CHAPTER 3 IMPLEMENTATION PLAN

Chapter 3 Implementation Plan

3-1 Implementation Plan

The present Project is scheduled to be implemented under the scheme of Japanese Grant Aid Program. After the decision for the Project Implementation, Government of Lao DPR selects a consultant, which is registered under the raw of Japan, for detailed design and construction supervision. And followed by selection of a contractor, which is also registered under the raw of Japan, construction works of the Project will be carried out.
The basic items for the Project Implementation is described as shown in the following sections.

3-1-1 Implementation Concept

(1) Project Implementation Structure

1) Project Executing Agency

The Executing Agency is Ministry of Communication, Transport, Post and Construction (MCTPC) represented by Department of Housing and Urban Planning (DHUP). While, the Project Implementing Agency is Department of Communication, Transport, Post and Construction of Savannakhet Province (DCTPC).

During the implementation of the Project, Savannakhet Water Company (NPS) acts as the liaison office, handling for administrative matters of the project implementation. The future operation and maintenance of the improved water supply system is to be conducted by NPS.

After the Exchange Note for Grant Aid Assistance between Government of Japan and Government of Lao PDR has been agreed and signed, the owner of the Project, MCTPC has a contract with the consultant and the contractor for the project implementation.

The organization structure of the Project Implementation is presented on Fig. 3-1.

2) Consultant for Detailed Design

The Consultant will carry out detailed design and construction supervision for construction works including procurement of materials and equipment for the Project. During detailed design stage, the consultant will be responsible for 1) Detailed Design with Site Sruvey, 2) Detailed Cost Estimate for Procurement and Construction Works, 3) Plan for Construction Schedule, 4) Preparation of Tender Documents, 5) Assistance of Tendering, 6) Tender Evaluation, and 7) Assistance and Recommendation to MCTPC for Award of Contract for Construction Work.

During detailed design, the Consultant will subcontract with local contractor to carry out soil investigation applying standard penetration and laboratory tests to obtain design parameter for foundation of clear water reservoir newly constructed in the existing water treatment plant.

3) Construction Works

A Contractor will be selected from Japanese contractors and appointed through selective competitive bidding. A lump sum contract will be applied for the contract. The Contractor shall dispatch engineers and carry out all construction works within the specified time in the contract including procurement of all materials and equipment.

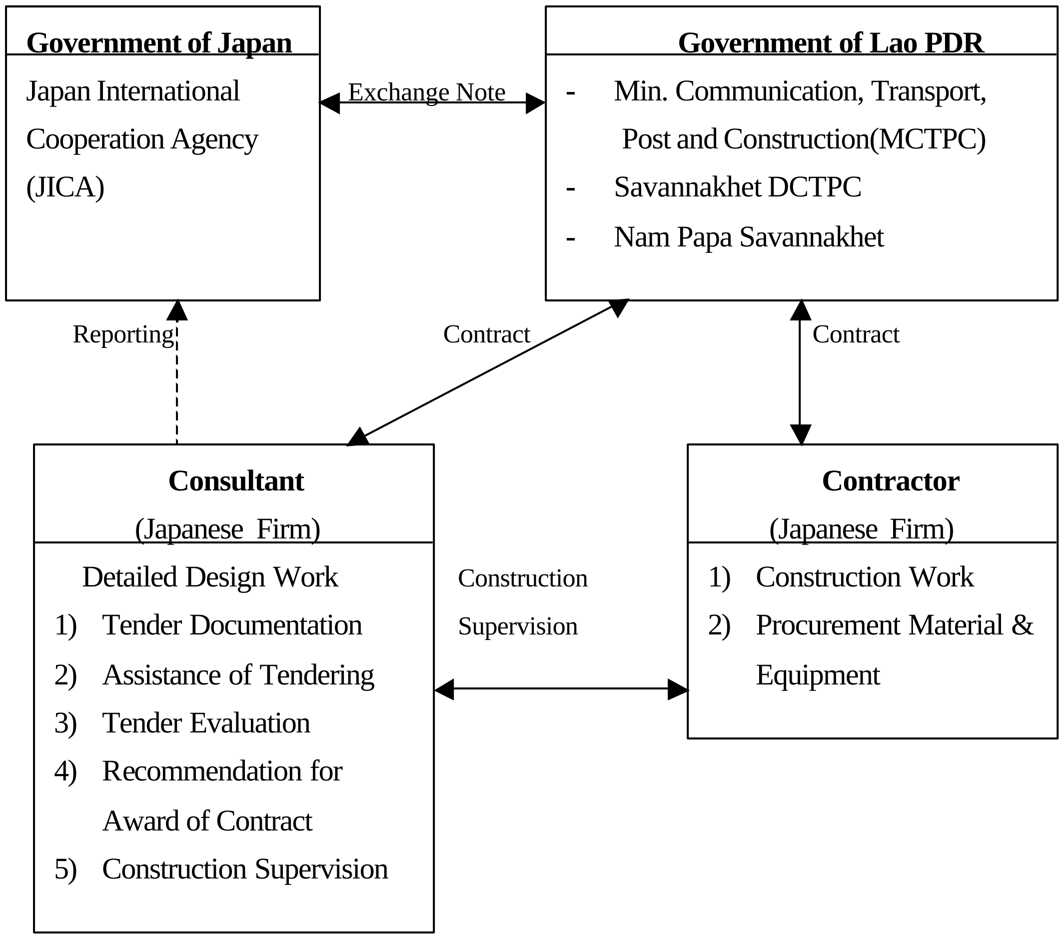

Fig. 3-1 Project Implementation Structure

(2) Utilization of Local Contractor

For execution of construction works for the Project, in principle, the Contractor will utilize local sub-contractors for construction to the at most.

Out of the proposed main construction works in the Project, such special works as mechanical and electrical portion for rehabilitation of Nake Water Treatment Plant, may have difficulty for execution by the local contractors. However, local contractors will be considered as sub-contractor for civil related construction works under the direction of the Japanese Contractor.

It will be difficult to apply local contractors, who's base in Khantabouly District and/or Savannakhet Province, for all kind of civil works. However, certain portion of civil works could be locally granted in the whole nation including Vientiane.

(3) Necessity of Engineer/s Dispatch

For the rehabilitation work of Nake Water Treatment Plant, considering its specific nature for the mechanical and electrical works, it is necessary to dispatch engineers who have full knowledge of the water treatment facilities.

At the time of completion of the works, some engineers for water quality control and plant operation and maintenance, will be necessary to be dispatched for training for plant operators. For the above staff training, spot-supervising engineers are recommended to be assigned for mechanical facilities, electrical facilities, water quality control/chemical feeding for system operation and test-run. Necessary and practical training will be conducted before hand-over of the facilities as OJT.

3-1-2 Implementation Conditions

(1) Rehabilitation of Facilities and Equipment

Detailed construction plan shall be prepared for repair and replacement of plant facilities and equipment so as to minimize inconvenience of consumers.

(2) Affects to the surrounding Area

The surrounding area of Nake Water Treatment Plant is plain land facing to the Mekong River with scarcely located houses. Therefore, any nuisance problems for noise and vibration derived from construction works will not be considered. However, it is necessary to have previous consent with closed communication to the residents dwelling along the access road about the expected noise, vibration, dust and obstruction for traffic caused by the heavy-loaded vehicles to transport construction materials.

As for the affect for groundwater, no specific problems are considered when extent of excavation with area and depth for reservoir's construction is taken into account.

(3) Transportation of Materials for Construction Works

As for the transportation of construction materials to the Nake water treatment plant site, the access road along the Mekong River has a sufficient width for heavy vehicles, thus no specific problem is found. However, care shall be taken for transportation during rainy season since the soil nature in the project site is silty-clay.

(4) Safety Control during The Execution of Construction

In such case as to utilize congested road in the town for transportation, sufficient care shall be taken for the safety of surrounding residents.

(5) Notes on Laws and Regulations

For the Lao labor regulations, related to the construction labor-force, there is「The Lao National Labor Law」, enforced in 1999. Its contents are not clearly prescribed. However, the revision of present law is scheduled in 2001, therefore it is expected that more detailed and clear clauses for the regulation will be provided in future. At the time of detailed design, follow-up survey on it is necessary to confirm any influence to the present project implementation.

3-1-3 Scope of Works

The present project included the construction of a clear water reservoir where the existing warehouses are located. The Lao side shall demolish mentioned warehouses before the construction works start. In addition, the Lao side shall provide 1) water, electricity and chemicals for construction and test run, 2) the provision of electricity due to increase of power receiving, 3) installation of service connections together with small size distribution pipelines to absorb increase of water supply, and 4) expenses related to the staff training including personnel cost and others

3-1-4 Consultant Supervision

The Consultant shall carry out construction supervision works, under the scheme of Japanese Grant Aid Program, to implement the Project with due understanding on the project background from the request of the grant aid up to the basic design study. The following matters are to be duly taken into account for carrying out the construction supervision:

① Due understanding the contents of Exchange Note, agreed between the governments of Japan and Lao PDR

② Due understanding the respective responsibility both for the Lao-side and Japanese-side, to coordinate and control the respective construction schedule.

③ Confirmation of the necessary procedures applied for the importation and taxation(or non-taxation) of materials and equipment for construction to Lao PDR, to avoid any delay of construction with necessary consultation with Lao side for importation.

④ Due consideration to residents during project implementation with understanding such features of environment, culture, history and background of people.

(1) Construction Supervision

1) Supervision Work

The Consultant shall execute the following item of works for construction supervision services:

a) Check & approve, the shop-drawings prepared by the Contactor,
b) Factory inspection of major materials and equipment before shipment,
c) Control of quality and progress of works,
d) Inspection after completion of construction,
e) Inspection of test operation for installed equipment,
f) Inspection of the procured materials and equipment,
g) Reporting of the progress of construction works to both Japanese side and Lao side,
h) Technical advice on responsible works of Lao side, and
i) Training and technical transfer for plant operation and maintenance.

In addition, the Consultant shall assist Lao PDR on necessary procedures for the Grant Aid program.

2) Structure of Construction Supervision

The present construction supervision services cover mainly the rehabilitation of the existing water treatment plant with repair and replacement of facilities and equipment. The following engineers will be dispatched periodically to carry out services. A resident engineer will be assigned for consistent supervision to control overall works during whole period of construction starting from initial stage of construction up to the completion. The scope of respective engineers for the supervision services is presented as follows:

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① **Project Manager**

At the time of completion of the construction, the project manager shall attend for final inspection of completed facilities and explanation to the Government of Lao PDR on the results of his inspection.

② **Resident Engineer**

The resident engineer shall supervise all construction and installation works by the contractor to control quality and progress of works with necessary advice and instructions. He will report to the Government of Lao PDR on the results of supervision services by monthly basis. The major responsibilities of the resident engineer among others are as follows:

To organize a pre-construction conference between the Owner, Consultant and Contractor to confirm their respective responsibilities, work contents, and construction schedule, etc.,

To maintain tender documents, drawings, respective standards applied for the works, technical specifications, results of survey & soil investigations, contractor's submissions, etc.,

To make review and approval for the construction schedule and shop drawings submitted by the Contractor with necessary advice and instructions,

To inspect and approve the materials and equipment supplied by the Contractor,

To inspect and approve the completed works by the Contractor

To control the construction schedule with necessary advice and instructions,

To inspect safety provisions for the works with necessary advice and instructions,

To organize periodical and ad-hoc meetings, when necessary, including the Owner, Consultant, and Contractor,

To carry out final inspection for approval,

To inspect and approve as-built drawings,

To assist the Lao side for hand over of the completed works upon the final inspection

③ **Spot Supervisor**

Along with the construction progress, following engineers in respective specialty, will be dispatched for such period as installation of equipment, test operation and staff training. The scope of the respective engineer is as follows:

- Mechanical Engineer; Check for shop drawings related to the mechanical equipment, inspection of installed mechanical equipment, inspection on test operation with necessary advice and related technical training.
- Electrical Engineer; Check for shop drawings related to the electrical equipment, inspection of installed electrical equipment, inspection on test operation with necessary advice and related technical training.
- Water quality analysis/ Chemical feeding; Technical training and advice water quality analysis and proper chemical feeding for plant operation under the soft component

(2) Methodology and Procedure of Construction

The present project consists of 1) rehabilitation of mechanical and electrical facilities/equipment, and 2) construction of a clear water reservoir. Due to the works required for rehabilitation such as cutting the existing pipes, providing opening on the existing structures, etc, it is inevitable to stop the plant operation partly or entirely. When the inconvenience of consumers is taken into account, it is important to minimize a time for stop operation of the plant as possible by arranging necessary temporary facility where applicable.

Especially for replacement of the existing distribution pumps, considerable time shall be required due to their complex piping system. It is therefore planned to install temporary pump system beside the newly constructed clear water reservoir with necessary pipe system to connect with the existing transmission pipeline, so as to avoid water supply stop using water in the reservoir when plant operation is required to stop. Upon the completion of pump replacement works, the temporarily installed pump with piping will be removed and restored for normal operation.

For the replacement works of other deteriorated mechanical and electrical equipment, it is also planned to make an appropriate plan to shorten the required time for replacement with necessary arrangement of temporary works such as related piping and wiring.

When it is considered as unavoidable to stop water supply, water supply stop shall be informed to consumers before hand with due discussion and consultation with NPS. Such arrangement shall be planned to avoid water supply stop in daytime, while necessary works are to be carried out during night time to revive water supply in the next morning.

The general construction procedure will be as shown below:

(1) Construction of a new clear water reservoir,

(2) Installation of temporary piping and wiring/cabling,

(3) Installation of temporary facility (distribution pump and piping),

(4) Replacing existing mechanical and electrical equipment including distribution pumps,

(5) Remove the temporary facilities, and

(6) Inspection and disinfections for installed facilities.

3-1-5 Procurement Plan

The required materials and equipment for construction works for the present project are principally procured from Japan and the market in Lao PDR. The Consultant will supervise the procedure for procurement of materials and equipment by the Contractor. The major materials and equipment included in the present project are presented in the following Table 3-1.

Table 3-1 Source Countries for Procurement

Materials Type	Materials Name	Japan	Lao PDR
Construction Materials	Cement, Sands & Gravel, Ply-wood, Steel-bar, Woods, Fuel, etc.		○
Construction Machine	Bulldozer, Back-how, Trucks, Crane, Generator, etc.		○
Equipment	Pumps, Valves, Pipes, Mixers, Chemical Feeding Equipment, Flow meters, Tools and Equipmant for Water Quality Analysis, etc.	○	

Such major construction materials as cement, sands & gravel for concrete work, plywood for form work, and reinforcing steel bars are available in the market in Lao PDR. Their quality and quantity are judged as acceptable. As for the construction machines, the necessary machines are also available for lease in Lao PDR for the proposed construction works.

The equipment for water treatment plant, such as pumps, chemical feeding, other mechanical and electrical equipment, is designed principally with similar specifications of the existing one. It is intended in the design that the similar specifications of the existing equipment make operators for easier operation and maintenance of the plant. Reliability of equipment with adequate technical level of the present system is also taken into account for the design of equipment. These equipments are not produced and not available in the Lao PDR, thus they are planned in principle, to be procured in Japan.

3-1-6 Implementation Schedule

After the Exchange Notes between the governments of Japan and Lao PDR has agreed and signed, the Consultant will be selected. The detailed design work is scheduled for 4 months, and after selection of the Contractor a 12 months period is scheduled for procurement and construction under the supervision of the Consultant. Before and after the completion of the construction works, soft component is planned for 6 months.

The implementation schedule for the present project is presented in Fig. 3-2.

3-1-7 Obligations of Recipient Country

(1) Responsible Part of Construction

Both for Japanese side and Lao side have respective responsible part of project implementation as follows:

Responsible part of Japanese side includes:

① Rehabilitation of Raw Water Intake Facilities,
② Rehabilitation of Water Treatment Plant Facilities,
③ Rehabilitation of Distribution Pump Facilities and Construction of Clear Water Reservoir, and
④ Supply of Tools and Equipment for Water Quality Analysis.

Responsible part of Lao Side includes;

① Land acquisition for project construction sites, before the construction start,
② Arrangement of power supply due to increase of power receiving capacity,
③ Preparation of water, power and chemical supply for construction and test operation,
④ Removal of existing warehouses located at construction site for the clear water reservoir,
⑤ Installation of service connections and related small size distribution pipelines to absorb increase of water supply,
⑥ Related cost for staff training for operation and maintenance of the plant and water quality control, and
⑦ Other general items
- Arrangement for tax exemption measures for importation of materials and equipment and other domestic taxation concerned,

- Arrangement for custom clearance for imported materials and equipment with necessary expenses for the procedures,
- Arrangement for entry visa application and stay permit for the assigned Japanese nationals for performance of their work, and
- Proper and effective operation and maintenance of completed facilities and supplied equipment under the present project.

The present project is for the rehabilitation of the existing water treatment plant, and construction of new clear water reservoir. The construction site of the reservoir is located within the present plant site. The access road is available although not paved. Therefore work item ① is ready for construction. Regarding work item ②, necessity for replacement of existing power receiving line will be confirmed during detailed design through discussions with related agencies. If it is found as necessary to replace the power line, proper capacity and timing for installation will be discussed and designed.

Upon the completion of the project, the Nake Water Treatment Plant will be able to supply water at its design capacity of 15,000 m3/day. Work item ⑤ for installation of service connection with related small size pipelines will be required by NPS to facilitate the effects of the present project at its maximum extent. As for work item ⑥ necessary expenses shall be born by NPS for staff training other than those included in the scope of Japanese side. The staff training will include water quality control which may be effectively carried out in the Chinaimo Water Treatment Plant in Vientiane.

3-1-8 Soft Component

NPS has been continuing water supply in Savannakhet for 24 years since its inauguration in 1977. However, the financial status of NPS is not necessarily satisfactory conditions. The balance sheet of NPS for the past 10 years from 1990 to 1999 was generally in deficit without making balance in income and expenditure. The major causes were inadequate water rate setting that revenue by water sales could not cover the expenditure for operation and maintenance. Although NPS raised water tariff for four times in the past, its financial status was not improved.

Since 1982, five years after the inauguration, water supply quantity has not been measured due to malfunction of flow meter. Since the necessary water supply quantity could not be grasped against consumption, adequate control of water production has not been maintained against consumption. Also effective measures could not be taken against water loss reduction since accurate unaccounted-for-water ratio could not be obtained due to malfunction of flow meter for distribution.

NPS was not sufficiently organized for proper financial analysis in long term water supply management. This will be derived from limited manpower resources and lack of skill for financial analysis.

As described, no rehabilitation as well as expansion of the water treatment plant in Savannakhet has been made since its inauguration in1977. Even deterioration of plant equipment has been advanced, the production of the plant is barely maintained by the efforts of operators although production capacity is decreasing from the design capacity. It is important to support the plant operators to be trained and capable enough for the operation and maintenance for renovated facilities and equipment. The plant operators shall have basic knowledge on water treatment process although they are working based on their experience so far obtained by the practices for plant operation. For example, optimum and effective chemical dosage based on the jar test will result in economical control of chemical feeding.

From the above points of view, an introduction of the following soft component is recommended:

(1) Financial and Managerial Aspect:

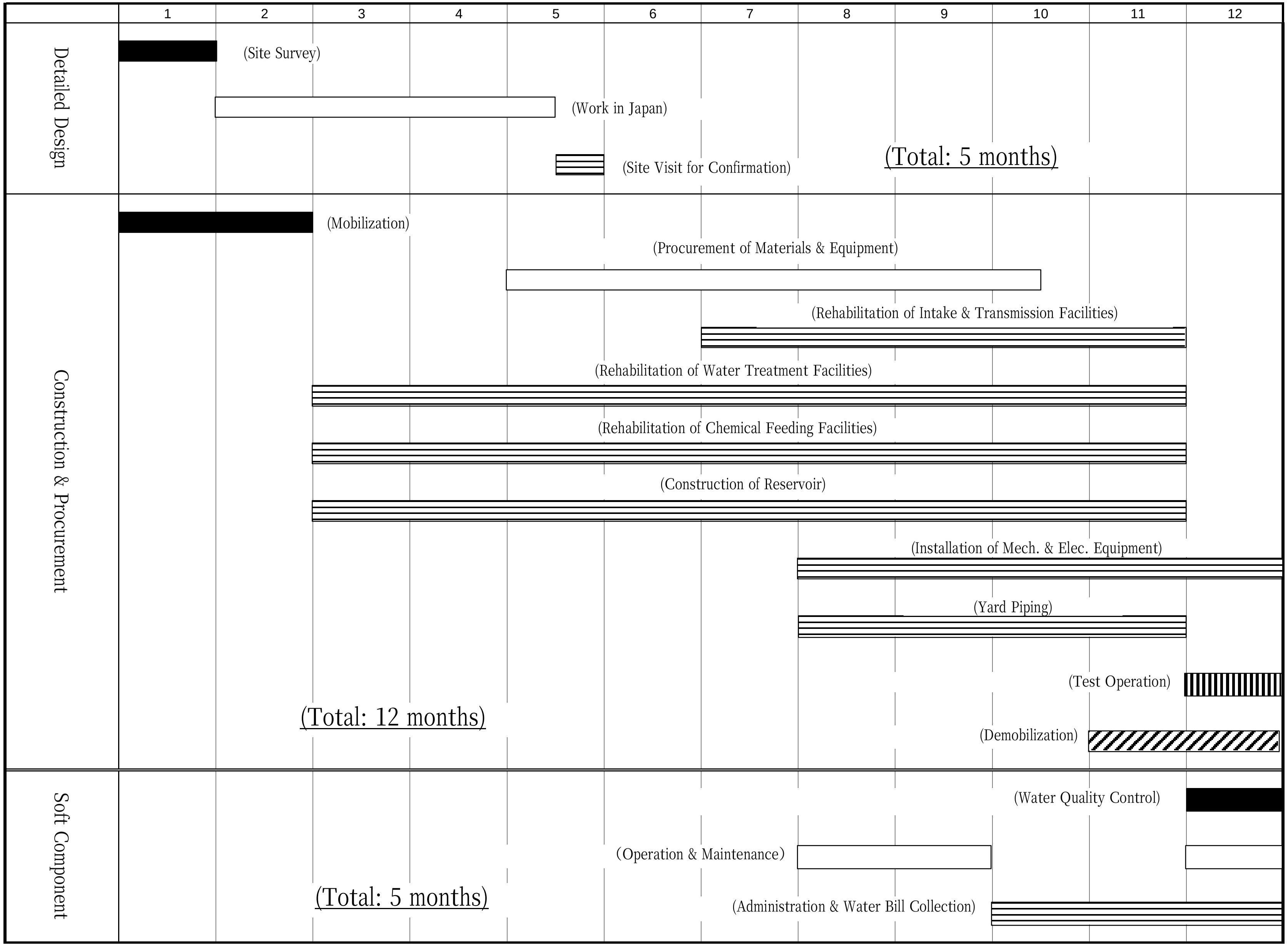
- Advice and guidance on managerial and financial aspects
- Advice and guidance on water tariff collection

(2) Operation and Maintenance of Water Treatment Plant

- Advice and guidance on plant operation after the improvement
- Advice and guidance on water treatment process
- Support for training for plant operators

Details on the soft component are described in Appendix B

Fig. 3-2 Project Implementation Schedule



3-2 Project Cost Estimation

According to the aforementioned responsible portions by Lao side, the required cost was estimated at Kip.1,686 million which is composed of following cost items:

1) Supply of Water, Power and Chemicals for Construction and Test Operation	Kip. 48 million
2) Power receiving (replacement of power line)	Kip. 21 million
3) Removal of existing warehouse	Kip. 116 million
4) Installation of service connection and small size pipelines	Kip. 1,480 million
5) Staff Training	Kip. 21 million

3-3 Operation and Maintenance Costs

Upon the completion of the Project, NPS will have the responsibility for operation and maintenance of renovated facilities. In this section, future operation and maintenance costs after the completion of the Project are studied and estimated.

(1) Operation and Maintenance Costs

1) Personnel Costs

The necessary staff for future operation and maintenance works are examined and summarize in Table 3-2 together with estimated personnel cost.

Table 3-2 Staffing Plan of NPS and Personnel Cost

Division	As of 2000	After Rehabilitation
1. Management	2	2
2. Administration	4	4
3. Business	27	29
4. Financial	7	8
5. Technical	7	7
6. Repairing and Installation	15	15
7. Water Treatment Plant	14	15
8. Branch Offices	4	4
Total Staff	80	84
Personnel Cost (per year)	Kip. 133,200,000 (Kip.1,665,000/person)	Kip. 142,000,000 (Kip.1,700,000/person)

The basic consideration for staffing plan after the completion of the Project is presented as follows:

- To increase staff number in the Business Division with improvement of water tariff collection system since work load for meter reading with preparation of water bills at present is rather heavy as 500 connections per meter reader.
- To improve organization for proper financial planning by promoting a qualified accountant for financial analysis in the Financial Division to improve financial status.
- To improve level of technical staff in Technical Division for future technical planning including system expansion and improvement.
- To provide tools and equipment including drain pumps for effective maintenance, installation and repair works such as installation of small size pipelaying, installation of new service connections, repair of defects pipelines and leaks, while present staff number will be kept in Repairing and Installation Division.
- To enforce staffing and improve organizational structure of Water Treatment Plant Division to facilitate proper operation and maintenance of water treatment plant including water quality control.

2) Electricity and Chemical Costs

For other major operation related costs, electricity and chemical costs are estimated based on the rated water production capacity after the rehabilitation of the water treatment plant. As the results, these costs show considerable increase from the expenditure in 1999. Table 3-3 shows the production cost including maintenance cost.

(2) Analysis for Income and Expenditure

Based on the present water rate, tariff structure and other income and expenditures, analysis for income and expenditure of NPS's water supply after the completion of the Project was attempted. Depreciation of the existing facilities was incorporated in this analysis.

The analysis were made for the following three cases, and the results are presented in Table 3-4:

(Case 1) : Same water rate at the present,

(Case 2) : Water rate is increased 5% against the present rate, and

(Case 3) : Water rate is increased 10% against the present rate.

The results of analysis suggest that average water rate is to be raised for 10 ~ 15 % from the present water rate when production capacity of Nake Water Treatment Plant at 15,000 m3/day is supplied.

It is vital to set up water tariff for sustainable operation of the water supply system with sufficient budget for operation and maintenance of facilities and provision for certain extent of depreciation, while customer's ability and willingness to pay will become restriction to raise water tariff. According to the customer survey conducted during the site survey, the rate for water charge was estimated at about 4 % against income. This rate was reported at about 2 % in the report on Savannakhet Water Supply Improvement Program, Lao People's Democratic Republic (1999 by JICWELS). While, the report of the World Bank estimated that the rate is around 5 to 6 % for water supply and drainage. From the above survey results and studies, it is judged that the rate for water charge against income will be around 3 to 4 %.

It is important to promote financial specialist with training for financial analysis to be conducted time to time in accordance with changes of circumstances and to set up proper water tariff taking adequate level of depreciation into account. The discussions with agencies concerned for proper tariff setting shall be required. Based on the above, practicable project implementation could be realized with financial background.

3-4 Water Tariff Setting

NPS raised water tariff for 4 times since 1996 to 2000 caused by its financial deficit in operation. The details of water tariff revision are shown in Table 3-5. Table 3-6 shows changes of water rate.

From these records, the water rate increase was about 550 % in average from 1996 to 2000 composing of 740 % for domestic use and 340 % for non-domestic use. Average water rate in 1999 was Kip.223/m^3, while it was raised at kip.385/m^3 as of August 2000. On the other hand, the production cost in 1999 was Kip.181/m^3 which will be increased at Kip.220/m^3 after rehabilitation of the plant facilities as shown in Table 3-3.

As shown in Table 3-4, the balance between income and expenditures was compared for the year 1999 and the future after the rehabilitation of the water treatment plant. Two cases for the analysis were made at 10% and 15% water tariff raises. Average water rate will be Kip.443/m^3 when water tariff will be raised at 15 %.

In the present basic design study, the following customer survey was conducted:

- The customer survey was conducted for 469 customers randomly selected in the four districts of present NPS service area composing of 376 for domestic customers and 93 for non-domestic customers.

- The customer survey was made by NPS's staff who visited each customer for interview per respective survey items in the questionnaire.

The results of the above customer survey are as shown in the following.

	Average Income (Kip/month/house)	Water Consumption (m^3/day/connection)	Water Charge (Kip/month/house)	Rate to Income (%)
Domestic User	83,000 - 98,000	0.75 - 1.15	6,500 - 8,800	7.8 - 8.9
Non Domestic User	185,000 -251,000	1.20 - 1.50	16,000 – 24,000	8.6 - 9.5

From the above customer survey, obtained income level is considered too low and it is estimated at about two times of the answer in the survey. Thus the rate for water charge is estimated at 4 ~ 4.5 % of income for domestic customer. Similarly, it is estimated in the rage of 4 ~ 5 % for non-domestic customer.

Based on the above water consumption and water charge, the average water rate is calculated at 255-288 Kip/m^3 for domestic consumer and for non-domestic user it is 444-530 Kip/m^3.

As described, average water rate in 1999 was Kip.223/m^3 according to NPS's water bill record, while financial balance was deficit. Therefore it is obvious that water tariff shall be revised. As shown in the analysis for income and expenditures, some 15 % of water tariff raise will be required. In such case, the average water rate will be at 443 Kip/m^3, and the rate for water charge against income will increase at about 5 % in average. This is however considered in the tolerable range, while proper tariff structure shall be examined so as to reduce the burden to the low income group.

Proposal for revision of water tariff by NPS, after assessment of DCTPC, shall be reported to the Governor of Savannakhet Province for approval. While, rate of increase may be adjusted sometimes by the opinion of the Governor. However, it is vital to examine long-term revisions with adequate water tariff level for sound operation and management of water supply system in Savannakhet based on proper financial analysis. In this circumstance, the understanding and support of DCTPC and Savannakhet Province shall be inevitable for revision of water tariff.

Table 3-3 Water Production Cost

ITEM	UNIT	1995	1996	1997	1998	1999	After Rehabiritation
Production	m^3/year	3,586,340	3,559,643	3,593,534	4,136,274	4,377,880	5,475,000
	m^3/day	9,826	9,752	9,845	11,332	11,994	15,000
Operation Cost							
1.Eectricity	Kip	36,096,115	38,687,714	52,353,881	89,638,946	214,260,186	517,900,000
		10	11	15	22	49	
2.Chemical Cost							
2.1 Alum		57,113,701	59,034,000	55,131,500	103,902,594	307,745,910	431,200,000
2.2 Chlorine		4,079,100	3,348,891	4,547,065	6,647,106	9,930,100	207,000,000
2.3 Lime			0	0	0	0	0
2.4 Polymer						9,041,772	0
Total for Chemical Cost		61,192,801	62,382,891	59,678,565	110,549,700	326,717,782	638,200,000
		17	18	17	27	75	
3.Maintenance Cost	Kip						
3.1 Supply of Materials		11,454,338	11,973,347	20,832,530	52,911,611	104,496,000	15,000,000
3.2 Repairing		2,961,641	2,877,200	1,452,125	7,521,745	31,541,376	5,000,000
Total for Maintenance	Kip	14,415,979	14,850,547	22,284,655	60,433,356	136,037,376	20,000,000
4. Labour Cost	Kip						
(excluding permanent		45,582,878	48,127,726	50,521,183	83,545,442	113,192,750	27,000,000
staff cost)							
Total for 1-3	Kip	157,287,773	164,048,878	184,838,284	344,167,444	790,208,094	1,203,100,000
Unit Cost of Operation	Kip/m^3	44	46	51	83	181	220

Table 3-4 Analysis for Income and Expenditure of NPS

Description	1999	After Rehabiritation Case-1(Present Rate)	After Rehabiritation Case-2(10%increase)	After Rehabiritation Case-3(15%increase)
1.Revenue				
1.1 Water Sale				
Private	469,720,790			
Government	278,387,310			
Total for Water sale	748,108,100	1,401,700,000	1,543,700,000	1,612,900,000
1.3 Connection Fee	26,845,270	157,500,000	157,500,000	157,500,000
1.4 Others	209,502,324	38,700,000	46,300,000	44,500,000
Total for Revenue	984,455,694	1,597,900,000	1,747,500,000	1,814,900,000
2. Expense				
2.1 Personnel	133,192,750	142,000,000	142,000,000	142,000,000
2.2 Administration	124,036,970	124,000,000	124,000,000	124,000,000
2.3 Depriciation	91,374,702	80,000,000	80,000,000	80,000,000
2.4 Production				
-Chemical Cost	326,717,782	638,200,000	638,200,000	638,200,000
- Electricity Cost	214,260,186	517,900,000	517,900,000	517,900,000
- Maintenance Cost	249,230,126	47,000,000	47,000,000	47,000,000
Total for Production Cost	790,208,094	1,203,100,000	1,203,100,000	1,203,100,000
2.5 Installation and Repairing	81,846,621	82,000,000	82,000,000	82,000,000
Subtotal	1,220,659,137	1,631,100,000	1,631,100,000	1,631,100,000
2.6 Others	66,987,210	67,000,000	67,000,000	67,000,000
2.7 Government Tax	51,936,504	47,937,000	52,425,000	54,447,000
Total for Expense	1,339,582,851	1,746,037,000	1,750,525,000	1,752,547,000
Balance	-355,127,157	-148,137,000	-3,025,000	62,353,000

Note: Depreciation (2.3) is for the existing facilities only, not for the facility to be rehabilitated.
Government tax is based on 3% for total revenue.

Water Sale

Annual Water in m^3	15,000	3,832,500	Revenue(90%)
Unit Price(Kip/m^3)- present rat	385	1,475,512,500	1,401,700,000
Unit Price(Kip/m^3)-10% increase	424	1,624,980,000	1,543,700,000
Unit Price(Kip/m^3)-15% increase	443	1,697,797,500	1,612,900,000

Connection Fee

Number of Connection /Year		450
Connection Fee(per Connection)		350,000
Connection Fee (Kip/Year)		157,500,000

Table 3-5 Revision of Water Tariffs (1996—2000)

1996		1998		1999		2000	
Categories	Rate(kip/m3)	Categories	Rate(kip/m3)	Categories	Rate(kip/m3)	Categories	Rate(kip/m3)
1.Domenstic Use		1. Domestic Use		1. Domestic Use		1. Domestic Use	
1-20 m3/m	60	0-30 m3/ m	150	0-30 m3/m	185	1-10 m3/m	215
21-30 m3/m	70	more than 31m3/m	155	more than 31m3/m	310	11-20 m3/m	325
31-40 m3/m	120					21-30 m3/m	375
more than 41m3/m	140					more than 31m3/m	430
2.Business Use	190	2. Business Use	200	2. Business Use	450	2. Business Use	550
3. Administration	140	3. Administration	160	3. Administration	350	3. Administration	same as
Use		Use		Use		Use	domestic use
4. Factory	250	4. Factory	250	4. Factory	500	4. Factory	650
Use water as raw				Use water as raw		Use water as raw	
material				material		material	

Note: (1) Category 4 includes Ice factory and water vender.
(2) Business use includes shop, restaurant, hotel, and guest house.
(3) Revision of tariff , increasing water rate, is subject to approval of the Governor of Savannkhet Province

Table 3-6 Changes of Water Rates (1996~2000)

	Water Sale (m3/year)			Water Sale (in Kip)			Unit Rate		
	Domestic	Others	Total	Domestic	Others	Total	Domestic	Others	Total Average
1995	2,102,397	579,529	2,681,926	105,295,405	98,932,720	204,228,125	50	171	76
1996	2,352,593	643,417	2,996,010	106,735,460	101,813,040	208,548,500	45	158	70
1997	2,315,388	659,195	2,974,583	187,398,540	111,160,760	298,559,300	81	169	100
1998	2,642,682	746,778	3,389,460	341,458,120	142,512,860	483,970,980	129	191	143
1999	2,552,725	802,009	3,354,734	469,720,790	278,387,310	748,108,100	184	347	223
2000-Aug.	245,630	84,434	330,064	82,211,220	44,930,000	127,141,220	335	532	385

CHAPTER 4 PROJECT EVALUATION AND RECOMMNENDATIONS

Chapter 4 Project Evaluation and Recommendation

4-1 Project Effect

Nake Water Treatment Plant has been in operation for 24 years and its facilities have been deteriorated especially for the mechanical and electrical equipment. It is therefore obvious that the production as well as water distribution capacity has been decreasing from the rated capacity. The present production capacity is estimated at about 12,000 m3/day, or at 80 % of the rated capacity and the decrease of production capacity is estimated at the rate of 4 ~ 5 % annually. Contrary to such plant conditions, water demand in Savannakhet city has been increasing due to population increase, and the plant produces mostly at its full capacity at the present. Due to further deterioration of the plant equipment, the present production capacity would not be cope with increasing water demand in 2 years against maximum water demand or 5 years for average water demand when no rehabilitation works will be carried out. Thus it is urgently required to implement the present project. The aims of the rehabilitation works are as follows:

- Effective utilization of the existing plant with rehabilitation of mechanical and electrical equipment for its efficient and stable operation,
- Quantitative and qualitative plant operation through installation of flow meters and test equipment for water quality analysis, and
- Decreasing the maintenance cost cause by frequent repair of equipment and replacement of its spare parts.

Upon the completion of the Project, the consumer in the Savannakhet city will receive improvement of supply services with stable and safe water supply.

By means of the Project, the summary of the direct effects are presented as follows:

Items	Evaluation Index			
	Index	Before Project Implementation	After Project Implementation	Note
Water Supply Improvement in The Project Area	Population Served	40,800 (year 2000)	45,000 (year 2004)	
	Day Average Water Supply	9,033 m3/day	9,968 m3/day	
	Production Capacity	12,000 m3/day	15,000 m3/day	
	Annual Production	70 % of Rated Capacity	100 % of Rated Capacity	Production decrease is estimated at 4~5% annually from 7 years ago
Other Direct Effects 1) Stable water supply (for 24 hrs continuous supply) by rehabilitating water treatment plant 2) Safe water supply by water quality control (strengthening chlorination and monitoring of water quality) 3) Improvement of water supply pressure including surrounding areas of city center due to increase of water supply quantity				

In the Forth Five-Year Plan, the improvement of infrastructure of cities including water supply is positioned as the most high priority program. Moreover, Savannakhet city has a high priority as the second largest city of Lao PDR for the improvement of water supply as stated in the 'Management and Development of Water Supply Sector in Lao PDR by Prime Minister's Office as of 30 August 1999 (No. 37/PM)'. The project will greatly contribute to improve sanitary and living conditions of Savannakhet city as well as its economic development.

In addition to the above direct effects, the following indirect effects are expected by introducing soft component items as follows:

- Improvement of financial management taking appropriate costs for operation and maintenance of the water treatment plant,
- Improvement of efficiency for water tariff collection,
- Improvement of rate for metered service connections,
- Improvement of water quality control,
- Improvement of data accumulation and filing of them, and
- Proper operation of water treatment plant based on measurement and testing, and practicable and proper future planning based on the accumulated data.

4-2 Recommendation

The execution of the Project will greatly contribute to improve environmental conditions for the dwellers in the project areas. For the acceleration and continuation of effects for the Project, the following actions shall be taken by Lao PDR:

(1) Installation of Distribution Pipelines and Service Connections

Along with the completion of the Project, it is required by Lao PDR to install necessary pipelines and service connections by his own budget for effective use of increased water supply quantity due to the Project in accordance with the demand increase.

(2) Revision of Water Tariff

Necessary expenditures for the operation of water supply system should be borne by its consumers. As stated previously, the revisions of water tariff has to be planned properly and implemented based on adequately arranged financial program with due consideration for overall operation and management of water supply system. NPS will be necessary to receive advises from MCTPC for the above revisions of water tariff, and it will be effective also to receive advise and guidance on this matter from Vientiane Water Supply Company which is sole agent for water supply system in the capital city of Loa PDR.

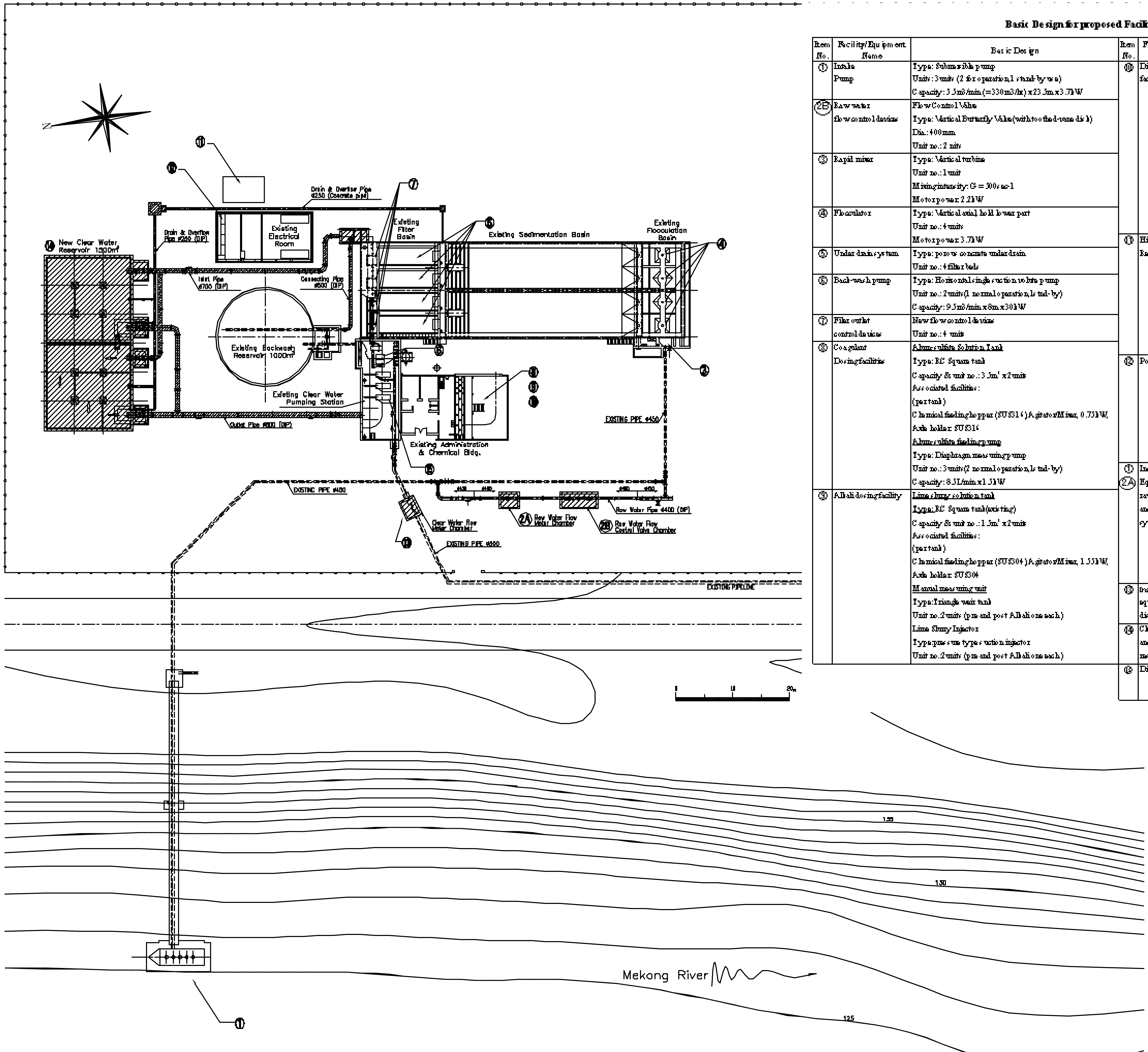
(3) Operation and Maintenance of Water Supply System

Staff training shall be carried out for operation and maintenance of the Nake Water Treatment Plant after the completion of the Project as well as training for water quality control. Such training shall be planned and continued periodically. Regarding reduction of unaccounted-for-water, the continuous endeavors shall be paid for leak reduction and proper maintenance of customer's water meters. The above activities are important to be carried out based on adequately arranged program.

ATTACHEMENT DRAWINGS

Drawing List

Drawing No.	Title
Drawing － 1	General Plan of Nake Water Treatment Plant
Drawing － 2	Flow Diagram of Nake Water Treatment Plant
Drawing － 3	Water Flow Diagram
Drawing － 4	Existing Raw Water Intake Tower & Raw Water Pipe Bridge
Drawing － 5	Detail of Raw Water Intake Pump
Drawing － 6	Plan of Existing Water Treatment Plant
Drawing － 7	Section of Existing Water Treatment Plant
Drawing － 8	Existing Filter Basin
Drawing － 9	Detail of Connection Well
Drawing －１０	Existing Pumping Station, Administration Bldg. & Chemical Bldg.
Drawing －１１	Distribution Flow Meter Chamber
Drawing －１２	Inlet Water Flow Control Valve Chamber & Raw Water Flow Meter Chamber
Drawing －１３	New Pipe Line of Water Treatment Plant
Drawing －１４	New Clear Water Reservoir
Drawing －１５	Existing Electrical Room



Basic Design for proposed Facilities and Equipment

Item No.	Facility/Equipment Name	Basic Design
①	Intake Pump	Type: Submersible pump Units: 3 units (2 for operation, 1 stand-by use) Capacity: 5.5m3/min (=330m3/hr) x23.5m x3.7kW
②B	Raw water flow control devices	Flow Control Valve Type: Vertical Butterfly Valve (with toothed-vane disk) Dia.: 400mm Unit no.: 2 nits
③	Rapid mixer	Type: Vertical turbine Unit no.: 1 unit Mixing intensity: G = 300 sec-1 Motor power 2.2kW
④	Flocculator	Type: Vertical axial, hold lower part Unit no.: 4 units Motor power 3.7kW
⑤	Under drain system	Type: porous concrete under drain Unit no.: 4 filter beds
⑥	Back-wash pump	Type: Horizontal single suction volute pump Unit no.: 2 units (1 normal operation, 1 stand-by) Capacity: 9.5m3/min x8m x30kW
⑦	Filter outlet control devices	New flow control devices Unit no.: 4 units
⑧	Coagulant Dosing facilities	Alum sulfate Solution Tank Type: RC Square tank Capacity & unit no.: 3.5m³ x2 units Associated facilities: (per tank) Chemical feeding hopper (SUS316) Agitator/Mixer, 0.75kW, Axle holder: SUS316 Alum sulfate feeding pump Type: Diaphragm measuring pump Unit no.: 3 units (2 normal operation, 1 stand-by) Capacity: 8.5L/min x1.5kW
⑨	Alkali dosing facility	Lime slurry solution tank Type: RC Square tank (existing) Capacity & unit no.: 1.5m³ x2 units Associated facilities: (per tank) Chemical feeding hopper (SUS304) Agitator/Mixer, 1.55kW, Axle holder: SUS304 Manual measuring unit Type: Triangle weir tank Unit no. 2 units (pre and post Alkali one each) Lime Slurry Injector Type pressure type suction injector Unit no. 2 units (pre and post Alkali one each)
⑩	Disinfectant dosing facility	Hypo chlorite solution tank Type: RC Square tank (existing) Capacity & unit no.: 1.5m³ x2 units Associated facilities: (per tank) : Chemical feeding hopper (SUS304) Agitator/Mixer, 1.55kW, Axle holder: SUS304 Manual measuring unit Type: Triangle weir tank Unit no.: 2 units (pre and post chlorination one each) Solution Injector Type: pressure type suction injector Unit no.: 2 units (pre and post chlorination one each)
⑪	High Voltage Power Receiving Facility	Power receiving transformer Type : outdoor, oil immersed, self cooling Capacity : 550KVA Voltage : 22kV/380V, 3-phase Unit : 1 unit High voltage switch gear Type : outdoor, manual cut-out, fuse-included Voltage : 400V, 3-phase Unit : 1 unit
⑫	Power Control Panel	Power control panel Type : Outdoor type, metal enclosed, self-standing Voltage : 400V, 3-phase Unit : 1 unit Local switch box Type : Indoor type, metal enclosed, stand type Voltage : 400V, 3-phase Unit : 1 unit
① ②A	Instrumentation/ Equipment for raw water intake and water treatment system	Level gauge Type : Ultra supersonic type Unit nos. : 1 unit Flow meter Type : Ultra supersonic type, out-door type Unit nos. : 1 unit (include trans-mitter) Instrument panel Type : Wall-type, Metal enclosed Unit nos. : 1 panel
⑬	Instrumentation equipment For distribution system	Flow meter Type : Ultra supersonic type, out-door type Unit nos. : 1 unit (include trans-mitter)
⑭	Clear water reservoir and distribution reservoir	Nos. : 1 basin Capacity : 1,500m³ Dimension: W15.0m x L15.0m x D3.5m x 2 units
⑮	Distribution pumps	Type : Single suction volute pump Unit no. : 3 units (2 normal operation, 1 stand-by) Spec. : 6.0m3/min (=360m3/h) x45m x 75kW

The Lao People's Democratic Republic
Ministry of Communication, transport, Post and Construction

The Basic Design Study on
The Project for Rehabilitation of
Water Supply Facilities in Savannakhet Area

TITLE
General Plan of Nake Water Treatment Plant

SCALE

DRAWING NO.
Drawing−1

Approved By | Date

Designed By | Date

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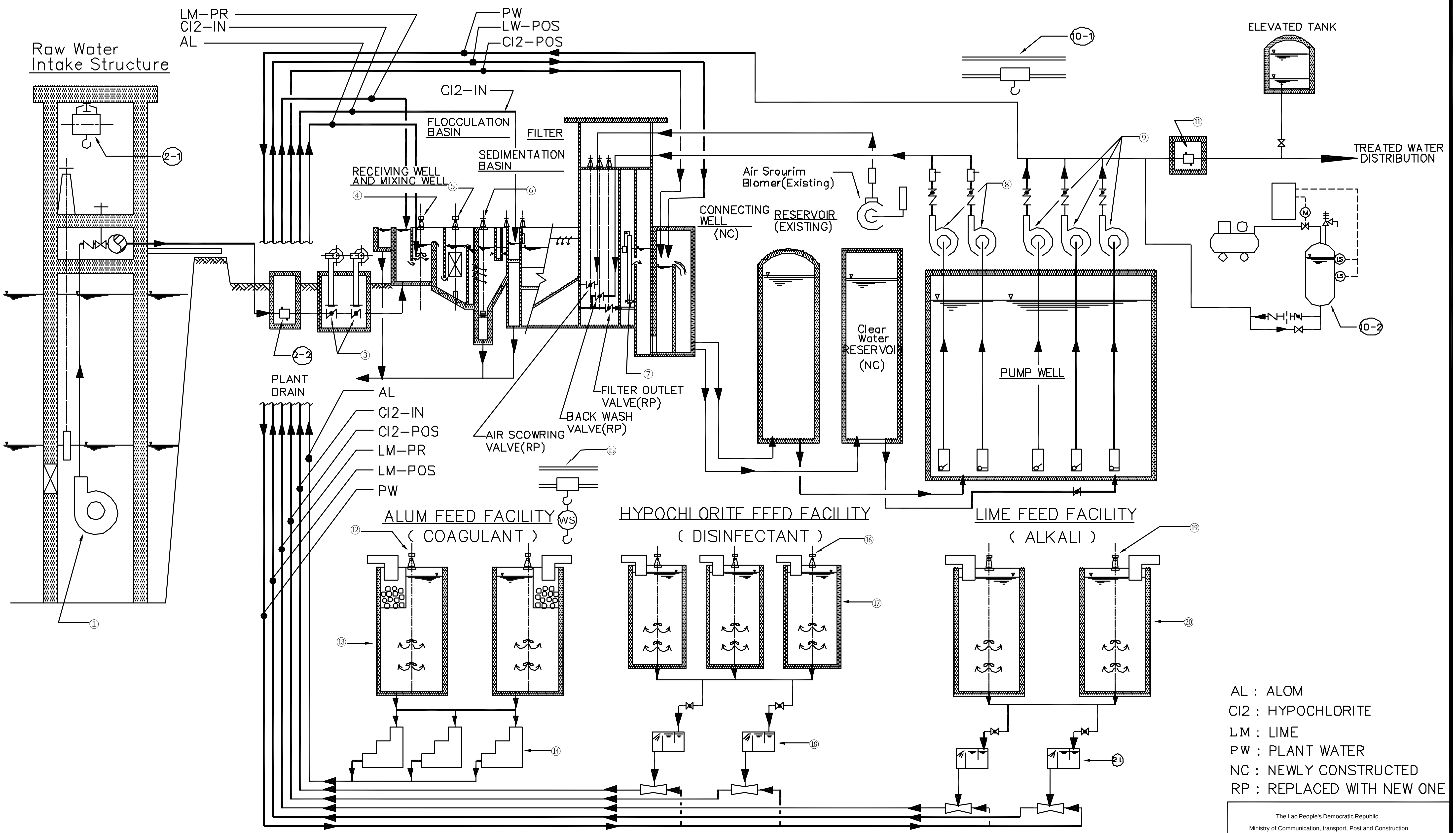

