REPORT ON WATER SUPPLY FACILITIES IN VIENTIANE CITY THE KINGDOM OF LAOS

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MAY 1972

OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

CONTENTS

CHAPTER 1 INTRODUCTION 1

1. Construction of Water Supply Facilities in Vientiane 1
2. Object of Investigation 1
3. Composition of Survey Team 2
4. Period and Activities for Investigation 2
5. Local Personnel Concerned 3

CHAPTER 2 GENERAL SITUATION OF THE KINGDOM OF LAOS 4

1. Geography and Climate 4
2. Population, Race, Language and Religion 4
3. Form of Government and Political Situation 5
4. Industry and Trade 6
5. Transportation 6

CHAPTER 3 PRESENT CONDITION OF AND MEASURES FOR THE WATER SUPPLY FACILITIES 7

1. Outline of the Water Supply Facilities 7
   1) Intake Equipment 7
   2) Filtration Equipment 7
   3) Distribution System 8
   4) Elevated Tank 8
   5) Electric Equipment 8
   6) Instrumentation 8

2. Present Condition. 8
   1) Organization of Nam Papa Lao 10
   2) Water Rates and Collection 10
   3) Works for Water Service and Water Supply Pervasion 12
   4) Control of Water Quality 13
   5) Others 14
      a) Electric Power Cost 14
      b) Revetment Works and Flood Measures 15
      c) Change in Exchange Rate 15

CHAPTER 4 REPAIR 17

1. Problems 17

1) Intake Pump 17
2) Orifice Meter 17
3) Flash Mixer in Mixing Basin 17
4) Chemical Feeding Equipment 18
5) Flow Controller 18
6) Chlorination Equipment 18
7) Distribution Pump 18
8) Starting Compensator for Distribution Pump 18
9) Venturi Meter 19

2. Parts and Cost Necessary for Repair 19

CHAPTER 5 IMPROVEMENT 24

1. Problems 24
2. Improvement 32
3. Cost of Improvement 40

1) Estimation Bases for Construction Costs 40
2) Construction Costs 40

CHAPTER 6 FUTURE EXTENSION 41

1. Consideration on Future Extension 41

1) Population and Designed Water-Consumption 41
2) Outline of Extension Plan 42

CHAPTER 7 CONCLUSION 47

Report on Water Supply Facilities
in Vientiane City, the Kingdom of Laos

CHAPTER 1. INTRODUCTION

1. Construction of Water Supply Facilities in Vientiane.

In return for the abandonment by the Laotian Government of the right to demand war reparations the Japanese Government promised to provide an economic aid amounting to one billion yen in December 1956. Mr. Kishi, the then Prime Minister of Japan, paid a friendship visit to Laos in November in the following year, 1957, and made the formal offer for the economic aid at the talks with Prince Phouma, the Prime Minister of Laos, when it was decided to construct water supply and power generation facilites for the city of Vientiane.

The Japanese Government who adopted this waterworks project as a priority matter started to design for it at once but the project was interrupted for a time due to a coup d'etat which took place abruptly in the country in August 1960. Later in January 1962 the Laotian Government requested the Japanese Government anew to make an on-the-spot investigation, upon which request the latter Government sent the engineers to the site for the study of construction method, adjustment of the amount of money and the concrete consultation with the Laotian authorities, which led a final agreement. In June of the same year Société Centrale des Eaux du Laos (hereinafter referred to as Nam Papa Lao) signed a contract with the Japanese contractor for constructing the water supply facilities.

The contract provided that construction materials and equipments equivalent to ¥573.3 million is supplied from Japan without cost, that the costs of inland transport and construction at the site amounting to U. S. $1,180,800 is paid by semi-annual installments spread over thirteen years including two-year grace period after the completion of works, and that the construction period is two years after the approval by the Japanese Government.

With the said contract authorized by the Japanese Government on 30 November 1962, the construction work was started on 24 January 1963, and the work which had been completed in September 1964, more than four months earlier than the prescribed date was formally delivered to the Loatian Government on 21 of that month.

2. Object of Investigation

For nearly eight years since its services were started in September 1964, the waterworks in Vientiane has been operated anyway without a suspension of water supply even for one day and the redemption of loan to Japan made punctually, although there have been various technical and financial problems such as the collection of water rates, measure to counter flood, extension of distirbution pipe networks, power cost and increased loss from the difference of quotations on foreign currency debts due to devaluation.

However, various facilities of the filtration plant have become so deteriorated owing to an inadequate maintenance resulting from the lack of repair parts as well as skilled technicians that they need all-out repair. While, the extension of distribution pipe networks was carried out by the Laotian authorities to meet the demand of repidly increasing population in recent years around the supply areas planned at the time of designing, and the absence of any fundamental measure conjointly with the increase in the consumption of water exceeding the estimates for the planned supply areas has caused wide areas to have poor water supply, with the dissatisfaction of citizens increasing.

In order to solve the problem Nam Papa Lao requested the Japanese Government through the Laotian Government to send a survey team, upon which request the present investigation has been carried out.

The investigation is to be conducted in three stages for repair, improvement and future extension of the existing water supply facilities; the present survey has been carried out focussing especially on the technical investigation for the repair and improvement and at the same time the problem of extending the said facilities in future has been taken up as far as possible.

We desire that the present investigation will contribute in some measure to solve the problem of the water supply facilities in Vientiane which were completed with the aid of the Japanese Government and have been thanked for by the citizens of Vientiane in that it has served to raise their living level for eight years since then, doing very much for furthering the friendly relations between both countries.

3. Composition of Survey Team

The survey team was composed of the following members :

Toshiya Sano	Non-regular staff member of Japan Water Works Association
Kazushige Sasaki	Non-regular staff member of Japan Water Works Assocation

4. Period and Activities for Investigation

Date	Weekday	Activities
Mar. 28	Tue.	Left Tokyo and arrived in Bangkok.
29	Wed.	Left Bangkok and arrived in Vientiane.
30	Thu.	Paid a visit of courtesy to the Japanese Embassy and the persons concerned of Nam Papa Lao.
		Made arrangements as to affairs and conducted investigation at the filtration plant.
31	Fri.	Examined the equipments to be repaired and collected data.

Apr.	1	Sat.	Surveyed the areas having poor water supply and the extended supply areas.
	2	Sun.	"
	3	Mon.	Made a detailed examination of equipments to be repaired and collected data.
	4	Tue.	Collected data; made arrangements as to parts for repair and plan for improvement.
	5	Wed.	Collected data; made arrangements.
	6	Thu.	Made on-the-spot investigation.
	7	Fri.	"
	8	Sat.	Collected data; heard about the situation of city planning at the Ministry of Public Works.
	9	Sun.	Adjusted the collected data.
	10	Mon.	Made arrangements; Explained the circumstances to the Embassy.
	11	Tue.	Paid a visit of courtesy to the Embassy and Nam Papa Lao before returning to Japan; Left Vientiane and arrived in Bangkok.
	12	Wed.	Left Bangkok and arrived in Tokyo.

5. Local Personnel Concerned

Japanese Embassy --

Mr. Tani, Ambassador
Mr. Yamashita, Councelor
Mr. Yamakawa, Secretary
Mr. Nishii, Secretary

Ministry of Planning and Cooperation --

Dr. Pane Passavong, Commissioner Gerneral
Dr. Oudone Voratanouvong, Commissioner General

Nam Papa Lao --

Mr. Sengkham Phinith, Director General
Mr. Kitsana Vongpouthone, Works Manager

Japan Overseas Cooperation Volunteer --

Mr. Masaharu Fijimura (in charge of machinery)
Mr. Masakazu Ishii (in charge of water quality)

CHAPTER 2: GENERAL SITUATION OF THE KINGDOM OF LAOS

1. Geography and Climate

Laos has a area of about 237,000 km^2 approximating to that of Honshu of Japan. It has a distinctive feature that it is a land-locked country with no outlet opened to the sea and its territory extends lengthwise from south to north. It is bordered by six countries, South and North Vietnams, Cambodia, Thailand, Burma and People's Republic of China, and the Mekong, a great river of 4,200 km in length coming from Tibet forms the whole of borderline between Burma and a part of it between Thailand.

The climate is divided broadly into rainy season from May to September and dry season from October to April. The country as a whole receives the annual mean rainfall of 2,000 mm, while it ranges from 1,000 to 4,000 mm according to different places. The temperature fluctuates little during the rainy season and that in Vientiane is 27°C on the average with small difference of temperatures between day and night. In the dry season the temperature goes down gradually from October to January when it is most cool and then it turns to rising from February. Having no rain, the period from March to May just before the rainy season is the most unbearable in the year.

2. Population, Race, Language and Religion

As there has been no complete census in Laos the population is unknown; one putt it at 1.5 million and other at 4 million. But the estimates published by the Statistics Bureau of the Government in March 1967 place the population at 2.7 million. Therefore it is sparsely populated with the density of 11.4 capita per 1 kg^2. The population of Vientiane, the capital of Laos, was 132,000 in November 1966, and is 175,000 as of 1972.

The population consists of Laotians and other minorities, 40,000 people, including Thais, Vietnamese, Chinese, Black Thais (refugees from North Vietnam; and other nationals including French, Filipinos, Indians, Cambodians, Americans, Pakistanis and Japanese.

By race, the population is broadly divided into the Thai peoples (Lao, Lum, Black Thai, and Red Thai), the natives of Indonesian origin, the peoples of Chinese origin and those of Tibet origin. The Thai peoples account for 60 % of the total population; the Lao peoples who advanced south from Yunnan in the 10 th century and thereafter to settle in the flat land of Mekong river basin hold a dominant position in Laos.

Lao and Thai are the sister languages since Lao and Siamese races are the sister races. Among foreign languages French which is used as an official language holds an important position and although English is being rapidly popularized in recent it is still far behind French.

The state religion is Buddhism introduced from Cambodia in the 12th century and the constitution provides that the king must be a devout Buddhist. There are two religious parties, Mahanikhai sect and Thamahuto sect introduced from Thailand, and the former is more predominant as in Cambodia.

3. Form of Government and Political Situation

The Kingdom of Laos became independent as a constitutional monarchy freed from the control by France, the then suzerain state, in March 1945 when the former Japanese armed forces dealt with French Indo-China.

After that the people split into the rightists, leftists and neutralists and the hostilities were repeated several times. In 1961 the Laotian problem was referred to the conference met by 14 nations at Geneva and though an international agreement was reached on the neutralization of Laos it took time to solve the problem of setting up a coalition government of three factions in the country. After the so-called three-faction's top talks between Princes Boun Oum (rightist), Phouma (neutralist) and Souphannouvong (leftist) were held lengthily at Geneva of Swiss and Hin Heup, Vientiane or Jars Pleateau in Laos, a government of National Union (the present government) was formed in June 1962 under Prince Phouma. In the following month, July, Laotian united delegation was sent to Geneva to declare the nuetralization of Laos which was accepted by the 13 countries attended the conference with the declaration to respect the neutrality of Laos, putting an end to the conference continued over one year and two months.

Though Laos started as a neutral state blessed internationally the neutralist army split into right-and left-wings taking advantage of the assassination of Quinim Pholsena, the left-wing neutralist Foreign Minister, in April 1963 and a hostility took place again on Jars Plateau. Leftist Prince Suphannouvong who attended the commencement ceremony for the construction of Vientiane waterworks held in January in that year representing the Laotian Government drew off Vientiane together with the Pathet Lao (patriotic party) ministers and the government of National Union has now become a mere scrap of paper.

After that, in spite of the endeavors to restore to the status quo Pathet Lao inclined more to the left and the Phouma Administration more to the right with the intensification of Vietnamese War, widening the gaps between them. For the present, the contact between them is scarecely maintained by means of the exchange of letters and the control of Laotian internal trouble is dependent on the settlement of war in the neighboring country, Vietnam.

Since the Laotian Constitution which was promulgated on 11 May 1947 had been framed after the type of the Franch Constitution it did not match with the actual conditions of Laos and was revised several times since then.

The Parliament consists of the two chambers, Upper House (Conseil de Roi) and Lower House (Assemble Nationale).

In Laos there is no steady organization which can be called as a political party except Pathet Lao (a patriotic party) that may be called as an antigovernment belligerent body rather than a political party judging from its actual condition.

Now that the Pathet Lao ministers dropped off, the Phouma Government of National Union has diminished its value to exist as a neutralist government and it may be a rightist government under the cloak of neutralism.

4. Industry and Trade

Owing to the hostilities the development of Laos is much delayed and it may be said that there is no industry worthy of mention. The articles manufactured in the country are confined to matches, sandals, cigarettes and soft drinks, depending on the import for all other goods. Rice was self-sufficient previously but its production has become so unsufficing that it is imported from Thailand due to the shortage of labor resulting from the rapid increase of soldiers called out for the civil war.

The war expenditure accounts for more than half of the budget of which two thirds in the red are covered by foreign aids every year.

Although it is said that Laos is rich in underground resources their exploitation is delayed owing to the impact of the hostilities and also to the difficulty of transportation as the greater part of trade is handled through the port of Bangkok for geographical reason. The only article exploited so far is tin produced in Central Laos and 6.8 million tons of it is exported annually, constituting the most important article of export. Woods and coffee are also exported but they account for only 3% of the total amount of export. Besides, the intermediary trade of gold is an important revenue source for Laos in the form of import duty. The principal articles of import include rice, gasoline, cars, motorcycles, textile goods, machineries, and processed foods.

At present, the imbalance of export and import is covered by the foreign aids which are by no means sufficient due to the financial limitation of contributing countries and the Laotian economy is continuously troubled with inflation.

The long-awaited Nam Ngum dam was completed in December 1971 and a concrete movement has been started for the construction of bridge across the Mekong to connect Thadeua (Laos side) with Nongkhai (Thailand side). In addition to these facts, if the possibility of exploiting the underground resources is taken into consideration it is expected that the economy will be normalized gradually in the future.

5. Trasportation

At present, the international air services are maintained on three routes between Vientiane and Bangkok by Thai Airways, Saigon and Vientiane by Air Vietnam and Vientiane and Hong Kong by Royal Air Lao. The air services inside Lao are maintained by Royal Air Lao on the north route from Vientiane to Ban Houei Sai via Sayaboury and Luang Praband and the south route from Vientiane to Pakse via Savannakhet.

Although it is possible to reach Vientiane by land routes respectively from Bangkok, Phnom Penh and Saigon the roads except one coming from Bangkok are in poor condition and the use of them is difficult also in view of public peace.

There is no railway in Laos, but the Thai railway system extends to Nongkhai, on the Thai bank of the Mekong opposite to Vientiane.

CHAPTER 3 PRESENT CONDITION OF, AND MEASURES FOR THE WATER SUPPLY FACILITIES

1. Outline of the Water Supply Facilities

The dimensions of the water supply facilities in Vientiane delivered to Laos in September 1964 are as follows:

Estimated water-consumption	20,000 m^3/d.
Estimated population served	100,000 pop.
Water-consumption per capita per day	200 *l*
Period of design	10 years

(1) Intake Equipment

Intake tower	4.5 m x 7.5 m x 31.7 m (in height), Oval, reinforced concrete-made.
Intake pump	22,000 m^3/d. in capacity, 350 mmø, Q = 7.65 m^3/min., H = 19 m, 37 kw - 3 sets (of which 1 set for reserve).
Water pipe bridge	1.5 m x 1.5 m x 30.0 m (in span), water main = 500 mmø, steel supporting structure.

(2) Filtration Equipment

Mixing basin	2.8 mø x 4.0 m (in height), 7.5 ps, with flash mixer, circular, reinforced concrete-made.
Chemical sedimention basin ...	6.0 m x 32.0 m x 5.1 m, reinforced concrete-made ----- 4 units
Chemical dissolving and feeding equipment	Alumina Sulphate solution tank -- 2 units. Soda ashes solution tank ------- 2 units. Rock-salt solution tank -------- 2 units.
Rapid filter basin	Filter area of 5.6 m x 8.5 m = 47.6 m^2 --------- 4 units, filtering capacity = 5,700 m^3/d./unit, of perforated pipe collection system, with stationary surface and back washing equipment, hand operated, with loss of head gauge, and double-sheet type controller.

Clean water reservoir	32 m x 16 m x 4 m x 2 reservoirs = 4,000 m^3, reinforced concrete-made, built underground.
Chlorination room	4 m x 8 m, block-made, built on clean water reservoir, of soda hypochlorite feeding system by electrolysis as rock-salt is available easily on the spot.

Pump

Distribution pump	250 mmø x 200 mmø, 6.3 m^3/min. x 67 m x 110 kw ----- 4 sets (of which 1 set for reserve).
Back washing pump	14.5 m^3/min. x 16 m x 55 kw ------ 2 sets.
Vacuum pump	25 mmø, 0.75 kw -------- 2 sets.

(3) Distribution System

Distribution pipe	Cast iron pipe, of 450 mmø - 75 mmø, 49,000 m in length. Galvanized steel pipe, of 50 mmø, 5,000 m in length.
Venturi meter	450 mmø
Post hydrant	at 155 points
Public tap	at 37 points

(4)	Elevated Tank	25 m high, 2,000 m^3 in capacity, surge tank installed at the terminal of distribution pipe networks.
(5)	Electric Equipment	750 KVA transformer ------- 1 set, 15,000 V/380 V/220 V high voltage receiving equipment, distribution equipment.
(6)	Instrumentation	Concentrated equipment for transmitting changes in raw water run, water delivery and water levels of clean water reservoir and elevated tank.

2 Present Condition

The characteristics of the water supply facilities in Vientiane city are as follows:

a) In order to simplify the maintenance of various facilities for the treatment plant, the equipments of manual operating system have been adopted rejecting mechanical and automatic equipments as far as possible.

b) As regards chlorination, the feeding method of soda hypochlorite has been adopted at the strong request of the Laotian authorities at the time of designing, in order to use soda hypochlorite to be obtained by electrolyzing the solution of rock-salt which is produced in abundance on the spot.

c) Since the topography of Vientiane city is flat all over its city area with the difference of elevation being only 5 m, the pressure direct conveyance method of water by means of distribution pump has been adopted to distribute the water, with the elevated tank of 2,000 m^3 in capacity installed at the terminal of distribution pipe networks to adjust the water pressure and store any surplus water.

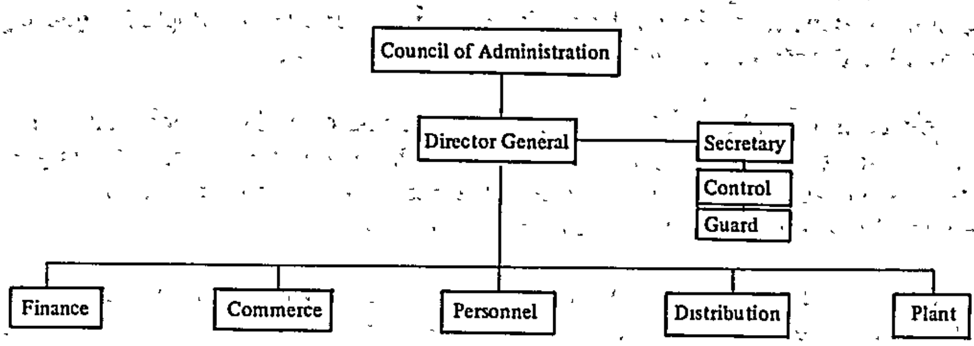
Being nearly 8 years old since the start of services the waterworks of Vientiane city as it is now poses several problems including the repair of various facilities in the treatment plant (see Chapter 3, 2 - Repair), the improvement measures for the areas having poor water supply which have increased rapidly with the growth of population served and the extension of supply areas, and the extension of water supply facilities for the future development of the city. All these problems are related to the financial circumstances of Nam Papa Loa and it seems most difficult to solve them immediately by Nam Papa Lao's own efforts, judging from the result of examination of the data furnished by Nam Papa Lao during the present investigation.

According to the data mentioned above, it is deemed that the financial problems were caused to arise during the first four years in particular after the start of services. In brief, it may be said that they have resulted from the inexperience in any waterworks business. To put it concretely, the problems may be summalized as follows:

1) Inconsistent collection of water rates.
2) Free services from public taps.
3) Stolen water from hydrants during the night.
4) Increased burden for the cost of installing water service equipments.
5) Comparatively high cost of electric power.
6) Expenses for revetment works.
7) Special outlays for flood protection measures.
8) Loss resulted from the change of exchange rate due to devaluation, in relation to the loans in foreign currency.

Nam Papa Lao is tackling with these problems including the inconsistent collection of water rates and in the following is described the general situation.

(1) Organization of Nam Papa Lao



The Council of Administration, an organ which controls Nam Papa Lao and decides on important problems, consists of nine members including those representing respectively the ministries of Finance, Civil Works and Home Affairs, Planning and Electric Bureaus and the National and the Development Banks, the mayor of Vientiane, and one representing the National Hotel Operating Bureau of the Ministry of Foreign Affairs. At present, the Minister of Finance hold office as the President and a director of bureau of the Ministry of Civil Works as the Vice-President.

The office of Managers of Commercial and Plant Departments is held concurrently by Director General at present.

(2) Water Rates and Collection

The fixing of water rates is subject to the resolution of the Council of Administration. The present rate is 90 Kip per 1 m^3 to which water meter rent and taxes are added to make the final rate of 100 Kip per 1 m^3 (about ¥50). (U.S.$1 = K. 600)

This rate is very higher compared with that in Japan and the percentage of water rates accounted for in the household expenses is 3 - 5 % for the family of an average income earner as against 0.4 - 0.5% of national average for Japan.

The water rates were revised four times since the start of services.

Year	Rate per 1 m^3
1964 - 1967	104 Kip
1968 - 1969	95 Kip
1970	92 Kip
1971	90 Kip

At present, Nam Papa Lao is endeavoring for the collection of water rates by replacing time-worn water meters with new ones to effect more accurate metering or suspending water supply to the deliquents of the rates. The actual results of consumption of water (indicated by water meters) and collection of water rates are shown in Tables - 2 and - 3.

The present quantity of water conveyed being about 16,000 m^3 per day there is a difference of about 3,000 m^3 per day (20%) between the conveyance and consumption judging from the related data; for this the principal cause seems to be attributable to the inadequate functioning of water meters. Apart from the above, there are accounts receivable corresponding to about 2,000 m^3 per day (13%). The loss due to the metering error can be solved by the renewal of water meters for which the work is under way. As for the accounts receivable, it is desired that Nam Papa Lao will take a drastic measure to collect them and tha Laotian Government give an all-out cooperation to it.

Table-2 Actual Amount of Water Rates Collected

Year	Consumption (in Kip)	Collected amount (in Kip)	Percentage
1965	88,934,000	63,589,000	77.8
1966	138,749,000	107,990,000	77.8
1967	205,241,000	177,587,000	86.5
1968	247,321,000	241,138,000	97.5
1969	282,186,000	250,389,000	88.7
1970	313,006,000	251,705,000	80.4
1971	167,383,000	203,315,000	120.7

Note - For 1971, the consumption is that for the first half of the year and the collected amount includes the balance carried over from the preceding year.

Table-3 Actual Quantity of Water Conveyed

(In 1,000 m^3)

Month \ Year	1965	1966	1967	1968	1969	1970	1971
Jan.	29	109	178	210	240	285	282
Feb.	44	120	192	230	261	295	298
Mar.	75	136	204	251	270	300	308
Apr.	99	148	228	275	285	317	326
May	115	160	248	280	300	320	335
June.	94	147	200	233	270	306	308
July	74	110	170	185	226	264	283
Aug.	85	122	162	197	242	253	268
Sept.	98	134	182	226	263	289	214
Oct.	110	150	200	248	290	305	312
Nov.	120	162	195	225	275	294	307
Dec.	119	150	220	260	297	302	320
Total	1,062	1,648	2,374	2,820	3,217	3,520	1,857
Proceeds	769	1,200	1,783	2,149	2,454	2,790	1,525
Loss	293	448	591	671	763	740	352
Percentage	27.5	27.0	24.0	24.0	24.0	20.0	19.0

(3) Works for Water Service and Water Supply Pervasion

The works for supplying water to the consumers were carried out by the staffs of Nam Papa Lao itself who had received on-the-spot technical training by the Japanese engineers for about 6 months after the completion of the water supply facilities.

The present water supply pervasion is 55 - 60% and there are new applications from about 50 consumers every month for which the works are being rather delayed.

As seen clearly in the map of distribution pipe-lines (Fig. 9 - 3), the city of Vientiane extends along the Mekong long and narrow and the distribution pipes are laid along the streets. Later, with the gradual extension of residential districts into the back land outside the initially planned supply areas many of new consumers, except a part of shopping district, have been separated considerably far from the water main and to that extent the distributing branches tapped the main have become longer to reach the service equipments at the consumers. The networks of distributing branches laid so far are shown in the plan (Fig. 9 - 3) and Tables - 4 and - 5 shows the actual layings by year.

Table-4 Actual Installations of Water Meters by Year

Year	No. of meters installed
1964	600
1965	1,100
1966	942
1967	914
1968	707
1969	497
1970	547
1971	621
Total	5,928

Note - The figure for 1964 is the actual number of meters installed for 4 months.

Table-5 Works for Water Service

Year	Work cost (In Kip)	Collected amount (In Kip)	Rate of collection (%)
1965	35,357,000	33,024,000	93.4
1966	22,590,000	20,358,000	90.1
1967	35,754,000	27,724,000	77.5
1968	46,156,000	30,141,000	65.3
1969	23,545,000	23,678,000	100.5
1970	30,871,000	22,131,000	71.7
1971	30,706,000	10,894,000	35.5

Note - (1) Work cost includes that of distributing branch.
(2) Collected amount for 1969 includes the balance carried over from the preceding year.

The reason for the low percentage of collection for 1971 is that Nam Papa Lao executed the works by the advance of costs for the convenience of consumers.

The work cost for distributing branch is allotted to the consumer along that branch to recover it together with the work cost for water service after the completion of the work. However, as the number of consumers has not yet reached that estimated initially, Nam Papa Lao has been compelled to bear the balance.

(4) Control of Water Quality

The results of examination of water quality carried out in the dry and rainy seasons (February and August) by Nam Papa Lao are shown in Tables - 6 and - 7.

Since the Mekong is used as a water source any special water pollution is not found. During the rainy season from May to September the turbidity becomes very high, reaching 2,500 - 3,000 degrees on some days. Alkalinity is 85 - 95 degrees throughout the year and the turbidity is eliminated by only a coagulant (aluminum sulphate) of which annual mean rate of feeding is 40 - 50 p.p.m.

The coagulant is wholly imported at present and its import amounted to K. 13,700,000 (18 - 25 tons per month) in 1971.

As regards chlorination, the feeding equipment of soda hypochlorite installed initially was removed because of frequent troubles and difficulties of repair and replaced with a feeding apparatus of high-power bleaching powder easy for maintenance. The feeding rate of high-power bleaching powder (available chlorine of 60%) is 2.00 p.p.m in annual average.

This agent is too wholly imported and its actual amount of import was K.3,800,000 (1.8 - 2 tons per month) in 1971.

The water quality test room is equipped with sufficient laboratory equipments and chemicals with the aid of Japan and operated in a satisfactory manner under the administration and instruction by the member in charge of water quality of Japan Overseas Cooperation Volunteer.

