7.5 Design of Roads

7.5.1 Alignment Study

A. Route Description

Based on the best route, (selected as outlined in Chapter 6), a detailed alignment study was made and the general description for the route of each Project Road is presented below:

i) The Coastal Road

Based on the offshore area and of the existence of the reclaimed area, the horizontal alignment is planned to be a straight line except for the R-10 junction.

On the Coastal Road, one interchange with C-5 is planned, while the connection with C-6 is not considered as an interchange, but as a bend of the throughfare. An interchange C-4/R-10 Coastal Road was considered to be beyond of the scope of this Project.

ii) C-5

Sta. 0+000 - Sta. 4+650

Generally the topography in this section is flat and characterized by low land and land use is predominantly for fish ponds.

In the section from Sta. 3+650 (National Highway 369) to Sta. 4+650, the area is partially covered by rice paddies, and partially by residential areas and industrial areas.

The C-5 begins at the interchange with the Coastal Road and its intersecting point is located 600 m offshore from the existing coastline.

For the channel between the reclaimed area and the existing coastline, a bridge with a total span of 280 m is planned.

Beyond Sta. 1+000 the route turns slightly eastward with a radius of curvature of 3,400 m avoiding a major tributary of the Navotas River.

At Sta. 3+170, the route crosses the Polo-Malabon road providing a sufficient skew angle.

At the crossing of National Road 369, utmost attention was paid to the distance from the intersection existing at the north. Because of thus required distance, two large factories must be relocated.

The existing Rizal Gate on the Banghulo-Polo Road is maintained.

Sta. 4+650 - Sta. 9+550

The topography in this section gradually rises up toward the east from El. 3 m to El. 19 m. The land use is still predominantly for rice paddy except in Malinta. In Malinta, development for both residential and industrial areas has taken place.

At the crossing with McArthur Highway, the location of the route was determined based on a consideration of the distance to the Malinta Intersection and the location of Fil-Hispano Ceramic Inc. business establishment.

At Sta. 5+800, a grade separation structure was planned at the crossing of Malinta Interchange Access Road considering the existing traffic conditions and the distance to the planned C-5/McArthur Highway Interchange. The route alignment in this area was controlled by two college buildings which are located along the access road. After passing a factory at Sta. 6+000, the route runs across a cattle pasture located at Sta. 6+400.

Between Stas. 6+400 and 8+400 many small villages are scattered among the rice paddy areas. The proposed route was selected as an extension of the future Republic Avenue generally avoiding these small villages.

iii) C-6

Sta. 0+000 - Sta. 6+000

Generally the topography in this section is also flat and low land. Land use for fish ponds predominates, but it is also partially a rice paddy area and some limited residences exist along the existing roads. No factories are located in this section.

The C-6 route also starts from the connecting points with the Coastal Road. For the channel between the reclaimed area and the existing coastal line a 280 m bridge was planned.

The route between Sta. 0+600 (existing coastal line) and Sta. 3+850 (crossing with National Road 369) was established considering the crossing of a major tributary of the Meycawayan River in order to reduce the total length of bridge required for this crossing. A bridge span length of about 140 m is necessary for future training of the tributary.

In the section between National Road 369 and McArthur Highway, no serious control point was found.

Therefore the route alignment was selected considering the crossings of several minor rivers and roads.

Sta. 6+800 - Sta. 10+000

The general terrain from Sta. 6+800 to Sta. 8+800 varies in elevation between 2 m and 6 m due to the crossing of several tributaries of the Meycawayan River. From Sta. 8+800 the ground rises gradually to an elevation of 16 m. Rice paddy area is the predominant land use however, the area is also partially residential.

The crossing of McArthur Highway is a primary control point since the existing intersection is located close to the planned C-6/McArthur Highway Interchange.

Beyond this crossing the route passes over the Philippine National Railway and then passes the edge of a subdivision. After this, the route runs through rice paddy areas to the Manila North Expressway.

B. Study of Vertical Alignment

The Initial Study for the vertical alignment was made simultaneously with the study for the horizontal alignment and following a study of the bridges and culverts, the adjustment of the vertical alignment mentioned above was executed.

Where the Project Road crosses a river, hydrological and hydraulic studies were made in order to determine the high water levels for waterway and drainage structures. High water levels determine the required height of bridges and culverts and therefore become very important control points in the vertical alignment study.

Basic requirements controlling the engineering aspects of the vertical alignment study were as follows:

- In areas subject to flooding, the finished grade of the roadway will be maintained 1.0 m above the water surface;
- Minimum gradient of 0.30% will be adopted for roadway surface drainage;
- Flatter vertical gradients and a larger length of vertical curve will be adopted for the interchange sections as much as possible;
- The maximum gradient at at-grade intersection will be 2%;
- The minimum vertical clearance for grade separation structure will be 4.9 m considering future overlay; and
- A combination of horizontal and vertical alignments will be considered.

In addition to the basic requirements mentioned above, the following primary control points were considered for the determination of vertical alignment:

i) Coastal Road

- Navigation clearance for the Navotas canal at Sta. 3+374 is 12 m (30 m for alternative scheme) above mean sea level;

- Navigation clearance between blocks III and IV at Sta. 5+450 is 3.0 m above mean sea level; and

- At-grade intersections to be provided at Stas. 1+520 4+900 and 6+400.

ii) C-5

- Navigation clearance for banca boats at the bridge planned at Sta. 0+500 is 3 m above mean sea level;

- At-grade intersection to be provided are:

  Sta. 2+250
  3+150
  3+670 National Highway 369
  4+070

- Grade-separation structures to be provided are:

  Sta. 5+060 McArthur Highway and P.N.R.
  9+045 Manila North Expressway.

iii) C-6

- Navigation clearance for banca boats at the bridge planned at Sta. 0+500 is 3 m above mean sea level;

- Grade-separation structures to be provided are:
  Sta. 3+840 National Road 369
  4+300
  4+920
  5+600
  6+260
  6+830 McArthur Highway
  7+370 P.N.R.
  7+570
  9+490 Manila North Expressway

C. Plan and Profiles

The horizontal and vertical alignments adopted for each Project Road are presented on the plan and profile sheets at 1:400 vertical scale and 1:8,000 horizontal scale and are compiled in Volume III: Drawings (See Plans and Profiles Sheet Nos. 1 thru 11).

The elements of horizontal and vertical alignments, the stations, radii of horizontal curves, finished grade line, existing ground line, profile of bridges and culverts are included on these sheets together with other salient features.

7.5.2 Typical Cross-Section of Roads

The elements of cross-section component applicable to the Project Road were described in 7.3.1 Road Design Standards. The Figs. III-7-3 thru III-7-8 present the typical cross-sections applicable to the Project Roads.

Fig. III-7-3 TYPICAL CROSS SECTION MANILA-BATAAN COASTAL ROAD (C-4 TO C-6) ULTIMATE STAGE

R.O.W. = 70 m

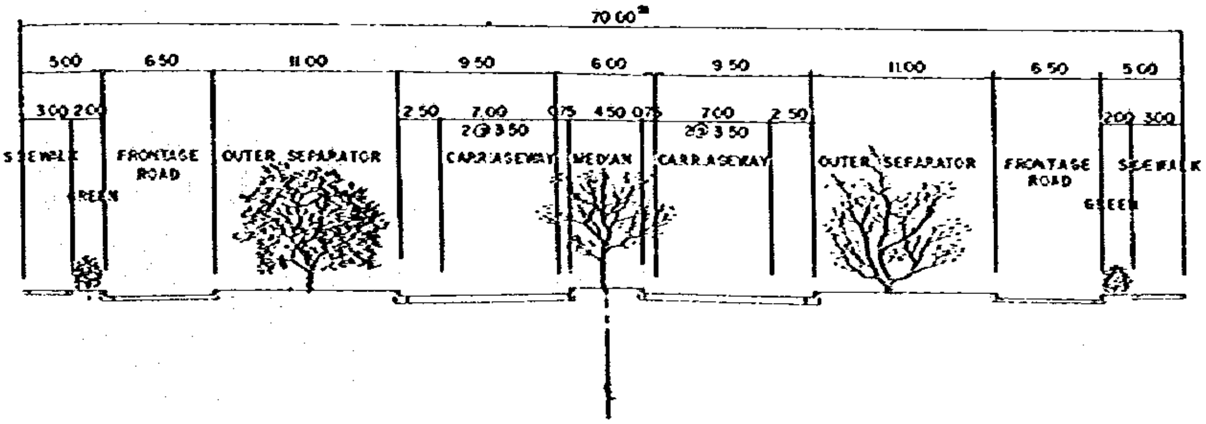


Fig. III-7-4 TYPICAL CROSS SECTION MANILA-BATAAN COASTAL ROAD (C-4 TO C-6) INITIAL STAGE

R.O.W : 70m

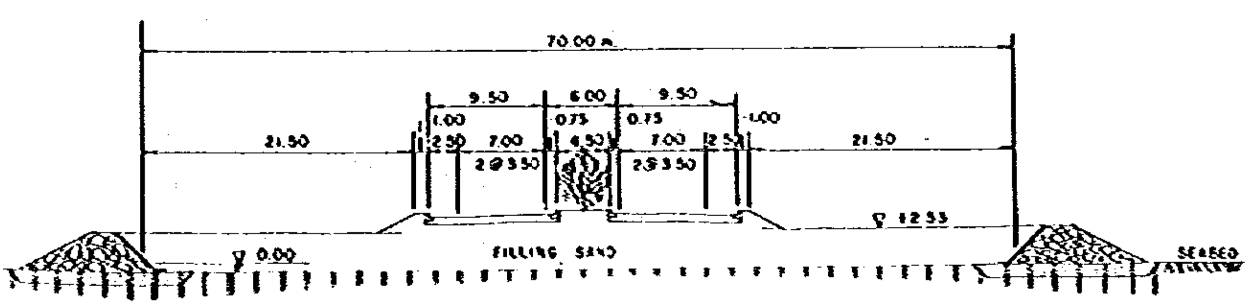
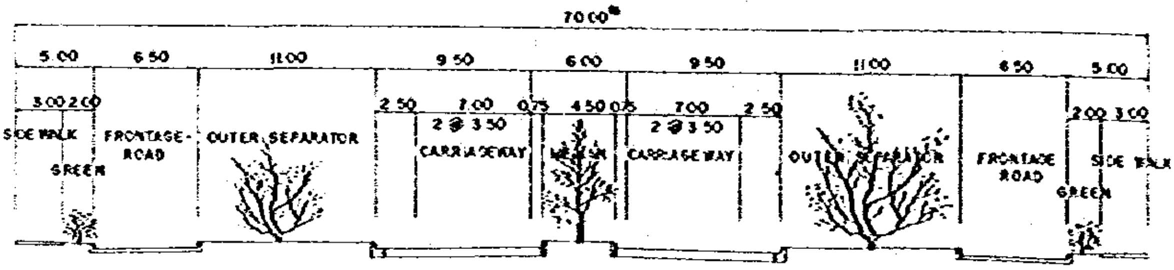


Fig. III-7-5 TYPICAL CROSS SECTION MANILA-BATAAN COASTAL ROAD (C-4 TO C-6) INITIAL STAGE

RECLAMATION BLOCK II



RECLAMATION BLOCK III

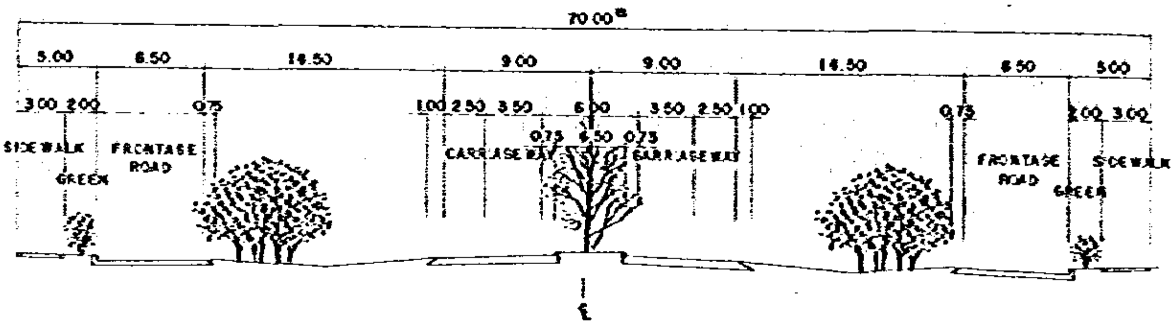
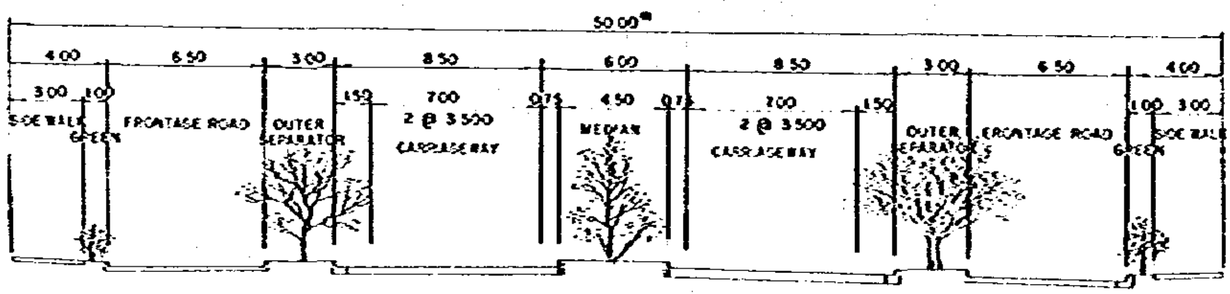


Fig. III-7-6 TYPICAL CROSS SECTION C-5

ULTIMATE STAGE

SECTION: COASTAL ROAD TO NATIONAL HIGHWAY 363 AND MCARTHUR HIGHWAY TO MANILA NORTH EXPRESSWAY



INITIAL STAGE

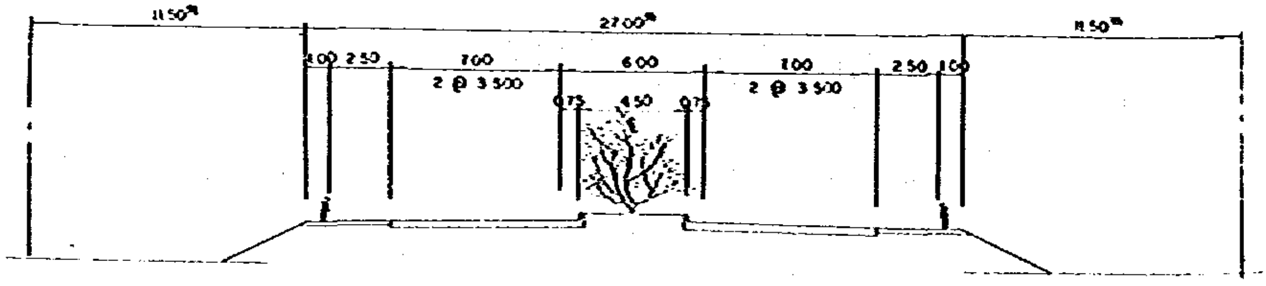


Fig. III-7-7 TYPICAL CROSS SECTION C–5
INITIAL AND ULTIMATE STAGE

R.O.W. = 50m

SECTION: NATIONAL HIGHWAY 369 TO MCARTHUR HIGHWAY

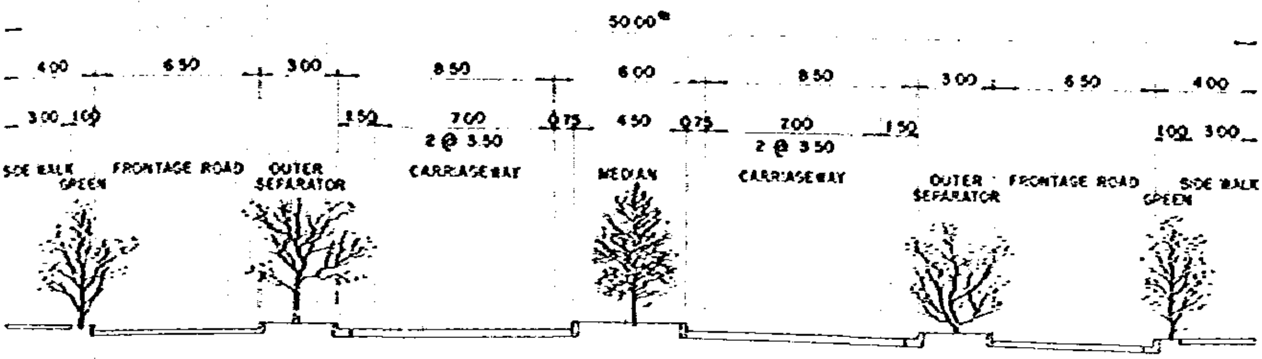
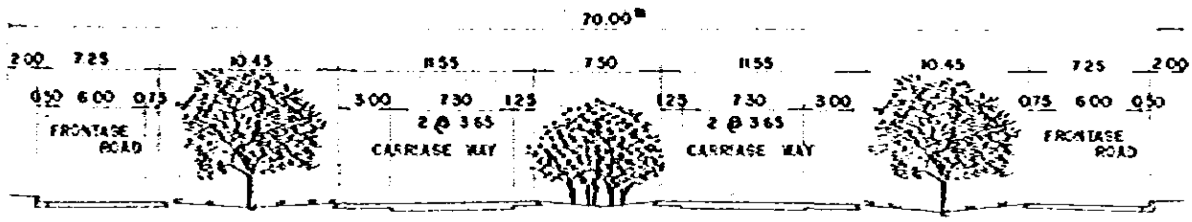


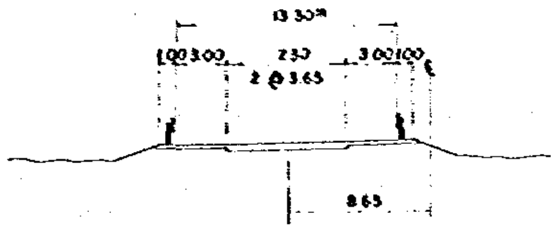
Fig. III-7-8 TYPICAL CROSS SECTION C–6

R.O.W. = 70m

ULTIMATE STAGE



INITIAL STAGE



7.5.3 Study of Interchanges

A. General

Interchanges are the vital connecting facilities for the roadway system. There should be an adequate number of them in order to attain the utmost of traffic efficiency and to aid in future regional development.

Two major interchanges on the Manila North Expressway and one major interchange on the Coastal Road are studied in this Chapter as well as minor interchanges for each Project Road.

i) Location of Interchange

The location of interchanges are listed as follows:

Interchange At	Number of Legs	Crossing Road
Coastal Road	3	C-5
"	4	Arterial Street in Reclaimed Area
C-5	4	McArthur Highway
"	4	Manila North Expressway
C-6	4	National Road 369
"	4	McArthur Highway
"	4	Manila North Expressway

ii) Selection of Interchange Type

The factors considered in deciding the type of interchange are as follows:

- Type of connecting road and its design speed;
- Characteristics of future intersecting traffic;
- Terrain conditions;
- Existing structures, buildings and land use affecting the design of the interchange;
- Safety and efficiency of traffic; and
- Cost.

iii) Geometric Design Criteria of Interchange

It is recommended that the Common MPH Standards as shown in Table III-7-7 be adopted in the design of interchanges.

Table III-7-7 INTERCHANGE GEOMETRIC DESIGN CRITERIA

Item	Unit	Interchange		
		Manila North Expwy.	Coastal Road	Others
Design Speed	km/h	40 or 60	40	40
One-way Lane width	meter	3.5 for C-5	3.50	3.50
Shoulder Width	meter			
Right		3.00	2.50	2.50
Left		1.00	1.00	1.00
Median Width for two-way one-lane	meter	1.00	1.00	1.00 or none
Cross Slope of Pavement	%	2	2	2
Type of Pavement	-	Cement Concrete	Asphalt Concrete	Asphalt Concrete
Maximum Superelevation	%	10	10	10
Minimum Radius	meter	45 or 70	40	40
Maximum Gradient	%	4 or 6	6	7
Stopping Sight Distance	meter	40 or 75	40	40
Minimum Vertical Curve Length	meter			
Crest		8A or 15A	8A	3A ~ 8A
Sag		5A or 10A	5A	3A ~ 5A
Single-Lane Terminal		Highway Design Speed (km/h)		
		120	100	80
Acceleration Lane (including tapers)	meter	270	250	230
Deceleration Lane (including tapers)	meter	180	150	130

Note: Design speed of 40 km/h is applicable to loop ramp, while 60 km/h is applicable to directional and semi-directional ramp.

B. Interchanges provided on the Manila North Expressway

i) General

In suburban areas a high capacity diamond or a full cloverleaf may generally be adequate for an interchange between a freeway and an arterial street. Based on the characteristics of the Project Roads, however, a diamong is not considered suitable because an at-grade intersection on minor roads would be necessary.

Interchanges of two freeways almost always involve some directional or semidirectional ramps and frequently require individual design to accomodate the volume and pattern of turning movements.

Although directional and semi-directional ramps are usually used for the principal turning movements, loop ramps will be employed for the minor movements.

Full cloverleafs, preferably with collector-distributor roads, will be suitable in outlying areas of the city. The layout of an interchange of two expressways should be free of any restrictive weaving on the through-travelled ways.

ii) Type of Interchange to be Adopted

Two types of interchanges for C-5 and C-6 were considered, namely, cloverleaf and directional types, as shown in Appendixes I-39 thru I-42.

Among the many schemes which are commonly used for directional interchanges, the type which was adopted for the comparison was based on the inherent traffic conditions anticipated for the life of the project.

iii) Location of Toll Gate

The Manila North Expressway is a toll road with toll gates at each interchange; the future extension of C-6 is also expected to be a toll road.

The planned interchange, therefore, should be provided with toll gates within it or near to it.

The key factors in deciding toll gate locations are summarized as follows:

- A limited number of toll gates is more profibitable for a toll levy system;
- The location should be in a flat area with ample sight distance; and

- No toll gate for the C-5 through-traffic to and from the eastward extension need to be provided because of the said extension is not a toll road; however, a toll gate for the C-6 in this project necessary.

On the basis of these considerations, the locations of the C-5 toll gate were chosen in four quadrants in accordance with the turning traffic to and from the Manila North Expressway. Toll gates for C-6 were chosen in only two quadrants of C-6, while that of the C-6 extension will be used as a toll barrier gate in the future extension project based on reasons as follows:

- In case of the connection between a toll road (C-6 extension) and a non-toll road (C-6 in this project), the toll road must provide the toll gate at or near the end portion of the toll road; and

- It is more economical to locate one throughfare toll gate (barrier type) together with those of two ramps in two quardrants of the extension on the throughway of the extension road rather than to locate the above toll gates separately.

iv) Comparison of Alternative Types of Interchange

A cloverleaf (Alternative A) and a directional interchange (Alternative B) are compared as shown in Table III-7-8.

Table III-7-8 COMPARISON OF CHARACTERISTICS OF EACH ALTERNATIVE OF INTERCHANGE

Item	Alternative A	Alternative B
Cost		
Construction	Low	High due to additional four bridges required
Land Acquisition	The same area for both alternatives	
Traffic Capacity	Small	Large
Traffic Movement	Fair	Good

v) Conclusion

Alternative A is recommended based on economy.

It is further recommended that the directional ramps for the Alternative A will be located in accordance with that of the Alternative B in order to allow for the future up-grading and to accomodate increased traffic volume after the design life.

C. Coastal Road/C-5 Interchange

The future traffic flow between C-5 and R-10 would predominate, however a full service interchange must be designed because of the traffic flow between C-5 and the reclamation blocks III and IV.

Three types of interchanges were considered as shown in Appendixes I-43 thru I-45.

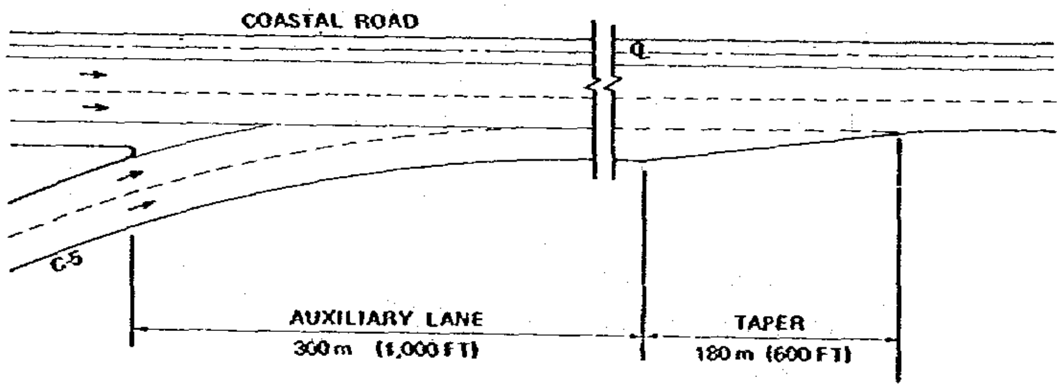
Alternative A - Directional
Alternative B - Cloverleaf
Alternative C - Rotary

A directional interchange with no loop ramps and no weaving was recommended to provide larger traffic capacity and to ensure better traffic movements.

To realize efficient traffic operation through and beyond an interchange, there should be a balance in the number of traffic lanes on the road and ramps. The number of lanes beyond the merging of two traffic streams should not be less than the sum of all traffic lanes on the merging roadways minus one.

Based on these principles, the number of lanes of the Coastal Road beyond the merging of the C-5 traffic was established to be 3 lanes (See Fig. III-7-9).

Fig. III-7-9 AUXILIARY LANE AND TAPER



D. Further Study of Coastal Road/C-5 Interchange

Based on the results of the Navotas Bridge study, the type of crossing structure was determined as the high bridge structure allowing 100-foot navigation clearance beneath it.

Therefore, the approach of this bridge will be increased from 495 to 1,395 meters long. If the junction ramp toward Manila crosses over the Coastal Road at the approach end of the bridge, substantial travelling length over a large area will be necessary. Consequently, it is quite reasonable that the design speed of the rampway be reduced to 50 km/hour from the viewpoints of economy and design of rampway.

The design standards to be adopted for the rampway are as follows.

Description	Recommended Design Criteria
Design Speed	50 km/hr.
Minimum Radius	100 meters
Maximum Gradient	6%
Minimum Vertical Curve Length	
Crest	8A - 12A
Sag	7A - 10A

E. Coastal Road/Arterial Street Interchange

In order to provide a connection between the Coastal Road and a arterial street in the reclaimed area, a modified diamond type interchange was designed using the bridge crossing Navotas Waterway as a grade separation structure.

F. C-5/McArthur Highway Interchange

The connection at McArthur Highway is a half cloverleaf interchange with ramps in 2 quadrants as shown in Appendix I-30. This type was adopted because the McArthur Highway and the railroad of the Philippine National Railways are located closely parallel to each other.

G. C-6/National Road 369 Interchange

For low volume rural crossroads, a diamond interchange is the least costly and a logical type and is also characterized by simplicity, compactness and clearness.

Thus this type has been adopted for the C-6/National Road 369 Interchange. This type is recommended particularly for to major-minor roads or streets and can accomodate traffic efficiently without any hazard on difficulty.

H. C-6/McArthur Highway Interchange

The diamond type interchange is adopted for the same reasons described in Paragraph 7.5.3.G.

I. Typical Cross-Sections of Ramps

On the basis of the interchange geometric design criteria shown in Table III-7-7, above the typical cross-sections of ramps were studied and are shown in Figs. III-7-10 thru III-7-12.

