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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

TECHNICAL MEMORANDUM NO. 25

PROJECTED WATER AND WASTE QUANTITIES

This is a draft of Section 3 of the Master Plan Report
for Water Supply and Sanitation

NOVEMBER 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 26, Phone 20716, Medan-Sumatra, Indonesia

Our ref.: 79/1193/MUDS/313 6 November 1979

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

Subject: Technical Memorandum No. 25,
Projected Water and Waste Quantities

Dear Sir:

Attached are 20 copies of the subject Technical Memorandum for your information and review. The material contained in this memorandum constitutes submission of Section 3 of the draft Master Plan for Water Supply and Sanitation report.

Yours faithfully,

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
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AID - Jakarta, attn.: P. Thorn, Project Officer
ES - Arcadia
SINOTECH - Taipei
DACREA - Jakarta

JM/1

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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
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19.	Public Health and Environmental Aspects	October, 1979
20.	Alternative Solid Wastes Management Systems	October, 1979

SECTION 3

PROJECTED WATER AND WASTE QUANTITIES

3.1 POPULATION AND LAND USE PROJECTIONS

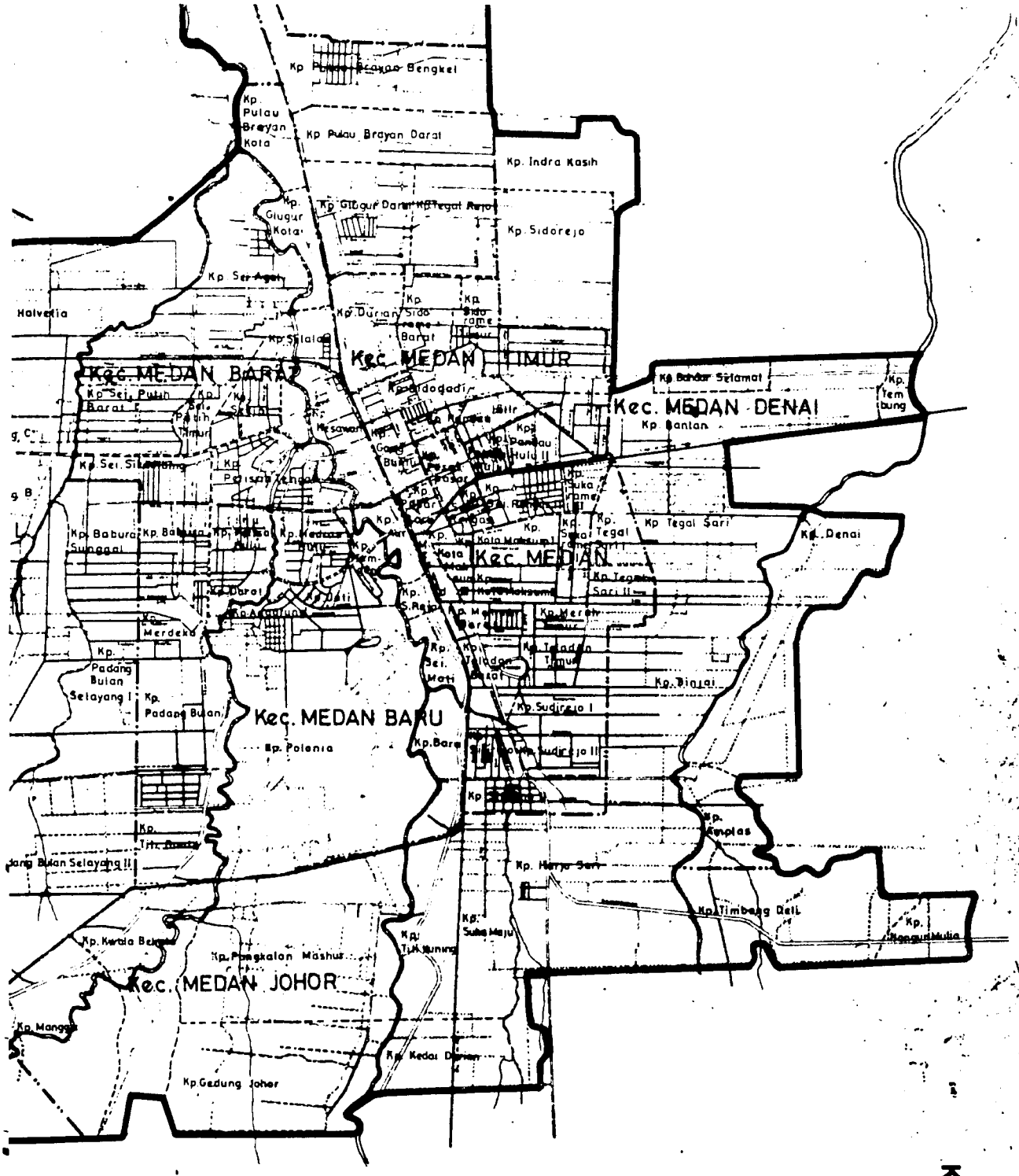
General estimates of projected population in the study area were developed by Kecamatan in Section 2 of the Long-Term Development Report which was prepared as part of these investigations. To determine water demand and waste generation patterns, however, it was necessary to assess population distribution on the basis of smaller political units — Kampungs — and further subdivide these into percentages of residential types according to income and population densities.

The existing population distribution by Kampungs was obtained from registration records. The numbers and locations of the various residential categories of consumers are necessary to make realistic projection because water use and waste generation are functions of the affluence level. The following residential classes were identified by density and income level within each Kampung by using 1972 aerial photographs.

High Income - Low density
High Income - Medium density
Medium Income - Low density
Medium Income - Medium density
Medium Income - High density
Low Income - Low density
Low Income - Medium density
Low Income - High density

Projections of the population in different income-density groups within the 1978 built-up area were based on the existing income-density distribution. Details of the population distribution by income and density in the 75 Kampungs in the 1978 built-up area are shown in Table -- of Appendix ——— . The locations of these Kampungs are shown in Figure 3.1 . Projections made in areas which are not presently built-up but will be by the year 2000 were based on the following assumed pattern:

Low Income - Low Density - 70 percent
High/Medium Income - Low Density - 30 percent



KAMPUNG BOUNDARIES WITHIN STUDY AREA

FIGURE 3-1

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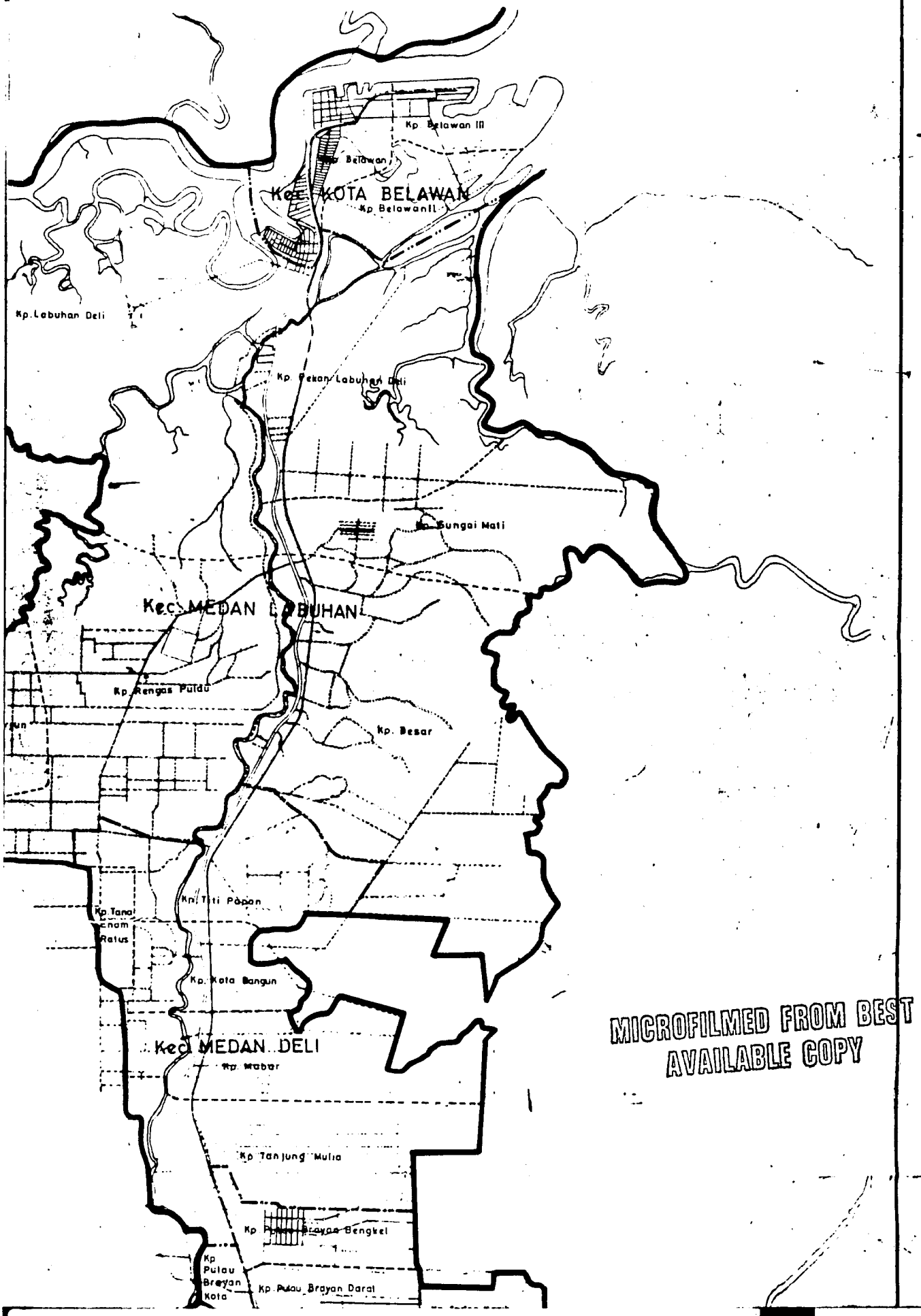

