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REPUBLIC OF THE PHILIPPINES
MINISTRY OF PUBLIC WORKS & HIGHWAYS

THE FEASIBILITY STUDY OF PHILIPPINE ROAD DISASTER PREVENTION PROJECT

FINAL REPORT

EXECUTIVE SUMMARY

(VOLUME I)

JUNE, 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Republic of the Philippines, the Government of Japan decided to conduct a feasibility study on the Philippine Road Disaster Prevention Project and entrusted the study to the Japan International Cooperation Agency (JICA).

The JICA sent to the Philippines a study team headed by Mr. Masahiko Thoi, from May 1983 to March 1984 under the guidance of the Supervisory Committee chaired by Mr. Kazuhiro Matsuno, Chief of Road and City Planning Division, Hokkaido Development Agency.

The Team had discussions with the officials concerned of the Government of the Philippines and conducted a field survey in the Philippines. After the field survey, further studies were made and the present report has been prepared.

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

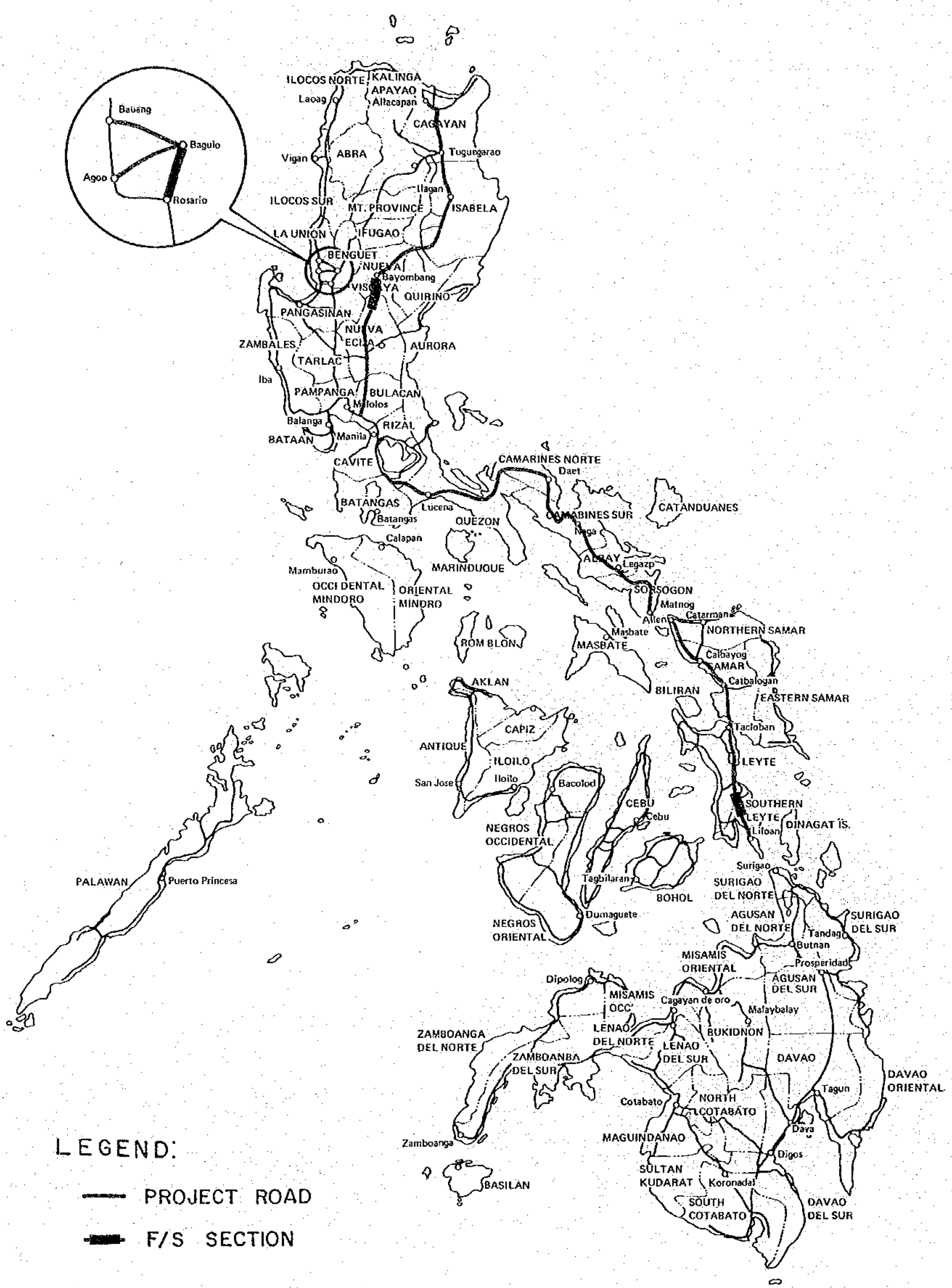
I wish to express my deep appreciation to the officials concerned of the Government of the Philippines for their close cooperation extended to the team.

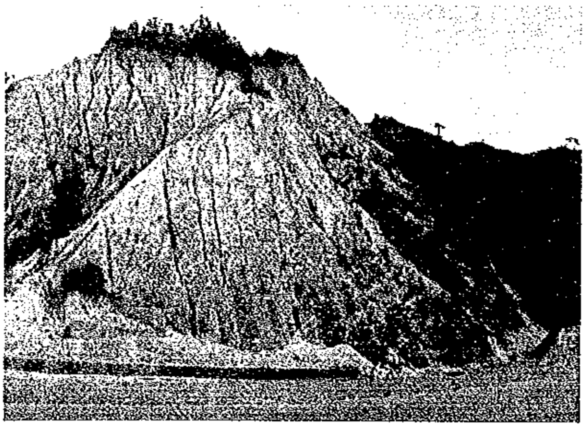
June, 1984

Keisuke Arita

Keisuke Arita
President
Japan International Cooperation Agency

LOCATION MAP

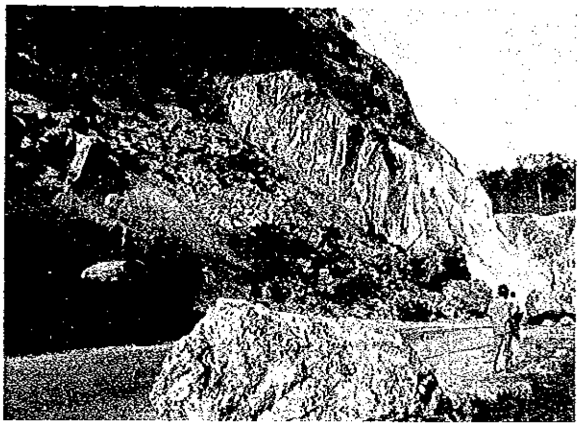




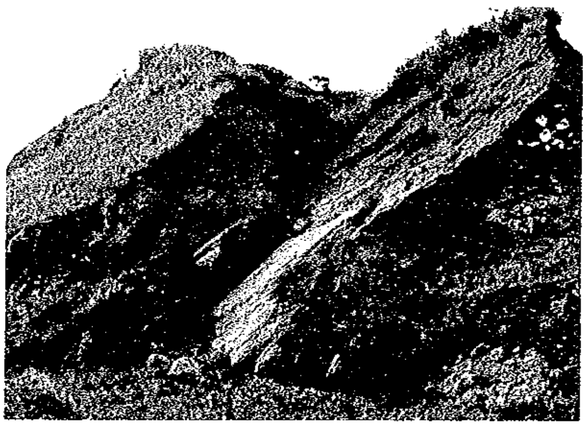
CUT SLOPE SURFACE FAILURE (EROSION) C-S.F (E) — *MAHARLIKA HIGHWAY, NORTH LUZON km 215 + 600*

CUT SLOPE DEEP FAILURE (SCOURING) S-D.F (S) — *MAHARLIKA HIGHWAY, LEYTE km 1019 + 690*

CUT SLOPE SURFACE FAILURE (WEATHERING) C-S.F (W) — *KENNON ROAD km 237 + 800*



CUT SLOPE DEEP FAILURE (ROTATIONAL) C-D.F (R) — *MAHARLIKA HIGHWAY, SOUTH LUZON km 158 + 500*



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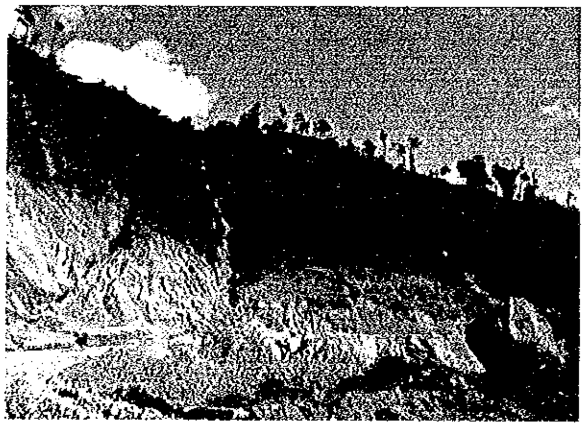
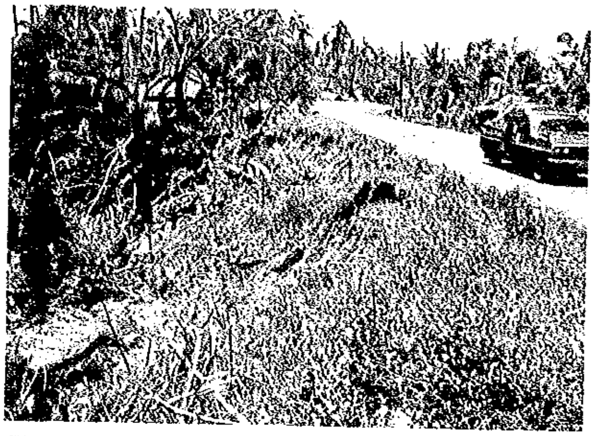
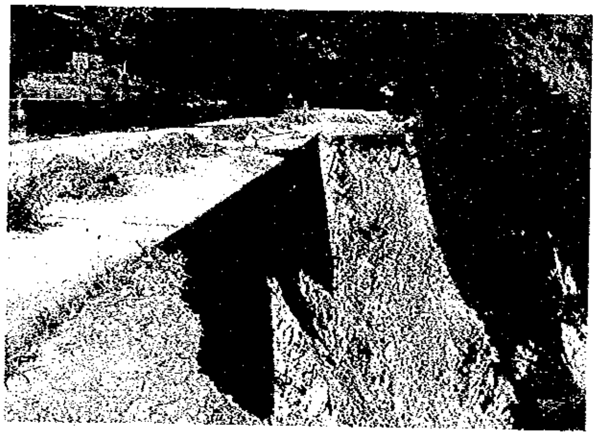


CUT SLOPE DEEP FAILURE (TRANSLATIONAL) C-D.F (T) — *MAHARLIKA HIGHWAY, LEYTE km 1009 + 600*



EMBANKMENT SLOPE SURFACE FAILURE (EROSION)
E-S.F (E)

MAHARLIKA HIGHWAY, SOUTH LUZON
km 406 + 490

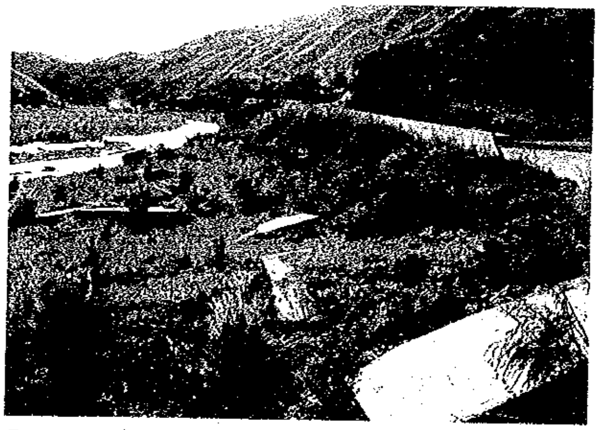


EMBANKMENT SLOPE DEEP FAILURE (SATURATION)
E-D.F (P)

KENNON ROAD
km 227 + 750

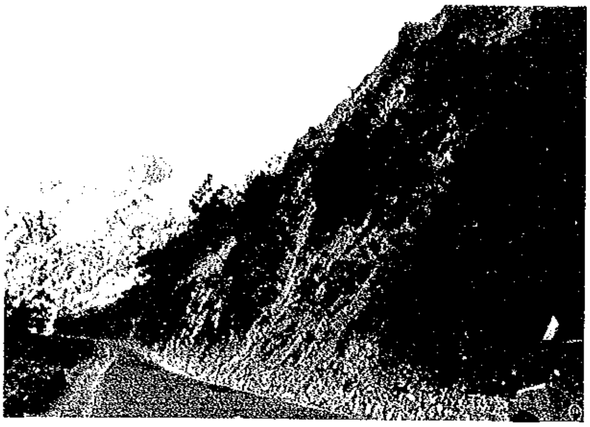
EMBANKMENT SLOPE DEEP FAILURE (SCOURING BY SURFACE WATER)
E-D.F (S)

MAHARLIKA HIGHWAY, LEYTE
km 1009 + 700



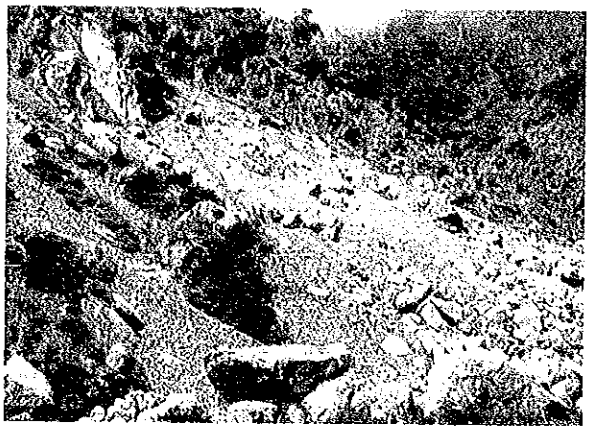
EMBANKMENT SLOPE DEEP FAILURE (SCOURING BY RIVER)
E-D.F (S)

MAHARLIKA HIGHWAY, NORTH LUZON
km 225 + 700



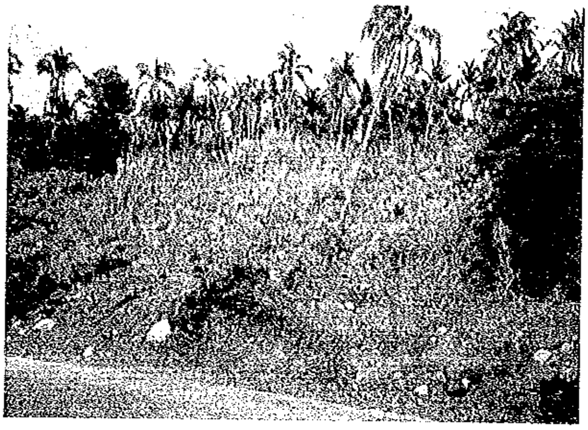
FALLS
ROCK FALL
C-F (R)

KENNON ROAD
km 235 + 800



FALLS
DEBRIS FALL
C-F (D)

AGOO-BAGUIO ROAD
km 277 + 600



LANDSLIDE
SOIL LANDSLIDE
L.S (S)

MAHARLIKA HIGHWAY,
LEYTE
km 1021 + 100

DEBRIS FLOW
DEBRIS FLOW
D.F (D)

MAHARLIKA HIGHWAY,
NORTH LUZON
km 173 + 450

DEBRIS FLOW
MUD FLOW
D.F (M)

MAHARLIKA HIGHWAY,
NORTH LUZON
km 188 + 200

TABLE OF CONTENTS

I INTRODUCTION

I INTRODUCTION

1. BACKGROUND

The development of the highway network in the philippines is one of the major programs being implemented by the government in support of the overall socio-economic development goals of the country. Major road improvement and construction activities began in early 1970 and has been pursued continuously since then. At present, the main roads system would now seem adequate in terms of location and extent. Despite the achievements made, however, some or the most important roads suffer many deficiencies including, among others, disasters due to slope failures. fall, landslide, debris flow, and the like, which impairs the efficiency of the road transport system and, if not corrected, will appreciably set back the economic gains already achieved.

Cognizant with the problems attached to road disaster which has recently become increasingly alaming, the Government of the Philippines (GOP) envisaged a road disaster prevention program for which the Japan International Cooperation Agency (JICA) has generously provided technical assistance, thru a request from the GOP, in the formulation of the same under the Feasibility Study of the Philippine Road Prevention Project, hereinafter called the Study.

The implementing agreement for the said technical assistance was signed in February 1983 between the JICA and the GOP represented by the Ministry of Public Works and Highways (MPWH) as the implementing agency. The Study started in May 1983 and was completed in June 1984.

