14.2 Implementation Schedule and Investment

In Chapter 14.1, the following 67 projects are identified, based on the three (3) sector plans conceived as road, public transport, and traffic management plans.

1) Road Facilities Development Projects

a) Existing road improvement projects	9 Projects
b) Grade separated intersection project	1 Project
c) New road (At-grade) construction projects	18 Projects
d) Urban Expressway construction projects	3 Projects

2) Public Transport Development Projects

e) Trunk bus development projects	15 Projects
f) Express bus development projects	6 Projects
g) Bus terminal construction projects	2 Projects
h) Railway construction projects	2 Projects
i) Transport terminal projects	4 Project

3) Traffic Management Development Projects

j) Traffic management projects	9 Projects

In this section, the implementation schedule and investment cost per year are examined, based on the above mentioned 67 projects.

14.2.1 Basic Analysis for Identification of the Project Priority.

For identification of the project priority within the 67 projects, the following four (4) viewpoints of the projects are examined.

a) From the viewpoint of the economic effect of the project
b) From the viewpoint of the traffic improvement effect of the project
c) From the viewpoint of the characteristics of the project
d) From the viewpoint of the balance of annual investment

(1) From the Viewpoints of the Economic Effect

As shown in Figure 14.2-1, cost-benefit analyses (B/C) of the major projects are done for the identification of the priority of the project, in the Short, Mid, and Long Term Plans. The cost-benefit analyses (with and without project cases) is conducted based on the two (2) transport networks; one is the future transport network in 2020, and the other is the do-nothing (existing) transport network in 1995. In Figure 14.2-1, the horizontal axis of the figure shows the B/C ratio based on the future transport network and the vertical axis of figure shows the B/C ratio based on the existing transport network. In this figure, basically, projects with a high value of B/C ratio on both transport networks are selected for the Short Term Plan, and projects with a low value of B/C on both transport networks are selected for the Long Term Plan. From the viewpoints of economics, the following classification is defined:

1) For Short Term Projects

a) Autopista Medellin Improvement Project (RP-05)
b) Autopista Sur Improvement Project (RP-07)
c) Autopista Norte Improvement Project (RP-09)
d) Avenida Cundinamarca New Road Construction Project (RP-100)
e) Kennedy Area New Road Construction Project (RP-115)
f) Avenida San Jose New Road Construction Project (RP-105)

g) Avenida Cali New Road Construction Project (RP-101)
h) Engativa Area New Road Construction Project (RP-114)

2) For Long Term Projects

a) Avenida Usme Improvement Project (RP-04)
b) Norte Area New Road Construction Project (RP-109)
c) Bosa Area New Road Construction Project (RP-116)
d) Suba Area New Road Construction Project (RP-112)
e) Radial Urban Expressway Construction Project (HP-03)
f) Railway Construction Project (FP-01)
g) Railway Construction Project (FP-02)

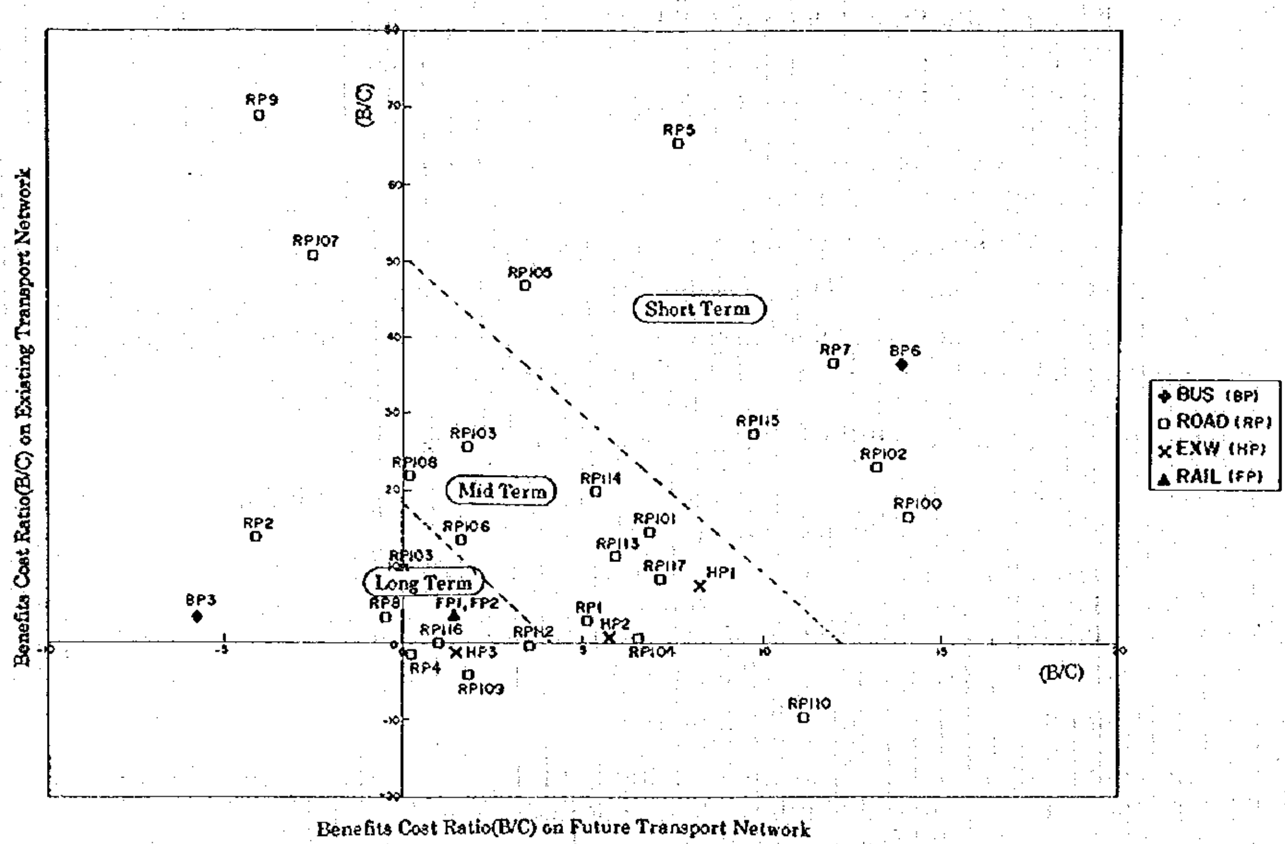


Figure 14.2-1 Economic Analysis of Each Project

(2) From the Viewpoints of Traffic Improvement Effects

Figure 14.2-2 shows the results of the travel speed comparison analysis between with and without projects, based on the existing transport network in 1995. Figure 14.2-3 shows the results of the travel speed comparison analysis between with and without project, based on the future transport network in 2020. From these figures, the following matters are pointed out.

1) Travel Speed Improvement Based on the Existing Transport Network

a) Average travel speed in 2020 on the existing transport network is estimated at about 7.1 km/h.
b) When railway project (FP-01) will be constructed, average travel speed is improved to 7.5 km/h.

c) Average travel speed on the Cundinamarca construction project is improved to 8.1 km/h.
d) Average travel speeds on the urban expressway (HP-01), Autopista Sur (RP-07), Avenida Americas (RP-107), and Avenida Suba Norte projects are improved to 7.3 km/h.
e) Considering the results of average travel speed on the projects, the above-mentioned projects are identified as higher traffic effect projects.

2) Travel Speed Improvement Based on the Future Transport Network

a) Average travel speed in 2020 on the future transport network is estimated at about 20 km/h.
b) If the Cundinamarca Construction project (RP-100) is not constructed, the average travel speed is decreased to 16 km/h.
c) When the urban expressway projects (HP-01 and HP-02) will not be constructed, the average travel speed is decreased to 18 km/h.
d) Without railway projects (FP-01 and FP-02) on the future transport network, the traffic service level will be down to 19 km/h.

Considering the results of travel speed analysis on major projects, the above-mentioned projects are identified as higher traffic effect projects.

(3) From the Viewpoint of the Characteristics of projects

1) Ongoing Projects

At present, there are many projects under construction or planned in Bogota, and these projects are controlled by IDU. Considering project progress report, prepared by IDU, the implementation program in the Master Plan should be identified. Basically, the ongoing projects are identified as Short Term Plan projects. The major ongoing projects prepared by IDU are as follows;

a) Existing road improvement projects(various road sections)
b) Avenida Cundinamarca construction project
c) Avenida Cali construction project
d) Grade-separated intersection(33vol.)
e) Bus trunk road improvement projects (various routes)
f) Side-walk improvement projects

2) Project Characteristics

The concept of traffic management plans is to prepare the plans implying no large additional land acquisition, easy construction, and comparatively small size. Considering these planning concepts, basically, the traffic management projects are identified as Short Term Plan.

The public transport network plan is formulated in accordance with future transport demand. The public transport plans are recommended as staging plans, such as the trunk bus system, express bus system, and railway system in accordance with demand increase. Considering the public transport planning concept, the trunk bus projects are identified as Short Term Plans.

(4) From the Viewpoint of a Balance of Investment

When preparing the implementation schedule for the Master Plan, the balance of investment is considered, due to the importance of continuous implementation of the projects in the future. The Short-Term period is 5 years, 1997 to 2001, Mid Term is 10

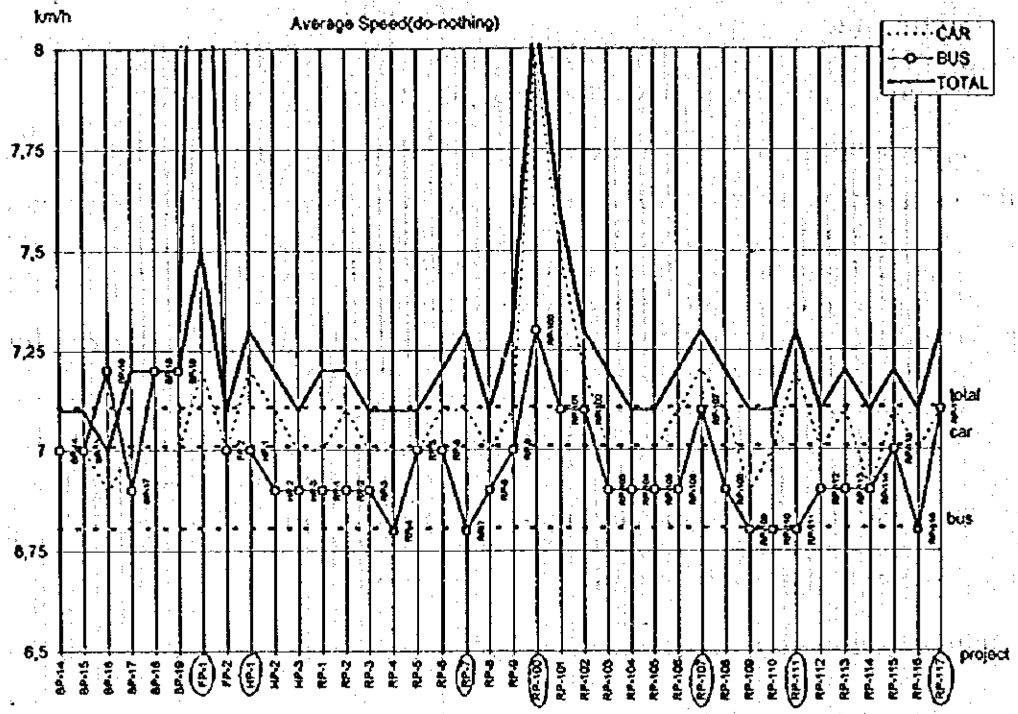


Figure 14.2-2 Average Travel Speed on Existing Transport Network

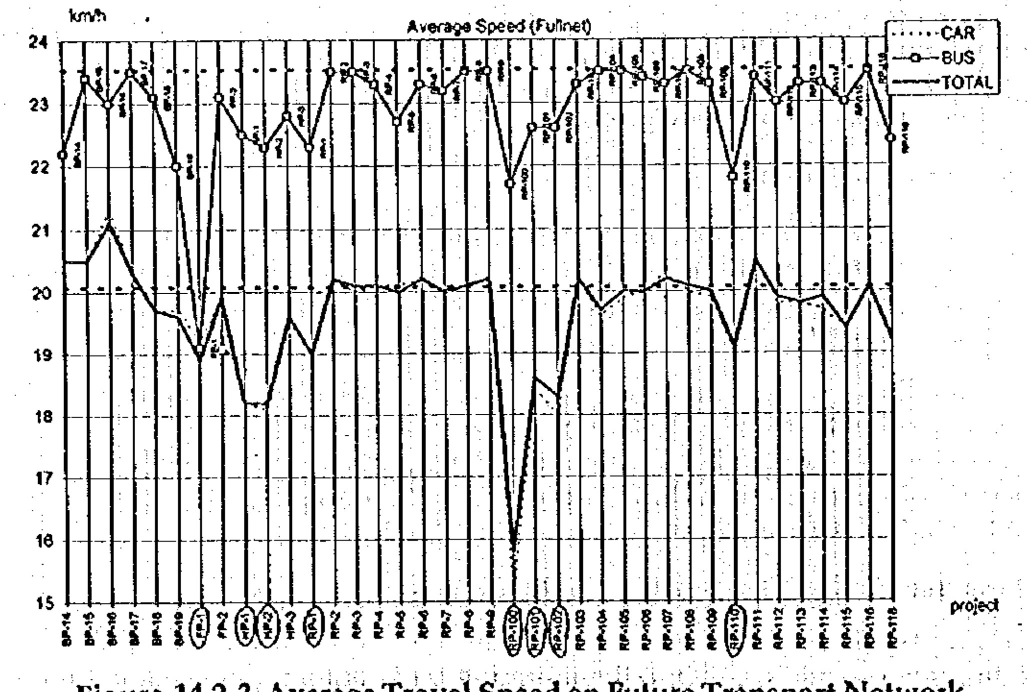


Figure 14.2-3 Average Travel Speed on Future Transport Network

years, 2002 to 2010, and Long Term is 10 years, 2011 to 2020. Considering economic growth in Bogota (annual growth ratio is 5 %), the following balance of percentages is desired for each term.

a) Short Term ------------------13 %
b) Mid Term--------------------33 %
c) Long Term ------------------54 %

14.2.2 Implementation Program and Investment

Based on the policy for the preparation of the implementation schedule, and full discussion with members of Steering Committee and Counterpart personnel of Colombia, the implementation program and investment by year for the Comprehensive Urban Transport Master Plan are identified as shown in Figure 14.2-4. Location maps of projects by each stage of implementation program are shown in Appendix Figures A-1, A-2 and A-3 in which the project Nos. represent the project locations. The arrangement of investment by year is shown in Figure 14.2-5.

(1) Short-Term Plan

According to the implementation program, the comprehensive urban transport network for the Short Term Plan (in 2001) is shown in Figure 14.2-6, and the results of traffic volume assignment to the transport network in 2001 are shown in Figure 14.2-7. The total investment of the Short-Term Plan is estimated at US$ 2,105 million, and this is 22.8 % of total investment.

(2) Mid Term Plan

The comprehensive urban transport network for the Mid Term Plan (in 2010) is shown in Figure 14.2-8, and the results of traffic assignment to the transport network in 2010 are shown in Figure 14.2-9. The investment for the Mid Term is estimated at US$ 2,782 million, and this is 30.1 % of total investment.

(3) Long Term Plan

The comprehensive urban transport network for the Long-Term Plan (in 2020) is shown in Figure 14.2-10, and the results of traffic volume assignment to the transport network in 2020 are shown in Figure 14.2-11. The investment for the Long Term is estimated at US$ 4,353 million, and this is 47.1 % of total.

(4) Comments on Implementation Program

As shown in Figure 14.2-4 and 14.2-5, the implementation schedule and investment cost for Comprehensive Urban Transport Master Plan are identified. However, the following three (3) comments are offered for a further study.

1) In accordance with the implementation program, the Railway Project(FP-01) will be completed in 2015, based on the examination of public transport demand and the capacity of public transport modes. Construction of the railway route No. 1 will take less than five years, excluding detailed design period, because it needs for land acquisition and the underground section is not so long. However, considering the importance of strengthening the public transport system, a more detailed study covering railway alignment, facilities, and the implementation schedule of Railway Projects should be conducted.

Project Name	Project Size	Project Cost (1000 US$)
Traffic Management Projects		
MP-1 At-Grade Intersection	34 vol	1,474
MP-2 Traffic Facilities	13 vol	44,930
MP-3 Traffic Education	1 unit	1,572
MP-4 Parking Facilities	14 Places	82,366
MP-5 Traffic Cell	1 vol	16,155
MP-6 Pedestrian Mall (Calle 85)	1 vol	11,620
MP-7 Bicycle Road	23.1 km	23,100
MP-8 Carrera 15 Pedstrian Mall	1.50 km	20,000
MP-9 Av. Jimeneze Ped. Mall	1.50 km	25,000
Bus Troncal Projects		
BP-1 Cra. 7ª	21.40 km	1,700
BP-2 Av. Caracas	37.50 km	2,300
BP-3 Av. Cuidad de Quito	28.80 km	2,900
BP-4 Cra. 68	15.90 km	1,600
BP-5 Av. Boyaca	24.50 km	2,500
BP-6 Calle 22S/ Av. 1ºde Mav.	11.00 km	900
BP-7 Villa del Rio-Cundinamarca	9.50 km	25,800
BP-8 Av. de Las Americas	8.20 km	800
BP-9 Av. Centenario	13.40 km	1,300
BP-10 Av. Ciudad de Lima	4.00 km	400
BP-11 Autopista El Dorado	13.40 km	1,100
BP-12 Calle 68/ Av. 68	6.60 km	500
BP-13 Av. 78 / Av. 81	10.30 km	1,000
BP-14 Av. Suba	5.40 km	400
BP-15 Calle 170	4.90 km	400
Mass Transit Projects		
BP-16 Av. Caracas - South Line	18.99 km	9,900
BP-17 Av. Caracas - North Line	9.24 km	112,800
BP-18 Av. Boyaca	18.39 km	5,800
BP-19 Av. Boyaca - P. El Tuna	4.98 km	500
BP-20 Autopista Medellin	14.95 km	5,500
BP-21 Av. Lima - West Line	12.83 km	63,500
FP-1 Line No.1 (Ato. Norte Av. Quito-Atp. Sur)	32.00 km	2,275,000
FP-2 Extension of Line No.1 (Co Chia)	8.00 km	201,000
Terminal Projects		
BT-1 Main Bus Terminal	1 vol	40,000
BT-2 Sub-Bus Terminal	8 vol	48,000
BT-3 Feeder Bus Terminal	7 vol	14,000
BT-4 Truck Terminal	1 vol	20,000
Existing Road Improvement Projects		
RP-1 Centro Road Imp.	30.00 km	144,955
RP-2 Santa Monica Rd Imp.	17.80 km	70,129
RP-3 Fontibon Rd. Imp.	9.40 km	49,128
RP-4 Usme Rd. Imp.	37.90 km	155,124
RP-5 Medellin Rd. Imp.	12.08 km	47,975
RP-6 Centenario Rd. Imp.	10.92 km	43,368
RP-7 Sur Rd. Imp.	9.10 km	36,140
RP-8 7ª Rd. Imp.	9.54 km	63,410
RP-9 Norte Rd. Imp.	9.15 km	36,338
RP-10 Grade Separeted IC Imp.	34 vol	136,000
New Road Construction Projects		
RP-100 Cundinamarca Rd.	40.62 km	734,230
RP-101 Cali Rd.	35.03 km	451,002
RP-102 Suba - Kennedy	34.36 km	288,600
RP-103 Suba Extension	12.28 km	155,929
RP-104 Norte - Estoril	16.36 km	130,392
RP-105 San Jose	7.12 km	85,590
RP-106 Centenario	10.21 km	106,722
RP-107 Americas	5.91 km	105,396
RP-108 1º de Mavo	5.95 km	57,258
RP-109 Norte	22.00 km	175,370
RP-110 Villa Cristina	22.97 km	222,414
RP-111 Suba Norte Area	18.02 km	117,029
RP-112 Suba Area	29.10 km	182,599
RP-113 Barious Unidos	6.93 km	122,291
RP-114 Engativa Area	13.90 km	88,074
RP-115 Kennedy Area	24.20 km	174,316
RP-116 Bosa Area	14.80 km	75,536
RP-117 Usme Area	60.20 km	268,753
Urban Expressway Projects		
HP-1 1st Rind	17.65 km	511,329
HP-2 2nd Ring	23.89 km	666,939
HP-3 Radial	22.97 km	671,307
Total of Each Target Years		Million US$ 9,239

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Sub-Total	0	231	411	497	562	403	288	241	259	274	265	357	298	398	406	424	366	399	396	393	422	446	456	508	553
Total of Each Target Years	Short Term: 2,105						Medium Term: 2,782									Long Term: 4,353									

Note: Preparation Work Period
Construction Work Period
Possible Construction Work

Figure 14.2-4 Implementation Schedule for Master Plan

2) The traffic management plans are prepared as a Short Term Plan. These plans should be reviewed in accordance with the changing traffic conditions in Bogota, and traffic management plans should be implemented continuously.

3) Considering the balance of investment cost among the three stages, the implementation schedule is identified. However, the investment cost of the Short Term is higher than that of the Mid Term. It is required that the budget for implementation of the Short Term Plan should be reinforced by the Government of Colombia.