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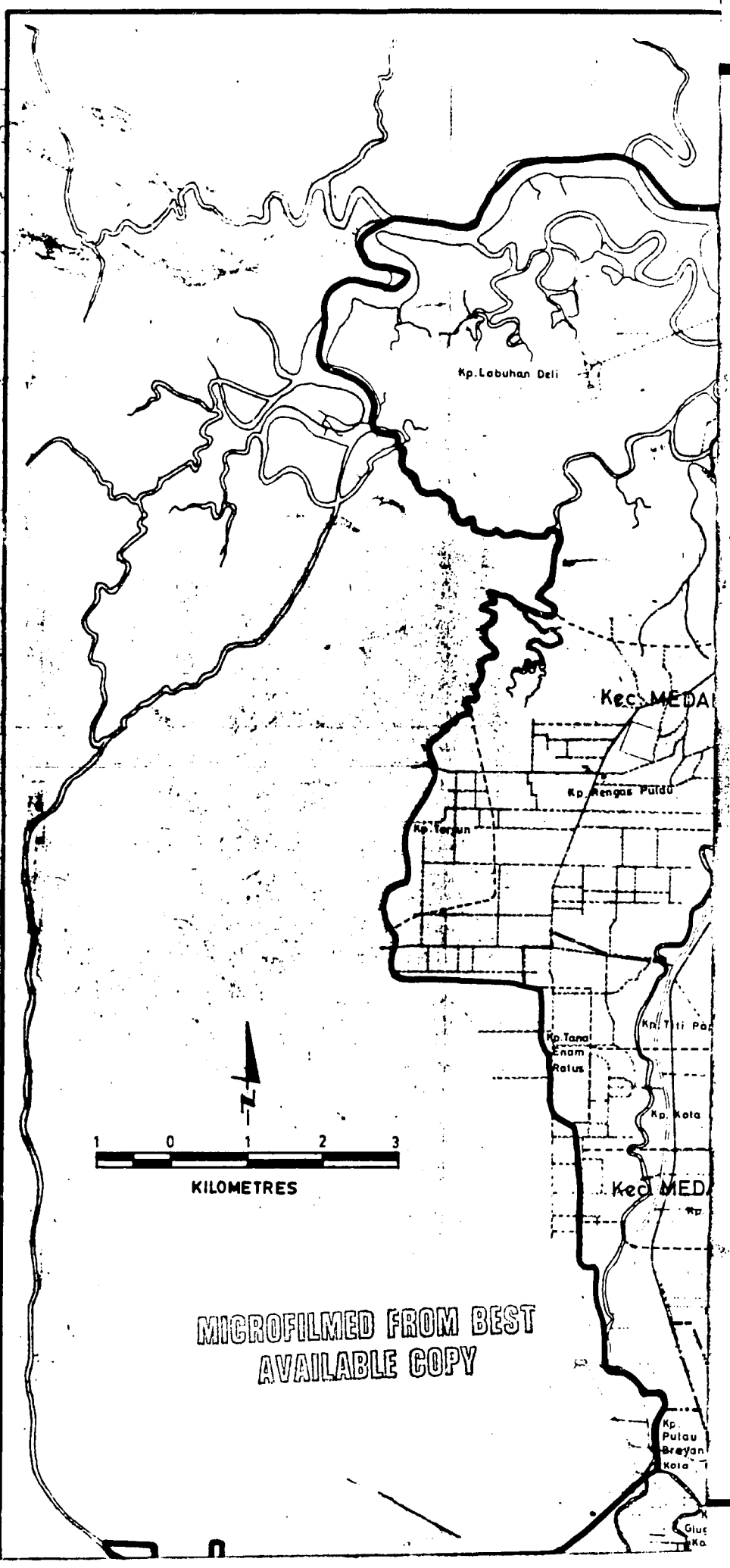

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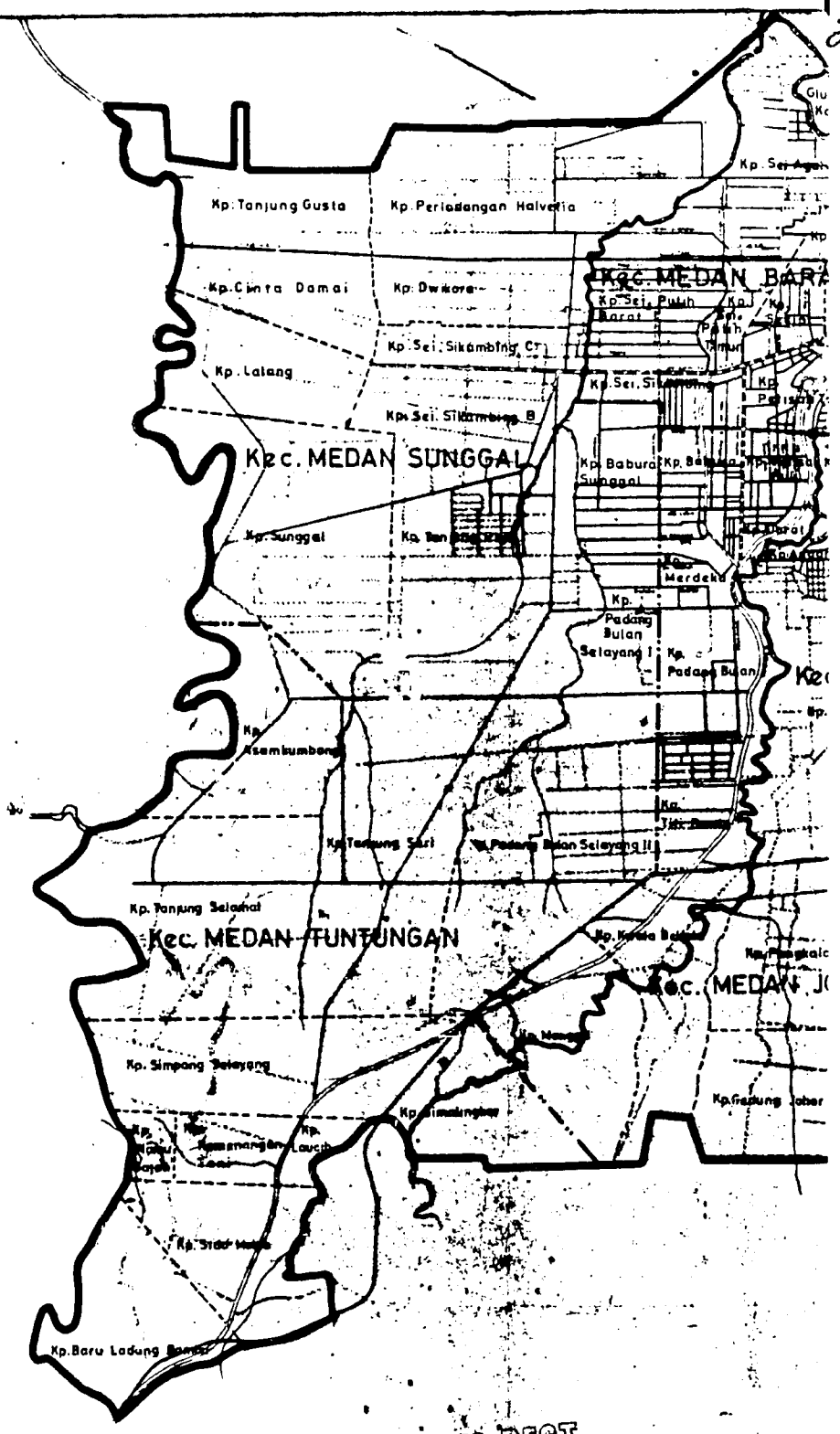

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The population projections by Kecamatan are presented below in Table 3.1.

