6.4 Dredging Improvement

6.4.1 Brief Background

The navigation channel along Boca Grande and Rio Grande as shown in Fig. 6-4-1 hereunder is about 339 kilometers long with 78 kilometers of Outer Channel from the river mouth towards the sea at Boca Grande and 261 kilometers of Inland Channel along Rio Grande. The riverbed consists generally of uniform fine sand deposits while the bed at Boca Grande consists generally of fine soft silt deposits. Some 78 and 50 kilometers long of maintenance dredging needs to be conducted along the Outer Channel and Inland Channel respectively to ensure safe navigation of the vessels.

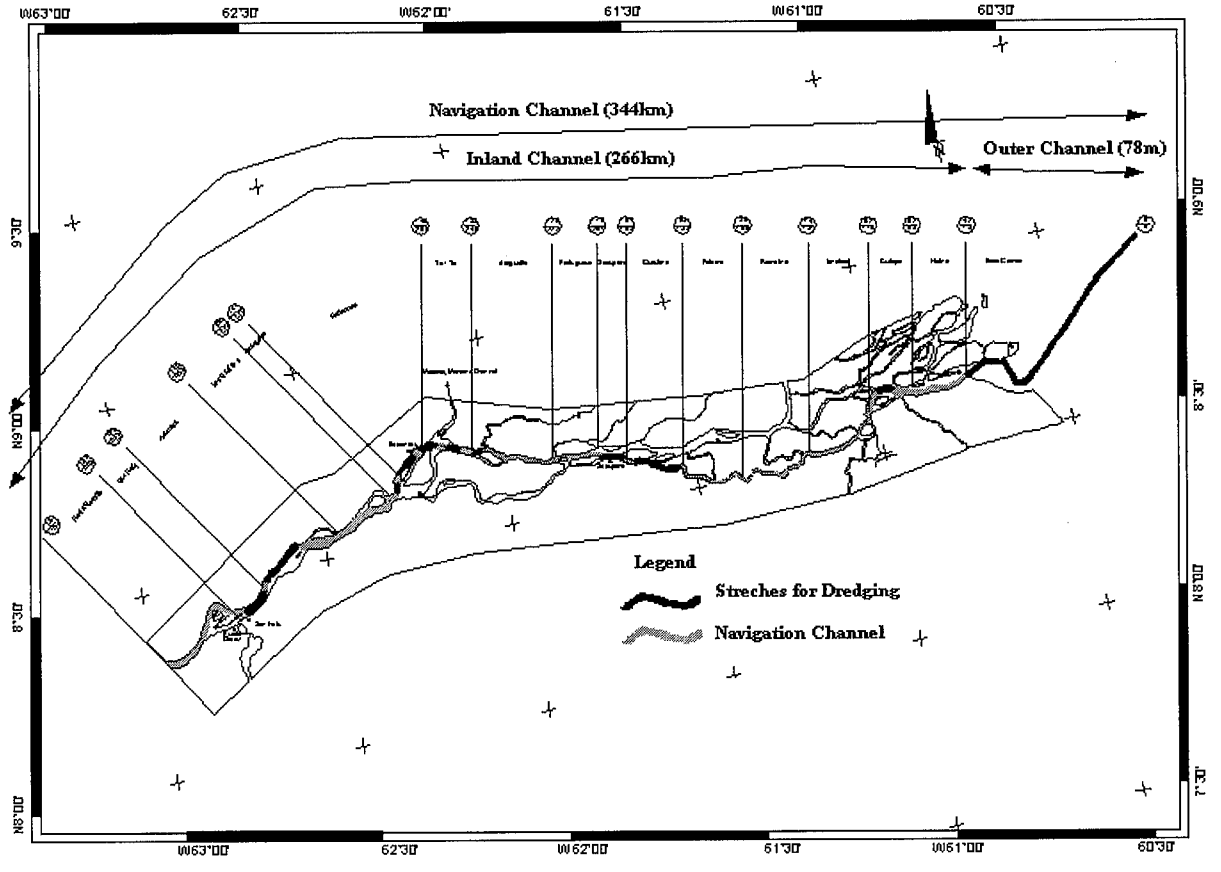


Fig. 6-4-1 Inland and Outer Channel

6.4.2 Dredging Activities

The Institute Nacional de Canalization (INC) is the implementing arm of the Government of Venezuela tasked to maintain the necessary depth along the Outer Channel and Inland Channel to make it navigable. The maintenance dredging should be undertaken in accordance with the following considerations:

(1) Typical Section of Outer Channel

The Channel should be maintained to a depth of 44 feet below MLLW with a bottom width of not less than 400 feet and side slope of 1: 6 as shown in Fig. 6-4-2 hereunder. It should be able to accommodate 65,000 ton Panamax size vessels with draft of up to 42 feet below MLLW with 2 feet for safety allowance as shown.

