11.5 General Port Development plan

11.5.1 Premise of the Planning

As already mentioned in the previous section 11.1, the following development principles are assumed to be the premises of the Port Development Plan up to the year 2010.

(1) Transportation network around Bai Chay Bay will be established

- The high bridge hanging over Cua Luc Strait will be completed.
- The road No 18A and 18B as well as the connection roads will be upgraded and completed so as to pass through the ring traffic around Bay Chay Bay (ring road network will be established).
- Railway facilities and track improvement between Cai Lan and Ha Noi will be completed and necessary branch lines will be constructed.

(2) Hon Gai Port will be relocated to Cam Pha Port.

(3) B - 12 will be removed to Cam Pha Port or outer Ha Long Bay.

(4) Tourism development will be separated from Port development.

(5) The industries and EPZ suggested in Chapter 10 will be operated.

(6) Three cement factories will each have private berths which will be used for domestic transportation and the cement and clinker for export will be transferred mainly by barge from these private berths to public berths.

11.5.2 Cargo Handling Volume and handling type

According to the demand forecast in Chapter 10, cargo volume can be estimated as follows.

Considering the nature of each commodity and easiness of handling and cost, handling type can be decided. (Cf. table 11-5-1)

Table 11-5-1 Cargo Handling Volume by Handling Type

Unit 1000 tons

Commodity	Handling type	In the year 2000	Handling type	In the year 2010
Export				
Ore(tin,manganese,		-	Dry Bulk	545
cupper)				
Metal		-	Break Bulk	71
Rice	Bag	200	Dry Bulk	513
Maize	Dry Bulk	300	Dry Bulk	316
Grained Wheat	Bag	30	Dry Bulk	125
Cement and Clinker	Bag	120	Bag	1,030
General cargo	Dry Bulk	120	Dry Bulk	1,030
Container	Box etc.	37	Box etc.	310
Sub total	Container	94	Container	1,240
		901		5,180
Import				
Coal	Dry Bulk	10	Dry Bulk	31
Other Ore	Dry Bulk	-	Dry Bulk	204
Scrap	Break bulk	287	Break bulk	854
Fertilizer	Bag	103	Bag	124
Chemicals	Drum	89	Drum	525
Asphalt	Drum	30	Drum	120
Wheat grain	Dry Bulk	240	Dry Bulk	1,001
General cargo	Box etc	87	Box etc	702
Container	Container	225	Container	2,807
Sub total		1,071		6,368
Domestic				
Ore Out		-	Dry Bulk	74
Gypsum In		-	Dry Bulk	84
Rice In	Bag	158	Bag	148
Cement &			Bag	190
Clinker Out			Dry bulk	190
steel Out	Break bulk	350	Break bulk	1,050
Fertilizer Out	Bag	74	Bag	153
General Cargo I.O	Box etc	122	Box etc	863
Sub Total		704		2,752
Total		2,676		14,300

The cargo volume by each handling type is shown in table 11-5-2.

The port facilities should be planned based on these results.

Table 11-5-2 Total Cargo Volume

(in the year 2010)

Handling type	Export	Import	Domestic In	Domestic Out	Total
Box etc	310	702	432	431	1,875
Bag	1,030	124	148	343	1,645
Drum	0	645	0	0	645
Dry Bulk	2,529	1,236	84	264	4,113
Break Bulk	71	854	0	1,050	1,975
Container	1,240	2,807	0	0	4,047
Total	5,180	6,368	664	2,088	14,300

11.5.3 Necessary number of Berth

(1) Average cargo handling volume by each ship.

Cai Lan Port is a new port, thus there is no actual ship distribution record. Therefore, the records (average ship size, average loading cargo volume, loading ratio, average cargo handling volume per day per ship) of Hai Phong Port are referred to.

Considering the ship size tendency in the future and high efficiency of cargo handling system, the average cargo handling volume and cargo handling volume per day, per ship can be assumed as followings.

Table 11-5-3 Average Ship Size and Handling Capacity

	Average ship size DWT	Loading ratio	Cargo volume per ship ton	Average cargo handling volume/day/ship ton
Break Bulk	20,000	0.6	12,000	2,400
Dry Bulk	25,000	0.8	20,000	-
(grain)	(30,000)	0.8	(24,000)	10,000 (Grain)
-	-	-	-	6,000 (the other)
Bag and Drum	20,000	0.8	16,000	2,400
General Cargo	15,000	0.6	9,000	1,600(foreign trade)
Container	20,000	0.8	16,000	8,600

(2) Necessary number of berths

If using the above average cargo handling volume per ship per day, and average berth occupancy rate 0.65, working day per year, 365 x 0.9 (rainy day) x 0.9 (berthing/unberthing time loss, maintenance etc.) = 296 days, the necessary number of berth can be calculated as follows.

1) Dry Bulk Berth

Grain, etc.

$$n = \frac{\text{Total Cargo Volume}}{\text{Berth occupancy x Working day x Handling volume/day/ship}}$$

$$= \frac{1{,}442{,}000 \text{ ton}}{0.65 \times 296 \text{ days} \times 10{,}000 \text{ ton/day/ship}} = 0.7$$

Other (cement, coal)

$$n = \frac{\text{Total cargo volume}}{\text{Berth occupancy x Working day x Handling volume/day/ship}}$$

$$= \frac{2{,}671{,}000 \text{ ton}}{0.65 \times 296 \text{ days} \times 6{,}000 \text{ ton/day/ship}} = 2.3$$

2) Break Bulk Berth

(including Bag, Drum, Steel, Scrap)

$$n = \frac{\text{Total Cargo Volume}}{\text{Berth occupancy x Working day x Handling volume/day/ship}}$$

$$= \frac{4{,}265{,}000 \text{ ton}}{0.65 \times 295 \text{ days} \times 2{,}400 \text{ ton/day/ship}} = 9.2$$

3) General Cargo Berth

$$n = \frac{\text{Total cargo volume}}{\text{Berth occupancy x Working day x Handling volume/day/ship}}$$

$$= \frac{1{,}875{,}000 \text{ ton}}{0.65 \times 296 \text{ days} \times 1{,}600 \text{ ton/day/ship}} = 6.1$$

4) Container Berth

$$n = \frac{\text{Total Cargo Volume}}{\text{Berth occupancy x Working day x Handling volume/day/ship}}$$

$$= \frac{4{,}047{,}000 \text{ ton}}{0.65 \times 296 \text{ days} \times 8{,}600 \text{ ton/day/ship}} = 2.5$$

Total 20.8 = 21 Berths

In conclusion, it is necessary to construct 21 berths in order to handle the cargo volume expected in 2010.

11.5.4 Allotment of Cargo Handling Volume to Each Berth

Table 11-5-4-(1) ~ (2) shows the cargo handling volume allocated to each berth.

Berth No B-1 is the existing berth with the depth -9.0m for 10,000 DWT class ship. The berths with the depth -9.0m will be used mainly for the domestic cargo handling.

Berth No B-6 will be the multi purpose berth for general cargo and container cargo in order to meet the demand for container transportation in the year 2000. Since the container cargo volume will not be large enough to justify the construction of a specialized container berth,it is recommended that general cargo will be handle here as well.

Berth No B-2 to B-7 shall be constructed up to the year 2000 in the first stage then well equipped for high efficiency berth up to the year 2010 in the second stage.

The principle for cargo allocation to the berth is as follows.

(1) The cargo will be separated into domestic and foreign commodity for convenience of customs and documentation as much as possible.

(2) Dirty cargo such as coal, ore, and clean cargo (cf. general cargo) will be separately handled.

(3) The same commodity will be handled in the same berth as much as possible (specialized berth).

(4) The grain, maize, wheat and the commodity concerned grain will be handled at berth No 7, that is, the specialized grain berth.

Table 11-5-4-(1) Cargo Handling Volume Allocated to Each Berth
(in the year 2000, 2010)

Berth No	Water Depth (m)	Berth Length (m)	Ship Size (DWT)	Domestic Export Import	Handling Type	Commodity	In 2000 Tonnage (1,000 T)	In 2010 Tonnage (1,000 T)
B-1	-9.0	166	10,000	D. In	Bag	Rice	80	20
				D. In. Out	Box, etc	General Cargo	122	302
							(202)	(322)
B-2	-9.0	160	10,000	D. In. Out	Bag, etc	Rice	78	128
				D. Out	Bag	Fertilizer	74	153
				D. Out	Break bulk	Steel	50	70
							(202)	(351)
B-3	-10.0	185	15,000	D. Out	Break bulk	Steel	300	400
							(300)	(400)
B-4	-11.0	210	20,000	Import	Break bulk	Scrap	287	350
				Import	Drum	Asphalt	30	70
				Import	Dry bulk	Coal	10	31
							(327)	(451)
B-5	-12.0	240	30,000	Export	Bag	Cement	120	120
				Export	Dry bulk	Clinker	120	120
				Import	Bag	Fertilizer	103	124
				Import	Drum	Chemicals	89	89
							(432)	(453)
B-6	-12.0	240	30,000	Export	Container	General cargo	94	211
				Import	Container	General cargo	225	225
				Export	Box, etc	General cargo	37	50
				Import	Box, etc	General cargo	87	157
							(443)	(643)
B-7	-13.0	260	40,000	Export	Bag	Rice	200	0
				Export	Dry bulk	Rice	0	513
				Export	Dry bulk	Maize	300	316
				Export	Bag	Grained wheat	30	125
				Import	Dry bulk	Wheat	240	1,001
							(770)	(1,955)
Total		1,461					2,676	4,575

Table 11-5-4-(2) Cargo Handling Volume Allocated to Each Berth
(in the year 2010)

Berth No	Water Depth (m)	Berth Length (m)	Ship Size (DWT)	Domestic Export Import	Handling Type	Commodity	Tonnage (1,000 tons)
B-8	-12	250	20,000	Export	Container	General cargo	300
				Import	Container	General cargo	832
							(1,132)
B-9	-12	250	20,000	Export	Container	General cargo	335
				Import	Container	General cargo	825
							(1,160)
B-10	-9	160	10,000	D.In.Out	Box. etc	General cargo	265
				D.Out	Bag	Cement	90
							(355)
B-11	-9	160	10,000	D.In.Out	Box. etc	General cargo	265
				D.Out	Bag	Cement	90
							(355)
B-12	-9	160	10,000	D.Out	Break bulk	Steel	230
				Import	Break bulk	Scrap	130
							(360)
B-13	-9	160	10,000	D.Out	Break bulk	Steel	160
				Import	Break bulk	Scrap	200
							(360)
B-14	-9	160	10,000	D.Out	Break bulk	Steel	190
				Import	Break bulk	Scrap	174
							(364)
B-15	-9	160	10,000	D.Out	Break bulk	Clinker	200
				D.In	Break bulk	Gypsum	84
				D.In	Break bulk	Ore	74
							(358)
Subtotal		1,460					4,444
S-1	-13	300	30,000	Export	Container	General cargo	394
				Import	Container	General cargo	925
							(1,319)
S-2	-11	210	20,000	Export	Pallet	General	160
				Import	Pallet	General	240
							(400)
S-3	-11	210	20,000	Export	Pallet	General	100
				Import	Pallet	General	305
							(405)
S-4	-13	260	40,000	Export	Dry bulk	Ore	545
				Import	Dry bulk	Ore	204
				Import	Dry bulk	Coal	31
							(780)
S-5	-12	240	30,000	Export	Dry bulk	Cement	1,820
							(1,820)
S-6	-12	240	30,000	Export	Break bulk	Metal	71
				Import	Drum	Chemicals	436
				Import	Drum	Asphalt	50
							(557)
Subtotal		1,460					5,281
Total		4,381					14,300

11.5.5 General Layout Plan

(1) Principle and Basic Idea for making General Layout Plan

The principles and the basic ideas for making the general layout plan are as follows.

- In order to minimize the total construction cost , in the first stage, the berth No B-2 next to the existing berth shall be located toward Cua Luc Strait, considering the existing access channel has been already dredged.

- As regarding the channel, Cua Luc - Hon Mot channel will be dredged -11.0m deep and 130m wide at the bottom of the channel where the 40,000 DWT bulk carrier is able to navigate safely (cf. Chapter 12.1).

The adjacent area of the existing B-12 oil buoy berth to Cua Luc Strait is deep enough for 30,000 DWT class ship to moor, so berths deeper than -9.0m will be located toward Cua Luc Strait in larger berth order.

- The alignment of existing berth No B-1 shall be kept because back yard area behind the existing berth No B-1 has almost been completed.

- B-12 oil buoy berth and oil terminal will be moved after the year 2000. However considering these areas are near Bai Chay sea side area where it will be specialized for tourism purpose, and in order to prevent water pollution and to reserve the space for environmental protection, these areas shall not be reclaimed nor will berths be constructed here. Water area and land area can be used for a green park.

- The dirty cargo handling berth should be constructed far from Cua Luc Strait so as not to interfere with tourism or degrade landscape.

In this sense, it is better to construct the container berths near Cua Luc Strait.

To keep the water quality in good condition, the waterway from the right side of the residential area for Ha Long Ship Building Corporation facing inside Bai Chay Bay to Ha Long Bay shall be improved. (Now there are several dikes across the waterway which are stopping the natural flow).

- The port related industries in the EPZ suggested in the chapter 9.1 are operating, so cargo related to these industries will be handled in the berths being of shorter distance from the EPZ.

(2) The scale of port facilities

Transport systems up to the year 2010 will radically change because motorization or containerization in Vietnam will be expected to progress a great deal. However the scale of port facilities can be estimated referring to the examples or experiences in Japan or other countries. The scale of port facilities for making general layout plan up to the year 2010 is summarized below.

- The Berth:

  berth for 10,000 DWT ship (water depth -9.0m)
  7(number) 1120m(berth length,excluding the existing berth)
  berth for 15,000 DWT ship (water depth -10.0m)
  1(number) 185m (berth length)
  berth for 20,000 DWT conventional ship (water depth -11.0m)
  3(number) 630m (berth length)
  berth for 20,000 DWT container ship (water depth -12.0m)
  2(number) 500m (berth length)
  berth for 30,000 DWT conventional ship (water depth -12.0m)
  4(number) 960m (berth length)
  berth for 30,000 DWT container ship (water depth -13.0m)
  1(number) 300m (berth length)
  berth for 40,000 DWT conventional ship (water depth -13.0m)
  2(number) 520m (berth length)

Total 20(number) 4215m(berth length)(excluding the existing berth)

- Port area: 200ha

  Cargo handling area:140ha

  Considering the necessity for the land storage function in future (for warehouse area), the length of vertical line to the berth line is adopted as 250m at least. For specialized container berth the length of vertical line to the berth line is adopted as 350m. General cargo berth is also 350m, considering that here container will be also handled. Large bulk cargo berth is also adopted as 350m for the necessity of stock for cargo.

Thus the total cargo handling area is approximately 140ha (including the existing berth area)

The other area: 60ha in total.

The administration,green and future expansion area are totally 60ha.

- Channel and basin(for 40,000 DWT ship, cf.the study in Chapter12.1)

  Channel: Cua Luc- Hon Mot channel depth:-11.0m width:130m Turning basin: r=1.5L=300m circle here:r=radius L= ship length overall

  Berth basin: width: 2B=40m and 50m here:B= ship moulded breadth depth: the same depth as berth

- Road and Railway(cf.the study in Chapter 12.2)

  Road: trunk road: 22.0m wide, 4 lanes for motor vehicles 2 lanes for bicycle and pedestrian

  semi-trunk road: 11.0m wide, 2 lanes for motor vehicle, 2 lanes for bicycle and pedestrian branch road: 7.0m wide 2 lanes for motor vehicle

  Railway: Estimated cargo volume by rail is approximately 1,400 thousand tons per year.

  Wagon operating yard: 2ha

- Transit shed and warehouse:(cf.the study in Chapter 12.2)

  Transit shed: Necessary area of transit shed varies from cargo handling volume and kind of commodity. standard square of transit shed: 5000m2/berth

  Warehouse: standard area of Warehouse: 5000m2/berth

- Administration and workers office:

  Total area: 18,000m2 for 1800 persons

(3) Alternative plan

According to the study and conclusion mentioned in the previous section, three alternative plans can be drawn.

Alternative 1 is the plan starting the construction work from the next berth (B-2) to the existing berth (B-1) and toward Cua Luc strait B-3, B-4 B-5, B-6 and B-7 will be constructed in numerical order by the year 2000.

After the year 2000 B-8 and B-9 specialized container berths or B-10 B-11 mainly used for domestic cargo handling should be constructed by meeting the demand.

There are shallow rocks found between berth No 5 and No 7. There are three alternative plans by which this obstacle can be overcome; two of the plans stipulate diverting the alignment of the access channel while the other recommends excavating there rocks.(cf. in detail Chapter 12.2)

After the year 2000, it is necessary to have the deep berths both for container and bulky cargo transportation. In this stage the Bai Chay bridge hanging over Cua Luc Strait can be available, therefore in alternative 1 these deep berths will be constructed in Dao Sa To area.

Instead of constructing deep berths in Dao Sa To area, in alternative 2, deep berths will be constructed west ward of the existing berth against the principle that the deeper berths should be constructed near Cua Luc Strait. Then the water front line of EPZ should be used for the berths.

As already mentioned in chapter 9.2 an area of approximately 100 ha is designated for EPZ in the Ha Long City urban Plan. However, if EPZ could be located in another place within the area or if its area could be reduced slightly making the coast line available for port facilities, a better alternative could be drawn.

The shore line in the Bai Chay Bay, which will be lead to the outer sea by a deep water channel is considered to be very valuable from not only the environmental point of view but also as a natural resource. Therefore it would be much more appropriate to utilize its advantages and at the same time to make the largest effort to preserve coastal lines.The EPZ does not necessarily have to be on the shore line as many precedents show.

In case of alternative 3, instead of using the water front area for EPZ, the berth construction space for S-1 to S-6 berths will be procured in the opposite side area of EPZ where the shrimp feeding pond is now being constructed.

Comparing these alternatives, alternative 2 seems to be the best if the water front line is available for berth construction. Alternative 1 is also feasible except for the access problem in which the traffic originating from or destined to Dao Sa To area must pass through the Bai Chay Bridge hanging over Cua Luc Strait or through the new roads connecting with route No 18B.