Fig. III-7-10 TYPICAL CROSS SECTION OF RAMP

APPLICABLE FOR: COASTAL ROAD / C-5 I.C.
COASTAL RD./SECONDARY RD. I.C.
AND C-5/MCARTHUR HIGHWAY I.C.

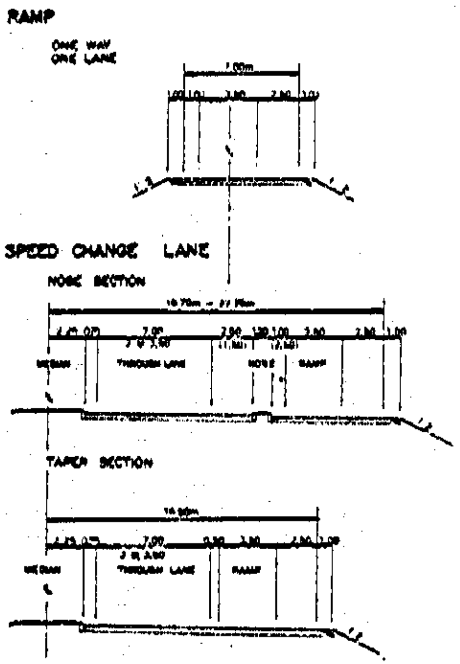


Fig. III-7-11 TYPICAL CROSS SECTION OF RAMP

APPLICABLE FOR: C-6/NATIONAL RD. 369 I.C.
C-6/MCARTHUR HIGHWAY I.C.
AND C-6/MANILA NORTH
EXPRESSWAY I.C.

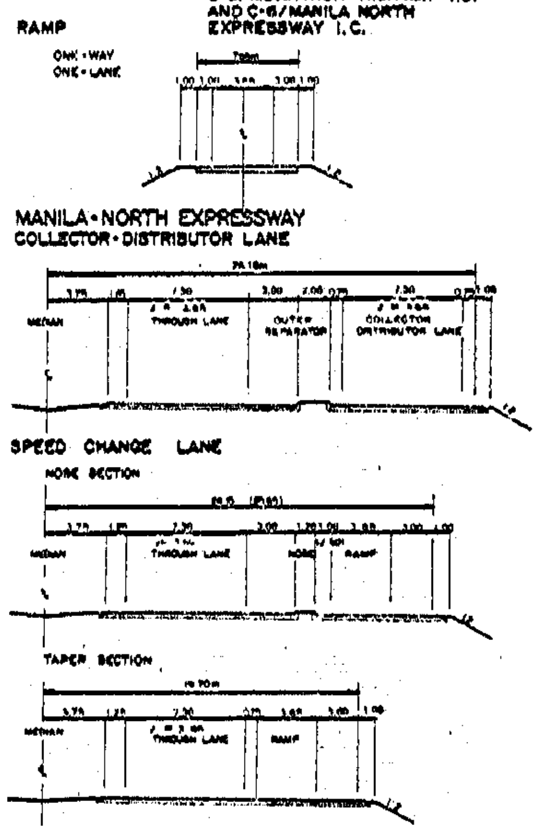
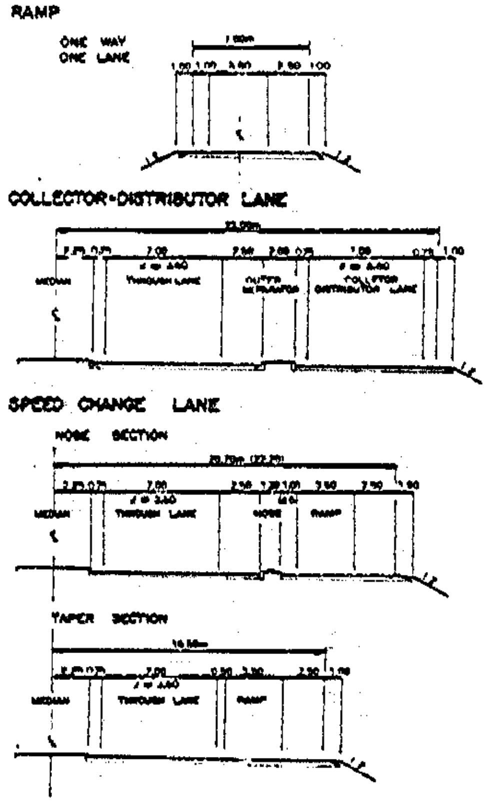


Fig. III-7-12 TYPICAL CROSS SECTION OF RAMP

APPLICABLE FOR: C-6/ MANILA NORTH EXPRESSWAY



7.6 Soft Ground Treatment and Pavement Design

7.6.1 Soft Ground Treatment

A. General

It is vital for the Project Road that the embankment be safely constructed without ground sliding or future ground settlement in excess of the maximum allowance (10cm) after opening to traffic.

It was found that the bearing ground along the C-5 and C-6 was adobe at the eastern section of the McArthur Highway and very soft at the western section of the said road.

The soft ground is defined by an STP value of $N \leq 4$ for fine soil and $N \leq 10$ for coarse soil.

In connection with the settlement of the Coastal Road, a soft ground study was made in Section 6.8 of Part IV.

B. Sub-Soil Conditions

i) BH-1 & BH-2 of C-5

A complex of interlayering soils taken from two boring logs was composed of clay, silt, seashell and sand which ranged from very soft to very hard or very loose to very dense.

The necessary portion for soft ground treatment was defined up to the 10 meter depth for BH-1 and 13 meter depth for BH-2 beneath the ground surface based on the standard N-value (See Appendix I-46 for borehole location plan).

The sub-soil condition of the greater part of C-5 is assumed to be much better than that of the C-6. At the eastern part of C-5 from BH-2, the thickness of the clay layer which is badly influenced the embankment of the road is around 10 meters thinner than that of C-6, and has a good layer of sand and seashell inter-layed between clay.

The clay layer gets thicker toward the shoreline and the sand and seashell layers lying in the 10 meter portion beneath the ground surface do not exist at the shoreline.

ii) BH-3 & BH-4 of C-6

The complex of layers of BH-3 and BH-4 are the same as those of BH-1 and 2, but the clay layers predominates.

The portion of soft layer defined up to 24 meters for BH-3 and 12 meters for BH-4.

The total thickness of clay layers was 12 meters for BH-4 and 16 meters for BH-3, however towards the shoreline this thickness becomes smaller.

iii) Settlement

The settlement was calculated based on the data obtained from the laboratory test or by using assumed values when there was no available laboratory data.

The soils conditions and the estimates of settlement are shown in Table III-7-9.

iv) Recommendation

C-5

It is very difficult to assume that settlement for whole section of soft ground from coastline to the McArthur Highway will be as small as from these two bore holes. However, it is very safe to assume that at the eastern section of these bore holes, the settlement would be equal to or a little larger than the settlement of BH-1, while the settlement in the western section excluding the 500 meter section from the coastline would be almost same based on the soil profile E-E (BH-1 ∿ BH-004) in Appendix I-47.

For the coastal section of 500 meters from the shoreline, sand piling is necessary. Sand piling is a very effective method for the soft ground treatment for reasons as follows:

- To promote early settlement by consolidation;
- To restrain the soft ground from shearing strain;
- To strengthen the bearing force of the ground; and
- To resist ground sliding.

The following countermeasures for soft ground are recommended.

Sta. 0+650 ∿ Sta. 1+100

Sand Mat	1 meter thickness	
Sand Pile	Diameter	ϕ400 mm
	Pitch	2 meters each way
	Length of pile	L = 15 meters

Table III-7-9 SOILS CONDITIONS AND ESTIMATES OF SETTLEMENT

Soils Conditions

Description	C-5		C-6	
	BH-1	BH-2	BH-3	BH-4
Assumed Embankment Height, H (m)	4	4	4 and 7	4 and 7
Thickness of Clay and Silt (m)	4.0	3.0	16.0	12.0
Sand and Sandy Soils (m)	1.0	5.0	4.0	-
N-Value of Clay & Silt	0 ∿ 1	0 ∿ 2	1 ∿ 3	1.0
N-Value of Sand & Sandy Soils	2 ∿ 9	1 ∿ 9	1 ∿ 2	-
Unconfined Compression Strength, qu of Clay (kg/cm^2)	0.007	0.047	0.006 ∿ 0.0066	0.083 ∿ 0.271
Coefficient of Consolidations, Cv (cm^2/sec)	$9x10^{-4}$	$12x10^{-4}$	$3x10^{-4}$	$11x10^{-4}$
Compression Index, Cc	0.65	0.27	0.93	0.70
Drain Condition	both sides	both sides	both sides	both sides

Estimates of Settlement

Description	C-5		C-6			
	BH-1	BH-2	BH-3		BH-4	
	H=4 m	H=4 m	H=4 m	H=7 m	H=4 m	H=7 m
Total Settlement (cm)	7.1	0.1	90	163	32	75
Remaining Settlement One year After Opening to Traffic (cm)	-	-	65	140	20	45

Note: The settlement of BH-1 and BH-2 were calculated within a tollerance of 10cm while that of BH-3 and BH-4 were calculated larger than tolerances ranging from 75cm to 163cm, with long lasting settlement based only on available laboratory data. This means that the total settlement estimate for each bore hole is much bigger than the calculated value.

Sta. 1+100 ∿ Sta. 4+600

1 meter Sand Mat without Sand Piling

The reasons for placing a sand mat for section of Sta. 1+100 ∿ Sta. 4+600 are as follows.

- A good drain is necessary in the ground at the lowest part of embankment due to water of fishpond; and
- The bearing force of the ground surface is not sufficient to ensure the trafficability of heavy construction machines.

In connection with the stability of embankment, generally there are no problems such as sliding for settlement test than 50 cm.

C-6

Sand mat plus sand piling are recommended for such soft ground.

This countermeasure should be applied to full section from shoreline to the McArthur Highway. Furthermore, the above mentioned countermeasure is also effective to stabilize the embankment.

The recommended treatment are as follows:

Sand Mat .... 1 meter thickness

Sand Pile	Diameter	ϕ400 mm
	Pitch	1.5 meters each way
	Length of pile	L = 13 meters.

Coastal Road

A sand mat will not be necessary because good sand will be dredged and filled for use as bearing ground of the Coastal Road. The details of sand piling are as follows: (See Section 6.8 in Part IV for full study background)

Reclamation Block	Pile Diameter (mm)	Pitch (m)	Length (m)
I ∿ III	400	2.0 eachway	7.0

7.6.2 Pavement Design

In the AASHTO method, the design elements for the flexible pavement are daily traffic volume, serviceability of the pavement, values of soil support and a regional factor. For rigid pavement, the design element are daily traffic volume, composite Kc-Value on the top of sub-base, working stress in concrete slab and serviceability of the pavement. Check was made on this design, using the method shown in TRRL ROAD NOTE 29, developed by the Department of the Environment, UK.

A. Selection of Pavement Type

The type of pavement was determined by studying the comprehensive factors, such as roadbed and sub-soil conditions, meteorological conditions and economy.

In this project, the area from the coastal line to the McArthur Highway is defined as soft ground and the area from the McArthur Highway to the Manila North Expressway is adobe. In case of soft ground with anticipated large and long-term settlement, the flexible pavement structure is more applicable than the rigid pavement structure.

The pavement type for this project was mainly selected on the basis of sub-soil conditions as follows:

Type of Pavement	Applicable Section
Flexible pavement	- The Coastal Road (entire stretch)
	- C-5 (From the Coastal Road to the McArthur Highway)
	- C-6 (From the Coastal Road to the McArthur Highway)
Rigid pavement	- C-5 (From the McArthur Highway to the Manila North Expressway)
	- C-6 (From the McArthur Highway to the Manila North Expressway)

B. Design of Flexible Pavement

i) Average Daily Traffic

The average daily traffic for the Coastal Road and the western sections of C-5 and C-6, are taken from the preliminary estimate of Annual Average Daily Traffic.

A 10-year design period, from 1988 to 1998 was selected for the flexible pavement design considering the lower initial investment. The traffic volumes of each section for selected years are as follows.

For the Coastal Road and the Western Section of C-5

Description	1988 (Opening Year)	1998 (10 years hence)	2003 (15 years hence)	2008 (20 years hence)
Average Daily Traffic (veh/day)	23,100	36,900	45,546	56,200
Design Traffic Volume (veh/direction/lane/day)	10,395	16,600	20,496	25,290
Heavy Vehicles (veh/day)	2,287	3,652	4,509	5,563

For the Western Section of C-6

Description	1988 (Opening Year)	1998 (10 years hence)	2003 (15 years hence)	2008 (20 years hence)
Average Daily Traffic (veh/day)	8,450	13,498	16,661	20,565
Design Traffic Volume (veh/direction/lane/day)	4,225	6,749	7,497	10,285
Heavy Vehicles (veh/day)	465	1,485	1,650	2,262

ii) Equivalent 18-kip Single Axle Load

The number of equivalent 18-kip single axle load applications per day in the design lane were obtained by multiplying the traffic volume per lane and the 18-kip equivalence factors for all heavy vehicles; the results are as follows:

For the Coastal Road and C-5

Description	1988	1998	2003	2008
Equiv. 18-kip Single Axle Load, Frequency	-	6,817,000	11,740,000	18,141,000

For the C-6

Description	1988	1998	2003	2008
Equiv. 18-kip Single Axle Load, Frequency	-	2,740,000	4,451,000	7,290,000

Note: The equivalent factors are 0.03 ~ 3.27 for trucks and 0.34 for buses, varying due to the serviceability index.

iii) Soil Support Value

The soil support value for this design was obtained by converting the Design CBR, determined by the laboratory test results according to the design method in the AASHTO INTERIM GUIDE:

- Design CBR = 3.0%
- Soil Support Value = 3.2%

iv) Structural Layer Coefficient

Each thickness of the surface course, base course and sub-base course was determined by the following equation.

$$SN = a_1D_1 + a_2D_2 + a_3D_3$$

Where: SN = Structural number

a_1, a_2, a_3 = Coefficients of relative strength of pavement layers

D_1, D_2, D_3 = Actual thickness, in inches, of surface, base and sub-base courses, respectively.

Using Table C.4-1 in the AASHTO INTERIM GUIDE, the following layer coefficient values were obtained.

Pavement Component	Coefficient
Surface Course:	
Plant Mix (High Stability)	0.44
Base Course:	
Bituminous-Treated (Coarse-Graded)	0.34
Sub-base Course:	
Sandy Gravel	0.11

v) Regional Factor

A regional factor of 1.5 was adopted considering the adverse conditions in the Project Site, such as the strength loss of the roadbed materials which may occur during the rainy season.

vi) Serviceability Index

The terminal serviceability index of 2.5 is recommended for the design of this project since the Road is defined as a major highway.

vii) Pavement Thickness

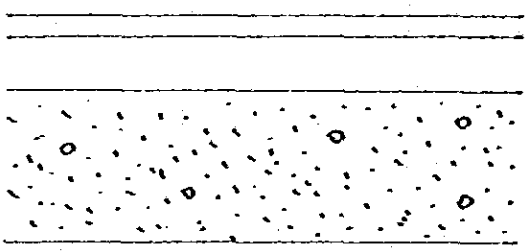
The required design structural number (SN) over the roadbed soil were determined from the Fig. II-1, of the AASHTO INTERIM GUIDE.

From the above mentioned factors, the weighted structural number (SN) for each Project Road were calculated as follows:

- For the Coastal Road and C-5 $SN = 5.45$
- For the C-6 $SN = 4.93$

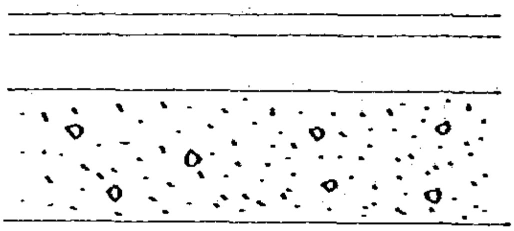
The pavement structures resulted in these calculations are shown as follows (figures in parenthesis show the thickness calculated by TRRL Note 29):

<u>The Coastal Road & C-5, Section from the Coastal Road to the McArthur Highway</u>



A.C. Surface t = 6cm (10cm)
Bituminous Treated Base t = 20cm (16cm)
Sandy Gravel t = 40cm (44cm)

<u>C-6 Section, from the Coastal Road to McArthur Highway</u>



A.C. Surface t = 5cm (10cm)
Bituminous Treated Base t = 20cm (13cm)
Sandy Gravel t = 40cm (40cm)

These pavement thicknesses are used for the preliminary design and the cost estimates.

C. <u>Design of Rigid Pavement</u>

The rigid pavement structures are applied to the sections from the McArthur Highway to the Manila North Expressway of the C-5 and C-6.

i) <u>Average Daily Traffic</u>

The average daily traffic volume in future are projected in Chapter 4 of Part III.

A 20 year design period from 1988 to 2008, was selected for the rigid pavement design. The traffic volume of each section for selected years are as follows.

<u>For the C-5</u>

Description	1988 (Opening Year)	1998 (10 Years hence)	2008 (20 Years hence)
Average Daily Traffic (veh/day)	15,100	24,120	36,749
Design Traffic Volume (veh/direction/lane/day)	6,795	10,854	16,537
Heavy Vehicle (veh/day)	985	1,537	2,397

For the C-6

Description	1988 (Opening Year)	1998 (10 Years hence)	2008 (20 Years hence)
Average Daily Traffic (veh/day)	8,450	13,498	20,565
Design Traffic Volume (veh/direction/lane/day)	4,225	6,074	10,283
Heavy Vehicle (veh/day)	930	1,336	2,262

ii) Equivalent 18-Kip Single Axle Loads

The number of equivalent 18-kip single axle load applications per day in the design lane were obtained by multiplying the traffic volume per lane and the 18-kip equivalence factors for all heavy vehicles; the results are as follows:

For the C-5

Description	1988	1998	2008
Equiv. 18-kip Single Axle Load Frequency	-	3,317,000	8,694,000

For the C-6

Description	1988	1998	2008
Equiv. 18-kip Single Axle Load Frequency	-	2,542,000	7,350,000

Note: The equivalent factors are 0.03 ~ 3.45 for trucks and 0.34 for buses, varying to the serviceability index and the thickness of concrete slab.

iii) Composite Kc-Value

The composite Kc-value on the top of sub-base was estimated by a sub-base thickness, the sub-base stiffness (E) and the modulus of sub-grade reaction (K).

The values of the above mentioned elements are as follows:

- Sub-base thickness = 8 inches
- Sub-base stiffness (Granular) E = 15,000 psi
- Modulus of sub-grade reaction K = 125 psi (poor sub-grade)

Using the Fig. D.4-1 in the AASHTO INTERIM GUIDE, the composite Kc-value was determined as 160 psi.

iv) Working Stress in Concrete

Working stress of 490 psi was used to determine the thickness of concrete slab.

v) Serviceability Index

The terminal serviceability index of 2.5 was adopted for the design of this project since the road sections are defined as a major highway.

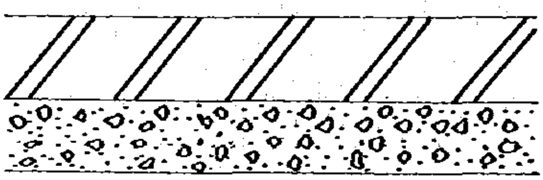
vi) Determination of Pavement Slab Thickness

The thickness of the concrete pavement slab was determined by the use of the design chart shown in Fig. D.4-2 of the AASHTO INTERIM GUIDE.

From this chart, the thickness of concrete pavement slabs were obtained by entering all values mentioned before.

The pavement structures resulting from this procedure are as follows (figures in parenthesis show the thickness calculated by TRRL Note 29):

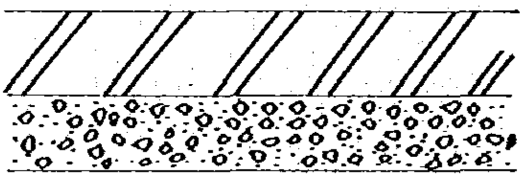
C-5, Section from the McArthur Highway to the Manila North Expressway



Concrete slab t=25cm (23cm)

Sandy gravel sub-base t=20cm (23cm)

C-6, Section from the McArthur Highway to the Manila North Expressway



Concrete slab t=25cm (22cm)

Sandy gravel sub-base t=20cm (23cm)

7.7 Preliminary Design of Bridges and Drainage Structures

7.7.1 General

The preliminary engineering described hereinafter has the purpose of determining the magnitude of construction cost for the Project. A type and dimension of structure were determined from existing data on structures of a similar nature or based on data obtained from site investigations.

Prior to the commencement of the detailed design, the following investigations and comparative designs should be undertaken in order to determine the final type, dimensions, span length, etc.;

- More detailed hydrological study pertaining to the rivers, including the highest flood level, ordinary flood level and low water level, shape and slope of rivers, intensity and frequency of heavy rainfall in the catchment area, etc.;

- Sub-surface soils survey at locations of proposed substructures, including machine borings with undistrubed soils sampling, standard penetration tests, and if possible, measurements of lateral bearing forces of the underlying soils;

- Topographical surveying and soundings at bridge sites; and

- Other relevant investigations, including availability of materials, means of transport for materials, erection methods, navigation clearance, etc.

7.7.2 Site Investigations

For the purpose of studying alternative routes, preliminary site investigations were conducted during the period from February 23 to March 6, 1979. After the final alternative route was selected and approved, the site investigations along the selected alternative route were carried out during the period from August 22 to 28,to obtain the data necessary for the preliminary engineering.

By means of the investigations mentioned above, the general information for the sites was gathered, and the following major points were considered for the structure studies:

- There are two rivers in the study area namely, the Navotas river and the Meycawayan river;

- The area, surrounded by the above two rivers, National Highway 369 road and Manila bay, consists mainly of fishponds;

- There are an expressway (Manila North Expressway) and three main roads (National Highway 369 road, McAthur Highway and Polo to Banghulo road) in the direct influence area; and

- Selected alignments of C-5 and C-6 cross the existing railway (P.N.R.) at the points near the towns of Malinta and Malanday, respectively.

7.7.3 Preferable Types of Structures

In selecting the type of superstructure for bridges and culverts, the following are deemed generally to be preferable from economical and technical points of view:

- Long span bridges in the areas with poor soils conditions shall be of steel constructon;
- Intermediate long span bridges ranging approximately from 20m to 30m shall be prestressed concrete;
- Short span bridges ranging approximately from 7m to 20m shall be of reinforced concrete type;
- Reinforced concrete box culverts shall be used in minor river, creeks and channels whose widths are less than 7m. The box culverts shall be of mono-opening type or multi-opening type depending on the widths of the creeks or channels; and
- For grade separations with existing roads and railways, prefabricated prestressed concrete beam shall be adopted as the overpass bridge.

7.7.4 Preliminary Design of Bridges

A. Superstructure

The following points are taken into consideration in determining the type of bridge superstructures.

- Required span length subject to the river and/or terrain conditions at the bridge sites;
- Optimum span length to minimize the total construction cost;
- Technical and economical advantages in construction of substructures and erection of superstructures; and
- Esthetic point of view.

Based on the points mentioned above, the following type of superstructures were adopted in the preliminary design according to their span length.

Span Length	Type
below 20m	R.C. Hollow slab bridge
20m to 30m	P.C. Composite girder bridge
above 30m	Steel girder bridge

For the purpose of estimating the magnitude of construction cost, STANDARD AASHO PC GIRDERS was adopted for P.C. composite girder bridges.

At the mouth of the Navotas River, a steel girder type of superstructure can be advantageously utilized from both the technical and economical points of view. As for type and span length, 3-span continuous box girders bridge with span of 40m + 55m + 40m = 135m is planned considering possibility of adopt in staging erection methods. The main reasons why a steel bridge shoud be used for the above mentioned waterway crossing are as follows:

- The bridge superstructure has to rest on high piers, at an elevation of about 20 meters. This criteria is based upon a request of the Philippine Shipbuilders and Repairers Association to provide a 12 meter (40 ft.) vertical clearance and 6m (20 feet) depth of water from the MSL water level so that their facilities won't be displaced from their present positions along the Navotas River. The foundations for the bridge must be constructed on very poor underlying soils as revealed by the soil investigations. Therefore, the light dead load of superstructure of a steel bridge is deemed necessary;

- Compared to that of R.C. or P.C. beams, the light dead load of a steel bridge will result in smaller vertical and horizontal forces on the substructures and foundation during an earthquake, which may mean reduction in the total construction cost of the entire bridge; and

- Quality control and techniques needed in steel construction will be easier than that for continuous P.C. bridge, and also the construction period can be shortened (See Appendix I-48. "Comparative Analysis of Bridge Type Crossing Navotas Waterway").

On the basis of the comment on the Working Draft Report requesting additional study for preparing 100-foot navigational clearance under the Navotas Waterway bridge, the following comparison of construction cost was conducted to determine superstructure type of the bridge.

<u>CONSTRUCTION COST COMPARISON (COMPARISON RANGE: THE CORE SPANS = 240m)</u>

TYPE-A: 3 Spans Continuous Steel Box Girder + P.C Composite Girder (40m + 55m + 40m + 5@21m)

Superstructure	₱8,300,000.-
Substructure	₱20,300,000.-
Total:	₱28,600,000.-

TYPE-B: 3 Spans Continuous Truss (60m + 120m + 60m)

Superstructure	₱20,600,000.-
Substructure	₱12,200,000.-
Total:	₱32,800,000.-

In terms of the purpose of this study which is to obtain the magnitude of construction cost, the construction cost of Navotas Bridge having a 100-feet navigational clearance was calculated based on TYPE-A: 3-Spans Continuous Steel Box Girder + PC Composite Girder, because it is cheaper (See Volume III for general view of adopted bridge type).

However, the bridge which has a 100-feet navigational clearance in the flat reclaimed land seems to have many difficult economical, aethetic and technical problems.

B. Substructure

i) Abutment

In situations where there is sufficient space to provide an embankment slope at the end of the bridge, the pile bent type abutment is recommended because of its economy and the aesthetic aspects.

In situations where a retaining wall or a stone masonry wall is necessary at the approach to the abutment, a reversed T type abutment is recommended for walls up to 10m in height, and a counterforted abutment for walls more than 10m in height.

ii) Piers

From the economical and construction viewpoints, the pile bent piers are recommended for short span river bridges. The comparatively low value of velocity of flow of the river, as revealed by the hydrologic study, makes this type of pier quite suitable also.

For the overbridges of roads and railway, the thin wall type is recommended in order to enhance the scenery in the area. For long span bridges, T-type piers are suitable, because of their high capacity to resist horizontal forces during an earthquake.

C. Foundations

Except in the area between the Manila North Expressway and McArthur Highway, the bearing stratum in the area is deeper than 5m below the ground surface. Hence, pile foundations are necessary for the bridge foundations. Since P.C piles are produced in the Philippines, they can be used in the areas where the bearing strata is deeper than 5m from the ground surface.

For the Navotas Waterway bridge, steel pipe foundation and steel pile well foundation are adopted from technical and economical view point.

In the area where the bearing stratum exists within 5m below the ground surface, spread foundations should be used.

7.7.5 Standard Design of Culverts

Since the Project is located in highly cultivated paddy area and fish pond area a lot of channels for irrigation and brackish water circulation are found along the route. Based on past experience, it is known that concrete box or pipe culverts will offer the most economical solutions when the span length is smaller than about 7m. For the required span length, the type of culvert is established as follows:

Span Length	Type
below 1.5m	R.C. pipe culvert
1.5m to 3.0m	R.C. mono-opening box culvert
3.0m to 7.0m	R.C. multi-openings box culvert

At the present time standard drawings for culverts are available in MPH. Therefore no specific design of culverts was made for this PROJECT.

