REPORT
ON
IMPROVEMENT AND EXTENSION PROJECT
FOR
BACOLOD AND DAVAO
WATERWORKS SYSTEMS
THE PHILIPPINES

SEPTEMBER 1966

OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

ERRATA

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PREFACE

By the request of the Government of the Republic of the Philippines, the Government of Japan entrusted the Overseas Technical Cooperation Agency to conduct an initial survey with regard to the construction of waterworks facilities in both Bacolod City, Negros Island, and Davao City, Mindanao Island, in the Republic. Therefore, our agency dispatched a survey mission consisting of five experts headed by Mr. S. Matsushita to the Philippines during a period of 45 days, from March 28 to May 11,1966, being fully aware of the significance of the mission for the development of native people's welfare and of the important role of waterworks in accelerating the prosperity of both cities. The kind cooperation of the authorities of these cities has made possible the successful fulfillment of the mission's task including the examination of the exsisting facilities and equipment as well.

In Bacolod City, the survey was focused on the selection of a dam site for water-intake on the Bago river, which runs east and west of the city covering a distance of 12 km from its center, the volume of water, speed of the current, configuration of land and the location of distributing facilities which seemed suitable between the dam site and the city. Meteorogical matters were also taken up as part of the program. In davao City, the place to install a water-intake gate was selected at the widely curved part of the Davao river which is full of drinkable water and runs 8 km from the center of the city from north to south through Lapandai village. Finally, the most economic and reasonable plan has been formed with the utilization of a 65 meter high hill located by the river.

Nothing would be more gratifying to our agency than if this report could be of any use for developing waterworks or any other industries, and also for promoting closer relationships as well as economic interchange between our two countries.

In conclusion, our agency takes this opportunity to express its hearty

thanks for the kind cooperation and assistance extended to our mission by the Government of the Republic of the Philippines and its agencies during the mission's stay there.

September 1966

Sinichi Shibusawa,

Director General,

Overseas Technical Cooperation Agency.

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CHAPTER I

INTRODUCTION

1. Object of the Survey

The Government of the Republic of the Philippines has been paying keen attention to the problem of environment sanitation, a problem that has an important influence on the betterment of national health, yet it may be said in general that adequate and satisfactory measures for this have not necessarily been taken by the authorities concerned. Speaking of the actual state of waterworks systems in the country, Manila including the suburbs is the only city that is provided with the facilities which may be called modern, and other cities and municipalities are still carrying on with rather primitive and old waterqworks equipment.

We came to survey for the development of Bacolod and Davao Waterworks Systems in compliance with the request of the Philippine Government.

The City of Bacolod, with sugar production of as much as about 65 % of the total national output, is the capital city of Negros Occidental Province in Negros Island and promises to prosper in the future as a commercial and industrial city.

The City of Davao, the port of entry between Indonesia and the Philippines for trade, is also expected to have a greater increase in population in the future, being supported by such developing industries as lumber, coconuts, fisheries and so forth.

It should, therefore, be a very important and opportune scheme at this stage to establish basic plans for future water supply to these principal cities by having necessary and fundamental surveys made for their waterworks systems. It is devoutly hoped for by us that this surveying work should contribute somehow to bringing about greater understanding and friendship between the Philippines and Japan.

2. Members of the Survey Team

The following are the members comprising the Bacolod and Davao Waterworks Survey Team which was sent by the Japanese Government:

Shinichi Matsushita
(Kubota Waterworks Construction Co., Ltd.)

Shoichi Inagaki
(Overseas Technical Cooperation Agency)

Haruji Makita
(Kubota Waterworks Constraction Co., Ltd.)

Tsukasa Hirabayashi
(Kubota Waterworks Construction Co., Ltd.)

Takayuki Tange
(Nihon Suido Consultants Co., Ltd.)

3. Itinerary of the Survey Team

(a) Surveying Schedule

Mar 28 (Mon)	Left Tokyo. Arrived at Manila.
Mar 29 (Tue)	Visited Japanese Embassy. General talks with Mr. Takeuchi, Ambassador, and Mr. Kimura, Secretary, about survey. Visited Balara Filters, Manila Waterworks.
Mar 30 (Wed)	Visited NWSA (National Waterworks & Sewerage Authority).
Mar 31 (Thu)	Left Manila. Arrived at Bacolod.
Apr 1 (Fri)	AM: Visited City Hall. General discussion with Mayor, City Engineer, Waterworks Administrator, etc. about survey. PM: Observed Boro-boro and Bocal-bocal Springs and Reservoir.
Apr 2 (Sat)	Surveyed upstream of Bago River to look for water source.
Apr 3 (Sun) through Apr 13 (Wed)	Engaged in collection of necessary data, discussions with persons concerned, determination of water intake point and survey and measuring thereof, survey of water treatment plant area and water supplying area, other necessary survey and study of relative data, and making up of basic plan and construction plan.

Apr 14 (Thu)	Met Mayor, Chairman of City's Public Works Committee, City Engineer, Waterworks Administrator and other staff members of waterworks office. Reported result of survey and study, and held discussion necessary re plan.
Apr 15 (Fri)	Left Bacolod. Arrived at Cebu.
Apr 16 (Sat)	Observed Cebu Waterworks facilities.
Apr 17 (Sun)	Left Cebu. Arrived at Davao.
Apr 18 (Mon)	Visited Davao Provincial Capitol Hall. Governor being absent, talked with acting Governor of the Province and Waterworks Superintendent. Visited City Hall. Talked with Vice-Mayor, City Engineer and Fire Chief.
Apr 19 (Tue) through Apr 30 (Sat)	Surveyed and studied existing water sources, settling basins, including Sibulan Water System. Engaged in collection of relative data and survey of water supplying area. Surveyed and studied Davao River Water System, including water intake, water treatment, and water distribution facilities. April 25, visited Governor.
May 1 (Sun)	Met the Hon. Mr. Duterte, Secretary of General Affairs and former Governor of Davao, and Waterworks Superintendent. Reported result of survey and study, and held necessary discussion re plan.
May 2 (Mon)	Left Davao. Arrived at Manila.
May 3 (Tue) through May 5 (Thu)	Visited Japanese Embassy and reported outcome of survey. Observed Marikina River and Montalban Weir. Visited liquid chlorine manufacturing plant in Bulacan.
May 6 (Fri)	Matsushita, Makita, and Tange left Manila for Tokyo. (Hirabayashi and Inagaki left Manila, May 11.)

(b) Persons Contacted

By listing the names of the gentlemen to whom we owe much for our surveying work, in Manila, Bacolod, and Davao, we wish to express our sincere appreciation of their kind cooperation extended to us on respective occasions.

Manila

NWSA: Mr. Florencio Moreno, Chairman

Mr. Leopoldo C. del Rosario, Technical Assistant to General Manager

Bacolod

Mr. Romeo G. Guanzon, Mayor

Mr. Rolando C. Estrella, Chairman of City's Public Works Committee

Mr. Jesus A. Sembrano, City Engineer

Mr. Archimedes V. Rio, Yulo Waterworks Administrator

Mr. Dominador C. Carmona, Ass't Waterworks Administrator

Mr. Andresito Gellecanao, Civil Engineer, Sanitary Engineer

Yulo Waterworks Office: Mr. Benjamin V. Canlas

Mr. Ariano Sayson

Mr. Pedro B. Aguilar

Davao

Hon. Mr. Vincente G. Duterte, Secretary of General Affairs
(Former Governor of Davao)

Mr. Paciano V. Bangoy, Governor

Mr. Crescencio P. Lascuna, Board Member of the Province

Mr. Vincente Franco, Waterworks Superintendent

Mr. Martin B. Oferario, Supervising Plumber

Mr. Isidro B. Laconico, National Irrigation Administration

Mr. Samuel Dumulao, City Engineer

Mr. Severo M. Barza, Ass't City Engineer

Mr. Isidro L. Palacio, Chief, Fire Department

Mr. Dacanay, Major, Fire Department

(c) Major Items Discussed and Reported Locally

April 1: At City Hall, Bacolod City

We had a meeting with Mayor, City Engineer, Waterworks Administrator and other staff members of Yulo Waterworks Office. There were requirements revealed by the mayor which were:

The survey and study by the team should cover not only engineering

and technical but also financial aspects, and also some consideration should be paid to the use of excess water for the sake of irrigation.

April 14: At the residence of Mayor, Bacolod City

We had a meeting with the Mayor, Chairman of City's Public Works Committee, City Engineer, Waterworks Administrator, and other staff members of Yulo Waterworks Office, to make a report on the result of the survey.

Suggestions made by us were that:

The plan for future waterworks construction should accomodate a population of 530,000, estimated for the year of 1985 or twenty years later, as its target, and the maximum amount of water supply per day to take from Bago River should be planned to be 105,000 m^3.

The Mayor agreed to this and disclosed his desire for the early materialization of the plan, telling us that the quick solution of the problem of water shortage had been an ardent wish of the citizens for many years.

May 1: At Apo View Hotel, Davao City

Mr. Duterte, formerly the Governor of Davao Province and now Secretary of General Affairs, had the greatest interest in the waterworks matter while in office as the Governor and still has the most effective authority for realization of the Davao water project. On the occasion of his return to Davao City for a week-end on May 1, we were able to meet him to report on the outcome of the survey and study. With Mr. Franco, Waterworks Superintendent, in attendance, we reported to him as follows:

The target year of the basic plan will be 1986 or twenty years afterwards, when we estimate a population of 500,000 and daily maximum water supply of 63,600 m^3. Even after completion of the Sibulan Water System now under way, the total output will not fill even the present water demand, so a separate additional construction program is most urgently necessary to meet the craving by Davao citizens.

As the conclusion of the present study, we recommend construction of

an independent system to take water from the Davao River. According to this plan, which holds an advantage of geographical position, the construction work will be finished within such a short period as two years. The greatest possible attention should be paid by everyone concerned to the actualization of this Davao River plan that would be the key to solve future water problems of the city.

As for the implementation of the Sibulan Project, we note that sufficient study has so far been made by NWSA and the Province, and more than half of the works have been finished while necessary measures are to be taken for the remaining portion, so that it is hoped that, by expending more effort in the future as well for securing national budget funds through NWSA, they will have the Sibulan River water flow into the city at the earliest possible date.

The above report and recommendation were accepted by both Mr. Duterte and the Waterworks Superintendent, and it was requested by them that further cooperation be extended by Japanese parties for the sake of developing the Davao Waterworks.

4. General Situation of the Existing Waterworks

In order to improve environmental sanitation of the people, develop industries, and ensure against fire, all the countries in the world are endeavoring to expand public waterworks systems. In the case of the West, there are many countries where the rate of water supply pervasion reaches about 80 %, and in Japan it is near 70 %.

After the investigation of the public waterworks facilities in the Republic of the Philippines, we have found out that the rate of pervasion is about 27 %, and there is only one system which can be graded as modern. That is the Manila and Suburban Waterworks, which supplies water to Manila City and it's suburbs.

The Manila and Suburban Waterworks is said to be approximately 700,000 m^3 in capacity against a population of about 2,800,000 served. This

supply capacity is not adequate enough to cover the demand, and moreover, during the dry season, it suffers from a shortage of source water. Consequently, the actual supply volume is considerably below the official statement. While the team stayed in the Philippines, rainfall was scarce around Manila, causing streams to decrease in rivers which are the source of the water and forcing the water supply to be curtailed to below 500,000 m^3 per day. The papers were so full of reports every day about reduction or suspension of water supply that the President had to direct personally ways and means as how to solve the water-supply shortage. As the result, construction has been undertaken hurriedly and at great expense for the improvement and extension of the facilities. Even the only representative modern waterworks in the country are under such conditions.

Besides the Manila and Suburban Waterworks, there are approximately 1,100 local waterworks systems scattered in provinces, cities, and towns, the water sources of which are springs and artesian wells in most cases and many of which are unsatisfactory from the standpoint of water quality, volume, pressure and others which are requisites for service water, necessitating improvements and extensions. According to the data available, these local waterworks supply water to about 5,500,000 persons in total, but the actual population served with water must be far less.

For the purpose of supplementing the insufficiency of public waterworks systems, the government is spending money in order to increase artesian wells equipped with hand pumps and accommodate facilities to utilize spring water in all provinces, and supervising them directly or indirectly. This data gives their respective total numbers as:

Artesian Wells:	20,000, approx.	Population Served:	4,800,000, approx.
Spring Facilities:	2,000, approx.	Population Served:	1,300,000, approx.

Waterworks systems in the Philippines used to be controlled by the Ministry of Public Works, Transportation and Communication and maintained by the local provinces, cities, and towns, but in 1955, in order to expand and

develop waterworks and sewerage systems, an independent agency was set up in the central government under the name of National Waterworks and Sewerage Authority (NWSA), to which construction and maintenance services of waterworks were transferred.

Since the foundation of NWSA, waterworks facilities in the Philippines have shown considerable improvement. In the NWSA Annual Report for the 1963--64 fiscal year, the following figures are shown:

	June '56	June '64
Public Waterworks Systems	500	1,075
Population Served (Excluding population served by Manila Waterworks)	1,500,000	5,430,000
Public Artesian Wells	7,500	19,270
Public Spring Facilities	250	1,995

As far as control is concerned, quite a number of public waterworks have recently been transferred to local provinces, cities, and towns, and those which are still under direct supervision by NWSA are 682 in number, as of the end of June, 1964.

CHAPTER II

BASIC PLAN FOR IMPROVING AND EXTENDING YULO WATERWORKS, BACOLOD

1. Introduction

The city of Bacolod is the capital of Negros Occidental. The City faces Guimaras Strait to the west and spreads to the east up to the foot of the mountain as high as about 60 m. The coast line stretches from north to south as long as about 15 km, and the width of the city from east to west is about 25 km, containing a total area of approximately 120 m^2.

The city is located at $10^{\circ}40'$ N. Lat., and there is no remarkable variation of temperature observed through the year.

The statistics made out by the Philippine Weather Bureau indicate the temperature record for the past ten years as per Table 1.

Table 1. Temperature in Bacolod City (Centigrade)

Month	Maximum	Minimum	Average
January	30.0	22.5	26.4
February	30.9	32.3	26.7
March	31.8	22.5	27.2
April	33.5	22.8	28.1
May	29.6	23.2	26.4
June	28.2	23.0	25.5
July	30.6	22.9	26.6
August	30.7	22.9	26.8
September	31.0	22.7	26.9
October	31.2	22.6	26.9
November	31.0	22.7	26.9
December	30.4	22.3	26.4
Average	30.7	22.7	26.7

According to the same Bureau, the monthly average rainfall and monthly average rainy days recorded in Silay City and Bago City are as shown in Table 2.

Table 2. Monthly Average Rainfall and Monthly Average Rainy Days around Bacolod City

Month	Silay City		Bago City	
	Rainfall	Rainy Days	Rainfall	Rainy Days
January	176 mm	20 days	120 mm	7 days
February	107 mm	14 days	44 mm	6 days
March	121 mm	14 days	47 mm	6 days
April	95 mm	10 days	85 mm	7 days
May	182 mm	15 days	278 mm	15 days
June	205 mm	19 days	302 mm	19 days
July	300 mm	20 days	460 mm	22 days
August	270 mm	20 days	388 mm	20 days
September	252 mm	20 days	385 mm	20 days
October	325 mm	22 days	355 mm	19 days
November	434 mm	22 days	264 mm	14 days
December	267 mm	22 days	132 mm	10 days
Yearly Total	2,730 mm	218 days	2,860 mm	165 days

In the table, we note that the months from May to November may be said to be the rainy season, and that the yearly rainfall in this district is somewhat greater than the country's average.