The following table shows the evaluation results by criteria for arrangement of port facilities.

Table 11-5-5 Evaluation of Alternative Plan

Criteria	Alternative 1	Alternative 2	Alternative 3
1 - a	◎	○	△
b	◎	△	△
c	○	◎	△
2 - a	△	◎	△
b	△	◎	○
c	○	◎	◎
3 - a	△	◎	○
4 - a	◎	◎	△
b	◎	◎	◎

Note: ◎ Good
○ Normal
△ Not good

As a result, alternative 2 seems the best if the EPZ could be rearranged. However, if the EPZ location is fixed , then alternative 1 is the most appropriate.

Criteria for arrangement of port facilities in Cai Lan Port long term general layout plan are as follows:

1) Technical Point of View

a) The construction cost of wharf, channel and basin as well as land reclamation is the minimum.

b) The maintenace cost for channel and basin is minimized.

c) The construction cost of access means is minimixed.

2) Environmental Point of View

a) The topographical and bathymetrical alteration is minimized.

b) The impact to inhabitants is minimized.

c) The negative interaction with tourism is minimized.

3) Human Rights Point of View

a) The number of families who have to move is minimized, regardless of whether it is compulsory or not.

4) Possibility of Future Expansion

a) Channel and access are commonly used in the future to the maximum extent.

b) Land and shore line are preserved in the areas where facilities are planned.

Port Area

EPZ

Figure 11-5-1 Alternative Plan

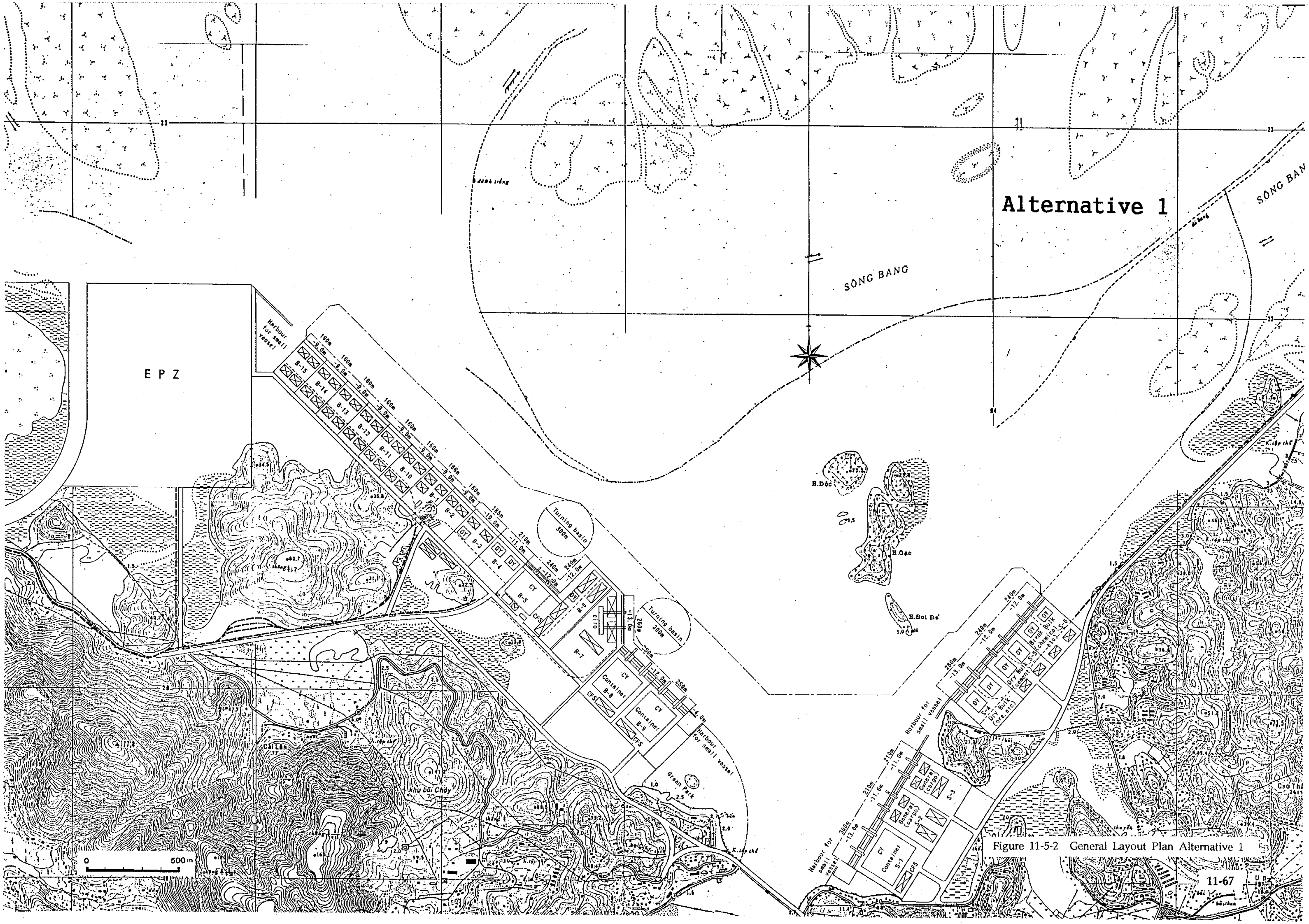


Figure 11-5-2 General Layout Plan Alternative 1

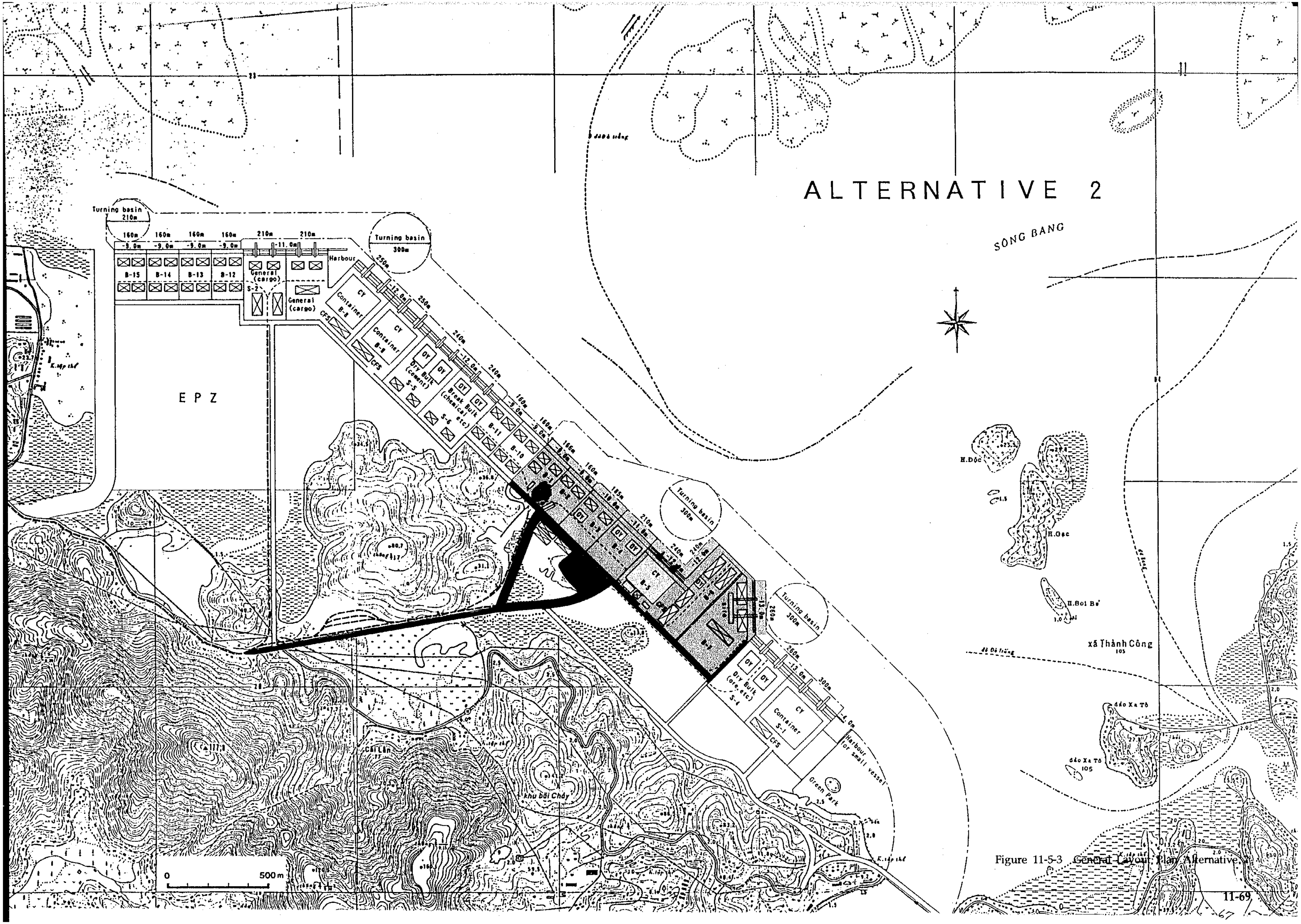


Figure 11-5-3 General Layout Plan Alternative 2

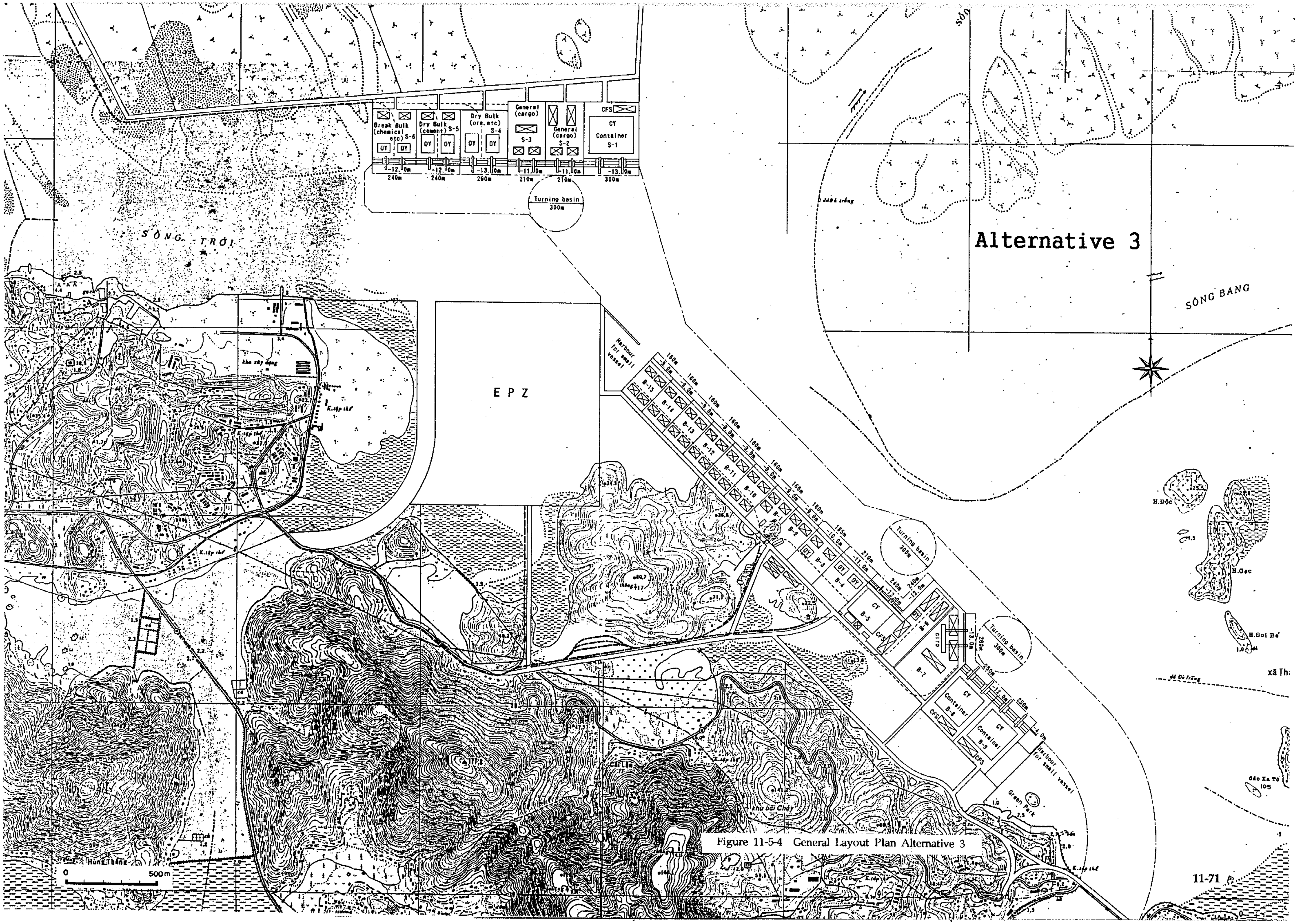


Figure 11-5-4 General Layout Plan Alternative 3

CHAPTER 12 SHORT TERM PORT DEVELOPMENT PLAN UP TO THE YEAR 2000

12.1 Channel Planning

12.1.1 Outline of Present Channel

The distance from the entrance of the navigation channel (Hon Sam) to Cai Lan Port (existing berth No 1) is approximately 33 km (cf. figure 12-1-1). The navigation channel is divided into 3 parts.

The first part,Lach Mieu,stretches about 19 km with the direction line of 158 - 338 degrees. This channel is a so called natural channel and is comprised of two sections.

In the first section the natural depth is more than -14m, in case of the 300 m bottom width of straight, navigable channel and the length is 15.2 km.

The second section from Dau Trau island to Hon Mot is a transitional section to the next straight channel (Hon Mot - Cua Luc). This 3.8 km long section consists of 2 opposite curved sections with a radius over 1000m. The depth of this section is -12.0m to - 15.0m in case of the 300m bottom width of the channel.

The second part is from Hon Mot to Cua Luc strait with the 160 - 340 degrees of direction line, totally 11 km long. From Hon Mot to the buoy No 1 -No 2, section which is about 1.2 km long, depth varies from -18.0m to -8.0m. The channel alignment is straight from the buoy No 1 - No 2 section to the buoy No 13 - No 14 and 6 km long.

The water depth is -7.5m - 8.0m with the bottom width 50 - 60m, where, in order to accommodate the tanker entering and mooring B - 12, VINAWACO (State Dredging Company) conducted dredging in 1978.

At that time the dredging depth and width were -8.1m and 120m respectively, and natural depth was -2.0m ~ 3.0m. In this section, there are thick silt strata, therefore, it can be surmised that the collapse of slope and siltation made the depth shallower and made the bottom width narrower.

Next to the end of the shallow section, there is an abyss which has an average natural depth of -15.0m ~ -20.0m, that extends to the Cua Luc strait.

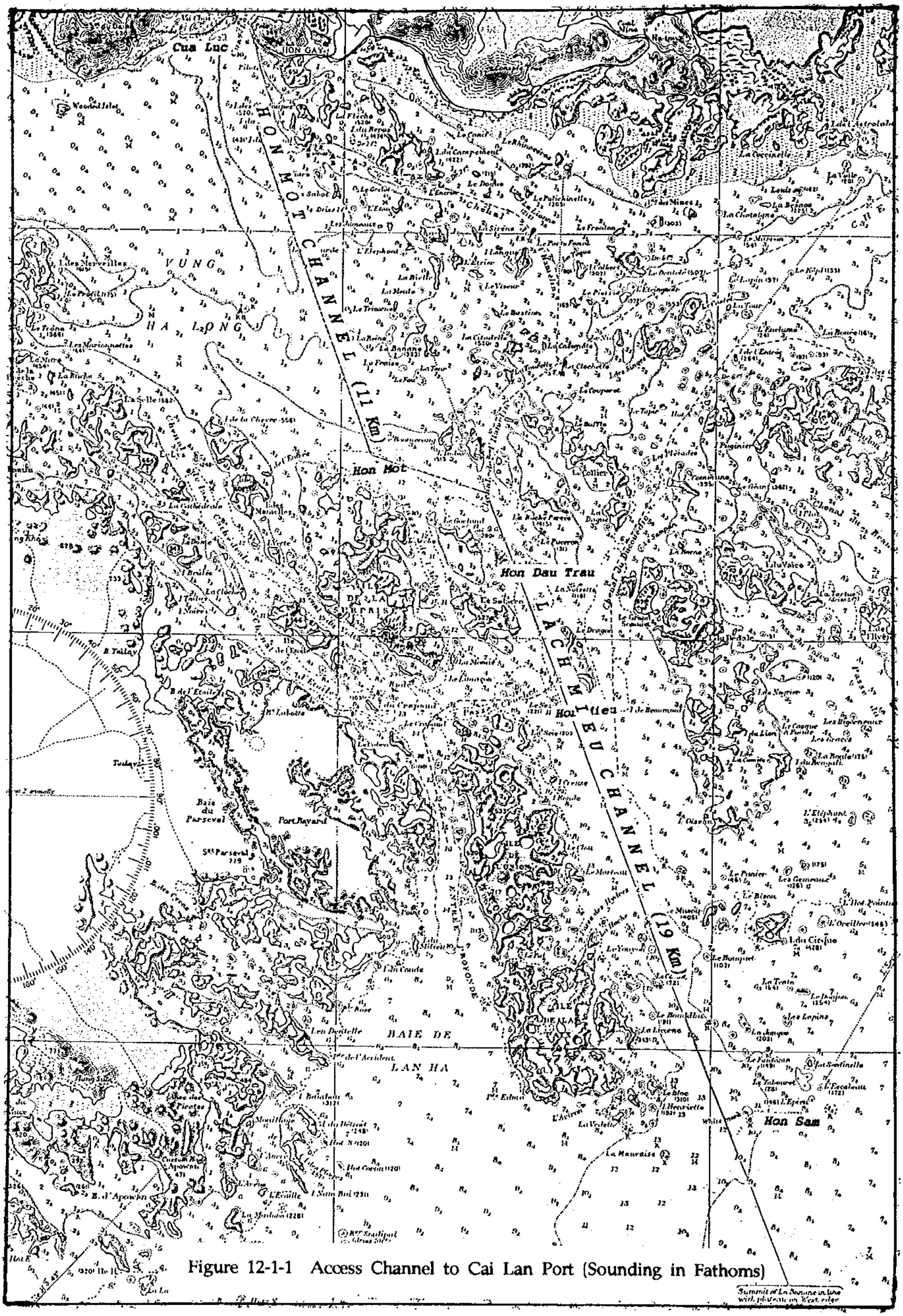


Figure 12-1-1 Access Channel to Cai Lan Port (Sounding in Fathoms)

The third part is a 3 km stretch from the Cua Luc strait to the existing berth at Cai Lan. From the Cua Luc strait to B12, the depth is more than -10.0m, where the curve section is 1030m long and curvature radius is 1000m with the included angle 59°.

