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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
REPUBLIC OF THE PHILIPPINES

FEASIBILITY STUDY
ON
PAN-PHILIPPINE HIGHWAY REHABILITATION PROJECT
(MINDANAO SECTION)

FINAL REPORT
EXECUTIVE SUMMARY

MAY 1995

KATAHIRA & ENGINEERS INTERNATIONAL
NIPPON ENGINEERING CONSULTANTS CO., LTD.

The exchange rates used in the Study are:

US$ 1.00 = Philippine Pesos 24.10

J. Yen 1.00 = Philippine Pesos 0.2410

P1.00 = Y4.15

(As of December 1994)

Source: Central Bank of the Philippines

PREFACE

In response to a request from the Government of the Republic of the Philippines, the Government of Japan decided to conduct a feasibility study on Pan-Philippine Highway Rehabilitation Project (Mindanao Section) and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to the Philippines a study team headed by Mr. Kunihiko Sawano, Katahira & Engineers International, twice between March 1994 to March 1995.

The team held discussions with the officials concerned of the Government of the Philippines, 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 concerned of the Government of the Republic of the Philippines for their close cooperation extended to the team.

May 1995

Kimio Fujita
President
Japan International Cooperation Agency

SUMMARY

OBJECTIVES OF THE PROJECT

The Mindanao section of the Pan-Philippine Highway suffers from various problems such as progressive deterioration of pavement, structural and hydraulic problems in bridges, repeated slope failures in mountainous areas and frequent occurrence of floods, resulting in aggravation of riding quality, rise of transport cost and even traffic interruptions for a certain period. The Pan-Philippine Highway Rehabilitation Project in Mindanao (the Project) aims to cope with such problems and make the road solid, reliable and comfortable.

STUDY ROAD

The Study Road is the Pan-Philippine Highway from Lipata Ferry Terminal up to the end of Davao City Diversion Road with a length of 403.4 km.

TRAFFIC VOLUME

Traffic volume as of 1994

- Surigao-Tagum (343km) : 640-2,990 veh/day
- Tagum-Davao (60km) : 4,910-8,070 veh/day

Traffic growth

- In 2000, 1.4 times 1994 volume
- In 2010, 2.9 times 1994 volume
- In 2020, 4.6 times 1994 volume

PROPOSED REHABILITATION WORKS

Proposed rehabilitation works include:

- **Pavement rehabilitation**: PCC reconstruction, AC reconstruction or AC overlay for pavement deteriorated sections depending on degree and type of distress, traffic condition and subgrade strength.
- **Shoulder improvement**: graveling of earth shoulder, repair of defective shoulder, and paving of steep sections and residential sections.
- **Drainage improvement**: replacement of earth ditch with concrete ditch, provision of additional concrete ditch, replacement of pipe/box culverts of insufficient capacity and provision of additional culverts.
- **Bridge rehabilitation**: total or partial reconstruction of structurally deteriorated bridges, widening of carriageway and/or sidewalk, repair/reinforcement of damaged components, and aseismatic protection.
- **Slope protection**: protection of failed slopes and slopes with high potential of failing.
- **Countermeasures against flood**: protection of road from damage by flood water where flood depth is low, and flood prevention measures or bypass construction to avoid the flood section where flood depth is high.

WORK QUANTITIES

Pavement rehabilitation		
PCC reconstruction	107.36	km
AC reconstruction *	11.67	km
AC overlay	94.85	km
Total	213.88	km
Shoulder improvement		
Graveling	330.23	km
PCC paving	103.45	km
AC paving	36.80	km
Total	470.48	km
Drainage improvement		
Concrete Side ditch	148.16	km
Subsurface drainage	8.00	km
Pipe culvert replacement	529	
Additional pipe culvert	439	
Box culvert replacement	74	
Additional box culvert	10	
Bridge rehabilitation		
Total reconstruction	8	bridges
Partial reconstruction	30	bridges
Widening	4	bridges
Other rehabilitation	44	bridges
Aseismatic protection only	3	bridges
Total	89	bridges
Slope protection		
Cut slope failure	8	slopes
Embankment slope failure	61	slopes
Debris flow	5	slopes
Landslide	2	slopes
Total	76	slopes
Countermeasures against flood		
Protection of road	2	sections
Flood interception canal	3	sections
Raise of road	8	sections
Riverbed dredging	2	sections
Sabo dam	**	
Flood protection dike	2	sections
Cut-off channel	**	
Bypass road	1	section
Total	18	sections

* includes weak subgrade treatment.
** used as subsidiary measures to other main measures.

PROJECT COST

Construction Cost		
Pavement, shoulder and drainage rehabilitation/improvement	P	2,677.4 M
Bridge rehabilitation	P	304.1 M
Slope protection	P	96.8 M
Countermeasures against flood	P	840.8 M
Cost for general requirements	P	391.9 M
Sub-total	P	4,311.0 M
Right-of-way cost	P	40.6 M
Detailed design cost	P	172.4 M
Construction supervision cost	P	301.8 M
Total project cost	P	4,825.8 M

ECONOMIC ANALYSIS

The economic cost of the project is accounted at 4,614.3 million pesos, while the sum of 10,061.7 million pesos of economic benefit at present value is expected to accrue in 20 years after implementation. The sources of economic benefits are vehicle operating cost saving, road maintenance cost saving, saving in detour cost when a bridge is unfunctionable, saving in restoration cost after a disaster, and rise of land value by flood control.

As the result, evaluation indicators are:

- IRR: 30.5%
- NPV: 5,447.4 million pesos
- B/C: 2.18,

all of which show that the project is highly feasible from economic point of view and also stable against sensitivity analysis.

IMPLEMENTATION SCHEDULE

Detailed Design 1995-1996 (1.5 years)
Construction 1997-2002 (5.75 years)

ANNUAL FUND REQUIREMENT (unit: Mil. P)

	Detailed Design	ROW	Construction	Supervision	Total
1995	86.2	-	-	-	86.2
1996	86.2	-	-	-	86.2
1997	-	25.7	572.7	40.0	638.4
1998	-	14.8	738.6	57.5	810.9
1999	-	0.1	838.3	57.5	895.9
2000	-	-	796.6	57.5	854.1
2001	-	-	906.6	57.5	964.1
2002	-	-	458.2	31.8	490.0
Total	172.4	40.6	4,311.0	301.8	4,825.8

PROJECT EVALUATION

- **Technical Aspect**: No technical problem is expected in the project implementation.
- **Economic Aspect**: Economic evaluation proves a high economical viability of the project.
- **Financial Aspect**: The project can be implemented within reasonable financial framework in accordance with the proposed schedule.
- **Environmental Aspect**: No significant adverse impact is foreseen.

RECOMMENDATIONS

Early Implementation: It is highly recommended to implement the project in the earliest possible time, even ahead of the proposed schedule if there is a fair prospect of increased fund for the project.

Mitigation Measures of Environmental Impacts: Due considerations should be given to mitigate adverse environmental impacts, as follows:

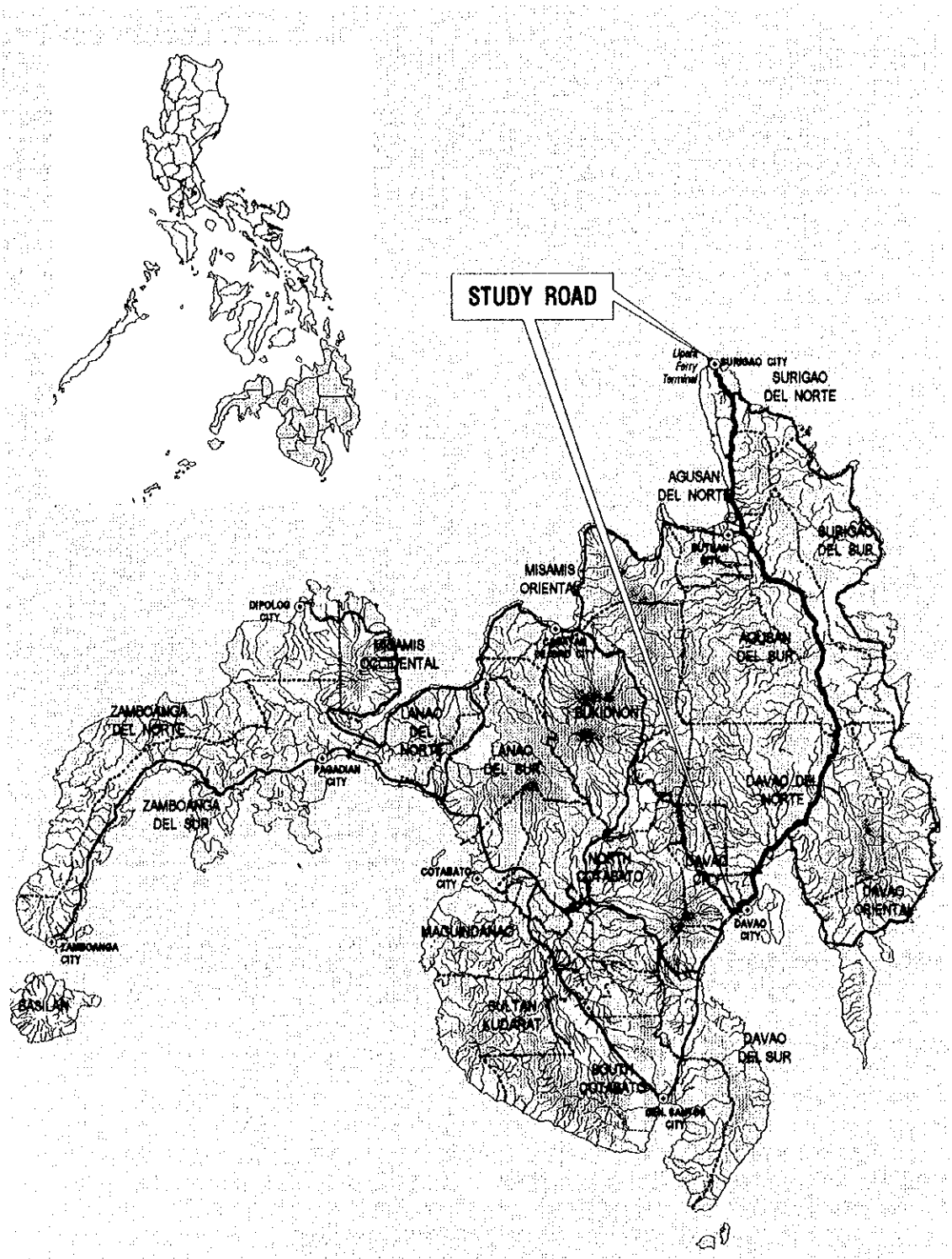
- Relocation of inhabitants:
  A proper relocation plan including provision of resettlement area in the vicinity.
- Traffic interference during construction:
  Proper traffic control, provision of safety devices, etc.

Maintenance Requirements: Future maintenance should be focused on:

- Maintenance of the sections where no rehabilitation work is proposed.
- Minor repair works of the bridges not covered by the project.
- Cleaning of drainage facilities, especially in flood sections and mountainous sections.
- Periodic dredging of riverbed sediments, especially for the bridges where dredging is proposed in the project.
- Strengthening of monitoring system.

Conduct of Related Projects: It is recommended to undertake the related projects to maximize the effect of this project, including:

- Widening of a 21.6-km section in Davao City
- Improvement of access roads.
- River control.



LOCATION MAP

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1 INTRODUCTION

BACKGROUND

In the Philippines, the needs for road development were rapidly raised in the late 1960's due to the economic growth attended with rapid motorization. To meet these needs, the Government of the Philippines pursued the systematic development of road network from the late 1960's through the early 1980's.

Since the middle of 1980's when the quantitative expansion of roads was by-and-large attained, the quality of roads has become a matter of primary concern. As the trunk roads constructed in or before 1970's are being deteriorated resulting in aggravation of riding quality and rise of transport cost, the rehabilitation of such roads has become a key issue. Thus, the road development in the Philippines is now in the stage of pursuing qualitative improvement after the lapse of the stage of quantitative expansion.

The Pan-Philippine Highway is the most important trunkline in the country's road network running through the four major islands of Luzon, Samar, Leyte and Mindanao with a total length of 2,100 km. The construction of the Highway, which was then a long-cherished desire of the country to attain the national targets such as regional development, industrial growth, preservation of peace and order, national unification, etc., was started in 1969 and completed in 1979.

Now, in 16 to 25 years after opening to traffic, the Pan-Philippine Highway suffers various problems such as progress of pavement deterioration, repeated slope failures in the mountainous areas, damage of many bridges and so on.

To cope with the said problems, the Government of the Republic of the Philippines (GOP) conducted various feasibility studies with technical assistance provided by the Japan International Cooperation Agency (JICA). These studies cover the Luzon, Samar and Leyte sections of the Pan-Philippine Highway and the rehabilitation projects formulated therein are now being implemented.

Rehabilitation of Mindanao section of the Highway, however, has been left behind although it is of urgent necessity to promote the development of Mindanao. Now in high time, GOP has decided to start the rehabilitation of the Mindanao section of the Highway and sought a technical assistance from the Government of Japan (GOJ) for the conduct of the FEASIBILITY STUDY ON PAN-PHILIPPINE HIGHWAY REHABILITATION PROJECT (MINDANAO SECTION) (the Study).

In response to the request of GOP, GOJ decided to conduct the Study. JICA which is the official agency responsible for the implementation of GOJ technical cooperation programs, organized a study team to be engaged in the Study. The JICA Study Team, in close collaboration with the DPWH Counterpart Team, commenced the work in March 1994 and completed it in May 1995.

OBJECTIVES OF THE STUDY

The objectives of the Study are to identify the problem sections and spots along the Pan-Philippine Highway in Mindanao and to conduct a feasibility study for the Highway rehabilitation.

STUDY ROAD

The study road is the Pan-Philippine Highway from Lipata Ferry Terminal (KM 1,113+397) up to the end of Davao City Diversion Road (KM 1,515+949).

REPORTS

The final report is organized with the following:

- Executive Summary
- Main Text
- Appendix
- Drawings

2 PHYSICAL PROFILE OF THE STUDY AREA

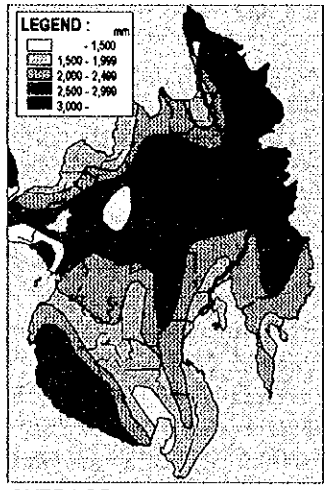
The Study Road runs through three topographical divisions; Diwata Cordillera, Agusan Valley Plain and Davao Upland.

Diwata Cordillera is a slender fold mountain range that is located in the east of Agusan River and runs nearly north to south. It was formed by the orogenic movement in Miocene period. There are faults and developed fracture zones caused by upheavals of the land after the fold. Geological composition in areas surrounding Lake Mainit is mainly effusive rocks such as andesites and volcanic ashes. The composition in other areas is mainly sandstone and limestone.

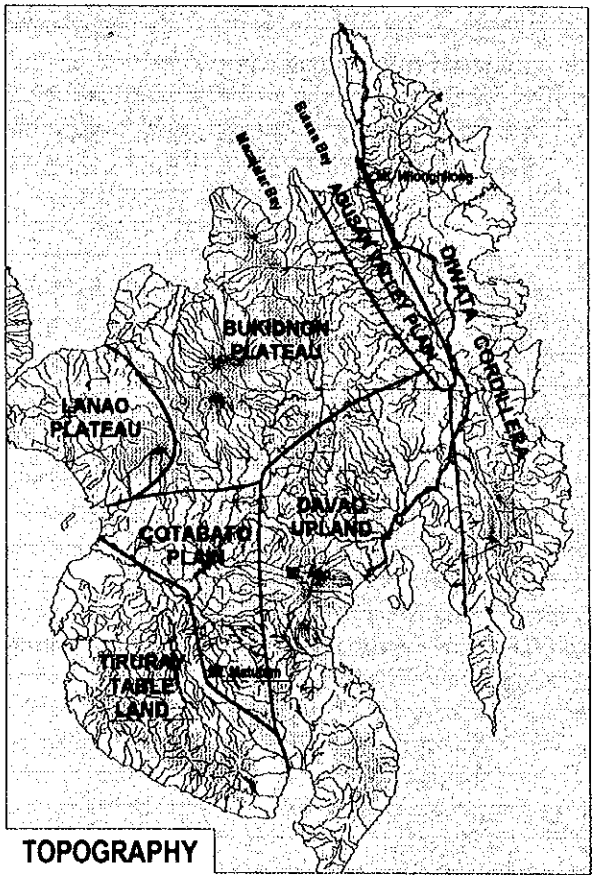
Agusan Valley Plain is a long vale that is located between Bukidnon Plateau and Diwata Cordillera and extends north and south. Since the valley lies on a great tectonic line running through the Philippine Archipelago, there is a large number of faults and earthquake centers along the valley. Geology of the area is mostly composed of Tertiary sandstone and mudstone which are fractures by the faults.

Davao Upland is a mountainous area lying between Mt. Apo and Agusan River. Geological composition of the upland is generally Tertiary or Mesozoic Cretaceous sedimentary rock such as sandstone, mudstone and limestone, and effusive rock such as andesite.

