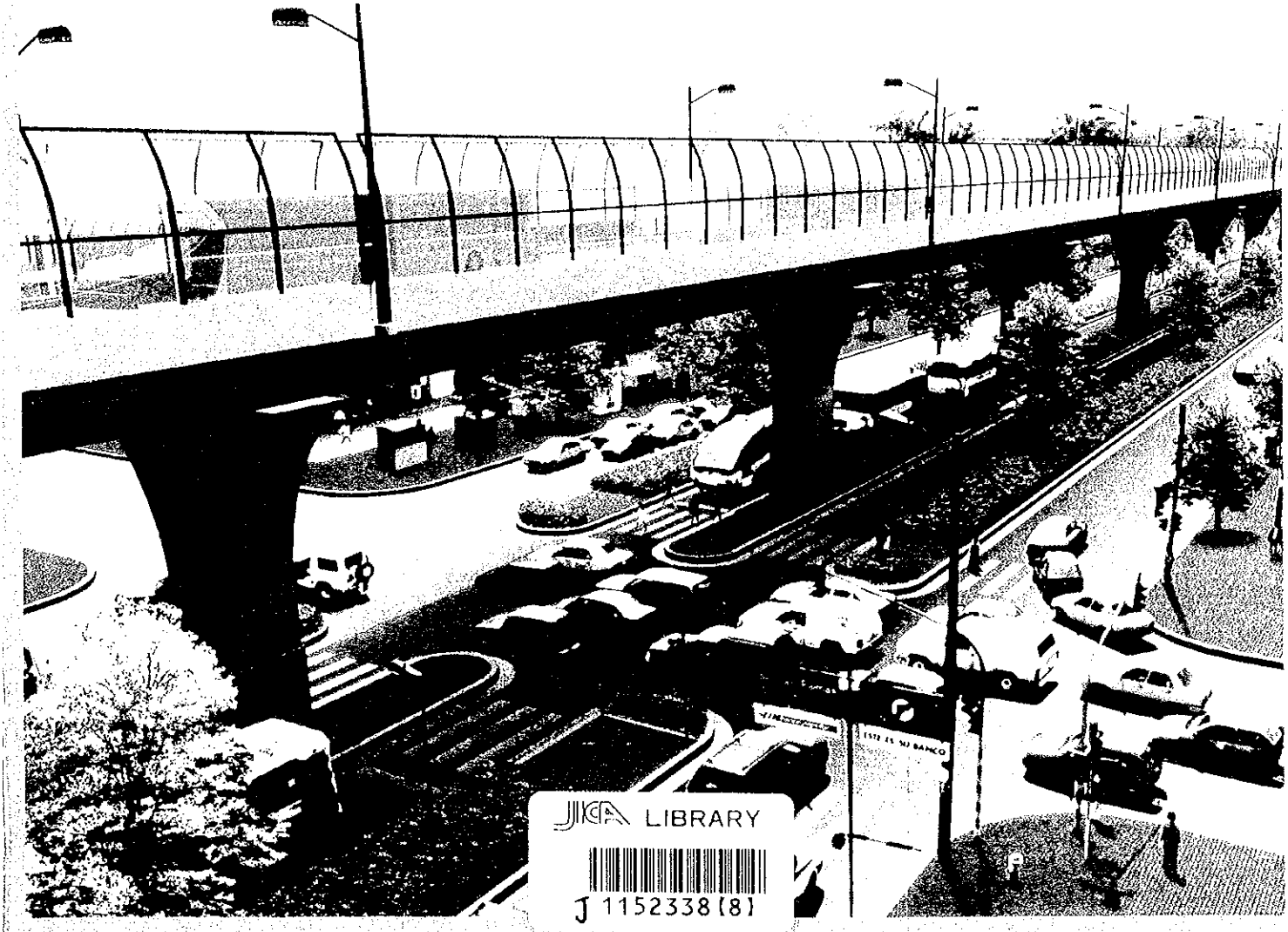
No. 51

Santa Fe de Bogota
The Republic of Colombia

The Feasibility Study on The Project of Highway and Bus-Lane of Santa Fe de Bogota in The Republic of Colombia

Final Report (Main Report) Volume-I



June 1999

Chodai Co., Ltd
in Association With
Yachiyo Engineering Co., Ltd

Japan International Cooperation Agency (JICA)
Santa Fe de Bogota
The Republic of Colombia

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Preface

In response to a request from the Government of the Republic of Colombia, the Government of Japan decided to conduct the Feasibility Study on the Project of Highway and Bus-Lane of Santa Fe de Bogota in the Republic of Colombia and entrusted the study to the Japan International Cooperation Agency (JICA).

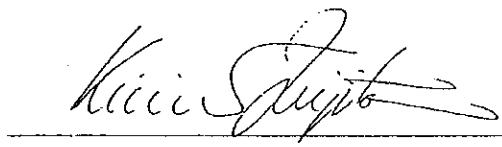
JICA selected and dispatched a study team headed by Mr. Koichi Tsuzuki of Chodai Co., Ltd., to Colombia, three times between April 1998 and March 1999. In addition, JICA set up an advisory committee headed by Koichi Yamagata, Professor of Ibaraki University between April 1998 and March 1999, which examined the study from specialist and technical points of view.

The Team held discussions with the officials concerned of the Government of Colombia, and conducted a field survey at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Colombia for their close cooperation extended to the team.

June 1999



Kimio Fujita

President
Japan International Cooperation Agency

Letter of Transmittal

June, 1999

Mr. Kimio Fujita
President
Japan International Cooperation Agency

Dear Sir.

It is a great honor for me to submit herewith the final reports of the Feasibility Study on the Project of Highway and Bus-Lane of Santa Fe de Bogota in the Republic of Colombia.

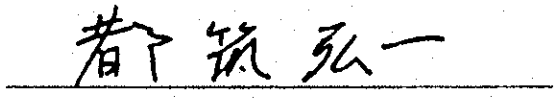
A study team, which consists of Chodai Co., LTD. and Yachiyo Engineering Co., LTD. and headed by myself, conducted field surveys, data analysis and planning works of feasibility study in Bogota based on the terms of references instructed by the Japan International Cooperation Agency (JICA) from April, 1998 to March, 1999.

The study team held thorough discussions and investigations with officials concerned of the Government of Colombia, accordingly, various traffic surveys, present condition analysis, preliminary engineering design, conduct of environmental impact assessment, preparation of implementation program and project evaluation. The results were collected in the final reports, main and summary reports.

On behalf of the team I wish to express my heartfelt appreciation to the Officials concerned of the Government of Colombia for their warm friendship and cooperation extended to us during our stay in Colombia.

Also, I wish to express my sincere appreciation to JICA, the Ministry of Foreign Affairs, the Ministry of Construction, the Ministry of Transport, the Embassy of Japan in Colombia and other concerned government authorities for their valuable advice and cooperation given to us in the course of the site surveys and preparation of the final reports.

Yours Faithfully,



Koichi Tsuzuki

Team Leader

The Feasibility Study on the Project of Highway and Bus-Lane of Santa Fe de Bogota in the Republic of Colombia

The Feasibility Study on The Project of Highway and Bus-Lane of Santa Fe de Bogota in the Republic of Colombia

Study Duration: April 1998 – March 1999
Requesting Organization: Santa Fe de Bogota

Outline of the Study

1. STUDY BACKGROUND

Santa Fe de Bogota, the capital city of Colombia, is recently experiencing urban transport problems caused by insufficient transport facilities against to the rapid growth of population and car ownership. Accordingly, heavy traffic congestion is prevailing in many places of the city and has been disturbing sound and functional activity, efficiency and fair environmental condition of the capital city. Bus transport is the only mass public transport in Bogota. The current public bus transport system has many problems and issues. Every bus route concentrates into the central area in Bogota from the residential areas near fringe of Bogota. It causes traffic congestion in the central urban area. Weak administration tolerates illegal bus route operations and security problems on board.

Recognizing the importance of the improvement of traffic and transport system in the city, the Government of Colombia requested the Government of Japan to conduct a Feasibility Study following the Master Plan (The Urban Transport Master Plan Study in Santa Fe de Bogota) carried out under the technical cooperation of the Government of Japan from 1995 to 1996.

In response to the request made by the Government of Colombia, the Government of Japan conducted the Feasibility Study on the Project of " Highway and Bus-lane of Santa Fe de Bogota" in the Republic of Colombia (hereinafter referred to as " the Study"). The Study was carried out in 1998 and 1999.

2. STUDY OBJECTIVES

The objectives of the Study are as follows;

1) to formulate a Feasibility Study for Inner Ring Expressway (IRE) as an urban expressway project recommended as high priority project in the Master Plan,
2) to formulate a Feasibility Study for Trunk and Express Busway Projects recommended as high priority projects in the Master Plan and
3) to transfer relevant technology and know how to the Colombian counterpart personnel in the course of the Study.

The year 2005 is defined as the target year for the Feasibility Study.

3. STUDY AREA

The Study Area for the Feasibility Study covers the city of Santa Fe de Bogota. The planning route for Inner Ring Expressway is inside the central urban area, while the Study trunk busways are on six (6) existing major roads.

4. STUDY DURATION

The Study was commenced in April, 1998 and completed in March, 1999.

5. OUTLINE OF THE STUDY

Major activities of the Study are as follows:

1) Data collection and its analysis
2) Natural conditions and road inventory survey such as topographic, environment and soil investigation surveys
3) Identification of planning policies and strategies
4) Future traffic and transport demand forecast
5) Preliminary engineering design of Inner Ring Expressway
6) Preliminary engineering design of Six (6) Trunk Busways
7) Conduct of environmental impact assessment
8) Preparation of implementation program
9) Economic and financial evaluation
10) Project evaluation

6. RECOMMENDATION

6.1. INNER RING EXPRESSWAY PROJECT

The outline of proposed plan for Inner Ring Expressway is shown in Table 1. This plan is feasible from the technical, environmental and economical points of view.

Table 1 Proposed Plan for Inner Ring Expressway

Items	Plan	Remarks
Class	Motorway and Toll Road	
Design Speed	60 -80 km/h	
Design Traffic Volume in 2015	35,000 - 45,000 pcu/hour/d	
Number of Lanes /dualway	4 lanes / dualway	
Road Type	Elevated road	
Bridge Type	PC Concert Bridge	
Road Length	16.6 km	
Project Cost	US$ 638.587 thousands	
Economic Internal Rate of Return (EIRR)	14.70%	
Financial Internal Rate of Return (FIRR)	5.60%	

6.2. TRUNK BUSWAY PROJECT

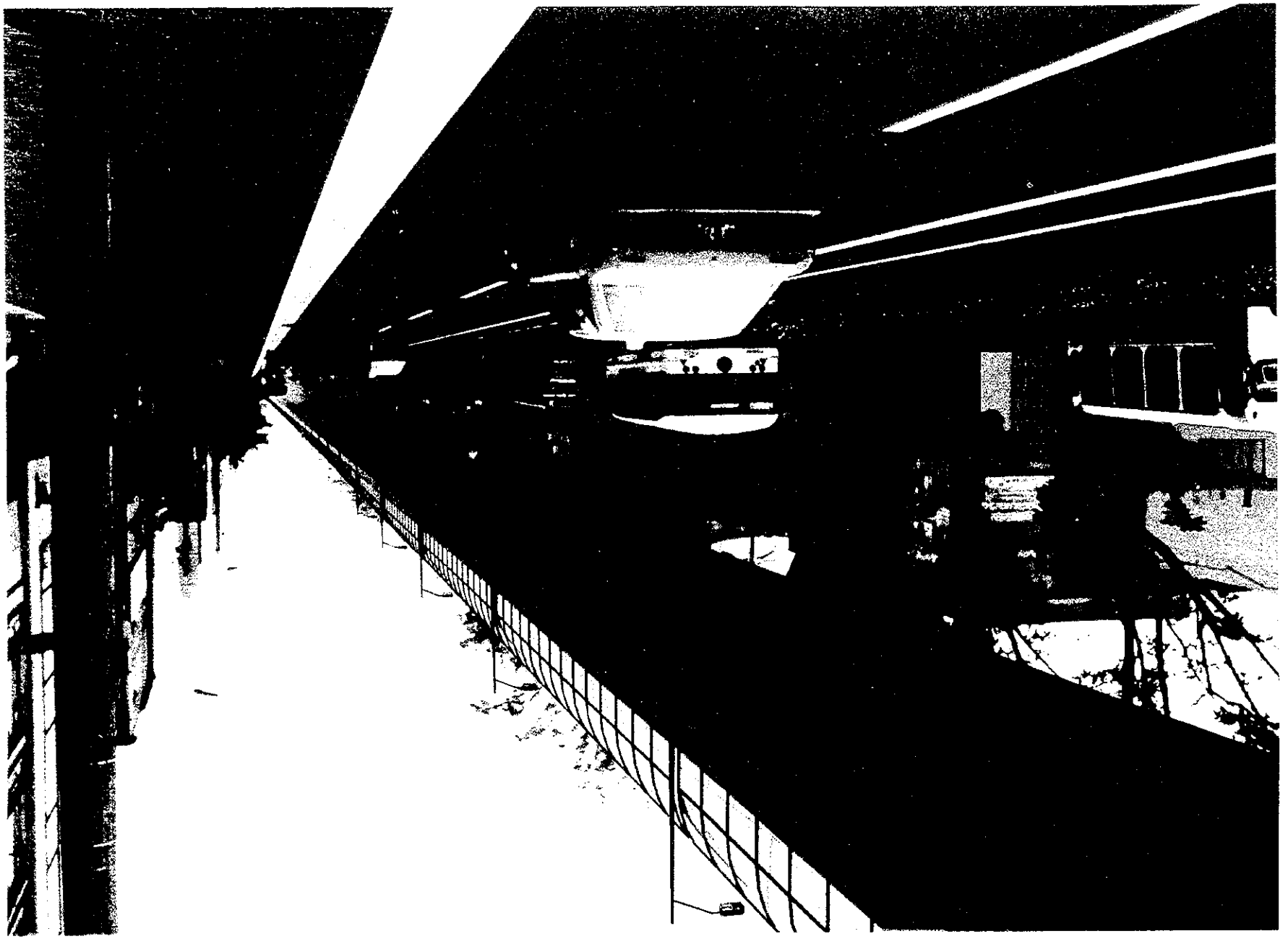
Three types of operation system namely, operation on an express busway, a trunk busway and a bus priority lane are proposed in the trunk busway system. The busways are planed on existing eight (8) major roads. Those busway projects are also feasible from the technical, environmental and economic points of view. Table 2 shows bus passenger demand, operation system, construction cost by busway in the year 2005.