Table 6 Examination of Water Quality

Vientiane
Date 15/8/71

Item	Raw Water (Mekong)	Supplywater
Temperature (Atmosphere) oC	29	29
Temperature (Water) oC	26	26
Turbidity (P.P.M.)	1280	0
Color (P.P.M.)	100	0
Odor	Undetected	Undetected
pH (B.T.B)	7.4	7.0
M - Alkalinity (P.P.M.)	0.0	66.0
Total Acidity (P.P.M)	0.6	0.6
Ammonia - Nitrogen (N)	Detected	Trace
Nitrite - Nitrogen (N)	Trace	Trace
Nitrate - Nitrogen (N)	Trace	Undetected

Chlorine (Cl-) P.P.M	9.50	6.38
Sulfate (SO_4^-) P.P.M	-	-
$KMnO_4$ Consumed (P.P.M)	12.00	4.74
Residual Chlorine (P.P.M)	0.0	0.3
Specific Conductance Ohm.cm	5500	4500
Total Hardnese (P.P.M)	91.8	103.2
Iron (Fe) (P.P.M)	0.02	0.0
Manganese (Mn)	Undetected	Undetected
Aluminium (Al) (P.P.M)	0.002	0.001

Table 7 Vientiane Water Supply
Date 15/2/71

Item	Raw Water (Mekong)	Supply Water
Temperature (Atmosphere) °C	23	24
Temperature (Water) °C	21	14
Turbidity (P.P.M)	120	0
Color (P.P.M)	0	0
Odor	Undetected	Undetected
pH (B.T.B)	7.4	7.0
M-Alkalinity (P.P.M)	85.0	65.8
Total Acidity (P.P.M)	0.26	0.9
Ammonia - Nitrogen (N)	Undetected	Undetected
Nitrate - Nitrogen (N)	Undetected	Undetected
Nitrate - Nitrogen (N)	Detected	Trace
Chlorine (Cl^-) P.P.M	0.70	13.5
Sulfate (SO_4^-) P.P.M	-	-
$KMnO_4$ Consumed (P.P.M)	8.55	4.74
Residual Chlorine (P.P.M)	0	0.6
Specific Conductance Ohm. cm	4100	5000
Total Hardnese (P.P.M)	57.6	76.0
Iron (Fe) (P.P.M)	0.01	0.
Manganese (Mn)	Undetected	Undetected
Aluminuum (Alo)	0.001	0.2

(5) Others

Even after nearly eight years since its start of services the business of Nam Papa Lao is yet hard going in spite of the water rates that are high compared with those in Japan as stated above. Apart from the causes such as the problems of collection of water rates and increased burden for equipment costs to meet new demands as aforesaid, the following special circumstances can be pointed out as the factors which cause the increase in expenditures of Nam Papa Lao and restrain its management remarkably.

(a) Electric Power Cost

In order to supply the electric power to the water supply facilities including the pumping station, Nam Papa Lao installed the high-voltage receiving and transforming equipments at the time when the facilities were completed, to buy the electricity at K. 30 per kwh. The power cost per 1 m^3 amounted to K. 14.91 as much as twice that of Japan, accounting for a very large percentage of prime cost. The unpaid power rates accumulated to K. 98,600,000 by March 1971 and in that month Nam Papa Lao completed its non-utility generating facilities with 4 generators each of 250 kw installed, spending

K. 41,800,000 for construction cost. As a result the power cost has lowered to K. 16 per kwh, only half of the cost when the electricity was purchased and, nevertheless, it is still considerably high compared with the general prices.

Since the Nam Ngum Dam waited for by the Laotian Government was completed in December 1971 and the supply of abundant power has become possible, it is desired that the power will be provided at a low cost in view of the water supply business as a public utility.

(b) Revetment Works and Flood Measures

The treatment plant of these facilities is adjacent to the Mekong with the intake tower installed at a distance of 25 m from the river shore. When the intake tower was constructed the revetment works should have been conducted as a matter of course together with the main works as there is much of fears for any change in the river stream and any erosion of the river shore. However, such works were omitted from the plan for budgetary reasons, and after that Nam Papa Lao had to carry out the revetment works for itself over a period of several years spending K. 16,000,000 for them.

On the other hand, the treatment plant was submerged under the flood of the Mekong for three times in 1966, 1969 and 1970. Though any suspension of water supply was avoided anyhow by the strenuous efforts of the staffs of Nam Papa Lao, the plant suffered considerable damage which costs Nam Papa Lao as much as K. 5,000,000 for the works of restoration.

(c) Change in Exchange Rate

The contract for these water supply facilities provides that the dollar portion amounting to U.S.$1,180,800 is to be paid by semi-annual installments spread over thirteen including two-year grace period after the completion of works. The schedule of payment is shown in Table-9 and the payment has been made punctually as of December 1971.

The par of exchange was U.S.$1 = K. 80 at the time point, June 1962, when Nam Papa Lao made the contract, but after that the Laotian Government effected the devaluations as follows:

	Fixed rate	Free rate	
Oct. 1958	80 Kip/U.S.$1	— Kip/U.S.$1	
Jan. 1964	240	500	Exchange stabilization fund was set up.
Nov. 1971	240	600	

When Kip was devaluated to U.S.$1 = K. 240 the double exchange rates, fixed rate (U.S.$ 1 = K. 240) and free rate (U.S.$1 = K. 500), were adopted and the fixed rate has been applied to quite limited transactions of the Government. At the same time, an exchange stabilization fund was set up with the foreign currency contributed by the advanced nations in order to stabilize the exchange rate.

After the fixed rate (U.S.$1 = K. 240) was applied to the payment of debt in dollar currency of Nam Papa Lao for first several times, the payment was excluded from the application of it with the deterioration of foreign currency situation of the Government.

Therefore, the amount provided in domestic currency by Nam Papa Lao has been increased by more than seven times of that calculated by the basic rate of U.S.$1 = K. 80 at the time when the contract was made. On the other hand, the water rates which are the revenue source have been lowered gradually from K. $104/m^3$ at first to K. $90/m^3$ at present partly from the viewpoint of social policy, and coupled with this the increase in expenditures due to the changes of exchange rate has been constituting an extremely heavy burden on the finance of Nam Papa Lao.

Table-9 Schedule of Payment

Nr.	Date of payment	Amount (In U.S.$)	Exchange Rate (In Kip)	Remarks
1	1 Dec. 1966	90,415	240	
2	1 June 1967	131,221	240	
3	1 Dec. 1967	128,508	240	
4	1 June 1968	125,796	240	
5	1 Dec. 1968	123,830	Unknown whether 240 or 500	Paid
6	1 June 1969	120,379		
7	1 Dec. 1969	72,664		
8	1 June 1970	71,302		
9	1 Dec. 1970	69,939	500	
10	1 June 1971	68,577	500	
11	1 Dec. 1971	67,215	600	Not repaid U.S.$844,732
12	1 June 1972	65,852	600	
13	1 Dec. 1972	64,490	Exchange rate unknown	
14	1 June 1973	63,127		
15	1 Dec. 1973	61,765		
16	1 June 1974	60,402		
17	1 Dec. 1974	59,039		
18	1 June 1975	57,677		
19	1 Dec. 1975	56,314		
20	1 June 1976	54,952		
21	1 Dec. 1976	53,590		
22	1 June 1977	52,228		
23	1 Dec. 1977	50,865		
24	1 June 1978	49,503		
25	1 Dec. 1978	48,140		
26	1 June 1979	46,788		

CHAPTER 4 REPAIR

1. Problems

The various facilities in the treatment plant of which maintenance has been carried out so far by the staffs of Nam Papa Lao and the members of Japan Overseas Cooperation Volunteer, has been in a condition necessitating some repair but they are operated under a defective state owing to the difficulties of obtaining repair parts in Vientiane or Bangkok.

The present states of various facilities needing repairs are as described below and later is shown the lists of spare parts for repair which have been prepared after examining the individual items.

1) Intake Pump

Three sets of intake pump are installed, of which two are for regular operation and one is in reserve. Due to the unavailability of spare parts the operation of two sets is maintained making use of parts taken from the reserve set which is, therefore, unserviceable. In addition, the two sets in service are operated repairing one of them by turns and thus it is unable to attain the designed quantity of water intaken, 22,000 m^3 per day; the present intake seems to be about 16,000 m^3 per day.

One of the causes for trouble has been of course the inadequacy of periodic inspections; one among others has been a heavy load imposed on the vertical shaft at the time of starting pump by the mud which had been accumulated at the bottom in the intake tower and frequently reach the inlet port of the pump.

Therefore, in order to provide for an occasion when the turbidity of the Mekong exceeds 3,000 degrees during a rainy season, it is necessary to install a blow-off pump apart from any repair of the intake pumps.

2) Orifice Meter

In the operation of water supply business, it is very important to grasp accurately the quantity of water conveyed and that of water intaken as well. However, the orifice meter to measure the latter quantity has broken down due to the floods on three past occasions and is left intact.

3) Flash Mixer in Mixing Basin

The flash mixer plays an important role in the first stage of treating process to mix the raw water and coagulant rapidly to effect a sedimentation of higher degree.

The flash mixer is unserviceable due to the wear of its vertical shaft and bearings. Accordingly, the treated water sent to the rapid filter while the sedimentation effect is yet inadequate imposes a heavy burden on the filter bed and this is uneconomical because the effect duration of filter bed is reduced, leading to the lowered functioning of facilities as a whole.

4) Chemical Feeding Equipment.

Each two solution tanks are installed respectively for coagulant and alkaline material. As seen from the results of water examination (see Tables - 6 and - 7) the alkalinity of raw water is as high as 85 - 95 degrees and from the first a satisfactory coagulation and sedimentation effects have been attained by the use of only aluminum sulphate, a coagulant. It is necessary to replace the flow controller, vinyl pipe and valve of the feeding equipment to which coagulant has sticked heavily.

5) Flow Controller

The rapid filter is equipped with a flow controller of Simplex type to regulate the rate of filtration (run) and its diaphragm (of rubber made) is so worn away due to flowing water that the flow controller is not functioning properly.

It is necessary to replace such diaphragm with a new one because if the rapid filter is left over in a condition in which any flow control is impossible the rate of filtration will become unstable giving an unfavorable effect on the quality of water.

6) Chlorination Equipment

The initial method adopted for chlorination was to feed soda hypochlorite obtained by electrolyzing the solution of rock-salt.

For four years after the start of operation the system carried out the chlorination at a low cost as designed. However, an overload on the cooling plant due to the high temperature of the surroundings caused frequent troubles in the circulating system of cooling water and the aquisition of specific parts being impossible the plant was removed to install instead a device of simple structure for dissolving and feeding bleaching powder.

The flow meter of this equipment is in trouble at present.

7) Distribution Pump

Though the 4 sets of distribution pump (of which 1 set is in reserve) are working or serviceable at present, an adequate maintenance of them is not conducted for the lack of spare parts and the absence of periodical inspections as well as the technician in charge of their adjustment, resulting in the lowering of their efficiencies by 10% - 15% (see CHAPTER 5; Characteristic Curve of Pump).

Alike the intake pumps, many parts are necessary to repair these distribution pumps.

8) Starting Compensator for Distribution Pump

Four sets of starting compensator in use now are of hand-operated type, and all of them are in dangerous conditions under the influence of abnormal heat due to severe wear of contact parts of their interiors. The replenishment of spare parts from Japan being difficult because of the old types of their main bodies, it is needed to replace them with the starting compensators of push-button type for easy operation.

As for the parts in the pannel, the thermal relays, etc. must be replaced too with new ones.

9) Venturi Meter

Alike the orifice meter, the venturi meter to measure the water delivery is unserviceable with its transmitter damaged by the floods in several occasions.

Since the grasping of quantity of water intaken and water delivery is an essential requirement fundamental to the operation of facilities and the management of water supply business, the instruments must be repaired so that their metering functions can be restored.

2. Parts and Cost Necessary for Repair

The particulars of parts and the estimates of cost necessary for the repairs mentioned above are shown in the separate tables (for parts numbers of the intake and distribution pumps, see the related Fig. 9 - 1 and - 2).

The estimates of costs include the expenses for sending 2 specialist respectively in charge of repairs of pumps and electric equipments.

No. of parts	Names of parts		Unit	Quantity
1).	Spare Parts for 3 sets of EBARA PUMP Model 260 VYM			
39.	Taper pin	SUS-27	pcs	24
38.	Bell mouth	FC-20	"	3
37.	Nut	BC-6	"	3
36.	Liner ring	LBC-1	"	6
35.	Key	SUS-22	"	3
34.	Impeller	BC-7	"	5
33.	Liner ring	LBC-1	"	6
32.	Bearing metal	Graphite	sets	6
30.	Bearing metal case	BC-6		
31.	Top casing	FC-20	pcs	3
29.	Joint	SUS-22	"	6
28.	Pump shaft	SUS-22	"	6
27.	Internal pipe	SGP & SS-41	"	36
25.	Middle shaft	SS-22	"	15
24.	Stabilizing spider	Rubber	"	8
23.	Internal pipe for spider	SGP & SS-41	"	8
22.	Middle bearing metal	BC-6	"	33
21.	Shaft coupling	SS-41	"	18
19.	Top shaft	SUS-22	"	3
18.	Shaft enclosing tube	SGS & SS-41	"	3
16.	O-ring	Rubber	"	6
15.	Top distance piece	FC-20	"	3
14.	Stuffing box	BC-6	"	3
13.	Packing	Valqua	"	12
12.	Gland	BC-6	"	3
11.	Oil tube	SGP & SS-41	"	3
10.	Bearing case	FC-20	"	3
9.	Ball bearing	7215 B	"	6
8.	Bearing cover	FC-20	"	3
7.	Felt ring	Felt	"	3
6.	Journal	FC-20	"	3

No. of parts	Names of parts		Unit	Quantity
	5. Key	S45C	"	6
	4. Coupling	FC-20	sets	3
	3. Coupling bolts	SS-41 & Rubber	pcs	48
	1. Nut	SS-41	sets	3
	Copper pipe		m	20
	Cap nut and union		sets	12
2)	Mercury switch for flow relay			
	Type: F1B9. 10HB		pcs	9
3)	Orifice plate			
	Pipe dia. 500 mm,	SUS27	set	1
4)	Flexible diaphram for flow rate controller			
	Dia: 250 mm	Rubber	pcs	8
5)	Flow meter for chloride of lime			
	Type: Rota meter		sets	2
6)	Flow meter for Al_2SO_4			
	Type: Rota meter		"	2
7)	PVC Piping materials		"	2
8)	Vacuum tube			
	NEC, 12AU7 J2		pcs	6
9)	Micro switch			
	AC 15A - 125, 250 V, DC 0.5 A - 125 V, 0.25 A - 250 V		"	6
10)	Magnetic contactor			
	Type : RC 3631-8		"	4
11)	Graphite packing for valve			
	t = 16 mm, 5 kg/roll		rolls	10

No. of parts	Names of parts	unit	Quantity
12)	Spare Parts for 4 Sets of KUBOTA PUMP DVL 250/200		
3.	Impeller	pcs	4
5.	Liner ring	"	12
6.	Shaft	"	4
7.	Sleeve	"	8
8.	Packing sleeve	"	16
9.	Packing ring	"	16
10.	Shuft nut	"	32
11.	Lantern ring	"	16
12.	Grand packing	"	160
13.	Grand follower	"	8
14.	Water slinger	"	8
15.	Rubber ring	"	16
16.	Coupling key	"	4
	Coupling between pump and motor	sets	4
17.	Impeller key	pcs	4
18.	Sleeve key	"	8
19.	Distance ring	"	4
20.	Angular contact ball bearing #7314	"	24
21.	Radial ball bearing #6314	"	12
22.	Bearing nut	"	8
23.	Lock washer	"	8
	Bearing for motor #6315	"	12
	Bearing for motor #6318	"	12
13)	Vacuum pump and motor		
	Capacity 0.17 m^3/min	sets	2
14)	Nozzle for fire hydrant hose ø2"	pcs	4
15)	Drain pump for Intake pump		
1.	Submersible motor pump for drain	sets	2
2.	Hose with coupling 150 mmø x 25 m	"	2
3.	Control panel for pumps	"	1

16)	Hose with couplings for pump, 2" ø, L = 20 m	pcs	10
17)	Shaft bearing, 55 mmø	"	2
18)	Shaft of mixer L = 4200 mm x 55 mmø, with bolt & nut	"	1
19)	Spare blade of pipe cutter	sets	4
20)	Iron lid of surface box	pcs	200
21)	Reactor starting compensator for 110 KW, Push button type, 380 V	sets	4
22)	Spare parts for electric panels		

1.	Pipe fuse	300 A, L = 120 mm	pcs	10
2.	Thermostat relay	RCA 3737-4	"	4
3.	Thermostat relay	RCA 3737-4	"	4

Whole sets of parts for repairing listed above C.I.F Vientiane	U.S.$59,000
Mechanician and electrician each @U.S.$2,000	U.S.$ 4,000
TOTAL	U.S.$63,000

CHAPTER 5 IMPROVEMENT

1. Problems

The important problems that Nam Papa Lao confronts are to carry out the repair works and at the same time to improve the services for the districts having a poor water supply in the supply areas which so far have been expanded by Nam Papa Lao.

The districts having a poor water supply are --

Thatlouang;
Sisangvone;
Dongtaohai;
Khouakhao; and
Ban Nong Lo.

During the peak demand hours the districts of Thatlouang, Sisangvone and Ban Nong Lo, in particular, have the worst supply and the reasons for this are supposed to be as follows:

(1) The functionings of distribution pumps have lowered due to the inadequate maintenance of pumps.

(2) The supply areas have been expanded in excess of those that can be supplied as designed originally and wide differences have been produced between the actual consumption of water by district and the presumed consumption in the supply areas at the time of original designing.

The further examination of these causes reveals that the lowered functioning of pump has direct influences on the water delivery and service pressure as the direct pumping system has been adopted. This fact, as a matter of cource, constitutes a cause of poor water supply alike the extension of supply to the outside of the planned supply areas.

In many cases the distribution pipe networks are designed on the basis of consumption of water allotted evenly to the planned supply areas in proportion to the sizes of land as it is difficult to estimate the consumption by district in such areas. By the present investigation it has been found that the actual consumption differs from the consumption estimated for the designing by far beyond that expected.

In the districts lying between the treatment plant (Kaoliao district) and Houamuang district, for example, the actual consumption of water is only about 2,000 m^3 per day compared with the estimated comsumption of about 5,000 m^3 per day. On the other hand, mast of high-class residential quarters which are the large consumers at present are situated in an uneven manner at the ends of distribution pipe networks or in the supply areas increased newly.

For these facilities that adopt the direct pumping system, such a wide difference between the actual consumption and the estimated one for the designing has lead to the inability to attain the effective operation of distribution pumps. Thus, the insufficient demonstration of designed pump capacity coupled with the lowered functioning by about 10% due to the high head pumping operation at present has caused a decrease in the quantity of water conveyed, with the present capacity being only about 16,000 m^3 per day (see the result of investigation of pumps described later).

Unless these problems are solved, it is impossible to attain the full functioning of these facilities that have the distribution capacity of 20,000 m^3 per day and it is not too much to say that the electric power is being used wastefully.

In view of the development (population at present and its growth rate) of Vientiane city it is judged that the time has already come when any extension plan should be considered for the future in order to serve a sufficient quantity of water to the areas spreading widely, and in advance of this the above problems involving the said facilities must be solved at an early date.

The results of investigation of water distribution pumps are as follows.

a) Data of Measurement

Head and current value when respective sets of pump are operated one by one and those when each set of pump is in shutdown operation.

Table 10

Pump NO.	Ordinary (normal operation)	2 min. after shutdown	3 min. after shutdown	Full delivery (normal operation)	Remarks
1	Discharge pressure 74 mAq	82	83	74	Full delivery 200 mm
	Suction pressure -3.2 mAq	-2.5	-2.5	-3.2	
	Head 77.2 mAq	84.5 m	85.5 m	77.2 m	
	Current value 140 A	75 A	75 A	138 A	
2	79	88	88		
	-2.7	-2.2	-2.2	Operation suspended	
	81.7 m	90.2 m	90.2 m		
	150 A	80 A	80 A		
3	72	81	81.5	72	Leakage at full delivery
	-3.2	-2.7	-2.7	-3.2	(Opening 175 mm)
	75.2 m	83.7 m	84.2 m	75.2 m	Leakage at full shutdown
	136 A	85 A	85 A	135 A	(No opening)
4	69 (-27 cmHg)	82.5 (-24 cm Hg)	82.5 (-24 cm Hg)	69 (-26 cm Hg)	Leakage at full delivery
	-3.6 mAq	-3.2	-3.2	-3.4	(Opening 170 mm)
	72.6 m	85.7 m	85.7 m	72.4 m	
	150 A	80 A	80 A	152 A	

b) Study

(1) Head after shutdown

For the heads after shutdown, it is judged that the capacities have lowered due to the wears of suction rings, etc. (see the characteristic curves). However, in the case of no. 3 set shown on the data of measurement, the current value after shutdown is rather high even at the full delivery because of leakage. In the case of no. 2 set, the head after shutdown has become higher than that at the time of its installation, and this seems to be due to the defective meter.

(2) Operation at Full Delivery

The quantity of water conveyed is estimated from the current value and head for the operation at full delivery for each pump (see the characteristic curves of pumps).

The quantity of water pumped up which have been found from --
intersection A (ϕ) found on the graph from the current value; and
intersection B (-ō-) found on the graph from the head;
shows the approximate values for no. 1, 2 and 3 sets but the head is low for no. 4 set showing a great difference.

The average values of quantity of water pumped up found from respective intersections for respective pumps are as follows:

Table 11

Pump	Value found from current value	Value found from head	Average quantity of water pumped up	Remarks
1	4.05 (m^3/min)	3.75	3.90	
2	4.22	4.25	4.24	
3	3.55	3.90	3.73	
4	4.07	5.15	4.61	

Average quantity of water pumped up 4.14 m^3/min.
However, such quantity for no. 4 pump is 3.99 m^3/min., if 4.07 m^3/min. is presumed to be a correct value.

(3) Quantity of Water Conveyed per Day

Operating hours are--
from 6 : 00 a.m. to 8 : 00 p.m. with 3 sets working;
from 8 : 00 p.m. to 6 : 00 a.m with 2 sets working.

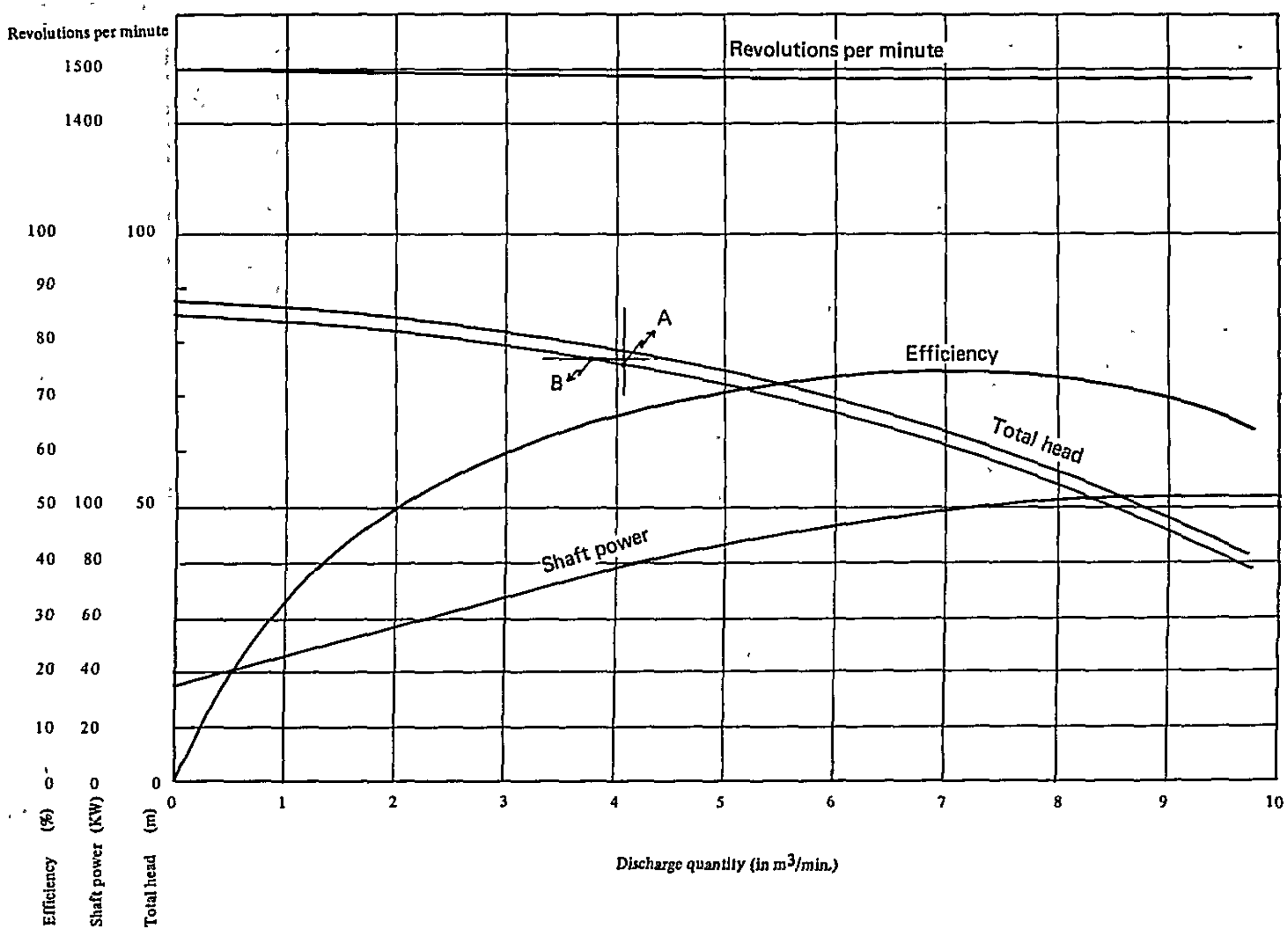
Therefore, the operating hours of pumps are --
14 hrs. x 3 sets + 10 hrs. x 2 sets = 62 hrs.

The quantity of water conveyed per day is --
3.99 m^3/min. x 60 mins. x 62 hrs. = 14,850 m^3/d.
(4.14 m^3/min. x 60 mins x 62 hrs. = 15,400 m^3/d.)

If the difference in operating hours is taken into account, the quantity of water conveyed per day will be 16,000 m^3/d. agreeing with the actual quantity.