1	Intake Pumps 5m3/min x 23.5m x 37kw x 3units	8	Backwash Pumps, 9.5m3/min x 8m x 30kw x 2units	15	Motorized Chain Hoist, 500kg x 1unit
2-1	Motorized Chain Hoist, 3ton x 1	9	Distribution Pumps, 6m3/min x 45m x 75kw x 3units	16	Mixcer for Hypochlorite, 0.4kw x 3units
2-2	Flow Meter, Ultrasonis Type450mm x 1unit	10-1	Manual Chain Hoist, 1.5ton x 1unit	17	Hypochlorite Solution Tanks x 3units
3	Flow Control Valves (Manual) x 2units	10-2	Air Chamber, 7.5m3 x 1unit	18	Manual Measuring Devices x 2units
4	Rapid Mixer, 2.2kw x 1unit	11	Flow Meter,Ultrasonic 500mm x 1unit	19	Mixcer for Lime Milk, 1.5kw x 2units
5	Flocculators, 3.7kw x 4units	12	Mixers for Alum, 0.75kw x 2units	20	Lime Slury Tanks x 2units
6	Sludge Extraction Valves, 350mm x 4units	13	Alum Solution Tanks x 2units	21	Manual Measuring Devices x 2units
7	Filter Outlet Control Devices x 4units	14	Alum Feeding Pumps, 8.5L/min x 3units		

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TITLE
FLOW DIAGRAM OF NAKE WATER TREATMENT PLANT

SCALE
Non-Scale

DRAWING NO.
Drawing－2

Approved By Date

Designed By Date

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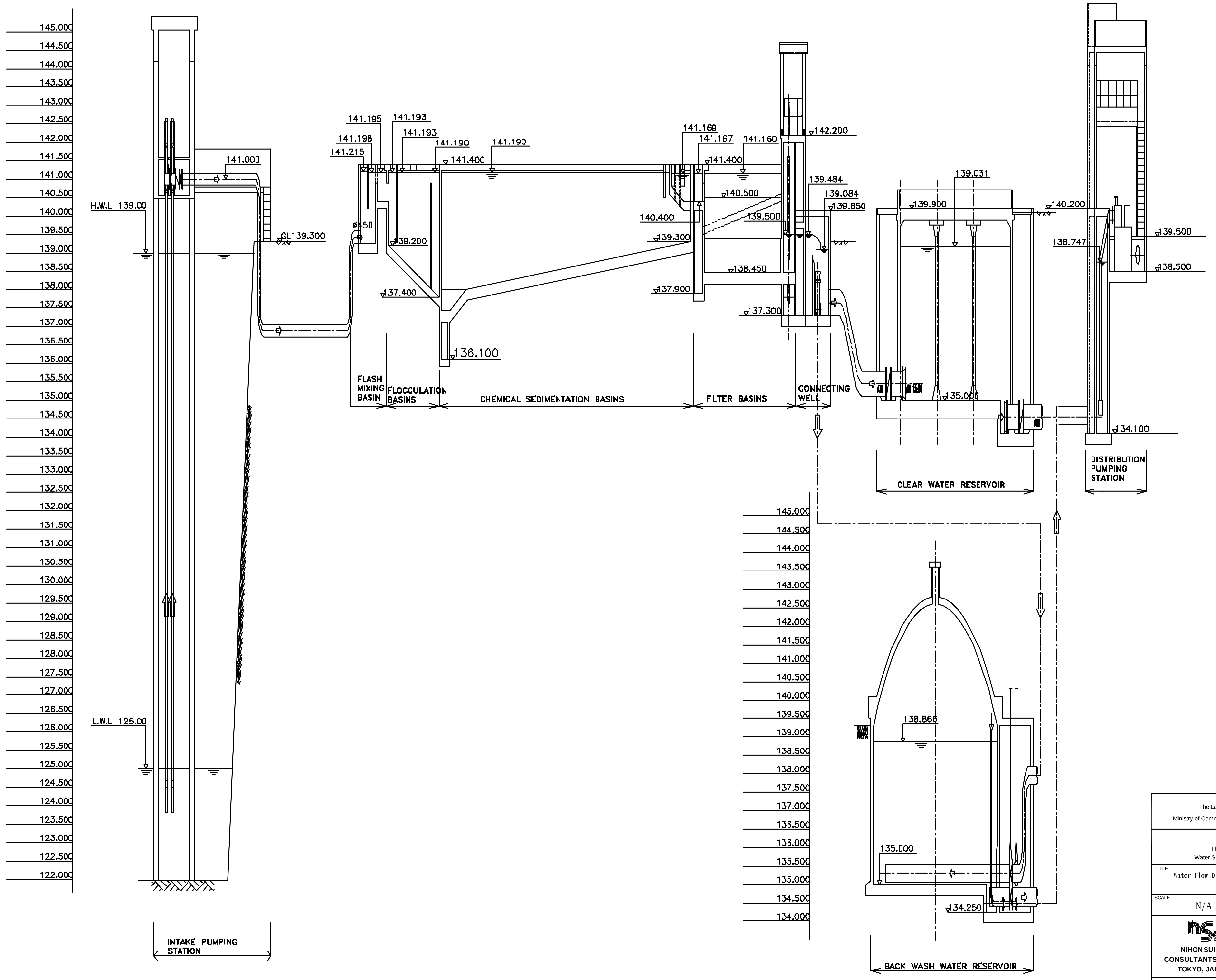

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TITLE
Water Flow Diagram

SCALE
N/A

DRAWING NO.
Drawing－3

Approved By — Date

Designed By — Date

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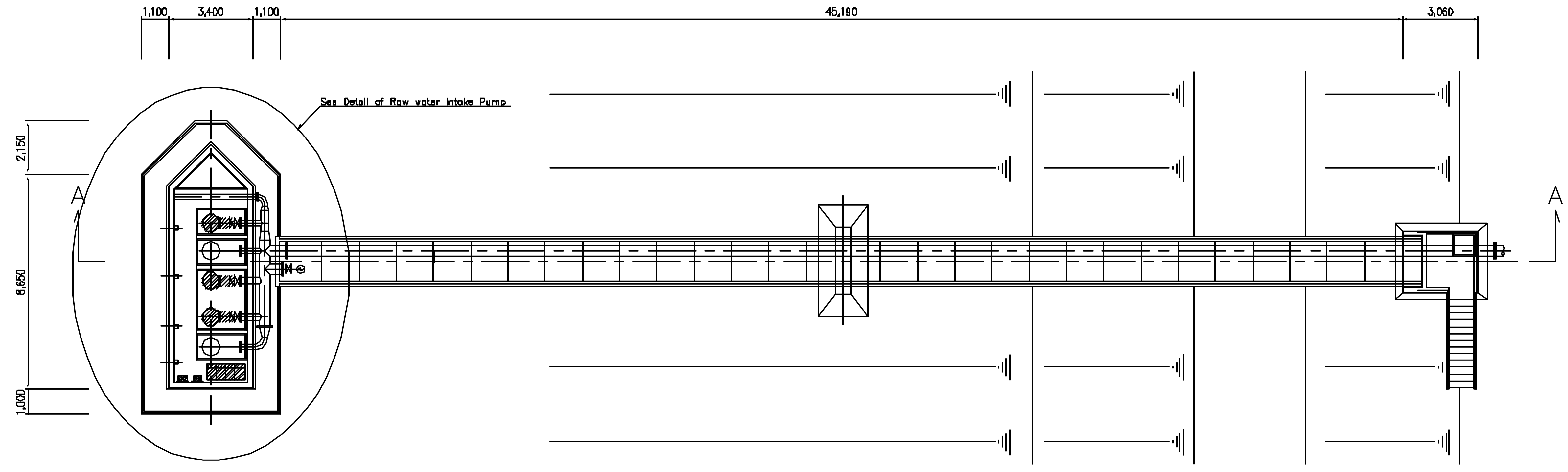
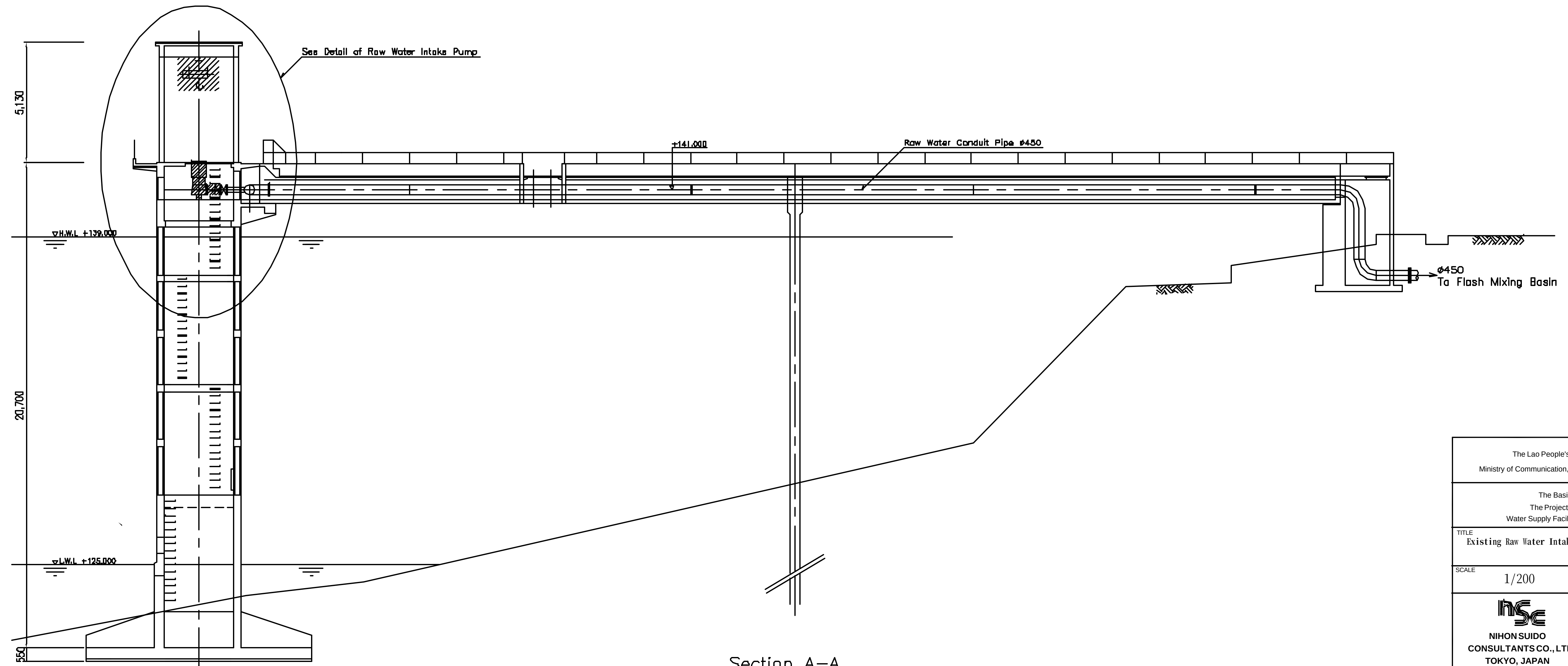
Plan of Existing Raw Water Intake Tower & Raw Water Pipe Bridge





Section A—A

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The Basic Design Study on
The Project for Rehabilitation of
Water Supply Facilities in Savannakhet Area

TITLE Existing Raw Water Intake Tower & Raw Waterpaipe Bridge	
SCALE 1/200	DRAWING NO. Drawing-4
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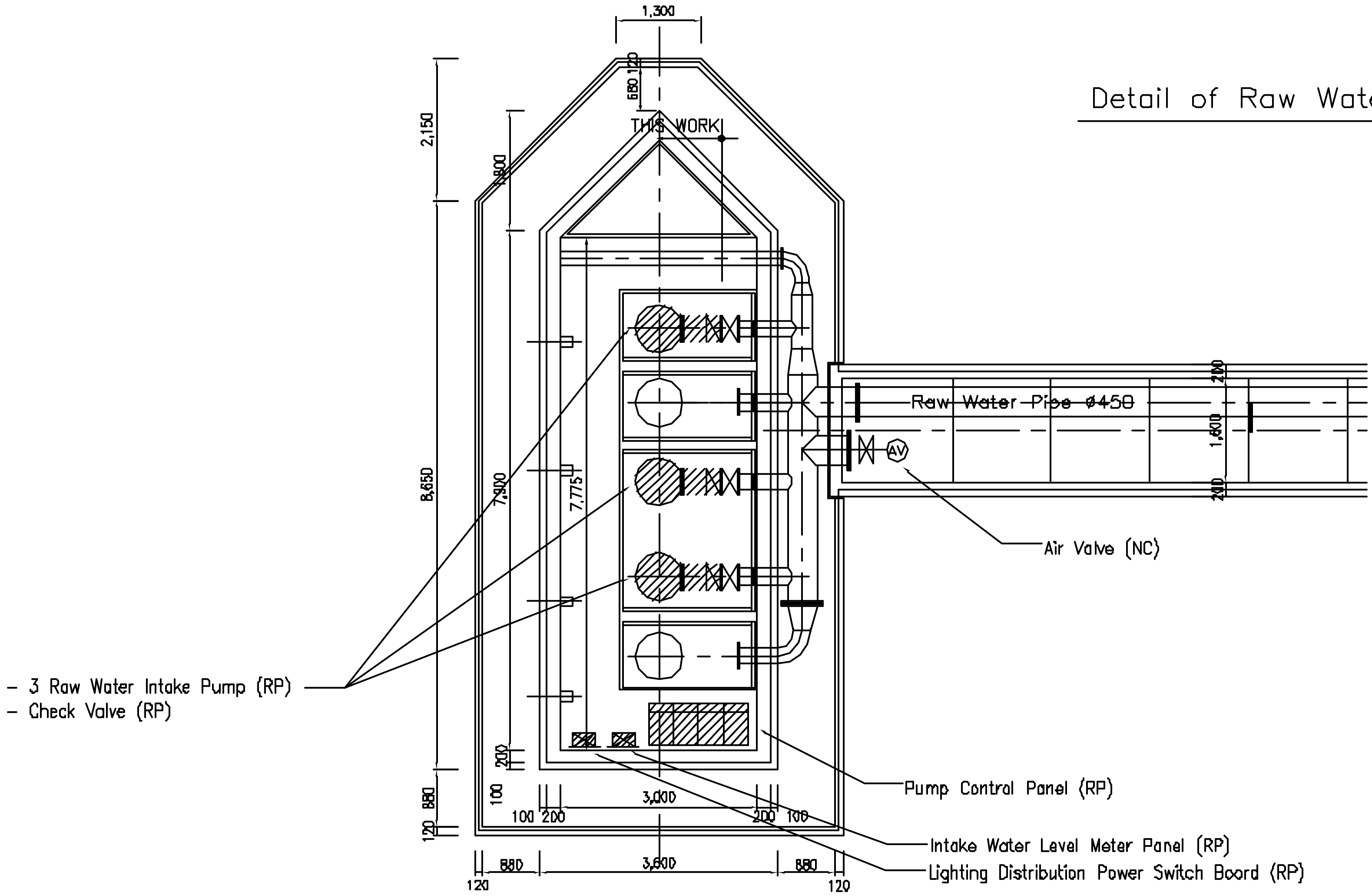
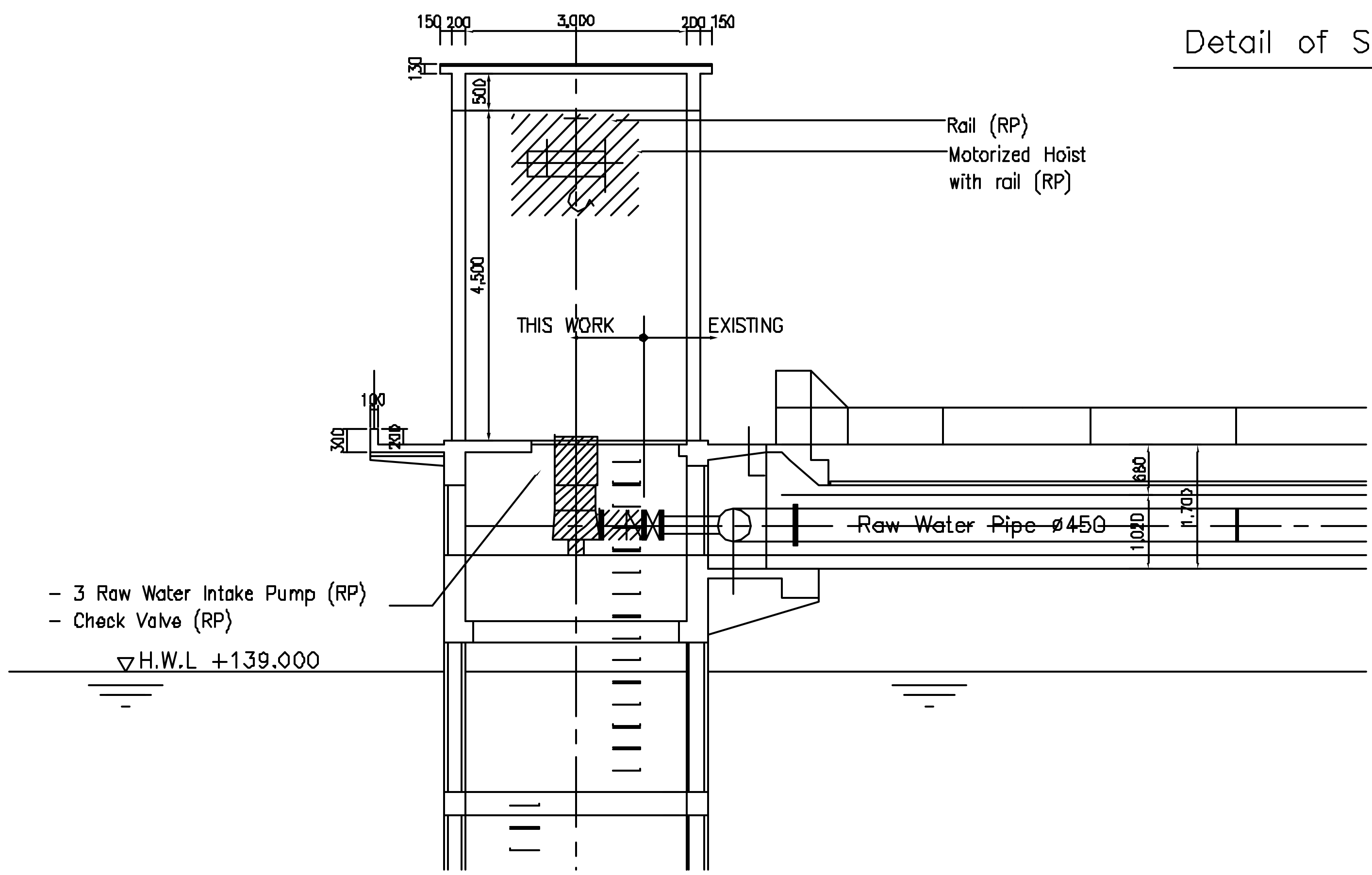
Detail of Raw Water Intake Pump



Detail of Section A-A



Legend

(NC) : Newly Instullation & Constraction

(RP) : Replace with New Equipment

(CL) : Clearance

The Lao People's Democratic Republic Ministry of Communication, transport, Post and Construction	
The Basic Design Study on The Project for Rehabilitation of Water Supply Facilities in Savannakhet Area	
TITLE Detali of Raw Water Intake Pump	
SCALE 1/100	DRAWING NO. Drawing-5
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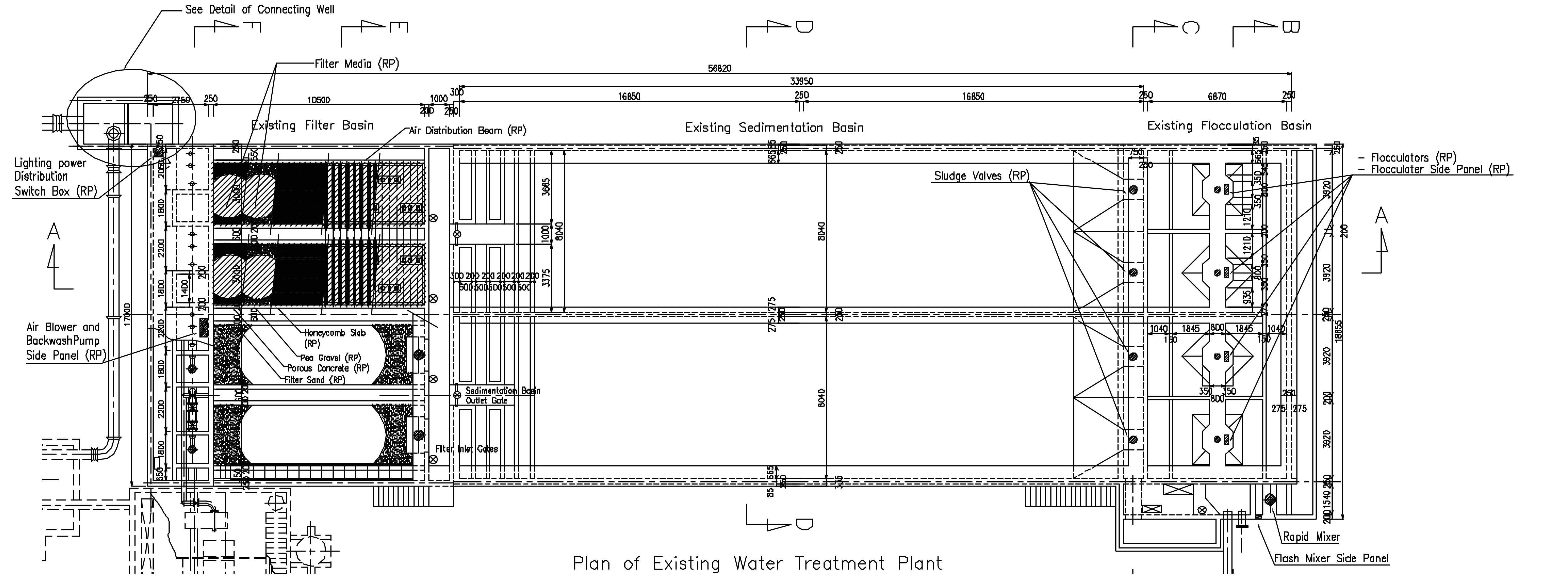
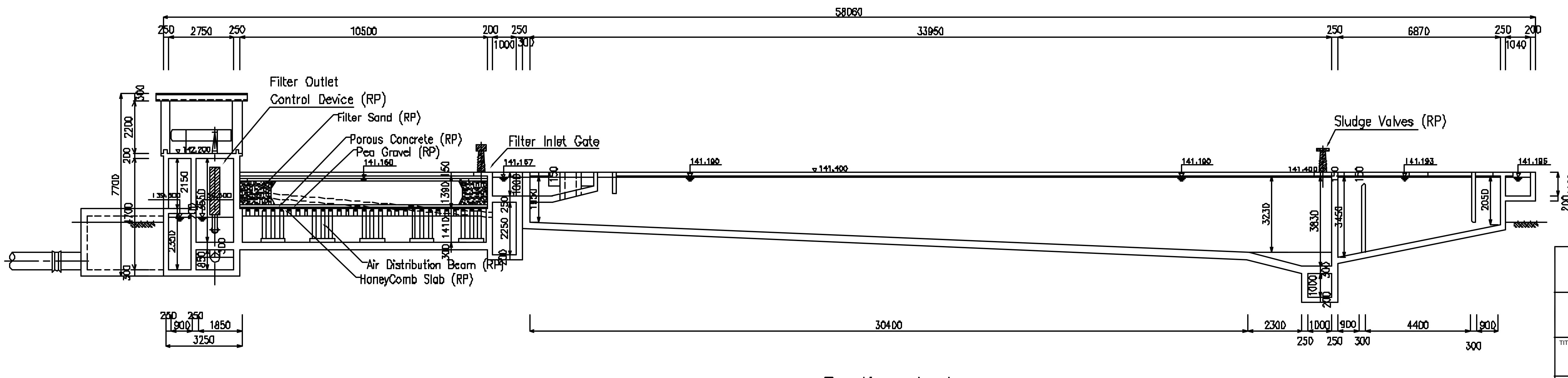


Plan of Existing Water Treatment Plant



Section A–A

Legend

(NC) : Newly Installation & Construction

(RP) : Replace with New Equipment

(CL) : Clearance

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The Basic Design Study on
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Water Supply Facilities in Savannakhet Area

TITLE: Plan of Existing Water Treatment Plant
(既設浄水施設　全体平面図)

SCALE: 1/200

DRAWING NO.: Drawing－6

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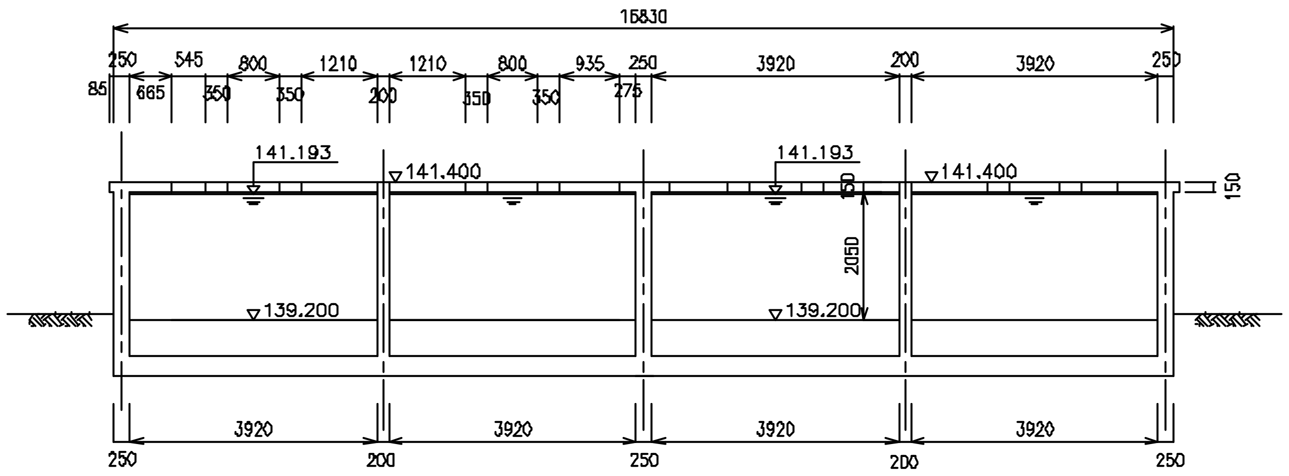
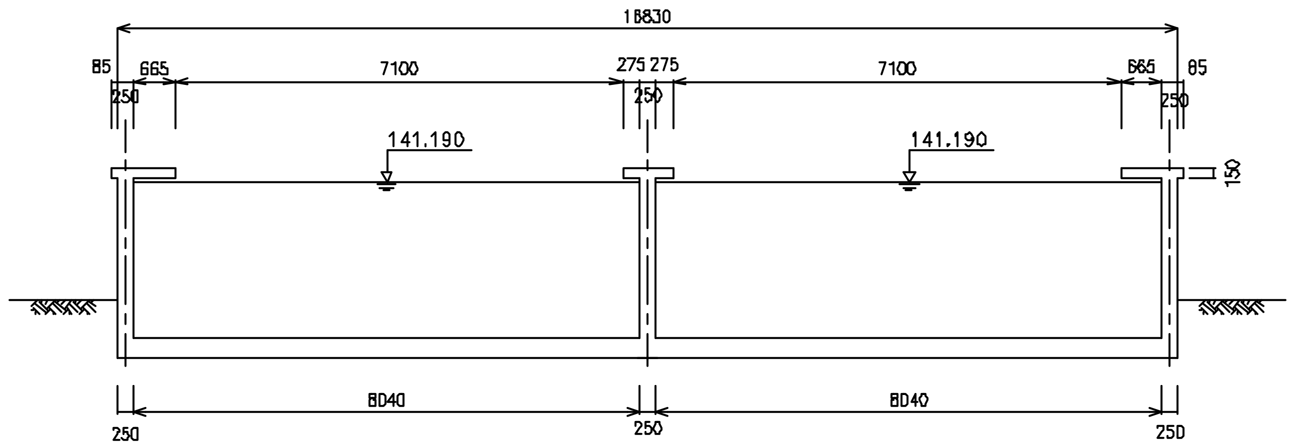


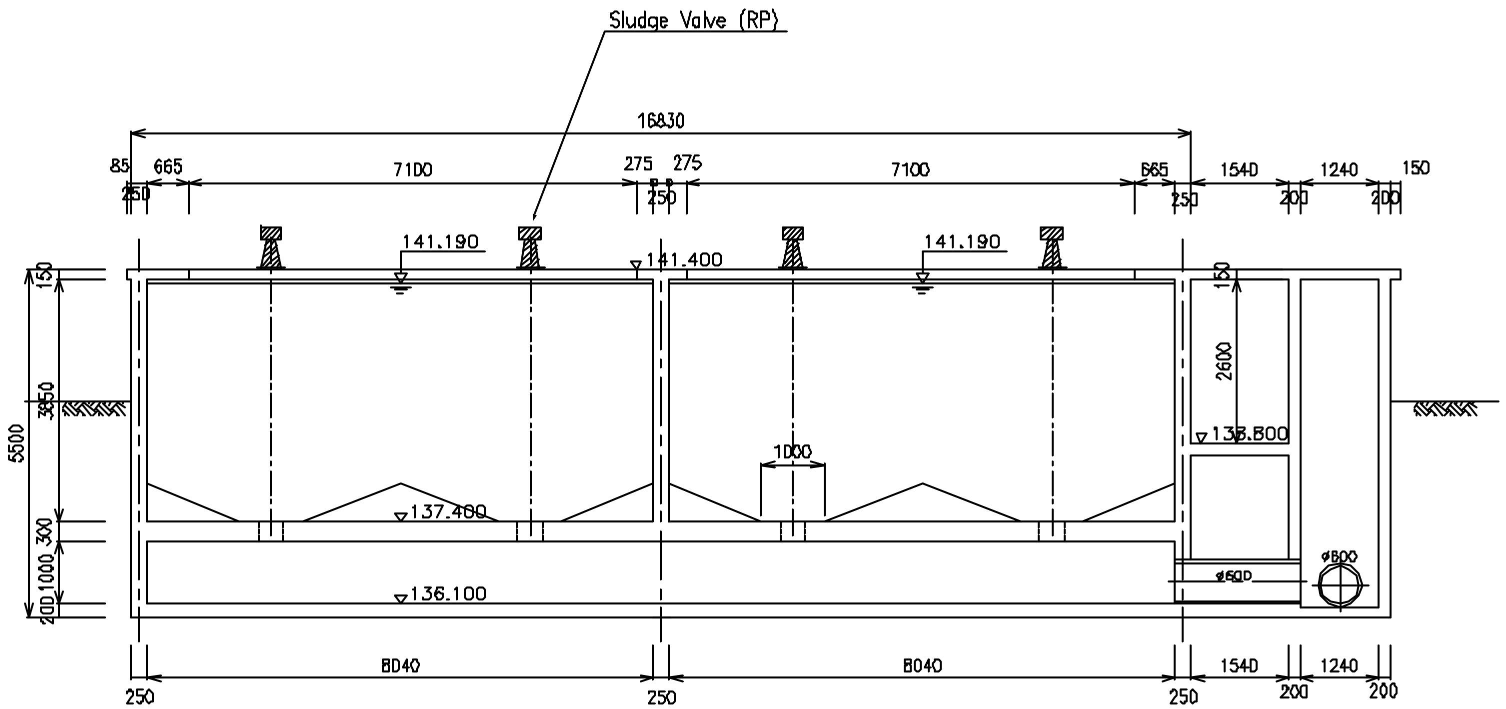
Section B–B

Section of Existing Flocculation Basin



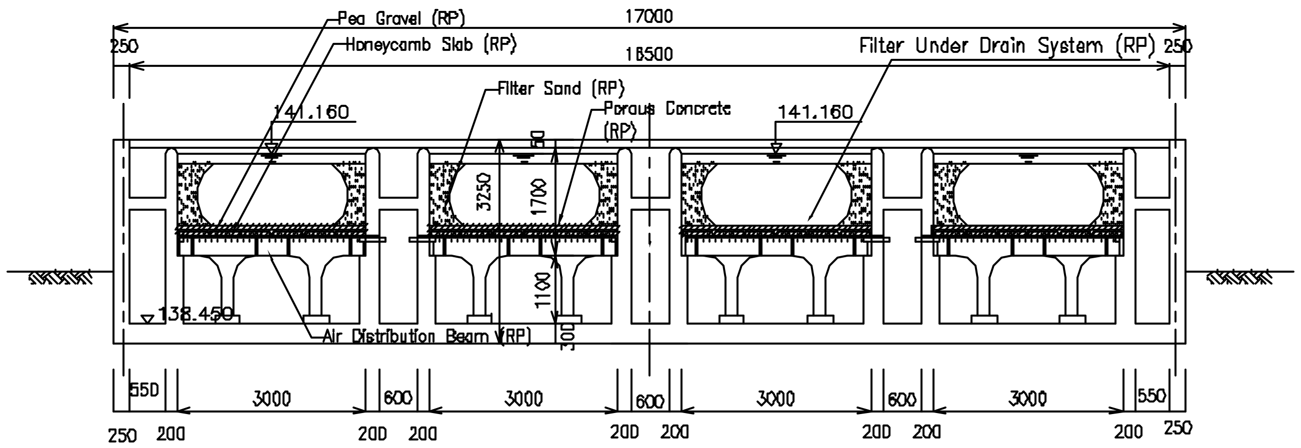
Section D–D

Section of Existing Sedimentation Basin 2



Section C–C

Section of Existing Sedimentation Basin 1



Section E–E

Section of Existing Filter Basin

Legend

(NC) : Newly Installation & Construction

(RP) : Replace with New Equipment

(CL) : Clearance

The Lao People's Democratic Republic Ministry of Communication, transport, Post and Construction	
The Basic Design Study on The Project for Rehabilitation of Water Supply Facilities in Savannakhet Area	
TITLE Section of Existing Water Treatment Plant （既設浄水施設　断面図）	
SCALE 1/200	DRAWING NO. 添付図－7
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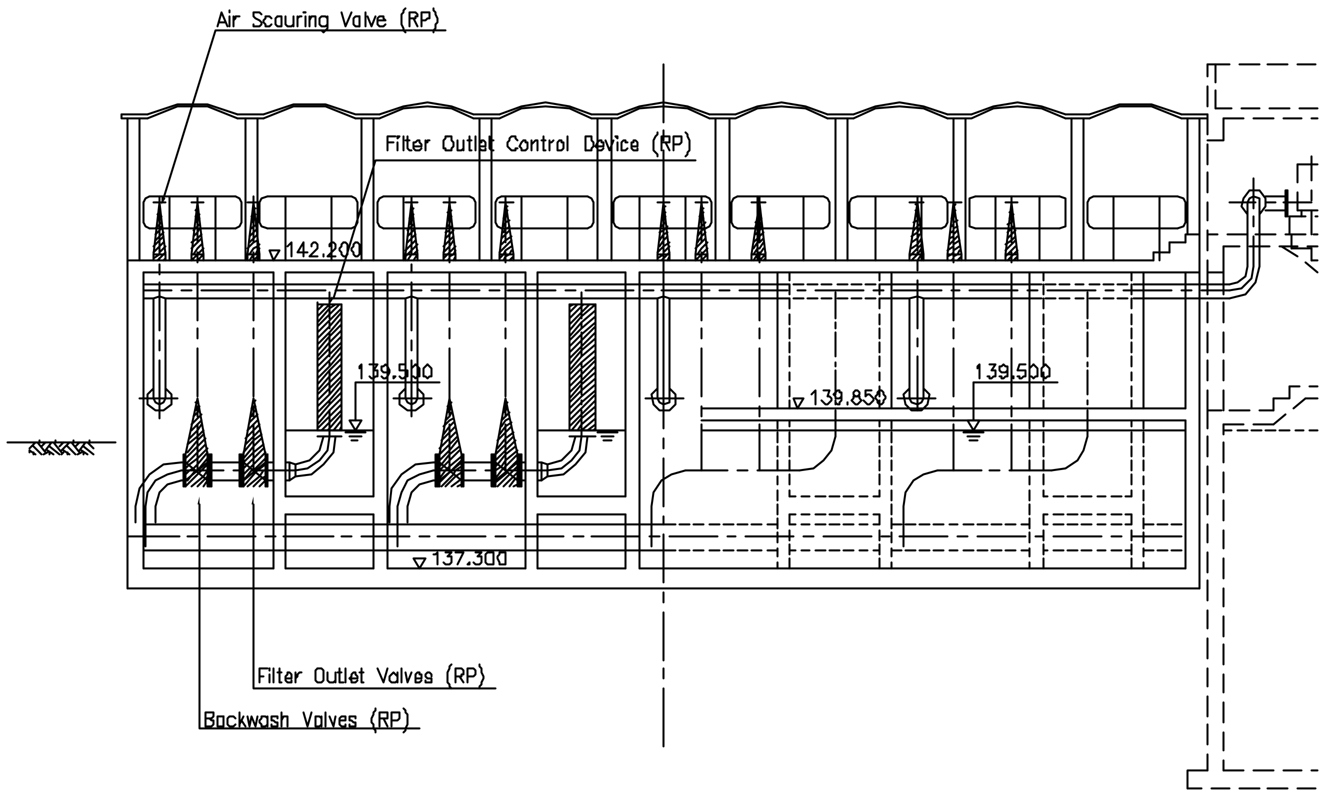
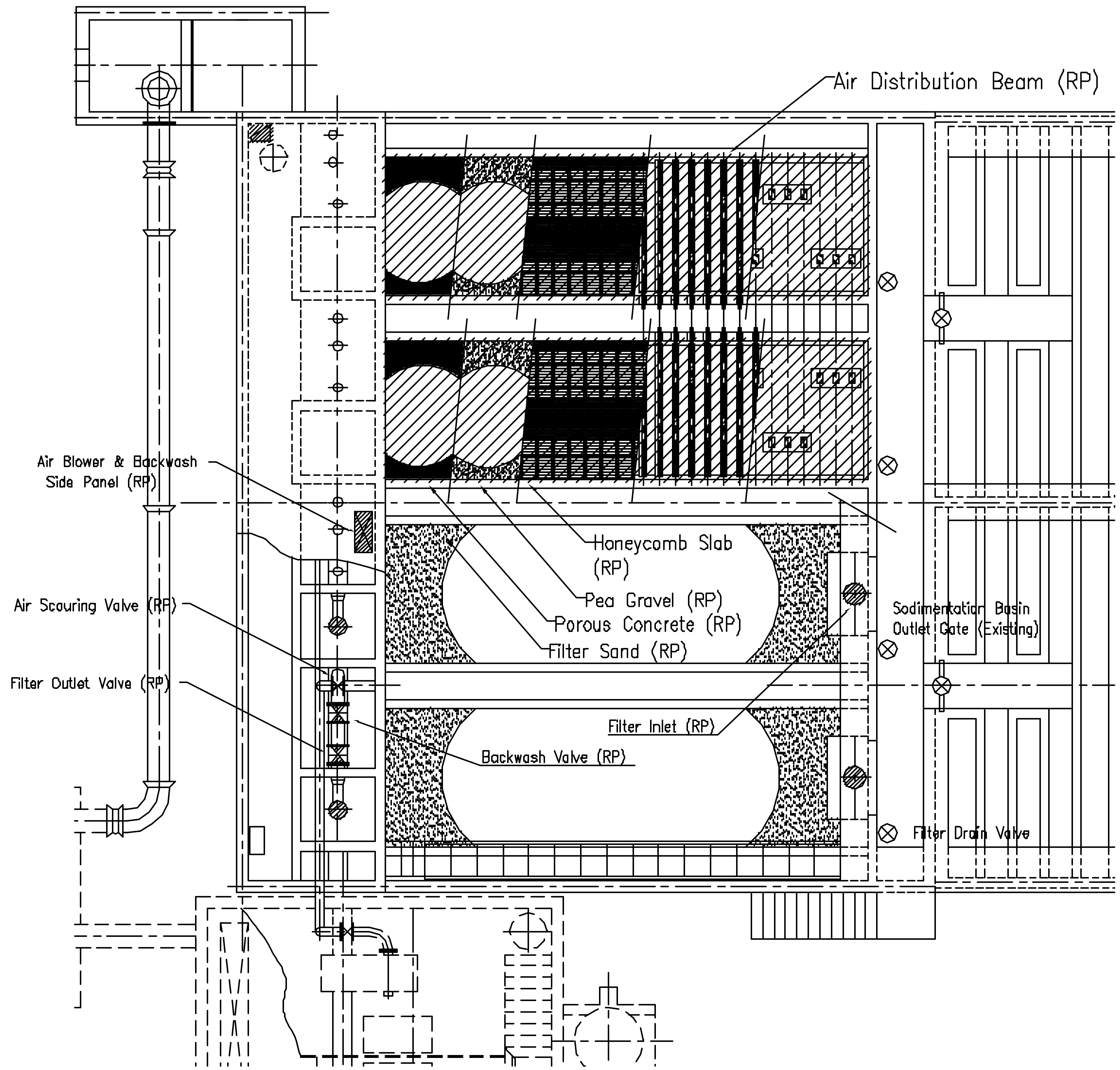


Section F–F

Section of Existing Filtered Water Control Room



Detail of Existing Filter Basin

Legend

- (NC) : Newly Installation & Constraction
- (RP) : Replace with New Equipment
- (CL) : Clearance

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TITLE Existing Filter Basin	
SCALE 1/100	DRAWING NO. Drawing－8
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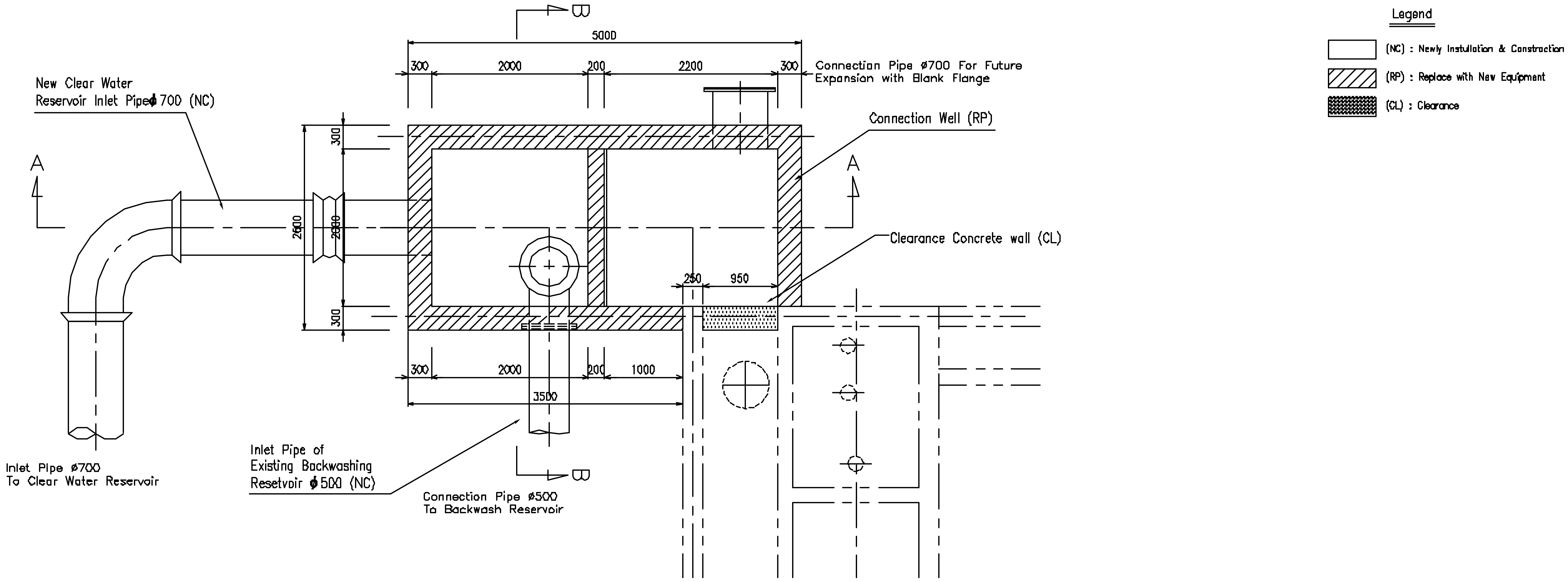
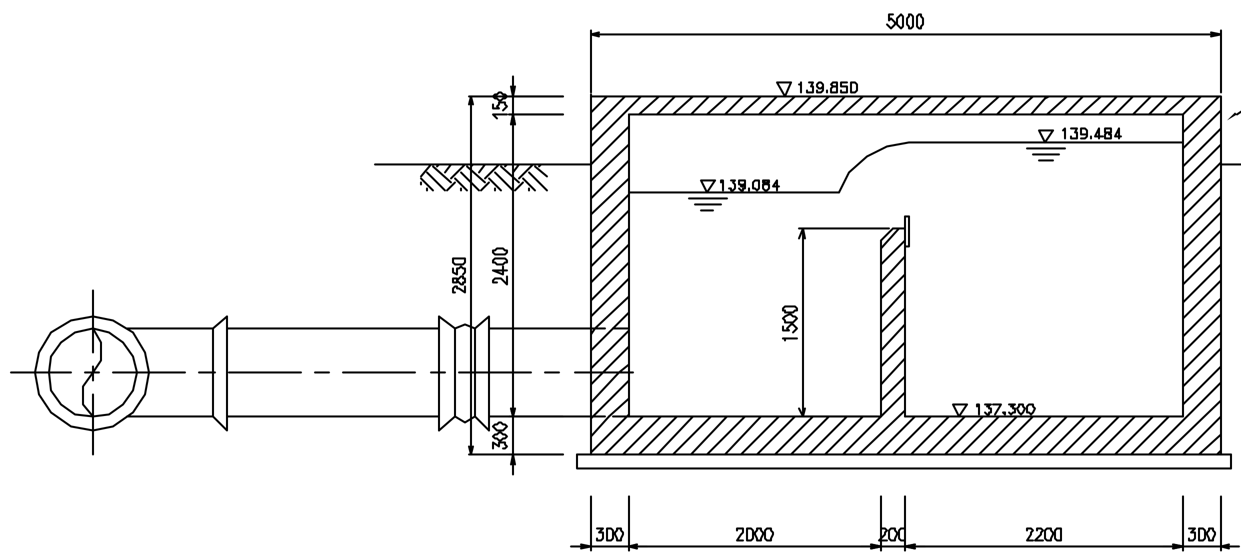
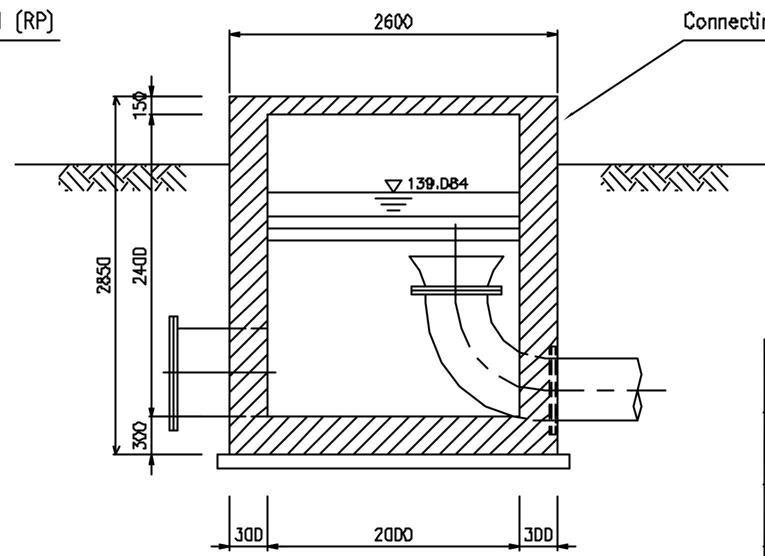
Detail of Connection Well





Section A-A



Section B-B

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The Basic Design Study on
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Water Supply Facilities in Savannakhet Area

TITLE
Detail of Connection Well

SCALE 1/50

DRAWING NO. Drawing－9

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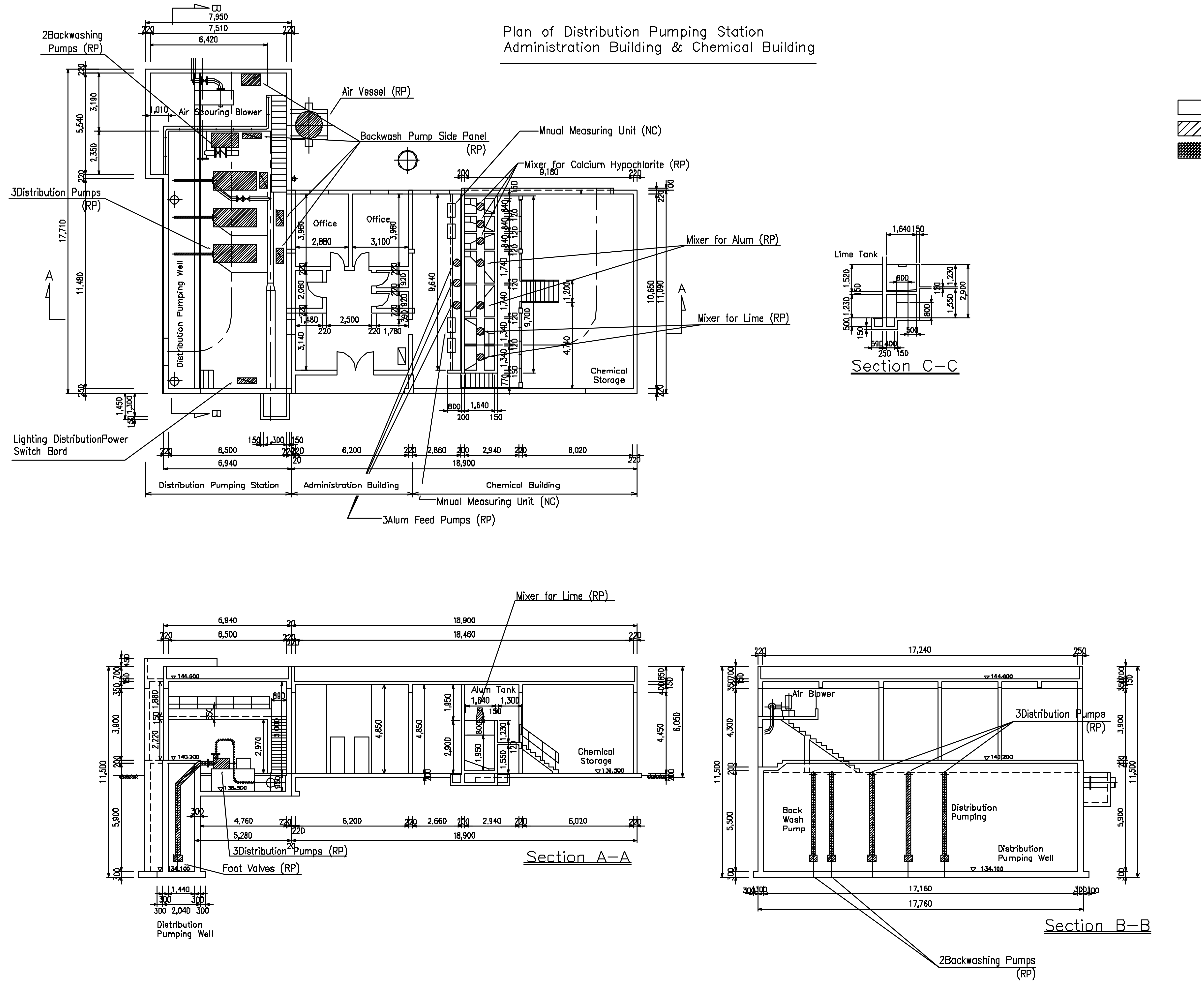

Legend

(NC) : Newly Instullation & Construction

(RP) : Replace with New Equipment

(CL) : Clearance

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Ministry of Communication, transport, Post and Construction

The Basic Design Study on
The Project for Rehabilitation of
Water Supply Facilities in Savannakhet Area

TITLE
Existing Pumping Station, Administration Bldg. & Chemical Bldg.

