

CHAPTER 8. CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

The river navigation on the Orinoco river is an indispensable transportation system for development of the Orinoco – Apure region in the inland area of Venezuela. The transportation of minerals and industrial products in lower Orinoco basin, specially iron ore, is heavily dependent on the improvement of the navigation channel. Since Venezuelan policy is encouraging export oriented steel industries, the export of industrial steel products will increase according to the change of transportation forecast. However, contrarily, iron ore exportation, which is the most critical factor in deciding the capacity of the channel, would decrease to 4 million ton/year in 2003 from present volume of 9 million ton/year. The main conclusions derived from the study on Integrated Orinoco River Improvement conducted to identify the suitable methods to improve the Orinoco river as a reliable and efficient waterway transportation system are summarized below, coping with the changes in future cargo transportation.

- 1) **[Navigation Route and Vessel Size]:** It is recommended that the Rio Grande channel is the most suitable navigation route for large vessels among all the alternative routes in the Orinoco delta. The channel should be maintained to accommodate Panamax size carriers (65,000 DWT) in terms of its depth and width, according to the present and foreseeable future cargo requirements. The barge train navigation in the Macareo channel would also be a desirable alternative means for iron ore transportation by waterway navigation in future, in case of circumstances are changed and necessity is emerged.
- 2) **[Structural Measures]:** It is technically feasible to minimize the periodic dredging requirement in the Rio Grande channel with the provision of structural measures; closing dikes according to the results of two-dimensional hydraulic analysis. However, these structural measures are evaluated as economically and financially not viable due to the high construction cost. Moreover, as a result of the closure of channel, potential adverse environmental effects on the social environment and ecosystem due to stagnation of water body, sediment deposition, disturbances on the waterway transportation and fisheries industry are also evaluated as significant. Furthermore, unforeseen phenomena in long-term view such as river course changes and morphological variations due to the large-scale structural measures could not be analyzed by presently available tools of hydraulic analysis and remained as unsolved problems. Therefore, it is risky to propose any structural measure without considerably high benefit compared to the cost. Consequently, in an overall sense, structural measures to deepen the navigation channel in the Rio Grande are evaluated as not feasible.

[Numerical Simulation for Hydraulic Analysis]: The two-steps approach of one-dimensional and two-dimensional hydraulic simulation applications are conducted in the river improvement study as the objective area is vast in extent and consists of complicated river networks. In first step analysis, one-dimensional hydraulic analysis is applied to reproduce the channel bed profile in the whole objective area and the characteristics of changes in channel course are identified as the key points aiming at the river improvement. Accordingly, practical alternatives of channel improvement could be discussed in macro viewpoint.

For the second step, two-dimensional analysis which considers the secondary flow phenomena, is conducted to evaluate the hydraulic effects by the implementation of structural measures, such as eroding the side banks and the changes in deepest channel bed at complicated meandering sections as well as the effects of lowering the navigation channel bed. This two-steps approach of one-dimensional and two-dimensional numerical model applications can be used as a reference for the other similar future river improvement studies.

- 3). **[Dredging Improvement Measures]:** The periodic maintenance dredging is evaluated as the only viable means to meet the navigation requirement from the overall viewpoints of technical, economic, financial and environmental aspects. The following dredging improvements are recommended within the scope of work of this study.

- Provision of RTK/GPS with precision location recording system and drag head positioning system to locate precisely shallow reaches and high spots.
- Minimize return of disposed materials into the navigation channel by introducing barge system. As a result, the deterioration of water quality caused by the present method of agitation dredging would be reduced.
- Reduction of non-operation time of dredges by means of proper employment system, spare parts management system and orderly maintenance works etc.

It is obviously ascertained that, regarding the dredging works at Boca Grande, the principal dredging plan consisting of dredging system, dredging method, dredge type, etc. could not be efficiently established, unless the fluff characteristics are not well investigated.

8.2 Recommendations

Based on the above conclusions, in order to sustain the maintenance dredging continuously in the future and to ensure the safe, efficient and reliable waterway transportation system in the Orinoco river, MARN-PROA should promote to carry out the following recommendations with coordination of relevant implementation agencies.

- 1) **[Comprehensive Dredging Study]:** Implement an integrated dredging study including the executing methods, dredging system, dredging constituent etc., together with following items.
 - Review of institutional structure for maintenance dredging (Administrative Measures).
 - Dredging system including dredging methods and techniques, dredge types etc. (Technical Measures).
- 2) **[Fluff Characteristics Investigation]:** Execute an integrated study to examine the physical properties of fluff to determine the most appropriate method of dredging operation at the outer channel (Boca Grande Section).
- 3) **[Establishment of Committees for Institutional Restructure]:** To overcome the present institutional and management deficiencies, establish a committee to study the effectiveness of assigning the maintenance dredging activities to private companies under the planning, management and supervision of INC. Moreover, to expedite the overall port management in Puerto Ordaz coping with the future cargo throughput and vessel traffic, establish a single entity called Port Authority, for a wide range of port activities related to development, maintenance, administration and management of port facilities as well as the enhancement of port use.
- 4) **[Introduction of Vessel Traffic Management System]:** In order to cope with the increase of future traffic volume as well as to ensure the safe and effective navigation in the Rio Grande navigation channel, in which there are several narrow reaches enough only for one way traffic, introduce a vessel traffic management system (VTMS) to identify the positions of all the vessels at any instance and to co-ordinate and control the vessel movements.
- 5) **[Periodical Review for Channel Alignment]:** As a non-structural measure, conduct of regular bathymetric surveys by INC and realign the navigation route through the deepest area of the channel to reduce the maintenance dredging requirement.