REPUBLIC OF SINGAPORE

SINGAPORE URBAN TRANSPORT IMPROVEMENT STUDY (SUTIS)

TECHNICAL REPORT No. 4

Environmental Surveys

NOVEMBER 1988

Japan International Cooperation Agency

REPUBLIC OF SINGAPORE

SINGAPORE URBAN TRANSPORT IMPROVEMENT STUDY (SUTIS)

TECHNICAL REPORT No. 4

Environmental Surveys

NOVEMBER 1988

Japan International Cooperation Agency

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 OBJECTIVES

The objectives of the environmental study are as follows:

1) To understand the existing condition of the study area; and

2) To provide the results of environmental assessment for the over-all evaluation of the proposed new transportation system.

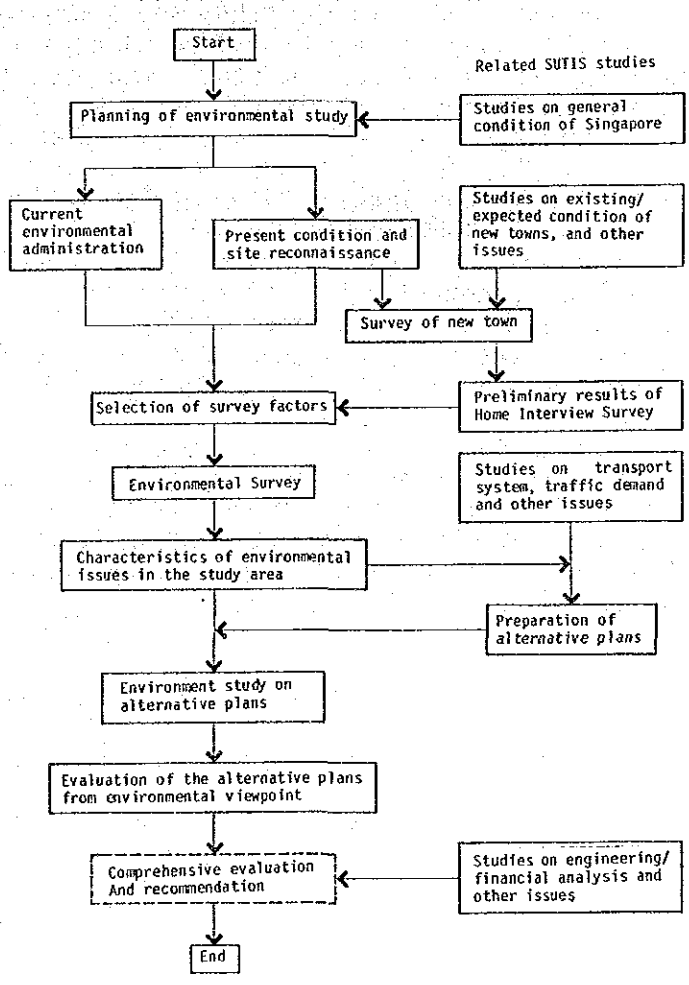
1.2 APPROACH

The methodology of the environmental study is outlined in the flowchart shown in Figure 1.1.

Among the study items shown in Figure 1.1, particular emphasis is placed on the environmental survey in a selected new town and along the alternative routes in the other areas in order to understand the present environmental characteristics. The outcome of the survey are used as the basic data for evaluating the alternative plans.

Figure 1.1

Approach of Environmental Study



2 PLANNING OF ENVIRONMENTAL STUDY

2.1 URBAN TRANSPORTATION AND ENVIRONMENTAL PROBLEMS

In the early stage of human activity, exchange of goods was the basic motivation of transportation. In the later stage, mobility of people increased in its distance and frequency as their surplus commodities increased. The intensification of goods exchange led to the formation of markets and cities, typically on seacoasts and along rivers, where goods were transloaded from one transportation mode to another. This is obvious from the present distribution of such cities throughout the world as Singapore, Istanbul, Rotterdam, New York and Tokyo.

Industrialization and the following economic activities stimulated growth of cities. New jobs in cities offered employment opportunities and attracted the rural population with the prospects of higher wages, and consequently accelerated urbanization.

The diversified need for mobilization of people and goods in urban areas stimulated the development of different modes of transportation which has different characteristics of capacity, speed, convenience, comfort and reliability. Former popular street cars were substituted by gasoline-powered vehicles supported by the advanced technology. In the modern society, people have noticed that the handicapped should be cared for. For transport planning, more consideration is now given to the "transportation poor", or the people who are either too young or too old to drive, or who cannot drive or cannot afford private vehicles.

Innovation of technology enabled people to travel faster and more comfortably; however on the other hand, it has accompanied such problems as traffic congestion, accidents, energy consumption and deterioration of environment. People in large cities became more concerned today about their living conditions as their living standard rose. The factors they are interested are different city to another dependent on local condition.

Typical environment factors specifically related to individual transportation mode are marked in Table 2.1. The degree of of impact caused by transport operation is given by rule of thumb in A, B, and C each refers to significant, moderate and not noticeable, respectively.

Table 2.1

Transportation Mode and Related Environmental Factors

Transport-ation Mode	Environment Factors					
	Air Pollution	Noise	Vibration	Disruption of Access	Visual Disruption	Privacy
Bus	A	A	B	B	B	C
Trolley Bus	C	B	B	B	B	C
Streetcar	C	A	B	B	B	C
Train	C	A	A	A	B	C
Rapid Transit	C	C	B	C	C	C
Private vehicle	A	A	B	B	B	C
Walk	C	C	C	C	C	C

LEGEND: 1. Degree of impact

A : Significant
B : Moderate
C : Not noticeable

2. Transportation mode

Train : Inner-city at-grade transport
Rapid transit : Inta-city subway

2.2 ENVIRONMENTAL PROBLEMS IN SINGAPORE

Singapore is considered to be one of the few metropolises being relatively free fromc so-called urban transport problems such as traffic congestion, excessive environmental pollution, high accident rate, etc. This is largely due to the successful and simultaneous implementation of several measures and policies, supported by financial, institutional and technical capabilities. They include:

a) extensive road network

b) well-controlled land use and urban development

c) discouraged ownership of private vehicles

d) extensive implementation of traffic control and management, including Area Licensing Scheme for CBD

e) well-developed bus transport system

f) strong/effective enforcement capabilities

g) development of MRT

While the present situation looks quite acceptable as far as the environmental problems due to urban transportation is concerned, there has been a trend that the demand of people has been changing as the economy has grown. More people would demand improved level of services and higher quality of environment. It is the main objective of this study to understand the existing and potential environmental problems as well as to utilize the findings for evaluation of sathe alternative plans of new transport system.

The practical study started from attaining the current attitude of people toward living environment. The operation of MRT in November 1987 seems to have given the residents living along its viaduct some impact on noise problem. Through the analysis of the Home Interview Survey (HIS), it became evident that the detail study on noise and air pollution would be necessary for understanding the present environmental condition and people's attitude on it. Thus, the horizontal and vertical characteristics of noise and air pollution caused by traffic was considered appropriate to be selected as the main target of environmental survey.

3. CURRENT ENVIRONMENTAL ADMINISTRATION IN SINGAPORE

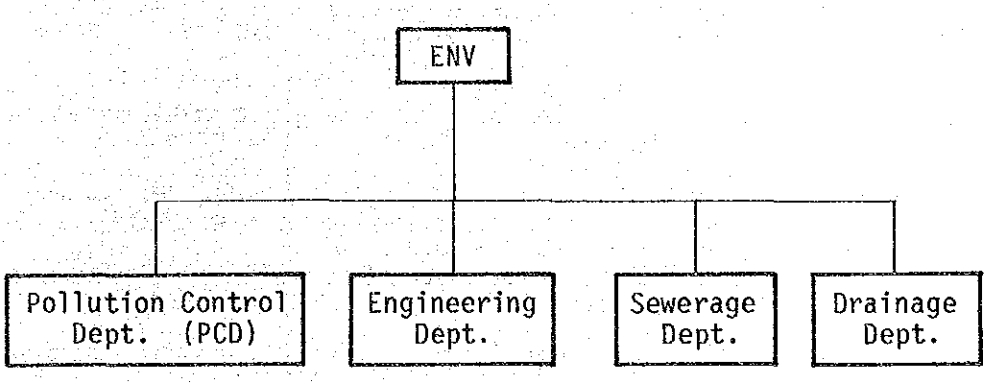
3.1 ORGANIZATION

1) Ministry of the Environment

The Ministry of the Environment (ENV) consist of departments as shown in Figure 3.1

Figure 3.1

Organization of the Ministry of the Environment



Management of air and water pollution is under purview of PCD. It took over the functions of Anti-Pollution Unit which used to manage only the air pollution, and expanded its role to cover water pollution. The Ministry is the authorized body to implement the Clean Air Act and the *Water Pollution Control and Drainage Act.*

2) The Ministry of Communication and Information (MCI) is authorized to make rules as to the use of vehicles including rules to prohibit excessive noise due to the design or condition of the vehicle.

3.2 CURRENT STANDARDS

1) AIR POLLUTION

The existing emission standards for air pollutants from any industrial or trade premises in Singapore are summarized in Table 3.1.

Table 3.1

Emission Standards for Air Pollutants

Pollutant	Standard applicable to	Standard
Smoke	All stationary fuel-burning sources	Ringelmann No 2 or equivalent capacity. (Not to exceed more than 5 minutes in any period of one hour)
Solid particles	Any trade, industry, process, industrial plant or fuel-burning equipment	0.20 gm/Nm (Corrected to 12% CO)
Sulphuric acid mist or sulphur trioxide	Any trade, industry or process (other than combustion processes and plants for the manufacture of sulphuric acid)	0.10 gm/NM sulphur trioxide
Acid gases	Any trade, industry or process in which sulphuric acid is manufactured	3.0 gm/NM as sulphur trioxide
Flourine compounds	Any trade, industry or process in the operation of which flourine, hydrofluorine acid or any inorganic flourine compounds are emitted	0.10 gm/NM as hydroflouric acid
Hydrogen chloride	Any trade, industry or process	0.20 gm/NM as hydrogen chloride
Chlorine	Any trade, industry or process	0.10 gm/NM as chlorine
Hydrogen sulphide	Any trade, industry or process	5 ppm as hydrogen sulphide gas
Nitric acid or oxides of nitrogen	Any trade, industry or process in which the manufacture of nitric acid is carried out	2.0 gm/NM as nitrogen dioxide
Nitric acid or oxides	Any trade, industry or process	1.0 gm/NM as carbon monoxide
Copper and its compound	Any trade, industry or process	0.02 gm/NM as copper
Lead and its compounds	Any trade, industry or process	0.02 gm/NM as lead
Arsenic and its compounds	Any trade, industry or process	0.02 gm/NM as Arsenic
Antimony and its compounds	Any trade, industry or process	0.01 gm/NM as Antimony
Cadmium and its compounds	Any trade, industry or process	0.01 gm/NM as cadmium
Mercury and its compounds	Any trade, industry or process	0.01 gm/NM as mercury

2) NOISE

The Motor Vehicles (contruction and use) (amendment) Rules 1987 were based on the Road Traffic Act, and came into operation on 1st July 1987. The rule essentially states that: Every new motor vehicle registered in Singapore on or after July 1987 shall not emit any noise exceeding the levels shown in Table 3.2.

Table 3.2

Noise Level Permitted by Type of Vehicle

Types of Vehicles	Noise level in decibels (A)
1. Motorcycles (with or without side-cars) including scooters and trivans	83
2. Motorcars including station wagons (with passengers only, or goods-cum-passengers) and taxis	82
3. Light Goods Vehicles	86
4. Goods Vehicles including buses not exceeding 10,000 cc	90
5. Goods Vehicles including buses exceeding 10,000 cc	92

As result of vehicle operation on the roads, people living along them suffer from the traffic noise. Studies have been done in Singapore to establish the ambient noise standard. At this moment a value of L10 (18 hr) = 70 dBA is suggested to be used as a preliminary criterion to assess the need for noise abatement measures. Table 3.3 gives Japans's guideline on noise level for different landuse and areas.

Table 3.3

Japan's Guideline on Noise Level by Area

			Day Time	Morning Evening	Night Time
Landuse	1) Area requiring particular quiteness		45	40	35
	2) Residential Area		50	45	40
	3) Commercial Area		60	55	50
Area Facing Road	1) Residential Area requiring particular quietness	No. of lanes : 2	55	50	45
		No. of lanes :more than 2	60	55	50
	2) Other Residential and Commercial Areas	No. of lanes : 2	65	60	55
		No. of lanes :more than 2	65	65	60

3) Buffer Zone Guidelines

A set of buffer zone guidelines as shown in Table 3.4 was adopted to prevent the environment of areas adjacent to roads from air and noise pollution and was implemented in 1984.

Table 3.4

Approved Buffers Along Roads

Proposed Use/Developement	Minimum width of Buffer (in meters)	Specifications of Buffer
Category 1 - Expressway		
Residential/Educational	30	5m green, 25m physical
Industrial/Institutional/commercial (5 storeys of above)	30	5m green, 25m physical
Industrial/Institutional/Commercial (up top 4 storeys)	15	5m green, 10m physical
Development of restricted site	15	5m green, 10m physical (or evaluation based on individual merits)
Category 2 - Major Arterials A		
Residential (5 storeys or above)/Educational	15	5m green, 10m physical
Residential (up to 4 storeys)	12	5m green, 7m physical
Industrial/Institutional/Commercial (up to 4 storeys)	15	5m green, 10m physical
Industrial/Institutional/Commercial (up to 4 storeys)	7.6	3m green, 4.6m physical
Development of restricted site	7.6	3m green, 4.6m physical (or evaluation based on individual merits)
Category 3 - Major Arterials B		
Residential (5 storeys or above)/Educational	10	3m green, 7m physical
Residential (up to 4 storeys)	7.6	3m green, 4.6m physical
Industrial/Institutional/Commercial (up to 4 storeys)	10	3m green, 7m physical
Industrial/Institutional/Commercial (up to 4 storeys)	5	3m green, 2m physical
Development of restricted site	5	3m green, 2m physical (or evaluation based on individual merits)
Category 4 - Other Major Roads		
All uses/development	7.6	3m green, 4.6m physical (or evaluation based on individual merits)
Category 5 - Other Major Roads		
All uses/development	2.3	2m green

Source: PWD

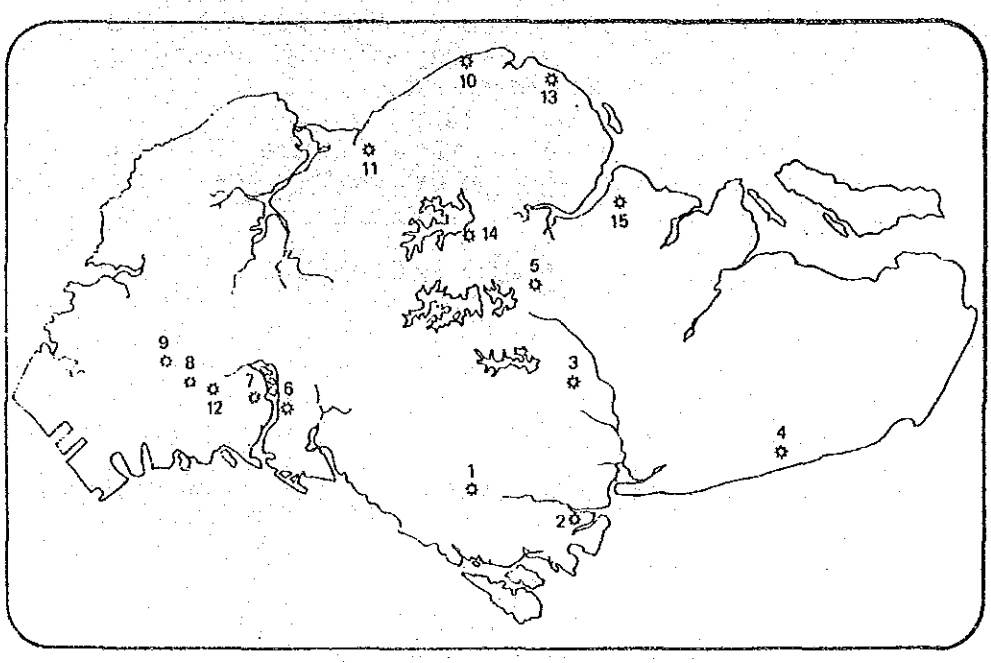
3.3 POLLUTION CONTROL PROGRAMME

1) Air Pollution Control Programme

Air pollution measurements were carried out at 15 permanent air monitoring stations as shown in Figure 3.2. These stations survey was conducted to measure total acidity, sulphur dioxide, smoke, oxides of nitrogen, suspended particles, dust fall out and ozone. Occasional spot surveys are made to measure carbon monoxide level at road.

Figure 3.2

Location of Monitoring Stations



STATION NUMBER AND NAME

1) Princess House
2) URA Building
3) Toa Payoh Library
4) St Andrew's Orthopaedic Hospital
5) Parks and Recreation Serangoon Depot
6) Jurong Industrial Waterworks
7) Jurong Town Corporation Flat
8) Civil Radio Transmitting Station
9) Nanyang Technological Institute
10) Senoko
11) Woodlands Home for the Aged
12) Boon Lay Secondary School
13) Sembawang Primary School
14) Seletar Reservoir
15) Seletar Sewage Treatment Works

2) Vehicular Emmission Control Programme

These standards, based on the United Nations/Economic Commission for Europe (UN/ECE) Regulation No. 15.03, were in force until 1st October 1986 when the more stringent UN/ECE Regulation No. 15.04 came into effect.

To improve motor vehicular emmissions, the lead content in petrol was further reduced from 0.4 gm/liter to 0.15 gm/litre from 1st June 1987 onwards.

4. STUDY ON ENVIRONMENTAL FACTORS

4.1 RESULTS OF HOME INTERVIEW SURVEY

1) Outline

The Home Interview Survey (HIS) was undertaken by the JICA Study Team with consultation and support of PWD to obtain information including the people's attitude toward,

a) level of feeder bus service,
b) condition of the bus interchange, and
c) the living/environmental conditions.

Among the existing HDB New Towns, Ang Mo Kio New Town was selected as a survey area. It is one of the largest new towns in Singapore with a population of about 200,000. Two MRT stations are located in this town, and the residents started commuting by it in November 1988.

Out of 1,000 households from which the data were intended to be collected, 731 replied showing the performance ratio of 73.1%.

2) Attitude Towards the Level of Feeder Bus Service

The survey form is shown in Figure 4.1.

Figure 4.1

Survey Form 1. How do you assess the present feeder bus operation?

ITEM		Very Bad	Bad	Accept-able	Good
1) Service Frequency	a) Peak Hours	☐1	☐2	☐3	☐4
	b) Off-peak Hours	☐1	☐2	☐3	☐4
2) Operation Hours	a) Morning	☐1	☐2	☐3	☐4
	b) Night	☐1	☐2	☐3	☐4
3) Attitudes of Driver/Conductor		☐1	☐2	☐3	☐4
4) Availability of seats		☐1	☐2	☐3	☐4
5) Riding Comfort		☐1	☐2	☐3	☐4
6) Cleanliness		☐1	☐2	☐3	☐4
7) Discomfort in Bus	a) Air Pollution	☐1	☐2	☐3	☐4
	b) Noise	☐1	☐2	☐3	☐4
	c) Heat/Temperature	☐1	☐2	☐3	☐4
8) Step/Door	a) Steps	☐1	☐2	☐3	☐4
	b) Width of door	☐1	☐2	☐3	☐4
	c) Safety	☐1	☐2	☐3	☐4

The survey shows that 71.9% of people thought the level of bus service was acceptable. The largest ratio of either very bad or bad is given to Heat and the second largest to Noise. Air pollution on the bus was thought bad and recorded a higher ratio than the average.

3) Attitude Towards the Condition of the Bus Interchange

The survey form is shown in Figure 4.2.

Figure 4.2

Survey Form 2. How do you find the existing bus interchange

ITEM			Your Assessment of Present Condition: Very Bad	Bad	Acceptable	Good
1) Average Waiting Time	Peak Hours'	Feeder _____ min	1	2	3	4
		Trunk _____				
	Off-Peak Hours'	Feeder _____				
		Trunk _____				
2) Transfer Condition between Feeder and Trunk Bus			1	2	3	4
3) Waiting Condition/Facilities			1	2	3	4
4) Environment	Cleanliness	a	1	2	3	4
	Noise	b	1	2	3	4
	Air Pollution	c	1	2	3	4
	Space	d	1	2	3	4
5) Others (Specify) _____			1	2	3	4

The result of this questionnaire is shown in Table 4.1.

