# CHAPTER 10
# CABANATUAN BYPASS DESIGN

## 10.1 Highway Design

### 10.1.1 Design Policy

The same design policy as Plaridel Bypass was adopted for Cabanatuan Bypass.

Figure 10.1-1(1) and (2) show the standard cross-sections with frontage roads and without frontage roads, respectively.

### 10.1.2 Alignment of the Bypass

Figure 10.1-2 shows the alignment of the bypass and the locations of intersections.

- The total length of the bypass is about 34.25 km. Sections with frontage roads have a length of 6.91 km.
- The bypass has one (1) new access road connected to the small-scale ring road of the city area which provides access to the Bus/Jeepney Transport Terminal.
- There are ten (10) major at-grade intersections, twenty five (25) minor intersections, and twenty one (21) under-boxes.
- Thirteen (13) out of minor intersections are openings for crossing only, including maintenance roads along irrigation canals.
- Sixteen (16) out of under-boxes are for farmers or pedestrians. Those vertical clearances are 2.5 m.

### 10.1.3 Intersection Layout

Cabanatuan Bypass has fifty nine (59) intersections. The features and roles of intersecting roads are explained in Table 10.1-1. Figure 10.1-3 shows traffic movement along Cabanatuan Bypass.

**TABLE 10.1-1 FEATURES AND ROLES OF INTERSECTING / ACCESS ROADS (CABANATUAN BYPASS)**

| Type of Intersections | Descriptions |
|---|---|
| A-1 (Major Intersection) | The starting point of bypass from the existing Pan-Philippine Highway. A traffic signal shall be installed. |
| A-2* | An existing 4.0m unpaved road. This road connects the existing highway to another barangay road. Along this road are vast areas of rice fields. An at-grade crossing only at bypass. |
| B-1* | A farm underpass crossing. This access is a 2.5m clearance underpass crossing for farmers to cross the bypass towards other rice field areas. |
| A-3* | Existing 4.0m unpaved road shall be connected to the bypass as at-grade crossing only. |
| B-2* | A 2.5m clearance farm underpass crossing. |
| A-4 | An existing 3.5m unpaved barangay road. This road connects to the existing highway from another barangay road. A minor road. |
| A-5* | An existing 3.0m unpaved barangay road. This road connects to the existing highway from another barangay road. An at-grade crossing only at bypass. |
| A-6 | An existing 4.0m unpaved barangay road. This road connects to the existing highway and the town of Gen. Tinio. A minor road. |
| A-7 | An existing old PNR line with 4.0 m wide unpaved road. A minor road. |
| B-3* | A farm 2.5m clearance underpass crossing. |
| A-8 | An existing 4.0m unpaved barangay road. This road connects to the existing highway and a barangay road. A minor road. |
| A-9* | Existing 3.5m unpaved dead end road which connects to another barangay road. An at-grade crossing only at bypass. |
| B-4* | A farm 2.5m clearance underpass crossing. |
| B-5* | A farm 2.5m clearance underpass crossing. |
| A-10 (Major Intersection) | An existing provincial road 5.0m wide PCCP. This is a major road to and from the existing highway. This road connects Santa Rosa to Fort Magsaysay and vice versa. A traffic signal shall be installed. |
| A-11 | An existing 3.5m unpaved barangay road. This road connects the existing provincial road and a barangay road. A minor road. |
| A-12* | An existing 3.5m unpaved road. This is a dead-end road that connects to the existing barangay road. An at-grade crossing only at bypass. |
| B-6* | A farm 2.5m clearance underpass clearance crossing. |
| A-13* | An existing 3.5m unpaved road. This barangay road connects to another barangay road. An at-grade crossing only at bypass. |
| A-14 (Major Intersection) | New Access road connecting the bypass and circumferential road near city proper. A traffic signal shall be installed. |
| A-15 (Major Intersection) | An existing 5.0m unpaved road. This road connects city proper to a barangay road. However, several residential subdivisions is developing along this road. A traffic signal shall be installed. |
| C-1 | Existing unpaved road 2.5m wide. This road connects to frontage road of the bypass. An underpass B-7 is 300m away. |
| B-7 | A farm road 4.4m clearance underpass crossing only. This road uses the frontage road as an access to the bypass. |
| A-16 | Existing 3.5m unpaved dead end road which connects to a municipal road. A minor road. |
| C-2 | Existing earth road 3.0m wide. This is a dead end road towards few communities. This road connects from barangay to frontage road of the bypass. An underpass B-8 is 250m away. |
| B-8 | A farm road 4.4m clearance underpass crossing only. This road uses the frontage road as an access to the bypass. |
| A-17* | An existing barangay road branching from another barangay road 3.5m wide. An at-grade crossing only at bypass. |
| C-3 | An existing private access road to connect to the frontage road. An underpass B-9 is 150m away. |

| | |
|---|---|
| B-9 | A farm road 4.4m clearance underpass crossing only. This road uses the frontage road as an access to the bypass. |
| A-18 (Major Intersection) | A major provincial road connecting Cabanatuan City to Palayan City. A 6.10m existing PCCP. A traffic signal shall be installed. |
| B-10 | An existing barangay road 3.0m wide. An underpass crossing 4.4m clearance will be provided. This road uses the frontage road as an access to the bypass. |
| A-19 (Major Intersection) | This road connects the existing highway to provincial road. A 5.0m existing PCCP. A developing residential subdivision is along this road. A traffic signal shall be installed. |
| C-4 | An existing barangay road 4.0m connecting to another barangay road. This road only connects to the frontage road. |
| A-20 | An existing municipal paved road that links Cabanatuan City and Gen. Natividad. A minor road. |
| B-11* | A farm 2.5m clearance underpass crossing. |
| B-12* | A farm 2.5m clearance underpass crossing. |
| A-21 (Major Intersection) | A major route to the town of *Gen Natividad from* existing highway. A traffic signal shall be installed. |
| B-13* | A farm 2.5m clearance underpass crossing. |
| A-22* | An existing 4.0m wide irrigation road. This road is for irrigation maintenance access. An at-grade crossing only at bypass. |
| B-14* | A farm 2.5m clearance underpass crossing. |
| A-23 | An existing municipal road that will link to a provincial road. A minor road. |
| B-15* | A farm 2.5m clearance underpass crossing. |
| B-16* | A farm 2.5m clearance underpass crossing. |
| B-17* | A farm 2.5m clearance underpass crossing. |
| A-24* | An existing 4.0m irrigation road. This road is for irrigation maintenance access. An at-grade crossing only at bypass. |
| A-25 (Major Intersection) | A major provincial road that will link to Llanera town. A traffic signal shall be installed. |
| B-18* | An existing barangay road 3.0m wide. A road underpass 2.5m clearance crossing only. |
| A-26* | An existing 3.5m wide unpaved road. This barangay road connects to an irrigation road. An at-grade crossing only at bypass. |
| A-27 | An existing 3.5m wide unpaved barangay road that connects to the irrigation road. A minor road. |
| A-28* | An existing 3.5m unpaved road that connects to the irrigation road. An at-grade crossing only at bypass. |
| A-29* | An existing 3.5m unpaved road. This barangay road connects to a municipal road. An at-grade crossing only at bypass. |
| A-30 (Major Intersection) | An existing 5.0m paved municipal road that *links to the existing highway.* This is a major route to Talavera proper from many barangays. A traffic signal shall be installed. |
| B-19* | A farm 2.5m clearance underpass crossing. |
| B-20* | A farm 2.5m clearance underpass crossing. |
| A-31* | An existing 3.5m unpaved road. This barangay road connects to Talavera town proper. An at-grade crossing only at bypass. |
| A-32 | A minor municipal unpaved road connecting to existing Pan-Philippine highway 5.0m wide. |
| B-21 | Existing barangay road 3.0m wide. Farm/ road underpass 2.5m clearance shall be placed for community access. |
| A-33 | Existing is a 4.0m wide dead-end barangay road. A minor road. |
| A-34 | An existing barangay road 5.0m wide to connect to existing Pan-Philippine highway to another barangay road. A minor road. |
| A-35 (Major Intersection) | This major road connects the existing Pan-Philippine Highway to the bypass. A traffic signal shall be installed. |

***Note:*** *Shown intersection "Type A" with asterisk (*) are just at-grade crossing only. Not designed with turning movements to and from the bypass. Intersection "Type B" with asterisk (*) are farm underpass crossing only located along rice field or other agro-industrial farm areas.*

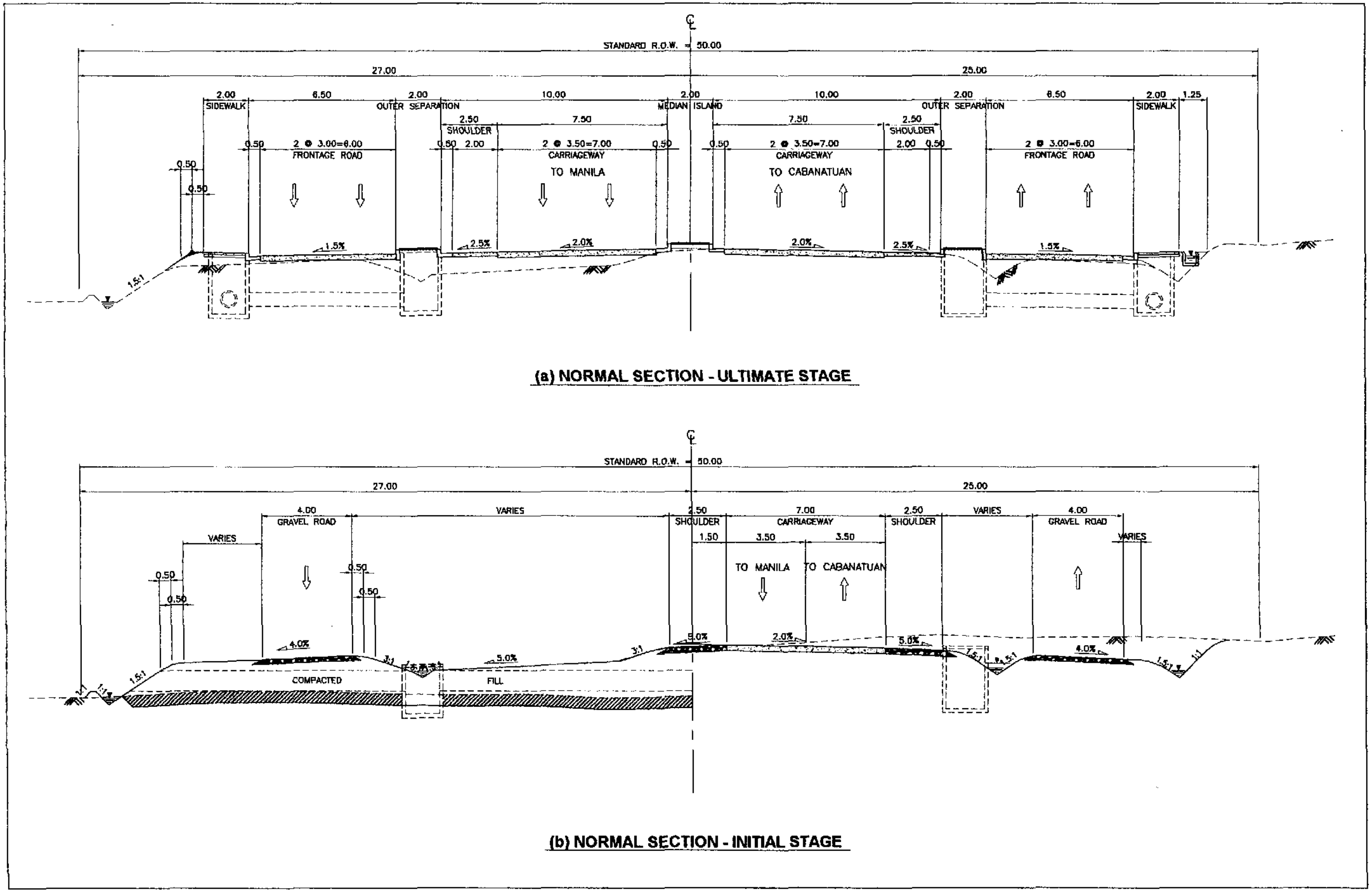
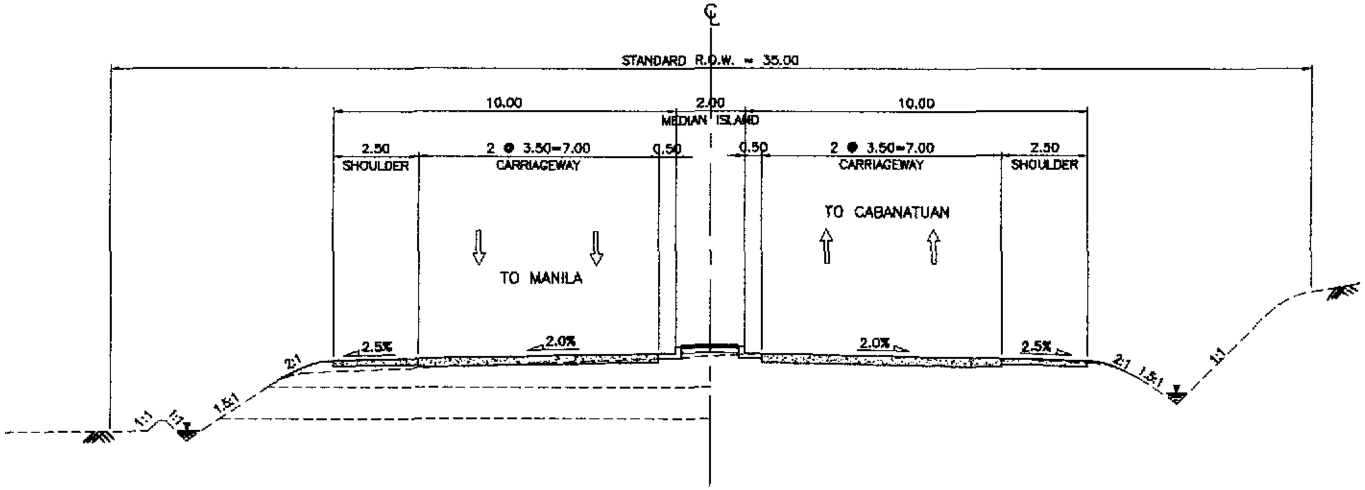
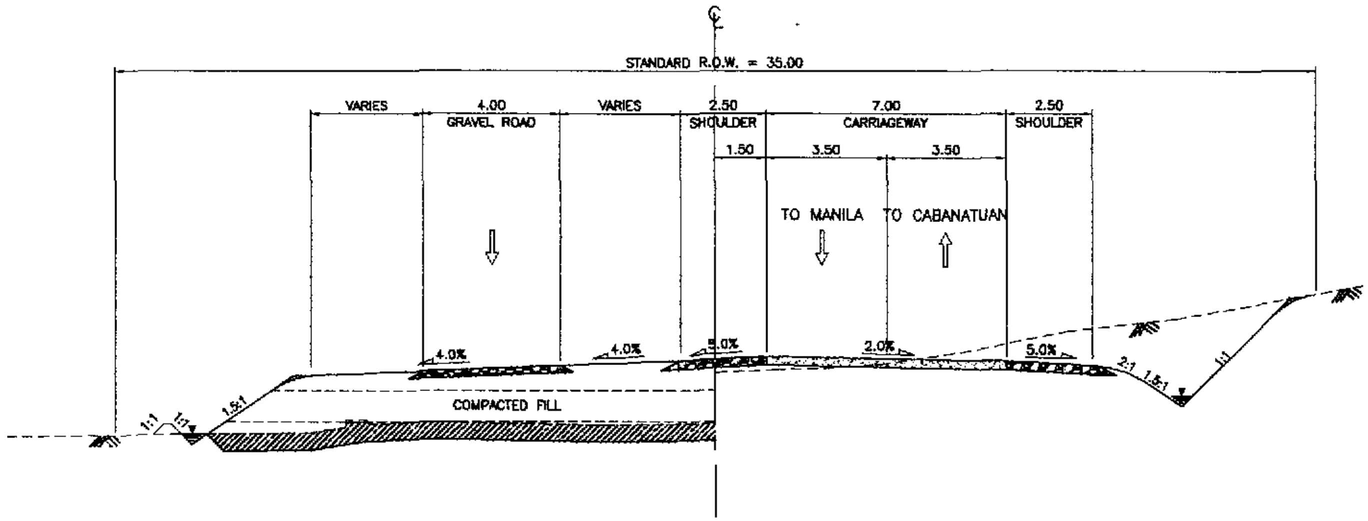



FIGURE 10.1-1(1) TYPICAL CROSS SECTIONS - WITH FRONTAGE ROAD (CABANATUAN BYPASS)




(a) NORMAL SECTION - ULTIMATE STAGE




(b) NORMAL SECTION - INITIAL STAGE

**FIGURE 10.1-1(2) TYPICAL CROSS SECTIONS - WITHOUT FRONTAGE ROAD (CABANATUAN BYPASS)**

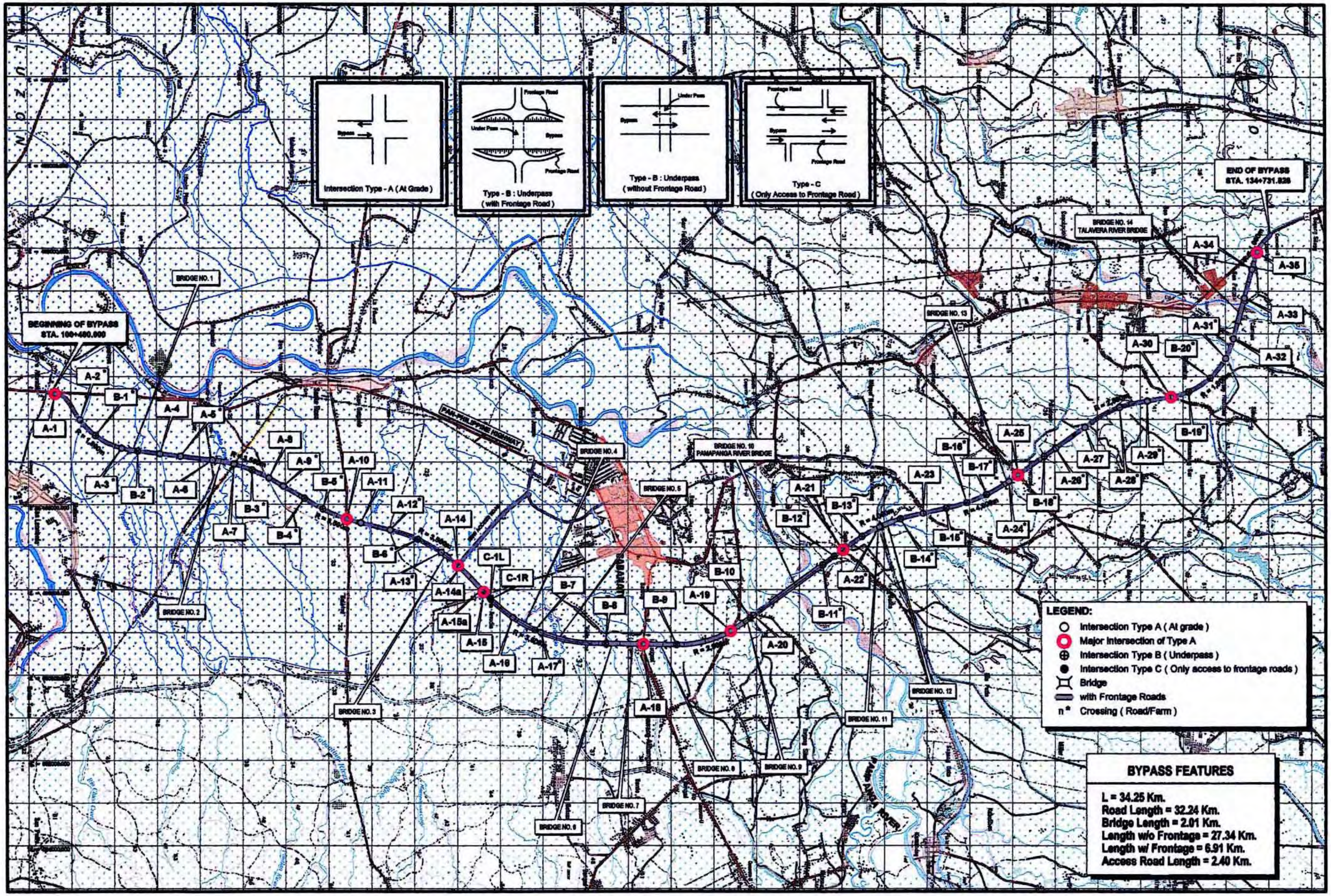
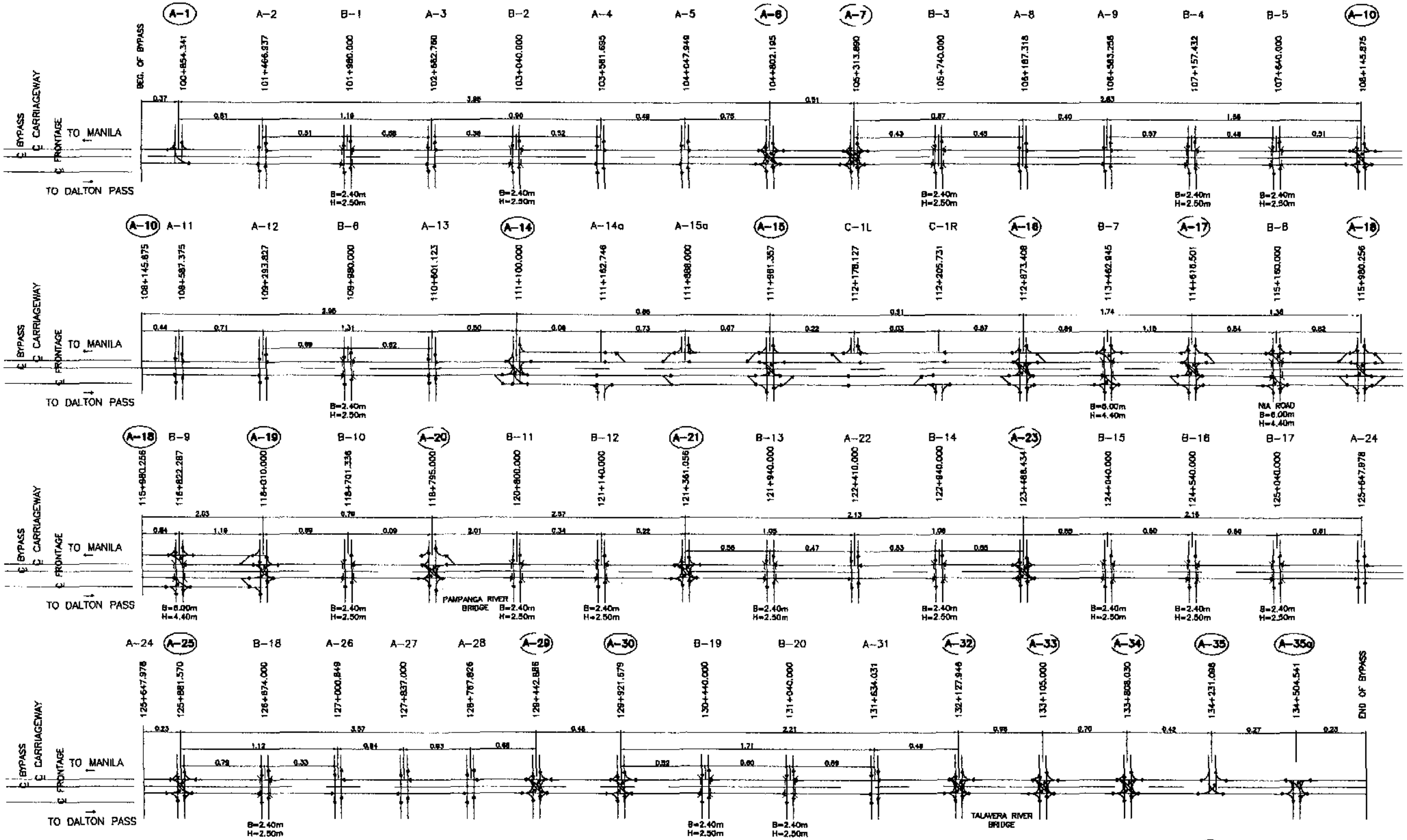



**FIGURE 10.1-2 ALIGNMENT OF CABANATUAN BYPASS**




MAJOR INTERSECTION
MINOR INTERSECTION

**FIGURE 10.1-3 TRAFFIC MOVEMENTS AT INTERSECTIONS OF CABANATUAN BYPASS**

### 10.1.4 Directional Traffic Flow at Major Intersection

Figure 10.1-4 (1) and (2) show the forecasted directional traffic flow at the major intersections in year 2020.

