### 7.3.3 Results of Analysis

The depth averaged velocity and discharge distribution for each alternative was analyzed using the hydrodynamic module. For these simulations, applied flow discharge was 66,000 $m^3/s$, which is the annual maximum discharge during 1943-1998 at San Felix section and regarded as the standard peak discharge at the apex of the Orinoco Delta. As explained in the Chapter 3, since the sediment transport in the priority reaches is dominant in rainy season, only the peak discharge was used for the selection of appropriate alternatives.

After evaluating the discharge distribution by hydrodynamic analysis, appropriate alternatives were selected to analyze the riverbed changes using sediment transport and bed change modules. For these selected alternatives, numerical simulations were carried out applying actual hydrographs for 5 years period by repeating boundary conditions shown in Fig. 7-3-4 for consecutive 5 years. The changes of navigational channel depth are given in Table 7.3.2 and discharge distributions for several alternatives are shown in Fig. 7-3-5. The results of hydrodynamic analysis are illustrated below (Fig. 7-3-6).

**(1) Complete Closing Dike:**

- The location at upstream of the Tortola channel (Alternative [B2-1]) would be appropriate for the closing dike, since alternative [B2-2] would raise the water level in the Tortola channel by about 2m than that of alternative [B2-1] which might cause unfavorable conditions. However, location of the dike does not affect the discharge distribution.

In addition to the hydraulic effects, the economical location for dike construction would also be the upstream section; i.e. location of alternative [B2-1], (Section 30 as shown in Fig. 7-3-7), which is shallower and wider compared to any other sections of midstream or downstream. The structural volume of dike in the Tortola channel at upstream is the lowest as shown in the Table 7.3.3. This estimation was based on the recent bathymetric survey results of September 1999.

**Table 7.3.3 Estimated Volume of Dike at Alternative Locations**

| Alternative Location | Length of Dike (m) | Max. Height (m) | Volume of Dike (m3) | Volume of Footing (m3) | Total Volume (m3) |
|---|---|---|---|---|---|
| 1. Upstream (Sec. 30) | 2,200 | 14.5 | 745,000 | 154,000 | 899,000 |
| 2. Midstream (Sec.28) | 670 | 39.5 | 1,059,000 | 48,000 | 1,107,000 |
| 3. Downstream (Sec.25) | 1,720 | 17.5 | 941,000 | 124,000 | 1,065,000 |

Dike Features Assumed: - Dike Type: Complete Closing Dike - Dike Slope: 1:1.8
- Dike Top Width: 10m - Foot Protection (12m wide x 3m high)

- In the alternatives [B2-1] and [B2-2] for complete closing dikes, nearly zero velocity indicates water stagnation in the Tortola channel. Under this condition, sedimentation would occur at both upstream and downstream of the dike. The sand bar formation would close the Tortola channel either at its entrance after bifurcation of the Piacoa channel for alternative [B2-2] or at the confluence to the Rio Grande for alternative [B2-1]. Consequently, Tortola channel will be filled with sediments.

