PART V

FEASIBILITY STUDY

CHAPTER 12

PRELIMINARY ENGINEERING DESIGN

CHAPTER 12

PRELIMINARY ENGINEERING DESIGN

12.1 TECHNICAL SURVEYS

Three kinds of technical surveys consisting of geo-technical survey, topographic survey, and hydrological survey were carried out in the field to provide data and informations for the preliminary engineering design.

12.1.1 Geo-technical Survey

The geo-technical survey was carried out as follows:

- For bridge foundations design

- Angat River Bridge	(2-holes)
- Pampanga River Bridge	(2-holes)
- Talavera River Bridge	(2-holes)

- For examination of existence of soft ground

- Plaridel – Baliuag Bypass	(1-hole)
- Cabanatuan Bypass	(1-hole)

The ground features of each location are as follows:

Angat River Bridge Site (Plaridel – Baliuag Bypass)

- The ground consisted of the relatively dense sand stratum at both right and left banks.
- Gravel stratum at 14.0m to 15.0m depth was considered as the bearing stratum for the bridge foundation.

Pampanga River Bridge Site (Cabanatuan Bypass Section)

- The ground consisted of the relatively dense sand stratum at both right and left banks.
- Gravel stratum at 12.0m to 15.0m depth was considered as the bearing stratum for the bridge foundation.

Talavera River Bridge Site (Cabanatuan Bypass Section)

- From the ground surface to the bearing stratum, the composition of ground was the alternation of the strata of silty clay, sand and clayey. N-values of this stratum were between 10 to 30.

- Gravel stratum at 16.5m to 24.0m depth was considered as the bearing stratum for the bridge foundation.

Examination of Existence of Soft Ground (Plaridel – Baliuag Bypass Section)

- The stratum from ground surface to 5.5m depth was silty clay of which N values were over 5.0, hence not judged to be soft ground.
- The unconfined compressive strengths of the silty clay stratum were 0.7 kg f/cm^2 and 1.0 kg f/cm^2.
- Very dense silty sand appeared below 6.5m depth and continued up to 11.0m depth.
- From 11.0m depth, the stratum consisted of the alternation of strata of very dense gravel and stiff silt.

Examination of Existence of Soft Ground (Cabanatuan Bypass Section)

- The stratum from the ground surface to 4.0m depth was silty clay, of which N value was about 10, hence not considered as soft ground.
- This unconfined compressive strengths were 0.63 and 1.6 kg f/cm2.
- There is a hard clay silt between 4.0m and 5.0m depth.
- Below 5.0m depth, the alternation of the strata of very dense sand and gravel was found.

The detailed information of geo-technical survey results are attached in Appendix 12.1-1.

12.1.2 Topographic Mapping

Topographic maps of scale 1/5,000 were prepared along the proposed bypass routes covering the following width based on the aerial photographs taken for the Study:

Bypass		Width Covered
Plaridel – Baliuag Bypass	:	3 km
Cabanatuan Bypass	:	3 km
San Jose Bypass	:	1 km

The scope of work of each bypass was as follows:

Sta. Rita, Plaridel

• Ground control survey (by GPS)	10 points
• Pricking	10 points
• Minor order leveling	55 km
• Field ID	78 km2
• Aerial triangulation	22 models
• Stereo plotting	78 km2
• Editing and plotting	78 km2

Cabanatuan City

• Ground control survey (by GPS)	14 points
• Pricking	14 points
• Minor order leveling	69 km
• Field ID	102 km2
• Aerial triangulation	42 models
• Stereo plotting	102 km2
• Editing and plotting	102 km2

San Jose City

• Ground control survey (by GPS)	7 points
• Pricking	7 points
• Minor order leveling	19 km
• Field ID	10.5 km2
• Aerial triangulation	9 models
• Stereo plotting	10.5 km2
• Editing and plotting	10.5 km2

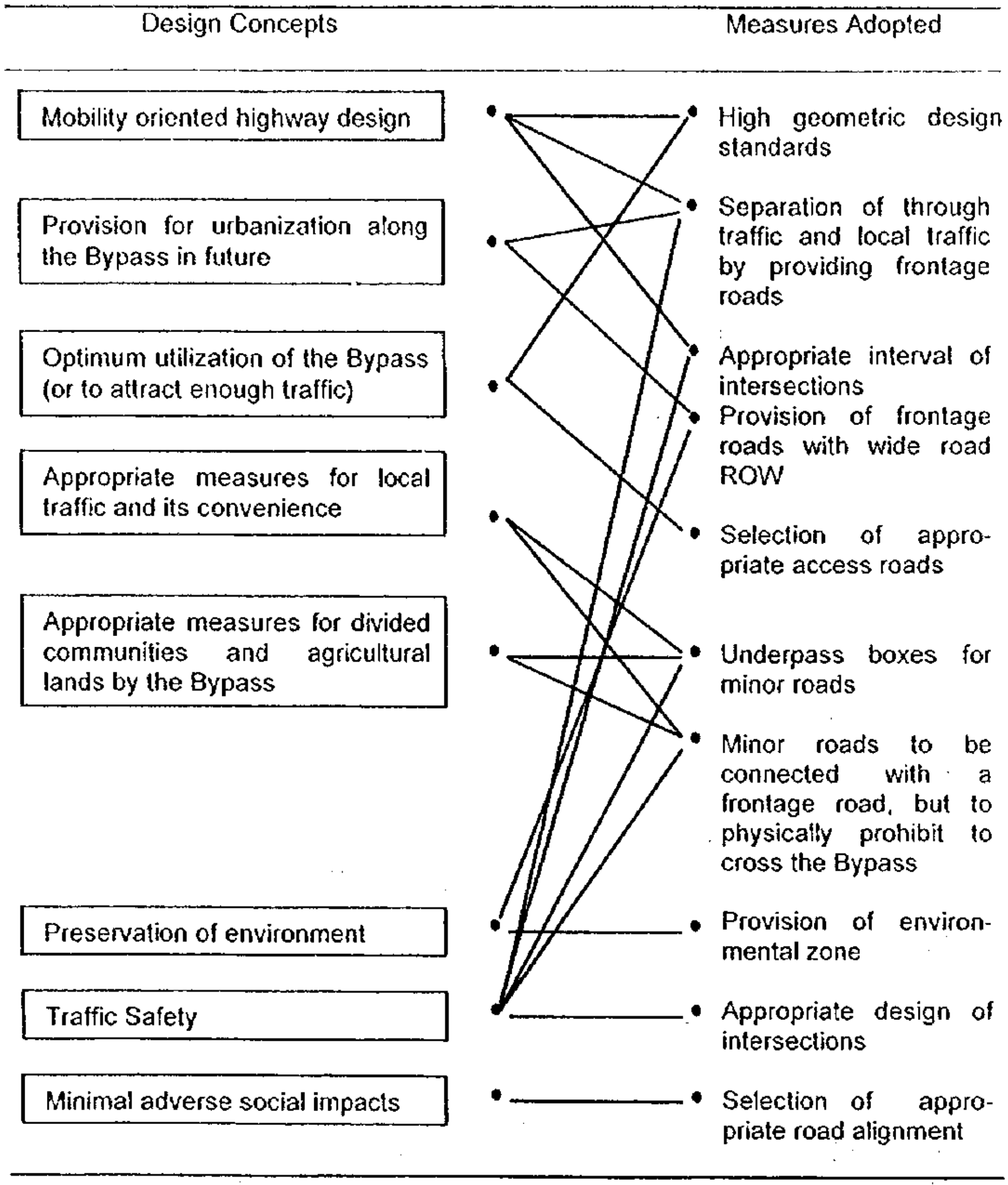
The survey standards and map accuracy were as follows:

- Geodetic reference ellipsoid : Clark 1866
- Map projection : Philippine Plane Coordinate System (P.P.C.S.)
- Datum of height : Mean Sea Level
- Sheet size : 80cm x 60cm
- Map scale : 1/5,000
- Contour interval : Intermediate contour 5m, Supplementary contour 1m, Index contour 2.5m
- Map style and its application rule : NAMRIA map

12.2 HIGHWAY DESIGN

12.2.1 Design Concepts

Design concepts adopted were as follows:



Herein, the considerations for environmental issues of slope protection are as follows:

① Ordinary Sections (vegetation works are main)

- Grass
- Grass + Small Trees
- Stone masonry → for the steep slope

② Flood Sections (around the culvert boxes and the abutments)

- Grouted stone masonry
- Wire-cylinder

12.2.2 Design Standards

1) Geometric Design Standards

Various design standards were presented in Chapter 7 and summarized in Table 12.2-1.

TABLE 12.2-1 COMPARISON OF BASIC ELEMENTS OF VARIOUS DESIGN STANDARDS

- FLAT TERRAIN -

Standards	Road Class	Design Speed (km/hr)	Lane Width (m)	Shoulder Width (m)
DPWH Design Guideline	ADT Over 2,000	Min. 90 Desirable 100	3.35 3.65	3.0 3.0
Pan-Philippine Highway		80-100	3.35	2.5
AASHTO	Rural Arterials	100-110	3.60	3.0 2.4 (min)
	Urban Arterials (Outlying CBD)	80-100	3.60	3.0 2.4 (min)
Japan's Design Standards	Rural Area, Type III Grade I	80	3.50	1.25
	Urban Area, Type IV Grade 1	60	3.25	0.5

In determining basic elements of design standards for the bypasses, the following were taken into account:

- To maintain at least the design standards adopted for the existing Pan-Philippine Highway.
- Urbanization would be expanded beyond the bypass in the future, particularly Cabanatuan Bypass. Standards under urban arterials of AASHTO would be good reference.

Basic elements of design standards were determined as follows and the proposed design standards are summarized in Table 12.2-2:

Design Speed : 80 km/hr
Carriageway width : 3.5m
Shoulder Width : 2.5m

TABLE 12.2-2 PROPOSED GEOMETRIC DESIGN STANDARDS FOR BYPASSES

Design Element	Standard	
Design Speed	80 km/hour	
Cross-sectional Elements		
Lane width	3.5m	
Shoulder width	2.5m	
Cross Fall – Carriageway	1.5%	
Shoulder	2.0%	
Center median width	2.0m	(Plaridel-Baliuag Bypass)
	5.0m	(Cabanatuan Bypass)
Frontage road width (one way)	5.5m	
Sidewalk	3.0m	
Design Elements		
Minimum horizontal radius	280m	
Minimum horizontal curve length	140m	
Maximum super-elevation	8%	
Maximum vertical grade	4%	
Non-passing sight distance	115m	
Passing sight distance	560m	

2) Standard Cross-Section

Characteristics of future land use along the bypasses are as follows:

Plaridel – Baliuag Bypass

Most of the areas along the Bypass are designated as the agricultural land under the future land use plan. It passes through existing and future residential land at limited areas which are mostly located at the intersections with the existing roads. Thus, the bypass can be divided into the following areas:

- Populated area
- Non-populated area

The frontage road was proposed to be provided for the populated areas. The road right-of-way width was proposed to be 45.0m throughout the bypass section for the provision of future need of the frontage road.

Cabanatuan Bypass

The Bypass is planned along the fringe of future residential area, but industrial areas and institutional area are planned outside of the Bypass. Thus, the Bypass is located within the planned urban area of Cabanatuan City, where the frontage road is vitally needed.

The section between Cabanatuan City and Talavera (beyond Pampanga River toward the north) is located in the outskirt of planned urban area and the area is designated as agricultural land, thus, the frontage road is not needed yet.

The road right-of-way width was proposed to be 52.0m throughout the bypass for the provision of future need of the frontage road.

San Jose Bypass

The Bypass is planned along the fringe of future residential area and passes along the foot of mountains, thus the frontage road is judged not necessary.

The standard cross-sections of three bypasses are presented in Figure 12.2-1.

The geometric alignment of the bike road follows that of the carriageway because the bike road will be used as the carriageway in the future.

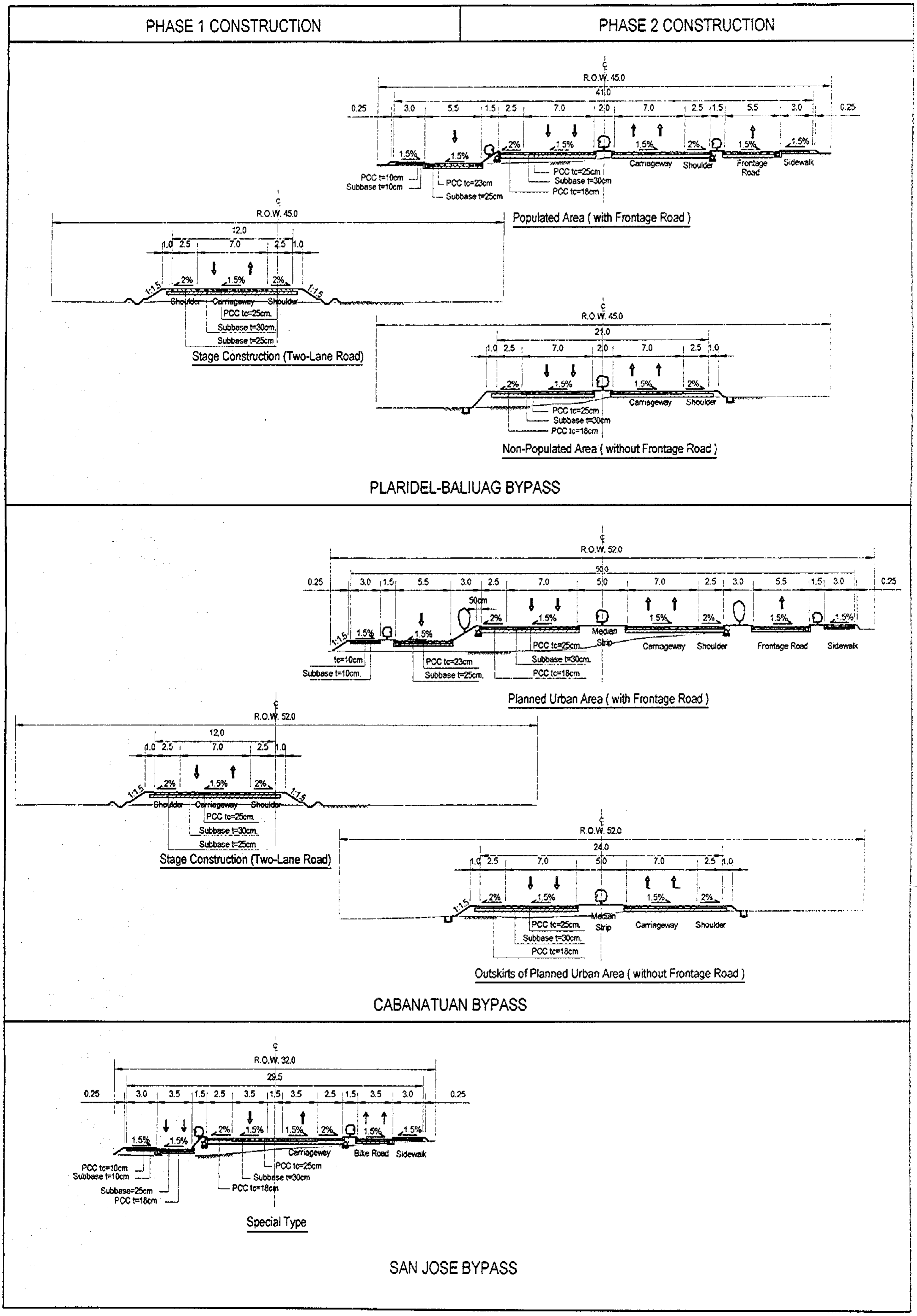


FIGURE 12.2-1 STANDARD CROSS SECTION OF EACH BYPASS

12.2.3 Selection of Alignment

The approximate route (or corridor) of each bypass was selected as presented in Chapter 11. Within the selected corridor, several alignments were studied to select the best one based on the photo mosaics, 1/50,000 topographic maps and field investigations.

Major considerations paid in selecting an alignment were as follows:

- Minimization of the adverse social impacts.
- Conformity with the land use plan and the local road network plan.
- Access points to the urban center and other major facilities and the planned development sites.
- Location of a long bridge.

1) Plaridel – Baliuag Bypass

Control Points

Identified control points in establishing alignments are shown in Figure 12.2-2. Major control points are as follows:

- Beginning point at Wawa Junction of North Luzon Expressway (converted to the Burol Interchange) as discussed in 8.3 of Chapter 8.
- High density residential areas scattered in the corridor.
- Crossing location of a bridge over Angat River (the shorter, the better, but due to the development of built-up areas along the River banks, bridge crossing location is limited).
- End point – high density residential areas along the existing Pan-Philippine Highway.

Alternative Alignments

Two alternative alignments were prepared (see Figure 12.2-2) as follows:

Alternative – 1: This is the alignment studied during the route selection discussed in Chapter 8. The alignment mostly passes through the agricultural land. Access to the proposed agro-industrial areas in Plaridel and Pandi is focused.

Alternative – 2: This alignment intents to provide the shortest link in due consideration of access to the proposed agro-industrial areas.

Comparison of two alternatives are shown in Table 12.2-3.