SCALE 1/200

DRAWING NO. Drawing－10

Approved By / Date

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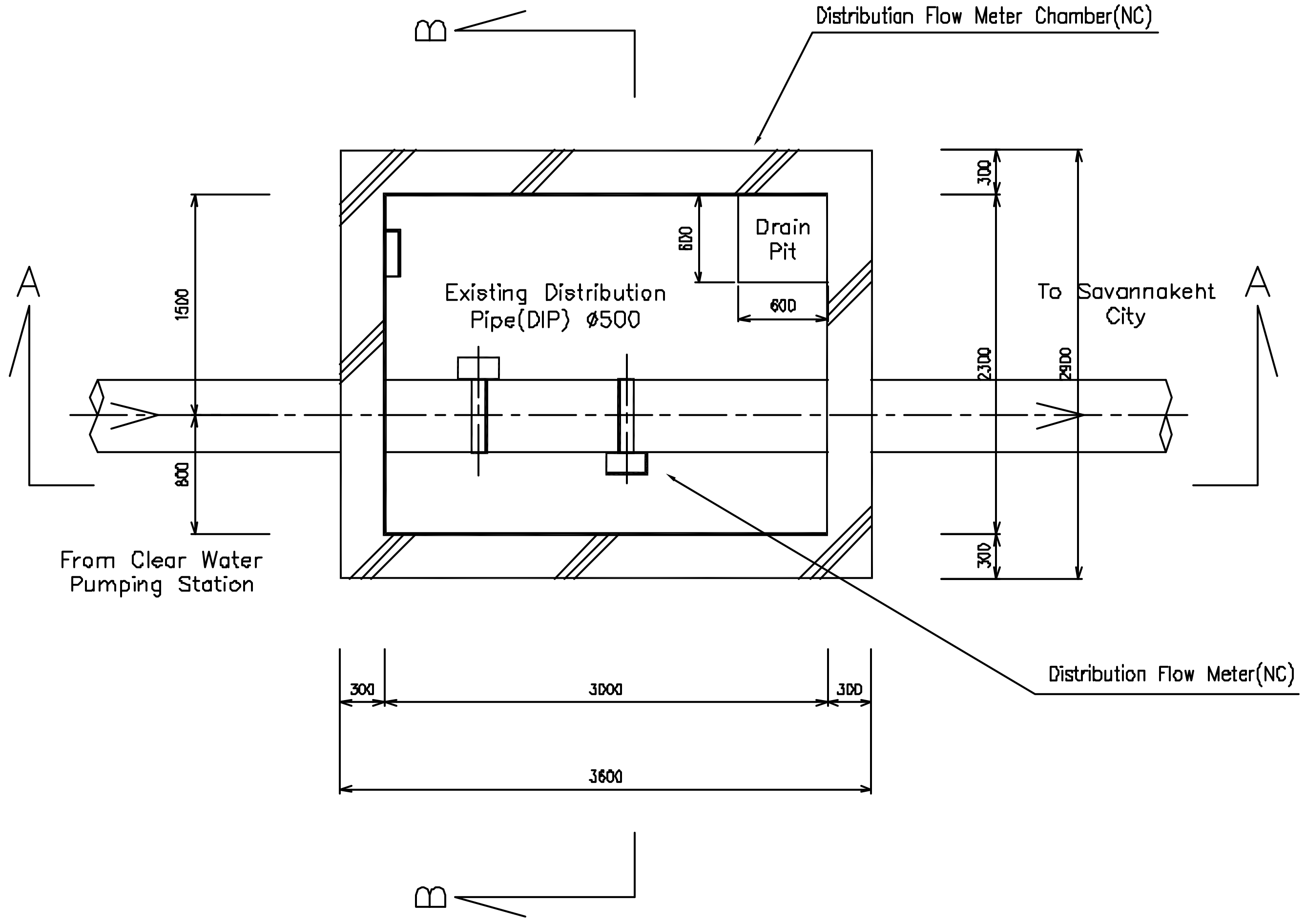
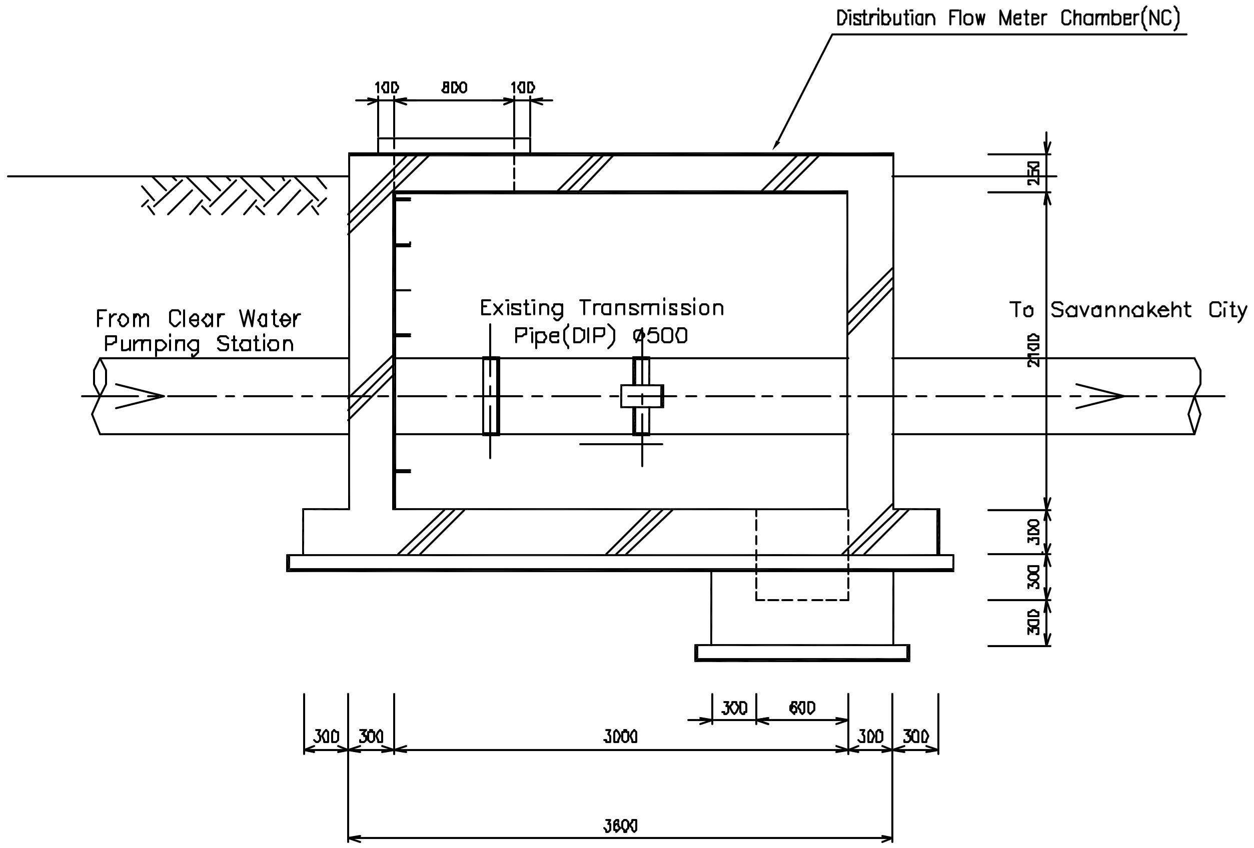
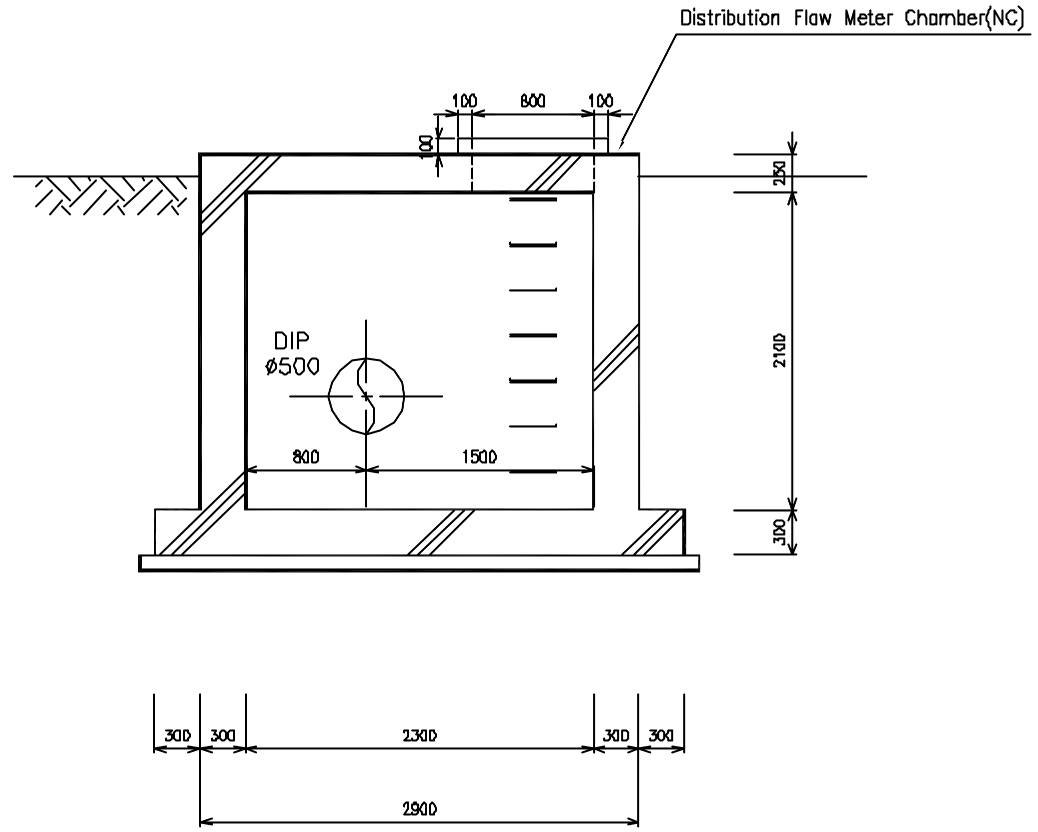


Plan of Clear Water Flow Meter Chamber



Section A–A



Section B–B

Legend

(NC) : Newly Installation & Construction

(RP) : Replace with New Equipment

(CL) : Clearance

The Lao People's Democratic Republic
Ministry of Communication, transport, Post and Construction

The Basic Design Study on
The Project for Rehabilitation of
Water Supply Facilities in Savannakhet Area

TITLE
Distribution Flow Meter Chamber

SCALE 1/50

DRAWING NO. Drawing－11

Approved By | Date

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TOKYO, JAPAN

Designed By | Date

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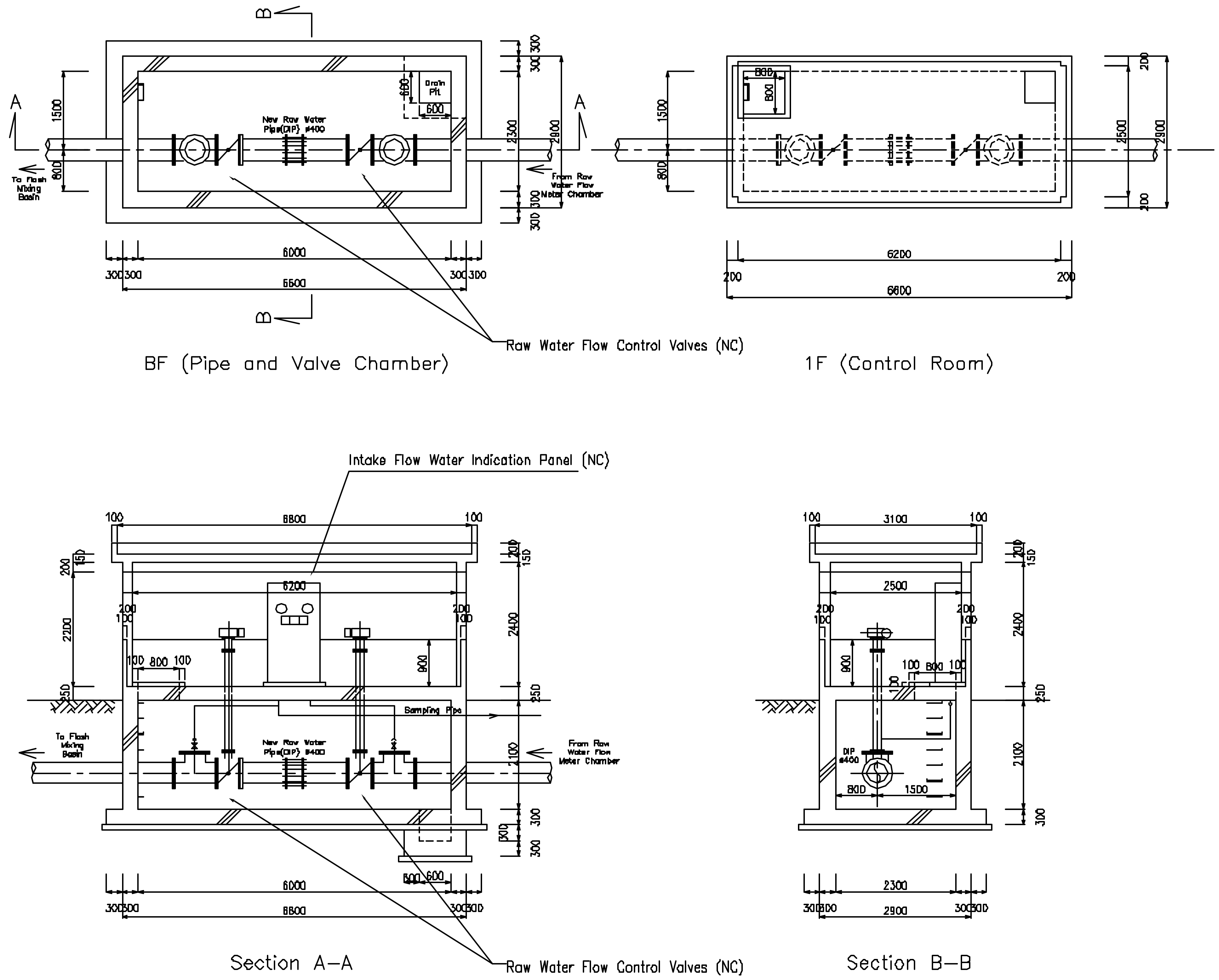
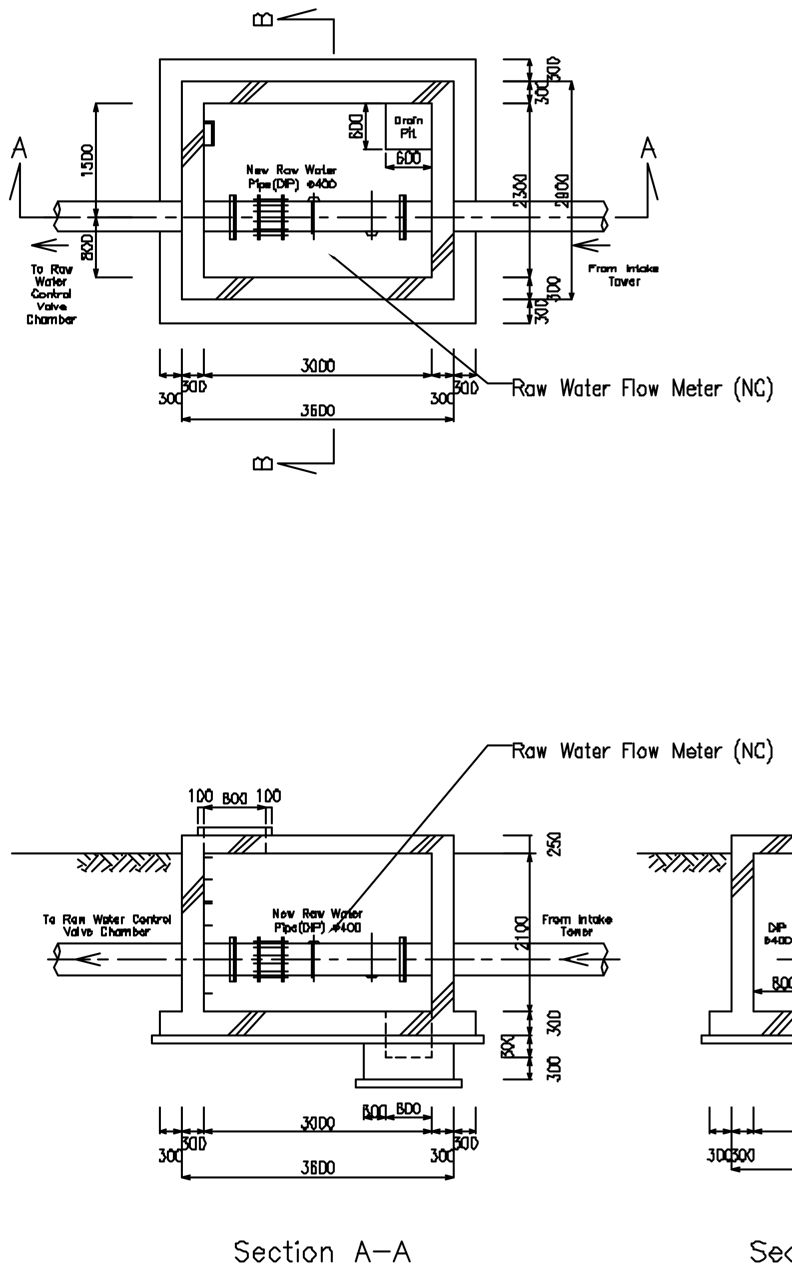
Plan of Raw Water Flow Control Chamber



Plan of Raw Water Flow Meter Chamber



Legend

(NC) : Newly Installation & Construction

(RP) : Replace with New Equipment

(CL) : Clearance

The Lao People's Democratic Republic
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The Basic Design Study on
The Project for Rehabilitation of
Water Supply Facilities in Savannakhet Area

TITLE: Inlet Water Flow Control Valve Chamber & Raw Water Flow Meter Chamber

SCALE: 1/100

DRAWING NO.: Drawing－12

Approved By | Date

Designed By | Date

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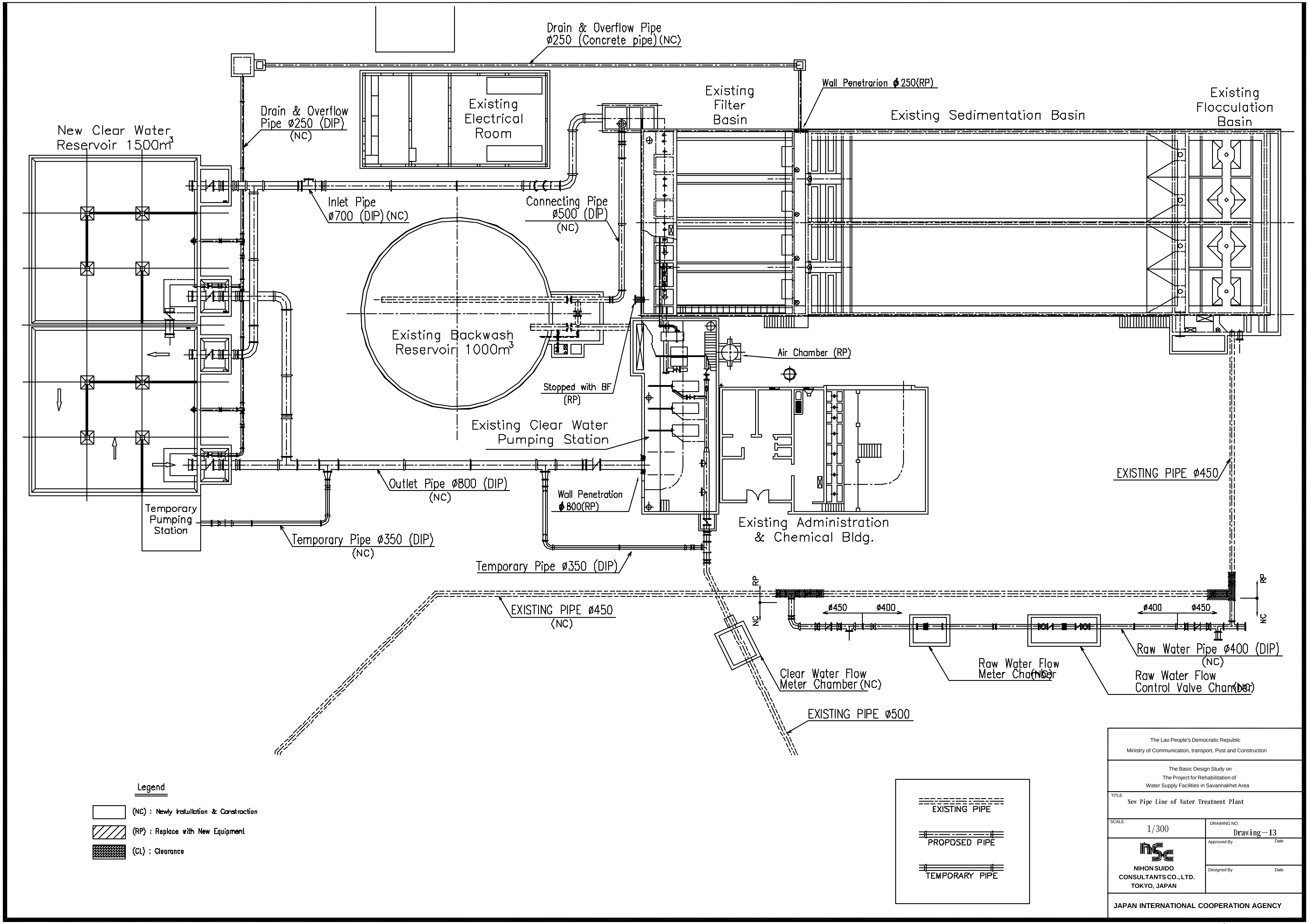


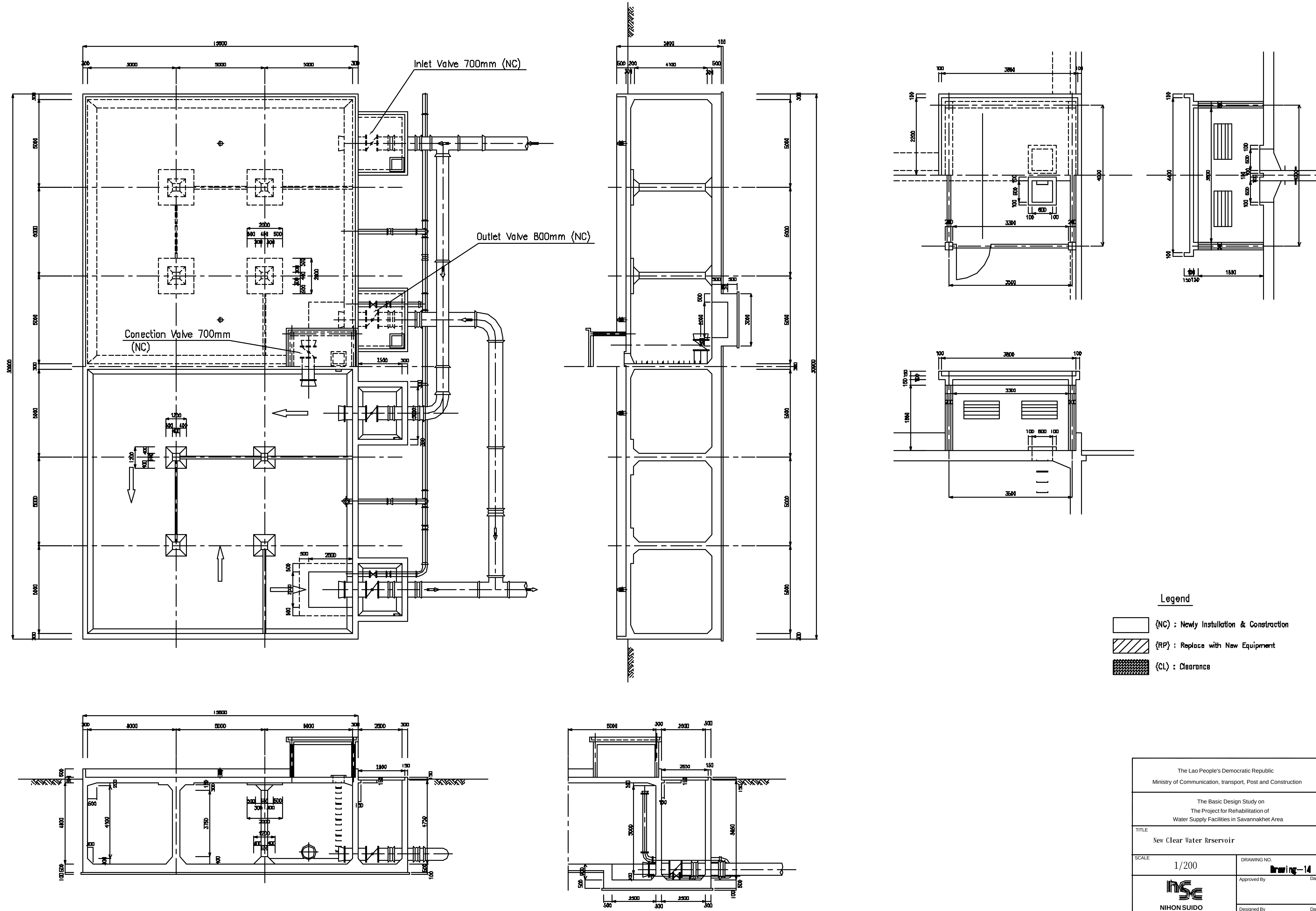
The Lao People's Democratic Republic
Ministry of Communication, transport, Post and Construction

The Basic Design Study on
The Project for Rehabilitation of
Water Supply Facilities in Savannakhet Area

TITLE
New Pipe Line of Water Treatment Plant

SCALE 1/300	DRAWING NO. Drawing－13
NIHON SUIDO CONSULTANTS CO., LTD. TOKYO, JAPAN	Approved By / Date Designed By / Date

JAPAN INTERNATIONAL COOPERATION AGENCY



The Lao People's Democratic Republic
Ministry of Communication, transport, Post and Construction

The Basic Design Study on
The Project for Rehabilitation of
Water Supply Facilities in Savannakhet Area

TITLE
New Clear Water Rrservoir

SCALE
1/200

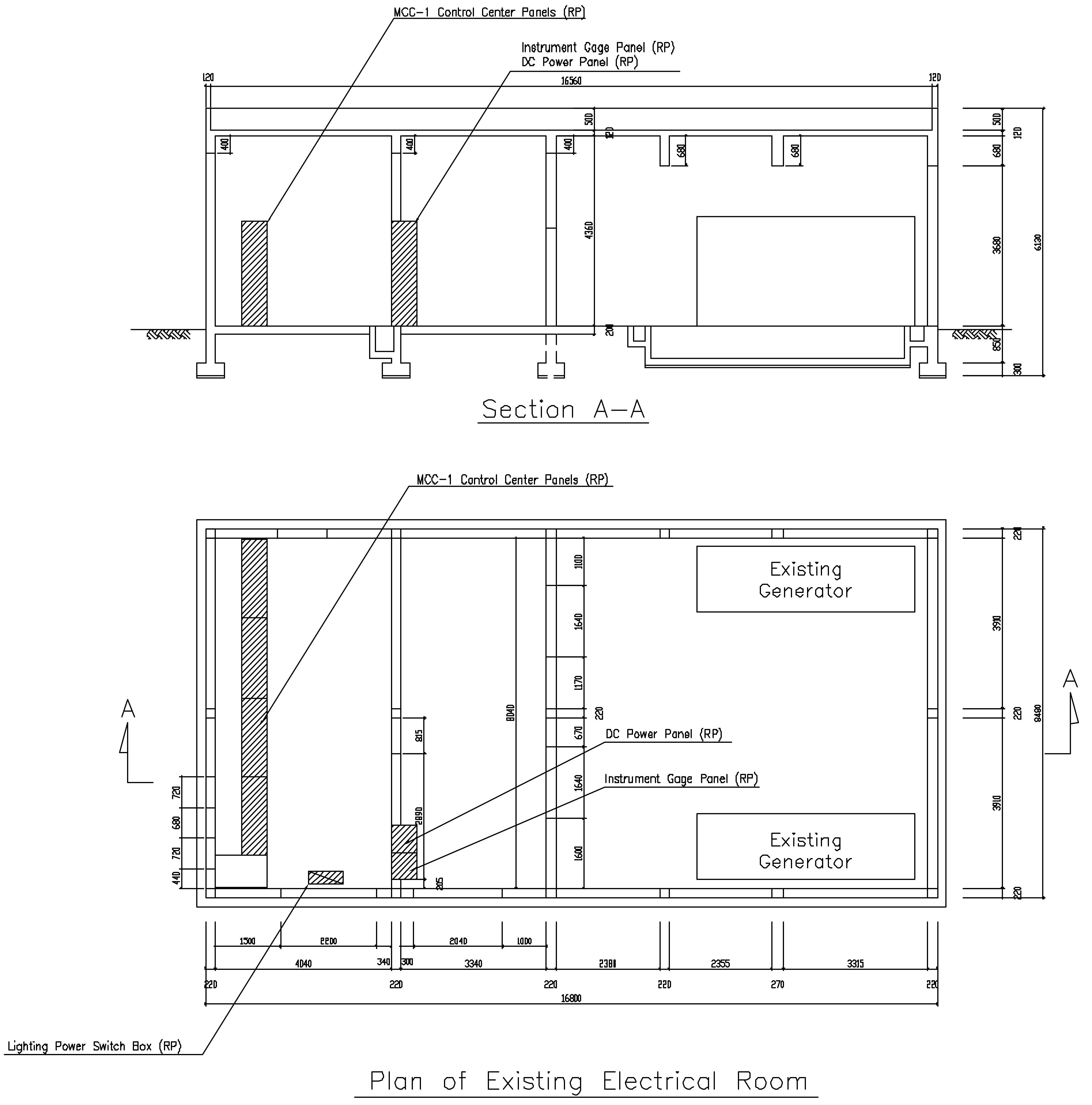
DRAWING NO.
Drawing-14

Approved By
Date

NIHON SUIDO
CONSULTANTS CO., LTD.
TOKYO, JAPAN

Designed By
Date

JAPAN INTERNATIONAL COOPERATION AGENCY



The Lao People's Democratic Republic
Ministry of Communication, transport, Post and Construction

The Basic Design Study on
The Project for Rehabilitation of
Water Supply Facilities in Savannakhet Area

TITLE: Existing Electrical Room

SCALE: 1/100

DRAWING NO.: Drawing−15

Approved By / Date

Designed By / Date

NIHON SUIDO CONSULTANTS CO., LTD.
TOKYO, JAPAN

JAPAN INTERNATIONAL COOPERATION AGENCY

APPENDIX-A

1. **Member List of the Survey Team**
2. **Survey Schedule**
3. **List of Party Concerned in the Recipient Country**
4. **Minutes of Discussion**
5. **Other Relevant Data**
6. **Cost Estimation Borne by the Recipient Country**

1. Member List of the Survey Team

Appendix 1 Member List of the Survey Team

The member list and their positions of the Survey Team are shown below:

Name	Position	Duration
AOKI Makoto	Team Leader of Basic Design Team (Resident Representative of JICA Laos Office)	2000/10/8 – 10/14
AKIBA Michihiro	Advisor of Basic Design Team (Institute of Public Health, Ministry of Health, Labor and Welfare)	2000/10/8 – 10/14
WATANABE Makiko	Advisor and Coordinator of Team (Grant Aid Management Department, JICA)	2000/10/8 – 10/14
MACHIDA Hiroshi	Team Member (Nihon Suido Consultants Co., Ltd.)	2000/10/2 – 11/9
NAKADONARI Tamaki	Team Member (Nihon Suido Consultants Co., Ltd.)	2000/10/2 – 11/9
ISHII Eiichi	Team Member (Nihon Suido Consultants Co., Ltd.)	2000/10/2 – 11/9
OYAMA Yoshinori	Team Member (Nihon Suido Consultants Co., Ltd.)	2000/10/2 – 11/9
OBARA Kohzoh	Team Member (Nihon Suido Consultants Co., Ltd.)	2000/10/2 – 10/29
KIMURA Naganobu	Team Member (Nihon Suido Consultants Co., Ltd.)	2000/10/16 – 11/9

2. Survey Schedule

Appendix 2 Survey Schedule

The Survey Schedule of the Basic Design Team is as shown below:

Schedule 1

Date	Movement	Stay	Activities
Oct 01 (Sun)	Arrive at Bangkok	Bangkok	Consultants Study Team of 5 members, Mr. Machida, Mr. Naka-donari, Mr. Ishii, Mr. Ohyama, and Mr. Obara
Oct 02 (Mon)	Arrive at Vientiane	Vientiane	Courtesy call to JICA, MCTPC and WASA Arrangement of Counterparts
Oct 03 (Tue)		- do -	Investigation of Chinaimo Treatment Plant Discussion with MCTPC and WASA
Oct 04 (Wed)	Move to Savannakhet	Savannakhet	Courtesy call on DCTPC, Nampapa Savannakhet (NPS) Nake Treatment Plant and existing pipelines
Oct 05(Thu)			Discussion with DCTPC and NPS Site investigation
Oct 06 (Fri)			Consul. Study Team Discussion with DCTPC, NPS Site Survey
Oct 07 (Sat)	Official Study Team Arrive at Bangkok	Bangkok	Site investigation Nake Treatment Plant survey
Oct 08 (Sun)	Official Study Team Arrive at Vientiane	Vientiane	Consul. 2 members …. To Vientiane Internal Meeting (Official Study Team and Consul. Team)
Oct 09 (Mon)	Move to Savannakhet	Savannakhet	Courtesy call to the Vice-Governor at Savannakhet Provincial Office & persons concerned Courtesy call to NPS office
Oct 10 (Tue)		Savannakhet	Discussion with DCTPC, NPS Investigation of Nake Treatment Plant
Oct 11 (Wed)	Move to Vientiane	Vientiane	Courtesy call to MCTPC and WASA Courtesy call to Embassy of Japan
Oct 12 (Thu)		Vientiane	Discussion with MCTPC, WASA, DCTPC, NPS Sign on the Minutes of Discussion
Oct 13 (Fri)	(Buddhist Lent Day)	Vientiane	Official Study Team … Investigation of Chinaimo Treatment Plant Consul. Team …. Data collection in Vientiane
Oct 14 (Sat)	Depart to Bangkok …. Official Study Team	Bangkok (Official) Savannakhet (Consul.)	Move to Savannakhet (Consultant Team)

Date	Movement	Stay	Activities
Oct 15 (Sun)	Arrive at Narita……. Official Study Team	Savannakhet	Consul. …. Internal Meeting Site survey and investigation
Oct 16 (Mon)			Field investigation and Site survey
Oct 17 (Tue)	Arrive at Bangkok (Mr. Kimura)		Field investigation, and Site survey, Data collection and analysis Consul. Study member Mr. Kimura, arrival at BKK
Oct 18 (Wed)	Arrive at Vientiane (Mr. Kimura)		Field investigation, and Site survey, Data collection and analysis Courtesy call on JICA, MCTPC, WASA
Oct 19 (Thu)	Arrive at Savannakhet.		Field investigation, and Site survey, Data collection and analysis Move to Savannakhet (Mr. Kimura)
Oct 20 (Fri)			Field investigation, and Site survey, Data collection and analysis Courtesy call on DCTPC, NPS by Mr. Kimura
Oct 21 (Sat)			Field investigation, and Site survey, Data collection and analysis Questionnaire survey and analysis
Oct 22 (Sun)			Data processing, Internal meeting Information analysis
Oct 23 (Mon)			Field investigation, and Site survey, Data collection and analysis Questionnaire survey and analysis
Oct 24 (Tue)			Field investigation, and Site survey Data collection and analysis
Oct 25 (Wed)			Field investigation, and Site survey, Data collection and analysis Questionnaire survey and analysis
Oct 26 (Thu)			Field investigation, and Site survey, Data collection and analysis Questionnaire survey and analysis
Oct 27 (Fri)			Field investigation, and Site survey, Data collection and analysis Questionnaire survey and analysis
Oct 28 (Sat)	Travel to Vientiane (Mr. Obara)		Field investigation, and Site survey, Data collection and analysis (Mr. Obara, travel to Vientiane)
Oct 29 (Sun)	Travel to Bangkok (Mr. Obara)		Field investigation, and Site survey, Data collection and analysis (Mr. Obara, travel to BKK)
Oct 30 (Mon)	Arrive at Japan (Mr. Obara)		Field investigation, and Site survey, Data collection and analysis (Mr. Obara, travel to Japan)
Oct 31 (Tue)			Field investigation, and Site survey, Data collection and analysis Field survey investigation

Date	Movement	Stay	Activities
Nov 01 (Wed)			Field investigation, and Site survey, Data collection and analysis Field survey investigation
Nov 02 (Thu)			Field investigation, and Site survey, Data collection and analysis
Nov 02 (Thu)			Field survey investigation
Nov 03 (Fri)			Field investigation, and Site survey, Data collection and analysis Discussion with DCTPC, NPS
Nov 04 (Sat)			Field investigation, and Site survey, Data collection and analysis Discussion with DCTPC, NPS, and Office Arrangement
Nov 05 (Sun)	Move to Vientiane	Vientiane	Arrival at Vientiane (Consul. Study Team); Mr. Machida, Mr. Nakadonari, Mr. Ishii, Mr. Ohyama, And Mr. Kimura
Nov 06 (Mon)		Vientiane	Prepare the Report, Report to MCTPC, WASA,
Nov 07 (Tue)		Vientiane	Report to JICA, and Embassy of Japan (11 am)
Nov 08 (Wed)	Arrive at Bangkok	Bangkok	Leaving Vientiane to Bangkok
Nov 09 (Thu)	Arrive at Narita		

Schedule 2 (Explanation on Draft Final Report)

Date	Movement	Stay	Activities
Mar 18 (Sun)	Arrive in Bangkok	Bangkok	
Mar 19 (Mon)	Arrive in Vientiane	Vientiane	Courtesy call and meeting with JICA, Embassy of Japan, MCTPC and WASA
Mar 20 (Tue)		Savannakhet	Courtesy call to Savannakhet Provincial Office Courtesy call and meeting with DCTPC and NPS
Mar 21 (Wed)		Vientiane	Site survey at Nake Treatment Plant
Mar 22 (Thu)		- do -	Meeting on M/D at MCTPC Meeting at JICA Office
Mar 23 (Fri)		- do -	Signing of M/D at Novotel Hotel Report to JICA Office and Embassy of Japan
Mar 24 (Sat)	Arrive in Bangkok Depart to Tokyo		Travel from Vientiane to Bangkok Leaving for Bangkok
Mar 25 (Sun)	Arrive in Tokyo		

3. List of Party Concerned in the Recipient Country

Appendix 3 List of Party Concerned in the Recipient Country

The parties and persons concerned in Lao PDR government are shown bleow:

Ministry of Communication, Transport, Post and Construction

Housing & Urban Planning Department

Director General	Bounleuan SISOULATH
Head of Division	Khanthone VORACHITH

Water Supply Authority

Director	Somphone DETHOUDOM

Nam Papa Vientiane

General Manager	Daophet BOUAPHA
Vice Manager	Somlith SILAPHET
Deputy Manager	Sisamone KONGMANY

Savannakhet Province

Vice-Governor	Soukaseum BODHISANE
Deputy Director	Bouakkham SISOULATH

Department of CTPC

Director General	Vamhkham INTHICHACK
Deputy Director	Sythonh NANTHARAT
Deputy Director	Sinouane SIHARATH
Deputy Director	Xayarath BAPHANITH

Savannakhet Water Supply Company

Director	Somsy KONGDALA
Deputy Director	Xone SISOMBATH
Chief of Plannning Section	Momboune HUANGSAVANH
Chief of Treatment Plant	Phandola KHUANMUANGCHANCH
Prospective Program Officer	Sirixai PHANTHAVONGS

4. Minutes of Discussion

MINUTES OF DISCUSSIONS
ON THE BASIC DESIGN STUDY
ON THE PROJECT FOR REHABILITATION AND EXPANSION OF
WATER SUPPLY FACILITIES
IN SAVANNAKHET AREA IN LAO PEOPLE'S DEMOCRATIC REPUBLIC

Based on the results of the Preparatory Study in March 2000, the Government of Japan decided to conduct a Basic Design Study on the Project for Rehabilitation and Expansion of Water Supply Facilities in Savannakhet Area in Lao People's Democratic Republic (hereinafter referred to as "the Project") and entrusted the study to the Japan International Cooperation Agency (hereinafter referred to as "JICA").

JICA sent to Lao People's Democratic Republic (hereinafter referred to as "Lao PDR") the Basic Design Study Team (hereinafter referred to as "the Team"), which is headed by Mr. Makoto Aoki, Resident Representative, JICA Lao PDR Office, and is scheduled to stay in Lao PDR from 8th October to 8th November, 2000.

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 works and prepare the Basic Design Study Report.

Vientiane, 12th October, 2000

Mr. Makoto Aoki
Leader
Basic Design Study Team
JICA

Mr. Bounleuam Sisoulath
Director General
Dept. of Housing and Urban Planning
Ministry of Communication, Transport, Post and Construction (MCTPC)

Mr. Sinouane Siharath
Deputy Director
Dept. of Communication, Transport, Post and Construction (DCTPC)
Savannakhet Province

ATTACHMENT

1. Objective of the Project

The objective of the Project is to alleviate water deficit and improve treated water quality in the central area of Khanthabouly District in Savannakhet Province by rehabilitating and expanding the Water Supply Facilities.

2. Study Area

The Study area is the central area of Khanthabouly District between Kaysone Road and A2 Road in Savannakhet Province as shown in Annex-Ⅰ.

3. Responsible and Implementing Organizations

3-1.The responsible and executing agency is Ministry of Communication, Transport, Post and Construction (MCTPC) represented by Department of Housing and Urban Planning (DHUP) through Water Supply Authority (WASA).

3-2.The Implementing agency is Savannakhet Provincial Government through Department of Communication, Transport, Post and Construction (DCTPC) in collaboration with Nam Papa State- Owned Enterprise (NPSE), Savannakhet.

The organization charts are shown in Annex-Ⅱ.

4. Items Requested by the Government of Lao PDR

After discussions with the Team, the items described in Annex-Ⅲ were finally requested by Lao side. However, both sides agreed that priority will be given to the rehabilitation and the expansion of the water treatment plant and that the equipment will be considered if found necessary.

Both sides also agreed that the final components of the Project will be determined by Japanese side after further studies in Japan.

5. Japan's Grant Aid System

5-1. Lao side understood the system and characterictics of Japan's Grant Aid Scheme explained by the Team, as described in Annex-Ⅳ.

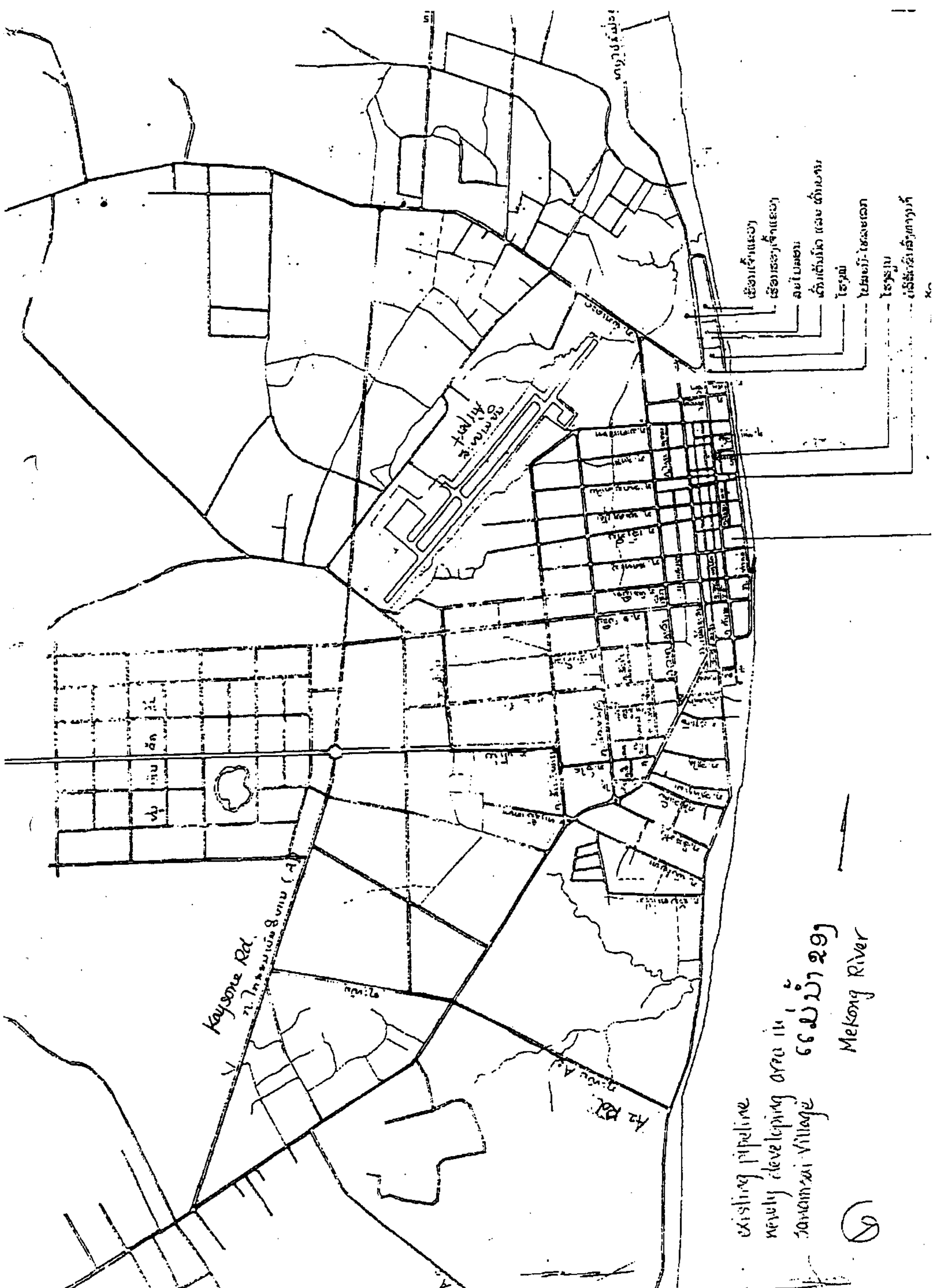
5-2. Lao side will take necessary measures as described in Annex-Ⅴ, for smooth implementation of the Project, as a condition for the Japanese Grant Aid to be implemented.

6. Schedule of the Study

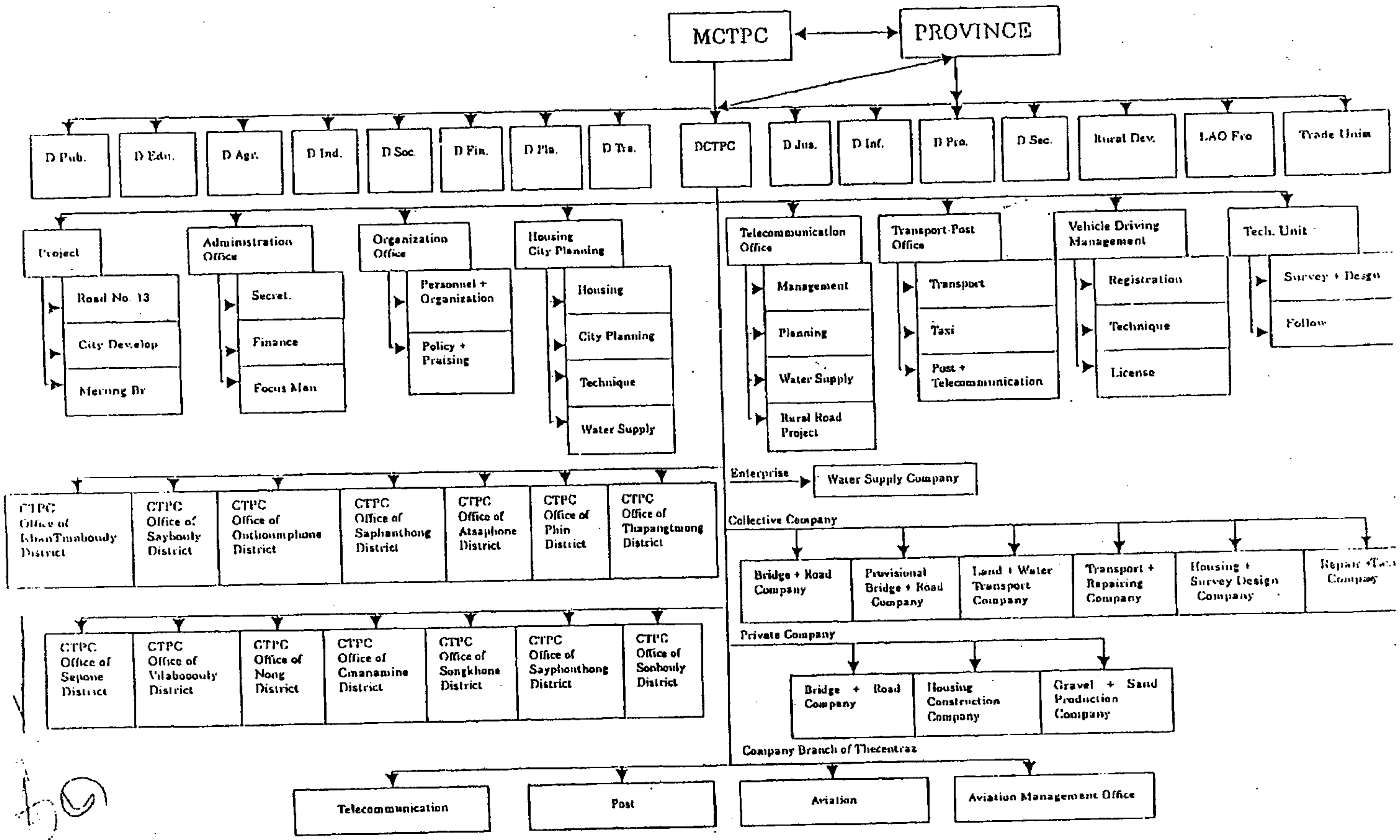
6-1. The consultants will proceed to further studies in Lao PDR until 8th November, 2000.
6-2. JICA will prepare the draft report in English and dispatch a mission to Lao PDR in order to explain its contents around January, 2001.
6-3. In case that the contents of the report is accepted in principle by Lao side, JICA will complete the final report and send it to Lao PDR in or around March, 2001.

7. Other relevant issues

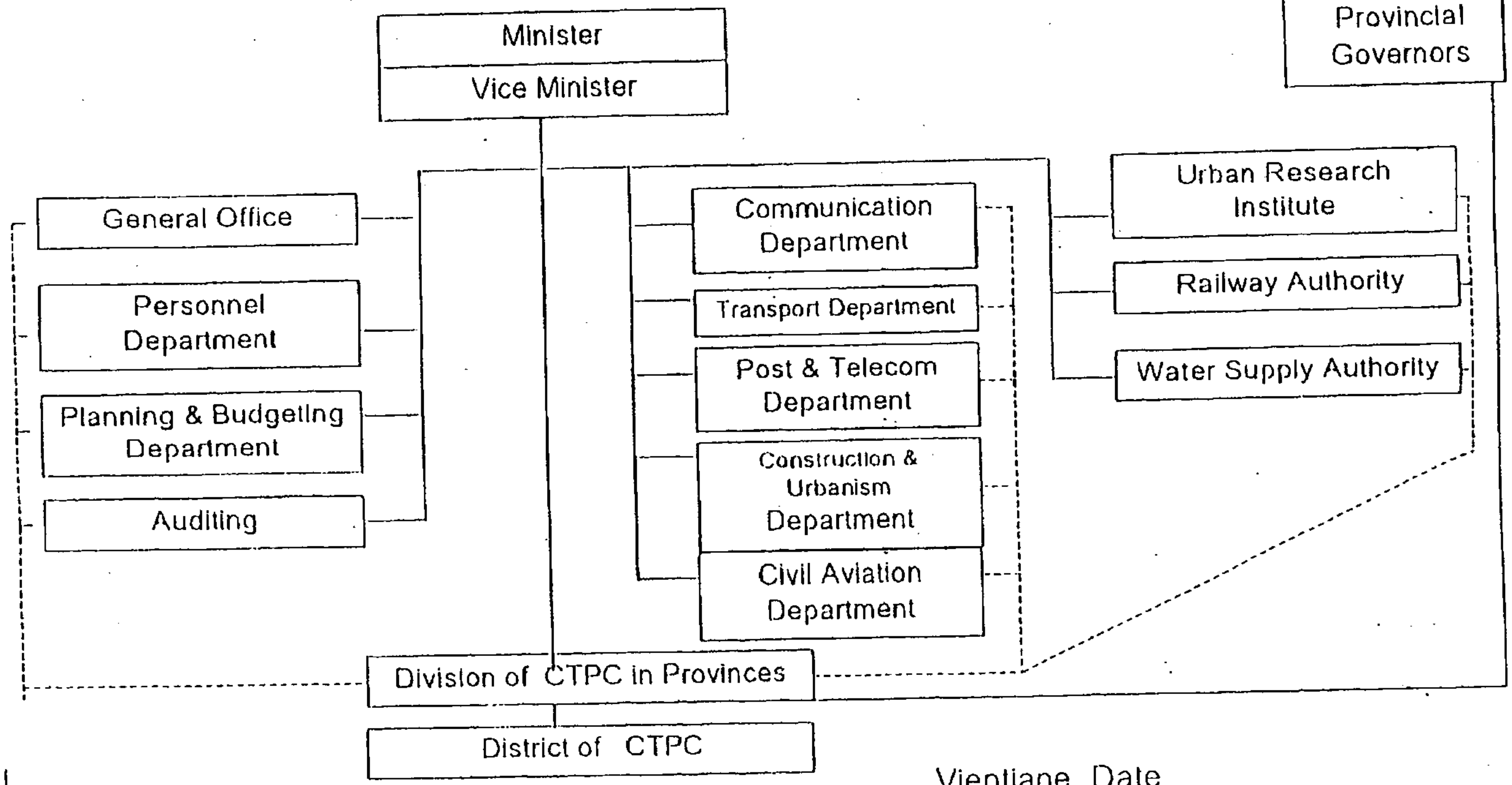
7-1. Both sides agreed that the target year will be around 2008, a few years after the completion of the Project. However, the exact target year will be determined accordingly after detailed study in Japan.
7-2. Lao side strongly requested to include the newly developing area in Sanamsai Village as part of the Study area, and both sides agreed that the necessity to include that area will be considered after further studies in Japan.
7-3. Lao side understood that the components, sizes, dimensions and locations of the requested facilities will be reviewed based on the study in Japan with the aim to achieve maximum output with available resources.
7-4. Both sides agreed that rehabilitation and expansion of the water treatment plant take precedence over the provision of equipment.
7-5. Lao side requested for technical assistance in financial management and water treatment/water quality control for sustainable operation and maintenance of the water treatment plant.
7-6. Both sides agreed that raising the water charges to an appropriate level is necessary to allocate enough budget and staff with appropriate technical skills to ensure proper and effective operation and maintenance of the facilities and equipment provided under the Project.