## Table 7.3.2 Results of Hydrodynamic Flow Analysis (1/3)

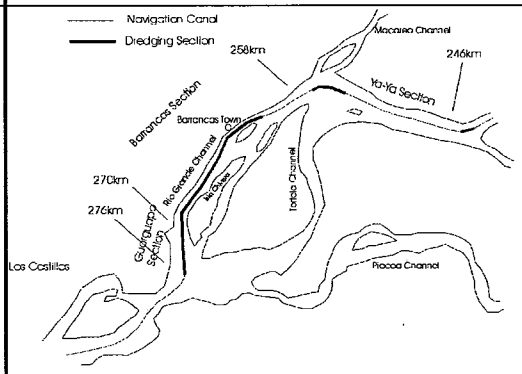
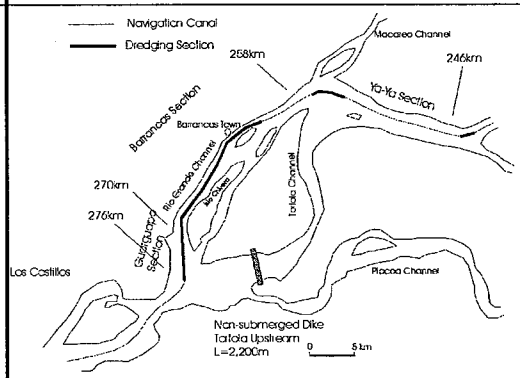
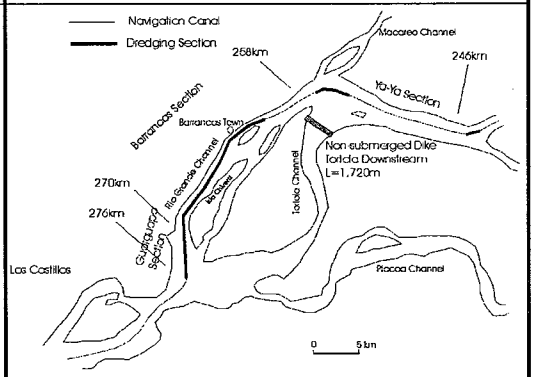
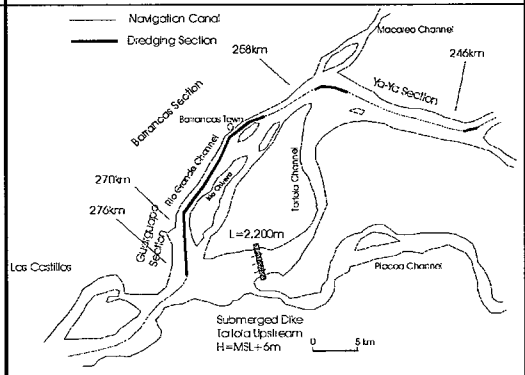
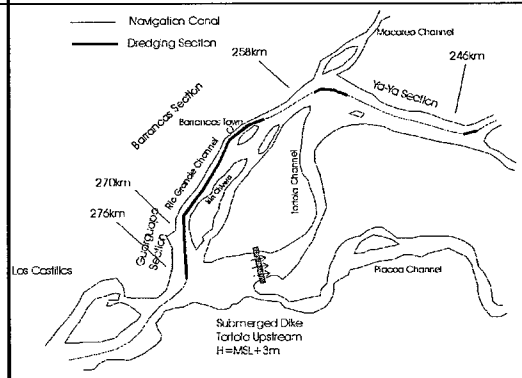
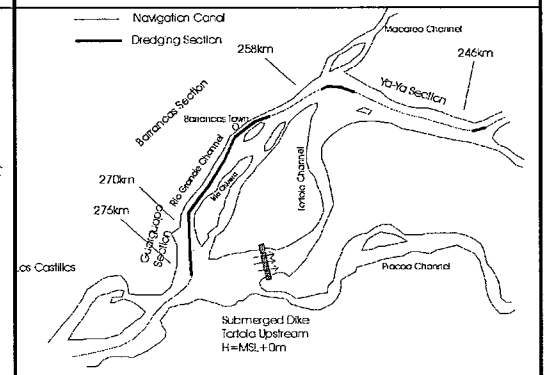
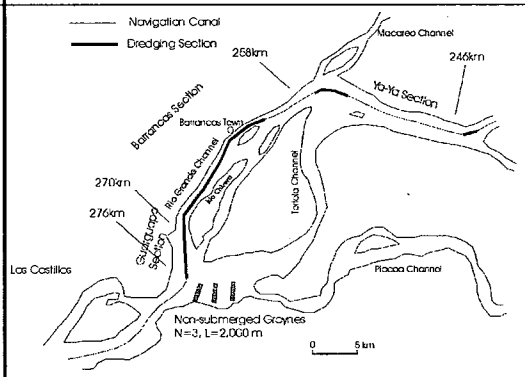
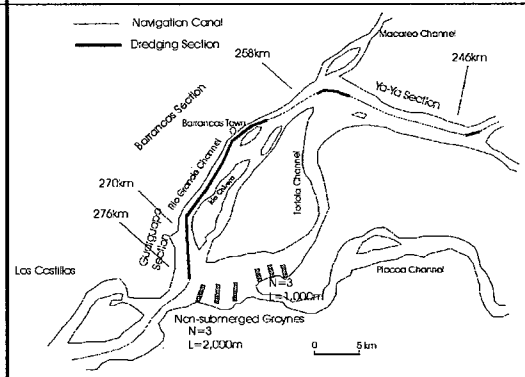
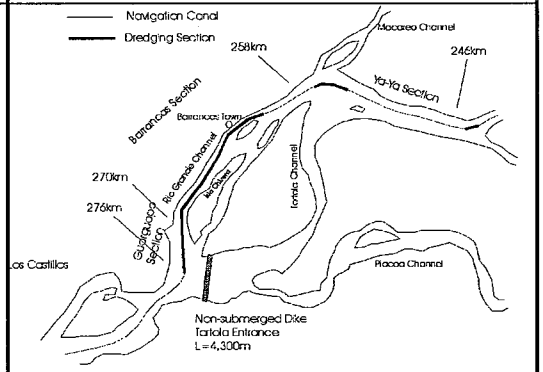
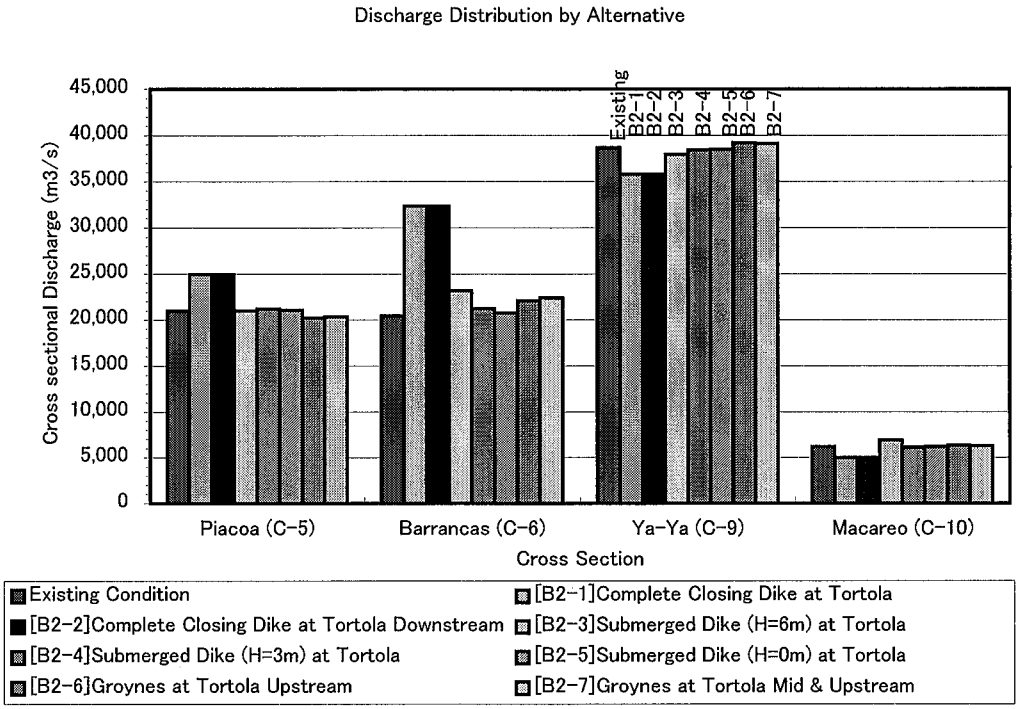
| Alternative | | Existing Condition | [B2-1] Complete Closing Dike at Tortola Upstream | [B2-2] Complete Closing Dike at Tortola Downstream |
|---|---|---|---|---|
| Location of Structures | |  |  |  |
| Change of Navigation Channel Depth (Compared to Existing Condition) | | Same as Existing | -3.9m as an average in the dredging sections | -3.9m as an average in the dredging sections |
| Water level | Guarguapo Section / Structure Downstream | MSL+9.0m / - | MSL+9.5m / MSL+8.0 m | MSL+10.0m / MSL+8.0 m |
| Velocity | Velocity along the Left Bank of the Rio Grande Channel | 0.6～1.4m/s | 0.6～2.0m/s | 0.6～2.0m/s |
| | Length of Bank Protection | 0km | 4km | 4km |
| nvironmental Impac | Transportation through Structure | No Effect | Complete Interrupt, but to be allowed by waterway for boat | Complete Interrupt, but to be allowed by waterway for boat |
| | Sedimentation in Tortola Channel | Same as Existing | The sedimentation will take place in both downstream and upstream reachs of the dike. | The sedimentation will take place in both downstream and upstream reachs of the dike. |