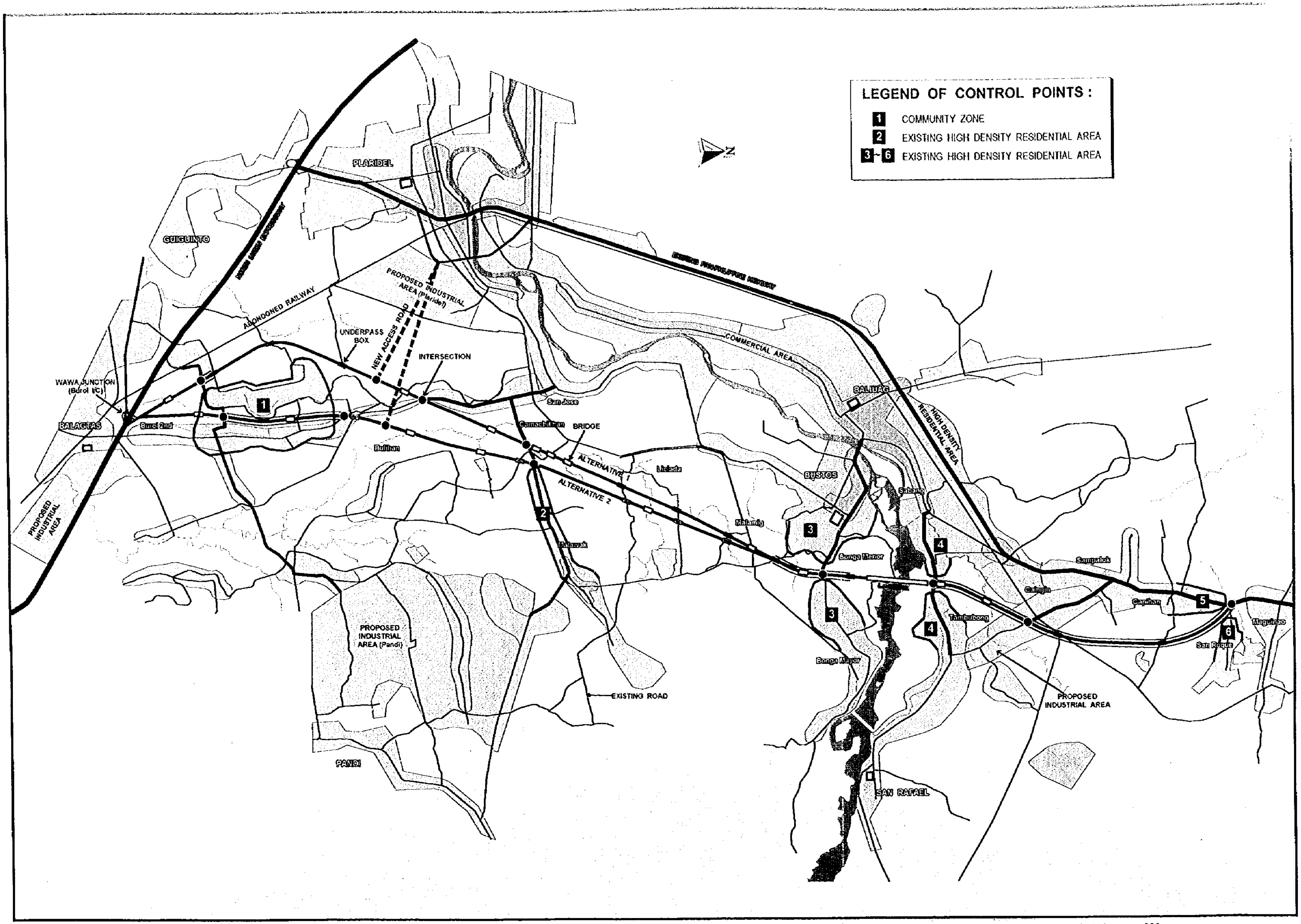


FIGURE 12.2 - 2 CONTROL POINTS OF PLARIDEL-BALIUAG BYPASS

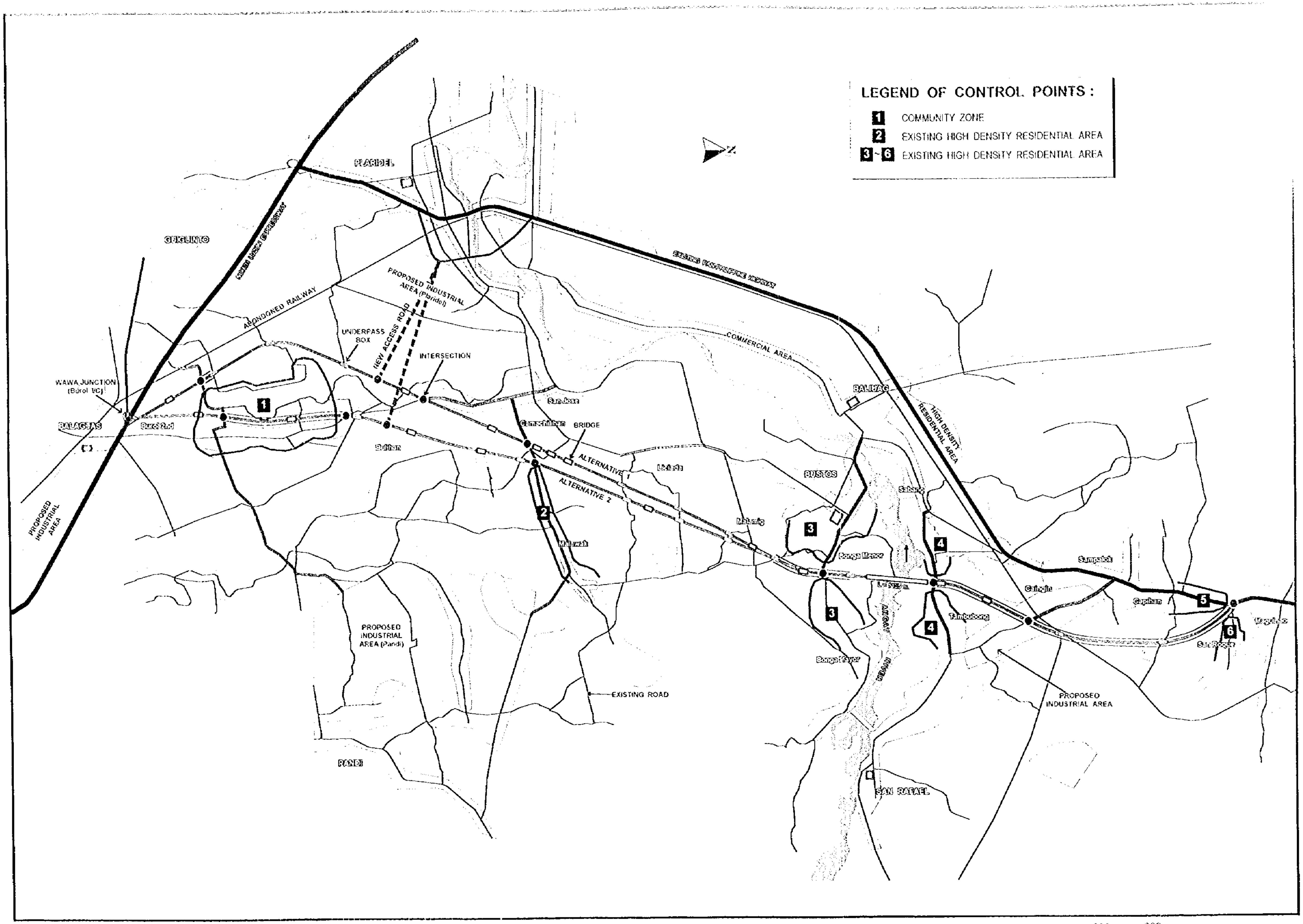


FIGURE 12.2 - 2 CONTROL POINTS OF PLARIDEL-BALIUAG BYPASS

TABLE 12.2-3 COMPARISON OF ALTERNATIVE ALIGNMENTS: PLARIDEL – BALIUAG BYPASS

	Alternative - 1	Alternative – 2
1) Length (km)	22.0	20.9
2) Construction Cost (Million Pesos)	2,830 (1.00)	2,850 (1.007)
3) No. of houses affected	76 (1.00)	102 (1.34)
4) Mobility		
- No. of intersection		
- shortest interval of intersection		
5) Access to Existing Urban Centers		
- Plaridel	Good	Fair
- Baliuag	Good	Good
6) Access to the proposed agro-industrial areas	Good	Good
7) Conformity with local road network	Good	Bad
8) Impacts on local development	High	Medium
9) Linkage with Metro Manila	Fair	Good
Overall Evaluation	○	△

Selected Alignment

Based on the above evaluation, Alternative-1 was selected for the Plaridel – Baliuag Bypass.

2) Cabanatuan Bypass

Control Points

Identified control points are shown in Figure 12.2-3. Major control points are as follows:

- Beginning point – before the beginning of high density residential area.
- Agro-industrial area in Sta. Rosa.
- High density residential areas scattered along the corridor in Cabanatuan City.
- Proposed inner and outer circumferential roads.
- Proposed industrial areas.
- Crossing location of a bridge over Pampanga River
- End point – high residential area along the Pan-Philippine Highway.

Alternative Alignments

Two alternative alignments were prepared (see Figure 12.2-3) as follows:

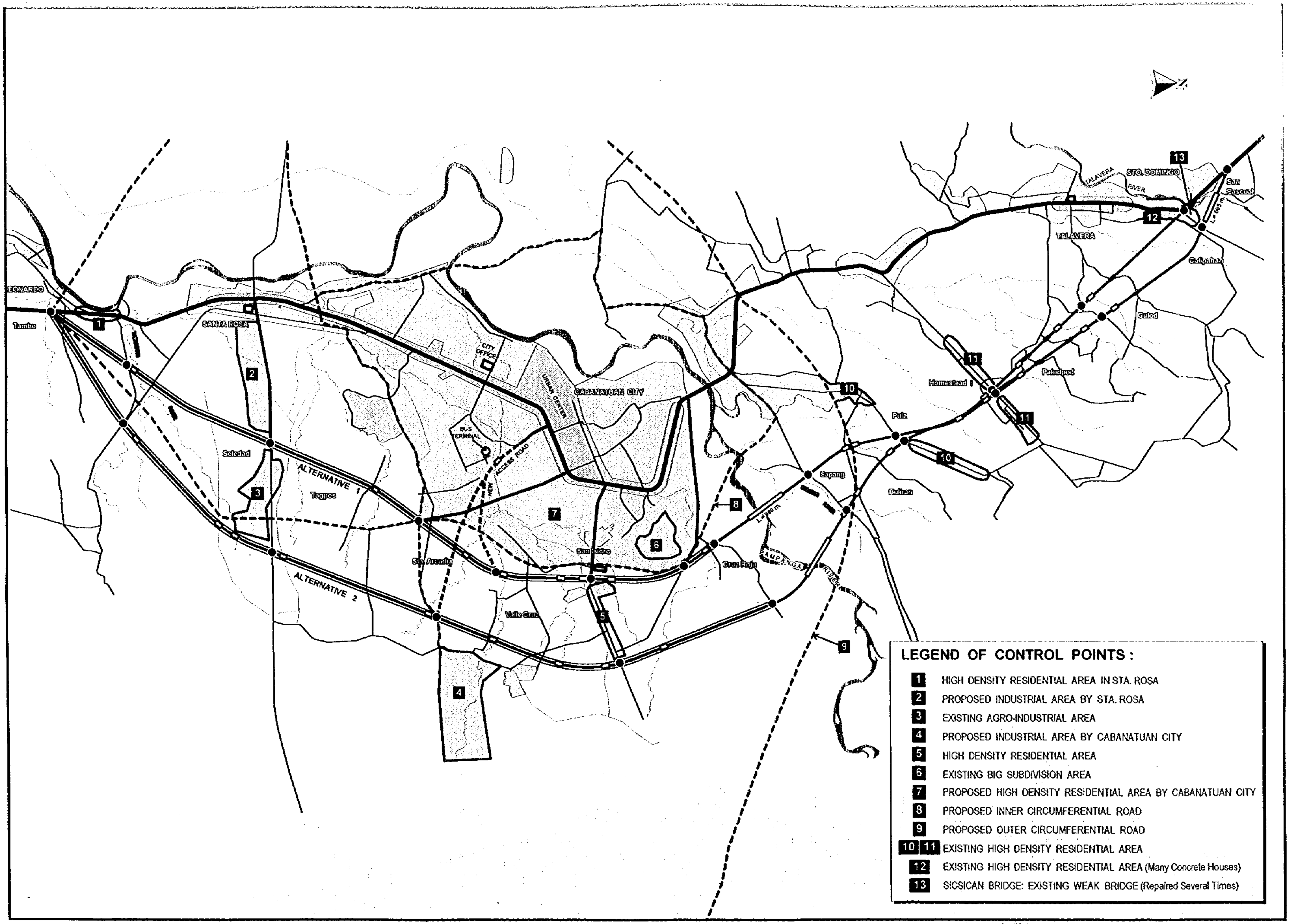


FIGURE 12.2 - 3 CONTROL POINTS OF CABANATUAN BYPASS

Alternative – 1: To pass through the middle portion of the agro-industrial area in Sta. Rosa, then to more or less follow the proposed Cabanatuan City inner circumferential road and crosses Pampanga River. At the end point, this alignment avoid high density residential area at the outskirt of Talavera and also Sicsican Bridge which has been damaged and repaired several times in the past, therefore, considered a new bridge preferable.

Alternative – 2: This is the alignment studied during the route selection discussed in Chapter 8. The alignment passes outside of Sta. Rosa agro-industrial, about 1.2 to 2.2 km outside of the proposed residential area, then is connected with the Pan-Philippine Highway before Sicsican Bridge.

Comparison of two alternatives are shown in Table 12.2-4.

TABLE 12.2-4 COMPARISON OF ALTERNATIVE ALIGNMENTS: CABANATUAN BYPASS

	Alternative - 1	Alternative – 2
1) Length (km)	30.4	31.0
2) Construction Cost (Million P)	3,479 (1.00)	3,156 (0.91)*
3) No. of houses affected	43 (1.00)	104 (2.41)
4) Mobility		
- No. of intersection		
- Shortest interval of intersection		
5) Access to Existing Urban Centers		
- Sta. Rosa	3.1 km (1.00)	5.5 km (1.77)
- Cabanatuan	2.1~3.5 (1.00)	4.0~5.1km (1.90~1.46)
- Talavera	2.5 km (1.00)	2.0 km (0.80)
6) Access to the proposed industrial area		
- Sta. Rosa	Good	Fair
- Cabanatuan	Fair	Good
7) Access to the existing Bus/Jeepney Terminal	2.1 km	3.6 km
8) Conformity with local road network	Good	Fair
9) Impacts on local development	High (Medium Term)	High (Long Term)
Overall Evaluation	○	△

Note: * does not include Talavera River Bridge.

Selected Alignment

Based on the above evaluation, Alternative-1 was selected for the Cabanatuan Bypass.

3) **San Jose Bypass**

Control Points

Identified control points are shown in Figure 12.2-4. Major control points are as follows:

- Beginning point –high density residential area along the Pan-Philippine Highway.
- High density residential areas in the corridor.
- Big creek
- Hills
- End point -- high density residential area along the Pan-Philippine Highway.

Alternative Alignments

This bypass is rather small in scale and control points dictated the alignment, therefore, no alternative alignments were prepared.

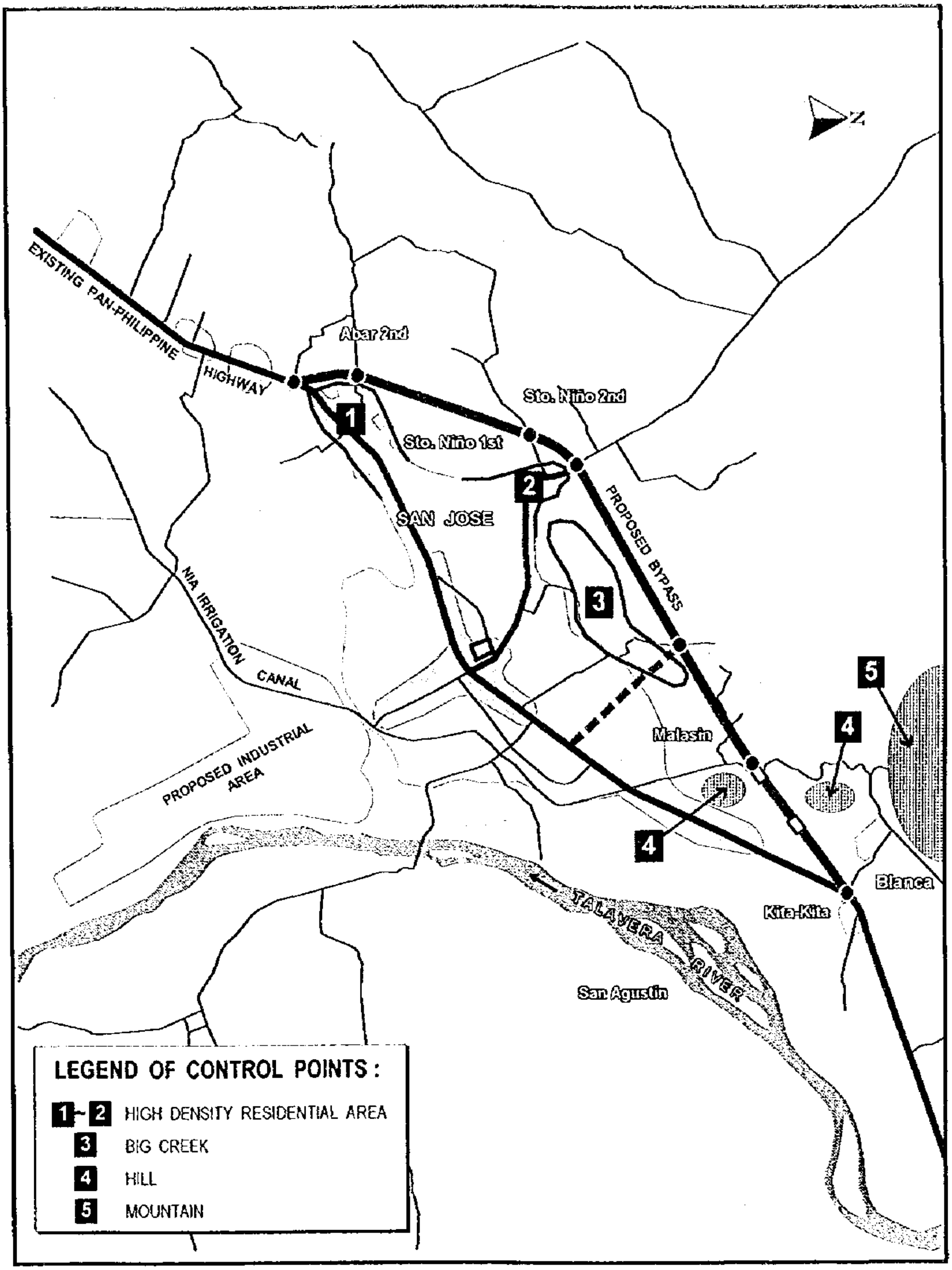


FIGURE 12.2 - 4 CONTROL POINTS OF SAN JOSE BYPASS

12.2.4 Number of Lanes Required

1) Estimated Traffic on Bypasses

Future traffic demand forecasted in a form of OD distribution was assigned on a road link network to estimate traffic volume on each bypass. Results of traffic assignment are shown in Figures 12.2-5 to 7 and summarized in Table 12.2-5.