Kaysone Rd.
existing pipeline
newly developing area
Village
Mekong River

ORGANIZATION CHART OF SAVANNAKHET DCTPC



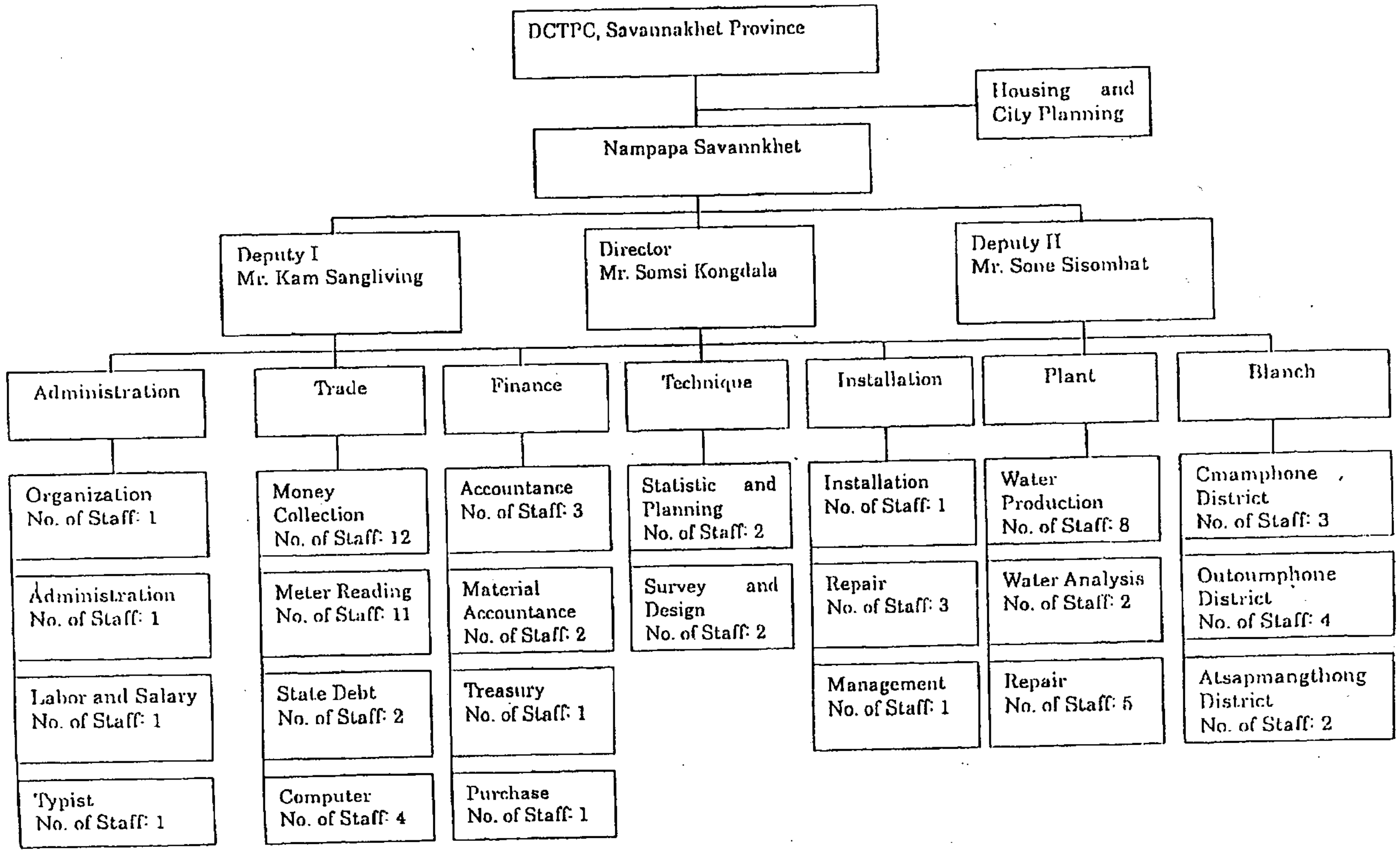
Ministry of Communication Transport Post and Construction



Minister of M C T P C

Vientiane, Date________________
Director of Personnel Department

ORGANIZATION CHART OF NPS(Nam PaPa Savannakhet)



Annex-III Items requested by Lao side

1. Rehabilitation of Water Supply Facilities
1) Water Intake Pumps
2) Rapid Mixing Basin
3) Flocculation Basin
4) Sedimentation Basin (Inlet & Outlet Valves, Gates and Weirs)
5) Filtration
6) Electrical Equipment (Substation Equipment)
7) Distribution Pumps
8) Chemical Dosing Facilities

2. Expansion of Water Supply Facilities
1) Raw Water Transmission Pipe
2) Rapid Mixing Basin
3) Flocculation Basin
4) Sedimentation Basin
5) Filtration
6) Electrical Equipment (Switch & Panels, Diesel Generator)
7) Treated Water Reservoir
8) Laboratory

3. Others
1) Distribution Pipeline
2) Bank Protection Works around the Intake Tower
3) Elevated Tank in the City

4. Equipment
1) Wheel-type Back-hoe (1 unit)
2) Truck with crane (1 unit)

Annex-Ⅳ

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 (hereafter 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:

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

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

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

d) Preparation of a basic design of the Project.

e) 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 consultant firm(s) used for the Study is(are) recommended by JICA to the recipient country to also work on the Project's implementation after the Exchanges 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 the "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 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 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 Grand 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-V Major Undertakings to be taken by Each Government

The following necessary measures should be taken by the Lao side on condition that the Grant Aid by the Government of Japan is extended to the Project:

1. To provide data and information necessary for the Project.

2. To secure and provide cleared and leveled land for the Project and secure the authority to build facilities prior to the commencement of the construction.

3. To remove existing facilities, if necessary.

4. To use and maintain properly and effectively all the equipment purchased and facilities constructed under the Grant Aid.

5. To bear commissions to the Japanese bank for its banking services based upon the Banking Arrangement, namely the advising commission of the "Authorization to Pay" and payment commission.

6. To ensure prompt unloading, tax exemption, customs clearance at the port of disembarkation and prompt internal transportation therein of the materials and equipment for the Project purchased under the Grant Aid.

7. To exempt Japanese juridical and physical nationals engaged in the Project from customs duties, internal taxes and other fiscal levies which may be imposed in Lao PDR with respect to the supply of the products and services under the verified contracts.

8. To accord Japanese nationals whose services may be required in connection with the supply of the products and the services under the verified contract such facilities as may be necessary for their entry into Lao PDR and stay therein for the performance of their work in accordance with the relevant laws and regulations of Lao PDR.

9. To provide necessary permissions, licenses and other authorizations for implementing the Project, if necessary.

10. To bear all the expenses, other than those to be borne by the Japan's Grant Aid within the scope of the Project.

MINUTES OF DISCUSSIONS
ON THE BASIC DESIGN STUDY
ON THE PROJECT FOR REHABILITATION OF
WATER SUPPLY FACILITIES
IN SAVANNAKHET AREA IN LAO PEOPLE'S DEMOCRATIC REPUBLIC
(CONSULTATION ON DRAFT REPORT)

In October 2000 the Japan International Cooperation Agency (JICA) dispatched a Basic Design Study on the Project for Rehabilitation of Water Supply Facilities in Savannakhet Area in Lao People's Democratic Republic (hereinafter referred to as "the Project") to the Lao People's Democratic Republic (hereinafter referred to as "Lao PDR"), and through discussions, site surveys, and technical examination of the results in Japan, JICA prepared the draft report of the study.

In order to explain and to consult the Lao side on the components of the draft report, JICA sent to Lao PDR the Draft Report Explanation Team (hereinafter referred to as "the Team"), which is headed by Mr. Makoto Aoki, the Resident Representative, JICA Lao PDR Office, from 19th March to 24th March, 2001.

As a result of discussions, both sides have confirmed the main items described on the attached sheet.

Vientiane, 23rd March, 2001

Mr. Makoto Aoki
Leader
Basic Design Study Team
Japan International Cooperation Agency (JICA)

Dr. Somphone Dethoudom
Director General
Water Supply Authority,
Ministry of Communication, Transport, Post and Construction (MCTPC)

Mr. Sinouane Siharath
Deputy Director
Dept. of Communication, Transport, Post and Construction (DCTPC)
Savannakhet Province

ATTACHMENT

1. Contents of the Draft Report

The Government of Lao PDR agreed and accepted in principle the contents of the draft report explained by the Team.

2. Japan's Grant Aid Scheme

The Lao side understands the Japan's Grant Aid Scheme and the necessary measures to be taken by the Government of Lao PDR as explained by the Team and described in Annex-Ⅳ of the Minutes of Discussions signed by both parties on 12th October 2000.

3. Schedule of the Study

JICA will complete the final report after further study in accordance with the discussed items and send it to the Government of Lao PDR around May 2001.

4. Soft Component

The Lao side requested the Japanese side to implement "soft components" for strengthening the institutional and administrative capacity of Savannakhet Water Supply Company (NPS), as one of the component of the Grant- Aid Scheme. The summary of the "soft components" will be described in Annex-Ⅰ.

5.Other Relevant Issues

(1) Based on the basic design study, the Japanese side had considered that urgent necessities to be implemented are to rehabilitate the mechanical and electrical facilities/equipment in Nake Water Treatment Plant (Production capacity: 15,000 ㎥/day). The Project will be composed of components described in Annex-Ⅱ after the Japanese Government finally approves the Project.

(2) The Lao side explained that the following components will be requested by the Government of Lao PDR as "The Project Phase-2" when water shortage should occur in the central area of Khanthabouly District. The Team will carry the message to the Japanese authority.

—Expansion of Nake Water Treatment Plant.

—Expansion and rehabilitation of distribution pipelines.

—Implementation of "soft components" for reduction of water leakage.

(3) Reflecting the components of the project, both sides agreed that the project name will be changed from "The Project for Rehabilitation and Expansion of Water Supply Facilities in Savannakhet Area in Lao PDR" to "The Project for Rehabilitation of Water Supply Facilities in Savannakhet Area in Lao PDR."

(4) Both sides agreed that Lao side will take necessary measures described in Annex-V of the Minutes of Discussions signed by both parties on 12th October 2000 for smooth implementation of the project.

(5) Both sides reconfirmed that NPS will allocate enough budget and staff with appropriate technical skills to ensure proper and effective operation and maintenance of the facilities and equipment to be provided under the project.

(6) The Japan side requested the Lao side to prepare the necessary electric supply to the Nake Water Treatment Plant before the construction starts.

(7) The Lao side requested the Japanese side to reconstruct a warehouse if removal of the existing warehouse is required for construction of a new water reservoir.

Annex- I

SUMMARY
OF
SOFT COMPONENT PROPOSAL

To strengthen the institutional and administrative capacity of Savannakhet Water Supply Company (NPS), the soft component will be introduced into the present Project. For executing the soft component, following three-pillars activities are considered to achieve the objectives: (1) Management and Financial, (2) Water Bill Collection, and (3) Operation and maintenance of the water works. Every activity of the three aspects is as shown below:

1) Recommendations and Instruction for Management and Financial Aspect

The items of recommendations and instructions for management and financial aspects are:

(1) Training and instruction on the general aspect of water works services,

(2) Instruction on the costs related to the unit water production, training on calculation of the costs required for water works management,

(3) Instruction on the methodology of financial analysis,

(4) Training and instruction on the water tariff setting,

(5) Instruction and recommendation on ledger keeping and materials stock list keeping, and

(6) Follow up service after facilities hand-over.

2) Recommendations and Instruction for Water Billing and Collection System

The recommendations and instruction for water billing and collection system include the following items:

(1) Records of computerized and other meter reading, instruction on methodology of water billing/collection control,

(2) Recommendations and instruction on filing and control of water billing records and collection deposit records,

(3) Training and instruction water meter readers, on the methodology to find the water meter-loss,

(4) Training and instruction water meter readers, on the above item No. (1), and

(5) Preparation of manuals for (i) water meter reading, and (ii) water bill collection.

3) Recommendations and Instruction for Operation and Maintenance of Installed/Constructed

Facilities and Equipment include the following item of activities:

The Recommendations and Instruction for Operation and Maintenance of Installed/Constructed Facilities and Equipment include the following item of activities.

(1) Technical training and instruction on the entire system facilities,

(2) Training and recommendation on plan making for the operation and maintenance works,

(3) Training and recommendation on repair and control works for facilities, and procurement of spare parts,

(4) Preparation of a manual for daily facility's operation and repair works,

(5) Training on water quality control (chemical dosing amount etc.) (include training in Chinaimo Water Treatment Plant),

(6) Training on filling the operation reports & records, and records keeping & filing,

(7) Training on facility's operation and maintenance, upon facility test-operation,

(8) Follow up training after facilities handed-over to NPS.

The proposed soft component services are planned to be conducted by the following three Japanese technical advisors:

(1) Expert for Management and Water Billing & Collection System,

(2) Expert for Operation and Maintenance for Water Treatment Facilities, and

(3) Expert for Water Quality Control.

No.	Facility	No.	Facility
Intake Facilities			
201)	Intake Pumps	202)	Discharge pipe
204)	Ceiling crane		
205)	Pump control panel	103)	Raw Water Transmission Main
206)	Raw water flow control devices		
Water Treatment Facilities			
211)	Rapid mixer		
212)	Flocculator	213)	Control panel of Flocculator
216)	Sludge valve	219)	Inlet gate
220)	Filter beds	221)	Underdrain system
222)	Back-wash pump	224)	Pipelines and valves
225)	Filter outlet control devices	226)	Local control panels
227)	Pumps for plant-use water		
Chemical Dosing Facilities			
231)	Weigh scale	232)	Chain host
233)	Coagulant dosing facilities	234)	Alkaline dosing facilities
235)	Chlorine dosing facilities	238)	Chemical controlling panel
239)	Laboratory and equipments		
Electrical and Instrumentation Equipment			
241)	High Voltage Power Receiving Facility	242)	Power Control Panel
243)	Lightning Facility	244)	Cable and Wiring
Instrumentation Equipment for Water Treatment Plant Facilities			
246)	Instrumentation/equipment for raw water intake and water treatment system		
247)	Instrumentation equipment for distribution system		
Distribution Facilities			
121)	Clear water reservoir with connection chamber, connection pipes and drain system		
251)	Distribution pumps	252)	Discharge pipes
253)	Flow-meter for distribution system	254)	Air Vessel
255)	Air compressor	256)	Monorail chain hoist
257)	Control panel for distribution pumps		
Others			
	Warehouse		

5. Other Relevant Data

5.1 Study on The Type of Raw Water Intake Pump

(1) Present Status of the Raw Water Intake Pump

In the existing raw water intake tower, three vertical bore hall (mixed flow vane wheel type) pumps were equipped. Their technical specifications, presented on the name plate, are read as shown below:

Table A.5-1 Technical Specifications of Existing Raw Water Intake Pump

Raw Water Pump		Electric Mortar	
Pump Fabrication No	: 3508940	Rated Mortar Power	: 37 kW
Rated Capacity	: 330 m3/hr	Rated Voltage	: 380 V, 50 Hz
Rated Pump Head	: 23.5 m	Rotation	: 960 ppm
Pump Rotation	: 950 ppm	Mortar Power factor	: 0.86

The original design was 2 units for normal operation and one unit for standby. According to the operation records, in several cases, all three pump-units were operated to meet the demands during the daytime in March to June in dry season. It is suspected that the existing pump capacity has decreased.

In the present study, an ultra-sonic flow meter was installed on the existing transmission main to measure the raw water flow. The results of flow measurement were at around 83- 86% of the design flow. Even, there will be measurement error, the existing pump capacity was evaluated to decrease at considerable rate at about 85% of the rated capacity.

The main cause for this decrease is judged that the pump vane has been worn away from more than 20 years operation of raw water with heavily contained silt in the river water.

Table A.5-2 Estimated Raw Water Intake Pump Capacity

Measured flow (m^3/min)	Intake water level (+m)	Units/Nos. of pump operation	Measured pump discharge (m^3/min)	Estimated pump Design discharge (m^3/min) *
19.10	133.4	3	6.36	7.40
13.43	133.4	2	6.72	8.13

* estimated from pump characteristic curve and intake water level

(2) Rehabilitation Plan

1) Rehabilitation Concept

As discussed in the preceding section, decrease of pump capacity is derived not only from the maintenance of pump, but also from the capacity decrease of pump itself due to wearing. Thus, the all three existing pump units are designed for replacement with new pumps. The same design conditions such as pump capacity and head will be used. Two units of pump operation shall cover the design intake flow.

2) Type of Pump

As for the newly designed pump, following two types of pump were studied for technical comparison purpose. Since the new pumps will be installed at the existing raw water intake tower, such types of pumps as (1) the same type of existing vertical axial flow type pump, and (2) submersible pump are selected for comparison

.

As the result of the comparison study, the submersible pump is recommended for newly installed pump. It has advantages of easier maintenance and cheaper price. This type of pump has been widely used as the raw water intake pump.

Table A.5-3 Technical Comparison of Two Types of Pump

	Vertical Mixed Flow Type Pump	Submersible Mortar Pump
1. Structural Feature	Pump casing (include pump vane) and discharge elbow pipe are connected with lifting pipe (with cover pipe, intermediate shaft and shaft support). Pipe length is to be adjusted as required. Mortar is installed on pump bed above the elbow pipe, and connected with pump axial shaft which penetrate the elbow pipe. Mortar is installed above water level. The designed pump shaft length is as long as 16m fixed to shaft supports with three meters interval.	Pump vane and submersible mortar are combined as one unit in discharge pipe casing. Motor is completely sealed and water tight. The shaft length is only 1/10 of vertical mixed flow pump with only 2 shaft supports. Pump can be hanged by lift pipe and fixed to the discharge pipe by connecting with elbow pipe.
2. Operation & Maintenance	Operation & maintenance: Easy Vane is submersed in the water, thus no prime water is required Repair & maintenance: Complicated re-assembling works are necessary after dismantle and repair work is finished (centering of pump shafts between every shaft supports, followed installation of elbow pipe and pump.	Operation & maintenance: Easy Vane is submersed in the water, thus no prime water is required Repair & maintenance: For dismantling/reassembling of pump, no specific skill is required such as centering of pump shaft. Only ordinal works such as flange jointing work is required for dismantling/reassembling of pump.
3. Pump Selection	Intermediate shaft is rather long, and complicated dismantling and re-installation works are necessary with skill. Special care shall be taken for centering pump shafts and pump to avoid harmful vibration in pump operation.	Repair and maintenance works are easy. Maintenance cost is cheaper compared with vertical mixed flow pump. The same type of pump was used for Chinaimo W. T. Plant, in Vientiane Water Supply Company, thus it is already familiar in Lao PDR.
	Not adopted for present design.	Adopted for present design.

3) Specifications of Pump

Following technical specifications are applied for new raw water intake pump to replace the existing pump:

Pump Type:	Submersible pump
Unit Nos.:	3 units
Rated Capacity:	5.5m^3/min (330m^3/hr)
Rated Pump Head:	23.5m
Mortar Power:	37kW

5-2 Raw Water Flow Control

1) Status for Pump Operation

Pump discharge shall increase when raw water intake level becomes higher than designed low water level due to decrease of static head of pump. As the results, mortar is operated at overload status, and frequent operation in such status makes its life shorten. It is therefore necessary to control discharge flow of pump in accordance with intake water level to avoid the above mentioned status for pump operation, and to supply required raw water flow for optimum plant operation as well.

2) Rehabilitation Plan

There are two methods for flow control of pump operation. One is to control flow by changing pump rotation of pump itself, another is to give head loss by flow control valve at the downstream of the pump. In this design, it is recommended to apply latter method as it has the following advantages, 1) simple system, 2) easy repair and maintenance, and 3) lower cost

The operator can control required flow by adjusting the flow control valve manually in accordance with the flow rate shown on the flow indicator.

a. Design Conditions

The lowest static pump head is obtained at the highest raw water intake water level. This operation condition makes pump at overload operation, thus required flow control. The conditions for raw water flow control are presented in the following table.

Table A.5-4 Design Conditions for Raw Water Flow Control

Design Highest Water Level	+139.25m			
Design Maximum. Raw Water Flow	15,840m^3/day			
Cases for Study				
Items	Unit	Case1	Case 2	Case 3
Water Flow	m^3/min	5.5	8.0	11.0
Pump Units	Unit	1	2	2
Total Pump Head	m	23.5	26.5	23.5
Static Pump Head	m	1.94	1.94	1.94
Head Loss of Pipeline	m	0.45	0.95	1.79
Head at Valve Downstream	m	4.59	4.59	4.59
Head Loss by Control Valve : Ha	m	Ha0=21.11	Ha1=23.61	Ha2=19.77

As for the pump units for operation, the maximum pump discharge of a pump is determined at 8.0m3/min. When, the required raw water intake flow is below 8.0m3/min, one unit of pump is in operation. While, two units of pump are in operation when raw water intake flow is to be more than 8.0 m3/min. When, two units of pump are in operation at the required raw water intake flow of 8.0 m3/min, discharge per pump becomes 4.0 m3/min, which is about 72 % of rated capacity of the pump. For the above case, the estimated pump head is calculated at 26.5 m or 113 % of rated pump head from the pump characteristic curve.

The minimum static pump head is obtained from water level of the receiving chamber (+141.19m) and highest water level of raw water intake (+139.25m). While head loss of raw water transmission pipeline is calculated as 0.45 m at the intake flow rate of 5.5 m3/min as shown below:

Maximum Head Loss of Pipeline = Rated Pump Head – Maximum Static Pump Head

= 23.5 – (149.19 – 124.85) = 7.16 m

Therefore, Head Loss of Pipeline at Flow Rate of 5.5 m3/min

=7.16 x (5.5/22.0)^2 = 0.45 m

where, maximum raw water intake flow is 22 m3/min (5.5 m3/min x 4 units)

A total pump head is obtained as the sum of static head and head loss of pipeline. In case the required total pump head at certain raw water intake flow is lower than the rated pump head, the excess head shall be added for pump operation. Such additional head (Ha) is made by control valve. Water head of the control valve at its downstream is obtained as a difference between water level of the receiving chamber and elevation of valve center. This is calculated at 4.59 m (141.19 – 136.60). Where elevation of the control valve or transmission pipeline is + 136.60.

b. Type of Flow Control Valve

Out of the different types of flow control valve, following three types of valve are considered as appropriate for the present design. They are (1) Butterfly valve, (2) Teeth disk valve, and (3) cone valve. The selection of the most appropriate control valve is studied based on the above design conditions.

c. Study on Hydraulic Condition

Within the above design conditions, the hydraulic analysis is made at the maximum head loss by control valve (Ha) as 23.61m. Considering adequate range of velocity and economy of the control valve, the size of valve is determined at 400 mm in diameter, which is one size smaller than the existing raw water transmission pipeline of 450 mm in diameter, for hydraulic analysis as follows:

a) Case 1 (operate one control valve)

In this case, the hydraulic conditions for valve control is illustrated on Fig. A.5-1.

Flow control valve (FCV):	1unit
Flow rate:	8m3/min = 0.1333m3/sec (under 2 pumps operation)
Velocity:	1.06m/sec
Velocity head ($V^2/2g$):	0.057m
Heads Loss by Valve:	P1= Ha1 = 23.61m
Head of Valve at its downstream:	P2= 4.59m

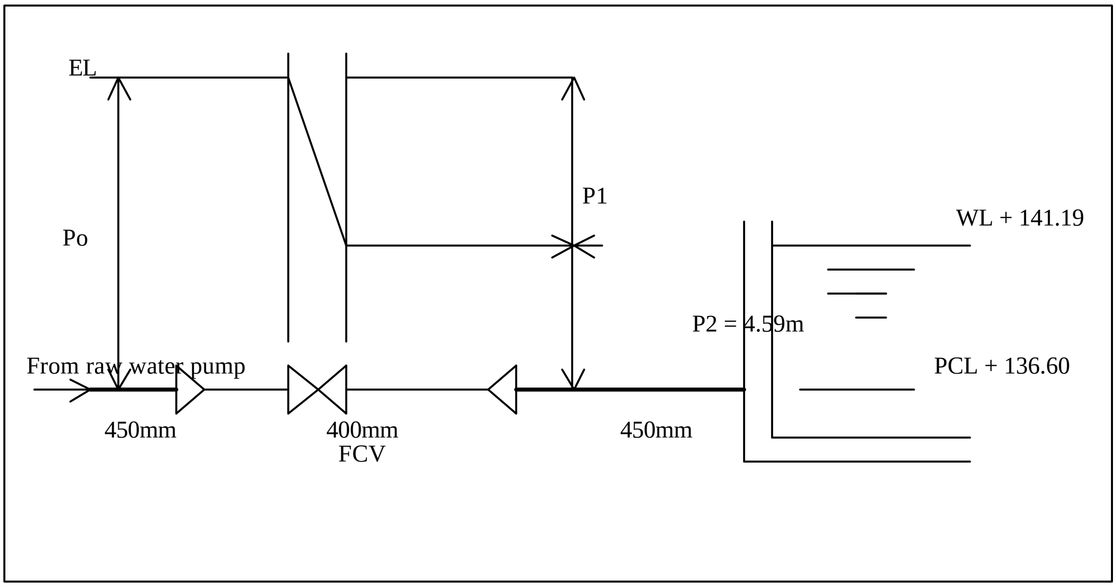


Fig. A.5-1 Case 1 Hydraulic Conditions for Valve Control

The head loss due to Control Valve, Ha is presented in the following equation:

Ha = P1 = f x $V^2/2g$ f: loss coefficient of Control Valve

therefore, f = P1 x 1/(V2/2g) = 23.61m x 1/0.057m = 414.2

While, cavitation factor is calculated as follows:

Ca = (10m + P2)/P1 = (10m+4.59m)/23.61m = 0.618

According to the above loss coefficient of valve and valve opening rate, cavitation factor is calculated for each type of control valve as shown in Table A.5-5.

Table A.5-5 Summary Hydraulic Analysis for Case 1

Valve Type	Valve Opening(%)	Cavitation Factor (allowable) Ca..al	Cavitations Factor (calculated) Ca.cl.	Evaluation Ca.al. <Ca.cl.
Butterfly Valve	16.0	2.8	0.618	Cavitation arise
Teeth Disk Valve	14.3	0.9	0.618	Same as the above
Cone Valve	20.5	1.0	0.618	Same as the above

From the above study, it is found that cavitation will occur for all three types of valve in Case 1. As an alternative case, use of two valves installed in series is studied to control large head loss of 23.61m. This alternative case is shown as follows:

b) Case 2 (use two control valves)

Hydraulic conditions of this case are illustrated in Fig. A.5-2

Flow control valve (FCV):	2units (FCV1 & FCV2)
Flow rate:	8m3/min = 0.1333m3/sec (under 2 pumps operation)
Velocity:	1.06m/sec
Velocity head ($V^2/2g$):	0.057m
Head Loss of Valve:	Ha1 = 23.61m = P1 + P3
	where, Ha1' controlled by FCV1 = 11.61m
	Ha1" controlled by FCV2 = 12.0m
Head of Valve at its downstream:	P2 = 16.59m
	P4 = 4.59 m

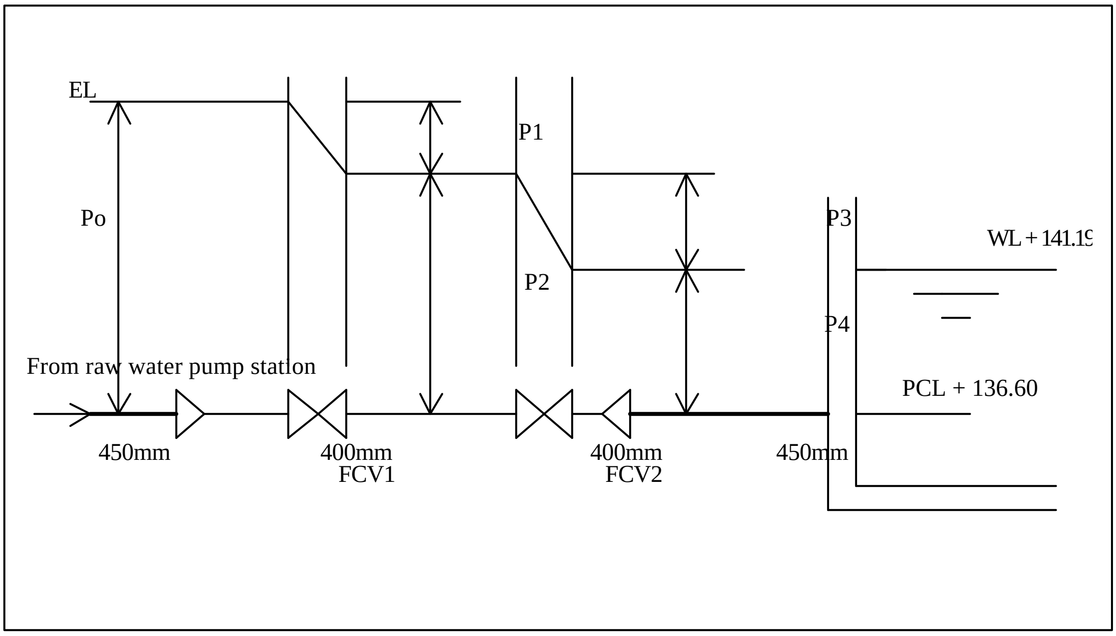


Fig. A.5-2 Case 2 Hydraulic Conditions for Valve Control

The head loss due to control valve FCV2 is calculated as shown below:

P3 = f2 x V2/2g f: loss coefficient of control valve

therefore, f2 = P3 x 1/(V2/2g) = 12m x (1/0.057)m = 210.5

While, cavitation factor of FCV2 is calculated as follows:

$Ca = (10m + P4)/P3 = (10m + 4{,}59m)/12m = 1.22$

The head loss due to control valve FCV1 is calculated as shown below:

$P1 = f1 \times V2/2g$ f: valve loss factor

therefore, $f1 = P1 \times 1/(V2/2g) = 11.61m \times 1/0.057m = 203.7$

Then, cavitation factor FCV1 is calculated as shown below:

$Ca = (10m + P4 + P3)/P = (10m + P2m)/11.61m = (10m + 16.59m)/11.61\ m = 2.29$

Valve opening rate and cabitation factor for each type of control valve are calculated and shown in Table A.5-6 and A.5-7.

Table A.5-6 Hydraulic Analysis for FCV2 (Case 2-1)

Valve Type	Valve Opening(%)	Cavitation Factor (allowable) Ca.al	Cavitations Factor (calculated) Ca.cl.	Evaluation Ca re. <Ca.cl.
Butterfly Valve	20.5	3.0	1.216	Cavitation arise
Teeth Disk Valve	18.7	1.0	1.216	No cavitation arise
Cone Valve	27.0	1.05	1.216	Same as the above

Table A.5-7 Hydraulic Analysis for FCV1(Case 2-2)

Valve Type	Valve Opening(%)	Cavitation Factor (allowable) Ca.al	Cavitations Factor (calculated) Ca.cl.	Evaluation Ca.al <Ca.cl
Butterfly Valve	20.5	3.0	2.29	Cavitation arise
Teeth Disk Valve	18.7	1.0	2.29	No cavitation arise
Cone Valve	27.0	1.05	2.29	Same as the above

In the above Case study, both of FCV1 and FCV2 arise cavitation when they are butterfly valves. As for the teeth disk valve and cone valve, both valves can be applied for FCV1 and FCV2 without cavitation. The price of teeth disk valve is about one to seventh(1/7) against the corn valve, thus the teeth disk valve is recommended to be applied for the flow control valve.

The above three types of flow control valve have following technical features as shown in Table A.5-8 below.

Table A.5-8 Technical Feature of Control valves

	Butterfly Valve	Teeth Disk Valve	Cone Valve
1. Structure	Valve disk is placed in valve box, and it rotates around valve stem for 90degrees for valve open and close. Even full open position, valve disk interrupts flow section, thus pressure loss is larger than sluice valve. Shut-off is made by contact with metal valve body and valve disk with rubber seat.	Basically structure is the same as butterfly valve. To improve cavitation factor, teeth-like projections are provided on the valve disk to separate the water flow to small streams. By this projections, flow section is smaller than butterfly valves, thus pressure loss is larger than butterfly valves.	Circular truncated cone is placed in the valve body, and this cone is rotated around the valve stem for valve open and close. Shut-off of flow is made by contact between valve body and this corn. Water flows in the cylindrical outer space between the cone and valve wall, thus pressure loss is very small.
2. Controllability	Correlation between valve opening rate and flow rate is almost liner. Practical control range is 30-70% opening. Below 20% opening, flow becomes too sensitive to control practicably.	Basically same conditions as butterfly valves for flow control. Due to the teeth-like projections on valve disc, flow controllability is improved. Practical control range is 15-70% opening. Below 10 % of opening, practicable flow control is difficult.	Correlation between valve opening rate and flow rate is not linear. Flow variation become small at smaller opening rate of valve, while it becomes larger at larger valve opening rate. Practical control range is 15-80 % opening.
3.Characteristics of Cavitation	Valve Opening (%) Cavitation Factors 15 2.80 20 3.05 25 3.35 30 3.85 35 4.30 40 4.80	Valve Opening (%) Cavitation Factors 15 0.95 20 1.07 25 1.25 30 1.50 35 1.70 40 1.95	Valve Opening (%) Cavitation Factors 15 1.00 20 1.00 25 1.02 30 1.06 35 1.15 40 1.25
4. Price Indicator	100%	130%	700%

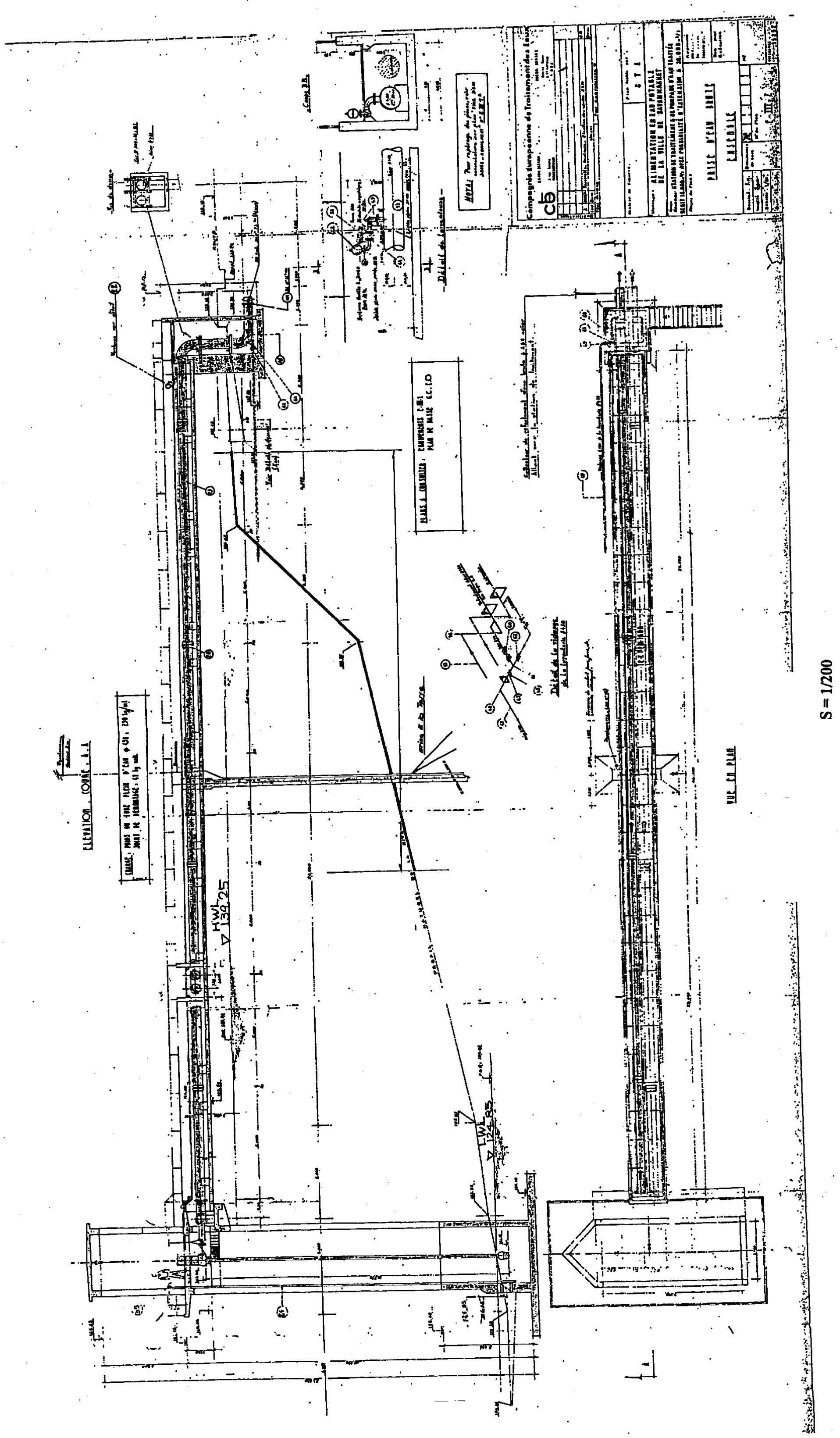


Fig. A.5-3 Section of Intake Facility

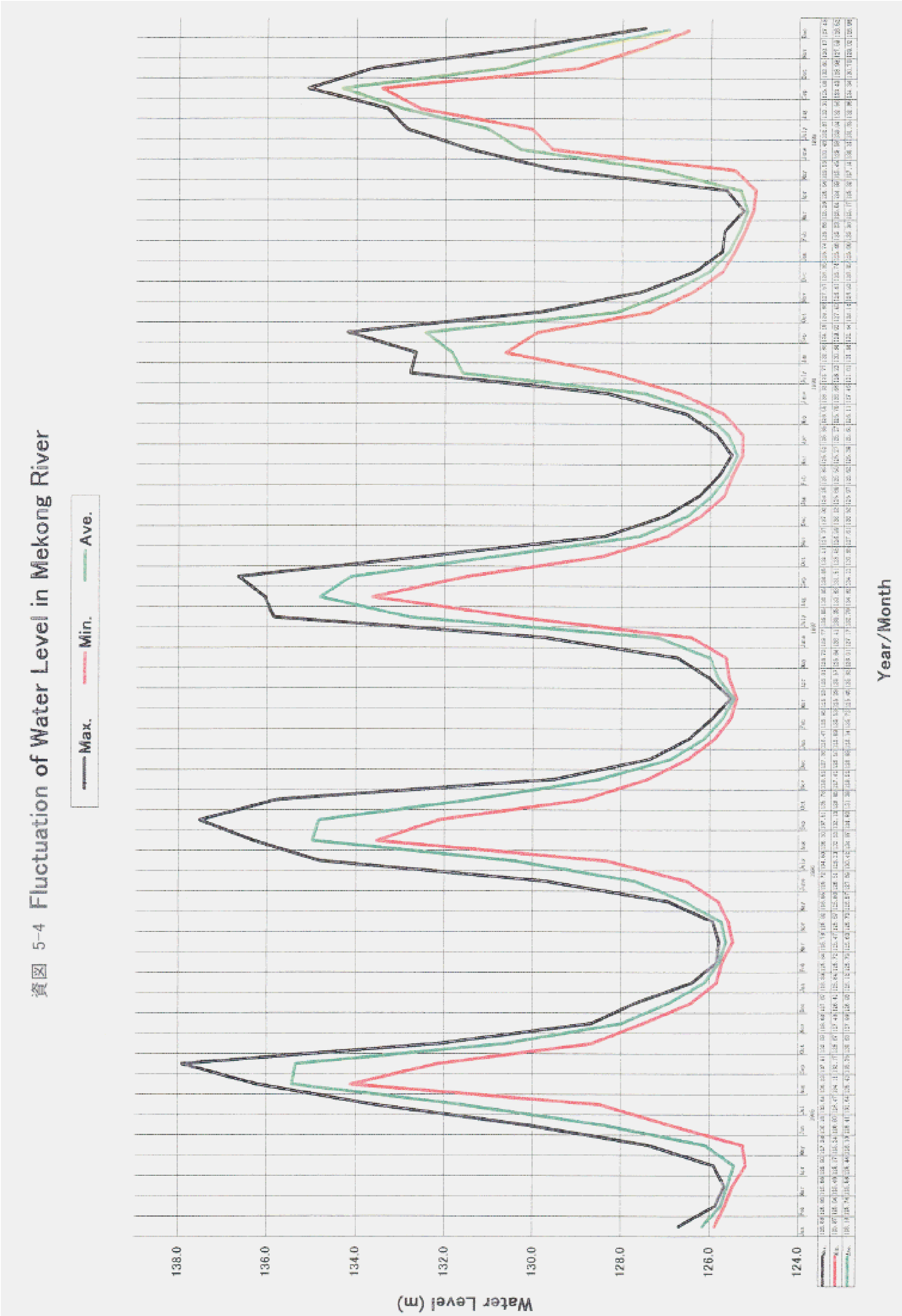
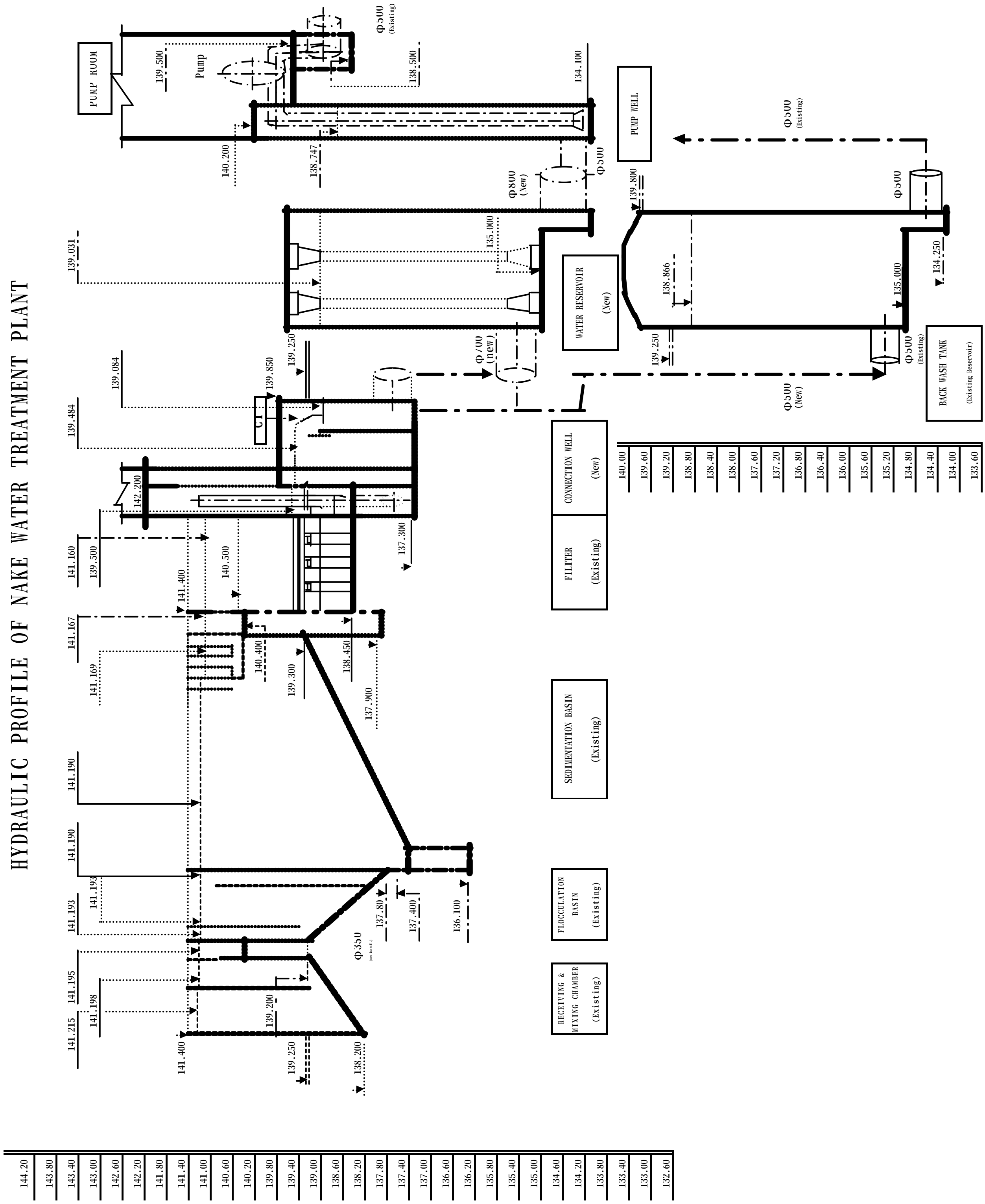


Fig. A.5-4 Fluctuation of Water Level in Mekong River

5.3 Hydraulic Analysis of Water Treatment Plant



★HYDRAULIC CALCULATION (WATER LOSS ANALYSIS)

＊WATER INTAKE TOWER

a) Inlet velocity for Gate(V1) through 4-Gates at LWL

$V_1 = Q / A$

whrer, Q; Planed Maximum Intake Capacity

A; Section Area of 4-Gates

$V_1 =$ 0.18 m^3/sec ／(1/4 0.40 ^{2} * 4 Places) = 0.365 m/sec

b) Head Loss at Gates (H_{ig}) at LWL

$H_{ig} = 1/C^{2} * (V_1^2 / 2*g)$

where, C; Coefficient of Orriffice = 0.60

V_1; Inlet Velocity through Gates (m/sec) = 0.365 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

$H_{ig} =$ 1／ (0.6) ^{2}* (0.365) ^{2}／ (2 * 9.81) = 0.0189 m

＊RAW WATER TRANSMISSION PIPE(Existing)

a) Head Loss of Transmission Pipe (H_{fr})

* Friction Loss

Hazen & William's Formula

$H_{fr} = 10.666 * C^{-1.85} * D^{-4.87} * Q^{1.85} * L$

where,	C; Coefficiency of Velocity =	SP;	100		DIP;	110
	D; Pipe Diameter (m) =	SP;	0.45	m	DIP;	0.45 m
	Q; Flow Rate (m^3/sec) =	SP;	0.1833	m^3/sec	DIP;	0.1833 m^3/sec
	L; Pipe Lngth (m) =	SP;	52.8	m	DIP;	134.0 m

$H_{frs} =$ 10.666 * (100)$^{-1.85}$*(0.45)$^{-4.87}$*(0.183)$^{1.85}$* 52.8 = 0.238 m

$H_{frd} =$ 10.666 * (110)$^{-1.85}$*(0.45)$^{-4.87}$*(0.183)$^{1.85}$* 134.0 = 0.506 m

$\therefore H_{fr} = H_{frs} + H_{frd} =$ 0.7440 m

b) Velocity of Raw Water Pipe (V_{fr})

$V_{fr} = 0.84935 * C * (D/4)^{0.63} * (H_{fr}/L)^{0.54}$

where,	C; Friction Coefficient =	SP;	100		DIP;	110
	D; Pipe Diameter (m) =	SP;	0.45	m	DIP;	0.45 m
	H_{fr}; Friction Loss of Pipeline (m) =	SP;	0.2379	m	DIP;	0.5061 m
	L; Pipe Lngth (m) =	SP;	52.8	m	DIP;	134.0 m

$V_{frs} =$ 0.84935* 100 * (0.45 ／ 4)$^{0.63}$ * (0.238 ／ 52.8)$^{0.54}$ = 1.16 m/sec

$V_{frd} =$ 0.84935* 110 * (0.45 ／ 4)$^{0.63}$ * (0.5061 ／ 134.0)$^{0.54}$ = 1.16 m/sec

c) Inlet Loss at Receiving Well (H_o)

$H_o = f_o * V_o^2 / 2 * g$

where, f_o ; Coefficient of Inlet = 1.00

V_o ; Velocity of Inlet (m/sec) = 1.160 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^{-2}

$H_o = f_o * V_o^2 / 2 * g =$ 0.0685 m

d) Total Head Loss (ΣH)

$\Sigma H = H_{fr} + H_o =$ **0.8125** m

★ HYDRAULIC CALCULATION (Head Loss/Water Level Analysis)

《Receiving Well》

a) Inflow Velocity at Inlet Opening of Mixing Chamber (V_{iw})

V_{iw}= Q／A

where, Q; Design Maximum Flow (m^3/sec) = 0.1833 m^3/sec

A; Sectional Area of Gate (m^2) = 0.5250 m^2

V_{iw}= 0.1833 m^3/sec ／ 0.5250 m^2 = 0.3490 m/sec

b) Head Loss at Inlet Opening of Mixing Chamber (H_{is})

H_{is}= 1／C^2* (V_{Ir}^2／2*g)

where, C; Coefficient of Oriffice = 0.60

V_{Ir}; Inlet Velocity at Gate (m/sec) = 0.3490 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

H_{is}= 1／ (0.60) ^{2}* (0.3490) ^{2}／ (2 * 9.81) = 0.0172 m

c) Water Level of Mixing Chamber

* Water Level of Mixing Chamber 141.215 m

Water Level at Mixing Chamber 141.215 m - 0.017 m = 141.198 m

◎During Rehabilitation(Sedimentation Basin 1 & 1 Filter Bed stop operation)

* Water Level at Reciving Well 141.230 m

Water level at Mixing Chamber; 141.230 m - 0.017 m = 141.213 m

《Mixing Chamber》

a) Overflow Height Analysis for Submerged Weir

Ishihara & Ida's Formula

Q= C*B*$h^{3/2}$

C=1.785+ 0.00295／h + 0.237 * (h／W) ∗ (1＋ε)

where, Q; Flow Rate (m^3/sec) = 0.1833 m^3/sec (Estimated

B; Width of Weir (m) = 1.5000 m Head Loss)

h; Overflow Heoght of Weir (m) = 0.1643 m → 0.003286 m

C; Flow Coefficient ($m^{1/2}$/sec) = 1.8353 $m^{1/2}$/sec

W; Height from Bottom of Channel (m) = 1.600 m

ε ; Coefficient for Correction, when W>1, ε= 0.55*(W-1) = 0.3300

∴Q= C*B*$h^{3/2}$ = 0.1833

∴C=1.785+ 0.00295／h + 0.237 * (h／W) ∗ (1＋ε) = 1.8353

b) Water level at Inlet Conduit of Flocculation Basin

Water Level at Inlet Conduit; 141.198 m - 0.0033 m = 141.195 m

(Present Water Level: 141.20m

◎During Rehabilitation(Sedimentation Basin 1 & 1 Filter Bed stop operation)

Water level at Inlet Conduit of Flocculation Basin 141.213 m - 0.0033 m = 141.210 m

★HYDRAULIC CALCULATION (Head Loss/Water Level Analysis)

a) Head Loss of Flocculation Basin

＊Head Loss of 90 Bend

V_b = Q／A

where, Q; Flow Rate of Flocculation Basin (m^3/sec) = 0.0458 m^3/sec

A; Sectional Area of Inlet Channel (m^2) = 0.7945 m^2

V_b = 0.0458 m^3/sec ／ 0.7945 m^2/Gate = 0.0580 m/sec

H_b = f_b * V_b^2／2*g)

where, f_b; Coefficient of 90 ° Bend = 4.00

V_b; Velocity in Inlet Channel (m/sec) = ##### m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

H_b = 4.00 * (#####)^2／(2 * 9.81)= ##### m

***Head Loss of Orifice**

V_c = Q／A

whrer, Q; Flow Rate of Flocculation Basin (m^3/sec) = 0.0458 m^3/sec

A; Sectional Area of Inlet Gate (m^2) = 0.4290 m^2

V_c = 0.0458 m^3/sec ／ 0.4290 m^2/Gate = 0.1070 m/sec

H_c = f_c * V_c^2／2*g)

where, f_c; Coefficient of Orifice = 0.60

V_c; Velocity in Gate (m/sec) = ##### m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

H_c = 0.60 * (#####)^2／(2 * 9.81)= ##### m

Then, Head Loss at Inlet Gate:

H＝ H_b ＋ H_c ＝ **0.0011 m**

b) Flow Velocity at Opening to Flocculation Basin (V_{if})

V_{if} = Q／A

where, Q; Design Maximum Flow Rate (m^3/sec) = 0.0458 m^3/sec

A; Sectional Area of Opening (m^2/cell) = 1.3330 m^2

V_{if} = 0.0458 m^3/sec ／ 1.3330 m^2/cel = 0.0340 m/sec

c) Head Loss at Opening to Flocculation Basin (H_{sf})

H_{sf} = 1／C^2* (V_{Ir}^2／2*g)

where, C; Coefficient of Oriffice = 0.60

V_{if}; Inlet Velocity in Opening (m/sec) = 0.0340 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

H_{sf} = 1／ (0.6) ^{2}* (0.0340) ^{2}／ (2 * 9.81) = **0.0002 m**

d) Analysis of Overflow Height of Weir (submerged weir)

Ishihara & Ida's Formula

Q= C*B*$h^{3/2}$

C=1.785+ 0.00295／h ＋ 0.237 * (h／W)* （1＋ε）

whrer, Q; Flow Rate (m^3/sec) = 0.0458 m^3/sec (Estimated:

B; Width of Weir (m) = 3.920 m Head Loss)

h; Overflow Height of Weir (m) = 0.0338 m → 0.003383

C; Flow Coefficient ($m^{1/2}$/sec) = 1.878 $m^{1/2}$/sec

W; Height from Bottom of Channel (m) = 2.900 m

ε ; Coefficient for Correction, when W>1, ε= 0.55*(W-1) = 1.045

∴Q= C*B*$h^{3/2}$ = 0.045804

∴C=1.785+ 0.00295／h ＋ 0.237 * (h／W)* （1＋ε） 1.877855

e) Flow Velocity into Split Roll (V_{io})