Table 4.1

Result of Survey Form 1 (Unit = %)

Item		Consciousness					
		Very Bad	Bad	Acceptable	Good	Not Known	Total
Service frequency	Peak hours	3.2	15.2	64.4	10.3	7.0	100.0
	Off-peak	3.0	15.1	68.5	6.7	6.7	100.0
Operation	Morning	3.4	8.6	70.8	10.5	6.7	100.0
	Night	1.7	12.4	67.3	12.0	6.7	100.0
Attitude of driver		0.7	8.9	75.7	8.1	6.7	100.0
Availability of seats		1.9	12.2	72.8	6.4	6.7	100.0
Riding Comfort		1.2	7.9	78.1	6.1	6.7	100.0
Cleanliness		1.2	17.0	70.2	5.0	6.7	100.0
Discomfort in bus	Air Pollution	1.4	17.8	71.1	3.0	6.7	100.0
	Noise	2.4	24.2	64.1	2.8	6.7	100.0
	Heat	4.3	26.0	60.6	2.4	6.7	100.0
Step/Door	Steps	0.8	3.7	83.4	5.4	6.7	100.0
	Width of door	0.8	6.4	79.9	6.3	6.7	100.0
	Safety	0.5	5.7	80.1	7.0	6.7	100.0
Average		1.9	12.9	71.9	6.6	6.7	100.0

The result regarding item 4) shows that the ratio of noise marked the largest for both very bad and bad as shown in Table 4.2. The ratio of air pollution is the second largest for bad.

Table 4.2

Result of Survey Form 2 (Unit = %)

Item	Consciousness					
	Very Bad	Bad	Acceptable	Good	Not Known	Total
Cleanliness	2.1	16.4	69.4	6.8	5.3	100.0
Noise	4.3	28.1	59.3	3.1	5.3	100.0
Air Pollution	1.0	24.1	65.6	4.0	5.3	100.0
Space	3.0	16.1	69.1	6.5	5.3	100.0
Average	2.6	21.2	65.9	5.1	5.3	100.0

4) Attitude Towards the Living/Environment Conditions

The survey form is shown in Figure 4.3.

Figure 4.3

Survey Form 3. How do you assess the living/environmental conditions listed below?

	A Good / No problem at all	B Accept-able	C Bad/ Dis-satisfied	D Very bad/ serious problem
1. Cost of living	☐	☐	☐	☐
2. Availability of goods at market and shop	☐	☐	☐	☐
3. Utility Services	☐	☐	☐	☐
4. Public security	☐	☐	☐	☐
5. Playing space for children	☐	☐	☐	☐
6. Safety of playing space for children	☐	☐	☐	☐
7. Health/Medical services	☐	☐	☐	☐
8. School/Educational Services	☐	☐	☐	☐
9. Sport/Recreation Facilities	☐	☐	☐	☐
10. Traffic noise	☐	☐	☐	☐
11. Traffic vibration	☐	☐	☐	☐
12. Noise from neighbours	☐	☐	☐	☐
13. Exhaust fumes pollution	☐	☐	☐	☐
14. Dust air pollution	☐	☐	☐	☐
15. Cleanliness of neighbourhood	☐	☐	☐	☐

The result reveals that the traffic noise scored the remarkably high ratio both in very bad and bad as shown in Table 4.3. Cost of living and traffic vibration are the third and fourth highest in bad, respectively.

Table 4.3

Result of Survey Form 3

	Good	Acceptable	Bad	Very Bad	Not Known	Total	Priority
Cost of Living	6.1	61.1	26.7	2.0	4.2	100.0	14.1
Availability of goods	28.6	61.4	5.3	0.5	4.1	100.0	2.6
Utility Services	24.8	64.8	5.1	1.1	4.1	100.0	4.1
Public Security	19.1	65.8	9.9	1.0	4.1	100.0	6.5
Playing space	13.1	65.1	15.0	1.9	4.9	100.0	5.9
Safety of playing space	12.3	67.3	13.9	1.8	4.7	100.0	5.4
Health/Medical	20.9	69.7	4.7	0.5	4.1	100.0	0.8
School/Educational	26.2	64.1	5.0	0.6	4.1	100.0	0.7
Sport/Recreation	17.8	66.0	10.5	1.5	4.1	100.0	2.7
Traffic noise	5.5	55.4	28.8	6.2	4.0	100.0	25.5
Traffic Vibration	8.3	60.8	22.3	4.4	4.1	100.0	8.3
Noise from Neighbors	15.2	65.9	12.9	2.0	4.1	100.0	5.6
Exhaust fumes pollution	12.1	65.6	15.8	2.5	4.1	100.0	4.5
Dust air pollution	10.9	63.1	18.0	3.9	4.1	100.0	6.0
Cleanliness of neighborhood	15.6	67.1	10.8	2.1	4.4	100.0	6.1
Total	15.8	64.2	13.6	2.1	4.2	100.0	6.6

4.2 SELECTION OF ENVIRONMENTAL FACTORS

From the results of HIS, it became clear that people are concerned about their living and environmental conditions. The reply to the questionnaire survey forms 1, 2 and 3 showed that the respondents are more conscious about the condition of noise and air pollution. Based upon this finding, these two factors are determined to be the main factor and to be studied in detail through environmental survey.

5. SELECTION OF SURVEY SPOTS

Before selecting the spots for environmental survey of the alternative plans, characteristics of the study areas are carefully examined through the site reconnaissance and existing data on topography, transport network and land use. The priority of survey is given to Ang Mo Kio New Town, because this town is selected out of all the new towns through the studies on urban transport issues in Singapore as explained in the other technical papers. Comparatively coarse survey was carried out on the other 5 study areas in terms of number of survey spots. It is based on the concept that the study should be made on wide range of land use characteristics to have clear idea of the present condition in Singapore.

1) Ang Mo Kio New Town

The total number of 28 spots were selected mainly based on the land use patterns and road network so that the expected survey results would thoroughly explain the air pollution characteristics of this area. (See Figure 5.1). Eleven blocks were chosen from those where HIS was made. For each block, from 2 to 4 spots were selected for the purpose of using the results for vertical comparison. To obtain the data for horizontal attenuation of traffic noise, 2 lines were selected. Furthermore, to understand the characteristics of MRT noise and ambient noise, 3 blocks and 4 ground spots were added. Consequently, total number of 51 spots were selected for noise survey. The location and detail of survey spots are shown in Chapter 6.

2) Simpang New Town

Planning of Simpang New Town is still under consideration and not fixed yet, and the site is a desert area where people can hardly explore. Thus, the survey spots were selected along the alternative route in Yishun New Town. For obtaining the environmental characteristics of this wide area in an effective way, three spots were selected on the west, north and south end of the route (See Figure 5.2).

3) Ang Mo Kio - Hougang - Bedok Route

Detail survey is made in Ang Mo Kio New Town and described in Chapter 6. For the study of this route, a survey spot was selected in Serangoon, 3 spots in Hougang New Town and 2 in Bedok New Town (See Figure 5.3). Industrial estate was excluded from the survey, because this area is not used for ordinary living.

4) Orchard - Mt Faber - Sentosa Route

Six spots along the route and additional spot on Mt Faber are selected for survey (See Figure 5.4).

5) Orchard - Marina Centre Corridor

Six spots along the route were selected for survey (See Figure 5.5).

6) CBD Ring Routes (1) - (3)

Two spots were selected for each ring route (See Figure 5.6).

