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The Martin Garcia Channel Project



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Abstract

The Upper Rio de la Plata forms the corridor for the passage of ships from and to the Rio Parana and Rio Uruguay. These two rivers are used to reach the large upstream Argentine harbours used for exporting grain and importing all kinds of goods. The Rio Parana also provides a connection with Paraguay and Bolivia. There are two access channels to the Rio Parana: One is an artificial navigation route, the Canal Mitre; the other is a natural access route, following the Uruguayan coast and running through the Martin Garcia Channel. This area is known as *Sistema Fluvial del Norte*, and carries the major part of the water volume of the Parana River.

The Martin Garcia access route goes from the mouth of the Rio Uruguay and via the Delta of the Parana River through the Parana Guazu and Parana Bravo. This route is used by the larger PANAMAX and Cape Size Vessels in order to avoid the difficult navigation in the winding Parana de las Palmas.

In Phase 1 of the project the channel will be deepened to 32 ft and widened to approximately 100 m, in order to give access to the larger bulk carriers with increased loading capacity compared to what is presently possible at draughts of 24 or 25 ft.

In Phase 2, the channel will be maintained, a buoyage system put in place and a toll collection system implemented for a period of eight years.

This article describes the design and execution, including the tendering process of the dredging project in the Martin Garcia Channel.

Introduction

The large grain exporting harbours of Argentina are situated on the Parana River, about 300 km upstream from the mouth of the Rio de la Plata. The Rio de la Plata can be described as shallow inland sea with natural depths between 1 and 6 m. The distance from the mouth of the Parana to the deep ocean waters is approximately 250 km; the Rio de la Plata has a width of 40 km on the upstream side near Buenos Aires, and of about 200 km downstream, where it joins the

ocean at the level of Montevideo. Both, the Rio Parana and the Rio Uruguay, flow into the Rio de la Plata.

There are actually two access channels to reach the upstream harbours along the Rio Parana (Figure 1), both of which until recently had water depths of only 6.00 to 8.00 m:

There is an artificial navigation route, situated in Argentine waters, dredged through the shallow Playa Honda. This channel, the Canal Mitre, gives access to the winding Parana de las Palmas, and is subject to very heavy siltation. The deepening and maintenance of this waterway are carried out by the Hydrovia Group, comprised of Jan De Nul and the Argentine EMEPA.

The alternative route is The Martin Garcia Channel. It is a natural waterway starting at Km 37 of the entrance channel to Buenos Aires. In the vicinity of the city Colonia del Sacramento, the channel turns and follows the coast of Uruguay running through the mouth of the Rio Uruguay, and via the Delta of the Parana River through the Parana Guazu and Parana Bravo. This area is known as *Sistema Fluvial del Norte*, and the major part of the water volume of the Parana flows through this route. The route is used by the larger PANAMAX and Cape Size Vessels in order to avoid the difficult navigation in the winding Parana de las Palmas.

The project involving this waterway is being carried out by the Riovía group, formed by Dredging International N.V. and its Italian subsidiary SIDRA, together with the Dutch contractors Boskalis International B.V., HAM and Ballast Nedam Dredging, the Argentine Dyopsa and Pentamar, and the American Great Lakes.