TABLE 3.1

POPULATION DISTRIBUTION BY KECAMATANS

Kecamatan	1978	1980	1985	1990	1995	2000
Medan Kota	232,230	236,900	249,000	261,100	275,000	289,000
Timur	178,790	183,958	193,338	214,000	225,000	236,500
Baru	121,508	126,400	141,076	159,000	178,100	206,640
Barat	132,287	137,600	151,900	175,700	194,800	215,100
Denai	119,416	124,240	138,275	178,000	207,400	249,000
Labuhan	54,031	57,316	63,300	69,900	78,800	87,000
Johor	54,660	56,870	62,800	79,300	95,300	120,200
Tuntungan	17,475	18,180	56,070	66,900	83,863	107,590
Sunggal	94,383	99,200	109,500	143,900	179,600	211,100
Deli	51,456	56,200	62,050	68,500	76,000	86,200
Belawan	60,000	61,200	64,300	67,600	71,000	75,000
Medan II	-	46,800	51,670	57,100	63,000	69,600
Total	1,116,036	1,204,864	1,343,279	1,541,000	1,727,863	1,952,930

The existing and projected land use needs were based on 1972 aerial photographs and 1976 land use maps and are summarized below:

ESTIMATED LAND USE NEEDS (hectares)

Type	1980 (existing)	1985	1990	1995	2000
Commercial	391	479	654	656	761
Industrial	358	399	440	480	516
Institutional	323	378	437	502	576
	1,072	1,245	1,430	1,628	1,843

The detailed demographic and land use projections from which Table 3.1 and the above land use summary were prepared are presented in Table of Appendix —— for each of the 75 Kampungs. The estimated water use and wastewater and solid waste generation rates were based on these detailed projections.

3.2 PRESENT WATER USE

3.2.1 Municipal System (Tirtanadi)

The municipal system presently supplies water to an estimated service population of 220,000. About 200,000 people receive water through 29,560 metered service connections and an estimated 20,000 obtain water from 93 public standpipes. Commercial, industrial, and institutional customers are also served via an additional 6,900 metered connections. Unaccounted for losses amount to about 25 percent of the water produced. A summary of municipal water use in the Study Area is presented below:

Category	Estimated Quantity, in m^3/d
Domestic	40,500
Institutional	11,700
Commercial/Industrial	13,900
Unaccounted for losses	21,800
Total	87,900

3.2.2 Non-municipal Deep Wells

A number of commercial, industrial, and institutional water users obtain their supplies from deep wells not connected with the municipal system. The largest of these is the Belawan Port Authority which derives an estimated 4,580 m^3/d from deep wells. Approximately 60 deep wells supply an estimated 5,960 m^3/d to various other non-residential water users.

3.2.3 Non-municipal Domestic

The information available on this category of water use is very scanty and the following figures are therefore necessarily tentative.

While about 25 percent of the population obtain their water requirements from the municipal system, the balance obviously obtain theirs from the only two other sources available to them — shallow wells and surface water from rivers and streams. Based upon limited surveys carried out under this investigation and by others, it is estimated that, of the 850,000 people not presently served by the municipal system, about 700,000 own their own shallow well supply. The remaining 150,000 obtain supplies from public shallow wells or surface streams, and must carry their water supplies a significant distance. The individual shallow well owners are generaly middle and lower income people, while those who are forced to carry their water from public sources are in the lowest income groups.

Based upon experience elsewhere, it is estimated that consumers with individual shallow wells would use about 80 lpcd. From experience in other similar areas where water must be carried from public sources, the water use for this consumer category is estimated at 35 lpcd. Using these per capita figures, the estimated amount of water presently being obtained by residential water users from non-municipal sources is as follows:

Consumer Category	Estimated Water Use, m^3/d
Individual households with shallow wells	56,000
Public sources from which water must be carried	5,250

3.2.4 Present Unit Water Use

3.2.4.1 Domestic

An examination of recent Tirtanadi billing records revealed that the average domestic consumption in 1978 was 176 lpcd. Specific residential areas where high and medium income groups predominated were identified and their unit water use estimated from these records. Residents in the more affluent areas (such as Polonia) use about 265 lpcd, while use in medium income, high density areas (multi-storey mixed commercial/residential housing in the central business area) was approximately 145 lpcd.

Based upon an examination of Tirtanadi water records in areas served partially by the municipal system and partially by individual household

shallow wells, it is estimated that this type of consumer would use about 100 lpcd if connected to the municipal system.

It is assumed that domestic users presently obtaining water from public shallow wells or rivers would continue to consume the same amount of water if they were able to obtain their supply from public standpipes (35 lpcd).

Based upon the above, the estimated present unit water use for all domestic categories is as follows:

Domestic Category			Present Water Use, in lpcd
High income	-	Low density	265
High income	-	Medium density	265
Medium income	-	Low density	215
Medium income	-	Medium density	215
Medium income	-	High density	145
Low income	-	Low density	145
Low income	-	Medium density	100
Low income	-	High density	35

3.2.4.2 Commercial, Industrial, and Institutional

Present commercial, industrial and institutional land use within the municipal water system service area was estimated from 1972 aerial photographs and 1976 land use maps to be as follows:

Land Use Type	Area within Tirtanadi Service Area, ha
Commercial and industrial	311
Institutional	549
Total	860

Estimated commercial, industrial and institutional water use within the Tirtanadi service area is summarized below:

Water Source	Estimated Water Use, in m^3/d
Commercial and Industrial	
Municipal (from 1978 Tirtanadi records)	13,900
Deep wells	5,960
Shallow wells and surface streams	3,020
Institutional	
Municipal	11,700
Total	34,580

Combining the above information, we obtain an estimate of present commercial, industrial, and institutional water use in the Tirtanadi service area of 40,200 l/ha.d. For purposes of this analysis, a unit rate figure of 41,000 l/ha.d has been adopted.

3.3 PROJECTED WATER USE

3.3.1 Projected Unit Water Use

Allowing for a gradual increase in per capita domestic water use with time to reflect future increases in general affluence levels, the projected unit domestic water use rates in the Study Area are as presented in Table 3.2.

TABLE 3.2

PROJECTED UNIT DOMESTIC WATER USE

Residential Type		Unit Water Use, lpcd				
Income	Density	1978	1980	1985	1990	2000
High	Low	265	265	265	275	300
High	Medium	265	265	265	275	300
Medium	Low	215	215	225	240	260
Medium	Medium	215	215	225	240	260
Medium	High	145	145	160	175	200
Low	Low	145	145	160	175	200
Low	Medium	100	100	115	125	150
Low	High	35	35	35	35	35

The amount of water used by people who must carry their supplies from public standpipes is strongly limited by the amount which can or will be carried and can therefore expected to remain constant at 35 lpcd.

Unit water use rates for commercial, industrial and institutional activities can be expected to remain essentially unchanged at 41,000 l/ha/d and this figure was adopted for use in making projections of future non-residential water use.

3.3.2 Future Unaccounted for Water

A study of the amount of water entering the city, and the metered amounts distributed by Tirtanadi, as of the end of 1978, revealed an unaccounted amount of 25 percent. The introduction of new pipes will tend to reduce this figure while the continued use of the old pipes coupled with higher pressures will tend to increase it. Taking all the above factors into consideration, it is estimated that 25 percent of the water brought into the new service area will continue to be unavailable to consumers. This figure includes leakage and illegal use by unauthorized tapping.