Figure 5.1

Survey Spots in Ang Mo Kio

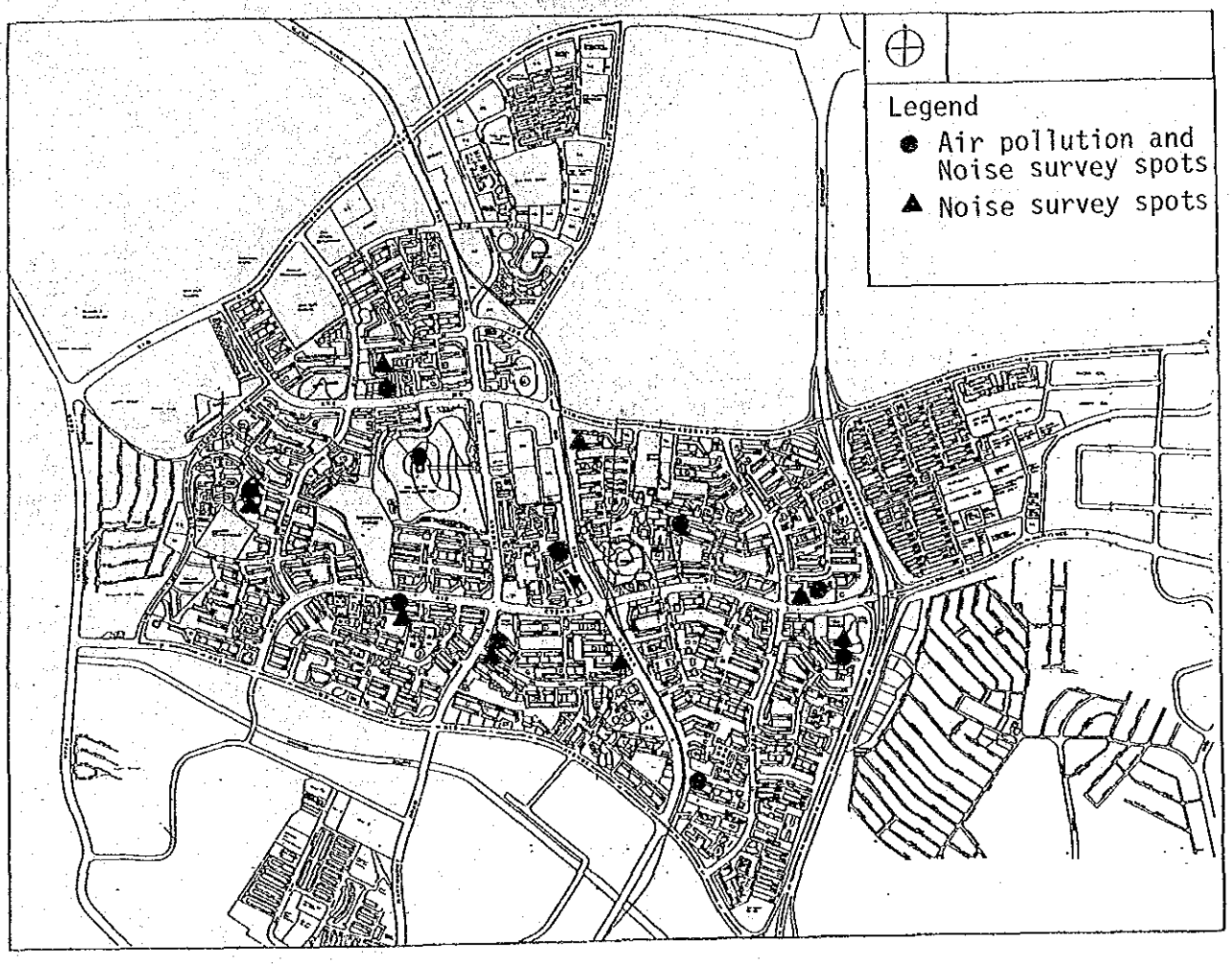


Figure 5.2

Survey Spots in Simpang New Town

Scale 1:10,000

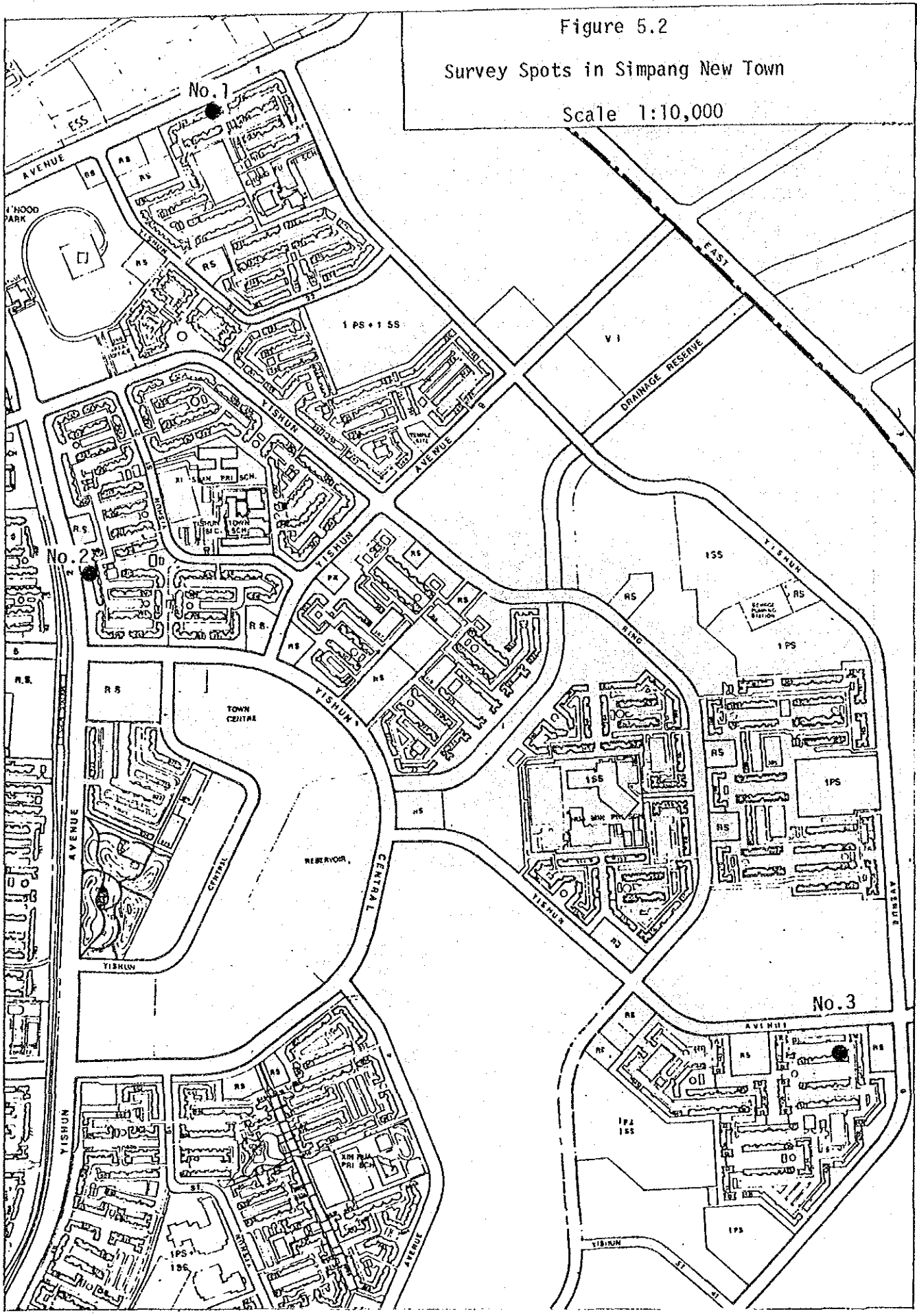


Figure 5.3

Ang Mo Kio - Hougang - Bedok Route

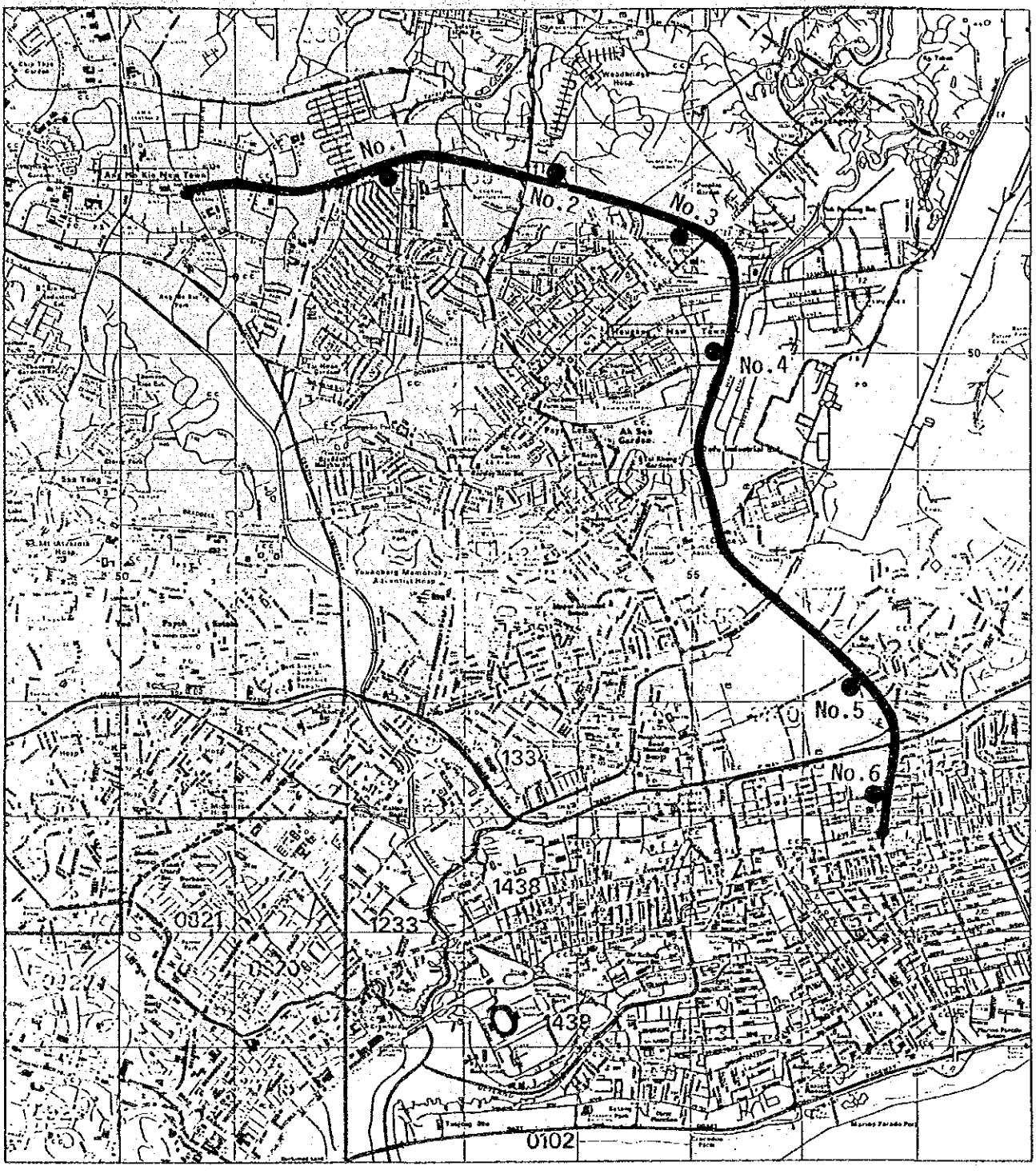


Figure 5.4

Survey Spots of

Orchard - Mt. Faber - Sentosa Route

0 0.5 1.0 km

Scale 1:25,000

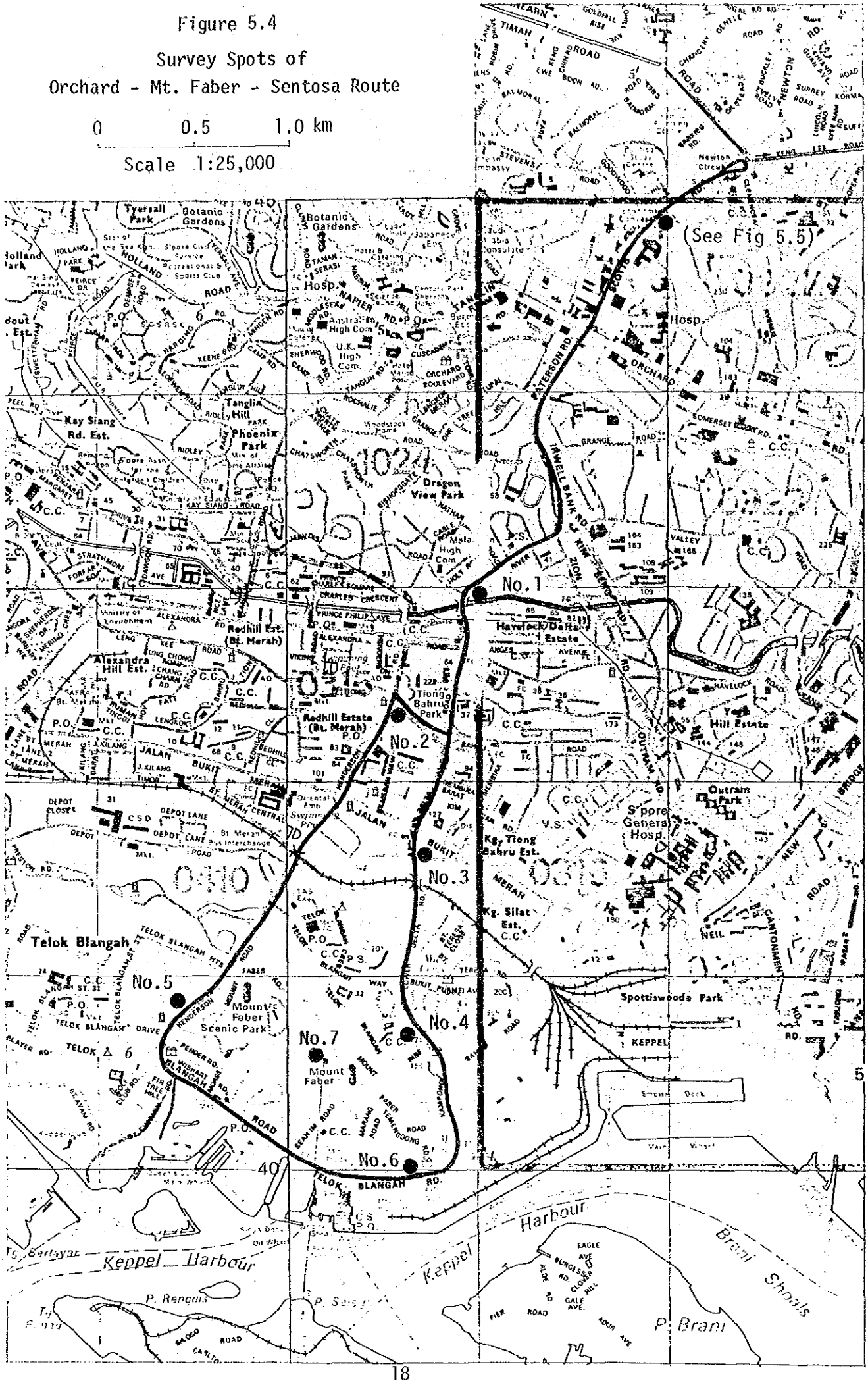


Figure 5.5

Survey Spots of Orchard - Marina Centre Corridor

0 0.5 1.0 km

Scale 1:25,000

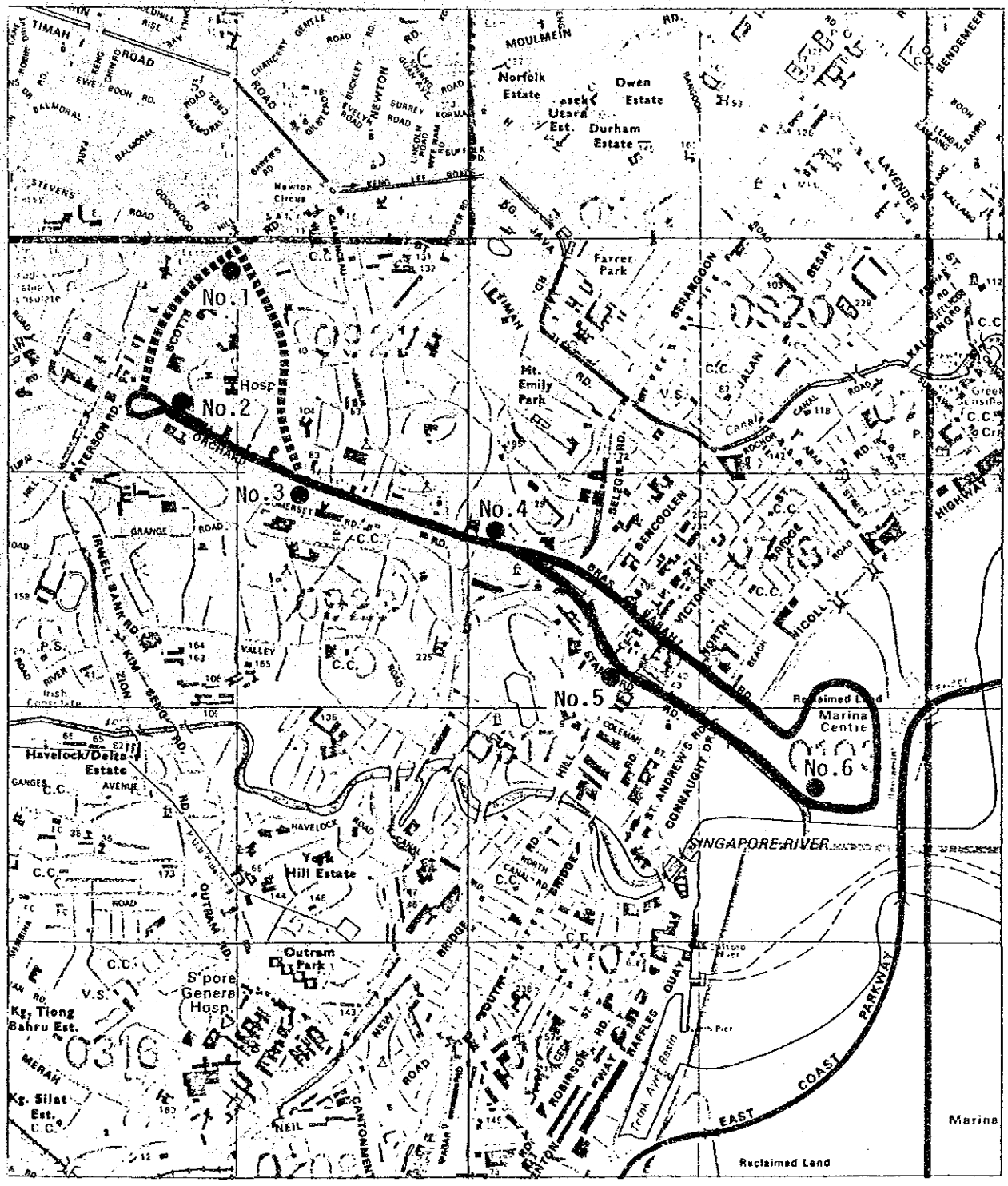
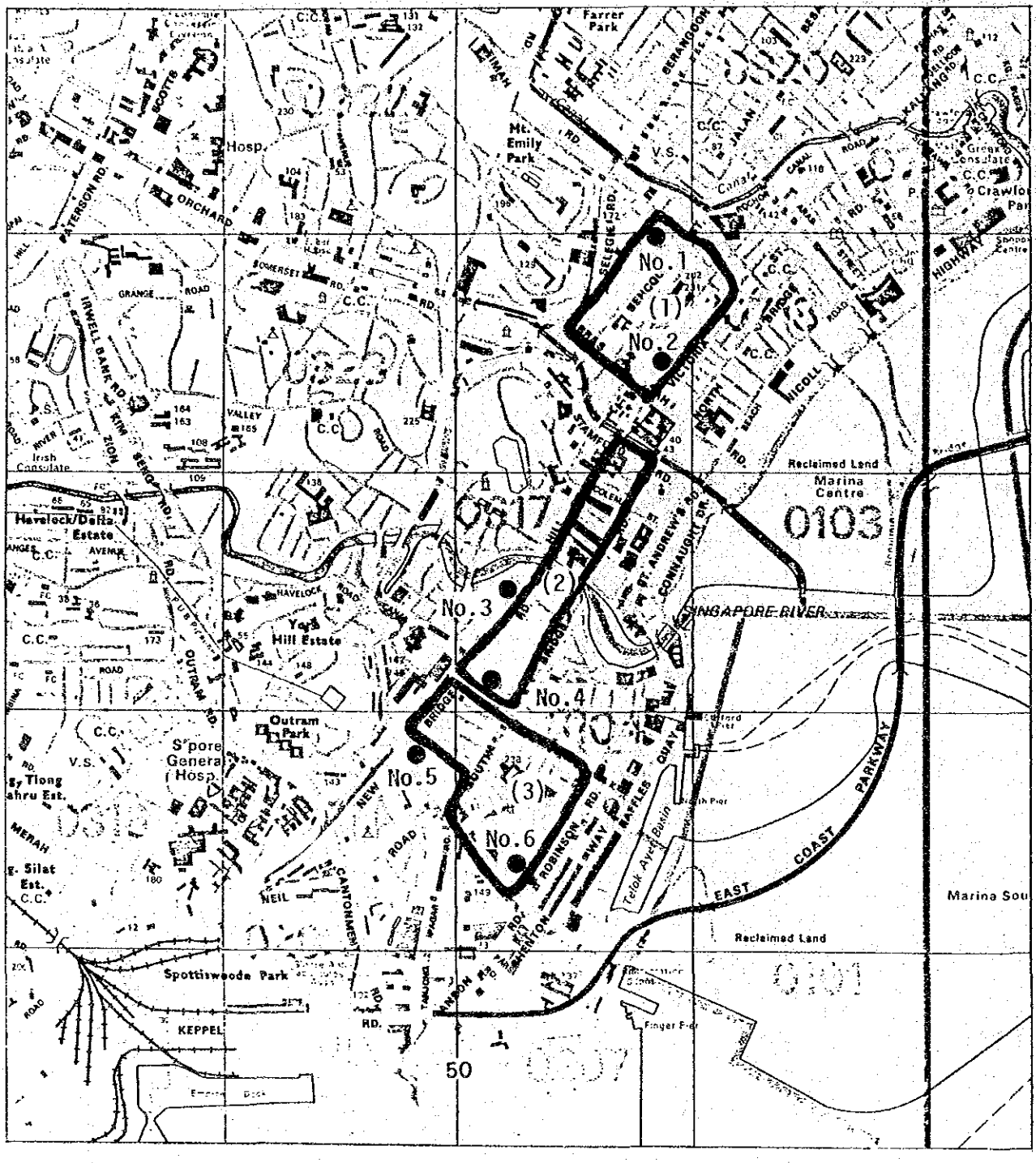


Figure 5.6

Survey Spots of CBD Ring Routes

0 0.5 1.0 km

Scale 1:25,000



6. ENVIRONMENTAL SURVEY IN ANG MO KIO NEW TOWN

6.1 AIR POLLUTION SURVEY

1) Survey Method

According to the Annual Report 1985 prepared by the Anti-Pollution Unit, Ministry of Environment of Singapore, air pollution measurements were carried ort at 14 permanent air monitoring stations during 1985. Among them, the station at the Serangoon district office is the closest to the Study Area. The measured pollutants there were oxides of nitrogen, smoke, sulphur dioxide, total acidity, suspended particles, dust fallout and ozone.

For this study, the level of oxides of nitrogen was determined to gauge the local condition of air pollution within the Study Area. This pollutant, which is easily sampled, normally reflects changes in traffic condition.

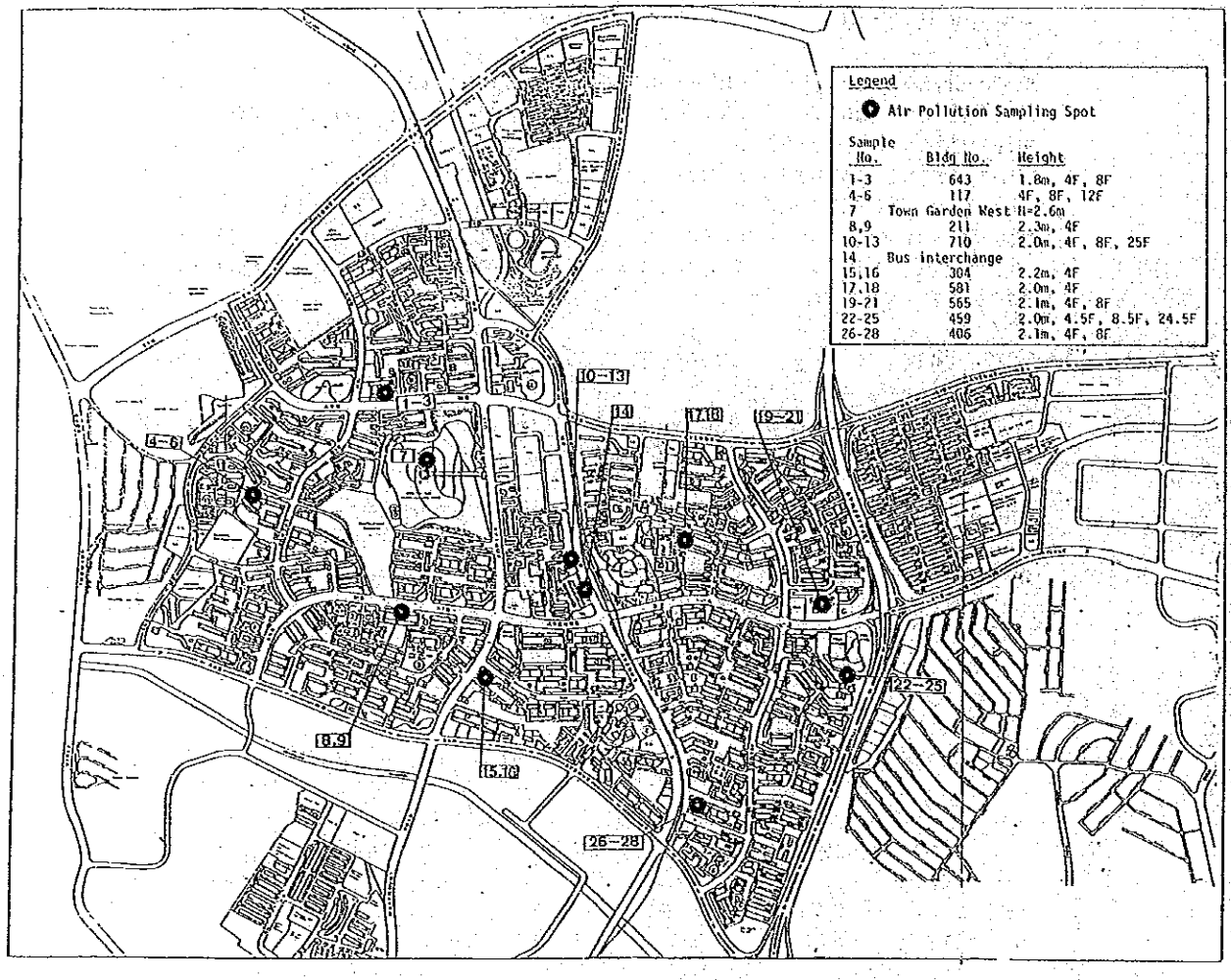
The samplers were placed at 38 spots of interest for about 24 hour. These were then picked up and sent for anlysis in a laboratory. The concentration of nitrogen dioxide (NO_2), in terms of micro-gram per normal cubic meters, was obtained.

2) Sampling Locations

The sampling locations were determined after careful examinations of the areal characteristics of the Study Area, such as the geological characteristics, zones for the Home Interview Survey (HIS), bus service network as well as the present land use. The buildings which had been selected for HIS were selected again, because the results of this survey are expected to be used for comparison with the resident's attitude. A total of 28 points, based on the above criteria, were selected and these are shown in Figure 6.1. (The detailed location and photographs are shown in Appendices A and B.)

Figure 6.1

Air Pollution Sampling Spots



3) Survey Results

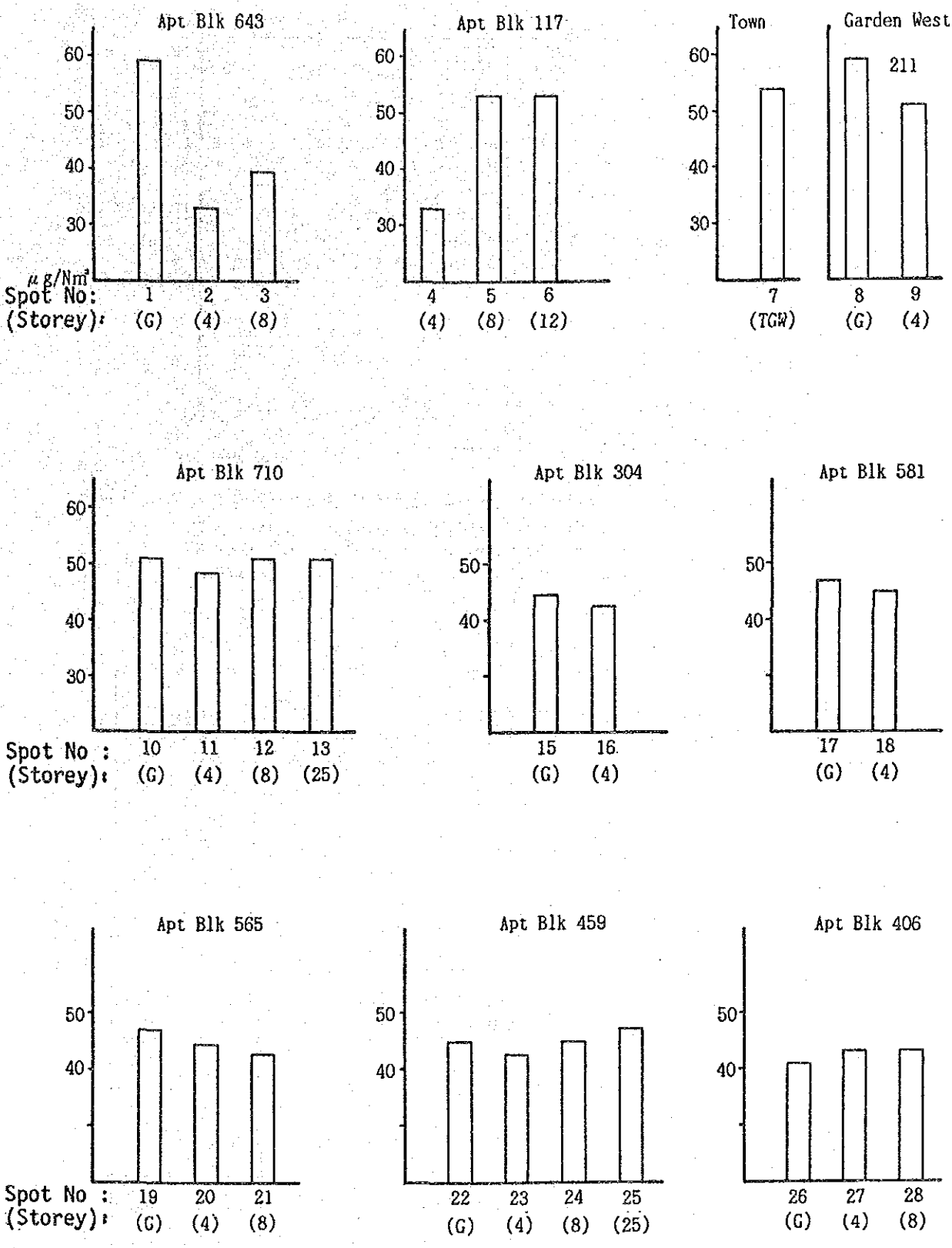
The survey results are shown in Table 6.1 and Figure 6.2. The concentration on NO2 at 27 points ranged from 33 to 59 ug/nm3, while that measured at the bus interchange gave the highest concentration, 150 ug/NM3, and did not show any significant difference from the other sample points. On a horizontal plane, the survey showed no significant difference among the locations except for the bus interchange.

However, on a vertical plane, it may be observed from the results that the concentration of NO2 is less on the 4th storey than that on the ground floor. However, it became higher on the 8th storey. Thus, the survey did not prove that the air is less polluted on the higher floors.

The survey results are all within the range of measurement of urban and industrial areas made by the Anti-Pollution Unit of Singapore as Shown in Figure 6.3.

Figure 6.2

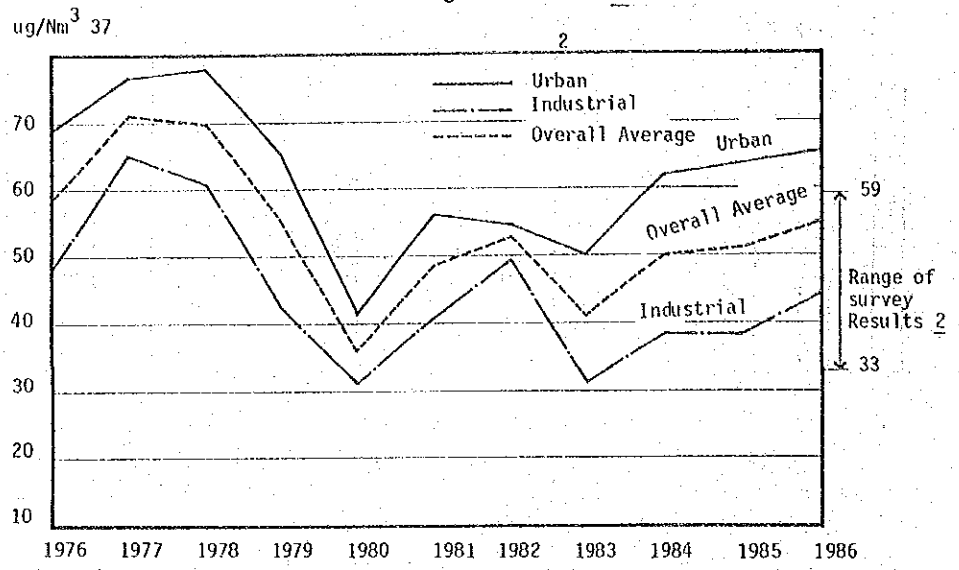
Air Pollution Survey Results



Souce: Study Team

Figure 6.3

Annual Average Levels of Total Oxides of Nitrogen as NO^2 1/



Source: Pollution Control/Department Annual Report 1986

1/ TGS-ANSA method applied
2/ Primary air quality standard for NO^2 of US EPA is 100 mg/m^3 (annual mean)
3/ ug/Nm^3 : micro gram is 10^{-6} gram while normal cubic meter the volume of gas under normal atmospheric pressure at 0° C.

Table 6.1

Air Pollution Survey Results

Block No.	643			117			Town Garden West	211	
Storey	G	4	8	4	8	12	G	G	4
Spot No.	1	2	3	4	5	6	7	8	9
NO2 (ug/NM3)	59	33	39	33	53	53	53	59	51
Front Road	Avenue 5			Street 13			-	Avenue 3	

Source: Study Team

Block No.	710				Bus Inter	304		581	
Storey	G	4	8	25	G	G	4	G	4
Spot No.	10	11	12	13	14	15	16	17	18
NO2 (ug/NM3)	51	49	51	51	51	150	45	43	45
Front Road	Bus Interhange				-	Avenue 6		Street 52	

Source: Study Team

Block No.	565			459				406		
Storey	G	4	8	G	4	8	25	G	4	8
Spot No.	19	20	21	22	23	24	25	26	27	28
NO2 (ug/NM3)	47	45	43	45	43	45	47	41	43	43
Front Road	Avenue 3			Central Expressway				Avenue 8		

Source: Study Team

6.2 Noise Survey

1) Survey Method

The Environmental Public Health Act 1987, Article 47 prescribes that the Commissioner of Public Health may impose requirements, as to the way in which such works as the construction of roads and the breaking up of adjacent land are to be carried out on the responsible persons. They may, in particular, specify the level of noise which may be emitted from the premises in question.

