values of COD and BOD, both indicating the extent of organic matters contained, are comparatively high.

No quality standard is in force in Nepal, regarding raw water for waterworks. Notwithstanding, according to the grade classification adaptable in the different water uses in the Japanese Guidelines for the Conservation of the Living Environment, the quality of raw water for waterworks and the treatment method specifically needed to such graded water, are as shown in Table 2.2.9.

Table 2.2.9 Quality of Raw Water and Treatment Method

Grade	Classification and Water Use Purpose	Range of Indicator Values					Classification for waterworks and treatment method
		pH	BOD (mg/l)	SS (mg/l)	DO (mg/l)	Coliform (MPN/100 ml)	
AA	1st Class for waterworks & environmental protection	6.5～8.5	< 1	< 25	> 7.5	Below 50	1st Class for waterworks: By comparatively simplified method of treatment such as slow sand filtration
A	2nd Class for waterworks & 1st Class for fisheries	6.5～8.5	< 2	< 25	> 7.5	Below 1,000	2nd Class for waterworks: By ordinary method of treatment using coagulation, rapid sand filtration and others
B	3rd Class for waterworks & 2nd Class for fisheries	6.5～8.5	< 3	< 25	> 7.5	Below 5,000	3rd Class for waterworks: By high-level method of treatment such as ordinary method plus pre-treatment

According to the Table, quality of Manahara river water corresponds to that of 2nd class water for waterworks; however, in the dry season, some indicators have values of 3rd class water for waterworks. Accordingly, an ordinary treatment method with a series of coagulation, sedimentation and rapid sand filtration processes will be indispensable, through which not only materials causing turbidity increase but organic matters, coliforms and others might be removed.

Considering the probable quality decline to come, river bed water will be taken in the Manohara Project. Quality of river bed water corresponds to Class 2 water for waterworks as well, also requiring precisely conducted an ordinary treatment with coagulation-sedimentation-rapid sand filtration.

(4) Water Source Plan

1) Manohara Project

Water source in the Manohara Project will be Manohara River water. The intake amount shall be based on the exploitable amount in JICA Master Plan Study in consideration of the existing water rights (refer to Table 2.2.10).

Table 2.2.10 Exploitable Amount in Manohara Project

(Unit: 1,000 m^3/day)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
Groundwater	-	8.4	8.4	8.4	8.4	-	-	-	-	-	-	-
River water	44.0	26.7	13.8	13.8	18.1	32.8	508	770	481	146	92.4	54.4
Total	44.0	35.1	22.2	22.2	26.5	32.8	508	770	481	146	92.4	54.4

The groundwater taken in the existing deep wells is of unfavorable quality; an appropriate pre-treatment is required in the use for raw water of waterworks. Moreover, the duration of groundwater usage for the substitution of river water is short, only 2 months, during which the river discharge reduces; the cost of groundwater intake as raw water would be almost 8 times that of river water.

In this consequence, the existing intake amount of the groundwater shall be converted to irrigation; instead, the same amount of water shall be taken from Manohara River, as raw water, in the Manohara Project. The planned intake amount in the Manohara Project is, considering the above exploitable amount from the source as well as seasonal fluctuation of water demand, determined as shown in Table 2.2.11.

Table 2.2.11 Planned Intake Amount in Manohara Project

(Unit: 1,000 m^3/day)

		Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept	Oct.	Nov.	Dec.
Planned intake amount		18.5	18.3	18.0	18.1	17.9	20.1	21.5	21.7	21.4	20.9	20.0	17.9
Break down	River water for substitution of groundwater for irrigation	-	-	4.2	4.3	-		-	-	-	-	-	-
	River water	18.5	18.3	13.8	13.8	17.9	20.1	21.5	21.7	21.4	20.9	20.0	17.9

2) Shaibhu Project

Water source in the Shaibhu Project shall be the same existing ones (3 springs and 2 wells in Pharping well field) from which water can be taken in a stable condition.

The planned intake amount in the Shaibhu Project is as shown in Table 2.2.12.

Table 2.2.12 Planned Intake Amount in Shaibhu Project

(Unit: 1,000 m^3/day)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Planned intake amount	20.8	20.7	20.3	20.5	20.2	22.7	24.3	24.5	24.2	23.5	22.6	20.3

3) Intake Method of River Water

At present, at the planned intake point in the Manohara Project, no artificial embankment is built, and 500 m to 600 m width of river bank are used for farming. It is, therefore, difficult to take water through constructing intake facilities such as weir. In case the river bed water taken in the infiltration gallery, the installation work of water collecting pipes would require a considerable amount of costs in temporary work such as steal sheet piling and dewatering, and might give an impact to the surrounding farm land.

In this consequence, water shall be taken in the shallow wells to be dug in the left bank of Manohara River, within the limit of east-west 350 m and north-south 200 m, located upstream of the existing NWSC shallow well. The area has been proven to contain favourable strata of sand and gravel of over 10 m thickness, according to results of the boring test and electrical probing in the Study. As the required number of wells cannot be laid at an appropriate interval (more than 100 m-influential range) in the area, water shall be taken in a group of wells 50 m to 85 m apart with each other. (Refer to Appendix 7, relating to examination on water intake facilities).

(5) Water Treatment Plan

So as to attain Project Objective, it is imperative that the water treatment plant be properly operated and maintained and that its water treatment functions be displayed as planned. If considering the technical skills of NWSC personnel to be manned at the water treatment plant, efficient and lasting functioning of the plant requires:

- Easy operation and handling, without high-level of technical skills
- Maintenance-free, or durable with low-level of maintenance practices

And, therefore, the water treatment plant made in Japan is desirable because of both easy and endurable characteristics in operation and maintenance.

From the above viewpoint, and based on an examination of treatment method, facilities, chemicals, and sludge discharge system (comparative examination is included in Appendix 8, refer), the following shall be adopted in the Project:

- Coagulant mixing:	Weir-type using the potential energy
- Flocculation:	Vertical-baffling type
- Sedimentation:	Horizontal flow type
- Sludge discharge:	Hopper type
- Rapid sand filtration:	Natural equilibrium type (by valve)
- Coagulant:	PAC made in India
- Sterilising agent:	Bleaching powder
- Sludge and drainage management:	Supernatant water return, and sludge drying bed

The most important in water treatment is an appropriate control of coagulant feeding. In the Project, PAC will be used as a coagulant, because of ease of feeding control due to its fast coagulation effects and a wide range of proper coagulation effects.

Similarly to the importance of coagulation process, an appropriate sterilisation is also indispensable in water treatment, in order to attain the objective of waterworks in supplying safe and hygienic water. At the moment, in NWSC water supply facilities in the Katmandu Valley, partly (such as in Mahankal Chaur water treatment plant) sodium hypochlorite from the generator is used as a sterilising agent, but mostly used is bleaching powder.

Though sodium hypochlorite being excellent in feeding control and in economic performance, taking into account the previous maintenance situation of the sodium hypochlorite generators (such as spare-parts procurement and electrode replacement), bleaching powder sterilisation equipment shall be adopted in the Project. Nevertheless, due consideration being taken towards the characteristics of chemicals (including coagulants) to be used in the water treatment plant, the feeding equipment capable of an adequate control shall be used.

(6) Construction

1) A survey (interview survey) on the time required by Nepalese workers to complete a unit construction work revealed that it is approximately 3 to 6 times longer than that required by Japanese workers. From this result, it might be implied that the skilled workers be in the shortage in Nepal. Considering this situation, the facility structure in the Project shall be as simple as possible, so that local workers might be used in construction work.

2) Most of general-purpose construction materials can be procured in Nepal. The common structure (fundamentally, RC structure) shall be applied in construction, not requiring extra-ordinary materials to which local procurement is difficult. Of general-purpose construction materials, bricks are readily available in a large quantity in Nepal and will be used as structural materials for wall, etc.

3) Locally-available construction machinery will be utilised in Nepal. The machinery not locally available shall be procured (leased) in third country.

4) The construction method causing minimum affections on traffic as well as in the surrounding environment will be adopted, especially in the work in built-up areas such as transmission/distribution pipe installation work and foundation work for elevated tanks.

(7) Design Conditions

1) Manohara Project

(a) Facility Capacity

- Water Intake Facilities: Planned water supply amount x 1.05
- Water Treatment Plant: Planned water supply amount x 1.05
- Water Distribution Facilities: Planned supply amount

(b) Intake Facilities

- Possible intake amount: As in Table 2.2.10
- Planned intake amount: As in Table 2.2.11
- Water level of river bed water: EL: +1,310.0 m (LWH)
- Water level in WTP receiving well: EL: +1,325.4 m (HWL)
- Intake method: Intake of river bed water in shallow wells

(c) Water Treatment Plant

Among the turbid matters, those of diameter up to 10^{-2}mm can be removed through the ordinary sedimentation; however, those of diameter below 10^{-3}mm, generally called colloidal particulate, will not be settled as it is and cannot be caught in the process of the rapid sand filtration. In the rapid-sand-filtration water treatment system, a pre-treatment is indispensably required, in which these colloidal particulates are coagulated through the unit process and characteristics transformed for easy removal in the process of sedimentation and filtration.

The process unit might be divided functionally into two steps: in the first step, the turbid particulates are coagulated into minute flocs through mixing as rapidly as possible after fed with coagulant.; the latter step is to make the generated minute flocs grown larger in the gentle mixing. In such the steps, pollutant are also caught in the flocs, leading to improvement of water quality. The first step is called mixing, and the latter step as flocculation. The basin is, accordingly to the functions, composed of the mixing basin and the flocculation basin.

The process from coagulant feeding through the mixing to the flocculation is important in the succeeding process of the sedimentation and the rapid sand filtration, being an essential factor in the effectiveness of water treatment. In consequence, the state of the flocculation shall, at all times, precisely controlled in the water treatment plant.

a) Coagulation Sedimentation Basin

[Mixing Basin]

This process is, considering the coagulant's characteristics of extremely quick hydrolysis and polymerisation, to conduct rapid mixing to generate a lot of small colloids of aluminum hydroxide, achieve an uniform dispersion of colloids, and facilitate the reaction of turbid colloids dispersed in raw water.

Nevertheless, otherwise regarded as an electrochemical surface reaction of much complicated particulates, an excessive agitation might destroy the electrochemical binding of generated colloids with strong shearing force. The formation of favorable flocs will be thereby hampered in the next flocculation process.

G (mean velocity gradient) value is an indicator of mixing process, indicating the level of shearing force and a work amount. Target of G value differs dependent upon the quality of raw water and treatment amount.

Ordinarily, the standard value is set in the facility design at 100 to 200 sec^{-1} for G.

-	G value:	100 - 200 sec^{-1}
-	Detention time:	approximately 1 - 5 minutes

[Flocculation Basin]

The coagulation is the most important process in the rapid sand filtration-type water treatment system, and the maturing of minute flocs generated in the mixing process into a heavy, hard and uniform state is required.

For the formation of excellent flocs to be removed, it is desirable to produce a gradual decline of G value: approximately 70 to 80 sec^{-1} in high speed zone, 40 to 50 sec^{-1} in medium speed zone, and 15 to 20 sec^{-1} in low speed zone. GT value is set in the facility design at 23,000 to 210,000.

-	Vertical baffling type		
-	Detention time:	approximately 30 minutes	
-	G value:	upstream side	70 sec^{-1}
		downstream side	15 sec^{-1}
-	GT value:	23,000 - 210,000	

[Sedimentation Basin]

Most of flocs grown larger and heavier, after chemical feeding, mixing and flocculation, shall be separated through sedimentation to reduce the burden in the succeeding rapid sand filtration basin.

-	Drift-type sedimentation basin	
-	Detention time:	approximately 3 hours
-	Flow speed in basin:	15 - 40 cm/min.
-	Sludge hopper:	the basin is designed for 80% of flocs to be accumulated in the upstream one-fifth area of the basin, where a hopper is installed for sludge discharge at suitable intervals.

b) Rapid Sand Filtration Basin

The rapid sand filtration is to obtain the final treated water, involving filtering of the minute flocs passed through the sedimentation basin at a speed under the prescribed level through making flocs stick to the surface of filtering materials.

-	Filtering speed:	120 - 135 m/day
-	Backwashing:	0.6 m^3/m^2/min. × 6 minutes
-	Surface washing:	0.2 m^3/m^2/min. × 4 minutes; fixed-type surface washing system
-	Sand layer:	effective diameter of 0.6 mm; uniformity coefficient of 1.7 or lower layer thickness; 0.6 m

- Gravel layers: 2 - 3.5 mm; 3.5 - 7 mm; 7 - 13 mm; 13 - 20 mm layer thickness; 50 mm each
- Water collecting equipment: self-cleaning type perforated blocks
- Effective filtering head: 1.2 m

c) Clear Water Reservoir

The clear water reservoir functions to maintain filtration speed at an appropriate level through control and mitigation of fluctuation effects in treatment amount and transmission amount. Its capacity shall be sufficient to cope with power cut or sudden alteration of transmission amount.

- Reservoir capacity: equivalent to 1 hour operation (con-currently to be used as a reservoir of backwashing water)

d) Coagulant Feeding Equipment

A coagulant is used to make minute particles suspending in raw water form the flocs to be removed easily in the sedimentation and the sand filtration.

- Coagulant: PAC (poly-aluminum chloride); effective Al_2O_3: 30%; PAC is dissolved and diluted into 5% solution for feeding.
- Feeding rate: $P = 0.2\,T + 0.36\,\sqrt{T}$ (T: turbidity)
- Average feeding rate: rainy season: 6.8 mg/l (5% PAC)
  dry season: 5.2 mg/l (5% PAC)
- Dissolution tank: powdered PAC with content of Al_2O_3: 30% be dissolved by agitation, making 5% solution.
- Transfer pump transfer the solution from dissolution tank to storage
- Storage tank: the storage capacity is equivalent to the maximum feeding amount of one day.
- Feeding equipment: feeding pump

e) Alkaline Agent Feeding Equipment

The surface water to be treated in the Project has low pH values and alkalinity, especially in the rainy season. Accordingly, in order to raise coagulation efficiency, the alkaline agent shall be fed. However, PAC is less acidic than aluminum sulfate, and has not an effect of lowering pH value so much. In addition, owing to the wide-range coagulation ability of PAC, the feeding operation is not required so frequently.

- Alkaline agent: sodium hydroxide is dissolved into 10% solution for feeding.
- Average feeding rate: 10 mg/l
- Dissolution tank: granular sodium hydroxide be dissolved by agitation, making 10 %
- Transfer pump transfer the solution from dissolution tank to storage
- Storage tank: the storage capacity is equivalent to the maximum feeding amount of one day.
- Feeding equipment: feeding pump

f) Sterilisation Agent Feeding Equipment

- Pre-chlorination	for prevention of formulation of algae
Average feeding rate:	0.3 mg/l
Sterilising agent	bleaching powder
Feeding point	receiving well
- Post-chlorination	for sterilisation of filtrated water, control residual chlorine in the treated water at 1.0 mg/l.
Average feeding rate:	1.5 mg/l (effective chlorine)
Sterilising agent:	bleaching powder (15% effective chlorine content)
Feeding point	In front of regulating weir in the filtration basin
- Dissolution tank	bleaching powder be dissolved by agitation, making 0.5 % solution
- Transfer pump	transfer the solution from dissolution tank to storage and circulating the solution in the storage tank to prevent the sediment fixed in the equipment.
- Storage tank:	the storage capacity is equivalent to the maximum feeding amount of one day.
- Feeding equipment	feeding apparatus

(d) Transmission System

The transmission system to be adopted in the Project, is as follows, based on the relevant examination:

a) Bhaktapur West service area and Madhyapur service area

For Bhaktapur West, newly installed transmission pipe from the water treatment plant to Bode Service Reservoir will be branched off to connect to the existing transmission pipe from Bode Reservoir to Katunje Service Reservoir. The water will be conveyed to Katunje Service Reservoir by pump pressure and supplied.

For Madhyapur, water will be conveyed by pump pressure from the water treatment plant to the existing Bode Service Reservoir and supplied. Transmission pipe will be jointly used with Bhaktapur West service area.

- Transmission capacity:	5,900 m^3/day (maximum time factor of 1.25)
Bhaktapur west system	2,500 m^3/day
Madhyapur system	3,400 m^3/day
- Pumping-up Head :	44 m
WTP clear water reservoir	LWL= +1319.0 m
Existing Bode reservoir	HWL= +1363.0 m
Existing Katunje reservoir	HWL= +1350.4 m

b) Kathmandu Southeast service area

Water will be conveyed by pump pressure from the water treatment plant to the Min Bhawan elevated tank (capacity: 3,080 m^3).

- Transmission capacity: 14,800 m^3/day (maximum time factor of 1.25)

-	Pumping-up Head:	6.55 m
	WTP clear water reservoir	LWL= +1319.0 m
	Min Bhawan elevated tank	HWL= +1325.55 m

(e) Elevated Tanks

a) Min Bhawan elevated tank

An elevated water tank (storage capacity: 3,080 m^3) will be constructed at Min Bhawan located in the central part of the Kathmandu Southeast service area for efficient supply of water to the said service area as well as other service areas. The storage capacity will be equivalent to the supply amount of five hours.

b) Singha Durbar elevated tank

The current supply amount in the Mahankal Chaur system to Kathmandu Southeast service area, which is the direct-benefited area of the Manohara Project, will be applied to other service areas, while setting up of an appropriate service area corresponding to the supply capacity of the existing water supply system. For this purpose, an elevated tank (storage capacity: 2,700 m^3) will be constructed at Singha Durbar, and sub-division of the service area will be made for the efficient water supply to the different service areas, towards attainment of supply evenness and improvement of the leakage ratio in the whole Kathmandu service area, making the present leakage effective.

(f) Structure of the Basins

The water treatment plant described above has a complex structure with different types of water basins. The water depth in each basin ranges from 3 m to 5 m. In such a situation that one basin is full and the next is empty, the partition is under the high water pressure. In addition, water leakage have to be prevented as much as possible from the cracks made by temperature fluctuation or caused by uneven sinking.

These water basins will be made of reinforced concrete (RC), and proper quality control of concrete and procurement of reinforcing bars of favourable quality are the prerequisite in the structural design aiming at a high level of pressure resistance and water-proofing. The allowable stresses in the respective materials are as follows, based on the Guidelines for Concrete Standards of Japan Society of Civil Engineers (1996):

- Compressive stress of concrete $\sigma ca = 8.0$ N/mm^2
- Tensile strength of reinforcing bars $\sigma sa = 176$ N/mm^2
- Shearing stress of concrete $\tau a = 0.425$ N/mm^2

(g) Foundations

The tilting caused by uneven sinking might lower the functions of the water treatment plant by making control of an even overflow from the basins difficult. Accordingly, it is required for foundations to have sufficient bearing capacity as well as to provide an even bearing capacity to all members of the structure.

The bearing capacity of the ground at the water treatment plant site is estimated over 120 kN/m^2, according to N value in the standard penetration test by the Study Team. On the other hand, structure load is 50 to 100 kN/m^2. From these, spread foundations shall be adopted towards the structures inside the water treatment plant.

At construction site for the Min Bhawan elevated tank, consolidation layers were recognised partially. Since allowable bearing capacity of these layers is insufficient to support the elevated tank, pile foundations shall be adopted.

2-2-2 Basic Plan

(1) Manohara Project

1) Outline

A water treatment plant with the maximum water supply capacity of 20,700 m^3/day (treatment capacity: 21,700 m^3/day) will be constructed at the foot of a hill of the existing Bode reservoir, for the treatment of surface water to be newly taken from the Manohara River (including intake/conveyance facilities). From the water treatment plant, water will be supplied to the service areas of Bhaktapur West, Madhyapur and Kathmandu Southeast.

In the Project, the planned water supply system might be diagrammed as below.

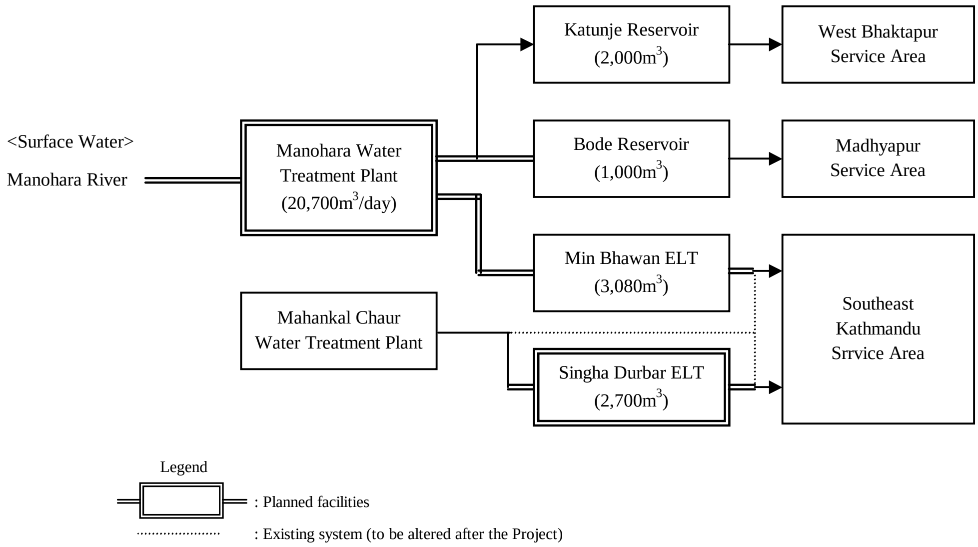


Fig.2.2.4 Water Supply System after Project Implementation (Manohara Project)

2) Intake Facilities

(a) Intake Facilities

The planned intake amount of 21,700 m^3/day will be taken from Manohara River, as a source of the Manohara Project. In the dry season when river discharge reduces, the same amount as planned to be taken in the existing wells will be taken so that the water from the existing wells might be used for irrigation purpose, etc. in addition to the possible intake amount (minimum 13,800 m^3/day) as examined in JICA Master Plan Study to secure the existing water rights such as for irrigation. The river water will be taken in the shallow wells.

- Planned intake amount: planned supply amount × 1.05
  = 20,700 m^3/day × 1.05 = 21,700 m^3/day
- Shallow wells: 8 nos. (diameter: 4 m, depth: 6.4 m)
- Intake pumps: 2.70 m^3/min. × 23.5 m × 15 KW × 2 nos.
  2.20 m^3/min. × 23.5 m × 15 KW × 2 nos.

2.13 m^3/min.×21.0 m×15 KW×2 nos.
1.67 m^3/min.×21.0 m×11 KW×2 nos.

- Conveyance pipe: PVC(VP/VM) φ125 - 400 mm×1,475 m

(b) Electrical Equipment

a) Power Receiving and Transforming System

- Receiving 11 KV of 3 phase 3 wires shall be transformed to 400V/230V of 3 phase 4 wires, to be supplied to power load and lighting load.
- Power receiving equipment is of cubicle type made of iron plate.
  Primary: 3 phase 3 wires 11 KV 50Hz
  Secondary: 3 phase 4 wires 400V/230V 50Hz
  Transformer(oil immersed): 200 KVA×1 no.

b) Trunk Power System

- Feeder cable will be installed to connect the secondary of exterior cubicle to the respective intake pump control panels.
- Feeder cable will be installed in the air, due to the location along the river, and poles will be put up at 40 m interval to support the cable.
- Electricity
  Power load (pump): 3 phase 3 wires 400V 50Hz
  Lightning load (exterior light): 1 phase 2 wires 230V 50Hz
- Intake pump control panels: 4 nos. (exterior, water-proof type, installed on the pole)

c) Power Distribution System

- Power wire will be installed from intake pump control panels to the pumps.
- Intake pumps operate automatically in response to water level.

d) Lighting System

- Exterior lighting will be installed at each intake pump for security in the night. Mercury-vapor lamp of 100W will be used.

- An extra power-outlet socket of capacity 2P-10A will be installed at each intake pump.

e) Others

- A lightning rod will be installed at each intake pump control panel, in order to protect the equipment from fire and damage to be caused by lightning.

3) Water Treatment Plant

(a) Facility capacity

- Planned treatment amount: 20,700 m^3/day × 1.05 = 21,700 m^3/day
- Planned supply amount: 20,700 m^3/day

(b) Receiving well and mixing basin

- Number of basins: 1 basin
- Capacity of basin: approx. 50 m^3 and 33.5 m^3
  (3.0 m width × 3.85 m depth × 4.3 m length)
  (2.5 m width × 3.35 m depth × 4.0 m length)
- Detention time: approx. 5.5 min. (for maximum water amount)
- Mixing method: gravity fall

(c) Flocculation basin

- Capacity of basin: 454 m^3
  (1.0m width × 3.2 m depth × 8.0 m length × 18rows)
- Number of basins: 18 basins
- Detention time: 30 min.
- Type of flocculation: vertical baffling
  lower bent sections: 5 places
  overflow weirs: 5 places
  G value: 15 - 66 $sec.^{-1}$

(d) Sedimentation basin

- Capacity of basin: 920 m^3 (per basin)
  (7.0 m width × 2.8 m depth × 46.1 m length)
- Number of basins: 3 basins
- Detention time: 3 hours
- Flow rate: 25.2 cm/min.
- Sludge removal equipment:
  hopper capacity: 3.3 m^3 (per basin)
  number of hoppers: 45 nos.
  sludge discharge valve: 15 nos.
  (sludge is discharged through a discharge valve of φ250 mm from 3 hoppers)

(e) Rapid sand filtration basin

- Filtration area of basin: 22.68 m^2 (3.15 m × 7.2 m)
- Number of basins: 8 basins
- Filtration rate: 120 - 137m/day
- Filtration layer: filtration sand
  effective diameter: 0.6 mm
  uniformity coefficient: below 1.7
  layer thickness: 0.6 m
- Supporting layer: gravel (2 to 20 mm)
  layer thickness: 0.2m

-	Water collecting device:	self-washing type perforated blocks (bottom)
-	Raw water distribution device:	0.9 m-width weir plate ϕ300 mm soft-sealed valve
-	Discharge device:	
	water discharge trough:	400 mm×400 mm×3,400 mm×5 pieces/basin
	water discharge gate:	600 mm square
-	Backwashing:	
	backwashing rate:	0.6 m^3/m^2/min.×6 min.
	backwashing flow rate:	22.68 m^2/basin×0.6 m^3/m^2/min. = 13.61 m^3/min. 13.61 m^3/min.×6 min. = 81.66 m^3
	replenishment flow rate:	maximum 4.54 m^3/min.
	replenishment pump:	4.54 m^3/min.×5 m×11 KW×1 unit
	replenishment pipe:	ϕ250 mm
-	Surface washing:	fixed-type surface washing device
	surface washing rate:	0.2 m^3/m^2/min.×5 min.
	surface washing valve:	ϕ250 mm soft-sealed valve
	surface washing pump:	4.54 m^3/min.×20 m×30 KW×2 units
	surface washing pipe:	ϕ250 mm
-	Clear water equipment:	
	clear water gate:	500 mm square
-	Filtration control weir:	1.5 m-width weir plate×10 nos.

(f) Clear water reservoir (concurrently to be used as a reservoir of backwashing water)

-	Number of basins:	2 basins
-	Capacity of basin:	561 m^3 (per basin)
-	Detention time:	approx. 1 hour
-	Inflow gate:	500 mm square×2 units
-	Outlet gate:	500 mm square×2 units

(g) Coagulant dissolution and feeding equipment

-	Coagulant:	poly aluminum chloride (PAC) effective Al_2O_3: 30% PAC with 30% of effective Al_2O_3 is dissolved, and diluted into 5% solution, thereafter to be fed. feeding ratio: $P = 0.2\ T + 0.36\sqrt{T}$ (T: turbidity in raw water)
-	Dissolution tank :	1.0 m^3×2 nos. (with an agitator)
-	Average feeding rate:	
	surface water (rainy season):	6.8 mg/l (as Al_2O_3: 30% PAC)
	surface water (dry season):	5.2 mg/l (as Al_2O_3: 30% PAC)
-	Storage tank:	2 m^3×2 nos.
-	Transfer pumps:	30 l/ min.×2 nos.
-	Feeding pumps:	5 nos.

(h) Alkaline dissolution and feeding equipment

-	Alkaline agent:	sodium hydroxide solid sodium hydroxide is dissolved into 10% solution to be fed
-	Average feeding rate:	10 mg/l
-	Dissolution tank:	1 m^3×2 tanks (with an agitator)
-	Transfer pumps:	30 l/min.×2 units
-	Solution storage tank:	2 m^3×2 tanks
-	Feeding pumps:	4 nos.

(i) Sterilisation equipment (bleaching powder dissolution and feeding equipment)

Bleaching powder with 15% effective chlorine is dissolved into 0.5% solution, and fed.

-	Pre-chlorination	
	feeding point:	receiving well
	average feeding rate:	0.3 mg/l
	dissolution tank:	1 m^3×2 tanks (with an agitator)
	transfer pump:	30 l/min.×2 nos.
	storage tank:	2.0 m^3×2 tanks
	feeding apparatus	4 units
-	Post-chlorination	
	feeding point:	in front of regulating weir in the filtration basin.
	average feeding rate:	1.5 mg/l
	dissolution tank:	1 m^3×4 tanks (with an agitator)
	transfer pump:	30 l/min.×2 nos.
	storage tank:	2.0 m^3×4 tanks
	feeding apparatus	6 units

(j) Sludge and drainage basin

-	Number of basins:	2 basins
-	Effective capacity of basin:	202 m^3 (per basin)

(k) Supernatant water return equipment

-	Supernatant water return pump:	2.3 m^3/min.×10 m×11 KW×2 units
-	Return water pipe:	DCIPφ200 mm×99 m

(l) Sludge Drainage equipment

-	Drainage pump:	0.67 m^3/min.×9 m×3.7 KW×2 units
-	Drain pipe:	PVC(VP)φ100 mm×97 m

(m) Sludge drying bed

-	Number of beds:	4 beds
-	Capacity of bed:	280 m^3 (per bed)

(n) Sampling equipment

-	Sampling pump:	35 l/min.×15 m×0.75 KW×2 units (including 1 reserve)
-	Sampling pipe:	PVC(VP)φ40mm×77 m

- Residual chlorine meter 1 no.

(o) Internal water supply unit

- Supply pump:0.5m^3/min.×30 m×3.7 KW×2 units
- Supply pipe: PVC(VP) 40-80 mm×140 m

(p) Water Quality Monitoring Equipment

- Turbidity meter: 1 no.
- pH meter: 1 no.

(q) Electrical Equipment

a) Power receiving and transforming system

- Electricity is supplied to power load and lighting load, by receiving 11 KV 3 phase 3 wires and transformed to 400V/230V 3 phase 4 wires.
- Power receiving equipment is of cubicle type made of iron plate.
  Primary: 3 phase 3 wires 11 KV 50Hz
  Secondary: 3 phase 4 wires 400V/230V 50Hz
  Transformer (oil immersed): 750KVA×1 no.

b) Trunk power and lighting system

- Trunk power and lighting wires is installed to connect the secondary side of low voltage distribution panel in the interior cubicle up to power control panels and lighting control panels.
- Feeder cable is laid underground with the steal-sealed cable (MAZV).
- Interior wiring is installed concurrently on cable ladder and in pipe. Polyethylene cable for bridge (CV) is used.
- Electricity
  Power Load (Pump): 3 phase 3 wires 400V 50Hz
  Lighting Load (Exterior light): 1 phase 2 wires 230V 50Hz

c) Power distribution system

- Distribution panel is installed for the group classified by load and equipment.
- Distribution panel is self-standing type made of iron plate. Stainless shall be used where the corrosion-proof measure is required. The same applies to the inner parts of the panel.
  Distribution panels (interior): 7 nos.

d) Lighting system

- Interior lighting: Fluorescent lamp starting by a grow lamp
- Exterior lighting: Mercury-vapor lamp is installed for security in the night. It operates manually.
- Average illuminance level: office: 300 Lx,
  laboratory: 200Lx,
  mechanical room: 100Lx
  Control panels: 7 nos.

e) Others

- A lightning rod is installed at each intake pump control panel, in order to protect the equipment from fire or damage caused by lightning.

4) Transmission Facilities

(a) Bhaktapur West service area

- Transmission pump: 2.63 m^3/min.×52 m×45 KW×3 units (including one reserve unit)
- Transmission main: DCIP φ250 mm×382 m

(b) Kathmandu Southeast Service Area

- Transmission pump: 2.70 m^3/min.×68 m×55 KW×5 units (including one reserve unit)
- Transmission main: PVC(VM) φ350 mm×8,251 m
  DCIP φ350 mm×172 m

5) Elevated Tanks

(a) Min Bhawan elevated tank

- Number: 1 no.
- Capacity: 3,080m^3 (5 hours amount of the planned water supply)

  $14,800\ m^3/day \times \frac{5}{24} \quad 3,080\ m^3$

(b) Singha Durbar elevated tank

- Number: 1 no.
- Capacity: 2,700m^3 (5 hours amount of the planned water supply)

  $13,000\ m^3/day \times \frac{5}{24} \quad 2,700\ m^3$

(2) Shaibhu Project

1) Outline

The existing Shaibhu system will be improved to increase water supply capacity to 24,500 m^3/day through construction of a new reservoir in the same yard of the existing one, including simplified filtration and sterilisation equipment. In addition to the existing 500 mm distribution pipe, supplying water to the current 2 division of East and West service areas in Lalitpur, a new distribution pipe of diameter 300/350 mm will be installed, and the water be supplied by gravity.

In the Project, the planned water supply system might be diagrammed as below.

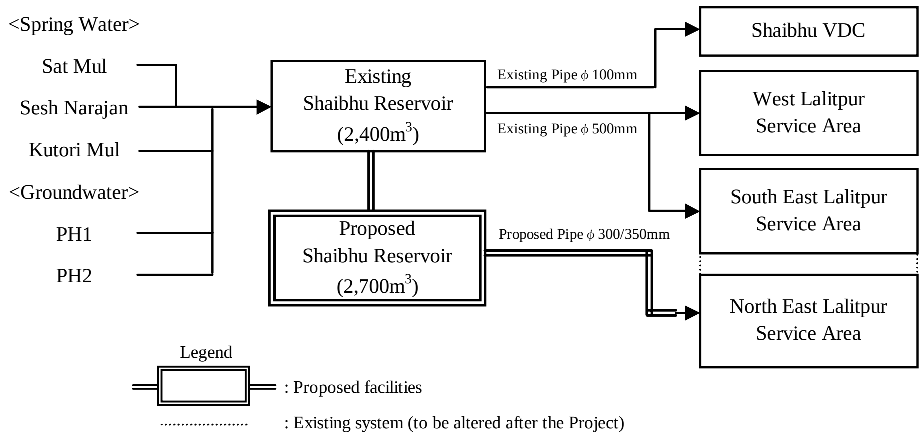


Fig.2.2.5 Water Supply System after Project Implementation (Shaibhu Project)

2) Distribution facilities

(a) Distribution reservoir

To make available capacity of 5-hour operation of the planned supply amount, a new reservoir will be augmented to fill the shortfall with the existing one.

- Number of reservoir: 1 reservoir
- Capacity of reservoir: 2,700 m^3

$$24{,}500\ m^3/day \times \frac{5}{24} = 5{,}100\ m^3$$

$$5{,}100\ m^3 - 2{,}400\ m^3\ (existing) = 2{,}700\ m^3$$

(b) Sterilisation equipment (Bleaching powder dissolution and feeding equipment)

Bleaching powder with effective 15% chlorine will be dissolved into 0.5% solution, and fed.

- Feeding point: receiving well
- Average feeding ratio: 1.5mg/l
- Dissolution tank: 1 m^3 × 3 tanks (with an agitator)

- Transmission pump: 30 l/min.×2 nos.
- Storage tank: 2 m^3×3 tanks
- Feeding apparatus: 2 units

(c) Electrical Equipment

a) Power Receiving and Transforming System (Existing)

- Receiving: 11 KV 3 phase 3 wires 50Hz
- Secondary: 400V/230V 3 phase 4 wires 50Hz
- Transformer (oil immersed): 50 KVA×1 unit

b) Trunk Power System

- From the secondary side of the existing transformer, feeder and power wires are branched off to supply power to the feeding control panel, with newly installed a switch on the pole.
- 600V cross-linked polyethylene insulated vinyl sheathed cables (JIS 3605) (CV) is used.
- Electricity
  Power Load (feeding pump): 3 phase 3 wires 400V 50Hz
  Lighting Load (fluorescent): 1 phase 2 wires 230V 50Hz
  Power Panel (Interior type): 1 no.

c) Power Distribution System

- Power supply wiring connects the power panel with the feeding control panel.

d) Lighting System

- Wiring for power supply from the power panel to the lighting fixture, switches and power-outlet sockets.
- Lighting Fixture: Fluorescent lamp is used; the average illuminance level is 200Lx.

(d) Water Quality Monitoring Equipment

- Residual chlorine meter 1 no.
- Turbidity meter: 1 no.
- pH meter: 1 no.

3) Distribution main

Shaibhu reservoir to North-east Lalitpur service area

- Lalitpur service area: PVC(VP)φ300 mm×3,454 m
  DCIPφ300 mm×46 m
  PVC(VM)φ350 mm×1,263 m

2-2-3 Basic Design Drawings

(1) Manohara Project

Basic design drawings in the Manohara Project consist of the following:

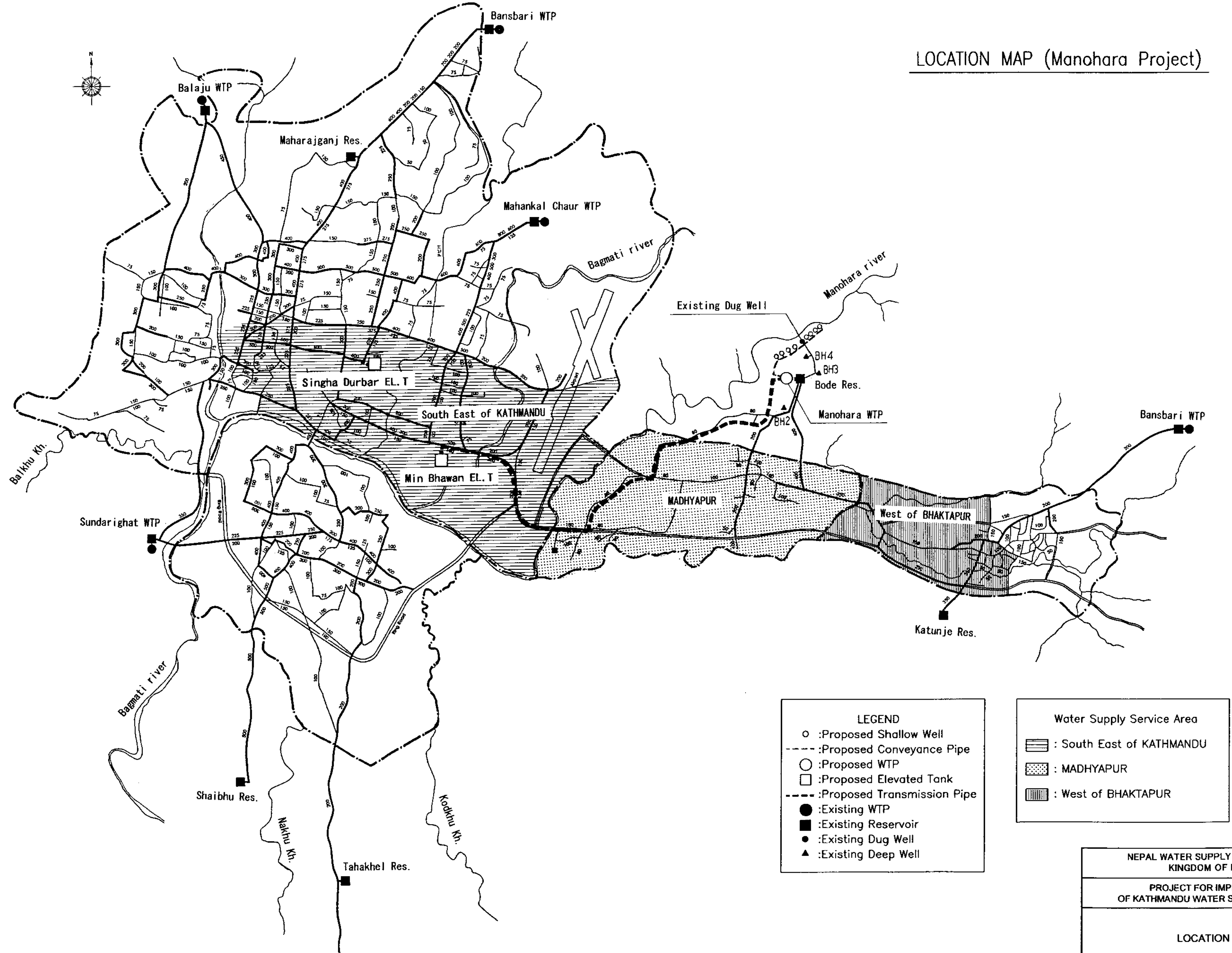
Drawing No.	TITLE
M-1	LOCATION MAP
M-2	WATER INTAKE GENERAL LAYOUT
M-3	WATER INTAKE STRUCTURE
M-4 - 5	RAW WATER CONVEYANCE PIPE (WATER INTAKE - WATER TREATMENT PLANT)
M-6	WATER TREATMENT PLANT GENERAL LAYOUT
M- 7	WATER TREATMENT PLANT DIFFERENCE IN WATER LEVEL
M-8	WATER TREATMENT PLANT FLOW SHEET
M-9 -12	FLOCCULATION AND SEDIMENTATION BASIN STRUCTURE AND FACILITES
M-13 - 14	RAPID SAND FILTER STRUCTURE AND FACILITES
M-15 - 16	CLEAR WATER RESERVOIR STRUCTURE AND FACILITES
M-17	SLUDGE AND DRAINAGE BASIN STRUCTURE AND FACILITIES
M-18	SLUDGE DRYING BED STRUCTURE
M-19	BLEACHING POWDER FEEDING ROOM
M-20	OFFICE & LABOLATORY, STORE
M-21	POWER ROOM
M-22	FLOW DIAGRAM OF COAGULANT (PAC) FEEDING EQUIPMENT
M-23	FLOW DIAGRAM OF BLEACHING POWDER FEEDING EQUIPMENT
M-24	FLOW DIAGRAM OF SODIUM HYDROXIDE FEEDING EQUIPMENT
M-25	ELECTRICAL INSTALLATIONS PLAN (WATER TREATMENT PLANT)
M-26	ELECTRICAL INSTALLATIONS PLAN (WATER INTAKE)
M-27	ELECTRICAL SYSTEM
M-28	SINGLE LINE DIAGRAM
M-29	POWER AND LIGHTING DIAGRAM
M-30	WATER TRANSMISSION PIPE (WATER TREATMENT PLANT - BODE RESERVOIR)
M-31 - 38	WATER TRANSMISSION PIPE (WATER TREATMENT PLANT - MIN BHAWAN ELT)
M-39	MIN BHAWAN ELEVATED TANK GENERAL LAYOUT
M-40 - 41	MIN BHAWAN ELEVATED TANK STRUCTURE
M-42	SINGHA DURBAR ELEVATED TANK GENERAL LAYOUT
M-43 - 44	SINGHA DURBAR ELEVATED TANK STRUCTURE

(2) Shaibhu Project

Basic design drawings in the Shaibhu Project consist of the following:

Drawing No.	TITLE
S-1	LOCATION MAP
S-2	NEW SHAIBHU RESERVOIR GENERAL LAYOUT
S-3 - 4	NEW SHAIBHU RESERVOIR STRUCTURE
S-5	FLOW DIAGRAM OF BLEACHING POWDER FEEDING EQUIPMENT
S-6〜9	WATER DISTRIBUTION PIPE (NEW RESERVOIR - LALITPUR)
S-10	ELECTRICAL SYSTEM

LOCATION MAP (Manohara Project)



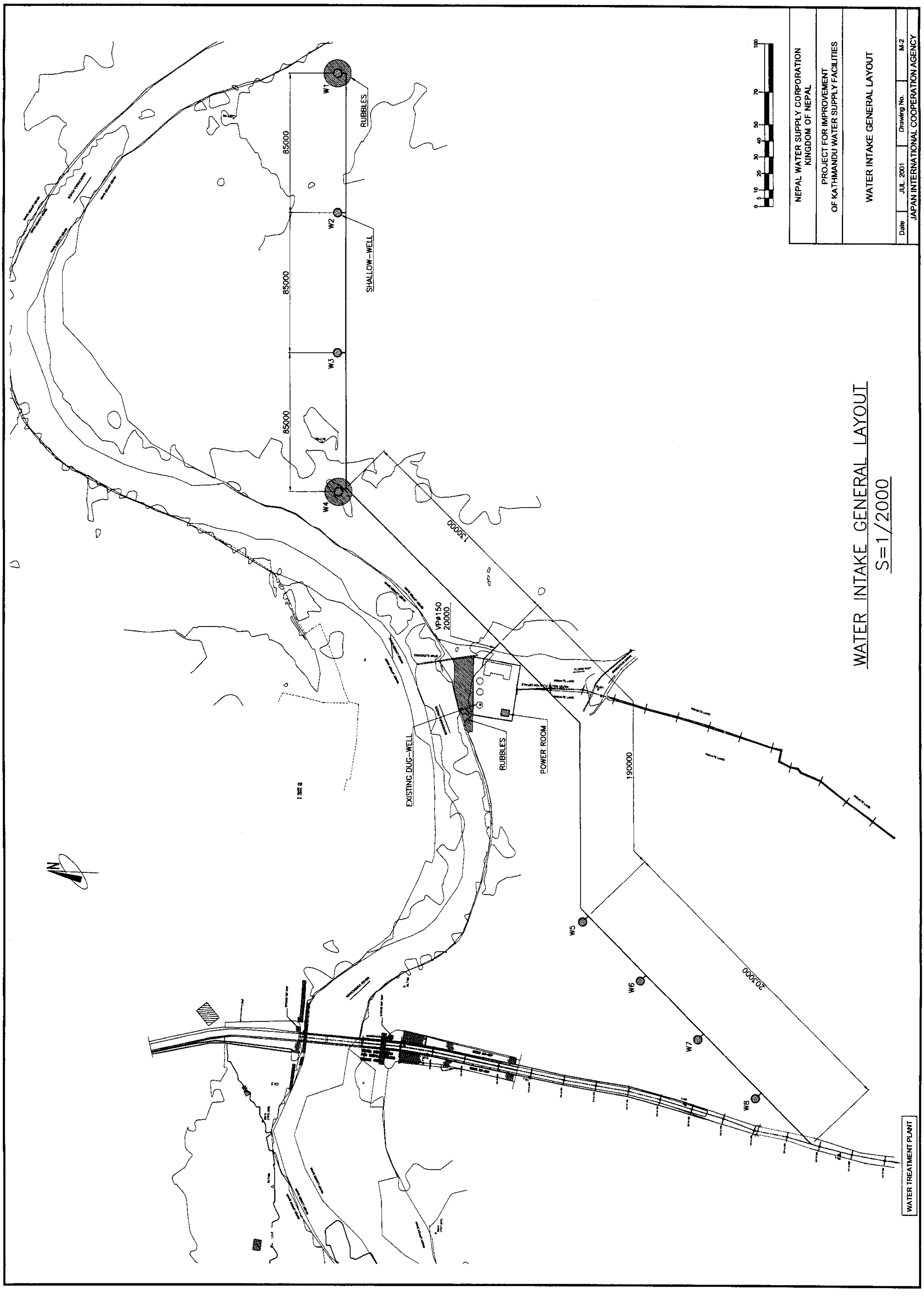
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL

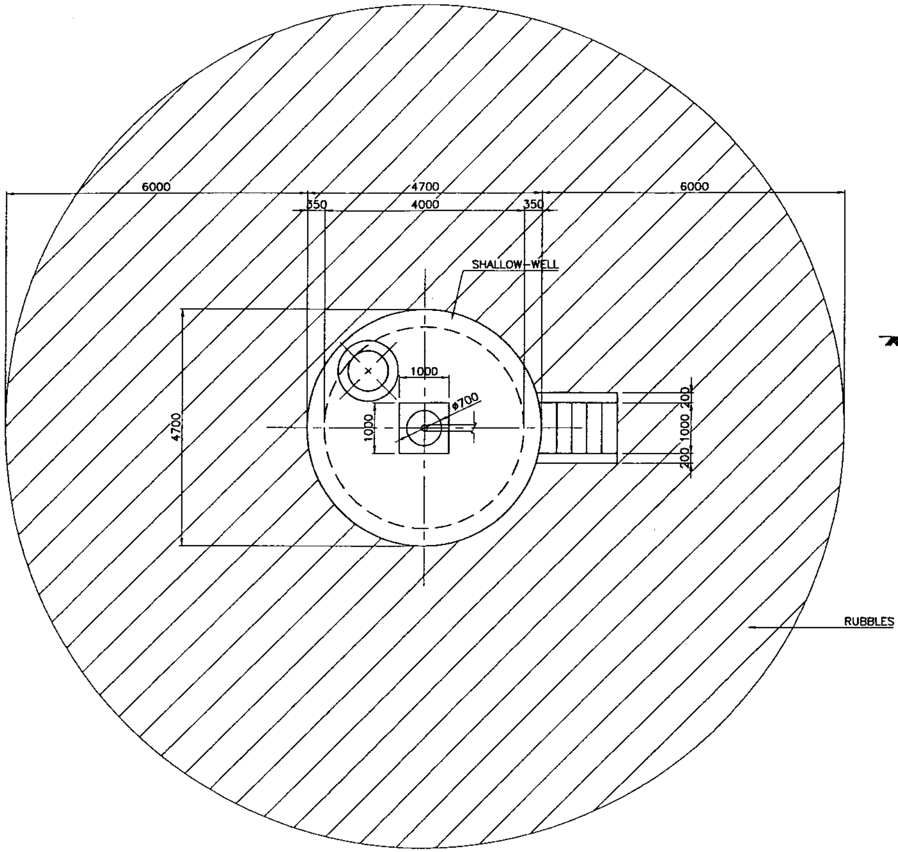
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES

LOCATION MAP

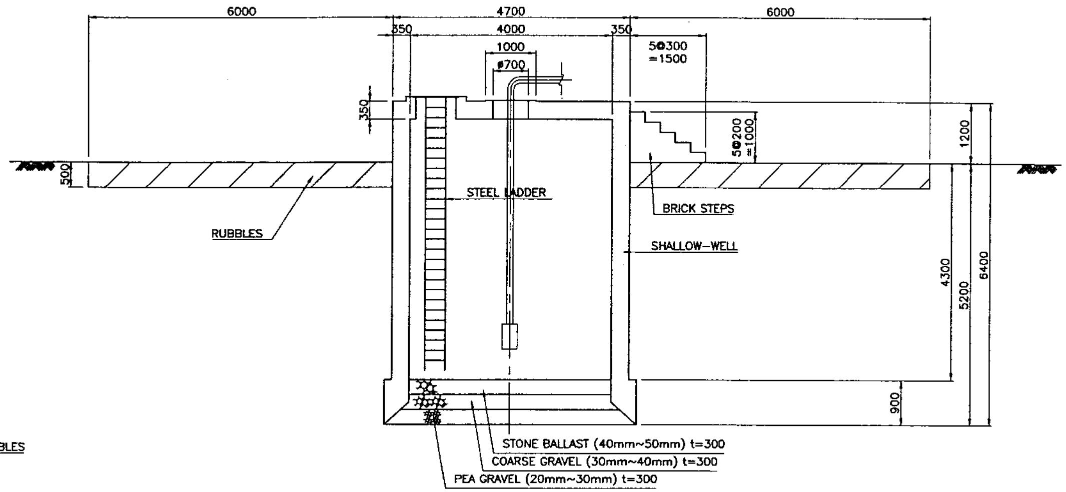
Date	JUL. 2001	Drawing No.	M-1

JAPAN INTERNATIONAL COOPERATION AGENCY


NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES
WATER INTAKE GENERAL LAYOUT
Date
JUL. 2001
Drawing No.
M-2
JAPAN INTERNATIONAL COOPERATION AGENCY
WATER INTAKE GENERAL LAYOUT
S=1/2000
W1
W2
W3
W4
W5
W6
W7
W8
RUBBLES
SHALLOW-WELL
85000
85000
85000
130000
VPφ150
20000
EXISTING DUG-WELL
RUBBLES
POWER ROOM
190000
203000
WATER TREATMENT PLANT