TABLE 12.2-5 ESTIMATED BYPASS TRAFFIC (PCU/day)

Year	Major Link Condition		Plaridel-Baliuag Bypass	Cabanatuan Bypass	San Jose Bypass
2005	2-lane bypass, w/o bxpressway	Max	31,771	32,022	17,534
		Min.	12,584	10,504	14,784
		Average	19,555	22,606	16,157
2010	2-lane bypass, w/o Expressway	Max.	34,936	34,016	22,282
		Min.	15,958	11,097	18,811
		Average	22,587	24,120	20,558
2010	4-lane bypass except San Jose Bypass, w/ Expressway	Max.	35,712	35,344	17,753
		Min.	10,715	10,396	13,709
		Average	20,922	22,298	15,761
2020	4-lane bypass except San Jose Bypass, w/ Expressway	Max.	68,567	53,288	25,452
		Min.	19,877	25,126	19,376
		Average	42,922	36,531	22,457

Note: Max. = Maximum link traffic volume among links of a bypass.
Min = Minimum link traffic volume among links of a bypass
Ave = Average traffic volume of all links of a bypass

Cabanatuan Bypass is expected to attract the highest traffic volume from 2005 to 2010. In year 2020, it is predicted that Plaridel – Baliuag Bypass will attract the highest traffic volume. San Jose Bypass is expected to be most sensitive to the cases of with and without an expressway.

2) Number of Lanes Required

Figure 12.2-8 shows the level of service of a 2-lane road and a 4-lane divided road. It also shows estimated traffic volume on each bypass. The level of service of each bypass is summarized in Table 12.2-6.

TABLE 12.2-6 ESTIMATED BYPASS TRAFFIC AND LEVEL OF SERVICE

Bypass	Year	Traffic Volume (PCU/day)	Level of Service 2-lane	Level of Service 4-lane
Plaridel-Baliuag Bypass	2005	19,600	E	B
	2010(w/o)	22,600	E	B
	2010(w)	20,900	E	B
	2020	42,900	F	D
Cabanatuan Bypass	2005	22,600	E	B
	2010(w/o)	24,100	E	B
	2010(w)	22,300	E	B
	2020	36,500	F	C
San Jose Bypass	2005	16,200	D	A
	2010(w/o)	20,600	E	B
	2010(w)	15,800	D	A
	2020	25,500	E	B

Note: W/O = Without an expressway
W/ = With an expressway
Traffic volume = Average traffic volume of all links of a bypass

FIGURE 12.2-5 ESTIMATED TRAFFIC VOLUME ON PLARIDEL-BALIUAG BYPASS
(Unit: 100 pcu/day)

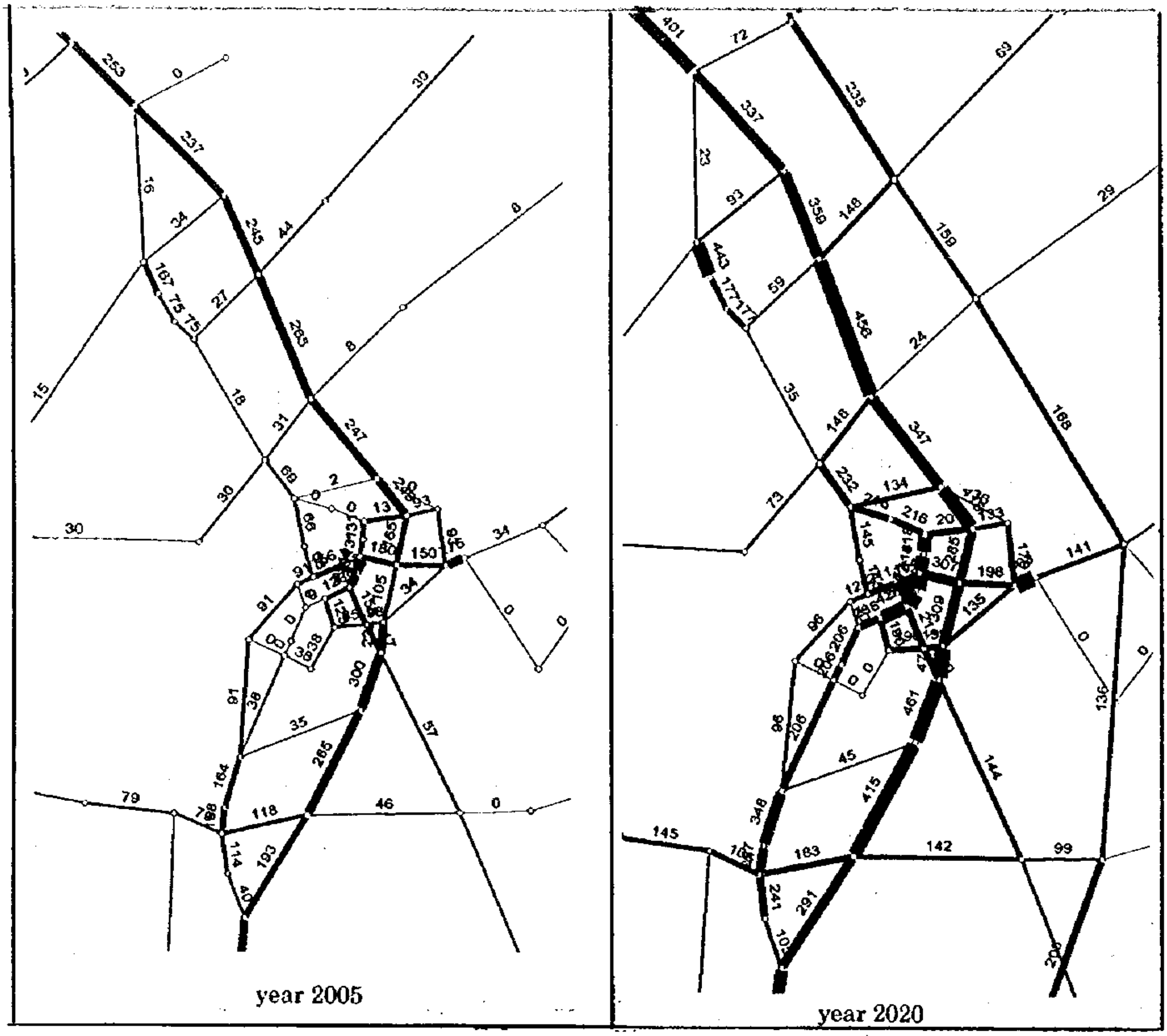


FIGURE 12.2-6 ESTIMATED TRAFFIC VOLUME ON CABANATUAN BYPASS
(Unit: 100 pcu/day)

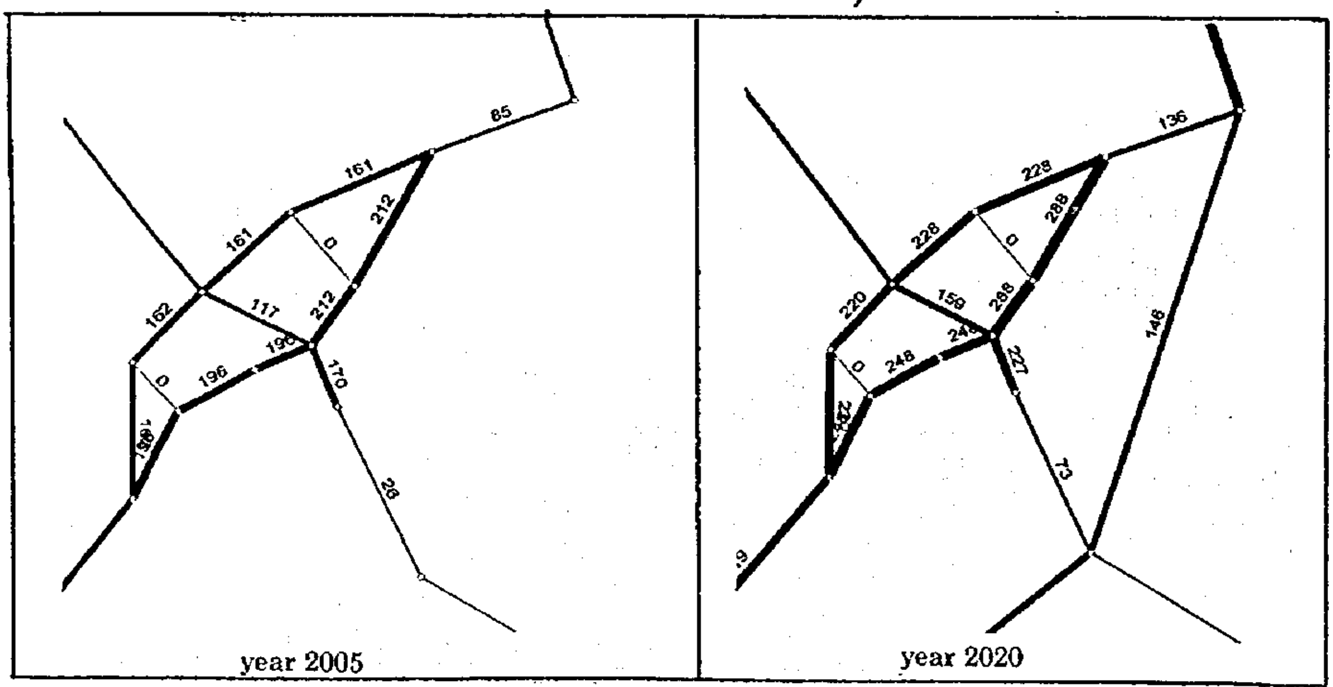


FIGURE 12.2-7 ESTIMATED TRAFFIC VOLUME ON SAN JOSE BYPASS
(Unit: 100 pcu/day)

Plaridel – Baliuag Bypass and Cabanatuan Bypass

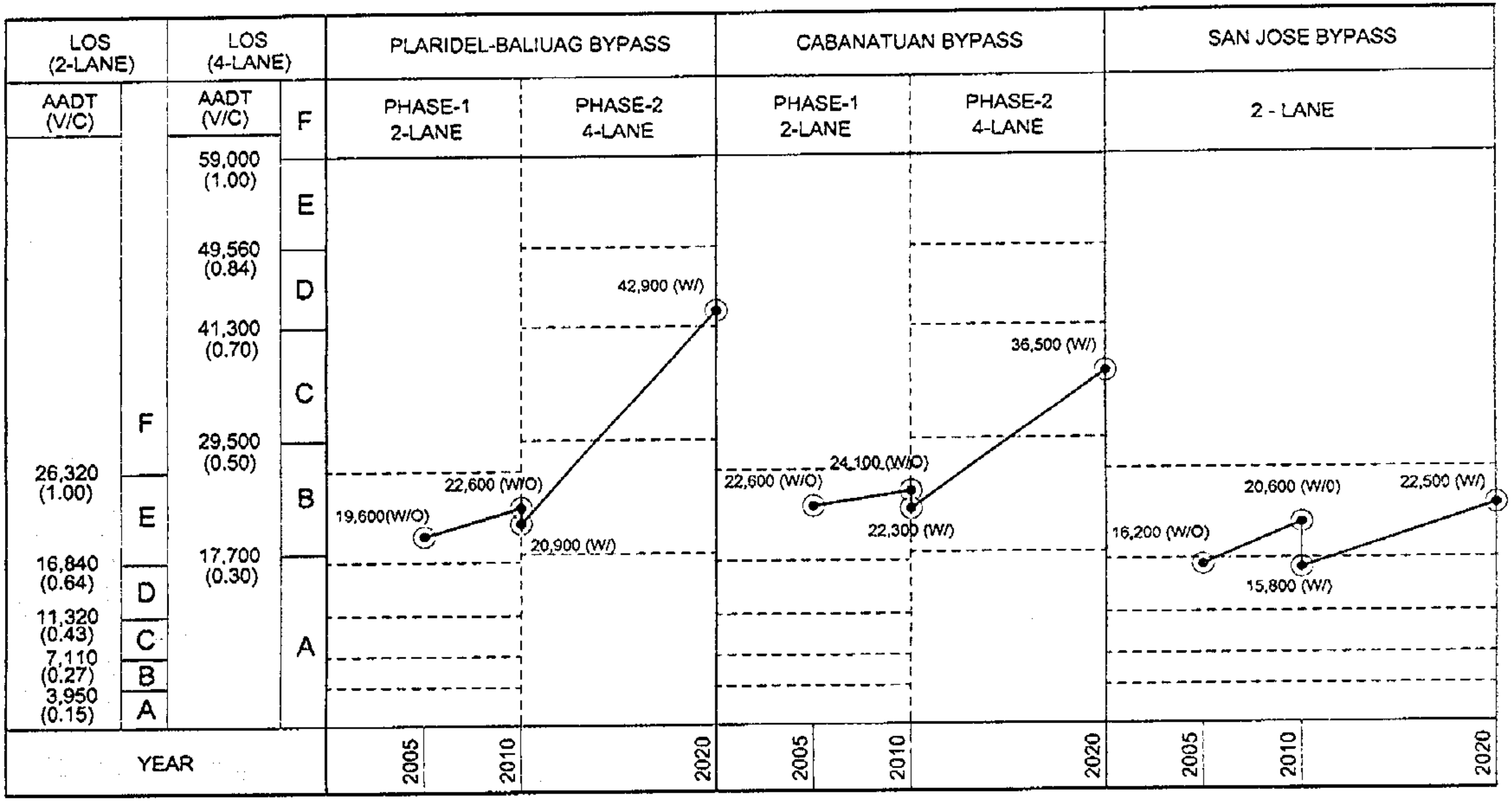
When the bypass is constructed as a 2-lane road, LOS is expected to be E in 2005 (just after completion of construction) and would be F in 2012 or so. In case of a 4-lane divided road, LOS in 2020 would be still D (Plaridel – Baliuag Bypass) and C (Cabanatuan Bypass).

It is preferred for both bypasses to be constructed as a 4-lane divided road from the initial stage, however, recommended from the viewpoint of financial requirement, to be initially a 2-lane, then widened to a 4-lane divided road by year 2010.

San Jose Bypass

It is recommended to be a 2-lane road, as LOS in year 2020 would not be F, but still E.

(pcu/day)



NOTE : W/ : WITH EXPRESSWAY W/O : WITHOUT EXPRESSWAY

FIGURE 12.2-8 ESTIMATED BYPASS TRAFFIC AND LEVEL OF SERVICE

12.2.5 Intersection Design

1) Intersecting Methods

Three types of intersecting methods were adopted depending upon the importance of intersecting roads as follows:

At-grade intersection : this type was adopted for an intersection between a bypass and a major road, allowing for an intersecting road an access to / from a bypass.

Under-pass : this type was adopted for a minor road in a rural area for the convenience of farmers and local communities. Access to a bypass is not allowed.

Access only to a frontage road : this type was adopted for a minor road in an urban area for the convenience of local communities. Direct access to a bypass is not allowed.

This section refers to an at-grade intersection.

2) Interval of at-grade intersections

An interval of intersections is one of the critical elements in the design of a bypass road, and the following must be taken into accounts:

- Mobility
- Attraction of traffic onto a bypass
- Traffic Safety
- Road environment, particularly population

Desirable minimum interval of 800m and absolute minimum interval of 500m was adopted in this Study.

3) Design Concept

Design concepts adopted were as follows:

- Traffic is to be controlled by traffic signals.
- Traffic movements are to be channelized as much as possible.
- Left turn lane is to be provided with enough storage length.
- Pedestrian crosswalks are to be provided.
- When an intersecting road intersects with a bypass at a skew angle less than 60° degree, an intersecting road is to be re-aligned so as to intersect at a right angle.