### 10.1.5 Beginning and End Intersection Scheme

The scheme of the beginning and end intersections of Cabanatuan Bypass is shown in Figure 10.1-5. These schemes are the same as those of the end and beginning intersections of San Jose Bypass, respectively. The selection of these intersection schemes is discussed in Chapter 11.

Another major at-grade intersections were designed applying the concept of those of Plaridel Bypass.

### 10.1.6 Minor Intersections

Intersection layout adopted by Plaridel Bypass was followed for this bypass.

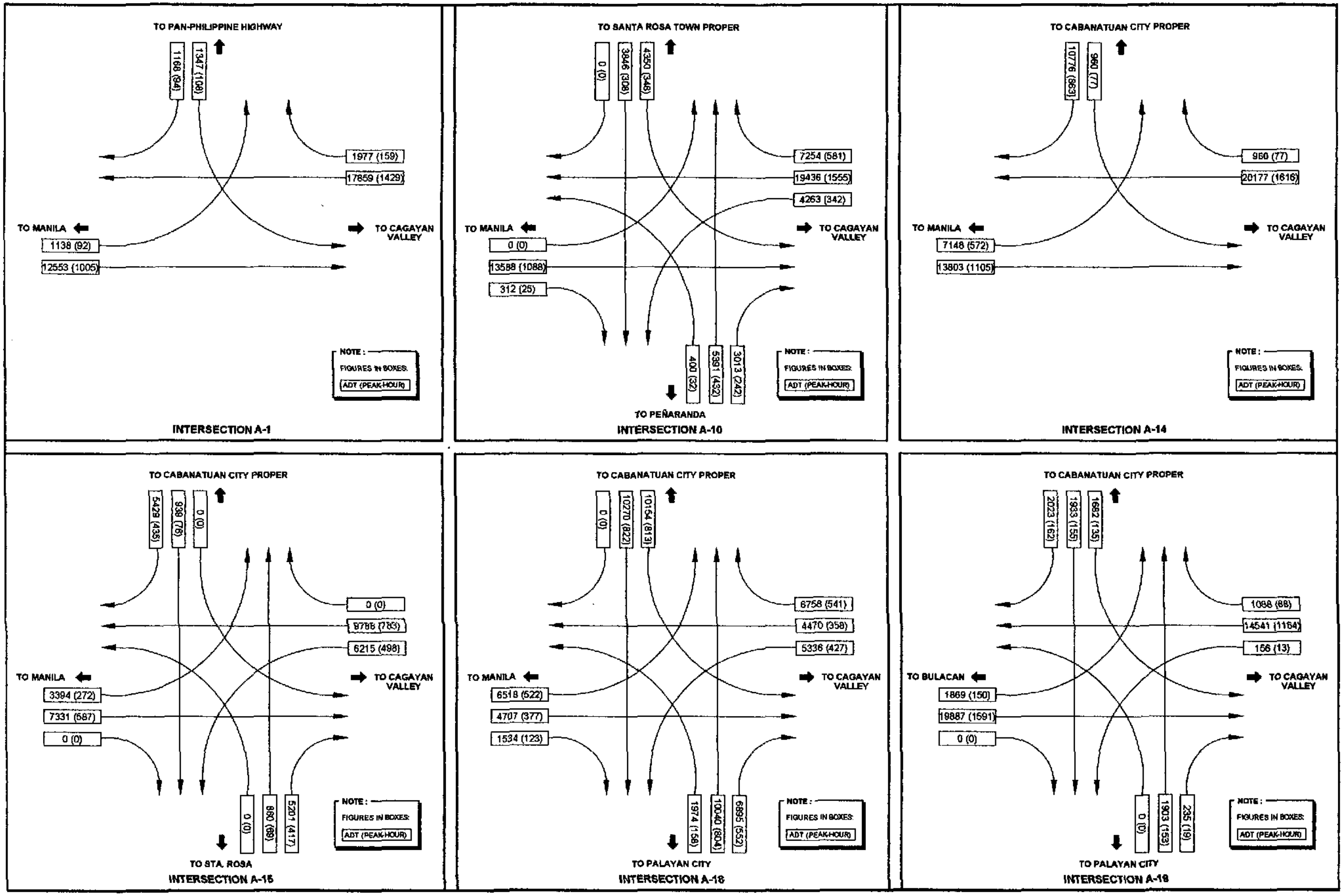



FIGURE 10.1-4 (1) YEAR 2020 DIRECTIONAL PEAK-HOUR TRAFFIC FLOW AT INTERSECTIONS ( CABANATUAN BYPASS )

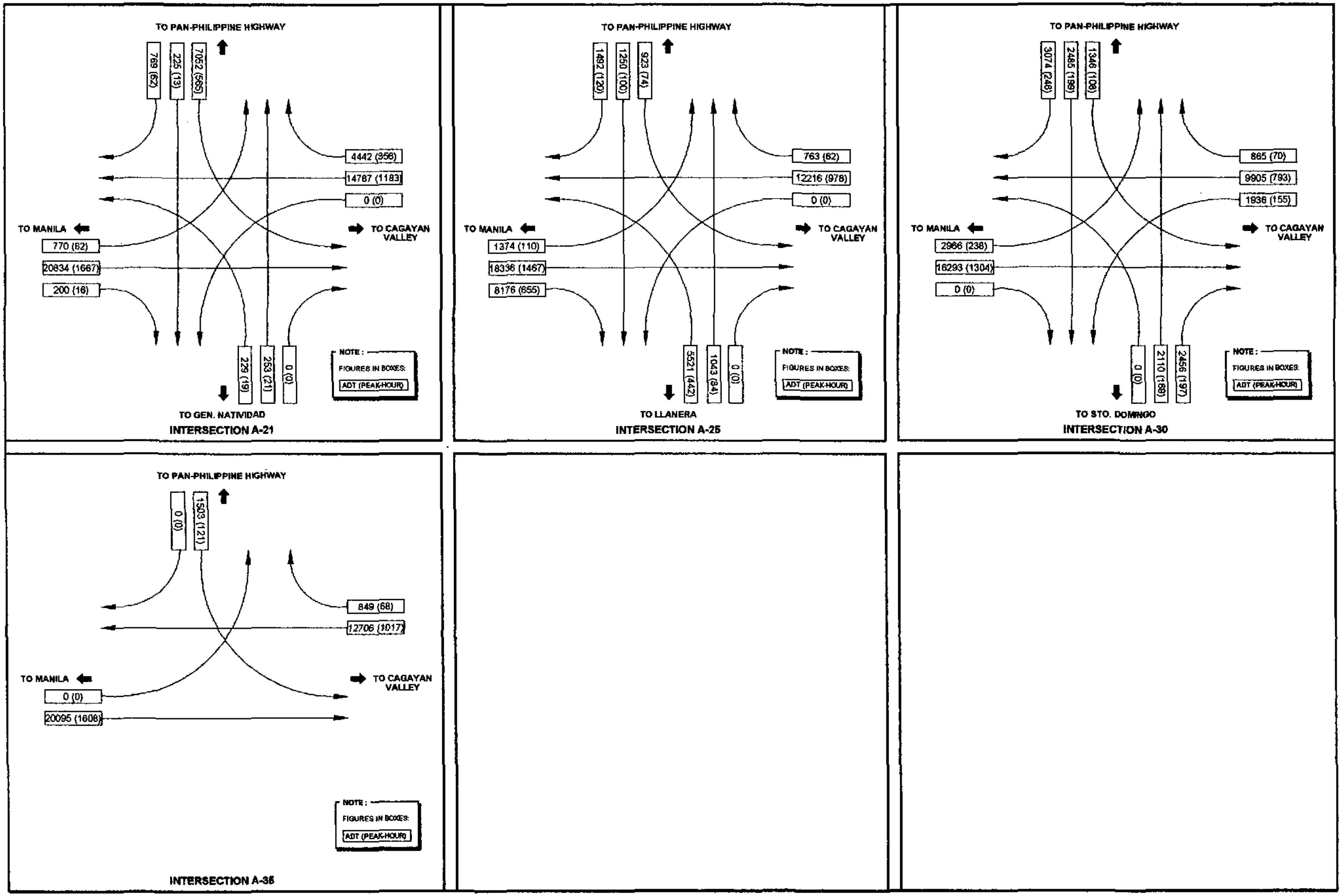
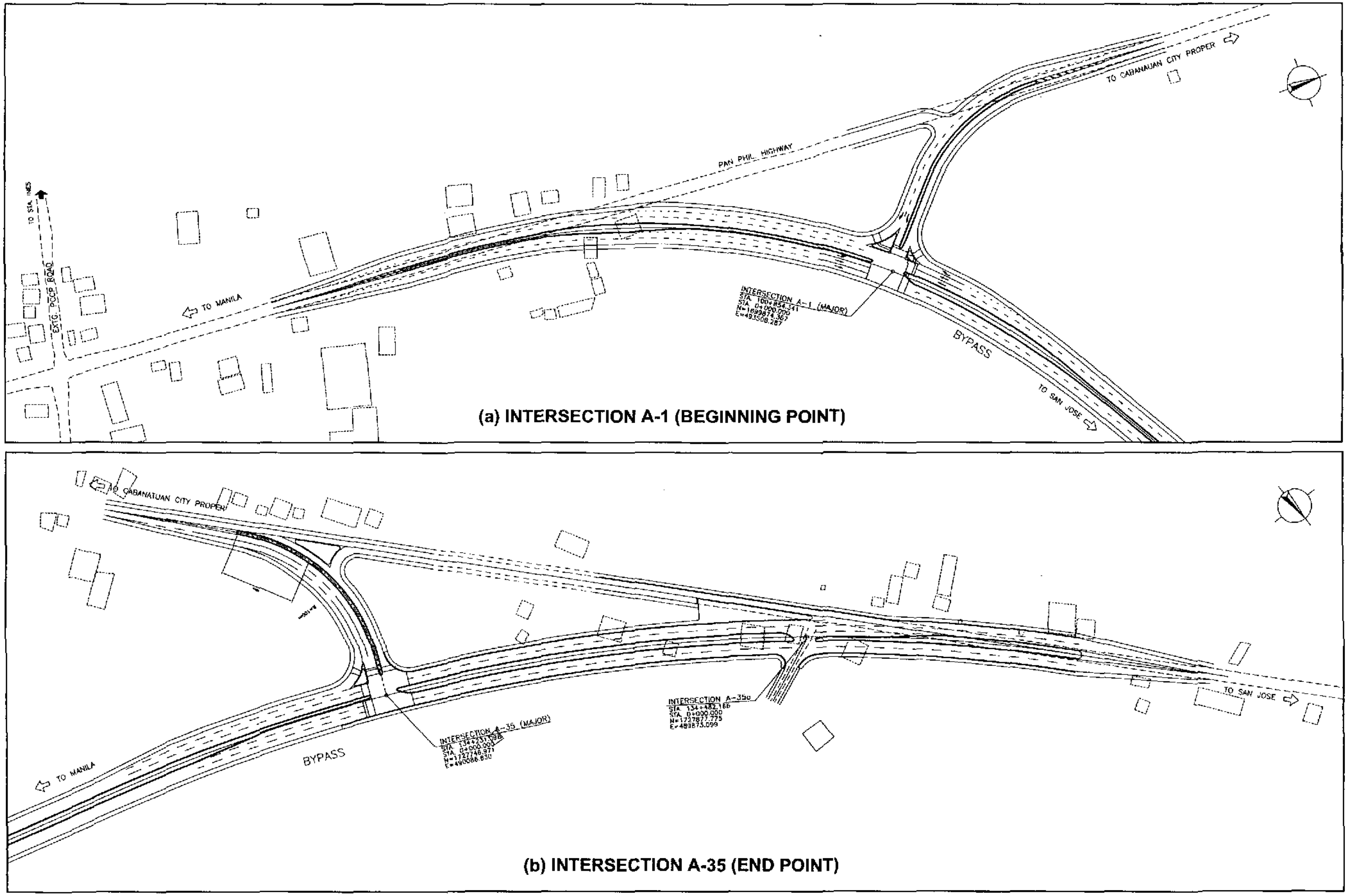



**FIGURE 10.1-4 (2) YEAR 2020 DIRECTIONAL PEAK-HOUR TRAFFIC FLOW AT INTERSECTIONS ( CABANATUAN BYPASS )**




(a) INTERSECTION A-1 (BEGINNING POINT)

(b) INTERSECTION A-35 (END POINT)

**FIGURE 10.1-5 MAJOR INTERSECTIONS OF CABANATUAN BYPASS**

## 10.2 Drainage Design

### 10.2.1 Cross Drainage

The same design concept and standards as Plaridel Bypass were adopted for this Bypass.

Catchment areas of Cabanatuan Bypass are shown in Figure 10.2-1. There are 80 catchment areas identified including 14 locations where bridges are constructed. The hydrological characteristics of these watersheds, their estimated discharge for the different return periods and capacity of proposed drainage structures are presented in Appendix 10.2-1. Ten (10) years return period for RCPC and 25 years for RCBC was considered.

Drainage system of Cabanatuan Bypass is shown in Figure 10.2-2.

### 10.2.2 Surface Drainage

1) System of Drainage

The same surface drainage system as Plaridel Bypass was adopted.

2) Curb Inlet Locations and Spacing

Tables 10.2-1 and 2 shows the estimated spread length of water in relation to inlet spacing for the main carriageway and the frontage road, respectively.

**TABLE 10.2-1 SURFACE RUNOFF OF MAIN CARRIAGEWAY**

| Inlet Spacing | Drained Area | Runoff Discharge | Spread Length |
|---|---|---|---|
| S (m) | A ($km^2$) | Q ($m^3$/sec) | T (m) |
| 10 | 0.000,150 | 0.00527 | 0.955 |
| 15 | 0.000,220 | 0.00790 | 1.112 |
| 20 | 0.000,290 | 0.01053 | 1.239 |
| 25 | 0.000,360 | 0.01317 | 1.347 |
| 30 | 0.000,440 | 0.01580 | 1.442 |
| 35 | 0.000,510 | 0.01844 | 1.528 |
| 40 | 0.000580 | 0.02107 | 1.607 |
| 45 | 0.000,650 | 0.02370 | 1.679 |
| 50 | 0.000,730 | 0.02634 | 1.747 |

Note: 50m is the maximum allowable spacing by DPWH Standard

**TABLE 10.2-2 SURFACE RUNOFF OF FRONTAGE ROAD**

| Inlet Spacing | Drained Area | Runoff Discharge | Spread Length |
|---|---|---|---|
| S (m) | A ($km^2$) | Q ($m^3$/sec) | T (m) |
| 10 | 0.000,110 | 0.00381 | 1.013 |
| 15 | 0.000,160 | 0.00572 | 1.179 |
| 20 | 0.000,210 | 0.00763 | 1.314 |
| 25 | 0.000,260 | 0.00954 | 1.429 |
| 30 | 0.000,320 | 0.01144 | 1.530 |
| 35 | 0.000,370 | 0.01335 | 1.621 |
| 40 | 0.000,420 | 0.01526 | 1.704 |
| 45 | 0.000,470 | 0.01717 | 1.781 |
| 50 | 0.000,530 | 0.01907 | 1.853 |

