ブラジル連邦共和国

スアッペ臨海工業開発計画

資料No. 6

BOOK IV - PART 1

PORT SYSTEM

VOLUME 1

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1.0 DIMENSIONING CHANNELS, BASINS AND THE FORE HARBOR

PART 1 - PORT SYSTEM

1.0 DIMENSIONING CHANNELS; BASINS AND THE FORE HARBOR

1.1 INTRODUCTION

Dimensioning of the channels, basins and the fore harbor followed the criteria defined in Chapter VI of Book II, "Bases for Dimensioning Channels and Basins".

Initially, the large possible vessels to operate in the port areas projected for the 1st stage and their growth over time were studied. Next, the stage was divided into phases and dimensions were established for each phase.

The sketch in Figure 2-XXXIV shows the projected internal port areas on which channel, basins and fore harbor dimensions were based.

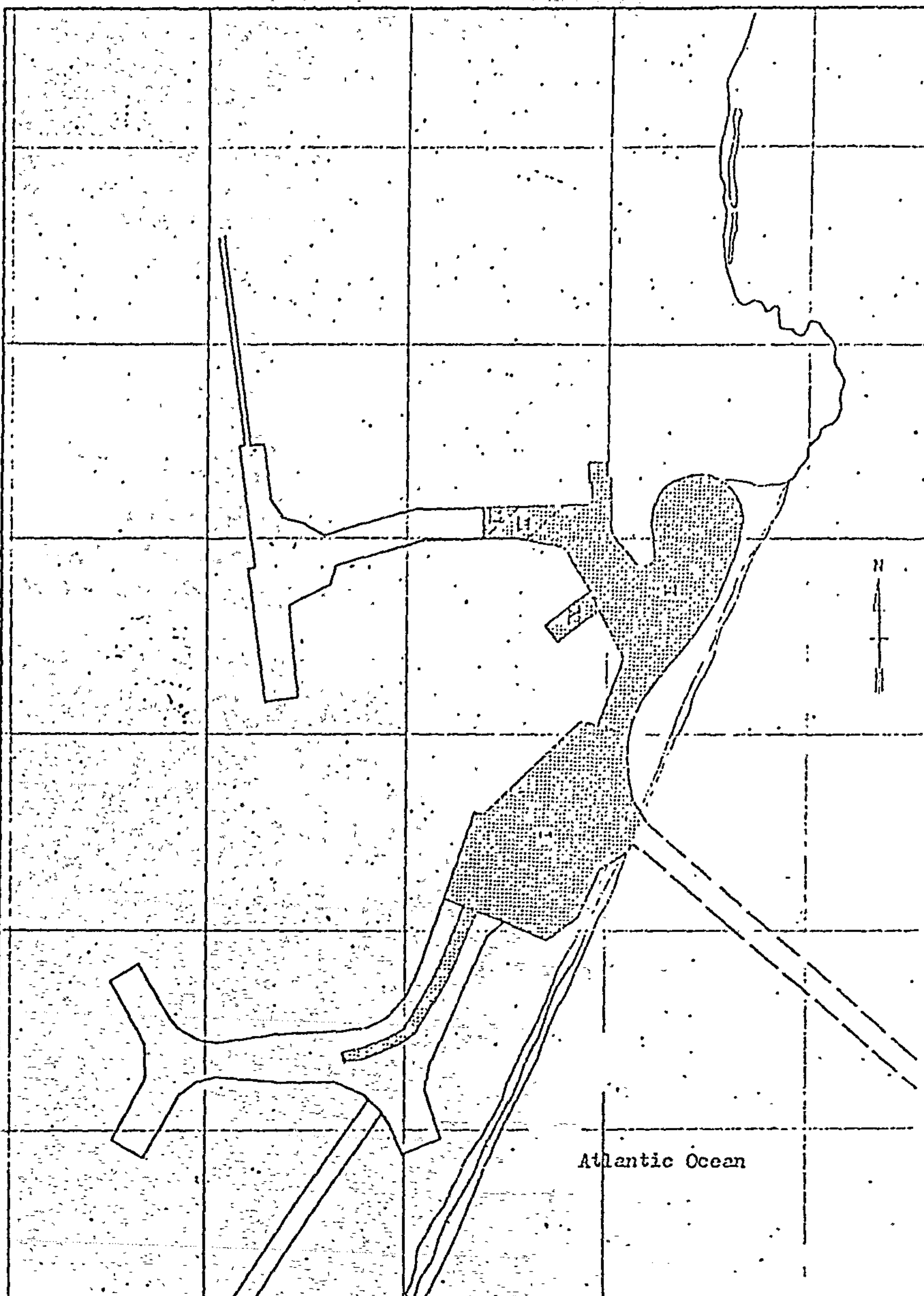

Figure 2-[illegible]

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Maritime Areas Planned for the 1st Stage

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1.2 MODEL TYPE OF VESSEL FOR EACH AREA

The model type of vessel conceptualized for each area is a synthesis of the characteristics of the largest vessels expected to operate in the area. The dimensions will therefore be sufficiently large to cover all vessels.

AREA I

This area includes the petroleum and cement terminals.

For the petroleum terminal it was assumed, based on the 8,000,000 ton level forecast for 1980, that in that year 135,000 tdw vessels will be handled.

Since vessels destined to carry petroleum could be of the combined type and consequently could return with cement, it was established that area I should handle 135,000 tdw vessels throughout the entire 1st stage.

Basic dimensions of 135,000 tdw vessels *

Tankers -	L = 277 m	B = 45 m	D = 16.50 m
Ore carriers -	L = 285 m	B = 41 m	D = 16.20 m

Model type of vessel for area I

L = 285 m	B = 45 m	D = 16.50 m

* L = Length, B = Beam, D = Draft

AREA II

The largest vessels to call at this area will carry phosphate rock.

An examination of the projected flows of phosphate rock and the possible transport vessels indicated the following rotations:

YEAR / VESSEL (TDW)	30,000	60,000	125,000
1984	8	4	2
1985	17	8	4
1986	25	12	6
1987 to 2005	33	16	8

Based on this table and the fact that the cargo flow increases rapidly through 1986 and stabilizes after 1987, it was decided that this material will be shipped by 60,000 tdw vessels through 1986 and by 125,000 tdw vessels from 1987 on.

Basic Dimensions

60,000 tdw ore carriers L = 218 m B = 31 m D = 12.20 m
125,000 tdw ore carriers L = 278 m B = 40 m D = 15.30 m

Model type of vessel for area II

through 1986

L = 218 m B = 31 m D = 12.20 m

from 1987 on

L = 278 m B = 40 m D = 15.30 m

AREA III

The largest vessels to call at this area will import wheat. The ships coming from the United States of America will be in the 25,000 to 30,000 tdw range, and those coming from Canada will be in the 30,000 to 60,000 tdw range. A comparison of the additional dredging costs needed to handle the 60,000 tdw vessels from Canada, or even from Rio Grande do Sul, versus the benefits of handling these large vessels, indicated that this area should be dimensioned to handle the vessels throughout the entire first stage.

Basic Dimensions

60,000 tdw bulk carriers - L = 218 m B = 31 m D = 12.20 m

Model type of vessel for area III

L = 218 m B = 31 m C = 12.20 m

AREA IV

The terminal planned for wheat exports by coastal navigation to ports in Northeastern Brazil was located in this area. Based on the Brazilian ports' draft limitations, on the order of 10 m, 25,000 tdw vessels were adopted for this shipping throughout the entire first stage.

Basic Dimensions

25,000 tdw bulk carriers - L = 165 m B = 22 m D = 9.0 m

Model type of vessel for area IV

L = 165 m B = 22 m D = 9.0 m

AREA IX

This area will handle small bulk carriers with small cargos for the fertilizer plant and for inputs to the aluminum plant.

Based on trends in the composition of the Brazilian merchant marine fleet, 25,000 tdw bulk carriers were assumed.

Basic Dimensions

25,000 tdw bulk carriers L = 165 m B = 22 m D = 9.0 m

Model type of vessel for area IX

L = 165 m B = 22 m D = 9.0 m

1.3 DEFINITION OF PHASES

In keeping with the model types of vessels proposed for each area, the following two phases were established for the first stage.

1.3.1 PHASE I

Start: 1980

The approach channel and areas I, II, III, IV and IX should be dredged so that they can handle, starting in 1980, the following vessels:

AREA	Dimensions (m)		
	L	B	D
Approach Channel	285	45	16.50
I	285	45	16.50
II	218	31	12.20
III	218	31	12.20
IV	165	22	9.0
IX	165	22	9.0

1.3.2 PHASE II

Start: 1987

In this phase area II should be dredged to handle 125,000 tdw vessels. The approach channel and all the other areas will remain unchanged.

AREA	Dimensions (m)		
	L	B	D
II	278	40	15.30

1.4 DEFINITION OF DEPTHS

The depths were based on criteria established in Chapter 6.0 of Book I and on the model types of vessels assumed in this chapter. Table 1/1 shows the depths calculated for each area and phase and the various parameters contributing to the depth calculations.

TABLE 1/1 - DEFINITION OF DEPTHS

Areas	Phase	(1) Max. Draft (m)	(2) Squat (m)	(3) Effect of the waves (m)	(4) Net Pilot Draft (m)	(5 =2+3+4) Gross Pilot Draft (m)	(7) Tolerance (m)	(8 =1+5+7) Calculated Depths (m)	
Approach Channel	I e II	16,50	1,30	0,85	0,50	2,65	0,70	20,00	rounded off from 19.85 m to 20 m.
I	I e II	16,50	0,30	-	0,50	0,80	0,60	18,00	rounded off from 17.90 m to 18 m.
II	I	12,20	0,30	-	0,50	0,80	0,30	13,50	rounded off from 13.30 m to 13.50 m
	II	15,30	0,30	-	0,50	0,80	0,30	16,50	rounded off from 16.40 m to 16.50 m
III	I e II	12,20	0,30	-	0,50	0,80	0,30	13,50	rounded off from 13.30 m to 13.50 m
IV	I e II	9,0	0,30	-	0,70	1,00	0,20	10,0	rounded off from 10.20 m to 10 m.
IX	I e II	9,0	0,30	-	0,50	0,80	0,20	10,0	

(*) Depths refer to zero hydrographic scale.

1.5 DEFINITION OF WIDTHS

The following table is based on the criteria established in Chapter 6.0 of Book I for one way traffic.

	Width - w (m)
Approach Channel	W = 5 B
Internal Channels	
Docking on both sides	W = 5.8 B + 50 m
Docking on one side	W = 5.3 B + 25 m
No docking	W = 4.8 B

NOTE: B = Beam of vessel

Table 1/2 shows the widths calculated for each area and phase. However, for sections where docking on both sides is forecast, the widths will conform to the Maximum Utilization Plan's layout. This is due to the need for heeding the docking structure arrangement.

TABLE 1/2 - DEFINITION OF WIDTHS FOR THE 1st STAGE

AREA	PHASE	TYPE	BEAM (B) (m)	WIDTH (W) (m)
Approach Channel	I e II	(*)	45	225,0
II	I	(1)	31	229,80
		(2)	31	189,30
		(3)	31	148,80
	II	(1)	40	282,0
		(2)	40	237,0
		(3)	40	192,0
III	I e II	(1)	31	229,80
		(2)	31	189,30
IV	I e II	(1)	22	177,60
		(2)	22	141,60
IX	I e II	(1)	22	177,60

(1) docking on both sides W = 5.8B + 50

(2) docking on one side W = 5.3B + 25

(3) no docking W = 4.8B

(*) approach channel W = 5B

1.6 CURVE RADII

1.6.1 CURVE RADIUS FOR THE PORT APPROACH CHANNEL

In compliance with the study described in Chapter 6.0 of Book II, the International Commission on Tankers (Commissão Internacional de Petroleiros) recommendation of radii equal to 5 L was adopted. Given the layout characteristics, a 1,200 m radius was chosen, which will allow direct access for vessels up to 80,000 tdw.

1.6.2 CURVE RADII FOR THE INTERNAL CHANNELS

In Chapter 6.0, curve radii of 29 L were adopted for the internal channels.

Since area II should accomodate vessels up to 125,000 tdw in the first stage, a minimum radius of 806 m (2.9 x 278 m) was adopted for this area. For the curve of the Massangana River, accessing area III, the minimum radius, calculated for 80,000 tdw vessels, is 696 m (2.9 x 240 m).

1.7 OVERWIDTHS

The formula adopted for calculation of overwidths is:

$$\Delta B = \frac{3\alpha}{R} \quad \frac{V^2}{C} \quad \frac{L^2}{S}$$

Where

ΔB = overwidth (in feet)

α = central angle (in degrees)

V = ship velocity (in knots)

C = index of maneuverability

L = vessel length in feet

S = visibility distance, in feet

For dimensioning overwidth in the curve at the port approach, the following values were used:

α_1 = 72° 30' (central angle of the approach curve for the northern internal channel)

α_2 = 110° (central angle of the approach curve for the southern internal channel)

R = 1,200 m = 3,937 feet

V = 10 knots (considering the worst approach conditions)

C = 2 (considered good maneuverability) (1=mediocre, 2=good, 3=very good)

L = 240 m = 787 feet (length of an 80,000 tdw vessel)

S = 1 mile = 6,111 feet

Substituting these values in the formula, the following overwidth calculations result:

$\Delta_1 B$ = 85 m (overwidth for direct approach to the northern internal channel)

$\Delta_2 B$ = 155 m (overwidth for direct approach to the southern internal channel)

1.8 MANEUVERING AREAS

1.8.1 AREA I MANEUVERING AREA

Two factors must be considered in dimensioning this area: stopping distance and maneuverability.

The study conducted in Chapter 6.0 of Book II concluded that for 210,000 tdw vessels at 4 knots, a stopping distance of 2 L would be necessary for full load reverse without the assistance of tugboats. The diameter of the maneuvering circle for 135,000 tdw vessels is 655 m (2.3 L).

Based on these data, the layout was designed so that a circle with a 700 m diameter can be inscribed in the area in front of the mouth. It should be noted that this diameter is equivalent to 2.46 L (L= length of the 135,000 tdw vessels), and therefore is a largerdiameter than that defined in the referenced study.

1.8.2 AREA II MANEUVERING AREA

This area will serve for ships calling at areas II, III and IV. Studies described in Chapter 6.0 of Book II indicated a maneuvering circle of 639 m for 125,000 tdw vessels. The layout of area II during the first phase was therefore designed so that a circle with a 650 m diameter can be inscribed.

1.9 FORE HARBOR

The fore barbor was dimensioned to handle four 125,000 tdw bulk carriers at the same time. This dimensioning was based on the assumption that the ships will be tied up to two buoys, one at the prow and the other at the stern.

The fore harbor was located in area II, which meets required surface area, shelter, depth, ease of approach and nature of bottom conditions.

TOMO II
PARTE I.
VOLUME I
2.0

2.0 OPENING THE PORT ENTRANCE

2.0 OPENING THE PORT ENTRANCE

2.1 ANALYSIS OF AVAILABLE DRILLINGS

The area under study is located in the area of drill holes F-11, F-28, F-49, F-51 and F-55.

Both knowledge of drill hole F-55's profile (over the reef) and the establishment of a drilling network forming a grid with mesh sized 100 m x 100 m, in the Barreta region chosen for opening an "entrance mouth" to the port, are of summary importance for finer detailing.

Drill hole 51, represented schematically in sketch no. 2/I, along with profiles of geophysical sections on both the internal and external sides of the reef, permits the assumption that a "clay cradle" exists under the reef, as shown in the brief schematics numbers 2/II, 2/III and 2/IV.

BARRETA REGION

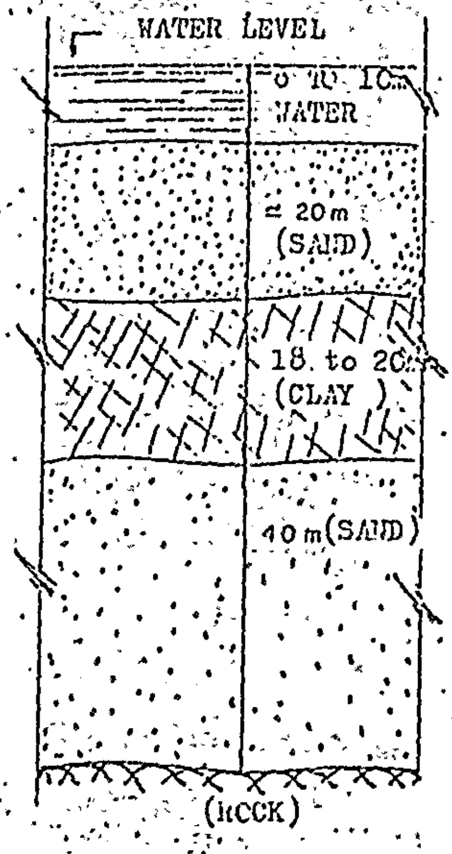
SP- 51 SCHEMATIC

DEPTH	MATERIAL
	Fine and medium sand, not very compact to mediumly compact
5	- same, compact turf with sand, soft consistency
10	- medium to coarse sand, not very clayey or silty, spongy
15	- medium to fine sand, not very silty, mediumly compact to compact
20	- very soft silty clay
25	- fine silty sand, spongy to mediumly compact
30	- same, medium to coarse, silty, very compact

SKETCH No. 2/I

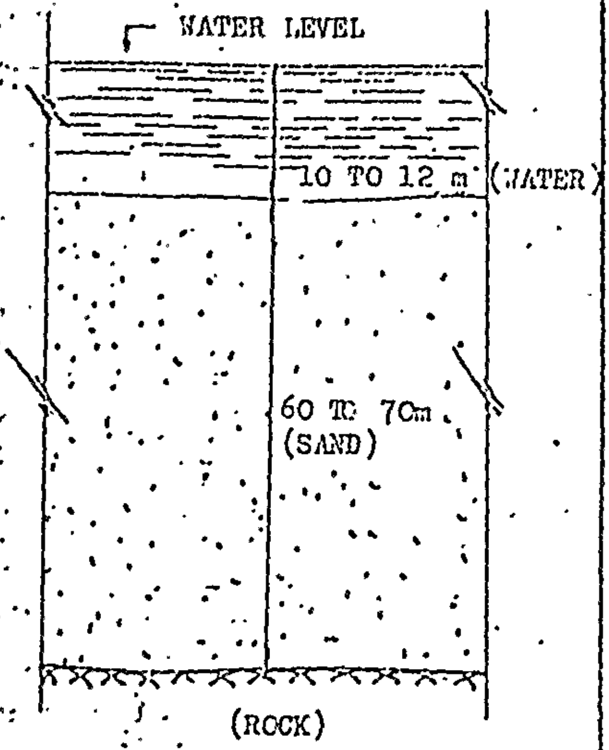
SKETCH Nº 2.II

INTERNAL SIDE OF THE REEF



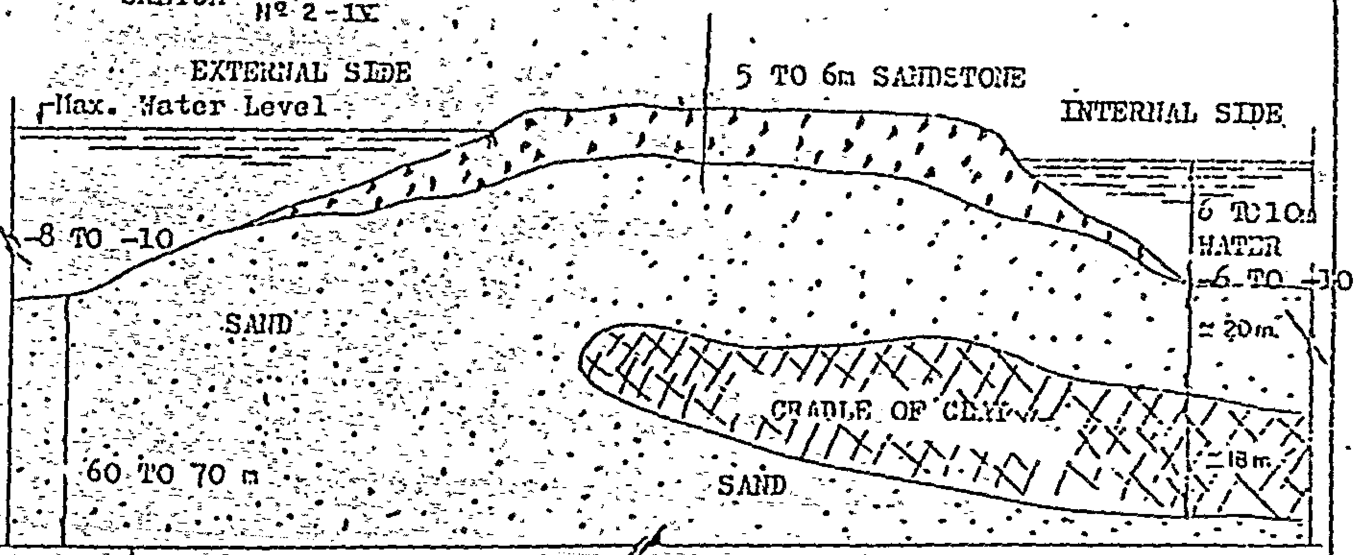
SKETCH Nº 2.III

EXTERNAL SIDE OF THE REEF



SKETCH Nº 2-IX

REEF – TRANSVERSAL SECTION – SCHEMATIC



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REEF – TRANSVERSAL SECTIO

TRANSCON S.A.

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2.2 GEOTECHNICAL PARAMETERS CONSIDERED AND HYPOTHESES FORMULATED

For preliminary design of the entrance mouth, the land was assumed to have the following characteristics, based on the drilling performed:

- Top layer of sandstone (4 to 6 m) ($\varphi = 33^o$ $\gamma = 1.9$ $\gamma' = 0.9$)
- Layer of compact sand ($\cong$ 20 m) ($\gamma = 1$ $\varphi = 28^o$)
- Layer of silty clay ($\cong$ 20 m) ($\gamma' = 0.7$ $\varphi = 0$ $C = 5$)

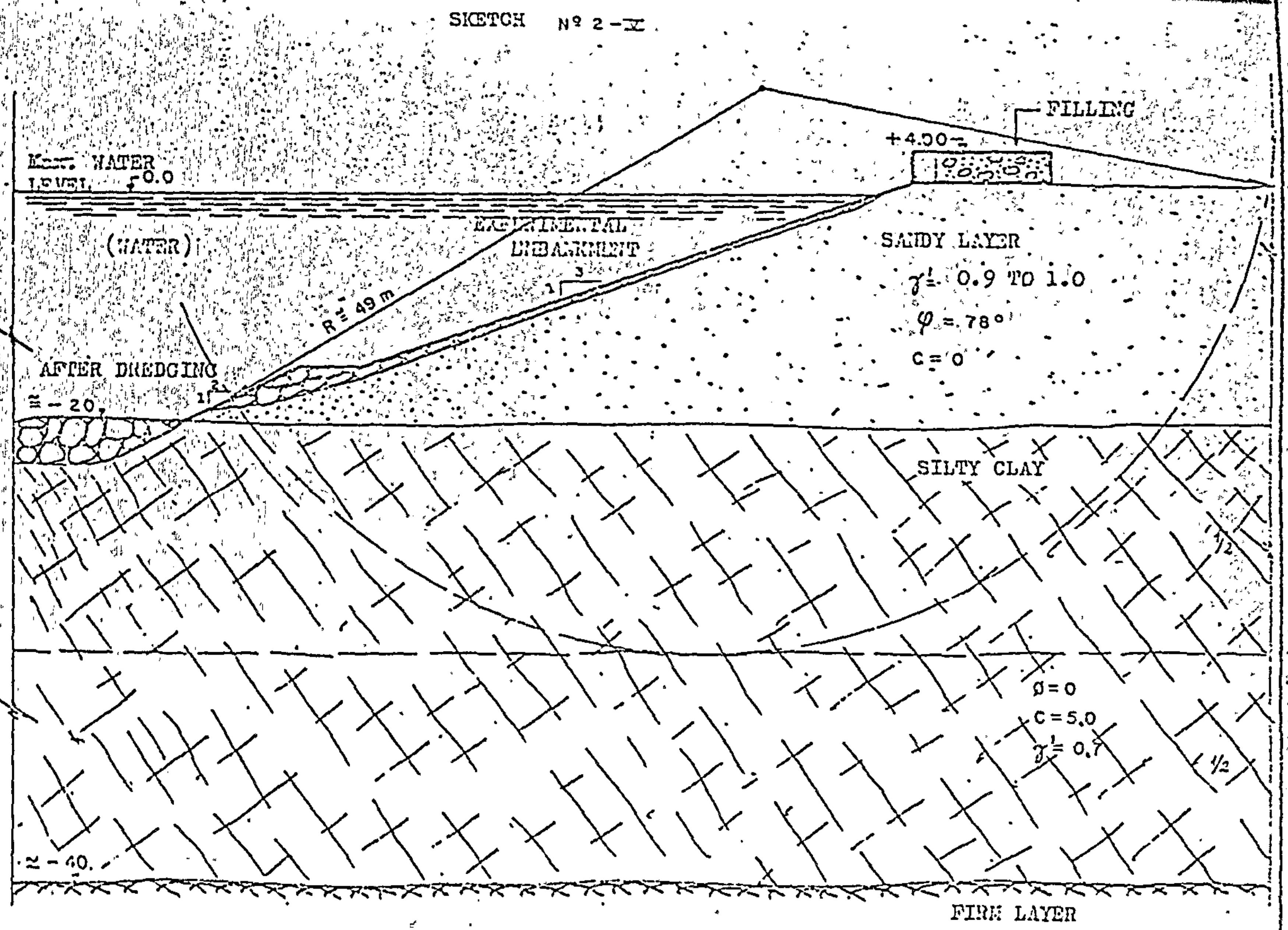
According to these asumptions it was possible to postulate stability of the mouth's embankments as per the configuration shown in sketch no. 2/V.

Results of geotechnical and maritime studies made in the field, as well as those of wind and current measurements, solids transport, etc., could modify the mouth protection preliminary design.

Since, however, a simple protective covering of a naturally stable embankment was believed to be the most reasonable solution, embankment protection by means of a sea wall was chosen. Besing being of high quality for absorbing the shock of waves, a sea wall is not too difficult to replace if the existence of a substratum of medium to soft clay were confirmed in the future.

Obviously, the existence of a thick layer of soft clay would alter the concepts described so far.

It is not believed, however, that the cradle of clay runs through the entire transversal section of the reef, because the geophysical profiles of the area indicate sand; it is believed that during dredging of the channel and the turning basin the clay would be shifted due to the weight of the upper layers. In this case, there would occur a depression of the embankment, which could be replaced by building the sea wall back up.



SKETCH Nº 2-V
FILLING
+4.00
MAX. WATER LEVEL 0.0
(WATER)
EXPERIMENTAL EMBANKMENT
3
1
R ≅ 49 m
AFTER DREDGING
≅ -20
SANDY LAYER
γ' 0.9 TO 1.0
φ = 78°
C = 0
SILTY CLAY
Ø = 0
C = 5.0
γ' = 0.7
1/2
≅ -40
FIRM LAYER

2.3 ANALYSIS OF THE ENTRANCE MOUTH'S STABILITY

2.3.1 INTRODUCTION

As has been stated, studies were made of the possibility of stabilizing the embankments of the entrance channel's mouth by simply protecting them in a manner that impedes not only massive dislocation but also escape, due to dredging of the channel, of sand lying under the standstone outcropping on the reef.

With these conditions and the adopted parameters, it was possible to arrive at the first approximation embankment shown in sketch no 2/VI.

2.3.2 PRELIMINARY ANALYSIS OF THE STABILITY OF THE PORT ENTRANCE MOUTH'S EMBANKMENT

A preliminary check revealed the possibility of stabilizing the embankment with the passage of a critical circle at half the height of the clay layer, as shown in sketch no. 2/V.

After the nature of the clay substratum is known, a detailed study of the problem should be made, at which time establishment of the embankment's critical circle and of the protective sea wall's stability will be possible.

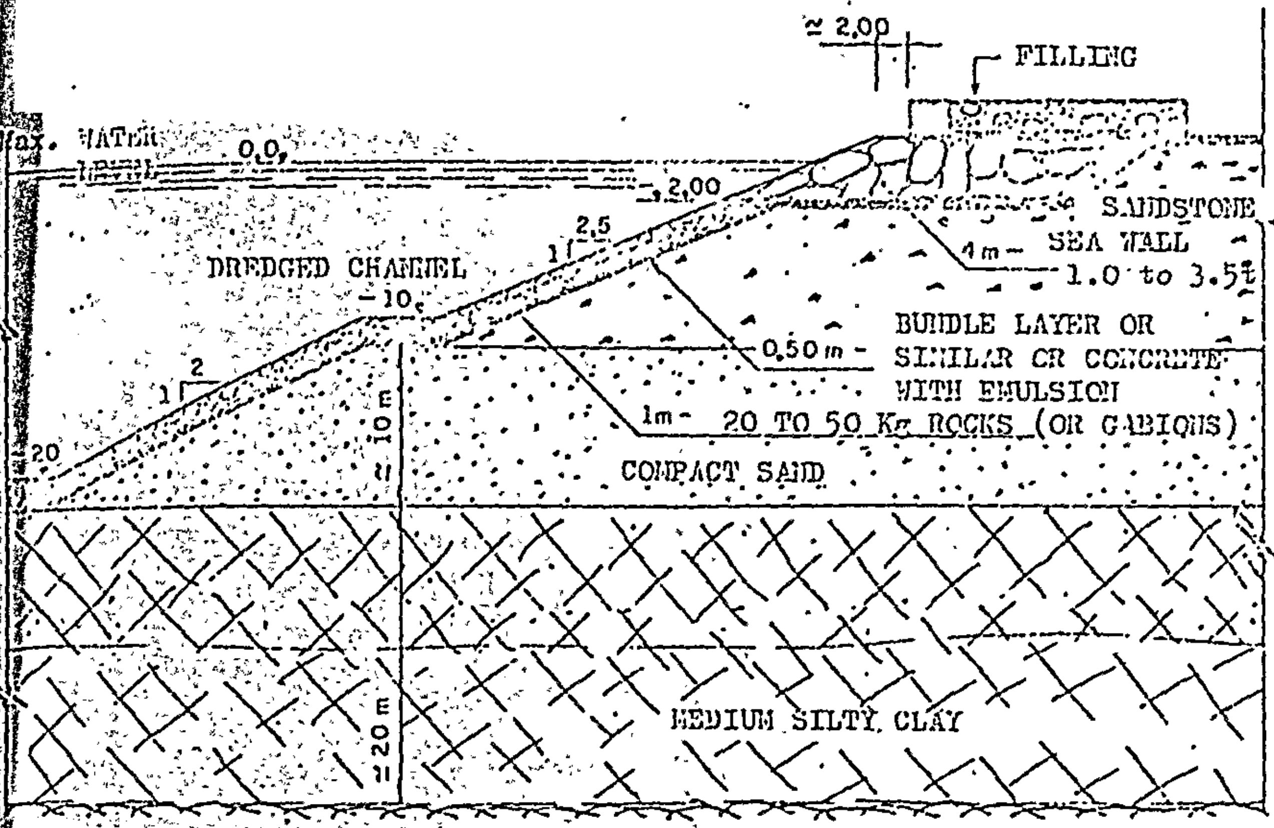
2.3.3 SUGGESTED SOLUTIONS

It was decided that only the simplest, most natural solutions possible, based on the hypotheses, be considered.

Therefore, opening the channel with embankments protected by a sea wall or another similar solution would be the best solution, based on its excellent shock absorbing possibilities and on its low cost when compared with other alternatives.

A comparative cost study of the alternatives was conducted to arrive at a preliminary aid to future laboratory studies of the stability of the port's entrance mouth and entrance channel.

SKETCH NO. 2-VI



Notes:

1. Weights of the sea wall rocks could be changed after measurement programs and laboratory studies.
2. Currents at the bottom of the dredged channel should be studied in the future from level -2.00 m down.
3. Periodic inspection should be made of the -10 to -20 m level to check on possible large scale settling.

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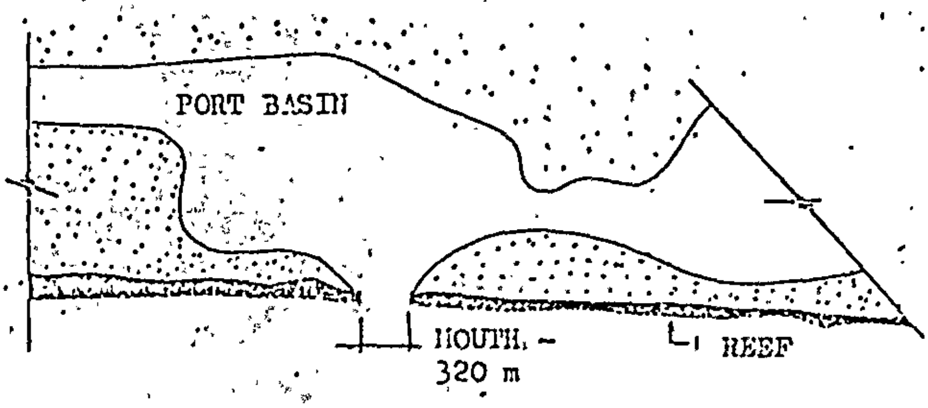
TRANSVERSAL SECTION - PORT ENTRANCE MOUTH

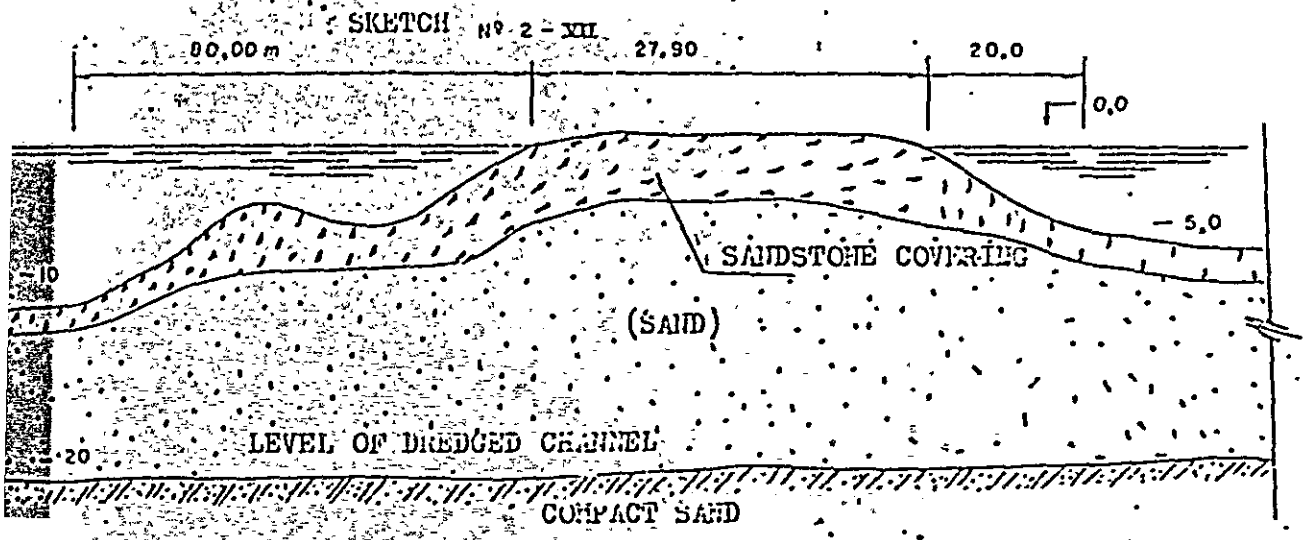
2.4 COST OF PROPOSED SOLUTIONS

2.4.1 1st PROPOSED SOLUTION

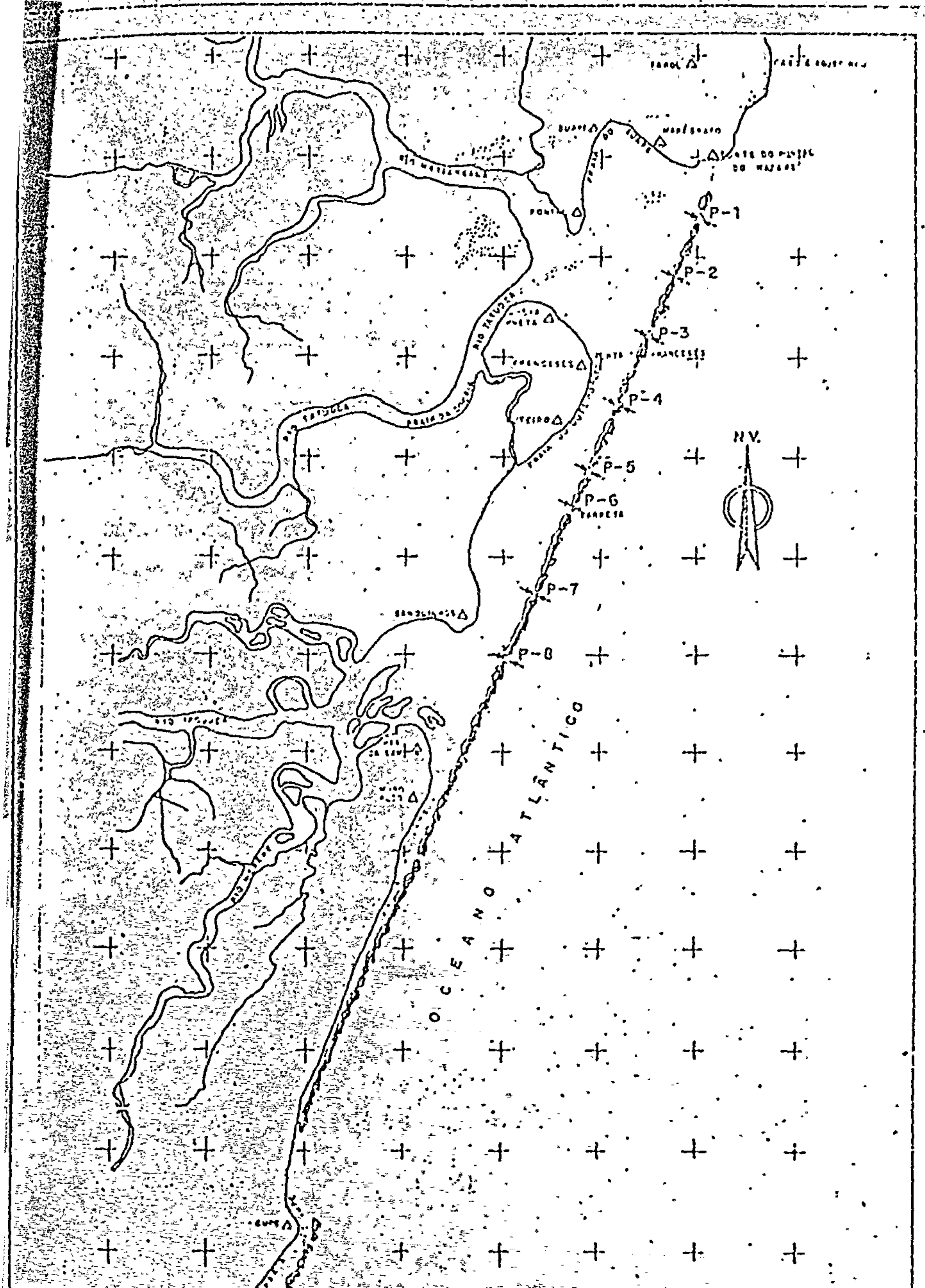
Opening a 320 m mouth, plus embankments, with a sea wall covering.



As per the "Reef Profiles" plan facing the Barreta, sketch no. 2/VII shows a sketch of profile P-6.



The profile to be dredged to the final level (- 20m) is approximated by the figure below which represents a transversal cut in the reef at the Barreta.