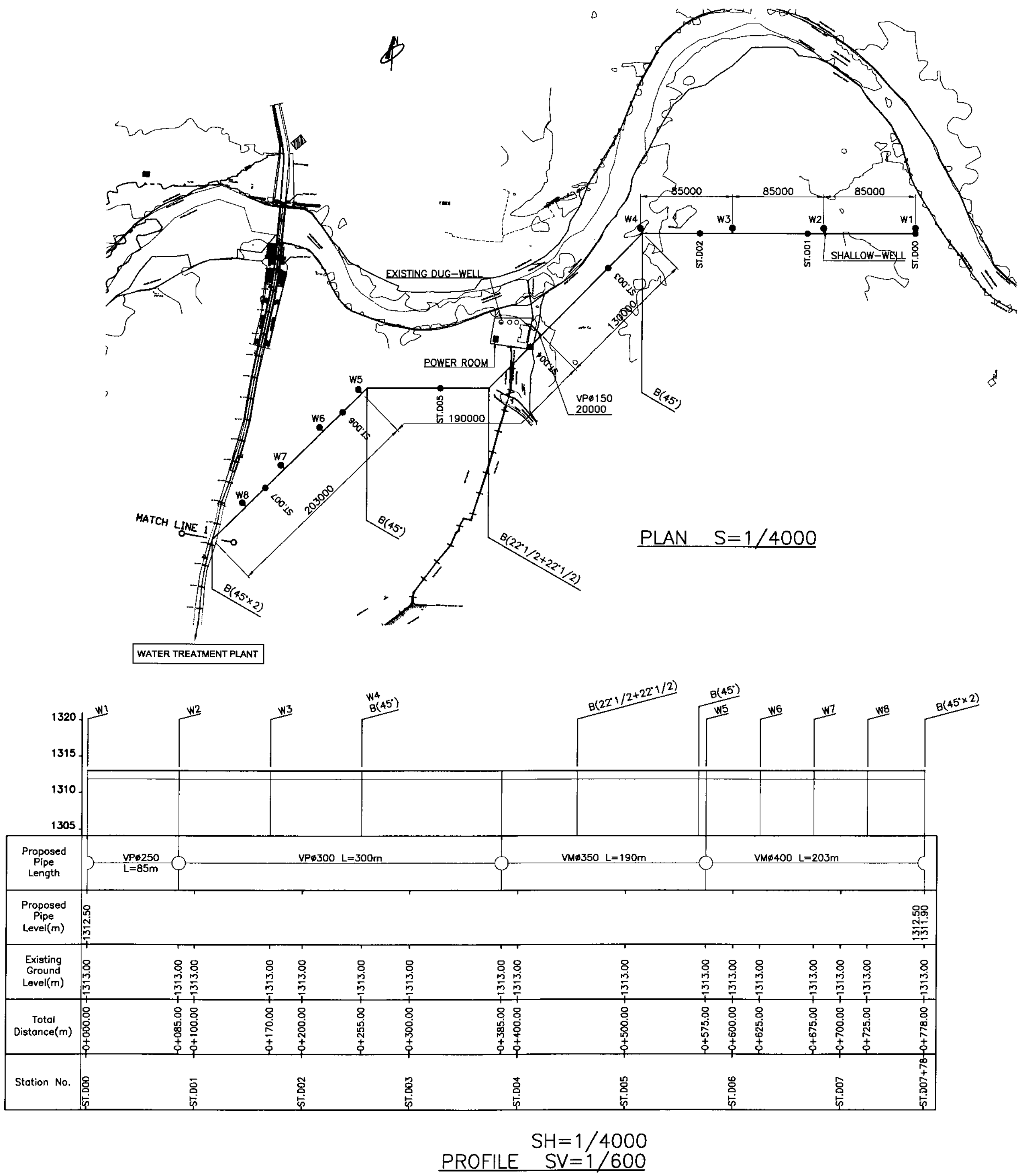


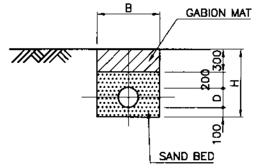
PLAN
S=1/100



PROFILE
S=1/100

NEPAL WATER SUPPLY CORPORATION KINGDOM OF NEPAL			
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES			
WATER INTAKE STRUCTURE			
Date	JUL. 2001	Drawing No.	M-3
JAPAN INTERNATIONAL COOPERATION AGENCY			

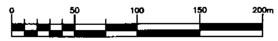




D (mm)	B (mm)	H (mm)
250	700	900
300	750	950
350	800	1000
400	850	1050

LEGEND

B BEND
TR REDUCING TEE
V VALVE



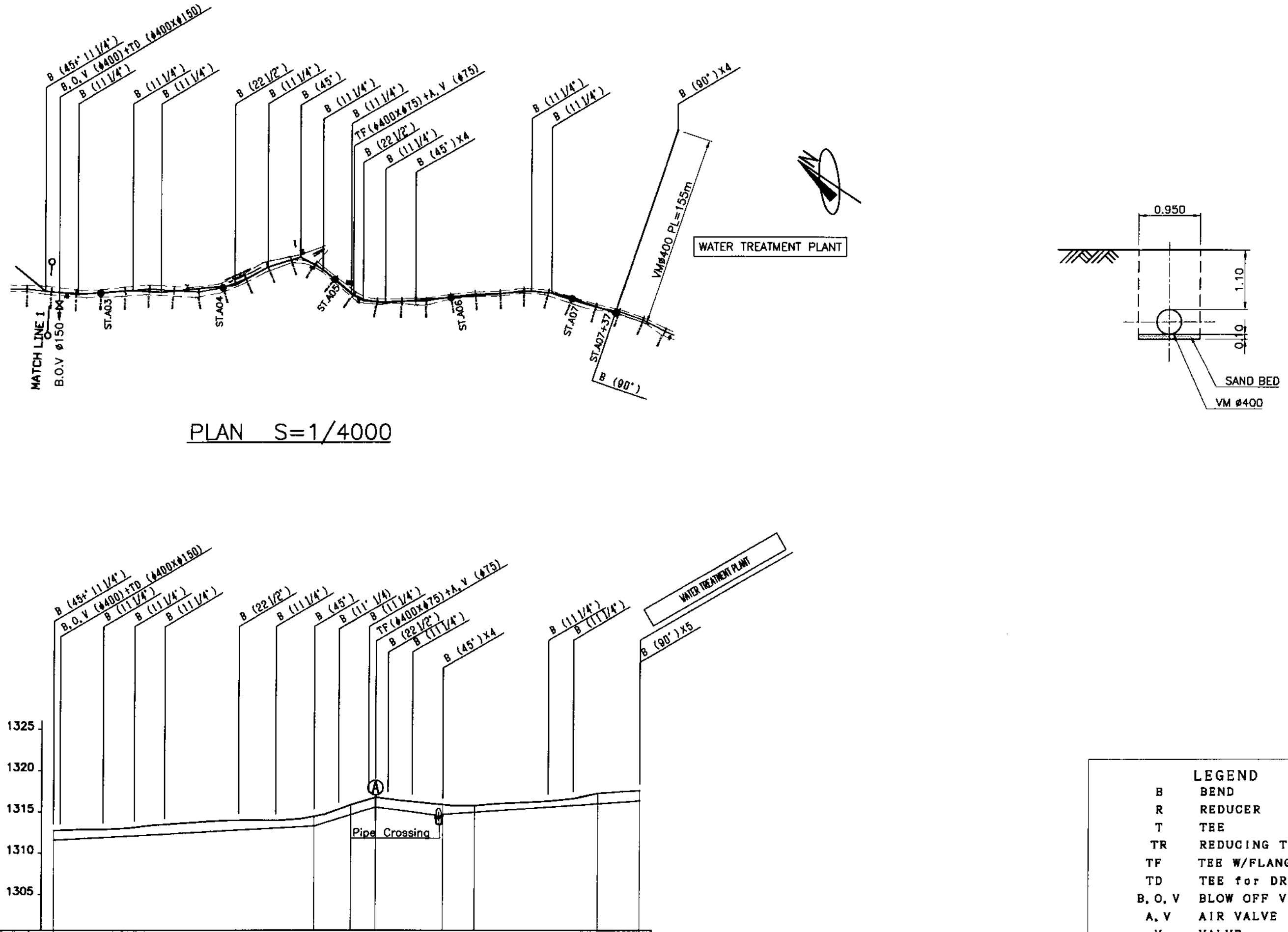
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL

PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES

RAW WATER CONVEYANCE PIPE
(WATER INTAKE-WATER TREATMENT PLANT 1/2)

Date	JUL. 2001	Drawing No.	M-4

JAPAN INTERNATIONAL COOPERATION AGENCY



PLAN S=1/4000

Proposed Pipe Length	VMø400 L=482m										
Proposed Pipe Level(m)	1311.90			1313.61		1315.59	1315.01			1316.43
Existing Ground Level(m)	1313.00	1312.90	1313.79	1314.71	1315.77	1316.69	1316.11	1315.71	1317.15	1317.53
Total Distance(m)	0+778.00	0+823.00	0+923.00	0+993.00	1+023.00	1+043.00	1+097.35	1+123.00	1+223.00	1+260.00
Station No.	ST.A02+55	ST.A03	ST.A04		ST.A05			ST.A06	ST.A07	ST.A07+37

PROFILE SH=1/4000 SV=1/600

LEGEND

B	BEND
R	REDUCER
T	TEE
TR	REDUCING TEE
TF	TEE W/FLANGE
TD	TEE for DRAIN
B.O.V	BLOW OFF VALVE
A.V	AIR VALVE
V	VALVE

0 50 100 150 200m

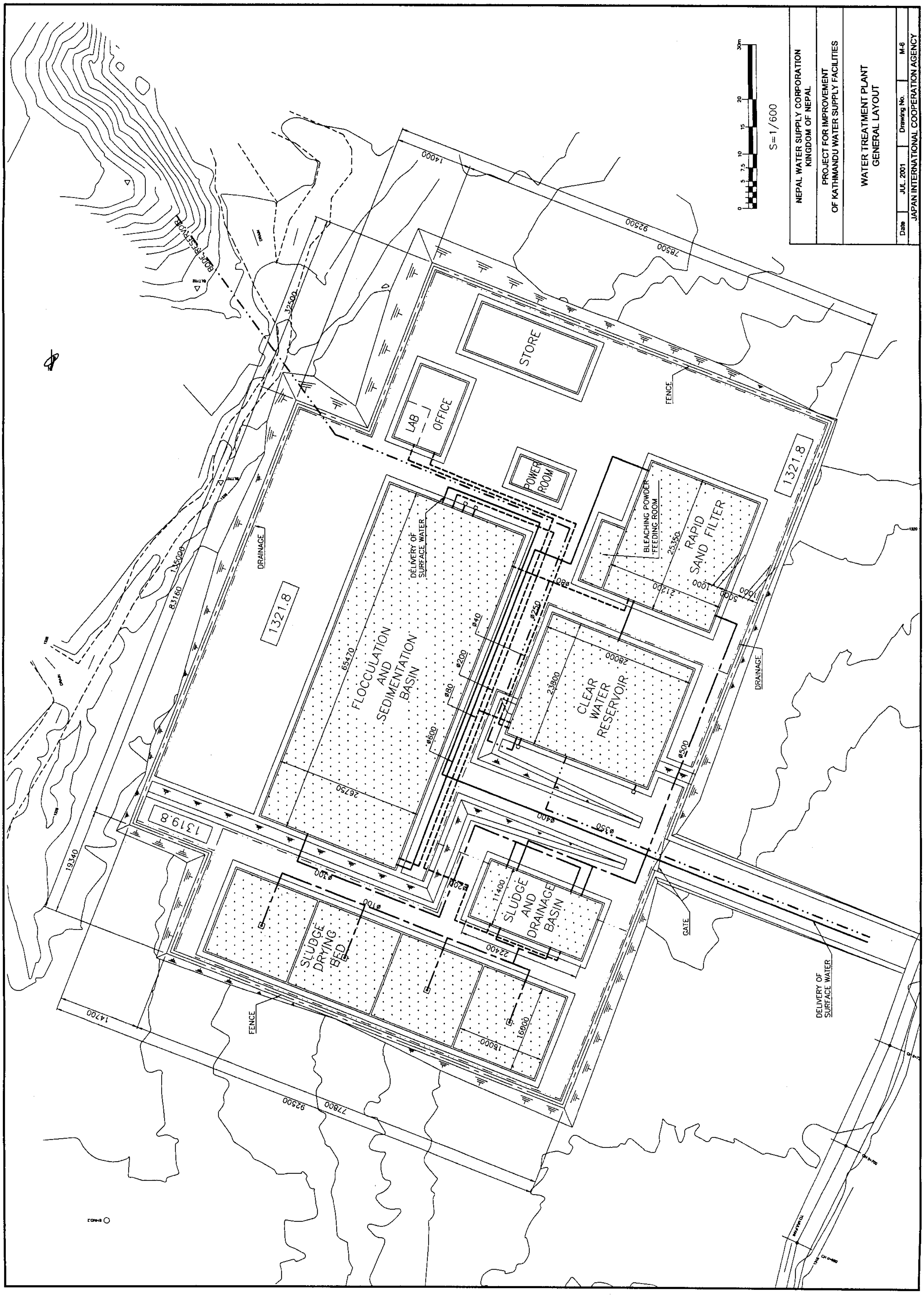
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL

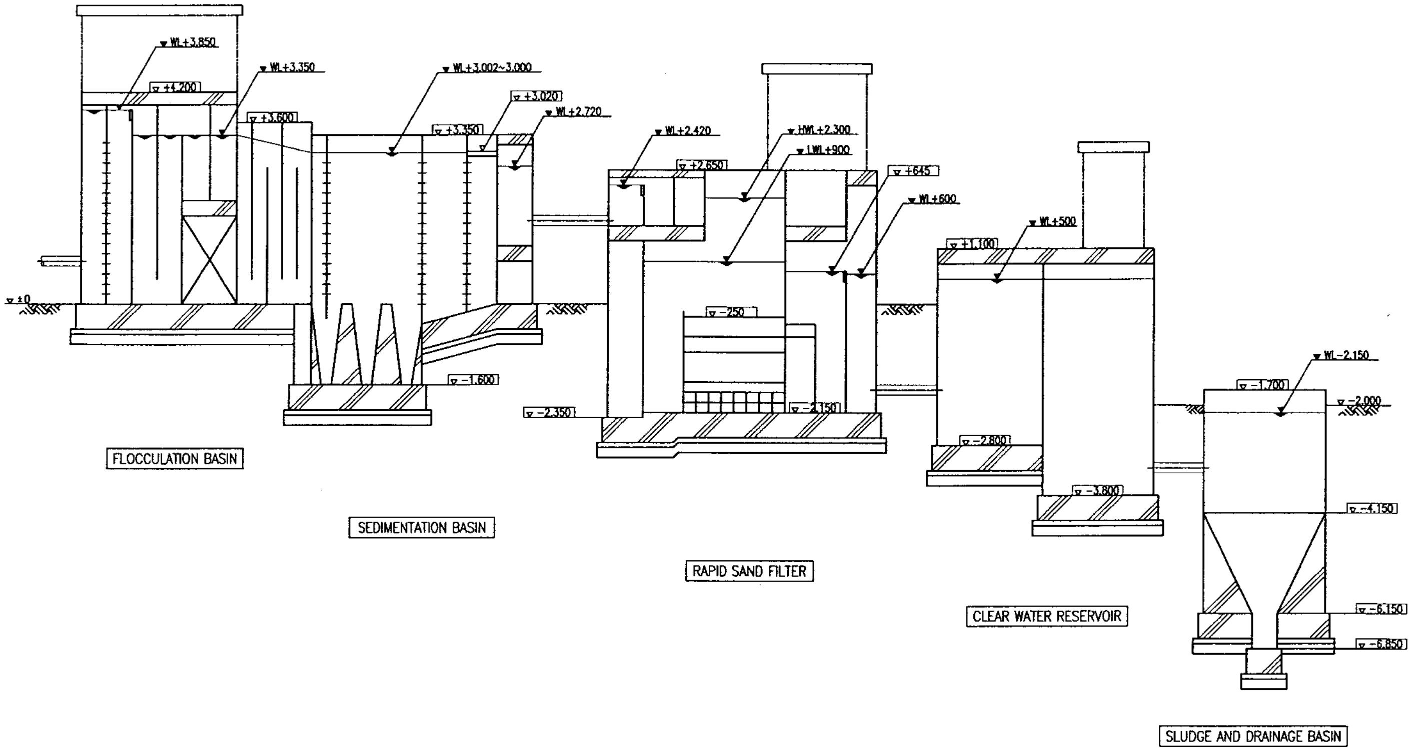
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES

RAW WATER CONVEYANCE PIPE
(WATER INTAKE-WATER TREATMENT PLANT 2/2)

Date	JUL. 2001	Drawing No.	M-5

JAPAN INTERNATIONAL COOPERATION AGENCY

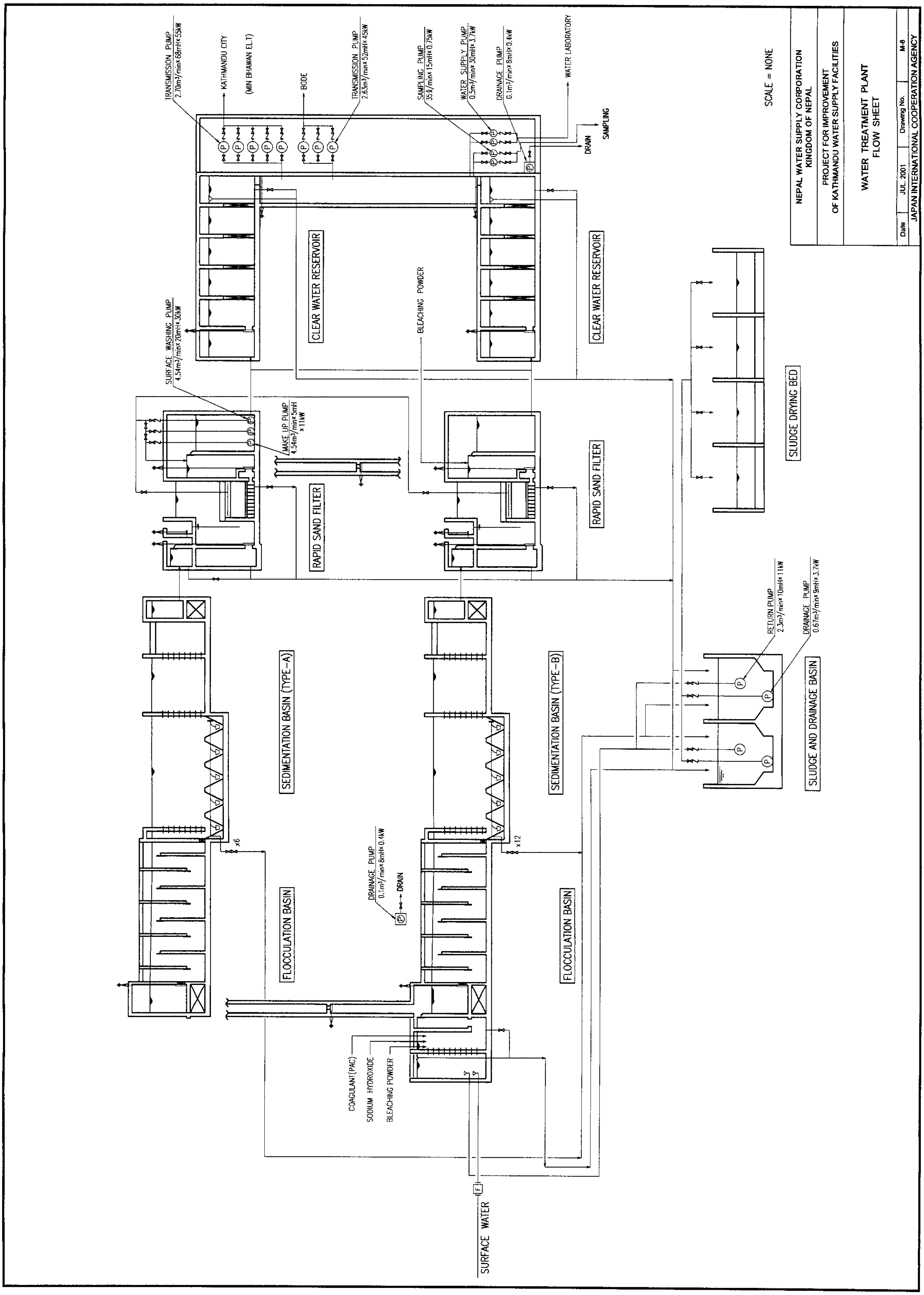

NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES
WATER TREATMENT PLANT
GENERAL LAYOUT
Date
JUL. 2001
Drawing No.
M-6
JAPAN INTERNATIONAL COOPERATION AGENCY
S=1/600
STORE
LAB
OFFICE
POWER ROOM
BLEACHING POWDER FEEDING ROOM
RAPID SAND FILTER
CLEAR WATER RESERVOIR
FLOCCULATION AND SEDIMENTATION BASIN
DELIVERY OF SURFACE WATER
SLUDGE AND DRAINAGE BASIN
SLUDGE DRYING BED
FENCE
DRAINAGE
GATE
1321.8
1319.8



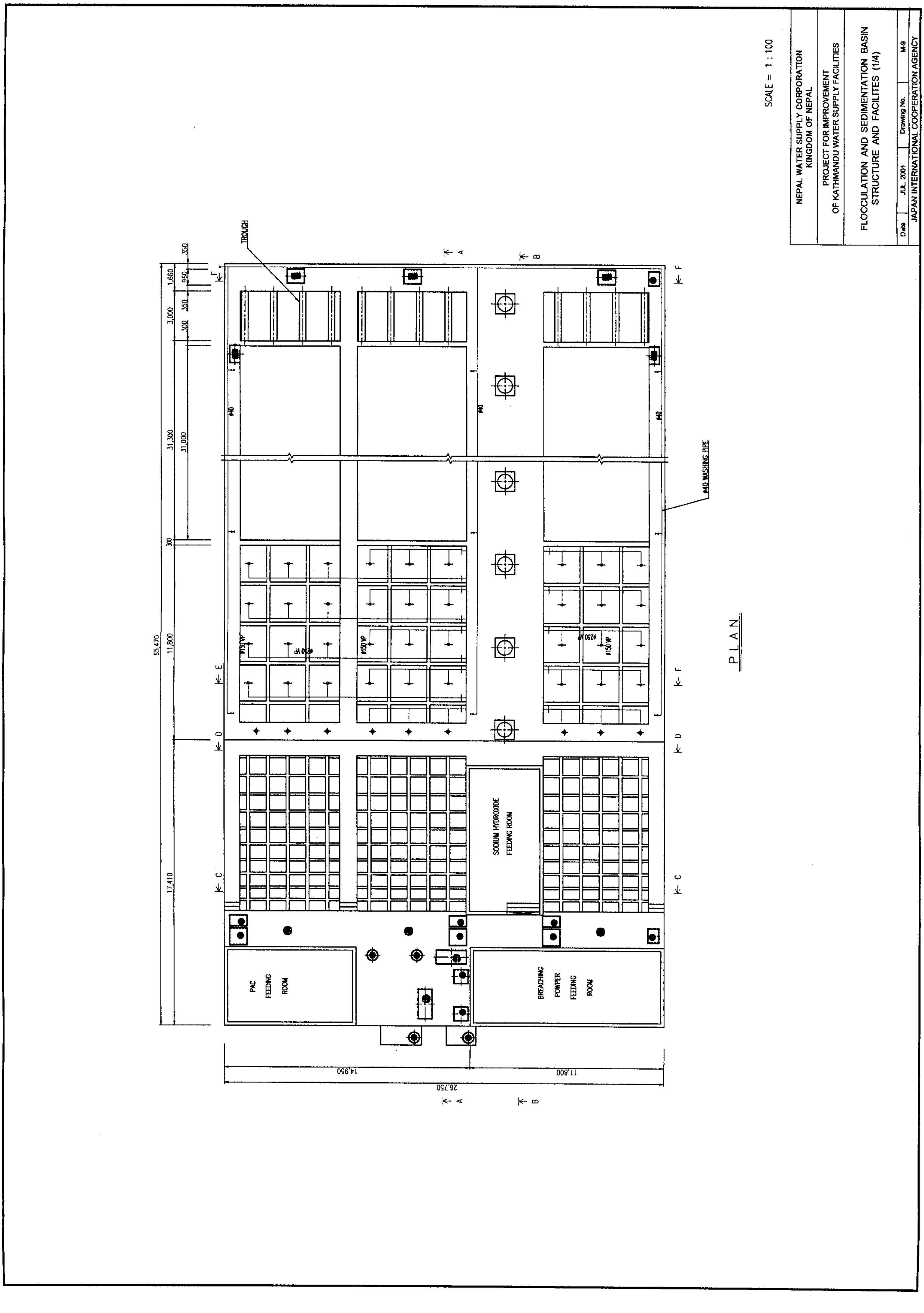
±0=1, 321. 8

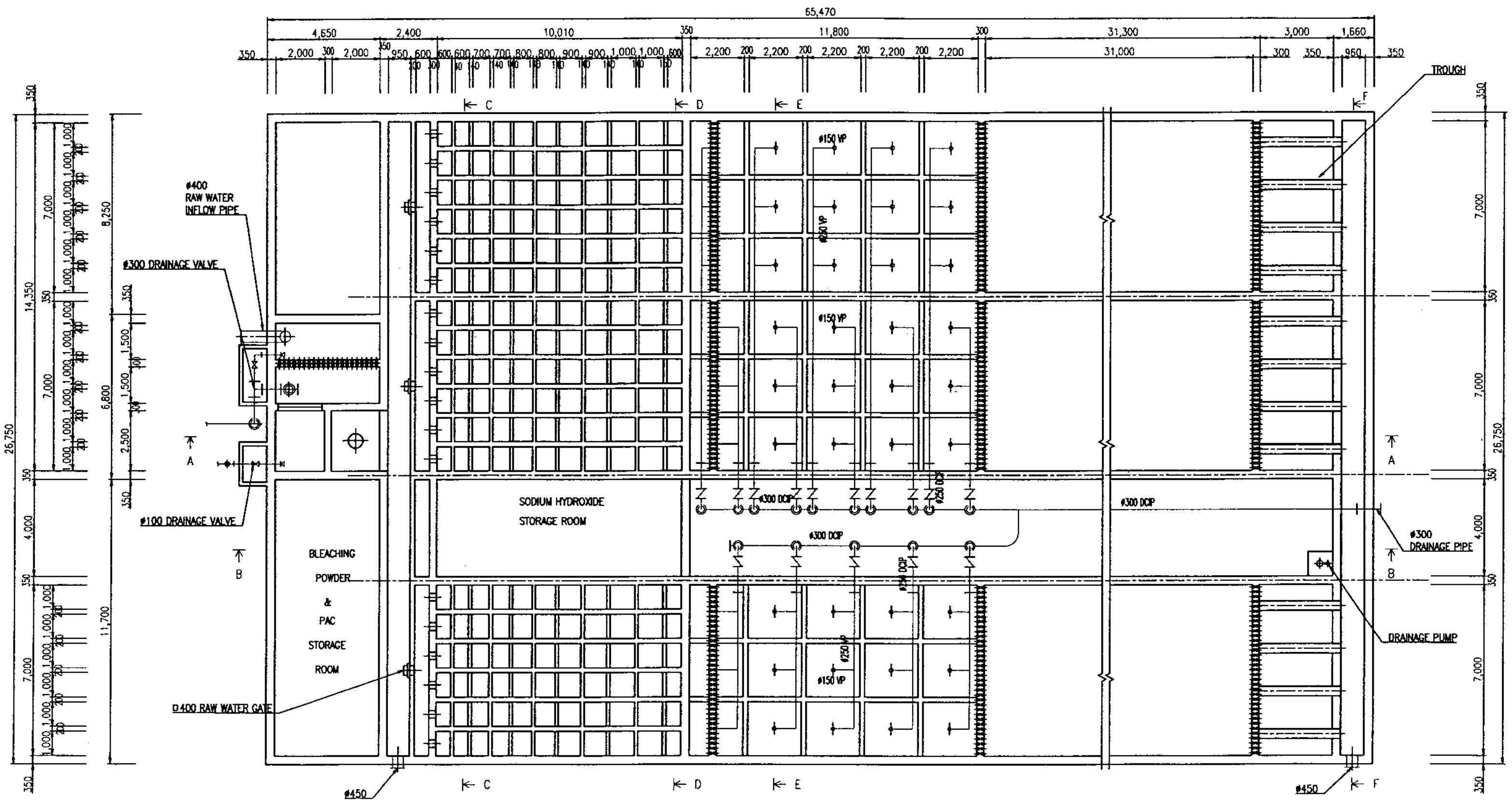
SCALE = NONE

NEPAL WATER SUPPLY CORPORATION KINGDOM OF NEPAL			
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES			
WATER TREATMENT PLANT DIFFERENCE IN WATER LEVEL			
Date	JUL. 2001	Drawing No.	M-7
JAPAN INTERNATIONAL COOPERATION AGENCY			



NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES
WATER TREATMENT PLANT
FLOW SHEET
Date
JUL. 2001
Drawing No.
M-8
JAPAN INTERNATIONAL COOPERATION AGENCY
SCALE = NONE
TRANSMISSION PUMP
KATHMANDU CITY
(MIN BHAWAN EL.T)
BODE
SAMPLING PUMP
WATER SUPPLY PUMP
DRAINAGE PUMP
WATER LABORATORY
DRAIN
SAMPLING
CLEAR WATER RESERVOIR
CLEAR WATER RESERVOIR
BLEACHING POWDER
SURFACE WASHING PUMP
MAKE UP PUMP
RAPID SAND FILTER
RAPID SAND FILTER
SLUDGE DRYING BED
SEDIMENTATION BASIN (TYPE-A)
SEDIMENTATION BASIN (TYPE-B)
RETURN PUMP
DRAINAGE PUMP
SLUDGE AND DRAINAGE BASIN
FLOCCULATION BASIN
FLOCCULATION BASIN
DRAINAGE PUMP
DRAIN
COAGULANT(PAC)
SODIUM HYDROXIDE
BLEACHING POWDER
SURFACE WATER

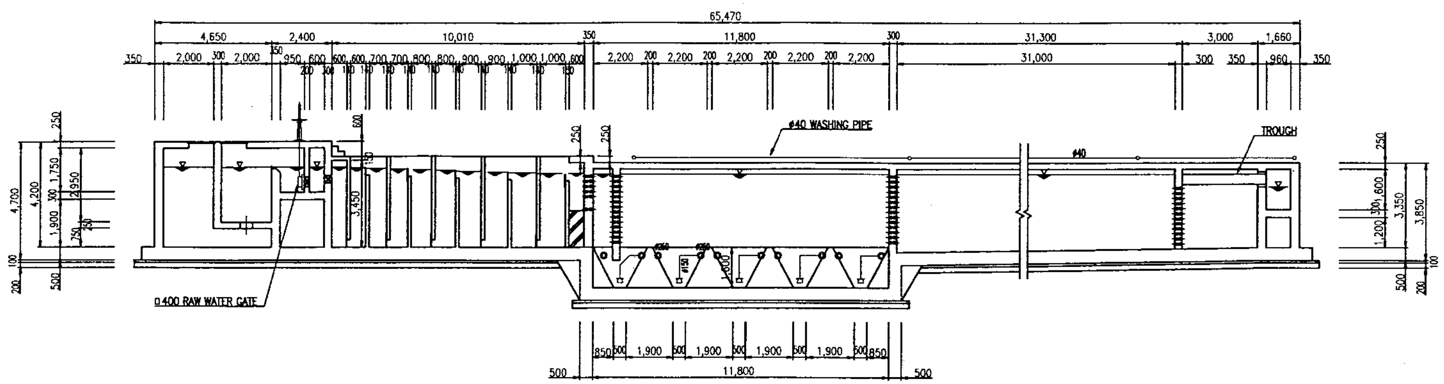

SCALE = 1 : 100
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES
FLOCCULATION AND SEDIMENTATION BASIN
STRUCTURE AND FACILITES (1/4)
Date JUL. 2001 Drawing No. M-9
JAPAN INTERNATIONAL COOPERATION AGENCY
TROUGH
ϕ40 WASHING PIPE
SODIUM HYDROXIDE FEEDING ROOM
PAC FEEDING ROOM
BREACHING POWPER FEEDING ROOM
PLAN
65,470
17,410
11,800
31,300
31,000
26,750
14,950
11,800



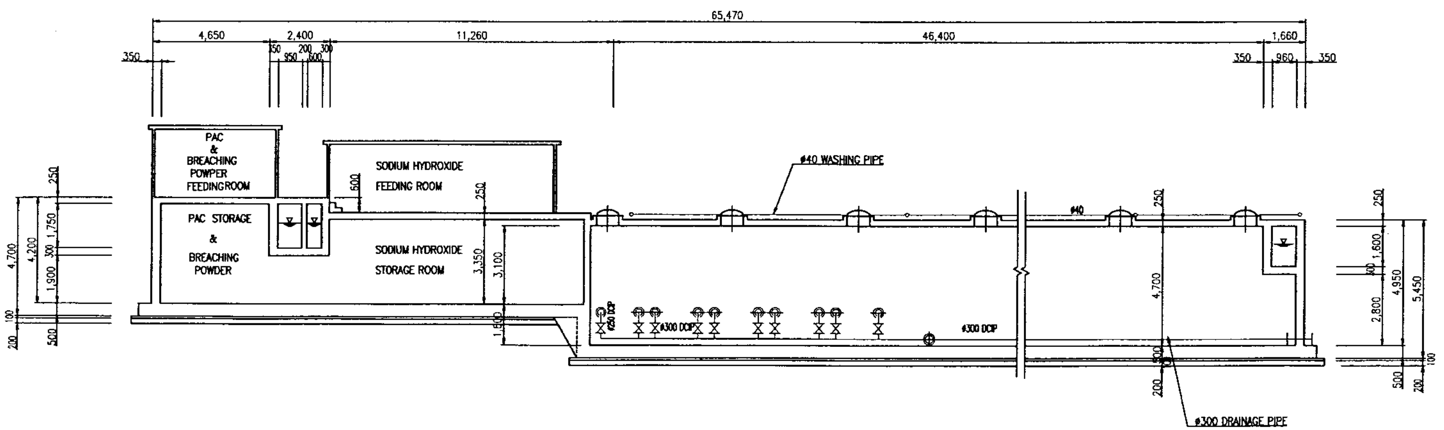
PLAN

SCALE = 1 : 100

NEPAL WATER SUPPLY CORPORATION KINGDOM OF NEPAL			
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES			
FLOCCULATION AND SEDIMENTATION BASIN STRUCTURE AND FACILITES (2/4)			
Date	JUL. 2001	Drawing No.	M-10
JAPAN INTERNATIONAL COOPERATION AGENCY			



SECTION A–A



SECTION B–B

SCALE = 1 : 100

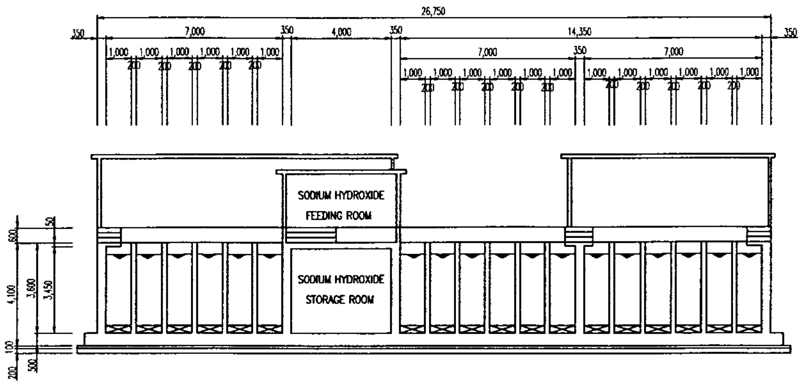
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL

PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES

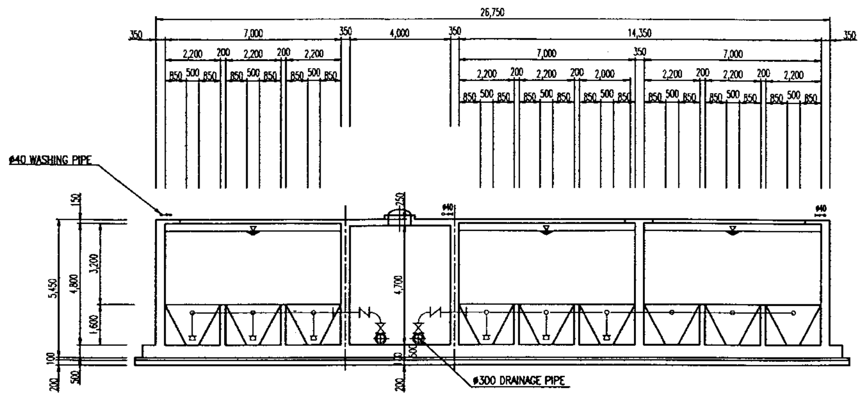
FLOCCULATION AND SEDIMENTATION BASIN
STRUCTURE AND FACILITES (3/4)

Date	JUL. 2001	Drawing No.	M-11

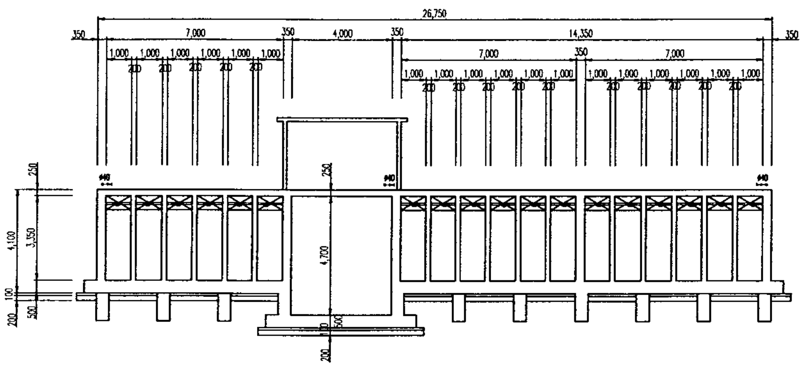
JAPAN INTERNATIONAL COOPERATION AGENCY



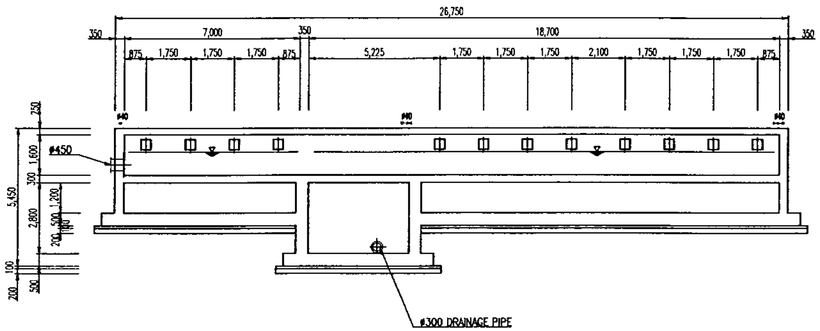
SECTION C–C



SECTION E–E



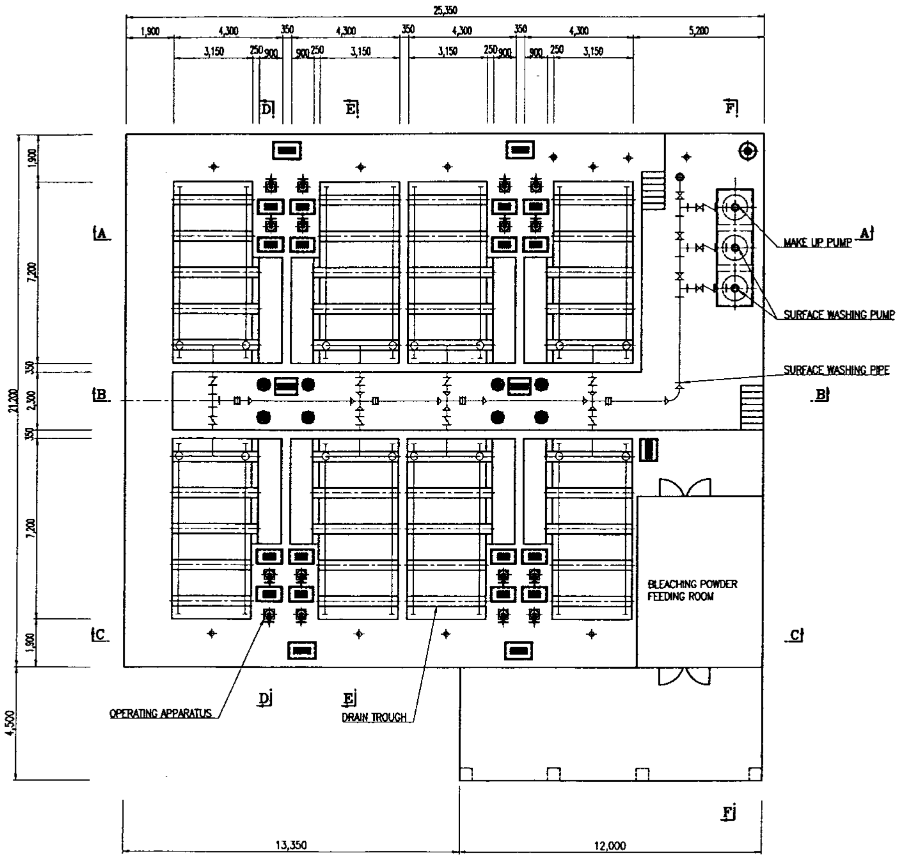
SECTION D–D



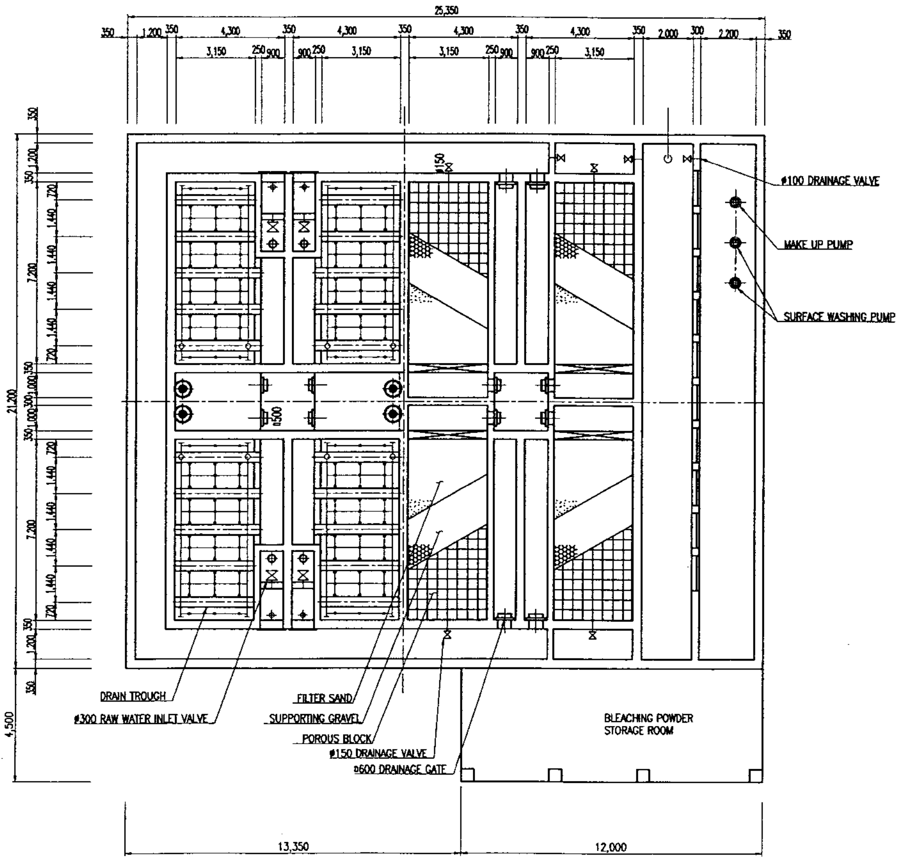
SECTION F–F

SCALE = 1 : 100

NEPAL WATER SUPPLY CORPORATION KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES
FLOCCULATION AND SEDIMENTATION BASIN STRUCTURE AND FACILITES (4/4)
Date: JUL. 2001 / Drawing No.: M-12
JAPAN INTERNATIONAL COOPERATION AGENCY



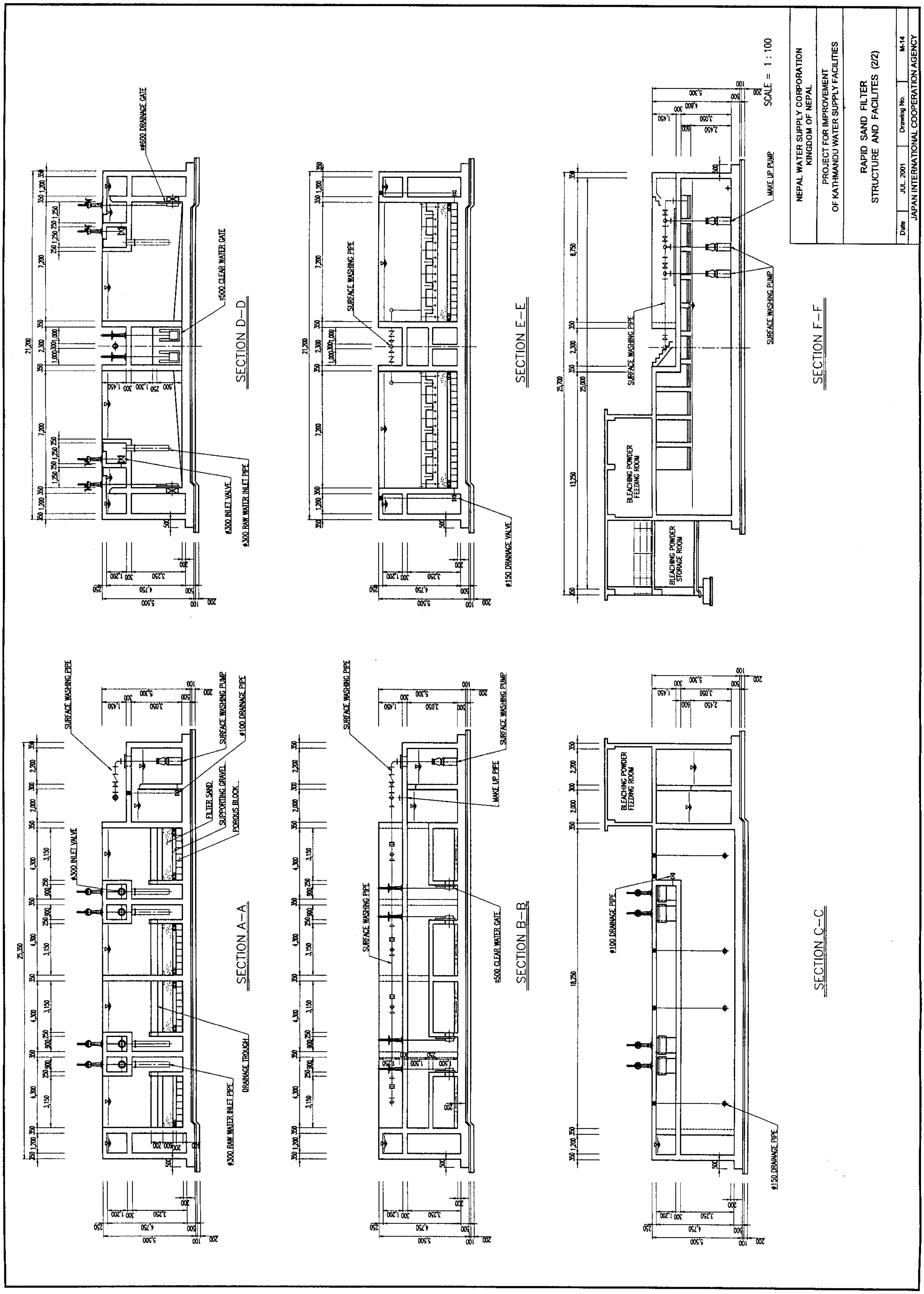
PLAN(1)

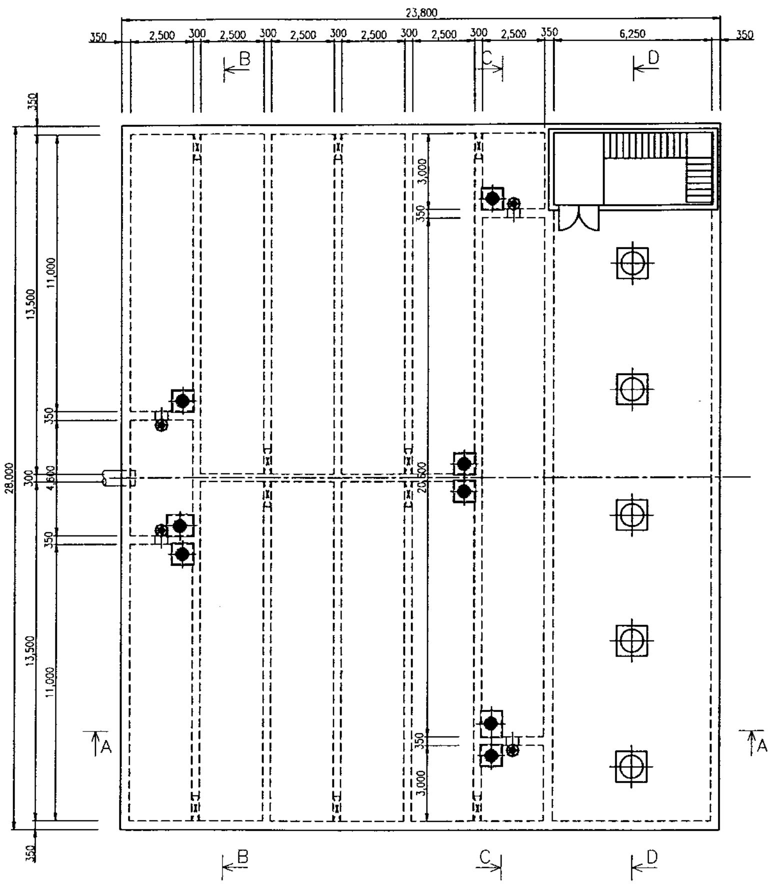


PLAN(2)

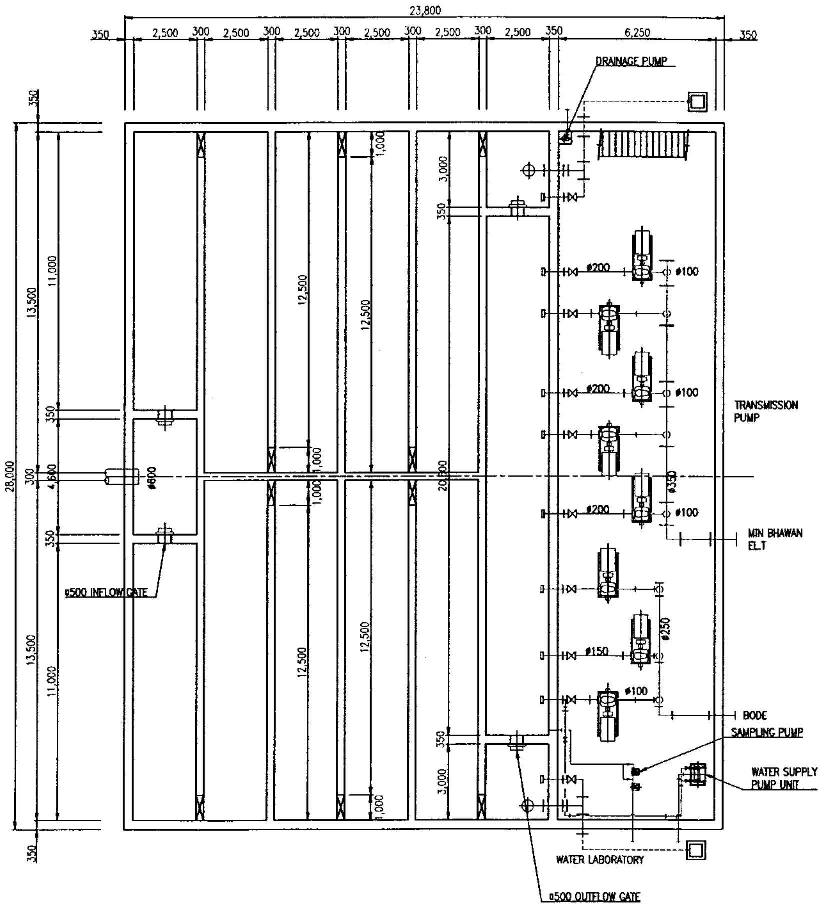
SCALE = 1 : 100

NEPAL WATER SUPPLY CORPORATION KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES
RAPID SAND FILTER STRUCTURE AND FACILITES (1/2)
Date: JUL. 2001 — Drawing No.: M-13
JAPAN INTERNATIONAL COOPERATION AGENCY


NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES
RAPID SAND FILTER
STRUCTURE AND FACILITIES (2/2)
Date
JUL. 2001
Drawing No.
M-14
JAPAN INTERNATIONAL COOPERATION AGENCY
SCALE = 1 : 100
SECTION D-D
SECTION E-E
SECTION F-F
SECTION A-A
SECTION B-B
SECTION C-C
ø600 DRAINAGE GATE
ø500 CLEAR WATER GATE
ø300 INLET VALVE
ø300 RAW WATER INLET PIPE
SURFACE WASHING PIPE
ø150 DRAINAGE VALVE
MAKE UP PUMP
SURFACE WASHING PUMP
BLEACHING POWDER FEEDING ROOM
BLEACHING POWDER STORAGE ROOM
ø100 DRAINAGE PIPE
FILTER SAND
SUPPORTING GRAVEL
POROUS BLOCK
DRAINAGE TROUGH
MAKE UP PIPE
ø150 DRAINAGE PIPE



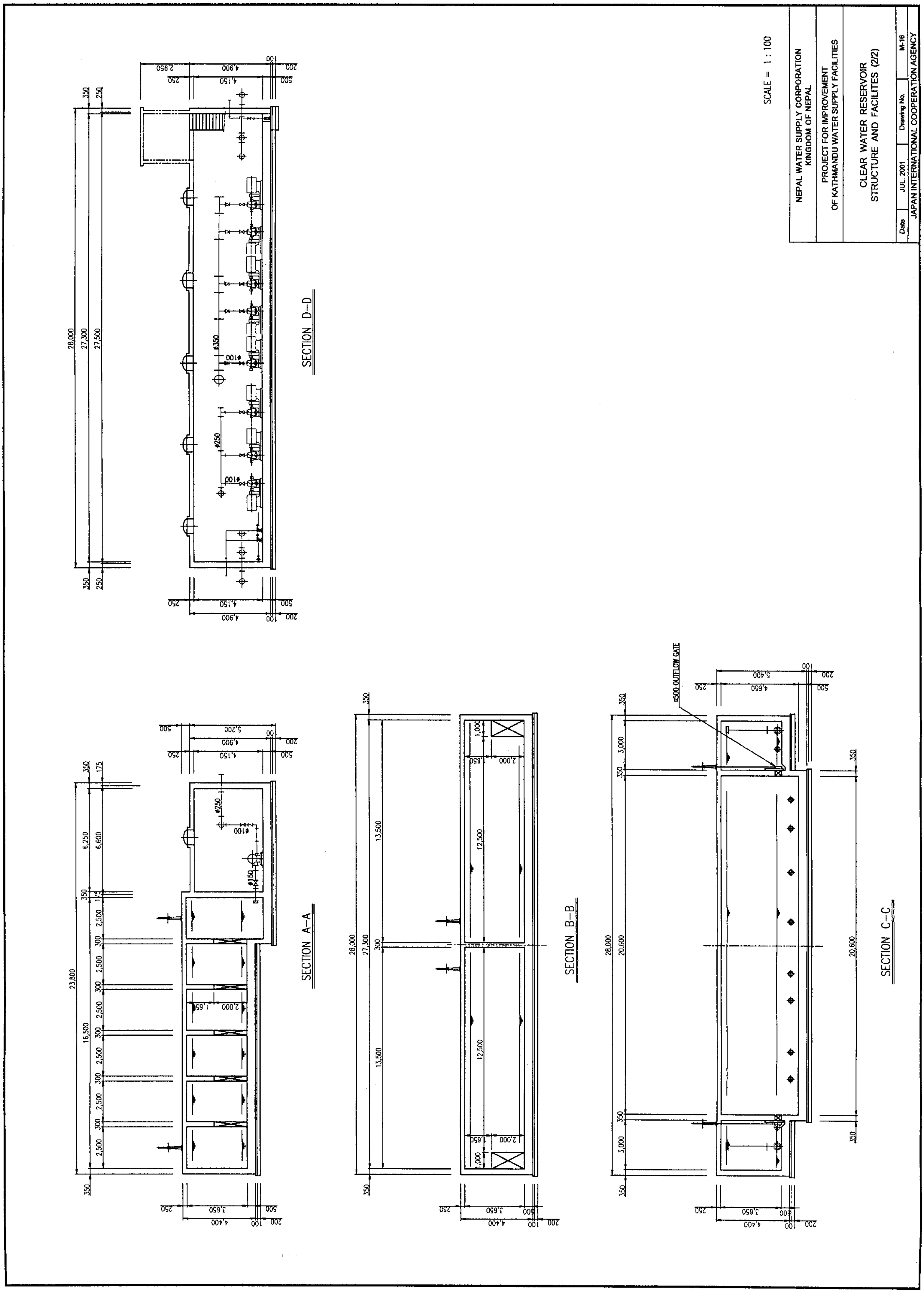
PLAN(1)