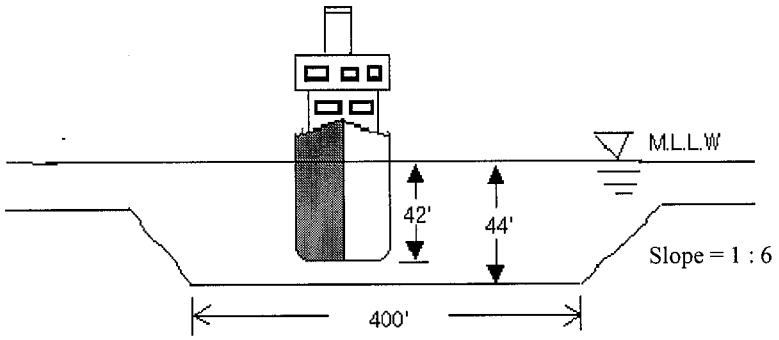


Fig. 6-4-2 Typical Section of Outer Channel

(2) Typical Section of Inland Channel

The Channel should be maintained to a depth of 34 feet below LWL with bottom width of not less than 300 feet and side slope of 1:6 as shown in Fig. 6-4-3 hereunder. It should be able to accommodate vessels with draft of up to 32 feet below LWL at dry season. Water levels in the Inland Channel rise drastically in rainy season and fall to LWL in dry season. In rainy season the water depth increases to about 10 m in Aramaya Section and about 5 m in Guasina Section, hence the water depths in Inland Channel become much larger than the depth of 44 feet in the Outer Channel during this season. The navigational depth in the Rio Grande Channel can be defined as the minimum navigable depth available from both the Inland Channel and Outer Channel. In dry season the depth of 34 feet in the Inland Channel, which is smaller than the depth in the Outer Channel, is generally defined as the navigational depth, while in rainy season the depth of 44 feet in the Outer Channel is the navigational depth.

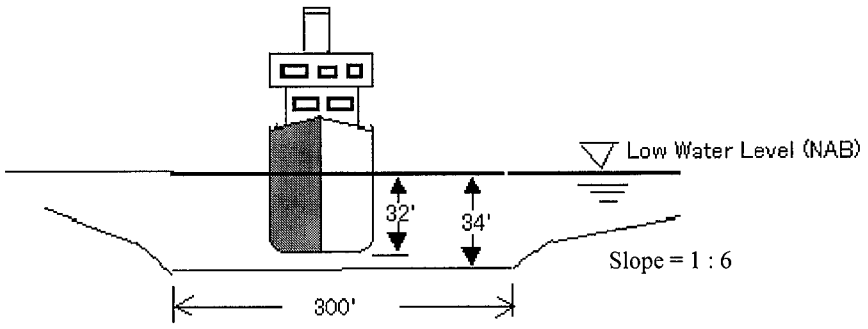


Fig. 6-4-3 Design Section of Inland Channel

(3) Soil Properties of the Bed Materials

The bed of the Outer Channel consists of fine silt deposits with minute diameter of no more than 2.1 microns, while the bed of the Inland Channel consists of uniform fine sand ranging from 0.7 mm (700 microns) to 0.3 mm (300 microns) in diameter. At the river mouth when the flow velocity decelerates, suspended sediments tend to flocculate and settle into fluff with high void ratio. The fluff with high void ratio does not affect the vessel navigation just after flocculating and settlement. However, the settled fluff may become an obstruction to safe vessel navigation when the void ratio decreases as time passes because the fluffs are compressed by the weight of deposits.

(4) Quantity of Dredged Volume

Based on INC Report dated January 1996, the annual average volumes dredged at the Outer and Inland Channels covering the period from 1965 to 1972 amounted to 10 million and 8.5 million cubic meters respectively. However, according to the recent INC record from January 1995 to December 1998, the navigable depth has decreased by 2-3 meters when compared with the design depth. Consequently the canal depth does not satisfy the required design depth. Hence, dredging is required to attain the design depth for safe navigation.

(5) Dredge Equipment, Period and Sequence

Maintenance dredging for both the Outer and Inland Channels is being pursued as shown in Fig. 6-4-4 hereunder.

The water level in the Inland Channel starts to rise in April thus the water depth along the navigable channel is deepened. As a result, the water depth in the Outer Channel becomes

comparatively shallower, hence, the need for dredging. The water level in the Inland Channel however, starts to fall in September, making the Inland Channel shallower than the Outer Channel, hence, dredging there becomes necessary during this period.

Fig. 6-4-4 Sequence & Period of Operation of the Dredge

Channel	Dredge	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Outer	Rio Orinoco				■	■	■	■	■				
	Hang Jun 6001			■	■	■	■	■	■				
	Guayana				■	■	■	■	■				
Inland	Rio Orinoco	■	■	■						■	■	■	■
	Hang Jun 6001	■	■							■	■	■	■
	Guayana	■	■	■						■	■	■	■