7.7.6 List of Bridges and Culverts to be Constructed

Appendixes I-49 present a list of bridges and culverts to be constructed in the Project respectively.

7.8 Hydrology

7.8.1 General

This study was carried out to furnish the data, from a hydrological and hydraulic point of view, for the design of the bridges and drainage structures, and to determine the minimum height of embankment at river basins so that the profiles of the Roads could be planned. It also had as its purpose:

- To obtain the required waterway width and depth for the extension of the Navotas River; and

- To solve the hydrological and hydraulic problems such as effects on flooding, fishponds and sedimentation by the planned roads.

The rivers related to the Project Roads are as shown in Fig. III-7-13.

7.8.2 Site Investigations

This investigation was aimed at identifying the extent of the watershed area and the coefficient of run-off for each river basin and tributary, and at determining the lowest safe finished grade in the embankment sections where the ground might be inundated with water from flooding.

To learn more about the existing hydrological data, the Study Team also made several site investigations and the characteristics of the area affected were investigated carefully.

7.8.3 Rainfall

The "Rainfall Intensity Duration Curves for the Manila Area" were analyzed as shown in Appendix I-50. These curves were adopted for shorter duration of less than two hours and shorter return period of twenty five years. For longer duration and return period of rainfall, the Study Team deduced the intensity from daily rainfall. The equation developed by Dr. Ito which generally gives the practical value was used in this study.

$$R_t = \frac{347.1}{T\ 1.35 + 1502} \times R\ 24$$

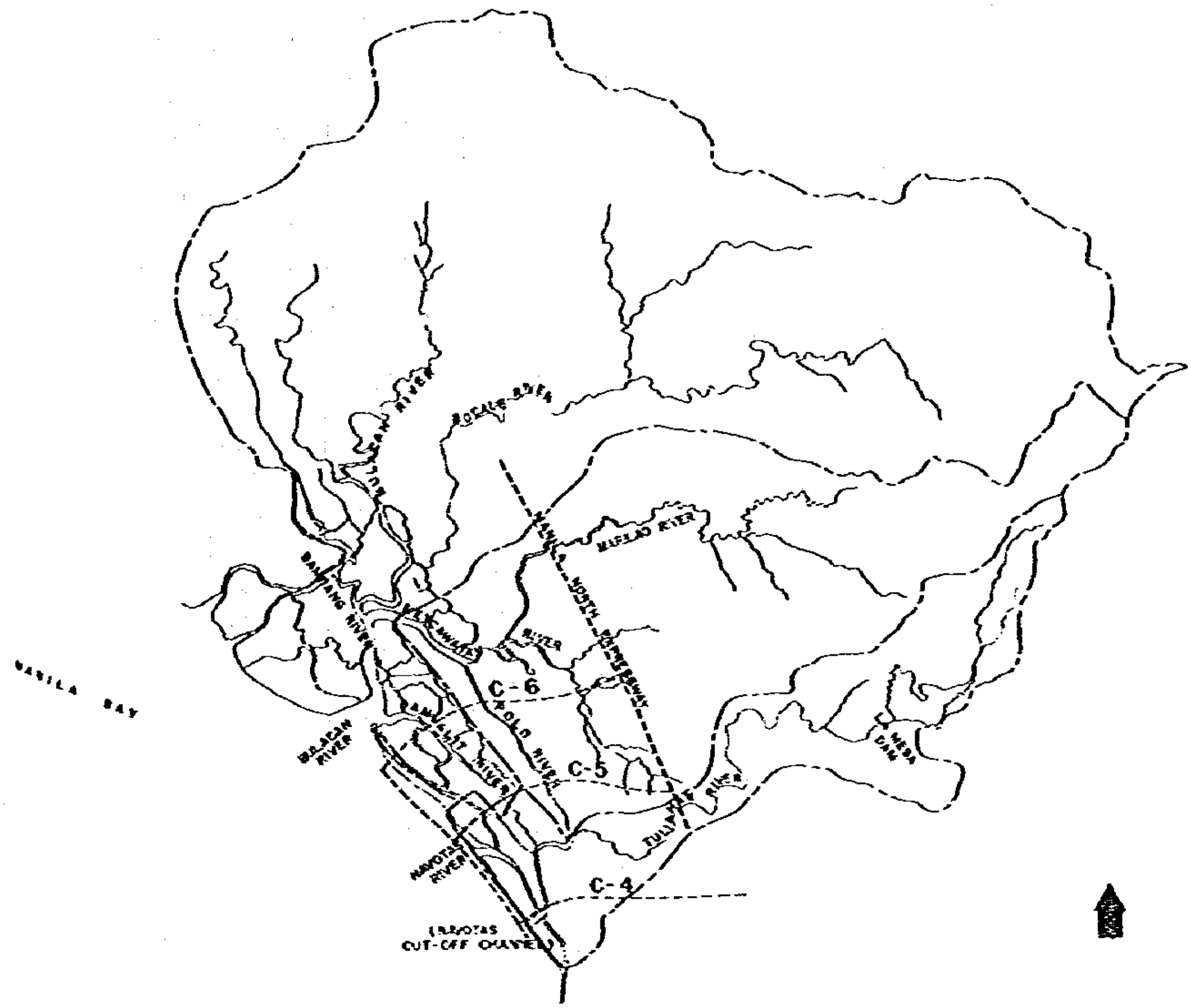
Where: R_t = rainfall intensity for duration T (mm/hr)

R24 = daily rainfall (mm)

T = duration (min.)

The data on rainfall applicable for this study were obtained from the rainfall records of Manila International Airport (MIA) gaging station for the following reasons:

Fig. III-7-13 RIVERS RELATED TO PROJECT ROADS



- The rainfall intensity distribution is relatively small in Manila (Port Area) and becomes larger toward the Norzagaray in the relevant area (See Table III-7-10). As mean value of rainfall intensity in the Bulacan and Navotas River basin, rainfall intensity at the MIA station will give the suitable value; and

- Records at other gaging stations in the area have only recent data except for the Manila and MIA stations.

Table III-7-10 DAILY RAINFALL DATA

Unit : in mm

Return Period (Year)	Manila	Norzagaray	MIA
2	173	261	153
5	231	356	243
10	270	514	305
15	292	455	340
25	324	505	395
50	367	570	465
100	408	640	535

Source: The report "Pampanga Delta/Candaba Swamp Area Development Project, Surface Water Studies, P 19".

For the relationship between 24-hour rain and return period based on the records of the MIA observation station (See Appendix I-51).

7.8.4 Run-Off Estimation Method

As mentioned in the previous section (See Section 7.3 in this part), the rational formula was used in the calculation of flood discharges for the following reasons:

- Catchment areas to be handled are not too large;

- Peak discharges are used for preliminary engineering purposes;

- Verification of the results is difficult if the other methods are used; and

- The formula is widely used in the Philippines and easy to calculate.

The rational formula is expressed as follows:

$$Q = \frac{1}{3.6} frA$$

Where: Q = peak discharge in cubic meters per second

f = coefficient of run-off

r = rainfall intensity for a duration equal to the time of concentration in millimeters per hour

A = drainage area in square kilometers

7.8.5 Hydraulic Design Principles

A. General

Hydraulic design for road employs the basic principles of fluid flow, particularly those relating to open channels and is primarily aimed at the single problem of accommodating occasional large volumes of storm water.

In many cases an area is subject to backwater effects and an increase in water level will be created upstream of the drainage opening as a result of the construction of the road. This phenomenon can cause the flood water to be diverted somewhere elsewhere it may cause serious damage. At the same time ponding, which if fully utilized will enable smaller hydraulic openings to be provided, must also be considered.

The height of the hydraulic structures greatly influences the vertical alignment of the road and often long stretches of high embankment are required in the vicinity of such structures. In such cases wider structures with smaller vertical clearances can be provided to minimize embankment costs.

Sometimes, there is the possibility of the high velocity of flow causing unsightly and costly erosion. Erosion in turn creates debris that is transported downstream and deposited at points where the velocity slackens and brings serious damage to the crops in paddy areas. A cardinal rule of drainage design could well be that existing drainage patterns should be disrupted as little as possible.

B. Hydraulic Design of Bridge

The hydraulic computations for the bridges are made to determine the bridge length and clearance, the maximum water under the bridge. Back-water calculations have been made based on the MHHW in Manila Bay (El. + 11.01 m).

C. Hydraulic Design of Culvert

The purpose of hydraulic design is to determine the type and size of culvert that will most economically accommodate the flow of the stream. In almost all cases, the primary control is the permissible level of the head water pool at the upstream side of the structure.

In some cases a higher headwater may cause serious damage and will not be permitted. For example, a higher headwater may result in inundation of valuable property in settled areas and fishponds and a relatively low embankment road in the vicinity may be over-topped, bringing lengthy interruptions to traffic and serious damage to pavement and embankment. Sometimes high velocities through the culvert may produce erosion problems at the downstream side or threaten damage to the culvert or its appurtenances.

To avoid these situations, therefore, the water must be disposed of quickly and safely through the structures provided.

D. Discharge Capacity

Based on the policies already discussed the discharge capacities and shape of channel required to deal with the major and medium size waterways are calculated by incorporating the available study data. Manning's formula is used to calculate the mean velocity and discharge capacity of each waterflow as shown below:

$$Q = V A = \frac{1}{n} A R^{2/3} I^{1/2}$$

Where: Q = Discharge, in cubic meters per second

A = Area of cross-sectional flow in square meters

V = Mean velocity in meters per second

R = Hydraulic mean depth in meters

I = Slope of the channel in meters per meter

n = Manning's roughness coefficient: typical values which are adopted for this study are shown in Table III-7-11.

Table III-7-11 VALUES OF MANNING'S ROUGHNESS COEFFICIENT

Type of Lining	Values of n
Natural river with slope protection	0.03
Artificial channels	
Earth ditches with vegetation	0.035
Concrete pipe culvert	0.013
Side ditches, cast-in-place concrete	0.014

7.8.6 Study of Required Waterway Width and Depth for the Extension of the Navotas River

A. Description of the Navotas River

The main stream of the Navotas River originates from the La Mesa Creek and flows toward the west and finally into the Manila Bay as shown in Fig. III-7-13. The Novaliches Reservoir (La Mesa Dam) is located in the upstream portion of the Tullahan River (La Mesa Creek).

This reservoir has been used to supply water in the Manila area. Although the water level is low under ordinary weather conditions, it reaches the crest of the spillway when the upstream basin experiences heavy rainfall. In this case, the water in the reservoir goes to Manila except for the overflow from the spillway. The middle stream area is being developed mainly for residential and industrial purposes.

The slope of the river is relatively steep except in the downstream lower portion. The width of the basin is narrow compared with its length. Flood waters of the Tullahan River are drained mostly by the Marala and Navotas Rivers; the construction of the Navotas Cut-Off Channel in the future will also help drain flood waters.

The drainage network of Navotas River system is partially connected with the Bulacan River system through rivers and channels.

The main features of the Navotas River system are as follows:

Main stream length	= 35 km
Drainage Area (including La Mesa Dam watershed)	= 88 km^2
Average slope (from the dam to the bay)	= 1/400

This study of the river system was carried out taking into consideration the results of the study on the Tondo Foreshore and Dagat Dagatan Development Project.

B. Run-Off Analysis of Navotas River

i) Drainage Area

The drainage area was measured from a topographic map (1:50,000). The watershed boundary lines were obtained based on a topographic map (1:25,000) for the available portion.

The retarding effects of Novaliches Reservoir were evaluated as follows:

- Water in the reservoir is used only for water supply. To prevent any shortage of water, the water level is being kept high. Therefore, when the upstream area of the dam is exposed to continuous rainfall, the water level continues to rise until overflowing occurs;

- Based on the overflow which occured on August 16, 1979, a total rainfall of around 500 mm within a week or so will cause the water to overflow from the spillway; and

- The maximum overflow discharge from the spillway which happened on October 26, 1978 was estimated at approximately 220 m^3/sec. This discharge is large enough to be included in the design of Navotas River system.

As a conclusion, the retarding effect of the reservoir can be expected during a small flood, but not during a large flood. Thus, the Study Team took the upstream of the La Mesa Dam watershed directly into account as a safety factor. The total drainage area of Navotas River system was measured to be 88.0 km^2.

ii) Run-Off Coefficient

The run-off coefficient of 0.7 was adopted considering the probable development of the middle stream area.

iii) Time of Concentration

The following time of concentration was adopted to calculate the peak discharge:

Inlet time	30 min
Flow time = 35,000 m/2 m/sec =	290 min
Total (T)	320 min

iv) Peak Discharge

The peak discharge for several design frequency was calculated as follows:

Frequency (year)	24-Hour Rainfall (mm)	Rainfall Intensity (mm/hr)	Discharge (m^3/sec.)
100	535	47.5	820
50	465	41.3	710
25	395	35.1	610
10	305	27.1	470

The above peak discharge will be drained by the Navotas Cut-Off Channel, Marala River and Navotas River.

C. Hydraulic Analysis

i) Attainable Discharge Capacity

Based on the NHA's "Flood Control and Drainage Studies in the Dagat-Dagatan Area" as well as considering the existing condition of the Navotas River, the attainable discharge capacities of the rivers are roughly estimated as follows, assuming coefficient of roughness n = 0.03:

Navotas-Marala River (Proposed Width = 47m)[5/]		88 m 3/sec.
Navotas Cut-Off Channel (Proposed Width = 50m)[5/]		201 m 3/sec.
Navotas River (Existing Width = 50m)		85 m 3/sec.
Total:	147m	374 m 3/sec.

Presently MPW is adopting a design storm frequency of 10 years for their rivers improvement plans. If this policy was applied to the hydraulic analysis, the above attainable discharge capacity of 374 m^3/sec could be judged generally acceptable to accommodate the peak discharge of 470 cubic meters per second for the 10-year frequency, since there is room to be modified the roughness coefficient and water depth of the Navotas Cut-Off Channel to increase the discharge capacities.

However, the Study Team considers that the recommended dimension of the extension of the Navotas River (hereinafter called the "Waterway") should meet the all possible river improvement plan(s) to be implemented by the Government in future. Thus the hydrological analysis was carried out based on the design storm frequency of 50-years in the following sub-sections. The aim was to obtain an optimum dimensions of the Waterway which assure the minimal adverse environmental impact to be caused by the reclamation project.

ii) Possible Improvement of the Navotas River System

Comparing the peak discharge and the discharge capacity, it is clear that the widening of rivers and the construction of Cut-Off Channel are necessary if the 50-year flood is adopted in the design. Among the Navotas Cut-Off Channel, Marala River and Navotas River, the Navotas Cut-Off Channel will play the major part of role for the drainage. Improvement of the Navotas River or Marala River is not effective compared with the Cut-Off Channel because of their stream length to the Manila Bay.

5/ NHA: Flood Control and Drainage Studies in the Dagat-Dagatan Area in connection with the Tondo Foreshore and Dagat-Dagatan Development Project, 1978.

The topographical map shows that the middle stream portion (from La Mesa Dam to PNR: Tullahan River) has a steep slope of about 1:400. Therefore, it is easy to adopt the design velocity of two or three meters per second for the narrower river widths. However, the downstream portion (approximately 10 km, from the Cut-Off Channel mouth to PNR) is low and flat. Deepening of the river in this portion will be limited by the water depth at its mouth. Widening will be the only effective measure to keep flood level as low as proposed in the Navotas Cut-Off Channel scheme now on-going.

The flood discharge of 710 m^3/sec will be drained by the three outlets as mentioned before. Roughly speaking, the following widths of the rivers and the Cut-Off Channel will be preferable to accommodate the total flood discharge of 710 m^3/sec.

- If all rivers and the Cut-Off Channel are widened, the total width of waterway must be:

$$B = \frac{710}{374} \times 147 = 280 \text{ m}$$

- If only the Cut-Off Channel is considered to the drainage improvement, the width of the Cut-Off Channel must be:

$$B = \frac{710-88-85}{201} \times 50 = 134 \text{ m}$$

The most effective way to increase the total discharge capacity of the Navotas River system will be the widening of the Navotas Cut-Off Channel. If the construction of the Cut-Off Channel and the improvement of upstream is done in accordance with this policy, the required opening for the extension of the Navotas River would be the same as the existing opening. However, due to the nature of the on-going project, it is observed that the increasing of the width of the Cut-Off Channel may entail problems.

Should difficulties be encountered in increasing the width of the Cut-Off Channel, the Navotas River will be improved to a certain extent. The Navotas River can be improved by the following:

- Widening and deepening of the Navotas River; or

- Widening and deepening of the tributary; or

- Providing an additional diversion channel.

However, these methods will be less effective than the increasing of the width of Cut-Off Channel from hydraulic point of view. The maximum practicable discharge capacity of the Navotas River will be 240 m3/sec after the completion of improvement of the said river.

iii) Required Waterway Width

(a) Required Waterway Width without Dredging

When no dredging in the waterway is assumed, the average waterway width of the extension of the Navotas River is calculated as follows:

Length of the waterway
= 3,000 m (including future reclamation)

Existing width of the Navotas River at river mouth
= 90 m

Downstream Waterway Width
= 90 m + 0.255 x 3,000 m = 855 m

Required Average Waterway Width
= (90 m + 855 m) x 1/2 ≑ 470 m

(b) Required Waterway Width with Dredging

If the Navotas River would be extended offshore, it would be possible to keep the water depth of the river deeper than at present because the sea bottom at river mouth would become deeper. On the other hand, the longer length of the waterway gives a negative effect on the backwater. Considering the positive and negative effects of reclamation on flood water disposal, the required waterway width of the extension of the Navotas River to allow a constant discharge capacity of 240 m^3/sec are analyzed as shown in Table III-7-12.

Table III-7-12 REQUIRED WATERWAY WIDTH FOR EACH ALTERNATIVE

Q = 240 m^3/sec

Alternative	Bottom Elevation of Waterway at Existing River Mouth	Required Waterway Width
1	El. + 8.1 m	195 m
2	El. + 6.3 m	137 m
3	El. + 7.1 m	120 m

Note: See Appendix I-52 for the profiles of the waterway.

iv) Backwater Analysis

(a) Existing Condition

The friction loss of the Navotas River in the bay was calculated as follows:

Assumptions

1. Area in front of the river mouth is shallow, but the head loss due to this is negligible.

2. Flow Width B = 1/2 (2 Bo + 0.255 L)

   Where: Bo = Existing flow width at the river mouth = 90 m

   L = Virtual stream length = 800 m (from 1.5 m water depth line to the mouth based on the sounding map)

   B = Mean flow width in the bay = 190 m

3. Bottom El. of Virtual Channel = +9.5 m

4. Water Level at Manila Bay = +11.01 m

5. Flood Discharge = 710 m^3/sec. (50-year frequency)

Calculation of Friction Loss (Backwater)

$$Q = \frac{1}{n} \; I^{1/2} \; R^{2/3} \; A \qquad \text{or}$$

$$I = (n\ Q/A\ R^{2/3})^2$$

Where: n = 0.03 and R = h (water depth)

Therefore, $I = (0.03 \times 710/h \times 190 \times h^{2/3})^2$,

$\Delta H = I\ L$, $\Delta H' = 1.0$ m, $H_2 = 12.01$ m,

$h = 2.01$ m, $\Delta H = 0.98$ m $\doteqdot \Delta H'$

The calculated head loss (backwater) for the existing condition is approximately 1.0 m.

(b) Head Loss (backwater) for Each Alternative

Head loss of the waterway for each alternative is calculated based on an assumed waterway width of 100 m and shown in Appendix I-52.

To find a friction loss (backwater) for Alternative 1 the following procedure can be applied:

Step 1: Required waterway width for Q = 240 m^3/sec. is 195 m from Table III-7-12.

Step 2: To find a friction loss (backwater) by Appendix I-52, use an equivalent discharge of 123 m^3/sec. ($240\ m^3/sec. \times \frac{100\ m}{195\ m}$) for 195 m wide waterway.

Step 3: Use the curve for Case 1, L = 1,300 m, bottom El. = 8.00 m (average) and find ΔH = 5 cm for the equivalent discharge of 123 m^3/sec.

The same procedure can be applied to obtain the head losses for other alternatives, and the result are shown in Table III-7-13.

Table III-7-13 WATERWAY WIDTH AND CALCULATED HEAD LOSS FOR EACH ALTERNATIVE

Q=240 m^3/sec

Alternative	Required Waterway Width	Discharge for 100m Channel Width	ΔH
1	195 m	123 m^3/sec.	5 cm
2	137 m	175 m^3/sec.	5 cm
3	120 m	200 m^3/sec.	5 cm

D. Adopted Width and Depth of the Waterway

Since the planned waterway at the extension of the Navotas River will also be used for navigation, this factor must be considered when determining the width of the waterway.

Judging from the sounding map, the following elevations of the waterway bottom are expected to be maintained without periodic dredging.

- When future reclamation is completed (Alternative 2) or the training dikes are provided .... El. + 6.0 m
- When future reclamation is not considered (Alternatives 1 & 3) .... El. + 8.0 m

The existing bottom elevation of the Navotas River is approximately 7 m with periodic dredging. We expect this condition will also be maintained by the concerned authority in future.

The water depth condition on completion of the dredging may be similar to Alternative 3 and it can be assumed that the bottom elevation would rise gradually by silting up to El. + 7.5 m.

When the bottom elevation of 7.5m was assumed, the required waterway width would be approximately 160m, (an average of Alternatives 1 and 3). However, to eliminate an adverse effect to the hinterland (flooding to be caused by an excess backwater) 200m width of waterway was adopted in this study considering the allowance for the cross slopes of bulkhead:

Adopted Waterway Width = 200m
Bottom Elevation of Waterway = +7.5m
Expected Backwater in the Waterway ≑ 5cm

When the future reclamation blocks are constructed, the waterway can be deepened to meet the requirement for Alternative 2 (See Appendix I-52) and can be dredged further to meet the required depth which would be determined by the navigation criteria.

In view of a large cost necessary for dredging work and the construction of training dikes, Alternative 2 was not adopted in the Project.

E. Siltation in the Waterway

The sediment discharge in the Navotas River is small for the following reasons:

- Sediment load from the upstream La Mesa Dam basin will be deposited in the reservoir. The volume of fine soil particles which overflows from the spillway during large floods will be negligible; and
- Once the Navotas Cut-Off Channel is provided, the greater part of sediment discharge will flow through it.

7.8.7 Bulacan-Meycawayan River and the Reclamation

A. River Course Study

If the width of the mouth of Bulacan-Meycawayan River (hereinafter called Meycawayan River) is reduced by reclamation, the flood damage in the upstream area will be great. In order to avoid such an undesirable effect it is recommended that no reclamation should be done in the effective flow region along the extension of the Meycawayan River (See Section 3.3.4 in Part IV for further description).

B. Siltation

The shallow portion of the Maycawayan River mouth may be dredged to obtain soils needed for the reclamation. The sediment discharge transported by the Meycawayan River will be large, even if the shallow portion is dredged once, since it will be silted year by year. Dredging will decrease flood damage in the upstream area until the dredged portion is silted again. Soils transported by Meycawayan River will be deposited around the river mouth in the long term and the extent of siltation will be similar to that at present.

7.8.8 Determination of Hydrological Requirement for Bridges and Culverts Designs

A. General

The rivers related to the C-5 and C-6 Roads and locations of the bridges are shown in Fig. III-7-14. These rivers are tributaries of the Meycawayan River or Navotas River system.

The area between McArthur Highway and the Manila Bay is low and flat consisting mainly of fishponds, rice fields and towns located along the roads. About 12 kilometers from the mouth of Meycawayan River to the Philippine National Railways, the inland area is low and the dikes are not high and almost flat. This area has been flooded frequently and overflowing of the fishpond dikes is a yearly occurrence. The discharge capacity of the Meycawayan River is quite small compared with the large catchment area and rainfall for the following reasons:

- River width is limited by artificial fishpond dikes;
- The presence of fish traps in the river and its mouth affect siltation which rises the flood level; and
- A large head loss is due to the shallow area (sand bar) around the river mouth.

Floods in the towns along the existing roads (Polo, Obando, etc.) are considered to be affected by backwater from the Meycawayan River.

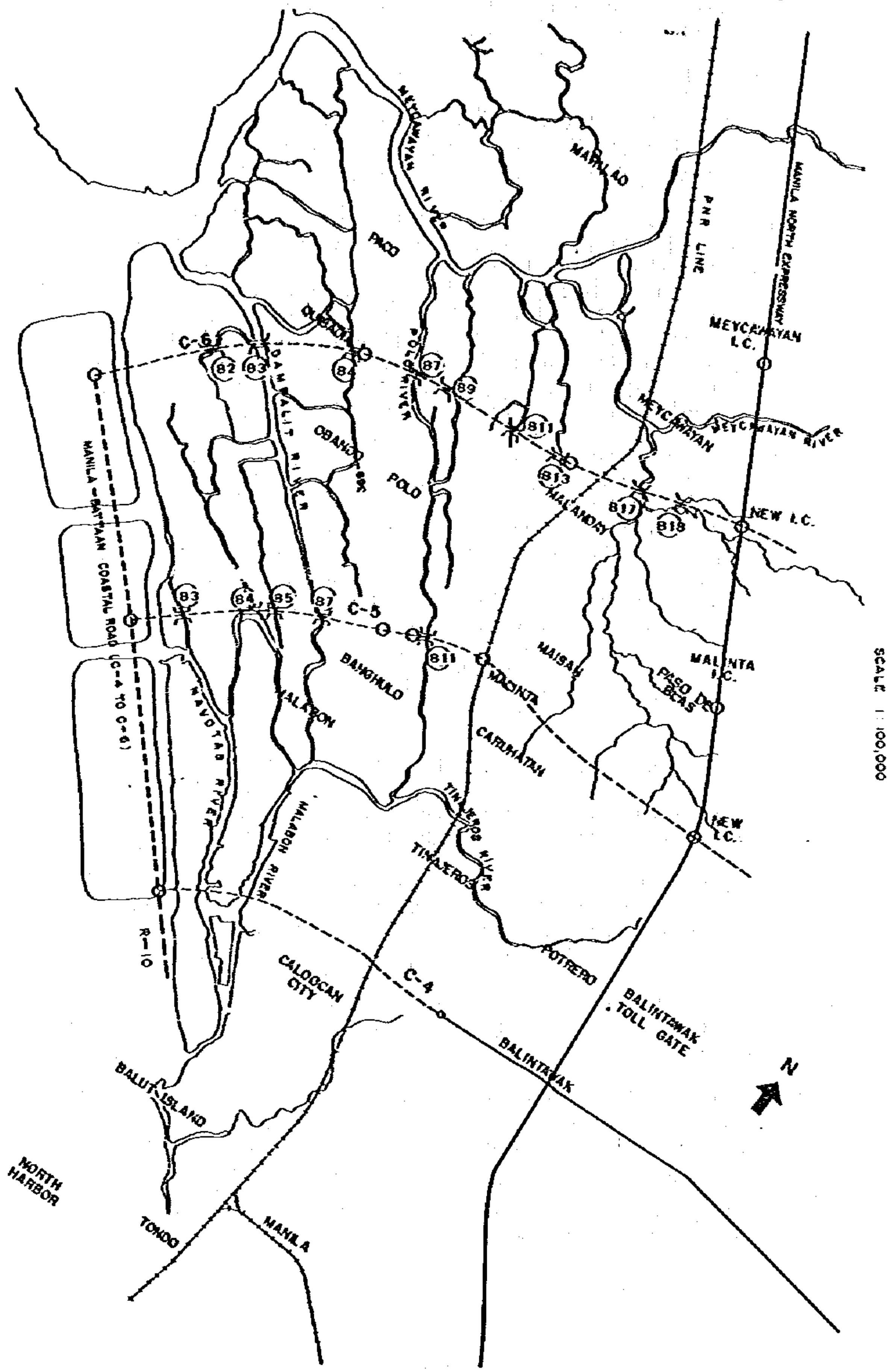
C-5 and C-6 Roads will traverse this low and flat area. In order to minimize the damage caused by floods, it is necessary to lower the flood level by dredging the riverbed or by providing high river dikes. Raising the ground level of habitable places is also considered as a countermeasure. High river dikes would necessitate pumping stations in future in the low areas while riverbed dredging would need training dikes along the extension of the Meycawayan River in the Bay to avoid siltation in the river course.