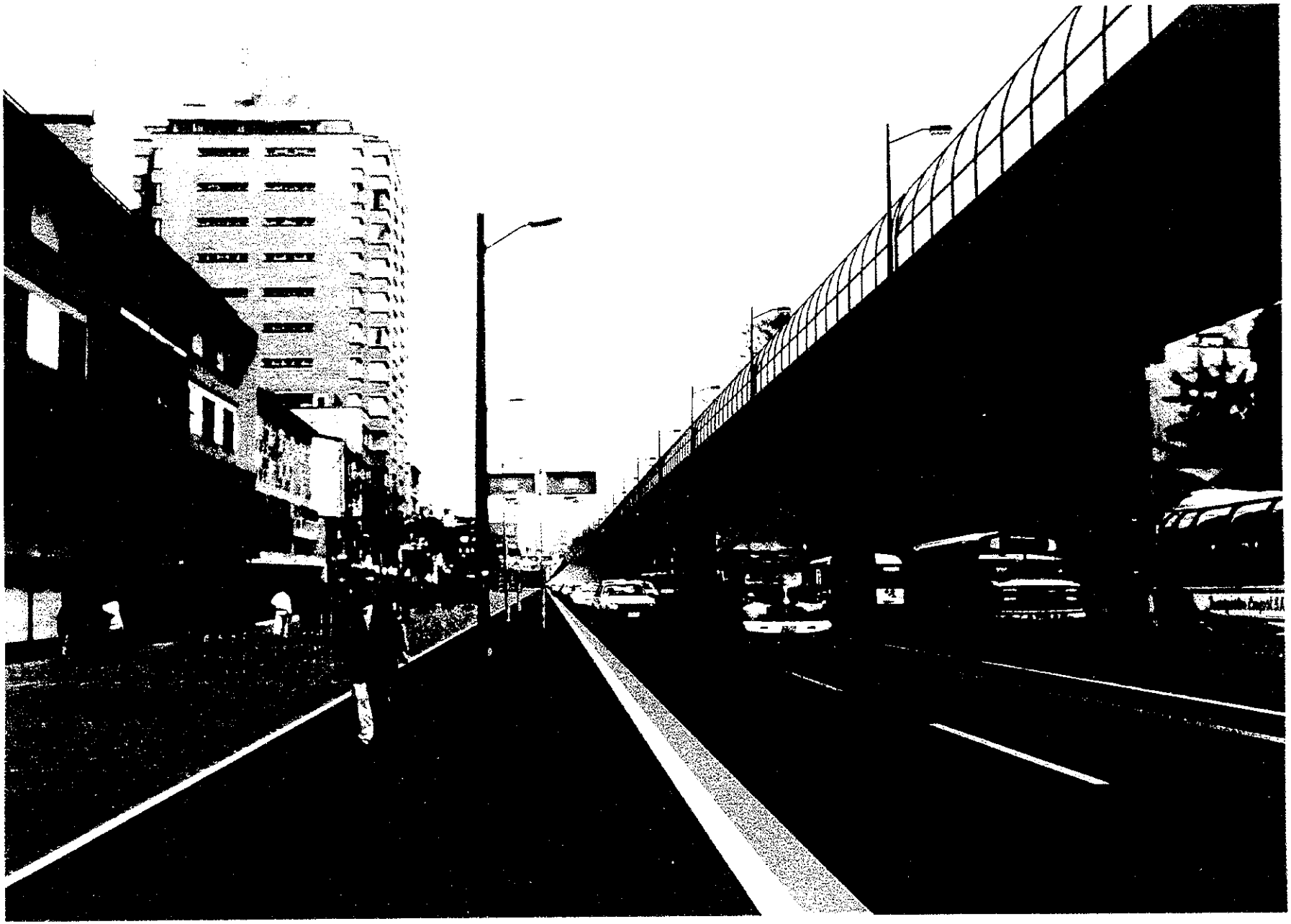
Table 2 Proposed Plan for Trunk busway System

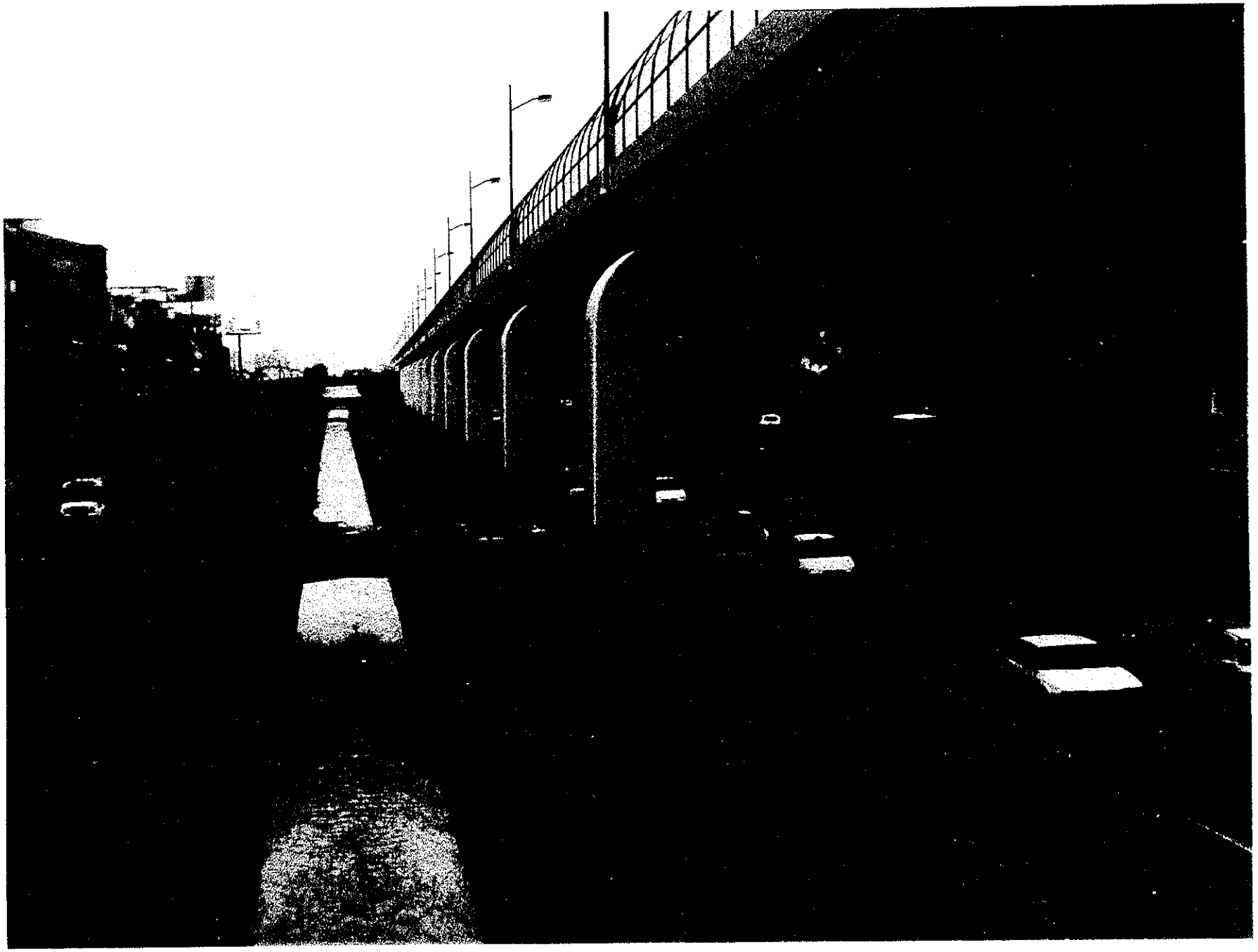
Road Name/Items	Cra. 7a	Av. Quito	Autopista Sur	Av. Caracas	Autopista Norte	Av. Suba	Cra. 68	Calle 170
Width of Existing Road (m)	40	60	60	40	100	30	40	40
Passenger Demand (thousands/hour)	21	23	29	34	23	20	17	12
Operation System	Priority Lan	Trunk Busway	Express Busway Trunk Busway	Express Busway Trunk Busway	Express Busway Trunk Busway	Priority Lane	Trunk Busway	Trunk Busway
Capacity of Proposed Bus fleet (passengers)	100	100	200 100	200 100	200 100	100	100	100
Number of Bus Lanes /dualway	2	2	2 lanes for Exp 2 for Trunk	2 lanes for Exp 2 for Trunk	2 lanes for Exp 2 for Trunk	2	2	2
Structure Type of Busway	At-grade	At-grade	At-grade	Viaduct Structur At-grade	At-grade	At-grade	At-grade	At-grade
Type of Intersection	At-grade	At-grade	Grade-separate At-grade	Grade-separate At-grade	At-grade	At-grade	At-grade	At-grade
Road Length (km)	25	16	11	17	17	15	17	5
Project Cost (million US$)	19	28	144	337	54	9	8	3

6.3. ENVIRONMENT ASSESSMENT

Damages or effects on social and natural environment caused by construction of the projects are not significant because the existing road area will be utilized for Inner Ring Expressway project and trunk busway projects. In order to decrease the noise impact caused by proposed viaduct structure of express busway and Inner Ring Expressway, noise barriers are provided on those structures. Air pollution in the Study area is lower for the "With" project case than "Without", due to the improvement of traffic flows. Therefore, the Study projects contribute the improvement of environment in the Study area.







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List of Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
B/C	Benefit/Cost
BMA	Bogota Metropolitan Area
Bogota	Santa Fe de Bogota
CBD	Central Business District
CAR	Corporación Autónoma Regional
C/D	Capacity/Demand
DAMA	Departamento Técnico Administrativo del Medio Ambiente
DANE	Departamento Administrativo Nacional de Estadística
DAPD	Departamento Administrativo de Palneación Distrial
DNP	Departamento Nacional de Planeación
FEDESARROLLO	Fundación para la Educación Superior y el Desarrollo
EIRR	Economical Internal Rate of Return
FIRR	Financial Internal Rate of Return
GDP	Gross Domestic Product
GRDP	Gross Reginal Domestic Product
HRT	Heavy Rail Transit
IBRD	International Bank for Reconstruction and Development
IDU	Instituto de Desarrollo Urbano
JICA	Japan International Cooperation Agency
LRT	Light Rail Transit
OD	Origin-Destination
PCU	Passenger Car Unit
PT	Person Trip
ROW	Right of Way
SOP	Secretaría de Obras Públicas del Distrito
STT	Secretaría de Trasporte y Transito
TDM	Transport Demand Management
TTC	Travel Time Cost
UTP	Unidad de Transporte Publico
V/C	Vehicle/Capacity
VOC	Vehicle Operating Cost
NPV	Net Present Value
$	Colombian Peso
US$	US Dollar

CONCLUSION AND RECOMMENDATIONS

CONCLUSIONS AND RECOMMENDATIONS

(1) Necessity for Implementing of the Projects Recommended by Feasibility Study

The Master Plan was conducted by JICA over a period of two years from 1995 to 1996, and the various projects were recommended to improve the traffic congestion and maintain sound activities in Bogota. Following the Master Plan, the Feasibility Study for trunk busway and inner ring expressway projects, which were recommended by the Master Plan as the high priority projects as well as the urgent implementation projects, were conducted. As the implementation of projects recommended under the Study will contribute to the followings, it is necessary to implement these projects as soon as possible:

1) to mitigate and to reduce traffic congestion as well as traffic accidents;
2) to contribute in setting up to maintain a modernized bus transport system, to ensure safety of bus operation system and to increase the use buses by shifting from private car use;
3) to contribute to the social and natural environment by reducing air pollution; and
4) to increase economic and social activities.

(2) Trunk Busway System and Type of Bus Vehicles

As a result of the various trunk busway system studies, the existing road facility conditions, and public or private transport demand in the future, three types of bus systems and the passenger capacity of bus fleets are recommended as shown in Table 1. The types of recommended bus fleets were 100 passenger capacity (single-body bus) operated on trunk busways and priority lanes, and 200 passenger capacity (articulated bus) on express busways. The articulated bus for express busways should be introduced, however, with regard to the trunk bus, it is possible to use a number of the existing large sized buses remodeled to 100 passenger capacity in bus interior on the trunk busways and priority bus lanes, in consideration of the scheduled phase out of old fleet under the laws in Bogota.

Table 1 Recommended Trunk Busway Type and Bus Vehicles

Type of System	Relation of Private traffic	Type of Busway	Location of Busway on Existing Road	Capacity of Bus Vehicle	Operation Speed to be Ensured	Distance of Bus Stop
1) Express Busway System	Fully Segregated	Elevated At-grade	Center-lane	200 passengers	30 km/h	1,000 ~ 1,500 m
2) Trunk Busway System	Partially Segregated	At-grade	Center or Side –lane	100 Passengers	20~25 km/h	500 ~ 600 m
3) Bus Priority Lane System	Non Segregated	At-grade	Side-lane	100 Passengers	20~25 km/h	500 ~600 m

(3) The Projects and Operation System of Trunk Busway

The total of eleven (11) trunk busways and bus terminal projects were examined in the Feasibility Study, and preliminary design was conducted for eight (8) trunk busways and the urban and sub-urban bus terminal projects. As a result of the various studies, the bus operation system of each busway, scale of busways, and the project cost of each busway are recommended as shown in Table 2.

Table 2 Recommended Operation System of Each Busway

Name of Project	Scale of Project	Operation System Introduced	Project Cost (Mill. US $)	Remarks
Trunk Busway Project				
1) Carrera 7a and Carrera 10 Project	L=25.15 km	Bus priority lane	19,409	1 de major
2) Av.enida Quito Project	L=16.33 km	Trunk busway system	28,902	
3) Autopista Sur Project	L=11.10 km	Express busway system Trunk busway system	109,987 34,851	Bridges At-grade
4) Avenida Caracas Project	L=17.58 km (14.5 km)	Express busway system Trunk busway system	337,960 33,794	Viaduct At-grade
5) Autopista Norte Project	L=17.24 km	Express busway system Trunk busway system	54,133	
6) Avenida Suba Project	L=15.29 km	Bus priority lane	8,846	Calle 127
7) Avenida 68 and Calle 100 Project	L=17.53 km	Trunk busway system Bus priority lane	8,404	
8) Calle 170 Project	L=5.12 km	Bus priority lane	3.050	
Bus Terminal Project				
1) Urban Bus Terminal	1 Vol.		59,751	
2) Sub-urban Bus Terminal Project	7 Vol.		18,715	
Total	125.32 km		717,802	

(4) Viaduct on Avenida Caracas Needed for Express Busway

In the estimation of bus passenger demands in the year 2005, about 30,000 to 35,000 passengers in the morning peak hour per direction on Avenida Caracas are forecasted. It is very difficult to control or to maintain these large numbers of passengers without maintaining traffic safety, and ensure the smooth traffic flows on at-grade road structure. In consideration of the future bus passenger demand as well as to improve traffic congestion, maintain good sound city activity, and mitigate pollution, the viaduct type of structure is recommended for express busway system. The proposed total viaduct length is about 14.5 km and its project cost is estimated at about US $ 338 million.

It is obvious that the bus passenger demand on Avenida Caracas will reach the capacity of bus transport system soon. In the future, the introduction of some kind of mass transit railway system on Avenida Caracas will be required. Considering the future bus passenger demand as well as the maximum transport capacity of general bus transport system, the structure of viaduct for express busway should ensure the need to maintain the dimensions or cross section elements of railway system proposed in the next further study.

(5) Inner Ring Expressway (IRE) Project

As a result of the feasibility study including other various studies, the route of IRE is selected in the center of existing roads and its structure is a viaduct type. The IRE project is economically and technically feasible. The difference of noise impact between "With" project and "Without" project is not remarkable along the road sides. About 720 trees, however, have to be re-planted by the project. These trees should be replanted at the locations of pedestrian walk outside of the medians on both sides of existing roads in order to mitigate the noise pollution. Noise protection walls should be designed on the viaduct at special residential areas and schools or hospitals. The recommended road systems or structures of IRE are summarized in Table 3.

