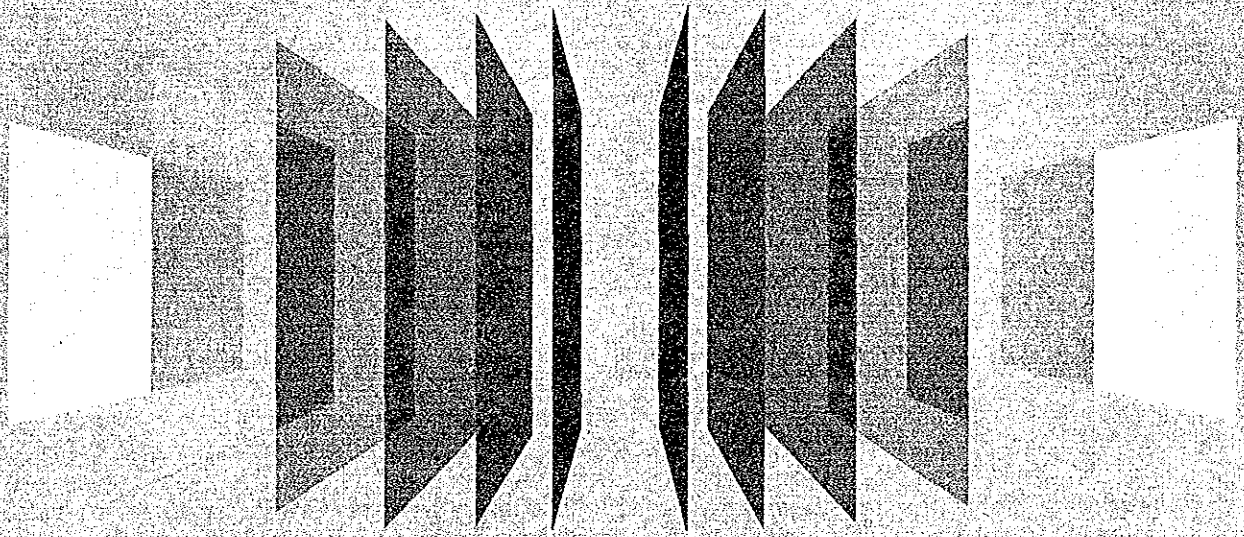
THE FEASIBILITY STUDY ON GUAYAQUIL CITY URBAN TRANSPORTATION PLAN IN THE REPUBLIC OF ECUADOR



FINAL REPORT

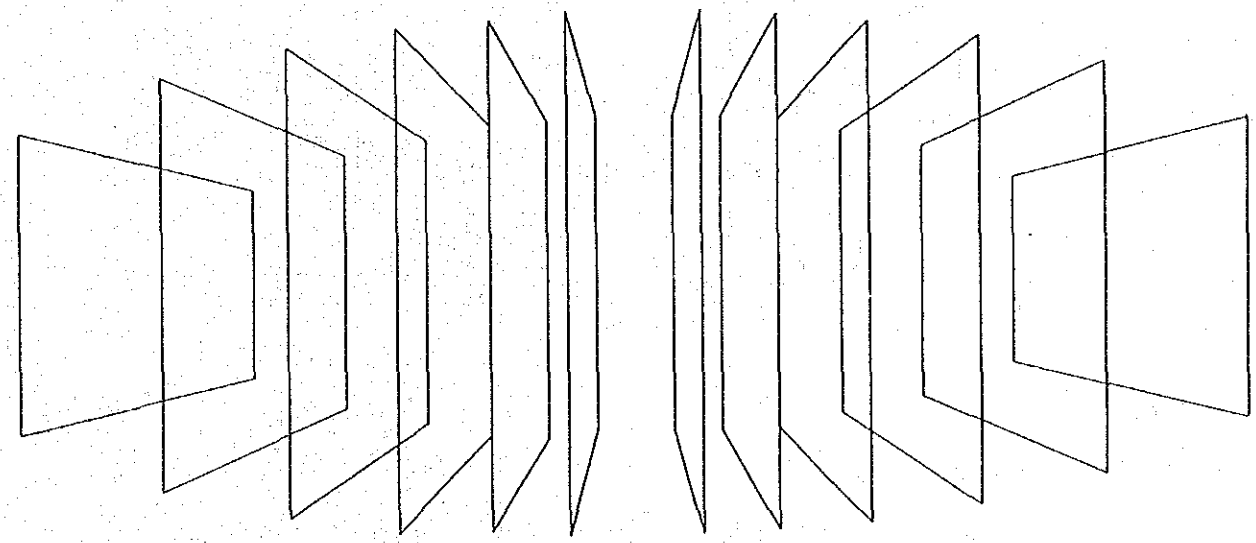
SUPPLEMENTARY VOLUME 1

EXISTING CONDITIONS AND REVIEW OF DATA
MRT DEMAND FORECAST, ALTERNATIVES OF MRT ROUTE AND SYSTEM

DECEMBER 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

THE FEASIBILITY STUDY
ON
GUAYAQUIL CITY
URBAN TRANSPORTATION PLAN
IN
THE REPUBLIC OF ECUADOR



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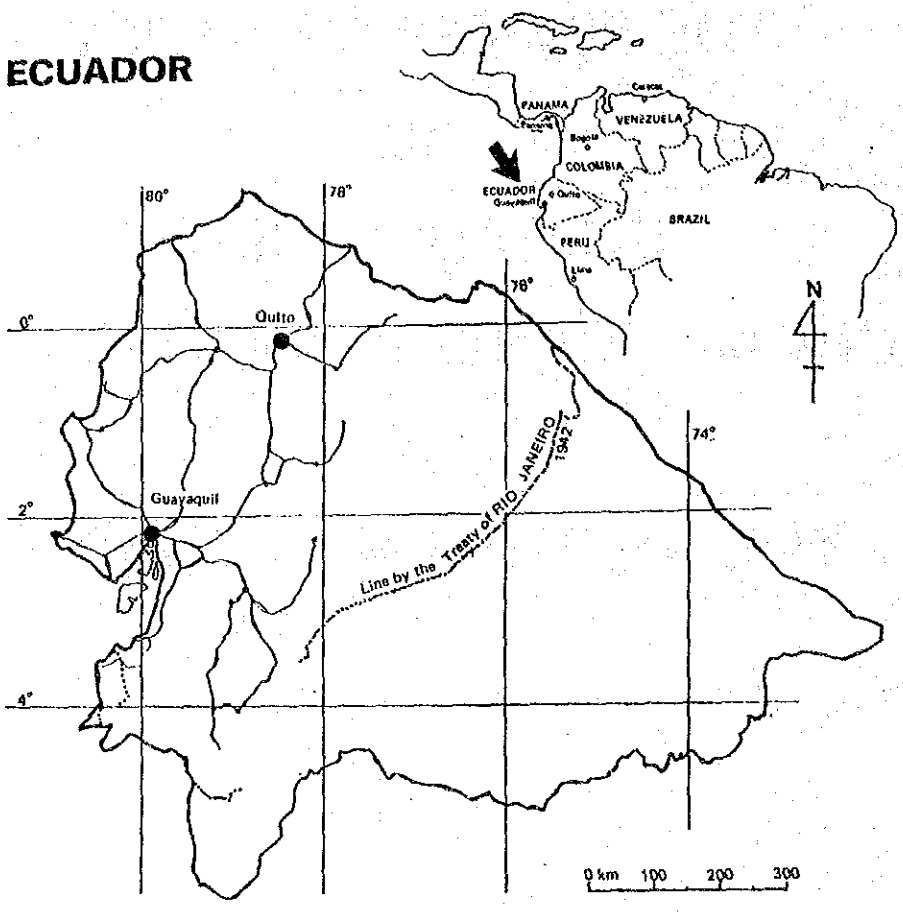
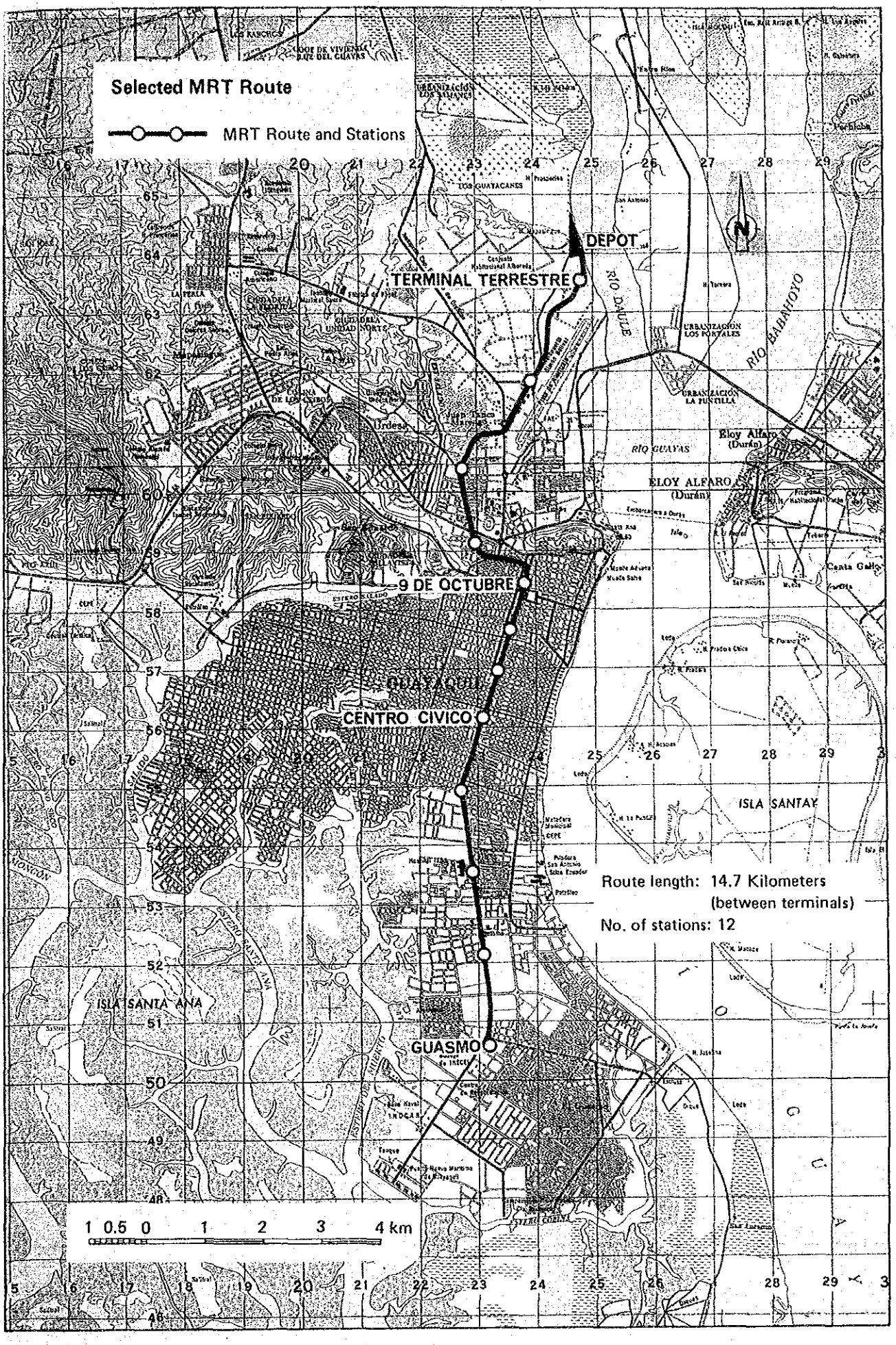
ECUADOR