Out of the vast area of the city, the city poblacion where houses are clustered together is generally speaking bad in sanitation conditions, the agricultural belt being excluded from this discussion.

At a glance, the main roads are kept clean, but on the whole, the streets are untidy, the sewerage system is bad, and the streams of small rivers which flow through the city are dark, bad odors emitting from some places. There is, however, little undulation and the city as a whole gently slopes down to the beach, so rain water is somehow swept away.

As to the lavatories, the main buildings in the city are furnished with flush toilets which are equipped with purifying tanks or simple storage tanks, but generally privy-type toilets are used and there are some which are as

simple as ground-sucking types.

At the beach, sea-water is very dirty, due to filthy water discharged thereinto from the city and from factories alongside the beach.

The waterworks system of the city of Bacolod, which has been called the Yulo Waterworks System, was founded in 1927 by a Japanese engineer, Mr. Ishiwata by name. It's water source is a natural spring located approximately 15 km to the east of the city poblacion, and also seven artesian wells in the city area are supplying water to the citizens.

Total capacity of water supply is said to be as follows:

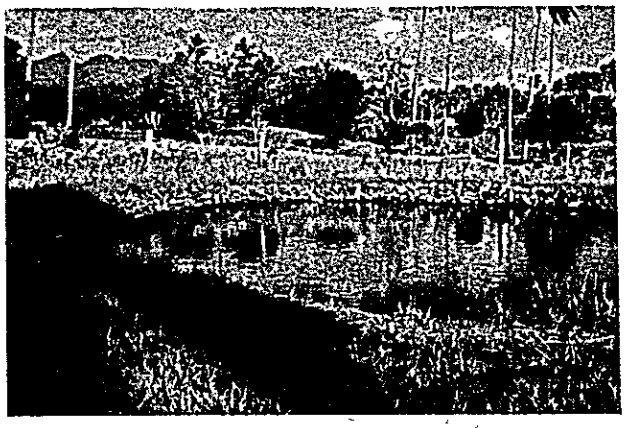
Springs	2.8 MGD (10,600 m^3/day, approx.)
Wells	1.0 MGD (3,800 m^3/day, approx.)

There are 5,390 connections, but the water pressure in the city distribution pipelines is very low (0--0.4 kg/cm^2) in most parts of the city.

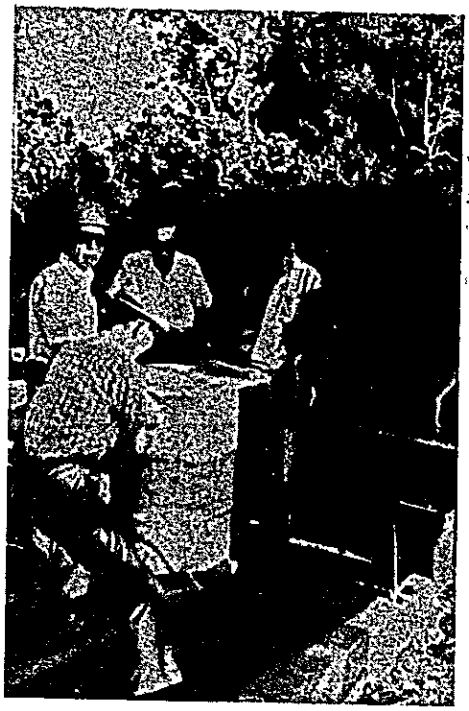
Population served at present is not known exactly, but the City authorities estimate it at about 110,000 persons, with 20 persons supposedly to get water from one tap.

As for the water quality, the water of the springs is good but that of the wells is poor. In any case, water of neither source being sterilized, it cannot be said that the water available is suitable for drinking.

Since the capacity of the waterworks is insufficient, most of big consumers and many houses in the city are equipped with their own artesian wells.



BORO-Boro Spring



Powder feeding equipment at Bocal-Bocal Spring

Reservior

Pumping water up from the artesian well

Such is the situation now prevailing in this city. No adequate measures have been taken for the improvement and extension of the system since its foundation some four decades ago, resulting in a supply of water for below the demand and thereby hampering badly the industrial development of the city.

Yulo Waterworks was put under the administration of NWSA when NWSA was organized in 1955, but in August, 1965, the control was shifted from NWSA to Bacolod City's own authorities. In the meantime, the city has made remarkable progress in parallel with the development of the sugar industry in and around the city and the subsequent increase in population at a surprising rate led to a serious demand for a higher capacity of water supply capacity. To cope

with this situation, the authorities concerned made a preliminary study a fairly long time ago with a view to utilizing the Bago River water flowing down through the south-east of the city as the source of supply, but the study has not been turned into a practical plan.

Under the circumstances, Mr. Guanzon, the mayor, who has once been to Japan and has acquired a good knowledge of the Japanese waterworks technique as to how it has been nurtured and how high its level is, submitted a letter of application to the government of Japan through the Department of Foreign Affairs of the Philippines for a waterworks survey team to be sent to the city.

The team, in carrying out the basic study of the waterworks plan for the city of Bacolod, did its best to make up a plan most suitable for the city, after having many discussions with the persons concerned in the waterworks administration. Plan of turning excess water to the use for irrigation, too, has been taken into the planning in addition to future extension of the system and improvement of the existing facilities.

2. Area and Population to be Served, Amount of Water Supply

In response to the requirement of the city authorities, we have taken the year of 1985, or twenty years in the future, as the target year of the basic plan for extending the Yulo Waterworks. It is recommended by us that the total construction work be divided into two stages, with the first stage plan aiming at meeting the water demand expected in 1975, or ten years later. However, for the water intake equipment and a part of the water conveyance equipment (tunnel), the total work should be constructed under the first stage plan rather than divided into two processes.

a. Area Served

According to the opinion of the City authorities, the area to be served with water will cover not only the present range such as the city poblacion and Barrio of Granada but also such regions as coastal divisions including Sumag, subdivisions around the city, reclamation land and even Silay City and a part of

Bago City.

b. Population Served

The city of Bacolod has seen an explosive increase in population in last six years, as is shown approximately in the following table:

Year	Population Approx
1948	102,000
1960	119,000
1961	128,000
1962	150,000
1963	180,000
1964	200,000
1965	230,000

We note that there has been an average increase of about 22,000 persons per year since 1960. Although the figures are approximate, such an excessive increment in population must be considered quite uncommon.

As for the future population, an estimate is made, through study of the rate of increase in the past and the opinion of the city authorities in relation to the implementation of city planning, its progress, etc. There will be an increase of 300,000 persons, in the coming twenty years, of which 160,000 increase will take place during the first ten years.

The water supply pervasion is very low, although the exact rate cannot be known, at present due to the deficiency of the supplying capacity. We estimate future rates of pervasion as follows, which should be accomplished by virtue of reasonable and careful administration and management of the waterworks authorities.

Year	Rate of Pervasion
1970	72.5 %
1975	75.0 %
1980	77.5 %
1985	80.0 %

From the above, total population and population to be served with water in coming years are estimated as below:

Year	Total Population	Population Served
1970	310,000	224,750
1975	390,000	292,500
1980	460,000	356,500
1985	530,000	424,000

c. Planned Maximum Amount of Water Supply per Day

60 gal--80 gal (230 lit--300 lit) may be proper as the planned maximum amount of water supply per day for a city such as Bacolod. In this plan, we are using the following figures in consideration an expected of increase of big consumers as the city's commerce and industry develop:

Year	Planned Max Amount of Supply/Day
1970	58.5 gal (222 lit)
1975	63.0 gal (238 lit)
1980	67.5 gal (256 lit)
1985	70.0 gal (265 lit)

Of the above, industrial usage is estimated at about 15 % of the amount for domestic, commercial and miscellaneous uses. Therefore, the planned daily maximum amount of supply is figured out as follows:

Year

1970 58.5 gal x 224,750 = 13.200.000 gal = 50,000 m^3

1975 63.0 gal x 292,500 = 18,427,500 gal = 70,000 m^3

Domestic usage, etc. ------ 61,000 m^3

Industrial usage ---------- 9,000 m^3

1980 67.5 gal x 356,500 = 24,000,000 gal = 91,000 m^3

Domestic usage, etc. ------ 79,000 m^3

Industrial usage ---------- 12,000 m^3

1985 70.0 gal x 424,000 = 29,680,000 gal= 112,300 m^3

Domestic usage, etc. ------ 96,300 m^3

Industrial usage ---------- 16,000 m^3

d. Planned Average Amount of Water Supply per Day

This shall be 80% of the daily maximum, in consideration of the local climatic conditions where the dry season and rainy season come alternately.

e. Planned Maximum Amount of Water Supply per Hour

This shall be 130 % of the hourly amount of the daily maximum.

3. Extension Plan and Water Source

In making up the basic plan, selection of the site of the water source has to be the first item to decide.

Springs in mountain places or artesian wells in the City area cannot be of sufficient water source for Bacolod City in the future. There are several rivers flowing near the city, of which Bago River about 20 km to the south-east of the city poblacion is the only river with ample enough discharge to become the water source for the city's water system.

A computation of the discharge of the Bago River previously made out by a hydroelectric engineer shows a minimum discharge of 7.87 m^3/sec (680,000 m^3/day) at the planned dam site about 40 km upstream from the river mouth.

The water intake of our plan is located downstream from the planned dam site, so we can expect more discharge than the above. Analysis of water at the intake point is shown in Table 2 which proves there will be no trouble about quality in the water source.

Table 2. Analysis of Water of Bago River at Intake Point

(Time: Noon, Apr 2, 1966)

Temperature:	32.0° C
Water Temperature:	28.5° C
Color:	0
Turbidity:	0
Odor:	0
pH:	6.8
Alkalinity:	100.0
Ammonia:	Negative

Nitrous Acid:	Negative
Nitric Acid:	Positive, slightly
Chlorine Ion:	31.25
Sulfate Ion:	Negative
Hardness:	175.0^{o}

The following elements were taken into consideration in determining the water intake site:

(1) Adequate water level allowing gravity flow of river water to supplying area,

(2) Suitable geographical features for construction of weir that can elevate water level during dry season,

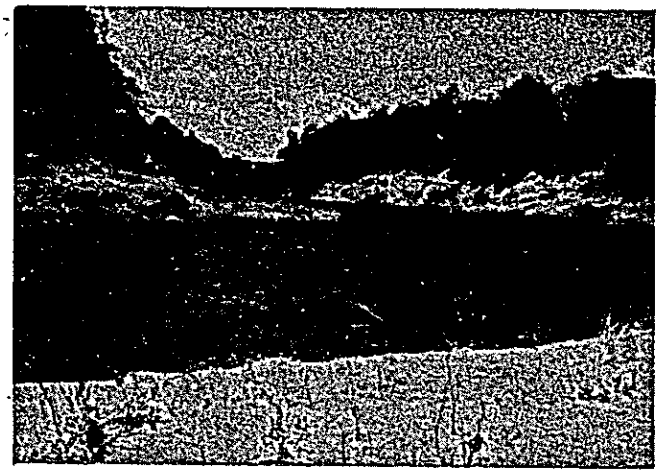
(3) Shortest distance possible from supplying area, and

(4) Feasibility of constructing water intaking and conveying equipment.

Based on the above, we have come to select the point as indicated in one of the attached drawings after making an on-the spot survey and measurments. The place is close to the junction of the Iglauan Creek with the Bago River and about 19 km from the city poblacion.

A minute survey had been conducted of the selected point for six days beginning on April 4, and the water level was thereby affirmed as +63.50 m and the discharge, 11.824 m^3/sec.

Starting to the spot for Land Surveying



Proposed IN-TAKE point of the Bago River

By a rough computation, we assumed that t he water level required at the intake point should be +66.00 m. For securing this level, we plan to construct a low weir so that the water level will become higher by about 2.50 m than that of the day of the survey. The actual topography at the site is such that cliffs, about 20 m high, are standing on both the banks with soil proper for the purpose and the river is rather narrow (72 m, approx.), so we foresee no troubles in planning to construct the weir there.

That there will be considerable turbidity in the water of this river during the rainy season is foreseen, but the turbidity can easily be eliminated by means of sedimentation equipment which is to be installed in the water treatment plant.

4. Location of Water Treatment Plant

Several factors should be considered in the selection of a site for the treatment plant that will be located between the water intake and the supplying area; viz., overall evaluations of construction cost and maintenance charges, extent of difficulty in executing main construction plan, perspective for future expansion of the system, and so forth. Also, proper elevation and extension of the land, as well as good enviromental circumstances, are required for the plant itself. Keeping the above factors in mind, we have decided the site as indicated in the Fig. 1 (General plan on the Extension Project)

The place belongs to Barrio Mansiligan, and the site is located in the middle of and to the south of a road which leads to the Municipality of Murcia from Bacolod. With an elevation of about 55.0 m, its area is satisfactory and the soil and drainage are good, being now in the midst of sugar cane fields. Transportation is quite convenient as the above-mentioned highway is running near the site.

The distance from the water intake to the treatment plant is 12 km, approximately, and from the plant to the city poblacion, about 7 km. It can be said that this place is most suitable for setting up the treatment plant with a view to constructing water conveyance and distribution pipelines and a well-controlled administration of the entire system.

5. Equipment under Extension Plan

Of the existing water sources, Boro-boro and Bocal-bocal Springs shall be used in the future as well, but the employment of artesian wells in the city shall be terminated after completion of the new system in view of the unfitness of the water. The amount of water produced by the springs is about 2,000,000 gal (7,570 m^3) per day.

The amount of water under this plan making Bago River its water source shall consequently be fixed as follows:

Planned Maximum Amount of Water Supply per Day

1975 18,427,500 gal - 2,000,000 gal = 16,427,500 gal
= 62,000 m^3

Domestic usage, etc. --- 53,000 m^3

Industrial usage ------- 9,000 m^3

1985 29,680,000 gal - 2,000,000 gal = 27,680,000 gal
= 105,000 m^3

Domestic usage, etc. -- 89,000 m^3

Industrial usage ------- 16,000 m^3

Planned Average Amount of Water Supply per Day

This shall be 80 % of the planned daily maximum suplly.

Planned Maximum Amount of Water Supply per Hour

This shall be 30 % of the hourly amount of the planned daily maximum supply.

