JAPAN INTERNATIONAL COOPERATION AGENCY

NO. 2

MINISTRY OF COMMUNICATIONS,
WORKS AND PUBLIC UTILITIES, GRENADA

社会開発調査部報告書

THE FEASIBILITY STUDY
ON
ROAD REHABILITATION AND IMPROVEMENT
IN
GRENADA

FINAL REPORT

MAIN TEXT

JANUARY 1998

KATAHIRA & ENGINEERS INTERNATIONAL

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PREFACE

In response to a request from the Government of Grenada, the Government of Japan decided to conduct "The Feasibility Study on Road Rehabilitation and Improvement in Grenada" and entrusted it to Japan International Cooperation Agency (JICA).

JICA sent a study team headed by Mr. Tsuneo Bekki, Katahira & Engineers International to Grenada, at three different times between March 1997 and January 1998.

The team held discussions with the officials concerned of the Government of Grenada, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

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

I wish to express my sincere appreciation to the officials of the Government of Grenada concerned with the project for their close cooperation extended to the team.

January 1998

Kimio Fujita
President
Japan International Cooperation Agency

January 13, 1998

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. Fujita,

Letter of Transmittal

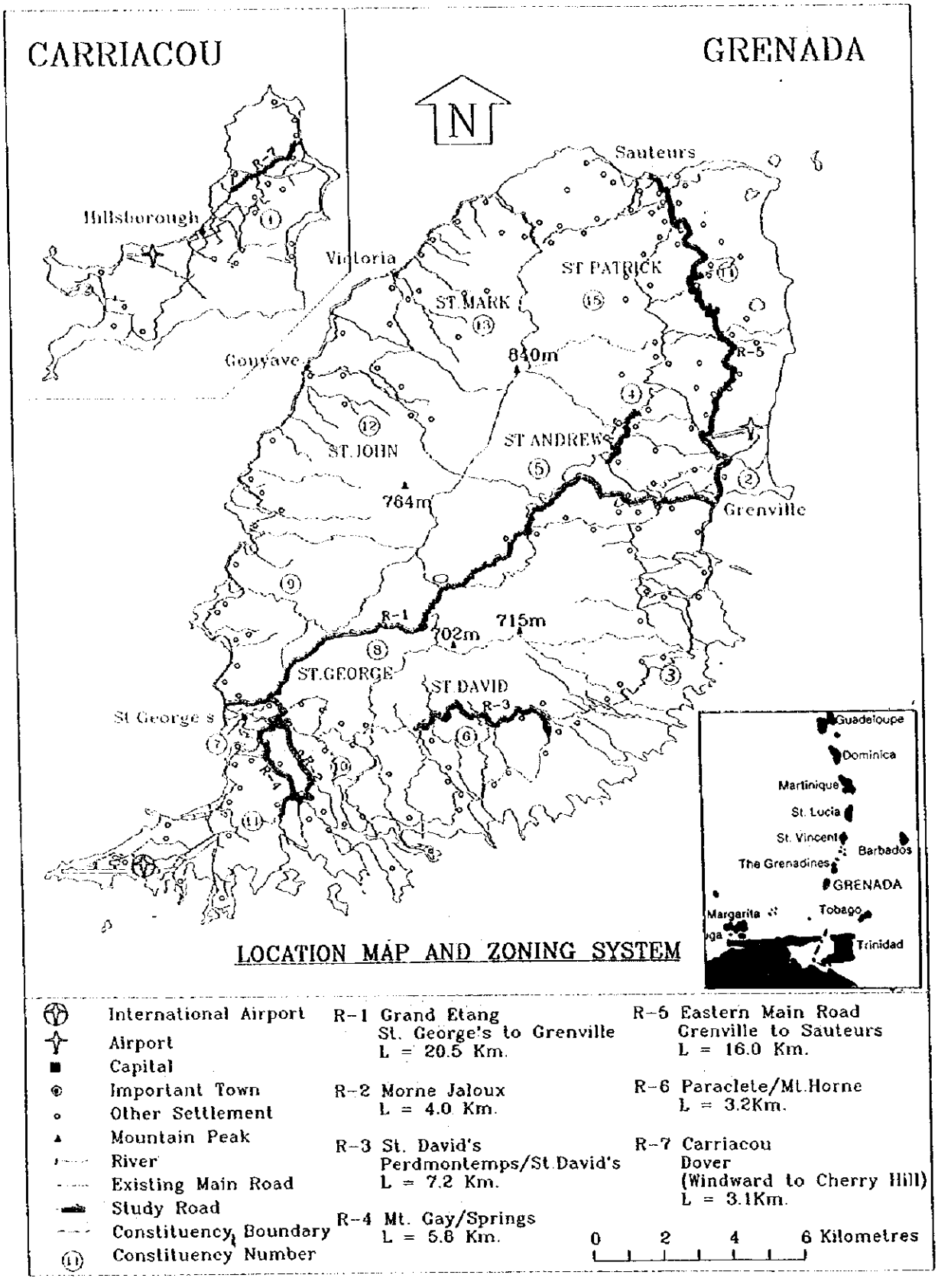
We are pleased to submit to you the Final Report of "The Feasibility Study on Road Rehabilitation and Improvement in Grenada". The report contains the advice and suggestions of the authorities concerned of the Government of Japan and your Agency as well as the comments made by the authorities of the Government of Grenada. The report consists of the Main Text, Executive Summary, Appendices and Drawings.

This report presents the results of the Study which had the objectives of evaluating the relative priority of seven study roads and carrying out a feasibility study on high priority roads. The report is divided into five parts which include information on the study area and roads, survey analysis and results, selection of priority roads, feasibility study and project implementation plan.

We wish to take this opportunity to express our sincere gratitude to your Agency and the Ministry of Foreign Affairs. We also wish to express our deep gratitude to the Ministry of Communications, Works And Public Utilities and other authorities concerned of the Government of Grenada for the close cooperation and assistance extended to us during the course of the Study. We hope that this Report will contribute to the effort made in the development of Grenada.

Very truly yours,

Tsuneo Bekki
Team Leader,
The Feasibility Study on Road
Rehabilitation and Improvement
in Grenada


CARRIACOU
GRENADA
N
Hillsborough
Victoria
Gouyave
Sauteurs
ST PATRICK
ST MARK
840m
R-5
ST JOHN
ST ANDREWS
764m
Grenville
R-1
702m
715m
ST.GEORGE
ST DAVID
R-3
St George's
R-4
R-2
Guadeloupe
Dominica
Martinique
St. Lucia
St. Vincent
Barbados
The Grenadines
GRENADA
Margarita
Tobago
Trinidad
LOCATION MAP AND ZONING SYSTEM
International Airport
Airport
Capital
Important Town
Other Settlement
Mountain Peak
River
Existing Main Road
Study Road
Constituency Boundary
Constituency Number
R-1 Grand Etang
St. George's to Grenville
L = 20.5 Km.
R-2 Morne Jaloux
L = 4.0 Km.
R-3 St. David's
Perdmontemps/St David's
L = 7.2 Km.
R-4 Mt. Gay/Springs
L = 5.8 Km.
R-5 Eastern Main Road
Grenville to Sauteurs
L = 16.0 Km.
R-6 Paraclete/Mt.Horne
L = 3.2Km.
R-7 Carriacou
Dover
(Windward to Cherry Hill)
L = 3.1Km.
0 2 4 6 Kilometres

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ABBREVIATIONS

(1) Agency

AASHTO	American Association of State Highway and Transportation Officials
ART	Agency for Rural Transportation
CDB	Caribbean Development Bank
ERD	Eastern Road Division
EDU	European Development Fund
EU	European Union
FAO	Food and Agriculture Organization
GOG	Government of Grenada
GOJ	Government of Japan
GNOW	Grenada National Organization of Women
JICA	Japan International Cooperation Agency
KEI	Katahira & Engineers International
LDCA	Land Development Control Authority
MOW	Ministry of Communications, Works and Public Utilities
ROC	Republic of China
TRRL	Transport and Road Research Laboratory
WRD	Western Road Division

The Study	The Feasibility Study on Road Rehabilitation and Improvement in Grenada, JICA

(2) Technical Term

ADT	Average Daily Traffic
AC	Asphalt Concrete
AOC	Annual Opportunity Cost
Av	Average
AWP	Annual Work Program
B/C	Benefit / Cost ratio
CBR	California Bearing Ratio
CRF	Capital Recovery Factor
EAL	Equivalent Axle Load
EC$	East Caribbean Dollar
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMR	Eastern Main Road

EPO	Engineer Projects Office
ESAL	Equivalent Single Axle Load
GDP	Gross Domestic Product
GER	Grand Etang Road
GNP	Gross National Product
GVW	Gross Vehicle Weight
HCM	Highway Capacity Manual
HT	Heavy Truck
IRI	International Roughness Index
IEE	Initial Environmental Examination
IVA	Impact and Consumer Tax
JPY	Japanese Yen
KI	Kiloliter
Kph	Kilometer per Hour
LT	Light Truck
MEC$	Million EC$
MFWL	Maximum Flood Water Level
MTESP	Medium Term Economic Strategy Papers
MWA	Maintenance Work by Administration
MWC	Maintenance Work by Contract
NP	National Park
NPV	Net Present Value
OD	Origin / Destination
PC	Passenger Car
PCC	Portland Cement Concrete
PCU	Passenger car Unit
PSIP	Public Sector Investment Program
QCI	Quarter Car Index
R-1	Study Road No. 1
RCBC	Reinforced Concrete Box Culvert
RCPC	Reinforced Concrete Pipe Culvert
RMMS	Road Maintenance Management System
ROW	Right of Way
SIA	Social Impact Assessment
SN	Structural Number
VAT	Value Added Tax
V/C	Volume Capacity Ratio
VOC	Vehicle Operating Cost
WID	Women in Development

PART I

GENERAL

CHAPTER 1

INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The internal transportation system in Grenada depends mainly on the road network. The country has a network of all-weather roads totaling 950 kilometers, of which 30% are paved. There are three main roads in the island and numerous secondary roads branch from the main three roads. Most of these secondary roads, which have the function of connecting communities together, are in poor condition. Rehabilitation and improvement of the secondary roads is yet to receive enough external financial support.

The urgent problem to be addressed currently is the rapid deterioration of many main and secondary roads due to a combination of weakness in the pavement structure, drainage design, under-estimation of the traffic volume growth, concessions regarding the quality of construction materials and inadequate maintenance. In addition, incentives given to manufacturing and agro-industrial sectors with a reduction of import duties on motor vehicles have resulted in an increase of motor vehicles imported since 1991.

Recent budgetary constraints resulting from the economic decline caused the postponement of periodic road maintenance interventions. This policy has taken its toll mainly on secondary roads which are essential in supporting the further development of tourism, agriculture and manufacturing, as well as the improvement in the quality of life of the people in rural communities. Therefore, one of the key actions identified in the Public Sector Investment Program (PSIP 1992-96) is a major rehabilitation of the economic and social infrastructure with high priority on the rehabilitation of the road network.

In response to the request of the Government of Grenada (hereinafter referred to as "Grenada"), the Government of Japan has decided to conduct "The Feasibility Study on Road Rehabilitation and Improvement in Grenada" (hereinafter referred to as the Study). The Government of Japan entrusted the Study to the Japan International Cooperation Agency (hereinafter referred to as JICA), the official agency responsible for the implementation of technical cooperation programs for the Government of Japan, who will undertake it in close cooperation with the authorities in Grenada.

JICA has organized and dispatched a Study Team consisting of eight experts from Katahira & Engineers International, headed by Mr. Tsuneo Bekki, to carry out the Study which has a total period of about 10 months from the end of March 1997 to January 1998.

1.2 OBJECTIVES OF THE STUDY

The objective of the Study is to evaluate the relative priority of the Study Roads and carry out a feasibility study on high priority roads.

1.3 SCOPE OF THE STUDY

The Study covers the following seven roads, as shown in the location map, which are located on the two islands of Grenada and Carriacou:

Grenada:		
(1) Grand Etang Road	20.5	km
(2) Morne Jaloux	3.2	
(3) Perdmontemps / St. David's	7.2	
(4) Mt. Gay / Springs	5.8	
(5) Eastern Main Road (Grenville / Sauteurs)	16.0	
(6) Paraclete / Mt. Horne	3.2	
Carriacou:		
(7) Dover (Windward / Cherryhill)	3.1	km

The Study is divided into two main phases and its tasks basically cover the following items:

Phase I:

(1) Review of existing relevant plans and studies
(2) Collection and analysis of existing data and information related to the Study
(3) Implementation of inventory survey on target roads
(4) Implementation of traffic surveys
(5) Implementation of initial social and environmental evaluations
(6) Forecast of future traffic demand of the Study Roads up to the year 2005, and the year 2025 for economic analysis purposes
(7) Formulation of a basic improvement plan
(8) Selection of priority roads

Phase II:

(1) Implementation of topographic and geological surveys
(2) Implementation of preliminary engineering design
(3) Formulation of construction and maintenance plans
(4) Cost estimation, financing plan and cost recovery plan
(5) Implementation of Physical and Social Environmental Impact Assessments (EIA)
(6) Economic Analysis
(7) Formulation of project implementation plan
(8) Overall evaluation and recommendation

1.4 EXECUTION OF THE STUDY

The Study was undertaken by the JICA Study Team joined by an MOW Counterpart Team under the guidance of the JICA Advisory Committee and the MOW Steering Committee as shown in the Organizational Chart in Figure 1.4.1.

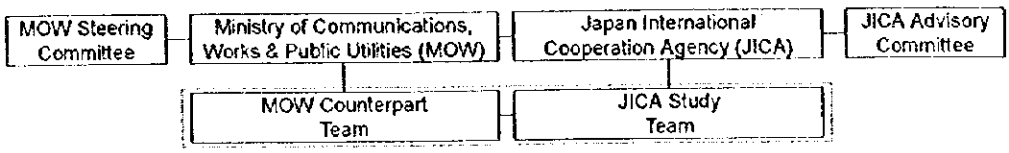

Figure 1.4.1 Organizational Chart

The members participating in the Study are as follows:

MOW Steering Committee:

Mr. Joseph CHARTER	Permanent Secretary, MOW
Mr. Winston GABRIEL	Chief Technical Officer, MOW
Ms. Coleen GOODING	Foreign Service Officer, Ministry of Foreign Affairs
Mr. Mervin HAYNES	Planning Officer, Ministry of Finance

MOW Counterpart Team:

Mr. John ST. LOUIS	Engineer, MOW
Ms. Jocelyn PAUL	Planning Officer, Ministry of Finance
Ms. Claris CHARLES	Prime Minister's Ministry

JICA Advisory Committee:

Mr. Yukihiro SANO	Honshu-Shikoku Bridge Authority
Mr. Toshinori TATEBE	Japan Highway Public Corporation
Mr. Hajime TAKEUCHI	Overseas Economic Cooperation Fund (OECF)
Mr. Keiichi OKITSU	Japan International Cooperation Agency (JICA) - Project Officer

JICA Study Team:

Mr. Tsuneo BEKKI	Team Leader / Highway Planner
Mr. Hajime TANAKA	Traffic Engineer
Mr. Masahisa TSUCHIHASHI	Deputy Team Leader / Highway, Structural and Maintenance Engineer
Dr. Hani ABDEL-HALIM	Transport Economist
Mr. Satoshi TAKAGI	Cost Estimator
Mr. Masao AIZAWA	Geological / Hydrological Engineer
Mr. Mike QUINN	Environmental / WID Specialist
Mr. Yasuaki MURAMOTO	Structural Engineer

The flow diagram of the Study which clarifies the work schedule of each task is illustrated schematically in Figure 1.4.2.

1.5 REPORTS

The following reports were prepared during the course of the Study:

- Inception Report – April 1997
- Progress Report – June 1997
- Interim Report – July 1997
- Draft Final Report – November 1997

The Final Report – January 1998, is organized as follows:

- Executive Summary
- Main Text
- Appendix
- Drawings

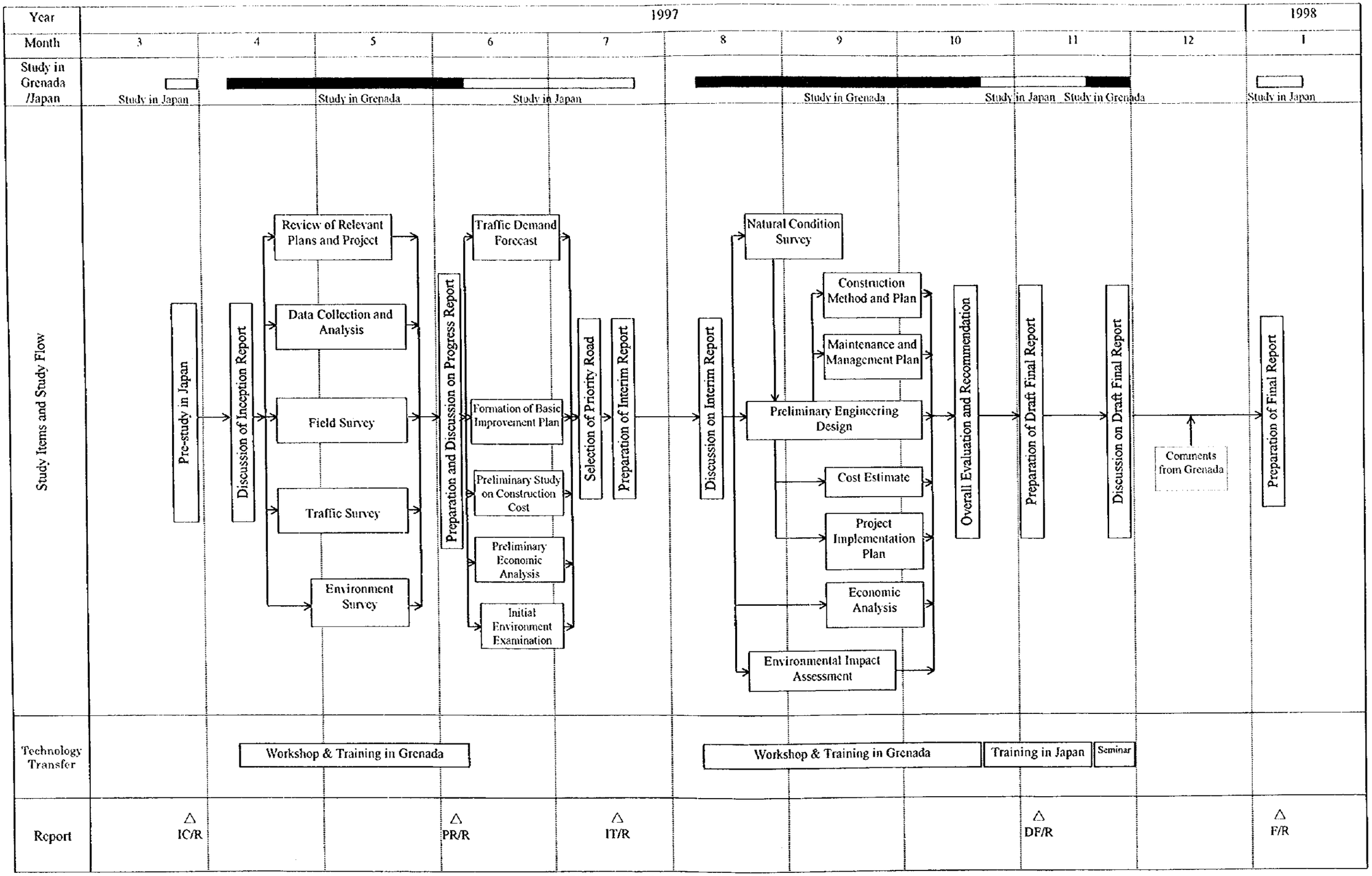

Figure 1.4.2 Study Flow Diagram

CHAPTER 2

PROFILE OF STUDY AREA AND ROADS

CHAPTER 2

PROFILE OF STUDY AREA AND ROADS

2.1 NATURE

2.1.1 Topography and Geology

Grenada consists of three main islands and many smaller islands. The largest of the three islands is Grenada Island with an area of 312 km^2, followed by Carriacou with 34 km^2 and Petite Martinique with 2.3 km^2. The islands are volcanic and the land topography in Grenada Island is mostly mountainous terrain. Soils in Grenada are predominantly clay-loam but clays and sandy-loam exist.

Grenada is characterized by rugged mountainous terrain in the interior and a more subdued rolling terrain on the coastal periphery. The principal peak, Mount St. Catherine (840m), rises in the northern half of the island as the centre of a massif surrounded by lessor peaks and ridges. From these central mountains the level descends fairly regularly to the sea. The rolling coastal terrain is probably due to fluviatile and mass movement processes removing material from elevated areas and depositing that material in the lowlands. There are some lowland areas in the northeast at Levera and in the southwest at Pt. Salines.