2. OBJECTIVE OF THE STUDY

The objectives of the study are:

1) To identify the sections with high incidence of disasters or those with such possibilities along the project roads.
2) To prepare a program for implementation of the recommended counter measures along the selected sections.
3) To develop techniques of road disaster prevention.

3. PROJECT ROADS

1) Maharlika Highway (Luzon and Samar-Leyte Sections only)
2) Kennon Road
3) Naguilan Road
4) Marcos Highway (Agoo-Baguio City Road)

4. SCOPE OF THE STUDY

Road disaster dealt with were generally cut slope failure, embankment slope failure, fall, landslide and debris flow. The scope of the Study was, however, limited where the disasters are considered of reasonable size from the viewpoint of a road project. Thus, large scale riparian and Sabo works were excluded.

The Study was conducted in the following phases:

Press – 1	:	Identification of priority Section for Feasibility Study
Press – 2	:	Feasibility Study
Technical Review	:	General review on disaster prevention measures

5. REPORTS

The following reports were prepared during the Study.

INCEPTION REPORT
PROGRESS REPORT (I) .... (Phase – 1)
PROGRESS REPORT (II) .... (Phase – 2)
DRAFT FINAL REPORT

The DRAFT FINAL REPORT is presented in five volumes:

VOLUME I : EXECUTIVE SUMMARY
VOLUME II : TEXT
VOLUME III : APPENDIX
VOLUME IV : DRAWINGS
VOLUME V : AN APPROACH ON ROAD DISASTER PREVENTION

The FINAL REPORT has been modified from the draft final report in accordance with the GOP's comments.

The Study was carried out jointly by a team composed of eight JICA experts and a group of GOP counterparts and support staff. Technical guidance in the conduct of the Study was provided thru periodic review by the Steering Committee of the Philippines and the Supervisory Committee of Japan, both were especially created to oversee the overall implementation of the Study.

II CONCLUSIONS AND RECOMMENDATIONS

II CONCLUSIONS AND RECOMMENDATIONS

CONCLUSION

1. IMPORTANCE OF ROSD DISASTER PREVENTION

1.1 Road disaster prevention in the philippines must be carried out in a stern environment. In most parts of the country, the topography is mountainous with rugged terrain. The geology is generally of a fragile structure of the Tertiary period that has been fractured due to the presence of numerous tectonic lines, the most severe representative of which is the philippine Fault. Furthermore, the geographical location of the country lies in the South Pacific typhoon belt where typhoon-bearing heavy rains hit nine times or more each year on the average.

1.2 The overall transport system of the country is highly dependent upon road transport which is at present catering for 97% of intra-island passenger and commodity transport demand. However, the efficiency of the system particularly in the role of the trunk roads is interfered due to road disasters, among others, causing substantial detrimental impacts upon the economic and social activities of the nation.

1.3 The trunk road network in the Philippines has been gradually developed in recent years. In terms of providing the basic access requirement to the areas served, the network may be considered adequate. However, in view of the increasing transport demand. the network still needs to be complemented with logical alternative routes to function in cases of emergency or closure of the main road due to disaster, but areas still remain where no alternative route is available in an emergency situation.

1.4 The existing trunk roads as developed have not been provided, if at all, significant protection against disaster, where these are required. Due to the susceptivity of the roads to disasters and in view of said stern natural environment of the country, even the Maharlika Highway which is considered the most important trunk road has often been closed in many sections due to disasters and which have impaired the efficiency of the system during these periods.

1.5 The present restoration work of road damage caused by disasters is no more than a stopgap measure. If potential disaster spots are left alone without drastic and complete disaster prevention measures, the scope of potential disaster will be greater and some road sections are liable to be completely destroyed beyond economic restoration measures before long.

1.6 Measures to prevent disaster damage on trunk roads are, therefore, of a vital and urgent issue in view of the above.

2. ROAD SECTIONS SUBJECT TO FEASIBILITY STUDY

The project roads included in the Study were divided into 24 road sections which were ranked into three priority categories, in accordance with the extent of potential disaster and road section importance, as shown in Table-A. After the comprehensive assessment of road sections included under the first priority category, the following three road sections have been selected for feasibility study.

. Aritao-San Jose Section (Dalton Pass Section)
. Mahapalg-Sogod Section (Leyte)
. Kennon Road

TABLE-A RANKING OF SECTIONS

Location	Factor for Evaluation		Rating	Ranking
	Disaster Potential	Importance		
Aritao – San Jose (Dalton Pass)	A	B	A	First Priority Sections
Kennon Road	A	B	A	
Agoo – Baguio	A	C	A	
Mahaplag – Sogod (Leyte)	A	C	A	
Allen – Calbayog (Samar)	A	C	A	
Lucena – Calauag (Region IV)	B	A	A	
Santiago – Bagabag (Region II)	B	B	B	Second Priority Sections
Naguilian Road	B	B	B	
Calauag – Daet (Region V)	B	B	B	
Bagabag – Aritao (Region II)	B	B	B	
Sogod – Liloan (Leyte)	B	C	B	
Calbayog – Catbalogan (Samar)	B	C	B	
San Jose – Sta. Rosa (Region III)	C	A	B	
Calamba – Lucena (Region V)	C	A	B	
Daet – Naga (Region V)	C	B	C	Third Priority Sections
Daraga – Sorsogon (Region V)	C	C	C	
Catbalogan – Tacloban (Samar)	C	C	C	
Sorsogon – Matnog (Region V)	C	C	C	
Allacapan – Tuguegarao (Region II)	C	C	C	
Tuguegarao – Naguilian (Region II)	C	C	C	
Naguilian – Santiago (Region II)	C	C	C	
Sta. Rosa – Sta. Riza (Region III)	C	A	C	
Naga – Daraga (Region V)	C	A	C	
Tacloban – Mahaplag (Leyte)	C	C	C	

3. FINDING OF THE FEASIBILITY STUDY

3.1 PROJECT EVALUATION

The evaluation carried out for the three road sections have proven that the projects are technically, economically and financially feasible.
The feasibility assessment result is summarized in Table-B.

TABLE-B PROJECT EVALUATION

	Technical Evaluation	Economic Evaluation	Financial Evaluation
Dalton Pass Section	• 73 spots with high disaster potential. • Suffered destructive road damages twice in 7 years. • Month-long traffic interruptions almost every 4 years. • Immediate restoration works required in many spots. • Practically no detour road.	• IRR = 18.7% • Provides the only access to the Cagayan Valley Region. • Secio-economic activities and development of the Cagayan Valley Region depended upon.	• 5-year implementation period assumed (1985 – 1990). • 3-year construction period (1987 – 1990) • Maximum annual financial requirement: P220 Million • Maximum annual financial requirement of local portion estimated at P79 million is within the Government's funding capability. • Foreign funds for foreign cost components will be required.
Mahaplag-Sogod Section	• 40 spots with high disaster potential. • Extent of disaster will increase year by year. • Would be totally destroyed in future, unless measures are taken. • Months-long traffic interruption almost every year. • No reliable detour road.	• IRR = 14.4% • Efficient operation of ferry service between Leyte and Mindanao relied on. • Enhance socio-economic development of Southern Leyte.	
Kennon Road	• 46 spots with high disaster potential. • Highly dangerous to traffic due to narrow roadway and shoulders. • Weeks-long traffic interruptions almost every year. • No reliable detour road.	• IRR = 16.6%. • Provides shortest access from Metro Manila to Baguio City. • Vitally supports the development of tourism industry and vegetable production in Baguio City and adjacent provinces.	

3.2 PROJECT COST

The total estimated project cost to implement the three sections is approximately ₱367.85 Million. The details are shown in Table-C.

TABLE-C PROJECT COST

Price : As of Oct. 1983
Unit : Million Pesos

	Detailed Engineering	Suoervision and Construction				Total
		Daiton Pass Section	Mahaplag-Sogod Section	Kennon Road	Sub Total	
Foreign	14.67	101.14	53.06	56.78	210.98	225.65
Local/Tax	7.91	67.30	33.82	33.17	134.29	142.20
Total	22.58	168.44	86.88	89.95	345.27	367.85

RECOMMENDATIONS

1. PROMOTION OF ROAD DISASTER PREVENTION PROJECT

1.1 Roads play a particularly important role in the Philippin's transport system in enhancing the overall socio-economic development objectives of the country thru the formation of well balanced and self reliant regional communities. Of all the truck roads, the importance of the Maharlika Highway and the Kennon road, which constitute in providing basic traffic access, will further increase along with the future economic and social development in the Philippines.

1.2 Road disaster prevention projects will secure the functions of these important roads by improving their reliability to the users. Such projects will result in the ensurance against road closures with reasonable investment, while realizing the maximum effect of the huge amount of road development funds that have already been invested. In this view, it is highly recommended that the road disaster prevention projects should be positively considered and actively implemented.

1.3 The Study has been carried out based mainly on Japanese experience with some time constraints and limited area coverage of the national trunk road network where potential disaster spots have been identified. Countermeasures were investigated on the same basis and were recommended, where appropriate. In view of the fact that the natural conditions in the Philippines are generally more stern than that in Japan, it is recommended that a disaster prevention system and technology be developed, using the experience and findings of the Study as a basis in achieving (1) compilation and accumulation of systematic disaster records, (2) the identification of potential disaster spots and the assessment of potential disaster intensity, (3) the formulation of guidelines for periodic monitoring of road disaster areas, and (4) the development of countormeasures using locally available materials.

2. IMPLEMENTATION OF THREE ROAD SECTIONS

2.1 EARLY IMPLEMENTATION

It is recommended that disaster prevention projects be implemented as soon possible on the three road sections subjected to Feasibility Study. Any delay in the project implementation will just increase the disaster potential and will compound the seriousness of the existing condition which inevitably may result in more expensive restoration works and longer traffic shutdown, thereby, further incurring greater costs to the economy.

2.2 IMPLEMENTATION SCHEDULE AND INVESTMENT PROGRAM

Assuming the simultaneous implementation of projects on the three road sections, recommended project implementation schedule and annual financial investment program are as shown in Table-D. Also presented is the foreign exchange component portion which has been assumed to be financed with external assistance from a foreign country or an international financial institution.

TABLE-D IMPLEMENTATION SCHEDULE

		1984	1985	1986	1987	1988	1989	1990
Feasibility Study (This Study)								
Financing Arrangement for Implementation								
Detailed Engineering Study (15 months)								
Tender (6 months)								
Construction (36 months)								
Construction Supervision (36 months)								
Financial Requirement – October 1983 Price – Unit: Million Pesos	Foreign Component	–	1.47 (1.70)	13.20 (16.09)	10.55 (13.69)	73.85 (101.18)	84.39 (122.61)	42.19 (64.92)
	Local and Tax Component	–	0.79 (1.06)	7.12 (10.52)	6.72 (10.59)	47.00 (79.54)	53.71 (97.25)	26.86 (52.04)
	TOTAL	–	2.26 (2.76)	20.32 (26.61)	17.27 (24.28)	120.85 (180.72)	138.10 (219.86)	69.05 (116.96)

Note : Figure in ( ) shows financial requirement in current price.

III SUMMARY

III SUMMARY

1. IDENTIFICATION OF PRIORITY SECTIONS

1.1 THE PROJECT ROADS

Maharlika Highway

The Maharlika Highway is undoubtedly the most important trunk line in the country's highway network linking the four major islands of Luzon, Samar, Layte and Mindanao. This artery extends as long as 2100 km starting from the province of Cagayan (Luzon) and ends in the City of Davao in the island of Mindanao. The Study, however covered only the Cagayan-Leyte Section, approximately 1,530 kms of the whole strech.

The Highway is generally concrete paved with 2 lanes –6.7 m wide with 2 to 2.5 m shoulders each side. It almost passes along the steep mountainous terrain in Dalton Pass, Lucena and Camarines sections where it runs parallel to the fractured zone of the main Philippine Fault, which was identified as the main cause of large-scale slope failures.

The Highway plays an important role in the overall highway transport system of the country, more inevitably in these regions where there are no alternative routes such as in Cagayan Valley, Bicol, Samar and Leyte.

Roads leading to Baguio

Baguio City is located about 300 kilometers North of Manila in a plateau with an elevation of 1500 m above sea level. Favoured by its cool climate, the city is famous as a tourist spot and regarded as the summer capital of the country. Leading to City are the Kennon, Naguilian and Agoo-Baguio Roads all branching off from Manila North Road at different points.

Kennon Road provides the nearest and shortest route to Baguio City from Manila. It has a total length of 34 km with 2 lanes asphalt pavament of 6 m wide with 0.5 to 1.0 m shoulders. The route runs alongside the Bued River in a winding alignment and stitching the steep mountainous terrain owing to the curved alingment and the sharp profile of the road. The slopes are composed of rocks such as conglomerate, andesite, deorite and the like.

Naguilian Road is the northernmost among the three access roads to Baguio City from Metro Manila. It has a total length of 47 km with poorly asphalted 2 lanes of 6 m wide and narrow shoulders. This road proceeds from the town of Bauang in rolling area for about 17 km and proceeds towerds Baguio city through the steep mountainous terrain. The slopes are observed to be generally made up of sandstone, shale, tuff and the like.

Agoo-Baguio Road is located in between the two above mentioned roads having a lengthof 49 km with newly concreted pavement of 6.7 m in width and 2.0 to 2.5 m shoulders. About 36 km in Baguio side are generally steep mountainous sections. The slopes are mainly composed of strongly weathered mudstone, conglomerate, tuff and the like. Figure 1–1 shows presnat traffic volume of the Project Roads. Geology, topography and climate of the Study Area are presented in Figure 1–2.

