4.8.2 Preparing and Updating the Yard Map (Container Locations)

The yard planner inputs container locations reported by a yard clerk and prepares a yard map so as to be able to refer locations and specifications of container when requested by the gate clerk as well as to issue gate passes at the time of delivery. The yard map, however, is not frequently revised or updated. Even when a container is shifted from one place to another so that a specific container stacked under the container can be picked up, the shifted container is put back in the previous location instead of the yard map being revised. This practice will be major problem as non-commercial handling will increase greatly after the deployment of transfer crane system which can stack containers higher than the system now used. Moreover reporting and monitoring of container location could be simplified by establishment of a centralized control room and installation of a yard communication system.

4.8.3 Simplicity of Documents Reception

These are two focal points in receiving necessary documents from the outside parties: manifests are received by the Cargo Department Office in the Finance Department, and stowage plans and dangerous/reefer cargo lists are received by the terminal office in the yard. Since the existence of two focal points presents disadvantage for the port users and thus a simpler, single window system should be used.

4.8.4 Preparing a Stowage Plan

In order to prepare a final stowage plan, three planner are now aboard the vessel, one chief planner and two planning clerks. When a pre-stowage plan is filed in the computer system it is easily to revise these data with a yard communication system through monitoring of the operation by a centralized control room.

4.8.5 Standardization and Simplification of Operations

There are a lot of containers stacked in the fore side back in the marshaling yard. This shows that the operation, especially for movement of handling equipment, is not standardized and streamlined.

One-way traffic in the marshalling yard would ensure safety and simplicitity of operations. Consequentially containers are stacked in one direction, correctly emplaced. Standardization and simplification of the operation can be achieved by means of a proper terminal control system and operation control system.

CHAPTER 5 DEMAND FORECAST

Chapter 5. DEMAND FORECAST

5.1 Socioeconomic Indices

5.1.1 Present Socioeconomic Situation

(1) Population

Since no census has ever been held in Oman, estimates of the Nation's Population are based upon supposition. The population growth rate and population by age are also items for which no firm figure is available.

According to the World Bank estimates, the population was 1,242,000 in 1985 and 1,345,000 in 1987. Some Government officials say that the population of Oman at present is 2,000,000 which seems to be a little high. For planning purposes in the Development Council, the population is assumed to be 1,500,000 for 1989 and the Study Team has adopted this figure.

(2) Gross Domestic Product (GDP)

Oil production began in 1967. Before then, the economy of Oman was based substantially upon agriculture and fishing, but it was not until 1970, when Sultan Qaboos Bin Said came to power, that the income from oil was invested in the country's economic development. Subsequently, Oman's economy expanded considerably. According to estimates by the World Bank, between 1970 and 1985 the country's gross national product (GNP) increased, in real terms, by 9.5% per year.

Under the Second Five-Year Development Plan (1981-1985), at the outset of which oil prices reached close to US$ 40/barrel compared to less than US$ 13.5/barrel five years earlier, emphasis was placed on diversification of the economy, improving infrastructure and encouraging private sector activity.

At the same time, oil output was raised to nearly 500,000 b/d in order to compensate for the price decline thereafter. Oil prices declined to a level of about US$ 27/b by 1985. Between 1981 and 1985, GDP in real terms increased at an annual rate of 14.5%. The manufacturing and agriculture/fishery sectors had growth rates of 34.4% and 13.2%, respectively. The share of the oil sector in the GDP declined from 58.5%

in 1981 to 47.5% in 1985 (at current prices).

However, at the beginning of the Third Five-Year Development Plan, which continues to emphasise private sector import substitution industries, expansion of social services and improvement of agriculture and fisheries, oil prices fell to less than US$ 10/barrel (July 1986) and a consequent decline in oil revenues led to critical financial problems in the Government of Oman.

Government expenditures in 1987 were reduced by 12.3% form the 1986 level. Even though the Government decided to step up oil production from 498,200 b/d in 1986 to 582,300 b/d in 1987 and 619,100 b/d in 1988 in order to increase oil revenues, between 1985 and 1988 GDP annual growth rate in real terms was only 1.7% and nominal GDP showed a minus growth rate of -5.5%. Under these circumstances, the manufacturing and agriculture/fisheries sectors had rather high growth rates of 9.0% and 7.6%, respectively, while construction, which has suffered a severe set-back, had a growth rate of -20.1%, while government services remained at 2.0%. The share of the oil sector of the GDP declined continuously to 39.2% in 1988 (at current prices).

The annual sectoral GDP from 1978 to 1988 at current prices is shown in Table 5-1-1 and GDP at 1978 constant prices is shown in Table 5-1-2.

There is no official figure available concerning GNP. The World Bank estimated Oman's GNP per capita at US$5,830 in 1987.

Table 5-1-1 Gross Demestic Product by Sector (at Current Prices)

(Unit:Million Rial Omani)

Year	Total	Oil	Agriculture Fisheries	Manufacuturing	Consturction	Trade, Hotels, Restaurants	Real Estate, Banking, etc	Government Services	Others
1978	946.9	493.8	30.7	8.5	71.4	104.0	100.1	109.2	29.2
1979	1,289.9	719.7	40.3	11.5	86.1	137.1	123.1	137.9	34.2
1980	2,063.5	1,280.5	52.6	15.6	117.8	188.3	162.8	194.6	51.3
1981	2,490.5	1,456.1	62.1	27.0	144.9	251.3	206.6	260.5	82.0
1982	2,613.6	1,402.0	66.1	39.6	169.8	299.5	231.2	305.0	100.4
1983	2,739.9	1,370.7	80.6	49.7	187.4	315.7	250.1	360.0	125.7
1984	3,046.7	1,427.8	89.0	72.1	226.9	369.0	275.9	423.9	162.1
1985	3,453.8	1,639.1	93.7	82.3	242.2	428.0	295.9	477.9	194.7
1986	2,800.4	1,024.6	95.9	103.1	220.8	383.2	281.2	495.8	195.8
1987	3,002.6	1,362.0	105.4	111.5	137.0	327.3	260.3	509.9	189.2
1988	2,919.3	1,143.7	123.6	122.7	119.4	388.8	269.4	535.2	216.5

Source: "Statistical Year Book 1985-88" (Development Council)

Table 5-1-2 Gross Demestic Product by Sector (at 1978 Constant Prices)

(Unit:Million Rial Omani)

Year	Total	Oil	Agriculture Fisheries	Manufacuturing	Consturction	Trade, Hotels, Restaurants	Real Estate, Banking, etc	Government Services	Others
1978	946.9	493.8	30.7	8.5	71.4	104.0	100.1	109.2	29.2
1979	987.5	461.0	40.6	10.5	74.6	117.5	111.0	137.9	34.9
1980	1,047.1	438.4	49.0	12.5	91.4	139.0	125.5	144.6	46.7
1981	1,225.6	493.6	49.7	20.6	107.1	180.4	143.5	170.2	60.5
1982	1,367.1	494.9	54.1	30.2	142.3	224.6	162.4	176.6	81.9
1983	1,585.3	583.6	64.2	37.8	174.7	238.6	179.1	203.9	103.5
1984	1,850.6	623.4	70.4	55.9	221.3	286.9	215.6	235.6	141.4
1985	2,105.2	750.5	81.7	67.3	239.3	316.9	239.6	248.1	162.1
1986	2,175.2	850.7	79.1	81.0	235.4	250.5	248.3	239.1	191.3
1987	2,095.4	905.7	83.8	84.3	144.5	191.9	226.1	259.7	199.5
1988	2,215.5	974.5	101.8	87.2	122.0	210.5	227.4	263.0	229.1

Source: "Statistical Year Book 1985-88" (Development Council)

5.1.2 Future Socioeconomic Framework

(1) Population

In the absence of a census, it is impossible to correctly estimate the future population growth rate. The Study Team, therefore, adopted an annual growth rate of 3.5%, which is assumed to be that used for planning purposes in the Government.

Table 5-1-3 Population in 1995, 2000 and 2010

(Unit: Thousands)

Year	1995	2000	2010
Population	1,844	2,190	3,089

(2) Gross Domestic Product (GDP)

Since the Fourth Five-Year Development Plan is now in the course of preparation and is to be published in late 1990, there are no authorized or published figures concerning future GDP. However, after some interviews with officials of the Development Council, it was found that the GDP growth rate between 1991 and 2000 will be an estimated 5.0% per annum on condition that the oil price is US$ 18/barrel from 1991 to 1995 and US$ 20/b from 1996 to 2000. Taking this into consideration, the Study Team has estimated that the annual growth rate of the GDP of Oman will be:

i) 5.1% from 1991 to 1995
ii) 5.0% from 1996 to 2000
iii) 5.0% from 2001 to 2010

(In this estimate the growth rate of the manufacturing and agriculture/ fishery sectors is more than 10%, the highest of all the sectors, while the growth rate of government services remains at 4%. The rate of inflation by sector is determined with reference to those of the past years. The price of oil is estimated at US$ 18/b in 1995, US$ 20/b in 2000 and US$ 24/b in 2010. Oil production remains at the same level as in 1988.)

The results of the estimate are shown in Table 5-1-4. (All figures are in current prices).

Table 5-1-4 Estimated GDP in 1995, 2000 and 2010 (at Current Prices)

(Unit:Million Rial Omani)

Year	Oil	Agriculture Fisheries	Manufacuturing	Consturction	Trade, Hotels, Restaurants	Real Estate, Banking, etc	Government Services	Others	Total
1995	1,440.9	238.0	240.8	156.0	617.2	373.2	699.3	305.9	4,071.3
2000	1,600.8	395.7	400.3	190.1	870.5	489.4	852.4	391.5	5,190.8
2010	1,899.9	907.0	917.7	282.4	1,731.8	841.6	1,205.9	641.3	8,427.6

5.2 Demand Forecast

5.2.1 Methodology

Two methods are used to forecast the cargo volume to be handled at ports.

The first method is to forecast the total volume as a whole by statistical correlation between the cargo volume and socioeconomic indices of the hinterland or by the past cargo volume trend (Hereinafter, this method is called the "total demand forecast").

The second method is a cumulative method which forecasts the volume of each major commodity group individually based upon the forecast of supply and demand in the hinterland or based upon analysis of the past cargo trend. The total cargo volume is then forecast by a summation of the forecast volumes for each commodity (hereinafter, this method is called the "commodity-wise demand forecast").

In this Study, both methods are used to forecast the local trade cargo (imports/exports), while only total demand forecast is applied to the transshipment cargo, of which the breakdown by commodity is not known.

The forecast of cargo volume is prepared for the years 1995, 2000, 2010 and 2015, given that the target years of the master plan of a new port and the development plan for Mina Qaboos are, respectively, 2015 and 1995-2000. The forecast in 2015 is made by extrapolation from that in 2010.

5.2.2 Premise

In this chapter the total demand for both of Mina Qaboos and a new port in Northern Oman is forecast on the premise that superior ports will be provided in Oman with enough handling capacity, high efficiency and price competitiveness.

It is assumed that the ports in Oman will be attractive to the port users and be competitive with the major ports in the UAE (e.g., Port Rashid, Jebel Ali Port, Port Khor Fakkan, Port of Fujairah and so forth) after the extension and improvement of Mina Qaboos and development of a new port. Port traffic between Mina Qaboos and a new port will be allocated later.

5.2.3 Hinterland

Taking into consideration the fact that there is no international port in Oman other than Mina Qaboos and that major imported cargoes are distributed across the country from Muscat, the Study Team has taken the whole country as the hinterland of Mina Qaboos and a new port.

5.3 Total Demand Forecast

The total demand forecast is conducted separately for import, export and transshipment cargoes.

5.3.1 Import Cargo

The total import volume of Oman is to be forecast first. After estimating what percentage of imports will enter through Mina Qaboos and a new port (hereafter this percentage is called "the share of the ports"), the cargo volume which will be handled at Mina Qaboos and a new port is forecast.

(1) Total Import of Oman

The imports of a country are closely related to its socioeconomic indices, in particular gross domestic product (GDP), or gross national product (GNP). For the purpose of analysing this correlation, GDP (or GNP) at constant prices should be used in order to remove the effects of price inflation.

In Oman, GDP figures at 1978 constant prices are available as well as at current prices. However, it can be easily determined that in the case of Oman, GDP at constant prices does not indicate the real economic situation of the country. To put it concretely, even in 1986, when the steep decline in oil prices gave a severe shock to the economy of Oman, where the Oil sector accounts for about 40% of total GDP and oil revenues account for about 80% of government revenue, GDP at constant prices showed a steady increase of 3.3% per year, although GDP at current prices plunged 18.9%.

Therefore, GDP at constant prices should not be adopted as an explanatory variable. Hence, the Study Team has adopted the summation of the following two items as GDP for regression analysis. (Hereinafter this GDP for regression analysis is called "GDP (R)").

(i) GDP of the oil sector at current prices.

(ii) Total GDP at 1978 constant prices exclusive of the oil sector.

GDP (R) and total import cargo volume of Oman between 1978 and 1988 are shown in Table 5-3-1.

Table 5-3-1 GDP (R) and Imports of Oman

(Unit: Million Rial Omani, '000 tonnes)

Year	① GDP at current prices (Oil)	② GDP at 1978 constant prices (exclusive of Oil)	GDP (R) (①+②)	Import of Oman
1978	493.8	453.1	956.9	1,584.7
1979	719.7	526.5	1,246.2	1,644.8
1980	1,280.5	608.7	1,889.2	1,960.5
1981	1,456.1	732.0	2,188.1	2,590.2
1982	1,402.0	872.2	2,274.2	3,036.8
1983	1,370.7	1,001.8	2,372.5	2,758.6
1984	1,427.8	1,227.2	2,655.0	2,852.9
1985	1,639.1	1,354.7	2,993.8	3,121.5
1986	1,024.6	1,324.6	2,349.2	2,121.8
1987	1,362.0	1,189.7	2,551.7	1,562.4
1988	1,143.7	1,241.0	2,384.7	1,524.9

Based upon "Statistical Year Book 1985-88" (DC)

The correlation between Oman's total import and GDP (R) for 1979 through 1988 can be expressed by the following equations:

$$Y = 0.9362 X_1 - 1,246.68 X_2 + 614.34$$

Where, Y : Total imports of Oman ('000 tonnes)

X_1: GDP (R) (two-year moving average)

X_2: Dummy variable (=1 from 1986 on)

$$\begin{bmatrix} r = 0.9624 \\ \text{F-value} = 43.9 > F(2,7;0.005) = 12.404 \\ \text{Durbin - Watson's Ratio} = 2.007 \end{bmatrix}$$

Note: Taking into consideration that the economic structure and situation of Oman has changed since 1986 (oil prices are estimated to remain at a low level and the growing domestic industries like cement have come to satisfy the domestic demand to some extent), a dummy variable has been introduced.

Table 5-3-2 shows the estiated results of future GDP at 1978 constant prices by sector (exclusive of the oil sector).

Table 5-3-2 Estimated GDP in 1995, 2000 and 2010 at 1978 Constant Prices (Exclusive of Oil Sector)

(Unit:Million Rial Omani)

Year	Agriculture Fisheries	Manufacuturing	Consturction	Trade, Hotels, Restaurants	Real Estate, Banking, etc	Government Services	Others	Total
1995	164.9	144.0	143.6	271.7	274.3	299.1	281.7	1,579.3
2000	242.3	211.6	162.5	330.6	325.7	330.3	326.6	1,929.5
2010	433.9	378.9	208.0	489.3	459.5	383.3	438.9	2,791.8

Total imports of Oman in 1995, 2000, 2010 and 2015 are shown in Table 5-3-3 and the past trend and future forecast of imports of Oman are shown in Fig. 5-3-1.

Table 5-3-3 Total Imports of Oman in 1995, 2000, 2010 and 2015

(Unit: '000 tonnes)

Year	1995	2000	2010	2015
Total Imports of Oman	2,146	2,622	3,699	4,393

(2) Share of Ports

The quantity of imports by points of entry is shown in Table 5-3-4. This table shows that Mina Qaboos accounts for 40 - 60% of the country's total imports and that more than 30% of imports (almost 50% in 1985) enter by road (most of them are from the UAE, Dubai in particular).

Although Mina Raysut handles about 10% of Oman's imports, it is not likely that the share of this southern port will increase hereafter.

Dubai, which is a successful trading center and has been established as the main distribution center in the Middle East, will remain the distribution center in this region. However, taking into account that 30 - 40% of the timber and 40 - 60% of the steel imoported by Oman now enter by road, it is very likely that the percentage of imports that will enter Oman through Mina Qaboos and a new port will increase to a certain extent after

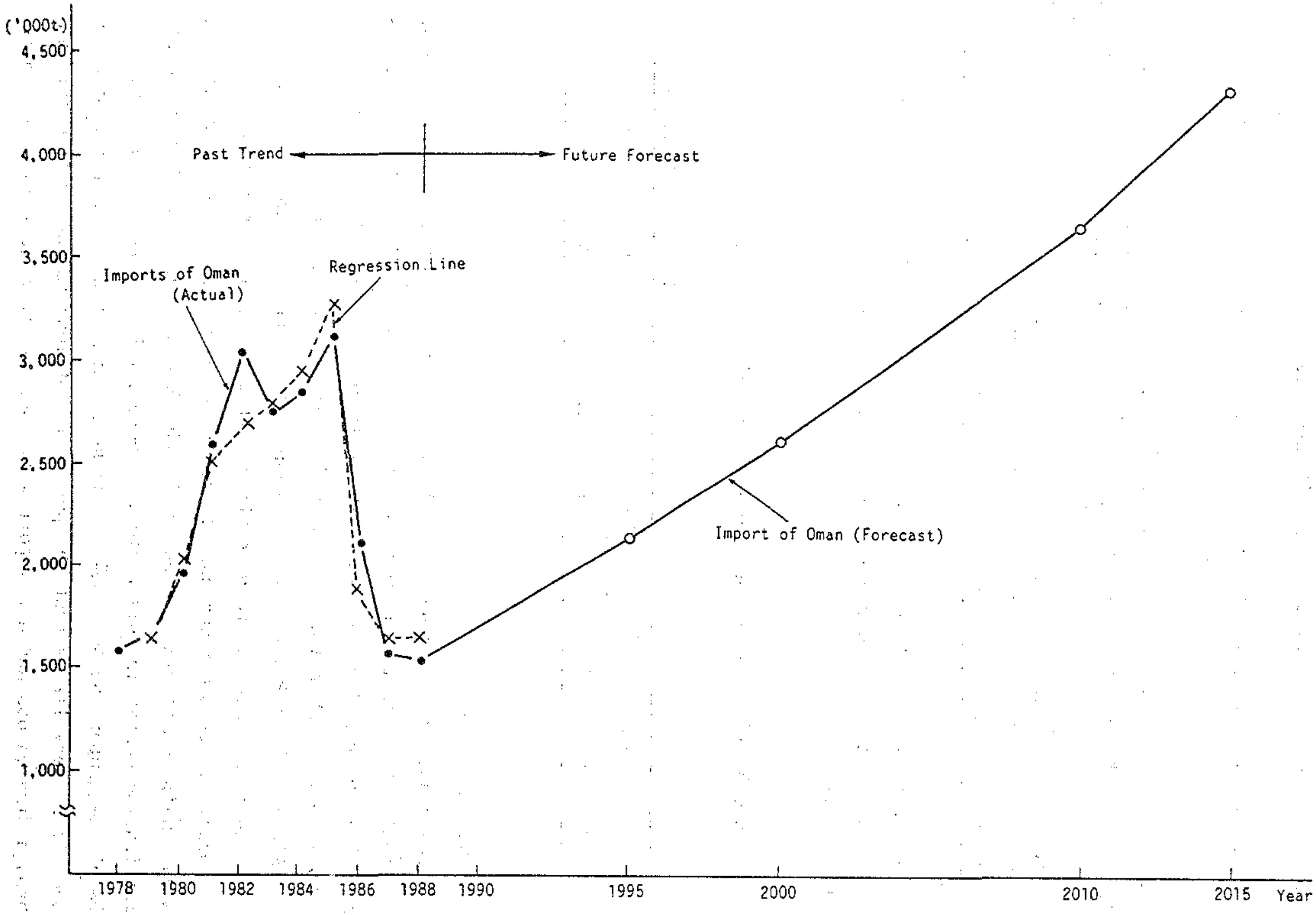


Fig. 5-3-1 Past Trend and Future Forecast of Oman's Imports

the extension and improvement of Mina Qaboos and the development of a new port. Since Mina Qaboos handled 58.3% of Oman's total imports in 1988, there is a possibility that the share of the ports will rise to 75% by the year 2000. (68% is estimated for 1995.)

Table 5-3-4 Quantity of Imports by Points of Entry

(Unit: '000 tonnes, %)

Point of Entry	1988		1987		1986		1985		1984	
I. By Seaports	1,062.0	69.7%	1,059.9	67.8%	1,188.8	56.0%	1,565.2	50.1%	1,537.2	53.9%
A. Mina Qaboos	888.2	58.3%	899.3	57.6%	997.4	47.0%	1,248.8	40.0%	1,205.1	42.2%
B. Raysut	173.5	11.4%	159.5	10.2%	190.1	9.0%	200.1	6.4%	208.7	7.3%
C. Al Fahal	0.0	0.0%	0.0	0.0%	0.0	0.0%	108.9	3.5%	119.8	4.2%
D. Other Ports	0.3	0.0%	1.1	0.1%	1.3	0.1%	7.4	0.2%	3.6	0.1%
II. By Land (on the border of)	451.3	29.6%	491.4	31.4%	916.2	43.2%	1,535.0	49.2%	1,299.5	45.6%
A. Katmat Milaha (UAE)	28.2	1.9%	54.6	3.5%	213.5	10.1%	502.7	16.1%	383.7	13.4%
B. Wajaja (UAE)	337.2	22.1%	298.4	19.1%	461.1	21.7%	857.5	27.5%	743.9	26.1%
C. Wadi Al Jizzi (UAE)	12.4	0.8%	57.0	3.6%	120.5	5.7%	40.0	1.3%	32.6	1.1%
D. Hafeet (UAE)	72.5	4.8%	76.2	4.9%	118.3	5.6%	128.2	4.1%	137.0	4.8%
E. Others	1.0	0.1%	5.2	0.3%	2.8	0.1%	6.6	0.2%	2.3	0.1%
III. By Air	10.7	0.7%	11.2	0.7%	16.8	0.8%	21.3	0.7%	16.2	0.6%
A. Seeb	7.1	0.5%	6.2	0.4%	10.4	0.5%	15.5	0.5%	10.8	0.4%
B. Salalah	0.2	0.0%	0.3	0.0%	0.3	0.0%	0.5	0.0%	0.8	0.0%
C. Others	3.4	0.2%	4.7	0.3%	6.1	0.3%	5.3	0.2%	4.6	0.2%
Total	1,524.0	100%	1,562.5	100%	2,121.8	100%	3,121.6	100%	2,852.9	100%

Source: "Quarterly Bulletin on Foreign Trade Statistics, June 1989" (Development Council)

The import cargo volume that will be handled at Mina Qaboos and a new port in 1995, 2000, 2010 and 2015 is shown in Table 5-3-5:

Table 5-3-5 Import Cargo Volume in 1995, 2000, 2010 and 2015

(Unit: '000 tonnes)

Year	1995	2000	2010	2015
Cargo volume	1,459	1,967	2,774	3,295

5.3.2 Export Cargo

Compared with imported cargo, the amount of which has greatly fluctuated, the amount of cargo exported from Mina Qaboos has been steadily increasing in the last decade. The future cargo volume of exports can be estimated by a time series correlation analysis.

$$Y = 5.613t + 5.75 \quad (r = 0.962)$$

Where, Y : Cargo volume of exports ('000 tons)
t : Number of years from 1978

However, the estimate obtained from this equation does not consider the increase of the share of the ports that will be caused by the improvement and extension of Mina Qaboos and the development of a new port.

Table 5-3-6 shows the quantity of exports by points of exit from 1986 to 1988.

Table 5-3-6 Quantity of Exports by Points of Exit

(Unit: '000 tonnes, %)

Point of Exit	1988		1987		1986	
I. By Seaports	72.5	31.2%	60.8	35.0%	54.4	42.2%
A. Mina Qaboos	67.3	28.9%	57.7	33.3%	50.0	38.8%
B. Raysut	2.3	1.0%	1.2	0.7%	1.3	1.0%
C. Al Fahal	2.0	0.9%	1.1	0.6%	2.5	1.9%
D. Other Ports	0.9	0.4%	0.8	0.5%	0.6	0.5%
II. By Land (on the border of)	127.8	54.9%	90.5	52.2%	64.3	49.8%
A. Katmat Milaha (UAE)	6.6	2.8%	4.8	2.8%	5.2	4.0%
B. Wajaja (UAE)	88.5	38.0%	58.4	33.7%	34.5	26.7%
C. Wadi Al Jizzi (UAE)	9.9	4.3%	10.0	5.8%	8.8	6.8%
D. Hafeet (UAE)	22.3	9.6%	17.2	9.9%	15.8	12.2%
E. Others	0.5	0.2%	0.1	0.1%	0.0	0.0%
III. By Air	32.4	13.9%	22.2	12.8%	10.3	8.0%
A. Seeb	32.4	13.9%	22.2	12.8%	10.3	8.0%
Total	232.7	100%	173.5	100%	129.0	100%

Base upon: "Foreign Trade Statistics 1986 - 1988" (Royal Oman Police) and data from the PSC

Note : Since the figures of Mina Qaboos in "Foreign Trade Statistics (Royal Oman Police)" are much different from the actual figures provided by the PSC, the Study Team has modified the figures in the above table.

This table shows that only 30 - 40% of all the exports handled at Mina Qaboos and about 50% went by road to the UAE (mainly to Dubai).

Since the major export-trading partners of Oman are the GCC countries, overland transport has an advantage over ocean transport and it is not likely that the share of road transport will be reduced a great deal. However, taking into consideration that some Omani exports are re-exported from Dubai (Port Rashid, Jebel Ali Port) to other countries, there is still a possibility for the share of the ports to rise to 50% after the improvement and extensions of Mina Qaboos and the development of a new port.

The export cargo volume that will be handled at Mina Qaboos and a new port in 1995, 2000, 2010 and 2015 is shown in Table 5-3-7. (The share of the ports is assumed to be 40% for 1995 and 50% after 2000):

Table 5-3-7 Export Cargo Volume in 1995, 2000, 2010 and 2015

(Unit: '000 tonnes)

Year	1995	2000	2010	2015
Cargo volume	148	233	330	393

These results for imports and exports do not consider the cargo volume that will be provided by Free Trade Zone (FTZ) or some large-scale projects to be located near a new port. If such kinds of projects were to be planned, these figures would have to be revised.

5.3.3 Transshipment Cargo

The volume of transshipment cargo has been on the rise in recent years (annual growth rate between 1985 and 1988 recorded 46.3%) and accounted for 37.2% of the total cargo handled at Mina Qaboos in 1988. However, it is impossible that transshipments will continue increasing at such a high rate in the future.

At present the French shipping line, "Compagnie Maritime d'Affretement" (CMA), is the only major shipping line using Mina Qaboos as a transshipment base in the Gulf. It handles more than 80% of the total transshipment cargo at Mina Qaboos. In 1986 CMA started its Far-Eastern Services, which bring containers from Europe/Mediterranean/Red Sea to the

Far East via Mina Qaboos, with feeder services to Gulf countries. In addition to this, the firm started feeder services to Karachi, Bombay and Colombo in June 1989.

The role of Gulf as transshipment bases for major shipping lines with feeder services between Gulf and the sub-continent (Karachi, Bombay), East Africa and Australia has increased over the past decade. Among Gulf ports, Port Rashid (Dubai) is overwhelming the other ports and almost all major shipping lines use Port Rashid as a transshipment base. Even newly developed and efficient ports like Port Khor Fakkan and Port Fujairah are patronized only by specific shipping lines (e.g., APL for Fujairah).

The key factors for transshipment are less deviation from great circle routes, quicker dispatch and reduced operating costs. Of these, less deviation from the great circle line is the main sales point of Mina Qaboos, which is located outside the Persian Gulf, considering that it is 317 nautical miles and takes nearly twenty hours to travel from Muscat to Dubai. It is clear that Oman has an absolute geographical advantage over other Gulf countries as a transshipment base. If CMA still remains the only major user of Oman's ports, it cannot be expected that the volume of transshipment cargo will increase. However, when there are superior ports in Oman with enough capacity, high efficiency, price competitiveness and less bureaucratic red tape, there is a great possibility that other shipping lines will use Oman's ports instead of Dubai ports as transshipment bases, even though some will remain in Dubai, which is the Middle East's trading center. In that case, transshipment throughputs will make rapid progress in Oman.

Table 5-3-8 shows the container throughputs in Oman and UAE ports between 1980 and 1988. Although a breakdown into imports, exports or transshipments is not available, part of this container movement undoubtedly comprises latent demand for transshipment in Oman.

Table 5-3-8 Container Throughputs in Oman and UAE Ports

(Unit: TEU, %)

Year		1980	1981	1982	1983	1984	1985	1986	1987	1988
Mina Qaboos (Oman)	Total TEU	18,537	28,908	44,112	65,901	90,175	111,596	110,635	139,256	148,182
	% gain	55.16%	55.95%	52.59%	49.39%	36.83%	23.75%	-0.86%	25.87%	6.41%
Port Zayed (Abu Dhabi)	Total TEU	12,289	22,667	30,319	30,737	30,051	25,633	21,226	29,901	N.A
	% gain	100.93%	84.45%	33.76%	1.38%	-2.23%	-14.70%	-17.19%	40.87%	
Jebel Ali (Dubai)	Total TEU	64,221	108,231	102,304	124,569	151,968	144,693	146,073	72,471	69,771
	% gain	116.88%	68.53%	-5.48%	21.76%	22.00%	-4.79%	0.95%	-50.39%	-3.73%
Port Rashid (Dubai)	Total TEU	208,941	237,020	221,372	296,826	294,648	371,632	383,189	523,145	557,521
	% gain	23.03%	13.44%	-6.60%	34.08%	-0.73%	26.13%	3.11%	36.52%	6.57%
Fujairah (Fujairah)	Total TEU	0	0	0	636	87,096	132,910	138,558	188,129	202,893
	% gain	—	—	—	—	—	52.60%	4.25%	35.78%	7.85%
Khor Fakkan (Sharjah)	Total TEU	21,238	N.A	N.A	N.A	79,000	122,000	183,000	70,400	124,218
	% gain	—	—	—	—	—	54.43%	50.0%	-61.53%	76.45%
Port Khalid (Sharjah)	Total TEU	30,532	37,812	57,385	49,893	34,274	36,784	53,657	70,328	40,381
	% gain	-39.94%	23.84%	51.76%	-13.06%	-31.30%	7.32%	45.87%	31.07%	-42.58%
Grand Total	Total TEU	355,758	434,638	455,492	568,562	767,212	945,248	1,036,338	1,093,630	1,142,966
	% gain	31.41%	22.17%	4.80%	24.82%	34.94%	23.21%	9.64%	5.53%	4.51%

Source: "Containerization International Year Book 1980-89", PSC and Port Authorities in each port

The future container throughputs in Oman and UAE ports can be estimated by a time series correlation analysis.

$$Y = 111{,}069.77t + 200{,}189.4 \quad (r = 0.9823)$$

Where, Y : container throughputs in UAE and Oman (TEUs)

t : Number of years from 1980

However, the results of this equation show that the annual growth rate of container throughputs in the UAE and Oman will be 6.86% between 1988 and 2000, which is apparently too high considering the present situation of Gulf countries in which oil prices will remain low and where the boom of the early 1980's is not likely to happen again. Hence, the Study Team has estimated the annual growth rate to be 5% in the future. Table 5-3-9 shows the estimated result of container throughputs in Oman and UAE ports in 1995, 2000 and 2010.