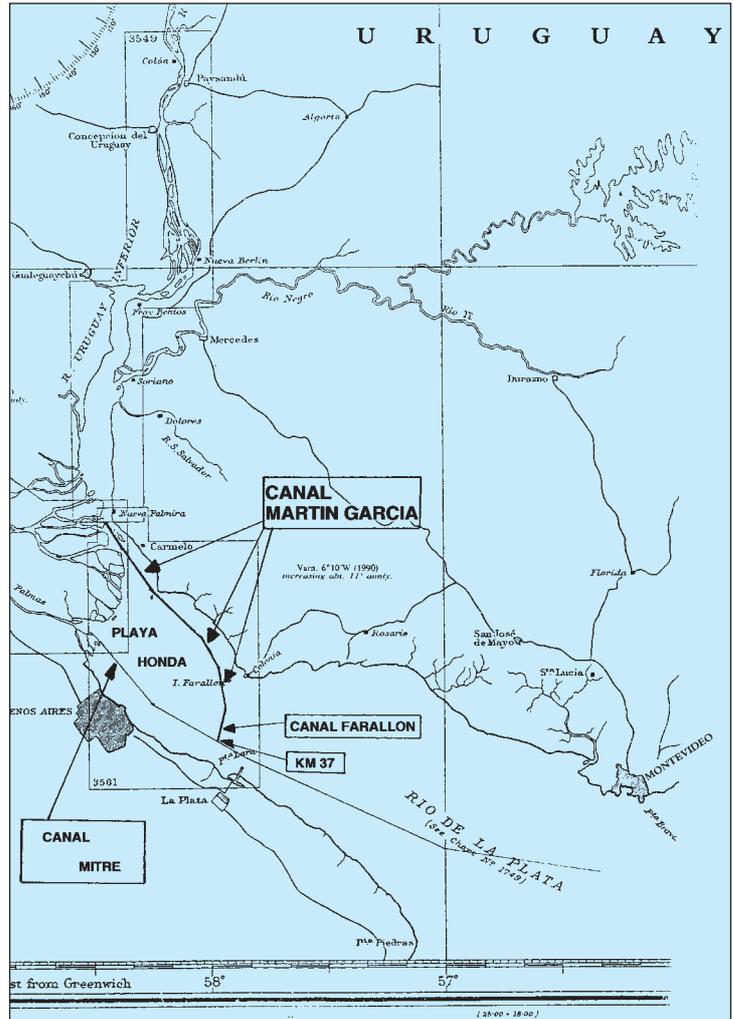


Figure 1. Map of the Rio de la Plata area indicating Martin Garcia Channel, the Rio Parana and Rio Uruguay.

THE CHANNEL PROJECT

The total length of the Martin Garcia Channel is 106 km of which 76 km has to be dredged; the remaining part has sufficient natural depth.

The employer for the Martin Garcia Project is a bi-national Argentine-Uruguayan organisation, the Comision Administradora del Rio de la Plata (CARP). The engineering group controlling the execution of the works comprises four consultants: the Argentines EIH and CEOPYD, Coopers & Lybrand, and the Belgian bureau of Engineers Haecon.

OBJECTIVES OF THE PROJECT

Owing to increased shipping and the need for a more efficient transport of bulk goods, there is a need to use larger ships which have the possibility of carrying more load. This requires wider and deeper channels. The Rio Parana, besides connecting to the Argentine grain harbours, also provides a connection with Paraguay and Bolivia. Furthermore, the Martin Garcia Channel offers a rapid connection with the harbour of

Nueva Palmira, located in Uruguay. At this moment loaded ships can only reach this harbour via a detour. All existing channels to and from the Rio Parana are one-way channels.

The objective of the project involves the design of a navigation route of 32 ft depth for vessels of 245 m length and 32 m beam, for one directional traffic. The deepening of the channel to 32 ft and widening to approximately 100 m will give access to larger bulk carriers with increased loading capacity compared to what is presently possible at drafts of only 24 or 25 ft. Furthermore, the creation of a second access route will decrease waiting time during periods of high traffic, and thus decrease waiting time overall considerably (Figure 1).

“Phase 1”, the capital dredging phase, which has to be completed in two years, consists of:

- the dredging works for the opening of the channel at the designed dimensions;
- the installation of buoys and beacons;
- the establishment of a toll system.

“Phase 2”, which is a concession period of eight years, involves :

- the maintenance dredging of the channel at the designed dimensions;
- the maintenance of the buoys;
- the administration and exploitation of the toll system.