The study of run-off and hydraulic analysis presented below is to draw up future river improvement plans to determine:

- Bridge length after the river widening;
- Finishing grade of the bridge to meet the higher level of future dikes; and
- Footing elevations which will allow the river dredging required for river improvement.

Fig. III-7-14 LOCATION OF RIVERS AND BRIDGES

SCALE 1:100,000



B. Road Planning & Hydrological Effects

i) Increase in Flood Discharge

In general, the paved surface of the roads will increase the run-off coefficient. However, in the low and flat area, the value of the coefficient is considered to be almost 1.0 during heavy rainfall, and the effect is considered to be minimal. This conclusion is based on the following considerations:

- Wide fishpond areas are covered by unbroken water surfaces; and
- Ground water level is high and therefore, the soil will become saturated after a small amount of rainfall.

ii) Decrease in Flood Water Storage

Fishponds and other low areas have a retarding effect on flood waters. Roughly speaking, the storage volume occupied by the planned road structures will be lost.

Even if an embankment structure is adopted for the C-5 and C-6 Roads, there will only be a minor decrease of about two percent in the existing storage volume.

iii) Effects on the Local Drainage System

Embankments will interrupt or change the existing flood flow. As a result, flood waters will have a tendency to concentrate and it will be necessary to consider the movement of water in the fishponds along C-6 Roads. In order to minimize the concentration of water, it is necessary to provide more drainage culverts across the Roads.

iv) Effects on the Brackish Water Supply System

Since it is necessary to supply the fishponds with brackish water, the construction of box culverts and channels will be necessary at various locations.

v) Factors considered in the Roads Planning

Among others, the following factors have been taken into consideration in the planning of the C-5 and C-6 Roads:

- A bridge or a culvert across a river or a drainage channel should have enough clearance, depth and width to minimize head loss under present and future conditions; and

- In the low and flat area, the movement of inland flood water must be fully considered. Fishponds should have a constant and ample supply of brackish water.

C. Run-Off and Hydraulic Analysis of Rivers

1) Meycawayan River (River Main)

(a) Run-Off Analysis

For the entire drainage area, the peak discharge was calculated in the following manner:

Total drainage area = 603.6 km^2

(See Appendixes I-53 and I-54 for the drainage areas distribution and plan of Meycawayan River).

Run-Off Coefficient = 0.6

Time of Concentration

Inlet time = 30 min (for upstream 2 km^2)

Flow time = (7,000 m/1.2 m/sec + 4,400 m/ 2.5 m/sec)/60

= 390 min

Total: 420 min

Peak Discharge

Calculated peak discharge for each frequency is as follows:

Frequency (Years)	24-Hour Rainfall (mm)	Rainfall Intensity (mm/hr)	Discharge (m3/sec)
100	535	37.3	3,750
50	465	32.4	3,260
25	395	27.5	2,770

Following the some manner described above, peak discharges at representative points of the Meycawayan River were calculated and are presented in Table III-7-14 and Appendix I-54.

(b) Hydraulic Analysis

In the design of bridges, it is necessary to determine the profile of the river at its crossings.

The total span of a bridge should be wider than the existing river width and the elevation of the underside of bridge girders should be higher than the existing flood level. Based on flood marks and interviews, the flood level in the Meycawayan River basin during previous big floods were around 12.3 meters in the downstream portion and 13.5 meters near the McArthur Highway. This flood level shall be considered, in determining the finished grades of bridges. Existing widths of the rivers were measured, either from aerial photographic maps or at the sites.

Table III-7-14 PEAK DISCHARGE AT REPRESENTATIVE POINTS OF THE MEYCAWAYAN RIVER

Station	Drainage Area (km^2)	Peak Discharge (m^3/sec)		
		100-year	50-year	25-year
0+000	603.6	3,750	3,260	2,770
0+500	603.6	3,820	3,310	2,820
"	591.1	3,740	3,250	2,760
4+000	578.3	4,090	3,550	3,020
"	177.3	1,210	1,050	900
8+000	168.0	1,320	1,140	970
"	161.0	1,260	1,100	930
9+750	152.9	1,280	1,110	940
"	53.4	800	700	590
12+800	49.5	820	720	590
"	26.7	550	480	400
14+150	26.2	560	490	400

Presently, there is no over-all improvement plan or hydrological study of the Meycawayan River system which is supposed to be used as a base in the design of the bridges. In this void therefore, several assumption are made in the flood control studies for future river improvement, such as:

- The flood discharge for 50-year period should be adopted as the design discharge;

- The 3.7 kilometer long training dikes should be provided along the extension of Meycawayan River in the Bay for the purpose of riverbed dredging;

- The design flood level upstream of the PNR should be lower than 12.5 meters;

- The coefficient of roughness is adopted as n = 0.03; and

- Rectangular cross sections of the rivers are assumed for hydraulic computations unless otherwise noted.

The results of the analysis as shown in Appendix I-55 provide the bases for the flood control studies of the tributaries related to the bridges of C-5 and C-6 Roads.

ii) Dampalit River

(a) Run-Off Analysis

The calculated rainfall intensities for each subdivided drainage area is as shown Table III-7-15.

Table III-7-15 RAINFALL INTENSITIES FOR EACH SUBDIVIDED DRAINAGE AREA OF DAMPALIT RIVER

Station	Stream Length (km)	Time of Concentration (min)	Rainfall Intensity (mm/hr)	
			50-Year	25-Year
0 + 000	5.7	105	2. 79.2	67.3
1 + 300	4.4	83	3. 92.6	76.3
3 + 000	3.2	63	3. 112.8	92.9
3 + 900	2.3	48	2. 138.7	111.5
4 + 400	1.8	40	3. 150.0	123.6

Notes:

1. Inlet time = 10 min and flow velocity = 1.0 m/sec.

2. Calculation basis: $R_T = 347.1 \times R24/(T^{1.35}+1,502)$

3. The results were obtained by using the Rainfall Intensity Duration Curve for Manila Area for 25-Year frequency and by using R_T = (80.6/66.4) x (25-Year R_T) for the 50-Year frequency.

The peak discharge at each selected station by each frequency is as shown in Table III-7-16.

Table III-7-16 PEAK DISCHARGE AT SELECTED STATIONS OF THE DAMPALIT RIVER

Station	Drainage Area (km^2)	Peak Discharge (m^3/sec)	
		50-Year	25-Year
0 + 000	12.5	250	210
1 + 800	10.5	245	200
"	8.5	200	165
3 + 000	6.4	180	150
"	5.4	155	125
3 + 900	3.8	135	110
"	3.4	120	95
4 + 400	3.3	125	105
"	1.8	70	60

Notes:

1. Run-off coefficient = 0.9 (Fishpond water surfaces were taken into consideration).

2. See Appendix I-56 for the plan of the Dampalit River.

(b) Hydraulic Analysis

The Dampalit River, which is located at the mouth of the Meycawayan River, is shallow but wide. Therefore, it has a relatively large discharge capacity compared with its small drainage area.

Under present conditions, the Dampalit River flood level is high because of the large head loss at the shallow mouth of the main stream of Meycawayan River. If this river mouth were improved, the flood level of the Dampalit River would be considerably lower.

Improvement of the Dampalit River is not very necessary. Dredging of only its riverbed, without widening should be considered in the design of bridges that will cross over it.

The results of the hydraulic analysis for the Dampalit River is shown in Appendix I-56.

iii) Polo River

(a) Run-Off Analysis

The calculated rainfall intensities for each selected station is as shown Table III-7-17.

Table III-7-17 RAINFALL INTENSITIES FOR EACH SUBDIVIDED DRAINAGE AREA OF THE POLO RIVER

Station	Stream Length (km)	Time of Concentration (min)	Rainfall Intensity (mm/hr)	
			50-Year	25-Year
0 + 000	6.4	117	2. 76.1	64.1
1 + 800	4.6	86	3. 90.1	74.2
3 + 500	2.9	58	3. 119.6	98.5
5 + 200	1.2	30	3. 173.9	143.3
5 + 500	0.9	25	3. 188.4	155.2

Notes:

1. Inlet time = 10 min and flow velocity = 1.0 m/sec.

2. Calculation basis: $R_T = 347.1 \times R24/(T^{1.35}+1,502)$

3. The results were obtained by using the Rainfall Intensity Duration Curve for Manila Area for 25-Year frequency and by using $R_T = (80.6/66.4) \times$ 25-Year R_T for the 50-Year period.

The peak discharge at each designated station by each frequency is shown in Table III-7-18.

Table III-7-18 PEAK DISCHARGE AT SELECTED STATIONS OF THE POLO RIVER

Station	Drainage Area (km^2)	Peak Discharge (m^3/sec.)	
		50-Year	25-Year
0 + 000	7.0	135	115
1 + 800	5.6	130	105
3 + 500	4.1	125	105
5 + 200	1.7	75	65
5 + 500	1.1	55	45

Notes:

1. Run-Off coefficient = 0.9
   (Developed area and high ground water table were taken into consideration).

2. See Appendix I-57 for the plan of the Polo River.

(b) Hydraulic Analysis

The Polo River is a tidal river connected with the Meycawayan and Tuliahan Rivers. During good weather, the flow depends on the tide in the Manila Bay and flow velocity is zero near the Letre Road bridge. During floods, the water level is affected by the water levels in the Meycawayan and Tuliahan Rivers.

Design flood levels for the Meycawayan and Tuliahan River Junctions are 11.92 and 12.1 meters respectively.

Ground levels of residential areas range between about 11.5 to 13.4 meters or an average of 12.5 meters. Under these conditions, the design flood level should be between 12.1 and 12.5 meters. Considering the hydraulic balance among these three rivers for flood design, a high flood level of around 12.2 or 12.3 meters, say 12.25 meters should be a practical value.

The improvement of the Meycawayan and Polo Rivers will lower the flood level and shorten the time of inundation. Nevertheless, the flood damage in the Polo River basin cannot be avoided because of the basin's low ground level and the high flood level of the Meycawayan River. In order to minimize flood damage, either the provision of pumping stations or the raising of ground levels of the low-lying areas in the basin will be necessary in future.

For the design of the bridges, the future profiles of the Polo River were prepared and are shown in Appendix I-57.

iv) Other Tributaries Related to the C-6 Road

(a) Run-Off Analysis

The calculated rainfall intensity for each bridge location is shown in Table III-7-19.

Table III-7-19 RAINFALL INTENSITIES FOR THE PEAK DISCHARGE AT EACH BRIDGE LOCATION

Bridge	Stream Length (km)	Time of Concentration (min)	Rainfall Intensity (mm/hr)	
			50-Year	25-Year
Br-11	2.5	37	2. 156.6	129.0
Br-13	2.5	37	2. 156.6	129.0
Br-18	2.8	33	2. 166.3	137.0

Notes:

1. Inlet time = 10 min and

   Flow Velocity = 1.5 m/sec for Br-11 & Br-13 and
   2.0 m/sec for Br-18

2. Results were obtained by using the Rainfall Intensity Duration Curve for Manila Area for the 25-Year frequency and by using R_T = (80.6/66.4) x 25-Year R_T for the 50-Year frequency.

The peak discharge at each bridge location by each period is shown in Table III-7-20.

Table III-7-20 PEAK DISCHARGE AT PROPOSED BRIDGE LOCATIONS

Station	Drainage Area (km^2)	Peak Discharge (m^3/sec)	
		50-Year	25-Year
Br-11	1.43	50	41
Br-13	1.78	62	51
Br-18	2.63	97	80

Notes:

1. The Run-off coefficient was adopted as 0.8 (Future development was taken into consideration)

2. See Appendix I-58 for the plan of related rivers.

(b) Hydraulic Analysis

Bridges Br-11 and Br-13 are located in the low flat area same as the Polo River basin. Therefore, the hydraulic characteristics are considered to be similar as that of the Polo River. To determine the capacity of waterway, a rather lower flow velocity of 0.5 meter per second was assumed at each crossing. However, for Br-18, the flow velocity of 2 meters per second was assumed because the river slope is relatively steep. The results of calculation are as shown in Table III-7-21.

Table III-7-21 HYDRAULIC ELEMENTS OF BRIDGES

Bridge	Discharge (m^3/s)	Flow Area (m^2)	Water Depth (m)	Flow width (m)
B11	50	100.0	4.0	25.0
B13	65	130.0	4.0	32.5
B18	100	50.0	2.5	20.0

The profiles of the tributaries were obtained based on the results of hydraulic analysis of the Meycawayan River and the Polo River, assuming trapezoidal cross sections.

H.W.L. of the Meycawayan River

Polo River Junction	:	11.915 m
Marilao River Junction	:	12.095 m
STA. 14+000	:	12.649 m

Using the backwater data of Polo River for Bridges Br-11 & Br-13 and the existing river profile for Br-18 the design high water level for each bridge was determined as shown Table III-7-22.

Table III-7-22 ESTIMATED H.W.L. AT PROPOSED BRIDGES

Bridge	Backwater or Slope of Water Surface	H.W.L. at Bridge
B11	0.068 m (11.983 - 11.915)	12.2 m (12.095 + 0.068)
B13	0.085 m (12.000 - 11.915)	12.2 m (12.095 + 0.085)
B18	1.000 m (1000 m x 0.001)	13.7 m (12.649 + 1.000)

Applying a constant freeboard of 0.6 m and considering future dredging of rivers for Br-11 and Br-13, the Table III-7-23 were obtained.

Table III-7-23 BOTTOM ELEVATION OF RIVER AND REVETMENT HEIGHT

Bridge	H.W.L. (m)	Bottom Elev. of River	Top Elev. of Revetment
B11	12.2	8.2 m	12.8 m
B13	12.2	8.2 m	12.8 m
B18	13.7	11.2 m	14.3 m

D. Required Cross-Sections of Waterway at Each Bridge Crossing

The cross-section of waterway envisaged for future river improvement at each bridge location is shown in Table III-7-24.

However, as described before, the flood level in the Meycawayan River basin at present should be considered in determining the finishing grades of bridges. Based on the results of field investigations on flood marks and interviews, it is recommended that the elevation of the underside of all bridge girders should not be lower than +12.50 m.

The total span length of a bridge across a river was determined from hydraulic and economic viewpoints. The factors considered from the hydraulic point of view in determining the total span length of the bridge are the following:

- Head loss due to the piers should be nil or negligible since the flow velocity in the rivers is slow. Nevertheless, the required opening should not be less than 90 percent of the river width (B_2); and

- Floating materials such as trees, water lilies, waste, etc. are anticipated to flow from the upstream during flood. If the clear span of the piers are short, such materials will obstruct the flood flow by forming "islands" around the piers.

E. Location and Required Size of Culvert

i) General

The culverts for C-5 and C-6 Roads are divided into two categories from the hydraulic point of view, viz:

- Culverts to be provided in the upstream area (rolling terrain, no inundation); and

Table III-7-24 ADOPTED CROSS-SECTION OF RIVER AT EACH BRIDGE LOCATION

Road	Bridge	Cross-* Section Type	Dimensions (m)				Top and Bottom Elevations (M)	
			B1	B2	H	h	Top	Bottom
C-5	Br- 3	A	13.6	20.0	3.2	-	+1.73 (12.20)	-1.47 (9.00)
	Br- 4	B	39.6	60.0	5.0	3.2	+1.73 (7.00)	-3.47 (11.56)
	Br- 5	A	6.6	15.0	4.0	-	+1.73 (12.20)	-2.47 (8.00)
	Br -7	A	33.6	40.0	3.2	-	+1.73 (12.20)	-1.47 (9.00)
	Br-11	A	50.6	59.4	4.4	-	+2.33 (12.80)	-2.07 (8.40)
C-6	Br- 2	A	16.6	25.0	4.2	-	+1.73 (12.20)	-2.47 (8.00)
	Br- 3	A	131.0	140.0	4.5	-	+2.03 (12.50)	-1.67 (8.80)
	Br- 4	A	5.0	12.0	3.5	-	+2.03 (12.50)	-1.47 (9.00)
	Br- 7	A	125.5	134.6	4.56	-	+2.12 (12.59)	-2.44 (8.03)
	Br- 9	A	13.0	22.2	4.6	-	+2.13 (12.60)	-2.47 (8.00)
	Br-11	A	20.4	29.6	4.6	-	+2.33 (12.80)	-2.27 (8.20)
	Br-13	A	27.9	37.1	4.6	-	+2.33 (12.20)	-2.27 (8.20)
	Br-17	B	71.2	88.8	5.83	3.0	+2.98 (13.45)	-2.85 (7.62)
	Br-18	A	16.9	23.1	3.1	-	+3.83 (14.30)	-0.73 (11.20)

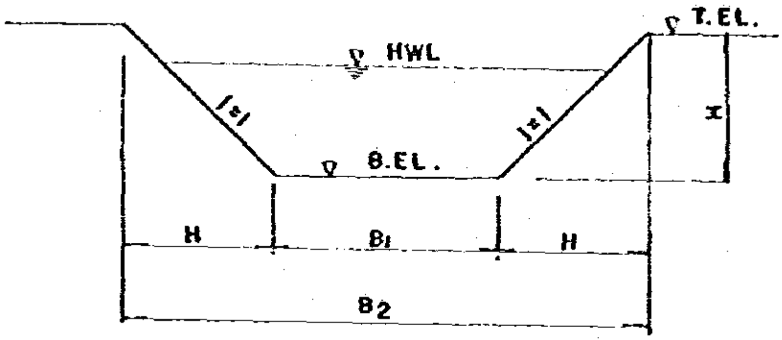
Note: * See Fig. III-7-15 for the full details of cross-section types of rivers.

Type-A : trapezoidal

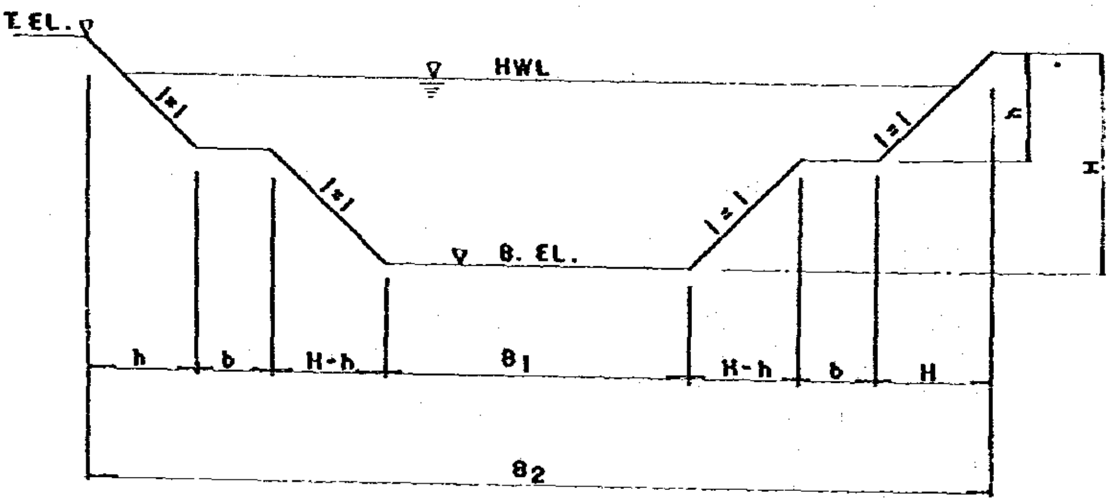
Type-B : stepped trapezoidal

Fig. III-7-15 CROSS-SECTION TYPES OF RIVERS

TYPE - A



TYPE - B



b = 5m for bridge B4 planned in the C-5 Road; and

b = 3m for bridge B17 planned in the C-6 Road.

- Culverts to be provided in the low land/fishpond area.

Locations of the culverts were chosen based on the above mentioned factors based on the topographic and aerial photo mosaics.

ii) <u>Culverts to be provided in the Upstream Area</u>

Drainage of flood water only is considered to be an important factor in deciding the size of the culverts. Once the Roads are constructed, it will be difficult to enlarge the culverts. Therefore, the culverts should have enough capacity to drain future flood discharges increased by the development of the watershed area.

(a) Run-off Analysis

The rainfall intensity was determined as follows:

Time of concentration = 20 min

Design storm frequency = 50-Year

Rainfall intensity

$= R_T(50\text{-Year}) = R_T(25\text{-Year}) \times (80.6/66.4)$

$= 169$ mm/hr x 1.2139 = 205 mm/hr

Run-off Coefficient = 0.8
(Future development was taken into consideration)

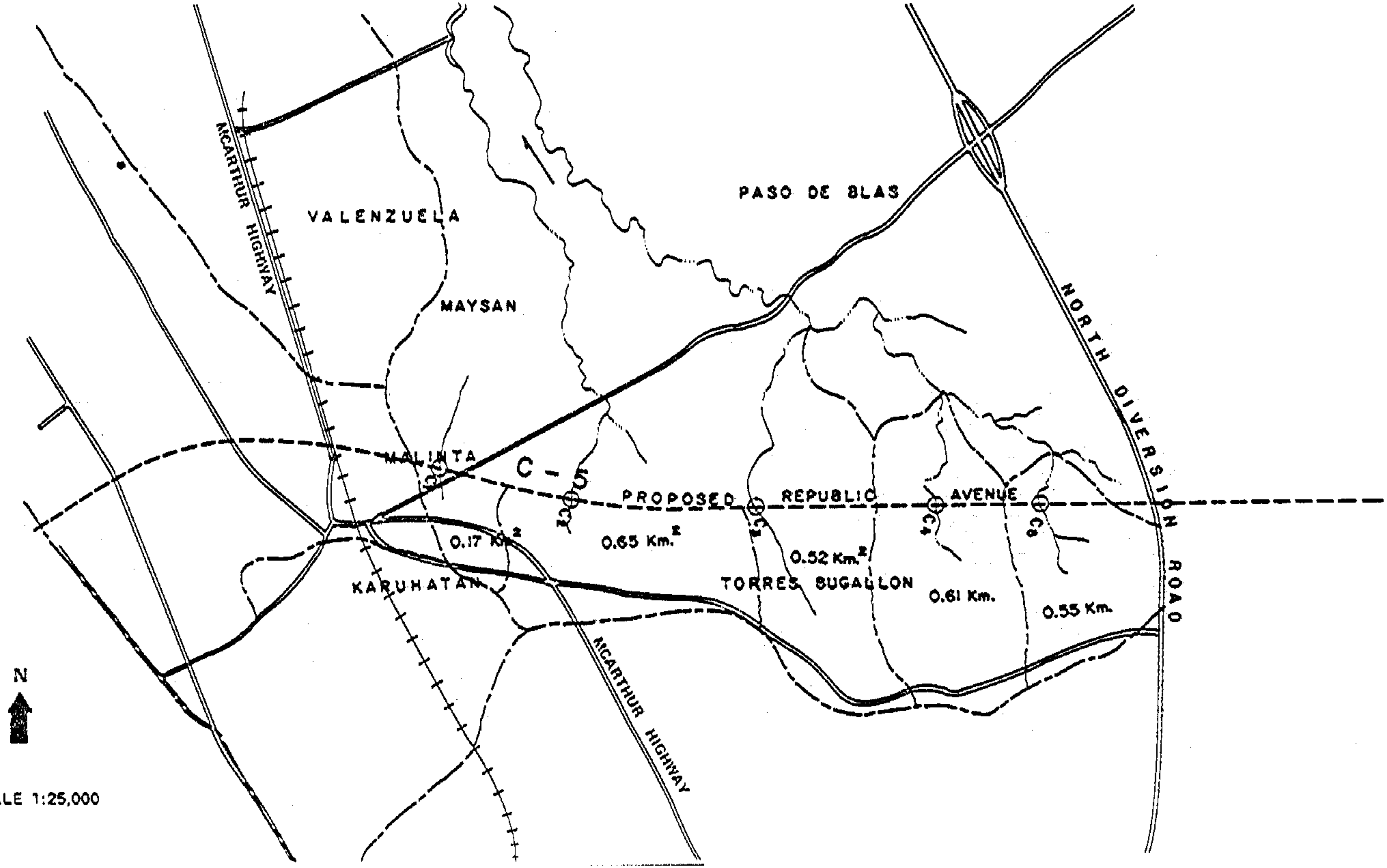
The peak discharge at each culvert location is as shown in Table III-7-25.

Table III-7-25 HYDRAULIC ELEMENTS OF CULVERTS IN THE UPSTREAM AREA

Culvert	Drainage Area (km^2)	Peak Discharge (m^3/s)	Flow Area (m^2)	Size of Culvert (m)
C1	0.15	7	2.8	2.0 x 2.0
C2	0.65	30	12.0	4.0 x 4.0
C3	0.49	22	8.8	4.0 x 4.0
C4	0.50	23	9.2	4.0 x 4.0
C5	0.25	11	4.4	3.0 x 3.0

Note: See Fig. III-7-16 for location of culvert.

Fig. III-7-16 LOCATION OF CULVERTS
(UPSTREAM AREA ALONG THE C-5 ROAD)



(b) Hydraulic Analysis

To determine culvert size, the following assumptions were made:

Flow velocity in culvert = 2.5 m/sec.

$$\text{Flow area} = \frac{\text{Peak discharge}}{\text{Flow velocity}}$$

Freeboard = 0.6 m

The results of the calculation of the hydraulic elements for each culvert are presented in also Table III-7-25.

iii) Culverts to be provided in the Low Land/Fishpond Areas

These culverts should have enough capacity to drain inland flood water downstream and to supply brackish water into the fishponds under existing and future conditions. The effects of the C-5 Road on floods are considered to be very small because its proposed route is located near the watershed boundary of the Meycawayan and Navotas River systems.

(a) Required Flow Area of Culvert as Brackish Water Supply Canal for Fishponds

Based on the conditions described below, 2.0 x 2.0 m concrete box culverts at intervals of about 200 meters of road length will be adopted:

Existing width of brackish water supply canal < 3.0 m

Volume of brackish water to be supplied every 6 hours (From MSL to MHHW)
= (11.01-10.47) x 20,000 m^2 average = 10,800 m^3

Capacity of culvert = Q
= 10,800 m^3/6 hr x 3,600 sec/hr = 0.5 m^3/sec

Assumed flow velocity = 0.3 m/sec

Required flow area
= 0.5 m^3/sec ÷ 0.3 m/sec = 1.7 m^2

(b) Required Flow Area of Culvert as Inland Flood Water Drainage System

For the culverts related to the C-5 Road, the same drainage pattern as brackish water supply canals mentioned above will be provided to drain inland flood waters.

The drainage culverts related to the C-6 Road will mainly be located in the Dampalit River basin. When the Maycawayan and Dampalit River systems are improved, it will not be necessary to provide special culverts to drain inland flood waters except for local drainage.