The abyss ends at the edge of this curve section and natural depth of the bottom becomes -5.0m within 500m from the abyss at the center line of the channel. Therefore we have to dredge from this section to the front of the existing berth. The dredging work has already been started, and will be completed in September, 1994. When the work is completed the access channel to the existing berth will be -6.8m (planning depth) deep and at least 80 m wide.

12.1.2 Natural condition of the channel

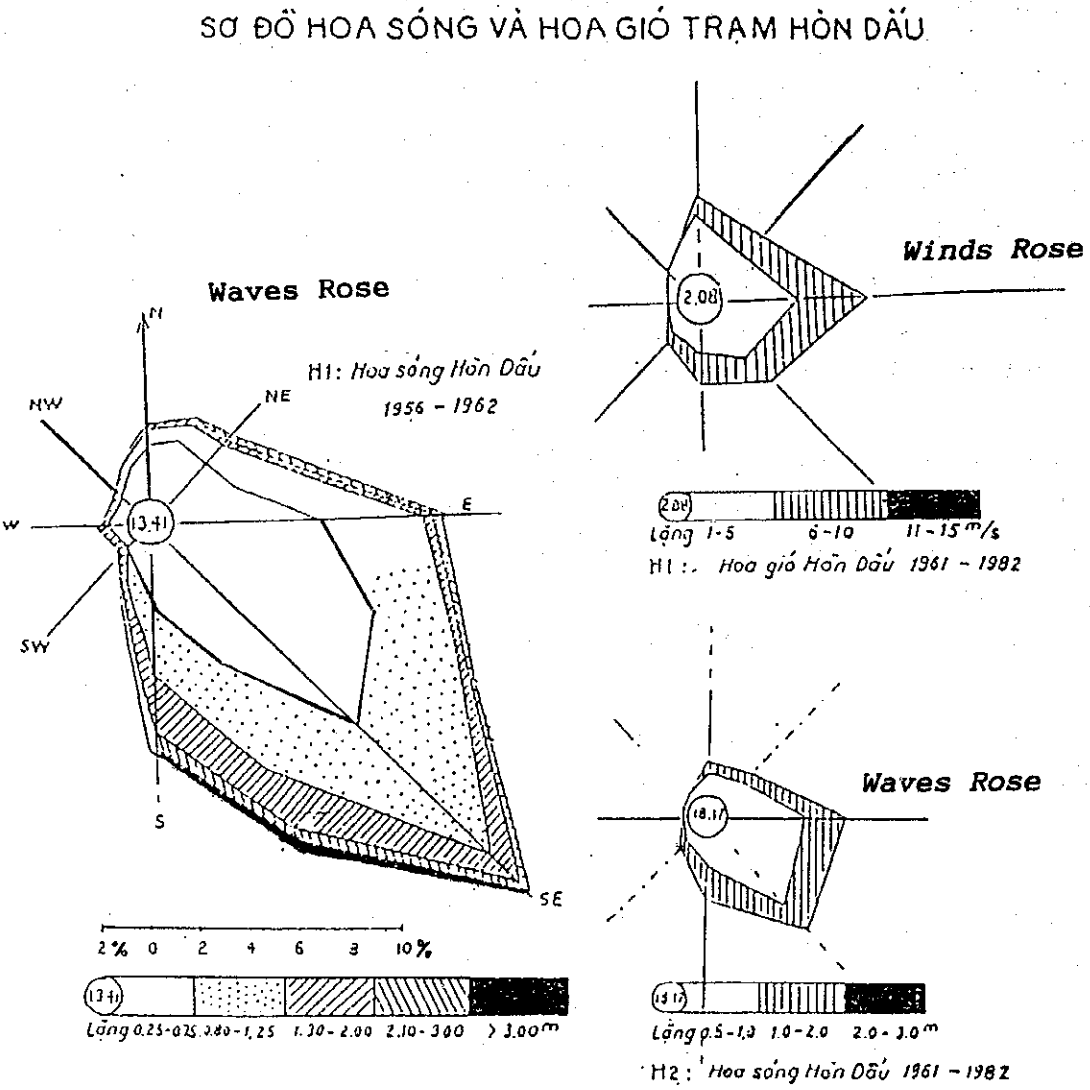
Through all these channels, calm sea conditions prevail because of the sheltering effect provided by the thousands of islands;only exception occurs when typhoons approach this area. There is no wave observation data, however it can be estimated that the wave height is less than 0.5m and also that the current is weak. According to the nautical map, at Do Son near Hai Phong the maximum current speed is 2.6 knot at slack time.

Figure 12-1-2 shows the frequency of winds and waves recorded at Hon Dau observation station, which, located in the open sea near Hai Phong is unsheltered.

Comparing Hon Dau with Lach Mieu area, waves are much less frequent than at Hon Dau and winds are weaker due to the sheltering effect of the surrounding islands. As shown in Table 5-2-4 in Chapter 5.2, fog and mist occur from January to April, however dense fog and mist were observed only 1.3 days per year on average. From the viewpoint of ship maneuvering,the natural conditions are not at all severe.

According to the bathymetric survey done by EGS and TEDI in February 1994, along Lach Mieu channel, 150m from the centerline on both sides, there are no shallow rocks.

Figure 12-1-3 shows the rock level of any type along the centerline of the outer channel (Cua Luc strait to Hon Sam). Since rock strata is not encoutered untill under -20 m, dredging up to -14.0 m would pose no problem.



Source: The Urgent Rehabilitation Plan of Hai Phong Port JICA 1993

Figure 12-1-2 Frequency of Winds and Waves

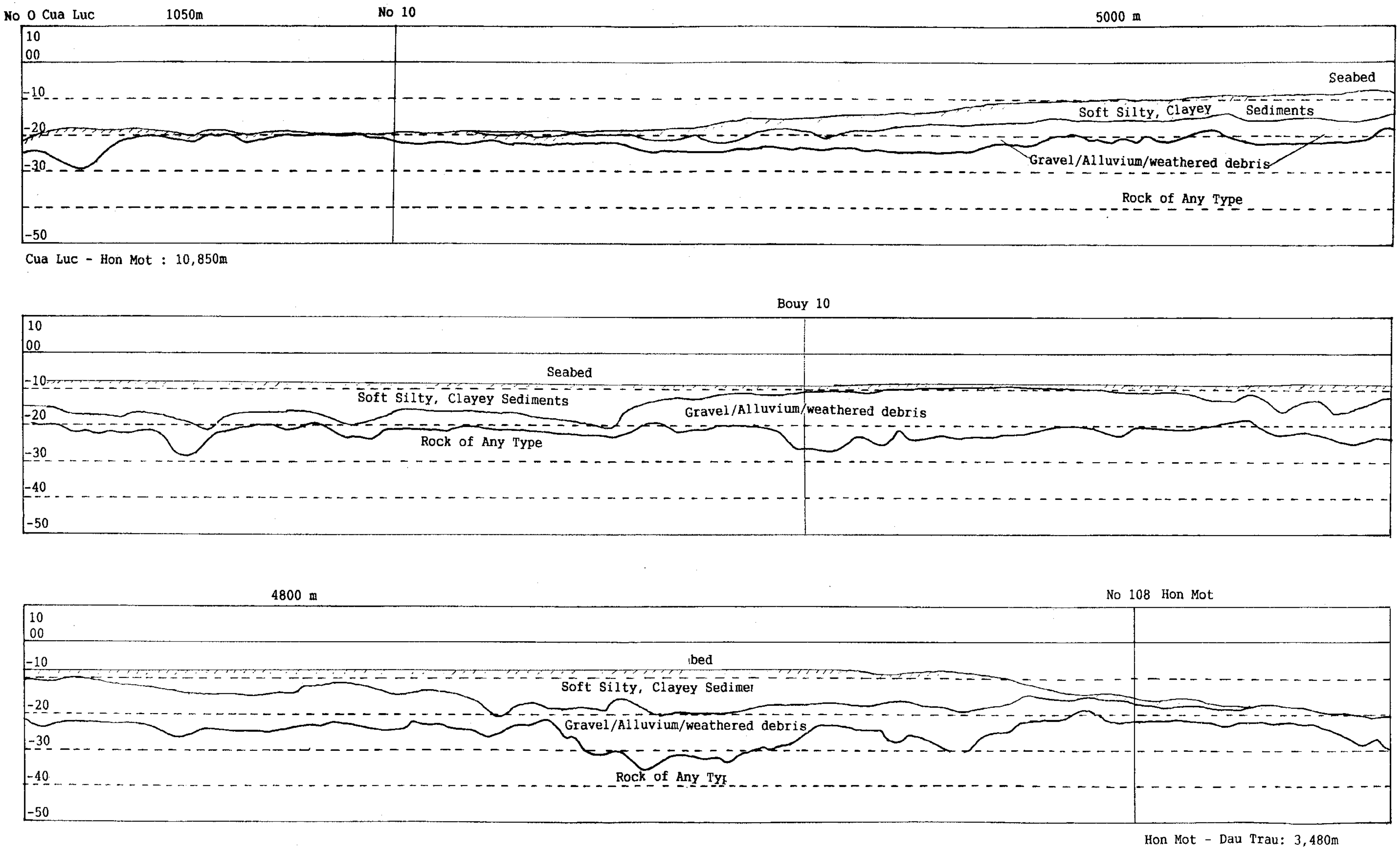


Figure 12-1-3-(1) Section along the Approach Channel Center Line

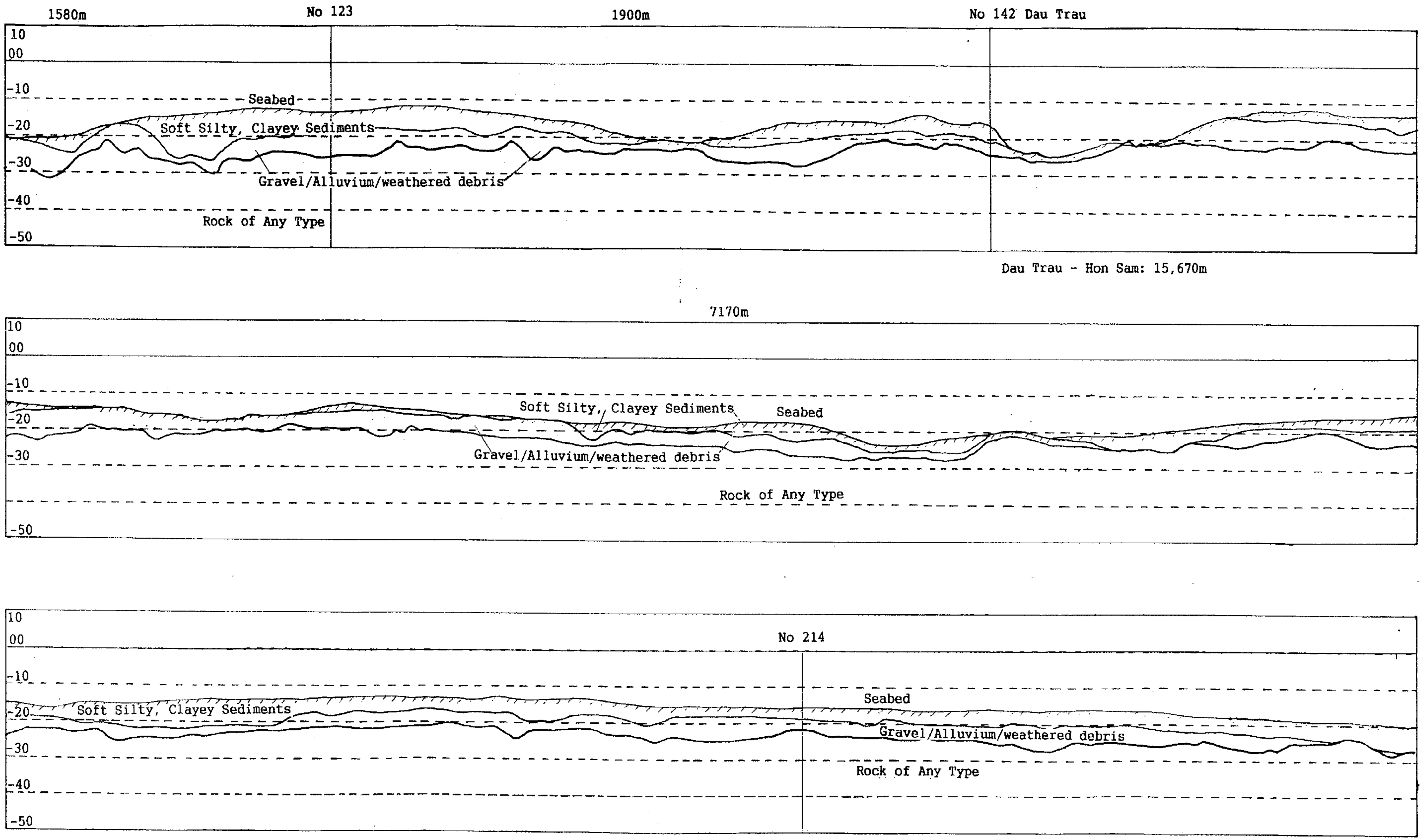
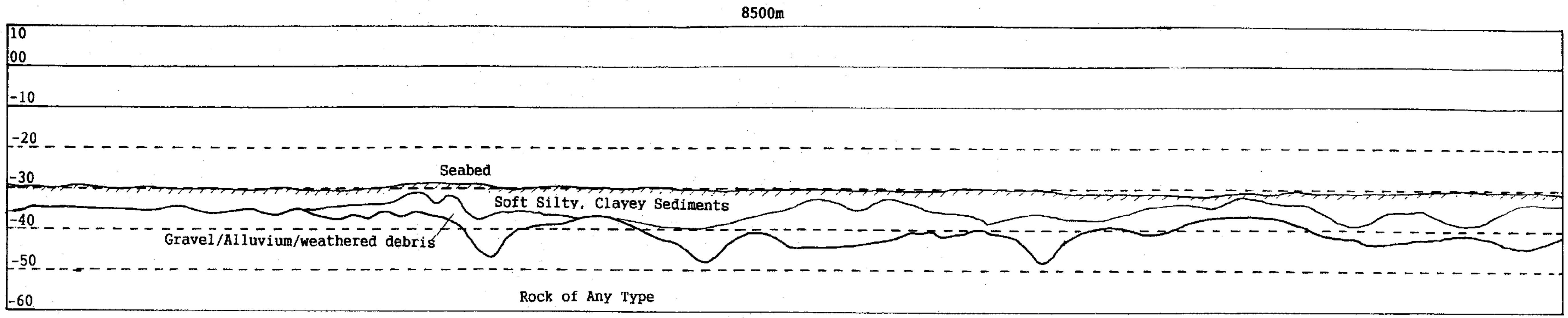


Figure 12-1-3-(2) Section along the Approach Channel Centre Line



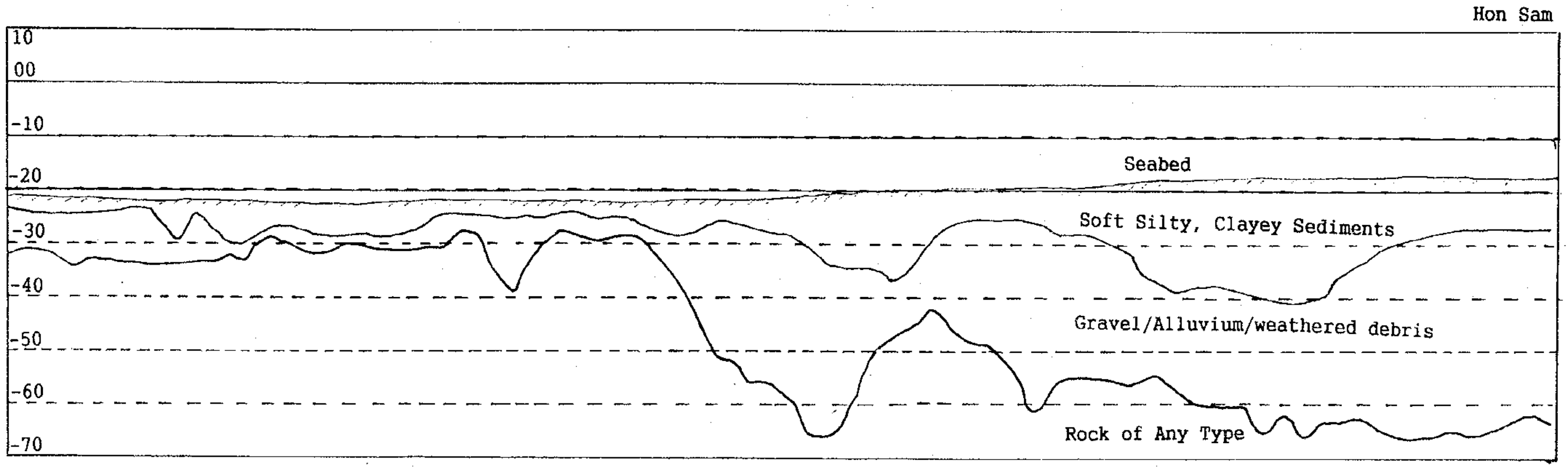


Figure 12-1-3-(3) Section along the Approach Channel Centre Line

12.1.3 Nautical Aspect

At present, B - 12 buoy berth can moor tankers up to 30,000 DWT and from the entrance of the channel to B - 12 berth, these tankers can enter and leave by their own propelling power with the assistance of tug boats and using tidal range.