The tolls are to be collected by the contractor, but must be transferred to the authorities. The amounts of toll collected will be deducted from the payments due by the authorities to the contractor. Thus, regardless of the navigation activity there is no risk to the contractor. Payments are done by lump sums, in US\$, which are subject to a revision, based on an American Consumer Price Index.

“DBOT”

This type of “Design-Build-Operate-Transfer” contract is rather unusual for a dredging contractor: it involves many uncertainties and many risks. The first problem arises at the tender stage: the channel has to be dredged as inexpensively as possible, and thus, should have minimum dimensions. On the other hand, it has to be technically viable and satisfactory to the navigators, even more so, because to a large extent the contractor stays responsible for the exploitation of the channel during Phase 2.

Preparing the offer is made even more difficult by the complicated tender procedure. Whilst establishing the design, a number of factors have an important impact on obtaining the most economic price:

- What width should be taken?
- What should be the localisation of the channel? Should bends be cut off? Should certain zones be avoided because of the hard subsoils? Should future deepening be taken into account? Should possible accesses to existing harbours be taken into account?
- Which slopes are considered acceptable?
- Owing to the fact that the channel has to be designed for a one direction traffic, cross sections have to be foreseen.
- Which overdepths have to be provided for? What buffer should be provided for the sedimentation?
- At what distance should the dumping areas be foreseen? Navigation and pumping distances are of a major importance in the economy of a dredging design. On the other hand, the soils should not flow back, as this would be at the contractor’s cost, the contractor being in charge of the maintenance at a lump sum rate.

Another important uncertainty is the sedimentation. The contractor is responsible for the maintenance during a period of eight years. Their retribution consists of a fixed amount and no reliable information was

available in respect of the behaviour of the channel after being deepened to 32 ft.

And, “last but not least”, how will the economy evolve over the next 10 years?

PROCEEDING WITH THE PROJECT

During the tender process in 1994, several field and engineering studies were conducted to determine the channel design, the dredging quantity, the type of material to be dredged, the selection of the dredging method and the disposal areas, and the annual sedimentation rate.

From July through October 1996 when the definitive Project Plan was drawn up, all available studies were deepened and detailed where necessary. Also an environmental impact study and a dredging spoil spreading study were added.

The design of the channel consisted of the following tasks:

1. Determining the parameters:
 - on the one hand, by examining existing information and statistics and executing a number of field studies; and
 - on the other hand, by studying the currents and water levels by means of hydro-dynamic models.
2. Based on this information, the location of the channel was fixed and the dimensions were calculated.
3. Subsequently, an estimation was made of the sedimentation to be expected.
4. A further task consisted in the selection of the dumping areas.
5. Finally, the execution method was determined and the selling price calculated.

Statistical information

The water levels are referred to a reference line having a denivelation of approx. 90 cm between both ends of the work. The water level is mainly influenced by the following three factors :

- the astronomic tides, causing a variation of approx. 30 cm only;
- the winds, which are the most important factors: the Pamperos, blowing from the SW, and the northern winds can cause decreases of the water level of up to 1 m below the reference level; the Sudestadas from the SE increase the levels, in extreme cases, up to 2 to 3 m above the reference level;
- the flow of the rivers.

The average water level is approx. 0.80 m above the reference level. Extreme levels vary from -1.00 to +4.00 m. The N and SW winds cause a significant decrease 10 to 20 times a year, the SE winds an increase, 5 to 8 times a year.

Generally, winds have a speed of less than 40 km/hr.

Currents are rather moderate, from SE direction, and less than 1 knot. The waves are short with significant heights, for 35% above 50 cm. They however have no influence on the “design ship”.

The flow of the rivers is very variable: the average for the Parana is 17,000 m³/sec, but can rise up to 38,000 m³/sec. The average sedimentation transport is 2.55 t/sec and is estimated to 71 million tonnes per year. At least once every 20 to 25 years, very large floods occur and cause exceptionally high sedimentation.