Table 12 Characteristic Curve of Pump

Type : DVL, Double Suction Volute Pump Caliber : 250 x 200 mm, Single Stage



Specifications of Pump

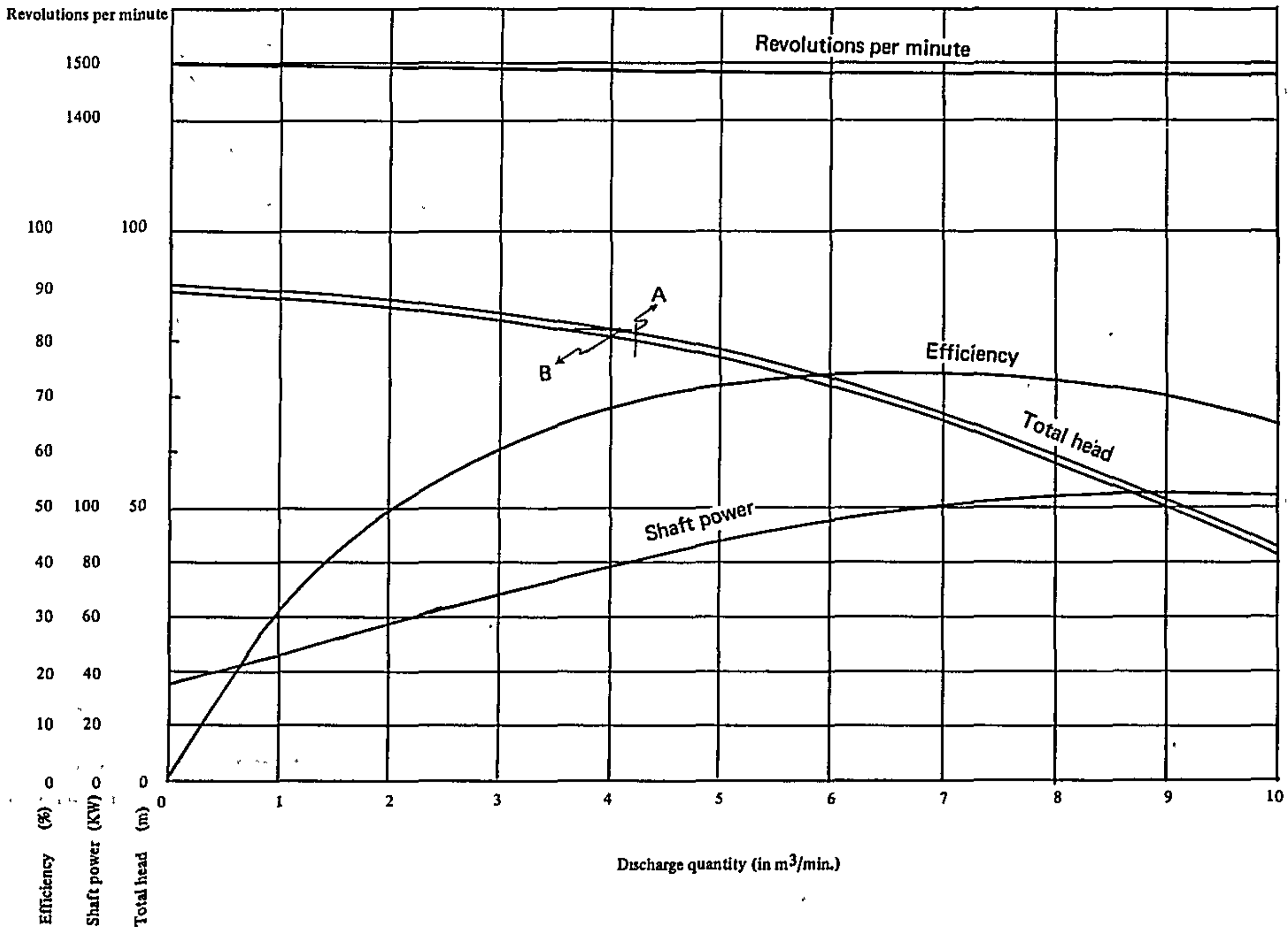
Quality of liquid	:	
Dia. of discharge bore	·	200 (mm)
Dia of suction bore	:	250 (mm)
Total head	·	67 (m)
Discharge quantity	:	6.3 (m^3/mn)
Nr. of revolution	:	1450 (r.p m)
Product No	:	387731

Specifications of motor

Type (Meidensha)	:	E-NNR
Output	:	110 (KW)
Nr of revolution	:	1470 (r.p.m)
Remarks	:	No. 1 set

Table 13 Characteristic Curve of Pump

Type : DVL, Double Suction Volute Pump Caliber : 250 x 200 mm, Single Stage



Specifications of Pump

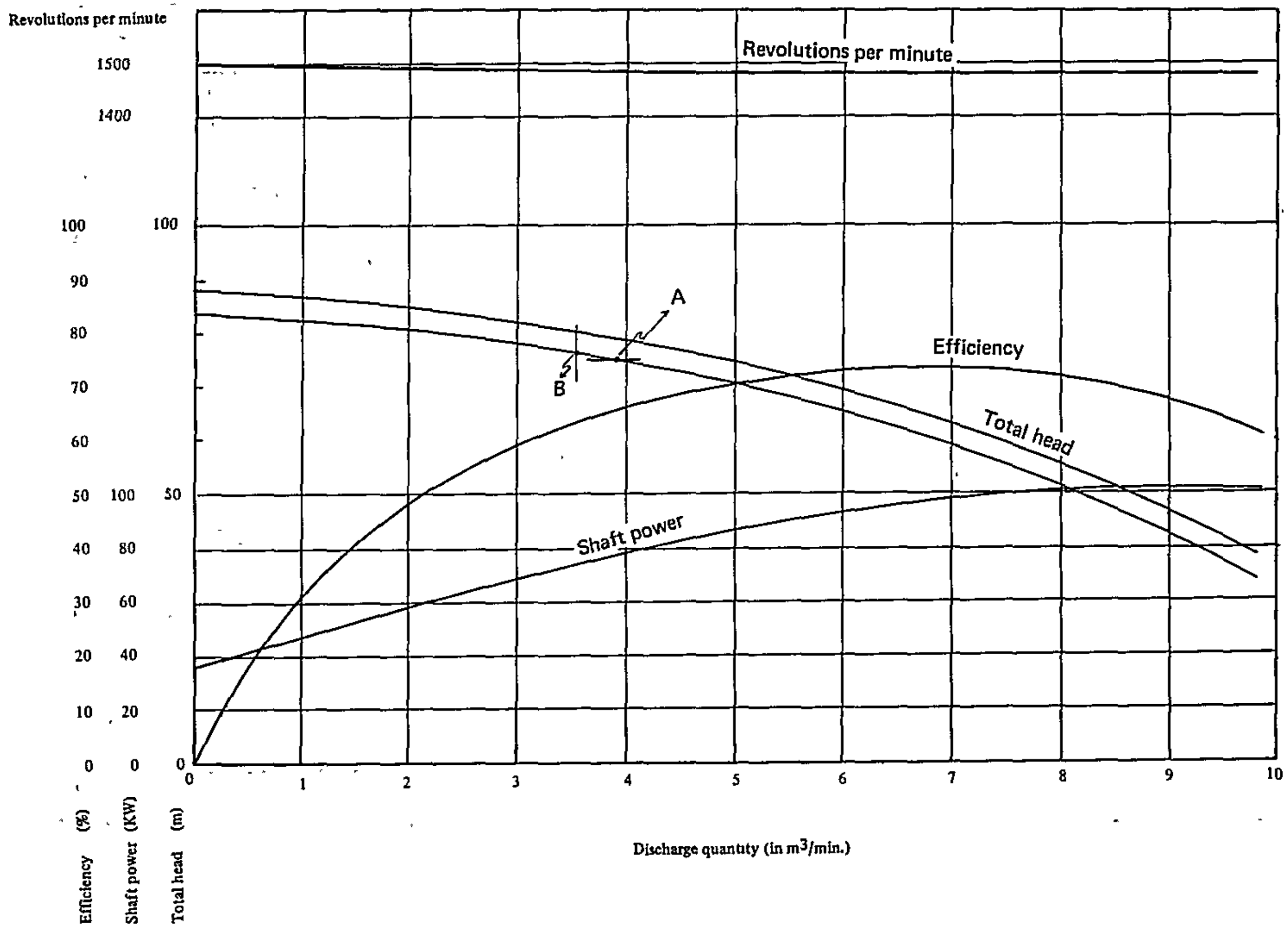
Quality of liquid	:	
Dia of discharge bore	:	200 (mm)
Dia of suction bore	:	250 (mm)
Total head	:	67 (m)
Discharge quantity	:	6.3 (m^3/mn)
Nr. of revolution	:	1450 (r.p.m)
Product No.	:	387732

Specifications of motor

Type (Meidensha)	:	E-NNR
Output	:	110 (KW)
Nr. of revolution	:	1470 (r.p.m)
Remarks	:	No. 2 sets

Table 14 Characteristic Curve of Pump

Type : DVL, Double Suction Volute Pump   Caliber : 250 x 200 mm, Single Stage



Specifications of Pump

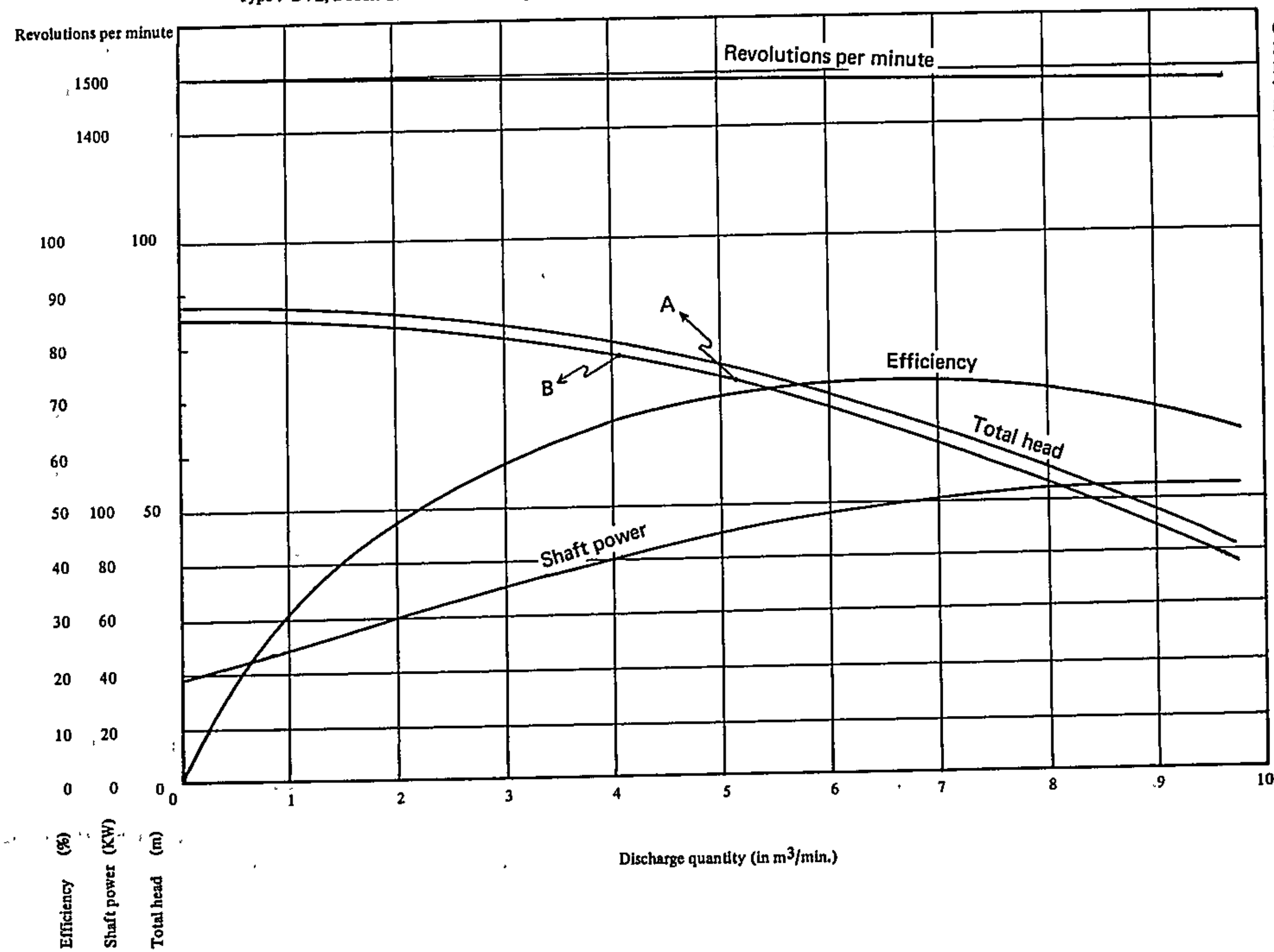
Quality of liquid	:	
Dia.of diacharge bore	:	200 (mm)
Dia.of suction bore	·	250 (mm)
Total head	:	67 (m)
Discharge quantity	:	6.3 (m^3/mn)
Nr. of revolution	:	1450 (r.p.m)
Product No.	:	387733

Specifications of motor

Type (Meidensha)	:	E-NNR
Output	:	110 (KW)
Nr. of revolution	:	1470 (r.p.m)
Remarks	:	No. 3 sets

Table 15 Characteristic Curve of Pump

Type : DVL, Double Suction Volute Pump Caliber : 250 x 200 mm, Single Stage



Specifications of Pump

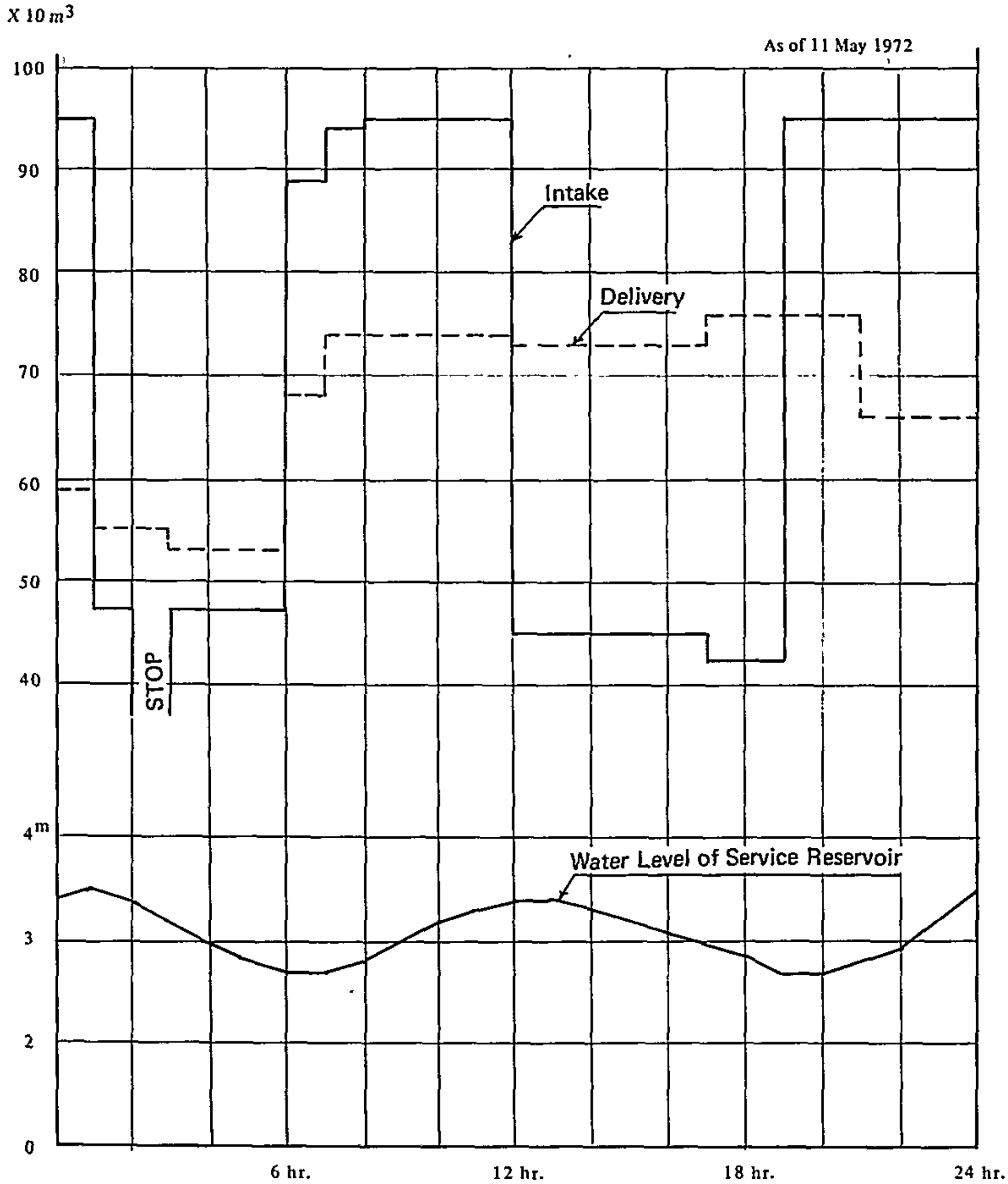
Quality of liquid	:	
Dia. of discharge bore	:	200 (mm)
Dia. of suction bore	:	250 (mm)
Total head	:	67 (m)
Discharge quantity	:	6.3 (m^3/mn)
Nr. of revolution	:	1450 (r p.m)
Product No.	:	387734

Specifications of motor

Type (Meidensha)	:	E-NNR
Output	:	110 (KW)
Nr. of revolution	:	1470 (r.p.m)
Remarks	:	No. 4 sets

Table 16 Quantity of Water Intaken and Delivered, and Behavior of Water Level of Service Reservoir

Intake : 16,200 m³/d.
Delivery : 16,090 m³/d.



2. Improvement

Some alternative measures conceivable to improve the above state of things are as follows:

A) To replace the existing distribution pumps by those with high head and to lay additional distribution pipes along some parts of the existing ones.

B) To repair the existing distribution pumps without changing their capacities and to lay some additional distribution pipes. Further, to install a booster pump and elevated tank of about 150 - 200 m^3 in capacity in a district for which the service pressure is inadequate.

C) To repair the existing distribution pumps without any change in the present capacities and to construct a new reservoir of about 3,000 m^3 in capacity and a pumping plant at a proper location for distributing water to the districts having poor water supply and also to install an elevated tank of about 150 - 200 m^3 in capacity at a necessary place.

In order to obtain the data to study the above three method the calculation of pipe networks has been made to indicate where the unreasonableness presents on the pipelines in making the actual water conveyance of 16,000 m^3 per day, and the results of such calculation are shown in Calculation Sheet - I and Reference Fig. 9 - 4.

Also the results of such calculation made for the water conveyance of 20,000 m^3 per day assumed on the basis of the present consumptions by district are shown in Calculation Sheet - II.

Calculation Sheets - III for Improvement ~ B

LOOP NO.	PIPE NO.	Q	I	V
1	1	231.4800	8.9376	1.4641
		DQ 0.0		
2	2	237.5900	6.1872	1.3763
		DQ 0.0		
3	3	205.6200	5.5722	1.3007
		DQ 0.0		
4	4	93.8587	9.4081	1.3368
4	5	85.6187	7.9373	1.2195
4	6	75.7487	6.3280	1.0791
4	-7	-10.5020	-1.1785	0.3373
4	-8	-88.8514	-8.5006	1.2655
		DQ 0.0000		
5	8	88.8514	8.5006	1.2655
5	9	5.4487	0.3501	0.1751
5	-10	-12.9082	-7.0071	0.7367
5	-11	-14.9582	-9.2038	0.8536
		DQ 0.0000		
6	12	19.8921	15.5954	1.1349
6	13	12.5025	6.6051	0.7136
6	-14	-2.5322	-0.3443	0.1448
6	-68	-25.2508	-5.9731	0.8102
6	-66	-28.0131	-7.2878	0.8987
		DQ 0.0001		
7	16	28.0136	7.2380	0.8987
7	-17	-21.1333	-4.2971	0.6782
7	-18	-49.3493	-6.9599	1.0127
7	7	10.5020	1.1785	0.3373
		DQ 0.0002		
8	93	12.8610	6.9598	0.7341
8	95	10.5910	4.9445	0.6103
8	-20	-2.9724	-0.1141	0.0956
8	-21	-12.4470	-6.5510	0.7104
8	-9	-5.4487	-0.3501	0.1751
		DQ 0.0001		
9	14	2.5322	0.3443	0.1448
9	22	9.1047	3.6735	0.5198
9	23	0.7417	0.0355	0.0425
9	-70	-16.8145	-2.8152	0.5397
		DQ 0.0001		
10	26	4.5730	1.0276	0.2613
10	26	0.6530	0.2021	0.0841
10	27	-1.7469	-0.1732	0.0999
10	-72	-15.2460	-2.3487	0.4894
10	-23	-0.7417	-0.0355	0.0425
		DQ 0.0000		
11	17	21.1333	4.2971	0.6782
11	29	19.0365	3.5418	0.6110
11	-30	-15.8773	-2.4731	0.5033
11	-98	-23.0233	-5.0860	0.7388
11	-19	-22.7951	-4.9431	0.7315
		DQ 0.0007		
12	15	25.2726	5.9826	0.8109
12	31	5.7396	1.5645	0.3279
12	-32	-20.3798	-4.0180	0.6540
12	-29	-19.0365	-3.5418	0.6110
		DQ 0.0009		
13	24	16.8046	2.8121	0.5394
13	33	0.9833	0.0576	0.0551
13	-34	-13.3612	-1.8399	0.4290
13	-75	-5.7927	-1.5914	0.3309
		DQ 0.0006		
14	28	15.2431	2.3479	0.4893
14	73	13.5111	1.8783	0.4338
14	74	13.5111	1.8783	0.4338
14	36	9.4433	0.9682	0.3033
14	-37	-3.8381	-0.7431	0.2193
14	-38	-5.9824	-1.6891	0.3417
14	-33	-0.9633	-0.0576	0.0551
		DQ 0.0002		
15	39	9.0388	0.8929	0.2903
15	-40	-2.5394	-0.3461	0.1452
15	-36	-9.4433	-0.9682	0.3033
		DQ 0.0001		
16	37	3.8381	0.7431	0.2193
16	41	0.5607	0.3383	0.1513
16	-42	0.1410	0.0482	0.0323
16	-43	-0.9035	-1.4960	0.2068
16	-44	-0.7096	-0.2357	0.0914
		DQ 0.0003		
17	20	2.9724	0.1141	0.0956
17	45	11.4351	1.3795	0.3672
17	-48	-0.8645	-0.3396	0.1113
17	-47	-5.1846	-1.2962	0.2962
		DQ 0.0004		
18	96	23.0233	5.0350	0.7388
18	97	7.3469	2.4702	0.4196
18	98	7.3469	2.4702	0.4196
18	48	10.2019	1.1170	0.3276
18	-49	-2.3603	-2.1776	0.3036
18	-45	-11.4351	-1.3795	0.3672
		DQ 0.0012		
19	100	9.4990	3.9732	0.5423
19	101	9.4990	3.9732	0.5423
19	50	7.0137	2.2869	0.4006
19	-51	-4.2767	-6.5396	0.5498
19	-48	-10.2019	-1.1170	0.3276
		DQ 0.0014		
20	78	8.7737	1.8407	0.5011
20	-52	2.5711	2.5512	0.8307
20	-53	-1.1388	-2.2955	0.2606
20	-87	-10.7903	-2.6991	0.8162
20	-79	-9.7733	-2.2474	0.5582
		DQ 0.0001		
21	51	4.2767	6.5398	0.5498
21	54	7.7033	2.6965	0.4399
21	55	1.4245	3.4734	0.3259
21	-56	-1.4771	-3.7141	0.3379
21	-57	-10.2648	-4.5860	0.5860
21	-58	-5.6454	-1.5173	0.3225
		DQ 0.0014		
22	49	2.3603	2.1776	0.3036
22	58	5.6454	1.5173	0.3225
22	-59	-7.6094	-2.6360	0.4345
		DQ 0.0010		
23	46	0.8645	0.3396	0.1113
23	59	7.6044	2.6360	0.4345
23	57	10.2548	4.5860	0.5860
23	-60	-2.8901	-3.1673	0.3717
		DQ 0.0003		
24	56	1.4771	3.7141	0.3379
24	-61	1.2492	2.7240	0.2858
24	-62	0.4767	0.4583	0.1092
24	-63	-8.5578	-3.2758	0.4886
		DQ 0.0013		
25	92	-4.3253	-0.4974	0.2472
25	-64	1.6400	4.5073	0.3751
25	-65	-1.8999	-4.8167	0.3888
		DQ 0.0000		
26	66	28.0131	7.2378	0.8987
26	67	2.7623	0.0996	0.0888
26	-16	-28.0136	-7.2380	0.8987
		DQ 0.0002		
27	68	25.2508	5.9731	0.8102
27	-69	5.9041	1.6485	0.3372
27	-15	-25.2726	-5.9826	0.8109
27	-67	-2.7823	-0.0996	0.0888
		DQ 0.0006		
28	70	16.8145	2.8152	0.5397
28	-71	2.3110	0.2907	0.1321
28	-24	-16.8046	-2.8121	0.5394
28	69	-5.9041	-1.8485	0.3372
		DQ 0.0004		
29	71	-2.3110	-0.2907	0.1321
29	72	15.2460	2.3487	0.4894
29	-28	-15.2431	-2.3479	0.4893
		DQ 0.0001		
30	75	5.7927	1.5914	0.3309
30	-76	-26.1148	-6.3567	0.8379
30	-31	-5.7396	-1.5645	0.3279
		DQ 0.0008		
31	35	13.5109	1.8783	0.4338
31	-74	-13.5111	-1.8783	0.4338
31	-75	-13.5111	-1.8783	0.4338
		DQ 0.0001		
32	83	1.9713	0.8375	0.2537
32	82	1.9713	0.8375	0.2537
32	-41	-0.8607	-0.8383	0.1513
		DQ 0.0003		
33	40	2.5394	0.3461	0.1452
33	80	2.1883	0.0218	0.0450
33	-81	0.5887	0.0840	0.0733
33	-82	-1.9713	-0.8375	0.2537
33	-83	-1.9713	-0.8375	0.2537
		DQ 0.0002		
34	76	26.1148	6.3567	0.8379
34	79	9.7733	2.2474	0.5582
34	-50	-7.0137	-2.2669	0.4006
		DQ 0.0010		
35	34	13.3612	1.8399	0.4290
35	71	2.1723	0.2593	0.1242
35	-78	-8.7737	-1.8407	0.5011
		DQ 0.0003		
36	38	5.9824	1.6891	0.3417
36	-84	-8.3750	-1.6890	0.4784
36	-77	-2.1723	-0.2593	0.1242
		DQ 0.0001		
37	44	0.7096	0.2357	0.0914
37	-85	-2.8897	-0.2359	0.1652
37	-86	-2.8897	-0.2359	0.1652
		DQ 0.0003		
38	87	10.7903	2.8991	0.6182
38	-88	-2.6788	-2.7523	0.3445
38	-54	-7.7068	-2.6965	0.4399
		DQ 0.0009		
39	88	2.6788	2.7523	0.3445
39	-89	12.3303	3.4546	0.7040
39	-55	-1.4245	-3.4734	0.3259
		DQ 0.0013		
40	-90	10.7528	2.6817	0.6140
40	91	4.7874	32.7067	1.0939
40	61	-1.2492	-2.7240	0.2858
		DQ 0.0013		
41	-91	-4.7874	-32.7067	1.0939
41	-92	4.3253	0.4974	0.2472
41	62	-0.6767	-0.4583	0.1092
		DQ 0.0013		
42	18	49.3493	6.9599	1.0127
42	-94	-2.1700	-0.2587	0.1241
42	-93	-12.8810	-6.9598	0.7341
		DQ 0.0002		
43	94	2.1700	0.2587	0.1241
43	16	22.7951	4.9431	0.7315
43	-95	-10.6910	-4.9445	0.6103
		DQ 0.0003		
44	30	15.6773	2.4731	0.5033
44	99	12.3539	1.5916	0.3967
44	-98	-7.3469	-2.4702	0.4196
44	-97	-7.3469	-2.4702	0.4196
		DQ 0.0011		
45	32	20.3798	4.0180	0.6540
45	-101	-9.4990	-3.9732	0.5423
45	-100	-9.4990	-3.9732	0.5423
45	-99	-12.3539	-6.4607	0.7051
		DQ 0.0014		
46	43	0.9035	1.4960	0.2068
46	-103	-2.6957	-1.4942	0.3468
46	-102	-2.6957	-1.4942	0.3468
		DQ 0.0003		
47	42	-0.1410	-0.0482	0.0323
47	-105	0.4197	0.0479	0.0541
47	-104	0.4197	0.0479	0.0541
		DQ 0.0003		
48	106	1.6196	0.0125	0.0334
		DQ 0.0		

FROM NODE 1

NODE NO.	Dynamic Water Level	Ground Height	Effective Head
1	233.3000	166.3000	67.0000
2	221.5755	170.0000	51.5755
3	211.5523	169.0000	42.5523
4	204.4198	169.0000	35.4198
5	202.3949	170.0000	32.3949
6	201.4092	170.0000	31.4092
7	198.8692	170.0000	28.8692
8	198.0849	170.0000	28.0849
9	196.3441	170.0000	26.3441
10	198.2287	170.0000	26.2287
11	192.8098	170.0000	22.8098
12	187.0834	170.0000	17.0634
13	186.0348	170.0000	16.0348
14	188.0260	170.0000	16.0260
15	187.1788	170.0000	17.1788
16	188.1954	170.0000	18.1954
17	189.1408	170.9000	18.2408
18	188.0127	169.0000	17.0127
19	186.8190	170.0000	16.8490
20	187.3308	170.0000	17.3808
21	187.9538	170.0000	17.9538
22	187.9743	170.0000	17.9743
23	186.0482	170.0000	16.0482
24	186.9058	170.0000	16.9958
25	187.4984	170.0000	17.4984
26	187.5596	170.0000	17.5596
27	183.0527	170.0000	13.0527
28	183.9662	168.0000	15.9662
29	183.2020	168.0000	15.2020
30	186.1006	170.0000	16.1006
31	184.1248	170.0000	14.7248
32	180.7956	169.0000	11.7956
33	180.4336	170.0000	10.4336
34	171.8136	175.0000	-3.1864
35	185.4542	169.0000	16.4542
36	185.2096	170.0000	15.2096
37	185.2512	170.0000	15.2512
38	184.7440	172.0000	12.7440
39	183.3154	173.0000	10.3154
40	183.5628	175.0000	8.5628
41	184.1127	169.0000	15.1127
42	184.0406	173.0000	11.0406
43	183.2443	175.0000	8.2443
44	183.2178	178.0000	5.2178
45	183.3128	175.0000	8.3128
46	188.1958	170.0000	18.1958
47	187.1804	170.0000	17.1804
48	186.0263	170.0000	16.0263
49	184.9694	170.0000	14.9694
50	186.8128	170.0000	16.8128
51	186.0120	169.0000	17.0120
52	184.0773	169.0000	15.0773
53	183.9709	168.0000	15.9709
54	180.8283	169.0000	11.8283
55	183.4121	175.0000	8.4121
56	189.1407	170.9000	18.2407
57	187.9496	170.0000	17.9496
58	187.9425	170.0000	17.9425
59	187.3744	170.0000	17.3744
60	187.0971	170.0000	17.0971
61	183.2193	178.0000	5.2193
62	183.2442	175.0000	8.2442
63	183.3109	177.0000	6.3109
64	183.1568	169.1000	14.0568