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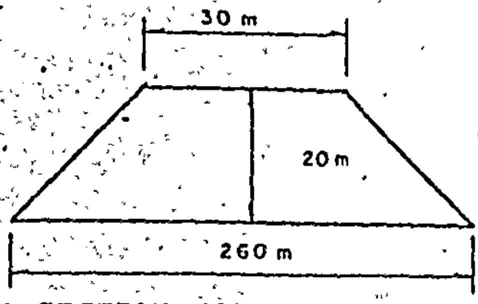
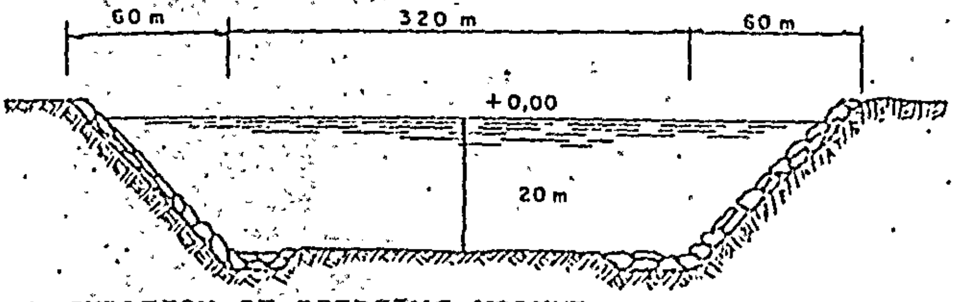
PROFILES OF THE REEFS

TRANSVERSAL SECTION FOR REEF DREDGING (APPROXIMATE)



LONGITUDINAL SECTION FOR REEF DREDGING (APPROXIMATE)



CALCULATION OF DREDGING VOLUME:

$V = 2,900\ m^2 \times 380\ m = 1,102,000\ m^3$

ESTIMATED DREDGING COST:

$C = 1,102,000\ m^3 \times Cr\$\ 10.00/m^3 = Cr\$\ 11,020,000.00$

PROTECTION OF THE MARGINS:

a) - With a sea wall:

$V = 62.5 \times 290 \times 2\ m \times 1.65 = 60,000\ t$

$C = 60,000 \times Cr\$\ 100.00/t = Cr\$\ 6,000,000.00$

B) - With Macaferri type gabions:

$V = 50,000\ t$

$C = 50,000 \times Cr\$\ 120.00/t \cong Cr\$\ 6,000,000.00$

Protecting the embankment margins by sea wall or by gabions are equivalent.

2.5 BUDGET ESTIMATE

<u>Approximate cost of entrance opening (mouth):</u>

a - dredging	Cr$	11,020,000.00
b - protection of margins	Cr$	6,000,000.00
T o t a l	Cr$	17,020,000.00

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VOLUME I
3.0

3.0 - PORT PROTECTION WORKS

3.0 PORT PROTECTION WORKS

3.1 DESCRIPTION OF THE WORKS

To assure complete protection of the Suape port area, to prevent the free rolling of waves through the port entrance or through the reef barrier opening, and to avoid the waves' breaking over the reef barriers, the following constructions were planned:

a) Construction of two converging breakwaters, situated on both sides of the port entrance.

b) Heightening the reef barrier between the southern breakwater and the end of the reef barrier at Pontal do Cupe.

c) Closing the present bar between the extreme end of the reef barrier and the Cape of Santo Agostinho.

d) Heightening and lengthening the reef barrier between the northern breakwater and the Cape of Santo Agostinho.

e) Creation of an artificial beach in the area bordering on this last section where the reef barrier is to be increased.

To facilitate construction and minimize cost, it was decided that the protective works will be constructed of dumped rock. This material can be obtained easily at the site and nonspecialized labor can work with it without difficulty, during both extraction of the rock and building of the protective works.

Each of these works deserved special consideration and an individual study taking into account each work's importance and degree of exposure to the action of the waves. The works can therefore be grouped into two large categories: the works designed to confront the action of the waves, and those protected from the waves by the artificial beach. These latter works are planned to support the beach's sand and prevent it from shifting to the internal port area. The two breakwaters and the dike to heighten the reef barrier at the south of the port entrance fall into the first category; the remainder constitute the second category.

The elevation of the constructions in the first category was determined per the maximum level of the sea (2.80 m) and the maximum height of the waves that occur in the area (2.50 m). This elevation was fixed at + 3.828 m, in relation to zero C.N.G., which is exactly the height the National Department of Ports and Navegable Waterways adopted to reinforce and restore the reef barrier that protects the Port of Recife.

Transversal sections for the protective works may be found at the end of this section. A 6.0 m width was fixed for the breakwaters, and a 4.0 m width for the dike heightening the reef barrier. The embankment of the area exposed to the action of the sea was fixed at 1:2; the other embankments were set a 1:1.

Based on these decisions, the weight of the stones to be used in the layers of various sections of the work was calculated, using the Hudson formula developed by the U. S. Corps of Engineers. Even though these works were calculated by commonly used technical methods, their importance demands that they be tested in a channel and wave tank at the time that a scale model of the port is tested, and that adjustments be made if necessary.

For constructions to close the present bar and heighten the reef barrier on the northern side, the elevation chosen can be markedly less than that chosen for the above described works, since even the waves occurring at high sea will break over the artifical beach constructed in front of the protective works. Therefore the elevation was fixed at +2.50 m in relation to zero C.N.G., with 3.0 m width and 1:1 embankments.

Since these constructions will not be subject to the action of the waves, the design can be developed based on the experience of other similar constructions, and the weight of rock to be used need not be calculated.

To complement the . . . . protective works, an artificial beach, to be formed of sand dredged from the external approach channel and internal channels, especially in the far harbour, was planned. Based on the mean diameter of the internal and external sands, 0.4 mm, the slope of the beach was set at 1.20. This proposed slope should also be tested in a scale model.

To guarantee maintenance of this beach, a stone sea wall buttress based at the Cape of Santo Agostinho and forming the northern limit of the beach was planned. Also planned was the construction of Case type wooden buttresses, conveniently spaced to confine the sand between them and to prohibit removal of the sand even by rough seas.

3.2 CALCULATION OF WEIGHT OF THE ROCKS

3.2.1 BY THE U. S. CORPS OF ENGINEERS' HUDSON FORMULA

$$W = \frac{W_r \times H^3}{K_d \times (S_r - 1)^3 \times \text{cotg}\,\sigma}$$

Letting $K_d = 3$ and cotg $\sigma = 2$, we have

$$W = \frac{W_r \times H^3}{6\,(S_r - 1)^3}$$

And, for $W_r = 2.4$ tons/m^3 = 150 lb/ft^3 and $H = 2.5$ m = 8.2 feet, the weight of the blocks of rock will be

$W = 2.6$ tons

or, as was adopted:

$W = 3$ tons

2) By applying the equation found in Design and Construction of Ports and Marine Structures, by Alonzo D. Quinn.

For an embankment of 1.2 and a wave height of 2.5 m, we find

$W = 3$ tons

3.3 COST COMPARISONS OF PROTECTIVE WORKS TO THE NORTH OF THE PORT ENTRANCE WITH AND WITHOUT THE ARTIFICIAL BEACH

During the first stage the disposal of dredged material will provide sand which could permit formation of a beach to the north of the planned entrance to the port, next to the reef barrier. Immediate consequences would be better reef barrier heightening sections in view of the fact that the waves would break over the beach and would lose force there, and also a reduction in dredging waste disposal costs due to shortening transport distances.

A comparative cost study to determine the advisability of forming a beach follows.

3.3.1 BASIC INFORMATION

a) Volume of the sea wall to heighten the northern reef barrier at the port entrance, using the same profile adopted for the southern zone, i.e., without the artificial beach. 223,590.000 m^3

Volume of the sea wall to lengthen the reef barrier, linking it with the Cape of Santo Agostinho, adopting a profile equivalent to that of the breakwaters, for a mean depth of 6.20 m and a width of 40 m

209.670 m^3/m.1 x 550 m = 115,318.500 m^3

338,908.500 m^3

340,000.000 m^3

b) Volume of the sea wall to heighten the northern reef barrier at the port entrance, with the artificial beach 41,250.000 m^3

Volume of the sea wall to lengthen the

reef barrier, linking it with the Cape of Santo Agostinho, with the artificial beach — 31,372.000 m³

Volume of the stone sea wall buttress to protect the artificial beach, based at the Cape of Santo Agostinho — 41,250.000 m³

	113,872.000 m³
	114,000.000 m³

3.3.2 COSTS

a) Costs of heightening the northern reef barrier at the port entrance, without the artifical beach

340,000.000 m³ x Cr$ 50.00 = Cr$ 17,000,000.00

b) Costs of heightening the northern reef barrier at the port entrance, with the artificial beach

- cost of sea walls 114,000.00 m³ x Cr$ 50.00 =	Cr$ 5,700,000.00
- Difference in dredging cost per cubic meter by using a 2,000 m³ hopper dredge instead of a 9,000 m³ dredge	Cr$ 2,500,000.00
- Probable cost of a scale model to examine the artifical beach's stability and longevity	Cr$ 1,000,000.00
	Cr$ 9,200,000.00

c) Cost difference for port protection works to the north of the entrance

Without the artificial beach — Cr$ 17,000,000.00

With the artificial beach Cr$ 9,200,000.00

d) Savings to be obtained with the artifical beach Cr$ 7,800,000.00

The above analysis indicates the advisability of proceeding to studies of the artifical beach's stability.

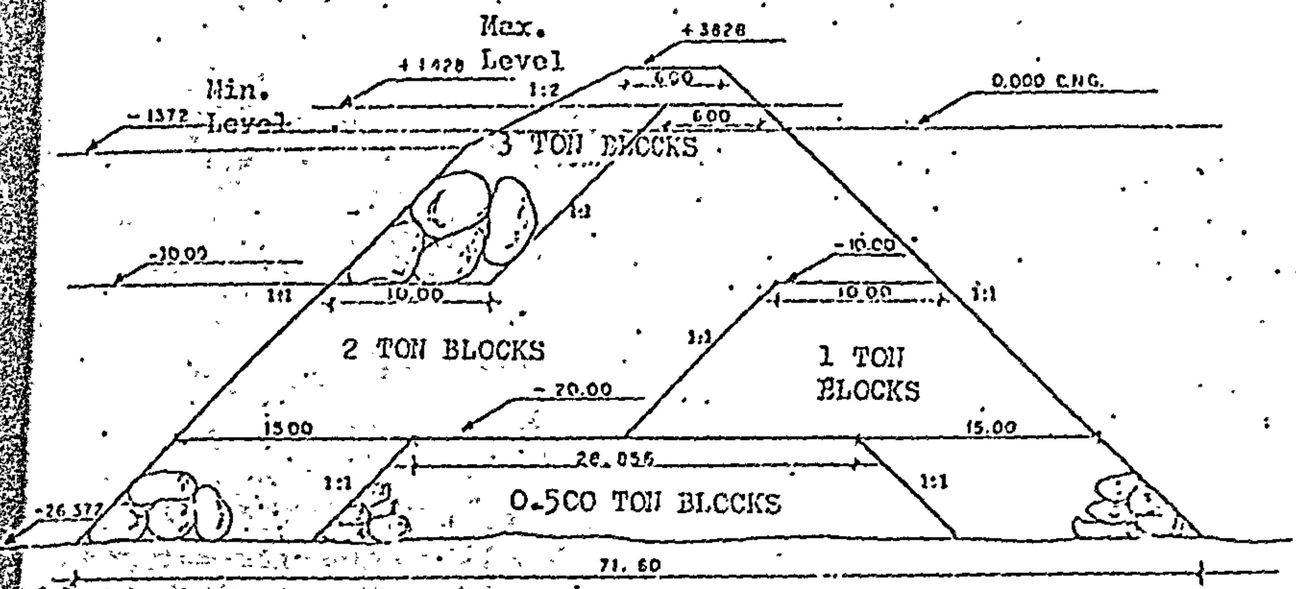
3.4 BUDGET ESTIMATE

Volume of sea wall to heighten the reef barrier, at the north of the port entrance	41,250.000 m^3
Volume of sea wall to heighten the reef barrier, at the south of the port entrance	447,180.000 m^3
Volume of sea wall to lengthen the reef barrier and connect it with the Cape of Santo Agostinho	31,372.000 m^3
Volume of seawall to build the protective breakwaters at the entrance of the port	1,187,289.600 m^3
Volume of sea wall for the buttress protecting the articial beach, at the Cape of Santo Agostinho.	41,250.000 m^3
	1,748,341,600 m^3
	1,750,000.000 m^3

Basic price of sea wall - Cr$ 50.00/m^3

Total cost of sea wall constructions:

1,750,000.000 m^3 x Cr$ 50.00 = Cr$ 87,500,000.00



VOLUME OF SEA WALL PER LINEAR METER — 1,236.76 m^3

LENGTH OF BREAKWATERS: NORTH – 530 m

SOUTH – 430 m

TOTAL – 960 m

TOTAL VOLUME OF SEA WALL — 1,187,289.600 m^3

NOTE: Elevations refer to zero C.N.G.

SCALE: VERT. – 1:500 HORIZ. – 1:500

0.000 CNG
1,372 m
0.000 Hydrographic (DHN)

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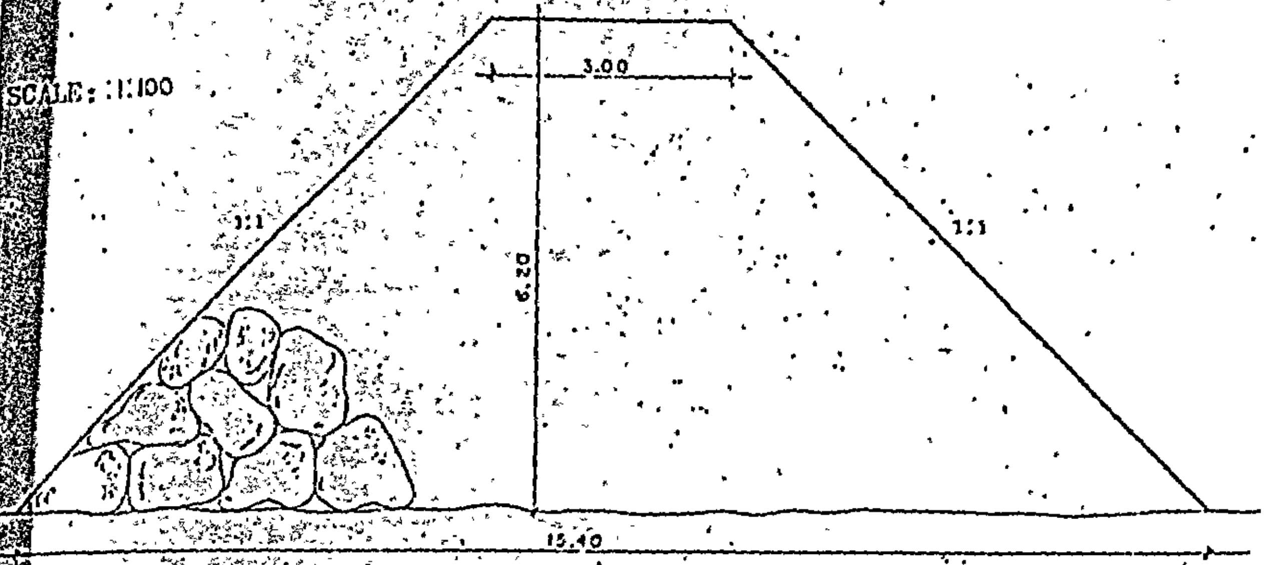
TYPICAL SECTION OF THE BREAKWATERS TO PROTECT THE PORT ENTRANCE

SEA WALL SECTION

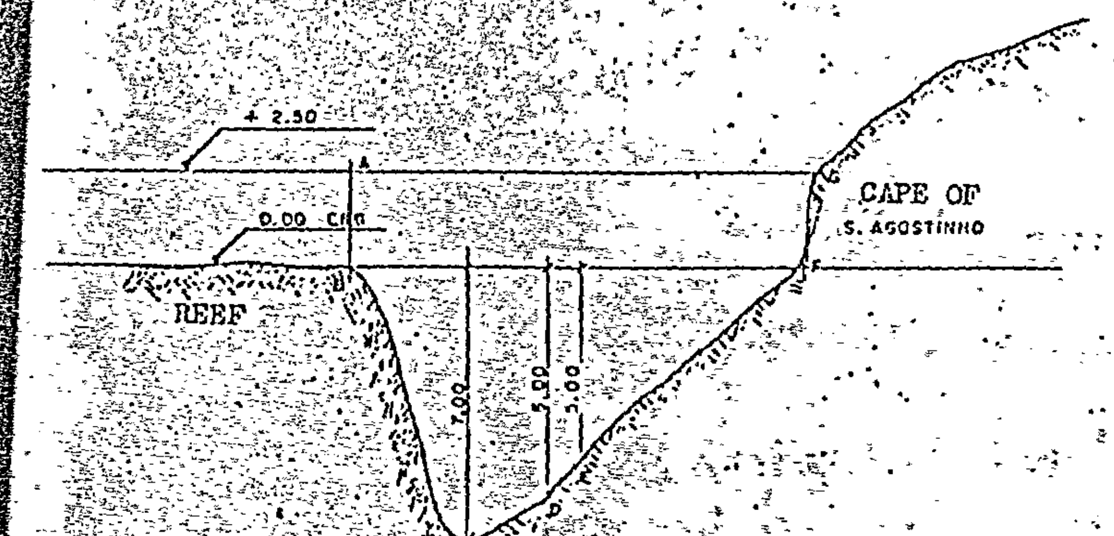


VOLUME OF SEA WALL PER LINEAR METER - 57,040 m^3

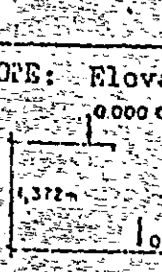
LENGTH OF THE SECTION TO BE CONNECTED - 550.00 m

TOTAL VOLUME OF SEA WALL - 31,372.00 m^3

PROFILE OF THE ALIGNMENT OF THE SEA WALL TO BE CONSTRUCTED



NOTE: Elevations refer to Zero C.N.G.



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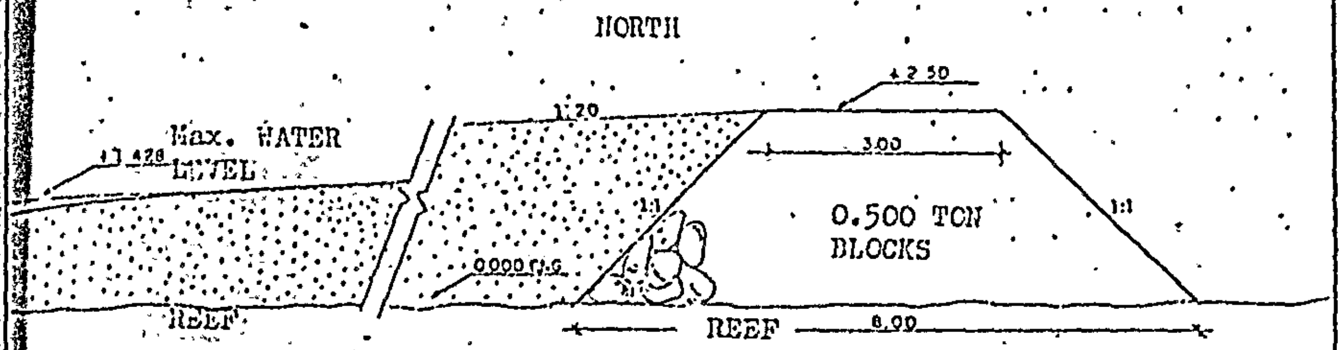
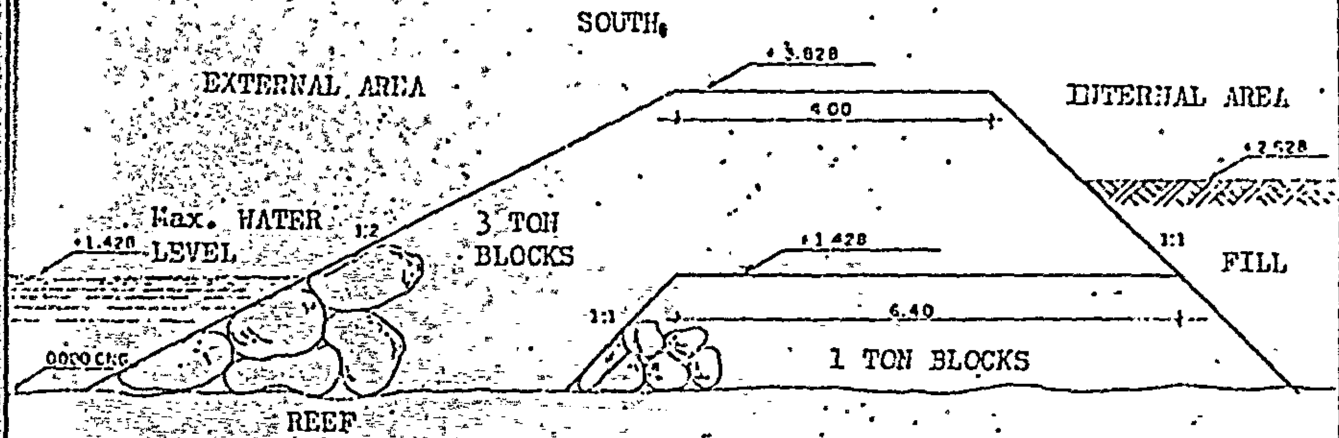
TYPICAL SECTION OF THE SEA WALL TO LENGTHEN THE REEF



VOLUME OF SEA WALL PER LINEAR METER — 13.750 m^3

LENGTH OF THE SECTION OF THE REEF TO BE HEIGHTENED - 3,000 m

TOTAL VOLUME OF SEA WALL — 41,250.000 m^3



VOLUME OF SEA WALL PER LINEAR METER — 74,530 m^3

LENGTH OF THE SECTION OF THE REEF TO BE HEIGHTENED — 6,000 m

TOTAL VOLUME OF SEA WALL — 447,180.000 m^3

NOTE: Elevations refer to Zero C.N.G.

0.000 CNG

1.372m

0.000 Hydrographic (DHN)

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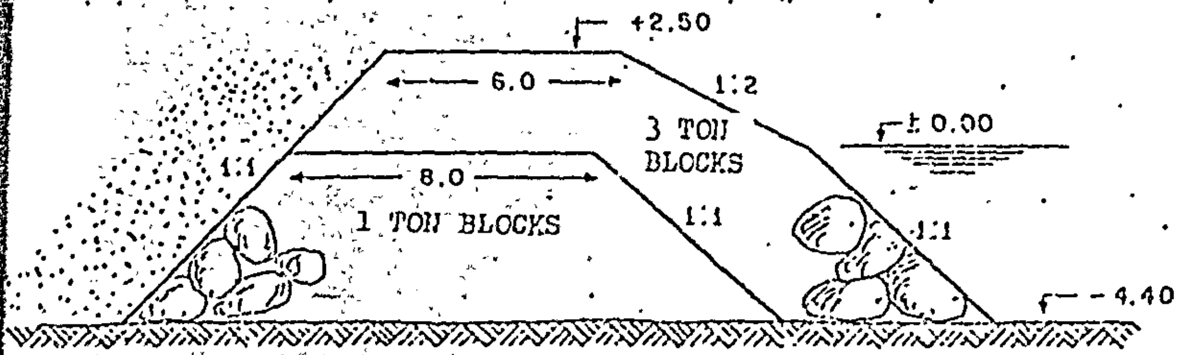
TYPICAL SECTION OF HEIGHTENING OF THE REEF (NORTH AND SOUTH OF THE ENTRANCE)

TYPICAL SECTION



VOLUME OF SEA WALL PER LINEAR METER — $103.14\ m^3$

LENGTH OF THE BUTTRESS — 400.00 m

TOTAL VOLUME OF SEA WALL — $41,250\ m^3$

NOTE: Elevations refer to Zero C.N.G.

0000 CNG.

1,372 m

0000 Hydrographic

(DNPVN.)

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DE PERNAMBUCO

COMPLEXO INDUSTRIAL DE SUAPE

TYPICAL SECTION OF BUTTRESS FOR THE ARTIFICAL BEACH AT THE CAPE OF SANTO AGOSTINHO

[illegible]

TOMO IV
PARTE 1
VOLUME 1
4.0

4.0 DREDGING PLAN

4.0 DREDGING PLAN

4.1 SUMMARY

4.1.1 OBJECTIVE

The Dredging Plan aims at meeting two final objectives: to permit traffic, maneuvering and docking of ships in the port, and to provide hydraulic fill for landfill areas.

Dredging was forecast to be performed in internal port areas and in the approach channel.

In general, the Dredging Plan for the Port of Suape can be divided into five parts:

- Dredging the port's approach channel
- Dredging the internal maritime area
- Dredging to support the opening in the reef
- Hydraulic fill to construct landfill areas
- Hydraulic fill to form a beach to protect the reef.

4.2 DREDGING THE APPROACH CHANNEL

The approach channel should be dredged up to -20 m. Analysis of geophysical surveys made in the area indicated that all the material to be dredged is sand. Since economic use of this sand is of interest, part of it will be used to form the beach planned for the area between the port entrance and the Cape of Santo Agostinho. According to studies made of the currents, the remainder should be dumped one mile to the north of the channel's center of gravity. For embankments, the most common ratio when using sand is 1:3. However, due to the present state of knowledge of this sand's size consist, and due to the effect that the high speed of ships in the channel will have on its margins, a 1:5 ratio was adopted. It should be clear that the above hypothesis cannot be relied upon and needs to be confirmed by later studies.

The agitation conditions in force in the external area demand that self-carrying dredges be used. A check of these dredges' operating costs, according to the various hopper volumes, showed a 9,000 m^3 hopper to be the most economical. However, this dredge's draft, on the order of 10 m, would definitely prohibit using sand dredged from the approach channel for formation of the beach. This factor makes advisable use of a dredge with a 2,000 m^3 hopper volume and 5.70 m draft. This dredge could evacuate sand to a depth of 7.70 m through opening the doors at the bottom of the hold.

4.1.3 DREDGING THE INTERNAL AREA

The internal maritime area is composed of areas I, II, III, IV and IX and the Ipojuca rectification channel.

The largest part of the dredging work will take place up to the start of the 1st phase, when 90% of the 1st part's volume will be dredged. Area II will be the only area dredged after the start of the 1st phase. This area will be deepened and its surface will be slightly increased.

Geophysical research and soils sampling done by drilling showed that the major part of the material to be dredged is sand. There also exist sandy and silty clays and 2 to 3 m thick layers of sandstone.

The dredged material will be shifted to fill areas or to the area along the outside of the reef to the north of the approach channel. The location will depend on whether the material is sand or clay.

An effort was made to plan the dredging so that there will always be the best combination of floating piping - onshore piping lengths. The combination was based on the higher costs and greater head loss for floating piping, and on minimizing the use cf boosters.

For embankments, a 1:5 ratio was adopted. For the margins where there are docking structures, embankments were planned to have tops and bottoms coinciding with the alignments indicated in the Maximum Utilization Plan.

Use of sets cf self-carrying and suction and pumping dredges was originally intended. However, in view of the objective of using for fill all of the sand dredged from the internal maritime areas, use of only suction and pumping dredges was decided upon. Based on comparative study of a series of dredges' operating costs, portable 26" dredges were chosen. Besides having lower operating costs, portable dredges have less draft and can be transported by truck. This last factor is significant for the Port of Suape since the present bar next to the Cape of Santo Agostinho doesn't always offer safe conditions for entrance of ships.

4.1.4 OPENING THE PORT ENTRANCE

The indicated method for breaking through the reef barrier and consequently opening the mouth of the port requires creation of a provisional beach between the entrance breakwaters on the outside of the barrier. This beach will be formed by sand dredged from the approach channel by self-carrying dredges and by sand dredged from the internal maritime areas by suction and pumping dredges. Description of this equipment is found in the items related to dredging the external and internal areas.

Once the mouth is opened, the beach will be dredged from both the external and internal sides and its sand will be used to form a beach to protect the reef.

4.1.5 HYDRAULIC FILL FOR FORMING LANDFILLS

For hydraulic fill, the Complex's land area was divided into the areas T_0, T_1, T'_3, T''_3, T'''_3, T_4, T_5, T'_6, T''_6, T_7, T_8, T_9, and T_{10}, as shown in Figure 1-I.

The volume of fill needed to raise these areas to the level desired (+2.70 m) is less than the fill forecast in the Maximum Utilization Plan. However it is greater than the fill volume available during the first stage.

Therefore, it was necessary to develop a policy for the 1st stage's hydraulic fill. This policy is based on three principles:

1. Guarantee complete use of the volume of fill available in the 1st stage. The volume originates in the internal areas, since due to the self-carrying dredge's characteristics the material to be dredged in the external area will not be used to form landfills.

2. Define priority areas, essential to the Complex's functioning, which will be filled to the elevation +2.70 m.

3. Define the distribution of the volume of fill still available in the remaining areas. Evolving use of these areas and estimation of the sand deposits in the maritime areas foreseen in the Maximum Utilization Plan should be considered. This would guarantee a lower cost for completing fills after the 1st stage.

The following decisions resulted:

fill areas T_1, T'_3, T'_4 and T_{10}, considered high priority, to +2.628 m.

fill areas T_0, T_2, T''_3, T''_4, T_5, T_8 and T_9 to the clearance elevation (+1.50 m).

The clearance elevation should be understood as the elevation above the maximum level of the sea.

Areas T'_6, T''_6 and T_7 will not be filled during the 1st stage.

The dredging - fill counterbalancing therefore was perfectly adjusted for the 1st stage, and rational completion of fill after the 1st stage was guaranteed.

4.1.6 HYDRAULIC FILL FOR FORMING THE REEF PROTECTION BEACH

The most economical solution for protecting the reef was shown to be the construction, by hydraulic fill, of a beach between the mouth of the port and the Cape of Santo Agostinho. This beach will be formed by sand dredged from the approach channel, the internal maritime areas and the beach in front of the mouth of the approach channel.

The following sections include a description of the equipment to be used in each of the dredging items.

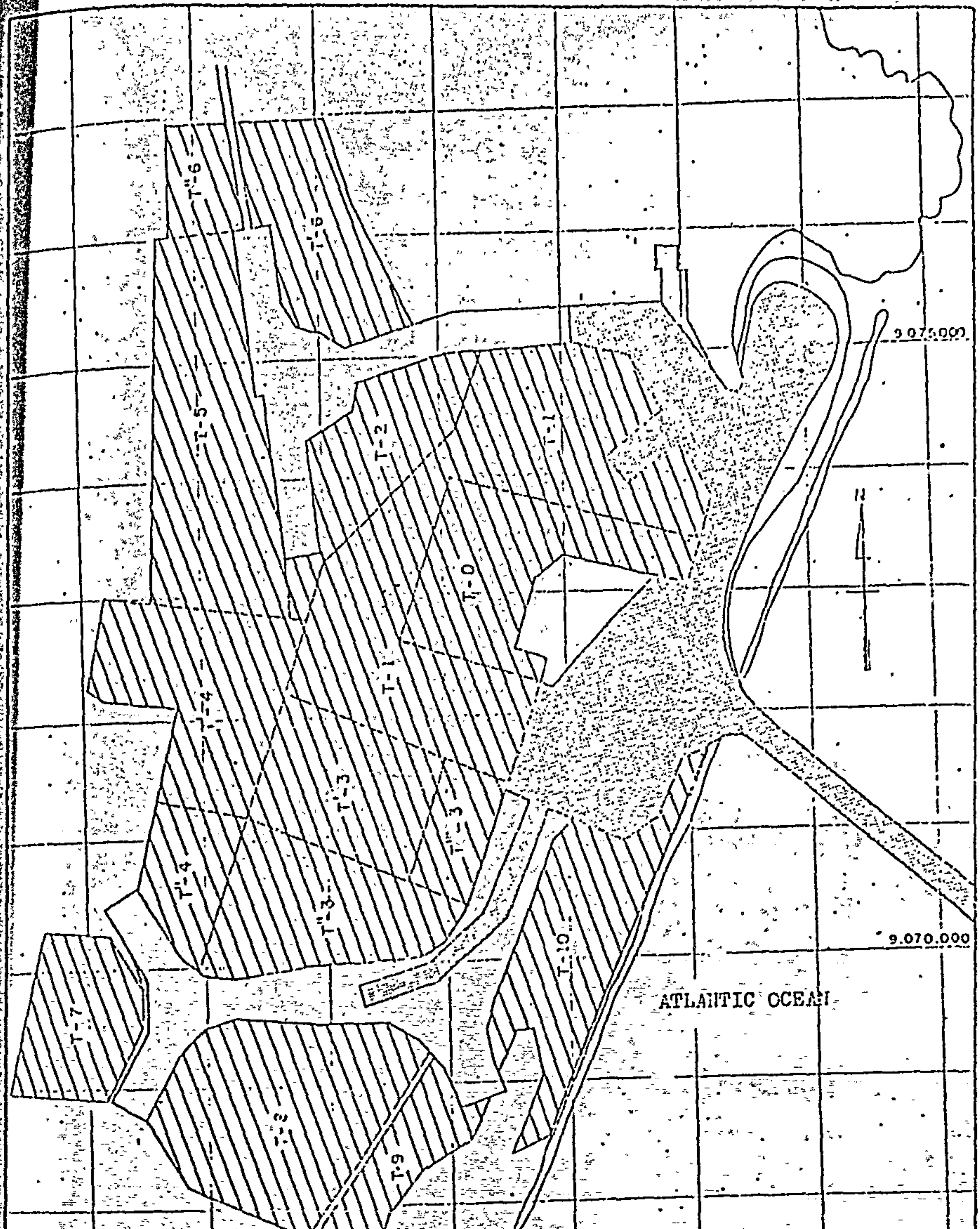

FIGURE – 11

DREDGING AREA

FILL AREA

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DREDGING AND FILL AREAS –
1st STAGE

4.2 COUNTERBALANCING

DREDGING - FILL

The following analysis of Dredging - Fill Counterbalancing aims at optimizing dredging operations and taking advantage of possible surpluses of good quality dredged material to reduce costs of heightening the reef barrier and to concomitantly to afford immediate clearance advantages to the areas to be implemented after the 1st stage.

Volumes calculations used in this analysis can be found at the end of this section and the drawings of the dredging and fill sections can be found in the respective book of drawings.

The preceeding figure shows the dredging and fill areas delimited in the present Plan.

4.2.1 ANALYSIS OF 1st STAGE COUNTERBALANCING

A BASIC ASSUMPTIONS FOR THE 1st STAGE

1) Areas T_6', T_6'' and T_7 will not be filled during the 1st stage;

2) Areas T_0, T_2, T_3'', T_3''', T_4'', T_5, T_8 and T_9 will be filled to +1.50 m with material dredged from the internal maritime areas;

3) Areas T_1, T_3, T_4' and T_{10} will be filled up to +2.70 m with material dredged from the internal maritime areas;

4) The beach will be filled below -7.70 m with material dredged from the approach channel and above -7.70 m with material from the internal maritime areas;

5) After opening the mouth of the port, the provisional beach will be dredged and the product of this dredging will be used to form the beach between the mouth and the Cape of Santo Agostinho.

6) Time periods:

1st phase - 2-1/2 years (from mid-1977 to 1980)

2nd phase - 6 years (from 1980 to 1986

7) Fill Priorities

1 T_1 and T'_3

2 T_{10}

3 T_4'

4 No priorities set for the remaining areas

B DREDGING - FILL COUNTERBALANCING DURING THE 1st STAGE

1 Sand dredging in the approach channel

$V_1 = 7{,}685{,}978\ m^3$

2 Sand dredging in the internal maritime areas

$V_2 = 57{,}471{,}714\ m^3$

3 Fill required to raise areas T_1, T'_3, T'_4 and T_{10} to the elevation + 2.70 m (fill material to be taken from the internal maritime area)

$V_3 = 26{,}648{,}025\ m^3$

4 Fill required to raise areas T_o, T_2, T''_3, T'''_3, T''_4, T_5, T_8 and T_9 to the elevation +1.50 m (to be taken from the internal maritime area)

$V_4 = 27,915,580\ m^3$

5 Fill required for the beach

$V_5 = 7.316,662\ m^3$

5.a Portion to be taken from the approach channel

$V_5' = 4,422,683\ m^3$

5.b Portion to be taken from the internal maritime area

$V_5'' = 2,893,979\ m^3$

6 Approach Channel dredging - fill counterbalancing

$V_6 = V_1 - V_5' = 3,623,295\ m^3$ surplus of dredged sand in relation to the fill

7 Internal maritime area dredging - fill counterbalancing

$V_8 = V_2 - (V_3 + V_4 + V_5'') = 14,130\ m^3$ surplus in relation to the fill

C SUMMARY OF DREDGING AND FILL VOLUMES

Dredging Volumes during the 1st Stage

A descriptive calculus of the volumes shown in the following tables may be found in Appendix 1-A at the end of this section.

1st STAGE DREDGING VOLUMES

	VOLUMES (m^3)			
	SAND	CLAY	SANDSTONE	TOTAL
Approach channel	7,685,978			7,685,978
Internal channels (FI + FII)	57,471,714	12,034,488	329,700	69,835,902
Total	65,157,692	26,839,043	329,700	92,326,435

FILL VOLUMES - DESCRIPTION BY AREA - 1st STAGE

AREAS	MEAN (m) ELEV. (1)	SURFACE AREA	FILL UP TO 2.70m	FILL UP TO 1.50 m	
			Volume (m^3)	Filled height	Volume (m^3)
T_o(2)		1,876,000			2,310,600
T_1(2)		4,407,700	9,239,620		
T_2	0.30	1,140,250		1.20	1,368,300
T_3' (2)			5,104,780		
T_3''	1.30	1,769,300		2.80	4,954,040
T_3'' (2)					1,189,275
T_4' (2)		2,158,250	7,230,520		
T_4''	0.30	793,850		1.80	1,428,930
T_5	2.30	2,958,700		3,80	11,243,060
T_6'		1,321,450			
T_6''		408,450			
T_7		1,420,350			
T_8		2,137,750		1.50	3,206,625
T_9		1,476,500		1.50	2,214,750
T_{10}(2)		1,757,250	5,073,105		
TOTAL		23,625,800	26,648,025		27,915,580

Total volume = 54,563,605 m^3

(1) - The elevations refer to zero CNG

(2) - Calculated by transverse sections

VOLUME OF FILL FOR THE REEF PROTECTION BEACH

Description	Volumes (m^3)
Total volume	7,316,662
Volume from the Approach Channel (1)	4,422,683
Volume from the internal area	2,893,979

VOLUME OF FILL FOR THE PROVISIONAL BEACH AT THE REEF OPENING

Description	Volumes (m^3)
Total volume	571,500
Volume from the Approach Channel (1)	252,720
Volume from the internal area	318,780

(1) = Using self-carrying, 2,000 m^3 dredges, reaching to a minimum depth of 7.70 m.

(2) = Using suction and pumping dredges.

4.2.2 ANALYSIS OF DREDGING - FILL COUNTERBALANCING AFTER THE 1st STAGE

For this analysis, the Complex's area was divided into three regions:

Massangana Region - including the maritime areas IV and V and the shore areas T_2, T_5, T'_6 and T''_6

Central Region - including the maritime areas I, II, III and IX and the shore areas T_0, T_1, T'_3, T'_4 and T_{10}

Ipojuca Region - including the maritime areas VI, VII and VIII and the shore areas T_3'', T_4'', T_8 and T_9

A ANALYSIS BY REGION

1) Massangana Region

Sand dredging from the maritime areas IV and V	14,207,000 m^3
Filling land areas T_2, T_5, T_6' and T_6''	13,568,240 m^3
Sand to be disposed of	638,760 m^3

2) Central Region

In this region only area T_o will be filled after the 1st stage. The necessary volume of fill (1,602,700 m^3) could be taken from area E_o (1,075,000 m^2 area), an area which is located in front of T_o. This area will not be dredged during the 1st stage.

3) Ipojuca Region

Sand dredging from maritime areas VI, VII and VIII	27,849,000 m^3
Filling land areas T_3'', T_3''', T_4, T_7, T_8 and T_9	11,487,735 m^3
Sand to be disposed of	16,367,265 m^3

SUMMARY OF DREDGING AND FILL VOLUMES

Sand dredging volumes after the 1st stage

(in m^3)

Areas	Volume of Sand
I	-
II	-
III	130,000
IV	3,669,000
V	10,538,000
VI	18,418,000
VII	2,133,000
VIII	7,298,000
IX	-
Approach Channel	
Total	42,186,000

Fill Volumes after the 1st stage

(in m^3)

Areas	Fill Volume
T_o	1,602,700
T_1	-
T_2	1,368,300
T_3'	-
T_3''	2,123,160
T_3'''	666,015
T_4'	-
T_4''	925,620
T_5	3,550,440
T_6'	6,607,250
T_6''	2,042,250
T_7	3,408,840
T_8	2,565,300
T_9	1,771,800
T_{10}	
Total	25,658,675

4.3 TECHNICO-ECONOMIC ANALYSIS

4.3.1 PRELIMINARY CONSIDERATIONS

In general, the Port of Suape dredging can be divided into three main parts:

- Dredging the port approach channel.
- Opening the mouth to the port approach.
- Dredging turning basins and internal circulation and docking channels.