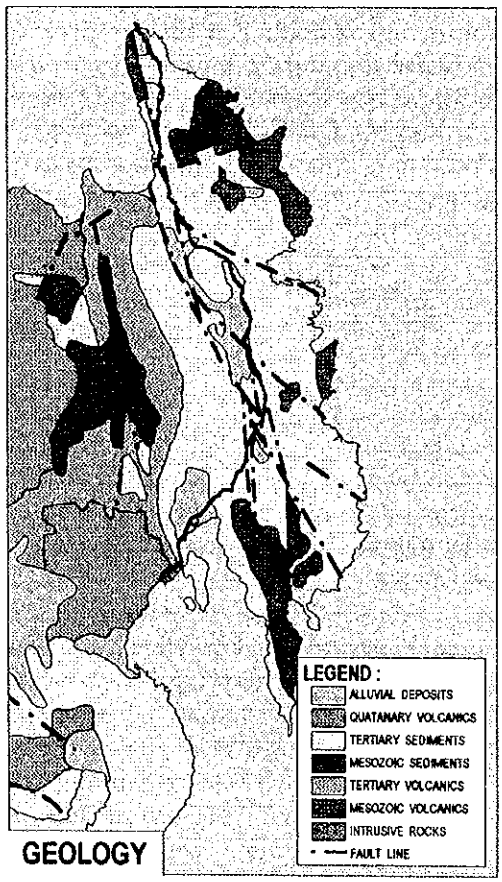
Meteorogically, eastern Mindanao is characterized by the abundant rainfall. In Surigao City, average annual rainfall amounts to 3,720 mm. As for the rainfall seasonal distribution, the Study Area belongs mostly to Climate type II: no dry season with a very pronounced maximum rainfall from November to January.



AVERAGE ANNUAL RAINFALL



TOPOGRAPHY



GEOLOGY

3 SOCIO-ECONOMIC FRAMEWORK

AREA AND LAND USE

Incorporating three cities (Surigao, Butuan and Davao) and four eastern provinces of Region X and XI as the Study Area directly influenced by the Study Road, it covers 248.8 km^2 or 41% of the total area of Region X and XI. One-fourth of the land is utilized for agricultural purpose, mainly producing coconut, corn, rice, sorghum, coffee and fruits. Other lands are dominantly occupied by forest (37%) and grass/shrub land (33%).

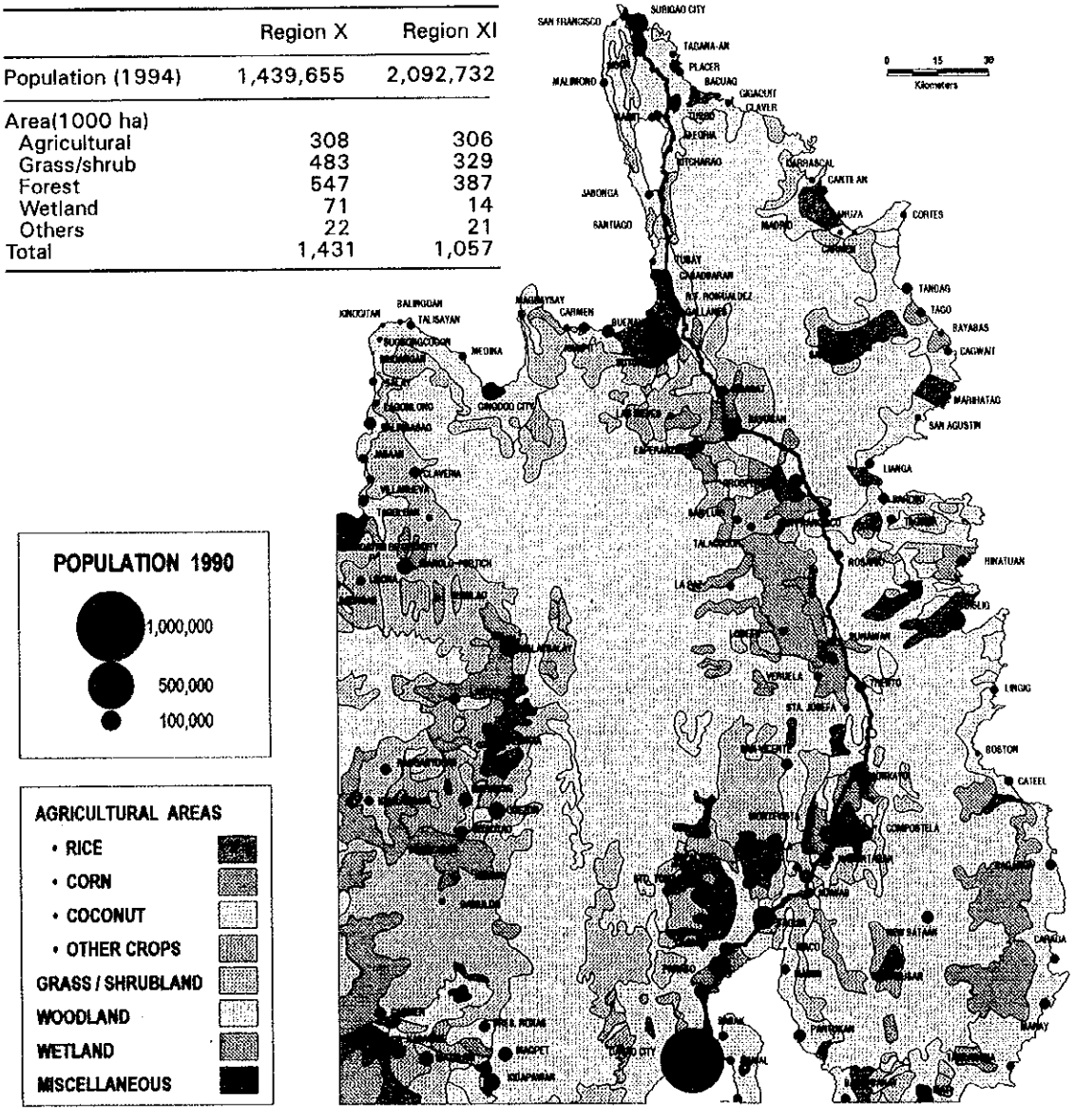
POPULATION

The Study Area is currently inhabited by 3.5 million of population, 42% of which are in the urban area. In 1990, population of Davao city reached 850,000, followed by 228,000 of Butuan city and 100,000 of Surigao city.

Most of other towns and villages are distributed in the same pattern as of farm land, namely, in the Agusan and Davao river basins and along the coast.

POPULATION AND AREA

	Region X	Region XI
Population (1994)	1,439,655	2,092,732
Area(1000 ha)		
Agricultural	308	306
Grass/shrub	483	329
Forest	547	387
Wetland	71	14
Others	22	21
Total	1,431	1,057



POPULATION DISTRIBUTION AND LAND USE

FUTURE POPULATION

Population has grown in the past decade, at 2.44% per annum in Region X, and 2.91% in Region XI, with a declining trend of growth rate.

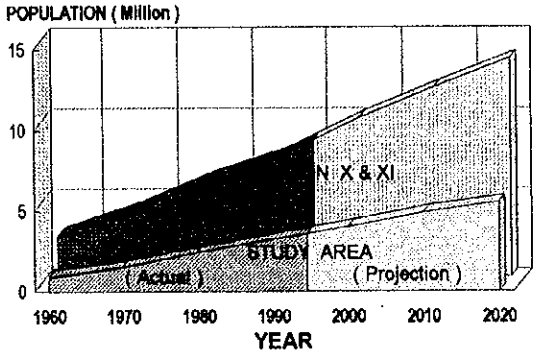
The Philippine Population Projection made in 1985 by NCSO, predicts that the net reproduction rate will fall down slowly to 1.0 by the year 2020 in the high growth scenario, which has well fitted to the past trend in the Study Area, while national population has been following the forecast under the medium growth scenario. Also in the future, population in the Study Area will grow generally faster than the national average, during 1994-2000 at the annual rate of 1.76% in Region X and 2.32% in Region XI.

Population in the Study Area will be 4.8 million in 2010 and reach 5.5 million in 2020, keeping almost the same share of 41% of the two Regions total.

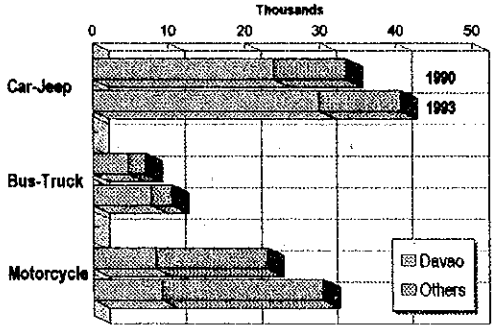
VEHICLES OWNERSHIP

The number of vehicles registered in the Study Area has rapidly increased recently, at 8.8% per annum in the last three years. Especially, increase of heavy vehicle is remarkable. In 1993, there are about 41,000 light vehicles and 10,000 heavy vehicles registered in the Study Area, 70% of which are in Davao city.

While the population increase of the Study area is estimated about 1.6 times for the period of 1994 to 2020, vehicles will increase over four times due to the expected economic growth and rises in household income.



POPULATION TREND AND PROJECTION



VEHICLES IN THE STUDY AREA

PROJECTED POPULATION IN THE STUDY AREA (In 1,000 population)

Region	Province/City	Population					Annual Growth Rate		
		Actual	Projected						
		1990	1994	2000	2010	2020	1994-2000	2000-2010	2010-2020
X	Surigao del Norte	425	462	512	592	675	1.73	1.48	1.31
	Agusan del Norte	465	505	560	647	733	1.74	1.45	1.26
	Agusan del Sur	421	473	561	716	859	2.88	2.47	1.84
	Rest of Region	2,198	2,370	2,598	2,946	3,297	1.55	1.27	1.13
	Total	3,509	3,810	4,231	4,902	5,564	1.76	1.48	1.28
XI	Davao del Norte	1,055	1,146	1,292	1,536	1,755	2.01	1.75	1.34
	Davao City	850	946	1,093	1,316	1,521	2.43	1.87	1.46
	Rest of Region	2,552	2,816	3,246	4,007	4,711	2.40	2.13	1.63
	Total	4,457	4,908	5,630	6,858	7,987	2.31	1.99	1.54
	Study Area	3,217	3,532	4,017	4,807	5,542	2.17	1.81	1.43
The Philippines		60,685	65,250	71,336	80,673	90,009	1.50	1.24	1.10

ECONOMIC GROWTH

The Region X and XI produced 154.3 billion pesos in 1992, that is, 11.5% of GDP worked out by 13.5% of national population. The Study Area contributed about 64% of this regional products. Agriculture and forestry sector plays a dominant role in the area.

The current Medium-Term Philippine Development Plan (MTPDP 1993-98) aiming at poverty alleviation and improved income and wealth distribution, set up three macro-economic objectives; (a) a sustained and broad-based growth of output and employment, (b) price stability, and (c) a sound balance of payments position.

To attain these objectives, the Plan says, at least two digits of annual growth rate of GDP will be needed in the last year of the plan period. Based on this, target of average growth rate is set forth at 7.47% for Region X and 9.37% for Region XI, respectively.

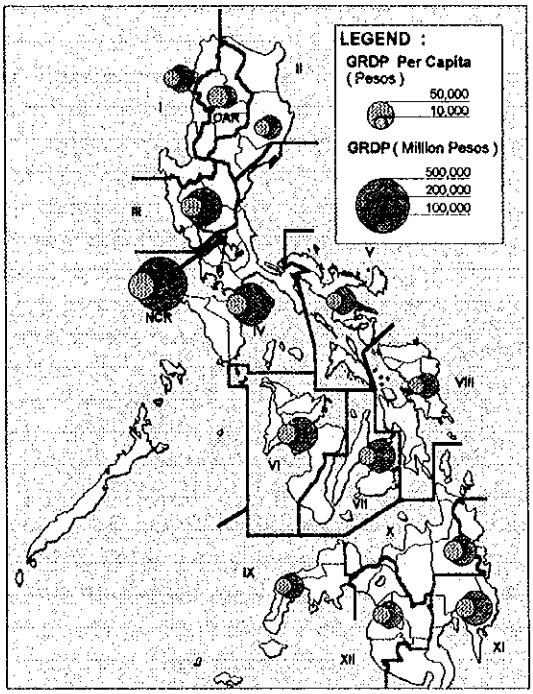
It may be difficult, however, to maintain such a rapid economic growth for many years, which will be slow down to a moderate pace. Presently, GRDP per capita in NCR is 3.0 times of that in Region X and 2.7 times of Region XI. In order to mitigate these regional imbalance to less than 2.0 times by the year 2020, these regions need to grow their economy at six to seven percent annually.

If this economic growth can be attained, GRDPs in 2020 of the Region X and XI will grow over 5 times and six times of the present ones, respectively.

PROJECTED GROWTH RATE OF GRDP

(% per annum)

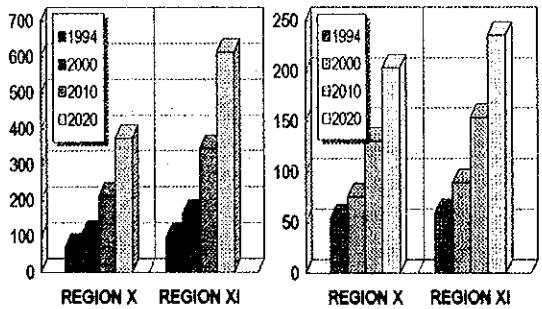
Region	1994 - 2000	2000 - 2010	2010 - 2020
X	7.47	7.20	5.84
XI	9.37	7.69	5.95



GRDP BY REGION IN 1992

Average family incomes in 1991 are 45,200 pesos in Region X and 51,800 pesos in Region XI, which are lower than the national average by 20 to 30%. In Mindanao, saving ratio is about 18% and Engels's coefficient is 48.5%, higher than the national average.

Granted that a household income will rise at the same rate of GRDP growth in the future, it will become 3.7 times in Region X and 3.9 times in Region XI by the year 2020. This income rise will also result in a rise of car ownership and people's mobility.



GRDP
(Billion Peso)

FAMILY INCOME
(1,000 P / Family / Year)

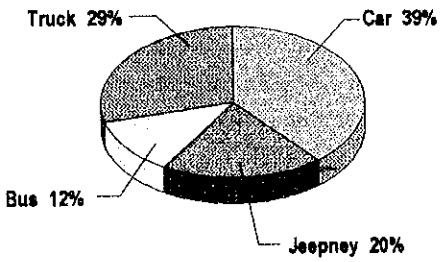
4 TRAFFIC FORECAST

PRESENT TRAFFIC ON THE STUDY ROAD

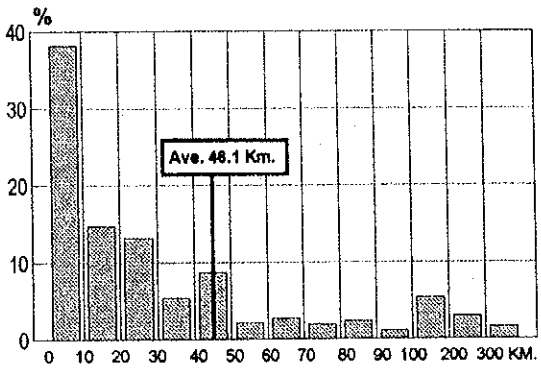
The data of AADT estimated based on the traffic survey in 1994 shows the traffic on the Study Road is not so heavy except the about 80 km section near Davao city. Traffic volumes of 1,000 to 2,000 vehicles/day are observed on the section in Surigao city, the 115 km sections between Cabadbaran and Rosario and the 75 km sections between Trento and Mawab. The other sections have traffic less than 1,000 vehicles/day.

On the sections south of Mawab, the nearer to Davao city, the more the traffic increases remarkably. The section with maximum traffic is between Panabo and the eastern entrance of the Davao City Diversion Road, showing 8,067 vehicles/day.

The vehicle-type composition in terms of vehicle-km shows 39% of cars, 29% of trucks, 20% of jeepneys, 12% of bus, respectively.



PRESENT TRAFFIC BY VEHICLE TYPE
(IN TERMS OF VEHICLE - KM.)



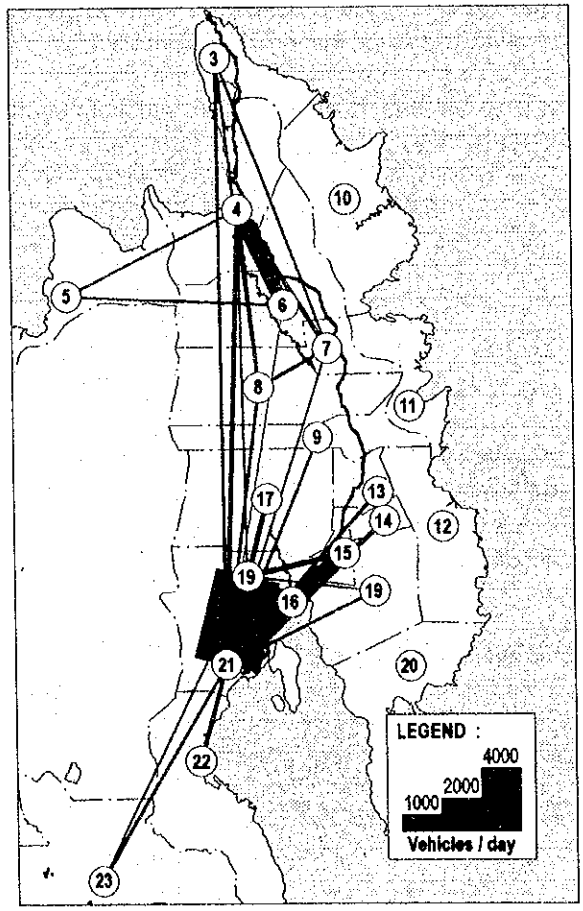
TRIP LENGTH DISTRIBUTION

The share of trucks is generally higher in a rural area than in an urban area.

Trip length of the traffic on the road is rather short: 38% of total trips run less than 10 km of the road and the two-third of the total less than 30 km. Only 10% of the traffic run over 100 km. The average trip length is 46.1 km.

COMMODITY FLOW

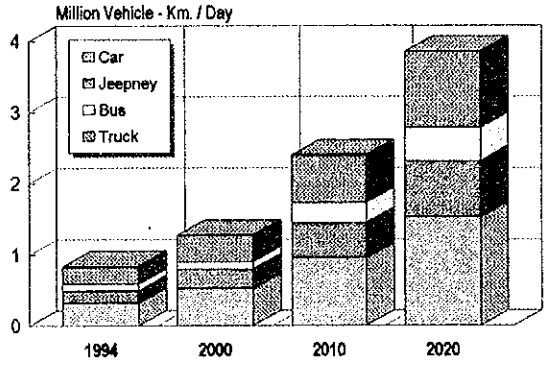
At Kicharao (KM 1,165), about 530 tons of cargoes are daily transported along the Study Road, and 1,500 tons at Butuan and also at Monkayo, 12,000 tons at Panabo which is the entrance of Davao city. Major commodities are construction materials such as cement and gravel, beverages, petro-product, wood, fruits and daily necessities. The vacant truck ratio varies by spot, in the range of 30 to 35%.