Grenada is located near the edge of the Caribbean Tectonic Plate. The geological history of Grenada began approximately 38 million years ago in the upper Eocene Period and continued in the Oligocene Period with the sedimentary deposit known as the Tufton Hall Formation. Volcanic activity continued throughout the Miocene, Pliocene and Pleistoscene Periods. The last volcanic structures are 12,000 years old.

Carriacou is also volcanic and can be divided into two geological zones. The fossiliferous limestone which forms outcroppings in the eastern part of the island is mainly of Miocene age. Volcanic rocks comprising the remaining two thirds of the island consist of lava flows, lava domes and other volcanic products ranging in age from Miocene to Pliocene. Between Grenada and Carriacou there is an active submarine volcanic known as Kick-em-Jenny. Its latest eruption was in 1978.

The soils of Grenada are dominated by clay looms, followed by clays and sandy looms. The dominant soil forming factors are climate and topography. Climate being the more important given the differences in total annual rainfall and the length of the dry season.

2.1.2 Climate

Grenada belongs to the tropical zone and precipitation in Grenada Island is recorded at more than 3,000 mm average a year. There is a dry season that runs from January to May. Precipitation concentrates during the rainy season which starts in June and continues until November.

In St. George's in January the average daily high temperature is 30°C, while the low average is 21°C. In July the average daily high is 31°C while the low average is 25°C. During the rainy season, June to November, rainfall average's 22 days a month in St. George's and the mean relative humidity is 78%. In the driest months, January to April, there is measurable rainfall 12 days a month and the humidity averages 71%. Annual rainfall is about 1,500 mm in St. George's and more than 3,000 mm in the Grand Etang rainforest as shown in Figure 2.1.1.

Carriacou is substantially drier than Grenada, averaging 1,000~1,500 mm of rain a year. The maximum rainfall in 24 hours was recorded at 233.3 mm in the past 18 years at St. George's. The heavy rainfall on the island of Grenada, especially in the Grand Etang rainforest area, can lead to areas of erosion and land slide on the roads and in agricultural lands as well.

The weather conditions along the study roads are as shown in Table 2.1.2. The table shows that Route No.1, which passes through mountainous area, is subject to the highest rainfall and the lowest temperature in the mid-section.

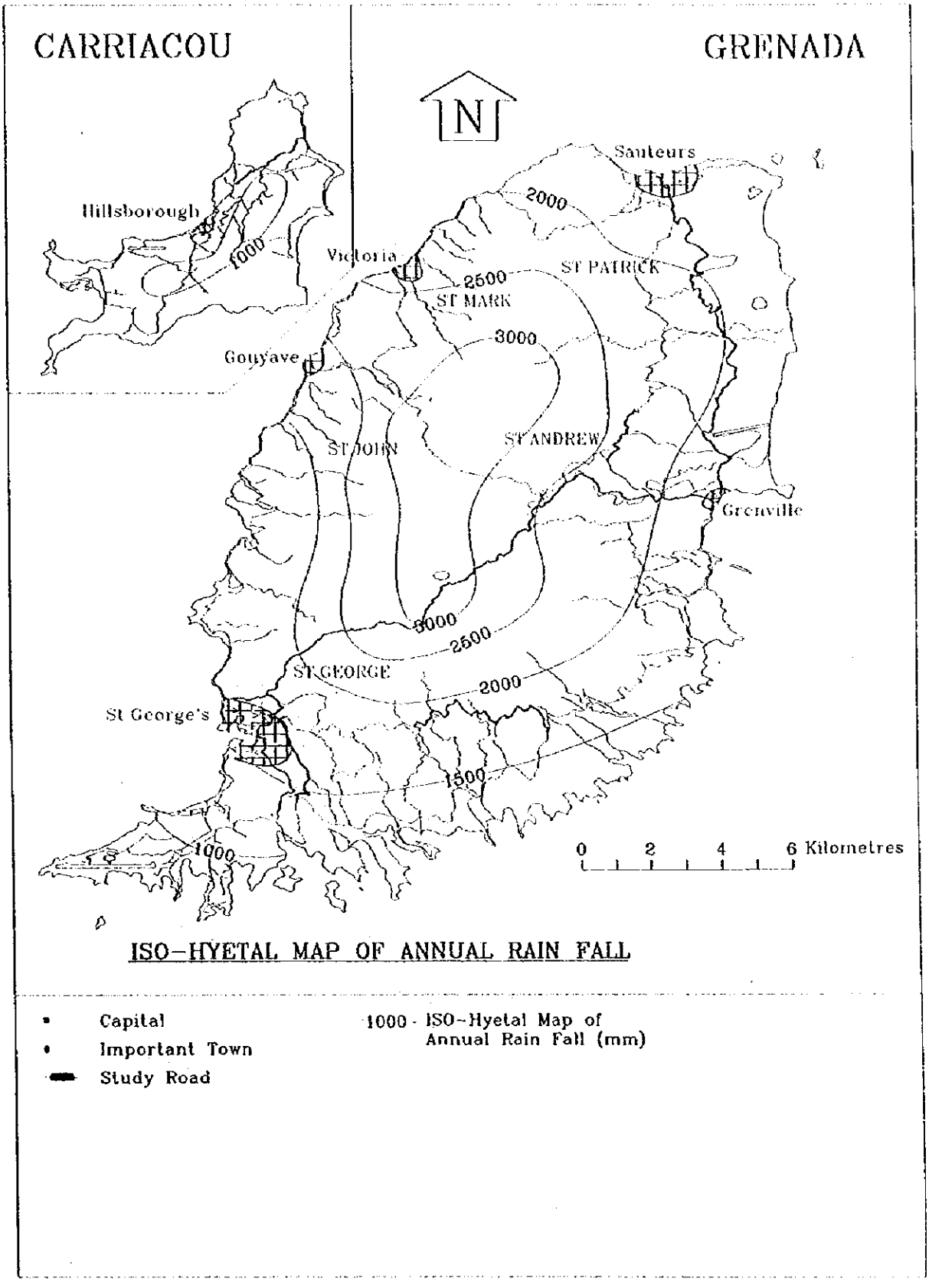

Figure 2.1.1 Iso-Hyetal Map of Annual Rainfall

2.2 SOCIOECONOMIC PROFILE

2.2.1 Demography

The country is divided into seven (7) parishes and is further divided into 15 electoral zones. This electoral zoning system is used as traffic zones in this Study. The population in the electoral zones vary from 4.4 thousands (St. Mark's) to 10.3 thousands (St. David's). The population of Grenada is around 100 thousands, of which 95 % live on Grenada Island and most of the others live on Carriacou Island. The major population centers are located at the capital, St. George's in the southwest, Grenville on the east-central coast and Sauteurs in the north.

An area of 137 km^2 of the 312 km^2 of Grenada Island is used for the cultivating of cash crops and only 44 km^2 are cultivated for food crops. Towns occupy 9 km^2 and the largest is St. George's, the second largest town is Grenville and other populated areas such as Sauteurs, Victoria, Gouyave scatter from south to northwest along the coast.

(1) Data Sources

Available data sources for population by electoral zone are the 1991 Census and Reports of Elections. In addition, the "estimated mid-year population by sex and five-year age group" and "registered births, deaths and mid-year population" estimated by the Statistic Office of the Ministry of Finance are available. Data collected are summarized in Table 2.2.1.

(2) Population Data Adjustment

Due to the various data sources, the data presented in Table 2.2.1 includes some contradictions which require adjustments and interpolation procedure. These were executed to the original data in the following steps:

1) To estimate population of each electoral zone (hereafter zone) of 1990 and 1995 using electors registered and voting age resident ratio calculated from five-years age group.
2) To estimate population of 1992, 1993, 1994 and 1996 by zone using interpolation or extrapolation methods from 1991 and 1995 population by zone.
3) To adjust Carriacou population of 1990 from 1991.
4) To adjust the summation of zone population data to total population estimated by the Statistic Office.

Table 2.2.1 Population Data Collected

			Year						
			1990	1991	1992	1993	1994	1995	1996
National Data									
	Population		94,700	95,600	96,500	97,000	97,800	98,500	98,900
	Live Births		2,448	2,487	2,372	2,220	2,254	2,286	2,096
	Deaths		808	666	657	745	777	807	782
	Population before Social movements			96,340	97,421	98,215	98,475	99,277	99,979
	Balance of Migration (Emigration : negative)			-740	-921	-1,215	-675	-777	-1,079
Parish and Electoral Data									
1	Carriacou	Carriacou	2,005	5,261	-	-		3,758	-
2	St. Andrew's	St. Andrew's South East	2,139	4,276	-	-	-	3,859	-
3		St. Andrew's South West	2,960	6,765	-	-	-	5,160	-
4		St. Andrew's North East	2,332	5,013	-	-	-	4,298	-
5		St. Andrew's North West	2,272	6,451	-	-	-	3,970	-
6	St. David's	St. David's	4,493	12,191	-	-	-	7,939	-
7	St. George's	Town of St. George's	2,301	4,267	-	-	-	4,358	-
8		St. George's North East	3,357	6,118	-	-	-	6,283	-
9		St. George's North West	2,387	4,563	-	-	-	4,144	-
10		St. George's South East	2,387	3,091	-	-	-	4,440	-
11		St. George's South	3,113	6,579	-	-	-	6,401	-
12	St. John's	St. John's	3,550	7,801	-	-	-	6,021	-
13	St. Mark's	St. Mark's	1,861	3,385	-	-	-	3,122	-
14	St, Patrick's	St, Patrick's East	1,799	3,773	-	-	-	3,260	-
15		St, Patrick's West	2,515	5,440	-	-	-	4,400	-

Source: 1991 Census, Report of the Grenada General Elections 1995, and Government GazetteVol.108,No.28

Table 2.2.2 Population Data Interpolated/Adjusted

			Year							Growth R.
			1990	1991	1992	1993	1994	1995	1996	(1990-96)
National Data										
	Population		94,700	95,597	96,500	97,000	97,800	98,500	98,900	0.7
	Live Births		2,448	2,487	2,372	2,220	2,254	2,286	2,096	-2.6
	Deaths		808	666	657	745	777	807	782	-0.5
	Population before Social Movements			96,340	97,418	98,215	98,475	99,277	99,979	
	Balance of Migration (Emigration: negative)			-743	-918	-1,215	-675	-777	-1,079	
Parish and Electoral data										
1	Carriacou	Carriacou	5,977	5,918	5,757	5,564	5,380	5,183	4,965	-3.1
2	St. Andrew's	St. Andrew's South East	5,065	4,810	4,961	5,083	5,211	5,322	5,406	1.0
3		St. Andrew's South West	7,009	7,610	7,526	7,393	7,267	7,117	6,930	-0.2
4		St. Andrew's North East	5,522	5,639	5,742	5,808	5,878	5,928	5,944	1.2
5		St. Andrew's North West	5,380	7,257	6,801	6,332	5,899	5,475	5,053	-1.1
6	St. David's	St. David's	10,639	13,715	13,037	12,310	11,631	10,950	10,250	-0.7
7	St. George's	Town of St. George's	5,448	4,800	5,106	5,396	5,705	6,010	6,296	2.4
8		St. George's North East	7,949	6,882	7,331	7,758	8,214	8,666	9,090	2.2
9		St. George's North West	5,652	5,133	5,302	5,441	5,587	5,715	5,814	0.4
10		St. George's South East	5,652	3,477	4,028	4,635	5,337	6,124	6,986	3.5
11		St. George's South	7,371	7,401	7,778	8,120	8,482	8,828	9,137	3.6
12	St. John's	St. John's	8,406	8,776	8,704	8,576	8,454	8,304	8,111	-0.6
13	St. Mark's	St. Mark's	4,407	3,808	3,949	4,067	4,192	4,306	4,397	-0.1
14	St. Patrick's	St. Patrick's East	4,260	4,244	4,330	4,388	4,450	4,496	4,517	0.9
15		St. Patrick's West	5,955	6,120	6,141	6,122	6,106	6,068	5,997	0.1

Sources: 1991 Census, Report of the Granada General Elections 1995, and Government Gazette Vol. 108, No. 28.

Figures of estimated population after adjustments are summarized in Table 2.2.2. An average increase of national population in the 1990's was 0.7% per annum. Regarding the zonal population base all zones of St. George's excluding St. George's North West attract social migration in the country and Carriacou loses residents, however, the increase and decrease of residents extends to a range below 4%.

2.2.2 Economy

Economic activities are characterized as typical island economy. Activities in agriculture (cash crop) field and in tourism are remarkable sources of foreign currency earning. The growth of the economy is low but steady. The growth rate of the GDP in the 1990s was 2.2% and in the sectorial distribution of GDP, the transport and communication sectors show 23.4% which are followed by the Government Services at 16.3%.

(1) Gross Domestic Product (GDP)

The average growth of the GDP (at constant 1990 prices) in the 1990's indicates a moderate rate of 2.2% p.a. Growth in the Tourism sector grew rapidly at 7.6% p.a. in share of GDP, which means a real figure of 16.7% p.a. when multiplied by the average growth rate of the GDP. The most remarkable area in the economic performance was the decline of Government Services by -4.4% in share or -9.7% in real figures, and of Agriculture -5.2% or -11.4% in average.

From the sectorial distribution point of view, Transport and Communications show the largest growth rate of 23.4% in 1996, and Government Services followed by a rate of 16.3% in spite of the said remarkable decline. Tourism shows a growth of 9.0%, which is located between Agriculture (9.7%) and Construction (8.2%).

The GDP per Capita at current prices show an average growth of 4.2% in the 1990's and it was 2,985 US$ in 1996.

(2) Central Government Finance

Due to the restructuring of the Government and a general strengthening of tax administration, despite a stagnant growth of 2.2% of GDP in the 1990's, Government revenue increased 5.2% in average and expenditure was suppressed with an increase of 2.9%.

The overall deficit after receiving capital revenues and grants, and paying capital expenditures and net lending, decreased from a deficit of EC$ 62.7mn. in 1990 to EC$ 1.5mn. +After 1993 the deficit started again to increase and reached 26.2mn. in 1996. The main cause of that is the increase in Capital Expenditure and Net Lending.

(3) External Public Debt

In the 1990's the Government started to eliminate remaining external arrears. The debt service ratio declined from 17.4% in 1990 to 4.6% in 1993, which resulted from elimination of remaining arrears during 1990 and 1993. An increase of new loan agreements is significant after 1995, but the debt service ratio has been sustained in 1996 to 4.4%, as the amortization was not started yet.

(4) Economic Development Strategy

To develop the economic performance of the country, the Government prepared the Medium Term Economic Strategy Papers (MTESP), 1996-1998 and Public Sector Investment Programme (PSIP), 1996-1998. Recurrent account surplus which was, for example, EC$ 17mn in 1996 may provide adequate counterpart funds for implementation of projects under the PSIP 1996-1998.

MTESP set the Goals of Economic Growth as 2.6% in 1995 and 3.4% in 1998, and Government Savings as 1.8% of GDP in 1995 and 3.4% in 1998. MTESP set also a Goal of Public Sector Investment as not less than 10% per annum during 1996-1998. In response to the Goals of MTESP, the planned expenditure is estimated at EC$ 167.2mn in which a total of EC$ 62.7mn is planned for transportation projects. Table 2.2.3 gives a summary for the economic indicators data of the country.

Table 2.2.3 Economic Indicators

Area	384 m2							
	Year							Growth R
	1990	1991	1992	1993	1994	1995	1996	(1990-96)
Mid Year Population ('000)	94.7	95.6	96.5	97.0	97.8	98.5	98.9	0.7
Per Capita GDP (US$)	2333.3	2526.7	2599.9	2577.7	2684.6	2805.0	2985.1	4.2
GDP								
GDP at Current Market Price (EC$ mn)	596.6	652.2	677.4	675.1	708.9	746.0	797.1	4.9
Demand Component								
Consumption Expenditure	499.7	553.7	602.7	594.4	533.1	490.9	580.2	2.5
Gross Domestic Investment	227.5	247.7	199.5	210.5	253.8	239.3	265.3	2.6
Exports of Goods	253.6	260.0	258.3	253.8	306.7	339.6	345.3	5.3
Imports of Goods	383.9	409.4	383.1	396.7	404.7	447.5	524.4	5.3
Gross Domestic Saving Ratio (%)	16.1	15.1	11.0	15.8	18.7	-	-	
Sectoral Distribution of Current GDP %)								
Agriculture	13.4	13.1	11.2	10.6	10.1	10.1	9.7	-5.2
Manufacturing	6.6	6.5	7.0	6.1	6.3	6.6	6.7	0.3
Construction	7.2	8.8	7.8	8.1	8.1	8.1	8.2	2.2
Transport and Communication	20.7	20.7	21.8	22.5	22.9	23.4	23.4	2.1
Tourism	5.8	6.3	7.3	8.2	9.7	9.0	9.0	7.6
Wholesale and Retail Trade	11.7	11.1	11.0	11.4	11.3	11.3	11.4	-0.4
Government Services	21.3	19.3	19.1	18.5	16.8	16.2	16.3	-4.4
Others	13.3	14.2	14.8	14.6	14.8	15.3	15.3	2.4
GDP at Constant 1990 Prices (EC$ mn)	477.8	495.1	500.5	494.4	510.8	526.6	543.0	2.2
Annual Rate of Growth in GDP (%)	5.2	3.6	1.1	-1.2	3.3	3.1	3.1	
Central Government Finance (EC$ mn)								
Recurrent Revenue	146.9	161.5	160.2	173.2	172.0	188.4	199.6	5.2
Recurrent Expenditure	153.7	164.5	156.3	161.5	161.7	170.3	182.6	2.9
Recurrent Account Surplus/(Deficit)	-6.8	-3.0	3.9	11.7	10.3	18.1	17.0	
Capital Revenue and Grant	14.7	22.5	11.5	19.2	21.0	20.6	23.5	8.1
Capital Expenditure and Net Lending	70.6	46.9	16.9	32.4	37.4	51.4	66.7	-0.9
Overall Surplus/(Deficit)	-62.7	-27.4	-1.5	-1.5	-6.1	-12.7	-26.2	
External Public Debt (US$ mn)								
Disbursed Debt Outstanding	82.5	81.6	78.8	77.1	79.3	56.8	73.9	-1.8
Debt Service Payment	16.3	15.8	9.0	4.3	5.3	5.4	5.6	-16.3
Amortization	15.1	14.2	7.2	2.6	3.8	4.1	4.1	-19.5
Interest Payments	1.2	1.6	1.8	1.7	1.5	1.3	1.5	3.8
Debt Service Ratio (%)	17.4	16.4	9.4	4.6	4.7	4.3	4.4	-20.5
Average Exchange Rate								
EC Dollars per US Dollar	2.7	2.7	2.7	2.7	2.7	2.7	2.7	

Sources: Inland Revenue Dept. and Central Statistic Office, Ministry of Finance

2.2.3 Vehicle Registration

Data of registration of vehicles is only available at the national level. Vehicles by Parish and by electoral zone are estimated from generated trips of electoral zones in the OD matrices under the assumption that generated trips per vehicle in any zone is fixed to a constant figure. Table 2.2.4 gives the number of

registered vehicles on a national level and estimated numbers on zonal basis.

Ratios of increase of vehicles are around 9% in the 1990's and the highest increase in ratio is shown by Buses while the lowest is for Pick-ups. In the Parish base, 52% of vehicles are found to be in St. George's and St. Andrew's follows with 21%.

Table 2.2.4 Registration of Vehicles

			Year						Growth R
			1990	1991	1992	1993	1994	1995	1990-96
National Data									
	Total of which		-	7,807	8,518	9,267	10,238	11,941	8.9
	Cars, Jeeps, Vans		-	5,454	5,931	6,472	7,187	8,517	9.3
	Pick Ups		-	1,220	1,316	1,399	1,505	1,620	5.8
	Trucks		-	576	619	664	732	840	7.8
	Buses		-	557	652	732	814	964	11.6
Parish and Electoral Zone Data								Estimates	
1	Carriacou	Carriacou	-	-	-	-	-	455	-
2	St. Andrew's	St. Andrew's South East	-	-	-	-	-	496	-
3		St. Andrew's South West	-	-	-	-	-	1,145	-
4		St. Andrew's North East	-	-	-	-	-	436	-
5		St. Andrew's North West	-	-	-	-	-	371	-
6	St. David's	St. David's	-	-	-	-	-	753	-
7	St. George's	Town of St. George's	-	-	-	-	-	1,696	-
8		St. George's North East	-	-	-	-	-	1,002	-
9		St. George's South North West	-	-	-	-	-	711	0
10		St. George's South East	-	-	-	-	-	1,155	-
11		South St. George's	-	-	-	-	-	1,678	-
12	St. John's	St. Joh's	-	-	-	-	-	893	-
13	St. Mark's	St. Mark's	-	-	-	-	-	323	-
14	St. Patrick's	St. Patrick's East	-	-	-	-	-	387	-
15		St. Patrick's West	-	-	-	-	-	440	-

Source: Inland Revenue Dept., Ministry of Finance

As for the public transportation services, private operators are carrying out their services along routes of large demand. However, this practice does not provide enough quality as a public transportation system to cover the whole needs of the passengers. In addition, the climate in Grenada does not allow along distance walking especially for elderly people. Due to the inconvenience of the public transportation system, the intention and demand to use/own a car is strong. The total number of registered vehicles, excluding motorcycles and heavy equipment, was 11,941 vehicles in 1996. Dividing the number of vehicles by population, the car ownership ratio can be estimated as 12% in 1996.