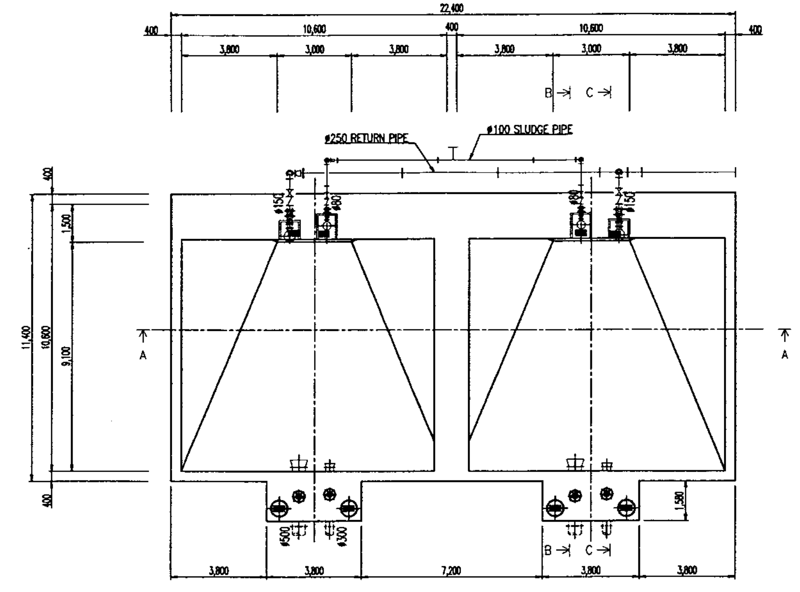


PLAN(2)

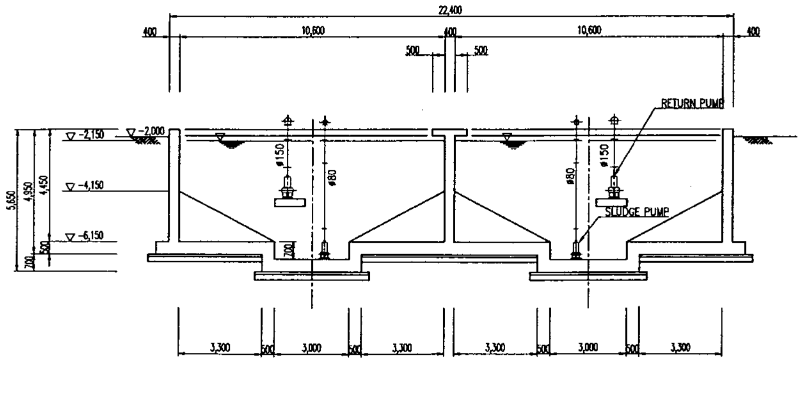
SCALE = 1 : 100

NEPAL WATER SUPPLY CORPORATION KINGDOM OF NEPAL	
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES	
CLEAR WATER RESERVOIR STRUCTURE AND FACILITES (1/2)	
Date JUL. 2001	Drawing No. M-15
JAPAN INTERNATIONAL COOPERATION AGENCY	

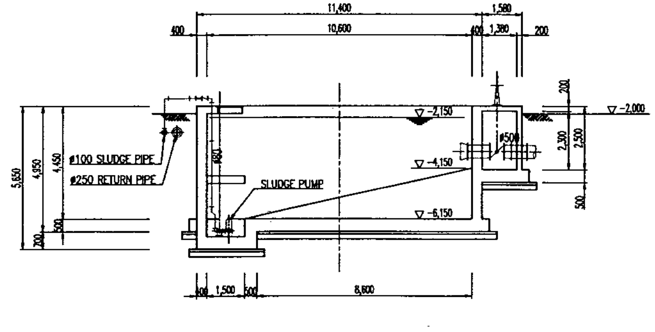

SECTION D-D
SECTION A-A
SECTION B-B
SECTION C-C
ø500 OUTFLOW GATE
SCALE = 1 : 100
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES
CLEAR WATER RESERVOIR
STRUCTURE AND FACILITES (2/2)
Date
JUL. 2001
Drawing No.
M-16
JAPAN INTERNATIONAL COOPERATION AGENCY



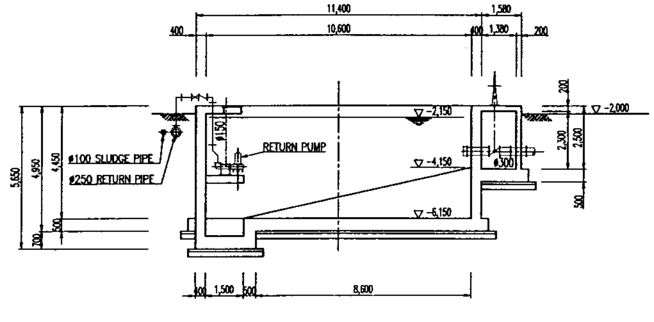
PLAN



SECTION A–A



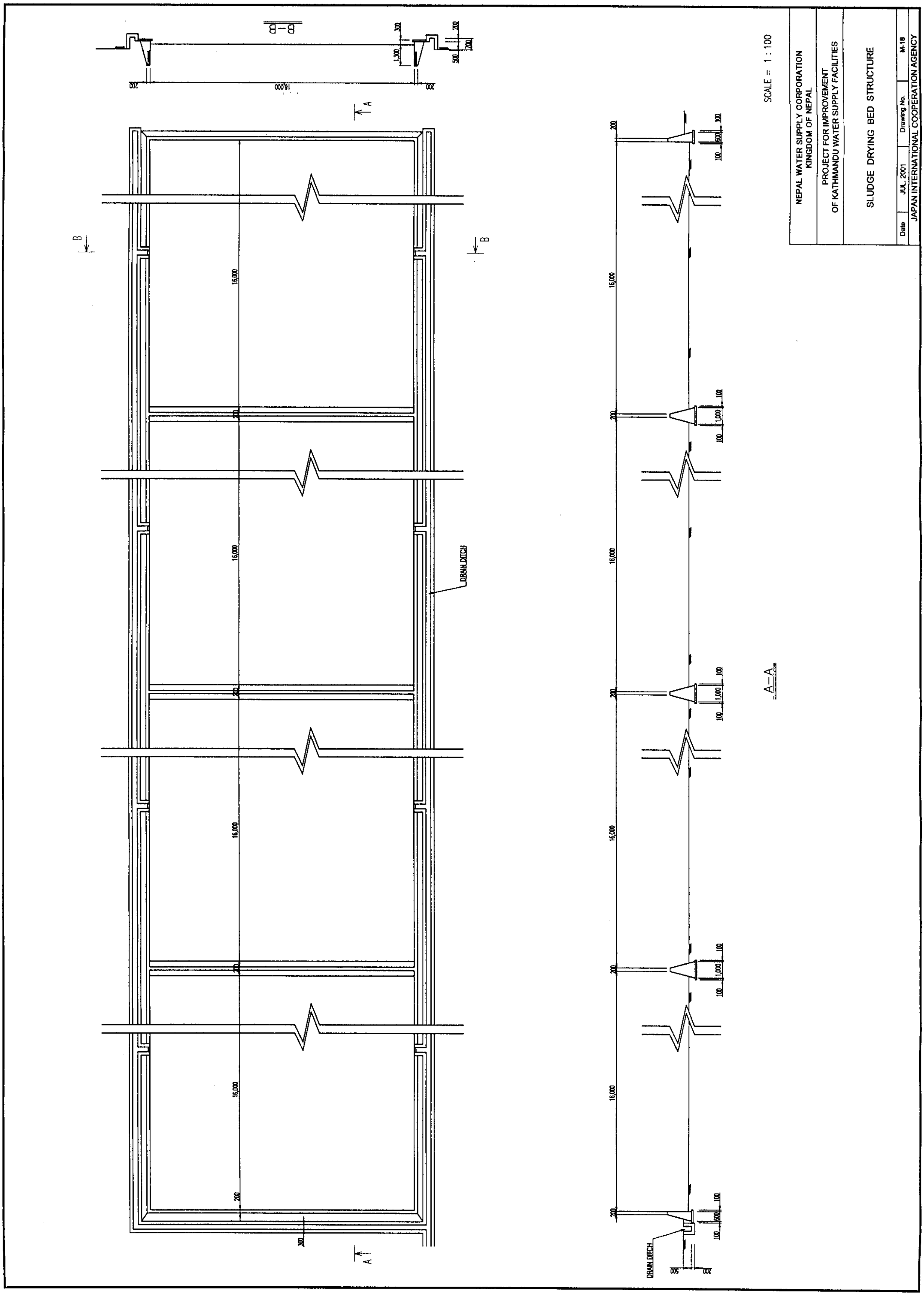
SECTION B–B



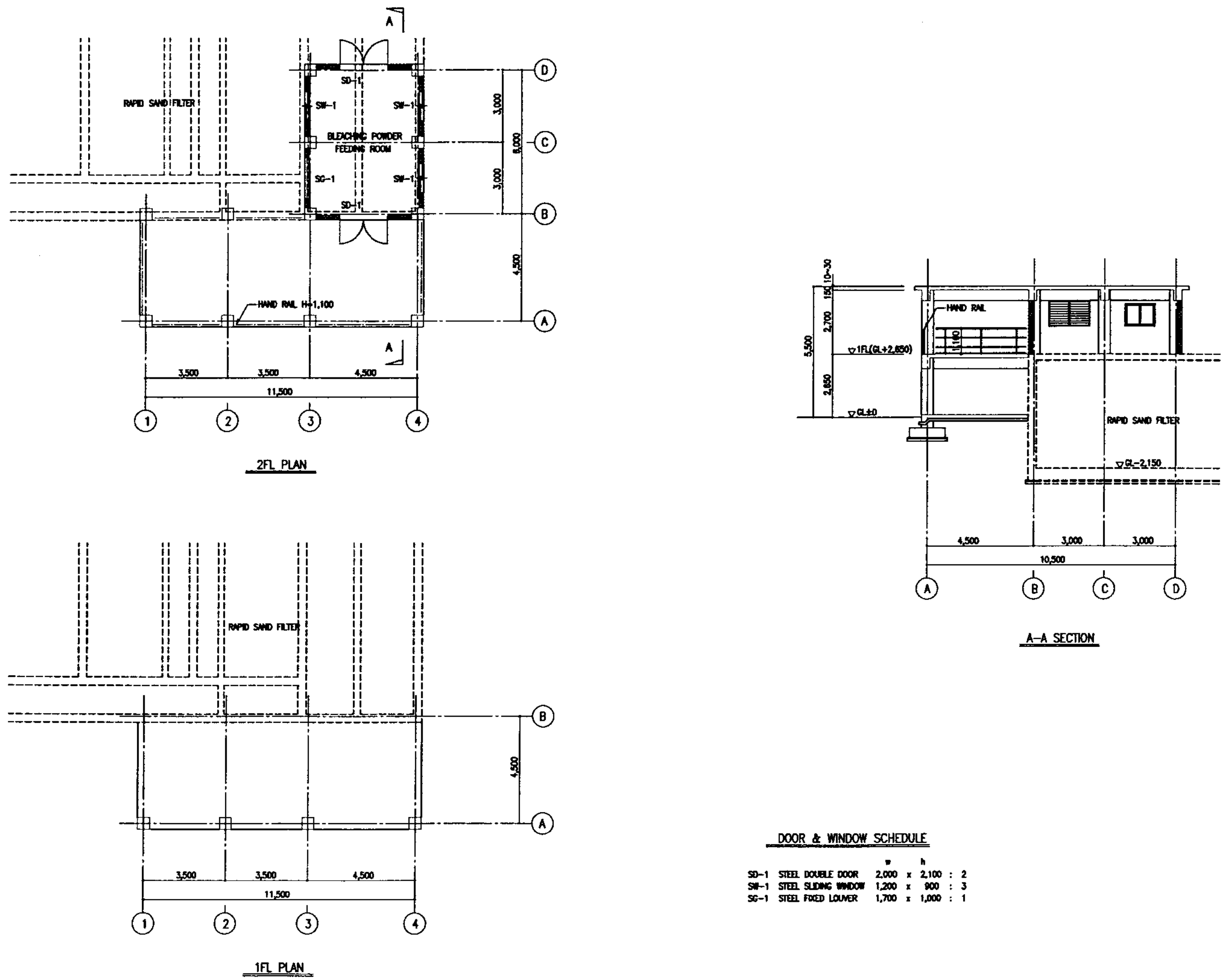
SECTION C–C

SCALE = 1 : 100

NEPAL WATER SUPPLY CORPORATION KINGDOM OF NEPAL			
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES			
SLUDGE AND DRAINAGE BASIN STRUCTURE AND FACILITES			
Date	JUL. 2001	Drawing No.	M-17
JAPAN INTERNATIONAL COOPERATION AGENCY			



B–B
A–A
DRAIN DITCH
SCALE = 1 : 100
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES
SLUDGE DRYING BED STRUCTURE
Date JUL. 2001
Drawing No. M-18
JAPAN INTERNATIONAL COOPERATION AGENCY



DOOR & WINDOW SCHEDULE

		w		h		
SD-1	STEEL DOUBLE DOOR	2,000	x	2,100	:	2
SW-1	STEEL SLIDING WINDOW	1,200	x	900	:	3
SG-1	STEEL FIXED LOUVER	1,700	x	1,000	:	1

BLEACHING POWDER FEEDING ROOM

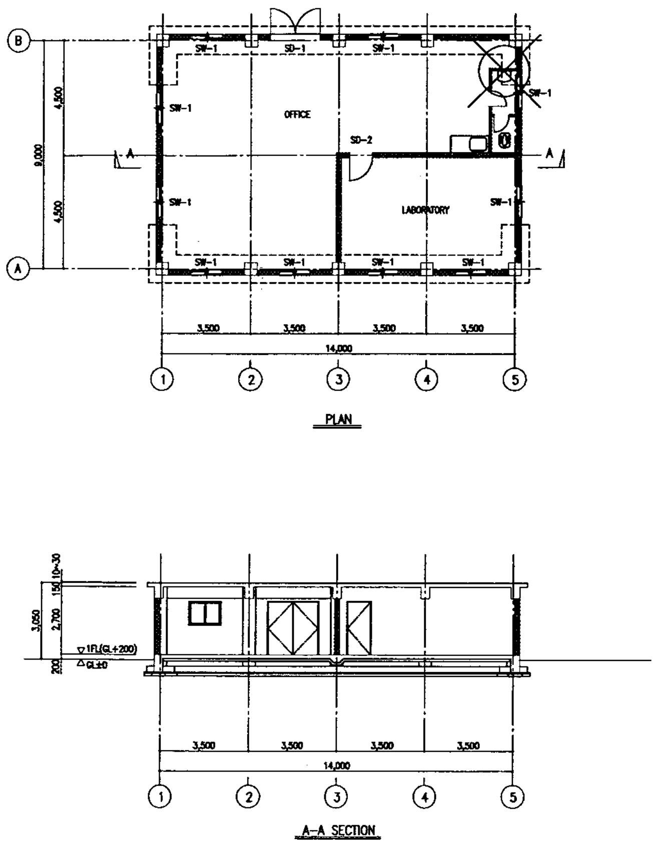
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL

PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES

BLEACHING POWDER FEEDING ROOM

Date	JUL. 2001	Drawing No.	M-19

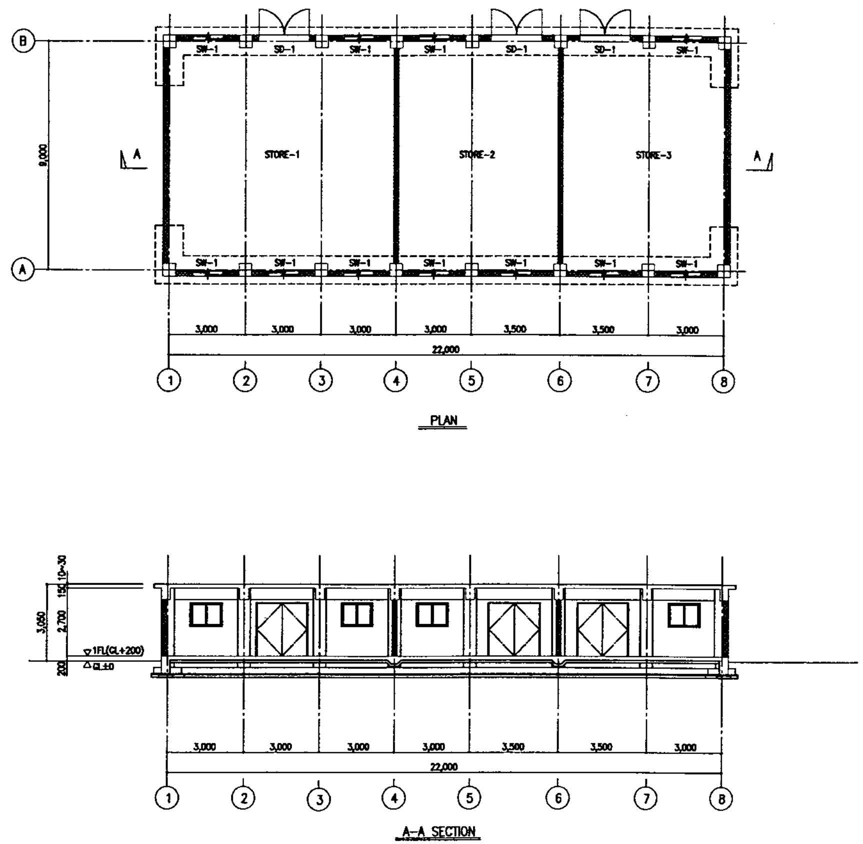
JAPAN INTERNATIONAL COOPERATION AGENCY



OFFICE & LABORATORY

DOOR & WINDOW SCHEDULE

		w		h		
SD-1	STEEL DOUBLE DOOR	2,000	x	2,100	:	1
SD-2	STEEL SINGLE DOOR	900	x	2,100	:	1
SW-1	STEEL SLIDING WINDOW	1,200	x	900	:	10

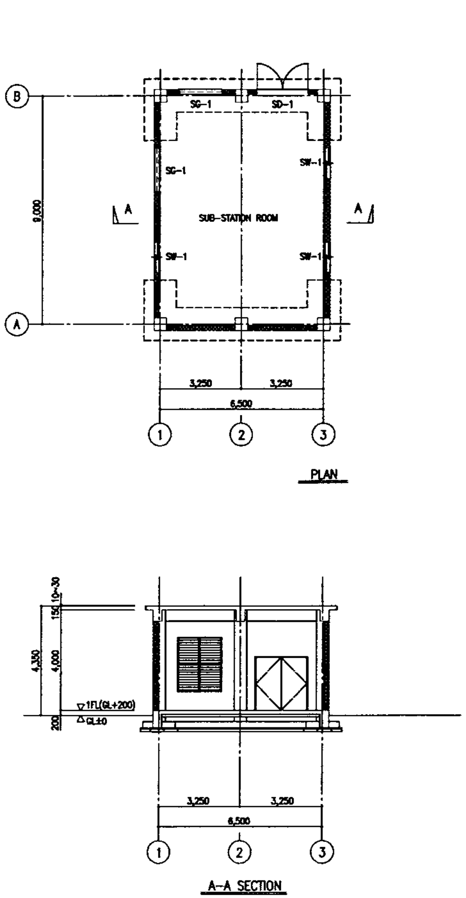


STORE

DOOR & WINDOW SCHEDULE

		w		h		
SD-1	STEEL DOUBLE DOOR	2,000	x	2,100	:	3
SW-1	STEEL SLIDING WINDOW	1,200	x	900	:	11

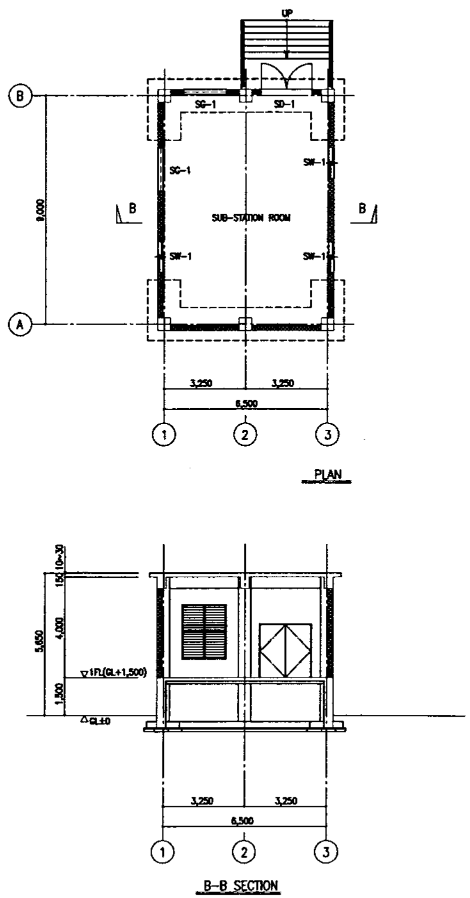
NEPAL WATER SUPPLY CORPORATION KINGDOM OF NEPAL			
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES			
OFFICE & LABORATORY, STORE			
Date	JUL. 2001	Drawing No.	M-20
JAPAN INTERNATIONAL COOPERATION AGENCY			



DOOR & WINDOW SCHEDULE

		w		h	
SD-1	STEEL DOUBLE DOOR	2,000	x	2,100	: 1
SG-1	STEEL FIXED LOUVER	1,700	x	2,100	: 2
SW-1	STEEL SLIDING WINDOW	1,200	x	900	: 3

POWER ROOM -1
(WATER TREATMENT PLANT)



DOOR & WINDOW SCHEDULE

		w		h	
SD-1	STEEL DOUBLE DOOR	2,000	x	2,100	: 1
SG-1	STEEL FIXED LOUVER	1,700	x	2,100	: 2
SW-1	STEEL SLIDING WINDOW	1,200	x	900	: 3

POWER ROOM -2
(WATER INTAKE)

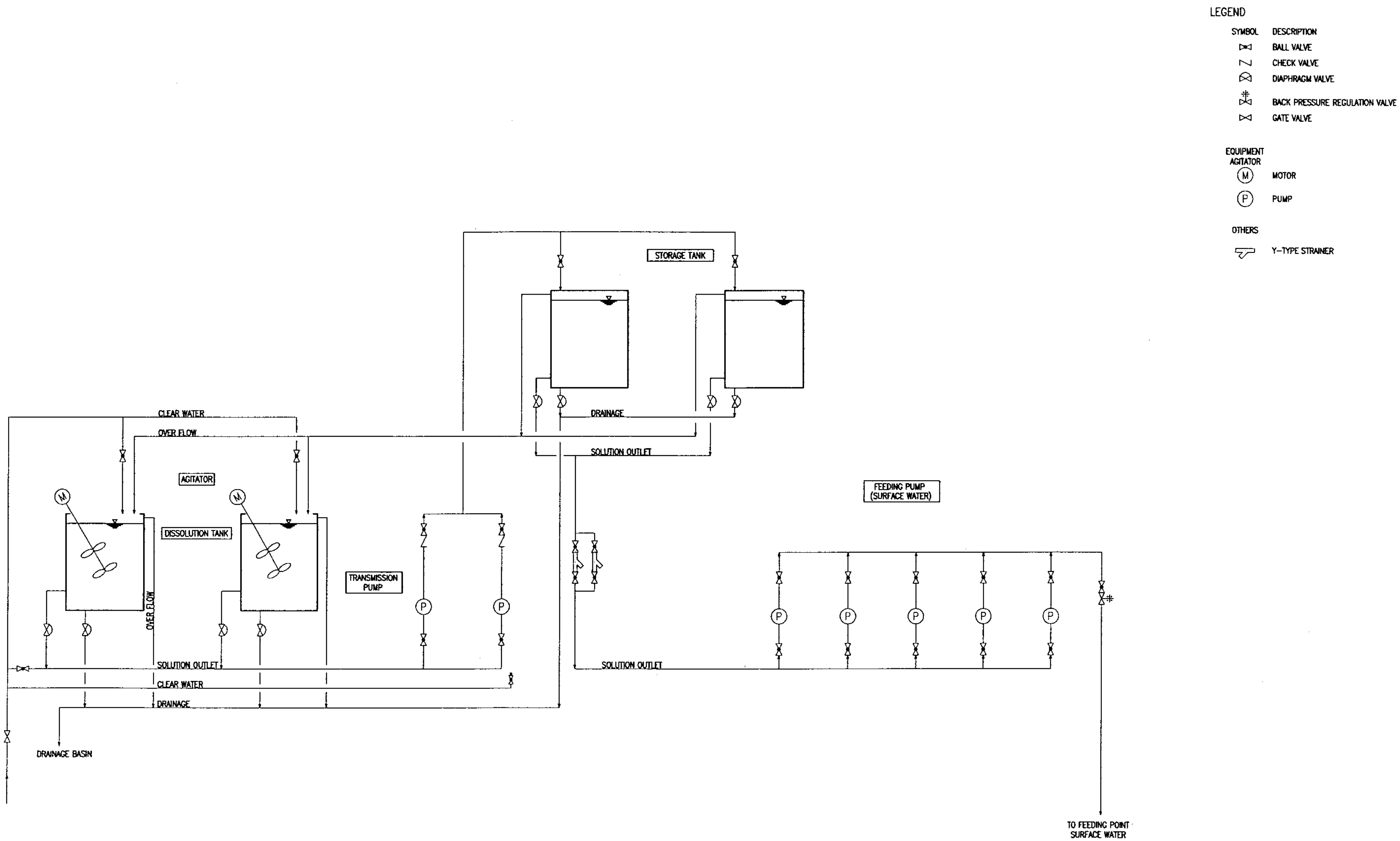
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL

PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES

POWER ROOM -1 , -2

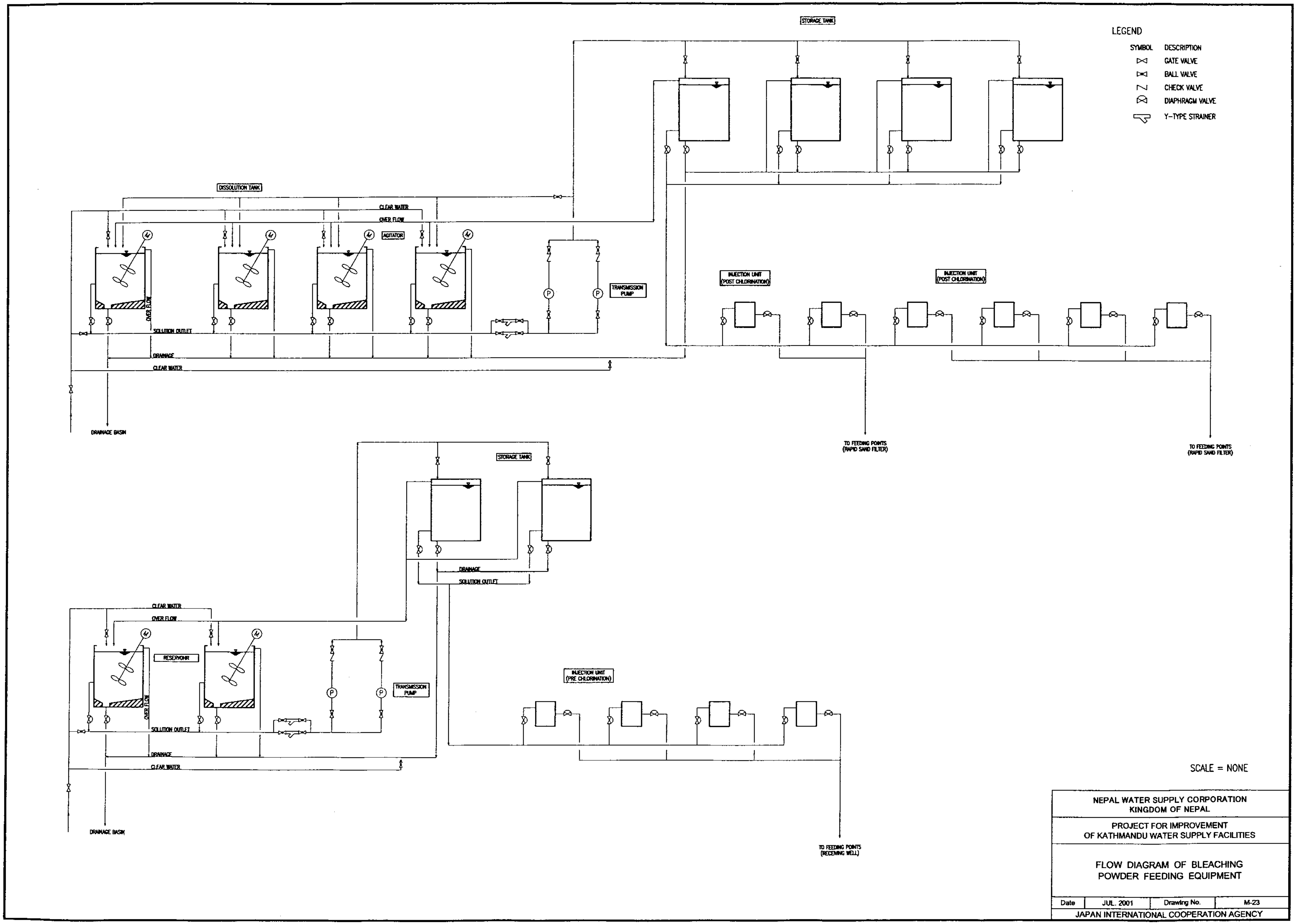
Date	JUL. 2001	Drawing No.	M-21

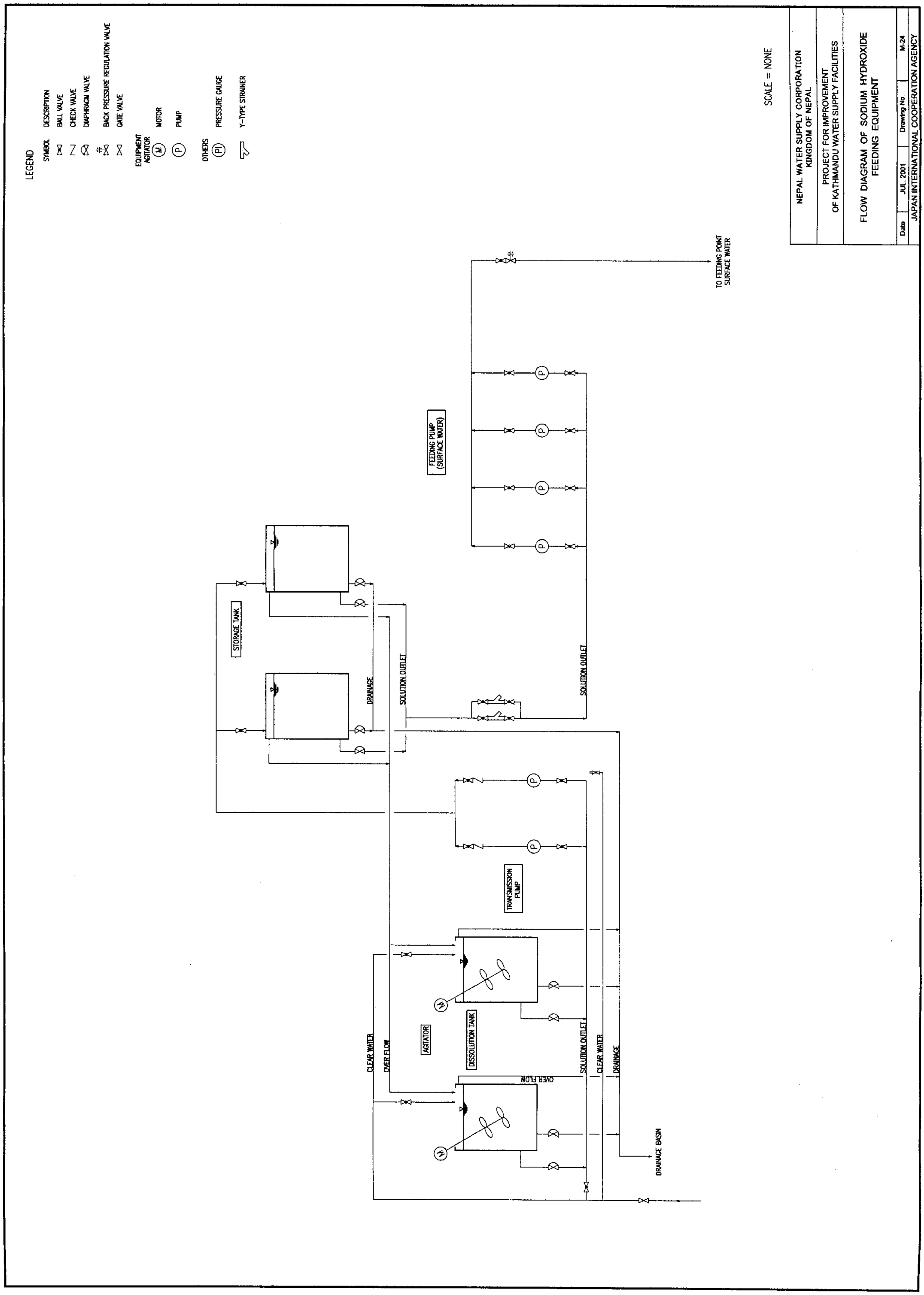
JAPAN INTERNATIONAL COOPERATION AGENCY

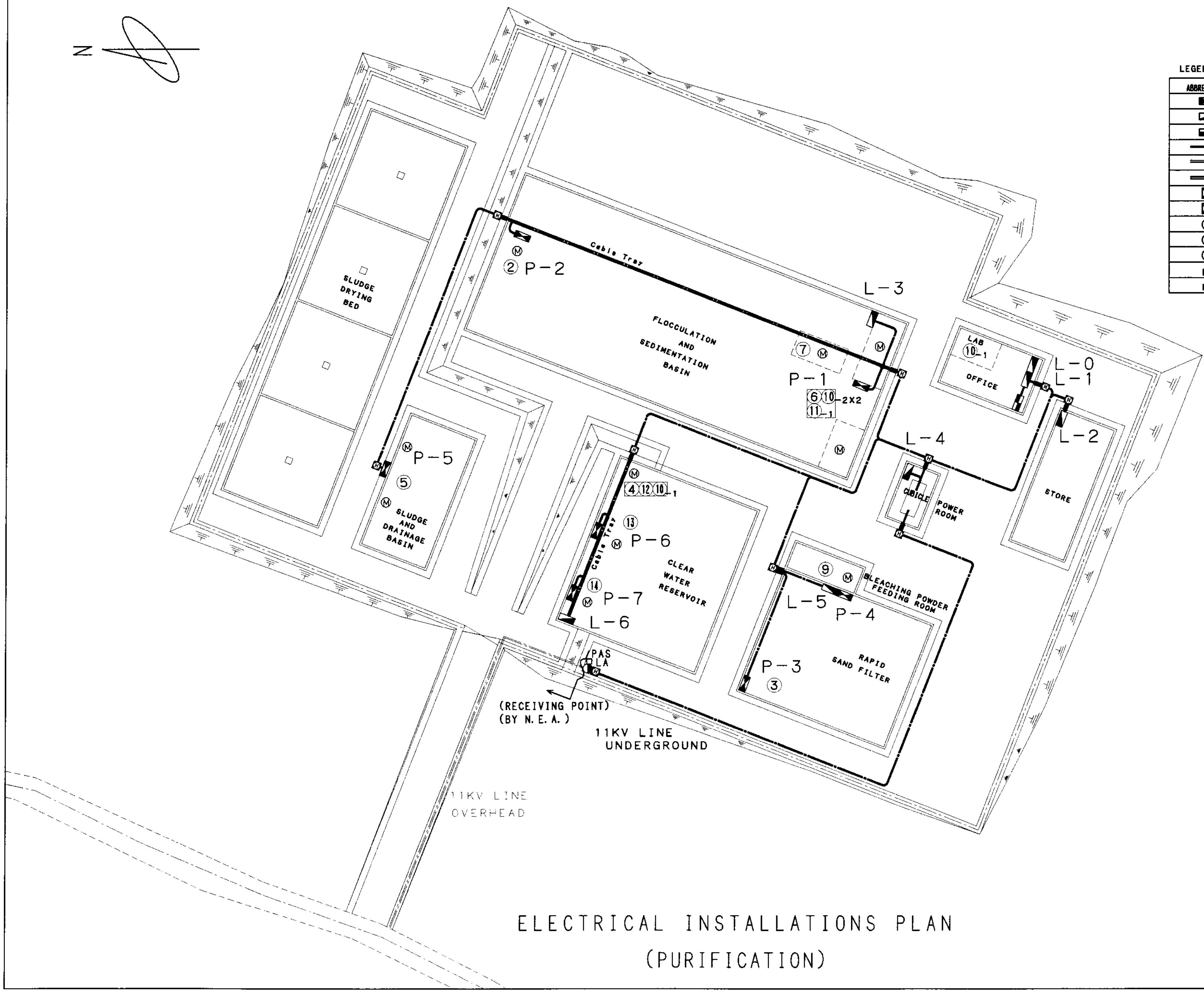


SCALE = NONE

NEPAL WATER SUPPLY CORPORATION KINGDOM OF NEPAL			
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES			
FLOW DIAGRAM OF COAGULANT (PAC) FEEDING EQUIPMENT			
Date	JUL. 2001	Drawing No.	M-22
JAPAN INTERNATIONAL COOPERATION AGENCY			


LEGEND
SYMBOL DESCRIPTION
GATE VALVE
BALL VALVE
CHECK VALVE
DIAPHRAGM VALVE
Y-TYPE STRAINER
STORAGE TANK
DISSOLUTION TANK
CLEAR WATER
OVER FLOW
AGITATOR
SOLUTION OUTLET
DRAINAGE
CLEAR WATER
DRAINAGE BASIN
TRANSMISSION PUMP
INJECTION UNIT (POST CHLORINATION)
INJECTION UNIT (POST CHLORINATION)
TO FEEDING POINTS (RAPID SAND FILTER)
TO FEEDING POINTS (RAPID SAND FILTER)
STORAGE TANK
DRAINAGE
SOLUTION OUTLET
CLEAR WATER
OVER FLOW
RESERVOIR
TRANSMISSION PUMP
SOLUTION OUTLET
DRAINAGE
CLEAR WATER
DRAINAGE BASIN
INJECTION UNIT (PRE CHLORINATION)
TO FEEDING POINTS (RECEIVING WELL)
SCALE = NONE
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES
FLOW DIAGRAM OF BLEACHING
POWDER FEEDING EQUIPMENT
Date JUL. 2001 Drawing No. M-23
JAPAN INTERNATIONAL COOPERATION AGENCY


LEGEND
SYMBOL DESCRIPTION
BALL VALVE
CHECK VALVE
DIAPHRAGM VALVE
BACK PRESSURE REGULATION VALVE
GATE VALVE
EQUIPMENT
AGITATOR
MOTOR
PUMP
OTHERS
PRESSURE GAUGE
Y-TYPE STRAINER
SCALE = NONE
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES
FLOW DIAGRAM OF SODIUM HYDROXIDE
FEEDING EQUIPMENT
Date
JUL. 2001
Drawing No.
M-24
JAPAN INTERNATIONAL COOPERATION AGENCY
TO FEEDING POINT
SURFACE WATER
FEEDING PUMP
(SURFACE WATER)
STORAGE TANK
DRAINAGE
SOLUTION OUTLET
SOLUTION OUTLET
TRANSMISSION
PUMP
AGITATOR
DISSOLUTION TANK
CLEAR WATER
OVER FLOW
OVER FLOW
SOLUTION OUTLET
CLEAR WATER
DRAINAGE
DRAINAGE BASIN

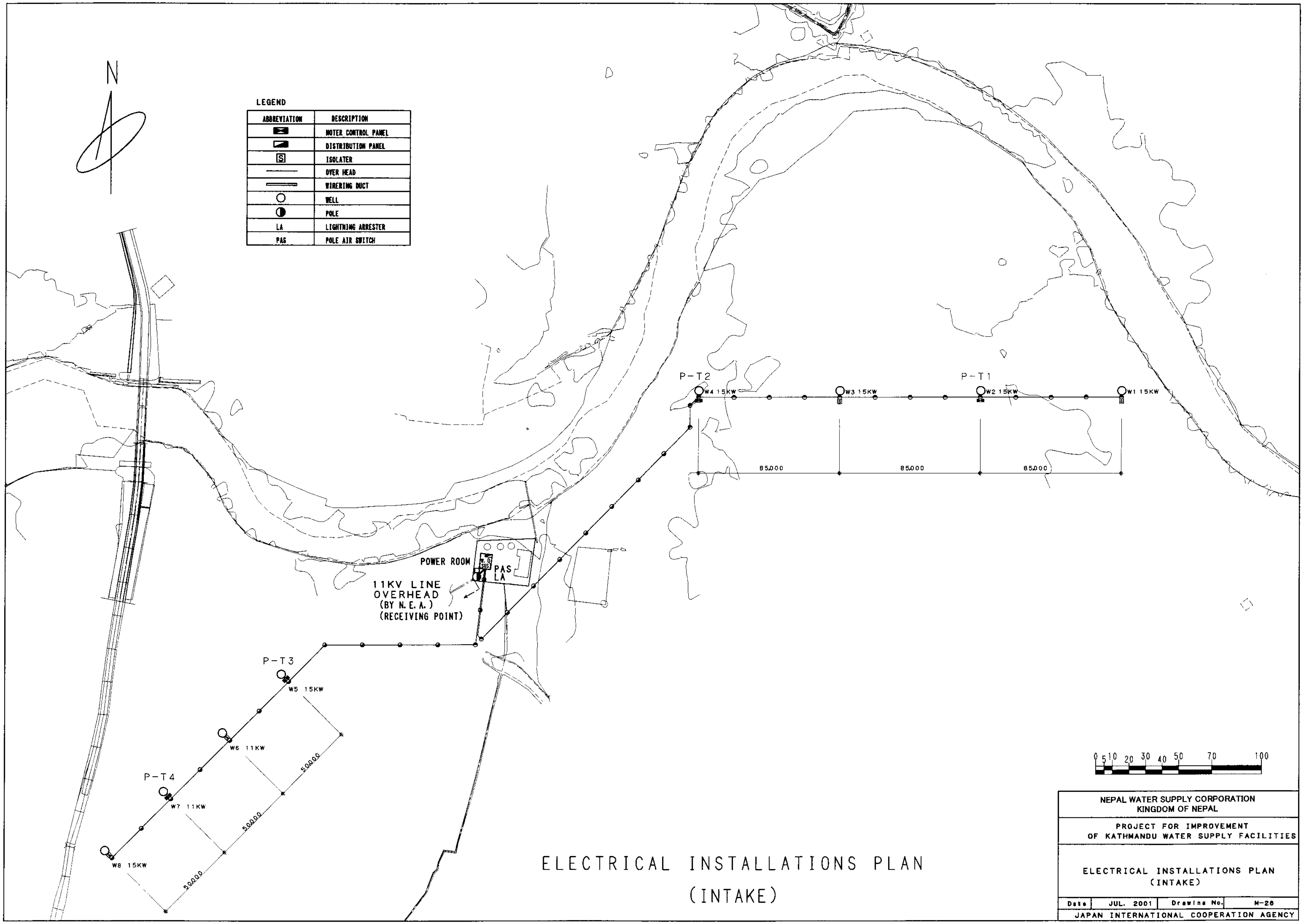


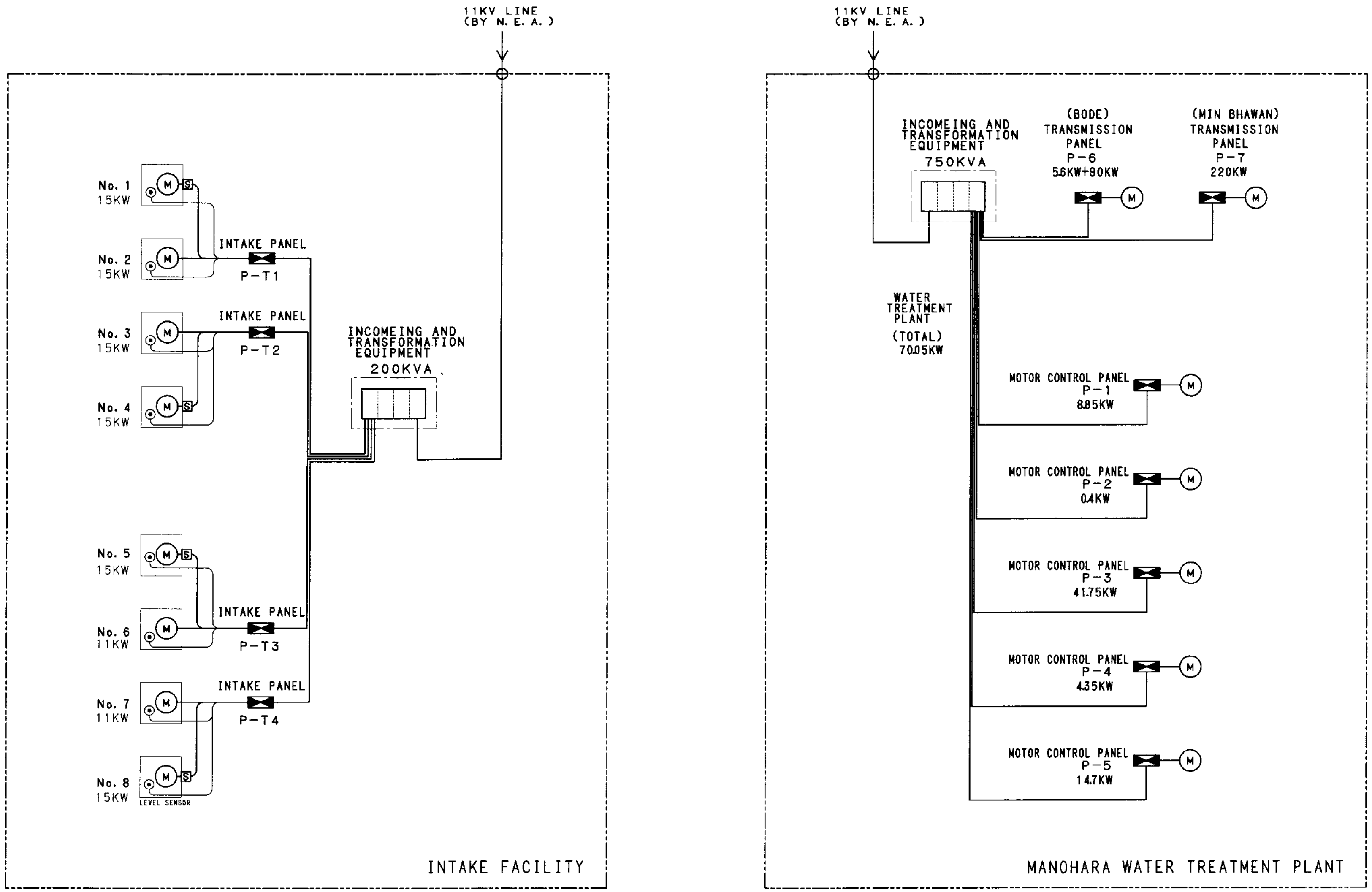
LEGEND

ABBREVIATION	DESCRIPTION
▬	MOTER CONTROL PANEL
▬	DISTRIBUTION PANEL
▬	ALARM PANEL
———	UNDERGROUND
═══	OVER HEAD
═══	Cable Tray
⊠	PULL BOX
H	HAND HOLE
M	MOTOR
①	GROUP NUMBER
◐	POLE
LA	LIGHTNING ARRESTER
PAS	POLE AIR SWITCH

ELECTRICAL INSTALLATIONS PLAN
(PURIFICATION)

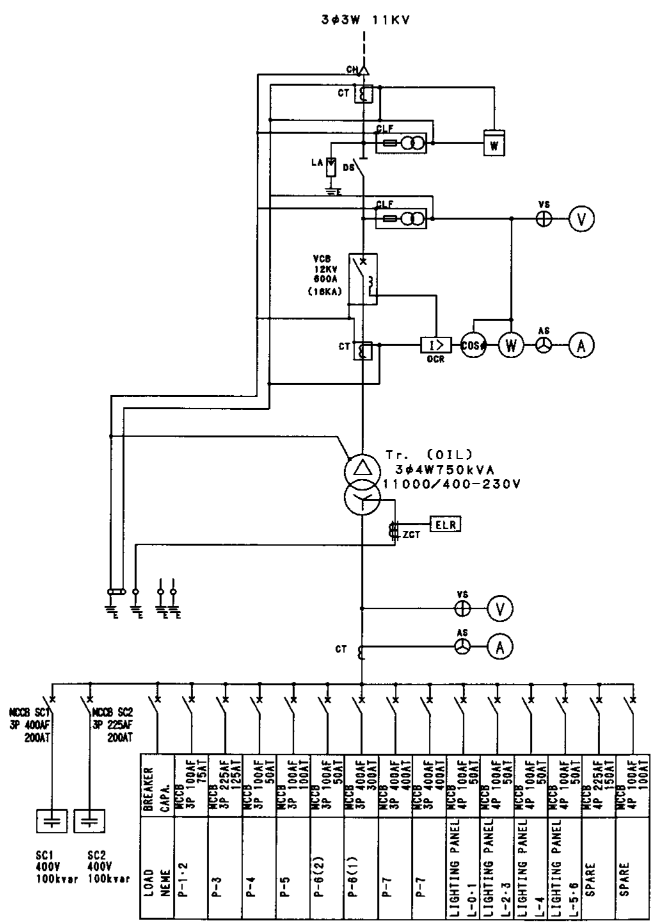
NEPAL WATER SUPPLY CORPORATION KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES
ELECTRICAL INSTALLATIONS PLAN (PURIFICATION)
Date: JUL. 2001 — Drawing No. M-25
JAPAN INTERNATIONAL COOPERATION AGENCY


N
LEGEND
ABBREVIATION | DESCRIPTION
MOTER CONTROL PANEL
DISTRIBUTION PANEL
S | ISOLATER
OVER HEAD
WIRERING DUCT
WELL
POLE
LA | LIGHTNING ARRESTER
PAS | POLE AIR SWITCH
P-T2
W4 15KW
W3 15KW
P-T1
W2 15KW
W1 15KW
85,000
85,000
85,000
POWER ROOM
PAS
LA
11KV LINE
OVERHEAD
(BY N.E.A.)
(RECEIVING POINT)
P-T3
W5 15KW
W6 11KW
P-T4
W7 11KW
W8 15KW
50,000
50,000
50,000
0 5 10 20 30 40 50 70 100
ELECTRICAL INSTALLATIONS PLAN
(INTAKE)
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES
ELECTRICAL INSTALLATIONS PLAN
(INTAKE)
Date JUL. 2001 Drawing No. M-28
JAPAN INTERNATIONAL COOPERATION AGENCY

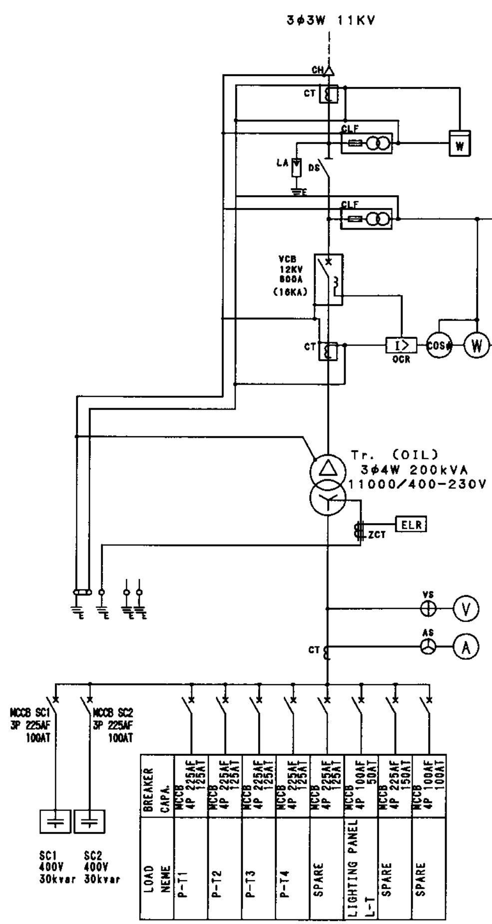


ELECTRICAL SYSTEM

NEPAL WATER SUPPLY CORPORATION KINGDOM OF NEPAL			
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES			
ELECTRICAL SYSTEM			
Date	JUL. 2001	Drawing No.	M-27
JAPAN INTERNATIONAL COOPERATION AGENCY			



