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REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF HOUSING BUILDING
PLANNING AND URBAN DEVELOPMENT (CIPTA KARYA)

MEDAN URBAN DEVELOPMENT, HOUSING, WATER SUPPLY AND SANITATION PROJECT

80p.

TECHNICAL MEMORANDUM NO. 18

PRESENT WATER SUPPLY AND SANITATION SYSTEMS

This is a draft of Sections 1 and 2 of the Master Plan Report for Water Supply and Sanitation

OCTOBER 1979

ENGINEERING - SCIENCE, INC. • SINOTECH ENGINEERING CONSULTANTS, INC
A JOINT VENTURE
in association with
PADCO and P.T. DACREA

MEDAN URBAN DEVELOPMENT, HOUSING, WATER SUPPLY AND SANITATION PROJECT

Jln. Singamangaraja 1-3, P.O. Box 28, Phone 20716, Medan-Sumatra, Indonesia

Our ref: 79/1171/MUDS/313

6 October 1979

Director General Cipta Karya
Ministry of Public Works
Jalan Pattimura 20
Kebayoran Baru
Jakarta Selatan

Subject: Technical Memorandum No. 18, Present Water Supply and Sanitation Systems

Dear Sir:

Attached are 20 copies of the subject Technical Memorandum for your information and review. The material contained in this memorandum updates the information on existing systems contained in Technical Memorandums 4, 5, 7, 12, and 16 and constitutes submission of Sections 1 and 2 of the draft Master Plan for Water Supply and Sanitation Report.

Yours faithfully,

ENGINEERING SCIENCE INC. MEDAN URBAN PROJECT INDONESIA

John M. McGill
Project Representative

C.C.: Ir. Ruslan Diwiryo, Director of City & Regional Planning
Ir. Susanto Mertodiningrat, Director of Sanitary Engineering
Ir. Sunaryo, Head Sub-Directorate Town Planning
Ir. K. Pohan, Project Manager, MUDS
AID - Jakarta, attn. P. Thorn, Project Officer
ES - Arcadia
SINOTECH - Taipei
DACREA - Jakarta

JM/1

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*	15	Organization and Finance

* Not yet submitted.

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1.	Preliminary Site Selection Criteria for Perumnas Medan III, SSCH/LCH Project	March, 1979
2.	Work Plan for Water Supply and Sanitation Master Plans and Feasibility Studies	April, 1979
3.	Policy Issues for Project Guidance	March, 1979
4.	Drainage - Principal Rivers and Rainfall Analysis	May, 1979
5.	Preliminary Evaluation of Sunggal Water Treatment Plant	May, 1979
6.	Public Health Considerations	July, 1979
7.	The Present Drainage System	August, 1979
8.	Recommended Drilling Program	August, 1979
9.	Medan Household Income/Expenditures	August, 1979
10.	Existing Land Use in Medan	August, 1979
11.	The Regional Functions of Medan	August, 1979
12.	Existing Solid Wastes Systems and Projected Solid Wastes Characteristics	August, 1979
13.	Evaluation of Medan Master Plan	August, 1979
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SECTION 1

INTRODUCTION

1.1 AUTHORIZATION

On 12 October 1978, an agreement was signed by the Government of Indonesia, Ministry of Public Works, Directorate General of Housing Building Planning, and Engineering Science, Inc., for consulting services in connection with the Medan Urban Development Housing, Water Supply, and Sanitation Project. The project was financed under the terms of a loan of the Government of Indonesia from the United States of America Agency for International Development (AID loan no.497-T-040, dated 28 July 1976). Engineering Science, Inc. and Sinotech Consultants, Inc. a joint venture, carried out the work in association with Planning and Development Collaborative International and P.T. Dacrea. Additional architectural expertise was provided to the project from P.T. Perencana Jaya through subcontractual arrangement with P.T. Dacrea.

1.2 OBJECTIVES OF THE PROJECT

The long range objective of the Project is to assist the Government of Indonesia in directing the long term urban development of Medan, particularly with regard to (1) the construction of new, and improvement of existing, urban settlements within the contexts of the governments kampung improvement (KIP), sites and services and core housing (SSCH), and Low Cost Housing (LCH) programs, and (2) improvement and expansion of water supply, sewerage, drainage, and solid waste disposal systems.

The immediate objective of the Project is to assist the Government in the preparation of a Long-term Urban Development Plan for Medan up to the year 2000 and to assist the government in preparing a Feasibility Study for a First Stage Housing Development Project which will permit appropriate investment decisions.

The housing development Feasibility Study is aimed at assisting the Government, as part of the Long-Term Urban Development Plan, to formulate a well defined first stage housing development project which will be ready for investment decisions. The first stage housing project will be designed to achieve an optimum balance between the City's short term

needs on the one hand, and resources, local capability and socio-economic aspects on the other with due consideration of financial and economic benefits.

Develop, as part of the overall urban development program for the City of Medan, long-range Master Plans through the year 2000 for water supply, wastewater, drainage and solid waste systems which will provide assistance in management, operation, and financing those systems.

A major objective is to prepare Feasibility Studies for the first stage development of the Master Plan which will include economic and technical evaluations of projects suitable and complete enough in detail to enable a consultant to proceed directly into final design and thereby allow the Government to obtain construction financing from an international or bilateral lending agency such as the World Bank, the Asian Development Bank, or AID.

1.3 SCOPE OF WORK

The scope of work is divided into five major components as follows:

1. Preparation of a long term urban development plan;
2. Preparation of a feasibility study for housing development projects including a Kampung Improvement Programme and a Sites and Services and Low Cost Housing Scheme.
3. Develop long-range Master Plans for water supply, wastewater, drainage and solid wastes systems in the study area through the year 2000.
4. Prepare First Stage Feasibility Studies for water supply, wastewater, drainage and solid wastes systems to meet needs through the year 1990.
5. Carry out detailed engineering for the first stage Sites and Services Scheme and the Low Cost Housing Scheme.

In addition, In-Service Professional Training Programs shall be conducted.

1.4 THE STUDY AREA

1.4.1 Description

Medan is located on the coastal plain of North Sumatra between the coast of Malacca Straits and a range of volcanic mountains which run roughly north-west to south-east throughout the island of Sumatra. Geographic proximity to the major neighbouring cities such as Kuala Lumpur and Singapore gives the city an international character in terms of trading business (see Figure 1.1).

Medan and Belawan port are the hub for an entire region which extends beyond the provincial boundaries of North Sumatra to include Aceh, Riau and parts of West Sumatra (see Figure 1.2).

A great portion of the influence over such a vast area is attributable to Belawan port, the third largest port of the country, and the presence of an international airport. Medan has grown to become the center of the region in terms of international trading, finance, business, employment opportunity, higher education and industrial development, as well as being the processing and distribution center for products of the surrounding agricultural areas.

The city has a population of approximately 1.2 million people and is the fourth largest city in the country. The total land area of the city is 26,500 hectares divided into eleven political districts called Kecamatans. Geographically, the urban form of the whole city area is rather irregular. Urban development is mainly around the central area of Medan. Except in the oldest portions of the city, housing is primarily single storey and of relatively low density. In the oldest portions of the city, densities are much higher, consisting largely of three or four storey walk-up flats, with shops and business located on the ground floor. Growth trends are visible outside the city boundaries with village development parallelling the banks of rivers. Rivers and railroads contain a small amount of high density informal housing for very low income groups. The rest of the city's area is made up of agricultural land including tobacco and coconut plantations, rice paddie and swamp.

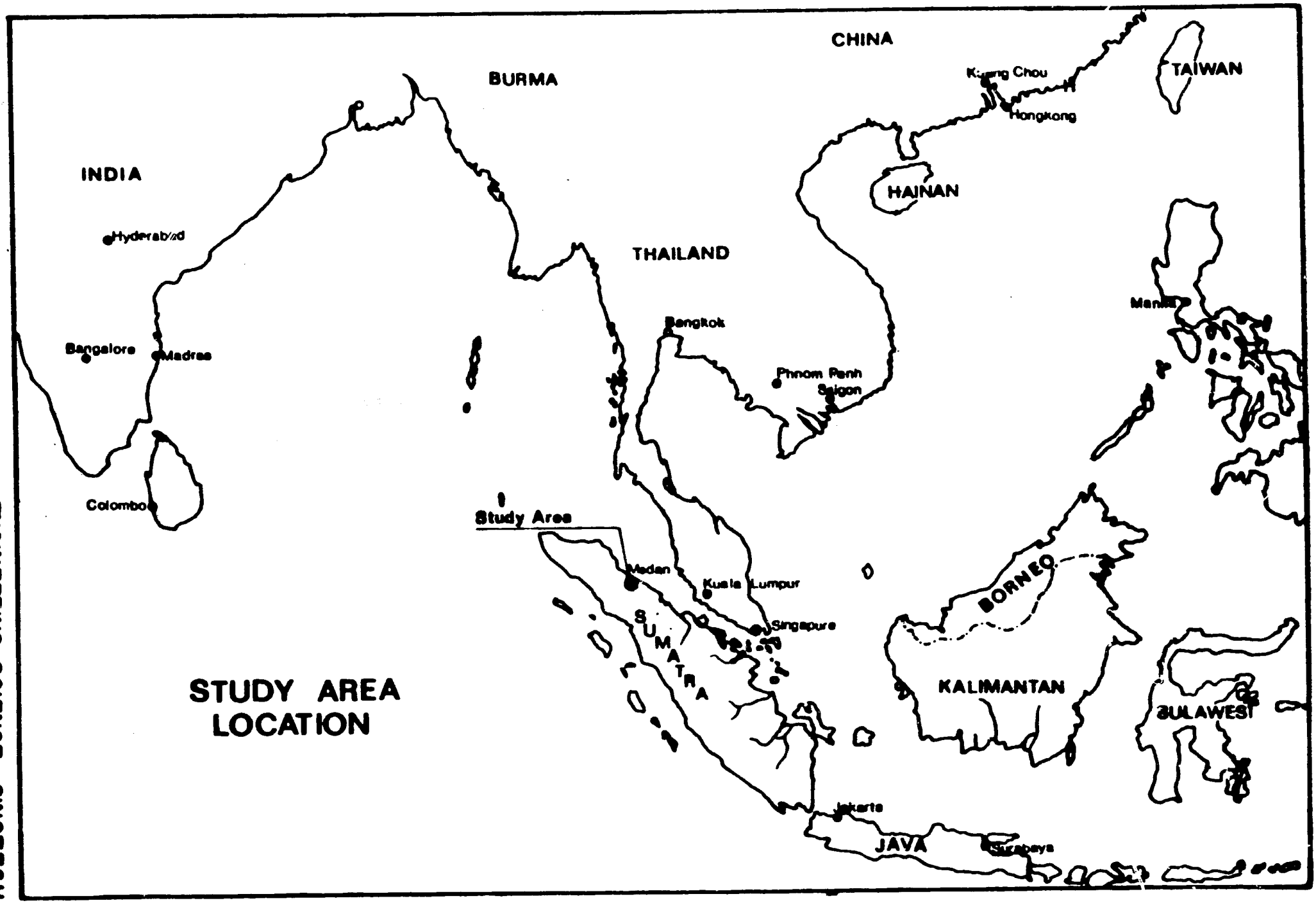
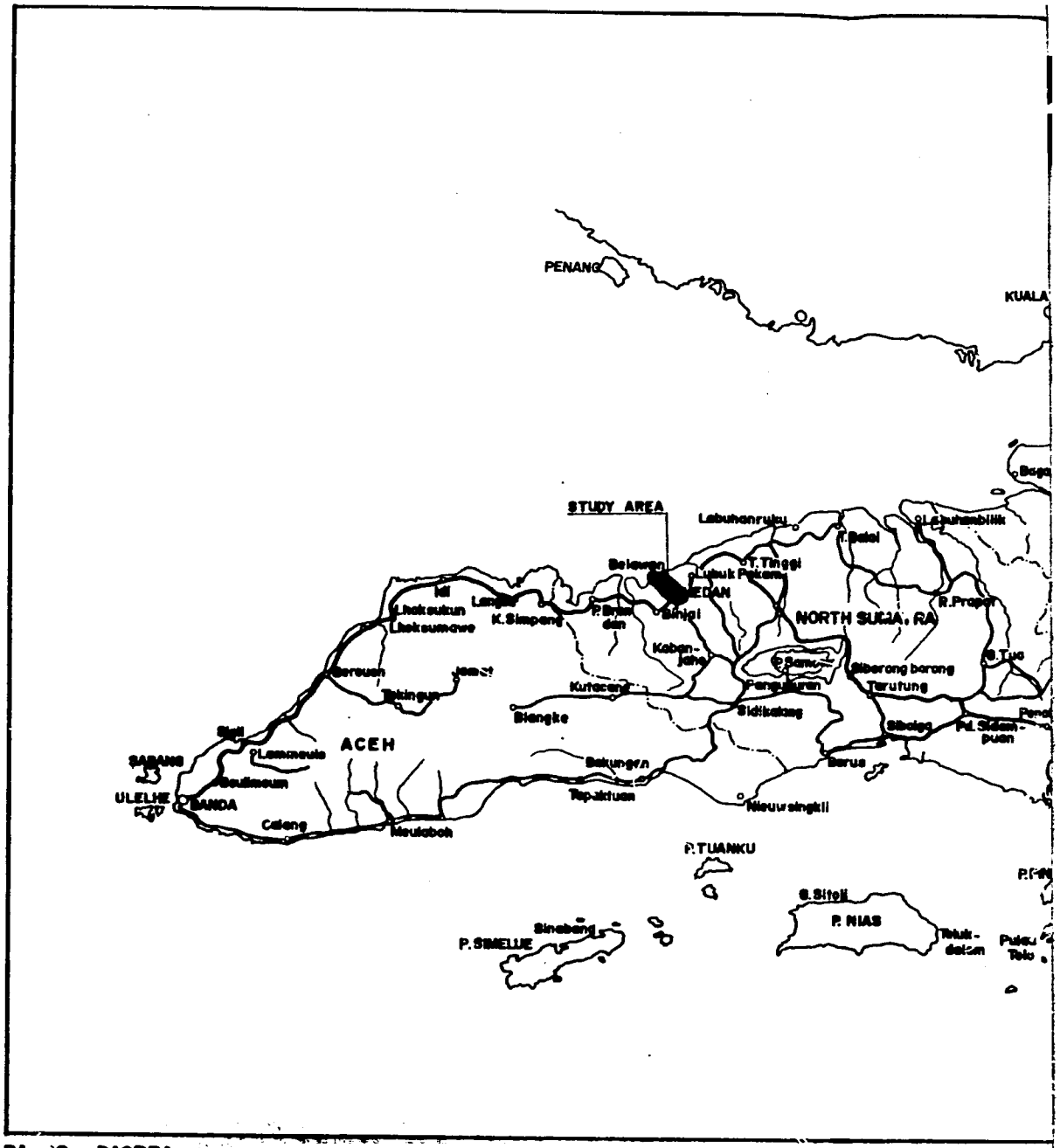

CHINA
BURMA
INDIA
TAIWAN
Kowloon Chou
Hongkong
HAINAN
Hyderabad
THAILAND
Bangkok
Bangalore
Madras
Phnom Penh
Saigon
Colombo
Study Area
Medan
Kuala Lumpur
Singapore
SUMATRA
BORNEO
KALIMANTAN
SULAWESI
Jakarta
JAVA
Surabaya
STUDY AREA
LOCATION

FIGURE 1.1


PENANG
KUALA
STUDY AREA
Labuhanruku
T.Tinggi
Belawan
Lubuk Pakam
MEDAN
Binjai
NORTH SUMATRA
R.Prapat
Lhokseutun
Lhoksumawe
K.Simpang
Kaban-jahe
Sibolga
Tarutung
Berusah
Takengon
Kutacane
Blangke
Sidikalang
Sibolga
Pd.Sidim-puan
Sigli
Lammeule
ACEH
SABANG
Beulimeun
ULELHE
BANDA
Calang
Meulaboh
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Berus
Nieuwsingkil
P.TUANKU
P.Sitoli
P.NIAS
Teluk-dalam
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Sinabang
P.SIMELUE

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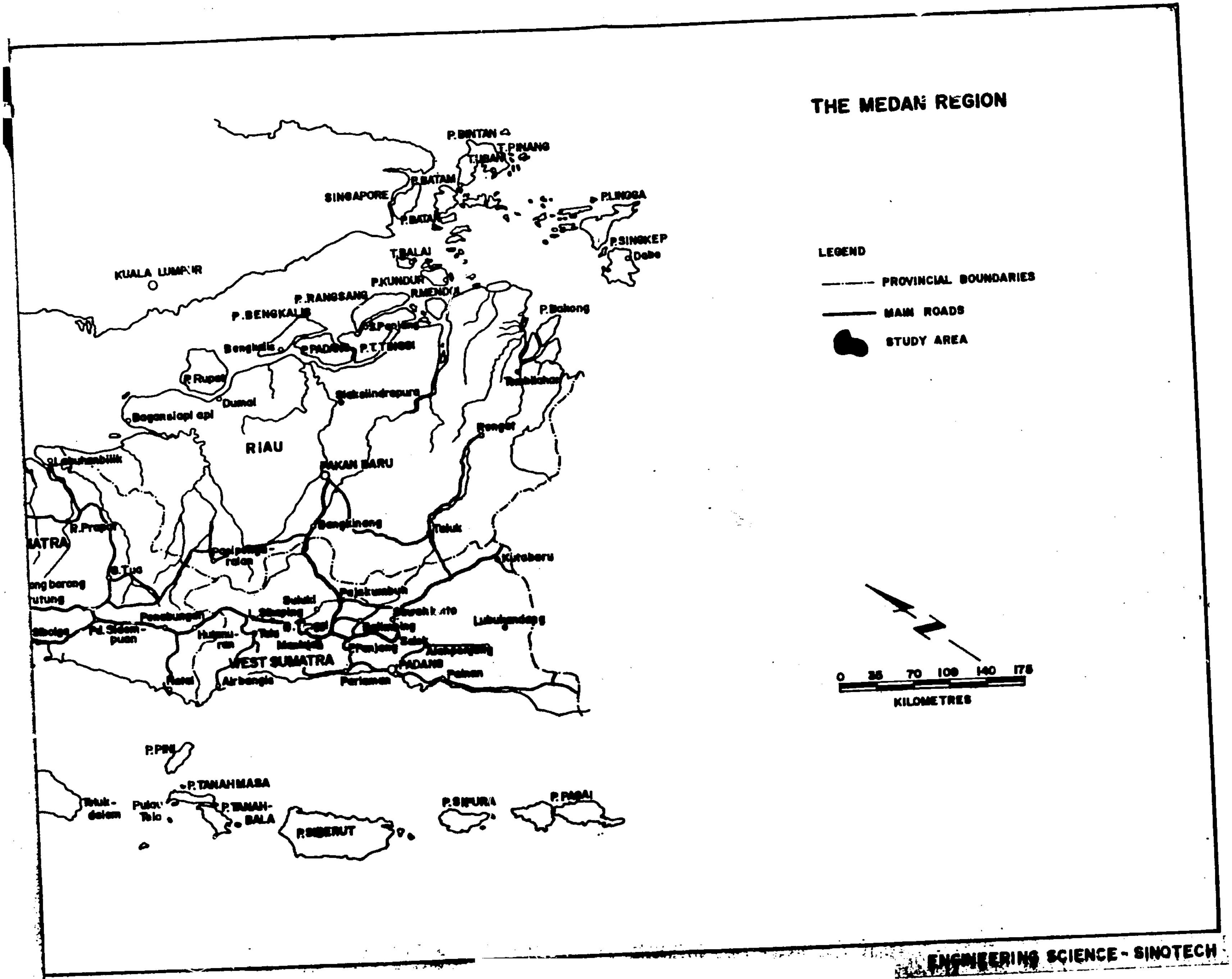
FIGURE 1.2



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1.4.2 Topography

The study area lies between sea level and about 55 metres above sea level, on the northern end of regional basins which continue upward to the crest of the Barisan range (2000 metres in elevation) near Brastagi, 60 kilometres to the south. General contours for the study area presented in Figure 1.3.

The northern end of the study area is in a coastal tidal zone which lies below 2.5 metres elevation. This zone is about seven kilometres wide in a north-south direction. The coastal plain lies above the zone of tidal influence and extends about eight kilometres up to about 15 metres elevation. The plain is relatively low, poorly drained ground.

Above 15 metres elevation, the land is better drained and underlain by consolidated bedrock or more developed soils. This portion of the study area covers a zone about 12 kilometres wide (north-south) between 15 and 35 metres elevation. South of Medan, the land begins to rise as a series of low hills followed by broad ridges. From about 70 metres elevation, the hills and ridges gradually narrow and the flat valley floors shrink. At 300 metres elevation, the terrain consists of steep slopes between ridges and streams. This terrain has occasional broad ridges, particularly above 700 metres. The ridges and peaks of the Barisan Mountains separate the Belawan-Deli-Percut basin from the Brastagi basin.

Relief and gradients within the study area are generally small although some steep slopes of 5 to 10 percent may be found along rivers and low ridges on the southern margin of the study area. Most slopes or river gradients are less than 0.4 percent within heavily urbanized areas and 0.1 to 0.2 percent in the coastal plain and tidal zones. Interpretations of 2.5 metre contour maps indicate significant slope changes on the east side of the Deli between 5 and 12.5 metres elevation and between 15 and 25 metres elevation.

Above 25 metres, numerous benches (wide, relatively gentle terrain) are located in the southwestern and southeastern sectors of the study area, while very small benches lie among the steep valley and ravines in the south central sector.

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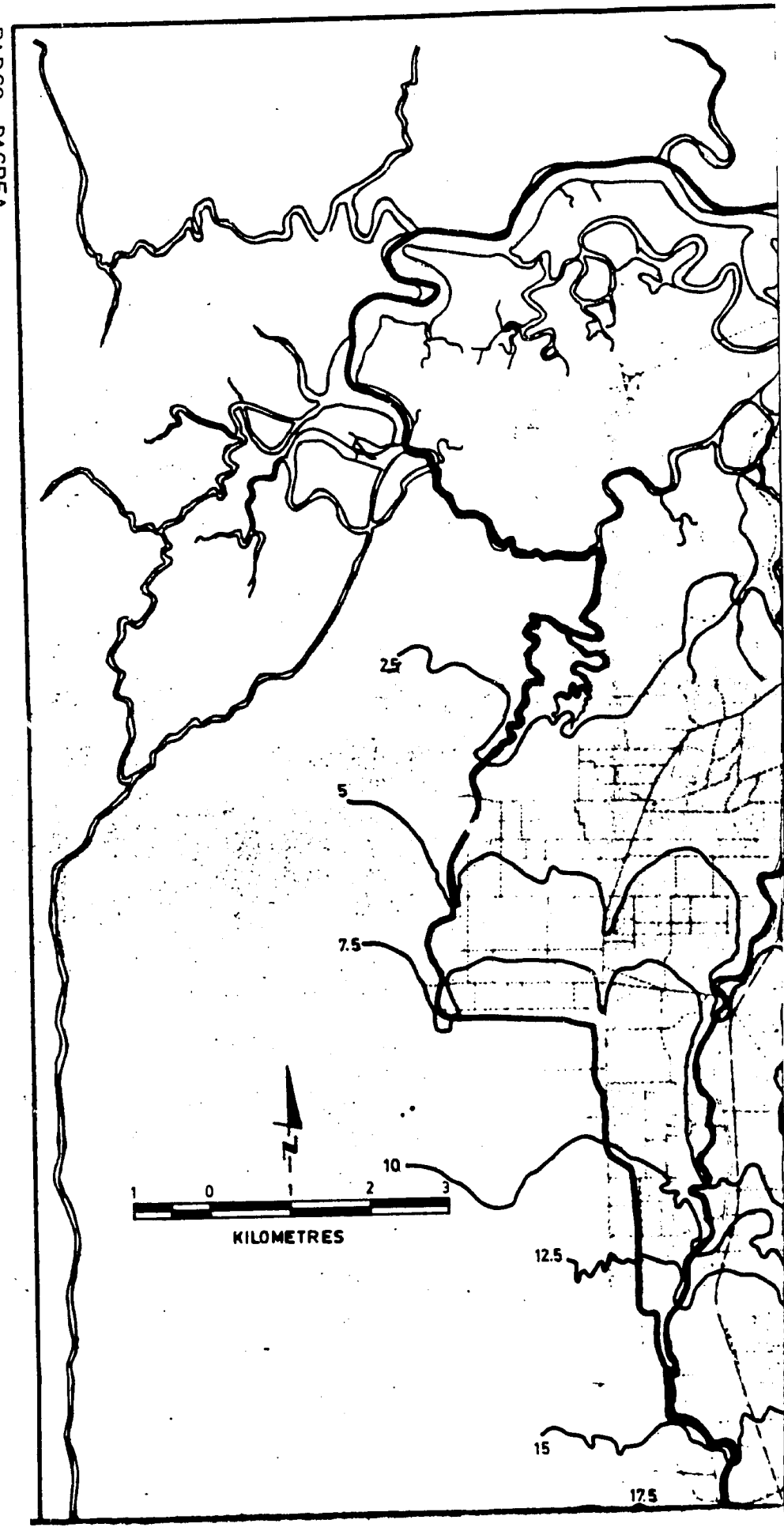

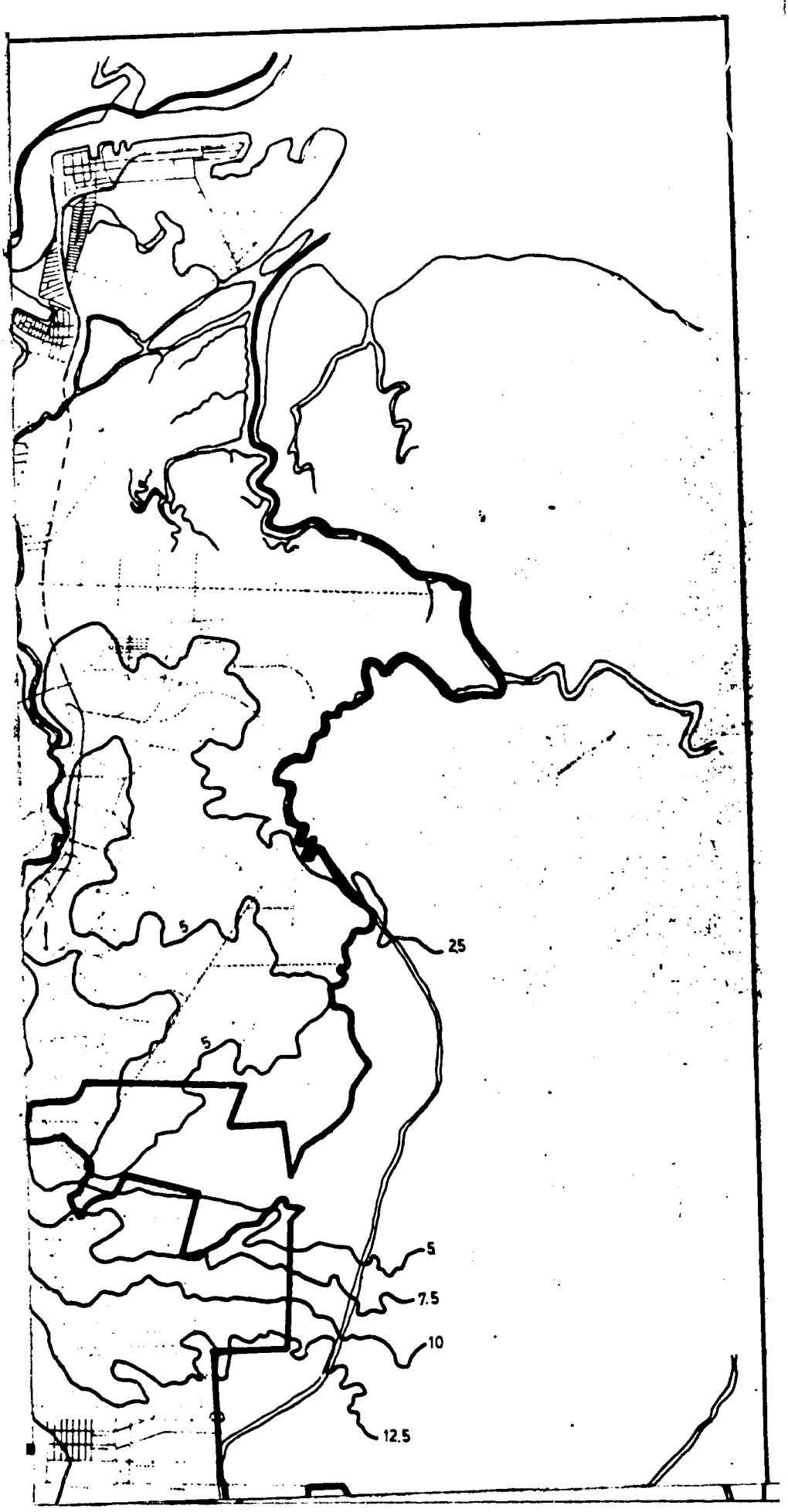
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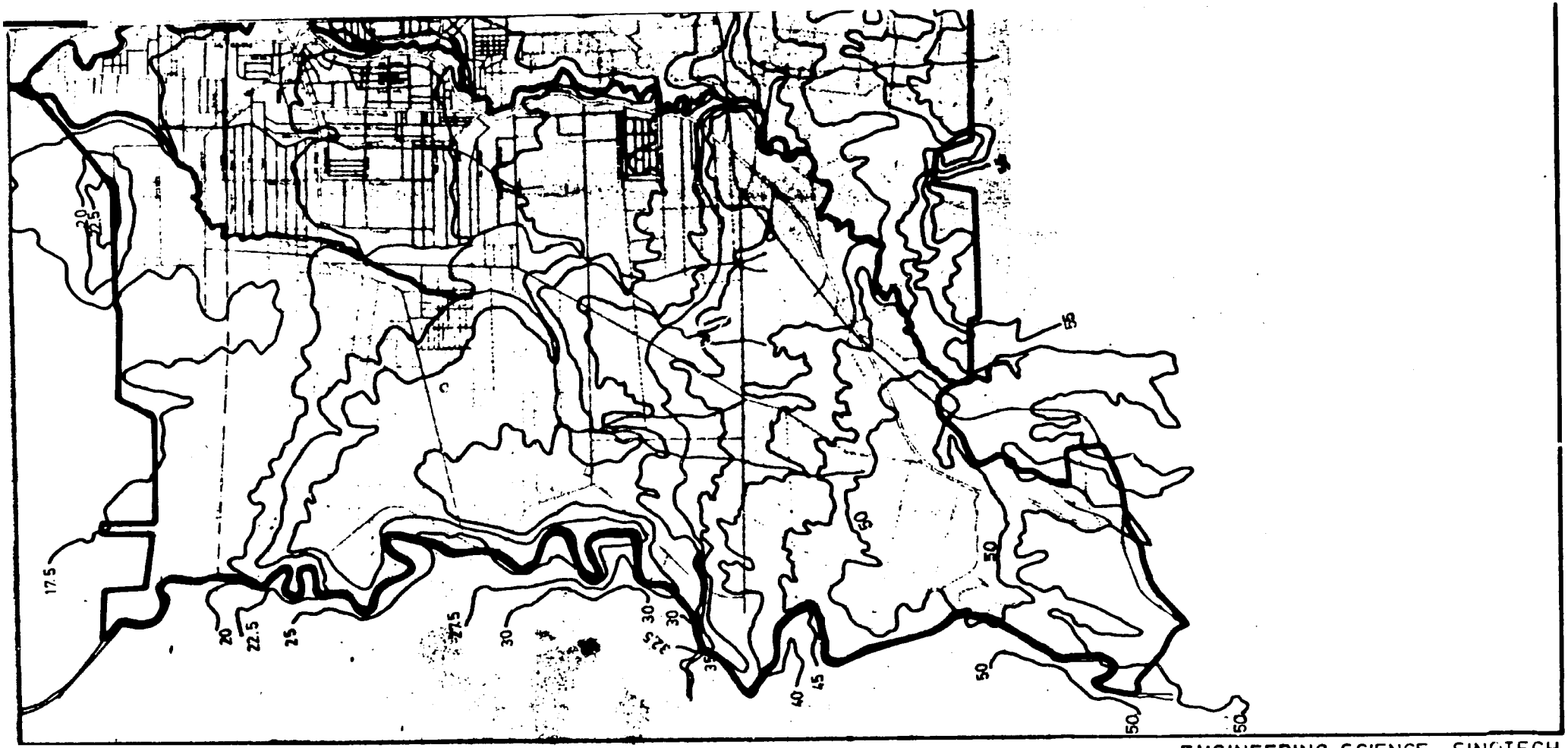