However, under existing conditions, the flood water overflowing fishpond dikes and water in the fishponds area flow slowly downstream when the flood level in the Meycawayan River goes down. According to the fishermen in this area, such over-flowing has been occuring almost every year.

Consequently, it will be necessary to provide enough flow area to minimize the head loss between the downstream and upstream of the culverts which would otherwise increase flood damage in the up-stream area.

To obtain the total flow area of planned culverts related to C-6 Road in the Dampalit River basin, the following conditions are assumed.

- The 50-Year frequency design flood discharge should be drained by the existing Dampalit River and the planned culverts;
- The flow velocities in the river and the culverts will be 0.5 meters per second; and
- Flood level will be El. + 12.0 meters.

Thus the required total flow area of the planned culverts was obtained as follows:

<u>Flood discharge capacity of the Dampalit River (Qo)</u>

$$Qo = (12.0-9.5) \text{ m} \times 140 \text{ m} \times 0.5 \text{ m/s} = 175 \text{ m}^3\text{/sec.}$$

<u>Required total flow area of planned culverts (A c)</u>

$$A\ c = (200-175)/0.5 \text{ m/s} = 50 \text{ m}^2$$

$$(Q\ c = 25 \text{ m}^3\text{/sec})$$

iv) <u>Summary of Planned Culverts</u>

The summary of planned culverts for the C-5 and C-6 Road has been prepared and is shown as Appendix I-49. Road stations designated are approximate and subject to change in accordance with the results of the actual route survey to be made in future detailed engineering.

CHAPTER 8. ENVIRONMENTAL IMPACT OF THE PROJECT ROADS

8.1 General

Environmental impacts were evaluated for three types of environments: namely, physical, biological and socio-economic. In addition to the favorable impacts on transportation and the basic human living environment mentioned below, adverse impacts and proposals for their mitigation were examined for the environments affected by the Project Roads on land and in the water and air.

The following components were adopped as the basis for this study.

Project Roads

- Coastal Road;
- C-5 Road: and
- C-6 Road.

Affected Areas

- Direct influence zone of the Project;
- MMA; and
- Corridor of the Project Roads.

Time Period for Consideration of Environmental Impact

- During construction; and
- After construction.

The preliminary qualitative analysis of the rasonably foreseeable effects of the Project Roads on the above environmental indicators was carried out.

8.2 Probable Environmental Impacts and Mitigation of Adverse Effects

8.2.1 Existing Environmental Conditions and Alternative Schemes

Descriptions of the existing environmental conditions, proposed road network alternatives, study of alternative routes of the roads, interchange schemes and selected bridge types have been discussed and are analysed in the respective sections and Appendixes mentioned below:

Description	Part	Chapter	Section/ Sub-section
Study objectives and Project Roads	III	1	1.1
Salient features of the Project Roads	III	6	6.1.2
Function of the Project Roads	III	6	6.1.3
Road network alternatives	III	5	5.1
Study of alternative routes	III	6	6.2
Design standard of the Project Roads and bridges	III	7	7.3
Typical cross-section of roads	III	7	7.5.2
Study of Interchanges	III	7	7.5.3
Preferable types of bridges	III	7	7.7.3
Hydrology	III	7	7.8
Physical environment of the Project Area	Appendix I-59		
Biological environment of the Project Area	Appendix I-59		
Socio-economic environment of the influence area	II	2	2.1∿2.5
Description of the direct influence zone for the Project Roads and future prospect	III	2	2.1∿2.5

A "Without project" alternative would involve using the existing road networks which are clearly inadequate for the present and future development projects in the area. The funds for the Project Roads could be used for other priority infrastructure and development projects planned in the Philippines, but the resulting traffic congestion throughout MMA and unrealized benefits of the development project far outweigh the costs to be incurred.

8.2.2 Favorable Environmental Impacts

Project elements producing a large magnitude of favorable effects are discussed assfollows:

A. Increase of Transport Mobility and Accessibility

The Coastal Road, together with the C-5 and C-6, will greatly enhance and strengthen the function if the road network system in the MMA.

The plan to construct the Radial Road R-10 are adready finalized and the tendering for certain parts of the road started in early 1978. That project covers not only the main trunk road between C.M. Recto Avenue and Spine Road at Navotas, but also the connecting stretches for the peripheral roads of C-2 and C-3.

The project of extending R-10 further up to C-4 is also under way and now the Government is proceeding with the final engineering stage. Therefore, it is expected that the construction of the Coastal Road will offer direct access to the reclaimed area.

The Circumferential Roads, C-5 and C-6, are not completely established at present. But the Project Roads will make crossing and by-passing central Manila possible and greatly enhance and strengthen the function of the road network system in the MMA.

Moreover, establishment of the Project Roads will improve traffic service within their surrounding area, and reduce traffic congestion within direct influence zone. Accordingly, transport mobility and accessibility of the corridor along the Project Roads will be improved because of reduction of travel and traffic cost.

B. Realization of Land Use Potentiality

Land use potentiality in the direct influence zone, especially the Coastal Road and C-5, will be greatly enhanced. The corridor of the Project Roads will be highly developed for industrial and housing land uses.

C. Increase of Land Value in Direct Influence Zone

The improvement in accessibility will reasonably induce enhancement in land use potentiality and cause an increase in development demand due to favorable location, conditions, and thus the increase in land value in the surrounding area of the Project Roads.

D. Better Community Cohesion

The growth of new community will be promoted by investors and inhabitants in the direct influence zone and the establishment of better communities will improve the comfort of the area.

E. Increase in the Value of Fishes produced in the direct influence zone

For fishery products, the Coastal Road will provide a shorter route to the marker of Manila. When the fishing industry is supported by an effective means of transport the economic returns to the industry are immense, since transportation costs and the freshness of fishes are important components of fish marketing.

8.2.3 Summary of Adverse Effects and their Mitigation

Possible adverse effects and their mitigation are summarized below;

Adverse Effect	Mitigation
1. Temporary air and water pollution during construction.	Nuisance and inconvenience during construction should be significantly reduced by introduction of proper construction management and supervision and adoption of proper construction equipment and methods.
2. Population displacement	The displaced families will be sufficiently compensated and/or resettled to proper areas. The squatter families affected by the Project Roads will be afforded better opportunities and improved quality of life in the resettlement projects of the Government. The relocation of these squatters will be undertaken with close coordination with the NHA and other Goverment agencies.
3. The embankment along C-5 and C-6 will slightly change existing drainage pattern and affect fishpond culture in surrounding area.	Sufficient investigation of biological, ecological and salinity conditions should be carried out to prepare the acceptable construction that will minimize adverse effects. Careful measures should also be provided against hydrological problems in the Navotas and Meycawayan Rivers Systems.

Continued

4. Loss of fishpond area	The fishpond area acquired for the right-of-way will be sufficiently compensated. Since transportation (between fishpond and consumer market) is one of the main components of fishing industry, the provision of adequate nodal points (i.e. from boat to truck) should be considered during the detailed engineering stage.

The futher discription of the environmental study is shown in Appendix I-59.

CHAPTER 9. CONSTRUCTION COST ESTIMATES

9.1 General

The TEAM established the unit prices of representative construction items using basic cost elements such as; labor, material, equipment, overhead, profit, etc. These unit prices were calculated under the economic conditions prevailing in June 1979. Current prices in Japan were used for the costs of imported construction machines, plants and materials while local prices were employed for other items that are domestically available.

Foreign currency and local currency components of each unit price were computed based on the following classification on basic cost elements.

The foreign currency component consists of the cost of:

- Imported equipments (depreciation), materials and supplies;
- Domestic materials which the country is a net importer;
- Wages of expatriate personnel; and
- Overhead and profit of foreign firms.

The local currency component includes the cost of:

- Domestic materials and supplies which the country is a net exporter;
- Wages of local personnel;
- Overhead and profit of local firms; and
- Taxes.

The rates of exchange used to convert the Peso currency of the Philippines to Japanese Yen and US$ are;

₱7.405 = Yen 215.424 = US$1.00

The result of the cost estimates were compared with the estimated unit prices established for the Radial-Road R-10 Project by Local Consultants.

9.2 Construction Quantities

The quantities for all work items were calculated based on the prepared preliminary drawing. The Team endeavored to limit the bill of quantities to the minimum number of price items with accurate rates for operations and materials.

9.3 Unit Price Analysis

The unit cost by work items is calculated from the material cost, labor cost, equipment cost, etc., taking into consideration the local condition in the area, and the results of the unit costs by items are listed in Table III-9-1. (See Appendix I-60 for the unit price analysis of representative work items).

An assessment of equipment hourly cost were made for the plant that would probably be used in the construction of the project. The hourly cost is shown in Table III-9-2.

A schedule of estimated local labor rates and cost of main materials are given in Tables III-9-3 and III-9-4.

The examples of unit price analysis for representative work items separated into worksheets and estimates sheets are shown in Appendix I-60.

The unit prices for equipment, labor, and materials in each cost estimate are direct costs, hence, do not include overhead and profit. To determine the estimated current contract unit price of each construction item including taxes, overhead and profit, a constant allowance of 25 percent was added to the direct price.

Table III-9-1 UNIT CONSTRUCTION COST

(Unit: in pesos)

	UNIT	F C	L C	TAX	TOTAL
1. Clearing and Grubbing classified Rice Field	sq.m.	-	0.36	-	0.36
2. Removal of Masonry or concrete structure	cu.m.	17.85	75.76	6.16	99.75
3. Removal of Old Pavement	sq.m.	7.57	6.82	2.46	16.85
4. Cut and Fill, 60m Hauling	cu.m.	5.62	4.50	1.81	11.93
5. Excavation, Borrow, Single Trip 2km	cu.m.	7.16	6.96	2.36	16.48
6. Excavation, Borrow, Single Trip 10km	cu.m.	11.12	11.43	3.74	26.29
7. Rock Excavation	cu.m.	24.61	38.33	7.70	70.64
8. Compaction of Foundation	sq.m.	1.39	1.30	0.45	3.14
9. Granular Borrow	cu.m.	32.11	29.88	9.34	71.33
10. Sand Drain, Ø 40 cm	l.m.	8.70	20.60	4.84	34.14
11. Subgrade Preparation	sq.m.	1.23	1.29	0.40	2.92
12. Subbase Course (Class B)	cu.m.	67.29	47.03	17.38	131.70
13. Base Course Coarse Aggregate Jobsite	cu.m.	78.47	73.40	23.79	175.66
14. Asphalt Prime Coat	t	1,593.60	1,022.10	591.80	3,207.50
15. Asphalt Tack Coat	t	1,370.00	850.00	520.00	2,740.00
16. Asphalt Seal Coat	t	2,200.00	1,680.00	790.00	4,670.00
17. Hot Bituminous Concrete Pavement	t	133.47	174.45	48.69	356.61
18. Asphalt Cement	t	945.00	508.10	406.50	1,859.60

Note: LC – Local currency component
and FC – Foreign currency component.

(Cont'd)

	WORK ITEM	UNIT	F C	L C	TAX	TOTAL
19.	Class A Concrete (plain)	cu.m.	167.70	134.02	49.74	351.46
20.	Class B Concrete (plain)	cu.m.	160.18	127.63	48.10	335.91
21.	Class C Concrete (plain)	cu.m.	154.45	124.89	45.74	325.08
22.	Structural Concrete C including formwork, seafolding, falsework, transportation and placing	cu.m.	348.96	475.15	105.62	929.73
23.	Class S Concrete (plain)	cu.m.	187.39	147.76	55.64	390.79
24.	Reinforcing Steel	kg	2.51	3.65	0.64	6.80
25.	Mortared Rubble	sq.m.	27.98	20.80	8.19	56.97
26.	Cement Mortar	cu.m.	201.35	235.04	59.90	496.29
27.	Guard Rail	l.m.	120.81	154.13	30.28	305.22
28.	Precast Reinforced Concrete Pile 45 cm x 45 cm (furnishing & driving)	l.m.	372.39	145.66	55.15	573.20
29.	Steel pipe pile Ø800 mm (furnishing & driving)	l.m.	1,534.40	77.00	170.00	1,781.40
30.	UPVC pipe Ø 100 mm	l.m.	3.28	91.95	1.00	96.23
31.	UPVC pipe Ø 150 mm	l.m.	3.28	166.57	1.00	170.85
32.	UPVC pipe Ø 200 mm	l.m.	4.43	242.96	1.37	248.76
33.	UPVC pipe Ø 250 mm	l.m.	5.57	339.03	1.74	346.34
34.	Concrete pipe Ø 300 mm	l.m.	56.76	81.84	15.30	153.90
35.	Concrete pipe Ø350 mm	l.m.	70.30	93.43	20.00	183.73

(Cont'd)

WORK ITEM	UNIT	F C	L C	TAX	TOTAL
36. Concrete pipe Ø 400 mm	1.m	88.92	122.76	23.54	235.22
37. Concrere pipe Ø 450 mm	1.m	103.84	146.16	27.64	277.64
38. Concrete pipe Ø 500 mm	1.m	115.98	164.92	31.10	312.00
39. Concrete pipe Ø 600 mm	1.m	139.93	201.77	37.71	379.41
40. Concrete pipe Ø 760 mm	1.m	233.25	326.58	62.17	622.00
41. Concrete pipe Ø 900 mm	1.m	275.51	389.38	73.72	738.61
42. Drainage pipe Ø 1000 mm	1.m	407.44	547.78	111.90	1,067.12
43. Box culvert 1.2m x 1.2m	1.m	1,010.00	1,085.12	271.75	2,366.87
44. Box culvert 2.0m x 2.0m	1.m	1,768.54	1,896.63	480.90	4,146.07
45. Box culvert 3.0m x 3.0m	1.m	2,862.10	3,003.88	790.06	6,656.04
46. Box culvert 2.0m x 1.7m	1.m	1,628.02	1,715.56	443.06	3,786.64
47. Box culvert 2.5m x 2.1m	1.m	1,997.68	2,094.97	545.32	4,637.97
48. Box culvert 3.0m x 2.3m	1.m	2,438.10	2,537.48	673.91	5,649.49
49. Box culvert 3.0m x 2.5m	1.m	2,554.60	2,657.70	704.71	5,917.03
50. Box culvert 4.0 m x 4.0m	1.m	4,909.78	5,344.14	1,341.34	11,595.26
51. Curb	1.m	29.88	25.39	8.55	63.82
52. Curb and Gutter Type A	1.m	31.30	25.84	9.22	66.36

(cont'd)

WORK ITEM	UNIT	F C	L C	TAX	TOTAL
53. Curb and Gutter Type B	l.m	41.85	34.40	12.48	88.73
54. Catch Basin	each	732.20	850.34	198.40	1,780.94
55. Manhole Ø 1.2 m	each	1,778.23	1,886.32	505.60	4,170.15
56. Manhole Ø 1.8 m	each	2,773.97	2,897.45	786.17	6,457.59
57. Strip sodding	sq.m	0.14	1.62	0.05	1.81
58. Solid sodding	sq.m	0.29	3.35	0.10	3.74
59. Road Marking	sq.m	25.63	28.55	6.78	60.96
60. Asph. Treated Base	t	144.48	101.17	53.75	299.40
61. Concrete Pavement	sq.m	55.67	44.81	16.28	116.76
62. Slope pitching	sq.m	69.53	106.46	20.45	196.44

Table III-9-2 HOURLY COST OF CONSTRUCTION EQUIPMENT

Unit: in pesos

EQUIPMENT	F C	L C	TAX	TOTAL
1. Crawler Tractor (Bulldozer, 21 ton class)	201.5	139.5	65.0	406.0
2. Crawler Tractor (Bulldozer, 17 ton class)	139.2	93.5	44.3	277.0
3. Convertible Excavator, 0.6 m^3	126.2	84.6	40.2	251.0
4. Motor Grader	110.3	74.5	35.2	220.0
5. Motor Scraper, 6 m^3	160.8	109.9	51.5	322.0
6. Tractor Shovel, Wheel 1.4 m^3	111.3	67.7	34.0	213.0
7. Tractor Shovel, Crawler 1.4m^3	123.0	79.4	38.6	241.0
8. Tandem Road Roller, 8 t	57.5	43.3	19.2	120.0
9. Macadam Road Roller, 10 t	50.8	38.2	17.0	106.0
10. Macadam Road Roller, 8 t	50.0	34.8	16.2	101.0
11. Tyre Roller, 10 t	66.0	49.9	22.1	138.0
12. Sheeps-foot Roller	52.6	30.6	15.8	99.0
13. Pile Driver, 3.5 t	391.5	236.8	119.7	748.0
14. Pile Driver, 4.5 t	449.3	269.7	137.0	856.0
15. Air Compressor, 10 m^3/min.	304.0	174.8	91.2	570.0/day
16. Motor Generator, 50 KVA	170.8	147.6	60.6	379.0/day
17. Motor Generator, 30 KVA	106.1	82.9	36.0	225.0/day
18. Dump Truck, 3 m^3	25.5	20.7	8.8	55.0
19. Flat bed truck, 3^t	27.1	22.5	9.4	59.0
20. Flat bed truck w/2^t crane	35.0	28.8	12.2	76.0
21. Trailer Truck, 20 t	120.0	97.0	41.0	258.0
22. Cross Country jeep	25.8	17.9	8.3	52.0
23. Mixer truck, 2 m^3	41.3	28.5	13.2	83.0
24. Fuel tanker, 5000 lit	38.3	25.5	12.2	76.0
25. Concrete Batching Plant, 0.75 m^3 x 2	967.0	352.0	251.0	1,570.0
26. Concrete Batching Plant, 0.8m^3	148.5	81.7	43.8	274.0
27. Asphalt Plant, 100 t/Hr	1,119.3	634.2	343.5	2,147.0
28. Bituminous Spreader	202.1	126.4	62.5	391.0
29. Asphalt Distributor, 4000 lit	108.1	70.9	34.0	213.0
30. Aggregate Spreader	129.5	80.5	40.0	250.0
31. Asphalt Kettle, 5000 lit	63.8	27.8	17.4	109.0
32. Rock Drill Sinker	68.3	22.4	17.3	108.0/day
33. Truck Crane, 30 t	173.0	115.0	55.0	343.0
34. Truck Crane, 10 t	87.0	58.3	27.7	173.0
35. Mechanical Broom	25.6	19.0	8.4	53.0
36. Vibration Roller, hand guide	13.5	10.0	4.5	28.0
37. Rammer	35.3	21.0	10.7	67.0/day
38. Rod Vibrator	20.5	9.7	5.8	36.0/day
39. Form Vibrator	19.5	9.1	5.4	34.0/day
40. Vertical Pump	43.8	49.5	17.7	111.0/day
41. Crushing Plant	917.1	333.7	238.2	1,489.0
42. Portable Belt Conveyor, 7 m	59.8	31.8	17.4	109.0/day
43. Concrete Spreader, 100 t/Hr	160.0	58.0	42.0	260.0
44. Concrete Finisher	166.0	61.0	43.0	270.0

Note: LC – Local Currency Component and
FC – Foreign Currency Component.

Table III-9-3 ESTIMATED LOCAL LABOR COSTS

Unit: in pesos

Classification	Rate per day given by MPH	Rate per hour
Foreman	40	4.98
Asst. Foreman	27	3.35
Operator (Heavy)	35	4.27
Operator (Light)	30	3.73
Mechanic	35	4.27
Carpenter	25	3.13
Skilled Labor	26	3.21
Unskilled Labor	21	2.58

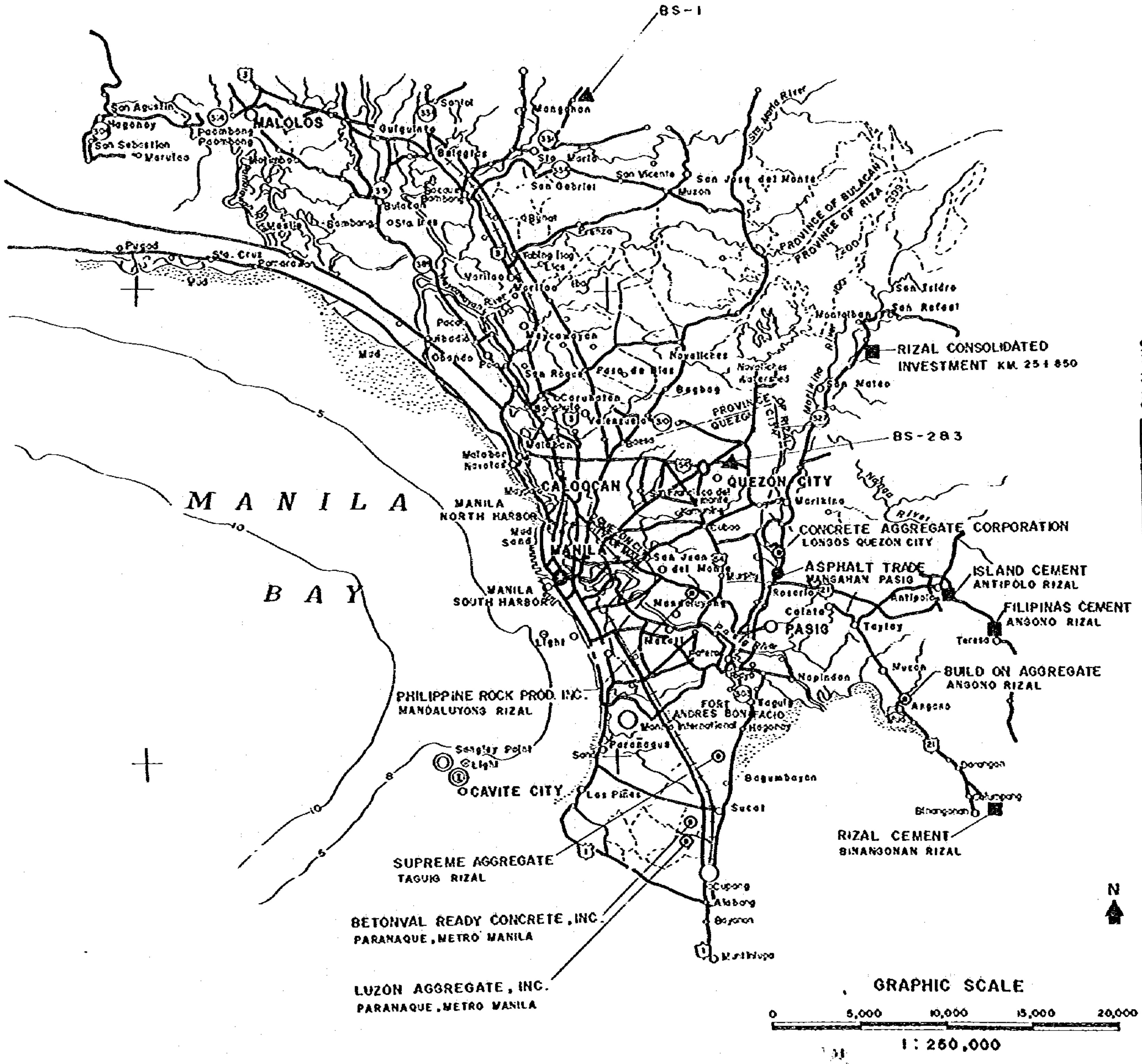
Prices of main materials which were planned to be used in this study are presented in the Table III-9-4 (See Fig. III-9-1 for material sources).

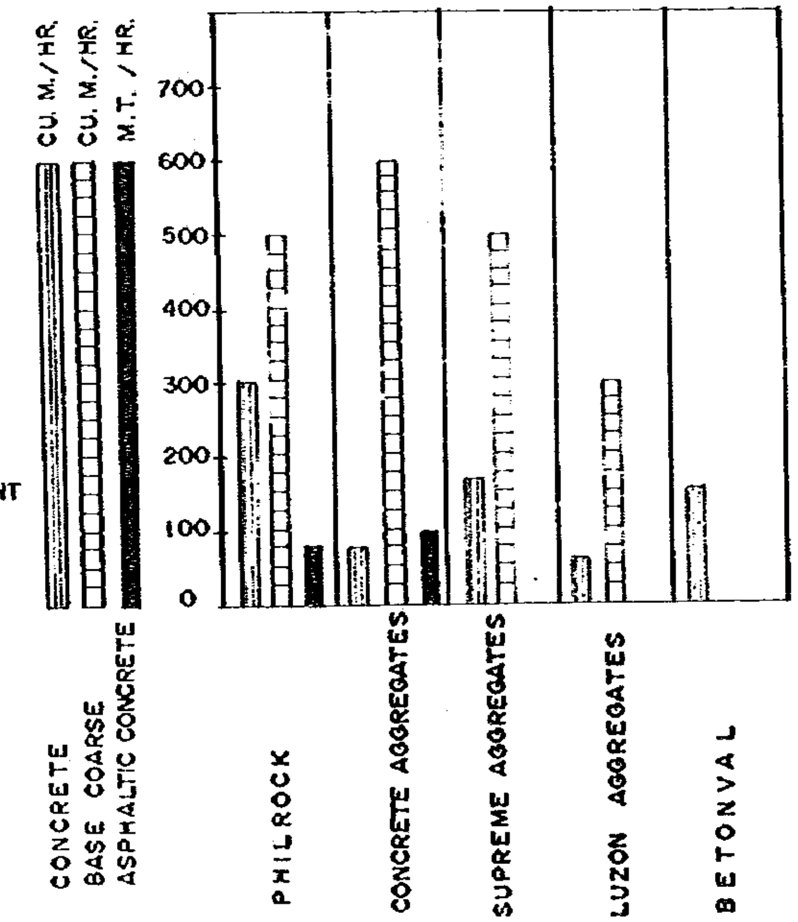
Table III-9-4 COST OF MAIN MATERIALS

Description	Unit	Unit Price (₱)	Component (%)		
			Foreign	Local	Tax
Portland Cement	ton	575	50	35	15
Sand	m^3	90	45	42	15
Gravel	m^3	90	45	42	13
Reinforcing Steel Bar	ton	6,800	40	50	10
Diesel	lit	1.42	51	27	22
Ready mixed concrete	m^3	351.5	48	38	14
Fabricates steel of box girder	ton	16,000	90	2	8
Steel pipe pile	ton	6,300	90	2	8
Asphalt cement	ton	1,860	51	27	22

Note: The cost of main materials are surveyed in mid 1979 and referred from other project.

Fig. III-9-1 MATERIAL SOURCES





PRODUCTION RATE
(AS OF SEPTEMBER 1979)

9.4 Land Aquisition and Compensation Cost

The land aquisition and compensation cost was estimated based on the tax declalation source obtained from the Municipality of Meycawayan and Bulacan. The unit costs are shown as follows.

Residential House:

Reinforced Concrete .... ₱850.00/sq.m.
Comb. Wood & Concrete .... 400.00/sq.m.

Commercial & Industrial Bldg. (Including Shops)

Reinforced Concrete

- One-Storey .... ₱780.00/sq.m.
- Two-Storey .... 880.00/sq.m.
- Three-Storey .... 980.00/sq.m.

Comb. Wood & Concrete

- One-Storey .... ₱650.00/sq.m.
- Two-Storey .... 780.00/sq.m.
- Three-Storey .... 840.00/sq.m.

9.5 Preliminary Construction Cost Estimates of the Project Roads

The preliminary construction cost estimates are carried out for several alternative road plans as shown in Tables III-9-5 thru III-9-7. The cost is split into foreign currency component, local currency component and taxes. It is to be noted that the cost of the Coastal Road on the reclamation area includes the averaged reclamation cost covering the bulkhead, dredging and others in proportion to the area of the right-of-way.