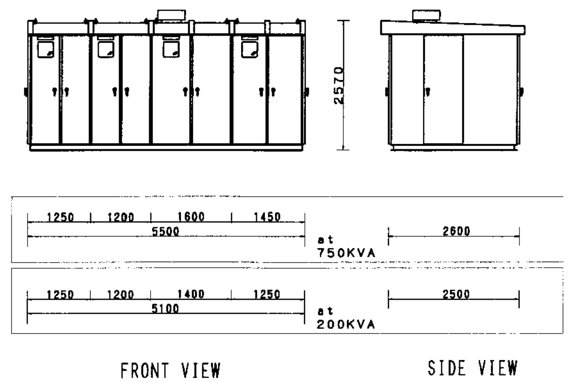
PURIFICATION SINGLE LINE DIAGRAM



INTAKE SINGLE LINE DIAGRAM

LEGEND

ABBREVIATION	DESCRIPTION
VCB	VACUM SWITCH
DS	Disconnecting Switch
OCR	OVER CURRENT RELAY
ELR	EARTH LEAKAGE RELAY
CLF	FUSE
LA	LIGHTNING ARRESTER
Tr	TRANSFORMER
W	WATT HOUR METER
V	VOLT METER
VS	VOLTMTER CHANGE-OVER SWITCH
A	AMPERE METER
AS	AMMETER CHANGE-OVER SWITCH
CT	CURRENT TRANSFORMER
MCCB	MOLDED CASE CIRCUIT BREAKER
SC	STATIC CONDENSER
CH	CABLE HEAD
E	EARTH



CUBICLE

NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL

PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES

SINGLE LINE DIAGRAM

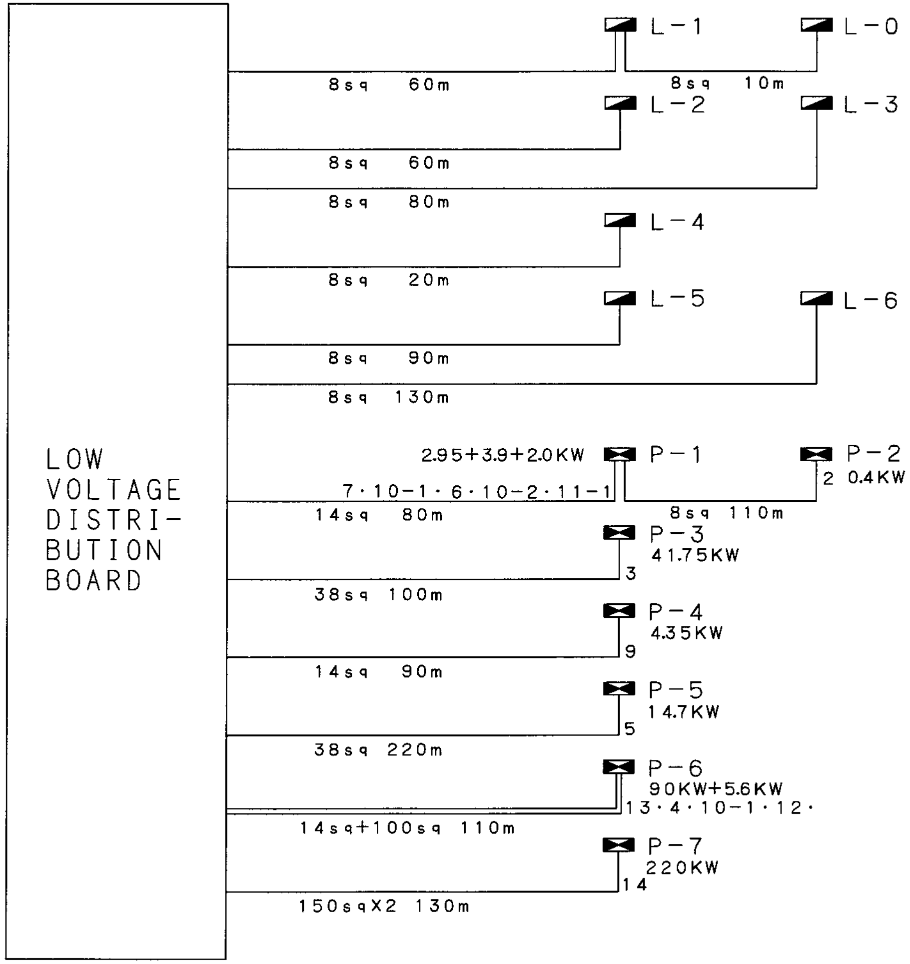
Date	JUL. 2001	Drawing No.	M-28

JAPAN INTERNATIONAL COOPERATION AGENCY

LIST OF LOADS

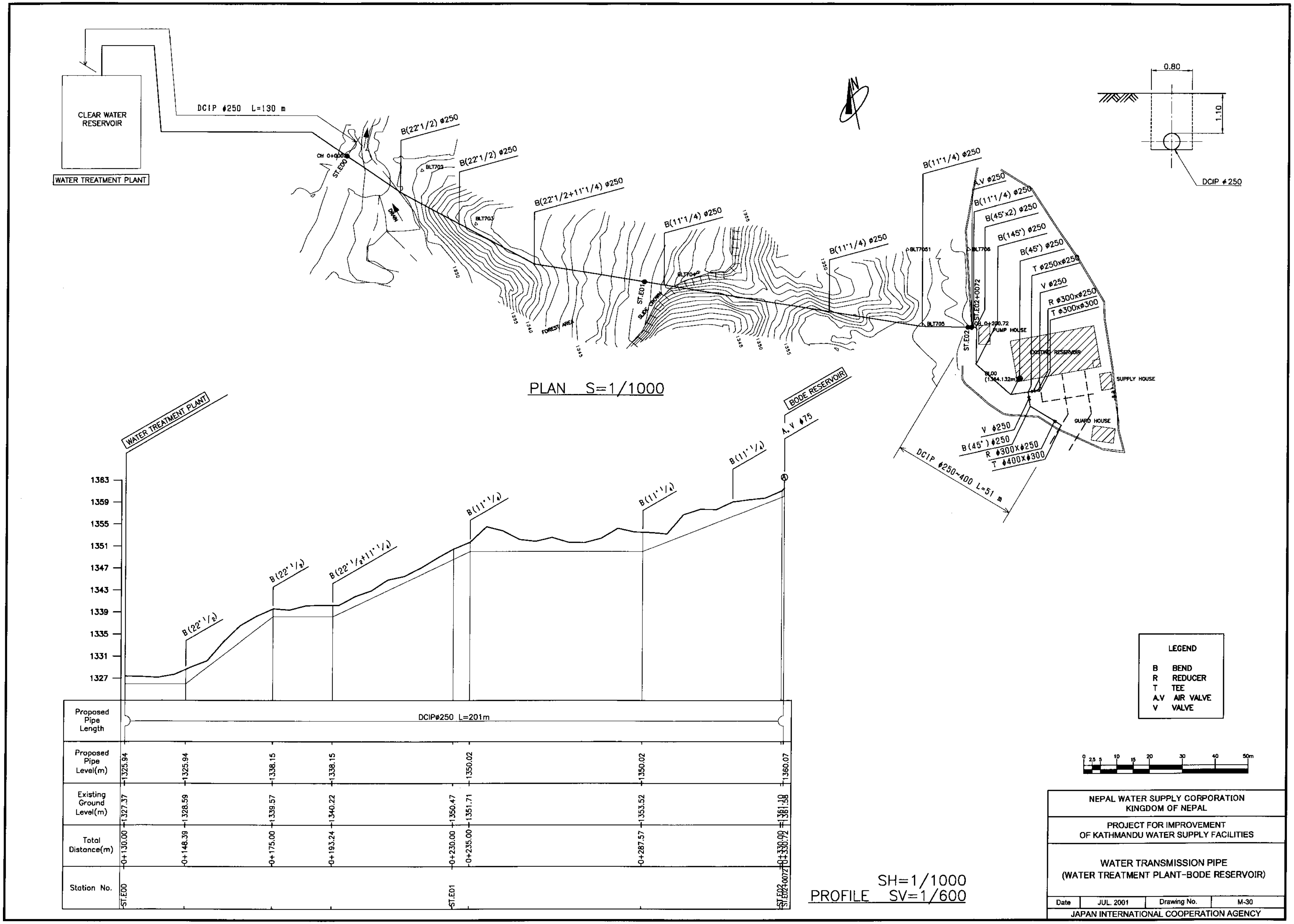
MANOHARA WATER TREATMENT PLANT							
PANEL No.	EQIP. No.	EQUIPMENT NAME	MOTER Q'ty FIX	SPARE	TOTAL	LOAD CAP. (KW)	TOTAL CAP. (KW)
P-1		SODIUM HYDROXIDE FEEDING EQUIPMENT-1					2.95
	7	TRANSMISSION PUMP	1	1	2	0.4	0.4
		AGITATOR	2	0	2	0.4	0.8
		FEEDING PUMP	3	0	3	0.2	0.6
		FEEDING PUMP	1	0	1	0.4	0.4
	10-1	EXHAUST FAN	1	0	1	0.75	0.75
		COAGULANT FEEDING EQUIPMENT					3.9
	6	TRANSMISSION PUMP	1	1	2	0.4	0.4
		AGITATOR	2	0	2	0.4	0.8
		FEEDING PUMP	4	0	4	0.2	0.8
		FEEDING PUMP	1	0	1	0.4	0.4
	10-2	EXHAUST FAN	2	0	2	0.75	1.5
		BLEACHING POWDER FEEDING EQUIPMENT					2.0
	11-1	AGITATOR	2	0	2	0.4	0.8
		TRANSMISSION PUMP	1	1	2	0.4	0.4
		INJECTION UNIT	2	2	4	0.4	0.8
P-2	2	FLOCCULATION AND SEDIMENTATION BASIN EQUIPMENT					0.4
		DRAINAGE PUMP	1	0	1	0.4	0.4
P-3	3	RAPID SAND FILTER EQUIPMENT					41.75
		SURFACE WASHING PUMP	1	1	2	30	30
		MAKE UP PUMP	1	0	1	11	11
		EXHAUST FAN	1	0	1	0.75	0.75
P-4	9	BLEACHING POWDER FEEDING EQUIPMENT					4.35
		TRANSMISSION PUMP	1	1	2	0.4	0.4
		AGITATOR	4	0	4	0.4	1.6
		EXHAUST FAN	1	0	1	0.75	0.75
		INJECTION UNIT	4	2	6	0.4	1.6
P-5	5	SLUDGE AND DRAINAGE BASIN EQUIPMENT					14.7
		SLUDGE PUMP	1	1	2	3.7	3.7
		RETURN PUMP	1	1	2	11	11
P-6	4	CLEAR WATER RESERVOIR EQUIPMENT					5.6
		DRAINAGE PUMP	1	0	1	0.4	0.4
		WATER SUPPLY PUMP	1	1	2	3.7	3.7
	10-1	EXHAUST FAN	1	0	1	0.75	0.75
	12	SAMPLING PUMP	1	1	2	0.75	0.75
	13	TRANSMISSION EQUIPMENT (BODE)					90
		TRANSMISSION PUMP	2	1	3	45	90
P-7	14	TRANSMISSION EQUIPMENT (MIN BHAWAN)					220
		TRANSMISSION PUMP	4	1	5	55	220
		TREATMENT+TRANSMISSION TOTAL					385.65
P-T		INTAKE EQUIPMENT					112
		INTAKE PUMP	6	0	6	15	90
		INTAKE PUMP	2	0	2	11	22

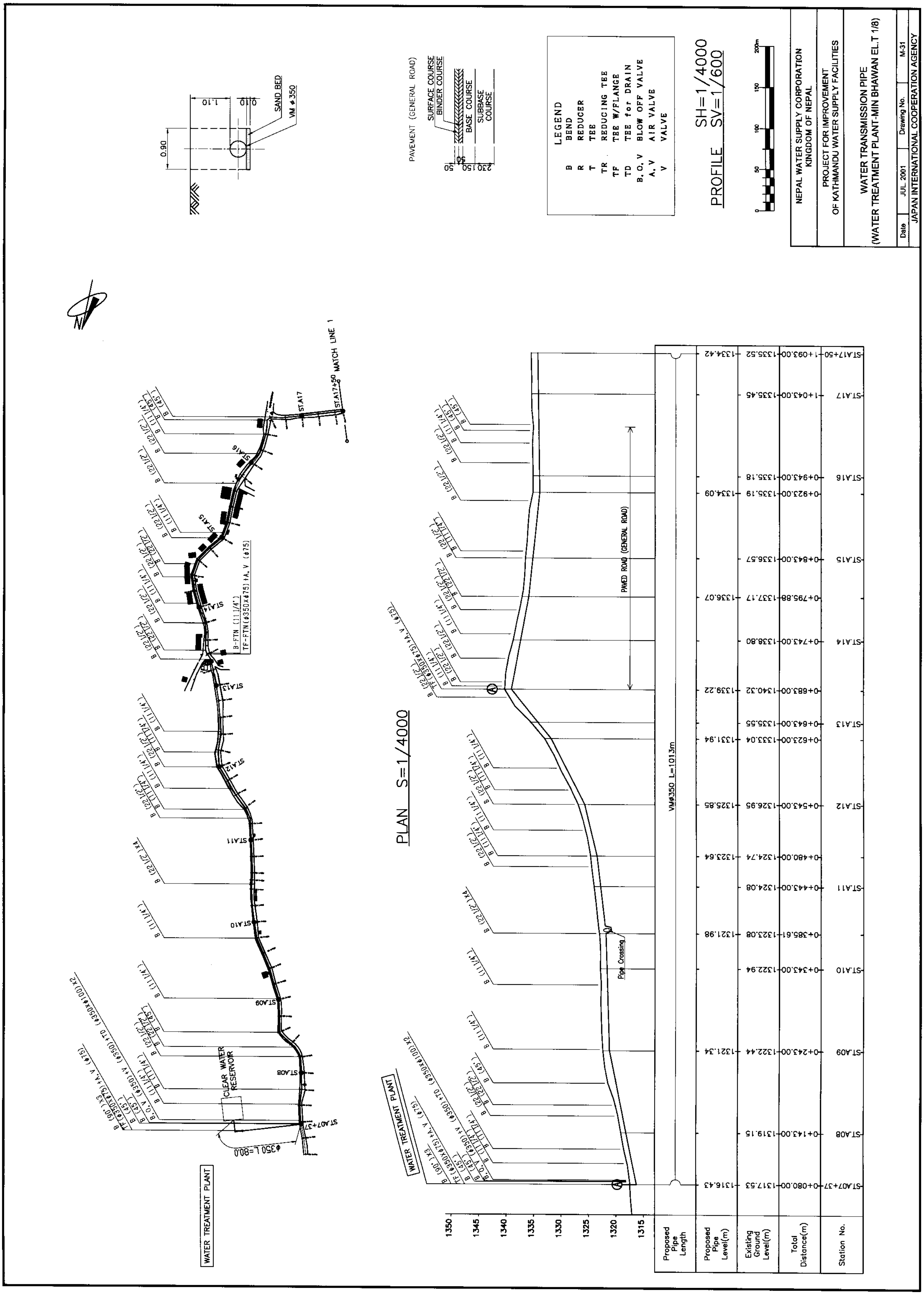
Note : These loads are worked by hand.



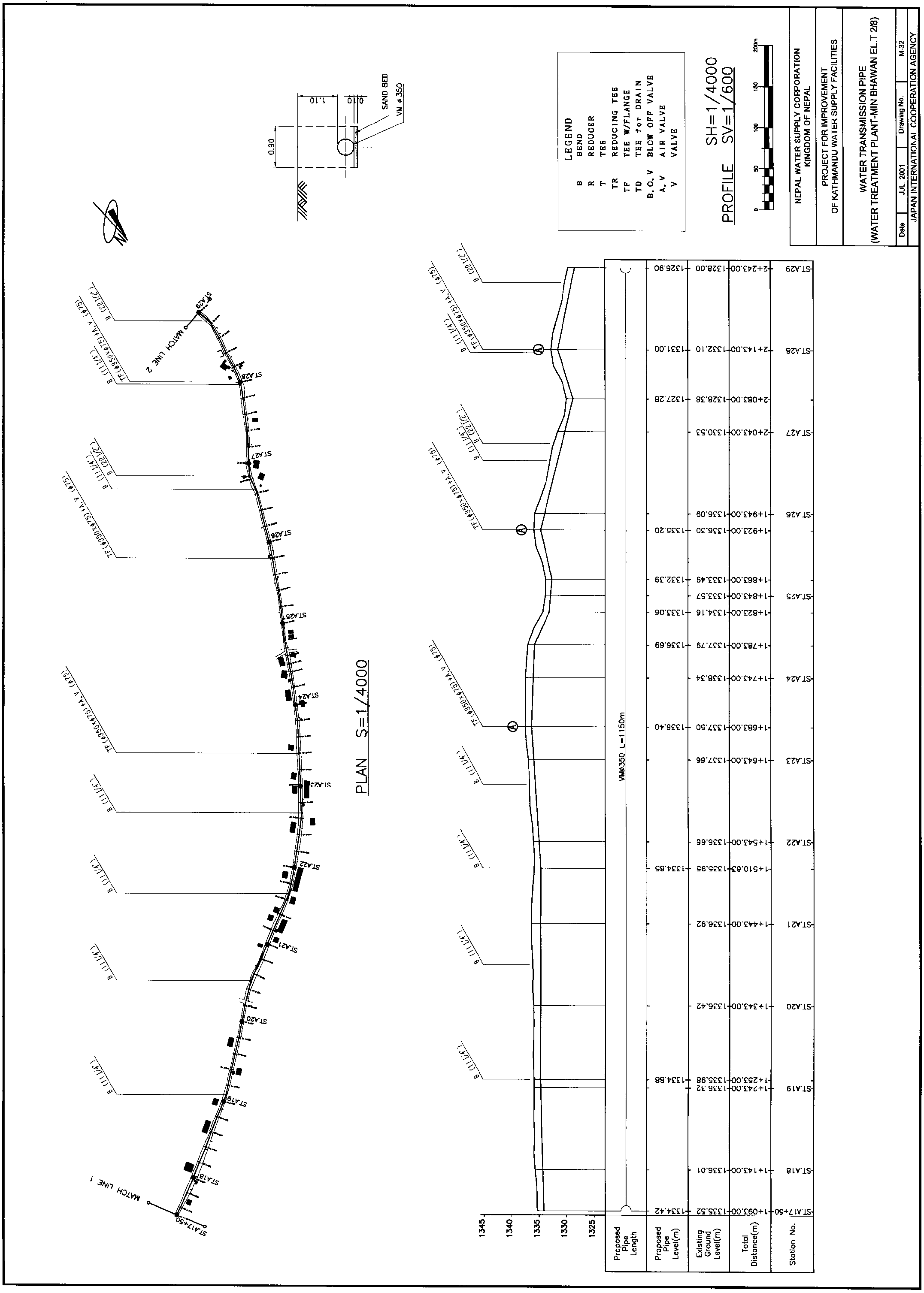
POWER AND LIGHTING DIAGRAM

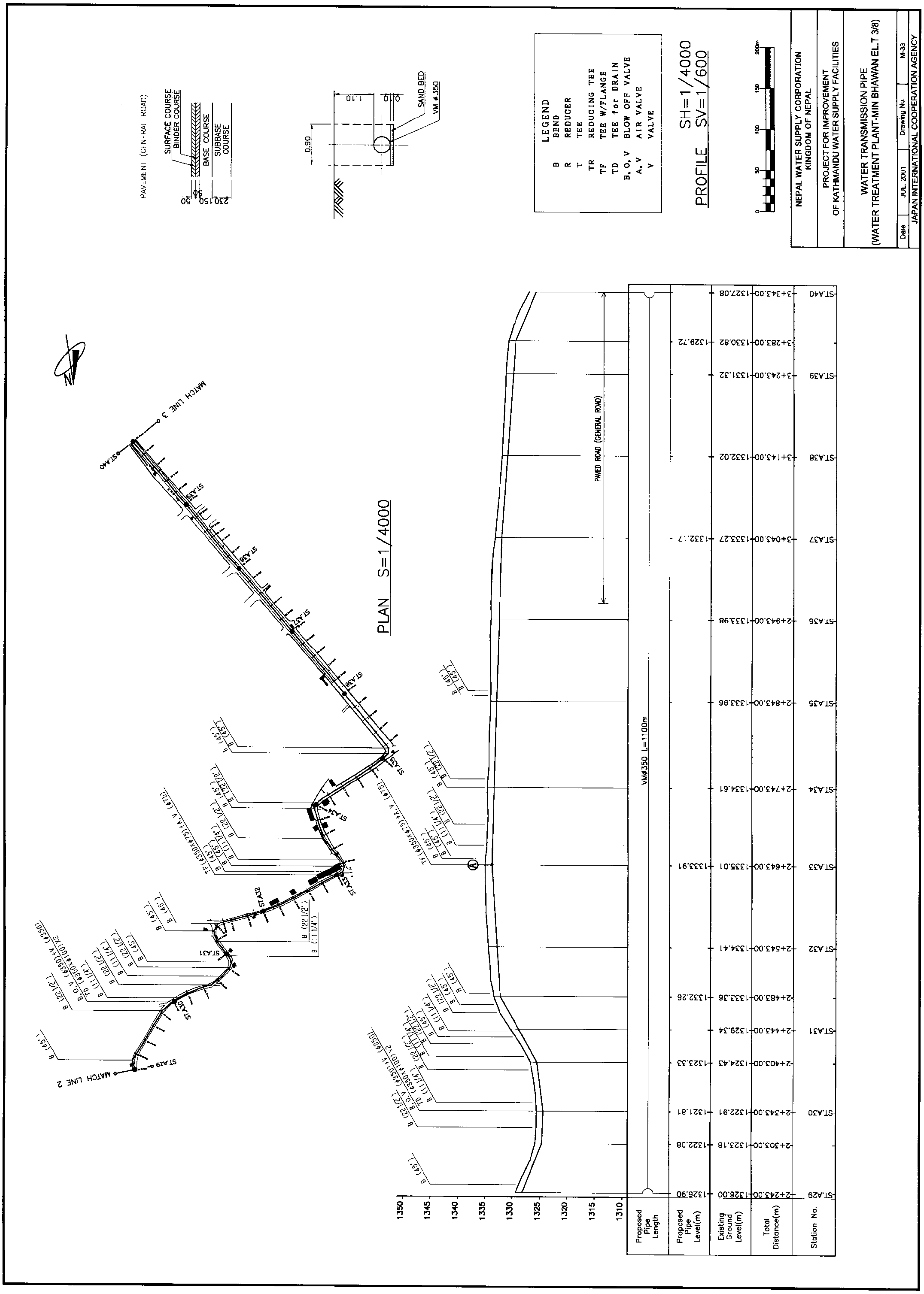
NEPAL WATER SUPPLY CORPORATION KINGDOM OF NEPAL			
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES			
POWER AND LIGHTING DIAGRAM			
Date	JUL. 2001	Drawing No.	M-28
JAPAN INTERNATIONAL COOPERATION AGENCY			


CLEAR WATER RESERVOIR
WATER TREATMENT PLANT
DCIP ϕ250 L=130 m
CH 0+000
ST.E00
B(22°1/2) ϕ250
B(22°1/2) ϕ250
B(22°1/2+11°1/4) ϕ250
B(11°1/4) ϕ250
B(11°1/4) ϕ250
B(11°1/4) ϕ250
ST.E01
FOREST AREA
ST.E02
ST.E02+0072
PUMP HOUSE
EXISTING RESERVOIR
SUPPLY HOUSE
GUARD HOUSE
A.V ϕ250
B(11°1/4) ϕ250
B(45°x2) ϕ250
B(145°) ϕ250
B(45°) ϕ250
T ϕ250xϕ250
V ϕ250
R ϕ300xϕ250
T ϕ300xϕ300
V ϕ250
B(45°) ϕ250
R ϕ300Xϕ250
T ϕ400Xϕ300
DCIP ϕ250~400 L=51 m
0.80
1.10
DCIP ϕ250
PLAN S=1/1000
WATER TREATMENT PLANT
BODE RESERVOIR
A.V ϕ75
B(22°1/2)
B(22°1/2)
B(22°1/2+11°1/4)
B(11°1/4)
B(11°1/4)
B(11°1/4)
1363
1359
1355
1351
1347
1343
1339
1335
1331
1327
Proposed Pipe Length
DCIPϕ250 L=201m
Proposed Pipe Level(m): 1325.94, 1325.94, 1338.15, 1338.15, 1350.02, 1350.02, 1360.07
Existing Ground Level(m): 1327.37, 1328.59, 1339.57, 1340.22, 1350.47, 1351.71, 1353.52, 1361.10, 1361.58
Total Distance(m): 0+130.00, 0+148.39, 0+175.00, 0+193.24, 0+230.00, 0+235.00, 0+287.57, 0+330.00, 0+330.72
Station No.: ST.E00, ST.E01, ST.E02, ST.E02+0072
PROFILE SH=1/1000 SV=1/600
LEGEND
B BEND
R REDUCER
T TEE
A.V AIR VALVE
V VALVE
0 2.5 5 10 15 20 30 40 50m
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES
WATER TRANSMISSION PIPE
(WATER TREATMENT PLANT-BODE RESERVOIR)
Date JUL. 2001 Drawing No. M-30
JAPAN INTERNATIONAL COOPERATION AGENCY

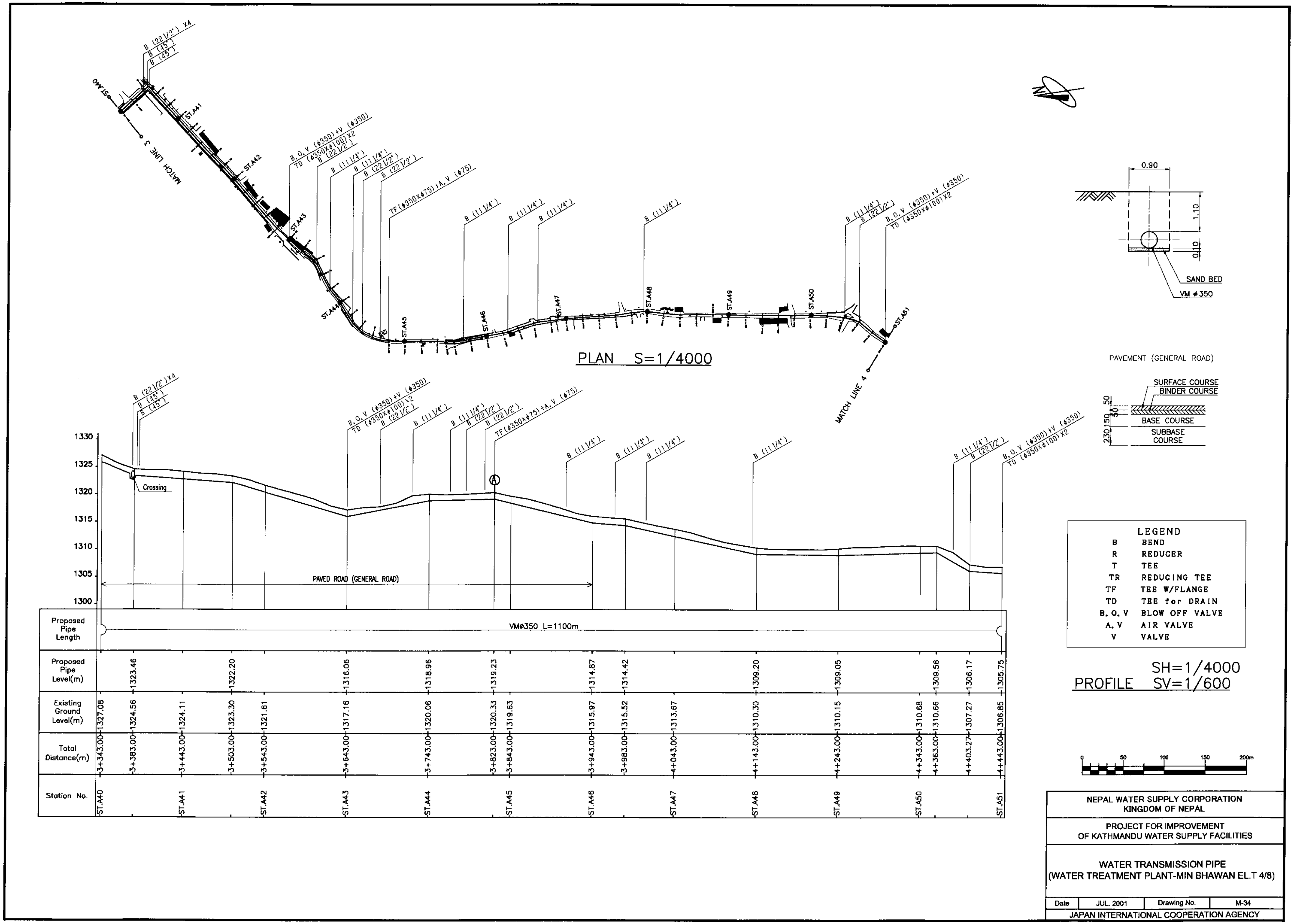


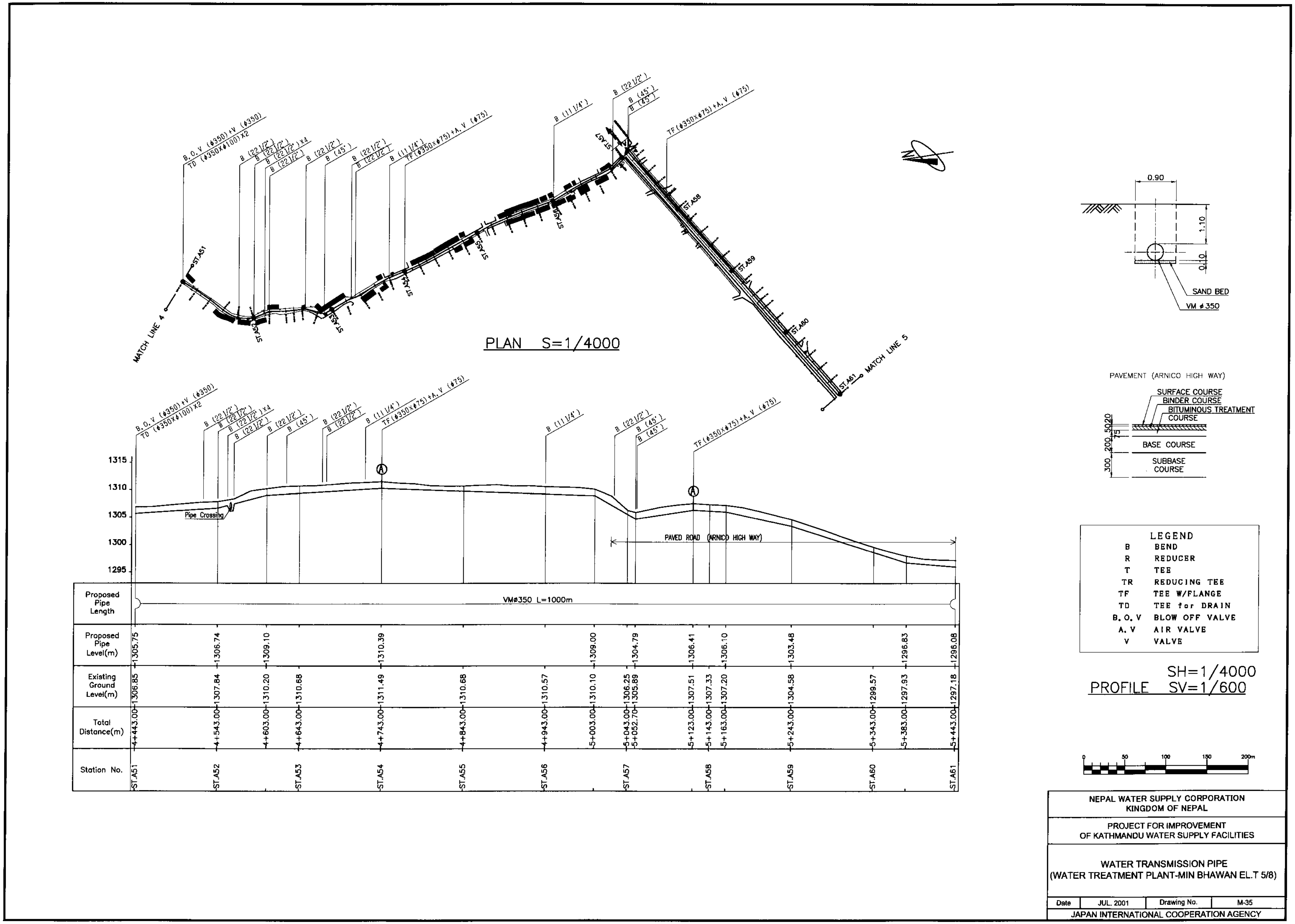
PLAN S=1/4000
PROFILE SH=1/4000 SV=1/600
LEGEND
B BEND
R REDUCER
T TEE
TR REDUCING TEE
TF TEE W/FLANGE
TD TEE for DRAIN
B.O.V BLOW OFF VALVE
A.V AIR VALVE
V VALVE
PAVEMENT (GENERAL ROAD)
SURFACE COURSE
BINDER COURSE
BASE COURSE
SUBBASE COURSE
SAND BED
VM φ350
WATER TREATMENT PLANT
CLEAR WATER RESERVOIR
MATCH LINE 1
PAVED ROAD (GENERAL ROAD)
Pipe Crossing
VM φ350 L=1013m
Proposed Pipe Length
Proposed Pipe Level(m)
Existing Ground Level(m)
Total Distance(m)
Station No.
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES
WATER TRANSMISSION PIPE
(WATER TREATMENT PLANT-MIN BHAWAN EL.T 1/8)
Date JUL. 2001
Drawing No. M-31
JAPAN INTERNATIONAL COOPERATION AGENCY

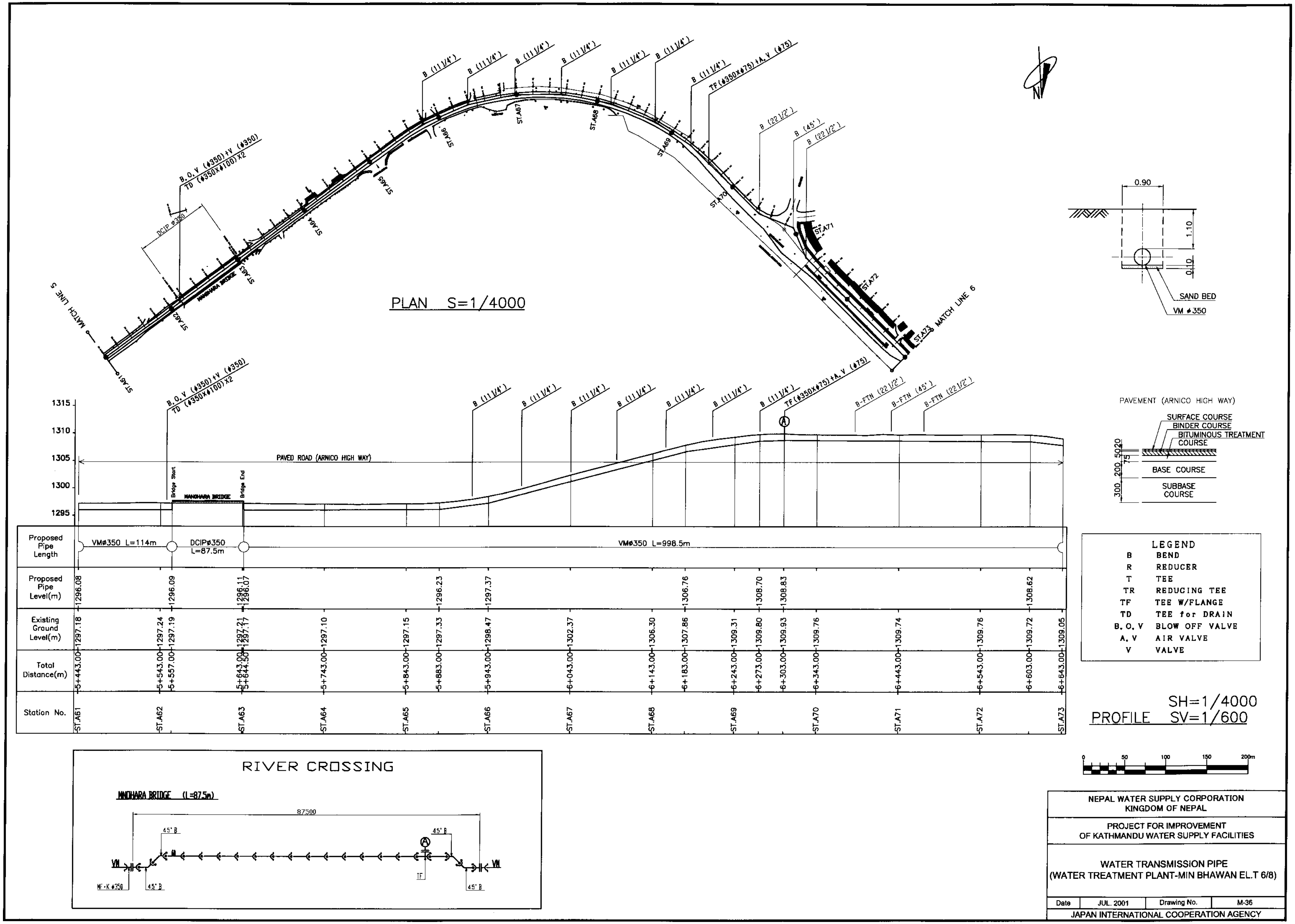

PLAN S=1/4000
PROFILE SH=1/4000 SV=1/600
LEGEND
B BEND
R REDUCER
T TEE
TR REDUCING TEE
TF TEE W/FLANGE
TD TEE for DRAIN
B.O.V BLOW OFF VALVE
A.V AIR VALVE
V VALVE
SAND BED
VM ϕ350
MATCH LINE 1
MATCH LINE 2
VMϕ350 L=1150m
Proposed Pipe Length
Proposed Pipe Level(m)
Existing Ground Level(m)
Total Distance(m)
Station No.
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES
WATER TRANSMISSION PIPE
(WATER TREATMENT PLANT-MIN BHAWAN EL.T 2/8)
Date JUL. 2001 Drawing No. M-32
JAPAN INTERNATIONAL COOPERATION AGENCY



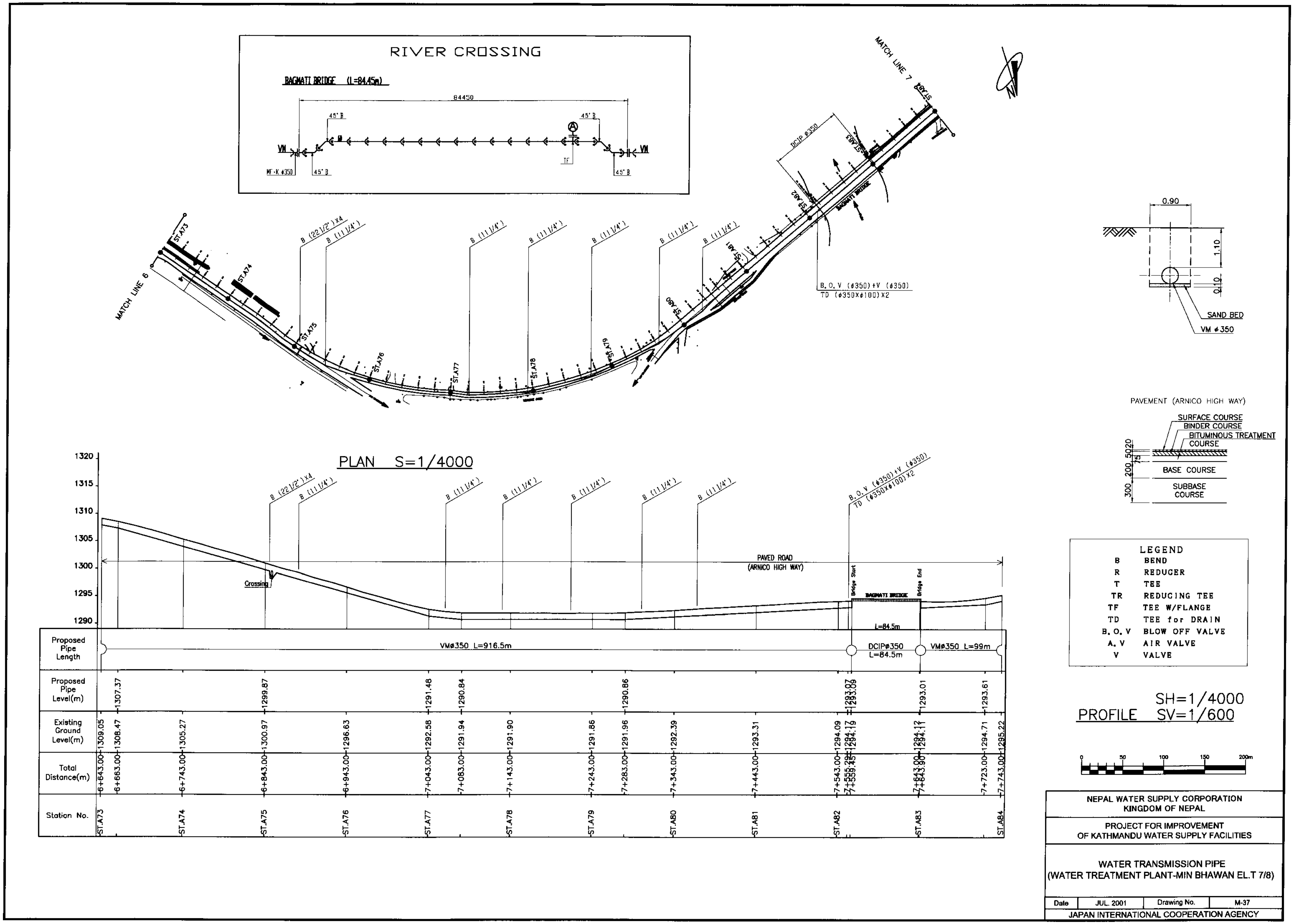
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES
WATER TRANSMISSION PIPE
(WATER TREATMENT PLANT-MIN BHAWAN EL.T 3/8)
Date
JUL. 2001
Drawing No.
M-33
JAPAN INTERNATIONAL COOPERATION AGENCY
PLAN S=1/4000
PROFILE SH=1/4000 SV=1/600
LEGEND
B BEND
R REDUCER
T TEE
TR REDUCING TEE
TF TEE W/FLANGE
TD TEE for DRAIN
B.O.V BLOW OFF VALVE
A.V AIR VALVE
V VALVE
PAVEMENT (GENERAL ROAD)
SURFACE COURSE
BINDER COURSE
BASE COURSE
SUBBASE COURSE
SAND BED
VM φ350
0.90
1.10
0.10
MATCH LINE 2
MATCH LINE 3
PAVED ROAD (GENERAL ROAD)
VMφ350 L=1100m
Proposed Pipe Length
Proposed Pipe Level(m)
Existing Ground Level(m)
Total Distance(m)
Station No.
ST.A29 2+243.00 1328.00 1326.90
2+303.00 1323.18 1322.08
ST.A30 2+343.00 1322.91 1321.81
2+403.00 1324.43 1323.33
ST.A31 2+443.00 1329.34
2+483.00 1333.36 1332.26
ST.A32 2+543.00 1334.41
ST.A33 2+643.00 1335.01 1333.91
ST.A34 2+743.00 1334.61
ST.A35 2+843.00 1333.96
ST.A36 2+943.00 1333.98
ST.A37 3+043.00 1333.27 1332.17
ST.A38 3+143.00 1332.02
ST.A39 3+243.00 1331.32
3+283.00 1330.82 1329.72
ST.A40 3+343.00 1327.08
1350
1345
1340
1335
1330
1325
1320
1315
1310


PLAN S=1/4000
MATCH LINE 3
MATCH LINE 4
ST.A40
ST.A41
ST.A42
ST.A43
ST.A44
ST.A45
ST.A46
ST.A47
ST.A48
ST.A49
ST.A50
ST.A51
B (22 1/2°) x4
B (45°)
B (45°)
B.O.V (φ350)+V (φ350)
TD (φ350xφ100)x2
B (22 1/2°)
B (11 1/4°)
TF(φ350xφ75)+A.V (φ75)
0.90
1.10
0.10
SAND BED
VM φ350
PAVEMENT (GENERAL ROAD)
SURFACE COURSE
BINDER COURSE
BASE COURSE
SUBBASE COURSE
50
50
150
230
Crossing
PAVED ROAD (GENERAL ROAD)
VMφ350 L=1100m
Proposed Pipe Length
Proposed Pipe Level(m)
Existing Ground Level(m)
Total Distance(m)
Station No.
LEGEND
B BEND
R REDUCER
T TEE
TR REDUCING TEE
TF TEE W/FLANGE
TD TEE for DRAIN
B.O.V BLOW OFF VALVE
A.V AIR VALVE
V VALVE
PROFILE SH=1/4000 SV=1/600
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES
WATER TRANSMISSION PIPE
(WATER TREATMENT PLANT-MIN BHAWAN EL.T 4/8)
Date JUL. 2001
Drawing No. M-34
JAPAN INTERNATIONAL COOPERATION AGENCY

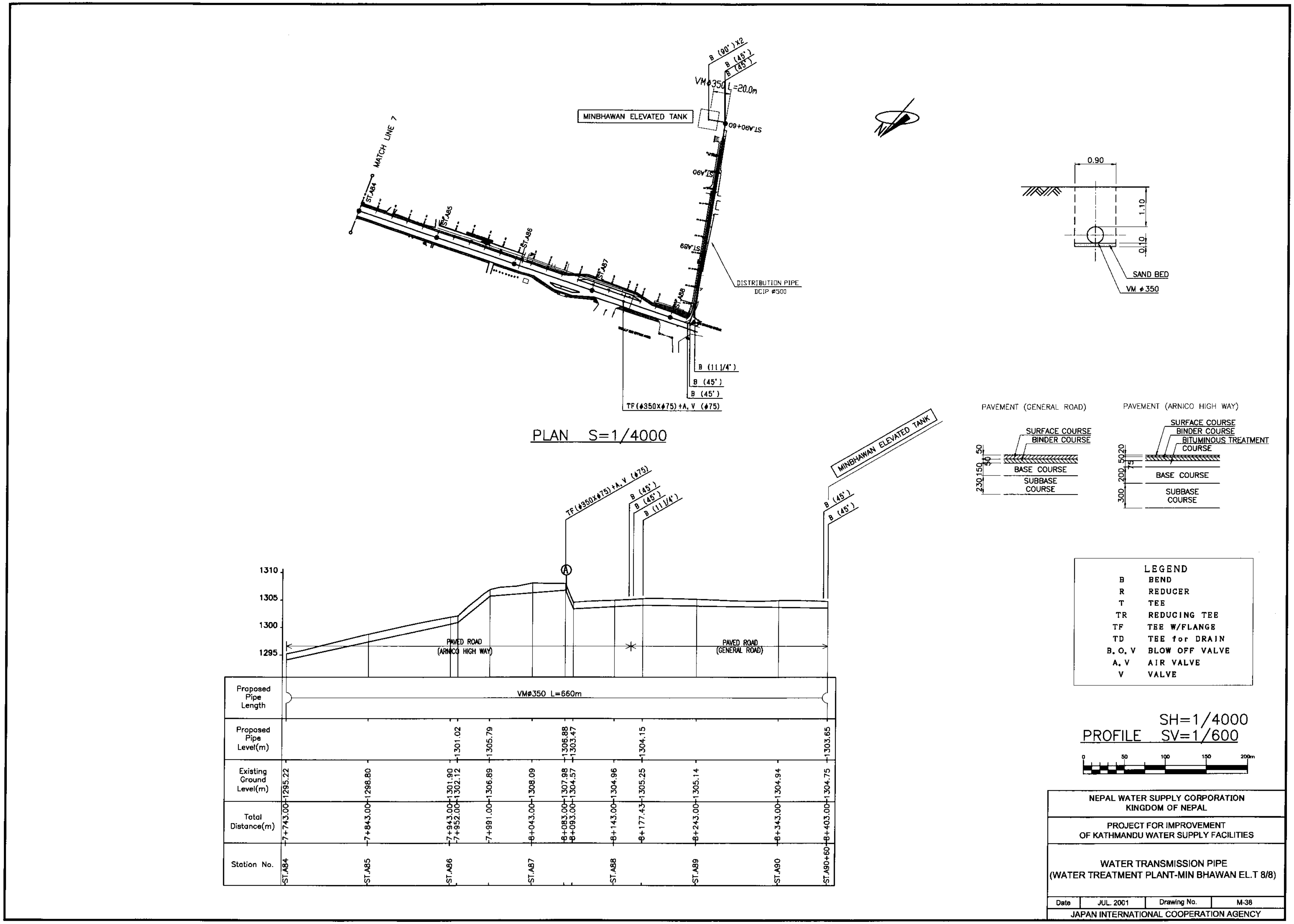

PLAN S=1/4000
MATCH LINE 4
MATCH LINE 5
ST.A51
ST.A52
ST.A53
ST.A54
ST.A55
ST.A56
ST.A57
ST.A58
ST.A59
ST.A60
ST.A61
B.O.V (ϕ350)+V (ϕ350)
TD (ϕ350Xϕ100)X2
B (22 1/2°)X4
B (45°)
B (11 1/4°)
TF (ϕ350Xϕ75)+A.V (ϕ75)
Pipe Crossing
PAVED ROAD (ARNICO HIGH WAY)
VMϕ350 L=1000m
Proposed Pipe Length
Proposed Pipe Level(m)
Existing Ground Level(m)
Total Distance(m)
Station No.
0.90
1.10
0.10
SAND BED
VM ϕ350
PAVEMENT (ARNICO HIGH WAY)
SURFACE COURSE
BINDER COURSE
BITUMINOUS TREATMENT COURSE
BASE COURSE
SUBBASE COURSE
LEGEND
B BEND
R REDUCER
T TEE
TR REDUCING TEE
TF TEE W/FLANGE
TD TEE for DRAIN
B.O.V BLOW OFF VALVE
A.V AIR VALVE
V VALVE
SH=1/4000
PROFILE SV=1/600
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES
WATER TRANSMISSION PIPE
(WATER TREATMENT PLANT-MIN BHAWAN EL.T 5/8)
Date JUL. 2001
Drawing No. M-35
JAPAN INTERNATIONAL COOPERATION AGENCY



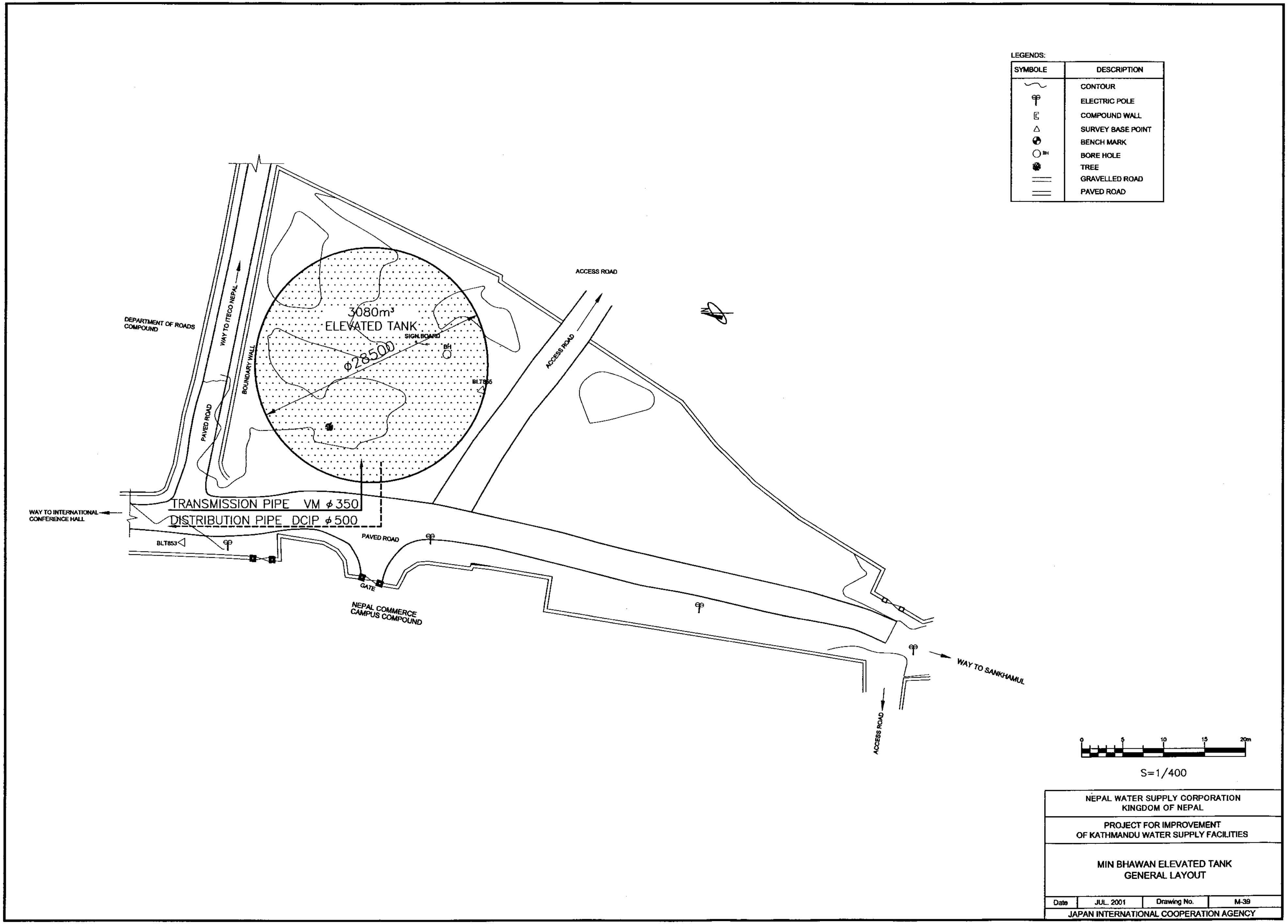
PLAN S=1/4000
MATCH LINE 5
MATCH LINE 6
PROFILE SH=1/4000 SV=1/600
PAVED ROAD (ARNICO HIGH WAY)
MANOHARA BRIDGE
Bridge Start
Bridge End
VMø350 L=114m
DCIPø350 L=87.5m
VMø350 L=998.5m
Proposed Pipe Length
Proposed Pipe Level(m)
Existing Ground Level(m)
Total Distance(m)
Station No.
ST.A61
ST.A62
ST.A63
ST.A64
ST.A65
ST.A66
ST.A67
ST.A68
ST.A69
ST.A70
ST.A71
ST.A72
ST.A73
B.O.V (ø350)+V (ø350)
TD (ø350Xø100)X2
TF(ø350Xø75)+A.V (ø75)
B (11 1/4°)
B (22 1/2°)
B (45°)
B-FTN (22 1/2°)
B-FTN (45°)
SAND BED
VM ø350
PAVEMENT (ARNICO HIGH WAY)
SURFACE COURSE
BINDER COURSE
BITUMINOUS TREATMENT COURSE
BASE COURSE
SUBBASE COURSE
LEGEND
B BEND
R REDUCER
T TEE
TR REDUCING TEE
TF TEE W/FLANGE
TD TEE for DRAIN
B.O.V BLOW OFF VALVE
A.V AIR VALVE
V VALVE
RIVER CROSSING
MANOHARA BRIDGE (L=87.5m)
87500
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES
WATER TRANSMISSION PIPE
(WATER TREATMENT PLANT-MIN BHAWAN EL.T 6/8)
Date JUL. 2001
Drawing No. M-36
JAPAN INTERNATIONAL COOPERATION AGENCY