Note: 50m is the maximum allowable spacing by DPWH Standard

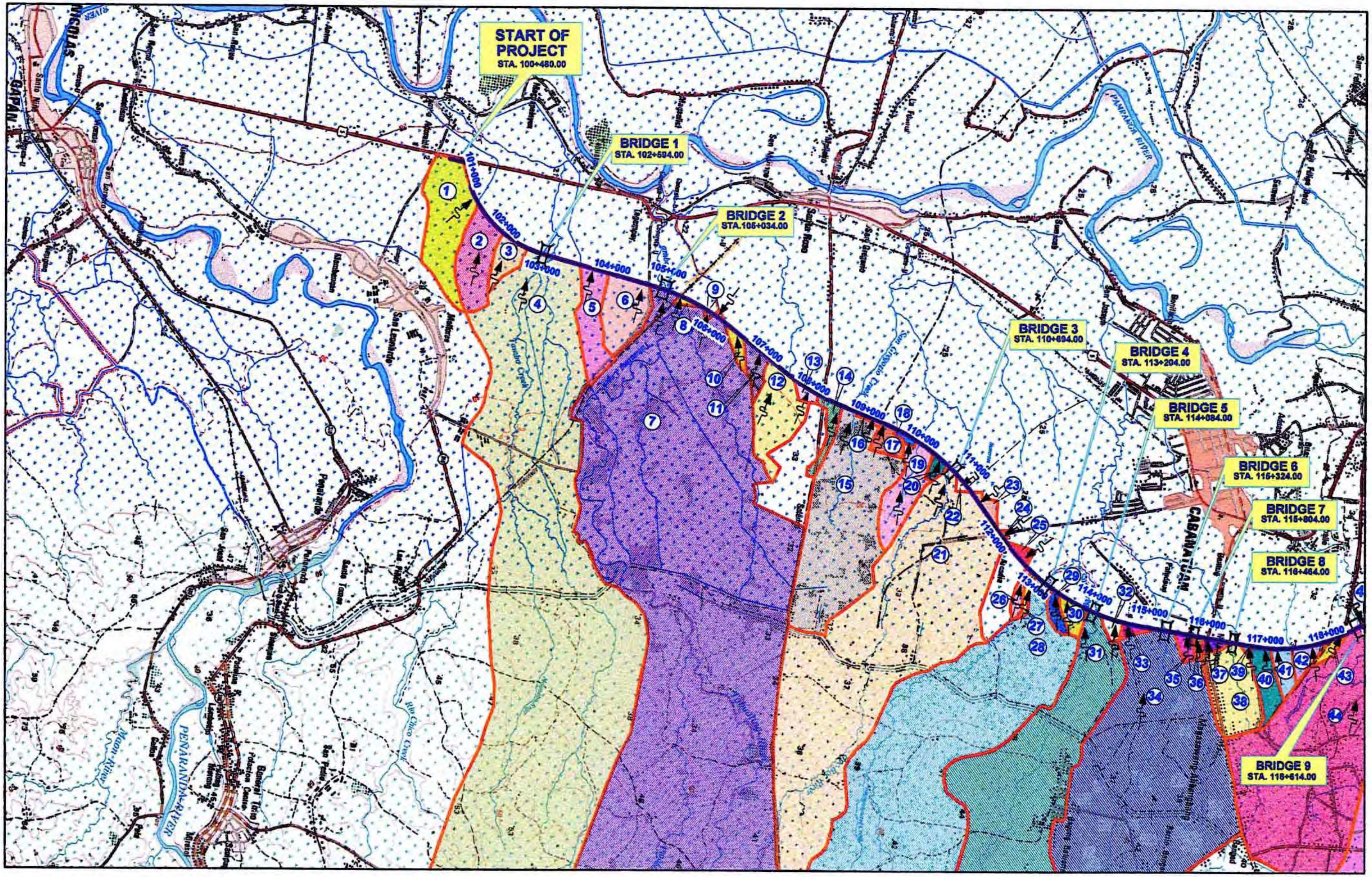



**FIGURE 10.2-1 CABANATUAN BYPASS CATCHMENT AREAS ( 1/2 )**

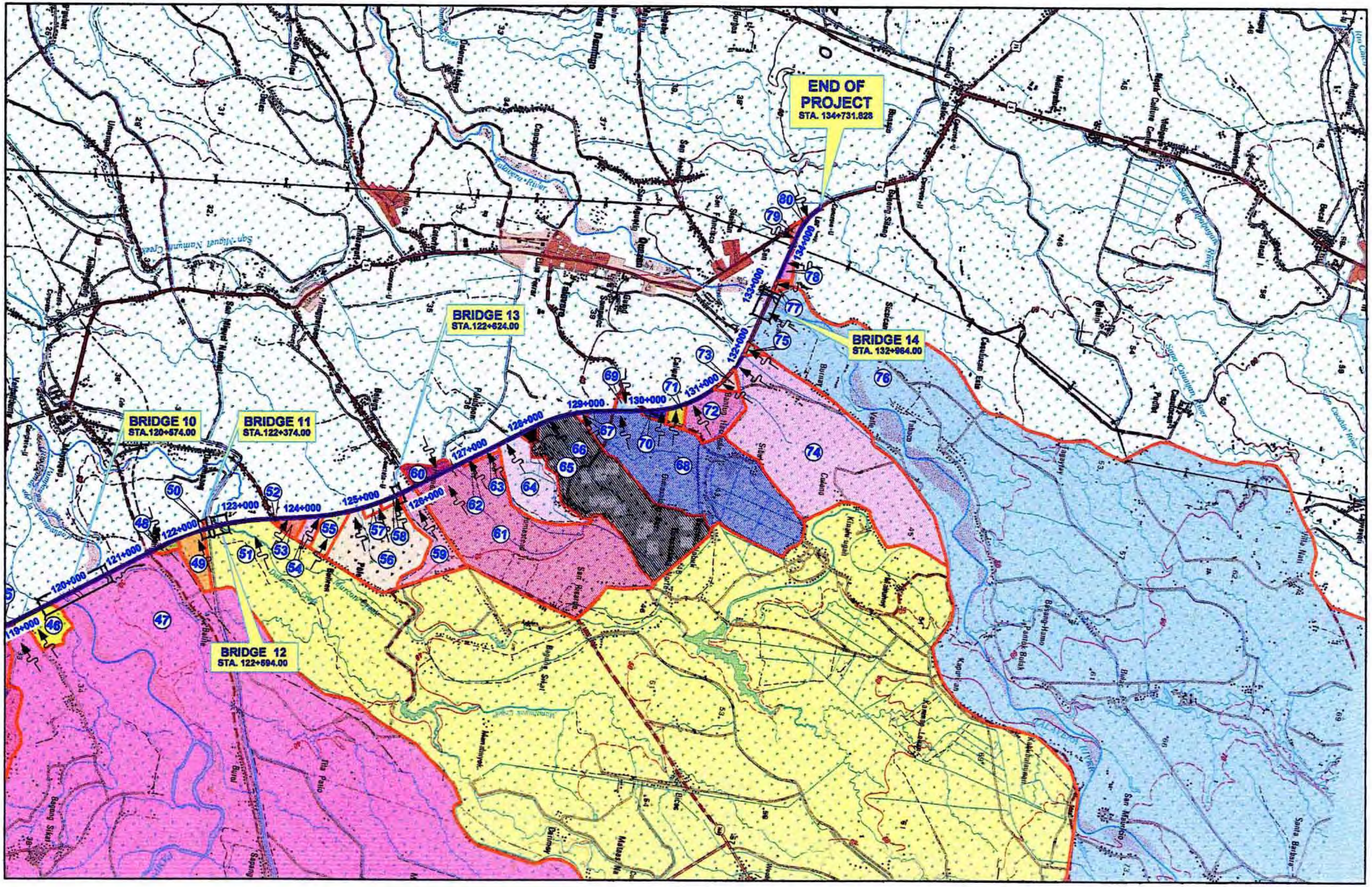



**FIGURE 10.2-1 CABANATUAN BYPASS CATCHMENT AREAS ( 2/2 )**

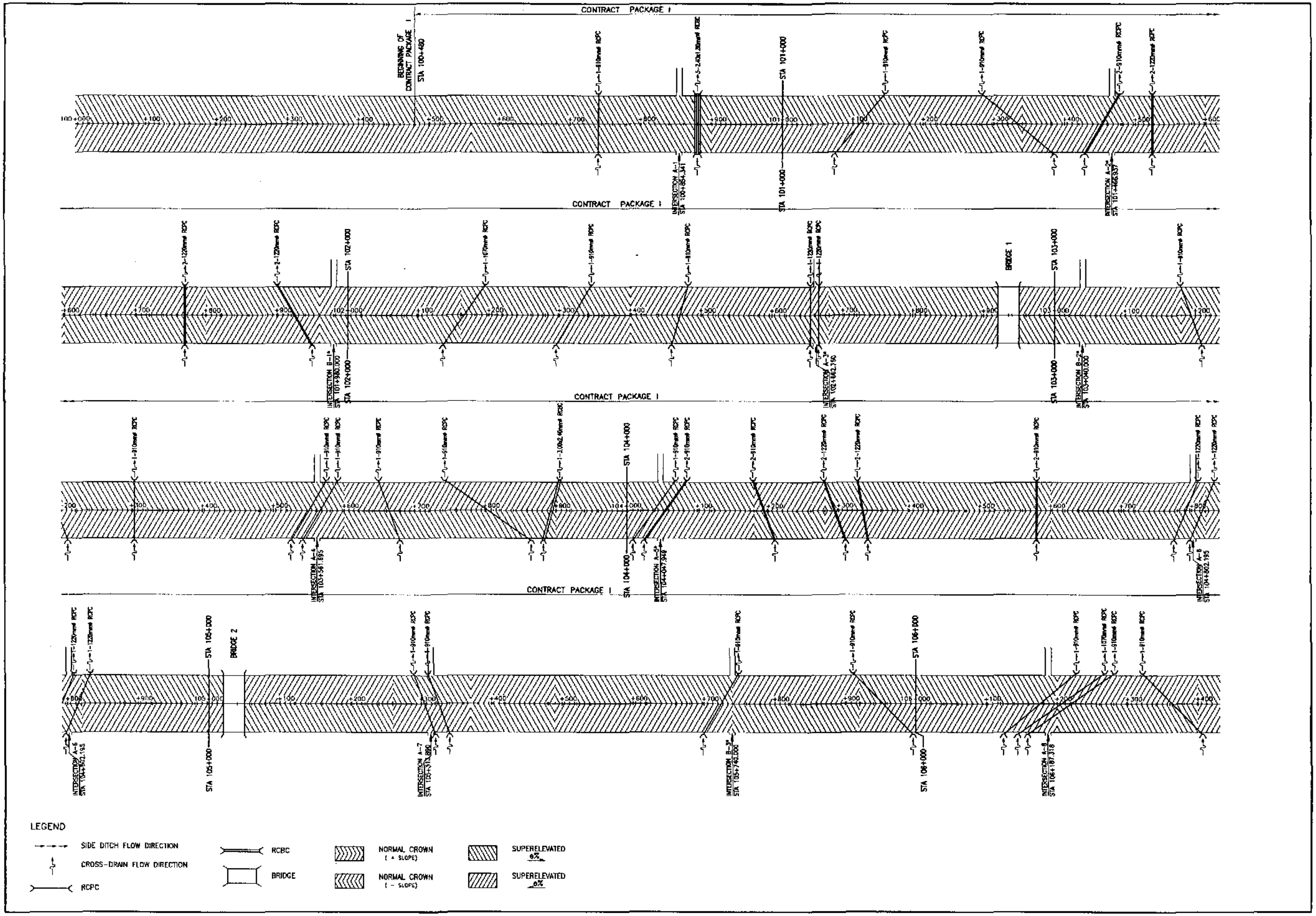



**FIGURE 10.2-2 (1/6) - DRAINAGE SYSTEM OF CABANATUAN BYPASS**

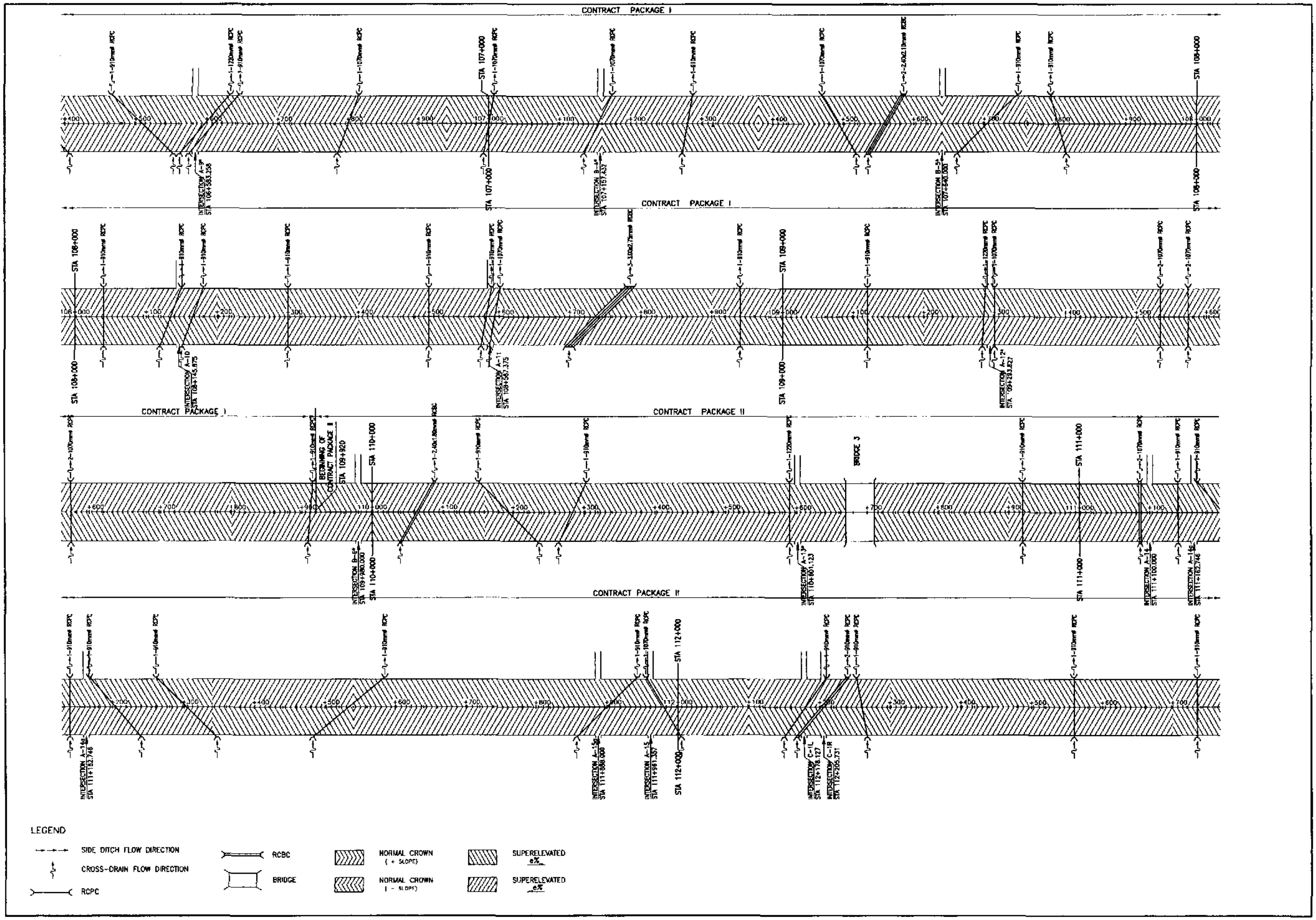



**FIGURE 10.2-2 (2/6) - DRAINAGE SYSTEM OF CABANATUAN BYPASS**

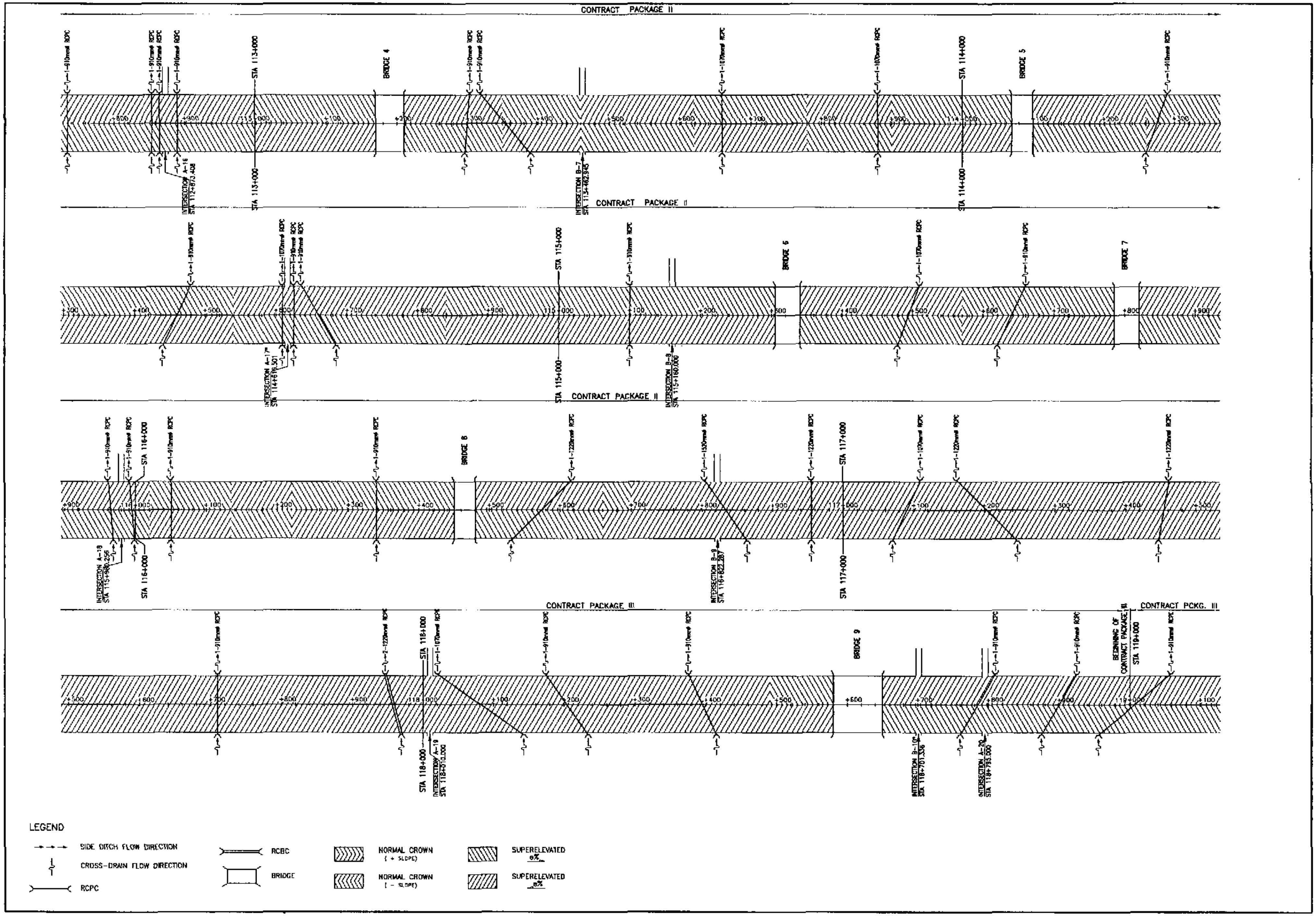



FIGURE 10.2-2 (3/6) - DRAINAGE SYSTEM OF CABANATUAN BYPASS

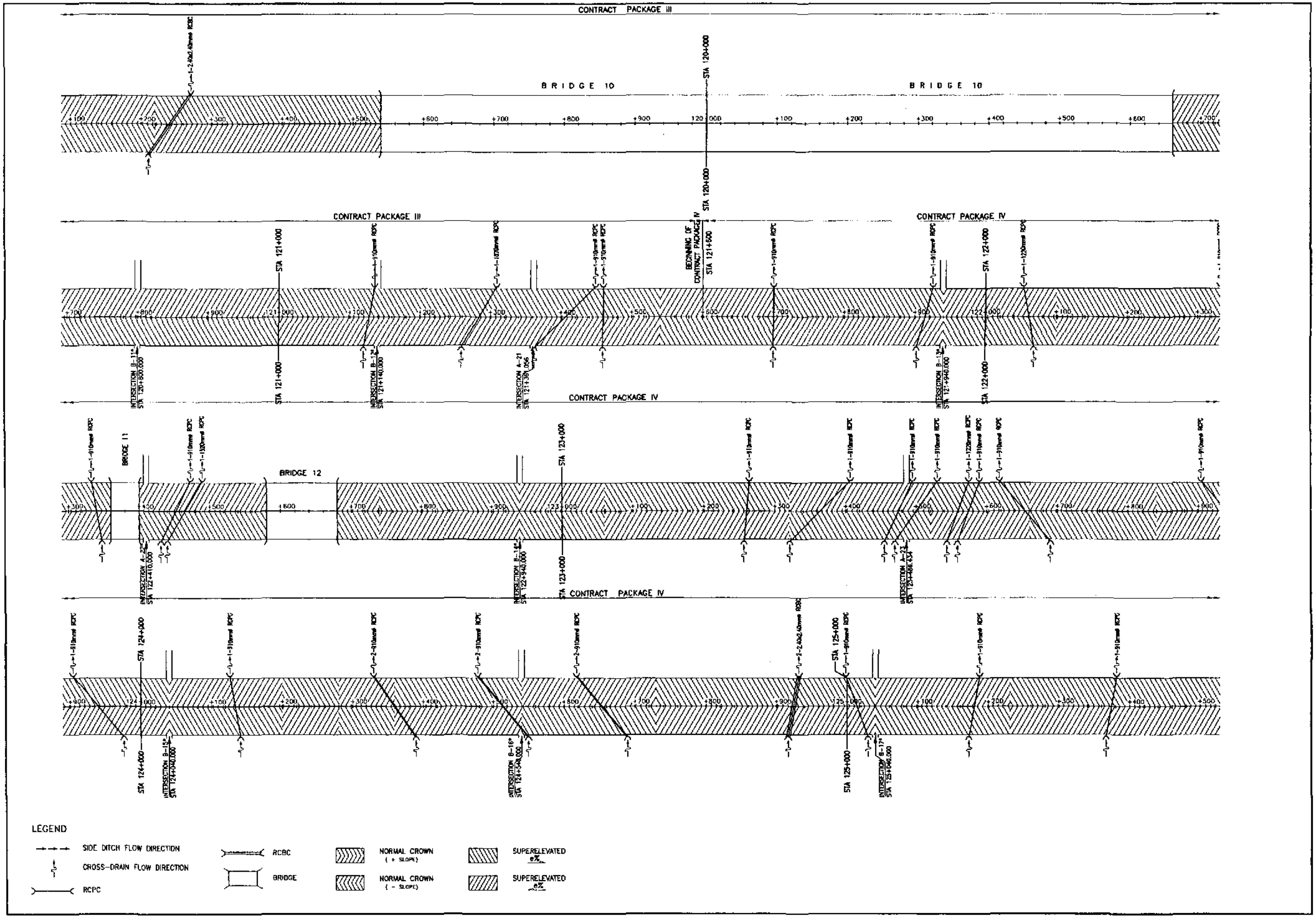



FIGURE 10.2-2 (4/6) - DRAINAGE SYSTEM OF CABANATUAN BYPASS

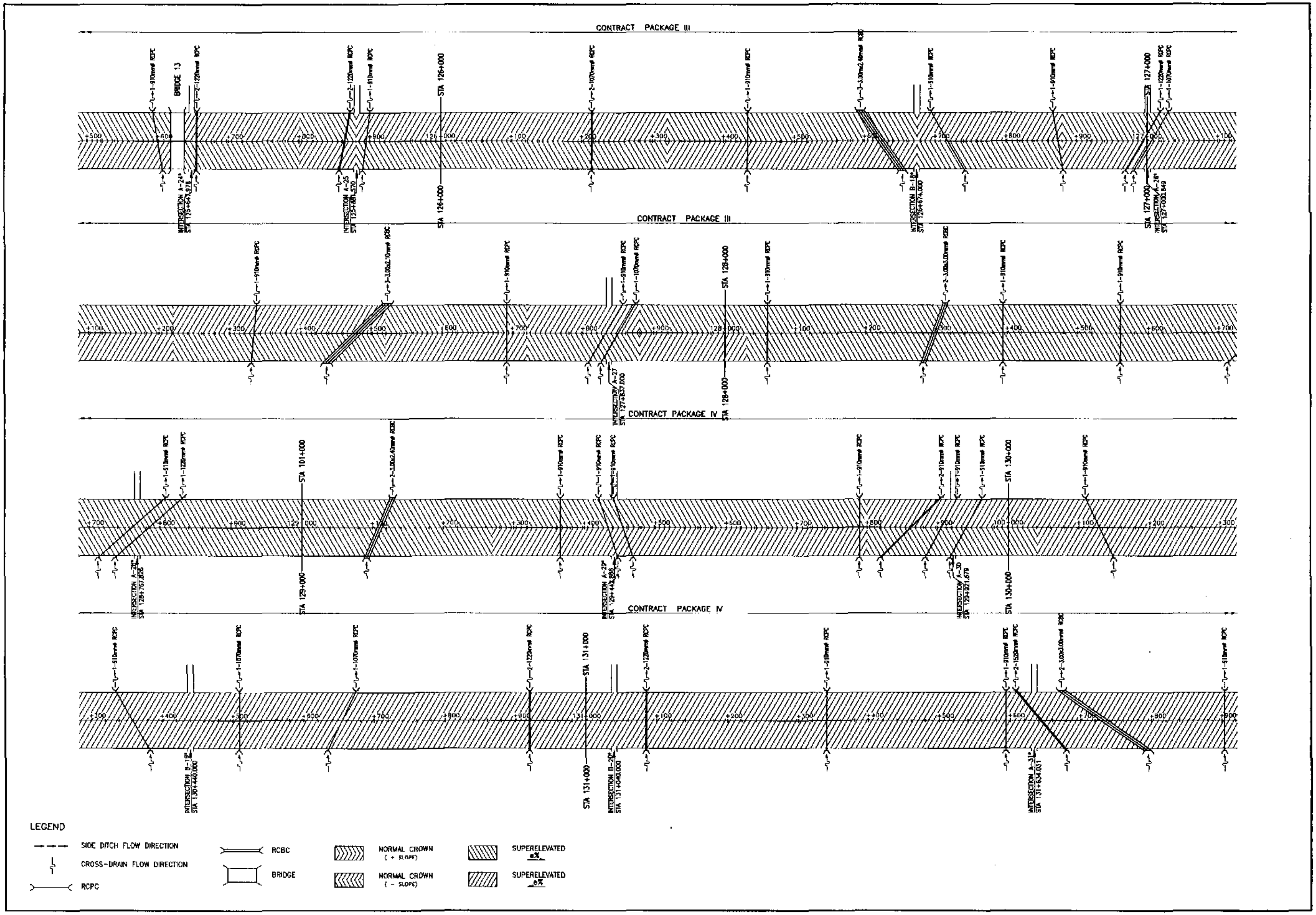



**FIGURE 10.2-2 (5/6) - DRAINAGE SYSTEM OF CABANATUAN BYPASS**

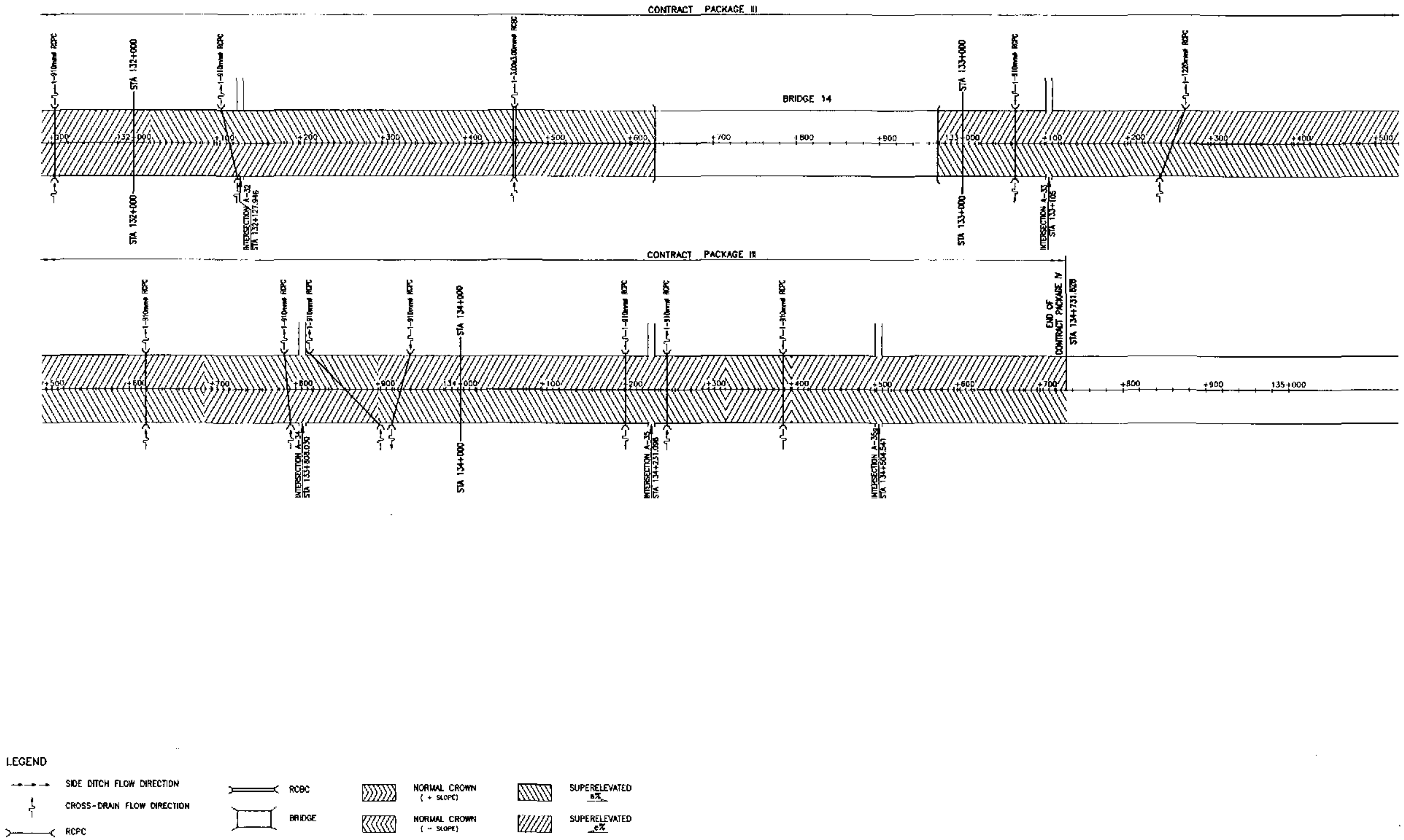



FIGURE 10.2-2 (6/6) - DRAINAGE SYSTEM OF CABANATUAN BYPASS

From the above analyses it can be concluded that:

- The maximum allowable inlet spacing as defined by DPWH Guidelines is 50 m. However, even this spacing is acceptable by the abovementioned analyses but the maximum spacing is taken at 40 m.
- In case of the main carriageway, the spread water length from the curb edge will be always less than the shoulder width even in case of supper elevation.
- In case of frontage road, the spread of water from the curb edge will be always less than one half of the lane width that coincides with USBPR Practice.

3) Curb Opening Length

The maximum inlet spacing is taken at 40m and the curb opening length is designed as 1m following the standard design. It can be concluded based on the maximum estimated runoff discharge of about 0.025 $m^3$/sec that the design is acceptable and have the enough safety margin since under this maximum rate of flow the required opening length will be:

$$L_T = 0.076\ Q^{0.42}\ S^{0.3}\ (1/nS_x)^{0.6}$$

$$L_T = 0.076 \times 0.025^{0.42} \times 0.02^{0.3} \times (1 / (0.013 \times 0.08))^{0.6}$$

$L_T$ = 0.31 m that is quite less than 1 m.

### 10.2.3 Surface Drainage of Highway Bridges

Maximum inlet spacing for surface drainage of bridges is summarized in Table 10.2-3.

**TABLE 10.2-3 DRAINAGE OF BRIDGES ALONG CABANATUAN BYPASS**

| Bridge Number | Main Carriageway | | | | Frontage Road (Ultimate-Stage) | | | |
|---|---|---|---|---|---|---|---|---|
| | Max. Inlet Spacing (m) | Runoff ($m^3$/sec) | Spread (m) | Shoulder Width (m) | Max. Inlet Spacing (m) | Runoff ($m^3$/sec) | Spread (m) | Shoulder Width (m) |
| 1 | 15 | 0.0058 | 1.53 | 2.5 | | | | |
| 2 | 15 | 0.0058 | 1.53 | 2.5 | | | | |
| 3 | 15 | 0.0058 | 1.53 | 2.5 | | | | |
| 4 | 15 | 0.0057 | 1,51 | 2.5 | 15 | 0.0046 | 1.40 | 2.5 |
| 5 | 15 | 0.0057 | 1,51 | 2.5 | 15 | 0.0046 | 1.40 | 2.5 |
| 6 | 15 | 0.0057 | 1,51 | 2.5 | 15 | 0.0046 | 1.40 | 2.5 |
| 7 | 15 | 0.0057 | 1,51 | 2.5 | 15 | 0.0046 | 1.40 | 2.5 |
| 8 | 15 | 0.0057 | 1,51 | 2.5 | 15 | 0.0046 | 1.40 | 2.5 |
| 9 | 15 | 0.0057 | 1,51 | 2.5 | 15 | 0.0046 | 1.40 | 2.5 |
| 10 | 6 | 0.0019 | 1.02 | 0.75 | | | | |
| 11 | 15 | 0.0058 | 1.53 | 2.5 | | | | |
| 12 | 15 | 0.0058 | 1.53 | 2.5 | | | | |
| 13 | 15 | 0.0058 | 1.53 | 2.5 | | | | |
| 14 | 15 | 0.0058 | 1.53 | 2.5 | | | | |
| 15 | 6 | 0.0019 | 1.02 | 0.75 | | | | |

*Note: Capacity of 150 mm pipe diameter is 0.0064 $m^3$/sec.*

## 10.3 Short / Medium Bridge Design

There are 14 bridges along Cabanatuan Bypass, of which two are long bridges (Pampanga River Bridge and Talavera River Bridge. Bridge locations are shown in Figure 10.3-1.

Hydraulic and hydrological features of each bridge are shown in Table 10.3-1. Summary of proposed bridges is shown in Table 10.3-2. Detailed description of each bridge is presented in Appendix 10.3-1.

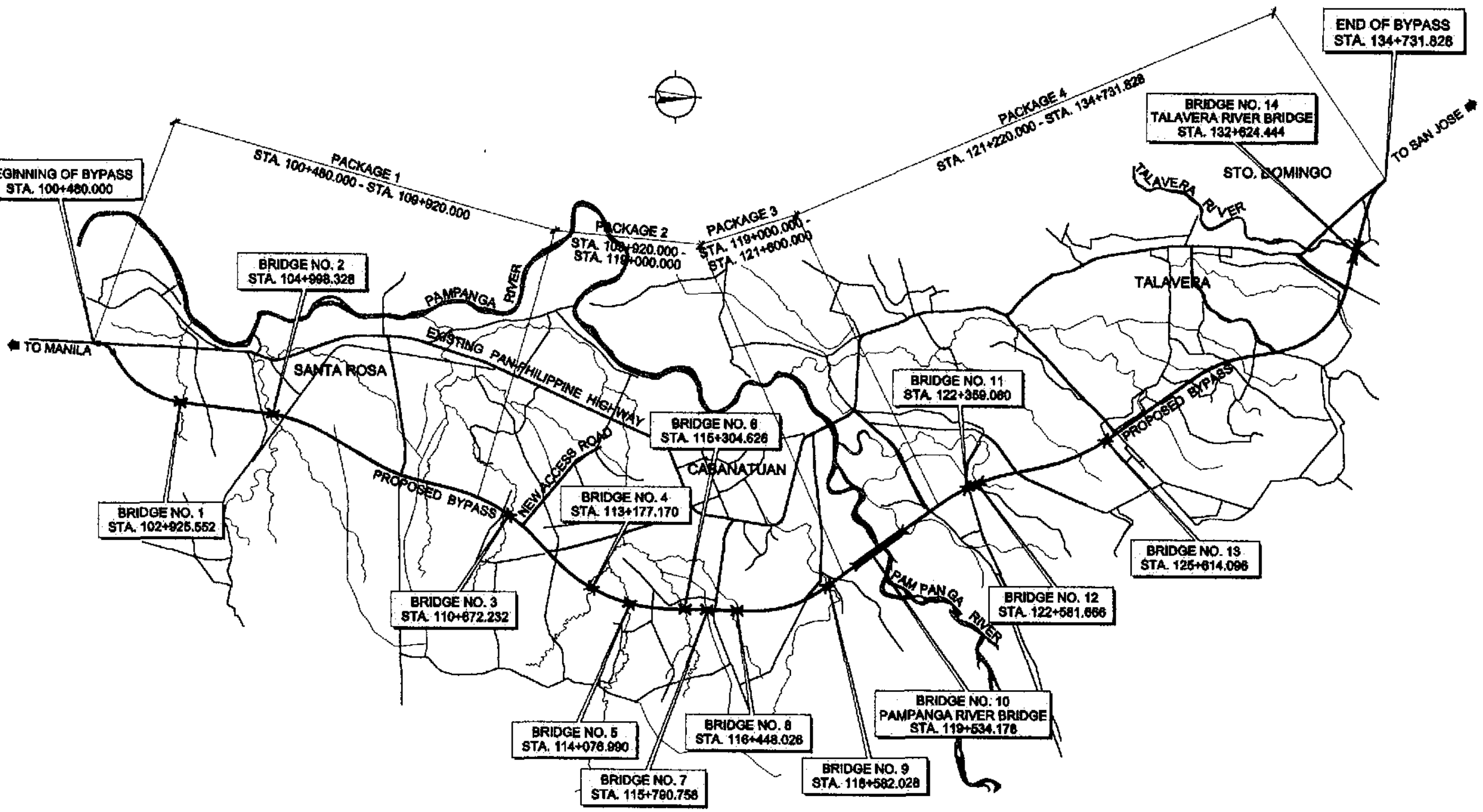
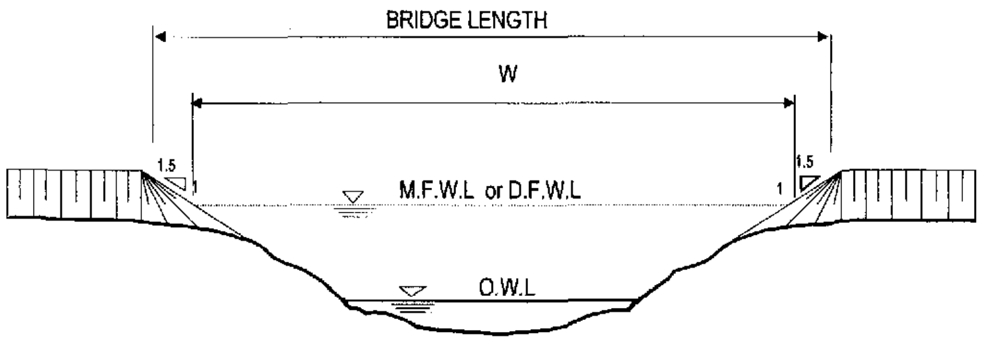



FIGURE 10.3-1 BRIDGE LOCATION : CABANATUAN BYPASS

TABLE 10.3-1 HYDRAULIC AND HYDROLOGICAL RESULTS OF SMALL AND MEDIUM RIVERS ( CABANATUAN BYPASS )

| Bridge Number | Beginning Station | 50 - year Design Hydraulics | | | | River Width,W (m) |
|---|---|---|---|---|---|---|
| | | M.F.W.L from Field Survey | Design Flood El. | Discharge Q (m3/s) | Velocity (m/s) | |
| 1 | 102 + 925.552 | 22.80 | 22.922 | 92.70 | 1.578 | 41.90 |
| 2 | 104 + 998.328 | 23.70 | 22.154 | 512.80 | 3.046 | 44.60 |
| 3 | 110 + 672.232 | 27.40 | 27.470 | 40.60 | 2.235 | 30.40 |
| 4 | 113 + 177.170 | 30.70 | 30.845 | 99.70 | 2.726 | 16.40 |
| 5 | 114 + 076.990 | 30.90 | 31.177 | 63.40 | 1.937 | 12.50 |
| 6 | 115 + 304.626 | 31.10 | 31.231 | 69.00 | 2.900 | 17.90 |
| 7 | 115 + 790. 758 | 33.70 | - | IRRIGATION | | 24.40 |
| 8 | 116 + 448.026 | 33.70 | 33.610 | 32.30 | 2.677 | 11.40 |
| 9 | 118 + 582.028 | 36.00 | 33.867 | 65.00 | 2.097 | 54.90 |
| 10 | 119 + 534 178 | PAMPANGA RIVER | | | | |
| 11 | 122 + 359.060 | 38.40 | - | IRRIGATION | | 28.60 |
| 12 | 122 + 581.666 | 34.30 | 34.422 | 735.50 | 3.200 | 50.30 |
| 13 | 125 + 614.095 | 40.20 | 39.520 | IRRIGATION | | 13.00 |



## TABLE 10.3-2 SUMMARY OF PROPOSED BRIDGES FOR CABANATUAN BYPASS - INITIAL STAGE (1/2)

| Bridge No. | Type of Waterway | Beginning | | End | | Free Board (m) | M.F.W.L EL. (+m) | Bridge Length | No. of Span | Span Length (m) | Superstructure | Substructure | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Abutment | | Pier | |
| | | Station | Elev. (m) | Station | Elev. (m) | | | | | | | Type | Foundation | Type | Foundation |
| 1 | River | 102+925.552 | 26.543 | 102+976.812 | 26.543 | 1.500 | 22.922 | 51.260 | 2-Span | 25.00+25.00 | PSCG (AASHTO Type IV) | Seat Type | RC Pile (450 x 450) L=6.0 m | Two Column | RC Pile (450 x 450) L=6.0 m |
| 2 | River | 104+998.328 | 27.450 | 105+062.188 | 27.450 | 1.500 | 23.700 | 63.860 | 3-Span | 20.00+22.00+20.00 | PSCG (AASHTO Type IV) | Seat Type | RC Pile (450 x 450) L=7.0 m | Two Column | RC Pile (450 x 450) L=7.0 m |