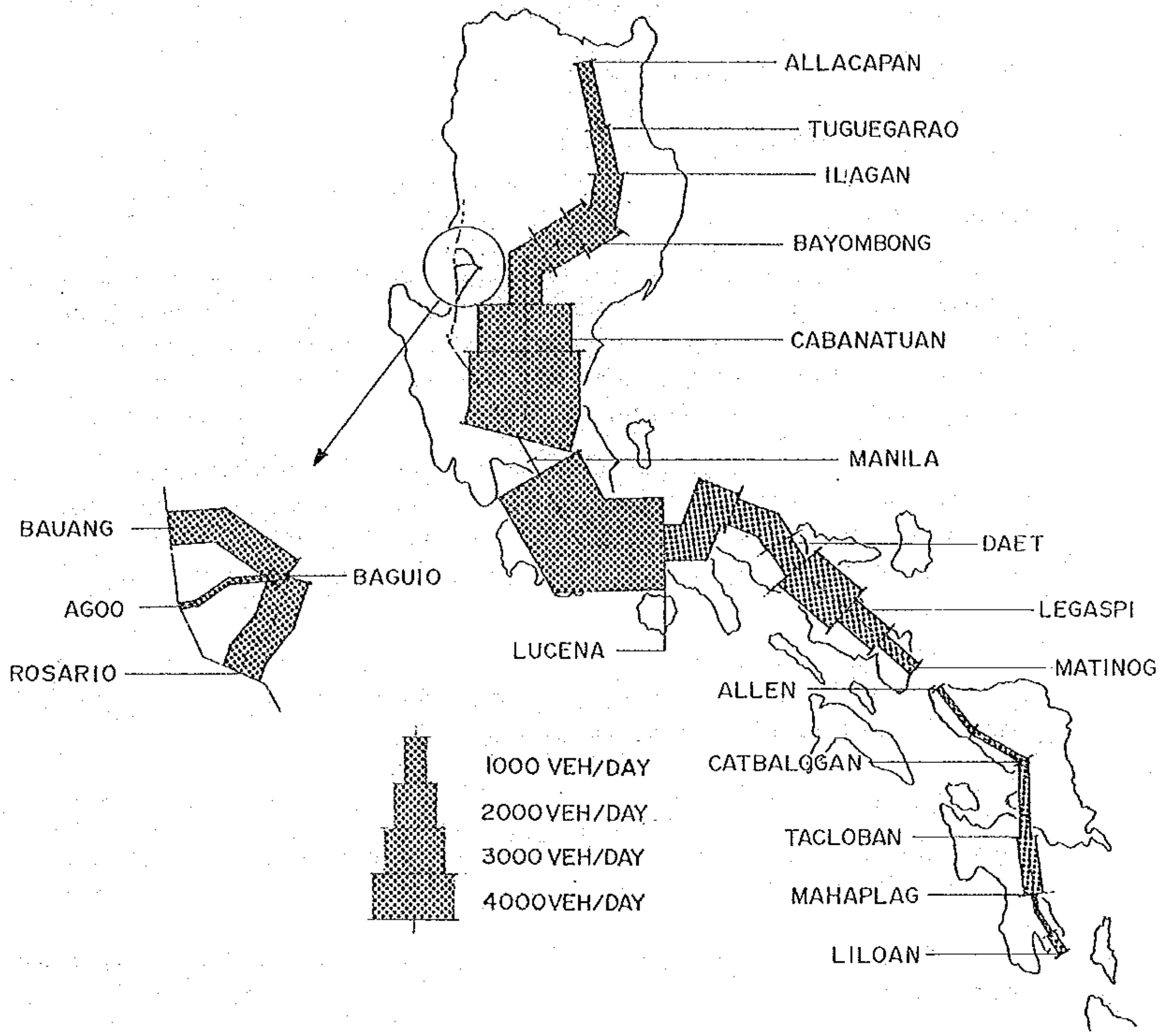


FIGURE 1-1 PRESENT TRAFFIC VOLUME

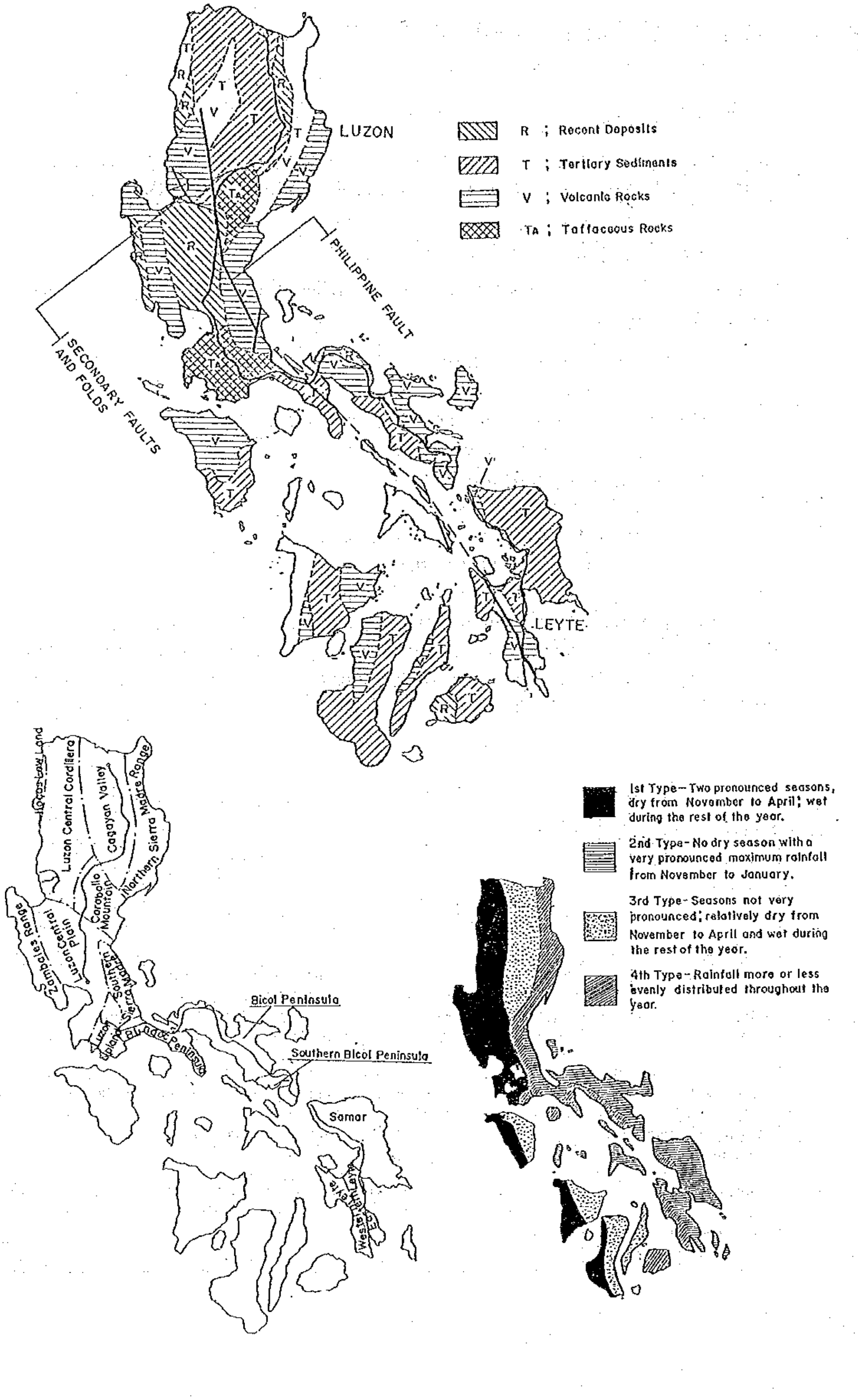


FIGURE 1-2 GEOLOGY, TOPOGRAPHY AND CLIMATE OF THE STUDY AREA

1.2 IDENTIFICATION OF ROAD DISASTERS

Types of Road Disasters

Road disasters are classified into five types based generally on the shapes of failures which were assessed thru visual inspection as shown in Figure 1–3.

Identification of Disaster Potential Spots

Disaster potential spots were qenerally identified thru actual field investigation considering the following items.

- Height and gradient of slope
- Types of rocks
- Couditions of weathering, cracks, joints and faults
- Thickness and compactness of topsoil
- Degree of water saturation of slope
- Existence of seepage water
- Influence of force of waves from sea or stream
- Evidence and scale of past disaster

Each spot investigated was ranked into three categories, Category A (Heavy), Category B (Medium) and Category C (Light) considering the above items and giving emphasis on the impact of the disaster on traffic. The criteria adopted in determining the disaster potential are shown in Table 1–1.

TABLE 1-1 CRITERIA FOR DISASTER POTENTIAL

IMPACT	Type of Disaster		
	Cut Slope Failure, Landslide, Debris Flow, etc.	Rock Fall	Embankment Slope Failure
Category A (Heavy) (Urgent countermeasure is required)	• Failure or moved material may cover full lanes of pavement. Expected to be closed to traffic.	• Fallen materials may cover full lanes or large sized rocks (more than 50 cm) may fall to part of carriageway.	• Pavement structure may collapse.
Category B (Medium) (Urgent countermeasure is required)	• Failure or moved materials may cover about one lane.	• Fallen materials with size of less than 50 cm may cover about one lane.	• Shoulder may fully collapse.
Category C (Light) (No urgent countermeasure is required.	• Failure or moved materials may not extend to carriageway.	• Fallen materials may not extend to carriageway.	• Shoulder may partially collapse.

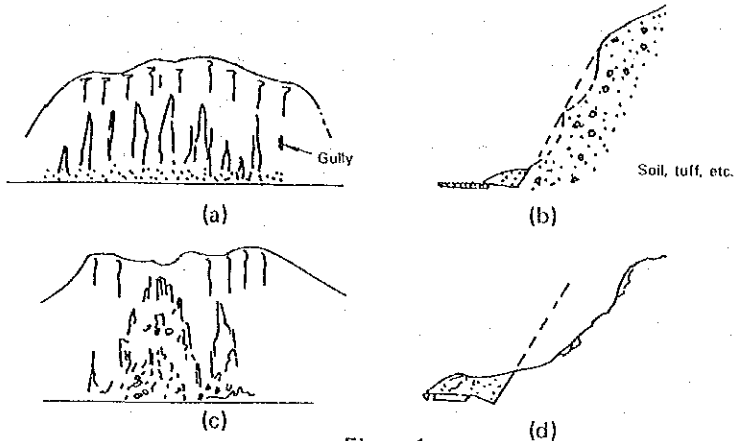


Figure 1

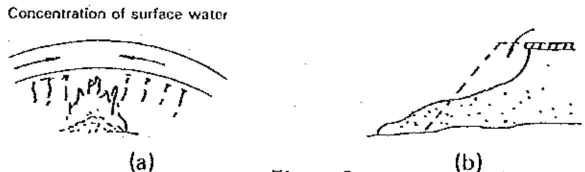


Figure 2

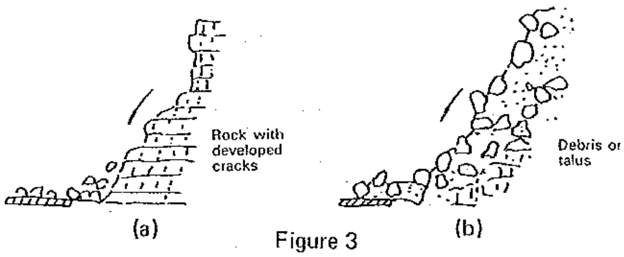


Figure 3

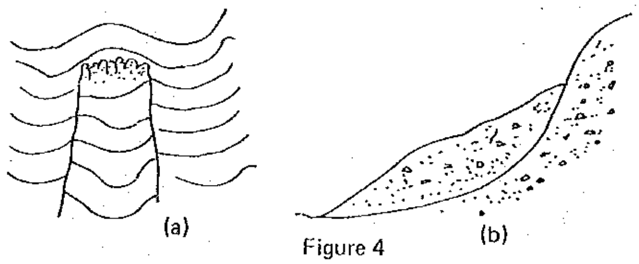


Figure 4

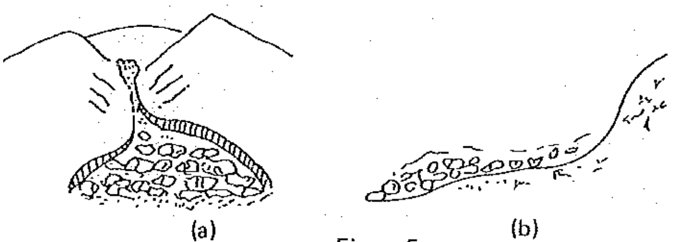


Figure 5

Road Disaster is classified into the following five (5) types.

1. Cut Slope Failure

   This type is sub-classified into surface and deep failures. Causes of the former are erosion, weathering and structural weakness. The latter is classified into scouring, rotational and translational failure. Figures 1 (a) and (b) show a surface failure due to erosion, while (c) and (d) show a deep failure due to scouring.

2. Embankment Failure

   This type is sub-classified into surface failure due to erosion and deep failure due to scouring and saturation. Figures (a) and (b) show a deep failure due to scouring.

3. Fall

   This type is sub-divided into rock and debris falls. Figures 3 (a) and (b) show rock and debris falls, respectively.

4. Landslide

   This type is sub-classified into rock and soil landslides. Figures 4 (a) and (b) show a soil landslide.

5. Debris Flow

   Debris flow is sub-classified into debris and mudflow. Figures 5 (a) and (b) show a debris flow.

FIGURE 1-3 CONCEPTIONAL ILLUSTRATION OF FAILURES

Summary of Road Disasters

There are a total of 545 disaster spots identified along the project roads of which 390 are along the Cagayan to Leyte section of the Maharlika Highway and 155 disaster spots along the three roads leading to Baguio City (Kennon = 48; Agoo-Baguio = 84; Naguilian = 23).

Distribution of the disaster spots by road sections and types are shows in Figure 1—4 below.

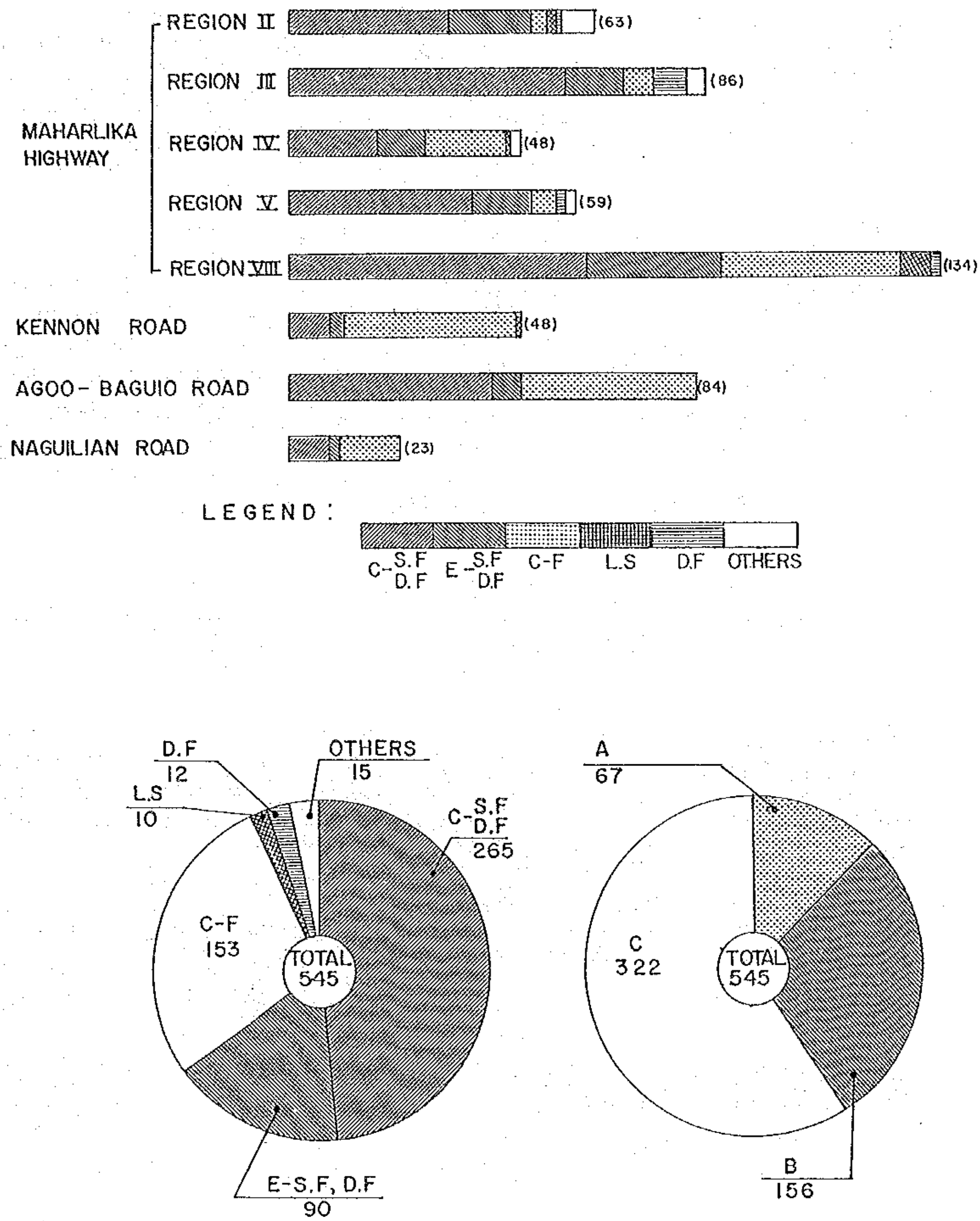


FIGURE 1-4 DISASTER SPOTS BY REGION, TYPE AND POTENTIAL

1.3 DESCRIPTION OF IDENTIFIED DISASTER SPOTS

Of the 545 disaster spots observed along the project roads, cut slope failure is more prevalent with 265 spots or 49 percent of the total, followed by fall with 153 spots or 28 percent, embankment slope failure with 90 spots or 17 percent and debris flow, landslide, and others representing 6 percent.

Cut Slope Failure

This type of failure is predominant in all mountainous sections, specifically in: i) Dalton Pass section in Nueva Vizcaya ii) Agoo-Baguio road: iii) Mahaplag-Sogod section in Southern Leyte; and iv) Sta. Elena-Daet section in Camarines Norte. Large-scale failures were recognized in i) and iii).

The average scale of cut slope failures have occurred in all types of rocks. It is no exaggeration to mention that the cause of these failures is water. The water flowing down on the surface of the slope has created erosion and socuring. On the other hand, the large-scale failure observed in sections i) and iii) may be due to the fractured zone of Philippine Fault.

As predicted, the failures could not have been prevented because of the following deficiencies.

- No drainage facilities to prevent erosion and scouring due to heavy rain.
- No berms on high slopes to ease velocity of surface water.
- No slope protection by vegetation and the like.

Embankment Slope Failure

This type of failure was also widely observed along the project roads, especially at the spots with the following topographical conditions: i) spot inside the curve with the steep gradient, ii) sections along sea coast and river and iii) approach to bridges.

Embankment failures were generally attributed to scouring due to rains. Therefore, the failure frequently occurred for the following reasons.

- Inadequate drainage facilities in terms of number and capacity
- Inadequate connection and protection at the outlet of cross drain facilities
- No or inefficient protection of slopes

Fall

Falls were predominantly observed in the section along Kennon Road. Agoo-Baguio Road, and the two sections between San Isidro and Calbayog in Samar and between Mahaplag and Sogod in Leyte.

This type of failure arises mainly at the portion with developed open cracks and at the open boundaries of different types of rocks on slopes. These slopes are composed of debris, diorite, andesite, sandstone and the like. The size of fallen rocks varies from 2.0 to 0.5 meters in diameter, but the biggest is about 3 m in the section along Agoo-Baguio Road.

The deficiencies which may have caused the failure are similar to those mentioned in "cut slope failure" of this section.