DESIRED LINE OF OD TRAFFIC ON STUDY ROAD

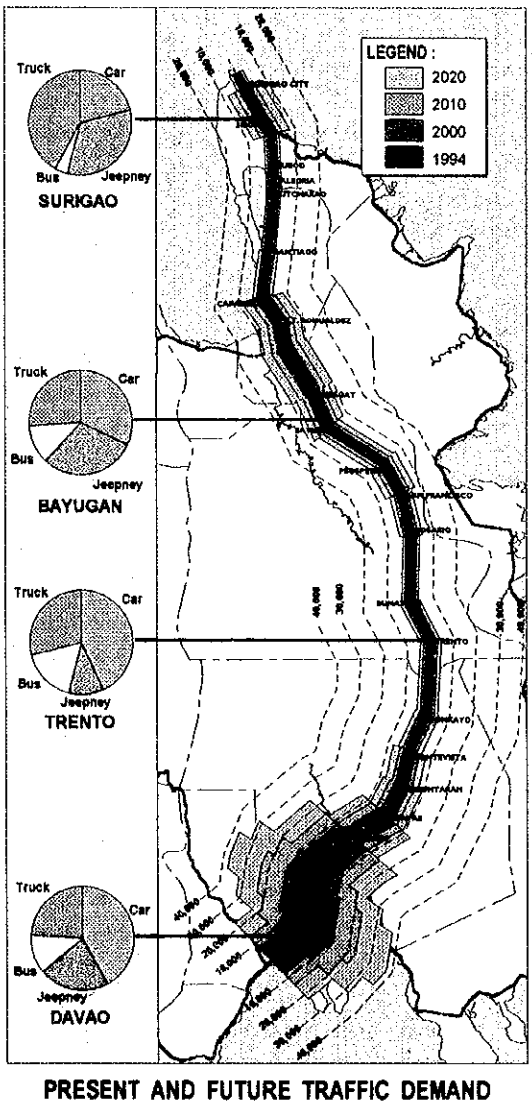
FUTURE TRAFFIC

Passenger traffic will increase due to the population increase and up-rise of people's mobility. According to the DPWH Highway Planning Manual (vol. 3), the elasticity of private transport to income is estimated at 0.8 to 1.0 for relatively low income group. Future OD volume of passenger traffic was estimated by multiplying the average of growth rates at the origin zone and destination zone to the present OD volume.



TRAFFIC INCREASE ON STUDY ROAD

All commodities are classified into three categories; agro-products, capital goods and general consumption goods and a different approach was taken for each category. For agro-products, growth rates were set based on the target growth rates stated in the MTPDP. For capital goods, the same growth rates as future economic growth were applied. For general consumption goods, the same rate as household income increase was assumed. Finally, future traffic OD volumes were assigned on the Study Road, in order to estimate future AADT and vehicle-km.



PRESENT AND FUTURE TRAFFIC DEMAND

Traffic on the Study Road will significantly and rapidly increase in the future. In terms of vehicle-km, passenger-vehicle traffic will increase 1.6 times in 2000 as of the present volume, 2.8 times in 2010 and 4.6 times in 2020. Although the increase of commodity-vehicle traffic is slightly lower than these up to 2010, it will become 4.3 times of the present.

Daily traffic volume of every section will also grow 4.5 to 5.0 times by the year 2020, without changing the present pattern. Sections currently with less than 1,000 vehicles will have 2,500 to 4,000 vehicles in 2020, while sections near Surigao city and Butuan city will have more or less 10,000 vehicles in the same year.

Traffic of sections south of Tagum will exceed 20,000 vehicles in the first decade of the next century and the maximum section will become over 40,000 vehicles in 2020. Therefore, widening project of these sections should be started in this century.

5 PRESENT ROAD CONDITION

PAVEMENT

The pavement condition in connection with necessity/urgency of rehabilitation is evaluated in terms of the rehabilitation requirement index (RRI), which was developed in this study. The RRI is obtained from measurements of roughness and distress such as crack, patching, scaling, etc., as follows:

$$RRI = 5.12 - 2.1 \log R - 0.087 \sqrt{D_2}$$
$$D_2 = C + 0.63P + 0.18S + 6D + 2H$$

where,

R = roughness (IRI)
D_2 = distress factor for RRI calculation
C = crack (m/1,000m²)
P = patching (m²/1,000m²)
S = scaling (m²/1,000m²)
D = depression (No./1,000m²)
H = pothole (No./1,000m²)

The scale for RRI ranges from 0 through 5, with the value of 5 representing the highest index. The terminal RRI is the lowest acceptable level before rehabilitation becomes necessary. An index of 2.5 is recommended for use as the terminal RRI in the rehabilitation design of major highways.

Pavement condition of the Study Road, expressed in terms of the RRI, is summarized as follows:

	South Bound	North Bound
Gravel Section	1.15 km	1.15 km
Paved Section		
RRI below 2.5	85.60 km	90.18 km
RRI 2.5 - 3.0	78.26 km	81.13 km
RRI above 3.0	233.07 km	225.62 km
Total Road Length	398.08 km	398.08 km

Common pavement distresses are:

- Extensive block/alligator cracks with depressions
- Potholes
- Severe scaling

SHOULDER

Shoulder is classified, according to the surface material, into concrete accounting for 5%, gravel 51% and earth 44%. Concreted shoulders are used in the sections within municipal towns. About 37% of shoulders are damaged, as dropped-off (35%), heaved (1%) and scoured (1%).

DRAINAGE

Surface drainage facilities along the Study Road are summarized as follows:

Side Ditch (km)	
Earth	59.49
Riprap	6.77
Concrete	5.02
Total	71.28
Pipe Culvert (No.)	
in good condition	179
defective	812
Total	991
Box Culvert (No.)	
in good condition	101
defective	86
Total	187

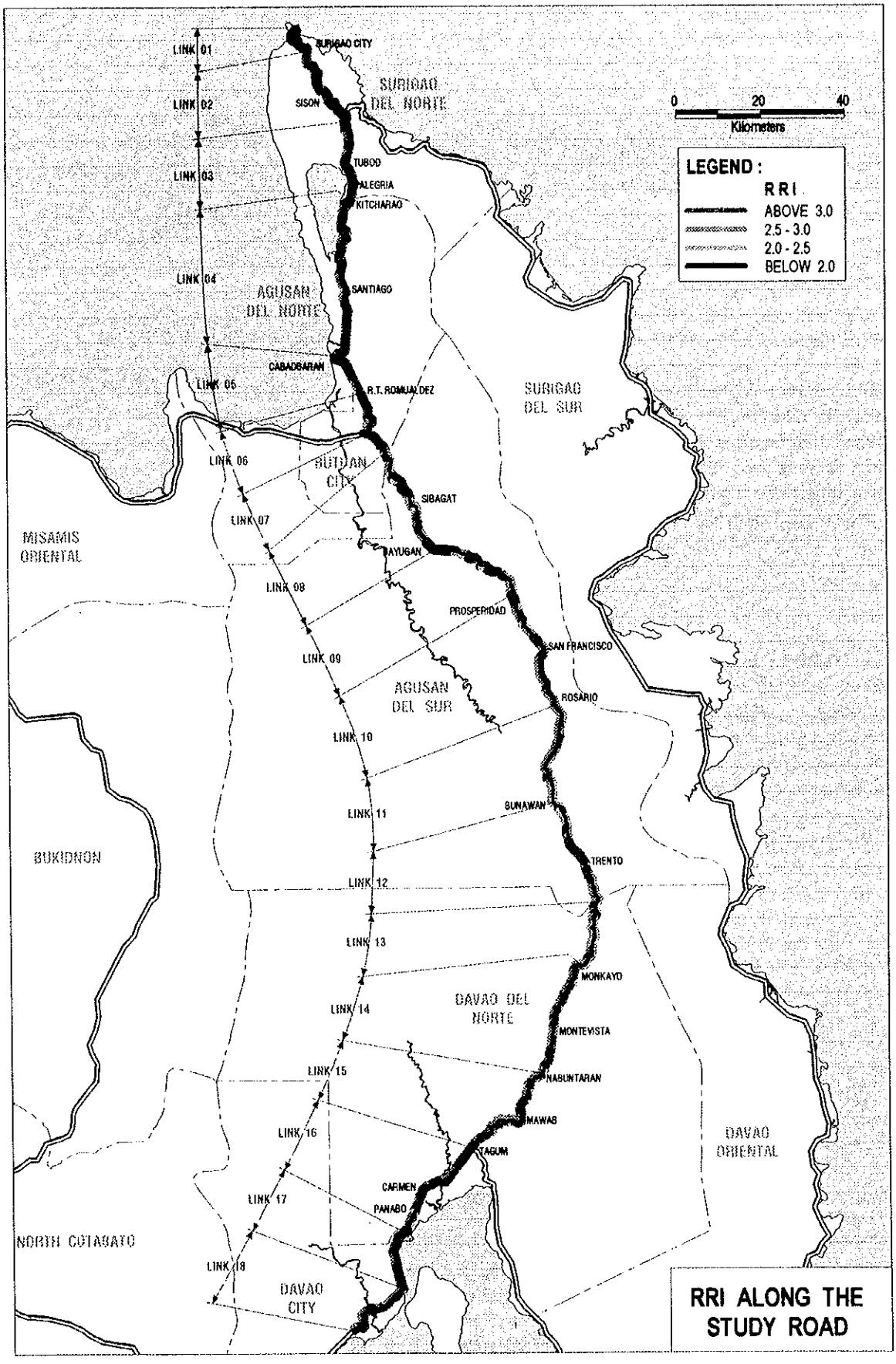
Most earth side ditches are silted and not functioning well. Furthermore, 94.3 km more ditches are needed to be additionally provided.

Problems of pipe/box culverts are as follows:

- Insufficient capacity
- No or improper outlet facility
- Clogged by debris

UNEVEN SURFACE

Uneven surface caused by consolidation of soft ground is observed at the sections between Prosperidad and Trento in Agusan del Sur, amounting to 7.6 km in aggregate length.


LINK 01
LINK 02
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BUTUAN CITY
SIBAGAT
AYUGAN
PROSPERIDAD
SAN FRANCISCO
ROSARIO
BUNAWAN
TRENTO
MONKAYO
MONTEVISTA
NABUNTURAN
MAWAB
TAGUM
CARMEN
PANABO
DAVAO CITY
SURIGAO CITY
SISON
TUBOD
ALEGRIA
KITCHARAO
SANTIAGO
CABADBARAN
R.T. ROMUALDEZ
SURIGAO DEL NORTE
AGUSAN DEL NORTE
SURIGAO DEL SUR
AGUSAN DEL SUR
DAVAO DEL NORTE
DAVAO ORIENTAL
MISAMIS ORIENTAL
BUKIDNON
NORTH COTABATO
0
20
40
Kilometers
LEGEND :
RRI
ABOVE 3.0
2.5 - 3.0
2.0 - 2.5
BELOW 2.0
RRI ALONG THE STUDY ROAD

BRIDGE

There are 125 bridges along the Study Road of which the structural type, year built and load limit vary widely as shown in the table below.

Problems of the existing bridges are summarized as follows:

- Problems of Standards

86 bridges have narrower carriageways than the DPWH standard width of 7.32m with the narrowest being 6.70 m. 112 bridges have no or narrower sidewalks than the DPWH standard width of 0.76m. 86 bridges are given substandard load limits below 20 ton, including two bridges with 10 ton limit.

- Problems of Hydraulic Regime

There are 13 bridges in which freeboards are remarkably insufficient causing rivers to flood during high-water. 18 bridges are subjected to lateral scour causing erosion of river bank, and 33 bridges subjected to local scour at abutment ends and/or pier foundations.

- Structural Deterioration

Structural deterioration is observed in many bridges due to various causes such as insufficient structural capacities, passage of overloaded vehicles, collision of vehicles, river stream action, etc.

Bridges with Structural Deterioration

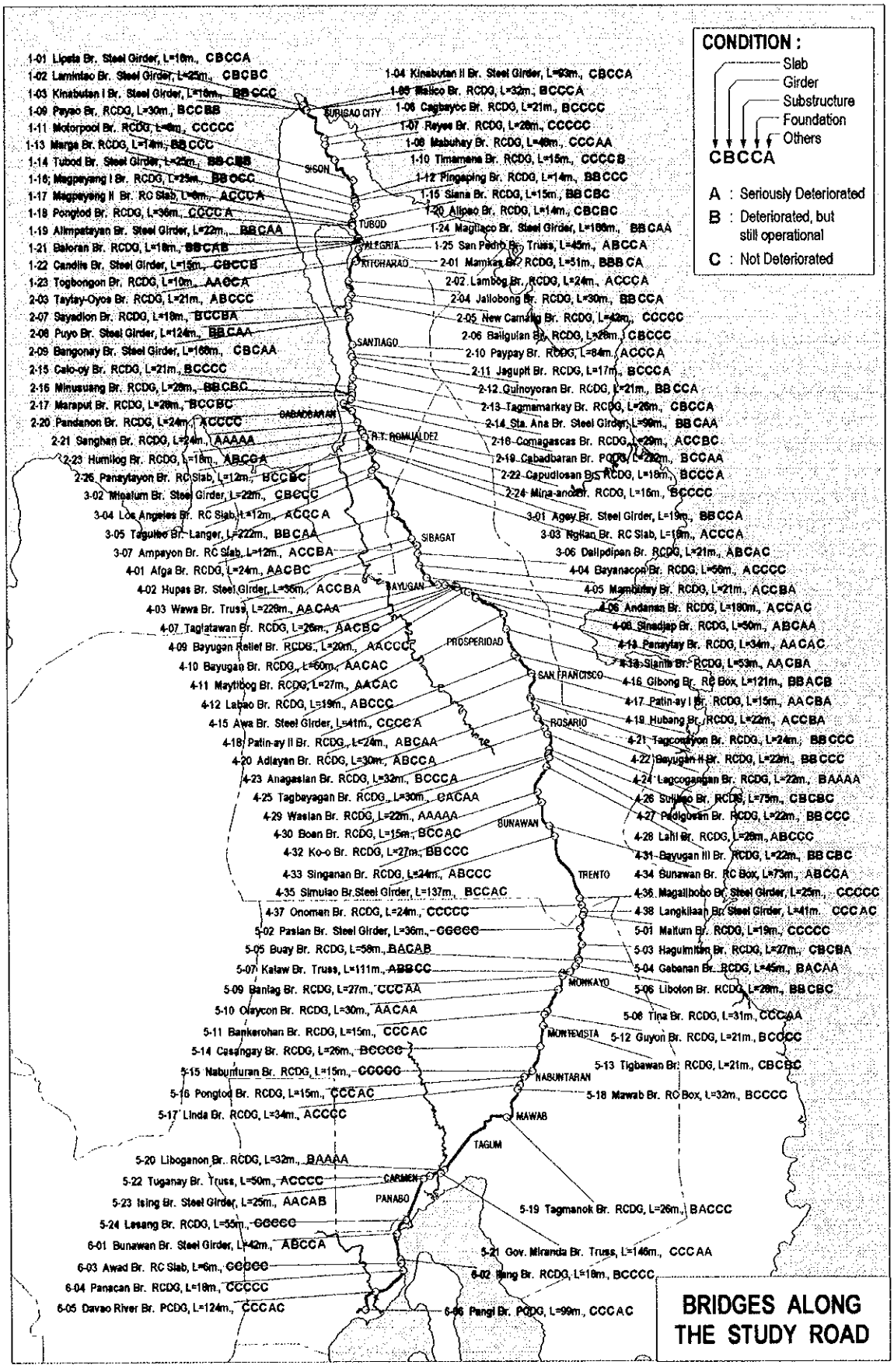
Bridge Component	Seriously Deteriorated	Deteriorated but still operational
Slab	42	47
Girder	20	49
Substructure	5	2
Foundation	36	23
Bearing/ Bridge Seat	4	0
Approach Road	31	1

- Lack of Aseismicity

No special aseismatic consideration is given to the existing bridges. Especially, the width of bridge seat is insufficient in most bridges.