Table 5-3-9 Container Throughputs in Oman and UAE Ports in 1995, 2000 and 2010

(Unit: TEUs)

Year	1995	2000	2010
Total TEU	1,608,268	2,052,603	3,343,474

In 1987 and 1988, the share of transshipment containers at Mina Qaboos of the total container throughputs in Oman and UAE ports was about 7% (Before the great increase in transshipments, Mina Qaboos had accounted for only 1 - 2%). It is very difficult to forecast the volume of transshipment cargo on a long term basis because the flow of transshipment cargo can be changed easily and rapidly. But based on the premises mentioned in the above paragraph, there is a possibility that Mina Qaboos and a new port will obtain a share of 10%. Table 5-3-10 shows the transshipment cargo volume which will be handled at Mina Qaboos and the new port in 1995, 2000, 2010 and 2015. (The share in 1995 is estimated to be 8%.)

Table 5-3-10 Transshipment Cargo Volume in 1995, 2000, 2010 and 2015

(Unit: TEUs, '000 tonnes)

Year	1995	2000	2010	2015
Total TEU	128,662	205,260	334,348	426,722
Tonnage	978	1,560	2,541	3,243

Note: Weight per TEU is estimated 7.6 tons/TEU, the same as in 1988

(4) Results of the Total Demand Forecast

Table 5-3-11 shows the results of the total demand forecast.

Table 5-3-11 Results of Total Demand Forecast

(Unit: '000 tonnes)

Year	1995	2000	2010	2015
Imports	1,459	1,967	2,774	3,295
Exports	148	233	330	393
Sub-total	1,607	2,200	3,104	3,688
Transshipments	978	1,560	2,541	3,243
Total	2,585	3,760	5,645	6,931

5.4 Commodity-wise Demand Forecast

The volume of each major commodity group is individually forecast and the total cargo volume is then calculated by the summation of these volumes.

Based upon classification by the PSC, the major commodity groups are categorized as follows:

Imports: Rice, Wheat, Other Grains, Sugar, Other Foodstuffs, Timber, Steel, Cement, Other Building Materials, Vehicles, Livestock, Other General Cargo

Exports: Fish, Copper, Chromite, Vehicles, Other General Cargo

5.4.1 Imports

(1) Rice

Since there is no production of rice in Oman, all the rice consumed in the country is imported.

Table 5-4-1 shows the import volume of rice in Oman and the cargo volume handled at Mina Qaboos from 1983 to 1988.

Table 5-4-1 Import of Rice

(Unit: '000 tonnes)

Year	Import Volume of Rice in Oman	Handled at Mina Qaboos
1983	62.8	48.7
1984	83.0	55.7
1985	69.8	61.8
1986	80.8	60.1
1987	83.4	60.5
1988	102.4	82.3

Source: "Foreign Trade Statistics 1986-88" (ROP)
PSC

Calculated based upon an estimated population of 1.45 million, per capita consumption of rice in Oman for 1988 is estimated to have been 70.7kg. Per capita consumption of wheat, which will be mentioned in the next section, is 69.0kg/year, which means that per capita consumption of rice and wheat totals 139.7kg/year in Oman.

Table 5-4-2 shows per capita consumption of rice and wheat in some Arabian countries and some other countries in the world.

Table 5-4-2 Per Capita Consumption of Rice & Wheat (1979-81)

(Unit: kg/year)

Country	Rice Consumption per Capita	Wheat Consumption per Capita	Total	GNP per Capita 1981 (US$)
UAE	68.6	62.2	130.8	30,520
Kuwait	81.8	87.7	169.5	20,590
Egypt	46.3	148.3	194.6	530
Libya	21.3	172.0	193.3	9,150
Saudi Arabia	56.2	86.3	142.5	14,360
Tunisia	0.9	183.4	184.3	1,390
India	103.3	44.5	147.8	270
Malaysia	152.9	33.8	186.7	1,890
United Kingdom	2.7	83.3	86.0	9,270
United States	6.2	71.0	77.2	13,270

Source: "Food Balance Sheets 1979-81 Average" (FAO, 1984)

Although the consumption of food depends upon the eating habits in the region and cannot be generalized, it seems that there is some room for per capita consumption of rice to increase in the future. Therefore, in this Study, it is assumed that per capita consumption of rice will increase by 1% per annum during the planning period.

The consumption of rice, i.e., the import of rice, is then estimated by multiplying per capita consumption by the population in the future.

Per capita consumption of rice and the volume of rice imports are shown in Table 5-4-3.

Table 5-4-3 Per Capita Consumption of Rice and Import Volume

Year	1995	2000	2010
Per Capita Consumption of Rice (kg/year)	75.8	79.7	88.0
Volume of Rice Imports ('000 Tonnes)	139.8	174.5	271.8

Approximately 70 - 80% of rice imports have been handled at Mina Qaboos in the last few years. After the development of the nation's ports, the share of the ports will rise to 90% by the year 2000. (85% is estimated for 1995.) The figure for the year 2015 is extrapolated from the figures for 2000 and 2010.

The results of the forecast are shown in Table 5-4-4:

Table 5-4-4 Forecast Cargo Volume of Rice at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	118.8	157.1	244.6	305.2

(2) Wheat

Almost all wheat imports are handled by Oman Flour Mills Company Ltd. (S.A.O.). The firm imports all of the wheat through Mina Qaboos.

Wheat is used for: 1) production of flour, 2) animal feed, 3) exports to Saudi Arabia and the UAE, 4) supply to the countryside as wheat itself or semi-products.

According to an interview with Oman Flour Mills Co., approximately 25,000 - 30,000 tons of wheat are used for the items 2) - 4). It is not likely that wheat consumption for these purposes will increase greatly in the future. Therefore, only a slight increase is assumed in this Study. (The results are: 30,000 tons in 1995, 35,000 tons in 2000 and 45,000 tons in 2010. All of the wheat consumed will be imported.)

The production capacity of Oman Flour Mills Co. is 100,000 tons a year, which seems to satisfy domestic demand in Oman. As with rice, per capita consumption of wheat for 1988 can be estimated at 69.0kg/year in Oman and is assumed to increase an estimated 1% per annum during the planning period.

The consumption, i.e., the import volume of wheat for flour production, is then estimated by multiplying per capita consumption by the future population. The results are shown in Table 5-4-5:

Table 5-4-5 Per Capita Consumption of Wheat and Import Volume

Year	1995	2000	2010
Per Capita Consumption of Wheat (kg/year)	74.0	77.8	85.9
Volume of Wheat Imports ('000 Tonnes)	136.5	170.4	265.3

These results show that the total per capita consumption of rice and wheat will be 173.9kg/year in 2010. This figure seems to be reasonable, given the figures in Table 5-4-2.

The summation of the figures in Table 5-4-5 and the consumption for uses of other than flour production gives the total import volume of wheat in Oman. As concerns wheat, all the import will be through Mina Qaboos and a new port.

The results of the forecast are shown in Table 5-4-6.

Table 5-4-6 Forecast Cargo Volume of Wheat at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	166.5	205.4	310.3	381.4

(3) Other Grains

Other grains consist of grains for animal feed such as barley, maize and other cereals. In the absence of output projection for animal feed, it is difficult to forecast the future cargo volume of other grains. Therefore, in this Study it is assumed that the growth rate of cargo volume in this category is the same that of the GDP.

The cargo volume of other grains in 1995, 2000, 2010 and 2015 is shown in Table 5-4-7.

Table 5-4-7 Forecast Cargo Volume of Other Grains at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	37.8	44.9	63.3	75.2

(4) Sugar

Table 5-4-8 shows the import volume of sugar in Oman and the cargo volume handled at Mina Qaboos from 1981 to 1988.

Table 5-4-8 Import of Sugar

(Unit: '000 tonnes)

Year	Import Volume of Sugar in Oman	Handled at Mina Qaboos
1981	21.4	4.8
1982	17.7	4.3
1983	25.4	6.0
1984	37.8	19.4
1985	22.1	7.5
1986	25.6	17.1
1987	31.1	16.0
1988	36.6	22.7

Source: "Statistical Year Book" (DC), PSC

Calculated based on the estimated population, per capita consumption of sugar in Oman in 1988 is estimated to have been 25.3kg/year. (All the sugar consumed in Oman is imported.)

Per capita consumption of sugar in some Arabian countries and some other countries in the world is shown in Table 5-4-9.

Table 5-4-9 Per Capita Consumption of Sugar (1979-81)

(Unit: kg/year)

Country	Sugar Consumption per Capita	GNP per Capita 1981 (US$)
UAE	41.7	30,520
Kuwait	49.7	20,590
Egypt	59.1	530
Libya	43.8	9,150
Saudi Arabia	29.0	14,360
Tunisia	26.4	1,390
Turkey	26.1	1,450
Singapore	47.8	5,450
Philippines	24.5	770
India	20.2	270
Mexico	43.7	3,000
United Kingdom	44.9	9,270
United States	60.0	13,270
Japan	26.6	10,390

Source: "Food Balance Sheets 1979-81 Average" (FAO, 1984)

This table shows that per capita consumption of sugar in Oman is still at a lower level than other countries with high GNPs like Oman. Therefore, in this Study, it is assumed that per capita consumption of sugar will increase to 40kg/year by the year 2010.

The consumption of sugar, i.e., the import of sugar is then estimated by multiplying per capita consumption by the future population.

Per capita consumption of sugar and the import volume of sugar are shown in Table 5-4-10.

Table 5-4-10 Per Capita Consumption of Sugar and Import Volume

Year	1995	2000	2010
Per Capita Consumption of Sugar (kg/year)	29.3	32.5	40.0
Volume of Wheat Imports ('000 Tonnes)	54.0	71.2	123.6

Nearly 30% of the sugar imported by Oman has entered through Wajaja from the UAE and only 50 - 60% has been handled at Mina Qaboos in the last few years. After the development of the ports, the share of the ports will rise to 80% by the year 2000. (70% is estimated for 1995.)

The result of the forecast is shown in Table 5-4-11.

Table 5-4-11 Forecast Cargo Volume of Sugar at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	37.8	57.0	98.9	130.3

(5) Other Foodstuffs

Other major foodstuff commodities are chilled/frozen foods such as lamb and poultry, milk, dairy food, vegetables, fruit, coffee and so forth.

The correlation equation between the import volume of other foodstuffs and GDP(R) is as follows:

$$Y = 0.1846X - 205.3 \qquad (r = 0.9182)$$

Where, Y: Import volume of other foodstuffs ('000 tons)
X: GDP(R) (Million RO)

The results of the calculation are shown in Table 5-4-12.

Table 5-4-12 Import Volume of Other Foodstuffs

(Unit: '000 tonnes)

Year	1995	2000	2010
Import Volume	340.7	432.5	637.7

More than 30% of all the other foodstuffs are accounted for by fresh fruit and vegetables, 85% of which enters by road, mainly from Dubai. Considering that Dubai is established as a distribution center of the Middle East for perishable foods, it is difficult to imagine that this route will change easily in the future. Therefore, it is assumed that the share of the ports will be 65% by the year 2000. (55% is estimated for 1995.)

Taking into consideration the past record of chilled/frozen foodstuffs handled at Mina Qaboos, the percentage of chilled/frozen foodstuffs to other foodstuffs is assumed to be 40%.

The result of the forecast is shown in Table 5-4-13:

Table 5-4-13 Forecast Cargo Volume of Other Foodstuffs at Mina Qaboos & New Port

(Unit: '000 tonnes)

Year	1995	2000	2010	2015
Chilled & Frozen Foodstuffs	75.0	112.4	165.8	201.4
Other Foodstuffs	112.4	168.7	248.7	302.0

(6) Timber

The elasticity coefficient of the growth rate of timber imports to that of the GDP of the construction sector was 0.72 from 1981 to 1984 and 0.84 from 1985 to 1988.

Considering the above, it is assumed that the elasticity coefficient will be 0.8 for the planning period.

The import volume of timber in Oman is shown in Table 5-4-14.

Table 5-4-14 Import Volume of Timber

(Unit: '000 tonnes)

Year	1995	2000	2010
Import Volume	118.2	130.5	159.1

The share of Mina Qaboos has been 60 - 70% for the last few years, which seems to be rather low considering that timber is suitable for sea transport. Therefore, in this Study it is assumed that the share of the ports will rise to 95% by the year 2000. (85% is estimated for 1995.)

The results of the forecast are shown in Table 5-4-15:

Table 5-4-15 Forecast Cargo Volume of Timber at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	100.5	124.0	151.1	166.8

(7) Steel & Pipes

The correlation equation between the import volume of steel & pipes and GDP(R) is as follows:

$$Y = 0.22924X_1 - 162.38X_2 - 228.05$$

Where, Y : Import volume of steel & pipes ('000 tons)

X_1: GDP(R) (Million RO)

X_2: Dummy variable (=1 from 1986 on)

$r = 0.9122$

$F - \text{value} = 17.344 > F(2,7:0.005) = 12.404$

Durbin - Watson's ratio = 2.517

The results of the calculation are shown in Table 5-4-16.

Table 5-4-16 Import Volume of Steel

(Unit: '000 tonnes)

Year	1995	2000	2010
Import Volume	287.7	401.6	656.5

Only 50 - 60% of the total amount of imports has been handled at Mina Qaboos and it is obvious from interviews with some of the Omani road transport companies that what should be imported through Mina Qaboos has actually entered by road via the UAE owing to problems concerning port capacity, high tariffs and red tape.

On the other hand, some of the imported steel has originated from GCC countries such as Qatar and Kuwait, where sea transport does not seem to have an advantage.

Considering the above situation, it is assumed that the share of the ports will increase to 90% by the year 2000. (80% is estimated for 1995.)

The results of the forecast are shown in Table 5-4-17:

Table 5-4-17 Forecast Cargo Volume of Steel at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	230.2	361.4	590.9	755.6

(8) Cement

There are two cement companies in Oman at present:

(i) Oman Cement Co. (production capacity : 600,000 tons/year)

(ii) Raysut Cement Co. (production capacity : 220,000 tons/year)

The capacity of the factories is enough to satisfy the domestic demand for cement in Oman. They also have a plan to increase their production to meet revived demand in future.

However, Oman has imported special kinds of cement such as white Portland cement and supersulphate cement which Oman has no projects for producing and will continue to be imported in the future.

For the estimation of the import of cement, it is assumed that the growth rate of imports will be the same as that of the GDP of the construction sector.

The estimated volume of cement imports in Oman is shown in Table 5-4-18:

Table 5-4-18 Import Volume of Cement

(Unit: '000 tonnes)

Year	1995	2000	2010
Import Volume	22.5	25.5	32.6

Only 40 - 50% of the imports has been handled at Mina Qaboos and the rest has entered by road, because more than 50% of the imported cement comes form the UAE. Therefore, in this Study it is assumed that the share of the ports will be 50%.

The results of the forecast are shown in Table 5-4-19:

Table 5-4-19 Forecast Cargo Volume of Cement at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	11.3	12.8	16.3	18.4

(9) Other Building Materials

Other building materials consist of paints, asbestos, tiles & bricks, etc.

The correlation equation between the import volume of other building materials and the GDP of the construction sector is as follows:

$$Y = 0.6179X - 23.67 \qquad (r = 0.9210)$$

Where, Y : Import volume of other building materials ('000 tons)

X : GDP of construction sector (Million RO)

The results of the calculation are shown in Table 5-4-20.

Table 5-4-20 Import Volume of Other Building Materials

(Unit: '000 tonnes)

Year	1995	2000	2010
Import Volume	65.1	76.7	104.9

The share of Mina Qaboos is only 40 - 50% at present. However, because of the development of Oman's ports, it is assumed that the share of the ports will increase to 80% by the year 2000. (60% is estimated for 1995.)

The results of the forecast are shown in Table 5-4-21:

Table 5-4-21 Forecast Cargo Volume of Other Building Materials at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	39.1	61.4	83.9	98.1

(10) Vehicles

Statistics concerning vehicle registration in 1987 and 1988 are shown in Table 5-4-22.

Table 5-4-22 Vehicle Registration in 1987 and 1988

Year	1987	1988
Newly Registered Vehicles	13,740	14,710
Cancelled Vehicles	3,895	7,712
Total Number of Vehicles	178,638	185,636

Source: "Statistical Year Book 1987-1988" (DC)

The volume of the import of vehicles is forecast on the assumption that:

* the ownership ratio of vehicles will reach the level of one unit to seven persons in 2000.
* the cancellation ratio will also rise to 10% in 1995.
* all of the newly registered vehicles will be imported.
* weight per unit is two tons (the average weight for the past eight years).

The estimated import volume of vehicles in Oman is shown in Table 5-4-23.

Table 5-4-23 Import Volume of Vehicles

(Unit: '000 tonnes)

Year	1995	2000	2010
Import Volume	69.9	88.1	140.0
(Numbers)	(34,929)	(44,041)	(70,017)

More than 90% of all the imported vehicles are handled at Mina Qaboos at present. Therefore, it is assumed that the share of the ports will be 95% for the planning period.

The results of the forecast are shown in Table 5-4-24:

Table 5-4-24 Forecast Cargo Volume of Vehicles at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	66.4	83.7	133.0	167.7
(Numbers)	(33,183)	(41,839)	(66,516)	(83,868)

(11) Livestock

For the estimation of the import of livestock, the future annual growth rate of Oman's population and the volume of imported livestock in 1988 are used.

The estimated volume of livestock imports in Oman is shown in Table 5-4-25:

Table 5-4-25 Volume of Livestock Imports

(Unit: '000 tonnes)

Year	1995	2000	2010
Import Volume	17.8	21.2	29.8

The share of Mina Qaboos at present is quite high and very little livestock enters Oman by road. Therefore, it is assumed that the share of the port will be 98%.

The results of the forecast are shown in Table 5-4-26. (Weight per head is assumed at 50kg, which is the average weight for the past five years.)

Table 5-4-26 Forecast Cargo Volume of Livestock at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	17.4	20.8	29.2	34.6
(Heads)	(349)	(416)	(584)	(692)

(12) Other General Cargo

The correlation equation between the volume of the other general cargo handled at Mina Qaboos and GDP(R) is as follows.

$$Y = 0.1702X - 93.45 \qquad (r = 0.9279)$$

Where, Y : Volume of other general cargo handled at Mina Qaboos ('000 tons)

X : GDP(R) (Million RO)

According to the statistics for 1987 and 1988, nearly 90% of all the other general cargo is imported through Mina Qaboos and it is not likely that the share of the ports will rise in the future. Therefore, the increase of the share of the ports is not taken into account.

The results of the forecast are shown in Table 5-4-27:

Table 5-4-27 Forecast Cargo Volume of Other General Cargo at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	410.0	494.6	683.8	804.0

5.4.2 Exports

(1) Fish

Fishery is a sector on which the Government of Oman has put an emphasis in past Five-Year plans. It will likely continue to do so in the future, as well as emphasizing agriculture and manufacturing. In this Study, it is assumed that fish exports will increase at the same rate as that of the GDP of the agriculture/fishery sector.

Table 5-4-28 shows the export volume of fish of Oman in 1995, 2000 and 2010.

Table 5-4-28 Export Volume of Fish

(Unit: '000 tonnes)

Year	1995	2000	2010
Export Volume	57.2	84.0	150.4

The share of Mina Qaboos in recent years has been around 50%. After the development of the ports, it is possible that this share will rise to 70% by the year 2000. (60% is estimated for 1995.)

The results of the forecast are shown in Table 5-4-29:

Table 5-4-29 Forecast Cargo Volume of Fish at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	34.3	58.8	105.3	140.9

(2) Copper

Since there is no increased production schedule of copper in Oman, 15,000 tons are assumed to be exported through the ports hereafter, taking into consideration the past record of copper exports and the present production capacity of 20,000 tons.

(3) Chromite

A feasibility study on chrome ore is now under implementation by the United Nations Industrial Development Organization (UNIDO) and no chromite is now produced. It is impossible to forecast the cargo volume without the result of this study. However, this F/S by UNIDO will take so long that the result will not be available for our Study. Therefore, in this Study, taking into account that there is a possibility for chromite to become one of Oman's staple exports, the cargo volume of chromite is estimated as shown in Table 5-4-30:

Table 5-4-30 Forecast Cargo Volume of Chromite at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	10.0	50.0	50.0	50.0

(4) Vehicles

A small number of vehicles are re-exported to the other GCC countries from Oman. Considering the trend in recent years, the future export volumes are estimated as shown in Table 5-4-31. (Weight per unit is estimated at two tons, the same figure used for imports.)

Table 5-4-31 Forecast Cargo Volume of Vehicles (Re-export) at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	9.0	12.0	20.0	25.8
(Number)	(4,500)	(6,000)	(10,000)	(12,900)

(5) Other General Cargo

The future cargo volume of the other general cargo is obtained using a time series analysis.

As mentioned in the total demand forecast, the share of the ports will increase to some extent after the development of Oman's ports and this factor should be taken into account.

The results of the forecast are shown in Table 5-4-32.

Table 5-4-32 Forecast Cargo Volume of Other General Cargo at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	62.6	95.7	137.0	163.9

5.4.3 **Results of the Commodity-wise Demand Forecast**

Table 5-4-33 shows the results of the commodity-wise demand forecast.

Table 5-4-33 Results of Commodity-wise Demand Forecast
(Import and Export Cargo Volume at Mina Qaboos
& New Port by Commodity)

(Unit: '000 tonnes)

	1995	2000	2010	2015
(Imports)				
Rice	118.8	157.1	244.6	305.2
Wheat & Flour	166.5	205.4	310.3	381.4
Other Grains	37.8	44.9	63.3	75.2
Sugar	37.8	57.0	98.9	130.3
Chilled & Frozen Foodstuffs	75.0	112.4	165.8	201.4
Other Foodstuffs	112.4	168.7	248.7	302.0
Timber	100.5	124.0	151.1	166.8
Steel & Pipes	230.2	361.4	590.9	755.6
Cement (bagged)	11.3	12.8	16.3	18.4
Other Building Materials	39.1	61.4	83.9	98.1
Vehicles	66.4	83.7	133.0	167.7
Livestock	17.4	20.8	29.2	34.6
Other General Cargo	410.0	494.6	683.8	804.0
Total	1,423.2	1,904.2	2,819.8	3,440.5
(Exports)				
Fish	34.3	58.8	105.3	140.9
Copper	15.0	15.0	15.0	15.0
Chromite	10.0	50.0	50.0	50.0
Vehicles	9.0	12.0	20.0	25.8
Other General Cargo	62.6	95.7	137.0	163.9
Total	130.9	231.5	327.3	395.7

Compared with the results of the total demand forecast, these results seem to be fairly reasonable. Therefore, the level of future cargo volumes obtained by the commodity-wise demand forecast are adopted for the development plans for Mina Qaboos and a new port in this Study.

5.5 Summary of the Forecast

The future cargo volume to be handled at Mina Qaboos and a new port during the planning period is shown in Table 5-5-1.

Fig. 5-5-1 shows the past trend and the forecast of the total cargo volume at Mina Qaboos and a new port.

Table 5-5-1 Summary of the Forecast

(Unit: '000 tonnes)

Year	1995	2000	2010	2015
Imports	1,423	1,904	2,820	3,440
Exports	131	232	327	396
Sub-total	1,554	2,136	3,147	3,836
Transshipments	978	1,560	2,541	3,243
Total	2,532	3,696	5,688	7,079

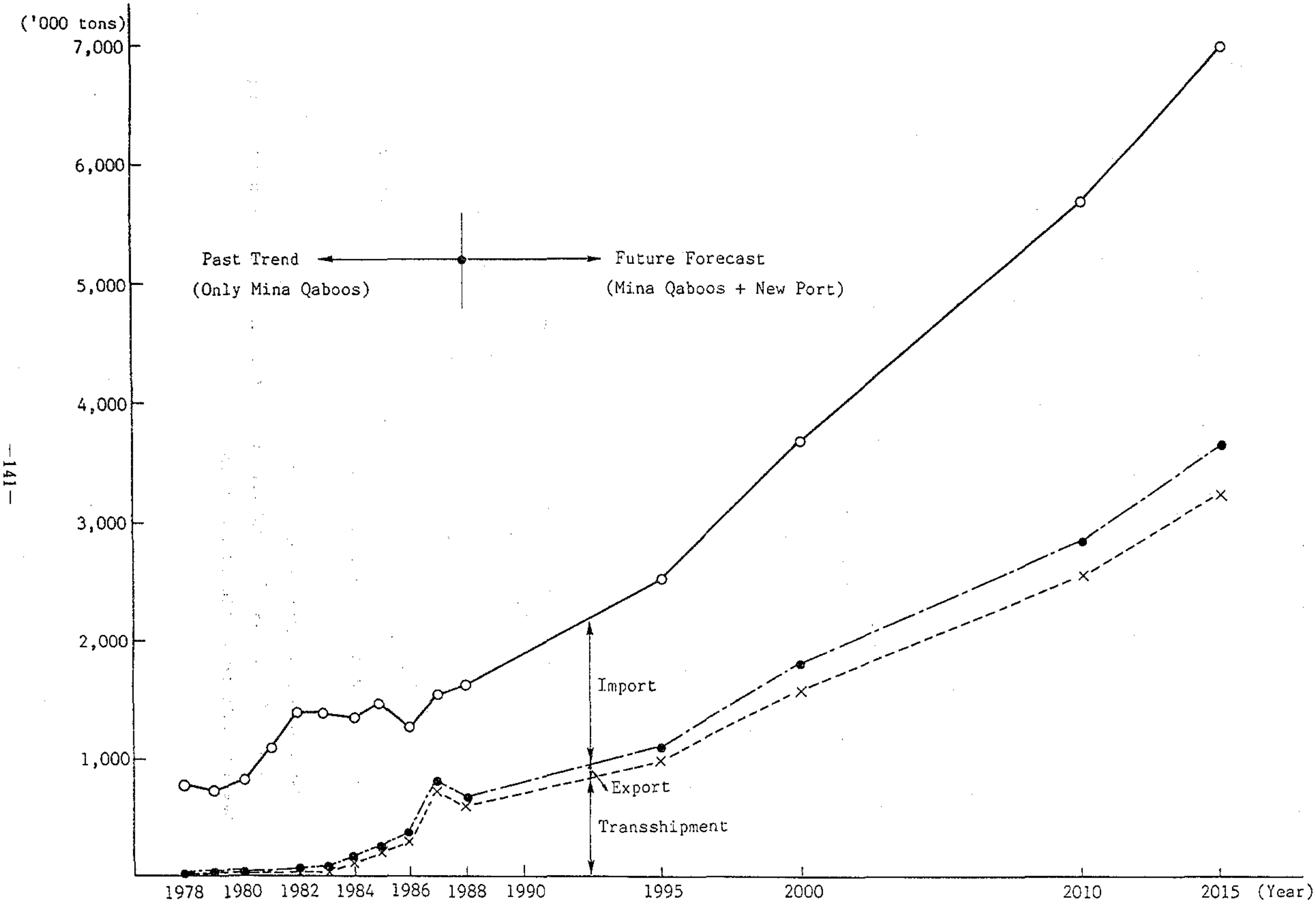


Fig. 5-5-1 Past Trend and Future Forecast of Total Cargo at Mina Qaboos & New Port

5.6 Cargo Volume by Handling Mode

(1) Bulk Cargo

Major bulk cargo commodities are wheat and other grains in terms of imports, and chromite in terms of exports. The cargo volume of these commodities is forecast by commodity in the last section.

In addition to these, other bulk cargoes are handled at Mina Qaboos, such as vegetable oil and bitumen. Since no detailed data on the other bulk cargoes are available, the forecast is carried out by the ratio of the volume of the other bulk cargo to the summation of other foodstuffs and other general cargo. (The ratio is estimated at 6%, based upon the average ratio for the last several years.)

(2) Container Cargo

The volume of container cargo and the number of containers are forecast by using the following procedure:

(a) Selection of containerizable cargo

(b) Estimation of the ratio of container cargo to containerizable cargo

(c) Estimation of the volume of container cargo and the number of containers

(a) Containerizable Cargo

Containerizable import cargo in Oman is composed of rice, sugar, chilled & frozen foodstuffs, other foodstuffs, bagged cement, other building materials and other general cargo excluding bulk cargo.

The volume of containerizable cargo is calculated as the sum of these commodities.

As regards export cargo, all the cargo, except chromite, is considered as containerizable cargo.

(b) Ratio of Containerization

Table 5-6-1 shows the past trend of the ratio of container cargo volume to containerizable cargo volume.

Table 5-6-1 Ratio of Containerization at Mina Qaboos

(Unit: '000 tonnes, %)

Year	Imports			Exports		
	Containerizable Cargo Volume	Container Cargo Volume	Ratio of Containerization	Containerizable Cargo Volume	Container Cargo Volume	Ratio of Containerization
1981	636.2	155.5	24.44%	21.6	2.8	12.96%
1982	651.7	220.0	33.75%	31.8	6.3	19.81%
1983	591.2	322.1	54.48%	38.8	12.3	31.70%
1984	653.7	412.3	63.07%	45.2	34.5	76.33%
1985	687.7	471.0	68.49%	60.9	32.3	53.04%
1986	574.3	416.6	72.54%	45.1	43.5	96.45%
1987	471.8	360.3	76.37%	57.7	50.5	87.52%
1988	530.3	385.9	72.77%	67.2	60.2	89.57%

The maximum limit of the ratio of containerization for import cargo is assumed to be 80% after estimating the containerized ratio of each commodity.

The ratio of containerization during the planning period is expressed by the following equation:

$$Y = \frac{80}{1 + e^{(1031.774 - 0.5206t)}} \quad (r = 0.9486)$$

Where, Y : Ratio of containerization (%)
t : Year

Fig. 5-6-1 shows the logistic curve and the past records of the ratio of containerization for import cargoes.

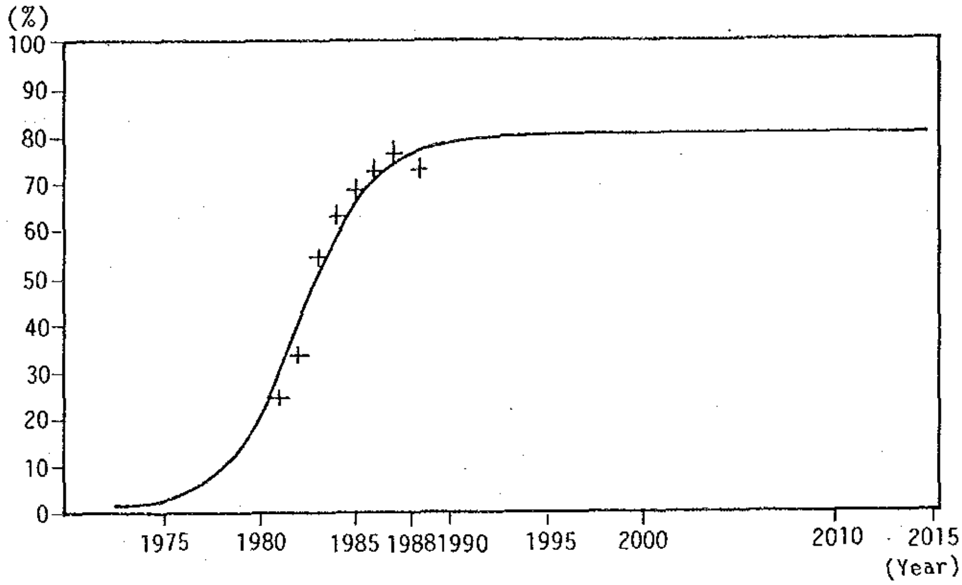


Fig. 5-6-1 Ratio of Containerization

As concerns exports, the ratio of containerization has reached nearly 90%, which seems to be the maximum. Therefore, it is assumed that the ratio of containerization for export cargo will remain at 90% during the planning period.