Water for Industrial Usage

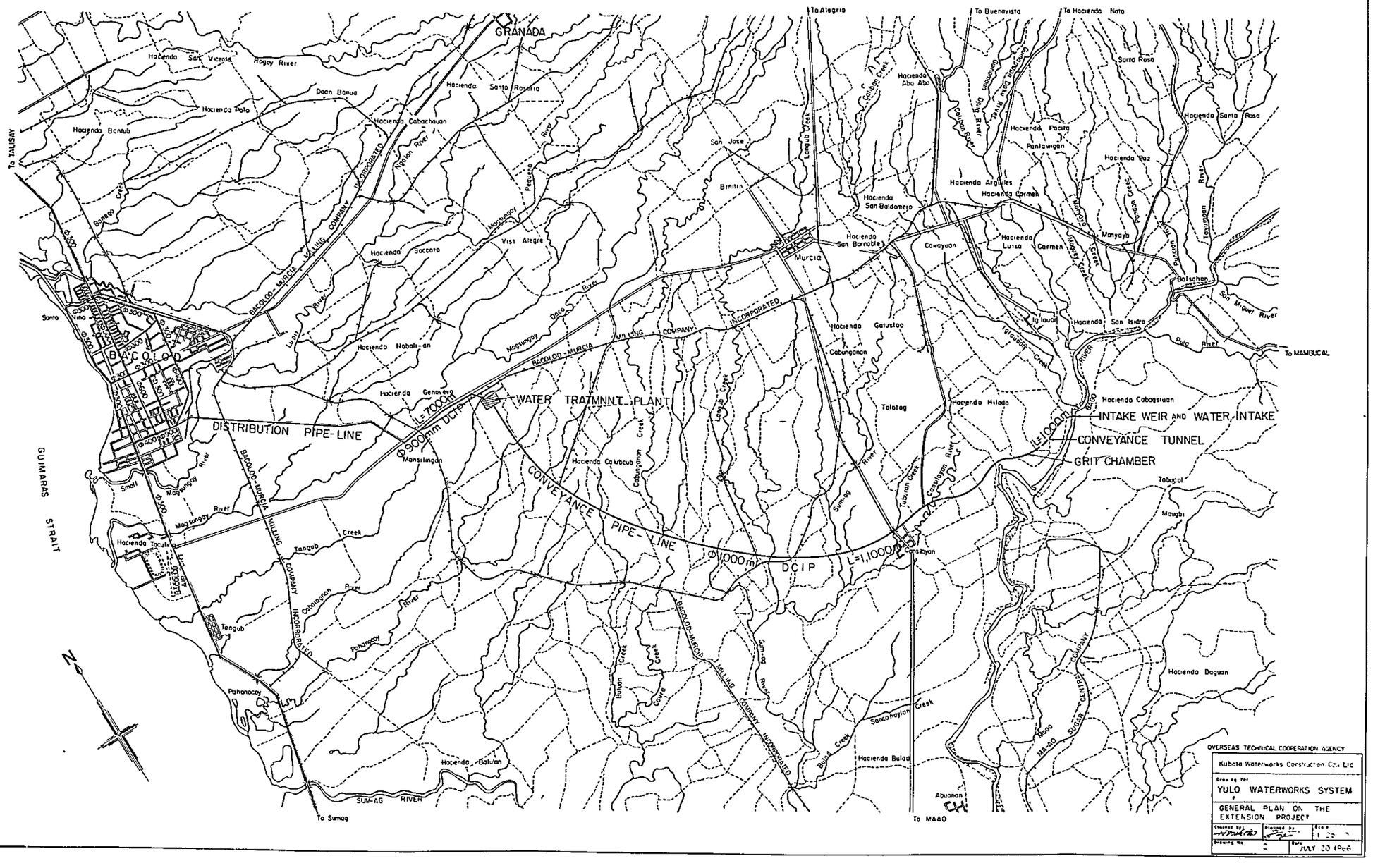
In the light of the fact that water for industrial usage may be supplied from sedimentation basins (before filtration), an independent pipeline was suggested by the city authorities to be laid for the exclusive purpose for carrying unfiltered water to factories. At the present stage, however, our study of the demand for industrial usage is not complete, and such items as the amount required by factories, period of use in a day, hourly maximum consumption, etc. cannot be fixed. Thus, this plan should be devided into two stages.

In the first stage work, the planned maximum amount of water supply in 1975 is 62,000 m^3 and in the second stage work in 1985, it is 105,000 m^3. Such being the case, it is recommended that in the first stage plan, industrial water will be taken from the pipe for domestic water distribution, which will give time for us to make the necessary study and investigation should to determine whether or not such separate pipelines should be planned in the second stage work, for industrial usage.

F I G. I

GENERAL PLAN ON THE EXTENSION PROJECT

Scale 1 0 1 2 3 km



a. Water Intake, and Conveyance

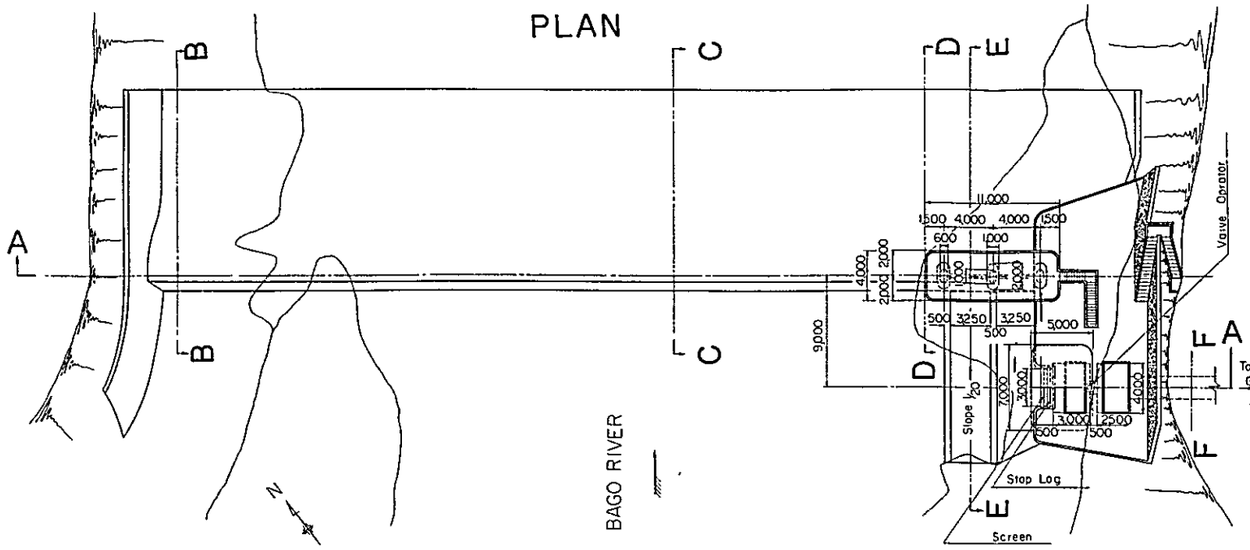
Water Intake Equipment:

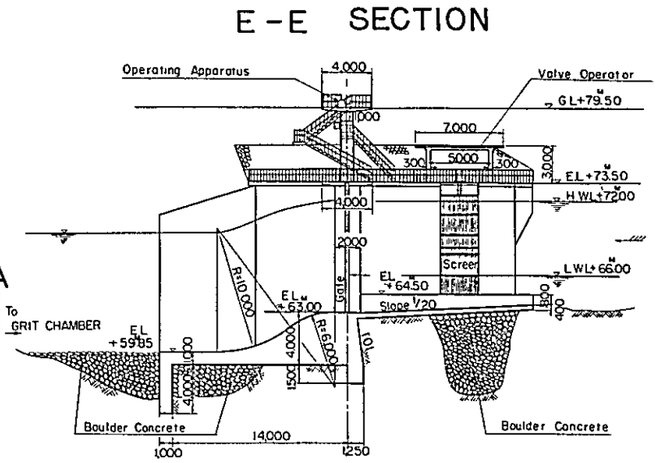
At the water intake, the daily maximum amount of 110,000 m^3 or 105 % of the daily maximum amount of supply shall be secured. A weir to attain a water level of +66.00 m at the in-take point shall be constructed with the following specifications:

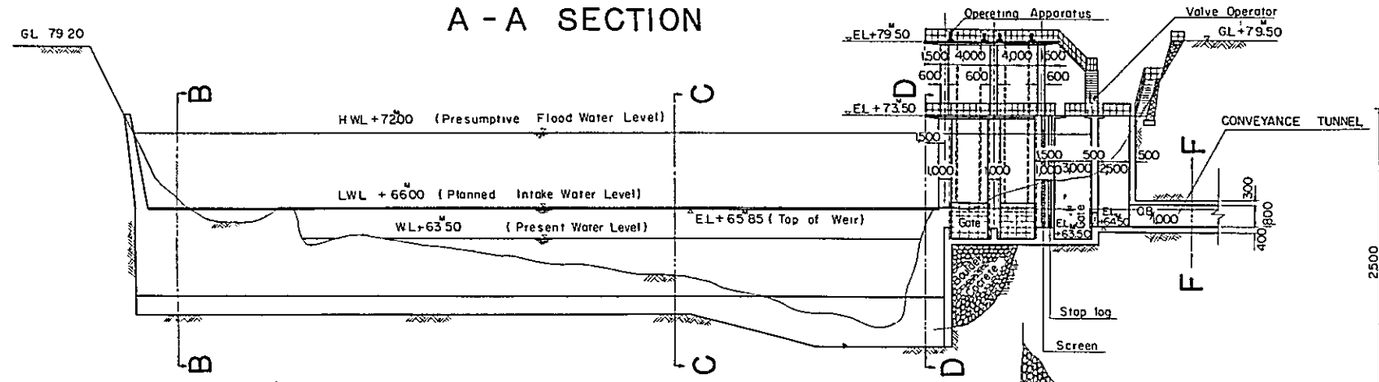
Elevation of Top of Weir:	+66.85 m
Length of Top of Weir:	72.00 m, approx.
Height of Weir:	7.00 m, approx.
Width of Water Inlet to Tunnel:	3.00 m

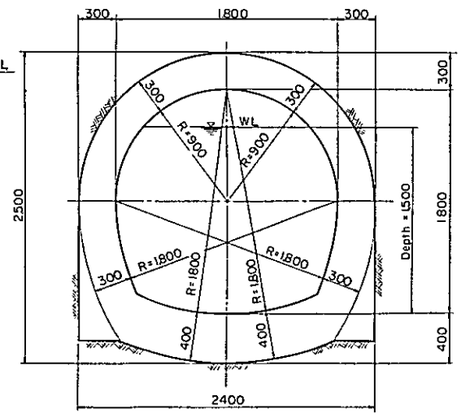
FIG. 2

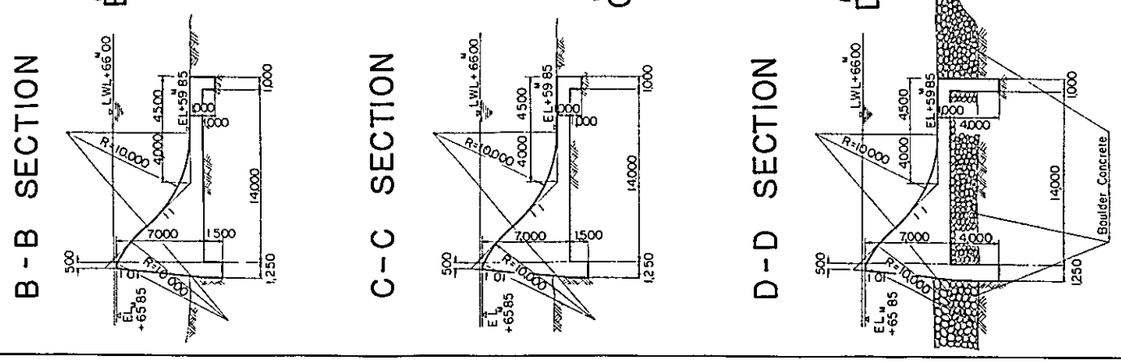
INTAKE WEIR AND WATER INTAKE











Scale:
For PLAN A-A ~E-E SECTION
5 0 5 10m
For F F SECTION
05 0 05 10m

OVERSEAS TECHNICAL COOPERATION AGENCY

Kubota Waterworks Construction Co. Ltd		
Drawing for: YULO WATERWORKS SYSTEM		
INTAK WEIR AND WATER INTAKE		
Checked by	Planned by	Scale 1:200 1:20
Drawing No. 4		Date JULY 20, 1966

Water Conveyance Equipment:

Of the total 12 km up to the water treatment plant, 1 km (approx.) will be covered by a tunnel and the outlet of the tunnel will be connected to a grit chamber to remove inflowing sand. Between the grit chamber and the treatment plant, there will run a pipeline, approximately 11 km in length.

Tunnel:	Horse-shoe shape, lined with concrete.	
Grit Chamber:	Settling period:	17 min., approx.
Conveyance Pipe:	1st stage plan:	ø 1,000 mm
	2nd stage plan:	ø 900 mm
Kind of Pipe:	Ductile iron pipe, mortar-lined.	

b. Water Treatment Plant

Modern equipment, which is easy to maintain, will be furnished for the treatment plant. The construction work shall be divided between the first and the second stages.

(1) Receiving well

HWL:	+55.70 m
Number:	One well, with retention period of 2 min., approx.

(2) Chemical mixing basin(s)

Mixing Period:	3 min., approx.	
Apparatus:	Equipped with rapid mixing equip.	
Capacity & Number:	1st stage plan:	140 m^3, 1 (one)
	2nd stage plan:	90 m^3, 1 (one)

(3) Flocculation basins

Horizontally-circulating type, easy to maintain.

Average Velocity of Flow: 20 cm/sec

Retention Period: 30 min, approx.

Capacity & Number: 1st stage plan: 700 m^3, 2 (two)
Total: 1,400 m^3

2nd stage plan: 500 m^3, 2 (two)
Total: 1,000 m^3

(4) Chemical sedimentation basins

Average Settling Period: 3 hrs, approx.

Average Velocity of Flow: 40 cm/min, approx.

Capacity & Number: 1st stage plan: 2,700 m^3, 3 (three)
Total: 8,100 m^3

2nd stage plan: 2,700 m^3, 2 (two)
Total: 5,400 m^3

(5) Chemicals feeding equipment

Feeding Rate: Aluminum sulfate 50 ppm, max.

Soda ash 20 ppm, max.

(6) Rapid filtration basins

Normal Rate of Filtration: 120 m/day

Filtration Area/Basin: 80 m^2, approx.

Normal Filtration Capacity/Basin: 9,600 m^3/day, approx.

Number of Basins: 1st stage plan: 8, incl. 1 as spare

2nd stage plan: 4

Treatable Water: 1st stage plan: 67,000 m^3/day

2nd stage plan: 38,000 m^3/day

(7) Elevated storage tank for back-washing water for filtration basins

Lowest Low Water Level: +67.00 m

Effective Depth: 3.00 m

Capacity: 640 m^3, approx.

Tank, cylinder shaped, shall be as high as 20 m above ground level and its inside diameter shall be 16.50 m.

(8) Chlorinator

Chlorine Feeding Rate: 2.5 ppm, max.

Capacity & Number: 1st stage plan: 5 kg/hr, 3 (three), incl.
1 (one) as spare

2nd stage plan: 5 kg/hr, 1 (one)

(9) Chemical feeding and storing building

Built of reinforced concrete, one storied.

Chemical Feeding Chamber: 81 m^2

Chemical Storing Chamber: 81 m^2

(10) Administration Building

Built of reinforced concrete, two storied above ground. Some part of underground portion to be used for filtered water tank.