Area	;	270,670 Km^2 (after 1942)
Population & Growth Rate	;	9,378,000 (1985),2.91%/year (80-85)
Foreign Money Exchange rate	;	US 1$ = 95 Sucres in free market of the Central Bank (A) =120 Sucres in free market (Nov.1985)
Gross Domestic Products	;	6,503 mil.US $ (1983, 87 S./ $ by (A))
GDP Per Capita	;	734 US $ (1983, 8.857 mil. Population)
Productive Structure	;	Agriculture 13.5%, Mine & Manifacture 39.7%, Services,etc. 46.8% (1983)
International Trade	;	Export 2,583 mil. US $/ Import 1.458 , Balance 1,125 mil. US $ (1984)
National Budget of Govern - ment	;	953 mil.US $ (1983, 87 S./$ by (A))
Index of Consumer's Prices	;	48.1%/year (1983), 30.4 (84)


Selected MRT Route
MRT Route and Stations
DEPOT
TERMINAL TERRESTRE
9 DE OCTUBRE
GUAYAQUIL
CENTRO CIVICO
GUASMO
RIO DAULE
RIO BABAHOYO
RIO GUAYAS
ELOY ALFARO
(Durán)
ISLA SANTAY
ISLA SANTA ANA
Route length: 14.7 Kilometers
(between terminals)
No. of stations: 12
1 0.5 0 1 2 3 4 km

FINAL REPORT

SUPPLEMENTARY VOLUME 1

CONTENTS

APPENDIX

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PART 3

PART 4

ABBREVIATION AND DEFINITION IN THIS REPORT

CBD	----------	Central Business District (the area surrounded by Rio Guayas, Av. Quito and Av. Olmedo)
CONADE	----------	Consejo Nacional de Desarrollo
CTG	----------	Comisión de Tránsito del Guayas
EMELEC	----------	Empresa Eléctrica del Ecuador
ENTE	----------	Empresa Nacional de Ferrocarriles del Estado
FODUR	----------	Unidad Ejecutora del Fondo de Dessarrollo Urbano de Guayaquil
INECEL	----------	Instituto Ecuatoriano de Electrificación
INTEL	----------	Instituto Ecuatoriano de Telecomunicaciones
INEC	----------	Instituto Nacional de Estadística y Censos
JICA	----------	Japan International Cooperation Agency
MRT	----------	Mass Rapid Transportation
the M/P Study	----------	the master plan study in 1983 by JICA
the Study, the F/S	----------	this feasibility study
the Team	----------	Japanese Study Team

PART 1

EXISTING CONDITIONS IN STUDY AREA

PART 1 EXISTING CONDITIONS IN STUDY AREA

1. Existing Conditions of Urban Transport

This chapter describes the present traffic condition and transport characteristics seen today in the Guayaquil city.

The M/P Study in 1983 analysed them in detail based on the information as of the year '82. Since the traffic situation might change considerably after that, this report collects latest traffic data and analyses it.

Following items are studied in this section:

(1) Transport systems

There are 3 kind of transport systems in the Guayaquil city, namely Bus system, Car and Taxi. Each system which has respective transport characteristics attracts particular trip with its own different transport importance.

(2) Vehicular traffic

All the transportation systems in the Guayaquil city are supported by land transportation, especially vehicular transportation. This brings that all transportation modes share the road space each other and it makes road traffic more congested.

(3) Buses and the Bus Terminal (Terminal Terrestre)

The bus is only public transportation system available in the Guayaquil city.

Its network covers each part of the city area and is managed to be maintained well, namely, the bus system can be taken for the most useful transport means in Guayaquil.

A new bus terminal commenced its service in October, 1985, displaying its function in full as a terminal point between the long-distance and urban bus.

1.1 Transport System of Guayaquil

Overall urban traffic demand in Guayaquil is mainly covered by both privates vehicles and the bus system. These transport systems had well functioned previously because the Guayaquil city was not large and its road system had developed in relatively sufficient level. However, now, they seem to be confronted with much heavier load than their transport capacity while the city is being urbanized extensively and its urban population is growing rapidly.

There are three typical transport modes in Guyaquil for the urban transportation demand such as private vehicles, taxis and buses according to the M/P study which presented traffic demand by modes as shown in Table 1-1.1

Table 1-1.1 PRESENT URBAN TRAFFIC DEMAND IN GUAYAQUIL BY MODES

Unit: Trips/day in 1982

MODE	TRIP VOLUME	SHARE(%)
Private Vehicles	1,051,000	45.4
Bus	842,000	36.4
Taxi	420,000	18.2
Total	2,313,000	100.0

Source) M/P study

The table shows that 45% of the urban traffic demand is by private vehicles, 36% is by bus and 18% by taxi, indicating that it largely depends upon private vehicles.

However, the trips of private vehicles will increase with the car ownership growth in future, resulting in making the road traffic congestion worse.

The public urban bus system plays a important role in urban transport and it provides mobility to the people who lack self-movable means. A bus can afford to carry more peoples than a small private vehicle and thus utilize roadway more efficiently. But mixed traffic on roads has a possibility of causing traffic accidents and a decrease in the transport capacity.

This means that the city will need a powerful transportation means like the MRT system.

1-2 Traffic Characteristics

1) Traffic Volume on Major Arterial Roads in Guayaquil

The Guayaquil city has such an urban development pattern that the suburban areas have been extended to the surroundings from the single heart of the city and the major roads connect them each other. Such major roads consist of wide multi-carriageways and have high capacity but the concentration of traffic on these roads leads to congestion.

The traffic volume on them was reported in the M/P study. The followings are the latest findings based on the comparison between the M/P study and the supplementary traffic survey results conducted in this Study.

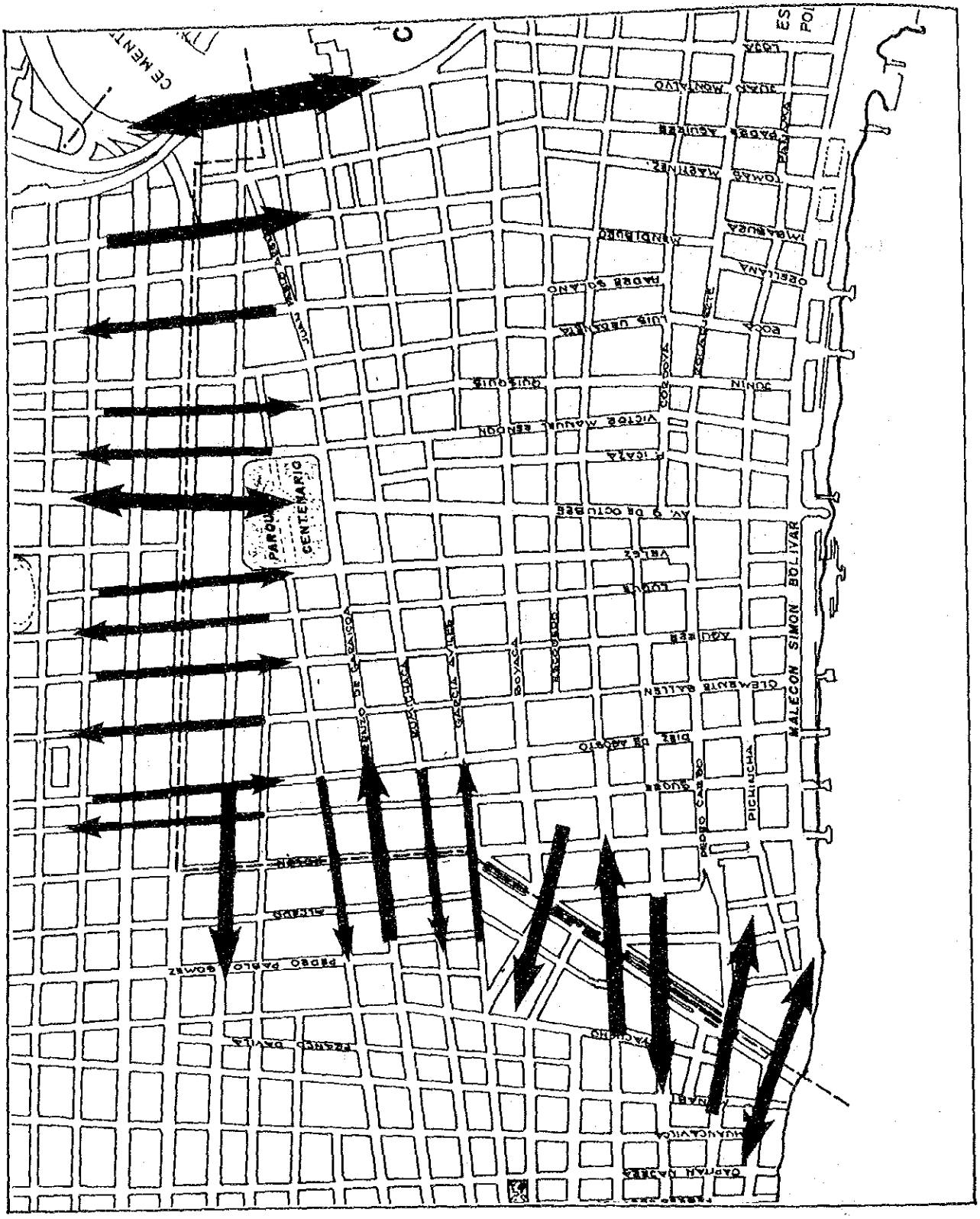
Figure 1-2.1 shows the traffic volume on the innermost road sections. Heavy traffic volume can be seen because these sections receive large traffic concentration to the CBD (Central Business District) of Guayaquil. There is, however, only a slight increase in the traffic volume in comparison with the M/P study results.

Figure 1-2.2 shows the traffic flows of the major arterial road sections situated at entry points toward the CBD.

This also explains the traffic volume changes for 3 years between year '82 and '85. A greater change can be seen mainly at the northern suburban sections, while minor changes occur at the innermost section near the CBD.