BRIDGE TYPE, YEAR BUILT AND LOAD LIMIT

		RC Deck Girder	RC Slab	RC Precast Slab	RC Box Girder	PC Deck Girder	Steel I-Beam	Steel Plate Girder	Pony Truss	Thru Truss	Steel Langer	Total
Year Built												
1950-1954		8	-	-	-	-	-	-	-	-	-	8
1955-1959	Grav. Road Cons.	42	-	1	1	-	2	-	1	1	-	48
1960-1964	Grav. Road Cons.	14	-	2	2	1	2	-	1	-	-	22
1965-1969		10	-	-	-	-	-	-	-	1	-	11
1970-1974	PJHL Project	2	-	-	-	-	9	-	-	1	1	13
1975-1979	PJHL Project	4	-	1	-	1	2	-	1	-	-	9
1980-1984	Jumbo Project	-	-	-	-	-	-	1	-	-	-	1
1985-1989	Jumbo Project	-	-	-	-	-	-	1	-	-	-	1
1990-1994	Jumbo Project	1	1	-	-	1	-	4	-	-	-	7
Unknown		4	-	1	-	-	-	-	-	-	-	5
Total		85	1	5	3	3	15	6	3	3	1	125
Load Limit												
10 Ton		2	-	-	-	-	-	-	-	-	-	2
15 Ton		65	-	4	3	-	3	3	1	2	1	82
18 Ton		1	-	-	-	-	1	-	-	-	-	2
20 Ton		17	1	1	-	3	11	3	2	1	-	39
Total		85	1	5	3	3	15	6	3	3	1	125


CONDITION :
Slab
Girder
Substructure
Foundation
Others
CBCCA
A : Seriously Deteriorated
B : Deteriorated, but still operational
C : Not Deteriorated
1-01 Lipata Br. Steel Girder, L=16m., CBCCA
1-02 Lamintao Br. Steel Girder, L=25m., CBCBC
1-03 Kinabutan I Br. Steel Girder, L=16m., BBCCC
1-09 Payao Br. RCDG, L=30m., BCCBB
1-11 Motorpool Br. RCDG, L=8m., CCCCC
1-13 Marga Br. RCDG, L=14m., BBCCC
1-14 Tubod Br. Steel Girder, L=25m., BBCBB
1-16 Magpayang I Br. RCDG, L=25m., BBCCC
1-17 Magpayang II Br. RC Slab, L=6m., ACCCA
1-18 Pongtod Br. RCDG, L=36m., CCCCA
1-19 Alimpatayan Br. Steel Girder, L=22m., BBCAA
1-21 Baloran Br. RCDG, L=18m., BBCAB
1-22 Candis Br. Steel Girder, L=15m., CBCCB
1-23 Togbongon Br. RCDG, L=10m., AACCA
2-03 Taytay-Oyoe Br. RCDG, L=21m., ABCCC
2-07 Sayadlon Br. RCDG, L=18m., BCCBA
2-08 Puyo Br. Steel Girder, L=124m., BBCAA
2-09 Bangonay Br. Steel Girder, L=168m., CBCAA
2-15 Calo-oy Br. RCDG, L=21m., BCCCC
2-16 Minusuang Br. RCDG, L=28m., BBCBC
2-17 Maraput Br. RCDG, L=28m., BCCBC
2-20 Pandanon Br. RCDG, L=24m., ACCCC
2-21 Senghan Br. RCDG, L=24m., AAAAA
2-23 Humilog Br. RCDG, L=18m., ABCCA
2-26 Panaytayon Br. RC Slab, L=12m., BCCBC
3-02 Misalum Br. Steel Girder, L=22m., CBCCC
3-04 Los Angeles Br. RC Slab, L=12m., ACCCA
3-05 Taguiloo Br. Langer, L=222m., BBCAA
3-07 Ampayon Br. RC Slab, L=12m., ACCBA
4-01 Afga Br. RCDG, L=24m., AACBC
4-02 Hupas Br. Steel Girder, L=56m., ACCBA
4-03 Wawa Br. Truss, L=228m., AACAA
4-07 Taglatawan Br. RCDG, L=26m., AACBC
4-09 Bayugan Relief Br. RCDG, L=20m., AACCC
4-10 Bayugan Br. RCDG, L=60m., AACAC
4-11 Maytibog Br. RCDG, L=27m., AACAC
4-12 Labao Br. RCDG, L=19m., ABCCC
4-15 Awa Br. Steel Girder, L=41m., CCCCA
4-18 Patin-ay II Br. RCDG, L=24m., ABCAA
4-20 Adlayan Br. RCDG, L=30m., ABCCA
4-23 Anagasian Br. RCDG, L=32m., BCCCA
4-25 Tagbayagan Br. RCDG, L=30m., CACAA
4-29 Wasian Br. RCDG, L=22m., AAAAA
4-30 Boan Br. RCDG, L=15m., BCCAC
4-32 Ko-o Br. RCDG, L=27m., BBCCC
4-33 Singanan Br. RCDG, L=24m., ABCCC
4-35 Simulao Br. Steel Girder, L=137m., BCCAC
4-37 Onoman Br. RCDG, L=24m., CCCCC
5-02 Pasian Br. Steel Girder, L=36m., CCCCC
5-05 Buay Br. RCDG, L=58m., BACAB
5-07 Kalaw Br. Truss, L=111m., ABBCC
5-09 Banlag Br. RCDG, L=27m., CCCAA
5-10 Olaycon Br. RCDG, L=30m., AACAA
5-11 Bankerohan Br. RCDG, L=15m., CCCAC
5-14 Casanggay Br. RCDG, L=26m., BCCCC
5-15 Nabuntaran Br. RCDG, L=15m., CCCCC
5-16 Pongtod Br. RCDG, L=15m., CCCAC
5-17 Linda Br. RCDG, L=34m., ACCCC
5-20 Liboganon Br. RCDG, L=32m., BAAAA
5-22 Tuganay Br. Truss, L=50m., ACCCC
5-23 Ising Br. Steel Girder, L=25m., AACAB
5-24 Lasang Br. RCDG, L=55m., CCCCC
6-01 Bunawan Br. Steel Girder, L=42m., ABCCA
6-03 Awad Br. RC Slab, L=6m., CCCCC
6-04 Panacan Br. RCDG, L=18m., CCCCC
6-05 Davao River Br. PCDG, L=124m., CCCAC
1-04 Kinabutan II Br. Steel Girder, L=93m., CBCCA
1-05 Malico Br. RCDG, L=32m., BCCCA
1-06 Cagbayoc Br. RCDG, L=21m., BCCCC
1-07 Reyes Br. RCDG, L=28m., CCCCC
1-08 Mabuhay Br. RCDG, L=40m., CCCAA
1-10 Timamana Br. RCDG, L=15m., CCCCB
1-12 Pingaping Br. RCDG, L=14m., BBCCC
1-15 Siana Br. RCDG, L=15m., BBCBC
1-20 Alipao Br. RCDG, L=14m., CBCBC
1-24 Magtiaco Br. Steel Girder, L=186m., BBCAA
1-25 San Pedro Br. Truss, L=45m., ABCCA
2-01 Mamkas Br. RCDG, L=51m., BBBCA
2-02 Lambog Br. RCDG, L=24m., ACCCA
2-04 Jallobong Br. RCDG, L=30m., BBCCA
2-05 New Camalig Br. RCDG, L=42m., CCCCC
2-06 Baliguian Br. RCDG, L=28m., CBCCC
2-10 Paypay Br. RCDG, L=84m., ACCCA
2-11 Jagupit Br. RCDG, L=17m., BCCCA
2-12 Quinoyoran Br. RCDG, L=21m., BBCCA
2-13 Tagmamarkay Br. RCDG, L=28m., CBCCA
2-14 Sta. Ana Br. Steel Girder, L=99m., BBCAA
2-18 Comagascas Br. RCDG, L=29m., ACCBC
2-19 Cabadbaran Br. PCDG, L=28m., BCCAA
2-22 Capudlosan Br. RCDG, L=19m., BCCCA
2-24 Mina-anodan Br. RCDG, L=16m., BCCCC
3-01 Agay Br. Steel Girder, L=19m., BBCCA
3-03 Nglian Br. RC Slab, L=19m., ACCCA
3-06 Dalipdipan Br. RCDG, L=21m., ABCAC
4-04 Bayanacon Br. RCDG, L=56m., ACCCC
4-05 Mambulay Br. RCDG, L=21m., ACCBA
4-06 Andanan Br. RCDG, L=180m., ACCAC
4-08 Sinadjap Br. RCDG, L=50m., ABCAA
4-13 Panaytay Br. RCDG, L=34m., AACAC
4-14 Sianib Br. RCDG, L=53m., AACBA
4-16 Gibong Br. RC Box, L=121m., BBACB
4-17 Patin-ay I Br. RCDG, L=15m., AACBA
4-19 Hubang Br. RCDG, L=22m., ACCBA
4-21 Tagcondiyon Br. RCDG, L=24m., BBCCC
4-22 Bayugan II Br. RCDG, L=22m., BBCCC
4-24 Lagcogangan Br. RCDG, L=22m., BAAAA
4-26 Sulitao Br. RCDG, L=75m., CBCBC
4-27 Poligutan Br. RCDG, L=22m., BBCCC
4-28 Lahi Br. RCDG, L=28m., ABCCC
4-31 Bayugan III Br. RCDG, L=22m., BBCBC
4-34 Sunawan Br. RC Box, L=73m., ABCCA
4-36 Magallobo Br. Steel Girder, L=25m., CCCCC
4-38 Langkilaan Br. Steel Girder, L=41m., CCCAC
5-01 Maitum Br. RCDG, L=19m., CCCCC
5-03 Hagumitan Br. RCDG, L=27m., CBCBA
5-04 Gabanan Br. RCDG, L=45m., BACAA
5-06 Libotan Br. RCDG, L=28m., BBCBC
5-08 Tina Br. RCDG, L=31m., CCCAA
5-12 Guyon Br. RCDG, L=21m., BCCCC
5-13 Tigbawan Br. RCDG, L=21m., CBCBC
5-18 Mawab Br. RC Box, L=32m., BCCCC
5-19 Tagmanok Br. RCDG, L=26m., BACCC
5-21 Gov. Miranda Br. Truss, L=146m., CCCAA
6-02 Ilang Br. RCDG, L=18m., BCCCC
6-06 Pangi Br. PCDG, L=99m., CCCAC
SURIGAO CITY
SISON
TUBOD
ALEGRIA
KITCHARAO
SANTIAGO
CABADBARAN
R.T. ROMUALDEZ
SIBAGAT
BAYUGAN
PROSPERIDAD
SAN FRANCISCO
ROSARIO
BUNAWAN
TRENTO
MONKAYO
MONTEMISTA
NASUNTARAN
MAWAB
TAGUM
CARMEN
PANABO
BRIDGES ALONG THE STUDY ROAD

SLOPE

Road slope disasters are classified into:

- Cut slope failure
- Embankment slope failure
- Debris flow
- Fall
- Landslide

Cut slope failures are found in Surigao del Norte, Agusan del Norte, Davao del Norte and Davao City. The disaster slopes located in Surigao del Norte and Agusan del Norte are composed of igneous rock, mainly andesite, while those in the southern sections are composed of Tertiary rocks such as sandstone, mudstone and tuff, and/or gravely or sandy soil that were produced from the heavily weathered Tertiary rocks. Slopes are mostly inclined at an angle of 30 degrees or more regardless of their height. Since no slope protection work is provided on unstable slopes with steep gradient, surface failures have been often occurred.

Embankment slope failures occur in many cases at the road sections crossing vales. Due to the insufficient capacity or absence of cross drainage facilities, the embankments are often overflowed during heavy rain, causing surface failures. There are two other cases: one is caused by decrease in shear strength of fill material due to seepage of groundwater as often seen in embankments constructed on inclined ground, and another is caused by scouring action of river stream where embankment slopes are located facing the river.

Debris flows are found in the section near KM 1177 in Agusan del Norte. Debris deposited on the side of a hill is sometimes washed down by floods. Although slopes are away from the road, debris often reaches the roadway.

Falls are mostly located in Surigao del Norte and Agusan del Norte where the road passes through the eastern tip of the Diwata Cordillera.

Landslides are seen at two locations in Agusan del Sur where the road crosses the Philippine Fault. Slopes are composed of mudstone. The slides are considered to be still in progress.

Slopes which have failed (failed slope) amount to 71, and slopes with disaster potential (potential slope) are 26. The potential slopes are divided into high and low potential slopes.

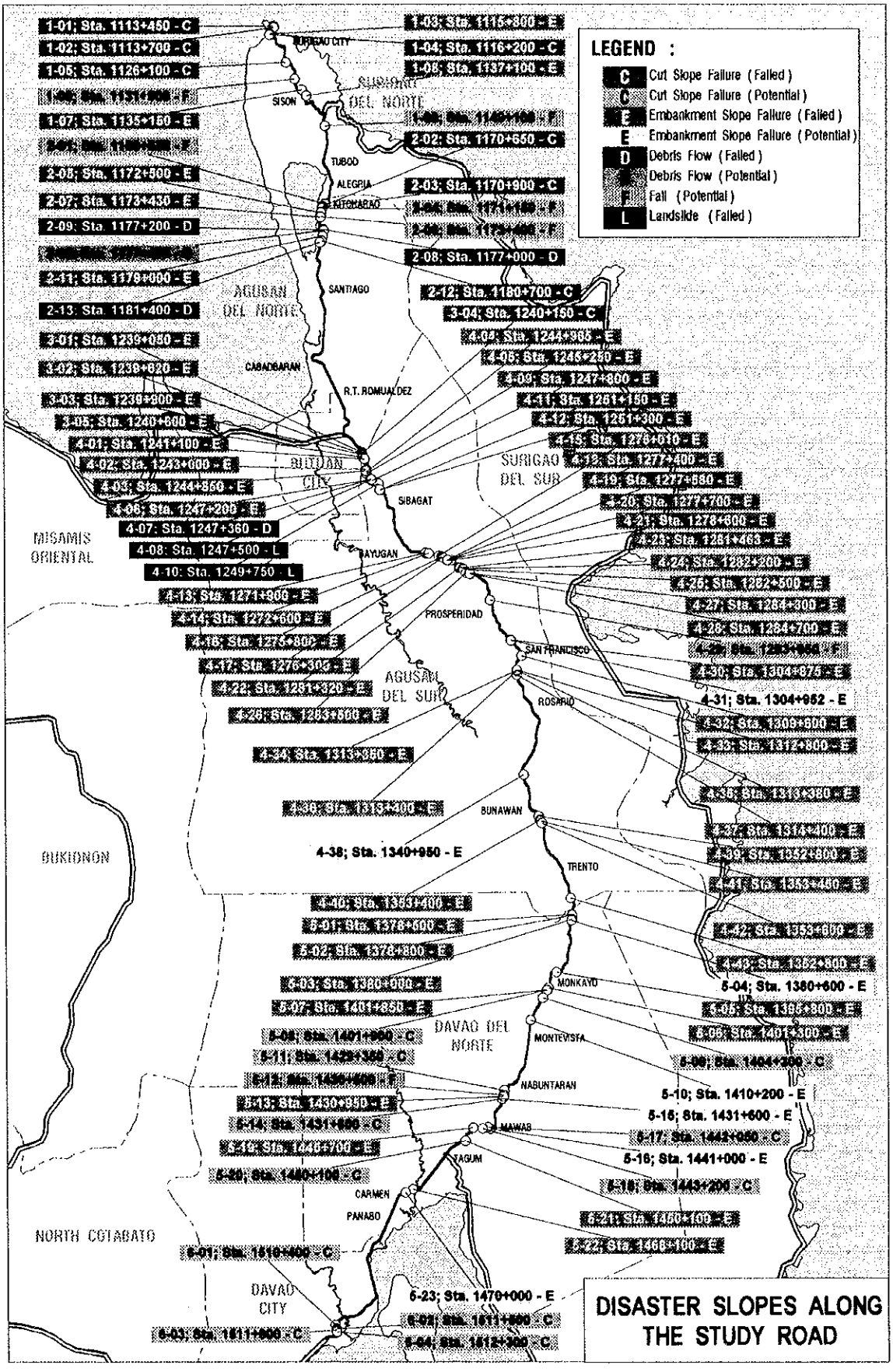
Potentiality of occurrence of disaster is evaluated by various factors, viz;

- Slope height
- Slope gradient
- Slope configuration
- Geological composition
- Surface water concentration
- Groundwater
- Vegetation cover
- Presence of unstable materials
- Others

Number of Failed/Potential Slopes

Type of Disaster	Failed Slope	High Potential Slope	Low Potential Slope	Total
Cut Slope Failure	8	-	11	19
Embank. Slope Failure	57	6	1	64
Debris Flow	4	1	-	5
Fall	-	-	7	7
Land-slide	2	-	-	2
Total	71	7	19	97

From the topographic reason, Agusan del Sur has the highest number of failed/potential slopes amounting to 43, while Davao city has the lowest of 4. Agusan del Sur has also the highest density of 0.315 slope/km, followed by Butuan City with 0.265 slope/km. The average density of the Study Road is 0.240 slope/km.


LEGEND :
C Cut Slope Failure (Failed)
C Cut Slope Failure (Potential)
E Embankment Slope Failure (Failed)
E Embankment Slope Failure (Potential)
D Debris Flow (Failed)
D Debris Flow (Potential)
F Fall (Potential)
L Landslide (Failed)
1-01; Sta. 1113+450 - C
1-02; Sta. 1113+700 - C
1-03; Sta. 1116+360 - E
1-04; Sta. 1116+200 - C
1-05; Sta. 1126+100 - C
1-06; Sta. 1137+100 - E
1-07; Sta. 1135+160 - E
2-02; Sta. 1170+550 - C
2-03; Sta. 1170+900 - C
2-05; Sta. 1172+300 - E
2-07; Sta. 1173+430 - E
2-08; Sta. 1177+000 - D
2-09; Sta. 1177+200 - D
2-11; Sta. 1179+000 - E
2-12; Sta. 1180+700 - C
2-13; Sta. 1181+400 - D
3-01; Sta. 1239+050 - E
3-02; Sta. 1239+820 - E
3-03; Sta. 1239+800 - E
3-04; Sta. 1240+150 - C
3-05; Sta. 1240+600 - E
4-01; Sta. 1241+100 - E
4-02; Sta. 1243+000 - E
4-03; Sta. 1244+850 - E
4-06; Sta. 1247+200 - E
4-07; Sta. 1247+360 - D
4-08; Sta. 1247+500 - L
4-10; Sta. 1249+750 - L
4-13; Sta. 1271+900 - E
4-14; Sta. 1272+600 - E
4-16; Sta. 1274+800 - E
4-17; Sta. 1276+300 - E
4-22; Sta. 1281+920 - E
4-26; Sta. 1283+800 - E
4-30; Sta. 1315+860 - E
4-31; Sta. 1304+952 - E
4-38; Sta. 1340+950 - E
5-01; Sta. 1376+400 - E
5-02; Sta. 1378+800 - E
5-03; Sta. 1380+000 - E
5-04; Sta. 1380+600 - E
5-07; Sta. 1401+850 - E
5-08; Sta. 1401+900 - C
5-10; Sta. 1410+200 - E
5-11; Sta. 1429+360 - C
5-15; Sta. 1431+600 - E
5-16; Sta. 1441+000 - E
5-20; Sta. 1460+100 - C
5-23; Sta. 1470+000 - E
6-01; Sta. 1610+400 - C
6-03; Sta. 1611+900 - C
6-04; Sta. 1612+300 - C
BUTUAN CITY
SISON
TUBOD
ALEGRIA
SANTIAGO
AGUSAN DEL NORTE
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NABUNTARAN
MAWAB
LAGUM
CARMEN
PANABO
NORTH COTABATO
DAVAO CITY
DISASTER SLOPES ALONG THE STUDY ROAD

FLOOD

18 sections are identified as flood-prone sections along the Study Road.