In order to appreciate the effects of noise level that will be caused by the recommended new transport system, the present condition of noise level in the Study Area was surveyed.

A study on the road traffic noise in Singapore was made by the Public Works Department in 1986. After reviewing the noise criteria established in the other countries and those conducted in Singapore, the report recommended that a value of 70 dBA, in terms of L10, be used as a preliminary criterion.

In this study, noise level in terms of L10, L50 and L90 were measured to gauge the range of noise. To understand the characteristics of noise in the Study Area, the following were considered at the relevant spots.

1) ambient noise level,
2) traffic noise level, and
3) MRT noise level

The ambient noise level was intended to be measured far away from the roads so that it is not affected by the road traffic. It was measured to know the level of noise caused by the day-to-day living of the people.

The traffic noise level was measured intensively to understand how it varies with the height from the ground and distance from the road.

The noise level caused by the operation of the MRT was a main concern of people living close to it. For this survey, the peak noise level was measured, because it reflects the characteristics of such noise since the trains operate at regular time intervals.

2) Survey Locations

The survey locations were basically determined in similar fashion as that for air pollution survey. The difference is that additional spots were chosen to measure the ambient noise, traffic noise and MRT noise. The locations are shown in Figure 6.4. (The detailed location and photographs are shown on Appendices C and D.)

3) Survey Results

1) Ambient Noise Level

The survey results of ambient noise level are shown in Table 6.2.

Table 6.2

Ambient Noise Level (in dBA)

Spot No.	4	8	9	12	38
L10	61	62	53	59	55
L50	56	57	51	56	53
L90	54	55	49	54	52
Remarks			Town Garden West		Park

Source: Study Team

1/ dBA (decibel A) is used to indicate the strength of noise including a correction of man's sensitivity. The noise level is referred to as follows

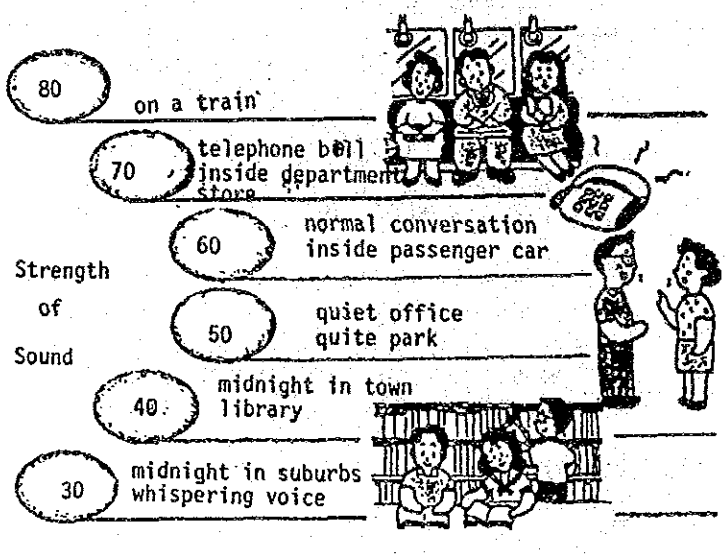
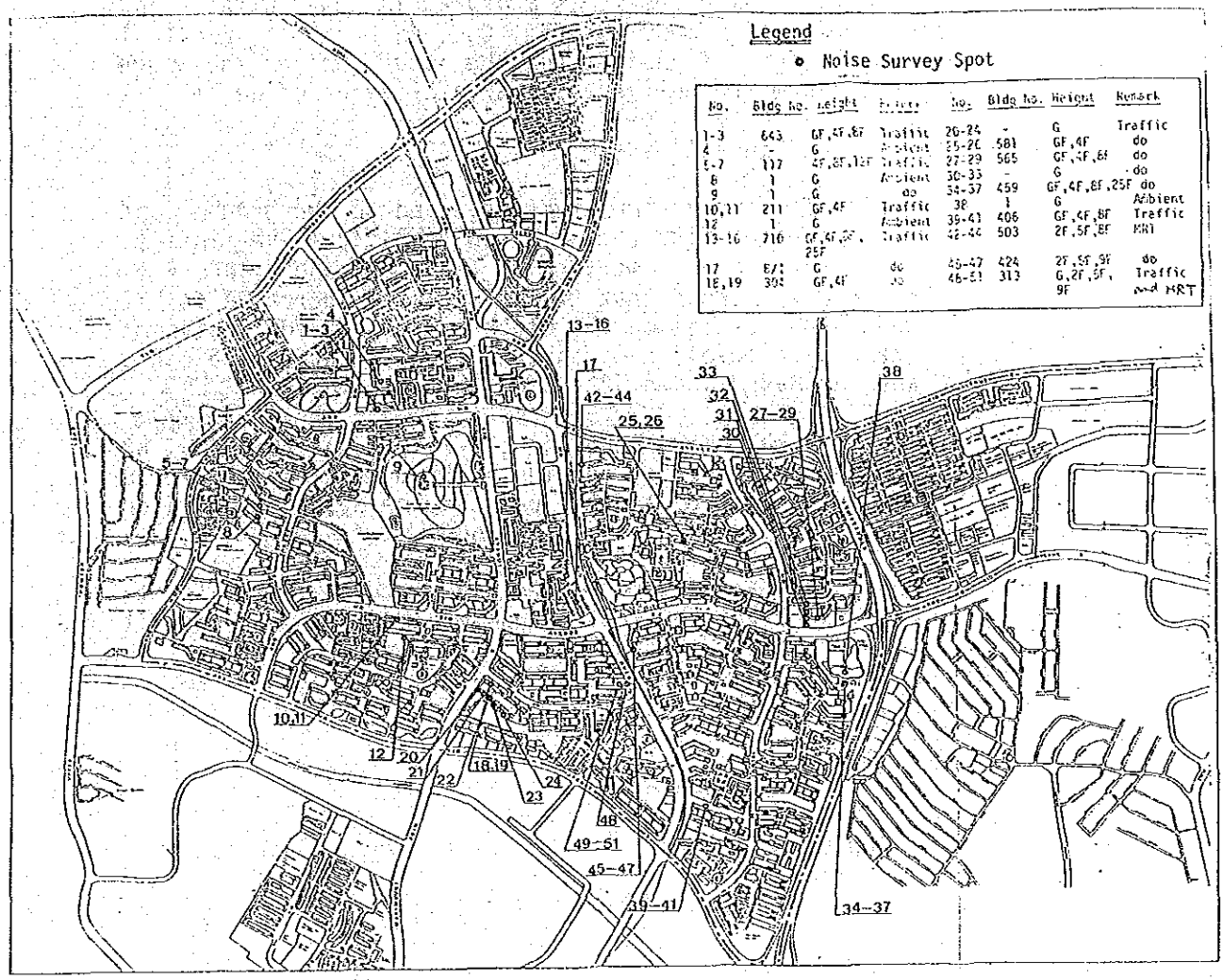


Figure 6.4

Noise Survey Spots



The ambient noise level, L10, ranged from 53 to 62 dBA. The lowest noise level was recorded at spot number 9, Town Garden West, where the nearest road was located more than 500 meters away.

The highest level was recorded at the spot number 9, which was located between two buildings. The spot had been expected to be quiet. However, the noise level was mainly due to human activities such as voice and footsteps.

The second lowest ambient noise level, L10-65 dBA, was measured at the spot number 38, in the middle of park about 100 meters away from the Central Expressway, which affected the noise level slightly.

From these measurements, it could be concluded that the ambient noise level of the Study Area is somewhere close to 53 dBA, although it is quite dependent on local conditions.

2) Traffic Noise Level

The traffic noise level was measured in two ways: one using the apartment blocks to know the vertical characteristics of noise, and the other using the open spaces to know the horizontal characteristics of noise.

1) Vertical Characteristics

The traffic noise level was measured on the ground and then on other floors to see how it differs vertically. The results are summarized in Table 6.3 and Figure 6.5. It clearly shows that the noise level increases as it goes higher. Taking the block number 643 for instance, the noise level, L10, on the ground floor was 66 dBA, and increased up to 72 dBA on the 8th storey.

The maximum noise level of L10-79 dBA was observed at the bus-interchange, and the minimum noise level of 58 dBAS was observed to the spots 34 and 39, both of which were measured on the ground floor.

From the fact observed here, it could be possible to conclude that the traffic noise becomes louder as it goes higher, at least up to 25th storey, (or about 65 meters from the ground surface) because noise is blocked by less obstacles.

Table 6.3

Characteristics of Traffic Noise

Block No.	643			117			211	
Storey	G	4	8	4	8	12	G	4
Spot No.	1	2	3	5	6	7	10	11
L10	66	68	72	61	61	62	69	75
L50	62	63	65	56	56	56	64	69
L90	58	59	60	53	53	53	61	65
Front Road	Avenue 5			Street 13			Avenue 3	

Block No.	710				Bus Interchange	304		581	
Storey	G	4	8	25	G	G	4	G	4
Spot No.	13	14	15	16	17	18	19	25	26
L10	67	69	71	72	79	65	68	67	69
L50	64	66	68	70	75	63	64	61	62
L90	61	64	66	68	73	60	60	57	58
Front Road	Bus Interchange				-	Avenue 6		Street 52	

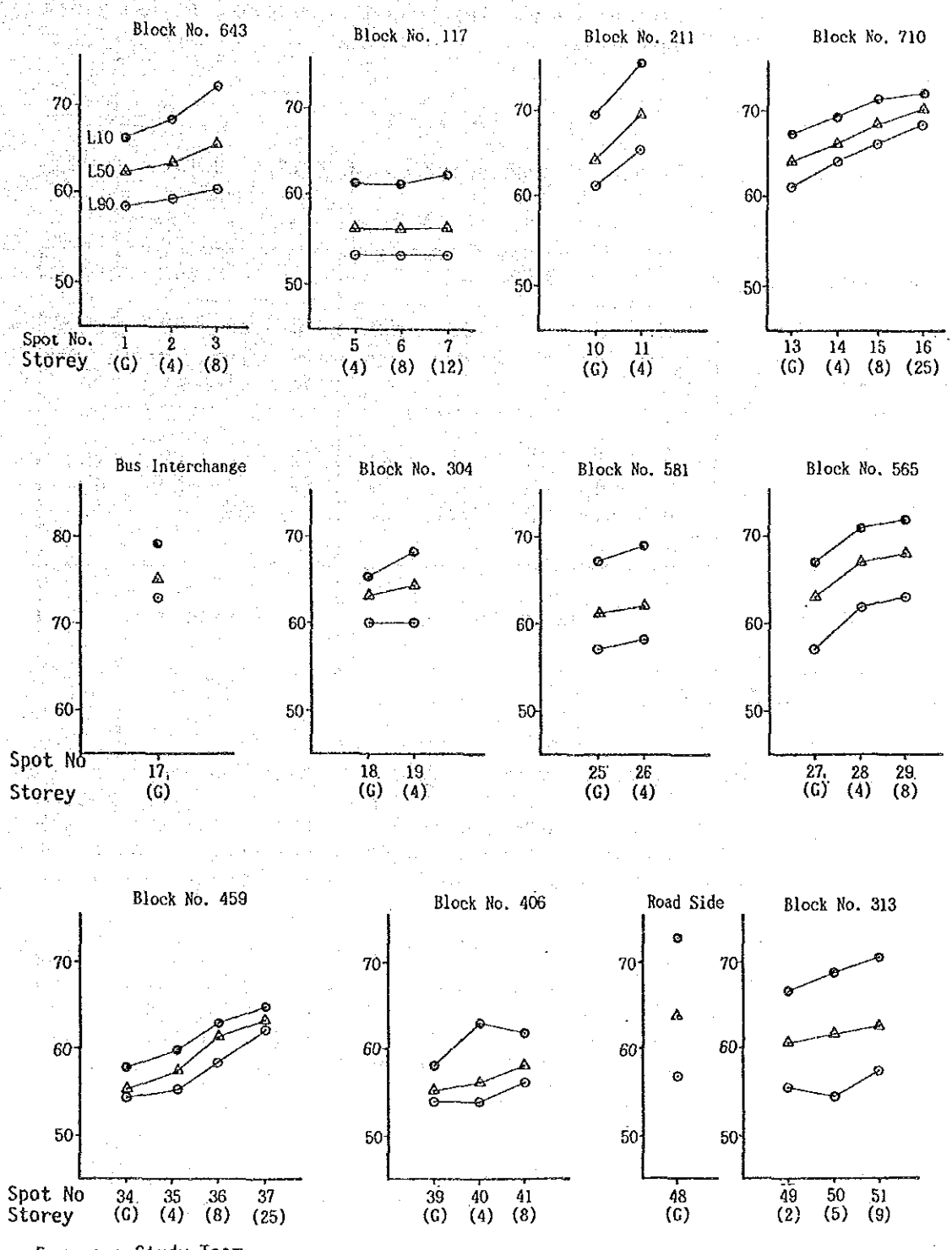
Block No.	565			459				406		
Storey	G	4	8	G	4	8	25	G	4	8
Spot No.	27	28	29	34	35	36	37	39	40	41
L10	67	71	72	58	60	63	65	58	63	62
L50	63	67	68	55	57	61	63	55	56	58
L90	57	62	63	54	55	58	62	54	54	56
Front Road	Avenue 3			Central Expressway				Avenue 8		

Block No.	Road-side	313		
Storey	G	2	5	9
Spot No.	48	49	50	51
L10	73	67	69	71
L50	64	61	62	63
L90	57	56	55	58
Front Road	Avenue 8			

Source: Study Team

Figure 6.5

Vertical Characteristics of Traffic Noise



Source : Study Team

2) Horizontal Characteristics

The traffic noise level was measured approximately one meter above the ground, at the roadside and then at spots further away. The results are shown in Table 6.4 and Figure 6.6.

Table 6.4

Horizontal Characteristics of Traffic Noise

Adjacent Block	304					565			
Distance (M)	0	25	50	100	150	0	25	50	100
Spot No.	20	21	22	23	24	30	31	32	33
L10	76	67	65	61	62	72	66	62	70
L50	70	64	61	59	59	67	61	59	60
L90	64	59	59	58	57	60	56	56	57
Front Road	Avenue 6					Avenue 3			

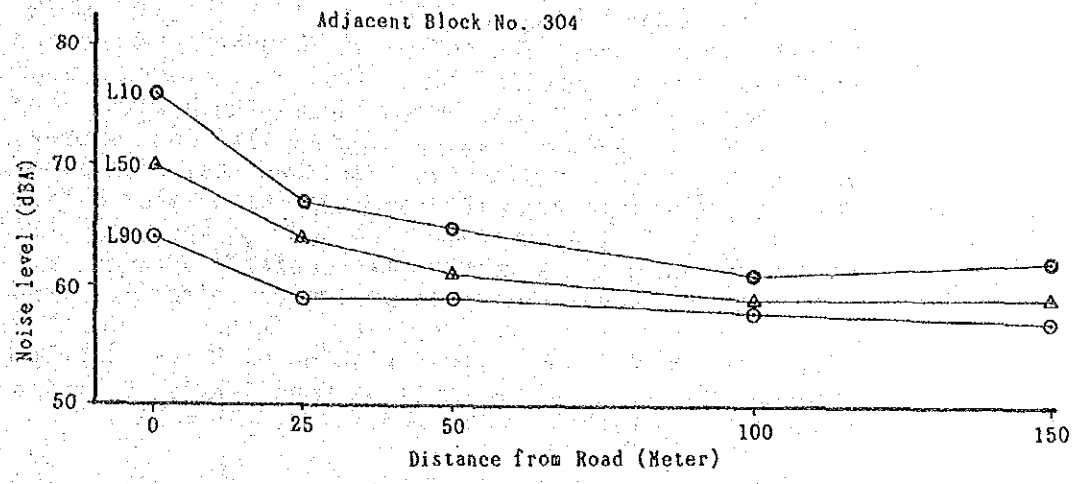
Source: Study Team

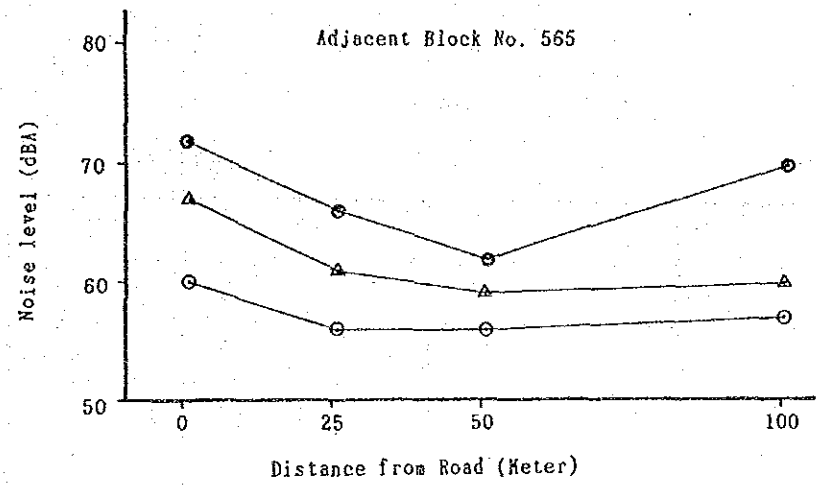
The figure shows that the noise level decreases as the spot gets further from the road. The level became higher at 150 meters away from the road for the block 304, and at 100 meters for the block 656, because at these points the noise level is not affected solely by traffic.

From the results of survey on the vertical and horizontal characteristics of traffic noise, it may be concluded that noise is reduced with horizontal distance, but increased at greater heights i.e. increases with vertical distances.

Figure 6.6

Horizontal Characteristics of Traffic Noise





Source: Study Team

3) MRT Noise Level

The noise level caused by the operation of the MRT was measured at three blocks as shown in Table 6.5 and Figure 6.7. The level indicates the average peak level of 3 trains which passed infront of the spot. The result shows that the noise is louder at greater heights. The noise of "B line" trains at block number 503 shows a shrap increase with increasing height. The rail level at spot 42 was as high as the 2nd storey, and the noise from B line was less than that of A line. This is probably due to the fact that noise from B line is blocked by the concrete slab and parapet of the viaduct. At greater heights the obstacle between the noise source and receiver is no longer effective and noise reaches the receiver more freely. At this particular point, the structure joint of Bline located between embarkment and viaduct is most likely to be the cause of such high level of noise (See Figure 6.7)

On the 5th and 9th floor of block 424, the level was largely influenced by the squeaking noise caused by the rails and wheels of the trains along the curve on the south of Ang Mo Kio station.