Table 3 Recommended Inner Ring Expressway Structures

Items	Contents	Remarks
1) System of Road	Full access control Toll road system	
2) Design Speed	60 ~ 80 km/h	
3) Number of Lane	4-lane dual carriageway	W= 3.5 m
4) Type of Road	Viaduct on the whole section	H=11 ~ 14 m
5) Length of Road	15.0 km	
6) Number of Ramp	4 locations	2-lane ramp
7) Utilized Existing Roads	On car.7a from Calle 127, Calle 100, Av. Quito, Car.6 to Caracas.	Center of road is selected for IRE
8) Noise Protection Walls	Special residential areas, Hospitals, schools	H=3 m
9) Project Cost	US $ 638 million	

(6) Financial Resources and Implementation Organization

The total investments for implementation of the busways and the inner ring expressway projects are estimated at US $ 1,356 million, and the investments from 2000 to 2005 by each year are also estimated at about US $ 130 million to 282 million. Comparatively, these investments apparently exceed the former budget in Bogota Municipality. For an early implementation stage of the projects, certain financial resources should be identified as soon as possible, to create a good sound city activity in Bogota.

On the other hand, the organizations of Bogota Municipality are gradually improving at present. In Bogota, the organization to coordinate the various official agencies related to transport sectors, as well as to continue the implementation plans or projects, however, is weak. For urgent execution and continuation of the projects recommended in the Feasibility Study, a strong and active authority should be established as soon as possible.

(7) Further Studies

In order to proceed with the implementation of the projects recommended by the Study, some further works are required in the next stage.

The Detailed Design of the following projects should be conducted urgently.

1) Busways for the express bus and trunk bus systems on Avenida Caracas and Autopista del Norte.

2) Busways for the express bus and trunk bus systems on Autopista del Sur.

Since 1995, the seismic design method became applicable for bridge design in Colombia. However, the bridges constructed before 1995 did not apply seismic design. In order to ensure soundness and strength of the existing infrastructure in the city, review of the structure design as well as physical inspection of the existing bridges including pedestrian bridges and other infrastructures should be required so their strengthening against earthquakes and other disasters will be carried out.

CHAPTER 1
Introduction

1. INTRODUCTION

1.1. BACKGROUND OF THE STUDY

The population of Colombia in 1997 is estimated at about 35 millions, of which 5.5 millions live in the city of Bogota. The population of Bogota has been increasing day by day due to the comparatively high population growth and the increased influx from other cities. Relating with increase of population and extension of urbanized area, traffic congestion has been occurred at many places in Bogota. They prevent sound city activities, and good environmental conditions in Bogota.

In order to alleviate the traffic congestion in Bogota, the Government of Colombia requested assistance from the Government of Japan for the conduct of the Study on the Master Plan for Urban Transport of Santa Fe de Bogota, as a technical cooperation program of the Government of Japan. In response to the request of the Colombia, the Government of Japan dispatched the Study team and conducted the Master Plan during a period of 1995 to 1996.

For advancing the Master Plan, the Government of Colombia requested assistance from the Government of Japan to conduct the Feasibility Study recommended as a high priority project in the Master Plan under the technical cooperation programs of the Government of Japan.

In response to the request of the Government of Colombia, the Government of Japan agreed to conduct the Feasibility Study on the Project of " Highway and Bus-lane of Santa Fe de Bogota" in the Republic of Colombia (hereinafter referred to as "the Study") in accordance with the relevant laws and regulations in force in Japan.

Accordingly, the Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical cooperation programs of the government of Japan, undertook the Study in close cooperation with the authorities concerned of Colombia.

The Preparatory Study Team was dispatched in December 1997, and after discussions with officials of the Government of Colombia, the Scope of Work for the Study was agreed upon between both sides, and signed on December 16, 1997.

JICA organized the Study Team to conduct the Study. The Study Team worked in close cooperation with the Colombia counterpart team in accordance with the agreed upon Scope of Work.

1.2. STUDY OBJECTIVES

The objectives of the Study are as follows,

1) To formulate the Feasibility Study for Inner Ring Expressway in the Urban Expressway Project which is recommended as the high priority project of the Urban Transport Master Plan Study in Santa Fe de Bogota.

2) To formulate the Feasibility Study for Trunk and Express Busway Projects which are recommended as high priority projects of the Urban Transport Master Plan Study in Santa Fe de Bogota.

3) To transfer relevant technology to the Colombian counterpart personnel in the course of conducting the Feasibility Study.

1.3. TARGET YEAR FOR THE FEASIBILITY STUDY

The year 2005 is defined as the target year for the Feasibility Study.

1.4. STUDY PROJECTS

The Study projects covered under the Feasibility Study are as follows:

1) One (1) Inner Ring Expressway (see Figure 1.4-1)
2) Six (6) Trunk busways (see Figure 1.4-1)
   a) Carrera 7a and Carrera 10 (21.4 km)
   b) Avenida Cuidad de Quito and Autopista Sur (28.8 km)
   c) Calle 100 and Carrera 68 (15.9 km)
   d) Calle 170 (4.9 km)
   e) Avenida Suba (5.4 km)
   f) Avenida Caracas/ Autopista Norte (37.5 km)

1.5. SCOPE OF THE STUDY

The major activities in the Study are classified into the following four (4) stages. The major study items at each stage are described below and the schedule of the study items is shown in Figure 1.5-1: the Study Flow Chart.

(1) First Stage of the Study

The first stage of the study was carried out in Colombia from April to August 1998. The major study items are listed below,

1) Confirmation of the projects planned by the Bogota city.
2) Review and analysis of data and information.
3) Supplemental traffic survey.
4) Natural conditions and road inventory survey.
5) Future traffic and transport demand survey.
6) Identification of planning policies and strategies.
7) Preparation of basic conceptual plan
8) Identification of environment and landscape conservation aspects.

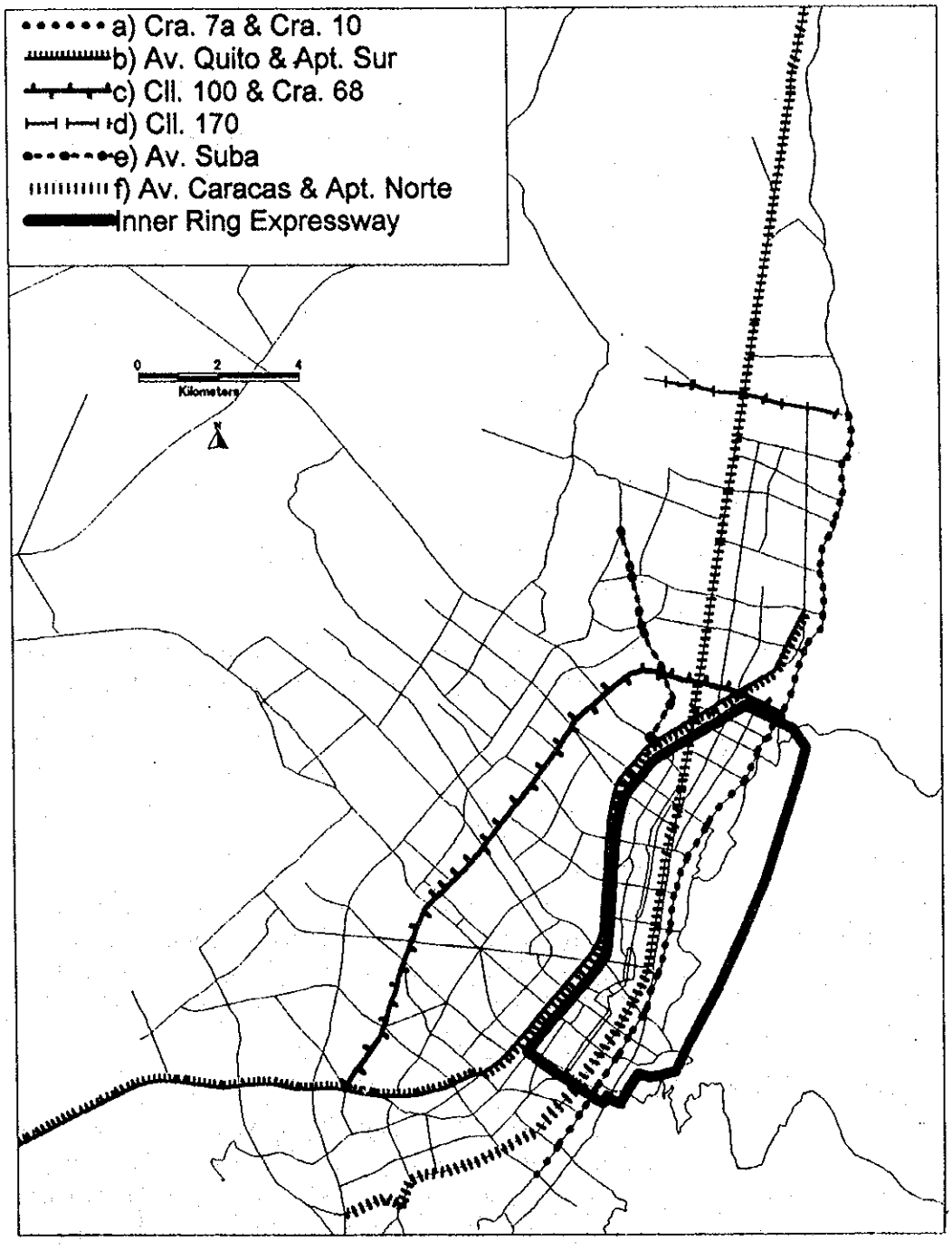


Figure 1.4-1 Location of the Study Area and Routes

(2) Second Stage of the Study

The second stage of the Study was conducted in Colombia from September to December 1998. The major study items are listed below,

1) Presentation of Interim Report and opening of workshop.
2) Preliminary engineering design.
3) Preparation of construction method.

(3) Third Stage of the Study

The third stage of the Study was carried out in Colombia from January to March 1999. The major study items are listed below,

1) Conduct of environmental impact assessment
2) Project cost estimate.
3) Preparation of implementation program.
4) Financial resources for the projects
5) Implementation organization for the projects.
6) Projects evaluation.
7) Conclusions and recommendations
8) Presentation of Draft Final Report and opening of workshop.

(4) Fourth stage of the Study.

This study was conducted in Japan from April to May 1999. The major study items include the preparation of the Final Report after receiving the comments on the Draft Final Report.

1.6. PROGRESS OF THE STUDY

The major events associated with the Study are as follows;

(1) Submitting the Inception Report

A Steering Committee Meeting was held on April 24, 1998 at the conference room of Bogota municipality. Attendance was the member of JICA Advisory Committee, the JICA Study Team, and the member of Steering Committee. The JICA Study Team submitted the Inception Report to the Colombian side. After the discussion, the contents of the Inception Report were accepted.

(2) Opening of Technical Meeting

In connection with the progress of the study, a meeting was held every Wednesday morning from 9:00 to 12:00. These technical meetings were held with the Colombian Counterpart, members of related authorities, and the JICA Study Team. Technical matters related to the study, and resolutions of issues or problems of planning were taken up.

(3) Progress Report (1)

The Steering Committee Meeting was held at the end of August 1998 with the member of Steering Committee and the JICA Study Team. The Progress Report covering the results of data collection and its analysis, general concept of the planning, and preparation of

alternative plans was submitted to the Colombian side. After discussion, the contents of the Progress Report were accepted.

(4) Interim Report

The Steering Committee Meeting was held on October 8, 1998 at the conference room of STT with the members of Steering Committee and JICA Study Team. The Interim Report covered the contents of Progress Report and the results of initial evaluation of various alternative plans. The Interim Report was submitted to the Colombian side, and after discussion, the contents of the Report were accepted.

(5) Progress Report (II)

The Steering Committee Meeting was held on December 9, 1998 with the members of Steering Committee and JICA Study Team. The Progress Report (II) covered the contents of Interim Report and the results of trunk bus operation system, preliminary design for facility of trunk busway and inner ring expressway. The Progress Report (II) was submitted to the Colombian side, and after discussion, the contents of the Report were accepted.

(6) Draft Final Report

The Steering Committee Meeting was held on March 9, 1998 with the members of Steering Committee and JICA Study Team. The Draft Final Report covered the contents of Progress Report (II), and construction plan and cost estimate, implementation plan, institutional plan, economic and financial evaluation, environmental impact assessment and conclusion. The Draft Final Report was submitted to the Colombian side, and after discussion, the contents of the Report were accepted.

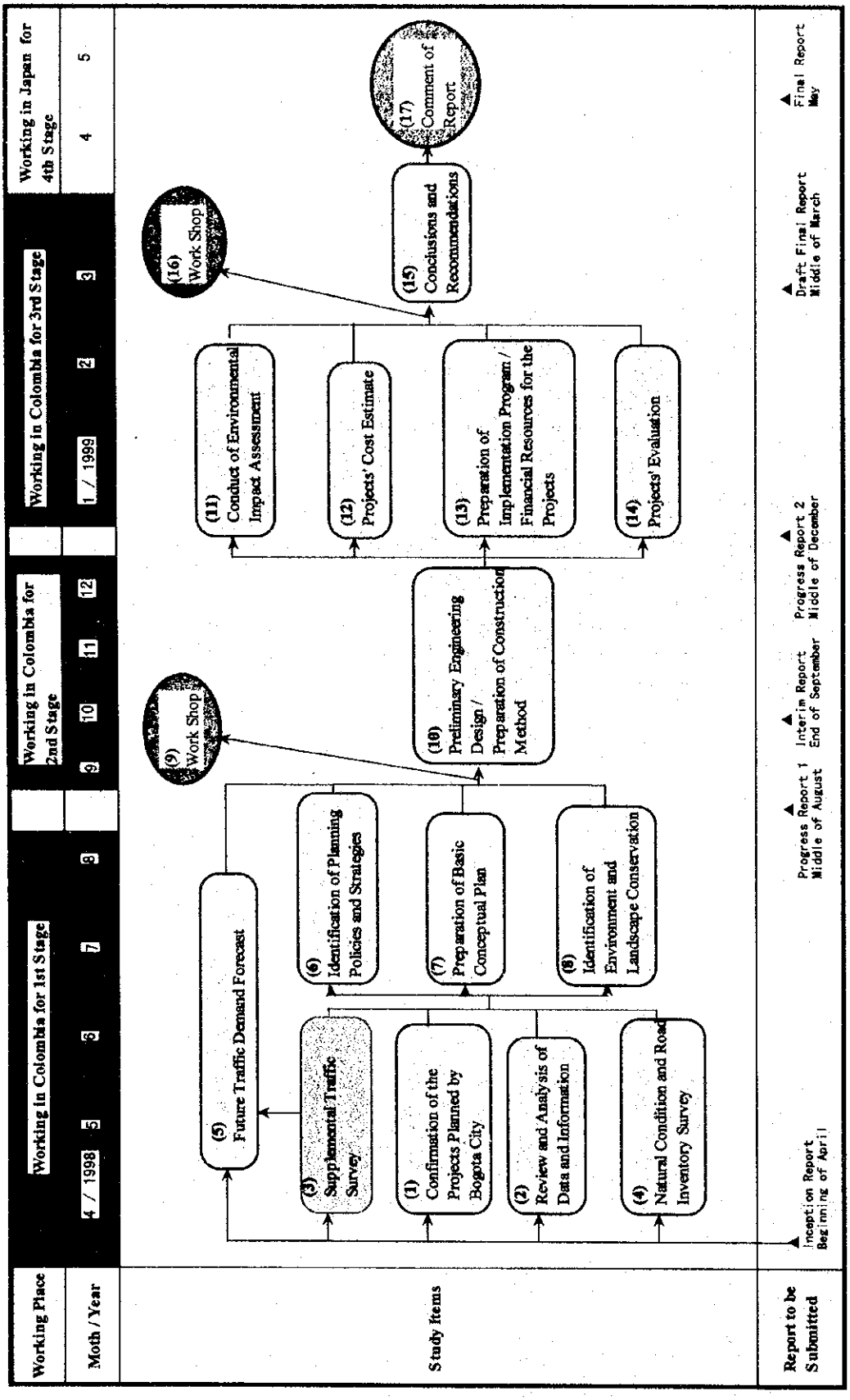


Figure 1.5-1 Study Flow Chart

1.7. STUDY ORGANIZATIONS

JICA organized both the Study Team, headed by Mr. Koichi Tsuzuki, and the Advisory Committee, chaired by Dr. Koichi Yamagata, to provide the advice for the Study. The Government of Colombia organized both the Counterpart Team and the Steering Committee, chaired by Dr. Enrique Penalosa Londono, Mayor of Santa Fe de Bogota. Figure 1.7-1 shows the Study organization.