3.3.3 Total Projected Water Use

A summary of total projected water use (municipal plus non-municipal) in the study area is presented in Table 3.3. Detailed projections of total water use by consumer category and Kampung are presented in Table ___ of Appendix ___ .

TABLE 3.3

SUMMARY OF TOTAL PROJECTED WATER USE

Category	Estimated Total Water Use, m^3/d			
	1980	1985	1990	2000
Domestic	136,510	169,430	214,190	317,870
Commercial, Industrial, Institutional	54,690	62,640	70,675	85,450
Un-accounted for water	63,760	77,330	94,955	134,440
Total	254,960	309,400	379,820	537,760

3.3.4 Projected Municipal Water Use

Conversion of water users from non-municipal sources to municipal supply will of course take place gradually over a considerable period of

time as the system is strengthened and expanded. For the purposes of this estimate, it has been assumed that the national Repelita III goal of providing potable water to 60 percent of the urban population by 1985 can be achieved, and that 80 percent will be served by the year 2000. It has also been assumed that commercial, industrial, and institutional users presently relying on their own water systems will gradually convert to municipal supply as that system is improved and becomes more reliable. A summary of the proportion of water needs assumed to be met by the municipal system is presented below:

Category	Served by Municipal System			
	1980	1985	1990	2000
Domestic (percent of population)	25	60	75	80
Commercial, industrial, and institutional (percent of demand)	71	73	76	84

A summary of the projected municipal system water requirements is presented in Table 3.4 Detailed projections of municipal water demand by consumer category and Kampung are given in Table ___ of Appendix ___

TABLE 3 4

SUMMARY OF PROJECTED MUNICIPAL WATER USE

Category	Estimated Municipal Water Use, m^3/d			
	1980	1985	1990	2000
Domestic	48,300	106,880	161,570	254,275
Commercial, Industrial, Institutional	42,250	45,100	52,190	71,200
Unaccounted for water	30,240	50,630	71,280	108,865
Total	120,790	202,610	285,040	434,340

3.4 PROJECTED WASTEWATER QUANTITIES

3.4.1 Methodology and Assumptions

It was assumed that the projected water use rates would provide the most reliable basis for estimating wastewater quantities since a substantial data base was available for these projections. It was further assumed that the average wastewater flow rates from domestic, commercial, industrial and institutional sources would be best represented as a fixed percentage of the average water use rates for this category. It was assumed that the average wastewater flows from domestic sources would be 70 percent of the projected water use and that flows from commercial, industrial and institutional sources would be 80 percent of the projected water use. These are referred to as wastewater return factors.

Water other than wastewater invariably enters sewerage systems in amounts great enough to require consideration from a design standpoint. Water which enters the system through leaky joints, cracked pipes and faulty service connections is referred to as infiltration and water which enters through illegal storm and house drain connections is referred to as inflow.

Two basic methods of estimating infiltration and inflow (I/I) are commonly used. One method is to estimate an I/I rate in terms of cubic metres per second per millimetre of pipe diameter per kilometre of pipe length. This method is most useful when the configuration of a proposed sewerage system is known in fairly great detail. The second method is more general and estimates I/I rates in terms of cubic metres per day per hectare of service area. For the purposes of this study, it was considered more appropriate to use the second method and an assumed I/I rate of 10 $m^3/d.ha$ was used for the wastewater flow projections. This figure was selected as being typical of the conditions encountered elsewhere under similar conditions.

3.4.2 Sewerage Service Areas

The drainage areas of the six major rivers in the study area, the Percut, Kera, Deli, Babura, Badra and Belawan, were analysed to determine what sewerage service area boundaries could be established in order to make the best use of gravity components in the collection system.

This analysis indicated that the study area should be divided into thirty sewerage service areas which correspond to the natural drainage sub-basins described in Section 2.3.1.2 and shown in Figure 2.16. The topography of these areas is in general favorable for the design of gravity collection systems.

3.4.3 Projected Wastewater Flows

The projected wastewater flows from each sewerage service area for the year 1985, 1990, and 2000 were determined by the following procedure.

First, that portion of each Kampung that fell within the boundaries of each sewerage service area was identified. If a Kampung was partially within a service area, the percentage of the area of the Kampung inside the service area was determined.

Next, the projected wastewater flows from each Kampung were determined for each design year. This was done by multiplying the projected Kampung water use rates for domestic and non-domestic purposes by the appropriate wastewater return factor. The projected average wastewater flows for each sewerage service area were then computed by adding the flows produced by each Kampung or portion of Kampung in each service area. The contribution of wastewater from Kampungs lying partially within a sewerage service area was considered to be proportional to the area.

Finally, the volume of flow contributed by infiltration and inflow was computed and added to both the average flows to produce the projected service area wastewater flows which will serve as the basis for long range planning and for evaluation of alternative wastewater management systems.

A summary of the projected total wastewater quantities and unconnected to municipal sewerage system is presented in Table 3.5.

TABLE 3.5

SUMMARY OF PROJECTED WASTEWATER QUANTITIES

Category	Estimated Quantity, in m^3/d			
	1980	1985	1990	2000
Domestic	95,560	111,340	139,770	205,950
Commercial, Industrial and Institutional	41,350	42,720	49,060	62,820
Infiltration and inflow	68,450	68,450	68,450	68,450
Totala	205,360	222,510	257,280	337,220

3.5 PROJECTED STORMWATER FLOWS

3.5.1 General

Given the extremely limited amount of river flow measurement data currently available, all estimates of present or future stormwater flows must be made and used with some caution. The runoff rates presented herein were developed in order to provide a basis for estimating the probable cost of drainage system requirements over the study period. Full recognition should be made of the relatively flimsy data upon which these estimates are based, and considerable care observed in making commitments to large channel modification projects before better data can be made available.

3.5.2 Rainfall Characteristics

The equatorial location and low elevation of Medan (3°35'N) largely determine the tropical climate of the region. Although rainfall, temperatures and sunshine show some seasonal changes, 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 occur over much of Asia. These vague periods more closely resemble those in southern India, Sri Lanka and Equatorial Africa.

Medan rainfall has been recorded since 1879 at three stations (different recording periods) and is summarized in several report. These reports and monthly records for 935 months in an 84 year period have been summarized to focus on the major storms which will affect drainage planning. During the period of record, annual rainfall has varied from 1,352 to 2,873 mm with 10 percent above 2,400 mm and 10 percent below 1,600 mm. About 50 percent of the annual rainfall records ranged from 2,000 to 2,400 mm, and the average annual rainfall for 40 years is about 2,050 mm.

The distribution of rainfall throughout the year shows two high rain months: October and May, although the long"rainy season" extends from September to January. Of the 935 months of rainfall records, 80 percent of the months have rainfall between 60 and 300 mm, while about eight percent have rainfalls from 300 to 400 mm and two percent (six months) had rainfalls greater than 400 mm per month.

The three stations in Medan had three different days with 250 to 290 mm of rain in 24 hours. Although these storms occured in December or January, they occured in widely different years: 1907, 1931, and 1956, and these storms coincide with high rainfall months (more than 300 mm storm) but not with highest rainfall years. Such temporal distribution indicates that the storms were of limited areal extent and period and that rainfall quickly decreased beyond the intense center of rain. Comparisons with twelve other northern North Sumatra Stations (below 50 m elevation) show average annual rainfall varied from 1,800 to 3,177 mm. Monthly averages for daily maxima varied from 26 to 85 mm, while storms of record ranged from 112-309 mm/during 10-20 years. Most records showed the storms of I/1931 and XI/1956 to have been most widespread with limited local centers of high rainfall.

The rainfall daily maxima for Sibolangit were 130 to 140 mm and are similar to the secondary maxima in the more northern, lower stations. This difference between primary maxima indicates that the very high rainfall came from local thunder-storms. A 1931 daily maximum at Binjei would further indicate that some frontal activity could produce widespread heavy rains.

Diurnal rainfall shows a strong tendency towards afternoon and night rains and relatively dry morning periods. For a 15 year period, rainfall of more than 5 mm/h during January to September generally occur between 12.00 to 01.00, while during the "rainy season" rains continued from 12.00 or 15.00 to 06.00 the next morning (adding 50 percent to the total rain period). These records indicate that periods of 6 to 12 hours separate daily rainy periods and thereby allow runoff and drainage before the next day's rains.