Table 6.5

MRT Noise Level

Unit: dBA

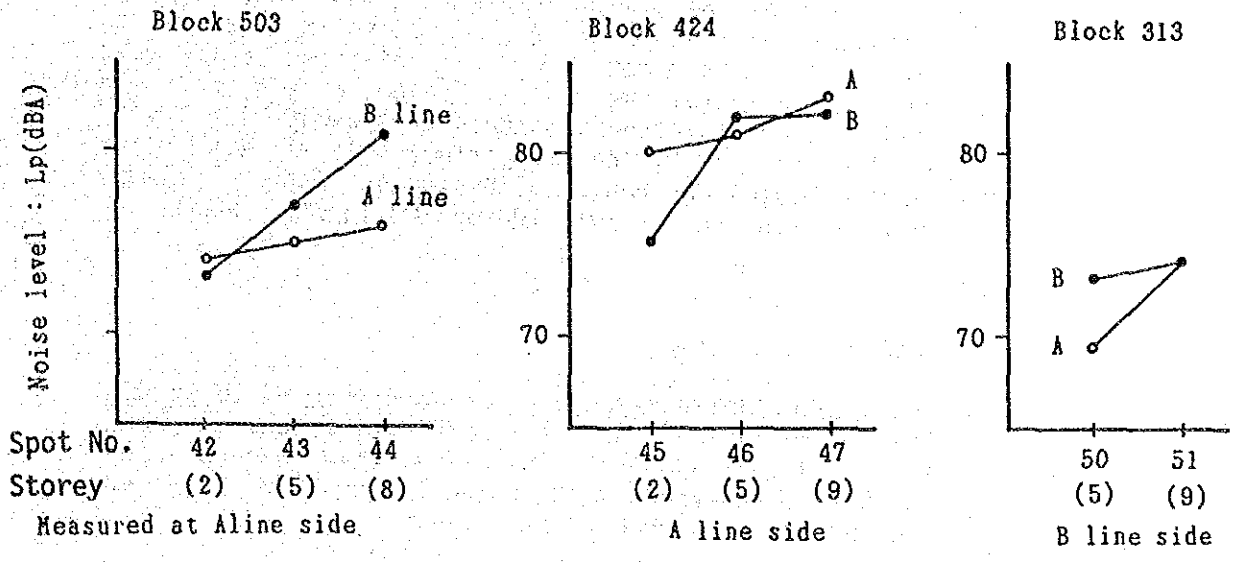
Block No.		503			424			313	
Storey		2	5	8	2	5	9	5	9
Spot No.		42	43	44	45	46	47	50	51
1/ Lp	A line2/	74	75	76	80	81	83	69	74
	B line	73	77	81	75	82	82	73	74
Measuring Side		A line side			A line side			B line side	

Source: Study Team

1/ Lp : Noise Level at peak
2/ A : South bound, B : North Bound

Figure 6.7

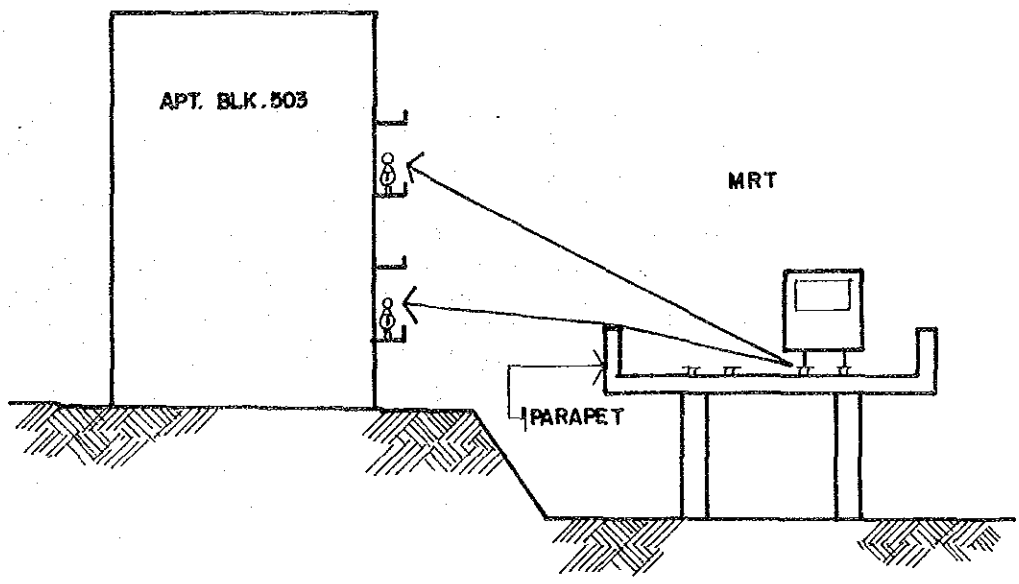
MRT Noise Level



Source: Study Team

Figure 6.8

Conceptual Sketch of Noise Barrier



6.3 Findings

1) Air Pollution

The survey on air pollution shows that the level did not differ much from the average level measured by the Anti-Pollution Unit of Singapore. The comparison of the results of sampling spots did not show any significant difference both on the horizontal and vertical plane, except that the result at the bus interchange showed remarkably high level. Except for this point, the air pollution level was below the United States Environmental Protection Agency primary air quality standard for NO2, 100 mg/NM3 (annual mean).

2) Noise

a) Ambient Noise Level

The ambient noise level, L10, ranged from 53 to 62 dBA. They were below the preliminary criterion, 70 dBA, suggested in Singapore. The lowest level was recorded at the Town Garden West, where the nearest road was located more than 500 meters away.

b) Traffic Noise Level

The highest noise level, L10-79 dBA, was recorded at the bus interchange, and the lowest 58 dBA, at the park 100 meters away from the Central Expressway.

The traffic noise decreased when the receiver moved further away from the road up to 100 meterrs. This appears to be the point at which disturbance from other noise source begins. The noise level increased when the receiver went up the apartment blocks. The survey revealed that the noise level on the 25th floor was 5-7 dBA higher than that on the ground floor.

c) MRT Noise Level

The average surveyed peak noise level of MRT operation ranged from 69 to 83 dBA. The lowest level surveyed was observed on the 5th storey of block 313 located on the other side of the road. The highest surveyed noise level was recorded on the 9th storey of block 424, which was influenced by the squeaking noise of rails. If the noise arising from the MRT operation proves to be a problem, a detailed study into the rail system and its effects is recommended.

7. ENVIRONMENTAL SURVEY FOR OTHER CASE STUDY AREAS

7.1 Yishun New Town

1) Air Pollution Survey

Reflecting the early stage of new town development, air pollution survey revealed that concentration of nitrogen diooxide (ND_2) isf quite low compared to the results of other spots. Concentration of ND_2 at Spoorts 1 and 3 was as low as 18 mg/Nm , which was the lowest of this survey (See Table 7.1 and Figure 7.1)

The survey tools were hung on the columns of apartment locks (See Appendix E and F).

2) Noise Survey

This noise level in Yishun New Town was rather low due to less volume of traffic on road as the area is not yet fully developed (See Table 7.2 and Figure 7.2). This highest level among three spots was 61 dBA at the Spot 2, and the lowest was 51 dBA at the Spot 3 where the objective building was about 55 meters away from Yishun Avenue 11 (See Appendix E and G). This was the lowest of all the survey resultsf of alternative plans.

Table 7.1

Air Pollution Survey Result of Case Study Areas

Route	Road	Spot No.	Sequence No.	ND Concentration mg/Nm
Yishun New Town	Yishun Ave 7	1	1	18
	Yishun Ave 2	2	2	27
	Yishun Ave 11	3	3	18
Ang Mo Kio - Hoougang - Bedok Route	Ang Mo Kio Ave 3	1	4	25
	Hougang Ave 2	2	5	25
	Hougang Ave 2	3	6	27
	Hougang Ave 3	3	7	29
	Jalan Eunos	4	8	21
	Jalan Eunoos	5	9	25
Orchard - Mount Faber - Sentosa Route	Delta Rd	1	10	25
	Henderson Rd	2	11	29
	Lower Delta Rd	3	12	29
	Lower Delta Rd	4	13	29
	Henderson Rd	5	14	31
	Telok Blangah Rd	6	15	18
	Mount Faber Rd	7	16	29
Orchard - Marina Centre Corridor	Scotts Rd	1	17	47
	Orchard Rd	2	18	41
	Orchard Rd	3	19	43
	Orchard Rd	4	20	51
	Stamford Rd	5	21	59
	Raffles Ave	6	22	23
CBD Ring Routes	Princep Rd	1	23	33
	Victoria St	2	24	41
	New Bridge Rd	3	25	35
	Upper Cross St	4	26	33
	Smith St	5	27	31
	Cecil St	6	28	35

Figure 7.1

Air Pollution Survey Result of Alternative Plans

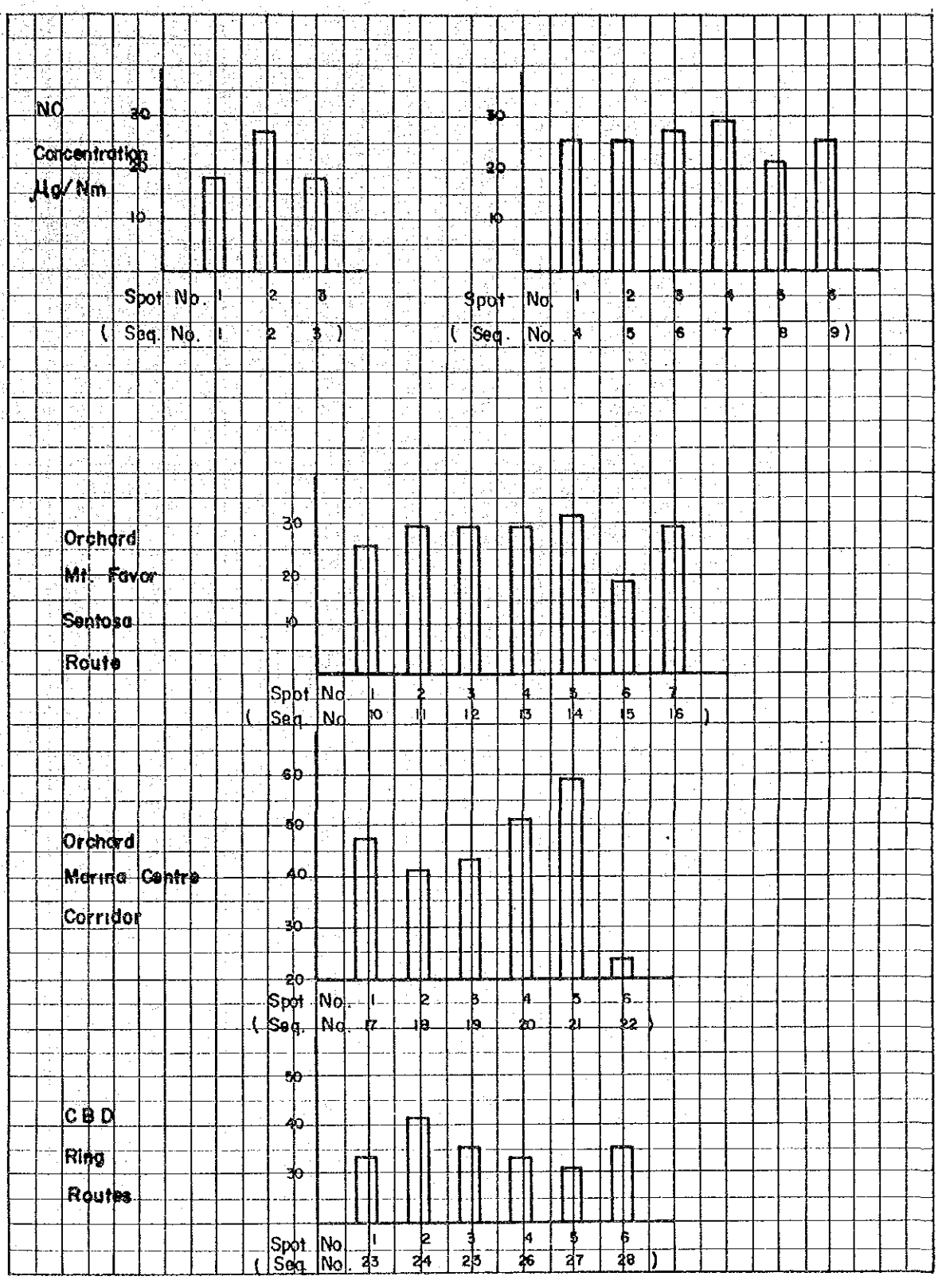


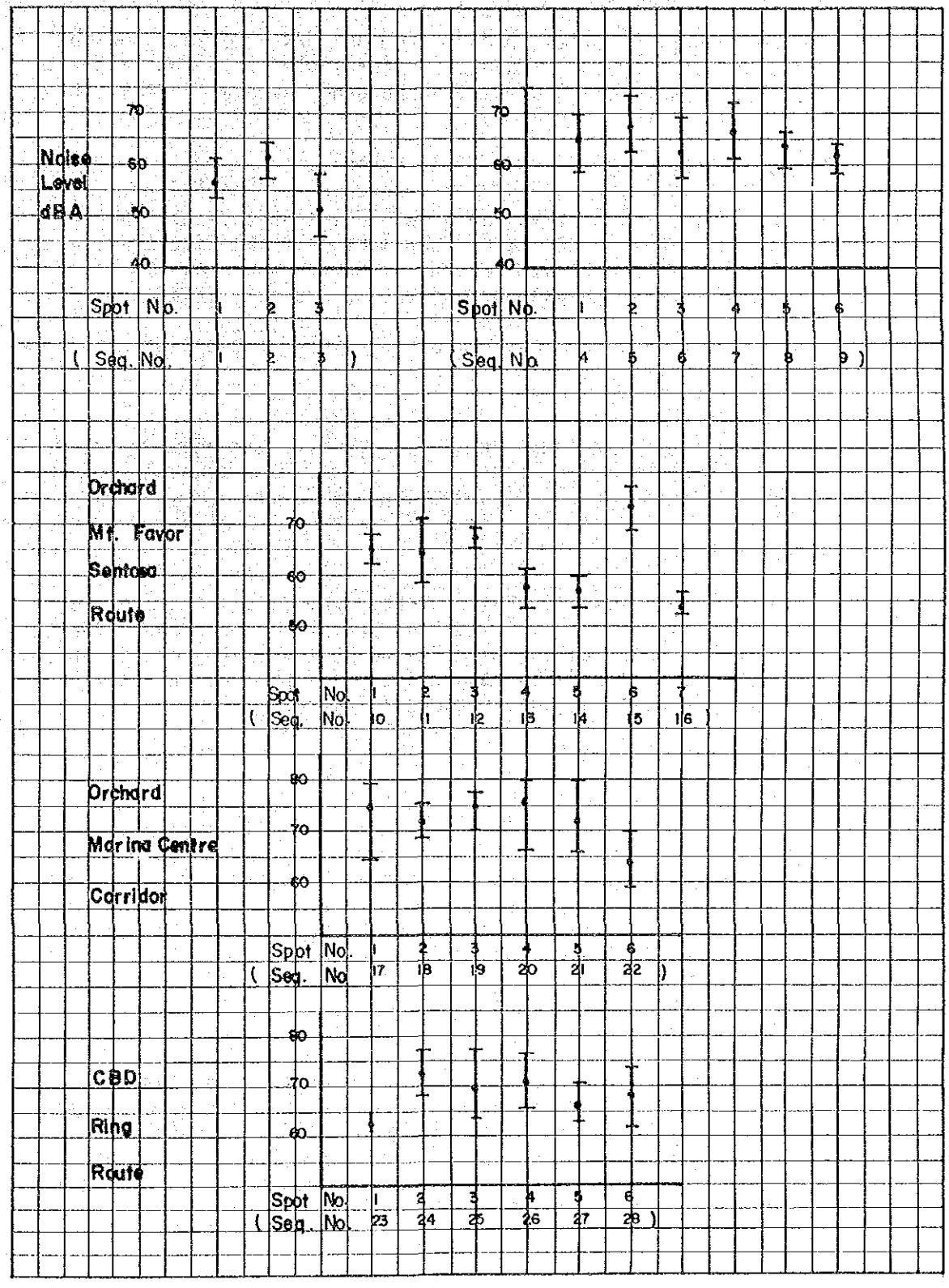
Table 7.2

Noise Survey Result of Case Study Areas

Route	Road	Spot No.	Sequence No.	Noise Level (dBA) L10	L50	L90
Yishun New Town	Yishun Ave 7	1	1	61	56	90
	Yishun Ave 2	2	2	64	61	57
	Yishun Ave 11	3	3	60	51	46
Ang Mo Kio - Hoougang - Bedok Route	Ang Mo Kio Ave 3	1	4	70	64	58
	Hougang Ave 2	2	5	73	67	62
	Hougang Ave 2	3	6	69	62	57
	Hougang Ave 3	3	7	72	66	61
	Jalan Eunos	4	8	66	63	59
	Jalan Eunoos	5	9	64	62	58
Orchard - Mount Faber - Sentosa Route	Delta Rd	1	10	68	65	62
	Henderson Rd	2	11	71	64	58
	Lower Delta Rd	3	12	69	67	65
	Lower Delta Rd	4	13	61	57	53
	Henderson Rd	5	14	59	56	53
	Telok Blangah Rd	6	15	77	73	68
	Mount Faber Rd	7	16	56	53	52
Orchard - Marina Centre Corridor	Scotts Rd	1	17	79	74	64
	Orchard Rd	2	18	75	71	68
	Orchard Rd	3	19	77	74	70
	Orchard Rd	4	20	80	75	66
	Stamford Rd	5	21	79	71	65
	Raffles Ave	6	22	70	63	58
CBD Ring Routes	Princep Rd	1	23	65	62	61
	Victoria St	2	24	77	72	68
	New Bridge Rd	3	25	77	69	63
	Upper Cross St	4	26	76	70	65
	Smith St	5	27	70	65	62
	Cecil St	6	28	73	67	61

Figure 7.2

Noise Survey Result of Alternative Plans



7.2 Ang Mo Kio-Hougang-Bedok Route

1) Air Pollution Survey

Concentration of ND_2 ranged from 32 mg/Nm^3 to 29, showing relatively small fluntuation (See Table 7.1 and Figure 7.1). That of Spot 4 along Hougang Avenue 3 was the highest of this route.

2) Noise Survey

The noise level (L50) of 6 spots fluctutated only 5 dBA ranging from 62 dBA to 67 (See Table 7.2 and Figure 7.2). The highest level was recorde at Spot 2 where a bus stop was located at Hougang Avenue 2 (See Appendix E and G).

7.3 Orchard-Mount Faber-Sentosa Route

1) Air Pollution Survey

The highest concentration, 31 mg/Nm^3 was observrd at Spot 5. along Henderson Road, and the lowest at Spot 6 along Telok Blangah Road (See Table 7.1 and Figure 7.1).

2) Noise Survey

The survey results ranged widely from 73 dBA at Spot 6, Telok Blangah Road to 53 dBA at Spot 7, Mount Faber (See Table 7.2 and Figure 7.2). The noise level at Spots 4 and 5 was 57 dBA and 56, respectively. They reflected the characteristics of calm residential area.

7.4 Orchard-Marina Centre Corridor

1) Air Pollution Survey

Concentration of ND_2 exceeded 40 mg/Nm^3 at Spots from 1 to 5 along the busiest roads of Scotts, Orchard and Stamford and the lowest wasf 23 mg/Nm^3 at the Oriental Hotel on Raffles Avenue (See Table 7.1 and Figure 7.1). The survey result of Spot 5 was 59 mg/Nm^3 which was the highest of this survey.

2) Noise Survey

Reflecting the busy activities of Orchard Road, the noise level (L50) of 5 spots exceeded 70 dBA, while the level was as loow as 63 dBA at Spot 6 in front of The Oriental Hotel (See Table 7.2 and Figure 7.2). The level of Spot 4 (McDonald House) was 75 dBA which was the of all the survey results of alternative plans.

7.5 CBD Ring Routes

1) Air Pollution Survey

Concentration of ND_2 fluctuated from 31 mg/Nm^3 to 29, at Spot 5 up to 41 at Spot 2, which were located at Smith Street in China Town and Victoria Street, respectivle.

2) Noise Survey

The lowest noise level of the Ring Route was 62 dBA recorded at Spoot 1 at the open space along Princep Road. Whereas, the highest level was found at Spot 2 at Tai Pan Ramada Hotel on Victooria Street.

7.6 Findings

1) Air Pollution Survey

The survey results ranged from 18 mg/Nm^3 up to 59, and can be classified into two groups; one is below 30 mg/Nm^3 , and the other is over this level. The results of three alternatives routes, i.e. Yishun New Town, Ang Mo Kio-Hougang-Bedok Route and Orchard-Mount Faber-Sentosa Route belong to the former except sequence number 14 which showed 31 mg/Nm^3 . The other results of two alternatives i.e. Orchard-marina Centre Corridor, and CBD Ring Routes belong to the latter except sequence number 22 which showed 23 mg/Nm^3 .

2) Noise Survey

The survey resultsf show that the noise level at busy areas such as Orchard was over 70 dBA in terms of L50. The noise level along the main roads of Ang Mo Kio-Hougang-Bedok Route was between 70 and 60 dBA. In the noise calm residential area along Henderson Road, the noise level was below 60 dBA. Thus, the noise survey result of slternative plans indicates that the present noise condition is dependent on the land use characteristics as shown in Table 7.3.

Table 7.3

Present Noise Condition of Relevant Land Use

Unit: L50, dBA

Land Use	Noise Level
Commercial Area	70 - 80
Residential Area	50 - 60
Residential Area Along Trunk Highway	60 - 70

8. EVALUATION OF ANG MO KIO SYSTEM

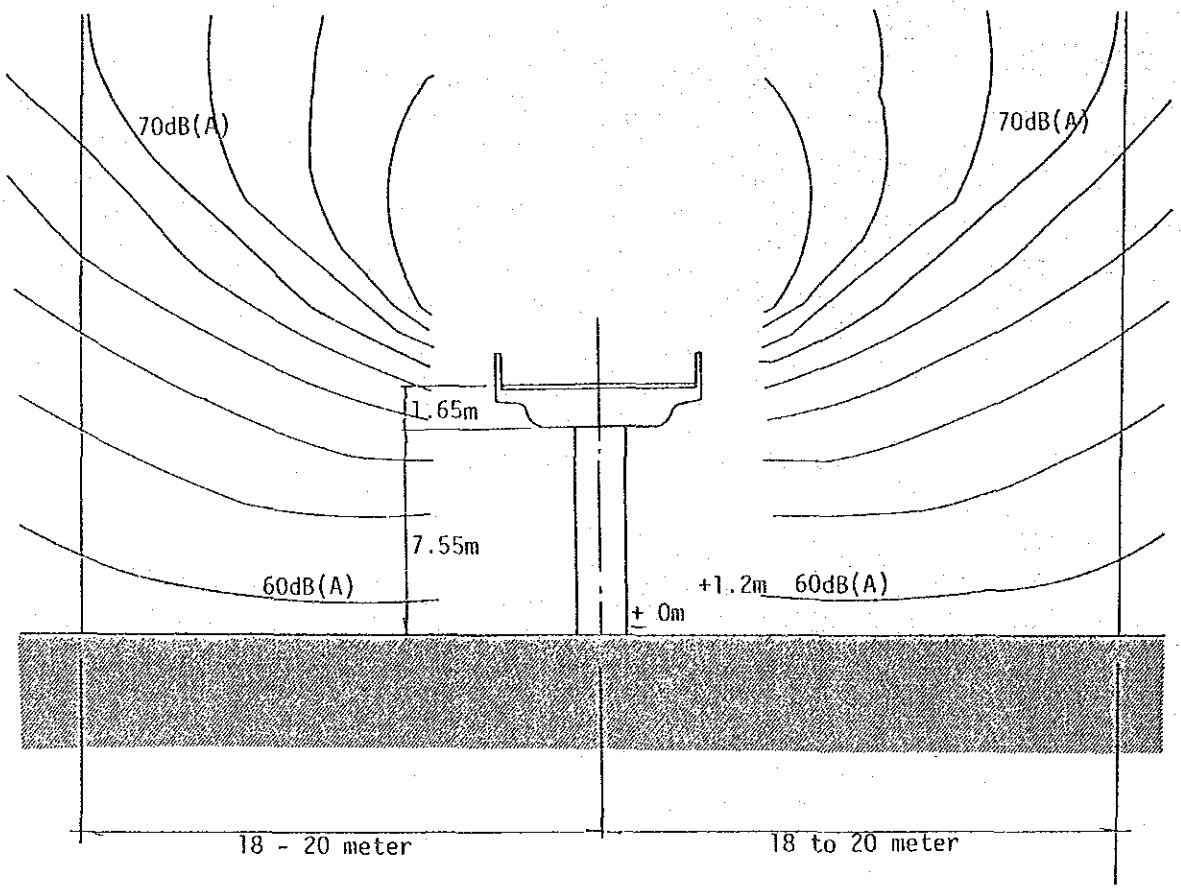
Though studies on the existing new transit system in Europe and Japan, a guideway system is selected for detail study as it seems to fit the present condition for detail study as it seems to fit the present condition of Ang Mo Kio from the view pooint of its terrain, size of population to be served, and the land use characteristics of the area. The detail process of selection is explained in a different technical paper.