The pilotage is compulsory for all foreign ships and for Vietnamese ships larger than 2000 DWT. The pilot point is located at 20°,43',30"N, 107°,10',05"E under usual condition where the pilots go on board.

After boarding the pilot manoeuvers the ship for about 2.0 hours until berthing at B - 12.

From Hon Sam to Dau Trau, the channel is sufficiently deep and wide and straight as well, that a ship can navigate at her own cruising speed without any escort boats. Usually tug boats escort a ship near Bouy No.10 after the ship come into Hon Mot channel where it is not easy to manoeuver because of its shallow and narrow one way channel. The ship passes through this part at a speed of around 10 knots.

At present, there are high voltage transmission lines and telephone lines spanning over the Cua Luc strait. The clearance from lowest point of these lines to the water surface is 32 m at maximum high tide. (The lowest line is ow voltage transmission line.)

To date, vessels with draft of 7m upward have had to wait for high tide, in addition Cua Luc -Hon Mot channel is a one-way channel and the ship size is limited to less than 32 m in height. (If the lowest line would be taken, the clearance will be easily changed to 37.5m.)

12.1.4 Tidal Operation

In Hai Phong Port, it is reported that due to the shallowness of the channel, under keel clearance commonly used is 0.3 m at minimum, and owing to thick muddy soil, there has been no fatal problem for ships to manoeuvre using tidal operation. Vessels calling the Hai Phong Port use the high tide zone which lasts from 4 to 6 hours. A water level of +2.5 m is available approximately 1800 hours per year.

Cai Lan Port also has the advantage of using tidal operation. Figure 12-1-4 shows the tide distribution by tide level and time bands in Cai Lan Port. These figures are calculated by using a computed tidal analysis based on the actual observation in February in 1994.

We estimate that over +2.5m tidal range with a duration time over 2 hours, necessary for the navigation time from entrance to Cai Lan Port, will be available 283 days and 2256.7 hours in 1994.

The frequency is nearly 78% and available time is 26% to total annual hours. Container ships are basically operated at quick despatch and it is desirable for container ships to enter and leave the port at any time.

However when we choose over +2.5 m tidal range for operation, the frequency of nearly 80% is practically allowed for container ships entering and going out the port and no waiting time for navigation due to the low tide will be expected.

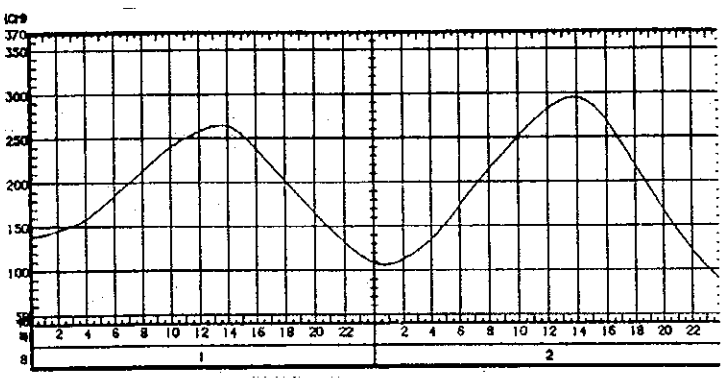
In addition to the tidal range, the delay time of tidal height between inner Cua Luc Bay and outer Cua Luc Bay sea area is favorable for a large ship's navigation in case of entering the port.

In conclusion,tidal range +2.5 m shall be used for channel planning.

Time Bands	Less 1 h		Over 1h		Over 1.5h		Over 2h		Over 2.5h		Over 3h	
	Freq.	T. hours	Freq.	T. hours	Freq.	T. hours	Freq.	T. hours	Freq.	T. hours	Freq.	T. hours
Tidal Level Over 350cm	8	4.4	32	61	24	50.8	13	32.1	6	16.3	1	3.1
	2.2%	0.1%	8.8%	0.7%	6.6%	0.6%	3.6%	0.4%	1.6%	0.2%	0.3%	0.0%
Over 325cm	2	1.3	145	505.9	138	497.5	132	487.5	118	455.7	99	402.9
	0.5%	0.0%	39.7%	5.8%	37.8%	5.7%	36.2%	5.6%	32.3%	5.2%	27.1%	4.6%
Over 300cm	1	0.3	201	1032.5	199	1030.1	199	1030.1	192	1014.3	183	990.8
	0.3%	0.0%	55.1%	11.8%	54.5%	11.8%	54.5%	11.8%	52.6%	11.6%	50.1%	11.3%
Over 275cm	3	1.2	248	1611.9	246	1609.1	245	1607.6	239	1594.2	236	1585.9
	0.8%	0.0%	67.9%	18.4%	67.4%	18.4%	67.1%	18.4%	65.5%	18.2%	64.7%	18.1%
Over 250cm	0	0	288	2264.1	286	2261.9	283	2256.7	279	2247.6	278	2244.8
	0.0%	0.0%	78.9%	25.8%	78.4%	25.8%	77.5%	25.8%	76.4%	25.7%	76.2%	25.6%
Over 225cm	1	0.2	328	3044.5	328	3044.5	325	3039.2	322	3032.4	319	3024.3
	0.3%	0.0%	89.9%	34.8%	89.9%	34.8%	89.0%	34.7%	88.2%	34.6%	87.4%	34.5%
Over 200cm	0	0	364	4051.9	363	4050.4	358	4042.3	358	4042.3	358	4042.3
	0.0%	0.0%	99.7%	46.3%	99.5%	46.2%	98.1%	46.1%	98.1%	46.1%	98.1%	46.1%

Source: These figures are obtained from the calculation by using a computed tidal analysis based on the data Hydrologic Survey Cai Lan Port Construction Project by TEDI

August 1994 Cai Lan



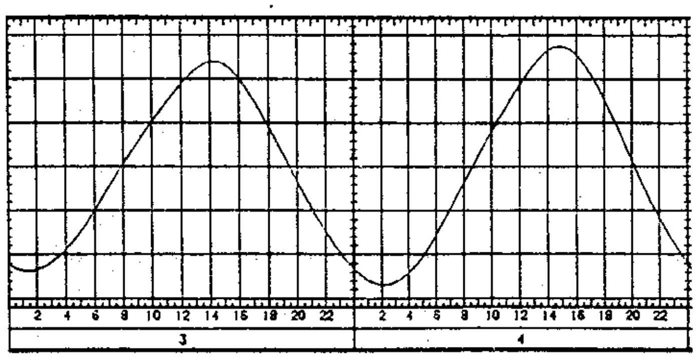


Figure 12-1-4 Tide Distribution Table by Tidal Level and Time Bands (1994)

12.1.5 Determination of Channel Depth and Width

(1) Depth

According to Vietnamese Standard for construction of ports, water depth for navigation channel is determined by the following formula:

$$H_{ct} = T + Z_1 + Z_2 + Z_3 + Z_0$$
$$H_o = H_{ct} + Z_4$$

H_o - The design water depth (m)
T - Draft of Ship (m)

Z_1 - Minimum reserved depth (m) (safety)
Z_2 - Reservation for waves (m)
Z_3 - Reservation for speed (m) (Squat)
Z_4 - Reservation for siltation (m)

By the TEDI's feasibility report, in case of 30,000 DWT bulk carrier, ship length, ship width and draft, are 186 m, 27.9 m and 10.9 m respectively and H_{ct} = 10.9 + 1.64 = 12.54 m

Z_4 varys 0.60 m to 1.2 m

In order to determine the channel depth the following formula is generally used.

$$H = df + ds + dr + dt + dw$$

Here;
H - Necessary depth
df - Maximum draft
ds - Allowance for sea bed geological condition
dr - Squat due to the navigation speed
dt - Allowance for turning (usual 0.001 L ~ 0.002 L. L=ship length)
dw - Allowance for wave action (usual 1/2 h . h = wave height)

In case of Cai Lan Port, from Hon Sam(the entrance of the channel) to Hon Mot, it is deep enough for 40,000 DWT class ship to navigate, therefore, we consider only the case of Hon Mot - Cua Luc channel.

Hon Mot - Cua Luc (except abyss near Cua Luc Strait)

df = 11.9 m (40,000 DWT Bulk Carrier)

ds = 0.04 df (using Vietnamese Standard soft silt 0.04 x 11.9 = 0.5)

dr = 0.56 m

When the ship navigates at about 8 knots. Then,

$$\text{Froude number } F_n = \frac{V - V}{\sqrt{LPP \times G}} = \frac{4.1}{\sqrt{207 \times 9.8}} = 0.091$$

$$H/df = \frac{13.5}{11.9} = 1.13$$

Here by:

V = 8 knots = 4.1 m/sec

LPP = Ship length = 207 m

G = Acceleration of gravity

Sinkage/LPP = 0.27%

Sinkage = 207 x 0.27/100 = 0.559 = 0.56

dt = 0 (Straight, no turning)

dw = 0 (Wave is less land 0.5m, using Vietnamese Standard, ship length over 150m Z_2 = 0)

H = 11.9 + 0.5 + 0.56 + 0 + 0 = 12.96 = 13.0 m

We can use tidal range 2.5m

13.0m - 2.5 m = 10.5 m

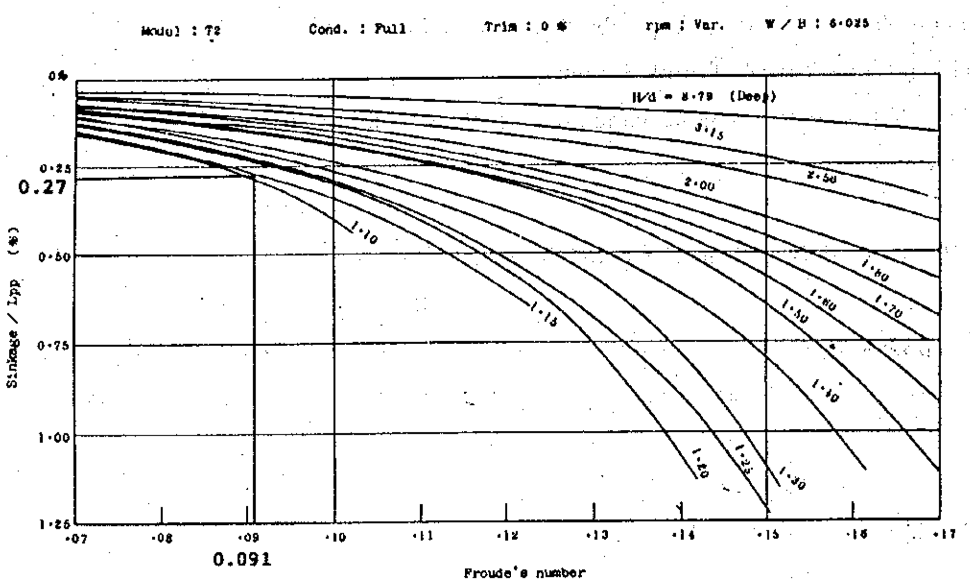


Figure 12-1-5 Relation Between Average Sinkage and Vessel Speed

Regarding Z_4, sediment reservation, TEDI's feasibility study says that, according to the data in the year 1959 ~ 1961, and 1963 ~ 1964 annual average silt coefficient (P) at Cua Luc ~ Hon Mot channel is P = 0.1 (P = Δ h/h, h is dredging depth and Δ h is height of siltation in the channel, and estimated maximum 1.2m thick of siltation and as siltation volume, 0.8 ~ 1.0 million per year in case of initial dredging depth -10.4m.

There is few data concerning wave, current and sediment density, in addition, siltation mechanism is not known. Therefore, at the moment, for determination of channel depth, 0.5m reservation for siltation shall be added.

Then as a conclusion, the water depth of the channel is -11.0m in case of 40,000 DWT ship's use.

Note : 0.5 m reservation is pre-dredging for siltation, which is stipulated in Engineering Design Standard of Ports in Viet Nam as the maximum case in general. It is better not to dredge too much from the economical point of view.

(2) Width

Technical Standard for Port and Harbour Facilities in Japan says that width of a channel other than a relatively long one required ship length where ships pass each other infrequently. (cf. Chapter 11.3)

However, the access channel to Cai Lan Port is quite long and siltation will occur in Cua Luc - Hon Mot channel.

Therefore, it is not reasonable to adopt the Japanese Standard; it is better to dredge the area in minimum width, unless the ship safety can not be secured.

According to the Port Development Handbook by United Nations, it is recommendable that a minimum value for the width of a one-way channel (width at full depth) would be 5 times the beam width (B) of the biggest vessel in the absence of cross currents.

This code comes from research and experience; actual one way channel width in existing ports varies between 4 to 10B.

Considering the above mentioned facts and particulars of planning the channel, the channel width in Cua Luc - Hon Mot channel shall be 130m (5 x Beam = 135 m).

12.1.6 Dredging Plan

(1) Cua Luc - Hon Mot channel

As already mentioned in the Chapter 12.1.1, dredging to secure navigational safety needs to be conducted in the section from Hon Mot to Cua Luc, particularly from Buoy No 1~2 to Buoy No 13~14. (cf.Figure 12-1-6 Channel dredging plan)

Figure 12-1-7 shows the relation between water depth - width and initial dredging volume.

In case of 40,000 DWT, it is recommendable that the channel bottom width is 130m,the slope is 1 to 7, and water depth is -11.0m

The Planning dredging volume can be calculated as 5,997,472 m3 from section No 28 to No 104.

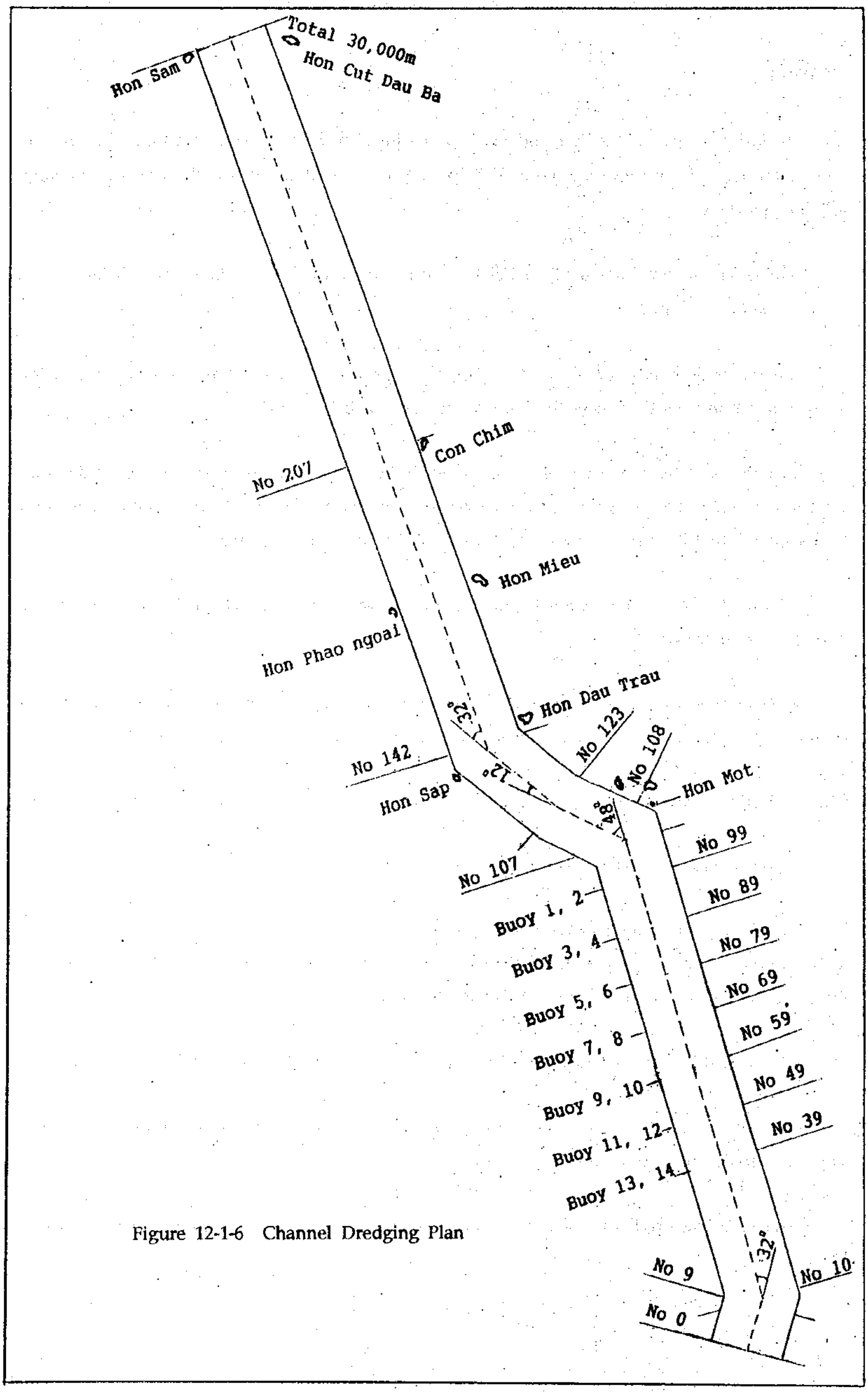
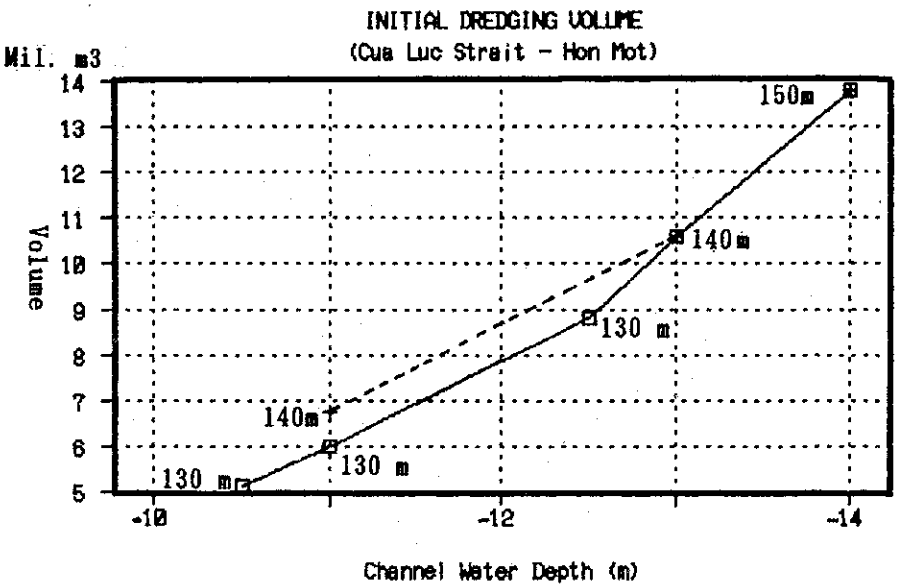
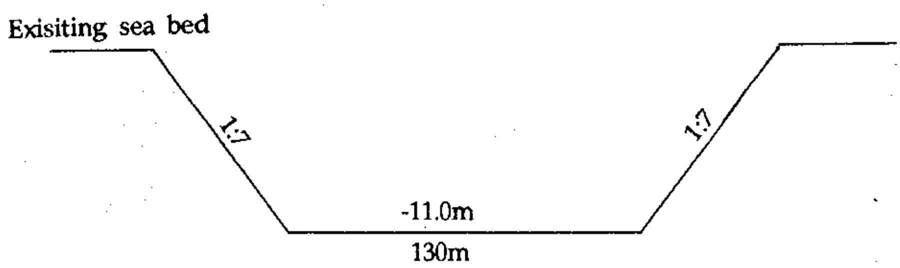


Figure 12-1-6 Channel Dredging Plan



Note: 130m, 140m, 150m, indicate channel width

Figure 12-1-7 Initial Dredging Volume by Water width



The maintenance dredging can be assumed at 494,000 m3 if the siltation speed is 0.5m per year.