Calculation Sheets - IV for Improvement ~ C

District - 1

LOOP NO.	PIPE NO.	Q	I	V	H
1	1	231.4800	6.9376	1.4641	11.7245
					11.7245
		DQ 0.0			
2	2	217.5900	6.1872	1.3763	10.0232
					10.0232
		DQ 0.0			
3	3	205.6200	5.5722	1.3007	7.1325
					7.1325
		DQ 0.0			
4	4	92.9581	9.2418	1.3240	2.9574
4	5	84.7181	7.7836	1.2067	2.4907
4	6	74.8481	6.1895	1.0663	2.7234
4	-7	0.9992	0.0152	0.0322	0.0033
4	-8	-89.4399	-8.6051	1.2739	-8.1748
					-0.0000
		DQ 0.0000			
5	8	89.4399	8.6051	1.2739	8.1748
5	9	10.2974	1.1364	0.3307	0.3750
5	-10	-13.2214	-7.3249	0.7546	-6.4460
5	-11	-15.2714	-9.5635	0.8715	-2.1040
					-0.0001
		DQ 0.0001			
6	12	23.8344	21.7904	1.3595	4.5760
6	13	16.4444	10.9666	0.9383	9.5409
6	14	10.5145	4.7946	0.6002	1.6302
6	-15	-20.9934	-4.2446	0.6737	-0.7216
6	-16	-39.6842	-13.7857	1.2727	-15.0264
					-0.0010
		DQ 0.0005			
7	16	39.6842	13.7857	1.2727	15.0264
7	-17	-26.8232	-6.6793	0.8606	-1.4694
7	-18	-69.4516	-13.0963	1.4248	-13.5547
7	7	-0.9992	-0.0152	0.0322	-0.0033
					-0.0010
		DQ 0.0012			
8	18	69.4516	13.0963	1.4248	13.5547
8	19	35.0382	10.9494	1.1238	2.6278
8	20	-7.9336	-0.7015	0.2548	-0.1263
8	-21	-17.6088	-12.4462	1.0047	-15.6822
8	-9	-10.2974	-1.1364	0.3307	-0.3750
					-0.0010
		DQ 0.0007			
9	22	28.6681	30.6638	1.6349	7.0527
9	23	-65.3816	-34.7200	2.0958	-4.8608
9	-24	-37.9139	-12.6696	1.2160	-2.9140
9	15	20.9934	4.2446	0.6737	0.7216
					-0.0006
		DQ 0.0011			
10	24	37.9139	12.6696	1.2160	2.9140
10	-25	-28.8422	-7.6391	0.9253	-1.7570
10	-19	-35.0382	-10.9494	1.1238	-2.6278
10	17	26.8232	6.6793	0.8606	1.4694
					-0.0014
		DQ 0.0037			
11	26	-0.6050	-0.0060	0.0195	-0.0020
11	-27	-3.8722	-5.4415	0.4978	-1.2516
11	-28	-12.1296	-1.5385	0.3895	-0.5077
11	25	28.8422	7.6391	0.9253	1.7570
					-0.0043
		DQ 0.0088			
12	28	12.1296	1.5385	0.3895	0.5077
12	29	-1.5965	-1.0565	0.2054	-0.1902
12	-30	-5.3852	-1.3905	0.3076	-0.4450
12	-20	7.9336	0.7015	0.2548	0.1263
					-0.0011
		DQ 0.0031			
13	27	3.8722	5.4415	0.4978	1.2516
13	31	0.6272	0.1876	0.0808	0.1107
13	-32	-7.5239	-2.5814	0.4297	-1.3682
					-0.0059
		DQ 0.0061			
14	32	7.5239	2.5814	0.4297	1.3682
14	33	5.1611	1.2853	0.2948	0.3856
14	-34	-2.3588	-2.1750	0.3034	-1.9467
14	-29	1.5965	1.0565	0.2054	0.1902
					-0.0027
		DQ 0.0020			
15	35	4.3999	0.9568	0.2514	1.2534
					1.2534
		DQ 0.0			

FROM NODE 1

NODE NO.	Dynamic Water Level	Ground Height	Effective Head
1	233.3000	166.3000	67.0000
2	221.5755	170.0000	51.5755
3	211.5523	169.0000	42.5523
4	204.4198	169.0000	35.4198
5	202.3158	170.0000	32.3158
6	201.4624	170.0000	31.4624
7	198.9717	170.0000	28.9717
8	196.2483	170.0000	26.2483
9	196.2449	170.0000	26.2449
10	195.8698	170.0000	25.8698
11	191.6723	170.0000	21.6723
12	182.1313	170.0000	12.1313
13	180.5012	170.0000	10.5012
14	181.2228	170.0000	11.2228
15	182.6902	170.9000	11.7903
16	173.4485	170.0000	3.4485
17	178.3093	170.0000	8.3093
18	180.0613	170.0000	10.0613
19	180.1876	170.0000	10.1876
20	178.3113	170.0000	8.3113
21	179.5525	170.0000	9.5525
22	179.7427	170.0000	9.7427
23	178.1816	170.0000	8.1816
24	177.7960	170.0000	7.7960
25	176.5426	170.0000	6.5426

District - 2

LOOP NO.	PIPE NO.	Q	I	V	H
1	-1	-29.8663	-2.7487	0.6132	-0.9345
1	14	61.6935	31.1839	1.9777	13.5650
1	-15	-0.5963	-0.1709	0.0768	-0.1982
1	-16	-4.3064	-26.8880	0.9841	-10.7552
1	-37	-21.1224	-509.5994	4.8193	-0.5096
1	-3	-21.6531	-1.5162	0.4447	-0.5837
1	-2	-21.6531	-1.5162	0.4447	-0.5837
					0.0000
		DQ 0.0000			
2	37	21.1224	509.5994	4.8193	0.5096
2	-5	16.8161	0.9498	0.3455	1.0448
2	-6	6.5778	0.1673	0.1353	0.0002
2	-7	0.6561	0.8276	0.1502	0.7283
2	-8	-2.5739	-10.3766	0.5885	-2.2829
					-0.0000
		DQ 0.0000			
3	-11	8.6072	0.2751	0.1769	0.1087
3	-10	8.6072	0.2751	0.1769	0.1087
3	-9	-0.3618	-0.2751	0.0829	-0.2173
3	6	-6.5778	-0.0002	0.0	-0.0000
					0.0000
		DQ 0.0000			
4	-13	1.6311	4.4620	0.3731	8.9239
4	-12	-1.7089	-4.8640	0.3909	-8.7066
4	10	-8.6072	-0.2751	0.1769	-0.1087
4	11	-8.6072	-0.2751	0.1769	-0.1087
					-0.0000
		DQ 0.0000			
5	2	21.6531	1.5162	0.4447	0.5837
5	3	21.6531	1.5162	0.4447	0.5837
5	-4	-5.6431	-1.5162	0.3224	-1.1675
					0.0
		DQ 0.0			
6	-17	-13.9408	-8.0793	0.7956	-1.8582
6	19	29.7283	8.0789	0.9537	0.8079
6	18	29.7283	8.0789	0.9537	1.0503
					-0.0001
		DQ 0.0001			
7	20	9.5284	3.9960	0.5440	0.9590
7	21	5.7384	1.5639	0.3278	0.8836
7	22	1.8184	1.3441	0.2340	1.6264
7	23	-0.5816	-0.0226	0.0333	-0.0054
7	-24	-34.2475	-10.4967	1.0985	-3.4639
					-0.0003
		DQ 0.0002			
8	24	26.5244	6.5423	0.8510	2.1590
8	25	28.9292	7.6817	0.9281	2.0741
8	26	11.1673	1.3204	0.3586	1.6108
8	-27	-2.9034	-0.4434	0.1660	-0.3281
8	-28	-12.4507	-6.5546	0.7107	-7.3739
8	17	13.9408	8.0793	0.7956	1.8582
					0.0001
		DQ 0.0003			
9	27	2.9034	0.4434	0.1660	0.3281
9	29	2.6741	11.1360	0.6114	4.2317
9	-30	1.5327	3.9769	0.3506	2.1873
9	-31	-2.6273	-10.7783	0.6007	-5.9281
9	-32	-2.6273	-2.6552	0.3379	-0.8231
					-0.0041
		DQ 0.0005			
10	33	9.2220	0.9266	0.2962	1.4826
10	-34	-0.2697	-0.0055	0.0155	-0.0039
10	-26	-11.1673	-1.3204	0.3586	-1.4788
					-0.0001
		DQ 0.0000			
11	24	34.2475	10.4967	1.0985	3.4639
11	35	3.1185	0.0421	0.0642	0.0050
11	-36	1.4986	0.9398	0.1928	0.7612
11	-29	-2.6741	-11.1360	0.6114	-4.2317
					-0.0015
		DQ 0.0014			
12	38	1.6199	0.0125	0.0334	0.0019
					0.0019
		DQ 0.0			
13	39	0.9499	1.6413	0.2174	0.7878
					0.7878
		DQ 0.0			

FROM NODE 1

NODE NO.	Dynamic Water Level	Ground Height	Effective Head
1	210.0000	170.0000	40.0000
2	209.0654	170.0000	39.0654
3	207.8980	168.0000	39.8980
4	205.6151	169.0000	36.6151
5	206.3434	169.0000	37.3434
6	206.1261	170.0000	36.1261
7	197.4195	175.0000	22.4195
8	194.5767	170.0000	24.5767
9	196.4350	169.0000	27.4350
10	196.6332	170.0000	28.6332
11	194.7903	170.0000	24.7903
12	193.9067	169.0000	24.9067
13	192.2803	170.0000	22.2803
14	192.2858	170.0000	22.2858
15	190.2117	172.0000	18.2117
16	188.7329	175.0000	13.7329
17	189.0611	169.0000	20.0611
18	188.2379	170.0000	18.2379
19	182.3099	178.0000	4.3099
20	184.4972	175.0000	9.4972
21	188.7290	173.0000	15.7290
22	185.2584	175.0000	10.2584
23	207.3884	168.0000	39.3884
24	208.4817	170.0000	38.4817
25	206.3434	168.0000	38.3434
26	206.2348	169.0000	37.2348
27	195.6270	170.0000	25.6270
28	185.2565	177.0000	8.2565
29	184.4687	169.1000	15.3687

The results of calculation - I (for 16,000 $m^3/d.$) shows clearly the defect of service pressure at No. 34 and No. 44 cross points of pipe-net. Also these results correspond with the values measured actually at the time of our investigation at No. 45 cross point where the elevated tank locates and with the actual conditions that the water supply is very poor particularly in Sisavone and Ban Nong Lo districts.

The results of calculation - II (for 20,000 $m^3/d.$) shows the negative pressures presenting at many cross points. The reasons for this seems to be that the water consumptions estimated by district on the basis of the size of planned supply areas at the time of initial designing do not correspond with the actual consumptions causing very wide differences between them, and that at present the supply areas have been extended over the areas planned by the original design with the distributing branches increased.

The aforesaid measures for improvement are discussed on the basis of results of calculation shown above.

- Plan-A for Improvement

This plan which suggests to install new pumps with high head is worth considering if an overall improvement can be expected only by the replacement of the existing pumps with a head of 67 m by ones with a head of up to 80 m. However, as seen from the results of Calculation - II, the pumps with a head of 112 m, one higher by 45 m, will be required in order to secure the service pressure only with pumps. On the other hand, even if the friction loss of head is reduced by the partial replacement of pipline a head of about 90 m will be required. Further, in order to assure a distribution system well flexible to meet the fluctuation of consumption it will need to install an elevated tank of about 150 - 200 m^3 in capacity in Ban Nong Lo district.

Merits:

1) The improvement can be completed in a short period.

2) The increase of pipeline is required only for a very limited part.

Demerits:

1) The service pressure in the supply areas will become remarkably uneven with a fear for leakage from the water main near the pumping station.

2) The replacement of the existing water main by one of 450 mmø requires much construction cost and the use of pumps with high head without any replacement of water main is not preferable from the viewpoint of economical bore of pipe.

3) This plan has very little relationship with the future extension plan described later for the developing districts of Vientiane city.

4) Not only much electric power is consumed affecting greatly the prime cost of services but it will prove to be mere waste of expensive power.

5) Not only the replacement of pumps and motors but of electric equipments is required at the same time.

Plan-B for Improvement

The existing distribution pumps will be repaired thoroughly and new distribution pipes will be installed additionally along the existing unreasonable pipeline identified by the results of calculation of pipe networks. The service pressure can be secured by the increase of distribution pipes in the districts except Ban Nong Lo district in which it will be required to provide an elevated tank of about 150 - 200 m^3 in capacity and a booster pump together with connecting pipes between them.

The merits and demerits of this improvement plan are as follows.

Merits:

1) Only small increase in the electric power cost is required to operate the new booster pump.

2) The restoration of designed operating point of the distribution pumps can be expected by a partial increase of pipeline.

3) In view of the relationship with the future extension plan described later, the new elevated tank and additionally laid distribution pipes will be utilized fully in the future.

Demerits:

1) The length of pipeline to be laid additionally is longer compared with that for plan - A.

2) Separate electric equipment is needed to supply the electric power to the booster pump.

Plan-C for Improvement

The existing distribution pumps will be repaired thoroughly and a reservoir of about 3,000 m^3 in capacity and a pumping station will be constructed at a suitable location according to the results of calculation of pipe networks.

Though this improvement method requires only to increase some distribution pipelines on very limited routes, the whole supply areas must be separated into two parts to be served respectively by the supply system of the existing pumping station and that of new station.

In addition, elevated tanks each of about 150 - 200 m^3 in capacity will be required in Ban Nong Lo and Simuang districts.

The merits and demerits of this improvement plan are as follows.

Merits:

1) The restoration of initially designed operating point of distribution pumps can be made by the construction of a reservoir and the electric power can be used effectively.

2) The increase of two elevated tanks provides a flexible distribution method to meet the increase and decrease in the consumption of water.

3) The increase of distribution pipeline is needed only for very limited parts.

Demerits:

1) A longer period is necessary for the construction compared with the Plans - A and - B.

2) The construction cost is far more expensive compared with the Plans - A and - B.

3) The reservoir and pumping station proposed by this plan will lose their values to exist after the completion of future extension work mentioned later.

Based on the merits and demerits of the Plans - A, - B and - C from a general point of view, it has been concluded that the Plans - B and - C are worth considering further in detail.

Therefore, for the Plans - B and - C the calculations of pipe networks have been made with the assumed bore of pipe of modified route for the water conveyance of 20,000 m^3 per day, in order to find in a concrete way which parts of the routes should be improved and which locations are suitable to construct the elevated tank and reservoir. The results of calculations are shown in Calculation Sheet - III and Reference Figure - III for the Plan - B and Calculation - IV and Reference Fig. 9 - 6 for the Plan - C.

Fundamentary, the calculation of pipe networks should be made naturally on the basis of the maximum water supply per hour in designing any distribution networks, but a very extensive improvement will be required as shown in the results of calculation - II made on such basis. Therefore, the Plans - B and - C have been studied on the assumption that at least the water of 20,000 m^3 per day can be supplied satisfactorily.

As the improvement Plan - B has been considered most suitable in view of the cost and construction period for improvement and the utilization of facilities in future, the necessary expenses have been worked out for this plan.

- **Calculation Sheet - I 16,000 m³/day**

LOOP NO.	PIPE NO.	Q	I	V	H
1	1	185.2000	4.5919	1.1716	7.7144
					7.7144
		DQ 0.0			
2	2	174./800	4.1254	1.1058	6.6419
					6.6419
		DQ 0.0			
3	3	185.8000	3.7419	1.0490	4.7522
					4 7522
		DQ 0.0			
4	4	74.5353	6.1418	1.0618	1.9347
4	5	67.8753	5.1652	0.9670	1.6012
4	6	59.3953	4.0983	0.8534	1.7622
4	-7	-1.3006	-0.0247	0.0419	-0.0052
4	-8	-72.8080	-5.8810	1.0372	-5.2929
		DQ-0.0000			0.0000
5	8	72.8080	5.8810	1.0372	5.2929
5	-9	7.6133	0.6500	0.2446	0.2145
5	-10	-10.8363	-5.0695	0.8186	-4.0556
5	-11	-12.4963	-6.5991	0.7183	-1.4518
					0.0000
		DQ 0.0000			
6	12	20.6462	16.706/	1.1778	3.5084
6	13	14.6763	8.8855	0.8376	7.5527
6	14	-1.2980	-0.1000	0.0743	-0.0340
6	-15	-29.7314	-8.0805	0.9538	-1.2929
6	-16	-32.1859	-9.3596	1.0326	-9.7340
					0.0002
		DQ-0.0001			
7	16	32.1895	9.3596	1.0326	9.7340
7	-17	-23.2629	-5.1324	0.7465	-1.0778
7	-18	-55.2440	-8.5766	1.1336	-8.6613
7	7	1.3006	0.0247	0.0419	0.0052
					0.0001
		DQ-0.0003			
8	18	55.2440	8.5756	1.1336	8.6613
8	19	25.8507	6.2382	0.8294	1.4660
8	-20	-2.7963	-0.1019	0.0899	-0.0183
8	-21	-13.6696	-7.7908	0.7802	-9.8944
8	9	-7.6133	-0.6500	0.2446	-0.2145
					0.0001
		DQ-0.0001			
9	22	11.1743	5.3660	0.6379	1.5025
9	23	4.8970	1.1663	0.2798	0.2799
9	-24	-21.7731	-4.5409	0.6987	-1.8164
9	-14	1.2980	0.1000	0.0743	0.0340
					0.0000
		DQ-0.0001			
10	25	3.2173	3.8625	0.4137	2.5879
10	26	0.0473	0.0016	0.0061	0.0017
10	27	-1.8926	-0.2009	0.1082	-0.0502
10	-28	-26.7497	-6.6455	0.8582	-2.2595
10	-23	-4.8970	-1.1663	0.2798	-0.2799
					0.0000
		DQ-0.0000			
11	17	23.2629	5.1324	0.7465	1.0778
11	29	19.5710	3.7279	0.6281	0.8388
11	-30	-14.5166	-2.1451	0.4660	-0.4505
11	-19	-25.8507	-6.2382	0.8294	-1.4660
					0.0001
		DQ-0.0002			
12	15	29.7314	8.0805	0.9538	1.2929
12	31	4.3602	0.9409	0.2491	0.2164
12	-32	-22.4080	-4.7889	0.7191	-0.6704
12	-29	-19.5710	-3.7279	0.6281	-0.8388
					0.0000
		DQ-0.0005			
13	24	21.7731	4.5409	0.8987	1.8164
13	33	-2.4295	-0.3189	0.1389	-0.0733
13	-34	-19.3046	-3.6346	0.6196	-1.5265
13	-31	-4.3802	-0.9409	0.2491	-0.2164
					0.0001
		DQ-0.0001			
14	28	26.7497	6.6455	0.8582	2.2595
14	35	23.4672	5.2160	0.7530	1.6691
14	36	8.7909	0.8481	0.2824	1.0262
14	-37	-1.9029	-0.2029	0.1088	-0.1502
14	-38	-9.9824	-4.3553	0.5699	-4.8780
14	-38	2.4295	0.3189	0.1389	0.(/33
					0.0000
		DQ-0.0000			
15	39	7.7665	0.6744	0.2495	1.0790
15	-40	-1.1233	-0.0765	0.0643	-0.0528
15	-36	-8.7909	-0.8481	0.2824	-1.0262
					0.0000
		DQ 0.0			
16	37	1.9029	0.2029	0.1088	0.1502
16	-41	3.0105	13.8659	0.6882	5.1304
16	-42	0.8806	1.4264	0.2015	0.7845
16	-43	-2.4794	-9.6830	0.5669	-5.3256
16	-44	-2.4794	-2.3854	0.3189	-0.7395
					0.0000
		DQ 0.0000			
17	20	2.7963	0.1019	0.0899	0.0183
17	45	12.5107	1.6291	0.4017	0.5213
17	-46	1.6449	1.1165	0.2117	0.2121
17	-47	-7.4032	-2.5054	0.4228	-0.7516
					0.0002
		DQ-0.0002			
18	30	14.5166	2.1451	0.4660	0.4505
18	48	10.0796	1.0923	0.3237	0.3714
18	-49	-1.8340	-1.3655	0.2360	-0.3004
18	-45	-12.5107	-1.6291	0.4017	-0.5213
					0.0001
		DQ-0.0011			
19	32	22.4080	4.7889	0.7191	0.6704
19	-50	5.4436	1.4185	0.3110	0.4823
19	-51	-3.9250	-5.5798	0.5046	-0.7812
19	-48	-10.0796	-1.0923	0.3237	-0.3714
					0.0002
		DQ-0.0002			
20	34	19.3046	3.6346	0.6196	1.5265
20	-52	1.9029	1.4619	0.2448	1.6812
20	-53	-1.0971	-2.1424	0.2511	-0.8998
20	54	-7.2886	-2.4341	0.4162	-1.8256
20	50	-5.4436	-1.4185	0.3110	-0.4823
					0.0001
		DQ-0.0001			
21	51	3.9250	5.5798	0.5046	0.7812
21	-54	7.2886	2.4341	0.4162	1.8256
21	-55	3.2816	16.2631	0.7501	3.2526
21	-56	-2.3333	-8.8537	0.5335	-3.4615
21	-57	-10.5803	-4.8502	0.6040	-1.4550
21	-56	-5.8585	-1.6250	0.3346	-0.9425
					0.0003
		DQ-0.0001			
22	58	5.8585	1.6250	0.3346	0.9425
22	-59	-7.1417	-2.3441	0.4079	-1.2424
22	49	1.8340	1.3655	0.2360	0.3004
					0.0005
		DQ-0.0003			
23	59	7.1417	2.3441	0.4079	1.2424
23	57	10.5803	4.8502	0.6040	1.4550
23	-60	-7.8982	-2.8240	0.4510	-2.4851
23	46	-1.6449	-1.1165	0.2117	-0.2121
					0.0002
		DQ-0.0005			
24	56	2.3333	8.6537	0.5335	3.4615
24	-61	3.0049	13.8176	0.6869	13.8176
24	-62	-2.3736	-8.9322	0.5427	-7.0565
24	-63	-13.6251	-7.7440	0.7776	-10.2221
					0.0005
		DQ-0.0000			
25	62	2.3736	8.9322	0.5427	7.0565
25	-64	0.8785	1.4203	0.2011	2.8406
25	-65	-1.8315	-5.5290	0.4189	-9.8969
					0.0001
		DQ-0.0000			
26	66	1.2997	0.0083	0.0268	0.0022
					0.0022
		DQ 0.0			
27	67	0.7597	1.0857	0.1739	0.5211
					0.5211
		DQ 0.0			

FROM NODE

NODE NO.	Dynamic Water Level	Ground Height	Effective Head
1	233.3000	166.3000	67.0000
2	225.5855	170.0000	55.5855
3	218.9436	169.0000	49.9436
4	214.1914	169.0000	45.1914
5	212.7396	170.0000	42.7396
6	212.2567	170.0000	42.2567
7	210.6555	170.0000	40.6555
8	208.8933	170.0000	38.8933
9	208.8985	170.0000	38.8985
10	208.6840	170.0000	38.6840
11	205.3848	170.0000	35.3848
12	197.8322	170.0000	27.8322
13	196.3297	170.0000	26.3297
14	196.0498	170.0000	26.0498
15	197.8662	170.0000	27.8662
16	199.1590	170.0000	29.1590
17	200.2371	170.9000	29.3371
18	196.1231	169.0000	27.1231
19	197.6498	170.0000	27.6498
20	198.3202	170.0000	28.3202
21	198.7713	170.0000	28.7713
22	198.7896	170.0000	28.7896
23	197.1675	170.0000	27.1675
24	197.9486	170.0000	27.9486
25	198.2501	170.0000	28.2501
26	198.0380	170.0000	28.0380
27	194.4419	170.0000	24.4419
28	195.3417	168.0000	27.3417
29	192.0891	168.0000	24.0891
30	197.0079	170.0000	27.0079
31	195.5529	170.0000	25.5529
32	178.2743	169.0000	9.2743
33	185.3308	170.0000	15.3308
34	175.4337	175.0000	0.4337
35	193.7418	169.0000	24.7418
36	193.7401	170.0000	23.7401
37	193.7903	170.0000	23.7903
38	192.1211	172.0000	20.1211
39	191.0421	173.0000	18.0421
40	191.0949	175.0000	16.0949
41	191.2451	169.0000	22.2451
42	190.5056	170.0000	20.5056
43	185.9645	175.0000	10.9645
44	185.1800	178.0000	7.1800
45	191.0399	177.0000	14.0399
46	190.5187	169.1000	21:4187