Field studies

In view of collecting additional information, a number of field studies have been executed, prior to the tender and during the design period:

1. A complete bathymetry of the zone, in August 1994 at tender stage, and in September/October 1996 after the award. During the elaboration of the design, the survey was carried out by sailing lines every 200 m perpendicular to the channel. The results of the bathymetric survey indicated an existing channel with a minimum depth of -6 m below reference level and, at some parts of the channel, a minimum width of approx. 60 m. A certain section of the channel, with a total length of 14 km passes through a bank with a natural depth of -3 to -4 m below reference level. This channel section is called Barra de San Pedro/Paso de San Juan.
2. Some twenty borings and taking of soil samples with piston samplers. Where hard materials were indicated extra borings were taken. Prior to the tender, those studies have been complemented by the execution of a geo-electric survey of 75% of the channel alignment. The results of this investigation showed a very variable geological profile with roughly five types of soils, summarised in Table I in relation to the total volume to be dredged:
 - the downstream part, near the junction with the Access Channel to Buenos Aires, consists of very soft clay with high plasticity. Considering the existing depths and the type of soil, a hopper dredger is most appropriate for this zone.
 - the soil in the channel passage through the Barra de San Pedro/Paso de San Juan consists of a top layer of silt on top of very soft marine clay with high plasticity.
 - the upstream part, closer to the Uruguayan coast, consists mainly of compact clay, sand and gravel. More upstream a number of hard spots were detected, mainly in the prolongation of existing capes. These soils consist mostly of weathered rock. Other material consists either of silty sand or of firm to stiff clay, with a shear strength between 75 and 150 kPa. This clay contains some shells and pieces of calcareous material.

Table I. Soil type and percentage of total volume

Soil type	% of total volume
1 very soft clayey silt, low plasticity	60
2 very soft clay, high plasticity	17
3 firm to stiff clay, variable plasticity	13
4 silty sand in various conditions of compactness	9
5 weathered rock	1

3. Finally, tide meters have been installed in order to get a better view of the water level variations.

Hydro-dynamic model

Furthermore, a hydro-dynamic model has been set up for studying the currents and water levels, with the assistance of the Danish Hydraulic Institute (DHI). Six different conditions have been studied, under extreme winds, combined with average or high flow of the rivers, characteristic of the Rio de la Plata area. These were selected within existing data from periods in 1984 and 1993.

For this study the model MIKE 21 HD has been used. This is a two-dimensional one-layer model used to calculate the circulation of an area for specified hydro-graphic conditions.

Two different models were used: a general model and a regional model with grids of 1000 m and 200 m respectively:

The general grid covers the whole Rio de la Plata with a southern border formed by a straight line from Mar de Ajó (Argentina) to La Paloma (Uruguay). The regional model covers the area of interest which is the northern part of the Upper Rio de la Plata.

Channel design

The design of the channel was based on the following criteria.

- the PIANC recommendations, according to Bulletins 35 and 87, which provide guidelines for approach channel design, as had been specified in the tender documents were followed;
- the experience on the Rio de la Plata was examined;
- after calculation of the dimensions, the most critical sections have been tested at the Maritime Simulation Centre in Wageningen, The Netherlands.

The concept design has been tested by using a computer model which simulates the manoeuvring behaviour of the design ship.

Location

The location of the channel has been fixed on basis of the bathymetry. There were two options:

- on the one hand, the “old” Canal de Buenos Aires,

- which cuts partly through the east edge of Playa Honda;
- on the other hand the Martin Garcia, which is closer to the Uruguayan coast, has more natural depths, with however more risks of rocky bottoms. This latter solution was chosen as in view of the future, considering the steady extension south and eastwards of the Playa Honda, the permanency of the Canal de Buenos Aires was judged too questionable and its maintenance involved a potential increase of dredging volumes.

The main objective was to follow the existing route as much as possible with only a few minor modifications being made to the existing channel (Figure 1). Therefore the channel has a total amount of 20 curves.