2.2.4 Land Use

(1) Overall Land Use

1) Agricultural Land

The Land Use Map of the country (S = 1 : 25,000, 1997) was prepared by the Land Use Division, Ministry of Agriculture. The outline is shown in Figure 2.2.1 and Table 2.2.5.

Agriculture is the most important sector for Grenada's economy, agricultural products held a share of about 70% of domestic exports in Grenada (about 29 million EC$). According to the figure and table, about 60% of the Island of Grenada is agricultural land. As is the case in most territories in the region mixed cultivation is the norm.

Mixed cropping is practiced as an insurance against the unpredictable drop in prices of export crops. Many estates were bought by the Government during the 1970's and some were parceled out to the landless farmers while others are now being farmed by farmers cooperatives. Initially cocoa and nutmeg were the most important tree crops, later followed by coconuts, limes and spices such as cloves and cinnamon. It was only after the 1955 hurricane that bananas became an important crop and now cocoa, nutmeg, and banana are Grenada's export crops.

Sugar cane is one of the main products, which is grown in the southern part of the island (5.22 km^2) in the vicinity of the sugar factory at Woodlands where most of the cane is processed into sugar. In the northern half of the island only 0.12 km^2 of sugarcane is cultivated, located near the two rum distilleries (Antoine and Boulogne).

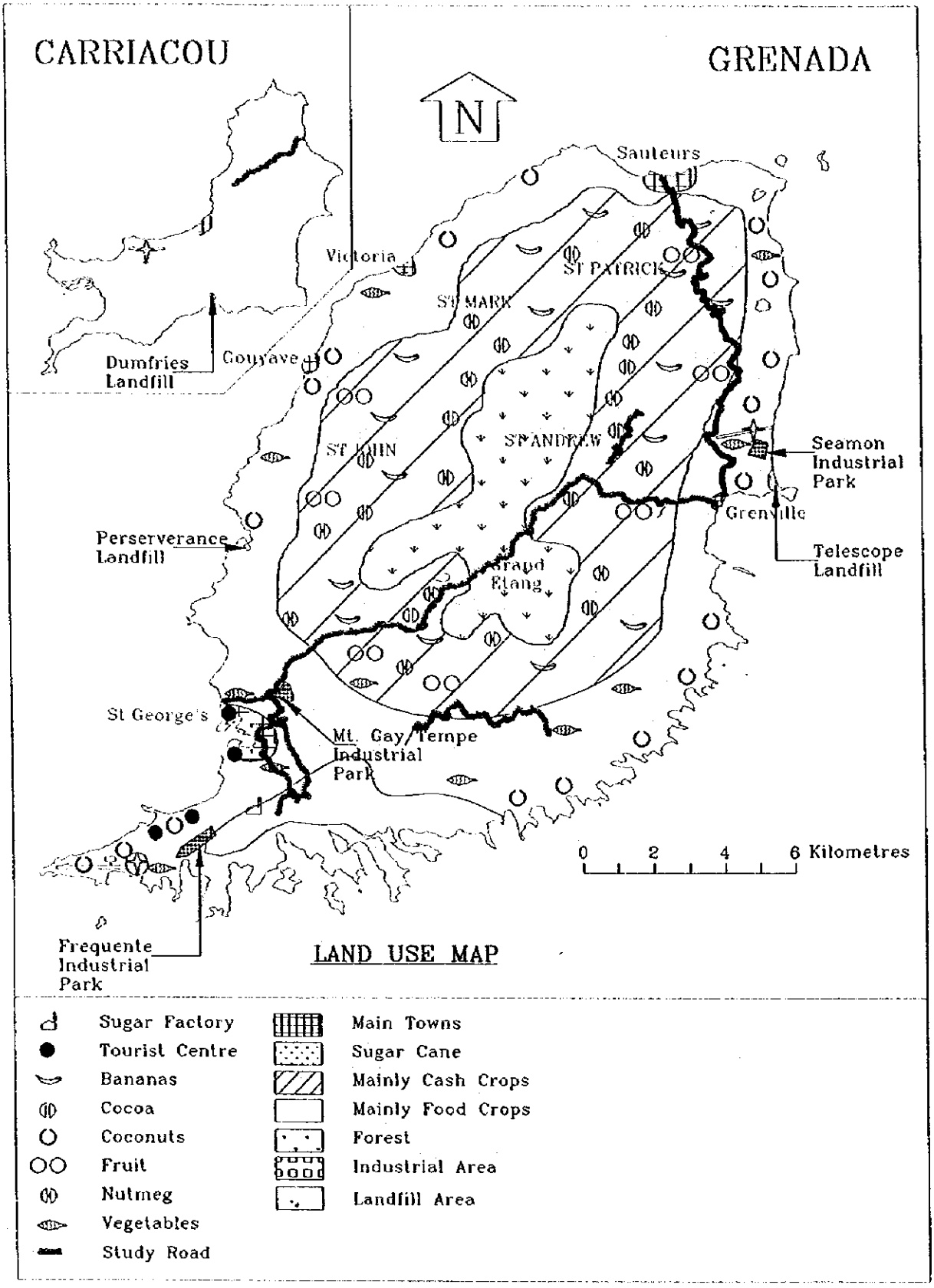

Figure 2.2.1 Land Use Map

Table 2.2.5 Overall Land Use on the Island of Grenada

Land Use		Used Area (km^2)	Contents of Land Use / Products by Land Use			
Food Crop (Mainly Domestic Consumption)		41.64	Vegetable : Corn, Potatoes, Tomatoes, Cabbage, Lettuce, Cucumbers, Peppers, Beans, Peas Fruits : Citrus, Breadfruits, Mangoes, and Partly Banana, Cocoa, Nutmeg			
Cash Crop (Mainly Export)		136.72	Bananas, Nutmegs/Mace, Cocoa, Pepper Products Flour, Fresh Fruits			
Sugar Cane (Mainly for Domestic)		5.34	Sugar			
Urban Areas	Town (Commercial Area)	2.35	Hotel & Restaurants/ Banking & Insurance Government services/ Wholesale & Retail Trade			
			St. George's	1.41	Victoria	0.19
			Grenville	0.20	Gouyave	0.19
			Sauteurs	0.19	Grand Roy	0.17
	Suburban (Housing / Partly Commercial Area)	6.39	Classification by Parish		St. George's	5.53*
					St. David	0.47
					St. Andrew	0.39**
	Industrial Area	0.02	Frequente: Manufactures for Beverages,			0.02
			Seamoon (Light Industries)			0.0003
	Sub Total	8.76				
Forest/ Wood-land etc.	Forest Area	39.66	Evergreen Rainforest = Lumbers			
	Woodland/ Scrub	52.73	Woods			
	Mangrove	2.19				
	Sub Total	94.58				
Grass-land	Pastures & Grazing	4.57	Livestock			
Others		20.39	Wasteland, Idle Land etc.			
Total		312.00				

Data Source : Land Use and Natural Vegetation Map (Land Use Division, Ministry of Agriculture) and Sites Investigation

2) Urban Area

The urban area totals 876 km^2 which is composed of town (commercial area) of 2.35 km^2, suburban (mainly housing area) of 6.39 km^2 and small industrial area of only 0.02 km^2. The business in the town is mainly offices, retail and restaurants and it is concentrated at St. George's (about 60 % of town area).

The hotel and restaurant's sector is used as a proxy to measure activities in the Tourism Industry. The contribution of this sector to the GDP in 1996 in real terms was approximately 10 % (60 million EC$). It is very important to Grenada's economy, on the same level as agriculture. Suburban areas are mainly residential with some small retail sale businesses and Tourism related businesses.

There are three general industrial areas in Grenada, which include the

Frequente Industrial Park and surrounding area, the Mt. Gay area and the Seamoon Industrial Park. The Frequente Industrial Park area, located near the Point Salines International Airport, has light manufacturing, beverages, steel products and paint. The Mt. Gay area, located near St. George's, consists of light manufacturing such as garment (textile industry), warehousing and other industries such as beverages and feed/ flourmill. The third area is the Seamoon Industrial Park, located near Grenville produces light industrial goods.

3) Rain Forest

Much all of the rain forest falls within the Grand Etang Forest Reserve and the total area is about 39.66 km^2. The rain forest area is divided into the very tall rain forest and the lower montane formation. The rain forest area of 16.88 km^2 is inaccessible and the forest species have no economic value as such. The lower montane area of 22.78 km^2 has species which are suitable for timber and recently more economic species have been planted. The rain forest area is providing a good water resource and commands a splendid natural environment.

4) Woodland and Scrub

This flora is mainly found in the southern part of the island and the total area is 52.73 km^2. The woodland forest has little economic value and consists partly of land which is unsuitable for agriculture. The scrub can be considered as ruinate and bush land, and it does not seem to offer much agricultural potential.

5) Mangrove Swamp

Mangrove swamps occur along the coast in the southern and eastern part of Grenada (total 2.19 km^2). In some drainage depressions and around small lakes swampy land is found.

6) Grassland (Pastures & Grazing)

Grassland and scrub (total 2.9 km^2) occurs almost exclusively in the southern half of the island mainly in the drier southwest corner. Many pastures are weedy (grazing lands) and merge into ruinate land.

7) Suburban areas:

Such areas include: isolated buildings, sports grounds, quarries, airports, water, roads. etc. are included here and are estimated to make up a total of 20.39 km^2.

(2) Land Use Along the Study Roads

The land use pattern along the Study Roads based on the land use map (S = 1 : 25,000) which was prepared by Land Use Division, Ministry of Agriculture is as shown in Tables 2.2.6 and 2.2.7. According to the table, the Grand Etang Route passes through the high economical area and the abundant green area, hence it is especially necessary to ensure that the Study considers the protection of the natural and social environment, as well as compensations for required land acquisition.

Table 2.2.6 Land Use Classified by Electoral Zone (1996)

Code	Parish	Electoral Zone	Population	House Holds	Land Use (Sq. Km)									
					Food Crop	Cash Crop	Forest	Glass	Sugar	Town	Sub-urban	Indust.	Other	Total
1	Carriacou	Carriacou	4,965	1,499	1.87	5.61	13.94	10.45	0.00	0.00	0.00	0.00	2.13	34.00
2	St.Andrew	South East	5,406	1,310	3.84	12.61	5.21	0.08	0.00	0.00	0.39	0.00	0.87	23.00
3	do	South West	6,930	1,679	4.91	16.16	6.67	0.12	0.00	0.00	0.00	0.00	1.11	28.97
4	do	North East	5,944	1,440	4.22	13.86	5.73	0.1	0.00	0.20	0.00	0.00	0.95	25.06
5	do	North West	5,053	1,224	3.59	11.77	4.85	0.08	0.00	0.00	0.00	0.00	0.80	21.09
6	St.David's		10,250	2,453	4.56	14.97	13.55	0.17	3.34	0.00	0.47	0.00	1.97	39.03
7	St.George's	Town Area	6,296	1,196	0.75	2.43	2.65	0.49	0.00	1.41	0.00	0.00	1.08	8.81
8	do	North East	9,090	1,871	1.07	3.53	3.84	0.69	0.00	0.00	1.62	0.00	1.57	12.32
9	do	North West	5,814	1,197	0.69	2.25	2.45	0.46	0.00	0.00	1.03	0.00	1.00	7.88
10	do	South East	6,986	1,438	0.83	2.71	2.95	0.54	0.00	0.00	1.24	0.00	1.21	9.48
11	do	South	9,137	1,880	1.08	3.54	3.86	0.69	2.00	0.00	1.64	0.02	1.57	14.40
12	St.John's		8,111	2,243	5.23	17.21	14.17	0.35	0.00	0.36	0.00	0.00	1.55	38.87
13	St.Mark's		4,397	955	4.58	15.07	13.67	0.29	0.00	0.19	0.00	0.00	4.87	38.67
14	St.Parick	East	4,517	1,009	2.7	8.86	6.43	0.22	0.00	0.00	0.00	0.00	0.08	18.29
15	do	West	5,997	1,339	3.59	11.75	8.55	0.29	0.00	0.19	0.00	0.00	1.76	26.13
Grenada Total			93,928	21,234	41.64	136.72	94.58	4.57	5.34	2.35	6.39	0.02	20.39	312.00
TOTAL			98,893	22,733	43.51	142.33	108.52	15.02	5.34	2.35	6.39	0.02	22.52	346.00

Data Source : Land Use and Natural Vegetation (Land Use Division, Ministry of Agriculture) Annual Abstract of Statistics, 1996 (Central Statistic Office , Ministry of Finance)

Table 2.2.7 Land Use Along the Study Roads

Area Division	Land Use	Activity
1. Grand Etang (St. George's ~ Grenville : L=20.5km)		
St.George's~1.0 km	Main Towns Area	(Commercial Area)
1.0 km ~1.5 km	Suburban Area	(Residential/ Partly Commercial)
1.5 km ~2.0 km	Food Crop (Mixed Cultivation)	Vegetable/Fruits/Banana/ Nutmeg
2.0 km ~4.5 km	Suburban Area	(Residential / Partly Commercial)
4.5 km ~7.5 km	Food Crop (Mixed Cultivation)	Vegetable/Fruits/Banana/Nutmeg
7.5 km ~12.0 km	Forest (Evergreen Rainforest)	Woods
12.0 km ~18.0 km	Cash Crop	Banana/ Cocoa / Nutmeg
18.0 km ~20.2 km	Food Crop (Mixed Cultivation)	Vegetable/Fruits/Banana/ Nutmeg
20.2 km ~20.5 km	Suburban Area	(Residential / Partly Commercial)
2. Morne Jaloux (White Gun-Mt.Hleicon-~The Cliff-Sugar Factory-: L=4.0 km)		
White Gun~0.5 km	Suburban Area	(Residential / Partly Commercial)
0.5 km~1.9 km	Food Crop (Vegetable)	Corn,Potatoes,Tomatoes,Cucumber
1.9 km~2.4 km	Food Crop (Mixed Cultivation)	Vegetable/Fruits/Banana/Nutmeg
2.4 km~2.6 km	Sugar Cane	Sugar
2.6 km~3.1 km	Suburban	(Residential/ Partly Commercial)
3.1 km~4.0 km	Sugar Cane	Sugar
3. Perdmontemps / St. David's (St. David's~Perdmontemps : L=7.1 km)		
St.David's ~1.2 km	Suburban Area	(Residential/ Partly Commercial)
1.2 km ~1.4 km	Food Crop (Mixed Cultivation)	Vegetable/Fruits/Banana/Nutmeg
1.4 km ~1.6 km	Suburban	(Residential/ Partly Commercial)
1.6 km ~5.8 km	Food Crop (Mixed Cultivation)	Vegetable/Fruits/Banana/Nutmeg
5.8 km ~6.0 km	Suburban Area	(Residential/ Partly Commercial)
6.0 km ~6.3 km	Food Crop (Mixed Cultivation)	Vegetable/Fruits/Banana/ Nutmeg
6.3 km ~6.6 km	Suburban	(Residential/ Partly Commercial)
6.6 km ~6.9 km	Food Crop (Mixed Cultivation)	Vegetable/Fruits/Banana/Nutmeg
6.9 km ~7.1 km	Suburban Area	(Residential/ Partly Commercial)
4. Mt. Gay / Springs (Mt. Gay ~ Sugar Factory down stream about 600m : L=5.8km)		
Mt. Gay ~0.2 km	Food Crop (Mixed Cultivation)	Vegetable/Fruits/Banana/Nutmeg
0.2 km ~1.4 km	Main Towns	(Commercial Area)
1.4 km ~4.4 km	Suburban Area	(Residential/ Partly Commercial)
4.4 km ~4.6 km	Forest	Evergreen Rainforest
4.6 km ~5.2 km	Sugar Cane	Sugar
5.2 km ~5.8 km)	Suburban Area	(Residential/ Partly Commercial)
5. Eastern Main Road (Grenville ~ Sauteurs : L=16.0km)		
Grenville ~ 1.5 km	Suburban Area	(Residential/ Partly Commercial)
1.5 km ~5.5 km	Food Crop (Mixed Cultivation)	Vegetable/Fruits/Banana/Nutmeg
5.5 km ~6.0 km	Cash Crop	Cocoa mixed with Banana
6.0 km ~9.0 km	Food Crop (Mixed Cultivation)	Vegetable/Fruits/Banana/Nutmeg
9.0 km ~12.0 km	Cash Crop	Cocoa mixed with Banana
12.0 km ~13.0 km	Food Crop	Vegetable mixed Fruits
13.0 km ~15.7 km	Food Crop (Mixed Cultivation)	Vegetable/Fruits/Banana/ Nutmeg
15.7 km ~16.0 km	Suburban	(Residential/ Partly Commercial)
6. Paraclete / Mt. Horne (Paraclete ~(Mt. Horne)~ Mirabeau Estate :L= 3.4 km)		
Paraclete ~0.5 km	Food Crop (Mixed Cultivation)	Vegetable/Fruits/Banana/Nutmeg
0.5 km ~3.4 km	Cash Crop	Cocoa mixed with Banana
7. Dover (Windward ~ Cherryhill : L=3.1 km) : Carriacou		

2.3 ROAD NETWORK

2.3.1 Major Transport Facilities

The major transport facilities in Grenada are composed of airports, seaports and roads as shown in Figure 2.3.1.

(1) Airport

Point Salines International Airport (Grenada) has a runway of 2,740 m and facilities to accommodate large commercial aircrafts. The passenger terminal can accommodate 1,500 passengers a day. Another airstrip is near Grenville. Lauriston airport is located in Carriacou Island and has a 457 m airstrip.

(2) Seaport

The major seaport of Grenada is the St. George's Port located in the capital. The port handles all major dry cargo, containers, general cargo, break-bulk, dry-bulk and passenger traffic. The port offers two berths of 245 m and 75 m. The commodities handled at the port amounted to more than 220 thousand tons, of which 90 % was for import, in addition to 7 thousand TEUs and 195 thousand passengers as an average of recent years. In addition to St. George's Port, Grenville and Carriacou have some port facilities.

(3) Road

Most of inner island passenger and freight transport movements are burdened to the road sector. The total length of the national road network is approximately 1,100 kms, of which about 30% is paved. The government has adopted a policy of providing an efficient road transportation system to promote development of socioeconomic activities and to facilitate the movement of people and goods at a minimum cost to the economy.

In the main island, the arterial network consists of the two coastal roads, namely the Eastern Main Road and Western Main Road, which are surrounding the island, and a road connecting St. George Town to Grenville. This is the Grand Etang Road which is steep with many small-radius curves as it was built in mountainous terrain. Based on the results of the 13hrs traffic surveys of the Study, daily traffic volumes handled by the arterial roads are estimated as shown in Table 2.3.1.