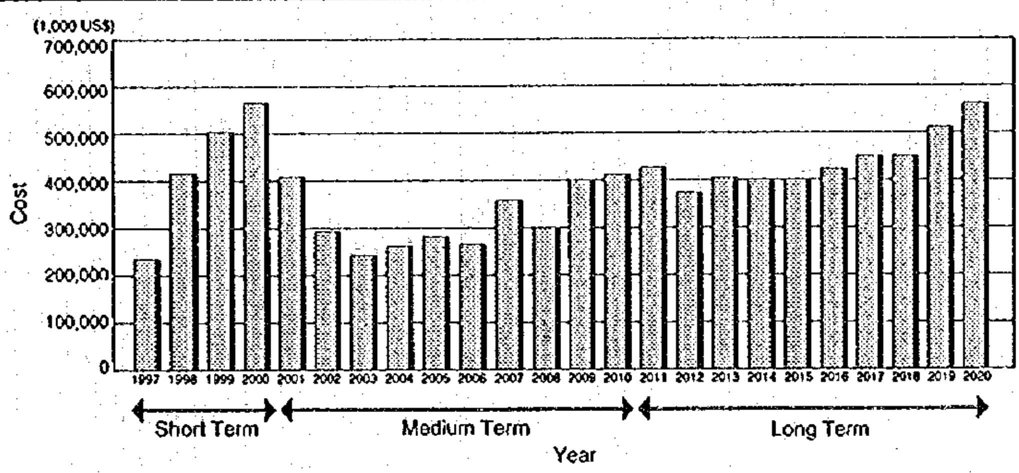


Figure 14.2-5 Arrangement of Investment Cost by Year

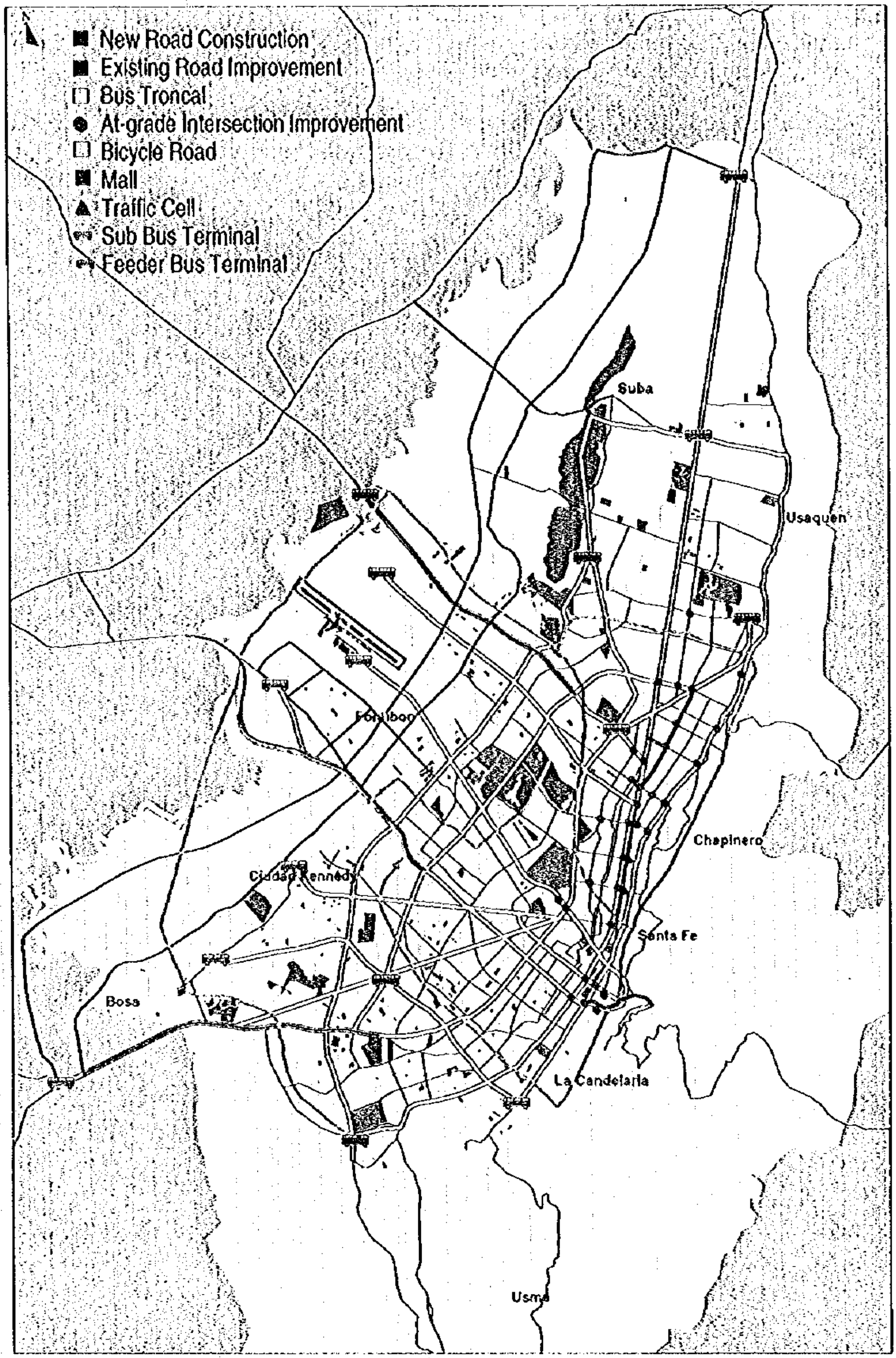


Figure 14.2-6 Short Term Plan for the Comprehensive Urban Transport Master Plan

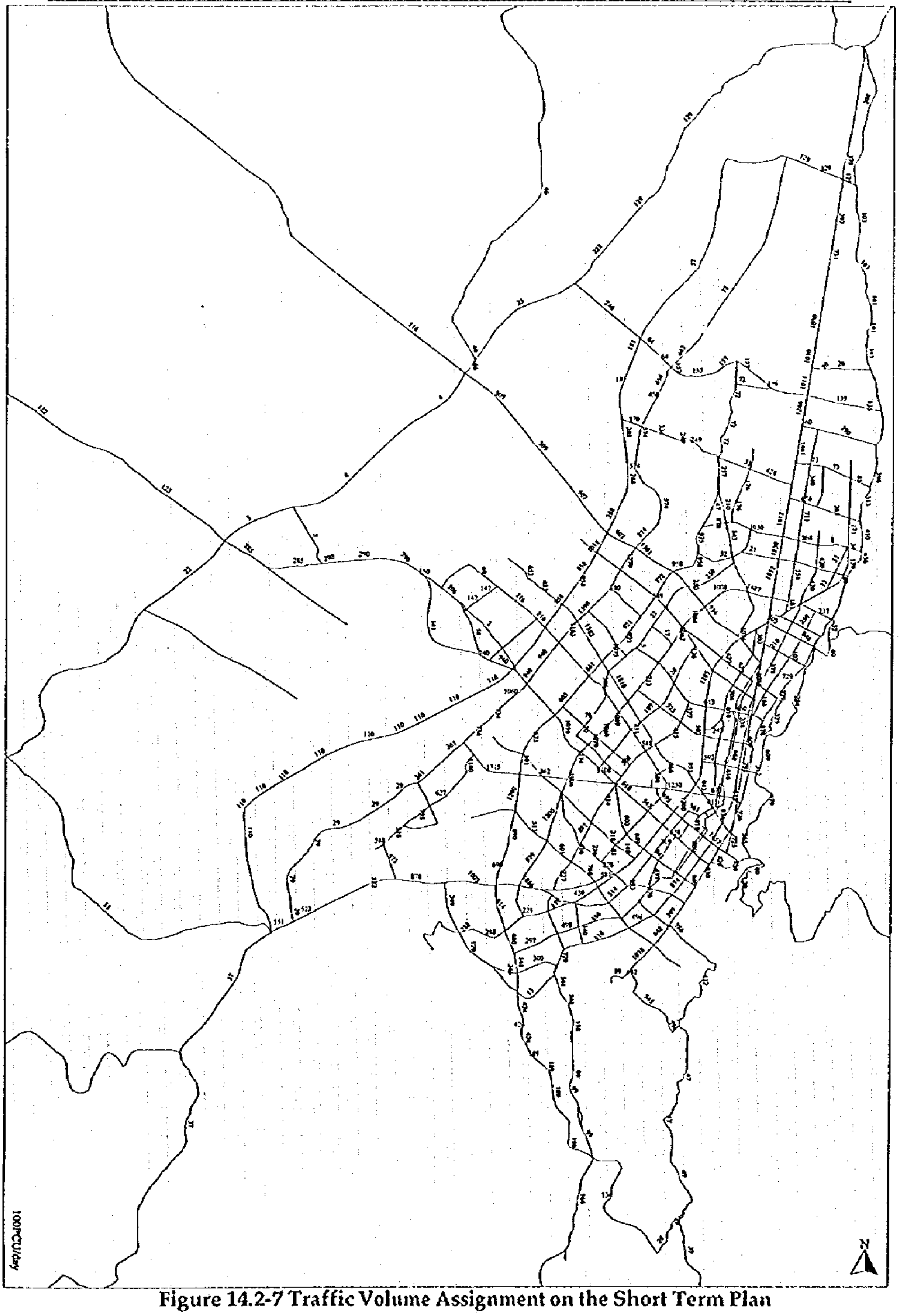


Figure 14.2-7 Traffic Volume Assignment on the Short Term Plan

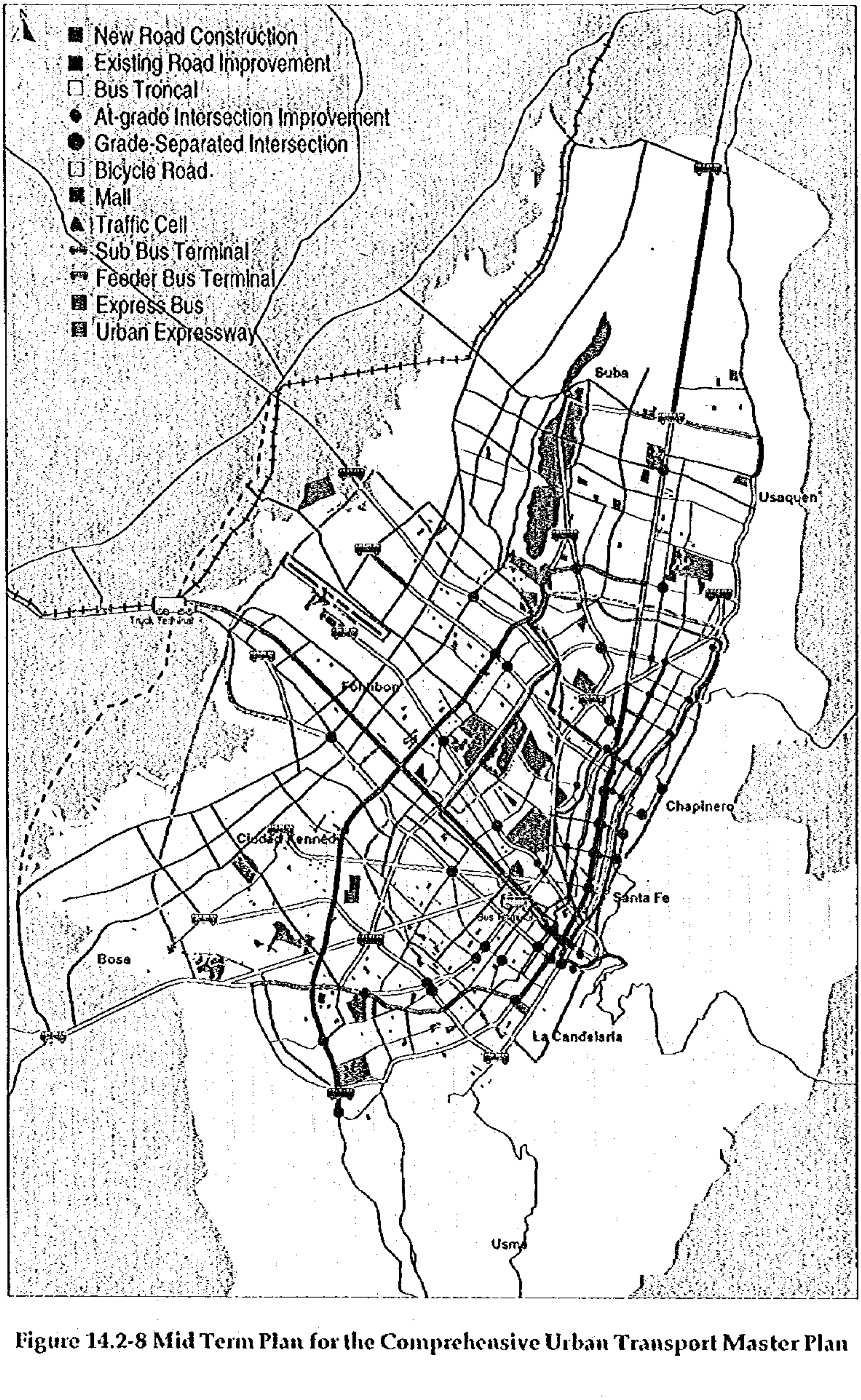


Figure 14.2-8 Mid Term Plan for the Comprehensive Urban Transport Master Plan

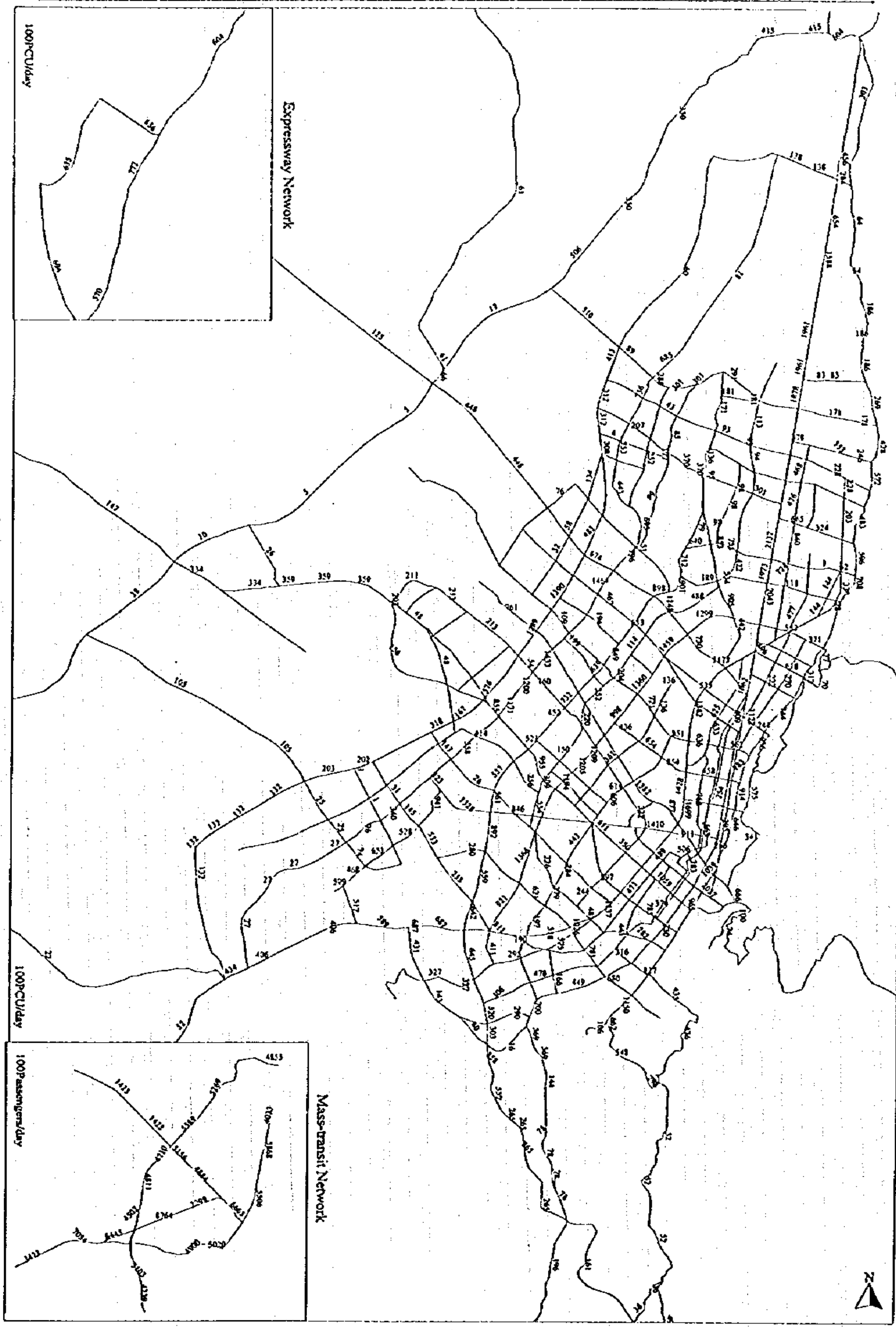


Figure 14.2-9 Traffic Volume Assignment on the Mid Term Plan

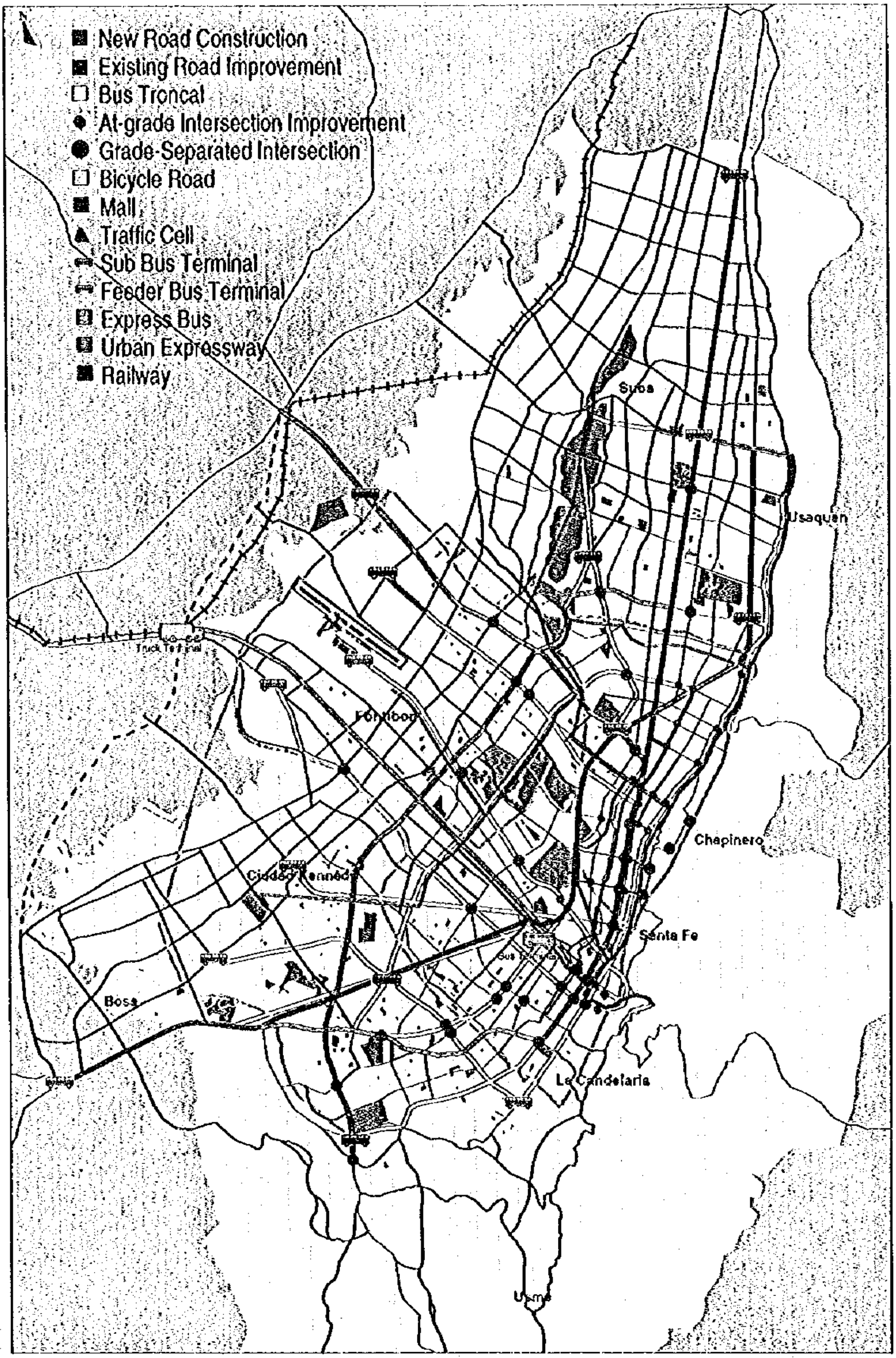


Figure 14.2-10 Long Term Plan for the Comprehensive Urban Transport Master Plan

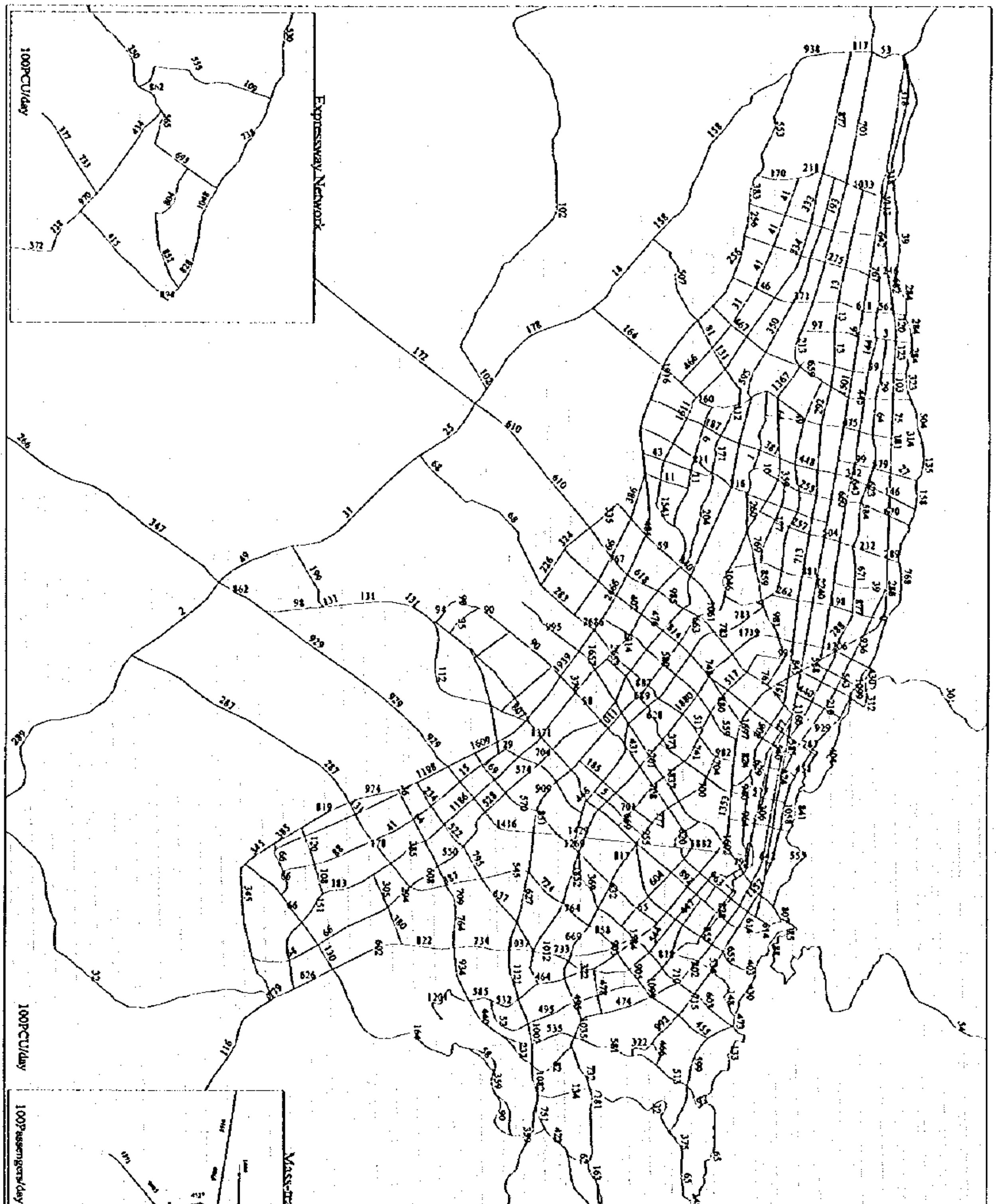


Figure 14.2-11 Traffic Volume Assignment on the Long Term Plan

CHAPTER 15
Evaluation of Comprehensive Urban Transport Master Plan

15. EVALUATION OF THE COMPREHENSIVE URBAN TRANSPORT MASTER PLAN

The Urban Transport Master Plan, which consists of various projects/project packages, has been examined from various viewpoints in order to compare some alternatives and justify a proposed Master Plan, in the each course of the planning stage of the Study.

The major aspects for the evaluation are;

a) Economic aspects,
b) Financial aspects,
c) Environmental aspects,
d) Technical aspects, etc.

In addition to examinations from these aspects, the final evaluation are conducted from a comprehensive/integrated viewpoint, and the most recommendable package of plans can be determined as the Master Plan.

In the interim stage, an economic evaluation of the 17 alternative transport network plans, which were proposed mostly based on technical/traffic demand considerations, was conducted. The purpose of the evaluation at that stage was not to judge the absolute feasibility of the proposed projects but to provide relative indicator for a further discussion on the comparison of Master Plan components.

In the meantime, the evaluation of the proposed Master Plan is conducted in this chapter in the same manner as in the interim stage, from the various viewpoints, as mentioned above.

15.1 Economic Evaluation

15.1.1 General Methodology

'Benefit/Cost (B/C)' analysis was applied both for evaluations of the 17 alternative transport network plans, and of the proposed Master Plan from general economic viewpoints. This methodology is very common for this purpose, and an overall work-flow of B/C analysis is illustrated in Figure 15.1-1.

The benefit and cost, which would be brought about by the implementation of the proposed projects, are measured at economic prices, and compared between the 'with project' and 'without project' cases.

As benefits accruing from a project and contributing to the national/regional economy, some quantifiable factors are examined, such as reductions of vehicle operating cost, travel time cost and so on. On the other hand, the cost is the monetary expression of the real consumption of goods and service to implement the project. Therefore, all the transfer cost, such as tax and subsidy, be deducted from the benefit and cost.