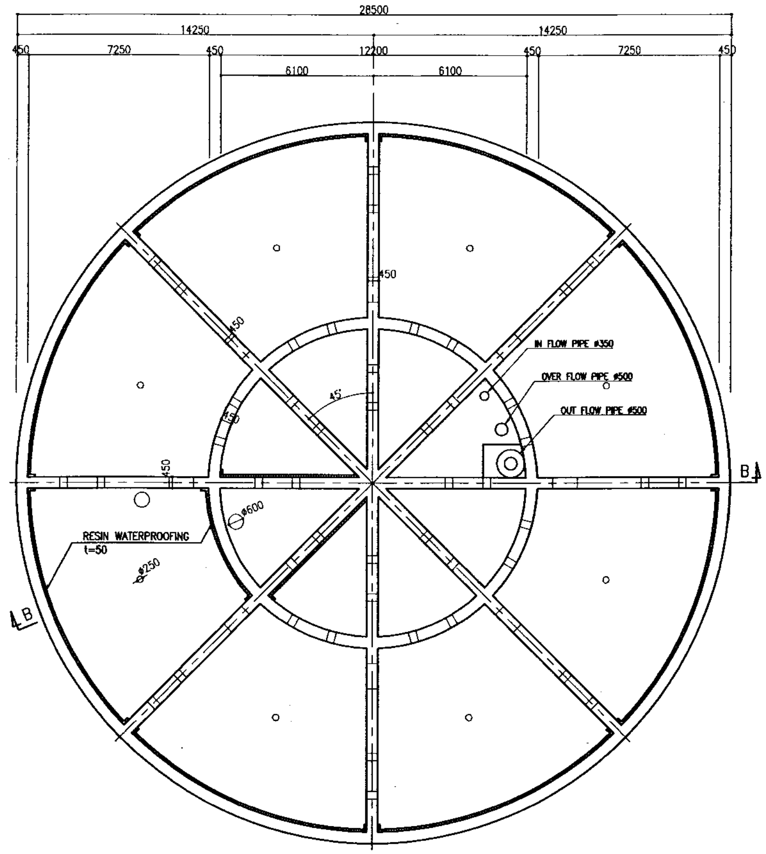


Station No.	Total Distance(m)	Existing Ground Level(m)	Proposed Pipe Level(m)
ST.A73	6+643.00	1309.05	
	6+663.00	1308.47	1307.37
ST.A74	6+743.00	1305.27	
ST.A75	6+843.00	1300.97	1299.87
ST.A76	6+943.00	1296.63	
ST.A77	7+043.00	1292.58	1291.48
	7+083.00	1291.94	1290.84
ST.A78	7+143.00	1291.90	
ST.A79	7+243.00	1291.86	
	7+283.00	1291.96	1290.86
ST.A80	7+343.00	1292.39	
ST.A81	7+443.00	1293.31	
ST.A82	7+543.00	1294.09	
	7+555.28	1294.17	1293.07
	7+559.45	1294.19	1293.09
ST.A83	7+643.00	1294.12	
	7+643.90	1294.11	1293.01
	7+723.00	1294.71	1293.61
ST.A84	7+743.00	1295.22	

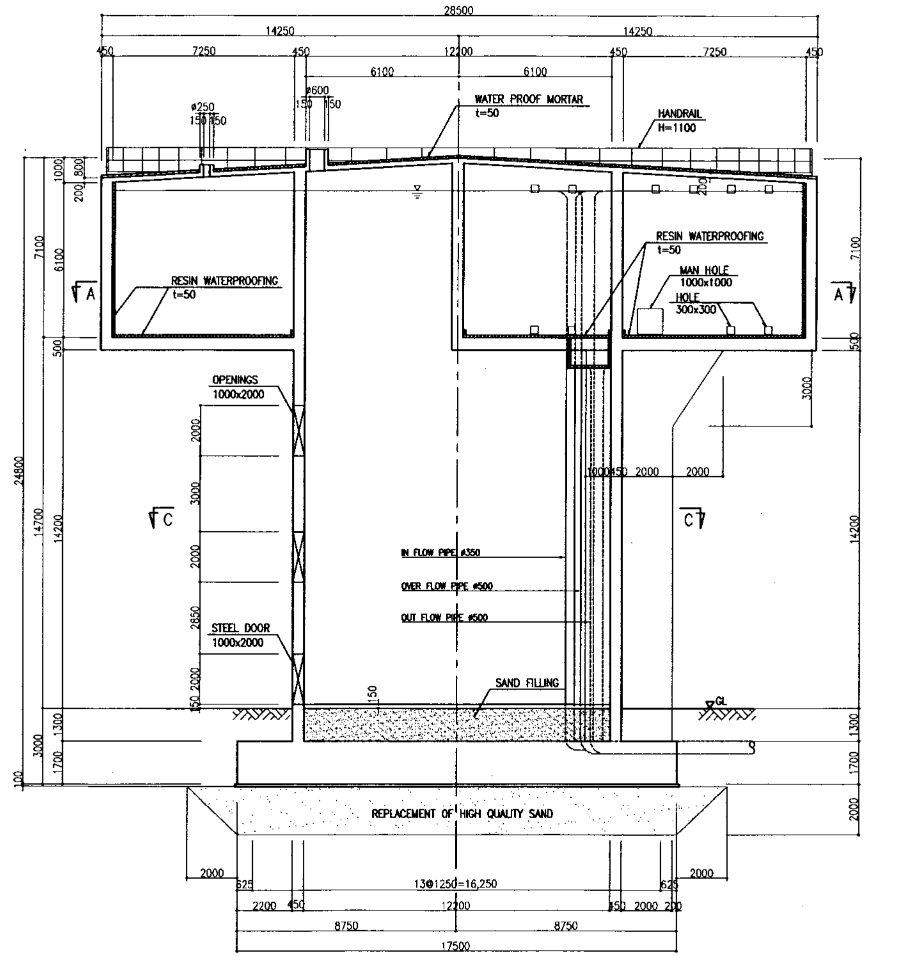


Station No.	Total Distance(m)	Existing Ground Level(m)	Proposed Pipe Level(m)
ST.A84	7+743.00	1295.22	
ST.A85	7+843.00	1298.80	
ST.A86	7+943.00	1301.90	
	7+952.00	1302.12	1301.02
	7+991.00	1306.89	1305.79
ST.A87	8+043.00	1308.09	
	8+083.00	1307.98	1306.88
	8+093.00	1304.57	1303.47
ST.A88	8+143.00	1304.96	
	8+177.43	1305.25	1304.15
ST.A89	8+243.00	1305.14	
ST.A90	8+343.00	1304.94	
ST.A90+60	8+403.00	1304.75	1303.65


LEGENDS:
SYMBOLE
DESCRIPTION
CONTOUR
ELECTRIC POLE
COMPOUND WALL
SURVEY BASE POINT
BENCH MARK
BORE HOLE
TREE
GRAVELLED ROAD
PAVED ROAD
3080m³
ELEVATED TANK
φ28500
SIGN BOARD
BH
BLT855
BLT853
TRANSMISSION PIPE VM φ350
DISTRIBUTION PIPE DCIP φ500
DEPARTMENT OF ROADS COMPOUND
WAY TO ITECO NEPAL
BOUNDARY WALL
PAVED ROAD
ACCESS ROAD
WAY TO INTERNATIONAL CONFERENCE HALL
GATE
NEPAL COMMERCE CAMPUS COMPOUND
WAY TO SANKHAMUL
0 5 10 15 20m
S=1/400
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES
MIN BHAWAN ELEVATED TANK
GENERAL LAYOUT
Date JUL. 2001 Drawing No. M-39
JAPAN INTERNATIONAL COOPERATION AGENCY

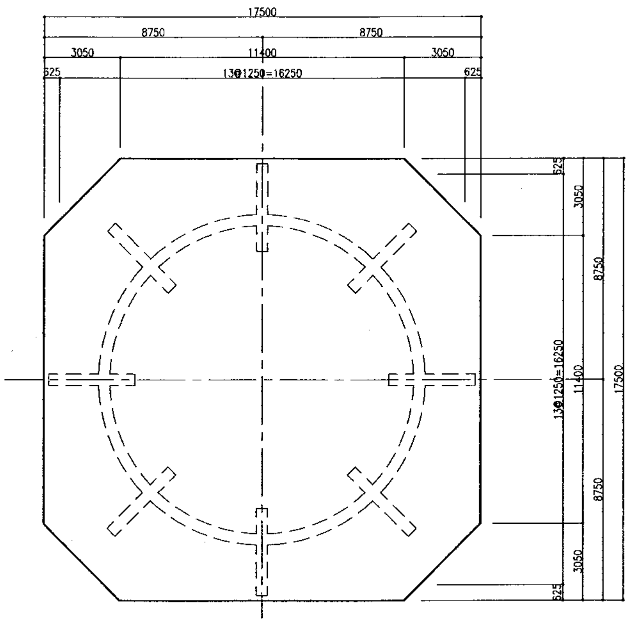


A–A SECTION
SCALE 1:100

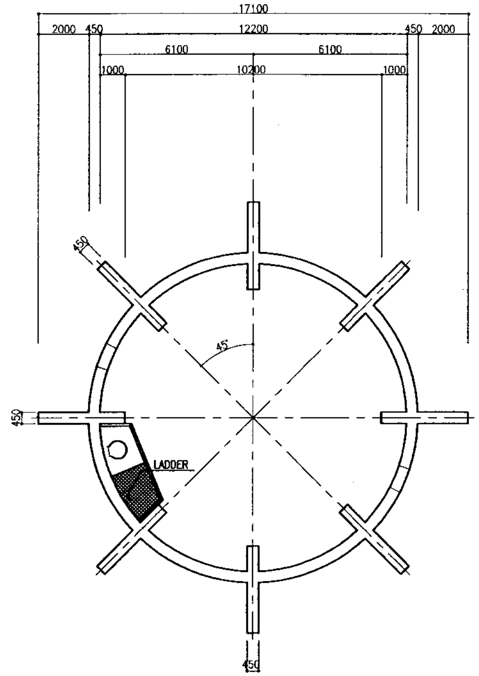


B–B SECTION
SCALE 1:100

NEPAL WATER SUPPLY CORPORATION KINGDOM OF NEPAL			
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES			
MIN BHAWAN ELEVATED TANK STRUCTURE (1/2)			
Date	JUL. 2001	Drawing No.	M-40
JAPAN INTERNATIONAL COOPERATION AGENCY			

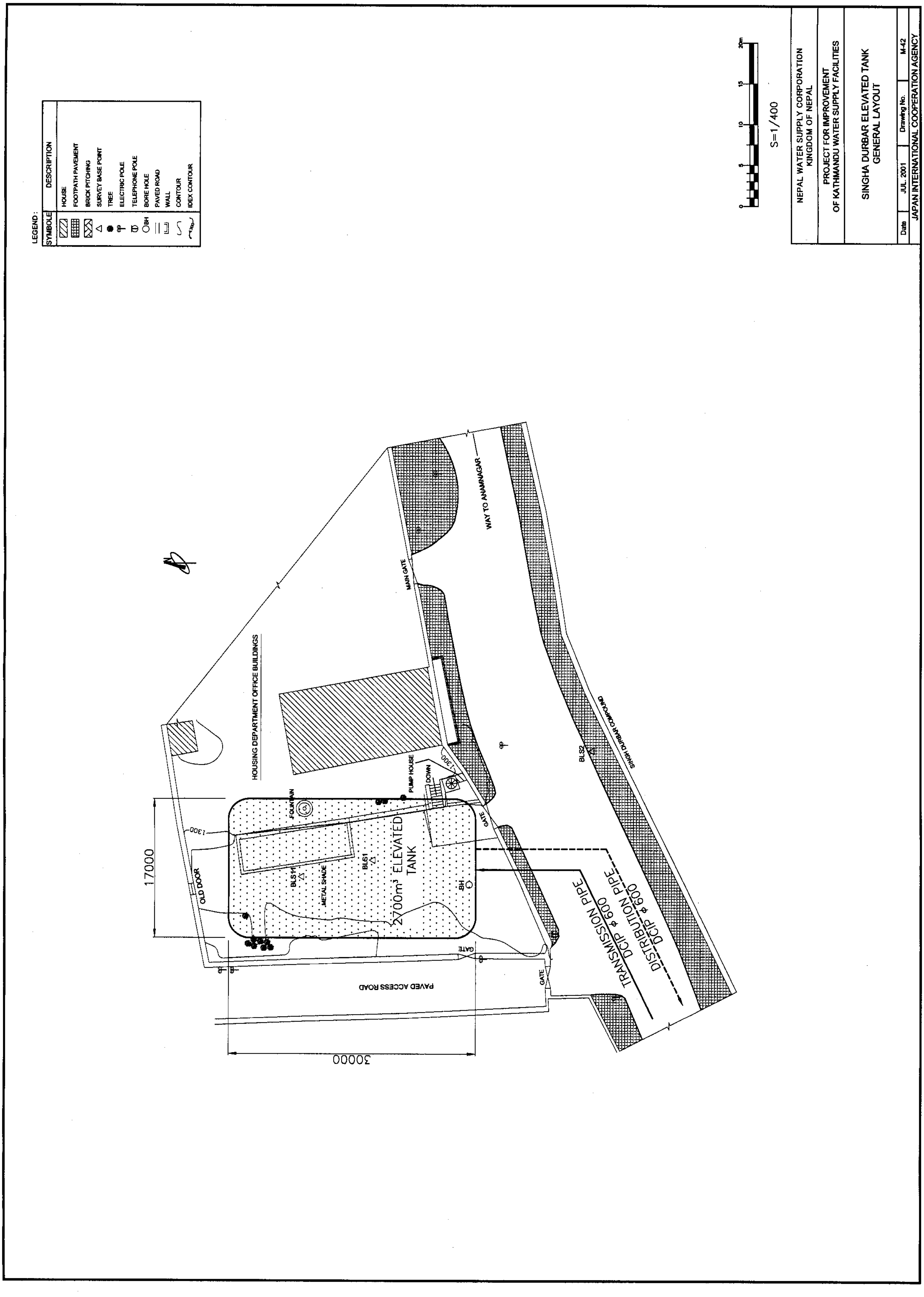


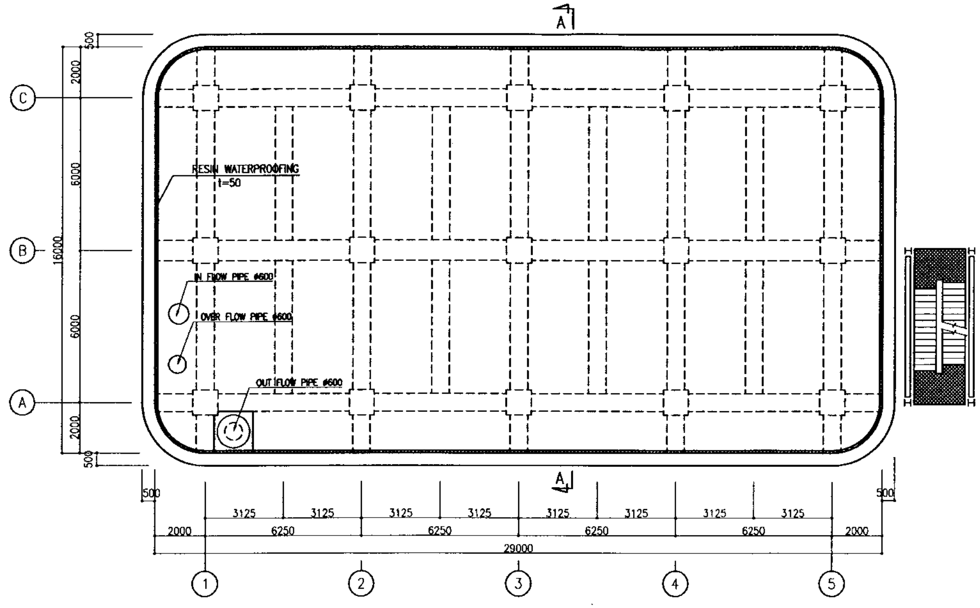
FOUNDATION PLAN
SCALE 1:100



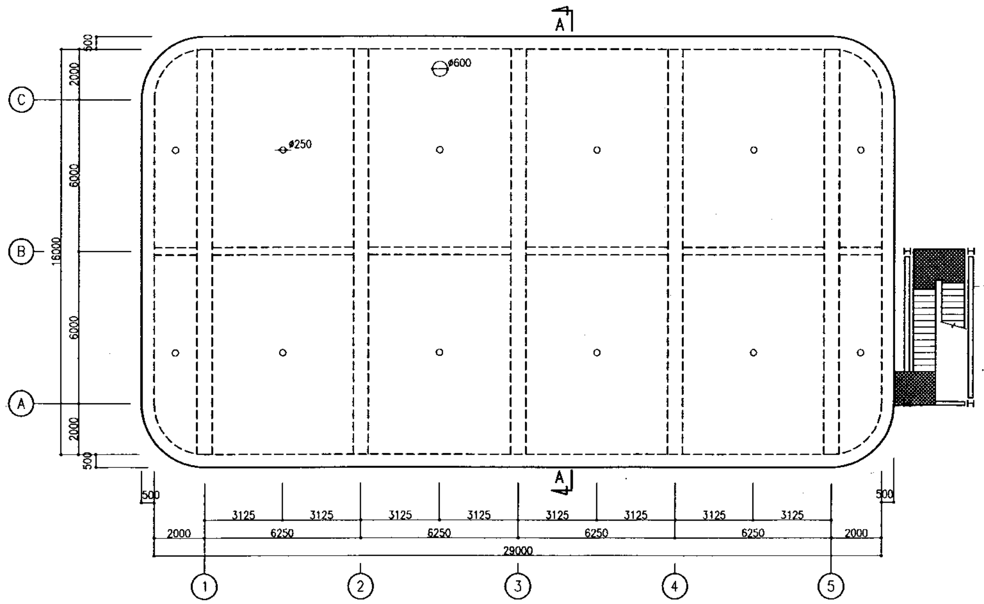
C–C SECTION
SCALE 1:100

NEPAL WATER SUPPLY CORPORATION KINGDOM OF NEPAL			
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES			
MIN BHAWAN ELEVATED TANK STRUCTURE (2/2)			
Date	JUL. 2001	Drawing No.	M-41
JAPAN INTERNATIONAL COOPERATION AGENCY			


LEGEND :
SYMBOLE
DESCRIPTION
HOUSE
FOOTPATH PAVEMENT
BRICK PITCHING
SURVEY BASE POINT
TREE
ELECTRIC POLE
TELEPHONE POLE
BORE HOLE
PAVED ROAD
WALL
CONTOUR
IDEX CONTOUR
S=1/400
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES
SINGHA DURBAR ELEVATED TANK
GENERAL LAYOUT
Date
JUL. 2001
Drawing No.
M-42
JAPAN INTERNATIONAL COOPERATION AGENCY
HOUSING DEPARTMENT OFFICE BUILDINGS
WAY TO ANAMNAGAR
MAIN GATE
PUMP HOUSE
DOWN
FOUNTAIN
METAL SHADE
BLS1
BLS11
BLS2
BH
GATE
OLD DOOR
2700m³ ELEVATED TANK
TRANSMISSION PIPE
DCIP φ600
DISTRIBUTION PIPE
DCIP φ600
SINGH DURBAR COMPOUND
PAVED ACCESS ROAD
17000
30000
1300

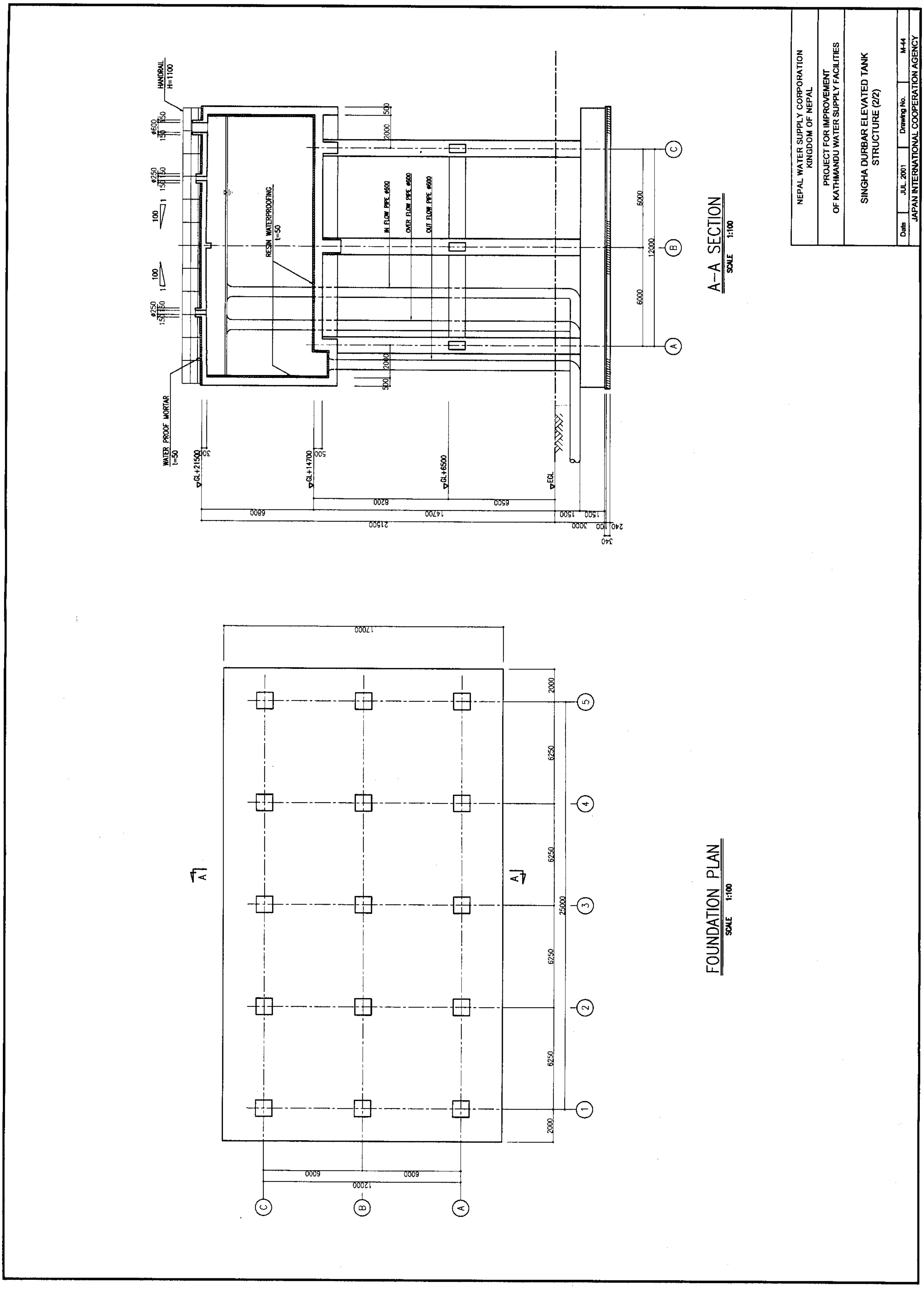


GL+14700
SCALE 1:100

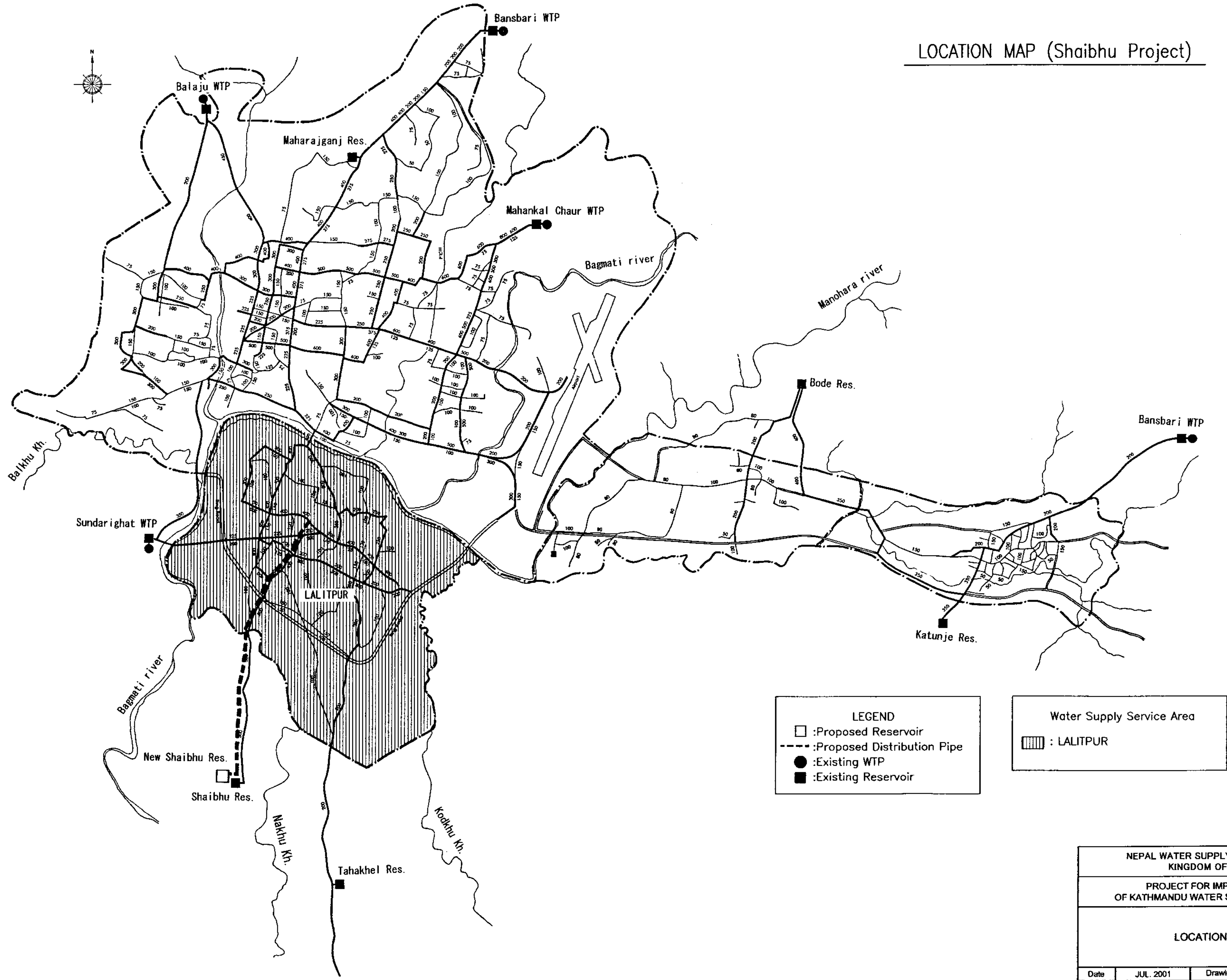


GL+21500
SCALE 1:100

NEPAL WATER SUPPLY CORPORATION KINGDOM OF NEPAL			
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES			
SINGHA DURBAR ELEVATED TANK STRUCTURE (1/2)			
Date	JUL. 2001	Drawing No.	M-43
JAPAN INTERNATIONAL COOPERATION AGENCY			


HANDRAIL H=1100
WATER PROOF MORTAR t=50
RESIN WATERPROOFING t=50
IN FLOW PIPE ø600
OVER FLOW PIPE ø600
OUT FLOW PIPE ø600
GL+21500
GL+14700
GL+6500
EGL
A–A SECTION
SCALE 1:100
FOUNDATION PLAN
SCALE 1:100
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES
SINGHA DURBAR ELEVATED TANK
STRUCTURE (2/2)
Date
JUL. 2001
Drawing No.
M-44
JAPAN INTERNATIONAL COOPERATION AGENCY

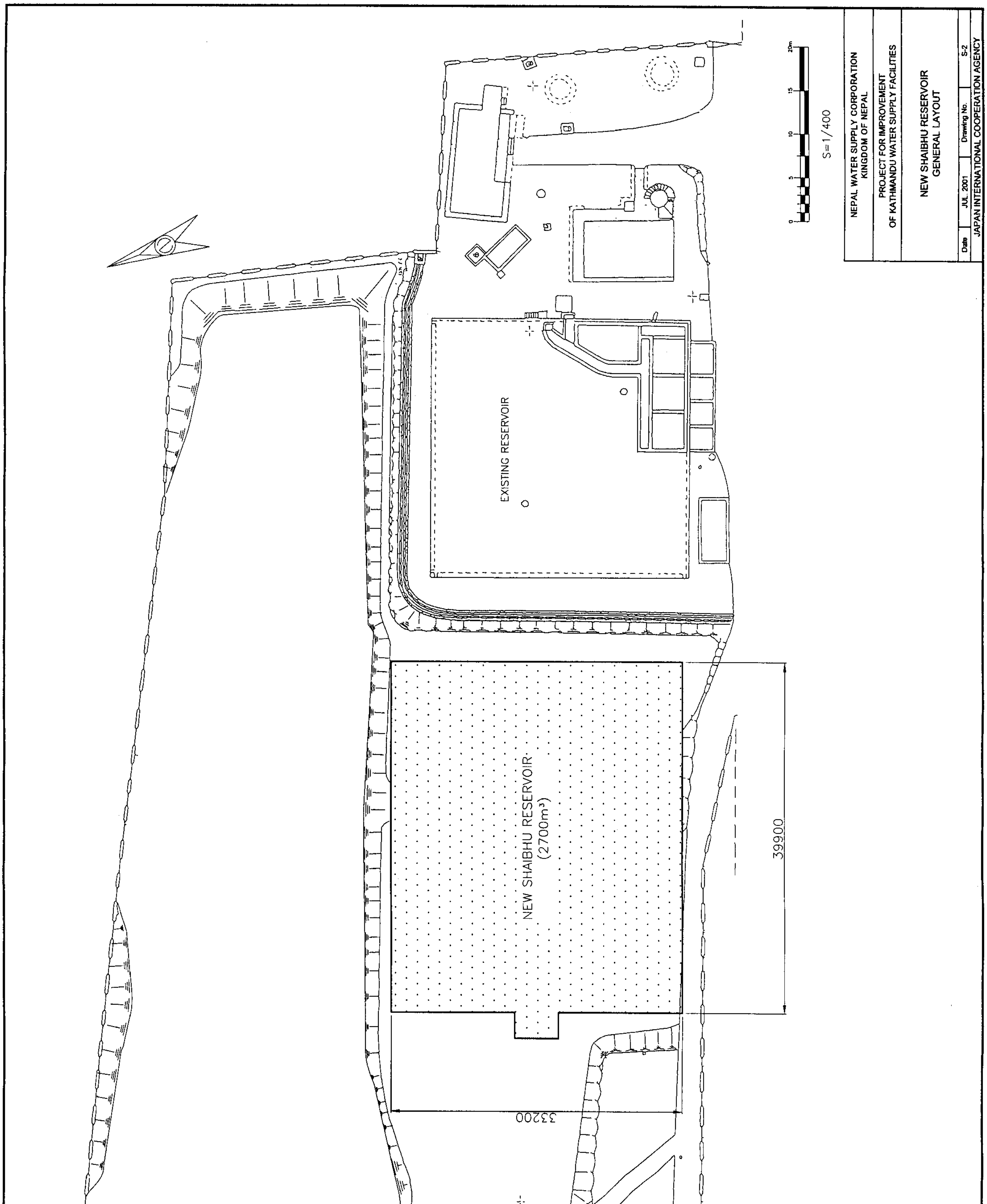
LOCATION MAP (Shaibhu Project)



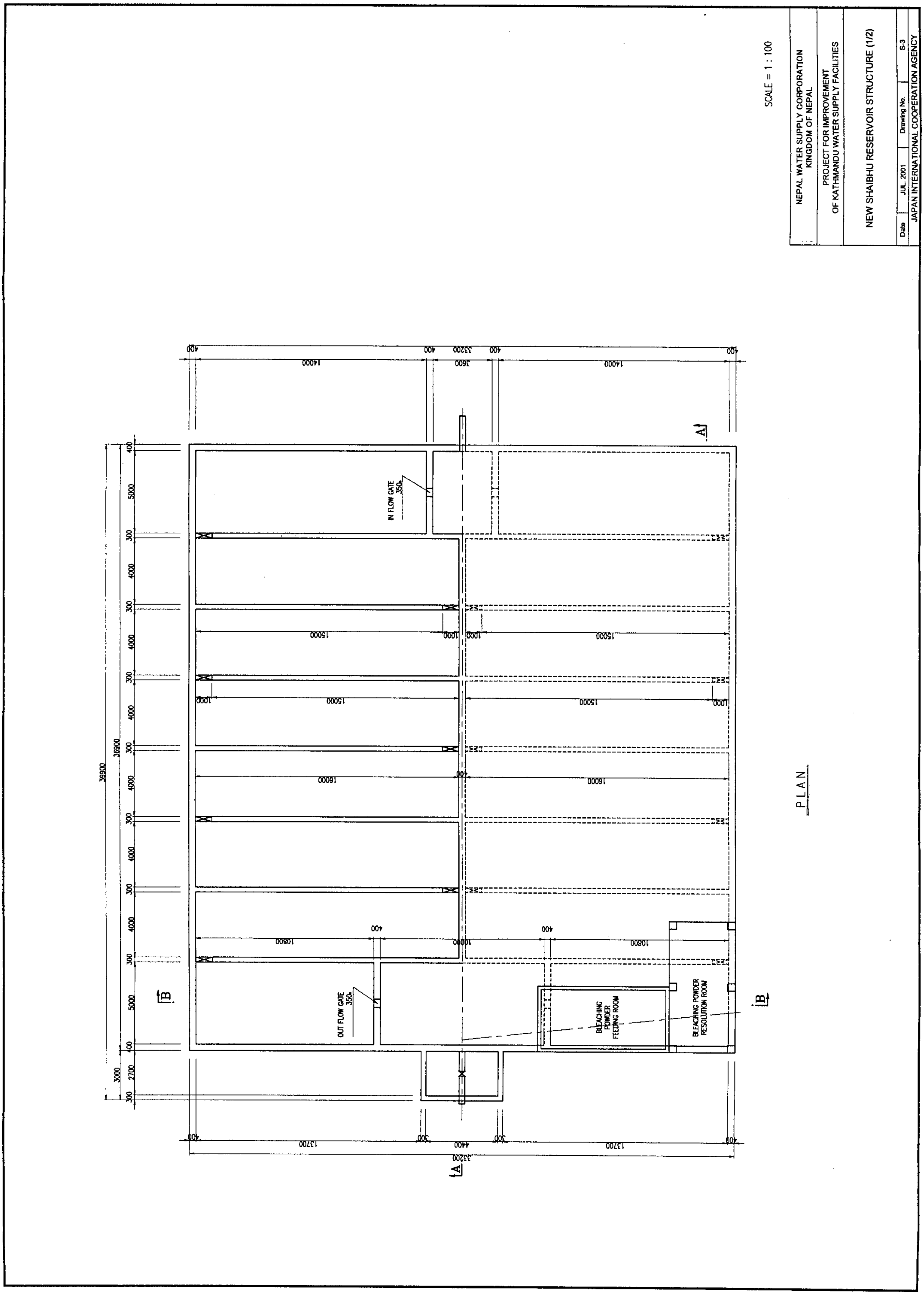
LEGEND
- □ :Proposed Reservoir
- - - - :Proposed Distribution Pipe
- ● :Existing WTP
- ■ :Existing Reservoir

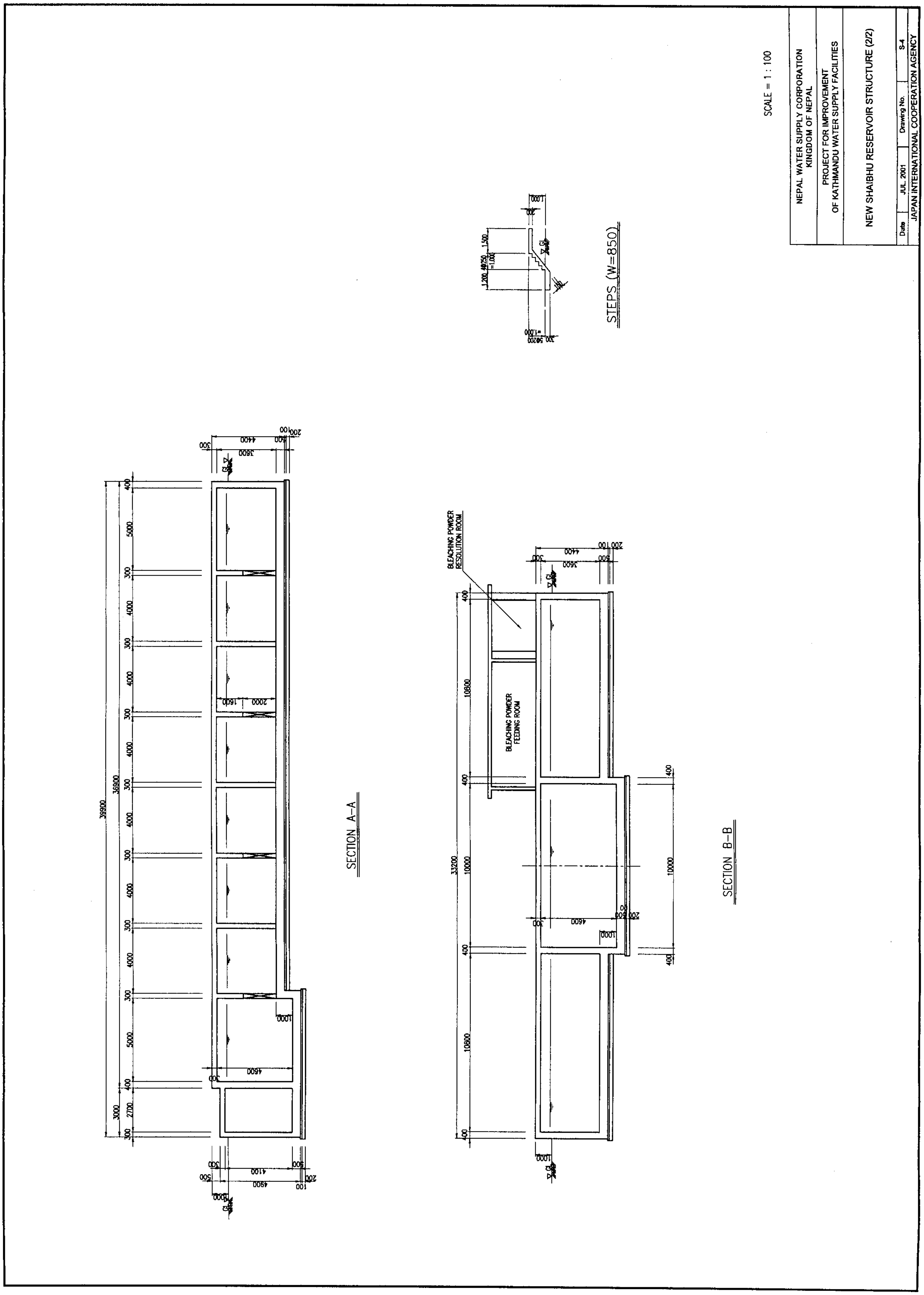
Water Supply Service Area
- : LALITPUR

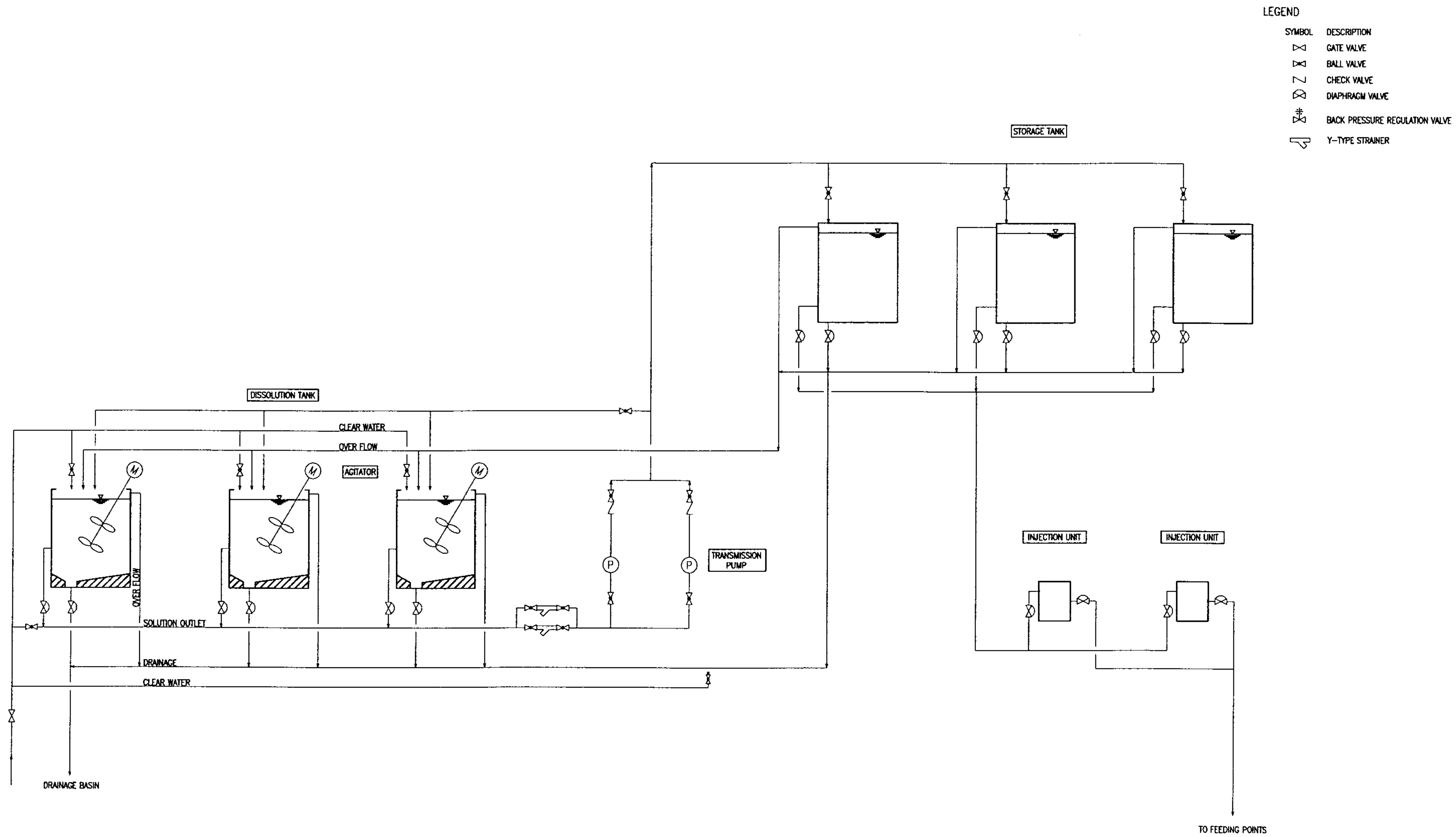
NEPAL WATER SUPPLY CORPORATION KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES
LOCATION MAP
Date: JUL. 2001 — Drawing No.: S-1
JAPAN INTERNATIONAL COOPERATION AGENCY



NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES
NEW SHAIBHU RESERVOIR
GENERAL LAYOUT
Date
JUL. 2001
Drawing No.
S-2
JAPAN INTERNATIONAL COOPERATION AGENCY
0
5
10
15
20m
S=1/400
EXISTING RESERVOIR
NEW SHAIBHU RESERVOIR
(2700m³)
39900
33200

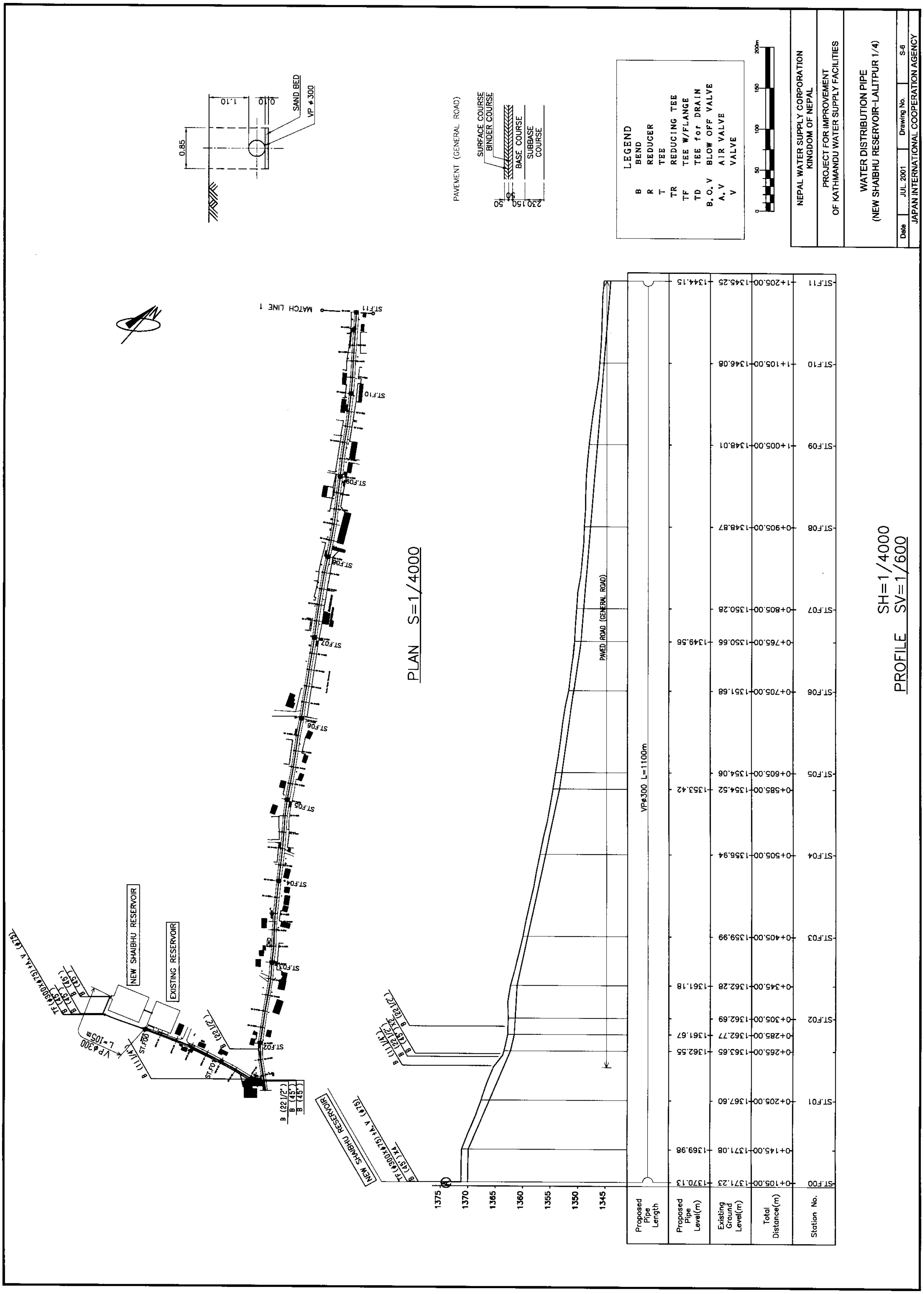

NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES
NEW SHAIBHU RESERVOIR STRUCTURE (1/2)
Date
JUL. 2001
Drawing No.
S-3
JAPAN INTERNATIONAL COOPERATION AGENCY
SCALE = 1 : 100
PLAN
IN FLOW GATE
OUT FLOW GATE
BLEACHING POWDER FEEDING ROOM
BLEACHING POWDER RESOLUTION ROOM


SCALE = 1 : 100
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES
NEW SHAIBHU RESERVOIR STRUCTURE (2/2)
Date
JUL. 2001
Drawing No.
S-4
JAPAN INTERNATIONAL COOPERATION AGENCY
STEPS (W=850)
SECTION A-A
BLEACHING POWDER
RESOLUTION ROOM
BLEACHING POWDER
FEEDING ROOM
SECTION B-B

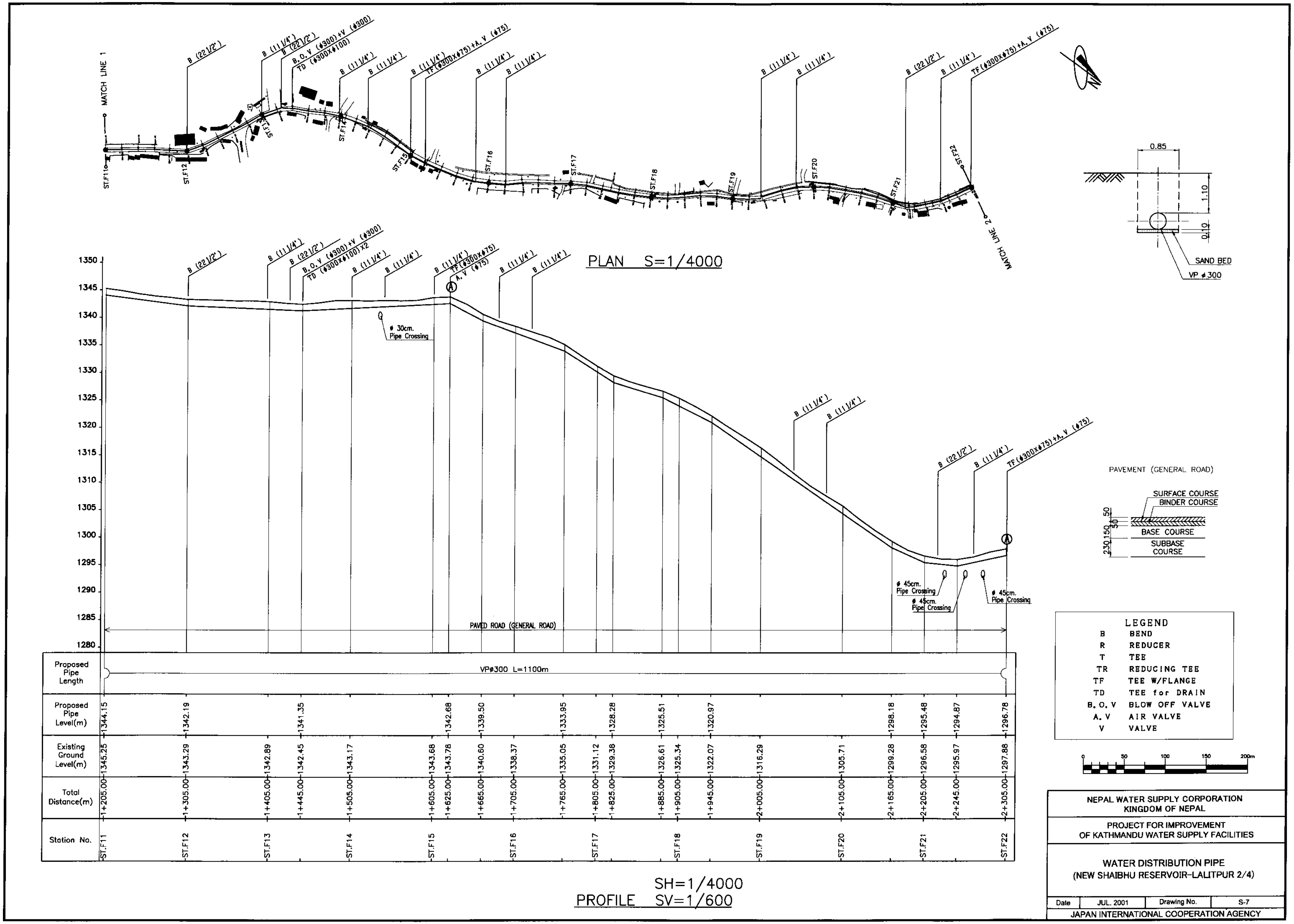


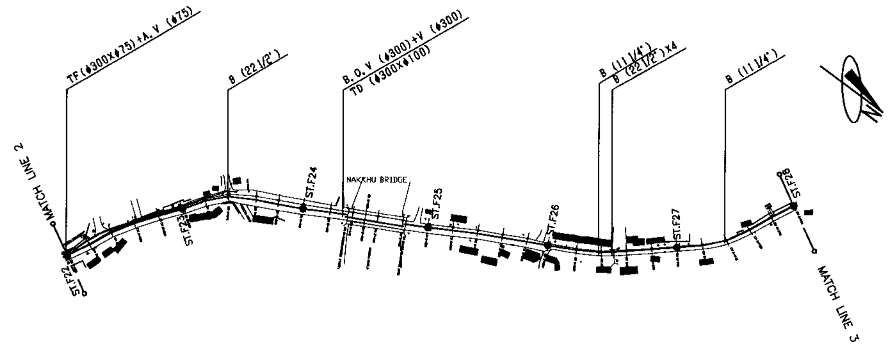
SCALE = NONE

NEPAL WATER SUPPLY CORPORATION KINGDOM OF NEPAL			
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES			
FLOW DIARGRAM OF BLEACHING POWDER FEEDING EQUIPMENT			
Date	JUL. 2001	Drawing No.	S-5
JAPAN INTERNATIONAL COOPERATION AGENCY			