4) Typical Intersection Layout (Phase-1: 2-lane bypass)

Typical layout is shown in Figure 12.2-9. Left turn lane and divisional center median island are provided.

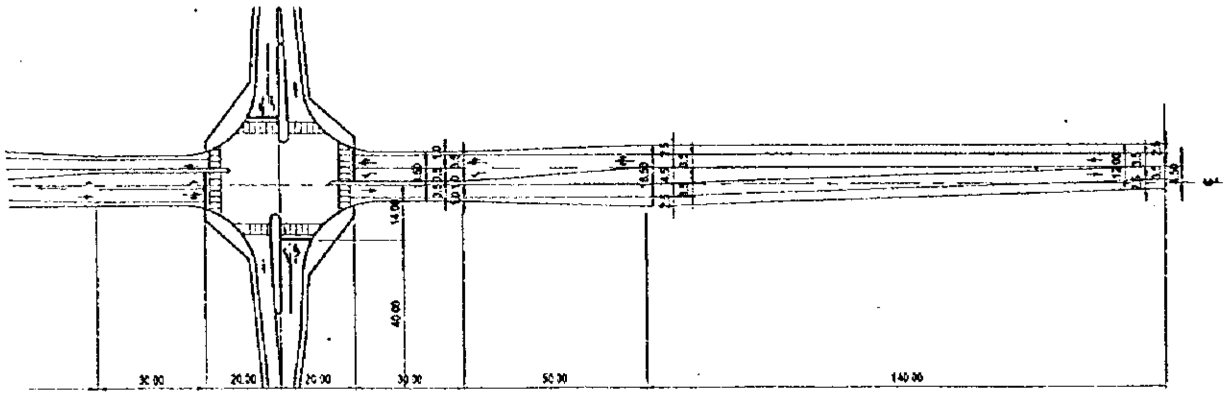


FIGURE 12.2-9 TYPICAL LAYOUT OF INTERSECTION (Phase-1)

5) Typical Intersection Layout (Phase-2: 4-lane divided bypass)

<u>Sections Without a Frontage Road</u>

Typical intersection layout is shown in Figure 12.2-10.

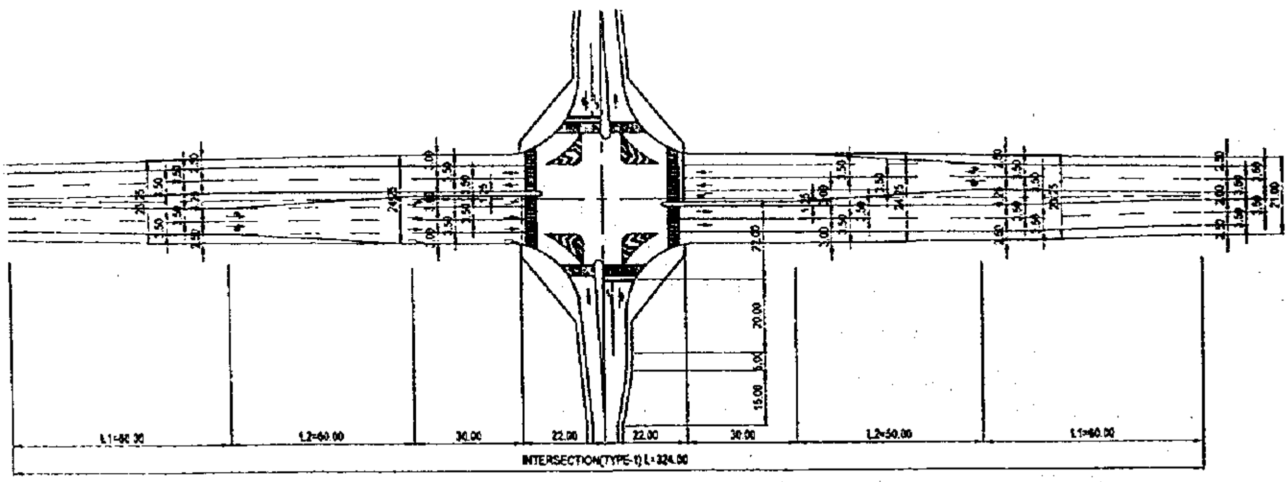


FIGURE 12.2-10 TYPICAL LAYOUT OF INTERSECTION (Phase-2, Without An Frontage Road)

Sections With a Frontage Road

Some of turning movements are recommended to be prohibited as follows:

- Right turn from a bypass to an intersecting road. Right turn vehicles is to enter into a frontage road ahead of an intersection, then make a turn using a frontage road.
- Left turn from a frontage road to an intersecting road. Left turn vehicles on a frontage road is to first make right turn to enter into an intersecting road, then make u-turn on an intersecting road.
- Right turn from an intersecting road to a bypass. Right turn vehicles on an intersecting road are to enter into a frontage road, then enter into a bypass through entrance ramp.
- Through traffic from a frontage road to a bypass, which is to go straight onto a frontage road ahead and go into a bypass through an entrance ramp.

Typical layout is shown in Figure 12.2-11.

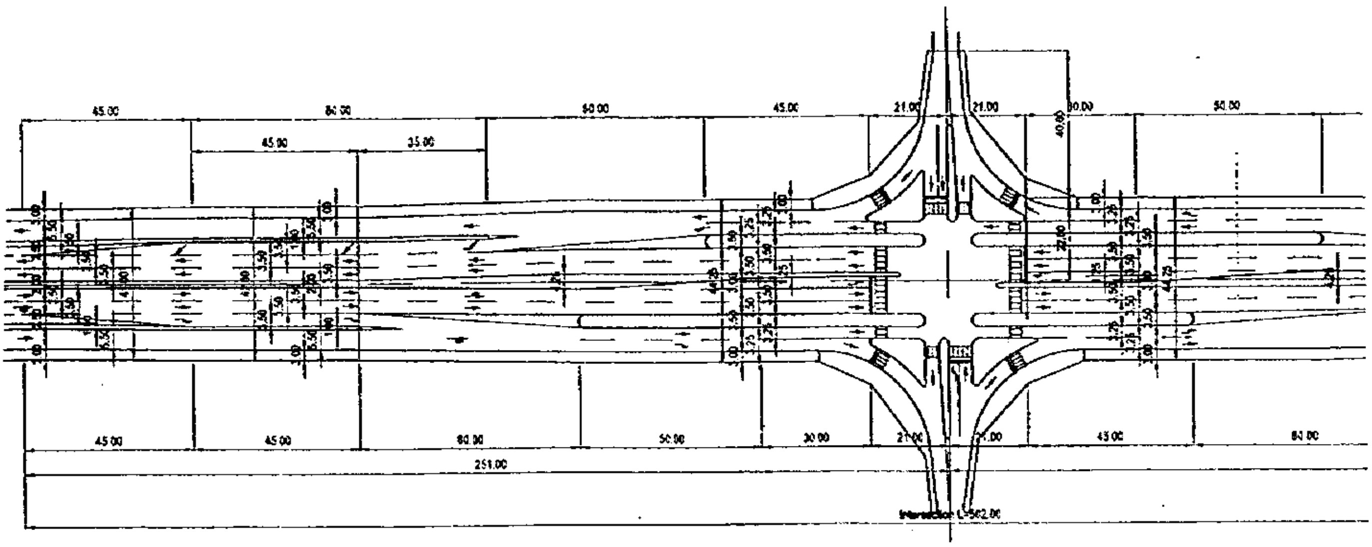


FIGURE 12.2-11 TYPICAL LAYOUT OF INTERSECTION (Phase-2: With Frontage Road)

An alternate layout of an intersection is shown in Figure 12.2-12. Under this scheme, traffic on a frontage road is required to go into an intersecting road and make necessary turns on an intersecting road. Traffic movements at an intersection is simplified, however, those along an intersecting road are sacrificed.

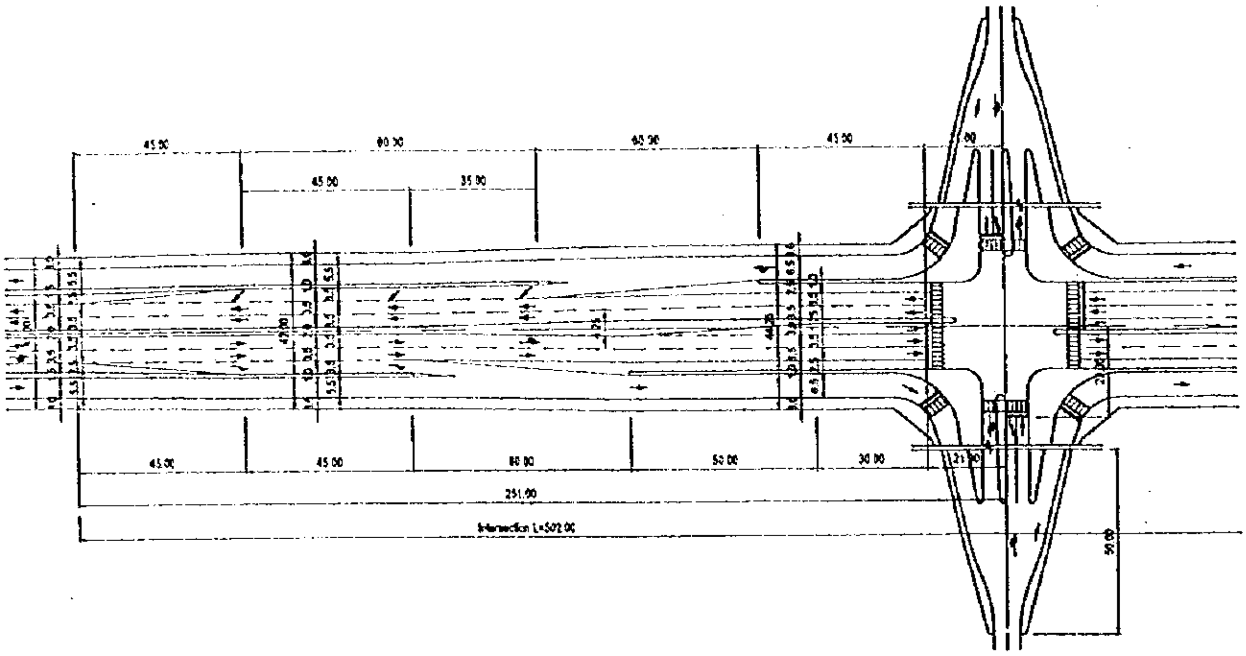


FIGURE 12.2-12 ALTERNATIVE LAYOUT OF INTERSECTION
(Phase-2: With Frontage Road)

6) 3-Leg Intersection Layout at the Beginning and the End of Bypass

Typical layout of an 3-leg intersection at the beginning and the end of a bypass is shown in Figure 12.2-13 and 12.2-14.

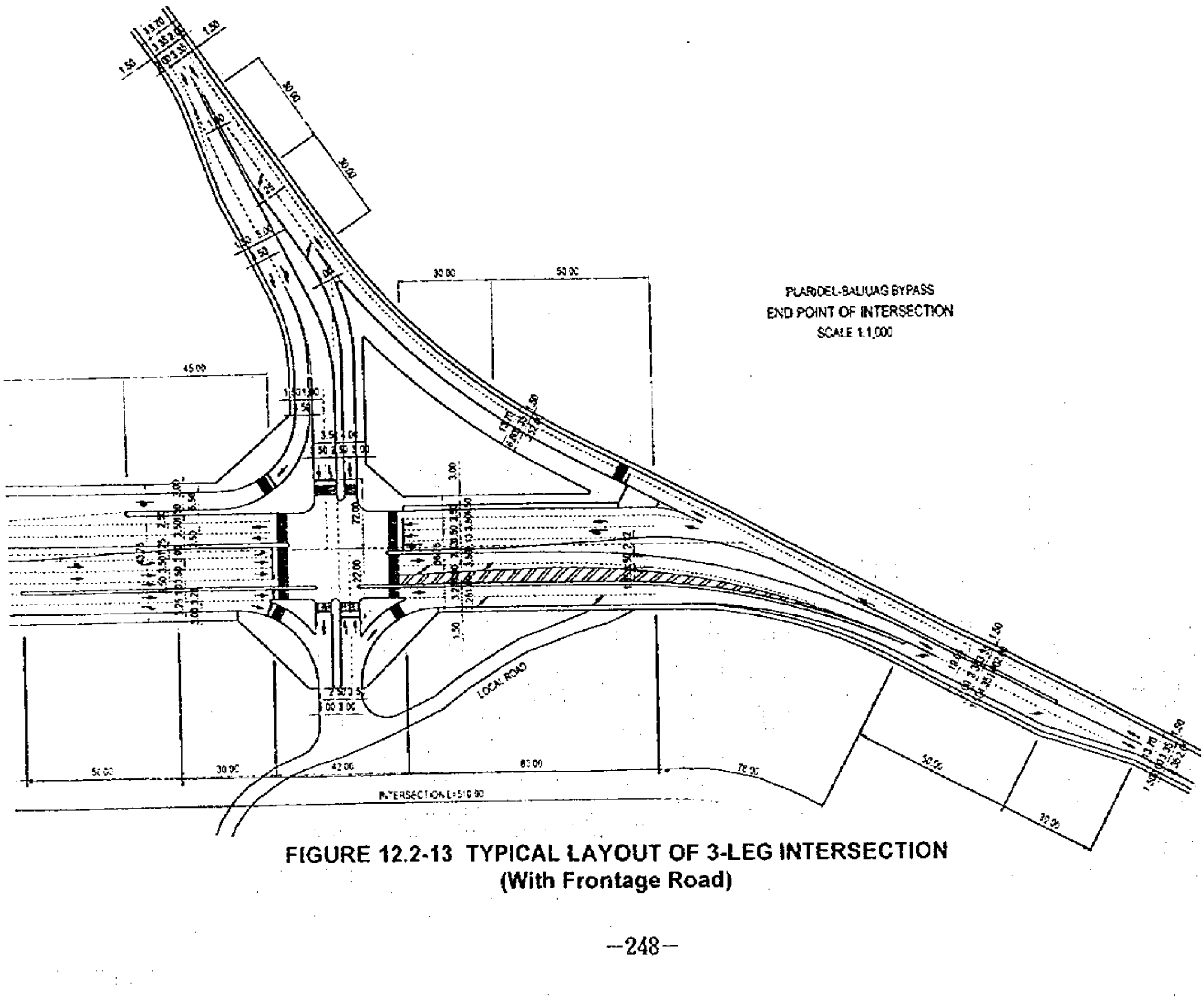


FIGURE 12.2-13 TYPICAL LAYOUT OF 3-LEG INTERSECTION
(With Frontage Road)

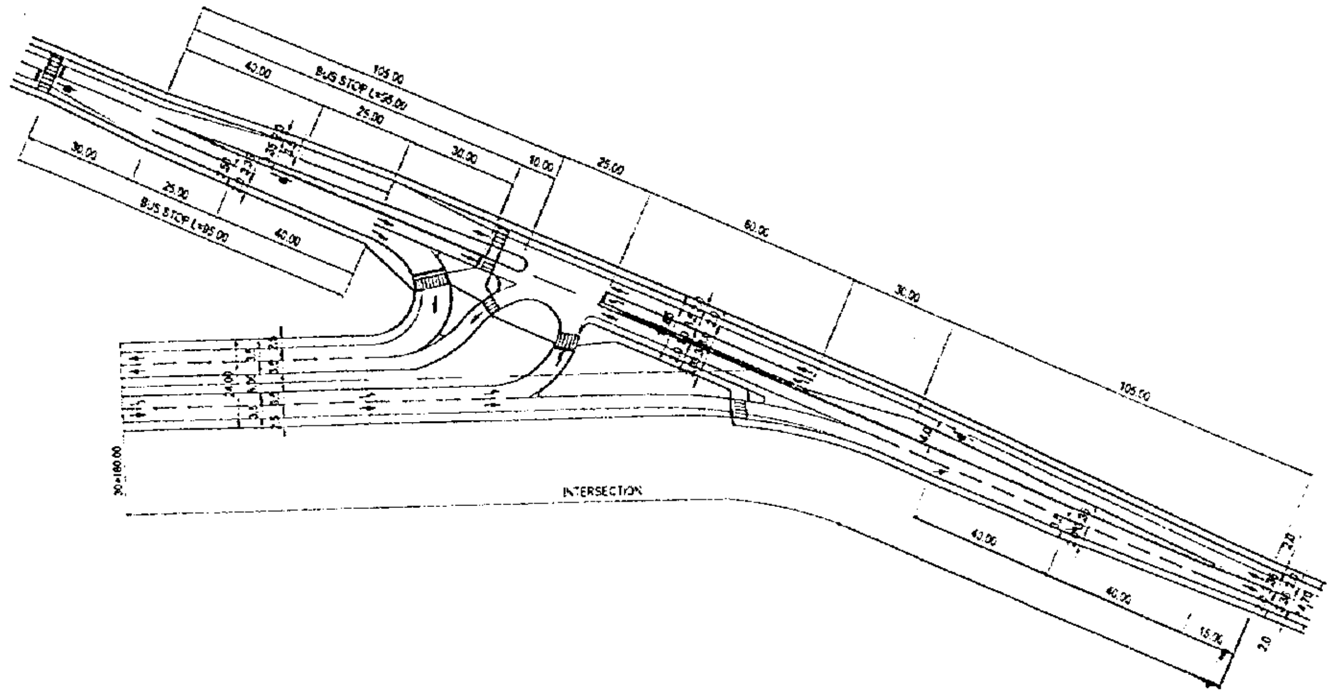


FIGURE 12.2-14 TYPICAL LAYOUT OF 3-LEG INTERSECTION
(Without Frontage Road)

12.2.6 Interchange Design

One interchange is required along the Plaridel – Baliuag Bypass which starts from the North Luzon Expressway. The location of the interchange was selected to be at the existing Wawa Junction (Junction between the North Luzon Expressway and its branch going to Malolos). The existing Wawa Junction was proposed to be converted to an interchange (named as "Burol Interchange").