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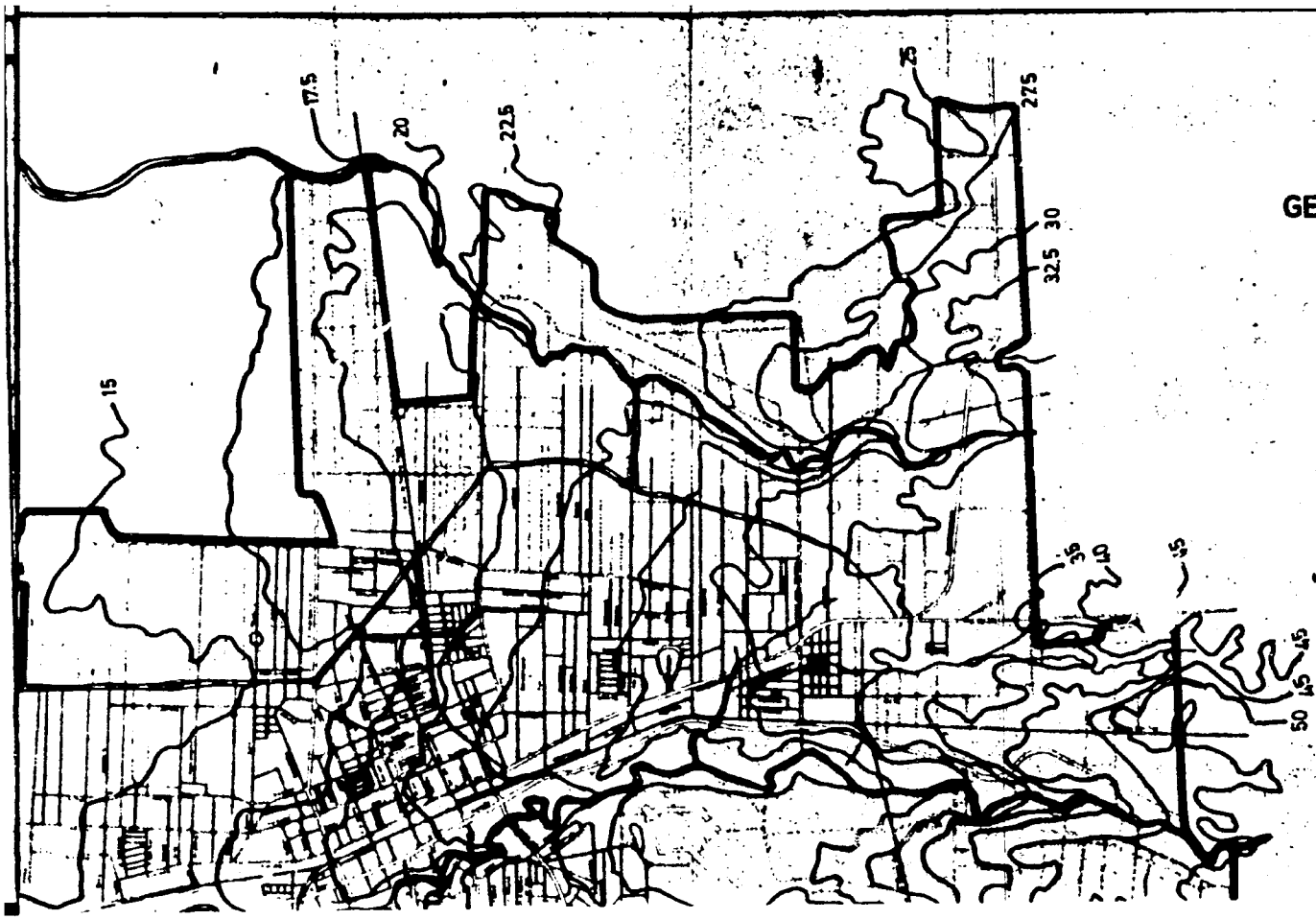
FIGURE 1.3



GENERALIZED CONTOUR MAP
OF
THE STUDY AREA

Above 50 metres elevation, wide ridges or benches are separated from the lower benches but many join in the Belawan River valley in the south-western sector.

1.4.3 Climate

The equatorial location and low elevation of Medan largely determines the tropical climate of the region. Although rainfall, temperatures and sunshine show some seasonal periods, these seasons are not as distinctly marked as in Java and many other areas of Asia. Two rainy periods occur during the fall and spring rather than during the more typical "monsoon" seasons which occurs over much of Asia. These rainy periods closely resemble those in southern India, Sri Lanka, and Equatorial Africa. Medan rainfall has been redorded since 1879 at three stations. During the period of record, annual rainfall has varied from 1352 to 2873 mm with 10 percent of the years having rainfall above 2400 mm and 10 percent below 1600 mm. About 80 percent of the annual rainfall ranged from 2000 to 2400 mm, and the average annual rainfall for 40 years was about 2050 mm. Distribution of rainfall throughout the year shows two high rain months: October and May, although the longer "rainy season" extends from September to January. Eighty percent of the months have rainfall betwen 60 and 300 mm, while about sixty percent of the months have rainfalls from 300 to 400 mm.

Long term rainfall data for Medan indicated only three days with 250 to 290 mm of rain in 24 hours. Although these storms occured in December or January, they occured at widely different years : 1907, 1937, and 1956, and these storms coincide with high monthly rainfalls (more than 300 mm - 250 - 290 mm), but not with highest rainfall years. Such scattered temporal distribution indicate than the storms were of limited areal extent and period and that rainfall quickly decreased beyond the intense center of rainfall.

Diurnal rainfall show a strong tendency towards afternoon and night rains and relatively dry morning periods. Records indicate that periods of 6 to 12 hours separate the rainy periods of each day and thereby allow runoff and drainage before the next day's rains.

1.4.4 Soils

Soil type and relatively high groundwater levels have strongly influenced the growth and changes of the urban and agricultural land uses in the study area. The general distribution of soils and groundwater tables may be separated into three zones : (1) coastal tidal zone, (2) coastal plain; and, (3) piedmont. Within the coastal tidal zone, alluvial soils are generally rich in organic material and clay and the water table is at or close to the ground surface.

Along the major rivers, some alluvial sands and gravels may be found and the water table is usually at the same level as the river. On the coastal plain, soils have developed on older alluvial deposits which are higher and somewhat coarser than those in the coastal tidal zone. Better drainage allows the water table drop to about 1.5 metres below ground surface, although the localized water tables may be higher due to poor local drainage.

The highly organic and fine-grained sediments in the tidal zone requires substantial filling and extra foundations in order to develop even the simplest structural uses. Some long-term subsidence or differential settlement could be expected even with special foundation preparations. Most organic and fine-grained sediments and high soil moisture content form corrosive acid conditions with a high sulphate content.

Within the study area and general vicinity, eight different soil types in five altitudinal zones have been identified. In the coastal tidal zone, two alluvial soils are recognized : (1) the grey humus soil of clay and grey alluvium phases and, (2) the grey hydromorph soils. The grey, brown and yellow-brown regosol and grey hydromorphic soils are most common on the coastal plains and lower hills. A brown andosol on pre-Toba and a brown podosol on Toba volcanics extend from the Percut River to the north and south, respectively. Above the project area, a brown podosol extends from about 150 metres upto 400 metres, and then it is replaced by a brown andosol developed on the volcanics which form the source for the Sibolangit springs. High moisture content increases the acidity in the clay soils and sediment derived from acid-volcanic bedrock. All soils are acidic and many are highly acidic; some have a high hydrogen sulfide content and are corrosive.

1.5 REGIONAL WATER RESOURCES

Northern North Sumatra contains a large number of perennial rivers and large springs, and groundwater aquifers underlie the coastal plains. Rainfall is evenly distributed through the year. River flows show little fluctuation during the year, although runoff rates tend to increase in October and January. Water quality in all sources is generally acceptable for potable supply given appropriate treatment and disinfection. Surface waters within and downstream from urban centers such as Medan, Binjai, Tanjung Morawa, and Lubuk Pakam are grossly pollutted. There is some evidence of groundwater pollution in shallow aquifers underlying heavily populated areas.

1.5.1 Rivers

There are several rivers within the study area all of which flow into the straits of Malaca. They are the Deli, Percut, Belawan, Bedra and Kera Rivers. In addition, two major tributaries of the Deli flow within this area, the Babura and the Sikambing. The most important rivers for this investigation are the Deli, Percut, and Belawan and the two tributaries of the Deli.

The Deli river catchment basin covers an area of 390 sq km, and has a total length of 80 km of which 42 km lies within the study area. The headwaters of the Deli are in the mountainous areas where the slopes of the river channel are 6 to 18 percent. Flowing downstream the river bed is at 300 metres above mean sea level, and at that elevation the slope decreases to about 0.5 to 1.0 percent. Past the city of Medan the slope of river channel is about 0.1 percent.

The tributary to the Deli River, the Babura, has slopes of about 0.5 to 1.0 percent and the Sikambing tributary has slopes ranging from 0.1 to 0.5 percent.

The Belawan river catchment basin in some what smaller, with a 270 sq km catchment area and a 66 km length, of which 26 km are within the study area. The Percut river is the smallest; its catchment basin covers 210 sq km and has a total length of 78 km, of which only 8 are within the study area.

The flows of these rivers vary substantially between low and high flows, actual measurements are not available as to high flows and the historical data for low flows on the Deli and Belawan rivers is extremely limited.

The major rivers of interest outside of the study area are the Wampu and Ular, located about 30 kilometres west and east of Medan, respectively. Both of these rivers have drainage areas and flows far larger than any rivers flowing through the study area.

1.5.2 Springs

The earliest municipal water supply in Medan was obtained from natural springs and seeps in the vicinity of Sibolangit and Sembahe, about 40 km south of the Medan urban center. Three other significant springs are located in the hills south of Medan from 20 to 40 km away from the city center. Estimated total flow from the springs at Sibolangit is 80,000 - 90,000 m^3/d. The unused flows from the springs pass into the Binjai, Belawan, Deli, and Belumai rivers.

1.5.3 Groundwater

Groundwater resources in the study area provide flows to the springs and much of the low flows in rivers and appear to underlie the entire study area. Significant deep groundwater production was begun in the Medan area in the 1880's and 1890's in order to provide safe potable sources for the Belawan port, Shallow, hand-dug wells provide water for most people in the study area. Three groundwater aquifers can be identified in the Study Area: (1) the shallow groundwater table, (2) an intermediate zone, and (3) a deeper aquifer at about 200 m below surface. The shallow groundwater table is unsuitable for large scale municipal water supply, but the intermediate and deep aquifers may represent a substantial potential water resource.

SECTION 2

THE PRESENT WATER SUPPLY AND SANITATION SYSTEMS

2.1 THE WATER SUPPLY SYSTEM

A relatively small proportion of the people in the study area are served by the municipal water system which obtains its water from three sources: (1) natural springs 35 to 40 km south of Medan, (2) treated water from the Belawan River, and (3) groundwater in the Belawan Port area. Most of the population obtains its water from shallow dug wells or from the surface streams.

2.1.1 The Municipal Water Supply System

The municipal water supply system is operated by PAM Tirtanadi, which was originally organized by the Dutch as a private water company in the early 1980's. In 1966, Tirtanadi became a Local Enterprise under Local Enterprise Law No. 5 of 1962. The Board of Directors of Tirtanadi is appointed by the government of the Province of North Sumatra, which has overall responsibility for all Local Enterprises.

2.1.1.1 Spring Supplies

The Medan Water Supply Scheme was begun in 1908 with water obtained from the springs at Sibolangit (Figure 2.1). The Rumah Sumbul source, consisting of 3 springs, was the first to be developed in 1908. Aeration is provided but not lime addition or chlorination due to the relative inaccessibility of the site. The Lau Bengklewang group (17 springs) was the next to be developed in 1912 with aeration; addition of lime was provided later around 1929. It is understood that 11 of these springs are now in operation. The fact that there has been no reduction in the amount of water supplied daily from this source indicates that the other 6 springs have not dried up as such but that the flow has merged, at some points further upstream, with the 11 that are now functioning. The third and final spring source, the Lau Kaban and Puangaja group consisting of 4 main springs was developed and commissioned in 1958 with treatment facilities being completed in 1968.

Water from the 3 groups of springs is transmitted to the city through three pipelines, the number varying at different points along

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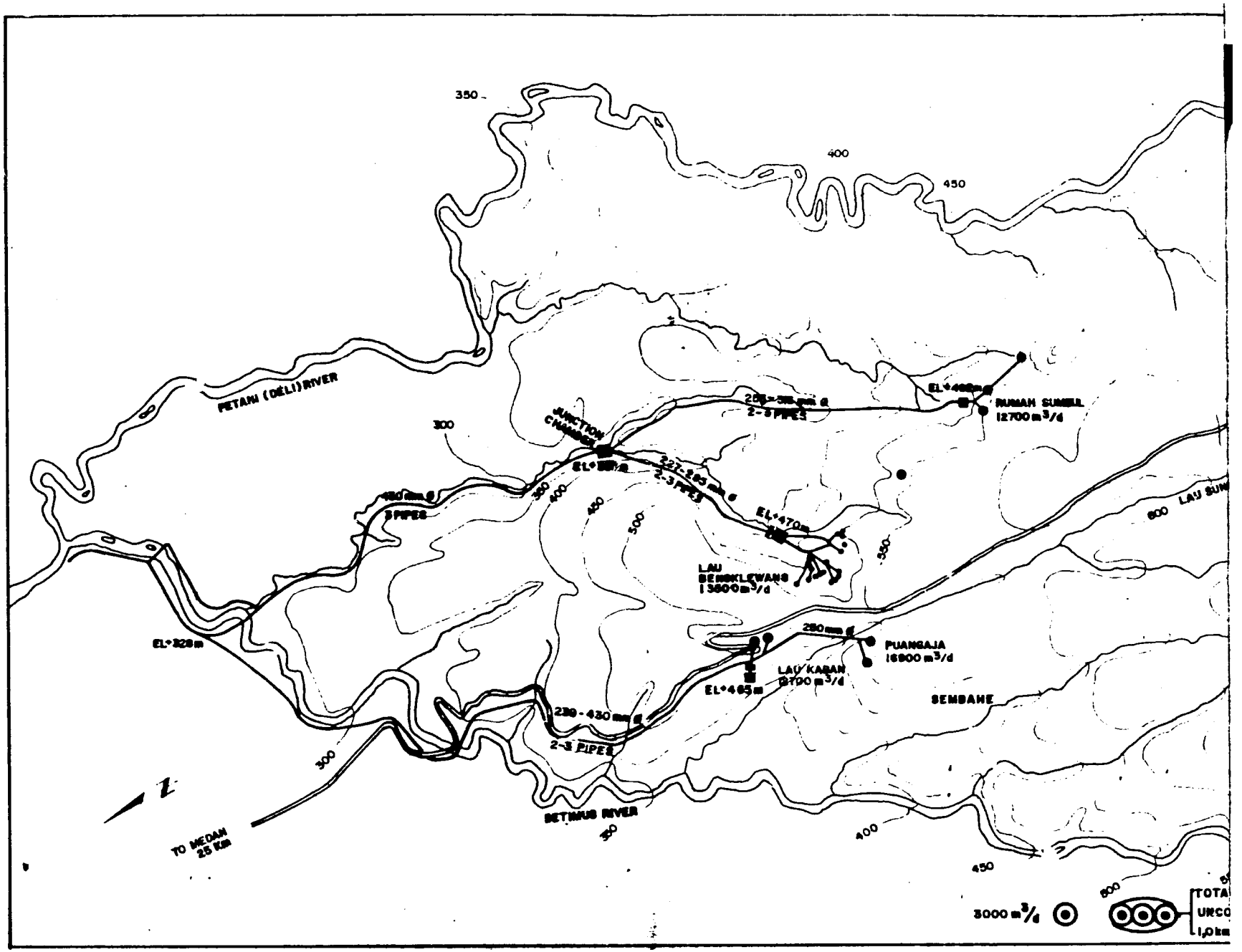
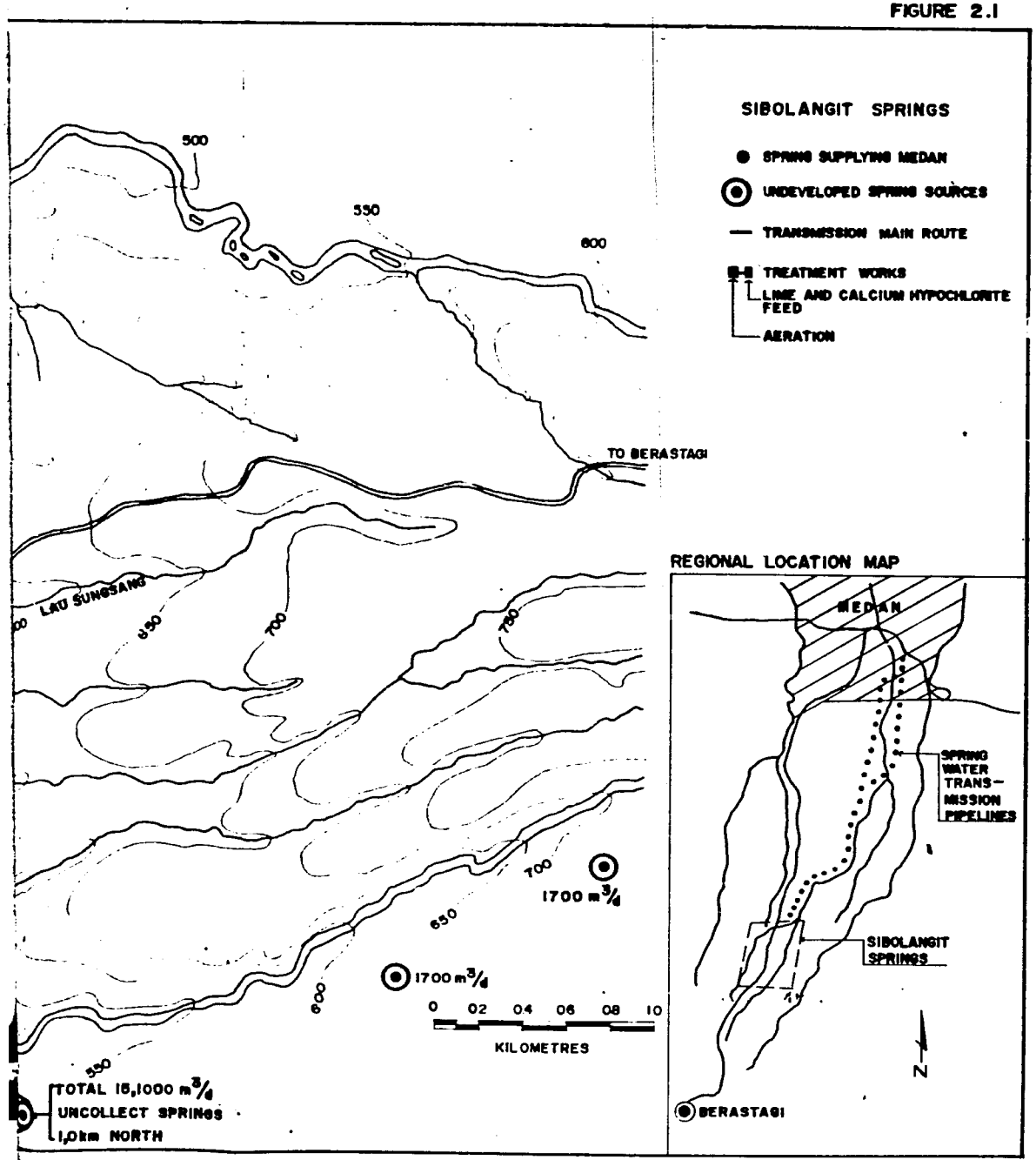


PADCO–DACREA

FIGURE 2.1



ENGINEERING SCIENCE–SINOTECH

the route. Input to the distribution system is at points along the southern boundary of the city.

The springs are located on steep, sloping hillsides which are too far from any habitable areas to be subject to contamination. The main infiltration units are arches of stone with open joints and are approximately 2 metres in diameter or smaller, dug into the hillside to distances of up to 20 metres. The bottoms of the arched sections are paved and slope into larger shallow paved basins from which the water flows to the treatment facilities through cast iron collector pipes. The collector pipe diameters vary from 125 mm to 500 mm and a number are cement-lined. Overflow arrangements divert the surplus water to natural water courses. One diversion is provided with a V-notch weir and gauge enabling the overflow to be measured. The whole unit is protected by a masonry foundation extending well above grade and earth cover has been laid to divert surface drainage. The springs are well constructed, with the danger of contamination reduced to a minimum.

Water quality measurements made between 1974 and 1978 are summarize in Table 2.1.

The first stage of treatment is aeration, the purpose of which is presumably the removal or reduction of free carbon dioxide. The second step is the addition of a solution of lime. This treatment has resulted in an encrustation of lime in the transmission pipelines as thick as 20 mm in some places. This encrustation has reduced the capacity of the transmission lines.

The addition of lime is standard procedure for a corrosive water, i.e., a water that is undersaturated in calcium carbonate. However, the encrustation found in the pipes indicates that too much lime has been applied.

One measure of a water's tendency to dissolve or deposit calcium carbonate is the Langelier Saturation Index (Reference 1):

$$I_s = pH - pH_s$$

where I_s = the saturation index

pH = the pH of the water

TABLE 2.1

WATER QUALITY FROM SPRING SOURCES

Parameter	Unit	Rumah Sumbul		Lau Kaban		Lau Bengklewang	
		Raw Water	Aerated Water	Raw Water	Aerated Water	Raw Water	Aerated Water
Temperature	°C				23 - 24		
Turbidity	FTU				.01 - .15		
pH		6.1 - 6.2	6.9	6.2 - 6.3	6.7 - 7.2	6.3	6.9
Alkanity		-	-	-	50.5 - 78	-	-
Bicarbonate	mg/1	69 - 71	69	6.1 - 7.2	60 - 130	63	63
Carbonate	mg/1	N.D.	-	-	-	-	-
Total Residue	mg/1	205 - 226	227	203 - 210	210	223	221
Non Filterable residue	mg/1	1 - 2	1	1	1	1	2
Total Fixed residue		161 - 167	171	143 - 156	155	163	163
Carbon dioxide	mg/1	23.9 - 25.7	9	18.4 - 28.3	8.0 - 41.6	22.1	6.2
Total hardness	mg/1 CaC03	86 - 100	97	77 - 81	37.2 - 98.5	91	91
Calcium	mg/1	21.7 - 25.3	23.1	19.5 - 23.1	13.6 - 28.6	22.4	22.4
Magnesium	mg/1	7.9 - 9.2	9.2	5.7 - 7.0	5.1 - 11.0	8.8	8.8
Iron	mg/1	0.03	0.05	0.02	0.02	0.02	0.02
Manganese	mg/1	N.D.	N.D.	0.01	N.D.	N.D.	N.D.
Copper	mg/1	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Chloride	mg/1	12 - 14	13	11	9 - 7	13	13
Sulfate	mg/1	39 - 45	42	34 - 48	48	43	44
Silica	mg/1	52 - 56	52	56	56	52	52
Fluoride	mg/1	0	-	0.08	-	-	-
Mercury	mg/1	-	-	0.003	-	-	-
Conductivity	μ mho/cm	-	-	-	197.5 - 269.5	-	-

ph_s = the saturation pH

If the index is negative, the water will dissolve calcium carbonate; if the index is positive, calcium carbonate will be deposited.

The saturation pH can be determined by calculation from a laboratory analysis of the water or empirically by saturating a sample of the water with pure calcium carbonate and measuring the pH. To calculate the saturation pH, a modified form of Langelier's equitions can be used.

$$pH_s = 8.313 - \log [Ca^{++}] - \log [A] + S$$

where

pH_s = the saturation pH

$[Ca^{++}]$ = the calcium concentration in me/l

$[A]$ = the alkanity in me/l

S = $2.5\sqrt{\mu}/(1 + 5.3\sqrt{\mu} + 5.5\,\mu)$

μ = 2.5×10^{-5} (total dissolved solids in mg/l)

If the extreme values for calcium, alkalinity, and total residue in Table 2.1 are used in this equation, the saturation pH is estimated to be from 7.8 to 8.5. The measured pH of the spring waters is between 6.1 and 7.2. Thus, the index would be negative and addition of some lime appears to be justified.

The proper amount to be added can be determined from laboratory tests of the relationships for the spring waters between calcium, alkanity, and pH. This should be done.

If any event, the addition of lime should be discontinued temporarily to reduce the encrustation in the pipes and increase their carrying capacity. After this has occured, treatment with the proper lime dosage can be started.

Chlorination is done at Lau Bengklewang and the Lau Kaban and Puangaja groups of springs. According to the operators, no chlorination in done at the Rumah Sumbul group but this is not a serious problem as the water from the three groups of springs mix together over a long distance before it reaches the city, and the adjustment of the chlorine dosages at the other two groups could easily compensate for lack of

chlorination at the Rumah Sumbul group.

Chlorination is achieved by the addition of calcium hypochlorite. Facilities for the storage, mixing and addition of lime and calcium hypochlorite, a field chlorine and pH kit and a few other accessories are maintained at Sibolangit. Transporting chemical to the springs is difficult, but investigations have revealed no suitable alternative locations along the route of the transmission lines. A low-pressure point where chlorine could be administered without pumping is not available in the existing system. On the other hand, injection of chlorine solution is not feasible due to the lack of electricity along the route. There appears to be no alternative to the present arrangements, at least for the present.

2.1.1.2 Sunggal Treatment Plant

The Sunggal Water Treatment Plant supplies about one-half of the total water demand of the city of Medan. Until summer, 1979, the production of the new section was consistently below expectation, producing about 450 l/s of the planned 600 l/s. Recent improvements to the pumping facilities have enabled the operators to force the full 600 l/s through the plant.

Phase No. 1 was constructed nearly 10 years ago and commissioned in December 1970. Situated on the right bank of the Belawan River, it consists of the following works:

1. Dam and intake structure
2. Presettling tank
3. Raw water pumphouse and sump situated partly under the pumphouse
4. Clearator
5. Set of six filters and a pipe and control gallery
6. Chemical house
7. Filtered water pumphouse
8. Filtered water tank
9. Generator house

In the second phase, another clearator, a filter gallery, and pumps were added and commissioned in December 1978. This represented about one-half of the originally planned second stage. Figures 2.2, 2.3, and

2.4 show the general layout, process diagram and hydraulic profiles of the plant, respectively.