The dredging in question presents a series of factors that should be interconnected during the execution phase. We forsee the use of Hopper dredges to dredge the approach channel and of suction and pumping dredges to dredge the internal areas and the internal (protected) part of the mouth of the port.

Even though the only equipment alternative for dredging the approach channel is the Hopper dredge, dredging of the basins and internal channels could be accomplished by jointly using Hopper and suction and pumping dredges.

Under these conditions, dimensioning of the equipment will be controlled by technico-economic restraints to minimize the overall dredging cost.

We can assume two basic hypotheses to be studied in determining the minimum dredging cost:

a FIRST:

a.1 Dredging the approach channel by Hopper dredge.

a.2 Dredging the mouth of the port with a Hopper dredge on the external portion and a suction and pumping dredge on the internal portion.

a.3 Dredging the basins and internal channels with a suction and pumping dredge.

b SECOND:

b.1 Dredging the approach channel with a Hopper dredge.

b.2 Dredging the mouth with a Hopper dredge on the external portion and a suction and pumping dredge on the internal portion.

b.3 Dredging the basins and internal channels with both Hopper and suction and pumping dredges.

In addition to the three main parts of the dredging work indicated above, two other secondary aspects should be considered:

c SECONDARY OPERATIONS:

c.1 Hydraulic fill of areas internal to the perimeter of the port's with land elevation up to +2.70 m and +1.50 m.

c.2 Dredging the Ipojuca River's rectification channel.

The above two secondary operations will require small and medium size suction and pumping dredges.

4.3.2 DREDGING EQUIPMENT AVAILABLE ON THE MARKET

To relate the different types of dredging equipment available on the market to the work that should be performed, we present the list below, which shows the range of the most common dredging equipment on the market.

A Hopper Dredges

Hopper volume	from 1,000 m^3 to 10,000 m^3
Total installed potential	from 2,500 HP to 20,000 HP
Transport rate	from 10 knots to 15 knots
Hopper yield time with broken up sand	from 45 minutes to 70 minutes
Loaded draft	from 5.0 meters to 10.0 meters
Dredging depth	from 16 meters to 35 meters
Length	from 70 meters to 140 meters
Beam	from 12 meters to 23 meters
Specific weight of load	from 1.6 tons/m^3 to 2.0 tons/m^3

B Suction and Pumping Dredges

Piping diameter	from 14" to 30"
Length	from 15 m to 60 m
Beam	from 6 m to 20 m
Draft	from 1.0 m to 4.5 m
Pump potential	from 700 Hp to 8,000 HP
	from 100 HP to 3,000 HP
Hourly production	from 300 m^3/hr to 1,000 m^3/hr
Dredging depth	from 10 m to 22 m

4.3.3 MATERIALS TO BE DREDGED

Geophysical surveys and soils sampling by geotechnical drilling showed that the major part of the material to be dredged is sand. There are also present sandy and siltly clays, and sandstone in layers of a mean 3.0 meter thickness.

4.3.4 PERFORMANCE OF THE DREDGES IN RELATION TO THE MATERIALS TO BE DREDGED

Even though the number of geotechnical drill holes available is very small in relation to the number that would be desirable for a more accurate estimate, we can assume the following dredge productivity indexes.

A Hopper dredge

Medium broken up sand	- 100
Medium compact sand	- 70
Fine broken up sand	- 70
Fine compact cand	- 50
Soft clay	- 70
Medium clay	- 30
Hard clay.	- 10
Sandstone	- 0

B Suction and pumping dredge

Medium broken up sand	- 100
Medium compact sand	- 90
Fine broken up sand	- 100
Fine compact sand	- 80
Soft clay	- 160
Medium clay	- 70
Hard clay	- 40
Sandstone	- 10

4.3.5 DISPOSAL AREAS FOR DREDGED MATERIALS

In order to simulate dredging and hydraulic fill operations, we are going to develop some hypotheses as to the locations where the dredged materials should be dumped. Basically, the shorter the transport distance, the lower the cost per cubic meter dredged.

Taking into consideration the results made of currents in the area, we can set the following disposal locations:

A Dredging of the approach channel - disposal of the dredged material 1 mile to the north of the channel's center of gravity.

B Dredging of the basins and internal channels - disposal of dredged material along the reefs to the north of the access channel.

C Hydraulic fill of the areas inside the port's approach line.

Materials will be disposed of in a manner that minimizes transport distance.

D Observation

The above hypotheses were drawn up based on the currents study and the economic factor, and are not fully reliable. At the time when a mobile-bed scale model of the port is studied, the possibility of studying the behavior of the materials disposed of in the manner which we postulate here should be considered. Nonetheless, until proven to the contrary, we consider the assumed hypotheses to be reliable, and we are going to use them as a basis for the proceding study, which establishes a methodology for dredging and fill operations and determines unit costs and conditions that will determine the minimum overall cost.

4.3.6 DETERMINATION OF OPERATING COSTS OF DREDGING EQUIPMENT WHICH COULD BE USED IN DREDGING THE PORT OF SUAPE

A Operating Cost of hopper dredges

The present study will be conducted in a manner to obtain operating costs of a series of hopper dredges of various theoretical capacities, and to arrive at data needed to optimize the dredging cost.

We will take as a base a 6,000 m^3 volume hopper dredge.

This dredge's principal characteristics are:

Length	125 m
Beam	20 m
Draft	8.5 m
Hopper Volume	6,000 m^3
Installed Potential	9,000 HP
Loaded Velocity	12.8 knots
Crew	35 men
Yield	18,000 tons
Load capacity	11,000 tons

Value of the dredge - US $ 1,000.00/ton x 11,000 = US$ 11,000,000.00
= Cr$ 80,300,000.00

Calculation of monthly operating cost.

1	Personnel		
1.1	Salaries	Cr$ 105,000.00	
1.2	Social Laws	Cr$ 68,250.00	Cr$ 173,250.00
2	Food		Cr$ 30,000.00

3 Fuel

0.80 x 9,000 HP x 0.185 l/HP.hr x 1.00 Cr$/l x 550 hrs/month — Cr$ 732,000.00

4	Lubricants (10% of fuel)	Cr$ 73,200.00
5	Maintenance and insurance - 12% per year	Cr$ 803,000.00
6	Provisions for biennial overhaul - 10% per year	Cr$ 669,167.00
7	Interest - 10% per year	Cr$ 669,167.00
8	Depreciation - 10 years 10 % per year	Cr$ 669,167.00
9	Unforeseen expenses - 10% of maintenance.	Cr$ 66,916.00
10	Overhead and profit (5% + 10%)	Cr$ 777,173.00
		Cr$3,885,867.00
		Cr$4,663,040.00
	Monthly operating cost -	Cr$4,663,040.00/month

Economic analysis of monthly operating cost

1 Working hours

24 hrs/day x 6 days/week x 4.3 weeks/month . 619 hours/month

Hours of operation: 619 x 0.89 = 550 hours/month

2 Personnel cost - P - Cr$ 173,250.00

This cost item will be constant, as it is independent of the dredging volume.

3 Food - A - Cr$ 30,000.00 (same as aboe)

4 Fuel - c

This item is proportional to the total installed potential. To calculate this cost we assume that potential varies linearly with the dredge hopper capacity and the rate.

With these conditions we have:

Installed potential = HP = K. V x v/v.

where:

$K = HP_o/V_o$ in HP/m^3

V = hopper volume in m^3

v = dredging rate

v_o = 12 knots

V_o = 6,000 m^3

HP_o = 9,000 HP

Thus $K = HP_o/V_o = 9,000/6,000 = 1.5\ HP/m^3$

$K = 1.5\ HP/m^3$

The v/v_o will be assumed to be 1, based on the operating conditions.

5 Lubricants - L

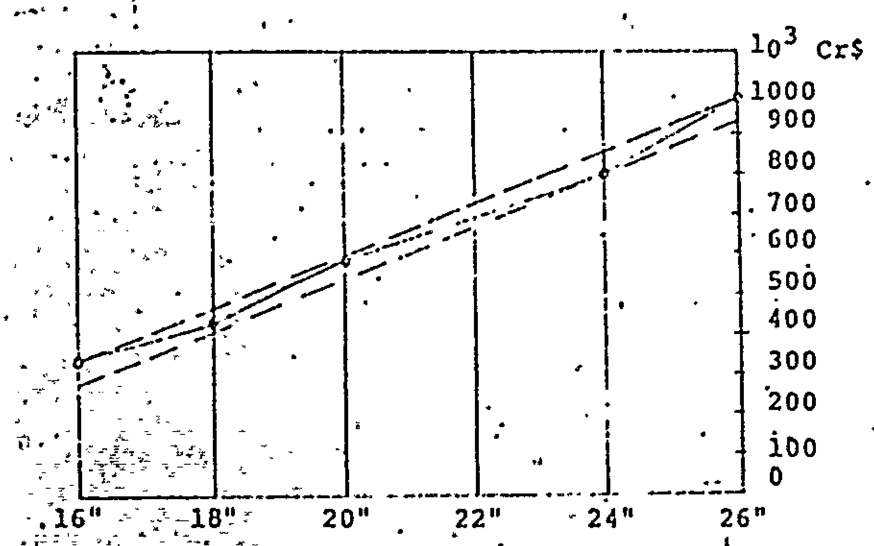
The cost of the lubricants will be calculated as a constant 10% of the fuel cost (diesel fuel).

6 Costs that depend on the value of the equipment: C_c

26" Dredge - Value - US$ 2,000,000.00	Cr$	14,600,000.00
1 Personnel		
2 Social Benefits		120,290.00
3 Food		
4 Fuel 67.01 x 4,585		307,195.00
5 Lubricants		30,719.00
6 Capital costs 0.43/.2 x 14,600,000.00		523,170.00
	Cr$	981,374.00

GRAPH OF SUCTION AND PUMPING

DREDGE MONTHLY COSTS



2 Determination of operating cost of auxiliary equipment

Work schedule - same as for dredges

Crew

Job	No.	Salary	Total
Dredge Masters	4	2,000.00	8,000.00
Engineers	2	2,000.00	4,000.00
Deck Hands	2	1,000.00	2,000.00
	8		14,000.00

Average salary = 14,000.00 ÷ 8 = 1,750.00

Overtime - 120 hours/month for each crew

Straight time = 1,750.00 ÷ 200 = 8.75 Cr$/hr (average)

Overtime = 1.5 x 8.75 = 13.125 Cr$/hr (average)

Operating cost for 16" dredge

Same equipment as for dredges up to 20"

Value = US$ 350,000.00 = Cr$ 2,555,000.00

Power = 2 x 150 = 300 HP

1 Personnel

Salary - 8 x 1,750.00 =	14,000.00	
Overtime - 8 x 120 x 13.25=	12,600.00	
	26,600.00	26,600.00

2	Social Benefits 0.65 x 26,600.00	17,290.00	
3	Food	7,000.00	
		50,890.00	50,890.00
4	Fuel 67.01 x 300		20,100.00
5	Lubricants - 10% of fuel		2,010.00
6	Capital costs - 0.43/12 x 2,555,000.00		91,560.00
			Cr$ 164,560.00

Operating cost for 26" dredge

Will be the same as for dredges from 22 to 26".

Value = US$ 500,000.00 = Cr$ 3,650,000.00 -

Power = 2 x 225 = 450 HP

1	Personnel and Food	50,890.00
2	Fuel 67.01 x 450	30,150.00
3	Lubricants - 10% of fuel	3,015.00
4	Capital costs	
	0.43/12 x 3,650,000.00	130,790.00
		Cr$ 214,845.00

3 Operating cost of floating and onshore piping

This cost will be calculated by meters of piping, in order to derive costs for each piping set. Basically the cost will be calculated per the value of capital invested.

For cost calculations we will use the following standard.

Floating piping

1	Maintenance	2.5% per year
2	Provisions for overhaul	2.5% per year
3	Interest	10.0% per year
4	Depreciation	
4.1	Piping - 0.15 x 100%	15.0% per year
4.2	Equipment 0.85 x 30%	25.5% per year
		55.5% per year

18" Piping

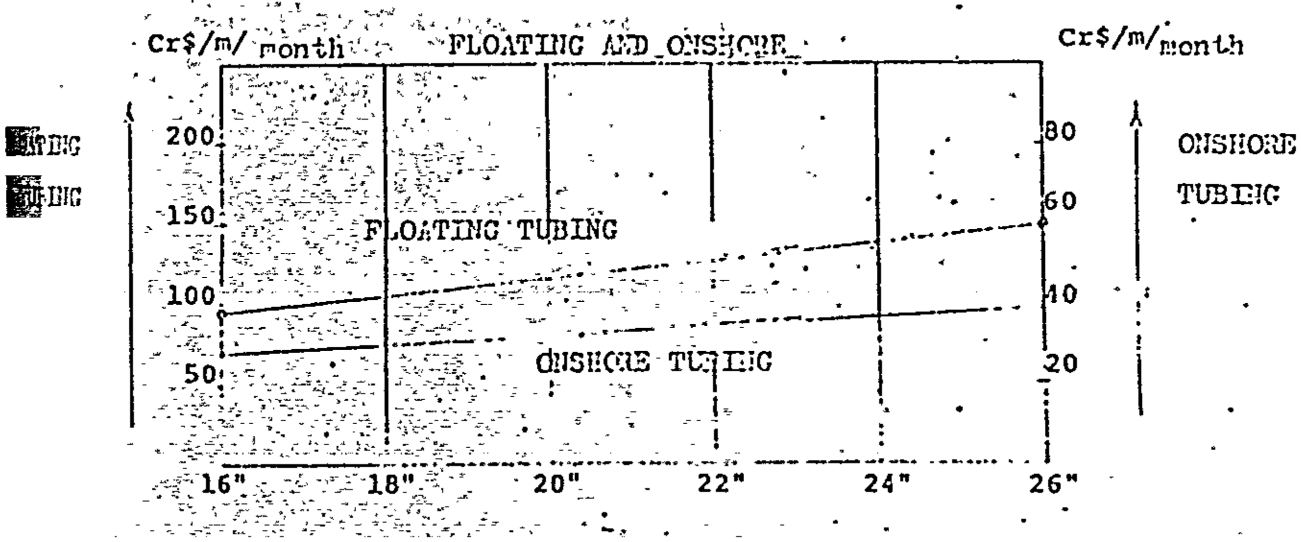
Monthly cost/meter = 0.555/12 x 2,022 = Cr$ 93.5/m/month

20" Piping

Monthly cost/meter = 0.555/12 x 2,628 = Cr$ 121.5/m/month

26" Piping = 0.555/12 x 3,204.7 = Cr$ 148.2/m/month

GRAPH OF MONTHLY COST PER METER OF PIPING



Onshore Piping

1	Interest	10% per year
2	Depreciation	100% per year
		110% per year

16" Piping

Monthly cost/meter = 1.10/12 x 297.62 = Cr$ 27.28/m/month

20" Piping

Monthly cost/meter = 1.10/12 x 368.50 = Cr$ 33.78/m/month

26" Piping

Monthly cost/meter = 1.10/12 x 416.6 = Cr$ 38.2/m/month

4.3.7 HYDRAULIC FILL

Counterbalancing the sand dredging and the hydraulic fill needs, at this phase of the dredging we have available 57,471,714 m^3 of sand to make 26,648,025 m^3 of fill for areas T1, T'3, T'4 and T10 up to an elevation of 2.70 m and a volume of 27,915,580 m^3 of sand to fill areas T0, T2, T3", T3''', T4", T5, T8 and T9 up to a clearance level of +1.50 m. This amounts to a total of 54,563,605 m^3, leaving a balance of 2,906,109 m^3 which could be used to form the beach. The volume of sand to be dredged from the port's approach channel is not included in the above computations.

The table of the distribution of volumes of sand to be dredged shows that the largest volumes are concentrated between sections S_6 and S_{20}, and that the remaining volumes represent less than 10% of to total to be filled, and therefore are not strategically significant to the areas to be filled.

A Filling Area T1

1 Section of area T1 located to the north of Area T0.

This area will absorb a volume of 3,775,170 m^3, which could come from the Massangana River rectification channel, with a volume of 3,443,470 between sections SD-19 and SD-23. However, it would be more advisable to use this material in the area T1 section to the west of area T0, and leave the section to the north of T0 to absorb the volume of sand to be dredged in the region of the Suape beach, and therefore avoid using a booster to pump this material.

Therefore, the section of area T1 to the north of area T0 will receive material from the basin next to the Suape beach, using 1,500 meters of floating pipecentering at point I and distributing the sand with up to 2,000 meters of of onshore piping.

To determine the cost of this section's fill, we can assume that 1,900,000 m^3 will be pumped with 1,000 m of onshore piping and that 1,875,170 m^3 will be pumped with a maximum of 2,000 m of onshore piping.

The costs will be:

1	Dredge	980,000.00
2	Aux. equipment	215,000.00
3	1,500 m floating pipe	224,000.00
4	1,000 m onshore pipe	38,000.00
		Cr$1,457,000.00

Production will be 800 m^3/hr, equivalent to 800 x 400 hrs/month = 320,000 m^3/month

The cost per cubic meter will be $\frac{1.2 \times 1,457,000.00}{320,000} = 5.46$ Cr$/m^3

Time period for performing the work -
1,900,000 ÷ 320,000 = 5.94 months

For the most adverse conditions, the cost will be:

Cr$	1,457,000.00	cost with 1,000 m onshore piping
Cr$	38,000.00	additional 1,000 m of onshore piping
Cr$	1,495,000.00	

Production will be 730 m^3/hr, equivalent to 730 x 400 = 292,000 m^3/month.

The cost per cubic meter will be:

$$\frac{1.2 \times 1,495,000.00}{292,000} = 6.14 \text{ Cr\$/m}^3$$

Time period for performing the work = 1,875,170 ÷ 292,000 = 6.42 months

Total cost will be:

1,900,000 m^3 x 5.46 Cr$/m^3 = Cr$ 10,374,000.00

1,875,170 m^3 x 6.14 Cr$/m^3 = Cr$ 11,514,000.00

Total = Cr$ 21,888,000.00

2 Filling the section of area T1 located to the west of Area T0.

This area will be filled with material from the Massangana channel. Piping will be:

1 500 m floating + 2,500 m onshore - 600,000 m^3 of fill

2 500 m floating + 3,500 m onshore - 685,660 m^3 of fill

The cost will be:

1 Dredge 980,000.00

Aux. equipment 215,000.00

500 m floating piping 75,000.00

2,500 m onshore piping 95,000.00

Cr$ 1,365,000.00

Production will be 800 m^3/hr = 800 x 400 = 302,000 m^3/month

The cost per cubic meter will be: $\frac{1.2 \times 1,365,000.00}{320,000}$ =

5.12 Cr$/$m^3$

The time period for performing the work will be
600,000 ÷ 320,000 = 1.88 months

2 Cr$ 1,365,000.00 cost with 2,500 m onshore piping

Cr$ 38,000.00 additional 1,000 meters

Cr$ 1,403,000.00

Production will be 730 m^3/hr = 730 x 400 = 292,000 m^3

The cost per cubic meter will be: $\frac{1.2 \times 1,403,000.00}{292,000}$ =

5.67 Cr$/$m^3$

The time period for performing the work will be:
685,660 m^3 ÷ 292,000 m^3/month = 2.35 months

The cost of the fill will be:

600,000 x 5.12 = Cr$ 3,072,000.00

685,660 x 5.67 = Cr$ 3,888,000.00

Cr$ 6,960,000.00

It should be noted that we propose performing part of the fill at a rate of 4.0 m/s to avoid using the booster for a relatively small volume.

3 Filling the section of area T1 located to the south of area T0.

This section will also receive sand from the area next to the Suape beach since this area has a close to 15,000,000 m^3 reserve and should be dredged.

A maximum of 1,500 m of floating piping will be used, entering through point I, and running across T1 (north side) and T0 to the center C1, where it will distribute the fill.

The I-C1 distance is 2,800 m, and the the farthest point to be reached is 1,400 m from C1.

We therefore would have the following, for the least favorable conditions.

1,500 m of floating piping and 4,200 m of onshore piping

With 1,500 m of floating piping we can reach 1,500 m with onshore piping, which is equivalent to total utilization of 3,400 dredge HP, at a rate of 4.3 m/s, and corresponds to approximately 3,600 m of onshore tubing. The booster dimensioned in item 4 would satisfy the objective of reaching 2,700 meters, since the booster HP = $3,400 \times \frac{2,700}{3,600} = 2,550$ HP. We will use a 2,250 HP booster, which will solve the problem, since the dimensioning situation is critical.

We can assume that 2/3 of the area to be filled will be filled with 800 m of onshore piping and 1/3 with 1,400 m starting out from C1. We can therefore calculate a unit price, with 1,000 m of onshore pumping in addition to C1.

Thus we have:

1,500 m floating piping + 3,800 m onshore piping

The cost will be:	26" Dredge	980,000.00
	Aux. equipment	215,000.00
	1,500 m floating piping	224,000.00
	3,800 m onshore piping	144,000.00
	26" booster	330,000.00
		Cr$ 1,893,000.00

Production will be = 850 m^3/hr x 400 hrs/month = 340,000 m^3/month

The cost per cubic meter will be = $\frac{1.2 \times 1,893,000.00}{340,000}$ =

5.568 Cr$/$m^3$

The time period for performing the work will be = 4,178,790 ÷ 340,000 = 12.29 months

The cost will be: 4,178,790 m^3 x 5.568 Cr$/$m^3$ = Cr$ 23,268,000.00

B FILLING AREA T10

With about 9,000,000 m^3 already having been used, there still will remain about 6,000,000 m^3 from the area next to the Suape beach and about 4,500,000 m^3 between sections SD-18 and SD-20, amounting to a total on the order of 10,500,000 m^3. Due to Area T10's position, we will have to use even more material from this zone, and therefore areas T'4 and T'3 should absorb volumes from this zone.

Area T10 will be filled with sand from sections bounding area T0.

The volume of fill for area T10, 5,073,105 m^3, can be taken from dredging done between sections SD-6 and SD-8.

piping for this fill will be:

500 m of floating piping centered at III + 1,000 m of onshore piping to fill 2/3 of the volume and 500m of floating piping + 2,000 m of onshore piping for the remaining 1/3, with small economically insignificant volumes at 2,500 m onshore.

For 500 m floating + 1,000 m onshore, production will be 930 m^3/hr, and for 500 m floating + 2,000 m onshore, production will be 830 m^3/hr. Mean production will be =

$$\frac{2 \times 930 + 1 \times 830}{3} = 897 \text{ m}^3\text{/hr}$$

The time period for performing the work will be:

5,073,105 ÷ 359,000 = 14.13 months

The monthly cost will be:

26" dredge	980,000.00
Aux. equipment	215,000.00
500 m floating piping	75,000.00
2,000 m onshore piping	76,000.00
Cr$	1,346,000.00

The cost per cubic meter will be: $\frac{1.2 \times 1{,}346{,}000.00}{359{,}000} = 4.5$ Cr$/$m^3$

The total cost will be: 5,073,105 x 4.5 = Cr$ 22,828,972.00

c Hydraulic fill of areas T3' and T'''3

The volume of fill for these areas will be 6,294,055 m^3, for an elevation of + 2.70 m in T'3 and + 1.50 m in T'''3.

Because of its location, we will have to transport sand from the area next to the Suape beach, dredging the fore harbor from which we have so far taken, in round numbers, about 9,000,000 m^3.

The transport distance will be 1,000 m of floating piping from the dredge to point I, where the transition is made from floating piping to 5,000 m of onshore piping.

Assuming a rate of 4.5 m/s, the dredge with 1,000 m of floating piping would reach only to a length of 1,600 m on shore. Thus, the remaining 3,400 m would have to be propelled by a booster, whose power would be:

$$HP = \frac{3,150}{3,400} \times 3,400 = 3,150 \text{ HP}$$

We therefore propose to use two 2,250 HP boosters which will permit reaching a distance of 6,000 m. Hourly production will be 830 m^3/hr, and monthly production:

$$400 \times 830 = 332,000 \ m^3/\text{month}$$

In this case, the cost will be:

26" Dredge	980,000.00
Aux. equipment	215,000.00
900 m floating piping	134,000.00
5,000 m onshore piping	190,000.00
2 26" boosters	660,000.00
	Cr$ 2,179,000.00

The cost per cubic meter will be: $\frac{1.2 \times 2,179,000.00}{332,000} =$ 7,8800 Cr$/$m^3$

The total cost will be: 6,249,055 x 7.88 = Cr$ 53,645,000.00

The time period for performing the work will be:

6,249,055 ÷ 332,000 = 18.96 months

6 - 9 Hydraulic fill of area T_4

To fill this area, a volume of 7,230,520 m^3 of sand from the area bordering on the port entrance mouth will be used.

The pumping distance will be 1,000 m of floating pipe and 2,200 m of onshore piping.

The dredge alone is sufficient to perform this fill at a rate of 4.3 m/s.

The cost will be:	25" Dredge	980,000.00
	Aux. equipment	215,000.00
	1,000 m floating piping	149,000.00
	2,200 m onshore piping	84,000.00
		Cr$ 1,428,000.00

Monthly production will be: 400 x 850 = 340,000 m^3/month

The cost per cubic meter will be: $\frac{1.2 \times 1,428,000.00}{340,000} = 5.1$ Cr/m^3

The cost of the work will be: 7,230,520 x 5.1 = Cr$ 36,876,000.00

The time period for performing the work will be:
7,230,520 ÷ 340,000 = 21.3 months

D - Filling Area TO

The volume of this area is 2,310,600 m^3 and the distance to be pumped will be approximately 1,000 m of floating piping and 2,000 m of onshore piping.

The dredge alone can perform the work at a rate of 4.3 m/s.

Monthly production will be 400 x 850 = 340,000 m^3/month.

6.1	Maintenance and insurance	12% per year
6.2	Provision for biennial overhaul	10% per year
6.3	Interest on invested capital	10% per year
6.4	Depreciation - 10 years	10% per year
6.5	Unforeseen contingencies - 10% of maintenance and insurance	1% per year.
7	Total	43% per year

In sum, we have a mathematical expression which reflects the operating cost C, of a dredge with a V m^3 hopper volume whose value is US$1,000.00/t.c.c. (t.c.c. = load capacity in tons), t.c.c. = j x V where:

j = specific weight of the load 1.833 tons/m

V = rated volume of the hopper

$C = P + A + c + l + C_c$

P = Cr$ 173,250 which gives Cr$ 175,000.00/month

A = Cr$ 30,000.00/month

$c = 0.80 \times K.V\ v/v_o \times 0.185$ hrs/HP.h x 1,000 Cr$/hr x .5 hrs/month = Cr$ 81.4 K.V. v/v_o

which for K = 1.5 and $v/v_o = 1$ gives:

c = Cr$ 81.4 x 1.5 x 1 x V

c = Cr$ 122.1 x V

l = 0.1 c (lubricant)

C_c = 0.43/12 x US$ 1,000/ton x 1.833 tons/m^3 x V x 1.3 Cr$/US$

C_c = Cr$ 479.48 x V.m-r

l = Cr$ 12.21 x V

Thus: C = 175,000 + 30,000 + 122.1 V + 12.21 V + 479.48.V

C = (613.70 x V +205,000) Cr$/month

For a 6,000 m^3 dredge we would have:

$$C = 613.79 \times 6{,}000 + 205{,}000 = 3{,}682{,}740 + 205{,}000$$

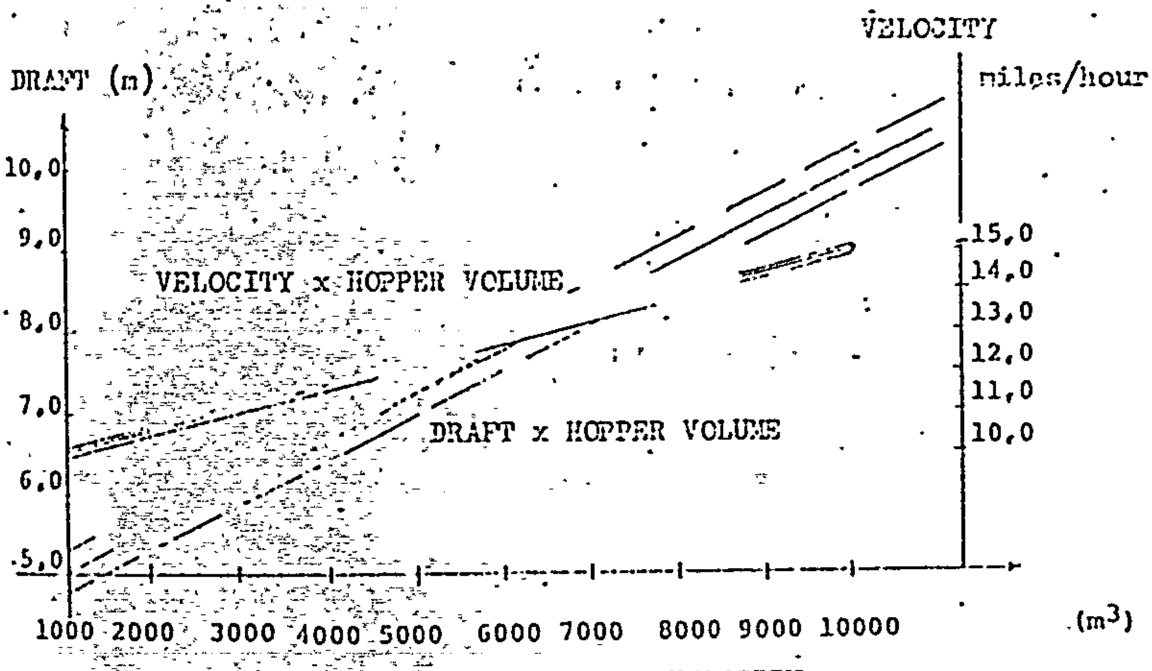
$$C = 3{,}887{,}740.00$$

Cost with overhead and profit -- C' = 1.20 c

$$C' = 1.20 \times 3{,}887{,}740.00 = 4{,}665{,}288.00$$

In summary, we have the following table for dredges with a transport velocity of 12 knots, and the draft x hopper volume graph.

Hopper Volume - V	Monthly Operating Cost - C'
1,000 m^3	Cr$ 982,548.00
2,000 m^3	Cr$ 1,718,880.00
3,000 m^3	Cr$ 2,455,644.00
4,000 m^3	Cr$ 3,192,192.00
5,000 m^3	Cr$ 3,928,740.00
6,000 m^3	Cr$ 4,665,288.00
7,000 m^3	Cr$ 5,401,836.00
8,000 m^3	Cr$ 6,138,384.00
9,000 m^3	Cr$ 6,874,932.00
10,000 m^3	Cr$ 7,611,480.00



GRAPH - DRAFT x HOPPER VOLUME x VELOCITY

B Monthly operating cost of suction and pumping dredges

We are going to define a series of 16" and 26" suction and pumping dredges and auxiliary equipment needed to perform the services in question.

Dredging outfit

In general, the dredging outfit is composed of:

1 Suction and pumping dredge
1 Oil and water barge
1 Flush deck barge
1 15 ton crane
1 Service and support launch
1 Tugboat
2,000 m floating/onshore piping

Characteristics of the dredges

In order to obtain the lowest operating cost, we are going to base our study on a series of portable dredges whose characteristics should satisfy to a large extent the dredging that should be performed. Only for dredging sandstone will dredges of greater disaggregator potential be needed.

The following list defines the principal characteristics of this equipment, by diamter of the pumping piping.

TYPE OF DREDGE	L(m)	B(m)	d(m)	HP PUMP	HP AUX.	HP DISAGG.
16"	21.00	6.70	1.00	850	335	250
18"	21.00	6.70	1.10	1125	335	250
20"	30.00	9.70	1.25	1700	670	400
22"	35.00	9.70	1.40	1950	670	400
24"	40.00	11.00	1.50	2250	850	500
26"	40.00	11.00	1.70	3400	1185	800

Determination of the expected production for each type of dredge and material to be dredged.

16" Dredge

Initially we will consider the minimum permissible velocities for each type of material dredged, in view of its settling in the pumping pipe.

a For sand - $v_m = 3.6$ m/s

b For hard clay and sandstone - $v_m = 6.2$ m/s

c For soft clay - $v_m = 3.0$ m/s

Determination of the maximum reach

For sand

Head loss for $\begin{cases} D = 16" = 0.40 \text{ m} \\ v = 3.6 \text{ m/s} \end{cases}$ $h = 2.8$ m/100 m

Calculation of the specific weight of the mixture j=0.15 x 2.0 + 0.85 x 1=1.15 tons/m^3 with 15% solids.

Head loss for the mixture - rectilineal piping/without unions

h_T = 1.15 x 1.0 x 2.8 = 3.22 m/100 m

Head loss for the mixture - floating piping, with unions

h_F = 1.5 x 3.22 = 4.83 m/100 m

Calculation of maximum reaches:

$$HP = \frac{j \times Q \times M}{75 \times n}$$

Q = A x v

A = 0.785 x 0.4^2 = 0.1256 m^2

v = 3.6 m/s

Q = 0.1256x3.6 = 0.452 m^3/s = 1627.7 m^3/hr

q = 0.15 x 1627.7 = 244.16 m^3/hr

n = 0.60

$$H = \frac{75 \times n \times HP}{j \times Q} = \frac{75 \times 0.60 \times 850}{1.15 \times 1{,}000 \times 0.42} = 73.6 \text{ m } H_2O$$

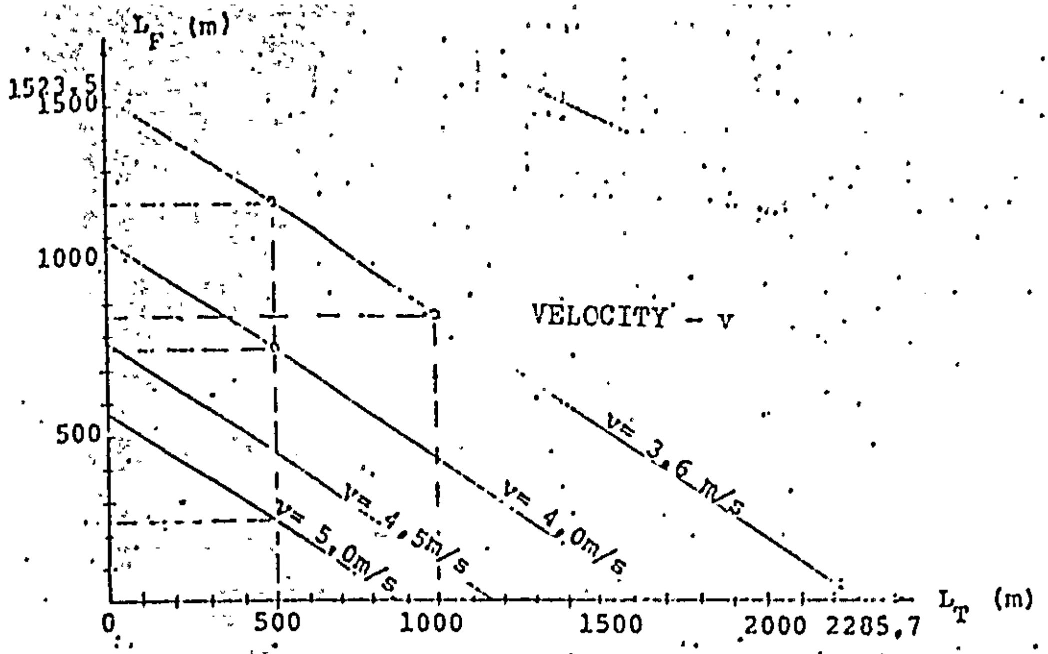
H = 73.6 m H_2O

The maximum length of the rectinlinear piping without unions will be:

$$L_T = H/h_T = \frac{73.6}{3.22} = 100 = 2{,}285.7 \text{ m}$$

The maximum length of the floating piping with unions will be:

$$L_F = H/h_F = \frac{73.6}{4.83} \times 100 = 1{,}523.8 \text{ m}$$



GRAPH - $L_F \times L_T \times v$

Material - sand

Dredge - 16"

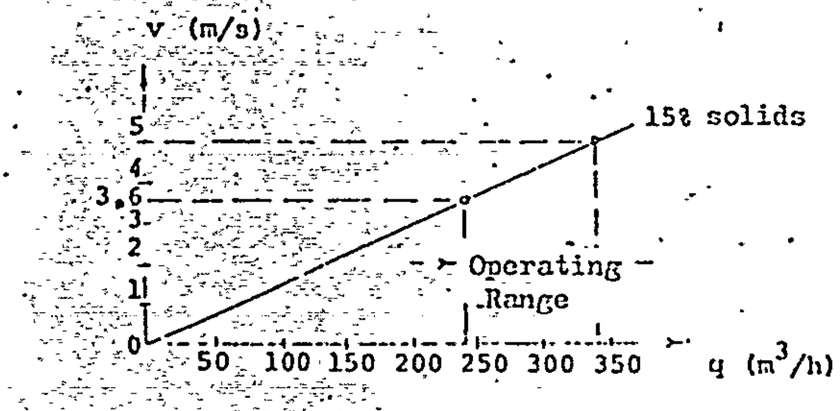
Reach - $L = L_T + L_F$

Determination of maximum production

For sand, the maximum admissable velocity would be 5.0 m/s

Thus: $Q = 0.1265 \times 5 = 0.628\ m^3/s = 2,260.8\ m^3/hr$

$q = 0.15 \times 2,260.8 = 339.12\ m^3/hr$



GRAPH - q x v

Determination of the curve $L_F \times L_T$ for velocities:

v = 4.0 m/s, v = 5.0 m/s and v = 4.5 m/s

For v = 4.0 m/s   h = 3.5m/100 m

$h_T = 1.15 \times 3.5 = 4.03$ m/100 m

$h_F = 1.5 \times 4.03 = 6.04$ m/100 m

$Q = 0.1256 \times 4 = 0.503\ m^3/s$

$$H = \frac{75 \times 0.60 \times 850}{1.15 \times 1{,}000 \times 0.502} = 66.26\ m/H_2O$$

$$L_T = H/h_F = \frac{66.26 \times 100}{4.03} = 1{,}644.2\ m$$

$$L_F = H/h_F = \frac{66.26 \times 100}{6.04} = 1{,}097.0\ m$$

For v = 5.0 m/s   h = 5.4 m/100 m

$h_T = 1.15 \times 5.4 = 6.21$ m/100 m

$h_F = 1.5 \times 6.21 = 9.32$ m/100 m

$$H = \frac{75 \times 0.60 \times 850}{1.15 \times 1{,}000 \times 0.628} = 52.96\ m/100m$$

$$L_T = H/h_T = \frac{52.96 \times 100}{6.21} = 852.8\ m$$

$$L_F = h/h_F = \frac{52.96 \times 100}{9.32} = 568.2\ m$$

For v = 4.5 m/s   h = 4.4m/100 m

D = 16"

$h_T = 1.15 \times 4.4 = 5.06$ m/100 $Q = 0.1256 \times 4.5 = 0.565\ m^3/s = 2{,}034.72\ m^3/hr$

$h_F = 1.50 \times 5.06 = 7.59$ m/100 m $q = 305.2\ m^3/hr$

$$H = \frac{75 \times 0.60 \times 850}{1.15 \times 1,000 \times 0.565} = 58.87 \text{ m } H_2O$$

$$L_T = H/h_T = \frac{58.87 \times 100}{5.06} = 1,163.4 \text{ m}$$

$$L_F = H/h_F = \frac{58.87 \times 100}{7.59} = 775.6 \text{ mm}$$

<u>18" Dredge</u>

We will initially consider the minimum permissable rates for each type of material in view of sedimentation in the dredge pumping piping.