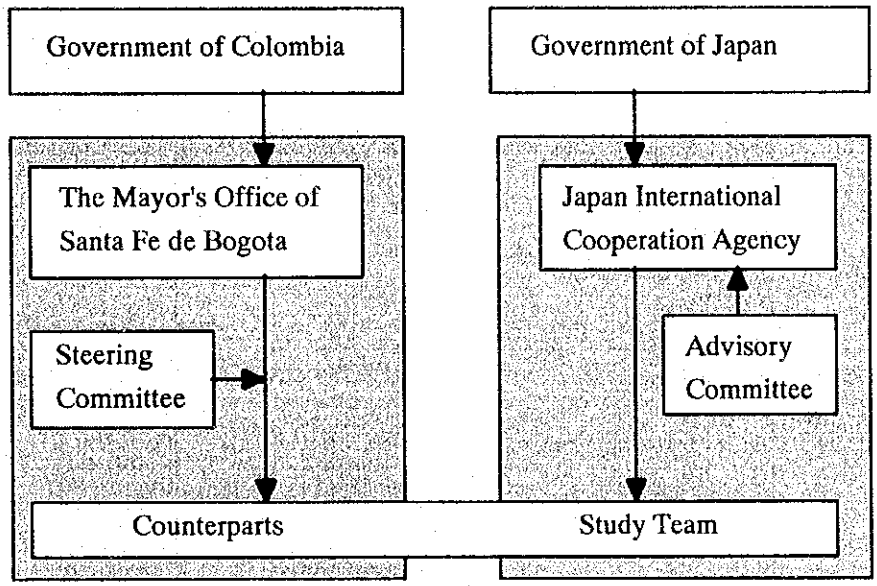


Figure 1.7-1 Study Organization

Study Organization Members

JICA Study Team		Colombian Counterpart Team	
Mr. Kouichi TSUZUKI	Team Leader	Ing. Ana Luisa Flechas Camacho de Arciniz*	Coordinadora del Estudio, Secretaría de Tránsito y Transporte (Asesora STT)
Mr. Kenichi SEKINE	Deputy Team Leader/ Public Transport Planner	Ing. Gustavo Calderón Herrera	Coordinador del Estudio, Instituto de Desarrollo Urbano
Mr. Kimio KANEKO	Traffic Planner	Ing. Javier Darío Tello Carrillo	Ex-Director Técnico de Planeación, Instituto de Desarrollo Urbano
Mr. Masaaki TUDA	Traffic Management/ Public Transport Planner	Ing. Leyla María Alvarez Piedrahita	Departamento Administrativo de Planeación Distrital
Mr. Yoshiaki NISIKATSU	Road Planner	Ing. Luis María Muñoz Alvarez	Secretaría de Tránsito y Transporte
Mr. Masahisa TUCHIHASHI	Road Planner	Ing. Héctor Julio Monguí Estupiñan	Secretaría de Tránsito Y Transporte
Mr. Masahiko MORI	Structure Designer/ Construction Method	Ing Norma Cristina Solarte Vanegas	Instituto de Desarrollo Urbano
Mr. Masayoshi KOMAGAMINE	Structure Designer/ Cost Estimation	Ing. Jorge Miguel	Instituto de Desarrollo Urbano
Dr. Takanori HAYASHIDA	Environment Analyst		
Mr. Iwao NAKAJIMA	Architecture/ Landscape		
Mr. Tetuo WAKUI	Economist		
Mr. Hisayuki YAMAGUCHI	Traffic Demand Analyst/ System Engineer		
Mr. Yoshihiro MIYAMOTO	Traffic and Transport Surveyor		
Mr. Kazue FURUKAWA	Interpreter		
Mr. Takatoshi KOSHIBA	Environment Analyst		

JICA Advisory Committee			Steering Committee	
Chairman	Dr. Koichi YAMAGATA	Professor, University of Ibaraki	Dr. Enrique Peñalosa Londono	The Mayor of Santa Fe de Bogota
Member	Mr. Toshiro KOHNO	Ministry of Construction	Dr. Andres Camargo	Director of IDU
Member	Mr. Seishiro TSUZUKI	City of Nagoya	Dra. Emilia C. Ruiz*	Director of ACCI
Member	Mr. Takashi UCHINO	The Overseas Economic Cooperation Fund, Japan	Dr. Jose David Marin	Director of ACCI
			Dra. Maria Perez*	Secretary of STT
			Dr. Guillermo Salcedo	Secretary of STT
			Dra. Claudia Franco	Secretary of SOP
			Dra. Nohora Aristizabal	Director of DAPD
			Dr. Manuel Olivera	Director of DAMA
			Dr. Ignacio De Guzman	Transmilenio Project, PNUD
			Dr. Gustavo Calderon	Coordinator on the Study, IDU

JICA Headquater	
Mr.Takao KAIBARA	Director, 1st Development Study Division
Ms. Eri HONDA	Deputy Director, 1st Development Study Division
Mr. Tomoyuki KOSAWA*	1st Development Study Division
Mr. Takahiro KASAI	1st Development Study Division

* Note; * Predecessor

PART A

EXISTING CONDITIONS OF THE STUDY AREA

CHAPTER 2
Existing Traffic and Transport Conditions

PART-A EXISTING CONDITIONS OF THE STUDY AREA

2. EXISTING TRAFFIC AND TRANSPORT CONDITIONS

2.1. FIELD TRAFFIC SURVEYS

2.1.1. GENERAL

Various field surveys were conducted during the first four months of the study in order to supplement basic data of the Study and to understand general traffic conditions of the study area.

2.1.2. ITEMS SURVEYED

Surveyed items are categorized into four groups, namely, traffic and transport surveys, soil survey, topographic survey and natural condition survey. In traffic survey, traffic volume count, intersection traffic volume count, bus passenger OD survey and bus passenger opinion survey were carried out. In soil survey, five locations were selected for drilling. Other relevant information regarding the subsurface conditions of Bogota were also collected. All planned routes, i.e., six busways and inner ring expressway route, were investigated in the topographic survey. Natural condition survey was also targeted to these study routes.

2.1.3. LOCATIONS OF EACH STUDY

Figure 2.1-1 shows the locations of the surveys conducted.

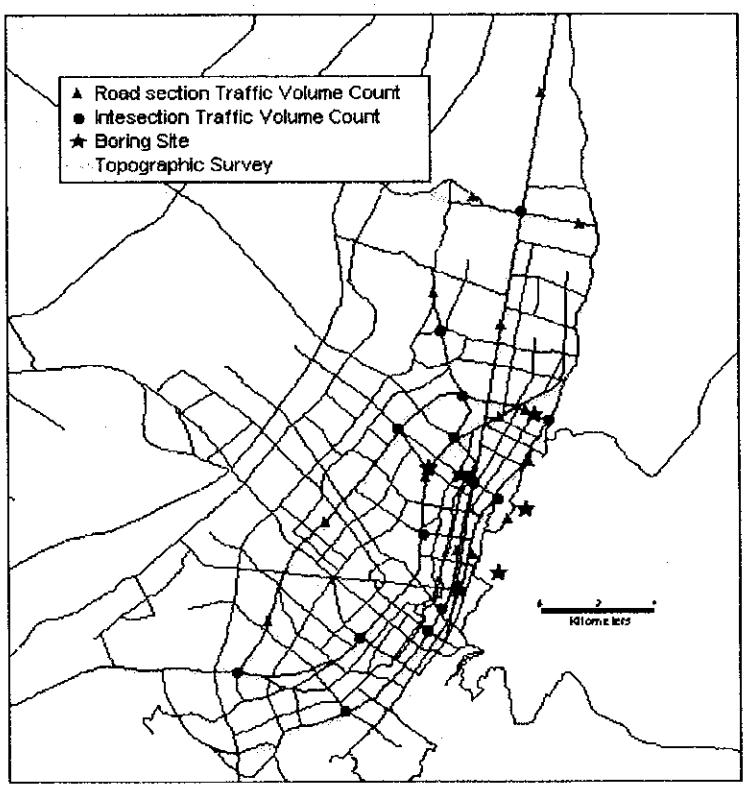


Figure 2.1-1 Location of Field Surveys

2.2. EXISTING TRAFFIC AND TRANSPORT CONDITIONS

There were four types of traffic surveys conducted in the Study. These were traffic volume count, intersection traffic volume count, bus passenger OD survey and opinion survey.

2.2.1. ROAD SECTION TRAFFIC VOLUME COUNT SURVEY

Traffic volume count surveys were carried out at 14 sections of road along the study routes. Survey was carried out for 13 hours from 6:00 to 19:00, on weekdays excluding Monday and Friday. Survey time and survey locations were decided through discussions with Colombian counterparts. As shown in Figure 2.1-1, all survey points are located on the study roads. Table 2.2-1 is a list of the survey points.

In this survey, vehicle types were classified into 7 categories, namely, car, taxi, truck, bus, buseta, microbus and private bus. Private buses are ones that are operated to carry only designated people, such as company employees or students.

Vehicles were counted by type as they crossed the survey points, and numbers were recorded every fifteen minutes in accumulation manner. Following section describes the results of the survey.

Table 2.2-1 Roadside Traffic Volume Count Site

	Roadside Traffic Volume Count Site
1	Calle 170 between Av 7a - Ferrocarril del Norte
2	Calle 170 between Carrera 58 - Carrera 60
3	Apt. Norte at centro recreativo Cafam
4	Apt. Norte between Diag 129 - Av 127
5	Av. Suba between Diag 129 - Calle 130
6	Calle 100 entere Carrera 10 - Carrera 11
7	Av. Quito between Calle 94 - Av. 19
8	Av. Quito between Calle 68-Calle 63
9	Av. Caracas between Calle 45 - Calle 46
10	Carrera 7a between Calle 45 - Calle 46
11	Carrera 7a between Calle 86 - Calle 85
12	Av. Circunvalar between Calle 76 - Calle 60
13	Av. 68 between Av. 1o de Mayo - Tran 64a
14	Av. 68 between Av. Luis Carlos Galan - Calle 13

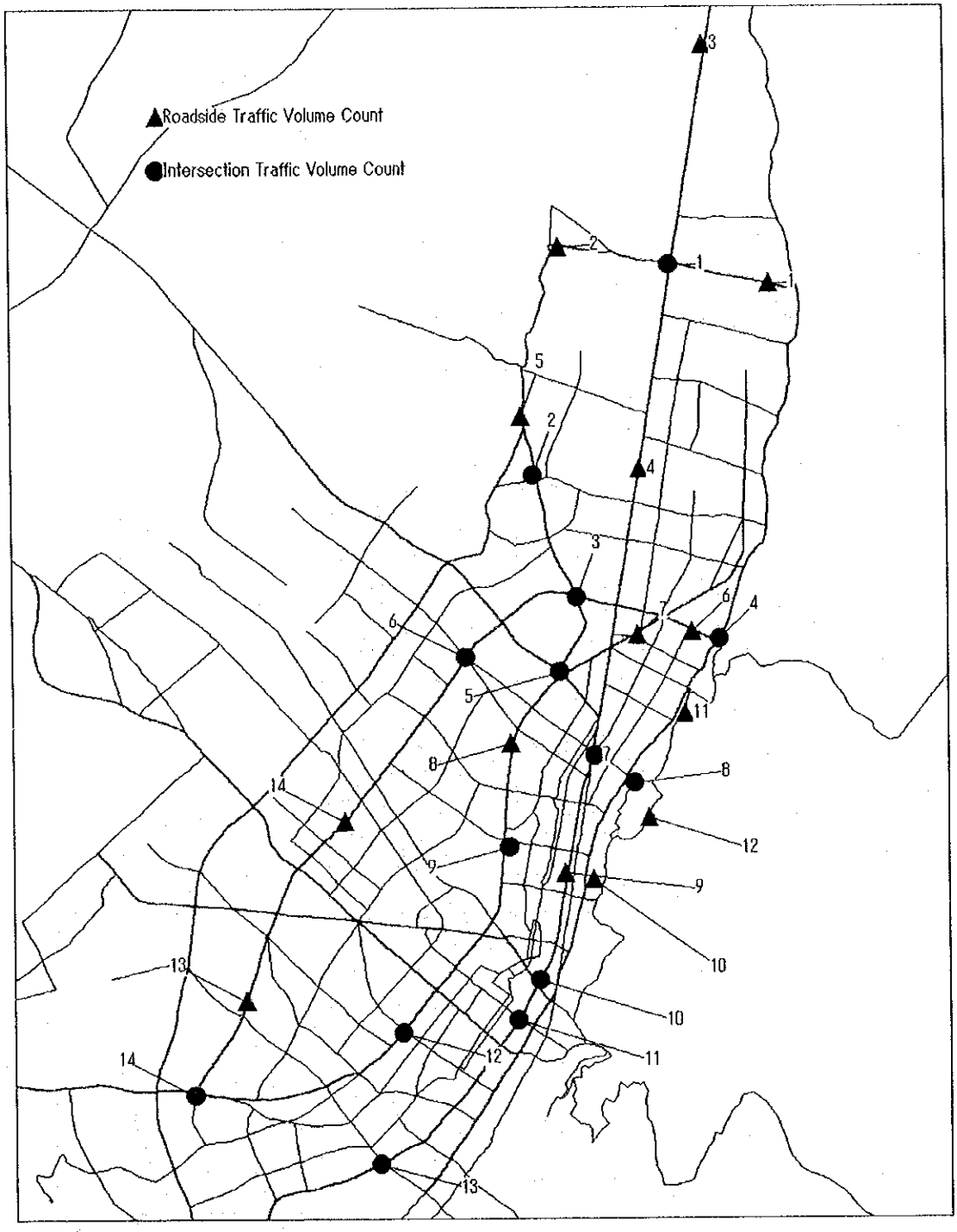


Figure 2.2-1 Traffic Volume Count Locations

(1) Traffic Volume on Calle 170

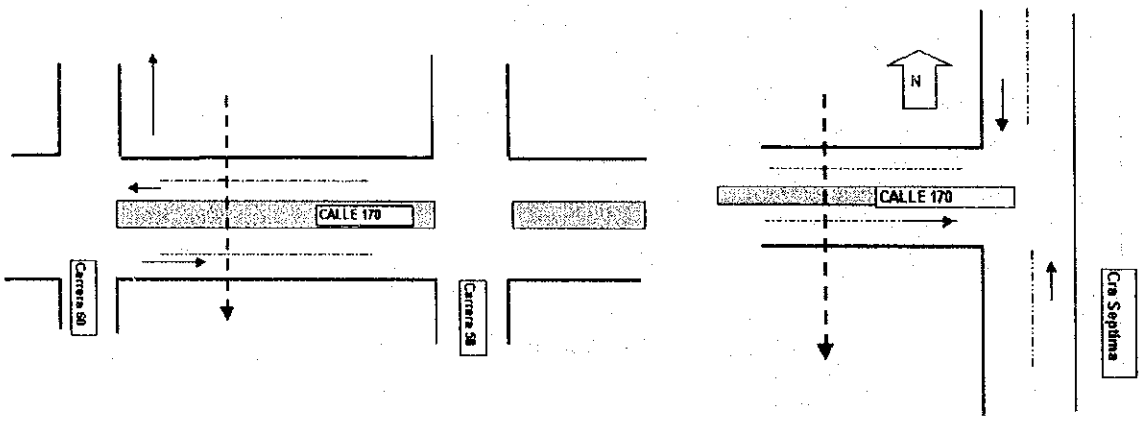
Along Calle 170, roadside traffic volume was counted at two locations. Location 1 was between railway track and Carrera 7a, and Location 2 was at Carrera 58 - Carrera 60. Table 2.2-2 shows number of vehicles by type in peak hours of morning and in evening. Numbers in parenthesis indicate peak ratio over 12 hours, i.e., ratio of peak hour volume to total of 12 hours. Figure 2.2-2 shows the traffic count locations on Calle 170.