| 3 | River | 110+672.232 | 31.398 | 110+708.092 | 31.291 | 1.500 | 27.470 | 35.860 | 1-Span | 35.000 | PSCG (AASHTO Type VI) | Seat Type | RC Pile (450 x 450) L=18.0 m | - | - |
| 4 | River | 113+177.17 | 34.385 | 113+201.83 | 34.407 | 1.500 | 30.845 | 24.660 | 1-Span | 24.000 | PSCG (AASHTO Type IV) | Seat Type | RC Pile (450 x 450) L=6.0 m | - | - |
| 5 | River | 114+076.990 | 34.755 | 114+101.650 | 34.766 | 1.500 | 31.177 | 24.660 | 1-Span | 24.000 | PSCG (AASHTO Type IV) | Seat Type | RC Pile (450 x 450) L=6.0 m | - | - |
| 6 | River | 115+304.626 | 35.122 | 115+336.486 | 35.152 | 1.500 | 31.231 | 31.860 | 1-Span | 31.000 | PSCG (AASHTO Type IV-B) | Seat Type | RC Pile (450 x 450) L=6.0 m | - | - |
| 7 | Irrigation | 115+790.758 | 36.455 | 115+823.418 | 36.423 | 1.000 | 33.700 | 32.660 | 3-Span | 10.00+12.00+10.00 | Flat Slab | Seat Type | RC Pile (400 x 400) L=9.0 m | Two Column | RC Pile (400 x 400) L=8.0 m |
| 8 | River | 116+448.026 | 37.537 | 116+479.886 | 37.575 | 1.500 | 33.700 | 31.860 | 1-Span | 31.000 | PSCG (AASHTO Type IV-B) | Seat Type | RC Pile (450 x 450) L=7.0 m | - | - |
| 9 | River | 118+582.028 | 39.294 | 118+643.888 | 39.294 | 1.500 | 36.000 | 61.860 | 3-Span | 20.00+20.00+20.00 | PSCG (AASHTO Type IV) | Seat Type | RC Pile (450 x 450) L=11.0 m | Two Column | RC Pile (450 x 450) L=7.0 m |
| 10 | River | 119 + 534.178 | P A M P A N G A R I V E R | | | | | | | | | | | | |
| 11 | Irrigation | 122+359.060 | 41.751 | 122+394.920 | 41.751 | 1.500 | 38.400 | 35.860 | 1-Span | 35.000 | PSCG (AASHTO Type VI) | Seat Type | RC Pile (450 x 450) L=9.0 m | - | - |
| 12 | River | 122+581.666 | 38.397 | 122+684.126 | 37.671 | 1.500 | 34.422 | 102.460 | 4-Span | 25.0+25.0+25.0+25.0 | PSCG (AASHTO Type IV) | Seat Type | BH Pile (450 x 260) L=6.0 m | Two Column | BH Pile (450 x 260) L=6.0 m |
| 13 | Irrigation | 125+614.096 | 43.088 | 125+634.756 | 43.086 | 1.000 | 40.200 | 20.660 | 1-Span | 20.000 | PSCG (AASHTO Type IV) | Seat Type | RC Pile (450 x 450) L=22.0 m | - | - |

## TABLE 10.3-2 SUMMARY OF PROPOSED BRIDGES FOR CABANATUAN BYPASS - ULTIMATE STAGE (2/2)

| Bridge No. | Type of Waterway | Beginning | | End | | Free Board | M.F.W.L EL. (+m) | Bridge Length | No. of Span | Span Length (m) | Superstructure | Substructure | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Abutment | | Pier | |
| | | Station | Elev. (m) | Station | Elev. (m) | | | | | | | Type | Foundation | Type | Foundation |
| 1 | River | 102+925.552 | 26.543 | 102+976.812 | 26.543 | 1.500 | 22.922 | 51.260 | 2-Span | 25.00+25.00 | PSCG (AASHTO Type IV) | Seat Type | RC Pile (450 x 450) L=6.0 m | Two Column | RC Pile (450 x 450) L=6.0 m |
| 2 | River | 104+998.328 | 27.450 | 105+062.188 | 27.450 | 1.500 | 23.700 | 63.860 | 3-Span | 20.00+22.00+20.00 | PSCG (AASHTO Type IV) | Seat Type | RC Pile (450 x 450) L=7.0 m | Two Column | RC Pile (450 x 450) L=7.0 m |
| 3 | River | 110+672.232 | 31.398 | 110+708.092 | 31.291 | 1.500 | 27.470 | 35.860 | 1-Span | 35.000 | PSCG (AASHTO Type VI) | Seat Type | RC Pile (450 x 450) L=18.0 m | - | - |
| 4 | River | 113+186.150 | 34.407 | 113+210.810 | 34.385 | 1.500 | 30.845 | 24.660 | 1-Span | 24.000 | PSCG (AASHTO Type IV) | Seat Type | RC Pile (450 x 450) L=6.0 m | - | - |
| 5 | River | 114+080.737 | 34.765 | 114+105.397 | 34.757 | 1.500 | 31.177 | 24.660 | 1-Span | 24.000 | PSCG (AASHTO Type IV) | Seat Type | RC Pile (450 x 450) L=6.0 m | - | - |
| 6 | River | 115+312.526 | 35.145 | 115+344.36 | 35.134 | 1.500 | 31.231 | 31.860 | 1-Span | 31.000 | PSCG (AASHTO Type IV-B) | Seat Type | RC Pile (450 x 450) L=6.0 ~ 8.0 m | - | - |
| 7 | Irrigation | 115+788.254 | 36.448 | 115+820.914 | 36.433 | 1.000 | 33.700 | 32.660 | 3-Span | 10.00+12.00+10.00 | Flat Slab | Seat Type | RC Pile (400 x 400) L=9.0 m | Two Column | RC Pile (400 x 400) L=8.0 m |
| 8 | River | 116+458.333 | 37.517 | 116+490.193 | 37.534 | 1.500 | 33.700 | 31.860 | 1-Span | 31.000 | PSCG (AASHTO Type IV-B) | Seat Type | RC Pile (450 x 450) L=7.0 m | - | - |
| 9 | River | 118+582.028 | 39.294 | 118+643.888 | 39.294 | 1.500 | 36.000 | 61.860 | 3-Span | 20.00+20.00+20.00 | PSCG (AASHTO Type IV) | Seat Type | RC Pile (450 x 450) L=11.0 m | Two Column | RC Pile (450 x 450) L=7.0 m |
| 10 | River | 119 + 534.178 | P A M P A N G A R I V E R | | | | | | | | | | | | |
| 11 | Irrigation | 122+359.060 | 41.751 | 122+394.920 | 41.751 | 1.500 | 38.400 | 35.860 | 1-Span | 35.000 | PSCG (AASHTO Type VI) | Seat Type | RC Pile (450 x 450) L=9.0 m | - | - |
| 12 | River | 125+577.857 | 38.454 | 122+680.335 | 37.691 | 1.500 | 34.422 | 102.460 | 4-Span | 25.0+25.0+25.0+25.0 | PSCG (AASHTO Type IV) | Seat Type | BH Pile (450 x 260) L=6.0 m | Two Column | BH Pile (450 x 260) L=6.0 m |
| 13 | Irrigation | 125+616.688 | 43.086 | 125+637.348 | 43.081 | 1.000 | 40.200 | 20.660 | 1-Span | 20.000 | PSCG (AASHTO Type IV) | Seat Type | RC Pile (450 x 450) L=22.0 m | - | - |

## 10.4 Pampanga River Bridge Design

### 10.4.1 River Condition

#### (1) River Hydraulics

The river condition along the proposed alignment of Pampanga river has the following characteristics:

- bank to bank distance is about 1125m with evidence of bank scouring observed on both upstream and downstream of the proposed location,
- main river waterway is 475m wide with an overflow area of about 650m on both sides,
- the main river section has an average water depth of 1.0m to 1.5m,
- the flow velocity during ordinary time is slow (< 1.0m/sec) and even during peak flood, the flow velocity is only 1.82 m/sec,
- river soil quarrying is one of the activities in the vicinity of the proposed bridge location that may affect the depth of foundation,
- the river hydraulics design parameter is presented in Table 10.4-1 while the river section at the proposed location is shown in Figure 10.4-1.