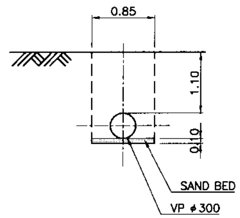


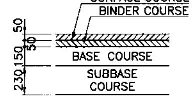
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES
WATER DISTRIBUTION PIPE
(NEW SHAIBHU RESERVOIR-LALITPUR 1/4)
Date JUL. 2001 Drawing No. S-6
JAPAN INTERNATIONAL COOPERATION AGENCY
LEGEND
B BEND
R REDUCER
T TEE
TR REDUCING TEE
TF TEE W/FLANGE
TD TEE for DRAIN
B.O.V BLOW OFF VALVE
A.V AIR VALVE
V VALVE
0 50 100 150 200m
PAVEMENT (GENERAL ROAD)
SURFACE COURSE
BINDER COURSE
BASE COURSE
SUBBASE COURSE
50 150 230
0.85
1.10
0.10
SAND BED
VP φ300
PLAN S=1/4000
PROFILE SH=1/4000 SV=1/600
NEW SHAIBHU RESERVOIR
EXISTING RESERVOIR
MATCH LINE 1
VPφ300 L=105m
VPφ300 L=1100m
PAVED ROAD (GENERAL ROAD)
1375
1370
1365
1360
1355
1350
1345
Proposed Pipe Length
Proposed Pipe Level(m)
Existing Ground Level(m)
Total Distance(m)
Station No.
ST.F00 0+105.00 1371.23 1370.13
0+145.00 1371.08 1369.98
ST.F01 0+205.00 1367.60
0+265.00 1363.65 1362.55
0+285.00 1362.77 1361.67
ST.F02 0+305.00 1362.69
0+345.00 1362.28 1361.18
ST.F03 0+405.00 1359.99
ST.F04 0+505.00 1356.94
0+585.00 1354.52 1353.42
ST.F05 0+605.00 1354.06
ST.F06 0+705.00 1351.68
0+765.00 1350.66 1349.56
ST.F07 0+805.00 1350.28
ST.F08 0+905.00 1348.87
ST.F09 1+005.00 1348.01
ST.F10 1+105.00 1346.08
ST.F11 1+205.00 1345.25 1344.15

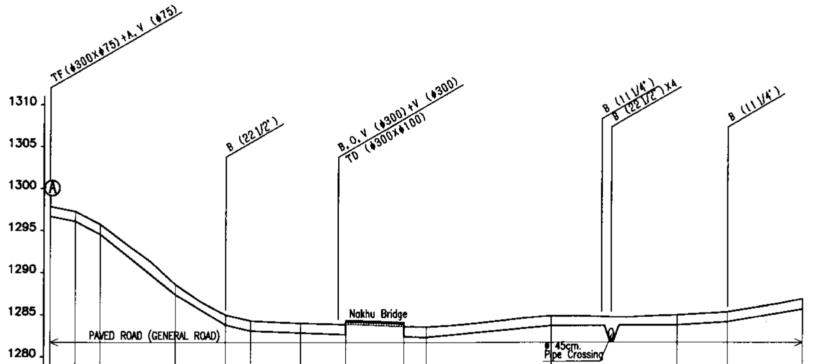

PLAN S=1/4000
MATCH LINE 1
MATCH LINE 2
PROFILE SH=1/4000 SV=1/600
PAVED ROAD (GENERAL ROAD)
VPφ300 L=1100m
φ 30cm. Pipe Crossing
φ 45cm. Pipe Crossing
SAND BED
VP φ300
PAVEMENT (GENERAL ROAD)
SURFACE COURSE
BINDER COURSE
BASE COURSE
SUBBASE COURSE
LEGEND
B BEND
R REDUCER
T TEE
TR REDUCING TEE
TF TEE W/FLANGE
TD TEE for DRAIN
B.O.V BLOW OFF VALVE
A.V AIR VALVE
V VALVE
Proposed Pipe Length
Proposed Pipe Level(m)
Existing Ground Level(m)
Total Distance(m)
Station No.
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES
WATER DISTRIBUTION PIPE
(NEW SHAIBHU RESERVOIR-LALITPUR 2/4)
Date JUL. 2001
Drawing No. S-7
JAPAN INTERNATIONAL COOPERATION AGENCY



PLAN S=1/4000







Proposed Pipe Length	VPφ300 L=235.9m							DCIPφ300 L=46.4m		VPφ300 L=317.7m				
Proposed Pipe Level(m)	1296.78	1296.19	1294.64	1287.47	1283.89	1283.19		1282.75	1282.52	1282.46	1283.82	1283.90	1284.27	1285.79
Existing Ground Level(m)	1297.88	1297.29	1295.74	1288.57	1284.99	1284.29	1284.01	1283.85	1283.62	1283.56	1284.92	1285.00	1285.37	1286.89
Total Distance(m)	2+305.00	2+325.00	2+345.00	2+405.00	2+445.00	2+465.00	2+505.00	2+540.90	2+587.30	2+605.00	2+705.00	2+805.00	2+845.00	2+905.00
Station No.	ST.F22			ST.F23			ST.F24			ST.F25	ST.F26	ST.F27		ST.F28

PROFILE SH=1/4000 SV=1/600

LEGEND

B	BEND
R	REDUCER
T	TEE
TR	REDUCING TEE
TF	TEE W/FLANGE
TD	TEE for DRAIN
B.O.V	BLOW OFF VALVE
A.V	AIR VALVE
V	VALVE

0 50 100 150 200m

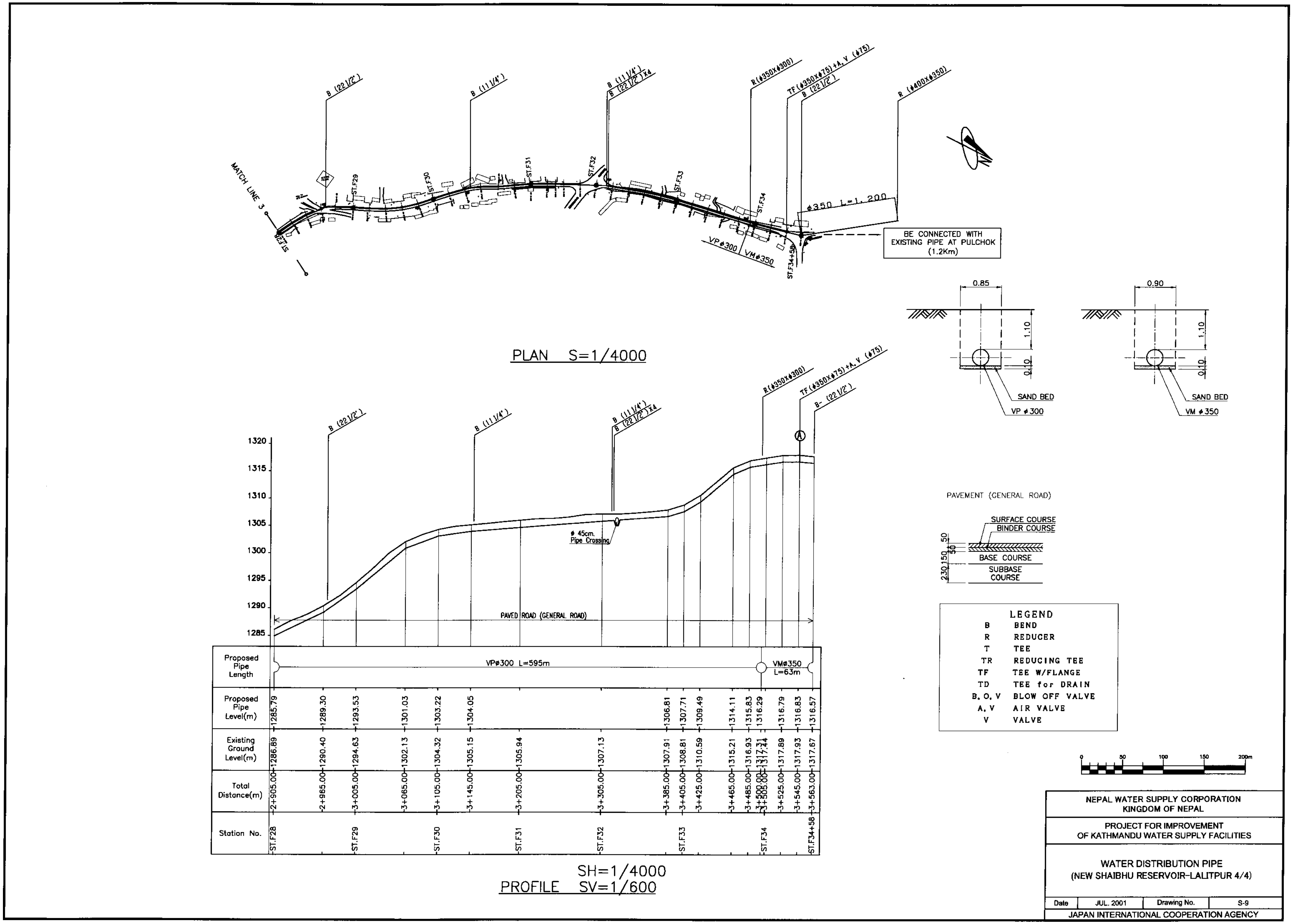
NEPAL WATER SUPPLY CORPORATION
KINGDOM OF NEPAL

PROJECT FOR IMPROVEMENT
OF KATHMANDU WATER SUPPLY FACILITIES

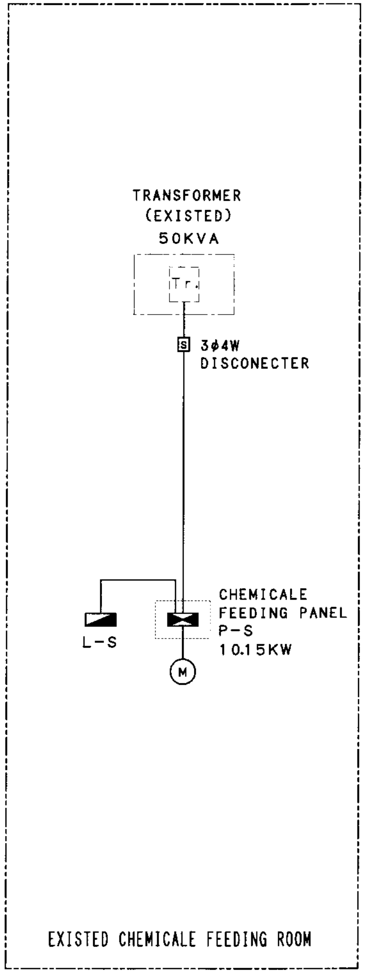
WATER DISTRIBUTION PIPE
(NEW SHAIBHU RESERVOIR-LALITPUR 3/4)

Date	JUL. 2001	Drawing No.	S-8

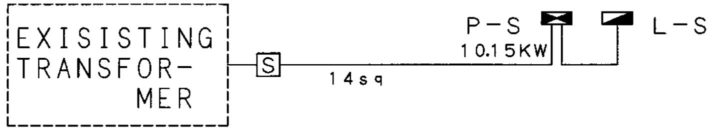
JAPAN INTERNATIONAL COOPERATION AGENCY



Station No.	Total Distance(m)	Existing Ground Level(m)	Proposed Pipe Level(m)
ST.F28	2+905.00	1286.89	1285.79
	2+965.00	1290.40	1289.30
ST.F29	3+005.00	1294.63	1293.53
	3+065.00	1302.13	1301.03
ST.F30	3+105.00	1304.32	1303.22
	3+145.00	1305.15	1304.05
ST.F31	3+205.00	1305.94	
ST.F32	3+305.00	1307.13	
ST.F33	3+385.00	1307.91	1306.81
	3+405.00	1308.81	1307.71
	3+425.00	1310.59	1309.49
	3+465.00	1315.21	1314.11
	3+485.00	1316.93	1315.83
ST.F34	3+500.00 / 3+505.00	1317.31 / 1317.44	1316.29
	3+525.00	1317.89	1316.79
	3+545.00	1317.93	1316.83
ST.F34+58	3+563.00	1317.67	1316.57



RESERVOIR TANK TREATMENT PLANT



POWER DIAGRAM

LIST OF LOADS

PANEL No.	EQUIPMENT NAME	MOTER Q'ty FIX	MOTER Q'ty SPARE	MOTER Q'ty TOTAL	LOAD CAP. (KW)	TOTAL CAP. (KW)
P-S	BLEACHING POWDER FEEDING EQUIPMENT					
	WATER SUPPLY PUMP	2	0	2	3.7	7.4
	AGITATOR	3	0	3	0.4	1.2
	TRANSMISSION PUMP	1	1	2	0.4	0.4
	DRAINAGE PUMP	1	0	1	0.4	0.4
	EXHAUST FAN	1	0	1	0.75	0.75
TOTAL						10.15

ELECTRICAL SYSTEM (SHAIBHU)

NEPAL WATER SUPPLY CORPORATION KINGDOM OF NEPAL			
PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES			
ELECTRICAL SYSTEM (SHAIBHU)			
Date	JUL. 2001	Drawing No.	S-10
JAPAN INTERNATIONAL COOPERATION AGENCY			

2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

1) Framework of Responsibilities

NWSC will be responsible for the implementation of the Project at the Nepalese side under the supervision of the Ministry of Physical Planning and Works (MPPW). NWSC will, therefore, sign the consultancy agreement as well as the construction contract for the Project.

Meanwhile, a Japanese consultant will be responsible for the detailed design (preparation of the design documents and assistance in the tender) and the supervision of construction work. Following the signing of E/N for Japanese grant aid for the Project, NWSC will conclude a consultancy agreement with the consultant in relation to the said consultancy services.

The construction work will be conducted by a Japanese construction company selected by NWSC through tender in the presence of the consultant.

2) Method for Implementation

The method to be employed in the Project will be the one in which the maximum of local workers, equipment and materials might be utilised in creating the employment and in promoting technology transfer, in consideration of the local construction situation and the technical level.

3) Dispatch of Engineers

The water supply facilities to be constructed in the Project are complex facilities involving civil engineering work, building work, and electrical/machinery equipment installation work. Towards the successful completion of work by satisfying the specifications required in the design, dispatch of Japanese engineers with the respective expertice would be necessary to provide guidance to local engineers in quality control and others.

4) Use of Local Subcontractors

In a Japanese grant aid project, a Japanese construction company concludes a construction contract with the government of the recipient country and acts as the main contractor (the Contractor). However, the participation of local construction companies (acting as subcontractors) will be important for smoothly carrying out the construction work in the outside country where the different legal system, custom and sense of values prevail. Some 150 construction companies are registered as Class-A in Nepal: these might have a sufficient capability of construction work under the guidance and supervision of the Japanese Contractor. Local subcontractors shall, therefore, be fully utilised in the Project, partly for the purpose of technology transfer.

2-2-4-2 Implementation Conditions

Construction work in the Project will be carried out, taking note of the site conditions, equipment and material procurement, labour, social conditions, and others, as delineated below.

1) Matters to be Taken Note in Major Construction Work

(a) Temporary Work

The height of facilities to be constructed in the Project will be less than 5 m, excluding overhead tanks. The excavation for foundations will require merely 2 to 3 m depth. No large-scale temporary work will be required for Project facilities, if considered these structural conditions.

Intake facilities of river bed water, the wells will be constructed with open caisson method. Since the method involves construction of a RC structure on the ground to be gradually sunk with its weight or load during the excavation inside the caisson, temporary work for shoring will not be necessary.

(b) Earth Work

Excavation, backfilling and compaction accompanying with the facility construction and installation of pipes will be done with machinery, as a rule.

(c) Foundation Work

Geological survey results revealed that the spread foundations might be adopted in the Project because of favourable ground condition for most of the planned facilities as well as due to a small facility load of around 50 KN/m^2. At the construction site of Min Bhawan overhead tank, however, formations were recognized partially to which the consolidation is likely to occur; to prevent the probable affection, the pile foundation will be required.

Out of the different pile foundation methods, reverse circulation method shall be adopted in this case, because of little vibration and noise, considering the impacts to nearby buildings.

(d) Concrete Work

There is no plant of ready-mixed concrete in Katmandu, and the on-site concrete mixing will be necessary. A proper mixture in weight is essential in maintaining the appropriateness in concrete quality. At least one simplified batcher plant shall be mobilised in the Project, for this reason.

Major construction sites in the Project are: Manohara Intake, Manohara WTP, Shaibhu Reservoir, Min Bhawan overhead tank, and Singha Durbar overhead tank. In order to minimise the number of batcher plants to be mobilised, it shall be considered to transport the mixed concrete from the plants to construction sites by concrete mixers.

(e) Form Work

Water supply facilities have an intricate structure with water channels, partition walls and others. The average thickness of each member is below 50 cm. Towards such a structure, plywood panels for concrete are commonly used. In the Project, plywood panels will also be used, in view of their workability and finish of the concrete surface.

(f) Shoring Work

Slab thickness (concrete floor) in the water treatment plant to be constructed in the Project will be 20 to 30 cm. The height of shoring will be less than 5 m at the maximum, and an appropriate support might be provided with pipe work. On the other hand, pipe work might not be applied to elevated tanks, because slabs are located approximately 20 m above the ground. Accordingly, prefabricated shoring will be used in the work for elevated tanks, concurrently to be used as a scaffold.

(g) Scaffolding Work

Scaffolding will be erected for steel reinforcement work, form work and concrete placing work. Prefabricated scaffolding will be used, while tubular scaffolding being used to the work not involving concrete placing.

(h) Piping Work

As described previously, piping work will, in principle, be conducted at night using machinery. So long as the traffic condition permit, however, the work will be manually done during daytime. Simple digging without trench timbering would be satisfactory to the trenches where water pipes are to be laid at almost all sections, judged from the geological characteristics of the sites.

(i) Electrical and Mechanical Equipment Installation

Electrical and mechanical equipment will be installed upon civil engineering and building work drawing to the end, and equipment delivery and installation being possible. Nevertheless, electrical conduit tubes, etc. shall be installed, prior to the concrete placing, with due confirmation of the route.

2) Measures for Safety

Safety measures vis-à-vis workers will be important equivalently with the quality control. Workers should always wear proper shoes (boots) and helmet, as the basic requirement for safety. A safety belt should be used in the construction of overhead tanks, because the workers will have to work about 25 m above the ground. A safety net will be put up to prevent the scattering of materials by wind.

3) Construction Schedule

Nepal has the rainy season from June to September, and the dry season from October to May. The construction work of Manohara Intake shall be completed in the dry season. Other works might be continued even in the rainy season, though work efficiency being reduced somewhat.

4) Observance towards Labour Standard

The Contractor shall follow the Labour Law and other relevant laws and regulations in Nepal when employing local workers in the Project. The Labour Law in Nepal has the following provisions:

- Basic working hours: eight hours/day or 48 hours/week
- Overtime allowance: overtime: hourly wage x 150%

	public holidays:	hourly wage x 150%
- Traveling and housing allowances:	none	
- Leave with allowance:	annual leave:	13 days/year
	home visit leave:	18 days/year
	injury/disease leave:	15 days/year
	ceremonial leave:	13 days/year
- Retirement allowance:	work duration: more than five years but less than 10 years: 0.5 months wage/year work duration: more than 10 years but less than 15 years: one month wage/year work duration: more than 15 years but less than 20 years: one and half a month wage/year work duration: more than 20 years: lifetime pension monthly pension = monthly wage at retirement x work duration (years) ÷ 50	
- Maternity leave	52 days/time (up to twice in the entire work duration)	
- Tax obligation:	all employees	

5) Observance towards Local Customs

The following public holidays based on religion and customs in Nepal shall be taken into consideration in determining working days:

Date	Name of Public Holiday
January 1	New Year's Day
January 11	Prithivi Jayanthi
January 29	Martyr's Day
February 18	Democracy Day
February 21	Maha Shiva Ratri
March 9	Holi Purnima
March 24	Horse Festival
April 1	Chitra Dasain
April 2	Ram Navami
April 14	Nepali New Year
May 1	Labour Day
May 16	Buddha Jayanti
August 3	Jani Purnima
August 4	Cow Festival
August 12	Krishna Astami
September 3	Indra Jattra
October 17	Ghastas Thapana
October 23 – 31	Dasain Festival
November 8	Constitution Day
November 13 – 16	Tihar Festival
December 29	HM the King's Birthday
December 31	New Year's Eve

2-2-4-3 Scope of Works

The division of work between the Japanese and Nepalese sides in the implementation of the Project is as below.

(1) Scope of Work for Japanese Side

1) Construction of the water supply facilities relating to the Manohara Project and the Shaibhu Project described in “2.2 Basic Plan”.

2) Maritime transportation of the equipment and materials procured in Japan to a port of landing near Nepal.

3) Inland transportation of the equipment and materials from the port of landing to the construction sites.

4) Consultancy work (detailed design, preparation of tender documents, assistance in the tender and construction supervision).

(2) Scope of Work for Nepalese Side

1) EIA study and the related procedures to be conducted in reference to the following items; if required, environmental impact prevention and mitigation measures to be undertaken:

(a) Social and economic environment

- Resettlement: residents to be displaced accompanying with land acquisition and plumbing work.
- Economic activity: opportunity lost in production often acquisition of farm land, etc.
- Area split: area split caused by traffic hindrance in the plumbing work.
- Water right: affection over the water right from river water intake.
- Waste disposal: sludge discharge from water treatment plant

(b) Natural environment

- River discharge: alternation in river flow from river water intake

(c) Public hazard

- Water contamination: pollution caused by inflow of sludge and drainage from the water treatment plant.

2) Expropriation of the land required for construction of the planned facilities in the Project and payment of the compensation required.

3) Power supply to the facilities to be constructed in the Project.

4) Leveling and clearance of the land at construction sites, prior to the commencement of construction work, if necessary.

5) Construction of perimeter fencing and a gate at the sites.

6) Improvement of distribution pipe in Bhaktapur and Madhyapur service areas.

2-2-4-4 Consultant Supervision

(1) Consultancy Work

Following the conclusion of the consultancy agreement after signing of E/N, the Consultant will conduct the detailed design, prepare tender documents, provide assistance in the tender, and conduct construction supervision towards the Contractor to be awarded with a construction contract. Major components of the consultancy work are outlined below.

1) Preparation of Detailed Design and Tender Documents

The Consultant will prepare the detailed design documents based on the survey drawings and the boring survey findings compiled under the basic design study and the findings of the more detailed field survey for the detailed design, and will also prepare the documents required in the tender. The Consultant shall consult with the Government of Nepal with a view to obtaining its approval.

2) Assistance in the Tender

The Consultant will provide assistance to the Government of Nepal in such work as announcement of the tender, pre-qualification, distribution of tender documents, acceptance of bids and analysis as well as evaluation of bids, and will also provide advice in contract negotiations between the Government of Nepal and a successful bidder. The Consultant will witness the signing of the construction contract between the Government of Nepal and the successful bidder (who will then become the Contractor).

3) Construction Supervision

Following witnessing in signing of the construction contract, the work of the Consultant will move to construction supervision. In Japan, the Consultant will examine the documents submitted by the Contractor for their approval by the Consultant. In Nepal, the Consultant will provide assistance to the Government of Nepal in regard to the pre-work consultation meetings and will guide and supervise the Contractor in regard to the transportation of equipment and materials. The Consultant will also conduct schedule control, quality control (including the quality inspection to be conducted by the Contractor) and material control. The Consultant will report the progress and other relevant matters to the Government of Nepal, JICA and Japan Embassy in Nepal, for the coordination and consultation required.

(2) Project Implementation Set-up

In order to smoothly carry out the detailed design and subsequent construction supervision, the Consultant will organise a project implementation set-up with those persons, mainly consisting of those who have participated in the basic design study, having an adequate knowledge of Japan’s grant aid scheme.

1) Preparation of Detailed Design and Tender Documents and Assistance in the Tender

The persons to be involved in the preparation of detailed design and tender documents and for assistance in the tender, with their respective roles, are as below.

- Project manager: overall supervision of detailed design and the tender
- Electrical engineer: detailed design of power receiving and transforming equipment and electrical installation in the water treatment plant
- Mechanical engineer: detailed design of water treatment equipment
- Plumbing engineer: detailed design of conveyance pipes, transmission/ distribution pipes and auxiliary equipment to the pipeline
- Civil engineer: planning of foundation for structures and detailed design of intake facilities and structures
- Cost estimator: estimation of prospective bidding prices of construction work
- Tender coordinator: pre-qualification, preparation of construction agreement and assistance in the tender

2) Construction Supervision

The Consultant will dispatch a water service engineer having the precedent experience of grant-aid projects in Nepal as a resident engineer. The Consultant will also dispatch a project manager and specialist engineers at crucial stages of project implementation, to coordinate as well as to supervise the work. The engineers to be dispatched at such crucial stages are as below.

- Project manager: coordination and technical control to ensure the smooth progress of construction work
- Resident engineer: daily project management and schedule control
- Civil engineer: inspection, control and guidance regarding the construction of structures, including testing of the banking materials and concrete aggregates and testing of the quality, mixture and strength of concrete
- Electrical engineer: inspection, control and guidance regarding power receiving and transforming equipment and installation of electrical equipment in the water treatment plant
- Plumbing engineer: inspection, control and guidance regarding the installation of conveyance pipes, transmission/ distribution pipes and auxiliary equipment for the pipeline

2-2-4-5 Quality Control Plan

In reference to facilities construction, the Consultant will direct the Contractor to conduct analyses and tests for the following items, the results of which shall be reflected in the quality control:

Table 2.2.13 Analysis and Testing for Quality Control

Classification of Work	Test Item	Test Frequency	Note
1. Concrete Work			
(1) Test Mixing	Grain size analysis of fine aggregates	Once in the mixing.	
	Grain size analysis of coarse aggregates	- do -	
	Chlorine ion concentration test	- do -	With simplified method
	Compressive stress test	- do -	7 days- and 28 days-stress
(2) Casting at Site	Slump test	Once for 50 m^3.	
	Chlorine ion concentration test	Once in 2 weeks.	With simplified method
	Compressive stress test	Once for 50 m^3.	7days- and 28 days-stress
2. Reinforcing Bar Fabrication Work	Tensile stress test	Once for 50 t	
3. Earth Work			
(1) Standard Test	Compaction test	Once for 5,000 m^3.	Towards filling materials
	Grain size examination	- do -	- do -
	Specific gravity test of the grain	- do -	- do -
(2) Daily Test	Water content test	Once in the compaction.	- do -
	Consolidation test at site	- do -	With sand replacement method
(3) Others	Plain-board loading test	Once by major facility.	
4. Plumbing Work	Water pressure test	After plumbing work completed, once in the section of a stop valve.	

Towards the major equipment such as generators and control panels, and large-diameter VU pipe, to which a special order will be given in the procurement from Japan, an inspection and tests shall be conducted at site, to confirm the quality and functions in advance. In case other general-purpose materials and equipment, the quality shall be confirmed by making the Contractor submit the test-result table conducted by manufactures, etc. or the mill sheet, as the case may be.

2-2-4-6 Procurement Plan

The main construction materials to be used in the Project are cement, reinforcing bars, ductile cast iron pipes, hard vinyl chloride pipes and asphalt, etc. The planned procurement of these materials is outlined below, taking their quality and ease or difficulty of procurement into consideration.

1) Portland Cement

There are two cement factories (at Hetauda and Udaipur Garhi) in Nepal. Although the quality of cement is not problematic, a stable supply is questionable because of frequent strike actions in the recent years. The cement made in India will be used, due to its quality and ease of procurement in Nepal.

2) Reinforcing Bars

There are more than 10 rolling mills in Nepal. No problematic points are observed in size, quality and quantity; the reinforcing bars will, therefore, be procured in Nepal.

3) Secondary Concrete Products

Secondary concrete products such as Hume concrete pipes and perforated concrete blocks are produced in Nepal. However, in view of questionable quality, procurable quantity and delivery reliability, these shall be produced on site by the Contractor.

4) Asphalt

Asphalt is not produced in Nepal. Asphalt products of India have the favourable quality, possible to be procured in Nepal; therefore to be used.

5) Ductile Cast Iron Pipes and PVC Pipes

While these pipes are not manufactured locally, pipes made in India can be procured in Nepal. However, only available are socket-type (T-shape) ductile cast iron pipes and PVC pipes of small diameter. From the viewpoint of reliable quality, quantity and delivery, these pipes shall be procured in Japan.

6) Construction Machinery

Even though the construction machinery leasing market in Nepal is not yet fully developed, general-purpose construction machinery can be leased locally. Construction machinery will, therefore, be leased locally wherever possible. If required, leasing from India shall be considered.

Table 2.2.14 Procurement of Materials and Equipment

Materials and Equipment	Nepal	Japan	Third Country
Cement	O		
Reinforcing Bars	O		
Secondary Concrete Products	O		
Asphalt	O		
Ductile Cast Iron Pipes		O	
PVC Pipes		O	
Construction Machinery (Leasing)	O	O	

2-2-4-7 Implementation Schedule

(1) Implementation Schedule

The implementation schedule of the Project, after signing of E/N between the Governments of Nepal and Japan, is as under.

After signing of E/N, the Nepalese side (NWSC) will immediately conclude a consultancy agreement to prompt the commencement of the detailed design work by the Consultant who will then conduct the necessary study, including a field survey, to prepare the detailed design documents. The Consultant will also provide assistance in the tender organised by the Government of Nepal, and will conduct a series of tender-related work, ranging from pre-qualification of construction companies in the bidding to selection of a successful bidder.

When the successful bidder has been selected, a construction agreement will be concluded between the successful bidder (the Contractor) and NWSC, after negotiation. The Contractor will commence the work upon the receipt of a notice to commencement of work issued by the Consultant.

The Project will be implemented in two phases, as described below, taking into consideration (i) conditions of work, including the type and scale of the planned facilities, construction cost and climate (dry and rainy seasons) and (ii) requirements in the grant aid scheme of the Government of Japan.

1) Phase 1

- Scope of work: detailed design and construction of the planned intake and water treatment facilities in the Manohara Project
- Detailed design period: 6 months
- Construction period: 9.5 months

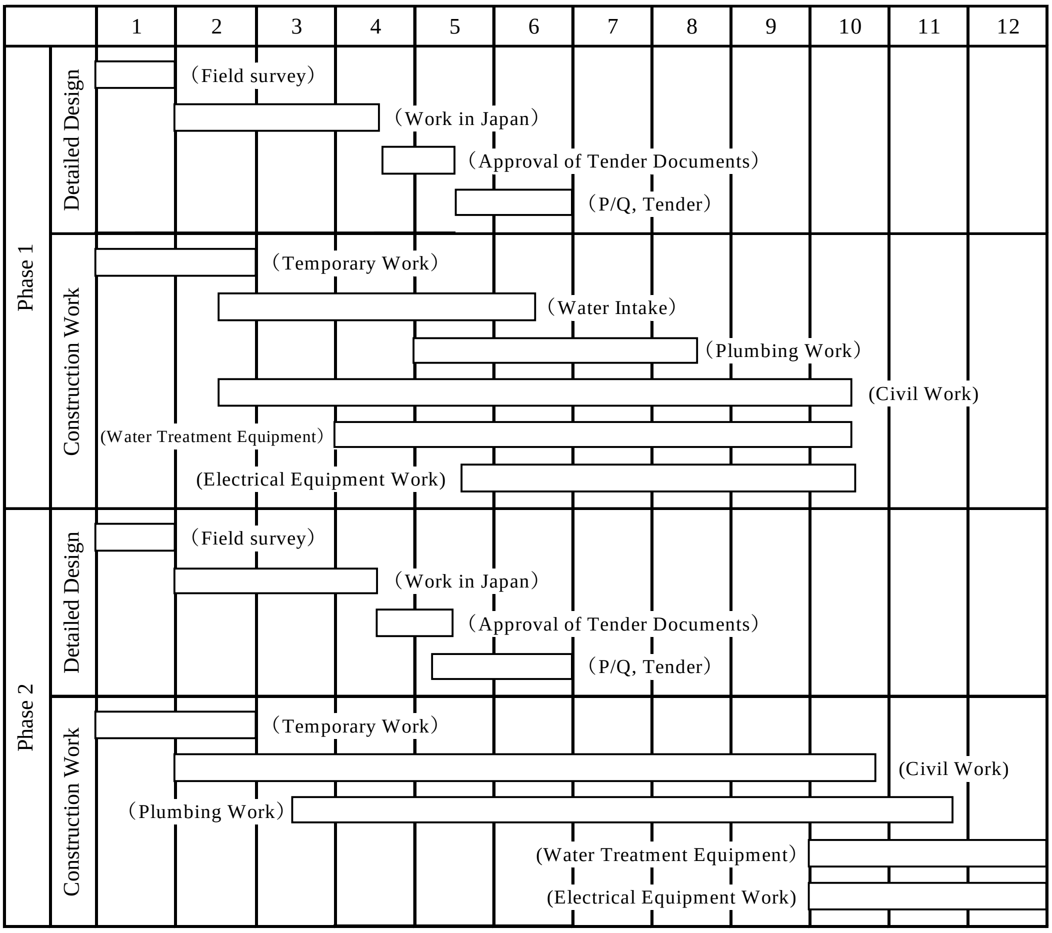
2) Phase 2

- Scope of work: detailed design and construction of the planned transmission/distribution facilities in the Manohara Project and Shaibhu Project.
- Detailed design period: 6 months
- Construction period: 12 months

(2) Project Implementation Schedule

The implementation schedule of the Project, with due consideration of the items above, is shown in Table 2.2.3.

Table 2.2.15 Project Implementation Schedule



2-3 Obligations of the Recipient Country

In the implementation of the Project, the Nepalese side will be responsible for the following:

1) Implementation of the EIA study and completion of the necessary procedures required in the implementation of the Project.

2) Acquisition of land at the sites for the construction of the following facilities:

Facility	Area for Land Acquisition
(a) Intake facilities	
- Intake well	: 2,000 m^2 (250 m^2/well x 8 wells)
- Maintenance road	: 1,600 m^2 (0.8 km length x 2 m width)
(b) Water treatment plant	: 13,100 m^2
(c) Elevated tank	
- Min Bhawan elevated tank	: 1,000 m^2
- Singha Durbar elevated tank	: 1,000 m^2

3) Power supply to the planned facilities

   Supply of high voltage power (11 KV) to the water intake facilities and the water treatment plant in the Manohara Project.

4) Leveling and clearance of the project sites prior to commencement of the construction work.

5) Construction of perimeter fencing and other fencing on the premises and a gate at the sites.

6) Improvement of distribution pipe in Bhaktapur and Madhyapur service areas.

7) Payment of banking commission for the A/P and payment to a Japanese bank.

8) Prompt customs clearance and tax exemption of the equipment and materials required in the implementation of the Project at the port of landing.

9) Granting of the relevant visas and permits of stay in Nepal towards the Japanese nationals involved in the Project in accordance with the contracts.

10) Exemption of the equipment and materials brought into Nepal and services provided by the Japanese nationals in accordance with the contracts, from customs duty, internal taxes and other levies.

11) Proper maintenance and use of the facilities and equipment provided with in the Japanese grant aid programme.

12) Payment of all the expenses not included in the grant aid programme.

2-4 Project Operation Plan

(1) Operation and Maintenance Practices

The following operation and maintenance practices shall be adopted to ensure an effective functioning of the water supply system established by the Project.

1) Manohara Project

(a) Operation Control Items

a) Operation control of surface water intake

b) Control of water treatment plant

[Coagulation Control]

- Feeding of coagulant: conducting of jar test at least once a day in response to alteration of the water quality in order to determine the optimal feeding rate; the optimal feeding rate shall be adjusted by the feeding pump so that an appropriate quantity of coagulant can be fed.
- Feeding of alkaline agent: control of the feeding volume of the alkaline agent to adjust the pH value of raw water to approximately 7.2.

[Flocculation and Sedimentation Basin]

- Flocculation: monitoring the state of flocculation and adjusting the feeding volume of agents based on the jar test results if the state of flocculation is judged unfavourable.
- Sludge discharge: conducting of sludge discharge at a rate of one basin per day in principle; the standard duration of the sludge discharge is 10 seconds at the fully opened position and all the valves shall be opened or closed in sequence to discharge the whole sedimented sludge.

[Rapid Sand Filtration Basin]

- Backwashing: monitoring of the water level of the filtration basin; once the water level in the filtration basin reaches the prescribed level or 2 days has passed, raw water valve, drainage gate and surface washing valve shall be operated to conduct backwashing in the filtration basin; the washing is conducted in the form of both surface washing and backwashing.
- Backwashing frequency: in the backwashing once in 2 days, the water level in the sludge and drainage basin shall be monitored and the successive operation be made at a prescribed interval. The backwashing time shall be controlled not to draw near with each other in the different filtration basins.
- Feeding of sterilising agent: control of the feeding volume of chlorine to the filtered water so that the residual chlorine level might become approximately 1.0 mg/l.

[Clear Water Reservoir and Transmission Pump]

- Water level control in the clear water reservoir: regulation of water level in the clear water reservoir to prevent from falling below the prescribed level as the clear water reservoir stores water for backwashing in the rapid sand filtration basin.
- Operation of transmission pump: manual operation of number of pumps determined in response to requirements.

[Coagulant and Alkaline Agent for Coagulation and Bleaching Powder]

- Dissolution: feeding of (chemical) agents to the water-filled dissolution tank and agitation to dissolve these agents to achieve the prescribed concentration. In case of bleaching powder, after mixing and setting still for a fixed duration, supernatant of extracted solution up to 50% height shall be used. The dissolution work shall be done during daytime in 6 hours.
- Disposal of insoluble: after mixing and dissolving bleaching powder, the solution shall be left still in a fixed duration; supernatant water is transferred to the storage tank, and the insoluble is disposed of after drying with sludge, etc.
- Storage: chemicals shall be stored in the form of solution, according to feeding amount; the maximum feeding amount of one day shall be stored, as a rule.

[Sludge and Drainage Basin]

- The basin is to concentrate solid materials in the discharge water from the sedimentation basin and the rapid sand filtration basin, and to return supernatant water.
- Receiving volume of discharge water and sludge: Before the discharging work from the both proceeding basins, the receiving volume shall be confirmed, taking notes of water level in the sludge and drainage basin.
- Supernatant water return: After 40 minutes of settlement period, the supernatant water shall be returned in one hour, after receiving the backwashing discharge from the filtration basin.
- Sludge discharge: The discharge water flown in shall be stored in 4 days per basin, to concentrate the solid materials. On the 4th day, sludge shall be sent to the sludge drying bed.

[Sludge Drying Bed]

- The sludge coming out from the center of the bed is of high fluidity, spreads over the bed, and water and solid materials will split off. The supernatant water is drained off from stop-log weirs (4 nos.) set at the corner of the bed, accelerating the sludge drying-up. The dried sludge shall be manually disposed of according to the drying condition however, in principle, after 4 months elapsed.

c) Distribution Facilities

- Water level control
- Water distribution control

(b) Maintenance Items

Typical daily maintenance items at the facilities in the Project are as below.

a) Intake Facility

[Intake Well]

- Measurement of water level
- Water pump: electric current and voltage values
- Flow meter
- Water pressure meter

b) Water Treatment Plant

[Coagulation Control]

- Coagulant feeding equipment: value of ammeter; delivery pressure; liquid level in the storage tank; leakage from the pipe
- Alkaline agent feeding equipment: value of ammeter; delivery pressure; liquid level in the storage tank; leakage from the pipe

[Coagulation Basin]

- Flocculation: state of coagulation in the flocculation basin; state of floc settling
- Sludge discharge valve, etc.: daily sludge discharge; leakage from the pipe or valve
- Floor drainage pump: unusual sound; vibration; state of lubrication; value of ammeter

[Rapid Sand Filtration Basin]

- Oxidising agent feeding equipment: value of ammeter; delivery pressure; liquid level in the storage tank; leakage from the pipe
- Washing valves: leakage
- Sterilising agent feeding equipment: value of ammeter; delivery pressure; liquid level in the storage tank; leakage from the pipe
- Make-up water pump: unusual noise; vibration; state of lubrication; value of ammeter
- Surface wash pump: unusual noise; vibration; state of lubrication; value of ammeter

[Clear Water Reservoir and Transmission Pump]

- Transmission pump: unusual noise; vibration; state of lubrication; value of ammeter
- Floor drainage pump: unusual noise; vibration; state of lubrication; value of ammeter
- Water supply pump: unusual noise; vibration; state of lubrication; value of ammeter
- Water level gauge: state of pointer operation

[Dissolution and Storage of Coagulant and Alkaline Agent for Coagulation and Bleaching Powder]

- Dissolution tank-cum-agitator: unusual noise; vibration; state of lubrication; value of ammeter; leakage from the piping for the tank
- Transfer pump: unusual noise; vibration; state of lubrication; delivery pressure; value of ammeter

[Sludge and Drainage Basin]

- Discharge water return pump: unusual sound, vibration, state of lubrication, ammeter
- Sludge transfer pump: unusual sound, vibration, state of lubrication, ammeter

[Sludge Drying Bed]

- Supernatant of sludge inflow
- Adjustment of stop-log weirs for water draining-off
- Management of dried sludge disposal

c) Electrical Equipment

[Power Receiving and Transforming Equipment]

- Monitoring of the state of operation (sound; vibration; over-heating; offensive odour; breakdown of instruments and indicator lamps)
- Monitoring of the measuring operation of and recording by the voltmeter, ammeter and watt-hour meter

[Trunk Power System and Distribution Panel]

- Monitoring of the state of operation (sound; vibration; over-heating; offensive odour; breakdown of instruments and indicator lamps)
- Monitoring of the measuring operation of the ammeter and inspection of the panel interior

[Lighting Equipment]

- Inspection of the external appearance; lighting conditions; replacement of lamps

[Water Quality Monitoring Equipment]

- Residual chlorine meter: zero point adjustment (as required); daily adjustment of the span (approximately every three months)

[Water Flow Gauge]

- State of pointer operation; leakage from the joints

d) Distribution Facilities

- Water level gauge: state of pointer operation
- Water supply pump: unusual noise; vibration; state of lubrication; electric current and voltage values
- Valves: leakage from the joints

2) Shaibhu Project

(a) Operation Control Items

a) Chemicals Control

[Feeding of Sterilising Agent]

- Control of feeding volume of chlorine to the distributed water so that the residual chlorine level might be approximately 1.0 mg/l.

[Bleaching Powder]

- Dissolution: feeding of bleaching powder to the water-filled dissolution tank and agitation to dissolve it to achieve the prescribed concentration. After mixing and setting still for a fixed duration, supernatant of extracted solution up to 50% height shall be used. The dissolution work shall be done during daytime in 6 hours.
- Disposal of insoluble: after mixing and dissolving bleaching powder, the solution shall be left still in a fixed duration; supernatant water is transferred to the storage tank, and the insoluble is disposed of after drying.
- Storage: chemicals shall be stored in the form of solution, according to feeding amount; the maximum feeding amount of one day shall be stored, as a rule.

b) Distribution Facilities

- Water level control
- Water distribution control

(b) Maintenance Items

Major daily maintenance items at the facilities in the Project are as below.

a) Sterilisation Facilities

[Dissolution and Storage of Bleaching Powder]

- Dissolution tank-cum-agitator: unusual noise; vibration; state of lubrication; electric current and voltage values; leakage from pipes of the tank
- Transfer pump: unusual noise; vibration; state of lubrication; delivery pressure; electric current and voltage values

b) Electrical Equipment

Power Receiving and Transforming Equipment (Existing)

[Trunk Power System]

- Monitoring of the state of operation (sound; vibration; over-heating; offensive odour; breakdown of instruments and indicating lamps)
- Monitoring of the measuring operation of the ammeter and inspection of the distribution panel interior

[Lighting Equipment]

- Inspection of the external appearance; state of lighting; replacement of lamps

[Water Flow Gauge]

- Monitoring of the state of pointer operation and leakage from the joints

c) Distribution Facilities

- Water level gauge: state of pointer operation
- Water supply pump: unusual noise; vibration; state of lubrication; electric current and voltage values
- Valves: leakage from the joints

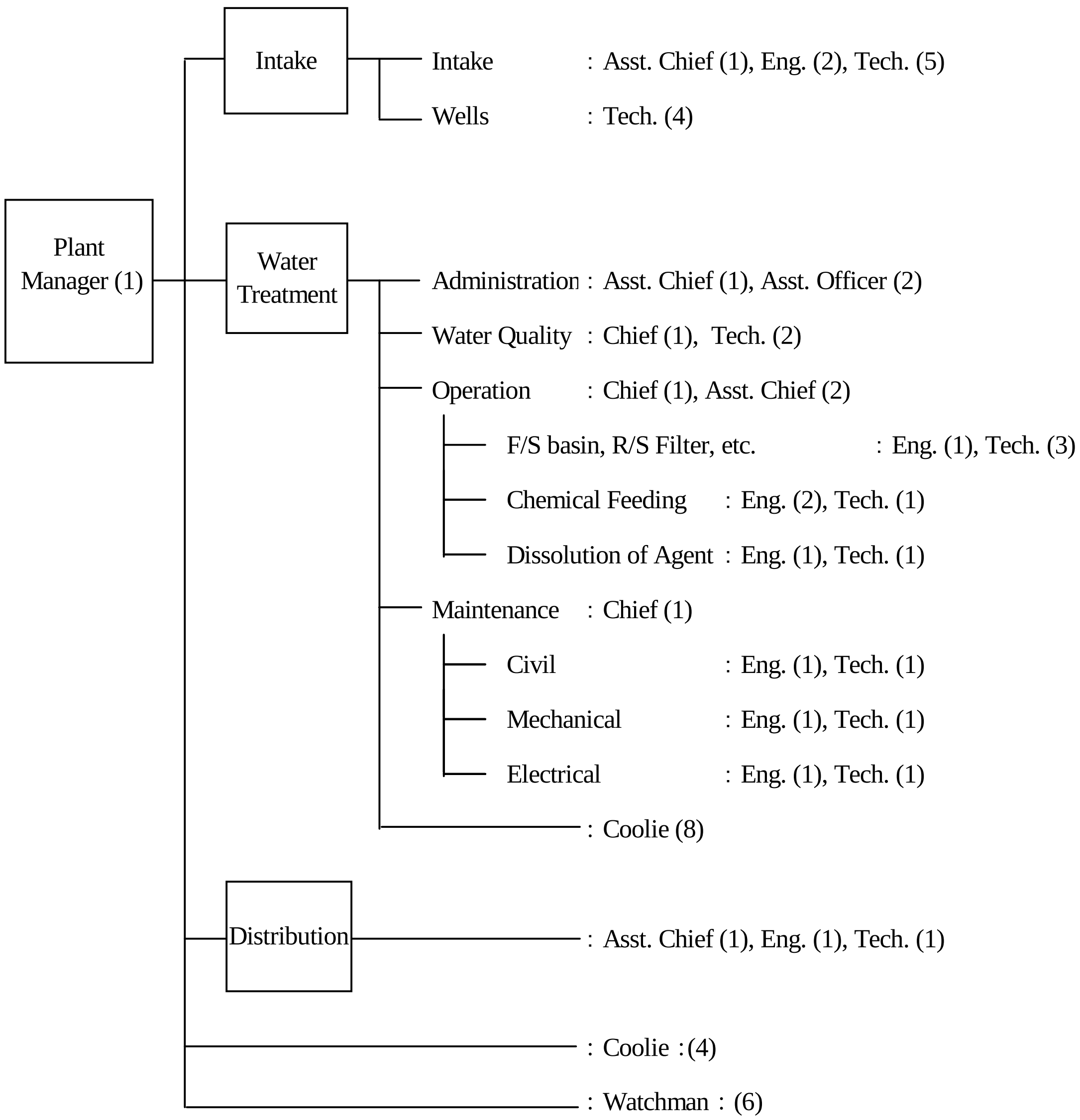
(2) Operation and Maintenance Organisation

In order to properly carry out the operation and maintenance work described in (1) above, the organisation shown in Fig. 4.1 for the Manohara Project and Fig. 4.2 for the Shaibhu Project shall be set up.

The efficient operation and maintenance of water supply facilities require not only an adequate organisation but also an appropriate deployment of the personnel. It is desirable that the operation and maintenance staff be well experienced in their expertice. However, number of experienced engineers is currently limited in Nepal, and there is a possibility that operation and maintenance might be hampered owing to the shortage of personnel. Such a probability calls for training of engineers/technicians, as an urgent need of NWSC.

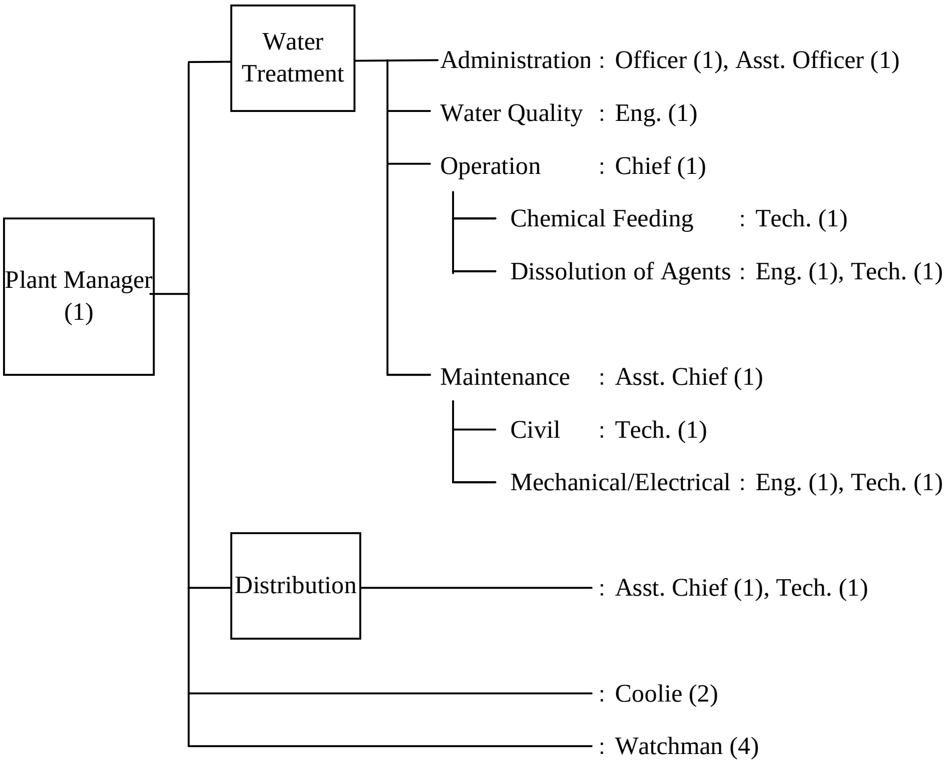
The envisaged operation and maintenance staff force is 59 persons in the Manohara Project, and 20 persons in the Shaibhu Project; totalling 79 persons. The beneficiaries of the Project being 427,000, number of staff per 1,000 beneficiaries is 0.19. Number of stuff per 1,000 service population is 0.22 in the Manohara Project which requires maintenance of water treatment plant. The manpower manning might be considered as adequate, if compared to that of the similar scale water treatment plant in the neighboring Bangladesh (0.38 per 1,000 service population).

Fig. 2.4.1 Operation and Maintenance Organisation for Manohara Project



Note: ( ) : The figures in brackets indicate the required number of staff.
Asst. : Assistant
Eng. : Engineer
Tech. : Technician

Fig. 2.4.2 Operation and Maintenance Organisation for Shaibhu Project



Note: ( ) : The figures in brackets indicate the required number of staff.
Asst. : Assistant
Eng. : Engineer
Tech. : Technician

(3) Operation and Maintenance Cost

The annual operation and maintenance cost of the facilities to be constructed in the Project is estimated as under.

1)	Manohara Project	NRs. 1,000/year
	- Personnel Cost	4,337
	- Administration Cost	217
	- Fuel Cost	300
	- Equipment Inspection and Maintenance Cost	16,917
	- Water Treatment Chemical Cost	5,629
	- Electricity Cost	11,444
	- Facility Maintenance Cost	1,010
	- Distribution Cost	775
	- Tariff Collection Cost	1,559
	Sub-Total	42,188
2)	Shaibhu Project	
	- Personnel Cost	1,602
	- Administration Cost	80
	- Fuel Cost	180
	- Equipment Inspection and Maintenance Cost	728
	- Water Treatment Chemical Cost	2,415
	- Electricity Cost	102
	- Facility Maintenance Cost	399
	- Distribution Cost	917
	- Tariff Collection Cost	1,845
	Sub-Total	8,268
	Total	50,456

Chapter 3 Project Evaluation and Recommendations

3-1 Project Effects

The direct-benefited area and population in the Manohara Project and the Shaibhu Project, both making up the Project, are as in Table 3.1.1.

Table 3.1.1 Target Area and Beneficiary Population

Project	Direct-benefited Area	Beneficiary *1 Population (thousand)	Note
Manohara Project	Southeast of Katmandu	222.4	
	Madhyapur	19.7	
	West of Bhaktapur	24.4	
	Sub-total	266.5	
Shaibhu Project	Lalitpur	160.1	
Total (The Project)		426.6 *2	

Note *1: Estimated service population in the year 2006.
*2: Corresponding to almost 42% of the total service population in the urban area.

In addition, as the above areas will be supplied water with Project facilities, the supply amount hitherto supplied to these areas with the existing facilities might be applied to other service areas. Consequently, water supply situation in the whole urban areas will be equally improved, and the benefiting effects of the Project would reach to the whole urban population of 1,007,000 in the Kathmandu Valley.

Directly, the effects as delineated below might be expected with the implementation of the Project.

(1) Augmentation of Supply Capacity in the Target Area

Through constructing the supply facilities in the Project, supply capacity will be augmented to 133,700 m^3/day from the current 113,100 m^3/day (augmentation: 20,600 m^3/day).

Table 3.1.2 Supply Capacity

(Unit: 1,000 m^3/day)

Service Area	Before Implementation (2000)	After Implementation (2006)
Katmandu	74.0	90.8
Bhaktapur	11.1 *	12.8
Lalitpur	28.0	30.1
Total (Whole Area)	113.1	133.7

Remark: *: Of the current supply capacity, 4,200 m^3/day is for not-good quality groundwater.

(2) Improvement of Leakage Ratio in the Target Area

Through constructing elevated tanks and installing the distribution main, the service areas will be sub-divided and an even pressure distribution and reduced average pressure level be effected. In consequence, the leakage ratio will be reduced to 32.8% from the current 43.5% (improvement: 10.7%).

Table 3.1.3 Leakage Ratio

Service Area	Before Implementation (2000)	After Implementation (2006)
Kathmandu	39.7%	28.9%
Bhaktapur	43.2%	36.7%
Lalitpur	53.6%	42.9%
Total (Whole Area)	43.5%	32.8%

(3) Increased Per Capita Consumption in the Target Area

Through supply capacity augmentation and leakage reduction, effective supply amount will be enhanced with 25,900 m^3/day. Per capita consumption for domestic use will be increased to 65.5 litre/capita/day from the current 46.6 litre/capita/day (increment: 18.9 litre/capita/day).