15.1.2 Economic Benefits

A variety of benefits, direct or indirect, can be expected by the implementation of urban transport improvement projects. For example, mitigation of traffic congestion and improvement of travel speed are significant as direct benefits, and other benefits are also recognized; such as improvements in accessibility, safety and comfort for urban transport users, and moreover the stimulation of the urban development potential.

In this study, however, two items of quantifiable benefits which are definitely known to exist and are well-studied for quantification purposes are examined. That is, savings in vehicle operating cost (VOC) and savings in passengers' travel time cost (TTC).

Benefits of the project are measured through so-called 'with project' and 'without project' comparison. Based on the results of the future traffic assignment to both transport networks, with projects (with improvement) and without projects (do-nothing), the total of VOC and TTC in each case is calculated and compared. And the benefit of the projects is obtained as the difference between the two cases: savings of costs; total cost of 'without' case minus (-) 'with' case.

For this calculation, usually both unit costs of VOC and TTC are examined.

a) VOC: Vehicle operating cost per unit distance and per unit time by type of vehicles, and
b) TTC: Travel time cost per unit time by passenger/trip purpose.

They are expressed as a function of running speed, and total transport cost is obtained as the sum of VOCs and TTCs at each link of transport network, where the running speed is estimated, with reference to the assigned/estimated traffic volume. An example of unit cost analysis is summarized as follows:

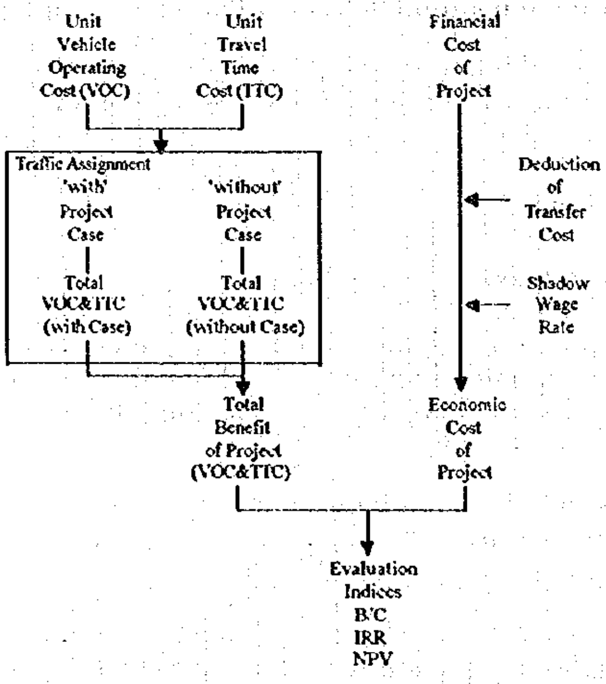


Figure 15.1-1 Overall Work-flow of Benefit/Cost Analysis

(1) Vehicle Operating Cost

This is a main source of economic benefits of a transport project and is estimated by type of vehicle, such as passenger car, taxi, small-bus, bus, light truck and truck. VOC is usually composed of the following items:

a) Fuel cost
b) Oil cost

c) Tire cost
d) Maintenance cost
e) Depreciation cost
f) Capital opportunity cost and
g) Crew and overhead cost

1) Selection of a Representative Vehicle

Because there are many different makes and models of vehicle actually running in the Study Area, and unit VOCs vary by makes/models and also vehicle age, one of the most popular model is selected as a representative and its VOCs are examined, for the convenience of the analysis.

The economic cost of each representative vehicle is calculated; financial cost (market price) less taxes, together with some necessary characteristics such as tire type, fuel type, vehicle life, etc.

Table 15.1-1 Characteristics of Representative Vehicles

	Car	Taxi	Buseta	Bus	Light Truck	Truck
1.Representative Model	Mazda 323NX	Chevrolet Chevette	International 1652 4x2	Chevrolet 4700 DT	Chevrolet Luv 4x4	International 4700 DT
2.Cost (000$)						
1) Financial	17,734	12,666	35,500	43,500	22,215	52,950
2) Economic*	11,740	10,920	30,600	37,500	19,150	45,650
3.No. of Tires	4	4	6	6	4	6
4.Fuel Type	Gasoline	Gasoline	Diesel	Diesel	Gasoline/Diesel	Gasoline/Diesel
Note: * = excluding IVA(value added tax), Import duty, etc.						
Import Duty	35%	0	0	0	0	0
IVA	16%	16%	16%	16%	16%	16%

2) Fuel Cost

The fuel price in the economic cost is calculated by type of fuel such as regular gasoline, premium, diesel, LPG, etc., deducting taxes from market prices. Since the fuel consumption rate depends on vehicle running speed, fuel cost per kilometer at each level of running speed is estimated based on the fuel consumption rate by vehicle type.

Table 15.1-2 (1) Cost of Fuel, 1996

($/litter)

Cost \ Type of Fuel	Regular Gasoline	Super Gasoline	Diesel	Liquid Propane Gas
Financial Cost	272	363	240	148
Tax (%)	32 (13)	42 (13)	0	0
Economic Cost	240	321	240	148

Table 15.1-2 (2) Fuel Composition and Average Fuel Cost by Vehicle Type

Type of Vehicle \ Type of Fuel	Regular Gasoline	Super Gasoline	Diesel	LPG	Average Fuel Cost (Economic: $/litter)
Car	55	45	-	-	276.5
Taxi	80	-	20	-	240.0
Buseta	20	-	80	-	240.0
Bus	20	-	80	-	228.1
Light Truck	80	-	20	-	240.0
Truck	50	-	50	-	228.1

Table 15.1-2 (3) Fuel Consumption by Vehicle Type

Speed (km/hr)	Car	Taxi	Buseta	Bus	Light Truck	Truck
Fuel Consumption Rate (litter/1,000Km)						
5	216.6	216.6	337.2	672.7	605.2	1,210.4
10	138.6	138.6	215.8	430.4	387.3	774.5
20	100.2	100.2	156.0	311.2	280.0	560.0
30	87.0	87.0	122.2	284.2	235.0	412.0
40	80.2	80.2	107.9	264.5	225.0	342.0
50	78.4	78.4	101.4	284.2	220.0	314.0
60	81.0	81.0	97.5	326.1	225.0	303.0
70	85.7	85.7	98.2	380.9	230.0	314.0
80	92.7	92.7	102.0	438.1	250.0	340.0
90	102.4	102.4	112.7	483.9	276.2	375.6
Fuel Cost ($/Km)						
5	59.9	52.0	80.9	153.4	145.2	276.1
10	38.3	33.3	51.8	98.2	93.0	176.7
20	27.7	24.0	37.4	71.0	67.2	127.7
30	24.1	20.9	29.3	64.8	56.4	94.0
40	22.2	19.2	25.9	60.3	54.0	78.0
50	21.7	18.8	24.3	64.8	52.8	71.6
60	22.4	19.4	23.4	74.4	54.0	69.1
70	23.7	20.6	23.6	86.9	55.2	71.6
80	25.6	22.2	24.5	99.9	60.0	77.6
90	28.3	24.6	27.0	110.4	66.3	85.7

3) Oil Cost

Lubricant oil cost, in economic pricing, is also estimated in the same manner as fuel cost calculation.

Table 15.1-3 Oil Consumption by Vehicle Type

Speed	Car & Taxi	Buseta	Bus	Light Truck	Truck
Oil Consumption Rate (litter/1,000Km)					
5	3.48	4.10	8.01	6.86	8.01
10	2.24	2.63	5.14	4.40	5.14
20	1.54	1.81	3.54	3.03	3.54
30	1.27	1.49	2.92	2.50	2.92
40	1.13	1.33	2.68	2.22	2.68
50	1.10	1.29	2.58	2.08	2.58
60	1.09	1.28	2.36	1.80	2.36
70	1.07	1.26	2.14	1.68	2.14
80	1.00	1.18	1.87	1.52	1.87
90	0.90	1.06	1.68	1.37	1.68
Oil Cost ($/Km)					
5	7.6	9.0	17.5	15.0	17.5
10	4.9	5.8	11.3	9.6	11.3
20	3.4	4.0	7.8	6.6	7.8
30	2.8	3.3	6.4	5.5	6.4
40	2.5	2.9	5.9	4.9	5.9
50	2.4	2.8	5.7	4.6	5.7
60	2.4	2.8	5.2	3.9	5.2
70	2.3	2.8	4.7	3.7	4.7
80	2.2	2.6	4.1	3.3	4.1
90	2.0	2.3	3.7	3.0	3.7

4) Tire Cost

Tire cost is estimated as one of the representative consumable parts of vehicles. Since this depends also on running speed, average tire life and road surface conditions, the estimate is conducted based on some experiential rate of consumption by running speed.

5) Maintenance Cost

The rate of annual maintenance cost against to the vehicle price (without tire price) is assumed based on experience, and the maintenance cost per kilometer can be calculated considering the annual running distance.

Table 15.1-4 Tire Cost

Tire Cost

Items	Car	Taxi	Buseta	Bus	Light Truck	Truck
No. of Tires	4	4	6	6	6	6
Type of Tire	175-70R13	175-70/13	750-16	900-20 1000-20	750-16	900-200
Market Price ($/unit)	103,200	68,800	119,500	297,500	119,500	226,600
Tax 16%						
Economic Cost ($/set)	355,862	237,241	412,069	1,025,862	618,103	781,379
	356	237	412	1026	618	781

Tire Consumption Rate and Tire Cost

	Car	Taxi	Buseta	Bus	Light Truck	Truck
Tire Life (Kilometers)	45,000	45,000	45,000	50,000	45,000	50,000
Tire Consumption Rate (% per 1,000Km)	8.9	8.9	13.3	12.0	13.3	12.0
Tire Cost at Av. speed	7.918	5.279	9.134	20.517	13.701	15.628
Tire Consumption Indices (56Km/h=100)						
Speed (Km/h)						
5	53	53	53	53	53	53
10	56	56	56	56	56	56
20	60	60	60	60	60	60
30	67	67	67	67	67	67
40	78	78	78	78	78	78
50	92	92	92	92	92	92
60	107	107	107	107	107	107
70	125	125	125	125	125	125
80	151	151	151	151	151	151
90	180	180	180	180	180	180
Tire Cost						
5	4.2	2.8	4.8	10.9	7.3	8.3
10	4.4	3.0	5.1	11.5	7.7	8.8
20	4.8	3.2	5.5	12.3	8.2	9.4
30	5.3	3.5	6.1	13.7	9.2	10.5
40	6.2	4.1	7.1	16.0	10.7	12.2
50	7.3	4.9	8.4	18.9	12.6	14.4
60	8.5	5.6	9.8	22.0	14.7	16.7
70	9.9	6.6	11.4	25.7	17.1	19.5
80	12.0	8.0	13.8	31.0	20.7	23.6
90	14.3	9.5	16.4	36.9	24.7	28.1

Table 15.1-5 Maintenance Cost by Vehicle Type

	Car	Taxi	Buseta	Bus	Light Truck	Truck
Economic Cost (000$) of						
Vehicle	11,740	10,920	30,600	37,500	19,150	45,650
A Set of Tires	356	237	412	903	412	781
Vehicle w/o Tires	11,384	10,683	30,188	36,597	18,738	44,869
Annual Maintenance Cost						
% of Vehicle Cost	4.0	8.0	8.0	8.0	4.0	8.0
Maintenance Cost /year	455.4	854.6	2,415.0	2,927.7	749.5	3,589.5
Annual Kilometerage	23,000	60,000	52,000	52,000	30,000	75,000
Average Speed (Km/h)	35	35	20	20	35	40
Maintenance Cost at Average Speed ($/Km)	19.8	14.2	46.4	56.3	25.0	47.9
Maintenance Cost Indices (Av. Speed=100)						
5	141	141	119	128	138	191
10	133	133	112	118	130	176
20	118	118	100	100	116	149
30	105	105	89	80	103	120
40	95	95	84	67	97	100
50	94	94	83	65	96	97
60	100	100	89	71	103	105
70	108	108	95	79	110	117
80	115	115	101	90	117	134
90	122	122	107	101	124	150
Maintenance Cost ($/Km)						
5	27.9	20.0	55.2	72.1	34.5	91.5
10	26.3	18.9	52.0	66.4	32.5	84.3
20	23.4	16.8	46.4	56.3	29.0	71.4
30	20.8	14.9	41.3	45.0	25.8	57.5
40	18.8	13.5	39.0	37.7	24.3	47.9
50	18.6	13.3	38.5	36.6	24.0	46.5
60	19.8	14.2	41.3	40.0	25.8	50.3
70	21.4	15.3	44.1	44.5	27.5	56.0
80	22.8	16.3	46.9	50.7	29.3	64.2
90	24.2	17.3	49.6	56.9	31.0	71.9

6) Depreciation Cost

The depreciable amount of vehicles is defined as the vehicle economic cost less salvage cost after the vehicle life period and salvage value is estimated under local conditions. This amount is also divided into two; depreciation subject to use and subject to time.

Table 15.1-6 Depreciation Cost by Vehicle Type

	Car	Taxi	Busets	Bus	Light Truck	Truck
Economic Cost (1,000$) of						
Vehicle						
A Set of Tires						
Vehicle w/o Tires	11,384	10,683	30,188	36,597	18,738	44,869
Salvage Value (%)	25	15	15	15	20	15
Annual Kilometerage	23,000	60,000	52,000	52,000	30,000	75,000
Average Speed (Km/h)	35	35	20	20	35	40
Vehicle Life (year)	12	12	10	12	12	12
Depreciable Amount (1,000$)						
Dep. subject to use	4,269	6,356	17,962	21,775	10,493	26,697
Dep. subject to time	4,193	2,724	7,698	9,332	4,497	11,441
Total	8,538	9,080	25,660	31,107	14,990	38,138
	15.46757871	8.828113027	34.54195955	34.89575044	29.14789272	29.66314368
Indices for Depreciation Cost subject to Use (Av. Speed=100)						
5	131	131	114	121	129	168
10	125	125	109	114	123	157
20	114	114	100	100	112	137
30	104	104	92	85	102	115
40	96	96	88	75	98	100
50	96	96	87	74	97	98
60	100	100	92	78	102	104
70	106	106	96	84	108	113
80	111	111	101	92	113	125
90	116	116	105	101	118	138
Depreciation Cost subject to Use ($/Km)						
5	20.3	11.6	39.4	42.2	37.6	49.8
10	19.3	11.0	37.6	39.8	35.9	46.6
20	17.6	10.1	34.5	34.9	32.6	40.6
30	16.1	9.2	31.8	29.7	29.7	34.1
40	14.9	8.5	30.4	26.2	28.6	29.7
50	14.9	8.5	30.0	25.8	28.3	29.1
60	15.5	8.8	31.8	27.2	29.7	30.8
70	16.4	9.4	33.2	29.3	31.5	33.5
80	17.2	9.8	34.9	32.1	32.9	37.1
90	17.9	10.2	36.3	35.2	34.4	40.9
Depreciation Cost subject to Time ($/day)						
	957	622	2,109	2,131	1,027	2,612

7) Capital Opportunity Cost

This cost is not affected by use but only as time passes, and is determined by vehicle price, life period, salvage value rate and interest rate.

Table 15.1-7 Capital Opportunity Cost by Vehicle Type

	Car	Taxi	Buseta	Bus	Light Truck	Truck
Capital Cost (1,000$)						
Economic Cost of Vehicle	11,740	10,920	30,600	37,500	19,150	45,650
SalvageValue (%)	25	15	15	15	20	15
Vehicle Life (year)	12	12	10	12	12	12
Capital Recovery Factor at 12% of Interest Rate	0.1614	0.1614	0.1770	0.1614	0.1614	0.1614
Capital Opportunity Cost	794.9937	784.6748	2002.7700	2694.6250	1336.4147	3280.2568
($/day)	2,178	2,150	5,487	7,383	3,661	8,987

8) Crew Cost and Overhead Cost

This cost is also affected only by time, consisting of taxi/bus/truck drivers' wages and their overhead.

Table 15.1-8 Crew Cost and Overhead Cost by Vehicle Type

	Car	Taxi	Buseta	Bus	Light Truck	Truck
Annual Crew and Overhead Cost (1,000$/year)						
Crew Cost	-	5,040	4,200	4,560	-	7,200
Overhead Cost	-	1,560	3,360	4,800	-	5,400
Total	-	6,600	7,560	9,360	-	12,600
Daily Cost ($/day)						
Crew Cost	-	13,808	11,507	12,493	-	19,726
Overhead Cost	-	4,274	9,205	13,151	-	14,795
Total	-	18,082	20,712	25,644	-	34,521

The unit VOC is finally obtained, in the two different categories; distance-related cost and time-related cost, as a result aggregating each item explained above.

Table 15.1-9 Vehicle Operating Cost, 1996

(1) VOC subject to use, Modified Vehicle Type

(per Vehicle; $/km)

km/hr	Car	Taxi	Bus	Truck
5	119.9	94.0	228.6	375.4
10	93.3	71.0	179.8	277.9
20	76.8	57.4	147.8	219.1
30	69.0	51.3	129.4	177.1
40	64.5	47.8	120.3	156.5
50	64.8	47.9	121.6	152.2
60	68.5	50.5	131.0	157.5
70	73.7	54.2	142.9	168.6
80	79.7	58.5	157.6	186.4
90	86.6	63.6	172.6	206.6

(2) VOC subject to time, (per Vehicle;$/day)

	Car	Taxi	Bus	Truck
Depriciation	957	622	2,117	2,084
Capital Opportunity Cost	2,178	2,150	6,183	7,212
Crew & Overhead Cost	-	18,082	22,523	34,521
Total ($/day)	3,135	20,854	30,823	43,817
($/hr)	131	869	1,284	1,826
($/hr)	5.4	36.2	53.5	76.1

(2) Travel Time Cost

In general, a traveler's time value is defined based on his productivity. The time value of people in the study area is estimated using household income data obtained by the person trip survey.

In this study, it is analyzed by car-ownership, trip purpose, etc., and future cost is estimated in accordance with the estimated growth of per capita GDP. The summary of the process and results is tabulated in Tables below:

Table 15.1-10 Present Hourly Income and Travel Time Value

Hourly Income By Car Ownership

Car Ownership	Family Income ($/month)	No. of Earners (person/HH)	Working Hours (hours/month)	Hourly Income ($/hr/person)
Car Owning (29.6%)	923,518	2.0	160	2,886
Non-car Owning (70.6%)	353,023	1.8	160	1,226
Average	521,914	1.9	160	1,717

Working Hours = 8hrs/day x (5/7 x 30 - 18holidays/12 month)

Travel Time Value

	Car Users	P.T. Passenger	Average
1. per Person			
1) Hourly Income	2,886	1,226	1,717
2) Time Value ($/hr)			
(1) Business Trip (1.0)*	2,886	1,226	1,717
(2) School Trip (0.0)*	0	0	0
(3) Other Trip (0.2)*	577	245	343
3) Trip Composition (%)			
(1) Business Trip	7.5	5.7	6.4
(2) School Trip	14.6	11.8	12.7
(3) Other Trip	77.9	82.5	80.9
(4) Total	100.0	100.0	100.0
4) Weighted Average Travel Time Value	666	272	388
2. per Vehicle			
(1) Average Occupancy	1.66	21.46	-
(2) Time Value per Vehicle	1,106	5,840	-

*: Estimated weight for time value by trip purpose, following the result of Cartagena study, JICA 1992.

Table 15.1-11 Travel Time Cost

($)

Travel Time Cost ¥ Year	1995	2000	2010	2020
1. per Person				
1) Car & Taxi Users	666	779	1,066	1,659
2) Public Transport Users	272	341	498	824
2. per Vehicle				
1) Car & Taxi Users	1,106	1,294	1,769	2,753
2) Public Transport Users	5,840	7,318	10,687	17,683

15.1.3 Economic Cost of Proposed Projects

Since investment in each transport project, initially, is estimated at the market price; so-called financial cost- must be converted into economic cost in order to compare it with the economic benefit. Major processes of conversion, from financial to economic cost are:

a) Break-down of construction cost into three items: material cost, equipment cost and labor cost.
b) Deduction of taxes such as import duty, value added tax and consumption tax from material and equipment costs.
c) Application of shadow wage rate, if necessary.
d) Addition of land acquisition cost, when the project includes publicly -owned land not included in the market price.
e) Necessary consideration of contingency for future inflation.

Table 15.1-12 shows a summary of tariff rates related to the master plan, for reference. Some import duties have been revised since 1996, and the rate of value added tax (VAT = I.V.A.) was also increased from 14% to 16% in 1996.

Table 15.1-12 Tariff of Major Goods related to Master Plan, 1996

1. Motor Vehicle			
Type of Vehicle		Import Duty	I.V.A.
1) Passenger Car		(%)	(%)
a) less than & 1,400cc		20	16
b) 1,400 - 1,800cc		35	16
c) 1,800 over / less $35million		45	16
d) $35million & over		60	16
2) Taxi		16	16
3) Bus (public)		16	16
4) Truck		16 / 35 / 45	16
5) Others		16 / 20 / 35	16
2. Rolling stock, signal, others for railway			
Code	Type of Goods	Import Duty	I.V.A.
8601/02	Loco	5%	16%
8603/04	Automotor, motor car	5	16
8605	Coach	5	16
8606	Wagon	20	16
8607	Parts for vehicle	5	16
8608	Electrical & Mechanical Equip.	15	16
3. Construction Machinery			
Code	Type of Goods	Import Duty	I.V.A.
8704	Grader-truck	15 / 35%	16%
8705	Crane-truck	15	16
8706-08	Parts for the above	5/ 15	16
8426	Crane, crane bridge	5 / 10 / 15	16
8429/30	Bulldozer	5 / 10	16
8454/57	Machine to transform iron/steel	5	16
8459	Drill machine	5	16
8462/63	Machine for iron/steel work	5 / 10	16
8474	Mixer,	5 / 10 / 15	16
8483	Crusher	5 / 10 / 15	16
8485	Parts for the above	5 / 15	16
4. Construction Material			
Code	Type of Goods	Import Duty	I.V.A.
6810	Cement, stone	15%	16%
6811	Asbestos	15	16
6815	Stone and others	15	16
7208/09	Steel/iron plate	5/10	16
7210/11	Steel/iron products	5 / 10 / 15	16
7213/17	Steel/iron wire	5 / 10 / 15	16
7216	Iron/steel ornaments	10	16
7302	Iron rail, bar	5 / 10 / 15	16
7303/04	Steel/iron tube	5 / 15	16
7307	Accessories	5 / 15	16
7308	Constructions and parts	15	16
7312	Steel/iron wire for electric use	5 / 10 / 15	16
7315	Chain	15	16

As this study is not a Feasibility Study but a Master Plan Study, detailed studies on economic cost estimation might not be necessary, keeping a consistency of accuracy with the estimation of project cost. And in case of urban transport projects in Latin

America, the economic cost of each project is usually about 80 to 95% against its financial cost. The total economic cost of the projects in master plan is finally estimated, adding the necessary operation/maintenance costs and considering the various conditions mentioned above.

15.1.4 Cost-Benefit Analysis

Annual profit estimated for the project life period is compared with investment in the form of cash flow. As a result of this analysis, three indices such as benefit-cost ratio (B/C), net present value (NPV) and economic internal rate of return (EIRR) are calculated under certain discount rates (in case of this study 12% per year is applied).

(1) Master Plan as a Whole

A total amount of 9,706 billion pesos is required to accomplish all the projects of the Master Plan and to maintain them, in economic costs at 1996 price. These projects consist of traffic management projects, bus troncal, mass transit, terminal, existing road improvement, new road construction and the urban expressway. And they would be implemented from 1997 to 2020. When all the projects are completed, total travel cost (both VOC and TTC) would amount to 7,400 billion pesos (at 1996 price) in the year of 2020. How ever, that would be 18,260 billion pesos if the present transport network remains as it is, without any projects. Therefore, the economic benefit in 2020 derived by the master plan is estimated to be 10,860 billion pesos. Out of this, 26% is attributed to VOC savings and 74% to TTC savings.