V_{io}= Q／A

whrer, Q; Design Maximum Flow Rate (m^3/sec)

A; Sectional Area of Opening (m^2)

V_{io}= 0.092 m^3/sec ／ 1.632 * 2 basins = 0.0280 m/sec

f) Head Loss at Sprit Roll (H_{io})

H_{io}= 1／C^2* ($V_{Io}{}^2$／2*g)

where, C; Coefficient of Oriffice = 0.60

V_{Io}; Inlet Velocity of Opening (m/sec) = 0.028 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

H_{io}= 1／ (0.6) ^{2}* (0.028) ^{2}／ (2 * 9.81) = **0.0001** m

g) Water Level of Flocculation Basin

*** Water Level at Inlet Zone of Flocculation Basin;**

141.195 m — 0.0011 m = **141.193** m

*** Water Level of Flocculation Basin;**

141.193 m - 0.0002 m = **141.193** m

*** Water Level at Outlet Zone of Flocculation Basin;**

141.193 m — 0.0034 m = **141.190** m

*** Water Level at Inlet Zone of Sedimentation Basin;**

141.190 m - 0.0001 m = **141.190** m

★ HYDRAULIC CALUCULATION (Head Loss/Water Level Analysis)

a) Head Loss at Watr Collection Pipe

* Inlet Velocity (V_{io}) of Water Collection Pipe (φ50mm)

V_{io} = Q／A

where, Q; Design Maximum Flow Rate (m^3/sec) 0.0917 m^3/sec

a; Sectional Area of Pipe (m^2) = 0.00196 m^2/piece

A; Total Sectional Area of Collection Pipes (m^2) = 0.24151 m^2

V_{io} = 0.092 m^3/sec ／ 0.242 m^2 = 0.3797 m/sec

* Head Loss of Water Collection Pipe (H_{io})

H_{io} = 1／C^2* ($V_{Io}{}^2$／2*g)

where, C; Coefficient of Orifice = 0.60

V_{Io}; Inlet Velocity of Orifice (m/sec) = 0.380 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

H_{io} = 1／ (0.6) ^{2}* (0.38) ^{2}／ (2 * 9.81) = 0.0204 m

b) Head Loss at Outlet Gate

V_c = Q／A

whrer, Q; Flow Rate of Sedimentation Basin (m^3/sec) = 0.0917 m^3/sec

A; Sectional Area of Outlet Gate (m^2) = 0.7693 m^2

V_c = 0.0917 m^3/sec ／ 0.7693 m^2/Gate = 0.1190 m/sec

H_c = ξ* ($V_c{}^2$／2*g)

where, ξ; Coefficient of Sudden Convergence = 3.60

V_c; Velocity of Gate (m/sec) = 0.1190 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

H_c = 3.60 * (0.1190)^2／ (2 * 9.81) = 0.0026 m

c) Water Level of Sedimmentation Basin

* Water Level of Sedimentation Basin; 141.190 m

(Existing Water Level;141.87m)

* Water Level of Collection Pipe; 141.190 m − 0.0204 m = 141.169 m

* Water Level at Inlet Conduit of Filter 141.169 m − 0.0026 m = 141.167 m

★HYDRAULIC CALCULATION (Head Loss/Water Level Analysis)

《Rapid Sand Filter》

a) Head Loss of Inlet Gate (H_{io})

***Inlet Velocity of Inlet Gate (V_i)**

V_{io}= Q／A

where, Q; Design Maximum Flow Rate (m3/sec) = 0.0458 m^3/sec

A; Sectional Area of Orifice (m2) = 0.2132 ㎡/basin

V_{io}= 0.046 m^3/sec ／ 0.213 ㎡/basin = 0.2150 m/sec

*** Hwad Loss of Inlet Gate (H_{io})**

H_{io}= 1／C^2* ($V_{Io}{}^2$／2*g)

where, C; Coefficient of Oriffice = 0.60

V_{Io}; Inlet Velocity of Orifice (m/sec) = 0.215 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

H_{io}= 1／ (0.6) ^{2}* (0.215) ^{2}／ (2 * 9.81) = **0.0065** m

b) Water Level of Filter Bed

***Water Level at Inlet Conduit;** **141.167** m

Water Level of Filter Bed 141.167 m － 0.0065 m = **141.160** m

(Existing Water Level; 141.16m)

c) Total Head Loss of Filter Bed

H_f= 1.66 m : same as the present loss

Then, Water Level at outlet Tank after Filter Flow Controller; 141.160 m - 1.6600 m = **139.500** m

d) Head Loss of Outlet Orifice (H_{oo})

*** Velocity of Outlet Orifice (V_{oo})**

V_{oo}= Q／A

where, Q; Design Maximum Flow Rate (m3/sec) = 0.0458 m^3/sec

A; Sectional Area of Orifice (m2) = 0.1350 ㎡/basin

V_{oo}= 0.046 m^3/sec ／ 0.135 ㎡/basin = 0.3390 m/sec

*** Head Loss of Outlet Orifice (H_{oo})**

H_{oo}= 1／C^2* ($V_{Io}{}^2$／2*g)

where, C; Coefficient of Orifice = 0.60

V_{oo}; Inlet Velocity of Orifice (m/sec) = 0.3390 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

H_{oo}= 1／ (0.6) ^{2}* (0.339) ^{2}／ (2 * 9.81) = **0.0163** m

Then,

Water Level of Filter Outlet Conduit; 139.500 m - 0.0163 m = **139.484** m

《FILTER CONNECTION WELL》

a) Calculation of Overflow Height at Filter Outlet

*** Ishihara & Ida's Formula**

$Q = C*B*h^{3/2}$

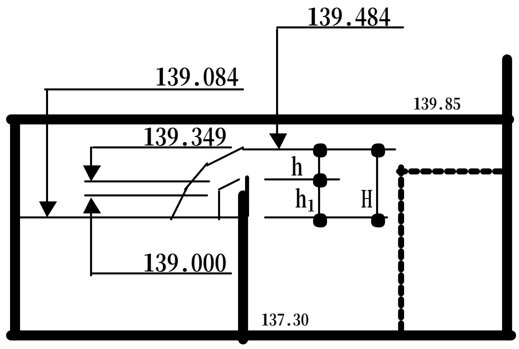
$C = 1.785 + 0.00295/h + 0.237 * (h/W)(1+\varepsilon)$

where,	Q; Over Flow rate (m^3/sec) =	0.183	m^3/sec
	B; Width of Weir (m) =	2.000	m
	h; Overflow Height of Weir (m) =	0.135	m
	C; Flow Coefficient ($m^{1/2}$/sec) =	1.845	$m^{1/2}$/sec
	W; Height from Bottom of Receiving Well (m) =	2.184	m
	ε; Coefficient for Correction, when W>1, ε= 0.55*(W-	0.651	

$\therefore Q = C*B*h^{3/2}$ = 0.1833

$\therefore C = 1.785 + 0.00295/h + 0.237 * (h/W)(1+\varepsilon)$ = 1.8453

Then,
Water Level after Overflow Weir
at Filter Outlet; 139.484 m - 0.400 m = **139.084** m



b) G-Value Calculation, for Total Filter Flow Meter Tank:
Generally, G=300～500sec^{-1} is applied

$G = (P/\mu * V)^{1/2}$ **: Equation in References from "Orugano"**

where,	G; Velocity Gradient (sec^{-1})		
	P; Power (kgf・m/sec)		
	$= \rho * B * (2*g)^{1/2} * (2/3 * h_1 * h^{3/2} + 2/5 * h^{5/2})$		
	= 8,833 * (0.009 + 0.003) =	101.2	kgf・m/sec
	ρ; Specific Gravity of Water at 25°C (kg/m^3) =	997.1	kg/m^3
	B; Width of Weir (m) =	2.000	m
	g; Accerated Gravity (m/sec^2) =	9.81	m/sec^2
	h; Overflow Height of Weir (m) =	0.135	m
	H; Head Loss (m)=	0.400	m
	h_1; Above Figure = H − h =	0.265	m
	μ; Dynamic Viscosity at 25°C (kgf・sec/m^2) =	0.00009157	kgf・sec/m^2
	V; Volume of unit (m^3) =	7.10	m^3

$\therefore G = (P/\mu * V)^{1/2}$ = 394.5 sec^{-1}

or

$G = (\rho * g * h/\mu * t)^{1/2}$ **: General equation**

where,	G; Velocity Gradient (sec^{-1})		
	ρ; Specific Gravity of Water at 25°C (kg/m^3) =	997.1	kg/m^3
	g; Accerated Gravity (m/sec^2) =	9.81	m/sec^2
	H; Head Loss (m)=	0.400	m
	μ; Dynamic Viscosity at 25°C (kg/m・sec)	0.000898	kg/m・sec
	t; Detention Time (sec) =	38.7	sec

$\therefore G = (\rho * g * h/\mu * t)^{1/2}$ = 335.4 sec^{-1}

★ HYDRAULIC CALCULATION (Head Loss/Water Level Analysis)

☆ Filtered Water Pipe-1 (Connected to New Reservoir): New construction

a) Head Loss at Inlet (H_i)

*** Inlet Flow Velocity (V_i) ; φ700mm**

$V_i = Q / A$

where, Q; Design Maximum Flow Rate (m^3/sec) = 0.1833 m^3/sec

D; Diameter of Connection Pipe (m) = 0.700 m

A; Sectional Area of C.W. Pipe-1 (m^2) = 0.3848 m^2

V_i = 0.1833 m^3/sec ／ 0.3848 m^2 = 0.4763 m/sec

$H_i = f_i * (V_i^2 / 2*g)$

where, f_i; Coefficient of Inlet = 0.50

V_i; Inlet Velocity of Pipe (m/sec) = 0.4763 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

H_i = 0.50 * (0.4763)^2 / (2 * 9.81) = **0.0058** m

b) Head Loss of Bed (H_{b1}) ;φ700x90°～6places

***Velocity at Band (V_{b1}) ;φ700mm**

$H_{b1} = f_{b1} * (V_{b1}^2 / 2*g) * n$

where, f_{b1}; Coefficient of Bend Pipe = 0.20

V_{b1}; Velocity (m/sec) = 0.4763 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

n; Places = 6 Places

H_{b1} = 0.20 * (0.4763)^2 / (2 * 9.81) * 6 = **0.0139** m

c) Head Loss of Butterfly Valve (H_{v1})

$H_{v1} = f_{v1} * (V_{v1}^2 / 2*g)$

where, f_{v1}; Coefficient of Butterfly valve = 0.25

V_{v1}; Inlet Velocity of Valve (m/sec) = 0.4763 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

H_{v1} = 0.25 * (0.4763)^2 / (2 * 9.81) = **0.0029** m

d) Friction Head Loss (H_{fr})

Hazen & William's Formula

$H_{fr} = 10.666 * C^{-1.85} * D^{-4.87} * Q^{1.85}$

where, C; Friction Coefficiency = 130

D; Pipe Diameter (m) = 0.700 m

Q; Flow Rate (m^3/sec) = 0.1833 m^3/sec

L; Pipe Lngth (m) = 59.00 m

H_{f1} = 10.666 * (130)$^{-1.85}$ * (0.700)$^{-4.87}$ * (0.183)$^{1.85}$ * 59.0 = 0.0190 m

e) Head Loss of Outlet to Water Reservoir (Ho)

$H_o = f_o * V_o^2 / 2 * g$

where, f_o ; Coefficient of Outlet = 1.00

V_o ; Outlet Velocity of Pipe (m/sec) = 0.4763 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^{-2}

$H_o = f_o * V_o^2 / 2 * g$ = **0.0116** m

f) Total Head Loss of Filtered Pipe-1 (ΣH)

$\Sigma H = H_i + H_{b1} + H_{v1} + H_{fr} + H_o$ = **0.0532** m

Then, Water Level of Reservoir; 139.084 m - 0.0532 m = **139.031** m

☆ Filtered Pipe-2 (to Backwash Tank): Existing & New Construction

a) Head Loss of Inlet (H_i)

*** Inlet Flow Velocity (Vi); φ500mm**

$V_i = Q / A$

where, Q; Design Maximum Flow Rate(Distribution) (m^3/sec) = 0.1890 m^3/sec

A; Sectional Area of Pipe (m π/4* (0.500 $)^2$ = 0.1963 m^2

V_i = 0.1890 m^3/sec / 0.1963 m^2 = 0.9628 m/sec

$H_i = f_i * V_i^2 / 2 * g$

where, f_i ; Coefficient of Inlet = 0.50

V_i ; Inlet Velocity of Pipe (m/sec) = 0.9628 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

$H_i = f_i * V_i^2 / 2 * g$ = **0.0236** m

b) Head Loss of Sluice Valve (H_{sv})

$H_{sv} = f_i * V_i^2 / 2 * g * n$

where, f_{sv} ; Coefficient of Sluice Valve = 0.10

V_i ; Inlet Velocity of Valve (m/sec) = 0.9628 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

n ; Number of Sluice Valve = 1 set

$H_{sv} = f_{sv} * V_i^2 / 2 * g * n$ = **0.0047** m

c) Head Loss of Bend (H_{b1}) ; 90° x 4-Bend

$H_{b1} = f_{b1} * f_{b2} * V_i^2 / 2 * g * n$

where, f_{b1} ; Coefficient-1 of 90° Bend = 0.25

f_{b2} ; Coefficient-2 of 90° Bend = 1.00

V_i ; Velocity of Pipe (m/sec) = 0.9628 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

n ; Number of Bend = 4 set

$H_{b1} = f_{b1} * f_{b2} * V_i^2 / 2 * g * n$ = **0.0472** m

d) Head Loss of Bend (H_{b2}) ; 45°x 2-Bend

$H_{b2} = f_{b1} * f_{b2} * V_i^2 / 2 * g * n$

where, f_{b1} ; Coefficient-1 of 45° Bend = 0.25

f_{b2} ; Coefficient-2 of 45° Bend = 0.70

V_i ; Velocity of Pipe (m/sec) = 0.9628 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

n ; Number of Sluice Bend = 2 set

$H_{b2} = f_{b1} * f_{b2} * V_i^2 / 2 * g * n$ = **0.0165** m

e) Friction Head Loss (H_{fc})

Hazen & William's Formula

$H_{fc} = 10.666 * C^{-1.85} * D^{-4.87} * Q^{1.85} * L$

		Exist. SP;	New DIP;	
where,	C; Friction Coefficient =	110	130	
	D; Pipe Diameter (m) =	0.500	0.500	m
	Q; Flow Rate (m^3/sec) =	0.1890	0.1890	m^3/sec
	L; Pipe Lngth (m) =	22.00	15.00	m

H_{fcs} = 10.666 * (110 $)^{-1.85}$*(0.500 $)^{-4.87}$*(0.189 $)^{1.85}$* 22.00 = **0.0526** m

H_{fcd} = 10.666 * (130 $)^{-1.85}$*(0.500 $)^{-4.87}$*(0.189 $)^{1.85}$* 15.00 = **0.0263** m

$H_{fr} = H_{frs} + H_{frd}$ = **0.0789** m

f) Head Loss of Outlet to Backwash Tank (H_o)

$H_o = f_o * V_o^2 / 2 * g$

where, f_o ; Coefficient of Outlet = 1.00

V_o ; Velocity of Pipe (m/sec) = 0.9628 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^{-2}

$H_o = f_o * V_o^2 / 2 * g$ = **0.0472** m

g) Total Head Loss of Filter Pipe-2 (ΣH)

$\Sigma H = H_i + H_{sv} + H_{b1} + H_{b2} + H_{fc} + H_o$ = **0.2181** m

Then, Water Level of Backwash Tank; 139.084 m - 0.2181 m = **138.866** m

☆ Filtered Pipe-3 (To Existing Pump Well): Existing

a) Head Loss of Inlet (H_i)

*** Inlet Flow Velocity (V_i) ;φ500mm**

$V_i = Q / A$

where, Q; Design Maximum Flow Rate (Distribution) (m^3/sec) = 0.1890 m^3/sec

A; Sectional Area of Pipe (m^2) = π/4* (0.500)^2 = 0.1963 m^2

V_i = 0.1890 m^3/sec ／ 0.1963 m^2 = 0.9628 m/sec

$H_i = f_i * V_i^2 / 2 * g$

where, f_i ; Coefficient of Inlet = 1.00

V_i ; Inlet Velocity of Pipe (m/sec) = 0.9628 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

$H_i = f_i * V_i^2 / 2 * g$ = **0.0472** m

b) Head Loss of Sluice Valve (H_{sv})

$H_{sv} = f_{sv} * V_i^2 / 2 * g$

where, f_{sv} ; Coefficient of Sluice Valve = 0.10

V_i ; Velocity of Pipe (m/sec) = 0.9628 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

n ; Number of Sluice Valve = 1 set

$H_{sv} = f_{sv} * V_i^2 / 2 * g * n$ = **0.0047** m

c) Friction Head Loss (H_{fc})

Hazen & William's Formula

$H_{fc} = 10.666 * C^{-1.85} * D^{-4.87} * Q^{1.85} * L$

where, C; Froction Coefficienct = SP; 110

D; Pipe Diameter (m) = SP; 0.500 m

Q; Flow Rate (m^3/sec) = SP; 0.1890 m^3/sec

L; Pipe Lngth (m) = SP; 8.300 m

$H_{fc} = 10.666 * (110)^{-1.85} * (0.5)^{-4.87} * (0.189)^{1.85} * 8.300$ = **0.0199** m

d) Head Loss of Outlet to Pump Well (H_o)

$H_o = f_o * V_o^2 / 2 * g$

where, f_o ; Coefficient of Outlet = 1.00

V_o ; Outlet Velocity of Pipe (m/sec) = 0.9628 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

$H_o = f_o * V_o^2 / 2 * g$ = **0.0472** m

e) Total Head Loss of Filtered Pipe-3 (ΣH)

$\Sigma H = H_i + H_{sv} + H_{fc} + H_o$ = **0.1190** m

f) Water Level of Pump Well

*** Water Level of Backwash Tank;** **138.866** m

Then,

Water level of Pump Well; 138.866 m - 0.1190 m = **138.747** m

☆ Filtered Pipe-4 (to Existing Pump Well) : New Construction

a) Head Loss of Inlet (H_i)

*** Inlet Flow Velocity (V_i) ;φ800mm**

V_i = Q／A

where, Q; Design Maximum Flow Rate (Distribution) (m^3/sec) = 0.1944 m^3/sec

A; Sectional Area of Pipe (m π/4* (0.800)^2 = 0.5027 m^2

V_i = 0.1944 m^3/sec ／ 0.5027 m^2 = 0.3867 m/sec

H_i= f_i * V_i^2 ／ 2 * g

where, f_i ; Coefficient of Inlet = 1.00

V_i ; Inlet Velocity of Pipe (m/sec) = 0.3867 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

H_i= f_i * V_i^2 ／ 2 * g = **0.0076** m

b) Head Loss of Bend (H_{b1}) ;φ800 x 90°～2places

H_{b1}= f_{b1} * (V_{b1}^2／2*g) ＊n

where, f_{b1}; Coefficient of 90 Bend = 0.20

V_{b1}; Velocity (m/sec) = 0.3867 m/sec

g; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

n; Places = 2 Places

H_{b1}= 0.20 * (0.3867)^2／(2 * 9.81) * 2 = **0.0030** m

c) Head Loss of Bend (H_{b2}) ;φ500 x 90°～1place

*** Inlet Velocity (V_i) ;φ500mm**

V_i = Q／A

where, Q; Design Maximum Flow Rate (Distribution) (m^3/sec) = 0.1944 m^3/sec

A; Sectional Area of Pipe (m^2) = π/4* (0.500)^2 = 0.1963 m^2

V_i = 0.1944 m^3/sec ／ 0.1963 m^2 = 0.9903 m/sec

H_{b2}= f_{b1} * f_{b2} * V_i^2 ／ 2 * g * n

where, f_{b1} ; Coefficient-1 of 90° Bend = 0.25

f_{b2} ; Coefficient-2 of 90° Bend = 1.00

V_i ; Velocity of Pipe (m/sec) = 0.9903 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

n ; Number of Sluice Valve = 1 set

H_{b2}= f_{b1} * f_{b2} * V_i^2 ／ 2 * g * n = **0.0125** m

d) Head Loss of Butterfly Valve (H_{v1})

*** Butterfly Valve; φ800mm**

H_{v1}= f_{v1} * V_i^2 ／ 2 * g＊n

where, f_v1; Coefficient of Butterfly Valve = 0.25

V_i ; Velocity of Valve (m/sec) = 0.3867 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

n ; Number of Butterfly Valve = 1 set

H_{v1}= f_{v1} * V_i^2 ／ 2 * g * n = **0.0019** m

e) Hwad Loss of Butterfly valve (H_{v2})

*** Butterfly Valve; φ500mm**

H_{v2}= f_{v2} * V_i^2 ／ 2 * g＊n

where, f_{v2}; Coefficient of Butterfly Valve = 0.25

V_i ; Velocity of Valve (m/sec) = 0.9903 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

n ; Number of Butterfly Valve = 1 set

H_{v2}= f_{v2} * V_i^2 ／ 2 * g * n = **0.0125** m

f) Friction Head Loss (H_{fc})

Hazen & William's Formula

H_{fc}= 10.666 * $C^{-1.85}$ * $D^{-4.87}$ * $Q^{1.85}$ * L

		New DIP;	New DIP;	
where,	C; Friction Coefficient =	130	130	
	D; Pipe Diameter (m) =	0.800	0.500	m
	Q; Flow Rate (m^3/sec) =	0.1944	0.1944	m^3/sec
	L; Pipe Lngth (m) =	53.000	12.500	m

H_{fc1}= 10.666 * (130)$^{-1.85}$*(0.800)$^{-4.87}$*(0.194)$^{1.85}$* 53.00 = **0.0099** m

H_{fc2}= 10.666 * (130)$^{-1.85}$*(0.500)$^{-4.87}$*(0.194)$^{1.85}$* 12.50 = **0.0231** m

H_{fc}= H_{fc1} + H_{fc2} = **0.0330** m

g) Head Loss of Outlet to Pump Well (H_o)

H_o= f_o * V_o^2 ／ 2 * g

where, f_o ; Coefficient of Outlet = 1.00

V_o ; Outlet Velocity of Pipe (m/sec) = 0.3867 m/sec

g ; Accerated Gravity (m/sec^2) = 9.81 m/sec^2

H_o= f_o * V_o^2 ／ 2 * g = **0.0076** m

h) Total Head Loss of Filtered Pipe (ΣH)

ΣH = H_i + H_{b1} + H_{b1} + H_{v1} + H_{v2} + H_{fc} + H_o = **0.0781** m

I) Water Level of Pump Well

*** Water Level of Clear Water Reservoir;** **139.031** m

Then,

Water Level of Pump Well 139.031 m - 0.0781 m = **138.953** m

Then, ↓

138.747 m

5-4 Raw Water and Distribution Water Quality

1. Raw Water and Distribution Water Quality

Referring to the water quality data collected on Nake Water Treatment Plant, those only after March 2000 are available. According to the mentioned water quality data, the highest turbidity for the Mekong River water was 630 NTU.

The data on water quality collected by the Study Team are presented in the following Table A.5-9.

Table A-5-9 Water Quality Data, NPS

ITEMS	Unit	1	2	3	4	5	6	7	8	9	10	11	12
Date		15/8/2000	18/8/2000	19/8/2000	21/8/2000	24/8/2000	30/8/2000	1/9/2000	4/9/2000	8/9/2000	11/9/2000	14/9/2000	17/9/2000
Water Temp.		30	30		34	25	29	28	27	28	28	28	27
Turbidity	NTU												
Raw Water		300	300	300	252	270	270	250	260	252	630		540
Clarified W.		5.5	4.2	4.1	3.8	4.6	4.5	10.3	5.6	7.4	8.5		8.5
Filtered W.		3.4	3.0	3.2	2.8	2.0	3.2	3.5	3.2	5.7	4.6		3.5
Alum Dosage	mg/l	26.9	26.9	26.9	26.9								
Polymer Dos.	mg/l	61.5	61.5	46.1	46.1								
pH													
Raw Water			6.6	6.6	6.9	6.9	6.8	6.9	6.8	6.8	7.6	6.6	6.8
Clarified W.			6.5	6.5	6.7	6.5	6.6	6.7	6.7	6.6	6.6	6.5	6.6
Filtered W.		6.5	6.5	6.5	6.6	6.3	6.7	6.8	6.5	6.5	6.5	6.4	6.5
Alkalinity	mg/l												

The water quality analysis was conducted for two times by the Study Team during the survey period. The turbidity of raw water was 247 NTU and 193 NTU respectively. For the other quality items, no specific problem was observed other than Iron content (Fe) which is relatively high. However, Iron could be removed by clarification process with chlorine dosage (Table A.5-10).

From the geographical map, any pollution inflow such as city drainage and industrial wastage is not observed at the upstream of raw water intake. Thus, it is considered that no significant change of raw water quality from the present one is expected in the near future.

The efforts by NPS are observed for water treatment from the results of water quality analysis on tap water made by the Study Team. The water quality analysis of tap water was carried out for 40 samples taken from various locations in the service area. 90 % of tap water showed that their turbidity were less than 2 mg/l. While results of analysis on residual chlorine were trace only for the most of samples. Bacteria was found from 3 samples and 9 samples show coliform. This will be derived from a lack of chlorine dosage due to financial constraint. The results of water quality analysis are summarized in Table A.5-11

Fig. A.5-10 (1/2) Water Quality Report

Ministry of CTPC
Lao Water Supply Authority (Nam PaPa Lao)
Chinaimo Water Treatment Plant Laboratory

Sampling Nam Savannakhet
Analysis Date: 26th Oct. '00
Sampling Date: 18th Oct. '00

	Description of Analysis	units	Mekong	Plant	Tap Water		Standard
			Intake	Pump Well	Naseng	Km7	
	Temp. Atomsphere	℃	28	27	28	27	
1	pH (T. Water ℃)	mg/l	7.9 (26.0)	7.2 (27.0)	7.2 (28.0)	7.2 (27.5)	5.8~8.6
2	Turbidity	NTU	247	4.8	0.7	2.6	5
3	Color		6	2	2	3	5
4	Odor and Taste	Nomal	Nomal	Nomal	Nomal	Nomal	Nomal
5	M. Alkalinity ($CaCO_3$)	mg/l	99	72	78	78	300
6	P. Alkalinity ($CaCO_3$)	mg/l	2	6	4	4	
7	Ammonia Nitrogenn (NH_4-N)	mg/l	N.D<0.01	0.05	0.03	N.D<0.01	0.5
8	Nitrite-Nitrogen (NO_2-N)	mg/l	N.D<0.1	N.D<0.1	N.D<0.1	N.D<0.1	1.0
9	Nitrate-Nitrogen (NO_3-N)	mg/l	1.22	1.1	1.29	0.91	10
10	Chloride ion (Cl^-)	mg/l	7.4	5.1	5.8	6.6	250
11	Sulfate ion (SO_4^{2-})	mg/l	N.D<2	14.3	14.4	14.5	250
12	$KMnO_4$ consumed	mg/l	9.2	1.8	2.4	2.2	10
13	Iron (Fe)	mg/l	2.5	0.04	0.09	0.1	0.3
14	Manganese (Mn)	mg/l	0.04	N.D<0.01	N.D<0.01	N.D<0.01	0.1
15	Total Hardness ($CaCO_3$)	mg/l	63	54	56	56	500
16	Cadmium (Cd)	mg/l	N.D<0.001	N.D<0.001	N.D<0.001	N.D<0.001	0.01
17	Cupper (Cu)	mg/l	N.D<0.1	N.D<0.1	N.D<0.1	N.D<0.1	1.0
18	Lead (Pb)	mg/l	0.03	0.07	0.01	0.02	0.05
19	Electric Conductivity μ s/cm	mg/l	177	179	194	189	
20	Aluminium (Al)	mg/l	N.D<0.001	0.01	0.05	0.06	
21	Chromium (Cr^{6+})	mg/l	N.D<0.001	N.D<0.001	N.D<0.001	N.D<0.001	0.05
22	Cyanide (CN^-)	mg/l	N.D<0.001	N.D<0.001	N.D<0.001	N.D<0.001	0.01
23	Zinc (Zn)	mg/l	0.5	0.5	0.5	0.5	1.0
24	Fluoride (F^-)	mg/l	N.D<0.1	0.5	N.D<0.1	N.D<0.1	1.5
25	Sodium (Na_2)	mg/l	7.1	5.3	4.9	4.7	
26	Sulfide (H_2S)	mg/l	0.07	0.08	0.09	0.04	
27	Total Chiromium (Cr)	mg/l	0.006	N.D<0.001	N.D<0.001	N.D<0.001	
28	Arsenic (As)	mg/l	N.D<0.001	N.D<0.001	N.D<0.001	N.D<0.001	0.01
29	Mercury (Hg)	mg/l	N.D<0.0001	N.D<0.0001	N.D<0.0001	N.D<0.0001	0.001
30	Total Phosphorus (T-P)	mg/l	0.1	N.D<0.01	N.D<0.01	N.D<0.01	
31	Total Residue	mg/l	370	170	170	150	500
32	Residual Chloride (Cl_2)	mg/l	NONE	NONE	NONE	NONE	
33	Coliform Group	0/ml	5/5	0/100	0/100	0/100	N.D
34	Total Colony 1/ml	/ml	800	400	137	93	100

Water Analysis Report on Sampling Site

Sampling Date: 18th Oct. '00

	Description of Analysis	units	Mekong	Plant	Tap Water		Standard
			Intake	Pump Well	Naseng	Km7	
	Weather		Cloud	Cloud	Cloud	Fine	
	Sampling Time		14:50	15:05	15:40	17:20	
	Temp. Atomsphere	℃	28	28	28	27	
	Temp. Water	℃	26	27	28	27.5	
1	pH (T. Water ℃)	mg/l	8.2 (26.0)	7.5 (27.0)	7.6 (28.0)	7.5 (27.5)	5.8~8.6
2	Residual Chloride (Cl_2)	mg/l	NONE	NONE	NONE	NONE	

Fig. A.5-10 (2/2) Water Quality Report

Ministry of CTPC
Lao Water Supply Authority (Nam PaPa Lao)
Chinaimo Water Treatment Plant Laboratory

Sampling Nam Savannakhet
Analysis Date: 20th Nov. '00
Sampling Date: 03rd Nov. '00

	Description of Analysis	units	Mekong	Plant	Tap Water		Standard
			Intake	Tap Water	Naseng	Km7	
	Temp. Atomsphere	℃	27	27	27	27	
1	pH (T. Water ℃)	mg/l	7.9 (18.0)	7.2 (19.8)	7.2 (18.3)	7.2 (20.3)	5.8~8.6
2	Turbidity	NTU	193	3.0	2.4	0.1	5
3	Color		5	NONE	NONE	2	5
4	Odor and Taste	Nomal	NOMAL	NOMAL	NOMAL	NOMAL	NOMAL
5	M. Alkalinity ($CaCO_3$)	mg/l	107	93	97	95	300
6	P. Alkalinity ($CaCO_3$)	mg/l	2	6	6	8	
7	Ammonia Nitrogenn (NH_4-N)	mg/l	0.1	0.04	0.01	0.01	0.5
8	Nitrite-Nitrogen (NO_2-N)	mg/l	NONE	NONE	NONE	NONE	1.0
9	Nitrate-Nitrogen (NO_3-N)	mg/l	0.91	0.60	0.35	0.51	10
10	Chloride ion (Cl^-)	mg/l	11.0	7.3	8.1	8.1	250
11	Sulfate ion (SO_4^{2-})	mg/l	NONE	NONE	NONE	2.0	250
12	$KMnO_4$ consumed	mg/l	9.1	1.5	1.2	3.0	10
13	Iron (Fe)	mg/l	0.63	0.09	0.05	0.06	0.3
14	Manganese (Mn)	mg/l	0.01	N.D<0.01	N.D<0.01	N.D<0.01	0.1
15	Total Hardness ($CaCO_3$)	mg/l	92	94	90	92	500
16	Cadmium (Cd)	mg/l	N.D<0.001	N.D<0.001	N.D<0.001	N.D<0.001	0.01
17	Cupper (Cu)	mg/l	N.D<0.01	N.D<0.01	N.D<0.01	N.D<0.01	1.0
18	Lead (Pb)	mg/l	0.03	0.04	0.03	0.03	0.05
19	Electric Conductivity μs/cm	mg/l	196	198	192	190	
20	Aluminium (Al)	mg/l	N.D<0.01	0.02	0.03	0.02	
21	Chromium (Cr^{6+})	mg/l	N.D<0.01	N.D<0.01	N.D<0.01	N.D<0.01	0.05
22	Cyanide (CN^-)	mg/l	N.D<0.001	N.D<0.001	N.D<0.001	N.D<0.001	0.01
23	Zinc (Zn)	mg/l	1.0	0.8	0.8	0.6	1.0
24	Fluoride (F^-)	mg/l	N.D<0.1	N.D<0.1	N.D<0.1	N.D<0.1	1.5
25	Sodium (Na_2)	mg/l	0.7	0.6	0.5	0.6	
26	Sulfide (H_2S)	mg/l	N.D<0.01	N.D<0.01	0.02	N.D<0.01	
27	Total Chiromium (Cr)	mg/l	0.007	0.008	0.008	0.008	
28	Arsenic (As)	mg/l	N.D<0.001	N.D<0.001	N.D<0.001	N.D<0.001	0.01
29	Mercury (Hg)	mg/l	N.D<0.0001	N.D<0.0001	N.D<0.0001	N.D<0.0001	0.001
30	Total Phosphorus (T-P)	mg/l	0.5	0.1	0.1	0.2	
31	Total Residue	mg/l	319	128	133	121	500
32	Residual Chloride (Cl_2)	mg/l	0	NONE	NONE	NONE	
33	Coliform Group	0/ml	5/5	0/5	0/100	0/100	N.D
34	Total Colony 1/ml	/ml	100	20	15	11	100

Fig. A.5-11 (1/3) Site Survey on Water Quality and Pressure Test of Tap (1)

No.	Date	Time	Weather	Loction/Address	Press. of Tap	Water Quality of Tap							
						Temperature		Turbid.	Color	Rsidual Chlorine	pH	Coliform Bacteria	Faecal Coliforms
						Atmos.	Water						
	Day/Mon.	Hr./Min.			MPa	℃	℃	mg/l	unit	mgcl/l		cfu/ml	cfu/ml
9	23th Oct.	9:35	Cloud	R'd No.9 Phone Savangtay	0.35	29.0	27.0	1.0	2.0	0	7.5	None	None
11	23th Oct.	10:20	Cloud	R'd. Santiphap, Nalao	0.34	29.0	28.0	2.0	4.0	0	7.0	ditto	ditto
10	23th Oct.	10:30	Sunshine	R'd. Makasavanh, Phoxay	0.35	30.0	30.0	1.0	4.0	0	7.5	ditto	ditto
12	23th Oct.	10:55	Sun	R'd. Makasavanh, Chomkeo	0.35	32.0	27.0	1.0	0.0	0	7.5	ditto	ditto
17	23th Oct.	11:08	Sun	R'd. Oudomsive, Tha Meang	3.50	32.0	29.0	1.0	0.0	0	7.5	ditto	ditto
24	23th Oct.	11:20	Sun	R'd. Phayapu, Xaya Phome	0.30	31.0	29.0	1.0	1.0	0	7.0	ditto	ditto
18	23th Oct.	11:30	Sun	R'd. Lusavong Seak, Latanalansy	0.20	33.0	28.0	1.5	3.0	0	7.5	ditto	ditto
7	23th Oct.	11:05	Sun	Phonsavang	0.25	31.0	28.0	1.0	3.0	0	7.5	ditto	ditto
8	23th Oct.	11:20	Sun	Phonsavang	0.14	30.0	29.0	1.0	3.0	0	7.5	ditto	ditto
14	23th Oct.	14:35	Sun	Sanam Xay	0.20	30.0	28.0	1.0	2.0	0	7.5	ditto	ditto
15	23th Oct.	14:45	Sun	Sanam Xay	0.20	30.0	28.0	0.5	2.0	0	7.5	ditto	ditto
23	24th Oct.	9:00	Sun	Xayamoungkune	0.25	29.0	27.0	3.0	10.0	0	7.5	Many	5
22	24th Oct.	9:08	Sun	Xay Oudom	0.28	29.0	27.0	3.0	5.0	0	7.5	None	None
21	24th Oct.	9:19	Sun	Lasavang Say	0.25	30.0	28.0	0.5	2.0	0	7.5	ditto	ditto
20	24th Oct.	9:27	Sun	Lasavang Say	0.25	29.0	28.0	0.0	2.0	0	7.5	Many	ditto
19	24th Oct.	9:40	Cloud	Lasavang Say	0.10	29.0	26.0	1.0	2.0	0	7.5	4	ditto
30	24th Oct.	9:50	Sun	None Savath	0.05	30.0	29.0	0.0	2.0	0	7.5	None	ditto
29	24th Oct.	10:00	Sun	None Savath	0.05	30.0	29.0	0.0	0.0	0	7.5	ditto	ditto
33	24th Oct.	10:05	Sun	Naseng	0.05	30.0	29.0	0.5	4.0	0	7.0	ditto	ditto
31	24th Oct.	10:15	Sun	Naseng	0.12	30.0	29.0	1.0	3.0	0	7.5	ditto	ditto

Fig. A.5-11 (2/3) Site Survey on Water Quality and Pressure Test of Tap (2)

No.	Date Day/Mon.	Time Hr./Min.	Weather	Loction/Address	Press. of Tap MPa	Water Quality of Tap: Temperature Atmos. ℃	Temperature Water ℃	Turbid. mg/l	Color unit	Rsidual Chlorine mgcl/l	pH	Coliform Bacteria cfu/ml	Faecal Coliforms cfu/ml
32	24th Oct.	10:23	Cloud	Naseng	0.10	30.0	29.0	1.0	5.0	0	7.5	None	None
34	24th Oct.	10:35	Cloud	Phone Xay	0.20	31.0	29.0	1.0	5.0	0	7.0	ditto	ditto
26	24th Oct.	14:10	Sun	Xay Oudom	0.21	33.0	28.0	1.5	10.0	0	7.5	ditto	ditto
27	24th Oct.	14:23	Sun	Saphane Nea	0.25	33.0	29.0	0.5	2.0	0	7.5	ditto	ditto
28	24th Oct.	14:34	Sun	Dong Dam Douane	0.09	32.0	29.0	0.0	2.0	0	7.5	ditto	ditto
39	24th Oct.	15:00	Sun	Phone Savanh	0.20	33.0	29.0	0.0	2.0	0	7.5	ditto	ditto
38	24th Oct.	15:17	Sun	Tha He	0.20	32.0	31.0	0.0	2.0	0	7.5	ditto	ditto
19	25th Oct.	9:12	Sun	Rasavong Xay	0.13	30.0	26.0	0.0	2.0	0	7.5	Many	ditto
29	25th Oct.	9:44	Sun	Nonesa At	0.15	30.0	29.0	3.0	20.0	0	7.5	None	ditto
13	25th Oct.	10:05	Sun	R'd. Rasadanay, Xayamoogkune	0.36	31.0	28.0	0.5	2.0	0	7.5	ditto	1
40	25th Oct.	10:50	Sun	Phonesa Vanh	0.05	33.0	29.0	0.5	2.0	0	7.5	ditto	None
6	25th Oct.	14:35	Sun	Oudom Vilay	0.10	31.0	29.0	0.0	2.0	0	7.5	ditto	1
1	25th Oct.	14:42	Sun	Oudom Vilay	0.05	31.0	28.0	0.5	2.0	0	7.5	3	None
3	25th Oct.	15:00	Sun	Phone Savang Nea	0.05	33.0	31.0	0.5	2.0	0	7.5	None	ditto
4	25th Oct.	15:12	Sun	Houa Meang	0.05	32.0	29.0	1.0	2.0	0	7.5	4	ditto
2	25th Oct.	15:40	Sun	Pak Bo	0.08	33.0	33.0	1.0	2.0	0	7.5	None	ditto
5	25th Oct.	16:00	Sun	Nake	0.35	32.0	30.0	3.0	4.0	0	7.5	ditto	ditto
25	26th Oct.	9:32	Sun	Xay Oudom	0.30	31.0	29.0	0.5	5.0	0	7.5	ditto	ditto
35	26th Oct.	9:45	Sun	Sone Xay	0.25	32.0	29.0	0.5	2.0	0	7.5	ditto	ditto
37	26th Oct.	10:00	Sun	Phon Saat	0.10	31.0	29.0	0.0	2.0	0	7.5	Many	ditto

Fig. A.5-11 (3/3) Site Survey on Water Quality and Pressure Test of Tap(3)

No.	Date	Time	Weather	Loction/Address	Press. of Tap	Water Quality of Tap							
						Temperature		Turbid.	Color	Rsidual Chlorine	pH	Coliform Bacteria	Faecal Coliforms
	Day/Mon.	Hr./Min.				Atmos.	Water						
					MPa	℃	℃	mg/l	unit	mgcl/l		cfu/ml	cfu/ml
36	26th Oct.	10:21	Sun	Doneseng	0.00	32.0	28.0	1.0	10.0	0	7.5	None	None
41	26th Oct.	10:53	Sun	R'd. Soutthanou, Latanalansy	0.15	32.0	30.0	0.5	2.0	0	7.5	Many	ditto
42	26th Oct.	10:57	Sun	R'd. Soutthanou, Latanalansy	0.20	32.0	29.0	0.5	4.0	0	7.5	None	ditto
43	26th Oct.	11:00	Sun	R'd. Soutthanou, Latanalansy	0.18	31.0	29.0	0.5	2.0	0	7.5	7	ditto
6	26th Oct.	11:07	Sun	Oudom Sine	0.25	31.0	29.0	1.0	4.0	0	7.5	None	ditto
13	26th Oct.	11:15	Sun	Tameang	0.30	31.0	29.0	1.0	4.0	0	7.5	—	ditto

2. Chemical Dosage Plan

2.1 Characteristics of The Raw Water Quality

Although available data on raw water quality are limited for Nake Water Treatment Plant, it is evaluated referring to raw water quality obtained from Chinaimo Water Treatment Plant which takes raw water from the Mekong River at about 470 km upstream of Nake Water Treatment Plant in Savannakhet.

(1) Results of Raw Water Quality Analysis made by The Study Team

The raw water quality analyses for the present study were conducted in two times, on October 18 and November 3, 2000. Its results are presented in Table A.5-12 & Table A.5-13. The main features of the raw water quality are presented below:

1) Turbidity: rather high as 247NTU and 193 NTU,
2) pH: around 7.9,
3) Alkalinity: 99mg/l and 107mg/l,
4) Ammonium nitrogen: 0 - 0.1mg/l,
5) Nitrate nitrogen: 0.9 - 1.2mg/l, and
6) Bacteria: observed.

Table A.5-12 Water Quality of Cinaimo & Nake W. T. Plants (2000/10)
：15 Items of Water Quality Items

	Item	Cinaimo W. T. Plant			Nake W. T. Plant			Comparison	
		Raw Water	Filtered Water	Tap Water	Raw Water	Filtered Water	Tap Water	Nake W.T.P	Chinaimo W.T.P.
1	Temperature atmosphere	29	29	29	28	27	28	0.97	1
2	Temperature water	26.7	26.4	26.7					1
3	Turbidity	272	3.7	0.1	247	4.8	0.7	0.91	1
4	Color	0	0	0	6	2	2		
6	PH	7.8	7.2	7.2	7.9	7.2	7.2	1.01	1
7	M-Alkalinity	88	71	70	99	72	78	1.13	1
8	Ammonia Nitrogen	0.05	0	0	0	0.05	0.03	0.00	1
10	Nitrate Nitrogen	0.2	0.1	0	1.22	1.1	1.29	6.10	1
11	Cholrine Cl	8	5.7	5	7.4	5.1	5.8	0.93	1
12	KMnO4 Consumption	6	3.2	1.8	9.2	1.8	2.4	1.53	1
13	Total Hardness	100	78	75	63	54	56	0.63	1
16	Total Colony	320	150	2	800	400	137	2.50	1
18	Iron (Fe)	2			2.5	0.04	0.09	1.25	1
19	Manganese(Mn)	0.04			0.04	0	0	1.00	1
21	Total Residue				370	170	170		

Table A.5-13 Water Quality in Cinaimo & Nake W. T. Plants (2000/11)
：14 Water Quality Items

	Item	Cinaimo W. T. Plant			Nake W. T. Plant			Ratio	
		Raw Water	Filtered Water	Tap Water	Raw Water	Filtered Water	Tap Water	Nake W.T.P	Chinaimo W.T.P.
1	Temperature atmosphere	26	26	26	27	27	27	1.04	1
2	Temperature water	24.3	25	24.8					1
3	Turbidity	222	4	0.1	193	3	2.4	0.87	1
4	Color	6	4	N-D					
6	PH	7.8	7.3	7.2	7.9	7.2	7.2	1.01	1
7	M-Alkalinity	100	94	90	107	93	97	1.07	1
8	Ammonia Nitrogen	N-D	N-D	N-D	0.1	0.04	0.01		
10	Nitrate Nitrogen	0.2	0.1	N-D	0.91	0.6	0.35	4.55	1
11	Cholrine Cl	8.4	7.3	6	11.0	7.3	8.1	1.31	1
12	KMnO4 Consumed	16	4.7	2.8	9.1	1.5	1.2	0.57	1
13	Total Hardness	98	96	91	92	94	90	0.94	1
16	Total Colony	315	150	2	100	20	15	0.32	1
18	Iron (Fe)	0.4	0.2	0.01	0.63	0.09	0.05	1.58	1
19	Manganese(Mn)	N-D	N-D	N-D	0.01	N-D	N-D		

(2) Water Quality Comparison with Chinaimo W. T. Plant in Upstream

The results of two time water quality analyses made on October 26 and November 26, 2000 are shown in Table A.5-12 and Table A.5-13 comparing with those for Chinaimo W. T. Plant which is located at upstream of Nake W. T. Plant. The major water quality items are illustrated on Fig. A.5-6 also comparing with two water quality. As the results, it was found that such coagulation related water quality items as turbidity, pH and Alkalinity are almost in the similar range between two.

Regarding the water quality items for pollution such as Bacteria, Nitrate Nitrogen and KMnO4 Consumption, such values for Nake W. T. Plant, located in downstream of Chinaimo W. T. Plant show higher than those for Chinaimo W. T. Plant. As for Ammonium Nitrogen, the upstream raw water for Chinaimo W. T. Plant contains 0.05mg/l while it is not counted in raw water for Nake W. T. Plant. However, no significant difference is considered between two since treated water of Nake W. T. Plant contains 0.05mg/l Ammonium Nitrogen. As for KMnO4 Consumption, raw water for Nake W. T. Plant shows lower value comparing with Chinaimo W. T. Plant according to the results of water quality analysis on 26 November. Finally it is judged that no significant difference between two raw water quality will exist for coagulation process as well as pollution concerned.

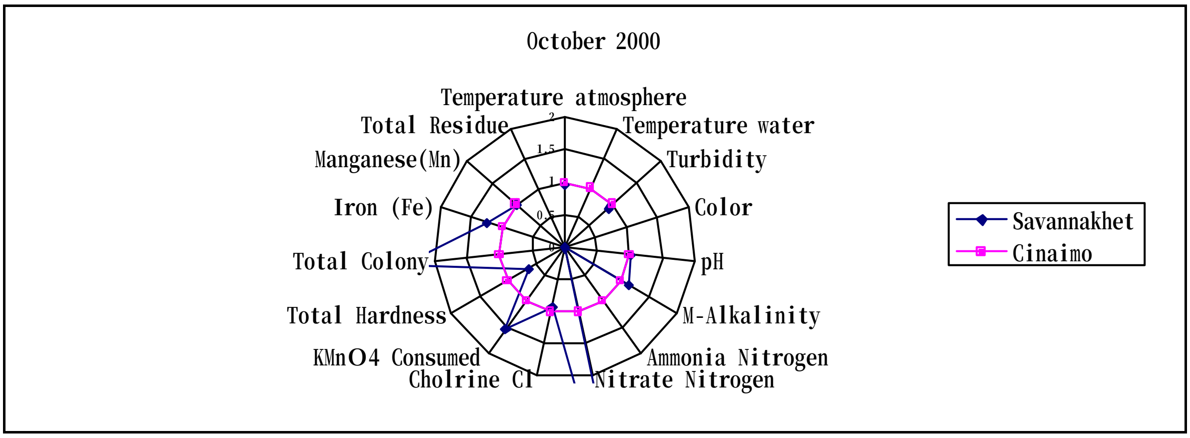


Fig. A.5-6 (1/2) **Comparison of Raw Water Quality (October, 2000) between Nake W. T. Plant and Chinaimo W. T. Plant**

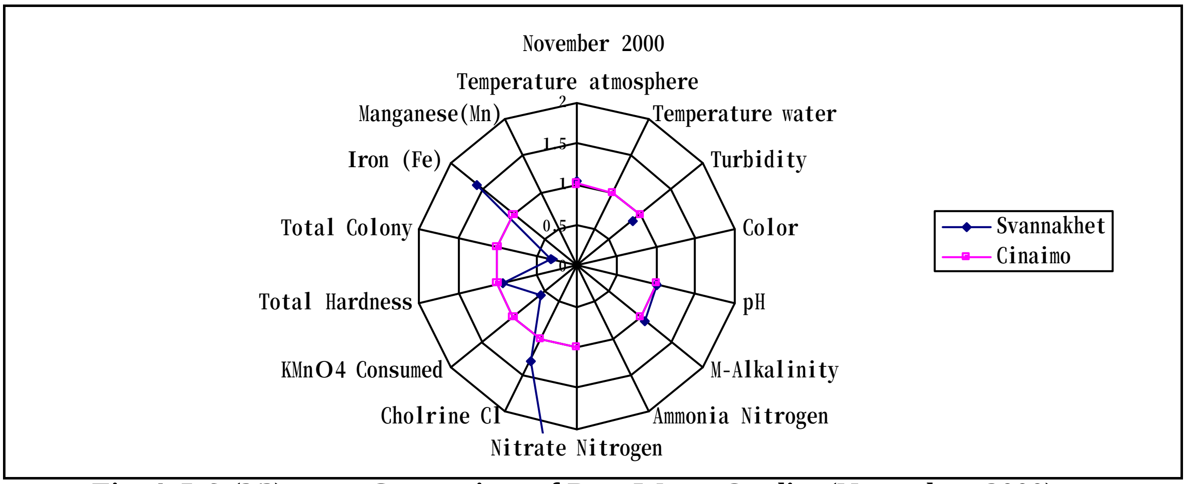


Fig. A.5-6 (2/2) **Comparison of Raw Water Quality (November, 2000) between Nake W. T. Plant and Chinaimo W. T. Plant**

(3) Characteristics of Raw Water Quality of Chinaimo Water Treatment Plant

The raw water and treated water quality for Chinaimo Water Treatment Plant is presented in Tables A.5-14 ~ A.5-16 and Fig. A.5-7 ~ A.5-13. High turbidity occurs during August ~ September, and its maximum value was recorded at 6,030 NTU in 1996. As for the pH value and Alkalinity, lower values are observed when turbidity raises. However they are still high as around 8.0 for pH and more than 80mg/l for Alkalinity. In such season as December to April, pH value reaches to 8.3 and Alkalinity shows as high as 120mg/l when its turbidity is low. Conclusively, it is judged that the variation for pH value and Alkalinity of raw water will not be wide throughout the year.

Regarding the relationship between the Turbidity and KMnO4 Consumption for raw water, the high values of KmnO4 are observed reflected by high Turbidity as shown on Fig. A.5-11. While KMnO4 value decreases to the level of 3 mg/l after clarification process as shown in filtered water quality. Average content of Ammonium Nitrogen is 0.14mg/l and its maximum content is at 0.36mg/l when Turbidity of raw water is high. The relationship between the Turbidity and Alkalinity of raw water is shown on Fig. A.5-12, and that between Alkalinity and pH of filtered water is shown on Fig. A.5-13.