2) Variation by Time

The hourly variation of the traffic flow measured at the main sections is shown in Figure 1-2.4. In general, the flows have a peak between 8 and 9 a.m., remain fairly constant throughout the day period and fall gradually after 6 p.m.



LEGEND

UNIT : VEHICLES/DAY

	40,000 ~ 20,001
	20,000 ~ 15,001
	15,000 ~ 10,001
	10,000 ~ 5,001
	5,000 ~ 0

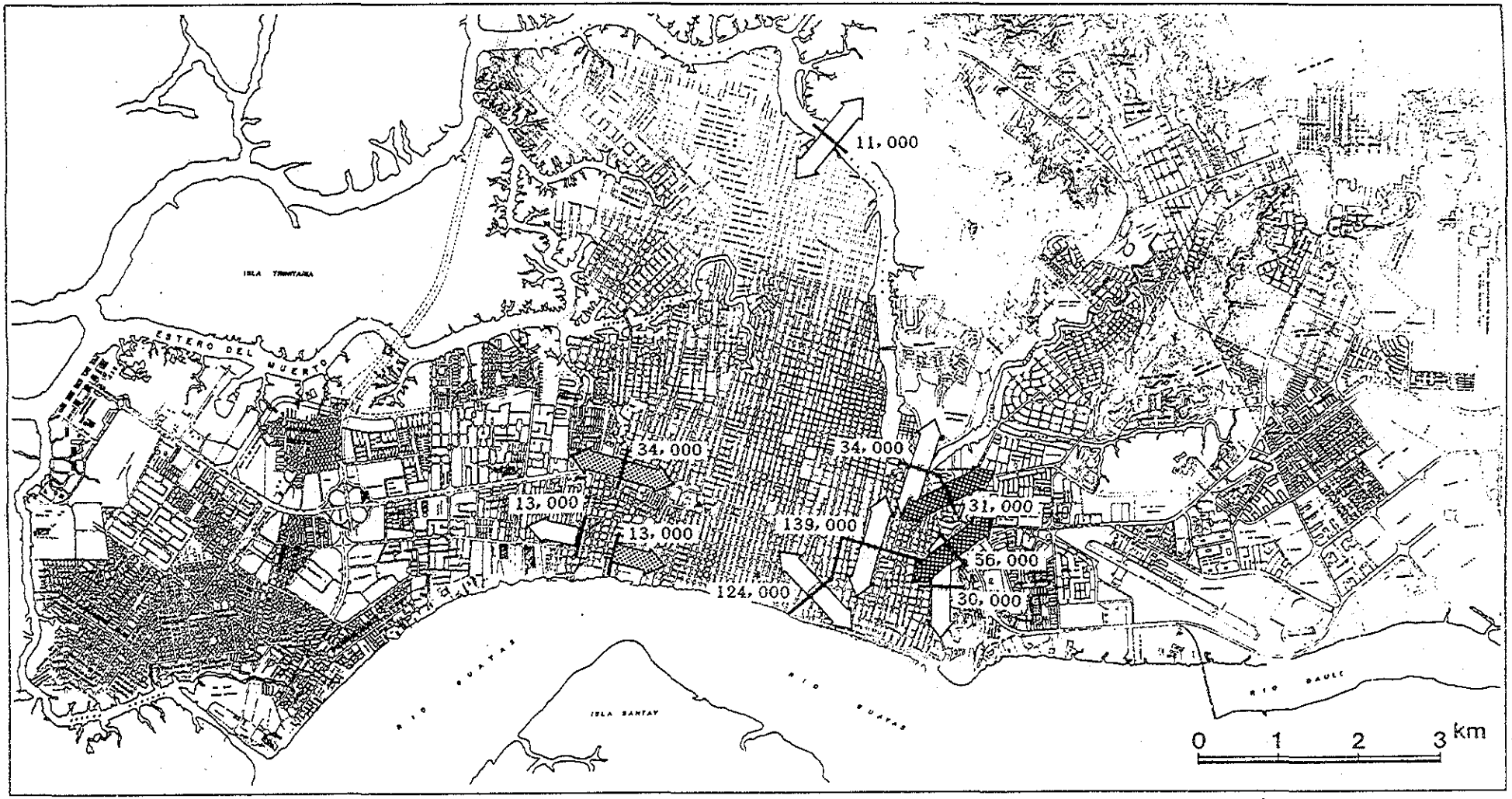
THE FEASIBILITY STUDY ON GUAYAQUIL CITY URBAN TRANSPORTATION PLAN IN THE REPUBLIC OF ECUADOR

Figure 1-2.1

THE TRAFFIC VOLUME ON THE INTERNAL SCREEN LINE

JAPAN INTERNATIONAL COOPERATION AGENCY

N



LEGEND

COMPARISON

1985/1982 = 1.2 ~

1.1 ~ 1.2

1.0 ~ 1.1

~ 1.0

THE FEASIBILITY STUDY ON GUAYAQUIL CITY URBAN TRANSPORTATION PLAN IN THE REPUBLIC OF ECUADOR

N

Figure 1-2.2

TRAFFIC VOLUME COMPARISON WITH M/P STUDY

JAPAN INTERNATIONAL COOPERATION AGENCY

The peak rate estimated from these results is about 10 percent of the total daily traffic flow.

3) Vehicle Composition

Figure 1-2.3 shows the vehicular composition of the traffic flow at the section mentioned before. It varies fairly depending on the road sections because each road has particular route characteristics from the viewpoint of the roadside land use.

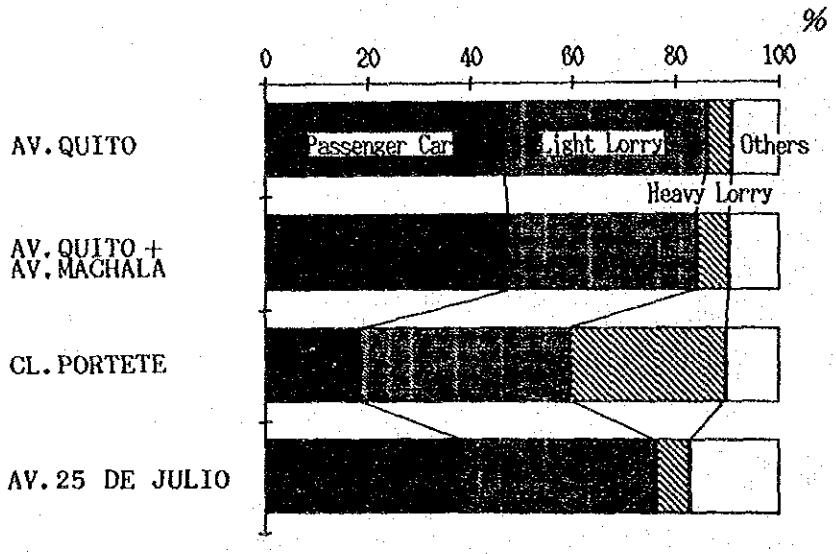
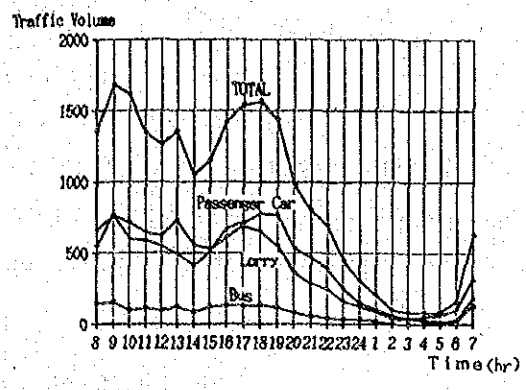


Figure 1-2.3 TRAFFIC COMPOSITION BY ROADS

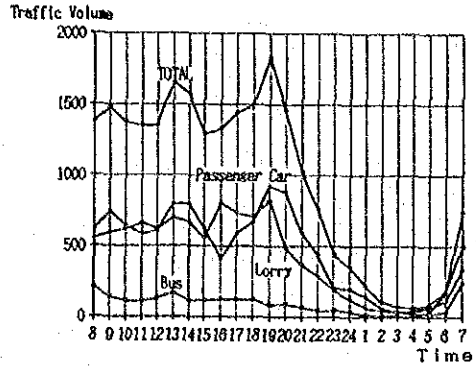
Source) The supplementary traffic survey by the Study Team

In general, the heavy vehicles composition rates are higher at the section 27, Puente Portete, while the passenger car rates are high at the section Av Quito + (Av Machara) and (Av Quito). (See Figure 1-2.4 and Appendix 1-1 at page A-14.)

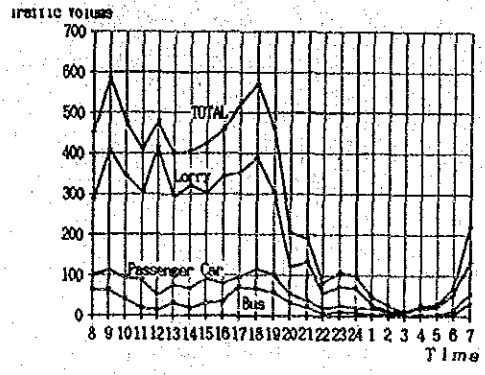
Road section (9 de Octubre (Entry))



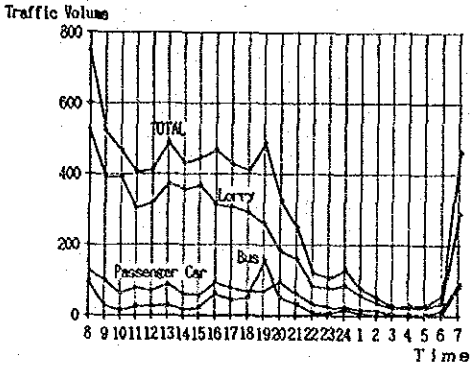
Road section (9 de Octubre (Exit))



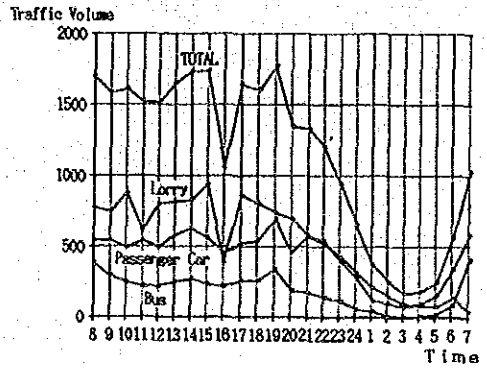
Road section
(Cl. Portete (Entry), Puente Portete)



Road section
(Cl. Portete (Exit), Puente Portete)



Road section
(Av. 25 de Julio (Entry))



Road section
(Av. 25 de Julio (Exit))

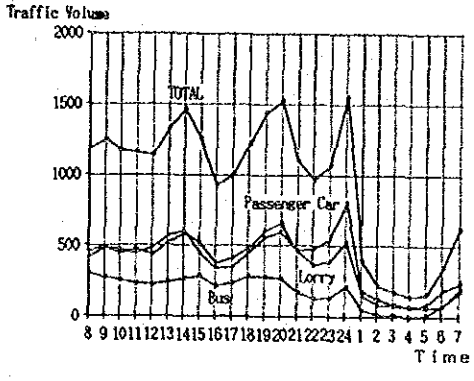


Figure 1-2.4 TRAFFIC VARIATION BY TIME

Source) The supplementary traffic survey by the Study Team

1-3 Bus Transport and Bus Terminal (Terminal Terrestre)

1) Bus Transport

The bus transport covers the city in a fairly high service level, and is a quite convenient transportation means. The total number of bus coaches is estimated about 2000 from the registered number of vehicles and the total number of operations is about 11,000 times a day.

a. Network

The network of the urban public bus route in the city is shown in the Figure 1-3.1. It has an almost radial pattern, but some routes connect the Terminal Terrestre (Inter-city bus terminal) with the CBD of the Guayaquil city.