Annual cash flow (benefit - cost) is analyzed during the master plan/project life period, as shown in Table 15.1-13. Under the discount rate of 12%, the benefit cost ratio (B/C) is 5.33 and the net present value (NPV) is 12,100 billion pesos, which assures quite high economic returns for the master plan. The economic internal rate of return (EIRR) is also very high at 42.40%.

If benefit is calculated only by VOC, without TTC savings, both indicators of economic evaluation become smaller than the base case, because VOC occupies only a quarter of total benefit; B/C ratio is 1.24 and EIRR is 14.25%. This indicates the proposed master plan contributes significantly to the reduction of traffic congestion in Bogota, though the economic feasibility of the master plan is still narrowly feasible.

As there are some uncertain factors in this economic feasibility examination of the master plan; such as conditions for traffic demand forecast, estimates on construction & maintenance costs of projects, implementation program, etc. Moreover, there might be other tangible benefits to have a direct/indirect effect on the projects' feasibility. Therefore, a sensitivity analysis is carried out, taking into general considerable range of uncertainty as follows;

a) Variation of benefit: -15% to +10% against the base case, and
b) Variation of cost: -10% to +20% against the base case.

The results are tabulated in Table 15.1-14: the proposed master plan is quite economically feasible even in the worst conditions; benefit = -15%, cost = +20%.

(2) Project Group by Implementation Stage

The proposed master plan consists of various project packages in three stages such as short-term, mid-term and long-term. The economic feasibility of the three alternatives by implementation period are compared in Table 15.1-15

Though each alternative indicates an economic feasibility to certain extent, short-term package reveals better effectiveness than others in comparison with EIRR and B/C. This reveals that the proposed investment schedule is reasonable from an economic point of view.

Table 15.1-13 Benefit-Cost Analysis of Master Plan as a Whole

($ billion)

Year	Cost: Investment	Cost: O/M	Cost: Total	Benefit: VOC	Benefit: TTC	Benefit: Total	Cash Flow: VOC+TTC	Cash Flow: only VOC
1996	0	0	0	0	0	0	0	0
1997	196	0	196	0	0	0	-196	-196
1998	349	0	349	17	68	84	-265	-332
1999	422	0	422	33	136	169	-253	-389
2000	478	0	478	66	271	337	-141	-412
2001	343	0	343	132	543	675	332	-211
2002	245	54	298	151	609	760	462	-147
2003	205	54	259	172	683	855	596	-87
2004	220	54	274	196	767	963	689	-78
2005	233	54	287	224	860	1,085	798	-63
2006	225	54	279	256	966	1,221	942	-23
2007	299	54	353	292	1,083	1,375	1,022	-61
2008	253	54	307	333	1,216	1,549	1,242	26
2009	338	54	392	380	1,364	1,745	1,353	-12
2010	345	54	399	496	1,718	2,214	1,815	97
2011	360	137	498	589	2,006	2,595	2,097	91
2012	311	137	448	700	2,341	3,042	2,594	252
2013	339	137	476	833	2,733	3,566	3,090	357
2014	337	137	474	990	3,190	4,180	3,706	516
2015	334	137	471	1,176	3,724	4,900	4,429	705
2016	359	137	496	1,398	4,347	5,745	5,249	902
2017	379	137	516	1,662	5,074	6,736	6,220	1,146
2018	379	137	516	1,975	5,923	7,898	7,382	1,459
2019	432	137	569	2,348	6,914	9,262	8,693	1,779
2020	470	137	607	2,791	8,066	10,857	10,250	2,184
2021	0	268	268	2,875	8,308	11,183	10,915	2,607
2022	0	268	268	2,961	8,557	11,518	11,250	2,693
2023	0	268	268	3,050	8,814	11,864	11,596	2,782
2024	0	268	268	3,141	9,078	12,220	11,952	2,873
2025	0	268	268	3,236	9,351	12,586	12,318	2,968
2026	0	268	268	3,333	9,631	12,964	12,696	3,065
2027	0	268	268	3,433	9,920	13,353	13,065	3,165
2028	0	268	268	3,536	10,218	13,753	13,485	3,268
2029	0	268	268	3,642	10,524	14,166	13,898	3,374
2030	0	268	268	3,751	10,840	14,591	14,323	3,483
	Residual		-3,002				3,002	3,002
Total	7,851	4,536	12,387	50,166	149,844	200,009	190,625	40,781
						EIRR	42.40	14.25
						B/C	5.33	1.24
						NPV	12,100	1,738

Table 15.1-14 Summary of the Sensitivity Analysis

Ratio of EIRR to Base Case

Benefit \ Cost	-10%	-5%	0%	5%	10%	15%	20%
10%	1.19	1.13	1.10	1.05	1.00	0.96	0.94
5%	1.14	1.08	1.05	1.00	0.98	0.94	0.91
0%	1.10	1.05	1.00	0.95	0.93	0.90	0.87
-5%	1.05	1.00	0.96	0.93	0.89	0.87	0.83
-10%	1.00	0.96	0.93	0.89	0.85	0.83	0.80
-15%	0.95	0.92	0.88	0.84	0.82	0.79	0.77

Table 15.1-15 Comparative Economic Analysis by Stage

	Economic Cost (in 1996)	EIRR (%)	B/C	NPV
	US$ mil			US$ mil
Short-term (1997 - 2001)	1,512.0	43.6	4.97	5,813
Mid-term (2002 - 2010)	1,454.0	20.0	3.55	2,651
Long-term (2011 - 2020)	4,887.0	13.5	1.16	68

15.2 Financial Evaluation

Economic evaluation of the proposed Master Plan in 15.1 resulted in a certain feasible condition as a whole. Other evaluations from financial viewpoints are conducted in this section.

- from the viewpoint of the investment framework in the public sector, and
- from the viewpoint of profits and expenses in the projects having revenue.

15.2.1 Investment Framework

Most of the projects proposed in the Master Plan, in general, might be invested in by public or semi-public sectors, except for some privatized projects. A review of the public sector budget both in the past and the future plan might provide useful information for this analysis.

(1) Present Status of Public Finance for Transport Investment

The outline of public investment for the transport sector in Bogota is summarized in the Tables below.

According to the general budget allocation in 1995 and 96, the transport & road sector occupies 7 and 9% of the total budget of 3,020 and 4,080 billion pesos. This amount includes administrative/operational expenditure as well as investments.

Meanwhile, other data on the investment budget in Bogota reveals that the total amount for the infrastructure sector was 40 to 150 billion pesos from 1992 to 95 (Table 15.2-2).

Moreover, 1,150 billion pesos is allocated for the transport sector during the plan period of 1995 to 1998, in the general city development plan called 'Formar Ciudad'. 118 billion pesos for 1995, 231 for '96, 304 for '97 and 496 for '98 as shown in Table 15.2-3. This means that two to three times the amount per annum, compared with actual ones, are expected to be invested for this sector, because of its importance.

Table 15.2-1 General Budget Allocation by Sector, 1995 and 1996

Sector	1995	share	1996 (Proposed)		96/95 (%)
	mil.$		mil.$		
1.Health	370,462.7	12.3%	403,663.4	9.9%	16.3
2.Education	125,276.7	4.2%	220,204.7	5.4%	75.8
3.Social Promotion	99,515.9	3.3%	111,330.0	2.7%	11.9
4.Housing & Development	36,477.0	1.2%	39,599.9	1.0%	8.6
5.Culture, Recreation & Sports	43,807.1	1.5%	60,716.30	1.5%	38.6
6.Security & Guard	44,858.4	1.5%	98,307.7	2.4%	119.2
7.Local Development	19,429.1	0.6%	98,832.6	2.4%	408.7
8.Public Service	1,545,132.2	51.2%	2,006,472.8	49.1%	29.9
9.Transport & Road	198,832.9	6.6%	345,322.8	8.5%	73.7
10.Institutional Support	467,395.3	15.5%	594,046.3	14.5%	27.1
11.Town Council & Control Org.	64,934.2	2.2%	78,733.0	1.9%	21.3
Total	3,016,121.7	100.0%	4,084,229.5	100.0%	35.4

Table 15.2-2 Investment Budget Allocation by Sector, 1992 to 1995

(in constant price of 1994)

Sector / Year	1992 million $	(%)	1993 million $	(%)	1994 million $	(%)	1995* million $	(%)
Admini. & Management	93,106	44.8	132,314	37.5	147,167	30.6	169,062	32.4
Social	38,786	28.3	100,860	28.6	187,230	39.0	259,528	49.8
Healt	10,406	5.0	43,555	12.3	61,404	12.8	120,261	23.1
Educatio	7,604	3.7	9,723	2.8	48,281	10.0	57,017	10.9
Other	40,776	19.6	47,582	13.5	77,545	16.1	82,250	15.8
Infrastructure	55,705	26.8	119,624	33.9	146,239	30.4	92,764	17.8
ID	24,489		53,101		103,921		54,849	
SO	7,696		6,434		6,077		5,932	
FOSO	16,756		52,447		31,741		19,309	
ST	0		0		0		174	
FONDATT	6,765		7,643		4,500		12,500	
Total	207,597	100.0	352,798	100.0	480,637	100.0	521,354	100.0

Note 1: Excluding Public Service Sector
Note 2: * = Estimated
Source: Bogota City, Alcaldia Mayor; Secretaria de Hacienda

Table 15.2-3 Budget Allocation for the Transport Sector in 'Formar Ciudad'

($ million)

Programe	Organizatio	1995	1996	1997	1998	Total
Highways	IDU	21,600	28,320	62,015	97,270	209,205
Major Roads		37,500	65,851	78,375	102,517	284,243
Access to Malla Rd.	IDU	19,320	35,164	44,781	67,637	166,902
Public space,Bus-stop,etc.	IDU	5,500	12,980	12,213	7,599	38,292
Access to Malla Rd.	SOP-FOSOP	11,530	14,160	16,284	27,281	69,255
Public space,	SOP-FOSOP	1,150	3,547	5,097	0	9,794
Road Maintenance	SOP-FOSOP	25,825	49,850	67,564	21,504	164,743
Public Transport		29,293	62,942	40,198	272,076	404,509
Terminal	SHB	1,000	1,770	2,714	4,560	10,044
Metro-bus,Metro,etc.	IDU	12,655	47,790	22,612	253,160	336,216
Bus-stop,Road sign	FONDATT	6,350	6,538	6,459	4,173	23,521
Traffic signal	ETB	9,288	6,844	8,413	10,183	34,728
Mitigation of Traffic Congestion in Peripheral Area	IDU	0	22,097	52,923	3,035	78,055
Study & Design	IDU	3,500	2,360	3,121	0	8,981
Grand Total		117,718	231,420	304,196	496,403	1,149,737

(2) Necessary Investment Amounts for the Master Plan

According to the proposed Master Plan, in the JICA Study, a total amount of 9,240 billion pesos (in 1996 price) is required as direct investment for all the proposed projects' execution. 2,105 billion pesos is required for the Short-Term Plan (5 years; 1997-2001), 2,782 billion pesos for the Medium Term (9 years; 2002 - 2010) and 4,353 billion pesos for the Long-Term (10 years; 2011-2020).

This amount of 420 billion pesos per annum on average during the Short Term Plan period seems to be reasonable range not exceeding a possible amount, compared to the proposed budgets of the general plan in 1997 and 98.

(3) Available Resources

However, in addition to those direct investment mentioned above, it is necessary to carry a certain amount of maintenance/operation cost, both for existing and newly developed facilities. Moreover, the financial status of Bogota might not be so hopeful because of the usual discrepancy between the budget and its performance, and limited revenue resources. The following can be considered as available revenue sources, now and in the near future, for transport infrastructure investment;

a) Gasoline consumption tax,
b) Valorization,
c) Capital resources,
d) Selling of ETB's stocks through privatization, and
e) Transfer from Federal Government.

Since on accurate forecast of those amount is impossible, but a shortage of financial resource is easy to anticipate , every possible measures should be examined in order to increase investment resources and discourage private vehicle use, as discussed in Chapter 16.

15.2.2 Various Financial Possibilities for Urban Transport

There are various new laws/ordinances on financial availability for urban transport/infrastructure investments during the course of the study. Though not all of them has been carried into effect, every possible efforts should be made for the implementation of the proposed project packages. They are summarized as follows;

(1) National Development and Investment Plan, 1995-1998 (El Salto Social)

National investment plan based on Law 188; In the urban transport sector, $4,380 billion of national budget is allocated for road and mass-transit system development, especially in Bogota and Cali.

(2) Action and Resource Plan for SantaFe de Bogota, 1995-1998

Plan based on Document CONPES No. 2766 by DNP; Basic urban transport development directions are determined, such as:

- Integrated Mass Transit System (SITM)
- Transport Master Plan
- Troncal Project
- Sabana Park Avenue Project
- Urban Railway Corridor
- Access Roads Improvement, etc.

(3) Development Plan for Bogota, 1995-1998 (Formar Ciudad)

Investment Program by City Government Decree No. 295; Necessary budget for integrated transport plan is listed, $644 billion by local and $274 billion by national government.

(4) Ordinance 310, Aug. 06, 1996

The subsidy for mass-transit system by national government will be provided; 40% in minimum case and 70% in maximum case (revised from Ordinance 86 in 1989).

(5) Gasoline Consumption Tax

The gasoline consumption tax is gradually revised; 13% in 1996, 14% in 1997 and 15% from 1998 to 2015, and 50% of this tax revenue amount will be spent for mass-transit system (Metro) development in Bogota (after 1999).

(6) Budget for Metro Construction

$125 billion will be transferred for the priority line of Metro, which was allocated for

SITM in 1994. This was based on Law No. 188 in 1995 and FONADE Contracts No. 961 & 972 in 1996.

(7) Subsidy for 'Cundinamarca' from National Government

National budget of $83.2 billion is allocated in 1994 for Cundinamarca road development project, which is being implemented by concession system through privatization.

(8) Budget for Access Roads in the South and South-west of Bogota

$19.7 billion in 1994.

(9) Offer and Transfer of Railway Estate for Roads and Mass-transit

Railway corridor from Bosa to Km-2 and Km-2 to Km-5, based on the agreements between FERROVIAS and IDU in June 1995 & January 1996.

15.2.3 Financial Assessments on Proposed Urban Toll Expressway

An introduction of elevated expressway is planned in the center of the study area, in order to solve one of the most critical road transport problems within Bogota Metropolitan Area. This urban expressway is composed of three components; 1st Ring (18 km), 2nd Ring (24 km) and Radial (23 km), and completely grade-separated from ordinary roads without any level-crossing. Vehicles can access/egress to/from expressway through ramps, paying the toll at the gates.

Toll road system for repayment of its initial construction cost has not been employed in Colombia, but road users' charge system for only maintenance purpose has been introduced at various sections of the national road. As necessary factors for simulation of toll-effectiveness cannot help depending on the various premises based on the examples in other countries, some financial analyses are carried out.

Table 15.2-4 Estimated Traffic Volume for Urban Expressway

(PCU/day)

Year	(1) Master Plan Network	(2) 1st Ring only	(3) 1st & 2nd Rings
	1) Free Charge	1) Free Charge	1) Free Charge
2010			
2020		377,749	639,321
	2) $1,000/Trip	2) $1,000/Trip	2) $1,000/Trip
2010	57,336 (100)	57,336 (100)	57,336 (100)
2020	243,175 (424)	162,376 (283)	225,194 (393)

An effectiveness of toll collection to traffic volume is estimated so significant; traffic volumes indicate certain decreases compared with the free-charge case, 35% to 43% in the case that toll charge is $1,000 per vehicle trip and time value for toll-expressway users is $10,000/hr in 2020. The different time value results in wide range of toll expressway users as shown in Table 15.2-5.

Table 15.2-5 Some Examples of Expressway Traffic Simulation by Time Value

(In case of 1st Ring only) (PCU/day)

Toll / Time Value	Free	$500	$1,000	$2,000
$5,000/hr	377,749	-	63,219	12,005
$10,000/hr	377,749	221,644	162,376	-

Meanwhile, traffic volumes by alternative component case, in terms of PCU/day, show not a certain difference between '1st Ring only' and '1st & 2nd Rings'.

The financial analyses of master plan case by cash flow ; 1st Ring, 2nd Ring and Radial by proposed phasing, result in not so desirable financial situation as an independent enterprise.

- This toll expressway system is narrowly financially feasible without any government subsidy.
- The financial internal rate of return (FIRR) indicates 3.51% in case of 'without subsidy for the initial investment cost'. It might be necessary to introduce some soft loan such as Japan's OECF loan to implement this project under this condition.
- In the case that half of total investment cost is available from no interest fund, FIRR will be quite favorable at 8.46%.
- If all the initial investment cost is derived from government; that is, only operational and maintenance costs are necessary to recover, FIRR is estimated at 31.0%.

Table 15.2-6 Cost-Revenue Flow of Urban Toll Expressway (1)

Year	Cost			Revenue	Net Revenue		
	1)Whole Cost	2) 1/2 Cost	3)O/M only	@$1,000	1)	2)	3)
1996	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0
2000	31,000	15,500	0	0	-31,000	-15,500	0
2001	31,000	15,500	0	0	-31,000	-15,500	0
2002	153,000	76,500	0	0	-153,000	-76,500	0
2003	153,000	76,500	0	0	-153,000	-76,500	0
2004	122,000	61,000	0	0	-122,000	-61,000	0
2005	122,000	61,000	0	0	-122,000	-61,000	0
2006	85,360	42,680	18,360	11,760	-73,600	-30,920	-6,600
2007	151,360	75,680	18,360	13,583	-137,777	-62,097	-4,777
2008	151,360	75,680	18,360	15,688	-135,672	-59,992	-2,672
2009	151,360	75,680	18,360	18,119	-133,241	-57,561	-241
2010	151,360	75,680	18,360	20,928	-130,432	-54,752	2,568
2011	85,360	42,680	18,360	24,172	-61,188	-18,508	5,812
2012	38,340	19,170	38,340	27,918	-10,422	8,748	-10,422
2013	38,340	19,170	38,340	32,246	-6,094	13,076	-6,094
2014	105,340	52,670	38,340	37,244	-68,096	-15,426	-1,096
2015	71,340	35,670	38,340	43,017	-28,323	7,347	4,677
2016	139,340	69,670	38,340	49,684	-89,656	-19,986	11,344
2017	105,340	52,670	38,340	57,385	-47,955	4,715	19,045
2018	172,340	86,170	38,340	66,280	-106,060	-19,890	27,940
2019	172,340	86,170	38,340	76,554	-95,786	-9,616	38,214
2020	172,340	86,170	38,340	88,759	-83,581	2,589	50,419
2021	58,440	29,220	58,440	102,517	44,077	73,297	44,077
2022	58,440	29,220	58,440	118,407	59,967	89,187	59,967
2023	58,440	29,220	58,440	136,760	78,320	107,540	78,320
2024	58,440	29,220	58,440	157,958	99,518	128,738	99,518
2025	58,440	29,220	58,440	182,441	124,001	153,221	124,001
2026	58,440	29,220	58,440	191,563	133,123	162,343	133,123
2027	58,440	29,220	58,440	201,141	142,701	171,921	142,701
2028	58,440	29,220	58,440	211,198	152,758	181,978	152,758
2029	58,440	29,220	58,440	221,758	163,318	192,538	163,318
2030	58,440	29,220	58,440	232,846	174,406	203,626	174,406
Total	2,987,620	1,493,810	4,481,430	2,339,925	-647,695	846,115	1,300,305

In the master plan case, a rough financing and repayment plan is examined, under the following premised conditions.

- 80% of total project cost will be borrowed from a soft loan and the balance will be subsidized by the government.

Interest	:3.0% per year,
Repayment Period	:30 years,
Grace Period	:10 years.

- Annual expenditure schedule is prepared in accordance with the planned implementation program.

Base cost	:in 1996 price,
Escalated cost	:5% per year,
Total amount of loan	:80% of total cost,
Principal repayment	:equal for 20 years.

Table 15.2-7 Example of Repayment Cash Flow Plan of The Project.

($ bill.)

Year	for 1st Ring				for 2nd Ring				for Radial				Total
	Principal	Interest	Pri. repaid	Repayment	Principal	Interest	Pri. repaid	Repayment	Principal	Interest	Pri. repaid	Repayment	Repayment
2000	30.14	0.90	0	0.90									0.90
2001	61.80	1.85	0	1.85									1.85
2002	225.82	6.77	0	6.77									6.77
2003	398.05	11.94	0	11.94									11.94
2004	542.25	16.27	0	16.27									16.27
2005	693.66	20.81	0	20.81									20.81
2006	693.66	20.81	0	20.81	87.31	2.62	0	2.62					23.43
2007	693.66	20.81	0	20.81	269.29	8.08	0	8.08					28.89
2008	693.66	20.81	0	20.81	460.37	13.81	0	13.81					34.62
2009	693.66	20.81	0	20.81	661.00	19.83	0	19.83					40.64
2010	693.66	20.81	34.68	55.49	871.66	26.15	0	26.15					81.64
2011	658.98	19.77	34.68	54.45	983.09	29.49	0	29.49					83.94
2012	624.29	18.73	34.68	53.41	983.09	29.49	0	29.49					82.90
2013	589.61	17.69	34.68	52.37	983.09	29.49	0	29.49					81.86
2014	554.93	16.65	34.68	51.33	983.09	29.49	0	29.49	128.99	3.87	0	3.87	84.69
2015	520.24	15.61	34.68	50.29	983.09	29.49	0	29.49	195.71	5.87	0	5.87	85.65
2016	485.56	14.57	34.68	49.25	983.09	29.49	49.15	78.65	410.09	12.30	0	12.30	140.20
2017	450.88	13.53	34.68	48.21	933.94	28.02	49.15	77.17	559.42	16.78	0	16.78	142.16
2018	416.20	12.49	34.68	47.17	884.78	26.54	49.15	75.70	873.00	26.19	0	26.19	149.06
2019	381.51	11.45	34.68	46.13	835.63	25.07	49.15	74.22	1202.27	36.07	0	36.07	156.42
2020	346.83	10.40	34.68	45.09	786.47	23.59	49.15	72.75	1548.00	46.44	0	46.44	164.28
2021	312.15	9.36	34.68	44.05	737.32	22.12	49.15	71.27	1548.00	46.44	0	46.44	161.76
2022	277.46	8.32	34.68	43.01	688.16	20.64	49.15	69.80	1548.00	46.44	0	46.44	159.25
2023	242.78	7.28	34.68	41.97	639.01	19.17	49.15	68.32	1548.00	46.44	0	46.44	156.73
2024	208.10	6.24	34.68	40.93	589.85	17.70	49.15	66.85	1548.00	46.44	77.40	123.84	231.62
2025	173.41	5.20	34.68	39.89	540.70	16.22	49.15	65.38	1470.60	44.12	77.40	121.52	226.78
2026	138.73	4.16	34.68	38.84	491.55	14.75	49.15	63.90	1393.20	41.80	77.40	119.20	221.94
2027	104.05	3.12	34.68	37.80	442.39	13.27	49.15	62.43	1315.80	39.47	77.40	116.87	217.10
2028	69.37	2.08	34.68	36.76	393.24	11.80	49.15	60.95	1238.40	37.15	77.40	114.55	212.27
2029	34.68	1.04	34.68	35.72	344.08	10.32	49.15	59.48	1161.00	34.83	77.40	112.23	207.43
2030					294.93	8.85	49.15	58.00	1083.60	32.51	77.40	109.91	167.91
2031					245.77	7.37	49.15	56.53	1006.20	30.19	77.40	107.59	164.11
2032					196.62	5.90	49.15	55.05	928.80	27.86	77.40	105.26	160.32
2033					147.46	4.42	49.15	53.58	851.40	25.54	77.40	102.94	156.52
2034					98.31	2.95	49.15	52.10	774.00	23.22	77.40	100.62	152.72
2035					49.15	1.47	49.15	50.63	696.60	20.90	77.40	98.30	148.93
2036									619.20	18.58	77.40	95.98	95.98
2037									541.80	16.25	77.40	93.65	93.65
2038									464.40	13.93	77.40	91.33	91.33
2039									387.00	11.61	77.40	89.01	89.01
2040									309.60	9.29	77.40	86.69	86.69
2041									232.20	6.97	77.40	84.37	84.37
2042									154.80	4.64	77.40	82.04	82.04
2043									77.40	2.32	77.40	79.72	79.72

In addition to the master plan case, other two cases are also analyzed; '1st Ring only' and '1st & 2nd Rings'.