Floor Area:	1st floor	300 m^2 (for chlorinator and electric machinery)
	2nd floor	300 m^2 (office and laboratory)

(11) Distribution reservoir

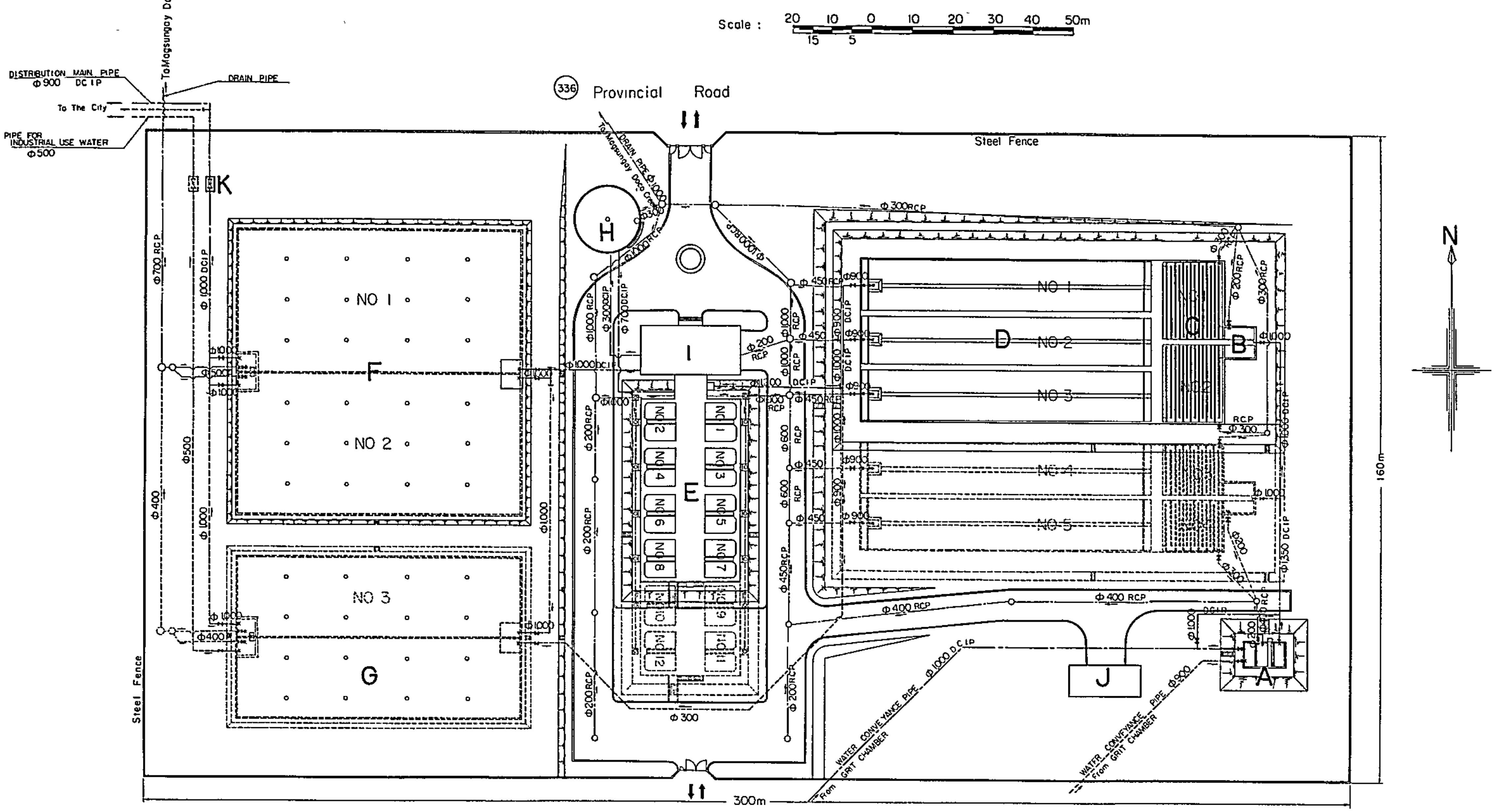
The capacity corresponds to a six (6) hours' proportion of daily maximum amount of supply.

Effective Storage & Number of Reservoirs'.

1st stage plan	8,500 m^3.	2 (two)	Total: 17,000 m^3
2nd stage plan	5,000 m^3.	2 (two)	Total: 10,000 m^3

FIG.3

PLAN OF WATER TREATMENT PLANT



A RECEIVING WELL
B CHEMICAL MIXING BASIN
C FLOCCULATION BASIN
D CHEMICAL SEDIMENTATION BASIN
E RAPID FILTRATION BASIN
F DISTRIBUTION RESERVOIR
G RESERVOIR FOR INDUSTRIAL USE
H ELEVATED STORAGE TANK
I OFFICE BUILDING
J CHEMICALS FEEDING AND STORING BUILDING
K VENTURI-METER

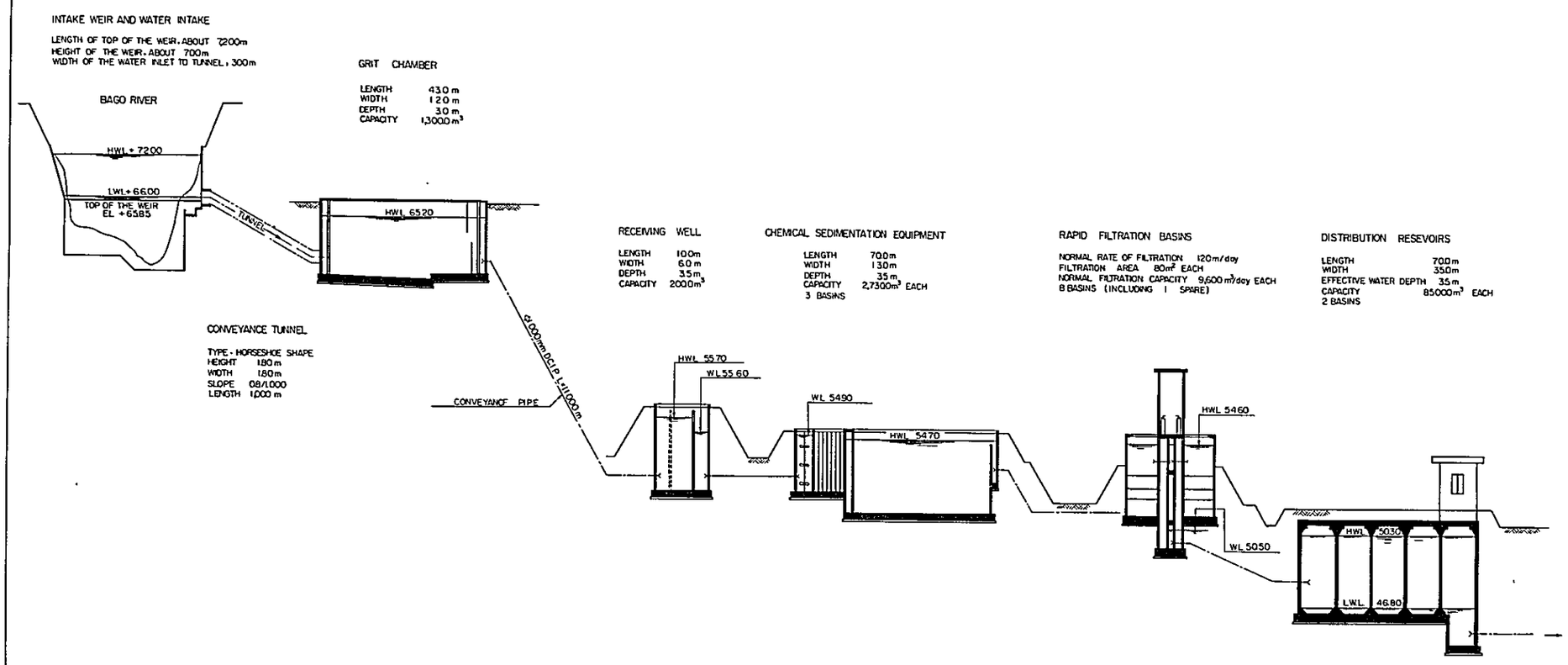
Remarks

▭ ▭	——— ———	1st Stage Plan
⬚ ⬚	- - - - - -	2nd Stage Plan
DCIP	Ductile Cast Iron Pipe	
RCP	Reinforced Concrete Pipe	

OVERSEAS TECHNICAL COOPERATION AGENCY		
Kubota Waterworks Construction Co.,Ltd.		
YULO WATERWORKS SYSTEM		
PLAN OF WATER TREATMENT PLANT		
[signature]	[signature]	1 500
	7	JULY 20, 1966

FIG. 4

WATER LEVEL DIAGRAM



OVERSEAS TECHNICAL COOPERATION AGENCY

Kubota Waterworks Construction Co., Ltd.		
Drawing for: YULO WATERWORKS SYSTEM		
WATER LEVEL DIAGRAM		
Checked by: H. Hidaka	Planned by: K. Ono	Scale: NONE
Drawing No: 3	Date: JULY 20. 1966	

c. Water Distribution Pipelines

An exact plan for distribution pipelines could not be made up at this time due to the situation where reliable data were not available regarding future expansion of population by districts, rates of increase of water demand, etc., yet we have estimated and made up the main pipeline plan on the assumption that the following districts will face a greater increase in water demand in the future.

The coastal area ranging from the north to the south of the city,

Subdivision,

Factory districts, and

Reclamation land

according to the advice of the city authorities and our general understanding of vavious aspects of the city, in addition to our view that the future expansion of the main pipelines to Bago City and the municipality of Talisay should be included in the plan.

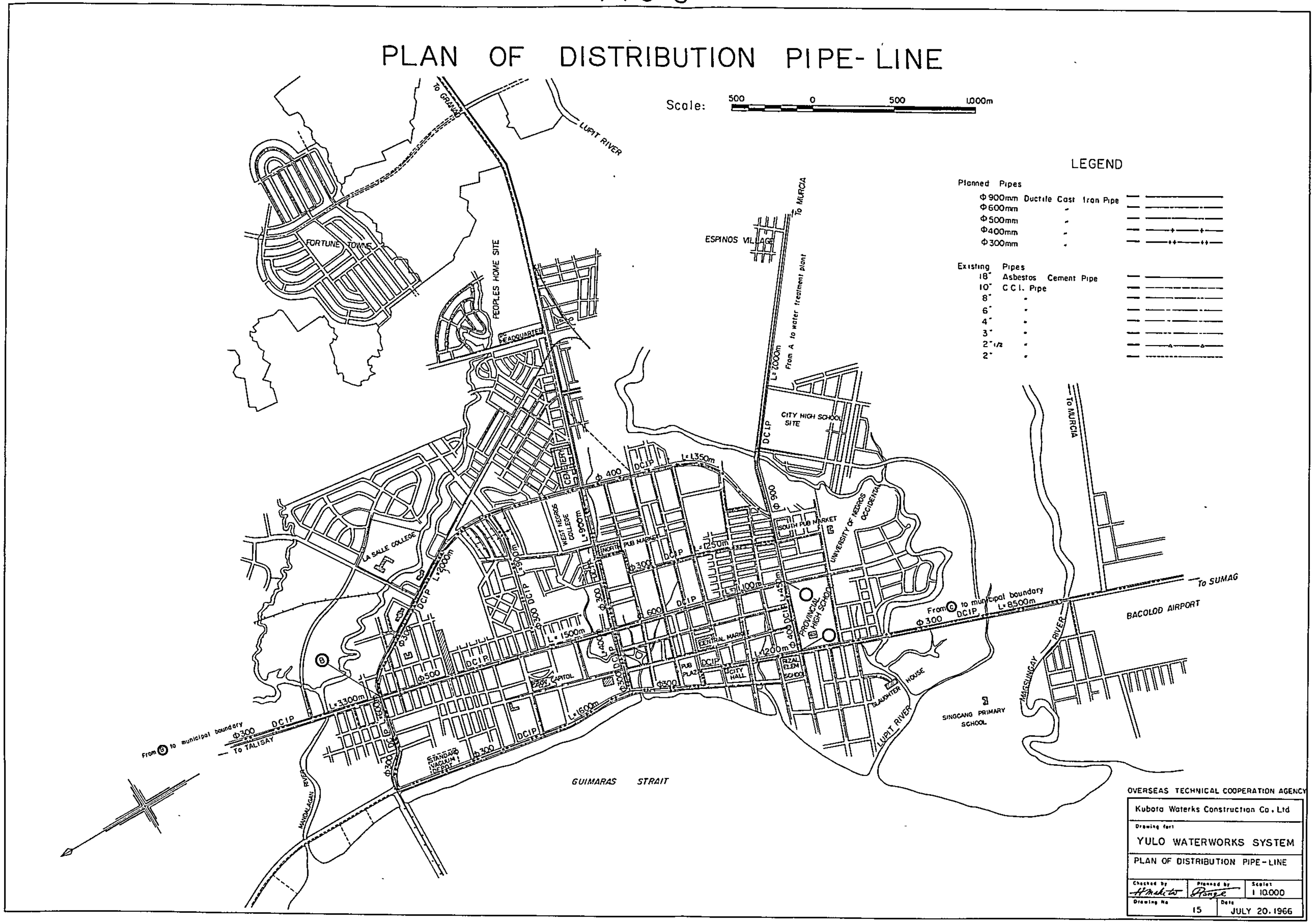
The plan for the first stage is shown in one of the attached drawings, which is broken down as follows:

900 mm	7,000 m
600 mm	1,100 m
500 mm	1,450 m
400 mm	1,700 m
300 mm	20,850 m
	Total : 32,100 m

Distribution and service pipelines of 250 mm and smaller shall be planned separately by the city authorities by giving consideration to the perspective of development by districts and working condition of the existing pipelines.

The distribution pipeline project for the second stage shall be begun after making proper study of the city planning of the city and after finding insufficiencies of the first stage pipelines.

FIG. 5



PLAN OF DISTRIBUTION PIPE-LINE
Scale: 500 0 500 1,000m
LEGEND
Planned Pipes
Φ900mm Ductile Cast Iron Pipe
Φ600mm
Φ500mm
Φ400mm
Φ300mm
Existing Pipes
18" Asbestos Cement Pipe
10" C.C.I. Pipe
8"
6"
4"
3"
2"1/2
2"
To GRANADA
LUPIT RIVER
FORTUNE TOWNS
PEOPLES HOME SITE
HEADQUARTERS
ESPINOS VILLAGE
To MURCIA
From A to water treatment plant
L=2000m
DCIP
CITY HIGH SCHOOL SITE
L=1,350m
Φ400
Φ900
WEST NEGROS COLLEGE
CEMETERY
NORTH PUB MARKET
SOUTH PUB MARKET
UNIVERSITY OF NEGROS OCCIDENTAL
LA SALLE COLLEGE
L=2000m
PROVINCIAL HIGH SCHOOL
CENTRAL MARKET
PUB PLAZA
CITY HALL
RIZAL ELEM SCHOOL
CAPITOL
L=1500m
L=1600m
L=1200m
L=3300m
From B to municipal boundary
Φ300 DCIP
To TALISAY
From C to municipal boundary
Φ300 DCIP L=8500m
To SUMAG
BACOLOD AIRPORT
MAGSUNGAY RIVER
SLAUGHTER HOUSE
LUPIT RIVER
SINGCANG PRIMARY SCHOOL
STANDARD VACUUM DEPOT
MANDALAGAN RIVER
GUIMARAS STRAIT
OVERSEAS TECHNICAL COOPERATION AGENCY
Kubota Waterks Construction Co., Ltd
YULO WATERWORKS SYSTEM
PLAN OF DISTRIBUTION PIPE-LINE
Scale: 1:10,000
Drawing No. 15
Date JULY 20, 1966

6. Construction Expenses

ESTIMATE

OF

CONSTRUCTION COST

		Materials and Equipment to be Supplied from Japan (CIF Iloilo)	Local Construction Cost	Total
I.	Water Intake	US$ 99,540.-	US$ 128,560.-	US$ 228,100.-
1.	Water intake	99,540.-	128,560.-	228,100.-
II.	Water Conveyance Equipment	US$1,569,350.-	US$ 392,610.-	US$1,961.960.-
1.	Tunnel	61,360.-	154,110.-	215,470.-
2.	Grit chamber	21,520.-	30,500.-	52,020.-
3.	Conveyance pipe	1,486,470.-	208,000.-	1,694,470.-
III.	Water Treatment Plant	US$ 970,216.-	US$ 780,200.-	US$1,750,416.-
1.	Receiving well	8,920.-	6,800.-	15,720.-
2.	Chemical feeding equipment	32,670.-	1,570.-	34,240.-
3.	Chemical sedimentation basins	118,360.-	140,130.-	258,490.-
4.	Rapid filtration basins	311,420.-	108,130.-	419,550.-
5.	Elevated storage tank	107,300.-	36,570.-	143,870.-
6.	Chlorinator	15,170.-	420.-	15,590.-
7.	Connecting pipe in the Plant	131,776.-	34,140.-	165,916.-
8.	Office building	28,300.-	68,500.-	96,800.-
9.	Chemical feeding & storing building	7,020.-	10,380.-	17,400.-
10.	Ground arrangement of Plant	9,960.-	48,860.-	58,820.-
11.	Distribution reservoir	199,320.-	324,700.-	524,920.-
IV.	Water Distribution Pipeline	US$1,379,770.-	US$ 440,870.-	US$1,820,640.-
V.	Machinery & Materials for Construction	US$ 808,924.-	-	US$ 808,924.-
VI.	Provisional Erection	-	US$ 24,360.-	US$ 24,360.-
VII.	Transportation (Iloilostockyard)	-	US$ 184,700.-	184,700.-
VIII.	Engineering Fee	US$ 347,200.-		US$ 347,200.-
	TOTAL:-	US$5,175,000.0	US$1,951,300.-	US$7,126,300.-

7. Use of Excess Water for Irrigation

A water conveyance pipeline of 1,000 mm in diameter and 11 km in length to be laid, under the first stage plan, between the water intake point in Bago River and the water treatment plant, will carry a maximum of 17.2 MG (65,000 m^3) of water per day.