The Sunggal Intake and Treatment Plant was designed (based on the description and manual of operations of the original plant) to be constructed in three phases, as follows:

Phase No.	Treated Water Capacity (m3/d)	(l/s)
1	25,920	300
2	51,840	600
3	51,800	600
	129,600	1,500

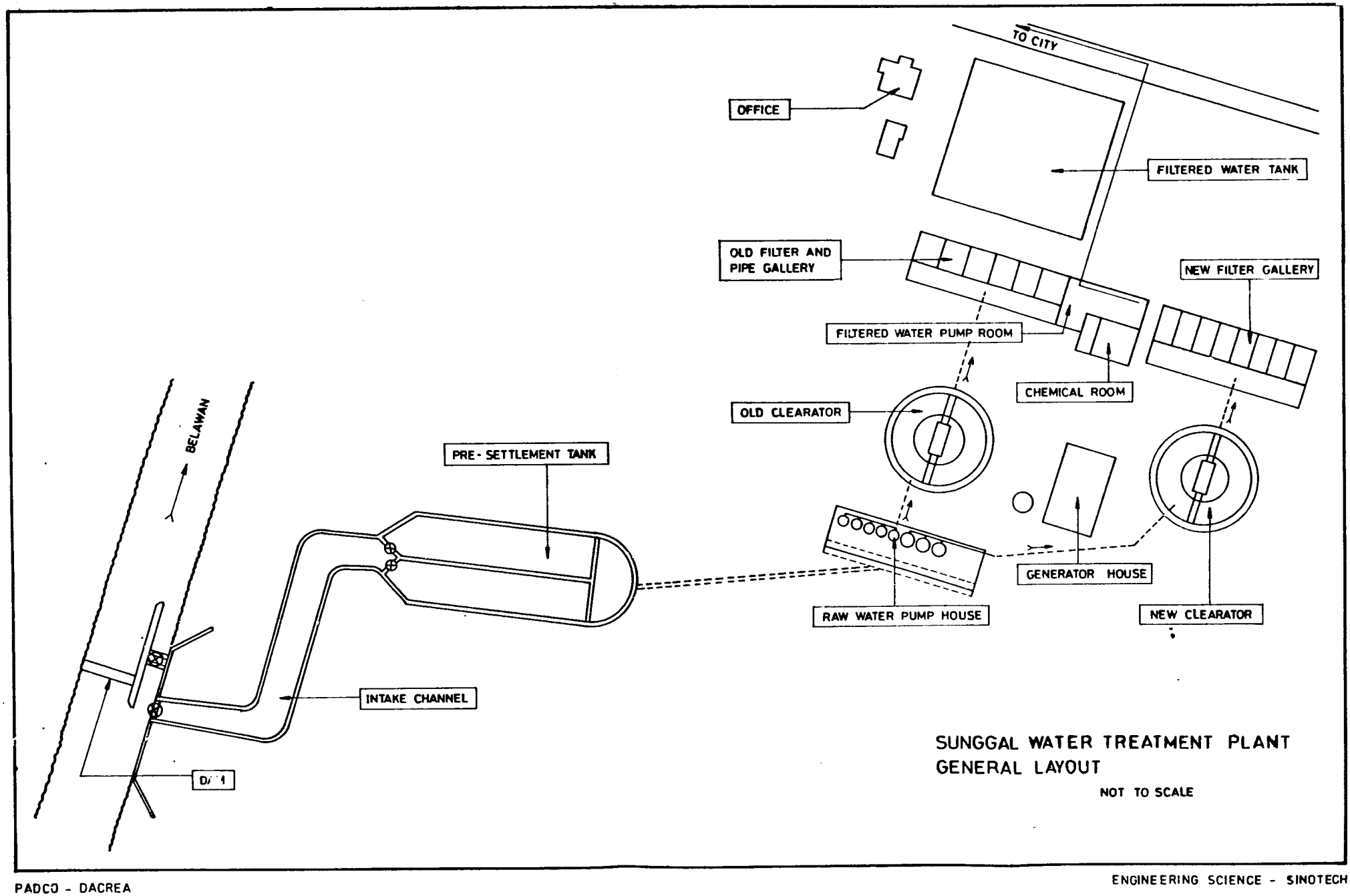
Dam and Intake Structure: The dam has been constructed across the Belawan River leaving a narrow channel on the right bank, ending in a sluice gate. The raw water outlet channel takes off from this channel and the flow is controlled by another sluice gate immediately in front of which is a bar screen to prevent the entry of logs and other large material carried down by the river. The intake has been designed to provide sufficient water for all three phases.

Presettling Tank: From the intake, the raw water flows into the presettling tank through an open channel. The tank has been divided into two compartments with two separate inlets, each controlled by a sluice gate to facilitate cleaning. The retention time, with only Phase No. 1 in operation, was 37 minutes with Phase No. 2 it is approximately 24 minutes.

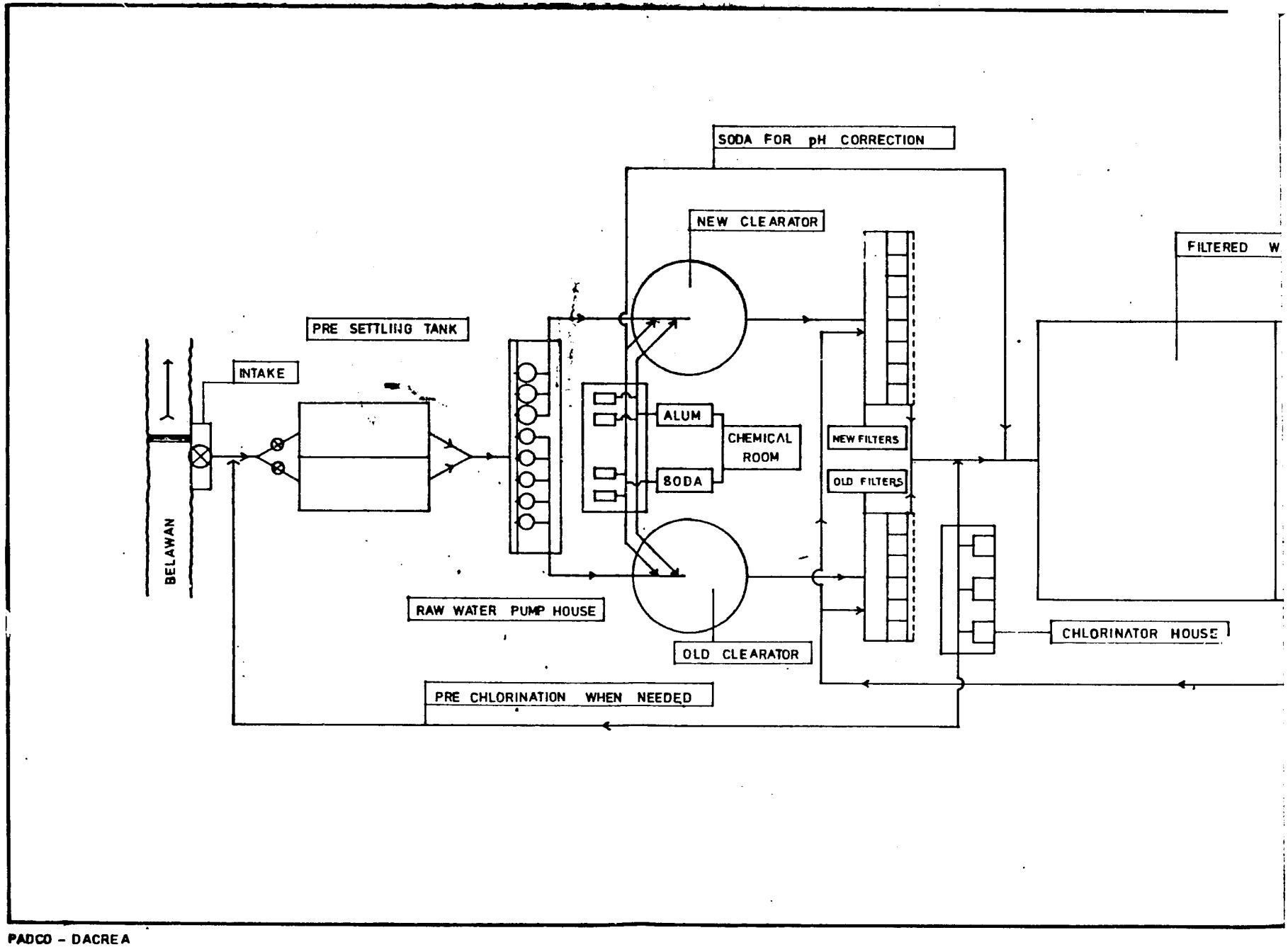
Provision has been made for prechlorination of the raw water, when necessary, at a point between the intake and the presettling tank. A wire-mesh screen fixed a few feet upstream of the presettling tank prevents the entry of leaves and other floating debris that escape the bar screen. The presettling tank is expected to be cleaned, one compartment at a time, when sand and sediment piles up to a height of 60 cm. Cleaning, at present, is done once in two to three months. The presettling tanks have a capacity of approximately 700 m^3.

Raw Water Pump House: Presettled water flows through a covered channel to a raw water sump, 7 m deep, 2 m wide, and 36.5 m long.

FIGURE 2.2


TO CITY
OFFICE
FILTERED WATER TANK
OLD FILTER AND PIPE GALLERY
NEW FILTER GALLERY
FILTERED WATER PUMP ROOM
CHEMICAL ROOM
OLD CLEARATOR
BELAWAN
PRE-SETTLEMENT TANK
GENERATOR HOUSE
RAW WATER PUMP HOUSE
NEW CLEARATOR
INTAKE CHANNEL
SUNGGAL WATER TREATMENT PLANT
GENERAL LAYOUT
NOT TO SCALE

20a



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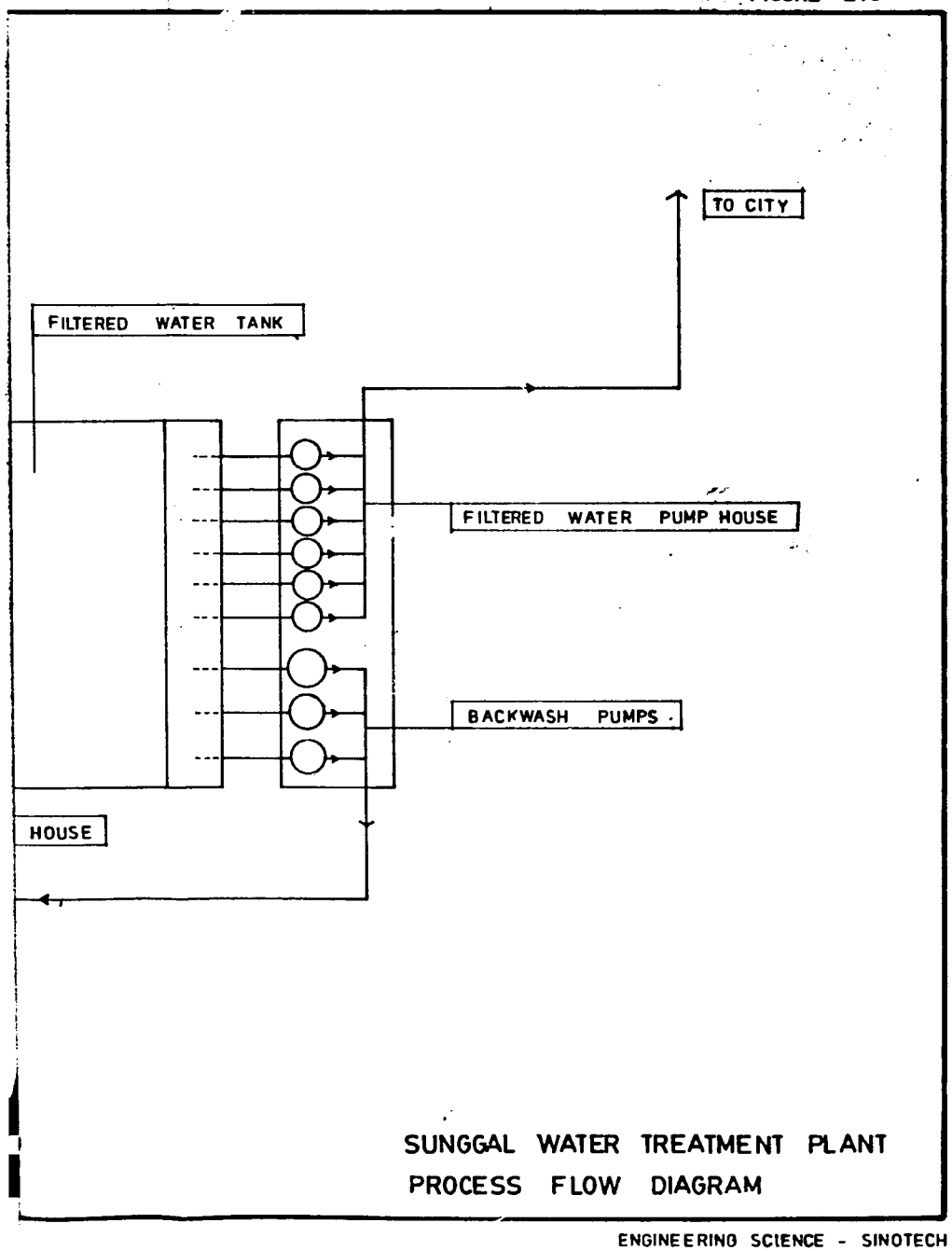
20B

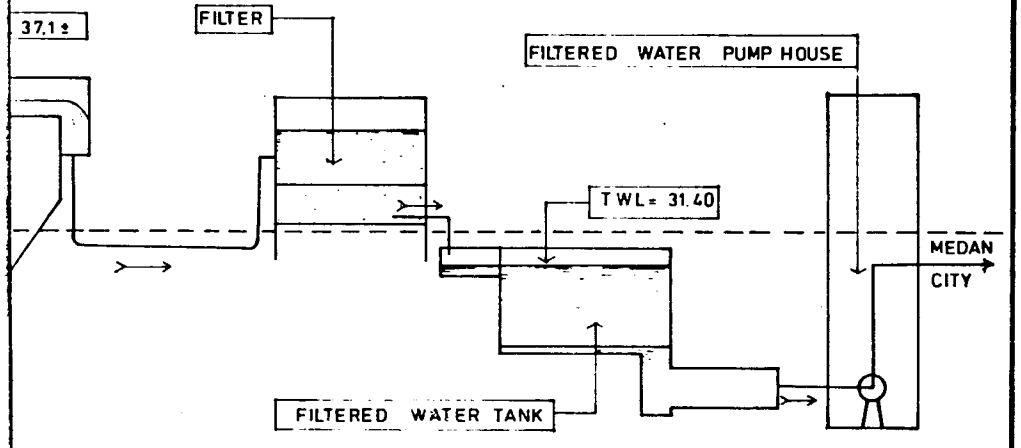
FIGURE 2.3



SUNGGAL WATER TREATMENT PLANT
PROCESS FLOW DIAGRAM

ENGINEERING SCIENCE - SINOTECH

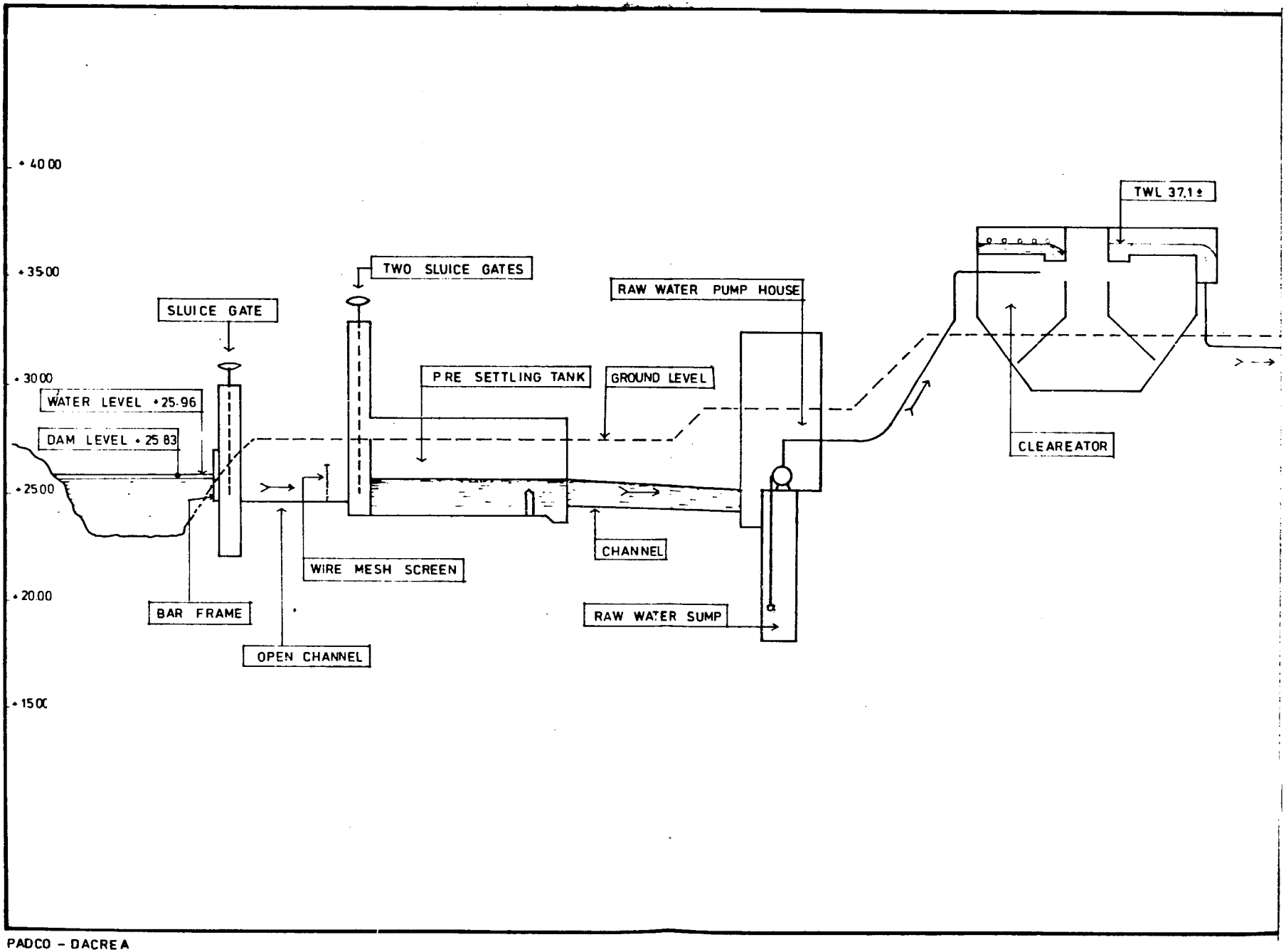
FIGURE 2.4



SUNGGAL WATER TREATMENT PLANT
HYDRAULIC PROFILE

NOT TO SCALE

ENGINEERING SCIENCE - SINOTECH



PADCO - DACREA

21B

Originally five horizontal axis centrifugal pumps were installed, each capable of pumping 80 l/s against a 15 m head. Four of these were sufficient to pump approximately 320 l/s of raw water with the fifth as a stand-by. When the second phase was implemented, three additional larger centrifugal pumps were provided, each having a capacity of 150 l/s against a 15 m head. Two of these operating simultaneously had a combined capacity of 300 l/s with the third as a stand-by.

With the passage of time the performance of the five original pumps has deteriorated and now, almost invariably, all five pumps have to be operated together to give an adequate supply. In fact, there are times when all five old pumps and the three new ones are operated together for appreciable periods. Provision has been made in the raw water pump station for the installation of additional pumps which would increase capacity of the raw water pump station to 960 l/s.

Clearators: The original clearator is actually an upward flow "accentrifloc" clarifier based on the original Paterson Candy International prototype. This clearator is continuously operated new its full capacity. The effluent obtained appears to be of fairly good quality, particularly in the mornings. The staff at Sunggal state that there is a marked deterioration in efficiency by afternoon, with the sludge blanket breaking up and large amounts of floc being carried over to the filters. They attribute this to the rise in temperature of the water. However, measurements of the temperature of the water, both at the surface and at reasonable depths, at the intake, presettling tanks, and clearators do not confirm this theory. It is not uncommon for convectional currents to be set up during the hotter parts of the day, but more careful operation of the concentrator is likely to improve the performance if regular attention is paid to this feature.

The second clearator was expected to be identical to the earlier one, with one exception. Though the main original structure was built with reinforced concrete, the internal compartments were made of steel. The second clearator has been constructed almost entirely of reinforced concrete. No detailed examination of the second clearator in an empty state was possible, but this should be done to identify any unintentional structural change which might adversely affect performance. There is a

fairly noticeable difference in the appearance of the coagulated and flocculated water in the central secondary reaction zones of the two clearators. The degree of flocculation appears to be different, and no stirring is visible. A smaller, different, or less effective type of agitator could be the cause. If so, an inexpensive modification might rectify the situation.

The overflow rate in the two clearators is 86 $m^3/m^2.d$ and the upward rate of flow is 3.58 m/h for the design flow rate. Both these figures are acceptable for sludge blanket type upward flow clarifiers. The detention period at average flow is 1.66 hours which is within the allowable limits for this type of clarifier.

Alum is used as the coagulant with soda ash (Na_2CO_3) as an auxiliary chemical. Both are added to the inlet pipe just before the raw water enters the primary reaction zone. Alum as a coagulant is generally most effective in the acid range of pH values from 4.0 to 7.0. In practice, a value of 6.5 is good. Analyses of the raw water of the Belawan River indicates that almost all the time the pH value is above 7.1. Based on jar tests the regular dosage of alum varies from about 17 to 20 mg/l. The theoretical amount of natural alkalinity needed for this dose of alum is about 9 mg/l expressed as $CaCO_3$. In practice however a dose 33 to 50 percent stronger than this theoretical amount has been found to be more effective. Allowing for this, the natural alkalinity needed is approximately 13.5 mg/l as $CaCO_3$. This si invariably available in the raw water. If any auxiliary chemical is added, it should be a weak solution of sulphuric acid to lower the pH rather than Na_2CO_3 which raises the pH making coagulation less effective.

The pH of the clarified and filtered water will then, of course, be lowered, but this can easily be corrected by the addition of Na_2CO_3 to the filtered water just before the filtered water tank but after chlorination. The above sequence, which can be tested with little expense, is likely to improve coagulation, and if found to be successful, could lead to a reduction in operating costs.

Filters: The filter system at Sunggal consists of:

1. A set of six filter units originally constructed in 1970 which receive clarified water from the old clearator.
2. A set of eight filters commissioned in December 1970 which receive water from the new clearator.

The old filters are of orthodox design. Flow controllers were provided, but have not been operational for many years. A bell-mouth overflow is provided in each unit, and the filters function as a form of declining rate of flow filter. Backwashing is done when the water level builds up due to head losses and is about to overflow. The filter run recommended by the makers is 23.5 hours (with an 0.5 hour allowance for back-washing), but at the moment, filter runs of two to three days appear to be the general practice. No serious harm is done however because very little overflow through the bell-mouths is noticed.

The back wash water is provided with two of the three pumps located in the filtered water pump gallery at a rate of 18.2 m^3/min which works out to 570 l/min/m^2. Normal backwash rates are generally more than 625 l/min/m^2. The cross-troughs collecting the rising wash water are suitably placed and the back-washing, in spite of the low rate, appears to be effective enough to provide filter runs longer than recommended.

The new filters, however, are quite different form the old ones and are reported to give constant trouble and a production rate much lower than that of the old filters. There are eight compartments in the new filter gallery but they cannot be regarded as separate units in the normal sense because they are interconnected above the trough-level. The new and the old sets of filters are different from each other both in concept and form. Not being based on an orthodox pattern, it is difficult to ascertain all of the causes of the low out-put of the new set, but some of the shortcomings can be identified without difficulty.

The first of these is the inability to backwash the filters efficiently. The normal practice is to place the collecting troughs at a height above the sand level approximately equal to the rise of the backwash water in one minute; 0.7 m is an average figure. At this height the two most important requirements are satisfied: (1) the particles of

sediment, floc, etc., do not have to travel an excessive height to pass into the trough, and (2) the distance is large enough for the expanded sand layer not to be washed away over a period of time. Another usual precaution taken is to place the troughs sufficiently close together to make it unnecessary for a particle of sediment or floc to travel a lateral distance of more than approximately one metre. In the case of the new filters the conditions are quite different. There are no cross-troughs as such, only two being provided for each compartment, one at each end, the distance from lip to lip being 4 metres. Any particle that rises to the surface at the centre has a travel distance of 2 metres to reach a trough. Furthermore the troughs are so placed that the lips are approximately 1.4 metres above the sand level. It is probable that most of the dirt that rises to the surface in the central area of each compartment settles back before it has the opportunity to fall over into a trough.

This problem is further aggravated by the comparatively low backwash rate of 570 $l/min.m^2$, which, though it appears to suffice for the old filters, is quite insufficient in this case. Increasing the backwash rate, not to the normal figure of 625 $l/min.m^2$, but to a higher figure of about 690 $l/min.m^2$ (in view of the excessive height of the troughs) may help but is unlikely to solve the problem entirely. The filters, are already backwashed nearly three times a day. An examination of the records of the various grades of sand used initially indicate that the smallest size used varies from 0.35 to 0.5 mm. This is too fine, and the media should be received and sizes less than 0.45 mm removed. The sand does not appear to have been either washed or graded when originally placed. For a final solution of this problem, a modification of the trough arrangement and a higher rate of backwash will also be needed.

Each of the eight units is washed three times each day for periods of 7 to 10 or more minutes each time. Taking a conservative figure of 8 minutes per wash, the total quantity of water used each day (the capacity of each of the two pumps being 9.1 m^3/min) is about 3.5 Ml/d. This is equivalent to the use of filtered water at an average rate of 40 l/s throughout the day. The output of two new raw water pumps is 303 l/s, and thus, approximately 13.3 percent is used for back-washing.

Arrangements are almost complete to provide air scour, and this will probably help, but the extent of improvement is not likely to be appreciable unless the other modifications are made.

Another continuing problem is that there is an overflow of water from two or three filters all the time, the quantity so lost not being separately assessable. Coupled with the excessive amount of water used for back-washing it is reasonable to assume that the contribution of the new set of filters to the total daily production is appreciably lower than expected when the second phase was implemented.

One other phenomenon has been noticed during the back-washing operations. Immediately after the wash water is admitted from the bottom, a large number of air bubbles leave the filter. The causes of air binding in filter beds of conventional design can generally be diagnosed, but in view of the unusual construction in this case, the reasons for this phenomenon are not clear. The absence of functioning flow controllers and the consequent high rates of flow through the bed followed by a rapid build-up of head losses could be contributing factors.

Chemical House: The Chemical House is located between the two filter galleries and almost above the filtered water pump house. Facilities are available to conduct jar tests and make chemical analyses of the raw water and to make residual chlorine assessments. There are three Wallace and Tiernan-type chlorinators of which one is not in working order. Additional chlorine safety equipment could be provided without much expense and are recommended. Prechlorination is done before presettling when necessary and the filtered water is chlorinated prior to entry into the filtered water tank immediately after which the pH is adjusted by adding Na_2CO_3.

Filtered Water Pump House: The Filtered Water Pump House has the following pumps:

1. Three backwash pumps, horizontal axis centrifugal type, each having a capacity of 9.1 m^3/min against a 15 m head. Two are used simultaneously to provide 18.2 m^3/min of washwater.

2. Three older, horizontal axis, centrifugal high-lift pumps each having a capacity of 4.55 m^3/min against a 50 m head.

3. Three new and larger horizontal axis, centrifugal high-lift pumps, the specifications of which were not available. From the motor details, the estimated capacity of these pumps is 8.5 to 9 m^3/min against a 50 m head.

As mentioned above, the performance of the five older raw water pumps has deteriorated noticeably. The same is very likely true of the three older pumps referred to in (2) above. The raw water pumps have a much greater suction lift, than the high lift pumps which increases the potential for operational problems.

Generator House: When the Sunggal Treatment Plant was commissioned in December 1970, all power requirements were provided by three generators, each having a capacity of 350 kVA. Two of these working together were capable of supplying the full power requirements, with the third available as stand-by.

In December 1978, power was obtained from the city supply and the generator house and equipment are now being maintained in working order for stand-by purposes.

Field Tests

The expansion of the Sunggal water treatment plant, which involved the construction of a second clearator and eight additional filters, was expected to increase the capacity of the plant from 300 l/s to 600 l/s. The absence of flow meters at the plant makes it difficult to verify these figures or to determine the capacity of the clearators and filters from existing records. For this reason two field tests were conducted to determine the total capacity of the plant, and the individual capacities of the old and new clearator and filter units.

Both tests were conducted by pumping raw water into the plant and filtered water out of the plant at a constant rate while temporarily diverting the filtered water from one clearator/filter set to a drain so that only the flow from the other clearator/filter set entered the clearwell. Flow entering the plant was estimated from the rated capacity of the raw water pumps, and the flow through each set of filters was estimated from the rated capacity of the treated water pumps and from the change in water level in the clear well during the test.

Test # 1

The average rates of flow through the old and new filters measured during this test were 282 l/s and 142 l/s, respectively. Additional flow measurements are shown in Figure 2.5. It was observed during this test that the rate of flow through the new filters decreased very rapidly after backwashing.