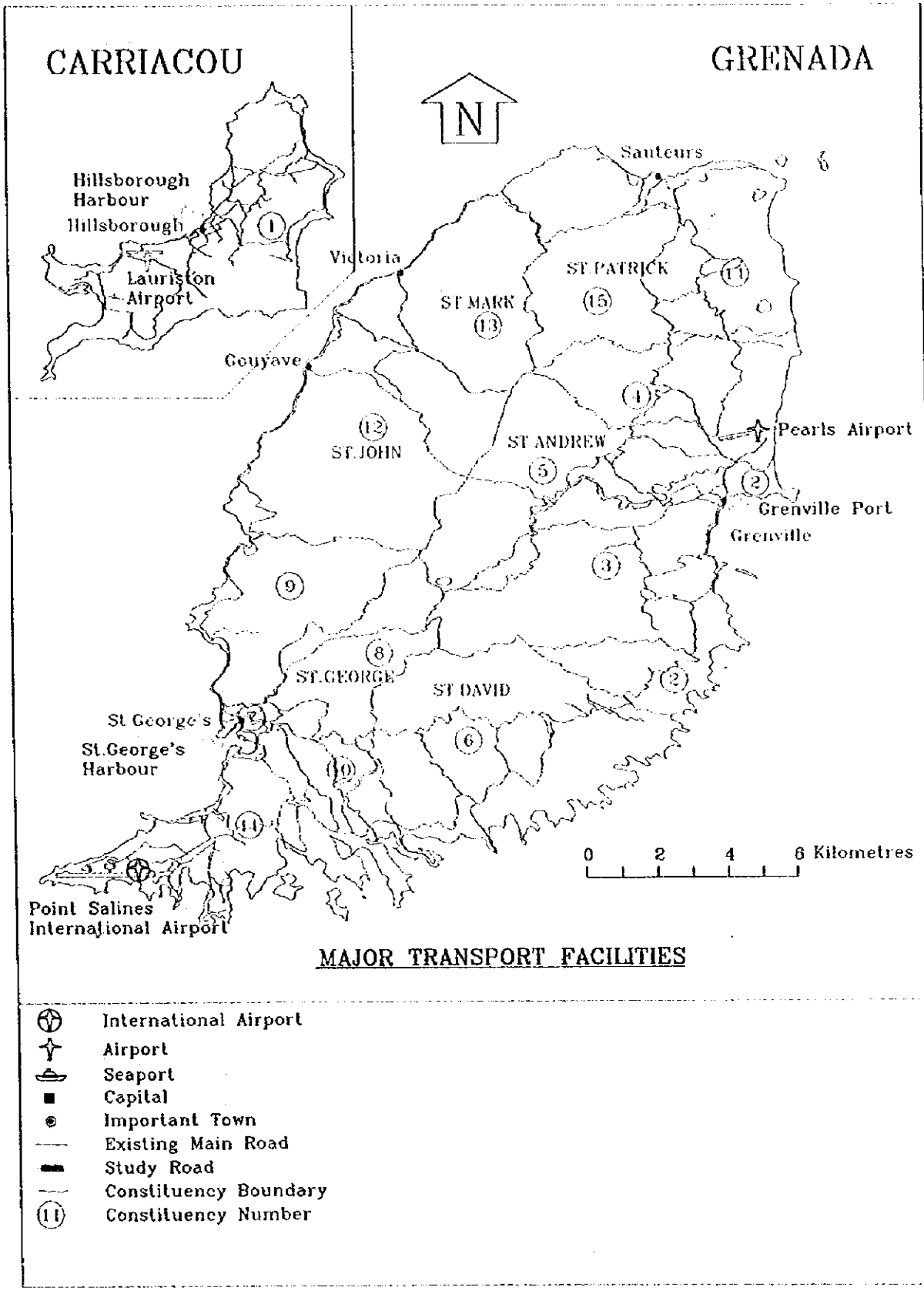

Figure 2.3.1 Major Transport Facilities

Table 2.3.1 Daily Traffic Volumes on Arterial Roads (vehicles)

Road	Section near St. George's	Typical Section
Eastern Main Road	5,018	1,533
Western Main Road	3,885	2,246
Grand Etang Road	5,261	1,599

2.3.2 Road Classification

The Land Development (Control) Act 1968 and the Land Development (Control, Amendment) Law require the permission to develop land. For the guidance of development, the Land Development Control Authority has established the road classifications and set backs from roads in accordance with the roads on the official road map of Grenada DOS442 (series 703) 1985 prepared on a scale of 1:50,000.

Under the classification system of roads in Grenada, the different road classes are defined as follows:

(1) Class 1A Regional Road
There is one road under this class which is the road between Point Saline Airport and the Sugar Mill Roundabout.

(2) Class 1 Regional Road
There are five roads under this class which compose the main arterial links in Grenada Island.
- Western/Eastern Main Road
- Western Main Road
- Grand Anse Main Road
- Woodlands Road
- Grand Etang Road

(3) Class 2 District Road

(4) Class 3 Local Road

(5) Class 4 Access Road

For each road, there is a specified setback minimum distance at which road right-of-way reservations and building lines should be sited as shown in Table 2.3.2. The distance is measured from the centerline of the road and the building line refers to the eaves of the buildings.

Table 2.3.2 Road Reservation Distance

Classification	Reservation	Building Line
1A Regional Road	13 m	20 m
1 Regional Road	6 m	9 m
2 District Road	5 m	9 m
3 Local Road	4 m	7 m
4 Access Road	3 m	6 m

2.3.3 Road Network

The country has a network of all-weather roads totaling more than 1,000 kilometers of which 30% are paved. The network includes a few main roads of about 130 kilometers in addition to other secondary and tertiary roads which connect communities and agriculture lands together. Some radial local networks of roads have been developed to transport farm products. Many of the minor roads have been paved at one time but surfacing has been deteriorated due to lack of maintenance. The main arterial links of the network are shown in Figure 2.3.2.

As graphically demonstrated in the figure, the road network is greatly affected by the high central peaks and ridges which make east/west coastal connections difficult to achieve. It is severely constrained by the physical geography of the island which is characterized by the central peaks and ridges. These consist of Mt. St. Catherine in the north, Grand Etang Forest Reserve Area and National Park in the center and the Southeast Mt. in the south. The main components of the road network are as follows:

(1) Regional Roads

Under this class, there are three main roads which were formed to meet the topographical and geographical conditions of the island.

- The Western Main Road: It has a length of approximately 37 km with paved surface and runs along the western coast of the island.
- The Eastern Main Road: It passes through a relatively flat area and its length is about 48 km with paved surface. It runs along the eastern coast of the island and it is presently under rehabilitation.
- Grand Etang Road: It connects the capital city of St. George's with the second largest city of Grenville with a length of about 20.5 km. It is in poor condition and runs through the central mountain range including forest reservation areas.

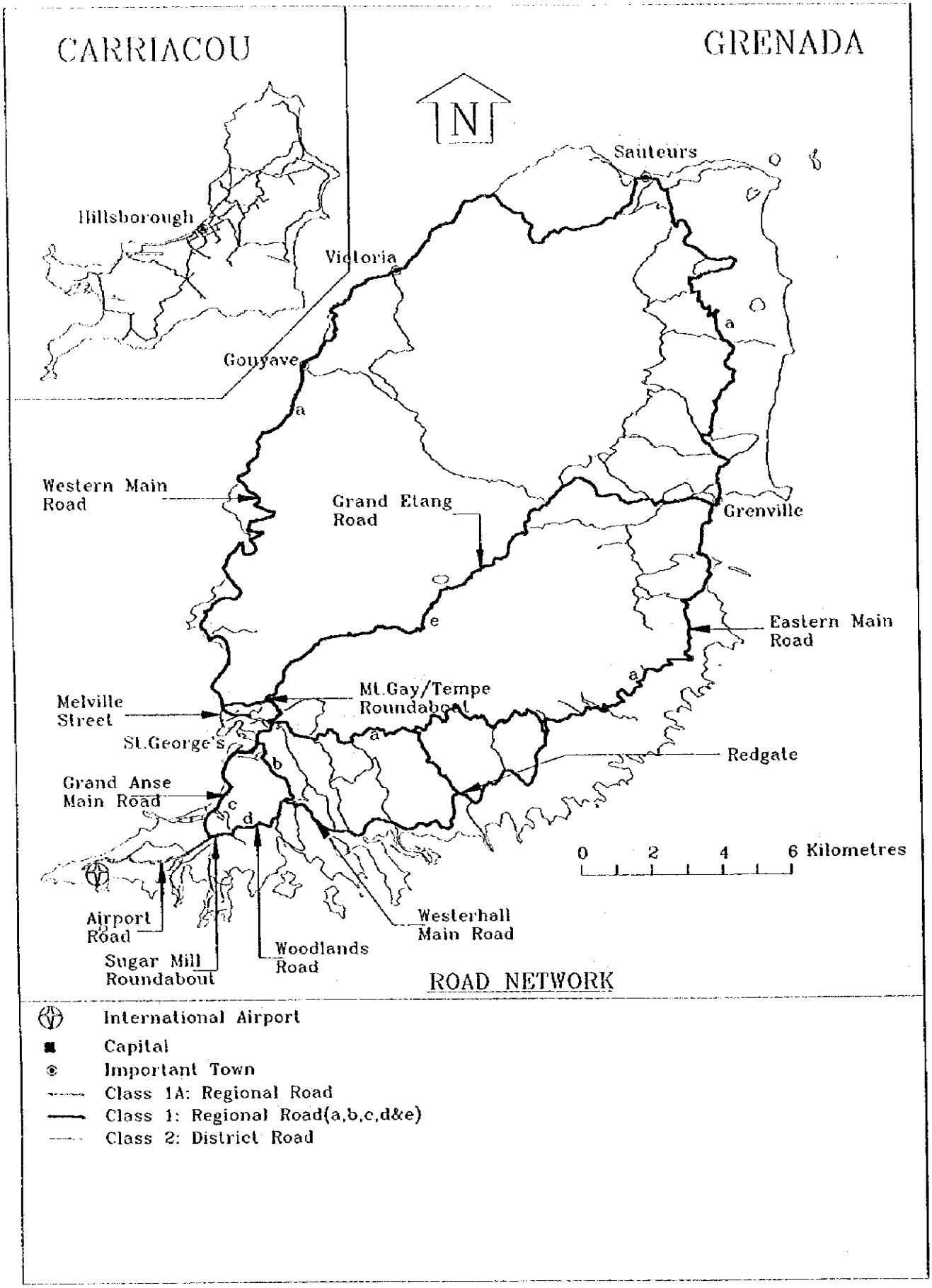

Figure 2.3.2 Road Network

(2) Secondary and Tertiary Roads

In addition to the regional roads under Class 1, there are approximately 960 kilometers of secondary and tertiary roads. Numerous secondary roads branched from the main roads join communities together but their condition is very poor. There are also tertiary roads which connect the farms to the secondary and main road networks.

2.3.4 Road Administration

The construction and maintenance of all roads in Grenada are functions of the Ministry of Works, Communication and Public Utilities (MOW) and a specific responsibility of the Roads Department. For purposes of administration, the Roads Department is divided into the following two regional subdivisions:

(1) Western Roads Division (ERD)
- St. Patrick's
- St. Mark's
- St. John's
- St. George's
- Carriacou
- Petite Martinique

(2) Eastern Road Division (WRD)
- St. Andrew's
- St. David's

The organizational structure of the Roads Department is presented in the chart shown in Figure 2.3.3. The budget for road maintenance works under the Roads Department is presented in Table 2.3.3 for the last five years.

Table 2.3.3 Road Maintenance Budget

Year	Budget (EC$)
1993	7,525,550
1994	9,998,258
1995	8,561,702
1996	6,121,828
1997	4,748,450

The Roads Department is utilizing some equipment for maintenance works as major rehabilitation and improvement projects are done comprehensively by contractors without utilizing the department equipment. Table 2.3.4 gives a list of the equipment in working condition.

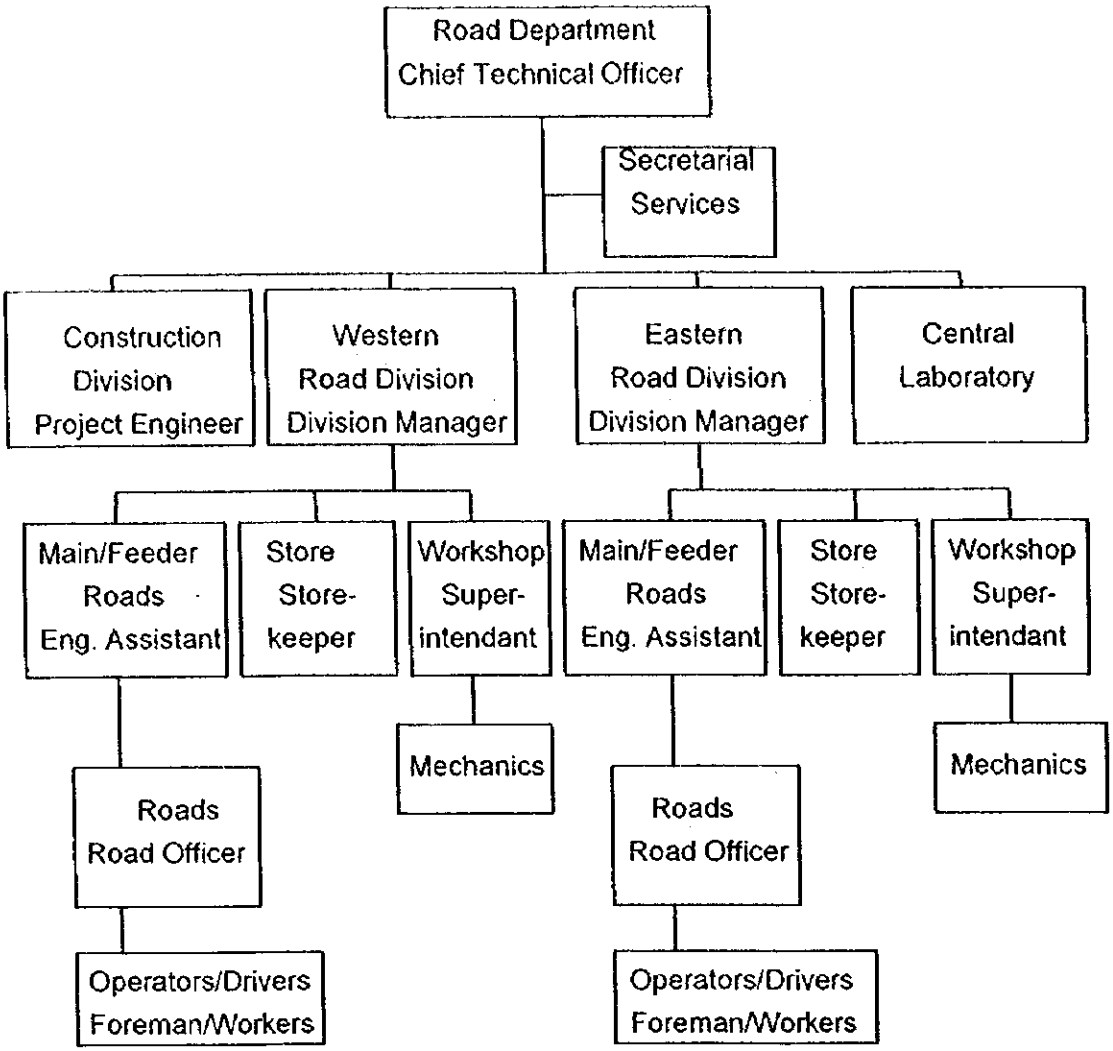

Figure 2.3.3 Roads Department Organization Structure

Table 2.3.4 Maintenance Equipment of Roads Department

Description	Number of Units	Year of Manufacturing
Bedford Tipper	2	1984
Leyland Tipper	5	1995
Dodge Tar Sprayer	1	1987
Bedford Tar Sprayer	1	1981
Ingram Roller PTR	1	1987
JCB 3XC Backhoe	1	1987
Skid Steer (Case)	2	1994
Bedford Dumper	3	1995
Thwaites Dumper	2	1987
Bedford Water Truck	1	1981
Aveling Bedford Grader	1	1981
Barber Green E Paver	1	1987
D175 Compressor	1	
Wacker Plates	3	
Errut Saw	1	
D6 Caterpillar Bulldozer	1	
Belarus Tractor and Brush	1	
AB Roller	1	
Bedford Roller	2	
Vibratory Rammers	3	1985
Generator	2	
Chain Saw	1	
Pavement Breaker Hydr.	1	
JCB Drill	1	
JCB Water Pump	1	
Honda Water Pump	2	
Battery Charger Velox 400	1	
Arc Welder	1	
Hydraulic Jack	1	
Land Rover (Defender 90)	3	1994
Daihatsu Delta Truck	1	1995
Aveling Barford Roller	1	
Suzuki Samurai JX 10	1	1981
Bobcat Skid Steer Machine	1	
Concrete Vibrator	1	1995
AB Vibratory Roller VXC	1	1986

2.4 RELEVANT PLANS AND PROJECTS

As the government has adopted the policy of improving the road network to provide an efficient transportation system in the country, there are several on-going and completed projects for the maintenance, improvement and rehabilitation of roads. With the recent budgetary constraints, the implementation of most of the large-scale improvement projects of roads was accomplished under foreign funded schemes. Figure 2.4.1 and Table 2.4.1 show the details of the foreign funded main road projects.

Table 2.4.1 Foreign Funded Road Improvement Projects

Foreign Fund Source / Road Section	Length (km)	Cost (MEC$)	Comments
1.KFAED funded	12.50	26.0	
1-a. Sugar Mill to Red Gate Road	5.60		In Progress
1-b. Gouyave to Union Road	6.90		In Progress
1-c. Sea Defenses (Gouyave to Union)	-		In Progress
2.ROC funded/Rehab.of 13 roads sect.	9.60	7.1	In Progress
3.CDB funded	12.10	40.0	In Progress
3-a. Airport Road	6.60		In Progress
3-b. Eastern Main Road	5.60		In Progress
4.CDB funded / Feeder Roads	12.00	16.4	Completed in 94
5.CDB funded/ Western Main Road	10.90	26.0	Completed in 90
St. George's to Gouyave	10.90	26.0	Completed in 90
6.EDF funded / Eastern Main Road	4.00	9.6	Completed in 96
Grenville to Hope	4.00	9.6	Completed in 96

More details of plans and projects related to the Study are presented in Appendix 1. As a conclusion of these projects and as shown in the figure, almost the coastal roads of Grenada are covered by improvement and rehabilitation projects. Roads selected for this study compose mainly the Trans-Grenada Highway which longitudinally traverse the island from north to south (R-5, R-1 and R-4) and a diversion road (R-2) at the urban area of St. George's, as well as some sections that provide better function for the road network.

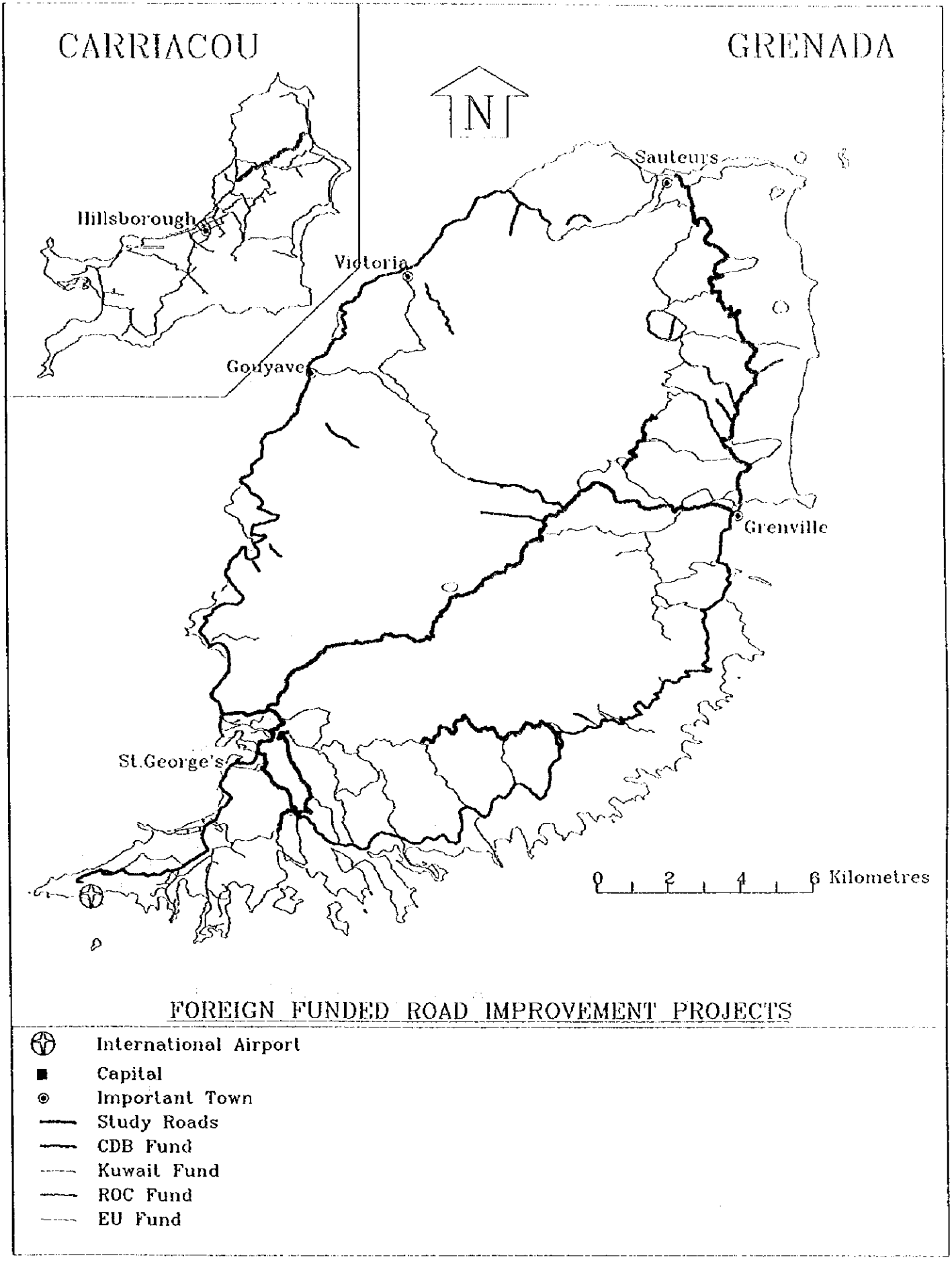

Figure 2.4.1 Foreign Funded Road Improvement Projects

2.5 STUDY ROADS

The Study covers seven (7) roads in which six (6) roads are spread in Grenada Island and one (1) road in Carriacou Island as shown in the location map in Figure 2.5.1. The physical profile and counted traffic data are presented in the following sections.