Four types of interchanges were studied in Chapter 13 and "Turbine Type with Direct Connection" was selected. This section 12.2.4 discusses the preliminary design of the selected type of the interchange.

The system of new Burol Interchange is shown in Figure 12.2-15 and Table 12.2-7.

The design standards for the new Burol interchange adopted were as follows:

(1) Design Speed

Expressway : 100 km/hr.
Ramps : 50 km/hr.

(2) Minimum Geometric Design of Ramps

Description	Unit	Value Adopted
Radius Curvature	m	80.0
Ramp width		
One-lane, One-way	m	6.60
Two-lane, One-way	m	8.40
Vertical Grade	%	6.0
Acceleration Length		
for Two-Lane	m	205
for Taper	m	90
Deceleration Length		
for One-lane	m	155
for Taper	m	90

A plan of the new Burol Interchange is shown in Figure 12.2-16.

TABLE 12.2-7 SYSTEM OF NEW BUROL INTERCHANGE

Direction	Name of Ramp	Nos. of Lane	Remarks
Bypass → Manila	A	1→ 2	Major Traffic
Manila → Bypass	B	1	Major Traffic
Malolos → Manila	C (Existing)	2 → 1 → 2	
Manila → Malolos	(Existing)	1→ 2	* (1)
〃	D (Relocated Existing Ramp)	1→ 2	Connect to E Ramp
Bypass → Malolos	E	1→ 2	
Malolos → Bypass	F	1	
Tarlac → Bypass	-	-	Not Provided
Bypass → Tarlac	-	-	〃
Malolos → Tarlac	-	-	〃
Tarlac → Malolos	-	-	〃

Note: * (1) The existing Ramp (Manila → Malolos) is relocated due to seriously deteriorated bridge crossing the expressway.

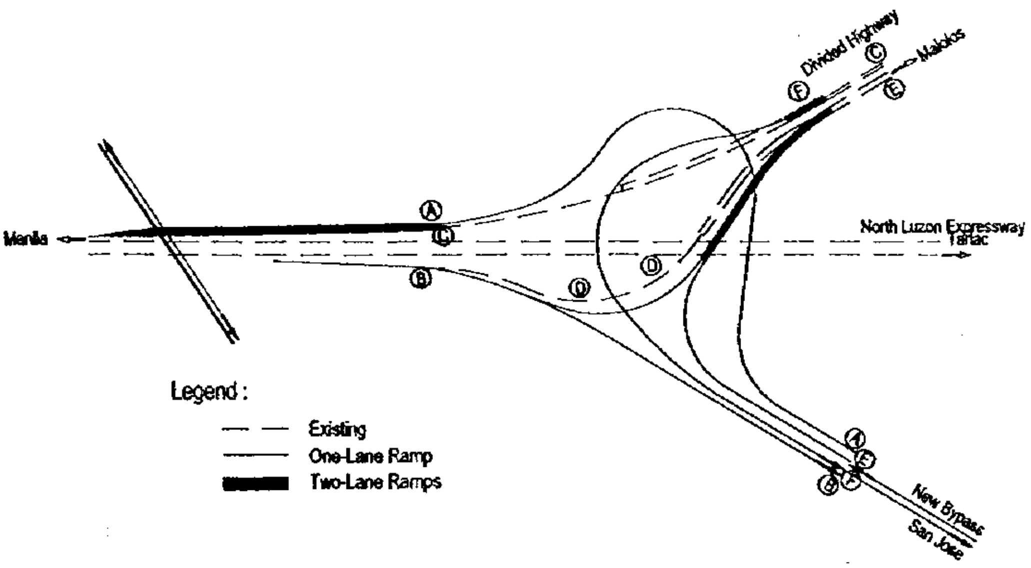


FIGURE 12.2-15 KEY PLAN OF BUROL INTERCHANGE

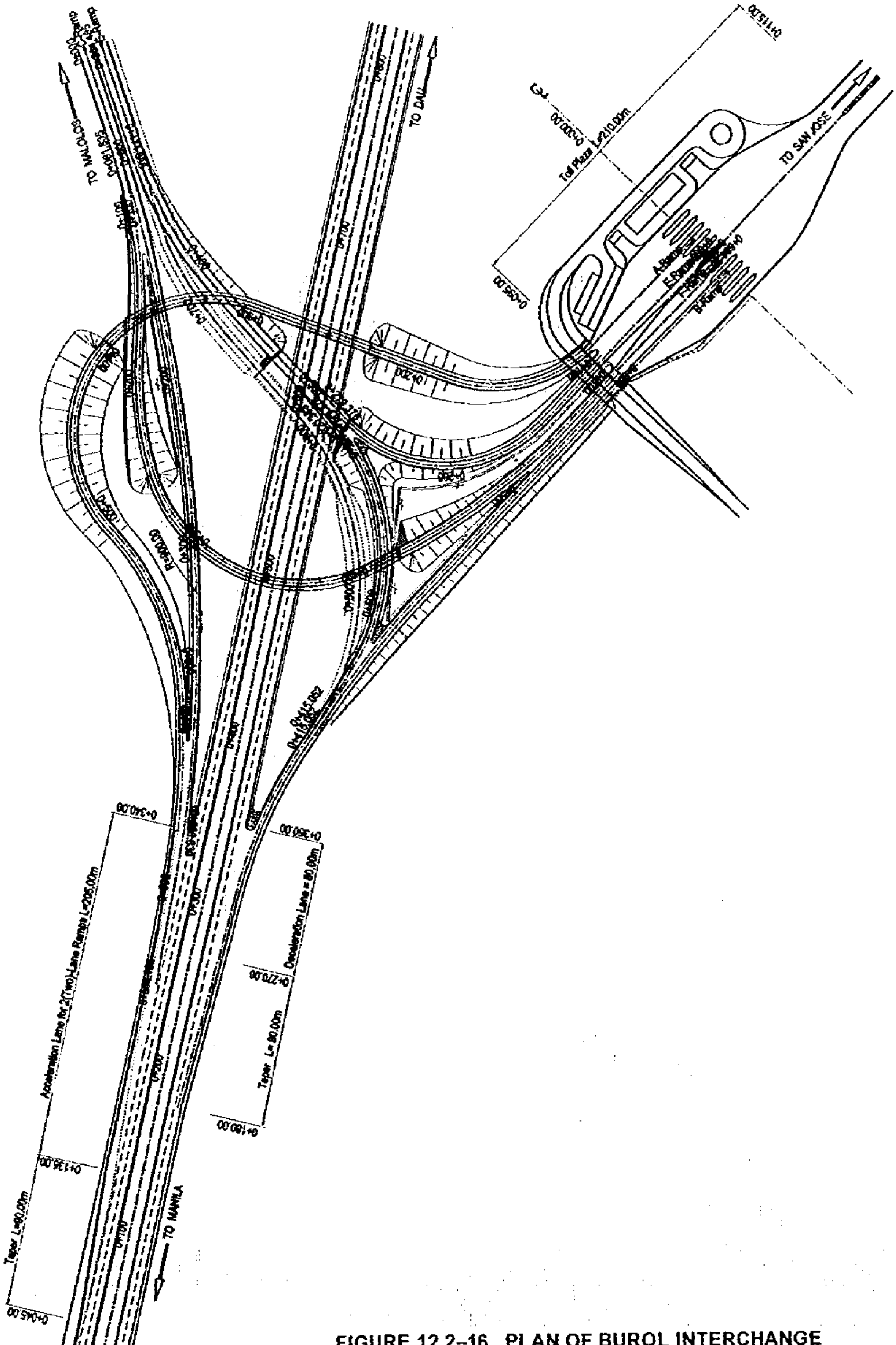


FIGURE 12.2-16 PLAN OF BUROL INTERCHANGE

12.3 BRIDGE DESIGN

12.3.1 Design Standards and Standard Cross-Sections

Design codes and standards adopted for the design were as follows:

- AASHTO Standard Specification for Highway Bridges, 16^{th} Edition, 1996 including Division A, Seismic Design.
- Specifications for Highway Bridges, Part IV, Japan Road Association.
- Design Guidelines, Criteria and Standards, Volume I & II, Ministry of Public Works and Highways.
- National Structural Code of the Philippines; Volume I, Fourth Edition 1992 & Volume II, Second Edition 1997
- Department of Public Works and Highways
  - Department Order No. 75, "DPWH Advisory for Seismic Design of Bridges", 17 July 1992
  - Department Order No. 56, "Quality of Plans", 22 March 1995
  - Department Order No. 229, "Guidelines on Soil Survey and Sampling for Highway Design and Subsurface Exploration for Design of and Construction of Foundation of Bridges", July 1993
  - DPWH Standard Specifications for Highway, Bridges and Airports, 1995.

Major elements for bridge design adopted were as follows:

- Live load : MS 20-44
- Seismic load : In accordance with Division 1A of AASHTO
- Free board : 1.5m

Figure 12.3-1(1), (2) shows cross-sections for a long bridge, a moderate / small bridge and a bridge for new access road. The center median and shoulder width of the moderate / small bridges are same as the roadway for traffic safety, and frontage road is provided to the moderate / small bridges in the with-frontage road sections.

In the longer bridge sections, the center medians are reduced to the roadway and the shoulder width is adopted to minimum standard width by considering the construction costs.

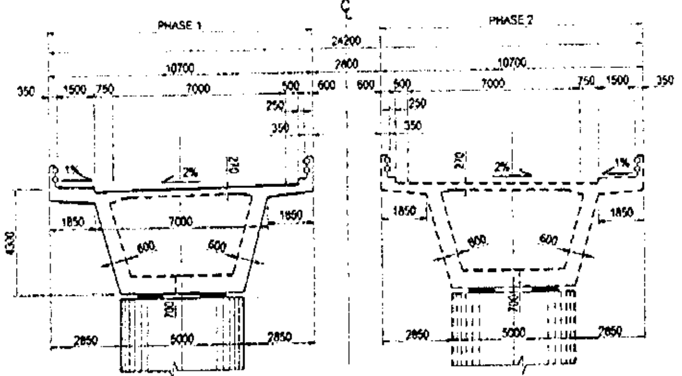
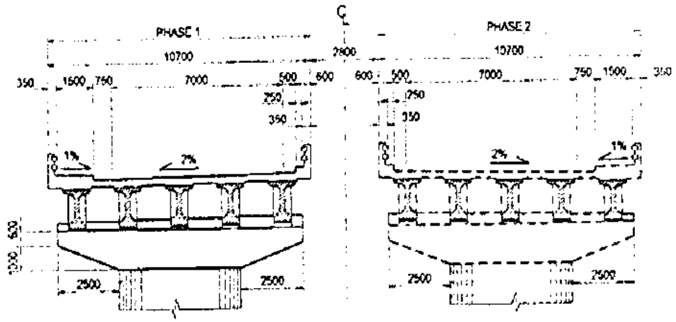
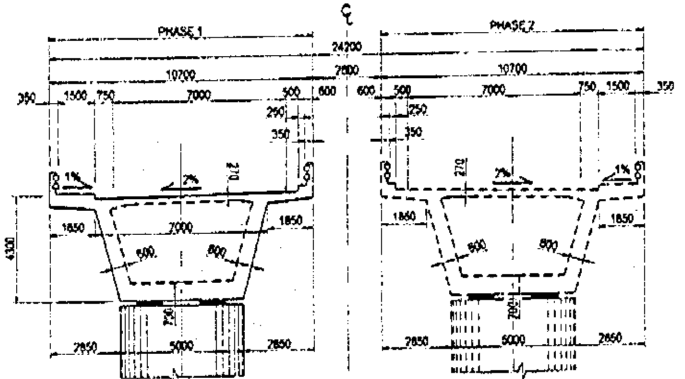
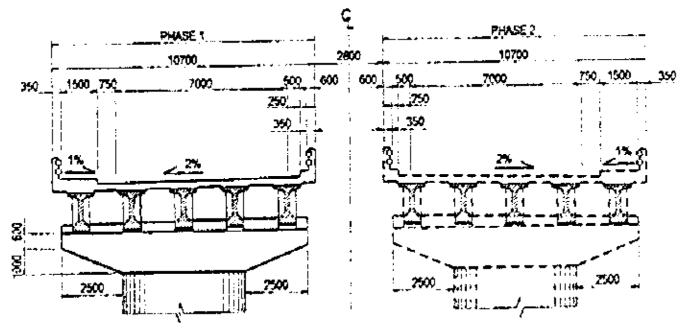
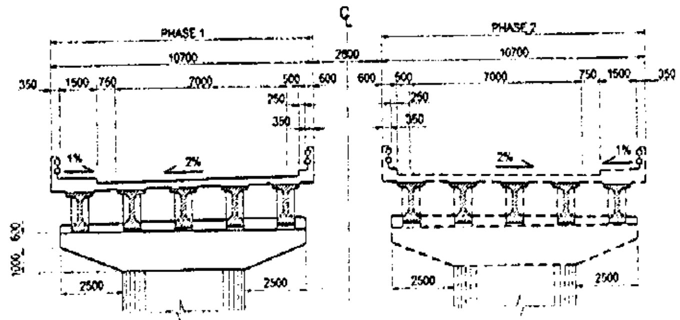
BYPASS	MAIN BRIDGE PORTION	APPROACH BRIDGE PORTION
ANGAT RIVER BRIDGE (PLARIDEL-BALIUAG BYPASS)		
PAMPANGA RIVER BRIDGE (CABANATUAN BYPASS)		
TALAVERA RIVER BRIDGE (CABANATUAN BYPASS)		

FIGURE 12.3-1(1) TYPICAL CROSS SECTION OF LONG BRIDGES

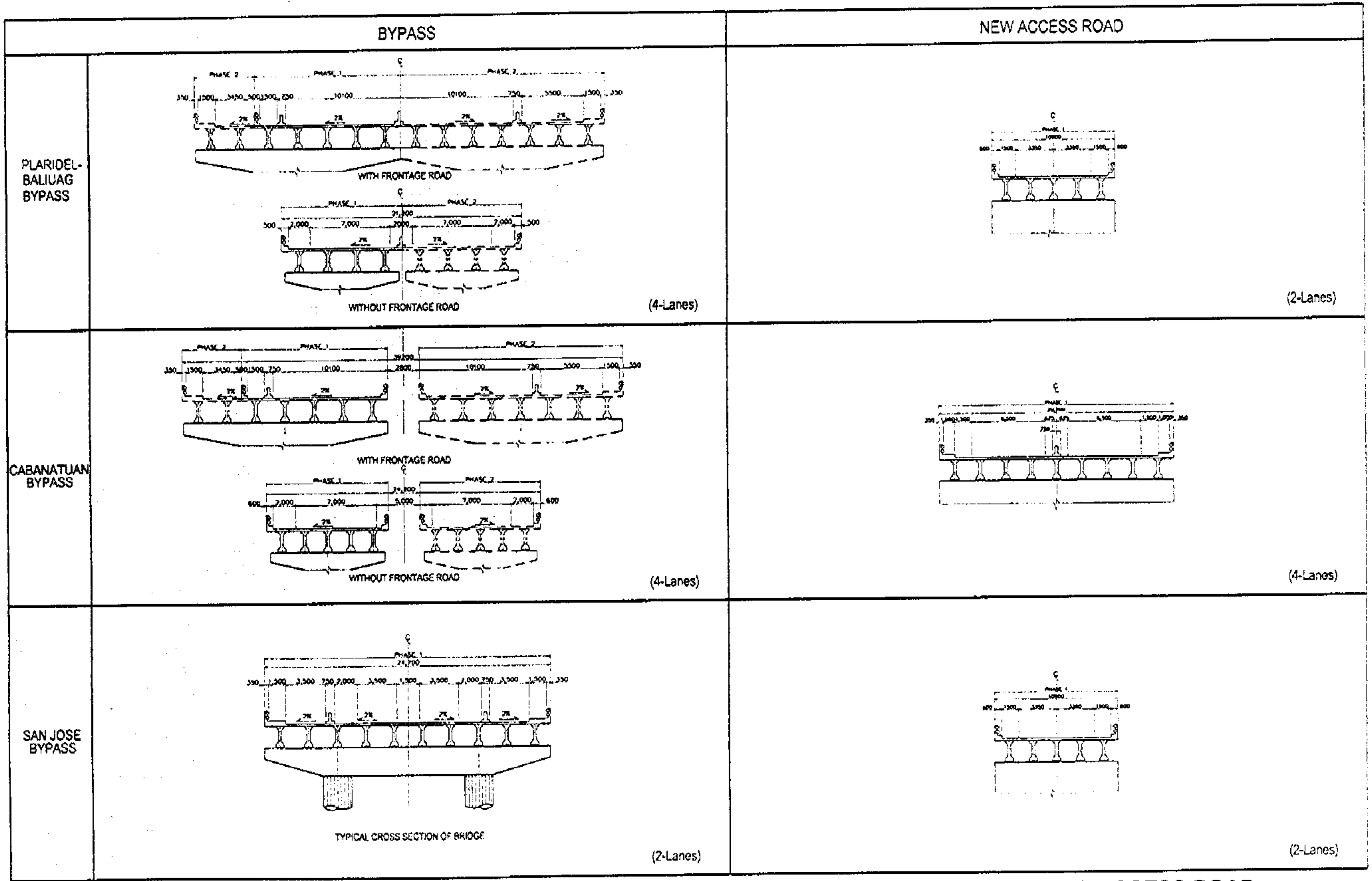


FIGURE 12.3-1(2) TYPICAL CROSS SECTIONS OF SMALL BRIDGES FOR EACH BYPASS AND ACCESS ROAD

12.3.2 Bridge Lists

Table 12.3-1 shows the list of bridges for each bypass. The total number of bridges and ranges of bridge length are as follows:

- Plaridel – Baliuag Bypass
  - 15 bridges (bypass: 11, interchange: 3, access road: 1)
  - long bridge: Angat River Bridge L = 1,135m
  - moderate bridges: L = 160~155 (all interchange viaduct)
  - small bridges: L = 16~50m
- Cabanatuan Bypass
  - 18 bridges (bypass: 17, access road: 1)
  - long bridges: Pampanga River Bridge L = 960m
Talavera River Bridge L = 665m
  - moderate bridge: L = 176m
  - small bridges: L = 12~60m
- San Jose Bypass
  - 3 bridges (bypass: 2, access road: 1)
  - small bridges: L = 25~54m

The general profile of long bridges is shown in Figure 12.3-2.