Table A.5-14 Raw Water Quality of Mekong River (Chinaimo W.T.Plant)

1999	1	2	3	4	5	6	7	8	9	10	11	12	Ave.
Turbidities	77	59	18	41	224	347	592	760	757	377	509	113	323
pH	8.2	8.2	8.3	8.3	8.1	7.9	7.9	8.0	7.9	8.0	8.0	8.2	8.1
Alkalinity	114	111	119	112	101	84	96	86	84	84	85	93	97
Ammonium Nitrogen	0.09	0.09	0.07	0.15	0.16	0.14	0.10	0.36	0.17		0.18	0.17	0.15
KMnO4 Consumption	8.3	3.8	8.0	8.9	11.5	13.6	11.4	32.6	16.7	19.7	20	9.5	13.7
Hardness	137	138	134	127	131	108	107	108	94	0.9	101	113	108
Soluble Iron	0.29	0.32	0.50	2.00	0.10	0.36	0.09	0.30	0.20	0.08	0.20	0.04	0.37
Manganese	0.05	0.09	0.10	-	N.D.	0.06	0.03	0.08	0.05	0.03	0.08	N.D.	0.06

Table A.5-15 Filtered Water Quality

1999	1	2	3	4	5	6	7	8	9	10	11	12	Ave.
Turbidities	2.0	2.6	2.2	2.6	3.9	4.3	4.7	5.2	5.3	4.0	4.9	6.2	4.0
pH	7.8	7.7	7.9	7.8	7.4	7.2	7.5	7.3	7.2	7.4	7.4	7.7	7.5
Alkalinity	99	100	107	102	85	72	83	70	64	75	74	87	85
Ammonium Nitrogen	N.D.	0.00	0.10	0.10	0.10	N.D.	N.D.	N.D.	0.03	N.D.	0.05	N.D.	0.06
KMnO4 Consumption	3.3	3.4	2	3.7	3.9	4.3	2.8	3.1	3.1	3.1	4.4	1.8	3.2
Hardness	119	137	141	125	132	104	107	100	90	93	92	111	113
Soluble Iron	0.15	N.D.	0.08	0.09	N.D.	0.1	0.05	0.08	0.03	N.D.	N.D.	0.12	0.09
Manganese	N.D.	0.05	0.08	-	N.D.	0.01	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.05

Table A.5-16 Finished Water Quality

1999	1	2	3	4	5	6	7	8	9	10	11	12	Ave.
Turbidities	0.2	0.2	0.3	0.1	0.2	0.2	0.2	0.2	0.4	0.4	0.5	0.7	0.3
pH	7.8	7.7	7.9	7.7	7.5	7.2	7.5	7.3	7.3	7.4	7.4	7.7	7.5
Alkalinity	100	99	106	101	86	70	83	68	65	73	73	87	84
Ammonium Nitrogen	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
KMnO4 Consumption	1.6	1.9	0.9	0.5	2.2	1.8	1.4	1.3	1.1	1.4	0.7	1.6	1.4
Hardness	106	129	142	116	126	94	101	101	90	91	92	108	108
Soluble Iron	0.10	N.D.	0.06	0.03	-	N.D.	0.02	0.00	0.03	N.D.	N.D.	N.D.	N.D.
Manganese	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

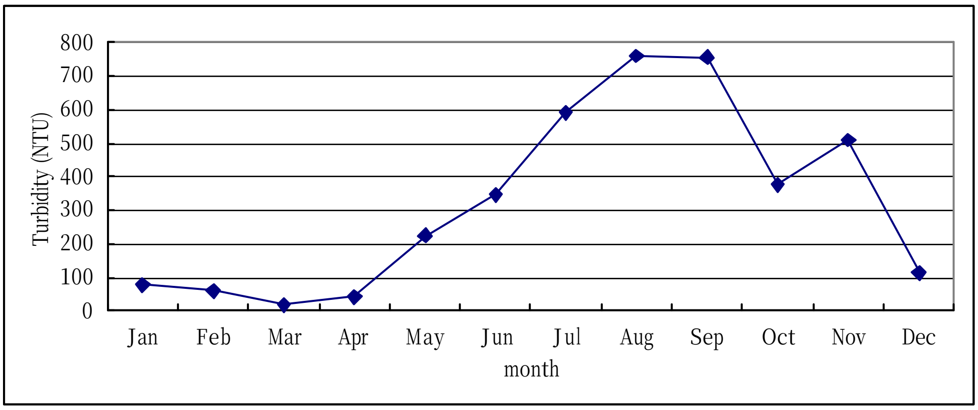


Fig. A.5-7 Yearly Variation of Turbidity of Raw Water at Chinaimo W.T.Plant (1999)

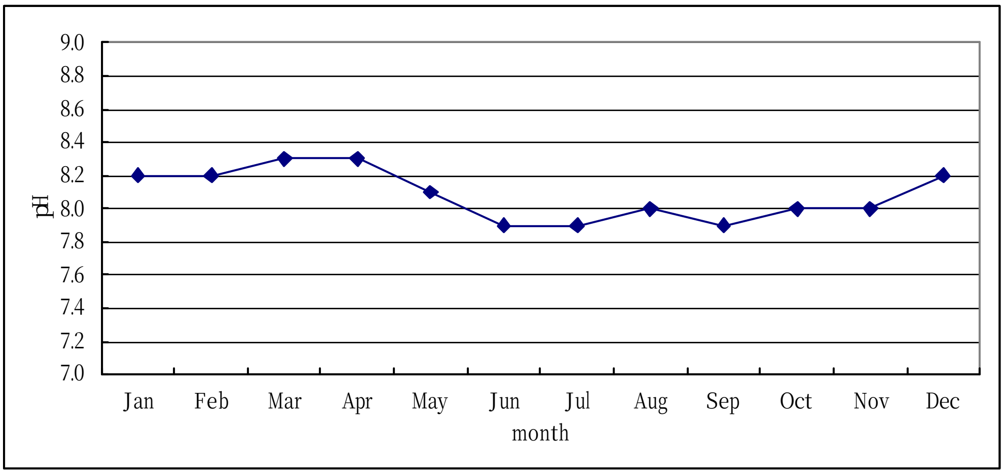


Fig. A.5-8 Yearly Variation of pH of Raw Water at Chinaimo W.T.Plant (1999)

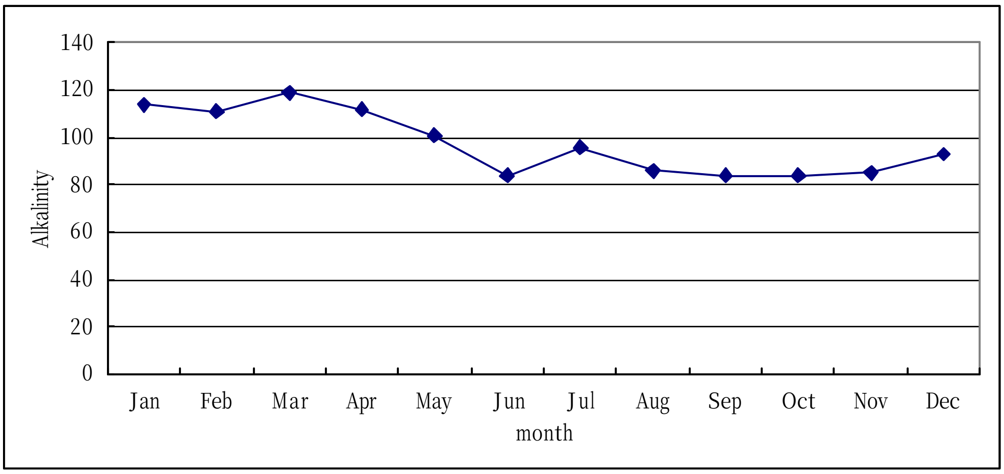


Fig. A.5-9 Yearly Variation of Alkalinity of Raw Water at Chinaimo W.T.Plant (1999)

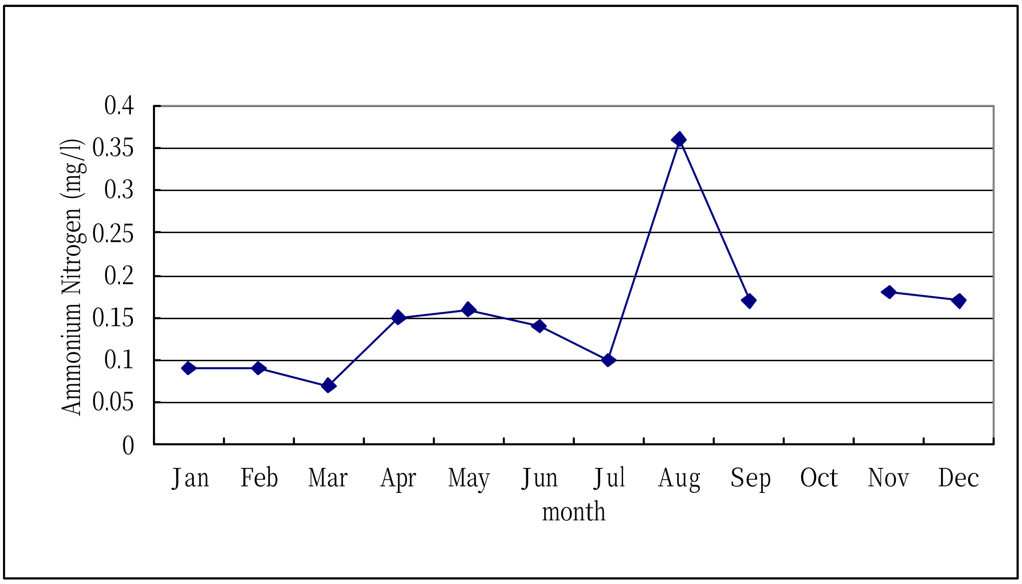


Fig. A.5-10 Yearly Variation of Ammonium Nitrogen of Raw Water at Chinaimo W. T. Plant (1999)

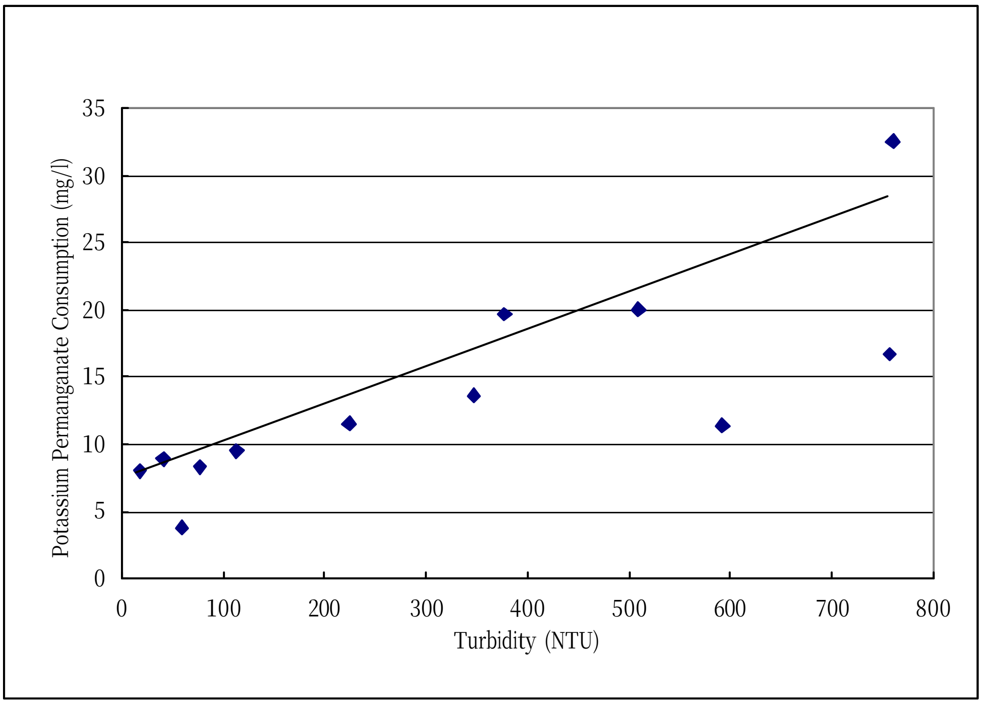


Fig. A.5-11 Relation between Turbidity and Organic Matter of Raw Water at Chinaimo W. T. Plant

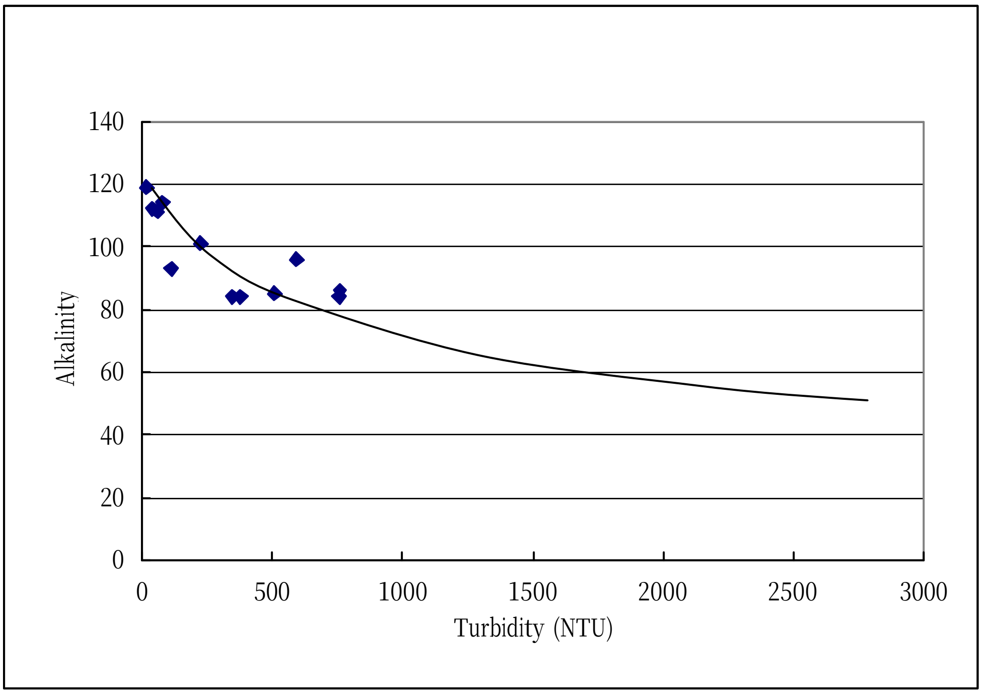


Fig. A.5-12 Relation between Turbidity and Alkalinity of Raw Water at Chinaimo W. T. Plant

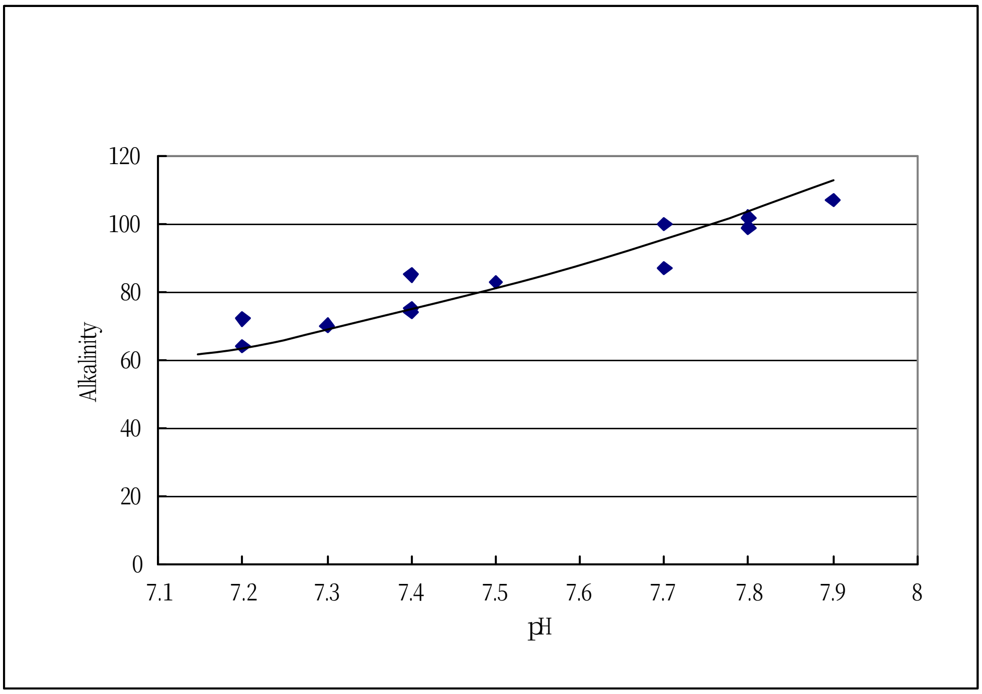


Fig. A.5-13 Relation between pH and Alkalinity of Treated Water in Chinaimo W. T. Plant

2.2 Chemical Dosage Plan

With confirmation of the raw water quality, which is almost similar features to Chinaimo W. T. Plant, the chemical application for Nake W. T. Plant is studied referring to the actual chemical application of Chinaimo W. T. Plant.

(1) Actual Chemical Application of Chinaimo W. T. Plant

In Chinaimo W. T. Plant, aluminum sulfate (Alum) is used for the coagulation. Polymer is applied for coagulation aid at the time of high turbidity of raw water. From the actual operation in 1996, the relationship between the raw water turbidity and Alum dosage is presented in Fig. A.5-14 to Fig. A.5-16. From these results, it is found that when the turbidity is over 100-150 NTU, Polymer is mostly applied. The Fig A.5-14 shows dosage rate of Alum when it is only applied for coagulation. While, Fig. A.5-17 shows an example for Alum dosage rate against turbidity applied in Japan (for liquid Alum of 8% solution of acid aluminum) as a reference. This shows almost equivalent dosage of the solid alum with acid aluminum contents of 15%. The dosage rate of Polymer increases as increase of turbidities, and the maximum dosage rate of Polymer was 0.5mg/l.

(2) Dosage Rate of Alum

In the present study, the organic polymer may not be considered due to its toxicity of monomer, and only Alum is planned to use for coagulation. The Alum dosage rate is designed as shown in below Table A.5-17 based on the actual dosage rate of Alum applied in Chinaimo W. T. Plant.

Table A.5-17 Alum Dosage Rate

Design Turbidities	Alum Dosage (Applied Fig. A.5-17)
Max. 6000 NTU Average 300 NTU	Max. 150mg/l for the Maximum turbidity Average 50mg/l for Average turbidity Min. 10mg/l for the Minimum turbidity

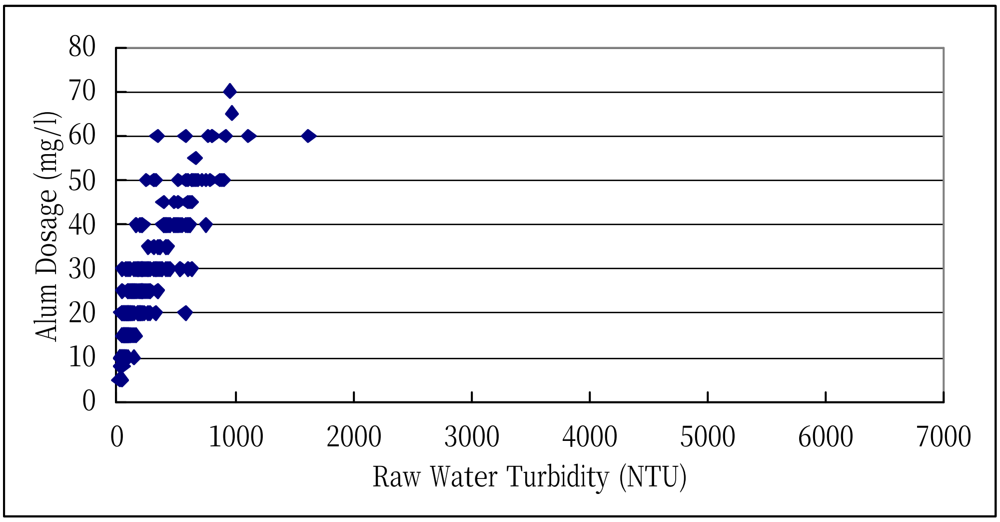


Fig. A.5-14 Alum Dosage Rate of Chinaimo W. T. Plan
(in case only alum is used for coagulation)

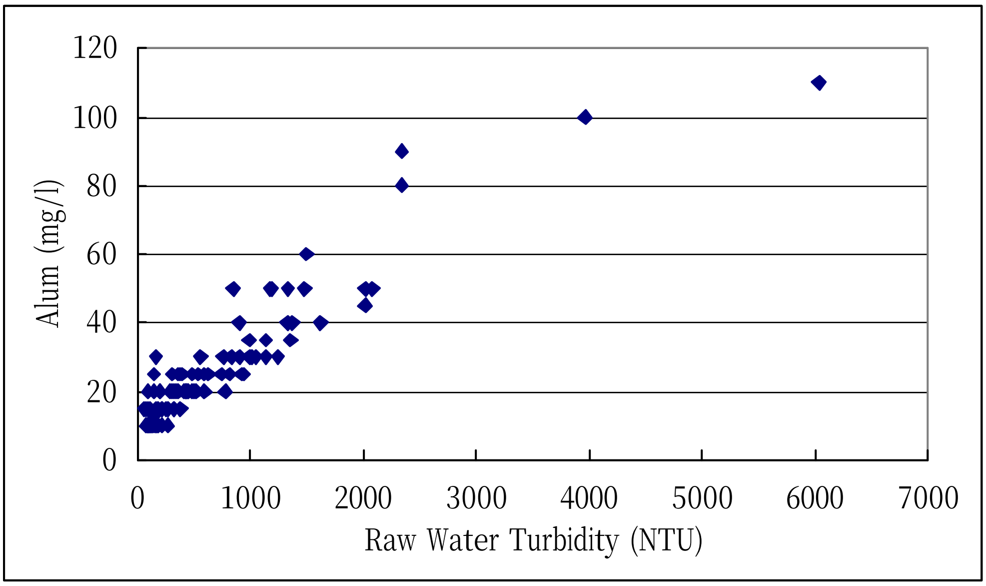


Fig A.5-15 Alum Dosage Rate of Chinaimo W. T. Plan
(in case polymer is used as coagulant aid)

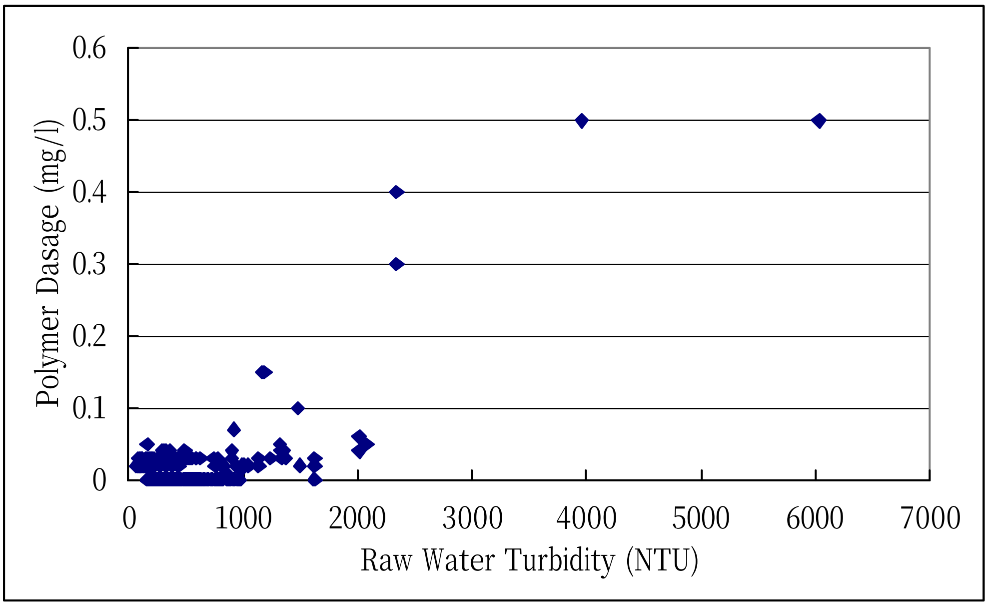


Fig A.5-16 Polymer Dosage Rate of Chinaimo W.T.Plant

(3) Alkali Agent

Alkali agent is not used for pH control for Chinaimo W. T. Plant as Polymer is applied when raw water is in high turbidity. However, in the present study, only Alum is planned to apply for coagulation, and therefore necessity of pre-alkali application is examined as shown in the following paragraphs.

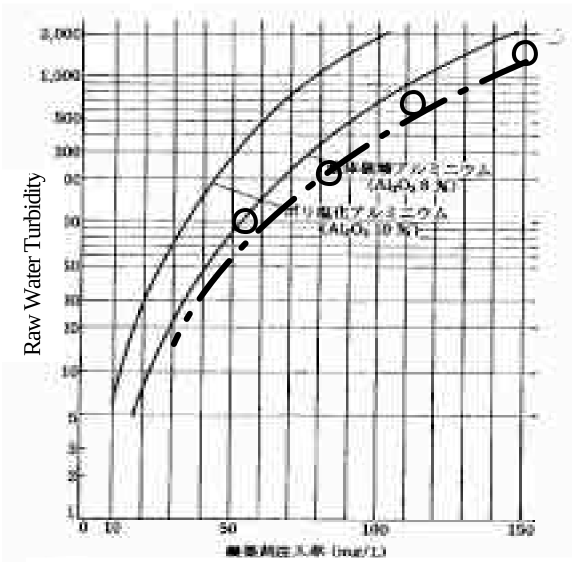
The relationship between the pH value and alkalinity is presented in the Fig. A.5-13. The pH value is usually in a range from 6.8 to 7.5 for proper coagulation. From this, the residual alkalinity after the coagulation is estimated at 50mg/l as the minimum value required.

When raw water is in high turbidity, its content of alkalinity becomes low as shown in Fig. A.5-12. From the above figure, the alkalinity of raw water is at the highest turbidity of 6000NTU is estimated at around 50mg/l. While, the maximum Alum dosage will be 150 mg/l when turbidity of raw water is the highest at 6000 NTU. The alkali consumption in this case is 68 mg/l. Therefore, 68 mg/l of alkali dosage is required to keep the residual alkali at 50mg/l as calculated below.

Raw water:	Maximum turbidity	6000 NTU
	Minimum Alkalinity	50 mg/l

Dosage rate of Alum	150 mg/l
Unit alkali consumption	0.45mg/l (per Alum 1 mg/l)
Alkali consumption	68 mg/l
Residual Alkalinity in treated water	50 mg/l
Dosage rate of Alkali agent	68 mg/l
Alkali content in Slaked Lime	1.35mg/l
Dosage rate of Slaked Lime	50 mg/l

The dosage rates of Alum and Slaked Lime are calculated and shown on Fig. A.5-18. The figure indicates that no dosage of Lime will be required when turbidity of raw water is less than 800 NTU. In principle, only dosage of pre-lime is required for this raw water, and no post-lime will be necessary. However, it is desirable to plan post-lime dosage to avoid corrosiveness of treated water due to low pH caused by excess dosage of Alum, which may happen



Coagulants Dosage(㎎/L)
(Liquid weight dosage)

Raw Water Quality	pH Value ：7.4～8.5 Alkalinity： 35～70 ㎎/L Average Water Temperature: 11℃

(Data from Ozaku W.T.Plant in Tokyo Metropolit an Water Works: Treatment Capacity: 280,000m3/d)

Fig. A.5-17 Water Turbidities and Dosage of Coagulant

Legend:

— - — - : Approximating Cur

○ : Chinaimo W. . T. P

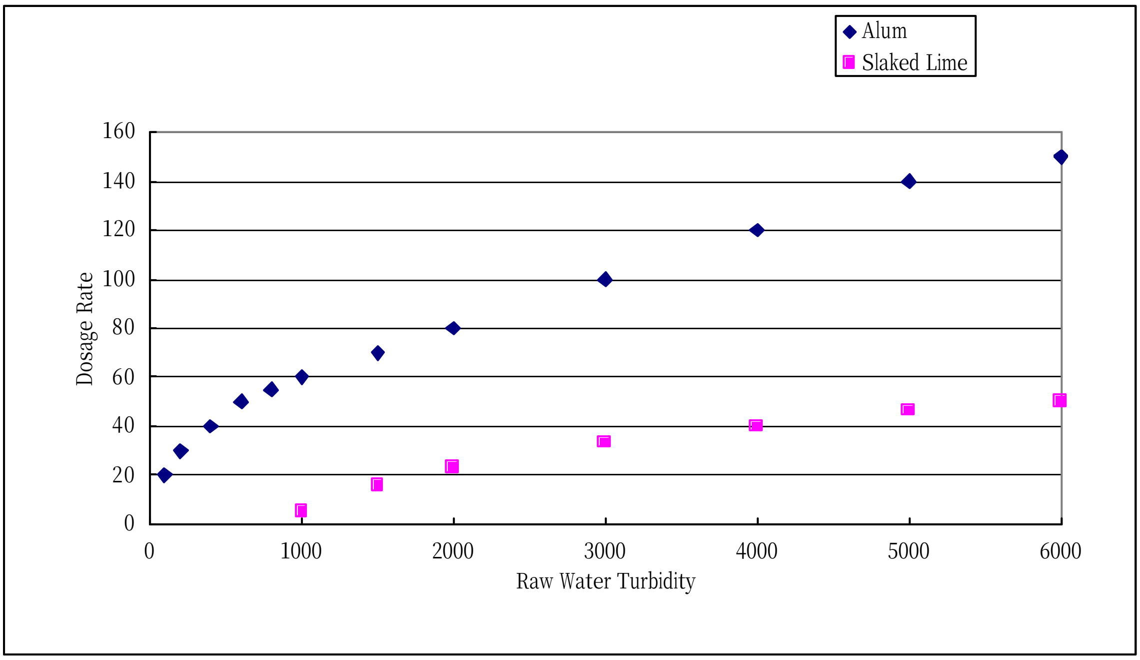


Fig. A.5-18Expected Chemicals Dosage to Raw Water Turbidities (Alum and Pre-Alkali: Slaked Lime)

(4) Chlorination

The dosage of chlorine is determined by the content of Ammonium Nitrogen. In Chinaimo W. T. Plant, an average 0.14mg/l of Ammonium Nitrogen is observed. The Ammonium Nitrogen usually change to Nitric Acids in time during flowing down in the river, therefore the same dosage rate of Chinaimo W. T. Plant is not necessarily be applicable for Nake W. T. Plant. The matter is the existence of pollution inflow between Chinaio and Nake W. T. Plants.

It is estimated however that extent of pollution at the both locations is similar. Thus the content of Ammonium Nitrogen is considered similar between both raw water of Chinaimo and Nake W. T. Plants.

As the raw water contains rather high turbidity, intermediate chlorine dosage is recommended to apply instead of pre-chlorine dosage considering efficiency of chlorination. Chlorine consumption should be higher for turbid water. Post chlorine dosage is applied for disinfection in addition to the above intermediate chlorination. The dosage for intermediate and post chlorine are planned as follows:

Chlorination points: Intermediate Chlorination:
Post-Chlorination

Intermediate Chlorine Dosage:

Maximum Dosage Rate: 5mg/l
Minimum Dosage Rate: 1mg/l
Average Dosage Rate: 2mg/l

Post-Chlorine Dosage:

Maximum Dosage Rate: 2mg/l
Minimum Dosage Rate: 0.5mg/l
Average Dosage Rate: 1mg/l

(5) Summary of Dosage Rates of Chemicals

In accordance with preceding studies, dosage rates of chemicals are summarized in the following Table:

Table A.5-18 Chemical Dosage Plan

	Min.	Ave.	Max.	Chemicals
Coagulant	10	50	150	Solid Alum
Pre-Alkali	2	25	50	100% Slaked Lime
Post-Alkali	1	5	10	100% Slaked Lime
Intermediate-Chlorine	1	3	5	Cl_2 100%
Post-Chlorine	0.5	1	2	Cl_2 100%

1) Coagulation Agent (Alum Sulfate: Alum) Dosage

The required dosage of Alum (solid alum) is presented in the following Table A.5-19 showing liquid alum (10 % solid alum by weight) dosage in the right column.

Table A.5-19 Coagulation Agent Dosage Plan

	Dosage (in weight)		Dosage (in Liquid Form)	
	Min. Treatment Capacity: 7,920m^3/d	Max. Treatment Capacity: 15,840 m^3/d	Min. Treatment Capacity: 7,920m^3/d	Max. Treatment Capacity: 15,840 m^3/d
Min. Dosage Rate; 10 mg/l	79.2 kg/d	158.4 kg/d	792 l/d 0.55 l/min	1,584 l/d 1.1 l/min
Ave. Dosage Rate; 50 mg/l	396 kg/d	792 kg/d	3,960 l/d 2.75 l/min	7,920 l/d 5.5 l/min
Max. Dosage Rate; 150 mg/l	1,180 kg/d	2,376 kg/d	11,800 l/d 8.2 l/min	23,760 l/d 16.5 l/min

2) Pre-Alkali Agent Dosage

The necessary dosage of Slaked Lime as Pre-Alkali agent is presented in the following Table A.5-20 showing dosage of lime milk in the right column.

Table A.5-20 Pre-Alkali Agent Dosage Plan

	Dosage (in weight)		Dosage (in Liquid Form)	
	Min. Treatment Capacity: 7,920m^3/d	Max. Treatment Capacity: 15,840 m^3/d	Min. Treatment Capacity: 7,920m^3/d	Max. Treatment Capacity: 15,840 m^3/d
Min. Dosage Rate; 2 mg/l	15.84 kg/d	31.68 kg/d	158.4 l/d 0.11 l/min	316.8 l/d 0.22 l/min
Ave. Dosage Rate; 25 mg/l	198 kg/d	396 kg/d	1,980 l/d 1.38 l/min	3,960 l/d 2.75 l/min
Max. Dosage Rate; 50 mg/l	396 kg/d	792 kg/d	3,960 l/d 2.75 l/min	7,920 l/d 5.5 l/min

3) Post-Alkali Agent Dosage

The necessary dosage of slaked lime as Post-Alkali agent is presented in the following Table A.5-21 showing dosage of lime milk in the right column.

Table A.5-21 Post-Alkali Agent Dosage Plan

	Dosage (in weight)		Dosage (in Liquid Form)	
	Min. Treatment Capacity: 7,920m^3/d	Max. Treatment Capacity: 15,840 m^3/d	Min. Treatment Capacity: 7,920m^3/d	Max. Treatment Capacity: 15,840 m^3/d
Min. Dosage Rate; 1 mg/l	7.92 kg/d	15.8 kg/d	79.2 l/d 0.055 l/min	158.4 l/d 0.11 l/min
Ave. Dosage Rate; 5 mg/l	39.6 kg/d	79.2 kg/d	396 l/d 0.28 l/min	792 l/d 0.28 l/min
Max. Dosage Rate; 10 mg/l	79.2 kg/d	158.4 kg/d	792 l/d 0.55 l/min	1,584 l/d 0.55 l/min

4) Chlorine Agent (Intermediate-Chlorine) Dosage

The necessary dosage of hypo-chlorite (effective concentrates 65%) as Intermediate Chlorine agent (by weights) is presented in the following Table A.5-22 showing dosage of liquid hypo-chlorite in the right column.

Table A.5-22 Intermediate-Chlorine Dosage Plan

	Dosage (in weight)		Dosage (in Liquid Form)	
	Min. Treatment Capacity: 7,920m^3/d	Max. Treatment Capacity: 15,840 m^3/d	Min. Treatment Capacity: 7,920m^3/d	Max. Treatment Capacity: 15,840 m^3/d
Min. Dosage Rate; 1 mg/l	12.18 kg/d	24.37 kg/d	243.6 l/d 0.17 l/min	487.4 l/d 0.34 l/min
Ave. Dosage Rate; 2 mg/l	24.37 kg/d	48.74 kg/d	731 l/d 0.34 l/min	974.8 l//d 0.68 l/min
Max. Dosage rate; 5 mg/l	60.92 kg/d	121.85 kg/d	121.84 l/d 0.85 l/min	2,437 l/d 1.69 l/min

5) Chlorine Agent (Post-Chlorine) Dosage

The necessary dosage of hypo-chlorite (effective concentrates 65%) as Post Chlorine agent (by weights) is presented in the following Table A.5-23 showing dosage of liquid hypo-chlorite in the right column.

Table A.5-23 Post-Chlorine Dosage Plan

	Dosage (in weight)		Dosage (in Liquid Form)	
	Min. Treatment Capacity: 7,920m^3/d	Max. Treatment Capacity: 15,840 m^3/d	Min. Treatment Capacity: 7,920m^3/d	Max. Treatment Capacity: 15,840 m^3/d
Min. Dosage Rate; 0.5 mg/l	6.09 kg/d	12.18 kg/d	121.8 l/d 0.08 l/min	243.6 l/d 0.17 l/min
Ave. Dosage Rate; 1 mg/l	12.18 kg/d	24.37 kg/d	243.6 l/d 0.17 l/min	487.4 l/d 0.34 l/min
Max. Dosage Rate; 2 mg/l	24.37 kg/d	48.74 kg/d	487.4 l/d 0.34 l/min	974.8 l/d 0.68 l/min

(6) Study on Feeding Method

The existing feeding method is designed that liquid is weighed by manual mechanical balance, then diluted liquid is injected using the negative pressure in the injector. Since weigh balance is not functioned properly at the present, accurate weighing is not practiced. Thus proper chemical feeding can not be made. In the planning of rehabilitation for chemical feeding works, appropriate feeding method is studied for each chemical.

The chemical feeding methods for the Nake Water Treatment Plant such as Alum, Slaked Lime and Hypo-chlorite are recommended for design as shown below in accordance with the examination presented in Table A.5-23.

- Alum for Coagulation: Diaphragm Type Flow Measuring Pump
- Slaked Lime for Alkali: Pressure Injector Type
- Hypo-chlorite for Chlorination: Pressure Injector Type

Table A.5-24 Study on Chemical Feeding Method

	Coagulation Agent: Alum	**Alkali Agent: Slaked Lime**	**Chlorine Agents: Hypo-Chlorite**
Importance in Water Treatment Process	Alum is the most important for coagulation and clarification process. Dosage shall be controlled accurately for proper treatment process	Lime dosage is required when turbidity of raw water is high, i.e., more than 800 NTU.	Important for treated water disinfection, Water without chlorination should not be supplied to the consumers.
Feeding Frequency	Continuous feeding shall be required.	Feeding will be required during three months of 7, 8 and 9 when turbidity of raw water is high.	Continuous feeding shall be required.
Feeding Accuracy	Accurate feeding shall be required	No such accurate feeding as Alum is required.	Same as Alkali Agents
Characteristics of Chemicals	Specific problem is found as the solubility is high.	Usually treated as slurry (10 % in weight) as solubility is as low as only 0.15%. React with carbon dioxide, then forms calcium carbonate, which causes problems such as clogging of pipe, sediment of slaked lime in pipe.	Solubility is high, but sometime clogging of pipe will occur due to bubbles.
Basic Consideration for Feeding Equipment	Accurate feeding rate to be kept. Simple feeding method is to be applied	Simple feeding method is to be applied.	Simple feeding method is to be applied.
Feeding Method	Existing method has some problems for accurate feeding: 1) Feeding rate will be influenced by changes of liquid level in solution tank. 2) Pressured water is always maintained for continuous feeding. Thus present feeding method is not recommendable. Diaphragm pump feeder is recommended as accurate and independent feeding system.	High accuracy is not required. Recommended as the same method of existing system, manually weighing pressure injector method.	Same as Alkali Agent

(7) Rehabilitation Plan

1) Alum Feeding Facilities

The most important chemical for water treatment process is coagulation agent (Alum), which feeding shall be accurate and continuous. The existing solution tanks (2 tanks of RC made) will be utilised with repair of concrete surfaces. FRP lining on inner surfaces of the tank shall be made for corrosion protection.

The feeding system is designed using diaphragm reciprocate type pump. Major items of rehabilitation for Alum feeding facilities are presented in the following Table A.5-25:

Table A.5-25 Major Rehabilitation Work Items for Alum Feeding Facilities

Alum Sulphate Solution Tank	Alum Sulphate Feeding Pump
Type: RC Square shape solution tank (Existing) **Capacity:** 3.5 m^3 **Unit:** 2 units **Accessories:** (for each tank) Chemical throwing hopper (SUS 316) Mixer for solution: 0.75kW Stem and Impeller: SUS 316	**Type:** Diaphragm type measuring pump **Capacity:** 8.5l/min x 1.5 kW **Unit:** 3units (2units for normal operation, one for standby)

2) Lime Feeding Facilities

The alkali agent is designed to feed for raw water of high turbidity (above 800NTU) which will occur during three months in a year, in July, August and September. Not so high accuracy for feeding rate is required. The existing solution tanks (2 tanks of RC made) are used with repair of concrete surfaces. The same feeding method as the existing one is planned without slurry circulating pump, which is used at the present system. The lime solution will be gravitated through manual measuring apparatus for feeding.

Major items of rehabilitation for Line feeding facilities are presented in the following Table A.5-26:

Table A.5-26 Major Rehabilitation Work Items for Lime Feeding Facilities

Lime Solution Tank	Lime Feeder
Type: RC Square shape solution tank (Existing) **Capacity:** 3.0 m^3 **Unit:** 2 units **Accessories:** (for each tank) Chemical throwing hopper (SUS 304) Mixer for solution: 1.5kW Stem and Impeller: SUS 304	**Measuring Equipment** **Type:** Triangle weir type flow measuring tank **Unit:** 2units (one each for pre-alkali & post-alkali feeding) **Lime slurry pressure injector** **Type:** pressurised vacuum injector **Unit.:** 2units (one each for pre-alkali & post-alkali feeding)

3) Chlorine Feeding Facilities

When chlorine feeding stops, water shall be distributed to the consumers without disinfection. Thus chlorine feeding is important to be continuous. But so high accuracy of feeding rate will not be required.

The existing RC tanks (2 for hypo-chlorite solution tanks and one for fluoride solution tank) are planned for use with repair of concrete surfaces. FRP lining shall be made for inner surfaces for corrosion protection. The same feeding method as the existing one will be applied for chlorine feeding system. Major items of rehabilitation for chlorine feeding facilities are presented in the following Table A.5-27:

Table A.5-27 Major Rehabilitation Work Items for Chlorine Feeding Facilities

Hypo-chlorite Solution Tank	Hypo-chlorite Feeder
Type: RC Square shape solution tank (Existing) **Capacity:** 1.5 m^3 **Unit:** 3 units **Accessories:** (for each tank) Chemical throwing hopper(Steel with rubber Lining) Mixer for solution: 0.4kW Stem and Impeller: Steel with rubber lining	**Type:** Triangle weir type flow measuring tank **Unit:** 2units (one each for pre-chlorine & post-chlorine feeding)

5.5 Conditions of Distribution System

1. Distribution Condition

(1) Present Conditions of the Water Distribution

The present supply condition in the service area is in general considered good when the pressure conditions of the distribution system are taken into account. The pressure contour lines of the distribution system shown on Fig. A.5-19 indicate that pressure in the central area is above 20 m and 10 m in its peripheral area. While the system pressure in the surrounding areas is reported lower than 10 m, where diameters of distribution pipelines are small and ground elevations there are high. In such areas, service condition is not necessarily appropriate. Improvement of the distribution network in such area will be necessary.

The existing elevated tank, located in the southern part of the service area, receives water during night to supply water for its surrounding area in daytime. This elevated tank sometimes receive no water due to lower pressure there, thus tank is sometimes empty of water. Improvement of distribution network in this area will be also required.

(2) Distribution Facilities

The most of service areas are supplied directly by the distribution pumps of Nake Water Treatment Plant. While water is supplied through the elevated tank in southern part of service area as mentioned.

The existing clear water reservoir has a nominal capacity of 1.6hours retention time of production capacity. The reservoir is used also as the wash water tank to reserve washing water for filter. Thus net volume to absorb variation for water distribution is estimated at one hour only. This capacity shall not be enough for present distribution system. At the time for filter washing, sudden drop of water level in the reservoir occurs. Due to insufficient capacity of the reservoir, the pump operation for raw water intake must be adjusted in accordance with the variation of the distribution flow.

The rated capacity for the distribution is 700 m3/hr or 16,800 m3/day by operating two distribution pumps in normal operation. However, the capacity of the existing distribution pump is estimated to decrease at about 80 % of its rated capacity due to deterioration. To cope with water demand, three pumps are sometimes in operation. Even water supply stops occurs sometimes due to mechanical trouble of the distribution pumps at the present. NPS worries about the repair works due to lack of spare parts.

A total pipeline length of the present distribution network is about 83 km, which size is ranging from 500mm to 40 mm in diameter. Conditions of the existing distribution pipelines are seemed good as corrosion of pipe was not observed during the field survey. However, capacity of distribution network is not necessarily enough around the border of service area where water pressure is low as mentioned.

Only single pipeline for trunk main, which diameters are 500mm and 400mm, is available from the Water Treatment Plant installed along the Mekong River to supply water throughout the service area. Another trunk main will be desirable to be installed along the eastern route of the service area in the future to facilitate stable water supply and to maintain water distribution at the time of emergency.

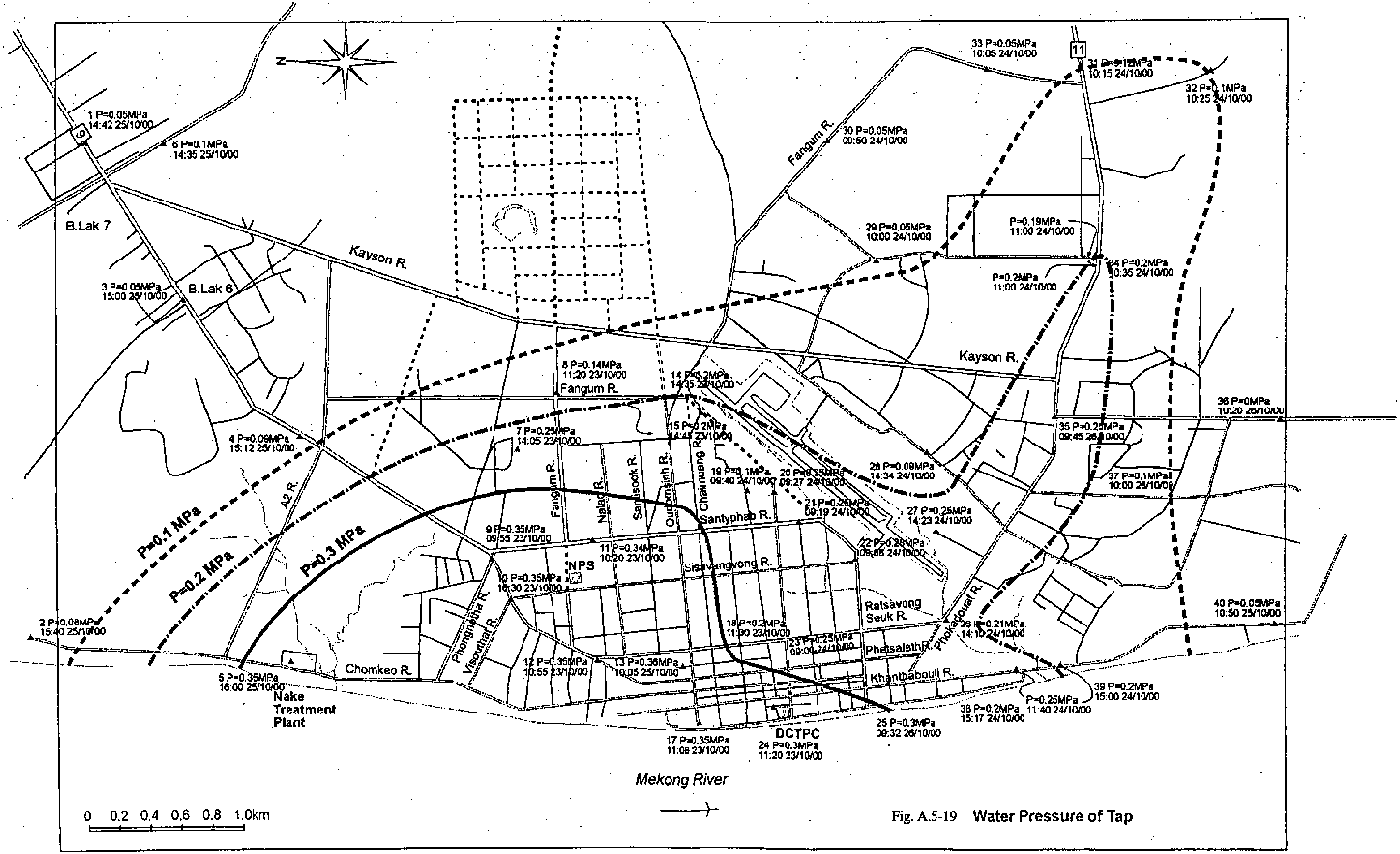


Fig. A.5-19 Water Pressure of Tap

5.6 Capacity of New Clear Water Reservoir

1. Existing Clear Water Reservoir

The structure and dimensions of the existing clear water reservoir of Nake Water Treatment Plant is as follows:

- Semi-underground Circular Reinforced Concrete Structure (one unit)
- Diameter: 16.8m, Water Depth: 4.5m, Capacity: 1,000m^3
- High Water Level: +144.5m, Low Water Level: +140.0m

The existing clear water reservoir has two functions as distribution balancing reservoir and tank for filter washing. Therefore, effective capacity used for distribution is only 600 m3 when volume for washing of filter (400 m3/washing) is deducted from the total capacity of 1,000 m3. This volume is calculated as equivalent to only one hour retention time for daily maximum production capacity as follows:

600 m3 / (15,000 m3/24hrs) = 0.96 hrs, say approximately one hour.

This capacity is too small to absorb variation of water demand in a day. Since the reservoir is used for both distribution of water and filter washing, water level in the reservoir drops suddenly at the time of filter washing. This causes negative effects for operation of distribution and backwash pumps due to sudden change of pump head. Further, filter washing is made only once a day at the present due to lack of capacity of the reservoir. Since there are four filters in operation, washing of filter shall be two times a day for the normal operation where the maximum filter run shall be 48 hours.

2 Capacity of New Reservoir

The necessary capacity for the clear water reservoir is calculated taking its roles into account as follows:

(1) As for reservation of water for plant operation such as filter washing water reservation, water uses for chemical solution and other water uses in plant operation, and

(2) As for distribution balancing reservoir to absorb hourly water demand variation and to reserve water for emergency case.

Considering about the above roles of clear water reservoir, the respective volume required is examined as follows:

As for reservation for plant operation:
One hour retention time against the maximum production capacity is usually provided as specified in the design criteria of Japan. When small number of filter (4 filters) of Nake Water Treatment Plant is taken into account, volume of one hour retention time for reservoir shall be required at least.
As for distribution balancing reservoir:
Necessary volume of reservoir is calculated using the mass-curve for distribution. The mass-curve is prepared by the Study Team based on the measurement of distribution flow in two times during the field survey as shown on Fig.A.5-20 and A.5-21. The retention time is analyzed based on the above mass-curve as follows:

1) Survey results as of Year 2000 October 10/11; (1,090/14,225) x 24 = 1.84hr
2) Survey results as Year 2000 October 18/19; (1,470/13,082) x 24 = 2.70hr

Where, (1) investigation included one hour water supply stop, while investigation (2) is the case for 24 hours continuous water supply. The survey was made in October during wet season, thus the distribution flow is considered smaller than that in dray season. Therefore, the required volume of reservoir is adjusted by adding 10 % to the volume obtained in the survey. Finally, the retention time as the distribution balancing reservoir is determined at 3 hours.

From the above study, the required retention time of clear water reservoir is obtained at 4 hours (1 hour for plant use + 3 hours for balancing reservoir). The capacity required for new reservoir is thus calculated at 1,500 m3 as follows:

$15,000m^3$ x 4.0hr/24hr – existing capacity: $1,000m^3 = 2,500\ m^3 - 1,000\ m^3 = 1,500\ m^3$

The existing and new reservoirs are required to be utilized to function as one reservoir in the system. Therefore, the connecting pipe between two reservoirs shall be designed with sufficient size so as to reduce its head loss as much as possible.

The construction of new clear water reservoir has following advantages:

(1) To ease pump operation for washing filter and distribution to avoid the influence of

sudden change of water level of reservoir/pump well caused by filter washing.

(2) To facilitate constant raw water pump operation to absorb variation of distribution flow by the enough volume of clear water reservoir.

(3) To minimize water supply stoppage due to the rehabilitation works by the construction of new clear water reservoir in advance (full volume of the reservoir can allow 8 hours operation of a distribution pump).