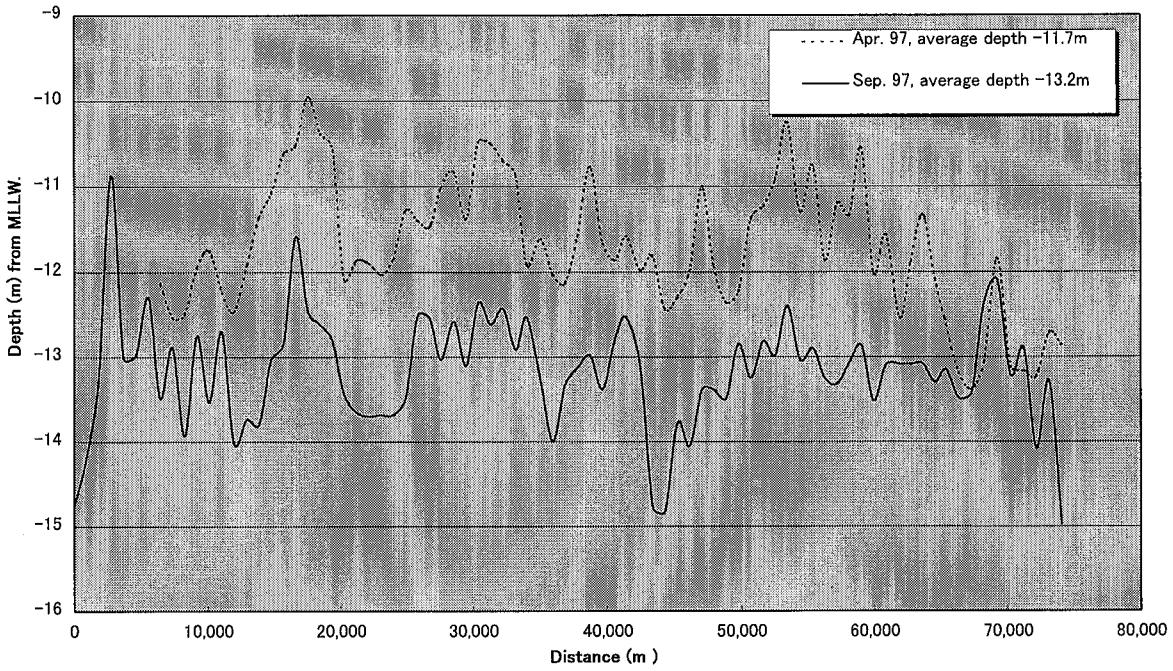
Where: Dredging ranges for outer channel;
Dreadging Range of Rio Orinoco : mile 20 to mile 40
Dreadging Range of Hang Jun 6001 : mile 10 to mile 20
Dreadging Range of Guayana : from mile 0 Up to mile 10

Note: Dredging ranges in the inland channel for each channel are not available. Source: INC
Hang Jun 6001 dredge has been hired by INC for a specific period.

As can be seen from Fig. 6-4-4, the Inland Channel is being dredged from September to December and from January to March during the dry season while the Outer Channel is being dredged from March to August during the rainy season.

(6) Bed Profile of the Outer Channel

The pre-dredge survey taken in April 1997 and the post survey conducted in September 1997 along the longitudinal section of the Outer Channel is shown in Fig. 6-4-5 hereunder.



Data source: INC sounding survey drawings

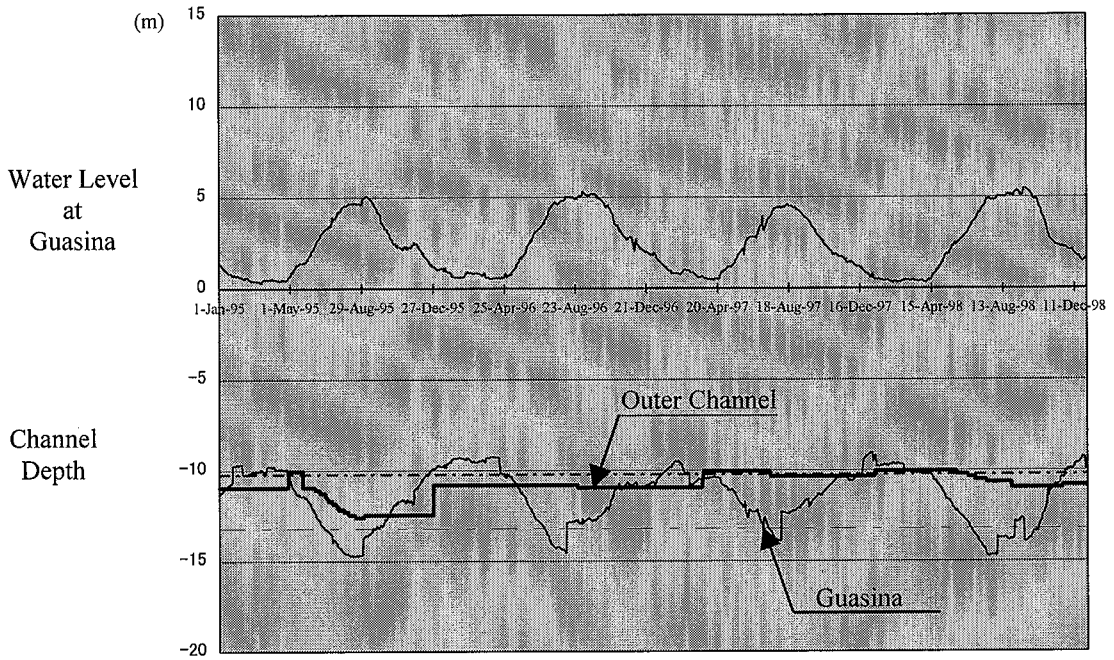
Fig. 6-4-5 Average Depth along the Profile of the Outer Channel

As can be seen from the Figure, prior to dredging in April 1997 the average depth in the Outer Channel was 11.7 m below MLLW. In September 1997 the Channel was dredged to an average depth of 13.2 meters below MLLW, thus satisfying the design depth. Fig. 6.4.4(c), however, shows a navigable depth of about 7.0 meters only below MLLW based on the highest spot of the unevenly dredged bed channel.