Test # 2

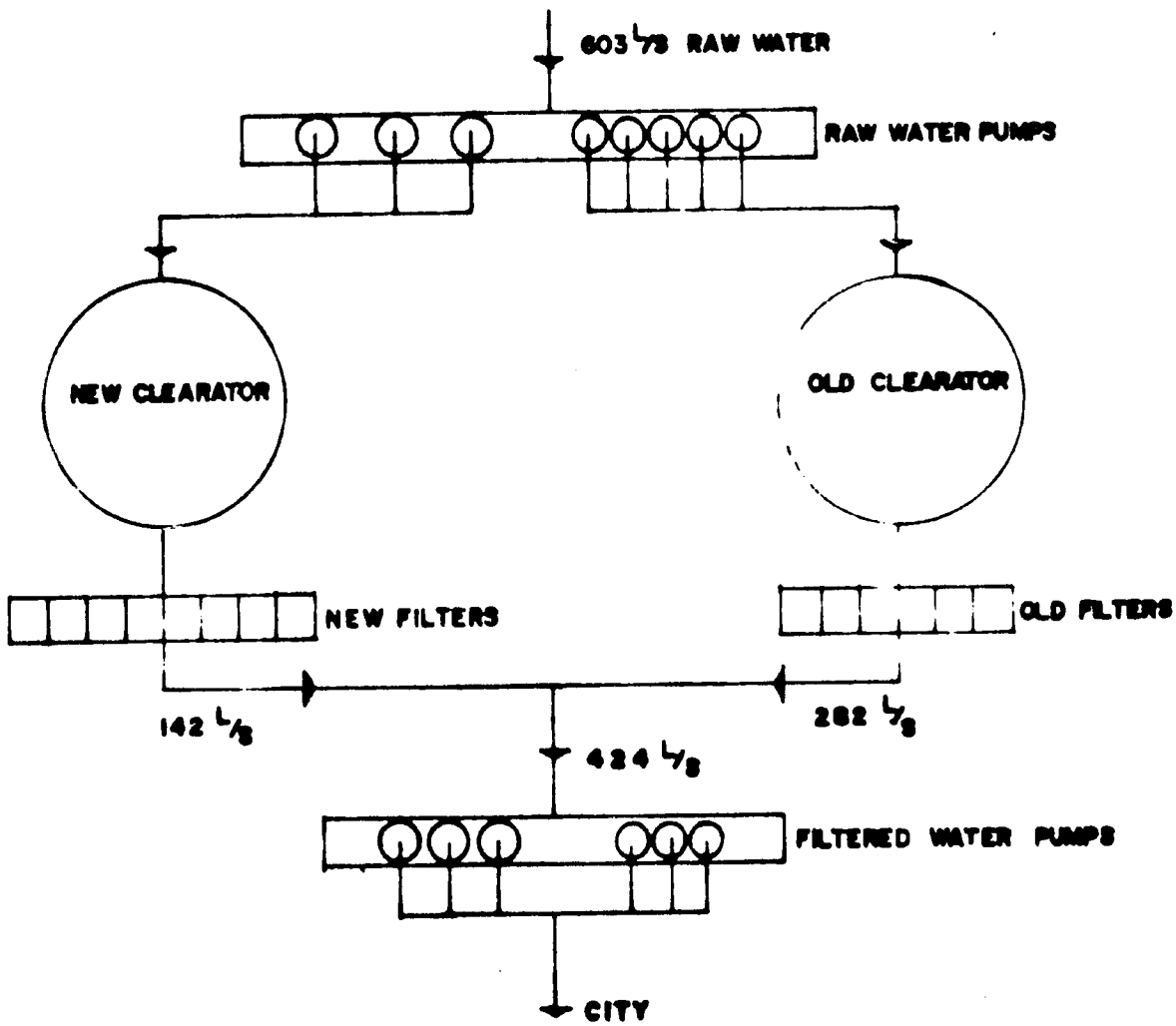
The second test was made after an additional transmission line had been placed in service and the plant output had been increased to its full capacity. All raw water and treated water pumps had been placed in operation, including stand-by units. In order to determine the unit flows more accurately, this test was conducted over a five day period beginning on 10 May, 1979. The average rates of flow through the old and new filters measured during this period were 230 l/s and 310 l/s, repectively. Additional flow measurements are shown in Figure 2.6 and the daily flow measurements are shown in Figure 2.7. The average filtration rates for the old and new filters during this period were 5.6 $m^3/m^2.h$ and 3.9 $m^3/m^2.h$, respectively. The amount of water used for backwashing the old and new filters was 5.4 percent and 15.8 percent of their total production, respectively.

During this test, it was observed that the performance of the clarators had deteriorated significantly as a result of the increase in flow, which exceeded their design capacity.

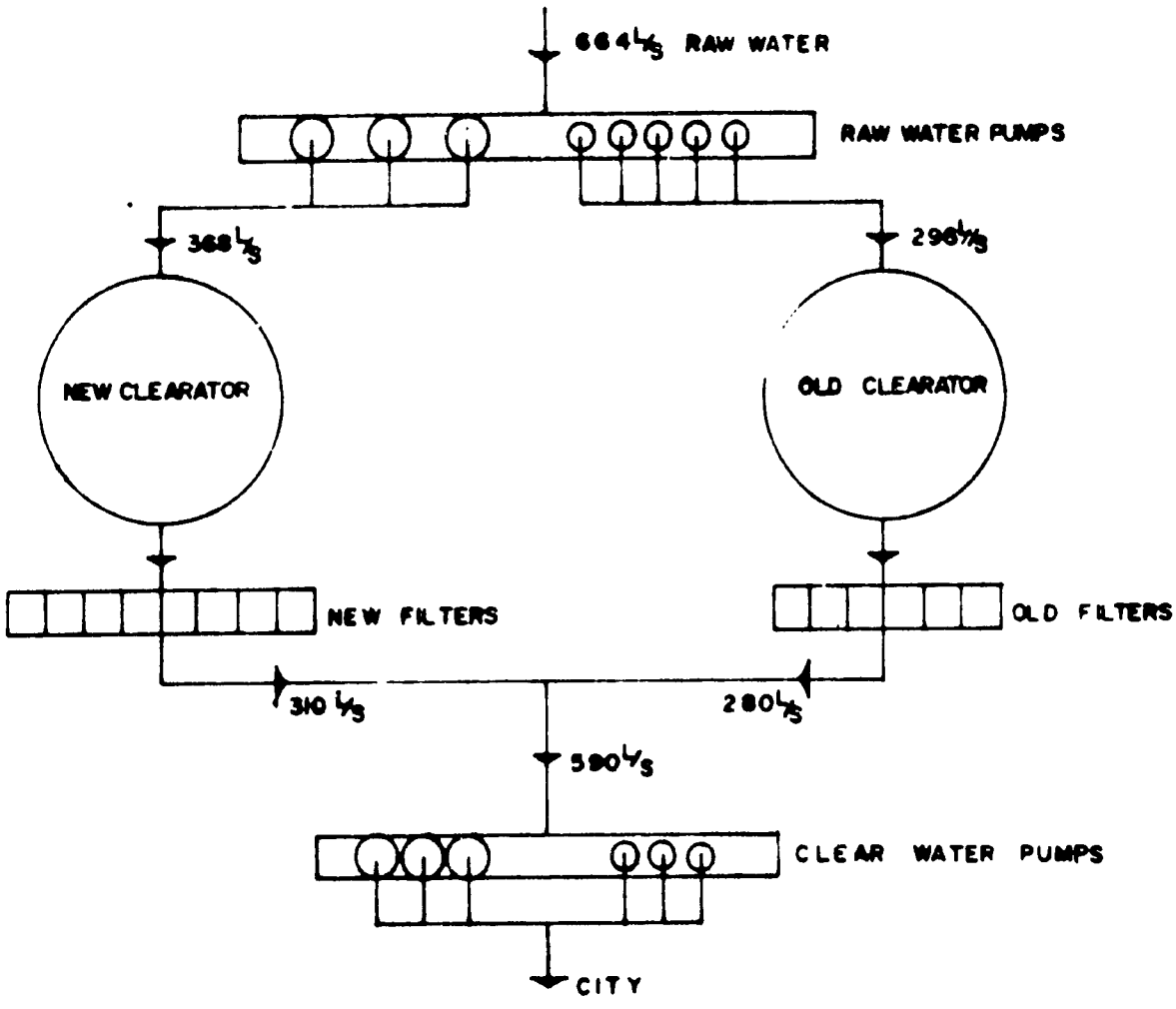
2.1.1.3 Springs Transmission Mains - Leakages Survey

A study of the transmission mains from the Sibolangit Spring to Medan was undertaken to ascertain whether there are any serious leakage losses between the sources and the city. The distance between the city and these sources is approximately 37 km and there are about 157 km of pipe used for transmission. The number of pipes varies between three and six in various sections, and the transmission lines are interconnected at several points. Pipe sizes vary between 150 mm and 400 mm, and different sections contain cast iron, ductile iron, steel and asbestos cement pipe.

FLOW CONFIGURATION OF SUNGGAL PLANT
DURING TEST Nº 1



FLOW CONFIGURATION OF SUNGGAL PLANT
DURING TEST N° 2



3/2

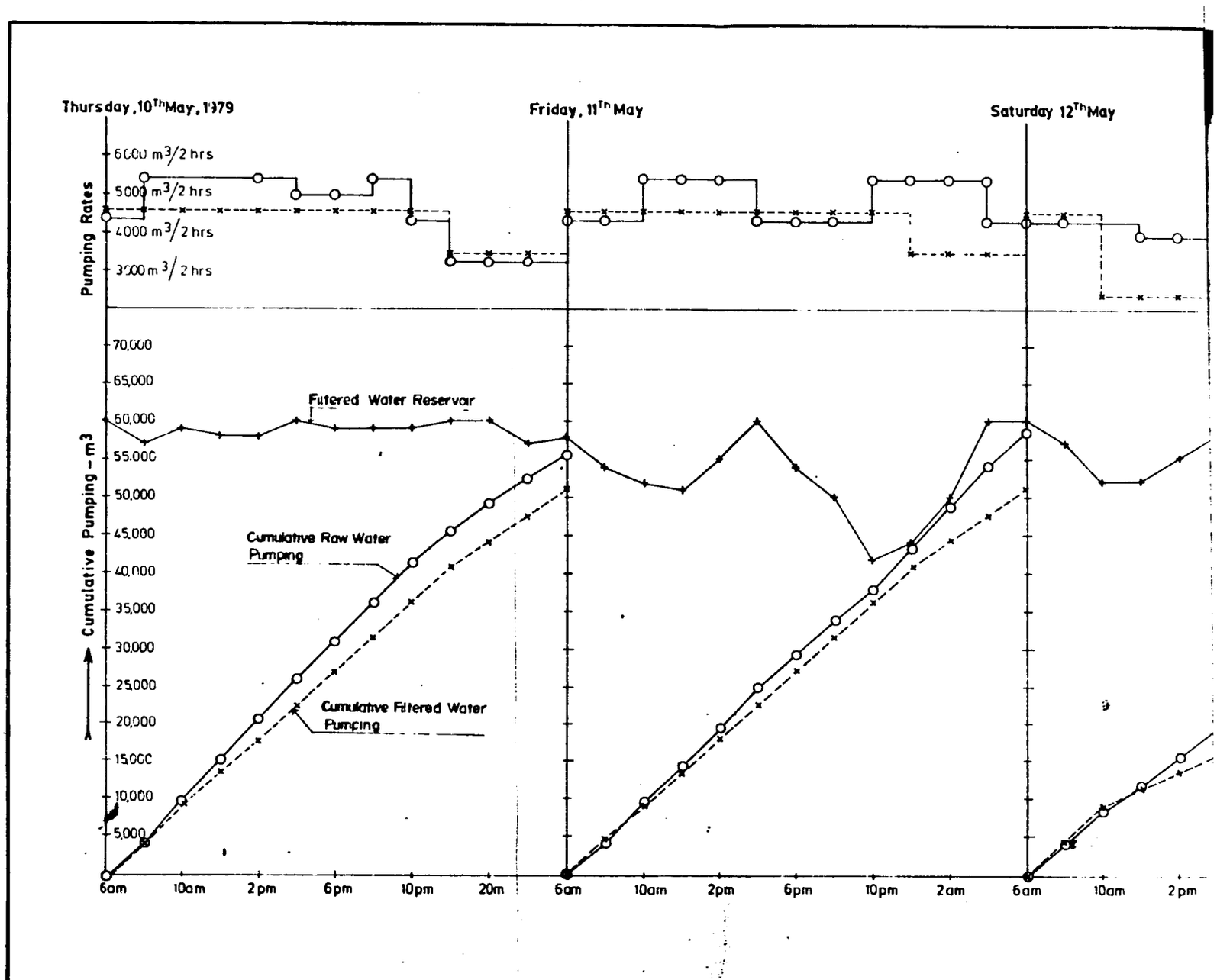


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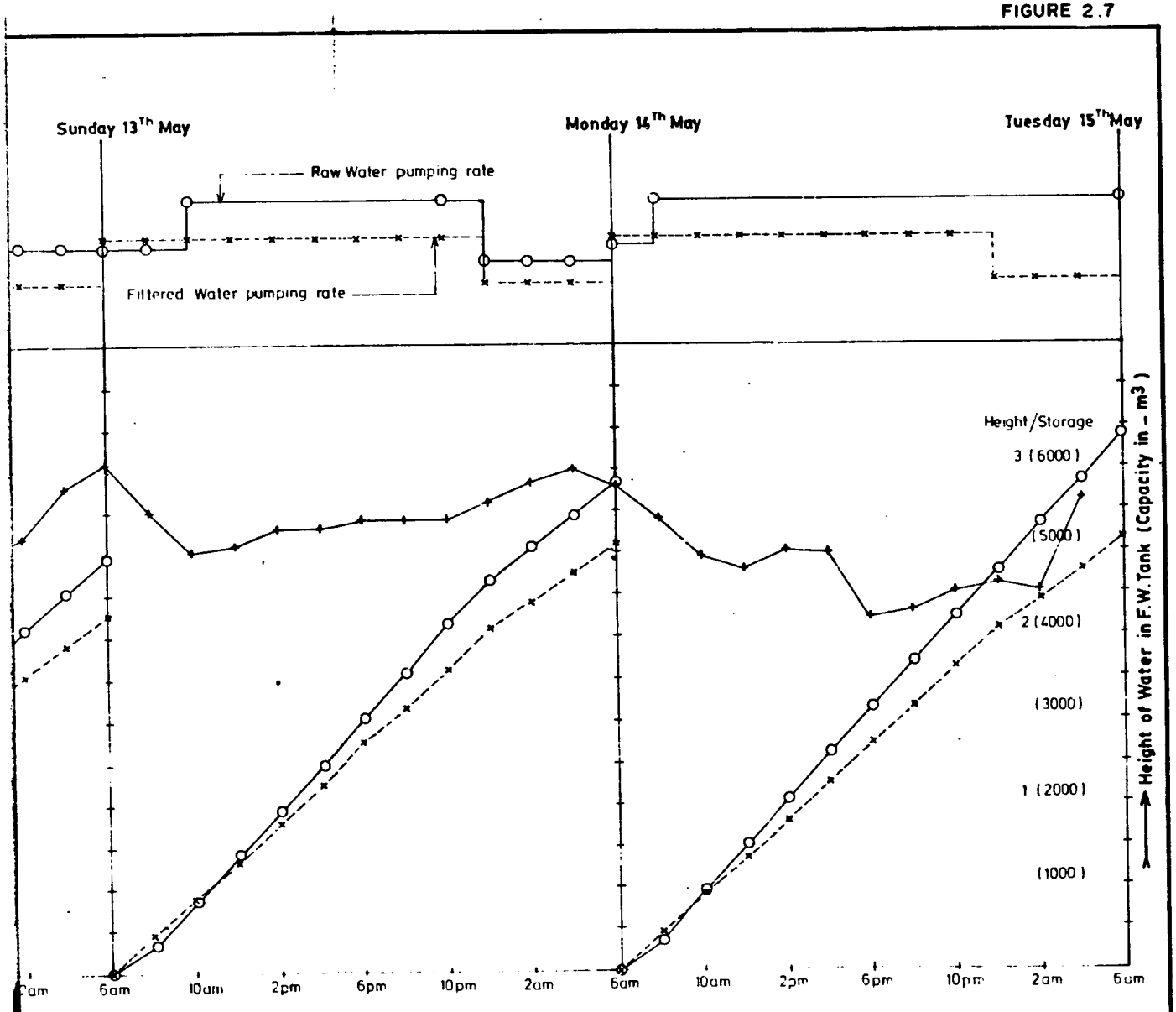
FIGURE 2.7



SUNGGAL WATER TREATMENT PLANT
DAILY FLOWS - TEST No. 2

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Three pipelines enter the city. They are as follows:

1. At Johor

   a. One 400 mm diameter cast iron line which divides at this point to east and west, serving as distribution mains.

   b. One 375 mm diameter line which proceeds through the Polonia area to the site of the elevated tank and booster station. It acts as a transmission and distribution main.

2. At Deli Tua

   One 325 mm diameter cast iron line entering the city a few kilometers north of Deli Tua and proceeding directly to the elevated tank and booster station site. This line also serves as a distribution main before reaching this site.

To determine whether there was any serious leakage occurring, the flows at the source and at the entry to the city had to be measured. There are ten flow meters installed on the transmission mains, three of which are at the points of entry to the distribution system. The other seven are near the spring sources. The meters on the distribution system were installed in 1974, and those near the sources were installed in 1978. One problem encountered in evaluating leakage losses was that these flow meters are frequently out of order. However, all meters were found to be in operation from 10 December, 1978 to 21 January, 1979 and from 22 February, 1979 to 18 March, 1979. The records for these periods indicated that the average flow entering the transmission lines was 557 l/s, and the average flow entering Medan was 536 l/s. There are two branch lines at intermediate points to serve Batu and Binjai. The average total flow withdrawn by these two lines was 8 l/s. The leakage during the period investigated was therefore (557-536-8) = 13 l/s which represents 2.3 percent of the total supply. Several small leaks were observed where air release valves had been installed.

2.1.1.4 Wells

The municipal water supply uses groundwater drawn from six wells in Belawan. These wells and three others have been transferred to PAM Tirtanadi from the Belawan Port Authority. These six wells produce

about 3,000 m^3/d for 1,500 building connections. All but one of the wells are stopped each night between 10:00 pm and 6:00 am. The six producing wells have been recently renovated.

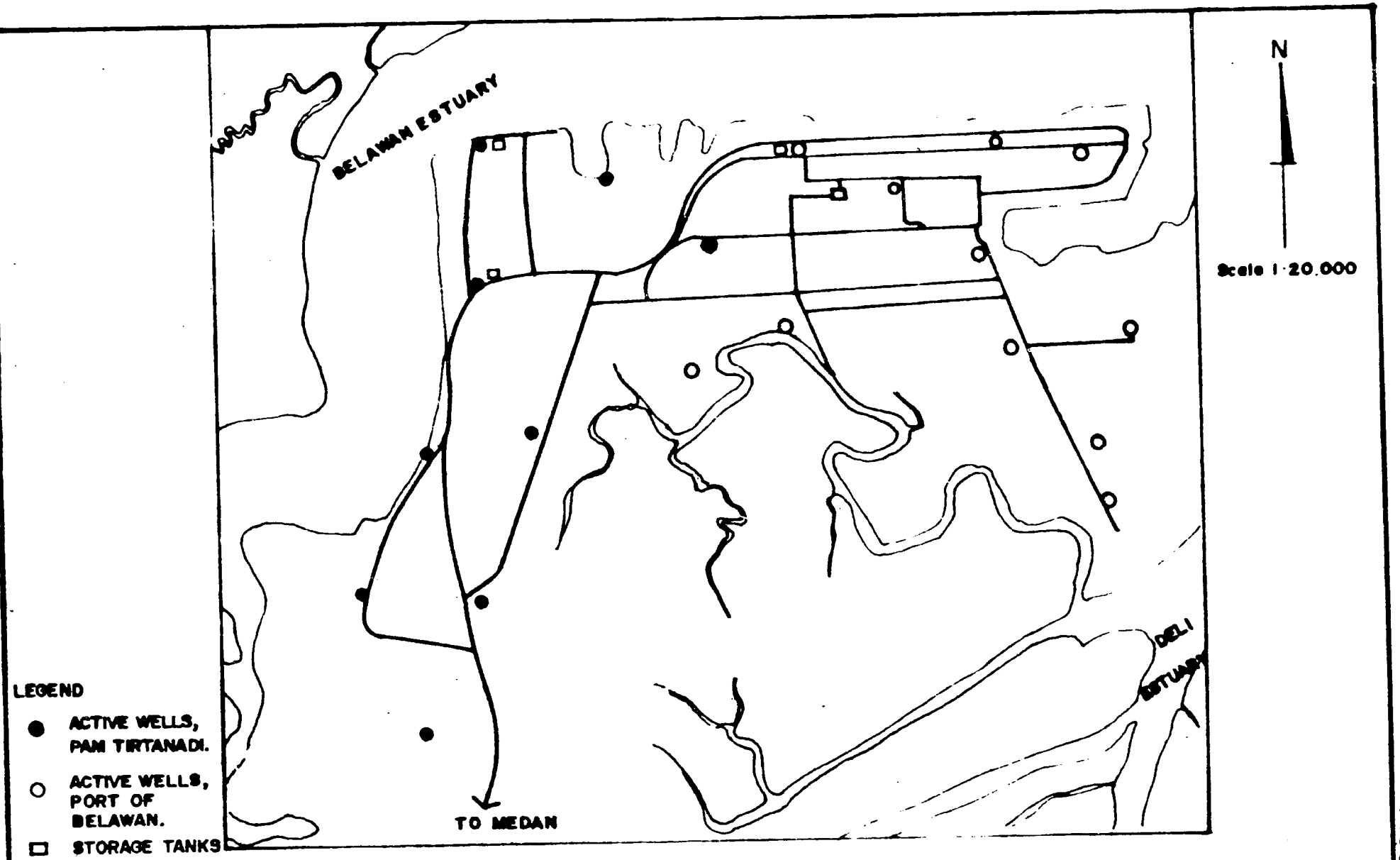
Location and Number: The nine wells transferred from the Belawan Port Authority to Tirtanadi are located in the western third of Belawan as shown in Figure 2.8. Of the original nine, three are inactive or abandoned, although the properties are under Tirtanadi's control. Distances between operating wells vary from 400 m to 600 m with a maximum distance of 2,200 m between the northernmost (No.5) and southernmost (No.12) wells. All wells lie within a few metres of sea level, and all sites have been raised with artificial fill.

The numbering system applied to the wells is based on that used by the Port Authority and generally indicates the order of their construction (Well No.1 the earliest, No.20 the most recent).

Description of Facilities: Since all of the Tirtanadi wells were constructed before 1972, the basic design of most reflect an older production method using the natural artesian pressure in the intermediate and deep aquifers. Wells Nos. 4, 5, 6, 9, 11, and 12 have large chambers to receive artesian flows, from which pumps deliver water into the distribution system (see Figure 2.9).

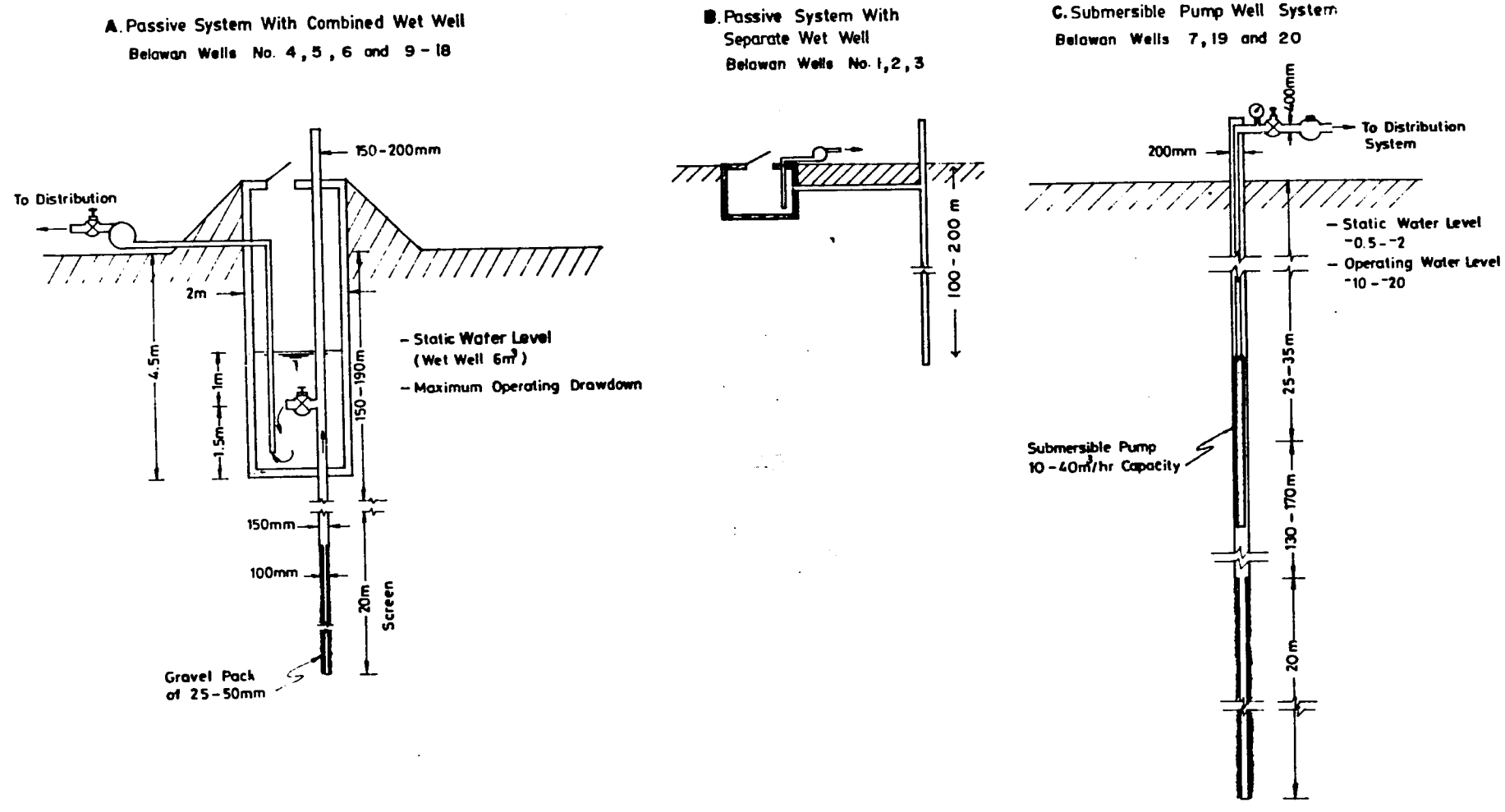
Declining artesian pressure within the aquifers has reduced or stopped flow into the chambers. When Tirtanadi assumed control of the wells in west Belawan, seven wells were cleaned and renovated. As part of the renovation, the wells, except for Nos. 3, 4, and 8, were fitted with submersible pumps and chlorinators, and the chambers are no longer used. These modifications have greatly increased the quantity of water for municipal supply. Wells Nos. 5, 9, 11, and 12 have been fitted with sand filters in order to reduce turbidity entering the distribution system. Well No.6 pumps directly to the elevated tank on Belawan Road, and Wells No.7 pumps small quantities directly into the distribution system.

All six operating wells and Well No.4 have full-time operators stationed at the well site. Operator housing forms a typical part of all Belawan well facilities operated by Tirtanadi and the Port of Belawan.



MAP OF WELLS AND MAJOR DISTRIBUTION FACILITIES FOR BELAWAN

FIGURE 2.8



TYPES OF WELLS
USED IN BELAWAN

A summary of the general features of the Tirtanadi Belawan wells is presented below.

Well Number	Date Drilled	Depth (m)	Rated Pump Capacity (m^3/d)	Production (m^3/d)
3[a]	1966	114	-	-
4[a]	1950	120	-	-
5[b]	1950	130	680	713
6	1950	145	12	-
7	1952	145	133	136
8[a]	1961	120	-	-
9[b]	1962	130	750	744
11[b]	1971	106	740	942
12[b]	1971	110	820	825

a. in-active
b. equipped with filter and chlorinator

Production, Quality, and Operation: Production from the Tirtanadi Belawan Wells is summarized in Table 2.2, and well water quality is summarized in Table 2.3. Water quality at these pumping rates and periods appears suitable for continued potable uses, although the overall quality is slightly poorer than that of the river and spring water above Medan.

Major operational duties involve switching the submersible pumps on and off for each day's operation. Flow meter and electrical power recordings are taken each day, and these are presented by the well operators each week to the Tirtanadi office in Belawan. Any power failures or other irregular operations are also indicated in these weekly reports. Water quality samples are taken each month and analysed at the Tirtanadi laboratories.

Evaluation and Recommendations: Tirtanadi operations reflect the standard operating procedures followed by the Port of Belawan and the distribution system limitations. Wells No. 3, 4, and 8 are inactive,

TABLE 2.2

PRODUCTION OF TIRTANADI WELLS IN BELAWAN

Well No.	Production (1000 m^3/mo)																	Mean (m3/d)
	1977		1978												1979			
	N 30	D 31	J 31	F 28	M 31	A 30	M 31	J 30	J 31	A 31	S 30	O 31	N 30	D 31	J 31	F 28	M 31	
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	1.3	1.4	1.5	1.5	1.7	1.7	1.4	1.4	-	-	-	-	-	-	-	-	-	49[a]
5	15.0	17.9	18.5	18.5	22.9	23.2	22.7	23.2	23.4	22.7	22.2	22.2	24.0	23.0	23.6	20.8	24.2	713
6	0.4	0.4	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11[a]
7	3.9	3.2	6.7	2.4	5.2	3.3	2.1	2.0	1.4	4.5	4.9	5.5	5.4	5.5	5.5	4.0	5.0	136
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	27.7	28.2	27.5	23.8	26.2	24.2	23.9	21.6	22.1	18.3	23.0	22.1	17.5	19.3	20.1	18.1	20.7	744
11	27.1	28.1	29.9	26.7	30.6	27.2	29.1	27.8	28.7	29.2	27.1	28.2	28.7	29.7	30.6	27.5	30.0	942
12	25.0	32.4	34.6	28.0	29.7	28.5	28.9	27.8	24.7	23.5	20.7	21.1	20.6	20.1	19.6	18.8	21.6	825
Total	100	112	119	101	116	108	108	104	100	98	98	99	96	98	99	89	102	3420

a mean production for months operated

TABLE 2.3

GROUNDWATER QUALITY - WELLS SUPPLYING
CENTRAL DISTRIBUTION SYSTEM
BELAWAN

Parameter	Unit	Well Number				
		5	7	9	11	12
Date		1978	1978	1978	1978	1978
Time		Range	Range	Range	Range	Range
Temperature	°C	31 - 33	30.5 - 32.0	27 - 32	29 - 32	30.5 - 32.5
Turbidity	FTU	0.05 - 0.2	0.02- 0.4	0.02 - 2.5	0.02 - 0.2	0.02 - 0.1
pH		7.1 - 7.8	7.3 - 7.8	7.3 - 7.8	7.3 - 7.8	7.1 - 7.8
Total alkalinity	mg/l	98 - 240.5	100 - 246.5	100 - 230	95 - 228	95 - 240.5
Bicarbonate alkalinity	mg/l	97 - 253.8	119 - 244.0	144 - 218.7	140.6 - 229.2	146.4 - 315.0
Carbon dioxide	mg/l	8.6 - 43.7	10.7 - 69.6	18.0 - 63.9	12 - 66.9	14 - 68.6
Hardness	mg/l	23.3 - 57.6	26.9 - 62.7	25.1 - 61.6	31.0 - 67.5	26.9 - 58.2
Calcium	mg/l	3.4 - 13.7	1.2 - 9.21	4.2 - 15.7	4.4 - 13.0	4.0 - 13.2
Magnesium	mg/l	1.3 - 8.7	1.5 - 9.6	1.4 - 9.0	1.7 - 10.0	1.7 - 8.2
Chloride	mg/l	ND - 6.0	ND - 7.9	0.8 - 6.4	1.8 - 15.8	1.9 - 7.2
Conductivity	μ mho/cm	208 - 290	209 - 276	209.5 - 253.5	201 - 261.5	219.5 - 264.5

although No.3 and 4 could be renovated for future production. Well No.8 appears to be too small for efficient municipal use and should be formally abandoned, but abandonment does require cleaning of the well and proper sealing and covering to prevent possible contamination of the major aquifers. Since residential water demand is high near Well No.8, a new production well on this site could be useful in the future.