Table 15.2-8 Cost-Revenue Flow of Urban Toll Expressway (2)

($ mill.)

Year	1) 1st Ring only			2) 1st & 2nd Rings		
	Cost	Revenue	Net Revenue	Cost	Revenue	Net Revenue
2000	31,000	0	-31,000	31,000	0	-31,000
2001	31,000	0	-31,000	31,000	0	-31,000
2002	153,000	0	-153,000	153,000	0	-153,000
2003	153,000	0	-153,000	153,000	0	-153,000
2004	122,000	0	-122,000	122,000	0	-122,000
2005	122,000	0	-122,000	122,000	0	-122,000
2006	18,360	13,786	-4,574	85,360	12,091	-73,269
2007	18,360	15,302	-3,058	151,360	13,869	-137,491
2008	18,360	16,986	-1,374	151,360	15,907	-135,453
2009	18,360	18,854	494	151,360	18,246	-133,114
2010	18,360	20,928	2,568	151,360	20,928	-130,432
2011	18,360	23,230	4,870	85,360	24,004	-61,356
2012	18,360	25,785	7,425	38,340	27,533	-10,807
2013	18,360	28,622	10,262	38,340	31,580	-6,760
2014	18,360	31,770	13,410	38,340	36,223	-2,117
2015	18,360	35,265	16,905	38,340	41,547	3,207
2016	18,360	39,144	20,784	38,340	47,655	9,315
2017	18,360	43,450	25,090	38,340	54,660	16,320
2018	18,360	48,229	29,869	38,340	62,695	24,355
2019	18,360	53,535	35,175	38,340	71,912	33,572
2020	18,360	59,267	40,907	38,340	82,196	43,856
2021	18,360	65,786	47,426	38,340	94,279	55,939
2022	18,360	73,023	54,663	38,340	108,138	69,798
2023	18,360	81,055	62,695	38,340	124,034	85,694
2024	18,360	89,971	71,611	38,340	142,267	103,927
2025	18,360	99,868	81,508	38,340	163,180	124,840
2026	18,360	104,862	86,502	38,340	171,339	132,999
2027	18,360	110,105	91,745	38,340	176,480	138,140
2028	18,360	115,610	97,250	38,340	181,774	143,434
2029	18,360	121,391	103,031	38,340	187,227	148,887
2030	18,360	127,460	109,100	38,340	192,844	154,504
2031	18,360	133,833	115,473	38,340	198,629	160,289
2032	18,360	140,525	122,165	38,340	204,588	166,248
2033	18,360	147,551	129,191	38,340	210,726	172,386
2034	18,360	154,929	136,569	38,340	217,048	178,708
2035	18,360	162,675	144,315	38,340	223,559	185,219
2036	18,360	167,555	149,195	38,340	230,266	191,926
2037	18,360	172,582	154,222	38,340	237,174	198,834
2038	18,360	177,759	159,399	38,340	244,289	205,949
2039	18,360	183,092	164,732	38,340	251,618	213,278
2040	18,360	188,585	170,225	38,340	259,166	220,826
Total	1,254,600	3,092,371	1,837,771	2,500,020	4,379,671	1,879,651

As shown in the table, both cases indicate better FIRRs compared with the master plan case; 5.40% in case of '1st Ring' and 3.74% in '1st & 2nd Rings'. Moreover, FIRRs are 9.56% in case 1 and 8.12% in case 2 respectively, if half of the total cost is available from the government without interest.

Though preliminary financial analyses result in the above-mentioned facts, it is necessary to conduct more detail studies focused on financial viability of urban toll expressway system based on certain data from various viewpoints.

15.3 Environmental Evaluation

15.3.1 Present Condition of Main Environmental Items Concerning the Project

(1) Noise

1) Noise Condition in the Daytime

Noise is one of the major factors resulting from traffic pollution in Bogota. This is especially due to vehicles' repeated starting/stopping because of traffic congestion in the center of the city. In addition, poor traffic manners cause bus drivers to use air-brakes, cause unnecessary acceleration and frequent use of their horn which makes for high noise levels. On the other hand, there are few cases where noise from urban transport has been measured. Accordingly, the JICA Study Team investigated the present state of the noise level along major roads. The objective of the survey was to investigate and analyze existing noise levels in the Study areas, and on the basis of these to appraise the effect to be caused by future traffic.

The criteria for the selection of monitoring locations was based on the future transport network, etc., and 23 locations were selected. Regarding measuring methods, noise measuring stations were located on the sidewalk and the sound level meter(RION NL-04) was set 1.2m above the ground. Regarding the method of evaluation, L_{eq} and L_{50} during 10 minutes in the daytime were used for noise levels. The results of noise monitoring are summarized in Table 15.3-1. These values show that the noise levels at each measuring point were higher than the standards of Colombia even though a decrease of noise level in private zones should be considered. Figure 15.3-1 shows the distribution of L_{eq}.

2) Power Level of Existing Vehicles in Bogota

There is no data from investigation of the noise made by each type of vehicle in the City. Accordingly, the JICA Study Team investigated briefly the sound power level of an actual passenger car on the dual-lane at-grade road(Avenida Medellin) with small traffic volume. The objective of the survey was to investigate existing vehicle noise levels for each type considering the velocity, and on the basis of this to appraise the method of estimating noise levels caused by transport in the future. The evaluation was based on methods used by the Acoustical Society of Japan(ASJ). Regarding the measuring method, the sound level meter was set 10m from the edge of the carriageway at 1.2m above the ground. Every peak level when a vehicle passed on each lane was recorded in the meter's Fast mode and the power levels (Lw) were calculated on the assumption of sound propagation in semi-spherical space.

The regression of power level with running vehicle speed was estimated using the measured values. The results with the regression formula fixed at 23 locations as the constant proportion, are shown in Table 15.3-2.

Table 15.3-1 Distribution of Noise

No.	Locations	Trans. Section	Measuring Time (10 minutes)		Noise Level(dBA)			Date	Land Use
			Start	Stop	L50	Leq	Lmax		
1	Calle 72 between Cr.9 and Cr.7	Cgt -3-P	16:40	16:50	69.4	75.9	92.2	6/11 Thc.	Multi-purpose Use
2	Carrea 7 near Cll.94	Cg -S-3-P	9:30	9:40	75.7	78.7	99.0	6/12 Wed.	Special Residential
3	Tranversal 10 near Calle106	Cg+R.way -3-gP	9:50	10:00	65.7	72.2	87.7	6/12 Wed.	Special Residential
4	Autopista del Norte near Cll.130	Cg 3-Sg-2-Sgt-P	10:20	10:30	74.5	79.8	102.8	6/12 Wed.	Special Residential
5	Avenida 68 near Trv.48	Cgt 3-St-2-gP	10:50	11:00	74.3	77.5	93.7	6/12 Wed.	Special Residential
6	Avenida 81 near Cr.76	Cg -3-P	11:10	11:20	75.3	78.4	98.6	6/12 Wed.	General Residential
7	Avenida Ciudad de Quito near Cll.63C	Cannal -3-3-P	11:40	11:50	75.3	80.2	103.6	6/12 Wed.	General Residential
8	Autopista el Drado near Don Bosco	Cg -3-Sgt-3-P	14:40	14:50	75.5	78.1	92.2	6/12 Wed.	General Residential
9	Avenida Boyaca near Cll.37	Cg 3-3-P	14:20	14:30	75.9	78.7	98.6	6/12 Wed.	General Residential
10	Diagonal 22A near Cr.45A	C -2-P	10:40	10:50	73.4	76.8	98.1	6/13 Thu.	Industrial
11	Av. de las American near Trv.71B	Cgw -3-P	15:00	15:10	75.5	78.0	94.0	6/12 Wed.	General Residential
12	Calle 39 between Diag.4B and 3B	Cgw+R.way -3-gP	16:00	16:10	67.7	73.4	93.6	6/12 Wed.	General Residential
13	Calle 13 near Cra.39	C -3-3-P	11:00	11:10	74.8	79.1	97.3	6/13 Thu.	Industrial
14	Calle 26 betwen Av.Quito and call.37	Ct -2-2-P	10:10	10:20	75.6	77.4	92.9	6/13 Thu.	General Residential
15	Avenida Caracas near Cll.47	Ct -2B-2-P	11:40	11:50	77.8	80.6	95.0	6/13 Thu.	Multi-purpose Use
16	Carrera 10 near Cll.17	Ct -3-P	14:40	14:50	75.1	81.2	106.3	6/13 Thu.	
17	Autopista Sur near Cr.55	C 6-P	15:50	16:00	75.3	77.4	95.8	6/13 Thu.	Multi-purpose Use
18	Avenida 30 near Cll.1C	Ct -3-S-3-P	15:10	15:20	72.1	76.3	94.6	6/13 Thu.	General Residential
19	Avenida Medellin near Rio Bogota	Ct -1	15:50	16:00	69.0	71.9	90.7	6/25 The	
20	Carrera 7 near Cll.61	Ct -3-P	14:10	14:20	74.5	76.7	92.2	6/28 Fri.	General Residential
21	Diagonal 111 near Cr.19	Ct -1-P	15:00	15:10	52.1	59.6	83.6	6/28 Fri.	Special Residential
22	Carrera 13 between Cll.63 and Cll.64	Ct -3-P	16:50	17:00	74.5	76.6	94.7	7/2 Thu	Multi-purpose Use
23	Diagonal 22A near Cr.43	Cgw+R.way -1-P	11:20	11:30	51.3	62.0	88.5	7/9 Thu	Special Residential

Ct:Center, S:Separation, 2~6: lanes, P:Sidewalk, R:Rail, B:Bus, g:greenbelt, t:tree, w:wide
Permitted noise level(Daytime): Residential-65dB; Commercial-70dB; Industial-75dB

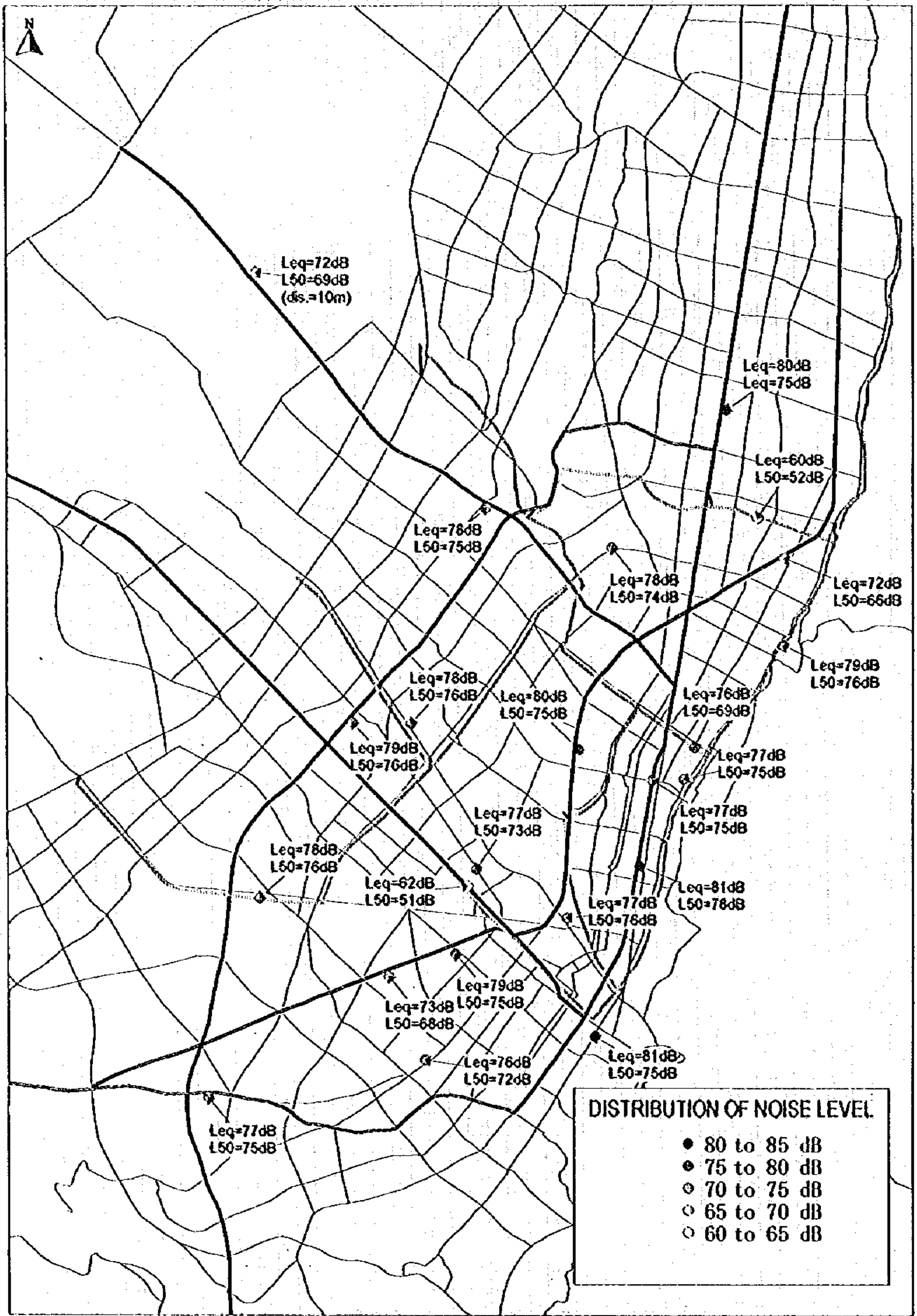


Figure 15.3-1 Distribution of Noise Level in Bogota

Table 15.3-2 Regression Of Power Level With Velocity

Type of vehicle	Regression formula	Correlation coefficient	Standard error	Sampling Number
Group of small vehicle	$Lw = 24.6 \log_{10} V + 63.6$ $Lw = 26.0 \log_{10} V + 60.9$	0.62	3.60	76
Group of large vehicle	$Lw = 28.2 \log_{10} V + 65.8$ $Lw = 26.0 \log_{10} V + 70.0$	0.49	10.6	25

small vehicles : cars, taxis, collectivos large vehicles: busetas, buses, trucks

Therefore, the average power level in Bogota classified by 2 types of vehicles is estimated by the following formula synthesized from the above-mentioned formulas.

$$Lw = 61.0 + 26 \log_{10}V + 10 \log_{10}(a_1 + 7.9 a_2)$$

a_1: Ratio of small vehicle
a_2: Ratio of large vehicle $a_1 + a_2 = 1.0$

For the purpose of verifying the above-mentioned formula, noise level L_{50} is calculated using surveyed traffic volume by the prediction method of the ASJ, and is compared with the surveyed noise level in Table 15.3-3. Comparison was made for 3 points and the results show that the formula is able to approach the actual measured values quite closely.

Table 15.3-3 Comparison Between Measured Level And Calculated Level

Locations	Lanes	Traffic volume A			Traffic volume B			Noise Level L50(dB)	
		Small	Large	Vel.	Small	Large	Vel.	Measured	Calculated
Av.Medellin	2	654	270	46	-	-	-	69.0	68.0
Cra.7	6	1666	138	30*	2360	277	30*	74.5	74.9
Av.Quito	10	4251	420	37	5229	473	37*	75.8	77.3

Small: Number of small vehicles/hour, Large: Number of large vehicles/hour, Vel.: running velocity(km/hour)
*: Estimated value

The prediction method of ASJ is as followed:

$$L_{50} = Lw - 8 - 20 \log_{10} l + 10 \log_{10}(\pi\ l/d \tanh 2\pi\ l/d) + \alpha_d + \alpha_i$$

where:

L_{50}	:	Median of traffic noise level (dBA)
l	:	Distance from sound source (m)
d	:	Average interval of vehicle (m) $d = 1000 V/N$
V	:	Average running speed (km/hour)
N	:	Traffic volume (Vehicle/hour)
α_d	:	Adjustment factor of diffraction
α_i	:	Adjustment factor of various causes

3) Hourly Noise Change at Avenida Ciudad de Quito

The JICA Study Team investigated hourly changes of noise level along the major roads which are proposed in the Master Plan, such as Avenida Ciudad de Quito. The objective of the survey was to investigate and analyze the relationship between noise level and traffic volume, and on this basis to appraise the method of predicting road traffic noise in the future. The traffic volume was counted and classified at the same time .

The locations selected and periods of survey were as follows:

Location: Avenida Ciudad de Quito between 53 and Calle 53B

Periods : from 7:00 am to 7:00 p.m.

Concerning methods of making measurements, the measuring locations of noise were 2-3m from the edge of the road. The microphone was set at 1.2 m above the ground. The changes in noise level and traffic volume during 12 hours are summarized in Table 15.3-4 and Figure 15.3-2. The noise levels along major roads such as Avenida Ciudad de Quito are consistently high.

Table 15.3-4 Changes in Noise Level and Traffic Volume

Measuring Time July 4th '96	Noise Level (dBA)			Hourly traffic volume (unit)				Velocity (A line) km/h
				A Line to Centro		B Line to Norte		
	L50	Leq	Lmax.	Small car	Large car	Small car	Large car	
7:00-7:10	77.7	80.4	96.5	7327	449	5195	504	43
8:00-8:10	76.0	78.1	90.9	7260	538	5908	519	30
9:00-9:10	76.0	78.1	90.5	6838	504	4337	434	39
10:00-11:00	76.5	79.3	96.3	6769	399	4525	413	39
11:00-11:10	76.5	79.6	99.4	5320	396	4401	373	43
12:00-12:10	75.8	78.9	105.5	5229	473	4251	420	37
13:00-13:10	75.4	80.9	105.3	5552	440	4228	459	39
14:00-14:10	75.8	78.5	102.9	5060	442	4672	601	41
15:00-15:10	77.7	82.4	106.7	5446	478	5947	388	34
16:00-16:10	76.0	79.0	100.2	6156	470	5962	422	43
17:00-17:10	76.5	79.3	93.7	6379	609	6195	415	35
18:00-18:10	76.0	78.2	97.4	5304	531	5893	350	32
19:00-19:10	75.4	78.3	96.2	-	-	-	-	40

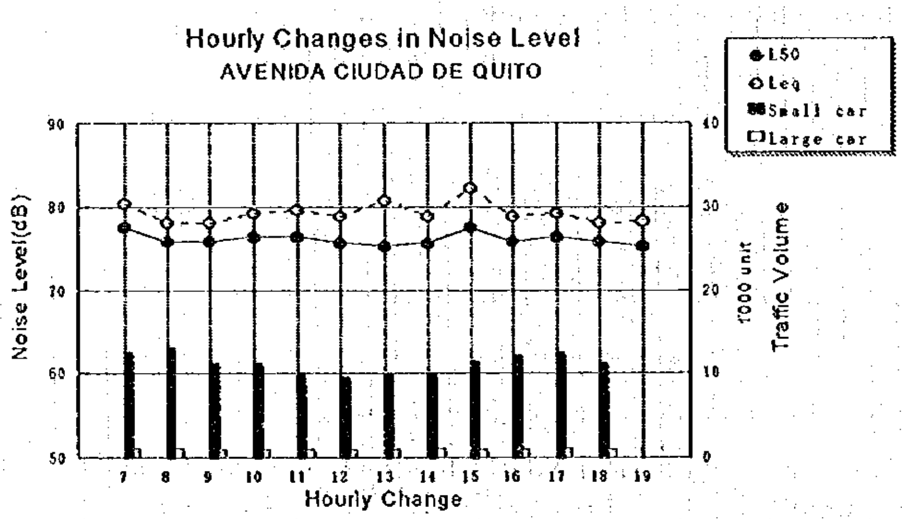


Figure 15.3-2 Hourly Changes in Noise Level and Traffic Volume

(2) Air Pollution

According to the traffic counting data on major roads in Bogota, the results show that the 12-hour traffic volumes are large in the city area, with a maximum volume of 153,000 PCU/12-hours. Traffic volumes of 30,000 PCU/12-hours or more are also observed on other arterial roads. The percentage of buses and busetas on major roads is high: 26% at Avenida Caracas ; 36% at Avenida 10.

In addition, travel speeds on major roads at the peak hour are 10 km/h or less. In particular, buses frequently stop for loading and unloading passengers, and at intersections.

The JICA Report '92 described the principal features of motor vehicles in Bogota: most are old and have large gasoline engines. These features, coupled with low atmospheric pressure, cause high emissions of CO and HC due to incomplete combustion.

Decreto 948 de 1995 enacted by the Ministry of the Environment, provides measures for prevention of air pollution, noise and offensive odors. In Bogota, Resolución 160/1996 was enacted on June 5th following Decreto 948. It specifies maximum levels of Carbon Monoxide(CO) and density of Hydrocarbon(HC) from automotive exhaust gas and the emission standards are shown in Table 15.3-5.

Table 15.3-5 Maximum level

Model of vehicles	% volume of CO	HC ppm
before 1974	7	1
1975-1980	5.5	800
1981-1990	5	650
1991-1995	4	500
1995-1997	3.5	450
after 1998	2.5	300

However, countermeasures against automobile exhaust have hardly been taken until now. At present, DAMA is monitoring exhaust fumes from vehicles at 14 stations in the city. In case the results exceed permitted values, owners of the vehicles are fined. However, as the vehicle inspection system is not operated with regularity and there is no equipment to measure exhaust fumes in auto repair shops, DAMA is contemplating the early establishment of a public service corporation.

(3) Landscape

The scenery of Bogota is composed of tree-lined streets, parks, buildings and mountains. Facilities along the streets such as residences and apartments are of unified design with dressed bricks. Therefore, when viewed from the road, the landscape is dominated by greenery from trees and shrubs, and the browns and whites of building facades. These elements of landscape express the particular individuality of Bogota and its regional character and history.

Concerning the roads in Bogota, there are not only roads devoid of environmental consideration such as Autopista del Sur but also roads with environmental greenbelts such as Autopista El Dorado and Autopista del Norte. In addition, there are many roads with well developed rows of trees. As effective use of the median strip will be expected in future major projects, the existing state of trees in the median strip is shown in Figure 15.3-3.

15.3.2 Fundamental View of Environmental Measures

(1) Noise/Vibration

Items which have to be noted when taking countermeasures against noise/vibration are as follows.

1) Road Traffic

a) Strengthening regulations

Traffic noise will rise on account of increasing traffic volume in the future. Therefore, there is a need to strengthen regulations and controls over the noise level from every vehicle contributing to road traffic noise. For instance, noise regulations applied to vehicles in Japan are shown in Table 15.3-6.

Table 15.3-6 Particulars Of Noise Regulation Concerning Vehicles In Japan (dB)

Type of vehicle	Acceleration running noise					Running noise	Exhaust noise
	1971	1976	1979	1982	2006?		
Small vehicle(Less than 10 person)	84	82	81	78	76	70	103
Large vehicle(Over 3.5ton, 200Hp)	92	89	86	83	82	80	107

b) Traffic Flow

It is particularly important for achieving noise reduction to plan and maintain the traffic flow more safely and smoothly. Steps to improve the road system follow: dispersion and facilitating movement of traffic by systematic improvement of roads; easing traffic jams by improving intersections and the establishment of a parking information system etc. Improving the traffic control system makes the traffic flow smoother. In managing traffic demand, introduction of High Occupancy Vehicles and rationalization of the transport of goods are needed. In addition, a good traffic environment will be encouraged by various regulations such as area-licensing, a license-plate numbering system, emission regulation etc. and promotion of use of mass-transit systems by providing areas where passengers can park their cars before boarding trains.