Dimensions

The dimensions have been defined on base of the PIANC recommendations:

- For the design, a navigation speed of 7 knots was considered. The depth/draft relation was taken as 1.10, considering that the waves have no influence on the design vessel.
- Furthermore, the channel has been divided into 3 sections, depending on the characteristics of wind, stream and slopes. Table II shows that dimensions of 90 and 100 m had to be adopted, for a one-way navigation scheme.

Slopes

At the first stage the slopes are dredged taking into account the static stability of the respective soils. Depending on the type of soil, slopes of 1/8 or 1/4 have been calculated. The slopes are dredged following the classical "boxcut-method".

It has been accepted that, in further stage, under the influence of the erosion caused by passing ships, and by the winds, waves and so on, the slopes would evolve to a much softer ratio which is very difficult to estimate. Depending on the type of soil, slopes of 1/20, 1/12 or 1/8 were considered.

This phenomenon will be left to its natural evolution; it was assumed that it would take approx. 5 years, to reach the final stable configuration. For the estimate it was considered that 30% would occur during Phase 1. The volume of the evolution, between Phase 1 and Phase 2 amounts to approx. 6 million m³. As this evolution will take place by natural erosion and sliding, the volume will be dredged by a trailer when the necessity arises, by cleaning up at the toe of the slopes. This dredging is part of the maintenance phase (Phase 2).

Bends

The dimensions of the bends have been calculated in accordance with the PIANC recommendations whilst still taking into account that navigators prefer to shorten as much as possible the time needed to sail in a bend, in view of the visibility of successive buoys and beacons.

At straight sections the maximum distance between a pair of buoys will be 2.7 km. In curves this will be reduced to 1 km. For marking curve sections the curves are divided into strong and weak curves. Figures 2 and 3 show the layouts of the buoys in the two types of curves.

In the section where the channel is enclosed by lateral banks the navigation route is marked by two opposed buoys, each positioned 30 m out of the toe line of the channel bottom.

Verification

Once the dimensions had been defined, the results found for the most critical sections were tested at the Maritime Simulation Centre, under the most disadvantageous ESE and SW winds.

At first, a number of tests have been executed in "reduced time scale", examining more specifically the following factors: the navigation path covered by the vessel, the accuracy of the positioning, the navigation errors, the waves, the safe distance from the banks, the negative influence of the reduced keel clearance. From these tests it appeared that, owing to cross-currents, it was recommended to increase the width from 100 to 110 m over a section of approx. 10 km. As a final test, 14 runs have been made in the simulator in "real time".

The assistance was requested of a pilot, familiar with the navigation conditions in the Rio de la Plata. These tests were conclusive and proved that the adopted dimensions were safe.

Sedimentation

An essential element for the calculating of the cost price is the sedimentation. The sedimentation estimates, using a mathematical model were performed by subdividing the channel into sections with similar geometrical and hydrodynamic conditions. Sections were defined based on the turning points in the channel and subdividing the distance between turning points in two or three sections when necessary.

Statistics of executed dredging works

Between 1988 and 1996 no dredging was carried out in the Martin Garcia Channel. Therefore the above-mentioned model was calibrated, in its early implementation stage, with survey data from 1988 and 1996 in order to verify that it adequately reproduced historical data, in order to ensure a smaller margin of uncertainty when applied to future situations. It was also discovered that the volumes doubled in periods of inundation. A large percentage of the sedimentation is concentrated in the downstream section in the Canal Farallon. This channel leads straight through the Rio de la Plata, near the Playa Honda, across the prevailing currents. In this respect, a direct connection in the direction of the harbour of La Plata, more parallel with the currents, would be a better solution. The specifications, however, provided Km 37 of the Canal Intermedio, as the

Table II. Determination of Channel Width

Sections	1	Km 34.5 - 49	Length :	14.5 Km	7.83 MN
	2	Km 49 - 61.5	Length :	12.5 Km	6.75 MN
	3	Km 61.5 - 110	Length :	48.5 Km	26.19 MN
				Total length :	75.5 Km 40.77 MN
Km 37.8 from Buenos Aires Access Channel Buoys					