a For sand - v.= 3.7 m/s

b For hard clay and sandstone - vm = 6.3 m/s

c For soft clay - vm = 3.0 m/s

Determination of maximum reach

1 For sand

Head los for D = 18" = 0.45   h = 2.60 m/100 m

v = 3.7 m/s

$h_T = 1.15 \times 2.6 = 2.99$ m/100 m

$h_F = 1.5 \times 2.99 = 4.48$ m/100 m

$A = 0.785 \times 0.45^2 = 0.159\ m^2$

v = 3.7 m/s

$$Q = 0.159 \times 3.7 = 0.588 \ m^3/s = 2{,}117.8 \ m^3/hr$$

$$q = 0.15 \times 2{,}117.8 = 317.6 \ m^3/hr$$

$$H = \frac{75 \times 0.60 \times 1{,}125}{1.15 \times 1{,}000 \times 0.588} = 74.86 \ m \ H_2O$$

$$L_T = H/h_F = \frac{74.86 \times 100}{4.48} = 1{,}670.9 \ m$$

Head loss for D = 18" h = 3.1 m/100 m

v = 4.0 m/s

$$h_T = 1.15 \times 3.1 = 3.57 \ m/100 \ m$$

$$h_F = 1.50 \times 3.57 = 5.35 \ m/100 \ m$$

$$Q = 0.159 \times 4.0 = 0.636 \ m^3/s = 2{,}289.6 \ m^3/hr$$

$$q = 0.15 \times 2{,}289.6 = 343.4 \ m^3/hr$$

$$H = \frac{75 \times 0.60 \times 1{,}125}{1.15 \times 1{,}000 \times 0.636} = 69.21 \ m \ H_2O$$

Head loss for v = 4.5 m/s

D = 18" h = 3.85 m/100 m

$$h_T = 1.15 \times 3.85 = 4.43 \ m/100 \ m$$

$$h_F = 1.50 \times 4.43 = 6.64 \ m/100 \ m$$

$$Q = 0.159 \times 4.5 = 0.716 \ m^3/s = 2{,}575.8 \ m^3/hr$$

$$q = 0.15 \times 2{,}575.8 = 386.37 \ m^3/hr$$

$$H = \frac{75 \times 0.60 \times 1{,}125}{1.15 \times 1{,}000 \times 0.716} = 61.48 \ m$$

$$L_T = H/h_T = \frac{61.48 \times 100}{4.43} = 1{,}387.9 \ m$$

$$L_F = H/h_F = \frac{61.48 \times 100}{6.64} = 925.9 \ mm$$

$$L_T = H/h_T = \frac{69.21 \times 100}{3.57} = 1{,}938.6 \text{ m}$$

$$L_F = F/h_F = \frac{69.21 \times 100}{5.35} = 1{,}293.6 \text{ m}$$

Head loss for $D = 18"$ $h = 4.7$ m/100 m

$v = 5.0$ m/s

$$h_T = 1.15 \times 4.7 = 5.41 \text{ m/100 m}$$

$$h_F = 1.5 \times 5.41 = 8.11 \text{ m/100 m}$$

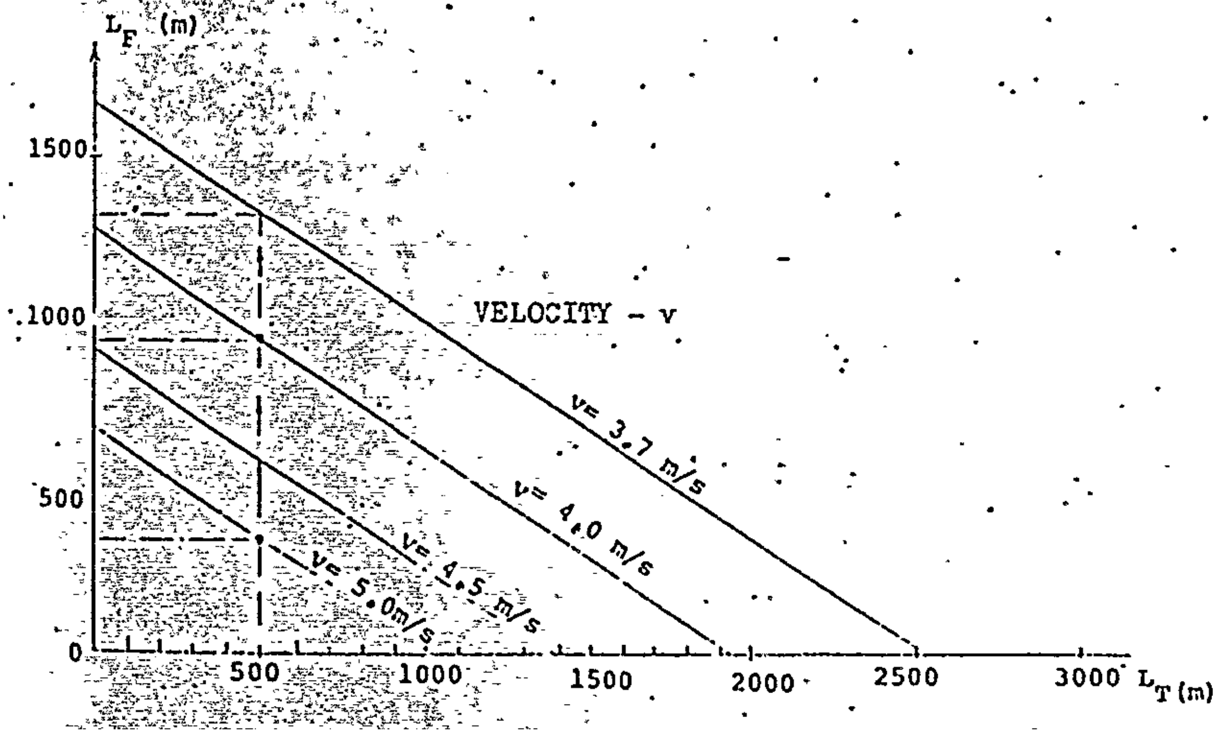
$$Q = 0.159 \times 5 = 0.195 \text{ m}^3/\text{s} = 2{,}862 \text{ m}^3/\text{hr}$$

$$q = 0.15 \times 2{,}862 = 429.3 \text{ m}^3/\text{hr}$$

$$H = \frac{75 \times 0.60 \times 1{,}125}{1.15 \times 1{,}000 \times 0.795} = 55.37 \text{ m } H_2O$$

$$L_T = \frac{55.37 \times 100}{5.41} = 1{,}023.5 \text{ m}$$

$$L_F = \frac{55.37 \times 100}{8.11} = 682.7 \text{ m}$$

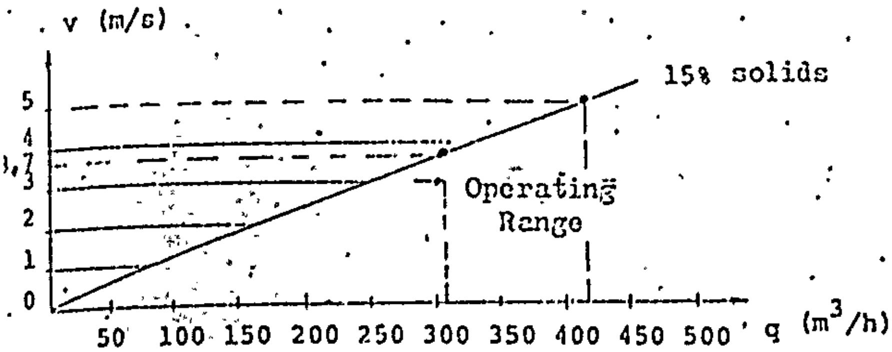


GRAPH - L_T x L_F x v

Material - Sand

Dredge - 18"

Reach - $L = L_T + L_F$



GRAPH - q x v

20" Dredge

We will initially consider the minimum permissable rates for each type of material in view of sedimentation in the dredge pumping piping.

a For sand $v_m = 3.8$ m/s

b For hard clay and sandstone $v_m = 6.5$ m/s

c For soft clay $v_m = 3.0$ m/s

Determination of maximum reach

1 For sand

Head loss for D = 20" h = 2.4 m/100 m

v = 3.8 m/s

$h_T = 1.15 \times 2.4 = 3.76$ m/100 m

$h_F = 1.5 \times 2.76 = 4.14$ m/100 m

$A = 0.785 \times 0.508^2 = 0.202$ m^2

$v = 3.8$ m/s

$Q = 0.002 \times 3.8 = 0.767$ m^3/s = 2,763.36 m^3/hr

$q = 0.15 \times 2{,}763.36 = 414.5$ m^3/hr

$$H = \frac{75 \times 0.60 \times 1{,}700}{1.15 \times 1{,}000 \times 0.767} = 86.73 \text{ m } H_2O$$

$$L_T = H/h_T = \frac{86.73 \times 100}{2.76} = 3{,}142.4 \text{ m}$$

$$L_F = H/h_F = \frac{86.73 \times 100}{4.14} = 2{,}094.9 \text{ m}$$

Head loss for D = 20" $h = 2.7$ m/100 m

$v = 4.0$ m/s

$h_T = 1.15 \times 2.7 = 3.105$ m/100 m

$h_F = 1.5 \times 3.105 = 4.657$ m/100 m

$Q = 0.202 \times 4.0 = 0.808$ m^3/s = 2,908.8 m^3/hr

$q = 0.15 \times 2{,}909.8 = 436.32$ m^3/hr

$$H = \frac{75 \times 0.60 \times 1{,}700}{1.15 \times 1{,}000 \times 0.808} = 82.33 \text{ m } H_2O$$

$$L_T = H/h_T = \frac{82.33 \times 100}{3.105} = 2{,}651.5 \text{ m}$$

$$L_F = H/h_F = \frac{82.33 \times 100}{4.657} = 1{,}767.7 \text{ m}$$

Head loss for D = 20" $h = 4.2$ m/100 m

$v = 5.0$ m/s

$Q = 0.202 \times 5.0 = 1.01$ m^3/s = 3,636 m^3/hr

$q = 0.15 \times 3{,}636 = 545.4$ m^3/hr

$$H = \frac{75 \times 0.60 \times 1{,}700}{1.15 \times 1{,}000 \times 1.01} = 65.86 \text{ m } H_2O$$

$L_T = 1.15 \times 4.2 = 4.83$ m/100 m

$h_F = 1.5 \times 4.83 = 7.25$ m/100 m

$$L_T = H/h_T = \frac{65.86 \times 100}{4.83} = 1,363.5 \text{ m}$$

$$L_F = H/h_F = \frac{65.86 \times 100}{1.25} = 909.0 \text{ m}$$

Head loss for D = 20" h = 3.5 m/100 m

v = 4.0 m/s

$h_T = 1.15 \times 3.35 = 3.85$ m/100 m

$h_F = 1.50 \times 3.85 = 5.78$ m/100 m

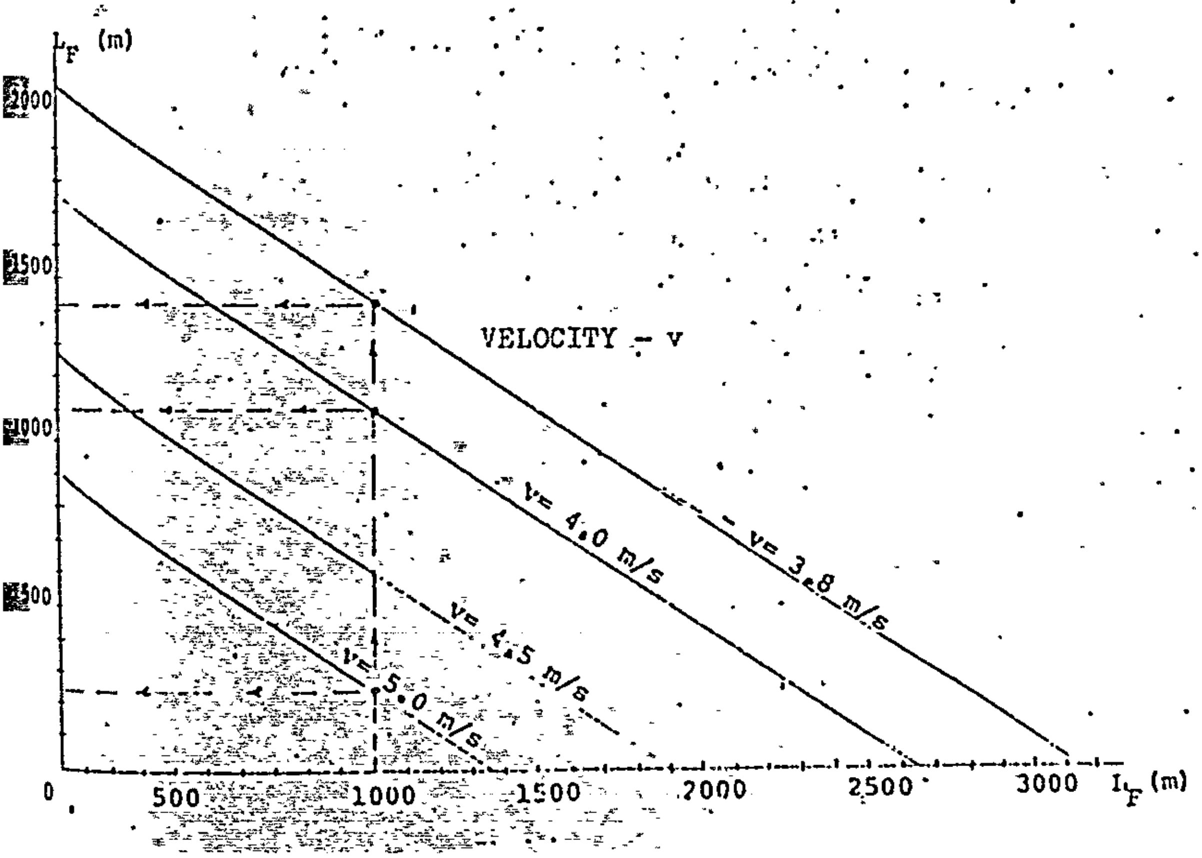
$Q = 0.202 \times 4.5 = 0.909 \text{ m}^3/\text{s} = 3,272 \text{ m}^3/\text{hr}$

$q = 0.15 \times 3,272 = 490.86 \text{ m}^3/\text{hr}$

$$H = \frac{75 \times 0.60 \times 1,700}{1.15 \times 1,000 \times 0.909} = 73.18 \text{ m } H_2O$$

$$L_T = H/h_T = \frac{73.18 \times 100}{3.85} = 1,900.7 \text{ m}$$

$$L_F = H/h_F = \frac{73.18 \times 100}{5.78} = 1,266.0 \text{ m}$$

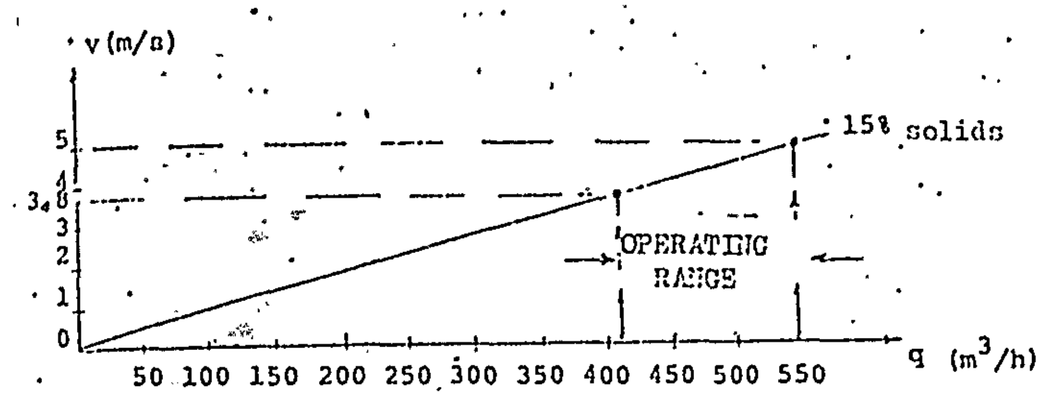


GRAPH - $L_T \times L_F \times v$

Material - Sand

Dredge - 20"

Reach - $L = L_T + L_F$



GRAPH - q x v

Dredge 20"

- Sand

24" Dredge

We will initially consider the minimum permissable rates for each type of material in view of sedimentation in the dredge pumping piping.

a	For sand	$v_m = 3.9$ m/s
b	For hard clay and sandstone	$v_m = 6.65$ m/s
c	For soft clay	$v_m = 3.0$ m/s

Determination of maximum reach.

1 For sand

Head loss for: $D = 24" = 0.61$ $h = 2.0$ m/100 m

$v = 3.9$ m/s

$h_T = 1.15 \times 2.0 = 2.3$ m/100 m

$h_F = 1.5 \times 2.3 = 3.45$ m/100 m

$A = 0.785 \times 0.61^2 = 0.292\ m^2$

$v = 3.9$ m/s

$Q = 0.292 \times 3.9 = 1.139\ m^3/s = 4,101\ m^3/hr$

$q = 0.15 \times 4,101 = 615.159\ m^3/hr$

$$H = \frac{75 \times 0.60 \times 2,250}{1.15 \times 1,000 \times 1,139} = 77.30 \text{ m } H_2O$$

$$L_T = H/h_T = \frac{77.30 \times 100}{2.3} = 3,360.8 \text{ m}$$

$$L_F = H/h_F = \frac{77.30 \times 100}{3.45} = 2,240.5 \text{ m}$$

Head loss for: $D = 24"$ $h = 2.15$ m/100 m

$v = 4.0$ m/s

$h_T = 1.15 \times 2.15 = 2.47$ m/100 m

$h_F = 1.5 \times 2.47 = 3.70$ m/100 m

$Q = 0.292 \times 4.0 = 1.168\ m^3/s = 4,204.8\ m^3/hr$

$q = 0.15 \times 4,204.8 = 630\ m^3/hr$

$$H = \frac{75 \times 0.60 \times 2,250}{1.15 \times 1,000 \times 1,168} = 75.38 \text{ m } H_2O$$

Head loss for: $v = 4.5$ m/s

$D = 24"$ $h = 2.7$ m/100 m

$h_T = 1.15 \times 2.7 = 3.105$ m/100 m

$h_F = 1.5 \times 3.105 = 4.66$ m/100 m

$Q = 0.292 \times 4.5 = 1.314\ m^3/s = 4,730.4\ m^3/hr$

$q = 0.15 \times 4,730.4 = 709.56\ m^3/hr$

$$H = \frac{75 \times 0.6 \times 2,250}{1.15 \times 1,000 \times 1,314} = 67.00 \text{ m } H_2O$$

$$L_T = H/h_T = \frac{67.00 \times 100}{4.66} = 1,438.5 \text{ m}$$

$$L_T = H/h_T = \frac{75.38 \times 100}{2.47} = 3,051.8 \text{ m}$$

$$L_F = H/h_F = \frac{75.38 \times 100}{3.70} = 2,037.3 \text{ m}$$

$$H = \frac{75 \times 0.60 \times 2,250}{1.15 \times 1,000 \times 1.46} = 60.30 \text{ m } H_2O$$

Head loss for: D = 24"   h = 3.3 m/100 m

v = 5.0 m/s

$L_T = 1.15 \times 3.3 = 3.795$ m/100 m

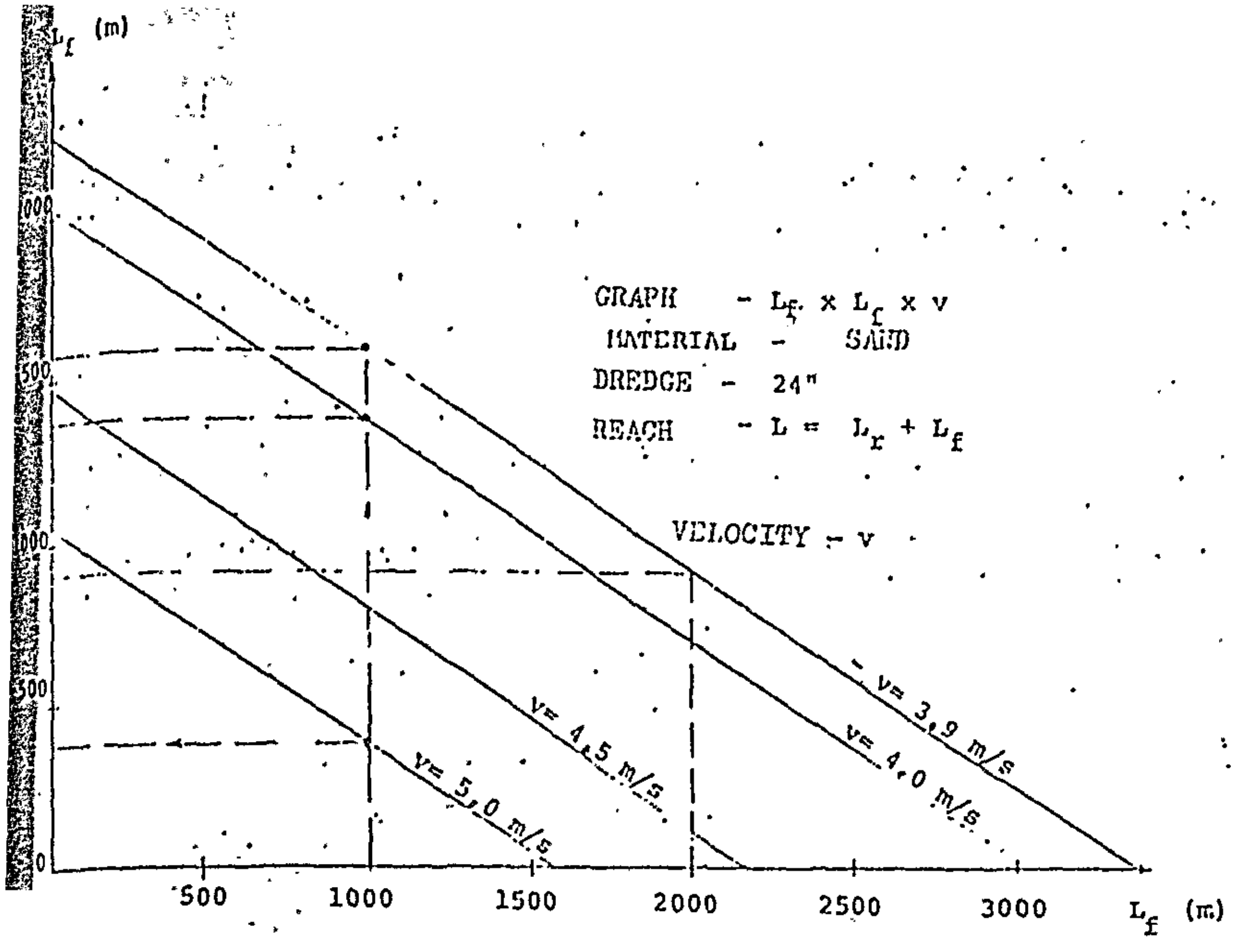
$h_F = 1.5 \times 3.795 = 5.692$ m/100 m

$Q = 0.292 \times 5.0 = 1.46\ m^3/s = 5,256\ m^3/hr$

$q = 0.15 \times 5,256 = 788.4\ m^3/hr$

$$L_T = H/h_T = \frac{60.30 \times 100}{3,795} = 1,589.0 \text{ m}$$

$$L_F = H/h_F = \frac{60.30 \times 100}{5,692} = 1,059.4 \text{ m}$$



GRAPH - $L_T \times L_F \times v$

Material - Sand

Dredge - 24"

Reach - $L = L_T + L_F$

26" Dredge

We will initially consider the minimum permissable rates for each type of material in view of sedimentation in the dredge pumping piping.

a For sand - 4.0 m/s

b For hard clay and sandstone - 6.8 m/s

c For soft clay - 3.0 m/s

Determination of maximum reach

1 For sand

Head loss for: $D = 26" = 0.66$ m $h = 1.95$ m/100 m

$v = 4.0$ m/s

$A = 0.785 \times 0.66^2 = 0.342\ m^2$

$v = 4.0$ m/s

$Q = 0.342 \times 4.0 = 1.368\ m^3/s = 4{,}924\ m^3/hr$

$q = 0.15 \times 4{,}924 = 738.6\ m^3/hr$

$$H = \frac{75 \times 0.60 \times 3{,}400}{1.15 \times 1{,}000 \times 1{,}368} = 97.25 \text{ m } H_2O$$

$h_T = 1.15 \times 1.95 = 2.24$ m/100 m

$h_F = 1.50 \times 2.24 = 3.36$ m/100 m

$$L_T = H/h_T = \frac{97.25 \times 100}{2.24} = 4{,}341.5 \text{ m}$$

$$L_F = H/h_F = \frac{97.25 \times 100}{3.36} = 2{,}894.3 \text{ m}$$

Head loss for: $D = 26"$ $h = 3.00$

$v = 5.0$ m/s

$h_T = 1.15 \times 3.00 = 3.45$ m/100 m

$h_F = 1.50 \times 3.45 = 5.17$ m/100 m

$Q = 0.342 \times 5 = 1.71\ m^3/s = 6{,}156\ m^3/hr$

$q = 0.15 \times 6{,}156 = 023.4\ m^3/hr$

$$H = \frac{75 \times 0.60 \times 3{,}400}{1.15 \times 1{,}000 \times 1.71} = 77.80 \text{ m } H_2O$$

$$L_T = H/h_T = \frac{77.80 \times 100}{3.45} = 2{,}255.0 \text{ m}$$

$$L_F = H/h_F = \frac{77.80 \times 100}{5.17} = 1{,}504.8 \text{ m}$$

For D = 26" $\quad h = 2.4$ m/100 m

$v = 4.5$ m/s

$h_T = 1.15 \times 2.40 = 2.76$ m/100 m

$h_F = 1.5 \times 2.76 = 4.14$ m/100 m

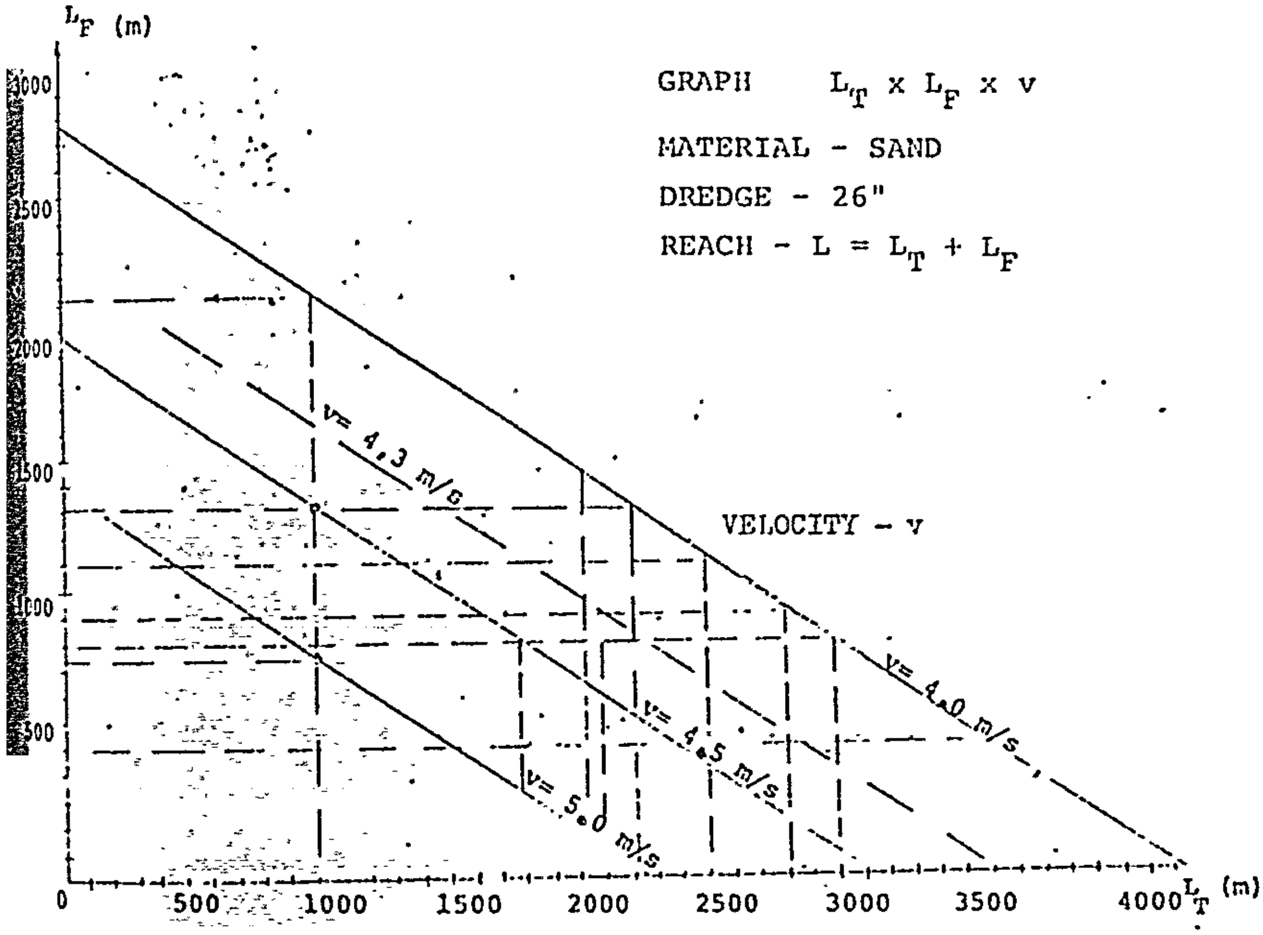
$Q = 0.342 \times 4.5 = 1.539\ m^3/s = 5,540\ m^3/hr$

$q = 0.15 \times 5,540.4 = 831.0\ m^3/hr$

$$H = \frac{75 \times 0.60 \times 3,400}{1.15 \times 1,000 \times 1.539} = 86.45 \text{ in } H_2O$$

$$L_T = h/h_T = \frac{86.45 \times 100}{2.76} = 3,132.2 \text{ m}$$

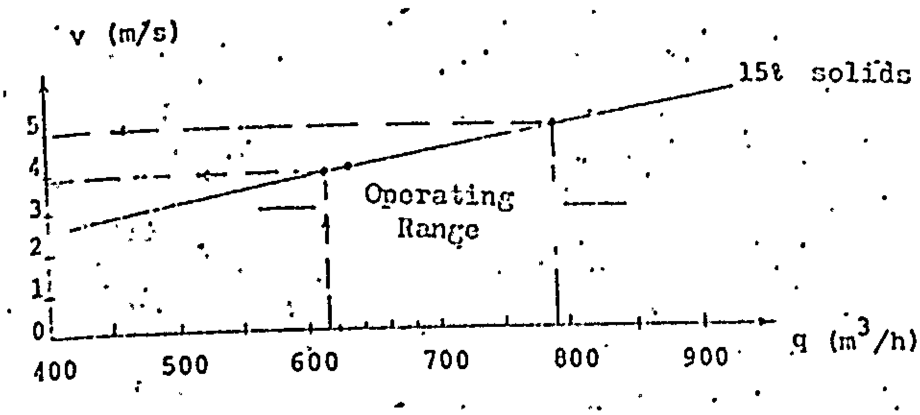
$$L_F = H/h_F = \frac{86.45 \times 100}{4.14} = 2,088.2 \text{ m}$$



GRAPH - q x v

Dredge - 24"

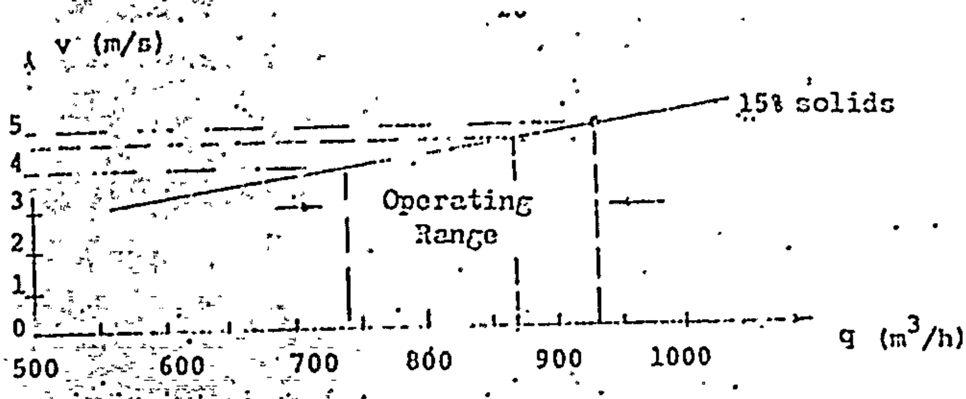
Sand



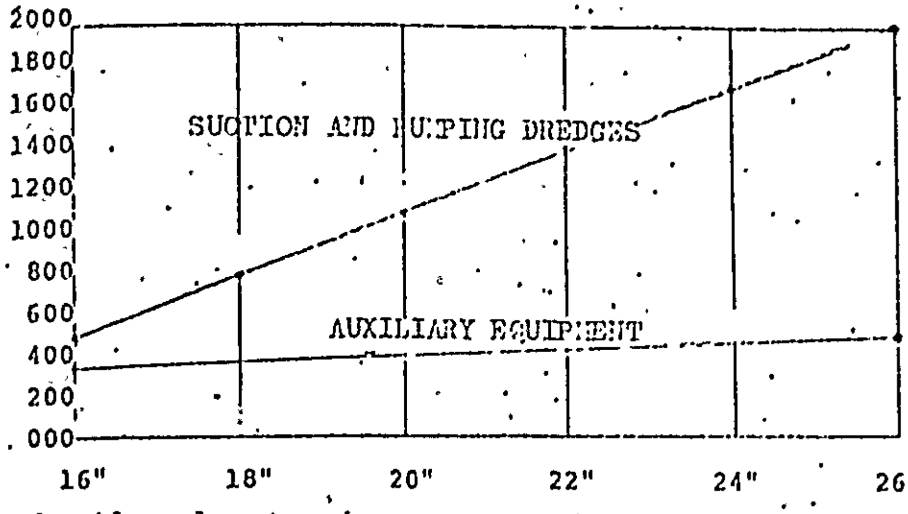
GRAPH - q x v

Dredge - 26"

Sand



GRAPHICAL DISPLAY OF THE VALUES OF SUCTION AND PUMPING DREDGES AND AUXILIARY EQUIPMENT



1 oil and water barge	US$ 120,000.00	70,000.00
1 Flush deck barge	80,000.00	50,000.00
1 Tugboat - head	200,000.00	160,000.00
1 Service launch	100,000.00	70,000.00
	US$ 500,000.00	350,000.00

C Determination of the value of floating and onshore piping for the average dredge types

Floating pipe: 16"

1 pipe - length -	50'	x US$ 11.12/ft	=	556.00
1 ball joint	1	x US$ 1,663.10	=	1,663.00
2 floating pontoon	2	x US$ 722.00	=	1,444.00
anchor and winches	2/10	x US$ 2,500.00	=	500.00
				US$4,163.00/15 m

Price per meter - US$ 4,163.00/15m = 277.00 US$/m = Cr$ 2,022/m

Floating pipe: 20"

1 pipe - length -	50'	x 12.30 US$/ft	=	615.00
1 ball joint	1	x US$ 2,142.00	=	2,142.00
2 floating pontoons	2	x US$ 1,029.00	=	2,058.00
anchor and winches	2/10	x US$ 3,000.00	=	600.00
				US$ 5,405.00/15 m

Price per meter - US$ 5,405.00/15m = 360 US$/m = Cr$ 2,628/m

Floating pipe: 26"

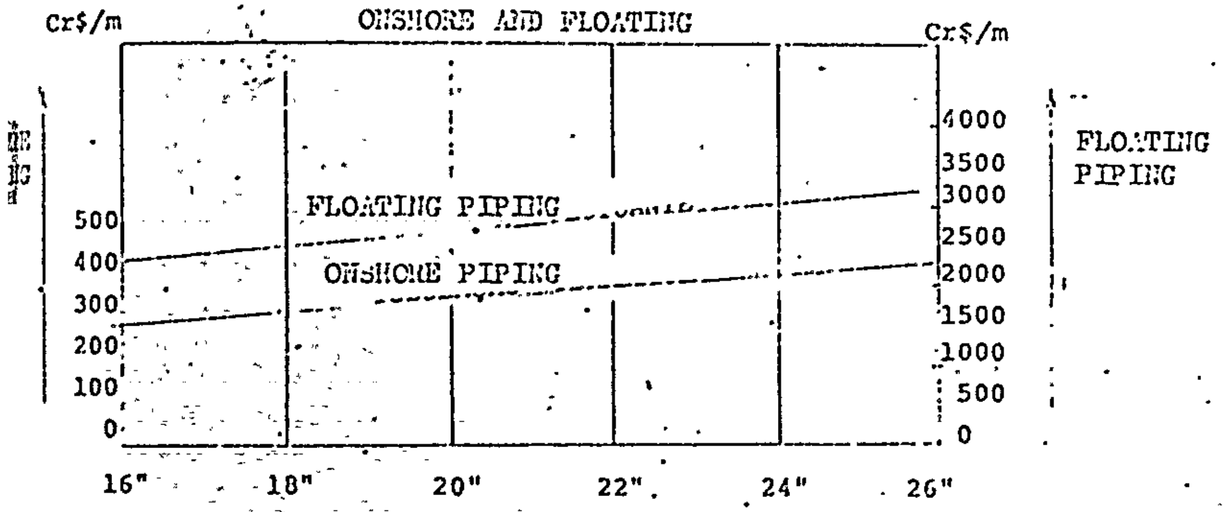
1 pipe	50' x US$ 17.2/ft	=	860.00
1 ball joint	1 x US$ 2,982.00	=	2,982.00
2 floating pontoons	2 x US$ 1,029.00	=	2,058.00
anchor and winches	2/10 x US$ 3,500.00	=	700.00
			US$ 6,590.00

Price per meter - US$ 6,590.00/15m = 439 US$/m = CR$ 3,204.7/m

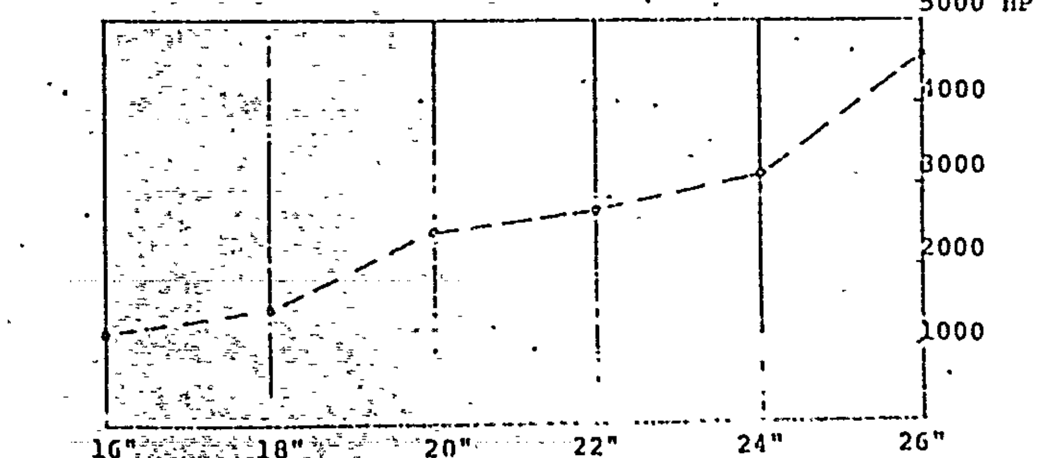
Onshore piping:

16" - 3.28 x 12.43 = US$ 40.77/m = Cr$ 297.62/m
20" - 3.28 x 15.39 = US$ 50.48/m = Cr$ 368.50/m
26" - 3.28 x 18.79 = US$ 61.64/m = Cr$ 416.60/m

GRAPHICAL DISPLAY OF PIPING UNIT PRICES



GRAPH OF TOTAL HP



D Composition of Suction and Pumping Dredges' Operating Cost

We are going to determine the operating cost of the dredges and their outfit of auxiliary equipment.