Table III-9-5 PROJECT COST, ROAD PLAN 2

(₱'000 in 1979 prices)

Description	The Coastal Road (as the causeway) and C-5 to be Constructed by 1987			
	Foreign	Local	Taxes	Total
1. Earthwork	77,162	72,297	23,286	172,655
2. Bridge & Structure	101,862	56,741	18,727	177,330
3. Paving Work	27,161	19,756	8,879	55,795
4. Miscellaneous	14,497	17,297	3,898	35,692
5. Sub-total	220,682	166,001	54,789	441,472
6. Overhead & Profit	55,170	41,501	13,697	110,368
7. Total	275,852	207,502	68,486	55,840
8. Detailed Design	11,033	8,301	2,740	22,074
9. Supervision	16,551	12,450	4,109	33,110
10. Right-of-way	-	50,224	-	50,224
11. Total	303,436	278,477	75,335	657,248
12. Physical Contingency	30,344	27,848	7,533	65,725
13. Total	333,780	306,325	82,868	722,973

Table III-9-6(A) PROJECT COST, ROAD PLANS 3&4

(₱'000 in 1979 prices)

Description	The Coastal Road (on the Reclamation Area) and C-5 to be Constructed by 1987			
	Foreign	Local	Taxes	Total
1. Earthwork	39,200	39,737	12,810	91,747
2. Bridge & Structure	103,254	58,389	19,115	180,758
3. Paving Work	32,177	23,470	10,457	66,104
4. Miscellaneous	16,726	19,857	4,455	41,038
5. Sub-total	191,357	141,453	46,837	379,647
6. Overhead & Profit	47,839	35,363	11,709	94,911
7. Total	239,196	176,816	58,546	474,558
8. Detailed Design	9,568	7,072	2,341	18,981
9. Supervision	14,351	10,609	3,513	28,473
10. Right-of-way 1)	35,835	69,246	8,658	113,739
11. Total	298,950	263,743	73,058	635,751
12. Physical Contingency	29,895	26,374	7,306	63,575
13. Total	328,845	290,117	80,364	699,326

Note: 1) The averaged reclamation cost per sq. meter is applied to estimate the cost.

Table III-9-6(B) PROJECT COST, ROAD PLANS 3&4

(₱'000 in 1979 prices)

Description	Construction of the Grade Separation Structures and Pavement Overlay for the Coastal Road and C-5			
	Foreign	Local	Taxes	Total
1. Earthwork	8,295	8,911	2,881	20,087
2. Bridge & Structure	10,217	7,596	2,143	19,956
3. Paving Work	10,354	7,711	3,409	21,474
4. Miscellaneous	2,663	3,382	718	6,763
5. Sub-total	31,529	27,600	9,151	68,280
6. Overhead & Profit	7,883	6,950	2,288	17,071
7. Total	39,412	34,500	11,439	85,351
8. Detailed Design	1,576	1,380	458	3,414
9. Supervision	2,365	2,070	686	5,121
10. Right-of-way 1)	13,651	10,812	3,299	27,762
11. Total	57,004	48,762	15,882	121,648
12. Physical Contingency	5,700	4,876	1,589	12,165
13. Total	62,704	53,638	17,471	133,813

Note: 1) The averaged reclamation cost per sq. meter is applied to estimate the cost.

Table III-9-7 PROJECT COST, ROAD PLAN 5

(₱'000 in 1979 prices)

Description	The Coastal Road (partly on the Reclamation Area and Partly as the Causeway) and C-6 to be Constructed by 1987			
	Foreign	Local	Taxes	Total
1. Earthwork	66,156	82,318	23,985	172,459
2. Bridge & Structure	87,164	47,771	16,110	151,045
3. Paving Work	33,513	24,381	10,797	68,691
4. Miscellaneous	15,245	18,612	4,063	37,920
5. Sub-total	202,078	173,082	54,955	430,115
6. Overhead & Profit	50,520	43,271	13,739	107,530
7. Total	252,598	216,353	68,694	537,645
8. Detailed Design	10,104	8,653	2,748	21,505
9. Supervision	15,156	12,982	4,121	32,259
10. Right-of-way 1)	35,835	48,186	8,658	92,679
11. Total	313,693	286,174	84,221	684,088
12. Physical Contingency	31,369	28,618	8,422	68,409
13. Total	345,062	314,792	92,643	752,497

Note: 1) The averaged reclamation cost per sq. meter is applied to estimate the cost.

9.6 Road Maintenance Cost

The maintenance cost of the Project Roads was estimated based on the data obtained from the Bureau of Maintenance, PPDO, MPH. The following activities are included in the maintenance cost.

Routine Maintenance

- Hand cleaning of ditches and culverts;
- Vegetation control;
- Erosion control;
- Traffic services;
- Repair of minor structures;
- Minor repair of bridges;
- Repair of P.C. concrete pavement;
- Cracks and joint filling (P.C. concrete pavement)
- Repair of lighting facilities; and
- Others.

Periodic Maintenance

- Surface treatment of bituminous surfaces;
- Pavement striping of panel surfaces;
- Bridge painting; and
- Others.

The road maintenance cost per kilometer are shown by width and by type of pavement as follows.

Type of Pavement	Road width((m)	Cost per km (₱)
Portland cement concrete road	5 ∿ 7.5	15,010
	7.5 ∿ 10	17,262
	> 10	19,513
Bituminous Concrete road	5 ∿ 7.5	16,511
	7.5 ∿ 10	19,063
	> 10	21,464

CHAPTER 10. ECONOMIC ANALYSIS

10.1 Vehicle Operating Cost

10.1.1 General

Studies on the vehicle operating cost were conducted on five vehicle types, each indicating a different pattern of traffic movement, namely:

Cars
Jeepneys
Buses
Pick-ups
Trucks, medium and large

The vehicle operating cost is composed of running-mileage-related and time-related cost (fixed hourly cost). The method of estimation in this study is similar to those used in recent studies such as the National Transportation System Study (Interim Report, 1978) and Feasibility on C-3 and R-4 and Related Roads Project (1978).

The Study Team has referred to the research on basic vehicle operating cost conducted by MPH since 1975. The MPH policy on basic traffic cost[6/] which has been used in previous and on-going feasibility studies, in order to maintain consistency has also been adopted for this study. There are, however, some minor modifications to be consistent with the findings of the Team.

10.1.2 Summary of Vehicle Operating Cost

The details of the distance related cost and the time related cost for the representative vehicles are shown in Appendix I-61. If they are compared to an example of the other traffic cost of MPH, the differences are quite modest (See Table III-10-1). It is understood, however, that the differences result from different findings of the Study Team.

6/ PPDO of MPH, Manual on Basic Traffic Cost Calculation Procedures, Price Level, July 1, 1979

Table III-10-1 TRAFFIC COST, JULY 1979

Vehicle Type	Luzon Unit Prices 1)		Manila Unit Prices 2)	
	Distance Related Cost (₱/km)	Time Related Cost (₱/hr)	Distance Related Cost (₱/hr)	Time Related Cost (₱/hr)
Bantam Car	0.367	1.02	0.303	1.236
Pick-up & Van	0.348	2.47	0.306	2.830
Jeepney	0.343	5.25	0.385	5.867
Large Bus	0.783	14.64	0.892	14.869
Medium Truck	0.829	10.46	0.585	9.823
Large Truck	0.955	14.39	1.033	15.262

Sources: 1) Ministry of Public Highways cost estimates based on data from Olongapo Road Study.
2) The Study Team cost estimates based on data from the PROJECT.

10.1.3 Time value of Passengers

Savings in time in passenger movement can be measured in terms of money and quantified in the economic evaluation, although the method of quantification is still a subject for discussion. In this study, the time is associated with the wage rate and assessed in terms of economic cost.

The daily wage rate of a skilled laborer in the Manila area effective June 1978 was in the range of ₱ 12.72-27.35 a day.[1] The rate of ₱14.55 a day for common laborers can be taken as the basis since this would be the average if house maids and other unskilled service sector workers are included. If we consider the wage rate as of June 1979, the rate would be increased by 10% to ₱16.00. Accordingly, the wage rate per hour would be at ₱2.00.

MPH, on the other hand, has found the hourly rate value of time as shown below to be applicable to the feasibility studies.

Descriptions	Wage Rate per Hr.
Car driver owner	₱11.50
Car driver otherwise and passenger	₱ 4.60
Jeepney passenger	₱ 2.30
Bus passenger	₱ 2.90

The above figures are applied to the Study. The calculation of the values in vehicle-hour is shown in Appendix I-61.

Further, it is necessary to note that the time saved is not always used in other productive activities. Considering the Philippine economy, in which full employment of resources and labor has not yet been attained (although the economy has deve-

1/ NEDA, Philippine Economic Indicators Vol. VI, No. 12.

loped steadily), the time value of passengers is determined to be half (1/2) of the preliminary time value in Appendix I-61. It is shown below:

Vehicles	Time Value of Passengers
Car	6.170 x 1/2 = ₱3.085/per vehicle-hour
Jeepney	9.692 x 1/2 = ₱4.846/per vehicle-hour
Bus	36.945 x 1/2 = ₱18.473/per vehicle-hour

10.2 Vehicle Transportation Cost

10.2.1 dl and dt Methods (application of basic traffic costs on the project roads

Individual running costs in various conditions are determined by applying dl and dt system to the basic running cost which is the cost of a vehicle running on a level, straight road with a good paved surface condition, free flow of traffic and insignificant side friction.

Individual running cost on a road not in ideal conditions are assumed to be equal to the cost of running with an ideal conditions on the same length plus an extra distance, dl, which varies in accordance with the actual conditions for that length.

MPH has developed a set of dl values applicable to various road conditions since 1975.[8/] The Study Team decided to adopt this system with an adjustment suitable to the actual road conditions for the road system in the Project Area. The elements of dl applicable to the PROJECT are stated in Appendix I-63.

10.2.2 Traffic Cost

The traffic cost for all zone pairs in the OD tables is computed by taking into account all the factors of dls, quantity-velocity (Q-V) relationship and toll fees of the Manila North Expressway. The summary is shown in Table III-10-2.

OD trips forecasted for 1988 are as follows (See also Table III-3-4):

Vehicle Type	1988 OD Trips	
Passenger cars	71,540	(44)
Pick-ups	23,847	(15)
Jeepneys	38,239	(24)
Buses	9,560	(6)
Trucks (medium)	13,599	(8)
Trucks (large)	5,030	(3)
Total	161,815	(100%)

8/ MPH and Norconsult A.S. & Hoff Overgaard, Road Feasibility Study II, June 1975.

The foreign cost component in the unit price of vehicle operating cost is weighted with the above percent resulting in the percent of foreign cost component in the total as follows. The figures are used for the adjustment factor of economic benefits shown in Table III-10-2.

Description		Adjustment Factor for the Total of Vehicle Cost
Vehicle running cost	36%	0.36 x 1.15 + 0.64 = 1.05
Vehicle time cost	23%	0.23 x 1.15 + 0.77 = 1.03

In the case of Highway Plan 3 & 4 (the Coastal Road and the C-5 Road), the composition of the savings in the annual transport cost in terms of adjusted economic cost is shown below in 1979 prices (₱'000) for the traffic forecast in 1988.

Vehicle Operating Cost	Passenter Time Cost	Induced	Total
104,732	18,177	10,212	133,121
(78.7%)	(13.7%)	(7.6%)	(100%)

10.3 Concept of Cost and Benefits

10.3.1 Adjustment Factors

In the economic analysis for the project, adjustments in cost and benefits are necessary prior to the determination of cost and benefit streams. The factors to be adjusted are listed as follows: Some are treated in "with and without" principle of the benefit cost analysis in Sub-Section 10.4.3.

A. Transfer Element

Customs duties and taxes included in the market prices should be taken out because they are transfer elements and indicate no use of real resources nor economic gains.

B. Unskilled Labor

Hired laborers are divided into two categories, namely those who have skills and technologies and those who have no particular skills but offer only simple manual work on a daily weekly basis. If the labor market indicates the existence of some unemployed and under-employed persons, this situation was taken into account in the economic evaluation.

In the economic study for the Project, the cost was measured as related to the opportunity for other uses. If there are many laborers who are looking for a simple manual work job or those in an under-employment situation, the economic cost of unskilled workers is evaluated to be less

Table III-10-2 ESTIMATED TRAFFIC COST, 1988

(Economic cost, ₱'000 in 1979 prices)

Road Alternative Plans	(1) Veh. Run. C	(2) Veh. Time C	(3) Sub-Total	(4) Pass. Time C	(5) Total	(6) Induced	(7) G-Total
A. Total Cost							
1. per day	2,029.2	859.9	2,889.1	694.8	3,583.9		
per year	740,658	313,864	1,054,522	253,602	1,308,124		
per year 2)	777,691	323,280	1,100,971	253,602	1,354,573		
2. per day	1,822.7	801.5	2,624.2	650.2	3,274.4	542.4	3,816.8
per year	665,286	292,365	957,651	237,323	1,194,974	197,976	1,392,950
per year 2)	698,550	301,136	999,686	237,323	1,237,009	205,895	1,442,904
3.4. per day	1,819.2	795.4	2,614.6	645.0	3,259.6	540.1	3,799.7
per year	664,008	290,321	954,329	235,425	1,189,754	197,137	1,386,891
per year 2)	697,208	299,031	996,239	235,425	1,231,664	205,022	1,436,686
5. per day	1,893.8	788.6	2,682.4	638.0	3,320.4	555.0	3,875.4
per year	691,237	287,839	979,076	232,863	1,211,939	202,575	1,414,514
per year 2)	725,799	296,474	1,022,273	232,863	1,255,136	210,678	1,465,814
B. Savings from the Alternative Plan I (the case without project)							
2. per day	206.5	58.4	264.9	44.6	309.5	25.6 1)	335.1
per year	75,372	21,499	96,871	16,279	113,150	9,399	122,549
per year 2)	79,141	22,144	101,285	16,279	117,564	9,775	127,339
3.4. per day	210.0	64.5	274.5	49.8	324.3	26.9 1)	351.2
per year	76,650	23,543	100,193	18,177	118,370	9.819	128,189
per year 2)	80,483	24,249	104,732	18,177	122,909	10,212	133,121
5. per day	135.4	71.3	206.7	56.8	263.5	19.5 1)	283.0
per year	49,421	26,025	75,446	20,739	96,185	7,100	103,285
per year 2)	51,892	26,806	78,698	20,739	99,437	7,384	106,821

Notes : 1) Multiplied by 0.5 by a rule to estimate the benefit.

2) Adjustment factor of 1.05 is multiplied to the vehicle running cost and 1.03 to the vehicle time cost. To the induced benefits, the average of 1.04 is multiplied.

than the market wage rate. The cost of employing unskilled laborers is rated at 0.5 times the market wage rate.

C. Foreign Exchange Component

In most developing countries foreign exchange currencies are considered more valuable than is indicated by the official exchange rate. The premium over the government controlled exchange rate is estimated by the following UNIDO formula.[9/]

$$SER = OER \frac{(M+Ti) + (X-Sx)}{M+X}$$

Where: SER : Shadow exchange rate
OER : Official exchange rate
M : CIF value of imports
X : FOB value of exports
Ti : Import duties & taxes
Sx : Export subsidies

Statistical data are shown in Appendixes I-64 through I-66 where the values of SER is estimated at 1.08 in 1977 and 1.10 in 1978 respectively. Besides the above premium, there is the import quota system in Philippines. It is determined that 15% higher value than the exchange rate is applicable when measuring the foreign exchange component. The exchange rate was $1.00 = ₱7.405 in July 1979, while the shadow rate is $1.00 = ₱8.52.

10.3.2 Economic Cost of the Road Project

The estimated cost for the Coastal Road and the C-5 and C-6 for the plans 2, 3, 4 and 5 are shown in Tables III-9-5 through III-9-7. Table III-10-3 gives the summary of the costs adjusted for economic evaluation.

According to the Plan 5, the Coastal Road on the reclaimed area and causeway together with the C-6, is the most cost project.

Plan 3 & 4 is estimated to cost 662 million pesos in adjusted economic cost. Plan 2 which includes the construction of the causeway without reclamation is 22 million pesos higher than the cost of Plan 3 & 4.

9/ UNIDO, Guide to practical Project Appraisal (Vienna, 1978)

Table III-10-3 PROJECT COST IN ADJUSTED ECONOMIC COST

(Phase I)

(₱'000 in 1979 Prices)

Plan No.	Alternative	(1) Foreign Currency Component	(2) Local Currency Component	(3) Shadowed Foreign Currency Component (1)x1.15	(4) Shadowed Local Currency Component (2)x0.98	(5) Total of Shadowed Economic Cost (3)+(4)
1.	Without project	-	-	-	-	-
2.	The Coastal Road (as the Causeway) and C-5	333,780	306,325	383,847	300,199	684,100
3. & 4.	The Coastal Road (on the Reclamation Area) and C-5	328,845	290,117	378,172	284,315	662,487
	Grade Separation of C-5 and the Bridge Over to Reclamation Block IV	62,704	53,638	72,110	52,565	124,675
5.	The Coastal Road (partly on the Reclamation Area and partly as the Causeway) and C-6	345,062	314,792	396,821	308,496	705,317

10.3.3 Economic Benefits of the Road Project

A. Savings in Vehicle Transport Cost

i) Normal and Diverted Traffic

The construction of the Project Roads, the Coastal Road from C-4 to C-6, C-5 and C-6, will contribute to the reduction of road congestion in the direct influence zone. The economic quantification of the reduction of road congestion is measured in terms of vehicle transport cost as estimated in Sections 10.1 and 10.2 of this Chapter.

The savings in vehicle transport cost are shown to be that of vehicle running cost, of time related cost, and time value of passengers, respectively. Each one of the Highway alternatives as shown in Fig. III-5-1 would result in the total traffic cost which is a summation of vehicle transport cost for the trips of all zone pairs. The total traffic cost for the alternative road network plans and their differences are shown in Table III-10-2.

ii) Induced Traffic

The construction of the Project Roads will induce additional traffic volume on the roads surounding the new Project Roads. It is calculated in Section 4.3.2 that the volume would be an additional 10% of the total trips in the OD table if the Coastal Road, C-5 or C-6 are completed.

The benefit acrrued to this induced traffic is estimated by applying "the general rule of triangular surplus area". Hence, the benefit per vehicle is measured at half of the savings of that vehicle of the normal traffic on the same road network. Table III-10-2 presents the induced benefits of all alternative cases in 1988.

iii) Generated Traffic in the Reclamation Area

The economic benefits of the reclamation are measured by the land value. Since it is supposed to represent all of the net gains generated from the activities related to the land reclamation, no benefits related to generated traffic are considered in order to avoid including them twice.

B. Increases in Land Values

Increases in land values in the area along the Project Roads are foreseen when the roads are completed. For example, if C-6 is constructed, the value of fish ponds or rice fields would be tripled or quardrupled. Some of the land will be sold and the land use pattern will be converted to residential or industrial purposes.

The quantification, however, is controversial. For example, the increase in land value can only be measured when an actual real estate transaction takes place and the land is utilized for a new purpose in the regional economy. It is difficult, therefore, to predict changes in land use and in prices of land which may result from the road construction.

MMA has grown in size, population, and economic activities together with the development of administrative and social problems. If an establishment is located in the area, adjacent to the new road, the reasons for such a location would not only be the accessibility of the road, but also other factors which result from the growth of MMA. In determining the land value the influence of a growing urbanization and economic development cannot be separated from that of the new road construction.

The economic impact of the new road construction on the land value in the project area is not measured quantitatively in this study. It is recognized however that it will be part of the benefits of the Project Road. It should be noted, however, that they are to be included as one item of those qualitative benefits which are excluded from the benefit/cost calculation.

C. Increases in the Productivity of the Economy of the Project Influence Zone

It is anticipated the existing economy in the direct influence zone of the Project may increase the outputs more than the increase measured in terms of the growth factor of traffic and benefits. Since the additional outputs caused by the increase of productivities of land and man-power associated with the Project Roads are hard to quantify and classify, they are not included in the benefit-cost analysis.

10.4 Benefit-Cost Estimates

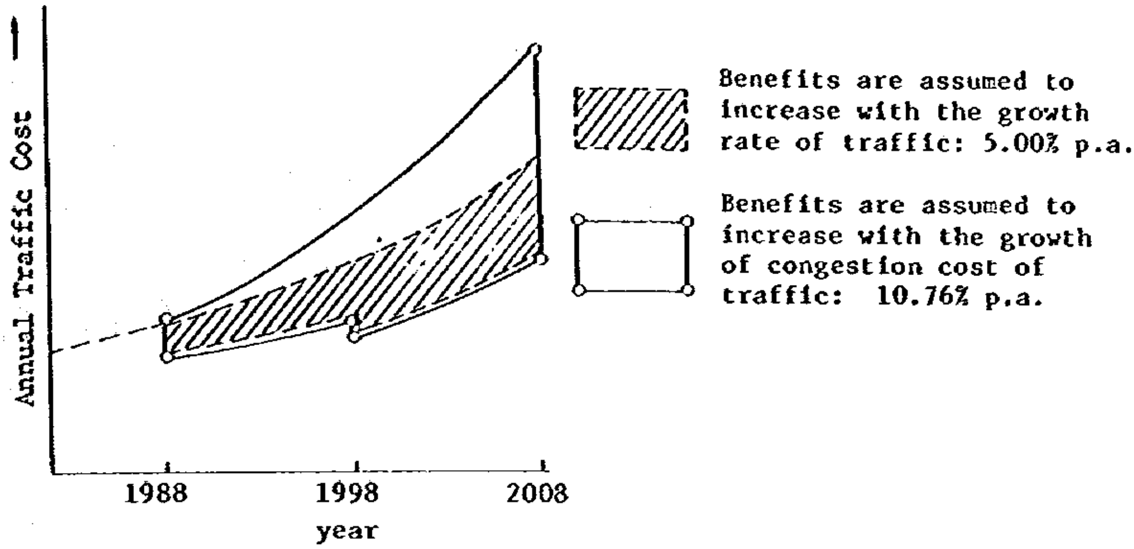
10.4.1 Assumption

A. A detailed engineering study will begin in 1982 and the construction will be completed in 1987. The disbursement of the cost during this period is based on the implementation program shown in Chapter 11 of this Part.

B. The project life subject to the economic evaluation is to be 20 years from 1988 to 2007. In addition, the years of construction from 1982 to 1987 are to be included.

C. Discount rate of 15% p.a. is adopted since the ratio is normally used in the project study by MPH.

D. The increase in the Benefits is interpolated by estimating the traffic cost for 1988, 1998 and 2008. The traffic cost is quantified by including the congestion cost on roads which increases much more rapidly than the rate of traffic growth. It is calculated that the average annual growth rate of the savings in traffic cost for the years 1988-2008 is 10.76%, while the average growth rate of Traffic in the same period is 5.00% p.a. The difference is shown below.



10.4.2 Alternative Plans of the Road Project

A. Plan 1

This is the case where no project is implemented. The road network will remain mostly as it is today.

B. Plan 2

This is the construction of the Coastal Road as a causeway 200 m or more offshore from Navotas without any land reclamation, and the construction of the C-5 up to the Manila North Expressway. Traffic volume on these sections is mostly the same as that in the following Plan 3, however, the cost of the Coastal Road as a causeway, makes the adjusted economic cost 22 million pesos higher than the cost of Plans 3 and 4.

C. Plan 3 (It is same to Plan 4 in the stage of 1988)

This is the plan of construction of the Coastal Road on the reclamation area and of the C-5 up to the Manila North Expressway. Ten years after the opening of the raods, the grade-separation structures will be constructed to pass over the existing roads in order to provide a larger capacity. The construction will meet the required traffic demand within the project life.

D. Plan 5

The construction of the Coastal Road is composed of two parts: the first part is on the reclaimed area and the second part is a causeway to be connected to the C-6. The construction of the C-6 is proposed to link the Coastal Road and the Manila North expressway near the Maycawayan interchange.

10.4.3 The Result of B-C Calculation

The comparative study is conducted to see how effective the road investment will be in terms of the investment cost and the savings in traffic cost. The plan 1 which is the case without a new project is taken as the base and the balances in cost and benefit with the other plans are determined within the project life, to form the cost and benefit streams. The marginal cost streams (e.g. cost and benefit streams) are shown in Appendix I-67.

The result of benefit cost calculation is shown in Table III-10-4 in which it is found that Plan 3 & 4 (the construction of the Coastal Road on the reclaimed area and C-5) is the most viable project among the three.

Table III-10-4 THE RESULT OF B.C. ANALYSIS

Alternative Road Plan	Present worth in ₱ mil. i = 15%	B/C Ratio i = 15%	Internal Rate of Return
2	341.3	1.934	22.4%
3 & 4	387.8	2.056	23.4%
5	215.2	1.572	19.8%

Plan 3 & 4 incorporates in the staged construction program which proposes in the first step the construction of the 4-lane divided highway with at-grade intersections in most road crossings. The improvement of those into the grade separated intersections in the second step. The second step is scheduled to be completed in 1997, ten years after the first step.

The evaluation period of the Project is determined 20 years after the opening of the first stage. The above staged construction program will meet the forecasted traffic demand in the period.

The construction of additional lanes on C-5 or new construction of C-6 will be necessary some years after 20 years. It is outside the evaluation period and is not considered in the staged program of the Project under the economic study.

10.4.4 Sensitivity Analysis - 1

Changes in the values of input factors are taken into account and the result is shown in Table III-10.5. Compared to the financial analysis of the reclamation project, the effect on the internal rate of return (IRR) is modest through all the alternative cases.

The Road Plan 3 & 4, the construction of the Coastal Road on the reclaimed area and C-5, holds the priority under these variations of cost and savings.

Table III-10-5 SENSITIVITY TEST, INTERNAL RATE OF RETURN

Unit: in per cent

Alternative Road Plan	Original[1] internal Rate of Return	Cost Increased by 20%	Benefit Decreased by 20%	Benefit Decreased by 33%	Cost+20% Benefit - 20%	Cost+20% Benefit - 33%
2	22.4	20.1	19.7	17.7	17.7	15.8
3 & 4	23.4	21.0	20.5	18.4	18.3	16.5
5	19.8	17.9	17.4	15.7	15.5	13.7

Note: 1) See Table III-10-4

10.4.5 Sensitivity Analysis - 2

The bridge between Reclamation Blocks II and III is planned to have the 40 ft clearance above sea level in Plan 3. If this bridge is elevated to have a 100 ft clearance, the bridge cost increases by more than 3 times.

Alternative	Foreign	Local	Taxes	Total
A. Bridge cost with 40 ft clearance (₱ million)	47.3	21.1	8.2	76.7
B. Bridge cost with 100 ft clearance (₱ million)	157.7	83.5	32.5	273.8
C. Additional cost (₱ million)	110.4	62.4	24.3	197.1

If the effect of the incremental cost is included in the benefit cost analysis, a lower value in benefit cost figure is estimated as follows:

Alternative	PW in ₱ mil. i = 15%	B/C Ratio i = 15%	Internal Rate of Return
A	387.8	2.056	23.4%
B	287.3	1.615	20.2%

The above figure does not include the effect on traffic cost because it is considered negligible. The bridge with a higher air draft clearance is not recommendable since it reduces the value in the economic cost benefit analysis.

If the ship-building establishments located along the Navotas River cannot accommodate larger vessels due to the limited clearance of 40 ft, other approaches should be studied to mitigate this adverse effect including the movement of some establishments in Navotas to the reclaimed area.

10.4.6 Sensitivity Analysis - 3

With the assumption that the Republic avenue (C-5 extension) beyond Manila North Expressway is completed by 1987 while the toll road of C-6 extension is not completed, the traffic flow is forecasted as shown in Fig. III-5-7. The IRR of benefit cost analysis for this case is estimated at 29% and B/C ratio at 2.80 with i = 15%.