Intensity of currents

Sections		Section 1			Section 2			Section 3		
Periods		1	2	4	1	2	4	1	2	4
Parameters										
Longitudinal currents	m/sec	0.14	0.17	0.16	0.32	0.35	0.35	0.65	0.73	0.74
Cross currents	m/sec	0.21	0.24	0.23	0.12	0.12	0.14	0.07	0.07	0.08
Width of channel according to Supplement to PIANC Bulletin 87										
Type of channel : outer										
Ship velocity : 7 Kn (slow)										
H/T : 1.1										

	PARAMETERS						COEFFICENTS		
	Section 1		Section 2		Section 3		Section 1	Section 2	Section 3
	m/sec	Kn	m/sec	Kn	m/sec	Kn			

Table 1

Maneuverability	good	1.3	1.3	1.3
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Table 2

a) additional straight sections	slow velocity	0	0	0
b) wind	15 29 15 29 15 29	0.5	0.5	0.5
c) cross currents	0.24 0.47 0.14 0.27 0.06 0.16	0.3	0.30	
d) longitudinal currents	0.17 0.33 0.36 0.7 0.74 1.44	0	0	0
e) wave	H < 1,0 m	0	0	0
f) helps/support	good	0.1	0.1	0.1
g) bottom	soft and smooth	0.1	0.1	0.1
h) depth	< 1,25 T	0.2	0.2	0.2
l) risk	low	0	0	0

Table 4

Side slopes	slow velocity	0.3	0.3	0.3	0.6	0.6	0.6		
Sum of coefficients							3.1	3.1	2.8

Width of channel	Beam (m) :	32
Sections	1	99.2 (m) Adopted 100 (m)
	2	99.2 (m) Adopted 100 (m)
	3	89.6 (m) Adopted 90 (m)

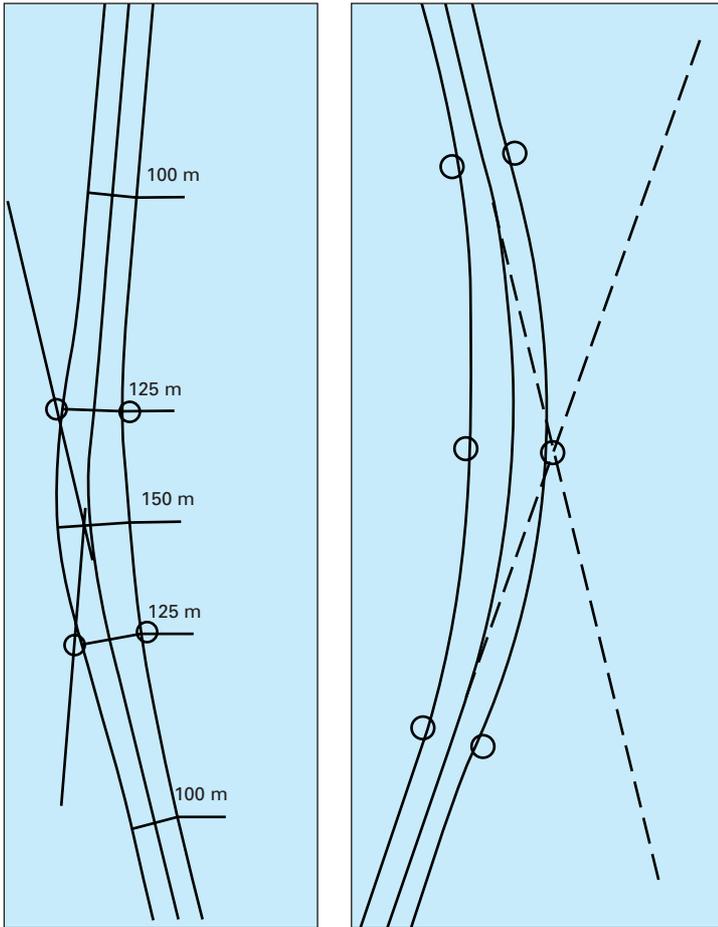


Figure 2. Left, Principal aids to navigation solutions for the weak curves.