Table 3.1.4 Effective Supply Amount and Domestic Per Capita Consumption

Service Area	Before Implementation (2000)		After Implementation (2006)	
	Effective Supply Amount (mld)	Domestic Per Capita Consumption (lcd)	Effective Supply Amount (mld)	Domestic Per Capita Consumption (lcd)
Kathmandu	44.6	45.4	64.5	65.7
Bhaktapur	6.3	50.7	8.1	65.2
Lalitpur	13.0	49.1	17.2	64.9
Total (Whole Area)	63.9	46.6	89.8	65.5

(4) Elimination of Affections Associated with Water Quality in the Target Area

At the moment, of the direct-benefited area of the Manohara Project, Madhyapur and west of Bhaktapur are served with untreated groundwater containing a high concentration of iron or ammonium nitrogen. The residents have been suffered from affections associated with water quality.

After Project implemented, these areas will be supplied safe and hygienic water from Manohara water treatment plant where raw water will be taken from Manohara river. The affections associated with water quality of approximately 45,000 residents (for beneficiary population, refer to Table 3.1.1) will be eliminated.

The indirect effects of the Project might be envisioned: through quantitative as well as qualitative improvement of water supply services and securing evenness of service level, satisfaction degree of the residents will be raised towards NWSC waterworks undertaking, thereby contributing to obtaining their cooperation and understandings in the promotion of waterworks facilities provision to come or in the smooth undertaking of waterworks (such as in water tariff lifting-up).

3-2 Recommendations

For the Project effects turning up and keeping on, the below enumerated actions shall be taken by the Government of Nepal, besides the programmed activities and inputs in the Project.

(1) Manning of Operation and Maintenance Personnel

So as to attain the Project Objective, the constructed water supply facilities shall be precisely managed in operation, and their functions be displayed just as planned. For this purpose, not only NWSC shall streamline its organisational structure but the adequate personnel shall be manned in accordance with the requirements in operation and maintenance.

Table 3.2.1 Personnel for Operation and Maintenance

Project	Advisable Number of Personnel	Major Items in Operation and Maintenance	Note
Manohara Project	59	- Management of water intake (intake wells, pump) - Control of water treatment (coagulation-sedimentation, rapid sand filtration, chemicals dissolving and feeding) - Control of water transmission/distribution - Facility maintenance (civil engineering work, mechanical work, electrical equipment)	New construction
Shaibhu Project	20	- Chemicals dissolving and feeding control (sterilising agent) - Control of water distribution - Facility maintenance (civil engineering work, mechanical work, electrical equipment)	Augmentation of the existing system
Total (The Project)	79		

Additionally, at the moment, operation and management of the waterworks undertaking in the Kathmandu Valley is ready to be entrusted to the private operator; however, even after the entrustment brought to effect, the above-mentioned staff force and manpower quality of operation and maintenance personnel shall be appropriately maintained.

(2) Procurement of Spare-parts, etc.

In the Project, the water treatment system made in Japan will be introduced, in view of simplicity as well as durability. Towards these foreign-made equipment, the following measures would be desirable:

(a) NWSC had already laid down the rules and regulation on procurement of spare-parts, etc., in which the required procedures also being established. An application of these to a practical case shall be certainly made.

(b) In order to smoothly undertake repair or replacement for maintenance, a system is desired in which capable and experienced private contractors be registered as the registered contractors and the work be contracted out to them with the predetermined unit price.

(3) Continuation of Water Supply with the Existing Facilities

The supply capacity after Project implementation is assuming that the existing water supply facilities continue their operation. It is required for the existing facilities to be appropriately managed in operation and maintenance as well.

Appendices

1. Member List of the Study Team
2. Study Schedule
3. List of Parties Concerned in the Recipient Country
4. Minutes of Discussions
5. Cost Estimation Borne by the Recipient Country
6. Examination on Leakage Reduction
7. Examination on Water Intake Facilities
8. Examination on Water Treatment System

Appendix 1

Member List of the Study Team

Member List of the Study Team

Study Team member with the duration is shown in the table below.

(1) Site Survey

No	Name	Assignment	Organisation	Duration
1	Eiichiro CHO	Team Leader	Japan International Cooperation Agency First Project Management Div. Grant Aid Management Dept.	Nov. 6 to Nov. 15, 2000
2	Hidetaka AOKI	Project Coordinator	Japan International Cooperation Agency First Project Management Div. Grant Aid Management Dept.	Nov. 6 to Nov. 16, 2000
3	Munetaka MORIO	Project Manager/ Waterworks Planner	Japan Engineering Consultants Co., Ltd. (JEC)	Nov. 6 to Dec. 20, 2000
4	Masari HOSAKA	Management, Operation, and Maintenance Planner	Japan Engineering Consultants Co., Ltd. (JEC)	Nov. 6 to Dec. 15, 2000
5	Kazumi MATSUDA	Facilities Designer 1	Japan Engineering Consultants Co., Ltd. (JEC)	Nov. 6 to Dec. 20, 2000
6	Akihiro MIYAKE	Facilities Designer 2	Japan Engineering Consultants Co., Ltd. (JEC)	Nov. 6 to Dec. 15, 2000
7	Hisatoshi NAITO	Civil Work Planner	Nippon Koei Co., Ltd. (NK)	Nov. 6 to Dec. 15, 2000
8	Michihiko TAWARAYA	Procurement Planner/ Cost Estimator	Japan Engineering Consultants Co., Ltd. (JEC)	Nov. 16 to Dec. 20, 2000

(2) Draft Report Explanation

No	Name	Assignment	Organisation	Duration
1	Eiichiro CHO	Team Leader	Japan International Cooperation Agency First Project Management Div. Grant Aid Management Dept.	July 29 to Aug. 5, 2001
2	Munetaka MORIO	Project Manager/ Waterworks Planner	Japan Engineering Consultants Co., Ltd. (JEC)	July 29 to Aug. 9, 2001
3	Kazumi MATSUDA	Facilities Designer 1	Japan Engineering Consultants Co., Ltd. (JEC)	July .29 to Aug. 9, 2001
4	Michihiko TAWARAYA	Procurement Planner/ Cost Estimator	Japan Engineering Consultants Co., Ltd. (JEC)	July 29 to Aug. 9, 2001

Appendix 2

Study Schedule

Study Schedule

(1) Site Study in Nepal: November 6 to December 20, 2000 (45 days)

<table>
<tr><th>No.</th><th>Month/Day</th><th>Schedule</th><th>Contents</th></tr>
<tr><td>1</td><td>Nov. 6 Mon</td><td>Narita to Bangkok (TG641)
(7 members except Tawaraya)</td><td></td></tr>
<tr><td>2</td><td>7 Tue</td><td>Bangkok to Kathmandu (TG319)</td><td>Briefing and discussion with JICA Nepal Office and Japan Embassy</td></tr>
<tr><td>3</td><td>8 Wed</td><td>Site Survey</td><td>Site study of the existing facilities in the Manohara Project and Bansbari WTP.</td></tr>
<tr><td>4</td><td>9 Thur</td><td>Courtesy Visit to MPPW
Courtesy Visit to NWSC</td><td></td></tr>
<tr><td>5</td><td>10 Fri</td><td>Discussion with NWSC</td><td></td></tr>
<tr><td>6</td><td>11 Sat</td><td>Site Survey</td><td>Site study of the existing facilities in the Shaibhu Project and Mahankal Cahur WTP</td></tr>
<tr><td>7</td><td>12 Sun</td><td>Internal Meeting</td><td>Analysis of survey results</td></tr>
<tr><td>8</td><td>13 Mon</td><td>Discussion with NWSC on the Minutes</td><td>Site study of the existing wells</td></tr>
<tr><td>9</td><td>14 Tue</td><td>Signing of M/D</td><td>Report to Japan Embassy and JICA Nepal Office</td></tr>
<tr><td>10</td><td>15 Wed</td><td>Kathmandu to Bangkok (TG320)
(Mr. Cho and Mr. Aoki)</td><td>Site study of Bhaktapur WTP and the environs</td></tr>
<tr><td>11</td><td>16 Thur</td><td>Bangkok to Narita (TG640)
(Ditto)
Natita to Bangkok (TG641)
(Mr. Tawaraya)</td><td rowspan="5">Survey on:
• Water demand, supply amount and consumption
• Capacity of the existing intake facilities, wells, water treatment plants and service facilities
• Current Operation and Maintenance
• Situation of the existing supply lines
• Tariff system, financial situation and organisation
• Progress on the Melamchi Project and other related projects
• Power supply
• Contractors in Nepal, ability of supplying the materials, equipment and machines and labourers
• Land for temporary work and facilities for temporary supply of electricity
• Laws and regulations for construction work
• Topographic survey, geotechnical site survey and water quality</td></tr>
<tr><td>12
to
38</td><td>Nov. 17 Fri
to
Dec. 13 Wed</td><td>Bangkok to Kathmandu (TG319)
(Ditto)</td></tr>
<tr><td>39</td><td>14 Thur</td><td>Kathmandu to Bangkok (TG320)
(Mr. Hosaka, Miyake and Naito)</td></tr>
<tr><td>40</td><td>15 Fri</td><td>Bangkok to Narita (TG640)
(Ditto)</td></tr>
<tr><td>41
to
42</td><td>16 Sat
to
17 Sun</td><td>Analysis of data collected
Report writing</td></tr>
<tr><td>43</td><td>18 Mon</td><td>Report and discussion with NWSC
Report to Japan Embassy
Report to JICA Nepal Office
(by Morio, Matsuda and Tawaraya)</td><td></td></tr>
<tr><td>44</td><td>19 Tue</td><td>Kathmandu to Bangkok (TG320)</td><td></td></tr>
<tr><td>45</td><td>20 Wed</td><td>Bangkok to Narita (TG640)</td><td></td></tr>
</table>

(2) Draft Report Explanation in Nepal: July 29 to August 9, 2001 (12 days)

No.	Month/Day	Schedule	Content
1	July 29	Narita to Bangkok (TG641)	
2	30	Bangkok to Kathmandu (TG319)	Meeting at JICA Kathmandu Office
3	31	Courtesy Visit to MPPW Visit to NWSC	Explanation of the Draft Report
4	August 1	Visit to NWSC Visit to Melamchi Board	Discussion on the Draft Report Hearing on the Project Progess
5	2	Discussion with NWSC, Site Survey	on the Minutes of discussion (M/D)
6	3	Visit to MPPW	Signing of the M/D
7	4	Kathmandu to Tokyo (Mr. Cho） Site Survey	Manohara site
8	5	Internal Meeting	
9	6	NWSC, JICA Office	
10	7	NWSC, Japan Embassy	Report
11	8	Kathmandu to Bangkok (TG320)	
12	9	Bangkok to Tokyo	

Appendix 3

List of Parties Concerned in the Recipient Country

List of Parties Concerned in the Recipient Country

【Site Study in Nov.2000】

1）Embassy of Japan

Yoshiyuki TOYOGUCHI	Second Secretary

2）Nepal Office of Japan International Cooperation Agency

Ken HASEGAWA	Resident Representative
Tetsuo YABE	Deputy Resident Representative
Kazuhisa ARAI	Resident Officer

3）Ministry of Physical Planning and Works

Mr. Hiranya Lal Regmi	Secretary
Mr. Dhruva Bd. Shrestha	Joint Secretary

4）Nepal Water Supply Corporation

Mr. Kaushal Nath Bhattarai	General Manager
Mr. N.M. Pradhan	Senior Deputy General Manager
Mr. Noor Kumar Tamrakar	Deputy General Manager
Mr. Tilak Mohan Bhandri	Assistant Manager
Mr. Sumil Dhoj Joshi	Deputy Manager

5）Nepal Electricity Authority, Thimi Branch

Mr. Laxmi Bhakta Silpakar	Chief Engineer
Mr. Jagadish Sharma Poudel	Assistant Engineer

6）Nippon Koei Co., Ltd.

Mr. Yoshihiro Nabeta	Team Leader of Management Consultant: for Melamchi Project

【Draft Report Explanation in July 2001】

1）Embassy of Japan

Yoshiyuki TOYOGUCHI	Second Secretary

2）Nepal Office of Japan International Cooperation Agency

Eitaro MITOMA	Resident Representative
Tetsuo YABE	Deputy Resident Representative
Katsuzi MIYATA	Resident Officer
Mr. Sourab Bickram Rane	Local Officer

3）Ministry of Physical Planning and Works

Mr. Dinesh C Pyakural	Secretary
Mr. Shree Ram Shrestha	Joint Secretary
Mr. Sohan Sundar Shresta	Joint Secretary

4）Nepal Water Supply Corporation

Mr. Kaushal Nath Bhattarai	General Manager
Mr. N.M. Pradhan	Senior Deputy General Manager
Mr. Mukunda Nanda Baidya	Deputy General Manager
Mr. Madan Shankar Shrestha	Manager
Mr. Madav Narayan Shrestha	Assistant Manager
Mr. Tilak Mohan Bhandri	Assistant Manager
Mr. Sumil Dhoj Joshi	Deputy Manager
Mr. Suriya Bhakta Shrestha	Deputy Manager

Appendix 4

Minutes of Discussions

MINUTES OF DISCUSSIONS

THE BASIC DESIGN STUDY
ON
THE PROJECT
FOR
IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES
IN
THE KINGDOM OF NEPAL

Based on the results of the Preparatory Study, the Government of Japan decided to conduct a Basic Design Study on the Project for Improvement of Kathmandu Water Supply Facilities (hereinafter referred to as "the Project") and entrusted the study to Japan International Cooperation Agency (hereinafter referred to as "JICA").

JICA sent to the Kingdom of Nepal (hereinafter referred to as "Nepal") the Basic Design Study Team (hereinafter referred to as "the Team"), which is headed by Mr. Eiichiro Cho, Deputy Director, Grant Aid Management Department, JICA, and is scheduled to stay in the country from November 7, 2000 to December 19, 2000.

The Team held discussions with the officials concerned of the Government of Nepal and conducted a field survey at the study area.

In the course of discussions and field survey, both parties confirmed the main items described on the attached sheets. The Team will proceed to further study and prepare the Basic Design Study Report.

Kathmandu, 14th November 2000

長 英一郎

Eiichiro CHO
Leader
Basic Design Study Team
Japan International Cooperation Agency

Dhruva Bd. Shrestha
Joint Secretary
Water Supply and Sanitation Division
Ministry of Physical Planning and Works

Kaushal Nath Bhattarai
General Manager
Nepal Water Supply Corporation

ATTACHMENT

1. **Objective of the Project**

The objective of the Project is to improve water supply situation in Kathmandu, Lalitpur and Bhaktapur municipalities in order to promote public health and to secure a stable living of inhabitants through the implementation of the Project.

2. **Project Site**

The sites of the Project are Manohara and Shaibhu areas in the Kathmandu valley (see map in Annex-I).

3. **Responsible and Implementation Agency**

The Responsible Agency is the Ministry of Physical Planning and Works (MPPW) and the Implementation Agency is Nepal Water Supply Corporation (NWSC).

4. **Items Requested by the Government of Nepal**

After discussions with the Team, the sites and the components described in Annex-II were finally requested by the Nepalese side. However, both sides agreed that the final components of the Project will be determined by the Japanese side after further studies in Nepal and Japan.

5. **Japan's Grant Aid System**

The Nepalese side understands the Japan's Grant Aid Scheme and the necessary measures to be taken by the Government of Nepal as explained by the Team and described in Annex-III and Annex-IV.

6. **Schedule of the Study**

1) The consultants will proceed to further studies in Nepal until December 19, 2000.
2) JICA will prepare the draft final report in English and dispatch a mission in order to explain its contents in February 2001.
3) In case that the contents of the report are accepted in principle by the Government of Nepal, JICA will complete the final report and send it to the Government of Nepal by May 2001.

7. **Other Relevant Issues**

1) The Nepalese side strongly requested the Team early implementation of the Project.

2) Both sides confirmed again that Melamchi project took into consideration of additional water supply capacity by the implementation of the Project. It was also felt that the project would greatly relieve the acute shortage of water to be increasingly faced during the 6 years implementation period of Melamchi project.

3) Both sides agreed that the target year will be around 2005, a few years after the completion of the Project. However, the exact target year will be determined accordingly after detailed study in Japan.

4) The Nepalese side understood that the components, sizes, dimensions and locations of the requested facilities will be reviewed based on the field survey in Nepal and further study in Japan with aim to achieve maximum output with available resources.
The specific points are as follows;
   a) the alternative locations for both project sites,
   b) the type of chemical dosing and disinfection system,
   c) the size of facilities after estimation of water demand.

5) The Team explained that problems on operation and maintenance of the existing facilities constructed by Japanese Grant Aid shall be reflected in the design for the Project so that the situation does not occur again.

6) Both sides agreed that the areas which will be directly benefited are southeast of Kathmandu, Madhyapur and the west of Bhaktapur by Manohara project, and Lalitpur by Shaibhu project. And the other water supply service area of NWSC will be indirectly benefited, where water supply of the existing system will be more effective by the implementation of the Project.

7) The water quality standard of the Project will be as per the WHO guideline.

8) The Nepalese side explained the progress of the Melamchi project as follows;
The Government Mission has already dispatched to Manila for loan negotiation with ADB Headquarter from November 13, 2000.
According to the tentative schedule, full operation of Melamchi project is scheduled to start in the middle of 2006.

9) The Nepalese side explained the progress of the Management Contract for water supply facilities in Kathmandu assisted by the World Bank as follows; Private Operator is scheduled to start in September 2001.

After the completion of the Project, Private Operator shall operate and maintain the facilities in Manohara and Shaibhu as well as the existing facilities in Bansbari and Mahankal Chaur.

But, Private Operator does not aim at full privatization and it will be regulated by an independent body of the government.

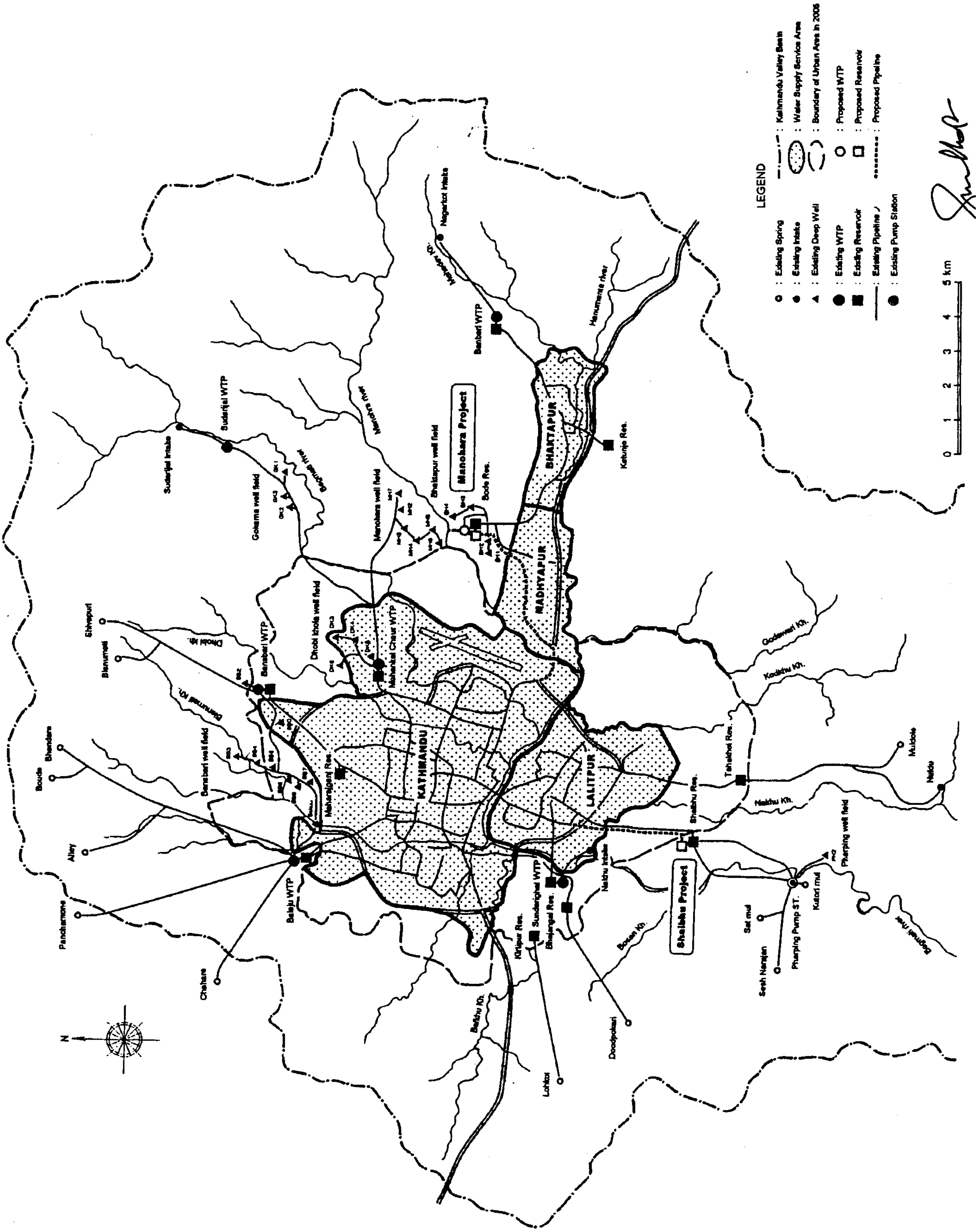
Management policy shall be decided by the operator but ownership of the facilities shall remain to NWSC as per the Nepalese law.

10) The Nepalese side will be responsible to coordinate the Project and the Melamchi project for their consistency between the respective project.

11) The Team will show the map of the Project sites for land acquisition needed for the implementation of the Project in February 2001. In accordance with the map, the Government of Nepal will complete land acquisition and compensation for property before the commencement of the Project.

Annex-I

Location Map



A-1

Annex-II

Items Requested by the Nepalese side

1. Manohara project

   a) Construction of an infiltration gallery type water intake on the Manohara river.

   b) Construction of a raw water conveyance facility from the water intake to the water treatment plant with a capacity of 23,000m^3/day.

   c) Construction of a water treatment plant with a treatment capacity of 23,000m^3/day.

- Bio-filter:	Capacity 8,000m^3/day
- Flocculation basin:	Vertical-baffling type
- Sedimentation basin:	Latitudinal-flow type
- Sludge removal facilities:	Hopper type
- Rapid sand filter:	Self-washing type
- Chemical feeding equipment:	Coagulant (alum), Alkali (lime)
- Disinfection equipment:	Bleaching powder, Sodium hypochlorite

   d) Construction of a service reservoir with a capacity of 3,000m^3.

   e) Installation of a new distribution main with a diameter of 350mm and a length of 7,500m from the new reservoir to Kathmandu city.

2. Shaibhu project

   a) Construction of a new service reservoir with a capacity of 4,500m^3.

   b) Installation of a new distribution main with a diameter of 350mm and a length of 3,500m from the new reservoir to Lalitpur city.

   c) Provision of disinfection equipment for bleaching powder and sodium hypochlorite.

   d) Provision of equipment and instruments for monitoring water quality.

Annex-III

Japan's Grant Aid Scheme

1. Grant Aid Procedures

(1) Japan's Grant Aid Program is executed through the following procedures.

Application	(Request made by a recipient country)
Study	(Basic Design Study conducted by JICA)
Appraisal & Approval	(Appraisal by the Government of Japan and Approval by Cabinet)
Determination of Implementation	(The Notes exchanged between the Governments of Japan and the recipient country)

(2) Firstly, the application or request for a Grant Aid project submitted by a recipient country is examined by the Government of Japan (the Ministry of Foreign Affairs) to determine whether or not it is eligible for Grant Aid. If the request is deemed appropriate, the Government of Japan assigns JICA (Japan International Cooperation Agency) to conduct a study on the request.

Secondly, JICA conducts the study (Basic Design Study), using (a) Japanese consulting firm(s).

Thirdly, the Government of Japan appraises the project to see whether or not it is suitable for Japan's Grant Aid Program, based on the Basic Design Study report prepared by JICA, and the results are then submitted to the Cabinet for approval.

Fourthly, the project, once approved by the Cabinet, becomes official with the Exchange of Notes signed by the Governments of Japan and the recipient country.

Finally, for the implementation of the project, JICA assists the recipient country in such matters as preparing tenders, contracts and so on.

2. Basic Design Study

(1) Contents of the Study

The aim of the Basic Design Study (hereinafter referred to as "the Study"), conducted by JICA on a requested project (hereinafter referred to as "the Project") is to provide a basic document necessary for the appraisal of the Project by the Japanese Government. The contents of the Study are as follows:

1) Confirmation of the background, objectives, and benefits of the requested project and also institutional capacity of agencies concerned of the recipient country necessary for the Project's implementation.

2) Evaluation of the appropriateness of the Project to be implemented under the Grant Aid Scheme from a technical, social and economic point of view.

3) Confirmation of items agreed on by both parties concerning the basic concept of the Project.

4) Preparation of a basic design of the Project.

5) Estimation of costs of the Project.

The contents of the original request are not necessarily approved in their initial form as the contents of the Grant Aid project. The Basic Design of the Project is confirmed considering the guidelines of Japan's Grant Aid Scheme.

The Government of Japan requests the Government of the recipient country to take whatever measures are necessary to ensure its self-reliance in the implementation of the Project. Such measures must be guaranteed even though they may fall outside of the jurisdiction of the organization in the recipient country actually implementing the Project. Therefore, the implementation of the Project is confirmed by all relevant organizations of the recipient country through the Minutes of Discussions.

(2) Selection of Consultants

For smooth implementation of the Study, JICA uses (a) registered consultant firm(s). JICA selects (a) firm(s) based on proposals submitted by interested firms. The firm(s) selected carry(ies) out a Basic Design Study and write(s) a report, based upon terms of reference set by JICA.

The consulting firm(s) used for the Study is (are) recommended by JICA to the recipient country to also work in the Project's implementation after the Exchange of Notes, in order to maintain technical consistency.

3. Japan's Grant Aid Scheme

(1) Grant Aid

The Grant Aid Program provides a recipient country with non-reimbursable funds to procure facilities, equipment and services (engineering services and transportation of the products, etc.) for economic and social development of the country under principles in accordance with the relevant laws and regulations of Japan. Grant Aid is not supplied through the donation of materials as such.

(2) Exchange of Notes (E/N)

Japan's Grant Aid is extended in accordance with the Notes exchanged by the Governments concerned, in which the objectives of the Project, period of execution, conditions and amount of the Grant Aid, etc. are confirmed.

(3) "The period of the Grant Aid" means the one fiscal year which the Cabinet approves the Project for. Within the fiscal year, all procedures such as exchanging of the Notes, concluding contracts with (a) consultant firm(s) and (a) contractor(s) and a final payment to them must be completed.

However in case of delays in delivery, installation or construction due to unforeseen factors such as weather, the period of the Grant Aid can be further extended for a maximum of one fiscal year by mutual agreement between the two Governments.

(4) Under the Grant Aid, in principle, Japanese products and services including transport or those of the recipient country are to be purchased.

When the two Governments deem it necessary, the Grant Aid may be used for the purchase of the products or services of a third country.

However the prime contractors, namely, consulting, contracting and procurement firms, are limited to "Japanese nationals". (The term "Japanese nationals" means persons of Japanese nationality or Japanese corporations controlled by persons of Japanese nationality.)

(5) Necessity of "Verification"

The Government of recipient country or its designated authority will conclude contracts denominated in Japanese yen with Japanese nationals. Those contracts shall be verified by the Government of Japan. This "Verification" is deemed necessary to secure accountability to Japanese taxpayers.

(6) Undertakings required of the Government of the Recipient Country

In the implementation of the Grant Aid project, the recipient country is required to undertake such necessary measures as the following:

1) To secure land necessary for the sites of the Project, and to clear, level and reclaim the land prior to commencement of the construction.

2) To provide facilities for the distribution of electricity, water supply and drainage and other incidental facilities in and around the sites.

3) To secure buildings prior to the procurement in case the installation of the equipment.

4) To ensure all the expenses and prompt execution for unloading, customs clearance at the port of disembarkation and internal transportation of the products purchased under the Grant Aid.

5) To exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which will be imposed in the recipient country with respect to the supply of the products and services under the Verified Contracts.

6) To accord Japanese nationals whose services may be required in connection with the supply of the products and services under the Verified Contracts, such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work.

7) Proper Use

The recipient country is required to maintain and use the facilities constructed and equipment purchased under the Grant Aid properly and effectively and to assign staff necessary for this operation and maintenance as well as to bear all the expenses other than those covered by the Grant Aid.

8) Re-export

The products purchased under the Grant Aid should not be re-exported from the recipient country.

9) Banking Arrangement (B/A)

(a) The Government of the recipient country or its designated authority should open an account in the name of the Government of the recipient country in a bank in Japan (hereinafter referred to as "the Bank"). The Government of Japan will execute the Grant Aid by making payments in Japanese yen to cover the obligations incurred by the Government of the recipient country or its designated authority under the verified contracts.

(b) The payments will be made when payment requests are presented by the Bank to the Government of Japan under an authorization to pay issued by the Government of the recipient country or its designated authority.

Annex-IV

Major Undertaking to be taken by Each Government

No.	Items	To be covered by Grant Aid	To be covered by Recipient Side
1	To secure land		●
2	To clear, level and reclaim the site when needed		●
3	To construct gates and fences in and around the site		●
4	To bear the following commissions to a bank of Japan for the banking services based upon the B/A		
	1) Advising commission of A/P		●
	2) Payment commission		●
5	To ensure prompt unloading and customs clearance at port of disembarkation in recipient country		
	1) Marine (Air) transportation of the products from Japan to the recipient country	●	
	2) Tax exemption and custom clearance of the products at the port of disembarkation		●
	3) Internal transportation from the port of disembarkation to the project site	●	
6	To accord Japanese nationals whose services may be required in connection with the supply of the products and the services under the verified contact such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work		●
7	To exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which may be imposed in the recipient country with respect to the supply of the products and services under the verified contact		●
8	To maintain and use properly and effectively the facilities constructed and equipment provided under the Grant Aid		●
9	To bear all the expenses, other than those to be borne by the Grant Aid, necessary for construction of the facilities		●

MINUTES OF DISCUSSIONS
ON
THE BASIC DESIGN STUDY
ON
THE PROJECT
FOR
IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES
IN
THE KINGDOM OF NEPAL

(EXPLANATION ON DRAFT FINAL REPORT)

In November 2000, the Japan International Cooperation Agency (hereinafter referred to as JICA) dispatched a Basic Design Study Team on the Project for the Improvement of Kathmandu Water Supply Facilities (hereinafter referred to as the Project) to the Kingdom of Nepal (hereinafter referred to as Nepal), and through discussion, field survey, and technical examination of the results in Japan, JICA prepared a draft report of the study.

In order to explain and to consult Nepal on the components of the draft report, JICA sent to Nepal the Draft Final Report Explanation Team (hereinafter referred to as the Team), which is headed by Eiichiro CHO, Deputy director, Grant Aid Management Department, JICA, from July 30 to August 8, 2001.

As a result of discussions, both parties confirmed the main items described on the attached sheets.

Kathmandu, August 3, 2001

長 英一郎

Eiichiro CHO
Leader
Basic Design Study Team
Japan International Cooperation Agency
(JICA)

Shree Ram Shrestha
Joint Secretary
Ministry of Physical Planning and Works
(MPPW)

Kaushal Nath Bhattarai
General Manager
Nepal Water Supply Corporation
(NWSC)

ATTACHMENT

1. Components of the Draft Final Report

The Nepalese side agreed and accepted in principle the components of the Draft Final Report explained by the Team. After discussions with the Team, both sides have confirmed the sites and components which will be constructed or procured under the Japanese Grant Aid listed in Annex-I.

2. Japan's Grant Aid Scheme

The Nepalese side understands the Japan's Grant Aid Scheme and the necessary measures to be taken by the Government of Nepal as explained by the Team and described in Annex-III and Annex-IV of the Minutes of Discussions signed by both parties on November 14, 2000.

3. Schedule of the Study

JICA will complete the final report in accordance with the confirmed items and send it to Nepal by November 2001.

4. Other Relevant Issues

(1) Responsible and Implementing Organization

The Responsible organization of the Project is the Ministry of Physical Planning and Works (MPPW) and the Implementing Agency is the Nepal Water Supply Corporation (NWSC).

(2) Operation and Maintenance of Facilities

The Nepalese side should be responsible for operation and maintenance of facilities to be constructed under the Project. Each system at the Project site should raise enough funds to cover the costs for the proper operation and maintenance of the facilities.

(3) Implementation of EIA

The Team requested the Nepalese side to implement EIA (Environment Impact Assessment) in accordance with "Environmental Protection Act, 1997". The Nepalese side answered that MPPW and NWSC will take necessary procedures in consultation with the Ministry of Population and Environment including countermeasures, which are necessary to mitigate negative impact, if necessary. The Team requested the Nepalese side to submit the document on EIA through JICA Nepal office to JICA Headquarter within three (3) months after the signing of Exchange of Notes for the Project. The Nepalese side agreed on it.

(4) Guarantee Letter for Land Acquisition

The Team requested the Nepalese side to submit the document, which guarantees the usage of necessary land for the Project within three (3) months after the signing of Exchange of Notes for the Project through JICA Nepal office to JICA Headquarter. The Nepalese side agreed on it.

(5) Power Supply

The Team requested the Nepalese side to install an electric line (11KV overhead feeder) between Thimi service station and the water intake site (required capacity of 300 KVA) and the water treatment plant site (required capacity of 750 KVA) of the Project. The Nepalese side requested the Team to provide generators for water intake and water treatment facilities. For this, the Team requested the Nepalese side to seek an assurance from NEA not to stop power supply to the facilities of the Project during load shedding at the Project sites. The Nepalese side agreed on the above-mentioned matters.

(6) Temporary Stock Yard

The Team requested the Nepalese side to provide temporary yard, which is necessary to stock construction materials during the construction period of the Project. The Nepalese side agreed on it.

(7) Sterilising Agent

The Nepalese side requested the Team to adopt sodium hypochlorite as sterilising agent. The Team answered it is difficult to be included into the Project because constant usage of repaired sodium hypochlorite generator at Mahankal Chaur, which has been out of use for about three (3) years, should be confirmed.

(8) Bio-filter

Regarding Manohara system, the Nepalese side requested the Team to construct a bio-filter. The Team answered it is difficult because groundwater would not be used as water source in Manohara system.

(9) Installation of Transmission Pipe

The Nepalese side requested the Team to install a transmission pipe between Bode reservoir and Katunje reservoir of approx. 600m in length. The Team answered it is difficult because it is out of scope of the Project. The Team asked the Nepalese side to install the pipe by their own expense.

(10) Design of Elevated Tanks

The Nepalese side requested the Team to make better design on out looking of elevated tanks. The Team answered to consider the request.

(11) Progress of Private Operator

The Nepalese side explained that re-invitation for letter of interest from private operators has been published because of withdrawal by two (2) companies out of three (3) which were short-listed earlier. Tentative schedule of the commencement of Private Operator will be February 2003.

(12) Request for Technical Cooperation

The Nepalese side requested the Team to include technical cooperation into the Project for the proper management and operation of the facilities. The Team answered to convey the request to related organizations in TOKYO and asked to submit necessary documents to the Japanese Embassy in Kathmandu.

(13) Keeping Documents Confidential

The Team handed six (6) copies of the draft reports and three (3) copies of drawings to the Nepalese side. Both sides agreed that these documents are confidential and should not be duplicated or released to any outside parties except for MPPW and NWSC.

Annex-I

THE PROJECT SITES AND COMPONENTS

(1) Manohara Project

1) Intake Facilities

- Planned intake amount:	21,700 m^3/day
- Shallow wells:	8 nos. (diameter: 4 m, depth: 6.4 m)
- Intake pumps:	8 nos.
- Electrical equipment:	Transformer 300KVA × 1 no.

2) Raw Water Conveyance Pipe

- Conveyance pipe:	PVC ϕ 125 - 400 mm × 1,796 m

3) Water Treatment Plant

(a) Facility capacity

- Planned treatment amount:	21,700 m^3/day (Planned supply amount × 1.05)
- Planned supply amount:	20,700 m^3/day

(b) Receiving well and mixing basin

- Capacity:	83.5 m^3 × 1 basin
- Mixing method:	gravity fall

(c) Flocculation basin

- Capacity:	454 m^3 (18 basins)
- Type of flocculation:	vertical baffling

(d) Sedimentation basin

- Capacity:	920 m^3 × 3 basins
- Sludge removal equipment:	hopper type

(e) Rapid sand filtration basin

- Filtration area of basin:	22.68 m^2 × 8 basins
- Replenishment pump:	1 unit
- Surface washing pump:	2 units

(f) Clear water reservoir

- Capacity:	561 m^3 × 2 basins

(g) Chemical dissolution and feeding equipment

- Coagulant (PAC):	1 Ls.
- Sodium hydroxide:	1 Ls.
- Bleaching powder:	1 Ls.

(h) Sludge and drainage basin

- Capacity:	202 m^3 × 2 basins
- Supernatant water return pump:	2 units
- Drainage pump:	2 units

(i) Sludge drying bed

- Capacity:	280 m^3 × 4 beds

(j) Sampling equipment
- Sampling pump: 2 units
- Residual chlorine meter 1 no.

(k) Internal water supply unit
- Supply pump: 2 units

(l) Water Quality Monitoring Equipment
- Equipment for laboratory: 1 Ls.

(m) Electrical Equipment
- Transformer: 750KVA × 1 no.
- Distribution panel: 1 Ls.

4) Transmission Facilities

(a) Bhaktapur West and Madhyapur service area
- Transmission pump: 3 units
- Transmission main: DCIP ϕ 250 mm × 382 m

(b) Kathmandu Southeast service area
- Transmission pump: 5 units
- Transmission main: PVC ϕ 350 mm × 8,251 m
  DCIP ϕ 350 mm × 172 m

5) Elevated Tanks

(a) Min Bhawan elevated tank
- Capacity: 3,080 m^3 × 1 no.

(b) Singha Durbar elevated tank
- Capacity: 2,700 m^3 × 1 no.

(2) Shaibhu Project

1) Distribution facilities

- Distribution reservoir: 2,700 m^3 × 1 reservoir
- Sterilisation equipment: 1 Ls. (bleaching powder)
- Electrical equipment: 1 Ls.
- Water quality monitoring equipment: 1 Ls. (potable type)

2) Distribution main

New reservoir to North-east Lalitpur service area

- Distribution main: PVC ϕ 300 mm × 3,454 m
  DCIP ϕ 300 mm × 46 m
  PVC ϕ 350 mm × 1,263 m

Appendix 5

Cost Estimation Borne by the Recipient Country

Cost Estimation Borne by the Recipient Country

(Unit: NRs.)

	Unit	Q'ty	Unit Price	Amount	Remarks
1. Expropriation of Land					
(a) Water Intake					
- Intake wells	m^2	2,000	400	800,000	Market price
- Maintenance road	m^2	1,600	400	1,040,000	- ditto -
(b) Water Treatment Plant	m^2	13,100	2,000	26,200,000	- ditto -
(c) Elevated Tank					
- Min Bhawan elevated tank	m^2	1,000	9,500	9,500,000	- ditto -
- Singha Durbar elevated tank	m^2	1,000	12,800	12,800,000	- ditto -
Sub-total				49,940,000	
2. Power Supply Work	LS.	1		6,480,000	NEA's Quotation
3. Fence and Gate Work	LS.	1		1,500,000	Local Contractor's Quotation
4. Improvement of Distribution Pipe in Bhaktapur & Madhyapur	LS.	1		30,000,000	NWSC's Estimation
Total				87,920,000	

Note: Lands for both of the above two elevated tanks belong to HMG/N.

Appendix 6

Examination on Leakage Reduction

Examination on Leakage Reduction

1. Preamble

In the Project, water demand in the target year 2006 is estimated to be 101.4 MLD (on the basis of effective supply amount), augumented with 37.5 MLD from the current water demand of 63.9 MLD. On the other hand, the augmentation of supply capacity would be confined to 20.6 MLD, in the Project. Accordingly, only augmenting supply capacity might not fulfill the water demand.

In this context, in the Project, the existing water supply service areas shown in Fig. 2.2.2, shall be sub-divided, coinciding with the water supply facilities provided, supply capacity of the planned water supply facilities, and areal demand distribution; as shown in Fig. 2.2.3, in order to reduce the currently high leakage ratio (43.5%), through making supply pressure distribution even as well as reducing the average supply pressure. Hereunder, estimated is the leakage in the case water supply facilities constructed and service area sub-divided, according to a plan in the Project.

2. Leakage Estimation Method

As an estimation method of leakage reduction reduction derived from the sub-division of water supply service areas, the following equation shall be adopted, in which the determinant parameters are the altered area of water supply associated with alteration and sub-division of the service area, and the altered supply pressure (elevation differance between the service area and the distribution reservoir, etc. before and after the Project implementation) associated with the new installation of the elevated tank and the distribution pipes:

[Equation of Leakage Estimation after the Project Implementation]

$$L = \sum_{i=1}^{n} Q \times \alpha \times \left(\frac{A}{Ao}\right) \times \frac{Ai}{A} \times \left(\frac{Pi}{Po}\right)^{\beta}$$

$$= \sum_{i=1}^{n} Q \times \alpha \times \left(\frac{Ai}{Ao}\right) \times \left(\frac{Pi}{Po}\right)^{\beta}$$

$$A = \sum_{i=1}^{n} Ai$$

, where

L: Leakage after sub-division of the service area (MLD)

Q: Planned supply amount in the service area (MLD)

α: Leakage ratio before sub-division of the service area

Ao: Area of the servive area before sub-division (km^2)

Ai: Area of each sub-divided area (km^2)

A: Area of the service area after sub-division (km^2)

Po: Avarage supply pressure in the service area before sub-division (kgf/cm^2)

Pi: Average supply pressure in each sub-divided area (kgf/cm^2)

β: Exponent (=1.15)

Reference: “Practical Water Leak Survey” March 1995, Japan Water Pipe System Research Center (JPRC)

3. Estimated Effects

In Table A6.1, indicated are parameters of the equation such as area and average lelevation of the respectice service areas, and elevation and supply amount of the reservoir/elevated tank supplying water to these areas, the current and after the Project implementation; as well as the calculation results. The effects of the Project, according to the estimation results in the Table, are as under.

Effects of the Project

	Kathmandu		Bhaktapur		Lalitpur		Total (The Whole Area)	
	Before (2000)	After (2006)	Before (2000)	After (2006)	Before (2000)	After (2006)	Before (2000)	After (2006)
Supply Capacity (MLD)	74.0	90.8	11.1	12.8	28.0	30.1	113.1	133.7
Leakage (MLD)	29.4	26.3	4.8	4.7	15.0	12.9	49.2	43.9
Leakage Rate (%)	39.7	28.9	43.2	36.7	53.6	42.9	43.5	32.8
Effective Supply Amount (MLD)	44.6	64.5	6.3	8.1	13.0	17.7	63.9	89.8
Domestic Per Capita Consumption (lcd)	45.4	65.7 (88.8%)	50.7	65.2 (88.0%)	49.1	64.9 (87.8%)	46.6	65.5 (88.6%)

Remarks: (1) Target domestic per capita consumption in target year 2006: 74.0 lcd.
(2) ( ): Fill-up ratio against the domestic per capita consumption target.

Table A6.1 Water Supply Situation of the Current and After the Project Implementation

Kathmandu Service Area

	Name of Water Supply Service Area	Area (km^2)	Elevation (m)	Reservoir/Elevated Tank: Name	Reservoir/Elevated Tank: Elevation (m)	Supply Pressure (kgf/cm^2)	Supply Amount (MLD)	Leakage Ratio (%)	Leakage (MLD)	Effective Supply (MLD)	Remarks
Current	1. Mahankal Chaur	26.26	1,305.1	Mahankal Chaur	1,335.9	3.08	39.8	32.2	12.8	27.0	
	2. Bansbari										
	2.1 Bansbari (Upstream)	10.44	1,315.7	Bansbari	1,368.1	5.24	20.8	48.6	10.1	10.7	
	2.2 Bansbari (Downstream)	3.74	1,302.1	Bansbari	1,368.1	6.60					
	3. Balaju	6.83	1,300.1	Balaju	1,353.3	5.32	7.5	42.7	3.2	4.3	
	4. Sundarighat	3.40	1,297.7	Sundarighat	1,358.4	6.07	5.9	55.9	3.3	2.6	
	Total	50.67					74.0	39.7	29.4	44.6	
Planned	1. Mahankal Chaur										
	1.1 Mahankal Chaur	12.93	1,314.6	Mahankal Chaur	1,335.9	2.13	56.6	23.0	13.0	43.6	14.8 MLD from Manohara Project 2.0 MLD from Shaibhu Project
	1.2 Min Bhawan	9.60	1,299.0	Min Bhawan	1,319.6	2.06					
	1.3 Singha Durbar	4.19	1,294.1	Singha Durbar	1,313.9	1.98					
	1.4 Newly-Created SA	1.73	1,289.7	New Shaibhu	1,320.0	3.03					
	2. Bansbari										
	2.1 Bansbari (Upstream)	9.17	1,317.5	Bansbari	1,368.1	5.06	20.8	34.9	7.3	13.6	
	2.2 Bansbari (Downstream)	3.74	1,302.1	Maharajgunj	1,329.6	2.75					
	3. Balaju	5.91	1,301.1	Balaju	1,353.3	5.22	7.5	36.1	2.7	4.8	
	4. Sundarighat	3.40	1,297.7	Sundarighat	1,358.4	6.07	5.9	55.9	3.3	2.6	
	Total	50.67					90.8	28.9	26.3	64.5	

Remark: "Bansbari (Downstream)" be supplied water from Maharajgunj Reservoir, after the Project implementation.

Bhaktapur Service Area

	Name of Water Supply Service Area	Area (km^2)	Elevation (m)	Reservoir/Elevated Tank: Name	Reservoir/Elevated Tank: Elevation (m)	Supply Pressure (kgf/cm^2)	Supply Amount (MLD)	Leakage Ratio (%)	Leakage (MLD)	Effective Supply (MLD)	Remarks
Current	1. East Bhaktapur	4.15	1,321.0	Bansbari	1,360.8	3.98	6.9	43.2	3.0	3.9	
	2. Madhyapur	10.16	1,308.4	Bode	1,360.0	5.16	4.2	43.2	1.8	2.4	
	Total	14.31					11.1	43.2	4.8	6.3	
Planned	1. East Bhaktapur	3.02	1,320.7	Bansbari	1,360.8	4.01	6.9	31.7	2.2	4.7	
	2. Madhyapur										
	2.1 West Bhaktapur	3.41	1,313.6	Katunje	1,347.4	3.38	5.9	42.5	2.5	3.4	5.9 MLD from Manohara Project
	2.2 Madhyapur	7.88	1,308.3	Bode	1,360.0	5.17					
	Total	14.31					12.8	36.7	4.7	8.1	

Remark: "West Bhaktapur" be supplied water from Katunje Reservoir, after the Project implementation.

Table A6.1 Water Supply Situation of the Current and After the Project Implementation

Lalitpur Service Area

	Name of Water Supply Service Area	Area (km^2)	Elevation (m)	Reservoir/Elevated Tank Name	Reservoir/Elevated Tank Elevation (m)	Supply Pressure (kgf/cm^2)	Supply Amount (MLD)	Leakage Ratio (%)	Leakage (MLD)	Effective Supply (MLD)	Remarks
Current	1. Shaibhu	12.34	1,301.6	Shaibhu	1,340.0	3.84	20.4	53.6	12.6	7.8	
Current	2. Tahakel VDC	3.27	1,321.2	Tahakel	1,360.0	3.88	7.6	53.6	2.4	5.2	
Current	Total	15.61					28.0	53.6	15.0	13.0	
Planned	1. Shaibhu										
Planned	1.1 Shaibhu VDC	1.66	1,283.7	Shaibhu	1,320.0	3.63	22.5	39.2	8.8	13.7	2.1 MLD from Shaibhu Project
Planned	1.2 West Shaibhu	2.94	1,298.6	Shaibhu	1,340.0	4.14					
Planned	1.3 South East Shaibhu	4.03	1,313.8	Shaibhu	1,340.0	2.62					
Planned	1.4 North East Shaibhu	3.71	1,298.8	New Shaibhu	1,320.0	2.12					
Planned	2. Tahakel VDC	3.27	1,321.2	Tahakel	1,360.0	3.88	7.6	53.6	4.1	3.5	
Planned	Total	15.61					30.1	42.9	12.9	17.2	

Remarks: (1) The elevation of Shaibhu reservoir and Tahakel reservoir id 1,374.8m and 1,497.4m, respectively. In view of the upper part of distribution pipes not filled with water, the elevation has been set, according to the pressure measurement at the time of field investigation.

(2) With the implementation of the Shaibhu Project, it would be possible for the respective divided areas to be supplied water through individual distribution pipes; the supply pressure shall, accordingly, be adjusted, according to the elevation of the service area.

Appendix 7

Examination on Water Intake Facilities

Examination on Water Intake Facilities

1. Planned Water Intake

The planned intake amount of Manohara river water and the existing groundwater, which is planned as the water source in the Manohara Project, shall be based on the possible intake amount (Table A7.1) in JICA Master Plan Study considering the existing water rights.

Table A7.1 Possible Intake Amount in Manohara Project

(Unit: 1,000 m^3/day)

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Possible intake amount	River water	44.0	26.7	13.8	13.8	18.1	32.8	508.0	770.6	481.2	146.0	92.4	54.4
	Groundwater	—	8.4	8.4	8.4	8.4	—	—	—	—	—	—	—
	Total	44.0	35.1	22.2	22.2	26.5	32.8	508.0	770.6	481.2	146.0	92.4	54.4

Source: JICA Master Plan Study, 1990.

The groundwater taken here from the existing deep wells is of no good quality. An appropriate pre-treatment is required in the use as raw water for waterworks. The duration of using the groundwater for substitution when river discharge is reduced being short, only 2 months, the cost of groundwater intake as raw water would be almost 8 times that of river water.

Consequently, the existing groundwater shall be converted for irrigation purpose, and, for the substitution, the same amount as at present groundwater taken, shall be taken from Manohara River, as the source in the Manohara Project. The planned intake amount in the Manohara Project is, considering the above possible intake amount as well as seasonal fluctuation of water demand, as shown in Table A7.2.

Table A7.2 Planned Intake Amount in Manohara Project

(Unit: 1,000 m^3/day)

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Planned intake amount	River water	18.5	18.3	13.8	13.8	17.9	20.1	21.5	21.7	21.4	20.9	20.0	17.9
	Groundwater substitution	—	—	4.2	4.3	—	—	—	—	—	—	—	—
	Total	18.5	18.3	18.0	18.1	17.9	20.1	21.5	21.7	21.4	20.9	20.0	17.9

2. Existing Intake Wells

(1) Operating Situation

Near the planned intake point in the Manohara Project, intake wells constructed by NWSC are in operation. Facility layout and structure of the wells are shown in Fig. A7.1 and Fig. A7.2, respectively.

The structure of the existing intake wells is, as shown in the Figures, a shallow well of 3 m diameter and 6 m depth, with a set of perforated water collecting pipes (11 m length, ϕ200 mm) installed to the direction of Manohara River, to augment the intake amount.

At Intake Well No.1 2 pumps of pumping capacity 1.0 m^3/min., and at Intake Well No.2 2 pumps of capacity 1.3 m^3/min. and capacity 0.9 m^3/min., are installed. A stable intake of river bed water has been undertaken since the commissioning in December 1998. Table A7.3 depicts the past performance of these intake wells.

Table A7.3 Discharge in the Existing Wells

(Unit: m^3/day)

Year	Month	Intake Well No.1		Intake Well No.2		Total
		Pump No.1	Pump No.2	Pump No.3	Pump No.4	
1998	Dec.	747	385	1,486	−	2,618
1999	Jan.	−	490	1,507	−	1,997
	Feb.	−	870	1,577	−	2,447
	Mar.	537	861	1,422	−	2,820
	Apr.	657	768	1,768	−	3,193
	May	1,053	1,198	1,759	−	4,010
	June	−	1,378	2,058	−	3,436
	July	−	1,426	1,908	−	3,334
	Aug.	−	1,372	1,784	−	3,156
	Sept.	485	1,064	1,817	−	3,366
	Oct.	79	1,105	1,769	−	2,953
	Nov.	−	1,358	1,763	−	3,121
	Dec.	−	1,365	1,713	−	3,078
2000	Jan.	−	1,173	1,615	122	2,910
	Feb.	−	1,506	1,538	19	3,063
	Mar.	−	1,343	1,595	−	2,938
	Apr.	−	1,466	1,929	−	3,395
	May	−	1,421	1,794	−	3,215
	June	−	1,472	1,911	−	3,383
	July	−	1,366	1,741	−	3,107
	Aug.	−	666	1,698	−	2,364
	Sept.	−	1,426	1,846	−	3,272
	Oct.	−	1,366	1,736	−	3,102

Remark: Statistical parameter values of the total discharge: Maximum; 4,010, Minimum; 1,997, Mean; 3,056, Standard Deviation (σ); 417, Mean -2 σ ; 2,222.