On the other hand, large buses produce much noise and vibration compared with cars, therefore it is desirable that an express bus line is arranged with an alignment that is far from dwellings.

c) Road Structure

When planning new roads, it is necessary to examine the following facilities and to try hard to preserve the environment.

*Road Structure --- Comparison of noise decay by distance under the same traffic conditions for basic types of road structure is shown in Figure 15.3-4. Receiver height is 1.2m; total hourly traffic volume is 6400; velocity is 60 km/hour; ratio of large cars is 15%. In case of an at-grade road, noise is higher and there is less decay.

*Barriers --- Barriers between the sound source and receivers can be used effectively to reduce outdoor noise by diffraction. In the case of an elevated road, establishment

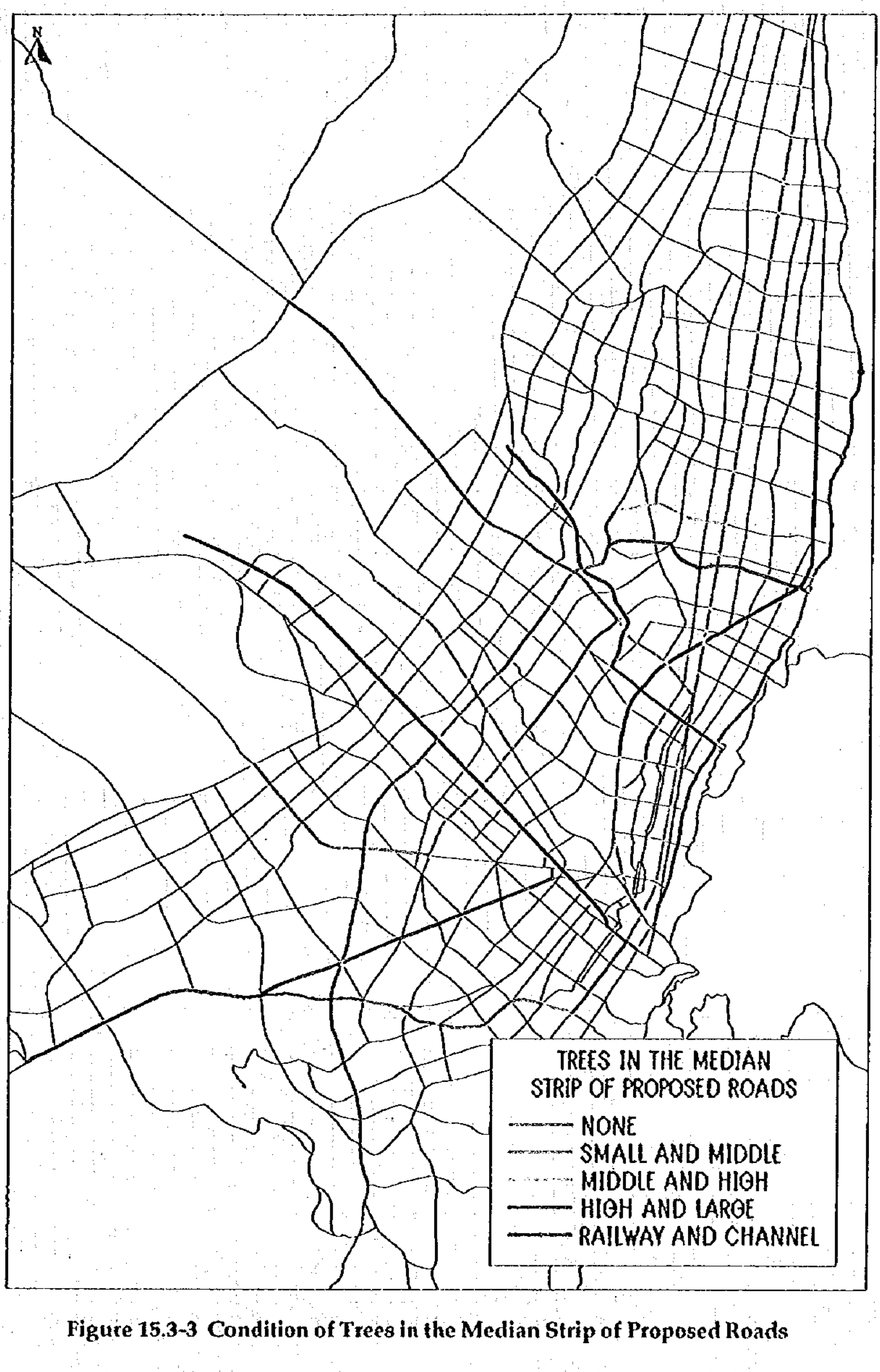


Figure 15.3-3 Condition of Trees in the Median Strip of Proposed Roads

of a 5m-barrier can reduce the noise level by 5-10 dB at a height of 1-3m above ground level.

*Continuous Girders --- Impact noise from vehicles and structural vibration due to traffic loading at expansion joints of the elevated road will occur. An effective countermeasure is to reduce the expansion joint and make the road surface continuous. Therefore, it is necessary to select not a simple girder bridge but a multi-span continuous girder bridge, and to arrange the expansion joint far from dwellings.

*Environmental Belt --- A zone between the road and dwellings should provide barriers and greenery for aesthetic considerations, and to reduce noise, vibration and air pollution by assisting decay with distance.

*Absorption Treatment --- In case of increasing noise levels caused by reflection of grade level noise from elevated roads running above them, absorbent treatment of the underside of the elevated road will reduce reflected noise. As for tunnels, absorbent treatment of the exits will reduce the diffusion of noise.

*Porous Asphalt Pavement --- Asphalt pavement using porous materials will control the noise produced by tires and pavement and reduce reflected noise from the road surface. It is expected that the noise level will be reduced by about 3 dB.

*Low Barriers --- For at-grade roads in the city, establishment of high barriers is not recommendable from the functional point of view. Therefore, establishment of a low barrier such as about a 1m high-hedge will reduce the noise level by 2-3 dB in an area 2-3m high behind it.

*Pier Type of Bridge --- In the case of a T type, vibration pollution is possible from bending vibration in the transverse direction. Therefore, selection of a 2-pier type is desirable when passing dwelling zones.

Overall countermeasures against noise and vibration are shown in Figures 15.3-5 and 15.3-6, respectively.

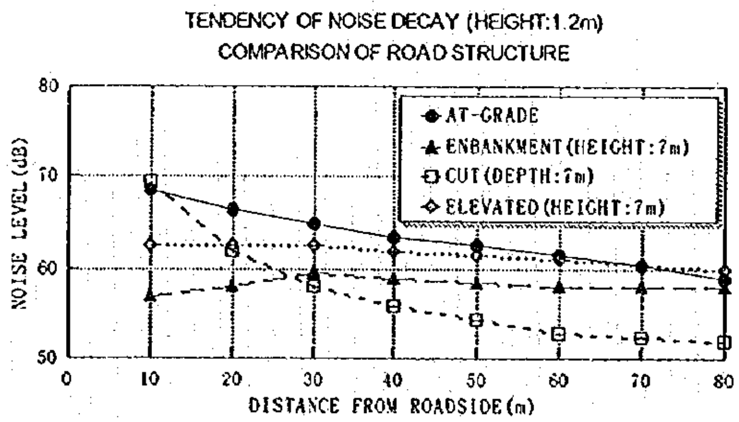


Figure 15.3-4 Noise Decay By Distance (1.2m)

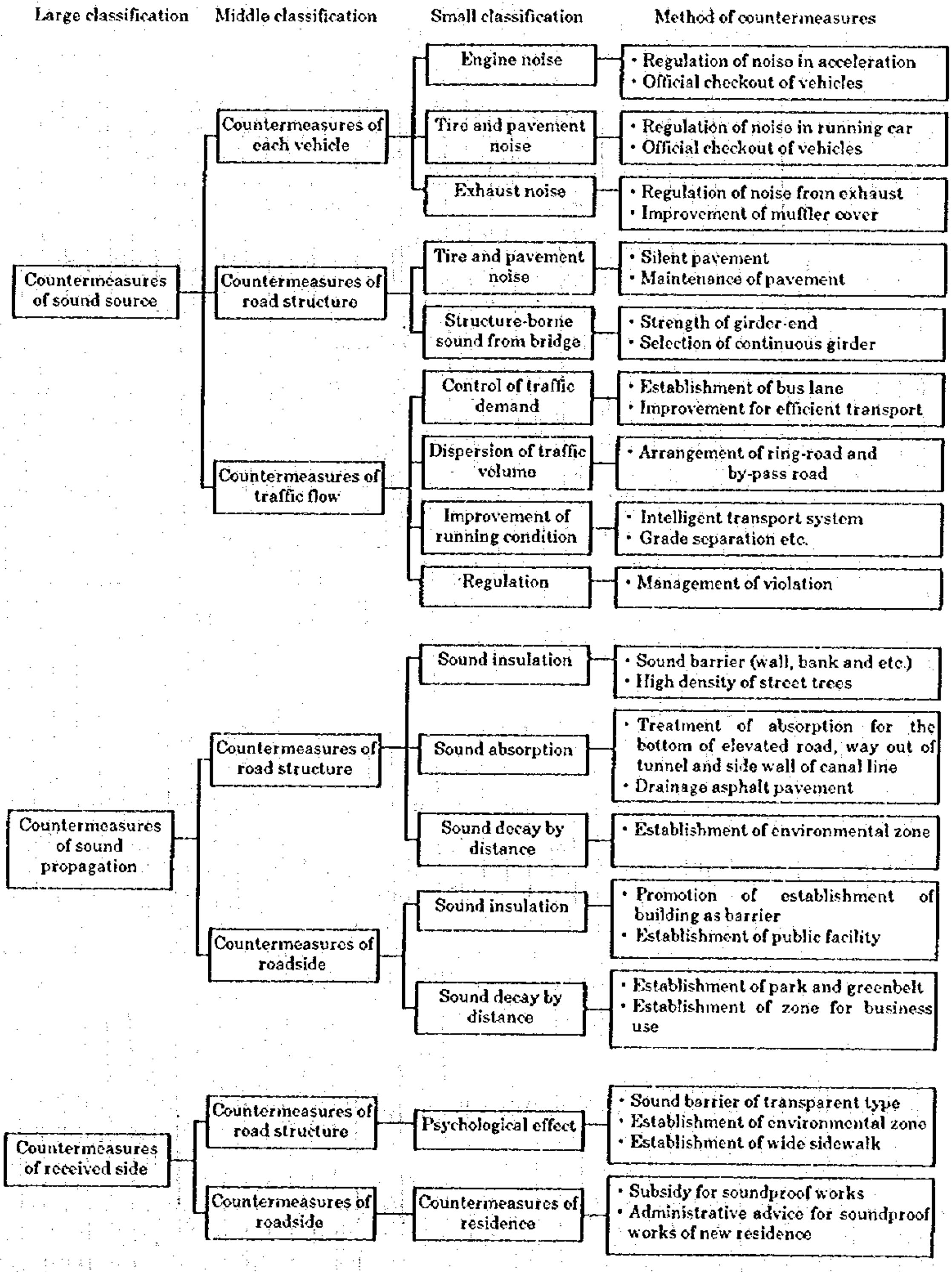


Figure 15.3-5 Overall Countermeasures On Noise

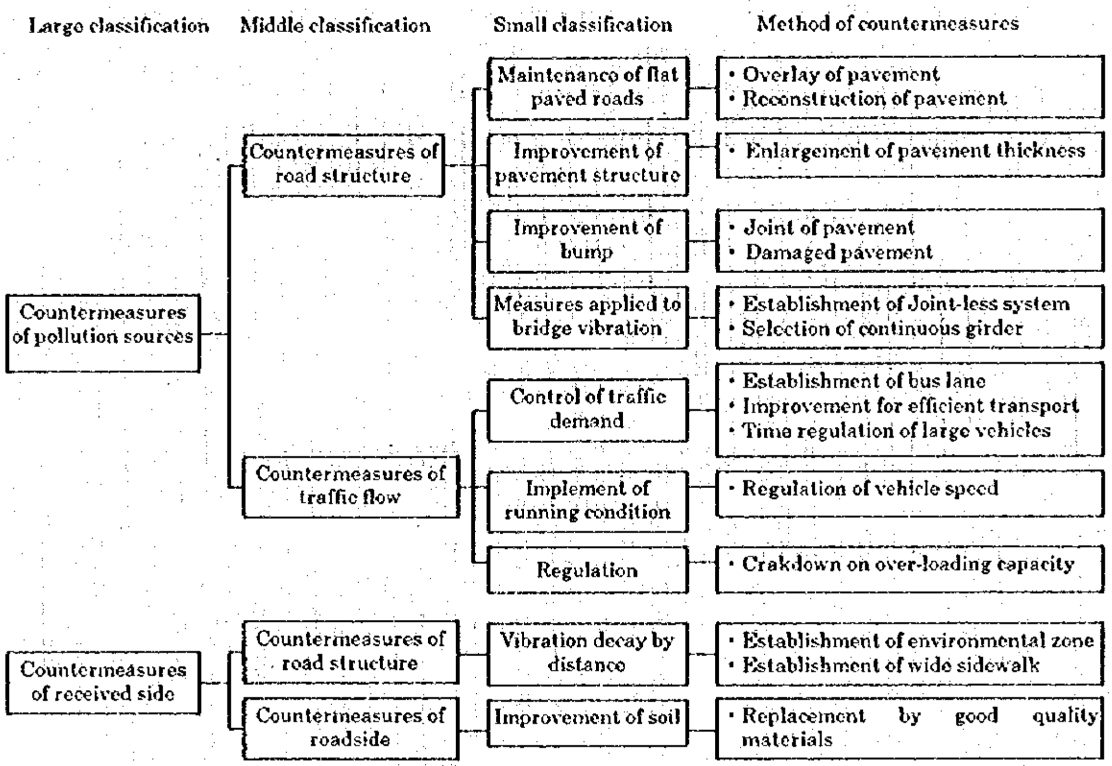


Figure 15.3-6 Overall Countermeasures On Vibration

2) Countermeasures for Railways

Countermeasures for railways are as follows: countermeasures against sound sources such as rail noise and structure-created sound; countermeasures on land use planning. Particularly, countermeasures on sound source are as follows: selection of car type such as LRT or HRT; rail noise caused by wheels and rails will be reduced by barriers such as inverted L type barrier; structure-created sound will be reduced by the selection of track type.

(2) Air Pollution

Items which should be noted as countermeasures against air pollution are as follows.

1) Improvement of Vehicles

Improvement of vehicles involves emission gas regulations applied both to new models and vehicles in use. It is important to strengthen regulations in the future. As for countermeasures for gasoline engines, the use of catalysts is effective for the reduction of CO, HC, NOx. In addition, the use of electronic controlled carburetors will reduce the volume of emission gas. In Santiago de Chile, a license-plate numbering system has been implemented for the purpose of environmental preservation in the city. Only, vehicles using catalysts are allowed to enter the city, so this factor encourages the purchase of a new car or use of effective catalysts. On the other hand, the present vehicle taxation system is based on the evaluated value of the vehicle. According to this system, the amount of tax decreases as the vehicle gets older. From the viewpoint of air pollution, however, older vehicles emit larger quantities of pollutants while making installation of control measures more difficult. In this context, the tax system should be modified in such a manner that users are encouraged to discard old vehicles and buy new vehicles equipped with emission control measures. Through the crackdown on emission gas in Bogota at present, it is important for vehicle owners to recognize that they are not only sufferers but are also responsible for the pollution and to understand that controlling engine emissions contributes to the improving environment of the city.

2) Improvement of Road Structure

The concentration of automotive emissions decreases by diffusion as the distance from the road increases. Therefore, it is important to maintain distance between roads and dwellings by the establishment of buffer zones and green belts. Comparison of air pollutants' concentration decay by distance under the same traffic conditions applied to basic types of road structure is shown in 15.3-7(receiver height is 1.5m; wind direction is transversal). In case the height of the emission source is low, such as at grade level, concentration on the roadside is high. Therefore when the height of the emission source increases, diffusion is more effective. Using barriers as countermeasures against noise, the emission height will theoretically be higher and is also effective for the diffusion of pollutants.

On the other hand, some plants are able to absorb and fix air pollutants. For instance, a 7m-wide greenbelt with trees on both sides has the ability to absorb 5% of NOx emitted from a traffic volume of 30,000 vehicles per day. Figure 15.3-8 shows that rows of trees along a roadway have the effect of promoting diffusion by disturbing the air flow. Overall countermeasures on air pollution are shown in Figure 15.3-9.

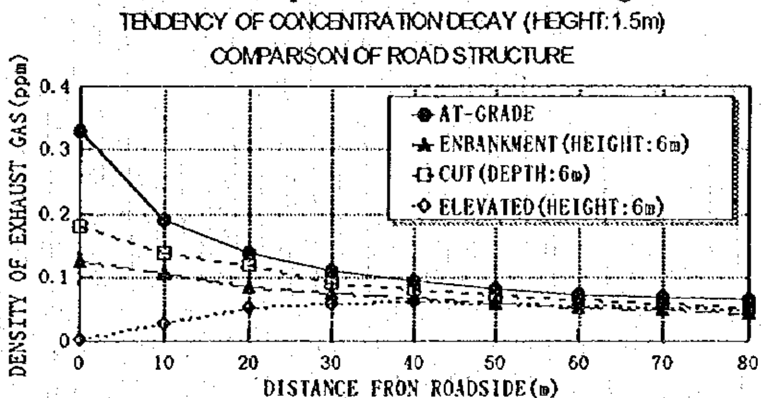


Figure 15.3-7 Comparison Of Air Pollutants Concentration Decay By Distance

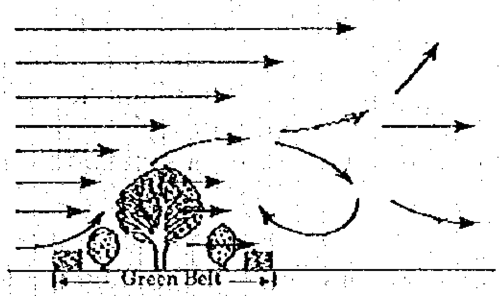


Figure 15.3-8 Function Of Diffusion Concerning Greenbelt With Trees

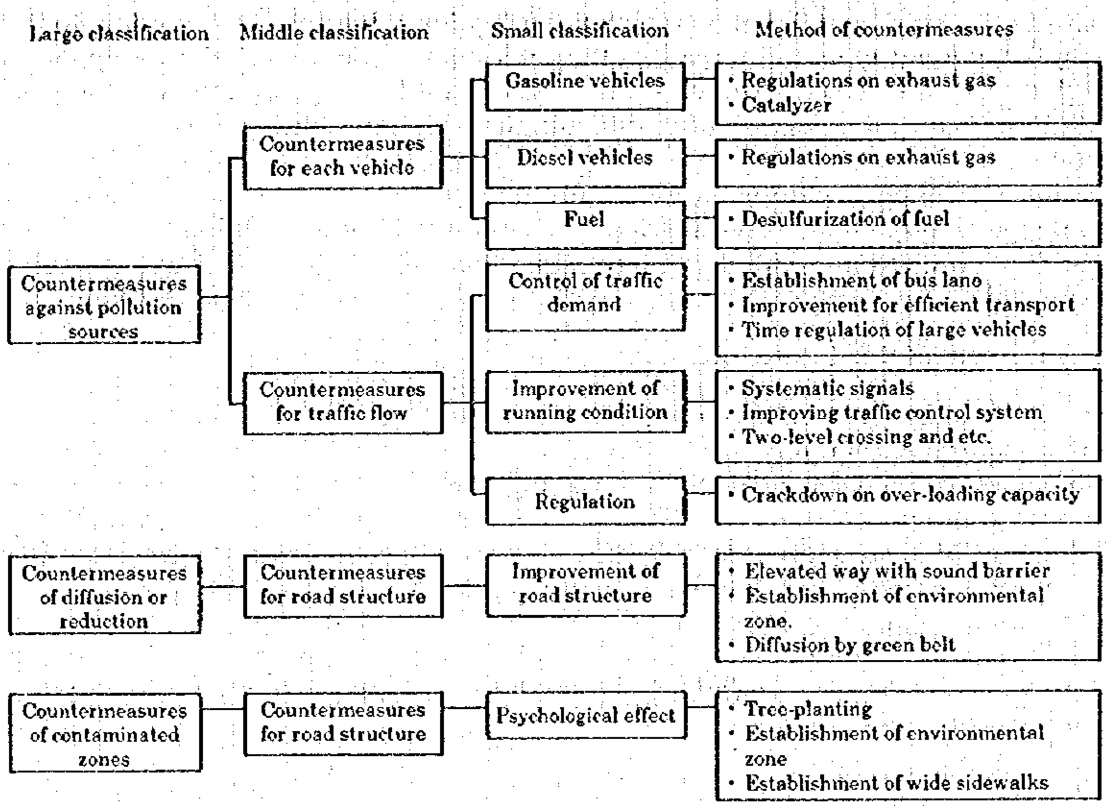


Figure 15.3-9 Overall Countermeasures On Air Pollution

(3) Landscape

Items which have to be considered regarding landscaping are as follows.

1) Road Landscape

Road landscape has 3 constituents, namely the road, the roadside and the distant view. The road constituent consists of the road itself and associated trees, shrubbery and lighting. The roadside constituent consists of facilities such as dwellings, stores and green zones such as farms and woods. The distant view constituent consists of natural surroundings such as hills, wetlands and cultural items such as monuments. Landscaping arrangements for roads aim at improving the landscape. Fundamental rules to be noted are as follows; 1) design in response to road character; 2) design for road user and residents in the region; 3) well-balanced shape; 4) harmony and variety. These projects can be classified as urban roads mainly, therefore the design should consider the individual character of districts such as Centro and residential areas. Moreover, roads should be designed in such a way that users and nearby residents can utilize them with pleasure as a part of their everyday life. A road is fundamentally an artificial structure, so arrangement of these structures without proper consideration will result in an unbalanced landscape. Therefore it is necessary to give careful consideration to the balance between the design of the road and its surrounding environment. A proper balance will produce harmony and variety.

2) Greenery and Individuality

It is necessary to improve the environment of Bogota, to consider greenery and individuality.

The function of greenery in road planning is to improve the scenery, conserve the natural environment, enhance traffic safety, provide shade and prevent disasters. The function of improving the scenery is for aesthetic reasons, camouflage, scenic unity and scenic harmony. Planting trees can accentuate the landscape and enhance its quality. Using greenery to camouflage can hide ugly structures from view. Scenic unity can serve to abet concentration and guide user's eyes by planting trees regularly. Scenic harmony can harmonize artificial structures with nature, e.g., by planting on the slopes of deep cuts. It is necessary, to promote greening activities, to select arrangement and types keeping in mind the functions assigned to the road and the region.

It is important when aiming to improve the scenery to express the individuality of the area. How to do this is to use materials from the region or associated with the region's history. For instance, using bricks for dwellings along roadsides will express the historical and regional individuality of Bogota and harmonize with its atmosphere.

Overall landscaping measures are shown in Figure 15.3-10.