For several years after the completion of the first stage plan, there will be a considerable amount of water in excess of the waterworks demand running through the pipe. So, it is quite reasonable to plan the use of such excess water for irrigation purposes.

Water volume in excess of the waterworks demand is estimated as follows:

Year	Daily Maximum Demand	Daily Excess
1970	44,000 m^3	21,300 m^3
1975	65,000 m^3	- - -

Such excess water may be distributed for irrigating agricultural field by means of branch pipes set out from the conveyance trunk pipeline at necessary points and connected to irrigation pipes and aqueducts.

The hydraulic gradient line of the water conveyance pipeline is, according to our plan, 65 m to 55 m, and the excess water in the pipeline shall be made available for irrigating sugar cane fields and rice fields south-east of Bacolod City, which spread below the elevation of the hydraulic gradient line.

It is recommended that a reservoir solely for irrigation use shall be constructed against larger demand for the irrigation water taken from the conveyance pipeline, so that variation of demand according to the hours of the day will be regulated in this reservoir.

As for details of the plan of utilizing excess water for irrigation, it is hoped that the authorities concerned will make further studies for its implementation.

8. Improvement of the Existing Water works System

Boro-boro and Bocal -bocal Springs are left unprotected from outside

invasions, having no covers over the water. Some of the springs are suffering from the growth of algas, something not desirable in water for drinking.

It is recommended that those springs and the reservoir shall be equipped with covers (simple ones will do) as early as possible to prevent invasion of exterior foreign matter and to keep the water therein clean all the time.

We noticed that the chlorination equipment existing in those springs and the reservoir was not working at all. Improvement of the equipment and stricter control of the water quality are quite necessary.

Main pipelines of 18" to 6" now running from the springs and reservoir to the city area had long use and their capacity for water conveyance has been proportionately reduced. It therefore is suggested that upon completion of the extension project of the system which will make it possible to supply the city with more than sufficient water, the improvement in conveyance capacity of the old pipelines should be implemented by means of replacement, inside cleaning, etc.

Of the existing distribution pipe net which consists of 8" to 2" pipes, the larger part is 3" to 4" in diameter. Those pipelines are also timeworn and have decreased in capacity due to considerable leakage. Consequently, very low water pressure results and inefficiency is expected in case of fire-fighting. The city waterworks authorities should plan, in the future, to lay additional pipelines and to go on replacing the old pipes parallel with future expansion projects.

Accessory equipment installed in the distribution pipelines, such as sluice valves, air valves, etc., should also be improved in quality as well as in quantity.

9. Problems re Waterworks Administration

a. Water Rate and Income

An official report of the Yulo Waterworks Office states that:

Number of connections at present is 5,390

Number of public faucets is 25

Number of fire hydrants is 225

The water rate, since May, 1965, has been regulated as follows:

Minimum charge per month for 20 m^3	₱ 4.00
Excess over the minimum, per m^3	₱ 0.20
Public faucets and fire hydrants	₱ 10.00/set/month
Meter rental, per m^3	₱ 0.70 or more/month
Service maintenance, per m^3	₱ 0.30 or more/month

Income in 1964--65 fiscal year amounted to ₱313,200.00.

When we assume that the daily water supply is 12,000 m^3 and the average water rate is ₱0.20/M^3, it is calculated that only 35 % of the total supply was converted to income in the fiscal year 1964--65.

Such a low percentage was caused by deficiency of meters, non-paying water consumption, illegal use of water, leakage of water from distribution and service pipelines, etc. Of these causes, the most serious is "insufficient number of meters installed", only 400 against 5,390 connections. Therefore, the actual situation is that the water office is compelled to collect monthly minimum charges only, or estimated small excesses thereof if things go well, from most of the consumers.

The most urgent task of the water authorities for the time being must be to provided sufficient number of meters and to maintain them in good condition. Such will incur a considerable amount of expense, but, in doing so, the admistration may be able to lessen some of the burden by charging a part of the cost to the consumers.

The prevailing system of water rate is as follows:

Meters in houses or buildings (minimum charge per month ₱ 2.00)	₱ 0.20/m^3
Meters in government houses or buildings Provincial Hospital and Maternity Hospital	₱ 0.16/m^3

For public fire hydrants or fountains (to be charged to the city general account) P10.00/month

Meter rentals and service maintenance charges are levied variously according to the size of the meters.

The above regulation is deemed reasonable. Yet, only a small portion of the wat er supply being turned into the administration's income, satisfactory revenue is not collected by the system, resulting in insufficient implementation of improvement and repair of the facilities and insufficient maintenance of adequate water pressure, and so forth.

Upon completion of the Bago River water system in the future, a remarkable increase of income corresponding to the rise in water supply amount can be anticipated by the administration. On the other hand, they should be prepared for a large amount of amortization of the principal and payment of interest on construction expenses, and also for maintenance and management of the system. For the disposal of this, thorough study and pre-arrangement should be made by the authorities concerned.

While greater pressure will be produced in the distribution pipelines after completion of the new system, more leakage from the pipes is feared at the same time. In this regard as well, the authorities concerned should not spare their effort in carrying out such dispositions as replacement of existing pipes and better control of service maintenance.

In order to improve the water income, it is advisable to make a re-study of the prevailing water rate system. One suggestion is:

Minimum charge per month for general domiciles shall be kept at a lower rate while excess charges shall be made higher. Also, water for such buildings as places of amusement, restaurants, offices, factories, etc., that are deemed to have larger paying capacities, shall be charged at higher rates.

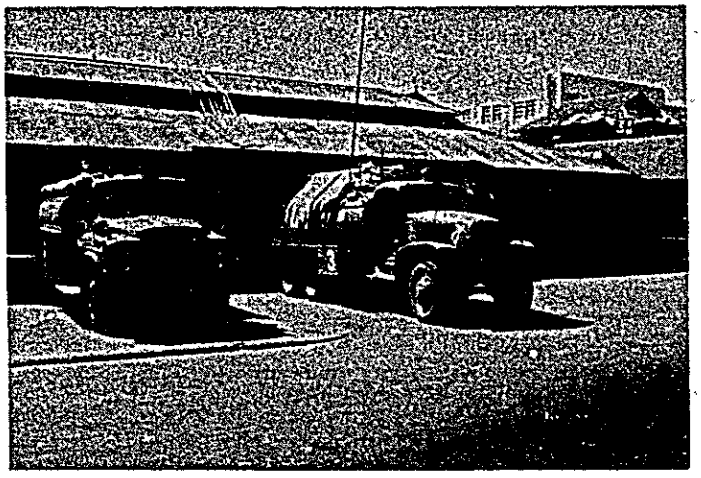
b. Water for Fire-Fighting

There are as may as 250 public fire hydrants in the city besides a

considerable number of private ones. Most of them seem to have been under loose control and maintenance, and many of the hydrants are unworkable now. We also note that most of the fire hydrants are connected to distribution pipes of 4" or smaller in diameter.

Hydrant installed on the pillar

Hydrant, standing type



Five engines made in Japan

Public bath (Free from charge)

The city is equipped with large fire-trucks of high efficiency, but these trucks are not able to operate at full capacity in case of fire due to fire hydrants which are insufficient in capacity as mentioned above. It is needless to say that fire hydrants can work more powerfully with increased pressure of water in distribution pipes. Besides, it is apparent that the larger the pipes connected are the better they can serve. For these reasons, it is recommended that public fire hydrants shall be connected to the pipelines of 6" or larger, in the future.

c. Control of Water Quality

In performing quality control of water from the natural springs, chemicals should be fed at a point as near as possible to the water service districts.

In case the artesian wells are put to continued use to supplement water supply for the city, the well water should also be fed with chemicals by proper means in order to keep the water sanitary, It is not good in quality because the origin is contaminated with excreta and sewage due to the unsatisfactory disposal. Feeding of chemicals should be done either directly at the outlets of the pumps or in elevated tanks which will be provided newly for collecting the well water.

10. Closing Remarks

It was a pleasure for us that the team could carry out the survey, measurement work, collection of relative data and necessary study for the plan, successfully during the short period of 15 days from March 31 through April 15 and under a blazing sunshine that was not quite familiar to us Japanese.

Now we have the honor of submitting to you this report on the improvement and extension plan of the Yulo Waterworks System, in which we have stated basic and general aspects of the new project. In the execution of the plan, it goes without saying that more actual survey and measurement, further study and decision of detailed structures, specifications, and method of performance, etc. will be necessary.

In closing this report, we wish to reiterate our cordial gratitude to the

mayor, waterworks personnel and other gentlemen of the city for their very warm cooperation and collaboration extended to us during our stay there. The sincerest appreciation should be conveyed to Mr. Archimedes V. Rio, the Waterworks Administrator, who spared no effort in providing us with thoughtful management of the surveying work and cooperation in order to obtain necessary data required throughout the days of our stay.

CHAPTER III

BASIC PLAN FOR IMPROVING AND EXTENDING DAVAO METROPOLITAN WATERWORKS

1. Introduction

The city of Davao is the capital of Davao Province. The city faces Davao Bay on the east and south and spreads to the west and north to the foot of the mountain. With an expanse of about 25 km from east to west and about 70 km north and south, the city boasts the widest area of any single city in the world. There run many rivers in the city including the Davao River and the Talomo River, each having a broad basin and large discharge.

The southern part of the city of Davao is at 7° N. Lat. The monthly average temperature of the city in the past five years recorded by the Philippine Weather Bureau is shown in Table A below.

Table A. Monthly Average Temperature of Davao City (Centigrade)

January	25.7
February	25.6
March	26.5
April	27.3
May	27.4
June	26.9
July	26.7
August	26.8
September	26.8
October	27.0
November	26.8
December	26.5

Also, the Westher Bureau revealed the monthly average rainfall and monthly average rainy days in the city of Davao as per Table B below.

Table B. Monthly Average Rainfall and Monthly Average Rainy Days in the City of Davao

Month	Davao City Poblacion		Tugbok	
	Rainfall	Rainy Days	Rainfall	Rainy Days
January	118 mm	10 days	121 mm	11 days
February	104 mm	9 days	107 mm	10 days
March	120 mm	9 days	114 mm	10 days
April	142 mm	10 days	257 mm	13 days
May	236 mm	15 days	281 mm	18 days
June	217 mm	15 days	250 mm	17 days
July	178 mm	13 days	225 mm	15 days
August	162 mm	12 days	220 mm	16 days
September	178 mm	12 days	248 mm	17 days
October	192 mm	13 days	229 mm	16 days
November	144 mm	11 days	202 mm	15 days
December	145 mm	11 days	230 mm	12 days
Total:	1,936 mm	140 days	2,484 mm	170 days

In the table we note that the rainfall in the city is somewhat smaller than the national average, but rain falls every month throughout the year in the city even if in slight amount and for a short time, and agriculture and forestry in and around the city are favorably influenced by this.

The city poblacion, where houses stand roof to roof, is generally speaking bad in environmental sanitation. The agricultural belt is excluded from this discussion because it is out of the huge area of the city.

Part of the roads is modern and kept clean, but the sewerage facilities on the whole are poor and ditches alongside roads are not sufficiently discharged, leaving some sections very dirty.

As to the lavatories, they are of privy type except a few which are flush equipped with storage tanks.

The Davao Metropolitan Waterworks System was founded in 1933. The water source is in Malagos, approximately 28 km to the north-west of the city poblacion.

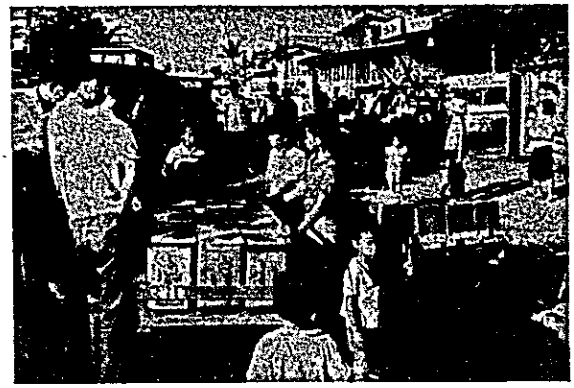
The place has an elevation of +370 m where there is a number of springs in a range of 350 ha. which are connected to the water intake through creeks. The water is conveyed to the city poblacion, after being settled in two basins of simple structure, through a pipeline 6" in diameter.

The amount of water supplied from this source is said to be 504,000 gal (1,900 m^3, approx.) per day. This being a very small volume, the Davao Metropolitan Waterworks Administration is supplementing the water supply by the help of five artesian wells drilled in the city area. Yet the total capacity of water supply by the Administration is so small as 3,000 m^3 (or less) per day. The area supplied with water covers only a part of the City poblacion, and water pressure in distribution pipelines is very low (0--0.4 kg/cm^2).

Speaking of the quality of water, the Malagos is supplying good water, but the water produced from the artesian wells in harder and higher in chlorine ion content than the standard. This water being mixed with the Malagos' before distributed to the consumers, the water from taps is unfit in quality for drinking, and the consumers are using it for washing and miscellaneous uses other than drinking purposes.

Since the public waterworks is so unreliable, most of the houses are equipped with water tanks, made of tin plates, which collect rain water from roofs for drinking uses and such big consumers of water as factories, hotels, offices, etc. are pumping up water from their own artesian wells. Some are buying water from peddlers who take the water from some wells which produce good water in a certain district of the city or from springs in the Barrio of Toril.

Water tank for collecting rain water



Site of bying water

In order to improve this situation, the Waterwprls Administration started implementing a new Sibulan River Project in 1958, with support from the NWSA. The work, however, is still under way and nobody knows when it will be completed.

The Davao Metropolitan Waterworks Administration has now recognized that an early solution of the water shortage is beyond the ability, both technically and financially, of the province as well as of the Philippine Government authorities.

The above are the circumstances under which the Province of Davao asked the Japanese Government to send Japanese engineers there for the survey and planning of the improvement and extension of the Davao Waterworks System so that their water problems can be solved as soon as possible.

2. Existing Facilities and the Sibulan Water System

According to data furnished by the Provincial authorities, the average amount of water supply per year as well as per day since 1960 is as follows:

Daily Average Amount of Supply: 684,000 gal
($2,590\ m^3$, approx.)