Diurnal rain records also indicate that the higher hourly rainfalls of 16 to 30 mm most commonly occured between 18.00 and 22.00 during March to September and between 23.00 and 01.00 during the rainy period of October to December. Maximum hourly rainfalls during January to March fell below 15 mm.

Rainfall records for 1879 to 1941 have been summarized (US 6) for 15 sections within the regional drainage basin of Medan (or the Deli Regency). These records clearly indicate the increase in annual rainfall with elevation:

Average Annual Rainfall (mm)	Location	Elevation (m)
1,773-2,036	Mabar	6-12
2,065-2,269	Medan	28-38
2,298-3,098	Two rivers, Deli Tua	60-101
3,127-3,978	Petani	129-174
4,520	Sibolangit	565
5,279-6,676	Bandar Baru	864-928

A comparison of monthly rainfall at Sibolangit and Medan showed the same high rainfall during October and May, but in Sibolangit, the rainy period extended from August through May with more than 250 mm of rain per month. Rainfall in the river basins above Medan is generally higher because of longer daily and seasonal rains rather than more intense rains.

3.5.3 Rainfall Data

Rainfall data from 1961 to 1941 and 1953 to 1976 were obtained from the Hydrology Design Unit, Provincial Department of Public Works Medan. This data will be published in the near future.

3.5.4 Probable Rainfall

Rainfall data have been analysed by the Hydrology Design Unit who have prepared rainfall intensity duration and frequency curves for Medan using the following methodology:

Horner's formula

$$i = \frac{A}{(t + d)^n}$$

where

i = rainfall intensity, in mm/hour

t = rainfall duration time, in hours

A, d and n are regional coefficients and exponents

The regional coefficients and exponents used to characterize the rainfall intensity for 2, 5, 10, 20, 50, and 100 year return periods are shown below, and the rainfall intensity duration curves are shown in Figure 3.2.

Return period, t (years)	Rainfall intensity, i (mm/h)
2	$i = \frac{83}{(t + 0.28) \cdot 0.95}$
5	$i = \frac{101}{(t + 0.28)\ 0.95}$
10	$i = \frac{115}{(t + 0.30)\ 0.95}$
20	$i = \frac{134}{(t + 0.31)\ 0.95}$
50	$i = \frac{161}{(t + 0.34)\ 0.95}$
100	$i = \frac{187}{(t + 0.36)\ 0.95}$

3.5.5 Runoff Analysis

The runoff coefficient represents the proportion of the rainfall that runs off the land surface and into drainage facilities. The value of the coefficient (which can vary from 0 to 1) depends on a number of

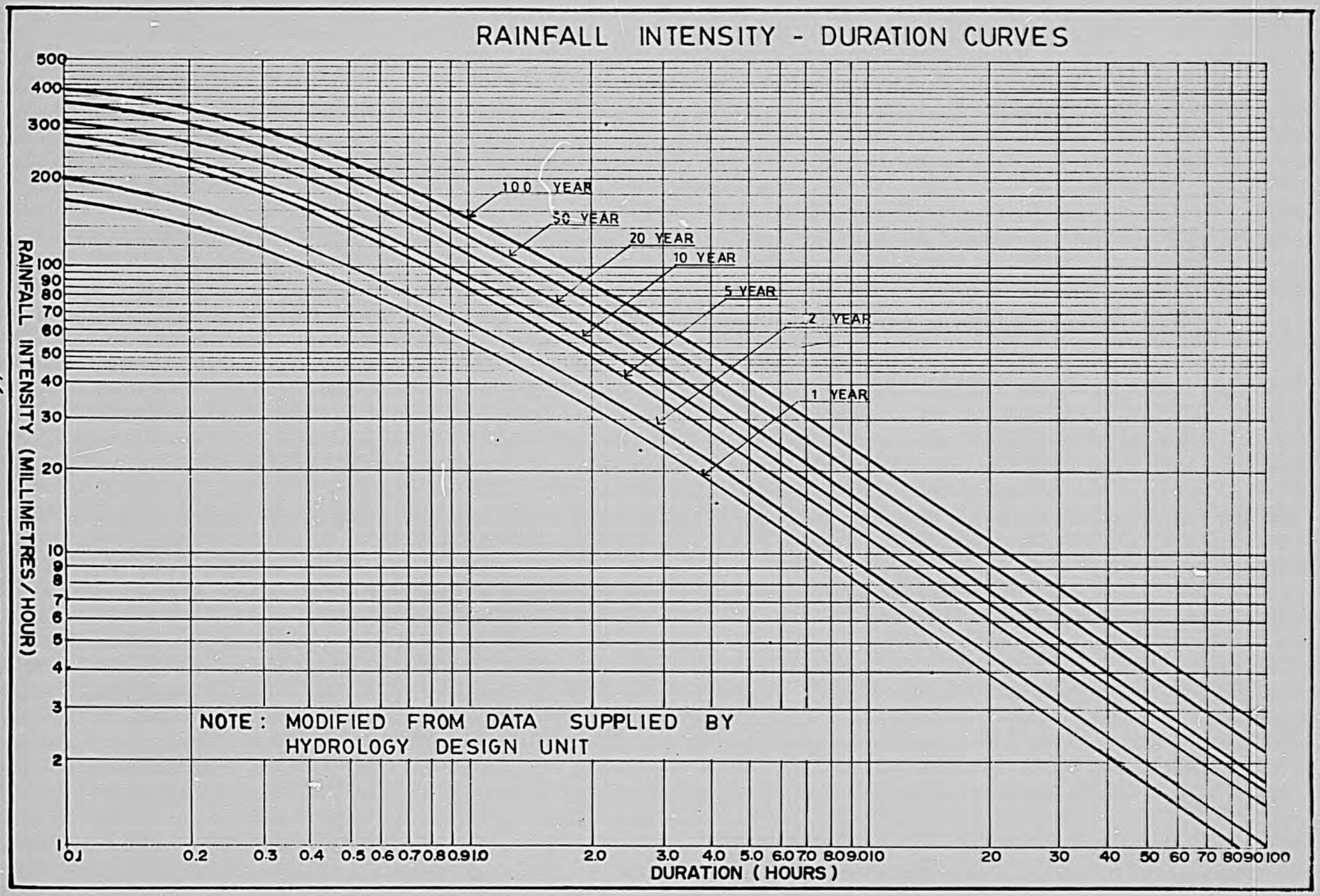

RAINFALL INTENSITY - DURATION CURVES
100 YEAR
50 YEAR
20 YEAR
10 YEAR
5 YEAR
2 YEAR
1 YEAR
RAINFALL INTENSITY (MILLIMETRES/HOUR)
500
400
300
200
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10
20
30
40
50
60
70
80
90
100
DURATION (HOURS)
NOTE: MODIFIED FROM DATA SUPPLIED BY
HYDROLOGY DESIGN UNIT

FIGURE : 3.2

factors including the permeability of the surface, surface roughness and slope, and the intensity and duration of rainfall. At the beginning of rainfall, water soaks into the ground and then fills small depressions in the surface. As the ground saturates and the surface depressions are filled, the water begins to flow over the surface and the coefficient increases in value.

The runoff coefficient can be estimated, according to Hoad (Reference 1), by the following equations:

For impervious areas (i.e., paved streets or pavement)

$$c_i = \frac{t}{t + 8}$$

For pervious areas (i.e., agricultural land)

$$c_p = \frac{0.5t}{t + 15}$$

where c_i, c_p = runoff coefficients for impervious and pervious areas

t = rainfall duration in minutes

The runoff coefficient for any area can be considered as a combination of impervious and pervious areas. Therefore, the composite runoff coefficient can be estimated by using a weighted average of c_i and c_p:

$$c = pc_i + (1 - p)\, c_p$$

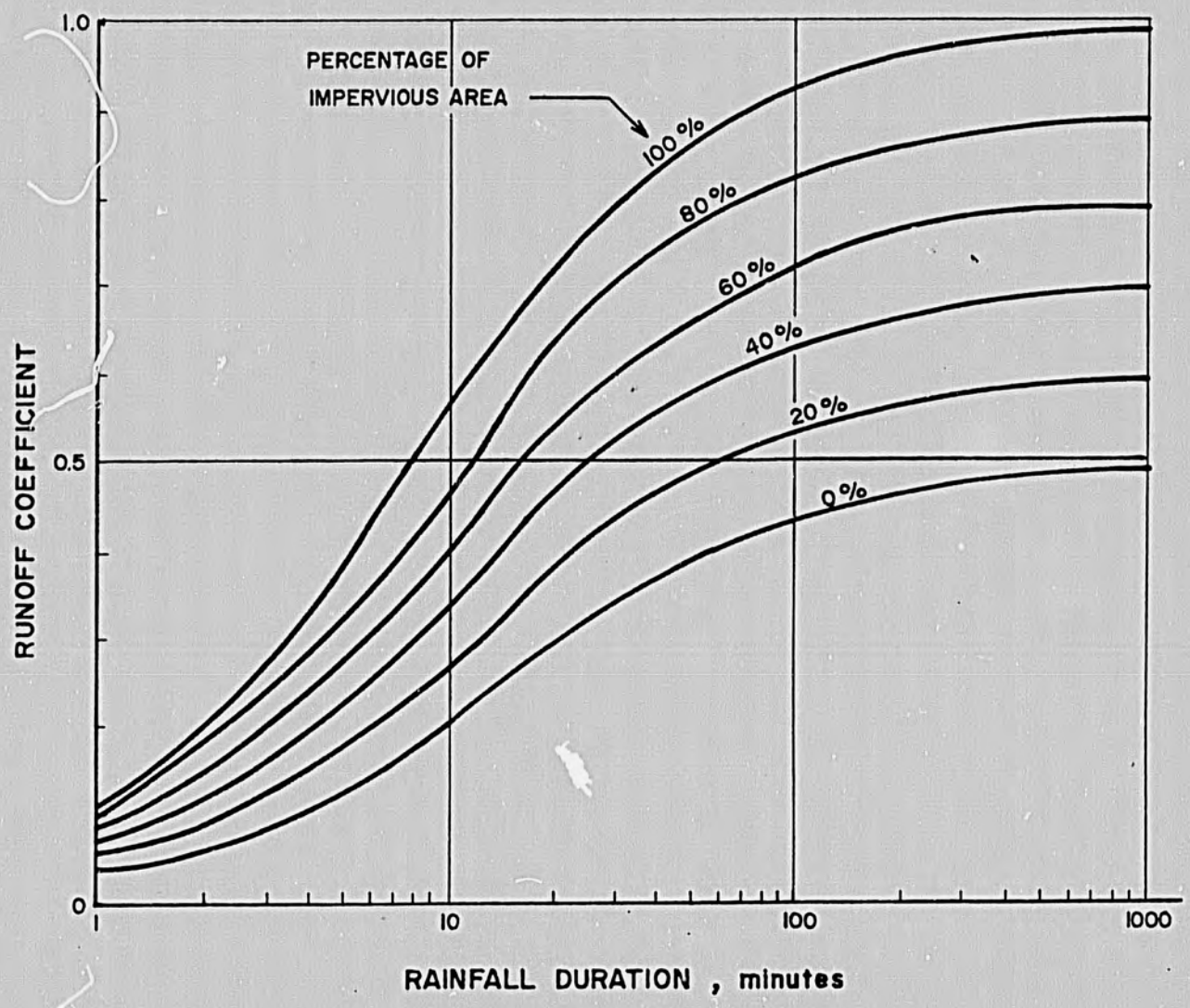
where c = the composite runoff coefficient

p = fraction of the area that is impervious

The variation of c with t for various percentages of impervious areas is shown on Figure 3.3.

Assumed percentages of impervious area for various land use classification are shown below:

Land Use	Percentage of Impervious Area
Commercial	95
Residential	65
Industrial	60
Institutional	35
Open Area	0



RUNOFF COEFFICIENTS AS A FUNCTION OF RAINFALL DURATION AND PERCENTAGE OF IMPERVIOUS AREA

The weighted average impervious area under present and projected (year 2000) land use conditions was estimated for each drainage area as shown in Figure 3.4.

3.5.6 Runoff Rates

Runoff is calculated from the formula:

$$Q = 0.00278\ ciA$$

where Q = runoff from the tributary area, m^3/s

c = runoff coefficient

i = rainfall intensity, mm/h

A = tributary drainage area, ha

Note that the values of c and i depend on the selection of a rainfall duration. Maximum runoff will occur when the rainfall duration is equal to the time required for water falling on the farthest point in the tributary area to travel to the point where the runoff is to be calculated. This time is composed of two parts: (1) the inlet time which is the time required for overland flow of water from the farthest point in the tributary area to reach the inlet to the drain, and (2) the time of flow in the drain from the inlet to the point where the runoff is being calculated.

An empirical formula from Kirpich is used to calculate the inlet time: t_i

$$t_i = 0.00032\ \frac{L^{0.77}}{S^{0.385}}$$

where t_i = inlet time, h

L = length of the tributary basin area, m

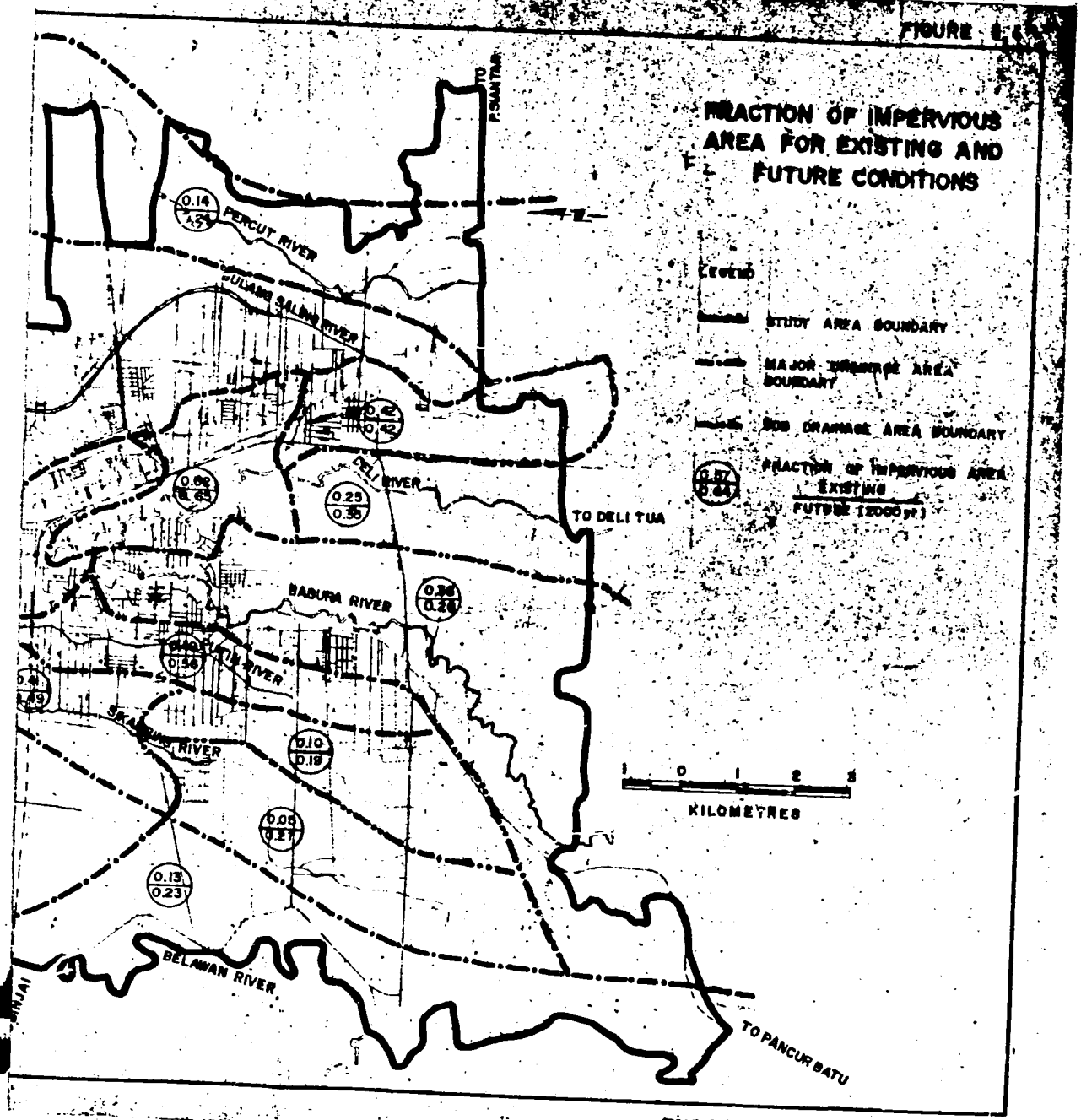
S = average slope of the tributary area from the farthest point to the inlet