The length of each route is about 30 km in one round, and it takes about 90 minutes.

The number of the urban bus routes has increased from about 50 in 1982 of the M/P study to 78 in 1985 and most of the new ones are access to the Terminal Terrestre.

b. Bus Fare

The fare system of the urban bus and its service category are as follows.

Table 1-3.1 BUS FARE SYSTEM

Fare (Sucre)	Type of Bus	Capacity	Service Characteristics
6	Bus	30-50	Ordinary Service
	Colectivo	"	
8	Buseta	30-50	Seating passengers only, a few bus stops
	Colectivo Especial	40-50	
10	Ejecutivo	40-50	Same as the above to/from the Terminal Terrestre.

As of November, 1985

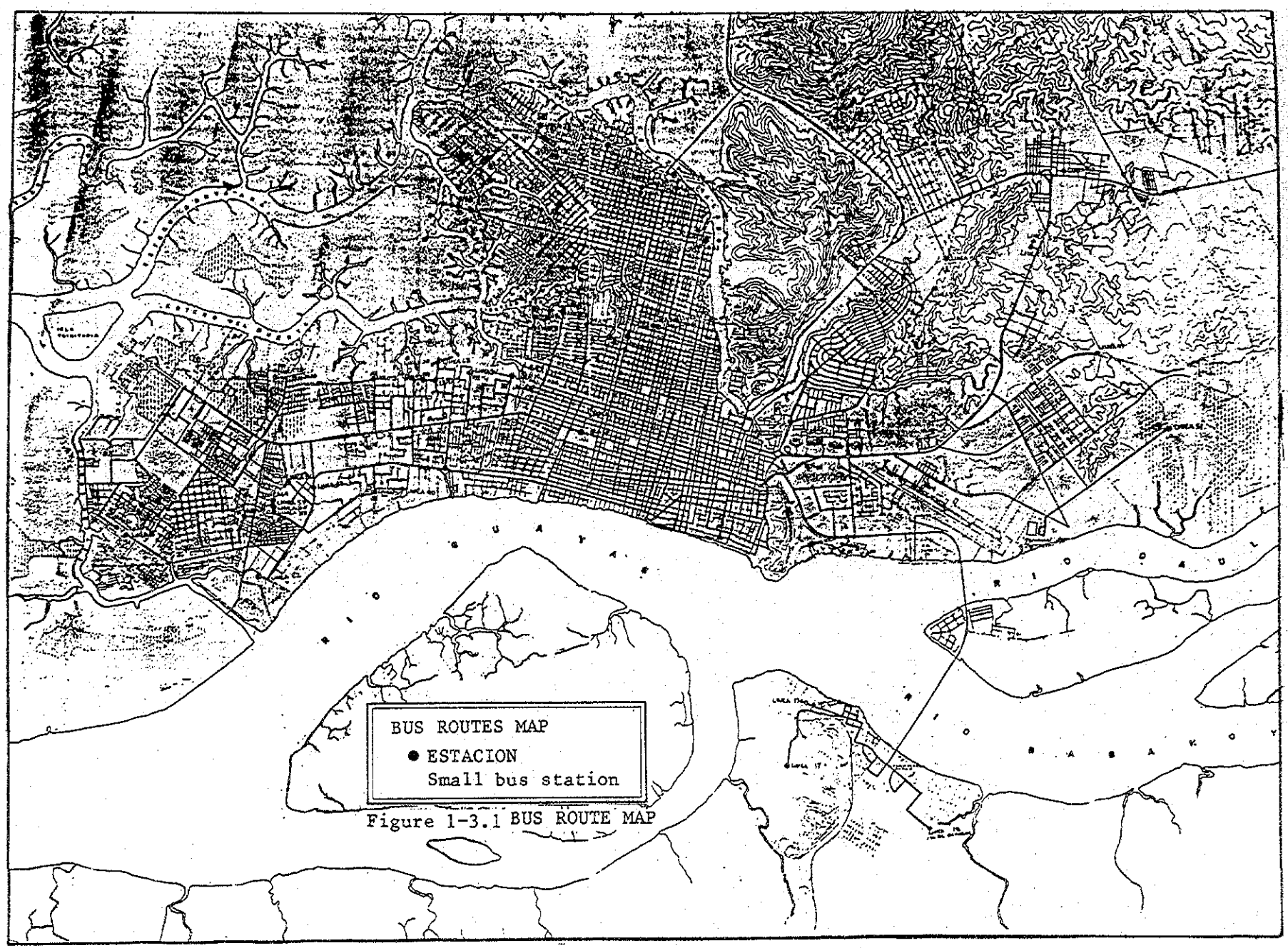


Figure 1-3.1 BUS ROUTE MAP

c. Type of Vehicle

Many kinds of vehicles are used for transport but, in principle, they are classified into two categories depending on their capacity as below:

Capacity (persons)	Name called
• 30 - 50	Bus, Colectivo, Colectivo Especial
• 10 - 20	Buseta, Furgoneta, Camioneta

d. Velocity of Urban Public Bus

The velocities of buses are 12 to 16 Km/h and not so different by direction and by area because the routes in the CBD are limited to the arterial roads.

e. Actual Condition of Urban Bus Transport

The actual condition of the urban bus transport is shown in Table 1-3.2. The numbers of bus operations is 10,948 in a whole day and the number of buses is about 2000.

The number of passengers is estimated to be 1,182,000 persons/a day except those to/from the Terminal Terrestre.

Table 1-3.2 ACTUAL CONDITION OF THE PUBLIC URBAN BUS

No. of routes	78
No. of vehicles	1,966
No. of round trips (Round trips/day)	10,948
No. of Group	66
No. of Passengers a day except to/from Terminal	1,182,000

f. Passenger Volume Variation by Time

Bus Passenger volume variation by time, observed at entry section to the CBD, is shown in Figure 1-3.2.

2) Bus Terminal (Terminal Terrestre)

The Terminal Terrestre for inter-city bus transport, which gathered the small terminals distributed in the city, commenced its operation on October 11, 1985. Its function is to control intensively the departure and arrival of the inter-regional and intra-regional bus fleets in order to separate the service area from that of the urban bus.

At the same time the access bus (Ejecutivo) started services between the Terminal and the CBD. Thus, intra-city and inter-city transport were separated into two parts and its coordination system improved the public urban transport.

Vehicles and passenger movements a month after the commencement of the Terminal Terrestre are described below.

a. Number of Vehicle Movement a Day

Inter-city bus		1,560	buses
Access Transport	Urban bus	1,941	"
	Private car	1,577	cars
	Taxi	2,353	"
	Sub Total	5,871	
Total		7,431	

Source) The supplementary traffic survey conducted by the Study Team in November, 1985.

Note) It shows the departure number a day.

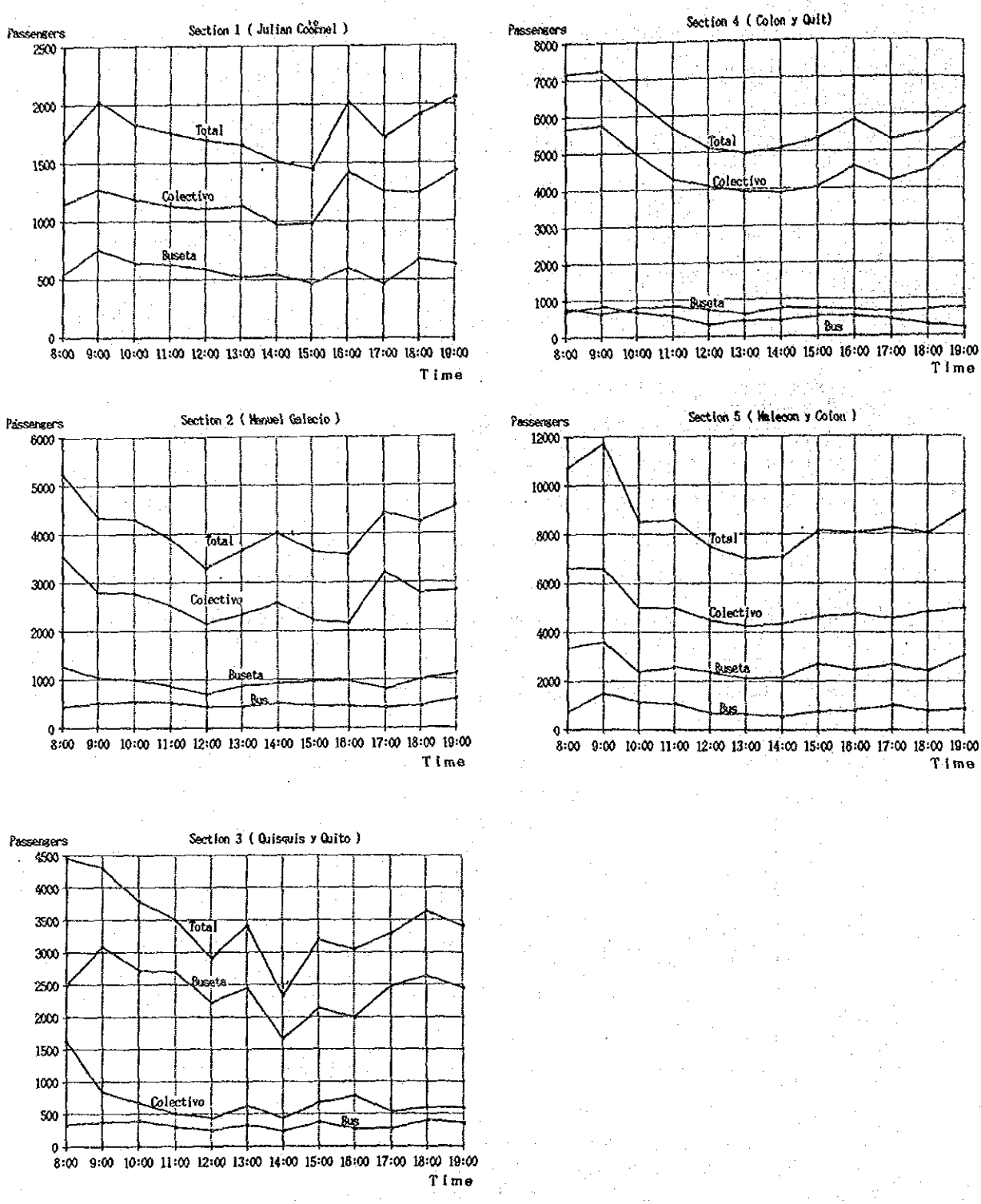


Figure 1-3.2 BUS PASSENGER VOLUME VARIATION BY TIME

As of November, 1985

b. Number of Passengers Utilizing Terminal Terrestre

At the concourse level	Departure passengers	27,580 Persons
	Others	7,954
	Total	35,534

Access to Terminal	Urban bus	Access	33,122
		Egress	33,212
	Taxi	Access	3,274
		Egress	3,651
	Private cars	Access	3,071
		Egress	2,089
	Total	Access	39,467
		Egress	38,952

Source) The supplementary traffic survey by the Study Team in November, 1985

Note) Figures show the number a day.

c. Variation by Time

Peak of departure passengers takes place during the time of 17:00 - 18:00, and that of arrival passengers during the same hours.

d. Variation by Day

Weekly variation of the bus operations is shown in Figure 1-3.3 and the peak takes place on Friday.