**TABLE 10.4-1 RIVER HYDRAULICS DESIGN PARAMETER**

| *DESIGN PARAMETERS* | *APPROACH 1* | *MAIN WATERWAY* | *APPROACH 2* |
|---|---|---|---|
| 50-Year Discharge, $Q_{50}$ ($m^3$/sec) | 464.1 | 5510.8 | 1015.1 |
| Flow Velocity, $V_{50}$ (m/sec) | 0.69 | 1.88 | 0.83 |
| Catchment Area, CA ($km^2$) | - | 2,508.6 | - |
| Minimum Span Length, S (m) | 23 | 58 | 26 |
| Design Flood Water Level, (El +m) | 32.3 | 32.3 | 32.3 |
| Design River Bed Level, (El +m) | 28.24 | 23.21 | 26.88 |
| Local Scour Depth (m) | 2.5 | 3.0 | 2.5 |

#### (2) Soil Condition

The results of soil investigation (as shown in Figure 10.4-2) at the proposed bridge site indicated that:

- the area is generally covered by thick granular deposits consisting of gravel and sand persisting to the end of boreholes as shown in Figure 10.4-2.
- the upper 7 to 8 meters is generally loose to medium dense consistency with N-blows ranging from 10 to 30. However, subsequent depths have N-blows hitting practical refusal (N>50). The soil specific gravity ranges from 2.65 to 2.83.

Since most of the SPT procedure conducted exhibited refusal at a shallow depth, the investigation was similarly augmented by a dynamic sounding test (DPH) to verify the soil underlying the gravel layer. DPH data indicates some weaker layer beneath the gravel layer but was also terminated when measured penetration after 60 blows is practically negligible. At least one case indicates DPH termination shorter than SPT.

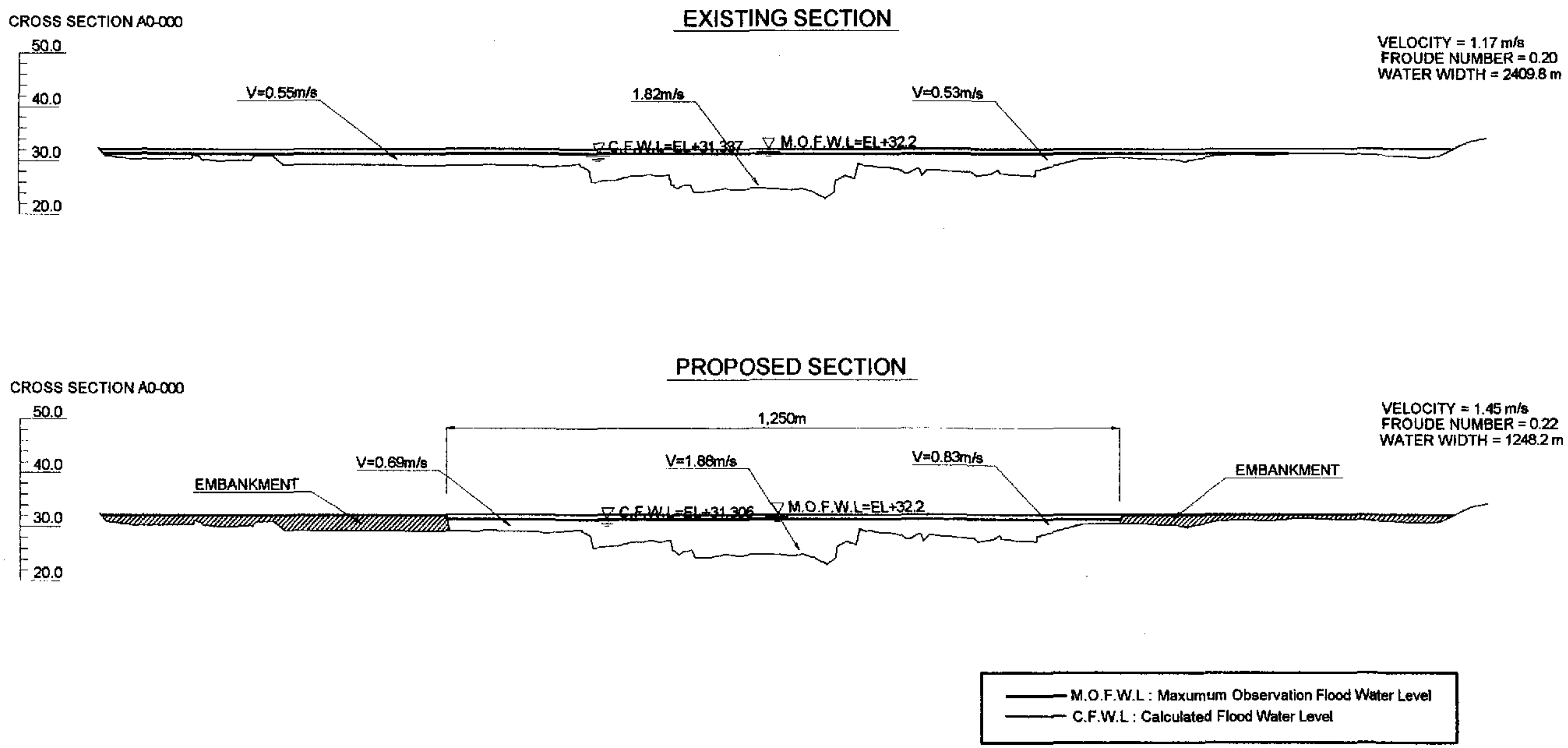



**FIGURE 10.4-1 PAMPANGA RIVER SECTION AND FLOOD WATER LEVEL (50-YEAR RETURN)**

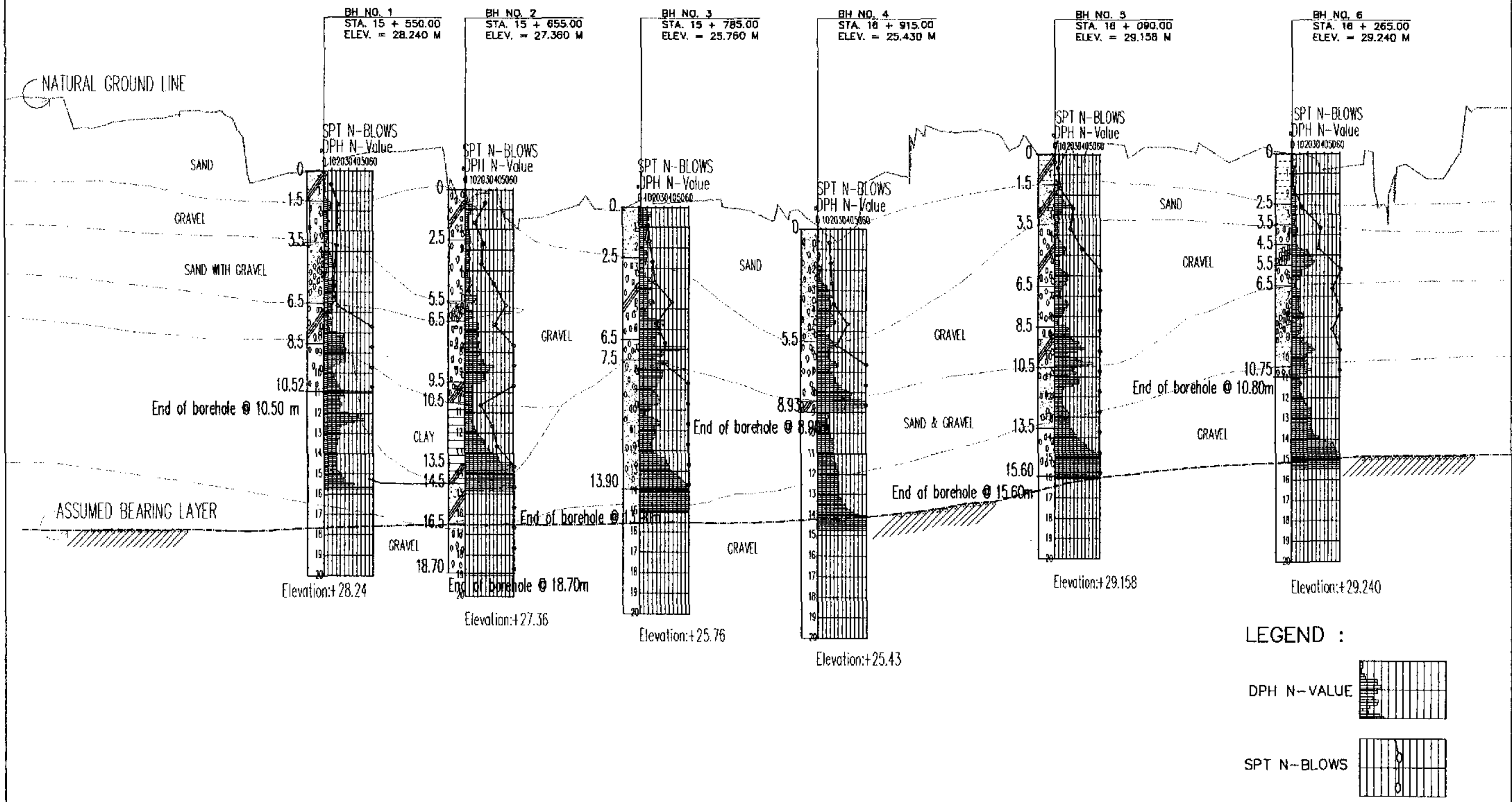



**FIGURE 10.4-2 SOIL PROFILE ALONG PAMPANGA RIVER**

With the given soil condition at the proposed bridge site, a comparison of probable foundation type is undertaken resulting to bored piles with diameters of Ø1200mm and Ø1500mm being more appropriate and cost-effective.

### 10.4.2 Final Bridge Scheme

#### (1) Design Requirements

The design requirements for the bridge crossing Pampanga river is presented in Table 10.4-2 below.

**TABLE 10.4-2 REQUIREMENTS FOR THE PROPOSED BRIDGE SCHEME**

| ***Design Requirements*** | | ***Items to be Considered*** |
|---|---|---|
| 1 | River Hydraulics | - 50 Year Return Flood: Abutments at 1125m apart to span the area covered by flood. The design flood water at site is El. +32.2.<br><br>- 50 Year River Discharge: The calculated river discharge of 5,510.8 $m^3$/sec requires a minimum pier span of 58m. A 9-span bridge structure is proposed with a 65m span between piers. |
| 2 | Topography and River Condition | - Main Waterway : Main bridge should span the 475m main river waterway<br><br>- Existing Ground Level: Pier heights will depend on the existing ground level and the design bridge profile.<br><br>- Bank and Bed Condition: Scouring observed on the banks and the bed necessitates minimizing pier encroachment on river section. |
| 3 | Soil Condition and Foundation | - Foundation Type : Bored piles are recommended to support the structure which can be embedded deep into the bearing layer.<br><br>- General Scour and Local Scour: Depth of foundation embedment should consider the design river bed (general scour elevation) and the effects of local scour due to pier encroachment (Table 10.4-1). A minimum footing embedment of 2.0m below lowest point of river section is recommended.<br><br>- Quarrying Activities: The design depth of piles should consider the loss in riverbed depth due to quarrying activities around the proposed bridge location. |

| | | |
|---|---|---|
| 4 | Construction | - Ordinary Water Depth: Since the ordinary water depth at Pampanga river is relatively shallow (averaging from 1.0m to 1.5m at normal time), the 2-Plate girder bridge erected by truck crane seems the most appropriate and cost-effective at this proposed bridge location.<br><br>- Bridge Structure: A 9-span bridge (5 + 4 spans continuous) using 2-Plate steel girder with precast prestressed slab erected by cranes is proposed.<br><br>- Cost: Different bridge types and schemes were compared and the proposed scheme is the most cost-effective – longer span scheme tends to be more expensive. |

### (2) Proposed Bridge Configuration

Considering the design requirements mentioned earlier, the final bridge scheme configuration is a 4 and 5-span continuous 2-Plate Steel girder with precast, prestressed deck slab which is found most cost-effective. Figure 10.4-3 shows the final bridge configuration of the proposed Pampanga river crossing as described in Table 10.4-3.

**TABLE 10.4-3 FINAL SCHEME FOR PAMPANGA RIVER BRIDGE**

| | | |
|---|---|---|
| BRIDGE LENGTH | Approach | 6 @ 30m = 180m +<br>12 @ 30m = 360m |
| | Main Bridge | 9 @ 65m = 585m |
| | Total Length | 1125m |
| BRIDGE TYPE | Approach | Type V AASHTO PC Girder with C.I.P. Slab<br>Span Length = 30m<br>Bridge Width = 9.95m |
| | Main Bridge | Steel 2-Plate Continuous Girder with Precast/Prestressed Slab<br>Span Length = 65m<br>Bridge Width = 9.95m |
| SUBSTRUCTURE | Approach | RC Oval Columns on □ 1200mm Bored Piles |
| | Main Bridge | RC Oval Columns on □ 1500mm Bored Piles |

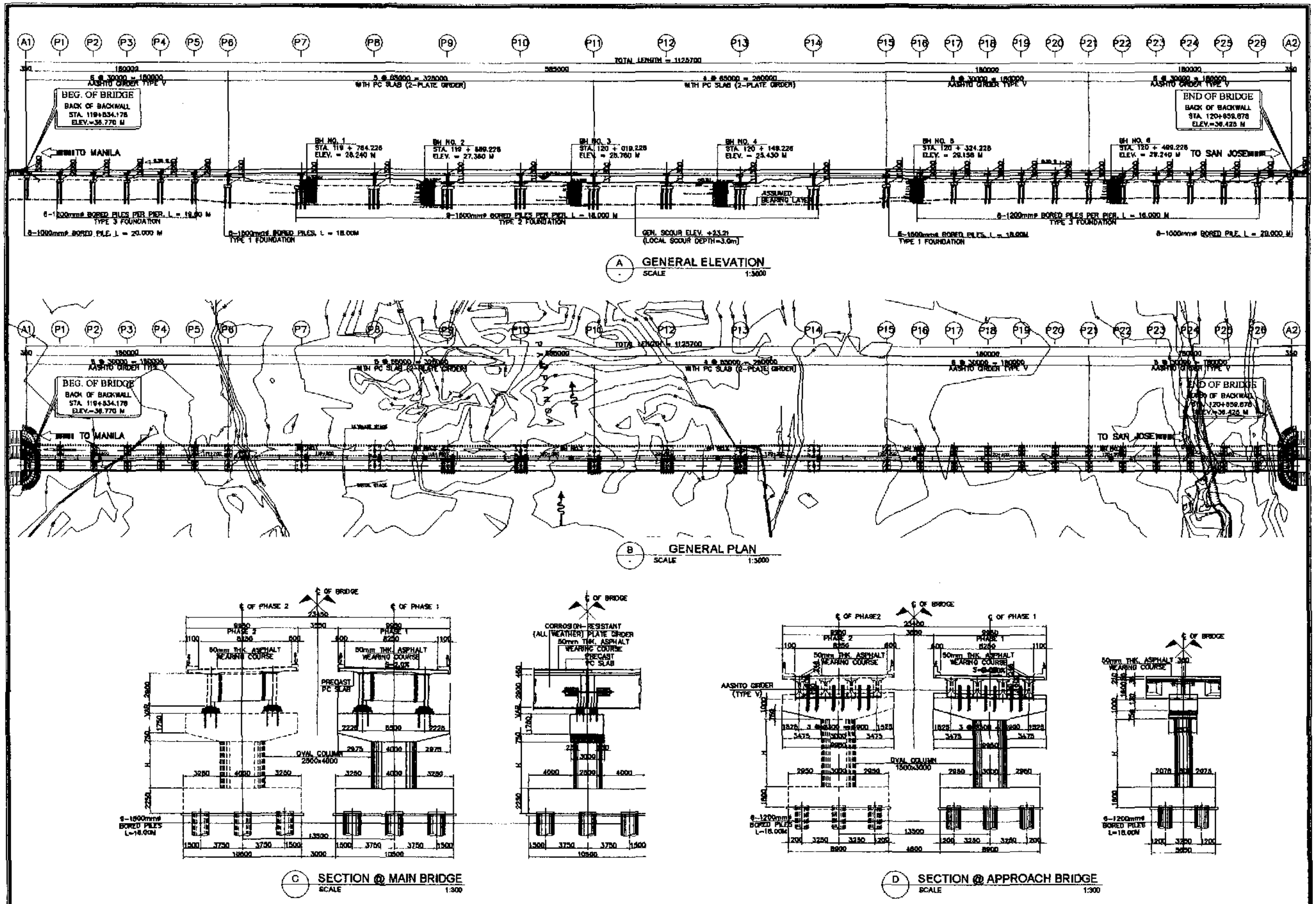



**FIGURE 10.4-3 PROPOSED PAMPANGA RIVER BRIDGE CROSSING**

The proposed bypass crossing Pampanga river carries a total of four-lane traffic with two lanes in each direction. However, construction of the bypass will be done in stages with the Initial stage carrying only two lanes and will be used as a two-way bridge. For this reason, the four-lane bypass will be constructed with two separate bridges with the initial stage construction catering for the first two lanes of traffic and the full bypass capacity augmented by the construction of a second bridge as shown in Figure 10.4-3.

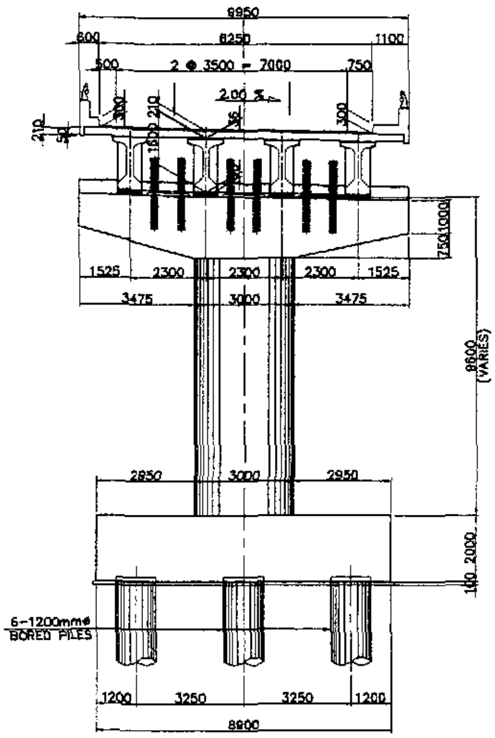
### 10.4.3 Detailed Design of Approach and Main Bridge

- The detailed design of the Pampanga river bridge crossing is carried-out with the principles and methodology similar to Angat river crossing mentioned in Section 9.5.

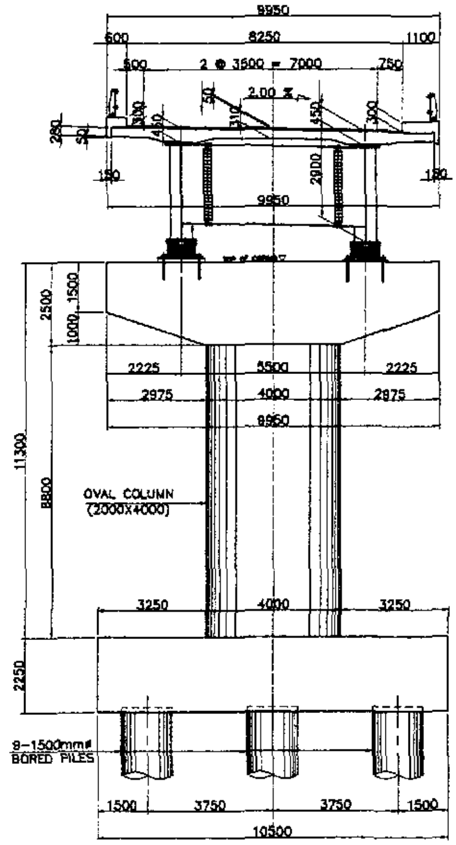
The following design conditions are applied to the detailed design of Pampanga river bridge crossing:

- Bridge Type : Main – 2-Plate Steel Girder with Precast, Prestressed Deck Slab erected by truck crane
  Approach – Type V PC AASHTO Girder erected by truck crane with C.I.P. Deck Slab
- Bridge Width : Main Bridge = 9.95m
  Approach Bridge = 9.95m
- Material : Steel Plate Girder , fy = 345 MPa
  Precast Prestressed Deck Slab = 41 MPa
  Prestressed AASHTO Girder , f'c = 41 MPa
  C.I.P. Deck Slab, f'c = 28 MPa
  Bored Piles, f'c = 28 MPa

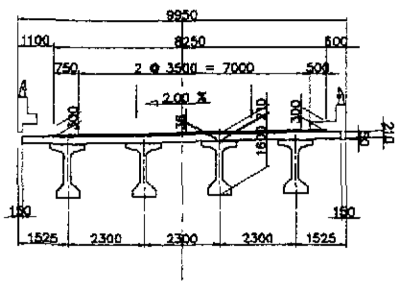
  Reinforcing Steel, fy = 415 MPa
  Prestressing Steel, fpu = 1862 MPa
- Live Loading : MS 18 (HS 20-44)
  B.O.D. Permit Live Load (LFD check)
- Seismic Loading : AASHTO Div. I-A
  Peak Ground Acceleration Coef., A = 0.40
  Seismic Response Coef., Figure 9.5-8
  Importance Classification, IC = 1.0
  Seismic Performance Category, SPC = D
  Soil Site Coefficient = 1.2
- Foundation : Ø1500mm Bored Piles for Main Bridge
  Ø1200mm Bored Piles for Approach Bridge
  Ø1000mm Bored Piles for Abutment