1 Dredge

2 Auxiliary equipment

3 Floating and onshore piping

1 Dredge Cost

Work schedule:

Available hours - 24 hrs/day x 6 days/week x 4.3 weeks/month = 619.2 hours/month

Assuming a coefficient of operational efficiency equal to 65% we have:

Hours of operation - 0.65 x 619.2 = 402.5 hrs/month

Crew :

Job	No.	Salary	Total
Dredge operator	4	2,000.00	8,000.00
Engineer	4	2,000.00	8,000.00
Coal bunkers	6	1,000.00	6,000.00
Deck hands	6	1,000.00	6,000.00
Foremen	2	2,000.00	4,000.00
	22		Cr$32,000.00

The average salary will be 32,000 ÷ 22 = 1,454.50

Overtime - 120 hrs/month for each crew

Average straight time hourly rate = 1,454.5 ÷ 200 = 7.27 Cr$/hr

Average overtime hourly rate = 1.5 x 7.27 = 10.90 Cr$/hr

Calculation of operating cost

16" Dredge - Value = US$ 500,000.00 = Cr$ 3,650,000.00

1	Personnel	
Salaries - 22 x 1,454.5 = 32,000.00		
Overtime		
22 x 120 x 10.90 = 28,780.00		60,780.00
2	Social Benefits	
0.65 x 60,780.00		39,510.00
3	Food	20,000.00
4	Fuel	
0.90 x 0.185 l/HP.h x Cr$1.00/l x 402.5 hrs/month x 1,185 HP x 67.01 x 1,185		79,415.00
5	Lubricants - 10% of fuel	7.940.00
6	Costs of capital	
	0.43/12 x 3,650,000.00	130,790.00
		Cr$ 338,435.00

18" Dredge - Value = US$ 800,000.00 = Cr$ 5,840,000.00

1	Personnel	60,780.00	
2	Social Benefits	39,510.00	
3 .	Food	20,000.00	120,290.00
4	Fuel 67.01 x 1,460.00		97,820.00
5	Lubricants		9.782.00
6	Capital costs 0.43/12 x 5,840,000.00		209,266.00
			Cr$437,156.00

20" Dredge - Value - US$ 1,100,000.00 x Cr$ 8,030,000.00

1	Personnel	
2	Social Benefits	120,290.00
3	Food	
4	Fuel 67.01 x 2,370	158,790.00
5	Lubricants	15,874.00
6	Capital costs 0.43/12 x 8,030.00	287,740.00
		Cr$582,699.00

22" Dredge - Value - US$ 1,400,000.00 =		Cr$ 10,220,000.00
1	Personnel	
2	Social Benefits	120,290.00
3	Food	
4	Fuel 67.01 x 2,620	175,540.00
5	Lubricants	17,550.00
6	Capital costs 0.43/12 x 10,220,000.00	336,220.00
		Cr$ 679,600.00

24" Dredge - Value - US$ 1,700,000.00 =		Cr$ 12,410,000.00
1	Personnel	
2	Social Benefits	120,290.00
3	Food	
4	Fuel 67.01 x 3,100	207,700.00
5	Lubricants	20,770.00
6	Capital costs 0.43/12 x 12,410,000.00	444,690.00
		Cr$ 793,450.00

The monthly cost will be:

26" Dredge	980,000.00
Aux. equipment	215,000.00
1,000 m floating pipe	1,490,000.00
2,000 m onshore piping	76,000.00
	Cr$1,420,000.00

The cost per cubic meter will be: $\frac{1.2 \times 1,420,000.00}{340,000} = 5.1$ Cr\$/m^3

The total cost of the work will be:

2,310,600 x 5.1 = Cr$ 11,784,060.00

The time period for performing the work will be:

2,310,600 ÷ 340,000 = 6.8 months

E Filling area T2

The volume to be filled is 1,368,300 m^3.

Using 3,300 m of onshore piping between points I and II and 500 m of floating pipe, the total transport distance will be 3,800 m. The rate of 4.5 m/s dredged reached 2,300 m.

We will have to use a 2,250 HP booster, whose reach would be:

3,100 m - 3,400

x 2,250

$x = \frac{2,250}{3,400} \times 3,100 = 2,051$ m

If we increase the rate to 4.7 m/s, the dredge reaches 2,000 m, and the booster will reach

2,600 - 3,400

x 2,250

$$x \quad \frac{2,250 \times 2,600}{3,400} = 1,720 \text{ m, which is compatible}$$

The cost will be:

26" dredge	980,000.00
Aux. equipment	215,000.00
500 m floating pipe	75,000.00
3,300 m onshore piping	126,000.00
1 26" booster	330,000.00
Cr$	1,726,000.00

Production will be: 400 x 870 = 348,000 m^3/month

The price per cubic meter $= \frac{1.2 \times 1,726,000.00}{348,000} = 5.95$ Cr\$/m^3

The total cost will be: 1,368,300 x 5.95 = Cr$ 8,141,385.00

The time period for performing the work will be: 1,368,300 ÷ 348,000 = 3.93 months

F Filling area T5

The volume of fill for this area is 11,243,060 m, of which 4,775,000 will be from the area close to the fore harbor, with a pumping distance of 5,000 m on shore and 700 m floating.

The dredge, at a rate of 4.3 m/s, will reach up to 2,500 m. A booster will be necessary to reach the additional 2,500 m onshore.

The power will be: 3,400 - 3,600 m

x 2,500

$$x \quad \frac{3,400 \times 2,500}{3,600} = 2,360 \text{ HP}$$

We conclude that the 2,250 booster will be sufficient if a rate of 4.2 m/s is used.

The monthly cost will be:

26" Dredge		980,000.00
Aux. equipment		215,000.00
700 m floating pipe		105,000.00
5,000 m onshore piping		190,000.00
1 26". booster		330,000.00
	Cr$	1,820,000.00

Production will be: 400 x 800 m^3/hr = 320,000

The cost per cubic meter will be = $\frac{1.2 \times 1,820,000.00}{320,000}$ =

6.82 Cr$/$m^3$

The cost of this portion will be: 4,775,000 x 6.82 = Cr$ 32,565,000.

The time period for performing the work will be -

4,775,000 ÷ 320,000 = 14.92 months

The remaining 6,468,060 m^3 will be taken from the same area.

Using 700 m of floating pipe, the distance to be covered with onshore piping will be 6,300 m.

At a rate of 4.7 m/s, the dredge will reach 1,700m onshore, making necessary 3 2,250 HP boosters to reach 4,600 m.

The required power will be: 6,015 HP

The monthly cost will be:

26" Dredge	980,000.00
Auxiliary equipment	215,000.00
700 m floating pipe	105,000.00
6,300 m onshore piping	240,000.00
2 26" boosters	990,000.00
Cr	2,530,000.00

Production will be 400 x 870 = 348,000 m^3/month

The price per cubic meter will be: $\frac{1.2 \times 2,530,000}{348,000} = 8.72$ Cr$/$m^3$

The cost of this portion will be:

6,468,060 x 8.72 = Cr$ 56,401,483.00

The time period for performing the work will be:

6,468,060 ÷ 348,000 = 18.58 months

G Filling areas T3" and T4"

The volume to be filled is 4,950,040 m^3 amd 1,428,930 m^3. With 500 m of floating pipe, entering by point IV, the transport distance will be:

3,800 m

At a rate of 4.5 m/s, the dredge reaches 2,300 m. For the remaining 1,500 m, a booster will be necessary.

Based on previous experience, we can therefore increase the rate to 4.7 m/s.

The dredge will therefore reach 2,000 m and the remaining 1,800 m will be impelled by the booster. Power = 2,353 HP, which is satisfactory.

We will use a rate of 4.6 m/s.

The cost will be:

26" Dredge	980,000.00
Auxiliary equipment	215,000.00
500 m floating pipe	75,000.00
3,800 m onshore piping	145,000.00
1 booster	330,000.00
	Cr$ 1,745,000.00

Production will be 400 x 860 = 344,000 m^3/month

The price per cubic meter will be = $\frac{1.2 \times 1,745,000.00}{344,000.00}$ = 6.08 Cr$/m

The total cost will be:

6,382,970 x 6.08 = Cr$ 38,808,457.00

The time period for performing the work will be = 6,382,970 ÷ 344,000 = 18.55 months

H - Filling areas T8 and T9

Using 1,500 m of floating pipe and entering at area T10 by point III, the transport distance will be 6,800 m, of which 5,300 m will be by onshore piping.

The dredge will reach 850m onshore, and the remaining 4,450 m will be impelled by booster at a rate of 4.5m/s.

Power will be: 4,803 HP.

We can consider the rate of 4.5 m/s as valid for all the work since only a small volume will be pumped at the maximum distance above.

Therefore, 2 2,250 HP boosters will be sufficient.

The monthly cost will be:

26" Dredge	980,000.00
Auxiliary equipment	215,000.00
1,500 m floating pipe	224,000.00
5,300 m onshore piping	202,000.00
2 26" boosters	660,000.00
	Cr$ 2,281,000.00

Monthly production will be 400 x 830 m^3/hr = 332,000 m^3/month

The cost per cubic meter will be $= \frac{1.2 \times 2,281,000.00}{332,000} =$ 8.24 Cr$/$m^3$

The total cost will be:

5,421,375 m^3 c 8.24 = Cr$ 44,672,130.00

Time period for performing the work = 5,421,375 ÷ 332,000 = 16.33

4.3.8 DREDGING CLAY AND SANDSTONE

A Dredging Clay

We are going to consider four basic situations:

1 . Dredging the rectification of the Massangana River and disposing material over the reef, at a maximum floating distance of 2,500 m.

2 Dredging the strip parallel to the reef, disposing at 1,000 m.

3 Dredging the T_1 spill area (north) with a 1,000 m disposal distance up to the reef.

4 Dredging the area boundering on areas T_1 (south) and T_0, outside of a radius of 1,000 m, with center at 0, whose maximum pumping distance will be 2,500 m.

In these cases, only floating piping will be used, and as a consequence of the distances, all the clay could be dredged with a dredge only, without requiring a booster, since with a rate of 4.0 m/s a distance of 2,900 m could be reached.

The costs will be:

For the 1st case we would have:

Cost will be calculated based on production for a distance of 1,700 m, from the area's center of gravity to the disposal point (this will be an average cost), using 2,500 m of piping.

The volume to be dredged will be: 2,217,519 m^3 of clay.

Production will be:

400 x 850 m^3/hr = 340,000 m^3/month, at 4.7 m/s and 15% solids

The cost will be:	26" Dredge	980,000.00
	Aux. equipment	215,000.00
	2,500 m floating pipe	373,000.00
	Cr$	1,568,000.00

Cost per cubic meter: $\frac{1.2 \times 1{,}568{,}000.00}{340{,}000} = 4.54$ Cr$/m^3$

Total cost: 2,217,519 x 5.54 = Cr$12,285,055.00

Time period for performing the work: 2,217,519 ÷ 340,000 = 6.52 months

For the second case we will have:

In this case, the rate could be approximately 5.5 m/s and

production will be: $400 \times 1{,}300\ m^3 \times \frac{0.20}{0.15} = 693{,}334\ m^3$/month

Correcting for 20% solids, the cost will be:

26" Dredge	980,000.00
Aux. equipment	215,000.00
1,000 m floating pipe	149,000.00
	Cr$ 1,344,000.00

Cost per cubic meter: $\frac{1.2 \times 1{,}344{,}000.00}{693{,}334} = 2.33$ Cr$/m^3

Volume to be dredged: 1,557,149 m^3

Total cost: 1,557,149 x 2.33 = Cr$ 3,628,157.00

The time period for performing the work will be:

1,557,149 ÷ 693,334 = 2.24 months

For the third case we will have:

The volume will be: 135,000 m^3

There is no sense in estimating only cost for this case.

We assume a 10% higher cost, or 2.56 Cr$/m^3.

Production would be 0.9 x 693,334 = 625,000 m^3/month.

Total cost: 135,000 x 2.56 = Cr$ 346,000.00

Time period for performing the work: 135,000 ÷ 625,000 = 0.22 month

For the fourth case we will have:

We will calculate the cost based on 2,500 m of floating pipe.

The production will be 400 x 830 x $\frac{0.2}{0.15}$ = 442,667 m^3/month

The cost will be:	26" Dredge	980,000.00
	Aux. equipment	215,000.00
	2,500 m floating pipe	373,000.00
		Cr$ 1,568,000.00

The cost per cubic meter will be:

$$\frac{1.2 \times 1,568,000.00}{442,667} = 4.25 \text{ Cr\$/m}^3$$

The volume to be dredged will be: 8,124.520 m^3

Total Cost: 8,124,520 x 4.25 = Cr$ 34,530,485.00

Time period for performing the work: 8,124,520 ÷ 442,667 = 18.35 months

B Dredging Sandstone

Dredging of sandstone can be performed using only a dredge and floating pipe, with disposal over the reefs.

For calculation purposes, the volume of sandstone can be considered as the material that the dredge can produce, at 10% of its production rate for sand.

sandstone exists between sections SD-9 and SD-11 and between sections SD-20 and SD-25.

Therefore the costs would be:

For the sandstone in the area between SD-9 and SD-11, the cost will be:

cost per cubic meter: $\frac{4.25}{0.10}$ = Cr$ 42.5/m^3

Volume to be dredged: 73,800 m^3

Total cost: 73,800 x 42.5 = Cr$ 3,136,500.00

The time period for performing the work will be:

73,800 ÷ 44,266 - 1.67 months

For dredging sandstone in the SD-20 and SD-25 areas the cost will be: $\frac{5.54}{0.10}$ = Cr$ 55.4/m^3

The volume to be dredged will be: 255,900 m^3

The total cost will be: 225,900 x 55.4 = Cr$ 14,176,860.00

The time period for performing the work will be: 255,900 ÷ 34,000 = 7.52 months

4.3.9 Dredging the Approach Channel

We will analyze the operating cycle of the hopper dredge that will operate in this area, dredging the channel and depositing the material along the reef. As we are interested in using the maximum amount of sand possible in constructing the beach, meaning an economic use of sand, and since the dredge will reach material to a maximum depth of 16.0 meters, we believe that a 2,000 m^3 dredge, one of the most common on the market, would be the most practical.

Assuming a mean transport distance on the order of 2.5 miles and a mean velocity of 10 knots, since the dredge will not have time to attain maximum speed, we will have:

Filling time	1.0 hours
Traveling time	
$\frac{2 \times 2.5}{10}$	0.5 hours
Unloading time	0.3 hours
Total time	1.8 hours

The cycle will therefore be 1.8 hours.

Assuming transport of 0.9 x 2,000 = 1,800 m^3 per cycle, the dredge will produce 1,800 m^3 ÷ 1.8 hours = 1,000 m^3/hr.

Working 500 hours per month, the production will be:

550 x 1,000 = 550,000 m^3/month

The cost per cubic meter will be:

$$\text{Cr\$ } \frac{1,718,880.00}{550,000} = 3.12 \text{ Cr\$/m}^3$$

Time period for performing the work: $\frac{7,685,978.00}{550,000}$ = 13.97 months

4.3.10 HYDRAULIC FILL OF THE BEACH

The beach will require 7,316,662 m^3 of sand. This volume will be provided in the following manner:

VOLUME M^3	ORIGIN	DREDGE
252,720	Provisional beach	Self-carrying
4,169,963	Approach Channel	Self-carrying
318,780	Provisional beach	Suction and Pumping
2,575,199	Internal area	Suction and Pumping
7,316,662	Total	-

The cost of the volume taken from the approach channel by self-carrying dredge has already been computed in the cost of dredging the approach channel.

a) fill with volume dredged from the provisional beach by a 200 m^3 hopper self-carrying dredge.

Monthly production: 550,000 m^3/month

Cost per m^3: $= \frac{1.2 \times 1{,}718{,}880}{550{,}000} =$ Cr\$ 3.75/m^3

Time period: $\frac{252{,}720}{550{,}000} = 0.45$ months

Total Cost: 3.75 x 252,720 = 947,700

b) fill with volume dredged from the provisional beach by a suction and pumping dredge.

This volume will be dredged two times: first, from the internal maritime area for the provisional beach in front of the port's entrance mouth, and then from this beach to the reef protection beach.

For the first dredging, 1,000 m of floating piping may be assumed.

The cost will be:

26" Dredge	-	980,000.00
Aux. equipment	-	215,000.00
1,000 m floating piping	-	149,000.00
		1,344,000.00

Assuming v = 4.7 m/s and 15% solids, production will be:

$400 \times 850 \ m^3/s = 340,000 \ m^3/month$

The cost per cubic meter will be:

$$C_1 = \frac{1.2 \times 1,344,000}{340,000} = Cr\$ \ 4.74/m^3$$

The time period will be: $\frac{318,780}{340,000} = 0.93$ months

For the second dredging, 200 m of floating piping and 2,000 m of onshore piping may be assumed.

Letting v = 4.7 m/s and 15% solids, production will be:

$400 \times 850 \ m^3/s = 340,000 \ m^3/month$

The cost will be:

26" Dredge	-	980,000.00
Aux. equipment		215,000.00
2,000 m onshore piping		76,000.00
200 m floating piping		29,800.00
		1,300,800.00

Cost per cubic meter

$$C_2 = \frac{1.2 \times 1,300,800}{340,000} = \text{Cr\$ } 4.59 \text{ m}^3$$

The time period will be: $\frac{318,780}{340,000} = 0.93$ months

Total cost: $C = C_1 + C_2 = \text{Cr\$ } 9.33/m^3$

Time period: 0.93 x 2 = 1.86 months

Total cost: Cr\$ 9.33 x 318,780 m^3 = Cr\$2,974,217.00

c) fill with sand dredged by suction and pumping dredges from the internal area.

Assuming 800 m of floating piping and 1,500 m of onshore piping.

Letting v = 4.7 m/s and 15% of solids

400 x 850 m^3/s = 340,000 m^3/month

The cost will be:

26" Dredge	-	980,000.00
Aux. equipment	-	215,000.00
800 m floating piping	-	119,200.00
1,500 m onshore piping	-	57,000.00
		1,371,200.00

Cost per cubic meter:

$$\frac{1.2 \times 1,371,200}{340,000} = \text{Cr\$ } 4.83/m^3$$

Total cost:

$$4.83 \times 2,575,199 = \text{Cr\$ } 12,438,211.00$$

Time period: $\frac{2,575,199}{340,000} = 7.57$ months

4.4 BUDGET ESTIMATE FOR THE 1st STAGE

4.4.1 TOTAL COST OF DREDGING WORK

The following tables result from the preceeding analysis and calculations.

Total cost of the work	-	Cr$ 462,234,076.00
Total volume dredged	-	77,760,470 m^3
Mean unit cost	-	Cr$ 5.94/m^3
Time period for performing the work	-	30 months
Number of dredges used	-	7

4.4.2 DREDGING WORK EXECUTION TIME

a) For suction and pumping dredges

TYPE OF WORK	Execution Time (Months)	
	1st Phase	2nd Phase
Filling the beach	9.43	-
Landfills	138.02	24.36
Dredging clay and sandstone	31.04	5.48
Total	178.49	29.84
Time period	30	72
Number of dredges	6	1

b) For self-carrying dredges

TYPE OF WORK	Execution Time (Months)	
	1st Phase	2nd Phase
Dredging the approach channel	13.97	
Total	13.97	
Time period	30	
Number of dredges	1	

4.4.3 COST OF LANDFILLS

(Computation of the cost of dredging sand from the internal area)

FILL AREA	AVERAGE COST ($Cr\$/m^3$)	VOLUME	COST	EXECUTION TIME (MONTHS)
To	5.10	2,310,600	11,784,060.00	6.80
T1-N a)	5.46	1,900,000	10,374,000.00	5.94
T1-N b)	6.14	1,875,170	11,514,000.00	6.42
T1-O a)	5.12	600,000	3,072,000.00	1.88
T1-O b)	5.67	685,660	3,888,000.00	2.35
T1-S	5.57	4,178,790	23,268,000.00	12.29
T2	5.95	1,368,300	8.141,385.00	3.93
T'3 & T3''	7.88	6,294,055	49,597,153.00	18.96
T'4	5.10	7,230,520	36,876,000.00	21.30
T"3 & T"4	6.08	6,382,970	38,808,457.00	18.53
T5 a)	6.82	4,775,000	32,565,000.00	14.92
T5 b)	8.72	6,468,000.	56,401,483.00	18.58
T8 & T9	8.24	5,421,375	44,672,130.00	16.33
T10	4.50	5,073,105	22,828,972.00	14.13
Total		54,563,605	353,790,640.00	162.38

Average unit cost . - $\frac{353,790,640}{54,563,605}$ = Cr\$ 6.48/m^3

4.4.4 COST OF WASTE MATERIALS

(Here the costs of dredging, from the internal channels and turning basins, clay and sandstone that cannot be used for fill are computed.)

AREA	UNIT COST (Cr$/m^3)	VOLUME	COST Cr$	EXECUTION TIME (MONTHS)
Clay a)	5.54	2,217,519	12,285,055.00	6.52
Clay b)	2.33	1,557,149	3,628,157.00	2,24
Clay c)	2.65	135,000	346,000.00	0.22
Clay d)	4.25	8,124,820	34,530,485,00	18.35
Sandstone SD11-SD9	42.5	73,800	3,136,500.00	1.67
Sandstone SD20-SD25	55.4	255,900	14,176,860.00	7.52
Total		12,364,188	68,103,057.00	36.52

Average unit cost - $\frac{68,103,057.00}{12,364,188}$ = Cr$ 5.50/m^3

SUMMARY TABLE

WORK	Cr$/$m^3$ UNIT COST	VOLUME (m^3)	COST (Cr$)
Landfills	6.48	54,563,605	353,790,640.00
Dredging clay and sandstone	5.50	12,364,188	68,103,057.00
Dredging approach channel	3.12	7,685,978	23,980,251.00
Filling the beach	5.19	3,146,699	16,360,128.00
Total	-	77,760,470	462,234,076.00

Average unit cost - $\frac{462,234,076}{77,760,470}$ = Cr$ 5.94/m^3

4.4.5 COST OF DREDGING THE APPROACH CHANNEL

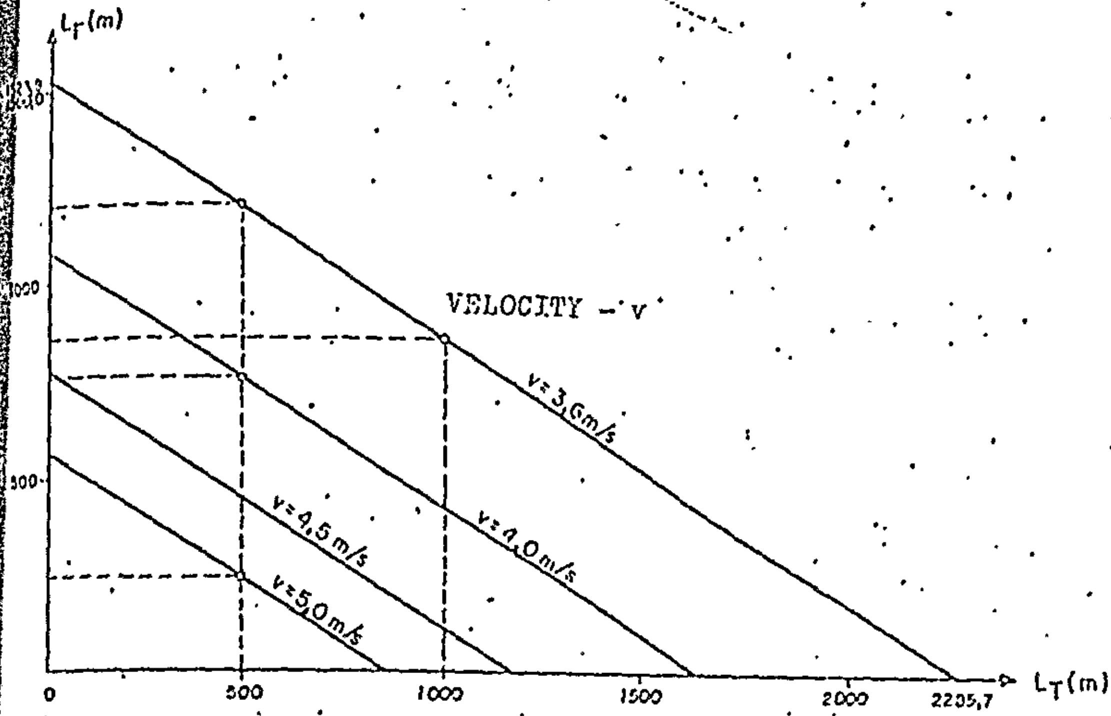
	UNIT COST CR$	VOLUME (m^3)	COST Cr$	(MONTHS) EXECUTION TIME
	3.12	7,685,978	23,980,251.00	13.97
Total	3.12	7,685,978	23,980,251.00	13.97

Average unit cost – Cr$ 3.12/m^3

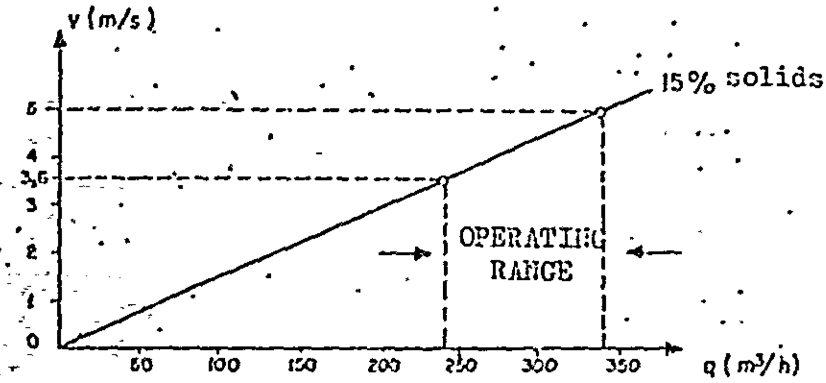
4.4.6 [illegible] COST OF THE BEACH

FILL AREA	UNIT COST (Cr$/$m^3$)	VOLUME	[illegible]	EXECUTION TIME (MONTHS)
Beach - a	3.75	252,[illegible]	[illegible]	0.45
Beach - b	9.33	318,7[illegible]	[illegible],217	1.86
Beach - c	4.83	2,575,1[illegible]	[illegible]	7.57
Total	-	3,146,[illegible]	[illegible]	

Average Unit cost - $\frac{16,360,[illegible]}{3,146,[illegible]}$ = [illegible].19/m^3

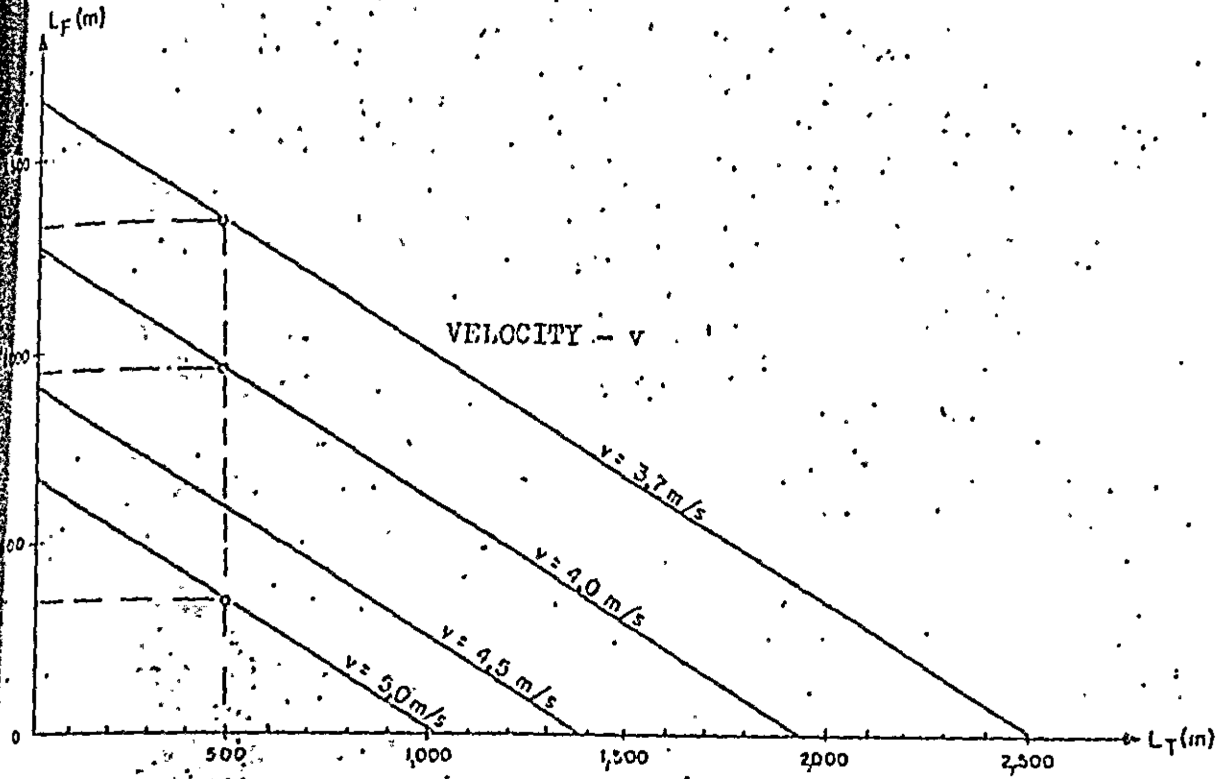


GRAPH — $L_F \times L_T \times v$

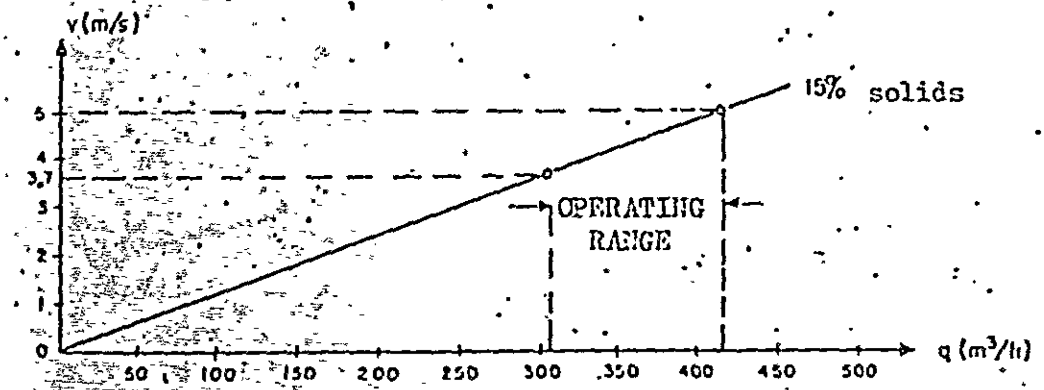


GRAPH q x v

MATERIAL - SAND DREDGE - 16" REACH - $L = L_T + L_F$	dipar TRANSCON S.A.	GOVERNO DO ESTADO DE PERNAMBUCO - PRAC COMPANHIA DE DESENVOLVIMENTO INDUSTRIAL DE PERNAMBUCO COMPLEXO INDUSTRIAL DE SUAPE 16" DREDGE - OPERATING CURVE

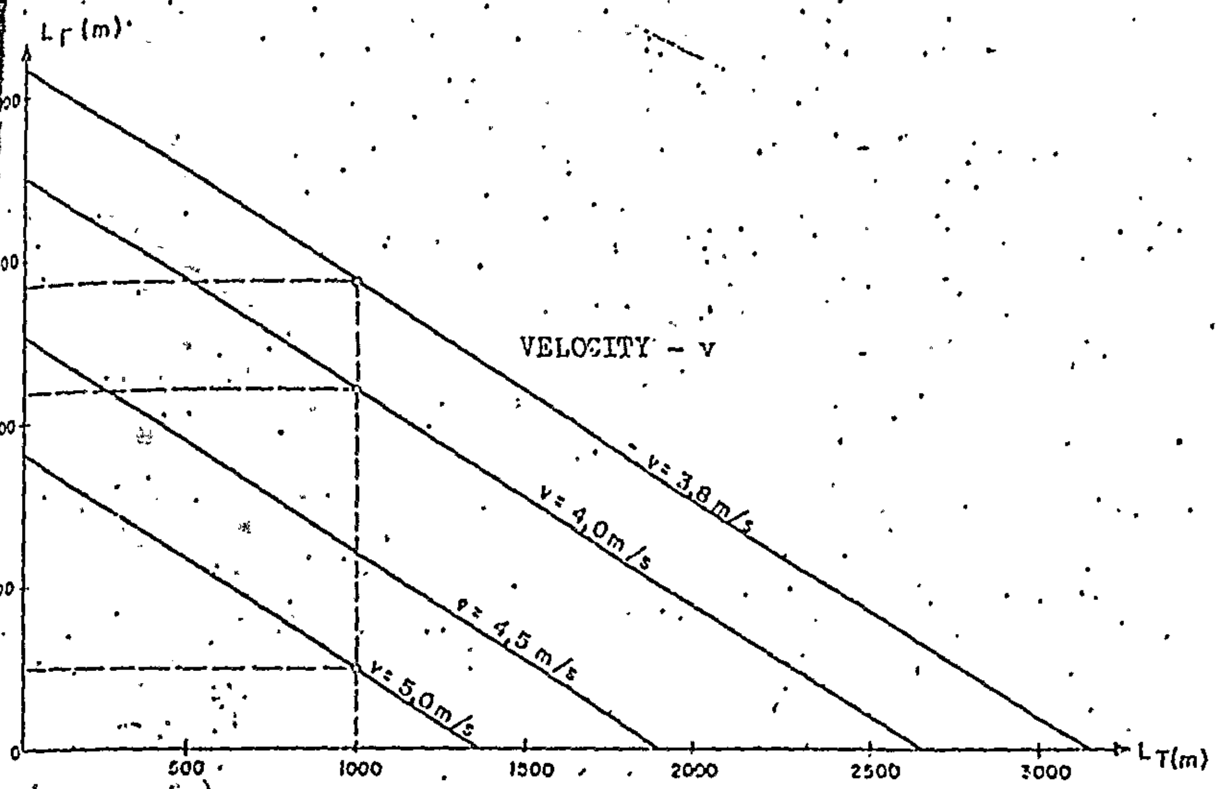


GRAPH – $L_F \times L_T \times v$

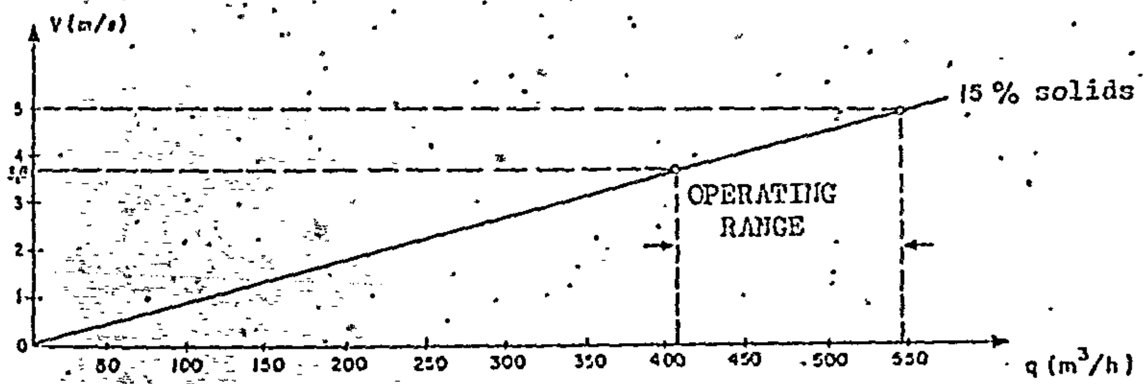


GRAPH – q x v

MATERIAL – SAND DREDGE – 18" REACH – $L = L_T + L_F$	dipor TRANSCON SA	GOVERNO DO ESTADO DE PERNAMBUCO - PRAC COMPANHIA DE DESENVOLVIMENTO INDUSTRIAL DE PERNAMBUCO COMPLEXO INDUSTRIAL DE SUAPE 18" DREDGE – OPERATING CURVE



GRAPH – $L_T \times L_F \times v$



GRAPH – q x v

Material — SAND
DREDGE — 20"
REACH — $L = L_T + L_F$

dipor

TRANSCON SA

GOVERNO DO ESTADO DE PERNAMBUCO - PRAC
COMPANHIA DE DESENVOLVIMENTO INDUSTRIAL DE PERNAMBUCO
COMPLEXO INDUSTRIAL DE SUAPE

20" DREDGE — OPERATING CURVE

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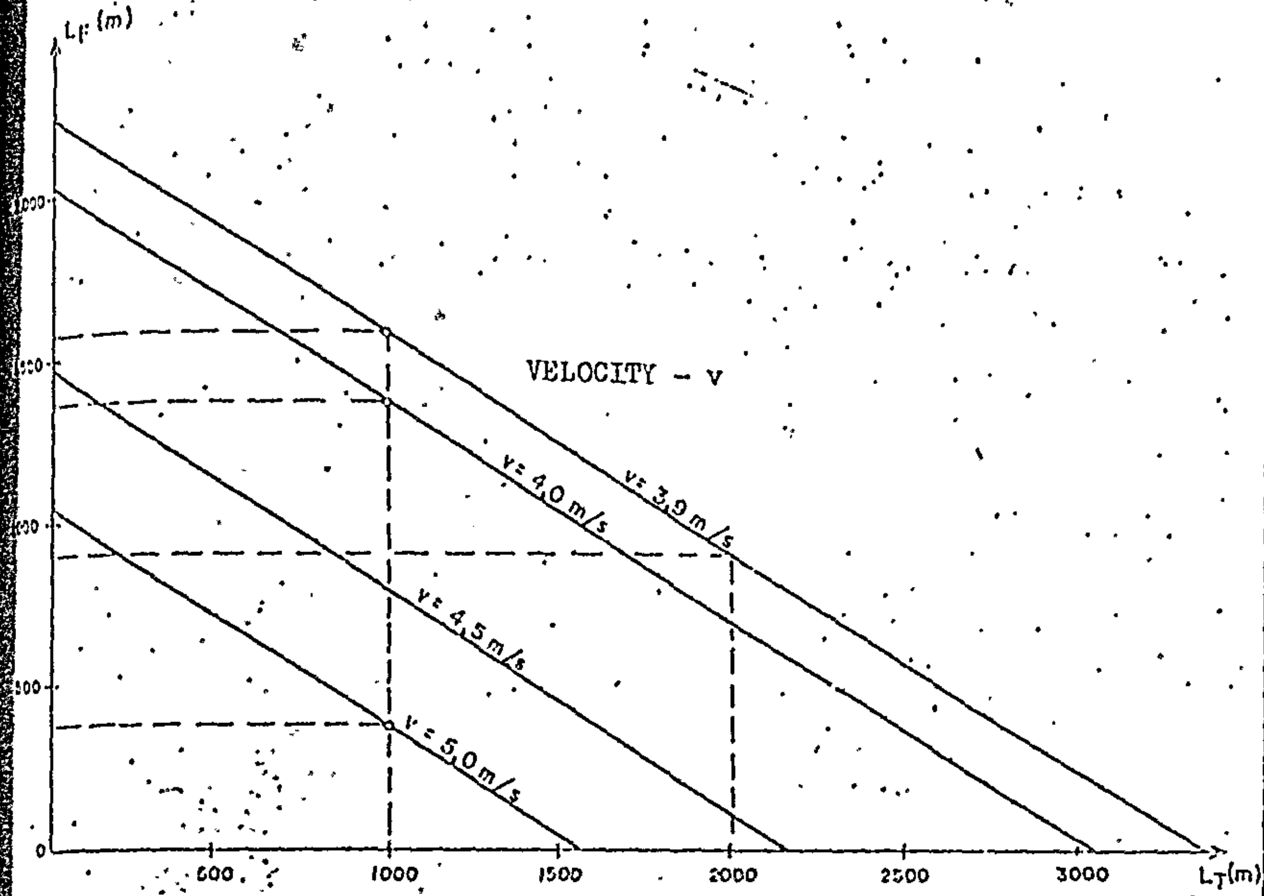
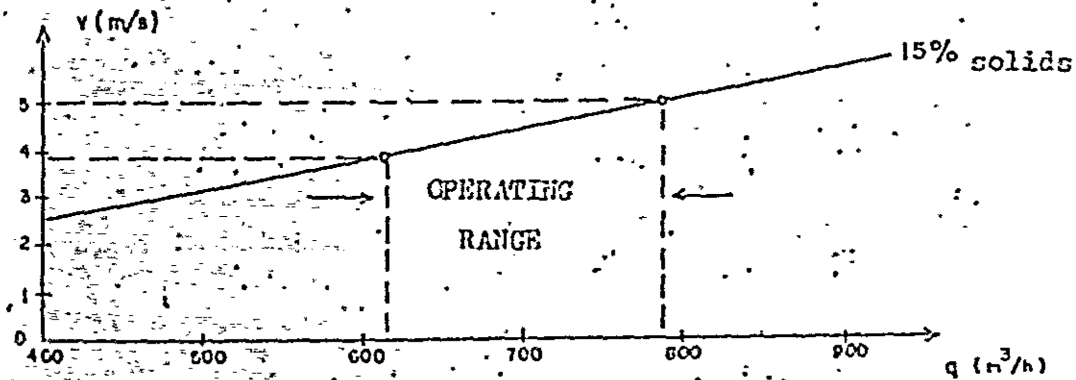
	DEZ.7[illegible]		[illegible]	[illegible]