Figure 2.2-3 shows hourly fluctuation of these locations by vehicle type and direction.

Table 2.2-2 Number of Vehicles in the Peak Hours along the Calle 170

	Location	Location 1		Location 2	
W -> E	Peak AM	8:00-9:00		7:00-8:00	
	Car	746	(12%)	1168	(13%)
	Truck	62	(8%)	54	(6%)
	Bus	73	(10%)	39	(10%)
E -> W	Peak AM	7:00-8:00		7:00-8:00	
	Car	640	(10%)	546	(11%)
	Truck	44	(5%)	67	(10%)
	Bus	72	(7%)	97	(8%)
W -> E	Peak PM	14:00-15:00		15:00-16:00	
	Car	553	(9%)	868	(10%)
	Truck	72	(9%)	77	(8%)
	Bus	65	(9%)	31	(8%)
E -> W	Peak PM	17:00-18:00		15:00-16:00	
	Car	901	(13%)	604	(13%)
	Truck	37	(4%)	51	(8%)
	Bus	80	(8%)	239	(20%)

Note: Numbers in parenthesis () indicate peak ratio over 12 hours, i.e., ratio of peak hour volume to total of 12 hours.

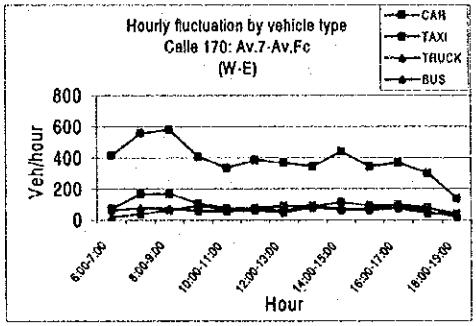


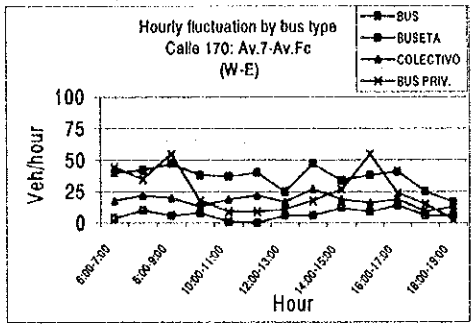
Location 2 Location 1

Figure 2.2-2 Traffic Count Locations on Calle 170

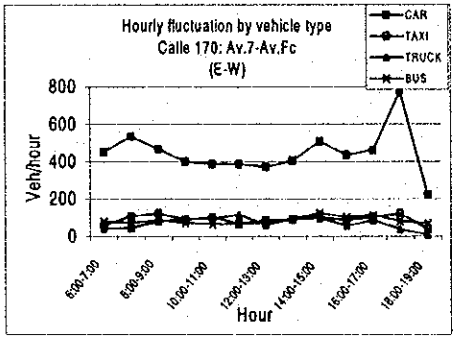
Location 1

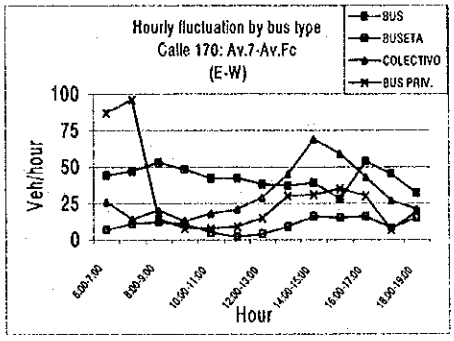
(1) West to East





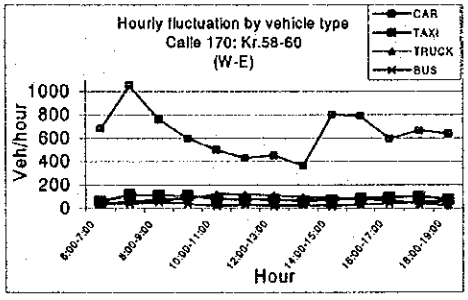
(2) East to West

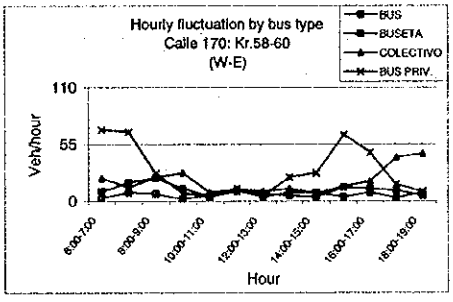




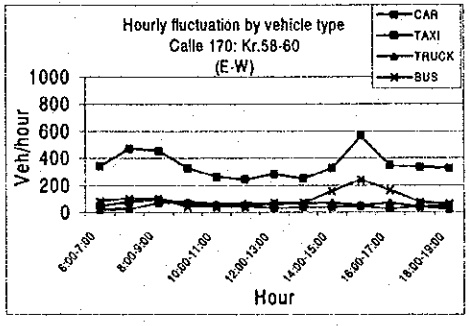
Location 2

(1) West to East





(2) East to West



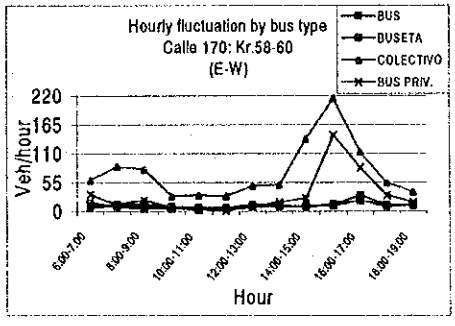


Figure 2.2-3 Hourly Traffic Volume on Calle 170 by Direction

(2) Traffic Volume on Autopista Norte through Avenida Caracas

Table 2.2-3 shows traffic characteristics along Autopista Norte through Avenida Caracas. Location 3 was in front of Club Cafam, which is about 4km north of intersection at Calle 170. At this section, each direction has three lanes carriage way. Location 4 was between Calle 129 and Calle 127. At this section of the road, each direction has 5 lanes, 3 lane in central part and 2 lanes in outer part. Location 9 was at Avenida Caracas, where central 2 lanes are designated only for buses, while outer 2 lanes serve for mixed traffic. Figure 2.2-4 and Figure 2.2-6 show hourly fluctuation by vehicle type and bus type.

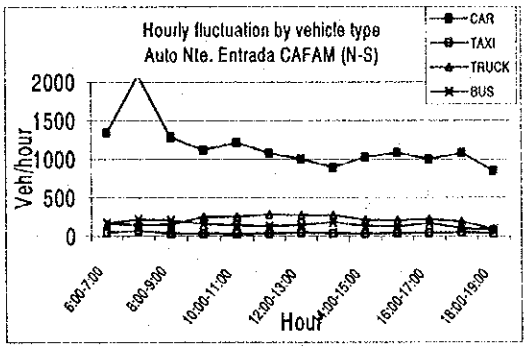
Table 2.2-3 Number of Vehicles in Peak Hours along the Autopista Norte

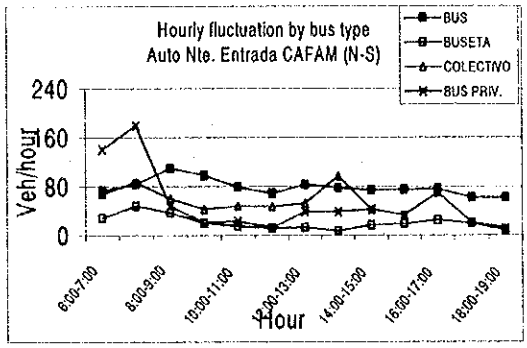
Direction	Location	Location 3		Loc. 4 (out)		Loc. 4 (center)		Loc. 9 (out)		Loc. 9 (center)	
N -> S	Peak AM	7:00-8:00		6:00-7:00		6:00-7:00		9:00-10:00		11:00-12:00	
	Car	2,159	(15%)	4,444	(13%)	1,046	(9%)	1,563	(11%)	0	(0%)
	Truck	147	(6%)	129	(4%)	48	(5%)	67	(13%)	0	(0%)
	Bus	219	(12%)	560	(8%)	145	(21%)	0	(0%)	755	(12%)
S -> N	Peak AM	8:00-9:00		11:00-12:00		9:00-10:00		10:00-11:00		8:00-9:00	
	Car	1025	(7%)	3,367	(10%)	1,668	(10%)	1,271	(10%)	0	(0%)
	Truck	210	(10%)	356	(11%)	39	(8%)	50	(12%)	0	(0%)
	Bus	161	(9%)	834	(12%)	49	(12%)	0	(0%)	547	(10%)
N -> S	Peak PM	12:00-13:00		15:00-16:00		16:00-17:00		17:00-18:00		12:00-13:00	
	Car	1046	(7%)	2,796	(8%)	1,024	(9%)	1,418	(10%)	0	(0%)
	Truck	275	(10%)	255	(9%)	77	(8%)	40	(8%)	0	(0%)
	Bus	149	(8%)	395	(6%)	51	(7%)	0	(0%)	608	(10%)
S ->N	Peak PM	15:00-16:00		17:00-18:00		15:00-16:00		17:00-18:00		17:00-18:00	
	Car	1396	(10%)	4,793	(14%)	1,806	(11%)	1,244	(9%)	0	(0%)
	Truck	202	(10%)	277	(8%)	107	(23%)	25	(6%)	0	(0%)
	Bus	108	(6%)	260	(4%)	32	(8%)	0	(0%)	502	(10%)

Note: Numbers in parenthesis () indicate peak ratio over 12 hours, i.e., ratio of peak hour volume to total of 12 hours.

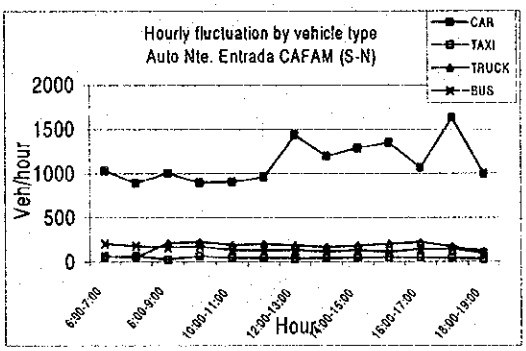
Location 3

(1) North to South





(2) South to North



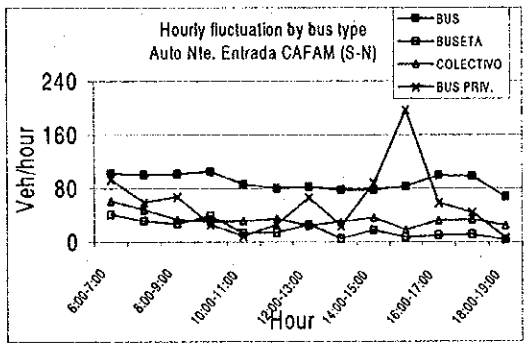
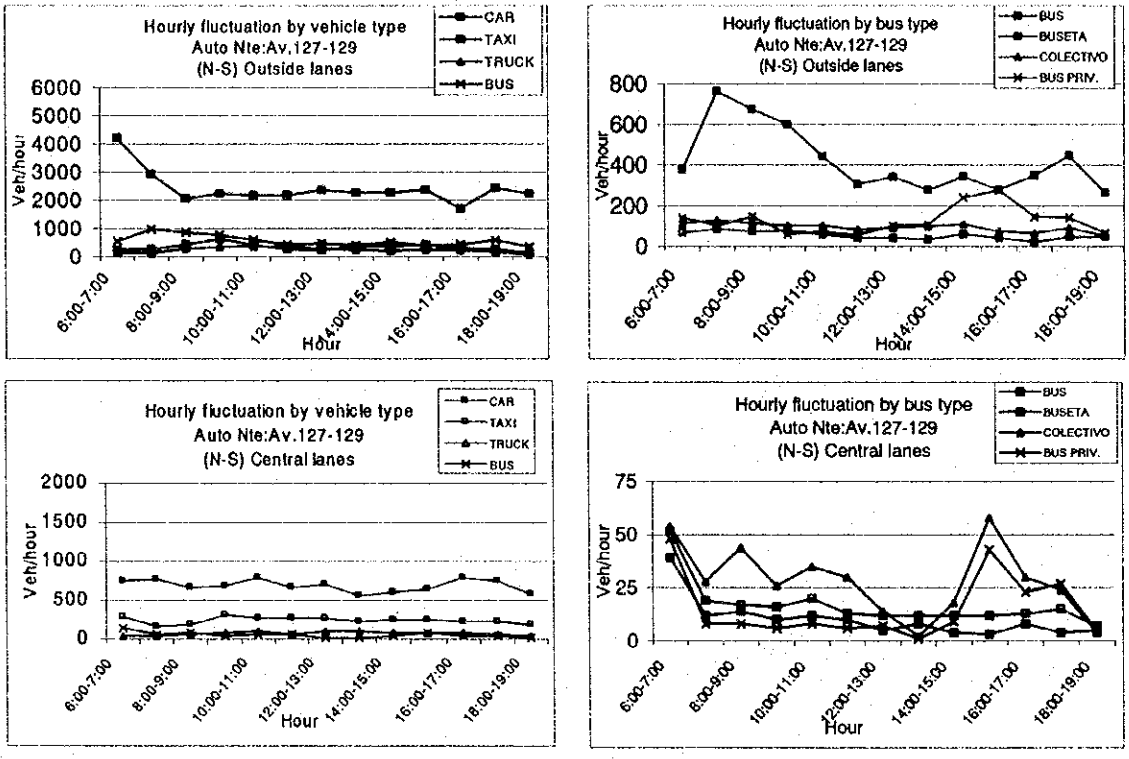