SECTION @ SUPPORT

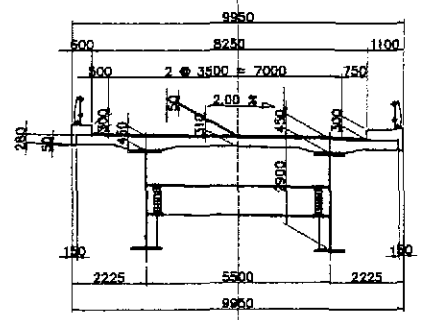



SECTION @ SUPPORT



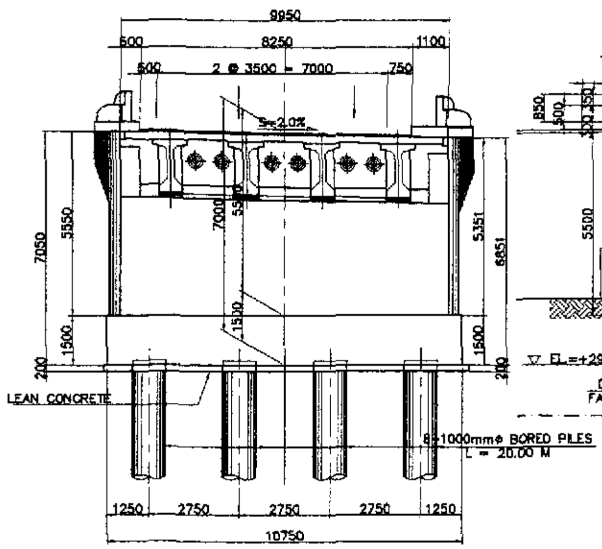
SECTION @ MID SPAN

a.) APPROACH

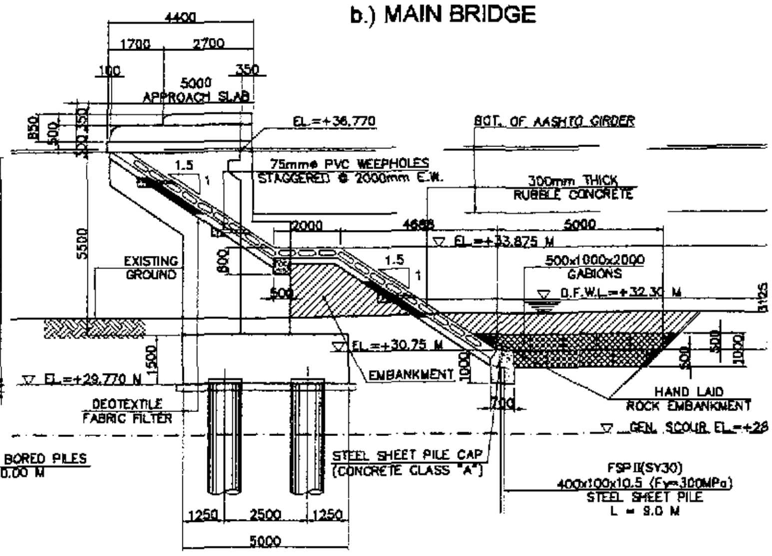


SECTION @ MID SPAN

b.) MAIN BRIDGE




FRONT ELEVATION




SIDE ELEVATION

c.) ABUTMENT

**FIGURE 10.4-4 TYPICAL STRUCTURE LAYOUT**

### (1) Basic Dimensional Requirement

Figure 10.4-4 shows the typical cross-section of the approach and the main bridge for a single two-lane bridge to be constructed during the initial stage. The basic dimensional requirements for the bridge is decided from the following:

<table>
<tr><th colspan="2"><u>ITEM</u></th><th>DESCRIPTION</th><th>BASIS</th></tr>
<tr><td colspan="4">1.0 General</td></tr>
<tr><td rowspan="3">Bridge Lengt h</td><td>Total</td><td>1125m</td><td>- this length covers the 50-year return flood and spans the banks of the river at the proposed alignment<br>- the total bridge length should be able to (a) maintain the original river width, (b) maintain the minimum freeboard from maximum flood water, (c) minimize pier encroachment on river section, and (d) the modified cross-section should be able to accommodate the design river discharge and minimize backwater.</td></tr>
<tr><td>Approach</td><td>South – 180m<br>North – 360m</td><td>- this length covers the approaches to the main bridge from both sides of the banks</td></tr>
<tr><td>Main</td><td>585m</td><td>- this length covers the main river waterway which has the deepest section of the river at this location</td></tr>
<tr><td rowspan="2">Bridge Span</td><td>Approach</td><td>30m</td><td>- the approach span length is the most cost-effective span</td></tr>
<tr><td>Main</td><td>65m</td><td>- the minimum span for the river discharge at this location is 58m; this is the most economical span</td></tr>
<tr><td rowspan="2">Deck</td><td>Width</td><td>9.95m</td><td>- cover 2 lanes @ 3.5m + shoulders (0.75m + 0.50m) + sidewalk & curb (1.1m + 0.60m)<br>- B.O.D. minimum deck width is 9.54m</td></tr>
<tr><td>Driveway</td><td>Lane width – 3.5m<br>Clear roadway – 8.25m</td><td>- B.O.D. minimum lane width is 3.35m<br>- B.O.D. minimum clear roadway is 7.32m</td></tr>
<tr><td colspan="2">Bridge Design Vertical Profile</td><td>as shown</td><td>- minimum clearance from maximum flood water level to lowest part of structure is 1.5m</td></tr>
<tr><td colspan="4">2.0 Approach Bridge (5-span Continuous Precast AASHTO Girders)</td></tr>
<tr><td colspan="2">Deck Slab Thickness</td><td>210mm</td><td>- determined by structural requirements</td></tr>
<tr><td colspan="2">Girder Type</td><td>AASHTO Girder Type V</td><td>- standard for 30m span; reinforcement shall be determined by structural requirements</td></tr>
<tr><td colspan="2">Pier Column</td><td>1.5m x 3.0m Oval</td><td>- 1.5m is 5% of span length; other dimension determined by seismic loading requirement</td></tr>
</table>

| | | | |
|---|---|---|---|
| Pile Foundation | Dia. | Ø1.2m | - determined by structural requirements; most economical |
| | Length | as indicated | - determined by structural requirements<br>- consideration due to river scour and quarrying at site |
| Abutment | | as indicated | - closed type abutment with superstructure on bearing seats<br>- determined by structural requirements |
| ***3.0 Main Bridge*** (5-span and 4-span Continuous 2-Plate Steel Girder) | | | |
| Plate Girder | Girder Spacing | 5.50m | - most efficient to resist transverse truck load; balanced section forces resulting in optimum utilization of deck slab |
| | Depth | 2.90m | - Minimum depth is controlled by deflection criteria under live load, $\delta$ < Span/1000<br>- Minimum depth using AASHTO Sec. 10.5 = S/25 or 2.60m |
| PC Deck Slab | Depth | Midspan – 280<br>Support - 380 | - determined by structural requirements<br>- minimum thickness at midspan and support is 275mm |
| | Cantilever | 2.225m | - controlled by deflection under live load<br>- cantilever to interior span ratio = 0.404 |
| Pier Column | | 2.5m x 4.0m Oval | - 2.5m is only 3.9% of span length < 5%<br>- other dimension determined by seismic loading requirement |
| Pile Foundation | Dia. | Ø1.5m | - determined by structural requirements; most economical |
| | Length | as indicated | - determined by structural requirements<br>- consideration due to river scour and quarrying at site |

### (2) Design of Abutment

The detailed design for the abutment at the approach side is carried out to determine the basic structural requirements to support the anticipated loads. The design approach and method of analysis is based on the recommendations of the AASHTO Div. I-A – Sec. 7.4 Foundation and Abutment Design Requirement for Seismic Performance Categories C and D.

The following conditions are being applied in the design of abutment:

- Abutment Type : Closed type Cantilever Wall Abutment on bored piles
- Abutment Width : 9.95m
- Superstructure Support : On sliding bearing

- Material : Reinforced Concrete, f'c = 28 MPa
  Reinforcing Bars, fy = 415 MPa
- Live Loading : MS 18 (HS 20-44)
- Earth Pressure : Rankine's formulation due to retained soil
- Seismic Load : Seismic active earth pressure is based on pseudo static Mononobe-Okabe formulation for soil

  Ground Acceleration Coefficient is taken as A = 0.40 and horizontal seismic coefficient is taken as $k_h$ = 0.5A
- Foundation : Multiple bored piles □1.0m

Figure 10.4-4 shows a typical layout of the abutment.

**(3) Design of Superstructure**

The load combinations for the design of superstructure follows the AASHTO recommendations as outlined in the Bridge Design Criteria. The live loading applied in the design is the AASHTO MS 18 Class (HS 20-44). However, permit design loading P-Load as recommended by BOD, DPWH is adopted to check the capacity of the members under load factor design.

**(a) Precast AASHTO Girders for the Approach Spans**

The design of precast prestressed AASHTO girders for the approach spans basically followed the AASHTO Standard Specifications for Highway Bridges.

The superstructure is taken as composite precast prestressed girder with cast-in-place slab made continuous on live load. The girders are supported on elastomeric bearing pads with fix dowel bars on continuous piers. Sufficient bearing support lengths is provided at expansion piers and dowel bars and restraining bars is utilized as fall down prevention device.

The design of the prestressed girder followed the sequence of construction similar to the AASHTO Girders of Talavera river bridge crossing.

Figure 10.4-5 shows a typical layout of the AASHTO girders for the approach to the main bridge.

**(b) 2-Plate Steel for Main Bridge**

The design of plate girders for the main bridge adopted the AASHTO Standard Specifications for Highway Bridges.

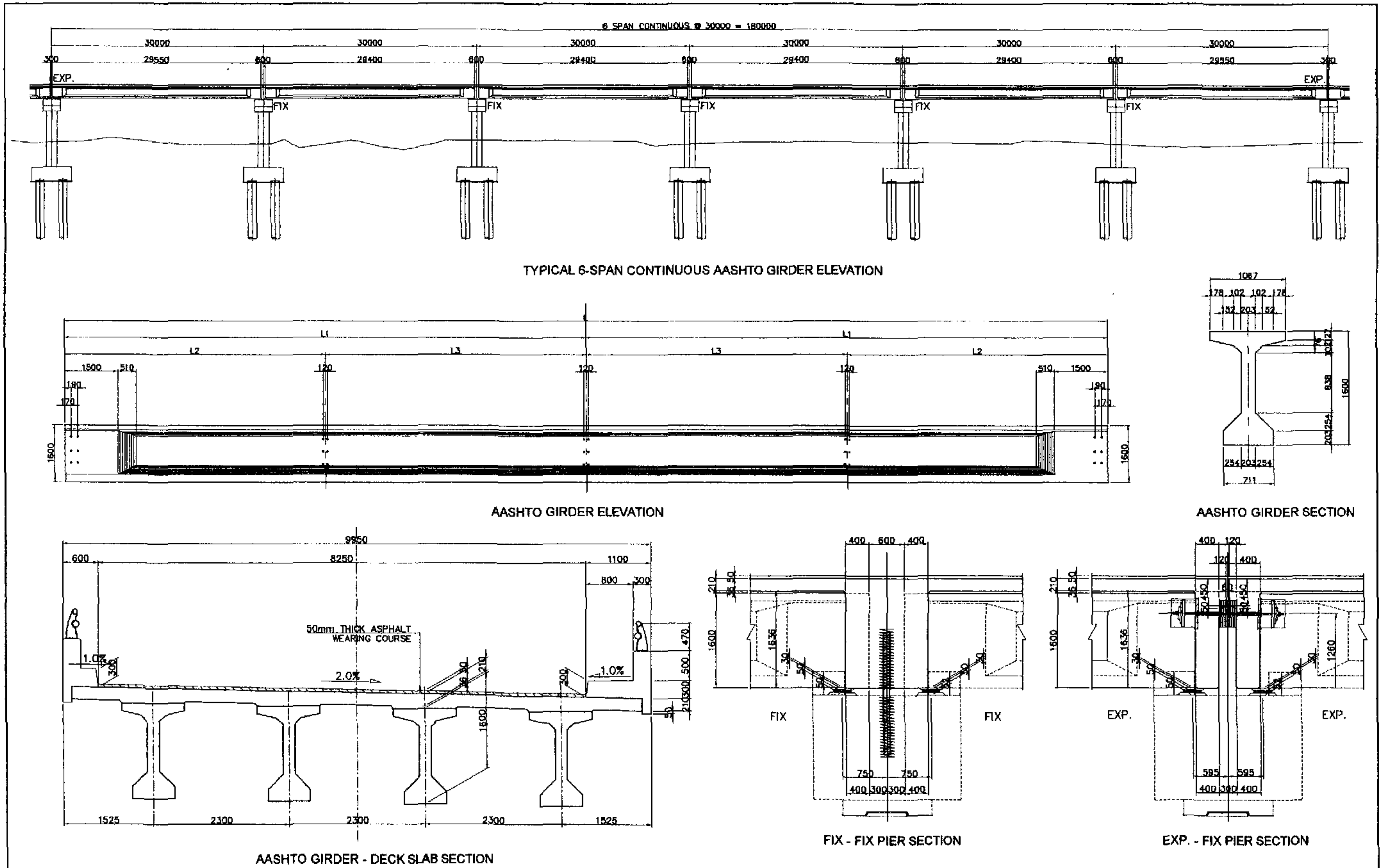



**FIGURE 10.4-5 AASHTO GIRDER FOR APPROACH SPAN**

The main bridge for Pampanga river crossing is a 585m 4 and 5-span continuous steel plate girder erected by truck cranes (Figure 10.4-6). In this construction method, the plate girders are delivered to site on segments and connected below to form longer segments before erecting on temporary bents. The girders are combined while being supported by temporary bents. Precast slabs are then erected and fixed to the girders by non-shrink grouts. Figure 10.4-7 shows the construction sequence for the main bridge.

*Analysis*. In the design of main bridge, elastic analysis and beam theory is used to determine the design moments, shears and deflections. The effects of creep, shrinkage and temperature differentials is considered for the deck slab. No composite action is taken in the design of deck slab and plate girders.

*Transverse Analysis*. The transverse design of precast deck slab assumed the member as hinge supported by plate girders. Slabs are analyzed as variable depth sections considering the fillets and haunches at the supports. The wheel loads are positioned to provide maximum moments and elastic analysis used to determine the effective longitudinal distribution of wheel load for each load location. The precast slab is taken as a prestressed pretensioned member so that the secondary effects of prestress will not be transferred to the plate girders. However, post-tensioned cast-in-place slabs considered such secondary forces due to prestressing.

The design of end diaphragms and intermediate bracings considered the unsymmetrical effects of live loading on the plate girders.

*Longitudinal Analysis*. The analysis and design in the longitudinal direction considered a non-composite action between the slab and the plate girders. Therefore, the plate girders are assumed to take all the vertical loads including changes and variation in temperature. Fatigue is investigated in all members including the effects of Permit Loads.

The superstructure is seated on elastomeric bearings which resists the longitudinal seismic forces to be transmitted to the columns. Sufficient gaps between superstructures are provided to minimize impact in the event of large seismic excitation.

**(4) Design of Substructure**

*Seismic Design.* The principles used in the detailed design of substructure is the same as the design of substructures for Angat river crossing.

The design of substructures basically adopted the recommendations of the AASHTO Div. I-A , Seismic Design.

For the seismic analysis, the multi-mode spectral analysis method under Seismic Performance Category D is used to determine the elastic design forces for the pier columns. The seismic response coefficients for various soil types is shown in Figure 9.5-8 while the peak ground acceleration will be based on DPWH recommendations using the acceleration coefficient A = 0.4.

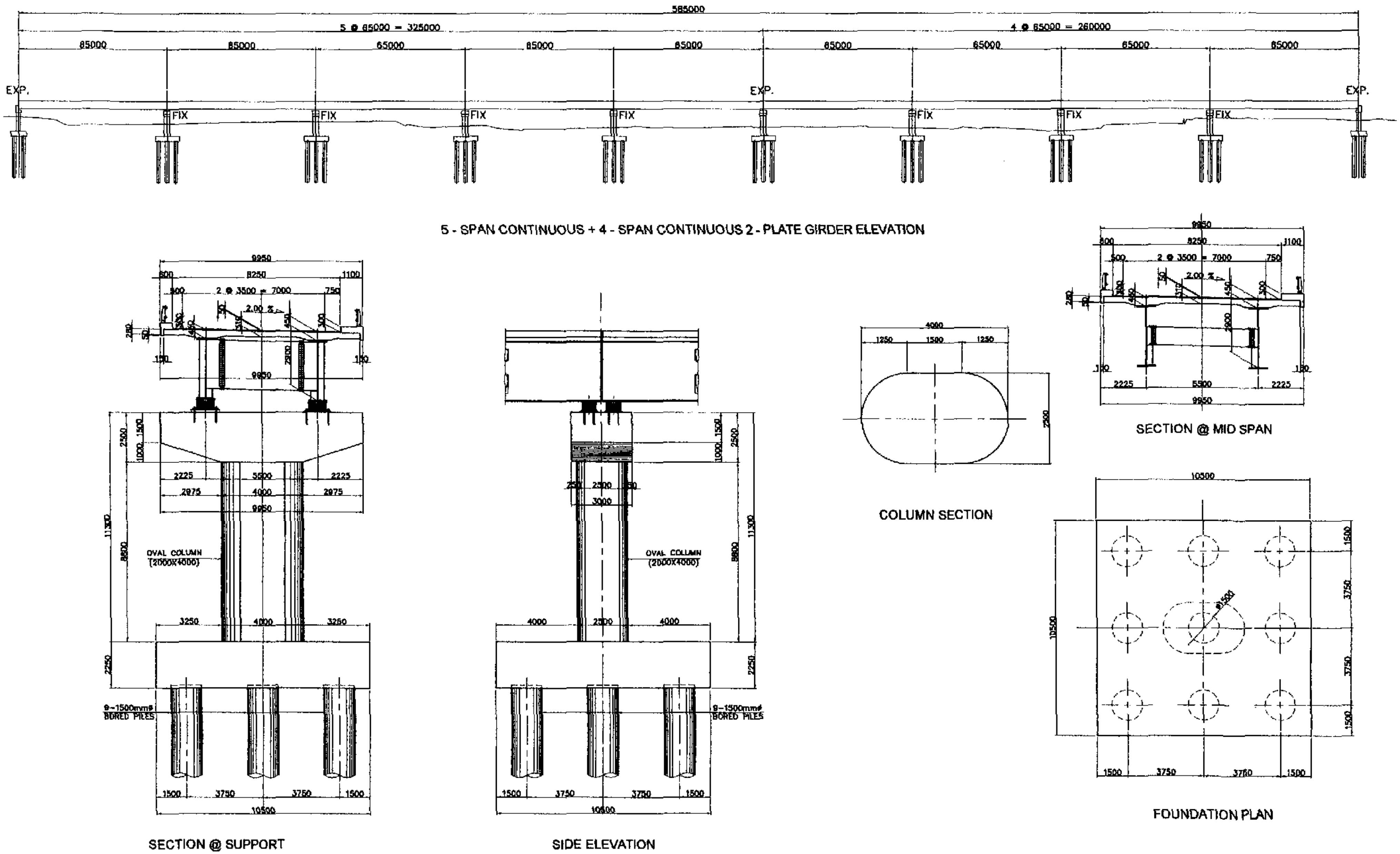



**FIGURE 10.4-6 MAIN BRIDGE FOR PAMPANGA RIVER CROSSING**

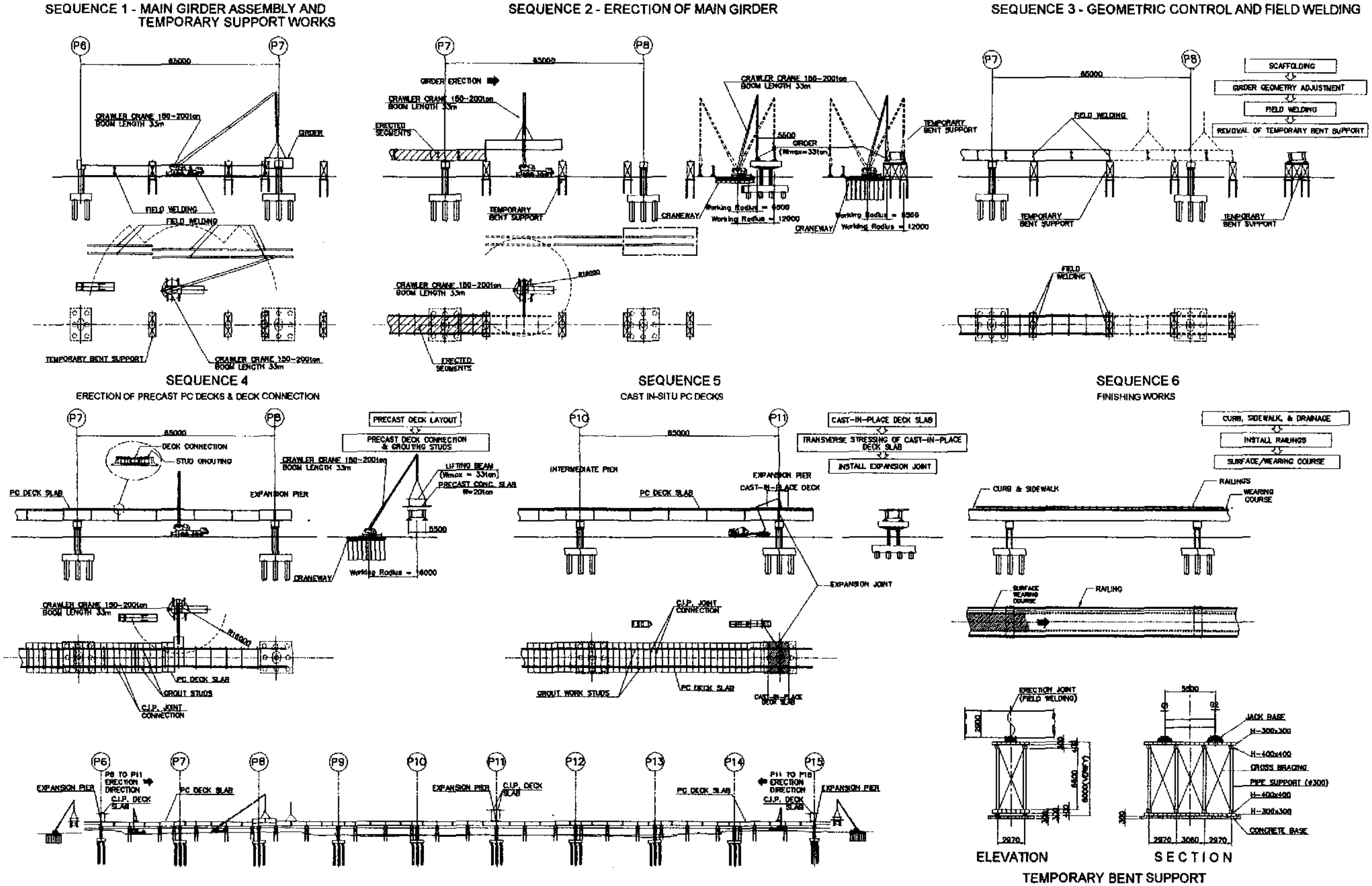



**FIGURE 10.4-7 CONSTRUCTION SEQUENCE FOR PAMPANGA RIVER MAIN BRIDGE**

*Pier Column Design*. Similarly, the design of pier columns will follow the procedures outlined in AASHTO Div. I-A.