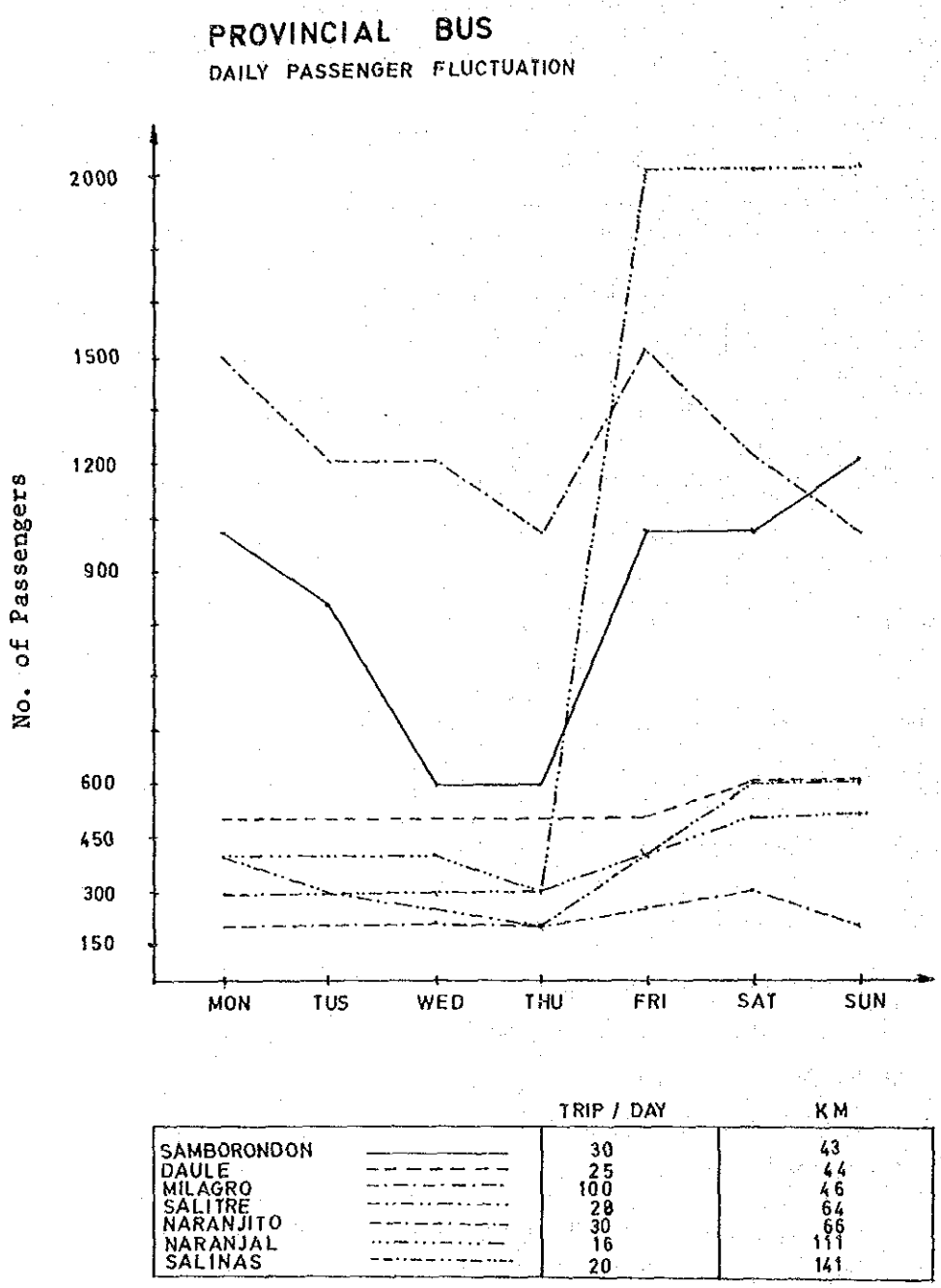


Figure 1-3.3 WEEKLY VARIATION OF PASSENGERS VOLUME FROM/TO BUS TERMINAL (TERMINAL TERESTRE)

As of November, 1985

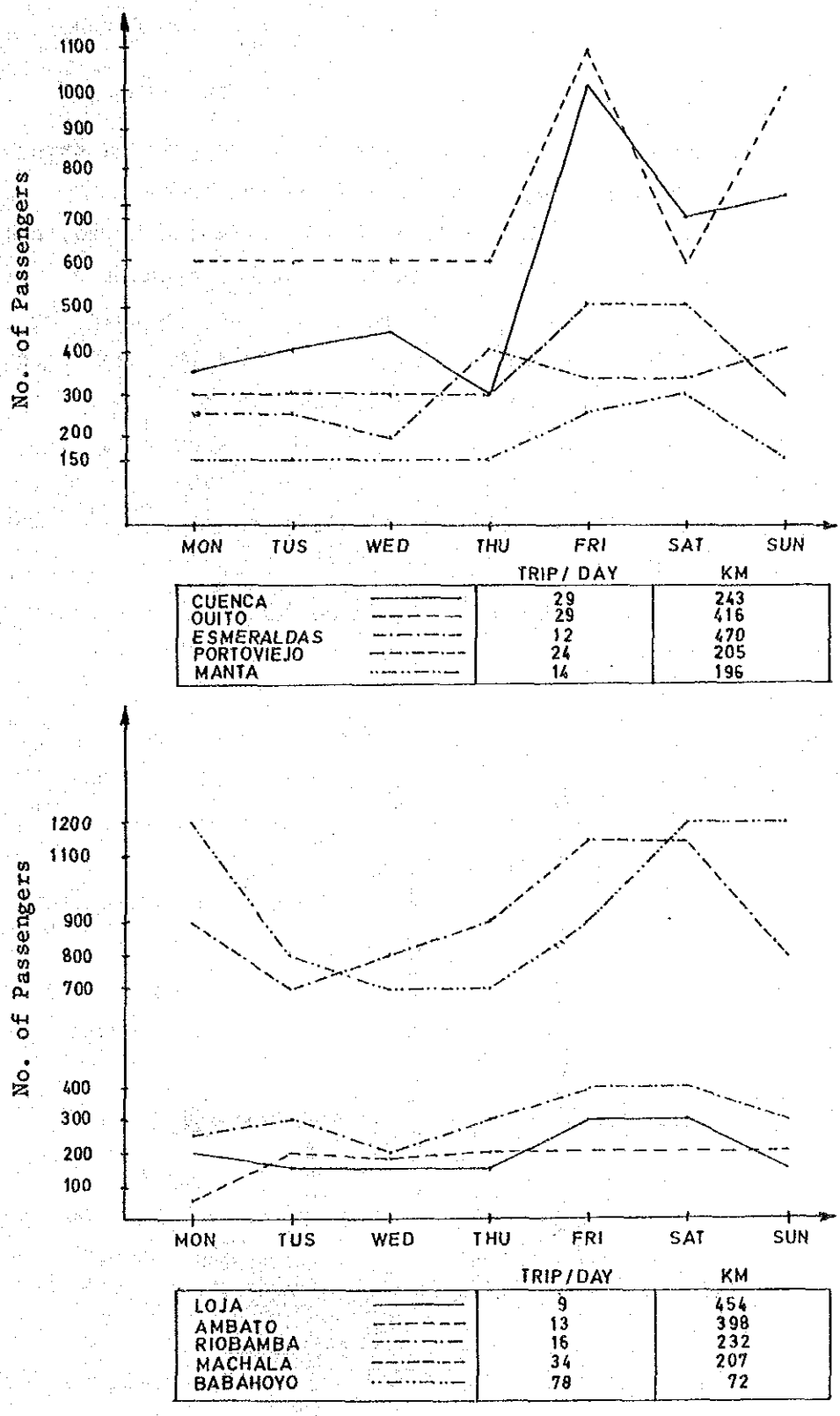


Figure 1-3.3 WEEKLY VARIATION OF PASSENGERS VOLUME FROM/TO BUS TERMINAL (TERMINAL TERESTRE) (Contin'd)

As of November, 1985

2. Existing Road Conditions

2-1 Road Network

The road network of the city is of a classic grid pattern and consists of quite a lot of number, extending to Av. Centenario Sur in the south, to Cero el Carmen in the north, and having the CBD in its center. Urban and Suburban areas are connected by radial arterial roadways. The streets within the city have almost uniform widths, in general 15m - 20m, and then one doesn't come across streets narrower than this.

During the thrice daily traffic jams these wide grid-patterned roads are literally filled with cars. The particularly wide arterial roads have been scrutinized for a MRT route since the M/P study in 1983.

The realization of the MRT would ease the vehicular traffic load and enable the planning and actualization of a better coordinated urban transport system.