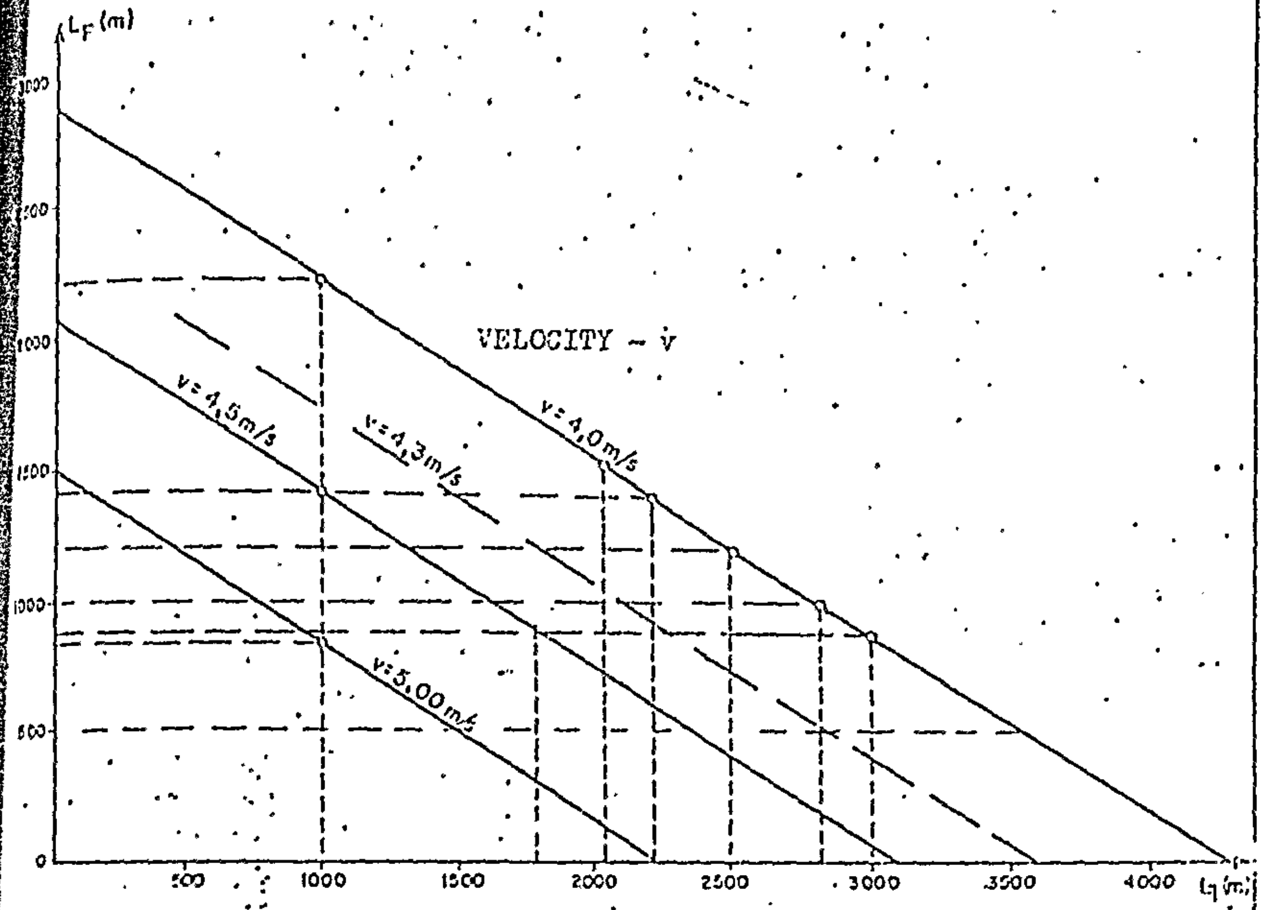


GRAPH - $L_T \times L_F \times V$

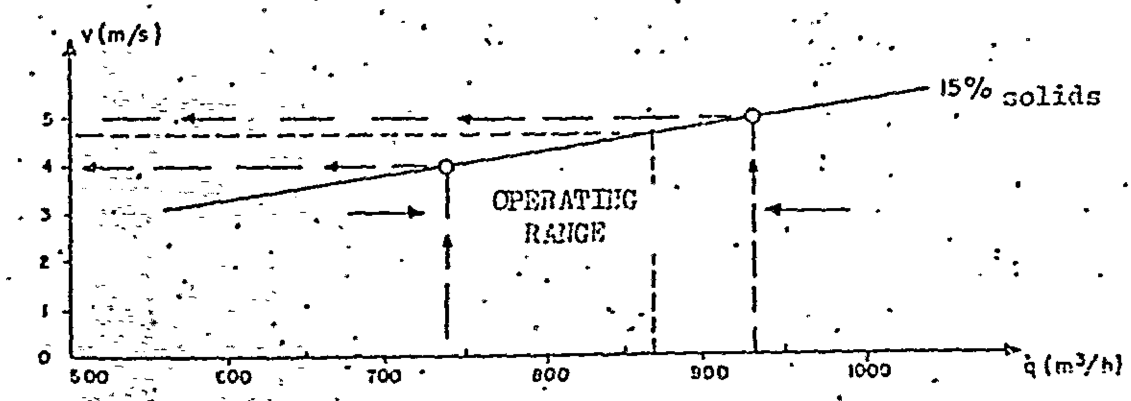


GRAPH q x v

Material — SAND DREDGE — 24" REACH — $L = L_T + L_F$	diper TRANSCON S.A	COMPLEXO INDUSTRIAL DE SUAPE 24" DREDGE — OPERATING CURVE



GRAPH - $L_T \times L_F \times V$



GRAPH q x V

MATERIAL - SAND DREDGE - 26" REACH - $L = L_T + L_F$	dlper TRANSCON S.A	GOVERNO DO ESTADO DE PERNAMBUCO COMPLEXO INDUSTRIAL DE SUAPE 26" DREDGE - OPERATING CURVE

TOMO I

[illegible] I

VOLUME I

APENDIX I-A

4.0

4.0 DREDGING PLAN

APPENDIX 1 - A

CALCULATION OF DREDGING AND FILL VOLUMES

FILL VOLUMES - 1st STAGE

DREDGING VOLUMES AFTER THE 1st STAGE in $m^3 \times 10^3$

	TOT VOL[1] MAX UTIL PLAN	TOT VOL[2] 1st STAGE	TOT VOL[1-2] AFTER 1st STAGE	VOL SAND After 1st St.		VOL CLAY After 1st Stage		VOL SANDSTONE After 1st Stage	
				%	V	%	V	%	V
I	38,432	38,432	-	89	-	10	-	1	-
II	40,919	40,919	-	89,8	-	10	-	0,2	-
III	1,376	1,167 [a]	209	62	130	28	59	10	20
IV	8,620	502 [b]	8,118	45,2	3,669	50	4,059	4,8	390
V	26,344	-	26,344	40	10,538	60	15,806	-	-
VI	27,189	877 [c]	26,312	70	18,418	30	7,894	-	-
VII	3,047	-	3,047	70	2,133	30	914	-	-
VIII	12,163	-	12,163	60	7,298	40	4,865	-	-
IX	1,334	1,334	-	80	-	20	-	-	-
[illegible]	7,686	7,686	-		-		-	-	-
Total			76,193		42,185		33,597		410

a) S_{-III} = 78,300 m^2

h = 1.4 m)
 ...pd = p + h = 14.9 m
p = 13.5 m)

V = 78,300 x 14.9 = 1,166,670 m^3

b) S_{-IV} = 37,500 m^2 (surface area of area IV, dredged during the first stage)

h = 1.4 m)
 ...pd = 13.4 m
p = 12 m)

V = 37,500 x 13.4 = 502,500 m^3

c) $V_{SD-1 - SD-5}$ = 876,762 m^3

CALCULATION OF FILL VOLUME FOR THE BEACH - 1st STAGE

SECTION	AREA	DISTANCE	VOLUME (m^3)
ST.39	952.50		
		1,600,00	2,604,000.00
ST.40	2,302.50		
		1,210.00	2,882,825.00
ST.41	2,462.50		
		850.00	1,829,837.00
ST.42	1,843.00		
Total			7,316,662.00

Calculation of fill volume for the provisional beach (in front of the mouth)

$V = 952.50 \times 600 = 571,500 \ m^3$

FILL VOLUMES - DESCRIPTION BY AREA

1st STAGE

AREAS	MEAN (1) ELEVATION (m)	SURFACE AREA (m^2)	FILL TO 2.70 m		FILL TO 1.50 m	
			HEIGHT FILLED (m)	VOLUME (m^3)	HEIGHT FILLED (m)	VOLUME (m^3)
T0(2)		1,876,000				2,310,600
T1(2)		4,407,700		9,239,620		
T2	0,30	1,140,250			1,20	1,368,300
T3'(2)				5,104,780		
T3"	-1.30	1,769,300			2,80	4,954,040
T3'''(2)						1,189,275
T42 (2)		2,158,250		7,230,520		
T4''	-0,30	793,850			1,80	1,429,930
T5	-2.30	2,958,700			3,80	11,243,060
T6'		1,321,450				
T6"		408,450				
T7		1,420,350				
T8		2,137,750			1,50	3,206,625
T9		1,476,500			1,50	2,214,750
T10(2)		1,757,250		5,073,105		
Total		23,625,800		26,648,025		27,915,580
						54,563,605

(1) The elevations refer to zero CHG

(2) Calculated by transversal sections

CALCULATION OF FILL VOLUME USING A SELF-CARRYING DREDGE

AREA - BEACH

AREA	SURFACE AREA (m^2)	DISTANCE	VOLUME (m^3)
ST.39	421.20		
		1,600.00	1,421,120.00
ST.40	1,355.20		
		1,210.00	1,806,590.50
ST.41	1,630.90		
		850.00	1,194,972.50
ST.42	1,180.80		
Total			4,422,683.00 m^3

Calculation of fill volume for the provisional beach (in front of the mouth) using self-carrying dredges.

$$V = 421.20 \times 600 = 252,720 \, m^3$$

CALCULATION OF FILL VOLUME - ELEVATION 1.5 AREA T-0

AREA	SURFACE AREA (m^2)	DISTANCES (m)	VOLUMES (m^3)
ST-6b	1,135		
		300	516,300
ST-19	2,307		
		150	298,700
ST-20	1,675		
		150	270,000
ST-21	1,925		
		300	475,500
ST-22	1,245		
		300	454,500
ST-23	1,785		
		220	295,600
ST-12b	902		
Total			2,310,600

CALCULATION OF FILL VOLUME - 2.70 AREA T-1

AREA	SURFACE AREA (m^2)	DISTANCES	VOLUMES (m^3)
		180	479,700
ST-1	2,665		
		300	811,950
ST-2	2,748		
		300	525,000
ST-3	752		
		300	699,750
ST-4	3,913		
		120	485,400
ST-5	4,177		
		180	773,370
ST-6	4,416		
		-	-
ST-6a	1,480		
		300	313,950
ST-7	613		
		150	98,625
ST-8	702		
		150	56,325
ST-9	49		

Continuation - 2.70 Area T-1

		300	190,050
ST-10	1,218		
ST-11	587	300	270,750
		220	355,960
ST-12a	2,649	-	-
ST-12	4,693		
		380	1,984,740
ST-13	5,753		
		300	1,602,450
ST-14	4,930		
		120	591,600
Total			9,239,620

CALCULATION OF FILL VOLUME - AREA T'3 ELEVATION 2.70 M

AREA	SURFACE AREA (m^2)	DISTANCE (m)	VOLUME (m^3)
		160	705,280
ST-15	4,400		
		300	1,304,250
ST-16	4,287		
		300	1,489,500
ST-17	5,624		
		300	1,605,750
ST-18	5,062		
Total			5,104,780 m^3

CALCULATION OF FILL VOLUME - ELEVATION 1.50 m

AREA T'''3

AREA	SURFACE AREA (m^2)	DISTANCE (m)	VOLUME (m^3)
		160	164,400
ST-15	1,027.00		
		300	330,375
ST-16	1,175.00		
		300	352,500
ST-17	1,175.00		
		300	342,000
ST-18	1,105.00		
Total			1,189,275

CALCULATION OF FILL VOLUME (ELEVATION 2.70 m) T'-4

AREA	SURFACE AREA (m^2)	DISTANCE (m)	VOLUME (m^3)
ST-32	4,973		
		250	1,303,375
ST-33	5,454		
		300	1,722,000
ST-34	6,026		
		300	1,679,700
ST-35	5,172		
ST-35A	3,124		
		300	949,050
ST-36	3,203		
		300	940,200
ST-37	3,065		
		210	636,195
ST-38	2,994		
Total			7,230,520

CALCULATION OF FILL VOLUME (ELEVATION 2.70 m) AREA T-10

AREA	SURFACE AREA (m^2)	DISTANCE (m)	VOLUME (m^3)
ST-26	9.639		
		165	1,430,055
ST-27	7,695		
		170	1,030,965
ST-28	4,434		
		180	742,230
ST-29	3,813		
		120	613,020
ST-30	6,404		
		230	1,256,835
ST-31	4,525		
Total			5,073,105

FILL VOLUMES AFTER THE 1st STAGE

LANDFILLS AFTER THE 1st STAGE

In accordance with the basic assumptions adopted for the 1st stage and with the maximum utilization plan's priorities, the following work will be performed after the 1st stage.

1) Filling areas T'6, T"6 and T7 to the elevation of 2.70 m.

2) Fill to raise the elevation from 1.50 m to 2.70 m in areas T0, T2, T"3, T"4, T5 T8 and T9.

3) No further work will be performed on areas T1, T'3, T'4 and T10, since they will have already been filled during the first stage.

FILL VOLUMES AFTER THE 1st STAGE (m^3)

AREAS	FILL TO 2.70 m	1st STAGE FILL	FILL AFTER 1st STAGE
To	3,913,300	2,310,600	1,602,700
T1	9,239,620	9,239,620	-
T2	2,736,600	1,368,300	1,368,300
T_3'	5,104,780	5,104,780	-
T_3''	7,077,200	4,954,040	2,123,160
T_3'''	1,855,290	1,189,275	666,015
T_4'	7,230,520	7,230,520	-
T_4''	2,381,550	1,428,930	952,620
T5	14,793,500	11,243,060	3,550,440
T_6'	6,607,250	-	6,607,250
T_6''	2,042,250	-	2,042,250
T7	3,408,840	-	3,408,840
T8	5,771,925	3,206,625	2,565,300
T9	3,986,550	2,214,750	1,771,800
T10	5,073,105	5,073,105	-
Total	81,222,280m^3	54,563,605	26,658,675

FILL VOLUMES - DESCRIPTION BY AREA

MAXIMUM UTILIZATION PLAN

AREAS	MEAN ELEV(1) (m)	SURFACE AREA (m^2)	FILL TO 2.70 m	
			HEIGHT FILLED (m)	VOLUME (m^3)
To(2)		1,876,000		3,913,300
T1(2)		4,407,700		9,239,620
T2	0.30	1,140,250	2.40	2,736,600
T_3'(2)		1,533,000		5,104,780
T_3''	-1.30	1,769,300	4.00	7,077,200
T_3'''(2)		493,500		1,855,290
T_4'(2)		2,158,250		7,230,520
T_4''	-0.30	793,850	3.00	2,381,550
T5	-2.30	2,958,700	5.00	14,793,500
T_6'	-2.30	1,321,450	5.00	6,607,250
T_6''	-2.30	408,450	5.00	2,042,250
T7	0.30	1,420,350	2.40	3,408,840
T8	0	2,137,750	2.70	5,771,925
T9	0	1,476,500	2.70	3,986,550
T10(2)		1,757,250		5,073,105
Total		25,652,300		81,222,280m^3

(1) The elevations refer to zero CNG.

(2) Calculated by transversal sections.

FILL VOLUME CALCULATION - ELEVATION 2.70m AREA T-0

AREAS	SURFACE AREAS (m^2)	DISTANCES (m)	VOLUMES (m^3)
ST-6b	2,936		
		300	1,009,200
ST-19	3,792		
		150	470,300
ST-20	2,479		
		150	399,600
ST-21	2,849		
		300	772,700
ST-22	2,302		
		300	747,600
ST-23	2,682		
		220	519,900
ST-12b	2,044		
Total			3,913,300

FILL VOLUME CALCULATION (TO +2.70 m)

ÃREA T'''3

AREAS	SURFACE AREAS (m^2)	DISTANCES (m)	VOLUMES (m^3)
		160	253,440
ST-15	1,584		
		300	498,450
ST-16	1,739		
		300	521,700
ST-A	1,739		
ST-18	2,139	300	581,700
TOTAL			1,855,290

DREDGING VOLUMES DURING THE 1st STAGE

DREDGING VOLUMES - 1st STAGE SUMMARY

	VOLUMES (m^3)			TOTAL
	SAND	CLAY	SANDSTONE	
Approach Channel	7,685,978			7,685,978
Internal Channels (FI e FII)	57,471,714	12,034,488	329,700	69,835,902
Mangrove Swamp		14,804,555		14,804,555
Total	65,157,692	26,839,043	329,700	92,326,435

CALCULATION OF DREDGING VOLUME FOR THE APPROACH CHANNEL

DREDGING SECTION (SD)	AREAS	AVERAGE AREAS	DISTANCES (m)	VOLUME (m^3)
26	4860,00			
		4351,37	110	478,705,700
27	3843,75			
		3540,50	130	460,265,000
28	3237,25			
		2913,0[illegible]	140	407,820,000
29	2588,75			
		2931,25	295	864,718,750
30	3273,75			
		2611,87	110	287,305,700
31	1950,00			
		1811,87	280	507,323,600
32	1673,75			
		1393,75	400	557,500,000
33	1113,75			
		990,00	1475	1,460,250,000
34	866,25			
		857,50	1700	1,457,750,000
35	848,75			
		721,25	1320	952,050,000
36	593,75			
		471,25	275	129,593,750
37	348,75			
		231,50	530	122,695,000
38	114,25			
TOTAL				7,685,978,000

ALL THE DREDGED MATERIAL WILL BE SAND.

CALCULATION OF DREDGING VOLUMES FOR INTERNAL CHANNELS

1st STAGE PHASE I

SECTIONS	AREAS (m^2) SAND	CLAY	SANDSTONE	DIST. BETW. SECTIONS (m)	VOLUME (m^3) SAND	CLAY	SANDSTONE
SD-1	370						
				780	288,600		
SD-2	370						
				620	218,860		
SD-3	336						
				580	144,942		
SD-4	163,8						
				400	224,360		
SD-5	958						
				120	394,680	320,280	
SD6-5	5620	5338					
				–	–	–	
SD6-6	10910	10452,5					
				240	3,228,480	1,815,180	
SD-7	15994	4674					
				520	7,726,290	3,149,640	
SD-8	13722,5	7440					
				350	5,295,937	1,831,900	
SD-9	16540	3028	240				
				330	4,545,750	809,820	59,400
SD-10	11010	1880	120				
				480	3,726,480	188,000	14,400
SD-11	4517,5						
				200	576,400		
SD-12	1247,4						
				670	1,766,790	101,505	
SD-13	4027,4	606					
				860	7,963,170	130,290	
SD-14	14492						
				390	4,234,815	74,587	
SD-15	7225	765					
				350	2,412,900	432,775	
SD-16	6563,2	1708					
				170			
SD-17							

SD-18	11231						
				340	2,040,000		
SD-19	6500,2						
				590	2,675,945	189,464	
SD-20	2571,6	1284,5					
				260	737,490	360,581	3,120
SD-21	3102	1489,2	48				
				390	1,193,010	514,644	104,910
SD-22	3016	1150	490				
				290	746,170	263,900	111,650
SD-23	2130	670	280				
				–	–	–	–
SD-24	1130	1000	30				
				540	766,800	135,000	23,220
SD-25	1710		56				
Total by type of material.					50,907,869	10,317,566	316,700
				Total :	61,542,135 m^3		

CALCULATION OF DREDGING VOLUMES FOR THE INTERNAL CHANNELS.

1st STAGE PHASE II

SECTIONS	AREAS (m^2) SAND	CLAY	SANDSTONE	DIST. BETW. SECTIONS (m)	VOLUME (m^3) SAND	CLAY	SANDSTONE
-11	1203						
				200	543,200		
-12	4229						
		953		670	1,525,255	159,627	
-13	324						
				860	976,960	204,895	
-14	1948						
				390	799,500	975	
-15	2152	10				49,000	
				350	430,325		
-16	307	560					
				170	792,965	403,495	
-17	9022	4187					
				-	-	-	
-18	2678						
					450,000		
-19	1707						
		1180		590	584,985	174. [illegible]	
-20	276						
				260	194,870	353,600	1,885
-21	1223	1540	29	29			
				390	265,785	371,280	11,115
-22	140	364	28				
				-	6,563,845	1,716,922	13,000
				TOTAL	8,293,767 m^3		

Phase I + Phase II

Sand - 57,471,714 m^3

Clay - 12,034,488 m^3

Sandstone - 329,700 m^3

Total - 69,835,902 m^3

DREDGING VOLUMES AFTER THE 1st STAGE

DREDGING VOLUMES CALCULATION - MAXIMUM UTILIZATION PLAN

AREAS	S (m^2)	pd (m)	Vc (10^3 m^3)	Vtal (10^3 m^3)	Vc (10^3 m^3)	V. SAND		V. CLAY		V. SANDSTONE	
						%	10^3 m^3	%	10^3 m^3	%	10^3 m^3
I	1,880,000	19.4	36,472	1,960	38,432	89	34,205	10	3,843	1	384
II	2,306,400	14.4	33,212	7,707	40,919	89.8	36,745	10	4,092	0.2	82
III	78,300	15.9	1,245	131	1,376	62	853	28	385	10	138
IV	519,500	14.9	7,741	879	8,620	45.2	3,896	50	4,310	4.8	414
V	1,762,600	14.0	24,676	1,668	26,344	40	10,538	60	15,806		
VI	1,230,000	18.8	23,124	4,065	27,189	70	19,032	30	8,157		
VII	144,100	15.4	2,219	828	3,047	70	2,133	30	914		
VIII	713,800	14.1	10,065	2,098	12,163	60	7,298	40	4,865		
IX	97,200	11.5	1,118	216	1,334	80	1,067	20	267		
Approach Channel					7,686	100	7,686				
Total				19,552	167,110		123,453		42,639		1,018

pd = p + h

pd - dredging depth (refers to zero CNG

p - depth required by area's type of vessel

h - [illegible] of area's land. For area II, h=-2m. For the other areas, h=1.4m (or zero CNG)

Vc - volume of the bottom of the channel

Vtal - volume to be dredged for embankment

Vt - total volume to be dredged

DREDGING VOLUMES AFTER THE 1st STAGE.

Approach Channel - will not be dredged

Areas I, II and IX - will not be dredged

Area III - should be dredged from -13.5m to -14.5m

Area IV - only a small portion will be dredged during the first stage

Area VI - the volume to be dredged will be that calculated for the maximum utilization plan, less the volume dredged for the Ipojuca rectification

Areas V, VII, VIII - since these areas will not be dredged during the 1st stage, the dredging volume will be calculated after the first stage for the Maximum Utilization Plan

TOMO [illegible]
[illegible] I
VOLUME: I
[illegible]

5.0 - STUDIES CONDUCTED FOR DIMENSIONING THE PORT COMPLEX

5.0 STUDIES CONDUCTED FOR DIMENSIONING THE PORT COMPLEX

5.1 PROJECTED CARGO FLOWS

Table 5/I shows the projected cargo flows for the port complex during the 1st stage.

TABLE 5.1

PROJECTED CARGO FLOWS THROUGH THE PORT (IN 1,000 TONS)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	1114	2241	2228	2572	2697	3235	3434	3623	3522	4031	4269	4490	4721	4976	5244	5519	5540	5634	5647	5691	5734	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	612	642	673	703	739	775	803	842	872	915	954	995	1037	1082	1128	1176	1191	1207	1224	1240	1257	1274	[illegible]	[illegible]	[illegible]	[illegible]
	612	642	673	733	739	775	803	842	872	915	954	995	1037	1082	1128	1175	1191	1207	1224	1240	1257	1274	1291	[illegible]	[illegible]	[illegible]
EXPORTS	1223	1401	1625	1377	2159	2450	2626	2791	2944	3116	3295	3485	3634	3834	4115	4243	4359	4537	4424	4451	4477	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
- Wheat (*)	300	316	333	351	369	389	403	425	445	466	457	510	533	558	534	610	618	627	635	644	652	651	[illegible]	679	[illegible]	[illegible]
- Sugar	513	762	691	1044	1222	1430	1520	1617	1719	1829	1944	2068	2195	2333	2437	2540	2649	2633	2503	2577	2632	2655	[illegible]	2713	2725	2735
- Molasses	293	272	235	332	374	450	435	521	553	595	634	573	714	755	793	542	320	333	657	375	833	632	[illegible]	[illegible]	[illegible]	[illegible]
- Alcohol	113	120	127	134	142	151	154	155	159	162	165	168	171	174	178	151	101	131	181	131	181	141	[illegible]	[illegible]	[illegible]	[illegible]
- Vegetable Oils	30	34	40	45	52	50	62	62	63	64	65	66	67	63	69	70	71	72	73	74	75	[illegible]	77	73	79	[illegible]
PRIVATE TERMINALS	15761	15322	15470	15315	15311	20226	20276	23520	21703	20762	24523	24912	25409	25170	25311	27977	28927	29222	29504	29721	31927	32115	32291	[illegible]	[illegible]	[illegible]
IMPORTS	10435	10528	10491	10351	10745	13324	12250	13503	13303	13563	15300	15563	15513	15300	15500	17655	16455	16633	15533	13655	20635	22253	[illegible]	[illegible]	[illegible]	[illegible]
- Phosphate Rock	22	75	117	157	197	351	537	785	795	785	785	735	725	735	735	785	735	785	765	735	735	755	735	735	[illegible]	[illegible]
- Sulfur	11	23	34	45	56	105	162	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213	[illegible]	213	[illegible]	[illegible]
- Potassium Chloride	43	55	69	85	111	133	161	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	[illegible]	[illegible]
- MAP	33	65	72	82	92	41	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Crude Oil	8000	8000	8000	8000	8000	6000	8000	8000	8000	8000	8000	8030	8000	3000	8000	10000	10000	10000	10000	10000	12000	12000	12000	12000	12000	12000
- Cryolite	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	5
- Aluminum Oxide	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	300	300	300	300	300	300	300	300	300	300	400
- Coke	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	105	105	105	105	105	105	105	105	105	105	140
- Coal	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	6	6	6	6	6	6	6	5	6	5	8
- Pitch	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	45	45	45	45	45	45	45	45	45	45	60
- Fluoride	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	5	5	5	5	5	5	3	3	5	5	6
- Clinker (*)	2000	2000	2000	2000	2000	4000	4000	4000	4000	4000	6000	6000	6000	6000	6000	6000	7000	7000	7000	7000	7000	7000	7000	7000	7000	[illegible]
EXPORTS	5245	5257	4365	4574	4546	7252	7015	7090	7500	7262	9023	9442	9909	9670	9431	10332	10332	10567	10349	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
- Cement	2000	2000	2000	2000	2000	4000	4000	4000	4000	4000	6000	6000	6000	6000	6000	7000	7000	7000	7000	7000	7000	7000	7000	7000	7000	5000
- Petroleum Derivatives	3245	3257	2365	2634	2446	3152	2915	2634	3058	2023	2587	5011	3132	3247	3012	2917	2917	3152	3434	3660	3357	4043	4233	4463	4752	5033
- Fertilizers	-	-	-	-	100	200	200	446	442	433	436	431	427	422	420	425	425	425	425	425	425	425	425	425	425	425
TOTAL IMPORTS	11068	11170	11274	11336	11504	13779	14058	14342	14378	16415	16454	16495	16537	16582	16528	18831	19846	19862	19879	19895	21912	21923	21947	21964	21982	22155
TOTAL EXPORTS	6447	6453	6494	6511	6705	9732	9642	9861	10444	10378	12313	12927	13593	13564	13547	14675	14701	14964	15273	15535	15743	15966	16131	15444	15757	16057
TOTAL CARGO FLOW	17515	17628	17768	17897	18209	23511	23700	24203	24822	24793	28772	29422	30130	30146	30175	33506	34547	34826	35152	35430	37661	37695	38120	38403	38739	47222

(*) - By Coastal Navigation.

5.2 DEFINITION OF TYPES OF SHIPS

Since the largest ships to call at the Port of Suape will require that the port have the same characteristic's as the ships' ports of origin and destination, a study of these ports was conducted.

A description of the port characteristics follows, grou ed by cargo types.

5.2.1 WHEAT CARRYING SHIPS

A STUDY OF THE PRINCIPAL PORTS OF ORIGIN AND THEIR CHARACTERISTICS

CANADA

- Baie Comeau, Quebec: depth = 40 feet
- Chaimenus, British Columbia: depth = 52 feet
- Halifax, Nova Scotia: Silo facilities for 5,152,000 bushels, 72,000 bu/hour (-900 tons/hour) unloading capacity; 45 foot draft
- Lakehead Harbour, Ontario: 150,000,000 silos
- Quebec, Chicobec: depth = 50 feet
- Sorel, Quebec: depth = 50 feet
- Vancouver, British Columbia: 90,000 bu/hour loading capacity

UNITED STATES OF AMERICA

- Baltimore, Maryland: depth = 42 feet
- Baton Rouge, Louisiana: depth = 40 feet
- Beaumont, Texas: depth = 40 feet

BRAZIL

- Port of Rio Grande: Capacity for handling 70,000 tdw ships

ARGENTINA

- Buenos Aires: depth = 23 feet
- Diamante: depth = 18 feet, 50,000 tdw capacity silo
- Mar del Plata: depth = 30 feet, 25,000 tdw capacity grain elevator

3 STUDY OF PORTS OF DESTINATION - COASTAL NAVEGATION

RECIFE

- Maximum depth: 10 m
- Facilities for handling 100 tons/hour of wheat, with conveyors and two silos with a total storage capacity of 38,535 tons.
- Possibility of loading wheat into trucks or railroad cars.

NATAL

- Maximum depth: 6.50 m
- Facilities for handling 30 tons/hour of wheat, with a total storage capacity of 4,800 tons.
- Wheat loaded into railroad cars or trucks.

MACEIÓ

- Maximum depth: 10 m
- Wheat unloaded into trucks by pneumatic elevators and transported to two silos with a total capacity of 10,320 tons.

CABEDELO

- Maximum depth = 8 m
- Unloading of wheat by portable 12 tons/hour effective capacity pneumatic elevators or by 10 tons/hour stationary pneumatic elevators.
- 5,700 ton silo storage capacity

C COMMENTS

The following conclusions were derived from the port descriptions above:

Port of Origin limitations:

- Canadian ports: ships with a maximum draft of 12 m and approximately 60,000 tdw
- American ports: ships with a maximum draft of 10 m and 30,000 tdw
- Port of Rio Grande: ~ 60,000 tdw ships
- Argentinian ports: ships with 7 to 9.50 m draft
- Ports in Northeastern Brazil: 10 m maximum draft, 25,000 tdw maximum

Since most of the wheat to be imported will originate in the United States and Canada, the ships that will most frequently call at the port will be in the 25 to 30 thousand tdw range (American ships) and in the 30 to 60 thousand (maximum) range (Canadian ships).

The average ship will be assumed to be 38,000 tdw with a 30,400 ton cargo ≅ 30,000 tons per voyage, using 80% of the tdw, and with a maximum draft of ≅ 34' (10.20 m).

For export for coastal trade, we assume an average ship to be 10,000 tdw with a 8,000 ton cargo.

Summary:

TYPE OF SHIPPING	VESSEL	TDW	CARGO/ VOYAGE (tons)	LENGTH (m)	BEAM (m)	DRAFT (m)	DEPTH (m)
For coastal trade export	Cargo Ship	10,000	- 8,000	165.0	24.30	8.0	- 9.10
	Cargo Ship	15.000	- 12,000	210.0	28.5	9.50	- 10.60
	Bulk Carrier	25,000	- 20,000	165.0	22.0	9.0	10.50
For long run import (high frequency)	Bulk Carrier	38,000	- 30,000	184.0	25.0	10.2	11.50
For long run import (lower frequency)	Bulk Carrier	60,000	- 48,000	217.0	31.0	12.2	13.50

5.2.2 SUGAR CARRYING SHIPS

A STUDY OF PRINCIPAL PORTS OF DESTINATION AND THEIR CHARACTERISTICS

JAPAN

- CHIBA

  Depth: 12 to 16 m

  18 silos with 40,000 ton capacity

  20,000 and 37,000 ton silos

- KAGOSHIMA

  Depth: 9 m

- KAWASAKI

  Depth: from 3 to 15.50 m for 120,000 grt ships

- SHIMIZU

  Depth: 13.5 m for 70,000 tdw ships

- TOBATA

  Depth: 13.60 m for 70,000 tdw ships

- YOKOHAMA

  Depth: 9.5 m for sugar terminal

  Capacity: 15,000 grt

- Other ports with depth varying from 10 to 12 m.

CHINA

- DAIREN

  Handles 30,000 tdw ships

- TSAMKONG

  maximum depth = 36 feet (11 m), 10,000 tdw ships

- Other ports, restricted by tides, handle 100,000 tdw ships

HONG KONG

- depth up to 44 feet (13.4 m)
- facilities for 80 tons/hour pneumatic loading and 21,000 ton warehouses for grains

INDIA

- average depth up to 37 feet (11.30 m)

  maximum depth = 13.80 m

IRAN

- depth up to 70 feet (21.3 m) for tank (KHARG ISLAND)
- other ports with up to 43.5 feet (13.30 m) depth
- average depth = 10.50 m

INDONESIA

- AMBOM - any draft
- BALIKPAPAM - 10 m depth (low tide)
- BENGRALIS - anchorage 200 to 300 m away from the pier; 9 to 11 m depth
- FULAU SAMBU - port depth = 12 m

  (channel depth = 16 m)

SURABATA - anchorage up to 18 m

- port depth = 9.00 m (low tide)

IRAQ

- BASRAH - 65,000 ton silo, 1,000 tons/hour capacity; maximum draft = 9.15 m
- KHOR-AL AWYA - depth = 22.5 m

ISRAEL

- EILAT: anchorage up to 36 m
- HAIFA: ships with up to 35 foot drafts can enter the port; docks with 11.50

JORDAN - depths up to 60 feet = 18 m

KOREA: YOSI: 20.5 m to 40 m depths

- INCHON - 30 feet (9m) depths; unloading of fertilizers: 1,500 tons/day - cement: 1,500 tons/day - grains: 1,700 tons/ day - grains: 1,100 tons/day

- POHANG: depth from 15 up to 63 feet

KUWAIT - depth up to 65 feet

LEBANON

- SIDOM - 50 foot depth - 1 mile from the coast

ARABIA: Maximum depth = 36 feet, docking facilities for 5 ships with a depth of at least 20 m.

UNITED STATES OF AMERICA: 40 to 42' depth

B COMMENTS

The descriptions of the ports show the following limitations:

- Japanese ports: handle 100,000 tdw ships
- Middle Eastern ports: 9 to 18 m depths
- Chinese ports: handle up to 30,000 tdw ships, 7 to 11 m depths.
- American ports: 25 to 30 thousand tdw ships for 10 m draft.

Judging by the growth trends in the worldwide market, it is probable that the relative position of the Middle East, China and Japan will influence the use of ships in the 30 to 100,000 tdw range. The United States, however, will probably not use ships larger than 30,000 tdw.

Due to the Chinese ports' equipment limitations and rather shallow waters, the product to be exported to China will be shipped in sacks in cargo ships with a maximum of 20 to 25 thousand tdw. Significant changes in Chinese port capacities are to be expected, according to current Chinese port improvement schedules.

TYPE OF SHIPPING	VESSELS	TDW	CARGO/ VOYAGE (tons)	LENGTH (m)	BEAM (m)	DRAFT (m)	DEPTH (m)
Export of sacked product	Cargo Ship	25,000	20,000	257.00	33.00	10.90	12.00
Export by long run (high frequency)	Bulk Carrier	80,000	64,000	240.00	34.00	13.30	14.50
Export by long run (low frequency)	Bulk Carrier	125,000	100,000	278.00	40.00	15.30	16.50

5.2.3 BULK SOLID CARRIERS

A STUDY OF THE PRINCIPAL PORTS OF DESTINATION AND THEIR CHARACTERISTICS.

MOLASSES

- Rotterdam, Holand: depth = 12.65 m
- USA: depth = 10 to 20 m
- Ravena, Italy: depth = 8 m
- Canary Islands: depth = 10.50 m

ALCOHOL

Not very significant; various ports of destination.

VEGETABLE OILS

- Germany: maximum dpeth = 14 m
- USA: depth = 12 to 12.80 m
- Canary Islands: depth = 10.50 m

B COMMENTS

Based on the above descriptions and the fact that in some cases these products represent only a fraction of the ships' cargo, small size ships were postulated, to be loaded to capacity with the mentioned products.

The following types of ships therefore result:

CARGO	TYPE OF VESSEL	TDW	CARGO/ VOYAGE(t)	LENGTH	BEAM (m)	DRAFT (m)	MIN. DEPTH (m)
OILS	CARGO SHIP	15,000	12,000	210,50	28,50	9,50	10,60
	TANKER	25,000	20,000	164,00	24,50	10,90	12,00
	TANKER	38,000	30,000	190,50	27,40	11,60	12,70

5.3 QUANTIFICATION OF FACILITIES' OPERATING CAPACITIES AND NUMBER OF BERTHS

The working hypotheses assumed for sizing the port complex's berth's took into consideration the types of ships, length of time in the berth and equipment operating capacity in order to achieve various equipment utilization rates with tolerable waiting lines. The length of time 60,000 tdw ships spend in specialized international ports, close to 4 to 5 days, was used to size loading and unloading equipment.

The following basic data were used:

1) Equipament efficiency = 80%

2) Hours worked = 20 hours/day

3) Basic equation

$R_n \times e \times H \times d \times \sigma = T$, where:

R_n = Rated yield

e = Equipment efficiency

H = Work hours per day

d = Working days per year

σ = Berth utilization rate in %

T = Projected tonnage

4) Maximum berth utilization rate = 50%

(Congestion rate of up to 5% is tolerable.)

(1) Ports of the World - BENN Brothers Limited.

5.3.1 WHEAT FACILITIES

Working Hypotheses

Possible working days per year = 270 days

Using the basic equation:

$$R_n \times e \times H \times d \times \sigma = T$$

$$R_n \times 0.80 \times 20 \times 270 \times \sigma = T :$$

$$R_n = \frac{T}{4,320} \times \frac{1}{\sigma}$$

$$= \frac{T}{4,320} \times \frac{1}{R_n}$$

DETERMINATION OF THE THEORETICAL CAPACITY (R_t) CAPABLE OF MEETING THE PROJECTED DEMAND; WITH A 50% to 40% UTILIZATION RATE; FOR ONE BERTH

Year	T	R_t (50%)	R_t (40%)
1980	612	283	354
1981	642	297	372
1982	673	312	390
1983	705	326	408
1984	739	342	428
1985	775	359	449
1986	808	374	468
1987	842	390	488
1988	878	407	508
1989	915	424	530
1990	954	442	552
1991	995	461	576
1992	1037	480	600
1993	1082	501	626
1994	1128	522	653
1995	1176	544	681
1996	1191	551	690
1997	1207	559	699
1998	1224	567	709
1999	1240	574	718
2000	1257	582	729
2001	1274	590	738
2002	1292	598	748
2003	1309	606	758
2004	1327	614	768
2005	1345	622	779

A reasonable estimate of the type of equipment to be used may be obtained, based on these results. In short, for 150 tons/hour modules, starting with 2 modules, the utilization rates for 2, 3 or 4 modules (σ_2, σ_3, σ_4) would be:

Year	T	σ_2 (MOD)	σ_3 (MOD)	σ_4 (MOD)
1980	612	47	31	24
1981	642	49	33	25
1982	673	51	35	26
1983	705	54	36	27
1984	739	57	38	28
1985	775	60	40	30
1986	808	62	41	31
1987	842	65	43	32
1988	878	68	45	34
1989	915	71	47	35
1990	954	74	49	37
1991	995	77	51	38
1992	1037	80	53	40
1993	1082	83	55	42
1994	1128	87	58	43
1995	1176	91	60	45
1996	1191	92	61	46
1997	1207	93	62	46
1998	1224	94	63	47
1999	1240	96	64	48
2000	1257	97	65	48
2001	1274	98	66	49
2002	1292	100	67	50
2003	1309	101	67	50
2004	1327	-	68	51
2005	1345	-	69	52

Analysis of the preceeding table shows that the utilization rate increases rapidly when the number of modules is decreased. This would mean including new equipment in short periods of time, to the detriment of the functioning of the port's permanent facilities.