(2) Cua Luc - Cai Lan Channel

Figure 12-1-8 shows the dredging plan from Cua Luc to Cai Lan (existing berth). It is preferable that the channel width be 130m, and the depth -11.0m.

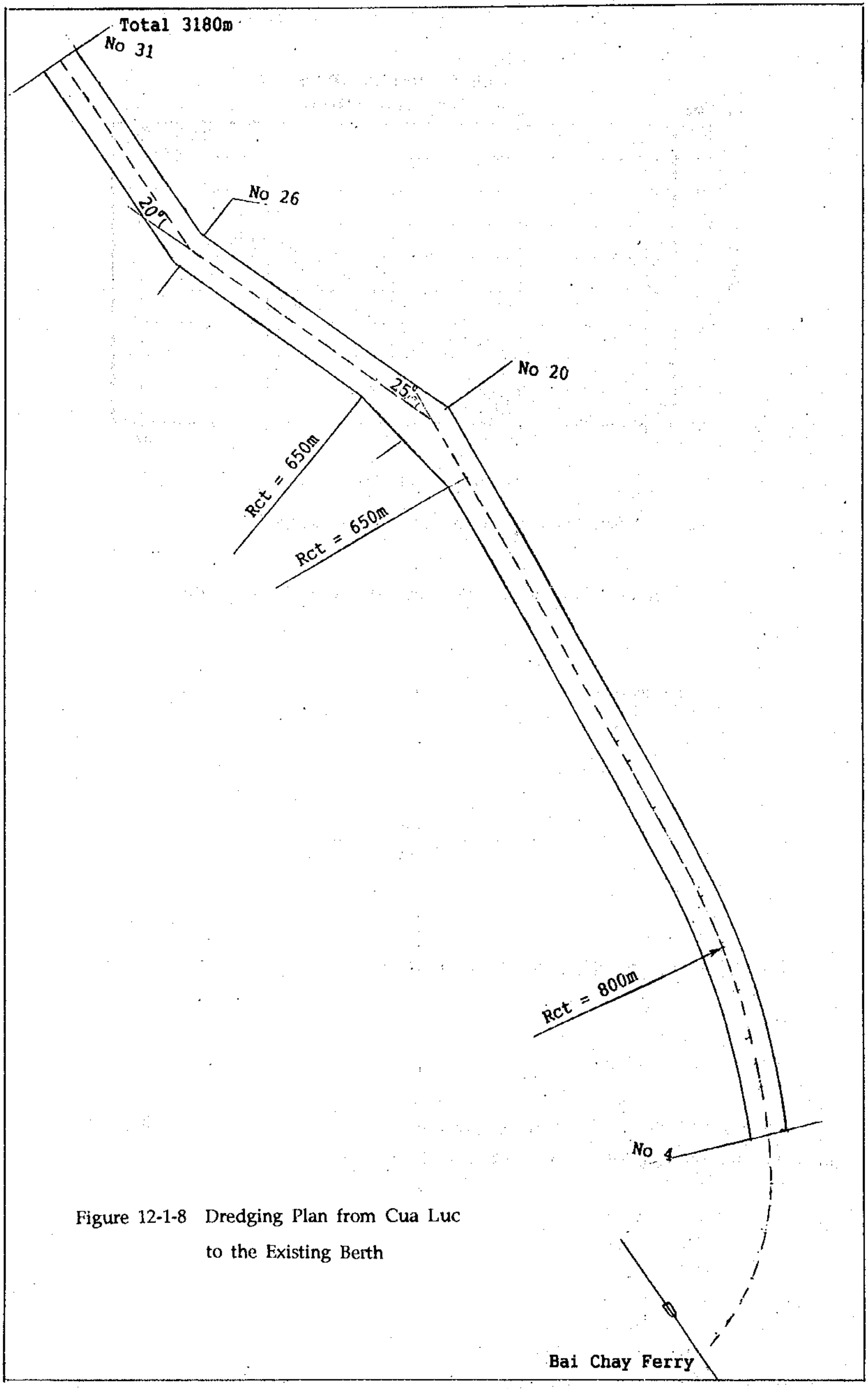


Figure 12-1-8 Dredging Plan from Cua Luc to the Existing Berth

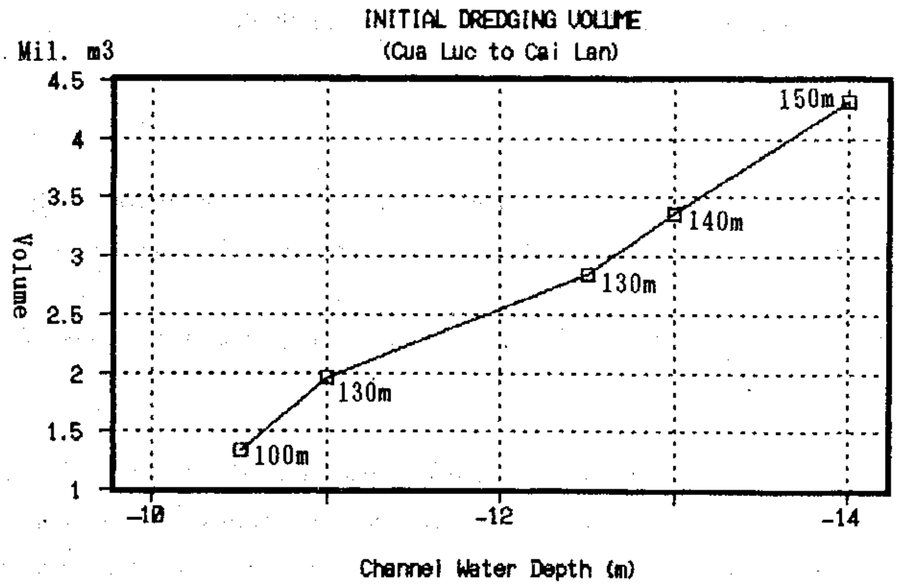


Figure 12-1-9 Initial Dredging Volume by Water Depth

Figure 12-1-9 shows that the initial dredging volume for the access channel (exclude basin) is 1.955.635 m^3. (The slope is one to seven). This dredging volume shall be examined in relation with the basin plan.

12.1.7 Evaluation of Safety Traffic Congestion in Cua Luc Strait

(1) Natural Condition

Cua Luc Strait is the entrance of Bai Chay Bay, having widths of approximately 280m (at -10.0m), 450m (at L.W.L) and 500m (at H.L.W) at the narrowest points. (cf. Figure 12-1-10)

Seabed is composed almost totally of rock and the deepest area is around -20.0m deep with sharp slope.

According to TEDI's Report, maximum current speed was 85 cm/sec (=1.7 knots) during flood tide and 134 cm/sec (= 2.7 knots) during ebb tide in the Hon Gai - Bai Chay Ferry area. Based on JICA's observation on 26 Jan. 1994 at spring tide, the maximum observed current speed at vertical No. 2, (due to the ferry traffic we couldn't select the center point of the Strait) was 40 cm/sec (= 0.8 knots) during ebb tide.

Fogs and mists occur in winter and early spring for several days, however dense fogs and mists total only 1.3 days on average (1974 - 1982).

Winds and waves are generally gentle except during typhoons.

Two to three typhoons hit the area each year from June to August.

(2) Present Traffic Condition

From the point of west side, Bai Chay, to the point of east side, Hon Gai, Ferry service at intervals of 7 - 15 minutes through the whole day is now being operated by Quang Ninh Ferry enterprise under Quang Ninh Province.

Table 12-1-1 and Table 12-1-2 show the number and type of ferry boats and traffic volume.

In 1993, the total number of cars carried by ferry boat reached 334,107. This number is nearly one thousand per day on average.

There were approximately 3.2 million passengers which corresponds to nearly 9 thousand per day.

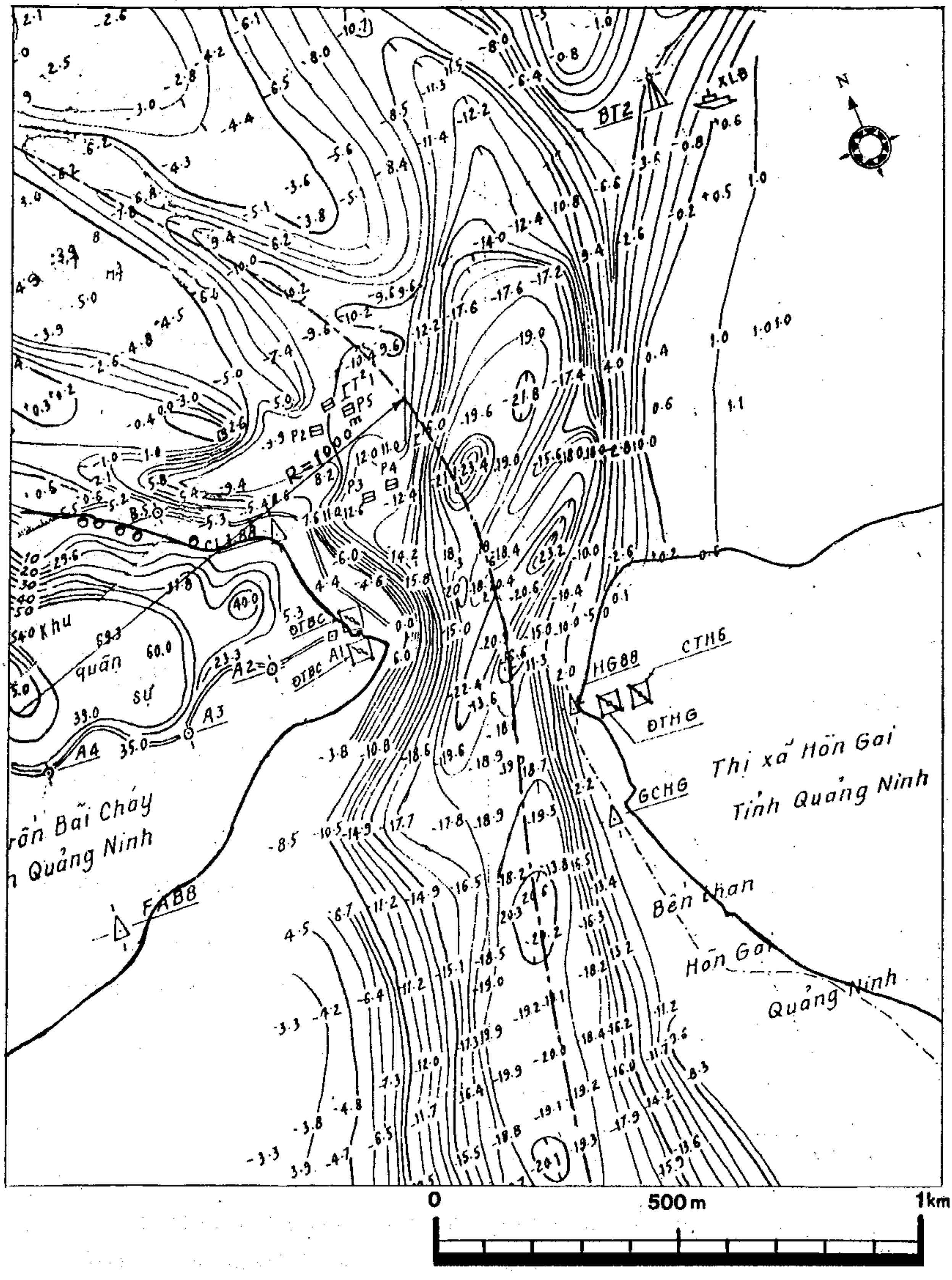


Figure 12-1-10 Cua Luc Strait

Table 12-1-1 Number of Ferry Boat by type

	1898	1990	1991	1992	1993
Self Propelled Ferry Boat (40T GWT)	3	3	2	3	2
Sub. Ferry Boat (30T GWT)	5	5	5	5	4
Passenger Ferry Boat	2	2	2	2	2

Table 12-1-2 Traffic Volume

	1898	1990	1991	1992	1993
Ferry Boat (Number of trip) and Self Propelled and Sub Ferry type.	270	302	4,636	8,770	16,758
Passenger Ferry Boat (Number of trip)	12,828	14,576	8,870	19,778	14,774
Number of cars	212,489	229,094	205,449	269,681	334,107

A sub Ferry boat means a fleet consisting of no propelled vessel accompanied with one tug boat on her side.

Total number of trips (one trip is one crossing of the Strait) is 31,532, which equals 86.4 trips per day, 3.6 trips per hour on average.

(3) Estimation of the Probability of Accidents

a. The Probability of Accidents at Present

The accidents reported by Quang Ninh Port are shown in Table 12-1-3.
There have been 9 accidents in the past 4 years (excluding those caused by typhoon).

The degree of accidents can be calculated by the following formula.

Table 12-1-3 Accidents List

(in 1990 - 1993)

Date	Location of Accident	Type of vessel	Type of Accident	Seriousness of Accident	Reasons for Accident (if know) or others
2. Mar. 90	Port basin	Dry cargo ship	Collision	Light	Bad control
16. July. 90	Berth B12	Oil tanker	Knocking against electric cables	Serious	Bad management of captain & pilot
1. Jan. 91	Port basin	Oil tanker	Electric fire	Light	Smoking
11. Aug. 91	Port basin	Oil tanker	Collision with lighter	Serious	Bad control
21. Mar. 91	Cam Pha-Hon Gai channel	Dry cargo ship	Sinking	Serious	Bad weather + bad control-wrong direction
25. Mar. 92	Cua Luc	Oil tanker	Collision with ferry	light	Captain's mismanagement
10. Nov. 92	Cam Pha Cannel	Dry cargo ship	Sinking	Serious	Unreasonable speed due to bad control-out of channel
29. Jan. 93	Hon Gai coal berth	Dry cargo ship	Knocking against berth	Light	Technical break down of vessel
16. Aug. 93	Hon Gai coal berth	Dry cargo ship	Collision with ferry	Serious	Bad control for entering

Source: Quang Ninh Port

P = (number of accidents) / (number of traffic volume)

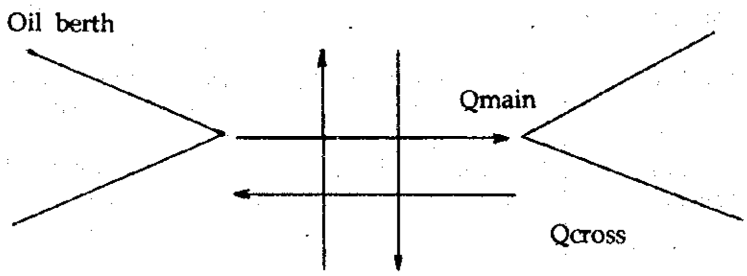
There were 85,500 trips by ferry boats from 1990 - 1993;there are no statistics' data on oil tankers entering and leaving the Cua Luc Strait, the number of tankers,however can be estimated from the handling volume of oil. Now B-12 is handling 700,000 - 1,000,000 T/year, therefore the number of vessels can be estimated at 70 - 100 per year.

$P = 9/8550 + 4\ (70 - 100) = 10^{-4.0}$

This figure seems quite reasonable when compared to the actual probability of accidents experienced in Japan. And it is known that the probability of accidents usually is around one ten thousandth in the case of straits.

b. The Probability of Accidents in Future

To classify the type and probability of accidents, the following formula will be used.



$P = Qmain \times Qmain + Qmain \times Qcross + Qcross \times Qcross$

Here Qmain x Qmain is the probability of collision in case of main traffic related with traffic volume.

Qmain x Qcross is the probability of collision in case of main traffic and ferry traffic related with traffic volume.

Qcross x Qcross is the probability of collision in case of ferry boats with each other.

If countermeasures to reduce accidents are not taken , number of accidents will increase proportionally to traffic volume.

(4) Estimation of Traffic Capacity in the Strait.

For estimation of traffic capacity it is necessary to simulate traffic flow in future.

However, using the bumper model, we can calculate the safety traffic capacity limit roughly.

The bumper model is defined at the port entrance as shown in Figure 12-1-11

The bumper model is made from observation of ship manoeuvering and the presence of the effective domain around a ship into which other ships avoid entering.