Figure 3. Right, Principal aids to navigation solutions for the sharp curves.

downstream end of the channel, this in view of the connection with the Port of Buenos Aires. A second source of information was gathered from previous studies. From the eight documents consulted, it appeared that the sedimentation was estimated between 2.5 and 11 million m³ a year. A comparison of consecutive bathymetric surveys did not permit any conclusive results. On the basis of a mathematical model, calibrated with the results of the hydro-dynamic model of DHI, it was predicted that the sedimentation would be of 2.9 million m³ per year with the initial slopes and of 3.5 million m³ per year with the final slopes.

As a last exercise the probability of exceptional water levels was investigated. This led to the conclusion that, for the considered period of 10 years, the probability was 22% for a sedimentation of 6.6 million m³ per year and 65% for a sedimentation of 5.2 million m³ per year.

The sedimentation volume will not be evenly spread over the channel:
 From the junction with the Canal de Buenos Aires to the curve near Colonia del Sacramento 74% of the total volume will be deposited over a total length of 27 km. In the Barra de San Pedro/Paso de San Juan area, 13% of the total volume will be deposited over a total length of 14 km. Consequently also 13% of the total will settle in the upstream part (34 km) .

Figure 4. The sea-going cutter suction dredger Amazone at work in the Rio de la Plata.





Figure 5. The HAM 311, a shallow draught trailing suction hopper dredger, is dredging the downstream area.

Selection of dumping areas

The localisation of the dumping areas is determining for the economy of the dredging operation, as well for the capital as for the maintenance dredging. The following factors have been taken into consideration:

- the dumped material should not flow back to the dredged channel;
- the dumping area has to be deep enough to give access to the hopper dredgers;
- the sea-bottom may only be undeeptened with a limited layer;
- in the case of cutters, the pumping distance has to be as short as possible;
- the velocity and direction of the currents have an important influence;
- the hopper dredger dumps at a minimum depth of 6 to 7 m;
- the cutter suction dredger pumps the material through a sinker and a floating pipeline, connected to a spreader pontoon.

The following matters have been investigated:

- the “plume” of sediments caused whilst dumping at sea: From previous experiments, it appeared that the plume only contains a small part of the material and a study led to the conclusion that only 3% of the quantity reached a distance of 500 m.
- the dumped “pancake”: this does not cause any problem on condition, however, that the dumping is done at 1000 m off the channel.
- the risk of resuspension of the dumped material under influence of waves and winds, has been investigated.

From these studies, it could be concluded that dumping distances of 600 to 700 m are sufficiently safe and

will cause no problems as to the maintenance of the channel. For conservative reasons however, distances of 1000 to 1500 m had been proposed.

The employer however requested to increase the dumping distances to approx. 3000 m. Presently, a monitoring programme is in progress in order to follow closely the behaviour of the dumped material. If the exactitude of the studies is confirmed, the dumping distance will be shortened to more economic values, as a function of the results of the measurements and in agreement with the employer.

Method of work

The Martin Garcia contract was signed in July 1996 and the design study was finalised in October 1996.

Figure 6. For the maintenance dredging (Phase 2), a small trailing hopper suction dredger, the Flevo, with a capacity of 2100 m³ is scheduled to be used.



Approval of the design took place at the end of the year. The dredging works were started on 19 January 1997. The total quantity to be dredged amounts to 38 million m³ capital dredging, plus 6 million m³ maintenance dredging during Phase 1. The volume to be dredged during Phase 2, the maintenance dredging, is estimated to fluctuate between 6 and 3.5 million m³ per year.

For the execution of Phase 1 two types of dredging equipment are being used: the 9980 kW-powered sea-going cutter suction dredger *Amazone*, and the 3,500 m³ trailing hopper suction dredger *HAM 311*.