According to the Table, the mean intake amount in the past is 3,056 m^3/day (standard deviation: σ =417 m^3/day), from the commissioning in December 1998 to October 2000. If considering the variance of intake amount, it is expected that the stable intake amount from the existing intake wells be 2,222 m^3/day (mean -2 σ)

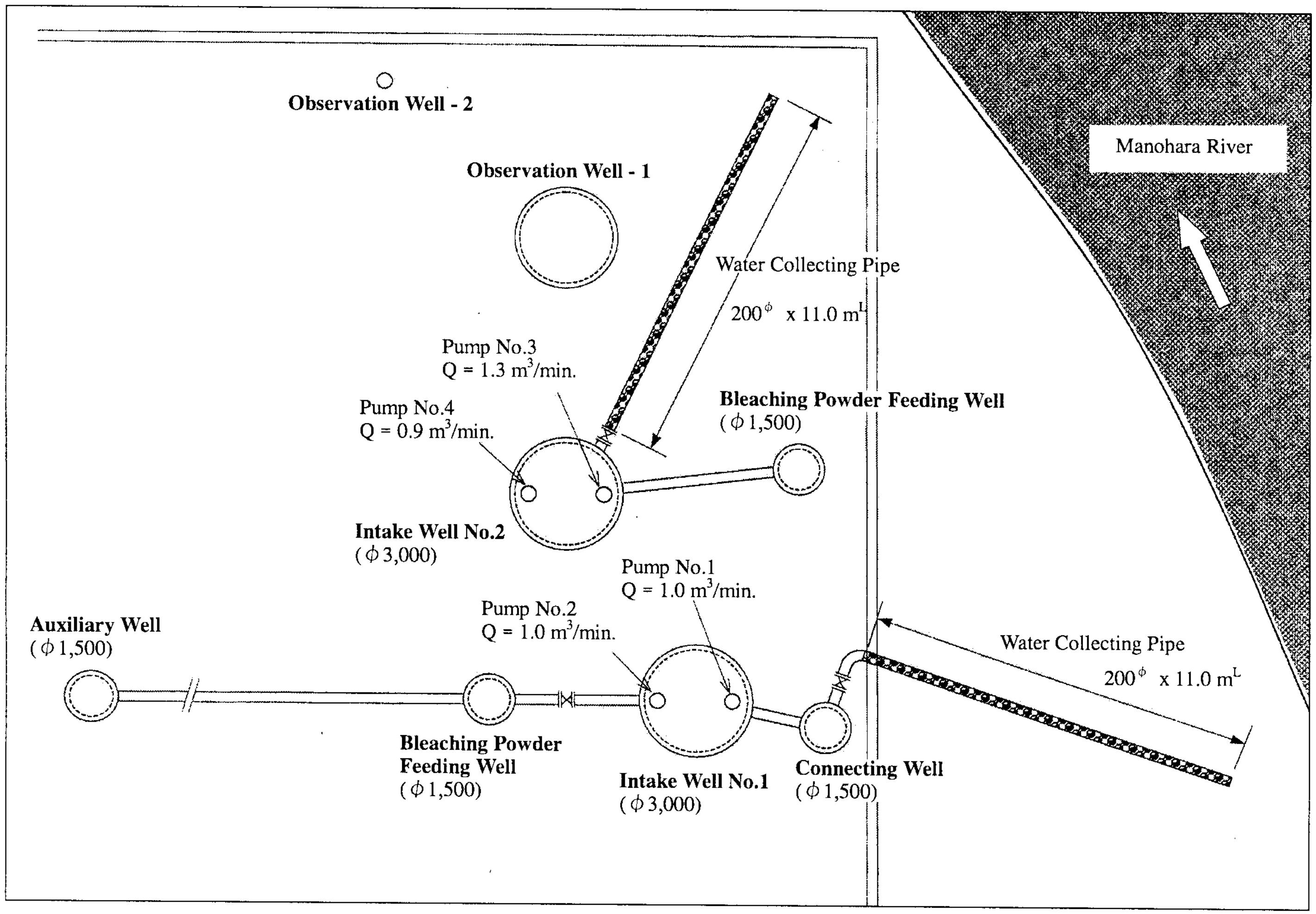


Fig. A7.1 Facility Layout of the Existing Wells

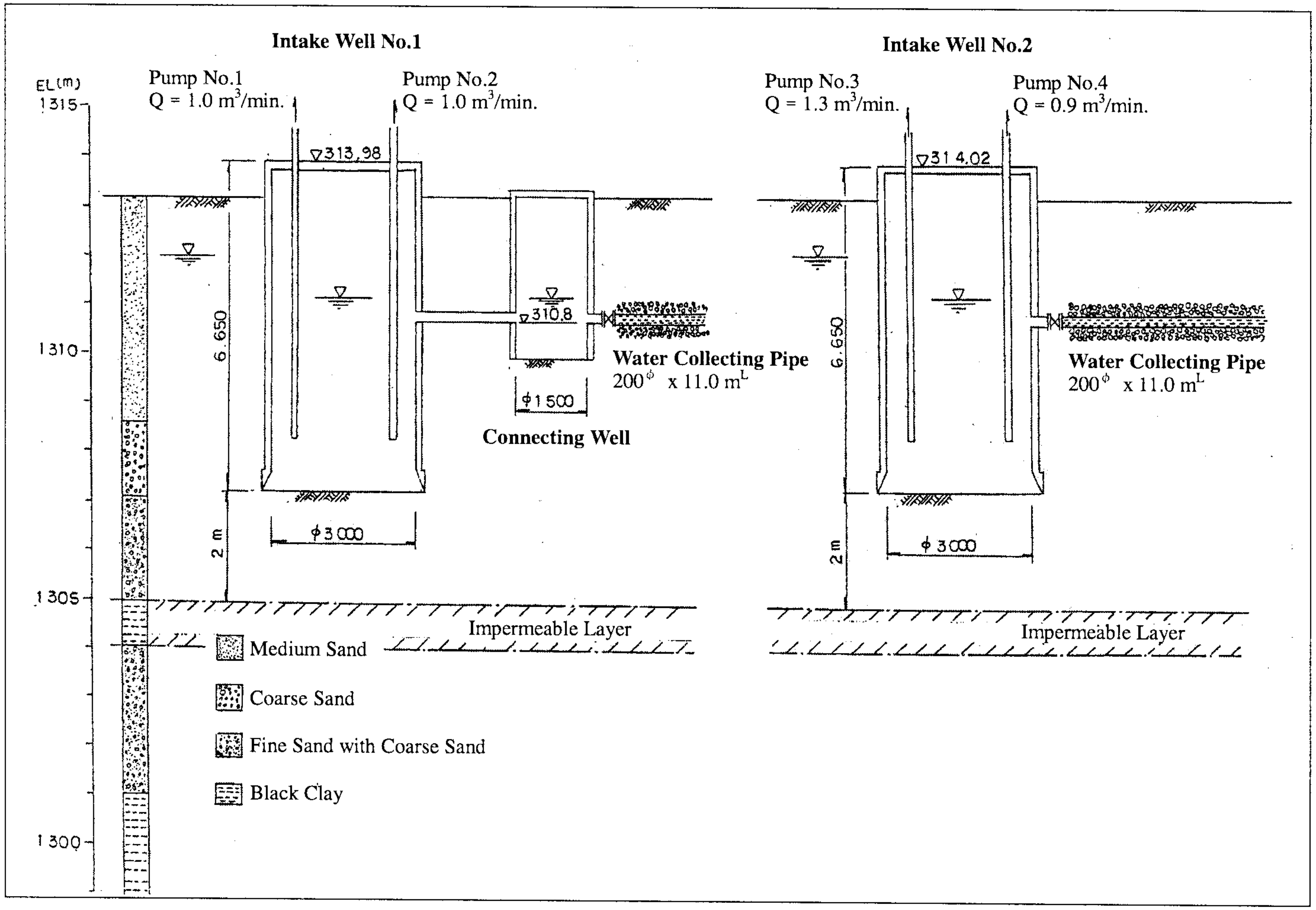


Fig. A7.2 Structure of the Existing Wells

(2) Pumping Test in the Existing Intake Wells

Pumping test was conducted towards Intake Well No.1 by using observation wells 1 and 2 and Intake Well No.2 as observation wells, through the following procedures, during which the inflow valve of the perforated water collection pipe was closed:

Step-1: Water level measurement in ordinary operation of 2 pumps (No.1 and No.2)
Step-2: Water level recovery after pumping operation stopped
Step-3: Measurement of water drawdown at times of No.1 pump operating
Step-4: Measurement of water drawdown with the concurrent operation of No.1 and No.2
(Pumping capacity: No.1 and No.2, the same 1.0 m^3/min.)

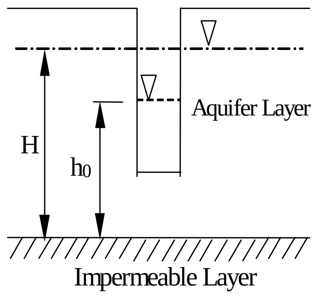
The test results are indicated in Fig. A7.3 and Fig. A7.4.

Assuming the existing intake wells to be stable with free surface, an applicable hydraulic equation is:

$$Q = 4 \cdot k \cdot r_0 \cdot (H - h_0)$$

, where

Q : Discharge (m^3/sec.)
k : Permeability coefficient of the aquifer (m/sec.)
r_0 : Radius of the well (m)
H : Depth of impermeable layer from original groundwater surface (m)
h_0 : Depth of impermeable layer from water level in the well (m)



From the equation, assuming that the original groundwater surface is that measured in Step-3 of the pumping test, the permeability coefficient (k) of the aquifer surrounding the intake well might be calculated as follows:

$$k = Q \div \{4 \cdot r_0 \cdot (H - h_0)\} = 0.01667 \div (4 \times 1.5 \times 0.96) = 2.9 \times 10^{-1} \text{ (cm/sec.)}$$

The permeability coefficient (k) of the aquifer in design is, considering the contingency, set as follows:

Permeability coefficient in design:

$$k = 2.0 \times 10^{-1} \text{ (cm/sec.)}$$

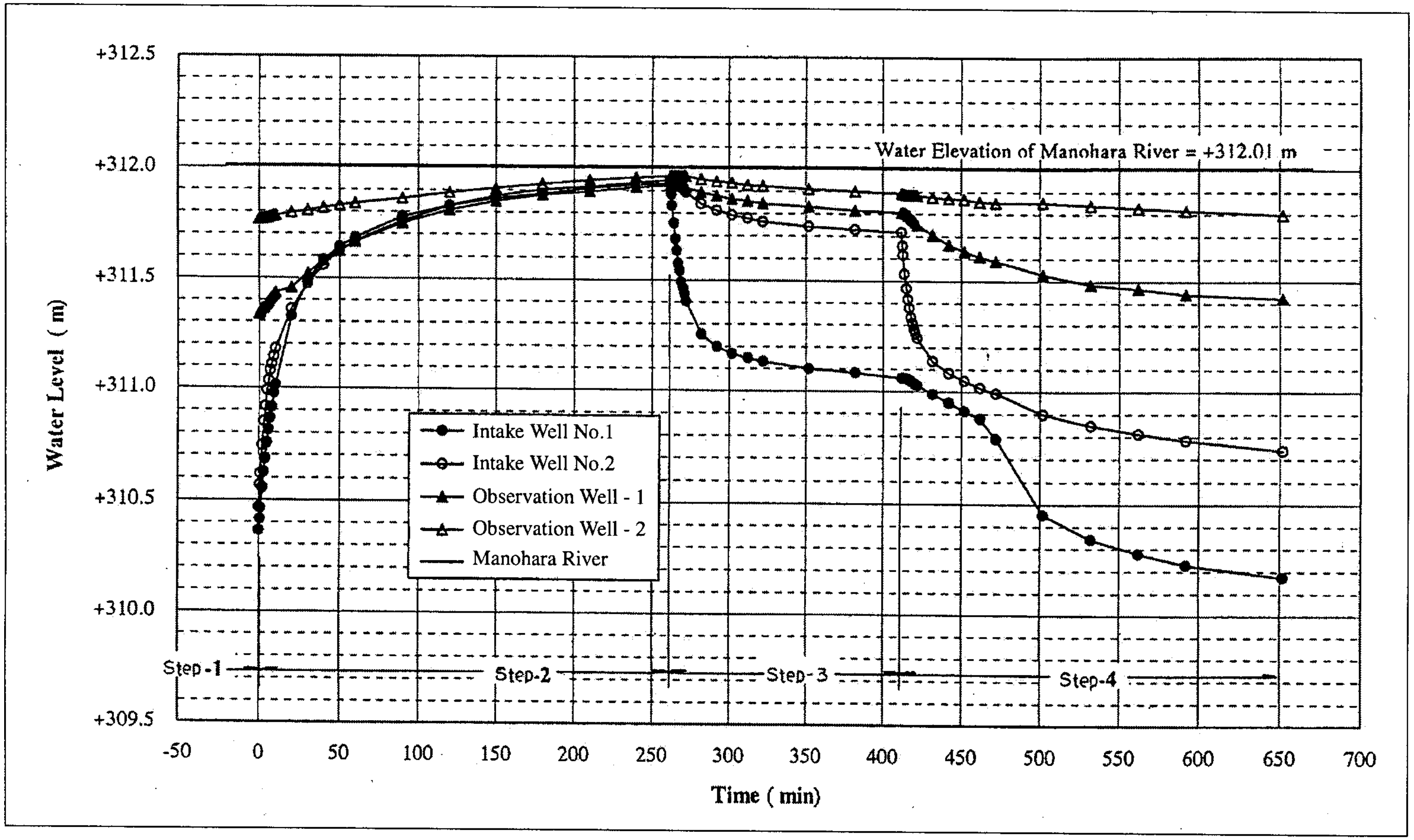


Fig. A7.3 Water Level Measurement in Pumping Test

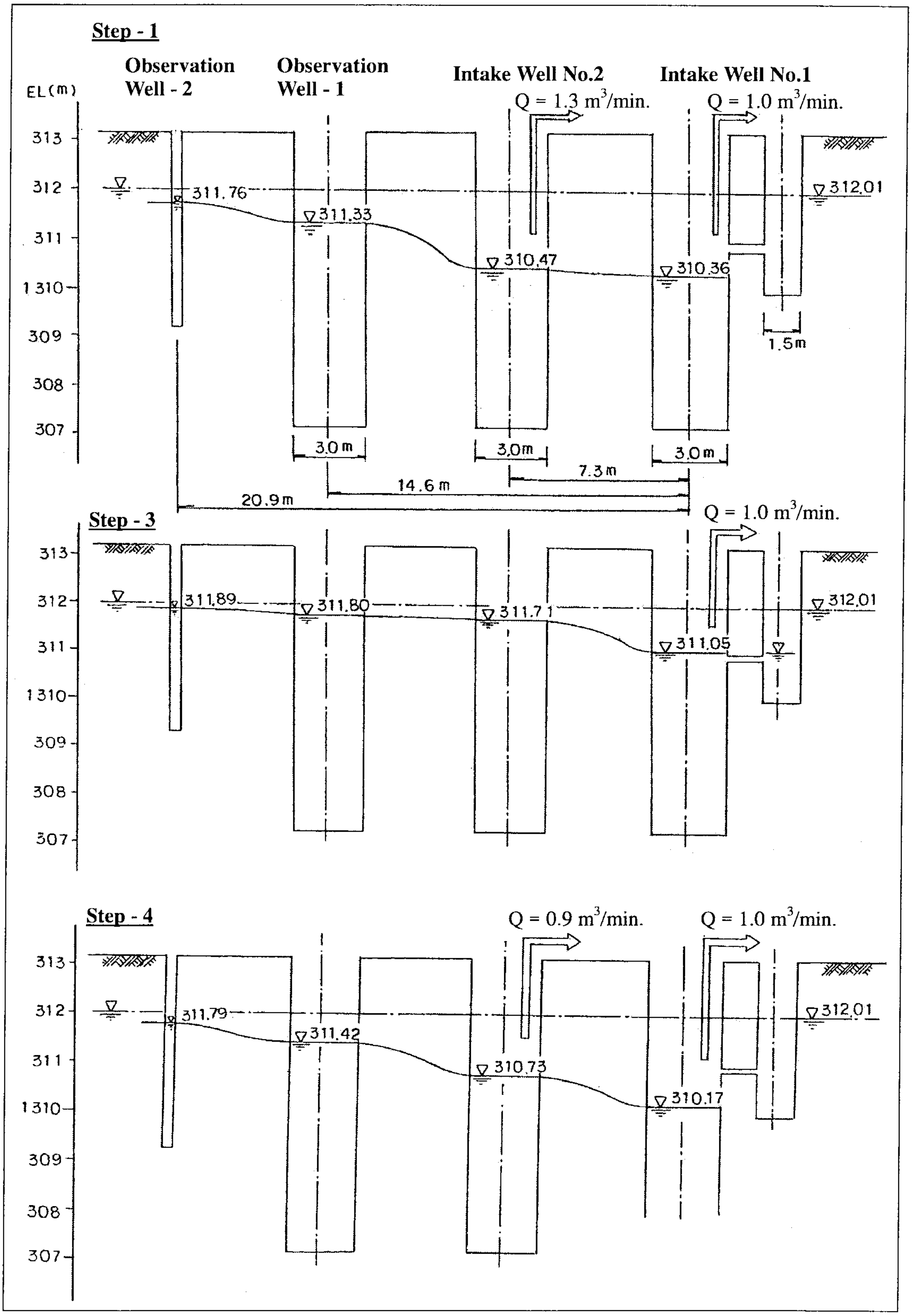


Fig. A7.4 Water Drawdown in Pumping Test

3. Intake Amount in the New Facilities

The intake amount of intake facilities to be newly constructed in the Manohara Project shall be equivalent to the planned intake amount minus intake amount of the existing intake wells. In examining the facility capacity, however, the planned intake amount applied with a contingency factor 1.25 is used.

Rainy season : 21,700 m^3/day×1.25－2,222 m^3/day＝24,903 m^3/day

Dry season : 17,900 m^3/day×1.25－2,222 m^3/day＝20,153 m^3/day

Others : 20,000 m^3/day×1.25－2,222 m^3/day＝22,778 m^3/day

4. Examination of Intake Method

At the moment, at the planned intake point in the Manohara Project, no artificial embankment is built, and 500 to 600 m width of the river bank are utilised in farming. It is difficult to adopt such an intake method that water is taken by constructing intake facilities such as weir. In consequence, hereinafter examined are the methods using shallow wells and an infiltration gallery, both exploiting river water in the form of river bed water.

(1) Shallow-well Method

Based on the afore-mentioned hydraulic equation towards the stable well as well as the permeability coefficient obtained from the pumping test results, the following intake amount of shallow-well method might be in hand:

Table A7.4 Intake Amount in Shallow Wells

Diameter of well	3.0 m			4.0 m			5.0 m		
Water level difference ($H-h_0$) (m)	2.0	2.5	3.0	2.0	2.5	3.0	2.0	2.5	3.0
Intake amount (m^3/day)	2,073	2,592	3,110	2,761	3,456	4,147	3,456	4,320	5,184

From the Table, when water is taken from shallow wells of 5 m diameter with the secured 3.0 m difference of water level between inside and outside the well, at least 5 wells would be required. In the boring test and electrical probing conducted in the Study, a favourable sand and gravel layer of 6 to 20 m thickness is recognized in the area within east-west 350 m and north-south 200 m, at the left bank of Manohara River, upstream of the existing NWSC intake wells; however, it is difficult to construct required number of wells in the area at an appropriate interval to make each other out of the influential range (R＝100 m).

(2) Infiltration-gallery Method

The applicable equation for the intake of groundwater with free surface, through infiltration-gallery method, is:

$$Q=\frac{kL(H^2-h_0{}^2)}{R}\sqrt{\frac{t+0.5r_0}{h_0}}\sqrt[4]{\frac{2h_0-t}{h_0}}$$

, where

- Q : Discharge (m^3/sec.)
- k : Permeability coefficient (m/sec.) $k=2.0\times10^{-3}$ m/sec.
- r_0 : Radius of the infiltration gallery (m)
- L : Length of the infiltration gallery (m)
- R : Influential Range (m)
- H : Depth from the original groundwater level to the impermeable layer (m)
- h_0 : Depth from water level in the gallery to the impermeable layer (m)
- t : Water depth in the gallery (m)

From the above, the intake amount of infiltration-gallery method might be calculated as in Table A7.5.

Table A7.5 Intake Amount of Infiltration-gallery Method

Diameter of gallery pipes	300 mm			400 mm			500 mm		
Water level difference ($H-h_0$) (m)	1.0	2.0	3.0	1.0	2.0	3.0	1.0	2.0	3.0
Intake amount per 1m (m^3/day/m)	7.6	15.2	23.2	8.8	17.6	26.6	9.8	19.6	29.8

As seen in the above discussion, almost 1,270 m of pipe length would be required when using water collecting pipes of 500 mm diameter in an infiltration gallery, even if 2 m of head difference secured between water level in the gallery and groundwater level. Moreover, problems are foreseen in the infiltration gallery: a large cost required in temporary works such as for steel sheet piling and for water replacement in installing water collecting pipes; intensive impacts to the surrounding farm land.

(3) Group-well Method

Shallow-well method has characteristics of easy work, cheap cost and less impacts to the surrounding environment during the construction; however, the wells might not be dug outside the influential range with each other. For this reason, hereunder examined is the group-well method, in which the wells are dug inside the influential range (50 to 85 m apart with each other) within the favourable aquifer recognized in the Study even though the discharge per well being reduced.

[Calculation Formula]

In calculating intake amount, applied is the following intake amount formula relating to a series of 3 wells at an equal interval (unconfined groundwater):

$$Q_1 = \frac{\pi \; K\,(H^2 - h_0^2)\,\log_e (m / r_w)}{2 \log_e (R / m) \log_e (m / r_w) + \log_e (m / 2r_w) \log_e (R / r_w)}$$

$$Q_2 = \frac{\pi \; K\,(H^2 - h_0^2)\,\log_e (m / 2r_w)}{2 \log_e (R / m) \log_e (m / r_w) + \log_e (m / 2r_w) \log_e (R / r_w)}$$

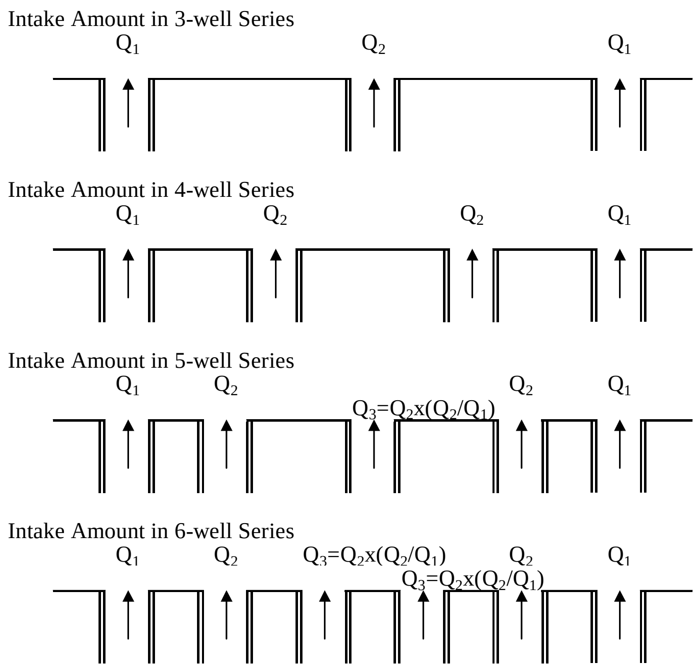
$$R = 1.5 \cdot \sqrt{(\nu \cdot t_0)}$$

, where

$K =$	0.002 m/sec.	: Permeability coefficient
$H =$	6.5 m	: Aquifer thickness (rainy season)
	5.8 m	: Aquifer thickness (dry season)
	6.0 m	: Aquifer thickness (others)
$h_0 =$	3.3 m	: Height of aquifer surface over the impermeable layer
m		: Interval of wells (m)
$r_w =$	2.5 m	: Radius of the well (diameter of the well is 5 m)
$R =$	100 m	: In the assumed stable condition, though R being prescribed as time's function: $1.5 \cdot \sqrt{(\nu \cdot t_0)}$ within the influential range.

[Intake Amount from Intermediate Wells]

In the intermediate well (located between other wells), the intake amount reduces influenced by the wells at both sides. The reducing ratio is set as Q_2 / Q_1, as shown below.



	Well Intake Amount	Total Intake Amount
3 Wells Series	Q_1 Q_2 Q_1	$2Q_1+Q_2$
4 Wells Series	Q_1 Q_2 Q_2 Q_1	$2Q_1+2Q_2$
5 Wells Series	Q_1 Q_2 Q_3 Q_2 Q_1	$2Q_1+2Q_2+Q_3$
6 Wells Series	Q_1 Q_2 Q_3 Q_3 Q_2 Q_1	$2Q_1+2Q_2+2Q_3$

$Q_3=Q_2\times(Q_2 / Q_1)$

[Total Intake Amount]

Total intake amount in group wells composed of 3 to 6 shallow wells is as shown in Table A7.6, based on the above-mentioned formula and conditions.

Table A7.6 Intake Amount in Group Wells

	Well Interval	Total Intake Amount in Group Wells (m^3/day)			
		3 Wells	4 Wells	5 Wells	6 Wells
Rainy Season H=6.5 m h_0=3.3 m	50 m	11,166	14,266	16,649	19,032
	60 m	12,126	15,534	18,198	20,862
	75 m	13,553	17,412	20,484	23,556
	85 m	14,511	18,670	22,012	25,354
Dry Season H=5.8 m h_0=3.3 m	50 m	8,099	10,348	12,077	13,806
	60 m	8,796	11,268	13,201	15,134
	75 m	9,832	12,632	14,862	17,092
	85 m	10,527	13,544	15,968	18,392
Others H=6.0 m h_0=3.3 m	50 m	8,940	11,422	13,330	15,238
	60 m	9,709	12,438	14,572	16,706
	75 m	10,852	13,942	16,402	18,862
	85 m	11,620	14,950	17,625	20,300

Remark: The groundwater level is estimated, assuming that H varies in response to river water level.

[Optimal Disposition of Group Wells]

Considering the area favourable aquifer is recognized in the Study, 2 series of group wells shall be dug 150 m apart with each other, at the left bank of Manohara River. A series at the river side shall be composed of 4 shallow wells with 50 m interval, or 3 shallow wells with 75 m interval, because only 160 to 170 m distance is available along the river. Regarding another series at inland side, examined are the number and interval of wells required to secure the intake amount in the different seasons. Thereafter, the estimated construction costs are compared among the respective cases of number and interval of shallow wells. (See Table A7.7).

Table A7.7 Construction Cost by Well Disposition

Well Disposition	Intake Amount (m^3/ day)			No. of Wells	No. of Pumps			
	Rainy Season (24,903)	Dry Season (20,153)	Others (22,778)		15 KW	18.5 KW	22 KW	30 KW
1. River Side 75 m×3 wells	13,553	9,832	10,852	3	–	–	1	2
Inland Side 85 m×4 wells	18,670	13,544	14,950	4	–	–	2	2
Total Intake Amount (m^3/day)	32,223	23,376	25,802	7	–	–	3	4
	Cost of Well Digging and Pump Installation			\184.5 Million				
2. River Side 50 m×4 wells	13,638	9,894	10,918	4	–	4	–	–
Inland Side 85 m×4 wells	17,588	12,760	14,082	4	–	–	4	–
Total Intake Amount (m^3/day)	31,226	22,654	25,000	8	–	4	4	–
	Cost of Well Digging and Pump Installation			\169.9 Million				
3. River Side 75 m×3 wells	12,232	8,722	9,685	3	–	1	2	–
Inland Side 75 m×5 wells	18,602	13,266	14,730	5	–	3	2	–
Total Intake Amount (m^3/day)	30,834	21,988	24,415	8	–	4	4	–
	Cost of Well Digging and Pump Installation			\174.9 Million				
4. River Side 50 m×4 wells	12,726	8,992	10,020	4	2	2	–	–
Inland Side 75 m×5 wells	18,163	12,824	14,287	5	3	2	–	–
Total Intake Amount (m^3/day)	30,889	21,816	24,307	9	5	4	–	–
	Cost of Well Digging and Pump Installation			\174.1 Million				

According to the Table, the optimal disposition of wells to meet the intake amount required in the different seasons, is 4 wells at 50 m interval at the Manohara river side and 4 wells at 85 m interval at the inland side, concluded from the economic cost in comparison.

Appendix 8

Examination on Water Treatment System

Examination on Water Treatment System

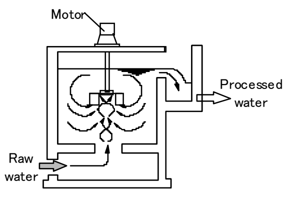
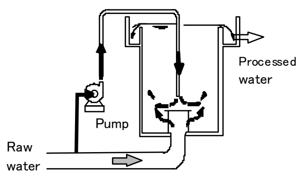
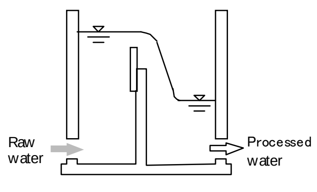
1. Chemicals Mixing and Coagulation

Coagulo-sedimentation involves three processes; coagulation, flocculation and sedimentation. Mixing of chemicals and coagulation are to coagulate fine particles or colloidal particles to minute flocs by rapid mixing after feeding coagulant to raw water. Available mixing types are:

・Machinery mixing
・Pump power mixing
・Gravitational force mixing by weir

Due to machine use, maintenance is required in machinery mixing and in pump power mixing. Gravitational force mixing by weir needs no machine, no maintenance required. Comparison of the mixing types is as in Table A8.1. Gravitational force mixing shall be adopted in the Project.

Table A8.1 Comparison of Chemicals Mixing Types

	Machinery Mixing	Pump Power Mixing	Fall with Weir (by gravity)
Configuration	Driving device Supporting Axis with screw Electrical equipment	Injection pump Piping and installation Agitator Electrical equipment	Weir plate
Mechanism	Agitation by a mixer	A part of raw water taken from inlet is injected to the bell-mouth by booster pump.	Mixing is done in the turbulence caused by gravity fall after a weir.
Advantage	Capable in responce to inflow quantity. No hydraulic head is needed.	Capable in responce to inflow quantity. No hydraulic head is needed.	Small construction cost No trouble likely to happen No maintenance cost Small installation area
Disadvantage	High construction cost High power cost Countermeasures to machinery sound are needed. Periodic maintenance is needed. High maintenance cost	High construction cost High power cost Large area is needed. Periodic maintenance is needed. High maintenance cost	Measures to adjust inflow quantity alteration are needed. Hydraulic head is needed.
Evaluation	Construction, power and maintenance costs are all large. Countermeasures to machinery sound are needed. High skills for operation are needed.	Almost same as the left. Pump installation area is needed. High skills for operation are needed.	By regulating a height, sufficient hydraulic head can be secured. Construction cost is small, and power and maintenance costs are not required.
	○	△	◎
Drawing			

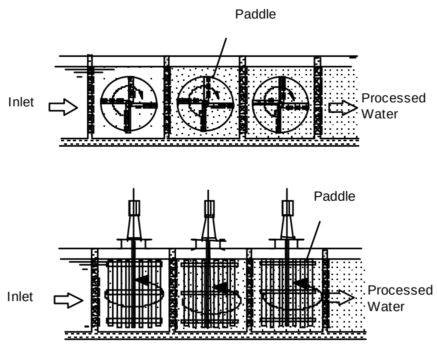
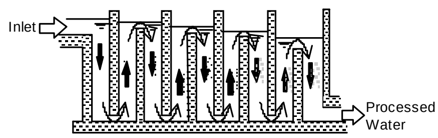
2. Flocculation

After mixing and coagulation, minute flocks shall be grown to favourably larger flocks through gentle agitation. Available flocculation types are:

・Machinery agitation
・Baffling-type

Machinery require maintenance, baffling-type without machines easy in O/M. Table A8.2 compares these 2 types. Baffling-type shall be adopted in the Project.

Table A8.2 Comparison of Flocculation Types

	Machinery agitation (flocculator)	Baffling-type
Functions and arrangement	One or a few rows of mixers with paddles are installed in the basin. There are two types of axis of paddles; vertical and horizontal. Rotation can be adjusted with the treatment quantity by changing a mixing strength (G value). Depth in the basin is 3-5 m.	There are two kinds of this type; vertical and horizontal. Both might be used concurrently. Using the hydraulic head and baffles, measurement of inflow quantity alteration is needed. Also required is to pay attention to sludge sedimentation when turbidity is high. Detention time and depth are the same as in machinery agitation.
Configuration	Driving device (motor and reduction gear) and paddles Submersible axis bearings	Baffle wall and weir plate
Detention time: T	20-40 min.	20-40 min.
Paddle velocity	15-80 cm/sec. (At most outer part)	—
G value	10-75 /sec.	10-75 /sec.
GT	23,000-210,000	23,000-210,000
Maintenance	Machine maintenance is needed.	Ease of maintenance
Advantage	Capable of adjusting to quality and quantity alteration. No hydraulic head is needed.	Small construction cost
Disadvantage	Large construction cost Needs periodic maintenance (cost). Maintenance cost is high.	Hydraulic head is needed. Difficulty in adjustment to quantity alteration
Drawing		
Evaluation	Construction, power and maintenance costs are large, and high-level of skills is needed.	Both construction and maintenance costs are small. Capable of adjusting to quantity alteration by changing number of basins used.
	△	◎

3. Discharge of Sludge in the Basin

For discharging the sludge sedimented in the basin, the gravitational method with hoppers shall be applied, not the machinery method requiring the maintenance cost.

A study was conducted on sludge distribution in the flow in the sedimentation basin in a water treatment plant in Japan, by using river water as raw water.

(1) Specification of the sedimentation basin

- Design Capacity : 30,000 m^3/basin/day
- Type of Basin : Horizontal flow type, inclined plates settler
- Shape and Size : Rectangular, 13 m W×27.3 m L×4.0 m D (1,420 m^3)
- Type of Sludge Discharge : Perforated drain pipes across the flow（13 rows）downside of the inclined plate settler

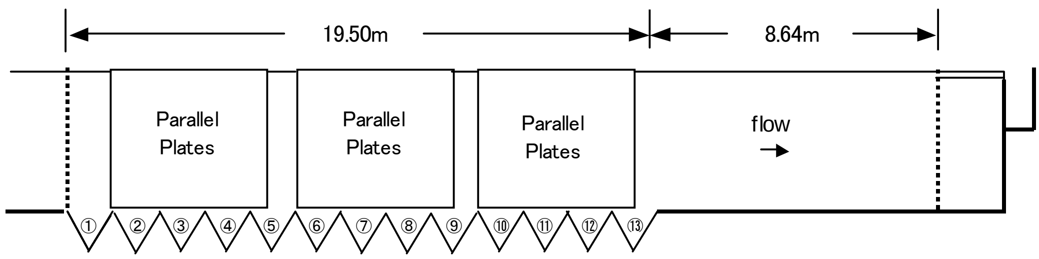


Fig. A8.1 Cross Section of the Basin

(2) Investigation method

① Before starting an investigation, sludge in the basin was taken away through all the perforated drain-pipes, one day prior.

② The investigation was conducted, after 24 hours of normal operation, by taking samples every 15 seconds from all the discharge valves. These were continued until transparent discharge water was identified through observation, the maximum duration being 300 seconds. Turbidity was measured and converted to concentration of suspended solids.

［Investigation conditions］

- Water Treatment Volume : Design Capacity
- Turbidity in Raw Water : 30 to 46 degree (equivalent to NTU)
- Discharge Valve : D.150 mm full open

(3) The results

Table A8.3 shows the sludge distribution in the flow. The cumulatives indicate non-dimensional figures, assuming that quantity of discharge in the meantime from every discharge pipe is equal and constant.

Table A8.3 Discharge Concentration and Flux by Discharge Pipe

Second \ Pipe No.		①	②	③	④	⑤	⑥+⑦	⑧+⑨	⑩+⑪	⑫+⑬
Concentration (PPM)	0	290	440	230	310	110	140	160	60	35
	15	22,000	18,000	15,000	9,000	4,700	5,300	2,600	1,900	340
	30	14,000	23,000	13,000	7,300	3,600	2,900	1,200	600	830
	45	13,000	17,000	6,000	4,600	2,700	1,800	830	430	300
	60	6,100	17,000	2,600	1,400	1,900	700	460	280	170
	75	3,200	11,000	1,400	720	1,100	450	370	190	
	90	1,400	3,800	960	600	550	300	240	140	
	105	800	3,200	1,250	690	490	270	140		
	120	650	3,500	680	300	250	160			
	135	440	2,300	490	21	190				
	150	360	2,000	330	160					
	165	350	1,400	200						
	180	300	1,600							
	195	330	2,000							
	210	240	1,200							
	225	310	800							
	240	280	760							
	255	280	950							
	270	250	660							
	285	180	400							
	300	200	580							
Cumulative		64,670	111,150	41,910	24,791	15,480	11,880	5,840	3,540	1,640
Settling Ratio (%)		23.0	39.6	14.9	8.8	5.5	4.2	2.1	1.3	0.6
Cumulative Ratio (%)		23.0	62.6	77.5	86.3	91.8	96.1	98.2	99.4	100.0

The basin is composed of inclined parallel plates settling equipment in the beginning part of 19.50 m with sludge draining devices and an ordinary settling in the succeeding part of 8.64 m.

As indicated in the results, the ratio of sediment is extremely high in the beginning part of parallel plates settler, followed by the entrance. The setting ratio in the last drainage is less than 1%. In general, the surface of settling is much larger in the parallel plates settler, than in the ordinary settling basin. Since the volume of sediment is negligible after the settling devices, the end of settler might be considered as the end of the basin.

Fig. A8.2 gives the distribution of sediment volume in the flow.

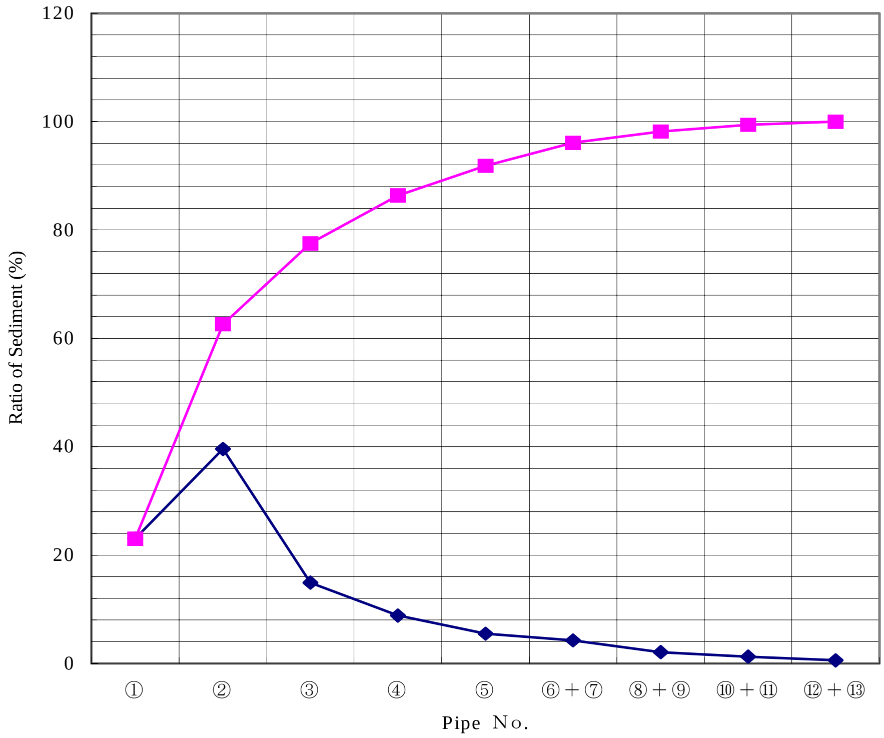


Fig. A8.2 Sediment in the Basin

Let the previously mentioned total length of the basin be at No.13 discharge pipe, then no less than 78% of sediment is settling up to No.3 discharge pipe, and 86% up to No.4 pipe (located at 31% of the total length). Thereafter, no more than 14% of sediment is remaining.

When assuming an average turbidity in raw water in the Manohara Project to be 25 NTU degree, the discharge volume of sludge might be calculated as approximately 22 m^3/day (2% of concentration). The hopper-installed area occupies 25% of the whole sedimentation basin; an average height of sediment corresponding to the sludge volume would be 9 cm/day in the Manohara Project.

The sludge height reaches, in part, as much as 3 to 4 times of the above average figure; even though, in the effective depth of 2.85 m in design, sediment be permitted up to 1 m (in such an occasion, average flow velocity in the basin becomes the maximum permitted 0.4m/min) in height, the sedimentation basin shall be cleaned up every 2 to 3 days, with suspension of basin operation.

Consequently, hopper installation is inevitable in the Manohara Project.

Number of hopper rows is examined, as indicated in Table A8.4.

Table A8.4 Comparison of Operability and Costs in Hopper Rows in Sedimentation Basin

Item	Hoppers (in plural rows) installed up to 30% position of the total length of the basin	Hopper installation in one row
Sludge Discharge	(In case high turbidity in rainy season) Sludge shall be discharged everyday by operating valves of the 3 basins. Discharge operation is made from the utmost upstream discharge valve, continuously in turn to the downstream valves. The time of operating the discharge valve shall be, including opening and closing, approximately 25 min. After 24 hours of detention, the sludge shall be transferred to the sludge drying bed. (In case mean turbidity) Sludge shall be discharged everyday from one basin. Discharge operation is made from the utmost upstream discharge valve, continuously in turn to the downstream valves. The time of operating the discharge valve shall be, including opening and closing, approximately 25 min. Discharge operation shall be once in 3 days, sludge detained in the basin. After 24 hours of detention (on the 4th day), sludge shall be transferred to the sludge drying bed.	To discharge sludge from the part other than hoppers, the method based on the drainage of water in the basin must be applied. Frequency: 1 to 2 times a week. Since a considerable duration of time is required in drainage, sludge discharge and replenishment, an ordinary operation calls for at least one basin reserved. In case draining the whole water from the basin, augmentation of capacity in returning water from the sludge and drainage basin is required. Not so frequently as above; however, almost once a week, the sludge shall be discharged.
Cleaning	Almost 2 times a year; by selecting the time when the quality of raw water is comparatively favourable and treatment amount is small.	
Configuration	Hoppers 45 nos (3 basin×15 nos) Discharge valve 15 nos (3 basin×5 nos) Discharge pipe 1 set	Hoppers 9 nos (3 basin×3 nos) Discharge valve 9 nos (3 basin×3 nos) Discharge pipe 1 set
Annually Required Cost (NRs)	Repayment cost of facilities 997,000 Maintenance cost (valve) 122,000 Loss in intake – Cleaning work 77,000 Replenishment work – Total 1,196,000	Repayment cost of facilities 495,000 Maintenance cost (valve) 61,000 Loss in intake 660,000 Cleaning work 928,000 Replenishment work 41,000 Total 2,185,000

Remark: In case only one row of hoppers installed at upstream side, to the same extent of treatment effects as in multiple rows of hoppers, in addition to the above facilities, the following facilities and annual costs will be further required:

(1) Reserved basin : NRs 2,470,000 (Repayment cost of facilities)
(2) Returning facility capacity augmented : NRs 286,000 (Repayment cost of facilities)
(3) Total additional costs annually required : NRs 2,756,000

4. Rapid Sand Filtration

Rapid sand filtration is the final process to finish and obtain safe and hygienic water; the fundamental objective of waterworks, for supplying to the user, by improving water quality up to the required level. In the process, the fine flocs not removed in the sedimentation basin are removed by passing through filter medium such as sand layer; at the same time, the substances inside the flocs that might consume the free residual chlorine and make the water non-resistant to the contamination from outside of the distribution pipes as well as cause secondary affections inside the pipes, are removed. Available rapid sand filtration types are:

・Standard-type rapid sand filtration
・Rapid sand filtration, automatic backwashing type (by valve)
・Rapid sand filtration, automatic backwashing type (by siphon)

Of these, standard-type rapid sand filtration requires high-level of technical skills in adjustment of filtration volume as well as in operation control. Rapid sand filtration, automatic backwashing type (by siphon) also requires high-level of skills in operation control and maintenance, due to a lot of devices used compared to rapid sand filtration, automatic backwashing type (by valve). Rapid sand filtration, automatic backwashing type (by valve) has a characteristic of easy operation control, and requires not so frequent maintenance practices owing to less use of devices inside. The examination with comparison of these 3 types is shown in Table A8.5. In consequence, the rapid sand filtration, automatic backwashing type (by valve) shall be adopted in the Project.

Table A8.5 Comparison of Filtration Types

		Standard-type	Automatic Backwashing Type (by valve)	Automatic Backwashing Type (by siphon)
Filtration	Raw water inlet	By valve or gate	By weir and valve	By siphon and adjusting weir
	Filtration velocity control	Flow meter and operation valve	Movable adjusting weir	Movable adjusting weir
	Filtration velocity control mechanism	Water level in the basin is kept constant. Constant filtration velocity by controlling valve with flow meter towards the filtration clogging.	Constant filtration velocity by keeping required hydraulic head through raising water level in the basin when filter clogged.	Same as the left
Backwashing	Backwashing discharge	By valve or gate	Same as the left	By siphon and valve
	Backwashing mechanism	By the pressure of backwashing pump or elevated tank, clear water in the storage washes out filtration sand.	Responding to an increment of head-loss to the highest level by choking of filtration layer, operation of discharge gate lowers water level to drainage trough level, then backwashing starts. Backwashing water with head comes from other filters in operation.	Responding to an increment of head-loss to the highest level, inflow siphon is broken to stop, drainage siphon works to lower water level to drainage trough; backwashing starts automatically. Backwashing water comes from other filters with head.
Filtration layer		Effective diameter: 0.6-0.7mm Uniformity coefficient: < 1.7 Layer thickness: 0.6-0.7m	Same as the left	Same as the left
Water collecting device		Perforated block, strainer or perforated board	Automatic washing type perforated block	Automatic washing type perforated block
Area necessary for installation		Large area including corridor for maintenance and inspection is needed due to installation of a lot of kinds of big equipment.	No large area is required, due to installation of pipes and gate both for inlet and outlet.	Small corridor is required for the installation of small pipes; and comparatively large area for inflow and drainage siphon, including siphon operation space.
Construction cost		Height of filter structure is less than 4.5m. Large clear water conduit down to the filtration basin as well as the complicated structure make construction cost high. The different big-size equipment is required, and their control panels should be of high standard.	Height of filter structure is around 5m with a simple design. Construction cost is minimal. Only three kinds of valves (for inflow, drainage and surface washing) are required in each basin. Two kinds of pumps (for surface washing and replenishment) and their control panels are added. Construction cost is small.	Height of filter is 5.5m due to siphon structure. Some space is required for siphon equipment of small pipes, vacuum generator, compressor and so forth; therefore, construction cost is high. Although these kinds of equipment are not so big-size as in standard-type, complicated siphon generating unit, vacuum unit and their control panels require complicated operation and high cost.
Construction cost ratio		1.0	0.85 *	0.9 *
Maintenance cost ratio		1.0	0.8 *	0.9*
Evaluation		High-level skills are needed in flow control. Bigger pump and backwashing valve make cost higher. Totally high-level of skills are needed in O/M, and frequently.	Operation required are only 3; inlet valve, outlet valve and surface washing device, easy to be controlled. Without complicated outflow adjusting mechanism, no high-level of technical skills is needed. Costs of both construction and maintenance are small. No frequent maintenance practice is required due to less use of devices.	Complicated siphon mechanism for inflow and drainage composed of many equipment require high-level of technical skills in operation more than the standard-type. The height is bigger, 30-50cm deeper than the valve-type. Countermeasures to siphon breaking noise and prevention of freezing in the pipe are required.
		△	◎	○

Remark: *: Cost comparative factor towards Standard-type 1.0

5. Coagulant

Coagulants are chemicals having functions to neutralise the charge of suspended and colloidal particles in raw water, as well as functions to coagulate and form flocs. The following are coagulants possibly to be used in the Project:

・Solid Aluminum Sulfate (Alum) made in India
・Granular Poly Aluminum Chloride (PAC) made in Japan
・Granular Poly Aluminum Chloride (PAC) made in India

Table A8.6 Comparison of Coagulants

	Alum (Available Al_2O_3 15%)	PAC made in Japan (Available Al_2O_3 30%)	PAC made in India (Available Al_2O_3 30%)
Unit price (NRs/ton)	17,000	176,700	40,000
Feeding rate (mg/l)	Surface Water (Rainy Season) 18 Surface Water (Dry Season) 13.8 Groundwater 50	Surface Water (Rainy Season) 5.4 Surface Water (Dry Season) 4.2 Groundwater 12	Surface Water (Rainy Season) 6.8 Surface Water (Dry Season) 5.2 Groundwater 15
Annual consumption volume (ton)	150.2	43.6	54.3
Problems and evaluation	Difficult to dissolve (necessary to be crushed into small pieces). Concentration of solution is not constant (Optimal feeding rate shall be determined every time after Jar-test). Flocculation effects become less below around 10℃ of water temperature. pH of raw water is low and highly corrosive, so feeding of alum makes pH further low. Therefore, alkaline agent feeding is indispensable.	The coagulation range being wide from pH6 to pH9, the effects are not lowered, even in low temperature and low pH. Foreign currency must be allotted in the procurement, and it is not easy. Feeding control is easy, and costs of operation and maintenance are small.	Coagulant effects are 20% to 30% lower than PAC made in Japan. If the feeding rate is increased, the same effects be appeared. Compared to Alum, the dissolving and feeding operation is easy. Unit price is lower than PAC made in Japan, and operation and maintenance costs are also small.
Annually required cost (NRs)	2,553,000 (Alum) 3,070,000 (NaOH) Total: 5,623,000	7,669,000	2,080,000

Note : 1 NRs = ¥1.5

In water treatment, an appropriate control of coagulant feeding is the most imperative. Without proper feeding control, water treatment functions cannot be displayed, and safe and hygienic water not supplied; fundamental objectives of waterworks not being fulfilled.

The attainment of Project Objective is dependent upon the proper operation of the water treatment plant; whether or not its functions displayed properly. In this consequence, PAC made in India shall be used in the Project, because of its precise and easy feeding control characteristics as well as comparatively excellent nature in the performance.

6. Sterilising Agent

Similarly to the coagulant, an appropriate sterilisation is indispensable in the fulfillment of the fundamental objective of waterworks in supplying safe and hygienic water. In sterilisation, residual chlorine shall be kept around 1.0 mg/l through controlling the sterilising agent feeding operation, in which required are safety in handling as well as easiness and preciseness in control.

The commonly used chloric agents in sterilisation are:

・Chloric gas
・Sodium hypochlorite (solution)
・Bleaching powder

Of these, chloric gas is stored in the cylinder, not manufactured in Nepal; high-pressure cylinders filled-up in India are transported. Partly for the reason of danger in handling, chloric gas was placed out of examination in the Project.

Also, sodium hypochlorite (solution) is not manufactured in Nepal; the solution has to be transported from India, or otherwise the generating device for electrolysing salt water shall be used. This kind of sodium hypochlorite generator was introduced in the Mahankal Chaur Project. Toward the generators, unit maintenance cost including the electrode replacement shall be counted.

Currently used bleaching powder in Nepal is of unfavourable quality; loss in the dissolution process is high, and making solution of a fixed concentration is difficult. The concentration cannot be identified easily, and the feeding control based on the identified concentration requires high-level of technical skills; with the current technical level of NWSC personnel, an appropriate feeding control would be difficult.

Operability, maintenance costs, and other costs of sodium hypochlorite (generated) and bleaching powder are indicated in Table A8.7.

Table A8.7 Comparison of Sterilising Agents

		Bleaching Powder	Generated SH (New Generator)	Generated SH (With Electrode Replaced)
Country of procurement		India	Made in place	Made in place
Effective chlorine		15%	1%	1%
Unit price (NRs/ton)		15,000	21,648	21,648
Repayment for equipment (NRs/m^3)		0.031	0.108	0.015
O/M cost per 1 m^3 of treated water (NRs/m^3)	Inspection and repair cost	0.021	0.030	0.030
	Chemicals cost	0.352	0.038	0.038
	Labor cost for dissolving	0.197	—	—
	Maintenance cost of electrode	—	0.154	0.154
	Total O/M cost	0.570	0.222	0.222
Total cost per 1 m^3 (NRs/m^3)		0.601	0.330	0.237
Problems		Difficult to dissolve and concentration of solution is not stable. Dissolving operation is troublesome, and feeding operation requires high skill.	Feeding operation is easy, and O/M cost is low. Derived of salt, transportation is not dangerous. Electrode shall be replaced every 4-5 years, requiring allotment of foreign currency.	Feeding operation is easy, and O/M cost is low. Derived of salt, transportation is not dangerous. Electrode shall be replaced every 4-5 years, requiring allotment of foreign currency.

From the above examination, the generated sodium hypochlorite is desirable, because of easy and precise feeding control characteristics as well as the maintenance cost being 1/3 that of bleaching powder. However, an anticipation was hold, relating to technical guidance and spare-parts procurement in electrode replacement. NWSC confirmed that spare-parts might be directly ordered to the manufacturer by making budget arrangement. Notwithstanding, unless this is further secured, bleaching powder shall be used in the Project, though feeding control being difficult, but safer than chloric gas.

7. Drainage Treatment

The drainage water and sludge discharged from the water treatment plant composed of: discharging water from the rapid sand filtration basin, and sludge from the sedimentation basin. The generating volume of drainage and sludge is equivalent to, as shown in Table A8.8, 3.8% of the maximum water treatment amount. These discharging water and sludge will not contain pollutants; and environmental impacts will not be so heavy even if a delusive discharge method applied. However, owing to raw water bearing intake cost, a considerable amount of supernatant water shall be returned for the reuse as raw water, thereby reducing the cost of intake. Settled and concentrated sludge shall be disposed, after arrangement of its content for carrying away on drying bed, in view of maintenance ease and cost-effectiveness not using electric power.

Table A8.8 Drainage and Sludge Volume

Water treatment amount (Daily maximum)		(m^3/day)	21,700
Volume of Drainage	Sedimentation basin sludge (1 basin/day)	(m^3/day)	90
	Rapid sand filtration basin drainage (4 basins/day)	(m^3/day)	730
	Total	(m^3/day)	820
Weight of dried sludge		(ton/day)	0.68

Table A8.9 compares maintenance costs between the direct discharge to the river without reuse and the recycle use of supernatant water.

Table A8.9 Cost Comparison between Direct Discharge and Reuse

(Unit: NRs Million)

	Direct Discharge		Reuse of Supernatant Water	
Annual Amount of Repayment for Construction	Discharge equipment	0.20	Supernatant return equipment	0.38
	Sludge and drainage basin (400 m^3)	0.58	Sludge drying bed	0.13
	Drainage retention basin (430 m^3)	0.62*	Sludge transmission equipment	0.13
			Sludge/Drainage basin (400 m^3)	0.58
Maintenance Cost	Intake cost of discharge water	0.66	Water return cost	0.09
	Discharge cost	0.05	Sludge disposal cost	0.18
Total		1.49 2.11**		1.36

Remarks: (1):* : Cost of retention to avoid the time zone (daytime) of river use.
(2):** : Total in case retention cost (*) added.

BASIC DESIGN STUDY REPORT
ON THE PROJECT FOR IMPROVEMENT OF KATHMANDU WATER SUPPLY FACILITIES IN THE KINGDOM OF NEPAL OCTOBER 2001