(c) Container Cargo Volume and Number of Containers

The cargo volume of containers for import and export is calculated by multiplying the containerizable cargo volume estimated in (a) by the ratio of containerization mentioned in (b).

The cargo volume in TEUs is then estimated by dividing the container cargo volume above by the tonnage per TEU of 11.8 tons and 11.0 tons for imports and exports, respectively. However, this result does not consider empty containers. Therefore, after the TEUs of empty containers, the ratio of which is assumed to be 3% for import containers, is added, the final amount of TEUs is obtained. (The tonnage per TEU and the ratio of empty containers is assumed based upon the actual figures for the last few years.)

As regards transshipment containers, weight per TEU is assumed to be 7.6 tons, as mentioned in the total demand forecast.

In calculating the number of containers, the ratio of 20-foot containers and 40-foot ones is assumed to be fifty-fifty during the planning period.

Table 5-6-2 shows the future cargo volume by handling mode and Table 5-6-3 shows the future cargo volume of containers.

Table 5-6-2 Cargo Volume at Mina Qaboos & New Port by Handling Mode

(Unit: '000 tonnes)

	1995	2000	2010	2015
(Imports)				
Bulk Grain	204.3	250.3	373.6	456.6
Other Bulk	31.3	39.8	56.0	66.4
Vehicles	66.4	83.7	133.0	167.7
Livestock	17.4	20.8	29.2	34.6
Timber	100.5	124.0	151.1	166.8
Steel & Pipes	230.2	361.4	590.9	755.6
Other Break-bulk	155.3	204.9	297.2	358.6
Containers	617.7	819.3	1,188.8	1,434.4
Total	1,423.2	1,904.2	2,819.8	3,440.5
(Exports)				
Containers	108.8	163.4	249.6	311.1
Break-bulk	12.1	18.2	27.7	34.6
Bulk	10.0	50.0	50.0	50.0
Total	130.9	231.5	327.3	395.7

Table 5-6-3 Future Container Cargo at Mina Qaboos & New Port

(Import)

Year	With Cargo (TEU)	%	Empty (TEU)	%	Total (TEU)	Boxes of 20ft.	Boxes of 40ft.	Boxes of Containers
1995	52,352	97.0	1,619	3.0	53,971	26,986	13,493	40,478
2000	69,429	97.0	2,147	3.0	71,576	35,788	17,894	53,682
2010	100,749	97.0	3,116	3.0	103,865	51,933	25,966	77,899
2015	121,556	97.0	3,759	3.0	125,315	62,658	31,329	93,986

(Export)

Year	With Cargo (TEU)	%	Empty (TEU)	%	Total (TEU)	Boxes of 20ft.	Boxes of 40ft.	Boxes of Containers
1995	9,892	18.3	44,079	81.7	53,971	29,986	13,493	40,478
2000	14,850	20.7	56,726	79.3	71,576	35,788	17,894	53,682
2010	22,688	21.8	81,177	78.2	103,865	51,933	25,966	77,899
2015	28,281	22.6	97,034	77.4	125,315	62,658	31,329	93,986

(Transshipment)

Year	With Cargo (TEU)	%	Empty (TEU)	%	Total (TEU)	Boxes of 20ft.	Boxes of 40ft.	Boxes of Containers
1995	64,331	50	64,331	50	128,662	64,330	32,166	96,496
2000	102,630	50	102,630	50	205,260	102,630	51,315	153,945
2010	167,174	50	167,174	50	334,348	167,174	83,587	250,761
2015	213,361	50	213,361	50	426,722	213,360	106,681	320,041

The summary of the cargo volume by handling mode is shown in Table 5-6-4.

Table 5-6-4 Summary of Cargo Volume by Handling Mode

(Unit: '000 tonnes)

Year	Bulk	Break-bulk	Container (TEUs)	Total
1995	246	582	1,705 (236,604)	2,532
2000	340	813	2,543 (348,412)	3,696
2010	480	1,229	3,979 (542,078)	5,688
2015	573	1,518	4,988 (677,352)	7,079

CHAPTER 6 FUTURE DEVELOPMENT PLAN OF MINA QABOOS

Chapter 6. FUTURE DEVELOPMENT PLAN OF MINA QABOOS

6.1 Development Strategy

a) According to the future traffic demand forecast, it is apparent that the existing handling capacity of Mina Qaboos cannot accommodate this demand in the near future.

b) In order to respond to the above situation, one of the following alternatives should be considered:

   i) Large-scale, long-term expansion of Mina Qaboos;
      no new port development.

   ii) Immediate development of new port;
      no Mina Qaboos expansion.

   iii) Combination of the above.

c) Taking account of the given topographical conditions (water depth, expected available space, etc.) and expected traffic congestion around Mina Qaboos, alternative (i) is not feasible, as shown in previous studies. On the other hand, alternative (ii) is not a practical alternative, judging from the expected time schedule. Hence alternative (iii) is the one to be adopted.

d) Based upon the factors stated above and considering the current major problems previously described, the Mina Qaboos development plan should be an intermediate one which is able to respond to the current situation quickly and efficiently. From this point of view, the plan should concentrate on efforts to improve the efficiency of port activities with a minimum of investment.

e) Mina Qaboos will continue to play an essential role in the economic activities of the country, considering its optimum functional allocation with a new port.

f) The target year of the plan is to be set at 2000. However, most of the related work is to be completed by 1995.

6.2 Evaluation of the Existing Development Plan of Mina Qaboos

6.2.1 Background

Since 1982, several studies have been done seeking the best alternatives in terms of the future role and specific development of Mina Qaboos. However no major development was executed in Mina Qaboos in this period. The following points are our understanding of the background that has led to the existing development plan of Mina Qaboos.

i) Responding to the increasing demand for Mina Qaboos' services, study was carried out to find the possibility of large-scale expansion of Mina Qaboos and several alternatives were proposed as a result of this study in 1982.

ii) However, according to the proposed plan, expansion would be limited by the configuration of the site and would further aggravate the severe road congestion in the vicinity of Mina Qaboos.

iii) Hence, the Government of Oman decided to examine the possibility of new port between Muscat and Sur. In 1985, a feasibility study was carried out and Quriyat was proposed as the best and most feasible alternative.

iv) At the same time, land utilization and development plans for Mina Qaboos were studied in 1985. This plan included the PSC Headquarters Building, the vehicles stacking yard and the container storage yard.

v) Even if a new port development plan could be approved, several years would be required before new port services become available. Therefore, it is apparent that the present capacity of Mina Qaboos cannot keep up with the increase in demand in the next several years.

vi) Reflecting these factors, practical countermeasures for the improvement of the port capacity of Mina Qaboos were proposed in a study in 1988.

vii) The JICA study was started under these circumstances.

6.2.2 Review of the Existing Plan

6.2.2.1 Outline of the Plan

The existing development plan of Mina Qaboos was proposed by Consulting Engineering Services (CES) through its study in 1988. The principal features of the plan are as follows:

(1) Phase I (by 1990 for 1995 traffic projection)

1. Conversion of Berths Nos.1, 1A, 2 to container berths.
2. Reclamation of Shutaify Bay.
3. Demolition and construction of several warehouses and CFS.
4. Installation of 2 gantry cranes and 6 transfer cranes.

(2) Phase II (by 1995 for 2000 traffic projection)

1. Dredging of approach channel, turning basin and slips up to -13 meters.
2. Installation of 1 gantry crane and 6 transfer cranes.

As stated above, the proposed plan is emphasized in the outline of measures for container cargoes and is aimed at improving the functions and dimensions of Mina Qaboos up to a level where the port can accommodate second-generation container ships.

6.2.2.2 Evaluation of the Existing Plan

Through the review of "Comprehensive Study on Development/Improvement Required in Mina Qaboos", several aspects which require more detail analysis have been noted. The outlines of these aspects are as follows:

(1) Land Use Layout

For the efficient use of land and management of cargoes, container cargoes should be separated from other cargoes and concentrated in specific areas. From this point of view, it is desirable to establish simple zoning for land use as much as possible. The existing plan still shows complicated land use allocation. Taking into account the fact that facilities already occupy the site, the possibility of simpler and more efficient use of land space should be examined in this study.

(2) Characteristics of Calling Ships

As repeatedly stated, Mina Qaboos suffers from berths of insufficient length and quantity. In order to evaluate the berths' cargo handling capabilities, it is essential to know the detailed berthing characteristics of calling ships. In the CES Study, the analysis of this aspect is not sufficient. In this study, the analysis of this aspect should be emphasized as a basis for reasonable port planning.

(3) Optimum Port Capacity

In the Gulf area, there are many ports with efficient facilities. Under these conditions, shipping companies can easily find another alternative when a port cannot give them efficient services. Therefore as a basis of the future development of Mina Qaboos, it is essential to identify the present optimum capacity as well as the expected future capacity considering the dimensions of the port's facilities, handling productivity and so on. Concerning this aspect, more detailed analyses are required for a more quantitative evaluation of the port's capacity.

(4) Required Storage Area

It is necessary to analyze minutely the essential factors such as dwelling time peak to average ratio in order to accurately assess the required storage area, the container stacking yard as well as covered and open storage yards for general cargo. As for general cargo, it is important to study possible stacking density by major commodity based on an expected improvement in handling expertise.

(5) Back-up system

There is some uncertainty involved determining the quantity of back-up equipment. This also concerns the CFS operation system. Further analysis of this aspect as well as an appropriate CFS operation system should be carried out.

(6) Container Movement

Further study on the breakdown of containers' by size and by delivery mode will make calculation of the area requirement more accurate. For instance, the ratio of LCL and FCL grounded containers to total throughput is directly linked to CFS capacity. The ratio applied in the existing plan is somewhat different from the analytical result carried out with the PSC's data.

(7) Dredging Method

The existing report states that the disposal of the dredging ground should not be done by means of a pipeline method but rather by a split hopper barge method, so as not to disrupt present port operations. However, a pipeline method should be studied since it is possible to place the disposal pipeline on the seabed across the entrance channels in order to reduce the negative effect on the port's operations.

(8) Revised Cost Estimate

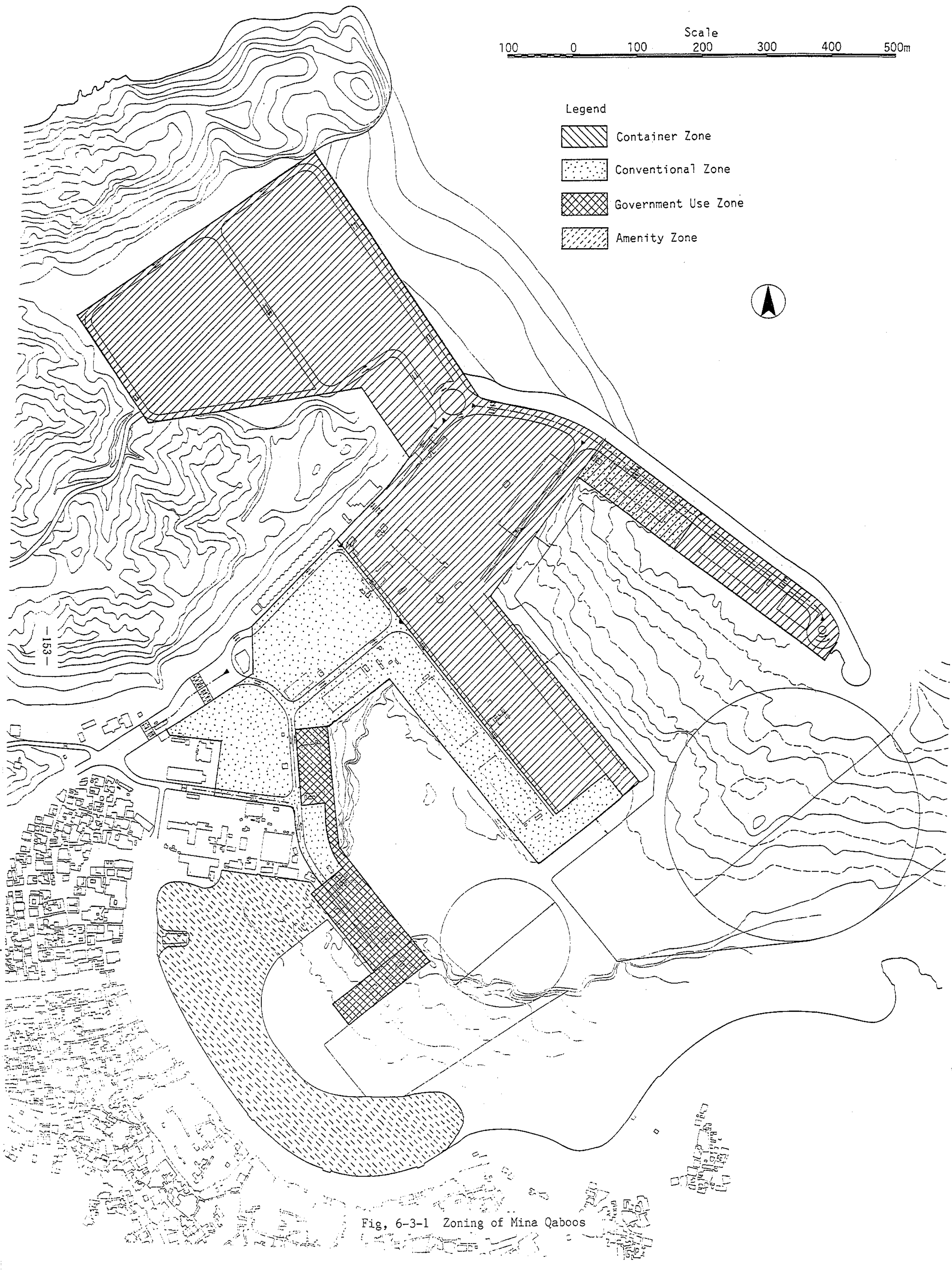
The future expansion of Mina Qaboos which CES had suggested was not economical because the construction cost of breakwaters up to the depth of 35 m seemed to be extraordinarily expensive conpared with the expandable quay length. The revised cost estimates are listed in Appendix 6-2-1.

6.3 Zoning

As already discussed in Chapter 4, the limited land area of Mina Qaboos has not been used efficiently. In addition to the lack of space, various kinds of demand including some unrelated to cargo transportation, such as the port's role as a base for His Majesty's yacht, naval vessels and fishing boats, etc., make this situation more serious. It is very apparent that large-scale countermeasures, such as reclamation of water area, are inevitable in terms of overcoming this problem. However, for the efficient use of land area, adequate zoning according to land use should be considered as a first step in implementing necessary countermeasures. From the point of view of land use allocation, the port activity zone of Mina Qaboos can be categorized into the following four basic zones:

i) Container Zone
ii) Conventional Zone
iii) Government Use Zone
iv) Amenity Zone

Fig. 6-3-1 shows the zoning of the port's land area schematically. In this scheme, the following aspects are taken into consideration:



Fig, 6-3-1 Zoning of Mina Qaboos

(a) Mina Qaboos has not been designed as a container port, hence its land area is limited with container cargoes and conventional cargos stocked in the same yard. Yards Nos.3 and 10 are typical examples. This makes the cargo movement line more complicated and decreases handling efficiency. From this point of view, container cargoes and conventional cargoes should be kept separate as much as possible.

(b) Mina Qaboos expected to continue being used as a base for government ships such as those of the Royal Oman Navy, the Royal Oman Police and His Majesty's yachts also in future. jHowever, from the perspective of the port's cargo handling capacity, the berths used for the above-mentioned ships should be concentrated as much as possible. This aspect is taken into consideration in this zoning plan.

(c) Mina Qaboos has a very attractive panorama reflecting the perfect combination of features such as white buildings, the brown, rocky mountains and the blue sea. Especially in the evening, the street along the shoreline is always crowded with people enjoying the beautiful scenery and comfortable atmosphere around the port. From this point of view, the shallow water area and the landscapes in the southern part of Mina Qaboos should be strictly preserved for the sake of amenity aspect activities.

6.4 Berth Use Plan

6.4.1 Cargo and Berth Characteristics

The result of commoditywise traffic demand forecast are shown in Table 6-4-1. Most of these commodities are transported by specialized ships. Among these commodities, bulk grain is unloaded by pneumatic and transported by belt-conveyers to silos. This system will also be used in future, hence the bulk grain berth is to be set at Berth No.3.

Containers will be handled at Berths Nos.4 and 5. However, these berths are not big enough to handle all of the future containers. Also, given the increase in the number of container cargos and the size of ships, it is necessary to make Berths Nos. 1, 1A and 2 capable of accommodating larger ships, especially container ships. Besides container ships, several kinds of large ships, like conventional ships, RO/RO ships, and livestock ships, are expected to call at these berths. Therefore Berths Nos.1 1A and

Table 6-4-1 Result of Commoditywise Traffic Demand Forecast

Commodity \ Year	1995 ('000Ton)	2000 ('000Ton)
Steel	230.2	361.4
Timber	100.5	124.0
Vehicles	68.7	86.6
Livestock	17.4	20.8
Bulk Grain	204.3	250.3
G. Cargo	208.8	313.1
Container (Boxes)	177,484	261,393
(TEUs)	236,646	348,524
Total	829.9 ('000Ton) 236,646 (TEUs)	1,156.2 ('000Ton) 348,524 (TEUs)

2 should be converted to multipurpose berths, as shown later, to respond to these situations.

Vehicles and livestock have been handled mainly at Berths Nos. 1, 1A and 2. According to calling ships statistics, these commodities have been transported by relatively large ships, and this tendency will continue in future. Hence these commodities should be handled mainly at these multipurpose berths. Steel, timber and general cargos will be handled at multi purpose berths and at Berths Nos. 7 and 8 as they now are. Also for these commodities, larger ships will be handled at multipurpose berths to ensure efficient use of berths.

Berth No.6 is now used mainly by the Royal Support Yacht. However, according to the future demand forecast, it is most probable that Mina Qaboos will be faced with a shortage of cargo handling capacity if berth use allocation remains as it is. Therefore, rearrangement of berth use allocations should be carried out in order to use the existing facilities as efficiently as possible. From this standpoint, Berth No.6 is well suited to be a commercial berth in terms of its length, depth and location. Hence it is proposed that this berth be used commercially and that new berth for Royal Support Yacht be built to replace it. This point is described move in detail in 6.6.6.

As previously described, Mina qaboos has various functions. It is not only a gateway for foreign trade but is also a base port for many different kinds of vessels and even serves as a marketplace for citizens. These aspects should also be considered in berth use allocation. Based upon above concept, berth use allocation can be set as follows:

.Berths Nos.1, 1A, 2 .....Converted to multipurpose berths for containers, vehicles, livestock etc.
.Berth No.3 .....Bulk grains
.Berth No.4,5 .....Containers
.Berths No.6,7,8 .....General cargoes, steel, timber etc.
.Berth No.9 .....Tugboats, other small boats
.Berth No.10,11,12,13 .....Government use

Detailed analysis of this allocation scheme will be provided in the following sections.

6.4.2 Berth Use Allocation

6.4.2.1 Cargo Allocation

Based upon the concept described in the previous section, cargoes in 1995 and 2000 are allocated to each berth as shown in Tables 6-4-2 and 6-4-3, respectively. In this table, several operating conditions are assumed. These factors will be discussed in detail in another chapter. Although the obtained berth occupancy ratios seem to be smaller than in standard cases, it should be noted that continuous berths such as Nos.1 &2, Nos.4 & 5 and Nos.7 & 8 cannot be evaluted as two different berths because large ships cannot berth simultaneously due to the shortness of these berths. And also, as discussed in Chapter 4, a considerable amount of berth occupancy by non-commercial ships, namely ship Type 9 in Table 3-4-2 in chapter 3, should be expected in future. Therefore it is necessary to keep the berth occupancy ratio to rather small values. These values will be evaluated quantitatively in the next section, taking account of the relation to ship waiting time.

Table 6-4-2 Berth Use Allocation ; (1995)

Berth	Commodity	Amount of Cargo (Unit/Yr)	Av. Amount of Cargo per Ship (Unit)	No.of Call (Call/Yr)	Productivity (Unit/Hr.G.S.)	Gangs	Shifts	Working HRS (Hr/G.S.D)	Total Productivity (Unit/Ship.D)	Preparation per Ship (Day)	Berthing Time per Ship (Day)	Total Berthing Time (Day)	Working Days (Day)	Berth ※ Occupancy (%)
1	Steel		2,420.0	0	30.0	3	3	8	2,160.0	0.1	1.1	0.0	365	0.0
	Timber		2,080.0	0	30.0	3	3	8	2,160.0	0.1	1.0	0.0	365	0.0
	Vehicle		300.0	0	76.0	1	3	8	1,824.0	0.1	0.2	0.0	365	0.0
	Bulk Grain		13,750.0	0	170.0	1	3	8	4,080.0	0.1	3.4	0.0	365	0.0
	Livestock		460.0	0	61.0	1	3	8	1,464.0	0.1	0.3	0.0	365	0.0
	G. Cargo		950.0	0	25.0	3	3	8	1,800.0	0.1	0.5	0.0	365	0.0
	Container	63,484.0	276.0	230	25.0	2	3	8	1,200.0	0.1	0.2	75.9	365	20.8
	Other Use													0.0
	(Total)													20.8
2	Steel	61,800.0	2,420.0	26	30.0	3	3	8	2,160.0	0.1	1.1	31.2	365	8.5
	Timber	53,500.0	2,080.0	26	30.0	3	3	8	2,160.0	0.1	1.0	27.3	365	7.5
	Vehicle	68,700.0	300.0	229	76.0	1	3	8	1,824.0	0.1	0.2	60.6	365	16.6
	Bulk Grain		13,750.0	0	170.0	1	3	8	4,080.0	0.1	3.4	0.0	365	0.0
	Livestock	17,400.0	460.0	38	61.0	1	3	8	1,464.0	0.1	0.3	15.7	365	4.3
	G. Cargo	29,400.0	950.0	31	25.0	3	3	8	1,800.0	0.1	0.5	19.4	365	5.3
	Container		276.0	0	25.0	2	3	8	1,200.0	0.1	0.2	0.0	365	0.0
	Other Use													0.0
	(Total)													42.2
3	Steel		2,420.0	0	30.0	3	3	8	2,160.0	0.1	1.1	0.0	365	0.0
	Timber		2,080.0	0	30.0	3	3	8	2,160.0	0.1	1.0	0.0	365	0.0
	Vehicle		300.0	0	76.0	1	3	8	1,824.0	0.1	0.2	0.0	365	0.0
	Bulk Grain	204,300.0	13,750.0	15	170.0	1	3	8	4,080.0	0.1	3.4	51.6	365	14.1
	Livestock		460.0	0	61.0	1	3	8	1,464.0	0.1	0.3	0.0	365	0.0
	G. Cargo		950.0	0	25.0	3	3	8	1,800.0	0.1	0.5	0.0	365	0.0
	Container		276.0	0	25.0	2	3	8	1,200.0	0.1	0.2	0.0	365	0.0
	Other Use													30.0
	(Total)													44.1
4	Steel		2,420.0	0	30.0	3	3	8	2,160.0	0.1	1.1	0.0	365	0.0
	Timber		2,080.0	0	30.0	3	3	8	2,160.0	0.1	1.0	0.0	365	0.0
	Vehicle		300.0	0	76.0	1	3	8	1,824.0	0.1	0.2	0.0	365	0.0
	Bulk Grain		13,750.0	0	170.0	1	3	8	4,080.0	0.1	3.4	0.0	365	0.0
	Livestock		460.0	0	61.0	1	3	8	1,464.0	0.1	0.3	0.0	365	0.0
	G. Cargo		950.0	0	25.0	3	3	8	1,800.0	0.1	0.5	0.0	365	0.0
	Container	57,000.0	276.0	207	25.0	1	3	8	600.0	0.1	0.5	115.7	365	31.7
	Other Use													0.0
	(Total)													31.7
5	Steel		2,420.0	0	30.0	3	3	8	2,160.0	0.1	1.1	0.0	365	0.0
	Timber		2,080.0	0	30.0	3	3	8	2,160.0	0.1	1.0	0.0	365	0.0
	Vehicle		300.0	0	76.0	1	3	8	1,824.0	0.1	0.2	0.0	365	0.0
	Bulk Grain		13,750.0	0	170.0	1	3	8	4,080.0	0.1	3.4	0.0	365	0.0
	Livestock		460.0	0	61.0	1	3	8	1,464.0	0.1	0.3	0.0	365	0.0
	G. Cargo		950.0	0	25.0	3	3	8	1,800.0	0.1	0.5	0.0	365	0.0
	Container	57,000.0	276.0	207	25.0	1	3	8	600.0	0.1	0.5	115.7	365	31.7
	Other Use													0.0
	(Total)													31.7
6	Steel	52,400.0	2,420.0	22	30.0	3	3	8	2,160.0	0.1	1.1	26.4	365	7.2
	Timber	15,000.0	2,080.0	7	30.0	3	3	8	2,160.0	0.1	1.0	7.7	365	2.1
	Vehicle		300.0	0	76.0	1	3	8	1,824.0	0.1	0.2	0.0	365	0.0
	Bulk Grain		13,750.0	0	170.0	1	3	8	4,080.0	0.1	3.4	0.0	365	0.0
	Livestock		460.0	0	61.0	1	3	8	1,464.0	0.1	0.3	0.0	365	0.0
	G. Cargo	59,300.0	950.0	62	25.0	3	3	8	1,800.0	0.1	0.5	39.2	365	10.7
	Container		276.0	0	25.0	2	3	8	1,200.0	0.1	0.2	0.0	365	0.0
	Other Use													15.0
	(Total)													35.1
7	Steel	58,000.0	2,420.0	24	30.0	3	3	8	2,160.0	0.1	1.1	29.2	365	8.0
	Timber	16,000.0	2,080.0	8	30.0	3	3	8	2,160.0	0.1	1.0	8.2	365	2.2
	Vehicle		300.0	0	76.0	1	3	8	1,824.0	0.1	0.2	0.0	365	0.0
	Bulk Grain		13,750.0	0	170.0	1	3	8	4,080.0	0.1	3.4	0.0	365	0.0
	Livestock		460.0	0	61.0	1	3	8	1,464.0	0.1	0.3	0.0	365	0.0
	G. Cargo	60,000.0	950.0	63	25.0	3	3	8	1,800.0	0.1	0.5	39.6	365	10.9
	Container		276.0	0	25.0	2	3	8	1,200.0	0.1	0.2	0.0	365	0.0
	Other Use													15.0
	(Total)													36.1
8	Steel	58,000.0	2,420.0	24	30.0	3	3	8	2,160.0	0.1	1.1	29.2	365	8.0
	Timber	16,000.0	2,080.0	8	30.0	3	3	8	2,160.0	0.1	1.0	8.2	365	2.2
	Vehicle		300.0	0	76.0	1	3	8	1,824.0	0.1	0.2	0.0	365	0.0
	Bulk Grain		13,750.0	0	170.0	1	3	8	4,080.0	0.1	3.4	0.0	365	0.0
	Livestock		460.0	0	61.0	1	3	8	1,464.0	0.1	0.3	0.0	365	0.0
	G. Cargo	60,000.0	950.0	63	25.0	3	3	8	1,800.0	0.1	0.5	39.6	365	10.9
	Container		276.0	0	25.0	2	3	8	1,200.0	0.1	0.2	0.0	365	0.0
	Other Use													15.0
	(Total)													36.1
TOTAL	Steel	230,200.0	2,420.0	95	30.0	3	3	8	2,160.0	0.1	1.1	116.1	365	4.0
	Timber	100,500.0	2,080.0	48	30.0	3	3	8	2,160.0	0.1	1.0	51.4	365	1.8
	Vehicle	68,700.0	300.0	229	76.0	1	3	8	1,824.0	0.1	0.2	60.6	365	2.1
	Bulk Grain	204,300.0	13,750.0	15	170.0	1	3	8	4,080.0	0.1	3.4	51.6	365	1.8
	Livestock	17,400.0	460.0	38	61.0	1	3	8	1,464.0	0.1	0.3	15.7	365	0.5
	G. Cargo	208,700.0	950.0	220	25.0	3	3	8	1,800.0	0.1	0.5	137.9	365	4.7
	Container	177484	276.0	643	25.0	2	3	8	1,200.0	0.1	0.2	212.2	365	18.5
	Other Use	0.0												9.4
	(Total)													34.6

※ Only cargo-related berth occupancy is shown.