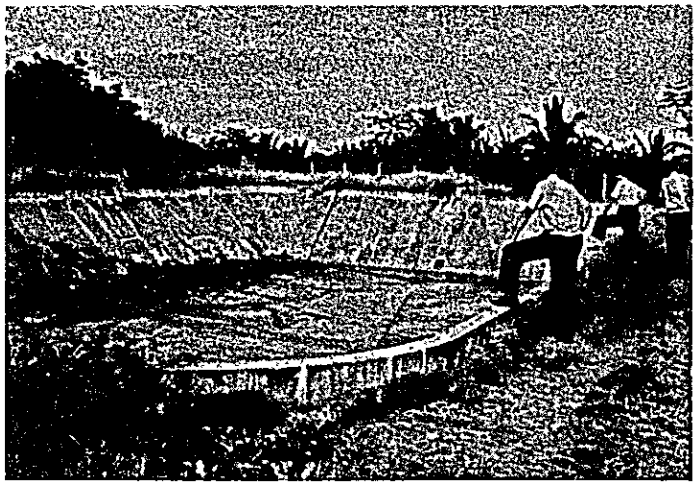
Yearly Average Amount of Supply: 159,660,000 gal
($605,000\ m^3$, approx.)

Such an amount is very small, so small that it cannot meet even one tenth of the estimated daily demand at present. Such insufficiency will become more acute when the use of well water that is not satisfactory in quality is terminated at the earliest possible occasion.

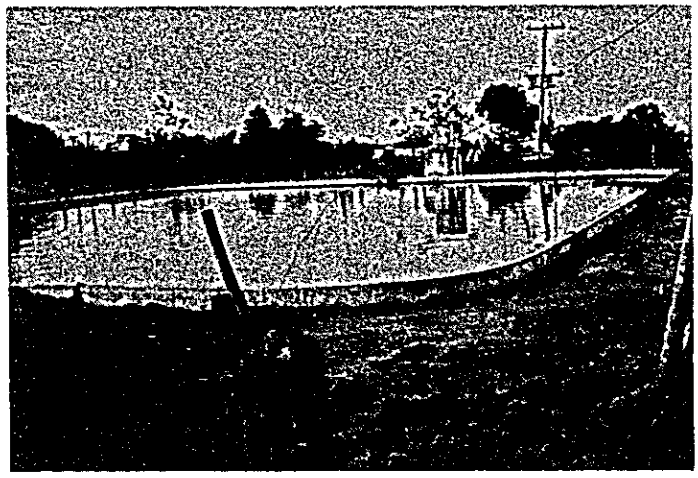
The Malagos source is said to have the capacity to supply 504,000 gal per day, but we note that the timeworn pipeline of 28 km length is reducing the original capacity to about 370,000 gal (about 1,400 m^3) per day. Though small in capacity, this source should be utilized in the future as well by providing additional purifying and sterilizing equipment in order to make the system complete.

Malagos Water Source from the Spring

Malagos Settling Basin



Matina Reservoir



Madapo Reservoir

The works that have been undertaken by NWSA are as outlined below:

* Water is taken from a dam 8 m in height located at a point about 12 km from the river mouth of the Sibulan River. The construction was completed in 1959, giving a water level of +415.00 m to the constructed dam. The minimum discharge at the intake is 55,000 gal. per minute (or 3.5 m^3 per second). This discharge and the quality of water discharged are both satisfactory as a water source.
* In Catalunan, located between the dam and the city poblacion, there was constructed in 1965 a sedimentation basin of 1,300,000 gal.

(4,900 m^3, approx.) which was connected to the pipeline from the Malagos source. This basin, however, has been left idle. The site has an elevation of about +85.00 m.

* A water conveyance pipeline was mapped out to cover the distance of 35.7 km from the Sibulan dam to the city poblacion passing through Catalunan with a diameter of 18", with the exception of a portion close to the poblacion which was 24" in diameter. Of the total length, about 19.7 km has not been implemented yet.
* Alongside the Talomo River near the Catalunan sedimentation basin there was installed a pumping station in 1962 with a pumping capacity of 1,000 gal per minute, which has been left idle.
* In Madapo in the north-west of the city and close to the poblacion, there is a reservoir of 350,000 gal in capacity. We are informed that another reservoir will be constructed close to the existing one, the planned capacity being 1,000,000 gal.

Equipped with the facilities explained above, the Sibulan Water System is expected to have the capacity as follows:

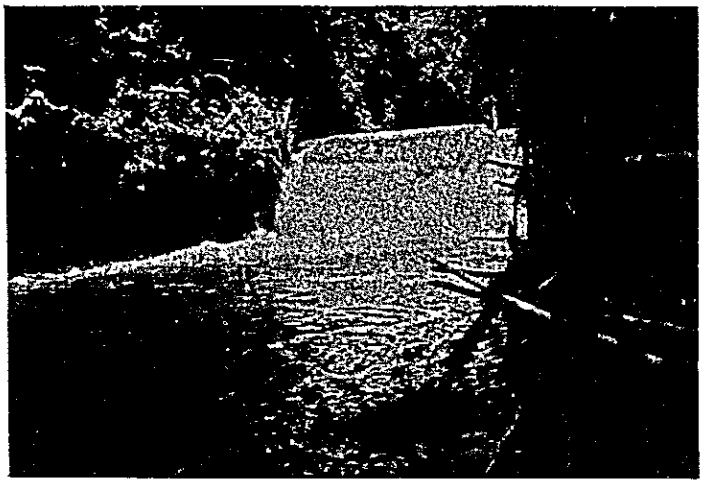
Water conveyance is planned to be 7,300 gal (27,600 m^3, approx.) per day maximum, while the actual conveying capacity of the pipeline is understood to be:

Sibulan to Catalunan: Daily maximum----26,000 m^3

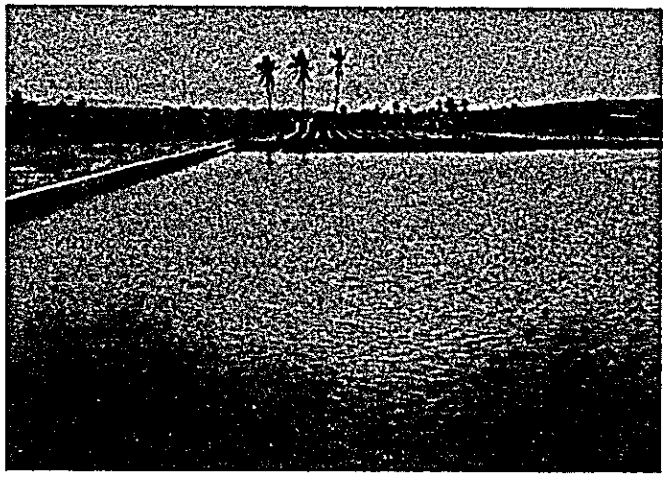
Catalunan to Madapo: Daily maximum ----24,000 m^3

So, a daily maximum of 25,400 m^3 may be sufficient as the capacity for the Catalunan treatment plant, expecting to receive water from the Malagos source as well. The Madapo reservoir capacity, after completion of the additional basin, will come to a total of 1,350,000 gal (5,100 m^3). This volume corresponds to about five hours' supply of the daily maximum and seems to be sufficient to apply to the hourly increase in the water demand. The planned H.W.L. (high water level) of the reservoirs is +39.00 m whereas

the elevation is about +5.00 m of the city distribution pipe net starting point that is located at the intersection of Tomas Claudio St. and Magallanes St. The diameter of distribution main pipe should therefore be 600 mm or larger to connect these two places, so that necessary water pressure can be secured.



Sibulan Dam, Water Source (8 m High)



Catalunan Settling Basin

3. Required Amount of Water Supply at Present and Target Date of Future Plan

The population of the city of Davao requiring a water supply at present is estimat ed at 120,000 or 80 % of the total population of 150,000 in the city poblacion, and the necessary amount of water seems to be about 30,000 m^3 maximum per day. From this, it will be noted that the daily supply of water is still

5,000 m^3 or more short even after completion of the Sibulan Water Project.

As to the target year of the basic plan to be mapped out on the basis of estimated future demand, it will be reasonable to set it at the year 1986 or twenty years later.

4. Area and Population to be Served, Amount of Water Supply

a. Area Served

The area of water service is planned to cover the following regions, based on the opinions of the City and Provincial authorities as well as on the survey we conducted.

(1) City poblacion and northern district on the left bank of Davao River up to Buhangin,

(2) Talomo and Matina including western district along the highway up to there,

(3) Sasa and airport area including north-eastern district along the highway up to there,

(4) Area along the pipeline from Malagos, including Calinan and Mintal.

b. Population Served

The population of the City of Davao in the past is approximately,

Year	Population , Approx
1948	111,263
1960	227,635

while the present population is estimated at,

1966	300,000.

From the above we note an average increase of about 10,000 per year. Under the circumstances, such a trend will continue in the future as well and based on the same rate as in the past an estimate of 500,000 persons as the population twenty years here after will not be too great

Assuming that the population in the planned water service area is 60 % of the total population of the city, the future population will be estimated as follows:

Year	Total Population of City	Population in Service Area
1971	350,000	210,000
1976	400,000	240,000
1981	450,000	270,000
1986	500,000	300,000

Of the population to be served as above, we estimate in our plan that about 80 % is supplied with water from the public waterworks system.

c. Amount of Water Supply

In the plan, we are taking the following figures as the maximum supply per head per day for coming years:

During the 5 years from 1967 to 1971: 250 lit

During the 15 years from 1972 to 1986: 251--265 lit
(Yearly increase of 1 lit)

The following values will then be arrived at:

Year	Population Served	Max Supply/Head/Day	Max Supply/Day
1971	168,000	250 lit	42,000 m^3
1976	192,000	255 lit	48,960 m^3
1981	216,000	260 lit	56,160 m^3
1986	240,000	265 lit	63,600 m^3

From the above table, it will be understood that in the year 1971, or five years later, the water supply will still be insufficient even after the completion of the Sibulan Water Project:

$$42,000\ m^3 - 25,400\ m^3 = \underline{\underline{16,600\ m^3 \text{ per day}}}$$

Since such is the situation of the water supply in the city of Davao, the Water Administration will continue to suffer from the water problems unless suitable measures are taken at the earliest moment possible.

5. Adequate Plan for the Future

a. Early Completion of Sibulan Water Project

It is about seven years since the dam in Sibulan River was constructed, and yet the completion of the system under the Project is still kept pending. Every possible effort should be made by all persons concerned for completing the entire project as soon as possible, so that the citizens can be relieved from the shortage of water.

b. Means to Supplement Water Supply

(1) It is not advisable to plan an expansion to the Sibulan Project which is now under way.

(2) A study was made by us to draw water from highlands around the city utilizing the force of gravity, but the implementation of such a plan will necessitate water to be conveyed from sources very for from the city in view of the geographical features of the province. This means difficulty in getting sufficient volume of water, difficulties in the construction work, and infeasibility of future improvement and expansion, so this plan is not recommendable either.

(3) Use of surface water near city poblacion:

Where there is arive, with plenty of discharge, close to the water supply area, it is natural that a study of utilizing the same should be made.

It is true that the use of surface water of a river that flows on low land requires the water to be pumped up for treatment, incurring thereby considerable expenses for motive power for pumping. It, however, will not be wise to refrain from utilizing such water only because of the motive power expenses, when we look at many cities and towns in the world that are enjoying sound administration of water enterprises by pumping up river water for their water supply.

For t he Davao Metropolitan Waterworks System, there is the Davao River in the city area, and we think that this river is most suitable as a new water source for the extension plan in the light of key items such as discharge of

river and quality of water as well as construction and maintenance charges of the water system. The discharge of Davao River is, according to a report prepared by the National Irrigation Administration, 40 m^3 per second, minimum, during the dry season, which is about 80 times the waterworks demand.

6. Davao River Water System

a. Location of Water Intake and Water Treatment Plant

In mapping out the plan, it should be kept in mind to set the sites of water intake and treatment plant as close to the water supply districts as possible. It is also required that both of the sites be appropriate in both elevation and area.

In the Davao River Water Plan, the site of intake has been chosen at a point about 12 km from the river mouth, near Lapanday, being connected with a plateau that has been chosen to be used as the site of treatment plant. The river snakes down on a slowgrade, so floods, which take place occasionally, sometimes alter the center line of the river at some places. However, the place selected as the site of intake may be free from such alterations.

The quality of the water of the river was analyzed by us, the result being shown in Table C. We see no troubling components and factors for taking the water for the system. The water would become turbid to a considerable degree during the rainy season, but this turbidity could be eliminated without difficulty by chemical sedimentation equipment which is to be installed in the water treatment plant.

Table C. Water Quality of Davao River at Intake Point

(Date of Inspection: Apr 23'66)

Water Temperature:	28° C
Color:	0
Turbidity:	5--10
Odor:	0
pH:	7.4
Alkalinity:	125

Ammonia:	Negative
Nitrous Acid:	Negative
Nitric Acid:	Negative
Chlorine Ion:	31.25
Sulfate Ion:	Negative
Hardness:	150^{o}

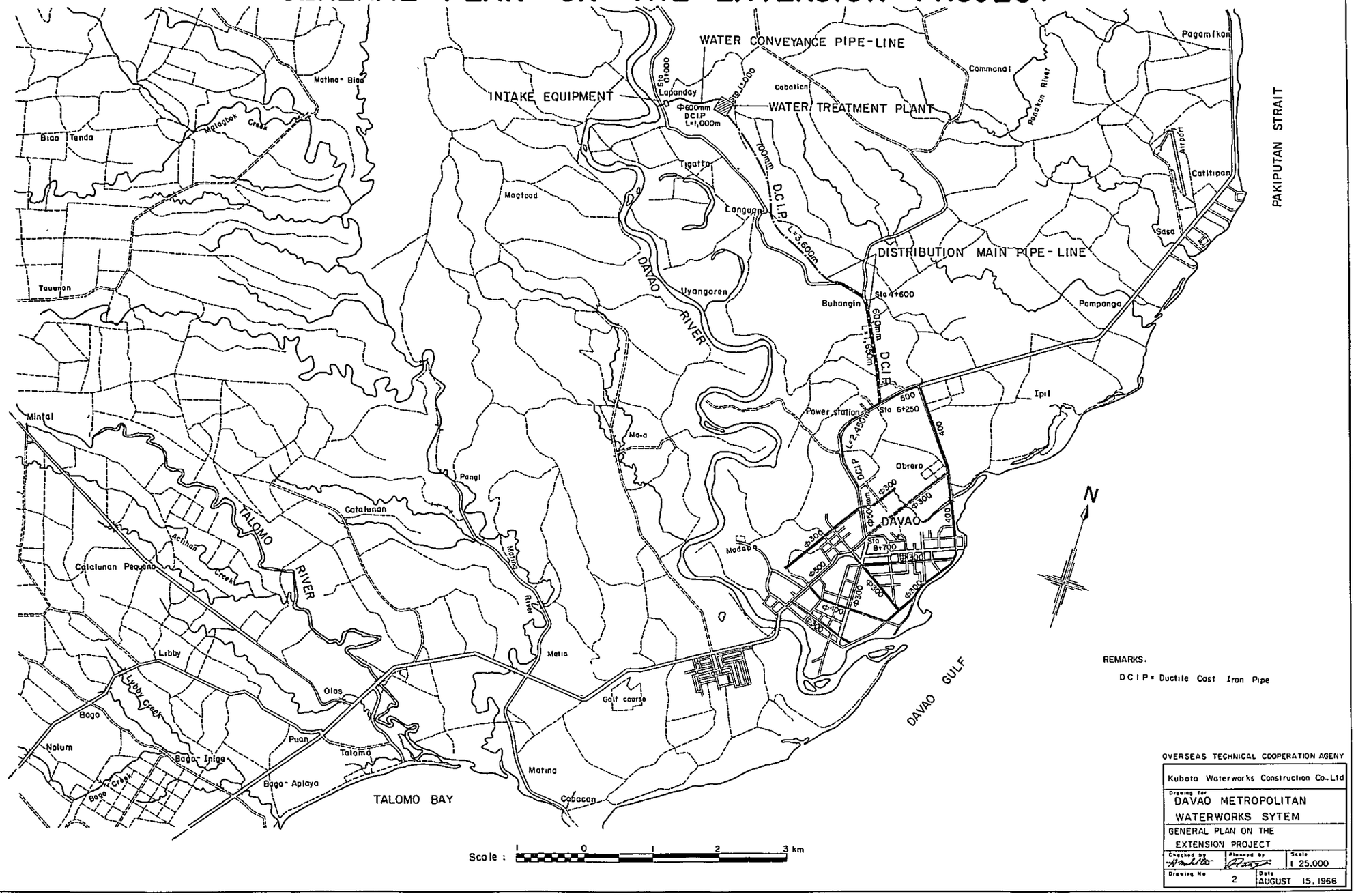
The plateau on which the water treatment plant is planned to be built is +80.00 m in height and about 1,000 m to the east of the water intake. The place is not much undulated and the soil seems to be suitable for the purpose. From there it is about 4,600 m to Buhangin and about 6,250 m to the Davao-Agusan National Road, which means the location of the plant will be close enough to the future water supply districts. To make the circumstances more suitable, there is a road running northward from Buhangin to the east of the plant site, affording facilities for transporting necessary materials and equipment to the site.