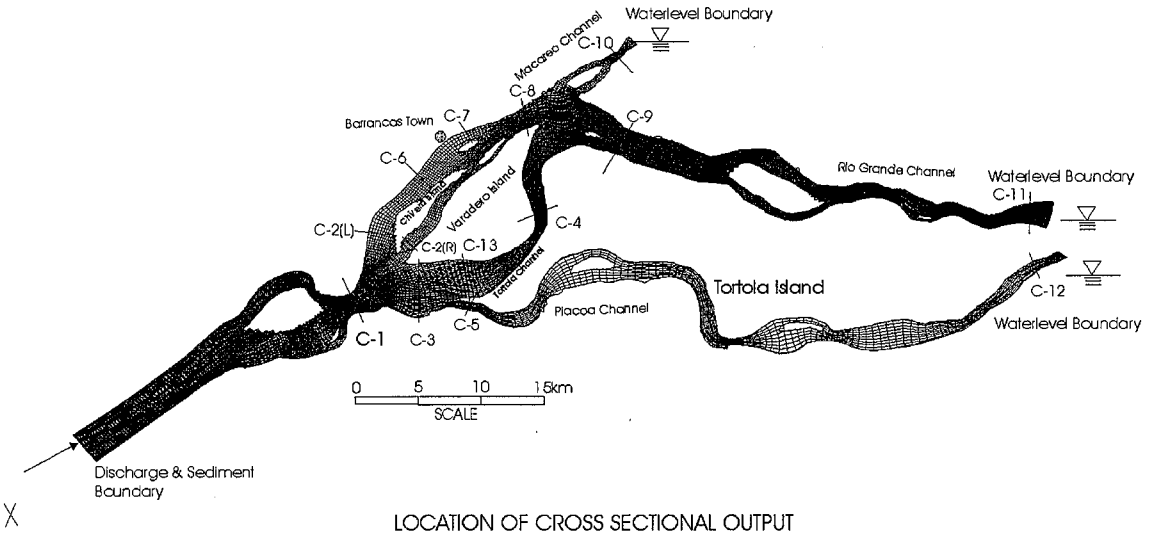
Table 7.3.2 Results of Hydrodynamic Flow Analysis (2/3)