Table 6-4-3 Berth use Allocation ; (2000)

Berth	Commodity	Amount of Cargo (Unit/Yr)	Av. Amount of Cargo per Ship (Unit)	No.of Call (Call/Yr)	Productivity (Unit/Hr.G.S.)	Gangs	Shifts	Working HRS (Hr/G,S.D)	Total Productivity (Unit/Ship.D)	Preparation per Ship (Day)	Berthing Time per Ship (Day)	Total Berthing Time. (Day)	Working Days (Day)	Berth ※ Occupancy (%)
1	Steel		2,420.0	0	30.0	3	3	8	2,160.0	0.1	1.12	0.0	365	0.0
	Timber		2,080.0	0	30.0	3	3	8	2,160.0	0.1	0.96	0.0	365	0.0
	Vehicle		300.0	0	76.0	1	3	8	1,824.0	0.1	0.16	0.0	365	0.0
	Bulk Grain		13,750.0	0	170.0	1	3	8	4,080.0	0.1	3.37	0.0	365	0.0
	Livestock		460.0	0	61.0	1	3	8	1,464.0	0.1	0.31	0.0	365	0.0
	G. Cargo		950.0	0	25.0	3	3	8	1,800.0	0.1	0.53	0.0	365	0.0
	Container	70,580.0	276.0	256	25.0	2	3	8	1,200.0	0.1	0.23	84.4	365	23.1
	Other Use													0.0
	(Total)													23.1
2	Steel	59,100.0	2,420.0	24	30.0	3	3	8	2,160.0	0.1	1.12	29.9	365	8.2
	Timber	40,900.0	2,080.0	20	30.0	3	3	8	2,160.0	0.1	0.96	20.9	365	5.7
	Vehicle	86,600.0	300.0	289	76.0	1	3	8	1,824.0	0.1	0.16	76.3	365	20.9
	Bulk Grain		13,750.0	0	170.0	1	3	8	4,080.0	0.1	3.37	0.0	365	0.0
	Livestock	20,800.0	460.0	45	61.0	1	3	8	1,464.0	0.1	0.31	18.7	365	5.1
	G. Cargo	25,200.0	950.0	27	25.0	3	3	8	1,800.0	0.1	0.53	16.7	365	4.6
	Container		276.0	0	25.0	2	3	8	1,200.0	0.1	0.23	0.0	365	0.0
	Other Use													0.0
	(Total)													44.5
3	Steel		2,420.0	0	30.0	3	3	8	2,160.0	0.1	1.12	0.0	365	0.0
	Timber		2,080.0	0	30.0	3	3	8	2,160.0	0.1	0.96	0.0	365	0.0
	Vehicle		300.0	0	76.0	1	3	8	1,824.0	0.1	0.16	0.0	365	0.0
	Bulk Grain	250,300.0	13,750.0	18	170.0	1	3	8	4,080.0	0.1	3.37	63.2	365	17.3
	Livestock		460.0	0	61.0	1	3	8	1,464.0	0.1	0.31	0.0	365	0.0
	G. Cargo		950.0	0	25.0	3	3	8	1,800.0	0.1	0.53	0.0	365	0.0
	Container		276.0	0	25.0	2	3	8	1,200.0	0.1	0.23	0.0	365	0.0
	Other Use													30.0
	(Total)													47.3
4	Steel		2,420.0	0	30.0	3	3	8	2,160.0	0.1	1.12	0.0	365	0.0
	Timber		2,080.0	0	30.0	3	3	8	2,160.0	0.1	0.96	0.0	365	0.0
	Vehicle		300.0	0	76.0	1	3	8	1,824.0	0.1	0.16	0.0	365	0.0
	Bulk Grain		13,750.0	0	170.0	1	3	8	4,080.0	0.1	3.37	0.0	365	0.0
	Livestock		460.0	0	61.0	1	3	8	1,464.0	0.1	0.31	0.0	365	0.0
	G. Cargo		950.0	0	25.0	3	3	8	1,800.0	0.1	0.53	0.0	365	0.0
	Container	56,984.0	276.0	206	25.0	1	3	8	600.0	0.1	0.46	115.6	365	31.7
	Other Use													0.0
	(Total)													31.7
5	Steel		2,420.0	0	30.0	3	3	8	2,160.0	0.1	1.12	0.0	365	0.0
	Timber		2,080.0	0	30.0	3	3	8	2,160.0	0.1	0.96	0.0	365	0.0
	Vehicle		300.0	0	76.0	1	3	8	1,824.0	0.1	0.16	0.0	365	0.0
	Bulk Grain		13,750.0	0	170.0	1	3	8	4,080.0	0.1	3.37	0.0	365	0.0
	Livestock		460.0	0	61.0	1	3	8	1,464.0	0.1	0.31	0.0	365	0.0
	G. Cargo		950.0	0	25.0	3	3	8	1,800.0	0.1	0.53	0.0	365	0.0
	Container	56,984.0	276.0	206	25.0	1	3	8	600.0	0.1	0.46	115.6	365	31.7
	Other Use													0.0
	(Total)													31.7
6	Steel	51,100.0	2,420.0	21	30.0	3	3	8	2,160.0	0.1	1.12	25.8	365	7.1
	Timber	9,200.0	2,080.0	4	30.0	3	3	8	2,160.0	0.1	0.96	4.7	365	1.3
	Vehicle		300.0	0	76.0	1	3	8	1,824.0	0.1	0.16	0.0	365	0.0
	Bulk Grain		13,750.0	0	170.0	1	3	8	4,080.0	0.1	3.37	0.0	365	0.0
	Livestock		460.0	0	61.0	1	3	8	1,464.0	0.1	0.31	0.0	365	0.0
	G. Cargo	46,500.0	950.0	49	25.0	3	3	8	1,800.0	0.1	0.53	30.7	365	8.4
	Container		276.0	0	25.0	2	3	8	1,200.0	0.1	0.23	0.0	365	0.0
	Other Use													15.0
	(Total)													31.8
7	Steel	55,000.0	2,420.0	23	30.0	3	3	8	2,160.0	0.1	1.12	27.7	365	7.6
	Timber	10,000.0	2,080.0	5	30.0	3	3	8	2,160.0	0.1	0.96	5.1	365	1.4
	Vehicle		300.0	0	76.0	1	3	8	1,824.0	0.1	0.16	0.0	365	0.0
	Bulk Grain		13,750.0	0	170.0	1	3	8	4,080.0	0.1	3.37	0.0	365	0.0
	Livestock		460.0	0	61.0	1	3	8	1,464.0	0.1	0.31	0.0	365	0.0
	G. Cargo	50,000.0	950.0	53	25.0	3	3	8	1,800.0	0.1	0.53	33.0	365	9.1
	Container		276.0	0	25.0	2	3	8	1,200.0	0.1	0.23	0.0	365	0.0
	Other Use													15.0
	(Total)													33.1
8	Steel	55,000.0	2,420.0	23	30.0	3	3	8	2,160.0	0.1	1.12	27.7	365	7.6
	Timber	10,000.0	2,080.0	5	30.0	3	3	8	2,160.0	0.1	0.96	5.1	365	1.4
	Vehicle		300.0	0	76.0	1	3	8	1,824.0	0.1	0.16	0.0	365	0.0
	Bulk Grain		13,750.0	0	170.0	1	3	8	4,080.0	0.1	3.37	0.0	365	0.0
	Livestock		460.0	0	61.0	1	3	8	1,464.0	0.1	0.31	0.0	365	0.0
	G. Cargo	50,000.0	950.0	53	25.0	3	3	8	1,800.0	0.1	0.53	33.0	365	9.1
	Container		276.0	0	25.0	2	3	8	1,200.0	0.1	0.23	0.0	365	0.0
	Other Use													15.0
	(Total)													33.1
TOTAL	Steel	220,200.0	2,420.0	91	30.0	3	3	8	2,160.0	0.1	1.12	111.0	365	3.8
	Timber	70,000.0	2,080.0	34	30.0	3	3	8	2,160.0	0.1	0.96	35.8	365	1.2
	Vehicle	86,600.0	300.0	289	76.0	1	3	8	1,824.0	0.1	0.16	76.3	365	2.6
	Bulk Grain	250,300.0	13,750.0	18	170.0	1	3	8	4,080.0	0.1	3.37	63.2	365	2.2
	Livestock	20,800.0	460.0	45	61.0	1	3	8	1,464.0	0.1	0.31	18.7	365	0.6
	G. Cargo	171,700.0	950.0	181	25.0	3	3	8	1,800.0	0.1	0.53	113.5	365	3.9
	Container	184548	276.0	668	25.0	2	3	8	1,200.0	0.1	0.21	283.9	365	10.8
	Other Use	0.0		0										9.4
	(Total)			1,326										34.5

※ Only cargo-related berth occupancy is shown.

6.4.2.2 Queuing Simulation

Using a queuing simulation method, several important factors, such as average ship waiting time and berth occupancy ratio, can be obtained, simulating complex port activities. Fig.6-4-1 shows the flowchart of a queuing simulation model. As input data for this simulation model, various information is required. Among others, this data includes distribution of ship arrival intervals, distribution of berth service time and productivity of cranes. This data was prepared by processing original data given by the PSC. Figs.6-4-2 (a), (b) show the distribution of ship arrivals for conventional ships and full container ships as examples. Table 6-4-4 shows the average ship waiting time by ship type obtained through this simulation model. In order to compete with neighboring ports, ships should not be made to wait for a long time. Especially in case of container ships, regularity of service is essential. Hence waiting time should be strictly controlled. In this calculation, cargo allocation to each berth is set such that ship waiting time is limited to about three hours.

6.4.2.3 Berth Use Allocation in 1995 and 2000

Based upon the above-mentioned cargo allocation concept, the cargo handling capacity of Mina Qaboos has been evaluated. In the year 2000, Mina Qaboos will not be able to deal with all the commodities that are expected according to demand forecast described in Chapter 5 for the reasons given in the previous section. Hence cargo allocation between Mina Qaboos and the New Port is set as shown in Table 6-4-5. Berth use allocations in 1995 and 2000 are already shown in Tables 6-4-2, 6-4-3, however, it should be realized that each of the pairs comprising Berths Nos.1 & 2, Berths Nos.4 & 5 and Berths Nos.7 & 8 should be evaluated as one long berth because of their limited length and that berth occupancy ratios should remain smaller than those of independent berths.

Berth No.3's occupancy ratio is very low. This is because this berth is planned to be used for non-commercial ships. It is very difficult to estimate the required occupancy ratio for non-commercial use in future. Based on the statistics for 1988, about 50% of occupancy is reserved for this use. A 50% occupancy ratio cannot be maintained only by Berth No.3, hence the remaining portion will be covered by Berths Nos.6, 7 & 8 as shown in Tables 6-4-2 and 6-4-3.

After making a shift of Royal fleets from Berth No.6 to a new berth, the berth occupancy notes of Berths Nos.6, 7 and 8 will respectively be 35.1%, 36.1% and 36.1% in 1995, and 31.8%, 33.1% and 33.1% in 2000.

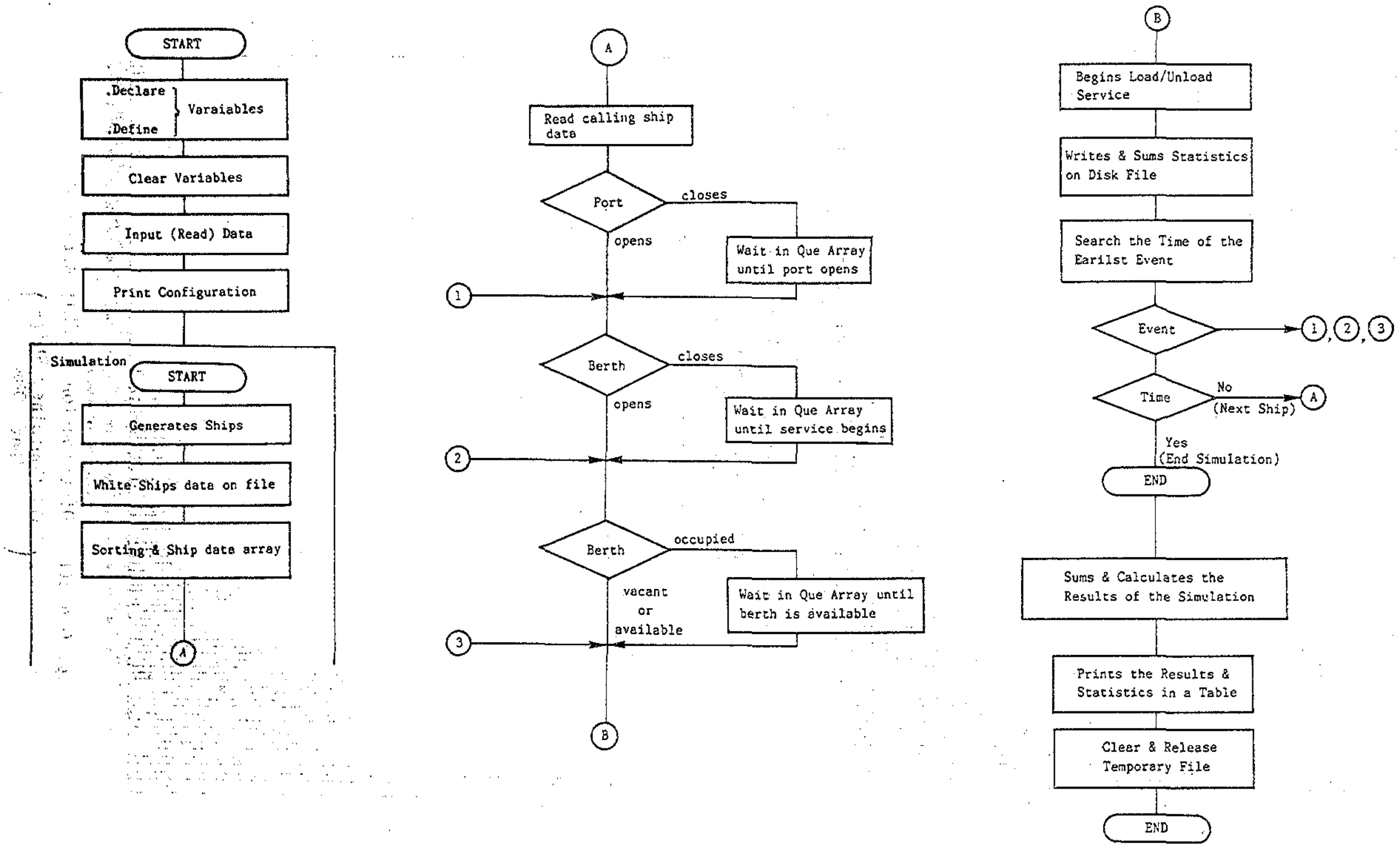


Fig. 6-4-1 Flowchart of Queuing Simulation Model

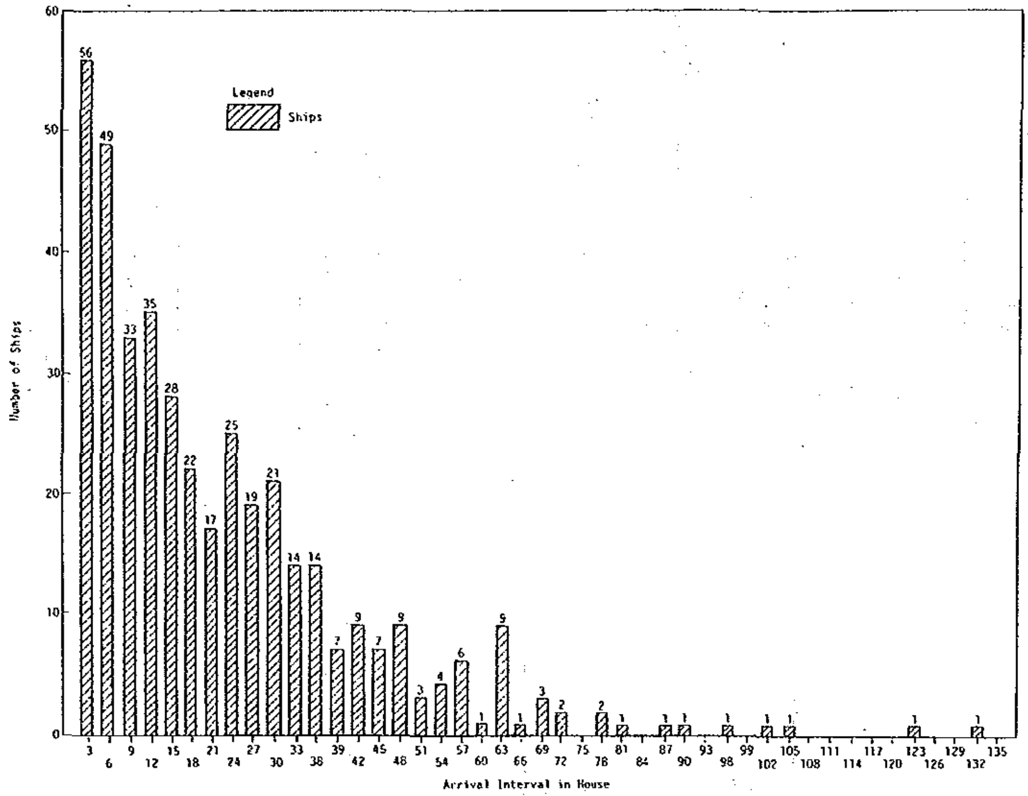


Fig. 6-4-2(a) Distribution of Ship Arrivals
(Conventional Ships
Year 1988)

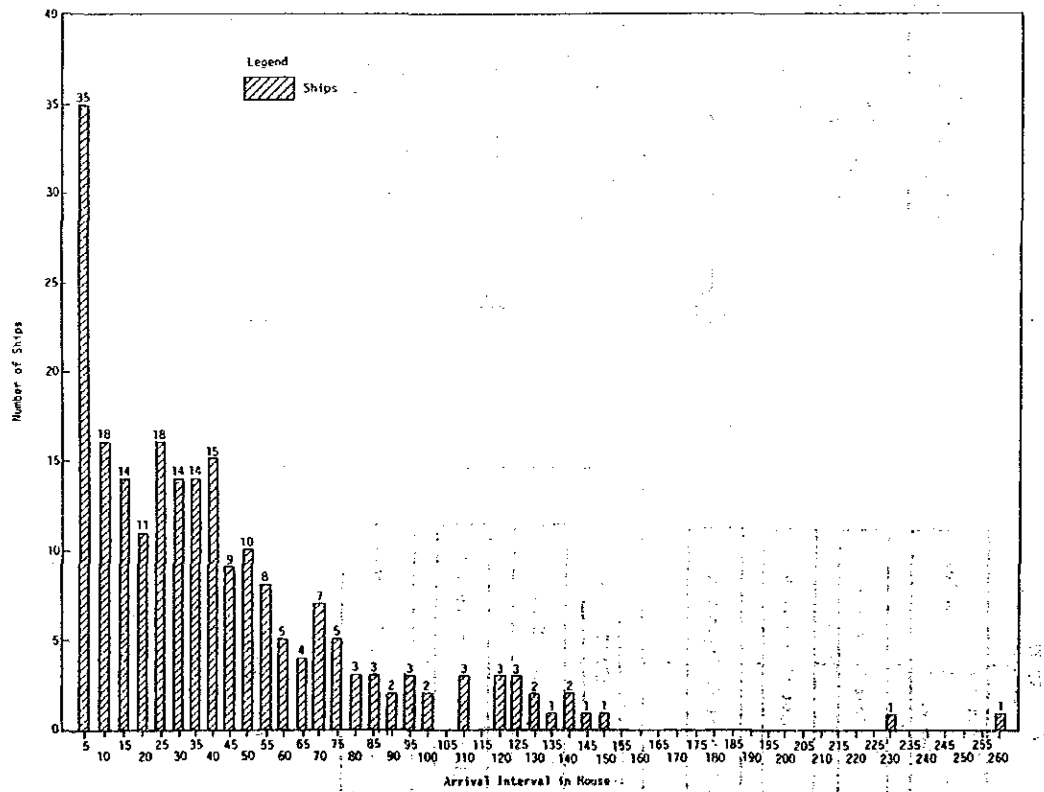


Fig. 6-4-2(b) Distribution of Ship Arrivals
(Full Container Ships
Year 1988)

Table 6-4-4 Calculated Average Ship Waiting Time

(Hours)

Ship Type \ Year / Berth No.	1995			2000		
	1 & 2	4 & 5	6,7 & 8	1 & 2	4 & 5	6,7 & 8
Container	1.9	3.0	–	2.4	2.6	–
Timber	1.1	–	0.6	1.9	–	0.1
Steel	1.5	–	3.3	2.2	–	3.8
Vehicle	1.4	–	–	1.5	–	–
Livestock	1.0	–	–	1.4	–	–
G. Cargo	1.9	–	0.8	2.3	–	0.8

Table 6-4-5 Cargo Allocation between Mina Qaboos and New Port

Cargo	1995		2000	
	Mina Qaboos	New Port	Mina Qaboos	New Port
Steel	230,200(Ton)	0	220,200(Ton)	141,200(Ton)
Timber	100,500(Ton)	0	70,000(Ton)	54,000(Ton)
Bulk Grain	204,300(Ton)	0	250,300(Ton)	0
Vehicle	68,700(Ton)	0	86,600(Ton)	0
Livestock	17,400(Ton)	0	20,800(Ton)	0
General Cargo	208,800(Ton)	0	171,700(Ton)	141,400(Ton)
Container	236,646(TEUs)	0	246,058(TEUs)	102,354(TEUs)
(Total)	829,900(Ton)	0	819,600(Ton)	336,600(Ton)
	236,606(TEUs)	0	246,058(TEUs)	102,354(TEUs)

6.5 Land Use Plan

6.5.1 Land Use of Existing Area

The zoning of land area at Mina Qaboos has already been explained in 6.3. In terms of total available land area, about 5,600m^2 of area will increase, as shown in Table 6-5-1. Responding to the increase of container cargos, the open storage portion will increase rapidly, but, on the other hand, the covered storage are will decrease rapidly. Detailed discussions will be provided in the following sections.

Table 6-5-1 Land Use of Existing Area

Land Use	Area	
	Present	After Zoning
Covered storage	19,094 m^2	10,065 m^2
Open storage	37,910 m^2	67,780 m^2
CFS	4,722 m^2	0 m^2
Marshalling yard	87,425 m^2	76,954 m^2
Total	149,151 m^2	154,799 m^2

6.5.2 Required Land Area in 1995 and 2000

6.5.2.1 Characteristics of Cargo Movement

Cargoes have different movements in a port according to commodity, and the characteristics of movement have to be clarified in order to estimate the required storage area in a port. For this purpose, cargo movements for principal non-containerized cargoes in the port are characterized, as shown in Table 6-5-2, based on the analysis of Mina Qaboos' cargo data.

Table 6-5-2 Characteristics of Conventional Cargo Movement
(% in terms of tonnage)

Commodity	Pattern of movement					
	Open storage		Covered storage		Direct Det.	
	(1995)	(2000)	(1995)	(2000)	(1995)	(2000)
Timber and plywood	12.1%	8.5%				
Steel and pipes	27.7%	26.9%				
Vehicles	8.3%	10.6%				
Bulk grain					24.6%	30.5%
Other bulk					3.8%	4.9%
Livestock					2.1%	2.5%
Break bulk	7.2%	2.1%	6.8%	5.8%	7.3%	8.2%

6.5.2.2 Estimation of Required Storage Area

(1) Formula

The required storage area can be calculated by using the following simple formula,

$$A = \frac{T \times p \times a}{\frac{W}{D} \times S}$$

Where A: Required Storage Area (m²)

T: Cargo Throughput (Ton/year)

W: Working Days (Day/year)

D: Dwelling Time (Day)

s: Stacking Density (t/m^2)

p: Peak Factor

a: Allowance Factor

(2) Dwelling Time

The dwelling time of principal cargoes is calculated based upon original port data provided by the PSC. Regarding containers, dwelling times were obtained from 41,282 data, as explained in Chapter 3. For general cargoes, cargo movement data for three month namely October, November and December in 1988, were analyzed and dwelling times were calculated for steel, timber, rice, vehicles and other general cargoes. Based upon these analyses, the dwelling time for each type of cargo is as follows;

Containers:

Import(loaded and empty)	:	8.6 days
Export(loaded)	:	7.0 days
Export(empty)	:	21.0 days
Reefer(export & import)	:	7.0 days
Transshipment	:	6.9 days

Conventional cargo:

Steel and Pipes	:	7.0 days
Timber and Plywood	:	8.1 days
Vehicles	:	5.3 days
Rice	:	10.0 days
Others	:	12.8 days

(3) Peak Factor

Peak factors for the formula are calculated based on the port data provided by the PSC.

① Container Cargoes

The change in the number of stocked cargoes is estimated by processing the data of 1987. These results are shown in Fig.6-5-1. In this figure the number of stocked containers as of January 1st 1987 is set at zero. From this data, Fig.6-5-2 and 6-5-3 can be obtained. From Fig.6-5-3, it is explained that if the peak factor is set as 1.4, 90% coverage can be guaranteed. On the other hand, the change in the number of containers through gate is also analyzed using one year's worth data from 1988. Figs.6-5-4 and 6-5-5 show the result. From this result, it is found that the balance of containers is around 20 TEU per day. The balance can be included in the above peak factor 1.4.

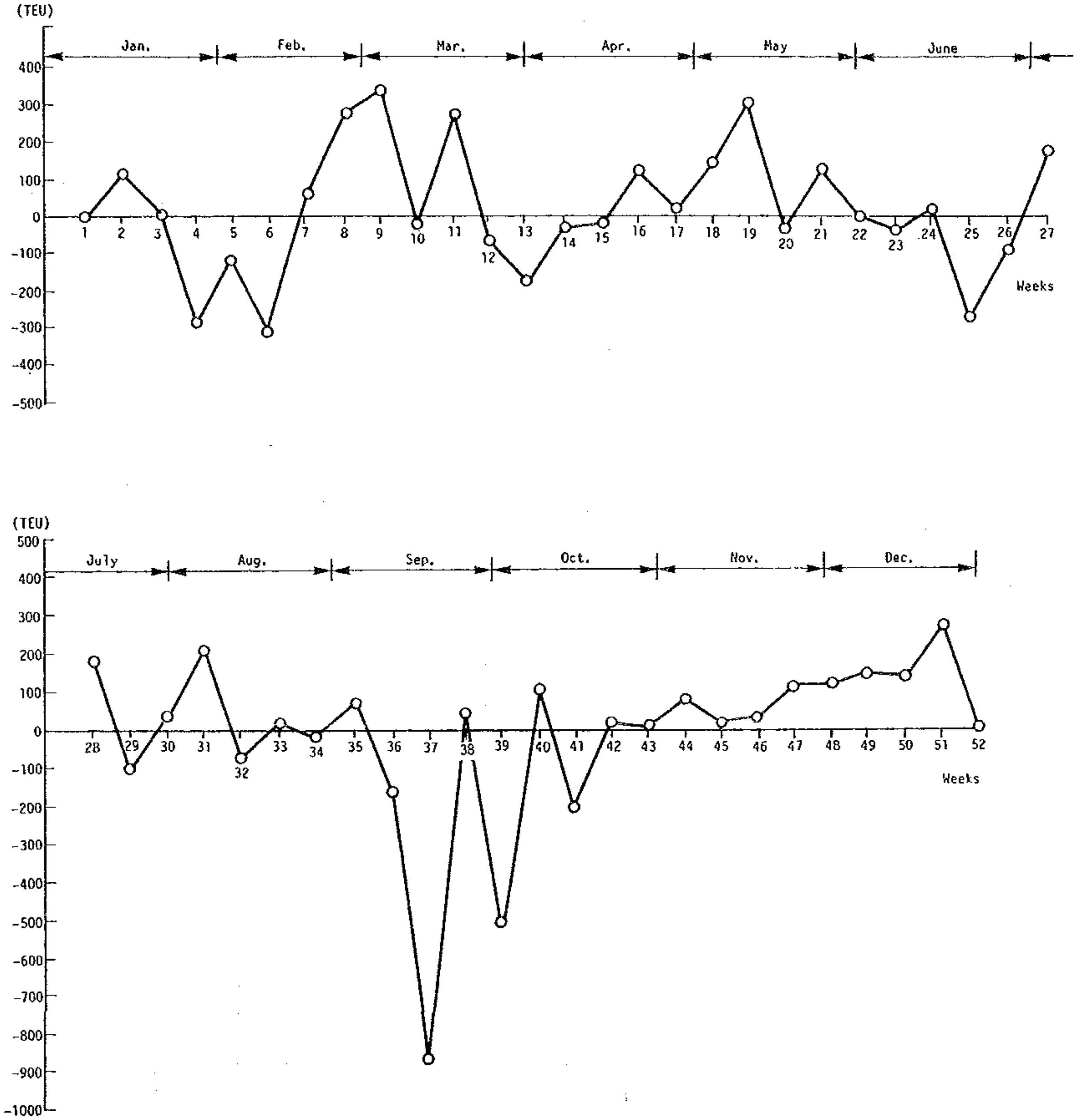


Fig. 6-5-1 Charcteristics of Stocked Containers (1987)
(Source: PSC data)