Landslide

Landslides are observed only in ten spots. Among these, largescale failures were noted in four spots; at Diadi along Dalton Pass section, along Kennon Road near Baguio City and near Layong Bridge and Libagon along the Mahaplag-Sogod section in Southern Leyte.

The deposited earth on bedrocks such as sandstone, tuff and mudstone can easily slide with rising of groundwater level during heavy rains.

The main causes of these failures are attributed to the following:

- No drainage facilities to prevent seepage of water
- No remedial facilities such as horizontal drain holes
- No proper consideration in design such as removal of earth or counter weight.

Debris Flow

Debris flows were identified mainly along the Dalton Pass section. The largest debris flow occurred during typhoon Aring in 1980, causing extensive destruction to property and death to many people.

Ordinary type of debris flow comes from small torrents in the mountains where the geology consists mainly of transfigured granite by weathering.

No countermeasures such as consolidation work and sabo dam were observed.

1.4 RECORDS OF ROAD DISASTER AND RESTORATION WORK

Road Disaster Record

The project roads were often reported closed to traffic due to disasters occurring during typhoons and heavy rains. Records of major traffic interruptions at Dalton Pass Section during and Mahaplag-Sogod Section along Maharlika Highway and at Kennon Road are summarized in Table 1–2.

TABLE 1-2 MAJOR ROAD DISASTER AT SELECTED SECTIONS

Section	Year	Name of Typhoon	Date of Occurance	Duration of Traffic Interruption
Dalton Pass Section	1976	Didang	May 15–25	30 days
	1978	Kading	Oct. 25–27	7 days
	1980	Nitang/Osang	July 18–27	7 days
	1980	Aring	Nov. 1– 7	29 days
	1981	Anding	Nov. 21–27	7 days
Mahaplag-Sogod Section	1979	Karing	May 10–16	30 days
	1980	Heavy Rain	Dec. 10–Jan. 26	90 days
	1981	Heavy Rain	Nov. 23–Dec. 3	60 days
	1982	Bising	March 22–29	60 days
Kennon Road	1974	Susang	Oct. 8–12	21 days
	1979	Ising-Mameng	July 29–Aug. 15	120 days
	1980	Nitang/Osang	July 18–27	135 days
	1981	Rubing	Sept. 15–21	14 days

Source: District/City Engineering Offices

Present Restoration Work

Application of a full-scale countermeasures to prevent slope failures has not yet been effected along the project roads. If at all, only small scale temporary countermeasures are being applied along the disaster spots. More often only remedial works and quick restoration of the damaged sections are being resorted to.

The sediments and debris deposited on the road surface are removed some time after the occurrence of slope failures. In many spots, stone masonry is widely adopted as a remedial measure of embankment slope protection. However, these are constructed structurally weak which can only withstand very small lateral pressure.

1.5 SELECTION OF FEASIBILITY STUDY SECTIONS

Ranking of Sections

The project roads were divided into 24 sections of which 21 are within the Maharlika Highway and the three roads leading to Baguio were considered each a section. Each section was evaluated in terms of its disaster potential and importance.

- The disaster potential of each section was evaluated based on the high concentration of potential failures within. The degree of concentration has been expressed at the disaster spot density derived with the following relationships shown below.

$$\text{Disaster Spot Density of Each Section } (\alpha) = \frac{\text{Total Length of Spots with High Disaster Potential (Category A and B)}}{\text{Section Length}}$$

  The sections were ranked A, B and C using the following criteria.

  Rank A : $30 \text{ m/km} \leqq \alpha$
  Rank B : $5 \text{ m/km} \leqq \alpha < 30 \text{ m/km}$
  Rank C : $\alpha < 5 \text{ m/km}$

- The importance of each section was assessed based on traffic volume and the quality of traffic with the same weight. The quality of traffic was assessed on three factors: commercial commodities, basic food and other consumption commodities, and passenger flow.

- The results of the evaluation based on disaster potential and the importance of road were integrated giving the higher weight to the former. The disaster spot density and importance of road of each section is illustrated in Figure 1–5.

Final Selection

Six sections ranked as the first priority were further studied in consideration of other factors such as the availability of detour road, constraints during implementation of the project and the characteristics of each section.

Finally, the following three links were identified as the subjects for the Feasibility Study.

. Aritao-San Jose (Dalton Pass Section)
. Mahaplag-Sogod (Leyte)
. Kennon Road

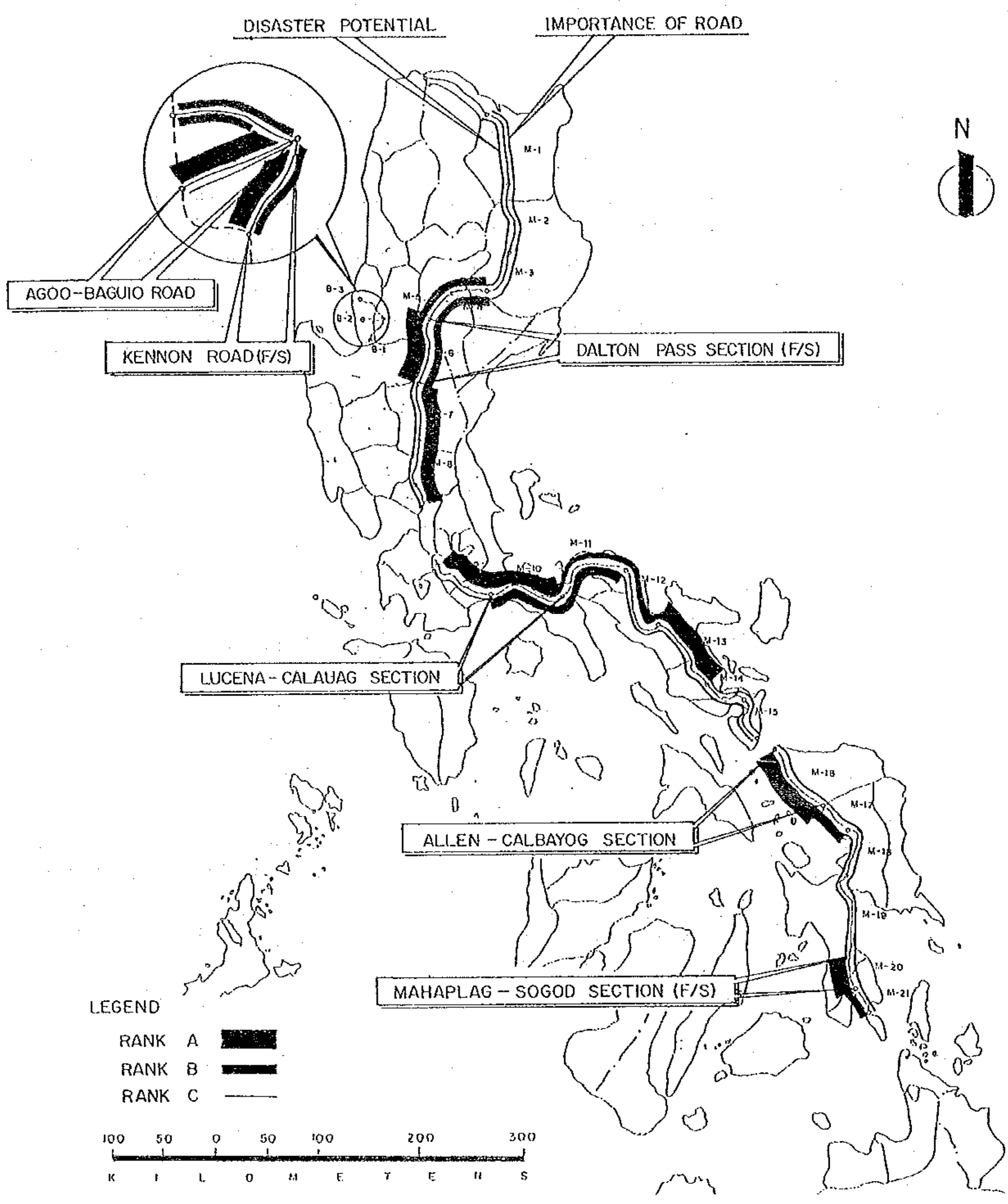


FIGURE 1-5 DISASTER POTENTIAL AND IMPORTANCE OF ROAD

2. FEASIBILITY STUDY OF SELECTED SECTIONS

2.1 ROLES OF SELECTED SECTIONS

Dalton Pass Section

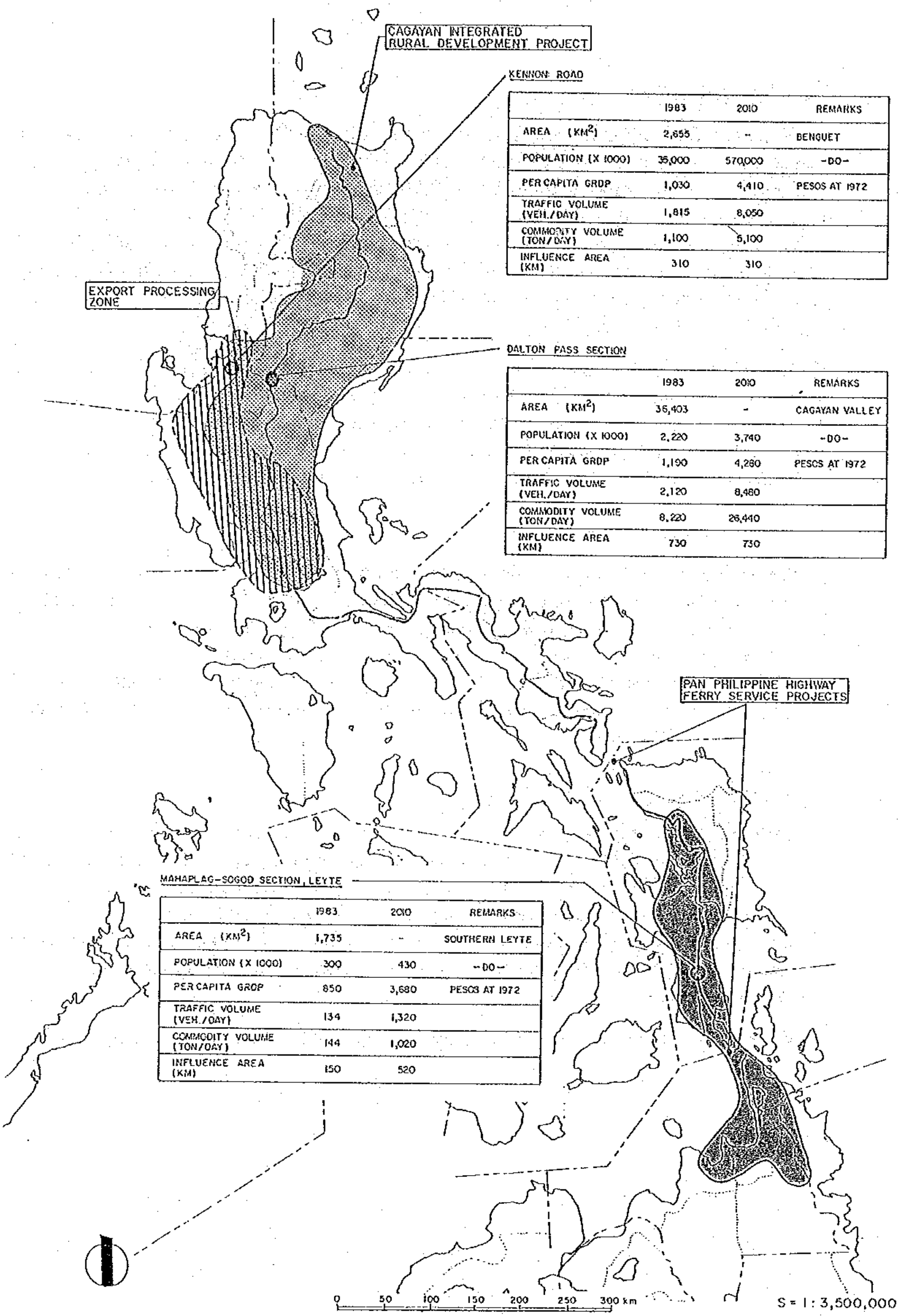
The only road connecting Cagayan Valley with Metro Manila is the Maharlika Highway. The Dalton Pass Section of the Maharlika Highway is located at the gateway to the Cagayan Valley Region whose influence area extends to Aparri in the northern tip of Luzon Island and to Metro Manila in the south. The road transport has an overwhelming share of 99% of total transport demand in the Cagayan Valley corridor where the main traffic generating sources are located at Ilagan in the province of Isabela, Bayombong in Nueva Vizcaya and Tuguegarao in Cagayan.

Mahaplag-Sogod Section

The key section along the Maharlika Highway which links Southern Leyte and Tacloban City, the center of Region VIII, with the shortest access is the Mahaplag-Sogod Section. The direct Leyte Island. However, upon operation of the ferry service between Leyte and Minadanao islands which is expected to start in 1984, the influence area will expand further to Mindanao. The said ferry service will finally realize the linkage of the four major islands in the Philippines by vehicle traffic by way of the Maharlika Highway. This section is one of the critical sections to be improved to ensure the continuity of the Maharlika Highway and in view of road disaster potentials inherent to it.

Kennon Road

Baguio City, largely depending on the tourism industry, Vegetable production and education center north of Manila has strong linkage with Metro Manila in the aspects. The shortest access is provided by Kennon Road which serves approximately 98 percent of traffic generated south of Baguio City. It has a long stretch of influence area extending to 310 kilometers in length. Traffic on it is mainly composed of inter-regional trips and commuting trips. Thus, Kennon Road has two functions; one as an inter-regional trunk road and two, as a local road.



KENNON ROAD

	1983	2010	REMARKS
AREA (KM^2)	2,655	-	BENGUET
POPULATION (X 1000)	35,000	570,000	-DO-
PER CAPITA GRDP	1,030	4,410	PESOS AT 1972
TRAFFIC VOLUME (VEH./DAY)	1,815	8,050	
COMMODITY VOLUME (TON/DAY)	1,100	5,100	
INFLUENCE AREA (KM)	310	310	

DALTON PASS SECTION

	1983	2010	REMARKS
AREA (KM^2)	36,403	-	CAGAYAN VALLEY
POPULATION (X 1000)	2,220	3,740	-DO-
PER CAPITA GRDP	1,190	4,260	PESOS AT 1972
TRAFFIC VOLUME (VEH./DAY)	2,120	8,460	
COMMODITY VOLUME (TON/DAY)	8,220	26,440	
INFLUENCE AREA (KM)	730	730	

MAHAPLAG-SOGOD SECTION, LEYTE

	1983	2010	REMARKS
AREA (KM^2)	1,735	-	SOUTHERN LEYTE
POPULATION (X 1000)	300	430	-DO-
PER CAPITA GRDP	850	3,680	PESOS AT 1972
TRAFFIC VOLUME (VEH./DAY)	134	1,320	
COMMODITY VOLUME (TON/DAY)	144	1,020	
INFLUENCE AREA (KM)	150	520	

FIGURE 2-1 EXPANSION OF INFLUENCE AREA BY F/S SECTION

2.2 FUTURE TRAFFIC

Dalton Pass Section

Present 1983 traffic passing this section is about 2120 vehicles per day with the predominant share of 50% of truck traffic. With an anticipated annual average growth rate of 5.3%, the traffic volume will be 8,500 veh/day in the year 2010, of which truck traffic will share 44%, reaching nearly the traffic capacity of the road section. The Philippines is predicted to suffer staggered economic development in 1980s, but will achieve sustained economic growth in the 1990s. Reflecting such economic development trend, traffic growth rate in 1990s will, therefore, slightly higher than that in 1980s.

Backed up by the vast agro-timber resources of the Cagayan Valley Region, guite large volume of commodities (8,200 tons/day) is transported through the section. Owing to extensive efforts to develop the region by such projects as the Cagayan Integrated Rural Development Project, volume of commodities carried through the Section will be 26,400 tons/day (or 3.2 times of the present volume) in the year 2010.

Mahaplag-Sogod Section

Present traffic volums is quite low at 134 veh/day partly due to the deteriorating road condition brought about by the recent disasters which have occurred in the section. Nevertheless, considering the socio-economic development potentials of the area served, including the impact of the ferry service between Leyte and Mindanao islands which will be operational in 1984, high traffic growth rate of 8.8% per annum is forecasted between 1983 and the year 2010. This will mean that the traffic volume will reach 1,300 veh/day in the year 2010.

Kennon Road

Kennon Road has present (1983) traffic of an average volume of 1,815 vehicles per day. This is anticipated to increase at an average annual growth rate of 5.7%. By the year 2010, the traffic would have increased to 8,100 vehicles per day. Due to the limited geometric standards of the section characterized with narrow roadway and steep grades, its traffic capacity is lower than a standard 2–lane road. That traffic volume of 8,100 veh/day will be almost the maximum traffic volume it will be able to accommodate.