TABLE 12.3-1 LIST OF BRIDGES

Bypass		Number of Bridge	Station	Length (m)	No. of Spans	Bridge Type	Type of Foundn.	Remarks
Plaridel-Baliuag	BYPASS	1	0+588	16	1	RCDG	RCP 400*400	Skewed
		2	5+505	25	1	PCDG	RCP 400*400	(Rd.+Irr. Canal)
		3	7+208	30	1	PCDG	RCP 400*400	
		4	8+010	30	1	PCDG	RCP 400*400	
		5	8+430	20	1	PCDG	RCP 400*400	(Rd.+Irr. Canal)
		6	8+786	16	1	RCDG	RCP 400*400	
		7	12+490	45	2	RCDG/PCDG	RCP 400*400	(Rd.+Irr. Canal)
		8	13+560	35	1	PCDG	RCP 400*400	(wt Fr. Rd.)
		9	14+865	1,135	27	PCDG/PCBG	CCP 1200	ANGAT Br.
		10	16+138	25	1	PCDG	RCP 400*400	(wt Fr. Rd.)
		11	17+075	30	1	PCDG	RCP 400*400	(wt Fr. Rd.)
		Sub-Total		1,407				
	Inter-change	Ramp A	0+228	160	6	PCDG	RCP 400*400	A Ramp
		Ramp E	0+276	50	2	PCDG	RCP 400*400	E Ramp
		Ramp F	0+266	155	7	PCDG	RCP 400*400	F Ramp
	Access Road			20	1	PCDG	RCP 400*400	Access Road
Cabanatuan	BYPASS	1	2+070	60	3	RCDG/PCDG	RCP 400*400	River
		2	7+952	16	1	RCDG	RCP 400*400	Stream
		3	10+317	20	1	PCDG	RCP 400*400	Stream
		4	11+265	16	1	RCDG	RCP 400*400	Stream
		5	12+526	22	1	PCDG	RCP 400*400	Stream
		6	12+997	16	1	RCDG	RCP 400*400	Ditch
		7	13+665	30	1	PCDG	RCP 400*400	River
		8	15+790	60	3	RCDG/PCDG	RCP 400*400	River
		9	17+465	960	24	PCDG/PCBG	CCP 1200	PAMPANGA Br.
		10	19+583	30	1	PCDG	RCP 400*400	
		11	19+770	176	6	PCDG	RCP 400*400	River
		12	22+177	12	1	RCDG	RCP 400*400	Ditch
		13	22+850	16	1	RCDG	RCP 400*400	Irrigation Canal
		14	23+850	12	1	RCDG	RCP 400*400	Stream
		15	25+493	14	1	RCDG	RCP 400*400	Stream
		16	26+270	20	1	PCDG	RCP 400*400	River
		17	29+053	665	19	PCDG/PCBG	CCP 1200	TALAVERA Br.
		Sub-Total		2,145				
	Access Road			30	1	PCDG	RCP 400*400	Accesss Road
San Jose	BY-PASS	1	5+985	54	2	PCDG	RCP 400*400	
		2	6+556	48	3	RCDG/PCDG	RCP 400*400	
		Sub-Total		102				
	Access Road			25	1	PCDG	RCP 400*400	Access Road

Notes:
RCDG : Reinforced Concrete Deck Girder
PCDG : Prestressed Concrete Deck Girder
PCBG : Prestressed Concrete Box Girder
RCP : Precast Reinforced Concrete Pile
CCP : Cast-in-place Concrete Pile

12.3.3 Hydraulic Analysis for Long Span Bridges

The hydrological survey was carried out to collect rainfall data, information on past high water level, etc., for three long bridge sites along the proposed bypasses. Based on the collected data and information, the hydraulic analysis was carried out (refer to Appendix 12.3-1) and summarized in Table 12.3-2.

TABLE 12.3-2 SUMMARY OF HYDRAULIC ANALYSIS

	Angat River Bridge (Plaridel – Baliuag Bypass)	Pampanga River Bridge (Cabanatuan Bypass)	Talavera River Bridge (San Jose Bypass)
Catchment Area (km^2)	873.1	2,443.8	439.4
Discharge (m^3/sec)	3,274	7,294	1,457
High Water Level (m above mean sea level)	11.23	32.68	43.33
Velocity (m/sec)	1.07	2.16	2.01

Note: Return period : 50 years

12.3.4 Bridge Type Comparative Study of Long-Bridges

There are three big rivers over which a bypass has to cross. They are Angat River along the Plaridel – Baliuag Bypass and Pampanga River and Talavera River along the Cabanatuan Bypass. According to Japan's Guidelines for River Control and Management, the minimum span length is determined by the following formula:

$$L \geq 20+0.005\,Q \quad (\text{for } 500 < Q \leq 2000)$$
$$L \geq 30+0.005\,Q \quad (\text{for } Q > 2000)$$

Where: L = minimum span length (m)
Q = Design discharge (m^3/s)

When above formula is adopted, the minimum span length required is as follows:

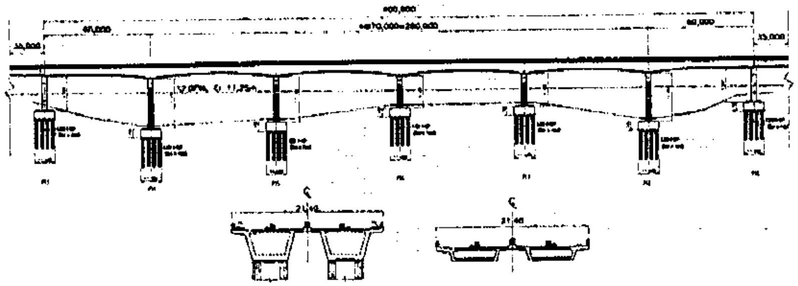
Angat River Bridge	:	L = 46m
Pampanga River Bridge	:	L = 66m
Talavera River Bridge	:	L = 28m

In due consideration of above minimum span length as a guide and river conditions such as ordinary water depth, maximum water depth, etc., three alternative schemes were studied for the main bridge portion of Angat River Bridge and Pampanga River Bridge as shown in Table 12.3-3 and Table 12.3-4, respectively. In each bridge, Scheme-1: Continuous PC Box Girder with 70m long central spans with 60m long side spans, was found the most advantageous.

Figure 12.3-2 shows the general profile of three long bridges prepared based on the selected type of bridge.

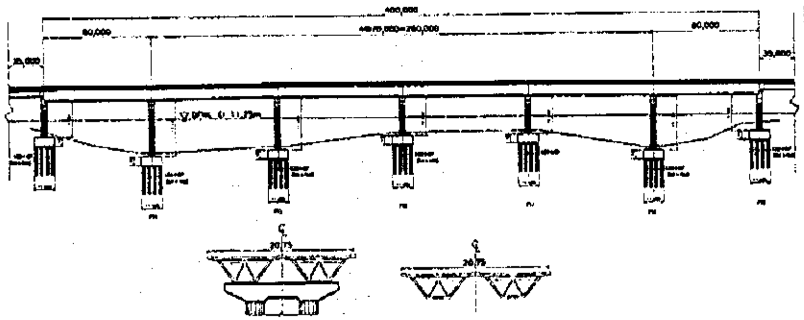
TABLE 12.3 - 3 COMPARATIVE STUDY OF BRIDGE TYPE : ANGAT RIVER BRIDGE

ANGAT BRIDGE / EVALUATION



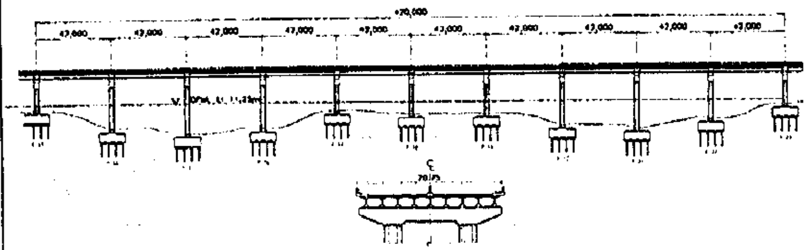
SCHEME 1 — 6 - CONTINUOUS PC BOX GIRDER

ITEM		RATING	
DIRECT CONSTRUCTION COST	P 288 MILLION (P 0.72 MILLION / meter) 1.00	SECOND	3
MAINTENANCE ASPECT	REQUIRED MAINTENANCE IS SMALL.	EXCELLENT	4
CONSTRUCTION PERIOD	THE STRUCTURE HAS THE LONGEST CONSTRUCTION PERIOD DUE TO CANTILEVER CONSTRUCTION METHOD BY CAST-IN-PLACE.	LONG	3
CONSTRUCTION ASPECT	ALL CONSTRUCTION MATERIALS ARE PRESENTLY AVAILABLE IN LOCAL MARKET. CONSTRUCTION OF SUBSTRUCTURE NEEDS ONLY FEW COFFERDAMS IN WATER.	GOOD	4
STRUCTURAL ASPECT	HIGH ASEISMICITY AND HIGH RIGIDITY OF THE SUPERSTRUCTURE. BETTER RIDING QUALITY BECAUSE OF LESSER JOINTS.	GOOD	4
HYDRAULIC ASPECT	THE SPAN LENGTH RESPECTS THE HYDRAULIC CRITERIA OF DESIGN GUIDELINES.	GOOD	4
	OVERALL RATING	RECOMMENDED	22



SCHEME 2 — 6 - CONTINUOUS STEEL BOX GIRDER

ITEM		RATING	
DIRECT CONSTRUCTION COST	P 312 MILLION (P 0.78 MILLION / meter) 1.09	THIRD	2
MAINTENANCE ASPECT	PERIODIC MAINTENANCE SUCH AS PAINTING IS REQUIRED.	POOR	2
CONSTRUCTION PERIOD	THE STRUCTURE HAS THE SECOND LONGEST CONSTRUCTION PERIOD. THE STEEL BOX GIRDERS ARE ASSEMBLED AT A STAGING AREA AND LAUNCHED INTO PLACE ACROSS TEMPORARY SUPPORTS.	LONG	3
CONSTRUCTION ASPECT	ALL CONSTRUCTION MATERIALS ARE PRESENTLY AVAILABLE IN LOCAL MARKET ALTHOUGH FABRICATORS OF THE STEEL BOX GIRDER ARE SMALL IN NUMBER. CONSTRUCTION OF SUBSTRUCTURE NEEDS ONLY FEW COFFERDAMS IN WATER.	FAIR	3
STRUCTURAL ASPECT	HAS THE ADVANTAGE ASEISMICALLY SINCE THE SUPERSTRUCTURE'S WEIGHT-TO-SPAN RATIO IS SMALLER THAN THE REST.	GOOD	4
HYDRAULIC ASPECT	THE SPAN LENGTH RESPECTS THE HYDRAULIC CRITERIA OF DESIGN GUIDELINES.	GOOD	4
	OVERALL RATING	DISCARDED	18

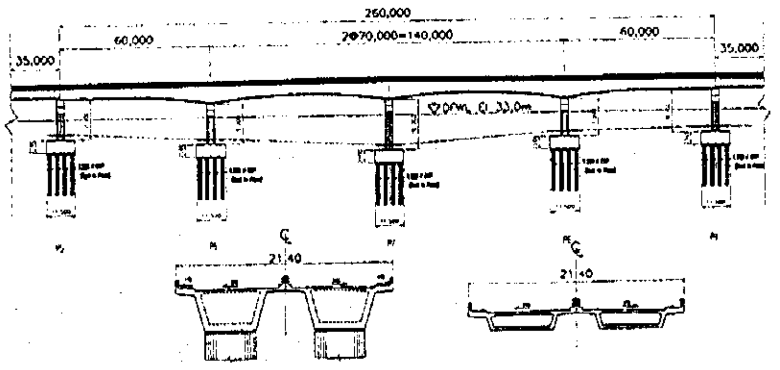


SCHEME 3 — 10 - CONNECTED PC T-GIRDER

ITEM		RATING	
DIRECT CONSTRUCTION COST	P 269 MILLION (P 0.64 MILLION / meter) 0.89	FIRST	4
MAINTENANCE ASPECT	REQUIRED MAINTENANCE IS SMALL.	GOOD	4
CONSTRUCTION PERIOD	THE SUPERSTRUCTURE HAS THE SHORTEST CONSTRUCTION PERIOD. HOWEVER, BECAUSE OF SHORTER SPANS, IT HAS THE DISADVANTAGE OF HAVING MORE PIERS THUS ADDING CONSIDERABLE CONSTRUCTION TIME.	LONG	3
CONSTRUCTION ASPECT	ALL CONSTRUCTION MATERIALS ARE PRESENTLY AVAILABLE IN LOCAL MARKET. GIRDERS ARE TOO LONG AND TOO HEAVY THEREFORE, THEY REQUIRE A SPECIAL ERECTION METHOD. CONSTRUCTION OF SUBSTRUCTURE REQUIRES MORE COFFERDAMS IN DEEP WATER THAN OTHER SCHEMES.	FAIR	3
STRUCTURAL ASPECT	THE BRIDGE IS A SIMPLE SPAN-MADE-CONTINUOUS TYPE. IT ACTS CONTINOUSLY IN CARRYING LIVE LOAD AND SEISMIC LOAD ON THE PIERS.	FAIR	3
HYDRAULIC ASPECT	SINCE THIS BRIDGE HAS SHORTER CLEAR SPAN, LOCAL SCOURING AROUND THE PIER IS HIGHLY POSSIBLE THAN THE REST. THE SPAN LENGTH IS SUBSTANDARD TO THE HYDRAULIC CRITERIA OF DESIGN GUIDELINES.	POOR	2
	OVERALL RATING	DISCARDED	19

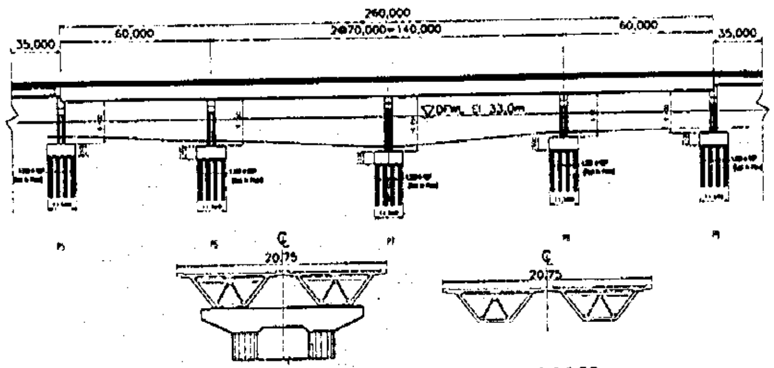
TABLE 12.3 - 4 COMPARATIVE STUDY OF BRIDGE TYPE : PAMPANGA RIVER BRIDGE

PAMPANGA BRIDGE



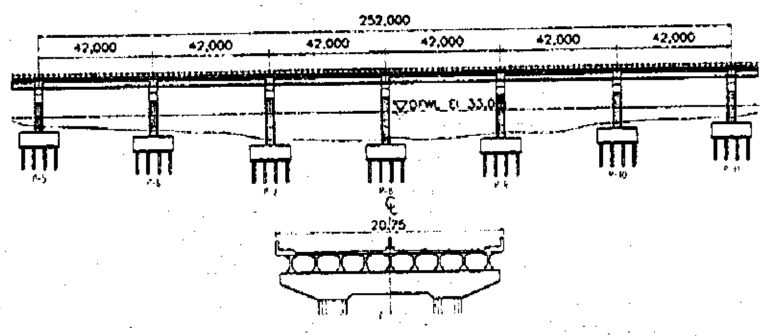
SCHEME 1 4 - CONTINUOUS PC BOX GIRDER

ITEM	EVALUATION	RATING	
DIRECT CONSTRUCTION COST	P 166 MILLION (P 0.64 MILLION / meter) 1.00	SECOND	3
MAINTENANCE ASPECT	REQUIRED MAINTENANCE IS SMALL.	EXCELLENT	4
CONSTRUCTION PERIOD	THE STRUCTURE HAS THE LONGEST CONSTRUCTION PERIOD DUE TO CANTILEVER CONSTRUCTION METHOD BY CAST-IN-PLACE.	LONG	3
CONSTRUCTION ASPECT	ALL CONSTRUCTION MATERIALS ARE PRESENTLY AVAILABLE IN LOCAL MARKET. CONSTRUCTION OF SUBSTRUCTURE NEEDS ONLY FEW COFFERDAMS IN WATER.	GOOD	4
STRUCTURAL ASPECT	HIGH ASEISMICITY AND HIGH RIGIDITY OF THE SUPERSTRUCTURE. BETTER RIDING QUALITY BECAUSE OF LESSER JOINTS.	GOOD	4
HYDRAULIC ASPECT	THE SPAN LENGTH RESPECTS THE HYDRAULIC CRITERIA OF DESIGN GUIDELINES.	GOOD	4
	OVERALL RATING	RECOMMENDED	22