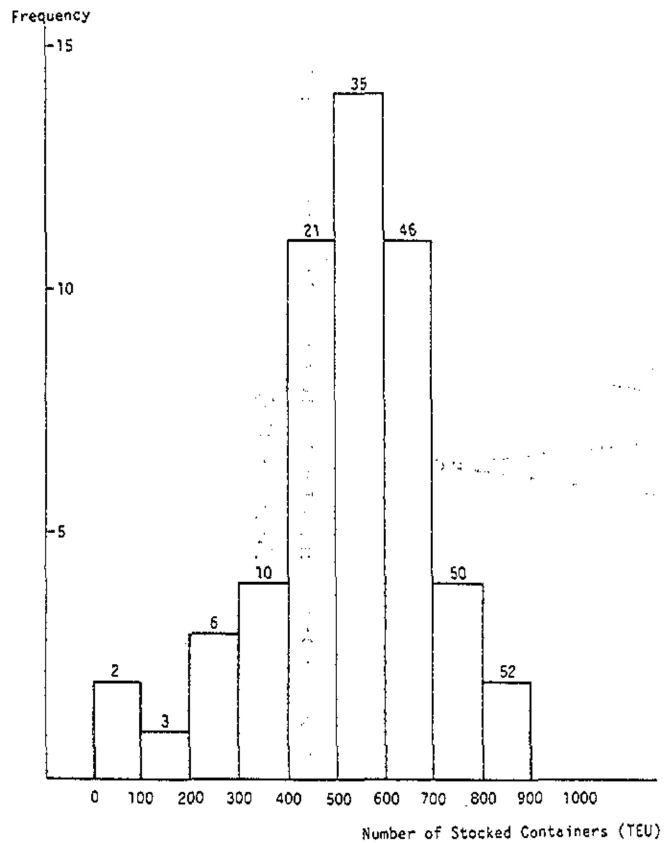


Fig. 6-5-2 Frequency Diagram for Number of Stocked Containers

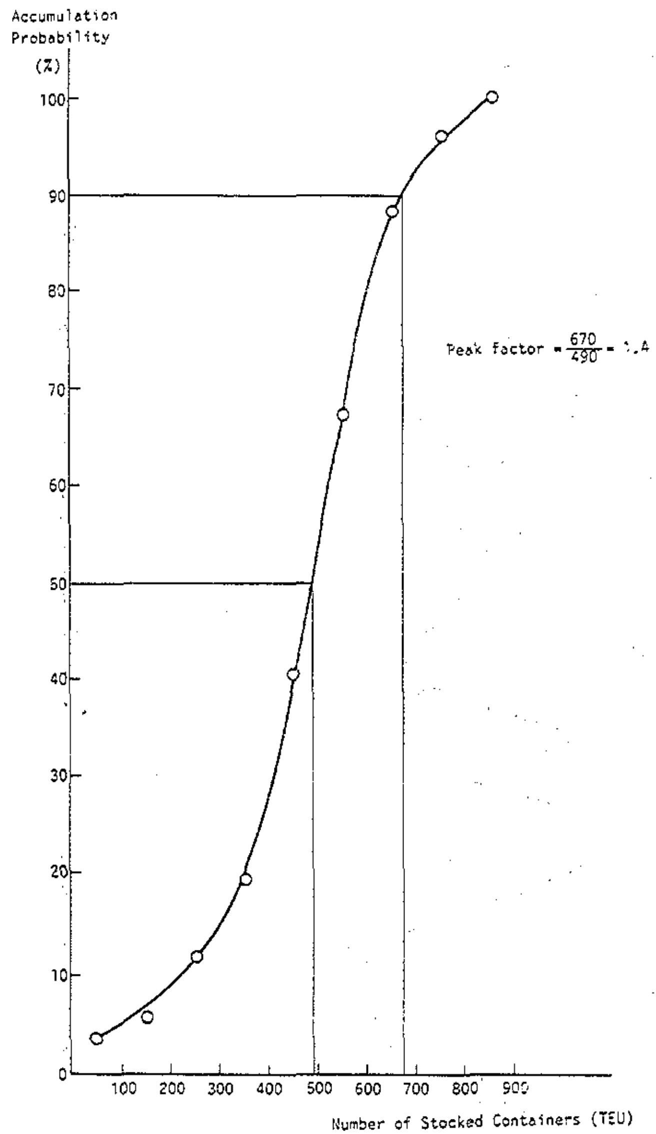


Fig. 6-5-3 Accumulation Curve for Number of Stocked Containers

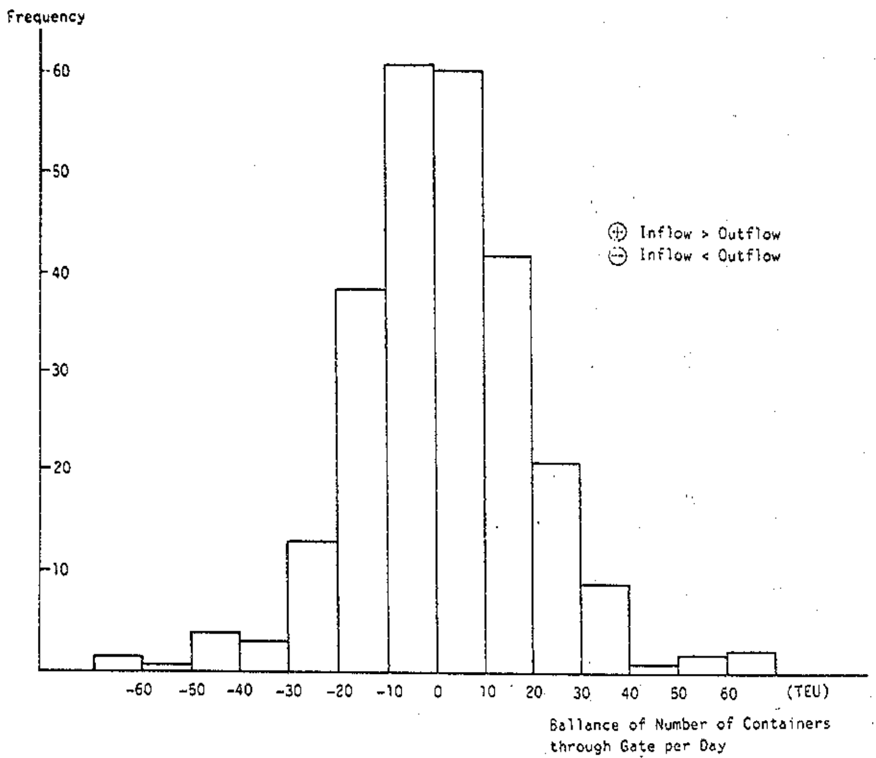


Fig. 6-5-4 Frequency Diagram of Container

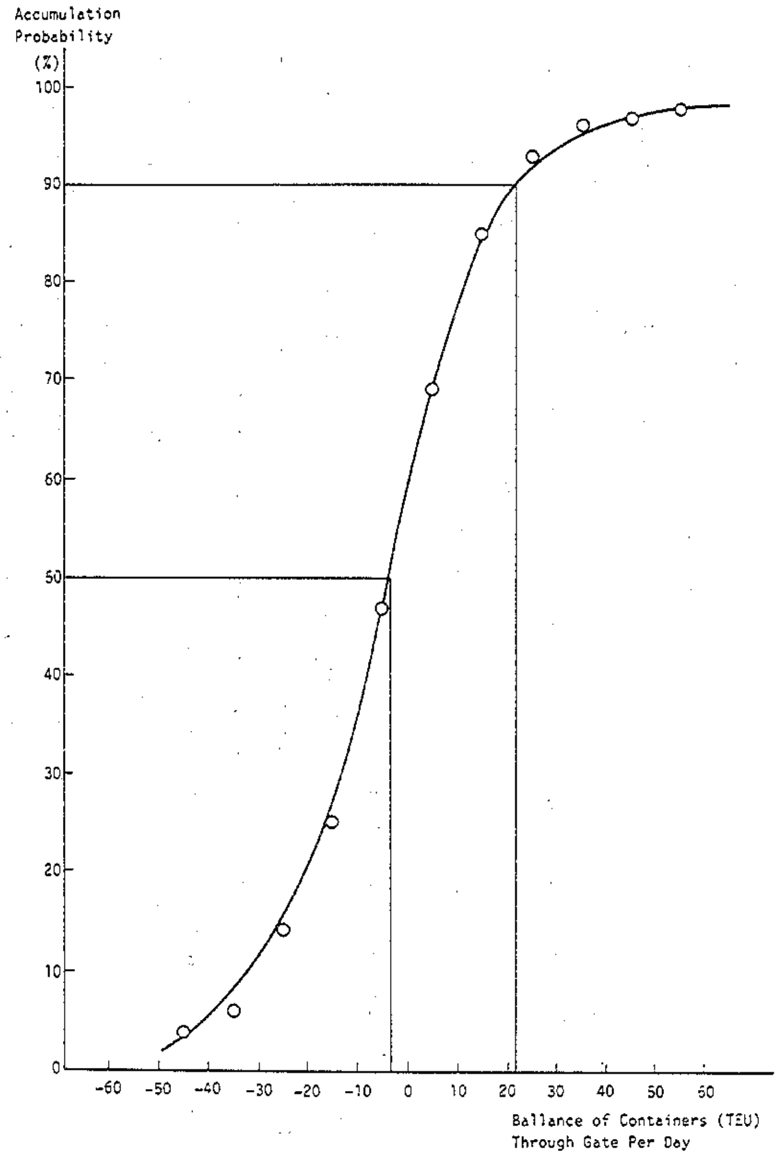


Fig. 6-5-5 Accumulation Curve of Container Ballance

② General Cargos

Concerning general cargoes, cargo movement characteristics were analyzed based on three months of data, namely October, November and December 1988. The daily changes, in the characteristics of volume of stocked cargoes are shown in Chapter 3. From this data, Figs.6-5-6 - Fig.6-5-11 are obtained for the open yard, vehicle yard and covered storage areas. The peak factors are thus set as 1.6, 1.8 and 1.5 for the open yard, vehicle yard and covered storage areas, respectively.

6.5.2.3 Required Land Area

The area required for each storage mode is shown below. All the cargo handled at Mina Qaboos is divided into 3 storage modes; covered storage, open storage and container yard. The relations between the required area and annual throughput in the years 1988, 1995 and 2000 are shown in Table 6-5-3, and Figs.6-5-12,13,14. These indicate that at present the total available area is more than the total required area, meaning land shortage is caused by inefficient allotment between three storage modes. However, a future shortage of land is inevitable even if zoning is carried out to ensure efficient land use. The land shortage is 6.0ha and 5.6ha in 1995 and 2000, respectively, on condition that the new port will function by 2000 and adequate cargo allotment is available between Mina Qaboos and the new port. Although the land shortage in 2000 is smaller than that in 1995, the maximum shortage will occur just before the new port begins operating, that is, between 1995 and 2000. If the new port is not functioning in 2000, the land shortage will amount to 12.5ha. Taking account of the above-mentioned factors, it is desirable to set aside 15ha of land for the future use of the port.

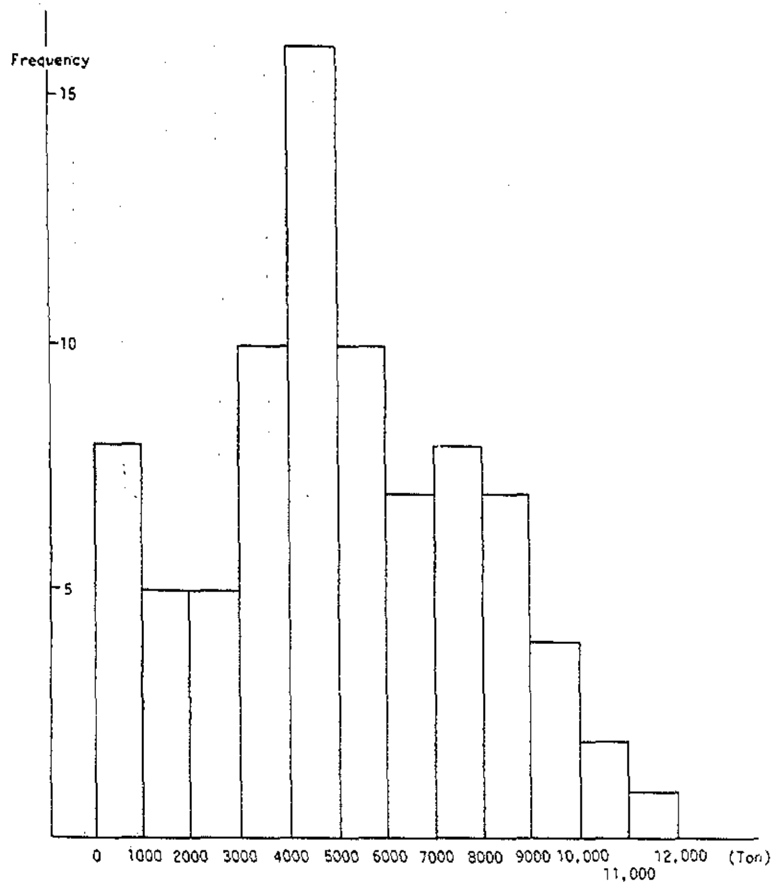


Fig. 6-5-6 Frequency Diagram for Volume of Stocked Cargo (Open Yard)

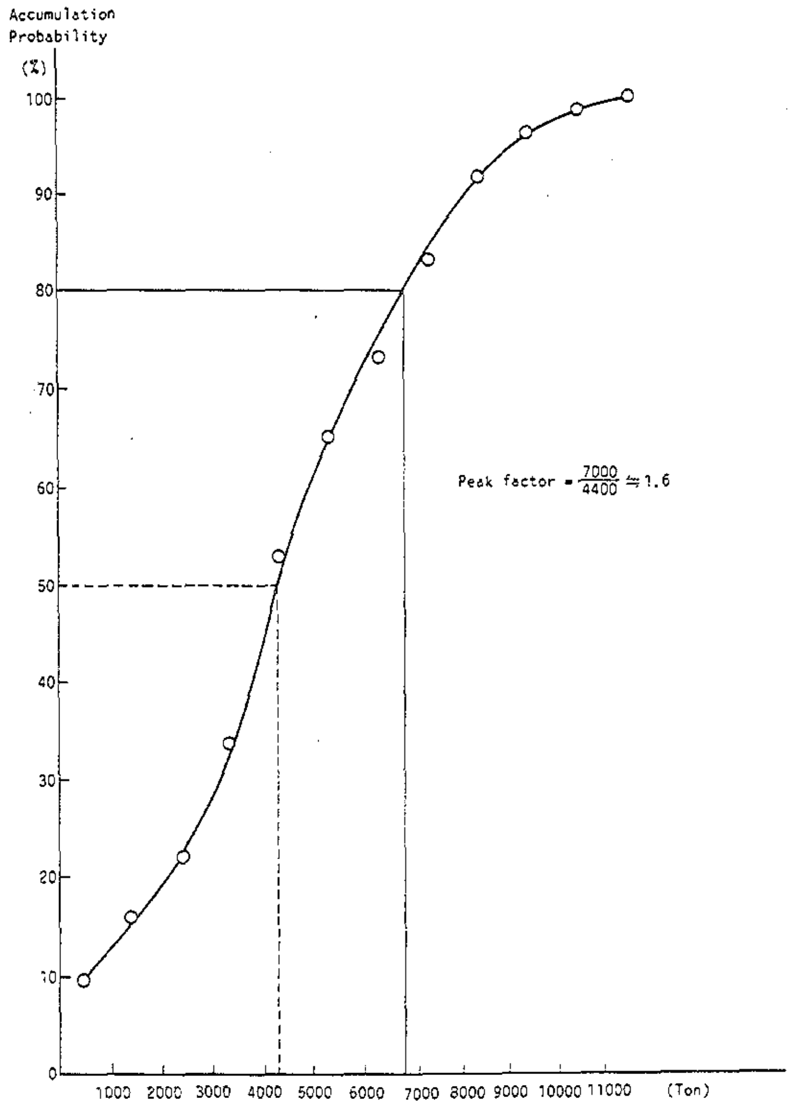


Fig. 6-5-7 Accumulation Curve for Volume of Stocked Cargos (Open Yard)

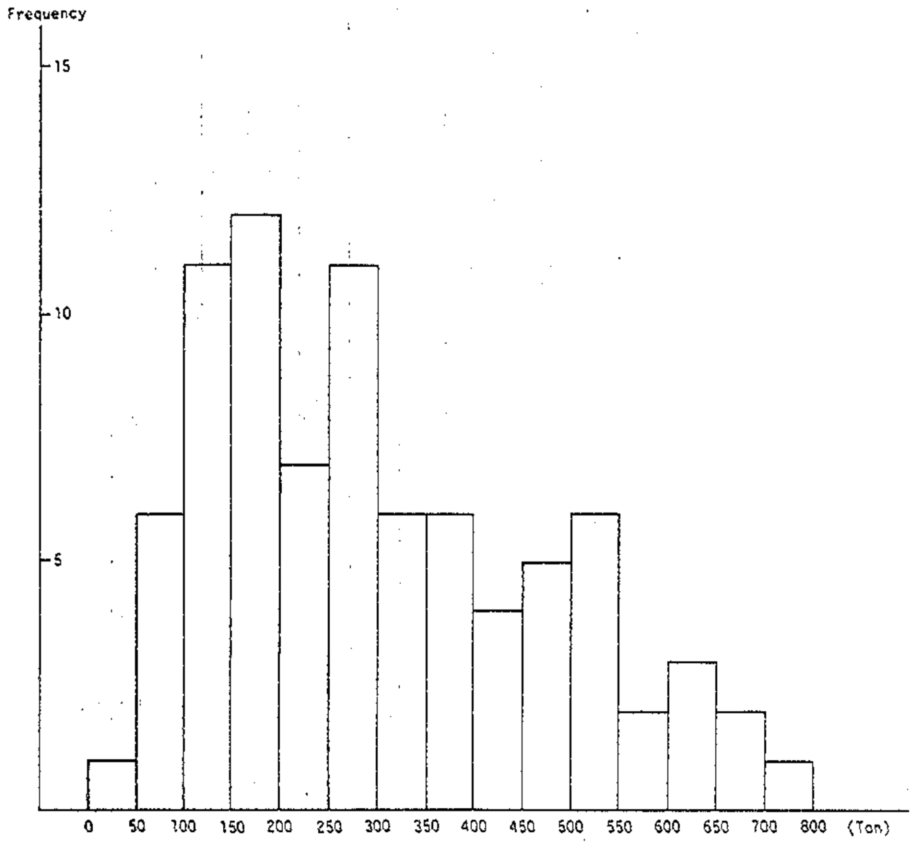


Fig. 6-5-8 Frequency Diagram for Volume of Stocked Vehicles (Vehicle Yard)

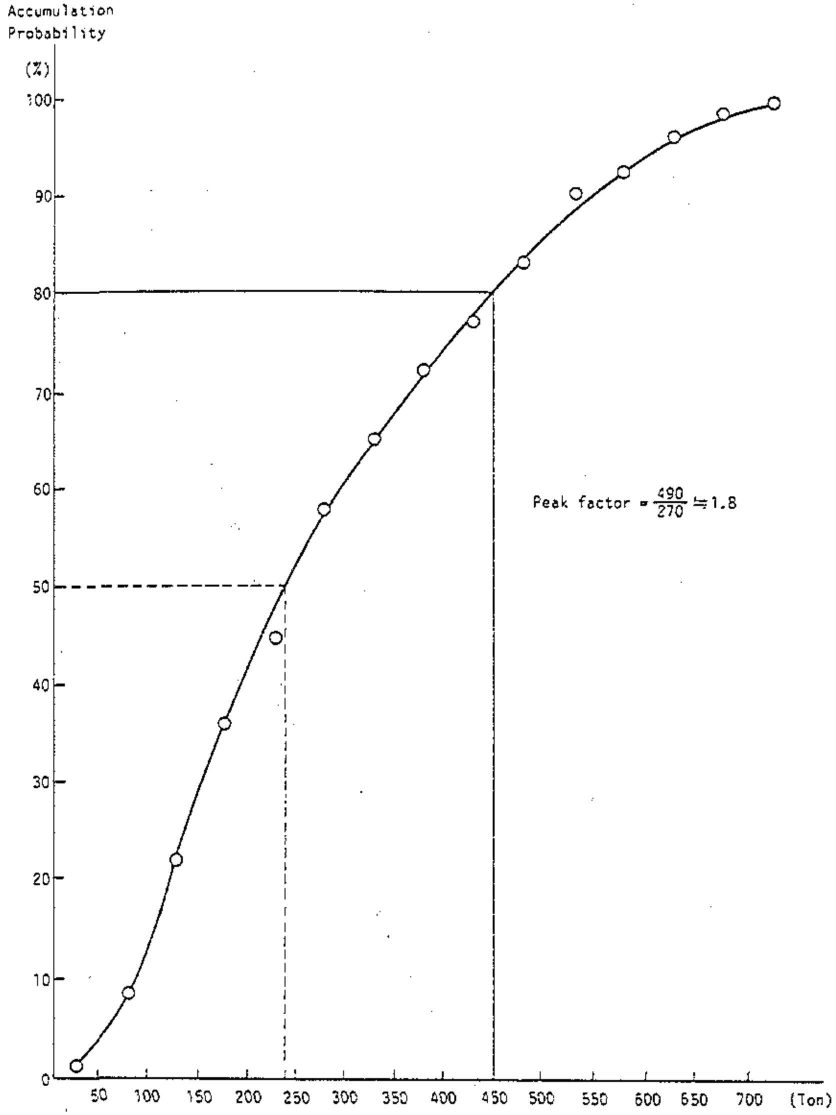


Fig. 6-5-9 Accumulation Curve for Volume of Stocked Vehicles (Vehicle Yard)

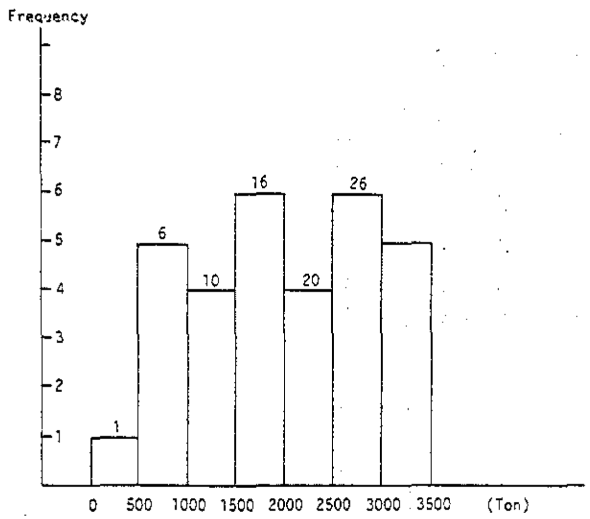


Fig. 6-5-10 Frequency Diagram for Volume of Stocked Cargoes (Covered Storage)

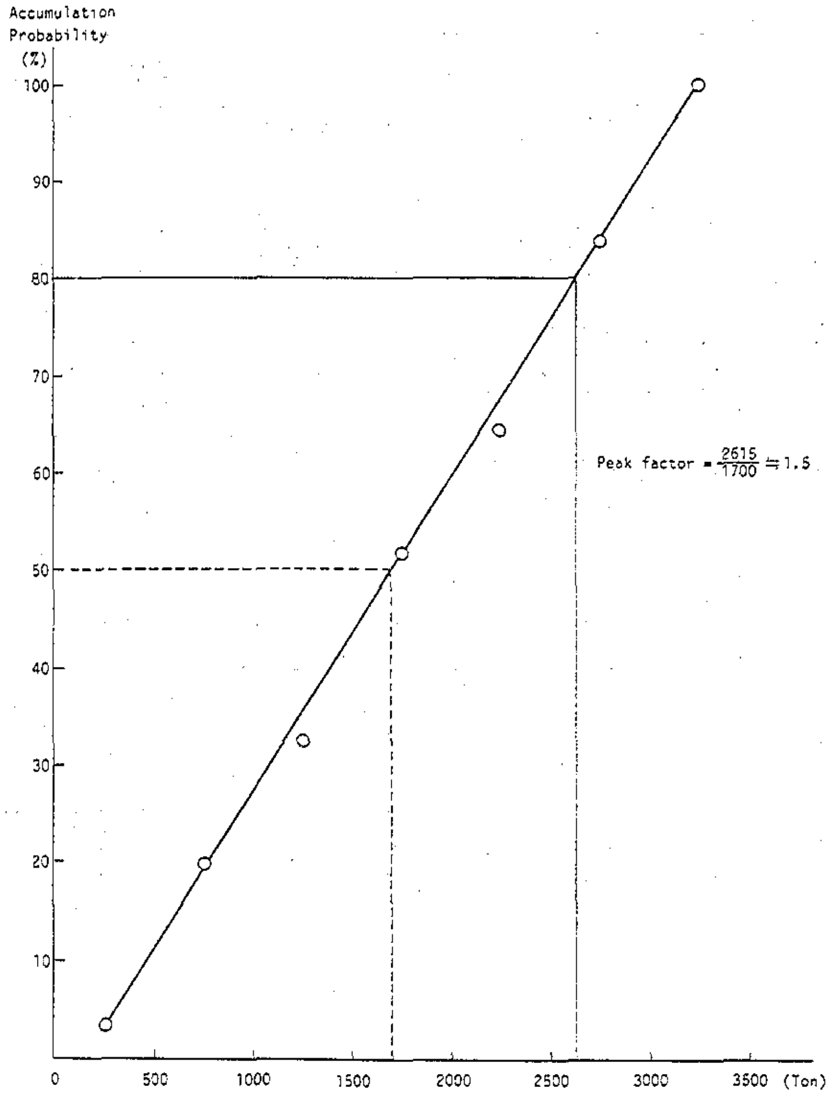


Fig. 6-5-11 Accumulation Curve fro Volume of Stocked Cargoes (Covered Storage)

Table 6-5-3 Relation between Required Area and Available Area

Storage	Required & Available Area	1988	1995	2000	2000
Covered Storage	Cargo throughput (Ton)	49,670	56,562	47,600	68,810
	Required Area (m^2)	2,227	2,596	1,653	4,187
	Available Area (m^2)	19,094	10,065	10,065	10,065
	(Balance of Area)(m^2)	16,867	7,469	8,412	5,878
Open Storage	Cargo throughput (Ton)	301,600	459,358	394,068	709,458
	Required Area (m^2)	23,904	40,285	39,174	61,465
	Available Area (m^2)	37,910	67,780	67,780	67,780
	(Balance of Area)(m^2)	14,006	27,495	28,606	6,315
Marshalling Yard	Cargo throughput (TEU)	147,882	236,464	246,065	348,524
	Required Area (m^2)	99,835	118,305	116,475	153,135
	Available Area (m^2)	87,425	76,954	76,954	76,954
	(Balance of Area)(m^2)	-12,410	-41,351	-39,521	-76,181
C F S	Cargo throughput (TEU)	6,308	10,329	9,979	12,041
	Required Area (m^2)	4,722	21,190	21,190	25,157
	Available Area (m^2)	4,722	0	0	0
	(Balance of Area)(m^2)	0	-21,190	-21,190	-25,157
Ground Service Area	Cargo throughput (TEU)	3,270	5,237	4,906	6,948
	Required Area (m^2)	4,892	7,854	7,339	10,394
	Available Area (m^2)	0	0	0	0
	(Balance of Area)(m^2)	-4,892	-7,854	-7,339	-10,394
Other Space	Required Area (m^2)	15,000	40,000	40,000	40,000
	Available Area (m^2)	15,000	15,000	15,000	15,000
	(Balance of Area)(m^2)	0	-25,000	-25,000	-25,000
Total Area	Required Area (m^2)	160,580	230,230	225,831	294,338
	Available Area (m^2)	174,151	169,799	169,799	169,799
	(Balance of Area)(m^2)	13,571	-60,431	-56,032	-124,539

*In case the new port is not functioning in 2000.

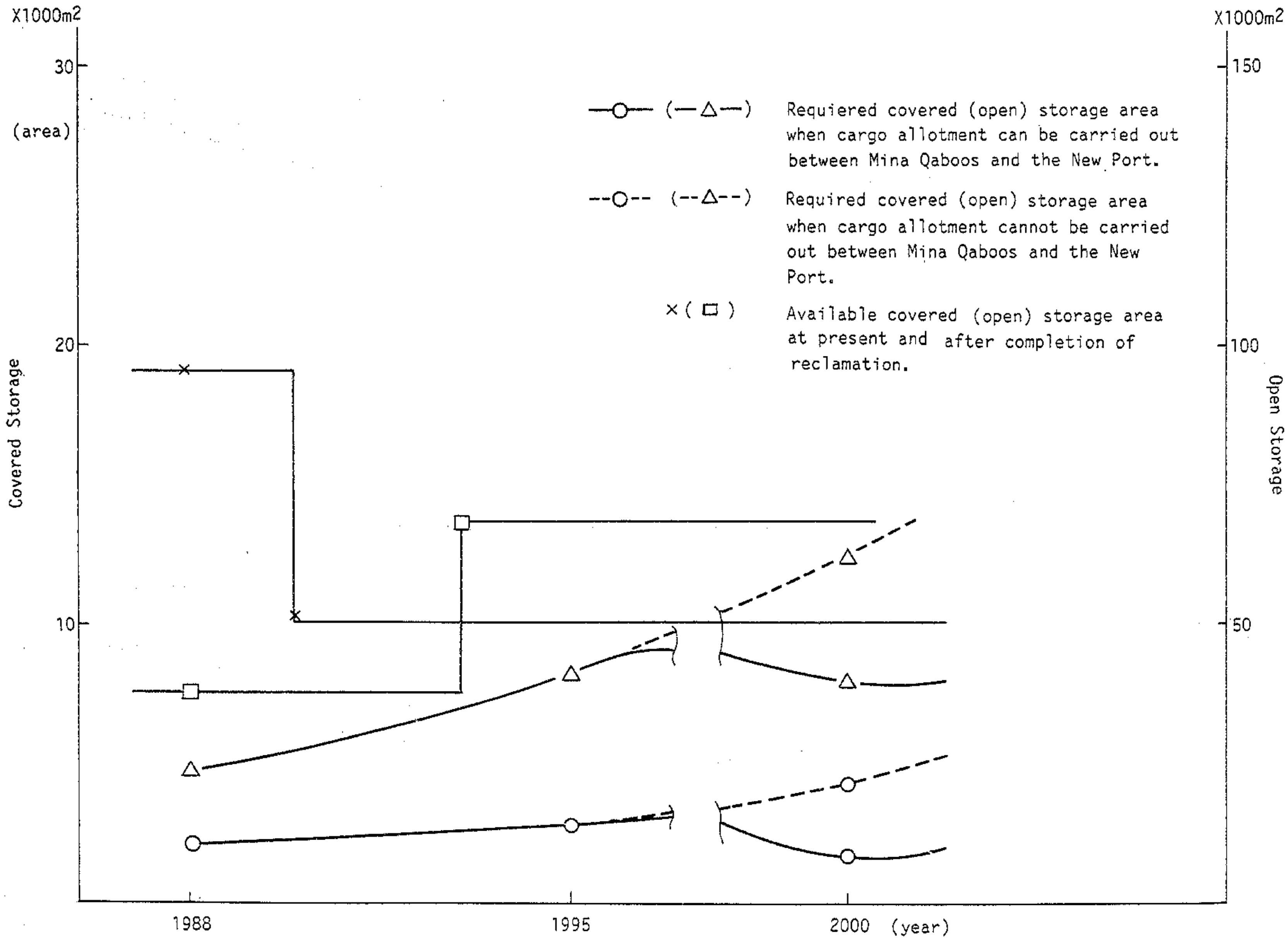


Fig. 6-5-12 Required and Available Storage Area (Covered Storage & Open Storage)

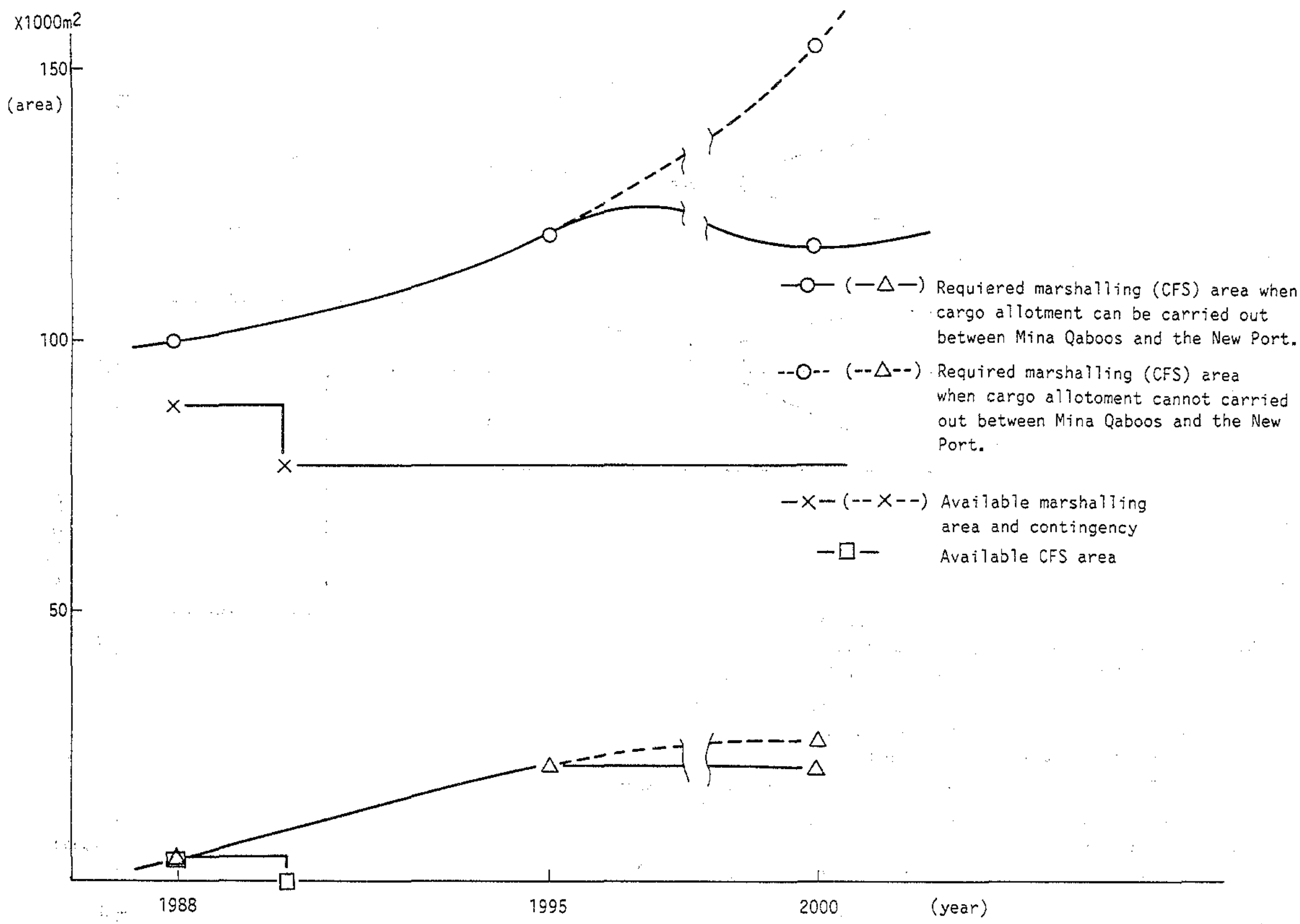


Fig. 6-5-13 Required and Available Storage Area (Container Storage)

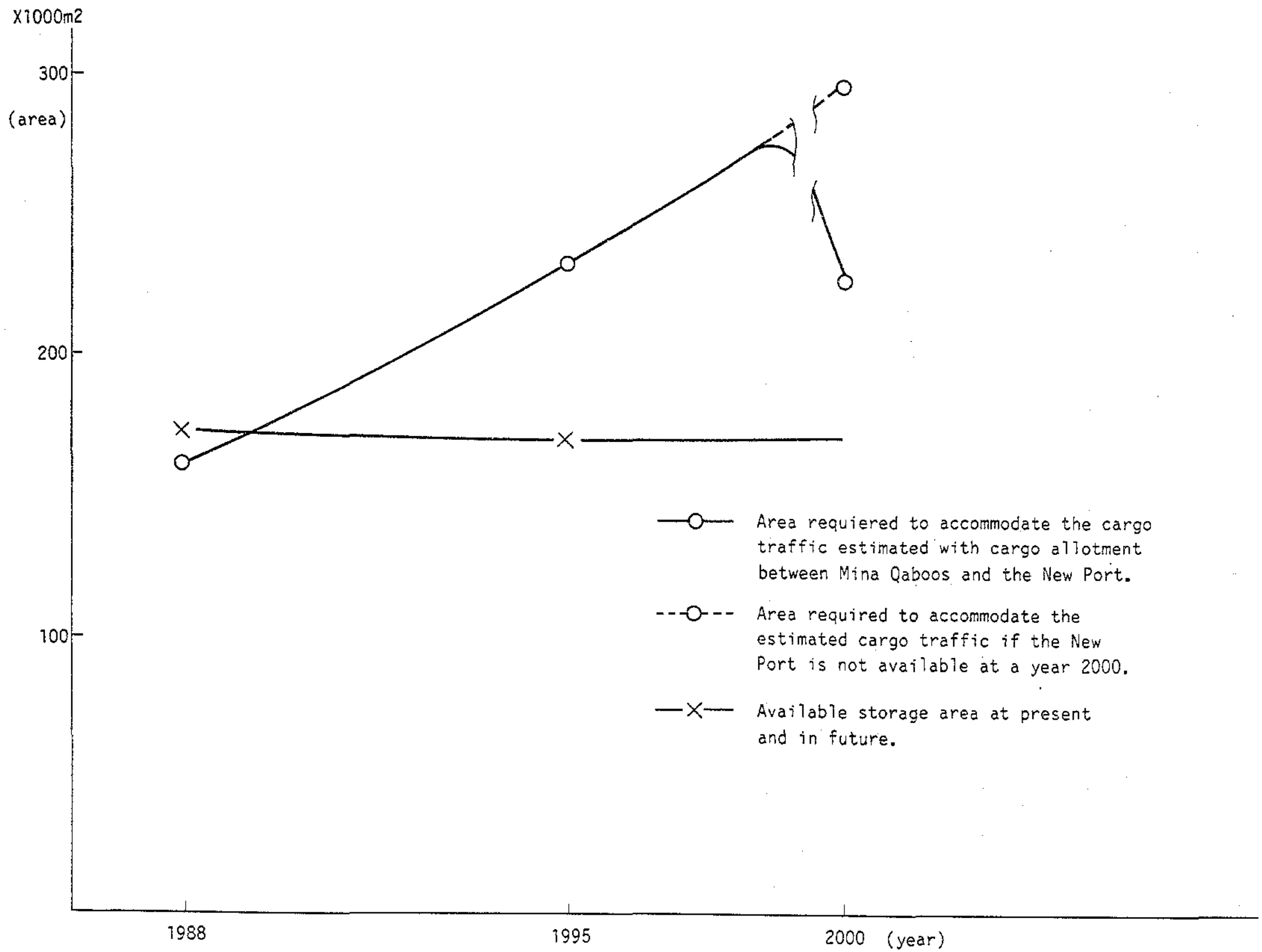


Fig. 6-5-14 Required and Available Storage Area (Total Area)

6.5.3 Reclamation of Shutaify Bay

As discussed in previous sections, 15 more hectares of land will be needed in order to accommodate future traffic demand by 2000. However it is impossible to find enough vacant space around Mina Qaboos presently. Therefore, the only feasible alternative is the reclamation of Shutaify Bay. The reclamation of Shutaify Bay has several favorable characteristics for the port fuctions of Mina Qaboos as follows:

(a) Shutaify Bay is a rather shallow bay, hence a large area of land can be obtained using a relatively small amount of reclaimed materials.