Flood sections are classified into four types based on the cause of flood.

Type I : Flood caused by surface run-off from mountain slope.

Type II : Flood caused by rise of water level in lowland area. Flood water comes from various rivers.

Type III : Flood caused by overflow from river due to siltation and aggradation of river at alluvial fan.

Type IV : Flood caused by overflow from river due to gentle riverbed slope and meandering of river channel.

Severity of flood is dependent on flood depth, duration and frequency. The following criteria is adopted for the evaluation of severity of flood.

Severity of Flood

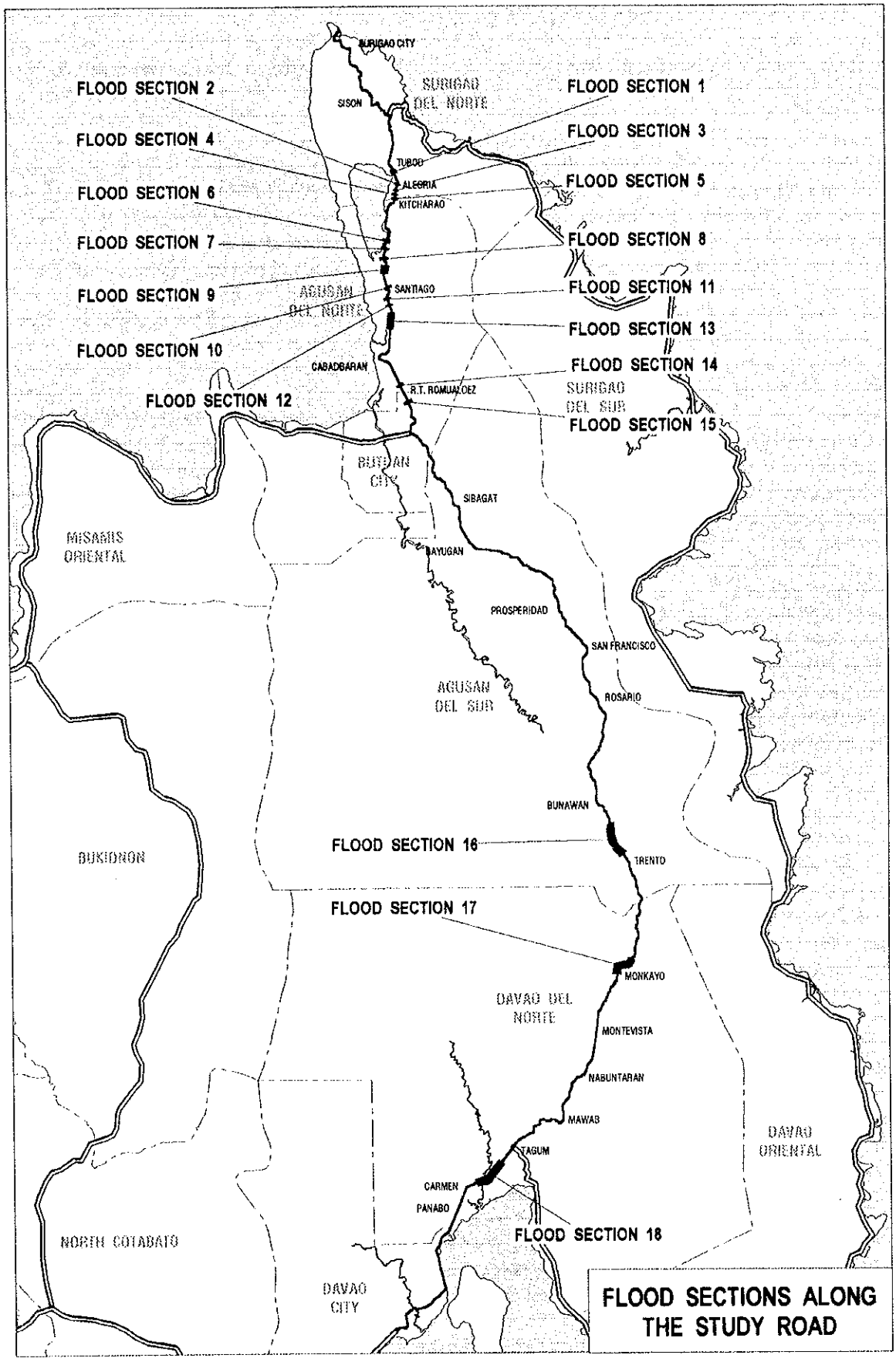
Average Depth	Duration	Return Period (year) Less than 2	2-5	5-10	10-15	More than 15
Less than 15cm passable to all types of vehicle	Any	B	C	D	D	D
15-30cm passable to bus & truck only	< 5hrs	B	B	C	D	D
	> 5hrs	A	B	B	C	D
30cm or more Impassable to all types of vehicle	< 5hrs	A	A	B	B	B
	> 5hrs	A	A	A	B	B

A: High, B: Medium, C: Low, D: Negligible

Outline of the Flood Sections

Flood Section No.	Location	Flood Type	Flood Section Length (m)	Nature of Flood Depth (cm)	Duration (hrs)	Frequency (/year)	Severity of Flood
1	Alipao, Surigao del Norte	I	1,000	60	6	3	A
2	Candiis, Surigao del Norte	I	500	30	4	3	B
3	Magtiaco, Surigao del Norte	III	350	35	12	2	A
4	San Pedro, Surigao del Norte	III	-	-	-	-	-
5	Alegria, Surigao del Norte	III	1,300	50	12	2	A
6	Baliguian, Agusan del Norte	III	490	30	4	2	B
7	Baliguian, Agusan del Norte	III	160	10	3	1/2	C
8	Toliago, Agusan del Norte	I	950	60	6	2	A
9	Bangonay, Agusan del Norte	III	1,600	30	6	1	A
10	Santiago, Agusan del Norte	I	1,800	40	6	2	A
11	Jagupit, Agusan del Norte	III	320	25	4	3	B
12	Guinoyoran, Agusan del Norte	III	-	-	-	-	-
13	Sta. Ana, Agusan del Norte	III	4,270	40	6	2	A
14	Agay, Agusan del Norte	II	400	15	6	3	C
15	Los Angeles, Butuan City	II	440	30	10	2	B
16	Trento, Agusan del Sur	IV	9,000	60	48	1/5	A
17	Monkayo, Davao del Norte	IV	2,400	200	72	1/5	A
18	Tagum, Davao del Norte	IV	7,500	60	24	1	A

Note: Flood sections 4 and 12 are not flooded at present but embankments of approach roads to bridges are severely scoured by flooded river streams.


BUTUAN CITY
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DAVAO ORIENTAL
MISAMIS ORIENTAL
BUKIDNON
NORTH COTABATO
DAVAO CITY
FLOOD SECTION 1
FLOOD SECTION 2
FLOOD SECTION 3
FLOOD SECTION 4
FLOOD SECTION 5
FLOOD SECTION 6
FLOOD SECTION 7
FLOOD SECTION 8
FLOOD SECTION 9
FLOOD SECTION 10
FLOOD SECTION 11
FLOOD SECTION 12
FLOOD SECTION 13
FLOOD SECTION 14
FLOOD SECTION 15
FLOOD SECTION 16
FLOOD SECTION 17
FLOOD SECTION 18
FLOOD SECTIONS ALONG THE STUDY ROAD

6 PROPOSED REHABILITATION WORKS

PAVEMENT REHABILITATION DESIGN CRITERIA

The rehabilitation requirement index (RRI) is used as an indicator to evaluate the necessity of rehabilitation of a pavement. The terminal RRI, which is the lowest acceptable value before rehabilitation becomes necessary, is set to be 2.5. Considering the possible decrease in the RRI until the time of implementation, the pavement with RRI of 3.0 or less as of 1994 is selected for rehabilitation.

Three types of rehabilitation methods are proposed; PCC reconstruction, AC reconstruction and AC overlay. The criteria for selecting the rehabilitation method is as follows:

PCC Reconstruction
- Pavement with RRI of 1.5 or less as of 1994.
- Pavement with such distress as heavy depression, pumping, water bleeding, block cracks with depressions, etc. to make AC overlay inapplicable.
- Section to carry heavy load, i.e., more than 1,300,000 of 18-kip equivalent single axle load applications predicted in the initial year.

AC Reconstruction
- Weak subgrade section where existing pavement settles.

AC Overlay
- All other sections than that where either PCC reconstruction or AC reconstruction is applied.

Initial performance period, which refers to the period of time that a rehabilitated or reconstructed pavement will last before it needs next rehabilitation, is selected as follows: 12 to 20 years for PCC reconstruction depending on traffic loading and 10 years for AC reconstruction and AC overlay.

SHOULDER IMPROVEMENT DESIGN CRITERIA

Shoulder improvement criteria are:
- Earth shoulder shall be graveled.
- Shoulder with distress such as drop-off, heave or score shall be restored.
- Shoulder with vertical gradient of 5% or more shall be paved.
- Shoulder in a dense residential area shall be paved.

DRAINAGE IMPROVEMENT DESIGN CRITERIA

Side ditch improvement criteria are:
- Earth ditch shall be replaced with riprap/concrete ditch.
- Damaged ditch and ditch with insufficient capacity shall be rehabilitated/ improved.
- Riprap/concrete ditch shall be additionally provided where needed.

Pipe/box culvert rehabilitation/improvement criteria are:
- Culvert with insufficient capacity shall be replaced with new one or additional culvert shall be provided.
- Where a culvert causes a slope damage, it shall be improved by providing proper inlet/outlet facilities and/or slope ditch.
- Additional culverts shall be provided in the flood prone areas.

Subsurface drainage shall be provided for sections where underground water level is high.

WEAK SUBGRADE TREATMENT DESIGN CRITERIA

Sections with significantly uneven surface due to consolidation of weak subgrade shall be properly treated in due consideration of probable further settlement, embankment slope stability, cost effectiveness and traffic management during construction.

BRIDGE REHABILITATION DESIGN CRITERIA

Major problems in the existing bridges are summarized into four: problems of standards, problems of hydraulic regime, structural deterioration and lack of aseismicity.

Measures for the problems of standards are:

- Widening of carriageway from 2 lanes to 4 lanes in case where abutting roads on both sides have 4 or more lanes and traffic volume is high.
- Widening of sidewalk to 0.76 or 1.50 m for the bridges located in residential area and having sidewalk of less than 0.60 m in width.
- Total reconstruction or reconstruction of superstructure of the bridges given a 10-ton load limit.

Measures for the problems of hydraulic regime are:

- Correction of insufficient freeboard by dredge of riverbed sediment and/or raise of bridge.
- Countermeasures against lateral scour such as river bank protection and spurdike.
- Countermeasures against local scour such as abutment slope protection and pier foundation protection.

Measures for structural deterioration are:

- Reconstruction of main structures (slab, girder, substructure) if they are deteriorated to the degree of dissatisfaction in their bearing/structural capacity.
- Repair or reinforcement of main structures if they are damaged but still repairable or economically reinforceable.
- Replacement or repair of other damaged components.

Measures for lack of aseismicity are:

- Widening of bridge seat for concrete bridges and trusses of 35 m or more in length.
- Installation of girder-to-abutment and girder-to-girder connection devices for steel bridges of 35 m or more in length.

SLOPE PROTECTION DESIGN CRITERIA

Problem slopes are divided into three categories; failed slopes, high potential slopes and low potential slopes. All failed slopes except two slopes which have been well restored, and all high potential slopes are to be protected in this project, while low potential slopes are excluded because of low impact on road traffic even if failing.

Protection method should be selected and designed in due consideration of various factors such as meteorological, topographical and geological conditions, economical aspect, constructability, impact on traffic during construction, etc.

General guidelines for selection/design of protection method for this project are as follows:

- Recutting of slope to stable gradient is an effective and economical way for cut slope failure if applicable. In addition, it is recommended to protect the cut slope surface by some measure such as vegetation, concrete spraying , concrete crib, etc. depending on surface material. Catch work is a possible alternative where enough space is available on hill side.
- In most cases, either gravity type retaining wall or grouted riprap is recommended for embankment slope failure. Where surface water concentrates, special care should be taken to well drain, usually by installing a culvert of sufficient capacity and providing proper inlet and outlet treatment.
- Recommended measures for debris flows are combination of raise of road, installation of box culverts, and the construction of gabion catch walls, considering that the slopes are away from the road and taking advantage of gabion's permeability.
- For landslide, removal of head portion of sliding mass and counterweight fill at foot portion of slope are economical and effective way.
- In all cases, sufficient drainage work is essential.

DESIGN CRITERIA FOR COUNTERMEASURES AGAINST FLOOD

Countermeasures against flood are broadly classified into three; road side measure, river side measure and special measure.

Type of Countermeasures

Road side measure	1.	Protection of road from damage by flood water
	2.	Installation of flood interception canal on the side of road
	3.	Raise of road above expected high water level
River side measure	4.	Riverbed dredging to increase discharge capacity of river
	5.	Construction of sabo dam
	6.	Construction of flood protection dike
	7.	Provision of cut-off channel to increase discharge capacity of river
Special measure	8.	Construction of bypass to avoid the flood section

Roadside measure is preferentially selected in accordance with the following criteria:

Severity of Flood	Roadside development	Measure
A or B	high	2
A or B	low	3
C	-	1

Adoption of river side measure is considered under the following circumstances:

- Flood damage other than the road is also serious, and it is economically worth to protect vicinity area as well as road itself.
- It is obvious that the river side measure is technically and economically superior than the road side measure.

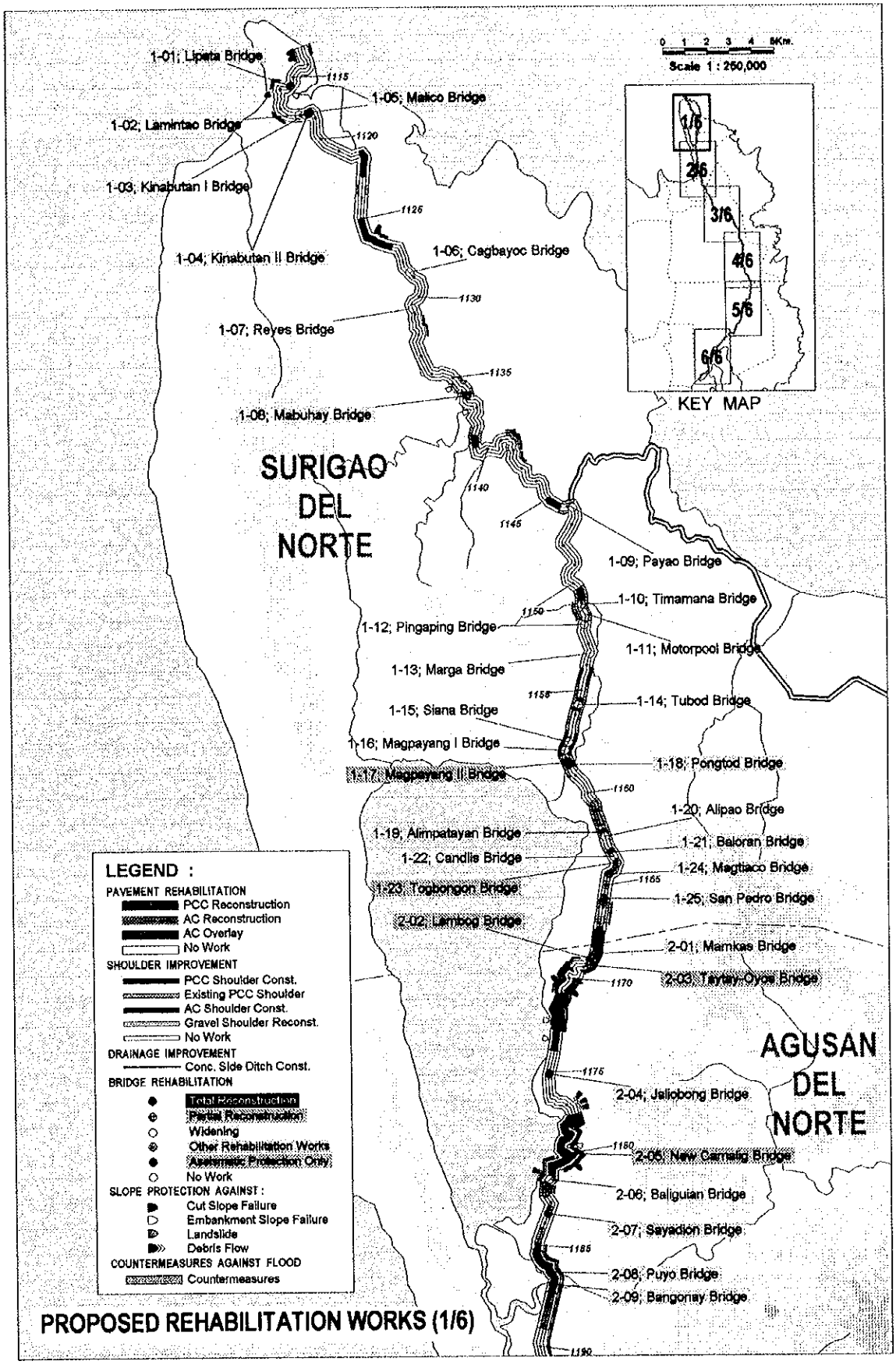
Special measure is adopted when other measure is costly and its effect is not very sure.