It is understood that the economic benefits accrued to the traffic in the direct influence zone are larger when C-5 extension road (the Republic Avenue) is constructed ahead of the C-6 extension.

However, this will not determine that the C-5 extension is more feasible than the C-6 extension. The priority should be based on the feasibility study of these two circumferencial roads in the eastern periphery of MMA.

CHAPTER 11. IMPLEMENTATION PLAN

11.1 General

To complete the construction, it is assumed that the Government will engage the contractor by international bidding. As this project requires construction of high standard urban highways, it should preferably be executed by a contractor who has experience in this type of project. The contractors, therefore, should be pre-qualified.

11.2 Construction Schedule

11.2.1 Construction Period

According to the overall construction schedule of the Project Roads, the maximum possible construction period for the Coastal Road and C-5 are three years respectively. Considering this condition, the following assumptions are made for the construction works.

11.2.2 Working Day

In the Philippines the usual working day is 8 hours. However, at construction sites, the average actual working time is found to range from 8 to 10 hours.

Number of Working Days in a Month

Based on the rainfall and storm data, shown in Table III-11-1, the number of working days in a month is assumed as follows:

Table III-11-1 ESTIMATED NUMBER OF WORKING DAYS IN A MONTH

Description	Dry Season Jan. ∿ Apr. (4 months)	Rainy Season May ∿ Dec. (8 months)
Average number of rainy or stormy days in a month	4 days	18 days
Number of holidays	3 days	6 days
Number of actual working days in a month	24 days	18 days
Working efficiency in a month	80% (24/30)	60% (18/30)

Therefore, the working efficiency throughout the year is assumed as follows:

$$\frac{240 \text{ days}}{365} = 66\%$$

11.2.3 Stage Construction

The construction of the Project Road requires a very large investment due to various design requirements. For this reason and to obtain maximum economic benefit, it is desirable to study the need for staged construction to meet the traffic demand instead of completing the final scheme in one initial stage. Staged construction will be divided into two categories involving making grade separations of at-grade intersections and by phasing the construction of the pavement.

A. Construction of Grade Separation

Except the intersections which are required to be grade-separated from the beginning, the Coastal Road and C-5 are constructed as roads with at-grade intersections.

In the analysis of intersection capacity, the following five intersections are grade-separated in 1998 (10 years after opening to traffic), while the San Roque - Malinta Road is constructed as grade-separated from the initial stage to avoid traffic congestion due to the adjacent McArthur Highway Interchange ramps.

Project Road	Crossing Road
Coastal Road	Arterial Road on Block I
C-5	Mervill Road
"	Polo-Malabon Road
"	National Highway 369
"	Polo-Caloocan Road

B. Pavement

Asphaltic concrete of 5cm layer was designed for the entire stretch of the Coastal Road and the section from the Coastal Road to the McArthur Highway of C-5 in the initial stage (See Chapter 7). It is proposed that the surface course layer should be overlayed in 1998 (10 years after opening to traffic).

11.3 Implementation Schedule

After careful study of the data collected during the field investigations and of the construction cost estimates of the Project Roads, it was determined that the Coastal Road and C-5 be constructed as one single construction package.

Before beginning construction, it is necessary to carry out such pre-construction preparatory works as to topographical survey, soil investigation, detailed design, land acquisition and compensation, and financial preparation. The period required for such preparatory procedures is estimated to be about 3 years. The detailed design will take about fifteen months and, assuming that at the same time, negotiations on financial preparation are successful, land acquisition can begin. During the period required for land acquisition and compensation to be completed, the contract for construction can be approved and awarded. Mobilization for construction can begin after the contract is awarded. It is assumed this process will take about twenty-one months.

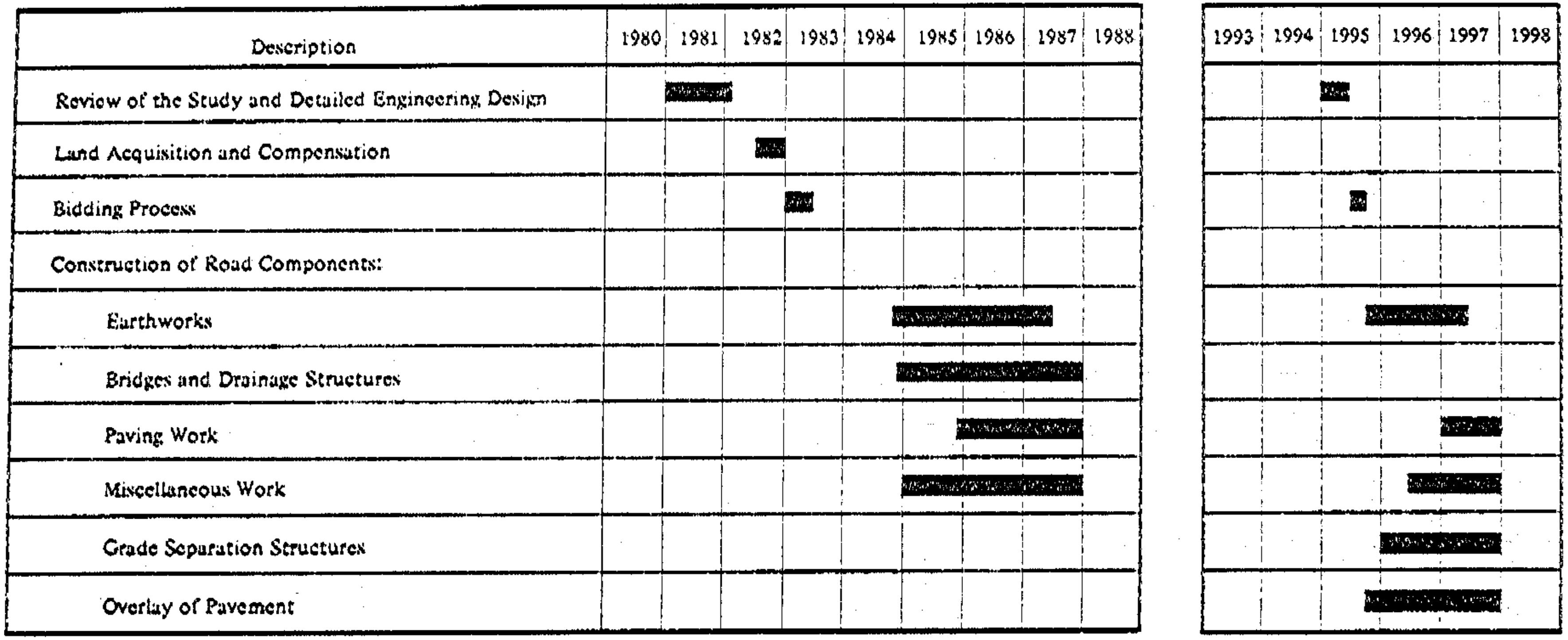
The schedule for the Project Roads (the entire stretch of the Coastal Road and C-5) is summarized as follows:

Stage I   The Coastal Road and C-5 with at-grade intersections

The construction of pavement overlay and the grade-separations for the Project Roads, to be completed by 1998.

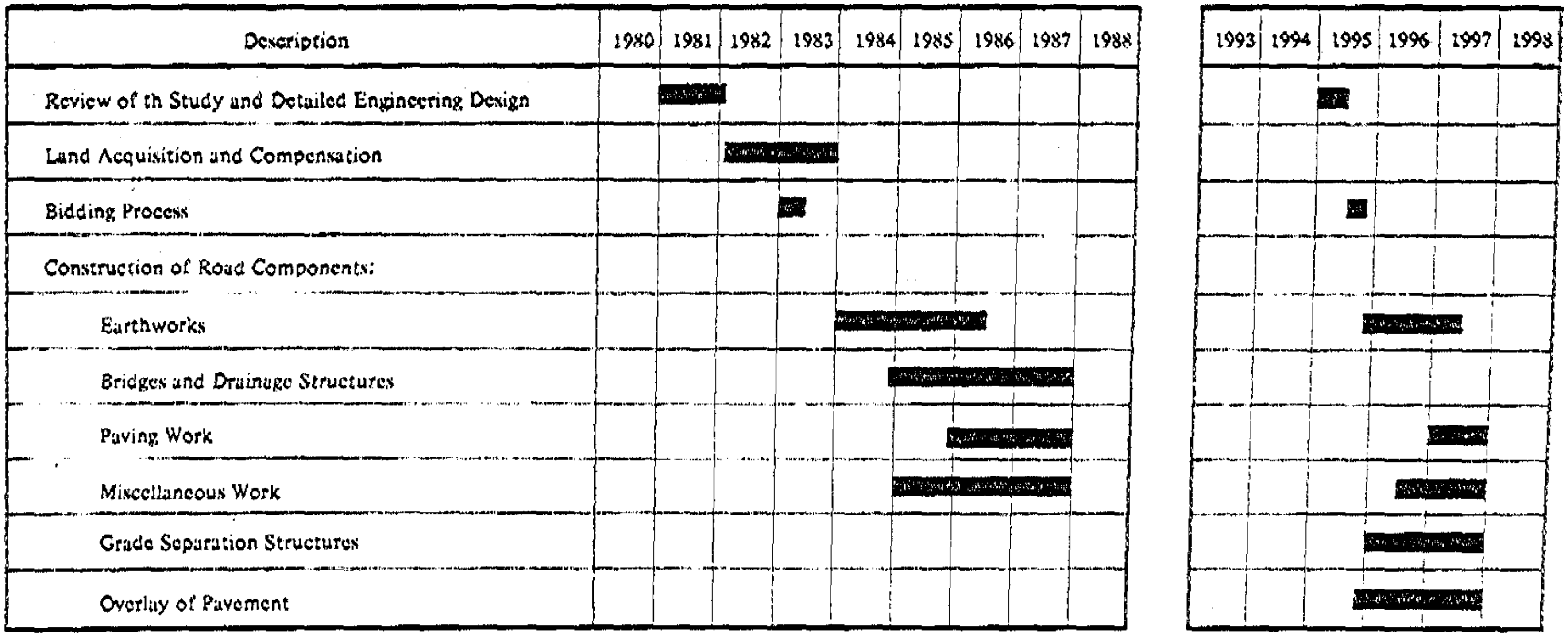
According to the stage construction schedule and cost estimates discussed in the foregoing, it is judged desirable that the Road Project be executed in accordance with the implementation schedule shown in Figs. III-11-1 and III-11-2.

Fig. III–II–1 IMPLEMENTATION SCHEDULE–STAGE I (COASTAL ROAD)



Note: The schedule in the years from 1995 – 1997 is for the construction of grade separation and overlay for the project road.

Fig. III–II–2 IMPLEMENTATION SCHEDULE–STAGE I (C–5)



Note: The schedule in the years from 1995 – 1997 is for the construction of grade separation and overlay for the project road.

PART IV. STUDY OF RECLAMATION AREA

CHAPTER 1 INTRODUCTION

1.1 General

Metropolitan Manila is now increasing more and more the importance of its leading role as the capital of the Philippines and a center of international activities. However, the rapid expansion of cities within the region is generating urban problems. Traffic congestion, inadequacy of basic infrastructures and land misuse are dominant among such problems.

The Government has dedicated itself primarily to the task of enhancing the quality of life for all Filipinos. Toward this end, it is taking all possible measures to harness available potentials by embarking on infrastructure projects such as highways, reclamation, flood control, urban development etc., all designed to enhance the environment and to allow every Filipino to enjoy a better quality of life. The Manila-Bataan Coastal Road Project is one of such projects.

The first segment, of the Manila-Bataan Coastal Road, from C-4 junction to C-6 junction (hereinafter called the Coastal Road) is envisioned to pass through the offshore areas of Manila Bay to avoid adverse socio-economic effects and environmental destruction. To do this, it is necessary to study reclamation problems as a part of the comprehensive study of the Manila-Bataan Coastal Road Project.

It is hoped that this report will facilitate the comprehensive study of the Manila-Bataan Coastal Road which has been envisioned to enhance mobility in the region, and also to contribute to the attainment of the socio-economic goals of the Government.

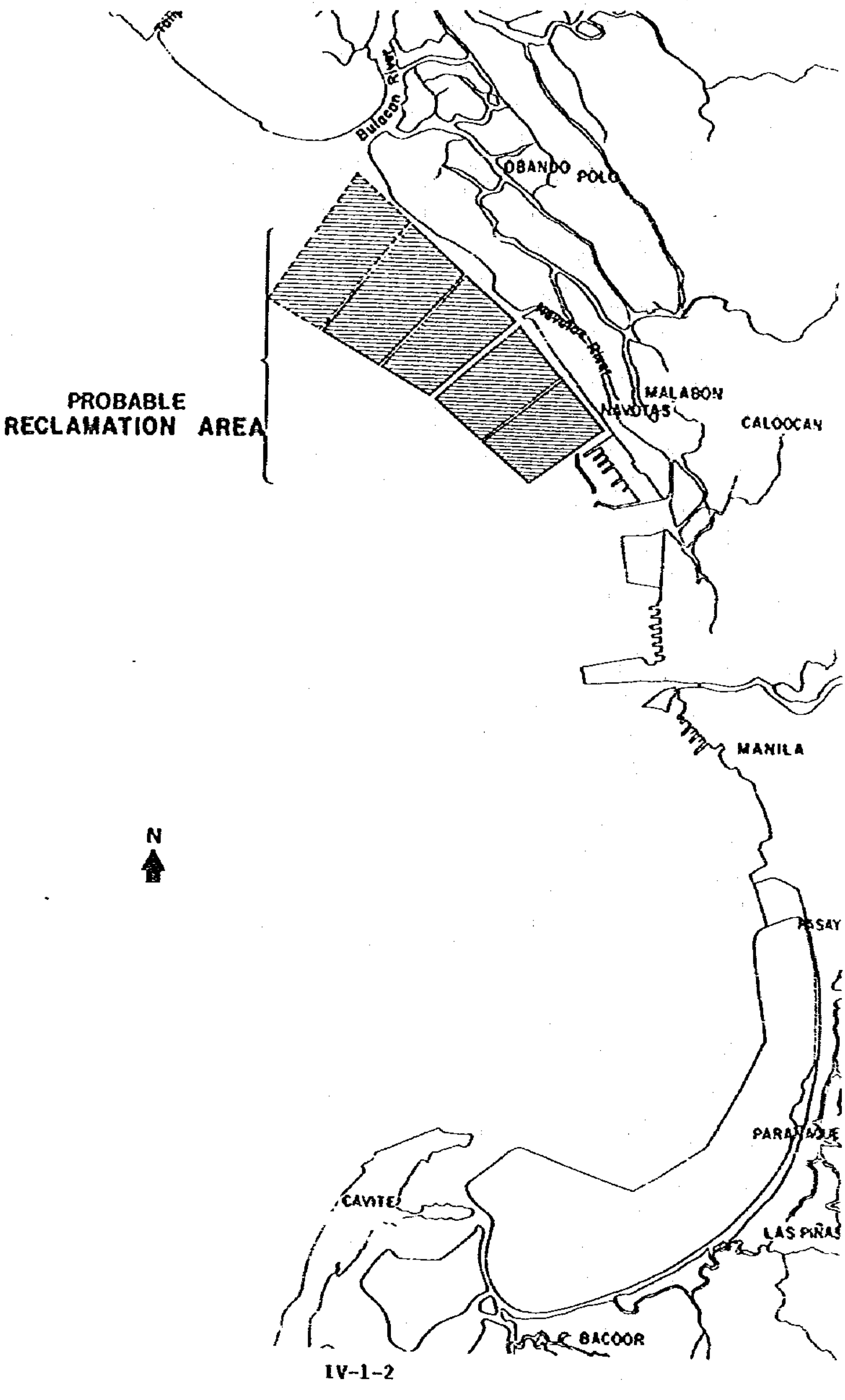
1.2 Study Objectives

The purpose of this study is to identify the technical, financial and economic aspects, and to prepare an optimum program for developing about 1,000 ha of reclaimed area along the Coastal Road. Fig. IV-1-1 shows the reclaimed area to be included in this study.

1.3 Scope of Work

The scope of work will include all works necessary to attain the objectives set out above, including field investigations, land use, engineering, financial and economic studies.

Fig. IV-1-1 PROBABLE RECLAMATION AREA



CHAPTER 2 LAND DEMAND ANALYSIS AND CASE STUDY OF LAND USE TO BE LOCATED IN THE RECLAIMED AREA

2.1 *Land Demand Analysis*

This section deals with the future needs of land based on future urban activities. These needs consist of manufacturing factories, commercial and business facilities, housing and others. Metro Manila hereinafter referred to includes 17 municipalities.

2.1.1 Industrial Area

No precise data are available for industrial areas. The broadly accepted figures for industrial areas in 1970 based on land use maps were approximately 2,000 ha.

Future industrial areas largely depend upon the economic growth, especially growth of manufacturing industry.

According to the Five-Year Development Plan, the major target annual growth rates are as follows:

(percent p.a.)

Descriptions	1978-1987	1978-1982	1982-1987
Net Domestic Product	7.9	7.7	8.1
Industrial Sector	10.8	10.0	11.4
Mining	9.3	9.0	9.5
Manufacturing	10.2	9.2	11.0
Construction	12.4	12.3	12.5
Electricity, Gas and water	11.5	10.9	12.0

Assuming that one-third of these growth rates is the result of increased labor-productivity, the following table has been forumulated:

(percent p.a.)

Designations	1978-1987	1978-1982	1982-1987
Total Manufacturing Growth Rate	10.2	9.2	11.0
Machinery Expansion	6.8	6.1	7.6
Increased Labor Productivity	3.4	3.1	3.4

The industrial areas needed in Metro Manila are calculated in proportion to manufacturing growth rate as follows:

Table IV-2-1 INDUSTRIAL AREA REQUIRED IN METRO MANILA 1970-1990

Year	Industrial Area			
	High Projection		Low Projection	
	Projection (ha)	Additional Area Required (ha)	Projection (ha)	Additional Area Required (ha)
1970	2000		2000	
1976	2500		2500	
1980	3100	600	2800	300
1990	6400	3900	4000	1500

Low projection: Assuming 1/2 of manufacturing growth rate.

In 1990, therefore the additional industrial areas that will be needed in Metro Manila will be from 3,900-1,500 ha.

2.1.2 Commercial Area

Commercial land use is not very feasible in the proposed reclaimed area because of the low commercial potential in the influence area of the project. Nevertheless, the commercial land requirements were also roughly projected in the study.

In 1970 it is assumed that the total area for commercial uses were roughly 2,500 ha. These uses are assumed to grow in proportion to be economic growth in Metro Manila. Hence the commercial areas needed are roughly projected as follows:

Year	Commercial Area
1970	2,500 ha
1976	2,800 ha
1980	3,200 ha
1990	4,600 ha

2.1.3 Housing Area

Housing is a basic need for human survival and development. In 1970, four million people lived in approximately 15,000 hectares of residential area making a population density of about 260 persons/ha.

Assuming 260 persons per ha of population density in the future, additional residential areas required by 1990 will be 16,900 ha and 26,600 ha by the year as shown in Table IV-2-2.

Table IV-2-2 RESIDENTIAL AREA REQUIRED IN METRO MANILA, 1970-2000

Year	Population (thousand)	Residential Area (thousand ha)	Additional Area Required (thousand ha)
1970	3,964	15.0	
1975	4,970	19.1	4.1
1980	6,092	23.4	8.4
1990	8,281	31.9	16.9
2,000	10,809	41.6	26.6

In this projection, it is assumed that composition of housing quality will be maintained. This means that makeshift areas on approximately one thousand ha will almost double by 1990. If one half of the makeshift housing area will be improved, additional land area will be required and the total land area that will be needed in 1990 is as follows:

Basic Additional Land Required	16,900 ha
Land Required to Upgrade the Makeshift Housing Area	900 ha
Total Additional Area Required	17,800 ha

It is concluded that an additional residential area of approximately 17,800 ha will be required in the year 1990.

2.2 Case Studies of Land Use to be Located in the Reclaimed Area

2.2.1 Summary of Land Demand in Metro Manila

The preceeding results of land demand projections for industrial, commercial and residential areas differ from that in the zoning plan of the Ministry of Human Settlement, as shown in Table IV-2-3. Nevertheless, the discrepancies are not so distant from each other as to considerably affect the rational bases being used by the Study Team.

Table IV-2-3 SUMMARY OF LAND DEMAND IN MMA

Land Use	Estimated Present Land Use 1970	Areas shown in Zoning Plan of the Ministry of Human Settlement 1978-1982	Areas Projected in this Study 1990
	(ha)	(ha)	(ha)
Industrial Area	2,000	3,986	4,000 - 6,400
Commercial Area	2,500	3,182	4,600
Housing Area	15,000	21,600	23,800

2.2.2 Reclamation Projects in Metro Manila

The rapid urbanization of the MMA has generated various urban problems which the Government in its present efforts hopes to remedy. Infrastructure plans have been designed and implemented. Reclamation of land is among these plans, and it considered to be one of the most effective approaches to solving urban problems. The reclaimed areas are to be utilized for land development purposes geared towards maximizing productive uses that will include socio-economic benefits to the region with minimal adverse effects and maximum enhancement and conservation of the existing natural environment.

In Metro Manila, various reclamation projects have been undertaken in recent years. Among these projects, the Manila-Cavite Coastal Road and Reclamation Projects (MCCRRP) is the largest. The other smaller reclamation projects have a total land area of only about 200 ha scattered along the east coast of the Manila Bay.

Since MCCRRP is aimed mainly at urban development, industrial development does not receive high priority. The breakdown of land use allocation in MCCRRP is as follows:

Residential area ----------	21.0%
Service cneter -----------	12.1%
Institutional area --------	11.3%
Industrial area -----------	2.9%
Utility farm --------------	3.0%
Parks, open spaces, water and recreational area ------------------	31.6%
Roads ---------------------	13.1%
Total	100%

Generally, reclaimed areas can be utilized for either water or land transportation. In the former case, reclaimed areas will include coastal industrial zones with port/wharf facilities, while the latter case, they will include various land uses such as residential area, commercial area, littoral air field, etc. The MCCRRP belongs to the latter case.

The possibility of the locating industries in the proposed reclaimed area seems to be feasible because of the following reasons:

- There is strong demand for land for industrial uses in the influence area;

- The hinterland has the highest industrial potential in the influence area (See Appendix I-2 Distribution of Industrial Land Use);

- The physical conditions of the reclamation site permit good water transportation;

- The proposed reclaimed area is very close to the port of Manila; and

- Industrial land use in the proposed reclaimed area is compatible with the MCCRRP.

2.2.3 Nature of the Case Studies

Prior to the formulation of the conceptual development plan of the reclaimed area, the Study Team looked into the various existing plans of the Government and of the private sectors for the coastal area.

However, it was found that these plans are still in the preliminary stage and do not treat the technical and economical/ financial studies at length.

Under such circumstances, the Team felt it necessary to undertake case studies on some existing land uses in the influence areas to propose a land utilization in the reclaimed area.

For the case studies, the Team selected the following major industries and public uses which are appropriate for location in the reclaimed land:

- Petroleum storage;
- Steel processing industry;
- Shipbuilding and repairing industries;
- Wood industry;
- Commodity distribution center; and
- Solid waste disposal.

The selection was based on the Team's past experiences gained in projects of similar nature as well as on the possibility of the locating industries mentioned in the previous subsection.

The studies are limited to the basic outline of development since the Study Team was aware that the details contain numerous variables which need thorough and lengthly studies and which the Government agencies and the private sectors are more in the position and capacity to perform.

The team is leaving room for exploration and improvement in the these studies. It is therefore hoped that appropriate agencies and private sectors pick up and continue with this endeavor.

2.2.4 Petroleum Storage

A. Past Trend of Energy Consumption

In 1978, 11.7 million metric tons of oil equivalent was consumed as against 9.6 million metric tons in 1973. Petroleum is the chief source of energy. In 1978, it comprised 94% of the total energy consumed by the entire nation (See Appendix I-68).

Appendix I-69 shows the petroleum products consumed during the period of 1973-1978. 77.5 million barrels or 96.6 percent of the petroleum products were used for energy products in 1978 and only 2.7 million barrels or 3.4 perdent for non-energy products. In the energy products, 48.6 percent were heavy oil, 20.1 percent diesel, and 19.6 percent were gasoline.

Appendix I-70 indicates the consumption of petroleum products in 1973. The main use of petroleum was for road transport, which accounted for 33 percent of the total consumption of petroleum products.

The other modes of transportation accounted for about 8 percent only. The electric power and industrial sectors consumed about 19 percent and 29 percent, respectively.

B. Existing Petroleum Storage Facilities

Major refinery factories of crude oil are located in Bataan and Batangas. The Bataan refinery factory has a capacity of 130-155 thousand barrels per day while that of Batangas 65 thousands barrels per day. Some of the petroleum products refined in Bataan are shipped to Pandacan Tankages by small barges, and those in Batangas are transported to Pandacan Tankages by a pipeline of 8 inch diameter.

At present, oil storage facilities which consist of more than 180 tanks are located at Pandacan Area along the south bank of Pasig River (See Appendix I-71).

Existing problems in the area are the following:

- There is no room for expansion to meet the demands of the increasing growth of the Metro Manila's economy;

- The POL storage facilities are located in the congested residential area;

- The distance between the POL storage area and Malacañang facilities is less than one kilometer;

- At present the Pandacan Terminals are accessible only to small barges because of the shallow water of the Pasig River.

These problems therefore necessitate the relocation of the Pandacan Terminals to a new location.

C. Projection of Future Petroleum Production

The past trend in energy use during the period from 1960 to 1978, shows that the average annual growth from 1960-1973 was 10.1 percent and that from 1973-1978 was only 3.2 percent. This decline was caused by the sharp increase in the cost of crude petroleum in 1973.

The World Bank estimated that total consumption of petroleum products will probably grow by about 9.5 percent[1/] per annum from now on. Also an annual growth rate of 14.0 percent was estimated in the Five-Year Development Plan. However, for the past five years, the average annual growth rate was only at 3.2 percent.

1/ Source: Priorities and Prospects for Development, 1976

The projection here, therefore, is made for current growth rate. The petroleum product consumption by the year 1990 is expected to grow as follows:

Year	Petroleum Product Consumption (in thousand barrels)	Index
1978	82,981	1.00
1980	88,377	1.065
1985	103,452	1.25
1990	121,098	1.46

In Metro Manila the petroleum storage facilities up to year 1990 for the existing POL (petroleum oil lubricant) storage situation will therefore be as follows:

Year	Required Storage Capacity
1978	2,540 thousand barrels
1980	2,705
1985	3,175
1990	3,708

The above figures indicate that an additional of 80 tanks are needed by year 1990.

D. Future POL Storage Facilities

The present storage capacity of petroleum in Metro Manila is good only for five days. Increasing its capacity is difficult since there is an acute shortage of space for the expansion of the tank farm area.

The POL complex, which is located along the Pasig River, had been reconstructed and the activities expanded in order to meet the continuous growth demand of the Metropolitan economy. However, dense residential houses have recently encroached the complex area thereby making expansion difficult.

Under such circumstances, there is a need to future development sites for POL storage facilities.

Generally, the basic requirements for POL complex sites are the following:

- As a safety precautionary measure, the location should be separated from the urban area. The chance of catastrophic disasters would be greatly aggregated with the presence of POL facilities in an urban area;

- For the convenience of supply and distribution of oil, the location must have good accessibility to both water and land transportation;

- To prevent an accidental outflow of oil, enough space should be required to provide oil protection dikes or walls.