(1) Grand Etang Road (GER)

This road connects the capital city St. George's to Grenville, which is the second largest town, through the central mountainous area. It starts from sea level and climbs to a pass at an elevation of 520 m, and then it loses its height as it descends to sea level on the other side. The total length of the road is 20.5 km. The geological features in the mountainous area are composed of Basalt or Andesite covered with around a one meter soil layer except in the plain areas it is Volcanic Ashes.

The road is steep and snaked with many sharp curves, but cars run with a speed of more than 30 km/hr even in the hairpin curve sections between Annandale and Grand Etang. The driving speed survey shows a car can maintain an average speed of 48 km/hr in the section between St. George's and Annandale and 59 km/hr in the section of Grand Etang to Grenville. Based on the count data collected during the traffic survey, estimated daily traffic volumes are varying from 1,599 vehicles per day at Grand Etang's mid-point and 5,261 vehicles near St. George's.

(2) Morne Jaloux Road

This road is located along the hill-side of St. George's and runs through residential areas of the capital. It starts from halfway uphill of a mountainous area, runs along a ridge line, and ends at a point halfway downhill of another mountain. Many houses are ceaselessly located along the ridge line. There are three forts along the road which may attract more tourists after improving the road. Based on the traffics counts, an average daily traffic of 1,034 vehicles was estimated while the driving speed was measured as 38 km/hr in average.

(3) St. David's - Perdmontemps Road

This road connects St. David's with Perdmontemps as a shorter alternative of the East Main Road. It runs, however, in a mountainous area and passes through nine (9) ridges and nine (9) valleys. The road has three sections with a

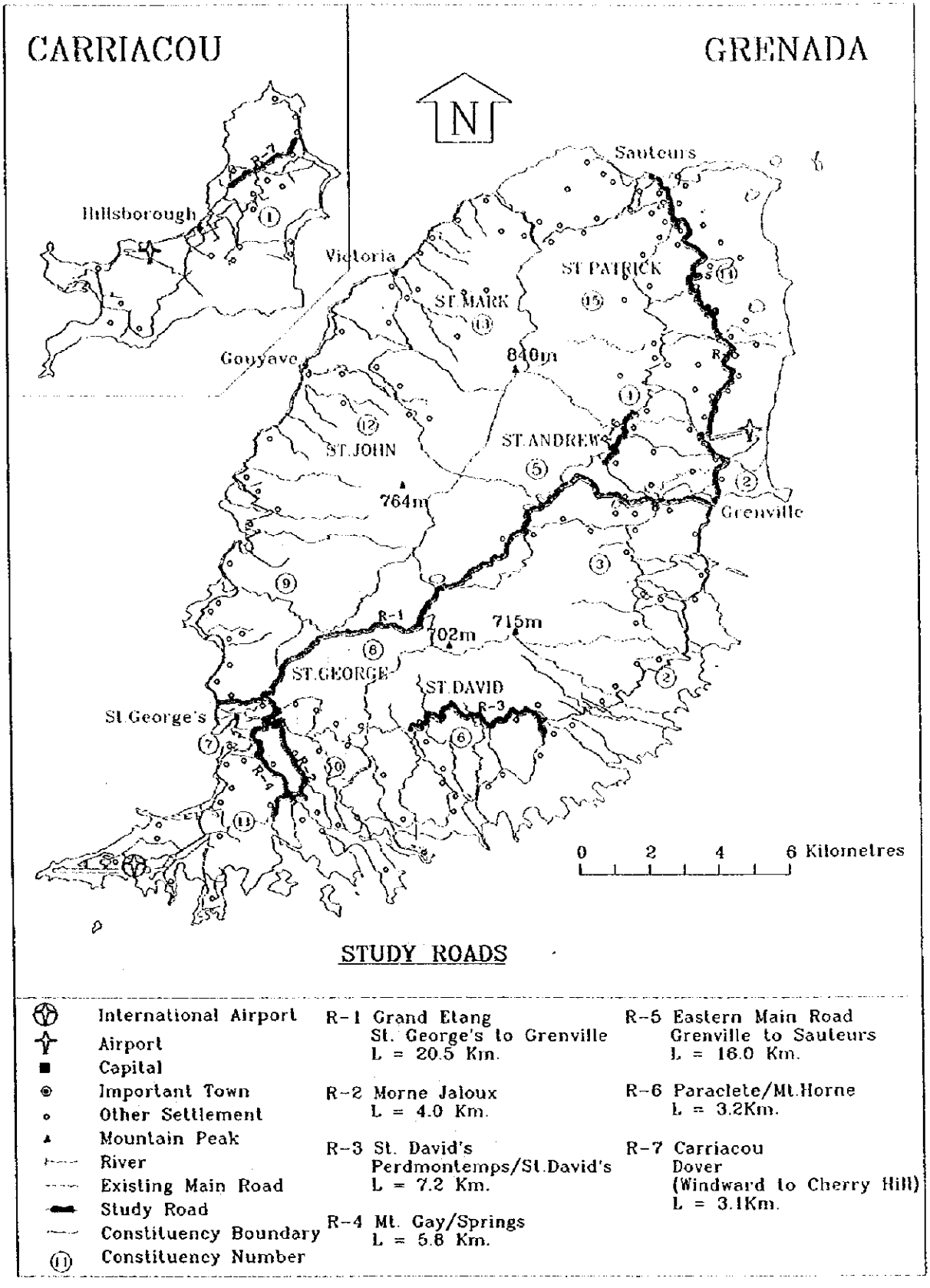

Figure 2.5.1 Study Roads

steep gradient of more than 10% and fifteen sharp curves. Based on the traffic counts, an average daily traffic of 276 vehicles was estimated while the driving speed was measured as 38 km/hr in average.

(4) Mt. Gay - Springs Road

The road functions as an arterial road in the urbanized area to transport commodities to/from the port of St. George's with its first 2.5 km passing through the urban area. The road handles relatively heavy traffic volumes estimated as 3,734 vehicles/day which indicate the importance of the road. The average driving speed was measured as 48 km/hr.

(5) Eastern Main Road (Grenville - Sauteurs Section)

The road penetrates the flat terrain located in the northeastern parts of the Grenada Island. The geometric characteristics including its vertical and horizontal alignment conditions are reasonable. The road serves many schools and churches which show the need for sidewalks for safe pedestrian movement.

The estimated average daily traffic on the road is fluctuating from 1,533 vehicles at the Grenville side to 729 vehicles at the mid section to 1,201 at the Sauteurs side. The figures show that about half of the traffic is intra-zonal local traffic for short trips between Grenville or Sauteurs and the suburbs, while the remainder represents inter-zonal long trips between Grenville and Sauteurs.

(6) Paraclete - Mt. Horne Road

This road functions as a local road passing through mountainous areas with steep vertical alignment conditions and many sharp curves. It handles a low traffic volume of 353 vehicle/day and the measured running speed was about 48 km/hr.

(7) Dover Road (Windward - Cherryhill Section) - Carriacou Island

The road crosses Carriacou Island. The highest elevation of the road is 100 m above sea level. The first 300 m from the starting point at Windward and the last 500 m at the end point at Cherryhill have some sections of severe vertical alignment. The estimated daily traffic volume on the road is 593 vehicles and the speed survey results are 40 km/hr from Cherryhill to Belvederre and 24 km/hr from Belvederre to Windward.

PART II

SURVEY AND ANALYSIS

CHAPTER 3

ROAD SURVEY AND EVALUATION

CHAPTER 3

ROAD SURVEY AND EVALUATION

3.1 METHODOLOGY

Accurate data collection and field surveys which assess the present serviceability of roads and evaluate residual life of facilities are vital to a successful rehabilitation and improvement effort. The road surveys shown in Table 3.1-1 were conducted in this Study to identify problems and to propose methods and requirements for the rehabilitation/improvement of roads.

Table 3.1.1 Types of Road Survey

Survey Type		Major Items to be Surveyed	Survey Methods
1.	Road Referencing System Survey	• Accurate Distance • Definition of Reference Points	• Odometer
2.	General Road Condition Survey	• Topography, Roadside Road Use • Cross section Type, -Shoulder • Pavement Width, -Row Width • Shays Curve, -Sharp Gradient • Surface Drainage Condition	• Visual Inspection
3.	Pavement Performance Survey 1. Pavement Serviceability Survey 2. Pavement Condition (Distress) Survey	• Present Serviceability Rating (PRS) • Roughness Survey • Cracking - Patch deterioration • Polished aggregate – Potholes • Pumping – Rutting	• Assessment by Road Users • Mays Ride Meter • Visual Inspection
4.	Pavement Structural Survey	• Structural Capacity of Pavement • Moisture - related damages	• CBR • Deflection of Pavement • Non-destruction Test (NDT)
5.	Drainage Survey	• Drainage Size • Condition	• Visual Inspection
6.	Bridge Condition Survey	• Assessment of Present Condition	• Visual Inspection
7.	Slope Condition Survey	• Finding of failures in Slopes and Evaluation of Suspicious Slopes	• Visual Inspection

3.1.1 Road Referencing System Survey

The survey was conducted to measure the exact distance between the defined reference points. Provincial/city boundary posts, kilometer posts, beginning and end of bridges, major intersections and other permanent structures were selected as reference points. The survey used as the common basis in terms of location and distance for the general road condition survey, the pavement survey, and other surveys. Distance between reference points was measured by a vehicle equipped with an odometer that can read to a level of 06 meters. The used survey format is presented in Appendix 2.

3.1.2 General Road Condition Survey

General road conditions of elements such as topography, cross section types, horizontal and vertical alignment, shoulder, surface drainage and roadside land use were surveyed by visual inspection. The above information was recorded for each homogenous unit section with an average length of 100m. The used survey format is presented in Appendix 2.

3.1.3 Pavement Performance Survey

The current concept of evaluating the pavement performance includes some consideration of functional performance, structural performance and safety.

The functional performance of a pavement concerns with how well the pavement serves the users. Riding comfort or ride quality is the dominant characteristic, which were assured as the Pavement Serviceability Survey (PSS) including riding comfort and roughness survey.

The structural performance of a pavement relates to its physical conditions; i.e., occurrence of cracking, raveling, rutting, or other conditions which would obviously affect the road-carrying capability of the pavement structure. Pavement condition (distress) survey was conducted in order to identify those physical conditions in the Study Roads.

(1) Pavement Serviceability Survey

Present Serviceability Rating (PSR): The present serviceability of a pavement is defined as the ability at time of observation to how well the pavement serves the user. Riding comfort or ride quality is the dominant characteristic. The present serviceability is expressed as the mean value of individual road users rating.

It is understood that the basis of judgment on present serviceability may be swayed by the tolerance of road users, national characteristics as well as economic conditions of the country, since riding comfort or ride quality is a matter of subjective response or the opinion of the users.

Present Serviceability Rating (PSR) is undertaken by rating panel and it was conducted by a Grenada Engineer and two Study Team Engineers.

Rating Method: Each engineer was asked to rate the serviceability/comfort based on his own judgement for every 200-m section of the road using the format presented in Appendix 2. The range of rating was from 5 to 0 as follows:

Table 3.1.2 Serviceability Rating Method

Rating Point	Class	Surface Condition	Pavement Status
5.0 - 4.0	Very Good	Very comfortable	No cracks
4.0 – 3.0	Good	Comfortable	A few short cracks
3.0 – 2.0	Fair	Satisfactory	Many cracks but not badly damaged
2.0 – 3.0	Poor	Uncomfortable	Badly deteriorated
1.0 – 0.0	Very poor	Very uncomfortable	Severely deteriorated

Acceptability: Each engineer was further asked to record his opinion whether the serviceability of 200-m was acceptable or not.

(2) Roughness Survey

1) Purpose

The measurement of road roughness is the basis for estimating the Present Serviceability Index (PSI). PSI is used to monitor the performance history of pavements and is used in the design of flexible pavements.

2) Equipment

Mays Ride Meter, Model #890, was the measuring device used to accomplish the road roughness survey. The equipment was installed in a Suzuki Vita which was determined to meet all the manufacturer's specifications. A rotary transmitter was attached to the car's body above the rear differential housing. The transmitter measures the relative motion between body and rear axle housing of the vehicle and this data transmitted to a recorder located at the front of the vehicle. A special odometer was also installed to provide accuracy to

100th of a mile. The recorder measures the distance in 0.05 mile increments, the profile or roughness of the road and landmarks were manually inputted. The unit is powered by the vehicle's battery.

3) Procedure

A two-man team composed of a driver and an observer conducted the survey. The driver maintains a constant speed in a precise wheel path while the observer sets up and starts the recorder, maintains the recorder's operation, and manually records landmarks. Each road was run in both directions. A chart paper was loaded and road number, name, direction, time, date and weather conditions were recorded at the start of each run. The odometer was set to zero and the run was made.

The International Roughness Index (IRI) was calculated using the following formula.

IRI (m/km) = Mays Ride Meter Roughness (in/mill) x 10.24/13

Where: 10.24 = 6.4 x 10 x 0.16
Including a factor for converting 1 inch of chart paper from 6.4 inches of total Axle vertical travel Roughness in/miles to Roughness in/0.1 miles (1/10) Quarter-car Index (QI))./16

- Converting ratio between Quarter-car Index and IRI = QI/13

The criteria for the judgement of roughness is that pavement sections with ratings over about 5 were proposed for pavement rehabilitation.

Roughness	Pavement Condition
0 ~ 3.5	New pavement
2.5 ~ 6.0	Old pavement (surface imperfections)
4.0 ~ 11.0	Damaged pavement (frequent depressions)

(3) Pavement Condition Distress Survey

Pavement condition (Distress survey was conducted to identify distress type, distress severity and distress amount. The type of distress used in evaluation is based on the method of "Design of Pavement Structure, AASHTO 1993".

1) Pavement Distress Survey

The following pavement distresses were recorded for each homogenous unit section of a length of about 100m.

- Cracking (class 2 and 3)
  - Longitudinal and transverse cracking
  - Alligator or fatigue cracking
  - Block cracking
- Patching
- Pothole
- Rutting

The definition of pavement distress is as follows:

Class 2 Cracking	:	cracking which has progressed to the stage where cracks have connected together to form a grid type pattern.
Class 3 Cracking	:	cracking in which the fitriminous surfacing rigment become loose.
Patching	:	repair of pavement surface by skin patching of deep patching.
Pothole	:	bowl shaped hole of various sizes in pavement.
Rutting	:	surface depression in the wheel paths.

2) Survey Methods

Experience highway engineers conducted a visual inspection roughly to evaluate area of each distress for each homogenous unit section of roads, using the survey format presented in Appendix 3.

3) Rating Method

While riding on a survey vehicle running at 20 kph, each engineer

recorded types, severity and amounts of distress. Based on the records, each engineer asked to rate his engineering judgement on rehabilitation/maintenance requirement for each homogeneous unit section.

The range of rating is from 5 to 0 and criteria of judgement is as follows:

Surface Condition

Very Good	:	Almost no distress
Good	:	No potholes or rutting or corrugation. Less than 5 potholes per 1000 meters
Fair	:	More than 5 but less than 20 potholes per 1000 meters and/or slight cracking and/or rutting and/or corrugated (less than 50% of the section length). Passenger car speed will exceed 30 km per hour
Bad	:	More than 20 potholes per 1000 meters and/or slightly rutted and/or corrugated (more than 50% of the section length
Very Bad	:	Pavement breaking up and gravel surface deteriorated into numerous potholes. Just passable for cars. Maximum comfortable travel speed for cars is about 20 km/hr

3.1.4 Pavement Structural Survey

Pavement Structural Survey is carried out by the soil classification test and CBR test, as explained in Chapter 10.

3.1.5 Drainage Survey

The existing condition of the cross drainage facilities along the Study Roads was investigated using the format presented in Appendix 2.

3.1.6 Bridge Condition Survey

The existing condition of bridges along the Study Roads was investigated using the format presented in Appendix 2.

The present conditions of each bridge and its components were classified into three classes as followed:

(1) Damage Class A; Reconstruction

Urgent repair/replacement to the superstructure or river protection facilities is necessary to restore the existing bridge to a safe operational condition. A Damage Class A Bridge is to be totally or partially replaced or urgently repaired and has at

least one critical component (i.e. girder, slab, abutment/pier, foundation, river bank and approach road) categorized as Damaged Class A.

(2) Damage Class B; Repair

Repair to the superstructure, substructure or river protection facilities is required to extend the life of the bridge, but restoration of the bridge to a safe operational condition is basically unnecessary. A Damage Class B bridge has at least one component categorized as Damage Class B.

(3) Damage Class C; Maintenance

Only maintenance of the superstructure, substructure or river protection facilities is required to be undertaken under the normal bridge maintenance program.

3.1.7 Slope Condition Survey

(1) Classification of Road Slope Disasters

Prior to the detailed field survey, road slope disaster were classified into five main types and each type was further sub-classified into sub-types as follows:

Table 3.1.3 Road Slope Disaster Classification

Main Type	Sub-Type
Cut Slope Failures	Surface failures Deep failures
Embankment Slope Failures	Surface failures Deep failure
Debris Flows	Debris flows Mud flows
Falls	Rock falls Debris falls
Landslides	Bedrock (or rock type) Colluvial (or talus type) Cohesive (or soil type)

Definitions of respective types are as follows:

1) Cut Slope Failures (including failures of mountainside natural slopes):

A surface failure is a shallow failure occurs on slope surface due to erosion weathering and structural weakness, and is generally induced by surface water flow during intensive rainfalls.

A deep failure is a failure that originates or extends deep within a slope, and is sub-classified into the types, scouring rotational failures and translational failures. Scouring generally appears on slopes composed of soil, soft rock or highly weathered rock, and is induced by concentrated flow of surface water down the slope.

2) Embankment Slope Failures (including valley side natural slopes):
A surface failure is a shallow failure which occurs on slope surface and is caused by erosion resulting from water flow. This type of failure often appears in slopes that are composed of soil eroded easily, that are not sufficiently compacted, and/or that have no or poor drainage facilities.

A deep failure is a failure that originates or extends deep within a slope. This failure is often caused by pore water pressure in embankments that are located on the sharply inclined ground containing rich ground water. The failure is also seen in embankments constructed on talus or where the ground suffered from a landslide.

Embankment slope failures are apt to occur at the following locations: (1) inner edge of curve in a road passing mountainous area, (2) semi-cut and filled road sections on the inclined ground, (3) the either side crossing a valley, (4) bridge approaches, and (5) the sides of a road hugging a river.

3) Debris Flows:
A debris flow is defined as a flow of riverbed deposits whose velocity distribution resembles the movement of viscous fluid. It is induced by the force of flow or bed. It is also seen that soil and sand that have been supplied by slope failures and deposited on the side of a hill are carried down by floods.

Debris flows are sub-classified into debris and mudflows, depending on the size of the flowed deposits. Debris flows contain large size stones, whereas mudflows mainly contain soils and sands with no large size stones.

4) Falls:
A fall is classified into a rock fall and debris fall. The former is a fall of rocks detached from slopes composed of highly cracked rocks. The latter is a fall of supportless stones from slopes of debris or talus.

5) Landslides:

Landslides is defined as movement of materials forming the slope caused by loss of balance between shear strength and movement force along the specific plane. Landslides are classified into three types, namely bedrock (or rock) type, colluvial (or talus) type and cohesive (or soil) type, depending on slope composition. The bedrock type mainly occurred along structurally weak planes such as planes of faults, bedding planes, etc. inside a bedrock. The colluvial type occurs inside colluvial soil. Tiered slopes slide continuously and recurrently. As for the cohesive type, a mass of soil composed of mainly cohesive soil with gravel that is divided into some blocks moves continuously.

(2) Survey Method

The surveys for the five slope condition types were conducted by experienced engineers for only slopes where they were not restored/protected to show great disaster potential.

The findings, including dimensional, geological and drainage condition of slopes by the visual inspection, were recovered in the format presented in Appendix 2.