If the width of channel is W, basic traffic volume is C_b and maximum traffic density at the speed V is ρmax,

$$C_b\ (V) = \rho max\ WV \qquad (1)$$

Then assuming the change of domain is small, when the ship is navigating at the average speed, then

$$\rho max = 1/rs \qquad (2)$$

Here; r = 6L, s = 1.6L. When average ship size is 10,000 DWT, L = 140m V = 10 knots = 18.5 km/hour 8 knots = 14.8 km/hour and W = 1.6L = 224 m.

Then C_b = WV/6L x 1.6L = 22 (17.6) ships/hour

This is corresponding to the case that there is no ferry service nor crossing traffic and one ship can pass through the strait every 3 minutes in one way traffic.

Actually there are ferry services and thus it is necessary to avoid large ship domain to prevent accidents. Ferry boats are now operating 3.6 times per hour on average, and when it takes 5 minutes per one trip, 20 minutes are required for ferry boats. Then traffic capacity is estimated as 22 (17.6) x 2/3 = 14.7 (11.7) ships/per hour.

These numbers are sufficient large for the number of ships entering and leaving the Cua Luc Strait per hour in the year 2000.

(5) Necessary Countermeasures and Evaluation

First of all special regulations are required for ship manoeuvering. From the view point of the width of the strait and ship size, one way control is necessary when large ships (more than 3000 DWT) enter or leave the strait and ferry boats should be prohibited from entering the domain of large ships.

Priority of navigation should be given to large ships.

For traffic control it is useful to adopt loud speakers because of the short distance to the ships passing through the strait. It is also necessary to introduce self propelled ferry boats which have good maneuverability; the sub type ferry has both limited maneuverability and navigation speed.

As mentioned in the previous section traffic capacity is sufficient for the number of the ships entering and leaving the port for handling cargo volume estimated in 2010.

Note: Bumper Model

1. Fujii[*] and others indicated the presence of the effective domain around a ship into which another ships avoid entering..

2. The domain for co-directional encounter is approximately elliptic with a long radius of 8L and short radius of 3.2L under ordinary navigational condition.

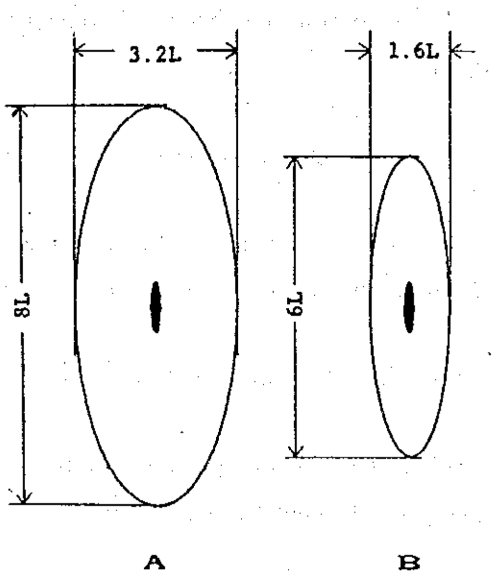


Figure 12-1-11 Bumper Model

3. Observation at port entrance suggests shrunk bumper shown as "B" in the above figure when navigating in very limited water, e.g., inner harbour and narrow strait with reduced speed.

(*) Fuji and Tanaka, Traffic Capacity, J. Navigation Vol. 24 P.543(1971)

12.2 Short Term Port Development Plan

12.2.1 Premise of Planning

On the basis of the long term port development concept plans, the short term port development plan up to the year 2000 will be formulated and according to this plan, the feasibility shall be assured through further study.

The premises and principles of planning are assumed to be as follows.

(1) The land transportation facilities should function well and easy access to the B-1 existing berth should be secured.

(2) The road No 18A should be improved for heavy traffic from/to port area.

(3) The road traffic originating from and destined to the port shall pass through the road No 18A separately from the traffic of tourists. That is heavy traffic of port should use the route which is located at the top of the hills and avoid the sea side route facing Ha Long Bay.

(4) The necessity of port railway connected with Ha Long station and such facilities as wagon operating yard will be examined.

(5) B-12 oil buoy berth and oil terminal are to continue operations.

(6) Hon Gai Port, and Quang Ninh Port, continue to operate mainly for coal transportation.

(7) The industries and EPZ suggested in chapter 9 will be operated.

(8) One cement factory will have private berths from which cement and clinker for domestic use will be directly transported to other districts.

12.2.2 Cargo Handling volume and Handling type

According to the selective criteria as already mentioned in Chapter 11.5, cargo handling volume by handling type is determined as in the following table.

Table 12-2-1 Cargo Handling Volume by Handling Type

Commodity		Handling type	In the year 2000
Export			
Rice		Bag	200
Maize		Dry Bulk	300
Grained Wheat		Bag	30
Cement and Clinker		Bag	120
		Dry Bulk	120
General cargo		Box etc	37
Container		Container	94
Sub total			901
Import			
Coal		Dry Bulk	10
Scrap		Break Bulk	287
Fertilizer		Bag	103
Chemicals		Drum	89
Asphalt		Drum	30
Wheat grain		Dry Bulk	240
General cargo		Box etc	87
Container		Container	225
Sub total			1,071
Domestic			
Rice	In	Bag	158
Steel	Out	Break Bulk	350
Fertilizer	Out	Bag	74
General Cargo	In Out	Box etc	122
Sub total			704
Total		-	2,676

Summing up cargo volume by each handling type, the amount of cargo volume by each handling type can be tabulated as below.

Table 12-2-2 Total Cargo Volume

Handling type	Export	Import	Domestic In	Domestic Out	Total
Box etc	37	87	61	61	246
Bag	350	103	158	74	685
Drum	0	119	0	0	119
Dry Bulk	420	250	0	0	670
Break Bulk	0	287	0	350	637
Container	94	225	0	0	319
Total	901	1,071	219	485	2,676

12.2.3 Necessary number of Berth

(1) Average handling cargo volume by each ship.

Cai Lan Port shall be designated as a deep sea port and a high efficiency port. Therefore it is considered that the average ship size entering and leaving Cai Lan port is relatively larger than in the case of usual ports.

Generally speaking a larger ship has many holds (4 ~ 5 holds), thus the number of the gangs increases. As a result, average cargo handling volume per day per ship increases.

Considering the present ship size for various cargo, and comparing with examples in Hai Phong Port, the average cargo handling volume and cargo handling volume per day per ship in Cai La Port can be assumed as in the following table.

Table 12-2-3 Average Ship Size and Cargo Handling Capacity

	Average ship size DWT	Loading ratio	Cargo volume per ship ton	Average Cargo Handling Volume/day/ship ton
Break Bulk	20,000	0.6	12,000	-
Dry Bulk	25,000	0.8	20,000	-
(grain)	(30,000)	0.8	(24,000)	9,000 (grain)
-	-	-	-	6,700 (the other)
Bag and Drum	20,000	0.8	16,000	2,200
General cargo	15,000	0.6	9,000	1,600
Container	20,000	0.8	16,000	8,600

(2) Necessary number of berth

If using the above average cargo handling volume per ship per day, and average berth occupancy rate 0.50 working day per year, 365 x 0.9 (rainy day) x 0.9 (maintenance) = 296 days, the necessary number of berth can be calculated as follows.

1) Dry Bulk Berth

Grain, etc.

$$n = \frac{\text{Total Cargo Volume}}{\text{Berth occupancy x Working day x Handling volume/day/ship}}$$

$$= \frac{570{,}000 \text{ ton}}{0.50 \times 296 \text{ days} \times 9{,}000 \text{ ton/day}} = 0.4$$

Other (cement, coal)

$$n = \frac{\text{Total cargo volume}}{\text{Berth occupancy x Working day x Handling volume/day/ship}}$$

$$= \frac{130{,}000 \text{ ton}}{0.50 \times 296 \text{ days} \times 5{,}700 \text{ ton/day/ship}} = 0.2$$

2) Break Bulk Berth

(including Bag, Drum, Steel, Scrap)

$$n = \frac{\text{Total Cargo Volume}}{\text{Berth occupancy x Working day x Handling volume/day/ship}}$$

$$= \frac{1{,}411{,}000 \text{ ton}}{0.5 \times 295 \text{ days} \times 2{,}200 \text{ ton/day/ship}} = 4.4$$

3) General Cargo Berth

$$n = \frac{\text{Total cargo volume}}{\text{Berth occupancy x Working day x Handling volume/day/ship}}$$

$$= \frac{246{,}000 \text{ ton}}{0.50 \times 296 \text{ days} \times 1{,}600 \text{ ton/day/ship}} = 1.1$$

4) Container Handling Berth

$$n = \frac{\text{Total Cargo Volume}}{\text{Berth occupancy x Working day x Handling volume/day/ship}}$$

$$= \frac{319{,}000}{0.50 \times 296 \text{ days} \times 8{,}600 \text{ ton/day/ship}} = 0.3$$

Total 6.4 = 7 berths

The productivity of container berth used in the above calculation is a little high because 8,600 ton/day/ship is referred to the productivity of a specialized container berth. So as to have the allowance for cargo handling capacity, 7 berths are planned to handle the cargo volume estimated in 2000.

12.2.4 Allotment of Cargo Handling Volume to Each Berth

Table 12-2-4 shows the planning cargo handling volume by each berth.

Berth No B-1 is the existing berth with a depth of -9.0m for 10,000 DWT class ship. The berths with the depth of -9.0m will be used mainly for domestic cargo handling.

Berth No B-6 is the multi purpose berth for general cargo. Since the container cargo volume is not sufficient to construct one specialized container berth, it is recommended to construct a multi-purpose berth where general cargo can also be handled.

The principle for cargo allocation to the berth is as follows.

(1) The cargo will be separated into domestic and foreign commodity for convenience of customs and documentation as much as possible.

(2) Dirty cargo such as coal, ore, and clean cargo (cf general cargo) will be separately handled.

(3) The same commodity will be handled in the same berth as much as possible (specialized berth).

(4) The grain, maize, wheat and the commodity concerned grain will be handled at berth No 7, that is, the specialized grain berth.

12.2.5 Alternative Plan

Alternative plans can be drawn, according to the principles and basic ideas mentioned in Chapter 11.5.5 and the study in the previous section. The most important thing is that construction and maintenance cost should be minimized without losing the efficient function.

(1) Alternative for berth alignment

During the dredging work for the access channel of the existing berth B-1 hard rocks near the light house BT1 were encountered. These hard rocks spread 1.0 km in long axis and 500m in short axis at the level of -10m and top of the rocks are located at the level of -2.0m (according to the seismic survey done by EGS and TEDI in March 1994).

Therefore, alternative plans can be drawn in which the rocks are either excavated or avoided.

Table 12-2-4 Planning Cargo Handling Volume by Each Berth (in the year 2000)

Berth No	Water Depth (m)	Berth Length (m)	Ship Size (DWT)	Domestic Export Import	Handling Type	Commodity	In 2000 Tonnage (1,000 T)	In 2010 Tonnage (1,000 T)
B-1	-9.0	166	10,000	D. In	Bag	Rice	80	20
				D. In. Out	Box, etc	General Cargo	122	302
							(202)	(322)
B-2	-9.0	160	10,000	D. In. Out	Bag, etc	Rice	78	128
				D. Out	Bag	Fertilizer	74	153
				D. Out	Break bulk	Steel	50	70
							(202)	(351)
B-3	-10.0	185	15,000	D. Out	Break bulk	Steel	300	400
							(300)	(400)
B-4	-11.0	210	20,000	Import	Break bulk	Scrap	287	350
				Import	Drum	Asphalt	30	70
				Import	Dry bulk	Coal	10	31
							(327)	(451)
B-5	-12.0	240	30,000	Export	Bag	Cement	120	120
				Export	Dry bulk	Clinker	120	120
				Import	Bag	Fertilizer	103	124
				Import	Drum	Chemicals	89	89
							(432)	(453)
B-6	-12.0	240	30,000	Export	Container	General cargo	94	211
				Import	Container	General cargo	225	225
				Export	Box, etc	General cargo	37	50
				Import	Box, etc	General cargo	87	157
							(443)	(643)
B-7	-13.0	260	40,000	Export	Bag	Rice	200	0
				Export	Dry bulk	Rice	0	513
				Export	Dry bulk	Maize	300	316
				Export	Bag	Grained wheat	30	125
				Import	Dry bulk	Wheat	240	1,001
							(770)	(1,955)
Total		1,461					2,676	4,575

Alternative 1 avoids excavating the rocks and reclaims the area around the rocks to utilize for wharves, area for jetty type wharf.

Alternative 2 also avoids the rocks, however the berth alignment is almost parallel type berth (no jetty type berth).

Alternative 3 excavates rocks for the access channel and basin and berth alignment is straight.

Each alternative has advantages and disadvantages as shown below.

Alternative 1

Advantage: Excavation is not necessary
Total berth length is longer than other alternatives.
The berth line is surrounded by rocks, therefore wharf area has good foundation suitable for heavy structural building like ciro.
Back filling material volume is smaller than in case of other alternatives.

Disadvantage: Behind jetty type berth, the area is not so wide to plan a wide open yard or container yard.

Alternative 2

Advantage: Avoid excavating hard rocks to utilize the rock area as hard foundation.

Disadvantage: Back filling material volume is larger than in case of other alternative.

Alternative 3

Advantage: Parallel berth is convenient for berthing various ship sizes.

Back filling material volume is smaller than in case of other alternatives.

Disadvantage: Excavation of hard rocks in back area is neccesary
Back area is smaller than in case of other alternatives.

(2) Evaluation of the alternatives

Considering the above advantages and disadvantages evaluation is summarized in table 12-2-5.

Table 12-2-5 Evaluation of Alternatives

	Alternative 1		Alternative 2		Alternative 3	
The length of berth line	Excellent	◎	Good	○	Good	○
Convenience of utilization in the wharf.	Good	○	Excellent	◎	Excellent	◎
Back yard space	Wide	◎	Medium	○	Small	△
Construction cost						
For foundation	Small	○	Large	△	Small	○
For back filling	Medium	○	Large	△	Small	◎
For Quay	Medium	○	Large	△	Small	◎
For rocks dredging	Zero	◎	Zero	◎	Large	△
Environment impact for (water quality)	Medium	○	Medium	○	Small	◎
Total	Good	◎	Normal	△	Fairly good	○

Evaluation of construction cost is based on a rough estimation and thus a more detailed estimation is necessary. However it is easily understood that alternative 1 is the most recommendable plan.