PROPOSED REHABILITATION WORKS

Pavement rehabilitation		
PCC reconstruction	107.36	km
AC reconstruction *	11.67	km
AC overlay	94.85	km
Total	213.88	km
Shoulder improvement		
Graveling	330.23	km
PCC paving	103.45	km
AC paving	36.80	km
Total	470.48	km
Drainage improvement		
Concrete Side ditch	148.16	km
Subsurface drainage	8.00	km
Pipe culvert replacement	529	
Additional pipe culvert	439	
Box culvert replacement	74	
Additional box culvert	10	
Bridge rehabilitation		
Total reconstruction	8	bridges
Partial reconstruction	30	bridges
Widening	4	bridges
Other rehabilitation	44	bridges
Aseismatic protection only	3	bridges
Total	89	bridges
Slope protection		
Cut slope failure	8	slopes
Embankment slope failure	61	slopes
Debris flow	5	slopes
Landslide	2	slopes
Total	76	slopes
Countermeasures against flood		
Protection of road	2	sections
Flood interception canal	3	sections
Raise of road	8	sections
Riverbed dredging	2	sections
Sabo dam	**	
Flood protection dike	2	sections
Cut-off channel	**	
Bypass road	1	section
Total	18	sections

* includes weak subgrade treatment.

** used as subsidiary measures to other main measures.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1-02; Lamintao Bridge
1-03; Kinabutan I Bridge
1-04; Kinabutan II Bridge
1-05; Malco Bridge
1-06; Cagbayoc Bridge
1-07; Reyes Bridge
1-08; Mabuhay Bridge
1-09; Payao Bridge
1-10; Timamana Bridge
1-11; Motorpool Bridge
1-12; Pingaping Bridge
1-13; Marga Bridge
1-14; Tubod Bridge
1-15; Siana Bridge
1-16; Magpayang I Bridge
1-17; Magpayang II Bridge
1-18; Pongtod Bridge
1-19; Alimpatayan Bridge
1-20; Alipao Bridge
1-21; Baloran Bridge
1-22; Candlis Bridge
1-23; Togbongon Bridge
1-24; Magtiaco Bridge
1-25; San Pedro Bridge
2-01; Mamkas Bridge
2-02; Lamboo Bridge
2-03; Tayay-Oyos Bridge
2-04; Jaliobong Bridge
2-05; New Carmelo Bridge
2-06; Baliguian Bridge
2-07; Sayadion Bridge
2-08; Puyo Bridge
2-09; Bangonay Bridge
1115
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0 1 2 3 4 5Km.
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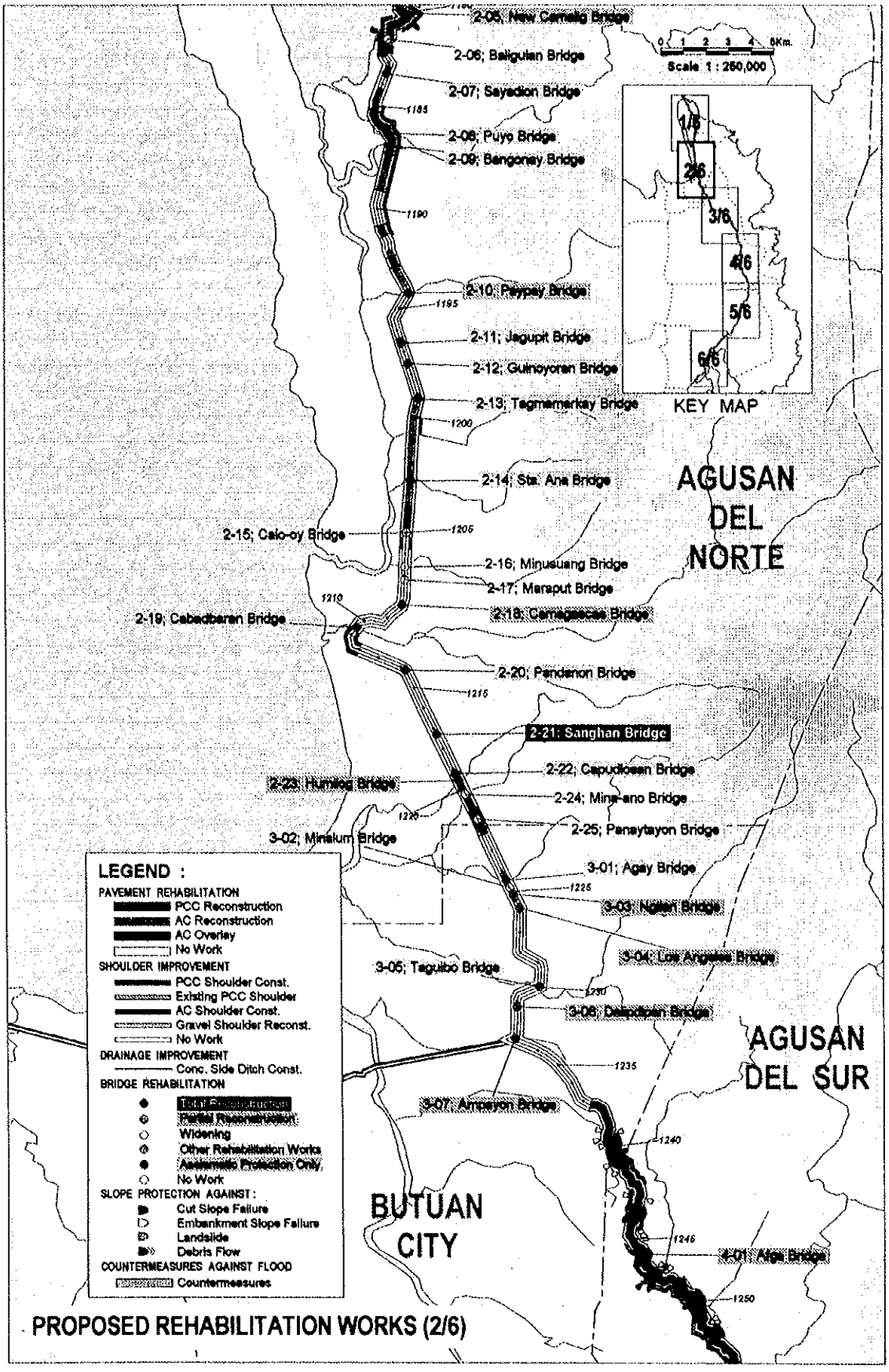
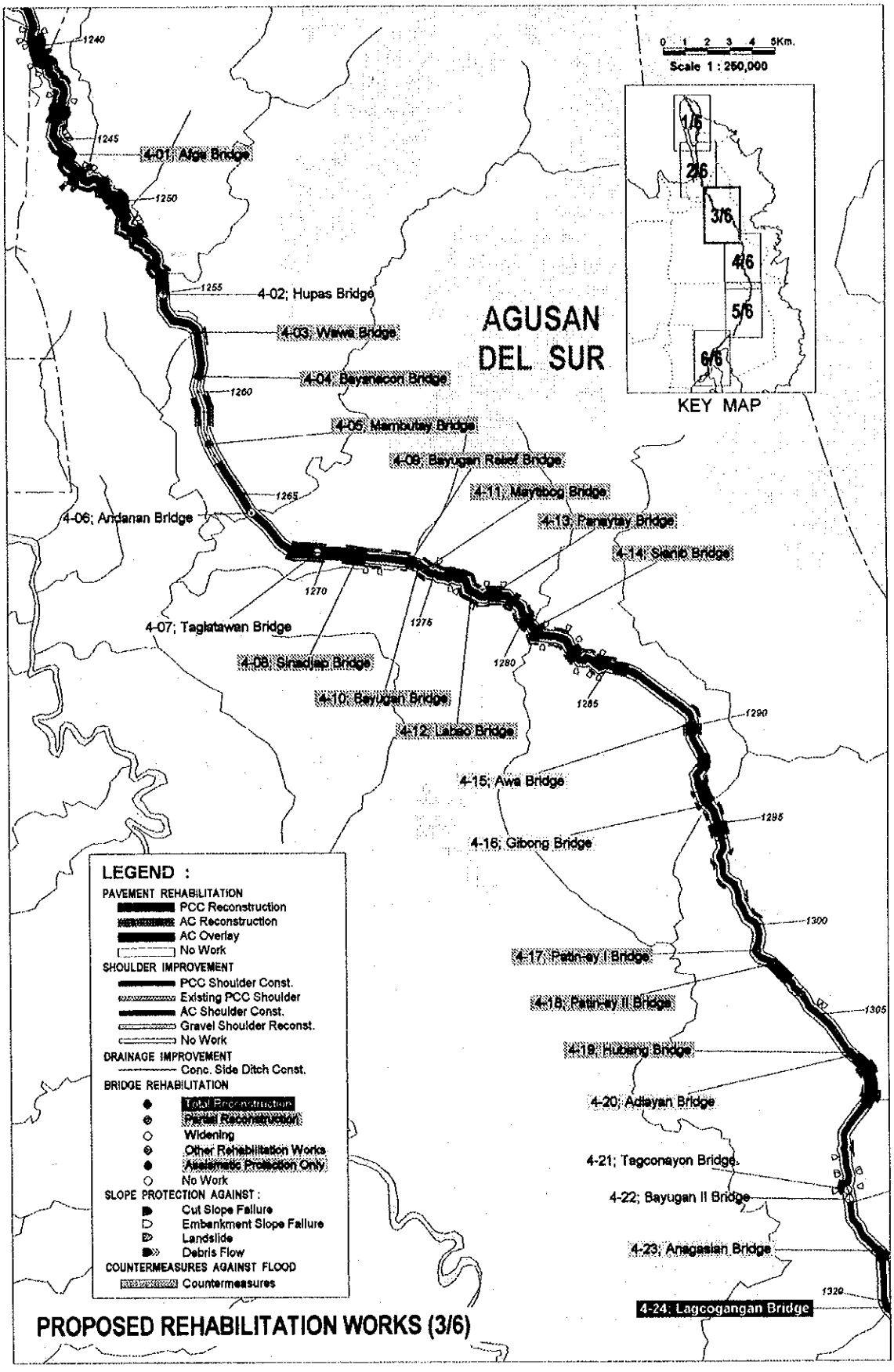
4/6
5/6
6/6
KEY MAP
SURIGAO DEL NORTE
AGUSAN DEL NORTE
LEGEND :
PAVEMENT REHABILITATION
PCC Reconstruction
AC Reconstruction
AC Overlay
No Work
SHOULDER IMPROVEMENT
PCC Shoulder Const.
Existing PCC Shoulder
AC Shoulder Const.
Gravel Shoulder Reconst.
No Work
DRAINAGE IMPROVEMENT
Conc. Side Ditch Const.
BRIDGE REHABILITATION
Total Reconstruction
Partial Reconstruction
Widening
Other Rehabilitation Works
Aesthetic Protection Only
No Work
SLOPE PROTECTION AGAINST :
Cut Slope Failure
Embankment Slope Failure
Landslide
Debris Flow
COUNTERMEASURES AGAINST FLOOD
Countermeasures
PROPOSED REHABILITATION WORKS (1/6)



PROPOSED REHABILITATION WORKS (2/6)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KEY MAP
AGUSAN
DEL SUR
1240
1245
4-01; Alge Bridge
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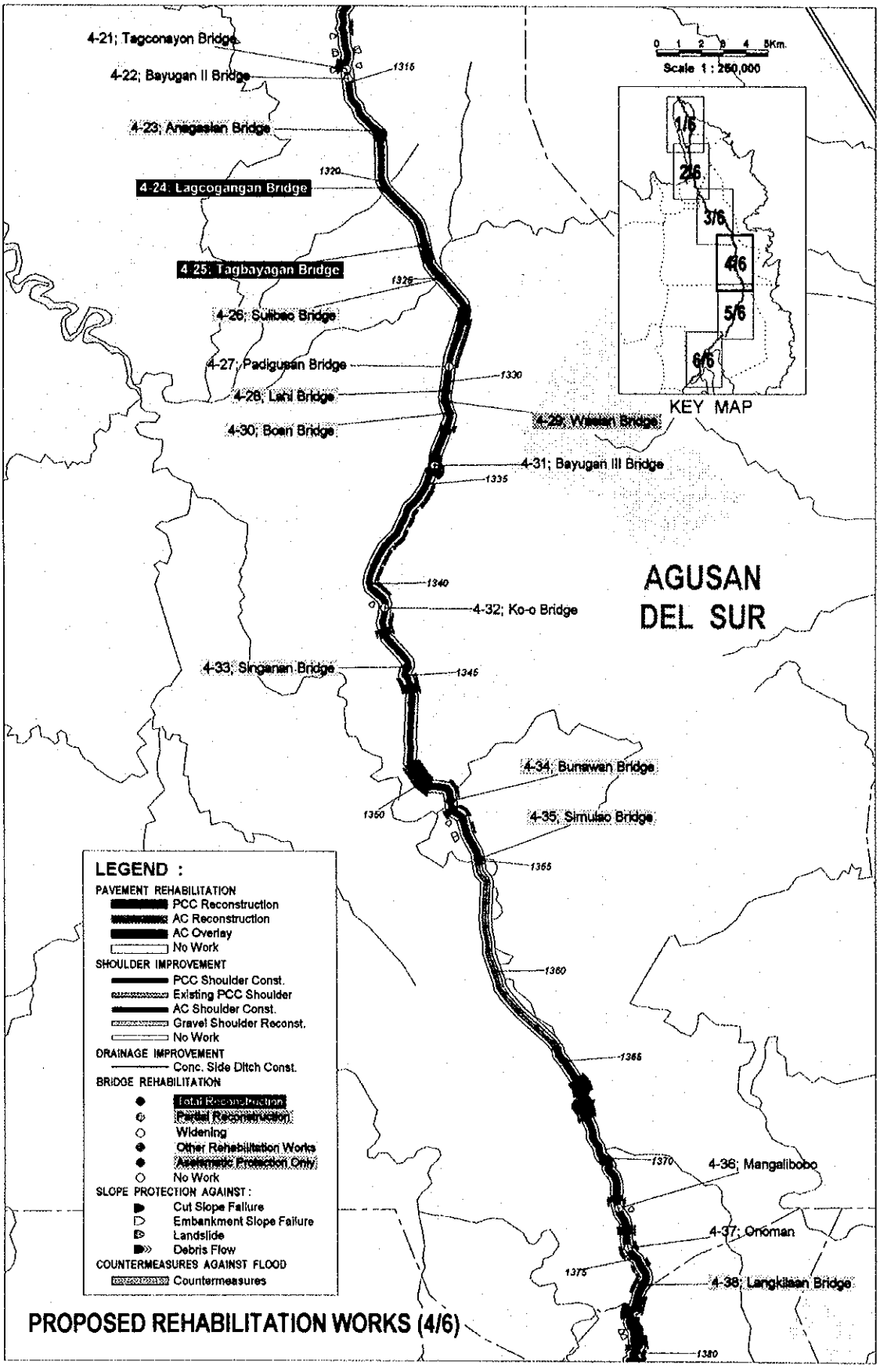
1255
4-02; Hupas Bridge
4-03; Wawa Bridge
4-04; Bayanacon Bridge
1260
4-05; Marriboltay Bridge
4-09; Bayugan River Bridge
4-11; Maydebog Bridge
1265
4-06; Andanan Bridge
4-13; Panaytay Bridge
4-14; Sienlo Bridge
1270
1275
4-07; Taglatawan Bridge
4-08; Sinadiao Bridge
1280
4-10; Bayugan Bridge
1285
4-12; Labao Bridge
1290
4-15; Awa Bridge
1295
4-16; Gibong Bridge
1300
4-17; Patin-ay I Bridge
4-18; Patin-ay II Bridge
1305
4-19; Hubang Bridge
4-20; Adlayan Bridge
4-21; Tagconayon Bridge
4-22; Bayugan II Bridge
4-23; Anagasian Bridge
1320
4-24; Lagcogangan Bridge
LEGEND :
PAVEMENT REHABILITATION
PCC Reconstruction
AC Reconstruction
AC Overlay
No Work
SHOULDER IMPROVEMENT
PCC Shoulder Const.
Existing PCC Shoulder
AC Shoulder Const.
Gravel Shoulder Reconst.
No Work
DRAINAGE IMPROVEMENT
Conc. Side Ditch Const.
BRIDGE REHABILITATION
Total Reconstruction
Partial Reconstruction
Widening
Other Rehabilitation Works
Aesthetic Protection Only
No Work
SLOPE PROTECTION AGAINST :
Cut Slope Failure
Embankment Slope Failure
Landslide
Debris Flow
COUNTERMEASURES AGAINST FLOOD
Countermeasures
PROPOSED REHABILITATION WORKS (3/6)