(3) Embankment of Disaster Potential

To conduct disaster potential of slopes, slopes were categorized into:

1) slopes not protected by sufficient measures after occurrence of disasters,
2) slopes with high disaster potential, and slopes with low potential, taking the following factors into considerations:

- Slope gradient and height,
- Type of rocks,
- Condition of weathering, crack alteration, fractures and faults,
- Thickness and compactness of top soil,
- Possibility of surface water concentrating and quality of ground water,
- Deformation of the slope and evidence of past disaster, and influence of river flow.

In this Study, type (a) and (b) were reported.

3.2 SURVEY RESULT

Several types of surveys were carried out on the Study Roads as explained in 3.1 of this chapter. Table 3.2.1 gives a summary for the survey results of each survey while Appendix 3 includes the results for each road segment. The main results of surveys can be stated as presented in the following sections together with the preliminary recommended rehabilitation and improvement works required for each of Study Roads.

3.2.1 Grand Etang Road

The existing condition of this road shows the following problems:

- Gradient : very steep in most sections
- Traveled way : narrow in most sections
- Curve : very sharp without enough sight distance
- Pavement :.fair to bad condition
- Drainage : poor system of side ditches and crossing facilities
- Bridge : two old bridges, one spillway, one narrow bridge and one rehabilitated bridge
- Slope : failure, fall rock and 3 cut and 7 embankment sections
- Roadside : houses in the first 5km and the end 3km section
- Nature : traversing forest reserve and national park area without impact mitigating measures
- Safety : lacking of all types of safety devices and facilities

The required works for rehabilitation and improvement are as follow:

- Width : widening the first 5km section and sharp mountainous curve sections to the geometric standards to provide enough sight distance
- Profile :practically and economically, no improvements are recommended
- Pavement : asphalt concrete overlay and reconstruction of the existing pavement structure
- Drainage : Improving of the drainage system
- Bridge : new construction for 3 bridges, and widening and rehabilitation for 2 other bridges
- Slope : slope protection measures at cut and embankment failure sections
- Safety : installation of traffic safety devices

Table 3.2.1 Summary of the Survey Results

Road Name	Road Section	Connected Town	Class	Pavement Condition	Drainage	Bridge and Structure Condition	Slope Condition	Road Improvement and Rehabilitation
Grand Etang Road (L=2020 .5km)	The road connects the west cgrand oast (St. George's) and east coast (Grenville) through the Etang pass (EL= 520) • Many steep-gradient sections and small-radius curves • Difficult to change the vertical alignment considering the natural environmental conditions • Lack of stopping sight distance at horizontal curves • Traveled-way is 4.0 m to 6.0 m without shoulder width • Lack of traffic safety devices (guardrail,regulatory and warning sign, information sign board)	St. George's St. Margaret Birch Grove Lower Capital Balthazar Estate Grand Bars Grenville	Class 1	Repeated overlay works were done for the surface rehabilitation without repairing the weak sub-base and cracking on surface. Surface is in a good/fair condition with good overlay works. • Raveling of asphalt surface is observed along the whole road in different magnitudes. • Before the present AC surface, emulsion mix type was used as there was no available AC mixing plant.	• Side ditches are installed at the cut sections With total length about 29.4km. • Side ditches are cement concrete and earthtype. • Cross drainages are installed at 119 places (about 170m/interval).	• There are 7 bridges along this road. The rehabilitation works required for 5 bridges. Reconstruction bridges include 2 old steel bridges and 1 overflow type spillway. • Narrow width bridge is disturbing traffic flow.	Embankment slop problems are mostly river scoring at toe of clope. • Cut slope section problems are the lack of stopping sight distance, narrow travel-way, falling rock and cut slope failure.	The first 5 kms need widening due to heavy traffic. Many curves are lacking sight distance. Pavement rehabilitation requires AC overlay and Scalification of existing surface with new AC. Old bridge and spillway requires reconstruction. Narrow traveled-way section need widening. Providing traffic safety devices along the road is required
Morne Jaloux (4.0km)	The road passes through the highest portion of St. George's where there is a tourism point for its panoramic view and French Fort. • Steep gradient at the beginning and end sections • End section has two hairpin curves within 500m distance • Traveled-way is 3.0m to 5.0m and lack of shoulder • [] Lack of Traffic safety devices	Richmondhill Morne Jaloux The Cliff	Class 2	• Beginning section of about 800m has good condition and Improved the traveled-way and pavement were improved to attract the tourists to visit the French Fort. From STA0+800 to STA2+650 has fair condition by maintenance work. • From STA2+650 to end section has bad condition with many problems	Side ditches are installed at the cut sections with a total length of about 2.3km. Only 4 cross drainage facilities are installed at the beginning and end sections. • Drainage system at the end section has poor condition.	• There are no bridges along this road	• There are no embankment and cut slope failure along this section.	• Narrow traveled way section need widening, but there is not enough space for widening. • A countermeasure of narrow traveled-way is required by constructing turnout areas. • Big trucks can't pass through this road, so the pavement rehabilitation needs AC overlay for middle section and scalification for end section.
St. David's ~ Perdmo ntemps (7.8km)	This road passes through a hard terrain of several ridges and valleys with more than 10% steep gradient and small curves. • Steep gradient section is more than 2.1km • Traveled-way is 4.0m to 5.5m without shoulder • [] Does not provide shorter alternative for the Eastern Main Road	St. David's Perdmontemps	Class 2	• Surface of this road has bad/very bad condition • Pavement was done using bituminus penetration macadam and asphalt cold mix. • Due to lack of maintenance, there are many cracks and potholes	Length of installed side ditch is about 6.7km, which is mostly an earth ditch. Cross drainages are installed at 42 place (about 170m/interval). More than half of cross drainage facilities are not functioning.	There are 4 bridges along this road which required rehabilitation works. • Abutment of 3 bridges have scoring problem. Scoring can be repaired by maintenance work. • 1 bridge is a temporary Bailey bridge.	Slopes of this section are not so high and steep. • There are 2 embankment and 1 cut slope failure sections. • These slope failures are only at surface of slope.	Traveled-way need widening for about 1.0m to 3.0m. Pavement rehabilitation requires AC overlay and scalification of existing surface with new AC. Baily bridge will be reconstructed. 2 bridges with abutment scoring requires protection work through road maintenance. Providing traffic safety devices along this road is required.
Mt. Gay ~ Springs Road (L=5.9k m)	This road is very important for the physical distribution of the transport system in Grenada. Urban road geometric standards should be applied on the section from Mt. Gay to Springs. • Steep gradient section is more than 1.5m back of St. George's	Mt. Gay Tempe Paddock Springs Woodlands Estate	Class 1	From beginning to STA0+500 section has bad condition From STA4+800 to STA5+800 section has bad condition • Bad and very bad sections need toscarification of existing road.	Length of installed side ditch is about 6.7km which is mostly concrete ditch. Cross drainages are installed at 31 places (about 190/interval). More than a quarter of cross drainage facilities are not functioning. • Near Tempe bridge, there is an overflow area due to heavy rain.	• There is 1 bridge along this road with a width of 4.2m, which cannot pass 2-way traffic. There are flooding areas caused by bending river alignment and steep gradient.	The slope of this section is almost in a stable condition. • Some of cut slope will be re-cut to provide a safe sigh distance.	The road improvement of this road should consider traffic safety and smooth driving for the road user. The road improvement of this The sharp curve in the Urban section (STAO+000 to STA3+050) requires widening. Pavement at the beginning and end sections require reconstruction. Tempe bridge needs widening and an RC box culvert installed after the bridge.
Eastern Main Road (Grenvill e ~ Sauteur s) (L=16.0k m)	This road connects Grenville to Sauteurs which is a northern town in Grenada island. This road was subject to a comprehensive improvement project in 1980. • The road passes through flat and rolling terrain. • There are a few narrow curves along this road	Grenville Telescope Paradise Dunfermline Moya Tivoli Morne Fendue Fortune Sauteurs	Class 1	• According to roughness survey, beginning to STA3+500, STA7+700 to STA9+000 and STA10+200 to STA14+500 are in a good to fair condition. Raveling in surface of AC pavement can be found along the whole road. • Longitudinal and alligator-shape cracks can be found on embankment and cut section. Previous overlay works didn't repair weak sub-grade and cracks in the original pavement.	Length of installed side ditch is about 20.5km, which is mostly concrete ditch. Cross drainages are installed at 85 places (about 190m/interval). More than 40% of cross drainage facilities are not functioning.	• There are 8 bridges along this road and required for 6. • Within 6 bridges, 3 bridges need to be widened and reconstructed. • [] The other 3 bridges deterioration can be repaired by maintenance work.	• There is no slope failure on this road.	• This road was improved in 1980, but birdges along this road are still in poor condition. • The French constructed paradise bridge in 1813. The bridge is still in a good condition. • Poynte Field bridge and Madeys bridge require new construction. • Dunfermiline bridge requires widening. • Providing safety devices along this road is required.
Parclete ~ Mt. Horne Road (L=3.2k m)	The road serves several socioeconomic activities including agricultural facilities and regional hospital • The road passes through 3 ridges and 2 valleys • About 0.0km length has a steep gradient more than 10% • The traveled-way of this road is ranging 4.5m to 5.0m	Parclete Mt. Horne Mt. Horne Estate Mirabeau Estate	Class 2	According to roughness survey, IRI of this road is 9 to 218. • Especially, sections from, STA1+500 to STA2+000 and STA3+000 to STA3+200 are in very bad condition with excessive raveling, potholes and gravel section in which bitumen and aggregate separated.	Length of installed side ditch is about 5.1km, which is mostly earth ditch. Cross drainages are installed at 19 places (about 190m/interval). More than 70% of cross drainage facilities are not functioning.	• [] There are 2 bridges along this road and required rehabilitation work is only protection of abutment scoring and sealing of cracks of concrete slab.	• There is no slope failure on this road.	• Asphalt concrete pavement is required for the reconstruction and overlay owrks for this road. • Abutment of 2 bridges require protection work by gabion • Side ditches should be installed at cut sections. • Providing safety devices along this road is required. • Providing safety devices along this road is required.
Dover (Windwa rd ~ Cherryhi ll) (L=3.2k m)	This road connects east coast to west coast in Carriacou island • The road passes through middle the middle of a hill • The traveled-way of this road is ranging 4.0m to 6.0m	Windward Dover Cheryhill Craigston	Class 2	• First section about for 400m and end section about 2.1k. are in very bad condition. • Remaining section is fair/bad condition. • AC pavement used bituminus penetration macadam and emulsion mix.	• Side ditch is installed only 1.9km of 3.2km.Cross drainage is installed at 13 places (about 240m interval). • More than 25% of cross drainage facilities are not functioning.	• There are no bridges along this road.	• The road is traversing a gentle slope hill and there are no steep slope along this road.	• Asphalt concrete pavement is required for the reconstruction and overlay works for this road. • AC pavement construction equipment will be required for only 3.2km construction works. • Pavement of this road should be installed at cut section. • Providing traffic devices along this road is required.

3.2.2 Morne Jaloux Road

The first 800 m section was subject to improvement of road alignment and pavement. The existing condition of this road shows the following problems:

- Traveled way : 3.0m to 5.0m width
- Alignment :passing through ridge line of mountain
- Pavement :fair / bad condition
- Drainage : poor system with some rehabilitation works at the end section
- Slope : no failure, scoring section
- Roadside : many houses along the first 3 km section
- Nature : tourism spot at the French Fort and nice landscape view
- Safety : lacking of all types of safety devices and requirements

The required works for improvement and rehabilitation are required as below:

- Width : widening the end one km section and providing turnout areas
- Profile : no improvements are recommended
- Pavement : asphalt concrete overlay reconstruction of existing pavement structure
- Drainage : improving the drainage system
- Safety : installation of traffic safety devices

3.2.3 St. David's to Perdmontemps Road

The existing condition of the road shows the following problems:

- Function : expecting bypass road for Eastern Main Road
- Gradient : many steep sections
- Traveled way : 4.0m to 5.5 m width
- Pavement :bad to very bad condition
- Drainage : poor system of side ditches and crossing facilities
- Bridge : three scored bridges and one temporary bridge
- Slope : failure at two embankment and one cut section
- Roadside : few villages along the road
- Nature : nutmeg and cacao plantations
- Safety : lacking of all type of safety devices and requirements

The required works for rehabilitation and improvement are as below:

- Width : widening the narrow sections and improving the sight distance at

sharp curve

- Profile : no improvements are recommended
- Pavement : asphalt concrete overlay reconstruction of existing pavement structure
- Drainage : improving the drainage systems
- Bridge : new construction of one bridge and rehabilitation of two bridges
- Slope : slope protection measured at two embankment and one cut sections
- Safety : Installation of traffic safety devices

3.2.4 Mt. Gay to Springs Road

The existing condition of the road shows the following problems:

- Alignment : very steep in first 3 km
- Traveled way : 6.0m to 7.0m at narrow and sharp curve sections
- Curve : not enough sight distance at 8 sharp curves
- Pavement : bad condition at first 0.5 km and end one km
- Drainage : poor system of side ditches
- Bridge : one narrow width bridge
- Slope : no failure, scoring section
- Roadside : many houses at first 3km section
- Nature : road pass through Sr. George's port
- Safety : lacking of all types of safety devices and requirements

The required works for rehabilitation and improvement are as follow:

- Width : widening at narrow and sharp curve section
- Profile : no improvements are recommended
- Pavement : asphalt concrete overlay reconstruction of existing pavement structure
- Drainage : improving the drainage system and construction of R.C Box Culvert
- Bridge : widening of one bridge
- Safety : installation of traffic safety devices.

3.2.5 Eastern Main Road (Grenville to Sauteurs)

Existing condition of the road shows the following problems:

- Traveled way : improved at 1980, but the sharp curves remain

- Pavement : fair to bad condition
- Drainage : poor maintenance works for the crossing facilities
- Bridge : one temporary bridge, one spillway and one narrow bridge
- Slope : no failure, scoring section
- Roadside : many houses along the road
- Nature : cacao and banana plantation
- Safety : lacking of all type of safety devices and requirements

The required works for rehabilitation and improvement are as follow:

- Width : widening of narrow sections and improving the sight distance at sharp curve
- Pavement : asphalt concrete overlay reconstruction of existing pavement structure
- Drainage : improvement of drainage systems
- Bridge : new construction for two bridges and widening for one bridge
- Safety : installation of traffic safety devices

3.2.6 Paraclete to Mt. Horne Road

The existing condition of the road shows the following problems:

- Gradient : steep in two bridge section
- Traveled way : narrow in most sections with, 4.5m to 5.0m width
- Pavement : mostly fair condition except 2 very bad condition sections
- Drainage : poor system of side ditches and cross facilities
- Bridge : scoring at abutment and cracking on slab concrete
- Roadside : many houses at beginning and end section
- Nature : cacao plantation and agricultural center
- Safety : lacking of all types of safety devices and facilities

The required works for rehabilitation and improvement are as follow:

- Width : widening at narrow section and improving the sight distance at sharp curves
- Profile : no improvements are recommended
- Pavement : asphalt concrete overlay reconstruction of existing pavement structure
- Drainage : improvement of drainage systems
- Bridge : rehabilitation of two bridges
- Safety : installation of traffic safety devices

3.2.7 Dover Road (Windward to Cherryhill)

Existing condition of the road shows the following problems:

- Gradient : steep gradient at more than one-third of the whole length
- Traveled way : narrow in most sections, 4.0m to 6.0m, width.
- Pavement : mostly fair to bad condition.
- Drainage : very poor system of lateral and cross drainage facilities
- Roadside : a few houses along the road
- Nature : pasture
- Safety : lacking of all types safety devices and faciltiies

The required works for rehabilitation and improvement are as follow:

- Widening : widening at narrow sections
- Pavement : reconstruction by portland cement concrete pavement
- Drainage : improvement of drainage systems
- Safety : installation of traffic safety devices

3.3 PRESENT ROAD MAINTENANCE SYSTEM

Eastern and Western Road Divisions under MOW are responsible to execute the road maintenance activities in the Country. Grand Etang road, Mt. Gay to Springs road and Eastern Main road were subject to 3cm AC overlay, cleaning of side ditch and cutting glass beside shoulder. But remaining roads could not see any road maintenance works.

The organization, equipment and budget for road maintenance are discussed in Chapter 2.3.4, Road Administration.

In general, the main tasks which are carried out by maintenance crews include the following:

- Cleaning and grubbing of existing vegetation on shoulder/embankment
- Cleaning of existing lined drains
- Cut over hanging trees
- Refining unlined drain or earth ditch
- Cleaning existing culverts, bridges and causeways
- Repairs to culverts, drains, retaining walls and bridges
- Overlay existing raveled pavement
- Pot hole repairs to pavement

- Slurry sealing of existing cracks in the pavement
- Regraveling of roads
- Repairs to road sings
- Remarking center-line of road
- Grassing
- Slope stabilization
- Kerb walls
- Guard railing
- Gabion walls
- Cleaning of the existing rivers and streams

At present, there is no existing maintenance manual.

Inspection Items and Frequency are as follows:

- Pavement - Pothole repairs → every 2 months
  Slurry sealing → every 2 months
  Overlay → every 5 years
- Concrete roads → every 9 months
- Drains - lined drain every month
  Unlined drain every month
- Rivers and Streams → every 9 months
- Culverts → every month
- Gabion wall → every 2 months
- Bridge → concrete every 9 months
- Kerb wall metal → every 9 months
- Retaining wall → 9 months
- Cleaning, clearing and grubbing vegetation → every 9 months
- Road signs → every 6 months
- Road marking → every 4 months
- Slope stabilization → every 6 months
- Grassing and vegetation → every 6 months
- Regravelling of roads and shoulders → every 6 months
- Guard railing → every 9 months

The schedule for the above necessary maintenance works programme depends to a large extent on the amount of monies budgeted. In addition, the roads maintenance activities are limited to the limited amount of road maintenance available.

Road Rehabilitation and Improvement is done by foreign contractors, where

some aspects of the works is sub-contracted to local sub-contractors. The present policy of the Government of Grenada is to contract out all major Road Rehabilitation and Improvement works.

The road maintenance activities is done by the Roads Division Unit under the Ministry of Works.

CHAPTER 4

TRAFFIC SURVEY AND ANALYSIS

CHAPTER 4

TRAFFIC SURVEY AND ANALYSIS

4.1 TRAFFIC COUNT SURVEY

4.1.1 Methodology

(1) Survey Stations

The traffic count survey had two purposes which are: a) to establish OD matrices by vehicle type, and b) to clarify the transportation flow pattern along the Study Roads. In order to establish the OD matrices, the maximum entropy trip matrix estimation method presented in Appendix 4 was applied in this Study. That method requires a network connecting all of the traffic zones as well as traffic counts at all links composing that network. In addition these links must be the roads most probable to be used.

After a preliminary field reconnaissance, the present basic road network was established in close cooperation with the counterpart engineers. Figure 4.1.1 shows the road network. Based on this network, links to count traffic were selected. Survey Stations were located at sites suitable to carry out traffic count works. The locations of the designated survey stations are presented in Table 4.1.1 and geographically in Figure 4.1.2.

As the established basic network did not initially include all the study Roads, additional survey stations were located on the excluded roads so that the survey can cover all of the Study Roads for the purpose b) point of view.

(2) Survey Items and Period

Due to the shortage of experienced observers traffic counts could not be executed in the same day so they were executed during a period of about two weeks. Traffic counts was conducted for 13 hours from 06:00 to 19:00 based on 15 minute intervals and for the following four types of vehicles: passenger car and jeep, bus, light truck (2 axles/4 wheels), heavy truck (2 axles/6 wheels).