Volume of commodity flow was 1,100 tons/day in 1983 and will be 5,100 tons/day in the year 2010.

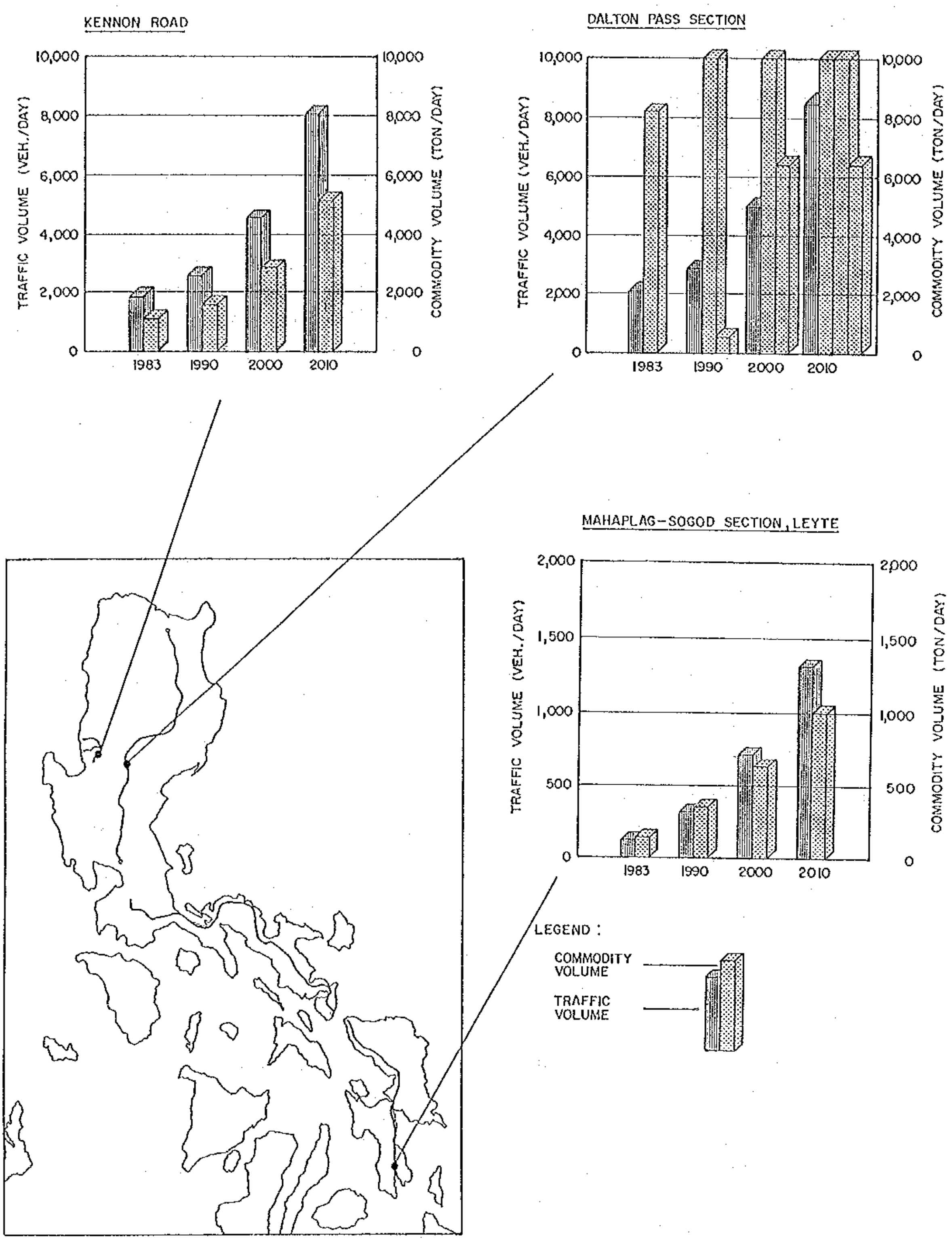


FIGURE 2-2 FUTURE TRAFFIC/COMMODITY VOLUME

2.3 EXISTING CONDITIONS OF ROAD DISASTER

Dalton Pass Section

After the improvement of the section in 1975, two large scale road disasters occurred. One in 1976 and the other in 1980 caused by typhoons "Didang" and "Aring",, respectively. During these periods, substantial damages on the section were attributed to cut slope failures and embankment failures, resulting in interrupted traffic for quite sometimes. From there on, small scale of road disasters occurred every year, disrupting traffic for 3 to 7 days.

The middle portion of the section passes through rugged and mountainous terrain with steep slopes on both sides of a roadway. The remaining portion runs along the Digdig River or Sta. Fe River with steep slopes and winding alignment.

Of the total of 73 spots evaluated as disaster potential category A or B, cut slope failure is dominant with 39 spot, followed by debris flow with 14 spots and embankment slope failure with 13 spots.

Occurrence of a large number of cut slope failures is mainly due to strongly weathered and fractured rocks.

The evidence of a large scale debris flow was observed at kms 221 + 500. In 1980 during typhoon "Aring", many lives of nearby residents were lost. Other spots are small in scale, but likewise often interrupt traffic after every heavy rain.

A large scale of embankment slope fainlures are mainly due to scouring caused by the strong stream flow of Digdig River or Sta. Fe River. In some spots, the embankment as well as the pavement are being washed out.

Mahaplag-Sogod Section

Since the opening of the section in 1978, months long traffic interruptions have occurred at least 5 times already, mainly due to continuous heavy rains and typhoons. The majority of slopes are still in unstable and the scale of failures are predicted to become bigger year by year, if no countermeasures are adopted.

The section about 16 kms north of Mahaplag is in flat and rolling terrain and runs along Layag River. The remaining section of about 20 kms is in steep mountainous terrain.

Of the total of 40 spots evaluated as disaster potential category A or B, 19 spots were identified as cut slope failure, 14 as embankment slope failure and 3 as landslides.

Rocks along the section are mainly andesite, tuff and sandstone which are fractured by the effect of the Philippine Fault. Therefore, these are easily eroded or scoured by surface water flowing down the slope during heavy rains.

The largest scale of cut slope failure exists at kms 1010 + 700 where the height of the slope is about 100 meters and deep gully valleys caused by scouring are observed on the slope. Large mass of soil falls down from the slope directly on to the road almost everytime during heavy rains causing the interruption of traffic.

Large scale embankment slope failures are also observed because the route is constructed along a deep valley. Scouring by surface water concentrated on the road surface have been the main cause of embankment slope failures in the section.

There are three spots of landslide noted. The main cause of the landslide in these spots is high groundwater level. At kms 1004 + 950 the slope continues to move causing upheaval of the road surface.

Kennon Road

Disaster along this road must have occurred many times during the last 47 years since its completion in 1937. However, no disaster records are available until two large scale disaster occurred in 1979 and 1980 when the road was closed to traffic for long periods. These disasters were caused by the damming up of Bued River caused by natural slope failure of the mountain on one side of the river. Apart from this special case, disasters do occur in other spots at an average of two times a year causing traffic interruption for one to three weeks.

About 30 kms from the town of Rosario where it starts, the road follows the generally mountainous terrain along the Bued river, then climbs up the mountain to Baguio City with steep gradients and many hairpin curves.

Of the total of 46 spots recorded, rock falls are dominant in 31 spots, followed with 9 spots of embankment slope fainlure and 5 spots with cut slope failure.

Rocks along the section are mainly conglomerate, limestone, andesite, and diorite. Since these are relatively hard with many open cracks. falls occur in many cut slopes.

The embankment slope failures are mainly due to scouring caused by Bued river and surface water concentrated from the road surface and the cut slope. A large scale of embankment slope failure which occurred at kms 227 + 500 in Ougust 1983 is mainly due to the fill material being saturated by seepage water.

A large scale of landslide exists near the end point of the road in Baguio City. It is said setting is at the rate of about 10 cm every year.

2.4 RECOMMENDED COUNTERMEASURES

Number of Designed Spots

As a general rule, preliminary design of the countermeasures was carried out only in spots classified under disaster potential categories A and B.

The number of spots where disaster countermeasure designed are listed in Table 2–1.

TABLE 2-1 NUMBER OF DESIGNED SPOTS

Type of Disaster	Section			
	Dalton Pass	Mahaplag–Sogod	Kennon Road	Total
Cut Slope Failure	39	19	5	63
Embankment Slope Failure	13	14	9	36
Fall	6	2	31	39
Landslide	–	3	1	4
Debris Flow	14	1	–	15
Others	1	1	–	2
TOTAL	73	40	46	159

Selection of Countermeasures

Various countermeasures commonly adopted in other countries have been studied in accordance with the types and the causes of disaster. These were closely examined with regard to effectiveness and practicability in this country. Various countermeasures are presented in the attached tables.

The countermeasures were selected in due consideration of geology, topography, surface water, groundwater and other conditions of each disaster spot. In addition to these local conditions, the following considerations were paid in the selection of countermeasures;

- Introduction of new technology on disaster prevention
- Minimal traffic obstruction during construction
- Harmony with the environment
- Minimal maintenance work

Table 2-2 shows the number of countermeasures by section and type of disaster in relation with type of countermeasure adopted in the preliminary design.

TABLE 2-2 TYPES AND NUMBER OF COUNTERMEASURES

Type of Countermeasures		No. of countermesures by section			No. of countermeasures by type of sisaster						TOTAL 159 sols
		Dallon Pass Section 73 spots	Mahoolog-Sogod Section 40 spots	Kennon Road 46 spots	C-S.F, D.F 63 spots	E-S.F, D.F 36 spots	C-F 39 spots	L.S 4 spots	O.F 15 spots	O.F 2 spots	
EARTH WORK	REMOVAL/RE-CUTTING	37	22	36	55	0	38	2	0	0	95
	RE-FILLING/COUNTER-WEIGHT FILL	13	15	5	1	30	0	1	1	0	33
DRANAGE WORK	SURFACE DRAINAGE	37	28	11	40	28	6	2	0	0	76
	SUBSURFACE DRAINAGE	11	17	4	2	28	0	2	0	0	32
PROTECTION WORK	VEGETATION	23	23	1	32	13	0	2	0	0	47
	SPRAYING	19	8	14	27	0	14	0	0	0	41
	CONCRETE CRIB	11	5	9	13	8	4	0	0	0	25
	PITCHING	9	1	0	0	9	0	0	0	1	10
CATCH WORK		3	3	22	1	0	27	0	0	0	28
STRUCTURAL WORK	STONE MASONRY	8	5	3	5	9	0	0	0	2	16
	GRAVITY TYPE	3	1	4	1	5	0	0	2	0	8
	SUPPORTED TYPE	1	1	3	0	4	1	0	0	0	5
	GABION RETAINING WALL	1	8	2	1	8	0	2	0	0	11
	ANCHORING	0	1	3	1	2	1	0	0	0	4
	PILING	0	0	1	0	0	0	1	0	0	1
TORRENT WORK	STONE PITCHING WATER WAY	13	2	0	1	0	0	0	14	0	15
	GABION FOOT PROTECTION	9	1	1	1	9	0	0	1	0	11
CONCRETE SABO DAM		11	0	0	0	0	0	0	11	0	11
CULVERT		6	2	2	0	2	2	0	4	2	10
TOTAL		215	143	121	181	155	93	12	33	5	479

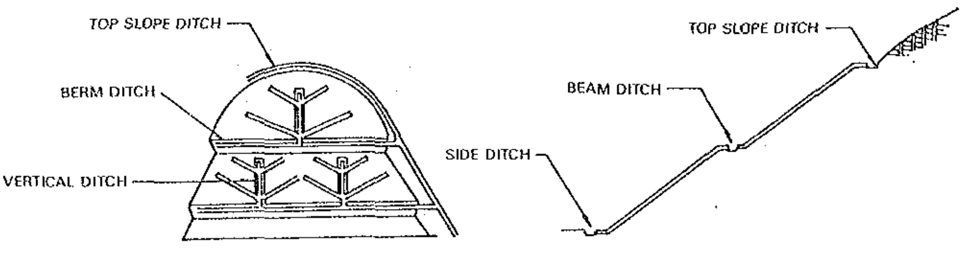
Type of Disaster

C–S, F, D.F Cut Slope Surface Falure, Deep Failure
E–S, F, D.F Emborkment Slope Surface Falkure, Deep Falkure
C–F Cut Slope Rock Call
L.S Landslide
D.F Debris Flow
O.F Overflow

Typical Countermeasures

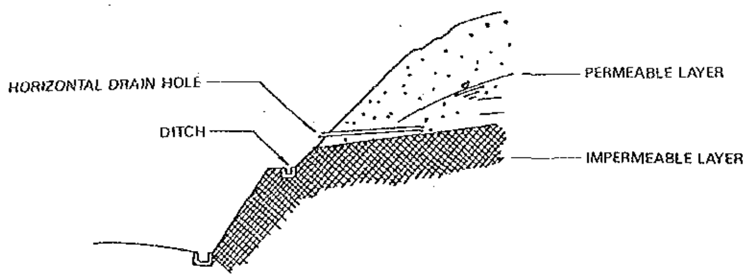
The following are typical countermeasures adopted.

Surface drain : Major cause of cut slope and embankment slope failures is surface water. Various kinds of ditches were applied in many sections. A side ditch is specifically planned for almost the whole section in Dalton Pass and Mahaplag-Sogod Sections.



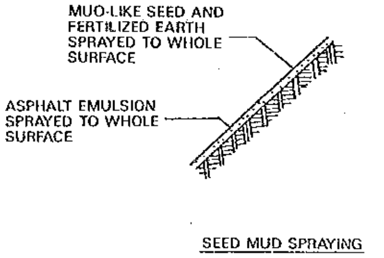
COMBINATION OF DITCHES

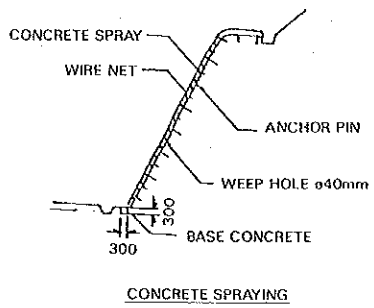
Subsurface drain : Horizontal drain holes were mainly applied for the spots of cut slope failue and landslide where seepage water was observed. In re-filled sections, horizontal drain holes were provided in the fill body to drain out seepage water from the ground.



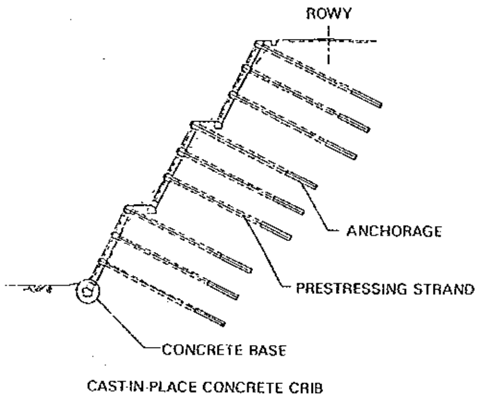
Re-cutting : Although re-cutting is one of appropriate countermeasures to ensure stability of cut slope with steep gradient, a large amount of excavation may disrupt traffic during the re-cutting. The application of re-cutting was avoided as much as possible, when traffic is anticipated to be greatly disturbed.

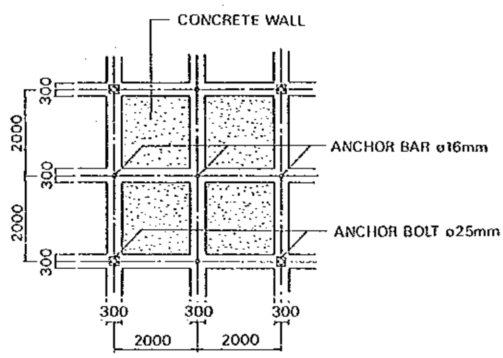
Slope protection : Except on slopes made out hard rock not susceptible to erosion and scouring, slope protection works were generally applied for all kinds of slope. Slope protection with vegetation works are applied for the slopes with soil and weathered rocks where vegetation can grow. For other slopes, concrete spraying, concrete pitching, stone pitching, concrete crib, etc. were applied.



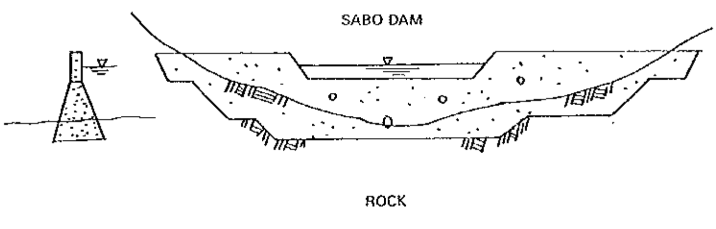


Structural Work : For steep and unstable cut and embankment slopes where the slope gradient can not be improved, such structures as stone masonry, gravity type retaining wall, cast-in-place concrete crib with P.C. anchor, which can resist lateral earth pressure, were applied.