SCHEME 2 4 - CONTINUOUS STEEL BOX GIRDER

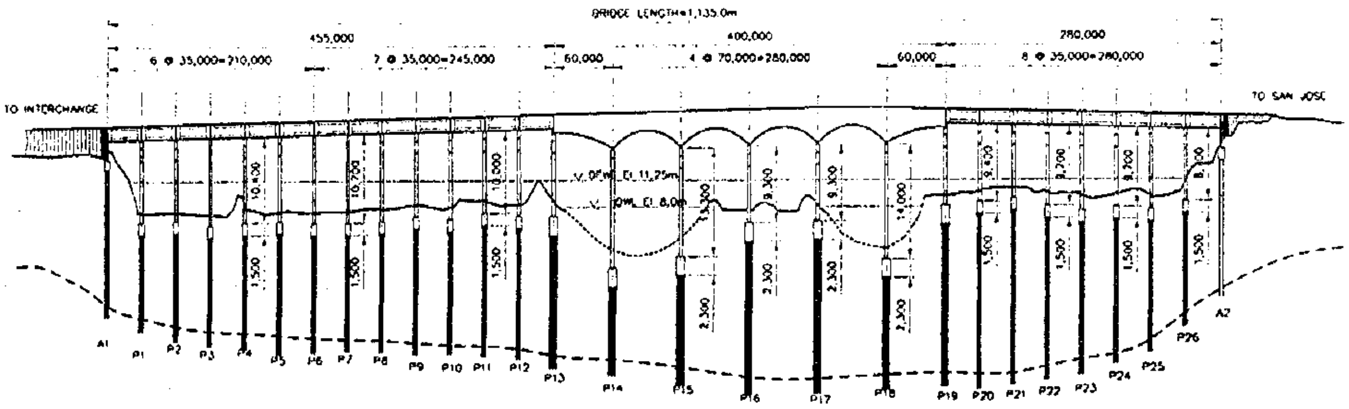
ITEM	EVALUATION	RATING	
DIRECT CONSTRUCTION COST	P 189 MILLION (P 0.73 MILLION / meter) 1.14	THIRD	2
MAINTENANCE ASPECT	PERIODIC MAINTENANCE SUCH AS PAINTING IS REQUIRED.	POOR	2
CONSTRUCTION PERIOD	THE STRUCTURE HAS THE SECOND LONGEST CONSTRUCTION PERIOD. THE STEEL BOX GIRDERS ARE ASSEMBLED AT A STAGING AREA AND LAUNCHED INTO PLACE ACROSS TEMPORARY SUPPORTS.	LONG	3
CONSTRUCTION ASPECT	ALL CONSTRUCTION MATERIALS ARE PRESENTLY AVAILABLE IN LOCAL MARKET ALTHOUGH FABRICATORS OF THE STEEL BOX GIRDER ARE SMALL IN NUMBER. CONSTRUCTION OF SUBSTRUCTURE NEEDS ONLY FEW COFFERDAMS IN WATER.	FAIR	3
STRUCTURAL ASPECT	HAS THE ADVANTAGE ASEISMICALLY SINCE THE SUPERSTRUCTURE'S WEIGHT-TO-SPAN RATIO IS SMALLER THAN THE REST.	GOOD	4
HYDRAULIC ASPECT	THE SPAN LENGTH RESPECTS THE HYDRAULIC CRITERIA OF DESIGN GUIDELINES.	GOOD	4
	OVERALL RATING	DISCARDED	18



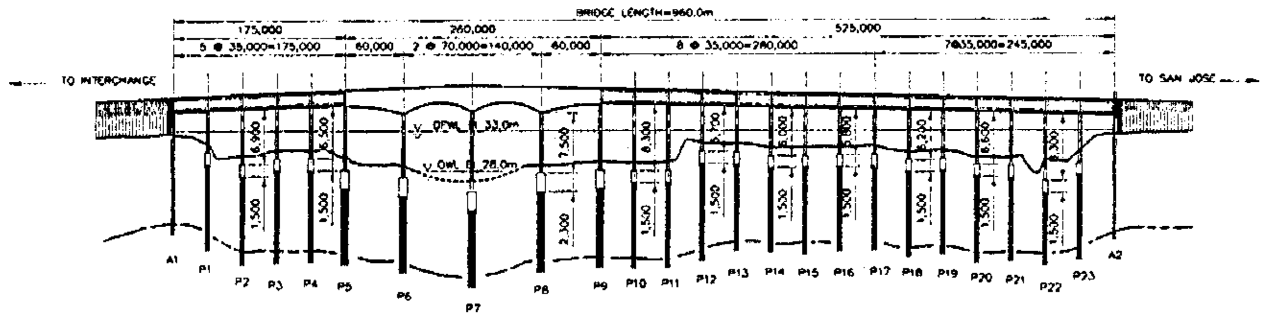
SCHEME 3 6 - CONNECTED PC T-GIRDER

ITEM	EVALUATION	RATING	
DIRECT CONSTRUCTION COST	P 153 MILLION (P 0.61 MILLION / meter) 0.95	FIRST	4
MAINTENANCE ASPECT	REQUIRED MAINTENANCE IS SMALL.	EXCELLENT	4
CONSTRUCTION PERIOD	THE SUPERSTRUCTURE HAS THE SHORTEST CONSTRUCTION PERIOD. HOWEVER, BECAUSE OF SHORTER SPANS, IT HAS THE DISADVANTAGE OF HAVING MORE PIERS THUS ADDING CONSIDERABLE CONSTRUCTION TIME.	LONG	3
CONSTRUCTION ASPECT	ALL CONSTRUCTION MATERIALS ARE PRESENTLY AVAILABLE IN LOCAL MARKET. GIRDERS ARE TOO LONG AND TOO HEAVY THEREFORE, THEY REQUIRE A SPECIAL ERECTION METHOD. CONSTRUCTION OF SUBSTRUCTURE REQUIRES MORE COFFER-DAMS IN WATER THAN OTHER SCHEMES.	FAIR	3
STRUCTURAL ASPECT	THE BRIDGE IS A SIMPLE SPAN-MADE-CONTINUOUS TYPE. IT ACTS CONTINOUSLY IN CARRYING LIVE LOAD AND SEISMIC LOAD ON THE PIERS.	FAIR	3
HYDRAULIC ASPECT	SINCE THIS BRIDGE HAS SHORTER CLEAR SPAN, LOCAL SCOURING AROUND THE PIER IS HIGHLY POSSIBLE THAN THE REST. THE SPAN LENGTH IS SUBSTANDARD TO THE HYDRAULIC CRITERIA OF DESIGN GUIDELINES.	POOR	2
	OVERALL RATING	DISCARDED	19

ANGAT RIVER BR.
LENGTH=1135.0m
(Plaridel-Baliuag Bypass)



PAMPANGA RIVER BR.
LENGTH=960.0m
(Cabanatuan Bypass)



TALAVERA RIVER BR.
LENGTH=665.0m
(San Jose Bypass)

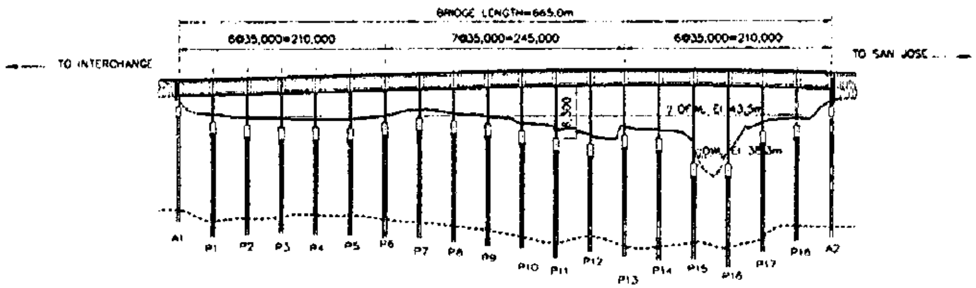


FIGURE 12.3-2 GENERAL PROFILE OF LONG BRIDGES

12.4 PAVEMENT DESIGN

12.4.1 Design Standard

DPWH's Design Guidelines, Criteria and Standards recommends two design methods, i.e., AASHTO method (AASHTO Interim Guide for Design of Pavement Structures, 1972) and TRRL method (Road Note 29, A Guide to the Structural Design Pavement for New Roads, 1970). TRRL method gives thinner concrete slab thickness than AASHTO method. The latest AASHTO method is compiled in the AASHTO Guide for Design of Pavement Structures, 1993, ("1993 AASHTO Guide") which covers design of new pavement as well as design of various rehabilitation methods.

Design requirements for rigid (PCC) pavement and flexible (AC) pavement are summarized in Table 12.4-1.

12.4.2 Major Design Variables

(1) The Predicted Number of 18-kip ESAL (W18)

W18 was estimated based on the projected traffic volume on the bypass and following bus and truck factors:

Bus factor = 1.0 Truck factor = 3.21

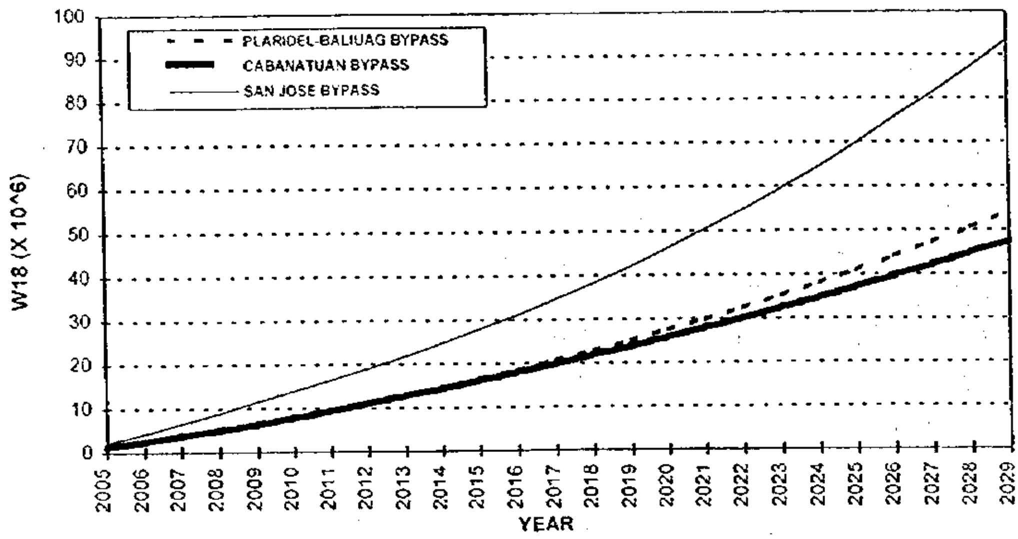


FIGURE 12.4-1 18 Kip ESAL OF EACH BYPASS FOR 25 YEARS

TABLE 12.4-1 DESIGN REQUIREMENTS

Category	Description
a. Design Variable	
a.1 Time Constraints	
• Performance Period	Life of Initial Pavement Structure
• Analysis Period	Planned Stage Construction; 25 years
a.2 Traffic Loading	W_{18} = 18-kip Equivalent Single Axle Load (ESAL) Application Traffic Loading Classes; 6 classes (A to E)
a.3 Reliability	Z_R = 1.645 for 95% Reliability R, not considered S_o = 0.3~0.4 for Standard Error, not considered
a.4 Environmental Impact	
• Roadbed Swelling	PSI_{sw} = Loss of PSI; not considered
b. Performance Criteria	
b.1 Serviceability	$PSI = P_o - P_t = P_o - \Delta PSI_w - \Delta PSI_{sw}$ (ΔPSI_{sw} ; not considered)
c. Material Properties for Structural Design	
c.1 Effective Roadbed Soil Resilient Modulus (Flexible)	MR (pci); estimated based on CBR
c.2 Effective Modulus of Subgrade Reaction (Rigid)	K-Value(pci); estimated based on CBR and subbase thickness
c.3 Pavement Layer Materials Characterization	E_{SB} = Modulus of Subbase (13,000 psi) E_{BS} = Modulus of Base (23,000 psi) E_{AC} = Modulus of Asphalt Concrete (350,000 psi) E_C = Modulus of Elasticity of PCC (3.28×10^6 psi)
c.4 PCC Modulus of Rupture (Rigid) (Flexural Strength)	S'_c = Estimated Mean Value for PCC Modulus of Rupture (psi); 580 psi
c.5 Structural Layer Coefficient (Flexible)	Asphalt Concrete Layer Coefficient ; 0.39 Bitumen Stabilized ; 0.2 Crushed Gravel Base ; 0.105 Subbase ; 0.095
d. Pavement Structural Characteristics	
d.1 Drainage	Flexible m = Layer Coefficient Modifying Factor; 0.9 Rigid CD = Drainage Coefficient; 1.0
d.2 Load Transfer (Rigid)	
• Jointed Pavement	
• Tied Shoulder or Widened Outside Lane	J = Load Transfer Coefficient; 3.8
d.3 Loss of Support (Rigid)	LS = Loss of Support 1.0~3.0 for unbounded granular materials 2.0~3.0 for fine granular or natural subgrade materials 0~1.0 for cement Treated Granular Base
e. Reinforcement Variables (Rigid)	
e.1 Slab Length	
e.2 Working Stress	Depending on local conditions, subbase type, course aggregate, etc.
e.3 Friction Factors	

(2) Performance Criteria (△PSI)

The initial serviceability indexes (Po) were observed at the AASHTO Road Test:

Po	=	4.5 for rigid pavement	(PCC)
Po	=	4.2 for flexible pavement	(AC)

AASHTO Guide (1993) suggests the terminal serviceability indexes (Pt) as follows:

Pt	=	2.5 for design of major highway
Pt	=	2.0 for design of highway

In this study, the following △ PSI was adopted because of the arterial road.

△ PSI = 4.5 – 2.5 = 2.0 (for PCC) △ PSI = 4.2 – 2.5 = 1.7 (for AC)

(3) Resilient Modulus (M_R) of Roadbed for AC Pavement

This value changes under stress level and moisture conditions. So in this Study, the following range of M_R values were assumed, and the total thickness were determined which correspond to M_R values.

M_R = 7,000 (psi)

This value is used for evaluating and studying relation between the total pavement thickness and the initial performance period.

12.4.3 Pavement Design

In order to determine the most appropriate pavement type for the bypass, the life-cycle cost analysis of pavement was carried out using the design variables in 12.4.2.

The results of the study are shown in Table 12.4-2. From this table, the results are summarized as follows:

- PCC pavement is more economical than AC pavement for three bypasses, since the life cycle cost of PCC pavement is lower than that of AC pavement.

- Among the PCC pavement thicknesses, 25 centimeter is the most economical one for Plaridel – Baliuag Bypass and San Jose Bypass. In Cabanatuan Bypass, 23 centimeter in thickness is the lowest in cost, but the cost gap between 23cm and 25cm thickness is very small, but the initial performance period of 25cm is longer than 23cm.

- It is recommended that PCC pavement of 25cm in thickness be adopted for the type of pavement.

TABLE 12.4-2(1) SUMMARY OF LIFE-CYCLE COST ANALYSIS: PCC PAVEMENT

Thickness	Items	Plaridel-Baliuag Bypass	Cabanatuan Bypass	San Jose Bypass
tc=23cm	Initial Performance Period (Year)	10.2	10.2	6.3
	Total Discounted Cost (MP/Km)	3.80	3.70	4.29
tc=25cm	Initial Performance Period (Year)	14.2	14.7	9.5
	Total Discounted Cost (MP/Km)	3.73	3.72	4.16
tc=27cm	Initial Performance Period (Year)	19.2	20.5	13.3
	Total Discounted Cost (MP/Km)	4.07	4.02	4.37

TABLE 12.4-2(2) SUMMARY OF LIFE-CYCLE COST ANALYSIS: AC PAVEMENT

Structural Number	Items	Plaridel-Baliuag Bypass	Cabanatuan Bypass	San Jose Bypass
SN=3.72	Initial Performance Period (Year)	4.2	3.9	2.3
	Total Discounted (*) Cost (MP/Km)	4.37	4.45	4.91
SN=4.33	Initial Performance Period (Year)	9.1	9.1	5.6
	Total Discounted Cost (MP/Km)	4.47	4.45	4.83
SN=4.83	Initial Performance Period (Year)	15.7	16.5	10.6
	Total Discounted Cost (MP/Km)	4.61	4.58	4.78
SN=5.3	Initial Performance Period (Year)	24.3	26.5	17.3
	Total Discounted Cost (MP/Km)	5.05	5.04	5.16

Note: (*) Discount rate 15%

12.5 SUMMARY OF EACH BYPASS

Scope of work of each bypass is summarized hereunder.