A three-dimensional finite element mathematical model using 3D beam elements is used to perform the response analysis under seismic excitation. The elastic forces obtained from the multimode response spectrum analysis are used to determine the design forces for the columns considering the Response Modification Factor R. This R-factor is a function of column ductility which allows plastic hinging to form in the columns with sufficient lateral confinement.

Determination of column structural requirements (size and reinforcement) is done following the resulting modified design forces. Column confinement is detailed using the plastic design shear force derived from the plastic capacity of the column section.

*Foundation Design*. The design of the Bored Pile foundations similarly followed the guidelines of Angat river bridge.

## 10.5 Talavera River Bridge Design

### 10.5.1 River Condition

#### (1) River Hydraulics

The river condition along the proposed alignment of Pampanga river has the following characteristics:

- the river waterway is about 200m wide with a flood area of about 700m,
- evidence of bank scouring is observed on both upstream and downstream of the proposed location,
- ordinary water at the proposed bridge location is less than 1.0m deep and only about 40m wide,
- the flow velocity during ordinary time is slow (< 1.0m/sec) and but becomes 2.08 m/sec during flood flow,
- river soil quarrying is one of the activities in the vicinity of the proposed bridge location that may affect the depth of foundation,
- the river hydraulics design parameter is presented in Table 10.5-1 while the river section at the proposed location is shown in Figure 10.5-1.

**TABLE 10.5-1 RIVER HYDRAULICS DESIGN PARAMETER**

| *DESIGN PARAMETERS* | *MAIN WATERWAY* |
|---|---|
| 50-Year Discharge, $Q_{50}$ ($m^3$/sec) | 1,570 |
| Flow Velocity, $V_{50}$ (m/sec) | 2.08 |
| Catchment Area, CA ($km^2$) | 463 |
| Minimum Span Length, S (m) | 38 |
| Design Flood Water Level, (El +m) | 43.25 |
| Design River Bed Level, (El +m) | 36.96 |
| Local Scour Depth (m) | 2.5 / 3.0 |

#### *(2) Soil Condition*

The results of soil investigation (as shown in Figure 10.5-2) at the proposed bridge site indicated:

- the presence of alternating layers of loose to medium dense sand/gravel and medium stiff to stiff clay which is about 17m to 25m thick as shown in Figure 10.5-2. The N-values at this layer ranged from 8 to 20.
- beneath the above layer is the very dense gravel and sand deposits with N>50 prevalent in all boreholes,
- the river bed soil condition consists of very loose silty sand until 2.5m deep while the west side bank soil consists of loose silty clay,
- evidence of scouring is observed on this west side bank as indicated by the results of topographic survey.

Bored pile foundation is thus proposed for this bridge with the assumed bearing at the dense sand or gravel layer shown in Figure 10.5-2. Since the river bed general scour is expected coupled with local pier scouring and quarrying activities at the proposed bridge site, the pile foundation is proposed to be brought to a deeper bearing layer.

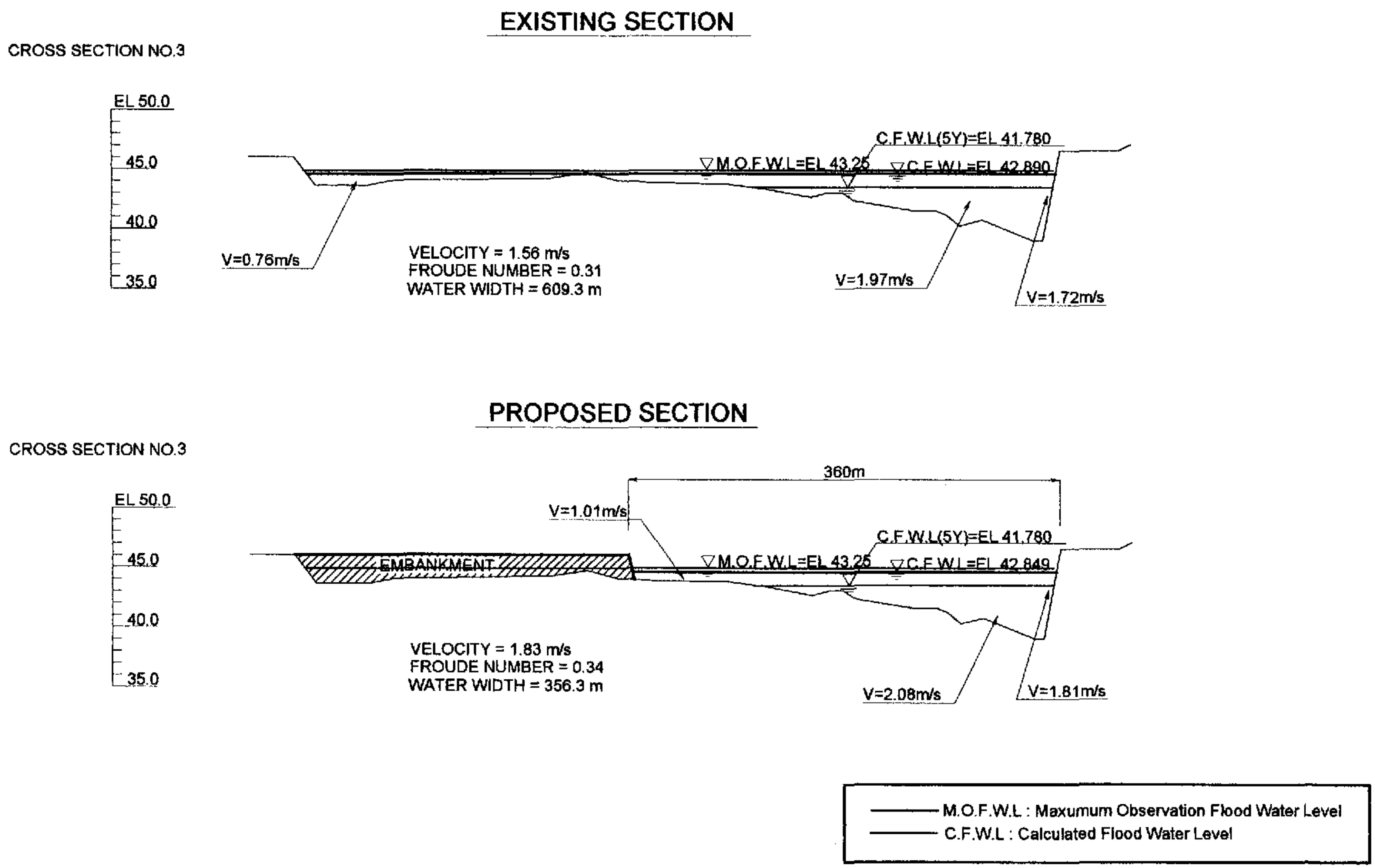



**FIGURE 10.5-1 TALAVERA RIVER SECTION AND FLOOD WATER LEVEL (50-YEAR RETURN)**

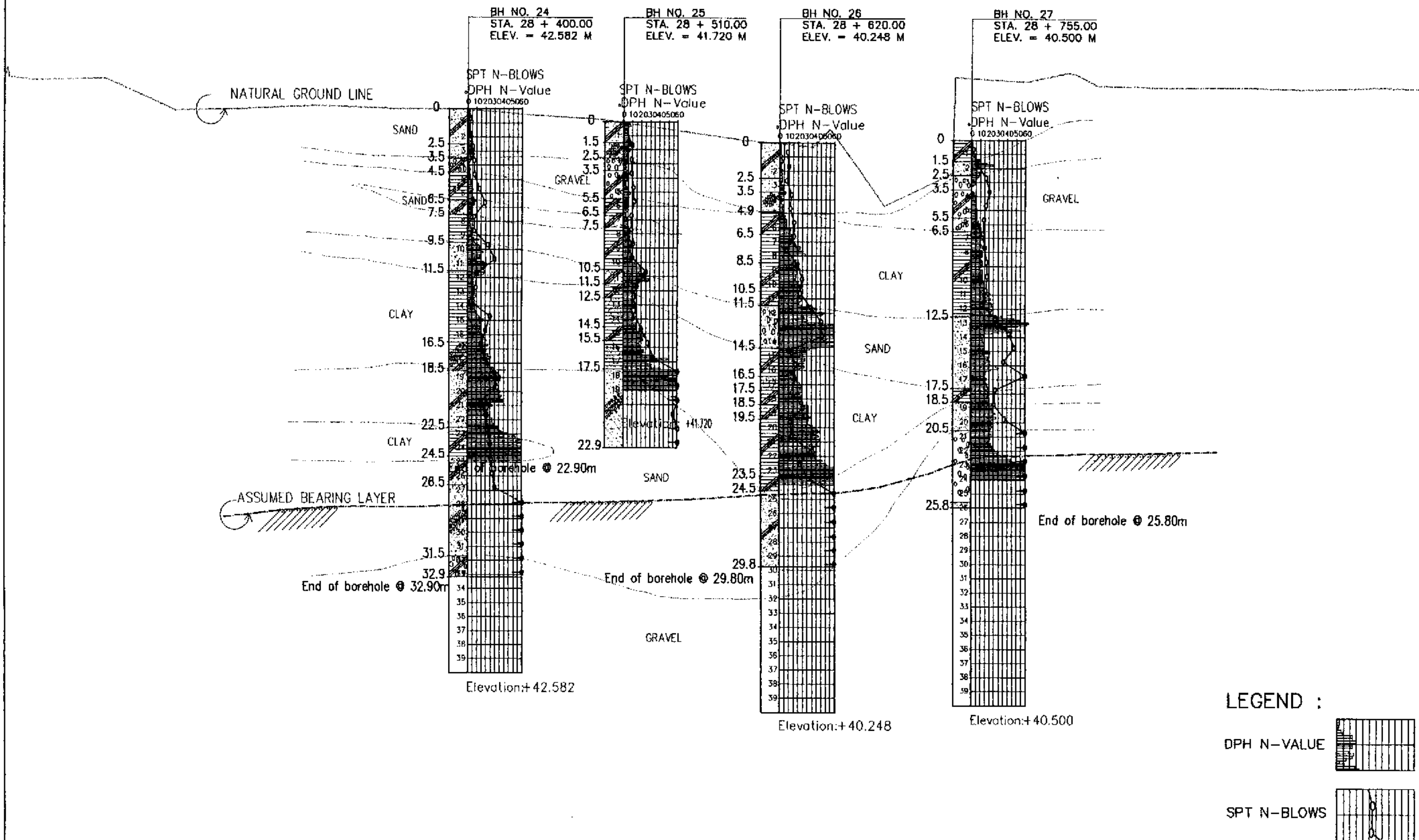



**FIGURE 10.5-2 SOIL PROFILE ALONG TALAVERA RIVER**

## 10.5.2 Final Bridge Scheme

### (1) Design Requirements

The design requirement used for the final bridge scheme is presented in Table 10.5-2 below.

TABLE 10.5-2 REQUIREMENTS FOR THE PROPOSED BRIDGE SCHEME

| *Design Requirements* | | *Items to be Considered* |
|---|---|---|
| 1 | River Hydraulics | - 50 Year Return Flood: Abutments at 360m apart to span the area required by river discharge. Down stream at 1km is the Sicsican bridge with only 150m length.<br><br>- 50 Year River Discharge: The calculated river discharge of 1,570 $m^3$/sec requires a minimum pier span of 38m. A 9-span bridge structure is proposed with a 40m span between piers. |
| 2 | Topography and River Condition | - Main Waterway : Ordinary river waterway is less than 50m but flood area is wider due to backwater from the existing Sicsican bridge.<br><br>- Existing Ground Level: Pier heights will depend on the existing ground level and the design bridge profile.<br><br>- Bank and Bed Condition: Scouring observed on the banks and the bed necessitates moving the east bank abutment forward and providing stronger protection for the banks and piers. |
| 3 | Soil Condition and Foundation | - Foundation Type : Bored piles are recommended to support the structure which can be embedded deep into the bearing layer.<br><br>- General Scour and Local Scour: Depth of foundation embedment should consider the design river bed (general scour elevation) and the effects of local scour due to pier encroachment (Table 10.5-1). A minimum footing embedment of 2.0m below lowest point of river section is recommended.<br><br>- Quarrying Activities: The design depth of piles should consider the loss in riverbed depth due to quarrying activities around the proposed bridge location. |

| | | |
|---|---|---|
| 4 | Construction | - Ordinary Water Depth: Since the ordinary water depth at Talavera river is relatively shallow (averaging to less than 1.0m at normal time), the precast AASHTO girder bridge erected by truck crane seems the most appropriate and cost-effective at this proposed bridge location.<br><br>- Bridge Structure: A 9-span bridge (3 – 3 @40m spans continuous) using precast AASHTO girder and cast-in-place slab is most appropriate.<br><br>- Cost: Different bridge types and schemes were compared and the proposed scheme is the most cost-effective – longer span scheme tends to be more expensive. |

## (2) Proposed Bridge Configuration

Considering the design requirements mentioned earlier, the final bridge scheme configuration is a 9-span bridge with 3-span continuous superstructure (minimum span of 40m on piers) and following the comparative study for bridge scheme, the AASHTO girder deck slab is found most cost-effective.

The final bridge scheme recommended is shown in Figure 10.5-3 with a total length of 360m. Type VI modified AASHTO girders are applied for the superstructure while bored piles of 1500mm□ diameter used for the substructures.

**TABLE 10.5-3 FINAL SCHEME FOR TALAVERA RIVER BRIDGE**

| | |
|---|---|
| BRIDGE LENGTH | 3 sets of 3 @ 40m = 360m |
| BRIDGE TYPE | Type VI AASHTO PC Girder with C.I.P. Slab |
| SUBSTRUCTURE | RC Oval Columns on □ 1500mm Bored Piles |

The proposed bypass crossing Talavera river carries a total of four-lane traffic with two lanes in each direction. However, construction of the bypass will be done in stages with the Initial stage carrying only two lanes and will be used as a two-way bridge. For this reason, the four-lane bypass will be constructed with two separate bridges with the initial stage construction catering for the first two lanes of traffic and the full bypass capacity augmented by the construction of a second bridge as shown in Figure 10.5-3.

A typical layout of structures for a single two-lane bridge is shown in Figure 10.5-4.

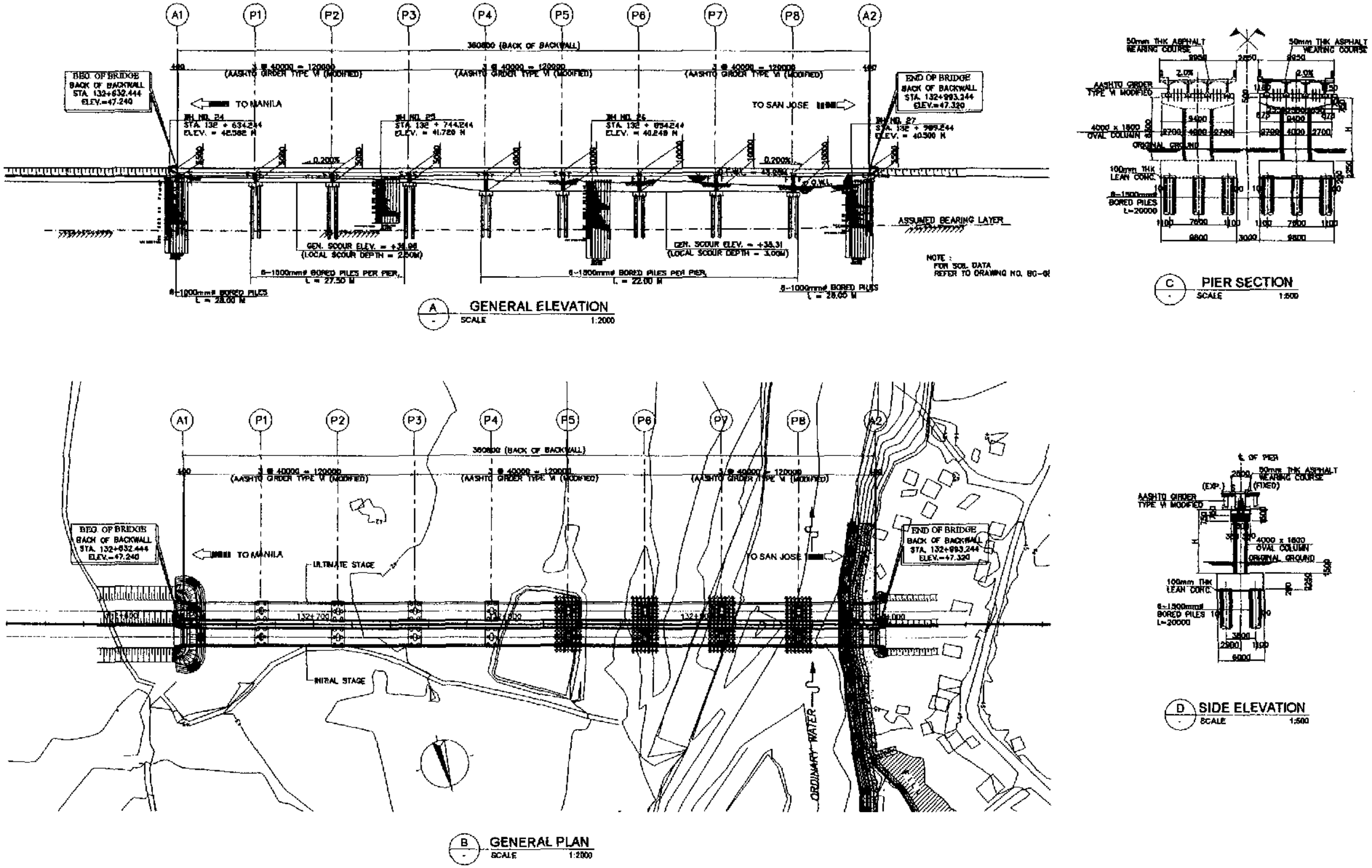



**FIGURE 10.5-3 PROPOSED TALAVERA RIVER BRIDGE**

### 10.5.3 Detailed Design of Talavera Bridge

The detailed design of the Talavera river bridge crossing is being carried-out with the principles and methodology similar to the Pampanga river bridge in Section 10.4 of this report.

The following design conditions are being applied to the detailed design of Talavera river bridge crossing:

- Bridge Type : Type VI Modified PC AASHTO Girder erected by truck crane with C.I.P. Deck Slab
- Bridge Width : 9.95m
- Material : Prestressed AASHTO Girder , f'c = 41 MPa
  C.I.P. Deck Slab, f'c = 28 MPa
  Bored Piles, f'c = 28 MPa

  Reinforcing Steel, fy = 415 MPa
  Prestressing Steel, fpu = 1862 MPa
- Live Loading : MS 18 (HS 20-44)
  B.O.D. Permit Live Load (LFD check)
- Seismic Loading : AASHTO Div. I-A
  Peak Ground Acceleration Coef., A = 0.40
  Seismic Response Coef., Figure 9.5-8
  Importance Classification, IC = 1.0
  Seismic Performance Category, SPC = D
  Soil Site Coefficient = 1.2
- Foundation : Ø1500mm Bored Piles for Piers
  Ø1000mm Bored Piles for Abutment

#### (1) Basic Dimensional Requirement

Figure 10.5-4 shows the typical cross-section of the bridge for a single two-lane bridge to be constructed during the initial stage. The basic dimensional requirements for the bridge is decided based on the following:

| ITEM | | DESCRIPTION | BASIS |
|---|---|---|---|
| Bridge Length | Total | 360m | - this length covers the 50-year return flood and spans the area required by river discharge.<br><br>- the total bridge length should be able to (a) maintain the original river width, (b) maintain the minimum freeboard from maximum flood water, (c) minimize pier encroachment on river section, and (d) the modified cross-section should be able to accommodate the design river discharge and minimize backwater. |

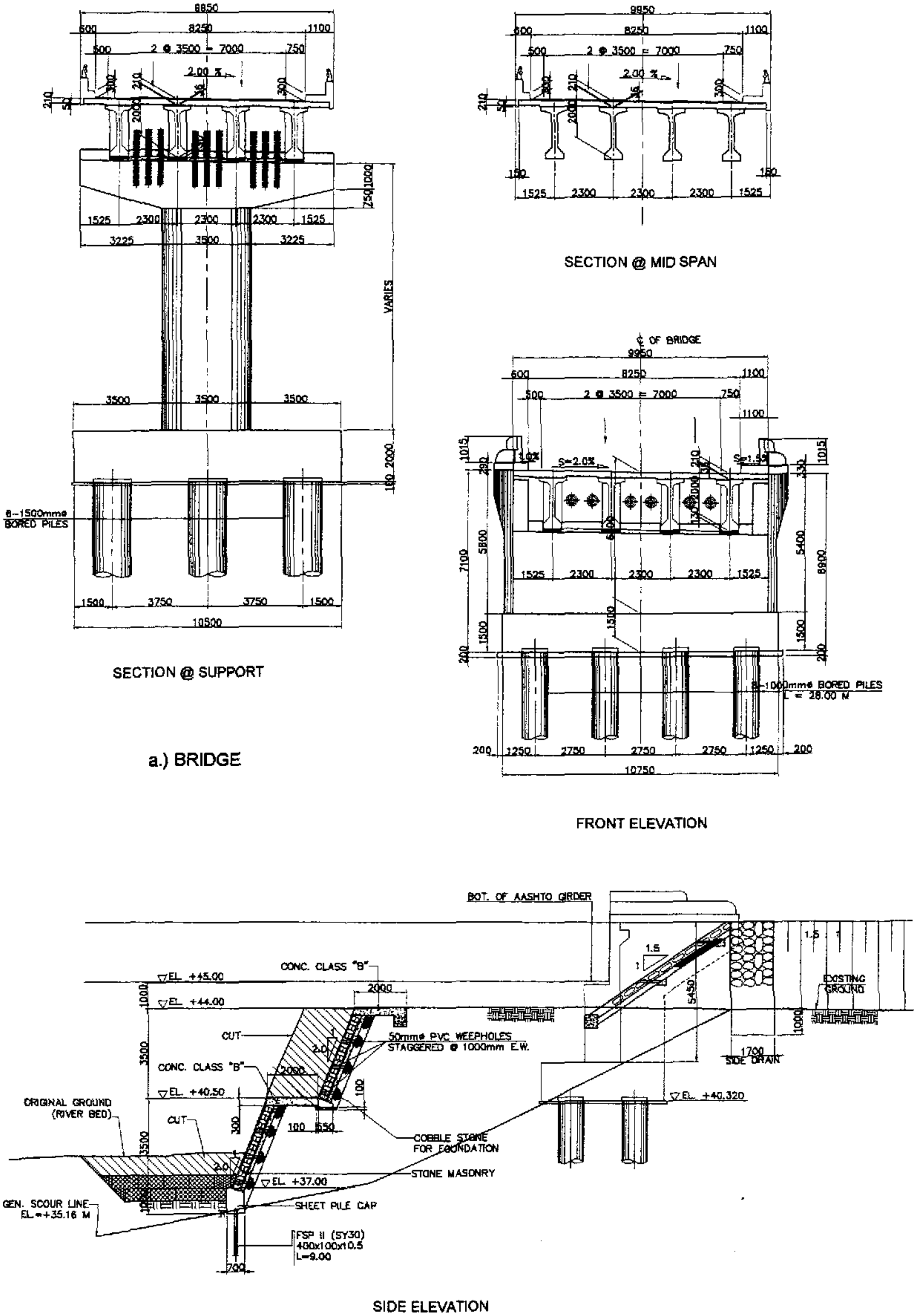



**FIGURE 10.5-4 TYPICAL STRUCTURE LAYOUT**

| | | | |
|---|---|---|---|
| Bridge Span | Main | 40m | - the span length is the most cost-effective span<br>- the minimum span length for the river discharge is 38m |
| Deck | Width | 9.95m | - cover 2 lanes @ 3.5m + shoulders (0.75m + 0.50m) + sidewalk & curb (1.1m + 0.60m)<br>- B.O.D. minimum deck width is 9.54m |
| | Driveway | Lane width – 3.5m<br>Clear roadway – 8.25m | - B.O.D. minimum lane width is 3.35m<br>- B.O.D. minimum clear roadway is 7.32m |
| Bridge Design Vertical Profile | | as shown | - minimum clearance from maximum flood water level to lowest part of structure is 1.5m |
| Deck Slab Thickness | | 210mm | - determined by structural requirements |
| Girder Type | | AASHTO Girder Type VI modified | - standard for 40m span; reinforcement shall be determined by structural requirements |
| Pier Column | | 1.8m x 3.5m Oval | - 1.8m is 4.5% of span length; other dimension determined by seismic loading requirement |
| Pile Foundation | Dia. | Ø1.5m | - determined by structural requirements; most economical |
| | Length | as indicated | - determined by structural requirements<br>- consideration due to river scour and quarrying at site |
| Abutment | | as indicated | - closed type abutment with superstructure on bearing seats<br>- determined by structural requirements |

**(2) Design of Abutment**

The detailed design for the abutment is carried out to determine the basic structural requirements to support the anticipated loads in a similar manner with the Pampanga river bridge crossing.