Extraordinary cases were seven days continuous counts at one station, and counts for 24 hours for one day at three stations. The purpose of these surveys of seven day traffic counts was to provide weekday fluctuation parameters to be

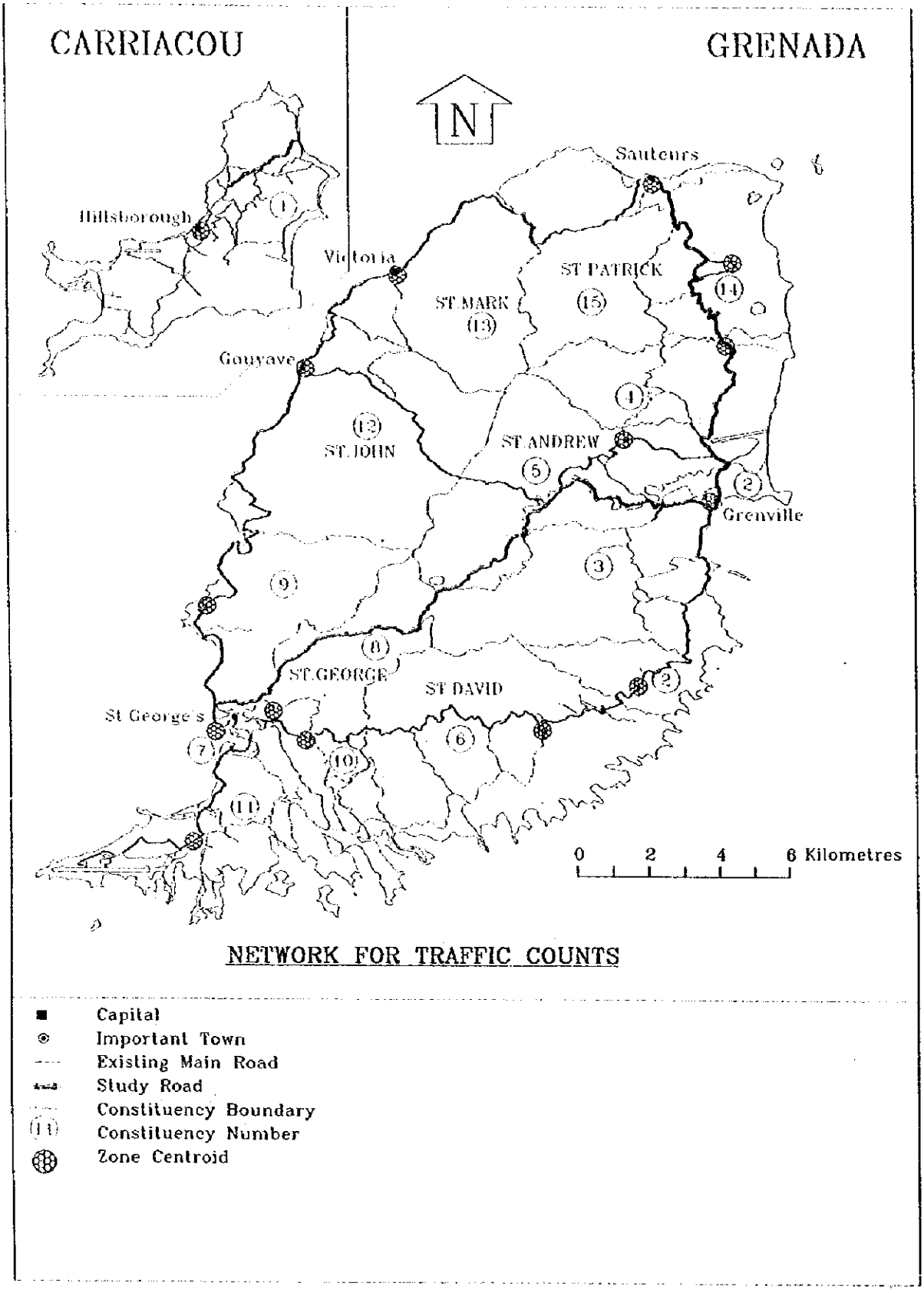

Figure 4.1.1 Network for Traffic Counts

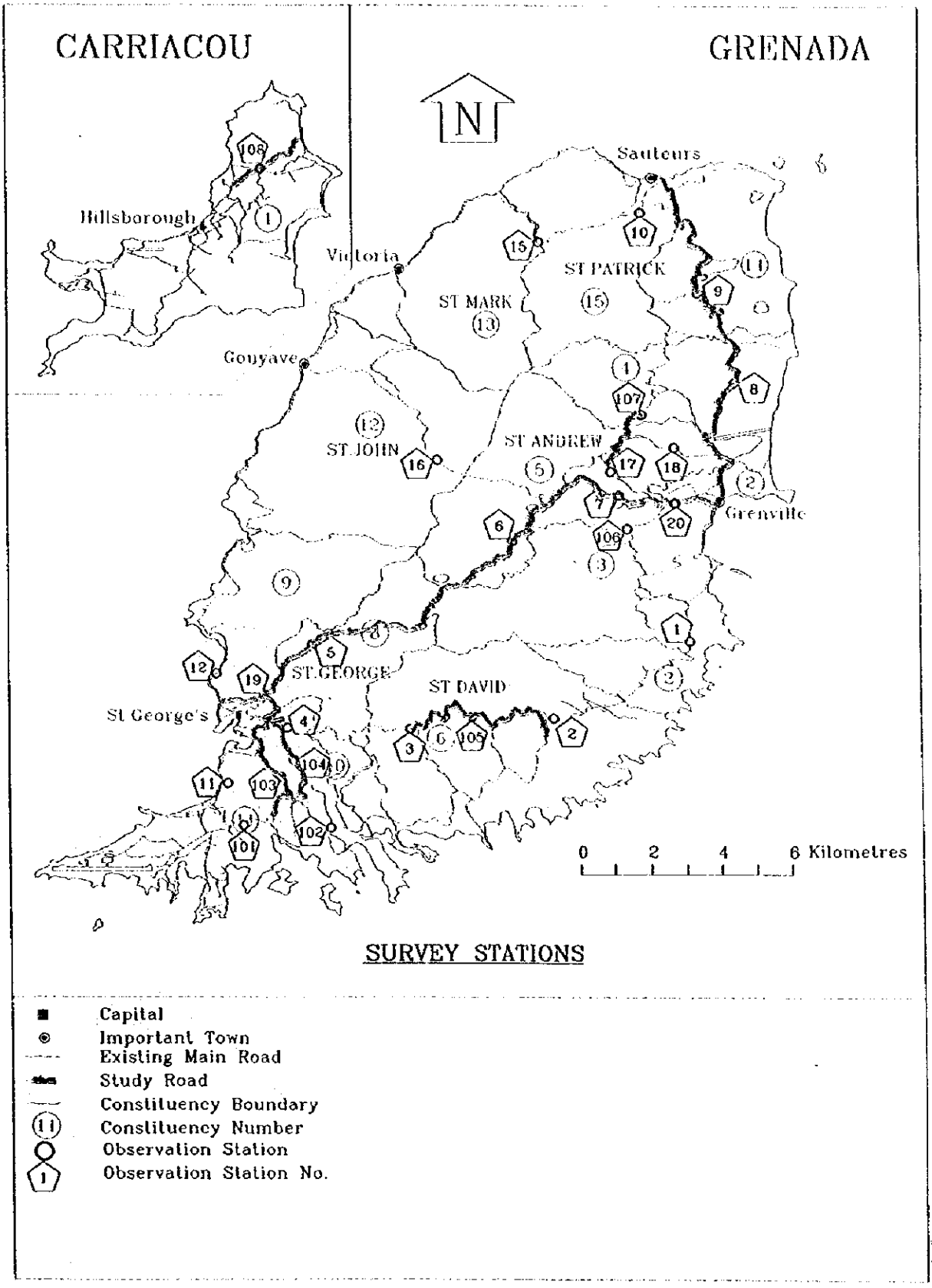

Figure 4.1.2 Survey Stations

applied on other traffic counts done for two days. Results of 24 hour traffic counts were used to establish an expansion ratio of 24 hours traffic to 13 hours traffic. The period of traffic counts by location are summarized in Table 4.1.2.

Table 4.1.1 Traffic Survey Station

Station No.	Road Name	Description of Location
1	Hope	Hope Bridge / Playng Field
2	Eastern Main Road	Bellevue Playing Field
3	Eastern Main Road (Upper)	Perdmontemps Old School
4	Eastern Main Road (Upper)	Parade
5	Grand Etang Road	Snug Corner
6	Grand Etang Road	Adelphi Gap / Bamboo Bar
7	Balthazar	Near Metal Bridge
8	Eastern Main Road	Upper Pearls / Dentist Lab Gap
9	Eastern Main Road	Mt. Rose / Seventh Day Advertist Gap
10	Eastern Main Road	Madeys / La Mode Junction
11	South St. George Main Road	Silver Sands Gap
12	Western Main Road	Cherry Hill / Fontenoy
13	Western Main Road	Gouyave
14	Western Main Road	Victoria
15	Western Main Road	Union / Nutmeg Station
16	Belviderre	Second Bridge
17	Mirabeau	Agricultural Station Gap
18	La Filette	Nutmeg Station
19	Grand Etang Road	Tempe / Mt. Gay Junction
20	Grand Etang Road	Near Grand Bras Gas Station
101	Grand Anse Valley	Near Clarks Court Bay Gap
102	Eastern Main Road (Lower)	Marian / Confer Gap
103	Eastern Main Road (Lower)	Springs / Cafe Gap
104	Lower Morne Jaloux	Near School
105	Vincennes	Near Nutmeg Station
106	La Digue	Water Works Gap
107	Paraclete	Nutmeg Station
108	Dover	Craigston Junction

Table 4.1.2 Type of Traffic Counts

Station	Type of Observation
Station 6	7 days continuous traffic counts
Stations 9, 19, 20	13 hours traffic counts for a day and 24 hours traffic counts for a day
Other Stations	13 hours traffic counts for two days

4.1.2 Survey Results

(1) Daily Fluctuation of Traffic Counts

At Station 6, the thirteen (13) hours traffic count survey was executed for seven (7) continuous days. This station is located in the middle of an arterial road, the Grand Etang Road, and has a reasonably large traffic volume but intra-zonal traffic is low as there are no large towns near the station. Survey results are summarized in Table 4.1.3 and illustrated in Figure 4.1.3. The table shows that the daily traffic volume exceeds 1,000 excluding Sundays.

Table 4.1.3 Thirteen Hours Observation of Traffic at Station No. 6

Day	Total Traffic	P. Car	Bus	L. Truck	H. Truck
Monday	1,290	528	332	270	160
Tuesday	1,333	539	335	275	184
Wednesday	1,401	588	353	272	188
Thursday	1,310	569	338	236	167
Friday	1,144	475	340	244	85
Saturday	1,009	521	291	168	29
Sunday	779	477	155	127	20
Ave. weekday	1,296	540	340	259	157

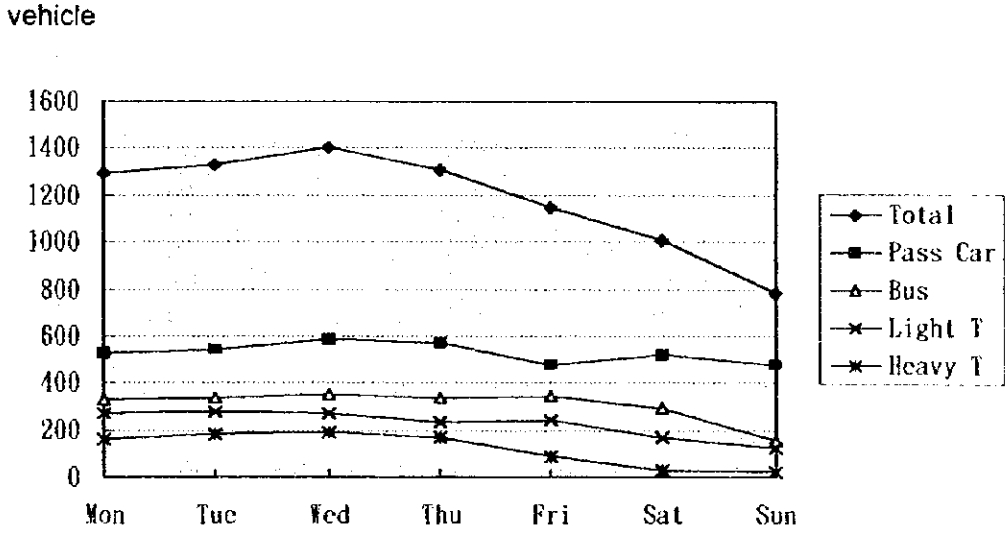

Figure 4.1.3 Daily Traffic Volume at Station No. 6

The average for weekday (Monday to Friday) traffic was found to be 1,296 vehicles in total and fluctuation of traffic was in the range of plus/minus 10% as shown in Table 4.1.4.

Table 4.1.4 Fluctuation of Traffic

Day	Total Traffic	P. Car	Bus	L. Truck	H. Truck
Monday	1.00	0.98	0.98	1.04	1.02
Tuesday	1.03	1.00	0.99	1.06	1.17
Wednesday	1.08	1.09	1.04	1.05	1.20
Thursday	1.01	1.05	0.99	0.91	1.06
Friday	0.88	0.88	1.00	0.94	0.54

(2) Ratio of 24 Hours Traffic Count to 13 Hours Traffic Count

At stations 9, 19 and 20, 24 hours traffic counts were performed for a day each. Station 9 was located at Eastern Main Road and other two were along Grand Etang Road. The results of these observations are tabulated in Table 4.1.5. Station 9 was observed to have rather low traffic, while station 19 and 20 were relatively larger.

The ratios of traffic for 24 hours to 13 hours for the three stations were similar excluding passenger cars at station 9. Those ratios by vehicle type varied from 1.06 to 1.23 excluding the ratio of passenger cars at station 19, which is 1.43. In addition, patterns of fluctuation by type of vehicle were similar at three stations.

Table 4.1.5 Ratios of Traffic Volumes for 24 Hours to 13 Hours

Station	Observation Hours	Type of Vehicle				
		P. Car	Bus	L. Truck	H. Truck	Total
9	13	175	192	106	56	528
9	24	250	226	128	59	663
19	13	1690	1455	740	413	4298
19	24	2083	1711	876	439	5109
20	13	1058	767	667	354	2846
20	24	1294	900	793	384	3371
9	Ratio (24/13)	1.43	1.18	1.21	1.07	1.26
19	Ratio (24/13)	1.23	1.18	1.18	1.06	1.19
20	Ratio (24/13)	1.22	1.17	1.19	1.08	1.18

(3) Traffic (24 hours equivalent) by Station

There are four ways of conversion to 24 hours from 13 hours observations. The four conversion types are classified in Table 4.1.6.

Table 4.1.6 Conversion Methods from 13 Hours to 24 Hours Counts

Conversion Type	A	B	C	D
CVR of Weekday Fluctuation	Not apply	Not apply	Apply	Apply
CVR of 13 hours to 24 hours by Type of Veh.	Not apply	Apply	Not apply	Apply
CVR of 13 hours to 24 hours of Total of Veh.	Apply	Not apply	Apply	Not apply
Total Traffic obtained	58,109	58,508	58,294	58,689

Note: CVR; Conversion Ratio

The calculation results of the four (4) cases are quite similar. It means that any conversion method is applicable to compute total traffic. However, traffic counts converted to a 24 hours base are to be input using the maximum entropy traffic matrix estimation and the PCU base OD matrices shall be used for the traffic demand assignment. Due to this, the study team adopted the conversion type D. Converted traffic is shown in Table 4.1.7.

Table 4.1.7 Traffic by Station (24 hours base)

Station Code No.	Traffic					Peak Ratio (Total Case)
	P. Car	Bus	L Truck	H. Truck	Total	
1	250	218	137	97	702	8.5
2	544	541	241	161	1,487	9.0
3	821	984	343	95	2,243	10.1
4	2,519	1,520	757	222	5,018	11.0
5	1,185	1,131	568	241	3,125	10.5
6	693	416	332	158	1,599	10.4
7	704	421	430	109	1,664	10.7
8	704	539	207	83	1,533	9.5
9	301	233	128	67	729	8.8
10	581	358	185	77	1,201	8.7
11	5,678	2,721	2,417	551	11,367	8.1
12	1,517	1,287	746	335	3,885	10.7
13	848	578	543	277	2,246	9.4
14	369	225	300	124	1,018	8.8
15	266	240	193	119	818	8.2
16	47	29	25	11	112	9.8
17	213	131	137	26	507	10.1
18	250	215	134	47	646	9.4
19	2,131	1,714	922	494	5,261	10.8
20	1,265	797	757	423	3,242	9.2
101	628	198	352	126	1,304	8.4
102	1,229	447	357	197	2,230	8.6
103	1,950	892	688	204	3,734	10.0
104	614	270	120	30	1,034	10.2
105	76	121	58	21	276	8.7
106	303	231	182	46	762	8.5
107	97	141	97	18	353	9.6
108	173	182	167	71	593	8.4

(4) Hourly Traffic (13 hours) of Major Stations

Hourly traffic for 13 hours (daytime) at stations along the Study Roads and major arterial roads are shown in Appendix 5 with the data of all stations. Traffic shown in positive was East or North Bound and traffic shown in negative was West or South Bound. The two lines on each side of the zero line indicates the total number of vehicles (large number in absolute value) and passenger cars including jeeps (small figure).

4.2 OD ROADSIDE INTERVIEW SURVEY

4.2.1 Methodology

This survey was carried out at two locations on the Grand Etang Road (GER) in order to supplement data required for the establishment of the present OD matrices.

(1) Interview Stations

The traffic passing the Grand Etang Road (GER) can be classified as follows:

1) Intra- and inter-zonal traffic to use GER at St. George's side only
2) Intra- and inter-zonal traffic to use GER at Grenville side only
3) Inter-zonal traffic to use GER at middle sections

The GER has several junctions such as Snug Corner, Birch Grove, Lower Capitol and so on, however, traffic to enter from a junction and exit from another junction has very small volumes when compared with traffic of the three types mentioned above. Due to these considerations, one OD interview station was located near the town of St. George's and the second station near the town of Grenville. The exact locations are the same as stations 19 and 20 of the traffic count survey shown in Figure 4.1.2.

(2) Interview Items and Period

The interview survey was executed for a period of three (3) days at each interview station. Due to the shortage of experienced interviewers, it was not possible to perform the interview survey at the two (2) stations during the same three (3) days.

Two types of interview survey were carried out. The first type was for vehicle drivers and the information observed included: origin, destination, trip purpose and the commodities loaded in the case of trucks. Supplementary data included recording the time of interview, type of vehicle, type of fuel, number of passengers and seat capacity. The second type of interview targeted only bus passengers and the information observed included: origin, destination and trip purpose as well as the time of the interview.

The number of interviews, which was collected on sample basis, during the three days of the OD survey and the adjusted 24 hours traffic counts (the previous section explains the adjustment methodology) are in Table 4.2.1.

Table 4.2.1 Number of Interviews and Traffic Counted

Station	P. Car	Bus	L. Truck	H. Truck	Total/Average
Number of OD Interview (Total of 3 interview days)					
19	783	153	317	106	1359
20	724	94	383	114	1315
Daily (24 Hours) Traffic					
19	2083	1711	876	439	5109
20	1058	767	667	354	2846
Expansion Factors					
19	2.660	11.183	2.763	4.142	3.759
20	1.461	8.160	1.742	3.105	2.164

To produce OD matrices for car trips in Grenada, the interview data from the OD samples was adjusted and expanded to daily traffic volumes using two types of expansion factors. The first is a car-type base factor which is used to produce OD matrices for each car type. To produce OD matrices on trip-purpose base, another expansion factor is used only for the total trips for all cars.

Due to applying two different expansion factors, the total of trips expanded on each car type base OD matrices and that of trip purpose base OD matrices shows different figures. The former factors give a total of 7,941 trips while the latter's total is 7,962 trips.

4.2.2 Survey Results

(1) Zones and Type of OD Matrices

To establish a zoning system for the origins and destinations of car trips in the country, the present electoral zones, with a total of 15 zones in which 14 zones are located in Grenada Island, were adopted to form the traffic zoning system of the Study as presented in the Figure 4.1.1.

Established OD matrices for the present transportation demand were compiled in the four (4) car types of: passenger car and jeep, bus, light truck (four tyres) and heavy truck (six or more tyres), and for the four (4) trip purposes of: to/from work, to/from school, business and private.

Due to the application of two different expansion factors for each of the trip matrices based on the car-type base and the trip-purpose base as explained in

4.2.1, the total number of trips is slightly different for both cases. In addition, the matrices of total number of trips on car-type base were prepared in two ways by number of vehicles and by passenger car units (PCU). Based on roadside observations, previous studies and broad inspection, the applied conversion factors of PCU were set as: 1.0 for passenger car, 1.5 for bus and light truck, and 2.5 for heavy truck.

(2) OD Matrices of GER by Type of Vehicle and by Trip Purpose

The estimated OD matrix for the present year 1997 by car base for all purposes and total number of vehicles is shown in Table 4.2.2, while Table 4.2.3 presents the same matrix after converting the number of vehicles into PCUs. Other OD matrices for each vehicle type and per trip purpose are attached in Appendix 6.