Calculation Sheet - II 20,000 m^3/day

LOOP NO.	PIPE NO.	Q	I	V	H
1	1	231.4800	6.9376	1.4641	11.7245
					11.7245
		DQ 0.0			
2	2	217.5900	6.1872	1.3763	10.0232
					10.0232
		DQ 0.0			
3	3	205.6200	5.5722	1.3007	7.1325
					7.1325
		DQ 0.0			
4	4	92.9848	9.2466	1.3244	2.9589
4	5	84.7446	7.7881	1.2071	2.4922
4	6	74.8746	8.1886	1.0666	2.7252
4	-7	-0.6301	-0.0065	0.0203	-0.0014
4	-8	-89.4399	-8.6051	1.2739	-8.1748
					0.0000
		DQ 0.0000			
5	8	89.4399	8.6051	1.2739	8.1748
5	9	9.8329	1.0434	0.3158	0.3443
5	-10	-13.1949	-7.2977	0.7531	-6.4220
5	-11	-15.2449	-9.5327	0.8700	-2.0972
					-0.0000
		DQ 0.0000			
6	12	25.7333	25.1104	1.4677	5.2732
6	13	18.3433	13.4237	1.0466	11.6786
6	-14	-1.9740	-0.2172	0.1129	-0.0738
6	-15	-36.6380	-11.8922	1.1751	-2.0217
6	-16	-39.4409	-13.6298	1.2649	-14.8565
					-0.0002
		DQ 0.0001			
7	16	39.4409	13.8298	1.2649	14.8565
7	-17	-29.2146	-7.8225	0.9372	-1.7210
7	-18	-68.2870	-12.8929	1.4009	-13.1372
7	7	0.6301	0.0085	0.0203	0.0014
					-0.0002
		DQ 0.0003			
8	18	68.2870	12.6929	1.4009	13.1372
8	19	31.4820	8.9826	1.0099	2.1558
8	-20	-5.8002	-0.3683	0.1800	-0.0663
8	-21	-17.1176	-11.8115	0.9767	-14.8825
8	-9	-9.8829	-1.0434	0.3158	-0.3443
					-0.0002
		DQ 0.0001			
9	22	14.3875	0.5647	0.8211	2.3981
9	23	4.5214	1.0062	0.2583	0.2415
9	14	1.9740	0.2172	0.1129	0.0738
					-0.0000
		DQ 0.0001			
10	25	6.0760	1.7383	0.3471	0.9822
10	26	2.1560	1.8419	0.2774	2.2287
10	27	-0.2440	-0.0045	0.0140	-0.0011
10	-28	-31.5052	-8.9949	1.0106	-2.9683
10	-23	-4.5214	-1.0062	0.2583	-0.2415
					-0.0000
		DQ 0.0000			
11	29	24.4175	5.6135	0.7835	1.2911
11	-30	-19.5578	-5.7233	0.6277	-0.8564
11	-19	-31.4820	-8.9826	1.0099	-2.1558
11	17	29.2146	7.8225	0.9372	1.7210
					-0.0001
		DQ 0.0004			
12	31	5.1336	1.2727	0.2933	0.2927
12	-32	-28.1835	-7.3098	0.9035	-1.0234
12	-29	-24.4175	-5.6135	0.7835	-1.2911
12	15	36.8380	11.8922	1.1751	2.0217
					-0.0001
		DQ 0.0004			
13	33	-3.2034	-0.5319	0.1831	-0.1223
13	-34	-23.6318	-5.2839	0.7583	-2.2985
13	-31	-5.1336	-1.2727	0.2933	-0.2927
13	24	26.8304	6.6182	0.8563	2.7135
					-0.0001
		DQ 0.0002			
14	28	31.5052	8.9949	1.0106	2.9683
14	35	29.5415	7.9852	0.9477	2.1560
14	38	11.1666	1.3202	0.3586	1.6107
14	-37	-1.8363	-0.1900	0.1050	-0.1406
14	-38	-11.8380	-5.9704	0.6757	-6.7167
14	-33	3.2034	0.5319	0.1831	0.1223
					-0.0000
		DQ 0.0000			
15	39	9.8350	1.0438	0.3159	1.6701
15	-40	-1.1747	-0.0381	0.0672	-0.0594
15	-36	-11.1866	-1.3202	0.3586	-1.6107
					-0.0000
		DQ 0.0000			
16	-41	3.7183	20.4821	0.8498	7.7870
16	-42	1.0783	2.0749	0.2467	1.1412
16	-43	-3.0817	-14.4784	0.7045	-7.9681
16	-44	-3.0817	-3.5667	0.3963	-1.1057
16	37	1.8363	0.1900	0.1050	0.1406
					-0.0000
		DQ 0.0000			
17	45	15.5244	2.4286	0.4983	0.8015
17	-46	-1.1337	-0.5809	0.1459	-0.1010
17	-47	-7.2275	-2.3964	0.4128	-0.7669
17	20	5.6002	0.3683	0.1800	0.0663
					-0.0001
		DQ 0.0002			
18	48	13.8320		0.4441	0.6670
18	-49	-2.6764	-3.1397	0.3699	-0.7221
18	-45	-15.5244	-2.4286	-/4093	-0.8015
18	30	19.5578	3.7233	0.6277	0.8564
					*-0.0003
		DQ 0.0006			
19	-50	7.1754	2.3648	0.4098	0.8039
19	-51	-4.7700	-8.0033	0.8131	-1.1605
19	-48	-13.8320	-1.9617	0.4441	-0.6670
19	32	28.1635	7.3098	0.9035	1.0234
					-0.0001
		DQ 0.0002			
20	-52	2.4206	2.2817	0.3114	2.6468
20	-53	-1.2894	-2.8884	0.2950	-1.1554
20	54	-9.3754	-3.8781	0.5353	-2.9861
20	50	-7.1754	-2.3646	0.4098	-0.8039
20	34	23.6318	5.2839	0.7583	2.2985
					-0.0001
		DQ 0.0000			
21	-54	9.3754	3.8781	0.5353	2.9801
21	-55	4.4860	29.0002	1.0251	6.3800
21	-56	-2.6469	-10.9278	0.6052	-4.4803
21	-57	-17.7599	-12.6445	1.0133	-3.7934
21	-58	-9.2984	-3.8194	0.5309	-2.2534
21	51	4.7700	8.0033	0.6131	1.1605
					-0.0004
		DQ 0.0001			
22	58	9.2984	3,9194	0.5309	2.2534
22	-59	-11.4517	-5.6150	0.6537	-2.9759
22	49	2.8764	3.1397	0.3699	0.7221
					-0.0004
		DQ 0.0004			
23	59	11.4517	5.6150	0.6537	2.9759
23	57	17.7599	12.6645	1.0133	3.7934
23	-60	-4.8638	-7.6786	0.5995	-6.8705
23	46	1.1337	0.5609	0.1459	0.1010
					-0.0003
		DQ 0.0001			
24	-61	3.4029	22.4146	0.8920	19.7248
24	-62	-2.7865	-12.0176	0.6371	-9.4939
24	-63	-16.6569	-11.2302	0.9505	-14.7115
24	56	2.6469	10.9276	0.6052	4.4803
					-0.0003
		DQ 0.0000			
25	-64	1.1295	2.2609	0.2585	4.5217
25	-65	-2.2105	-7.8301	0.5055	-14.0158
25	62	2.7865	12.0176	0.6371	9.4939
					-0.0002
		DQ 0.0000			
26	66	1.8197	0.0125	0.0334	0.0034
					0.0034
		DQ 0.0			
27	67	0.9497	1.6405	0.2174	0.7874
					0.7874
		DQ 0.0			

FROM NODE 1

NODE NO.	Dynamic Water-Level	Ground Height	Effective Head
1	233.3000	166.0000	67.0000
2	221.5755	170.0000	51.5755
3	211.5523	169.0000	42.5523
4	204.4198	169.0000	35.4198
5	202.3226	170.0000	32.3226
6	201.4609	170.0000	31.4609
7	198.9687	170.0000	28.9687
8	196.2435	170.0000	26.2435
9	196.2449	170.0000	26.2449
10	195.9000	170.0000	25.9006
11	190.9703	170.0000	20.9703
12	179.2917	170.0000	9.2917
13	176.8936	170.0000	6.8936
14	176.6521	170.0000	6.6521
15	179.3655	170.0000	9.3655
16	181.3872	170.0000	11.3872
17	183.1078	170.9000	12.2078
18	176.7744	169.0000	7.7744
19	179.0728	170.0000	9.0728
20	180.0962	170.0000	10.0962
21	180.9518	170.0000	10.9518
22	181.0180	170.0000	11.0180
23	178.2689	170.0000	8.2689
24	179.4293	170.0000	9.4293
25	180.1502	170.0000	10.1502
26	180.2512	170.0000	10.2512
27	174.1276	170.0000	4.1276
28	175.2830	168.0000	7.2830
29	168.9029	168.0000	0.9029
30	177.1740	170.0000	7.1740
31	173.3807	170.0000	3.3807
32	149.1752	169.0000	-19.8248
33	158.6691	170.0000	-11.3309
34	144.6535	175.0000	-30.3465
35	175.9114	169.0000	6.9114
36	173.6827	170.0000	3.6827
37	173.6838	170.0000	3.6838
38	171.5278	172.0000	-0.4722
39	169.8577	173.0000	-3.1423
40	169.9171	175.0000	-5.0829
41	170.0577	169.0000	1.0577
42	168.9520	170.0000	-1.0480
43	162.1301	175.0000	-12.8699
44	160.9889	178.0000	-17.0111
45	169.8543	177.0000	-7.1457
46	169.0669	169.1000	-0.0331

3. Cost of Improvement

1) Estimation Bases for Construction Costs

a) The construction costs have been estimated basing on unit prices of materials and labors in Vientiane, using the standard quantity per unit of construction work applied to such estimating generally in Japan.

b) Cost iron pipes, polyvinyl chloride pipes, iron bars and elevated tank (of steel - made) will be imported from Japan, and cement and temporary materials will be procured on the spot.

c) Land expenses for elevated tank and booster pump station are not included in the estimation.

d) Operation panel is included in the booster pump equipment but power line outside the station is not included in the cost.

e) Back-filling of excavation for additional installation of distribution pipes and gravel laying (in 10 cm thick) on the route portion under which cast iron pipes have been laid are included in the cost estimation but not the restoration of pavement.

f) Any taxes including duties levied on the imported materials are not taken into account for the estimation.

The construction costs estimated on these bases are as follow:

2) Construction Costs

	Description	Total amount	Foreign currency portion	Local currency portion	Remarks
1)	Distribution pipeline	US$197,600	US$169,300	US$ 28,300	Length of c.i.p. (200 mmϕ, 150 mmϕ) = 4,360 m Length of p.v.c pipes (150 mmϕ, 100 mmϕ, 75 mmϕ) = 9,720 m
2)	Elevated tank	81,800	56,100	25,700	150 m^3 in capacity, steel-made, 25 m high above ground
3)	Booster pump	9,770	9,180	590	H = 35 m, Q = 0.9 m^3/min.
	Sub-Total	US$289,170	US$234,580	US$ 54,590	
4)	Expenses for chief engineer	US$ 14,700	US$ 14,700	US$ 0	1 person for 7 mos.
5)	Expenses for technicians	12,000	12,000	0	2 persons for 6 mos. in all for installation of elevated tank
	Sub-total	US$ 26,700	US$ 26,700	US$ 0	
6)	General expenses	US$ 14,730	US$ 12,000	US$ 2,730	5% of 1) - 6)
	Total	US$330,600	US$273,280	US$ 57,320	

(Exchange rate - US$1 = K. 600)

CHAPTER 6 FUTURE EXTENSION

1. Consideration on Future Extension

(1) Population and Design Water-consumption

Table 17 Population in Vientiane

Year	Popuration	Rate of Increase	Population in Service Area
1962	270,147	2.4%	Report unavailable
1963	276,631	2.4	"
1964	283,270	2.4	"
1965	298,069	2.1	132,253
1966	Report unavailable	Report unavailable	Report unavailable
1967	304,000	2.6	"
1968	312,000	2.2	"
1969	319,000	2.2	"
1970	326,000	2.2	"
1971			175,235

The population served in 1971 was -----

$175,235^{pop.} \times 60\% = 105,141^{pop.}$ ($\fallingdotseq$ 105,000)

The water-consumption after the improvement works have been completed will be -----

$20,000\ m^3/d. \times 90 - 95\% = 18,000 - 19,000\ m^3/d.$

Therefore, the application of the maximum water-consumption per capita per day, or 200 l, which was taken into account as the basis at the time of original designing will produce -----

$18,000 - 19,000\ m^3/d. - 105,000^{pop.} \times 200 l.$
$= -3,000 \sim 2,000\ m^3/d.$

In the same manner, the application of the maximum water-consumption per capita per day, or 180 l, will produce -----

$18,000 - 19,000\ m^3/d. - 105,000^{pop.} \times 180 l$
$= -900 \sim + 100\ m^3/d.$

As seen clearly from the results of these calculations, even if the supply of water up to 18,000 - 19,000 m^3 per day is to be enabled after the improvement works have been carried out, it is expected that the problem of water shortage will become considerably serious in 1974, two years after now.

Now, the estimated water-consumption for the future may be calculated as follws:

Present population in the service areas .... 175,235 pop.
Period of design .... 15 years (to 1986)
Water supply pervation 75%

Growth rate of population .... 5% / yr.
Maximum water-consumption per capita per day ... 180 l

$Pn = P_0 (1 + r)^n$

$P_{15} = 175,235(1 + 0.05)^{15} \doteqdot 364,000$ pop.

Planned water-consumption -----

364,000 pop. x 75% x 180 l = 49,000 m^3/d. .... (1)

Service capacity of the existing water supply facilities -----

20,000 m^3/d. x 90 - 95% = 18,000 - 19,000 m^3/d. .. (2)

(1) - (2) = 31,000 - 30,000 m^3/d.

The service capacity of 30,000 m^3 per day will be appropriate for the future extension plan to meet the demands in the period of design for which the situation 15 years ahead is assumed. It is noted that Chinaimo district in the southern part is too covered in this plan.

During the present investigation, an inquiry was made into the conceptions of the future city planning and road project for Vientiane developed by the Ministry of Public Works, in order to use them as data for considering the future extension plan of water supply facilities proposed.

As a result of this inquiry, it has been ascertained that the paved road between Vientiane and Thadua running along the Mekong via Chinaimo and Bang Hong Heo was submerged by the floods of the Mekong occurred three times since 1966 and, therefore, the construction of new road has been already undertaken by the Ministry of Public Works to connect both cities by an approximately straight route extending through the higher ground of inland.

The city planning is being developed along this new road.

If these facts are taken into consideration, the hill on the east of Ban Nong Lo district will be proposed as a suitable site of treatment plant for the future extension plan of the water supply facilities proposed. (See Fig. 10 - 1)

In implementing the extension plan, it is advisable to carry out the works dividing them into two stages, No. 1 and No. 2, as the financial problems troubling Nam Papa Lao now must be settled first.

The works of No. 1 stage will cover the new construction of intake and treating facilities and a part of distribution pipeline (connection of new treatment plant with the existing distribution pipe networks and installation of pipeline leading to Chinaimo district), and in No. 2 stage the distribution pipe networks will be extended into the new service areas in line with the city planning.

(2) Outline of Extension Plan (See Figs. 10 - 1 ~ 10 - 10.)

In the following, the basic designs of various facilities covered by the extension plan are considered from the above viewpoint.

i. Intake Equipment

The intake facilities are constructed in Ban Nong Lo district downstream the Caorio intake tower on the Mekong.

The quantity of water intaken is 1.1 times of the estimated maximum water-consumption per day, including that of water to be used in the treatment plant.

Estimated quantity of water intaken :

$$30{,}000\ m^3/d. \times 1.1 = 33{,}000\ m^3/d.$$
$$= 1{,}375\ m^3/hr.$$
$$= 22.92\ m^3/min.$$
$$= 0.382\ m^3/sec.$$

Intake tower:

4.50 m x 7.50 m x 33.20 m (in height)

Oval, reinforced concrete-made.

Intake pump:

Capacity .... $33{,}000\ m^3/d.$

Quantity of water pumped up .... $Q = 11.46\ m^3/min.$
$= 191\ l/sec.$

Dia. of suction bore ....

$$D = 35.7 \times \sqrt{\frac{q}{v}} = 35.7 \times \sqrt{\frac{191}{2.0}} \fallingdotseq 350\ mm\phi$$

Head ....

Actual head (h_1) = 17.00 m

Pipe loss of head (h_2) = 15.00 m

$H = h_1 + h_2 = 32.00$ m

Shaft power ....

$$P_s = \frac{0.0098 \times Q \times H}{\eta}$$
$$= \frac{0.0098 \times 191 \times 32}{0.82}$$
$$\fallingdotseq 74\ kw$$

Output of motor ....

$$P = P_s\,(1 + \alpha)$$
$$= 74 \times 1.4 = 103.6$$
$$\fallingdotseq 104\ kw$$

Incidental establishment :	Electric equipment for blow-off submergible pump
Water pipe bridge :	1.50 m x 1.50 m x 32.0 m ... 2 spans
	Length .... 64 m
	Water main ...... 600 mmø
	Steel supporting structure

ii. Transmission Pipe

Length	1,100 m
Bore of pipe	600 mmø
Quantity of water conveyed	33,000 m^3/d.

iii. Filtration Equipment

Receiving Well — The quantity of raw water is metered in this well.

Size	7.00 m x 3.60 m x 3.25 m
Capacity	63.0 m^3
Retention period ..	2.7 mins.
No. of chamber ..	1
Incidental establishment ...	Weir flow meter

Mixing basin : This basin has the object to feed chemicals and mix raw water --- reinforced concrete-made.

Size	2.50 m x 3.00 m x 3.30 m
Capacity	21.0 m^3/chamber
Retention period ..	2.7 mins.
No. of chamber ...	3
Incidental establishment	7.5 ps flash mixer

Flocculation basin : This basin has the object to form flock and is of vertical circuit flow type, reinforced concrete-made.

Size	9.60 m x 5.00 m x 3.30 m
Capacity	130 m^3 /chamber
Retention period ..	34 mins.

Current velocity ... 0.25 m/sec.

No. of chamber 6

Chemical sedimentation basin :

This basin has the object to deposit floc and is of sloping plates settling system --- reinforced concrete-made.

Size .... 14.00 m x 5.00 m x 2.50 m in effective depth

Capacity .... 175 m^3/chamber

Retention period ... 45 mins.

Current velocity ... 0.35 m/sec.

No. of chamber ... 6

Chemical dissolving and feeding equipment :

It is a chemical feeding equipment to improve the sedimentation effect.

Solution tank of almina sulphate ..... 2 units

Solution tank of soda ashes .... 2 units

Rapid Filter : Green leaf filter type.

Filter area ...... 245 m^2/unit

Filtering capacity .. 16,500 m^3/d./unit

Rate of filtration ... 140 m/d.

Incidental establishment .....

Stationary surface washing equipment

Clean Water Reservoir :

It is constructed under the ground of administration house and has the object to store the surface water washed.

Size .... 5.60 m x 9.20 m x 3.0 m

Capacity .... 128 m^3

Chlorination Room :

It has the object to conduct the feeding of soda hypochlorite and is of block-made on the service reservoir

Area .... 63 m^2

Administration room : It is a two-storied reinforced concrete building with walls of hollow concrete blocks.

Area .... 1st floor - 168 m^2
2nd floor - 168 m^2

Accommodations.. 1st floor - operator room, electricity room, pump room, chemical feeding room, information and night duty room, hall, toilet, hot water room.

2nd floor - bacterial culture room, water examination room, office room, assembly-room, superintendent's room, toilet, hot water room

Distribution Equipment :

Service reservoir - The capacity of which shall be such that can supply the estimated maximum water- consumption for more than 6 hours. It is of covered type and reinforced concrete-made, with a chlorination room of hollow concrete block-made built on its inflowing side for chlorinating

Size .... 45.00 m x 22.50 m x 4.0 m in effective depth

Capacity ..... 4,050 m^3/chamber

No. of chamber ... 2

Distribution pump - The pumping up capacity of distribution pump shall be 1.5 times of the estimated maximum water-consumption, taking into account the water for hydrants.

$$30{,}000\ m^3/d. \times 1.5 = 45{,}000\ m^3/d.$$
$$= 31.25\ m^3/min.$$
$$= 527.5\ l/sec.$$

The selection of head and type of pump shall be made after the distribution pipe networks and the location of elevated tank has been determined.

Distribution pipe network -

shall be decided at the time of 2nd stage works.

CHAPTER 7 CONCLUSION

In completing the present investigation, the fact which has impressed us is that the services of the water supply facilities have been continued, though with difficulty, without any suspension of water supply even for one day by the endeavors of the staffs of Nam Papa Lao and the members of Japan Overseas Cooperation Volunteer sent from Japan, for eight years since the start of services regardless of their maintenance being by no means adequate due to the impossibility to replenish the needed spare parts of various equipments.

As stated previously in this report, the intake and treating facilities has been already in such conditions that need some overall repair and improvement urgently. Moreover, in order to tackle with the extended service areas lead by the growth of population in recent years, the time has come already when some extension plan must be studied for the future.

We desire earnestly that Nam Papa Lao will make its own hard efforts to solve the financial problems troubling it such as the increased burden for the liabilities in foreign currency due to devaluation, or others, so that the sound management of this water supply business can be attained as soon as possible.

REPAIR AND IMPROVEMENT PLAN

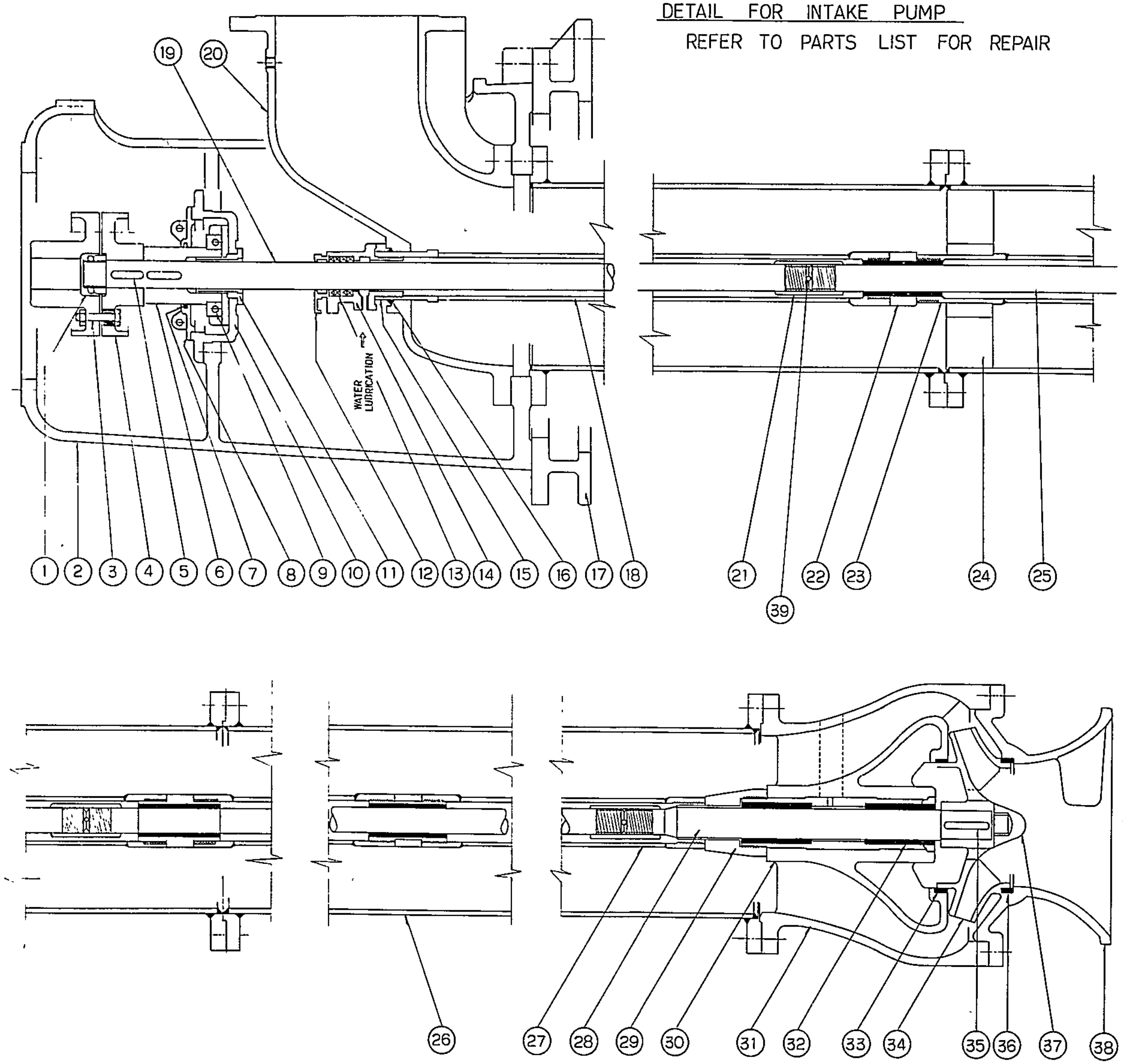
OF

VIENTIANE WATER SUPPLY SYSTEM

INDEX OF DRAWING	
NO	DESCRIPTION
1	DETAIL FOR INTAKE PUMP —REFER TO PARTS LIST FOR REPAIR—
2	DETAIL FOR DISTRIBUTION PUMP —REFER TO PARTS LIST FOR REPAIR—
3	PRESENT DISTRIBUTION PIPE-LINE
4	PRESENT DISTRIBUTION PIPE-LINE —REFER TO CALCULATION FOR PIPE NET-WORK—
5	MAIN DISTRIBUTION PIPE-LINE FOR IMPROVEMENT-B —REFER TO CALCULATION FOR PIPE NET-WORK—
6	MAIN DISTRIBUTION PIPE LINE FOR IMPROVEMENT-C —REFER TO CALCULATION FOR PIPE NET-WORK—
7	EXISTING AND ADDITIONAL DISTRIBUTION PIPE-LINE FOR IMPROVEMENT-B
8	BOOSTER PUMP STATION FOR IMPROVEMENT-B
9	ELEVATED TANK FOR IMPROVEMENT-B

DETAIL FOR INTAKE PUMP

REFER TO PARTS LIST FOR REPAIR



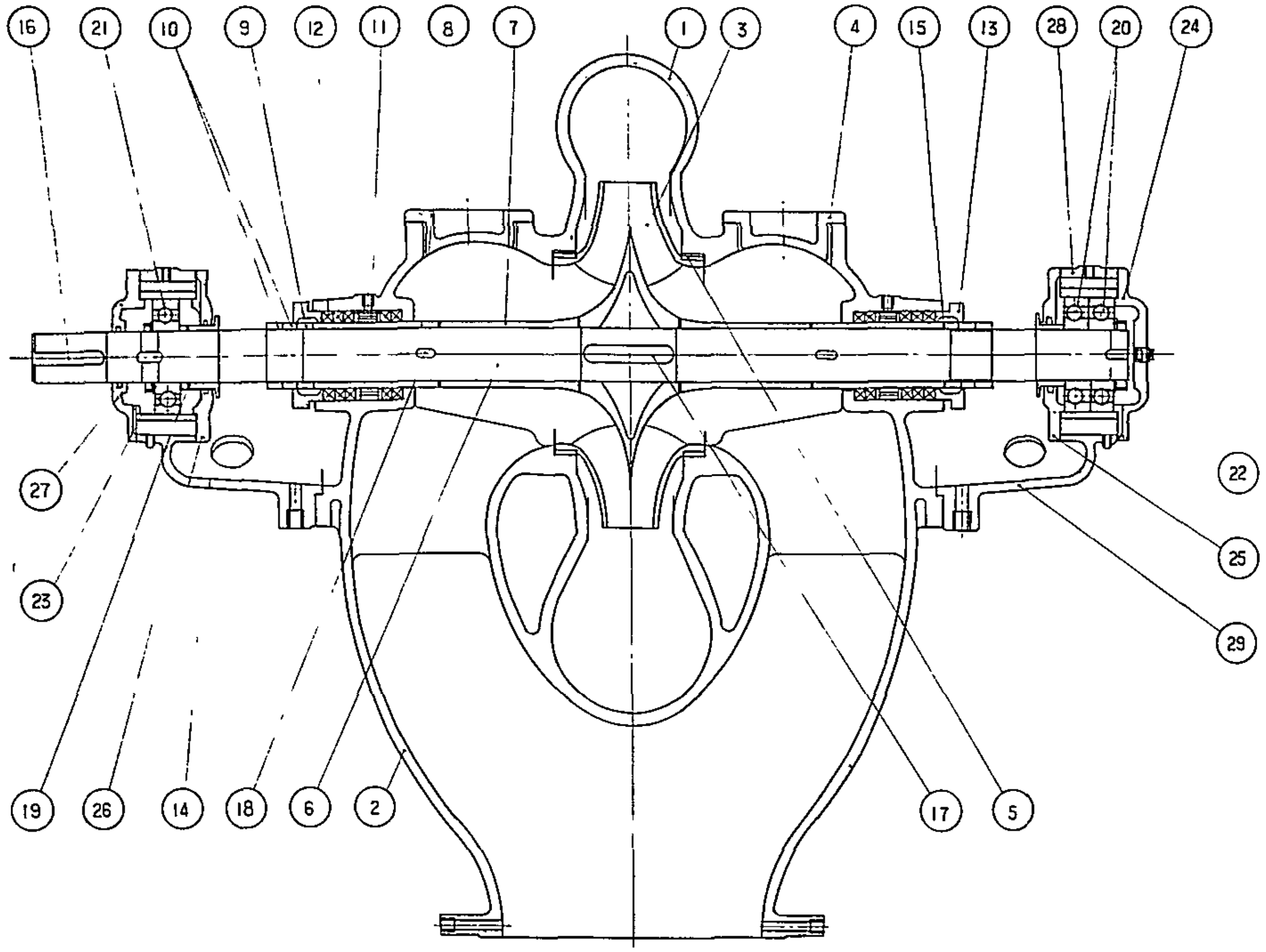
NO	NAME OF PARTS	MATERIAL(JIS)	REMARKS
1	NUT	SS-41	
2	MOTOR FRAME	FC-20	
3	COUPLING BOLTS	SS-41 & RUBBER	
4	COUPLING	FC-20	
5	KEY	SUS-22	
6	JOURNAL	FC-20	
7	FELT RING	FELT	
8	BEARING COVER	FC-20	
9	BALL BEARING		7215 B
10	BEARING CASE	FC-20	
11	OIL TUBE	SGP & SS-41	
12	GLAND	BC-6	
13	PACKING		VALQUA 134
14	STOFFING BOX	BC-6	
15	TOP DISTANCE PIECE	FC-20	
16	O RING	RUBBER	
17	BASE	FC-20	
18	SHAFT ENCLOSING TUBE	SGP & SS-41	
19	TOP CHAFT	SUS-22	
20	DISCHARGE BEND	FC-20	
21	SHAFT COUPLING	SS-41	ZINKING
22	MIDDLE BEARING METAL	BC 6, GRAPHITE BAKETITE	
23	INTERNAL PIPE FOR SPIDER	SGP & SS-41	
24	STABILIZING SPIDER	RUBBER	
25	MIDDLE SHAFT	SS-22	
26	COLUMN PIPE	SGP & SS-41	
27	INTERNAL PIPE	SGP & SS-41	
28	PUMP SHAFT	SUS-22	
29	JOINT	SUS-22	
30	BEARING METAL CASE	BC-6	
31	TOP CASING	FC-20	
32	BEARING METAL CASE	GRAPHITE BAKETITE	
33	LINER RING	LBC-1	
34	IMPELLER	BC-7	
35	KEY	SUS-22	
36	LINER RING	LBC-1	
37	NUT	BC-6	
38	BELL MOUTH	FC-20	
39	TAPER PIN	SUS-27	