Proposed IN-Take point of Davao River (The picture is taken from upper stream)

Proposed area for Water Treatment Plant

FIG. 1

GENERAL PLAN ON THE EXTENSION PROJECT



OVERSEAS TECHNICAL COOPERATION AGENY

Kubota Waterworks Construction Co.,Ltd		
Drawing for: DAVAO METROPOLITAN WATERWORKS SYTEM		
GENERAL PLAN ON THE EXTENSION PROJECT		
Checked by	Planned by	Scale: 1 25,000
Drawing No: 2		Date: AUGUST 15, 1966

b. Water Intake Equipment and Water Coveyance Pipeline

The lowest water level of the Davao River at the intake point is about +15.50 m, and the maximum amount of water intake per day, that is, approximately 105 % of the daily maximum amount of water supply, will be:

$$38{,}000\ m^3 \times 1.05 = 40{,}000\ m^3$$

(1) Water intake

The intake, 1.50 m x 1.50 m, shall be made of reinforced concrete, and its inlet rate shall be 0.32 m per second maximum.

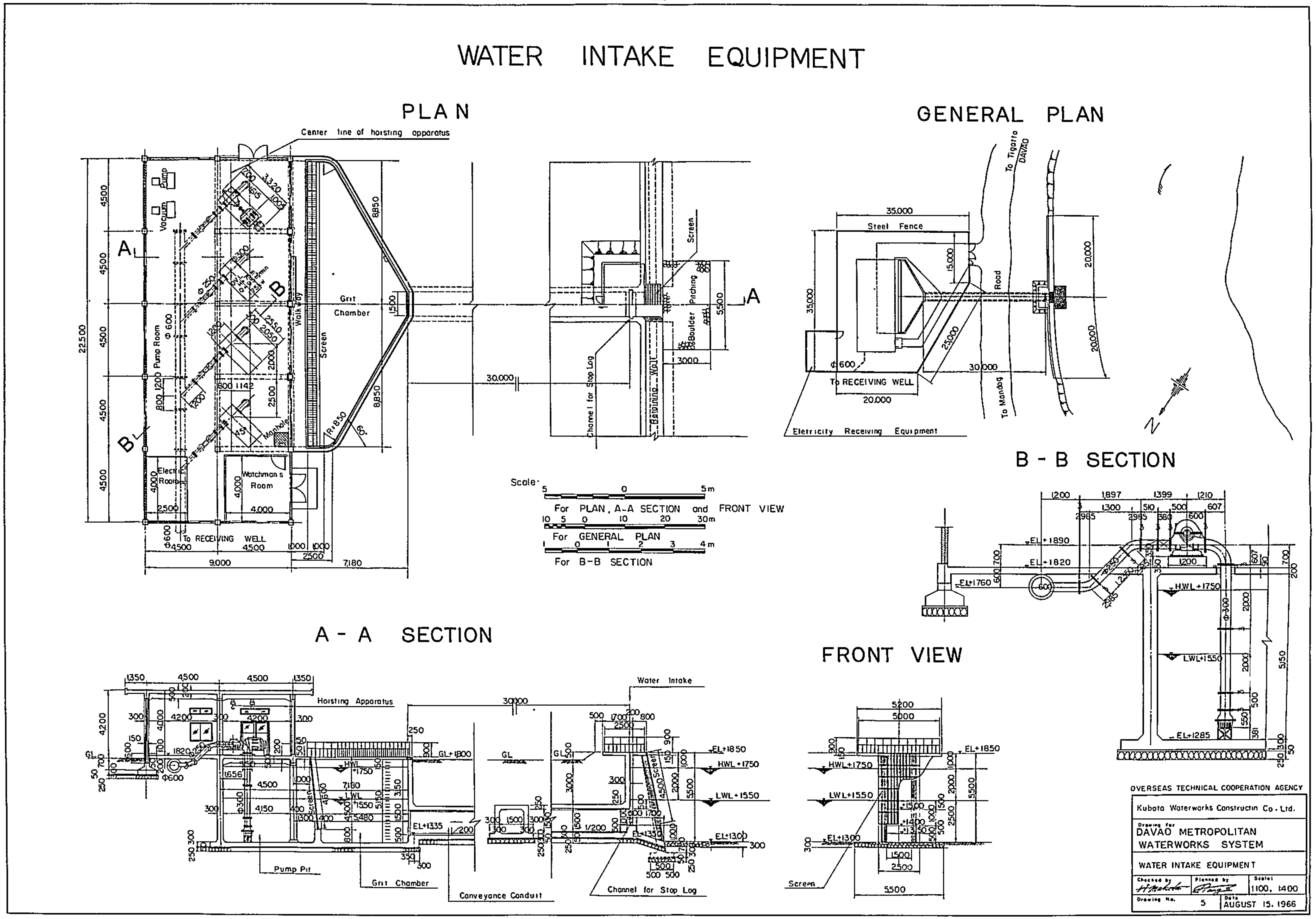
(2) Intake pump

Four (4) sets of intake pumps, including one spare, of 300 mm, shall be installed in a pump chamber made of reinforced concrete. The capacity of each pump shall be 9.5 m^3 per minute, with 75 m head.

(3) Water conveyance pipeline

The pipeline which should be installed over the distance of approximately 1,000 m from the intake pump chamber up to the receiving well in the treatment plant, shall be of ductile iron pipe 600 mm in diameter.

FIG. 2


WATER INTAKE EQUIPMENT
PLAN
Center line of hoisting apparatus
Pump Room
Grit Chamber
Screen
Walk Way
Manhole
Electric Room
Watchman's Room
To RECEIVING WELL
Channel for Stop Log
Beginning Wall
Boulder Pitching
Screen
GENERAL PLAN
To Tigatto DAVAO
Steel Fence
Road
To RECEIVING WELL
To Mandog
Electricity Receiving Equipment
B - B SECTION
Scale
For PLAN, A-A SECTION and FRONT VIEW
For GENERAL PLAN
For B-B SECTION
A - A SECTION
Hoisting Apparatus
Water Intake
Pump Pit
Grit Chamber
Conveyance Conduit
Channel for Stop Log
FRONT VIEW
Screen
OVERSEAS TECHNICAL COOPERATION AGENCY
Kubota Waterworks Construction Co. Ltd.
DAVAO METROPOLITAN WATERWORKS SYSTEM
WATER INTAKE EQUIPMENT
Scale 1:100, 1:400
Drawing No. 5
Date AUGUST 15. 1966

c. Water Treatment Equipment

Modern equipment which is easy to operate and maintain shall be installed in the water treatment plant.

(1) Receiving well

HWL:	+79.00 m
Retention Period:	2 min, approx.

(2) Chemical mixing basin

Mixing Period:	3 min, approx.
Apparatus:	Equipped with rapid mixing equip.
Capacity & Number:	90 m^3, approx., 1 (one)

(3) Flocculation basins

Horizontally-circulating type, easy to maintation.

Average Velocity of Flow:	15 cm/sec, approx.
Retention Period:	30 min, approx.
Capacity & Number:	450 m^3, 2 (two) Total: 900 m^3

(4) Chemical sedimentation basins

Average Settling Period:	3 hrs, approx.
Average Velocity of Flow:	35 cm/min, approx.
Capacity & Number:	2,500 m^3, 2 (two) Total: 5,000 m^3

(5) Chemical feeding equipment

Feeding Rate:	Aluminum sulfate	50 ppm, max.
	Soda ash	25 ppm, max.

(6) Rapid filtration basins

Normal Rate of Filtration:	120 m/day
Filtration Area/Basin:	67 m^2, approx.
Normal Filtration Capacity/Basin:	8,000 m^3/day
Number of Basins:	6, incl. 1 as spare

(7) Elevated Storage Tank for Back-Washing Water for Filtration Basins

LWL:	+89.80 m
Effective Depth:	3.50 m
Capacity:	500 m^3
Type:	Cylindrical shape, 14 m in inside diameter
Number of Tanks:	1

(8) Chlorinators

Chlorine Feeding Rate:	2.5 ppm, max.
Capacity & Number:	3 kg/hr, each 3(Three), incl. 1(One) as spare

(9) Chemical feeding and storing building

Built of reinforced concrete, one storied.

Chemical Feeding Chamber: 81 m^2

Chemical Storing Chamber: 81 m^2

(10) Administration building

Built of reinforced concrete, two storeys above ground, some of underground portion to be used for filtered water tank.

Floor Area:	1st floor	288 m^2 (for chlorinators and electric machinery)
	2nd floor	288 m^2 (office and laboratory)

(11) Distribution reservoir

Capacity shall correspond to approx. six (6) hours' proportion of daily maximum amount of supply.

HWL:	+73.50 m
LWL:	+70.00 m

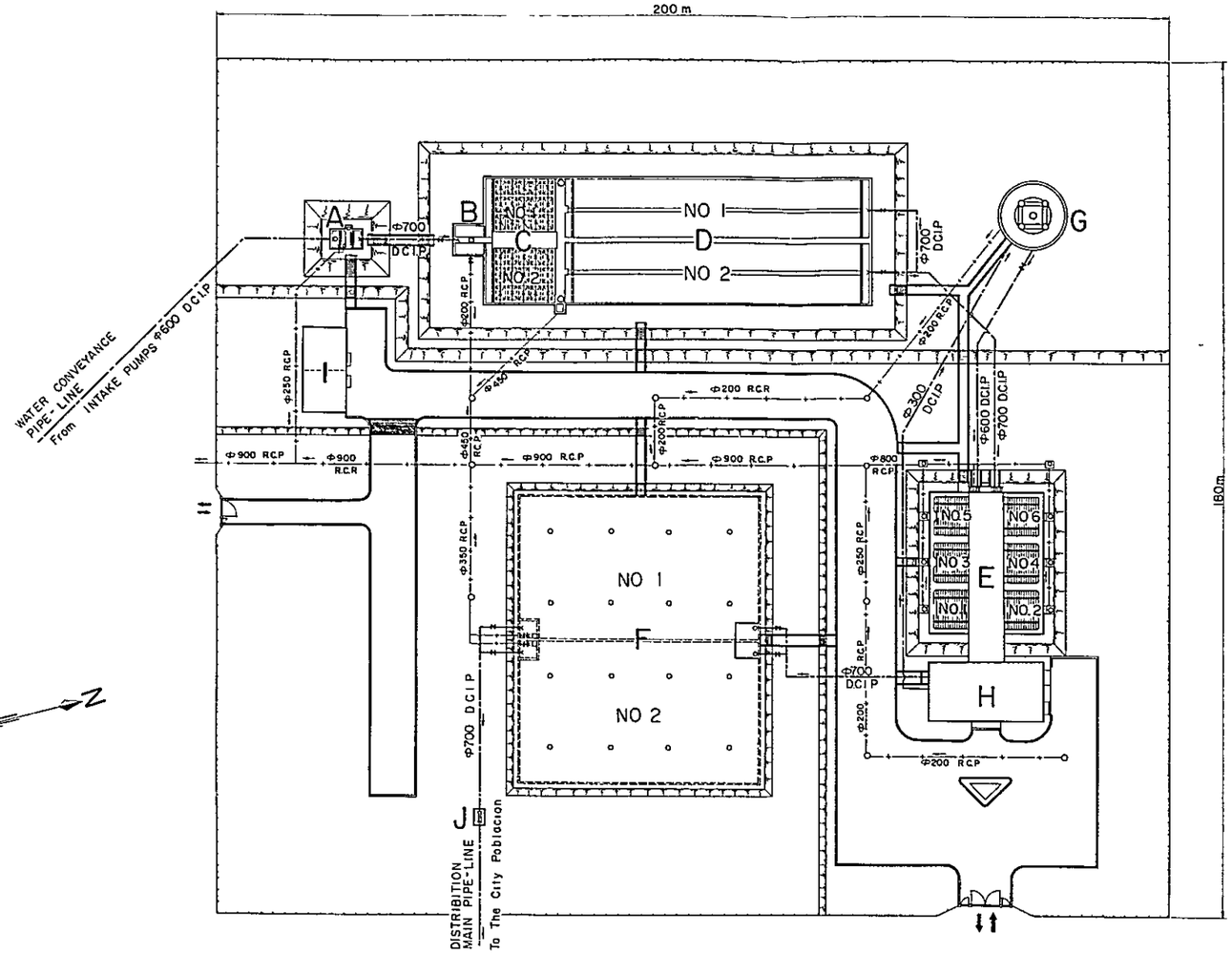
Effective Storage & Number of Reservoir:

5,000 m^3, 2 (two) Total: 10,000 m^3

FIG.3

PLAN OF WATER TREATMENT PLANT

Scale 20 10 0 10 20 30 40 50m



A RECEIVING WELL
B CHEMICAL MIXING BASIN
C FLOCCULATION BASIN
D CHEMICAL SEDIMENTATION BASIN
E RAPID FILTRATION BASIN
F DISTRIBUTION RESERVOIR
G ELEVATED STORAGE TANK
H OFFICE BUILDING
I CHEMICALS FEEDING AND STORING BUILDING
J VENTURI-METER

REMARKS

——— Connection Pipe
——+—— Drain Pipe
DCIP Ductile Cast Iron Pipe
RCP Reinforced Concrete Pipe
——— Steel Fence