Table 4.2.2 OD Matrix of All Purpose and All Vehicle Type (Car Base)

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	1	23	4	11	0	48	3	0	2	4	0	0	0	0	96
3	0	12	327	15	333	12	920	58	18	1	211	19	1	6	6	1939
4	0	0	20	1	38	0	114	0	0	0	18	0	0	0	0	191
5	0	23	349	20	83	6	75	7	0	0	25	1	0	2	2	593
6	0	0	23	0	5	12	18	34	7	0	6	0	0	0	0	105
7	0	49	867	78	72	0	83	884	130	0	4	5	0	46	47	2265
8	0	7	57	6	6	19	873	345	56	19	150	12	0	0	5	1555
9	0	0	23	10	2	5	261	113	19	3	27	3	0	0	0	466
10	0	0	15	3	4	0	0	27	8	0	0	0	0	0	0	57
11	0	10	138	18	17	3	8	155	21	0	0	0	0	12	10	392
12	0	3	7	0	4	0	1	8	0	0	0	0	0	0	0	23
13	0	0	1	0	0	0	0	11	0	0	3	0	0	0	1	16
14	0	0	6	0	10	0	52	0	3	0	16	0	0	0	0	87
15	0	0	11	0	9	0	89	17	4	0	26	0	0	0	0	156
Tot	0	105	1867	155	594	57	2542	1662	266	25	490	40	1	66	71	7941

Table 4.2.3 OD Matrix of All Purpose and All Vehicle Type (PCU Base)

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total.
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	1	30	10	17	0	80	8	0	3	4	0	0	0	0	153
3	0	15	450	18	470	15	1353	96	27	1	311	26	1	6	7	2796
4	0	0	33	1	46	0	191	0	0	0	31	0	0	0	0	302
5	0	29	462	25	120	12	91	15	0	0	31	1	0	3	3	792
6	0	0	26	0	6	18	25	42	15	0	9	0	0	0	0	141
7	0	93	1283	130	104	0	114	1211	189	0	10	5	0	66	69	3274
8	0	15	78	11	8	22	1167	454	78	22	184	20	0	0	6	2065
9	0	0	37	19	3	5	373	176	23	3	33	3	0	0	0	675
10	0	0	24	3	10	0	0	31	8	0	0	0	0	0	0	76
11	0	11	196	27	27	5	8	194	30	0	0	0	0	15	11	524
12	0	8	7	0	4	0	1	10	0	0	0	0	0	0	0	30
13	0	0	1	0	0	0	0	11	0	0	5	0	0	0	1	18
14	0	0	8	0	12	0	72	0	5	0	21	0	0	0	0	118
15	0	0	12	0	11	0	116	21	4	0	32	0	0	0	0	196
Tot	0	172	2647	244	838	77	3591	2269	379	29	671	55	1	90	97	11160

As the Grand Etang Road (GER) covers trips between only some zones in the island but due to the simple network of the country, collected OD data on the road can accurately represent a reasonable number of zone-pairs which are shadowed in Table 4.2.2.

In spite of the reasonable number of zone-pairs represented by this OD interview survey, 44.9 % of the traffic observed was found to belong to zone-pairs 3 and 7, and zone-pairs 7 and 8, which are the zones traversed and directly covered by the road.

The OD matrices are summarized as shown in Table 4.2.4. Shares of passenger cars and buses at station 19 are larger than those of station 20 but truck trips were vice versa. These facts clarify the characteristics of St. George's as the capital (station 19) and Grenville (station 20) as a country town. Regarding the purpose of trips, the "Business" and "Private" trips have a strong majority of all trips of vehicles passing through GER.

Table 4.2.4 Trips by Type of Vehicle and by Trip Purpose

Trips by Type of Vehicle					
Station	P. Car	Bus	L. Truck	H. Truck	Total
19	2,083	1,710	885	441	5,119
20	1,047	758	665	352	2,822
Total	3,130	2,468	1,550	793	7,941
Trips by Purpose					
Station	to/from work	to/from school	business	private	Total
19	719	46	2,346	2,028	5,139
20	392	27	1,401	1,003	2,823
Total	1,113	73	3,747	3,031	7,964

(3) Average Vehicle Occupancy

The average number of passengers on board the interviewed vehicles was estimated from information collected by interviewers during the OD survey. Vehicle occupancy results are summarized in Table 4.2.5.

Table 4.2.5 Average Number of Passengers on Board

Type of Vehicle	Number of Vehicles observed	Number of Passengers	Occupancy Rate (including driver)
Pass. Car, Jeep	2,839	1,151	2.5
Bus	2,182	236	9.2
Light Truck	1,224	530	2.3
Heavy Truck	475	188	2.5

4.3 OD MATRICES INDUCED FROM TRAFFIC COUNTS

4.3.1 Procedure

By applying the maximum entropy trip matrix estimation method (hereinafter MEM) to the traffic counts, the following OD matrices were estimated. Appendix 4 includes the formulation and references of MEM. The method is based on inter-zonal traffic counts, however, actual traffic counts include a considerable portion of intra-zone trips. It is an important task and also difficult work to eliminate intra-zonal trips from traffic counts. Procedures for this work are presented in Figure 4.3.1 and simplified as follows:

1) Based on the collected OD survey data, an OD matrix for all trip purposes and all types of vehicles was estimated.

2) From the nature of the road network in Grenada, the zones 3, 5, 7 and 8, which are traversed by the GER are considered to have the most accurate trip data in the OD matrix. For generated traffic from GER zones to other zones, necessary adjustment and calibration were carried out referring to the traffic count data collected at stations 1, 4, 8, 11 and 13, which are handling their traffic. In this manner, the traffic generated trips of the four (4) zones were estimated.

3) A zoning classification system was established referring to the characteristics of the four (4) GER zones as they represent the four types of: Center of the Capital City, Outskirts of the Capital, Town Center and Rural Villages. The population of the four zones was applied to the generated trips to produce trip generation rates for each of the specified four zoning classes.

4) The other eleven (11) zones were classified on the same basis as two towns, two outskirts of the Capital and seven villages, and by applying the concluded zonal trip generation rates, the number of generated trips was estimated for each zone. Incidentally, the total generated trips was estimated as 19,506 trip/day and the trip generation rate as 1.63 trip/car/day. The ratios of intra-zonal trips were estimated from the OD matrix along the GER in a similar way as described in item 2) as 0.18, 0.14 and 0.21 in the zones 3, 5 and 8, respectively.

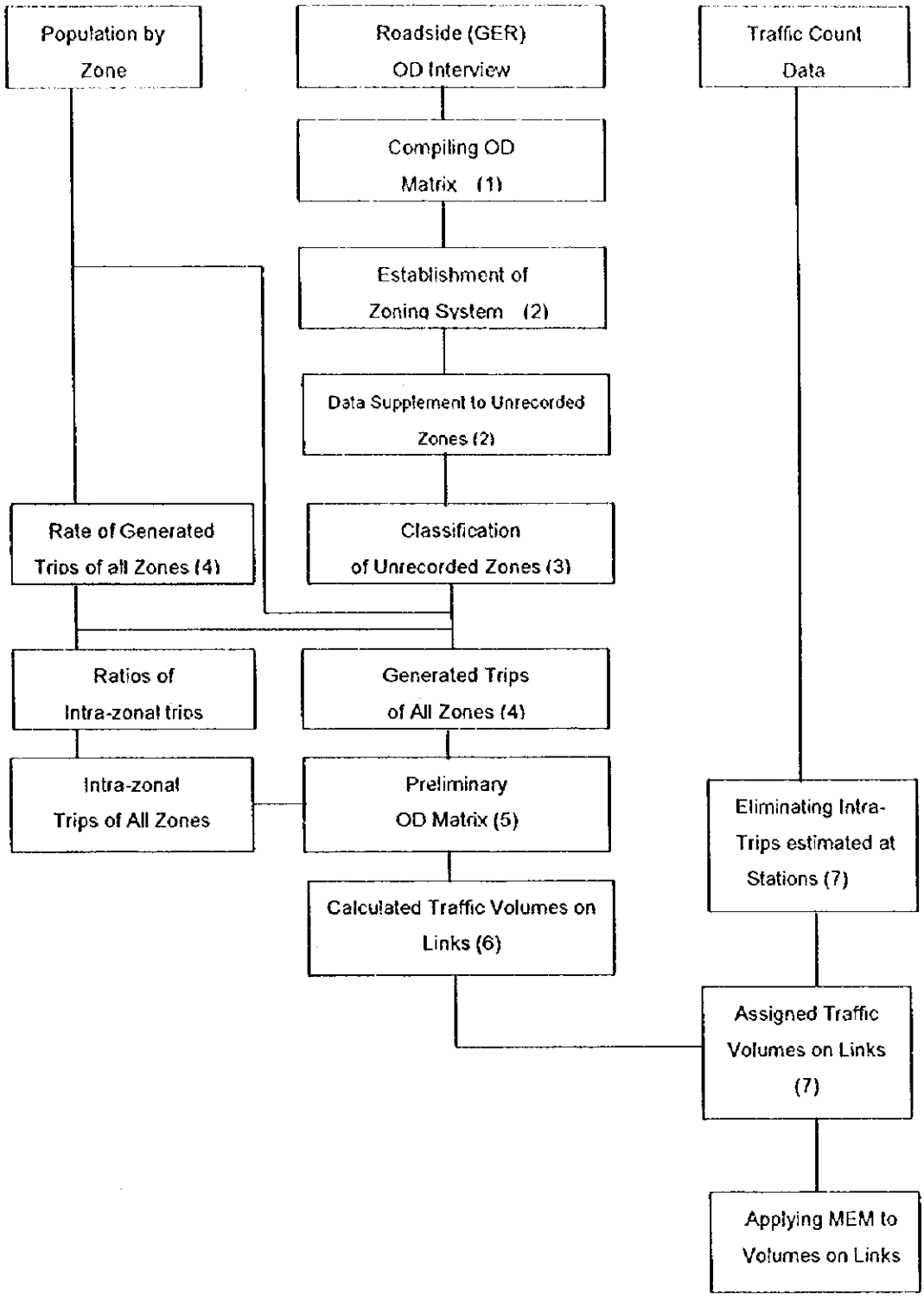

Figure 4.3.1 Steps to Establish an OD Matrix

5) For the trip distribution procedure of the total generated trips, the Fratar method was applied and a preliminary OD matrix was established based on the generated trips by zone, intra-zonal traffic and the OD pattern of the OD matrix along GER.

6) Based on this preliminary OD matrix, a feedback technique was applied to estimate traffic volumes on links of the road network previously used during the traffic count survey.

7) Results of the traffic count survey were compared with estimated traffic volumes from the preliminary OD matrix and examined in relation to traffic counts at adjacent stations.

8) MEM was reapplied to traffic counts concluded after applying the comparison and examination procedure in order to produce the car-base OD matrix of 1997.

4.3.2 Car OD Matrices - 1997

Table 4.3.1 shows the concluded car-base OD matrix for all purposes by all vehicles for the year 1997.

Table 4.3.1 PCU OD Matrix (All Purposes and All Vehicle)

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1	893	0	0	0	0	0	0	0	0	0	0	0	0	0	0	893
2	0	523	48	18	26	34	127	6	25	35	24	30	25	24	29	974
3	0	24	272	28	313	36	960	44	36	16	425	53	12	12	14	2245
4	0	17	30	316	64	25	212	7	18	26	62	23	19	17	20	856
5	0	49	312	40	84	19	84	6	11	17	54	14	12	11	13	726
6	0	22	48	22	12	1070	48	64	34	31	28	26	24	23	28	1460
7	0	140	1032	204	96	22	124	961	376	23	12	20	17	133	162	3322
8	0	14	50	12	6	61	968	278	120	65	319	35	12	11	13	1964
9	0	16	31	29	7	24	444	139	529	14	86	22	18	16	19	1394
10	0	26	38	16	12	36	17	61	47	1870	26	31	28	26	32	2266
11	0	53	324	89	46	23	24	328	116	40	2057	34	29	64	64	3291
12	0	29	19	28	13	40	18	20	32	40	30	1388	30	29	35	1751
13	0	23	11	22	12	32	13	22	25	32	14	29	367	23	6	631
14	0	20	11	19	20	29	119	8	13	30	65	25	22	354	24	759
15	0	17	17	16	16	24	167	23	14	25	88	22	18	17	404	868
Total	893	973	2243	859	727	1475	3325	1967	1396	2264	3290	1752	633	760	863	23420

Table 4.3.2 Number of Cars Observed and PCU

	P. Car	Bus	L. Truck	H. Truck	Total
No. of Cars	16,165	11,617	7,118	2,967	37,867
Total of PCU	16,165	17,426	4,451	7,418	45,456
Unit of PCU	1.00	1.50	1.50	2.50	1.20

Table 4.3.3 Car OD Matrix (All Purposes by All Vehicles)

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1	744	0	0	0	0	0	0	0	0	0	0	0	0	0	0	744
2	0	436	40	15	22	28	106	5	21	29	20	25	21	20	24	812
3	0	20	227	23	261	30	800	37	30	13	354	44	10	10	12	1871
4	0	14	25	263	53	21	177	6	15	22	52	19	16	14	17	714
5	0	41	260	33	70	16	70	5	9	14	45	12	10	9	11	605
6	0	18	40	18	10	892	40	53	28	26	23	22	20	19	23	1232
7	0	117	860	170	80	18	103	801	313	19	10	17	14	111	135	2768
8	0	12	42	10	5	51	807	232	100	54	266	29	10	9	11	1638
9	0	13	26	24	6	20	370	116	441	12	72	18	15	13	16	1162
10	0	22	32	13	10	30	14	51	39	1558	22	26	23	22	27	1889
11	0	44	270	74	38	19	20	273	97	33	1714	28	24	53	53	2740
12	0	24	16	23	11	33	15	17	27	33	25	1157	25	24	29	1459
13	0	19	9	18	10	27	11	18	21	27	12	24	306	19	5	526
14	0	17	9	16	17	24	99	7	11	25	54	21	18	295	20	633
15	0	14	14	13	13	20	139	19	12	21	73	18	15	14	337	722
Total	744	811	1870	713	606	1229	2771	1640	1164	1886	2742	1460	527	632	720	19515

4.4 DRIVING SPEED SURVEY

4.4.1 Methodology

The purpose of this survey was to obtain the maximum safe driving speed on major roads including the study roads for passenger cars or small jeep type cars frequently used in Grenada. The survey results are one of the input parameters used to establish the link capacity for the present road network used in traffic assignment modeling. The floating car method was used and the survey was carried out for two days using a Daihatsu Feroza jeep. The survey roads are as follows:

- Western Main Road
- Lower Eastern Main Road
- Morne Jaloux
- Mt. Gay / Springs
- Dover Road
- Eastern Main Road
- Grand Etang Road
- Perdmontemps / St. David's
- Paraclete / Mt. Home

4.4.2 Survey Results

The survey results, which are summarized in Table 4.4.1, show relatively high average speeds taking into consideration the bad road conditions and the sub-standard geometric design of the roads.

Table 4.4.1 Maximum Safe Driving Speed of Major Roads

Road	Section	Speed (km/hr)
Western Main Road	St. George's - Gouyave	61
	Gouyave - Duquesne	40
	Duquesne - Sauteurs	64
Eastern Main Road	Sauteurs - Grenville	59
	Grenville - Hope Estate	72
	Hope Estate - Belle Vue	35
	Belle Vue - Red Gate	64
Lower Eastern Main Road	Red Gate - Calivigny	29
	Calivigny - Paddock	72
Grand Etang Road	St. George's - Annandale	48
	Annandale - Grand Etang	32
	Grand Etang - Grenville	59
Morne Jaloux		38
Pardmontemps / St. David's		32
Mt. Gay / Springs		48
Paraclete / Mt. Horne		42
Dover	Cherryhill - Belvederre	40
	Belvederre - Windward	24

4.5 AXLE LOAD SURVEY

4.5.1 Methodology

(1) Purpose

The purpose of the Axle Load Survey is to obtain data to calculate Equivalent Single Axle Load (ESAL) factors used in the design of flexible pavements. The AASHTO method was applied to calculate the ESAL factors.

(2) Location and Time

The Axle Load Survey was conducted at two locations, station 19 and 20, at each end of the Grand Etang Road. At station 20, which is on the Grenville side, the survey was conducted for one thirteen (13) hour period from 6:00 a.m. to 7:00 p.m. on May 20, 1997. On the St. George's side, at station 19, the survey was conducted for two thirteen-hour periods from 6:00 a.m. to 7:00 p.m. on May 21 and 22, 1997. It was planned that the station 19 survey be conducted for twenty-four hours but the attending Police decided not to allow the night hours for security reasons.

(3) Equipment

The equipment used in the survey consisted of two portable wheel weight scales and four dummy scales. The portable wheel weight scales are calibrated by the manufacturer and weigh up to 10,000 kilograms in 10-kilogram increments. They have LED read-outs powered by rechargeable batteries. The equipment is manufactured by Intercomp and the Model is PT300.

(4) Procedure

The axle weighing procedure is as follows:

- A flat level weighing site was selected.
- Police pull over a randomly selected vehicle.
- The portable scales are placed in front of each of the front wheels and the dummy scales are placed in front of the rear wheels.
- The driver is requested to pull up on the scales. The dummy scales provide a level weighing surface.
- Each wheel weight is recorded and the driver is requested to drive off the scales.

- The weight scales are placed in front of the rear wheels and the dummy scales are placed in front of the front wheels.
- Again the driver is requested to pull up on the scale and the weights are recorded.
- Additional information is collected such as axle spacing, commodity carried, registered weight, vehicle type, etc.
- Driver is released.

4.5.2 Survey Results

The information collected in the survey forms was tabulated by vehicle type and the weight for each axle was inputted. The axles were then grouped according to the recommended AASHTO weight groupings and the total number of axles in each group was calculated. The average weight of the group was also calculated. Using the AASHTO Traffic Equivalency Factor tables, the prorated factors were obtained for each group. Then the 18 Kip EAL was calculated for each group and the ESAL factor for each vehicle type was established. The following tables illustrate the Computation of Vehicle Load Factors for Flexible Pavements with a SN=3 and a Terminal Serviceability of 2.0.

Table 4.5.1 ESAL Factor for Car/Jeep

Vehicle Type - Car/Jeep	Axle Load Group, lbs.	Representative Axle Load, lbs.	Traffic Equivalency Factor	Number of Axles	Equivalent 18 kip Single Axle Loads
Single Axles	Under 3,000	1,428	0.0002	154	0.03
	3,000-6,900	4,520	0.008	2	0.02
18 kip EAL's for all Cars/Jeeps weighed					0.05
Car/Jeep Load Factor =	18 Kip EAL's for all Cars/Jeeps weighed = 0.005 / Number of Cars/Jeeps weighed 78			=	0.0006

Table 4.5.2 ESAL Factor for Busses

Vehicle Type – Bus	Axle Load Group, lbs.	Representative Axle Load, lbs.	Traffic Equivalency Factor	Number of Axles	Equivalent 18 kip Single Axle Loads
Single Axles	Under 3,000	2,231	0.0002	90	0.02
	3,000 - 6,999	3,553	0.007	16	11
18 kip EAL's for all Busses weighed					0.13
Buss Load Factor =	18 Kip EAL's for all Cars/Jeeps weighed = 0.013 / Number of Cars/Jeeps weighed 53			=	0.002

Table 4.5.3 ESAL Factor for Light Trucks

Vehicle Type -Light Truck	Axle Load Group, lbs.	Representative Axle Load, lbs.	Traffic Equivalency Factor	Number of Axles	Equivalent 18 kip Single Axle Loads
Single Axles	Under 3,000	1,957	0.0002	114	0.02
	3,000 - 6,999	4,189	0.008	25	0.20
	7,000 - 7,999	7,011	0.032	1	0.03
	8,000 - 11,999	11,728	0.185	1	0.19
	12,000 - 15,999	12,677	0.321	3	0.96
	16,000 - 18,000	-	-	0	
18 kip EAL's for all Light Trucks weighed					1.4
Light Truck Load Factor = 18 Kip EAL's for all Cars/Jeeps weighed / Number of Cars/Jeeps weighed = 1.4 / 72 =					0.02

Table 4.5.4 ESAL Factor for Heavy Trucks

Vehicle Type -Heavy Truck	Axle Load Group, lbs.	Representative Axle Load, lbs.	Traffic Equivalency Factor	Number of Axles	Equivalent 18 kip Single Axle Loads
Single Axles	Under 3,000	2,348	.0002	2	0.004
	3,000 - 6,999	5,707	.010	37	0.37
	7,000 - 7,999	7,602	.034	11	0.37
	8,000 - 11,999	10,223	.161	11	0.77
	12,000 - 15,999	13,657	.345	7	2.42
	16,000 - 18,000	17,152	.953	2	1.91
	18,001 - 20,000	19,356	1.51	1	1.51
	20,001 - 21,999	21,219	2.27	2	4.54
	22,000 - 23,999	23,832	3.41	1	3.41
	24,000 and over	24,857	4.67	2	9.34
18 kip EAL's for all Heavy Trucks weighed					25.64
Heavy Truck Load Factor = 18 Kip EAL's for all Light Trucks weighted / Number of Light Trucks weighted = 1.4 / 72 =					0.02