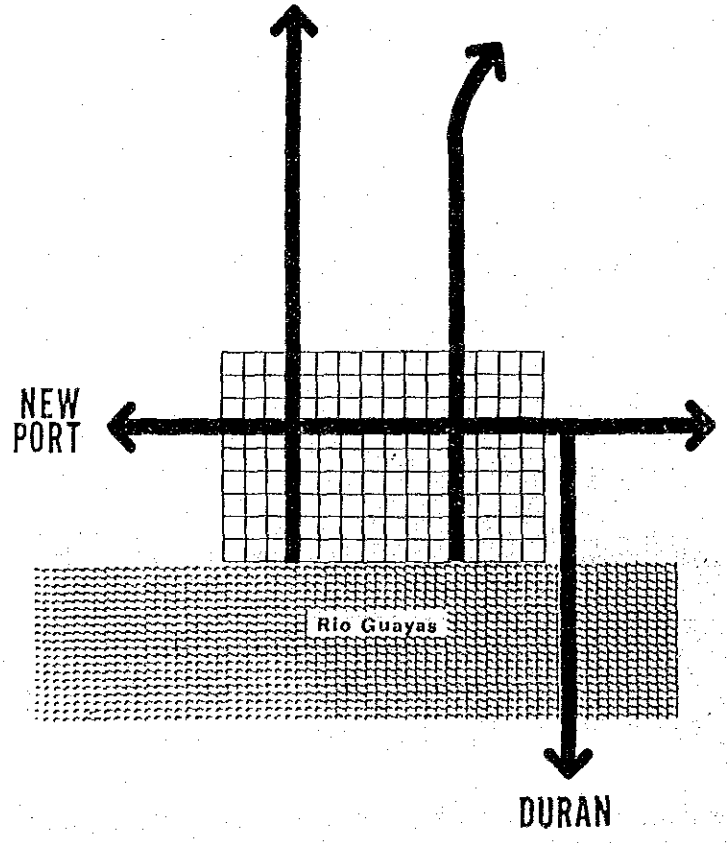


Figure 2-1.1
ROAD NETWORK PATTERN

2-2 Characteristics of Object Roads for MRT

1) Object Roads Used for Alternative Routes of MRT

In accordance with the basic conception of the M/P study, the streets indicated below were selected for alternatives of the MRT route.

Several possible alternatives of the MRT route will be examined later based on combinations of these roads. (see Figure 2-2.1).

* Av. 25 de Julio
* Av. Quito
* Calle Manuel Galecio
* Av. San Jorge
* Av. de las Americas

2) General Characteristics of Object Roads

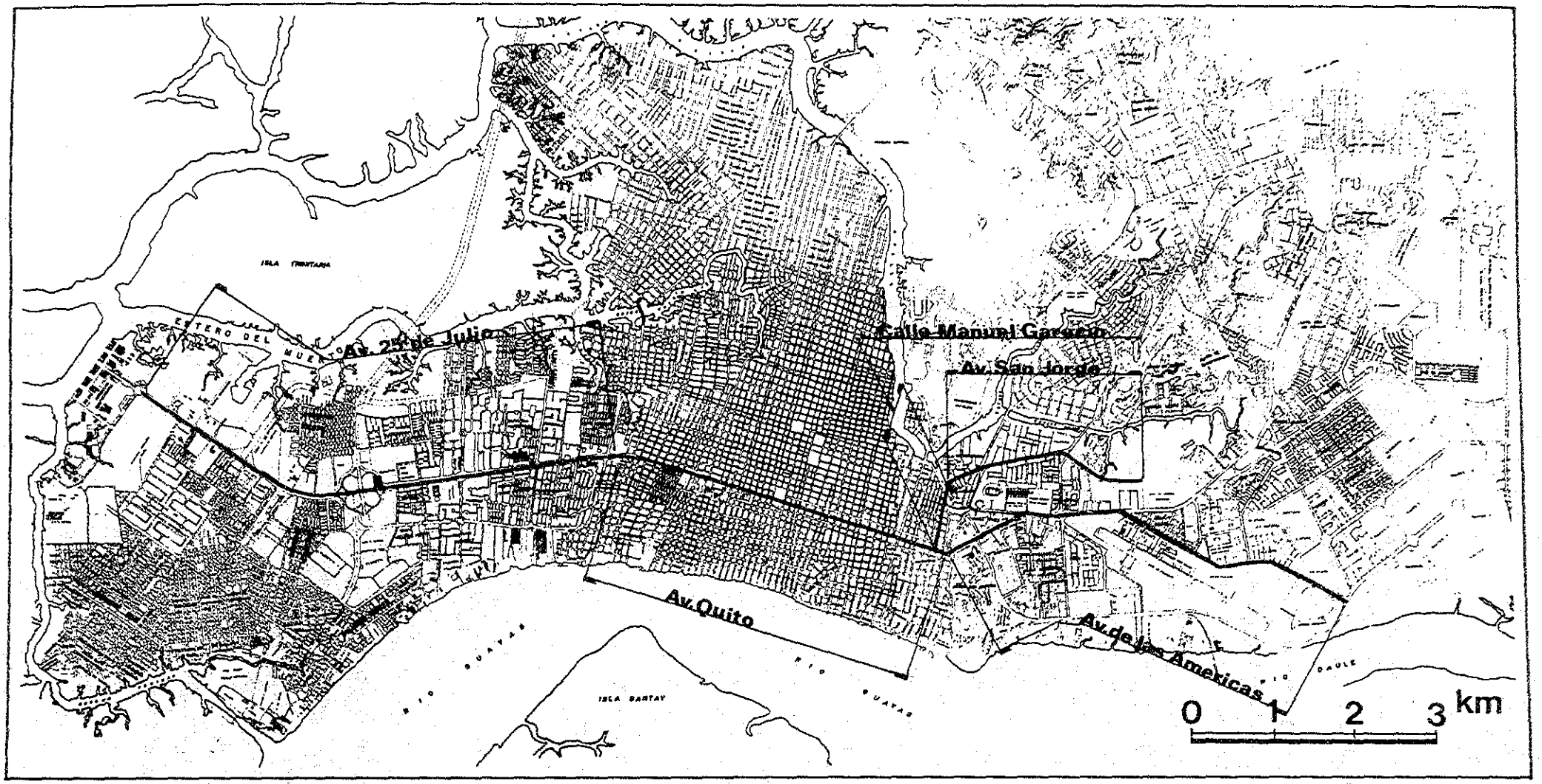
Av. 25 de Julio and Av. Quito are the largest arterial roads in the north - south direction and hitherto the city has expanded to the east and west, both sides of this axis. Av. Quito adjoins the CBD, then most of the east-west traffic crosses the axis or flows into Av. Quito.

Most of the streets which compose many small blocks in every 60-70 meters, are designated for one way traffic and Av. Quito is also used partially for the same toward the north.

3) Major Establishments along Object Roads

At the southern edge of the city, Equador's largest trading harbor, Puerto Nuevo, is located. To the North, an international airport, Terminal Terrestre, and other many large establishments are located along Av. de las Americas and Av. San Jorge. To the north of Terminal Terrestre, where 90 thousand people pass through in a day, a large residential district is expanding.

The locations of the various principal establishments along these object roads are shown in Figure 2-2.2.



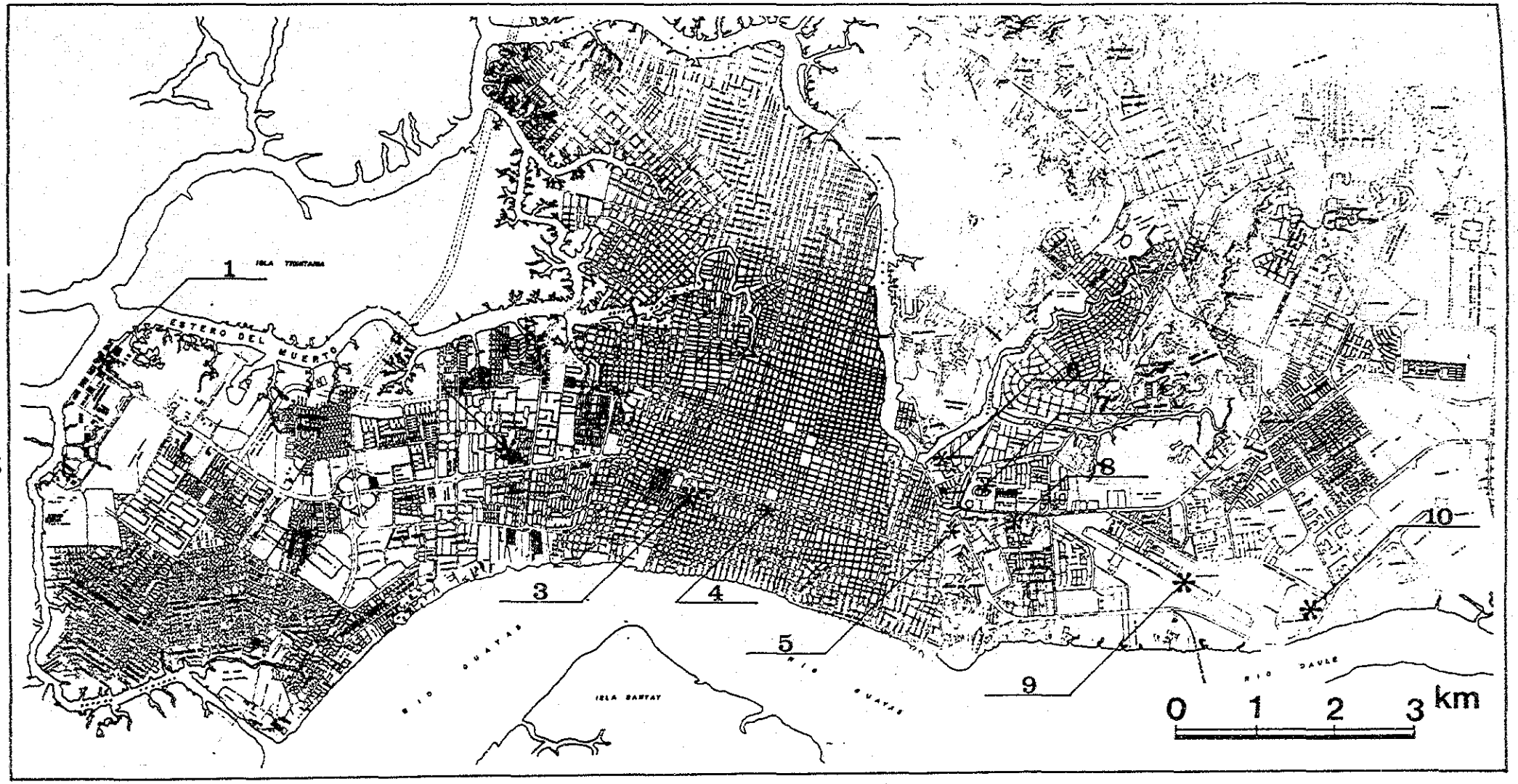
THE FEASIBILITY STUDY ON GUAYAQUIL CITY URBAN TRANSPORTATION PLAN IN THE REPUBLIC OF ECUADOR

Figure 2-2.1

ROAD NAME

JAPAN INTERNATIONAL COOPERATION AGENCY

N



1.Pto. Nuevo (New Port)	6.Guayaquil University
2.Public Hospital	7.Stadium
3.Citizn Center	8.Laica University
4.Infant Hospital	9. International Airport
5.Cemetery	10.Bus Terminal

THE FEASIBILITY STUDY ON GUAYAQUIL CITY URBAN TRANSPORTATION PLAN IN THE REPUBLIC OF ECUADOR

Figure 2-2.2
VARIOUS PRINCIPAL ESTABLISHMENTS

JAPAN INTERNATIONAL COOPERATION AGENCY

N

2-3 Width of Object Roads

The present widths of the object roads selected for the MRT route alternatives are shown in Figure 2-3.1.