NO 2304258		260 VYM				FOR MESSRS LAOS. VIENTIANE
CAPACITY	TOTAL HEAD	R.P.M.	MOTOR	SET	REMARKS	
7.65 M³/MM	190 M	1450	37 KW	3		

VIENTIANE WATER SUPPLY PROJECT

Drawing for : DETAIL FOR INTAKE PUMP REFER TO PARTS LIST FOR REPAIR		
Checked by : T. SANO	Planned by : K. SASAKI	Drawn by : K. SASAKI
Drawing No. 1/9	Scale : As Shown	Date : May 30, 1972

DETAIL FOR DISTRIBUTION PUMP
REFER TO PARTS LIST FOR REPAIR

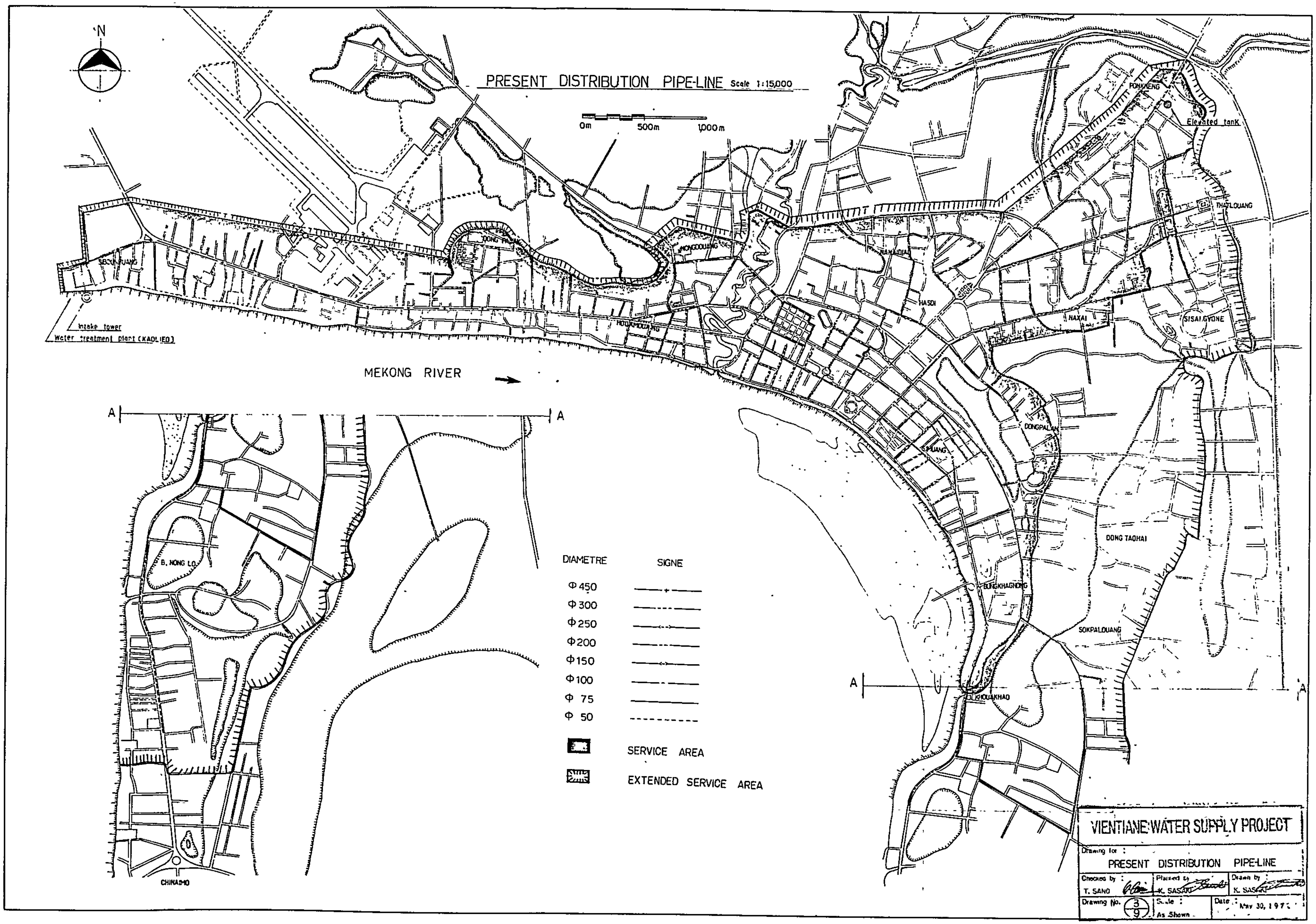


Parts No	Name of Parts	Materials	Q'ty
1	Upper Casing	Cast Iron	1
2	Lower Casing	Cast Iron	1
3	Impeller	Bronze	1
4	Hand Hole Cover	Cast Iron	2
5	Liner Ring	Bronze	2
6	Shaft	Carbon Steel	1
7	Sleeve	Bronze	2
8	Packing Sleeve	Bronze	2
9	Packing Ring	Bronze	2
10	Shaft	Bronze	4
11	Lantern Ring	Bronze	2
12	Grand Packing	Graphite Cotton	10
13	Grand Follower	Bronze	2
14	Water Slinger	Bronze	2
15	Rubber Ring	Rubber	2
16	Coupling Key	Carbon Steel	1
17	Impeller Key	Carbon Steel	1
18	Sleeve Key	Carbon Steel	1
19	Distance Ring	Cast Iron	1
20	Angular Contact Ball B'ring	# 7314	2
21	Radial Ball B'ring	# 6314	1
22	Bearing Nut	Carbon Steel	2
23	Lock Washer	Carbon Steel	2
24	Bearing Cover (1)	Cast Iron	1
25	Bearing Cover (2)	Cast Iron	1
26	Bearing Cover (3)	Cast Iron	1
27	Bearing Cover (4)	Cast Iron	1
28	Upper Bearing Bracket	Cast Iron	2
29	Lower Bearing Bracket	Cast Iron	2

VIENTIANE WATER SUPPLY PROJECT

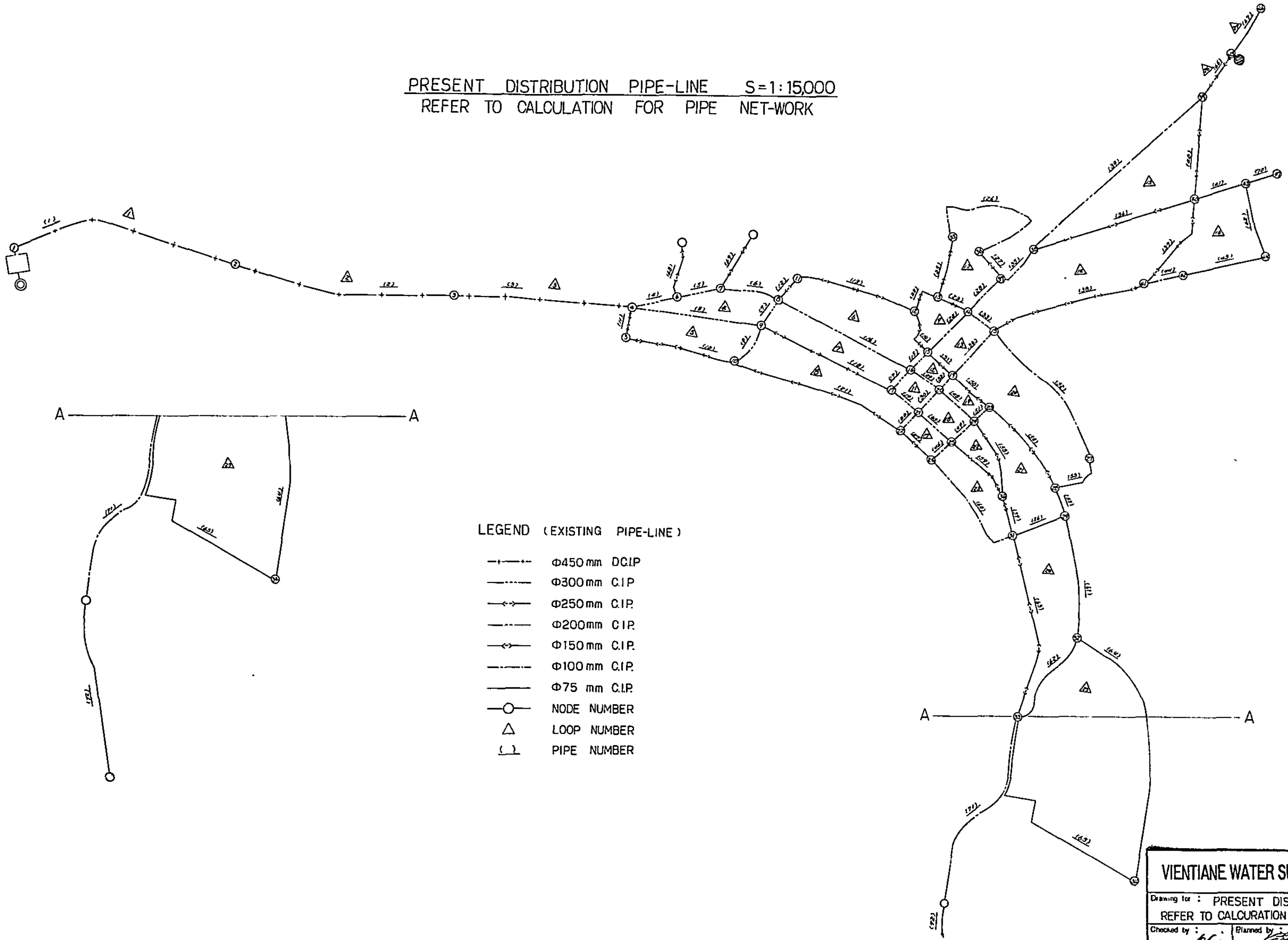
Drawing for : DETAIL FOR DISTRIBUTION PUMP
REFEP TO PARTS LIST FOR REPAIR

Checked by : T. SANO	Planned by : K. SASAKI	Drawn by : K. SASAKI
Drawing No. 2/9	Scale : As Shown	Date : May 30, 1972

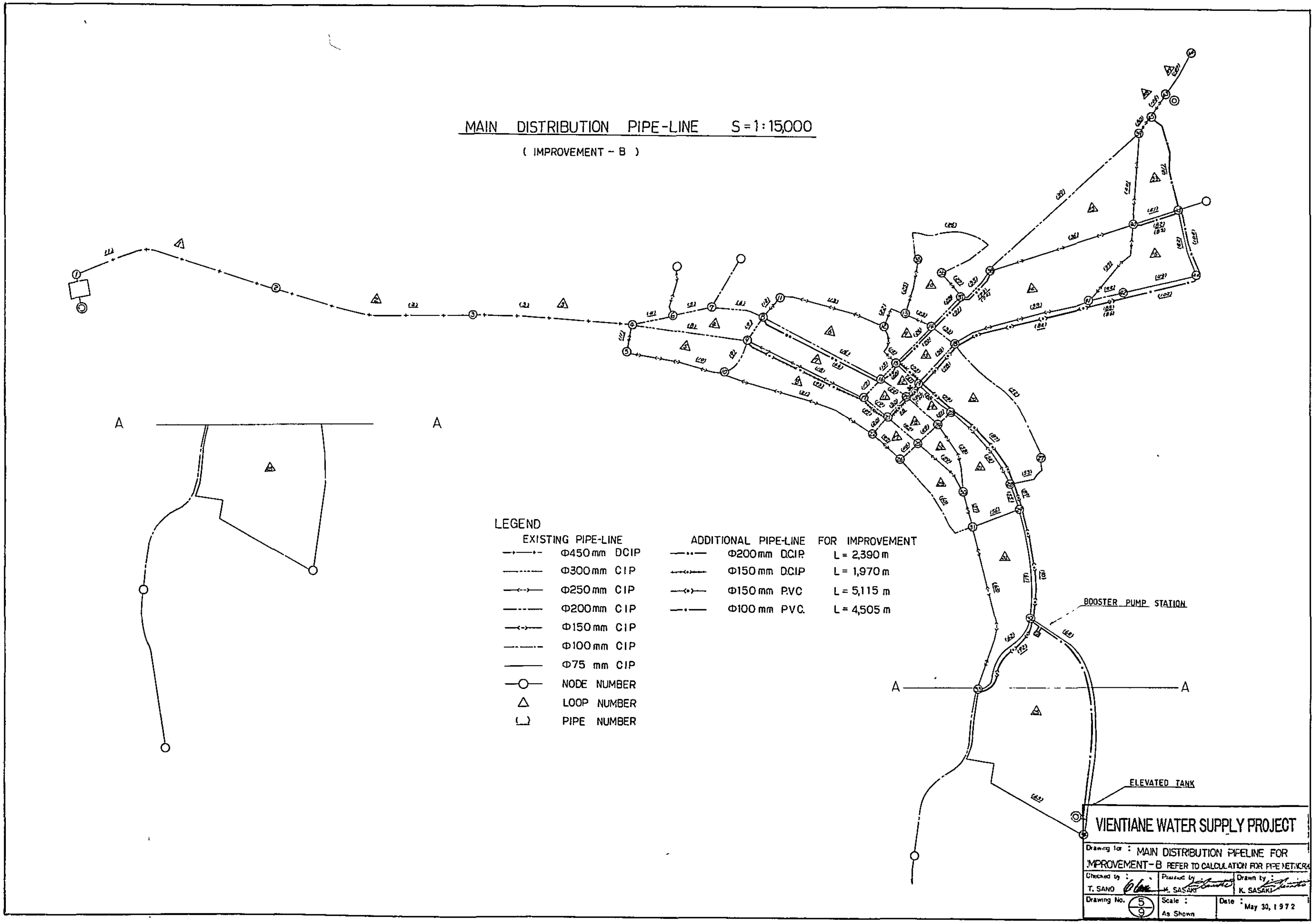


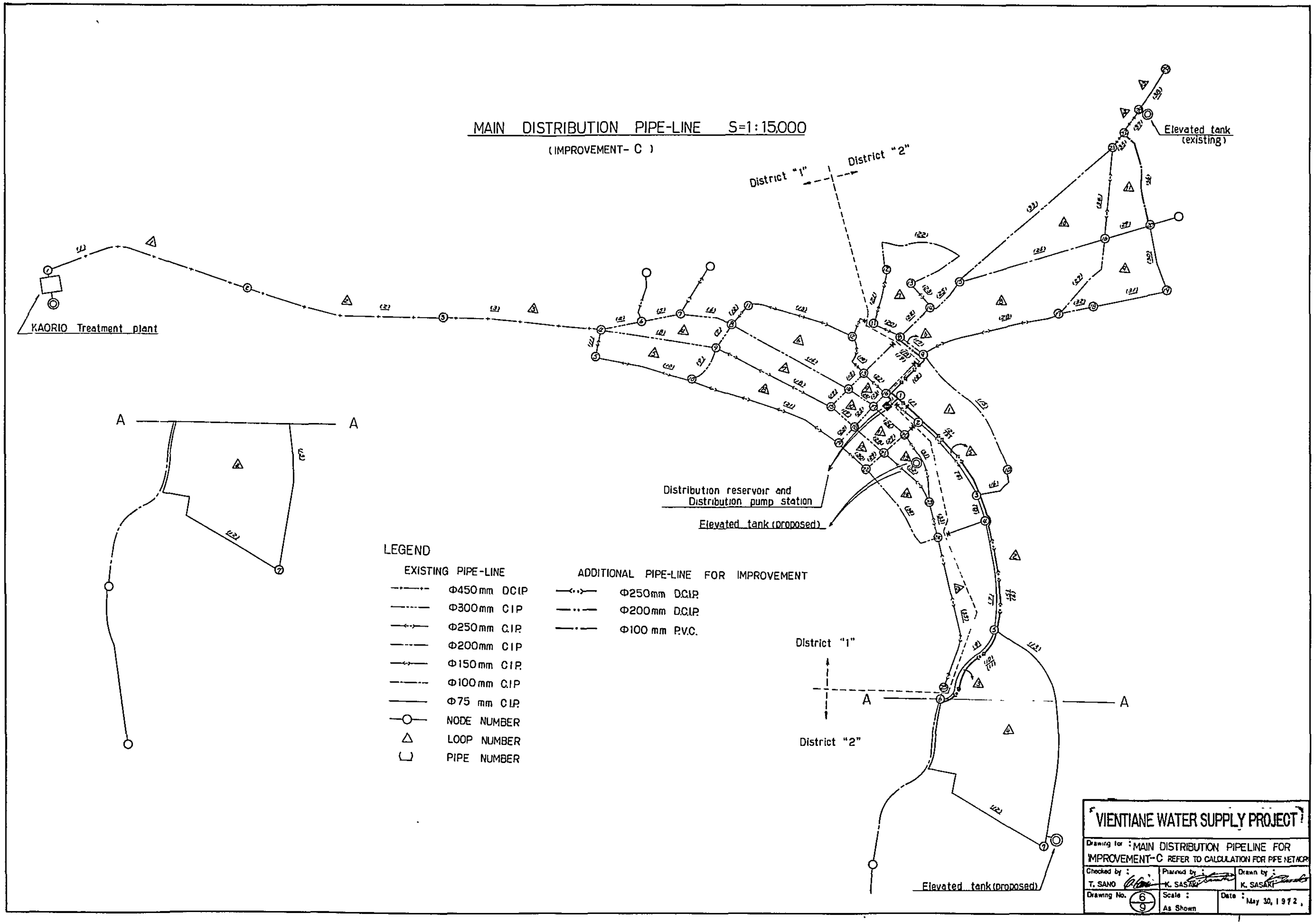
N
PRESENT DISTRIBUTION PIPE-LINE Scale 1:15,000
0m 500m 1,000m
Elevated tank
THATLOUANG
SISAI GVONE
NAXAI
HASDI
DONGPALAN
DONG TAOHAI
BUNGKHAGNONG
SOKPALOUANG
KHOUAKHAO
Intake tower
Water treatment plant (KAOLIEO)
MEKONG RIVER
A
A
A
A
B. NONG LO
CHINAIMO
DIAMETRE
SIGNE
Φ 450
Φ 300
Φ 250
Φ 200
Φ 150
Φ 100
Φ 75
Φ 50
SERVICE AREA
EXTENDED SERVICE AREA
VIENTIANE WATER SUPPLY PROJECT
Drawing for :
PRESENT DISTRIBUTION PIPE-LINE
Checked by :
T. SANO
Planned by
K. SASAKI
Drawn by :
K. SASAKI
Drawing No.
3
9
Scale :
As Shown
Date :

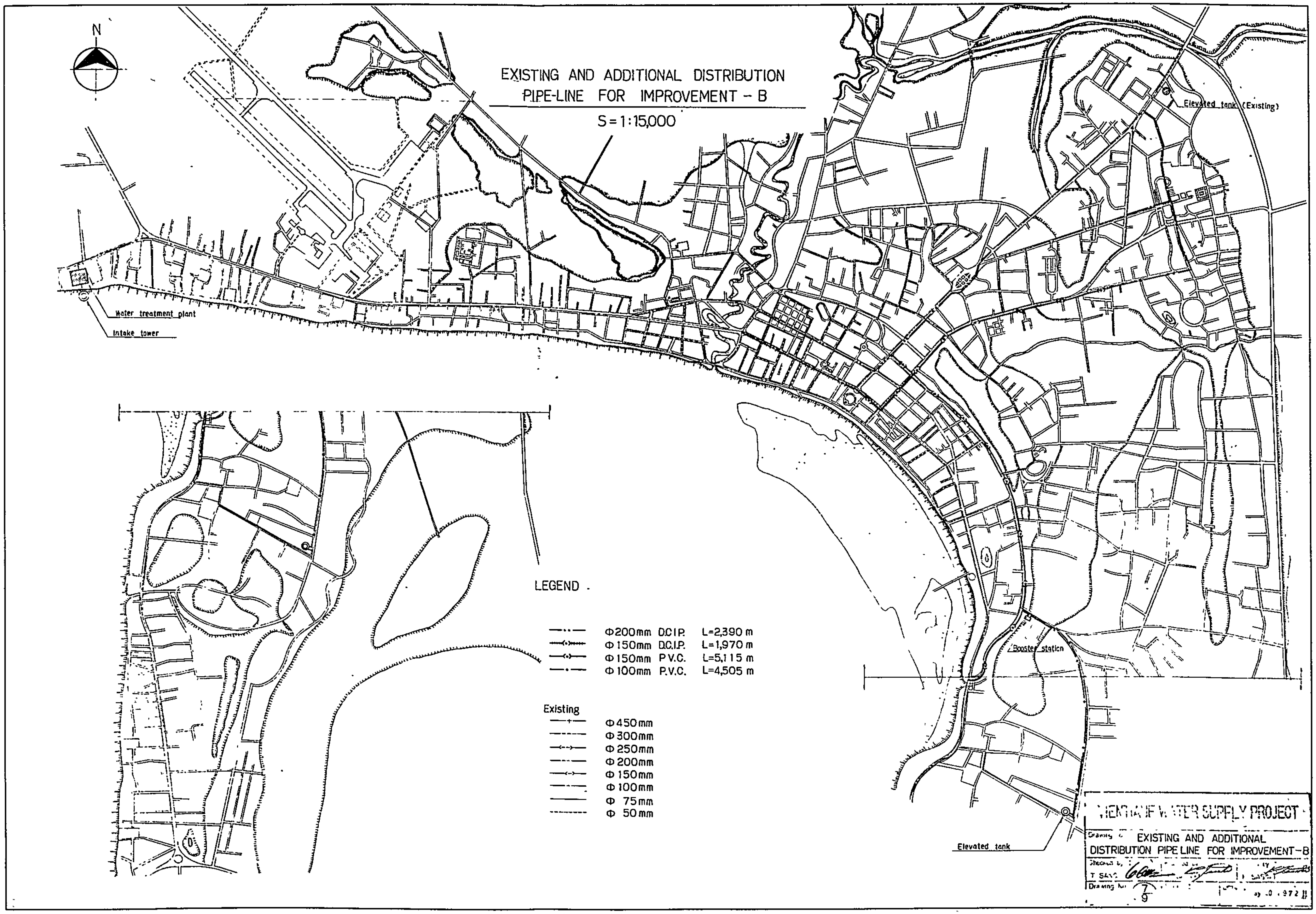
PRESENT DISTRIBUTION PIPE-LINE S=1:15,000
REFER TO CALCULATION FOR PIPE NET-WORK



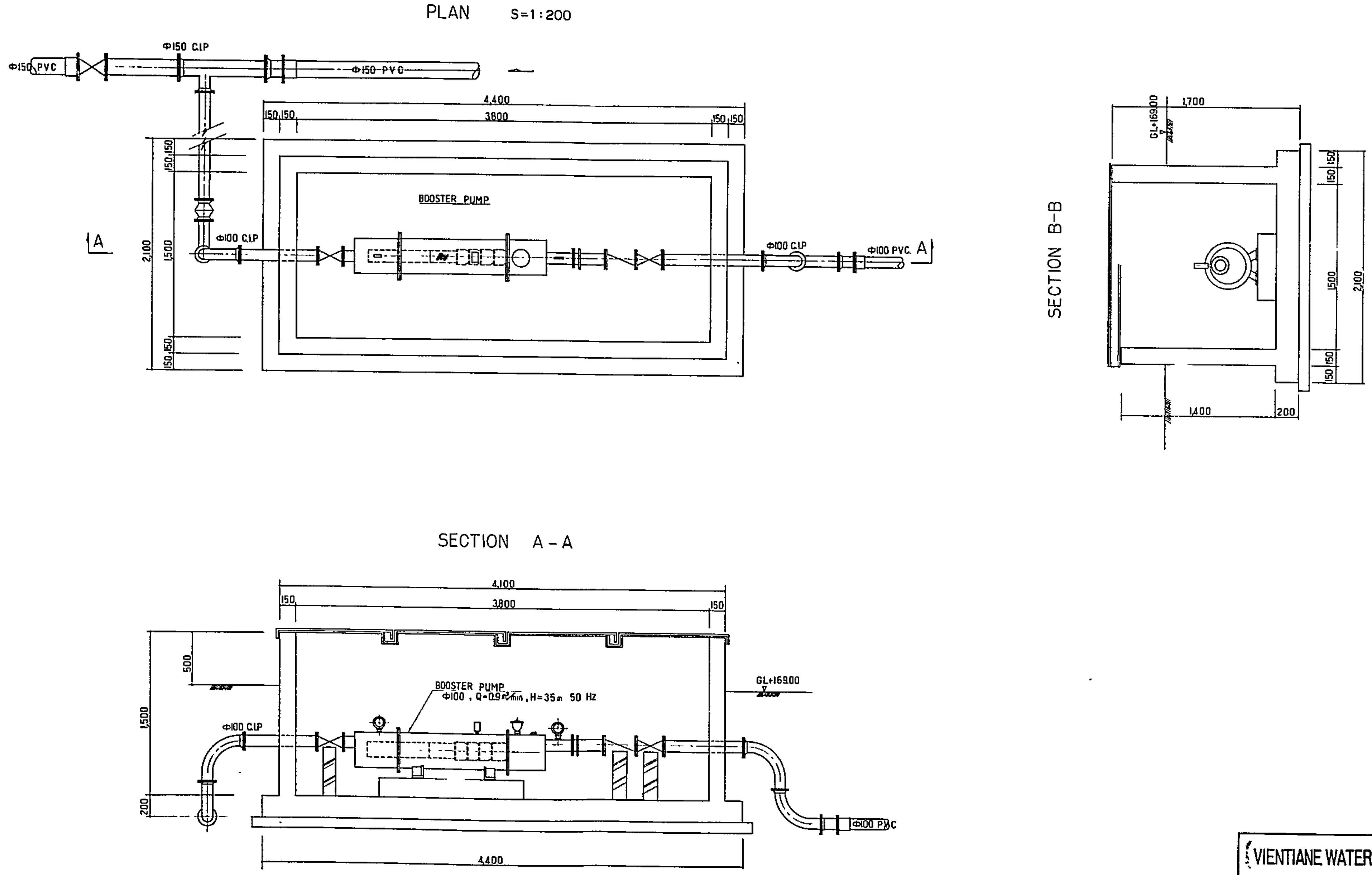
VIENTIANE WATER SUPPLY PROJECT		
Drawing for : PRESENT DISTRIBUTION PIPE-LINE REFER TO CALCURATION FOR PIPE NET-WORK		
Checked by : T. SANO	Planned by : K. SASAKI	Drawn by : K. SASAKI
Drawing No. 4/9	Scale : As Shown	Date : May 30, 1972


MAIN DISTRIBUTION PIPE-LINE S = 1 : 15,000
(IMPROVEMENT - B)
A
A
A
A
BOOSTER PUMP STATION
ELEVATED TANK
LEGEND
EXISTING PIPE-LINE
Φ450mm DCIP
Φ300mm CIP
Φ250mm CIP
Φ200mm CIP
Φ150mm CIP
Φ100mm CIP
Φ75 mm CIP
NODE NUMBER
LOOP NUMBER
PIPE NUMBER
ADDITIONAL PIPE-LINE FOR IMPROVEMENT
Φ200mm DCIP L = 2,390 m
Φ150mm DCIP L = 1,970 m
Φ150mm PVC L = 5,115 m
Φ100mm PVC L = 4,505 m
VIENTIANE WATER SUPPLY PROJECT
Drawing for : MAIN DISTRIBUTION PIPELINE FOR IMPROVEMENT-B REFER TO CALCULATION FOR PIPE NETWORK
Checked by : T. SANO
Planned by : K. SASAKI
Drawn by : K. SASAKI
Drawing No. 5/9
Scale : As Shown
Date : May 30, 1972