4-21; Tagconayon Bridge
4-22; Bayugan II Bridge
4-23; Anagasian Bridge
4-24; Lagcogangan Bridge
4-25; Tagbayagan Bridge
4-26; Sulibao Bridge
4-27; Padigusan Bridge
4-28; Lahi Bridge
4-29; Wasan Bridge
4-30; Boan Bridge
4-31; Bayugan III Bridge
4-32; Ko-o Bridge
4-33; Singanan Bridge
4-34; Bunawan Bridge
4-35; Simulao Bridge
4-36; Mangalibobo
4-37; Onoman
4-38; Langkilaan Bridge
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Scale 1 : 250,000
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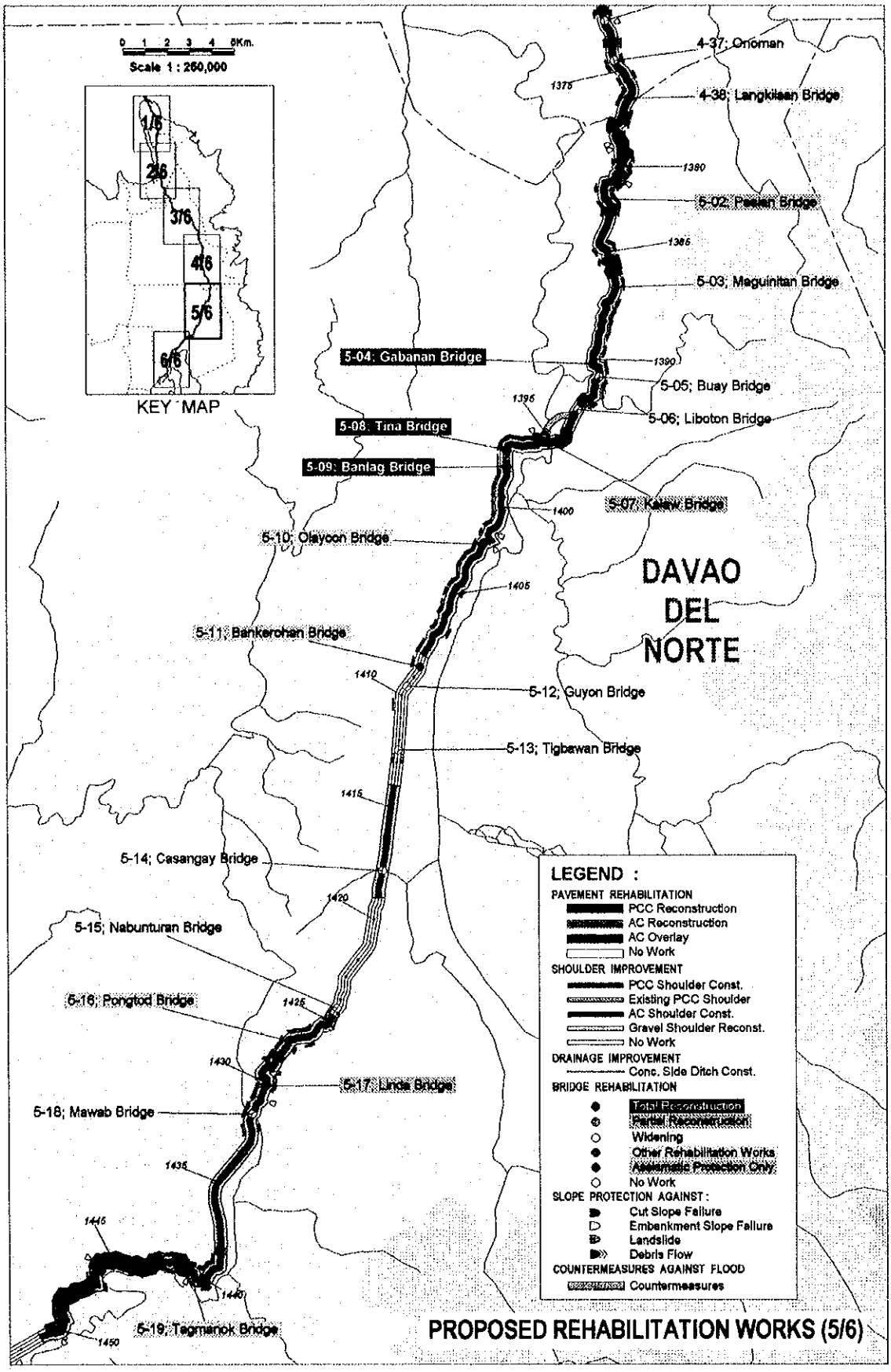
3/6
4/6
5/6
6/6
KEY MAP
AGUSAN
DEL SUR
LEGEND :
PAVEMENT REHABILITATION
PCC Reconstruction
AC Reconstruction
AC Overlay
No Work
SHOULDER IMPROVEMENT
PCC Shoulder Const.
Existing PCC Shoulder
AC Shoulder Const.
Gravel Shoulder Reconst.
No Work
DRAINAGE IMPROVEMENT
Conc. Side Ditch Const.
BRIDGE REHABILITATION
Total Reconstruction
Partial Reconstruction
Widening
Other Rehabilitation Works
Asphaltic Protection Only
No Work
SLOPE PROTECTION AGAINST :
Cut Slope Failure
Embankment Slope Failure
Landslide
Debris Flow
COUNTERMEASURES AGAINST FLOOD
Countermeasures
PROPOSED REHABILITATION WORKS (4/6)


0 1 2 3 4 5Km.
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KEY MAP
1/6
2/6
3/6
4/6
5/6
6/6
4-37; Oriomar
4-38; Langkilaan Bridge
5-02; Pasian Bridge
5-03; Maguinitan Bridge
5-04; Gabanan Bridge
5-05; Buay Bridge
5-06; Liboton Bridge
5-07; Kalaw Bridge
5-08; Tina Bridge
5-09; Banlag Bridge
5-10; Olayoon Bridge
5-11; Bankerohan Bridge
5-12; Guyon Bridge
5-13; Tigbawan Bridge
5-14; Casangay Bridge
5-15; Nabunturan Bridge
5-16; Pongtod Bridge
5-17; Linda Bridge
5-18; Mawab Bridge
5-19; Tagmanok Bridge
1375
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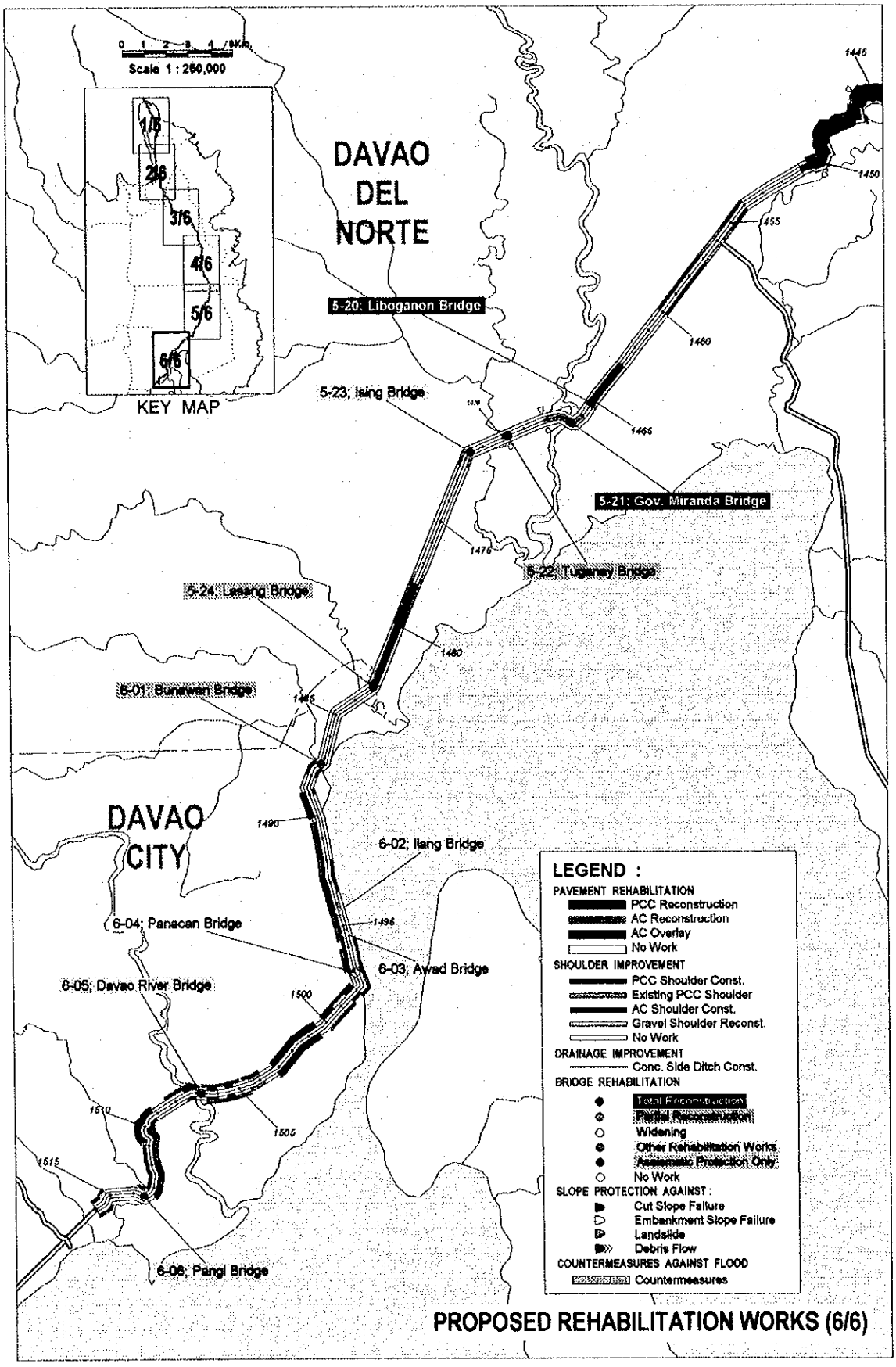
DAVAO DEL NORTE
LEGEND :
PAVEMENT REHABILITATION
PCC Reconstruction
AC Reconstruction
AC Overlay
No Work
SHOULDER IMPROVEMENT
PCC Shoulder Const.
Existing PCC Shoulder
AC Shoulder Const.
Gravel Shoulder Reconst.
No Work
DRAINAGE IMPROVEMENT
Conc. Side Ditch Const.
BRIDGE REHABILITATION
Total Reconstruction
Partial Reconstruction
Widening
Other Rehabilitation Works
Appropriate Protection Only
No Work
SLOPE PROTECTION AGAINST :
Cut Slope Failure
Embankment Slope Failure
Landslide
Debris Flow
COUNTERMEASURES AGAINST FLOOD
Countermeasures
PROPOSED REHABILITATION WORKS (5/6)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DAVAO DEL NORTE
DAVAO CITY
5-20; Liboganon Bridge
5-23; Isiang Bridge
5-21; Gov. Miranda Bridge
5-22; Tuganey Bridge
5-24; Lasang Bridge
6-01; Buhangin Bridge
6-02; Ilang Bridge
6-03; Awad Bridge
6-04; Panacan Bridge
6-05; Davao River Bridge
6-06; Pangi Bridge
LEGEND :
PAVEMENT REHABILITATION
PCC Reconstruction
AC Reconstruction
AC Overlay
No Work
SHOULDER IMPROVEMENT
PCC Shoulder Const.
Existing PCC Shoulder
AC Shoulder Const.
Gravel Shoulder Reconst.
No Work
DRAINAGE IMPROVEMENT
Conc. Side Ditch Const.
BRIDGE REHABILITATION
Total Reconstruction
Partial Reconstruction
Widening
Other Rehabilitation Works
Antiseismic Protection Only
No Work
SLOPE PROTECTION AGAINST :
Cut Slope Failure
Embankment Slope Failure
Landslide
Debris Flow
COUNTERMEASURES AGAINST FLOOD
Countermeasures
PROPOSED REHABILITATION WORKS (6/6)

7 COST ESTIMATE

CONTRACT PACKAGING

Basic considerations given in the division of the project into contract packages are as follows:

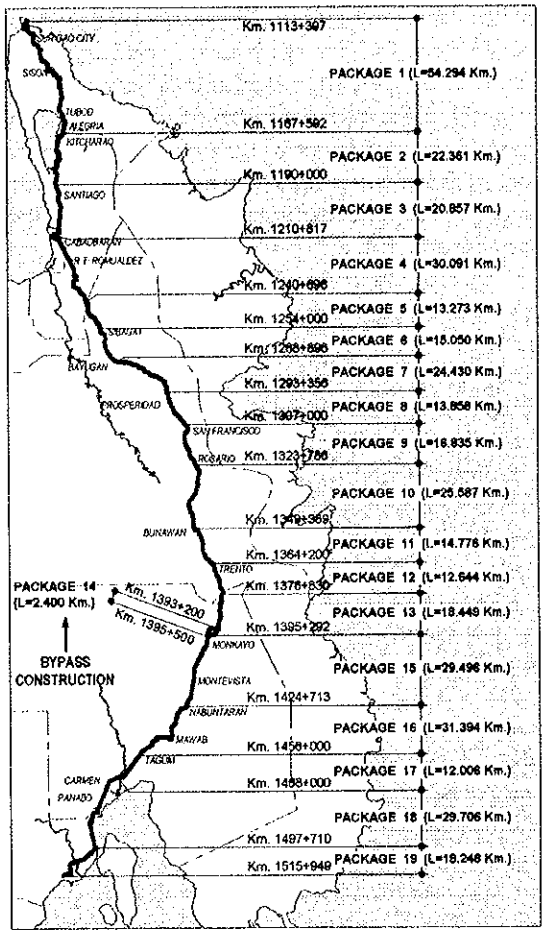
- Construction period of a package should not exceed three years.
- Construction cost of a package should be within the range between 100 and 400 million pesos.
- All works comprised in a certain road section should be covered by a package irrespective of the nature of work.

Based on the above considerations, the project is divided into 19 contract packages.

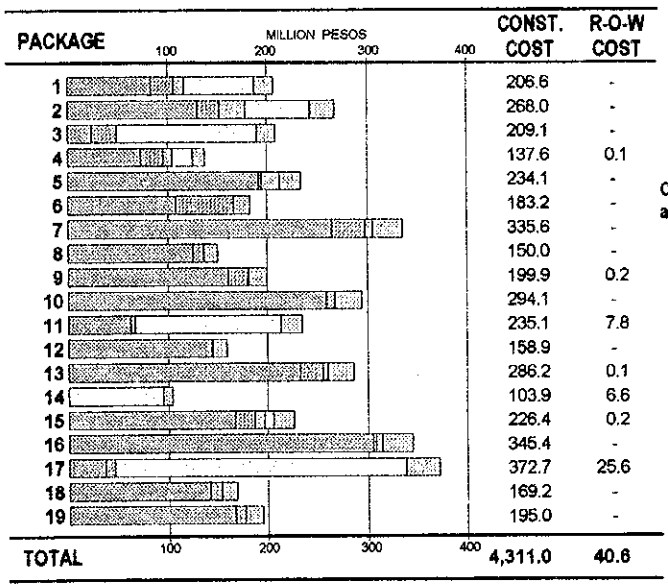
PROJECT COST

(at December 1994 price)

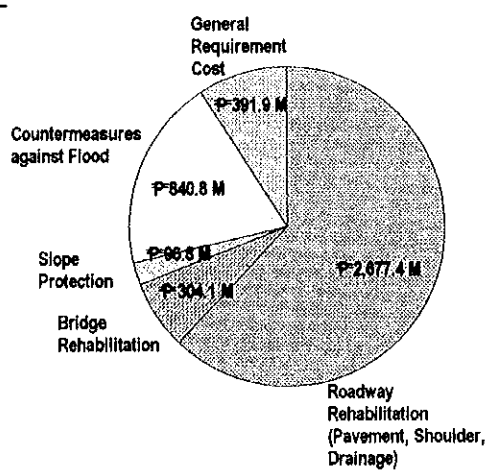
Component	Cost (Million pesos)
Construction cost	4,311.0
Right-of-way cost	40.6
Detailed design cost	172.4
Construction supervision cost	301.8
Total	4,825.8



CONTRACT PACKAGES



CONSTRUCTION COST AND RIGHT-OF-WAY COST BY CONTRACT PACKAGE



CONSTRUCTION COST BY ITEM

8 ECONOMIC EVALUATION

ECONOMIC COST

After deducting transfer-costs(taxes) from the financial cost of the project, the economic cost was estimated by applying the shadow exchange rate of 1.2 to the foreign portion and the shadow wage rate of 0.6 to unskilled labor costs.

The economic cost was further converted to the equivalent single year cost, applying 15% of interest rate to such costs scheduled to invest for more than one year as engineering cost and land acquisition cost. The economic cost of the project is accounted the sum of 4.61 billion pesos or 95.6% of the financial cost.

ECONOMIC COST OF THE PROJECT

(Million Peso)

Work Item \ Cost	Financial	Economic
Road Rehabilitation	3,269.1	3,111.8
Bridge Rehabilitation	372.7	354.1
Slope Protection	118.2	113.2
Flood Protection	1,065.8	1,035.2
Total	4,825.8	4,614.3

ECONOMIC BENEFIT

This trunk road rehabilitation project aims mainly at improvement of service level for the present and future traffic. Therefore, benefit estimation is limited only to the direct benefits, not including indirect benefits such as regional and industrial development impacts.

Economic benefits are taken into account for 20 years (1998 - 2017). In this period, traffic of some sections will exceed the capacity of two-lane road, while the recommended rehabilitation plan does not include any widening work. Thus, traffic benefits shall be accounted only up to the capacity of the two-lane road (20,000 vehicles/day).

Discounting annual benefits accruing over 20 years to the 1997 value, total benefit is 10.06 billion pesos, of which 73% will be generated by road rehabilitation, 12% by countermeasures against flood, 11% by bridge rehabilitation and 4% by slope protection.

Savings in vehicle operating cost is dominant source of benefit, namely, 77% of the total benefit, followed by 10% of savings in detour cost.

ECONOMIC BENEFIT DURING 1998 - 2017 (Million Pesos discounted to 1997 value)

	Economic Benefit						Total
	VOC Saving	Detour Cost Saving	Maint. Cost Saving		Restoration Cost Saving	Rise of Land Value	
			Periodic	Routine			
Road							
Pavement	3,401.8	-	-	170.6	-	-	3,572.4
Shoulder	1,460.4	-	8.4	-	-	-	1,468.8
Drainage	2,114.3	-	210.2	-	-	-	2,324.5
Bridge							
Rehabilitation	-	879.6	-	-	163.3	-	1,042.9
Widening	19.7	-	-	-	-	-	19.7
Slope Protection	335.8	-	-	-	55.8	-	391.6
Countermeasures against Flood							
Road	388.4	-	7.7	-	-	-	396.1
Bridge	-	153.3	-	-	29.6	-	182.9
Drainage/Dike	-	-	-	-	404.8	258.0	662.8
Total	7,720.4	1,032.9	226.3	170.6	653.5	258.0	10,061.7

EVALUATION RESULT

The internal rate of return(IRR) is estimated at 30.5%, far beyond the interest rate of capital opportunity (15%). Thus, this rehabilitation project is concluded as a highly feasible one from the economic point of view. Every work by link is also economically viable. In addition, sensitivity analysis proves that the benefit of the Project is quite stable against the change in traffic demand and the project cost.