12.5.1 Plaridel – Baliuag Bypass

1) Number of Lanes 4-lane divided (with and without frontage road)

2) Total Length = 21.989 km
   - Section with the frontage road = 7.453 km
   - Section without the frontage road = 13.129 km
   Roadway Section Total = 20.582 km
   - Bridge length = 1.407 km

3) Road Right-of-Way Width = 45.0 m

4) Bridges
   - Long bridge n = 1 L = 1,135m (Angat River)
   - Medium / Short Bridges n = 10 L = 272m

5) Interchange n = 1 (with North Luzon Expressway)

6) Intersecting Roads
   - Major intersections (Access allowed to bypass) n = 8
     - 3-leg intersection n = 1
     - 4-leg intersection n = 7
     - Shortest interval L = 950m
     - Longest interval L = 5,900m
     - Average interval L = 2,750m
   - Underpass (access to the bypass not allowed) n = 10
   - Access is allowed only to frontage road, but not to the bypass n = 5

7) Access Roads
   - New access road n = 1 L = 2.48km
   - Improvement of existing road
     - National roads n = 1 L = 2.45 km
     - Provincial roads n = 4 L = 7.90 km
     - Barangay roads n = 1 L = 1.90 km
   - Total n = 7 L = 14.73 km

8) Cross Drainage Facilities
   - RCBC n = 9
   - RCPC n = 64

The plan of the Bypass is shown in Figure 12.5-1.

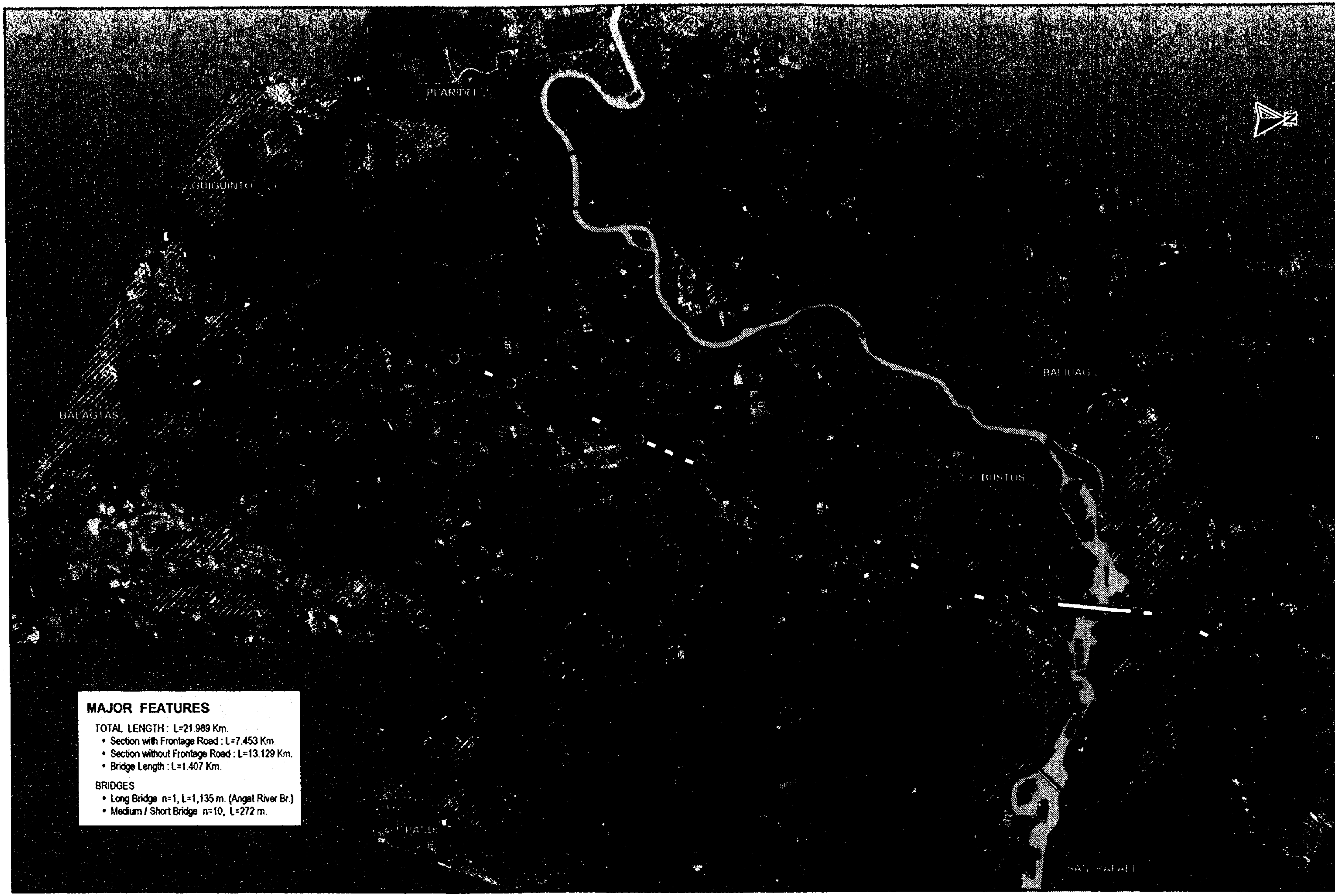


FIGURE 12.5 - 1 PROPOSED PLARIDEL-BALIUAG BYPASS

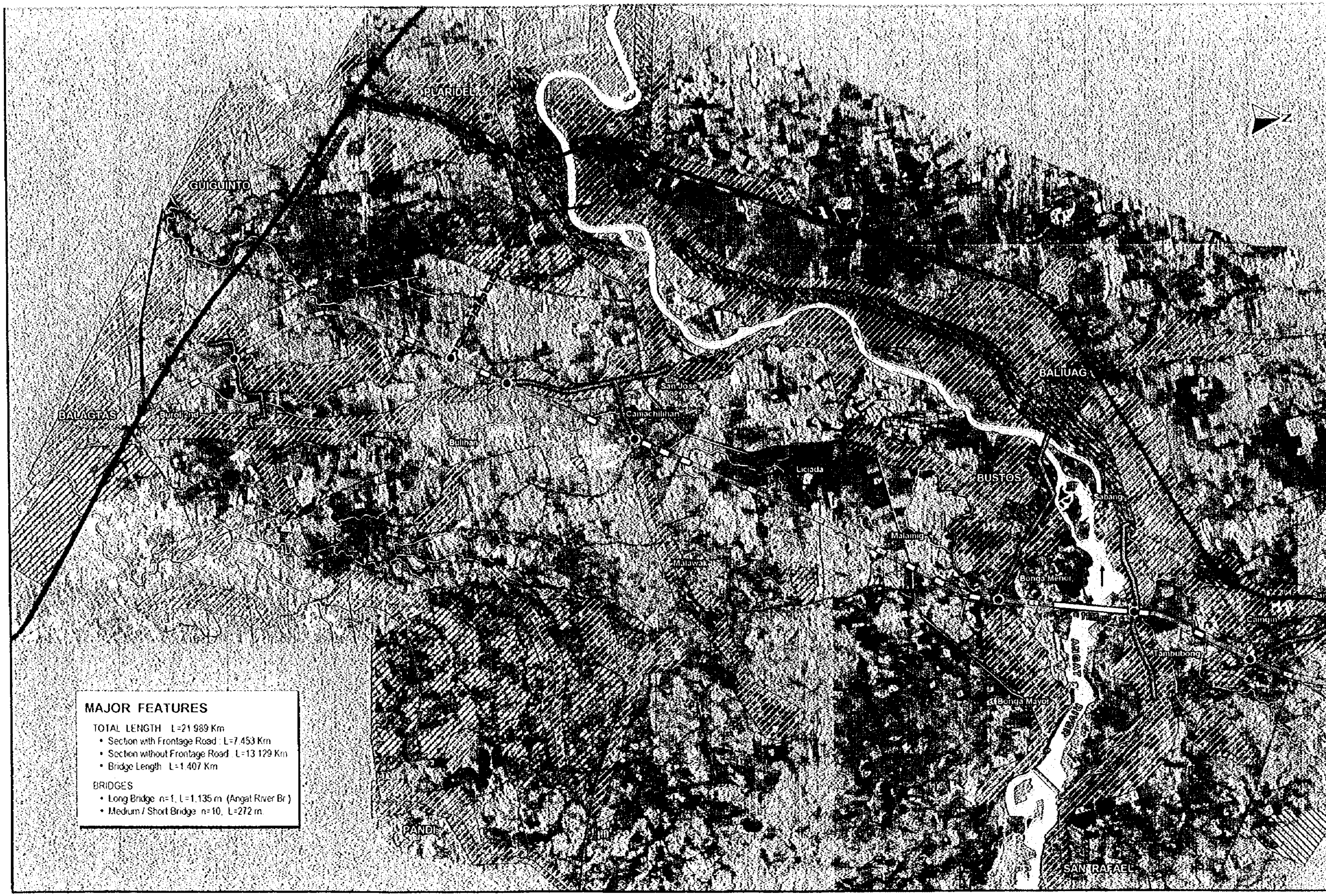


FIGURE 12.5 - 1 PROPOSED PLARIDEL-BALIUAG BYPASS

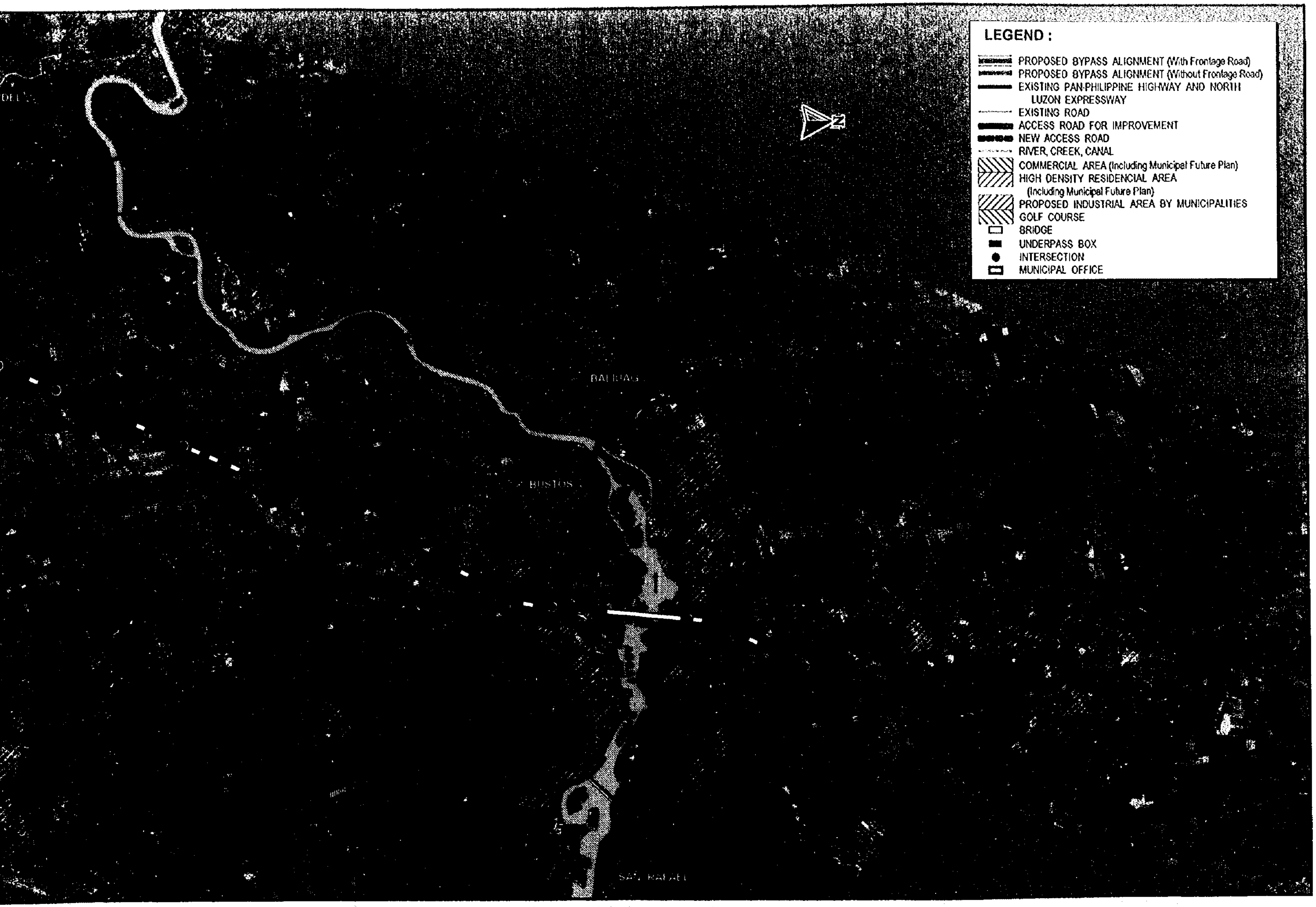


FIGURE 12.5 - 1 PROPOSED PLARIDEL-BALIUAG BYPASS

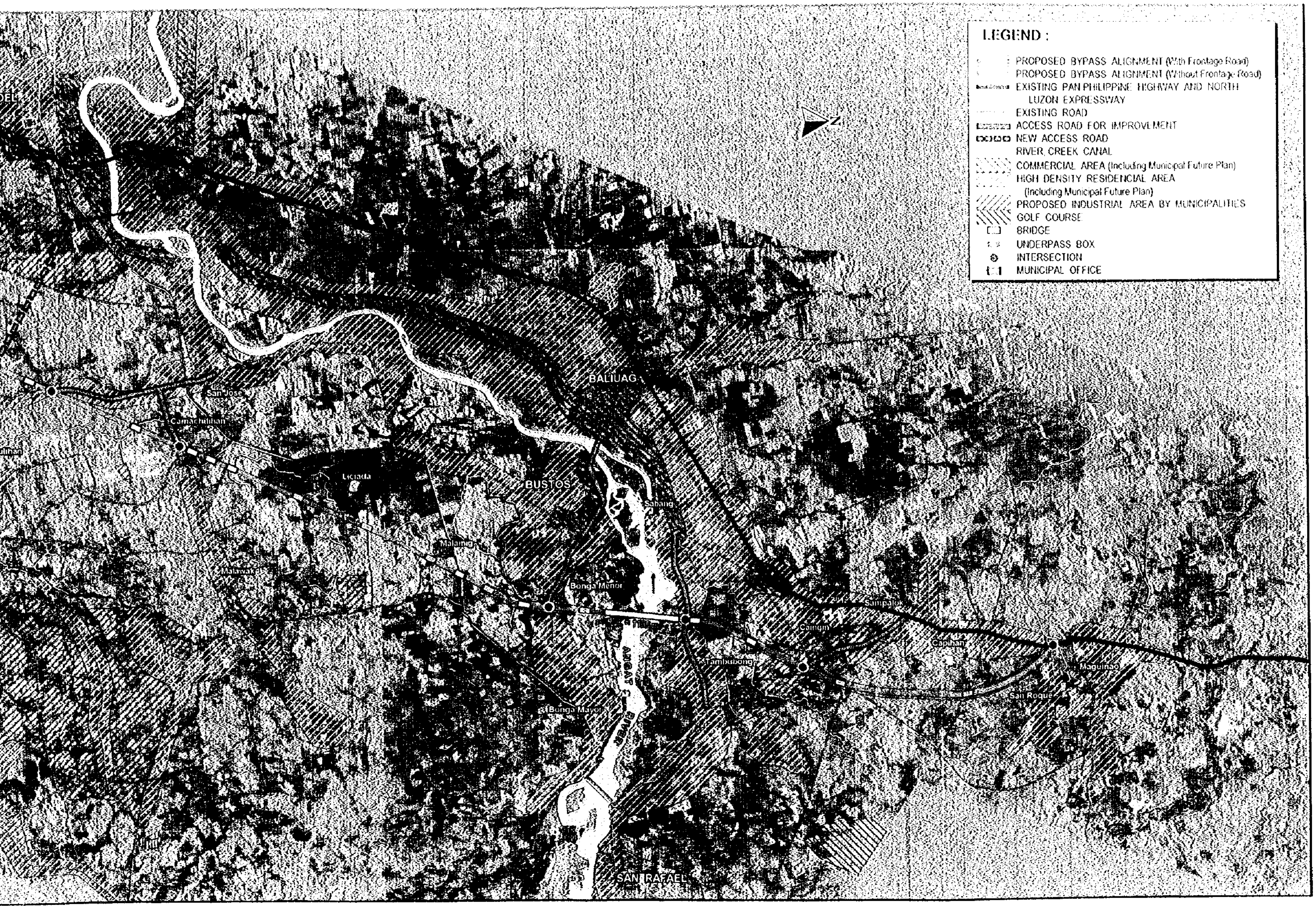


FIGURE 12.5 - 1 PROPOSED PLARIDEL-BALIUAG BYPASS