2.4 Improvement Schemes of Object Roads

1) Road Sections

a. Av. 25 de Julio

Although this road, at present, is used with 6 lanes of 37 meters wide, it has a 70m right of way which in future will enable expansion to 10 lanes.

b. Av. Quito

The north half of the street is operated as a one-way toward the north. However, the entire may be one-way in future.

c. Av. San Jorge

This street is already complete up to the modern super market, Policentro. In near future, it will be extended to connect with Av. Juan Tanca Marengo, because the entire right of way has been reserved.

d. Av. de las Americas

This is presently of four lanes, extending to the airport. Although it has an expansion plan to six lanes, a section being constructed between Terminal Terrestre and the airport has also four lanes.

2) Intersections

a. Av. 25 de Julio

A ring road (Via Perimetral) will intersect Av. 25 de Julio near its midway point. The plan for this ring road includes the construction of a reciprocal interchange for

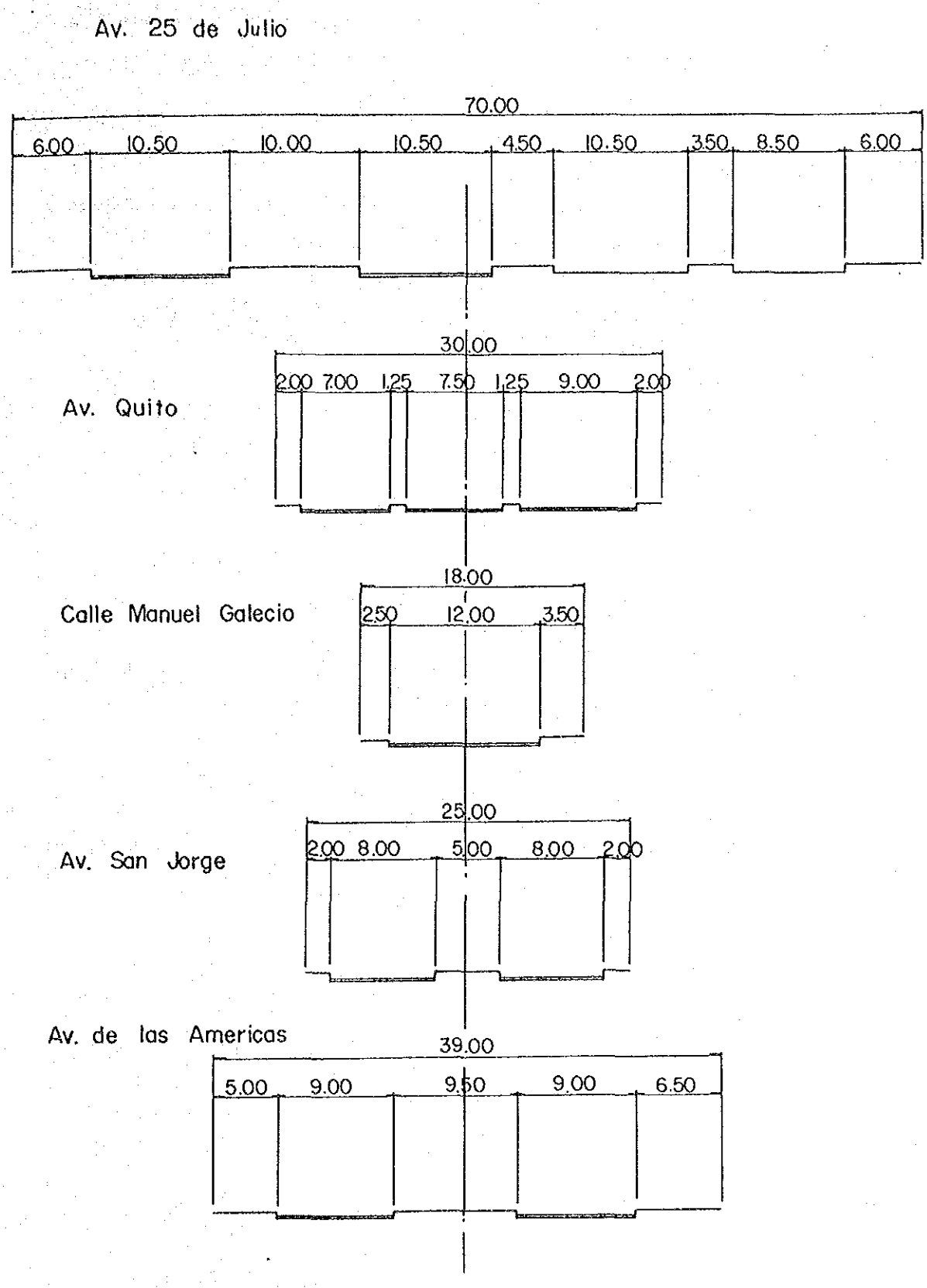


Figure 2-3.1 TYPICAL PRESENT CROSS - SECTION

connecting Av. 25 de Julio and the ring road. A cloverleaf type interchange is supposed to be adopted, and tenders for the construction are being examined.

b. Av. de las Americas

Over the rotary shaped intersection of Circulo Guayas y Quil, a new construction of the grade separation is on-going, and two additional grade separations are also under construction in front of Laica University and at Eloy Alfaro.

3. Natural Conditions and Obstacles along MRT Route

3-1 Topographical Feature

The topography of Guayaquil consists of the basin area brought about by the Guayas river in the city and the hillock zone in the northern part. The former is a kind of swamp of thick alluvium formed in front of the hillocks and is composed of the granular materials such as silt, clay, etc.

As shown in Figure 3-1.1, the city is located in the basin surrounded by the Salado estuary (Estero Salado) and developing toward the suburbs of both the north and south filling with the many branch streams of the Salado estuary. However, the complicated disposition of these branch streams have given difficulties for traffic improvement and been causing the bottlenecks at several points in the city.

This Study area is flat with an altitude of 3 to 4 m.

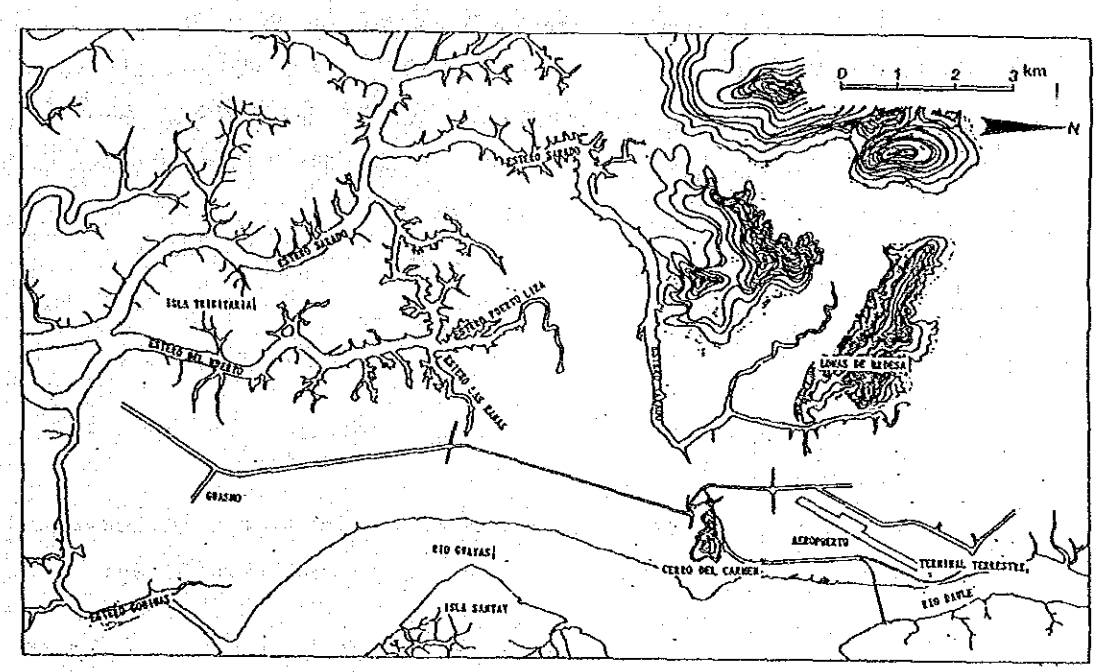


Figure 3-1.1 TOPOGRAPHY IN GUAYAQUIL

3-2 Meteorology and Seism

1) Meteorology

The meteorological data on Guayaquil City for the past 34 years (1951 - 1984) were obtained from the Meteorological Department of Civil Aviation. An example of the data in 1984 is shown in Appendix 1-9. Guayaquil City is situated close to the equator and the temperature is almost constant owing to the influence of the ocean current. The rainy season can be clearly distinguished from the dry season.

The main findings obtained from the meteorological data are as follows:

Temperature:	Maximum 37.2°C
	Minimum 17.1°C
Wind velocity:	Maximum 11 m/sec
Rainfall:	Average annual rainfall is about 700 mm. 90% of the average annual rainfall is concentrated in the rainy season. (December to April).

2) Seism

The historical seismic data on Ecuador is shown in Appendix 1-10.

Small scale seisms have occassionally occurred in Guayaquil and its vicinity, but no human losses and significant damage have been left on record.

3-3 Geological Conditions

1) outline

Geologically the Guayaquil city has developed on the thick alluvium accumulated by the Guayas river.
The Structure of the stratum is classified into two kinds of strata, soft clay and hard sand. The Clay strata is 15 - 40 meter deep in the area between the Guayas river and the Salado estuary.
In the both sides of the city, the sourthern part of Guasmo and northern part of the Airport, the clay strata is 15 - 20 meter deep, while the clay strata is thicker in the western part than the other area.

2) Characteristics of Geology

The Study Team conducted the boring of 12 points (8 of 12 are along the MRT route. see Figure 3-2.1) for soil survey and test in 1982 for the M/P study and the Team examined them again in this Study. These results are summarized below.

a. Geology

Typical geology of the area along the MRT route is shown in Figure 3-2.1.

The features of the clay are that it is formed with the strata consisting of a clay stratum and a thin sand stratum alternatively and that the strata of 3 to 10 meter deep under the ground surface is very soft. (The N value is less than 1.)