Figure 2.2-4 Hourly Traffic Volume at Autopista Norte

Location 4

(1) North to South



(2) South to North

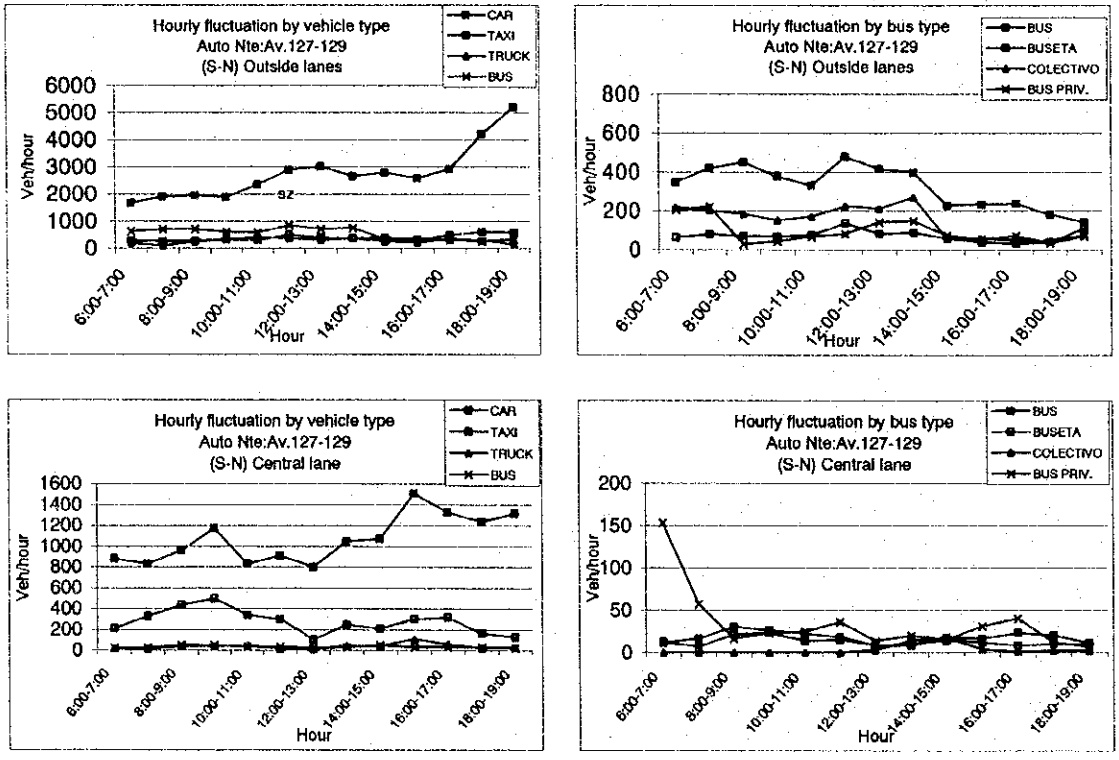


Figure 2.2-5 Hourly Traffic Volume at Autopista Norte

Location 5

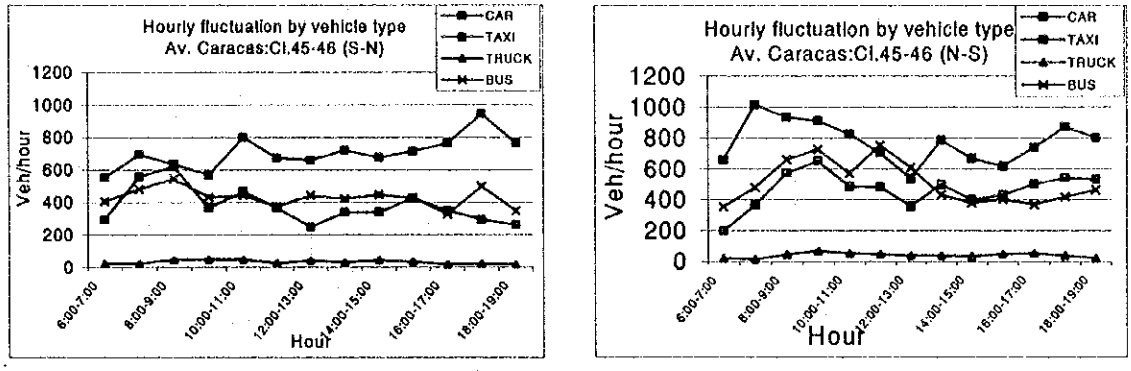


Figure 2.2-6 Hourly Traffic Volume at Av. Caracas

(3) Traffic Volume on Avenida Ciudad de Quito

Table 2.2-4 shows traffic volumes in peak hours along Avenida Ciudad de Quito. Countings were carried out at two road sections along Avenida Ciudad de Quito. Figure 2.2-7 shows description of the locations.

Location 7 was between Calle 94 and Avenida 19. Location 8 was located between Calle 68 and Calle 63. At Location 7, there are 3 lanes on each direction, and there are also traffic signals at both intersections of Calle 94 and Avenida 19. Location 7 was further to the north than Location 8, but both locations are rather in the northern part of the city. At Location 8, each direction has 5 lanes, but lanes are separated by median strip. Location 8L refers to outer 2 lanes and Locations 8C refers to central 3 lanes. Clearly, outer lanes have larger number of buses because they need to load and unload passengers. Figure 2.2-8 and Figure 2.2-9 show hourly fluctuation of vehicles on location 7 and 8, respectively.

Table 2.2-4 Number of Vehicles in Peak Hours along Avenida Ciudad de Quito

	Location	Location 7		Location 8L		Location 8C	
S -> N	Peak AM	11:00-12:00		9:00-10:00		10:00-11:00	
	Car	1562	(8%)	2531	(8%)	2779	(6%)
	Truck	58	(12%)	490	(16%)	28	(8%)
	Bus	19	(5%)	188	(9%)	51	(11%)
N -> S	Peak AM	7:00-8:00		8:00-9:00		7:00-8:00	
	Car	2850	(10%)	1201	(10%)	7736	(14%)
	Truck	9	(2%)	82	(6%)	62	(9%)
	Bus	21	(6%)	242	(12%)	4	(4%)
S -> N	Peak PM	14:00-15:00		16:00-17:00		16:0-17:00	
	Car	1902	(10%)	3227	(11%)	8226	(18%)
	Truck	40	(8%)	422	(13%)	63	(17%)
	Bus	45	(11%)	152	(7%)	20	(4%)
N -> S	Peak PM	16:00-17:00		14:00-15:00		17:00-18:00	
	Car	2171	(8%)	1224	(10%)	4573	(8%)
	Truck	72	(15%)	178	(13%)	90	(13%)
	Bus	15	(4%)	145	(7%)	17	(18%)

(2) South to

Note: Numbers in parenthesis () indicate peak ratio over 12 hours, i.e., ratio of peak hour volume to total of 12 hours.

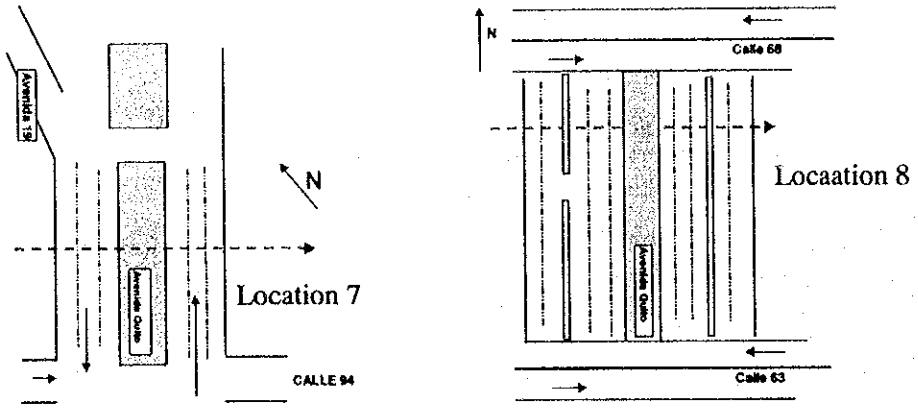
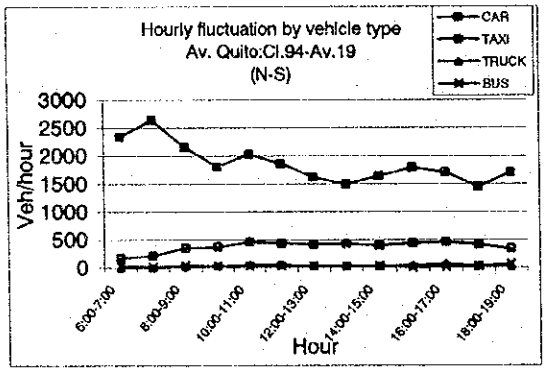
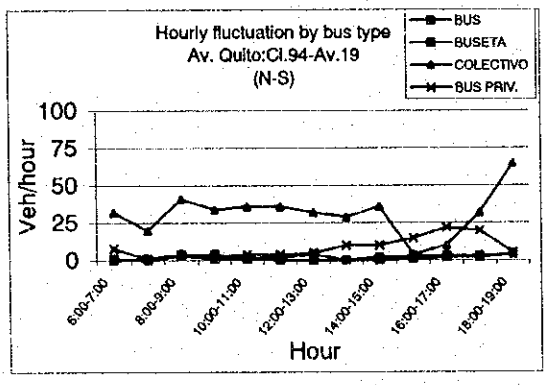


Figure 2.2-7 Description of Traffic Count Sites on Avenida Quito

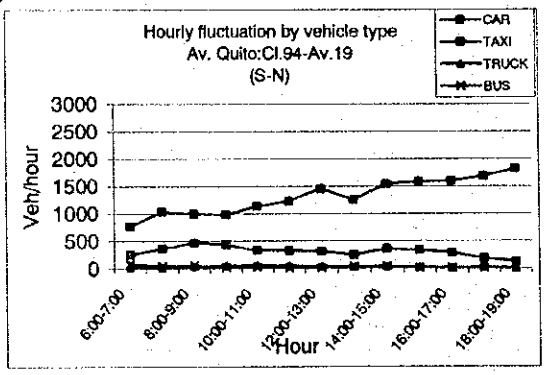
1) North to South

Location 7





2) South to North



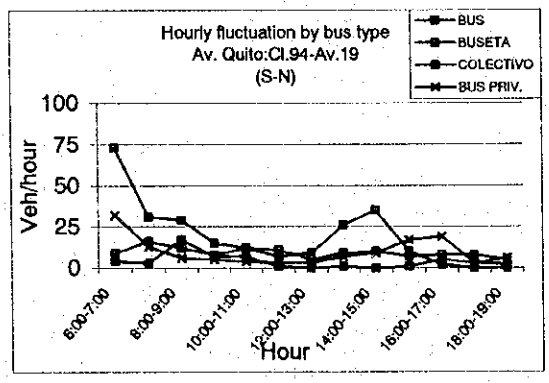
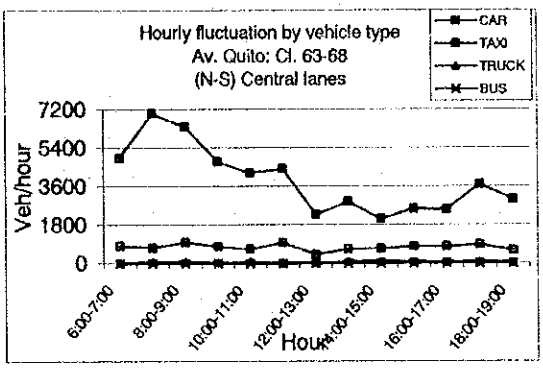
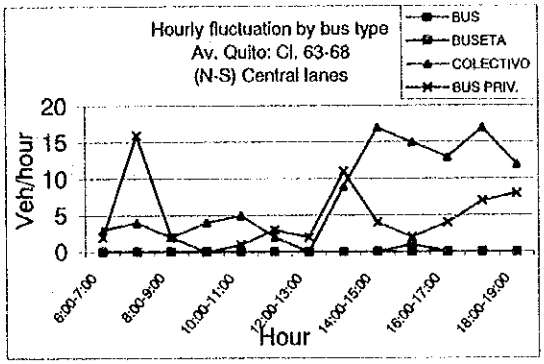


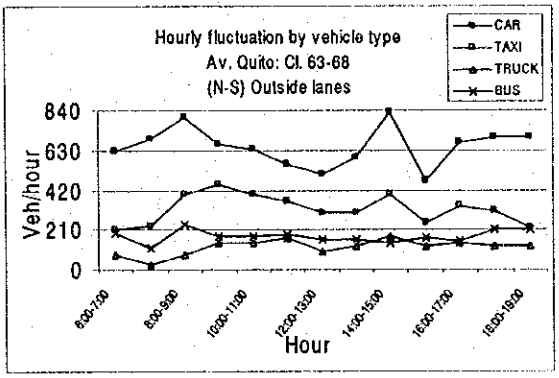
Figure 2.2-8 Hourly Fluctuation of Vehicles (Avenida Quito, Location 7)

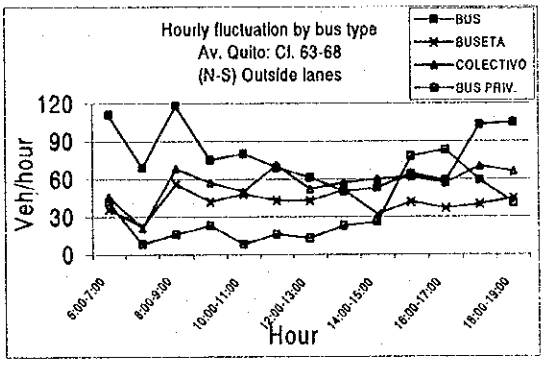
Location 8

1) North to south

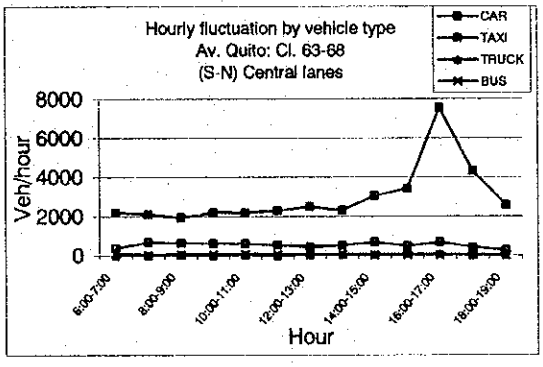


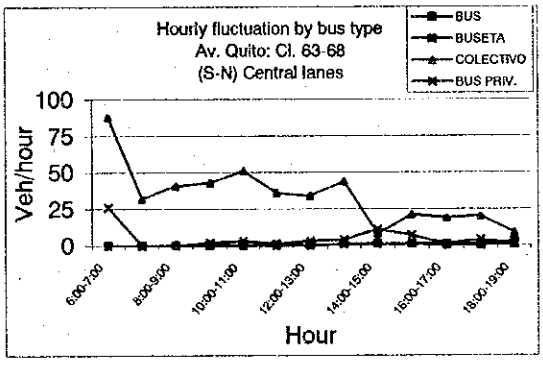


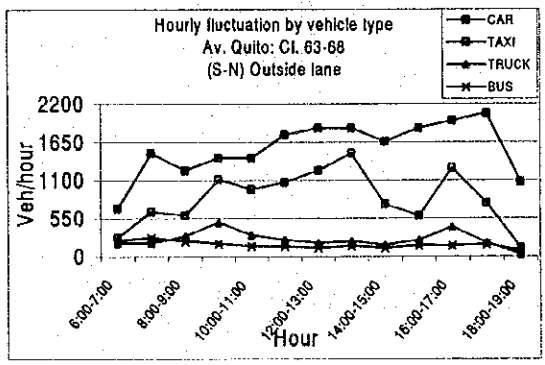




2) South to north







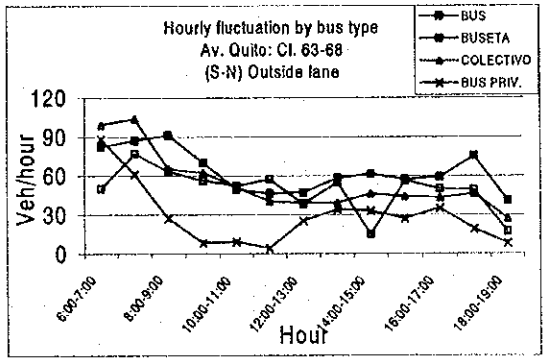


Figure 2.2-9 Hourly Fluctuation of Vehicles (Av. Quito, Location 8)

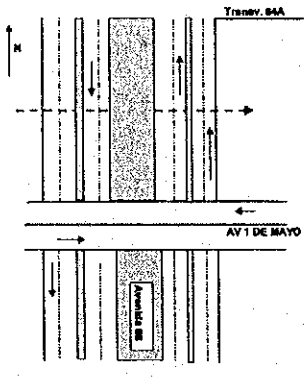
(4) Traffic Volume on Avenida 68

Along Avenida 68, two locations were selected for traffic volume counting. Location 13 was between Avenida 1o de Mayo and Transversal 64a, and Location 14 was between Avenida Luis Carlos Galan and Calle 13. At both locations, each directions had 4 lanes of carriageway, 2 lanes in outer section and 2 lanes in central section. Figure 2.2-10 shows description of the locations. Location 13 was further to the south than Location 14, although Location 14 was also in the southern part of the city. Table 2.2-5 shows traffic volumes in peak hours on Avenida 68. Figure 2.2-11 and Figure 2.2-12 show hourly fluctuation of vehicles.