Continuous operation of Wells No.9, 11, and 12 could equal the total production of the interrupted schedule for all six production wells (3,400 m^3/d). If all wells were operated continuously, water could be pumped southward through the existing and proposed transmission pipelines along the Medan-Belawan corridor.

Power is provided by the normal street distribution systems which are subject to numerous power outages, usually resulting from the loss of secondary transformers. In order to better assure uninterrupted pumping, each well should have powerlines from two different secondary and preferrably primary transformers or substations.

The four major production wells are fitted with pressurized sand filters in order to reduce turbidity. However, monitoring of turbidity or pressure drop across the filters has not been conducted and no basis of design has been found for the filters. Generally, turbidity in well water should be quite low. Therefore, after appropriate monitoring of water turbidity in the casing of each well and from the distribution system adjacent to the well, the continued use of the pressure filters should be reviewed. Removal of the pressure filters would increase the flow from the wells and the pressure within the distribution system.

Present well monitoring practices include daily readings of flow and electric power meters. A large amount of data regarding efficiency of the well operations, is available, and a simple compilation of the water produced per kilowatt hour would provide an important measure of well and pump efficiency. In addition to these daily records, measurements of water levels in the wells before switching off in the evening and before starting up in the morning should be taken each week to calculate the well capacity (m^3/d per metre of drawdown). Comparisons of well capacity and the week long production and power consumption would

quickly indicate if a well or pump were losing efficiency. These data would also serve as part of a data base for a long-term study of the Belawan aquifers and for selection of new well sites.

Major cost items within the operations and capital improvements for the wells of Tirtanadi include the housing and salary for fulltime, on-site operators at each well. Although this provides great security, the well equipment is generally not subject to vandalism, and enclosure of well facilities should be considered as an adequate alternative. One well inspector could be located full-time at one well and, with a vehicle (e.g. motorbike or pedal bicycle), could easily reach and inspect all wells in less than two hours in the morning and two hours in the evening.

2.1.1.5 Distribution System

Service Area: The existing Medan water system operated by m/s Tirtanadi mainly serves the presently developed residential and commercial areas of the city and Belawan. The service area covers:

1. Kecamatan Medan Kota, Medan Baru, Medan Barat, and Belawan almost fully
2. Kecamatan Medan Sunggal, Medan Timur, Medan Johor, and Medan Denai partially
3. A narrow strip along the road leading from Medan to Belawan.

Distribution Network: The existing network can be broadly divided into trunk mains 200 mm or more in diameter and feeder mains 175 mm or less in diameter.

Though not divided into a grid of any definite geometrical pattern, there is a major trunk main of 300 mm diameter or more running along the outer boundary of the service area and other trunk mains within (see Figure 2.10). Given below is a summary of the trunk mains in the city of Medan, the lengths given being in metres.

1. Medan

Diameter	Steel	Cast Iron	Ductile Iron	Asbestos Cement	PVC	
200 mm	4,300	7,750	4,450	1,440	1,000	
225 mm	-	740	-	-	-	
250 mm	2,400	18,830	2,455	-	4,540	
300 mm	-	2,190	14,540	-	-	
325 mm	-	2,100	-	-	-	
375 mm	-	4,960	-	-	-	
400 mm	4,000	-	2,700	-	-	
	10,730	36,570	24,145	1,440	5,540	78,425 m

2. From Medan to Belawan

   13,500 m of 250 mm pipe (up to Labuhan) and
   3,200 m of 200 mm pipe (all cast iron)

3. Belawan

   4,400 of 200 mm pipe (cast iron)

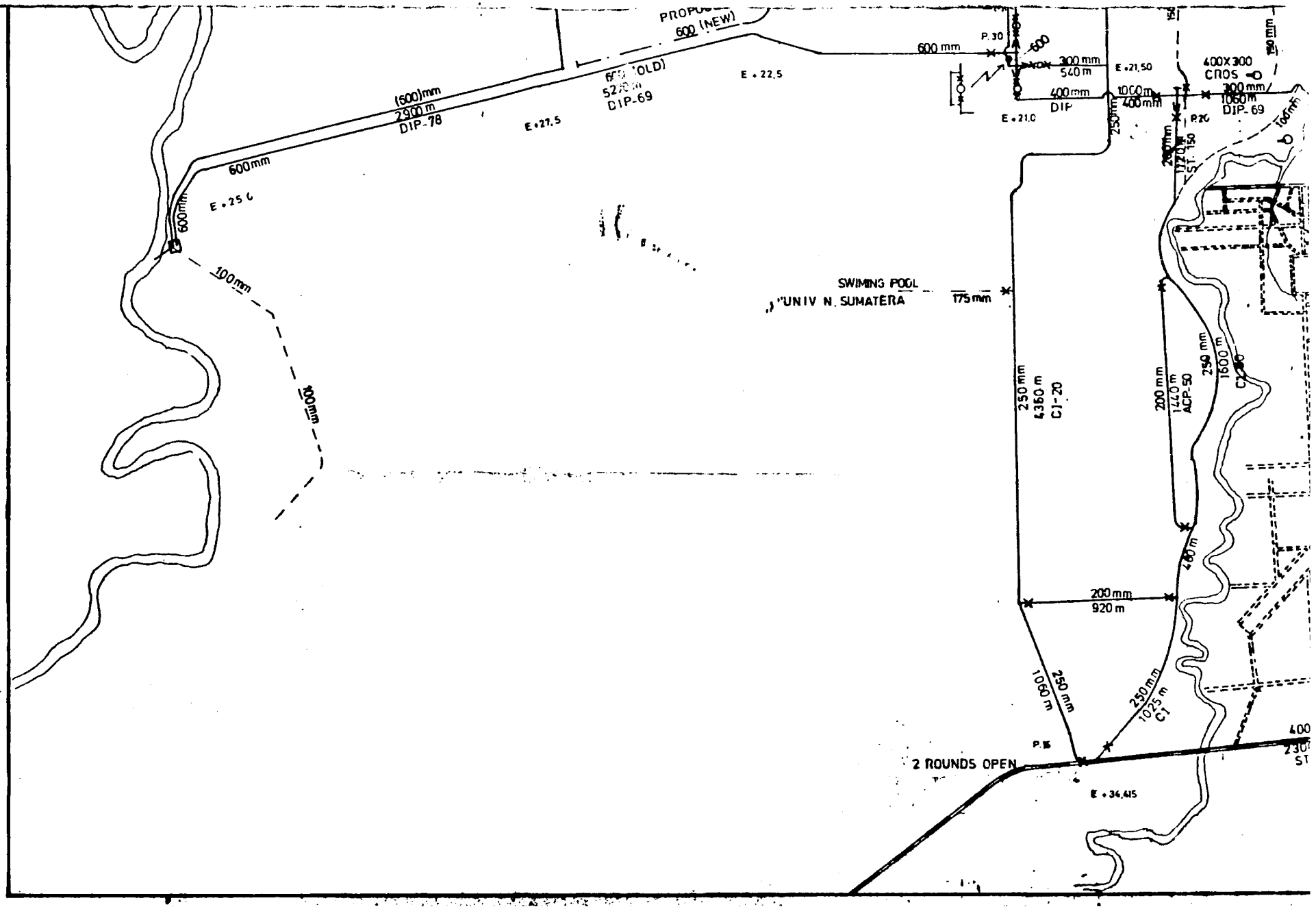
The age and estimated condition of these pipes are summarized below:

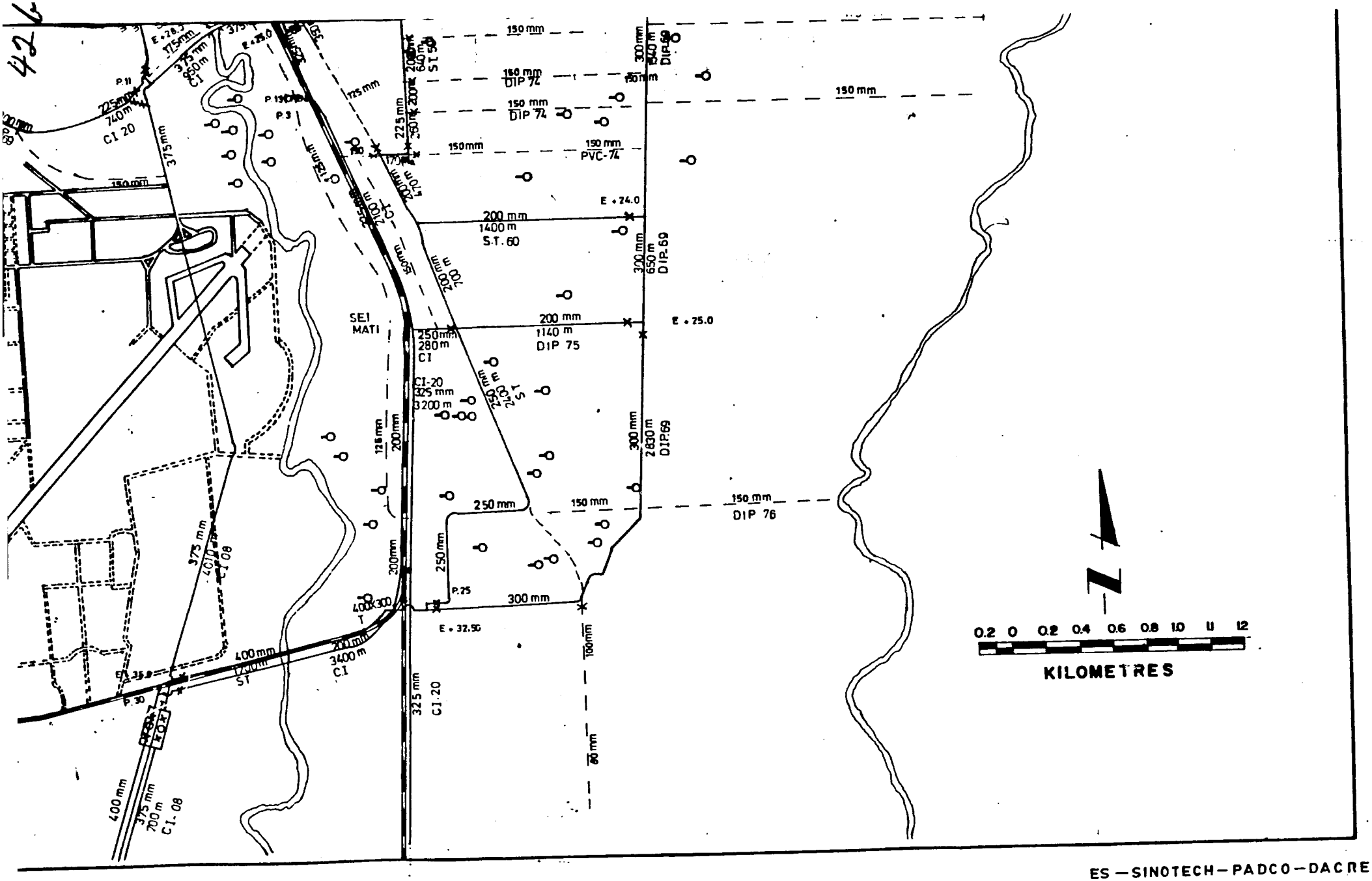
Pipe Material	Age	Estimated Hazen Williams "C" Value
Steel	20 - 30 years	80 - 95
Cast Iron	30 - 70 years	65 - 90
Ductile Iron	1 - 10 years	110 - 120
Asbestos Cement	1 - 10 years	120
PVC	1 - 5 years	130

According to Tirtanadi, the practice of scraping the larger mains was carried on regularly until 1977 when it was abandoned due to insufficient pressure to wash the lines. It is assumed that the mains have been maintained at least moderately well and that the reduction in the Hazen-Williams "C" values is due to the normal aging process.

Spring water reaching the booster station and storage tower site is either pumped into the elevated storage tank or allowed to flow by gravity into the ground level storage tanks. Water from the ground

42a


PROPOSED
600 (NEW)
(600)mm
2900 m
DIP-78
600 (OLD)
DIP-69
600mm
E + 25.6
E + 27.5
E + 22.5
600 mm
P. 30
300 mm
540 m
400mm
DIP
E + 21.50
E + 21.0
1000 m
400mm
400X300
CROS
300 mm
1060m
DIP-69
P.20
ST. 150
100mm
SWIMING POOL
UNIV N. SUMATERA
175mm
250 mm
4360 m
C1-20
200 mm
1440 m
ACP-50
250 mm
1600 m
C1-20
480 m
200 mm
920 m
250 mm
1060 m
250 mm
1025 m
C1
P.15
2 ROUNDS OPEN
E + 34,415



ES — SINOTECH — PADCO — DACREA

42C

TRUNK MAINS IN WATER DISTRIBUTION SYSTEM

LEGEND

250 mm = PIPE DIAMETER

4350 M = LENGTH OF PIPE SEGMENT

CI-20 — CI = PIPE MATERIAL; 20 = DATE INSTALLED (ie 20 = 1920)

CI = CAST IRON PIPE

ACP = ASBESTOS CEMENT PIPE

DIP = DUCTILE IRON PIPE

RAILROAD TRACKS

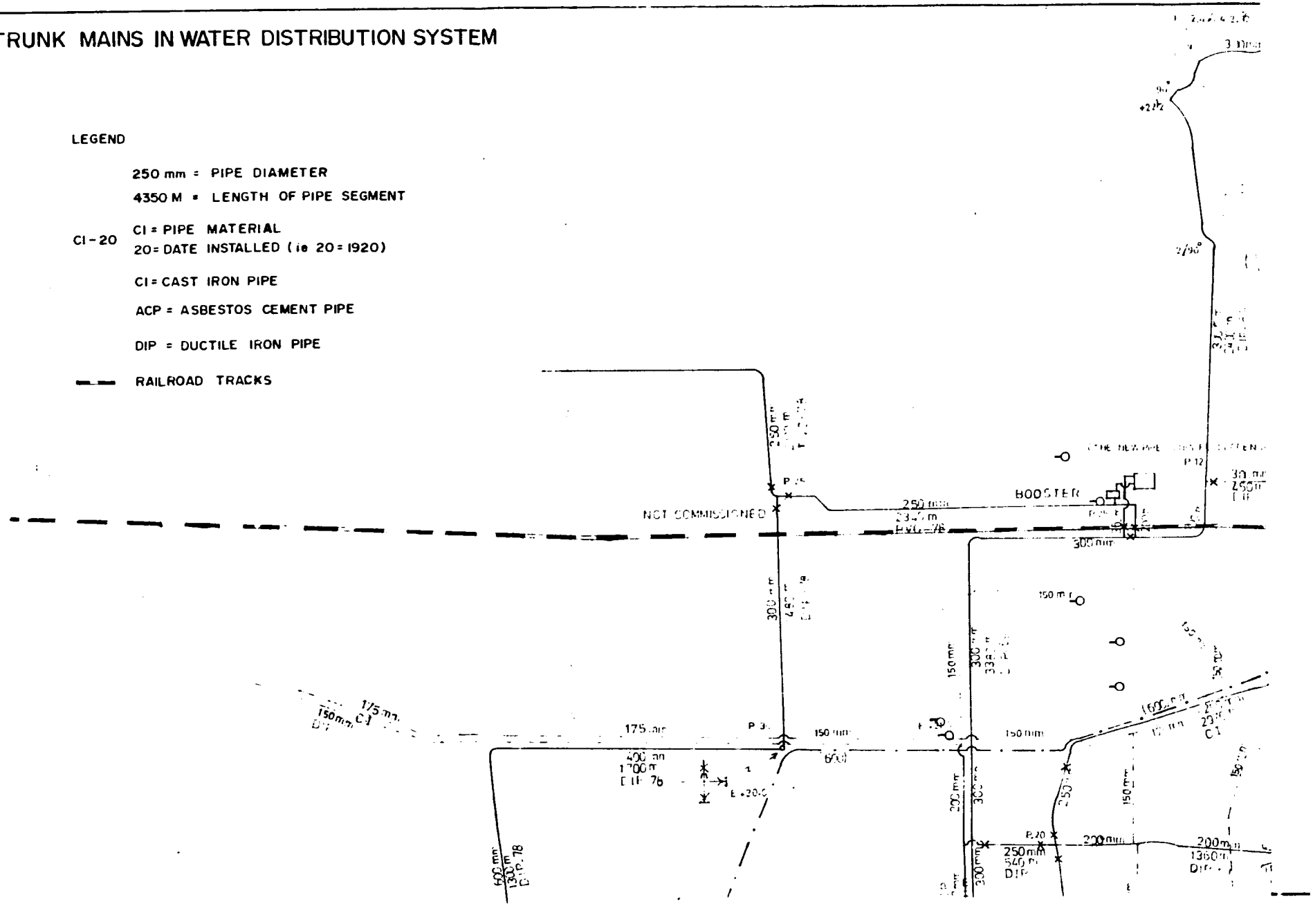
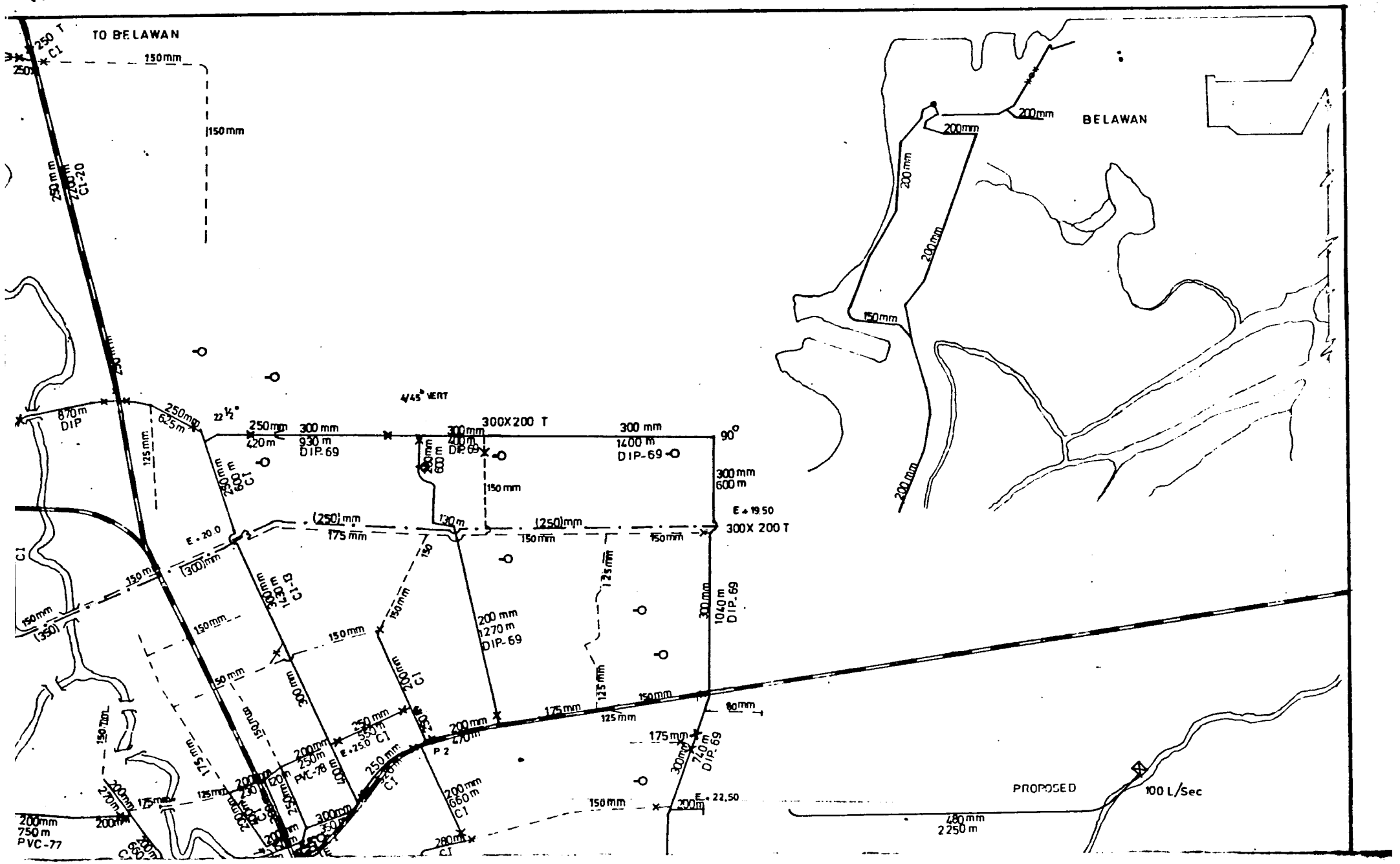


FIGURE 2.10


TO BELAWAN
BELAWAN
PROPOSED
100 L/Sec
300X200 T
300X 200 T
870m DIP
930 m DIP-69
1400 m DIP-69
1270 m DIP-69
1040 m DIP-69
740 m DIP-69
750 m PVC-77
PVC-78
660 m C1
2250 m
4/45° VERT
22½°
90°
E = 20.0
E = 19.50
E = 22.50
E = 25.0
P 2

tanks can either be pumped into the elevated tank or into the distribution system.

One major problem is that certain sections of the three major transmission lines which supply water to these storage tanks are very old and have gradually deteriorated to the extent that flow through these mains has become markedly restricted. The 375 mm diameter line from Johor to the storage tank site and the 325 mm line from Deli Tua to this site are both cast iron and are 60 and 70 years old, respectively. Water reaching these tanks from the Sunggal treatment plant must flow through a 740 m length of 225 mm diameter cast iron pipe which is nearly 60 years old. The reduction in the capacity of these lines is indicated by the slow rate at which the storage tanks fill at night.

Storage

The absence of adequate storage capacity is one of the major deficiencies of the existing system. Water from both supply sources is brought in at a nearly uniform rate, by gravity flow from the springs and by 24 hour pumping from the Sunggal plant. The minimum storage requirement is roughly 25 percent of the total daily demand, or about 24,500 m^3. The storage currently provided in the system is as follows:

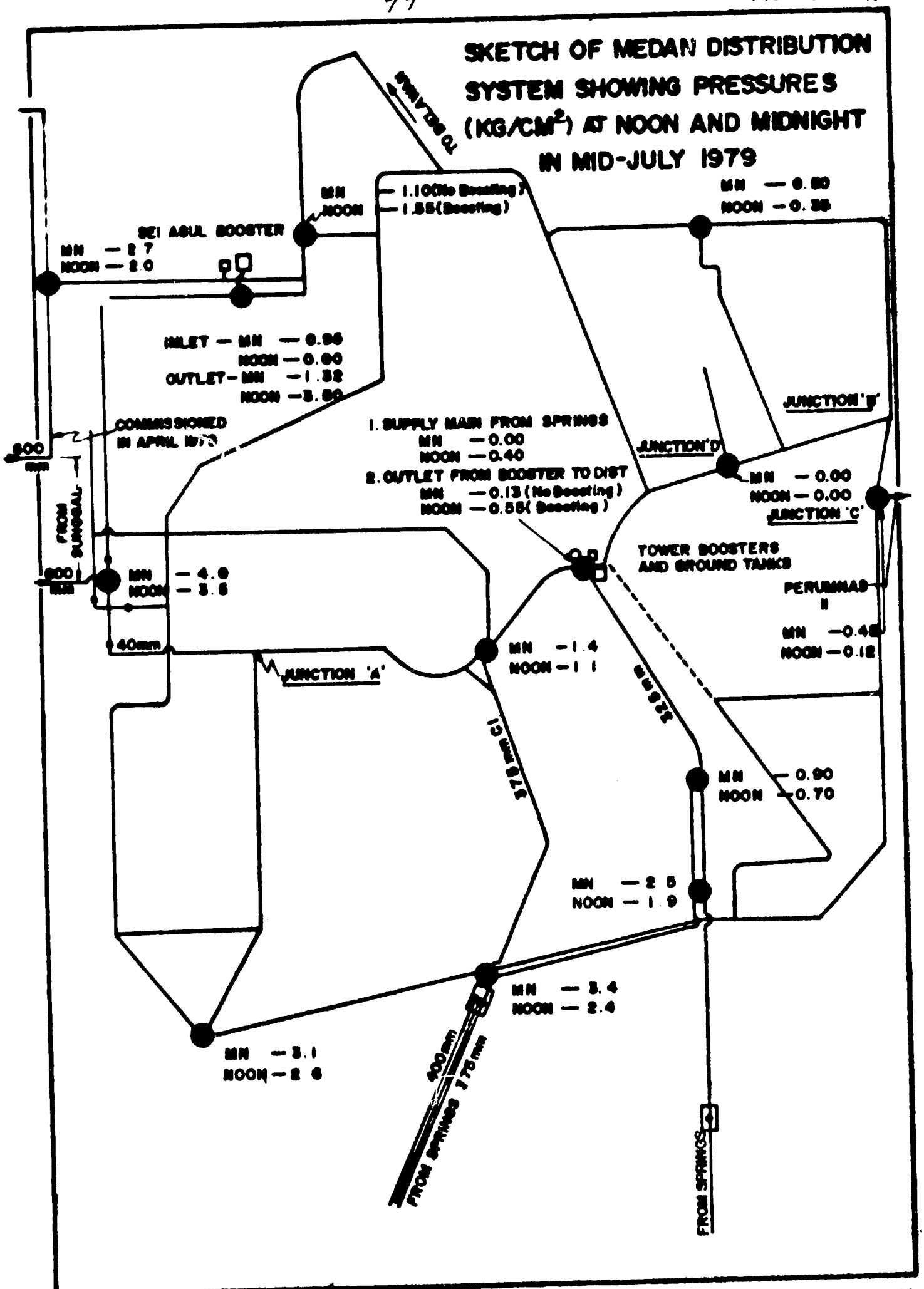
Ground Tanks	3,500 m^3
Elevated Tank	1,200 m^3
Sei Agul Booster	1,400 m^3
	6,500 m^3

This indicates that at least (24,500 m^3 - 6,500 m^3) = 18,000 m^3 of additional storage capacity is needed. Immediate action should be taken to correct this problem.

Pressure

The system pressures were measured at many locations in Medar during July, 1979. The information obtained is shown in Figure 2.11. In general, the pressures measured in the western and southern areas of the city were adequate throughout the day while the central and northern areas had significantly lower pressures that were often inadequate during peak demand periods.

FIGURE 2.11


SKETCH OF MEDAN DISTRIBUTION SYSTEM SHOWING PRESSURES (KG/CM²) AT NOON AND MIDNIGHT IN MID-JULY 1979
TO BELAWAN
MN — 1.10(No Boosting)
NOON — 1.55(Boosting)
MN — 0.50
NOON — 0.25
SEI AGUL BOOSTER
MN — 2.7
NOON — 2.0
INLET — MN — 0.96
NOON — 0.00
OUTLET — MN — 1.32
NOON — 3.50
JUNCTION 'B'
COMMISSIONED IN APRIL 1973
1. SUPPLY MAIN FROM SPRINGS
MN — 0.00
NOON — 0.40
2. OUTLET FROM BOOSTER TO DIST
MN — 0.13 (No Boosting)
NOON — 0.55 (Boosting)
JUNCTION 'D'
MN — 0.00
NOON — 0.00
JUNCTION 'C'
FROM SUNGGAL
TOWER BOOSTERS AND GROUND TANKS
MN — 4.0
NOON — 3.5
PERUMNAS II
MN — 0.45
NOON — 0.12
40mm
JUNCTION 'A'
MN — 1.4
NOON — 1.1
325mm
378mm CI
MN — 0.90
NOON — 0.70
MN — 2.5
NOON — 1.9
MN — 3.4
NOON — 2.4
MN — 3.1
NOON — 2.6
400mm
FROM SPRINGS 175mm
FROM SPRINGS

Present Improvement Programs: The following improvements are being implemented by Tirtanadi in 1979:

1. A 400 mm ductile iron pipeline will be laid from the Ground Tank junction to Junction 'D' and a 350 mm asbestos cement line from Junction 'D' to Junction 'B' (see Figure 2.10).

2. Quotations have been called for the supply of 400 mm ductile iron pipes to be laid between Junction 'A' and the Ground Tank junction.

The above improvements will result in more water from Sunggal being brought to the ground tanks and to the eastern part of the city, but the lack of adequate storage will prevent full use to be made of these additional mains. The work is expected to be completed in the latter part of 1980.

Standpipes, Fire Hydrants and Sluice Valves: Almost all trunk mains have been provided with gate valves at the junctions, most of which are kept fully open. One valve, at the south-west corner of the network is kept almost closed (with just 2 round open), to keep the springs water and the Sunggal water separate. The reasons for maintaining this separation are not known. Diversion of water to the low-supply areas by manipulation of valves is not done.

Some of the valves which could be inspected showed signs of rusting and disrepair, apparently as a result of long periods of non-use. The major sluice valves at the junction of the supply mains and the distribution network are housed in covered chambers which are usually kept locked. Pressure gauges and meters are generally provided close to these valves. The valves, meters and pressure gauges are maintained in fairly good condition.