The time of flow in natural channels (main rivers) was determined using the following emperical formula:

$$t_d = \frac{L^{1.6}}{150{,}000\ H^{0.6}}$$

where t_d = time of flow in drain

L = length of drain from the inlet to the point being considered, m



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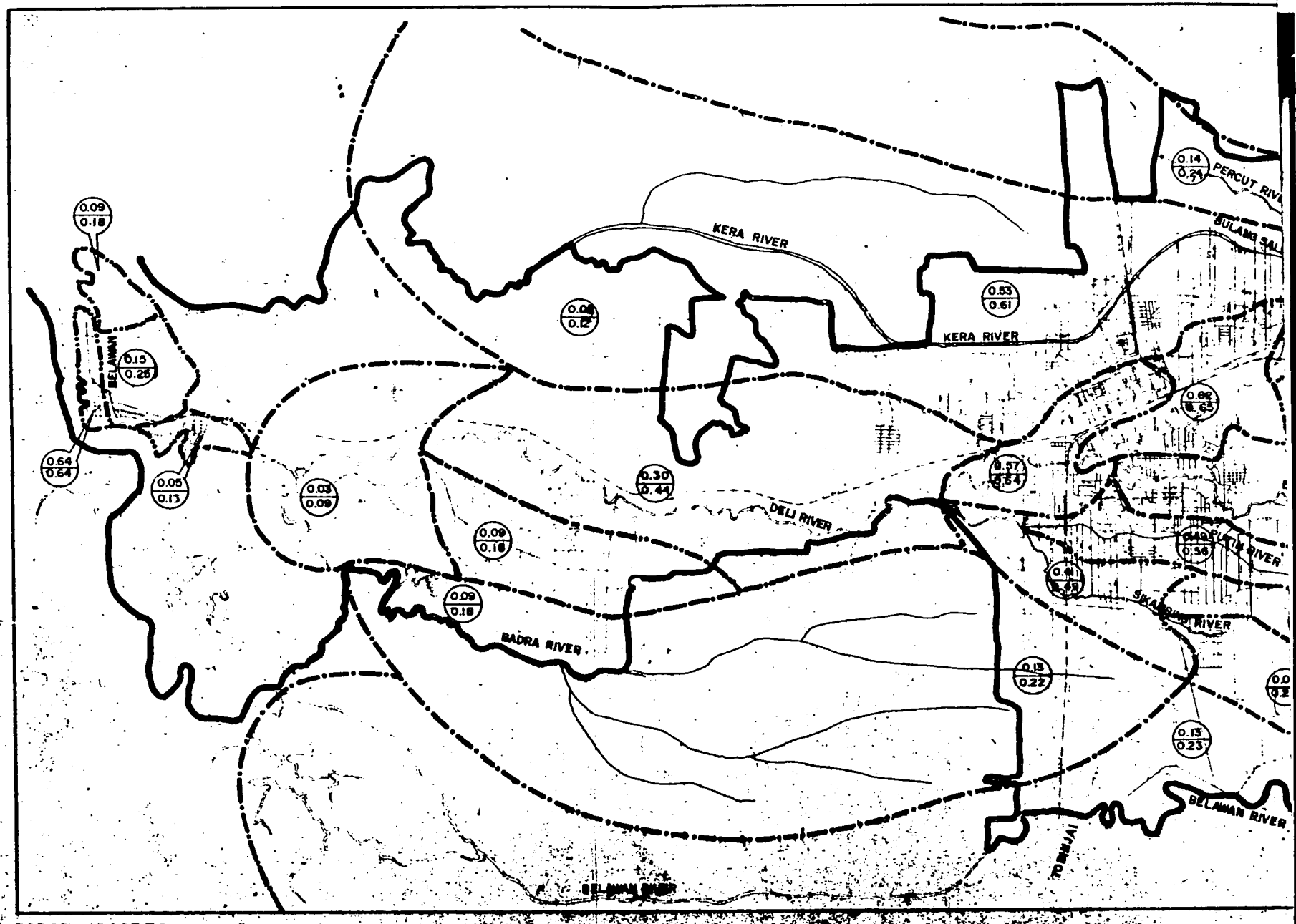

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H = difference in elevation between the inlet and the point being considered, m

In all improved drains time of flow in the drain was determined using the flow velocity calculated by the manning formula.

3.6 PROJECTED SOLID WASTES QUANTITIES

3.6.1 Present Unit Generation Rates

In 1976 a feasibility study of waste disposal in four cities in Indonesia was initiated jointly by the Government of Indonesia (Cipta Karya) and the Netherlands Government. The objective of the project was to obtain basic information with respect to:

- the quantity and composition of solid wastes in the four cities
- the most suitable equipment for the collection and disposal of solid wastes in Indonesian circumstances

The data resulting from the project were considered to be essential for the development of detailed Master Plans for each city.

The project consisted of replacing the existing solid waste collection systems in selected areas of Bandung, Medan, Pontianak, and Ujung Pandang and with alternative collection systems which had proven successful in other areas.

In April of 1979, a separate study of solid wastes generated within the primary service area of Medan was undertaken by senior operating staff of DKKP. Estimates of solid waste quantities generated each day were prepared based on field observations. These estimates included wastes from domestic, commercial, industrial and institutional sources. The total quantities of solid waste generated in each major source area were found to be as follows:

Source	Quantity, in tonnes/d
Kecamatan Medan Kota	103
Kecamatan Medan Timur	62
Kecamatan Medan Baru	95
Kecamatan Medan Barat	71
Kecamatan Kota Belawan	35
Parks	15
Markets	74
Total	455

This information, together with the unit domestic waste generation data obtained by the GOI/Netherlands study and current land use data, was used to calculate a per hectare generation rate for commercial, institutional and industrial sources.

A summary of the relevant unit generation data available is presented in Table 3.7.

TABLE 3.7

SUMMARY OF UNIT SOLID WASTE GENERATION RATE DATA

Location	Description	Unit Generation Rate		
		Domestic kg/cap.d	Commercial [a] (specified Kampungs) kg/cap.d	Commercial [b] Institutional Industrial T/ha.d
Bandung	Measured	0.35		
	GOI/Netherlands	0.30	-	-
	Study	0.36		
Medan	Measured			
	GOI/Netherlands			
	Study			
	Desa Mesjid		0.828	
	Desa Pandau Hulu I	0.50		
Medan	DKKP Special			
	Study (adapted)			
	Kec. Medan Kota			0.16
	Kec. Medan Baru			0.22
	Kec. Medan Barat			0.15
	Kec. Medan Timur			0.24
	Kec. Medan Belawan			0.16

3.6.2 Projected Unit Generation Rates

Increases in per capita domestic waste generation rates of between one and three percent per year are being experienced throughout the world resulting from increased per capita consumption and from increased use of

a. Applies to 9 desas: Mesjid, Pasar Baru, Pusat Pasar, Sei Rengas I, Aur, Kesawan, Gang Buntu, Petisah Tengah, Belawan.

b. The tabulated values were obtained by subtracting the domestic component from the DKKP estimates and dividing the difference by the total commercial, institutional and industrial land use in each Kecamatan.

packaging materials. In Medan a transition towards the increased use of plastic film in place of banana leaves for food wrapping could tend to decrease the quantity of solid wastes that would otherwise be generated.

Future commercial, institutional, and industrial unit generation rates are not expected to increase significantly over the study period as wastes from these sources already reflect the effects of higher technology and a higher living standard on waste production.

The projected unit solid wastes generation rates adopted for purposes of developing the Master Plan solid wastes program are as follows:

Category	Unit	Unit Rate			
		Present	1985	1990	2000
Domestic*	kg/cap.d	0.50	0.56	0.62	0.75
Commercial Institutional Industrial	kg/ha.d	0.2	0.2	0.2	0.2
Markets and Parks		Projected on the basis of total production in proportion to total Domestic production.			

* Projected at a 2 percent increase per year.

3.6.3 Projected Solid Waste Quantities

3.6.3.1 Present Total Generation

Based on the foregoing data, estimates of total solid wastes production in the Study Area have been prepared and are presented in Table 3.8.