ECONOMIC EVALUATION INDICATORS

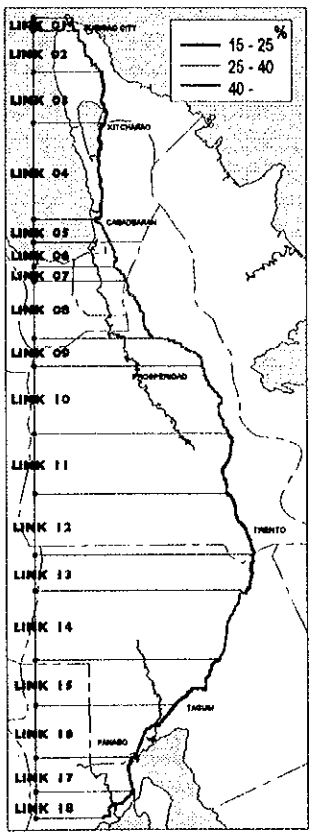
Work Item	IRR(%)	NPV	B/C
Road Rehabilitation	32.5	4,253.9	2.37
Bridge Rehabilitation	33.6	708.5	3.00
Slope Protection	45.0	278.4	3.46
Flood Protection	18.7	206.6	1.20
Whole Project	30.5	5,447.4	2.18

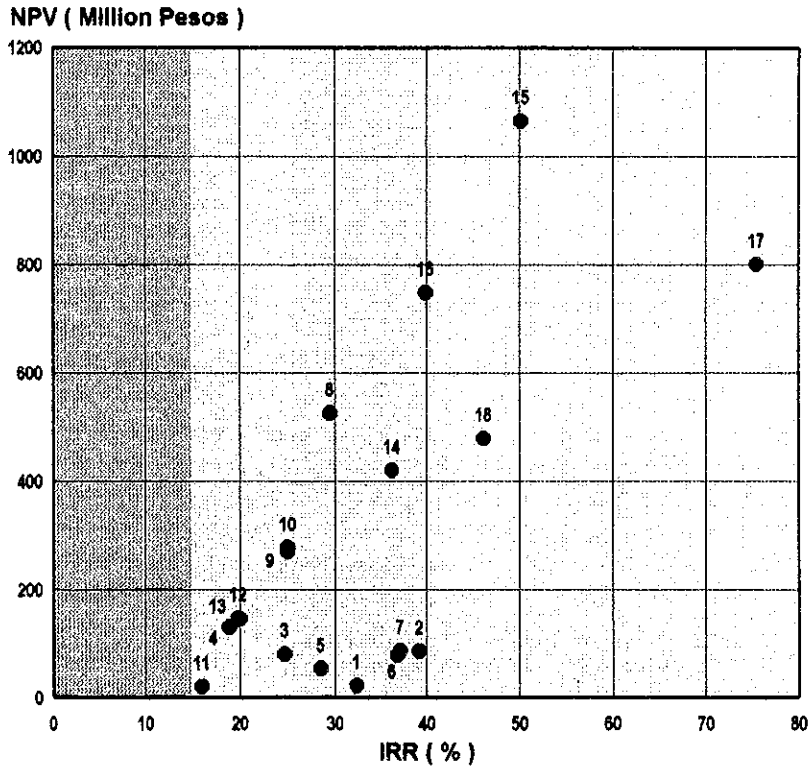
CONCLUSION

The first year benefit (FYB) of 1998 is already larger than the 15% of the project cost. If it is reasonable to consider that the optimal year to start a project is the year when its benefit exceeds the capital opportunity cost, then the commencement of this project is already too late, even in 1997. Therefore, an urgent implementation, not behind the proposed schedule, is recommended.

FIRST YEAR BENEFIT(FYB) OF THE PROJECT
(Million Peso)

Work Item	FYB	Cost	FYB/Cost
Road Rehabilitation	903.3	3,111.8	29.0%
Bridge Rehabilitation	67.3	354.1	19.0%
Slope Protection	40.4	113.2	35.7%
Flood Protection	238.4	1,035.2	23.0%
Whole Project	1,249.4	4,614.3	27.1%





IRR AND NPV BY LINK

9 ENVIRONMENTAL IMPACT ASSESSMENT

As the Project is to rehabilitate/improve the existing road, it was assessed that positive impacts are significantly large, on the other hand, negative impacts are negligibly small. Of the 23 factors evaluated, only 3 factors were found to have slight negative impacts. The rest of factors were assessed to have significant positive impacts or no/negligible impacts.

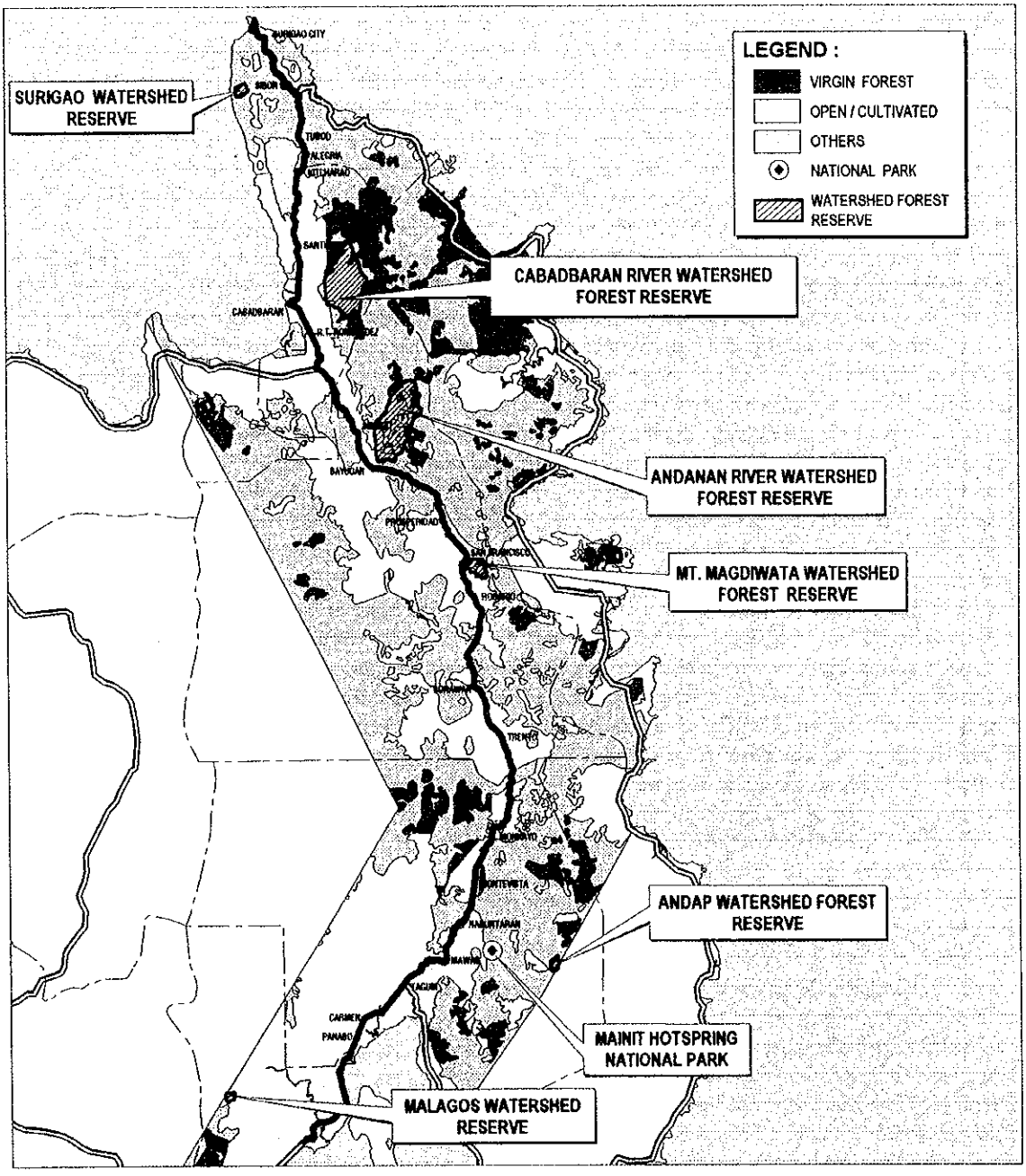
SOCIAL ENVIRONMENTAL IMPACT: The Project will vitally support the economic activities in the area by reducing transport costs and providing reliable means of transport. Three negative impacts are: the relocation of about 41 families, traffic congestions during construction and production of construction wastes, for which mitigating measures must be taken during construction.

SUMMARY OF ENVIRONMENTAL IMPACTS BY THE PROJECT

Environmental Factor		Impact	Remarks
Social Environment	1. Resettlement	Slightly negative	• 41 affected families in Simulao Section
	2. Economy	Significantly positive	• Enhancement of economic activities in Region X and XI • Enhancement of activities of construction sector • Increase of land productivity and land value
	3.1 Traffic, Life facilities (during construction)	Slightly negative	• Increase of traffic congestion in traffic section 21 and 22 (during roadway rehabilitation) • Increase of traffic congestion at four bridge rehabilitation sites (during bridge rehabilitation)
	3.2 Traffic, Life Facility (after completion)	Significantly positive	• Decrease of running costs • No traffic interruption at disaster potential spots • Fewer traffic accidents against pedestrians
	4. Community Disruption	None	
	5. Historic spots, cultural assets	None	• No historic spots/cultural assets observed
	6. Water Right, Common Right	Negligibly small	• Small fish catch in Project Area
	7. Sanitation	None	
	8. Waste	Slightly negative	• Removal of existing pavement (22.7 km) • Destruction of existing bridges (8 bridges) • Dredging river beds (10 rivers) • Recutting of slopes (6 slopes)
	9. Disaster	Significantly positive	• Prevention of disaster occurrence (30 critical spots observed)
Natural Environment	10. Topography/ Geology	None	
	11. Soil Erosion	Slightly positive	• Prevention of soil erosion due to slope protection (76 slopes)
	12. Ground Water	None	
	13. Lake/River	Slightly Positive	• Prevention of irregular water flow of rivers
	14. Coast/Sea	None	
	15. Animals and Plants	Negligibly small	• Virgin forest not affected • Traversing mostly cultivated areas
	16. Meteorology	None	
	17. Landscape	Negligibly small	• Improvement of existing desolated landscape on eroded slopes
Pollution	18. Air Pollution	Negligibly small	• Acceptable levels of air pollution
	19. Water Pollution	Negligibly small	• Most rivers classified into C or D • Only creak or small water stream classified into A
	20. Soil Pollution	None	
	21. Noise, Vibration	Negligibly small	• Decrease of noise level due to fewer speed changes of vehicles
	22. Land Subsidence	None	
	23. Nasty Smell	None	

NATURAL ENVIRONMENTAL IMPACTS: The Study Road traverses mostly cultivated/developed areas, thus virgin forests and environmentally protected areas are not affected. Impacts on natural environment are slightly positive or none.

POLLUTION: The Project will greatly improve road surface conditions, thus pollutions such as noise, air, vibration, etc., will be lessened compared with the "without" project case. Impacts on pollution are negligibly small or none.



LOCATION OF VIRGIN FOREST AND PROTECTED AREAS

10 IMPLEMENTATION SCHEDULE

FUND AVAILABILITY: After having analyzed past and future budget for the highway sector and previous budget allocation to individual projects and discussed with DPWH officials, the budgetary framework for this project was concluded to be 1,000 Million pesos per year.

PRIORITY OF CONTRACT PACKAGES: Based mainly on the physical condition, contract packages were classified into four groups; 6 packages for the 1st, 5 for the 2nd, 3 for the 3rd and 5 for the 4th priority groups.

IMPLEMENTATION SCHEDULE: Based on the fund availability and priority of contract packages, the implementation schedule was formulated.

Detailed Design	1995-1996 (1.5 year)
ROW Acquisition	Completed before construction
Construction	1997-2002 (5.75 years)
Construction Supervision	1997-2002 (5.75 years)

ANNUAL FUND REQUIREMENT: Maximum fund will be required in 2001 amounting to 964 Million pesos.

IMPLEMENTATION SCHEDULE

(Unit : Million Pesos in Dec. 1994 Prices)

		1995	1996	1997	1998	1999	2000	2001	2002	TOTAL
IMPLEMENTATION SCHEDULE	DETAILED DESIGN									172.4
	ROW ACQUISITION AND CONSTRUCTION — PACKAGE 1									206.6
	PACKAGE 2									268.0
	PACKAGE 3									209.1
	PACKAGE 4									137.7
	PACKAGE 5									234.1
	PACKAGE 6									183.2
	PACKAGE 7									335.6
	PACKAGE 8									150.0
	PACKAGE 9									200.1
	PACKAGE 10									294.1
	PACKAGE 11									242.9
	PACKAGE 12									158.9
	PACKAGE 13									286.3
	PACKAGE 14									110.5
	PACKAGE 15									226.6
	PACKAGE 16									345.4
	PACKAGE 17									398.4
	PACKAGE 18									169.2
	PACKAGE 19									195.0
	CONST. SUPERVISION									301.8
ANNUAL FUND REQUIREMENT	DETAILED DESIGN	86.2	86.2	-	-	-	-	-	-	172.4
	ROW ACQUISITION	-	-	25.7	14.8	0.1	-	-	-	40.6
	CONSTRUCTION	-	-	572.7	738.6	838.3	796.6	906.6	458.2	4,311.0
	CONST. SUPERVISION	-	-	40.0	57.5	57.5	57.5	57.5	31.8	301.8
	TOTAL	86.2	86.2	638.4	810.9	895.9	854.1	964.1	490.0	4,825.8

LEGEND : Detailed Design; ROW Acquisition; Construction; Construction Supervision

11 CONCLUSION AND RECOMMENDATIONS

CONCLUSION

The Study Road suffers from various problems such as progressive deterioration of pavement, structural and hydraulic problems in bridges, repeated slope failures in mountainous areas and frequent occurrence of floods, resulting in aggravation of riding quality, rise of transport cost and even traffic interruptions for a certain period. To cope with such problems, various rehabilitation/improvement works are proposed including pavement rehabilitation, shoulder improvement, drainage improvement, weak subgrade treatment, bridge rehabilitation, slope protection and countermeasures against flood. The proposed project will make the road solid, reliable and comfortable.

The project is discussed on its viability from various points of view and concluded to be feasible from every aspect as summarized below:

Technical Aspect: All proposed works can be completed by usual construction methods commonly used in the Philippines and all necessary equipment and materials are easily obtained at sites. Thus, no technical problem is expected in the project implementation.

Economic Aspect: Economic evaluation proves a high economical viability of the project for all work components in all links.

Financial Aspect: The project can be implemented within reasonable financial framework in accordance with the proposed schedule.

Environmental Aspect: No adverse environmental impact is foreseen except relocation of a few inhabitants and traffic interference during construction, which will be easily solved/mitigated.

Social and Developmental Aspects: The project will contribute to improvement of social environment and promote the regional development by providing reliable means of transport.

RECOMMENDATIONS

Early Implementation: It is highly recommended to implement the project in the earliest possible time. The proposed implementation schedule is prepared taking into account the reasonably estimated fund availability for each year. The implementation should, however, be hastened if there is a fair prospect of increased fund for the project.

Mitigation Measures of Environmental Impacts: Due considerations should be given to mitigate adverse environmental impacts. Possible adverse impacts and their mitigation measures are as follows:

- Relocation of inhabitants:
  A proper relocation plan should be prepared including provision of resettlement area in the vicinity.
- Traffic interference during construction
  Mitigation measures such as opening of at least one lane to traffic and maintenance thereof in comfort and safety, proper traffic control, provision of safety devices, etc. should be taken.

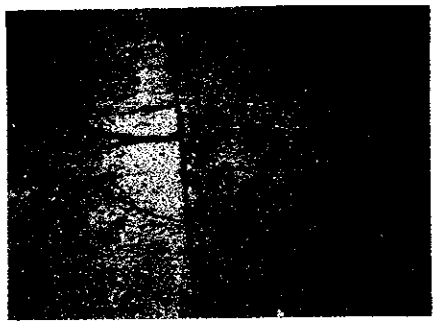
Maintenance Requirements: The Future maintenance should focus on:

- Maintenance of the sections where no rehabilitation work is proposed.
- Minor repair works of the bridges not covered by the project.
- Cleaning of drainage facilities, especially side ditches and cross drainages in flood sections and mountainous sections.
- Periodic dredging of riverbed sediments, especially for the bridges where dredging is proposed in the project.
- Strengthening of monitoring system.

Conduct of Related Projects: It is recommended to undertake the related projects to maximize the effect of this project, including:

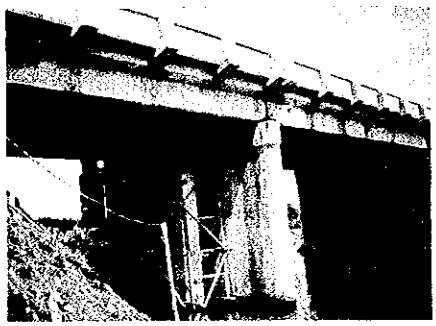
- Widening of a 21.6-km section from Davao del Norte-Davao City boundary up to Buhangin Junction on the Davao City Diversion Road.
- Improvement of access roads branching off from the Study Road.
- Control of the rivers flowing in the Study Area.

TOTALLY DESTROYED PAVEMENT IN AGUSAN DEL SUR



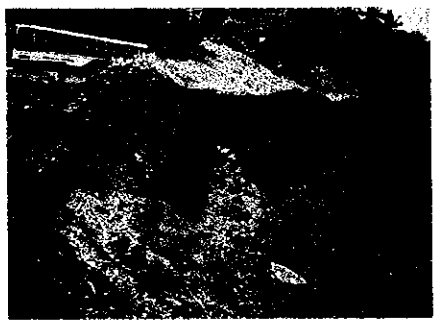
TYPICAL PAVEMENT CRACKS IN DAVAO DEL NORTE

PANAYTAY BRIDGE: SUPERSTRUCTURE NO LONGER FUNCTIONING



LIBOGANON BRIDGE: SUFFERING FROM PIER SETTLEMENT

CUT SLOPE FAILURE IN SURIGAO DEL NORTE



EMBANKMENT SLOPE FAILURE IN DAVAO DEL NORTE

FLOOD SECTION IN AGUSAN DEL NORTE. OVERFLOWED WATER FROM THE RIVER FLOODED THE HIGHWAY.

FLOOD SECTION NEAR LIBOGANON BRIDGE IN DAVAO DEL NORTE. THE SECTION SUBMERGED 3 HOURS AFTER THIS PHOTO WAS TAKEN.