Ninety-three metered standpipes are provided in the city. The water consumed is paid for by the Kepala Lorong (the heads of the subdivisions which Kampungs consist of). However, many densely populated, low income residential areas are without standpipes.

According to information obtained from the Fire Department the number of fire hydrants was increased from approximately 1360 in 1974 to more than 3000 in 1978. However, because of inadequate system

pressure, only 55 hydrants were in working condition in April 1978.

Water Supply to Belawan: A 250 mm pipeline runs from the northern end of the service area (close to the Sei Agul booster station) towards Belawan. At Labuhan the pipe changes to 200 mm diameter. The total length between Medan and Belawan is approximately 16,500 m. There is a small network of nearly 4,400 m of 200 mm pipes within Belawan.

Due to the low pressure in Medan, it is not likely that any appreciable amount of water from Medan reaches Belawan. Most of the water is probably used up by the residents in the narrow strip of developed area on either side of the Medan-Belawan highway.

The Belawan service area has two elevated storage tanks of about 100 m^3 capacity each. The system pressures have not been measured but appear to be adequate.

Services and Meters: At the end of 1978, the municipal system had 36,363 service connections. The population served by these is estimated to be approximately 220,000, representing about 22% of the total population.

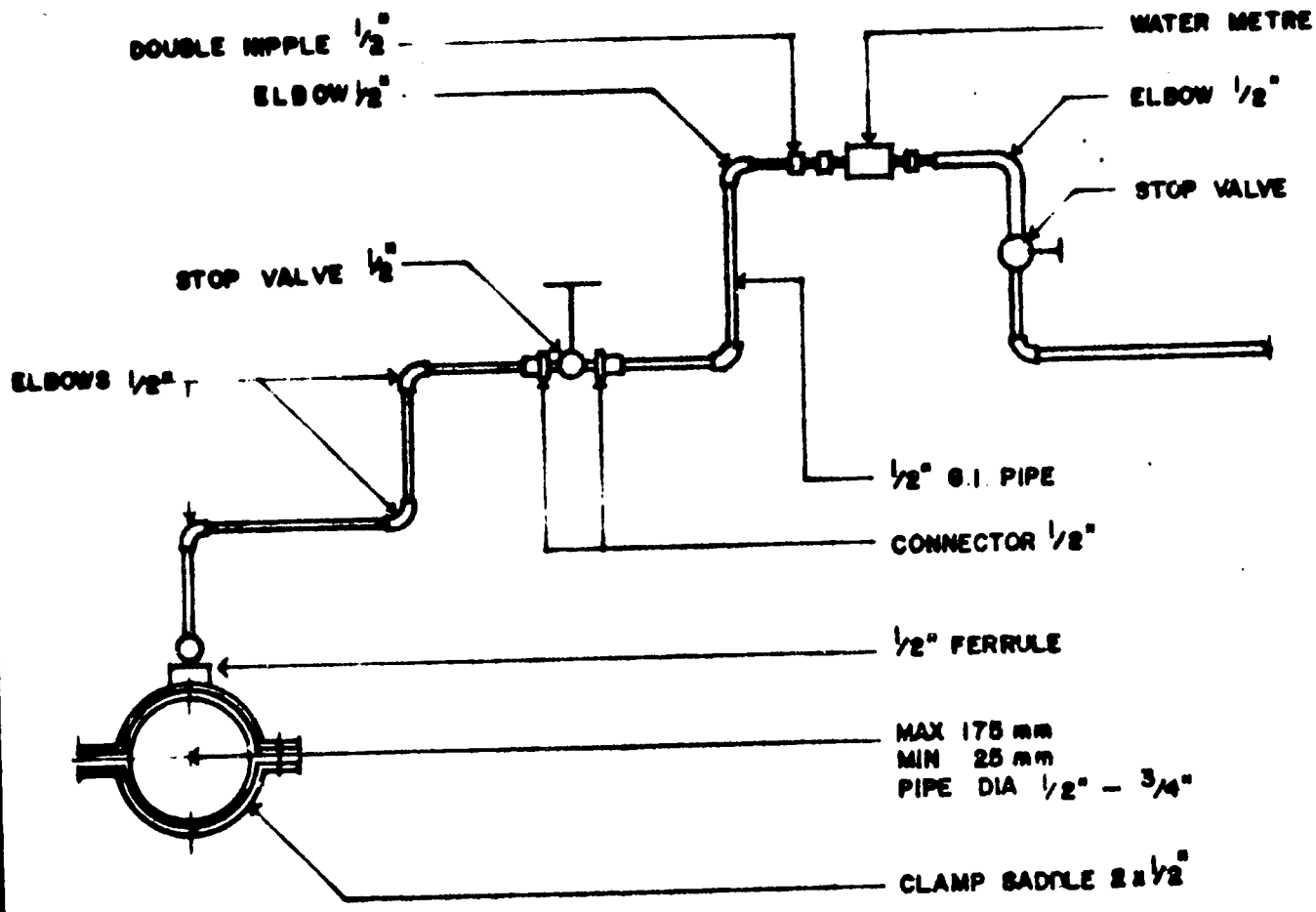
Most service connections are direct screwed — in type ferrules except in the case of PVC mains where saddles are used.

Most of the meters provided are manufactured by Kent Ltd. and are suitably installed and located for making convenient, regular readings and for carrying out repairs. The standard service connection is illustrated in Figure 2.12.

2.1.2 Other Water Supply Systems

2.1.2.1 Belawan Port Authority

The Belawan Port Authority operates a system of wells to supply water to residents, offices and industries within the Port Authority area. There are eight wells currently in operation. Prior to April of 1978, the average total production of these wells was about 6,000 m^3/d (70 l/s). Of this amount, 53 l/s were used by the Port Authority and 15.9 l/s were given to Tirtanadi for municipal supply outside the Port Authority area. After April of 1978, the Port Authority stopped supplying water to Tirtanadi. Since that time, records indicate that



THE STANDARD EXISTING SERVICE CONNECTION

the amount of water produced and distributed by the Port Authority has increased to about 6,500 m^3/d (75 l/s).

2.1.2.2 Commercial, Industrial and Institutional

About 60 percent of the total non-residential water requirements are met by Tirtanadi; most of the remaining 40 percent is obtained from private deep wells. About 90 percent of the water required by the government and its affiliated organizations is supplied by the municipal system and the balance from deep wells. In the case of commercial and and industrial organizations, 45 percent of the requirements are met by the municipal system, the balance being obtained from deep wells. The details of construction, operation, yield, aquifer characteristics, and quality of existing deep wells in the study area are dealt with elsewhere in this report.

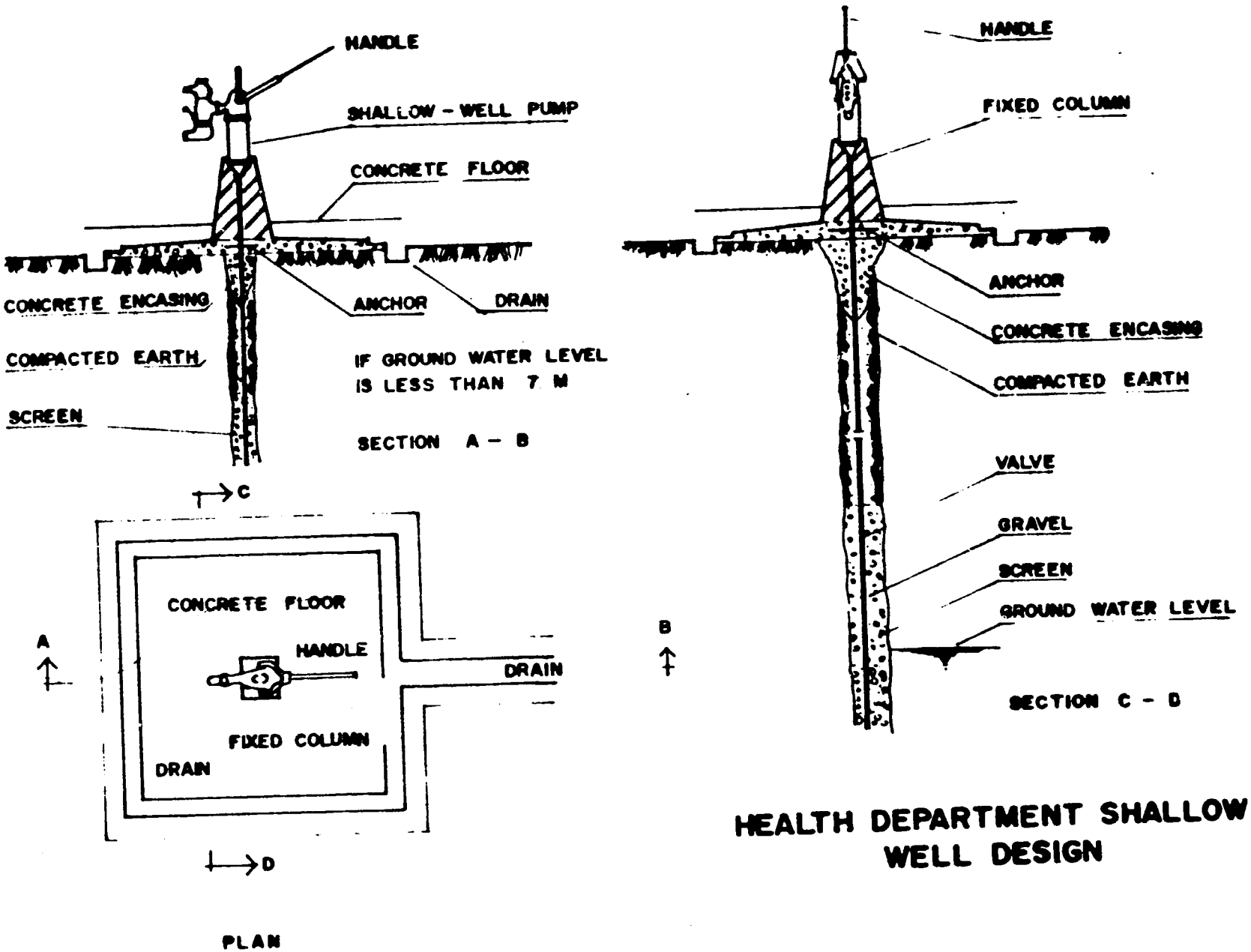
2.1.2.3 Individual Domestic

Out of the total 1978 population of 1,070,000 of the city, approximately 220,000 obtain their daily water needs from the municipal water supply system. It is estimated that the balance obtain water from shallow wells and surface streams as follows:

Predominant Residential Type	Source of Supply	Estimated Water Use (l pcd)	Estimated Population (and Percentage of Total Population)
Middle income, Medium density	Shallow well for individual household	100	700,000 (66%)
Low income, High density	River, standpipes and public shallow wells	35	150,000 (14%)

Shallow Wells can be divided into two broad categories:

1. Individual shallow wells built mainly by the middle income residents living in areas of medium density. These reveal a fair degree of attention to good sanitary practice although some degree of contamination is inevitable.



HEALTH DEPARTMENT SHALLOW WELL DESIGN

FIGURE 2.13

2.1.2.4 Government Shallow Well Program

A continuing goal of the Government Repelitas is to provide safe sources of public water supply in areas where it is not yet feasible to provide individual household connections. A shallow well program was carried out during Repelita II by the Public Health Department in order to increase the availability of safe water, particularly in areas where enteric disease rates are high and piped water supplies are not expected to be available within the next five years.

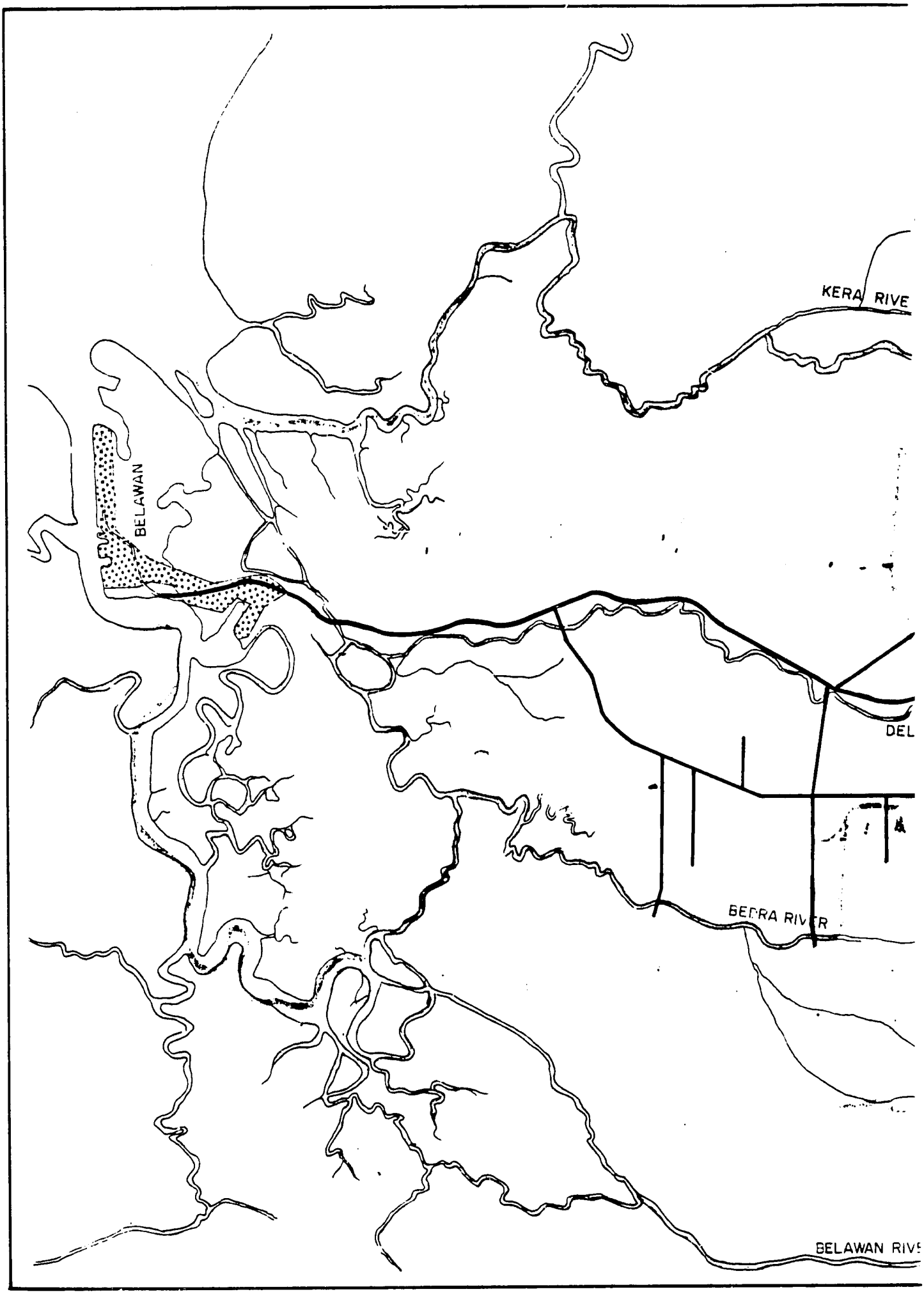
Wells constructed under this program have 32 mm diameter pipes and are properly cased with the tops sealed to prevent the entry of surface water. A concrete slab and drain are provided to maintain a dry area, free from mud, around the pump. The handpump has a pump shaft fitted with a gasket to prevent contamination and also permit the use of dual outlets. One outlet permits discharge into containers brought by the public and a valve enables the discharge to be transferred to a garden-type hose through an outlet provided for this purpose. Details of the type of well being built by the Health Department are shown in Figure 2.13.

Medan, with the low priority allotted to it, has been allocated 60 units for 1979. Each well costs approximately 140,000 Rps. Construction is generally supervised by one of the Health Department officers specially trained for this work.

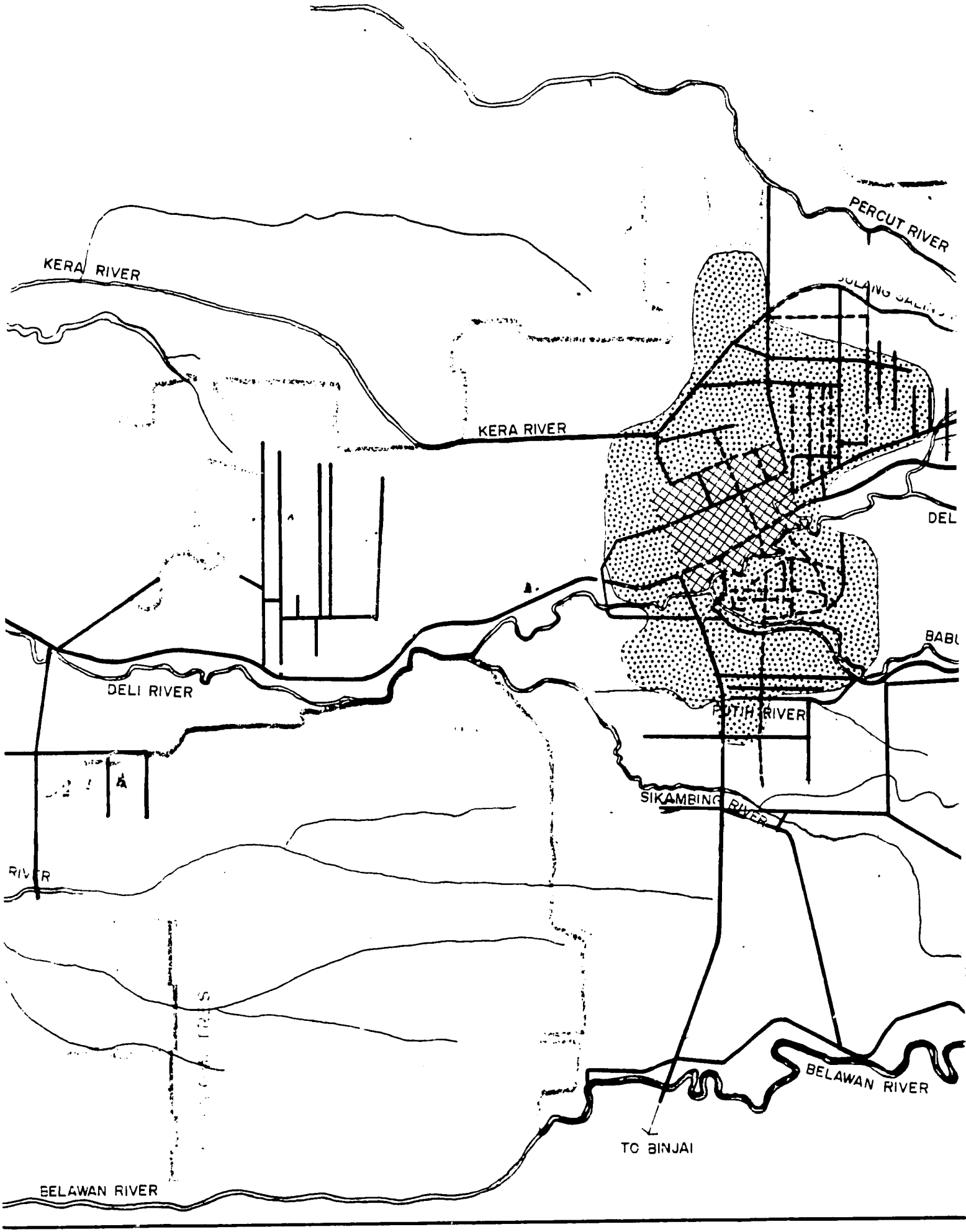
The success of this program has been limited. It has proven difficult to obtain water of acceptable quality from shallow aquifers, and many of the wells which were intended for use by the public are now in private ownership.

2.2 THE SEWERAGE SYSTEM

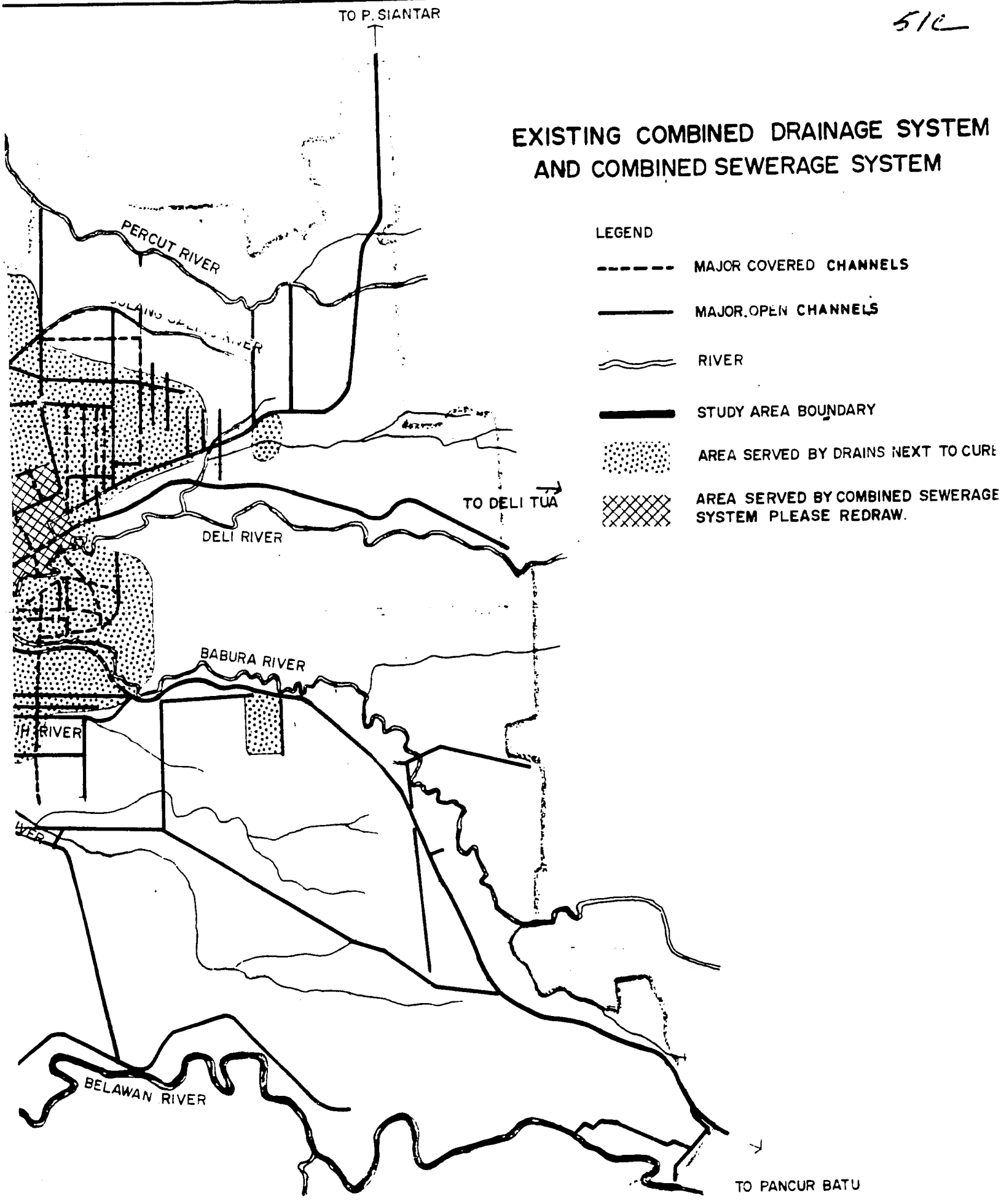
In the City of Medan, wastewater collection and disposal is provided almost entirely by a combination of surface drains and individual onsite disposal systems. Separation of wastewater flows into grey and black water components is typical throughout the city. Grey water (sink and basin drainage) is discharged to the surface drainage system which is comprised almost entirely of open roadside ditches. Black



PADCO — DACREA


PERCUT RIVER
KERA RIVER
KERA RIVER
DEL
BABU
DELI RIVER
SIKAMBING RIVER
BELAWAN RIVER
TO BINJAI
BELAWAN RIVER

5/C


EXISTING COMBINED DRAINAGE SYSTEM
AND COMBINED SEWERAGE SYSTEM
LEGEND
MAJOR COVERED CHANNELS
MAJOR OPEN CHANNELS
RIVER
STUDY AREA BOUNDARY
AREA SERVED BY DRAINS NEXT TO CURB
AREA SERVED BY COMBINED SEWERAGE SYSTEM PLEASE REDRAW.
TO P. SIANTAR
PERCUT RIVER
TO DELI TUA
DELI RIVER
BABURA RIVER
BELAWAN RIVER
TO PANCUR BATU

water (toilet wastes) are discharged to septic tanks or soak-away pit latrines. The restrictive soil conditions found in the city limit the success of these disposal systems, and a considerable quantity of septic tank effluent is entering the surface drains either directly or indirectly.

A social and economic survey carried out in Medan in 1978 and 1979 jointly by Bappeda S.U. and the provincial census and statistics office provided the following information on methods of sanitary waste disposal.

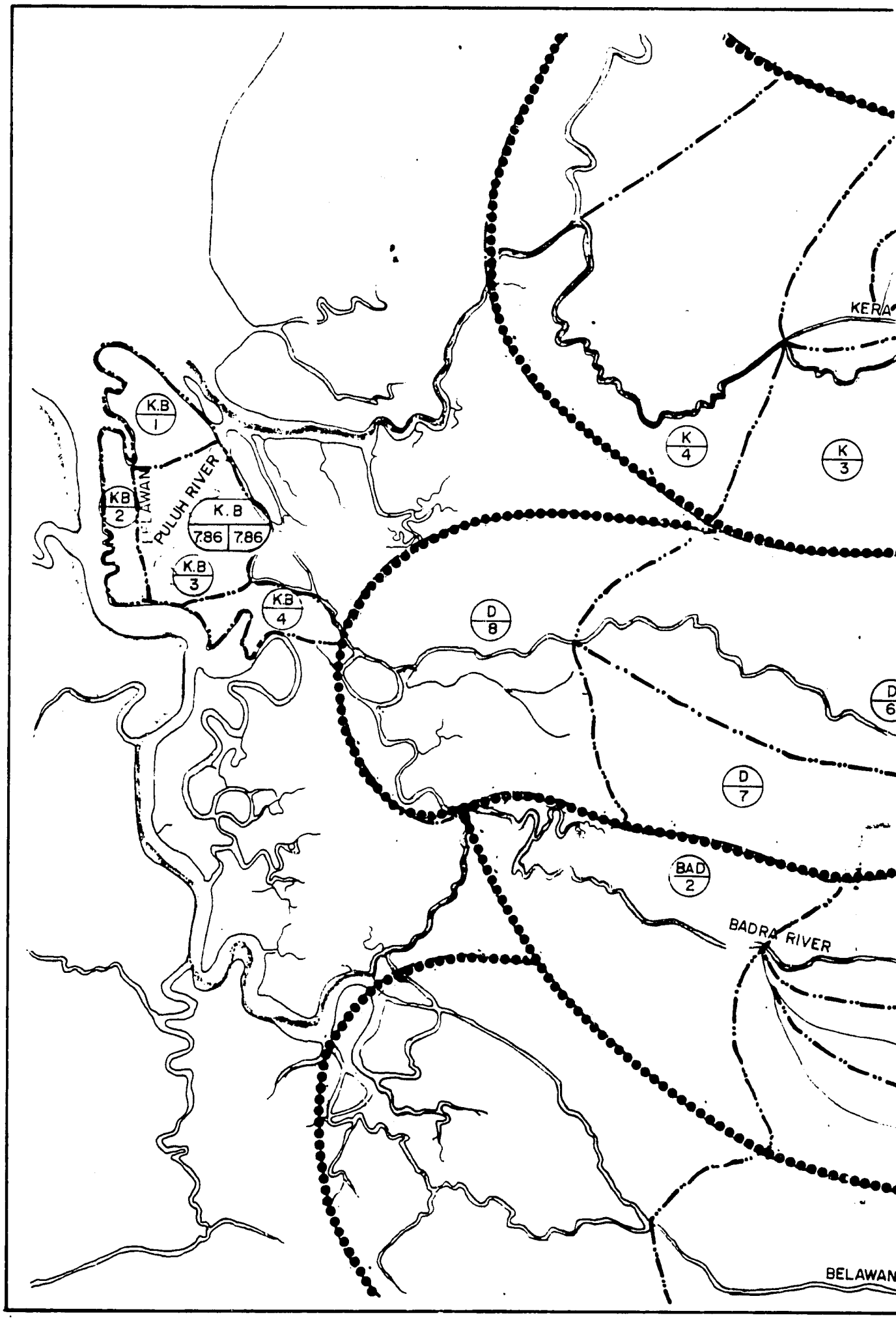
Households with toilet		84.3%
Households without toilet using:		
Streams	5.8%	
Joint use	2.8%	
Yard	1.3%	
Public toilet	1.1%	
Fish pond on rice paddy	0.2%	
Other	4.5%	15.7%

A survey of waste disposal practices in nine Kampungs carried out as part of this project generally confirmed these findings and provided additional data on areas where there are virtually no household toilets and the use of streams, yards and "other" methods for waste disposal is predominant.