3.6.3.2 Present Quantity of Solid Waste Collected

The following is a summary of the quantity of solid wastes collected in the Study Area during 1978 as estimated by the GOI/Netherlands Government Studies.

Month	Tonnes	Tonnes per day (average)
January	5.1	177
February	3.7	131
March	4.0	128
April	3.5	117
May	4.6	147
June	4.4	148
July	4.7	151
August	5.2	166
September	4.4	148
October	4.9	156
November	4.9	163
December	5.3	171
Total Annual Average	54.7	150

TABLE 3.8

SUMMARY OF PRESENT SOLID WASTE QUANTITIES

	Present Solid Waste Quantities, in thousands of tonnes/day				
Service Area	Domestic	Commercial (nine desas)	Other Commercial Industrial Institutional	Markets Parks	Total
Primary Area					
Medan Kota	77	10	16		
Medan Timur	27	3	32		
Medan Baru	48	4	43	89	
Medan Barat	36	8	26		
Kota Belawan	20	4	11		
Sub-Total	208	29	128	89	454
Secondary Area					
Medan Kota	39				
Medan Timur	63				
Medan Baru	12				
Medan Barat	30				
Kota Belawan	5				
Sub-Total	149				149
Tertiary Area					
Urban	111		47		
Rural	90				
Totals	558	29	175	89	851

During April and May 1979 the DKKP disposal site at Paya Babi was inoperative and all solid wastes were disposed of at the Binjei Road composting plant where the truck sources were recorded and weights measured, thus providing an independent check of quantities. The results were as follows:

Truck Source	Average Quantity, in tonnes per day
DKKP including parks	115
Markets	19
DAF container project	11
Perumnas	3
Total	148

The quantity of solid wastes presently collected for disposal is about 25 percent of the total estimated solid waste generated in the primary and secondary service areas.

3.6.3.3 Projected Solid Waste Quantities

Projected quantities of solid wastes generated were estimated using the previously developed unit generation rates and projected future population and land use data.

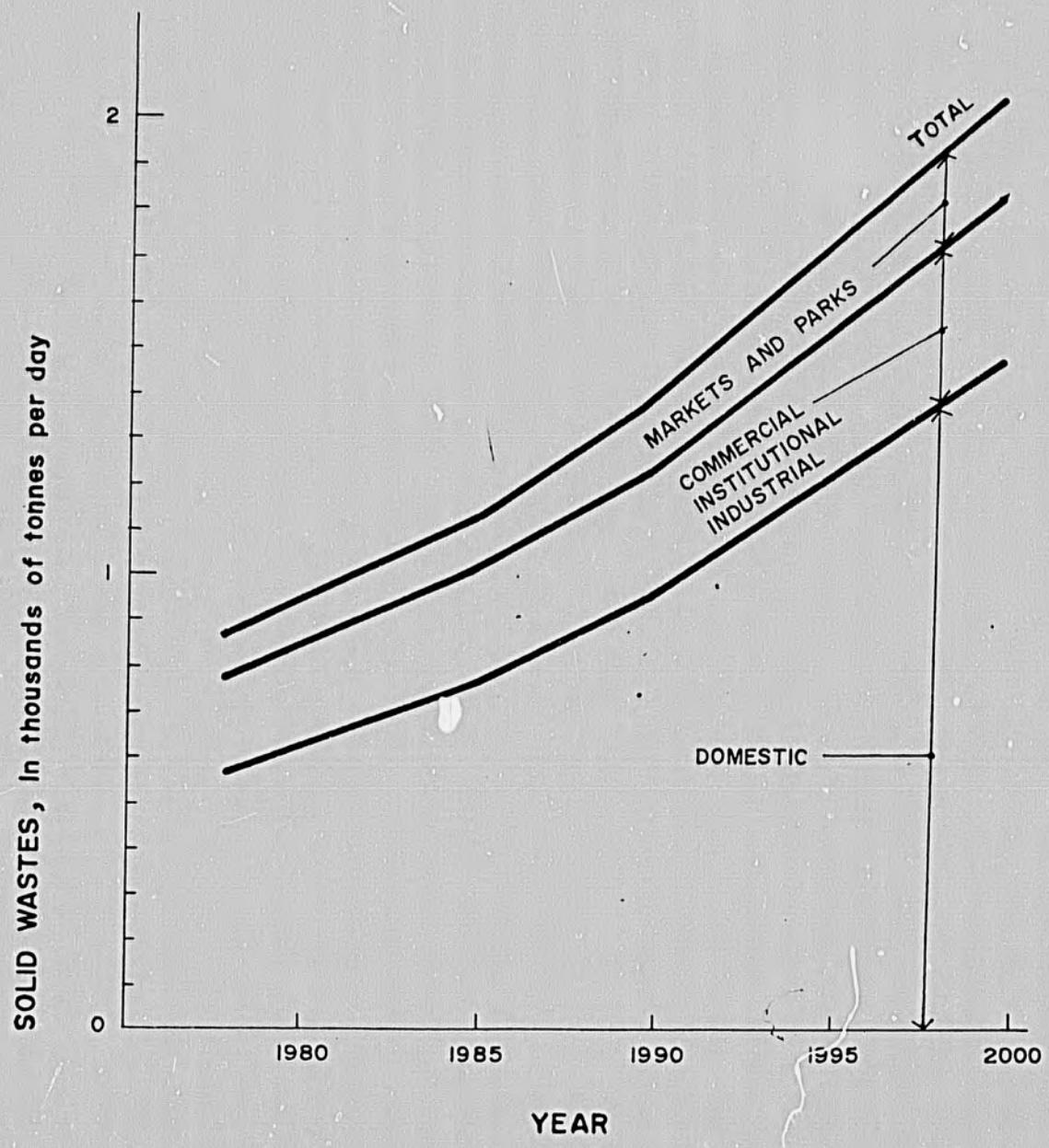
The total quantities of solid wastes generated within the study area throughout the program period are summarized below and are shown graphically in Figure 3.5 and summarized in Table 3.9.

TABLE 3.9

SUMMARY OF PROJECTED SOLID WASTE QUANTITIES

Source	Estimated Solid Waste Quantities, in thousands of tonnes/day			
	1978	1985	1990	2000
Domestic	558	751	941	1465
Commercial, Institutional, Industrial	204	241	275	355
Markets and Parks	89	120	149	233
Totals	851	1112	1365	2053

Details of projected solid waste quantities by consumer category and Kampung are given in Table —— of Appendix —— .



QUANTITY OF SOLID WASTES GENERATED

3.6.4 Solid Wastes Composition

3.6.4.1 Present Composition

There is little available information on the composition of solid wastes in Medan. In an effort to obtain an indication of the general character of the wastes several pool sites and disposal facilities were visited and estimates were obtained of the composition of materials salvaged. The results are summarized in Table 3.10.

TABLE 3.10

ESTIMATED SOLID WASTE COMPOSTION

	Composition as a percentage of total weight (including moisture)			
Component	Pool Medan Mentawai	Pool Medan Petisah	Medan Disposal Site	Medan Composting Plant
Paper	2.7	0.2	0.2	2.2
Plastic	0.5	1.2	4.0	12.3
Glass	0.2	0.1	2.5	4.2
Metal	0.2	0.5	2.5	8.8
Rubber	0	0	0.5	1.8
Leaves & food wastes	96.4	98.0	90.3	70.7

Moisture content was reported to vary from 65 to 90 percent at the composting plant.

The density of the solid wastes as collected has been measured by the GOI/Netherlands program with the result summarized in Table 3.11.

TABLE 3.11

SUMMARY OF DATA ON SOLID WASTE DENSITY

Source	Type	Observed Density kg/m^3	
Bandung	Domestic	210	240 (new system)
Medan	Domestic & market	277	257 (new system)
Pontianak		204	254 (new system)
Ujung Pandang		500	351 (Large container, new system)
Medan Desa Mesjid	Commercial	359	
Medan Desa Pandau Hulu I	Domestic	306	
Market DAF Truck		240	
Medan Total (excluding DAF)1978		280	

The following values are considered to be representative of average densities for Medan's solid waste.

Source	Density kg/m^3
Domestic	310
Commercial Area	360
Industrial	260
Markets & Parks	240
Weight Average	280

3.6.4.2 Future Composition

Long terms trends in solid wastes composition are expected to result in a decrease in the percentage of leaves and an increase in the percentage of paper and plastics with an overall decrease in the food waste component.