Sabo Dam : This type of countermeasures in relation to waterway, was applied to prevent debris flow from spreading on road surface.



2.5 PROJECT COST

The project costs were estimated based on the unit cost analysis in October 1983 prices. The aggregate total cost of the three sections was estimated at 367.9 million pesos, of which foreign currency component amounts to 225.7 million pesos (or 61%) and local currency component including taxes to 142.2 million pesos (or 39%).

Construction cost of Dalton Pass Section was estimated at 157.42 million pesos, Mahaplag-Sogod Section at 81.20 million pesos and Kennon Road at 84.07 million pesos.

The cost for detailed engineering and construction supervision services were estimated respectively to be 7% of the construction cost. (See Table 2–3)

TABLE 2-3 PROJECT COST

Unit: Million Pesos

	October 1983 Price			Current Price[2]		
	Foreign	Local/Tax	Total	Foreign	Local/Tax	Total
Detailed Engineering	14.67	7.91	22.58	17.79	11.58	29.37
Construction Supervision	14.67	7.91	22.58	19.58	15.65	35.43
Construction[1] Dalton Pass Section	93.98	63.44	157.42	135.46	112.15	247.61
Mahaplag-Sogod Section	49.37	31.83	81.20	71.07	56.36	127.43
Kennon Road	52.96	31.11	84.07	76.09	55.26	131.35
Sub-Total	196.31	126.38	322.69	282.62	223.77	506.39
TOTAL	225.65	142.20	367.85	320.19	251.00	571.19

1/ Includes 10% physical contingency

2/ 1983 prices are escalated

2.6 PROJECT EVALUATION

The viability of the projects was evaluated mainly from the viewpoints of economic, technical and financial viability but considering as well in the final analysis the various socio-economic impacts contributed by the project.

Quantifiable benefits were mainly derived from savings on reduced vehicle operation costs, traffic efficiency and from construction and restoration related costs savings, as discussed briefly below. The assessment of the unquantifiable benefits from the projects is discussed under the Socio-economic Impact Evaluation.

1) Economic Evaluation

The economic viability of the project was evaluated on the basis of the following quantified benefits/savings:

Project Contribution	Quantified Benefits
• No traffic interruption	• Savings in detour cost
	• Savings in commodity opportunity cost
• Improved vehicle running condition	• Savings in traffic accident cost
	• Savings in travel time cost
• No restoration work	• Savings in restoration cost

. Savings in detour cost

Savings in detour cost were estimated based on assessments of the kinds of detour trips, detour lenghts, duration of traffic interruption, future traffic volume and basic vehicle operation costs.

. Savings in commodity opportunity cost

Interruption of cargo truck trips results in economic losses. However, in anticipation of possible traffic interruption during the typhoon season, additional commodity reserves or stocks are maintained to ensure adequate supply for normal operation of factories, stores, etc. In such a case, the commodities lose these opportunity cost.

This benefit was considered only for the Dalton Pass Section as basic commodities were found being reserved for the typhoon season period in the Cagayan Valley region.

. Savings in traffic accident cost

Based on the traffic accident records, the number of traffic accidents caused by road disaster was estimated. The unit cost of traffic accident suggested in the "Highway Planning Manual" of MPWH was up-dated and used to estimate this benefit.

. Savings in travel time cost

Even after urgent restoration work to make a road passable, one-lane traffic operation remains and road surface as well remains in bad condition. Under such circumstances, drivers tend to reduce speed, resulting in loss of travel time. These benefits were estimated based on travel time results and in relation with duration of restoration work.

. Savings in restoration cost

Based on the predicted scale of damage by a large typhoon and a typhoon attack pattern, average annual cost for restoration work was estimated. Estimated costs were compared with previous Government expenditures on restoration works of similar situations.

A 20-year project life was assumed in the analysis. The results of the cost-benefit analysis and sensitivity analysis are presented in Table 2-4.

TABLE 2-4 RESULTS OF ECONOMIC ANALYSIS

		IRR (%)		
		Dalton Pass Section	Mahaplag – Sogod Section	Kennon Road
	Best Estimate Case	18.7	14.4	16.6
SENSITIVITY ANALYSIS	Case – 1 (Cost – 20 %)	22.5	17.7	20.1
	Case – 2 (Cost + 20 %)	16.0	12.0	14.0
	Case – 3 (Benefit + 20 %)	21.8	17.1	19.4
	Case – 4 (Benefit – 20 %)	15.4	11.5	13.4
	Case – 5 (Cost – 20 %, Benefit + 20 %)	26.0	20.7	23.3
	Case – 6 (Cost + 20 %, Benefit – 20 %)	12.9	9.3	11.1

2) Financial Evaluation

The maximum budget allocation for the local cost component in a single foreign assisted project in 1983 was 253 million pesos equivalent to about 1/12 of the total budget for construction/improvement of national roads. In the 5–year (1983–1987) highway investment program of the country the ratio of the possible allocation for the local cost component in a single project to that of the total yearly budget is estimated at 1/15, 1/25 and 1/40 for high, medium and low assumptions respectively. The medium assumption of 1/25 is, however, taken as the most realistic.

The maximum local fundings requirement of the Project with the six-year implementation period (1985–1990) is estimated to occur in 1989 at 97.3 million pesos in current prices which almost equivalent to the estimated possible amount of local budget allocation under the medium assumption.

TABLE 2-5 POSSIBLE AMOUNT OF BUDGET ALLOCATION
– CURRENT PRICE –

Unit : Million Pesos

Year	Estimated Budget from Major Roads[1/]	Possible Amount of Local Budget Allocation To a Single Project			Required Investment of the Project
		Low Assumption	Medium Assumption	High Assumption	
1983	3,155	79	126	210	–
1984	2,311	58	92	154	–
1985	2,137	53	85	142	1.1
1986	2,255	56	90	150	10.5
1987	2,338	58	94	156	10.6
1988	2,398	60	96	160	79.5
1989	2,590	65	104	173	97.3
1990	2,660	67	106	177	52.0

[1/] MPWH Medium Term Infrastructure Program

3) Socio-Economic Impacts

Benefits which could not be easily quantified but which have direct socio-economic impact within the influence areas were assessed for each project and are summarized as project impacts. Generally, traffic interruption due to road disasters adversely affects socio-economic activities in the influence areas of a section. These adverse impacts of the "without project" case which are described hereunder will be alleviated when the projects are implemented.

Dalton Pass Section

- The total population in the influence area of the project is estimated about 2.2 million in 1983 and 3.7 million in 2010.
- Transport of basic commodities for daily life consumption in the Cagayan Valley Region amounting to 1,900 tons/day in 1983 can not be assured without the project.
- Intentional price increases, social uneasiness and unstable peace and order situation could be induced due to inaccessibility to the region.
- Transport of major products from Cagayan Valley Region to Metro Manila can not be assured under the present conditions of the section. Forty percent of the demands of rice and logs/lumbers in Metro Manila are supplied from the region.
- Traffic flow of 2,100 veh/day and commodity flow of 8,200 tons/day (both in 1983 volume) will be seriously interrupted during disasters.
- An additional 300 to 400 kilometers in detour route will be needed to complete a trip from Manila to Cagayan Valley and vice versa. This detour trip will require additional transport cost of 600 pesos for passenger vehicle.
- The Manila North Road which is at present the only logical alternative route, will be congested for a stretch of about 680 kilometers in the year 2000 if traffic diverts into this route.
- Economic return from investments in other developmental projects such as the Cagayan Integrated Rural Development Project will be hindered.
- Overall economic development of the region will substantially slow down.

Mahaplag-Sogod Section

Without the project:

- Wide areas extending about 150 kilometers will be affected including 300,000 persons in 1983 and 430,000 persons in the year 2010.
- Transport of basic commodities for daily life consumption in Southern Leyte of about 90 tons/day (1983) can not be assured.
- Intentional price increase, social uneasiness and unstable peace and order situation could be induced.
- Medical services, educational and social amenities could be seriously affected.

- Disparity in per capita income between national average and Southern Leyte will be further widened. Per capita income of Southern Leyte is, at present, only a half of the figure of the national average.
- Effective use of ferry services between Leyte and Mindanao will not be realized resulting in the loss of economic returns of the ferry service project.

Kennon Road

- Delivery of basic commodities for daily life consumption in Baguio City estimated at 700 tons/day (1983) will have to follow a longer route.
- Community centered at Baguio City and extended along the road will be divided into two. About 2,300 commuters and students will be stranded.
- Tourist industry of Baguio City could substantially suffer some serious set backs resulting to further economic loss.
- Traffic flow of 1,800 veh/day and commodity flow of 1,200 tons/day (both in 1983 volume) will be disturbed.
- Naguilian Road and Manila North Road, an alternative route, will suffer traffic congestion for a stretch of about 100 kilometers, if Kennon Road is closed.
- Productivity of Export Processing Zone in Baguio City could be affected drastically.
- When all the three roads are damaged by a strong typhoon and closed to traffic, Baguio City could be considered completely isolated.

4) Overall Evaluation

Dalton Pass Section

- The best estimate of the Internal Rate of Return (IRR) of the Project in the Dalton Pass section is 18.7%. Results of the sensitivity analysis performed show that except in the worst case (cost + 20%; benefit – 20%) the IRRs exceed 15% in all cases.
- The section have suffered destructive road damages twice in seven years, resulting in traffic interruption for about a month, respectively. The section would suffer the same again, if no measures are taken immediately, as it contains a large number of spots with high disaster potential amouning to 73.
- In the year 2010, 8,500 vehicles and 26,400 tons of commodities will be transported daily through this section. Occurrence of a road disaster will seriously affect the socioeconomic activities within the influence areas particularly the Cagayan Valley Region.
- The Project will enhance the economic development resulting to increase productivity of which shares 2.8% at present in the overall GRDP of the country.

Implementation of disaster prevention work of this section is feasible as indicated by its economic rate of return as well in consideration with the various favorable impacts on social and developmental activities which could be also induced by the project.

Mahaplag-Sogod Section

- The best estimate of the IRR is 14.4%.
- The extent of road disaster in this section which is now serious will increase year by year, if countermeasures are not implemented. Technical assessment suggest that countermeasures for road disaster should be undertaken immediately, otherwise, the section would be totally destroyed in the near future.
- The section will be critical to the efficient operation of the ferry service between Leyte and Mindanao, which will be operational in 1984, as well as to effect the linkage of vehicle traffic along four major islands in the country by way of the Maharlika Highway.

Despite the marginal economic feasibility of the project in this section, it is, nevertheless, a project worthwhile undertaking considering its important role in the overall highway system of the country and its related socio-economic impact upon the direct influence area. Furthermore, it is reiterated that the problems and potentialities of disasters in the section are quite serious and to delay the implementation of the proposed countermeasure works will only aggravate the situation that can only lead to higher project costs and investment requirements later on.

Kennon Road

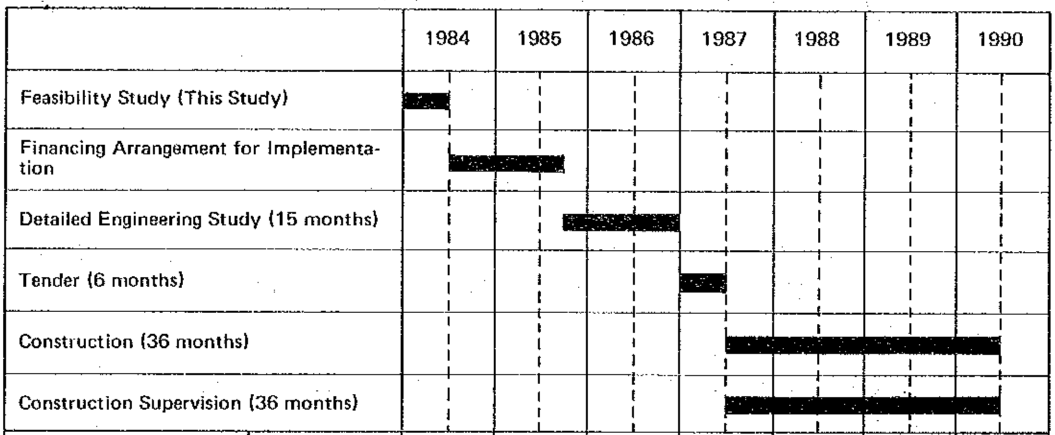
- The best estimate of IRR of the project along the Kennon Road is 16.6%.
- 46 spots with high disaster potential concentrated causing traffic interruption for one to three weeks every year. Even a small scale road disaster greatly affects traffic flow on the road due to narrow roadway and shoulders. Road users are always exposed to danger of being hit by falling rocks and the like, resulting in high incidence of traffic accidents caused by road disasters.
- Baguio City must be provided with at least one reliable and all-weather access roads. Kennon Road, the shortest route to link Baguio City and Metro Manila, should be given top priority.
- The project when realized, will substantially enhance the development of the tourism industry, vegetable and other agricultural production, and the overall socio-economic well-being of the population served.

The project is feasible in terms of its economic rate of return and various favorable impacts to the social and developmental activities in Baguio City and adjacent provinces.

2.7 PROJECT IMPLEMENTATION

Recommended implementation schedule and annual financial requirements broken down into foreign and local currency components are presented in Figure 2--3.

FIGURE 2-3 IMPLEMENTATION SCHEDULE



		1984	1985	1986	1987	1988	1989	1990
Financial Requirement – October 1983 Price – Unit : Million Pesos	Foreign Component	–	1.47 (1.70)	13.20 (16.09)	10.55 (13.69)	73.85 (101.18)	84.39 (122.61)	42.19 (64.92)
	Local and Tax Component	--	0.79 (1.06)	7.12 (10.52)	6.72 (10.59)	47.00 (79.54)	53.71 (97.25)	26.86 (52.04)
	TOTAL	–	2.26 (2.76)	20.32 (26.61)	17.27 (24.28)	120.85 (180.72)	138.10 (219.86)	69.05 (116.96)

Note : Figure in ( ) shows financial requirement in current price.

3. GENERAL REVIEW OF DISASTER PREVENTION MEASURES

In accordance with the implementing arrangement of the Study, a report entitled "An Approach on Road Disaster Prevention" was prepared. This report basically consolidates the findings of the research works and assessments conducted along the project roads in the course of the Study.

The emphasis of the review was given to the causes and problems on cut slope failures, embankment slope failures, rock falls, landslides, debris flow. Large scale riparians and sabo works were excluded.

This report is organized with the following five (5) parts.

PART I : GENERAL
PART II : IDENTIFICATION AND SURVEYS
PART III : DESIGN OF SLOPES AND SLOPE PROTECTION WORKS
PART IV : COUNTERMEASURES FOR ROAD DISASTERS
PART V : ADMINISTRATION AND MAINTENANCE

Road disasters are classified in accordance with their nature as described in Chapter 2 of PART I – CLASSIFICATION OF ROAD DISASTERS.

Potential of disaster spots are evaluated in accordance with the established rating method, with some modifications whenever deemed necessary, discussed in Chapter 3 of PART II – IDENTIFICATION OF ROAD DISASTERS.

The methodology of the surveys and analysis required for identified types of road disaster are presented in Chapter 4 of PART II – SURVEY FOR ROAD DISASTERS.

The outline of design of cut slope, embankment slope, drainage, protection works and retaining wall, which are the most fundamental methods as countermeasures, are discussed from Chapters 5 to 9 of PART III – DESIGN OF SLOPES AND SLOPE PROTECTION WORKS.

The types, the purpose and the application of countermeasures and the procedure in selecting the most appropriate countermeasure for the different types of disaster are discussed in Chapters 10 to 14 of PART IV – COUNTERMEASURES FOR EACH TYPE OF DISASTERS.

The recording of disaster and traffic control and information system during the occurance of disaster are mentioned in Chapter 15 of PART V – ADMINISTRATION.

Required maintenance works for road disasters including periodical and emergency cases are covered in Chapter 16 of PART V – MAINTENANCE.

IV PROPOSITION BASED ON FINDINGS

IV PROPOSITON BASED ON FINDINGS

It should be realized that the effects of disaster along the roads, without exception, are potential to be grave and severe if no protection works or countermeasures are adopted and can cause a lot of inconviniences or inflict substantial damages to lives and property.

Cognizant of the seriousness of the problems related to road disasters, it would thus be logical at this point to consider ways and means not only in finding immediate solutions, but perhaps in the longer term, a more systematic approach in considering the solutions to the problems. To do this several initial steps are suggested hereunder.

1) RECORD OF DISASTER

The records of heavy rain, typhoon, and calamity should be comprehensive and systematically compiled. These records can provide the basic engineering data to be analyzed for the identification of disaster spots, the frequency of the occurrence of disaster, and the selection of the appropriate countermeasures. The informations to be covered are topography, geology, influence of water, cause and size of road disaster, precipitation and the like.