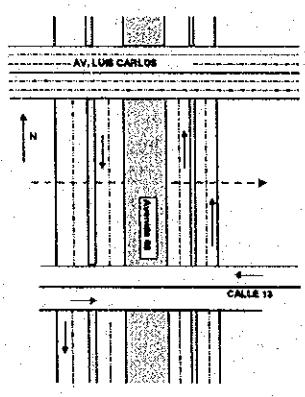
Table 2.2-5 Numbers of Vehicles in Peak Hours along Avenida 68

( ): Peak Ratio

	Location	Location 13L		Location 13C		Location 14L		Location 14C	
S -> N	Peak AM	11:00-12:00		7:00-8:00		7:00-:8:00		6:00-7:00	
	Car	389	(8%)	1536	(10%)	435	(7%)	1024	(12%)
	Truck	268	(13%)	67	(14%)	73	(3%)	29	(7%)
	Bus	478	(9%)	37	(10%)	1942	(20%)	100	(23%)
N -> S	Peak AM	8:00-9:00		7:00-8:00		10:00-11:00		7:00-8:00	
	Car	1004	(11%)	1970	(12%)	359	(7%)	964	(10%)
	Truck	122	(6%)	26	(6%)	218	(11%)	14	(6%)
	Bus	384	(8%)	8	(3%)	478	(9%)	0	(0%)
S -> N	Peak PM	14:00-15:00		17:00-18:00		16:00-17:00		14:00-15:00	
	Car	632	(13%)	1746	(11%)	800	(12%)	821	(9%)
	Truck	160	(8%)	20	(4%)	412	(19%)	73	(19%)
	Bus	406	(8%)	17	(5%)	683	(7%)	47	(11%)
N -> S	Peak PM	15:00-16:00		17:00-18:00		17:00-18:00		17:00-18:00	
	Car	687	(7%)	1405	(8%)	532	(10%)	951	(10%)
	Truck	199	(9%)	50	(12%)	134	(7%)	6	(3%)
	Bus	369	(8%)	27	(10%)	588	(11%)	11	(18%)



Location

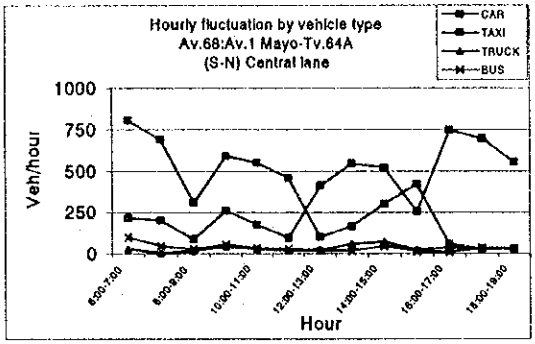


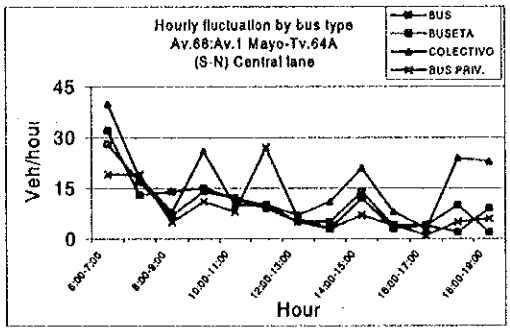
Location 14

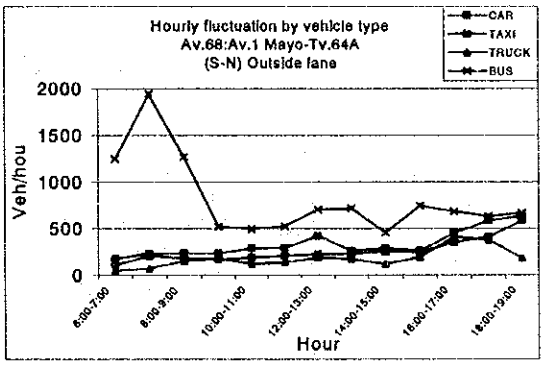
Figure 2.2-10 Description of Traffic Count Site (Avenida 68)

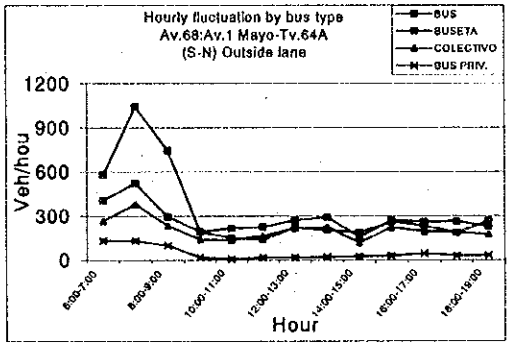
Location 13

1) South to North

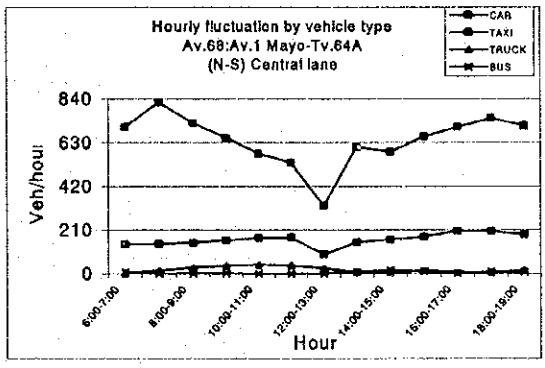


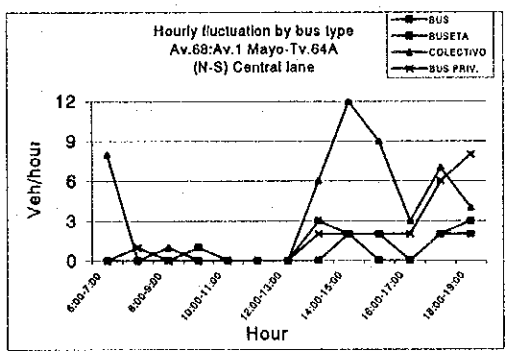


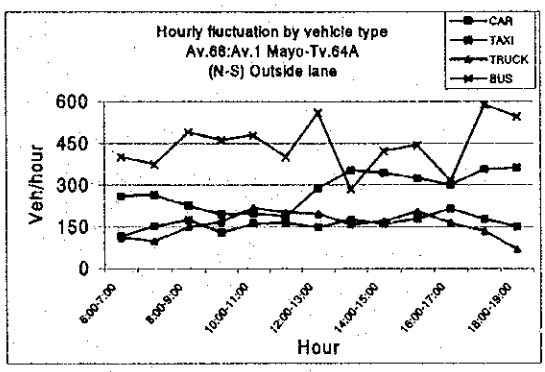




2) North to South







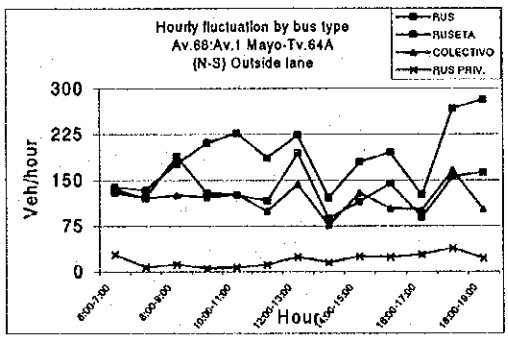
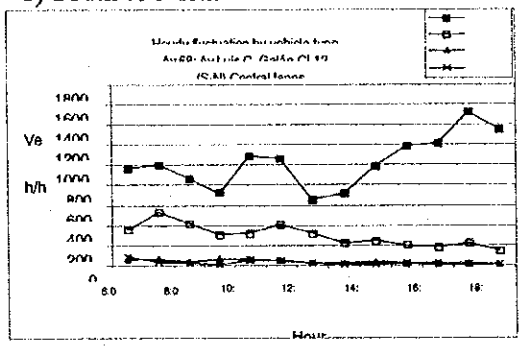
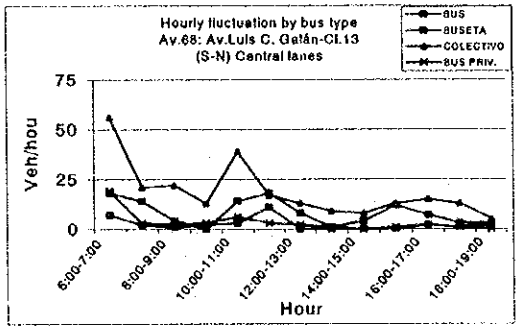


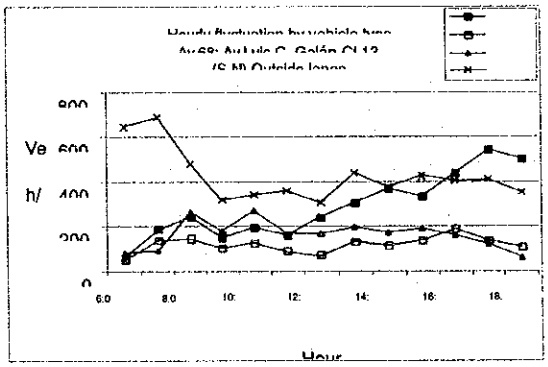
Figure 2.2-11 Hourly Fluctuation of Vehicles (Avenida 68, Location 13)

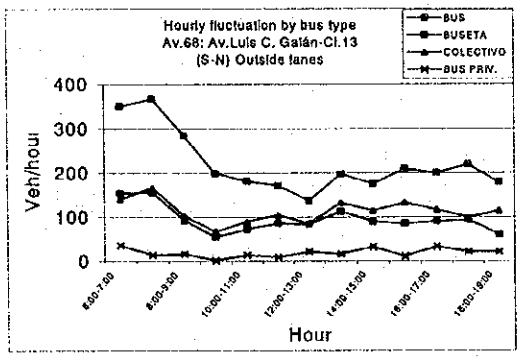
Location 14

1) South to North

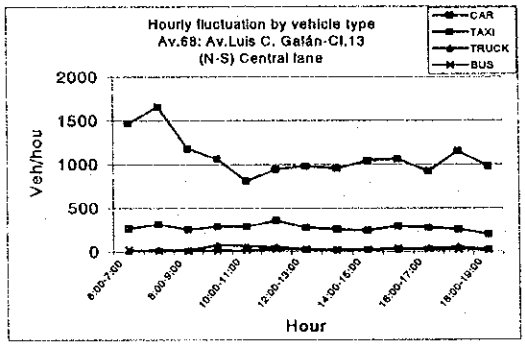


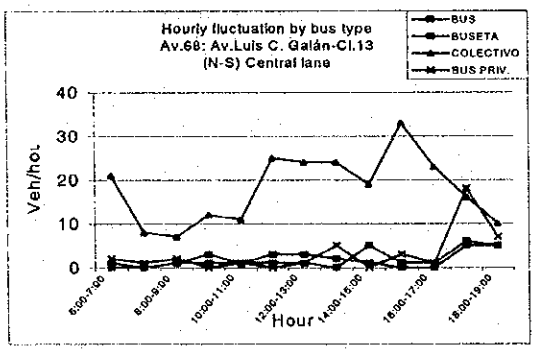


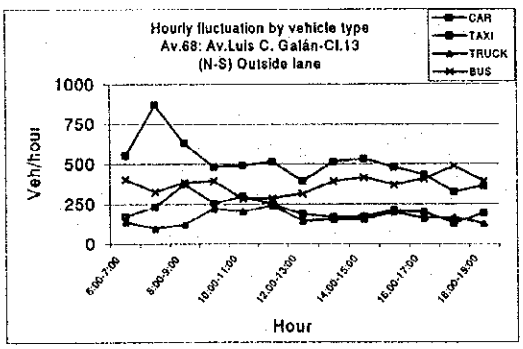




2) North to South







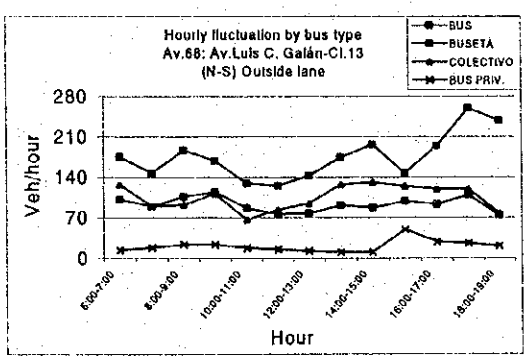


Figure 2.2-12 Hourly Fluctuation of Vehicles (Avenida 68, Location 14)

(5) Traffic Volume on Carrera 7a

Locations 10 and 11 are on Carrera 7a. Location 10 was between Calle 45 and Calle 46. Location 11 was between Calle 85 and Calle 86. Carrera 7a employs reversible lane system, which the directions of the traffic flow are changed depending on time. Table 2.2-6 shows number of vehicles in peak hours. Figure 2.2-13 is a description of the counting site.

At Location 10, there are two types of traffic flows. During the normal traffic time, each direction has 3 lanes, where lanes are separated by the median strip. During the traffic concentration time, all the lanes are changed to south-north direction. There are two traffic concentration periods designated at this section of the road, 12:00 p.m. to 1:30 p.m. and 5:00 p.m. to 7:00 p.m. As shown in Figure 2.2-14, there are no north-south movement during these period.