(7) Current Depth of Inland Channel and Outer Channel

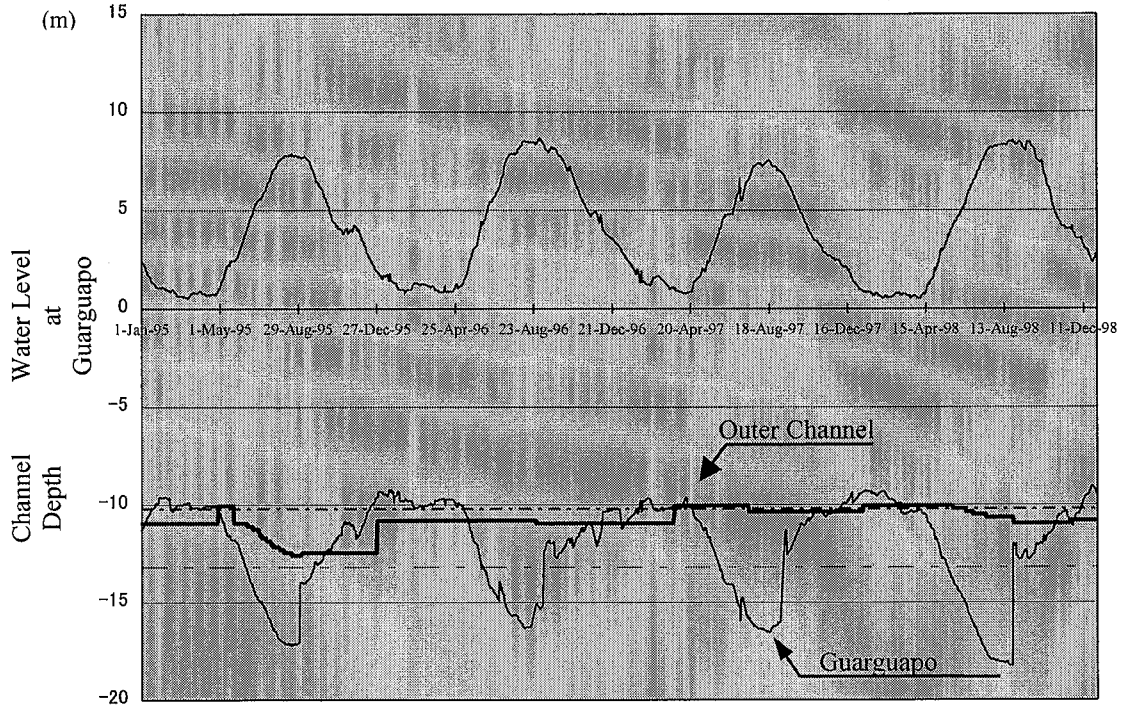
The depth of the Inland Channel covering the period 1995 to 1998 at Guasina, Guarguapo and Aramaya sections compared with the Outer Channel is shown in Fig. 6-4-6, Fig. 6-4-7 and Fig. 6-4-8 hereunder. (source: INC)

Apparently, the depth of the Inland Channel is deeper when compared with the Outer Channel due to the higher water line datum of Rio Grande particularly during the rainy season. Based on these figures the sequence of dredging the Inland Channel during the dry season and the Outer Channel during the rainy season appears to be a very effective technique.



Data source: Boletin de Profundidades de INC

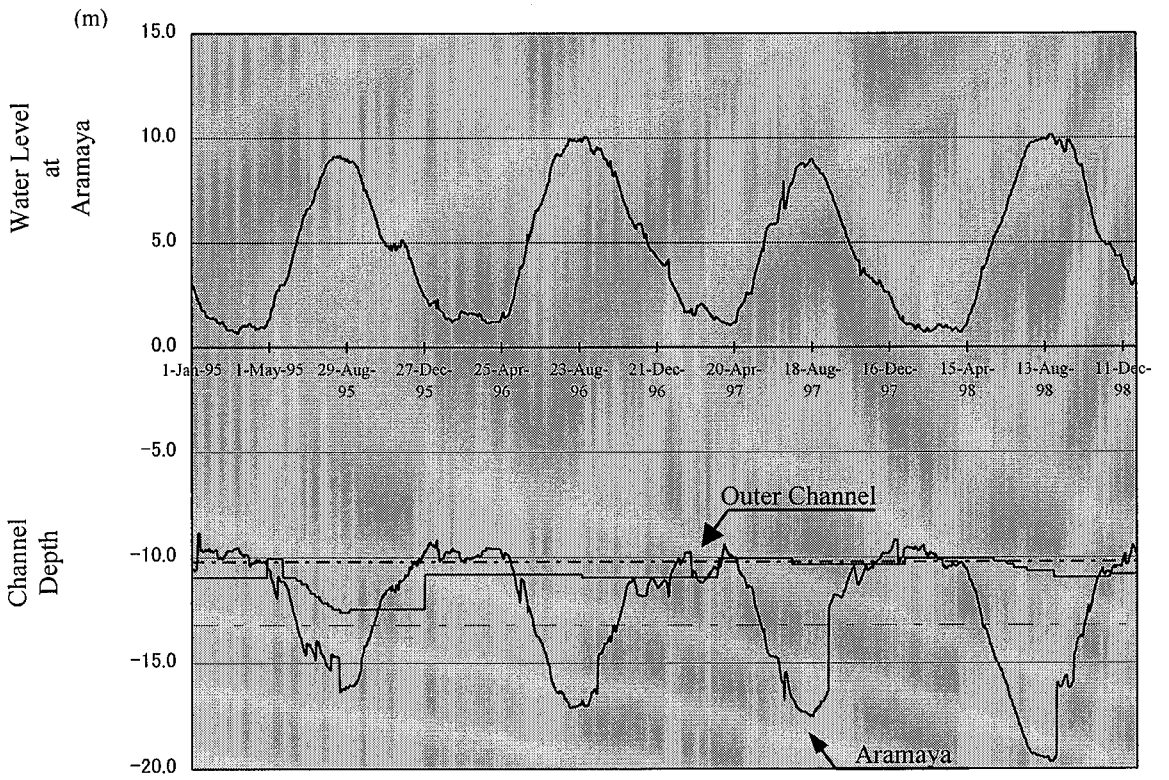
Fig.6-4-6 Channel Depth at Guasina Compared with the Outer Channel