(b) Shutaify Bay is located very close to Mina Qaboos, so reclaimed area can be utilized in conjunction with other operations of Mina Qaboos.

(c) Shutaify Bay can be used as a disposal site for dredged materials, which will be generated by dredging work in this project.

6.6 Facility Plan

6.6.1 Cargoes and Calling Ships

6.6.1.1 Cargoes

The future cargoes expected at Mina Qaboos have already been discussed in 6.4. In 1995, all cargoes should be handled at Mina Qaboos, but in 2000 some cargoes will be allocated to the new port. Hence, Mina Qaboos will handle the following cargoes at each stage. The facility plan is to be formulated based upon these cargoes:

.1995	Container Cargoes	236,606 (TEUs)
	Other Cargoes	829,900 (Tons)
.2000	Container Cargoes	246,058 (TEUs)
	Other Cargoes	819,600 (Tons)

Details of other cargoes are shown in Table 6-4-5

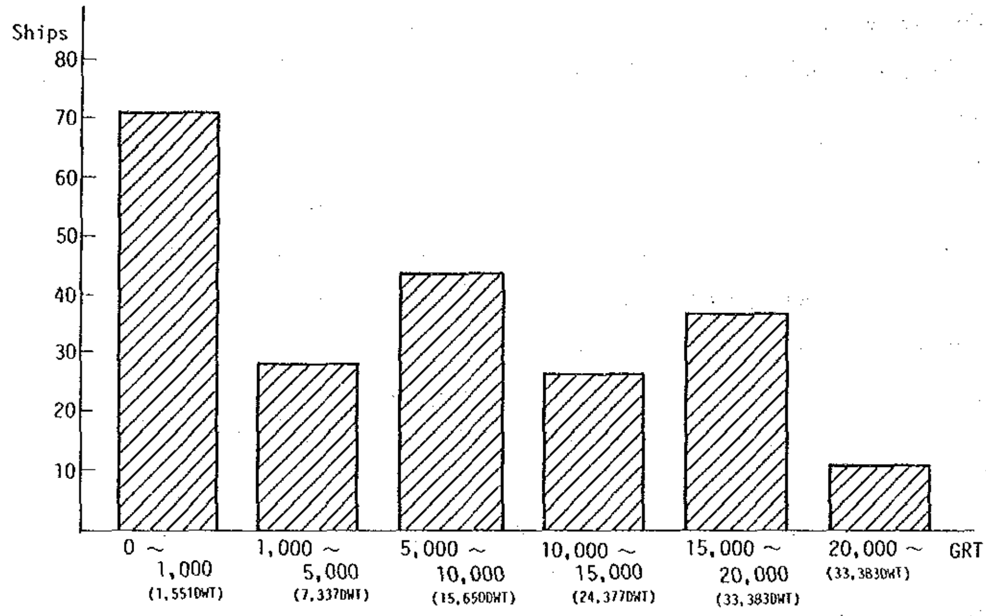
6.6.1.2 Calling Ships

(1) Conventional ships

Fig. 6-6-1 shows the distribution of conventional ships calling at Mina Qaboos in 1988. (The figures are shown in gross tonnage, while the figures in parentheses are in the dead weight tonnage equivalent to each gross tonnage figure.) As seen in this figure, while small ships (less than 1,000 G/T) have the largest ratio of all sizes of ships, bigger ships also have a large share (Ships of more than 20,000 G/T account for about one-third of all the ships.). Fig. 6-6-2 shows the breakdown of the ships, dividing them into those carrying steel, timber and other general cargo. It is apparent that steel and timber are carried by larger ships. Ships for timber and steel account for 76% of the ships of more than 15,000 G/T. Ships that carry other general cargo are generally much smaller.

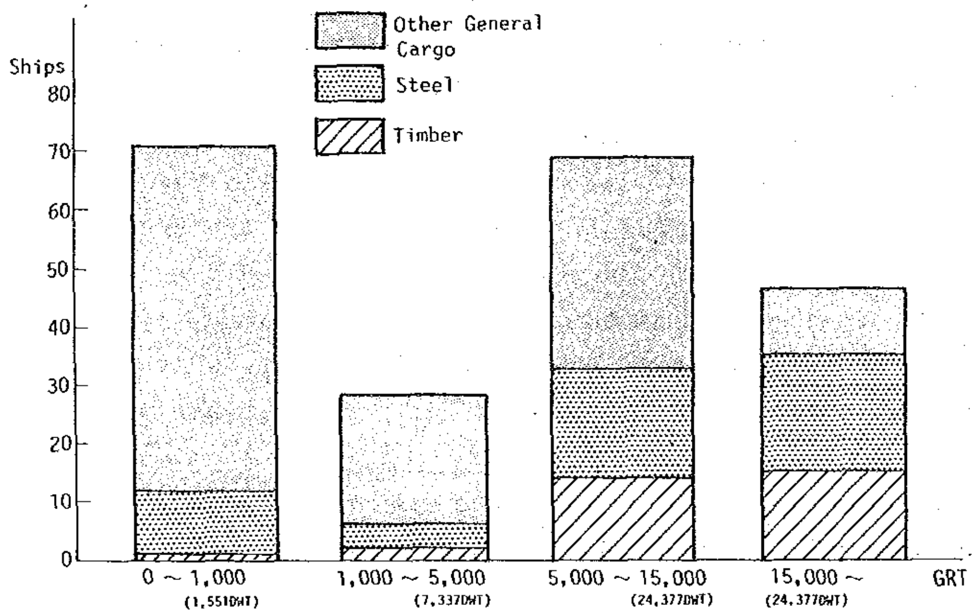
Fig. 6-6-3 and Fig. 6-6-4 show the distribution of conventional ships in the world and the number of ships by age for each size.

Compared with the world-wide trend, the ratio of larger ships at Mina Qaboos is at quite a high level already, and it is not likely that this ratio will rise in future. (Fig.6-6-4 shows that there is no tendency for conventional ships to become larger.) Therefore, in this study it is assumed that the distribution of conventional ships will not change by the year 2000.



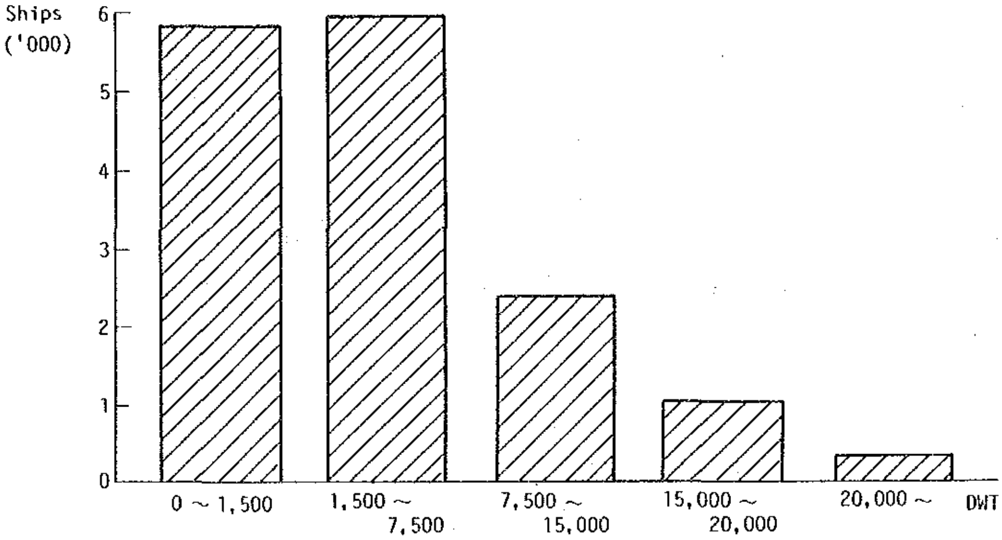
Source: The PSC

Fig. 6-6-1 Distribution of Conventional Ships at Mina Qaboos (1988)



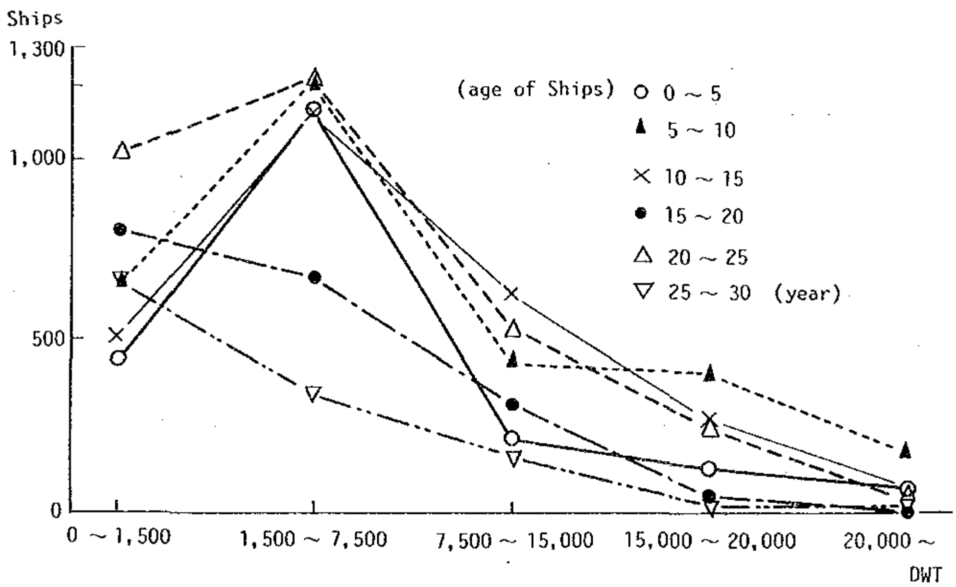
Source: The PSC

Fig. 6-6-2 Breakdown of Conventional Ships at Mina Qaboos (1988)



Source: The Port and Harbour Research Institute, Ministry of Transport, Japan

Fig. 6-6-3 Distribution of Conventional Ships in the World



Source: The Port and Harbour Research Institute, Ministry of Transport, Japan

Fig. 6-6-4 Conventional Ships in the World by Age

(2) Container Ships

Fig. 6-6-5 shows the distribution of full container ships calling at Mina Qaboos in 1988. (The figures are shown in gross tonnage, while the figures in parentheses are in the dead weight tonnage equivalent to each gross tonnage figure.) This Figure shows that while small ships of less than10,000 G/T, most of which seem to be feeder ships in the Gulf region, account for the largest share in terms of numbers, bigger ships of more than 30,000 G/T account for nearly 20%.

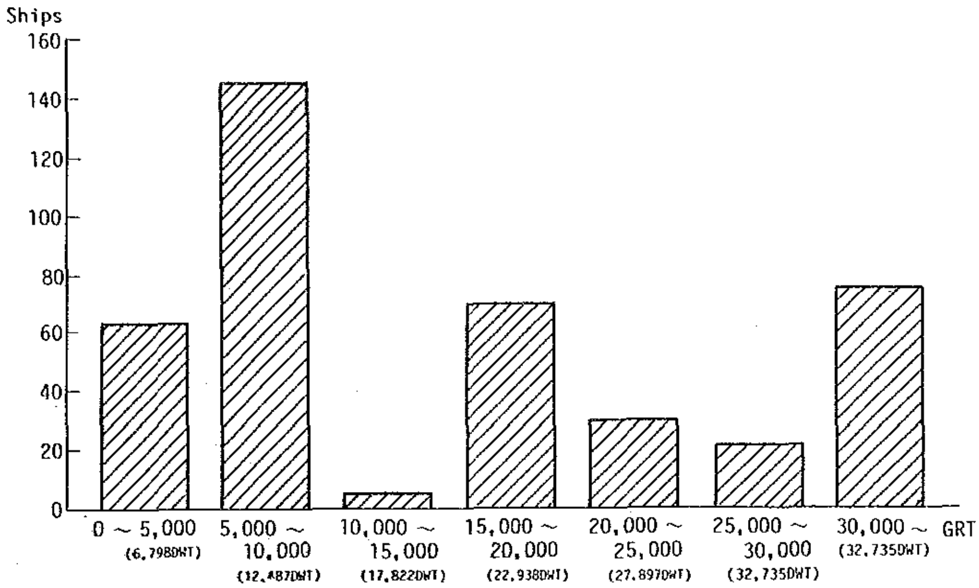
Figs. 6-6-6 and 6-6-7 show the distribution of full container ships in the world and the number of ships by age for each size.

World-wide, the ratio of larger ships of more than 30,000 DWT is quite high and it is remarkable that the construction of this size of ships has made tremendous progress in the last decade. However, as mentioned in Chapter 1, the largest ships are deployed exclusively on routes such as those in the Far East, North America and Europe, while the second-biggest type of ships are deployed on the Middle Eastern route. Therefore, in this Study it is assumed that the distribution of full container ships in terms of DWT or TEU will not change by the year 2000, although their length and draft may become larger after the physical problems of Mina Qaboos are solved.

(3) Other Ships

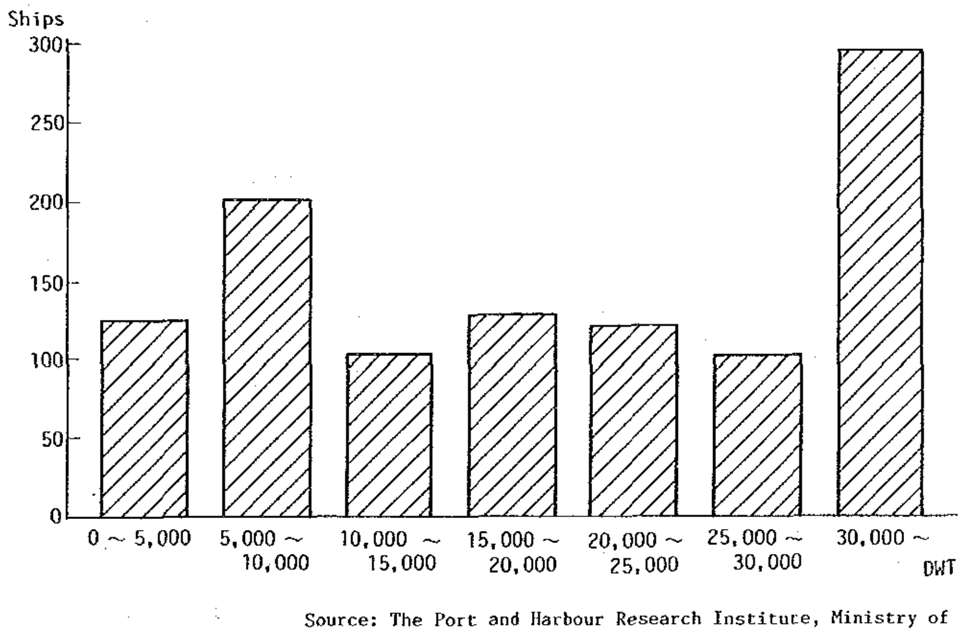
Figs. 6-6-8 to 6-6-10 show the distribution of bulk grain carrier ships, RO/RO ships and livestock carrier ships, respectively, calling at Mina Qaboos in 1988.

In this Study, it is assumed that the distribution of these ships will not change in the future.



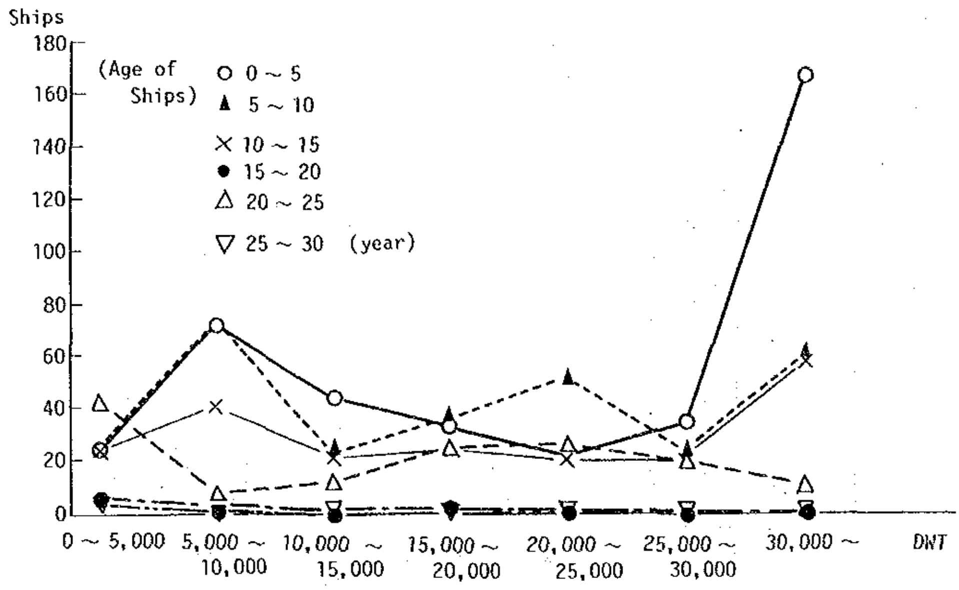
Source: The PSC

Fig. 6-6-5 Distribution of Full Container Ships at Mina Qaboos (1988)



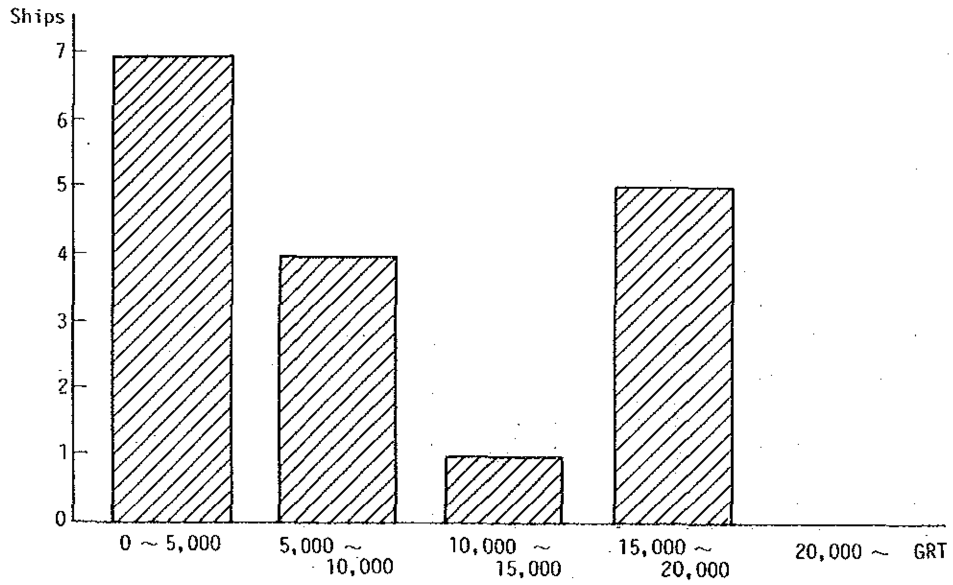
Source: The Port and Harbour Research Institute, Ministry of Transport, Japan

Fig. 6-6-6 Distribution of Full Container Ships in the World



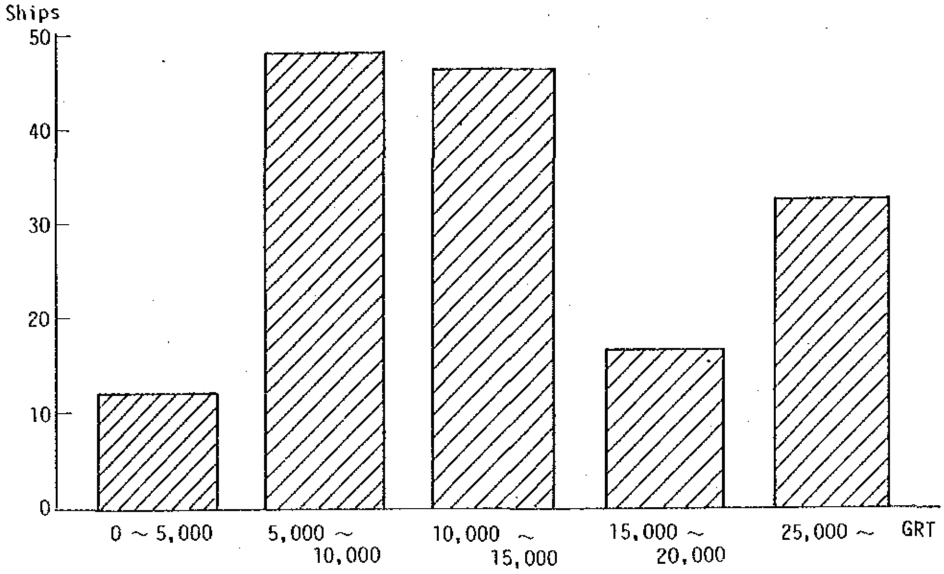
Source: The Port and Harbour Research Institute, Ministry of Transport, Japan

Fig. 6-6-7 Full Container Ships in the World by Age



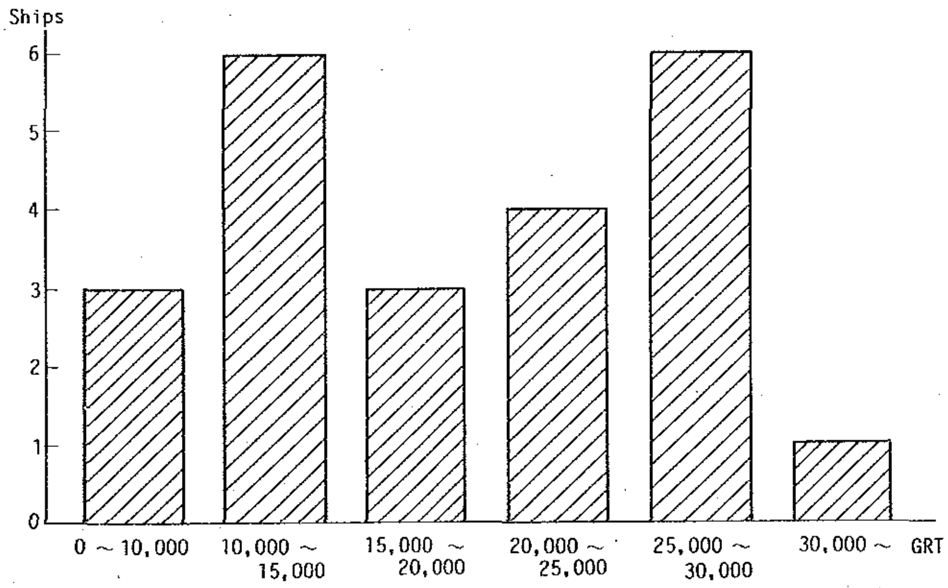
Source: The PSC

Fig. 6-6-8 Distribution of Grain Carrier Ships at Mina Qaboos (1988)



Source: The PSC

Fig. 6-6-9 Distribution of RO/RO Ships at Mina Qaboos (1988)



Source: The PSC

Fig. 6-6-10 Distribution of Livestock Carrier Ships at Mina Qaboos (1988)

6.6.2 Traffic Flow in Port Land Area

The road alignment in Mina Qaboos is shown in Fig. 6-6-11. The principal features of this road alignment are as follows:

(a) One-way traffic is used as much as possible for smooth traffic flow.

(b) Three traffic gates are provided. The center gate is the main gate for cargo trucks. The southern gate is to be used by non-cargo traffic, and the northern gate, which leads to a mountain road, is to be used by trucks which transport LCL cargoes to/from CFS at Shutaify Bay and by vehicles imported and stocked at Shutaify Bay.

(c) A new round-about is provided to connect the existing port area with Shutaify Bay yard.

(d) To be discussed later, multipurpose berths are connected with Shutaify Bay by container chassis. Hence these areas are connected with trunk roads with two lanes for one way.

(e) For the efficient use of the space behind Berth No.3, the road alignment is set parallel to the length of Berth No.3.