OVERSEAS TECHNICAL COOPERATION AGENCY

Kubota Waterworks Construction Co.,Ltd

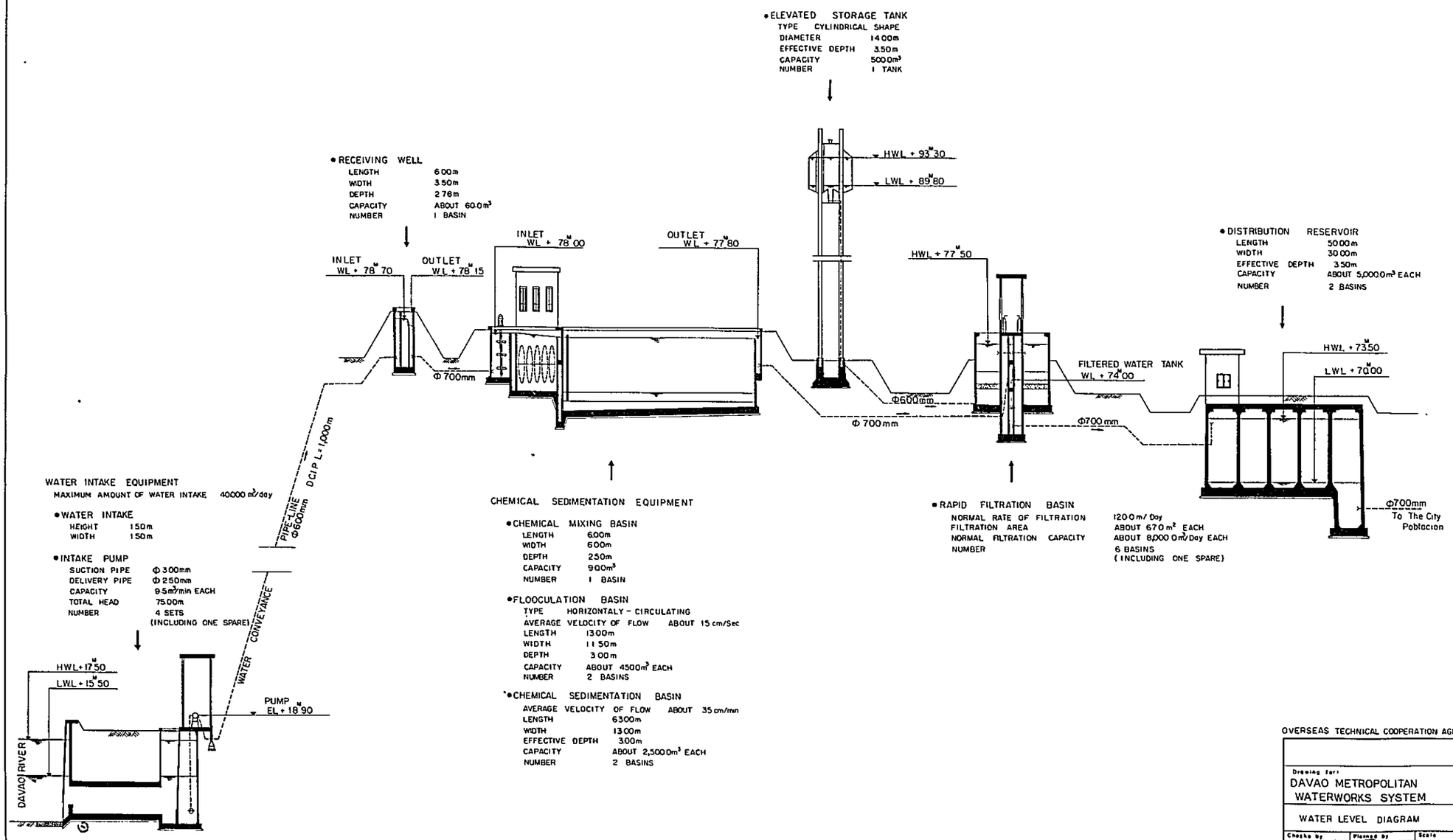
Drawing for
DAVAO METROPOLITAN WATERWORKS SYSTEM

PLAN OF WETER TREATMENT PLAN

Checked by:	Planned by:	Scale
		1 500
Drawing No 7	Dated: AUGUST 15, 1966	

FIG.4

WATER LEVEL DIAGRAM



OVERSEAS TECHNICAL COOPERATION AGENCY

Drawing for:
DAVAO METROPOLITAN WATERWORKS SYSTEM

WATER LEVEL DIAGRAM

Checke by	Planed by	Scale
		NONE
Drawing No 4		Date: AUGUST 15 1966

d. Water Distribution Pipeline

An exact plan of distribution pipelines could not be mapped out at this time due to the fact that reliable data were not available regarding future expansion of population by districts, rates of increase of demand for water, and others, yet we have made up a water distribution plan on the basis of our observation of the future water supply area in addition to advice given by the provincial and city authorities, the plan being as follows:

The distribution main pipeline starts from the distribution reservoir, with a diameter of 700 mm in the beginning and becoming smaller, down to 300 mm as the pipeline extends nearer to the city poblacion, as shown in one of the attached drawings.

In case the Davao River Water Project is carried out to draw water from the north of the city poblacion, the current distribution pipe net plan will have to be modified or altered since it is only based on the Sibulan Water Project.

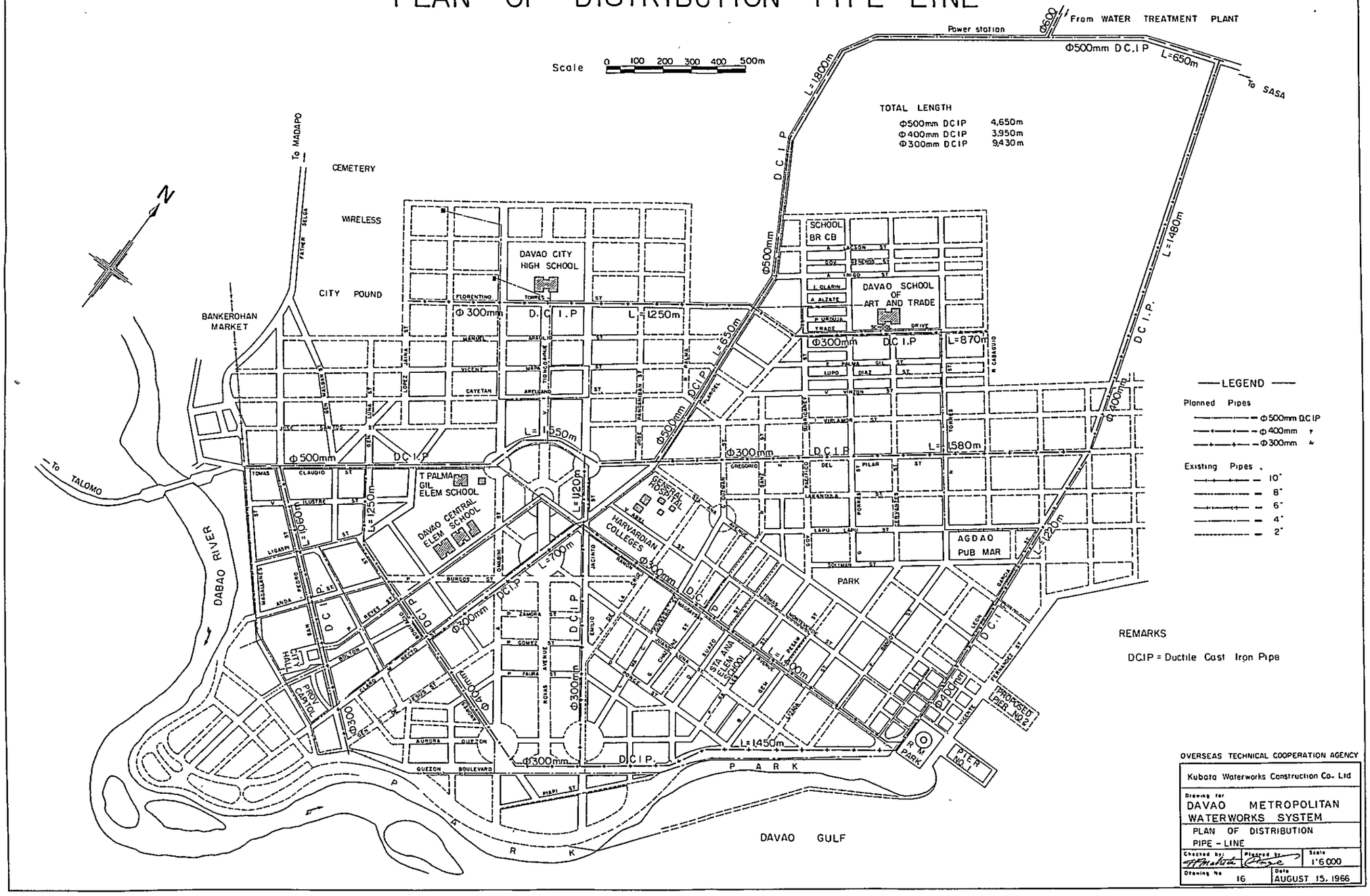
Regarding the laying of smaller pipes under 250 mm that will be employed for water service in consuming districts, it is advisable that the City authorities map out the plan separately by keeping step with the developing situation in these areas in the future.

The pipelines of 700 mm to 300 mm in diameter have the following extensions, as shown in the drawing:

700 mm	3,600 m
600 mm	1,650 m
500 mm	4,650 m
400 mm	3,950 m
300 mm	9,430 m
Total:	23,280 m

FIG. 5

PLAN OF DISTRIBUTION PIPE-LINE



7. Construction Expenses

ESTIMATE

OF

CONSTRUCTION COST

		Materials and Equipment to be Supplied from Japan (CIF Davao)	Local Construction Cost	Total
I.	Water Intake Work	US$ 179,690.-	US$ 41,780.-	US$ 221,470.-
1.	Water intake	45,730.-	14,600.-	60,330.-
2.	Intake pump	101,400.-	1,960.-	103,360.-
3.	Intake pump chamber	32,560.-	25,220.-	57,780.-
II.	Water Conveyance Pipeline	US$ 60,500.-	US$ 9,310.-	US$ 69,810.-
III.	Water Treatment Plant	US$ 724,820.-	US$ 558,160.-	US$1,282,980.-
1.	Receiving well	5,470.-	3,050.-	8,520.-
2.	Chemical feeding equipment	15,950.-	320.-	16,270.-
3.	Chemical sedimentation basin	116,930.-	92,290.-	209,220.-
4.	Rapid filtration basin	263,400.-	74,290.-	337,690.-
5.	Elevated storage tank	74,870.-	17,550.-	92,420.-
6.	Chlorinator	17,420.-	420.-	17,840.-
7.	Connecting pipe in the Plant	55,235.-	49,060.-	104,295.-
8.	Office building	26,150.-	65,880.-	92,030.-
9.	Chemical feeding & storing building	7,220.-	9,920.-	17,140.-
10.	Grading of ground	8,640.-	41,170.-	49,810.-
11.	Distribution reservoir	133,535.-	204,210.-	337,745.-
IV.	Water Distribution Pipeline	US$ 904,130.-	US$ 317,100.-	US$1,221,230.-
V.	Electric Equipment	US$ 166,100.-	US$ 12,030.-	US$ 178,130.-
VI.	Provisional Work	-	US$ 20,440.-	US$ 20,440.-
VII.	Construction Machinery & Tools	US$ 675,760.-	-	US$ 675,760.-
VIII.	Inland Transportation (Wharf-Stockyards)	-	US$ 64,180.-	US$ 64,180.-
	Sub-Total	US$2,711,000.-	US$1,023,000.-	US$3,734,000.-
IX.	Engineering Fee	US$ 196,000.-	-	US$ 196,000.-
	TOTAL:-	US$2,907,000.-	US$1,023,000.-	US$3,930,000.-

8. Problems re Waterworks Administration

a. Water Rate and Income

According to the Davao Metropolitan Waterworks Office, the following is the condition of water service at present:

Number of Service Taps: 3.500

Water Rate: Minimum/Month/10 m^3: --------₱2.00

Excess charge above 10 m^3:---- ₱0.20/m^3

Bill collection is effected every 3 months.

Yearly water income in the past five years is shown in the following table in which we see a remarkable decrease in the fiscal 1963--64 year, which is due to a great fire taken place in the City that year, and this downtrend is still continuing:

Fiscal Year	Water Income
1960--1961	₱130,000
1961--1962	₱130,000
1962--1963	₱125,000
1963--1964	₱ 97,157
1964--1965	₱ 80,315
Average	₱112,500

It is reported that the yearly average of water supply amount during these five years was 159,660,000 gal (605,600 m^3).

From these figures, the efficiency of collection of the water rate will be arrived at 93 % on the assumption that the average rate of water is ₱0.20 per m^3, which may be said to be rather high. It is also noted that in the year of 1964--65 when the yearly income was derived from 3,500 taps, one tap paid ₱1,92 per month, which is very close to the minimum rate of ₱2.00.

From the above we understand that probably most of the consumers were charged at the minimum rate irrespective as to whether they were supplied with water satisfactorily or not.

Insufficient volume of water supply, together with imperfectness in the

controlling the meters, causes the amount of annual income to be rather small for the Waterworks Administration, which makes it impossible for them to spare enough money for repair and improvement of the facilities after paying personnel expenses and power charges. In the future when the Davao River Water Plan as well as the Sibulan Water Project is implemented, the Administration will be able to anticipate a remarkable increase in the water supply and, subsequently, in the water income. On the other hand, however, they should be prepared for a rise of expenditures such as costs necessary for maintenance and administration of the waterworks system and also amortization of construction cost together with payment of the interest.

Under the circumstances, the waterworks authorities will have to pay attention to the following points so that sound management can be realized on the basis of well balanced income and outgo schedule:

(1) Complete metering system and good control of water meters- - - these are indispensable for improvement of income.

(2) Prevention of loss of water - - - more care should be taken in countermeasures against water leakage since leakage accidents will be more likely to take place with increasing water pressure, and the pressure in the new distribution pipelines will naturally be higher than at present.

Better management of water service apparatus is also necessary.

(3) Re-study of the current water rate system - - - it will be more effective, for instance, to collect higher rates against excess of the minimum while the minimum charge is left at low level, and to charge higher rates to big consumers who have larger paying capacity, such as theaters, restaurants, hotels , offices, factories, etc.

b. Water for Fire-Fighting

Reportedly there are 44 fire hydrants and 17 fire trucks in the city while 1,224 fires have broken out during the 9 years since 1958, resulting in the yearly average of 138 fires in this period. Of these, the big fire in 1964, which

has been referred to previously in this report, caused the administration great damage, amounting to ₱64,347,000.

Most of the city's fire trucks are excellent in quality, being equipped with a discharge capacity of 500 gal per minute. However, these trucks are unable to bring their efficiency into full play in case of fighting an actual fire under a situation where the larger part of the fire hydrants are not necessarily kept in good order and in addition the volume of water is insufficient. As a matter of fact, the trucks can serve to fight only at the beginning of the burning by charging their tanks with water.

Judging from this situation, it must be said that the most urgent task of the Waterworks Administration is to secure sufficient volume and pressure of water and to equip well working fire hydrants, which should better be larger in diameter, 6" or larger.

c. Control of Water Quality

The water from the Malogos may be sterilized with chlorination equipment installed by the settling basin of the Malogos water source, but it is advisable to have the water chlorinated at a point as close to the water service area as possible in view of the fact that the effect of disinfection will be decreased with increasing distance between the sterilization plant and the city poblaction.

As for the artesian wells, it is not advisable to continue using their water in the future. But in cases where it is considered inevitable to supplement the water supply with this water, proper care should be taken that the water is fed with chemicals in an adequate manner in view of the fact that well water is usually exposed to menace of disease germs if sewerage and lavatory systems are incomplete. Our suggestion is to feed chemicals directly into the pipe at the outlet of the pump or into an elevated tank unit which will be provided near the well to collect the water pumped up into it.

Regarding the water from the Sibulan, it is recommended that

chlorination be effected at Cabulunan and that a chlorinator be installed at the Madapo reservoir in order to reinforce the residual chlorine before the water is distributed to consumers.

9. Closing Remarks

Arriving at Davao on April 17 and leaving there on May 2, we, the survey team engaged in a site survey, collection of necessary data, etc. Although the period of our stay and investigations was as short as 15 days, we believe that we have been able to make up a plan most suitable for the Davao Metropolitan Waterworks System.

In the previous sections we have reported on a basic plan for the improvement and extension of the System. In your implementing of the plan in the future, it is needless to say that final structures, specifications, methods of execution, and others should be fixed after carrying out more detailed on-the-spot surveying and measuring.

In closing this report, we wish to convey our sincere appreciation to those concerned in Davao of their kind cooperations and assistance to us. Above all, our gratitude is expressed to the Hon. Mr. Duterte, the former governor and now the Secretary of General Affairs, and to Mr. Franco, the Waterworks Superintendent, to whose thoughtful directions and collaboration we owed very much and by which we were impressed so deeply.