The dredging of the upstream part is being executed by the *Amazone* (Figure 4). The dredged material consists of compact, ball-forming clay, fine sand, gravel and partly of weathered rock.

The material is discharged at a distance of 1000 to 1500 m from the channel, through a 800 m floating pipeline and a 1000 m sinker line, coupled to a second floating pipe of approx. 250 m.

In the dumping zone the material is dispersed by means of a spreader pontoon.

Productions, obtained in a pipe of 900 mm diameter, have reached up to 3000 to 4800 m³ per hour, when the layers to be dredged are sufficiently thick.

About 1000 m of channel is dredged per week.

Productions amount from 300,000 up to 600,000 m³ week, depending on the layer to be dredged.

The *Amazone* dredges a 49 km long section of approx. 100 m width and up to 6 m thick; an overdepth of 0.50 to 1.00 m is dredged.

The shallow-draught dredger, *HAM 311* (Figure 5) is operating in the downstream part of the channel, where depths seldom exceed 7 m. The material consists of silt, soft clay and moderately compacted plastic clay. The soils are dumped at a distance of 2500 to 3000 m from the channel, at depths of 5 to 6 m.

The hopper dredger obtains productions of 140,000 to 210,000 m³ per week. The plastic clay is difficult to be dredged and tracks are formed in the dredged channels. The draghead is however equipped with "side jets", which efficiently remove these peaks.

Phase 1 (capital dredging) should be completed by the end of 1998.

During Phase 2, the maintenance dredging, a small trailing hopper suction dredger such as the *Flevo* (Figure 6) or the *Saga* with a capacity of ± 2000 m³ is planned to do the work.

TENDER PROCEDURE

Finally, a few words in respect of the very complicated tender procedure.

In a first stage, prequalification is called in order to select qualified dredging contractors. The tender

procedure itself is organised according the so-called "double envelope" system, with a separated technical and financial-economic offer. The technical offers are opened first, publicly, and studied; only after approval of the technical offers, can the financial offers be opened publicly.

After public opening of the technical offers; they are available for examination and criticism by all competing parties. Each technical offer has to contain a detailed description of the proposed design, of the complete methodology, of the references of the concerned party, of the organisation and so on. The criticisms and observations of those documents can be submitted by all participating competitors to the tendering Authority, with a request to disqualify the considered parties.

In case these requests are rejected by the tendering Authority, an appeal can be made; this appeal is to be submitted jointly with a bank guarantee of US\$100,000. After termination of this procedure, parties are qualified for the public opening of the second envelope: the price. The second envelope, the price, is subject to the same procedures as the technical offer and again, the tendering Authority has to investigate, in two stages if so requested, the critics of the competing parties in respect of their competitors. Only at the end of this procedure, the project is awarded. However, if some competitors still do not agree with this final decision, they can request for arbitration.

For the Martin Garcia Project, the dredging companies have passed through this whole procedure, which has been very time-consuming and extremely expensive, as well for the competing contractors as for the Authority. The documents were published in June 1994. The contract only could be awarded in February 1996 and was signed in July 1996. The arbitration finally ended in a conciliation, whereby disputing parties joined to form one large joint venture of seven parties.

Conclusion

Although this type of "Design-Build-Operate-Transfer" contract is rather unusual for a dredging contractor, the project is now underway and seems to be making good progress. Because the waterway had not been dredged in many years, a great deal of field studies, computer models and mathematical models were performed to predict sedimentation for channel conditions. The sedimentation predictions are particularly important because the maintenance concession continues for a period of eight years in which the contractor bears a responsibility for the exploitation of the channel. The dredging of the Martin Garcia Channel will widen and deepen the water access to the grain harbours of Argentina, and beyond to Paraguay and Bolivia, making the channel more accessible to deep draught ships. To this end it will contribute to the improvement of the economic development of this area of South America.