6.6.3 Water Basin

The required dimension of dredging for channel, turning basin and slips are shown in Fig.6-6-12. The reasons for the requirement of each dredging operation are as follows:

6.6.3.1 Dredging to -13m Depth

As discussed in previous chapter, Mina Qaboos has suffered from insufficient depth. For container services especially, a regular time schedule is always expected. Therefore it is very difficult to compete *with neighboring large ports without an increase in available depth in the* port. As shown in Table 3-1-1, the Maximum declared depth of Mina Qaboos is only 10.4m. However, Fig.1-2-6 shows about 40% of the container ships that call at Mina Qaboos have maximum drafts of more than 11.0 meters. According to the 1988 statistics, the maximum arrival draft was 10.7 meters. This means some ships used tides to call at Mina Qaboos. Taking

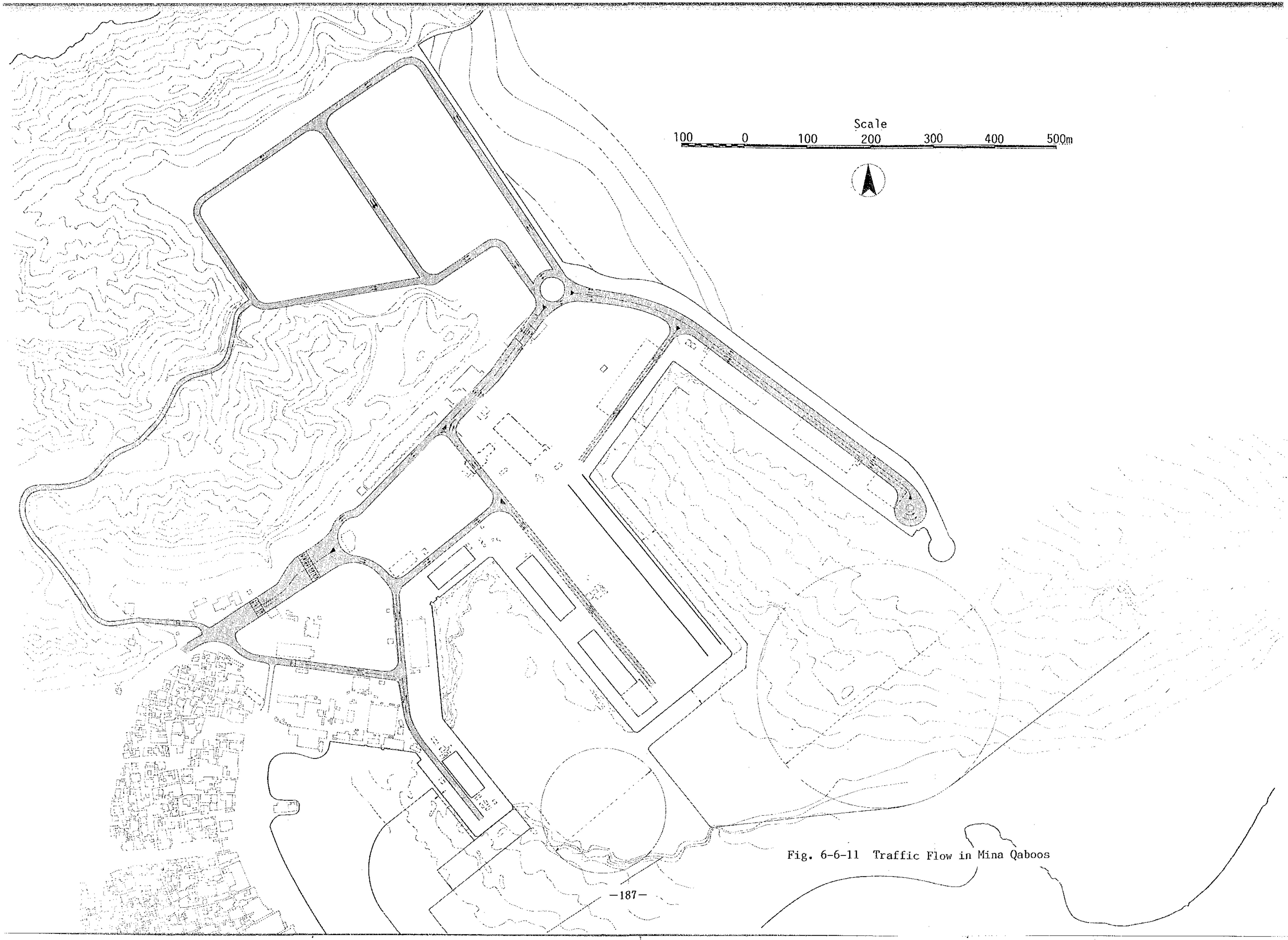


Fig. 6-6-11 Traffic Flow in Mina Qaboos

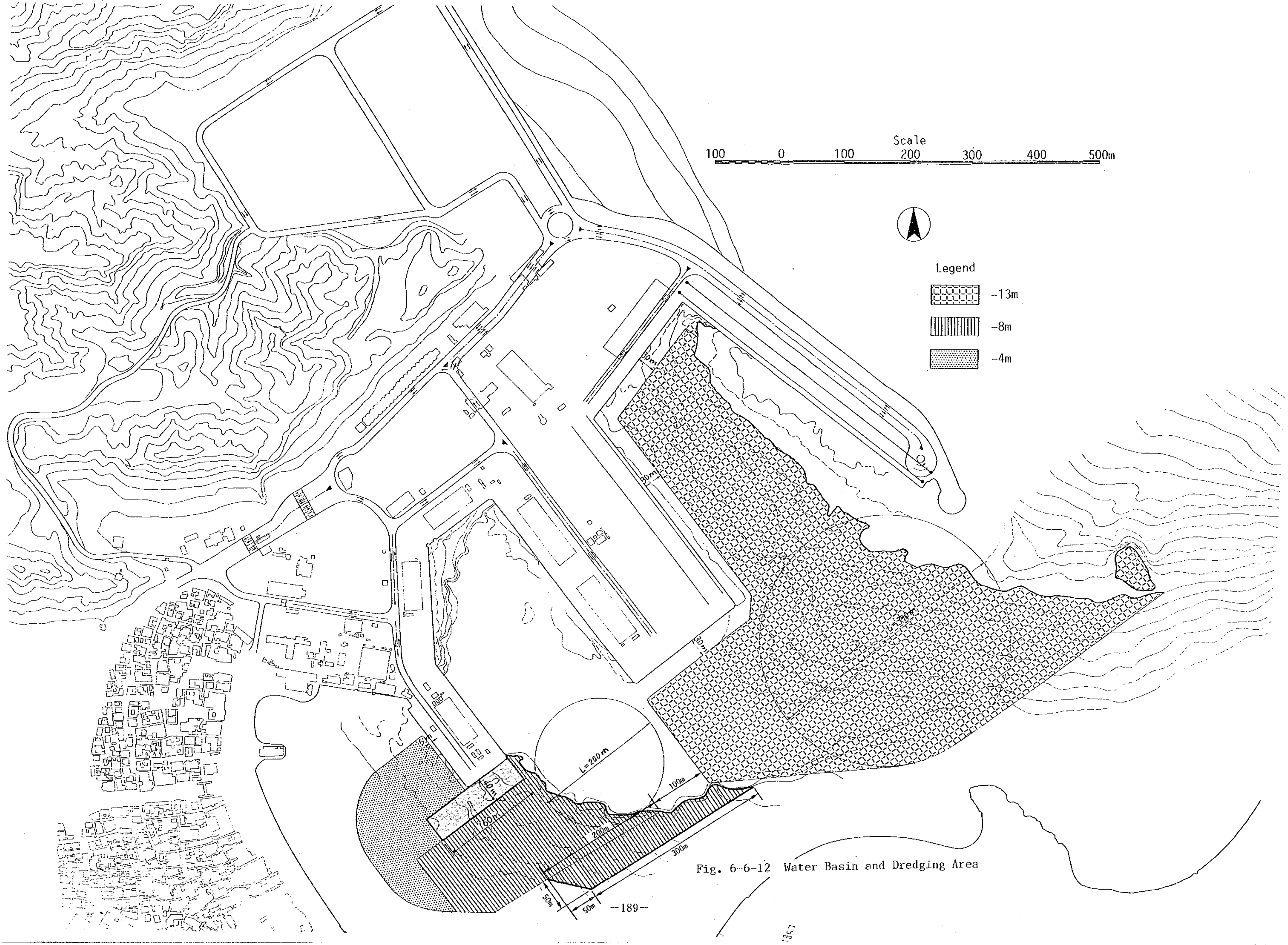


Fig. 6-6-12 Water Basin and Dredging Area

account of these circumstances, a depth, that allows these ships to call at Mina Qaboos without any draft constraint should be developed. And also in order to remain as an attractive container port to clients, its depth should be increased to an extent that allows second-generation container ships to call at Mina Qaboos without any constraints. Generally speaking, it is almost impossible to deepen the existing berth-side depth without major improvement work. However in the case of Berth Nos.1, 1A and2, there is already -13 meters depth. Hence it is possible to use these berths as -13m depth berths without any major improvement work. Given -13m depth, ships with -11.5m draft, which corresponds to the draft of second generation container ships, can call at Mina Qaboos without any constraints. Given the reasons stated above, the depth of the channel, turning basin and slips should be dredged up to -13 meters.

The areas to be dredged to -13m are shown in Fig.6-6-12. Turning basin is dredged in order to accommodate ships with a maximum length of 260 meters. Fig.1-2-7 shows that the portion of more than 230m length in Dubai is much larger than that at Mina Qaboos. This means the length constraint at Mina Qaboos is serious. According to the data on calling ships to these ports, there is only one ship whose length is more than 260m (see Appendix). Hence with this dredging, Mina Qaboos will no longer be limited in terms of turning basin area.

6.6.3.2 Dredging of Water Basin for Royal Yachts

As discussed in the following section, a new berth will be built next to existing Berth No.12 berth to accommodate the Royal Support Yacht with a draft of -6m, and the Royal Dhow, with a draft of -3.5m. In order to accommodate these yachts, the water basins should be dredged to -8m and -4m, respectively. The areas to be dredged are shown in Fig.6-6-12.

6.6.4 Container berth

6.6.4.1 Layout Alternatives

With a view to laying out the container yard behind berth No.3 and in the center pier effectively, we have studdied the merits and demerits of three plans as illustrated in Fig. 6-6-13(a)-(c) regarding the following items:

(1) The number of ground spots
(2) Maximum Container throughput to be stowed annually
(3) Eassiness to identify stacked containers by handling mode
(4) Safety of transportation in the marshalling yard
(5) Simplicity of transportation in the marshalling yard
(6) Average running distance per cycle
(7) Accessibility or inter-changeability to and from main roads in the port area
(8) The number of transfer cranes
(9) Construction cost of marshalling yard

The three plans have been studied on the basis of a transfer crane system. The marshalling yard studied here is for Berths No.4 and No.5 and the one for Berths No.1 and No.2 is to be constructed in the reclaimed land in Shutaify Bay which will be dealt in 6.6.5.4.

(1) The number of ground spots

This shows the number of the containers stored on the ground without taking into account the tier of the stowage. There is 10% difference between the maximum plan B and minimum plan C. The minimum plan C, however, will comply with the volume estimated to be handled in 2000. In both A & B plans, there is some margin in the number of ground spots, which shows the flexibility of capacity at the peak handling time.

(2) Maximum volume of cargo to be handled annually

This will be estimated taking into account the number of tiers and rotation of the container yard annually, and also the allowable maximum container throughput is considered. Result is maximum in plan B and minimum in plan C.

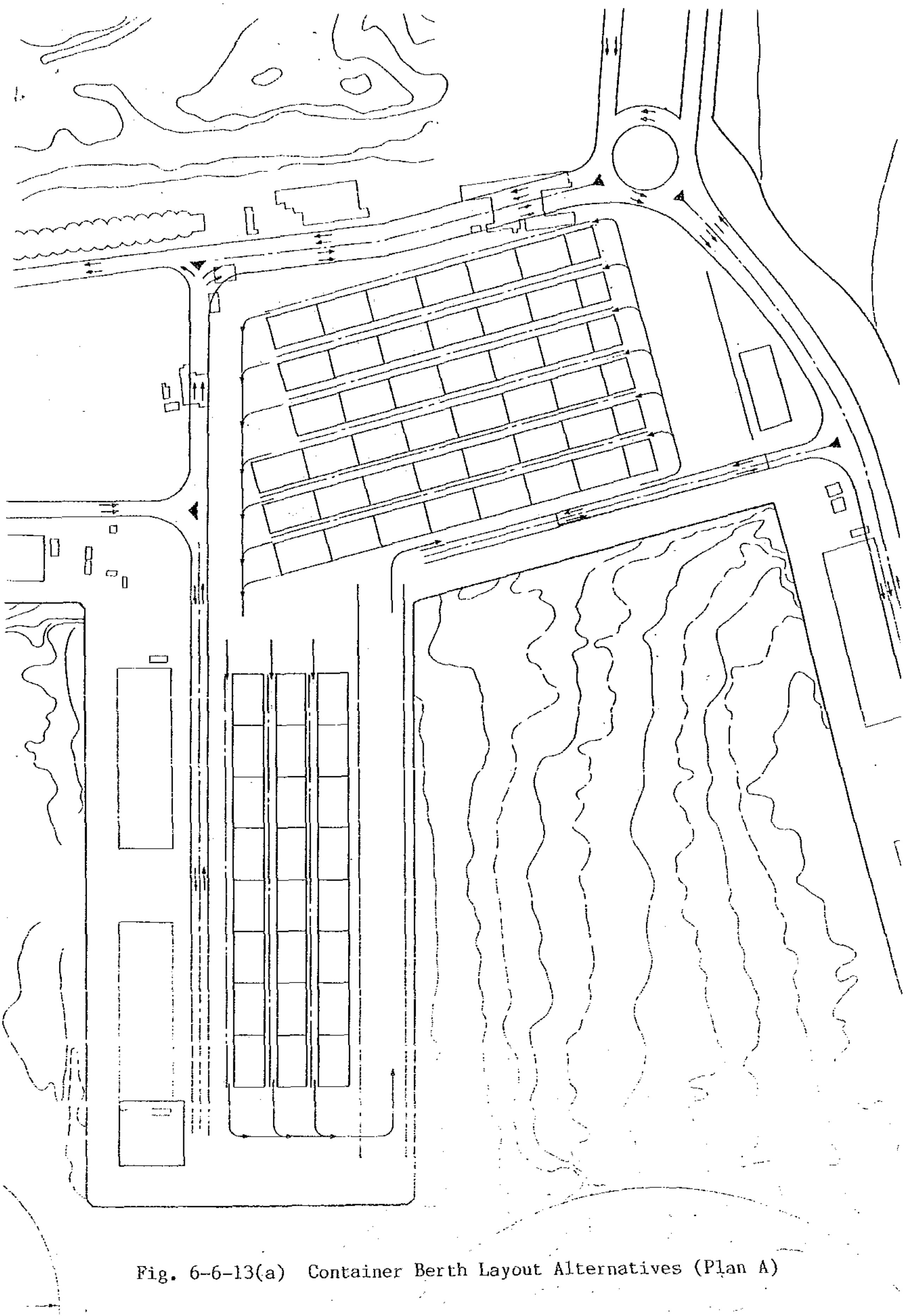


Fig. 6-6-13(a) Container Berth Layout Alternatives (Plan A)

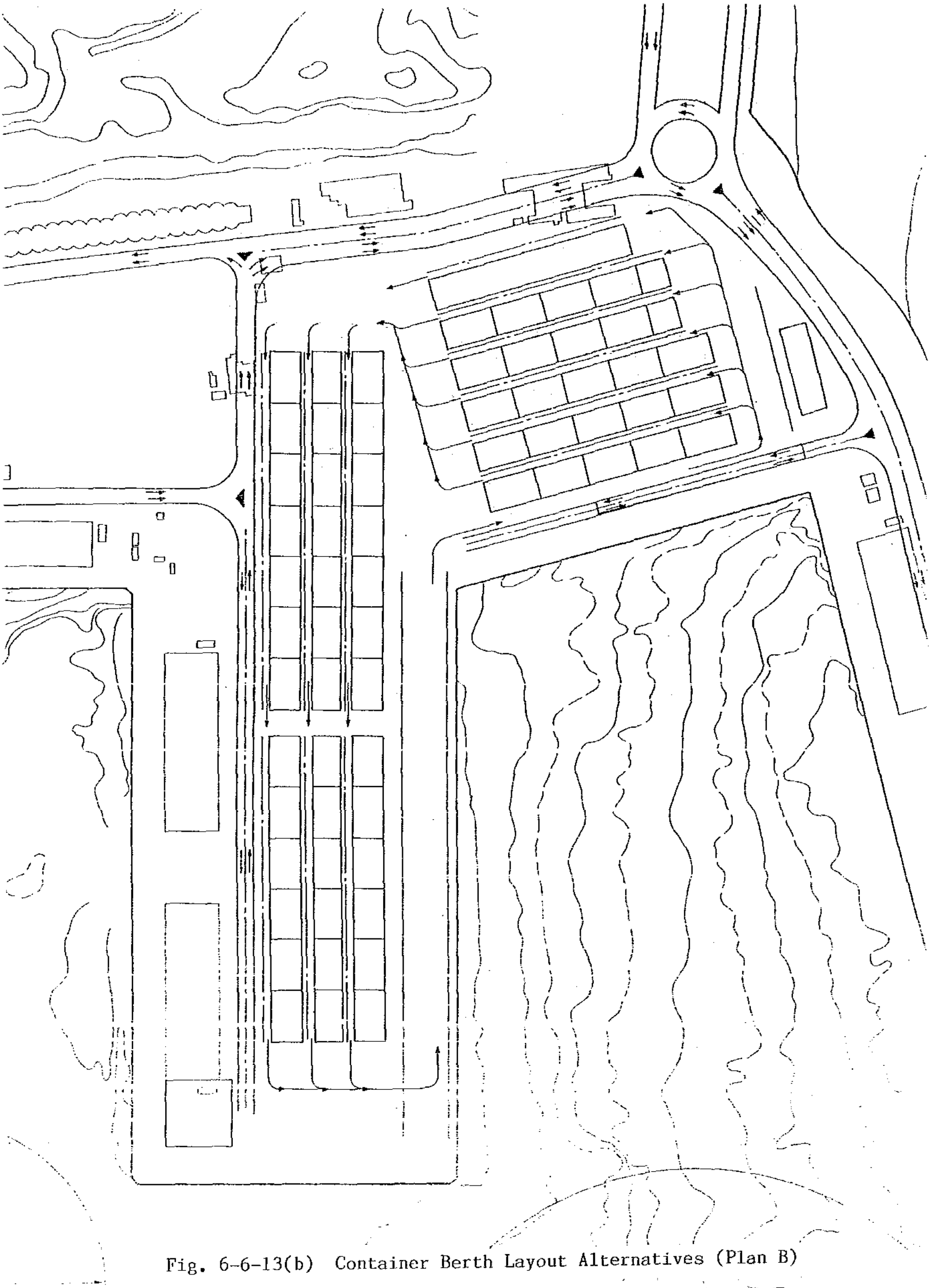


Fig. 6-6-13(b) Container Berth Layout Alternatives (Plan B)

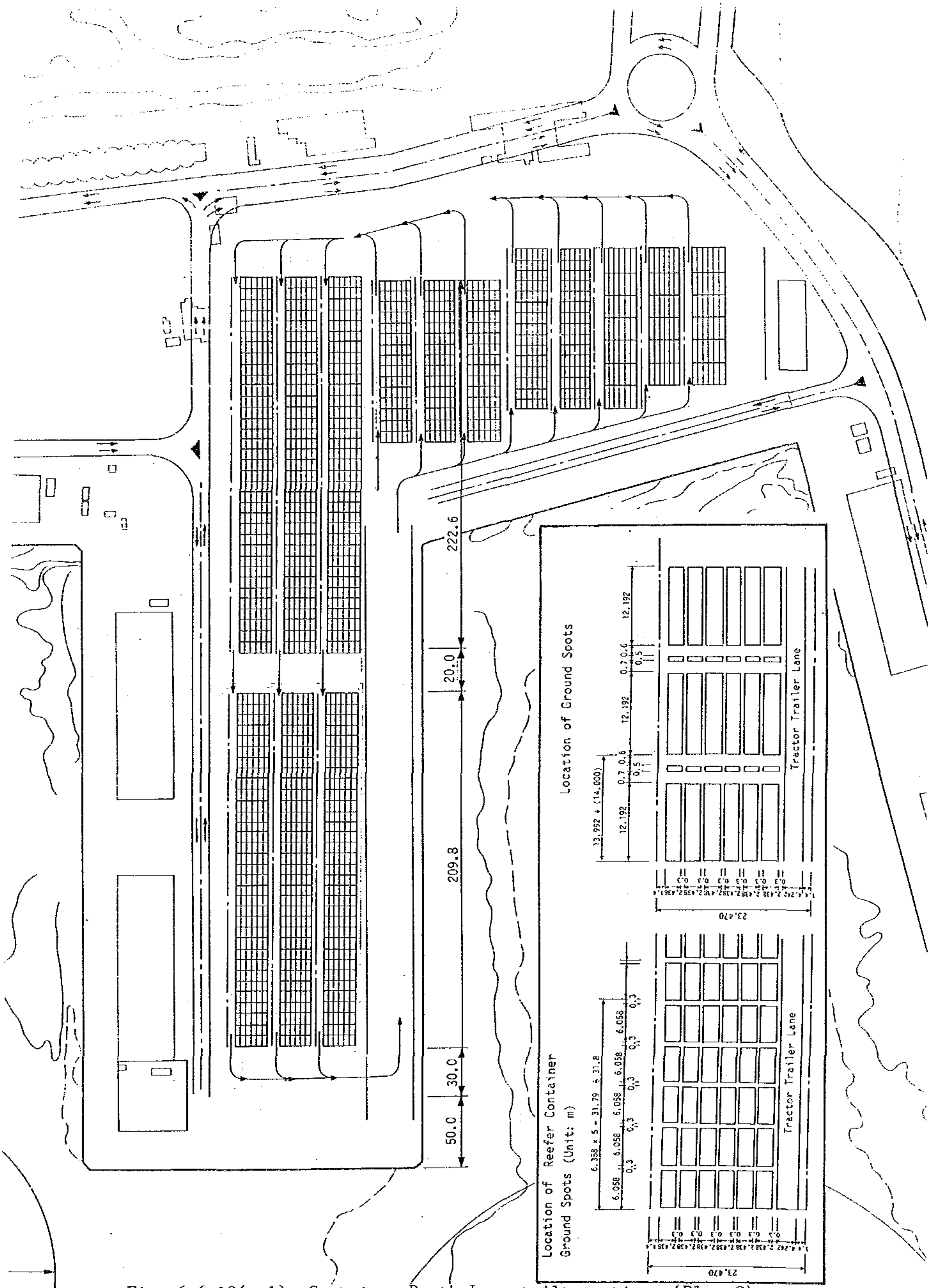


Fig. 6-6-13(c-1) Container Berth Layout Alternatives (Plan C)

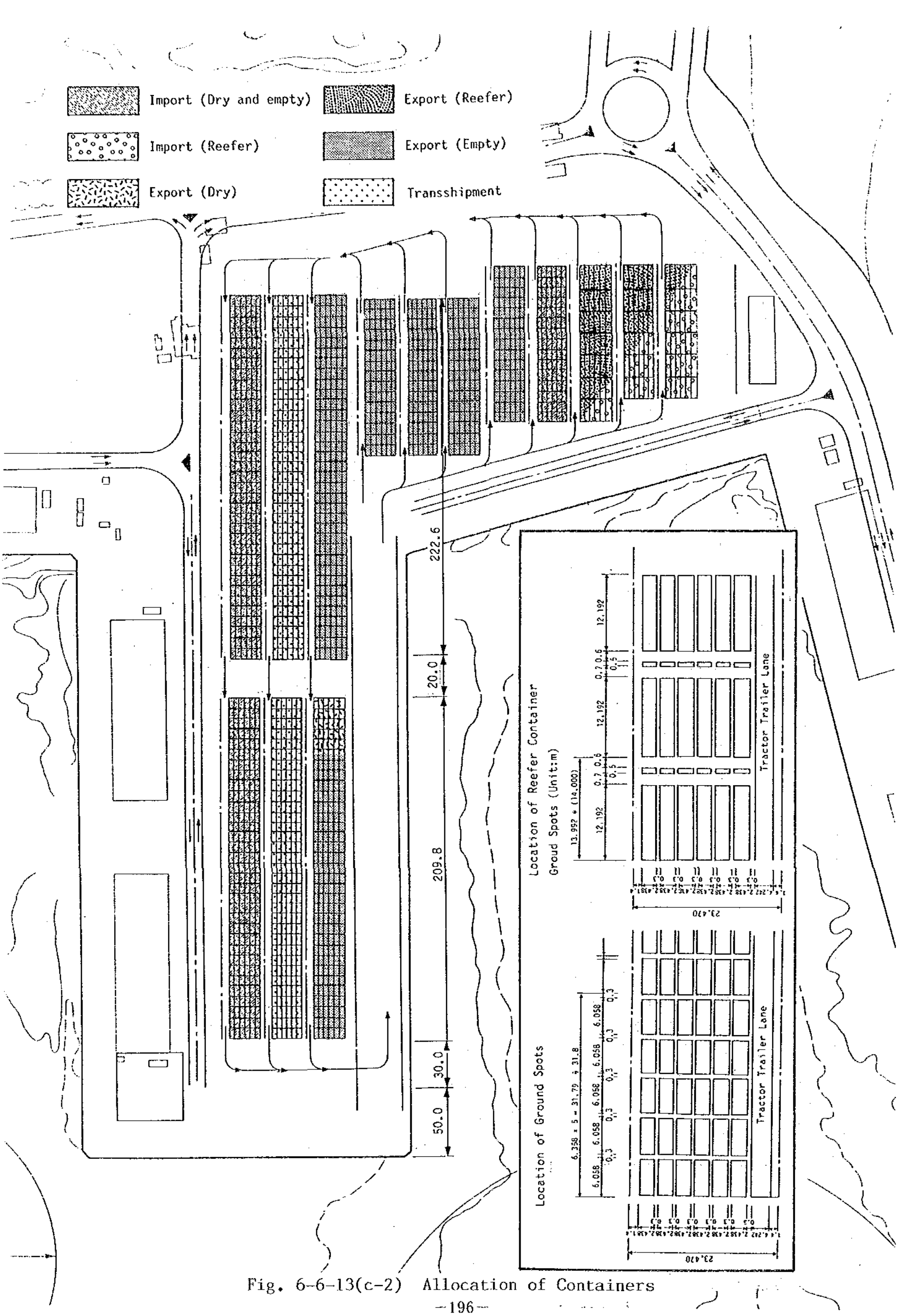


Fig. 6-6-13(c-2) Allocation of Containers

(3) Easiness to identify stacked container by handling mode

An analysis has been made for evaluate capability to identify features of stacked containers, i.e. for export or import transshipment, or loaded or empty. And in analyzing consideration should be made whether instruction can easily be conveyed to container-trailer drivers from outside.

(4) Transportation safety in the marshalling yard

Plan C is considered to be the best for safety, followed by B and A, since by the layout of plan C containers are shifted with fewer turns from the container stack to the crane.

(5) Simplicity

Plan C is considered to be the best, since all containers are stowed in the same direction, which facilitates handling, in case of plan A and plan B, some containers are stowed at a right angle to others.

(6) Average running distance per cycle

Plan A is considered to be the best in terms of average running distance required to carry containers between the stack and the container crane. This plan enables operators to handle containers by fewer tractor-trailers and to work promptly at peak handling times.

(7) Effectiveness of delivery

Effectiveness of delivery depends upon the accessibility or interchangeability of the road in the marshalling yard with the general road in the surrounding port area. Plan A and plan C are better than plan B in this regard.

(8) The number of transfer cranes

This matter has been studies from the viewpoint as to how many transfer cranes should be prepared in total. According to plan C, containers in each stack are stowed in the same direction but in plan A and plan B, they are stowed in two directions, as mentioned in (5). Therefore, transfer cranes deployed in one stacking group cannot be available for another stacking group due to their function. Consequently, the number of transfer cranes needed in plan A and plan B is more than one unit compared to plan C.

(9) Construction cost

There is no great difference in construction cost.

Based on the aforementioned studies, plan C is concluded to be the best yard layout behind No.3, No.4 and No.5 berths. A summary of the comparison is shown in Table 6-6-1. Economically, plan C is considered to be the best despite the fact that plan C is in lesser possition in terms of numbers of stored in ground; there will be no difference between plan A and plan B.

Table 6-6-1 Comparison of yard layout

	Plan(A)	Plan(B)	Plan(C)
(1) Number of ground spots	1884	1914	1782
(2) Maximum container throughput to be stowed annually	B	A	C
(3) Easiness to identify features of stacked containers by handling mode	C	B	A
(4) Safety of transportation in the marshalling yard	C	B	A
(5) Simplicity of transportation in the marshalling yard	B	B	A
(6) Average running distance per cycle	A	C	B
(7) Accesibility or inter-changiability to and from main roads in the port area	A	B	A
(8) The number of transfer cranes	B	B	A
(9) Construction cost of mershalling yard	B	B	A
Total evaluation	B	B	A

6.6.4.2 Allocation of Container Stacks

(1) Number of containers to be stored

On the basis of demand forecast and berth capacity as well as cargo allocation between Mina Qaboos and the New Port, we have estimated the number of containers, by handling modes, stored in the container yards to be constructed behind Berths Nos.3, 4 & 5 and on land reclaimed from Shutaify Bay. Fig. 6-6-14 shows the procedure of allocation of container stacks and a summary of these numbers is shown in Table 6-6-2.

Table 6-6-2 Summary of Numbers of Container Stacks

	1995		2000		2000*	
	No.1/2	No.4/5	No.1/2	No.4/5	No.1/2	No.4/5
Import(Dry)	17495	31417	17146	27687	24286	39216
Import(Reefer)	1817	3263	2195	3545	3109	5021
Export(dry)	2423	4350	2567	4145	3636	5870
Export(Reefer)	1116	2003	1443	2330	2044	3300
Export(empty)	15774	28326	15332	24757	21716	35066
Transshipment	23011	41320	27712	44747	39251	63379
Total	61635	110680	66396	107211	94042	151852

Note: *is shown the estimated number of containers unless allocation between Mina Qaboos and the New Port is performed as expected.

6.6.4.3 Marshalling Yard behind Berths Nos.3, 4 & 5

(1) Required slots and Storage capacity

This marshalling yard is utilized exclusively for the containers handled at Berths Nos.4 & 5. In this yard, there are three lines of reefer container stacks with 36 ground spots (G.S.) each, five lines of stacks with 90 G.S. each, three lines of stacks with 210 G.S. each, and three lines of stacks with 198 G.S. each. Reefer stacks are designed for 40-foot containers of stacked two containers high and a total of 216 plugs are to be provided, enabling storage of 432 TEU max. Table 6-6-3 shows the annual volume estimated to be handled in 1995 and 2000 at Berths Nos.4 and No.5, and the ground spots in the marshalling yard corresponding thereto:

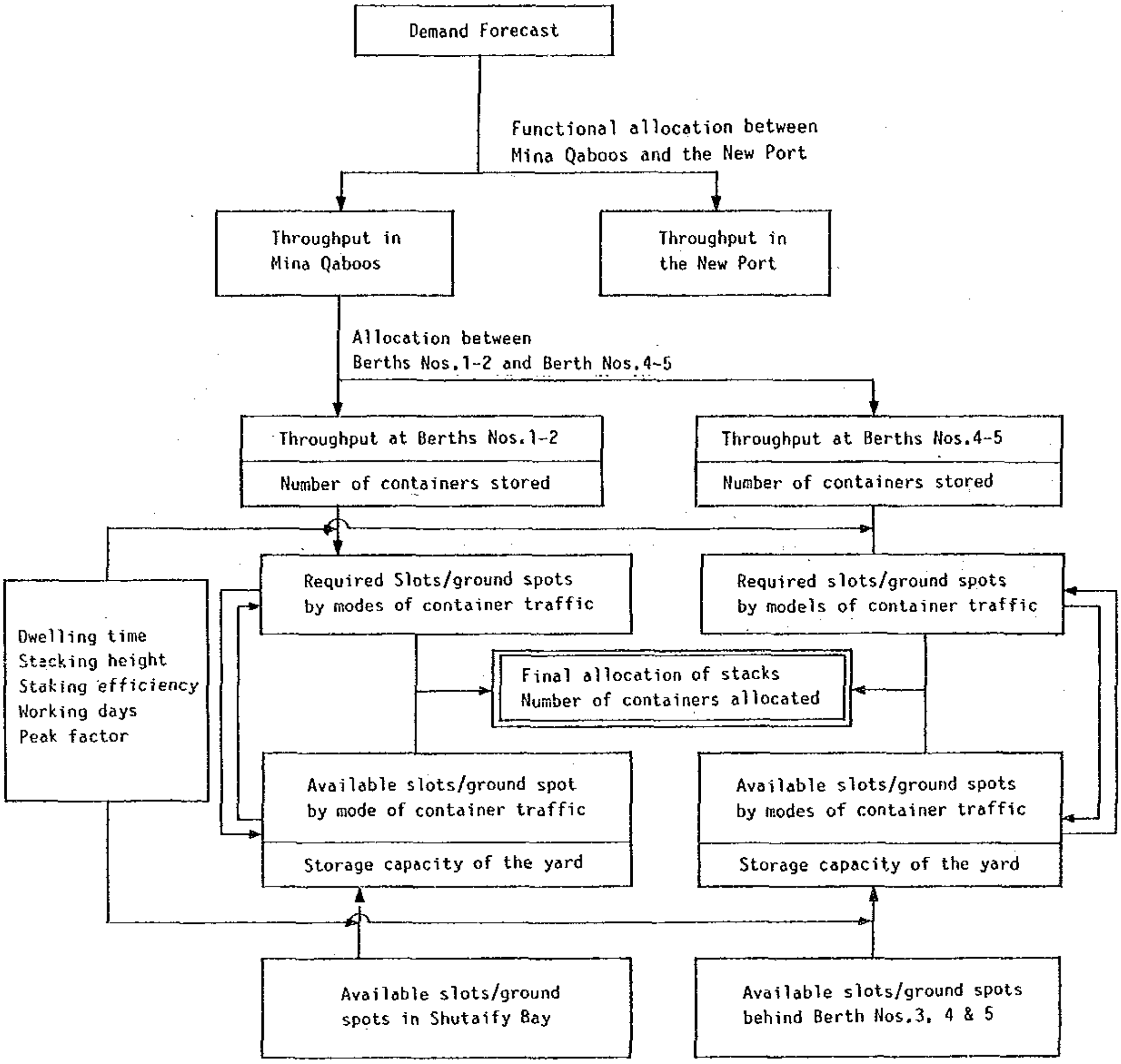


Fig. 6-6-14 Allocation of Container Stacks

Table 6-6-3 Storage Capacity of Berths Nos.4 & 5

Unit:TEUs

	storage capacity	required capacity 1995	balance 1995	additional g.spot
import	33969	31417	2552	37
export (e)	35220	28326	6894	174
export (1)	4291	4350	-59	0
reefer E&I	4505	5266	-761	-19
transship	49332	41320	8012	66
sum	127316	110679		257

	storage capacity	required capacity 2000	balance 2000	additional g.spot
import	33969	27687	6282	92
export(e)	35220	24757	10463	263
export(1)	4291	4145	146	1
reefer E&I	4505	5875	-1370	-35
transship	49332	44747	4585	38
sum	127316	107211		360

From the above data, it is clear that the ground spots for reefer containers are somewhat insufficient, but the relevant stacks are for 40 footers and have two times the capacity, if converted to TEU. Besides, there is some margin for reefer containers in the marshalling yard in Shutaify Bay and at the peak, stacking efficiency can be raised, since it was calculated on the basis of 75 % of the peak. It should be noted that other modes of containers can be handled with enough space left over.