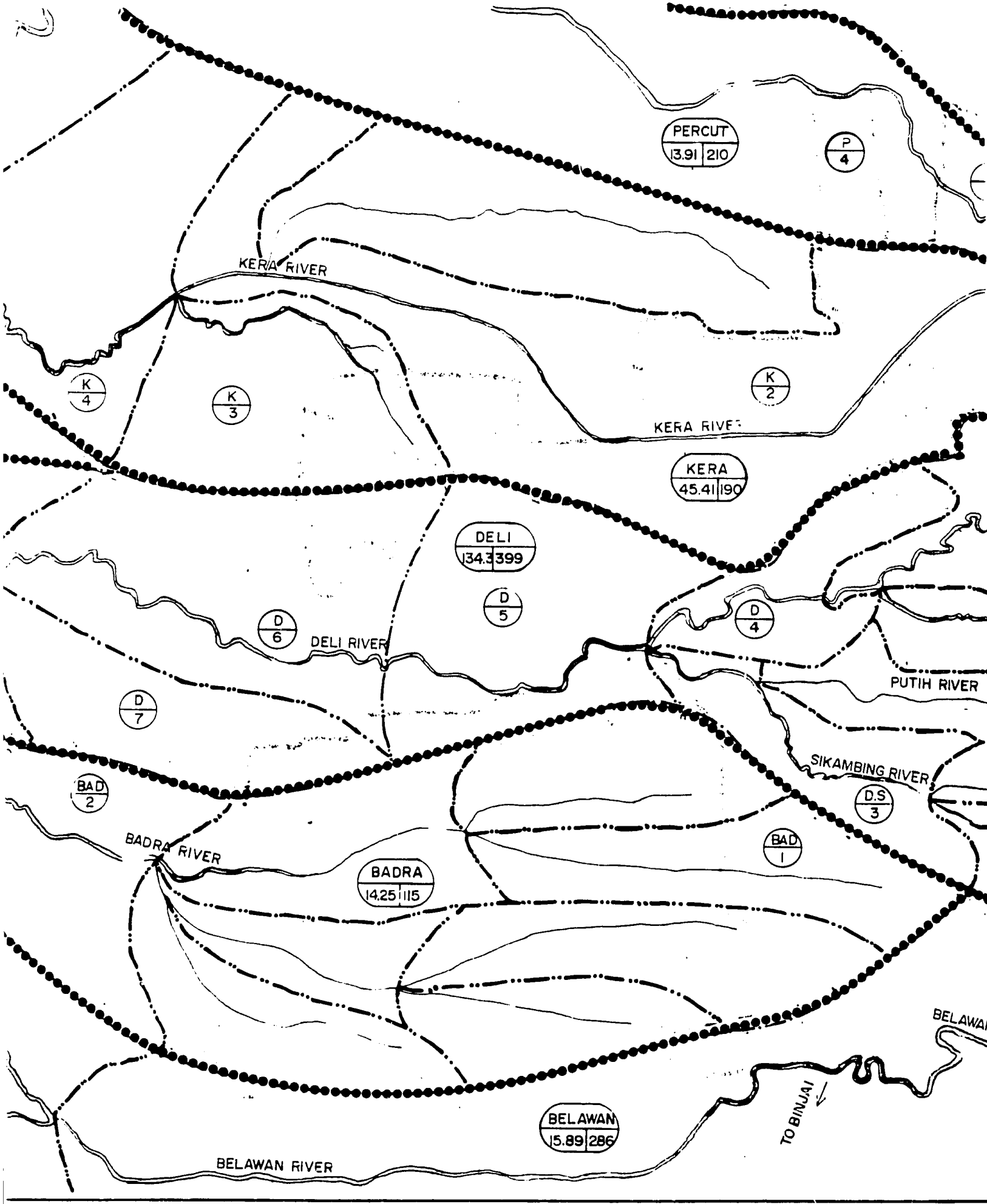
The pollution of streams and drainage ditches that enter the Deli River, which is extensively used for bathing and individual water supply, constitutes both a nuisance and a serious health hazard to the residents of Medan.

2.2.1 The Municipal Sewerage System

A small area of the city, which is shown on Figure 2.14, may be said to be served by a combined sewerage system. In this area, the connection of raw sewage discharges to underground drainage conduits was common prior to 1969. In many of the more densely populated areas of the city, the connection of septic tanks to underground conduits is presently allowed by special permit.

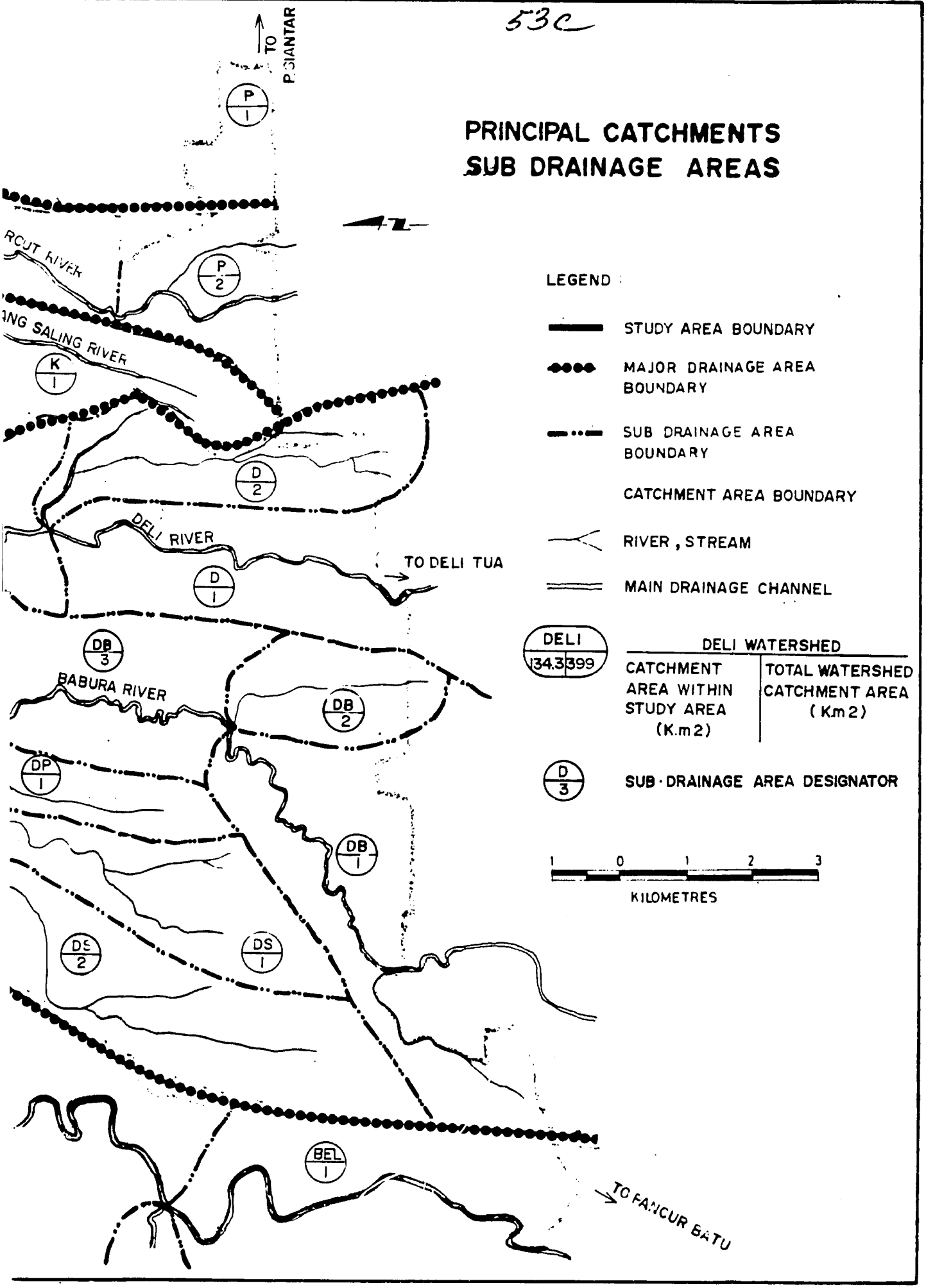


PADCO — DACREA


PERCUT
13.91 | 210
P
4
KERA RIVER
K
4
K
3
K
2
KERA RIVER
KERA
45.41 | 190
DELI
134.3 | 399
D
5
D
6
DELI RIVER
D
4
PUTIH RIVER
D
7
SIKAMBING RIVER
BAD
2
D.S
3
BADRA RIVER
BAD
1
BADRA
14.25 | 115
BELAWAN
TO BINJAI
BELAWAN
15.89 | 286
BELAWAN RIVER

53c

PRINCIPAL CATCHMENTS SUB DRAINAGE AREAS



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With these two exceptions, the City of Medan has no municipal sewerage system.

2.2.2 Other Sewerage Systems

2.2.2.1 Belawan Port Authority

The Belawan Port Authority area discharges wastes to nearby rivers and the ocean through combined drainage channels. A major expansion of port facilities is currently underway, and a site for future sewage treatment facilities has been set aside as part of the expansion plan (see Figure 2.15).

2.2.2.2 Public Facilities

The results of the Kampung survey indicated that public toilets and latrines are used by very few residents of Medan. This survey confirms the findings of the 1978-79 joint study conducted by Bappeda S.U. and the provincial census and statistics office which found that only 1.1 percent of the population used this type of facility. Moreover, the Kampung survey indicated that the demand for public facilities was very low and their use was limited to areas where no other means of disposal were available, such as very high density areas not adjacent to a stream or river.

2.2.2.3 Commercial and Industrial

A survey of commercial and industrial establishments was conducted in order to determine what practices are currently employed for the collection and disposal of wastewater from these areas. The Medan Jaya Building, a seven story structure which can accomodate up to 600 occupants, is representative of this type of establishment.

This building has a dual drainage system, as do most homes in the city. Grey water flows directly to surface drains. Black water flows to a septic tank disposal system which combines the functions of a septic tank and a cesspool. The system is comprised of two concrete tanks, each with a volume of 90 cubic meters, the bottoms of which are filled with layers of rock and fiber from palm trees. These materials act as a filter and liquid percolates into the soil. Maintenance of this sytem involves pumping each tank once every three years when the building is

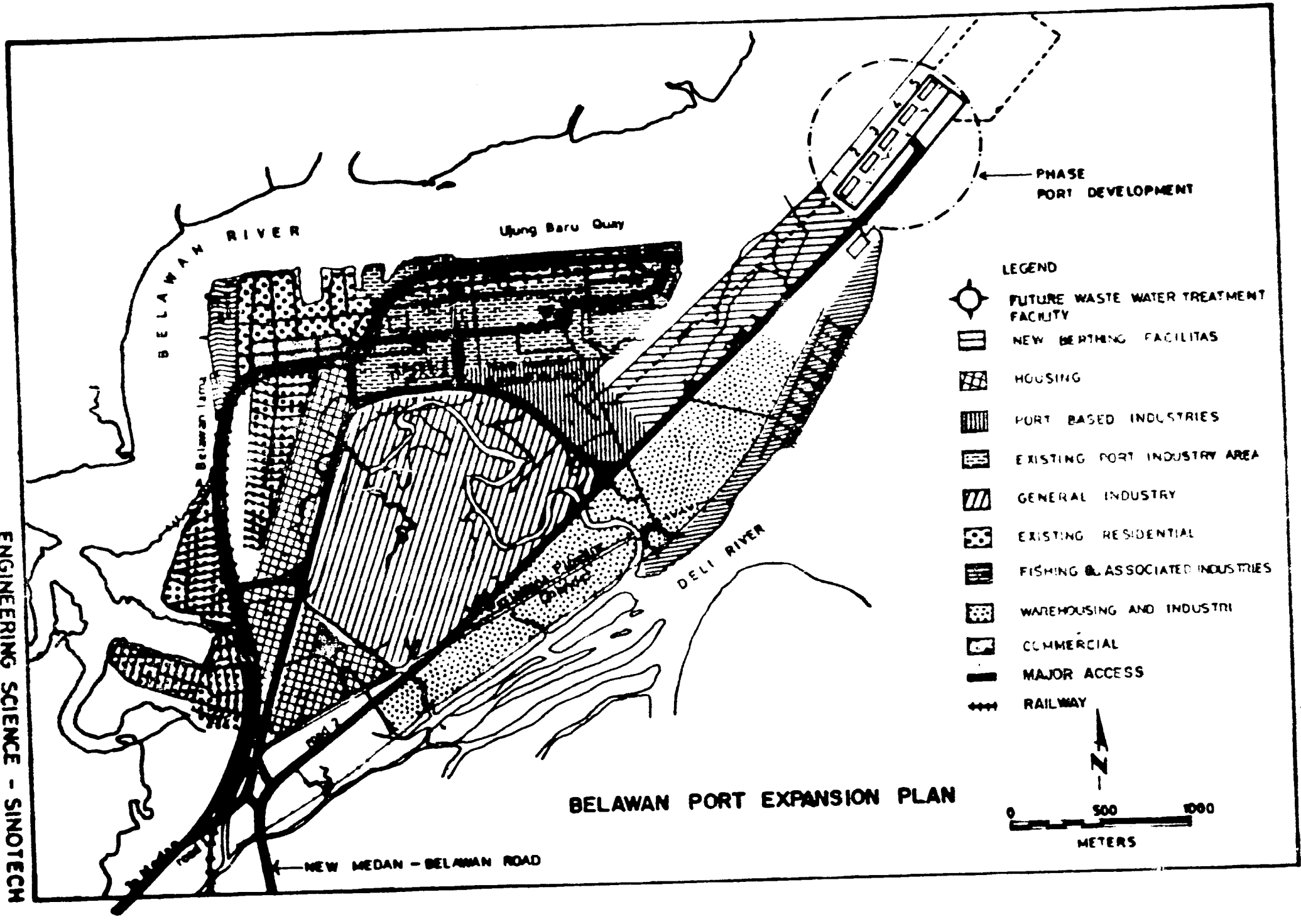

FIGURE : 2 15

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fully occupied, and less frequently when it is not.

2.2.2.4 Individual Domestic

The results of the Kampung survey and several other studies provide a great deal of information about individual domestic waste disposal practices in the city of Medan. From this information, it was found that the study area could be divided into three general categories with regard to these practices. These three categories are:

1. Semi-rural areas representing the northern and southern parts of Medan
2. Developed areas with a mixture of good and poor disposal facilities
3. Developed areas with poor disposal facilities

In semi-rural areas, such as Kampung Baru Ladang Bambu in the Tuntungan area and Kampung [illegible]jun in Labuhan, the overall quality of housing and sanitation is largely determined by the effectiveness of the Kampung leadership and by the efforts of the people in the community. In these area, nearly 100 percent of the households have individual outside latrines and problems related to waste disposal are, on the average, less common than in more densely developed urban areas. Many households have water-seal latrines provided by the Health Department or have constructed similar latrines themselves.

Kampung Harjo Sari, Kampung Sukaramai I and Kampung Bantan are representative of developed urban areas with a mixture of good and poor conditions. In Kampung Harjo Sari, for example, approximately 25 percent of the houses have indoor toilets with septic tanks and the remainder have private latrines, yet the schools have inadequate toilet facilities. Kampung Sukaramai I has become so densely developed that although 25 percent of the houses do not have private toilets or latrines, there is not enough room available to build more. Some latrines are used in common and some households use other disposal methods such as plastic bags. Roughly half the residents of Kampung Bantan have indoor toilets or private latrines. There are no public latrines. The problems resulting from the lack of toilets for possibly 10,000 residents are

indicated by excreta on the ground and the leader of the Kampung is concerned about disease.

A few developed areas of Medan were surveyed which have poor or nonexistent domestic waste disposal facilities. Kampung Lorong Aur and Kampung Desa Durian are representative of these areas. Less than 10 percent of the estimated 2000 residents of Kampung Lorong Aur have any type of toilet and nearly all the residents dispose of their wastes in the Deli River. Almost none of the 293 living units in Kampung Desa Durian have private toilet facilities. There are several public latrines which the people pay to have maintained. Nevertheless, many of these are either out of service or are too far away from the houses for convenient use, and residents often seek other disposal methods such as burial or plastic bags. Excreta is also evident on the ground.

2.2.2.5 Government Latrine Program

The government of Indonesia has instituted a program to provide improved waste disposal systems for families which are not presently, and will not be in the near future, served by a sewerage system. The immediate goal of this program, which is administered by the District Health Center of the Public Health Department, is to provide 1000 water seal latrines per year to Medan residents whose needs are most urgent. About 4300 of these latrines have been provided since 1975.

The principal unit provided is a concrete slab in which a squatting type step plate is arranged above a water-sealed opening. The slab is usually placed directly over a pit or vault which is constructed by the people, as are the curbs and shelters surrounding the latrine. These slabs may also be installed indoors with a discharge pipe leading to an outdoor pit or vault.

Public acceptance of and demand for these water seal latrines is high. Many people who were unable to obtain a slab from the Health Department have constructed their own latrines of this type from available materials. A survey of areas where several of these latrines had been installed found them to be generally free from odors and in good condition. The lack of excreeta on the ground indicated that their availability and use had resulted in significantly improved conditions.

2.3 EXISTING DRAINAGE SYSTEM

2.3.1 Description of the System

Surface drainage in Medan is accomplished by a system of open channels and closed conduits which carry surface runoff, grey water from buildings and houses, and some wastewaters to four rivers that run through the city. The system is, in many places, inadequate to handle the flows, and flooding is a common occurrence.

2.3.1.1 Drainage Channels

There are about 946 km of drainage channels in the study area. These can be classified as follows:

Type	Total Length (km)	
Open channel		
Fully concrete lined	550	
Partially concrete lined	250	
Unlined	122	922
Closed conduits		24
		946

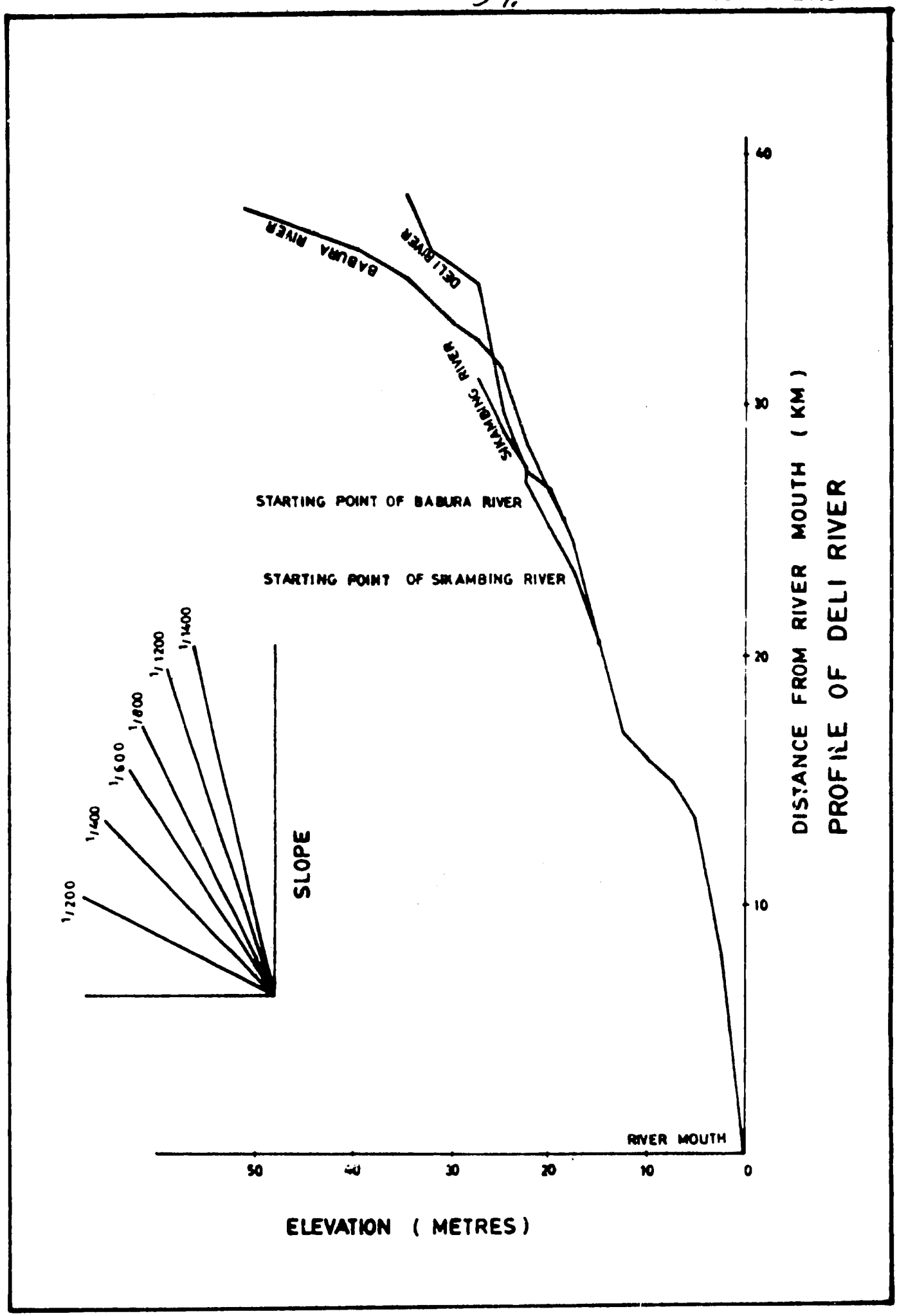
The channels range in size from the small channels that border each street in the urbanized area to major channels that discharge directly to a river. The major channels and the rivers are shown on Figure 2.14.

2.3.1.2 Rivers

The four major rivers that receive Medan's drainage are the Deli, the Kera, the Belawan, and the Percut. The catchment and sub-drainage areas drained by these rivers are shown on Figure 2.16.

Deli River: The Deli River, the most important drainage channel, runs through the central part of Medan Kotamadya. It has a length of about 80 km and has two principal tributaries, the Babura River and the Sikambing River. The Sikambing River also has a sub-tributary, the Putih River. The Bedra and Puluh Rivers also flow into the Deli in it's lower reaches. Flooding usually occurs annually in the downstream area. Slopes of these rivers vary from 0.038 to 0.357 percent in the study area. The river has a catchment area of about 400 km^2.

FIGURE : 2.18


PROFILE OF DELI RIVER
DISTANCE FROM RIVER MOUTH (KM)
ELEVATION (METRES)
RIVER MOUTH
BABURA RIVER
DELI RIVER
SIKAMBING RIVER
STARTING POINT OF BABURA RIVER
STARTING POINT OF SIKAMBING RIVER
SLOPE
1/1200
1/1400
1/1600
1/1800
1/1200
1/1400
0
10
20
30
40
50

Kera River: The Kera River is a small stream in the northern portion of the study area where it is the eastern boundary of the study area. It has been extended southerly with an open channel to connect with the Sulang-Saling River in the southern part of the study area. The water in the channel is grossly polluted with sewage, and its capacity is reduced by solid wastes dumped in the channel. About 4 km of the channel are masonry lined; the reminder is unlined, earth embankment. The slope of the channel in the study area various from 0.052 to 0.50 percent. The catchment area is about 140 km^2.

Belawan River: The Belawan River is located along the western boundary of the study area, with an average slope of 0.104 percent. Water in this river is still not seriously polluted. Its catchment area is about 285 km^2.

Percut River: The Percut River flows through the eastern part of the Medan Kotamadya. Its slope varies from 0.069 to 0.303 percent. Total length of the river is about 78 km, 42 km of which is in the study area. Its catchment area is about 210 km^2.

Coastal Tidal Zone: A broad band of low lying swampy area loosely connects the major rivers to the ocean.

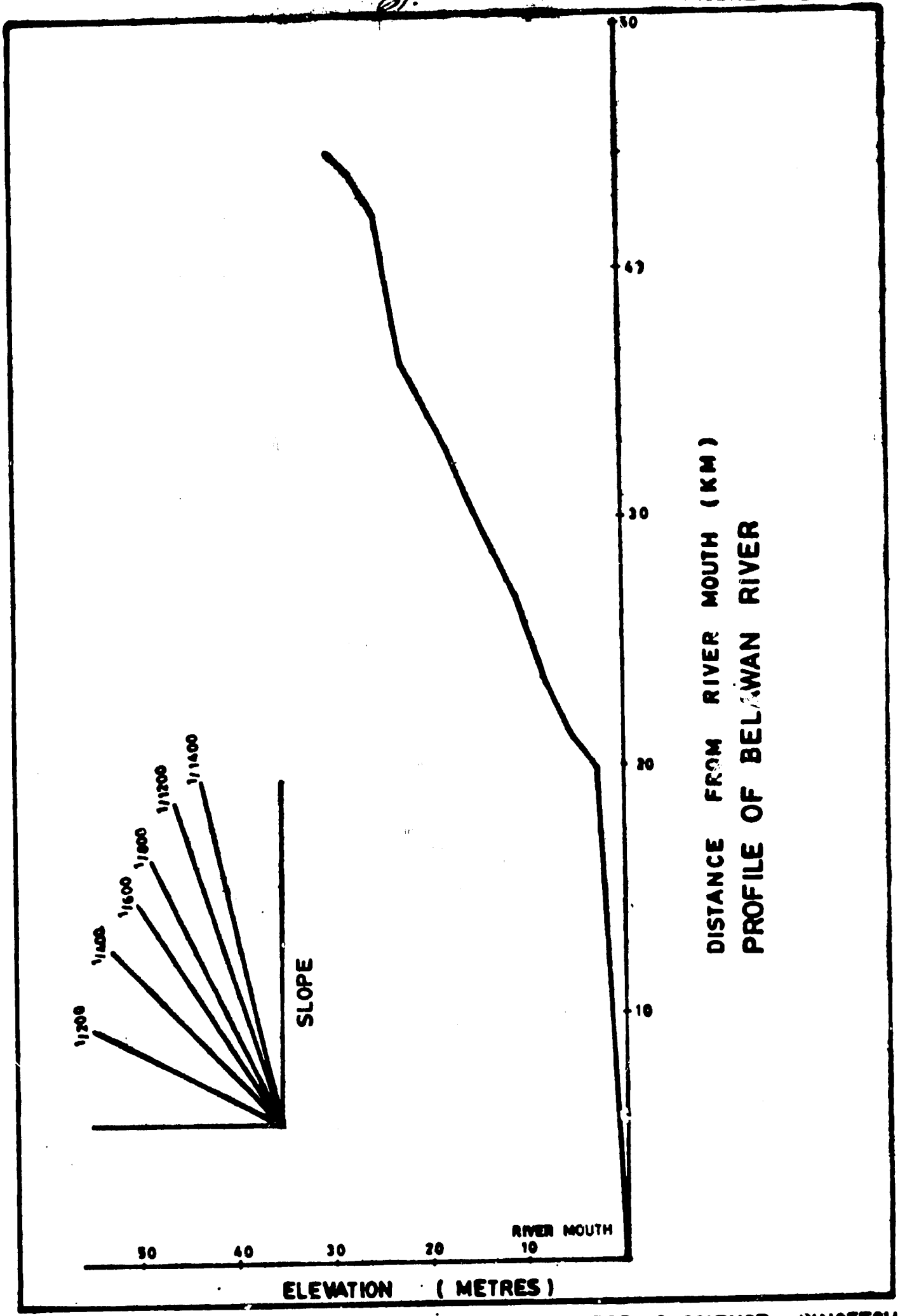
2.3.2 Flooding Experience

Flooding is a serious problem in Medan. Whenever there is a heavy rain, roads and low-lying areas are flooded with consequent property damage, pollution of shallow wells, and traffic interference. No formal records are kept of flood depths or frequencies. However flooding of two metres or more in some areas is common. Major floods occurred in 1956, 1965, and 1971.

Figure 2.17 shows the areas most prone to flooding. It is based on a map of Kotamadya Medan prepared by Dinas Planologi Kotamadya Medan and on field inspections and interviews by the Project staff. Most of the flood prone areas occur along the length of the Deli River in the study area and along the Sikambing and Babura Rivers.

2.3.3 Drainage System Deficiencies

The principal problem with the drainage system is insufficient


DISTANCE FROM RIVER MOUTH (KM)
PROFILE OF BELAWAN RIVER
50
40
30
20
10
RIVER MOUTH
ELEVATION (METRES)
SLOPE
1/200
1/400
1/600
1/800
1/1200
1/1400

capacity compounded by growths of weeds and the extensive dumping of refuse in the rivers and channels.

In the central city areas most of the inlets along the roads are too small to handle the flows, and they are often blocked with road sweepings or garbage. As a consequence, local flooding often occurs even after a relatively light rainfall.

Because of the flat topography, many drainage ditches have insufficient slope to carry the runoff. Weeds and refuse further reduce their capacity resulting in more frequent flooding than would otherwise occur. Increased urbanization and the increase in paved, impervious areas has also contributed to the problem because of increased runoff.

The original design of drainage channels (width, depth, slope) was not adequate to handle present runoff loads. In a number of cases, the upstream portions of channels have been constructed but the downstream portions have not been improved. The result, of course, is the transference of flooding from the upstream area to a downstream area. Lack of channel lining in some sections is another cause of inadequate channel capacity.

The frequency and severity of flooding, particularly local flooding, could be reduced with improved operation and maintenance. Difficult as it may be to enforce, people should not use ditches, channels, or rivers for solid waste disposal (realistically, though, it will probably not be possible to improve this situation substantially until more satisfactory methods for solid waste collection and disposal are available). However, in the central areas, street sweepings and refuse should be removed from the drains regularly. Ditches and channels should be kept free of weeds and refuse. If this were done, flooding frequency and severity would be reduced. This would also improve channel velocities and reduce sediment deposition which also reduces channel capacity.

Adequate maintenance of the drainage system is not possible with the manpower and equipment presently available.

2.3.4 River Cross-Section Measurement and Profiles

To provide a basis for estimation of the rivers' flow capacities,

cross-sections of the four rivers were measured at 50 locations during May 1979 (data for an additional 11 cross-sections on the downstream reaches of the Deli River were provided by DPU). All sections were measured at bridge crossings, and the locations of the section and the cross-section data are presented in Appendix

In general, the upstream portions of the rivers are narrow and relatively deep with rocky bottoms. The rivers are shallower and broader in the downstream reaches and have sandy silt bottoms. The streams are meandering, and the banks are lined with weeds and brush. The river velocities decrease with the decreasing slope from south to north. Generalized profiles of the rivers were derived from 1:50,000 scale topographical maps as illustrated in Figures 2.18, 2,19, and 2.20.