(Basis is LWL at Guasina.) Data source: Boletin de Profundidades de INC

Fig.6-4-7 Channel Depth at Guarguapo Compared with the Outer Channel

Fig.6-4-2 (f) Channel Depth at Guarguapo Compared with the Outer Channel

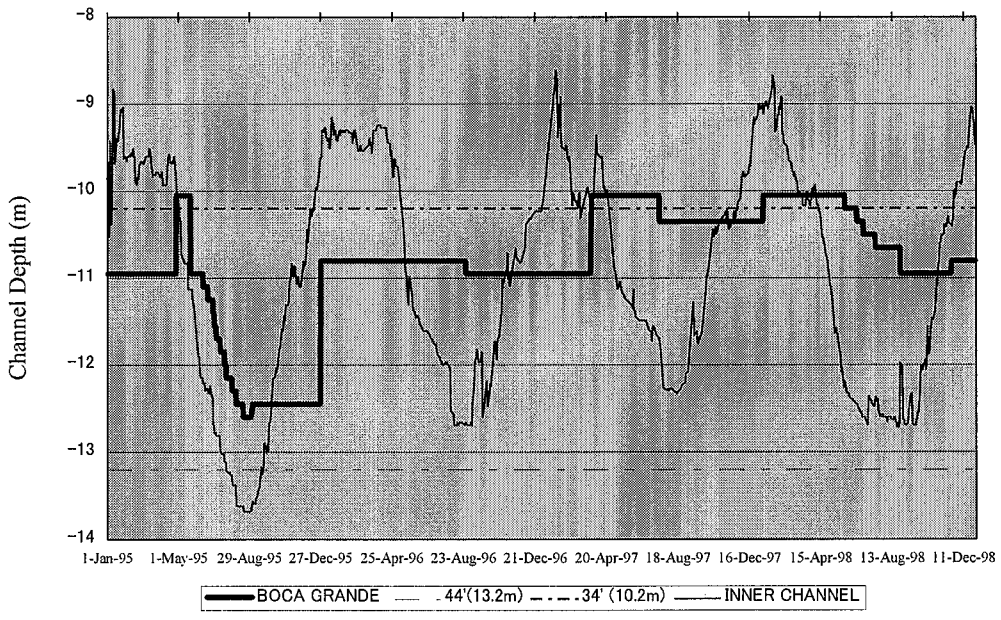


(Basis is LWL at Guasina.) Data source: Boletin de Profundidades de INC

Fig. 6-4-8 Channel Depth at Aramaya Compared with the Outer Channel

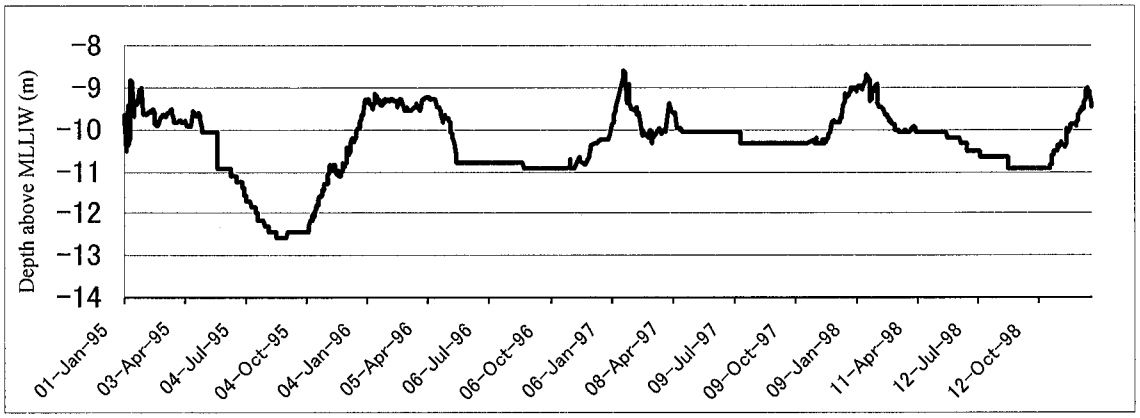
(8) Navigable Depth Comparison between the Outer Channel and Inland Channel

Based on the depth bulletin which the INC publishes daily, the depth profile of the Outer Channel and Inland Channel covering the period 1995 to 1998 was plotted as shown in Fig. 6-4-9 hereunder. Apparently from the Figure, the maintenance of the depth of the Outer Channel is more critical than the Inland Channel particularly during the rainy season when the depth of the River is higher than the depth of at the Outer Channel. The Figure also clearly shows that in April 1998 the depth of the Outer Channel is 10 meters below MLLW and was dredged to 11 meters below MLLW in September 1998. In such case, in order to attain the required depth of 13.2 meters below MLLW, the Channel must be deepened by about 2.2 meters. This deepening for the Outer Channel is estimated to involve a total volume of about 25 million cubic meters of spoils.