In view of the foregoing concept, it is recommended that future POL storage facilities be given preferential priority in the proposed reclamation area.

2.2.5 Steel Processing Industry

A. General

Between 1968 and 1978, apparent rolled-steel consumption increased from 796,000 tons to 1,203,000 tons, at an average annual rate of 4.2 percent. After the oil crisis, apparent consumption of all rolled-steels increased at an annual rate of 9.6 percent.

The projected Philippine national economy incorporates the total steel consumption to grow at an average rate of 8% per year after 1980. In this study, a future projection for steel consumption has been made based on the GNP forecast and the following conditions.

i) Steel consumption in the Philippines is forecast to grow at 7 - 10 percent per annum.

ii) The share of Luzon in total steel consumption of the Philippines is estimated at 85% in 1976 (or 850,000 tons). With economic growth spreading to the provinces of the country, this share can be expected to decrease in the future, but the dominant position of Manila will remain. Therefore, the share of Manila and the rest of Luzon are assumed as 85% and 80% for 1977-1981 and 1982-1991 respectively.

B. Steel Consumption and Industrial Sectors

Of the apparent steel consumption, construction accounts for 60 percent, containers 15 percent, ship-building 8 percent and automobiles 5 percent. These four sectors account for nearly 90 percent of the total.

The development of each sector is targeted to exceed the increase of GNP according to EPRS-NEDA, and the share of each sector will change consequently.

Growth rates are estimated on the basis of EPRS-NEDA data (Industry sector net domestic product 1978-1982 and 1987 and targets of net value added in manufacturing 1978-1982 and 1987) as shown in Appendix I-72.

Appendix I-73 depict the steel consumption of each sector in the future.

As shown in Appendix I-73, the demand for steel processing manufacture should increase substantially.

C. Steel Processing in the Proposed Reclaimed Area

Steel processing must eliminate unnecessary transportation costs. In Manila at present, steel coils are shipped to Manila port, transfered to barges, hauled and unloaded along the Pasig River and then transported by trucks to the factories. Finished products also take the same route. This situation increases transport and handling costs and consequently contributes to higher costs of the finished products.

Because of the need for good transport access, this type of industry should be located on the proposed reclaimed area.

2.2.6 Shipbuilding and Repairing Industries

A. General

According to the Five-Year Development Plan, the growth of the industrial sector should be geared to the following objectives:

- Employment generation;
- Increase in net foreign exchange earnings; and
- Greater self-reliance in the supply of important commodities.

The industrial sector, especially transport, manufacturing including shipbuilding, is envisioned to grow at an average rate of 12.3 percent from 1978 to 1987.

B. Present Situation of Shipyards

Almost all existing shipyards in the Philippines are used for ship repairs, very few are utilized for the building of new vessels because of the limited market for new ships.

At present, there are 33 companies with existing shipbuilding and dry docking facilities as shown in Appendix I-74.

Fifteen of these companies or 45.5 percent, are engaged in dry docking and marine ship repair. Most of these are engaged in dry docking barges, tugboats and fishing boats, while only about 5 companies have capabilities to dry dock vessels of inter-island class.

As shown Appendix I-75, these 33 companies have about 64 shipyard facilities with an aggregate capacity of 61,570 gross tons (G.T.).

Appendix I-77 shows the numbers and tonnages of the Philippine fleet during 1967-1974. With this as basis, the annual growth rate of the fleet was computed as shown in Appendix I-76.

The existing shipyard facilities in the Philippines are concentrated in Luzon, mostly in the Manila Bay area, with 38 facilities having a total capacity of 31,900 G.T. as shown in Appendix I-78.

In Metro Manila, there are 21 companies engaged in ship-building and repairs; 12 of these are located in Navotas, 5 in Manila, 2 in Pasig and one in Mandaluyong. Because of the physical conditions of docking sites (viz, narrow and shallow rivers) most of the companies are small in scale.

C. Projection of Future Fleet Requirement

Based on the report "The First Philippine Ship-building Industry Development Program", the Philippine fleet by the end of 1984 would be as follows:

Unit: in G.T.

Fleet Type	1974 Fleet	1975-1984 Build-up	1975-1984 (Repacement)	1984 Fleet	Annual Growth Rate (%)
Ocean-Going Fleet	727,935	807,482	323,962	1,535,417	7.7
Inter-Island Fleet	366,284	219,359	272,204	585,643	4.8
Barges, Lighters and Tugboats	438,776	369,525	246,813	808,301	6.3
Commercial Fishing Fleet	136,709	89,684	98,430	226,393	5.2

The annual growth rate of ocean-going fleet during 1975-1984 is slightly higher than the past trend. Therefore some modification should be made, using annual growth rate of 5.0 percent based on past data during the period of 1967-1974. The revised figures are shown below.

	1974 Fleet	1975-1984 Build-up	1975-1984 (Replacement)	1984 Fleet	Annual Growth Rate(%)
Ocean-Going Fleet	727,935	457,800	324,000	1,185,700	5.0

D. Conclusions

The shipbuilding industry in Metro Manila, although dating back to 1903, has recently stagnated.

This is due to the following reasons:

- There are no space for expansion for facilities of ship-building; and

- River channels are narrow and shallow.

If these problems are solved, the shipbuilding industry in the metropolis will attain its high target growth rate.

In view of the above, the Team assigns an adequate space in the reclamation area for the shipbuilding industry.

2.2.7 Wood Industry

A. Present Situation of Wood Industries[2/]

As of 1976, there were around 325 sawmills in the Philippines, 79 of which were located in Luzon, 22 in the Visayas and 124 in Mindanao. Around 44 percent of 144 of the mills have back-up timber concessions while 181 or 56 percent do not have. The total capacity of all these sawmills is around 7.6 million board feet per day and the total annual log requirement at attainable capacities is 7.7 million cubic meters. During the 1970-1976 period, the following quantities of lumber were produced in and exported from the Philippines:

Table IV-2-4 PRODUCTION AND EXPORT OF LUMBER IN THE PHILIPPINES, 1970-1976 (converted to ton)

Calendar Year	Production	Export	% Export
1970	523,210	126,764	24
1971	491,415	116,547	24
1972	909,037	158,059	17
1973	812,068	286,550	35
1974	883,842	173,925	20
1975	923,870	211,240	23
1976	1,156,996	326,173	28

1 bd.ft = 1.614 Kg
1,000 bd.ft = 1.614 t

Source of data: Presidential Committee on Wood Industries Development (PCWID)

The production as well as export of lumber have been exhibiting some wide fluctuations since 1970. From 1973 onwards, lumber production have been steadily growing at an average of around 13 percent/year while timber exports grew more rapidly (37.93 percent). For the period 1970-1976 however, the annual growth figure for lumber exports is 24 percent. The major export markets are the USA, France, Australia, Holland, Italy, Japan and the United Kingdom.

Table IV-2-5 shows the estimated lumber exports passing thru Manila since 1973. The share of Manila for 1973 and 1974 was calculated based on the loading statistics by port of the Philippine Lumber and Plywood Manufacturers Association. The 1975 and 1976 figures are based on summarized Manila loading statistics as compiled by the Bureau of Customs Statistics Division.[2/]

2/ SCG, BTMC, NEI, PTCBG, SCE and PPA, Master Plan Study Port of Manila, Volume I, Appendix PP70-72 (September 1978)

Table IV-2-5 ESTIMATED EXPORT OF LUMBER THRU MANILA

Unit: in tons

Calendar Year	Total Export[1)]	Export thru Manila	% share of Manila
1973	286,550	90,808	31.69
1974	173,925	48,699	28.00
1975	211,240	108,284	51.00
1976	326,173	205,959	63.00

Note: 1) Export figures were obtained from the Presidential Commission on Wood Industries Development (PCWID) in bd.ft and converted to MT utilizing the conversion factor of 1,000 bd.ft = 1.614 t

Manila lumber exports have undergone tremendous expansion specially over 1975 and 1976 because of the relatively better market that prevailed for Red Lawan, a wood variety that is produced mainly in Manila's hinterland (which includes the provinces of Cagayan, Isabela and Nueva Ecija), while the markets supplied by Mindanao such as Japan and Australia were very depressed.

B. Projection for Future Lumber Production

The wood industry is one of the noticeable export-oriented industries. In the Five-Year Development Plan, the target growth rate for wood industries was given as follows:

Average Annual Growth Rates	
1978-1982	9.1%
1978-1987	9.7%

Historical trends show that achievement of these targets within next five to ten years is realistic.

The projection for lumber products and its exports up to the year 1990 is reflected in the Table IV-2-6.

Table IV-2-6 PROJECTION FOR LUMBER PRODUCTION AND EXPORT, PHILIPPINES, 1980-1990

Unit: in thousand tons

Year	Production	Export	Percent of Production
1975	923	211	23
1980	1,427	326	23
1985	2,292	526	23
1990	3,776	863	23

Assuming that the share of Port of Manila to the total export is 50 percent. The volume of exports will be as shown in Table IV-2-7.

Table IV-2-7 EXPORT THROUGH MANILA INTERNATIONAL PORT

Unit; in thousand tons

Year	Export	Manila International Port	Share (%)
1980	326	163	50
1985	524	262	50
1990	863	432	50

C. Existing Problems and Future Prospect of Wood Industries

The following problems of existing wood industries in Metro Manila were observed:

- Several private companies located in Metro Manila are hauling their logs from the Manila North Harbor. This contributes to the present inefficient transportation system for logs and products, causing expensive handling and transport costs from the domestic port to the factories and sawmills situated in the inner core of Metro Manila.

- Sawmills and timber yards are scattered throughout the entire Metro Manila at the convenience of the operators without much consideration of their effect on the environment.

On the other hand, the Government has the policy of encouraging the integration of the wood industry, which calls for the processing of lumber at its point of origin instead of at it's point of destination.

Under the situation mentioned above, the most logical first step would be to select a very suitable new area for future expansion of wood industry. The future wood industry does not mean one which would process lumber (sawmills), but a more modernized industry which would produce high value-added primary and secondary products, such as high quality water proof plywood, special plywood for luxury wood floors and wall panels (prefinished veneered plywood planking and moulded plywood), laminated timber, mosaic parquet, etc., in the integrated process line.

It is therefore the intention of the Study to assign a portion of the proposed reclamation area for future qualitative expansion of wood industry. Allocated land for the above-mentioned future wood industry in the reclamation area is equivalent to the annual production space of about 760,000 board feet (1,230 tons) at maximum. This land use allocation was determined at a rather conservative level to consider the before-mentioned policy of the Government.

2.2.8 Commodities Distribution Center

A. Existing Conditions

The urban transport in Metro Manila suffers from chronic congestion, attributed to excessive crowding of population and activities in the urban area.

With only about 10 percent of the total Philippine population, Metro Manila accommodates over 40 percent of the total registered motor vehicles in the country.

Appendix I-79 shows the number of registered motor vehicles in Metro Manila. In 1975, 85,000 or 26 percent of the total registered vehicles were trucks. The annual growth rate over the period 1971-1975 was 7.9 percent.

There is no precise data regarding the trucking industry; however the team made some observations as follows:

In 1975, there were about 1950 trucking companies and 120 storage and warehousing establishments in the Philippines. It is assumed that one-half of these establishment were located in Metro Manila or about 800 trucking companies and 60 storage and warehousing establishments. Many of the truck operators were small in size, having one or two units of trucks only.

The number of transport, storage and communication establishments in Metro Manila is shown in Appendix I-80. Between the period 1972-1975 these establishment exhibited a 5.6 percent annual growth rate. During the same period, transport establishments were relocated to the areas outside of Manila, as reflected by the negative growth of -5 percent and the increased growth in other areas. This phenomenon was attributed to the efforts to decongest Manila.

There are many trucking companies located in the downtown of Manila as shown in Appendix I-84. Interviews with these trucking companies revealed that they want to relocate outside of Metro Manila because of traffic congestion and strict regulations.

B. Projection for Commodities Distribution Center

The commodity flow of a nation is largely dependent upon the national economy. As the commodity flow increases, the need for cargo trucks also increases. Therefore the growth of national economy.

At present, there are 800 trucking companies in Metro Manila, owning some 7,000 trucks. Since the GNP for the next ten years (1977-1987) is projected to grow by 7.0 - 8.0 percent annually, the growth of the trucking industry up to year 1990, is projected as follows:

Year	Number of Units of Trucks
1978	7,000
1980	8,000
1985	11,700
1990	17,200

By year 1990 therefore, some 10,000 trucks would be added to the 1978 fleet.

C. Conclusion

Considering the existing conditions and the projected rapid growth of the trucking industry, ample areas for commodities distribution centers which are conveniently accessible for the urban population and the business establishment and for inbound and outbound regional commodities are urgently needed.

The commodities distribution centers, therefore, should be located near the expressways and major highways between Metro Manila and rural areas. Proposed locations are as follows:

Northern part	:	Places nearby the interchanges of the north expressway or along highways connected to the north expressway.
Eastern part	:	Places along the Manila-Infanta Road
Southern part	:	Places near the interchanges of the south expressway or along highways connected to the south expressway.

The total volume of commodities to be handled by the three centers will be about 12,000 - 18,000 tons per day,[3/] based on the projected truck units for 1990 so that the capacity of each center will be approximately 4,000 tons per day. The space requirements for each center, therefore, will be about 10-15 ha.

The northern center is proposed to be located in the reclaimed land. The location would be ideal for the center because of its proximity to the urban areas, efficient road network and water transportation. The ease of acquiring the needed land in the reclaimed area rather than on the inner of Metro Manila and the considerable volume of commodity flows to be generated will also receive many advantages from location of the proposed commodities distribution center in the reclaimed area.

3/ These figures are obtained on the basis of the projected truck units and space requirements

2.2.9 Solid Waste Disposal

A. Present Situation of Solid Waste Disposal System

Reliable information on the type, quantity and nature of the solid waste in the Metro Manila is limited but a report "Solid Waste Management in Metropolitan Manila" is available and is herein used as reference material. This report presents the various aspects of solid waste management and describes the existing conditions of solid waste system in the Metro Manila Area.

i) Quantities of Waste

Based on the size of the population, the estimated solid waste generated in the whole Metro Manila is as shown in Appendix I-81.

ii) Composition of Solid Waste

Composition analysis of solid waste in Metro Manila indicates that the moisture content may get as high as 80 percent because of local climatic conditions. The major average composition of solid waste is 43% kitchen refuse, 17% paper and 17% Pebbles/Sand (See Table IV-2-8).

Table IV-2-8 AVERAGE COMPOSITION OF MUNICIPAL REFUSE IN METRO MANILA (1977)

Composition	Percent by Weight
Kitchen refuse	43.0
Paper	17.0
Taxtile	3.7
Metal	1.5
Glass	5.3
Plastic	4.5
Bamboo/Wood	1.0
Straw/Wood/Leaves	4.8
Rubber	1.0
Leather	1.0
Pebbles/Sand	17.2
Total	100.0

A comparison of the waste in Manila with several cities from other parts of the world, shown in Appendix I-82, indicates that the waste in Manila is typical of a tropical country with a high putrescible fraction and low paper, metal and glass content.

iii) Collection of Solid Waste

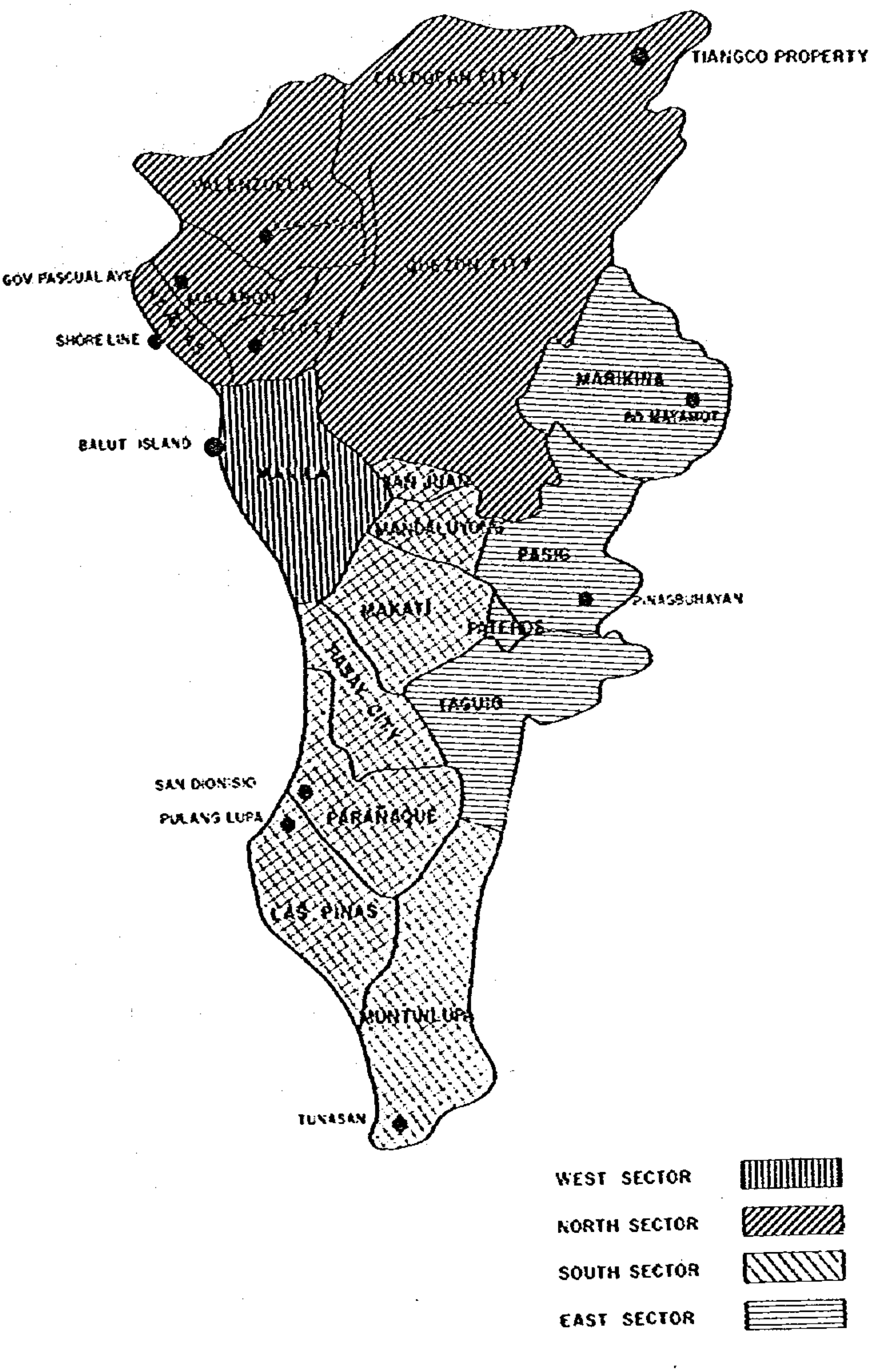
Collection of solid waste in the Metropolitan Area is extremely inadequate. This is caused by old and inefficient equipment being used.

There are 315 dump trucks and 27 collectomatics (packer trucks) serving the entire Metropolis. Of the 342 total number of trucks, 135 (39%) are government owned and 207 (61%) privately owned, but only 141 (41%) are operational.

iv) Disposal of Solid Waste

A big portion of the collected waste is disposed of in open dumps. There are eleven dumpsites serving the Metro Manila. The sites and their locations are indicated in Appendix I-83 and Fig. IV-2-1.

Fig. IV-2-1 PRESENT LOCATION OF GARBAGE DISPOSAL IN METRO MANILA



B. Problems to be solved

Major urban areas lack the essential muncipal infrastructure to provide a clean or sanitary environment. Presently, 30 percent of the population in Metro Manila is living in an environment with a very low level of sanitation.

The major problems plaguing the collection and disposal of solid waste in Metro Manila are:

- Insufficient and inadequate collection vehicles;

- Inadequate disposal sites;

- Lack of personnel training;

- Acute poverty which leads to overcrowded areas; and

- Lack of public cooperation.

The method of disposing the collected waste in open dumps can also pose a problem to the public health.

Collection is also hampered by the quality of roads leading to the dump sites since these roads become hardly passable during the rainy season.

Because of rapid population growth and increase in standard of living, garbage problems will remain unless they are checked and efforts to solve them are intensified.

C. Projection of Future Solid Waste Generation

According to the Refuse and Environmental Sanitation Center of MMA, the estimated figures of waste handled by MMA operation range from 0.3 to 0.5 kg/capita/day. If the waste dumped directly by factories and establishments is added, the figure would be 0.8 kg/capita/day according to information supplied by the Ministry of Human Settlement. The Manila figure of 0.8 kg is almost equivalent to that of HongKong (0.87 kg/capita/day) and of Singapore (0.85 kg/capita/day).

The volume of waste should increase in proportion to the increase of population and income. For the next 20 years, if it is assumed that per capita national income will increase at 3% p.a. (See 4.1.2A of Part III), and that the population of Manila city will increase at 1.4% p.a. (See Table II-2-3 of Part II, the annual rate of increase of the solid waste generated from Manila city is estimated to be 5% p.a. The equivalent volumes of solid waste in selective years from 1980 to 2000 are shown in Tables IV-2-9 and IV-2-10.

Table IV-2-9 VOLUME OF SOLID WASTE IN MMA

Year	Population in million [1)]	Waste kg/capita/ day	Waste '000 tons/ day	Waste mil. tons/ year	Waste mil. m^3/s year [2)]
1980	6.1	0.80	4.83	1.76	4.4
85	7.1	0.91	6.46	2.36	5.9
90	8.3	1.04	8.65	3.16	7.9
2000	10.8	1.43	15.49	5.65	14.1

Note: 1) The populations are quoted from Table II-2-3.
2) The average specific gravity of waste in assumed as 0.4 ton/m^3 from Appendix I-83.

Table IV-2-10 VOLUME OF SOLID WASTE IN MANILA CITY

Year	Population in million [1)]	Waste kg/capita/ day	Waste '000 tons/ day	Waste mil. tons/ year	Waste mil. m^3/s year [2)]
1980	1.67	0.80	1.34	0.49	1.2
85	1.78	0.91	1.62	0.59	1.5
90	1.90	1.04	1.98	0.72	1.8
2000	2.17	1.43	3.10	1.13	2.8

Note: 1) The populations are quoted from Table II-2-3.
2) The average specific gravity of waste is assumed as 0.4 ton/m^3 from Appendix I-83.

In the above forecast, the refuse and waste of other municipalities in the MMA is not taken into account since these municipalities have their own dumping spots as shown in Fig. IV-2-1 and have less difficulty in expanding or relocating their waste dump sites to serve their respective municipality.

If it is assumed that the recycle ratio of waste will be 50% during 1980-1990 and 40% during 1991-2000, the annual volume of dumped waste in Manila city is forecast as shown in Table IV-2-11. If the new dump site on reclaimed land with a capacity of 8.45 million cubic meters (See Table IV-2-12) is opened in 1984, the new site will be able to serve as the solid waste disposal site for a period of 10 years up to 1993.

Table IV-2-11 DUMPED WASTE OF MANILA CITY, 1980-1995

Year	Gross waste in mil. cu.m.	Net waste ratio in per cent	Net waste in mil. cu.m.	Accumulated net waste in mil. cu.m.
1980	1.2	50 %	0.60	
81	1.2	50 %	0.60	
82	1.3	50 %	0.65	
83	1.3	50 %	0.65	
84	1.4	50 %	0.70	0.70
85	1.5	50 %	0.75	1.45
86	1.5	50 %	0.75	2.20
87	1.6	50 %	0.80	3.00
88	1.6	50 %	0.80	3.80
89	1.7	50 %	0.85	4.65
90	1.8	50 %	0.90	5.55
91	1.9	60 %	0.95	6.50
92	2.0	60 %	1.00	7.50
93	2.1	60 %	1.05	8.55
94	2.2	60 %	1.10	9.65
95	2.3	60 %	1.15	10.80
96	2.4	60 %	1.20	12.00
97	2.5	60 %	1.25	13.25
98	2.6	60 %	1.30	14.55
99	2.7	60 %	1.35	15.90
2000	2.8	60 %	1.40	17.30

D. Future Solid Waste Disposal System

As for a solid waste disposal system, three alternatives can be considered; namely: sanitary layer system, press processing plant system and incineration system.

The sanitary layer system is generally the cheapest in terms of initial and maintenance cost if sufficient reclamation areas are available in the vicinity of the city.

Presently, Metro Manila has elevan dump sites as mentioned before, the biggest of which is located in Tondo. However, this site is causing pollution problems to the surrounding urban and sea areas.

To find other dump sites in inland area is rather difficult, and hence, their location in the proposed reclamation area is imperative.

The future solid waste disposal area using the sanitary layer system will be surrounded by a bulkhead for the purpose of controlling pollution. Reclamation with solid waste will be designed so as not to interfere with the port utilization and the long run plan of port arrangement. The space intended for the disposal site should not obstruct, but instead support, the port plan.

Since the solid wastes to be dumped will have varying characteristics, the disposal area should be divided into several blocks by means of a dike system to contain pollution. This dike system can also be utilized for access roads during the disposal period and can serve as a better land access after the completion of the said sanitary fill.

Fig. IV-2-2 shows the arrangement of the dike system. In this system, each block will be utilized for the following purposes:

i) <u>Block A</u>

This block is for general and industrial waste and for sludge from sewage treatment plants. After the completion of the sanitary fill process, this area will not be suitable for large buildings, but only for park or green area. Disposed materials in this block are highly polluting, hence, strict filling control is required.

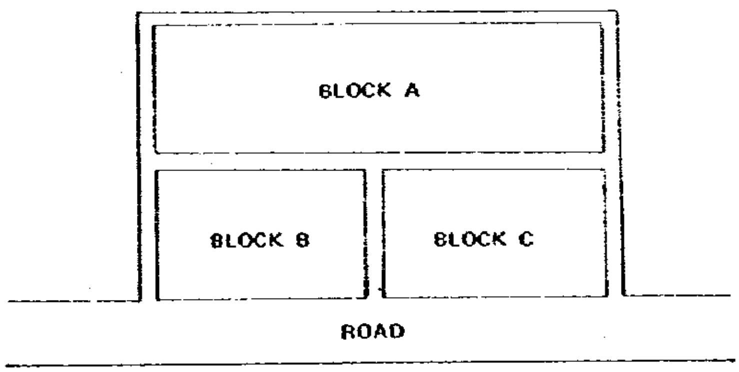
ii) <u>Block B</u>

This block is to accomodate the soils from the maintenance dredging of rivers and ports and for the rubbish to be disposed. The ground condition after completion of the sanitary fill will be fair, and therefore, it will be suitable for heavy buildings.

iii) <u>Block C</u>

This block is for industrial waste, and the filled area will have similar characteristics to Block B.

Fig. IV-2-2 <u>ARRANGEMENT OF DIKE SYSTEM</u>



The assumed size and capacity for the solid waste disposal areas are shown in Table IV-2-12. The planned total capacity is estimated to last for about 10 years, which was forecasted in Paragraph 2.29.c of this chapter.

Table IV-2-12 CAPACITY OF DUMP SITE

Block	Area (ha)	Finished Level above MLLW	Capacity (10,000 cu.m.)
A	51	+10.0	517
B	24.5	+ 5.0	164
C	24.5	+ 5.0	164
Road	50	+ 3.5	-
Total	150		845

Notes: 1. Average sea bottom is 3.4 m below MLLW.

2. Net capacity for the solid waste disposal is assumed at 80% of the gross volume in cu.m.