| Alternative | | [B2-3] Submerged Dike H = MSL+6m | [B2-4] Submerged Dike H = MSL+3m | [B2-5] Submerged Dike H = MSL+0m |
|---|---|---|---|---|
| Location of Structures | |  |  |  |
| Change of Navigation Channel Depth (Compared to Existing Condition) | | -2.6m as an average in the dredging sections | 0m | 0m |
| Water level | Guarguapo Section / Structure Downstream | MSL+9.5m / MSL+9.0 m | MSL+9.0m / MSL+8.5 m | MSL+9.0m / MSL+8.5 m |
| Velocity | Velocity along the Left Bank of the Rio Grande Channel | 0.6～1.6m/s | 0.6～1.4m/s | 0.6～1.4m/s |
| | Length of Bank Protection | 4 km | 0km | 0km |
| nvironmental Impac | Transportation through Structure | Interrupted except for flood season, but to be allowed by waterway for boat | Interrupted except for flood season,but to be allowed by waterway for boat | No Effect |
| | Sedimentation in Tortola Channel | The sedimentation will take place in both downstream and upstream reachs of the dike. | The sedimentation will take place in both downstream and upstream reachs of the dike. | No Effect |

# Table 7.3.2 Results of Hydrodynamic Flow Analysis (3/3)

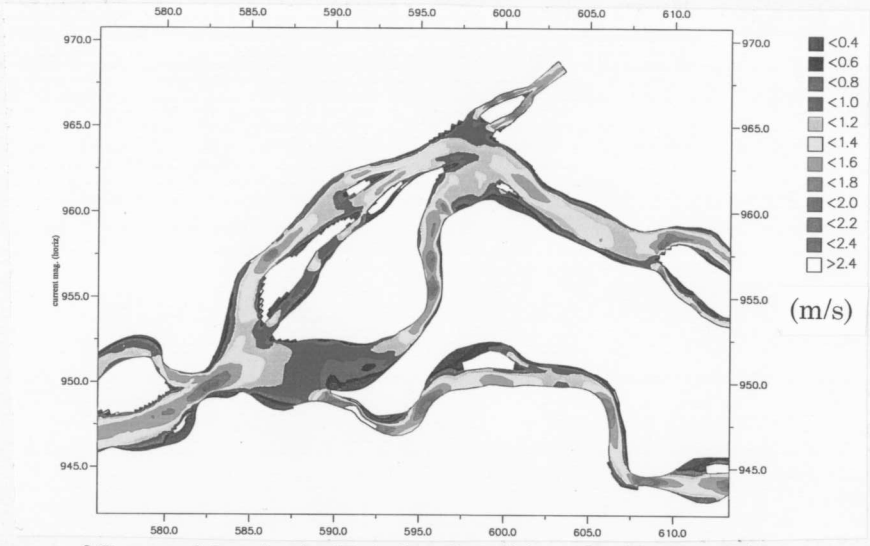
| Alternative | | [B2-6] Groynes at Tortola Entrance | [B2-7] Groynes at Tortola Entrance and Midstream | [B2-8] Non-submerged Dike at Tortola Entrance |
|---|---|---|---|---|
| Location of Structures | |  |  |  |
| Change of Navigation Channel Depth (Compared to Existing Condition) | | 0m | 0m | -5m ( estimated from the result of [B2-1]) |
| Water level | Guarguapo Section / Structure Downstream | MSL+9.0m / MSL+8.5 m | MSL+9.0m / MSL+8.5 m | MSL+11.5m / MSL+8.0 m |
| Velocity | Velocity along the Left Bank of the Rio Grande Channel | 0.6～1.4m/s | 0.6～1.4m/s | 0.6～2.4m/s |
| | Length of Bank Protection | 0km | 0km | 13km |
| nvironmental Impac | Transportation through Structure | No Effect | No Effect | Complete Interrupt, but to be allowed by waterway for boat |
| | Sedimentation in Tortola Channel | No Effect | No Effect | The sedimentation will take place in both downstream and upstream reachs of the dike. |