Data source: Boletin de Profundidades de INC

Fig. 6-4-9 Navigable Depth Comparison between the Inland Channel and Outer Channel



Data source: Boletin de Profundidades de INC

Fig. 6-4-10 Channel Depth

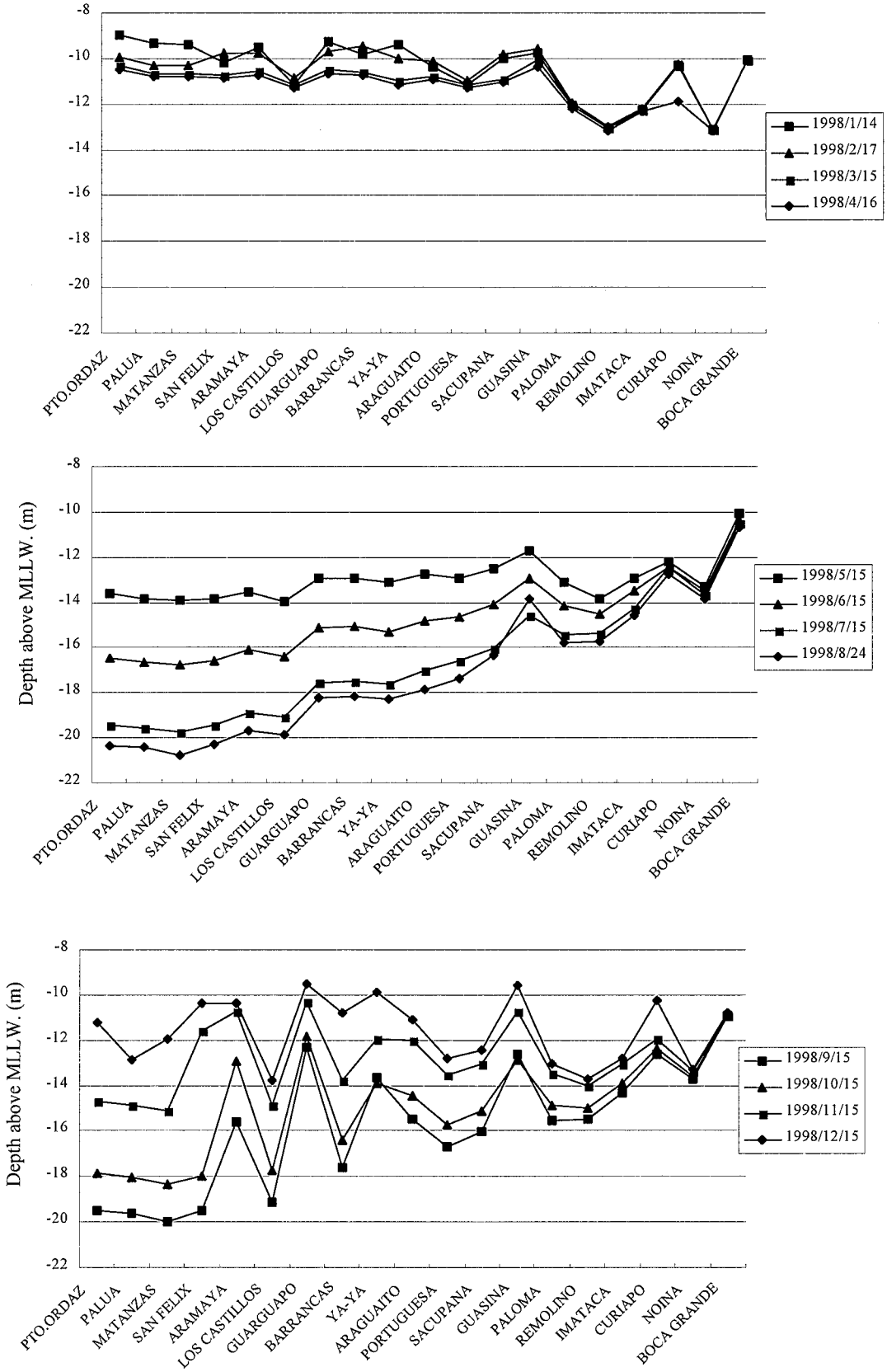
As can be seen in the graph (Fig. 6-4-10), the shallowest section of the channel is 9 meters below MLLW and the deepest is 11 m below MLLW or an average of 10 meters below MLLW.

The graphs hereafter summarize the INC Bulletin of the channel depth along BOCA GRANDE, Puerto ORDAZ covering the period January to December 1988 (Fig. 6-4-11). Based on the graphs, the following measurements are obtained:

- Depth of Inner Channel is in a range of 9 to 10 meters below MLLW for the month of January. This appears to be shallowest depth during the year.
- Depth of Inner Channel from March to April is in a range of 10 to 11 m below MLLW along Boca Grande, Guasina and Barrancas.
- Abundance of rain in May makes the Inner Channel deeper. The depth of the Inner Channel in June becomes deeper and satisfies the design depth of 13.2 m below MLLW. The channel depth along Boca Grande however, ranges from 10 to 10.5 meters below MLLW, appears to be the shallowest.
- From November to December, the depth of the Inner Channel is in a range of 11 to 12 meters below MLLW. The depth along Boca Grande during this period is 11 meters below MLLW.