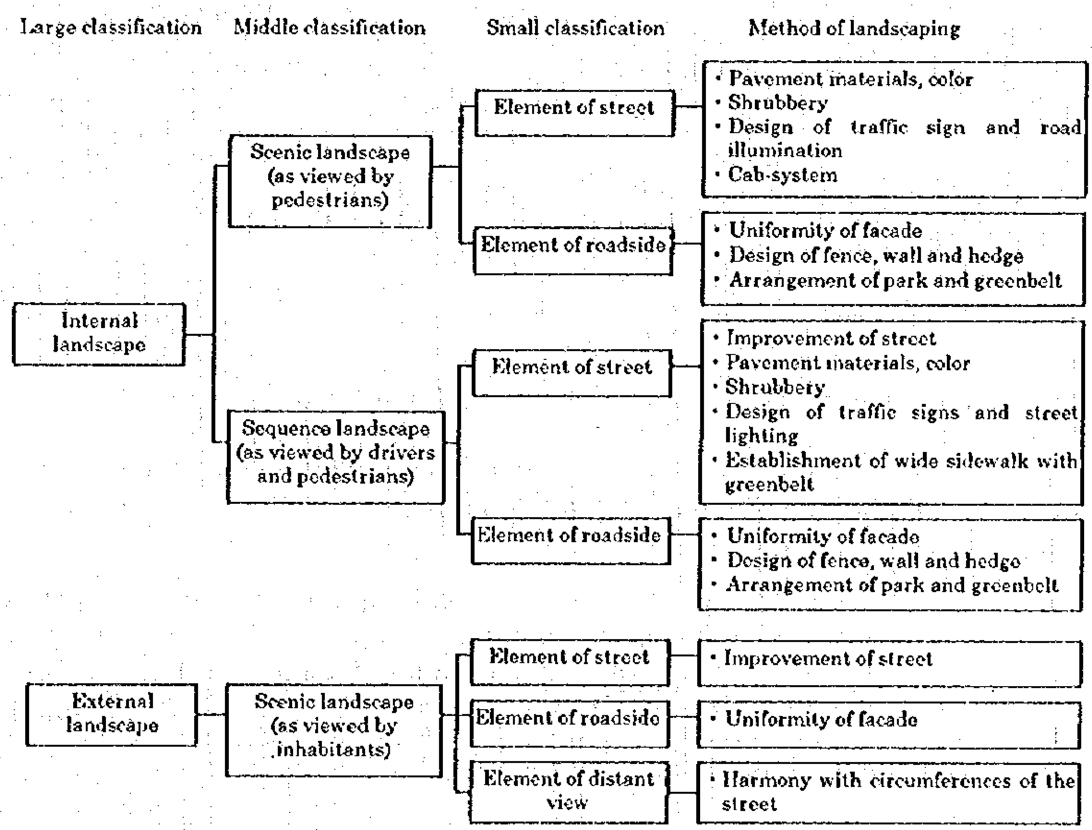


Figure 15.3-10 Overall Landscaping Measures

15.3.3 Environmental Impact and Evaluation

(1) Resettlement

The Master Plan for elevated roads, bus-express ways, railways, will use existing routes such as roads, railway, canal and basically avoid the need for much land acquisition. Therefore, it is not necessary to obtain large amounts of land for main routes, but only smaller parcels for intersections, curves, junctions the and on-off ramps of highways. The widening of Avenida 68 will entail the acquisition of land along the roadside. A study is required for the resettlement of inhabitants displaced from these areas. It is necessary to take measures against illegal occupation of railway right of way, as in the Gorgonzona district.

(2) Transport and Public Facilities

Transport facilities are planned, e.g., bus and railway terminals. Therefore, a feasibility study needs to assess the impact of these works. Meanwhile, traffic jams and noise pollution during construction are expected, so construction planning need prudent environmental consideration.

Many public facilities such as schools, hospitals and churches exist along the roads. Therefore, the above-mentioned countermeasures should be carried out in order to protect the environment.

(3) Cultural Property

The distribution of important historical monuments listed in Decree No. 677/94 are shown in Figure 15.3-11, overlaid on the proposed routes. Though some monuments exist along the routes, they do not exist in the proposed land acquisition areas, e.g., for highway junctions, grade separations of Avenida Caracas, etc.

(4) Waste

Waste expected in this study consists of waste dumps resulting from construction. Especially, much waste resulting from construction of highway foundations, railway tunnels etc. will be created. Guidelines concerning the construction of mass transport and pubic works were issued by DAMA, in April 1996, so it is necessary to consider environmental conservation and obtain an environmental license before execution starts.

a) *Términos de Referencia Elaboración de Estudios de Impacto Ambiental para la Construcción y Desarrollo de Sistemas de Transporte Masivo*
b) *Términos de Referencia Estudios de Impacto Ambiental para la Ejecución de Obras Públicas de la Red Vial, No Pertenecientes al Sistema Nacional*

(5) Flora and Fauna (Marshes)

The area along Rio Juan Amarillo is one of marshland under the protection of DAMA and will be planned as a park area in the future. From the point of view DAMA, basically it is not permitted to construct not only in marshland in protected areas but also in areas proposed for parks in the future. Therefore, the proposed highway route should be arranged along the border of this area and adoption of an elevated roadway will be needed to mitigate any effects on the marshes.

(6) Landscape

There are generally three points which should be noted for landscaping.

1) Tree-lined Street

This study is planning to construct road facilities using median strips effectively, e.g., for elevated highways. An abundance of trees grow in the median strips of proposed routes, therefore, these trees may be transplanted to parks etc. when necessary. They include large trees more than dozens of years old on Calle 72. If the proposed sites have sufficient space, it may be possible to avoid removing the trees. However, a situation where trees will have to be felled will occur on all the proposed routes.

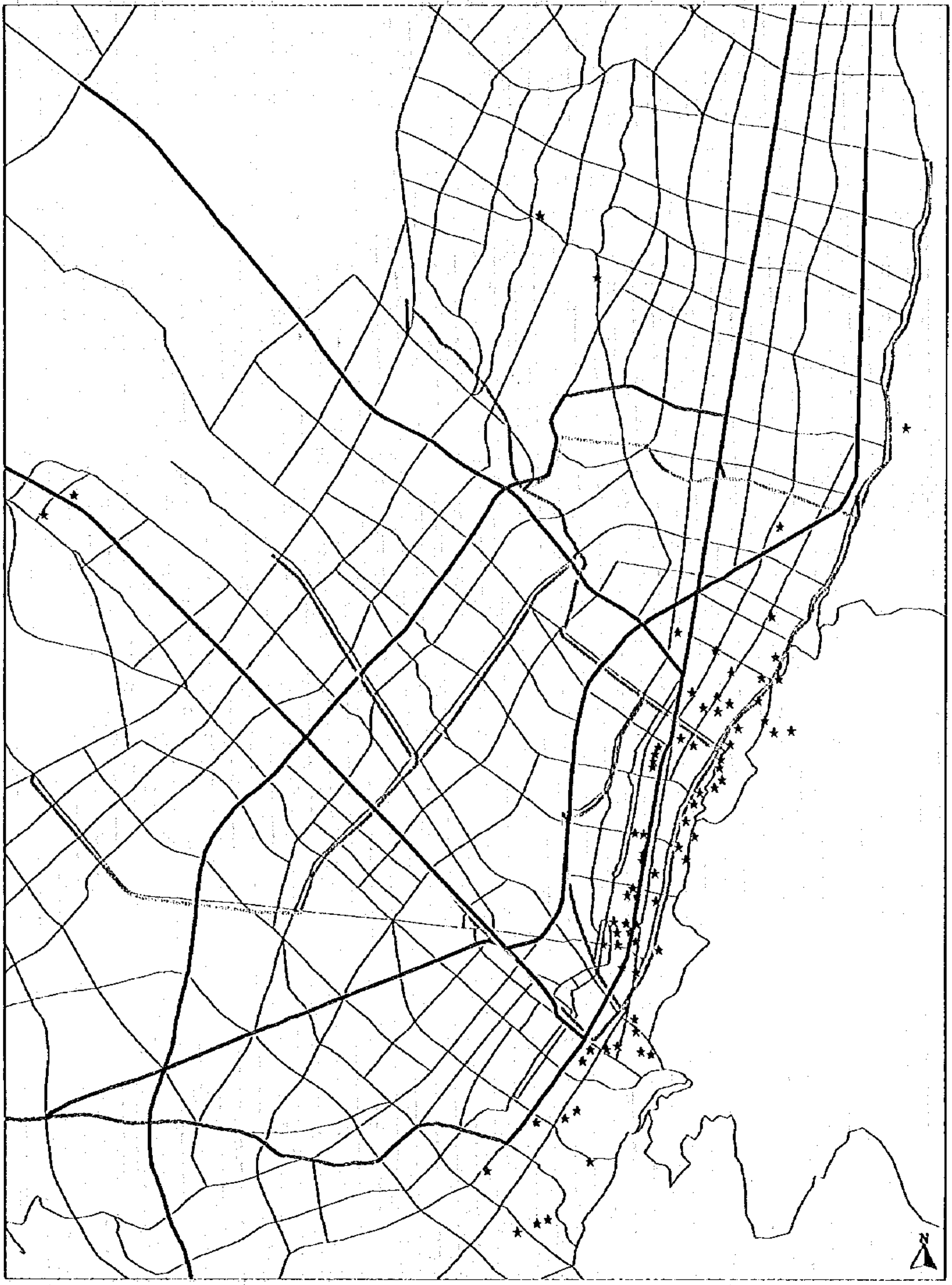


Figure 15.3-11 Distribution of Important Historical Monuments

DAMA has experience in the transplantation of trees and permits the felling of trees which are not rare species or important historical landmarks. In such a case, DAMA requires that scenic improvement should be sufficiently considered in the road improvement plan and that environmental measures are taken, e.g. replanting trees.

2) Dwelling Zone

Circumstances along the Canal de los Molinos, planned as a highway route are calm in the dwelling district. High trees are arranged on both banks of the canal and this forms a good residential environment with greenery. Therefore, it is necessary for the design of the proposed elevated road to create a shape in harmony with the surrounding environment. For instance, the elevated road will be expected to have a sound barrier in order to reduce traffic noise. In that case, it will be necessary to consider the adoption of a design such as a transparent type barrier of curved shape. In addition, camouflaging the structure with trees is desired, by retaining existing trees and planting new trees when necessary.

3) Marshes and Parks

The situation along Rio Juan Amarillo is one of marshland under the protection of DAMA, and the adjacent area will be planned as park-land in the future. As functions of this zone recreation activities, habitats of animals and plants, amenities and a natural scenic environment etc. will be expected. Therefore, it is necessary not only to harmonize the elevated road with the natural environment, but also to design its features so that it will be in keeping with the existing residential area.

(7) Air Pollution

As a result of the Master Plan, traffic will flow more smoothly and running speeds will rise. The relation between vehicle velocity and emission volume is shown in Figure 15.3-12. The combination of improvement of speed and control of unnecessary start/stops is expected to reduce the concentration of exhaust gas from vehicles. This will be especially effective for large diesel-engine vehicles. However, the growth of traffic volume in the future will counter this effect unless suitable measures are taken. Therefore, as mentioned above, it is necessary to promote exhaust gas regulations and traffic demand management etc.

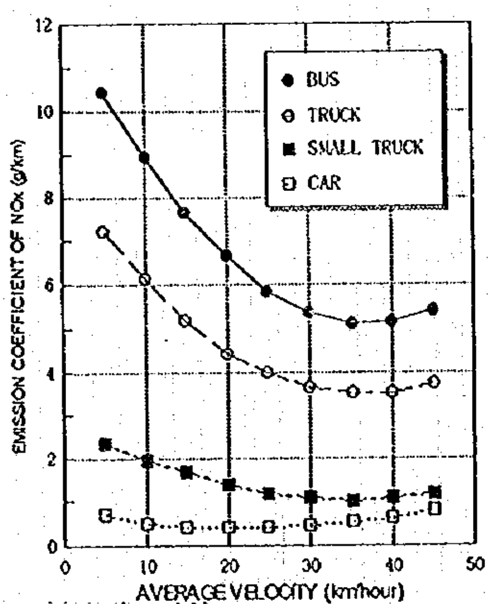


Figure 15.3-12 Relation between Vehicle Velocity and Emission Volume

Concerning road structure, the diffusion of emission gas will occur easily for wide roads such as Autopista del Norte due to decay by distance and greenbelt. However, for narrow roads surrounded by high buildings in the city such as Avenida 7a, emissions from ground level road will remain under the elevated road. Therefore, it is necessary to design the elevated road higher and to diffuse pollutants.

(8) Noise/Vibration

1) Road

Power levels in 2020 is expected to reduce from the present level in consideration of the regulatory standards for vehicle noise and improvement of vehicle efficiency. Today, the vehicle noise in Bogota is higher than that of Japan, however it is assumed that the future condition of Bogota will be close to the present one of Japan.

In the prediction method, though the formula of power level is based on the ASJ, the ratio of power between small vehicles and large vehicles is applied based on the surveyed values due to the heavier nature of vehicles in Bogota than in Japan.

$Lw = 65.1 + 20 \log_{10}V + 10 \log_{10}(a_1 + 4.4 a_2)$ JAPAN today

$Lw = 65.1 + 20 \log_{10}V + 10 \log_{10}(\underline{a_1 + 7.9 a_2})$ BOGOTA in the future

Using above mentioned power level formula, the distribution of noise level L_{50} in 2020 is calculated. Predicted sections as the subject of highway planning are 3 sections as follows; Avenida 7a as V-2 road; Canal de los Molinos in dwelling zone; Avenida 68 as V-1 road. Hourly traffic volume, ratio of large vehicle and speed are stated as follows:

a) Hourly traffic volume; peak hourly traffic volume is the value of the daily traffic volume of the future network multiplied by 0.08 as a peak hourly coefficient
b) Ratio of large vehicles; the value is classified by daily traffic volume on classification of vehicle types.
c) Speed; design speed is expected.

The above calculation conditions are shown in Table 15.3-7.

Table 15.3-7 Calculation conditions

	Road Structure	Daily Traffic Volume	Peak Hourly Traffic Volume	Ratio of Large vehicles	Velocity (km/hour)
Cr.7	At-grade road(186)	89442	7155	0.121	40
	Elevated highway(hw3040)	56686	4535	0.190	60
Canal	Elevated highway(hw3041)	12285	983	0.080	60
Av.68	At-grade road(295)	186333	14907	0.083	50
	Elevated highway(hw3047)	53769	4302	0.033	60

Using these data, the results of calculation predicted by the ASJ method are shown in Figure 15.3-13 a. b. c. L_{eq} is about L_{50} plus 2-3 dB. According to these figures, road traffic noise is mainly derived from at-grade traffic and the effect of noise from the elevated highway is small. So the effect of noise on dwellings along Canal de los Molinos will be small. On the other hand, the calculated noise levels along the roadside of Avenida 7a and Avenida 68 are nearly equal to measured noise levels. If the target of environmental protection will be the existing noise level, no special countermeasures against noise will be required. Now, according to the environmental standards, countermeasures on noise in the case of at-grade roads will be needed. However, it is difficult to cope with sound insulation in the case of at-grade roads, because a high barrier, which is effective, has a negative effect on road function and scenery.

Therefore a low barrier together with shrubs, which reduces noise levels by 2-3 dB, is recommended.

2) Railway Noise

Using the elevated railway noise prediction method of the Tokyo Metropolitan Government, railway noise is calculated. However, this prediction method is applied to Japanese HRT, based on conditions like RC (reinforced concrete) structures, ballast track, long rails etc. So the predicted result indicates the tendency of noise level only approximately. The prediction method is as follows:

$$L_A = 10\log_{10}(10^{L_{A1}/10} + 10^{L_{A2}/10})$$

$$L_{A1} = L_{w1} - 8 - 10\log_{10}r_1 + 10\log_{10}((l/2r_1)/(1+(l/2r_1)^2) + \tan^{-1}(l/(2r_1)) + \alpha_d$$

L_{A1} : Rolling noise (dBA)
Lw1 : Power Level of train(dBA) Lw1 = 25log10V + 57
l : Train length(m)
r1 : Distance from center of track(m)
α d : Adjustment factor of diffraction

$$L_{A2} = L_{W2} - 8 - 10\log_{10}r_2 + 10\log_{10}(\cos\theta \tan^{-1}(l/2r_2))$$

LA2 : Structure-created sound (dBA)
LW2 : Power Level of structure-created sound (dBA) LW2 = 92
r2 : Distance from center of slab(m)
θ : Direction from center of slab

Calculation givens are HRT, car length 20m×8 cars =160m, velocity 80km/h. Calculated results are shown in Figure 15.3-13 d. Maximum noise level at 10m from the edge of elevated railway is about 74dB. Supposing that the trains run every 5 minutes per single direction, the equivalent sound level in 1 hour is as follows:

Sound exposure level L_{AE} per train is as follows.

$L_{AE} = 74 + 10\log_{10}7.2 = 84$ dB (Passing time = 160/80 · 3600/1000 = 7.2 sec)

Equivalent noise level L_{eq} per hour as follows.

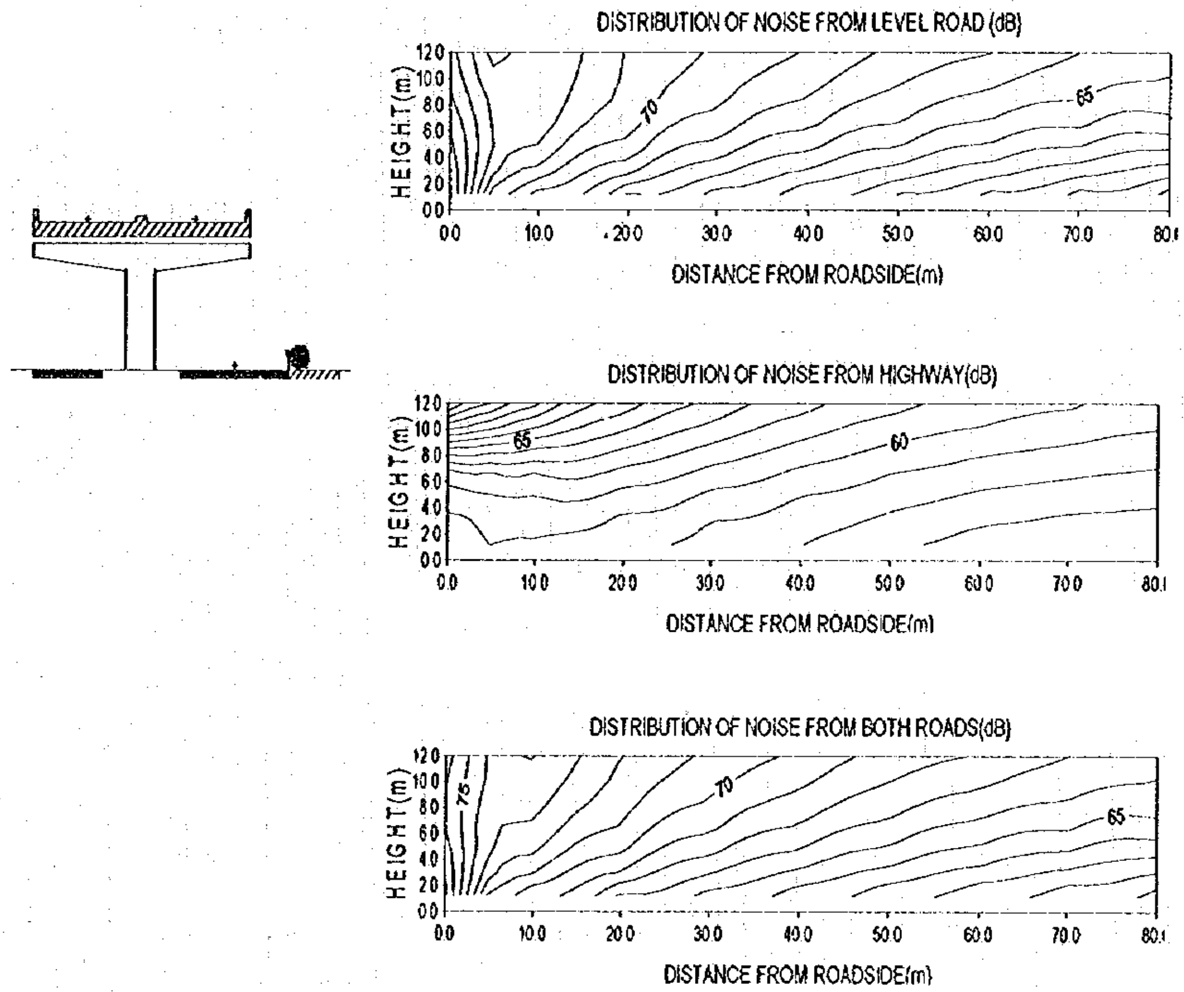
$L_{eq} = 10\log_{10}(10^{84/10} \cdot 60/5 \cdot 2/3600) = 61$ dBA

Therefore, environmental noise from trains is below the 65 dB ceilings of the environmental standard for residential areas.