As it was made clear through the Home Interview Survey and field survey that the residents were concerned about noise problem, effort has been made to collect the data of similar system (See Appendix I).

Consequently, an intermediate capacity transit system at Port Island in Kobe City, Japan was determined to be most appropriate to be referred, only because its elevated structure and the operated cars are very similar to the system that we might recommend, but the reliable noise data are available. The contour lines of noise level are shown in Figure 8.1 together with the cross section of viaduct. The indicated figures represent the peak levels of cars running at a speed of 60 km/h. The noise level tends to become higher as the height from the ground surface becomes higher until it reaches about 70 dBa.

Figure 8.1

Predicted Noise Level of New Transit System



For evaluation of these plans, the present condition of the areas along the routes were examined. From the noise survey spots, five spots were picked up as these are facing the route. Then the noise level on the 4th storey is listed in Table 8.1. In this table, the upper level of 80 percent range, L10, and the maximum level are shown.

Table 8.1

Present Noise Level of Residence Adjacent to Alternative Route

Unit: dBA

	Spot Number				
Surveyed Parameter	2	11	14	19	28
Peak Level	77	83	77	74	79
L10	68	75	69	68	71

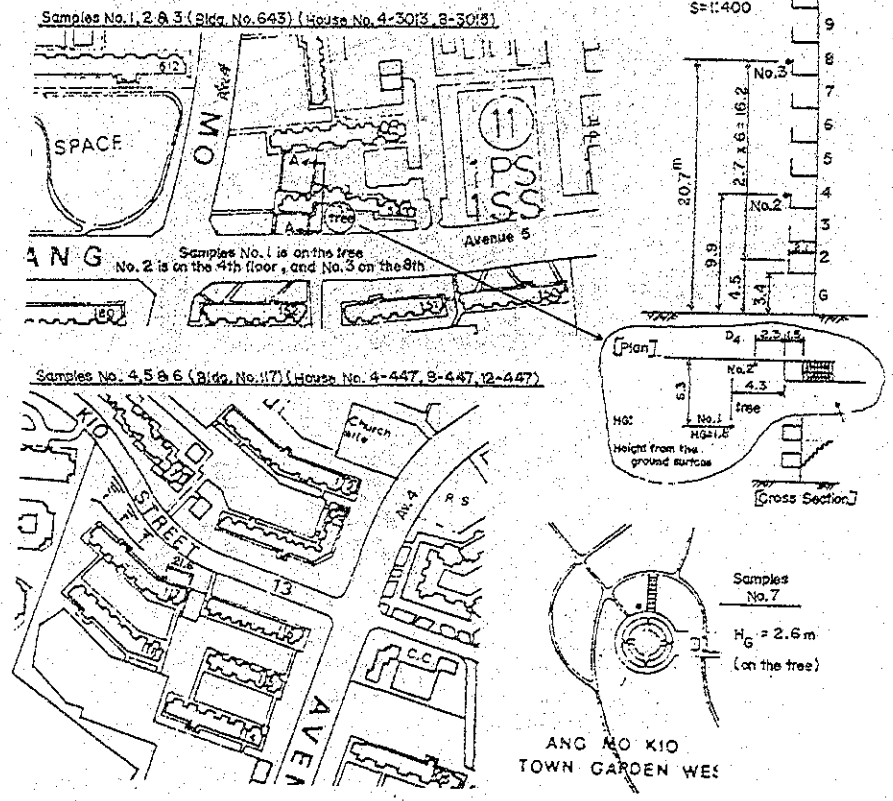
The peak level of these 5 spots are higher than that of expected peak level (70 dBA) of new transit system. Taking into account that the present peak level is presumably influenced a lot by such large vehicles as buses, it is likely that the noise level would become lower if the buses are substituted by new transit system.

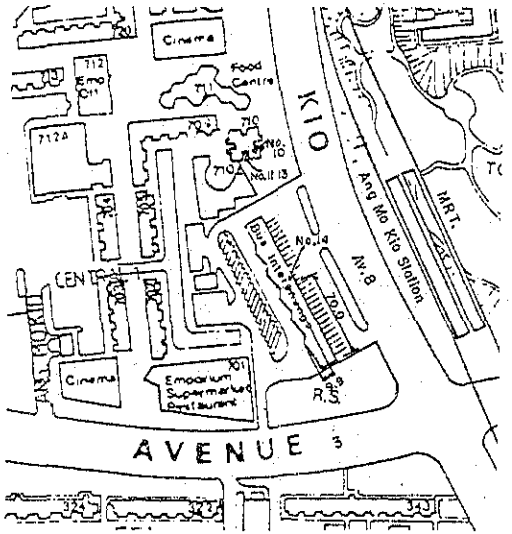
It is concluded, thus, that provision of new transit system would highly contribute to enhancement of residential environment of Ang Mo Kio.

Appendix A

Location Map of Air Pollution Survey in Ang Mo Kio New Town

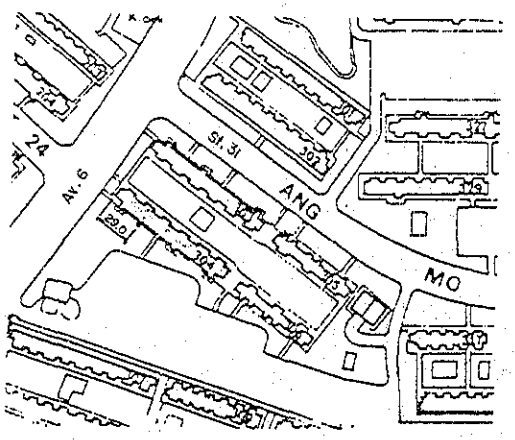
App. A Location Map of No. Samples (S=1:4000)





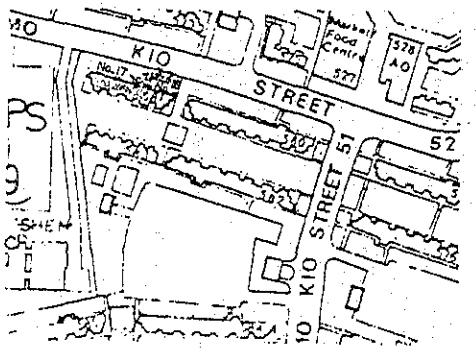
Samples No. 10 ~ 14
(Bldg. No. 710)

No. 10 Ground floor, H_G = 2.0
11 4-2615
12 8-2615
13 25-2615
14 Bus interchange
H_G = 2.5



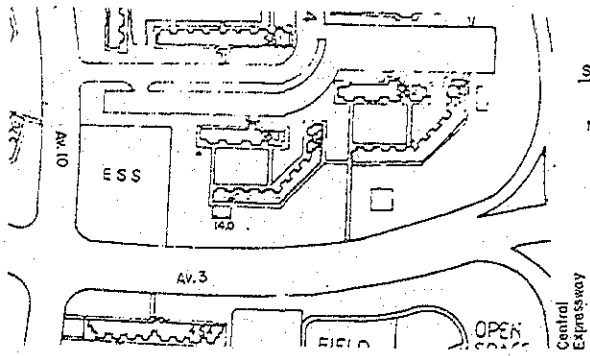
Samples No. 15 & 16
(Bldg. No. 304)

No. 15 Ground floor, H_G = 2.2
16 4-1143



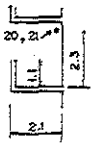
Samples No. 17 & 18
(Bldg. No. 581)

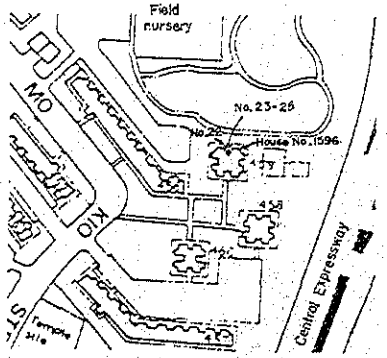
No. 17 Ground floor, H_G = 2.0
18 4-3143



Samples No. 19, 20 & 21
(Bldg No. 565)

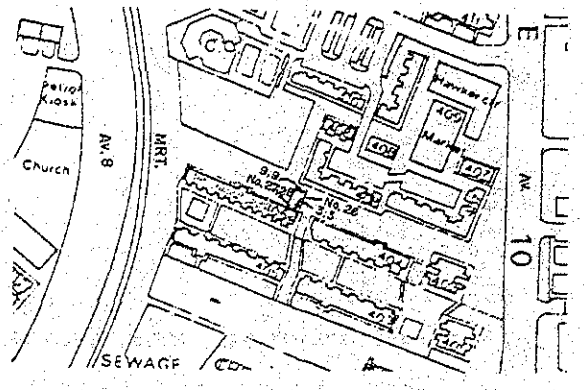
No. 19 Ground floor, H_G = 2.1
20 4-3401
21 8-3401





Samples No. 22 - 25
(Bldg. No. 459)

No. 22 Ground floor, H_G = 2.0
23 4.5-1596
24 8.5-1596
25 24.5-1596

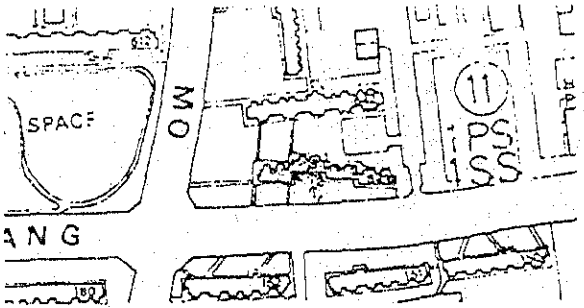


Samples No. 26, 27 & 28
(Bldg. No. 406)

No. 26 Ground floor, H_G = 2.1
27 4-695
28 8-695

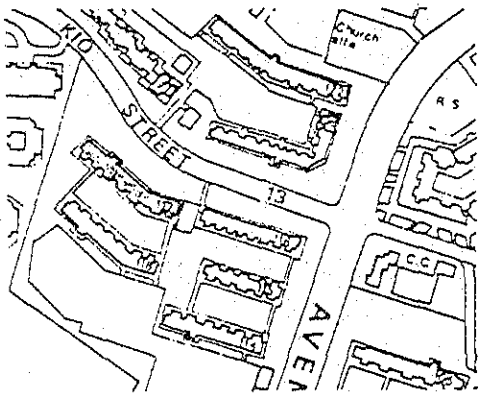
Appendix B

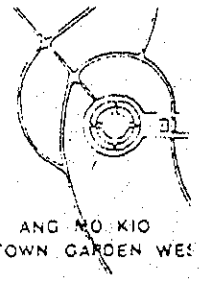
Photographs of Air Pollution Survey in Ang Mo Kio New Town



Bldg. No. 643

Photos 1-3





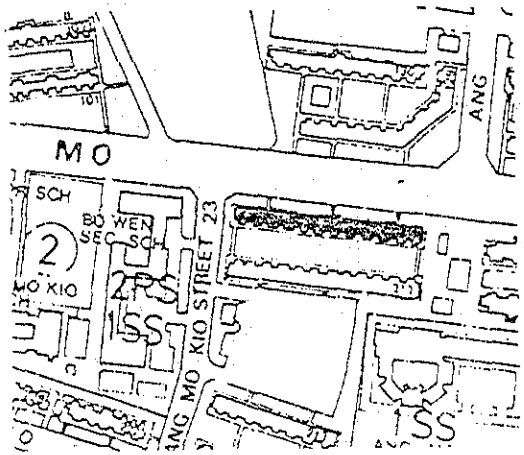


Photo 1

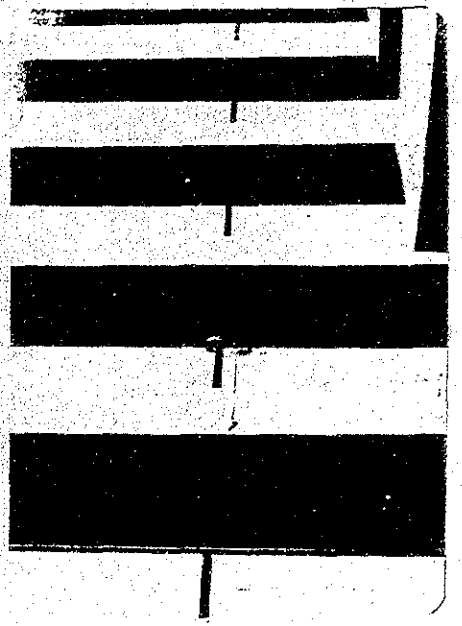


Photo 2

App. B

Photograph of air pollution sampling

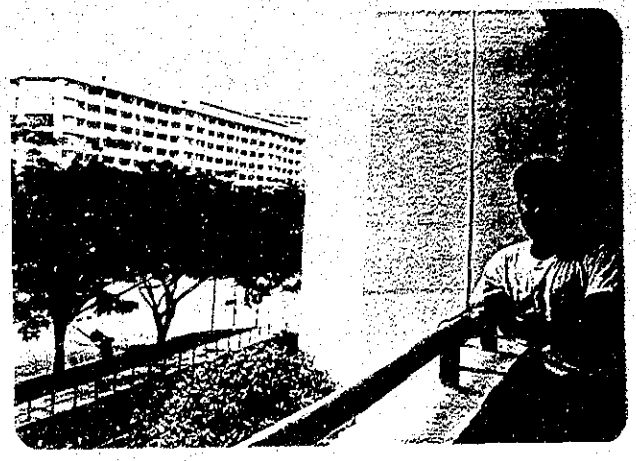
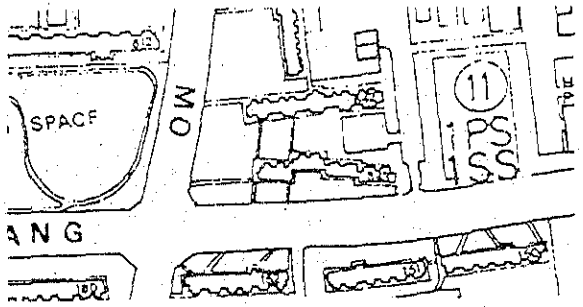
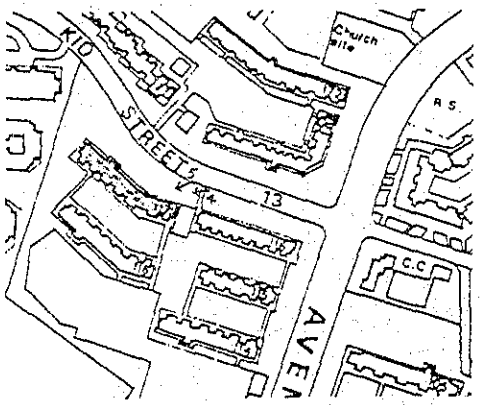


Photo 3

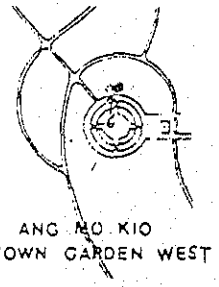


Bldg. No. 117

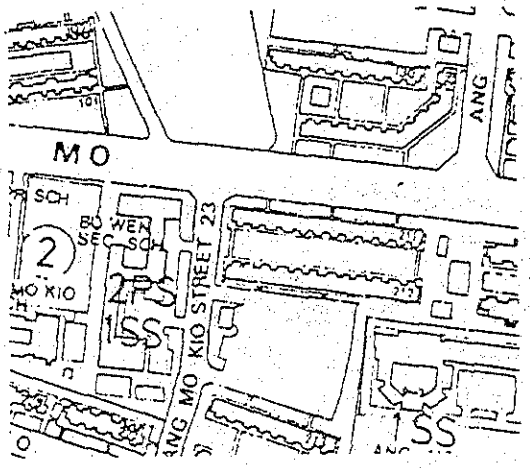


Photos 4 & 5

Photo 6



ANG MO KIO
TOWN GARDEN WEST



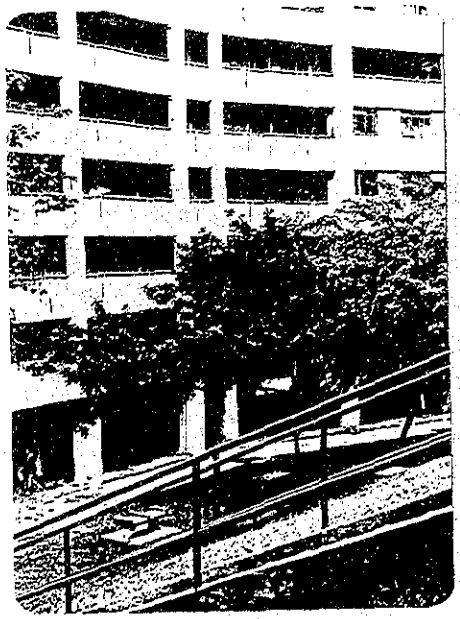


Photo 4

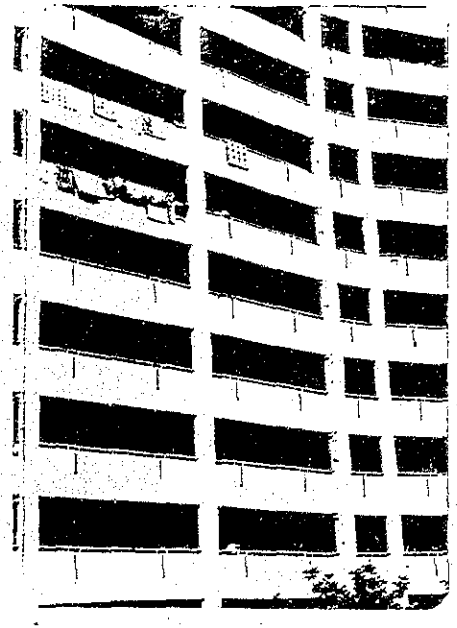
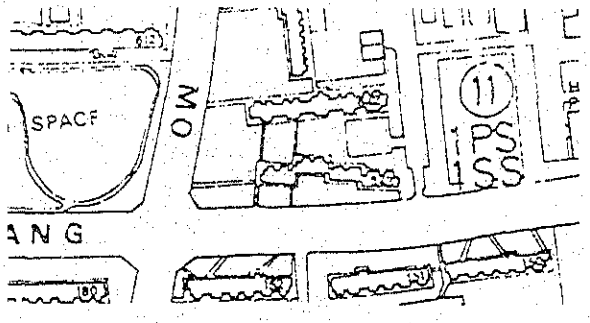
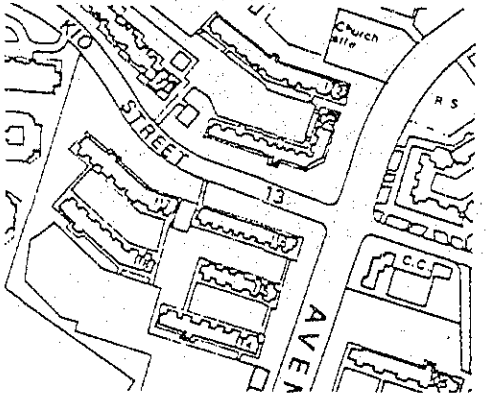
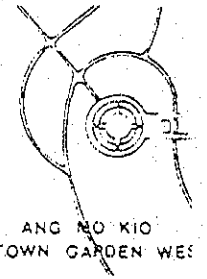