2.3.5 Estimated Existing Capacity

Each of the four major rivers were divided into reaches defined by the cross-sections, and the flow capacity of each reach was calculated using the Manning equation ($Q = Ar^{2/3} S^{1/2} n^{-1}$). Values for the coefficient "n" were estimated during field surveys. The estimated capacities and values used in calculating them are shown in Appendix , Tables and

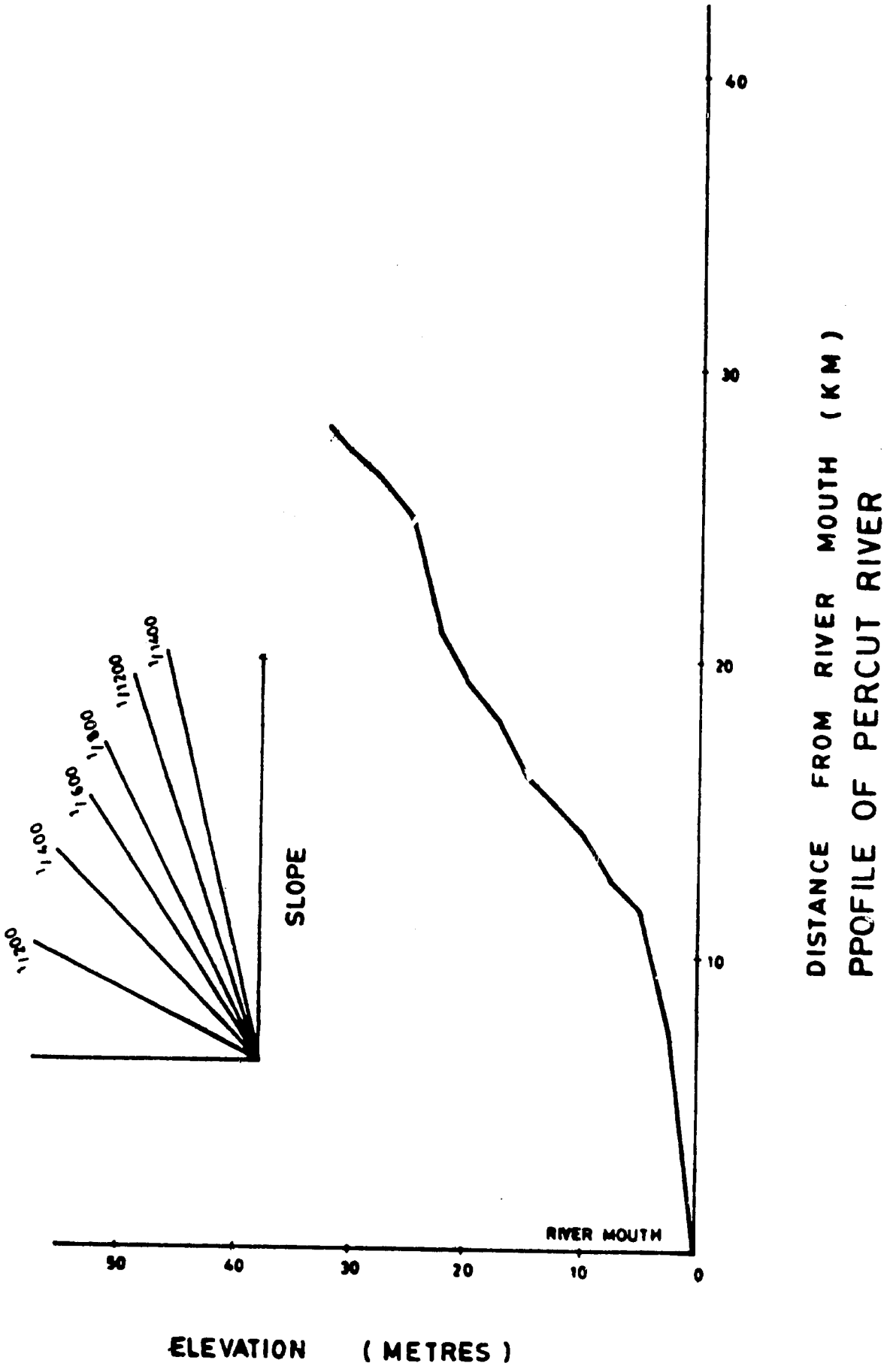
2.4 THE SOLID WASTE SYSTEM

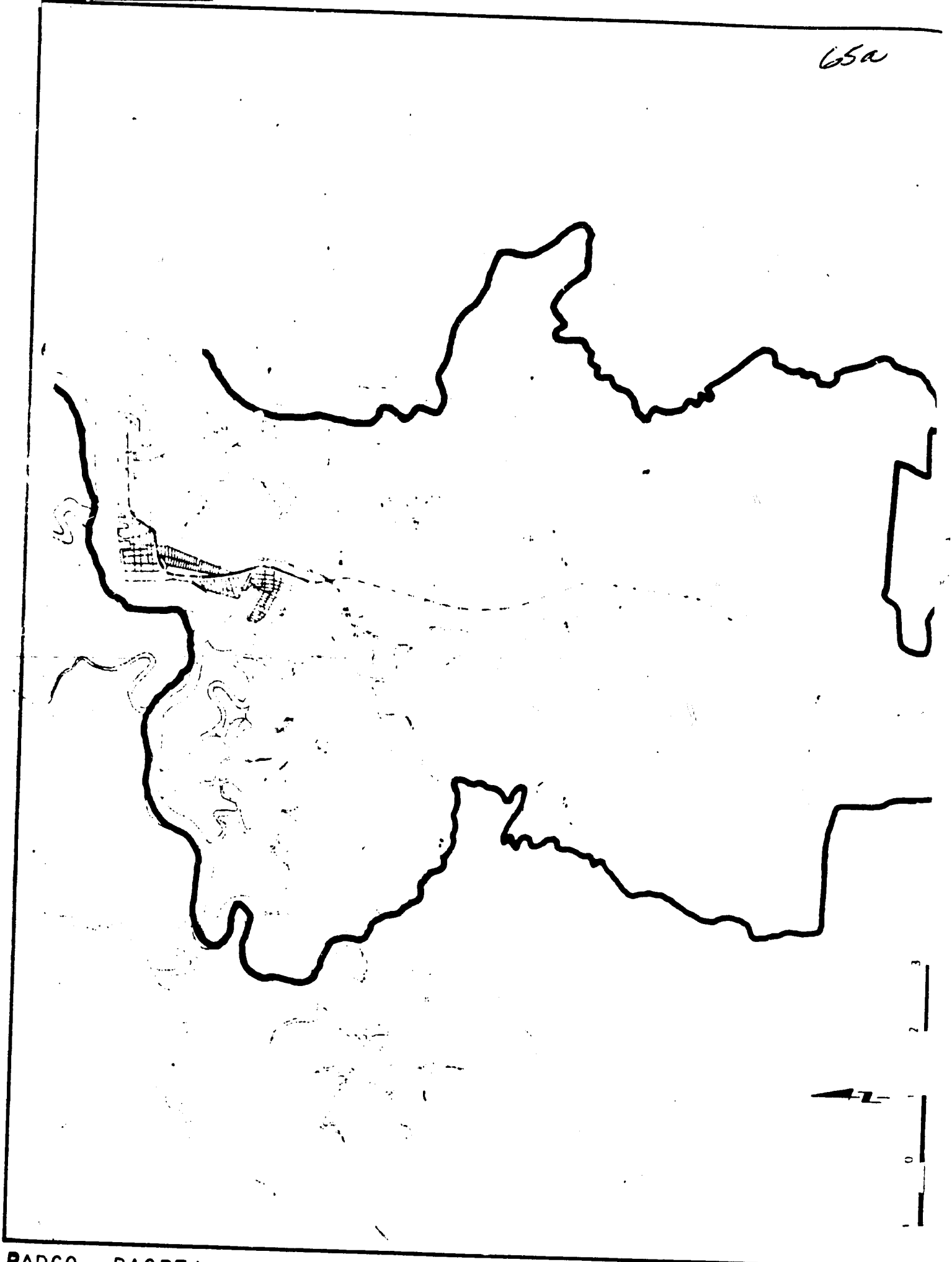
In 1979 the results of a 1978 household economic survey became available which provided information on current household solid wastes disposal practices and illustrated the continuing need for expanded solid wastes management services. Also in 1979, a report of a joint solid waste study being carried out in Medan and three other cities by the Government of Indonesia and the Netherlands Government was issued.

The information from these investigations and reports defines the current solid waste management problem in Medan.

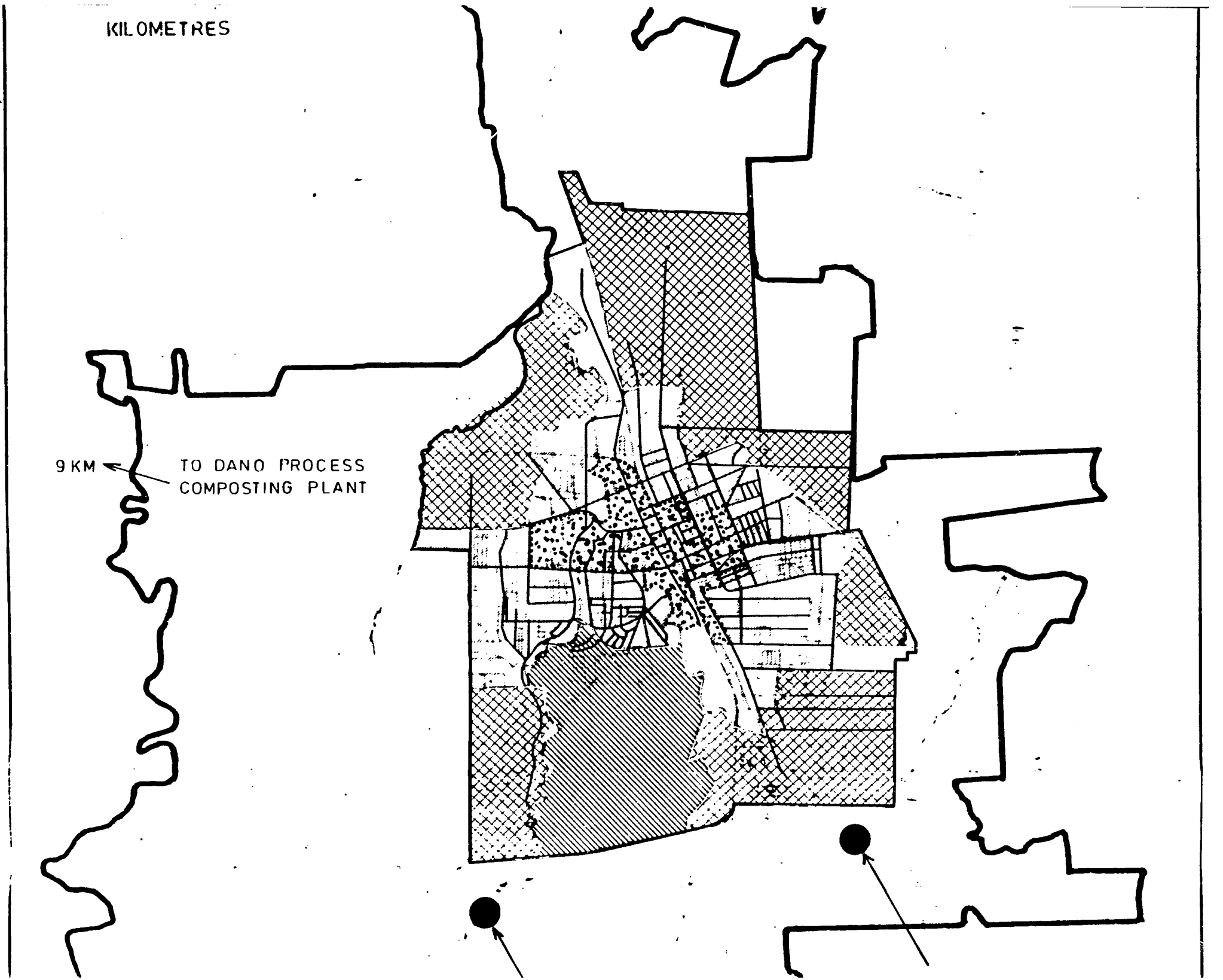
- About 25 percent of the solid wastes generated in the high density urban area is collected by the municipal system.
- In the study area 84 percent of households dispose of solid wastes by burning, disposal to streams, or burial.

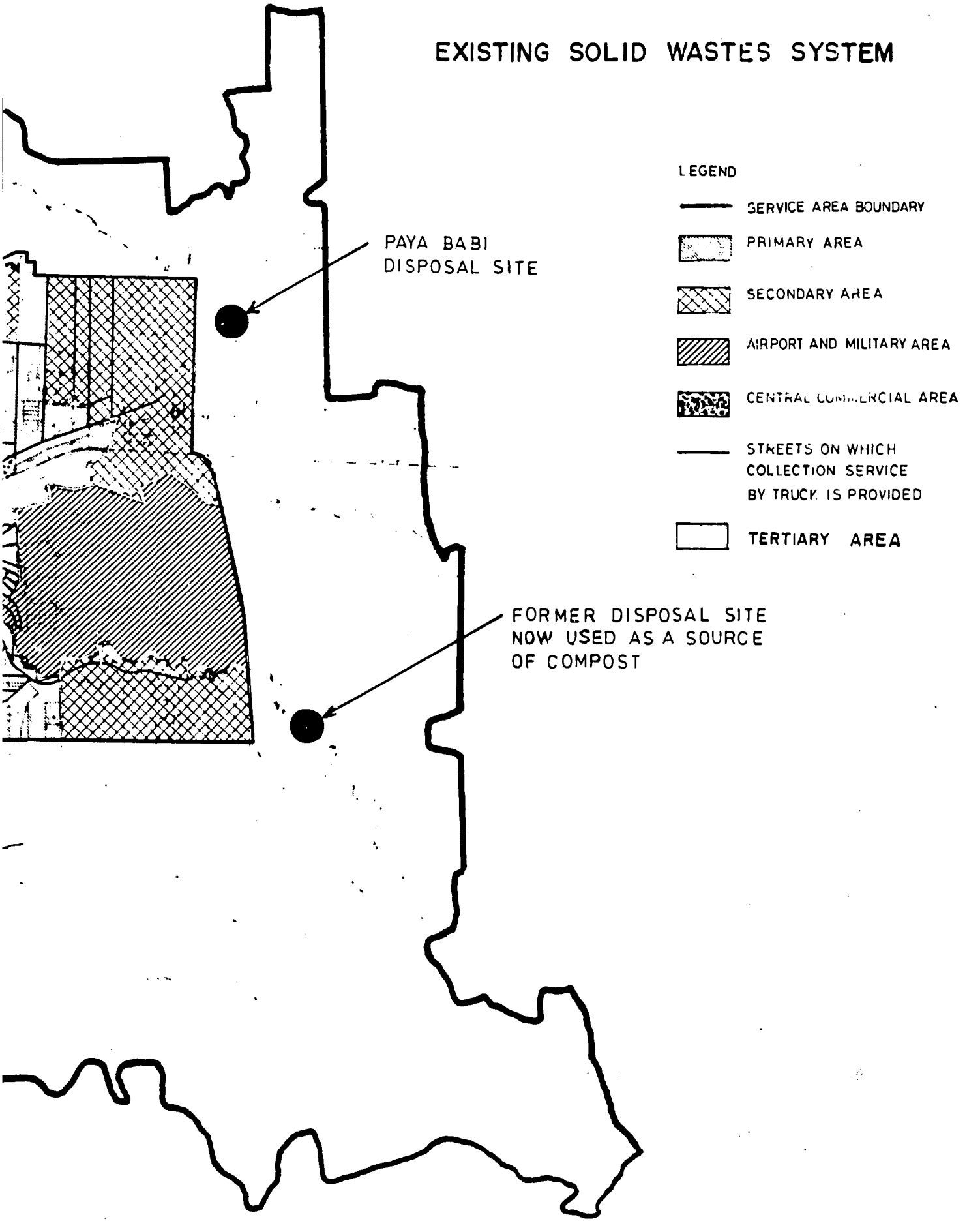
FIGURE : 2.20


DISTANCE FROM RIVER MOUTH (KM)
PPOFILE OF PERCUT RIVER
40
30
20
10
0
RIVER MOUTH
SLOPE
1/1200
1/1400
1/1600
1/1800
1/2000
1/2200
1/2400
50
40
30
20
10
ELEVATION (METRES)



PADCO – DACREA


KILOMETRES
9 KM
TO DANO PROCESS
COMPOSTING PLANT



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- The threat to public health, property damage due to flooding,. and the general nuisance created by accumulation of solid wastes are recognized by public officials as factors detracting from the quality of life in Medan.

2.4.1 The Municipal Solid Wastes System

2.4.1.1 General Description

DKKP provides a solid wastes management service within the area shown in Figure 2.21. The service includes:

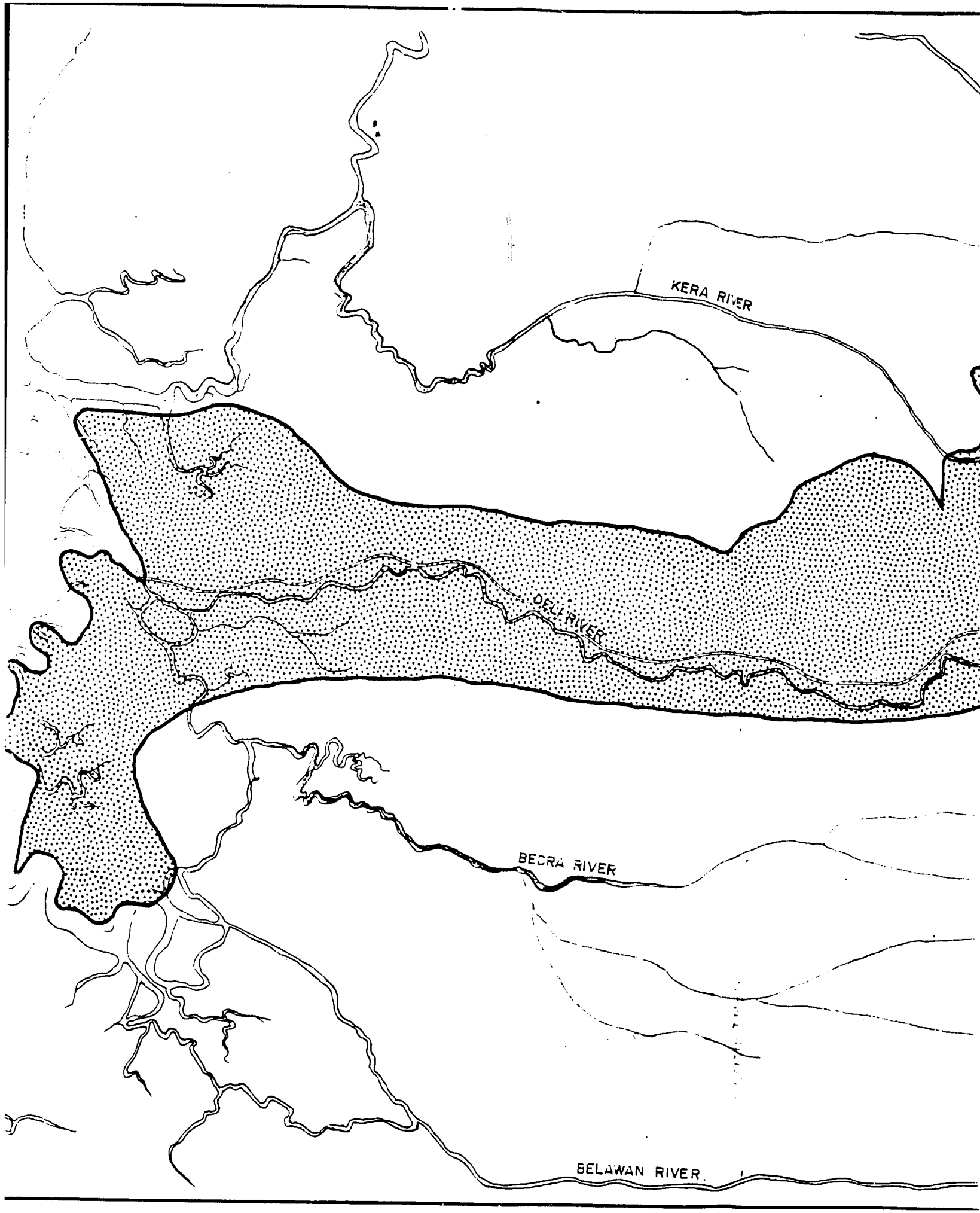
1. Collection (jointly with the Kampung administration), transportation, and disposal of solid wastes from residential, commercial, industrial and institutional areas.
2. Cleaning of roads, parks, and open drains.
3. Collection and disposal of septic tank pumpage.
4. Maintenance of green areas and cemeteries (green areas include playing fields, open spaces, road berms, traffic islands, and boulevards).

Kotamadya Medan area is divided into a primary area, a secondary area, and a tertiary area as shown in Figure 2.21.

In the primary area DKKP provides all men and equipment used in the collection service. Collection operations are controlled jointly with the Kampung administration.

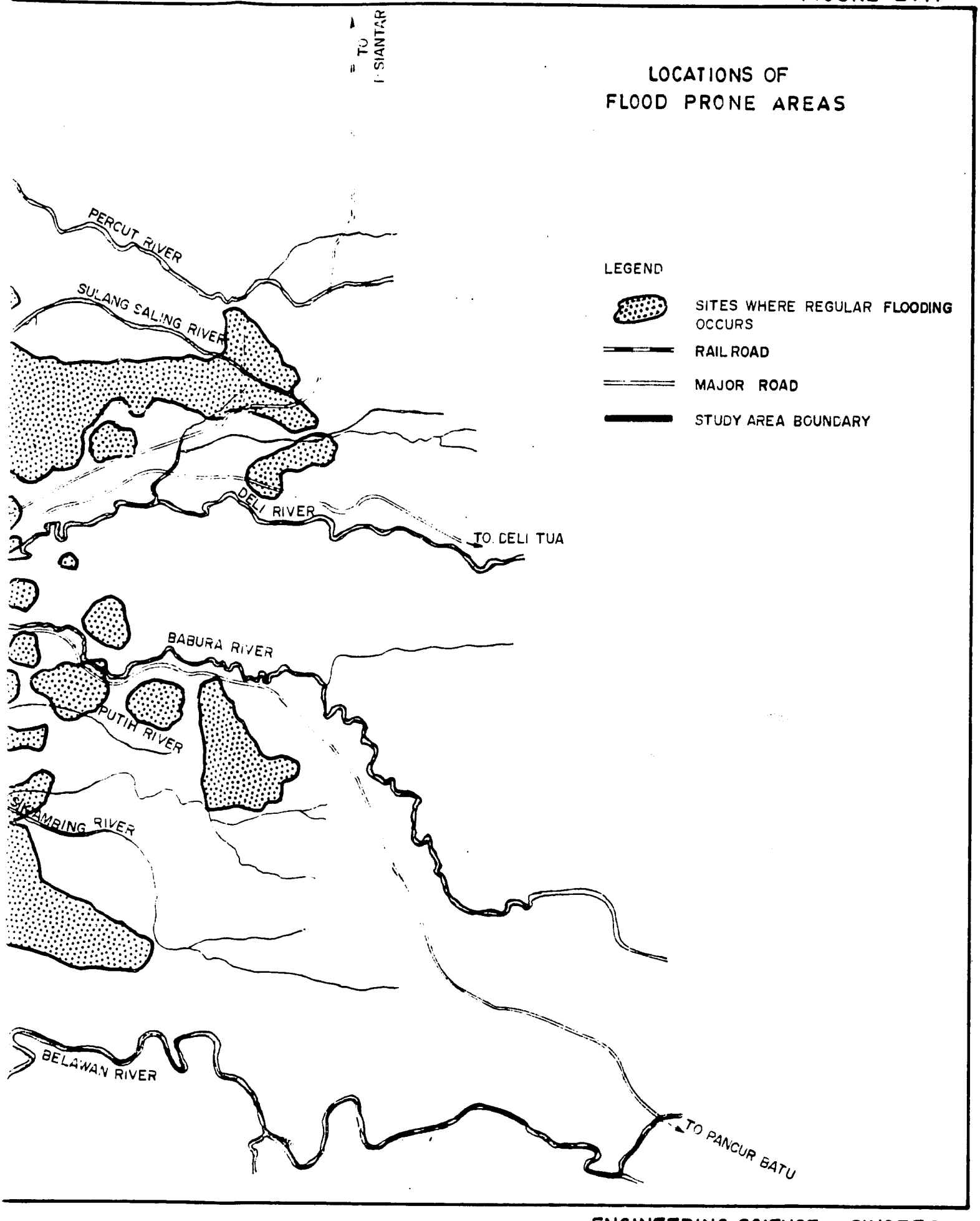
In the secondary area residents arrange to have their solid wastes taken to a pool site, and DKKP transports the solid wastes from there to the disposal sites. The primary and secondary areas constitute the current DKKP service area. DKKP provides assistance from time to time to the Kecamatan administrations in the tertiary area when emergency conditions exist. At the present time service is severely curtained in the primary and secondary areas because of a shortage of collection vehicles, and DKKP is able to collect only about 150 tons of solid waste per day.

Solid wastes from Perumnas I (Helvetia) housing site (in the tertiary area) are collected and transported to the city disposal site by Perumnas.


KERA RIVER
DELI RIVER
BECRA RIVER
BELAWAN RIVER

PERCUT RIVER
KERA RIVER
SULANG SALING RIVE
KERA RIVER
DELI RIVER
BABUR
PUTIH RIVER
SIRAMBING RIVER
BEDRA RIVER
BELAWAN RIVER
TO BINJAI
BELAWAN RIVER

FIGURE 2.17


LOCATIONS OF
FLOOD PRONE AREAS
TO SIANTAR
PERCUT RIVER
SULANG SALING RIVER
DELI RIVER
TO DELI TUA
BABURA RIVER
PUTIH RIVER
SIKAMBING RIVER
BELAWAN RIVER
TO PANCUR BATU
LEGEND
SITES WHERE REGULAR FLOODING OCCURS
RAIL ROAD
MAJOR ROAD
STUDY AREA BOUNDARY

The collection of solid wastes from the markets is carried out by the Dinas Pasar (Markets Department of the city administration) in cooperation with DKKP. A commercial composting operation (Dano Process) processes 100 tons per day of market wastes originating in Medan and Binjai.

In 1979 Bappenas and Kantor Sensus dan Statistik of North Sumatra carried out a survey in Medan in which 1,150 household were randomly selected and methods of solid waste disposal were determined. The results of the survey are as follows:

Household Disposal Method	Percentage of Households	
Service by DKKP (wholly or partially):		
Carried to a solid wastes pool	16.3	
Container removed at a scheduled time	6.7	23.0
Other:		
Burning	56.0	
Burial	7.8	
Disposal to ditch or stream	12.4	
Other	0.8	77.0
		100.0

These data illustrate the relatively minor impact of the municipal solid wastes management system on the collection and disposal of solid wastes in the study area.

2.4.1.2 Collection and Transfer Operations

Solid wastes are collected by DKKP with both trucks and gerobaks. Wastes collected by truck are hauled directly to the disposal site; those collected by gerobak are hauled to transfer areas where they are either held temporarily or transferred directly to a truck for haul to the disposal site.

Wastes are collected either from within the premises or from curbside. In the former case, collection workers enter the yard of the household or business, place the wastes in a collection basket, and carry the

wastes to the truck or gerobak on the street. For curbside collection, the owner places the wastes in a container at the curb, and the collection workers transfer the wastes from this container to the vehicle.

Truck collection requires a crew of four, one driver, two carriers, and one man to assist in loading the truck. Collection by gerobak requires a crew of two. The standard work day is seven and one-half hours for truck crews, and six hours for gerobak crews.

Except for one street sweeper truck (with container), streets are swept by hand. Usually four to six sweepers per kilometre are assigned who work a six-hour day. The streets that are swept are entirely in Kecamatans Medan Kota, Baru, Barat, Timur, and Belawan. A total of 224 km of streets are swept from once to four times per day as follows:

Sweeping Frequency (per day)	Length (km)
once	101
twice	104
three times	16
four times	3
	224

Wastes collected by gerobak are transported to transfer areas. The gerobaks are unloaded for storage at the transfer area or directly to a collection truck. The unloading and reloading operations are carried out manually. Many of the transfer areas are little more than an allocated space at the roadside with few facilities to contain stored refuse or to assist in the transfer of wastes to trucks. Frequently wastes remain in storage for a long period of time at the pool site creating both nuisance and potential threat to public health. Local residents consider the existing pool system extremely unsatisfactory, and this makes acquisition of new transfer sites difficult.

2.4.1.3 Disposal

The low wet area at Paya Babi used for the disposal of solid wastes by DKKP has a total area of 8.7 ha and has been estimated by DKKP to have sufficient capacity for five years disposal. The site has two natural watercourses through it, and water leaching through the wastes

has polluted the water downstream which is used for livestock watering and rice irrigation. Because of complaints from local residents resulting from the many unsatisfactory features of the site, DKKP is looking for new disposal sites.

A large number of people salvage materials from the disposal site and from the various transfer areas (pool sites). Salvaged materials include metals, glass, plastics, and bones.

In addition to the commercial composting of market wastes mentioned before, a second commercial operation extracts about ten tonnes per day of compost from a former municipal disposal site.

2.4.1.4 DKKP Staff and Equipment

A total of 1464 persons are employed in the solid wastes management system in Medan in the following classifications:

1.	Officials and technical/administration staff		154 persons
2.	Laborers - Full time		133
	- Part time		7
3.	Day laborers		
	Area workers	723	
	Parks and cemeteries	75	
	Special area	100	
	Workshop	20	
	Disposal	28	
	Demonstration project	5	
	Drivers	33	
	Assistant drivers	132	
	Foremen	54	1170
	Total		1464 persons

DKKP has a total of 80 collection trucks. Five of these are five tonne trucks, the remainder are three tonne. Only about 50 of these trucks are in service. The organization has about 25 other vehicles (street sweeper, tank trucks, pickup trucks, cars, etc.) of which about 20 are in service. About 80 of the total of 150 gerobaks are operational.

Motor vehicles are usually repaired in commercial shops. Plans are being considered for a centralized city vehicle repair facility.

2.4.2 Other Solid Wastes Disposal

More than seventy-five percent of the people in Medan are not served by the municipal solid waste collection system. About three-quarters of these people burn their wastes (except for some food wastes that are fed to pigs). The remainder of the wastes are either buried or dumped in ditches and streams.