(9) Ground Subsidence

Surface soil consists of sand and silt in Bogota and numerous marshes existed formerly. Therefore, the possibility of subsidence is expected when constructing foundations and during tunneling. Especially, it is necessary when using the shield method in weak ground to sufficiently consider surface subsidence. Factors affecting surface subsidence are geology, groundwater, overburdening, tunnel section, method of execution of work etc. These items are shown in Figure 15.3-14. Cautious execution of construction with field monitoring and subsidence control using injection grouting techniques which do not contaminate ground, are recommended.

a. Carrera 7



b. Canal de los Molinos

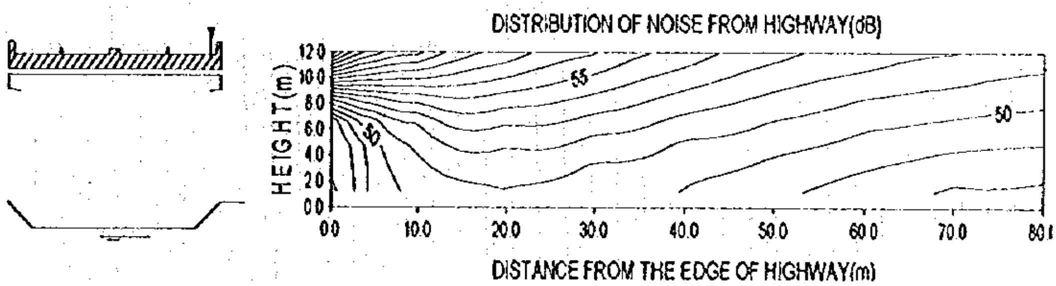
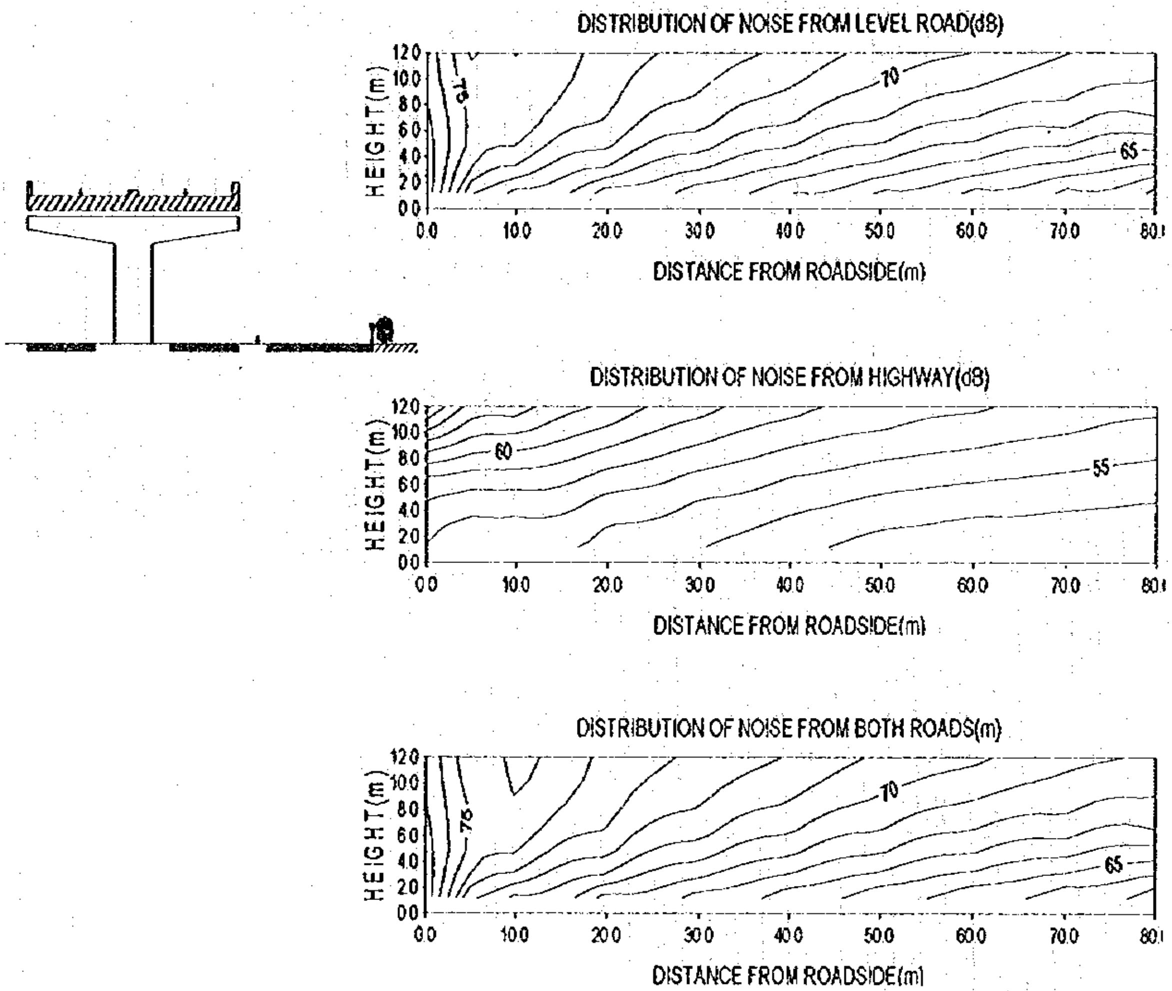


Figure 15.3-13 a, b Distribution of the Noise Level

c. Avenida 68



d. Railway

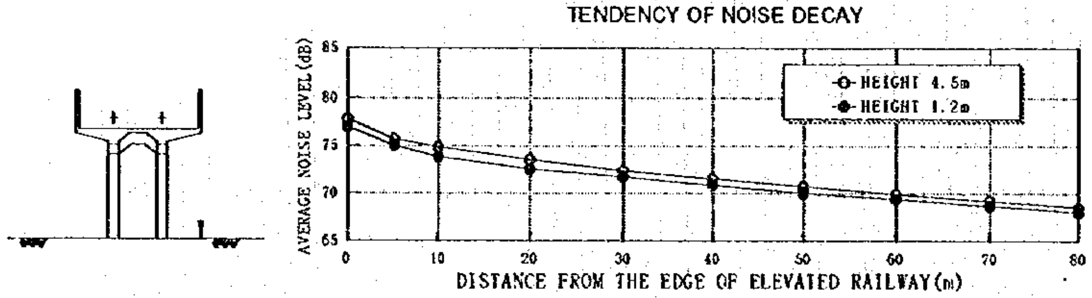


Figure 15.3-13 c, d Distribution of Noise Level

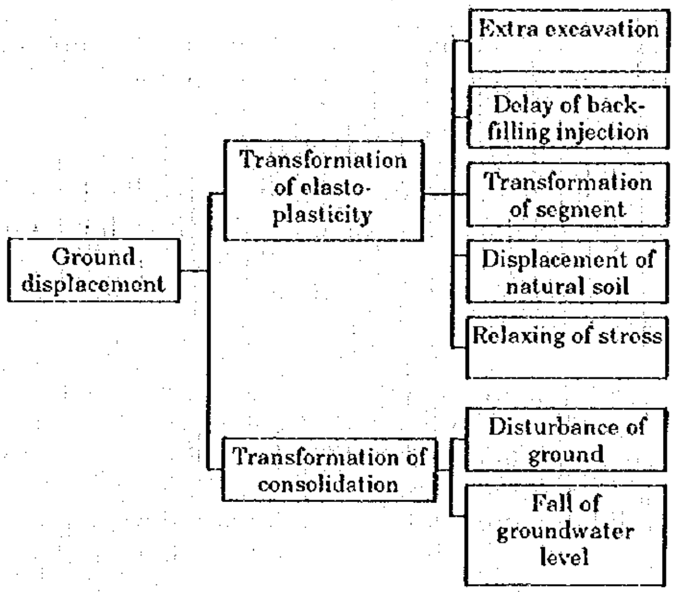


Figure 15.3-14 Factors Affecting Ground Displacement Using the Shield Tunnel Method

15.4 Traffic Evaluation

In the previous sections, economic, financial and environmental evaluation in Master Plan projects were made. In this section, traffic evaluation is made in terms of traffic volume, passenger travel volume for busway and railway, travel speed, and congestion length.

The 2001, 2010 and 2020 years' OD tables were assigned on the networks of the Short, Medium and Long Term Plan projects, respectively, to evaluate traffic aspects.

(1) Traffic Volume

Table 15.4-1 and Table 15.4-2 show traffic volume and travel time in PCU-km and PCU-hour, respectively. Figure 15.4-1 and Figure 15.4-2 show these rates of change by three target years. The PCU-km rises slightly by the year of 2010 and then, there is dramatic increase in 2020. In 2020, the rate stands at 2.3 times of the present figure which is estimated by the traffic assignment through applying the present OD table and transport network.

On the other hand, transport facilities rise in the cumulative planning period where the percentage rises at a similar rate as that of PCU-km until the year 2010. In 2020, the increase rate of the facilities is much lower than that of PCU-km. It indicates that the amount of transport facilities is not sufficient enough to carry the increase of traffic volume. The demand and supply appear to become somewhat unbalanced in 2020.

As for the share of traffic volume by each facility, the road facility in 2020 is predominant, about 90 % of all facilities, followed by 5 % for the expressways, 2 % for the railway and 2 % for the express busway.

The above-mentioned situations can also be seen on the figures of PCU-hours. In 2020, the travel time in PCU-hour rises to 2.7 times of the present figure. The rate is somewhat higher in contrast to 2.3 times in PCU-km. The reduction of travel speed is remarkable, compared to the increase of traffic volume.

In comparison between the Do-nothing case, which is without any future transport plan, and the Master Plan as shown in Figure 15.4-1 and Figure 15.4-2, PCU-hour in 2020 is dramatically contrasted in increase ratio to the present figure. The Do-nothing case stands at 8.7 times in PCU-hour while 2.7 is for the Master Plan case. As for PCU-km, figures in each case are slightly different. All this seems to indicate that the transport congestion is considerably heavier, if the Do-nothing case is selected.

Table 15.4-1 Traffic Volume in PCU-km

(unit: ,000 PCU-km)

	Case-1		Case-2		Case-3		Case-4		Case-2/Case-1	Case-3/Case-1	Case-4/Case-1
OD Table	1995		2001		2010		2020				
Network	1995	Share Rate	2001	Share	2010	Share	2020	Share			
Facility (km)	1071.4		1145.2		1340.9		1675.6		1.069	1.252	1.564
Roads	30,014	1.00	31,201	1.00	35,767	0.93	62,930	0.90	1.040	1.192	2.097
Expressway	0	0.00	0	0.00	1,134	0.03	3,836	0.05	-	-	-
Busway	0	0.00	0	0.00	1,240	0.03	1,447	0.02	-	-	-
Railway	0	0.00	0	0.00	407	0.01	1,536	0.02	-	-	-
Total	30,014	1.00	31,201	1.00	38,548	1.00	69,749	1.00	1.040	1.284	2.324

Table 15.4-2 Travel Time in PCU-hour

(unit: ,000 PCU-hour)

	Case-1		Case-2		Case-3		Case-4		Case-2/Case-1	Case-3/Case-1	Case-4/Case-1
OD Table	2001		2001		2010		2020				
Network	1996	Share Rate	2001	Share	2010	Share	2020	Share			
Facility (km)	1071.4		1145.2		1340.9		1675.6		1.069	1.252	1.564
Roads	1,222	1.00	1,074	1.00	1,263	0.93	3,003	0.90	0.879	1.033	2.457
Expressway	0	0.00	0	0.00	33	0.02	273	0.08	-	-	-
Busway	0	0.00	0	0.00	56	0.04	37	0.01	-	-	-
Railway	0	0.00	0	0.00	9	0.01	34	0.01	-	-	-
Total	1,222	1.00	1,074	1.00	1,361	1.00	3,347	1.00	0.879	1.114	2.739

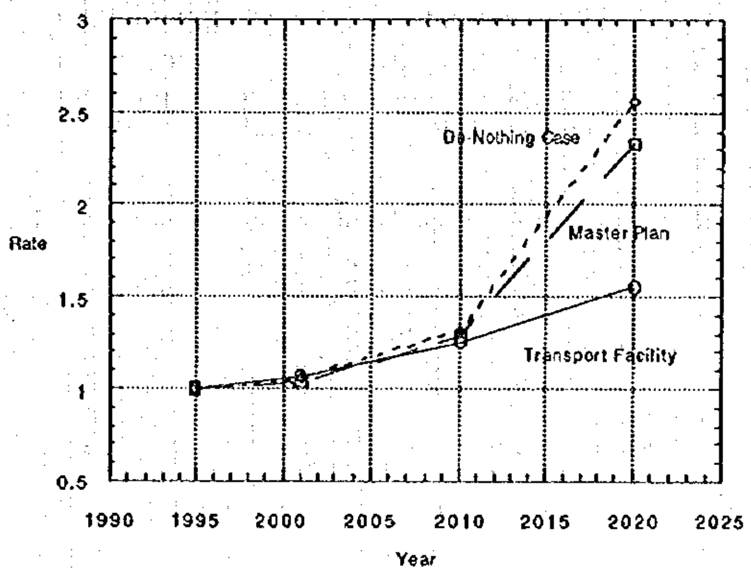


Figure 15.4-1 Rates of Change of Traffic Volume in PCU-km

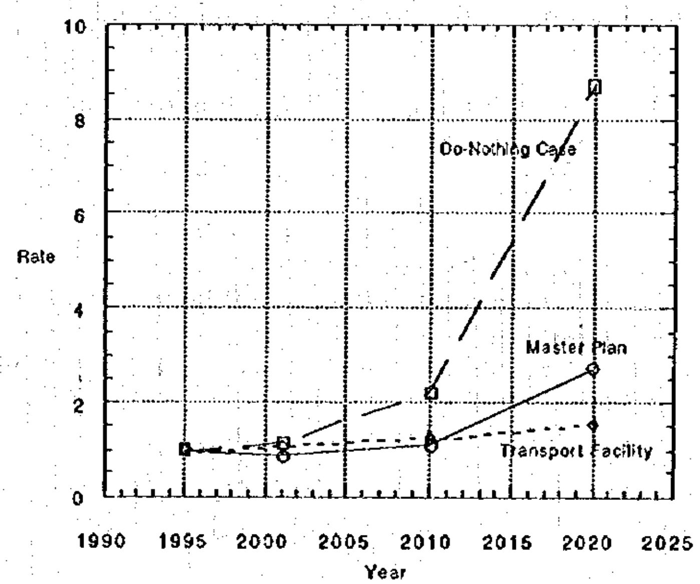


Figure 15.4-2 Rates of Change of Travel Time

(2) Travel Volume

Table 15.4-3 shows the average travel volume by four transport facilities: roads, urban expressways, express busway and railway. The figures for road facilities are the average traffic volume in PCU/km in dual directions on entire roads in the Study area. As for public transport facilities, the average travel volume in passengers/km on dual way in each facility is shown.

The traffic volume loaded on major roads (V-3 or more) rises from 28,000 PCU/km in 1995 to 42,000 in 2020. On the urban expressways, 60,000 to 65,000 PCU-km are loaded on them in future. The volumes are close to the capacity.

The express busway and railway serve at 400,000 to 460,000 persons/km on dual way for the busways and 600,000 to 850,000 person/km on dual way for railway. The busways slightly exceed the capacity in 2010, while the railway has enough capacity to the passengers. In 2020, only one line railway service becomes more difficult to cope with increasing passenger demand. It seems to indicate that it is necessary to plan many railway lines over 2020.

Table 15.4-3 Average Travel Volume by Transport Facilities

		Case-1	Case-2	Case-3	Case-4	Case-2/Case-1	Case-3/Case-1	Case-4/Case-1
OD Table		1995	2001	2010	2020			
Network		1995	2001	2010	2020			
Facility (km)	(km)	1071.4	1145.2	1249.8	1489.7	1.069	1.167	1.390
Roads	(pcu/km/dual)	28,015	27,322	28,618	42,244	0.975	1.022	1.508
Expressway	(pcu/km/dual)	0	0	64,257	59,461	-	-	-
Busway	(person/km/dual)	0	0	455,689	375,472	-	-	-
Railway	(person/km/dual)	0	0	567,194	842,310	-	-	-

(3) Travel Speed

The average travel speeds served on each facility are shown in Table 15.4-4 and Figure 15.4-3. The average travel speed is typical index to show a service level. From now until 2010, they are slightly better. The figures increase from 25 km/h at the present to 28 km/h in 2010. In 2020, the average travel speed falls to 21 km/h which is equivalent to 0.85 of the present. It is obvious that the service level presented in Master Plan does not reach to the present level.

The travel speed on the urban expressways will be estimated at 14 km/h which is lower than that on the ordinary roads (21 km/h). This shows that the routes of expressways are on congested central area. On the other hand, the express busway and railway serve at higher level.

In comparison to Do-nothing case as shown in Figure 15.4-3, the travel speed in 2020 is dramatically different in increase ratio to the present figure between Master Plan and Do-nothing cases. Do-nothing case stands at 0.3 times of the present while 0.85 are for Master Plan case. This is to indicate that the transport congestion is considerably heavier, if do nothing is selected.

Table 15.4-4 Average Travel Speed by Mode

(unit: km/h)

	Case-1	Case-2	Case-3	Case-4	Case-2/Case-1	Case-3/Case-1	Case-4/Case-1
OD Table	1995	2001	2010	2020			
Network	1995	2001	2010	2020			
Facility (km)	1071.4	1145.2	1340.9	1675.6	1.069	1.252	1.564
Roads	24.6	29.1	28.3	21.0	1.183	1.150	0.854
Expressway	0.0	0.0	34.1	14.1	-	-	-
Busway	0.0	0.0	22.2	39.1	-	-	-
Railway	0.0	0.0	45.0	45.0	-	-	-
Total	24.6	29.1	28.3	20.8	1.183	1.150	0.846

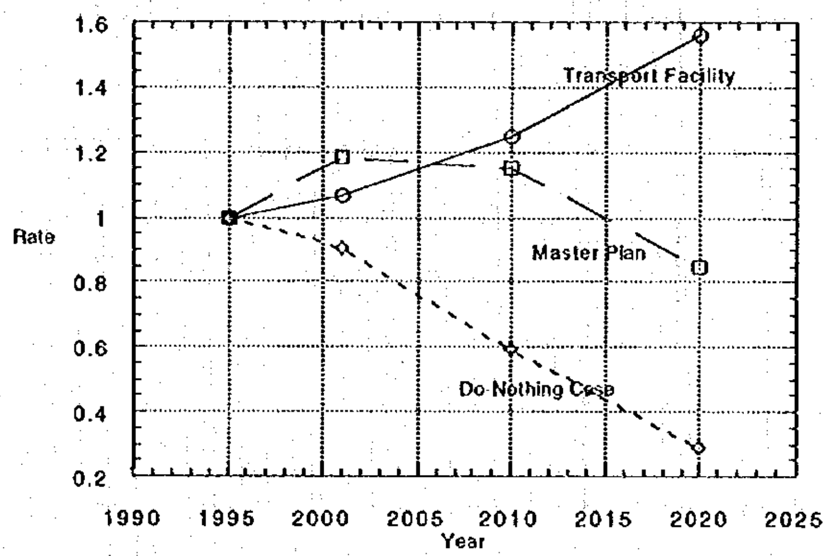


Figure 15.4-3 Rates of Change of Travel Speed

(4) Traffic and Transport Congestion

Table 15.4-5 shows the traffic and transport congestion in terms of congestion length ratio to total length, which is served at less than 10 km/h. from 1995 until 2010, the ratio are slightly better. The figure decreases from 8.1 % at the present to 5.8 % in 2010. In 2020, the ratio rises to 11.9 %, which is equivalent to 1.5 times the present. It is obvious that the service level presented in the Master Plan does not reach the present level.

Figure 15.4-4 shows the tendency of each target year comparing to the Do-nothing case. Until 2001, both cases, Do-nothing and Master Plan, are slightly different in congestion length. After 2010, the cases diverge, and the Do-nothing case indicates severe congestion.

Table 15.4-5 Ratio of Traffic Congestion Length (Less than 10 km/h)

(Ratio of PCU-km with less than 10km/h)

	Case-1	Case-2	Case-3	Case-4	Case-2/Case-1	Case-3/Case-1	Case-4/Case-1
OD Table	1995	2001	2010	2020			
Network	1995	2001	2010	2020			
Roads	0.081	0.057	0.059	0.112	0.706	0.730	1.391
Expressway	0.000	0.000	0.000	0.324	-	-	-
Busway	0.000	0.000	0.095	0.000	-	-	-
Railway	0.000	0.000	0.000	0.000	-	-	-
Total	0.081	0.057	0.058	0.119	0.706	0.716	1.476

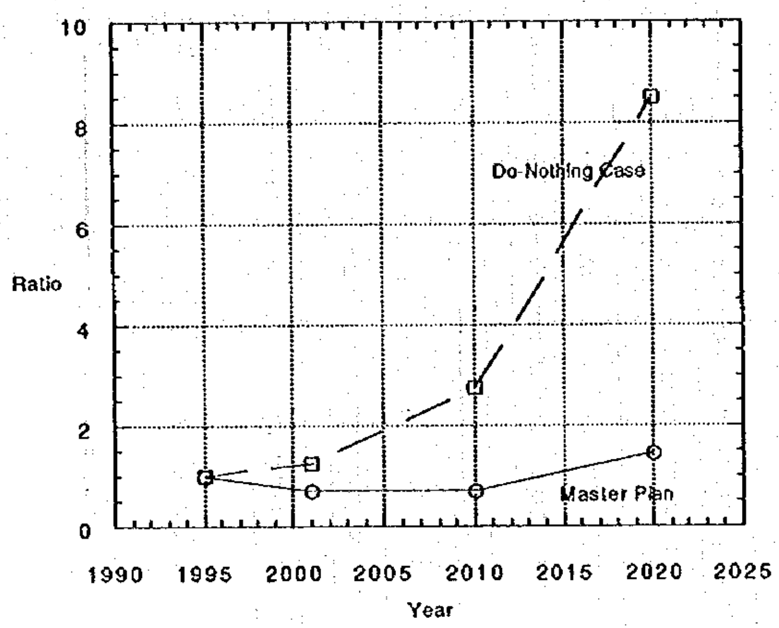


Figure 15.4-4 Traffic Congestion Length (Less than 10 km/h)

(5) Traffic Volume on the Boundary of Bogota

The socioeconomic framework of the plan indicates that the population in the surrounding cities will increase from 800,000 in 1995 to 2,400,000 in 2020. The future travel demand which flows into Bogota for persons who dwell outside Bogota will rise to approximately 3 times the present. Table 15.4-6 shows the traffic volume across the boundary of Bogota, shown by main directions from the years 2001 to 2020.

The increase ratio of traffic volume from 1995 to 2020 on the boundary of Bogota is 3.64 times the present volume. The increase ratio in the northwest and west directions is higher at 3.33 exclusive of south direction because the volume at present is lower, followed by 3.16 in the north and 2.18 in the southwest directions.

The passenger volume across the boundary is approximately 1 million trips in both directions, exclusive of the eastern direction.

Table 15.4-6 Traffic Volume on the Boundary of Bogota by Direction

Direction	City	Major Roads	1995	2001	2010	2020	2020	Increase Ratio		
			(unit: 100 PCU/day)				1000 persons	2001/1995	2010/1995	2020/1995
North	Chia	Autopista Norte	153	163	212	428	124			
	Cajica	Av. Boyaca Expansion	173	185	271	602	160			
		Total	326	348	483	1,030	284	1.07	1.48	3.16
Northwest West	Cota	Av. San Jose	-	-	-	507	101			
	Tenjo	Av. Cota	99	246	510	164	23			
	Funza	Autopista Medellin	152	309	448	610	78			
	Mosquera	Av. Jose Celestion	-	-	-	68	9			
	Madrid	Av. Centenario	558	290	359	131	49			
	Bojaca	Autopista Las Americas	-	-	-	929	201			
		Av. 1 de Majo	-	-	105	287	47			
		Total	809	845	1,422	2,696	508	1.04	1.76	3.33
Southwest	Soacha	Autopisata Sur	68	70	74	148	54			
		Total	68	70	74	148	54	1.03	1.09	2.18
South	Sumapaz	Av. Circunvalar	47	47	52	148	56			
	Caqueza	Autopista Al Llano		288	343	512	82			
		Camino de Pasquilla				12	13			
		Total	47	335	395	672	151	7.13	8.40	14.30
		Grand Total	1,250	1,598	2,374	4,546	997	1.28	1.90	3.64

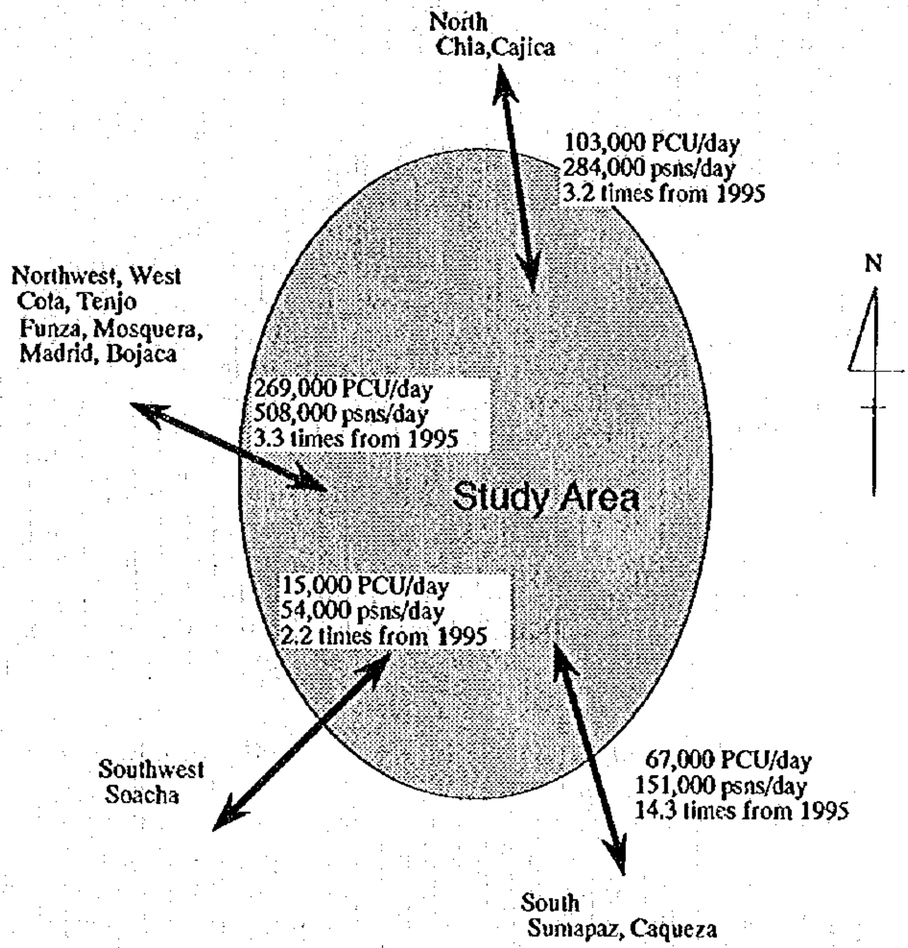


Figure 15.4-5 Traffic and Passenger Volumes on the Boundary of Bogota