The sand stratum of the diluvium is extremely hard and then it can be used as a supporting stratum for structural foundation. (The N value is more than 50.)

b. Physical Properties of Soil

Table 3-2.1 shows a typical value of the natural water content, liquid limit, specific gravity and unit weight of each stratum respectively.

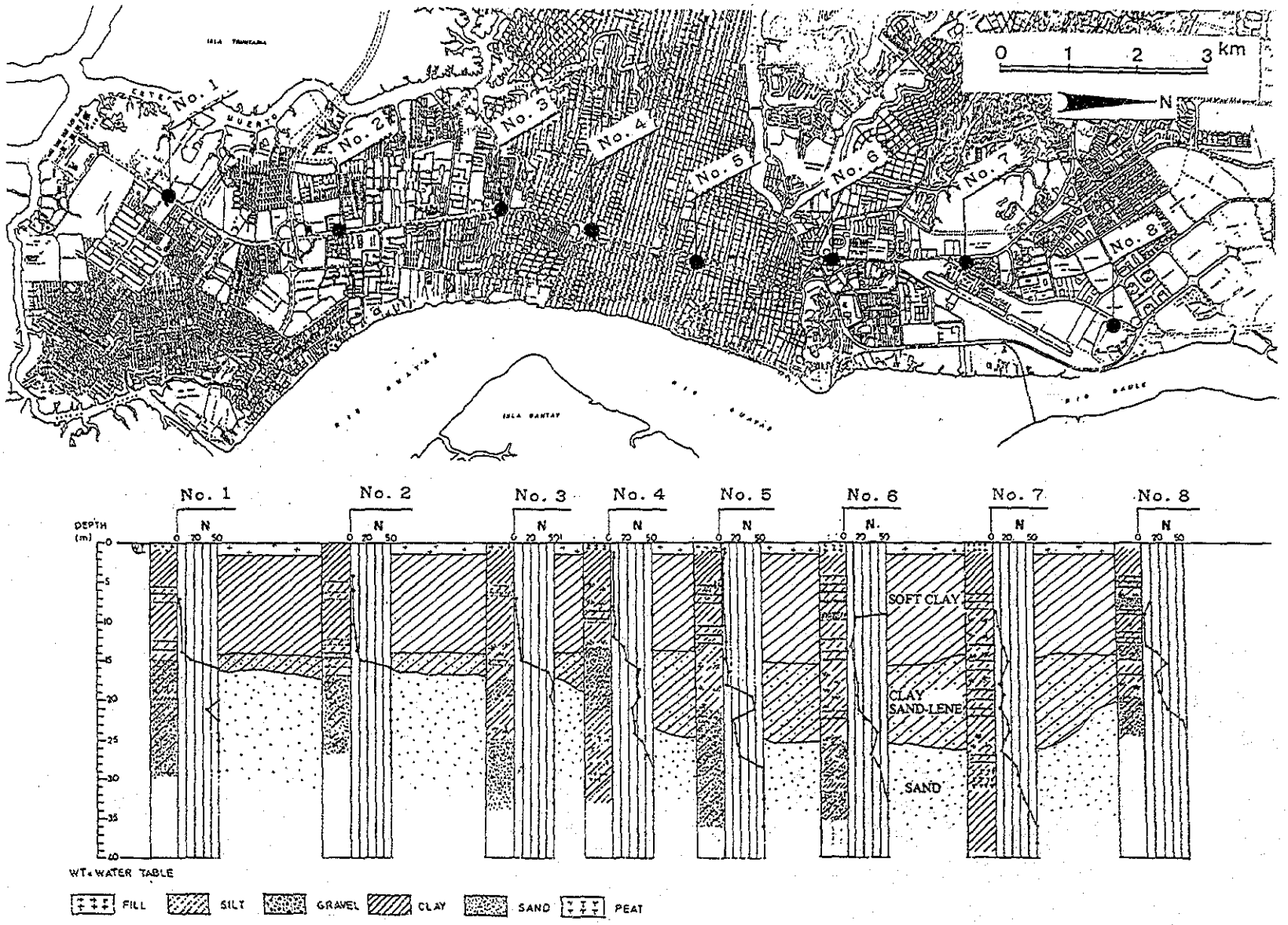


Figure 3-2.1 LOCATION OF DRILLING HOLES AND SOIL PROFILE

Table 3-2.1 PHYSICAL PROPERTIES OF SOIL

Strata	Natural water content	Liquid limit	Specific gravity	Unit weight
	W. (%)	LL (%)	Gs	γm. (g/cc)
Soft clay	50 - 120	67 - 136	2.40 - 2.71	1.34 - 1.58
Clay-Sand lens	33 - 85	43 - 98	2.50 - 2.69	1.50
Sand	-	-	-	-

c. Strength of Soil

Table 3-2.2 shows typical value of the standard penetration test (N value) and the unconfined compressive strength of each stratum respectively.

Table 3-2.2 STRENGTH OF SOIL

Strata	Unconfind compressive strength (Kg/cm^2)	Standard penetration blows/30 cm
Soft clay	0.36 - 0.96	0 - 9
Clay-sand lens	0.50	14 - 30
Sand	-	50

d. Ground Water

There are almost no changes in the ground water level which is 1 to 2 meter deep under the ground surface due to the ground being surrounded by the Guayas river and the Salado estuary.

3) Study on Structures

On account of the fact that there is no stratum which can support structures directly in the ground near the ground surface, that the underground water level is high and that a supporting stratum can only be found in the ground level so deep as 15 to 35 meter under the ground surface, pile foundation is adopted as a type of foundation.

Because the alluvium within 10 meter deep under the ground surface is extremely soft, there is a possibility of sinking of fill-up soil structures if such structures are adopted and, therefore, it is required to take sufficient countermeasures.

3-4 Obstacles along MRT Route

1) Aerial Obstacles

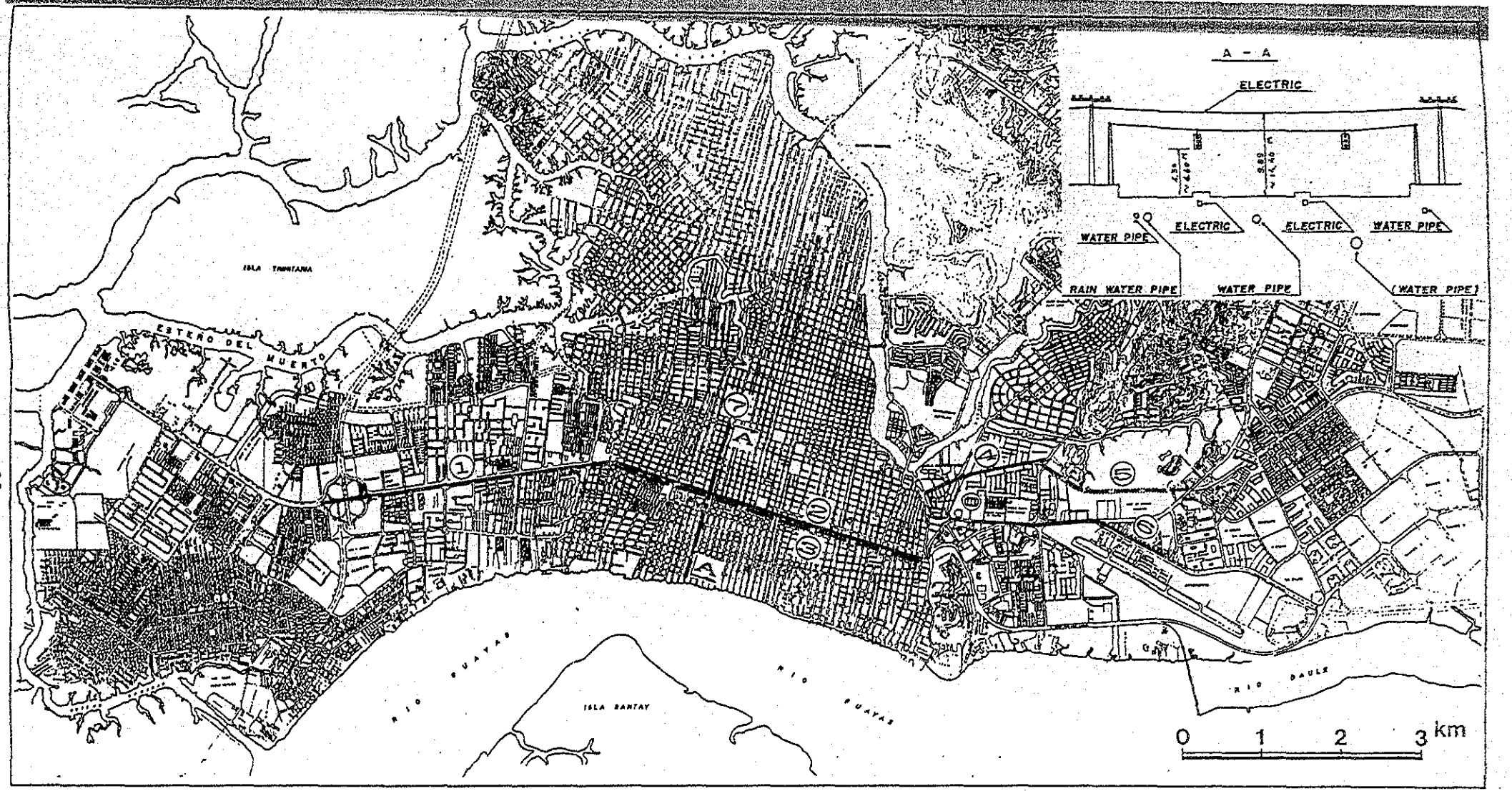
As the aerial obstacles, there are electric power cables, telecommunication cables, street lamps, street trees, etc.

In Av. Portete, there are high voltage (69 kV) electric power cables crossing Av. Quito.

2) Underground Obstacles

As the underground obstacles, there are water supply pipes, sewerage pipes and, beside them, power cables and telecommunication cables have been laid under the ground, as well (see Appendix 1-11).

Especially, as shown in Figure 3-4.1, there are water supply pipes and sewerage pipes with large diameter in Av. 25 de Julio and Av. San Jorge and it is conceivable that these pipes may hinder the construction works of the MRT.



① water supply pipe (ϕ=16", ϕ=800mm)
sewer pipe (ϕ=66")
telecommunication cable duct
② water supply pipe (ϕ=16")
③ water supply pipe (ϕ=1200mm)
in future
④ water supply pipe (ϕ=42")
⑤ water supply pipe (ϕ=1500) in future
⑥ water supply pipe (ϕ=16")
⑦ electric power cable (69 kv)

THE FEASIBILITY STUDY ON GUAYAQUIL CITY URBAN TRANSPORTATION PLAN IN THE REPUBLIC OF ECUADOR

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Figure 3-4.1 LOCATION OF OBSTACLES

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