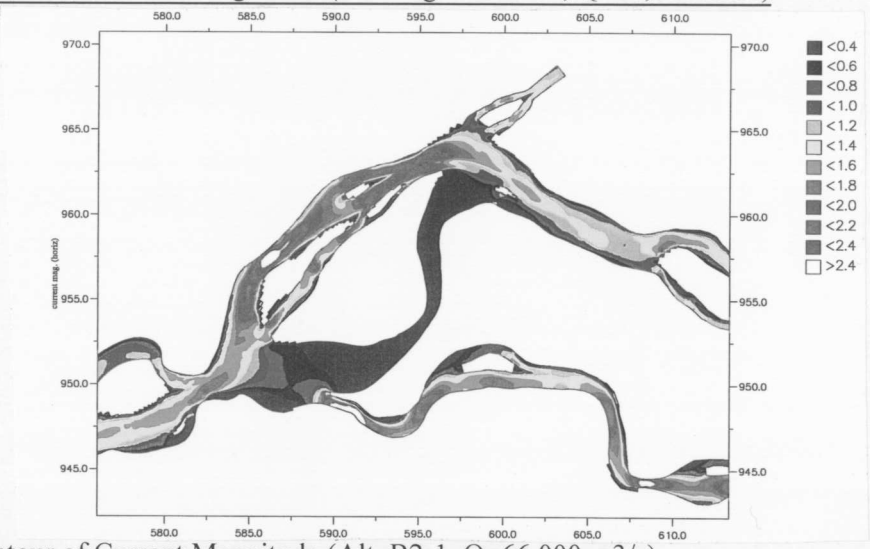




LOCATION OF CROSS SECTIONAL OUTPUT

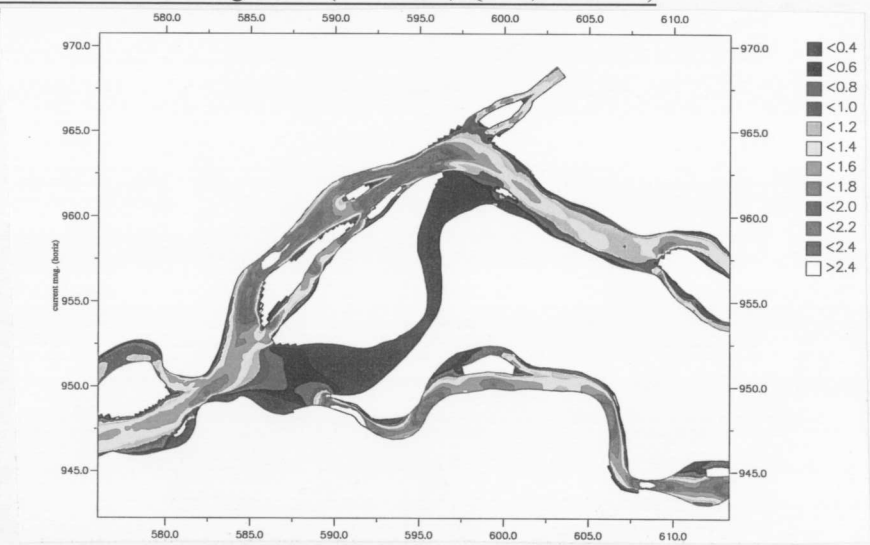
**Fig. 7-3-5 Discharge Distribution by Alternative**




Contour of Current Magnitude (Existing Condition, Q=66,000 m3/s)




Contour of Current Magnitude (Alt. B2-1, Q=66,000 m3/s)




Contour of Current Magnitude (Alt. B2-2, Q=66,000 m3/s)

**Fig.7-3-6(1/7)** **Results of 2 Dimensional Simulation Analysis**