The format prepared in the study is recommended for this purpose.

2) INVESTIGATION OF DISASTER POTENTIAL SPOT

All spots where failures are likely to occur should be identified and recorded by the concerned agencies. The availability of the data will enable those concerned to prepare and install appropriate warning signs at specific location for the information of the road users. Moreover, with the availability of such records, the engineering approach to the solution of the problem can be developed and corresponding preventive measures can be formulated.

The check table used in the study is recommended for the purpose.

3) PROVISIONAL REMEDIAL MEASURE

The study shows that the main cause of road disaster is water and the simple measures recommended to control water include;

- provision of earth ditch
- provision of drainage facilities for groundwater and spring water such as horizontal drain hole and closed conduits
- utilization of gabion, whenever applicable

4) ROAD ALIGNMENT

As mentioned in sections 1.3 and 2.2, the Maharlika Highway runs parallel to the Philippine Fault as a result of which large scale slope failures have occurred, the protection works needed are more extensive.

In the planning of new road alignment, a more comprehensive route study is suggested. Alternative routes should be evaluated according to the road functions, costs and extent of disaster control works.

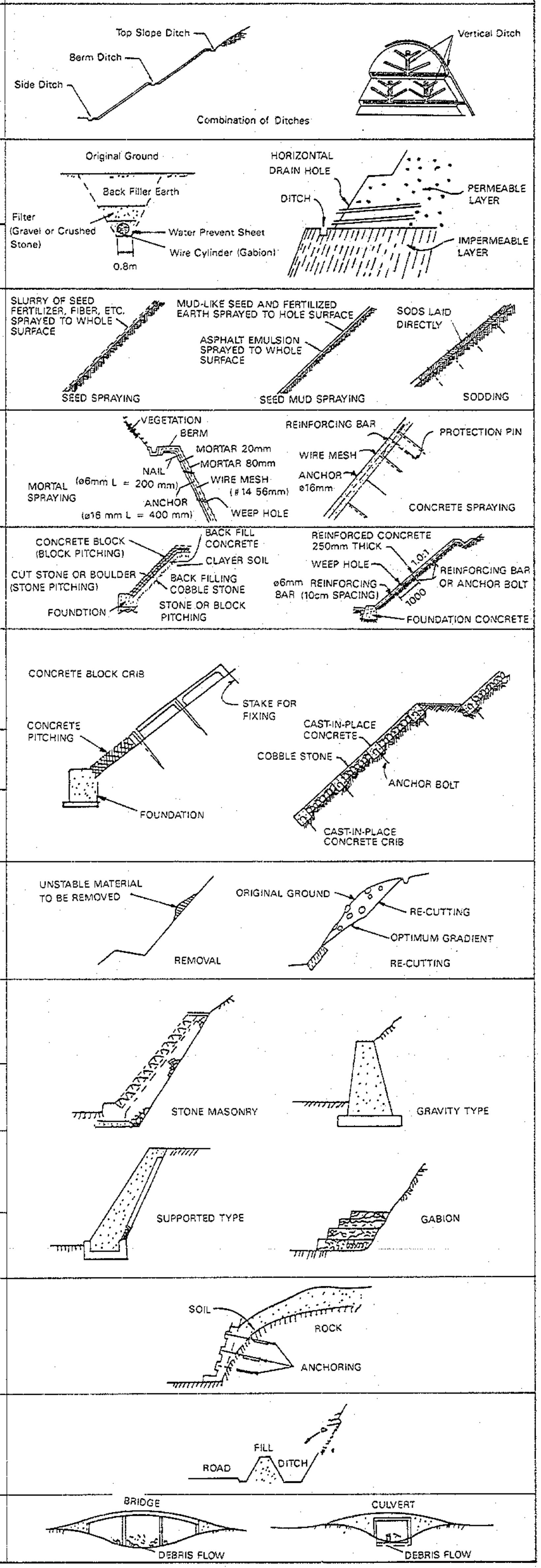
5) DISASTERS BEYOND THE SCOPE OF HIGHWAY WORKS

Some spots along the existing roads are heavily damaged mainly due to meandering or alterating river channel, large scale debris flow, devastation of hillside caused by mining activities, etc. Countermeasures to solve these problems normally involve large scale riparian works, sabo dam, hillside works, etc., which are all beyond scope of highway works. In such cases, it is recommended that coordination with various sectors and/or agencies concerned be initiated as soon as possible to prevent further damage on the road section. For new highways, these problems should be anticipated and considered in the overall project implementation.

ATTACHED TABLES

COUNTERMEASURES FOR CUT SLOPE FAILURE

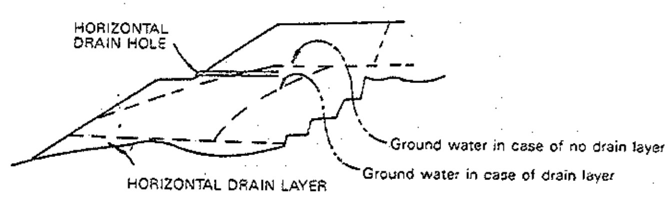
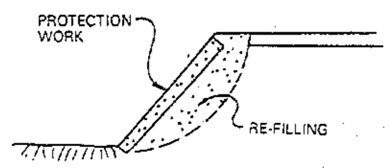
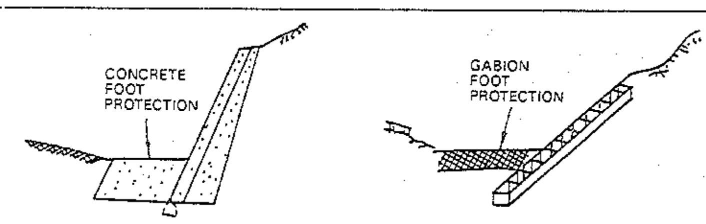
Work	Classification	Type of Work	Purpose	Application	Illustration
Drainage Work	Surface Drainage	Top slope Ditch	To collect surface water running directly on slope surface and thus prevent erosion and scouring of slope surface.	Required for almost all cases of slope protection, especially for slope with broad area or water concentration. Usually applied together with other countermeasures.	
		Berm Ditch			
		Side Ditch			
		Vertical Ditch			
	Subsurface Drainage	Subsurface Drainer	To drain groundwater, spring water and seepage water and lower pore with pressure and thus stabilize stability of slope.	Effective to drain water near ground surface. Generally used in combination with surface drainage.	
		Horizontal Drain Hole		Effective for slope where ground-water level is higher than plane of failure.	
Protection Work	Vegetation	Seed Spraying	To firmly bind materials of slope surface and thus prevent slope from erosion, scouring and weathering.	Mainly applied to slopes composed of soil or strongly weathered rock. When applied, gradient is preferred to be less than 0.8:1. It improves aesthetics view of the environment.	
		Seed Mud Spraying			
		Sodding			
	Spraying	Mortar Spraying	To cover whole surface of slope with mortar or concrete sprayed by concrete gun and thus prevent slope from erosion, scouring and weathering.	Mainly applied to slope of. . Easily weatherable rock with no spring water or not wet. . Weathered rock which may be stripped off. . Soil not suited for vegetation.	
		Concrete Spraying			
	Pitching	Stone or Block Pitching	To cover slope with stone, or concrete block or cast-in-concrete and thus prevent slope from erosion, scouring, weathering and slight surface failure.	Applied to slope gentler than 45°. Stone pitching is widely adopted.	
		Concrete Pitching			
	Crib	Concrete Block Crib	To prevent slope from erosion, scouring, weathering and slight surface failure. / Resisting force against earth pressure may not be expected.	Applied to slope gentler than 45°. Effective for slope with spring water.	
		Cast-in-place Concrete Crib			
		Sprayed concrete crib	Resisting force against earth pressure may be expected depending on size and space of crib.	Applied to slope steeper than 45°. Effective for weathered rock and large slope with spring water. *1 / *2	
Earth Work		Removal	To stabilize slope by completely or partially removing unstable materials on slope.	Basic method. Reliable when perfectly enforced. Applied together with drainage, vegetation and other protection works. Application is sometimes limited because of traffic interruption.	
		Re-cutting	To stabilize slope by cutting to optimum gradient.		
Structural Work	Retaining Wall	Stone Masonry Retaining Wall	To protect slope from small size failure, especially, near toe of slope.	Effective only for small earth pressure. Applied to slope with gradient steeper than 45° and with firm soil. Height less than 7 m.	
		Gravity Type Retaining Wall	To directly restraint slope failure or used as a foundation of other works.	Strong bearing ground is required. Height less than 5 m.	
		Supported Type Retaining Wall	To directly restraint slope failure and prevent erosion, scouring and weathering.	Applicable for soil with loose solidification. It can be constructed in limited area. Height less than 8 m.	
		Gabion Retaining Wall	To protect slope from small size failure, especially near toe of slope.	Effective for slope with seepage or spring water.	
	Anchoring	Rock Bolt	To directly restraint slope failure. Usually applied together with concrete pitching crib, etc.	Mainly applied to slope with strongly weathered rock or rock with many cracks and joints. Rock bolt is for small tension against anchoring, while p.c. is for high.	
		P.C. Anchor			
Catch Work		Catch Fill and Ditch	To prevent spread of damage providing ditch and fill or wall to catch failured materials. Occurance of failure can not be prevented.	Applied when other countermeasures are difficult or costly. Wide space for deposite is required between road edge and toe of slope.	
		Catch Wall			
Avoiding Problem Work		Route Relocation	To avoid problem by relocating route or pass over disaster site with bridge.	Applied when other countermeasure are difficult or costly.	
		Bridge			



Note: *1. Irregularity of slope surface shall be corrected. Form is required.

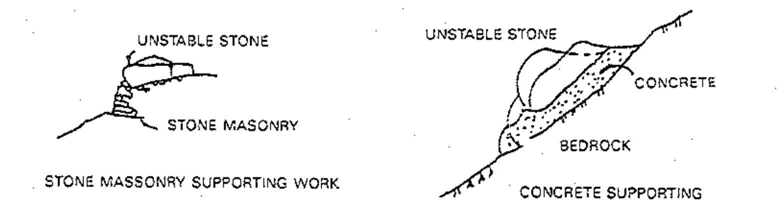
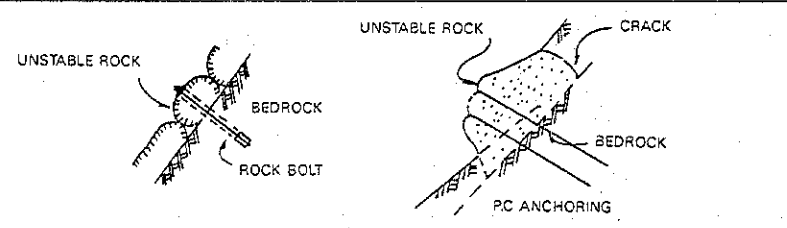
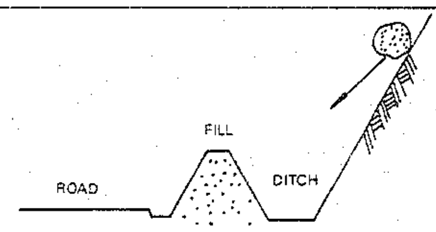
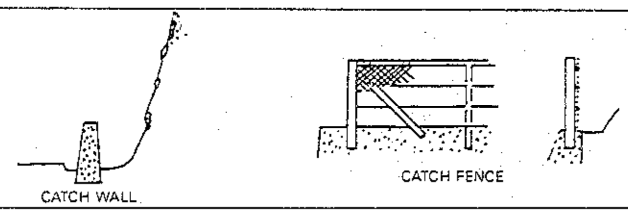
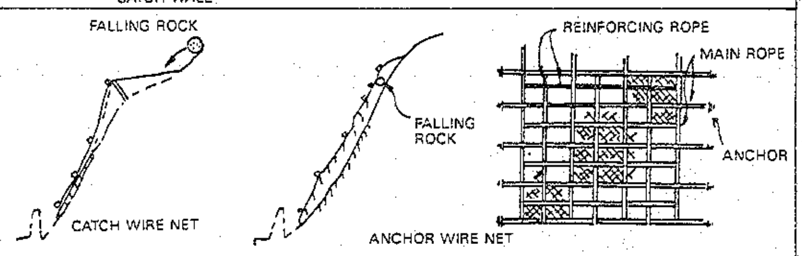
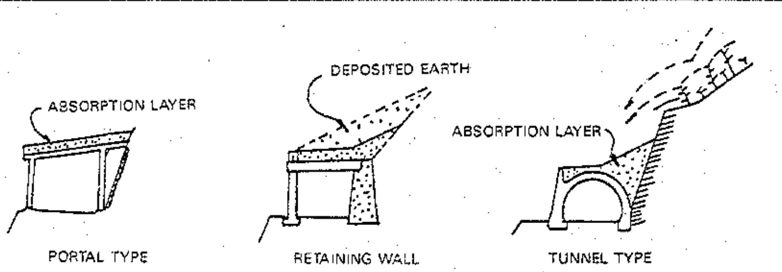
*2. Irregularity of slope surface is not necessary to correct. Form is required. Concreting is done by spraying with gun.

COUNTERMEASURES FOR EMBANKMENT SLOPE FAILURE

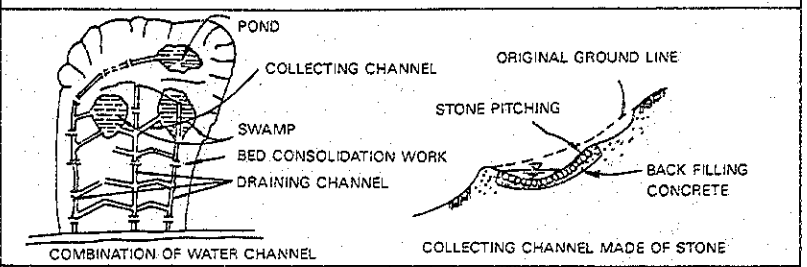
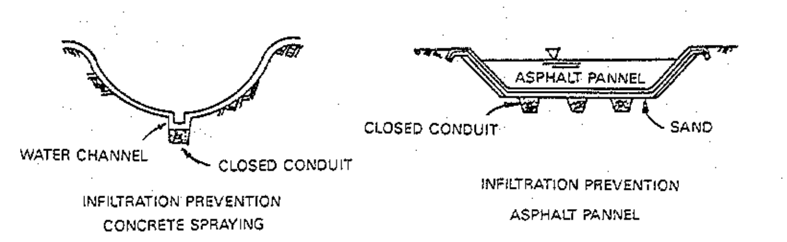
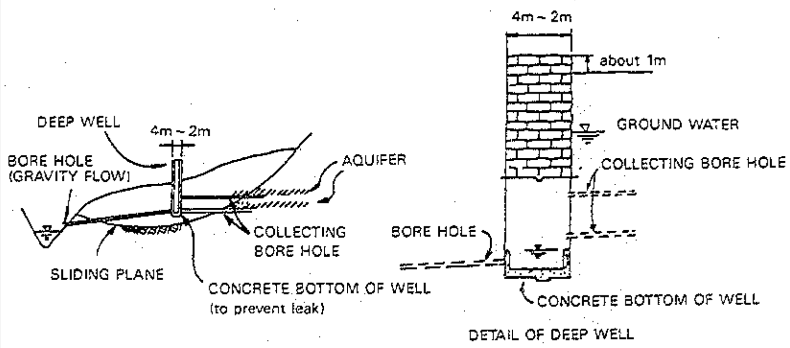
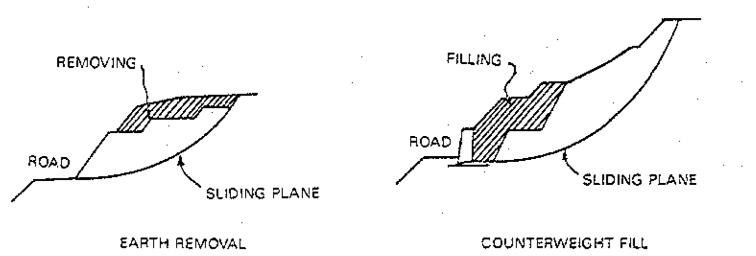
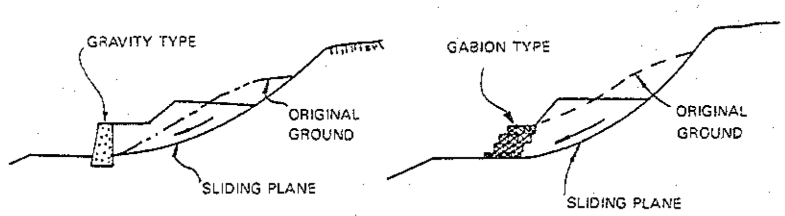
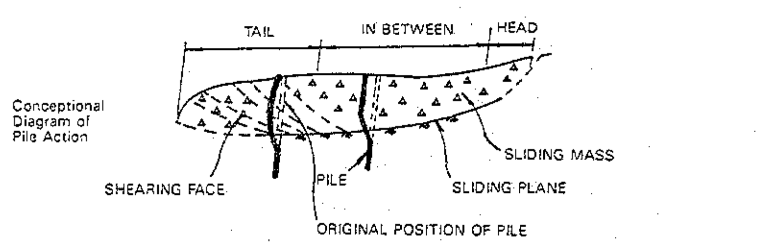
	Classification	Type of Work	Purpose	Application	Illustration
Drainage Work	Surface Drainage	Berm Ditch	Same as Countermeasures for Cut Slope Failure	Same as Countermeasures for Cut Slope Failure	Same as Countermeasures for Cut Slope Failure
		Side Ditch			
		Vertical Ditch			
	Subsurface Drainage	Subsurface Drainer	To drain groundwater, spring water and seepage water and lower pore water pressure and thus stabilize stability of slope.	Effective to drain shallow surface water.	
		Horizontal Drain Hole		Mainly applied to high embankment which is already or may be saturated. Effective for slope where groundwater level is higher than plane of failure.	
		Horizontal Drain Layer			
Protection Work	Vegetation	Seed Spraying	To firmly bind materials of slope surface and thus prevent slope from erosion, scouring and weathering.	Should be applied to any slope. It also improves aesthetics view on environmental aspect.	Same as Countermeasures for Cut Slope Failure
		Seed Mud Spraying			
		Sodding			
	Pitching	Stone or Block Pitching	To prevent erosion and scouring slight resisting force to protect surface failure may be expected.	Mainly applied to slope gentler than 45° of high embankment susceptible to scouring.	
	Crib	Concrete Block Crib	To prevent erosion, scouring and slight surface failure. Resisting force against earth pressure may not be expected for block crib, but expected for cast-in-place crib.	Applied to slope with broad area or steeper than 45° where vegetation can not be applied or not effective.	
		Cast-in-place Concrete with form			
Earth Work		Re-Filling	To fill washed-out and broken-off portion of slope with earth and then, usually cover surface with protection in order to prevent further failure.	Applied to collapsed slope. Usually applied with other measures such as vegetation or pitching.	
				For scouring due to river stream, concrete crib is also used.	
Structural Work	Retaining* Wall	Stone Masonry Retaining Wall	Same as Countermeasures for Cut Slope Failure	Same as Countermeasures for Cut Slope Failure	Same as Countermeasures for Cut Slope Failure
		Gravity Type Retaining Wall			
		Supported Type Retaining Wall			
		Gabion Retaining Wall			
	Foot Protection	Concrete Foot Protection	To protect foot of retaining wall or other protection work.	Applied to foot which may be scoured by river stream.	
		Gabion Foot Protection			