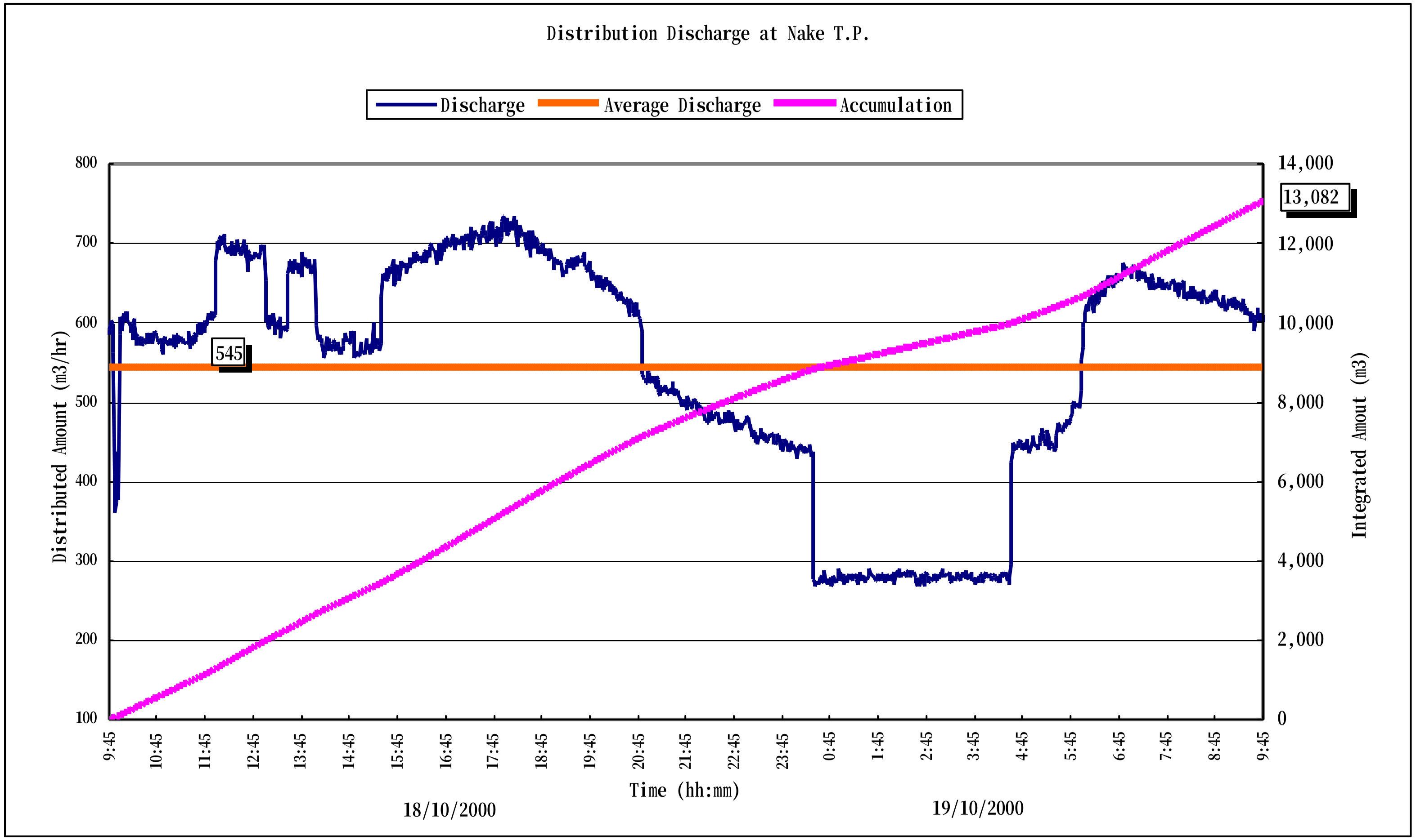


Fig. A.5-20 Distribution Discharge at Nake Treatment Plant on 18-19/10/2000

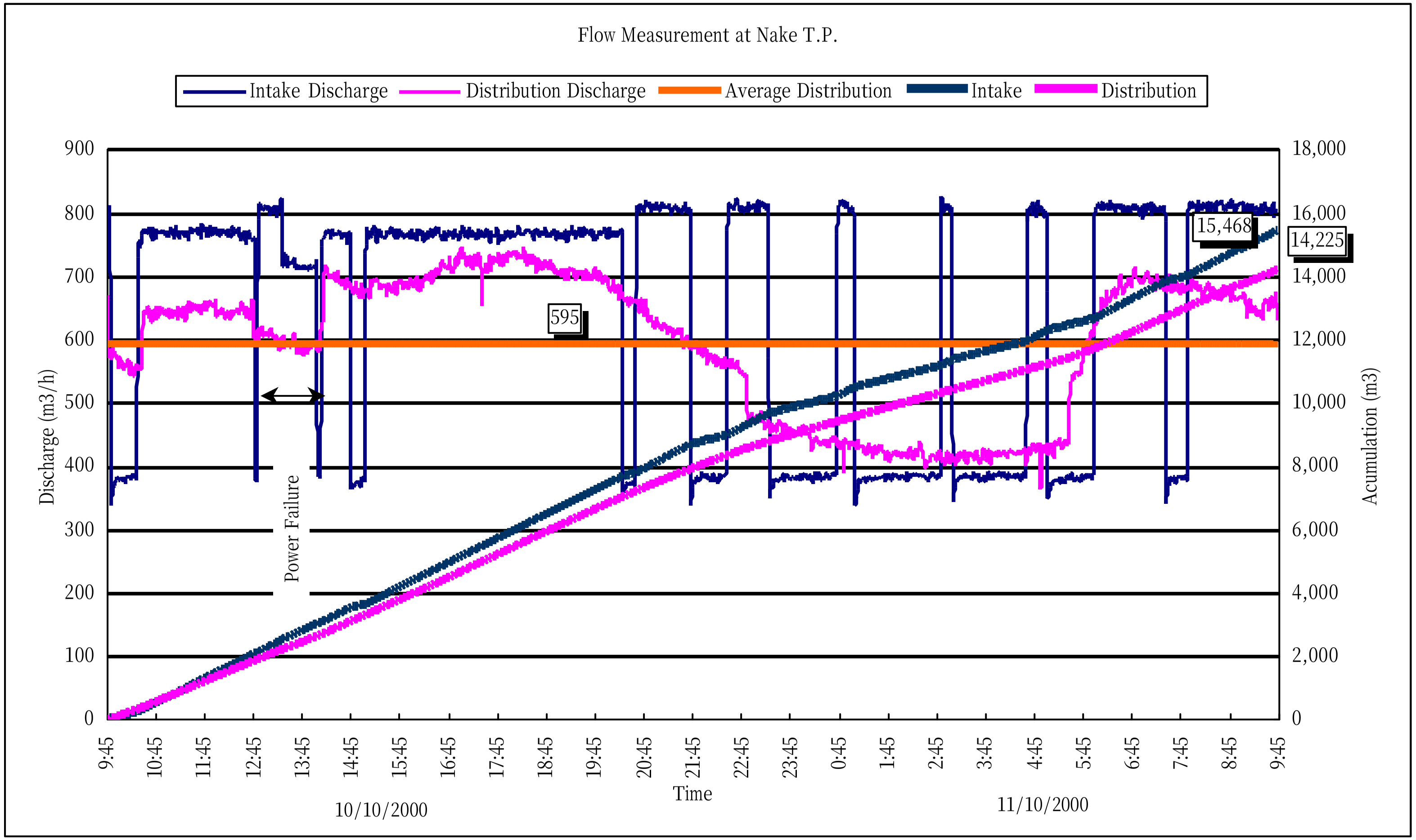


Fig. A.5-21 Intake and Distribution Discharge at Nake Treatment Plant

5.7 Surge Protection

1. Present Situation

In the present distribution pump system, an air chamber (capacity approximately $7m^3$) is installed to alleviate the pressure surge at the time of sudden stop of pump operation. As the associated facility to the air chamber, an air compressor was installed for maintaining the water level in the chamber by pressurized air. However, this air compressor was out of order and therefore the existing system is not functioned.

Since the air chamber has been working for a long time over 20 years keeping high pressure, such long use may weaken the mechanical strength of the cylinder wall and welded joints although outside appearance looks better. It is therefore judged that the existing air chamber is to be replaced for safety when surge control for the distribution system is concluded as required.

2. Necessity of Surge Control

The pressure surge in the distribution pipelines, created by a sudden stop of distribution pump operation due to electric power failure is analyzed as described in the following paragraphs:

(1) Occurrence of Pressure Surge and Water Hammer

The pressure in pipe varies along with the sudden changes of flow speed caused by a sudden stop of pump operation or sudden open/close of valve, due to power failure. This sudden pressure change in the pipeline is called as pressure surge. The severe pressure surge generates negative pressure in pipe, and if it becomes minus 10m, cavity is generated in the pipe, then which leads to water column separation. With this water column separation, after some time passed, high shock wave occurs at the water column separation point caused by clash of water column between up and down streams, which phenomenon is called as water hammer. To avoid occurrence of this high shock wave in the pipeline, it is necessary to avoid sudden change of flow velocity in the pipeline.

(2) Conditions for Surge Analysis

The existing distribution system is composed of two major pipelines, which are installed to the south and north directions from the Water Treatment Plant.

The main pipeline to the south direction covers 97 % of the total water demand, thus the surge analysis is made on this pipeline based on such assumption that water is transmitted to an elevated tank located at the center of the service area. The conditions for surge analysis are summarized as follows:

Design Maximum Flow Rate:	16,214mm^3/d = 11.26m^3/min
Water Level of Pump Well:	+136.0m
Water Level of Elevated Tank:	+172.0m
Pipeline:	φ500mm x 955m, φ450mm x 1,478m

(3) Analysis 1

This case is analyzed under the condition that the distribution pump will stop its operation suddenly due to power failure with no surge control. The result of the analysis for this case is presented in the Fig. A.5-22.

The figure shows that the negative pressure will occur along the pipeline at its span between 200m and 1,500 m away from the pump station. The negative pressure reaches over 10 m at the locations of 900 m and 1,700 m from the pump station. The water column separation may happen in these points, which generate water hammer phenomenon. It is therefore concluded that surge control should be necessary to protect the distribution pipelines.

(4) Analysis 2

This case is analyzed under the condition that the distribution pump will stop suddenly, while the system has an air chamber with the same capacity as the existing one. The result of the analysis is illustrated in Fig. A.5-23.

From the figure, it is confirmed that no negative pressure will occur along the entire span of the distribution pipeline. Thus it was proved that the air chamber would work effectively.

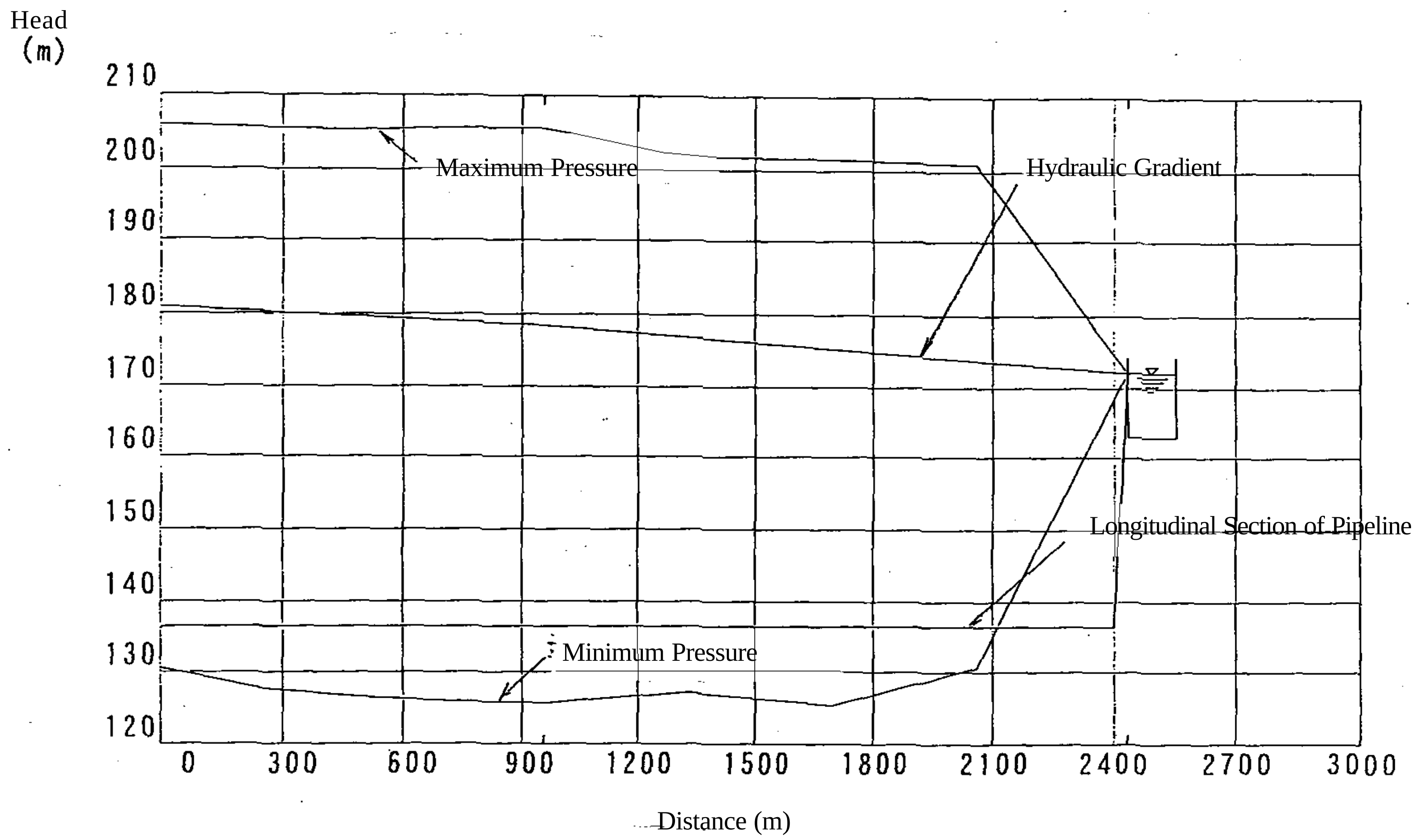


Fig. A.5-22 Surge Analysis 1

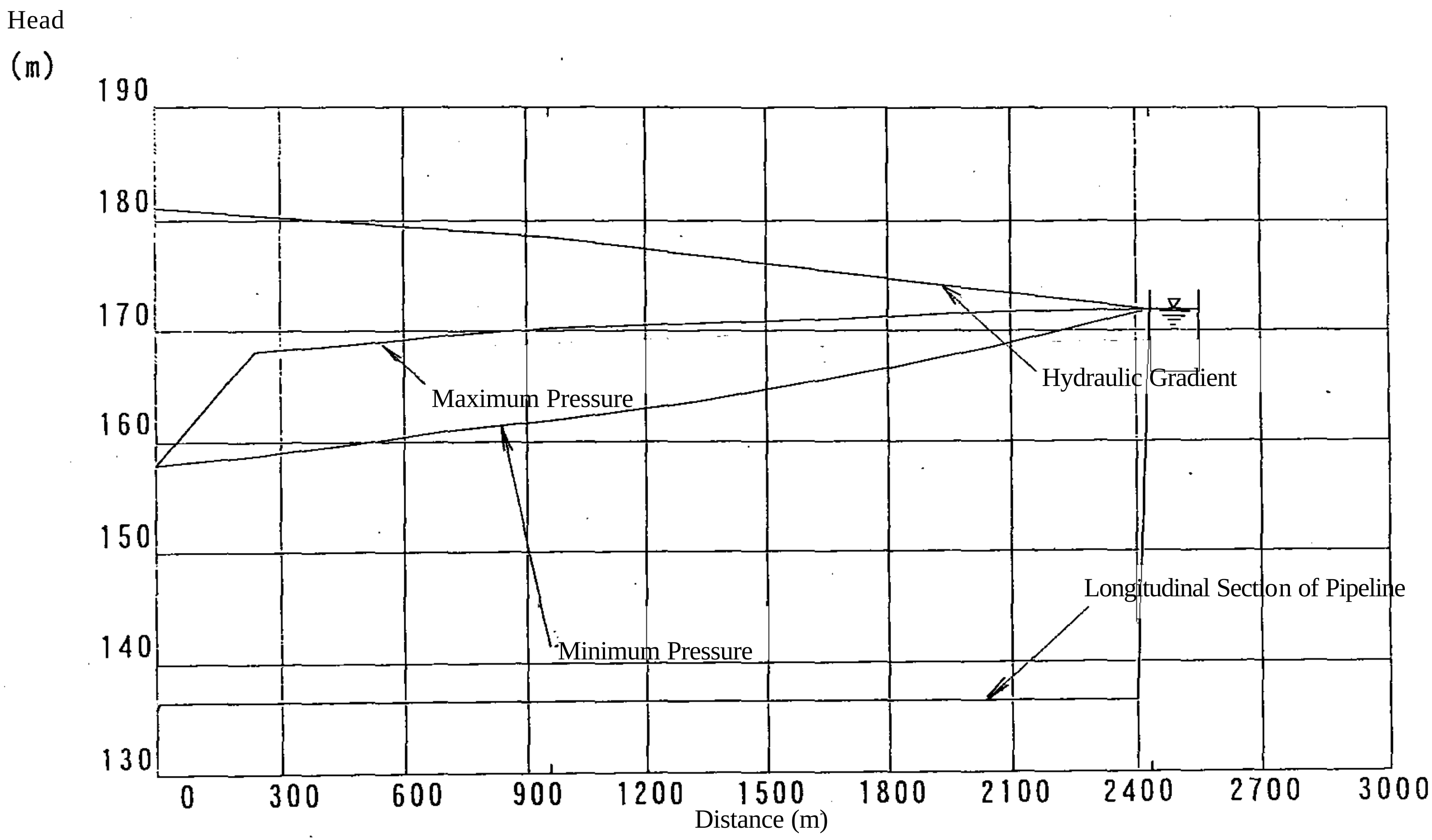


Fig. A.5-22 Surge Analysis 2

5.8 Leakage Survey

1. Unaccounted-For-Water and Leakage

It is important to control and reduce unaccounted-for-water (UFW) of water supply system as well as expansion of the system due to demand increase. Reduction of UFW results saving of electric power and chemical consumption as well as valuable raw water resource. However, reduction of UFW is hardly realized as planned within a short time. The difficulty is easily conjectured from the fact that many cities in the developing countries are suffered from high UFW as more than 50 %. A decade had been required to reduce UFW at only 3.3 % in Japan (Water Supply Statistics 1998, Japan Water Works Association).

(1) Unaccounted-For-Water of Savannakhet Water Supply System

1) Statistic Data of Savannakhet Water Supply Company

UFW of Savannakhet Water Supply System in the past 15 years are presented in Table A.5-28. According to the table, UFW ratio for the past 15 years was in the range of 11.7~22.6 %. This is however considered rather low.

Table A. 5-28 Water Supply Record in Savannakhet

Year	Production (m^3)	Water Sale (m^3)	Water Loss (m^3)	Water Loss (%)	Connec-tion	Population Served	Person/ Connection	Lcd	Remarks
1985	1,981,705	1,749,991	231,714	11.7	2,807	31,963	11.4	150.0	
1986	2,134,169	1,712,698	421,471	19.7	3,064	32,280	10.5	145.4	
1987	2,363,336	2,086,375	276,961	11.7	3,362	38,107	11.3	150.0	
1988	2,720,257	2,401,118	319,139	11.7	3,859	43,856	11.4	150.0	
1989	2,756,160	2,434,539	321,621	11.7	4,274	44,466	10.4	150.0	
1990	2,972,232	2,571,473	400,759	13.5	4,654	46,968	10.1	150.0	
1991	3,420,359	2,858,442	561,917	16.4	5,149	47,507	9.2	164.8	
1992	3,461,125	2,807,048	654,077	18.9	5,668	48,065	8.5	160.0	
1993	3,455,061	2,780,977	674,084	19.5	6,158	48,794	7.9	156.1	
1994	3,502,379	2,711,491	790,888	22.6	6,692	49,525	7.4	150.0	
1995	3,586,340	2,905,411	680,929	19.0	7,158	53,067	7.4	150.0	
1996	3,559,643	2,996,458	563,185	15.8	7,570	53,730	7.1	152.8	
1997	3,593,534	2,974,986	618,548	17.2	7,946	54,338	6.8	150.0	
1998	4,136,274	3,386,456	749,818	18.1	8,257	59,858	7.2	155.0	
1999	4,377,880	3,404,638	973,242	22.2	8,776	60,179	6.9	155.0	

Data Source: Savannakhet Water Supply Company

Note: Production record in the table is based on estimate as flow meter was malfunction since 1982.

As shown in Table A.5-29, UFW in Hong Kong and Bangkok is in the range of 30~40 %, while it is more than 50 % in Jakarta and Hanoi. UFW of about 20 % in Savannakhet is considered rather low comparing with other cities as mentioned.

Table A.5-29 UFW, Production Capacity and Served PopulationIn Major Cities In Developing Countries

	Unaccounted for Water (%)	Daily Production (m^3/day)	Population Served (Capita)	Lcd (liter/capita/day)
Singapore	6	1,375,156	3,000,000	458
Shanghai	14	4,728,000	8,197,000	577
Hong Kong	36	2,518,000	6,270,000	402
Bangkok	38	3,849,863	5,986,000	643
Dhaka	51	781,540	3,780,000	207
Jakarta	53	972,086	2,461,320	395
Phnom Penh	61	103,096	684,171	151
Hanoi	63	360,000	1,257,105	286

Data Source: Second Water Utilities Data Book; Oct 1997, ADB

According to the water supply company in Savannakhet, the above figure on UFW shown in Table A.5-28 will not be accurate enough. Quantity for annual distribution or average day distribution is obtained from rated capacity of distribution pump and its operation time as flow meter was out of order since 1982. The rated capacity of pump shall be changed due to changes of pump operating pressure and extent of its deterioration. On the other hand, total water consumption includes estimated consumption for such consumers with defect water meter. From the above, the data on both distribution and consumption are not necessarily accurate, thus recorded UFW ratio is also not accurate.

2) Examination on Results of Field Survey

Water consumption, which is sum of water meter reading, were in the range of 9,278~9,328 m3/day for the past two years of 1998 and 1999. The consumption in 2000 is assumed at 9,328 as no significant change of consumption is expected from 1999.

The distribution flow measured twice in October, 2000 during field survey were 14,200 and 13,100 m3/day as shown in Table A.5-30. The measured distribution flow is considered to show more or less average in a year since temperature in October is similar to annual average. From these measurements and assumed consumption, UFW is calculated at about 30 %.

Table A.5-30 Estimate of UFW

Date	Flow Measurement	Accounted-For Water	UFW Ratio
Oct.10～11	14,200 m^3／day	9,328m^3／day	34.3%
Oct.18～19	13,100 m^3／day	9,328m^3／day	28.8%

（2）Leakage of The System

1）Estimate from Supply Condition

Leakage of the system is considered not significant and serious level judged from the supply conditions of the distribution network and observation of conditions of pipeline as follows:

① From the estimate of UFW in the above, leakage of the system shall be less than 30 %.

② A few cases of leaks were found during field survey on the distribution network in spite of high supply pressure of more than 2 kg/cm2.

③ Conditions of distribution pipelines were observed as good by test diggings during field survey.

④ Record of leak repair shows monthly leaks at about 40 cases in average, which is mostly derived from small size of service connections. Amount of leakage as a whole is considered not large since each leak amount is small and quick repair has been carried out.

Table A. 5-31 Leak Repair Record

Date	Cases	Pipe Size (mm)	Date	Cases	Pipe Size (mm)
1999/1-6	278	15-20	1999/9-10	35	20-50
1999/7	35	15-20	1999/11	42	20-50
1999/8	66	15-20-50			
			Total	456	

2）Leakage Survey

Leakage survey was conducted for about 10 days during field survey. However, concrete measuring could not be made due to difficulties faced during the survey as follows:

① Isolation of planned leakage survey areas was really difficult due to uncertain conditions of valve opening position and pipe connections with other pipelines in adjacent areas.

② No record or map was available to show locations of valves and pipelines.

③ Many valves were buried under the pavement which enable to operate valves for isolation of survey area from others.

④ Only a few air valves are installed in the distribution network, which sometimes hamper flow measuring caused by existence of air in the pipeline.

⑤ In the remote area of the distribution network, water pressure was too low during peak hour supply to conduct continuous flow measuring, which make flow measurement impossible.

Although the above difficulties were exist, the leakage survey was attempt as described in the succeeding section. Even though complete measurement of flow could not be made, the level of leakage was grasped by night flow measurements. **The results of leakage survey are summarised and shown in Table A.5-32.**

Table A. 5-32 Results of Leakage Survey

Date of Survey	Survey Area	Connection	Level of Leakage	Night Flow	Note
①Oct.20 ～21	Lak 6	—	Same level as ④	5 m^3/hr	Continuous flow measurement could not be made due to air intrusion in pipe. Assume same level of leakage as ④
②Oct.23 ～24	Nonsa-Bath1・2	75	Low Level of Leakage	0.6m^3/hr	Flow measurement could not made during peak flow due to negative pressure of pipeline. Leakage is small judged from small night flow and number of service connections on pipeline.
③Oct.25 ～26	Nonsa-Bath 1	40	Low Level of Leakage	0.6m^3/hr	Continuous flow measurement could not be not made due to air intrusion in pipe. Leakage is small judged from the same reason as ②
④Oct.26 ～27	Ratsavong Seuk Road	115	65%	8 m^3/hr	
⑤Oct.27 ～28	Nonsa-Bath 2	45	Zero Leakage	Zero	Judged no leakage

(3) Evaluation on Survey Results

1) Evaluation

It is considered that the priority for rehabilitation of the existing distribution network will not be so high as the present UFW is moderate level. Regarding leakage level of the distribution network system, it is considered also not so high. However evaluation of the leakage is difficult only by the present survey due to the following reasons:

① Leakage is usually not uniform throughout the system, but different by areas with considerable extent as suggested in the survey results.

② Although the level of leakage is considered not significant, the average leakage obtained by the present survey is not necessarily shows the leakage of the entire system.

The result of present leakage survey at 5 areas indicate about 27 % when leakage of each area is simply applied as follows:

(65% x 1pl + 50%(assumed) x 1pl + 10% x 2pls + 0% x 1pl) / 5

Although the above estimate shall not be accurate enough, the level of leakage of the distribution network could be judge as not so high.

2) Necessary Measures

It is important to reduce UFW for efficient water supply system. However, present level of UFW for Savannakhet Water Supply System is judged not so high as required urgent measures to reduce UFW. Therefore, priority will be given for strengthen and expansion of the distribution system for time being in accordance with demand increase and extension of service area, rather than leakage abatement activities.

While, preparatory works shall be commenced for control and reduction of UFW including leakage abatement activities. They will include:

- Arrangement of distribution network inventory with maps,
- Valve rehabilitation to facilitate proper operation of them,
- Installation of air valves at proper locations,
- Replacement of defect water meters on service connections, and
- Installation of district meters where possible to measure distribution flow in districts.

(４) Factor of UFW

There are many factors which affect unaccounted-for-water. These factors are identified and systematically arranged as shown in Fig. A.5-24. It is important to identify such factors which affect UFW significantly, and take actions for reduction of such defects one by one with steady manner.

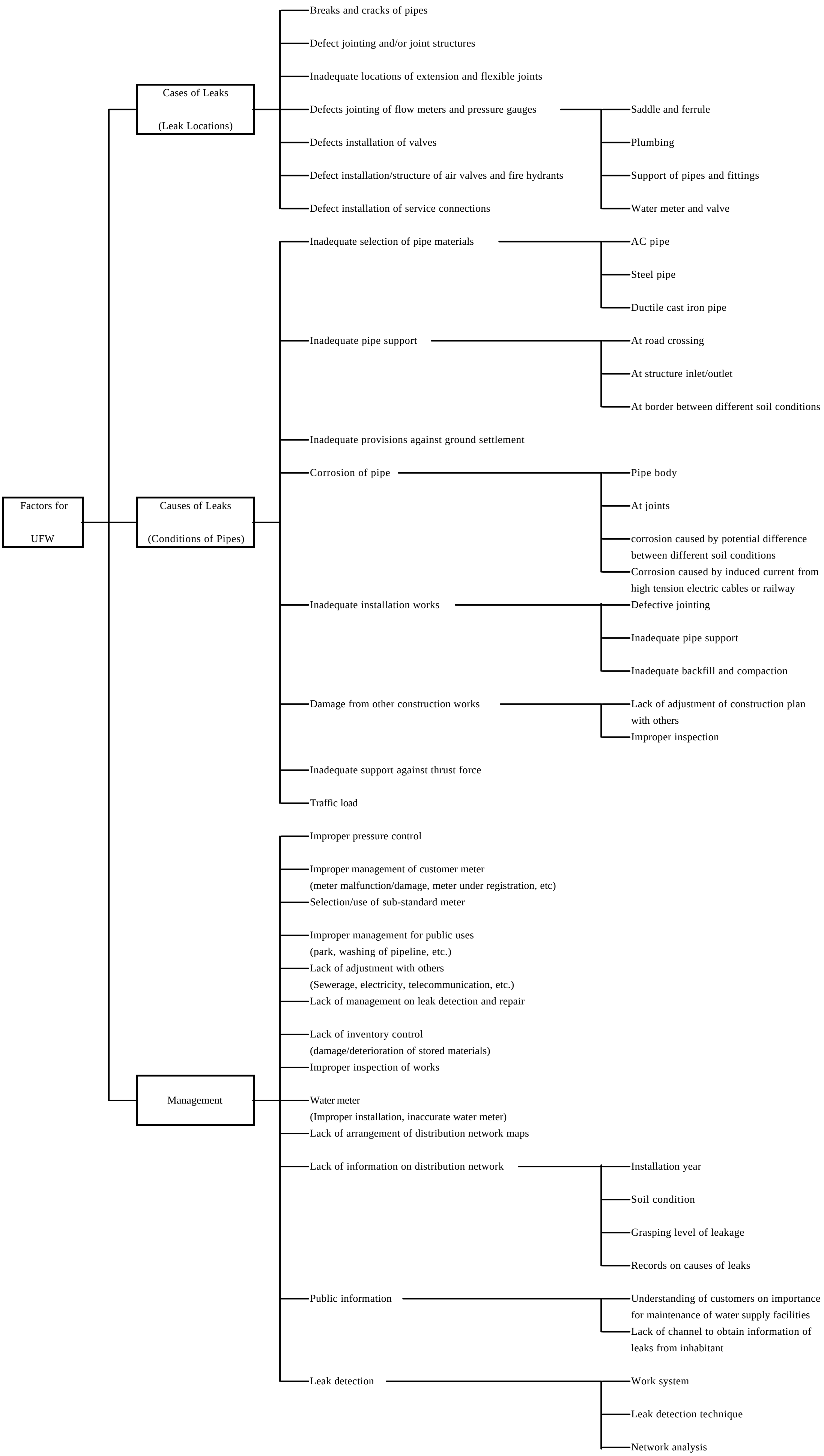


Fig.A.5-24 Factors of Unaccounted-For-Water

２. Field Survey on Leakage

(1) Outline of Leakage Survey

The leakage survey was conducted using following measuring equipment.

Ultrasonic Flow Meter（UFP-10 型）........... 2units

Potable pressure recorder (WPN 型） .... 5 台

Two methods were applied for measuring UFW and Leakage as follows:

Method１：Estimate UFW by comparing with distribution flow and recorded consumption by the Water Supply Company.

Method 2： Select supply blocks for estimate leakage by comparing inflow into such supply block and its consumption. Inflow of supply block is obtained from the balance of flow measurement between upstream and downstream of the supply block. While consumption of supply block is obtained from number of service connections and average daily consumption per connection.

From the existing distribution network map, the survey blocks, which are considered adequate for survey, were selected as shown on Fig. A.5-25 and proposed them to the Water Supply Company. However, those survey area could not applicable due to the reasons that most of valves could not be operable in such blocks because they were buried under the pavement caused by the road construction during a 1997~98 period. Since no approval for digging was obtained, the survey blocks were changed as shown on Fig. A.5-26. And the surveys were conducted at the places and date as shown in Table A.5-33.

Table A.5-33 Date and Place of Leakage Survey

①Oct. 20-21：Ban Lak 6（no flow measurement could be made due to air intrusion to pipeline）
②Oct. 23-24：Ban Nonsavath 1&2（flow measurement was conducted）
③Oct. 25-26：Ban Nonsavath 1（no flow measurement could not be made due to air intrusion to pipeline）
④Oct. 26-27：Ratsavong Seuk Road（flow measurement was conducted）
⑤Oct. 27-28：Ban Nonsavath 2（flow measurement was conducted）

After discussion and agreement with the Water Supply Company on survey blocks, flow measurements were conducted. The flow measurement were made for 24 hours at two points, upstream and downstream, in each supply block.

(2) Leakage Survey

１）Method of Survey

The survey was conducted at two supply blocks. One is at Ratsavong Seuk Road in populated area, and another is at Ban Nonsavath 2 located at the remote service area. Leakage is estimated applying the following formula:

Leakage＝upstream flow－No. of service connection×6.9persons×Average per capita consumption－downstream flow

At the time of survey start, the following survey methods were proposed and discussed with the Water Supply Company:

1）at the time of flow measurement, meter reading is carried out for all water meters located in the survey block, then leakage will be estimated using following formula;

Leakage＝upstream flow－measured consumption－downstream flow

2）close stop cock of service connection during flow measurement, then leakage will be estimated simply as follow;

Leakage＝upstream flow－downstream flow

As the result of discussion on the survey method with the Water Supply Company, method 1) was not applicable since it was difficult to employ numbers of meter readers temporarily. Method 2) was also not applicable due to difficulty to obtain consent of residents. Finally, it was concluded that the average per capita consumption is to be applied for estimation of leakage.

The results of survey are summarized in Table A.5-34.

Table A.5-34 Survey Result

No	Survey Result
1	Survey at Ban Lak 6 on Oct. 20~21 The survey was conducted at Ban Lak 6 along the national road 9. Affected by air intrusion at the measuring points (upstream flow at 2pls) selected at pipe bridges, flow could not be measured. The result of flow measurement at the downstream of supply bloc is shown on Fig. A.5-27. About 5 m3/hr was recorded as the night flow.
2	Survey at Ban Nonsavath on Oct.23~26 The survey was conducted at Ban Nonsavah where is east edge of the service area. It was realized that pipe was not filled with water during peak hour due to pressure drop at the downstream measurement point, thus flow could not be measured. From the upstream flow measurement on Oct.24~25, about 0.6 m3/hr was observed as the night flow as shown on Fig. A.5-28 and 5-29.
No	Survey Result
3	Survey at Ratsavong Seuk Road on Oct. 26~27 The survey was conducted at Ratsavong Seuk Roadin in populated area where distribution main (φ 450mmDIP)feeds water to this supply block with 115 service connection. The result of flow measurement was 348 m3/day as shown on Fig. A.5-30. The leakage is calculated as follow; Leakage $= 348m^3 - 115 \times 6.9p \times 155$ lcd $= 225\ m^3$ From the above, rate of leakage is estimated as high as 65 %. While, night flow was recorded at about 8 m3/hr.
4	Survey at Ban Nonsavath 2 on Oct. 27~28 The survey was conducted in Nonsavath 2 along the Kayson Road. The result of flow measurement was 30 m3/day as shown on Fig.A.5-31. As the connection of this supply block is 45, the leakage of this block is calculated as follow; Leakage $= 30m^3 - 45 \times 6.9p \times 155$ lcd $= -18\ m^3$ Since leakage was calculated as minus, no leakage in this block is assumed. The night flow in this block was also recorded zero.

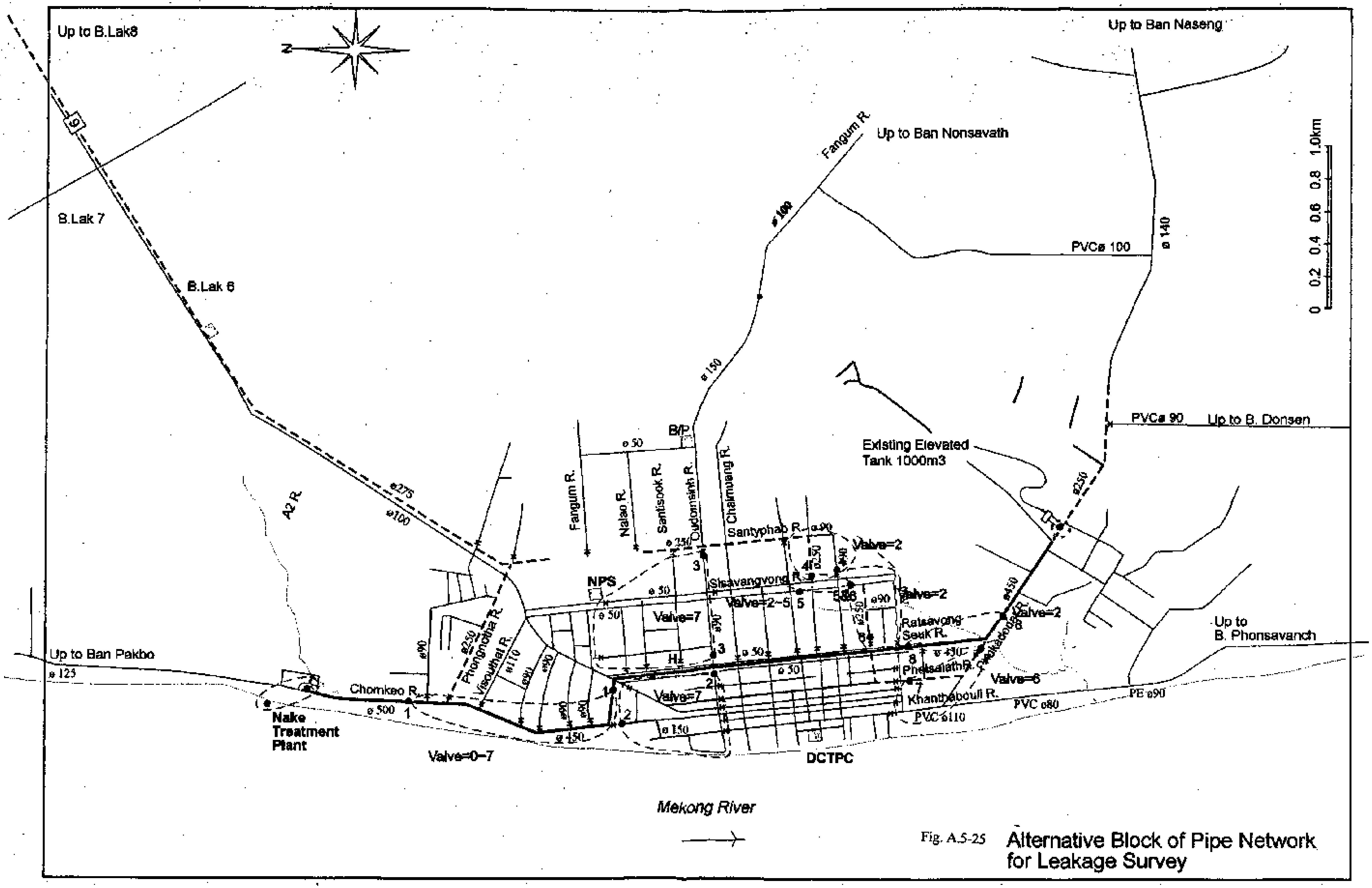


Fig. A.5-25 **Alternative Block of Pipe Network for Leakage Survey**

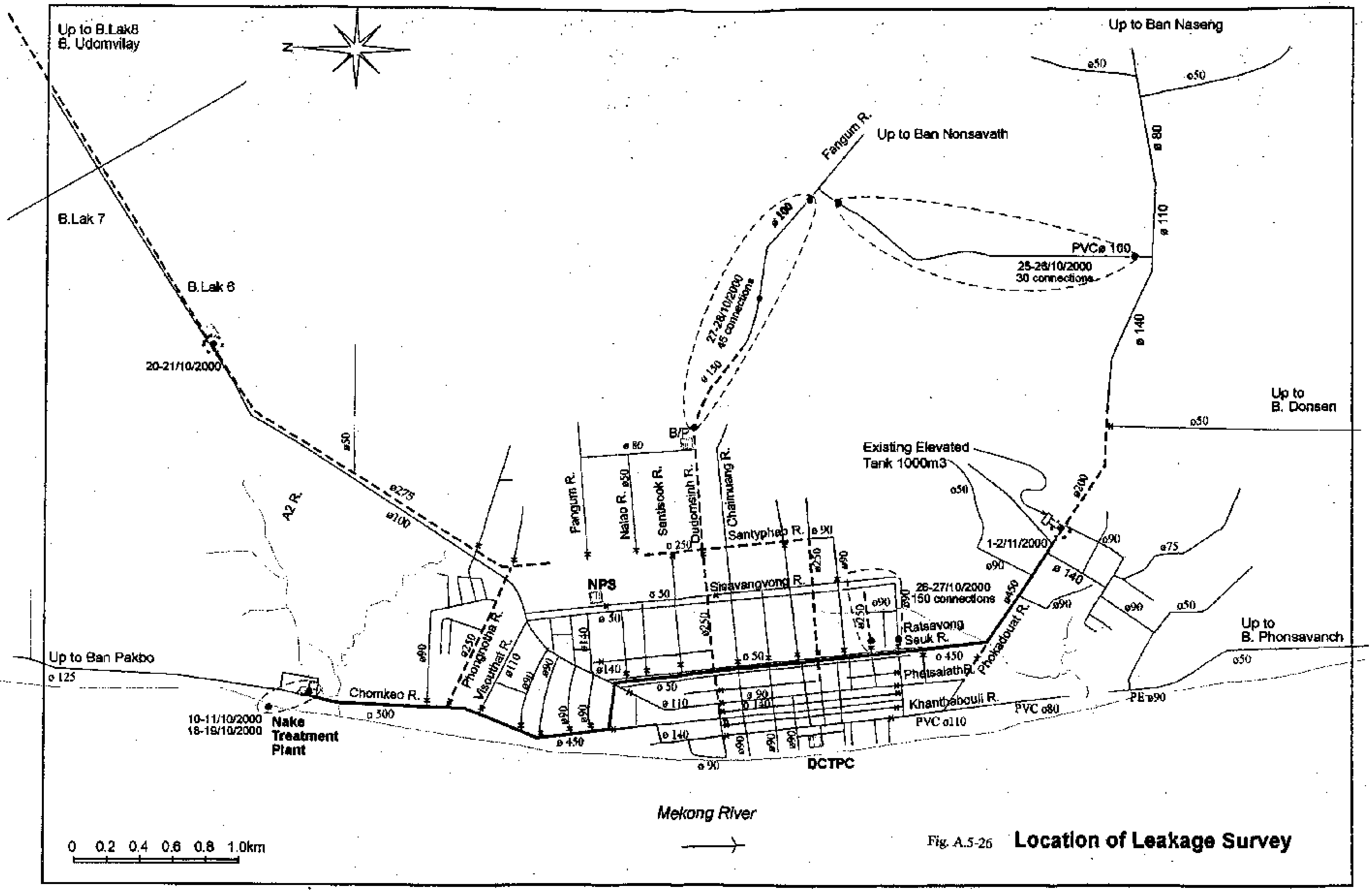


Fig. A.5-26 **Location of Leakage Survey**

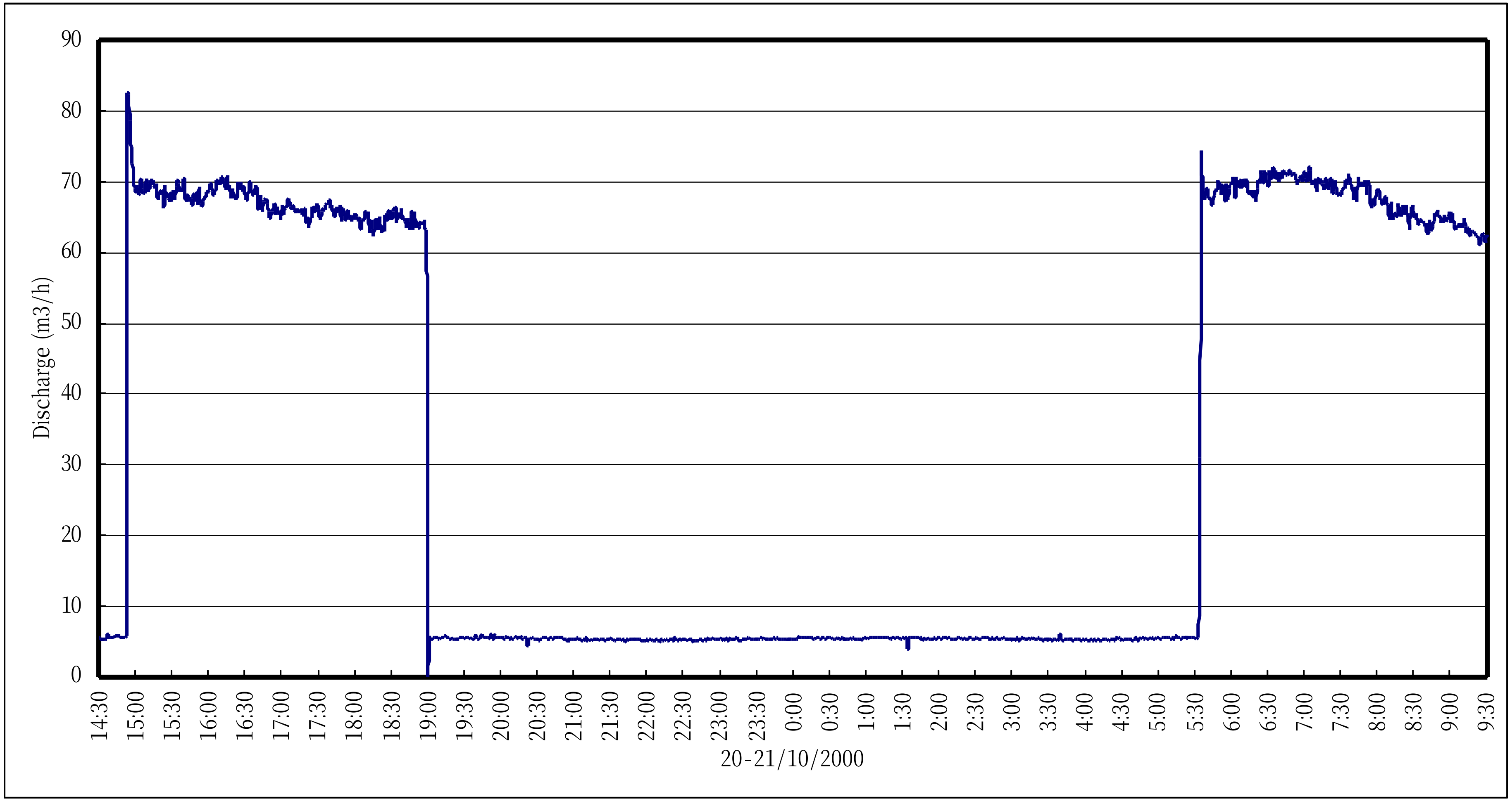


Fig. A.5-27 Distribution Discharge at Ban Lak 6 (Downstream Side) on 20 – 21/10/2000

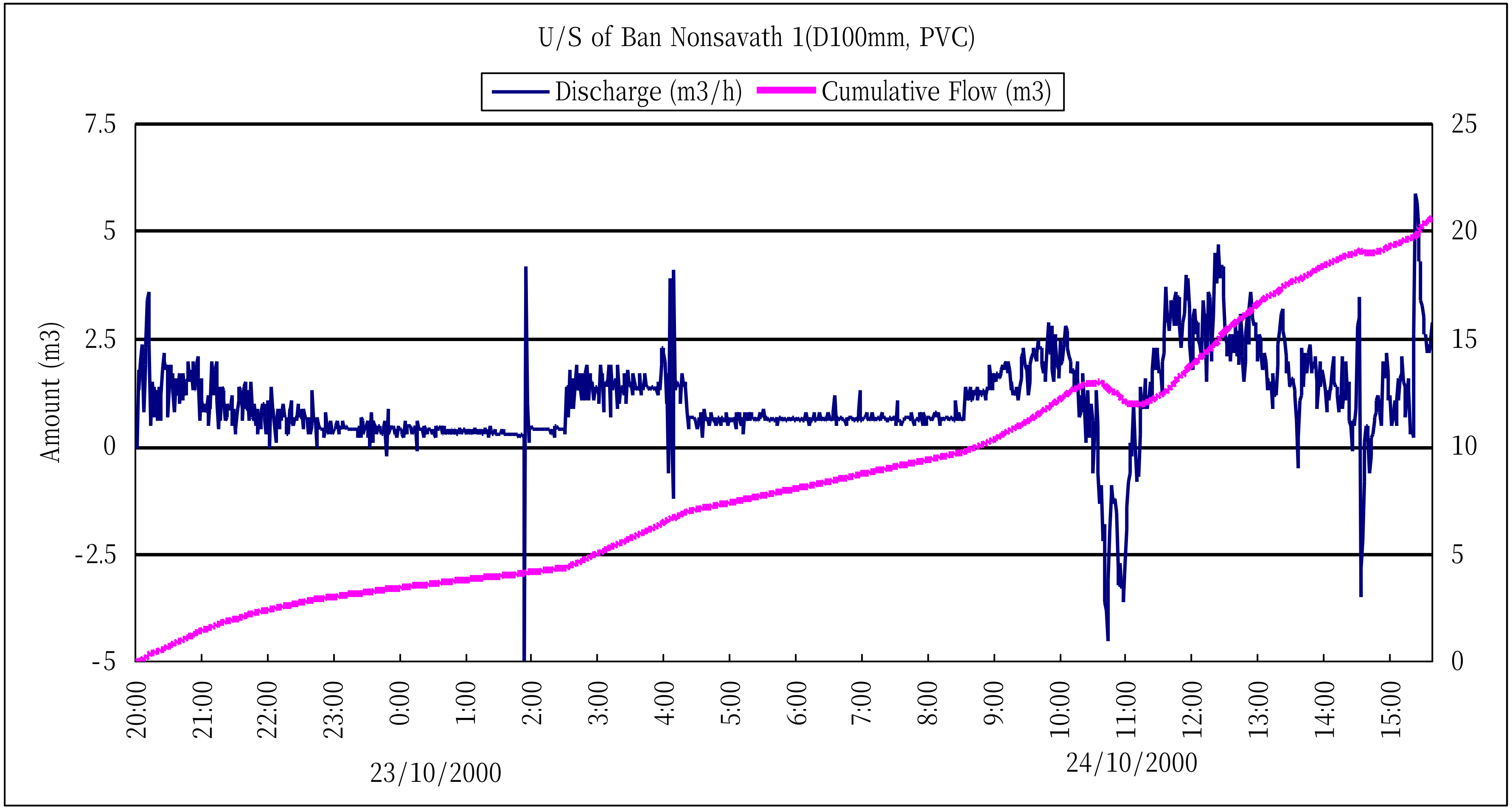


Fig. A.5-28 Distribution Discharge at Ban Nonsavath 1 (Upstream Side) on 23 – 24/10/2000

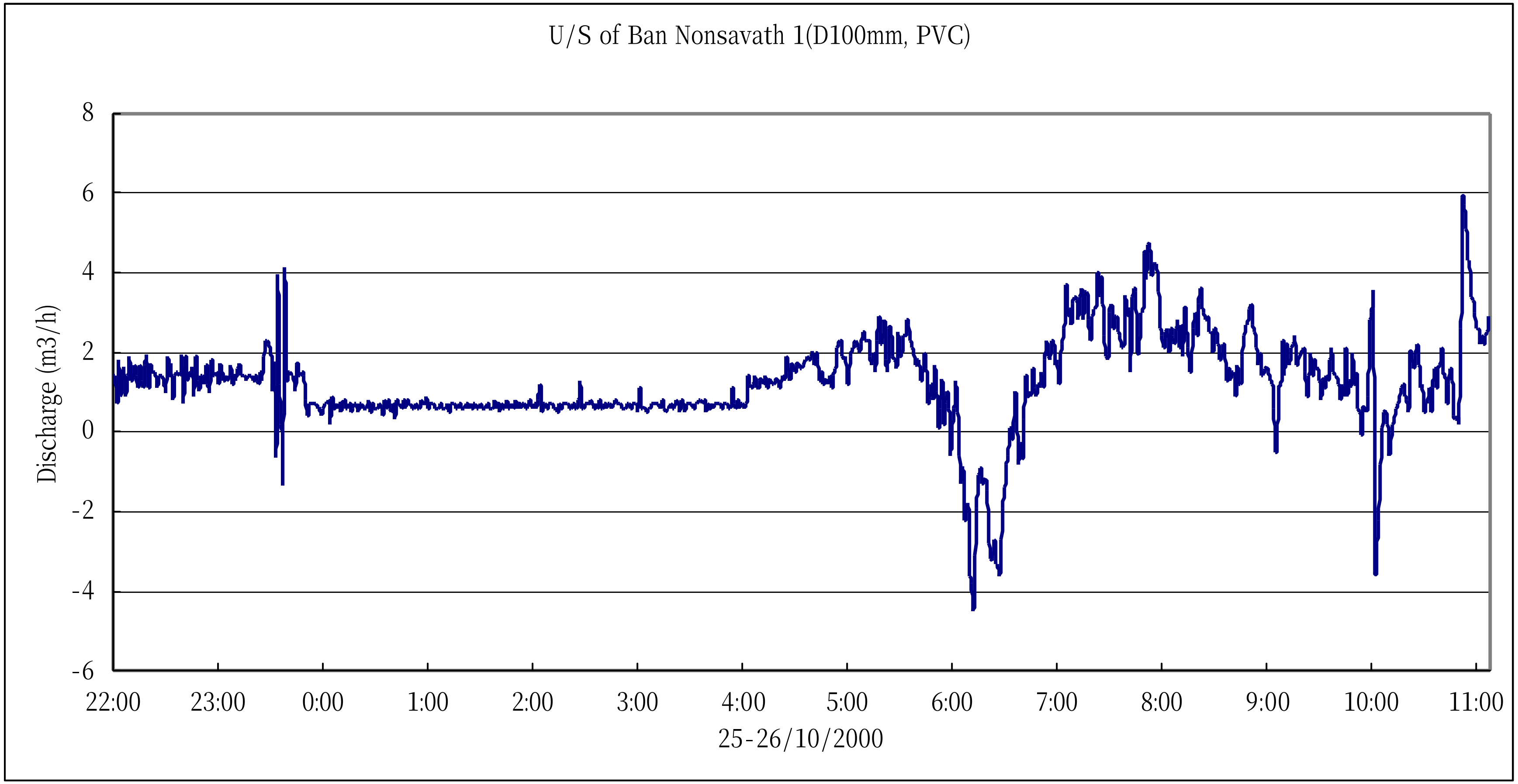


Fig. A.5-29 Distribution Discharge at Ban Nonsavath 1 (Upstream Side) on 25 – 26/10/2000

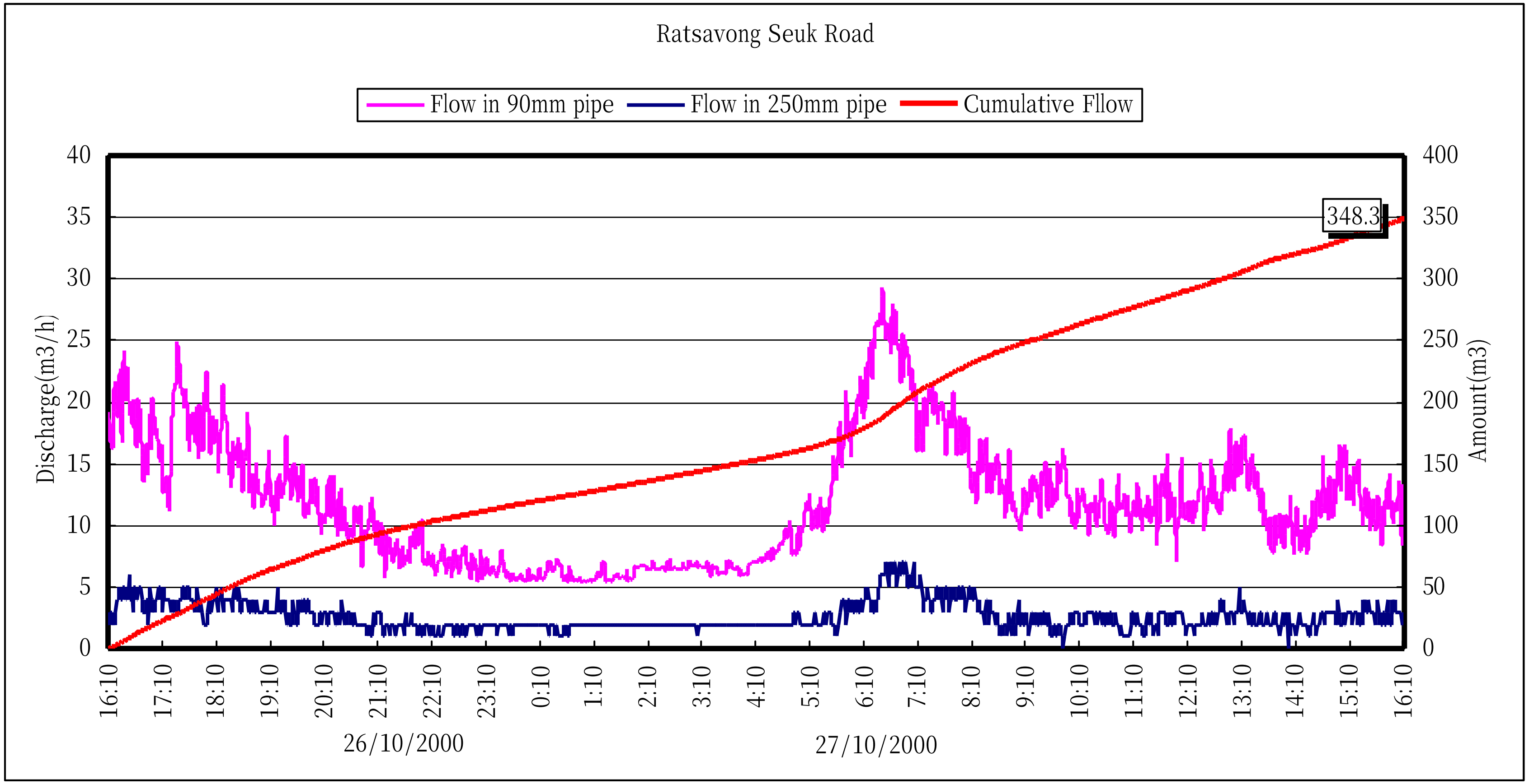


Fig. A.5-30 Distribution Discharge at Ratsavong Seuk Road on 26 – 27/10/2000

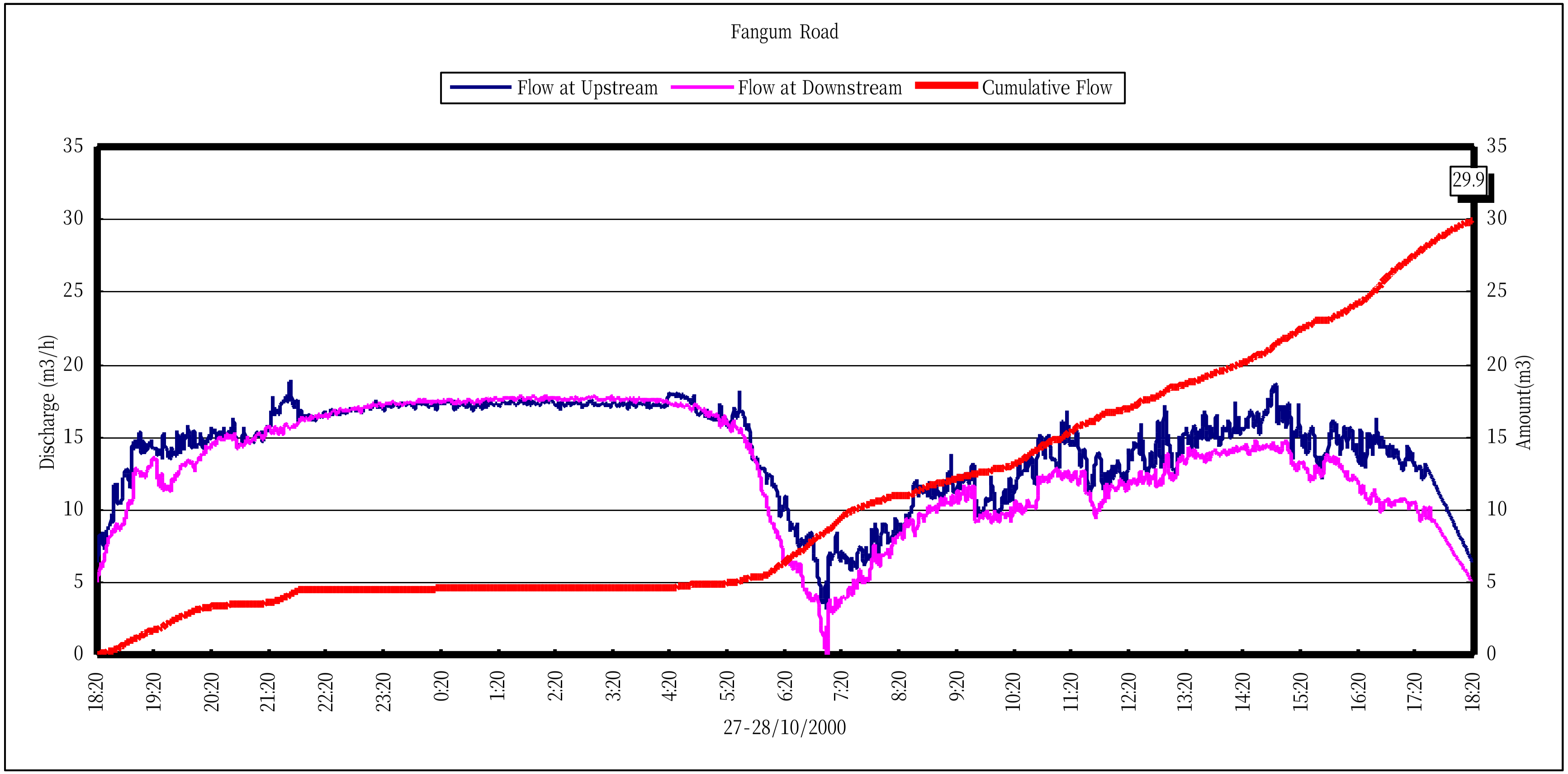


Fig.A.5-31 Distribution Discharge at Ban Nonsvath on 27 – 28/10/2000

5.9 Construction Plan

Major contents of the work for the Project is to rehabilitate the existing defect facilities/equipment and construction of a new clear water reservoir. The works will need sometimes to stop plant operation in such cases of cutting the existing pipes, change over the power source, provisions of opening on the existing structures, and so on. However, it is crucial matter to stop water supply for the service area in Savannakhet since only limited alternative water sources are available in the area. Groundwater in the Savannakhet is hard to use due to its inadequate water quality.