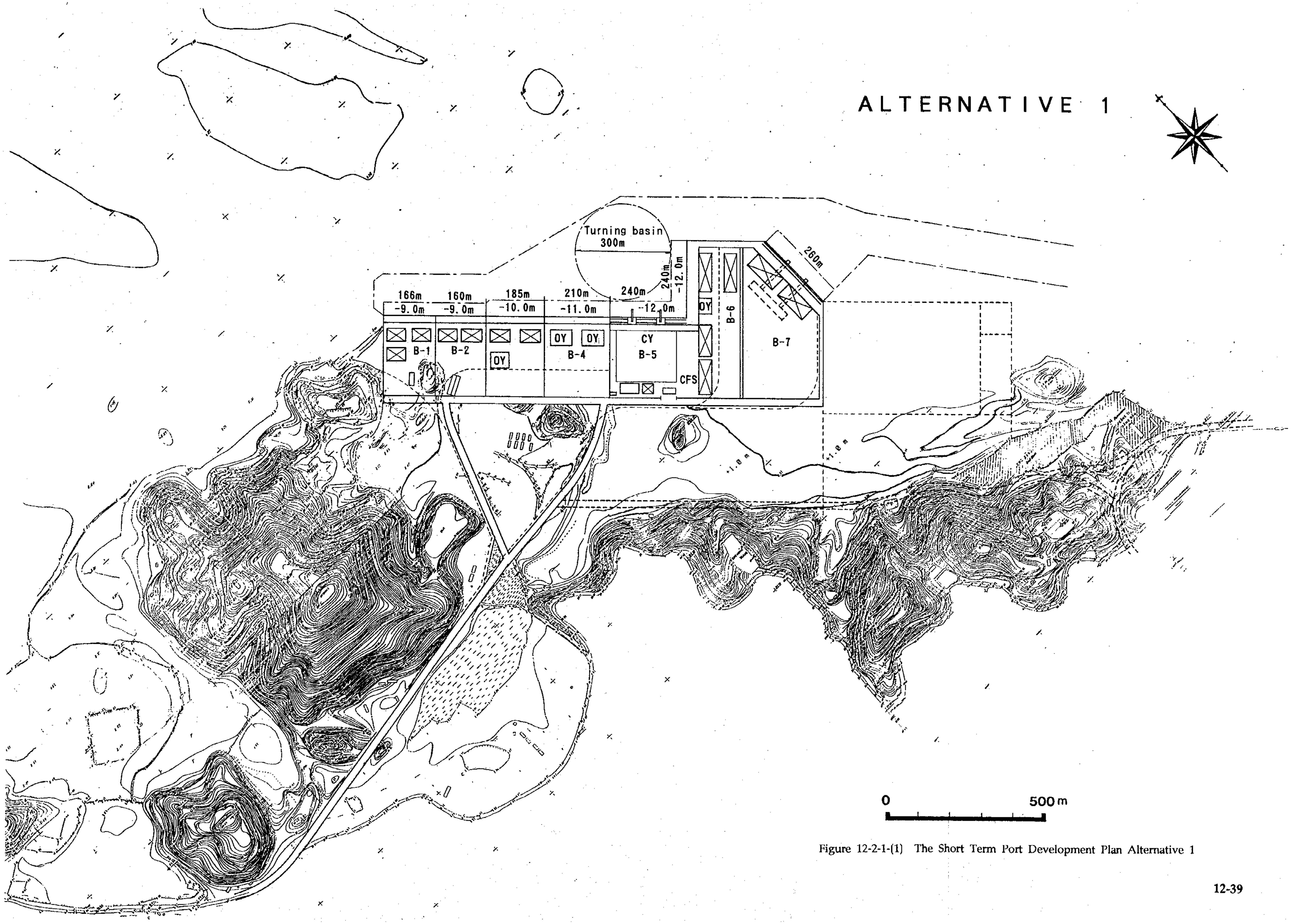


Figure 12-2-1-(1) The Short Term Port Development Plan Alternative 1

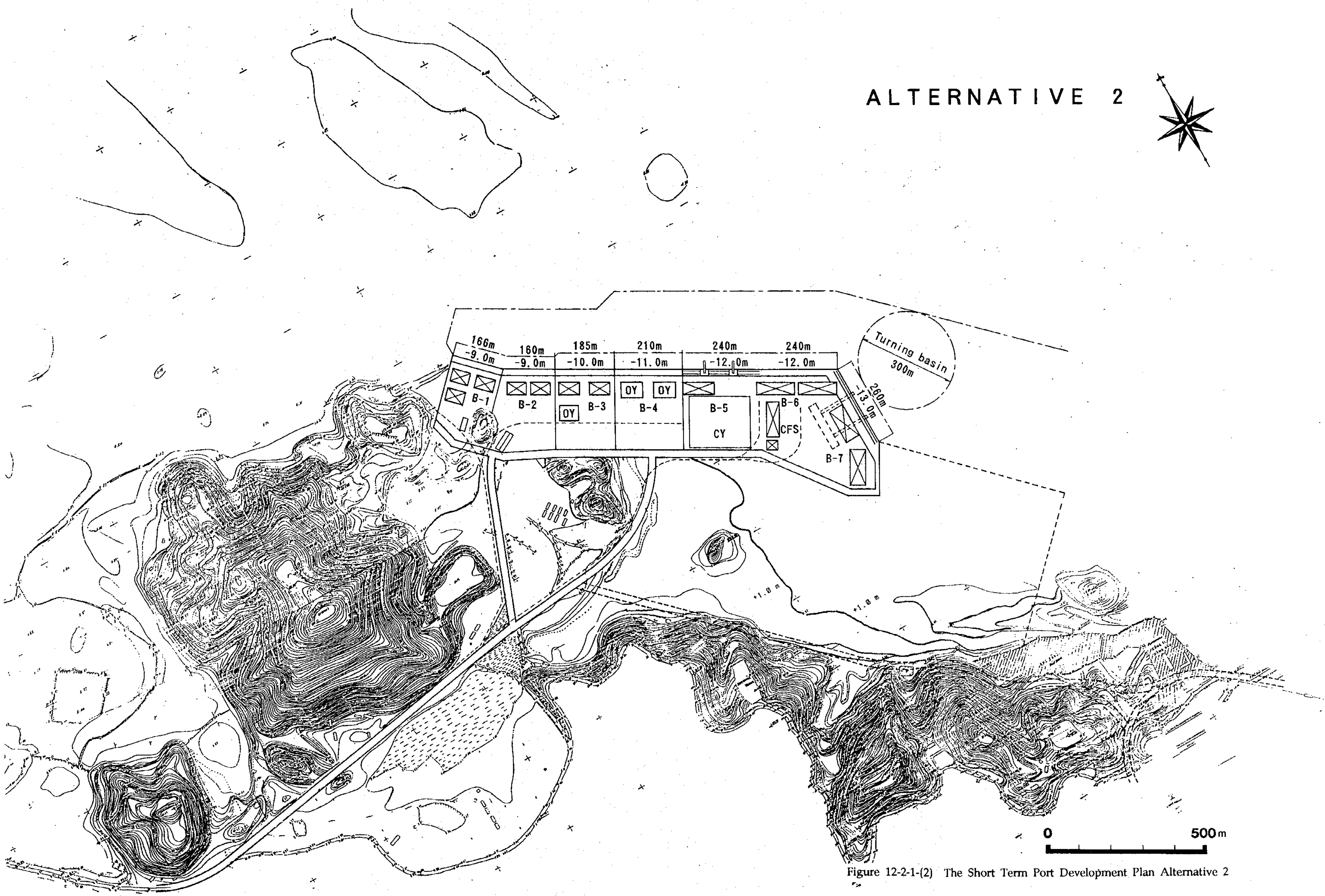


Figure 12-2-1-(2) The Short Term Port Development Plan Alternative 2

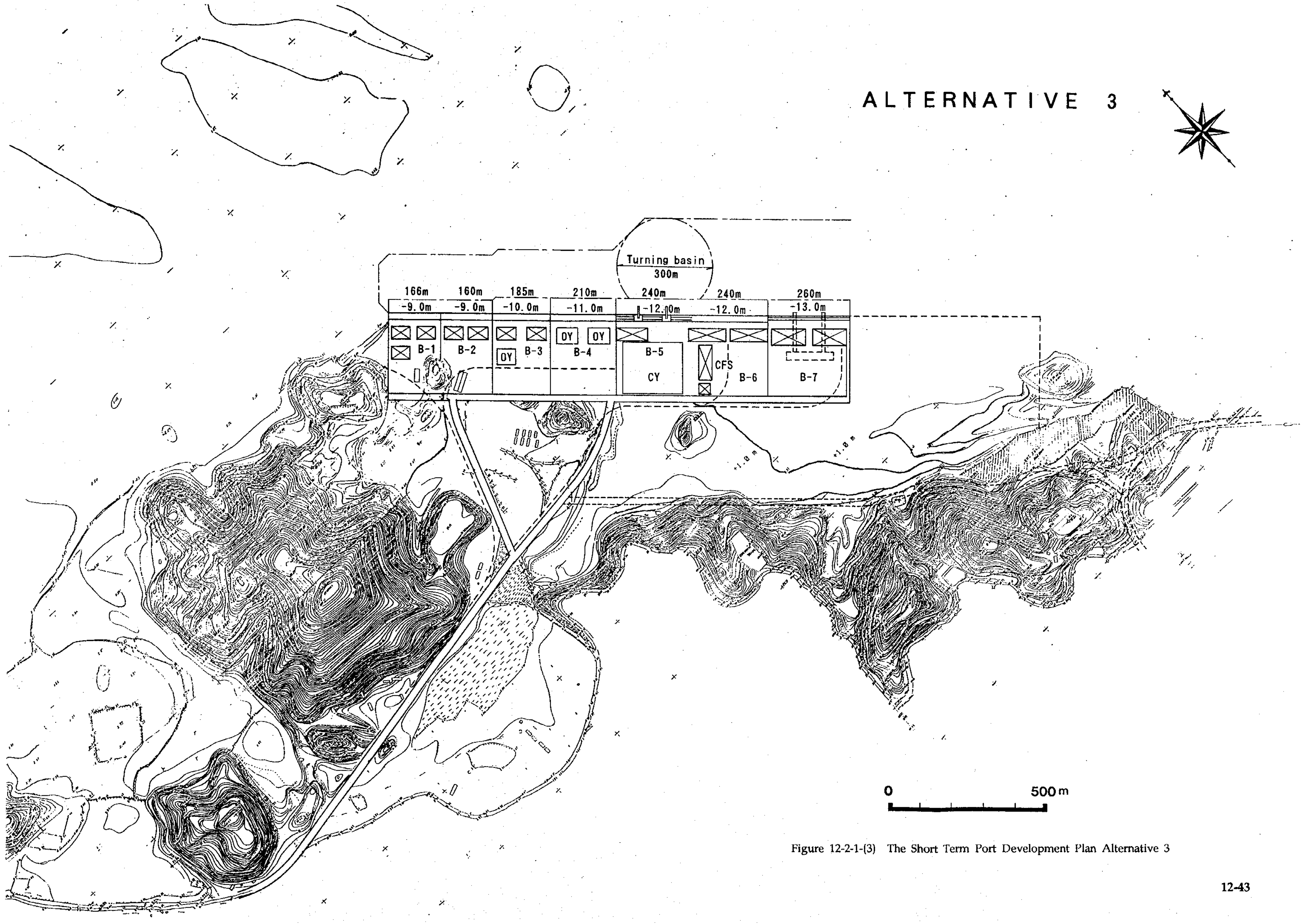


Figure 12-2-1-(3) The Short Term Port Development Plan Alternative 3

12.2.6 Facilities Layout Plan

Based on Alternative 1 which was selected as the optimum berth alignment plan, the facilities plan is studied.

(1) Berth and Berth Area (Cargo Handling Area)

Cargo handling area (berth area) consists of quay, apron,open yard, transit shed, warehouse, inner road, railway, motor pool, parking lot and office etc. Recently cargo handling area has become larger than those before. Container handling area needs large space for quick handling and a standard example is as follows.

For 20,000 DWT Berth : - water depth -12.0 m - Length 250 m - width 300 m - area 75,000 m^2

30,000 DWT Berth : - water depth -13.0 m - Length 300 m - width 350 m - area 105,000 m^2

As already mentioned in Chapter 11.5.4 up to the year 2000 container cargo volume will not be large enough to justify the construction of a specialized container berth. Hence container will be handled with general cargo in a general cargo berth. The actual width of general cargo berth is 150-250m (including width of apron, transit shed, road, railway and warehouse etc.).

In Viet Nam inland warehouses are undeveloped,so it is necessary to construct warehouses in the port area for smooth land transportation.
Considering the above mentioned facts, the width of the berth is set at 250 m.

Then the berths are planed as bellow.

B-2 10,000 DWT berth -9.0 m (water depth) 160 m (length) × 250m (width) = 40,000 m^2

B-3 15,000 DWT berth -10.0 m (water depth) 185 m (length) × 250m (width) = 46,250 m^2

B-4 20,000 DWT berth -11.0 m (water depth) 210 m (length) × 250m (width) = 52,500 m^2

B-5 30,000 DWT berth -12.0 m (water depth) ‹240 m (berth length) + 180m› × 250 m (20,000 DWT container ship) (width) = 105,000 m^2

B-6 30,000 DWT berth -12.0 m (water depth) 240 m (length) × 180 m (width) = 43,200 m^2

B-7 40,000 DWT berth -13.0 m (water depth) 260 m --- 70 × 490 + 184 × 398 = 107,500 m^2

Total 1,295 m Total 394,450 m^2

Including the area of existing B-1 berth (41,500m^2), total area is 435,950m^2.

(2) Access Channel(Cua Luc-Cai Lan) and Basin

The basin in front of berths should be dredged to the same depth as planned berth depth for the low tide. The width of these basins must be twice the ship's breadth. As shown in Chapter 11.3.1 in Table 11-3-1-(1), the moulded breadth of 10,000 DWT is 19.9 m (Japanese standard). So the width of basin is 40.0 m long. For over 15,000 DWT ships width of 50.0m is adopted.

The area of a basin for turning of bow of ship should exceed the area of circle with the diameter of 1.5 times as the overall length of the ship in case of using tugboats and an anchor (Japanese standard). Since the Japanese standard overall length of 40,000 DWT cargo ship is 201m, a turning basin is planned with 300 m in diameter.

Usually one turning basin is necessary every 3 or 4 berths. Therefore for convenience of other ships the turning basin is planned in front of berth No 5. The depth of access channel is 2.5 m less than the depth of the basin in front of the berth because tidal range is used for ship maneuvering.

The width of the access channel before the berth can be determined from the view point of which position the ship moor. If a ship will enter into the access channel and moor the berth without turning her bow, the wide area of 1.5L~ 1.8L (L : the overall length of the ship) for unmooring, leaving and turning is necessary.

When the ship will berth after turning her bow, the width of the access channel must be 0.8~0.9L (L : the overall length of the ship). Since a ship mooring at berth B-1 and B-2 after always turning and her bow toward Cua Luc, the width of the access channel before berth No B-1 and B-2 is planned as 130m wide. (130 = 0.9 × 140 140: overall length of 10,000 DWT)

The width of the access channel before the revetment between B-6 berth and B-7 berth is 130m. This width is minimum length for a 40,000 DWT ship passing through safely. (130 m = 5B here B = 27m : moulded breadth of planning ship size of 40,000 DWT)

(3) Land Transportation

Generally speaking port related cargo is transported by motor vehicle (mostly truck), railway and water surface transport (ferry boat,barge etc.). Each transportation mode has its own features. Motor vehicles are suitable for carrying various types of cargo across short distance transport. Railway is appropriate to transport heavy cargo and long distance cargo. Water surface transport is efficient for transporting bulky long distance cargo.

Average transport distance per ton by each means of transportation in Japan in 1991 is as follows.

Motor vehicle : 80 km, Railway (Japan Railway Corp.) : 465 km

Domestic sea transport : 434 km Source : statistics on land transport MOT

The share of each transportation mode changes according to topographical conditions, economic conditions, kinds of commodity transported and level of services of each means of transportation etc. However the above data in Japan can be referred in examining the share in Vietnam because of the similarity of the shape of countries.

Considering the share of each transportation mode in Hai Phong Port, the present actual transportation conditions in the northern part of Vietnam and the features of each means of transportation, the share of means of transportation in Cai Lan Port is set out as in Table 12-2-6.

Nearly 70% of estimated cargo volume in Cai Lan Port is originated from and destined to the factories near the port. Therefore nearly 90 % of cargo in the year of 2000 is transported by truck. The volume of cargo that can be transported by railway is estimated at 31 thousands ton per year. This volume is too small to construct a port railway, because one lane of railway wagons has the capacity to transport 1500 ton at one time. Thus in the year of 2000 port railway is not planned.

(4) Road

The volume of road traffic generated from port operations can be estimated using the following formula.

$$N = Z \times (\alpha/W) \times (\beta/12) \times (\gamma/30) \times \{(1+\delta) / \epsilon\} \times \theta$$

Here : N - Traffic Volume for planning (number of vehicle per hour)

Z - Cargo handling volume per year (ton)

W - Average loading volume per truck (ton)

Bulk and break bulk cargo	6.0 ton
General cargo	2.0 ton
Container	8.0 ton

α - Transportation share of motor vehicle 1

β - Monthly variation ratio (peak volume / average volume) 1.2

γ - Daily variation ratio (peak volume / average volume) 1.5

Table 12-2-6 Share and Cargo Volume by Each Means of Transportation

Berth No	Domestic Export Import	Handling Type	Commodity	Tonnage Thousand	Road %	Railway %	Barge %	Remarks	Truck (thousand tons)	Railway (thousand tons)	Barge (thousand tons)
B-1	D.In	Bag	Rice	80	100			100%truck between Red River Delta Region	80	0	0
	D.In.Out	Box.etc	General Car.	122	90	10		Railway10% same in present Hai Phong Port	110	12	0
									0	0	0
B-2	D.In.Out	Bag	Rice	78	100			100%truck between Red River Delta Region	78	0	0
	D.Out	Bag	Fertilizer	74	100			100%truck from Fertilizer factory	74	0	0
	D.Out	Break bulk	Steel	50	100			100%truck from Steel Factory	50	0	0
									0	0	0
B-3	D.Out	Break bulk	Steel	300	100			100%truck from Steel factory	300	0	0
									0	0	0
B-4	Import	Break bulk	Scrap	287	100			100%truck from Steel Factory	287	0	0
	Import	Drum	Asphalt	30	100			100%truck to Red River Delta Region	30	0	0
	Import	Dry bulk	Coal	10	100			100%truck from Red River Delta Region	10	0	0
									0	0	0
B-5	Export	Container	General Car.	94	100			100%truck from Red River Delta Region	94	0	0
	Import	Container	General Car.	225	100			100%truck to Red River Delta Region	225	0	0
	Export	Box.etc	General Car.	37	100			100%truck from Red River Delta Region	37	0	0
	Import	Box.etc	General Car.	87	90	10		Railway10% same in present Hai Phong Port	78	9	0
									0	0	0
B-6	Export	Bag	Cement	120			100	100%barge from Lang Bang Cement Factory.	0	0	120
	Export	Dry bulk	Clinker	120			100	100%barge from Lang Bang Cement Factory	0	0	120
	Import	Bag	Fertilizer	103	60	10	30	The same share in Hai Phong Port	62	10	31
	Import	Drum	Chemicals	89	100			100%truck to Fertilizer Factory	89	0	0
									0	0	0
B-7	Export	Bag	Rice	200	90		10	10%barge from Red River Delta Region	180	0	20
	Export	Dry bulk	Rice	0					0	0	0
	Export	Dry bulk	Maize	300	90		10	10%barge from Red River Delta Region	270	0	30
	Export	Bag	Grained Wheat	30	100			100%truck from Wheat Mill Factory	30	0	0
	Import	Dry bulk	Wheat	240	100			100%truck to Wheat Mill Factory	240	0	0
Total				2676					2324	31	321

δ - Number of related vehicle (number of related vehicle / number of truck) 0.5

ε - Loading ratio (number of loading truck / total number of truck) 0.5

θ - Hourly variation ratio (peak volume per hour/ volume per day) 0.16

The figures used here are based on the examples of port planning both in Japan and abroad.

Traffic volume generated from each berth is shown in Table 12-2-7 and in Figure 12-2-2. Total traffic volume resulted 1227 motor vehicles in number.

According to the technical standards for port and harbor facilities in Japan, the design standard traffic volume which refers to the maximum allowable vehicle traffic volume per hour for a two-lane roadway is 650 vehicles in number. Therefore four lanes are necessary for the trunk road. It is necessary to construct a trunk road parallel to the berth alignment line. (cf. Figure 12-2-2, This nearly 1,400 m trunk road is included in this port investment)

The width of a road is determined by lane for motor vehicles, bicycles and pedestrians. Standards width of lane for motor vehicles should be 3.25m -3.5m and for bicycle and pedestrian should be 3.0m.

Typical section for a trunk road and semi-trunk road (traffic volume under 650 vehicles per hour) and branch road (in cargo handling area) are shown in Figure 12-2-3.