MAIN DISTRIBUTION PIPE-LINE S=1:15,000
(IMPROVEMENT- C)
District "1"
District "2"
Elevated tank (existing)
KAORIO Treatment plant
A
A
Distribution reservoir and Distribution pump station
Elevated tank (proposed)
LEGEND
EXISTING PIPE-LINE
Φ450mm DCIP
Φ300mm CIP
Φ250mm C.I.P.
Φ200mm CIP
Φ150mm C.I.P.
Φ100mm C.I.P.
Φ75 mm C.I.P.
NODE NUMBER
LOOP NUMBER
PIPE NUMBER
ADDITIONAL PIPE-LINE FOR IMPROVEMENT
Φ250mm D.C.I.P.
Φ200mm D.C.I.P.
Φ100 mm P.V.C.
District "1"
District "2"
A
A
Elevated tank (proposed)
VIENTIANE WATER SUPPLY PROJECT
Drawing for : MAIN DISTRIBUTION PIPELINE FOR IMPROVEMENT-C REFER TO CALCULATION FOR PIPE NETWORK
Checked by : T. SANO
Planned by : K. SASAKI
Drawn by : K. SASAKI
Drawing No. 6/9
Scale : As Shown
Date : May 30, 1972,


N
EXISTING AND ADDITIONAL DISTRIBUTION
PIPE-LINE FOR IMPROVEMENT - B
S = 1:15,000
Elevated tank (Existing)
Water treatment plant
Intake tower
LEGEND .
Φ200mm D.C.I.P. L=2,390 m
Φ150mm D.C.I.P. L=1,970 m
Φ150mm P.V.C. L=5,115 m
Φ100mm P.V.C. L=4,505 m
Existing
Φ450mm
Φ300mm
Φ250mm
Φ200mm
Φ150mm
Φ100mm
Φ 75mm
Φ 50mm
Booster station
Elevated tank
WATER SUPPLY PROJECT
EXISTING AND ADDITIONAL
DISTRIBUTION PIPE LINE FOR IMPROVEMENT-B
Checked by
Drawing No
7/9

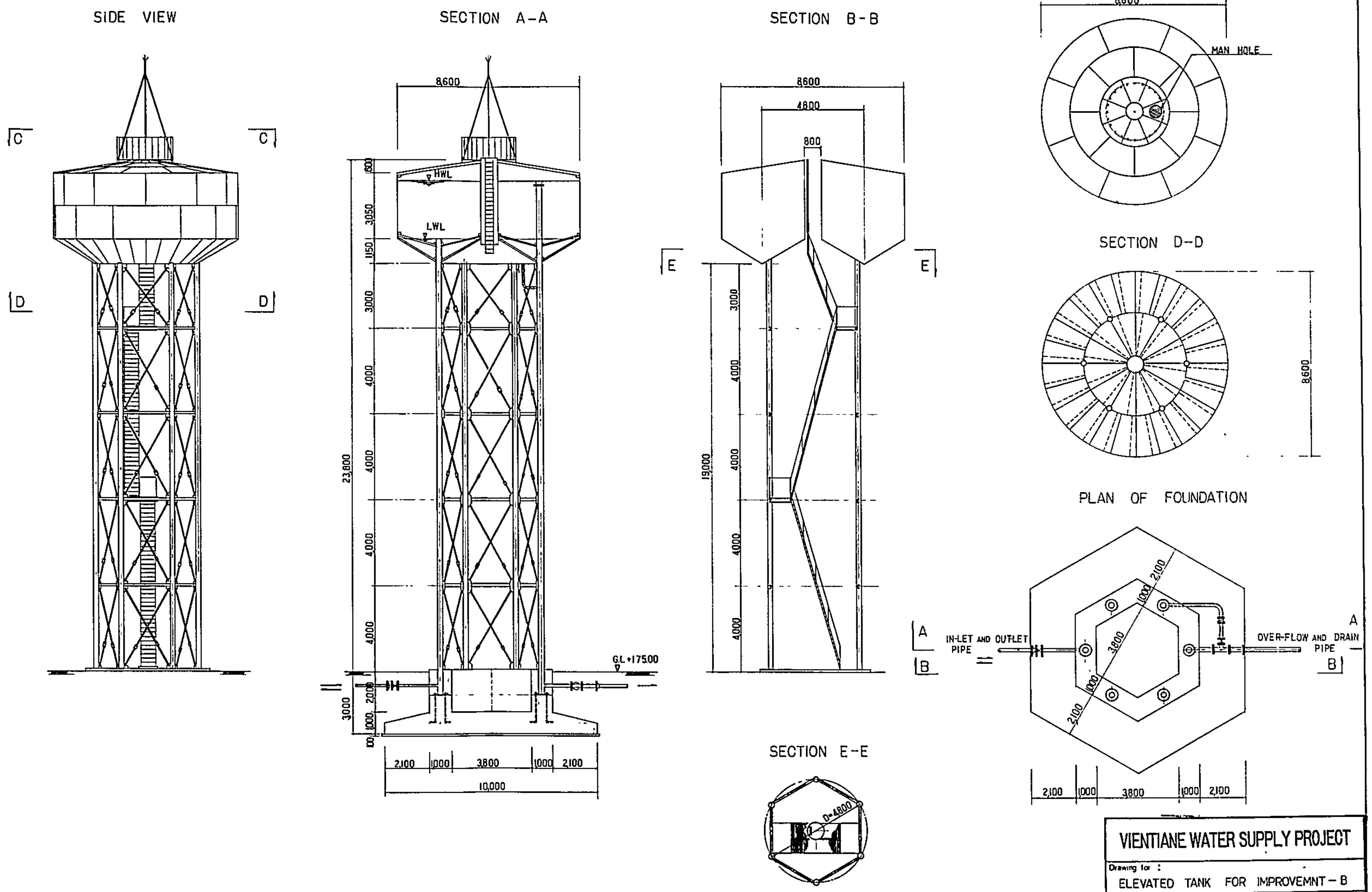
BOOSTER PUMP STATION FOR IMPROVEMENT - B



VIENTIANE WATER SUPPLY PROJECT		
Drawing for : BOOSTER PUMP STATION FOR IMPROVEMENT-B		
Checked by : T. SANO	Planned by : K. SASAKI	Drawn by : K. SASAKI
Drawing No. 8/9	Scale : As Shown	Date : May 30, 1972

ELEVATED TANK S=1:100

FOR IMPROVEMENT – B



VIENTIANE WATER SUPPLY PROJECT

Drawing for : ELEVATED TANK FOR IMPROVEMNT – B

Checked by : T. SANO

Planned by : K. SASAKI

Drawn by : K. SASAKI

Drawing No. 9/9

Scale : As Shown

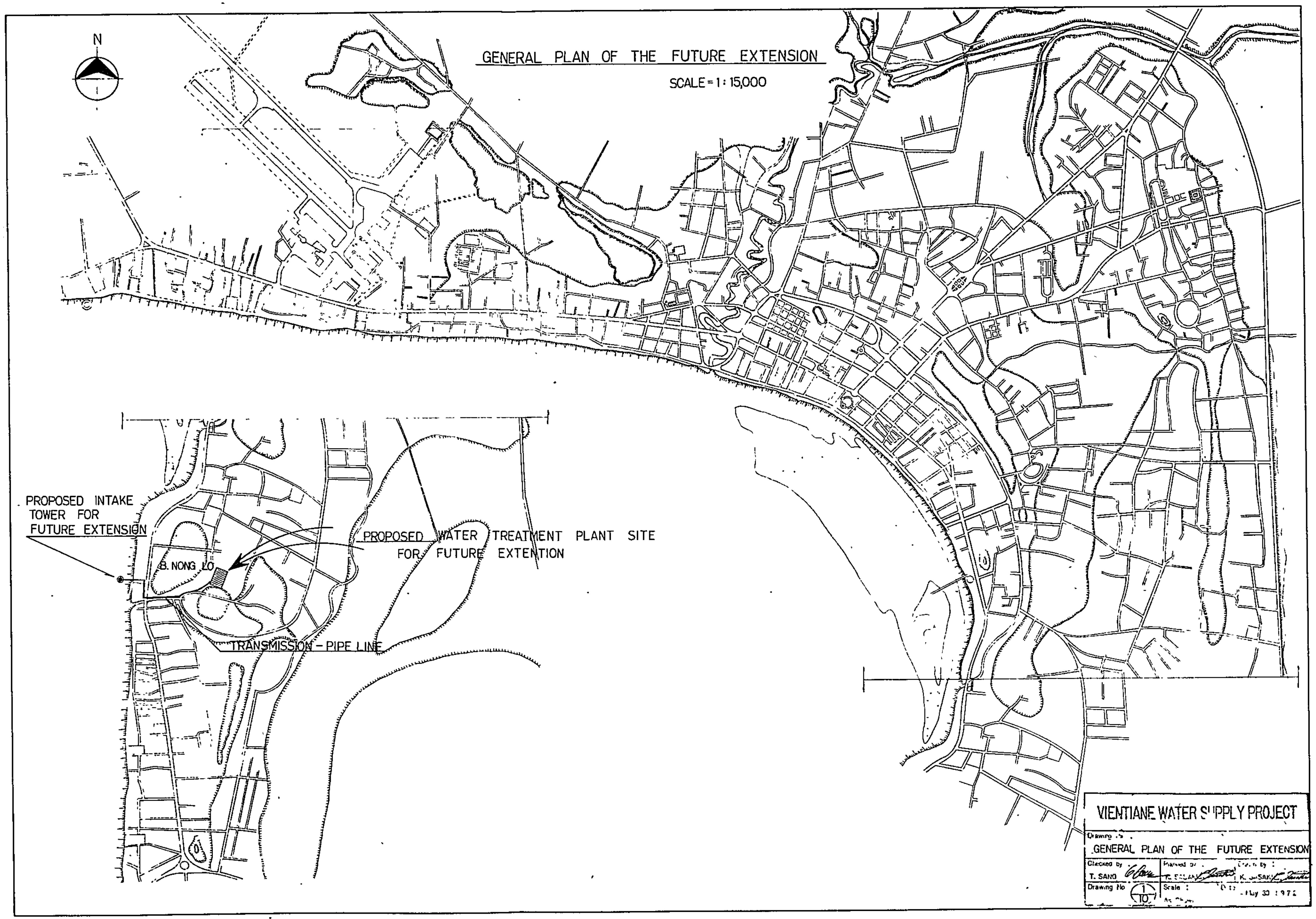
Date : May 30, 1972

FUTURE EXTENSION PLAN

OF

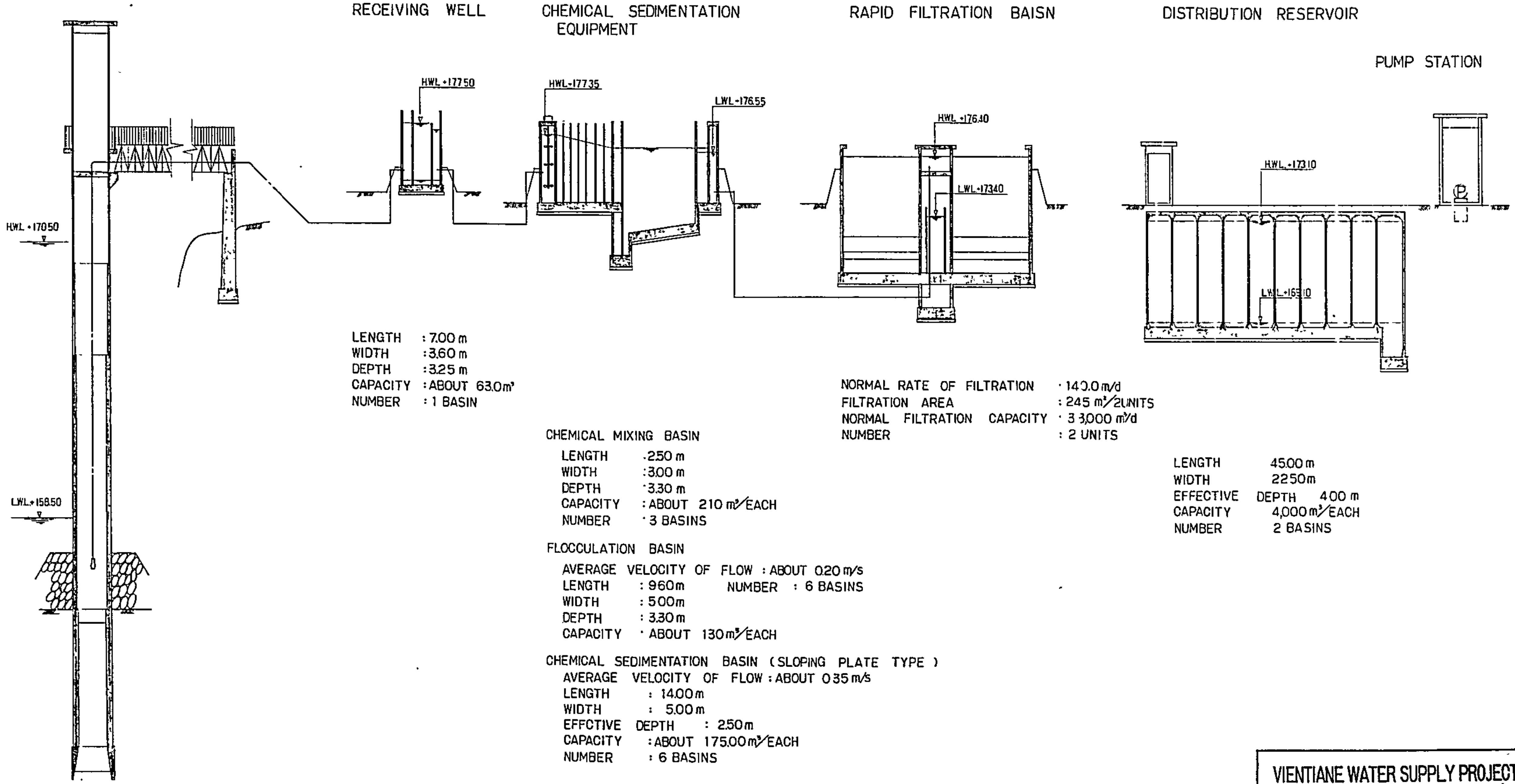
VIENTIANE WATER SUPPLY SYSTEM

INDEX OF DRAWING	
NO	DESCRIPTION
1	GENERAL PLAN OF THE FUTURE EXTENSION
2	WATER LEVEL DIAGRAM
3	INTAKE TOWER
4	GENERAL LAY-OUT OF THE WATER TREATMENT PLANT
5	PLAN OF THE WATER TREATMENT PLANT (CONNECTING PIPE LINE)
6	RECEIVING WELL
7	CHEMICAL SEDIMENTATION BASIN
8	RAPID FILTRATION BASIN
9	ADMINISTRATION BUILDING
10	DISTRIBUTION RESERVOIR


GENERAL PLAN OF THE FUTURE EXTENSION
SCALE = 1 : 15,000
N
PROPOSED INTAKE TOWER FOR FUTURE EXTENSION
B. NONG LO
PROPOSED WATER TREATMENT PLANT SITE FOR FUTURE EXTENTION
TRANSMISSION - PIPE LINE
VIENTIANE WATER SUPPLY PROJECT
Drawing
GENERAL PLAN OF THE FUTURE EXTENSION
Checked by
T. SANO
Planned by
Drawn by
Drawing No
1
10
Scale
Date
May 30 1972

WATER LEVEL DIAGRAM

Scale H = 1:400, V = 1:100



LENGTH : 7.00 m
WIDTH : 3.60 m
DEPTH : 3.25 m
CAPACITY : ABOUT 63.0 m³
NUMBER : 1 BASIN

CHEMICAL MIXING BASIN

LENGTH : 2.50 m
WIDTH : 3.00 m
DEPTH : 3.30 m
CAPACITY : ABOUT 21.0 m³/EACH
NUMBER : 3 BASINS

FLOCCULATION BASIN

AVERAGE VELOCITY OF FLOW : ABOUT 0.20 m/s
LENGTH : 9.60 m NUMBER : 6 BASINS
WIDTH : 5.00 m
DEPTH : 3.30 m
CAPACITY : ABOUT 130 m³/EACH

CHEMICAL SEDIMENTATION BASIN (SLOPING PLATE TYPE)

AVERAGE VELOCITY OF FLOW : ABOUT 0.35 m/s
LENGTH : 14.00 m
WIDTH : 5.00 m
EFFCTIVE DEPTH : 2.50 m
CAPACITY : ABOUT 175.00 m³/EACH
NUMBER : 6 BASINS

NORMAL RATE OF FILTRATION : 140.0 m/d
FILTRATION AREA : 245 m²/2UNITS
NORMAL FILTRATION CAPACITY : 33,000 m³/d
NUMBER : 2 UNITS

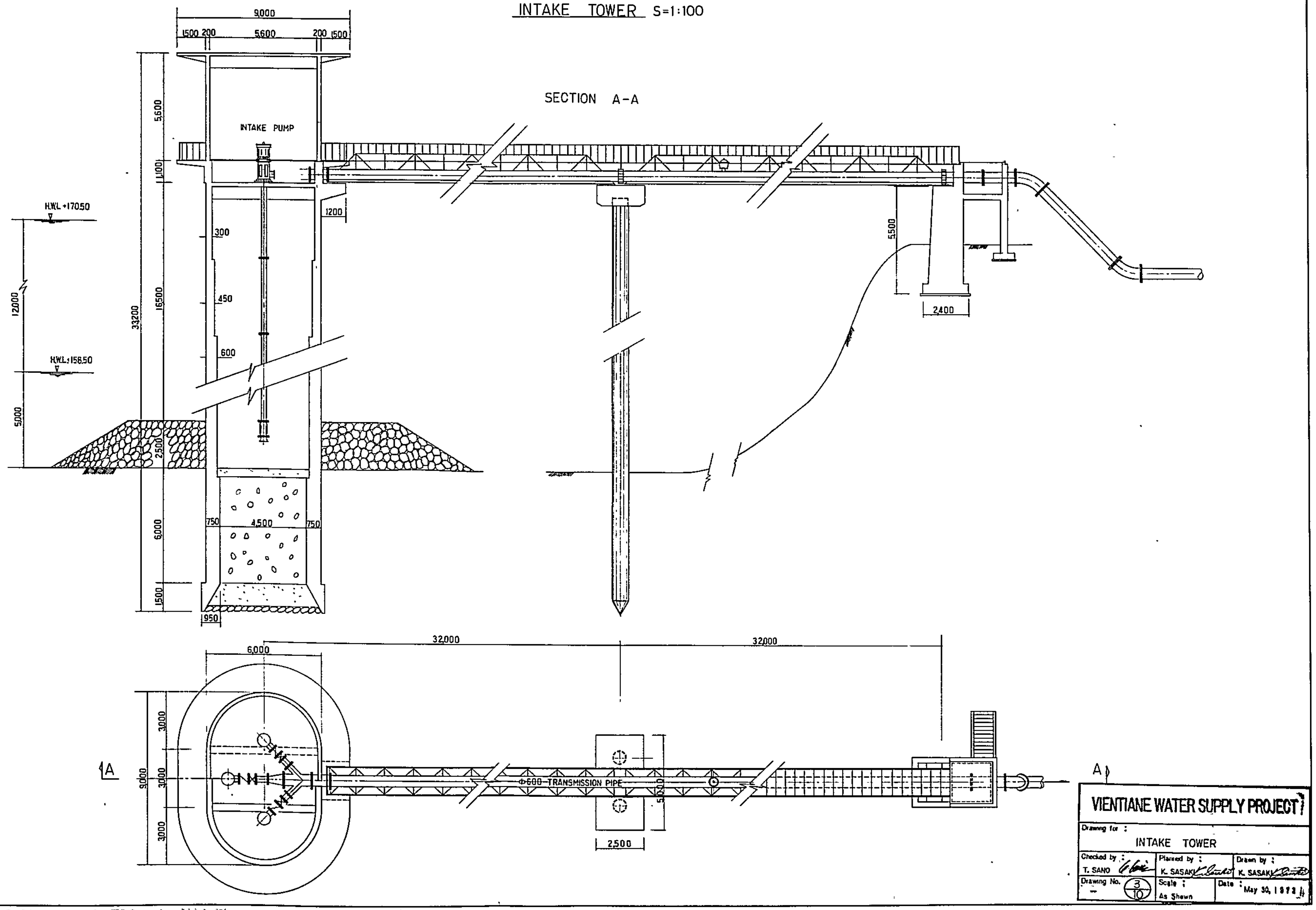
LENGTH 45.00 m
WIDTH 22.50 m
EFFECTIVE DEPTH 4.00 m
CAPACITY 4,000 m³/EACH
NUMBER 2 BASINS

VIENTIANE WATER SUPPLY PROJECT

Drawing for : WATER LEVEL DIAGRAM

Checked by :	Planned by :	Drawn by :
T. SANO	K. SASAKI	K. SASAKI
Drawing No. 2/10	Scale : As Shown	Date : May 30, 1972

INTAKE TOWER S=1:100

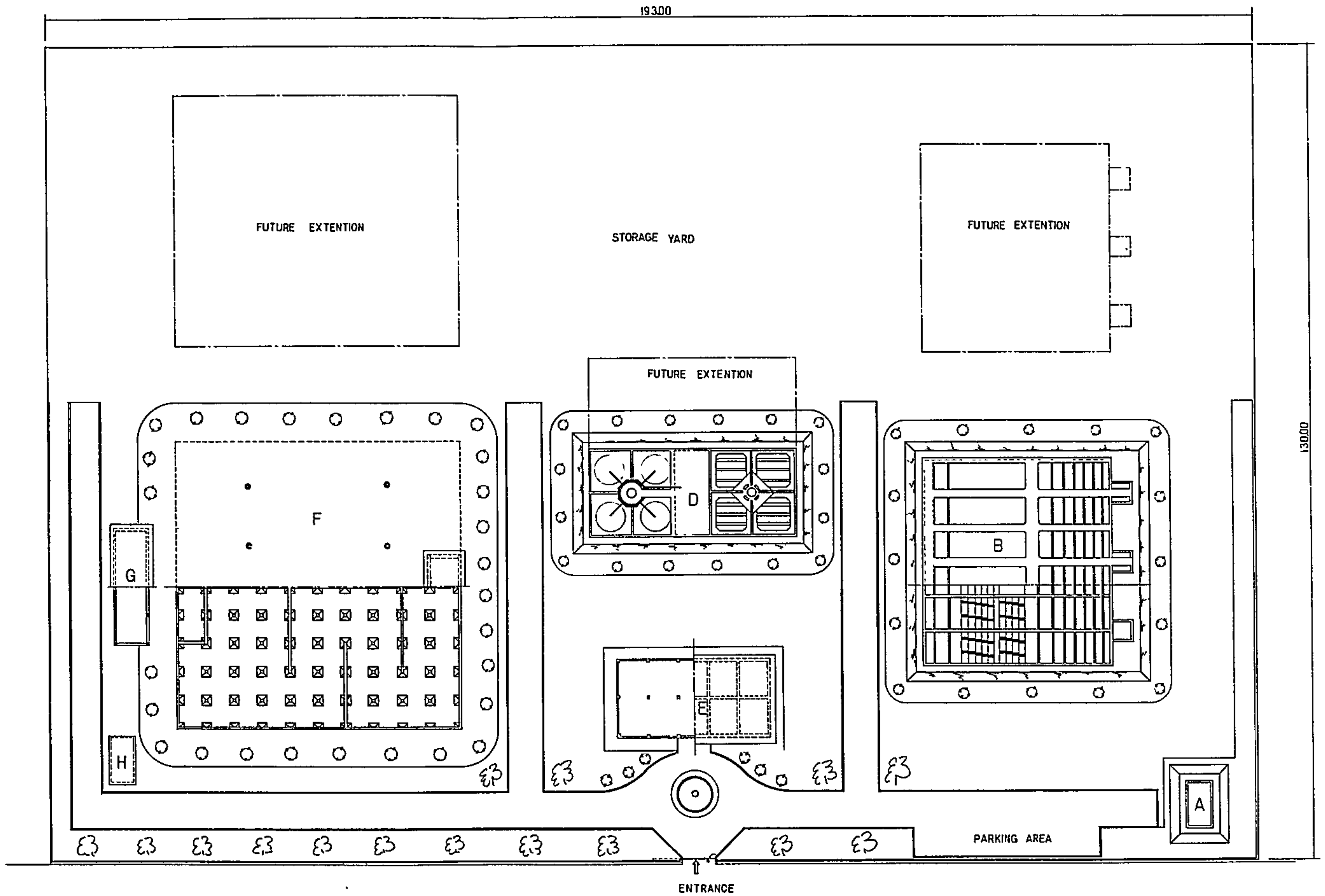


VIENTIANE WATER SUPPLY PROJECT

Drawing for : INTAKE TOWER

Checked by : T. SANO	Planned by : K. SASAKI	Drawn by : K. SASAKI
Drawing No. 3/10	Scale : As Shown	Date : May 30, 1973

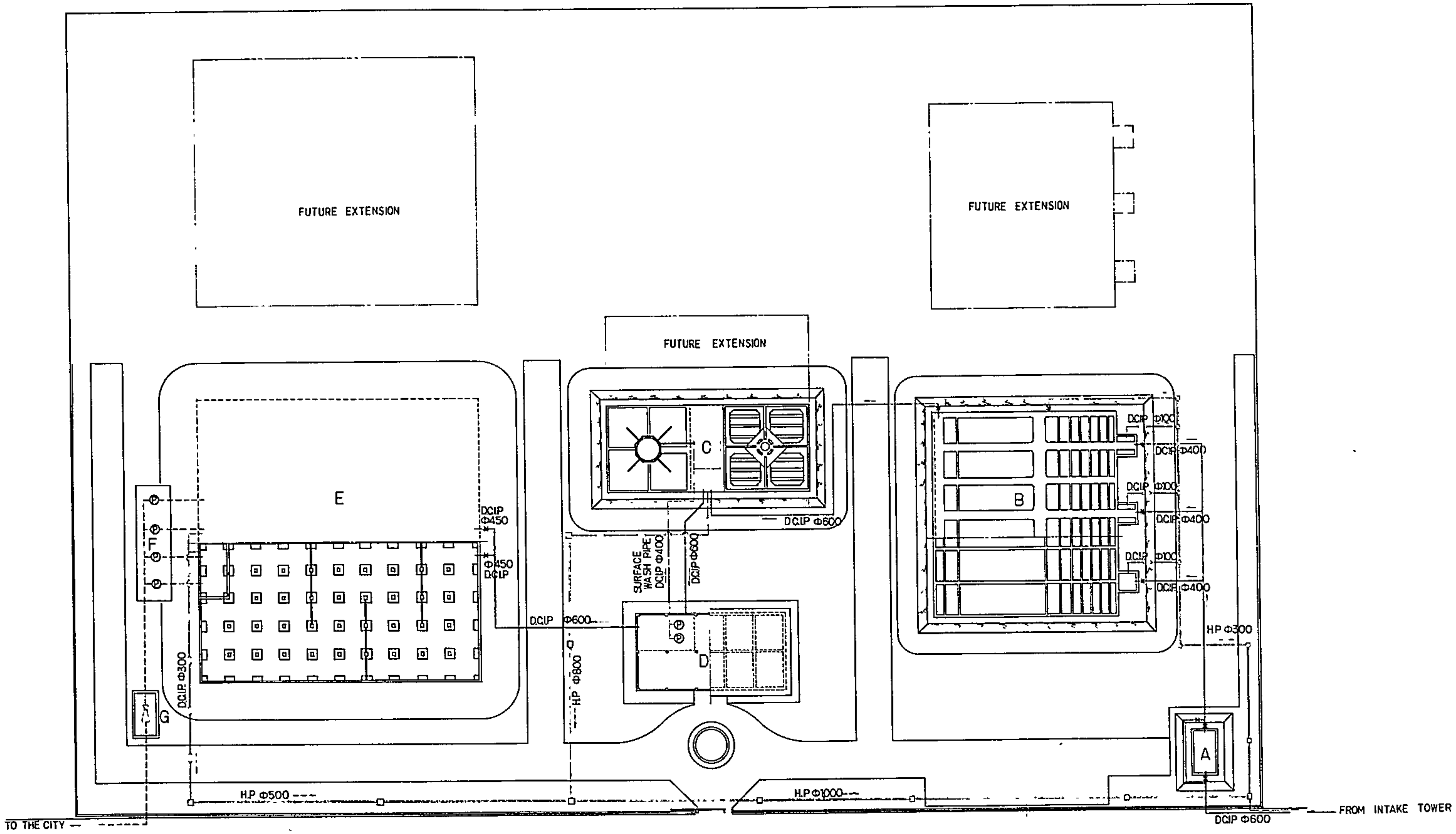
GENERAL LAY-OUT OF THE WATER TREATMENT PLANT S=1:400