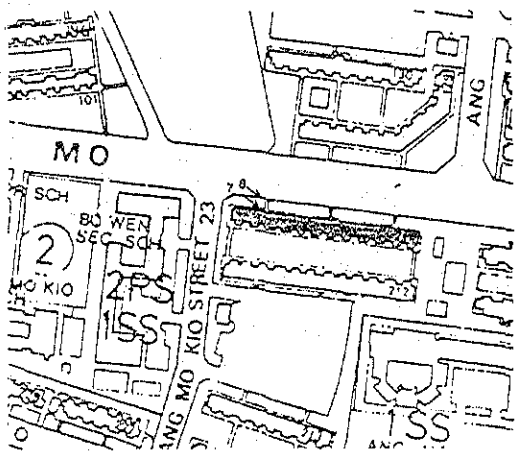
Photo 5

Photo 6









Bldg. No. 211

Photos 7 & 8

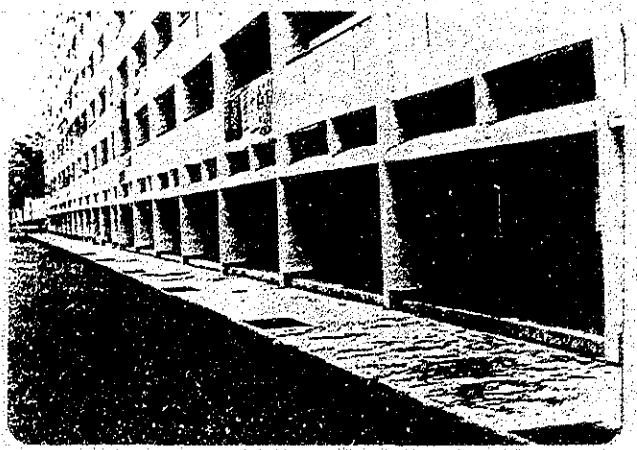
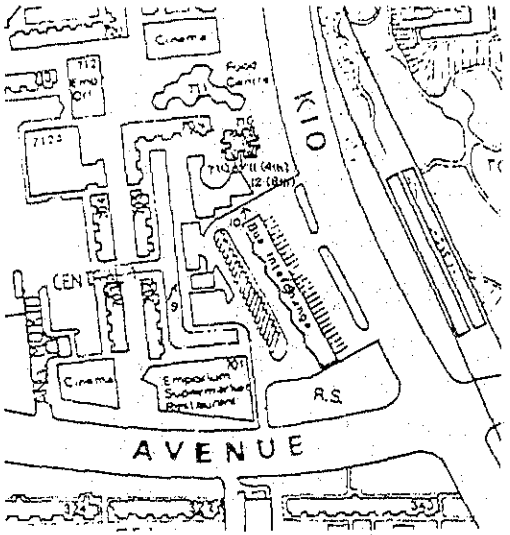


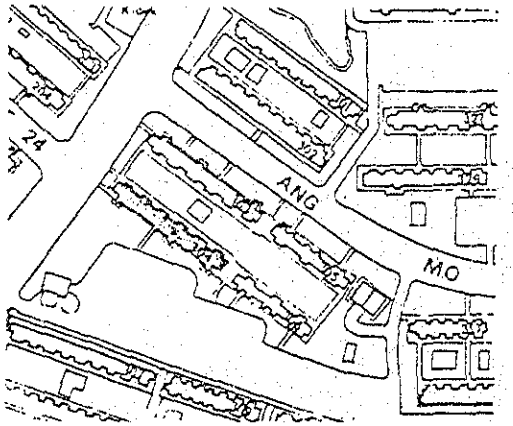
Photo 7

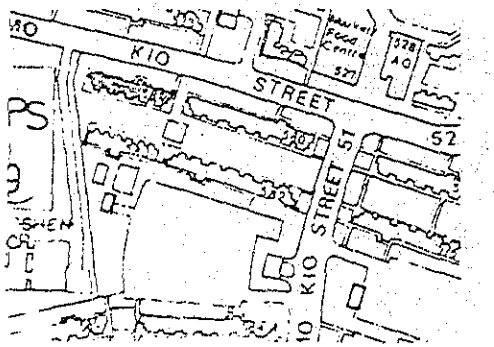
Photo 8



Bldg. No. 710

Photos 9~12





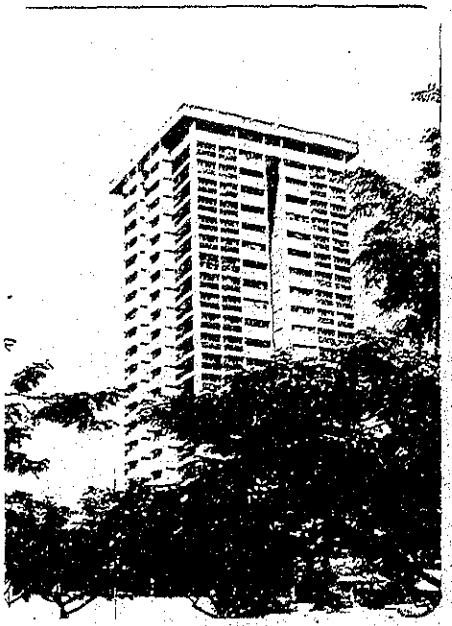


Photo 9

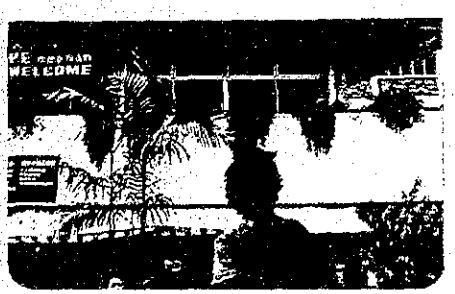


Photo 10

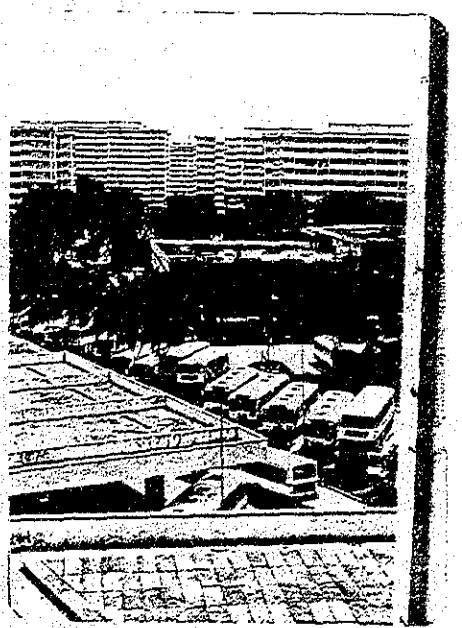
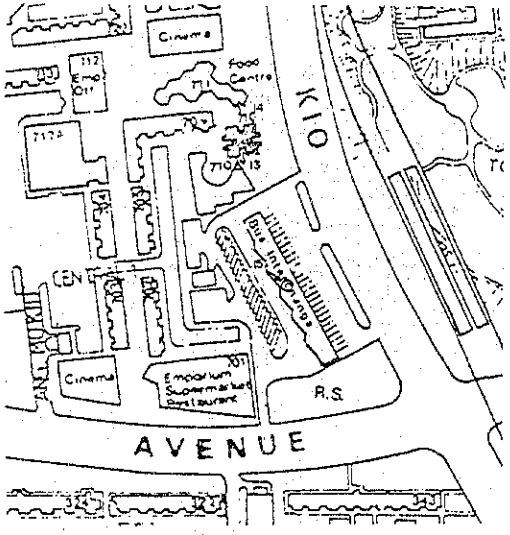


Photo 11 From 4th floor

Photo 12 From 8th floor

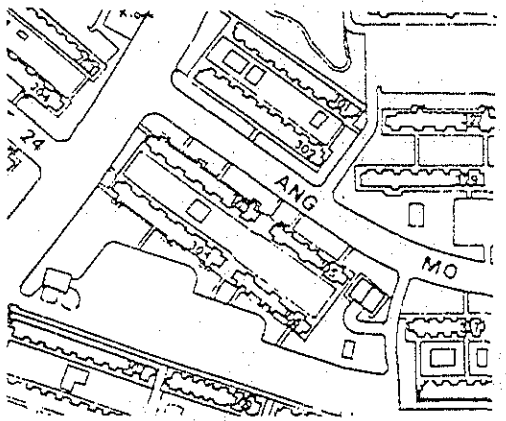


Bldg. No. 710

Photos 13 & 14

Bus interchange

Photo 15



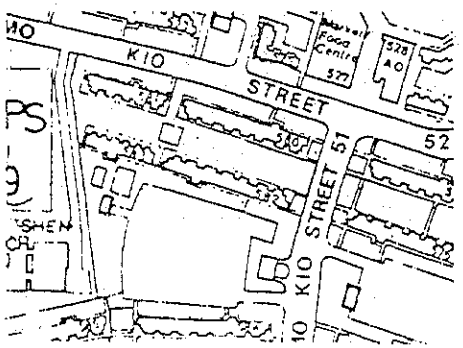


Photo 13 From 25th floor

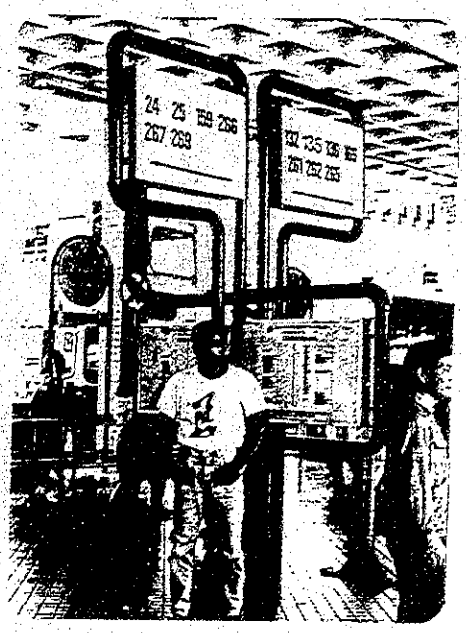


Photo 15

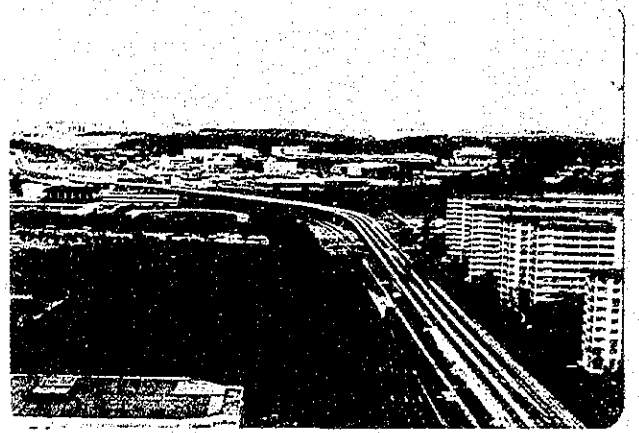
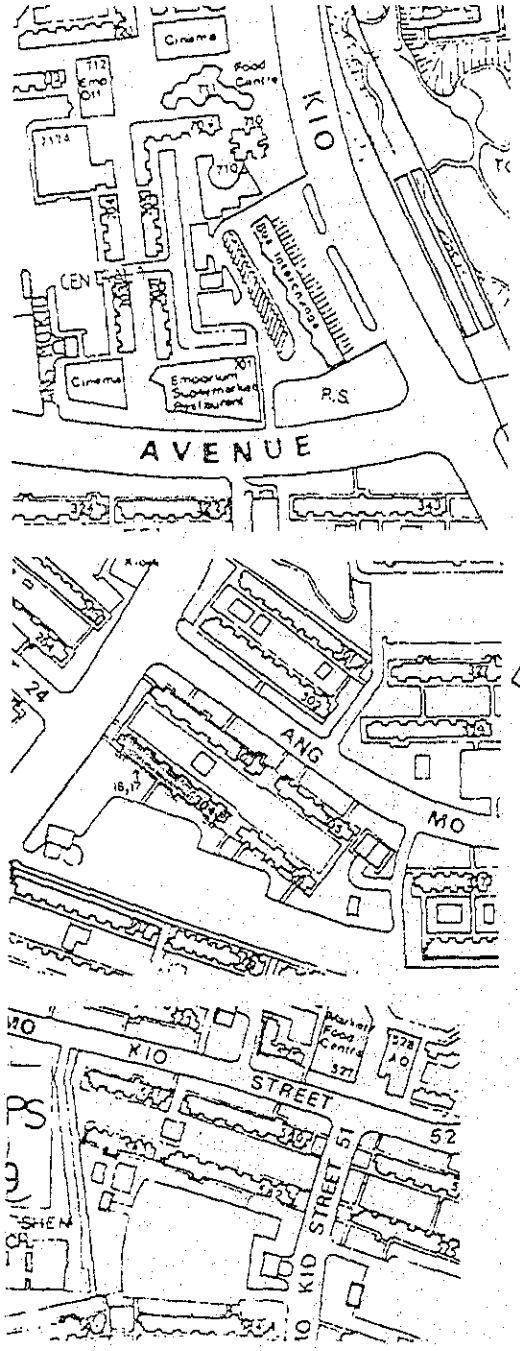


Photo 14 From 25th floor



Bldg. No. 304

Photos 16 & 17

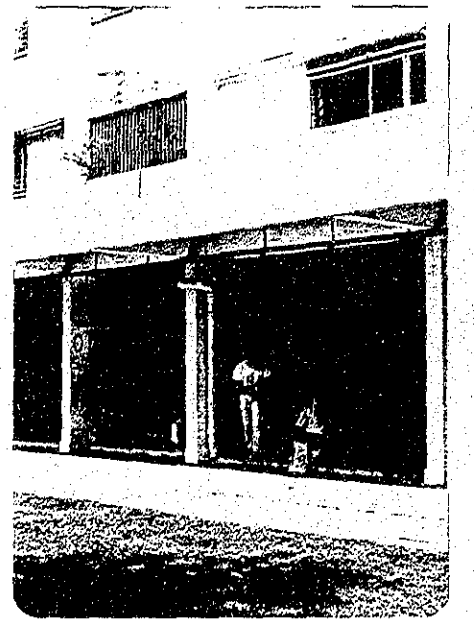
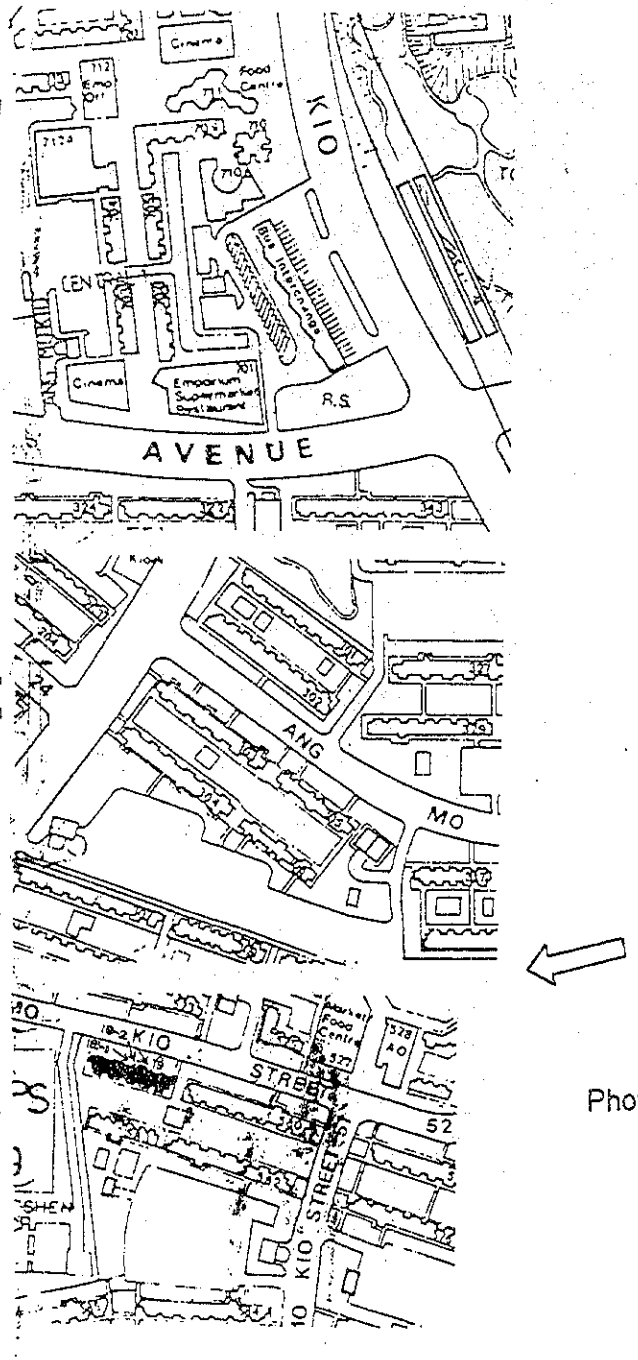


Photo 16

Photo 17



Bldg. No. 581

Photos 18-1 – 19

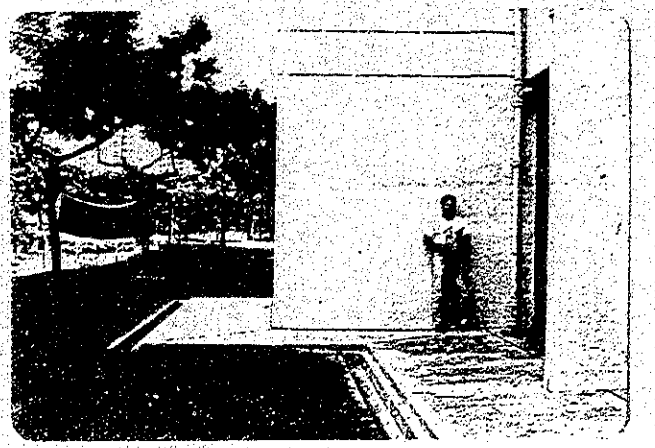


Photo 18-1

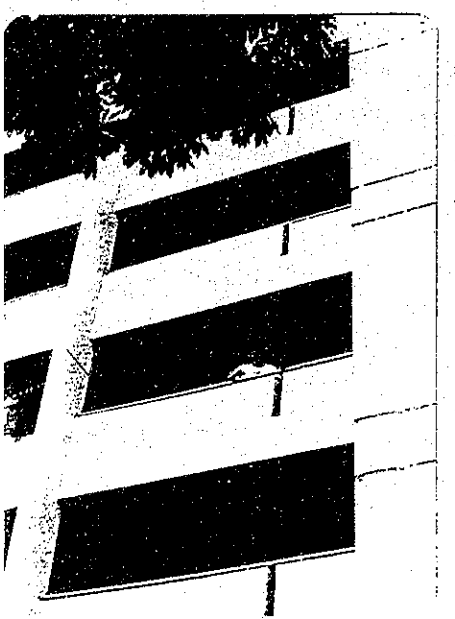
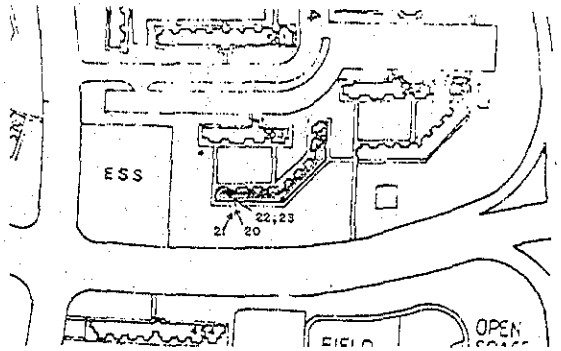
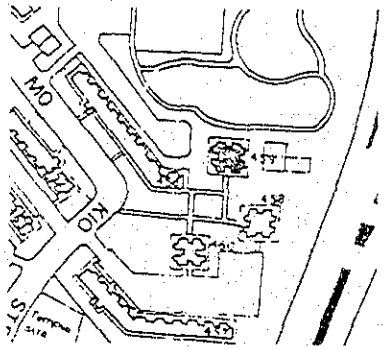
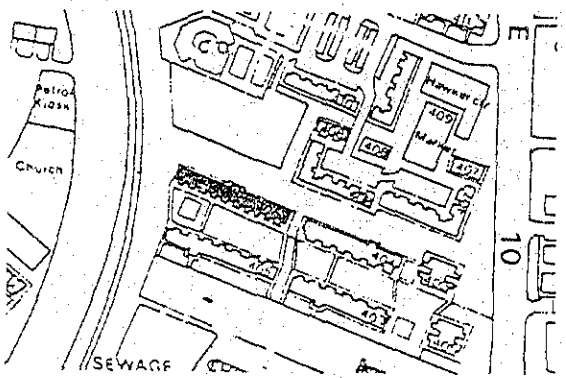