It is therefore necessary to minimize inconvenience to people in Savannakhet by reducing time for water supply stoppage as possible which caused by the rehabilitation works. Adequate plan is inevitable for construction to minimize supply stop. In such case that considerable time for water supply stop is necessary, the arrangement of works during night time shall be planned. It is important to maintain close communication with the Savannakhet Water Supply Company with detailed discussions on work schedule. The schedule for water supply stoppage is to be informed before hand to citizen in the service area.

1. Basic Consideration for Rehabilitation Works

(1) Basic Arrangement of Rehabilitation Works

The order of the works is studied and shown in Table A.5-35 to minimize water supply reduction or stoppage.

Table A.5-35

- Basically, planned facilities and equipment for rehabilitation will be repaired or replaced one by one when there are more than two units (e.g. divide works for four times to replace filter media and under drain),
  First of all the new clear water reservoir will be constructed to store water in it to facilitate water supply using stored water when supply stoppage is necessary (8 hours supply is possible to use one distribution pump for supply),
- New equipment for replacement with related pipes/electric wires will be installed first, then the existing one will be removed,
- As possible water stoppage shall be avoided, while reducing water supply quantity may be allowed,
- Water supply stoppage shall be scheduled in the nighttime when it is unavoidable.

(2) Principal Measure Against Water Supply Stoppage

It is inevitable to avoid water supply reduction and stoppage during the repair or replacement of facilities and equipment. As the principal measure against water supply stoppage, temporary installation of a distribution pump will be planned beside new clear water reservoir using new pump for replacement with temporary piping connected with the existing distribution main. Continuous water supply will be possible by this arrangement even if water supply quantity will be reduced. Temporarily installed pump and piping will be removed after the replacement of the existing distribution pumps by new ones. The replacement of pumps will be made one by one. The time for replacement shall be planned to minimize as possible for deteriorated equipment with new ones. As required, temporary piping and/or wiring shall be arranged to make shorten the time for stoppage of plant operation.

When repair or replacement of certain equipment is judged to cause water supply stop, the temporary pump for distribution will be operated. Although water supply quantity will be reduced during such time, it will considered not critical since most of consumers have their own storage tanks in their premises.
Fig. A.5-32 shows layout of piping for reservoir inlet and outlet with temporary piping for distribution, and layout of piping for raw water main is shown on Fig.A.5-33.

2. Examination on Arrangement of Work

(1) Stop of Plant Operation by Item of Work

Based on the above principal measure to install the temporary distribution pump, time required to stop plant operation is examined for each major work item. The result of examination is summarized in Table A.5-36.

Table A.5-36 Major Work Items and Stop of Plant Operation

Work Category	No	Work Items		Operat-ion stop	Order of Works				
		Works	Details Work Items		1	2	3	4	5
Civil Work	①	Filter Connection well	Connection work	8hrs	●				
	②	Distribution Suction well	Temporary Shut-off	1 day				○	
Pipeline	③	Raw Water Flow Control Equip	φ450mm～ φ400mm	5hrs			○		
	④	Filter Outlet Pipe	φ500mm connection	4hrs	○				
	⑤	New Distribut-Ion Main	800mm connect with pump well	14 days					○
	⑥	Temporary piping for distribution main	φ 350mm connection	8hrs		●			

Table A.5-36 Major Work Items and Stop of Plant Operation (Continued)

Work Category	No	Work Items		Operat-ion stop	Order of Works				
		Works	Details Works Items		**1**	**2**	**3**	**4**	**5**
Mechanical Equip.	⑦	Raw Water Intake Pump	Pump installation	5hrs					
	⑧	Rapid Mixer		5hrs			○		
	⑨	Flocculator		5hrsx2			○		
Mechanical Equip.	⑩	Sludge Valve of Sedimentation Baisn	φ350mm Flush Bottom V.	5hrsx2			○		
	⑪	Filter Valves	Inlet, Backwash Air Score, Outlet	8hrs x2x2		○	○		
	⑫	Filter Sand and Under Drain		14days				○	○
	⑬	Distribution Pump	Changeover between new and existing one	12hrs x 3units					
	⑭	Backwash Pump	Changeover between new and existing one	12hrs x 2units				○	●
Chemical Equip.	⑮	Storage Tanks and Feeder	Changeover between new and existing one	1~3hrs each				○	○
Electrical Equip.	⑯	Power Receiving	Connection between New and Existing one	5hrs	○				
	⑰	MCC1 Power Control Panel	Connection between New and Existing one(for plant)	1hr			●		
	⑱	MCC2 Power Control Panel	Install after removal of existing one	5hrs		○			
	⑲	Pipeing/cabling	Changeover between new and existing one	1~5hrs	○	○	○	○	○

● work items which need water supply stop

(2) Order and Arrangement of the Major Works

Although period required for each component of rehabilitation work will be longer, the work plan shall be prepared to minimize time for water supply stoppage or reduction of supply quantity. A total construction period could be maintained within predetermined time frame by arranging timing of construction for each work item and their combination properly. Table A.5-37 describes order and arrangement of construction/installation of work items and their combination which are planned in accordance with the above basic consideration for rehabilitation work.

Table A.5-37 Order and Arrangement of Works

Construction of new reservoir and filter connecting well with installation of related pipelines. Installation of temporarily used distribution pump beside new reservoir.

① Provision of opening on filter outlet channel to connect it with filter connecting well. ④ Cutting existing filter outlet pipe and connecting it with new filter outlet pipe installed in the above at the same timing. By these works, flow from filter to existing reservoir is maintained through new route. 8 hours is expected for stop of plant operation.

⑥ Installation of temporary piping between new reservoir and existing distribution main. Provision of power supply for temporary distribution pump is to be made before the above work. Then, the route: filter—filter connection well—new reservoir—temporary distribution pump—existing distribution main, is established. 8 hours is expected for stop of plant operation.

⑭ Replacement of one backwash pump after washing of filter (2 filters). Existing reservoir is to be closed. ② Installation of temporary shut-off in distribution pump well simultaneously. Allowable time for this work is 24 hours. After installation of temporary shut-off, existing reservoir is opened and used as usual. These works will be repeated to replace another backwash pump in 2~3days later. Water supply can be maintained using temporary distribution pump.

⑤ Connection of outlet pipe from new reservoir with pump well. Pump well will be empty for about 2 weeks for curing concrete placed at the time of connection work. Water supply is also maintained using temporary distribution pump.

⑬ Replacement of distribution pumps. For installation of temporarily installed pump in existing pump station, some 12 hours will be required and it is necessary to stop water supply during above installation work. ②Removal of temporary shut-off in pump well simultaneously.

③ Installation of raw water flow measurement and control equipment on the existing raw water main. ⑧ Installation of rapid mixer on mixing well. These works will be carried out in the nighttime after establishing temporary by-pass line for distribution as water supply stop is inevitable. No severe problem for supply is expected since water supply is maintained using temporary distribution pump during nighttime.

⑪ Replacement of valves of filter. Replacement works will be carried out for every 2 filters for 2 times with about each 8 hours period. No water supply stoppage will occur when this work is carried out in nighttime by storing water in new reservoir and operating temporary distribution pump.

⑫ Replacement of filter under drain and filter media one by one. No water supply stoppage will occur even though considerable time is necessary for the work as each filter can be operated independently after replacement of filter valves.

⑨ Replacement of flocculator. ⑩ replacement of sludge valve of sedimentation basin. Although supply quantity will be reduced, no supply stop will occur since replacement works can be carried out one by one. By filling water in the reservoir before starting the work, reduction of supply quantity can be minimized.

(3) Arrangement for Other Works

Other than major works described in the above, arrangement of rehabilitation works for chemical feeding and electrical equipment are examined as described below.

1) Repair and Replacement of Chemical Feeding Equipment

Rehabilitation works, i.e., repair and replacement works for chemical feeding equipment can be carried out by utilizing the existing ones as they have stand-by unit. Existing chemical storage tanks will be utilized with necessary repair and internal lining. Repair works or lining works can be carried out one by one without significant influence for plant operation. New piping will be made first, and necessary connection will be followed with 1~3 hours stoppage of operation. No stop for plant operation will be required by maintaining necessary water supply from new reservoir.

2) Power Receiving Equipment

Changeover work for replacement of the existing power receiving equipment will be carried out by Power Supply Company (EDL). The necessary materials and equipment for the work are to be provided before start of the work. Time for this changeover work is estimated for about 5 hours.

3) MCC1 Power Control Panel

MCCI power control panel will supply whole power of the treatment plant. Since new panel is planned to be installed different place from the existing one, no power-off is necessary. Care shall be taken during the work with proper connection of electric wire by confirming the existing wiring.

4) MCC2 Power Control Panel

MCC2 is a power control panel for raw water intake pumps. Due to the limited space available, this panel is to be installed after removal of the existing panel. And therefore power supply cut is inevitable. Further, changeover of the main electric wire shall be required, since the existing conduit pipe for wiring installed on the access bridge is planned to be utilized. Total 7 hours is estimated to stop pump operation of raw water intake pump composing of 3 hours for removal of existing panel and installation of new one and 4 hours for changeover of electric wire between the existing and new one.

3. Influence of The Rehabilitation Work for Reduction or Stoppage of Water Supply

Work items and time required for water supply stoppage is shown with ● mark in Table A.5-36.

As shown in the table, water supply stoppage during the rehabilitation works is expected as once for 12 hours stoppage, twice for 8 hours and once for 1 hour.

Thus the maximum water supply stoppage is 12 hours during the rehabilitation works.

The work which needs maximum water supply stoppage is however could be carried out during nighttime, and therefore it is judged that no severe influence to customer will be expected. However, the above examination was made to grasp the time and cases for water supply stoppage in the basic design stage only. It is important that adequate and detailed construction plan is to be prepared during the detailed design stage, and during implementation stage strict time control of construction/installation work shall be maintained in accordance with the construction plan.

Although adequate construction plan and strict time control for construction/installation is required against complex rehabilitation works, safety for the works shall also be taken into account with due arrangement of safety provision especially for night work and electrical work during power supply cut and recovery. It is important to establish proper organization for construction team with clear roles and responsibilities for staff members. Close communication shall be inevitable with Power Supply Company for confirmation on power supply cut and recovery to avoid unexpected accidents.

Fig. A.5-32 Piping Schematic for Reservoir Rehabilitation

NOT TO SCALE

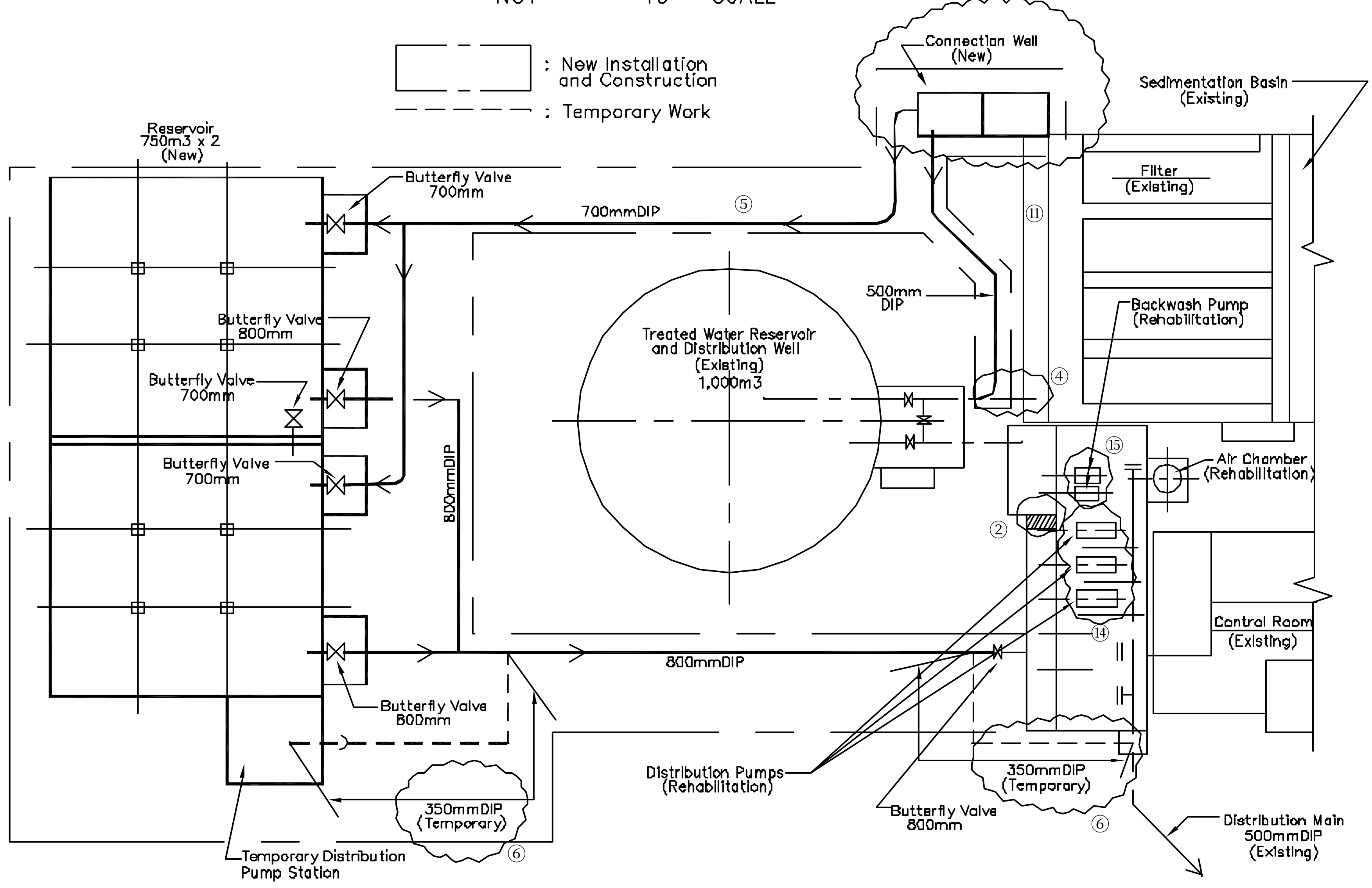
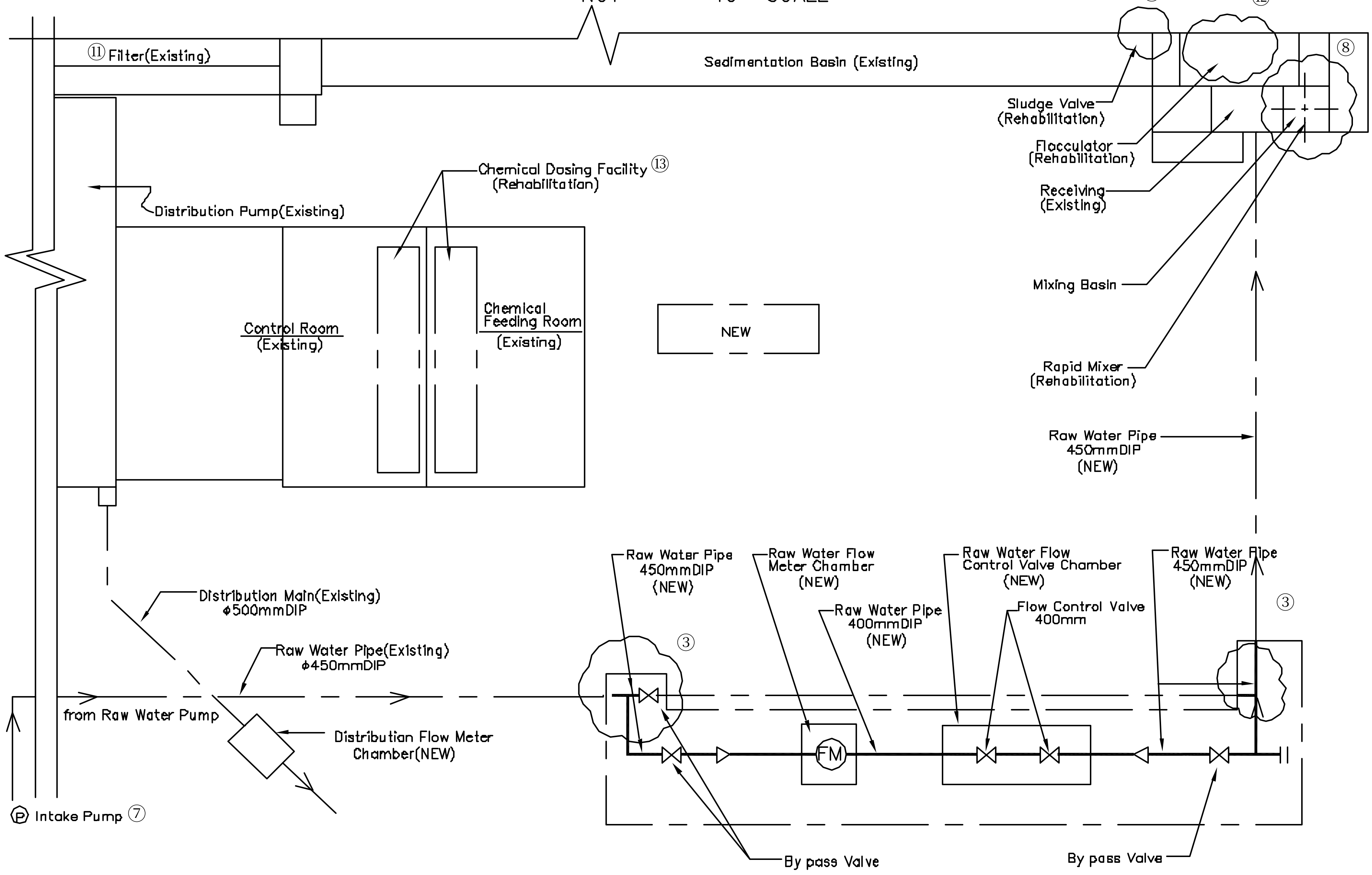


Fig. A.5–33 Rehabilitation of Raw Water Transmission Main

NOT TO SCALE



Appendix ５．１０

Photos

Photo No. 1

Nake Raw Water Intake Tower,
Raw Water Intake Pump and Piping -1

Photo No. 2

Nake Raw Water Intake Tower,
Raw Water Intake Pump and Piping -2

Photo No. 3

Nake Raw Water Intake Tower,
Raw Water Intake Pump and Motor

Photo No. 4

Nake Raw Water Intake Tower,
Raw Water Intake Pumps and Floor with Grating

Photo No. 5

Rotor of Motor for No.3 Raw Water
Intake Pump
(Rotor has been burnt out)

Photo No. 6

Motor Failure for No.3 Raw Water
Intake Pump
due to over lard (on 24 Oct'2000)

Photo No. 7

Support for Intermediate Pump Shaft
(made by manufacturer in Vietnam)

Photo No. 8

Support for Intermediate Pump Shaft
(original support)

Photo No. 9

Name Plate of Raw Water Intake Pump

Photo No. 10

Raw Water Transmission Main on
Operation Bridge
(spiral SP with dresser joint)

Photo No. 11

Rapid Mixer on Mixing Well and Piping
for Polymer

Photo No. 12

Flocculator on Flocculation Basin

Photo No. 13

V-Belt of Flocculator
(belt is being cut)

Photo No. 14

Flocculator (over view)

Photo No. 15

Motor Control Center for Wash Pumps of Sedimentation Basin, Rapid Mixers and Flocculators (front view)

Photo No. 16

Operating Floor Stand for Sludge Valve of Sedimentation Basin
(two operators try to open the valve)

Photo No. 17

Sludge Valve of Sedimentation Basin
(bent valve shaft with stain)

Photo No. 18

Sludge Valve of Sedimentation Basin
(after washing basin operator try to insert valve disk into body)

Photo No. 19

Wash Pipe of Sedimentation Basin

Photo No. 20

Inlet Gate of Filter (severe stain of gate is observe)

Photo No. 21

Filter Media

Photo No. 22

Worm (Larva of Caddis Fly) be found in Filter Media

Photo No. 23

Be in Filter Washing (damage of filter under drain is suspected from air blowing at the inlet of filter)

Photo No. 24

Backwash Pump of Filter and Piping (foot valve is installed on suction pipe)

Photo No. 25

Backwash Pump of Filter (priming pipe for suction pipe is connected with delivery header main)

Photo No. 26

Backwash Pump of Filter (Motor is out of order)

Photo No. 27

Removed Motor from Backwash Pump

Photo No. 28

Air Blower of Filter

Photo No. 29

Outlet and Backwash Valve (stained)

Photo No. 30

Filter Outlet Control Device (over view)

Photo No. 31

Filter Outlet Control Device (adjusting lever)

Photo No. 32

Filter Outlet Control Device (controller under water is stained)

Photo No. 33

Float for Filter Outlet Control Device (stained)

Photo No. 34

Distribution Pumps and Piping (vibration of discharge pipe is observed due to no support)

Photo No. 35

Distribution Pump (reported frequent failure)

Photo No. 36

Distribution Header Pipe (Orifice meter is out of order)

Photo No. 37

Distribution Pump (rubber pad for shaft coupling is Damaged frequently)

Photo No. 38

Distribution Pump (severe stain is observed on gland)

Photo No. 39

Monorail Hoist in Distribution Pump Room (hoist crane is out of order)

Photo No. 40

Air Chamber for Surge Control

Photo No. 41

Air Compressor for Air Chamber (out of order)

Photo No. 42

Control Panel of Distribution Pumps (front view - 1)

Photo No. 43

Control Panel of Distribution Pumps
(front view - 2)

Photo No. 44

Inside View of Control Panel of
Distribution Pumps
(deterioration of instrument is observed)

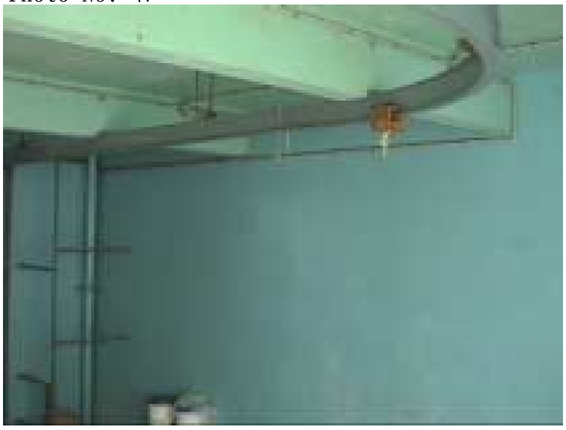
Photo No. 45

Inside View of Control Panel of
Distribution Pumps
(screwdriver is used for switch gear lever)

Photo No. 46

Weight Scale for Chemicals (out of order)

Photo No. 47



Monorail Hoist in Chemical Feeding
Room (hoist is removed)

Photo No. 48

Alum Feeding Equipment
(mixer on Alum Solution Tank No.1)

Photo No. 49

Alum Feeding Equipment
(mixer for Alum Solution Tank No2 is removed)

Photo No. 50

Alum Feeding Equipment (over view)

Photo No. 51

Alum Feeding Equipment (alum feeder)

Photo No. 52

Alum Feeding Equipment (air intrusion into injector is observed due to drop of liquid level)

Photo No. 53

Lime Feeding Equipment (over view, not used at present)

Photo No. 54

Lime Feeding Equipment (mixers on solution tanks are removed)

Photo No. 55

Lime Feeding Equipment (circulation pumps)

Photo No. 56

Hypo-chlorite Feeding Equipment (over view)

Photo No. 57

Hypo-chlorite Feeding Equipment (only one solution tank is used)

Photo No. 58

Hypo-chlorite Feeding Equipment (severe deterioration is observed on interior surfaces)

Photo No. 59

Hypo-chlorite Feeding Equipment (hypo-chlorite feeder)

Photo No. 60

Hypo-chlorite Feeding Equipment (air intrusion into injector is observed due to drop of liquid level)

Photo No. 61

Control Panel for Chemical Feeding Equipment (front view, out of order)

Photo No. 62

Control Panel for Chemical Feeding Equipment (inside view of panel)

Photo No. 63

Laboratory (over view)

Photo No. 64

Laboratory (glass ware)

Photo No. 65

Laboratory (jar tester)

Photo No. 66

Laboratory (turbidity meter)

Photo No. 67

Power Sub-station (over view)

Photo No. 68

Power Receiving Equipment
(transformer, out of order)

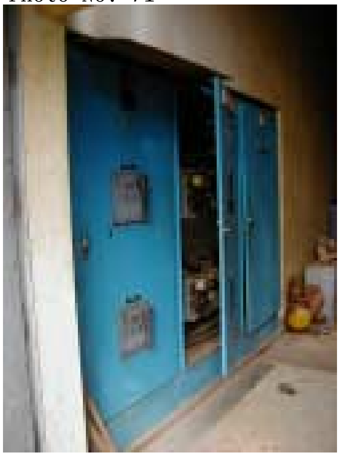
Photo No. 69

Power Receiving Equipment
(power receiving panel, out of order)

Photo No. 70

Power Receiving Equipment (condenser)

Photo No. 71



Power Receiving equipment
(presently used power receiving panel,
front view - 1)

Photo No. 72

Power Receiving equipment
(presently used power receiving panel, front view - 2)

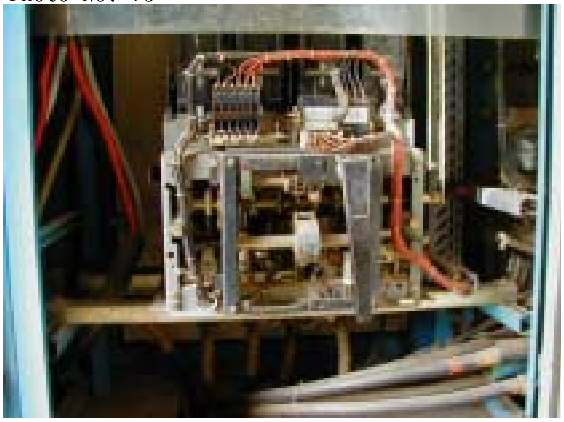
Photo No. 73

Power Receiving Equipment
(presently used power receiving panel, front view - 3)

Photo No. 74

Power Receiving Equipment
(inside view, screwdriver is used for switch gear lever)

Photo No. 75



Power Receiving Equipment
(inside view)

Photo No. 76

Stand-by Generator (over view)

Photo No. 77

Control Panel for Generator

6. Cost Estimation Borne by the Recipient Country

Appendix 6 Cost Estimation Borne by the Recipient Country

Base on the works to be carried out by the Lao PDR for smooth implementation of the Project and after its completion to facilitate the effects of the Project, the cost estimation is made. The total cost boned by Loa PDR is estimated at Kip.1,686 million. The breakdown of the cost estimation for each cost item is shown as follows:

1) Supply of Water, Power and Chemicals for Construction and Test Operation

- Water Supply during Construction;

10 m3/day x 10 months x 30 days/month		= Kip. 1,950,000

- Power Supply for Test Operation;

Raw Water Intake Pump	37 kW x 20 hrs x 3 pumps x 20 days =	44,400 KWH
Distribution Pump	75 kW x 20 hrs x 3 pumps x 20 days =	90,000 KWH
Other Equipment		10,000 KWH
Total Power Consumption		144,000 KWH
144,400 KWH x Kip.239/KWH		= Kip. 34,416,000

- Chemical Supply for Test Operation;

Alum	15,000 m3/day x 50 ppm x 10 days =	7,500 kg
7,500 kg x Kip.1,500/kg		=Kip. 11,250,000
Total Cost for Item ①		Kip. 47,616,000
	rounded	(Kip. 48 million)

2) Power Receiving (22 kV, 3 phase)

Installation of power cable for about 150m including cutting existing power cable and reconnection Kip. 21,000,000

rounded (Kip. 21 million)

3) Demolition and Removal of Existing Warehouse (6 m x 12 m x 2 warehouses)

Demolition	144 m2 x Kip.750,000/m2	=Kip. 108,000,000
Removal and Land Reclamation for Reservoir Construction		=Kip. 8,000,000
Total		=Kip. 116,000,000
	rounded	(Kip.116 million)

4) Installation of Service Connections and Small Size Pipelines

- Installation of Service Connections;
  1,100 connections x Kip.350,000/conn. =Kip. 385,000,000
- Installation of Pipelines(50mm PVC)
  13,200 m x Kip.83,000/m =Kip.1,095,600,000

  Total =Kip.1480,600,000
  rounded (Kip.1480 million)

5) Expenses for Staff Training

- Personnel Cots of Trainee
  6 persons x Kip.4,600/day x 5 months x 30 days =Kip. 4,140,000
- Training in Chinaimo Water Treatment Plant (accommodation in Vientiane City)
  3 persons x Kip.189,200/day x 30 days =Kip. 17,028,000

  Total =Kip.21,168,000
  rounded (Kip. 21 million)

APPENDIX-B

Soft Component Proposal

JAPAN INTERNATIONAL COOPERATION AGENCY

BASIC DESIGN STUDY ON THE PROJECT FOR REHABILITATION OF WATER SUPPLY FACILITIES IN SAVANNAKHET AREA IN LAO PDR

SOFT COMPONENT PROPOSAL

MARCH 2001

NIHON SUIDO CONSULTANTS CO., LTD.

BASIC DESIGN STUDY ON THE PROJECT FOR REHABILITATION OF WATER SUPPLY FACILITIES IN SAVANNAKHET AREA IN LAO PDR

SOFT COMPONENT PROPOSAL

CONTENTS

1. BACKGROUND

The water supply facilities in Savannakhet city were constructed under the assistance of French Government and its operation started in 1977. The facilities included Nake Water Treatment Plant with the capacity of 15,000 m^3/day and distribution networks consisting of 54 km pipelines. However, after 24 years operation since its inauguration, the production capacity of the existing treatment plant has been decreasing due mainly to the deterioration of plant facilities and equipment. Owing to this situation, frequent water supply stoppage has been occurred in the recent years, which generates unstable condition of water supply. The present project for "Rehabilitation of Water Supply Facilities in Savannakhet Area", is planned aiming at improvement of the existing water treatment plant by rehabilitation the deteriorated facilities and equipment to achieve safety and stable water supply services to the people in Savannakhet city.

To realize the Project's effect in early stage and to maintain its sustainability, it is vital for the implementation Savannakhet Water Supply Company (NPS) to maintain proper operation and maintenance of the improved water treatment plant which is constructed under the scheme of Japanese Grant Aid. Further, it is required for NPS to establish and organize the management system for future repair and maintenance of the facilities with his own force.

Especially, it is important to establish measuring and recording system for proper operation and maintenance based on the actual measurement and accumulated data. In the past, flow was not measured and water quality was not analyzed due to malfunction of the existing equipment.

It is essential to establish a proper system to improve financial status for sound operation of water supply system by appropriate financial analysis and improving water billing system. Adequate budgeting is to be planned for operation and maintenance of the system including repair works and procurement plan for spare parts.

By giving indirect aid to establish and improve the above mentioned organizational/institutional, financial and technical aspects, the effects of the Project will be accelerated and sustainability of water supply system operation will be maintained. In this connection, the introduction of soft component is recommended will cover managerial aspects including water billing system and technical aspects for operation and maintenance.

2. OBJECTIVES

The introduction of present soft component aims at the improvement of water supply operation of NPS in technical and managerial aspects, especially (1) to execute rational operation and maintenance based on the operation records/data obtained through actual measurements such as flow rate and water quality, (2) to improve billing and collection system for their efficient and accurate operation. With the above achievement, it is expected that the facilities and equipment due to the Project could be utilized effectively.

In addition to the above, it is aiming at the sound management of NPS with proper planning for improvement and extension of water supply system in Savannakhet city toward increasing water demand to grasp conditions of water supply services.

3. OUTPUT (DIRECT EFFECTS)

The expected direct effects due to the introduction of soft component are presented as follows:

- Financial control based on appropriate cost setting for operation and maintenance.
- Efficient billing and collection system.
- Improvement of ratio for metered connections with necessary repair and replacement of defective meters.
- Improvement of water quality control for supply.
- Improvement for accumulation of operation records/data and filing system.
- Undertaking proper system operation and maintenance based on the actual measurements.

4. ACTIVITIES

To achieve the above objectives, the activities of the present soft component will include three major aspects for: Management & Financial, Billing and Collection, and Operation and Maintenance. Manuals and forms for daily routine works will be provided by the respective experts which will be translated into Lao so as to utilized them by all NPS staff /workers.

At the commencement of each activity, workshop (one day around) will be held. This workshop will be organized by the purposes to discuss with NPS's staff of related field the problems and isssues which derive from their daily routine works, and to have a common understanding for the problrms. The discussions will find solutions for the problems and way to improve them where possible.

Based on the above discussions, practicable solutions and/or measures will be recommended, and necessary advice and guidance will be given to the NPS's staff by the experts through their activities during the implementation of the soft component.

In the workshop, PCM will be applied for the analysis of objectives and problems, so that all of the attendants may have a chance to present their opinions to define the problems on the routine works.

To enhance the consciousness of NPS's staff for the improvement of their services/works and to assist their self-supporting development, another workshop will be held at the end of each activity to discuss and identify the following issues:

1) Effects obtained through the present soft component.
2) Improved items that were identified as the problems in the previous workshop.
3) Subjects for future improvement of respective services/works.

4-1 Advice and Guidance for Managerial and Financial Aspects

The activities for managerial and financial aspects include the following items:

1) Guidance for general aspects of water supply services,
2) Advice and guidance on cost analysis such as unit production cost for operation of water supply system,
3) Advice and guidance on financial analysis,
4) Advice and guidance on water tariff setting,
5) Advice and guidance on book keeping for accounting and ledger keeping for inventory control, and
6) Follow up services after hand over of the facilities.

The expected direct effects due to the above activities include:

- To acquire basic knowledge on managerial and financial aspects for water supply system operation,,
- To enhance consciousness on costs required for water supply system operation,
- To acquire technical skill on financial analysis,
- To understand proper water tariff system, and
- To improve book keeping for accounting and ledger keeping for inventory control.

Products: Standard forms of book keeping for accounting and ledger keeping for inventory
control, and
Records on training.

4-2 Advice and Guidance for Billing & Collection System

The activities for efficient billing and collection system include the following items:

1) Advice and guidance on recording system for meter reading and bill collection using computer,
2) Advice and guidance on recording system for billing and money receiving,
3) Advice and guidance on detection of water meter under registration,
4) Guidance on repair of defective meter, and
5) Preparation of manual for meter reading and bill collection.

The expected direct effects due to the above activities include:

- To improve efficiency for meter reading and bill collection activities,
- To enhance efficient accounting through proper arrangement of recording system for billing and money receiving,
- To set up proper bill collection through effective detection of defect meters and prompt action for repair and replacement of them, and
- To set up efficient meter reading.

Products: Standard forms for recording of billing, money receiving and meter reading,
Manual for meter reading and bill collection, and
Records on training.

4-3 Advice and guidance for Operation and Maintenance of Water Supply Facilities and Equipment

The activities for operation and maintenance of water supply facilities and equipment include following items:

1) Guidance on general technical matters of water supply system,
2) Guidance on preparation of operation and maintenance plan,
3) Advice and guidance on repair and maintenance of facilities/equipment with procurement plan of spare parts,
4) Preparation of a manual for daily operation and maintenance,
5) Training for water quality analysis and control including chemical application (including training at Chinaimo W. T. Plant),
6) Guidance on recording and filing system for plant operation,
7) Training for operation and maintenance of water treatment plant during test operation, and
8) Follow up training after hand over of the facilities.

The expected direct effects due to the above activities include:

- To acquire knowledge on water treatment processing and maintenance of facilities/equipment of water treatment plant,
- To enhance efficiency of works by obtaining knowledge for operation and maintenance of water supply facilities/equipment,
- To facilitate adequate maintenance of facilities based on proper methods for repair/maintenance and properly arranged maintenance plan,
- To facilitate stable operation supported by proper procurement plan of spare parts,
- To facilitate proper water quality control supported by adequate chemical application to cope with raw water quality and to maintain its recording and filing, and
- To prepare reports on operation based on the actual measurement.

Products: Standard forms for O & M plan and reporting,
Manual for daily operation and maintenance plan, and
Records on training.

5. PROJECT CONTENTS AND EFFECTS FOR EACH TERM

The Project is scheduled to be implemented under the single fiscal year term based on the results of Basic Design Study. Consequently, the above mentioned activities with submissions of the relevant products such as manuals due to the present soft component, shall be carried out in accordance with the Project Implementation Schedule. The result of each activity in each component with its evaluation and records of each work shop are compiled in a final report and it will be submitted at the time of completion of services together with above products.

6. IMPLEMENTATION PLAN

6-1 Organazation

The proposed services for the Soft Component Services are planned to be conducted by three Japanese Experts as follows:

(1) **Expert for Management and Billing & Collection System**:
Provides advice and guidance with training on the above item 4, sub-item No.4-1: Managerial and Financial Aspect and item No. 42 Billing and Collection. And also organize workshop on his part.

(2) **Expert for Operation and Maintenance for Water Treatment Facilities**:
Provide advice and guidance with training on the above item 4, sub-item No. 4-3: Operation and maintenance for Water Supply Facilities and Equipment. As for the water quality analysis, he will work along with the expert for this item. And also, arrange workshop for this part.

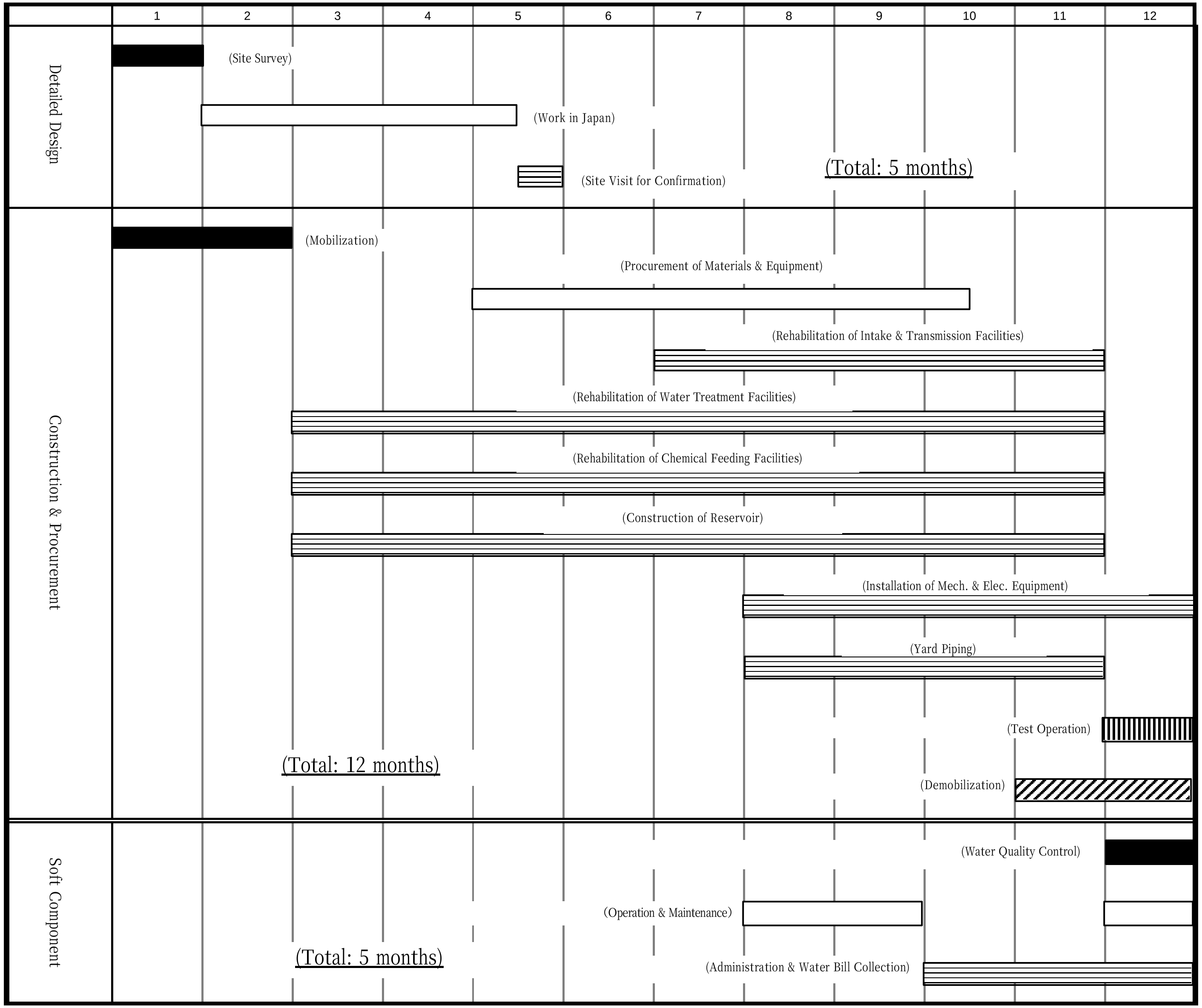
(3) **Expert for Water Quality Control**:
Provide advice and guidance with training on water quality analysis and control including chemical application. He will work with the Expert for Operation and Maintenance regarding chemical feeding in line with water treatment process.

Since the above services by the respective expert are provided for the staffs of NPS who are responsible to carry out their duties at the respective work sites, it is therefore inevitable to maintain the communication between experts and NPS's staffs as trainee through translators. In this connection, assistance by the staff from Water Supply Authority and Vientiane Water Supply Company will be necessary.

6-2 Implementation Plan

The present soft component is planned to be carried out in line with the project implementation schedule as shown on Fig. 1-1.

Appendix 1 Project Implementation Schedule



ATTACHMENT

PROJECT DESIGN MATRIX: PDM

Project Title : Project for Rehabilitation of Water Supply Facilities in Savannakhet Area in Lao PDR

Implementation Period : October 200 to March 2003

Target Area : Savannakhet Area

Target Group : Savannakhet Water Supply Company (NPS)

Narrative Summary	Objective Verifiable Indicator	Means of Verification	Important Assumptions
Overall Goal 1. Sound operation of water supply management 2. Preparation for practical planning of future water supply system development	1-1 Stabilize water sale of NPS. 1-2 Understand necessary costs for operation and maintenance. 1-3 Capable to repair and maintain facilities/equipment by providing appropriate budget. 2. Accumulate data to prepare future development /extension plan in accordance with demand increase.	1. Reports on water supply management with supported data such as records for operation & maintenance and billing & collection, and information from officials concerned on this matter. 2. Reports and information on future development/extension plan of water supply system.	
Project Purpose 1. Improvement of Water Supply management of NPS	1. Capable to prepare various reports based on accumulated records/data.	1. Reports on water supply management with supporting data such as operation & maintenance and billing & collection.	- Record keeping is maintained.
Output 1. Financial control based on appropriate cost setting for operation and maintenance. 2. Efficient billing & collection system. 3. Improvement of ratio for metered connections with necessary repair and replacement of defective meters. 4. Improvement of water quality control for supply. 5. Improvement for accumulation of records/data and filing system. 6. Undertaking proper system operation & maintenance based on actual measurements.	1-1 Capable to determine proper expenditures for production by examining unit production cost 1-2 NPS's staff can obtain basic knowledge for financial analysis and appropriate tariff structure. 2-1 Undertake effective routine works and daily services using computer. 3-1 Undertake routine repair and replacement works of defective meters. 4-1 Keep good water quality for supply maintaining water quality standard of Lao PDR. 5-1 Undertake data recording and filing. 6-1 Undertake operation & maintenance based on actual measurements. 6-2 Undertake efficient routine works and daily services. 6-3 Undertake proper maintenance with provision of necessary spare parts.	1-1 NPS's financial reports and related information from officials concerned. 1-2 Information through interview to officials concerned. 2-1 Records of water meter reading and billing. 3-1 Records of repair and replacement of water meters. 4-1 Records of water quality analysis. 5-1 Records on plant operation with information through interview to operators and workers. 6-1 Records on plant operation with information through interview to operators and workers. 6-2 Information through interview on use of manuals for operation & maintenance. 6-3 Procurement plan, inventory record, and other records for maintenance works.	- Record keeping is maintained. - NPS staffs continue their activities in accordance with the training, advice and guidance made by the experts.
ACTIVITIES 1-1 Guidance for general aspects on water supply services. 1-2 Advise and guidance on cost analysis such as unit production cost for operation of water supply system. 1-3 Advise and guidance on technical skill for financial analysis. 1-4 Advise and guidance on water tariff setting. 1-5 Advise and guidance on book keeping for accounting and ledger keeping for inventory control. 1-6 Follow-up services after hand over of the facilities. 2-1 Advise and guidance on recording system for meter reading and bill collection using computer. 2-2 Advise and guidance on recording system for billing and money receiving. 2-3 Advise and guidance on detection of water meter under registration. 2-4 Guidance on repair of defective water meters. 3-1 Guidance on general technical matters of water supply system. 3-2 Guidance on preparation of operation & maintenance plan. 3-3 Advise and guidance on repair and maintenance of facilities/equipment with procurement plan of spare parts. 3-4 Preparation of a manual for daily operation & maintenance. 3-5 Training for water quality analysis and control including chemical application (including training in Chinaimo W.T.Plant). 3-6 Guidance on recording and filing system for plant operation. 3-7 Training for operation & maintenance of W.T.Plant during test operation. 3-8 Follow-up training after hand over of facilities.	**Input** **Japan** Project Team Member of Consultants: Financial and billing & collection; 3 M/M Operation & Maintenance; 3 M/M Water quality control; 1 M/M Necessary expenses for project implementation (for transportation and other miscellaneous items)	 **Lao PDR** C/P NPS staff in charge of financial aspects including billing & collection. NPS staff in charge of technical matters for operation and maintenance. Training for water quality analysis (participation of staff of Chinaimo W.T.Plant) Translator Participation of officials from central office of water Supply Authority. Staff from Vientiane Water Supply Company.	**Pre-conditions** - Approval of water tariff revision. - Cooperation of Vientiane Water Supply Company for training of water quality analysis. - Supports from MCTPC and DCTPC.