Opting for an equipment module with a 400 tons/hour rated capacity and adding a second equipment module in 1985 results in the following:

Year	T	400 t/h σ_1	800 t/h σ_2
1980	612	35	18
1981	642	37	19
1982	673	39	20
1983	705	41	21
1984	739	43	21
1985	775	45	22
1986	808	47	23
1987	842	49	24
1988	878	51	25
1989	915	53	27
1990	954	55	28
1991	995	58	29
1992	1037	60	30
1993	1082	64	31
1994	1128	65	33
1995	1176	68	34
1996	1191	69	35
1997	1207	70	35
1998	1224	71	35
1999	1240	72	36
2000	1257	73	36
2001	1274	74	37
2002	1292	75	37
2003	1309	76	38
2004	1307	77	38
2005	1345	78	39

EXPORTING WHEAT BY LAND AND COASTAL TRADE

The working hypotheses for this type of shipping are the same as those mentioned above.

Calculation of utilization rates for equipment with rated yields of 300, 600 and 800 tons/hour, for coastal trade.

From the basic equation = $\sigma = \frac{T}{4,320} \times \frac{1}{R_n}$. yields:

For T = 215,000 tons/year, invariable over the course of the project, the result is:

σ_{300} = 17%

σ_{600} = 8%

σ_{800} = 6%

As can be seen, the utilization rate results are not very significant for coastal trade ships. Variation in the transport system capacity does not represent important cost variations since the structural elements remain virtually constant, notably around 500 tons/hour.

This assertion, and the fact that the lower the utilization rate, the greater the economies for navigationdue to more available berths for other cargos on the same docks, led to the adoption of a 600 tons/hour capacity.

FREQUENCY OF IMPORT AND EXPORT VESSELS

Types of vessels: - 30,000 tons/voyage for import
400 tons/hour until 1984
800 tons/hour after 1984
- 8,000 tons/voyage for export
600 tons/hour

YEAR	IMPORT VESSEL	LAY DAYS	YEAR	IMPORT VESSEL	LAY DAYS
1980	20	75	1993	36	72
1981	21	79	1994	38	76
1982	22	83	1995	39	78
1983	24	90	1996	40	80
1984	25	94	1997	40	80
1985	26	52	1998	41	82
1986	27	54	1999	41	82
1987	28	56	2000	42	84
1988	29	58	2001	42	84
1989	31	62	2002	43	86
1990	32	64	2003	41	88
1991	33	66	2004	44	88
1992	35	70	2005	45	90

Import ship's length of time in the berths:

Up to 1984 - 3.75 days/ship

After 1984 - 2 days/ship

An average of 27 coastal trade ships per year, with an average stage of only 1 day, is expected.

5.3.2 DETERMINATION OF THE WHEAT SILO'S STATIC CAPACITY

A WORKING HYPOTHESES FOR PRE-DIMENSIONING

1a) Equipment capacities up to 1985

Input = 400 tons/hour

Output = 800 tons/hour, as follows:

a) By land = 200 tons/hour

b) By coastal trade = 600 tons/hour

2a) Yields after 1985

Input = 800 tons/hour

Output = 800 tons/hour, as follows:

a) By land = 200 tons/hour

b) By coastal trade = 600 tons/hour

3a) Shipping by land:

Working hours per day = 8 hours

Working days per month = 23 days

4a) Maritime shipping:

Working hours per day = 20 hours

Working days per month = 23 days

B WHEAT FLOWS FOR 1985

Determination of monthly imports and exports:

Projected imports: 775,000 tons/year

Monthly imports : 775,000/12 = 64,583 tons/month or

Projected exports (coastal trade) = 215,000 tons/year

Monthly exports (coastal trade) = 18,000 tons/month

Monthly exports by land = 46,666 tons/month

No. of export ships (per year) = 215,000/8,000 = 27 ships per year

No. of vessels (per month) for export = 27/12 = 3/month

No. of vessels (per month) for import = 1 30,000 vessel alternating – 1 34,583 vessel

Cycle for coastal trade wheat carrier

$$C_{TE} = \frac{23 \text{ days}}{\text{month}} \div \frac{3 \text{ vessels}}{\text{month}} = 7 \text{ days/vessel (total cycle)}$$

C_{TE} adopted = 7 days/vessel

C cargo = 8,000 tons/voyage ÷ 600 tons/hour = 13 hours/voyage

Cycle of cargo adopted = C cargo = 1 day since low operating yields will occur for small ships

EXPORT BY LAND

This type of export was assumed to be a continuous daily flow amounting to a linearly increasing accumulated demand, as shown in graph I.

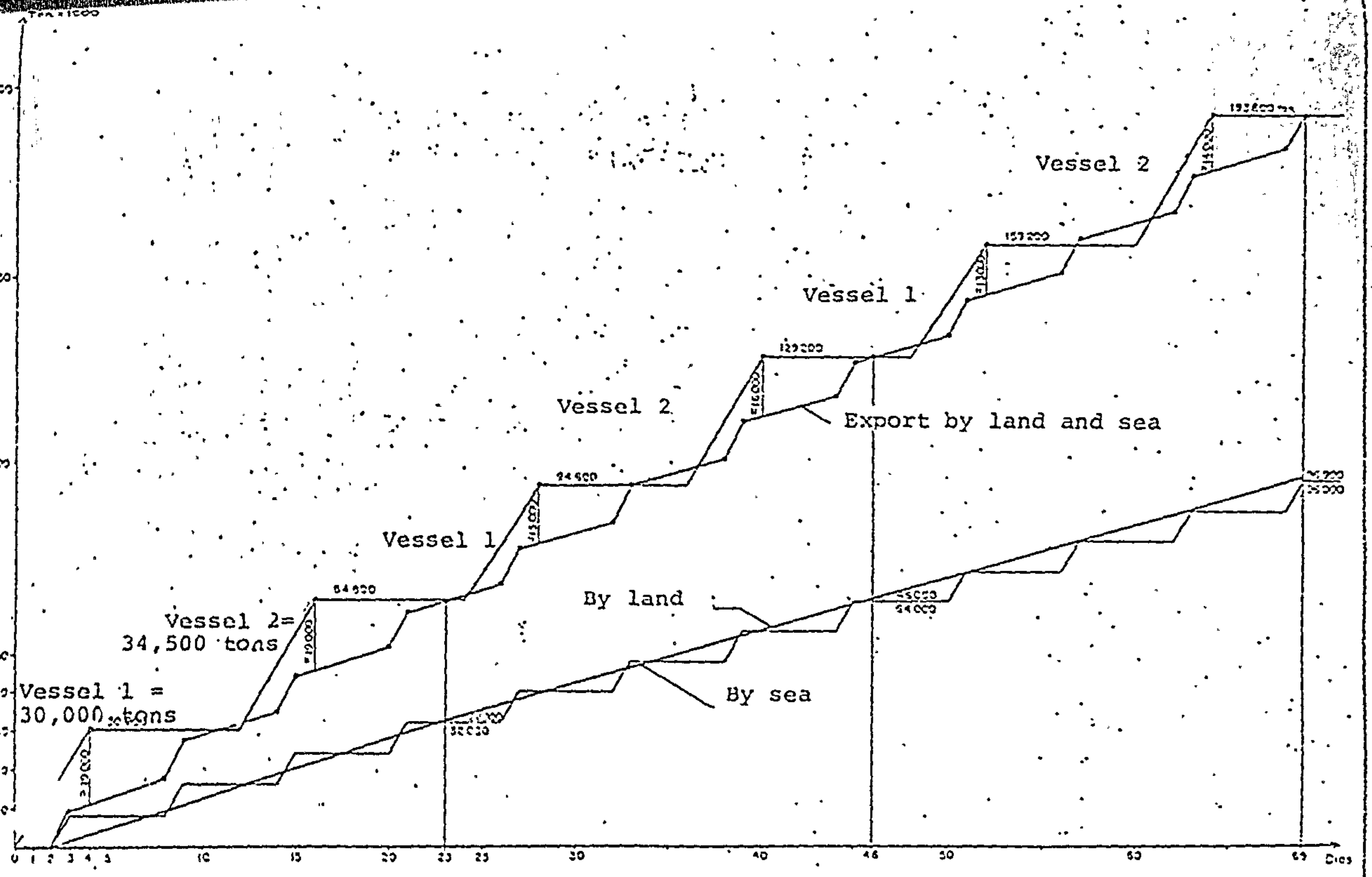
Cycle for import wheat carrier

$$C_{TI} = \frac{23 \text{ days}}{\text{month}} \div \frac{2 \text{ vessels}}{\text{month}} = 11.5 \text{ days/vessel}$$

≃ 12 days per vessel

C unloading = 30,000 tons/vessel :(400 tons/hour x 20 hours/day) = 3.75 days/voyage

Cycle adopted for unloading = C unloading = 4 days/vessel



dipar

TRANSCON S.A.

COMPLEXO INDUSTRIAL DE SUAPE

WHEAT SILO
STATIC CAPACITY 1985

A period of three months was considered; this would yield a total of 23 days x 3 = 69 days.

The silo was assumed to be empty.

C WHEAT FLOWS FOR THE YEAR 2005

Determination of monthly imports and exports

Projected imports = 1,345,000 tons/year

Monthly imports = 1,345,000 ÷ 12 = 112,083 tons/month

Exports unchanged

Cycle for coastal trade wheat carrier

Number unchanged

Cycle for import wheat carrier

No. of vessels per year = 45 vessels

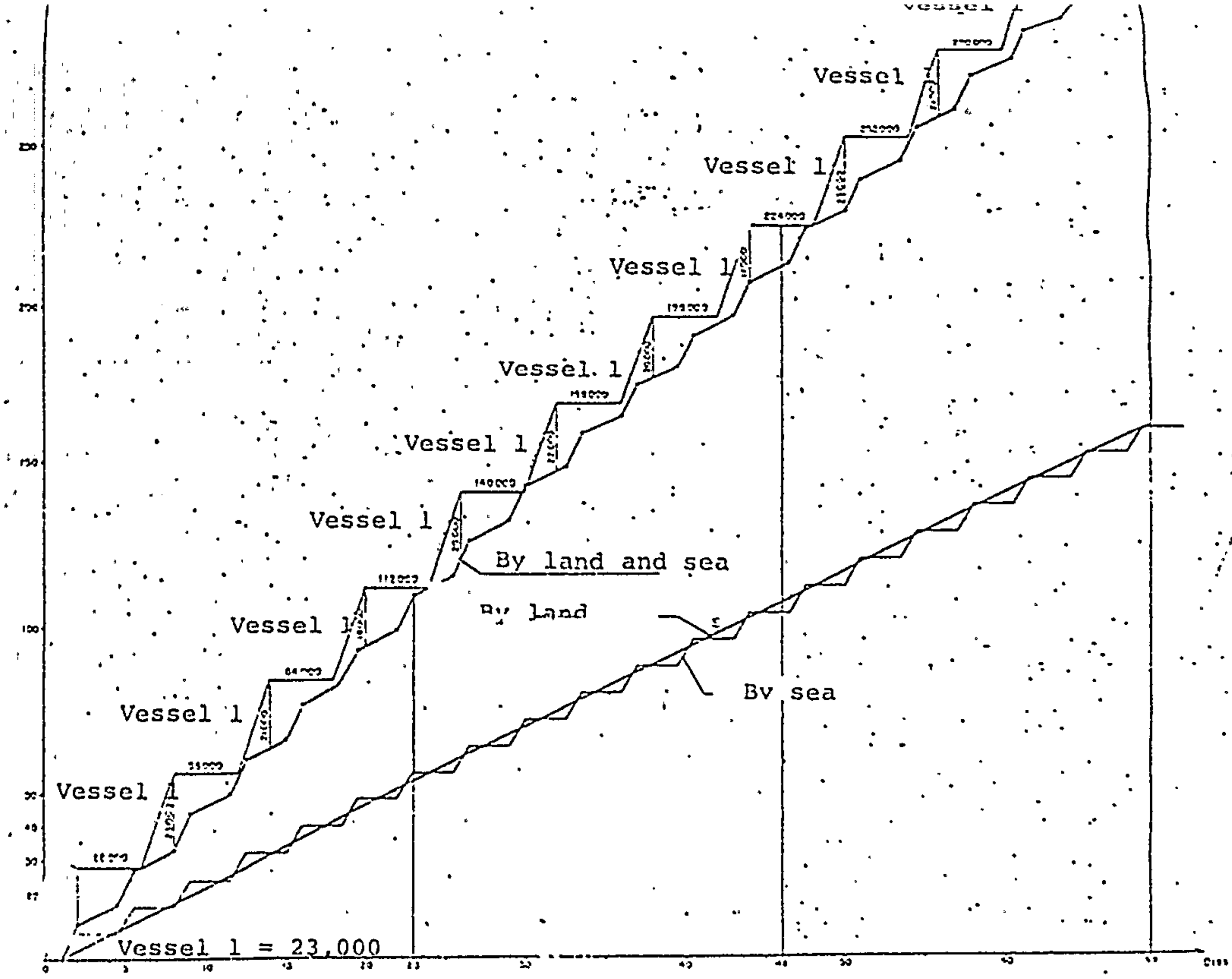
No. of vessels per month = 4 vessels/month

$$C_{TI} = \frac{23 \text{ days}}{\text{month}} : \frac{4 \text{ vessels}}{\text{month}} = 5.75 \doteq 6 \text{ days/vessel}$$

C unloading = 30,000 tons/voyage : 800 tons/hour = 37.5 hours $\doteq$ 2 days/vessel

Export by land

Same as for 1985.



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GOVERNO DO ESTADO DE PERNAMBUCO
COMPLEXO INDUSTRIAL DE SUAPE

WHEAT SILO
STATIC CAPACITY 2005

Analysis of the graphs shows a static capacity on the order of 19,000 to 20,000 tons for the two situations studied, and therefore a 25,000 tons capacity for stored wheat was assumed.

On the other hand, if we were to consider the arrival of 60,000 tdw vessels -- a possibility which was previously discussed and which would be perfectly feasible in terms of factors such as lay days, equipment quality and economic freight handling, as well as the port's physical facilities -- a second criteria based on the 60,000 tdw vessel's cargo would be assumed.

Thus, for the course of the first stage and assuming:

- Forecast arrival of 60,000 tdw vessel
- Silo completely empty
- Continuous daily shipments by land
- 100% equipment efficiency
- Forecast arrival of a 10,000 tdw coastal trade vessel

we would have:

EXPORT:	tdw = 10,000	80%	cargo = 8,000 tons
IMPORT:	tdw = 60,000	80%	cargo = 48,000 tons

Receiving capacity = 800 tons/hour

Shipping capacity = 200 tons/hour - by highway (for 8 hours/day)
600 tons/hour - by coastal trade (for 20 hours/day)

Day	Receivals (tons)	Export by Land (tons)	Export by Sea (tons)	Difference
1st	16,000	1,600	Ø	14,400
2nd	16,000	1,600	8,000	20,800
3rd	16,000	1,600	Ø	35,200

According to the criteria and using a coefficiency of safety of 25%, the result would be 45,000 tons.

D FINAL CALCULATION OF STATIC CAPACITY OF THE SILO

BINS AND SUB-BINS

Bin unit	Normal internal diameter	= 8.50 m
	Height	= 42.00 m
	Net volume	= 2,109 m^3
	Tonnage (0.75 tons/m^3)	= 1,580 tons
Sub-bin unit	Net volume	= 340 m^3
	Tonnage (o.75 tons/m^3)	= 255 tons
Arrangement	four bins per line	
	seven lines of bins	

TOTAL CAPACITY

Bins	:	7 x 4 x 1,580	=	44,240 tons
Sub-bins	:	6 x 3 x 255	=	4,590 tons
				48,830 tons

However, using the most realistic value for the product's weight, which increases in value due to compaction in the bin's, we would have:

Bins	:	7 x 4 x 2,109 x 0.80 =	47,242 tons
Sub-bins	:	6 x 3 x 340 x 0.80 =	4,896 tons
		total =	52,138 tons

E AREA NEEDED FOR THE BASIC LAYOUT:

A total area of around 3,600 m^2 is forecast based on a 25 m wide lifting tower, 9.00 external diameter per bin, for seven lines of four bins each.

For parking, an area of 5,500 m^2 is projected to allow good conditions for circulation of vehicles.

5.3.2. SUGAR TERMINAL

A Specific Working Hypotheses

- Sugar season = 8 months = 240 days
- Working days per year (d) = 180 days/year

Basic Equation

$$R_n \times e \times H \times d \times \sigma = T$$

For the parameters defined, the equation yields:

$$R_n = \frac{T}{2,880} \times \frac{1}{\sigma} \quad \text{or} \quad \sigma = \frac{T}{2,880} \times \frac{1}{R_n}$$

Pre-Dimensioning

Sugar exports from the Port of Suape will be divided into bulk and sacked sugar. It was assumed that export of sacked sugar will make up 21% of the total projected flow, which is equal to the import volume for China corresponding to the north northeastern section.

(in tons x 10^3)

	1975	1980	1985	1995	2005
Asia	900	2.585	3.895	5.185	5.215
China	300	900	1.000	1.100	1.100
Middle East	325	1.050	1.885	2.600	2.600
Japan	50	100	130	170	180
Others	225	535	880	1.315	1.335

Therefore, for the year 2005:

Total imported by China = 1,100 thousand tons

Total imported by Asia = 5,215 thousand tons

Chinese imports as a % of Asian imports $= \frac{1,100}{5,215} \times 100 = 21\%$

B CALCULATION OF THEORETICAL CAPACITY OF EQUIPMENT TO MEET THE PROJECTED DEMANDS, WITH THE UTILIZATION RATE FIXED AT $\sigma_1 = 40\%$; $\sigma_2 = 50\%$

YEAR	T	$R_t(\sigma_1)$	$R_t(\sigma_2)$	YEAR	T	$R_t(\sigma_1)$	$R_t(\sigma_2)$	YEAR	T	$R_t(\sigma_1)$	$R_t(\sigma_2)$
1980	650	564	451	1989	1829	1588	1270	1998	2668	2316	1853
1981	761	661	528	1990	1944	1688	1350	1999	2677	2323	1859
1982	891	773	619	1991	2068	1795	1436	2000	2686	2332	1865
1983	1044	906	725	1992	2199	1909	1527	2001	2696	2340	1872
1984	1222	1060	849	1993	2338	2030	1624	2002	2705	2348	1878
1985	1430	1241	993	1994	2487	2159	1727	2003	2715	2357	1885
1986	1520	1319	1056	1995	2640	2292	1833	2004	2725	2365	1892
1987	1617	1404	1123	1996	2649	2300	1840	2005	2735	2374	1899
1988	1719	1492	1194	1997	2659	2308	1847				

Assuming a 1,000 tons/hour capacity for bulk sugar and a 240 tons/hour capacity for sacked sugar, we will proceed to study the utilization rates for the equipment, taking into account the fact that for the year 2005, with rates between 40% and 50%, the theoretical capacity would be, according to the table above, 2,374 tons/hour and 1,899 tons/hour, respectively. These data represent the sum of bulk and sacked export capacities.

C CALCULATION OF UTILIZATION RATE (σ) FOR BULK SUGAR EXPORT; WITH A 1,000 TONS/HOUR MODULE

YEAR	T (1.000)	(1000 t/h) σ_1	(2000 t/h) σ_2
1980	513	18	9
1981	601	21	10
1982	704	24	12
1983	825	29	14
1984	965	34	17
1985	1130	39	20
1986	1201	42	21
1987	1277	44	22
1988	1358	47	24
1989	1445	50	25
1990	1536	53	27
1991	1634	57	28
1992	1737	60	20
1993	1847	64	32
1994	1965	68	34
1995	2086	72	36
1996	2093	73	36
1997	2101	73	36
1998	2108	73	37
1999	2115	73	37
2000	2122	74	37
2001.	2130	74	37
2002	2137	74	37
2003	2145	74	37
2004	2153	75	37
2005	2161	75	38

It can initially be seen that starting in 1990 a second module will be needed to maintain the berth utilization rate within the limit of tolerance. The exact determination of the year in which this module should be put into operation will be shown later in this work after all the utilization rates for the other products have been determined.

D CALCULATION OF UTILIZATION RATE FOR EXPORT OF SACKED SUGAR (21%) WITH A 240 TONS/HOUR MODULE

YEAR	T x 1000	σ_1	σ_2
1980	137	20	10
1981	160	23	12
1982	187	27	14
1983	219	32	16
1984	257	37	19
1985	300	43	22
1986	319	46	23
1987	340	49	25
1988	361	52	26
1989	384	56	28
1990	408	59	30
1991	434	63	31
1992	462	67	33
1993	491	71	36
1994	522	76	38
1995	554	80	40
1996	556	80	40
1997	558	81	40
1998	560	81	41
1999	562	81	41
2000	564	82	41
2001	566	82	41
2002	568	82	41
2003	570	82	41
2004	572	83	41
2005	574	83	42

In this case, the second equipment module will start to operate in 1988 when the utilization rate reaches 52%.

E FREQUENCY OF VESSELS FOR BULK AND SACKED SUGAR

Model Type of Ship

Bulk: 80,000 tdw - 64,000 tons/voyage - 1,000 tons/hour until 1990; 2,000 tons/hour after 1990

Sacked: 25,000 tdw - 20,000 tons/voyage - 480 tons/hour

Year	Bulk Sugar		Sacked Sugar	
	Vessels per year	Lay Days	Vessels per year	Lay Days
1980	8	26	7	18
1981	9	29	8	20
1982	11	35	9	23
1983	13	42	11	28
1984	15	48	13	33
1985	18	58	15	38
1986	19	61	16	40
1987	20	64	17	43
1988	21	67	18	45
1989	23	74	19	48
1990	24	77	20	50
1991	26	52	22	55
1992	27	54	23	58
1993	29	58	25	63
1994	31	62	26	65
1995	33	66	28	70
1996	33	66	28	70
1997	33	66	28	70
1998	33	66	28	70
1999	33	66	28	70
2000	33	66	28	70
2001	33	66	28	70
2002	33	66	28	70
2003	34	68	29	73
2004	34	68	29	73
2005	34	68	29	73

- Lay days for bulk sugar carriers:

  until 1990 - 3.2 days
  after 1990 - 2.0 days

- Lay days for sacked sugar carriers: 2.5 days

F DETERMINATION OF THE STATIC CAPACITIES OF BULK AND SACKED SUGAR WAREHOUSES

Based on the reasoning employed to dimension the wheat silo static capacity, i.e., assuming arrival of the largest vessel that would carry this cargo, which, for sugar, would be 125,000 tdw, with 100,000 tons of cargo per voyage, the results would be:

BULK SUGAR BY 100,000 TONS/VOYAGE VESSEL

- maximum receiving capacity by railroad = 500 tons/hour
- maximum receiving capacity by highway = 250 tons/hour

  750 tons/hour

- receiving hours per day = 8 hours

  ∴ 750 x 8 = 6,000 tons/day

- loading capacity per shiploader = 1,000 tons/hour
- shipping hours per day = 20 hours

  ∴ for the year 2005 : 2 x 1,000 x 20 = 40,000 tons/day

Days	Receiving	Shipping	Differences
D	6,000 tons	40,000 tons	-34,000 tons
D + 1	6,000 tons	40,000 tons	-68,000 tons
D + 1.5	3,000 tons	20,000 tons	-85,000 tons
TOTAL	15,000 tons	100,000 tons	-85,000 tons

Therefore using the same coefficient of safety as used for wheat (25%) we have: 85,000 tons + 25% = 106,250 tons.

Considering this product's season and the not unrealistic possibility of a second vessel's arriving at the end of eight days, as shown below:

- Projected sugar exports for 2005 : 2,161,000 tons

  2,161,000 tons/year ÷ 100,000 tons/vessel
  ≅ 22 vessels/year
  or 22 vessels/year ÷ 8 months/year ≅ 3 vessels/month

or: $\frac{23 \text{ days}}{\text{month}} \div$ 3 vessels/month $\simeq$ 1 vessel/8days

The cycle would be:

ARRIVALS	VESSEL 1 ARRIVAL	VESSEL 1 CARGO	VESSEL 2 ARRIVAL	VESSEL 2 CARGO	TOTAL DAYS
DAYS	0	2.5	5.5	2.5	10.5

Therefore:

- receiving capacity per 10.5 days = 10.5 x 6,000 = 63,000 tons
- shipping in 10.5 days = 200,000 tons (2 100,000 vessels)
- difference: 137,000 tons

Assuming a 25% margin, the result is: 137,000 tons + 25% = 171,200 tons

G SACKED SUGAR FOR 20,000 TONS/VOYAGE VESSELS

By the same line of reasoning we arrive at the choice of a 25,000 ton warehouse.

H AREA NEEDED FOR THE BASIC LAYOUT

It is estimated than an area 140 m x 160 m will be sufficient for construction of a 13,200 m^2 sugar warehouse; the projected area will provide the needed space for circulation of vehicles.

5.3.3. FACILITIES FOR LIQUIDS

A ALCOHOL

Working Hypotheses:

For alcohol we adopted the same working hypotheses as were adopted for sugar, including the same product season.

Calculation of theoretical capacity for utilization rate limits of: $\sigma_1 = 30\%$, $\sigma_2 = 40\%$, $\sigma_3 = 50\%$

YEAR	T	$R_n \cdot (\sigma_1)$	$R_n\ (\sigma_2)$	$R_n\ (\sigma_3)$
1980	113	87	65	52
1981	120	93	69	56
1982	127	98	74	59
1983	134	103	78	62
1984	142	110	82	66
1985	151	117	87	70
1986	154	119	89	71
1987	156	120	90	72
1988	159	123	92	74
1989	162	125	94	75
1990	165	127	95	76
1991	168	130	97	78
1992	171	132	99	79
1993	174	134	101	81
1994	178	137	103	82
1995	181	140	105	84
1996	181	140	105	84
1997	181	140	105	84
1998	181	140	105	84
2000	181	140	105	84
2001	181	140	105	84
2002	181	140	105	84
2003	181	140	105	84
2004	181	140	105	84
2005	181	140	105	84

Calculation of the utilization rate σ assuming a 150 tons/hour flow capacity for each module.

YEAR	σ_1 (150)	σ_2 (300)
1980	17	9
1981	19	9
1982	20	10
1983	21	10
1984	22	11
1985	23	12
1986	24	12
1987	24	12
1988	25	12
1989	25	13
1990	25	13
1991	26	13
1992	26	13
1993	27	13
1994	27	14
1995	28	14
1996	28	14
1997	28	14
1998	28	14
1999	28	14
2000	28	14
2001	28	14
2002	28	14
2003	28	14
2004	28	14
2005	28	14

A 300 tons/hour capacity was adopted.

FREQUENCY OF SHIPS

Model vessel type: 25,000 tdw tanker - 20,000 tons/voyage

Shipping capacity: 300 tons/hour

Lay days per ship: 20,000 : 300 : 20 = 3 days

YEAR	1.000 T	Number of Vessels	Lay Days
1980	113	6	18
1981	120	6	18
1982	127	6	18
1983	134	7	21
1984	142	7	21
1985	151	8	24
1986	154	8	24
1987	156	8	24
1988	159	8	24
1989	162	8	24
1990	165	8	24
1991	168	8	24
1992	171	9	27
1993	174	9	27
1994	178	9	27
1995	181	9	27
1996	181	9	27
1997	181	9	27
1998	181	9	27
1999	181	9	27
2001	181	9	27
2002	181	9	27
2003	181	9	27
2004	181	9	27
2005	181	9	27

Determination of the tankage static capacity. Three basic years were chosen to get an idea of the increases in total capacity necessary, according to the criteria, to establish each tank's capacity, assuming that tankers will not arrive every month.

Year / Exp.	1980		1990		2005	
	Per Year	Per Month	Per Year	Per Month	Per Year	Per Month
Tonnage	113,000	14,125	165,000	20,625	181,000	22,625

Assuming tanks with the following characteristics:

Dimensions: $\varnothing = 25$ m

$h = 12.00$ m

$V = 5,891\ m^3$

Capacities: a) 4,700 tons

b) 5,890,500 liters

we would have the following:

No. of tanks necessary = $\frac{14,125}{4,700} = 3,000 \sim$ 3 tanks (1980)

$\frac{20,625}{4,700} = 4.4$ - 5 tanks (1990)

$\frac{22,625}{4,700} = 4.8$ - 5 tanks

B MOLASSES

Working Hypotheses:

Since molasses is a sub-product of the sugar industry, we adopted the same hypotheses as used for sugar.

Calculation of the theoretical capacity for a utilization rate limit: $\sigma_1 = 25\%$

YEAR	T	R_n (σ_1)
1980	109	151
1981	170	236
1982	234	325
1983	302	419
1984	374	519
1985	450	625
1986	485	674
1987	521	724
1988	558	775
1989	595	826
1990	634	881
1991	673	934
1992	714	992
1993	756	1.050
1994	798	1.108
1995	842	1.169
1996	850	1.181
1997	858	1.192
1998	867	1.204
1999	875	1.215
2000	883	1.226
2001	892	1.239
2002	900	1.250
2003	908	1.261
2004	917	1.274
2005	925	1.285

Calculation of the utilization rate (σ) for the capacities below:

Modules			
σ_1 (300)	σ_2 (450)	σ_3 (600)	σ_4 (900)
13	8	6	4
20	13	10	7
27	18	14	9
35	23	18	12
43	29	22	14
52	35	26	17
56	37	28	19
60	40	30	20
65	43	32	22
69	46	34	23
73	49	37	25
78	52	39	26
83	55	41	28
88	58	44	29
92	62	46	31
97	65	49	33
98	66	49	33
99	66	50	33
100	67	50	34
101	68	51	34
102	68	51	34
103	69	52	34
104	69	52	35
105	70	53	35
106	71	53	35
107	71	54	36

A minimum capacity of 600 tons/hour was chosen to assure lay days = 30,000 tons : 600 tons/hour : 20 hours/day ≈ 3 days

FREQUENCY OF VESSELS

Model type of vessel

38,000 tdw tanker - 30,000 tons/voyage

YEAR		No. of SHIPS	No. of SHIPS PER MONTH
1980	109	4	Less than 1
1981	170	6	Less than 1
1982	234	8	Less than 1
1983	302	10	1
1984	374	13	1
1985	450	15	1
1986	485	16	1
1987	521	17	1
1988	558	19	2
1989	595	20	2
1990	634	21	2
1991	673	22	2
1992	714	24	2
1993	756	25	2
1994	798	27	2
1995	842	28	2
1996	850	28	2
1997	858	29	2
1998	867	29	2
1999	875	29	2
2000	883	29	2
2001	892	30	3
2002	900	30	3
2003	908	30	3
2004	917	31	3
2005	925	31	3

Static capacity of the tanks:

according to the calculation criteria adopted, for the years 1980, 1990 and 2005 we would have:

Year	1980		1990		2005	
Export	Year	Month	Year	Month	Year	Month
Tonnage	109,000	13,625	634,000	79,250	925,000	115,625

Tank adopted for molasses: $\emptyset = 25$ m

$h = 14.50$ m

$V = 7,118\ m^3$

Capacity: a) 10,300 tons

b) 7,117,660 liters

1980 --- $\frac{13,625}{10,300} = 1.3 \sim 2$ tanks

1990 --- $\frac{79,250}{10,300} = 7.7 \sim 8$ tanks

2005 --- $\frac{115,625}{10,300} = 11.23 \sim 12$ tanks

C VEGETABLE OILS

Working Hypotheses:

Same as previously used, with the exception of season, which does not exist.

CALCULATION OF UTILIZATION RATE FOR 150 tons/hour CAPACITY PER MODULE:

YEAR	1.000 T	σ_1 (150)	σ (300)
1980	30	5	2
1981	34	5	3
1982	40	6	3
1983	46	7	4
1984	52	8	4
1985	60	9	5
1986	61	9	5
1987	62	10	5
1988	63	10	5
1989	64	10	5
1990	65	10	5
1991	66	10	5
1992	67	11	5
1993	68	11	5
1994	69	11	5
1995	70	11	5
1996	71	11	5
1997	72	11	5
1998	73	11	5
1999	74	12	6
2000	75	12	6
2001	76	12	6
2002	77	12	6
2003	78	12	6
2004	79	12	6
2005	80	12	6

For berth arrangement purposes, a 300 tons/hour capacity was adopted:

FREQUENCY OF VESSELS

Model type of vessel: 15,000 tdw bulk carrier - 12,000 tons/voyage

Capacity = 200 tons/hour

YEAR	1.000 T	NUMBER OF SHIPS
1980	30	3
1981	34	3
1982	40	3
1983	46	4
1984	52	4
1985	60	5
1986	61	5
1987	62	5
1988	63	5
1989	64	5
1990	65	6
1991	66	6
1992	67	6
1993	68	6
1994	69	6
1995	70	6
1996	71	6
1997	72	6
1998	73	6
1999	74	6
2000	75	6
2001	76	6
2002	77	6
2003	78	7
2004	79	7
2005	80	7

4 Static capacity of the tanks:

Based on the same reasoning as used for the other liquids, we have:

Year / Export	1980		1990		2005	
	Year	Month	Year	Month	Year	Month
Tonnage	30,000	2,500	65,000	5,417	80,000	6,667

Tank adopted:

Dimensions: $\varnothing = 20$ m

$h = 9$ m

$V = 2,827\ m^3$

Capacities: in tons ~ 2,700 tons

in liters 2,827,430 liters

No. of tanks necessary:

$$1980 \text{ --- } \frac{2,500}{2,700} = 0.93 \sim 1 \text{ tank}$$

$$1990 \text{ --- } \frac{5,417}{2,700} = 2.04 \sim 2 \text{ tanks}$$

$$2005 \text{ --- } \frac{6,667}{2,700} = 2.47 \sim 3 \text{ tanks}$$

TOMO II
PARTE I
VOLUME 2
6.0

6.0 PHYSICAL PLAN OF THE PORT COMPLEX

6.0 PHYSICAL PLAN OF THE PORT COMPLEX

The area destined for the port complex is priviledged in terms of topography, It has large flat areas with estensive filled and leveled ground by the waterfront area on the order of 18 to 20 hectares, as well as approximately 12 hectares of flat backland in the direction of the fishing port.

Since the site also has elevations of up to 60 m, it is intended to construct platforms by cutting into the hillsides to make use of the force of gravity, rather than pumping equipment, for loading liquids onto ships.

Finally, it was decided that the valley existing in the area to the north of the waterfront area would be used for access to the port complex. The valley possesses the required technico-economic characteristics, such as ample curves and gentle slopes.

6.1 FINAL ARRANGEMENT

Based on the berth utilization rates, a summary of which is presented below, it can be seen that by the end of the first stage four sections of docks will be needed to meet the import and export demand that will occur in the Suape port complex, without the danger of reaching the maximum tolerable utilization rate.

SUMMARY TABLE OF UTILIZATION RATES
(in %)

Product / Year	Bulk Sugar	Sacked Sugar	Molasses	Alcohol	Veg. Oils	Wheat (Import)	Wheat (Export)	TOTAL	TOTAL 4 Berths
1980	18	10	6	9	2	35	12	92	23
1981	21	12	10	9	3	37	12	104	26
1982	24	14	14	10	3	39	13	117	29
1983	29	16	18	10	4	41	14	132	33
1984	34	19	22	11	4	43	14	147	37
1985	39	22	26	12	5	45	15	164	41
1986	42	23	19	12	5	23	16	140	35
1987	44	25	20	12	5	24	16	146	36,5
1988	47	26	22	12	5	25	17	154	38,5
1989	50	28	23	13	5	27	18	164	41
1990	53	30	25	13	5	28	19	173	43
1991	28	31	26	13	5	29	20	152	38
1992	30	33	28	13	5	30	21	160	40
1993	32	36	29	13	5	31	22	168	42
1994	34	38	31	14	5	33	23	178	44,5
1995	36	40	33	14	5	34	24	186	46,5
1996	36	40	33	14	5	35	24	187	47
1997	36	40	33	14	5	35	24	191	47
1998	37	41	34	14	5	35	25	193	48
1999	37	41	34	14	6	36	25	193	48
2000	37	41	34	14	6	36	25	194	48
2001	37	41	34	14	6	37	25	196	48,5
2002	37	41	35	14	6	37	26	196	49
2003	37	41	35	14	6	38	26	197	49
2004	37	41	35	14	6	38	26	197	49
2005	38	42	36	14	6	39	27	202	50,5

A basic layout for the projected facilities thus remains to be established.

Each type of product to be imported or exported through the port complex possesses inherent characteristics that require that a separate analysis be conducted for each.

For <u>wheat</u>, the type of soil for foundations is important because there will be a large concentration of cargo in a small area. Analysis of existing geophysical studies and drillings shows that the soil improves markedly when approaching the hills in the area. It was therefore decided to locate the wheat silo in this region, without, however, placing it so far away from the docks that high costs are conveyor belts are incurred. The summary table also suggests, in terms of utilization rates, the opening of two berths, one for export by coastal trade and the other for import by long run vessels.

For <u>sugar</u>, the required area is large and favors a more uniform load on the soil. It was therefore decided that the sugar terminal should be located as close as possible to the apron of the dock, allowing an appropriate distance for traffic in the waterfront area. The requirements of a bagged sugar terminal for small ships would conflict with the requirements of a bulk sugar terminal for 125,000 tdw bulk carriers since the smaller ships used to export bagged sugar would underutilize the depths offered in the area. It was therefore decided to place a closing dock at the extreme west of the port complex since the channel opened there will be well utilized if a fishing terminal is opened in the area.

For the <u>liquids</u>, the slopes of nearby hills were used to optimize the trade-off between the elevations of the tank bases and the technico-operational difficulties involved in constructing an access road to the tanks to take advantage of gravity when unloading the truck cargos.

For alcohol, however, the hazardous nature of this product influenced the choice of the rear hillside for the tanks; the hollow formed there will also be used for the pipeline descent. This hollow could also be used to form a retaining basin to protect the port complex in the event that overflows or fires occur. The 25 m elevation there will provide, according to studies conducted, a flow rate of approximately 500 tons/hour, which is higher than that projected for determination of utilization rates; this increase due to total use of gravity balances the cost of installing the underground ducts. The low viscosity of the product will require that it be pumped to receiving areas.

For vegetable oils, which are more viscous than alcohol, the hillside facing the docks was chosen. The +15 m elevation of the site will decrease the pipeline length and will attain, according to studies conducted, the same flow rate as for alcohol, 500 tons/hour, with a considerable margin in relation to the flow rate used to calculate the berth utilization rates.

For molasses, a very viscous product with a high specific weight (~1.4 tons/m^3), it was decided to locate facilities at a lower elevation (+5 m), which will shorten the pipeline length. Use of pumping equipment to attain a 900 tons/hour flow rate will assure rapid loading of the product. These pipelines, like the vegetable oil pipelines, will run at ground level to the pumping houses, and the high temperatures in the area will increase the liquids' fluidity. From there the liquids will be pumped through underground pipes with inspection posts at regular intervals. These inspection posts will be located in a manner so that they don't interfere with waterfront vehicles.

Finally, the large area of naturally level ground behind the sugar terminal was chosen for the administration buildings, maintenance and repair shops and other facilities.

6.2 FUNCTIONALITY

6.2.1 SUGAR TERMINAL

As already mentioned, the physical location of the sugar terminal, to the west of the port, would be optimized in terms of draft (16.50 m), since the gross tonnage of the largest vessel projected, 125,000 tdw, would call at the docks for bulk sugar, and the smaller ships for bagged sugar would call at the closing docks, at a 90° angle to the bulk sugar docks, in waters of a minimum depth of -12 m.