* Retaining wall is sometimes called as revetment, when it is used to protect scouring of slope due to river stream.

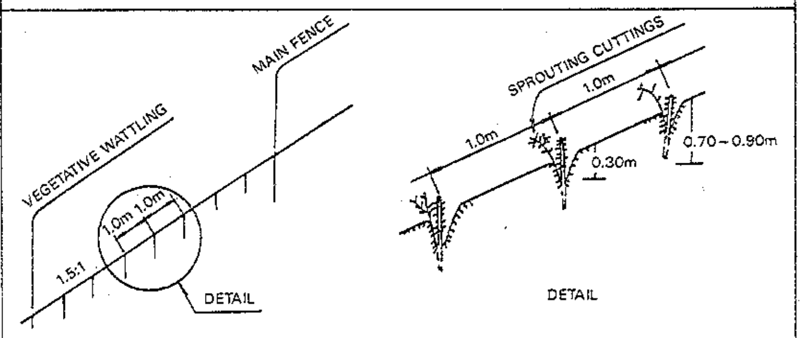
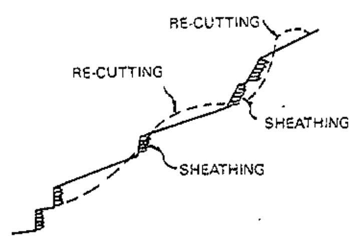
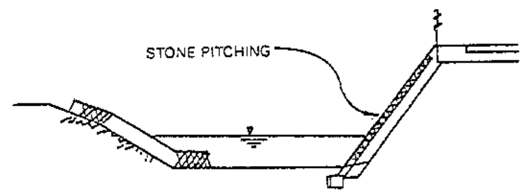
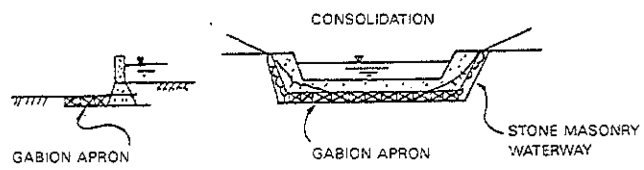
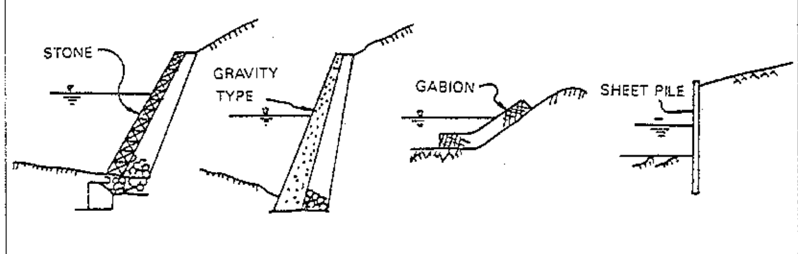
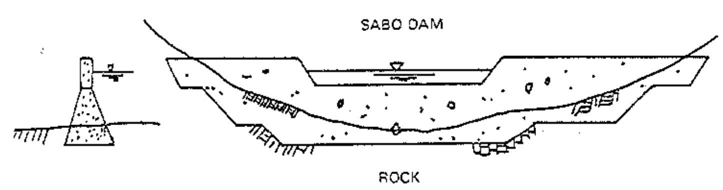
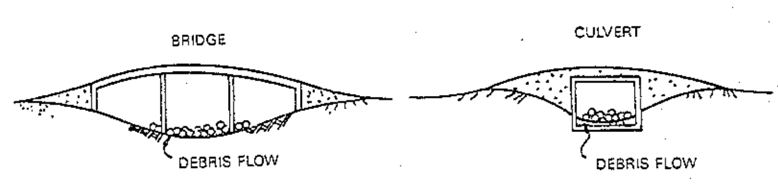
COUNTERMEASURES FOR FALL

Classification		Type of Work	Purpose	Application	Illustration
Drainage Work	Surface Drainage	Top Slope Ditch			
		Berm Ditch			
		Vertical Ditch			
	Vegetation	Seed Spraying			
		Seed Mud Spraying			
		Sodding			
Protection Work	Spraying	Mortar Spraying	Same as Countermeasures for Cut Slope Failure		Same as Countermeasures for Cut Slope Failure
		Concrete Spraying			
	Pitching	Stone or Block Pitching	It also aims to prevent rocks from separating and detaching from ground or bedrock.		
		Concrete Pitching			
	Crib	Concrete Block Crib			
		Cast-in-Place Concrete Crib with form			
		Sprayed concrete crib			
Earth Work		Removal	Same as Countermeasures for Cut Slope Failure		Same as Countermeasures for Cut Slope Failure
		Re-cutting			
Fixing Work	Supporting	Stone Supporting	To fix unstable rock supporting with stone or concrete.	Mainly applied to big and supportless rock difficult to remove. Base of supporting shall be firmly shored.	
		Concrete Supporting			
	Anchoring	Rock Bolt	To fix unstable rock anchoring to bedrock with rock or p.c. wire.	Mainly applied to big, hard and supportless rock difficult to remove. Anchoring shall be made into firm bedrock. Rock bolt for relatively small rock, while p.c. for boulders.	
		P.C. Anchor			
Catch Work		Catch Fill and Ditch	To prevent spread of damage by providing fill and ditch, wall or fence to catch falling materials. Occurrance of fall can not be prevented.	Wide space for deposite is required between road edge and toe of slope.	
		Catch Wall		A little wide space for deposite is required between road edge and toe of slope. Space for wall or fence is narrower than for fill and ditch.	
		Catch Fence			
		Catch Wire Net	To prevent spread of damage covering slope by net with pocket to catch falling rocks.	Applied where no space for deposite. Unsuitable to soil and rock slope which are easily weathered.	
		Anchor Wire Net	To provide resisting force to fall directly by covering slope with net but inefficient to prevent erosion and scouring.		
Rock Shed		Concrete Rock Shed	To avoid damage by covering whole width of road with shed.	Mainly applied to a large scale of fall. Applied only when other countermeasures are difficult and costly.	
		Steel Rock Shed			

COUNTERMEASURES FOR LANDSLIDE

Classification		Type of Work	Purpose	Application	Illustration
Drainage Work	Surface Drainage	Water Channel	To quickly collect and discharge precipitated rain inside landslide area in order to prevent seepage water.	Applied to all cases. Water channel consists of collecting channel and draining. Effective channel network is required.	
		Infiltration Prevention	To cover cracks with cement, clay or other materials in order to prevent seepage of water into cracked portion inside landslide area.	Applied to call cases. Effective for cracked portion where seepage water easily infiltrates and on swamp or water route.	
	Subsurface Drainage	Subsurface Drainer	To drain groundwater and thus lower its level and pore water pressure.	Effective where groundwater level is higher than sliding plane.	
		Horizontal Drain Hole			
		Deep Well		Applied when drain hole is too long or crowdedly placed near bedrock.	
Protection Work	Vegetation	Seed Spraying	To prevent seepage of surface water into slide mass and also to protect slope from erosion and scouring.	Applied to all cases, whenever applicable. Applied to bare area.	Same as Countermeasures for Cut Slope Failure
		Seed Mud Spraying			
		Sodding			
Earth Work		Earth Removal	To stabilize slope by removing a partial or whole earth of sliding mass, usually head portion of sliding mass.	Reliable and effective method. Applied to many cases.	
		Counterweight. Fill	To control movement force of landslide by weight and shearing strength of fill. Filling of earth shall be executed at tail portion of landslide.	Wide area is required at toe of slide for construction. Groundwater shall be completely discharged.	
Structural Work	Retaining Wall	Gravity Type Retaining Wall	To control movement force of landslide, increasing resisting force by shear strength and weight of fill and wall. Anchoring is sometimes used to increase resisting force of wall against thrust of landslide.	Mainly applied to small scale landslide or secondary failure at tail portion of a large scale landslide. Gabion wall is mainly used as counterweight for tail portion of landslide.	
		Gabion Retaining Wall			
	Piling	Precast Concrete Pile	To control movement force of landslide by bending movement and shearing strength of pile. Anchoring is sometimes used to increase resisting force of pile against thrust of landslide.	Mainly applied to landslide where sliding plane is deep.	
		Cast-in-Place Concrete Pile			
		Steel Pile			

COUNTERMEASURES FOR DEBRIS FLOW

Classification		Type of Work	Purpose	Application	Illustration
Hillside Work	Drainage	Water Channel	To collect surface water on hillside and thus prevent slope from erosion and scouring.	Applied to many cases. Used with other counter-measures.	Same as Countermeasures for Landslide
		Subsurface			Same as Countermeasures for Cut Slope Failure.
	Vegetation		To firmly bind materials of slope surface and thus prevent slope from erosion and scouring.	Vegetation is usually applied in combination with protection work such as terracing with stone, net muddling, etc.	
	Afforestation		To cover hillside with tree and shrub and thus prevent slope from erosion and scouring and sometimes to reduce velocity of surface water.	Applied to bare hillside.	
	Re-cutting		To stabilize slope by cutting unstable portion of hillside and reforming irregularity of surface of slope.	Applied to hillside with irregularity Used with vegetation, sheathing and others.	
	Sheathing		To retain unstable earth with stone or concrete wall or wicker etc.	Applied to a little steep slop where earth shall be retained. Mainly used with other hillside work.	
Torrent Work	Water Way	Stone Pitching Water Way	To smoothly lead flow of water and thus control turbulent flow and prevent scouring of stream bed and bank. Also to prevent overflow of flood to adjacent area.	Applied to stream bank composed of erodable soil or to stream bed with steep gradient. Usually used together with consolidation or sabo dam.	
		Concrete Pitching Water Way			
	Consolidation	Stone Consolidation	To control flow of water providing head of water to make gradient of stream bed gentler and to prevent turbulent flow and thus prevent scouring of stream bed and bank. Sometimes only to protect stream bed.	Applied to swift stream, meeting point of flow or stream bed susceptible to scouring. Usually used together with revetment, water way and sabo dam. Concrete consolidation is widely used.	
		Concrete Consolidation			
		Crib Consolidation			
	Revetment	Stone Masonry Revetment	To protect stream bank or hillside from waterclash due to curved flow of stream.	Applied to curved portion of stream.	
		Gravity Type Revetment			
		Gabion Revetment			
		Sheet Pile Revetment			
	Foot Protection	Concrete Foot Protection	To protect foots of revetment and water way from scouring.	Applied to foots of revetment and water way.	Same as Countermeasures for Embankment Slope Failure
		Gabion Foot Protection			
Sabo Works	Sabo Dam	Stone Dam	To control flow of debris and to catch and collect debris and sand, providing space for deposited materials and making gradient stream bed gentler and thus avoid spread of damage and, at the same time, prevent scouring of stream bed and bank.	Mainly applied to large scale of debris flow. Constructed at portion such as narrow stream width, hard bedrock or after meeting of flow.	
		Concrete			
		Concrete Dam			
		Steel Dam			
Avoiding Problem Work		Bridge	To avoid damage. Debris flows passes under bridge or inside of culvert.	Applied when other counter-measures are difficult and costly.	
		Culvert			

* Structural details of revetment may be same as those of retaining wall.

ATTACHMENT: BASIC INFORMATION OF THE PROJECT

BASIC INFORMATION OF THE PROJECT

1. NAME OF FEASIBILITY STUDY SECTIONS

- Dalton Pass Section .... 77.5 km
- Mahaplag-Sogod Section .... 36.7 km
- Kennon Road .... 34.2 km

TOTAL 148.4 km

2. NUMBER OF DISASTER SPOTS

TABLE-A NUMBER OF DISASTER SPOTS

Sections	Types of Disaster						
	Cut Slope Failure	Embankment Slope Failure	Fall	Landslide	Debris Flow	Others	Total
Dalton Pass	39	13	6	—	14	1	73
Mahaplag-Sogod	19	14	2	3	1	1	40
Kennon	5	9	31	1	—	—	46
TOTAL	63	36	39	4	15	2	159

3. INTERNAL RATE OF RETURN

TABLE-B IRR

Section	IRR (%)
Dalton Pass	18.7
Mahaplag-Sogod	14.4
Kennon	16.6

Project Life: 20 Years

4. PROJECT COST

TABLE-C PROJECT COST

Unit: Million Pesos

	October 1983 Price			Current Price		
	Foreign	Local/Tax	Total	Foreign	Local/Tax	Total
Detailed Engineering	14.67	7.91	22.58	17.79	11.58	29.37
Construction Supervision	14.67	7.91	22.58	19.58	15.65	35.43
Construction Dalton Pass Section	93.98	63.44	157.42	135.46	112.15	247.61
Mahaplag-Sogod Section	49.37	31.38	81.20	71.07	56.36	127.43
Kennon Road	52.96	31.11	84.07	76.09	55.26	135.35
Sub-Total	196.31	126.38	322.69	282.62	223.77	506.39
Total	225.65	142.20	367.85	320.19	251.00	571.19

5. RECOMMENDED IMPLEMENTATION SCHEDULE

TABLE-D IMPLEMENTATION SCHEDULE

		1984	1985	1986	1987	1988	1989	1990	TOTAL
Feasibility Study (This Study)		■							
Financial Arrangement for Implementation		■	■						
Detailed Engineering Study (15 Months)			■	■					
Tender (6 months)					■				
Construction (36 months)					■	■	■	■	
Construction Supervision (36 months)					■	■	■	■	
Financial Requirement	Foreign Componenent	—	1.47 (1.70)	13.20 (16.09)	10.55 (13.69)	73.85 (101.18)	84.39 (122.61)	42.19 (64.92)	225.65 (320.19)
– October 1983 Price – Unit: Million Pesos	Local and Tax Component	—	0.79 (1.06)	7.12 (10.52)	6.72 (10.59)	47.00 (79.54)	53.71 (97.25)	26.86 (52.04)	142.20 (251.00)
	TOTAL	—	2.26 (2.76)	20.32 (26.61)	17.27 (24.28)	120.85 (180.72)	138.10 (219.86)	69.05 (116.96)	367.85 (571.19)

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