LEGEND
- A RECEIVING WELL
- B CHEMICAL SEDIMENTATION EQUIPMENT
- C RAPID FILTRATION BASIN
- D ADMINSTRATION BUILDING
- E DISTRIBUTION RESERVOIR
- F PUMPING HOUSE
- G VENTURI METER CHAMBER

VIENTIANE WATER SUPPLY PROJECT		
Drawing for : GENERAL LAY-OUT OF THE WATER TREATMENT PLANT		
Checked by : T. SANO	Planned by : K. SASAKI	Drawn by : K. SASAKI
Drawing No. 4/10	Scale : As Shown	Date : May 30, 1972

PLAN OF THE WATER TREATMENT PLANT S=1:400

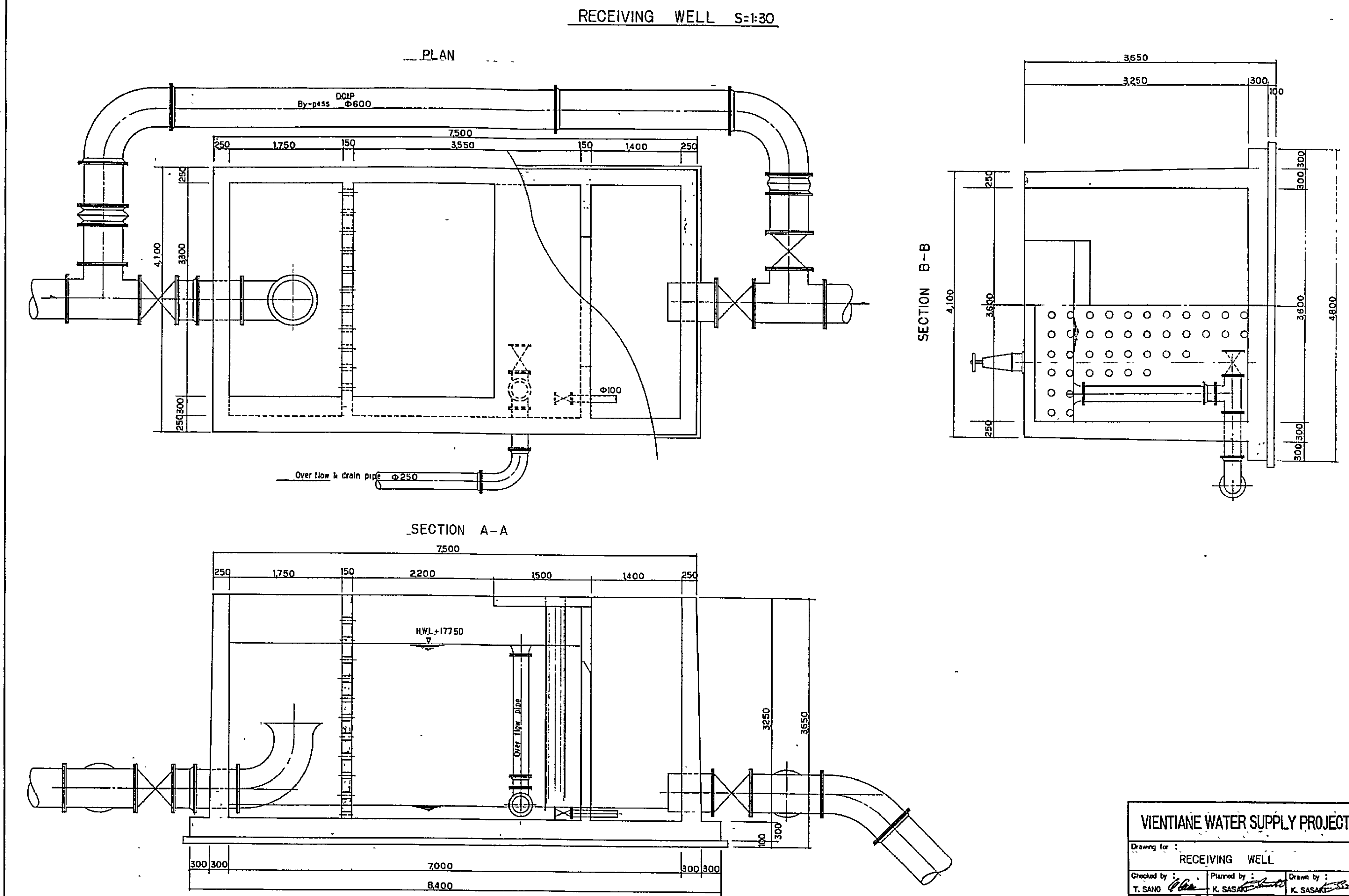


LEGEND

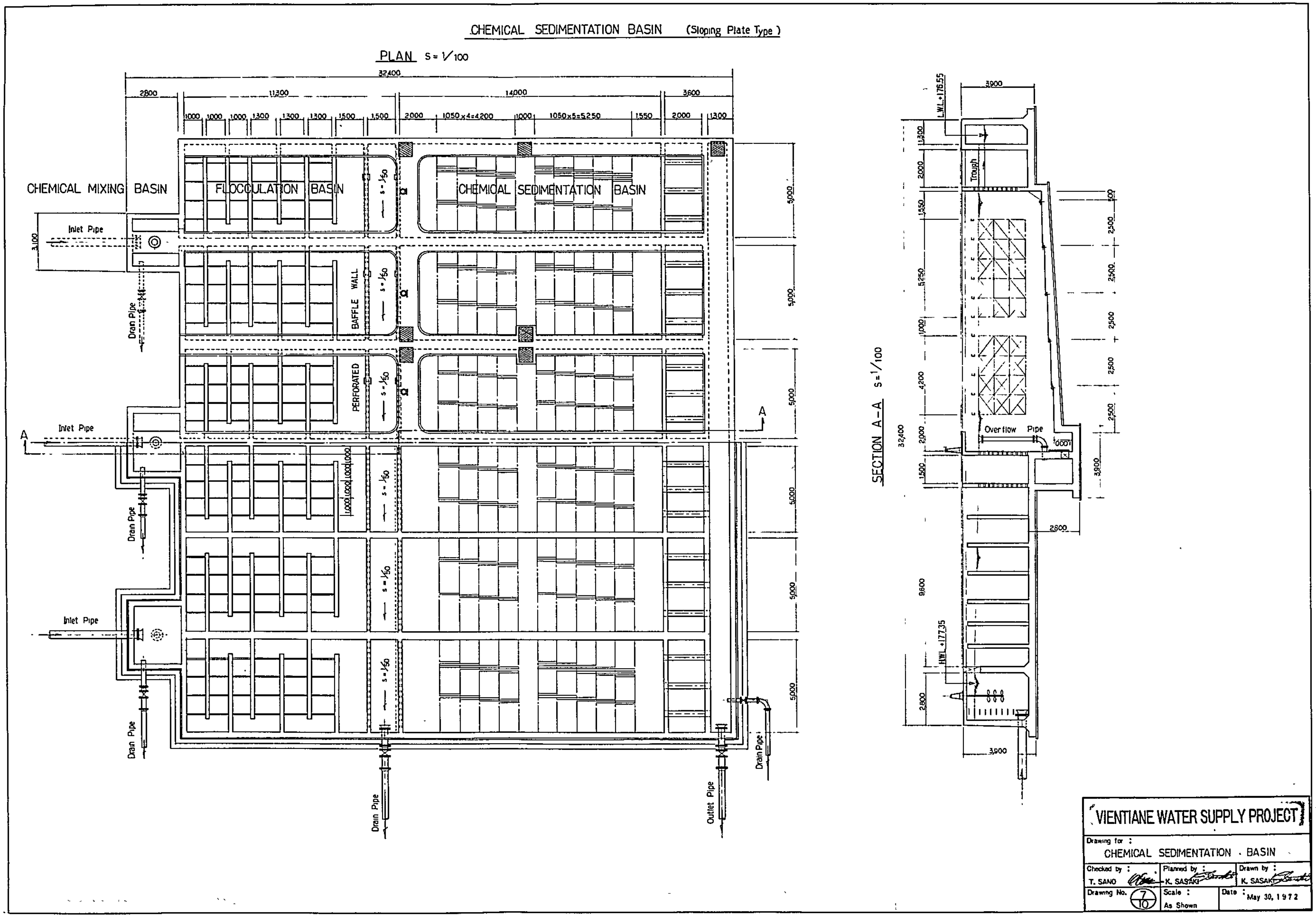
- A RECEIVING WELL
- B CHEMICAL SEDIMENTATION EQUIPMENT
- C RAPID FILTRATION BASIN
- D ADMINISTRATION BUILDING
- E DISTRIBUTION RESERVOIR
- F PUMPING HOUSE
- G VENTURI METER CHAMBER

VIENTIANE WATER SUPPLY PROJECT

Drawing for : PLAN OF THE WATER TREATMENT (CONNECTING PIPE LINE)		
Checked by : T. SANO	Planned by : K. SASAKI	Drawn by : K. SASAKI
Drawing No. 5/10	Scale : As Shown	Date : May 30, 1972



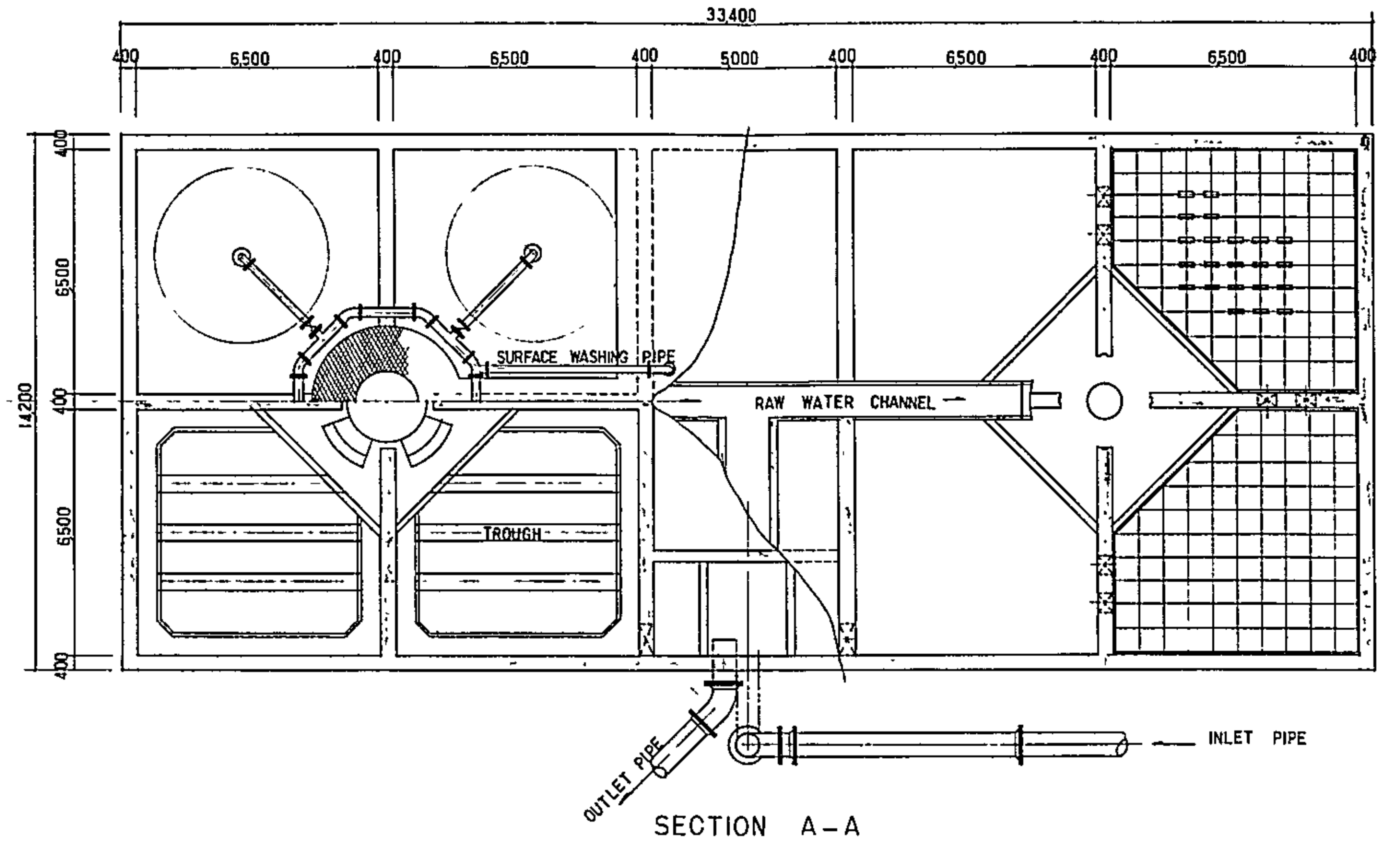
VIENTIANE WATER SUPPLY PROJECT		
Drawing for : RECEIVING WELL		
Checked by : T. SANO	Planned by : K. SASAKI	Drawn by : K. SASAKI
Drawing No. 6/10	Scale : As Shown	Date : May 30, 1972



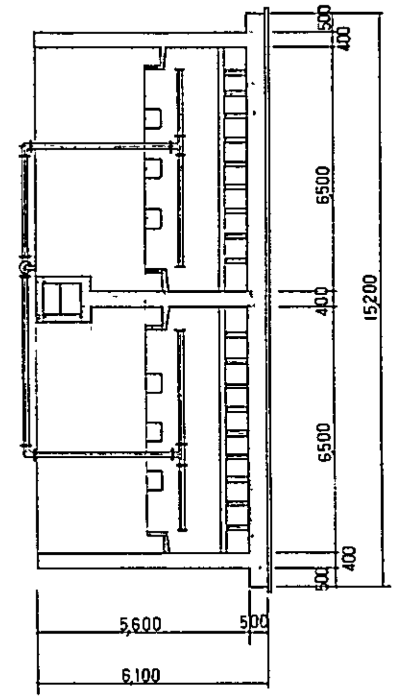
CHEMICAL SEDIMENTATION BASIN (Sloping Plate Type)
PLAN S = 1/100
CHEMICAL MIXING BASIN
FLOCCULATION BASIN
CHEMICAL SEDIMENTATION BASIN
BAFFLE WALL
PERFORATED
Inlet Pipe
Drain Pipe
Outlet Pipe
SECTION A-A S = 1/100
Trough
Over flow Pipe
L.W.L +176.55
H.W.L +177.35
VIENTIANE WATER SUPPLY PROJECT
Drawing for : CHEMICAL SEDIMENTATION . BASIN
Checked by : T. SANO
Planned by : K. SASAKI
Drawn by : K. SASAKI
Drawing No. 7/10
Scale : As Shown
Date : May 30, 1972

RAPID FILTRATION BASIN S=1:100

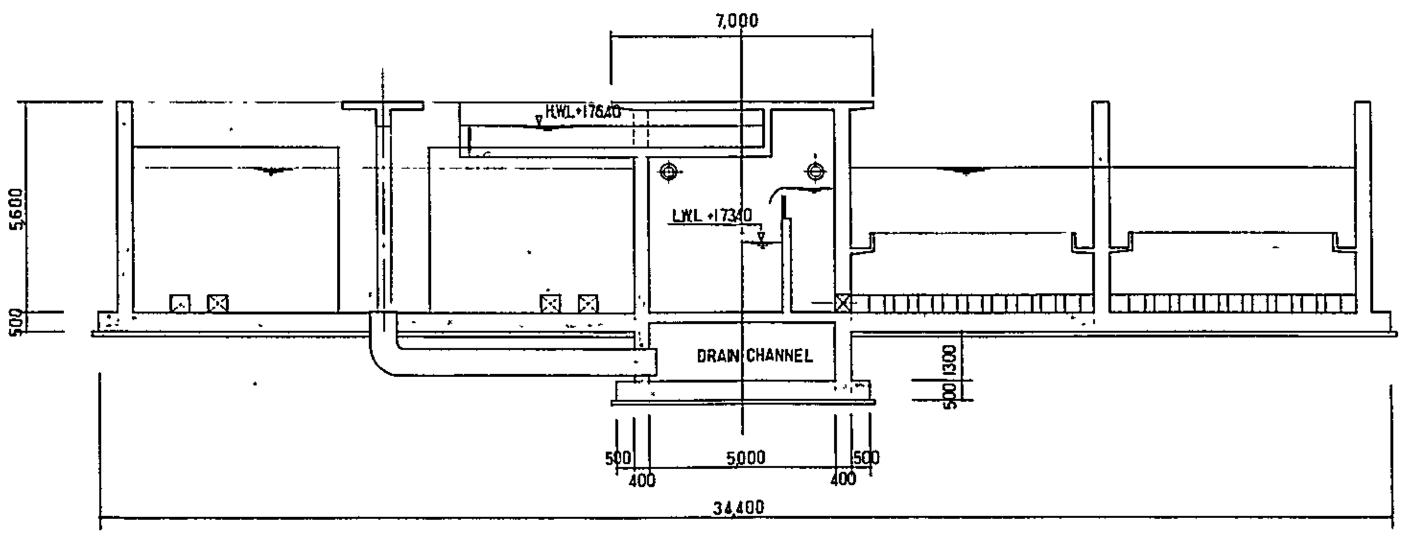
PLAN



SECTION B-B

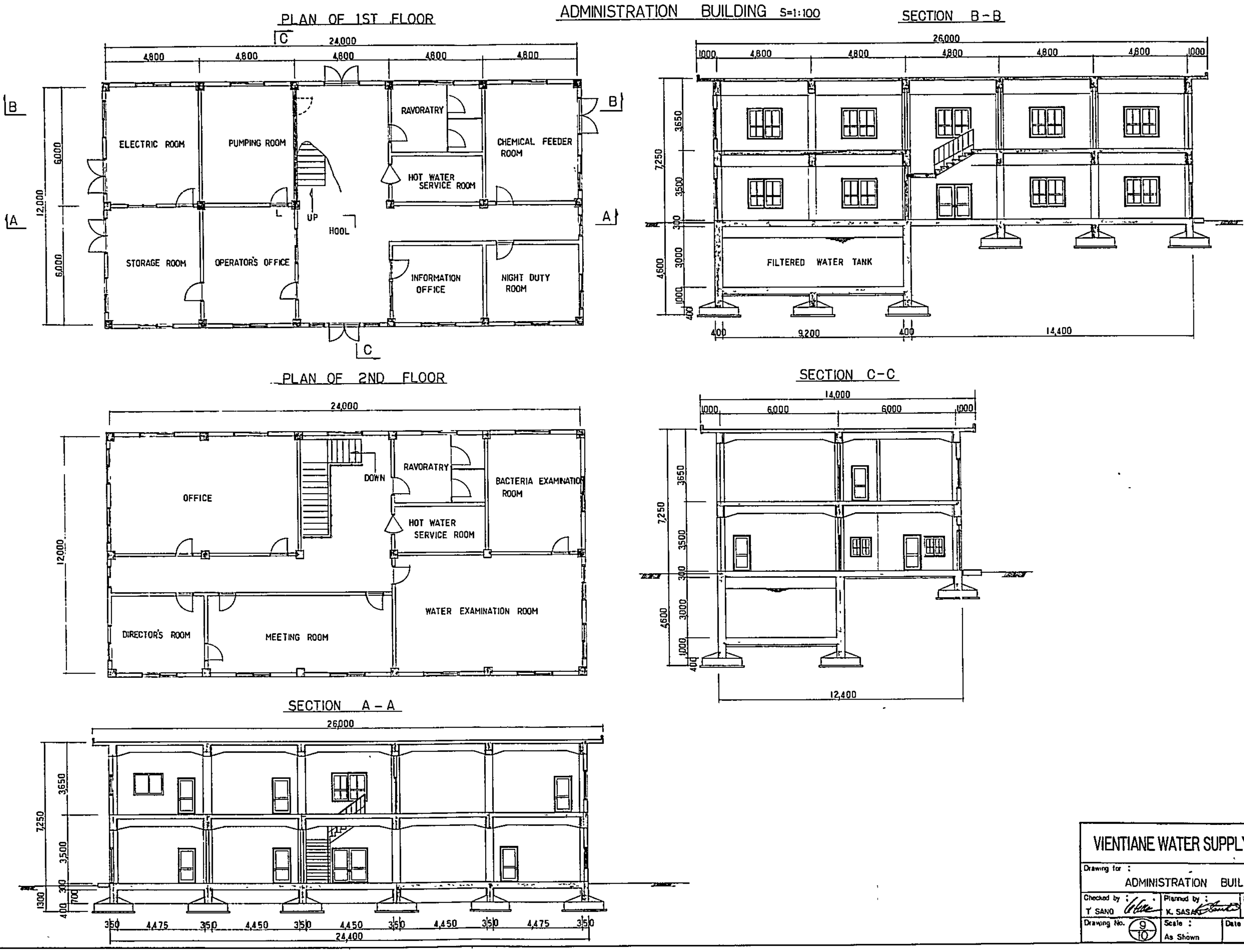


SECTION A-A



VIENTIANE WATER SUPPLY PROJECT		
Drawing for : RAPID FILTRATION BASIN		
Checked by : T. SANO	Planned by : K. SASAKI	Drawn by : K. SASAKI
Drawing No. 8/10	Scale : As Shown	Date : May 30, 1972

ADMINISTRATION BUILDING S=1:100

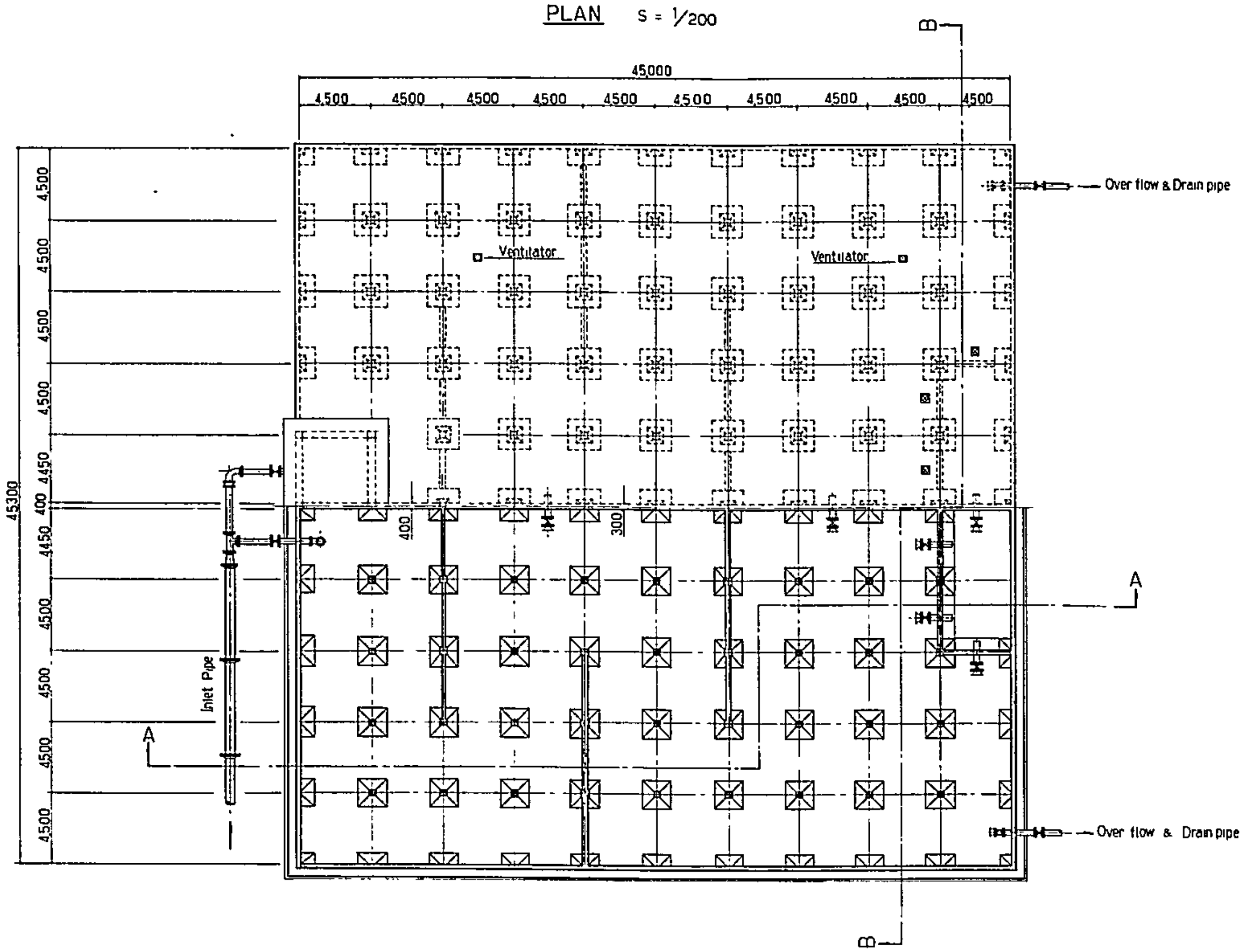


VIENTIANE WATER SUPPLY PROJECT

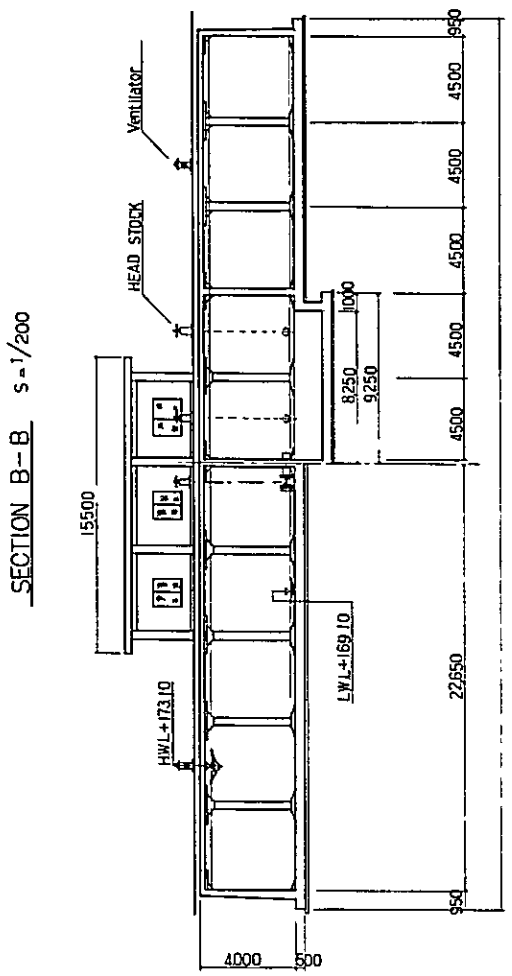
Drawing for : ADMINISTRATION BUILDING		
Checked by : T. SANO	Planned by : K. SASAKI	Drawn by : K. SASAKI
Drawing No. 9/10	Scale : As Shown	Date : May 30, 1972

DISTRIBUTION RESERVOIR

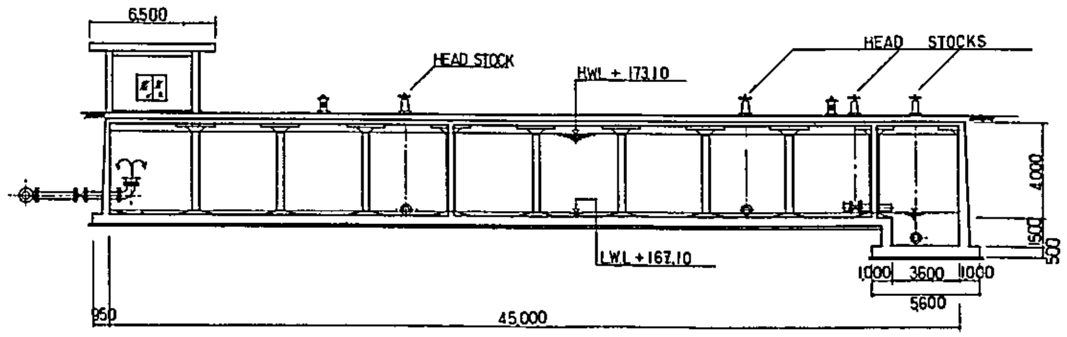
PLAN S = 1/200



SECTION B-B S = 1/200



SECTION A - A S = 1/200



VIENTIANE WATER SUPPLY PROJECT		
Drawing for : DISTRIBUTION RESERVOIR		
Checked by : T. SANO	Planned by : K. SASAKI	Drawn by : K. SASAKI
Drawing No. 10/10	Scale : As Shown	Date : May 30, 1972