The types of equipment used there, namely those with capacities of 250 tons/hour for receiving sugar from trucks and 500 tons/hour for receiving sugar from railroad cars, and those for loading sugar at a rate of 2,000 tons/hour, are highly mechanized and would require minimum labor inputs.

This terminal would also have highway/railroad access with specific spurs to permit rapid circulation of both railroad cars and trucks. This traffic will be facilitated by the equipment effectiveness and the large parking areas outside of the terminal area. The same can be asserted for the railroad shunting yard.

6.2 WHEAT TERMINAL

Since the wheat silo would be situated in the second line of storage, its internal movement would rarely interfere with port operations, especially since the parking lot was projected to be located behind the silo.

Shipping of wheat by land, with equipment for a rate of 200 tons/hour, was projected for the area between the silo and the hillside.

Wheat will be unloaded by pneumatic elevators mounted on two rolling gantries, with 400 tons/hour capacity each. The second gantry would be implemented in 1985.

Shipping by coastal trade would use the second berth and rolling gantries with 600 tons/hour capacity. If sugar operations were expanded to use this second berth, the wheat equipment would move to the fifth berth, immediately after the berth where importing will be achieved by simple shipping conveyor belt rehandling.

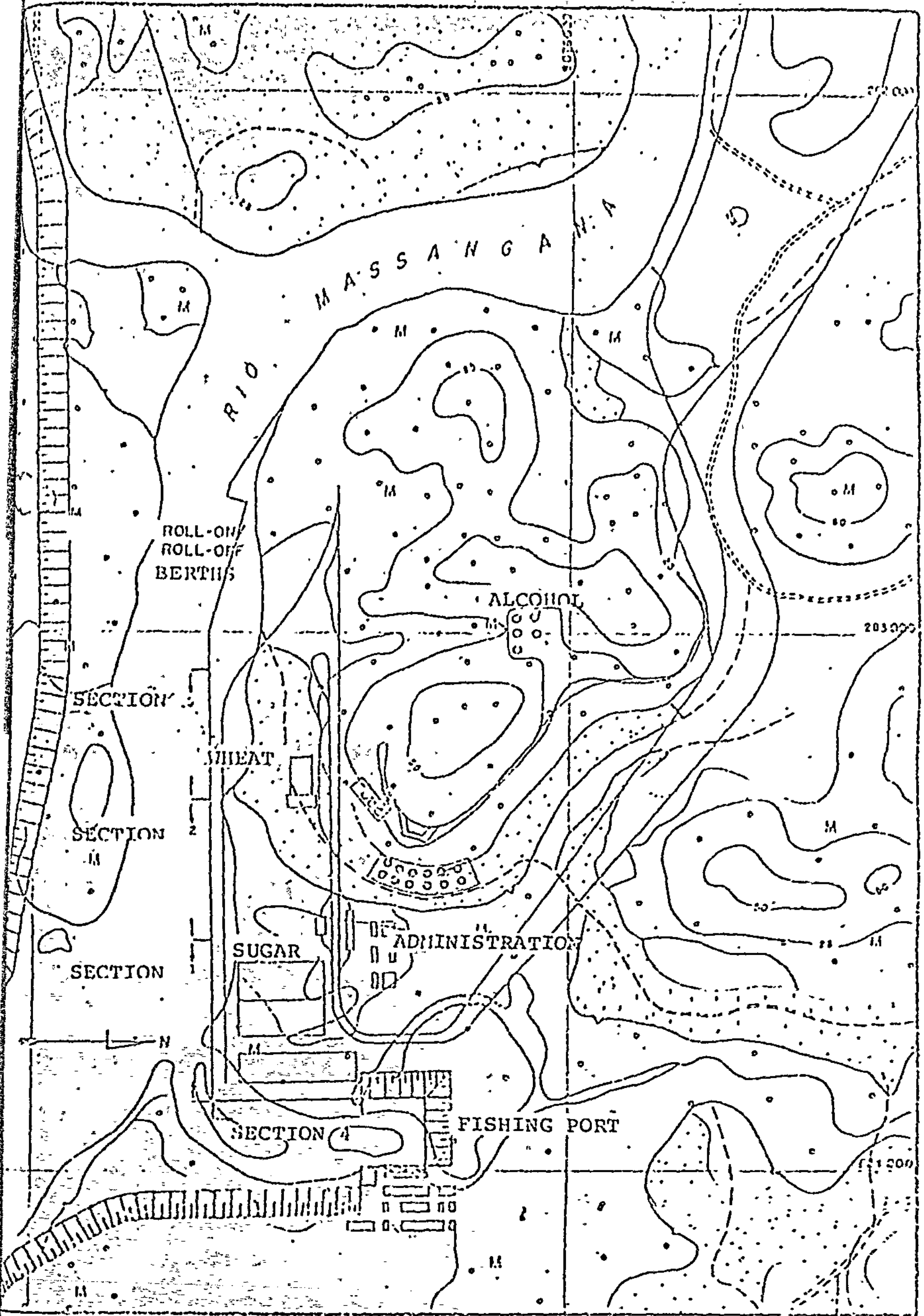
6.2.3 LIQUIDS

The pipelines should run along the entire length of the docks, rathen than to a single terminal designated exclusively for these products. This will minimize slack time in the other berths rather than compromise the utilization rate.

The liquids terminal will have two truck weighing scales to permit rapid throughput for highway shipping.

In general, it was attempted to give the port complex layout ample flexibility to accomodate unforeseen demands. Large areas were left free for construction of yards or warehouses.

These areas could accomodate lash barge operations and heavy cargos for the industries being built in the Industrial Complex.



Length=300.00m
Depth = 16.50m
Vessels=125,000tdw
Length=260.00m
Depth = 14.50m
Vessels=80,000 tdw
Length=280.00m
Depth = 12.00m
Vessels=250,000tdw

FIGURE - 3.4.1

SCALE

COMPLEXO INDUSTRIAL DE SUAPE

LOCATION OF THE PORT COMPLEX'S FACILITIES

6.3 BUDGET ESTIMATES

6.3.1 WHEAT FACILITIES

A Civil Constructions:

a)	Block of bins	Cr$	15,000,000
b)	Lifting tower	Cr$	8,000,000
c)	Conveyor lines infrastructure .	Cr$	400,000
d)	Water and sewage system	Cr$	800,000
e)	Paving, drainage, parking area and highway access to the silo.	Cr$	600,000
	SUBTOTAL	Cr$	24,800,000

B Mechanical Equipment:

a)	Pneumatic unloading equipment (2 pneumatic elevators, 400 tons/hour capacity each, the 1st by 1980 and the 2nd by 1985)	Cr$	9,200,000
b)	Equipment to connect the docks to the silo, such as conveyors, galleries, transfer towers and accessories: 2 x 400 m for 400 tons/hour	Cr$	4,000,000
c)	Internal silo operating equipment such as scales, dusters, valves, etc.	Cr$	11,000,000
d)	Internal silo equipment for 800 tons/hour shipping, including conveyors, weighing equipment for shipments, etc. . . .	Cr$	3,200,000
e)	Auxiliary equipment, including elevators, hoists, laboratory equipment, compressed air and distribution network	Cr$	900,000

f) Shipping equipment:

1. Transporting equipment from the silo to dockside, including conveyors, galleries, transfer towers, accessory equipment:
   2 x 400 m at 800 tons/hour . . . Cr$ 4,000,000

2. Shiploader for 800 tons/hour . . Cr$ 4,500,000

SUBTOTAL . . . . Cr$ 36,800,000

C **Electrical System:**

a)	Substation	Cr$	900,000
b)	Distribution panels	Cr$	3,200,000
c)	Signalling panels	Cr$	800,000
d)	Control stand	Cr$	1,500,000
e)	Control equipment	Cr$	900,000
f)	Lighting panels	Cr$	250,000
g)	Electrical equipment	Cr$	4,000,000
	SUBTOTAL	Cr$	12,150,000
	T O T A L (A + B + C)	Cr$	73,750,000

6.3.2 SUGAR TERMINAL

A **Civil Constructions:**

a)	Horizontal slip, 140 x 160 m	Cr$	44,800,000
b)	Receiving hoppers - 1 for 4 rail-	Cr4	550,000
	road cars and 1 for 1 truck	Cr$	50,000
c)	Shops: 30 x 10 m	Cr$	300,000
d)	Sacked sugar warehouse	Cr$	11,880,000
e)	Sacking facilities with a breathing silo	Cr$	640,000
f)	Water and sewage system	Cr$	1,000,000
g)	Paving, drainage, parking area, railroad and highway access	Cr$	4,000,000
	SUBTOTAL	Cr$	63,220,000

B **Transporting Equipment:**

a)	Conveyor belt, 140 m for 500 tons/hour	Cr$	2,200,000
b)	Trippers	Cr$	120,000
	SUBTOTAL	Cr$	2,320,000

C **Shipping:**

a)	Conveyor belts for 500 tons/hour . .	Cr$	3,900,000
b)	Conveyor belt for 1,000 tons/hour .	Cr$	1,700,000
c)	Rolling gantry for 1,000 tons/hour . . (until 1985)	Cr$	4,200,000
d)	Rolling gantry for 1,000 tons/hour (after 1985)	Cr$	4,200,000
e)	Galleries, etc.	Cr$	1,000,000
f)	Rotary shovels to reclaim sugar . .	Cr$	10,000,000
g)	Weighing station with 2 flow scales	Cr$	1,500,000
	SUBTOTAL	Cr$	26,500,000

D **Sacking Facilities:**

a)	Sacking equipment for 480 tons/hour	Cr$	1,500,000
b)	Internal transporting equipment including conveyor belts for bulk and sacked sugar, transfer towers and accessory equipment	Cr$	500,000
c)	Conveyor belts for sacked sugar, 40 m long, for 480 tons/hour	Cr$	120,000
d)	Conveyor belts for sacked sugar warehouse, including transfer tower	Cr$	660,000
e)	Direct conveyor belt to the docks, including transfer tower for 480 tons/hour in 350 m	Cr$	1,050,000
f)	Rolling gantry for 480 tons/hour . .	Cr$	4,200,000
g)	Shiploader with slewing boom from docks to ship	Cr$	2,000,000
	SUBTOTAL	Cr$	10.030,000

E Electrical and Other Systems:

a)	Electrical installations, auxiliary equipment, utilities, etc.	Cr$	10,000,000
	SUBTOTAL	Cr$	10,000,000
	GRAND TOTAL	Cr$	112,070,000

6.3.3 LIQUID BULK TERMINAL

A Molasses:

Civil Constructions

a)	Landfill, cuts, embankment treatment, drainage, paving	Cr$	850,000
b)	Tanks: 12 x 7,150 m^3	Cr$	12,870,000
c)	Infrastructure to support pipelines.	Cr$	150,000
	SUBTOTAL	Cr$	13,870,000

Mechanical Equipment:

a)	Receiving equipment, including troughs, piping, valves, etc. . . .	Cr$	120,000
b)	Shipping equipment, including piping, force pump, accessory equipment, etc.	Cr$	900,000
	SUBTOTAL	Cr$	1,020,000
	GRAND TOTAL	Cr$	14,890,000

B Alcohol:

Civil Constructions

a)	Landfills, cuts, etc.	Cr$	1,500,000
b)	Tanks: 5 x 5,900 m^3	Cr$	4,425,000
	SUBTOTAL	Cr$	5,925,000

Mechanical Equipment

a)	Receiving equipment including pumps, piping system, etc.	Cr$	23,000

b)	Shipping equipment including underground pipeline, accessory equipment, etc.	Cr$	1,000,000
	SUBTOTAL	Cr$	1,023,000
	GRAND TOTAL	Cr$	6,948,000

C **Vegetable Oils:**

Civil Constructions

a)	Cuts, landfills, etc.	Cr$	294,000
b)	Tanks: 3 x 2,850 m^3	Cr$	1,282,500
c)	Receiving pipeline infrastructure .	Cr$	30,000
	SUBTOTAL	Cr$	1,606,500

Mechancial Equipment

a)	Receiving equipment, including troughs, piping, valves, etc. . . .	Cr$	24,000
b)	Shipping equipment, including underground piping, joints, valves, etc.	Cr$	900,000
	SUBTOTAL	Cr$	924,000
	GRAND TOTAL	Cr$	2,530,500

D **Fuel Oil:**

Civil Constructions

a)	Cuts, landfills, etc.	Cr$	30,200
b)	Tank: 5,900 m^3 x 150/m^3	Cr$	885,000
	SUBTOTAL	Cr$	915,200

Mechanical Equipment

a)	Receiving equipment, including piping, valves, force pump, etc., 20 x 230 .	Cr$	4,600
b)	Shipping equipment, including underground pipeline, suction and pumping pumps, accessory equipment, 320 x 600	Cr$	792,000
	SUBTOTAL	Cr$	796,600
	GRAND TOTAL	Cr$	1,711,800

E Auxiliary Equipment and Constructions:

a)	2 highway weigh scales and accessory equipment	Cr$	400,000
b)	Control house and office, covered weighing yard, etc., 10 x 40 m . . .	Cr$	600,000
c)	Highway access to the tank area . . .	Cr$	1,800,000
d)	Water, sewage, fire prevention system	Cr$	1,500,000
e)	Electrical installations	Cr$	2,000,000
	SUBTOTAL	Cr$	6,800,000

6.3.4 GENERAL WORKS IN THE PORT COMPLEX

A Administration Area:

a)	Administration buildings: 10 x 30 m .	Cr$	300,000
b)	Work site, sanitary, customs, medical and police stations: 20 x 30 m	Cr$	600,000
c)	Shops, covered yard: 40 x 30 m . . .	Cr$	1,080,000
d)	Water, light, power and sewage systems	Cr$	2,000,000
e)	Landfills, paving, drainage of Administration area	Cr$	240,000
	SUBTOTAL	Cr$	4,220,000

B Highway/Railroad Access:

a)	Road to the Administration area . . .	Cr$	1,575,000
b)	Local railroad access	Cr$	2,200,000
c)	Railroad yard, with marshalling tracks, parking, surface treatment, dredging of the site	Cr$	1,900,000
	SUBTOTAL	Cr$	5,675,000

6.3.5 RANGE OF CHANNELS AND LANDFILLS FOR 125,000, 80,000, 60,000 and 25,000 TDW VESSELS

A Landfills

a)	Railroad spur	Cr$	4,000,000
b)	Treating landfill surfaces, drainage	Cr$	2,400,000

c)	Water, sewage, light, power and vessel servicing systems	Cr$	3,000,000
d)	Landfill of the area	Cr$	2,496,000
	SUBTOTAL	Cr$	11,896,000

B Docks:

1.	Platform	Cr$	19,000,000
2.	Simple Piles	Cr$	43,500,000
3.	Sheet Piles	Cr$	25,500,000
4.	Reconstitution of Land	Cr$	18,700,000
5.	Preliminary Services	Cr$	30,000,000
6.	Tie up Posts	Cr$	792,000
	SUBTOTAL	Cr$	137,492,000
	GRAND TOTAL (A + B)	Cr$	149,388,000

TOMO IX
PARTE I
[illegible]
7.0

7.0 PHYSICAL PLAN OF THE PORT COMPLEX DOCKS

7.0 PHYSICAL PLAN OF THE PORT COMPLEX DOCKS

7.1 DESCRIPTION

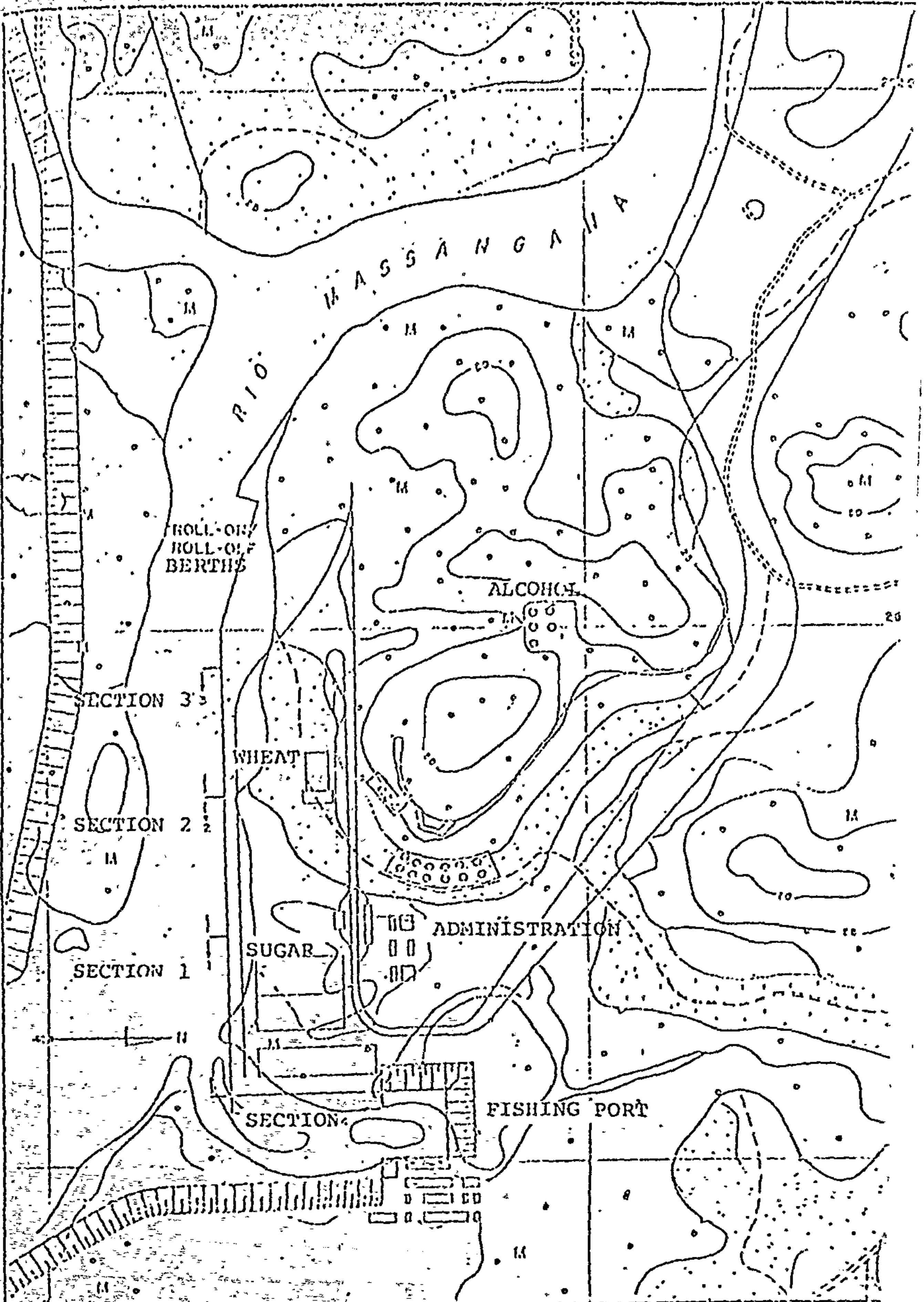
In view of the site's geotechnical conditions, the soft to very soft layer of clay between depths of 7.0 to 20.0 meters, and because of the minimum depths of the waters, from 13.00 to 16.50 meters, it was decided that platform docks with a curtain of sheet piles would be used.

This solution presents two alternatives: either partial or total dredging of the clay layer. The first alternative would require a considerable increase in the platform width and the sheet pile dimensions, as well as necessitate partial dredging of the clayey layer due to construction conditions imposed by the clay layer embankment's stability. In view of this factor and other economic aspects, removal of the entire clayey layer was decided upon.

Embankment ratios of V:H::1:5 were assumed for estimating dredging volumes. More detailed geotechnical studies could dictate lower dredging volumes.

After dredging, reformation of land areas by hydraulic fill, with 1:3 embankments, was planned. As soon as the pilings are set in place the platform docks and curtain of sheet piles will be constructed. After this phase the embankments between the dock facing and the curtain of sheet piles should be protected by a sea wall with 1:2.5 embankments.

Finally, backland should be completed behind the curtain of sheet piles.



S1-Length=300.00m
Depth= 16.50m
Vessels=125,000tdw
S2-Length=260.00m
Depth= 14.50m
Vessels=80,000tdw
S3-Length=240.00m
Depth= 13.50m

S4-Length=280.00m
Depth= 12.00m
Vessels=250,000tdw

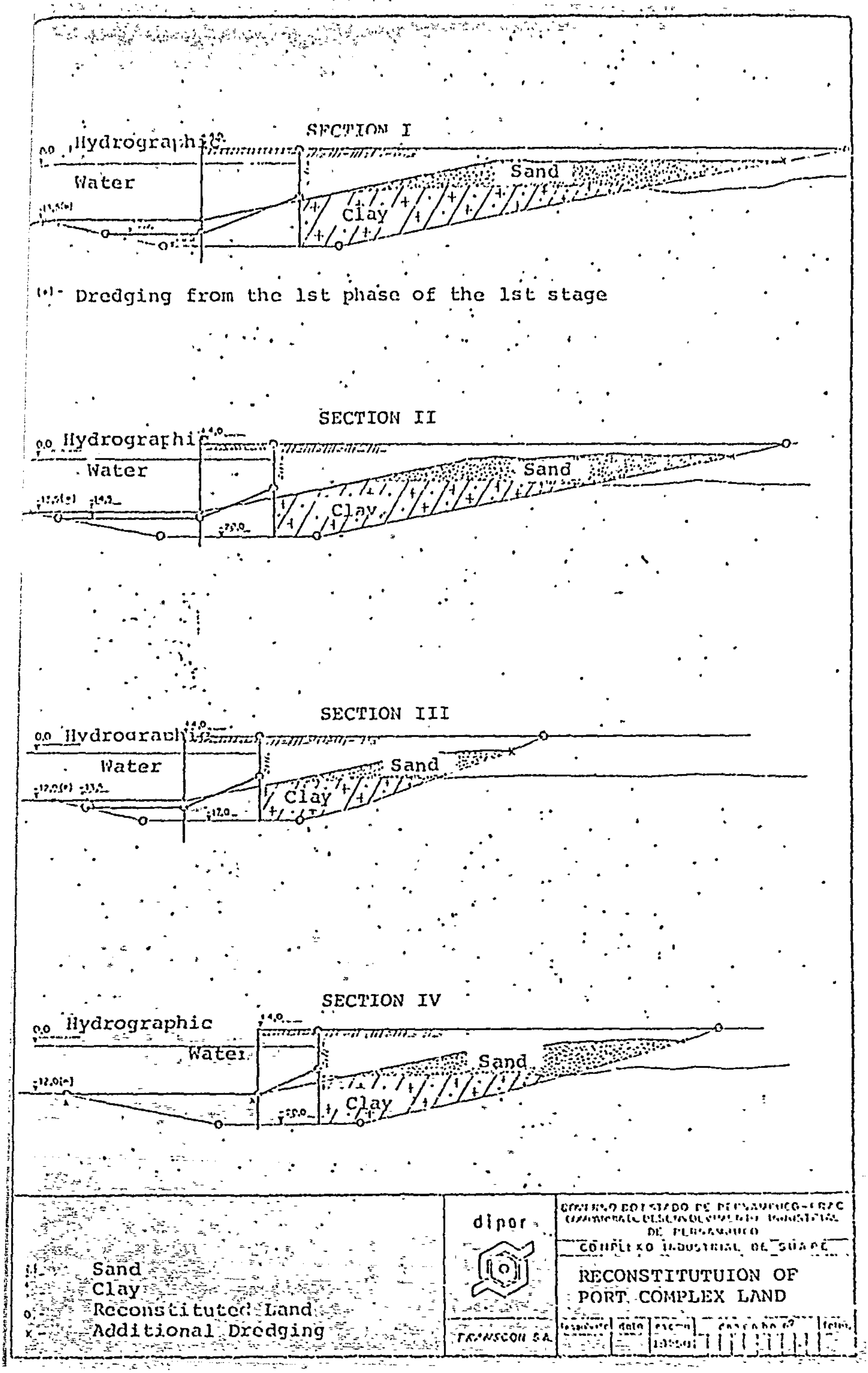
FIGURE - 3.4.1

SCALE

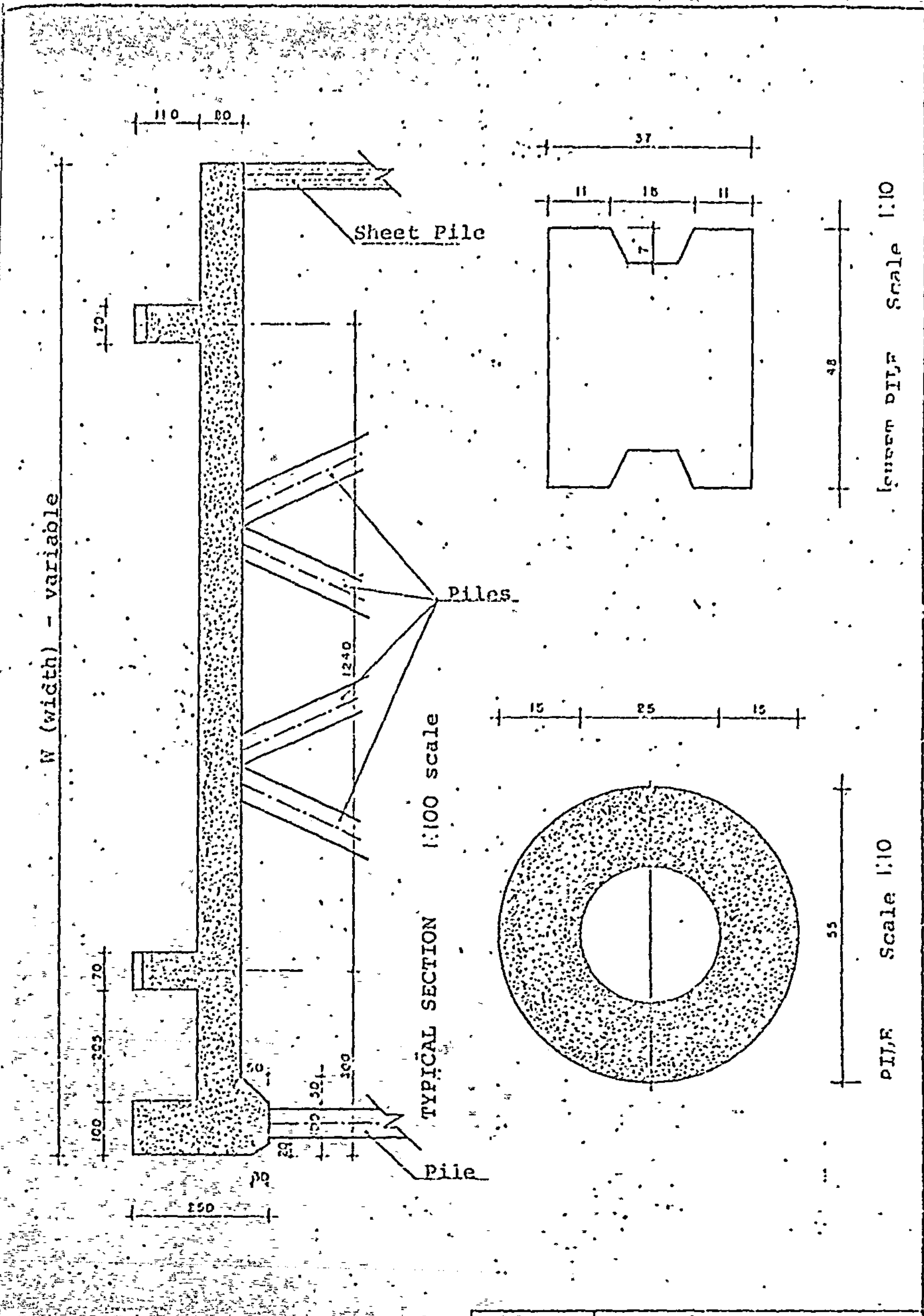
dlpor

COMPLEXO INDUSTRIAL

LOCATION OF THE PO
COMPLEX'S FACILITI



SECTION I
0.0 Hydrographic
Water
Sand
Clay
(*) - Dredging from the 1st phase of the 1st stage
SECTION II
0.0 Hydrographic
Water
Sand
Clay
SECTION III
0.0 Hydrographic
Water
Sand
Clay
SECTION IV
0.0 Hydrographic
Water
Sand
Clay
Sand
Clay
o - Reconstituted Land
x - Additional Dredging
dipor
TRANSCON S.A.
RECONSTITUTUION OF
PORT COMPLEX LAND



tion I	W=25.00m	Section I'	W=18.50m
t Area II	L=300m	Port Area II	L=28[illegible]m
	D=16.50m		D=12.00m
tion II	W=19.50m	Section III	W=19.50m
t Area	L=260m	Port Area IV	L=2[illegible]m
	D=14.50m		D=13.50m

GOVERNO DO ESTADO DE PERNAMBUCO - FRAC
COMPANHIA DE DESENVOLVIMENTO INDUSTRIAL
DE PERNAMBUCO
COMPLEXO INDUSTRIAL DE SUAPE

TYPICAL SECTIONS -
PORT COMPLEX DOCKS

TRANSCON S.A.

TOMO I.

PARTE I

VOLUME I

8.0

8.0 SUGGESTIONS FOR FISHING FACILITIES AND HANDLING SPECIAL VESSELS

8.0 : SUGGESTIONS FOR FISHING FACILITIES AND HANDLING SPECIAL VESSELS

A - Fishing

In an attempt to expand the fishing industry in the future, the implementation of fishing facilities at Suape was suggested. Encouragement of local fishing on a craft scale is mandatory for any development of the fishing industry.

The fishing layout must therefore be flexible enough to permit the takeoff of intense industrialization of the craft level fishing, starting with the formation of fishing cooperatives.

Based on this last statement, the following chronological order for implementation of fishing facilities was suggested:

1st phase

- Hall for receiving and preparing the fish
- Yard for direct sale
- Refrigeration facilities and ice factory
- Navigation support - maintenance and servicing

2nd phase

- Maritime facilities to handle the large vessels the will probably be used for tuna fishing
- Industry for fish products and sub-products
- Navigation support facilities and facilities to support the cooperatives, such as equipment and provisions stores, canteens, etc.

3rd phase

- Expansion of the two previous phases

- Installation of lifting facilities, such as slipways, Sincro-lift, shops, etc., for ship repairs

In this manner the port would be equipped to handle the demands of industrializing the fishing activities, giving Suape a fishing center capable of supplying the local consumer market and perhaps even capable of exporting fish.

B - Roll-on/Roll-off and Lash

Given SUNAMAM's support for the implantation of this type of very functional navegation, and the fact that definite facilities for handling these vessels are projected only for the Master Plan, it is suggested that the port complex have, from the start, provisional facilities capable of receiving Ro-Ro vessels and Lash barges. The latter could anchor in the fore harbour at the Suape beach. This suggestion was motivated by the fact that the Port of Recife is limited and at present is not equipped and does not have sufficient physical space available to handle these special vessels.

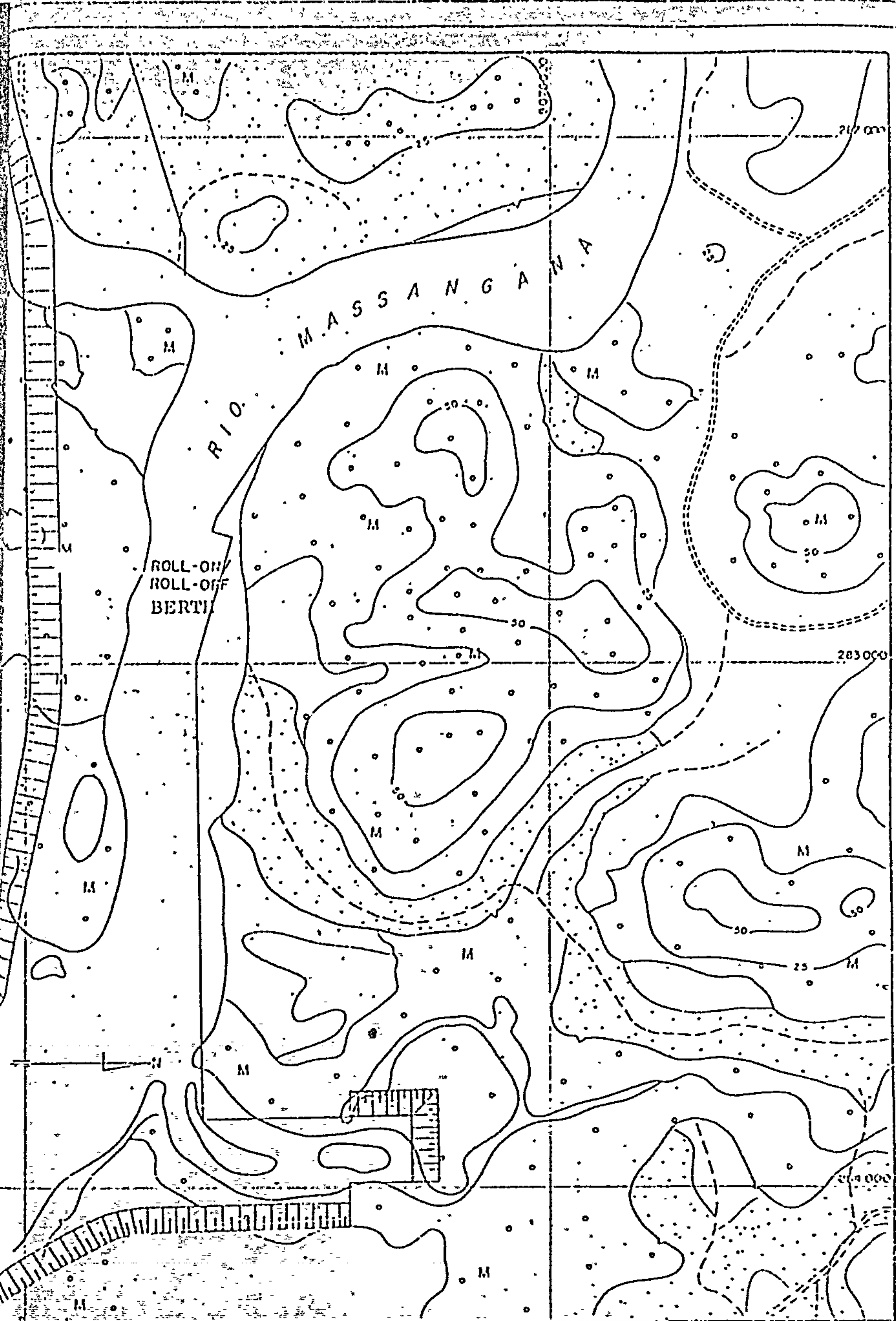


FIGURE - 31

SCALE

dlpor

TRANSCON S.A.

LOCATION OF ROLL-ON
ROLL-OFF FACILITIES

9.0

9.0 NAVIGATION SUPPORT

9.0 NAVIGATION SUPPORT

With the growth in vessel sizes -- one of the most marked phenomena in the present day Merchant Marine fleet, especially for petroleum and ore carrying vessels -- the difficulties in maneuvering these large ships increases substantially, for maneuvers in port entrances and in internal channels and basins, and imposes large scale modifications in port infrastructures.

In order to handle these vessels, the physical plan of a modern port must incorporate very special depth, width, curve radii and shelter conditions so that the vessels encounter the necessary safety and maneuvering ease when moving from one port area to another as well as when approaching docking areas, when docking, and when leaving the docks.

To minimize operating difficulties, large ports have started to be concerned with not only their physical plan characteristics but also with electronic equipment and devices which are grouped under the generic heading "Navigation Support". This equipment is designed to aid navigation of ships in the different port areas, safeguard the navigation, maintain ease of communication between the ship and the port and, finally, process loading and unloading heavy volumes of cargo for which the normal port resources are insufficient.

Naturally the larger the vessels projected to call at the port, the more sophisticated the electronic equipment and devices should be, and the more experienced the steersmen and ships pilots should be. This will require considerable resources, but the high requirements will be largely compensated by vessel safety and will be reflected in lower freight costs or freight expenses.

Among the mandatory equipment for a large, modern port, especially one which intends to handle large vessels, the most important are tugboats and cranes.

In general, Brazilian ports are not very concerned about this type of equipment, whether in terms of the number of tugboats and their power being compatible with the vessels to be handled, or in terms of the cranes' capacity and height hoisted.

This lack of concern, which is not advised even for a port at which medium sized vessels will call, virtually prohibits handling of vessels of 120,000 tdw or more.

In the case of the Port of Suape, for which the design criteria have tried to incorporate the most modern concepts on port activities, this practice will have to be overcome and the practice of obliging all the vessels, or at least the larger ones, to move in the port area only with the aid of tugboats will have to be adopted.

Experience has shown that for handling 60,000 tdw vessels two tugboats are sufficient; for 60,000 to 120,000 tdw vessels, three tugboats; for 120,000 to 170,000 tdw vessels, four tugboats; and for larger vessels, five tugboats. It was therefore planned that the port should have two 1,500 HP tugboats during the initial implementation phase.

To complement this tugboat projection, the port should also have launches to transport personnel that will have to board the ships, and water and oil barges to service an increasing number of ships as the port activity increases.

At a more advanced stage, the port should have a 200,000 ton crane to unload or load large units of cargo which cannot be disassembled.

For moving large vessels in the internal port areas and to facilitate their conditions for approaching the port, the following should be fully assured:

a) Clearly signal the external approach channel so that the vessels can set a course long before coming alongside the first buoys;

b) detect and identify the vessels whose course could threaten the vessels heading for or leaving the port. This includes measures to leave the channel open for these large ships;

c) maintain complete signalling of the internal and external channels not only along their centerlines but also along both lateral limits;

d) determine the position, velocity, direction and trends in the movements of these large vessels and communicate with them to transmit information pertinent to their navigation;

e) gather nautical and meteorological information needed for ship handling, such as visibility conditions, winds, currents, height of the sea, waves, water temperature, etc.

f) routinely transmit this information to the vessels;

g) maintain permanent contact with vessels in or heading for the port;

h) maintain the vessel's position and velocity under control when it is approaching or leaving the docks.

To fulfill this program, the port's external and internal areas should be perfectly signalled with radio beacons, blind buoys and light buoys whose positions are constantly under control. The port should also have electronic equipment, such as radar and decca. This equipment is constantly becoming more and more sophisticated.

The most modern types of radar equipment for ports permit permanent control over port traffic, since they are equipped with special devices for verifying buoy positions in the channels, and providing a security system for the vessels.

The use of Decca equipment, such as the Decca Navigator, permits knowledge, by direct reading, of the distance separating a vessel from the channel's centerline and margins.

These vessel position controls and the information gathered and analyzed at the port's meteorological and hydrographic station could be constantly communication to the ship to assure the maximum safety possible in the port area. To this end, the port should adopt a VHF station and maintain direct communication with all vessels.

Such electronic installations are evolving rapidly and becoming more and more perfect. In order that the port be equipped with the most modern equipment to be found on the market, this equipment should be selected and acquired close to the end of the first phase of the first stage of work.

TOMO III
PARTE 1
VOLUME 1
10.0

10.0 OVERALL BUDGET

WORK	DESCRIPTION	TOTAL BUDGET Cr$ 1,000	TOTAL FOR WORK Cr$ 1,000
Dredging	Dredging the Approach Channel	23,980	462,234
	Dredging for Landfills	353,791	
	Dredging clay and sandstone	68,103	
	Dredging to form the beach	16,360	
Port Complex	Wheat Terminal	73,750	378,183
	Sugar Terminal	112,070	
	Liquid Bulk Terminal	33,080	
	Complementary Works	9,895	
	Docks	149,388	
Protective Works	Sea wall to heighten the Reef; south of the entrance	22,359	86,137
	Sea wall to heighten the Reef; north of the entrance	2,063	
	Linking the Reef to the Cape of Santo Agostinho	1,569	
	Sea wall buttress at the Cape of Santo Agostinho	782	
	Protective Breakwaters at the Port Entrance	59,364	
Navigation Support	Signalling	3,000	25,000
	Decca Radar Location System	3,000	
	Radar Station *	–	
	Meteorological, Hydrographic and Mareographic Station	1,500	
	VHF Radio-Telephone Station	1,500	
	Tugboats	12,000	
	Auxiliary Vessels	4,000	

* Already computed in the Telecommunications budget.

TOTAL = 951,554