Photo 19

Photo 18-2







Bldg. No. 565

Photos 20 - 23

Photo 20

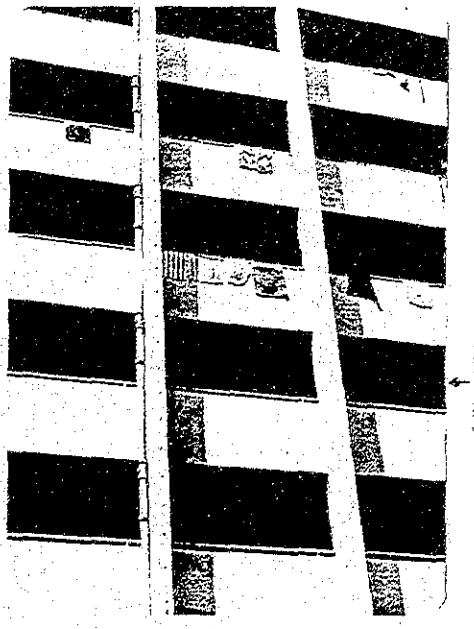
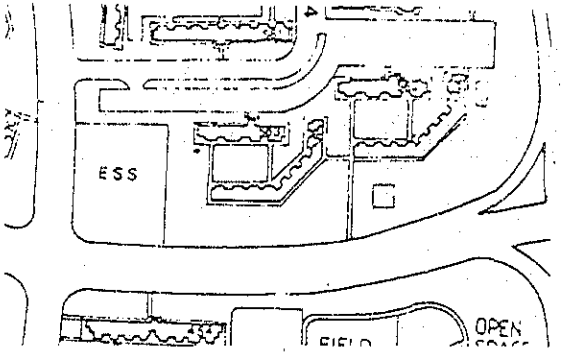
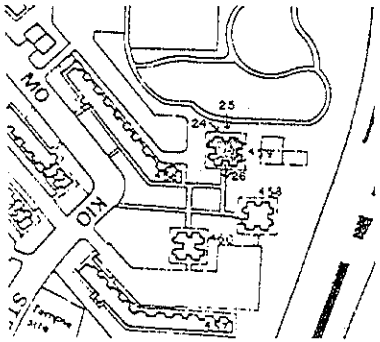


Photo 21

Photo 22 4th floor

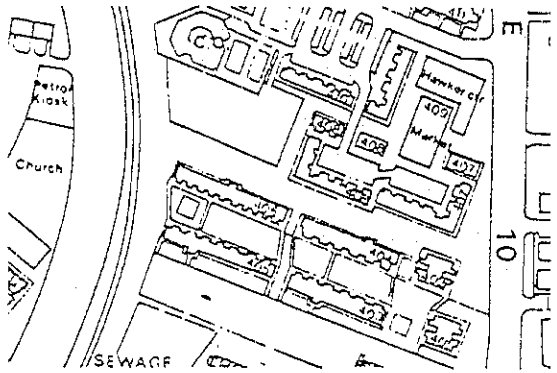
Photo 23 8th floor





Bldg. No. 459

Photos 24 – 26



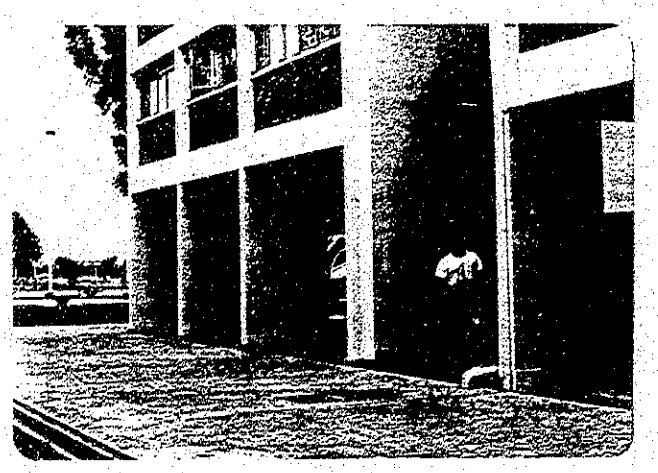


Photo 24

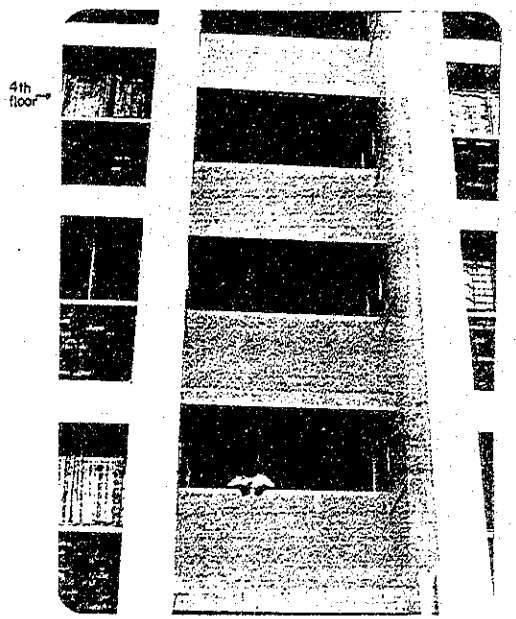


Photo 25

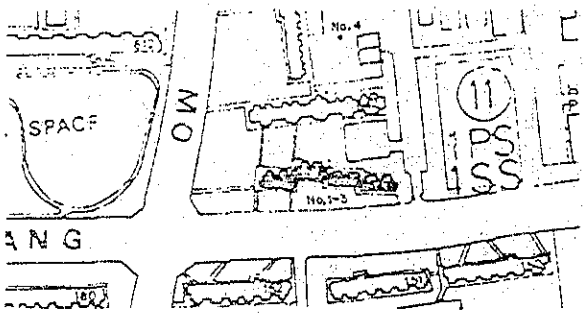
Photo 26 From 25th floor

Appendix C

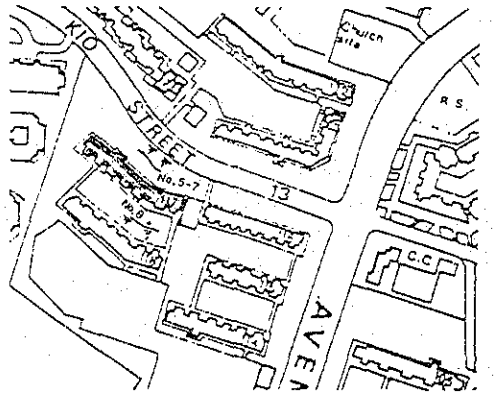
Location Map of Noise Survey In Ang Mo Kio New Town

App. C Location Map of Noise Survey (S=1:4,000)

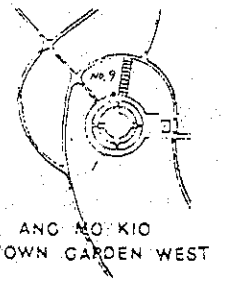
Spots No. 1-3 (Bldg. No. 643) (GF, 4F, 8F), No. 4 (Above ground H=1.0m)



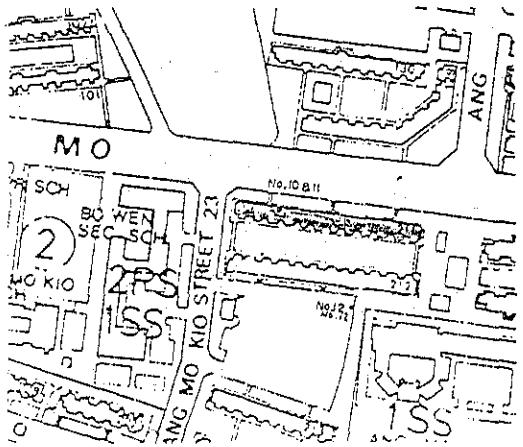
Spots No. 5-7 (Bldg. No. 117) (4F, 8F, 12F), No. 8 (H=1.0m)

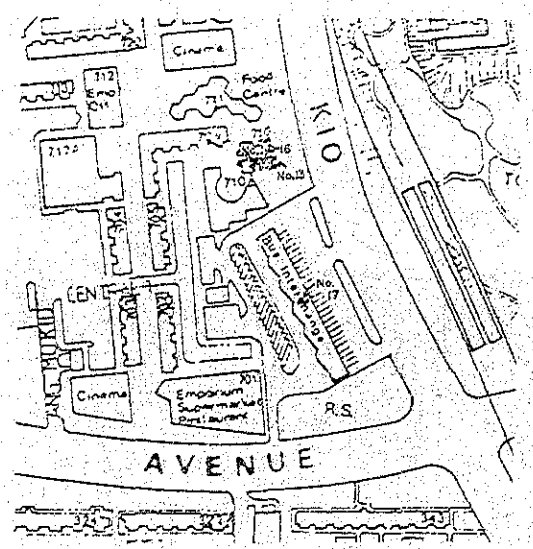


Spot No. 9 (H=1.0m)



Spots No. 10 & 11 (GF, 4F), No. 12 (H=1.0m)

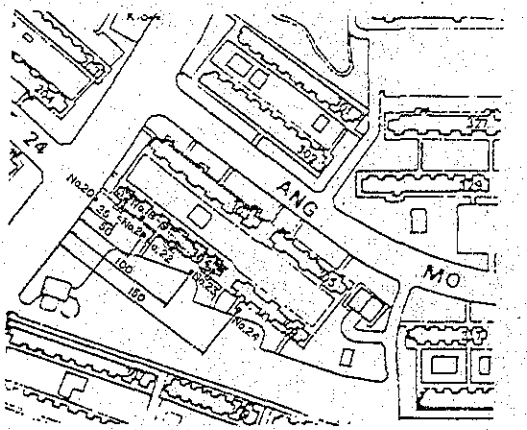




Spots No. 13-17

No. 13-16 (Bldg. No. 710) (GF, 4F, 8F, 25F)

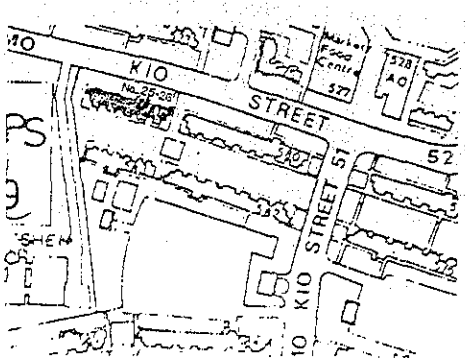
No. 17 (Bus interchange) (H=1.0)



Spots No. 18-24

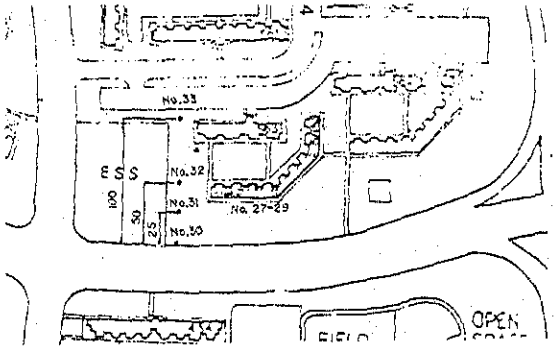
No. 18 & 19 (Bldg. No. 304) (GF, 4F)

No. 20-24 (H=1.0m)



Spots No. 25 & 26

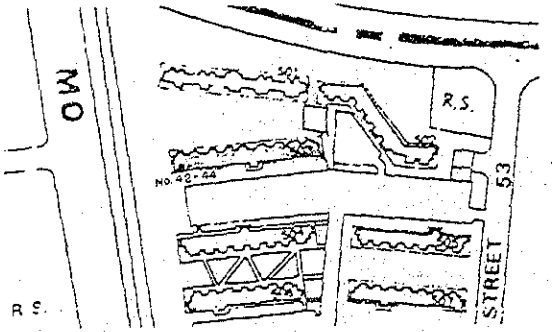
No. 25 & 26 (Bldg. No. 581) (GF, 4F)



Spots No. 27 - 33

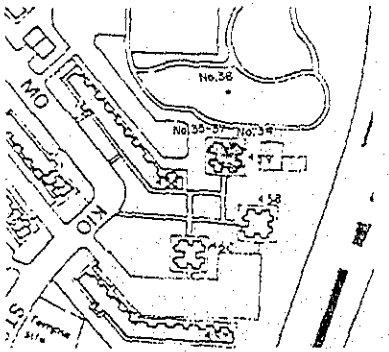
No. 27-29 (Bldg. No. 565)
(GF, 4F, 8F)

No. 30-33 (H=1.0m)



Spots No. 42 - 44

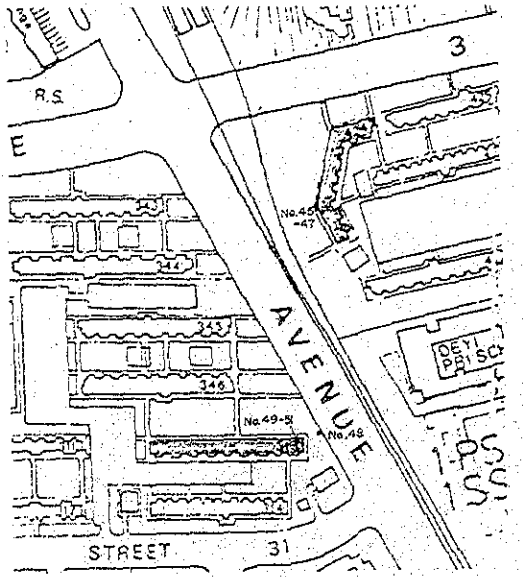
No. 42-44 (Bldg. No. 503)
(2F, 5F, 8F)



Spots No. 34 - 38

No. 34 - 37 (Bldg. No. 469)
(GF, 4F, 8F, 25)

No. 38 (H=1.0m)



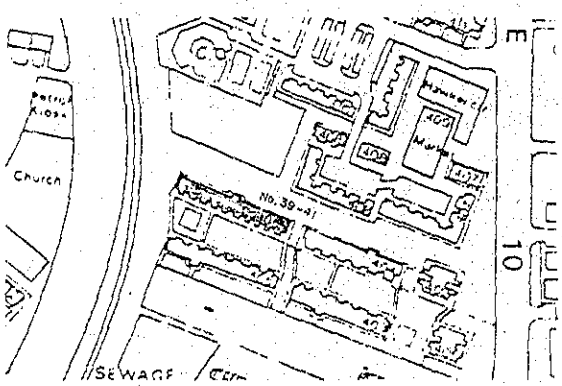
Spots No. 45 - 47

No. 45-47 (Bldg. No. 424)
(2F, 5F, 9F)

Spots No. 48 - 51

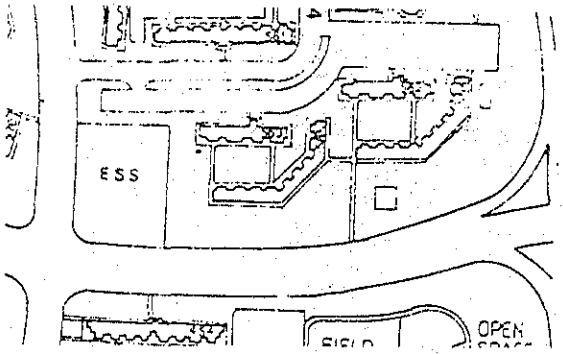
No. 48 (H=1.0m)

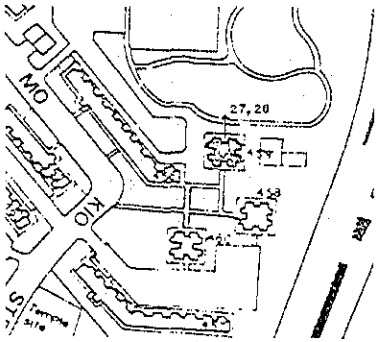
No. 49 - 51 (Bldg. No. 313)
(2F, 5F, 9F)



Spots No. 39 - 41

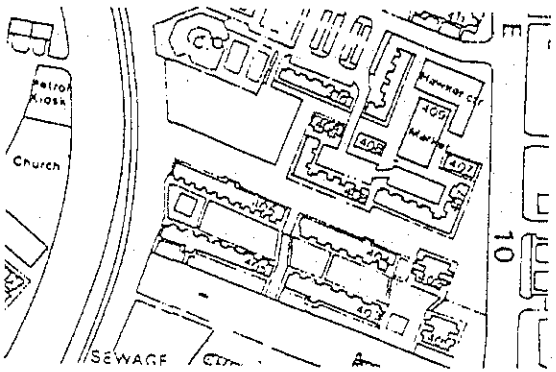
No. 39 - 41 (Bldg. No. 406)
(GF, 4F, 8F)





Bldg. No. 459

Photos 27 & 28



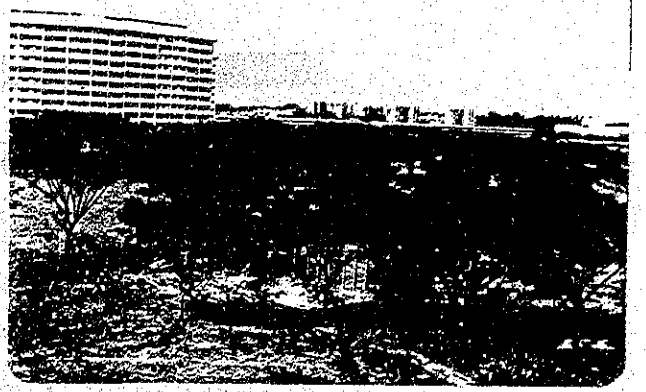


Photo 27 From 4th floor

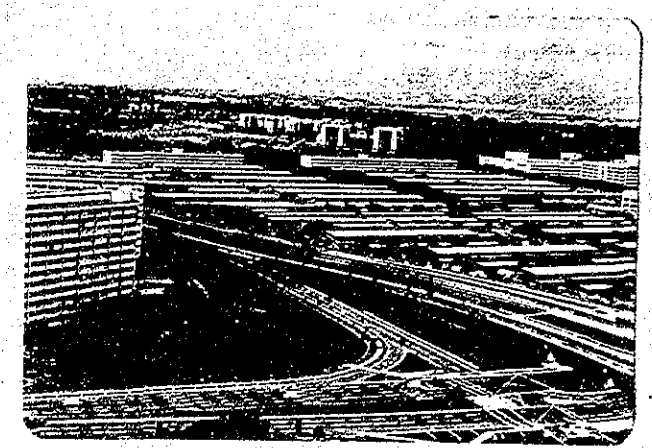
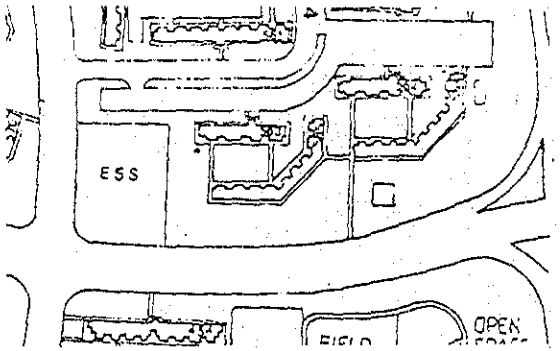
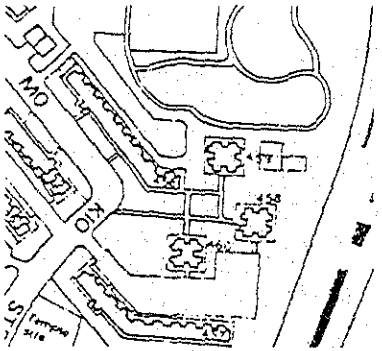
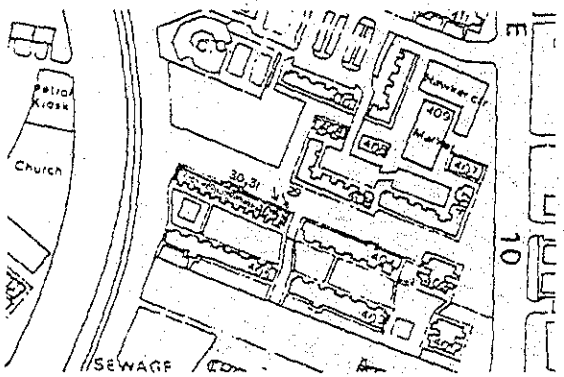


Photo 28 From 25th floor







Bldg. No. 406

Photos 29-31

Photo 29

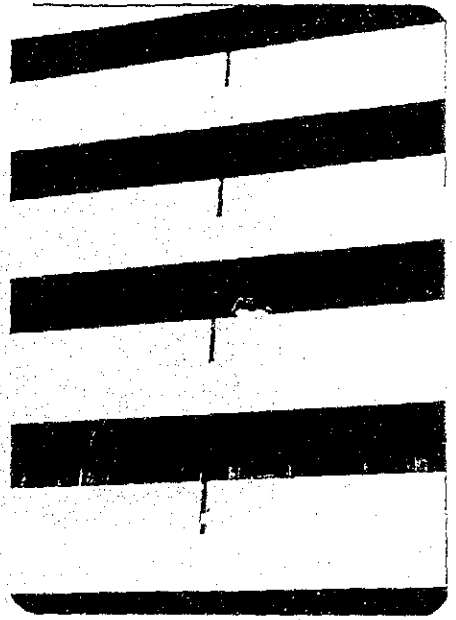


Photo 30 4th floor

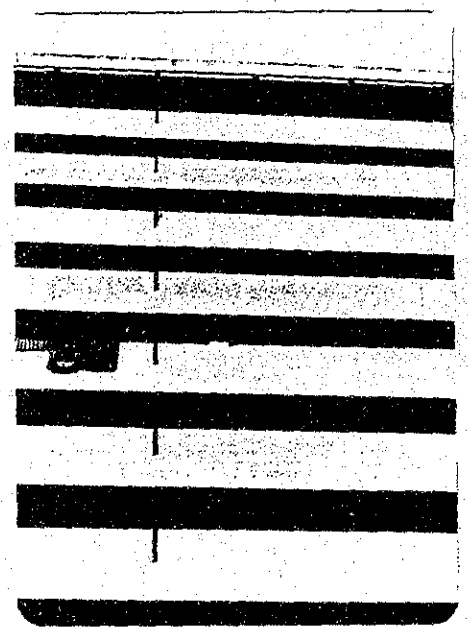


Photo 31

←8th floor