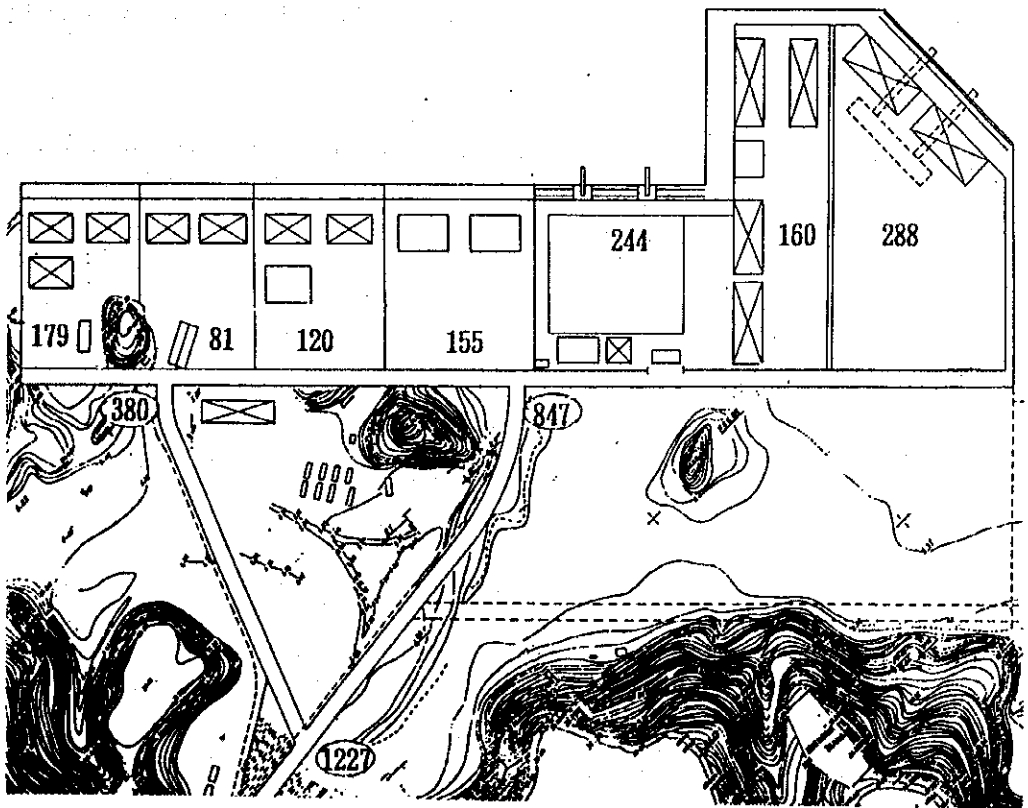


Figure 12-2-2 Traffic Volume Generating from Each Berth

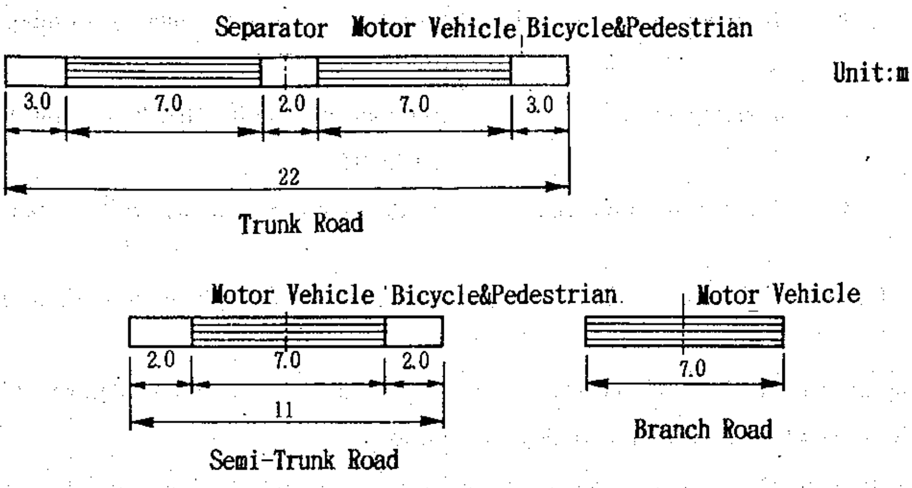


Figure 12-2-3 Typical Section of Port Road

(5) Cargo flow in the port

Cargo flow in the port is determined by many factors such as kind of commodity and handling type, cargo handling equipment,transport condition of hinterland etc. For instance bagged rice or cement must not be exposed to rain and should be carried to the transitshed or warehouse after / before loading / unloadig to / from ships. On the otherhand container cargo does not require transit sheds exept LCL cargo (less than container load cargo). Coal and many ore is usually stocked in the open yard.

Considering the examples in Hai Phong Port and other experience,cargo flow in Cai Lan Port is determined as shown in Figure 12-2-4.

Table 12-2-7 Traffic Volume Generated form Each Berth

Berth No	Domestic Export Import	Handling Type	Commodity	Tonnage Thousand	Road %	Truck Tonnage Thousand	Number of Car per Hour
B-1	D.In	Bag	Rice	80	100	80	32
	D.In.Out	Box,etc	General Car.	122	100	122	147
							179
B-2	D.In.Out	Bag	Rice	78	100	78	31
	D.Out	Bag	Fertilizer	74	100	74	30
	D.Out	Break bulk	Steel	50	100	50	20
							81
B-3	D.Out	Break bulk	Steel	300	100	300	120
							120
B-4	Import	Break bulk	Scrap	287	100	287	115
	Import	Drum	Asphalt	30	100	30	36
	Import	Dry bulk	Coal	10	100	10	4
							155
B-5	Export	Container	General Car.	94	100	94	28
	Import	Container	General Car.	225	100	225	68
	Export	Box,etc	General Car.	37	100	37	44
	Import	Box,etc	General Car.	87	100	87	104
							244
B-6	Export	Bag	Cement	120	50	60	24
	Export	Dry bulk	Clinker	120	0	0	0
	Import	Bag	Fertilizer	103	70	72	29
	Import	Drum	Chemicals	89	100	89	107
							160
B-7	Export	Bag	Rice	200	90	180	72
	Export	Dry bulk	Maize	300	90	270	108
	Export	Dry bulk	Grained Wheat	30	100	30	12
	Import	Dry bulk	Wheat	240	100	240	96
							288
Total				2676		2415	1227

Berth No	Domestic Export Import	Handling Type	Commodity	Ton. (1000)		Ship → Apron		Apron → Area	Area	Area → Inland	Inland Area
B-1	D.In	Bag	Rice	80	Ship	Ship's Gear (Truck Crane)	Apron	Forklift 64(80%)	Transit Shed	Truck 64(80%)	Inland Area
								Beltconveyor		Truck 16(20%)	
	D.In.Out	Box,etc	General Car.	122	Ship	Ship's Gear (Truck Crane)	Apron	Forklift 110(90%)	Transit Shed	Truck 110(90%)	Inland Area
										Truck 12(10%)	
B-2	D.In.Out	Bag	Rice	78	Ship	Ship's Gear (Truck Crane)	Apron	Forklift 62(80%)	Transit Shed	Truck 62(80%)	Inland Area
										Truck 16(20%)	
	D.Out	Bag	Fertilizer	74	Ship	Ship's Gear (Truck Crane)	Apron	Forklift 59(80%)	Transit Shed	Truck 59(80%)	Inland Area
										Truck 15(20%)	
	D.Out	Break bulk	Steel	50	Ship	Ship's Gear (Truck Crane)	Apron	Forklift 25(50%)	Transit Shed	Truck 25(50%)	Inland Area
								Truck 15(30%)	Open Yard	Truck 15(30%)	
										Truck 10(20%)	
B-3	D.Out	Break bulk	Steel	300	Ship	Ship's Gear (Truck Crane)	Apron	Forklift 150(50%)	Transit Shed	Truck 150(50%)	Inland Area
								Truck 90(30%)	Open Yard	Truck 90(30%)	
										Truck 60(20%)	
B-4	Import	Break bulk	Scrap	287	Ship	Ship's Gear (Shore Crane)	Apron	Truck 287(100%)	Open Yard	Truck 287(100%)	Inland Area
	Import	Drum	Asphalt	30	Ship	Ship's Gear (Shore Crane)	Apron	Truck 27(90%)	Open Yard	Truck 27(90%)	Inland Area
								Truck 3(10%)			
	Import	Dry bulk	Coal	10	Ship	Ship's Gear	Apron	Truck 10(100%)	Open Yard	Truck 10(100%)	Inland Area

Figure 12-2-4 Cargo flow in Cai Lan Port

Berth No	Domestic Export Import	Handling Type	Commodity	Ton. (1000)				Port Operation	Area	Inland	Area
B-5	Export	Container	General Car.	94	Ship	Shore Crane	Apron	Truck 28(30%)	CFS	Truck 28(30%)	Inland Area
								Truck 66(70%)	Cont. Yard	Truck 66(70%)	
	Import	Container	General Car.	225	Ship	Shore Crane	Apron	Truck 45(20%)	CFS	Truck 45(20%)	Inland Area
								Truck 180(80%)	Cont. Yard	Truck 180(80%)	
	Export	Box,etc	General Car.	37	Ship	Shore Crane	Apron	Forklift 33(90%)	Transit Shed	Truck 33(90%)	Inland Area
										Truck 4(10%)	
	Import	Box,etc	General Car.	87	Ship	Shore Crane	Apron	Forklift 78(90%)	Transit Shed	Truck 78(90%)	Inland Area
								Truck 9(10%)			
B-6										Barge 76(50%)	
	Export	Bag	Cement	120	Ship	Ship's Gear	Apron	Forklift 48(40%)	Transit Shed	Truck 48(40%)	Inland Area
										Truck 12(10%)	
	Export	Dry bulk	Clinker	120	Ship	Ship's Gear	Apron			Barge 120(100%)	Inland Area
								Barge 31(30%)			
	Import	Bag	Fertilizer	103	Ship	Ship's Gear	Apron	Forklift 72(70%)	Transit Shed	Truck 72(70%)	Inland Area
	Import	Drum	Chemicals	89	Ship	Ship's Gear	Apron	Truck 80(90%)	Open Yard	Truck 80(90%)	Inland Area
								Truck 9(10%)			
B-7										Barge 20(10%)	
	Export	Bag	Rice	200	Ship	Ship's Gear / Shore Crane	Apron	Forklift 140(70%)	Transit Shed	Truck 140(70%)	Inland Area
										Truck 40(20%)	
										Barge 30(10%)	
	Export	Dry bulk	Maize	300	Ship	Ship's Gear / Shore Crane / Beltconveyor	Apron	Beltconveyor 270(90%)	Transit Shed	Truck 270(90%)	Inland Area
	Export	Bag	Grained Wheat	30	Ship	Shore Crane	Apron	Forklift 15(50%)	Transit Shed	Truck 15(50%)	Inland Area
										Truck 15(50%)	
	Import	Dry bulk	Wheat	240	Ship	Shore Crane	Apron	Hopper+Truck 120(50%)			Inland Area
								Beltconveyor 120(50%)	Transit Shed	Truck 120(50%)	

Figure 12-2-4 Cargo flow in Cai Lan Port

(6) Cargo Sorting and Storage Facilities

Based on cargo volumes in the above figure, required storage capacity can be calculated using the following formula.

$W = N / R \times C = \alpha wA$

Here: - W Storage capacity (ton)

- N Cargo handling volume per year (ton)
- R Turn over ratio (32 turn per year)
- C Peak factor (1.5)
- α Use rate of area (0.6~1.0)
- w Average stacking weight per square meter (2.1~3.6)
- A Required space (m^2)

Results of calculation are shown in Table 12-2-8.

Table 12-2-8 Required Storage Capacity of Each Berth for the Target year 2000

Berth No.	Name of Facilities	Cargo Style	Cargo Volume Th. ton (N)	Peak Ratio (C)	Turn-over Ratio per year (R)	Use Rate (α)	Average Stack Weight (w)	Required Space (A)m^2
B-1	Transit Shed	Bag/GC/Stl	174	1.5	35	0.6	2.1	5,918
B-2	Transit Shed	Bag/GC/Stl	146	1.5	35	0.6	2.1	4,986
	Open Yard	Steel	15	1.5	35	0.6	2.1	510
B-3	Transit Shed	Bag/GC/Stl	150	1.5	35	0.6	2.1	5,102
	Open Yard	Steel	90	1.5	35	0.6	2.1	3,061
B-4	Open Yard	Scrap/Drum	324	1.5	35	0.6	2.1	6,929
B-5	C.F.S	GC/Bag	73	1.5	35	0.6	1.8	4,429
	Transit Shed	GC	111	1.5	35	0.6	2.1	3,776
B-6	Transit Shed	Bag	120	1.5	35	0.6	2.1	4,085
	Open Yard	Drum	80	1.5	35	0.6	2.1	2,721
B-7	Transit Shed	Bag	155	1.5	35	0.6	2.1	5,272
		Bulk	390	1.5	35	0.8	2.0	10,446

According to those figures the following sorting and storage facilities are planned.

B-1	- Transit Shed	No-1 40 m × 60 m = 2,400 m²	
		No-2 40 m × 60 m = 2,400 m²	
		No-3 40 m × 60 m = 2,400 m²	total 7,200 m²
B-2	- Transit Shed	No-4 40 m × 60 m = 2,400 m²	
		No-5 40 m × 65 m = 2,600 m²	total 5,000 m²
B-3	- Transit Shed	No-6 40 m × 65 m = 2,600 m²	
		No-7 40 m × 65 m = 2,600 m²	total 5,200 m²
	- Open Yard	OY-1 60 m × 50 m = 3,000 m²	
B-4	- Open Yard	OY-2 50 m × 70 m = 3,500 m²	
B-5	- Transit Shed	No-8 40 m × 100 m = 4,000 m²	
	- C.F.S.	No-1 40 m × 110 m = 4,400 m²	
	- Container Y	No-1 190 m × 160 m = 30,400 m²	
B-6	- Transit Shed	No-9 40 m × 120 m = 4,800 m²	
	- Open Yard	OY-3 50 m × 55 m = 2,750 m²	
B-7	- Transit Shed	No-10 40 m × 120 m = 4,800 m²	
		No-11 50 m × 110 m = 5,500 m²	
		No-12 50 m × 110 m = 5,500 m²	total 15,800m²

(7) Cargo Handling Facilities

Cargo handling facilities were examined in section of this Chapter. Up to the year 2000 two shore cranes (40KT) are installed in B-5 Berth for mainly container handling and necessary facilities for container handling such as truck scales and a maintenance shop etc.are also planned. Two level luffing cranes are planned for grain handling in B-7 berth, however ship' gears can be used from the viewpoint of cost.

(8) Other Facilities

In order to preserve a good environment a large green area is planned in the area behind B-2~B-4 berth surrounded by trunk roads. (nearly 11.5ha)
Administration offices and welfare facilities for port workers are also planned in this area. An administration building with 3000 m² is planned for the 580 stuffs in the year 2000 (unit dimensions: 5 m²/person). Such facilities as water and electricity supply, drainage, communication facilities, light buoys and tug boats are also necessary.

Facilities layout plan is shown in Figure 12-2-5.

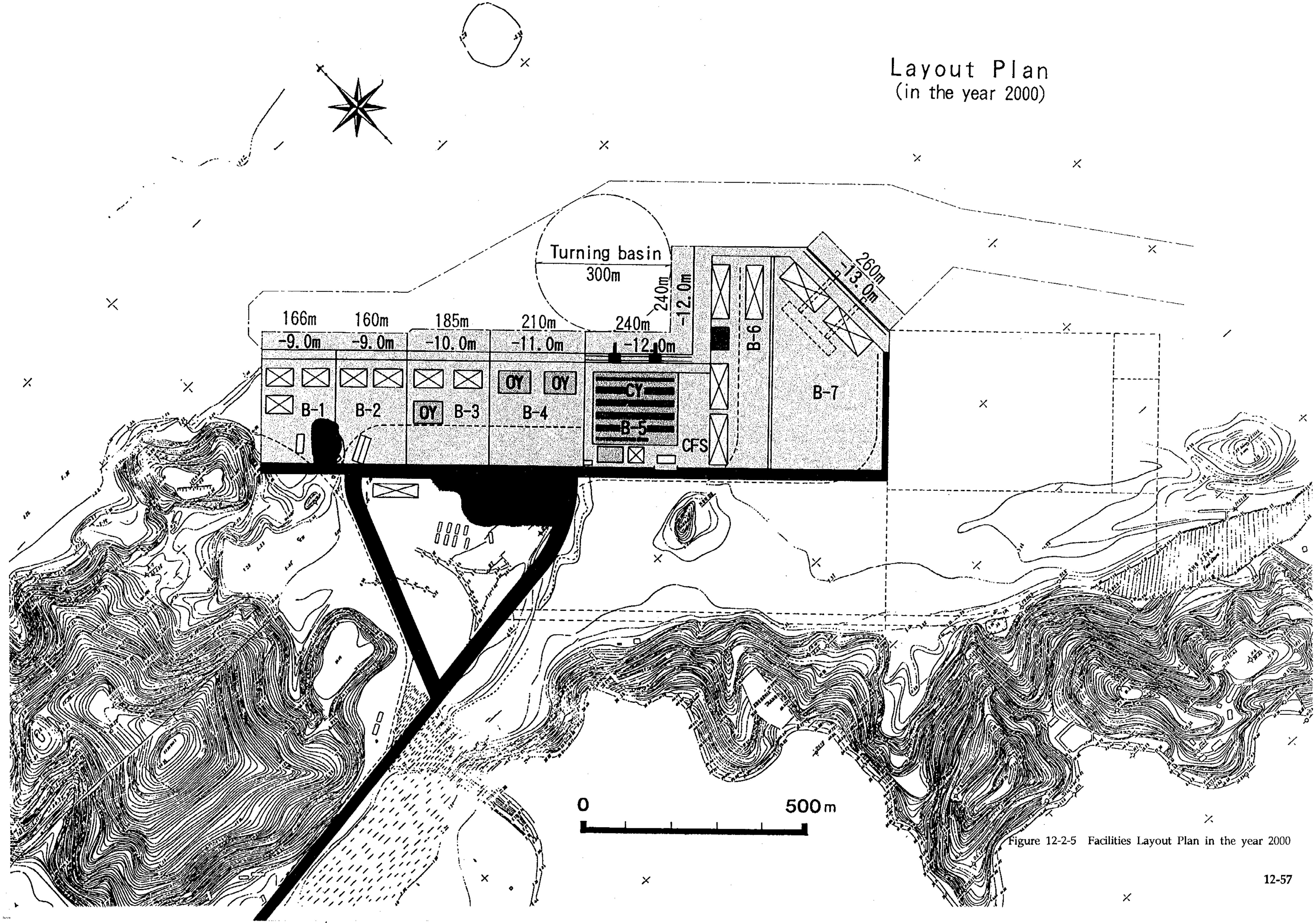


Figure 12-2-5 Facilities Layout Plan in the year 2000