The following conditions are applied in the design of abutment:

- Abutment Type : Closed type Cantilever Wall Abutment on bored piles
- Abutment Width : 9.95m
- Superstructure Support : On sliding bearing
- Material : Reinforced Concrete, f'c = 28 MPa
  Reinforcing Bars, fy = 415 MPa
- Live Loading : MS 18 (HS 20-44)

- Earth Pressure : Rankine's formulation due to retained soil
- Seismic Load : Seismic active earth pressure is based on pseudo static Mononobe-Okabe formulation for soil

  Ground Acceleration Coefficient is taken as A = 0.40 and horizontal seismic coefficient is taken as $k_h = 0.5A$
- Foundation : Multiple bored piles □1.0m

Figure 10.5-4 shows a typical layout of the abutment.

### (3) Design of Superstructure

The load combinations for the design of superstructure followed the AASHTO recommendations as outlined in the Bridge Design Criteria of this report. The live loading applied in the design is the AASHTO MS 18 Class (HS 20-44). However, permit design loading P-Load as recommended by BOD, DPWH is also adopted to check the capacity of the members under load factor design.

### (a) Precast AASHTO Girders

The design of precast prestressed AASHTO girders for the superstructure spans basically follows the AASHTO Standard Specifications for Highway Bridges.

The precast prestressed girders are taken as non-composite under self-weight and slab weight and composite with cast-in-place slab under superimposed dead loads and live load. The superstructure is made continuous on live load. The girders are supported on elastomeric bearing pads with fix dowel bars on continuous piers. Sufficient bearing support lengths is provided at expansion piers and dowel bars and restraining bars are utilized as fall down prevention device.

The design of the prestressed girder will follow the sequence of construction with the following steps:

| *DESIGN STEPS* | *ACTIVITIES* | *DESIGN CONSIDERATION* |
|---|---|---|
| STEP 1 | Girder Fabrication, Application of Prestressing and Erection | - the girder is taken as simply supported with self weight as the basic load<br>- additional impact due to transportation and erection are considered |

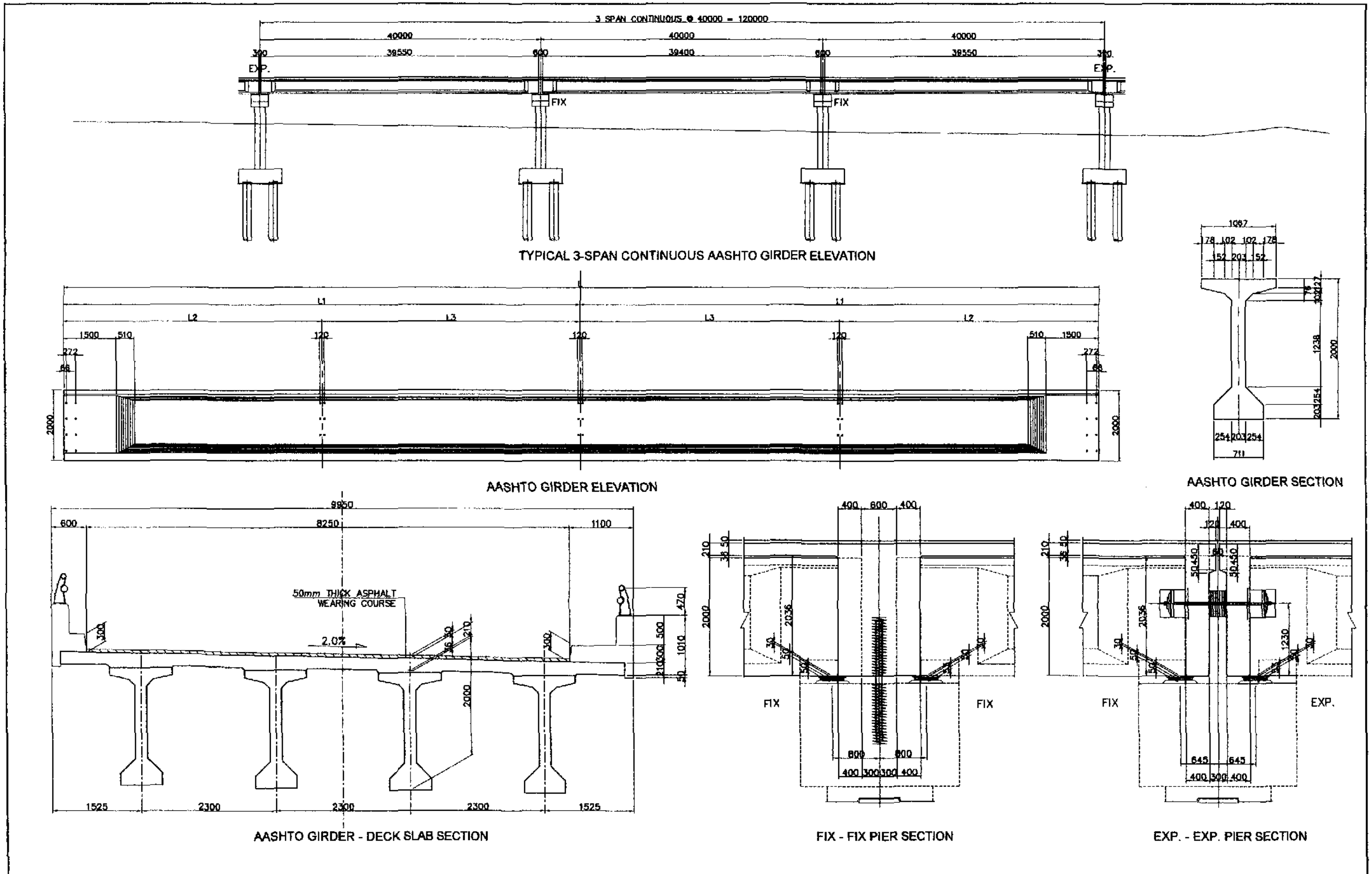



**FIGURE 10.5-5 AASHTO GIRDER FOR TALAVERA RIVER BRIDGE CROSSING**

| | | |
|---|---|---|
| STEP 2 | Pouring of Cast-in-Place Diaphragm and Deck Slab | - the girder is taken as simply supported with self weight plus additional load due to diaphragm and slab; construction loads will be added |
| STEP 3 | Pouring of Sidewalk and Railing and Placing Wearing Course | - the girder composite action with deck slab and its continuity over the pier will be taken as the structural system<br>- this structure system will support the superimposed dead load |
| STEP 4 | Service Condition Including Long Term Effects | - the girder is taken as composite and continuous over the piers<br>- live loading and other loads including long-term effects will be applied under this structure system |

Figure 10.5-5 shows a typical layout of the AASHTO girders for a 3-span continuous superstructure of this bridge while Figures 10.5-6 and 7 shows the sequence of superstructure construction.

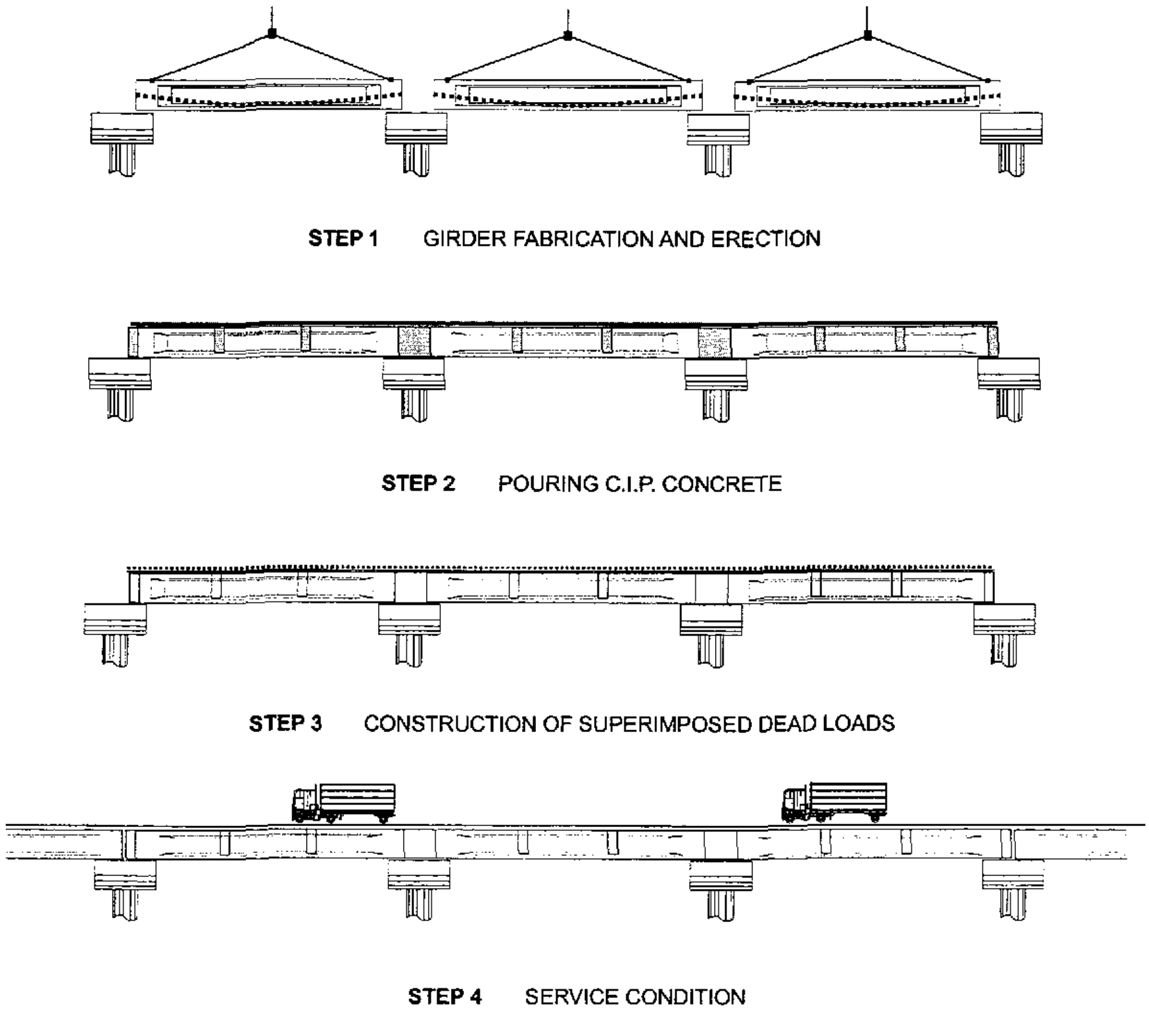
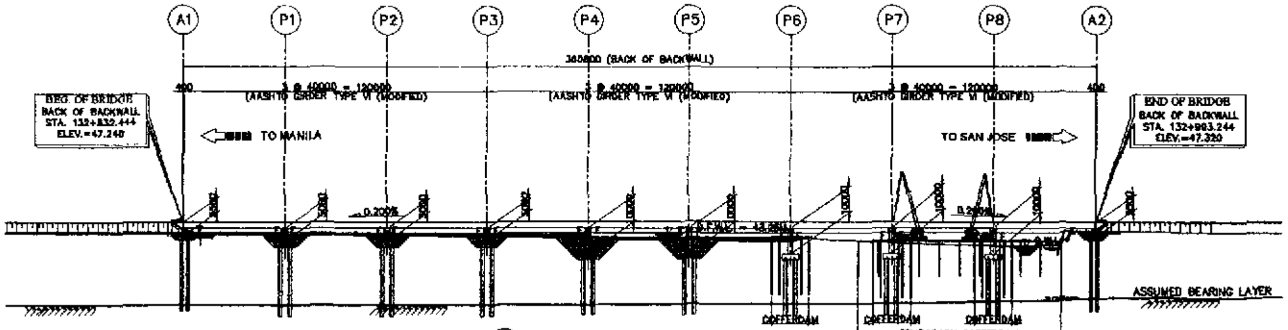
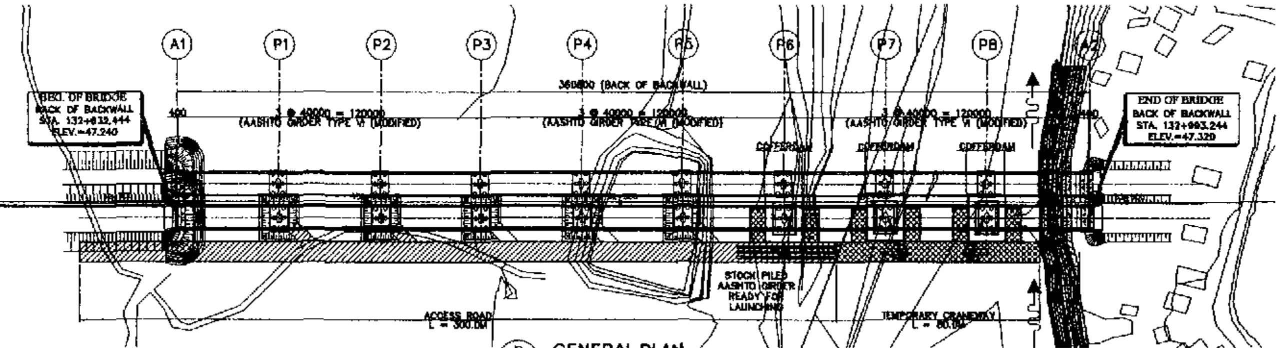


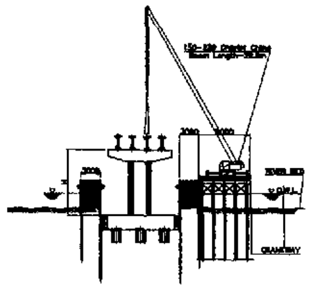

**FIGURE 10.5-6 SUPERSTRUCTURE CONSTRUCTION SEQUENCE**



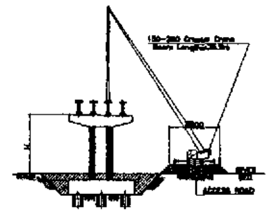

(A) GENERAL ELEVATION
SCALE 1:1000




(B) GENERAL PLAN
SCALE 1:1000



(C) SECTION SHOWING COFFERDAM
SCALE 1:1000



(D) SECTION SHOWING GIRDER LAUNCHING
SCALE 1:1000

100t Hydraulic Crane

| Work radius(m) | Lifting Capacity(tf) |
|---|---|
| 10.0 | 22.4 |
| 12.0 | 18.9 |
| 14.0 | 18.3 |
| 16.0 | 14.1 |
| 18.0 | 12.0 |
| 20.0 | 9.7 |

Boom Length 29.5m

CONSTRUCTION SCHEDULE OF TALAVERA BRIDGE
BRIDGE LENGTH = 360m

| ITEMS | MONTH 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. MOBILIZATION | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | |
| 2. CONSTRUCTION OF ACCESS ROAD | | ■ | ■ | ■ | | | | | | | | | | | | | | | | | |
| 3. CONSTRUCTION OF ACCESS ROAD | | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | | |
| 4. CONSTRUCTION OF TEMPORARY PLANTS & FACILITIES | | | | | | | | | | | | | | | | | | | | | |
| a. COFFERDAM FOR PIERS P7 & P8 | | | | | | | ■ | ■ | | | | | | | | | | | | | |
| b. BORED PILE & PILE CAP | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | |
| c. COLUMN & COPING | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | |
| 5. CONSTRUCTION OF ABUTMENTS A1 & A2 | | | | | | | | | | | | | | | | | | | | | |
| a. BORED PILE & PILE CAP | | | | ■ | ■ | ■ | | | | | | | | | | | | | | | |
| b. BREAST WALL & WINGWALL | | | | | | | ■ | ■ | ■ | | | | | | | | | | | | |
| c. EMBANKMENT /APPROACH SLAB | | | | | | | | | | | | | | ■ | ■ | ■ | | | | | |
| 6. CONSTRUCTION OF SUPERSTRUCTURE | | | | | | | | | | | | | | | | | | | | | |
| a. GIRDER FABRICATION | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | |
| b. LAUNCHING OF GIRDERS | | | | | | | | | | | ■ | ■ | | | | | | | | | |
| c. POURING SLAB END & INTERMEDIATE DIAPHRAGMS | | | | | | | | | | | | ■ | ■ | ■ | | | | | | | |
| d. SLAB & CONTINUITY DIAPHRAGMS (CLOSURE POUR) | | | | | | | | | | | | | ■ | ■ | ■ | | | | | | |
| e. SIDEWALK, RAILING & WEARING COURSE | | | | | | | | | | | | | | | ■ | ■ | ■ | | | | |
| 7. CONSTRUCTION OF SCOUR PROTECTION | | | | | | | | | | | | | | | | | | | | | |
| a. ABUTMENT SLOPE PROTECTION | | | | | | | | | | ■ | ■ | | | | | | | | | | |
| b. PIER PROTECTION | | | | | | | | | | | | | | | | | | | | | |
| c. RIVER PROTECTION | | | | | | | | | | | | ■ | ■ | ■ | | | | | | | |
| 8. FINISHING WORKS/MISCELLANEOUS | | | | | | | | | | | | | | | | | ■ | ■ | ■ | | |
| 9. DEMOBILIZATION | | | | | | | | | | | | | | | | | | | ■ | ■ | |

CONSTRUCTION SEQUENCE OF SUPERSTRUCTURE
(3–SPAN CONTINUOUS)

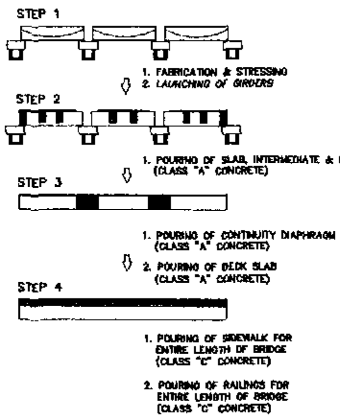



**FIGURE 10.5-7 CONSTRUCTION METHODOLOGY FOR TALAVERA BRIDGE**

**(4) Design of Substructure**

*Seismic Design.* The principles used in the detailed design of substructure are similar to Pampanga river bridge in Section 10.4.1.

The design of substructures basically adopted the recommendations of the AASHTO Div. I-A , Seismic Design.

For the seismic analysis, the multi-mode spectral analysis method under Seismic Performance Category D is used to determine the elastic design forces for the pier columns. The seismic response coefficients for various soil types is shown in Figure 9.5-8 while the peak ground acceleration is based on DPWH recommendations using the acceleration coefficient A = 0.4.

*Pier Column Design.* Similarly, the design of pier columns followed the procedures outlined in AASHTO Div. I-A.

A three-dimensional finite element mathematical model using 3D beam elements is used to perform the response analysis under seismic excitation. The elastic forces obtained from the multimode response spectrum analysis are used to determine the design forces for the columns considering the Response Modification Factor R. This R-factor is a function of column ductility which allows plastic hinging to form in the columns with sufficient lateral confinement.

Determination of column structural requirements (size and reinforcement) is done following the resulting modified design forces. Column confinement is detailed using the plastic design shear force derived from the plastic capacity of the column section.

*Foundation Design.* The design of the Bored Pile foundations is based on the guidelines set similar to Angat river bridge.

The design of foundation for the piers is based on the Capacity Design procedure. Here, the design concept would be to allow yielding or plastic hinges being formed in the column while keeping the foundation in the elastic range. To maintain such behavior, the design forces used for the foundation will be the plastic capacity forces of the columns. This will ensure that forces going into the foundation will be sustained by the foundation in the elastic range. The forces derived in this manner are taken as the ultimate load which becomes the basis of the Load Factor (Strength) Design for bored piles.