At Location 11, there are also changes in traffic flow according to the time of the day, but in different form and period. From 6:00 am and 9:00 am, the most central lane of south-north direction is reversed to north-south direction. Thus, during this period, there are 4 lanes provided for north-south direction, and only 2 lanes are provided for south-north direction. During the evening peak hour from 5:00 p.m. to 7:00pm, all the lanes are used for south-north direction. (See Figure 2.2-15)

Table 2.2-6 Number of Vehicles in peak hours along Avenida 7a

	Location	Location 10		Location 11	
S -> N	Peak AM	10:00-11:00		11:00-12:00	
	Car	2350	(9%)	1597	(8%)
	Truck	24	(14%)	23	(12%)
	Bus	402	(7%)	163	(7%)
N -> S	Peak AM	7:00-8:00		10:00-11:00	
	Car	2862	(16%)	2008	(10%)
	Truck	3	(1%)	51	(14%)
	Bus	122	(9%)	173	(11%)
S -> N	Peak PM	17:00-18:00		18:00-19:00	
	Car	4192	(16%)	4931	(26%)
	Truck	8	(5%)	12	(6%)
	Bus	733	(12%)	206	(9%)
N -> S	Peak PM	16:00-17:00		15:00-16:00	
	Car	1676	(9%)	2324	(12%)
	Truck	21	(10%)	29	(8%)
	Bus	157	(12%)	151	(10%)

Note: ( ): Peak ratio to 12 hours

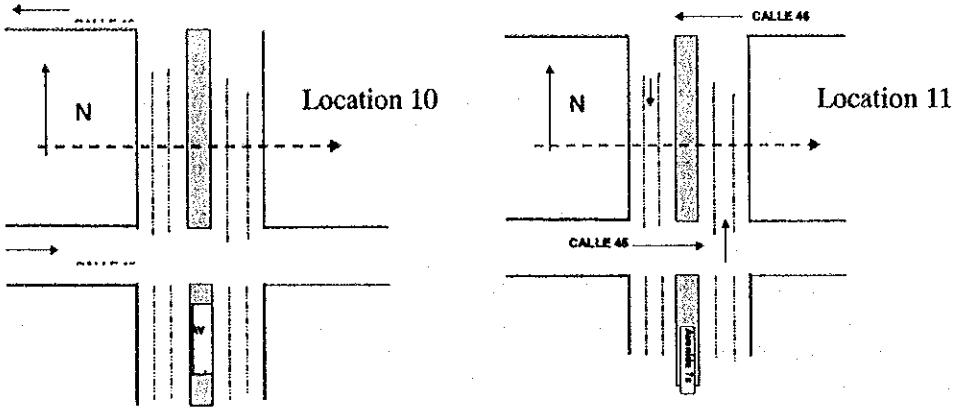
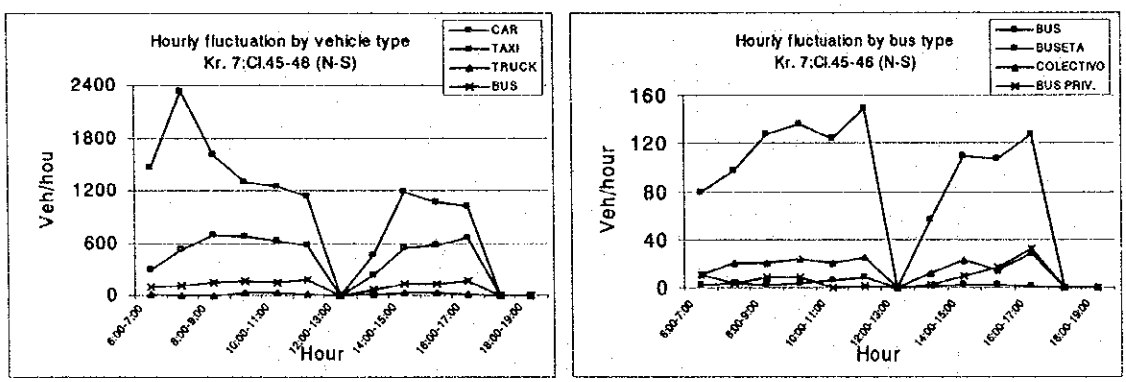


Figure 2.2-13 Description of Traffic Count Sites on Carrera 7a

Location 10

1) North to South



2) South to North

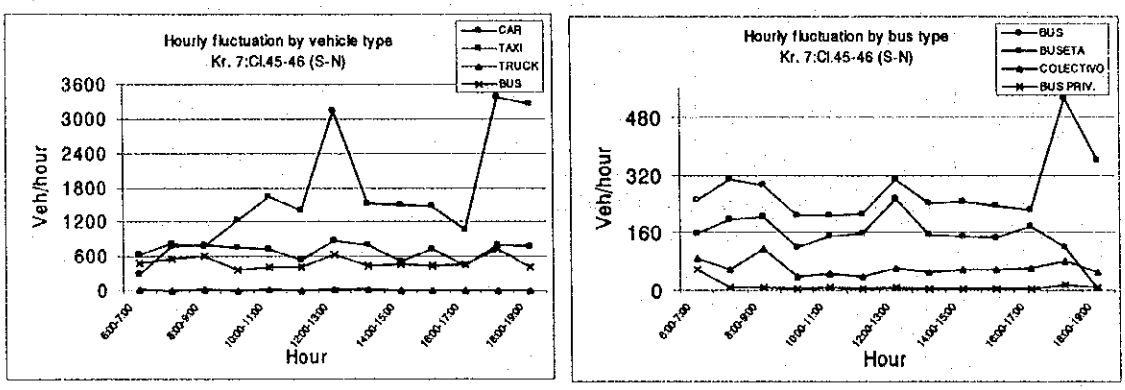
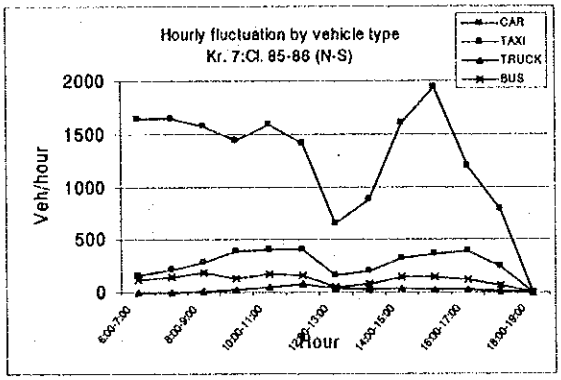
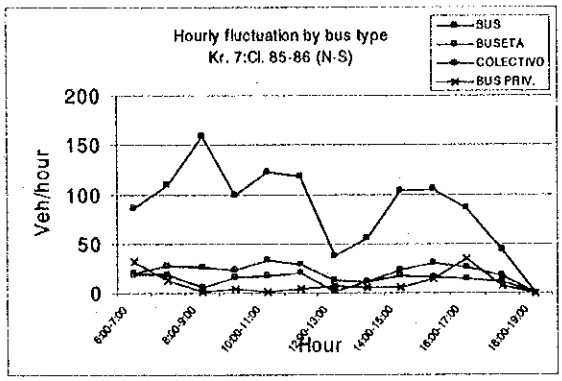


Figure 2.2-14 Hourly Fluctuation of Vehicles (Carrera 7a, Location 10)

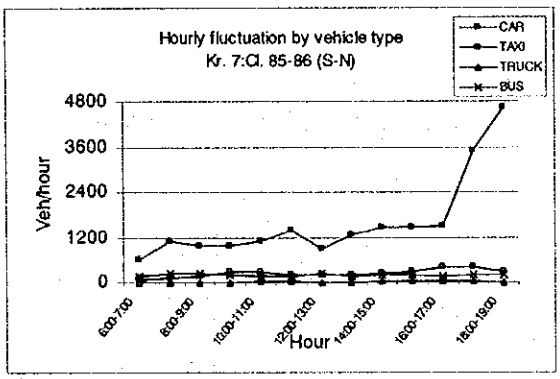
Location 11

1) North to South





2) South to North



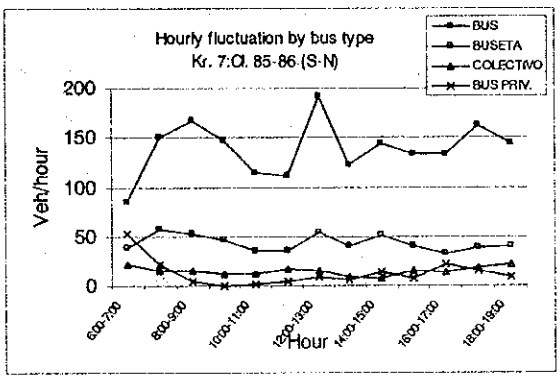


Figure 2.2-15 Hourly Fluctuation of Vehicles (Carrera 7a, Location 11)

(6) Traffic Volume on Avenida Suba

Avenida Suba is located at northwestern part of the city, which is one of the most fast growing parts of the city. Location 5 was located between Diagonal 129 and Calle 130 on Avenida Suba. Figure 2.2-16 shows description of the site.

Table 2.2-7 shows traffic volume in peak hours. There are many public transport on Avenida Suba. During a peak hour in the morning, there are more than 900 buses on north-south direction, which is toward the commercial center of the city. This account for almost 30% of the total traffic in that time period. Figure 2.2-17 shows hourly fluctuation of hourly traffic on Avenida Suba.

Table 2.2-7 Traffic Volumes in Peak Hours on Avenida Suba

	Location	Location 5	
S -> N	Peak AM	8:00-9:00	
	Car	1697	(8%)
	Truck	89	(8%)
	Bus	442	(11%)
N -> S	Peak AM	7:00-8:00	
	Car	2119	(15%)
	Truck	131	(20%)
	Bus	914	(17%)
S -> N	Peak PM	18:00-19:00	
	Car	3174	(16%)
	Truck	37	(3%)
	Bus	489	(12%)
N -> S	Peak PM	12:00-13:00	
	Car	1068	(8%)
	Truck	74	(12%)
	Bus	309	(6%)

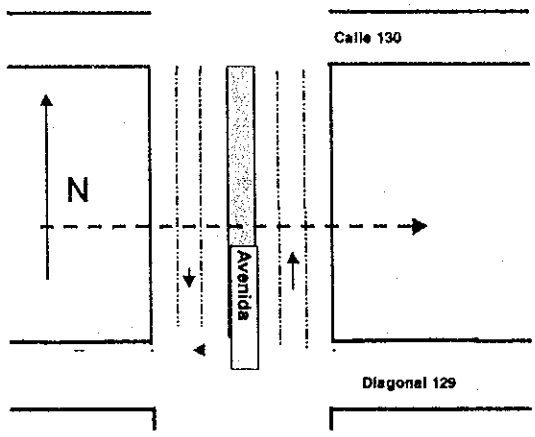
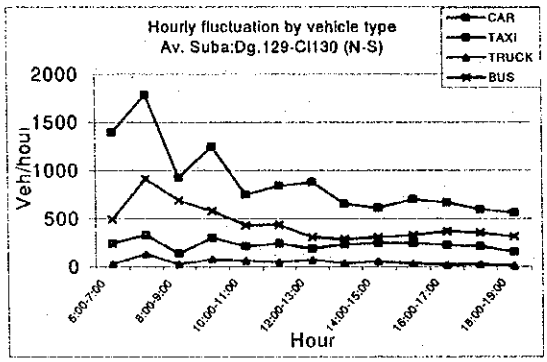
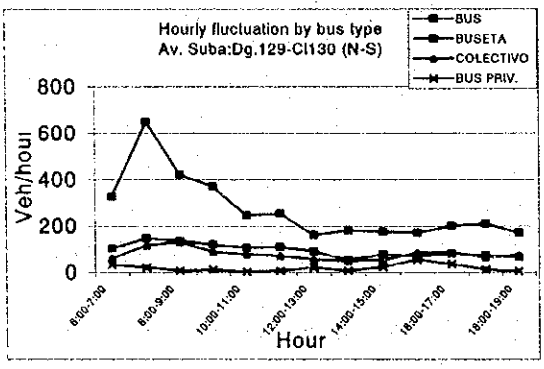


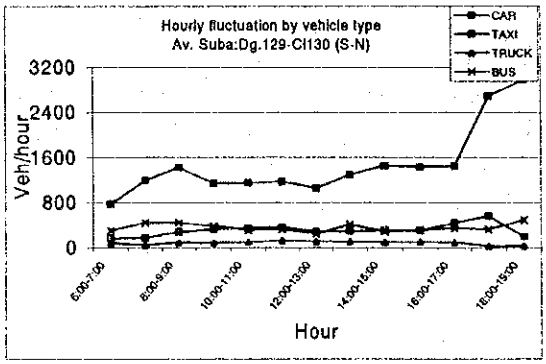
Figure 2.2-16 Description of Traffic Count Site (Av. Suba, Location 5)

1) North to South





2) South to North



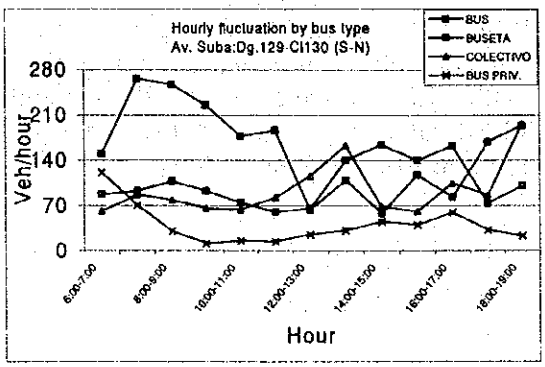


Figure 2.2-17 Hourly Fluctuation of Vehicles (Avenida Suba, Location 5)

(7) Traffic Volume on Avenida Circunvalar

Avenida Circunvalar is a mountainous road located at eastern end of the city along the oriental mountains. This road is mainly used to avoid traffic congestion in other arterial road such as Carrera 7a and Avenida Caracas. There is no public transport as there are no bus route designated to pass this road. Table 2.2-8 shows traffic volume in peak hour. On Av Circunvalar, most of the traffic is cars. Figure 2.2-19 shows hourly fluctuation of vehicles.

Table 2.2-8 Traffic Volumes in Peak Hours on Avenida Circunvalar

	Location	Location 11	
S -> N	Peak AM	11:00-12:00	
	Car	2005	(10%)
	Truck	33	(17%)
	Bus	0	(0%)
N -> S	Peak AM	8:00-9:00	
	Car	2420	(12%)
	Truck	2	(1%)
	Bus	0	(0%)
S -> N	Peak PM	17:00-18:00	
	Car	2121	(11%)
	Truck	14	(7%)
	Bus	0	(0%)
N -> S	Peak PM	17:00-18:00	
	Car	1625	(8%)
	Truck	27	(9%)
	Bus	0	(0%)

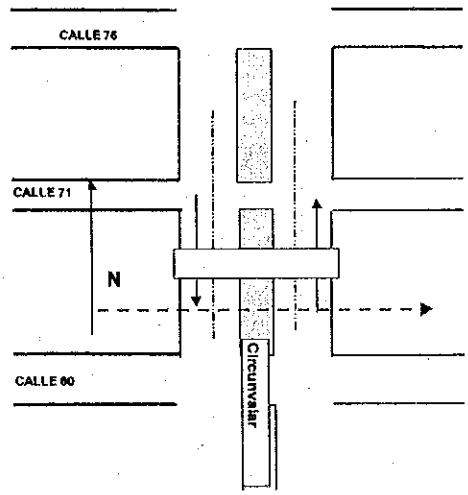
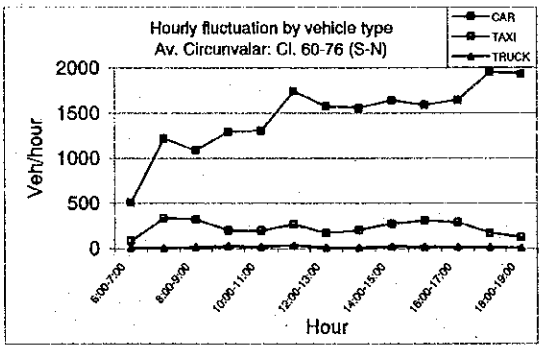


Figure 2.2-18 Description of Traffic Count Site



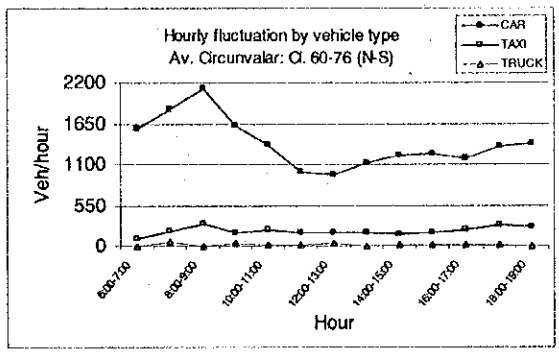


Figure 2.2-19 Hourly Fluctuation of Vehicles (Av. Circunvalar, Location 11)