In summary, depth of the Inner Channel from November to April or about 6 months period is more or less than 10 meters below MLLW which is about the same depth as that of Boca Grande, hence, the design depth of 10.2 meters is somewhat satisfied during the receding water line period.

Water level rises from May to October, hence, the depth along almost all the Inner Channel is more than 13.2 meters.



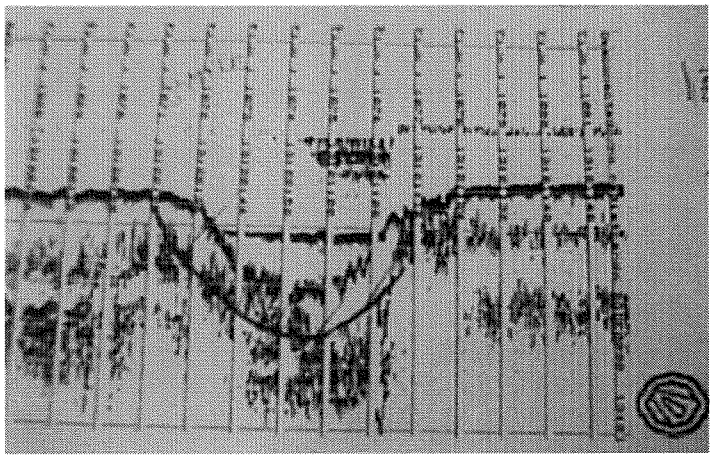
Data source: Boletin de Profundidades de INC

Fig. 6-4-11 Monthly Depth along Boca Grande to Pto. Ordaz

(9) Pre-Dredge Survey

Prior to the start of dredging operation, bathymetric survey is being conducted at the stretches of deposits. A 24 kHz echo sounder is used for the Outer Channel and a 200 kHz is used for the Inland Channel. Since the bed material in the Inland Channel consists of sand, both the 24 kHz or 200 kHz will detect the same depth. In the case of the Outer Channel however, the 200 kHz echo sounder can measure only extremely shallow depth when compared to the actual depth since the high spots of the uncompressed fluffs are measured. The 24 kHz echo sounder on the one hand can detect the deeper depth because the sound wave will reflect only when it hits denser stratum which might be the representative depth of obstruction for vessel navigation.

Samples of the registers are shown in Fig. 6-4-12 and Fig. 6-4-13 below.



Outer Channel

Fig.6-4-12 Sounding Record of both 200khz & 24khz Echo Sounder

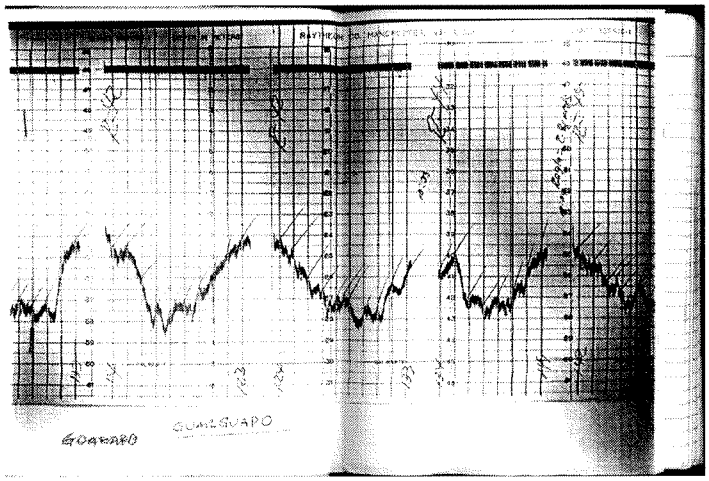


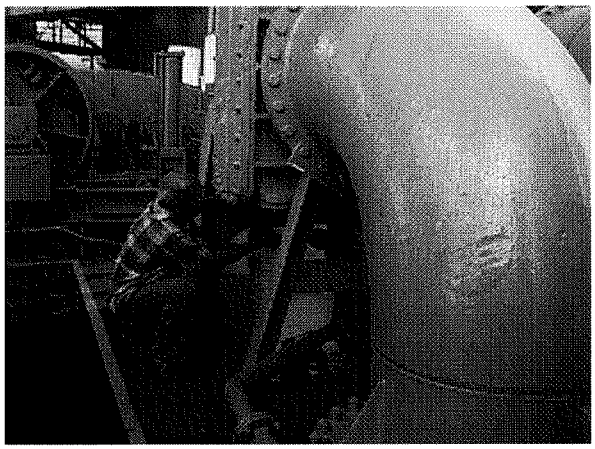
Fig.6-4-13 Sounding Record of 200khz Echo Sounder

(10) Calculation of Dredged Volume

According to the INC information, four methods such as concentration measurements of samples, production measuring of dredges, hopper gauging and use of pre and post dredging sounding charts are applied to calculate the quantity of dredged materials. The method of concentration measurements of samples can be described as follows:

1) Daily samples are obtained from the pump outlets as shown in Fig. 6-4-14 below and the solid contents are measured.

2) The quantity of materials dredged is then calculated based on the discharge volume, frequency and duration of the dredging operation and the measured concentration of the samples.



Open the valve under the pipe to obtain liquid sample.

Height of the solids in the bucket is measured.

Fig.6-4-14 Solid Content Measurement of Dredged Samples

(11) Navigation Depth Bulletin

INC publishes a daily bulletin on the depth of the Channel to ensure safe navigation of vessels. Based on the shallowest depth from the data, the shipping operators are required to subtract two (2) feet of the vessel's draft to ensure that the vessels would not run aground. In the case of the Outer Channel, when the ship encounters the occurrence of fishtails or is affected by a squat and the captain considers that passage is hazardous, the Port Authority is notified for INC to adjust the published depth accordingly. Samples of the bulletin are attached in the Supporting Report.

6.4.3 Dredge Fleet

INC possesses a fleet of three (3) dredge, namely: Rio Orinoco, Icoa and Guayana. Of the three, Icoa is no longer operational. The navigable depth of the Channel is currently being maintained by three (3) dredges including the Hang Jun 6001 Dredge contracted with China Harbor. Particulars of the dredges are shown in Table 6.4.1 hereunder while the various type of dredges are shown in Fig. 6-4-15, Fig. 6-4-16, Fig. 6-4-17 and Fig. 6-4-18 hereafter.

Cutter suction dredge, which is very popular worldwide, is not used because of the needed preparation before dredging could be started. Moreover, transferring the dredge to give way for navigating vessels would take much time.

Table 6.4.1 Particulars of the Dredge Equipment

Dredges	Río Orinoco	Hang Jun 6001	Icoa	Guayana
Owners	INC	CHINA HARBOR	INC	INC
Year Constructed	1979	1979	1961	1991
Length	116m	153m	147m	141m
Width	28m	29m	28,5m	23m
Gross Weight (GT)	8,750	14,328		
Propulsion	Self-propelled	Self-propelled	Self-propelled	Self-propelled
Type	Trailing Suction Discharge arm	Trailing Suction Discharge Arm Hopper	Trailing Suction Discharge Arm Hopper	Trailing Suction Hopper
Length of the arm from the center of the hull	86m	114m	108m	-
Height of the arm from water level	17m	17m	20m	-
Hopper capacity	-	6,300m^3	2,350m^3	7,500m^3
Number of pump	4 pumps	4 pumps	4 pumps	2 pumps
Pumping capacity of one pump	12,000m^3/h	10,500m^3/h	10,000m^3/h	15,000m^3/h

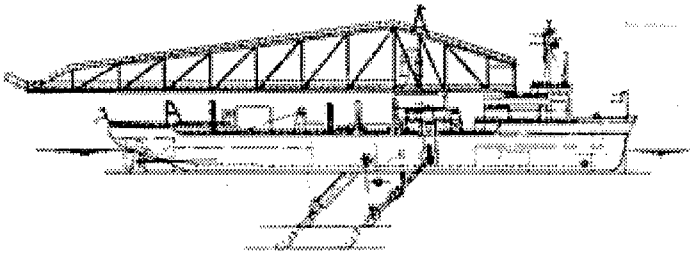


Fig. 6-4-15 Rio Orinoco Dredge

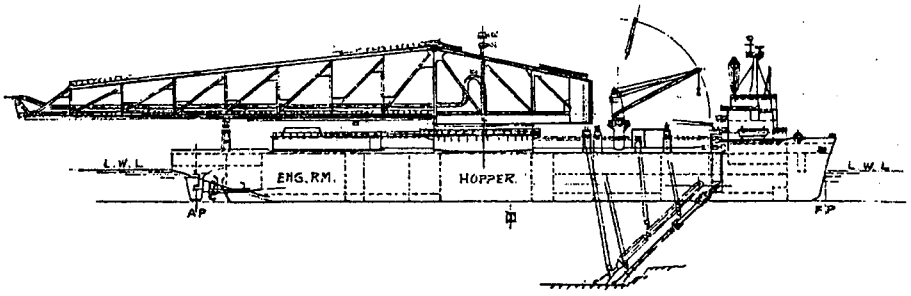


Fig. 6-4-16 Han Jun Dredge

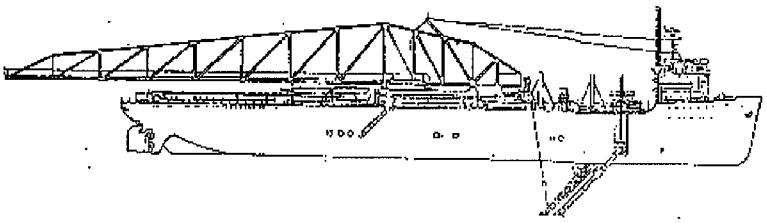


Fig. 6-4-17 ICOA Dredge

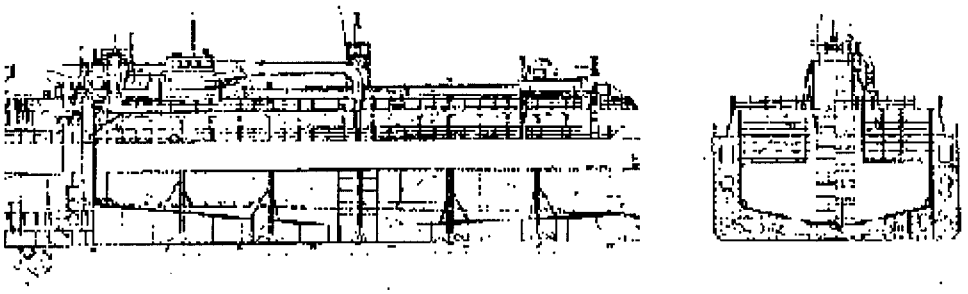


Fig. 6-4-18 Guayana Dredge