(2) *Allocation of container stacks*

The number of ground spots allocated for each container handlig mode is worked out taking into consideration such factors as dwelling time, stacking height, stacking efficiency, annual working days and peak factors. These have been minutely investigated. Allocation for each handling mode is shown in Table 6-6-4. Following the above, Table 6-6-5 together with a brief explanation on each function stack is provided.

Table 6-6-4 Allocation of Container Stacks

No.of stack	application	g.spot	dwell time(day)	stack high	efficiency	peak fact.	serv. day(day)	throughput
1,2,3	reefer E&I	108	10.0	2.0	0.80	1.4	365.0	4505
4	export(e)	90	21.0	4.0	0.80	1.4	365.0	3576
5	export(e)	90	21.0	4.0	0.80	1.4	365.0	3576
6	export(e)	90	21.0	4.0	0.80	1.4	365.0	3576
7	export(e)	90	21.0	4.0	0.80	1.4	365.0	3576
8	import	90	8.6	3.0	0.75	1.4	365.0	6139
9	export(e)	210	21.0	4.0	0.80	1.4	365.0	8343
10	transship	210	6.9	4.0	0.80	1.4	365.0	25391
11	import	210	8.6	3.0	0.75	1.4	365.0	14324
12	export(e)	162	21.0	4.0	0.80	1.4	365.0	6436
13	transship	198	6.9	4.0	0.80	1.4	365.0	23940
14	import	198	8.6	3.0	0.75	1.4	365.0	13506
12	export(1)	36	7.0	4.0	0.80	1.4	365.0	4291
sum		1782						121177

Note: (e) denotes empty containers, and (1) denotes loaded containers.

Table 6-6-5 Function of Stack Yard

No. of stack	No. of G.S.	Application
No.1, 2 & 3	108(36x3)	All the import and export reefer containers to be stacked
No.4, 5,6 & 7	360(90x4)	Export empty containers to be stacked
No. 8	90	Import containers to be stacked
No. 9	210	Empty export containers to be stacked
No.10	210	Transshipment containers to be stacked
No.11	210	Import containers to be stacked
No.12	162	Empty export containers to be stacked
	36	Loaded export containers to be stacked
No.13	198	Transshipment containers to be stacked
No.14	198	Import containers to be stacked

6.6.4.4 Layout of Container Yard

The layout of container yard behind Berth Nos.3, 4 and 5 is shown in Fig. 6-6-13(c-1), 6-6-13(c-2), 6-6-15, 6-6-16. There are six long stacks behind berths Nos.4 and 5 and eight short stacks behind berth No.3. The six long stacks are arranged in three lines on the pier and its extension, and the eight stacks are parallel arrenged in behind berth No.3. Three units of transfer cranes are to be provided for the six stacks and two are for the eight stacks. As for a pair of long stacks, each has 408 ground spots in terms of TEU within a space 460m in length. The maneuvering space is arranged in the middle of each stack for the convenience of changing lanes when necessary.

As for the eight stacks, there are three stacks for reefer containers, each of which has 36 ground spots accomodating 40-foot containers and five stacks for other containers, each of which has 90 ground spots in terms of TEU.

The efficiency of the operation of the transfer cranes in the short stacks will be less effective than those provided in the long stacks due to possible frequent lane changes. Systematic storage of container should be established by using an appropriate computer system.

6.6.5 Multipurpose Berth

Berths Nos. 1, 1A and 2 will be converted to multipurpose berths to accommodate relatively large ships, including container ships, RO/RO ships, livestock ships and general cargo ships. Berths Nos. 1 and 1A are expected to handle mainly container cargoes and Berth No.2 is to handle mainly other cargoes. The volume of cargoes allocated this Berth has been shown in Table 6-4-2, 6-4-3.

6.6.5.1 Concept of Facility Layout

For the handling containers, two gantry cranes will be installed. Although containers are to be mainly handled at Berths 1, and 1A, rail tracks for gantry cranes will be extended to Berth No.2. Details for gantry cranes will be explained in a later section. In order to use the yard space efficiently for a multipurpose basis, transit sheds Nos.1A, 1 and 2 will be demolished and used as open storage areas. The yard behind Berths Nos.1A and 1 will not be used as a container stockyard as shown in detail in next sub-section because of its limited land area and the

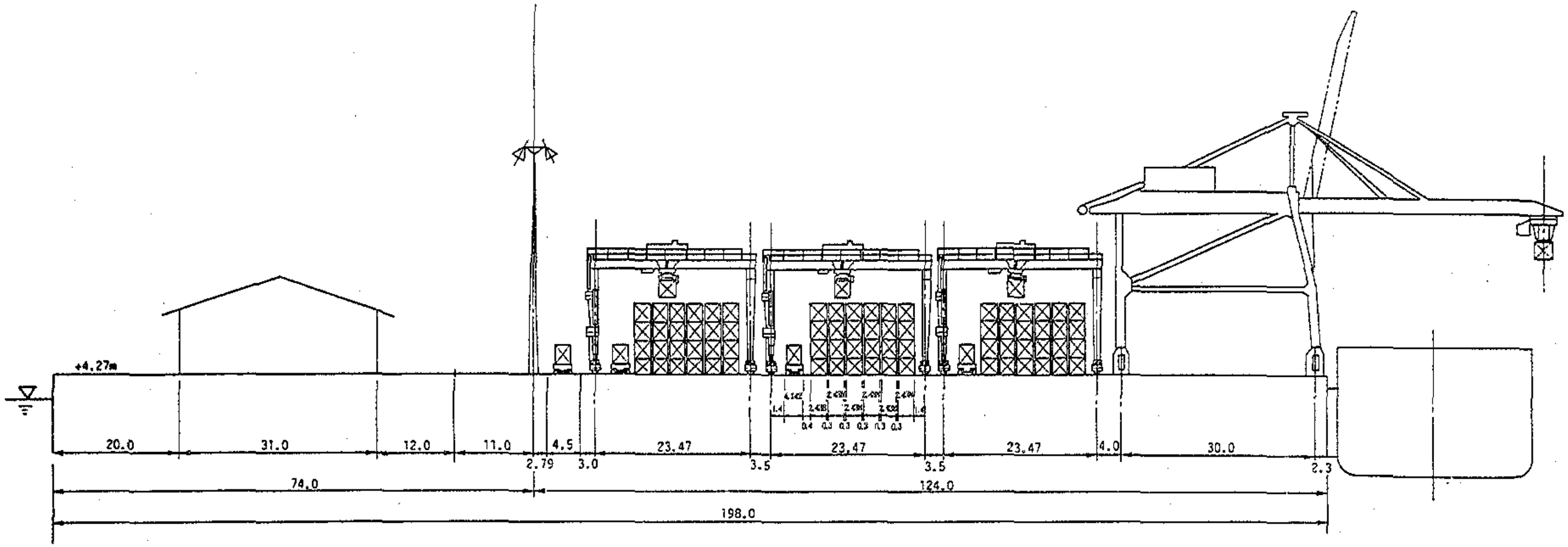


Fig. 6-6-15 A Cross Section of No.4, 5 Berth and No.7, 8 (Unit: m)

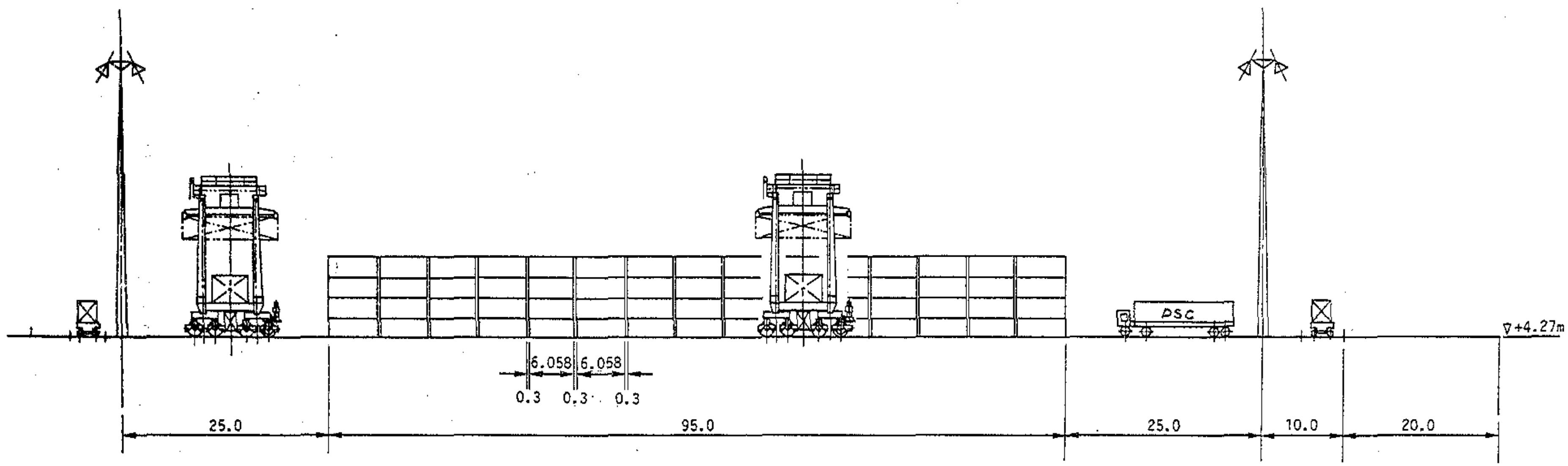


Fig. 6-6-16 A Cross Section of No.3 Container Berth (Unit: m)

container stockyard for this Berth will be developed on Shutaify Bay. The layout of the facilities at the multipurpose berth is shown in Figs. 6-6-17, 6-6-18.

6.6.5.2 Land Side Operation system of Containers

The characteristics of the container yard for multi purpose berths would be as follows:

Total length of stacks	:	150m
Ground spots	:	150 TEU
Slots	:	300-375 (2-2.5 tiers in average)
Handling system	:	Transfer crane system (2 units)

A transfer crane system should also be used for this yard form the reasons mentioned previously, and this system would be also adopted at this berth. Two alternatnies, viz a yard on the Berth No.1, 1A and 2 which is converted to multipurpose berths. The merits and demerits of adopting a transfer crane system at the multipurpose berth are as follows:

a Merits

(1) Efficiency of cargo work of container vessels, especially at the peak of operation.

(2) Higher ability to store containers throughout the whole port.

(3) Fewer tractor-trailers and drivers

b. Demerits

(1) Berth No.1 will be almost entirely occupied by container stacks and a tractor-trailers would have an ill effect of the handling at Berth No.2, at times paralyzing it.

(2) It necessitates installing two transfer cranes exclusive for Berth No.1, which inevitably increases amount of the investment and in view of the fact that the transfer crane moves only straight or at a right angle, diversion to another yard is impossible even when it is disengaged. Replacement in the event of breakdown is also difficult.

(3) Increase of temporary storage will increase handling frequency.

(4) The merits mentioned in a) above are not definite. For example, in peak periods can be covered by on increase in the number of

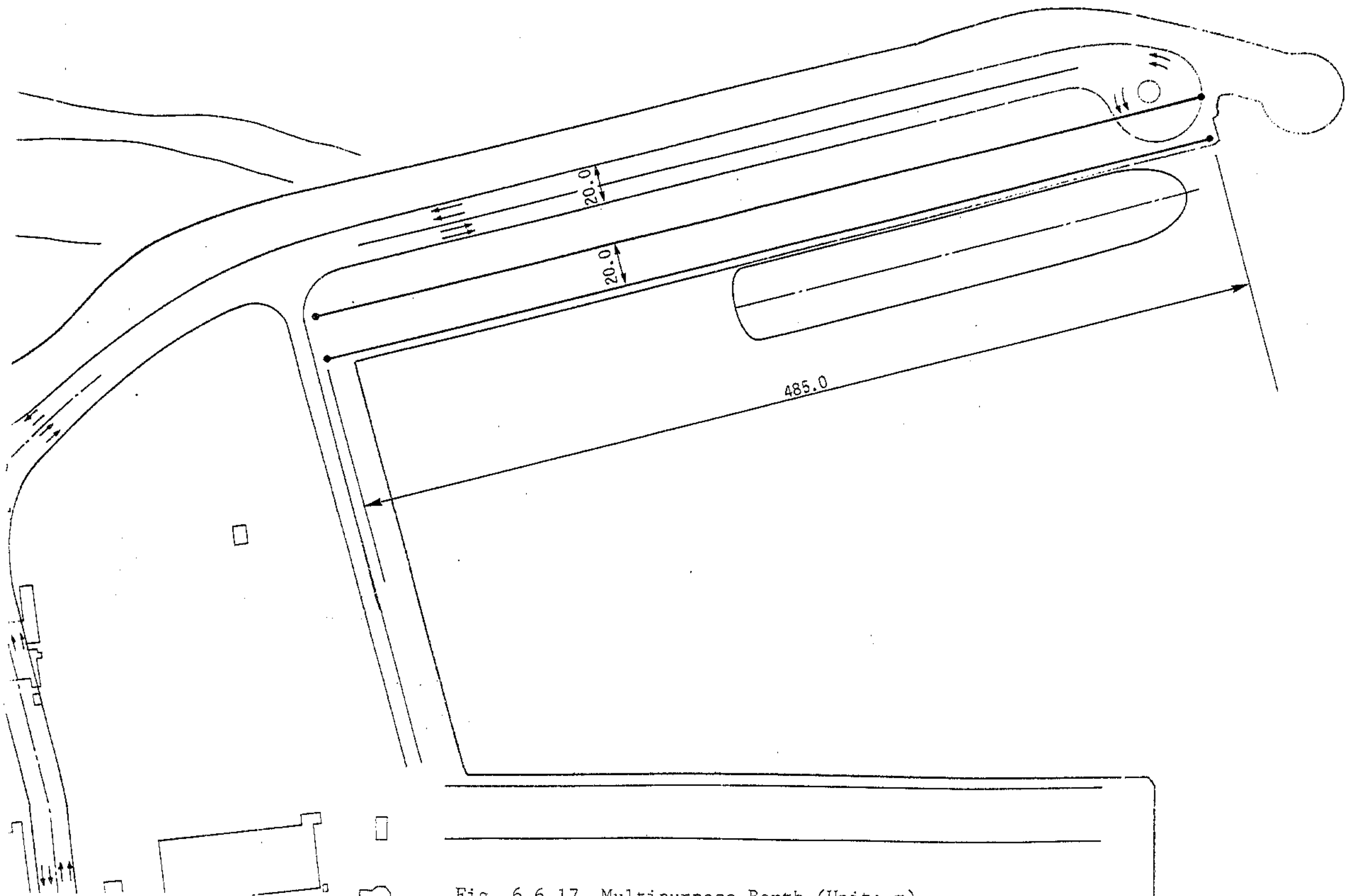


Fig. 6-6-17 Multipurpose Berth (Unit: m)

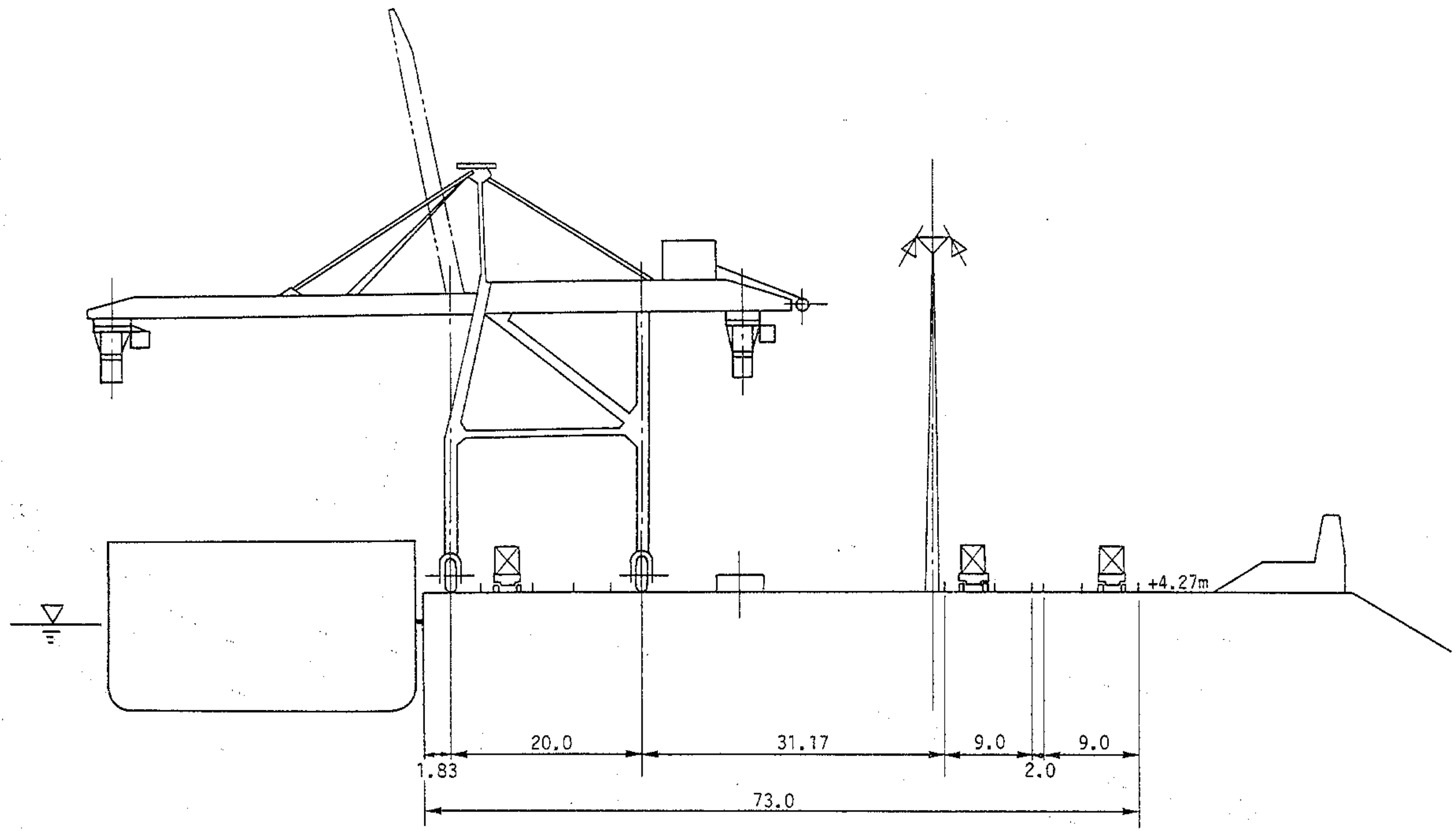


Fig. 6-6-18 A Cross Section of No.1 & 1A Berth (Unit: m)

tractor-trailers. This would be less expensive; three units of tractor-trailer each for a container crane(two), six units in total for Berth No.1, which can be procured at a cost of 50-60% of the cost of installation of a transfer crane.

(5) Installation of container stacks on the wharf reduces visibility and restricts inevitably the arrangement of running lanes.

Based upon the analysis, a container stockyard in the multipurpose is not planned for this Berth.

6.6.5.3 Container Freight Station

For the handling of container cargoes (LCL cargo), Mina Qaboos requires a container freight station (CFS) with an adequate capacity. However, adequate space for CFS is not available in the existing port area, even after zoning of the land area. Hence CFS will be developed at Shutaify Bay Yard.

(1) Function of CFS

A container freight station has the following facilities and deals with LCL containers to stuff and strip small lot cargoes,

a. Stuffing export FCL/LCL
b. Unstuffing import FCL/LCL
c. Open storage of consignments that cannot be stored in the shed.
d. Berths for containers on chassis
e. Berths for trucks of the consignees

In addition to the LCL container, there are many import and export FCL containers which are stuffed or unstuffed in the port area.

Of these, export FCL containers are under the custody of the PSC and are dealt with through CFS under the control of the PSC. Hence they do not disturb terminal operations. Import FCL containers to be unstuffed in the port are delivered to the consignees but they are grounded and will stay in the port area until all the consigments are unstuffed, which are called as grounded containers. These containers are used as warehouses under the custody of the consignees because of their lack of premises or undeveloped private warehouses in the area. These containers which are used for warehouses are usually stacked in one tier and occupy a large area of limited land. This situation should be improved soon before the limit of utilization of land is revealed. In this section we first consider the function of the CFS for LCL containers and export FCL containers and secondly, grounded containers. Estimation of the area requirement for the CFS area is carried out according to the flow chart shown in Fig. 6-6-19.

(2) Expected Container Throughput at CFS.

According to gate control data in 1988, which were obtained by the available data base and interviews with the PSC, we note that 15% of loaded import containers and 25% of loaded export containers were stuffed and unstuffed at the CFS. 10% of loaded import containers are dealt as grounded contaiers. We assume these percentages will not significantly change until 2000. Estimated container and cargo throughput are summarized in Table 6-6-6.

Table 6-6-6 Estimated Container and Cargo Throughput at CFS

	1995		2000	
	Container(TEU)	Cargo(ton)	Container(TEU)	Cargo(ton)
Import LCL	7,856	92,701	7,358	86,824
Export FCL stuffed	2,473	27,203	2,621	28,831
Sub total	10,329	119,904	9,979	115,655
Grounded containers	5,237	61,797	4,906	57,891

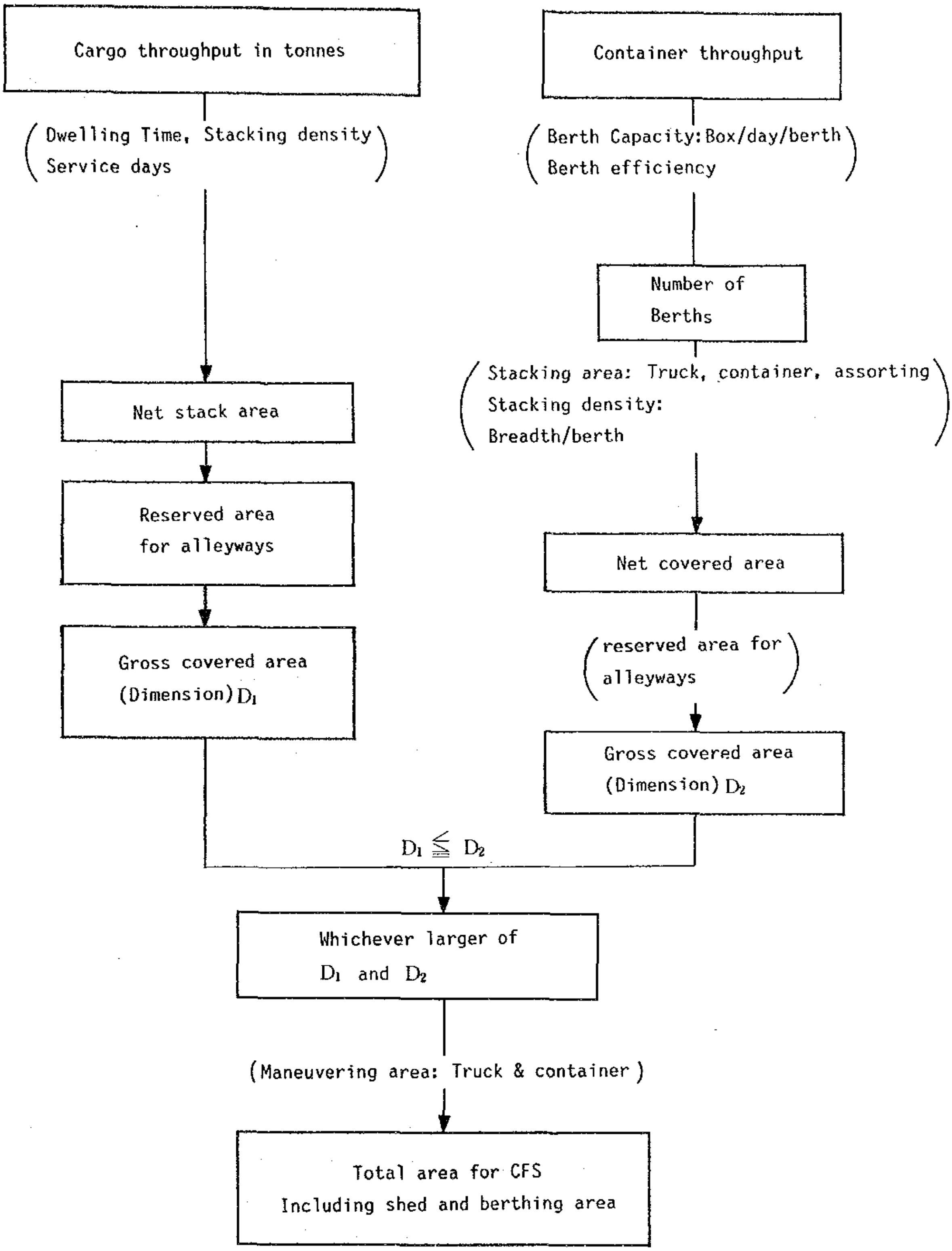


Fig. 6-6-19 CFS Capacity Planning Flow

(3) Area and Dimension of CFS Area

Based on the cargo throughput in Table 6-11 and on the basis of following specifications, calculation is made for the CFS shed area and the result is 5,658m^2 and 5,457m^2 in 1995 and 2000, respectively. Specifications are as follows;

Annual working days	:	300 days
Average cargo density	:	0.6ton/m^2
Dwelling time of cargo in the shed	:	7 days
Stacking height	:	1.5m
Peak factor	:	1.3
Alleyways against stacking area	:	40%

The dimension, therefore, becomes 50m x 113m.

It is necessary to prepare the berths at both ends of the CFS shed for trucks and trailers laden with containers as well as the maneuvering area for these pieces of equipment around the shed. Taking account of these spaces, the dimension of the area will be 130m x 163m, 2.1ha.

Required area for storage of grounded container is worked out on the basis of the following specifications:

Maximum annual throughput	:	5,237TEUs
Dwelling time after grounded	:	7 days
Working days	:	365 days
Peak factor	:	1.3
Occupied area per TEU	:	60m^2
Required area	:	7,834m^2

In the case of ground service containers beig dealt in the CFS together with import LCL and export FCL containers, the required space of the shed and total CFS area can be worked out to be 8,600m^2 and 28,860m^2, respectively. In this case the dimensions of the CFS shed and the CFS area are 50m x 172m and 130m x 222m, respectively.

On the oherhand, the space required for the CFS area and the grounded area, which are calculated separately, are 21,190m^2 and 7,834m^2

respectively, totaling 29,024m^2. Thus, there is no significant difference on these two cases for area requirements, hence we proposed the CFS area of 130m x 222m.

(4) Type of CFS shed

As regards the type of CFS shed, there are ground and platform systems. The latter is now in general use. The merits and demerits of the two systems are as follows:

Platform system	Ground system
1. Many trailers are needed.	Can be handled with fewer trailers.
2. Containers need not be lifted and grounded	Containers must be lifted and grounded.
3. Passage between the bays are narrow.	Passage has to be wide, unless a straddle carrier is used.
4. Dock levelers are necessary on the container side and the truck side	A slope is necessary for containers.

For simultaneous handling of containers, the ground system is disadvantageous from the viewpoint of land utilization, since each bay needs 15 meters' space for the container and forklift.

Further, in this system, containers must be lifted up and down each time and a large top-lifter must stand by. For this port, the above two demerits exceed those of the platform system, which requires investment for the chassis. Based on the recent CFS trend showing that terminals which do not adopted straddle carriers system choose a platform system, a platform system is recommended.

6.6.5.4 Layout of Shutaify Bay Yard

(1) Required slots and storage capacity

Containers handled here, for import, export and transshipment, will be stored in the marshalling yard to be constructed on the reclaimed land in Shutaify Bay. In this yard, four lines of container stacks with 240 ground spots each and one line of reefer container stacks with 108 ground spots (for 40 footers) will be installed. 216 plugs is to be set in the reefer container stacks for two high stacking. Table 6-6-7 shows the annual volume estimated to be handled in 1995 and 2000 at Berth No.1, 1A and 2, and the required and available ground spots in the marshalling yard in Shutaify Bay corresponding thereto.

The calculation was carried out on the basis of yard layout of Plan A discribed in sub section (2):

Table 6-6-7 Required and Available Ground Spots

Unit: in TEUs

	storage capacity	required capacity 1995	balance 1995	balance g.spot
import	18417	17495	922	14
export(e)	16686	15774	912	23
export(1)	3576	2423	1153	10
reefer E&I	4224	2933	1291	33
transship	29019	23011	6008	50
sum	71920	61636		129

	storage capacity	required capacity 2000	balance 2000	balance g.spot
import	18417	17146	1271	19
export(e)	16686	15332	1354	34
export(1)	3576	2567	1009	8
reefer E&I	4224	3638	586	15
transship	29019	27712	1307	11
sum	71920	66395		87

From the above it is noted that the ground spots in the marshalling yard are sufficient to store the maximum number of containers estimated in the previous section. An 8% margin in 2000 and 11% in 1995 can contribute to reducing stacking hight for the convenience of container handling.

(2) Layout Alternatives

With a view to laying out the container yard effectively in the area reclaimed from Shutaify Bay, we have considered the merits and demerits of two plans, as illustrated in Fig. 6-6-20(a-1), (b) regarding the following items:

1) The number of ground spots
2) Maximum annual container throughput to be stowed
3) Easiness to identify stacked containers by handling mode
4) Safety of transportation in the marshalling yard
5) Simplicity of transportation in the marshalling yard.
6) Average running distance per cycle.
7) Accessibility or interchangeability to and from the main roads
8) The number of transfer cranes
9) Costs of constructing the marshalling yard

1) The number of ground spots

There is no significant difference in terms of ground spots between plan A and plan B.

2) Maximum annual container throughput to be stowed

There is no significant difference in terms of the annual throughput between plan A and plan B.

3) Easiness to identify stacked containers by handling mode

Plan B has many more lanes of stacks than plan A, hence plan B is easier in terms of to allocating the stacks for containers segregated by mode.

4) Safety of transportation in the marshalling yard

Plan A is considered to be better in terms of safety, since plan A adopts a layout for transferring containers with fewer turns from the container stack to the crane

5) Simplicity

Plan A is considered to be better for the same reason as factor 4). However there is no significant difference for either plan in terms of

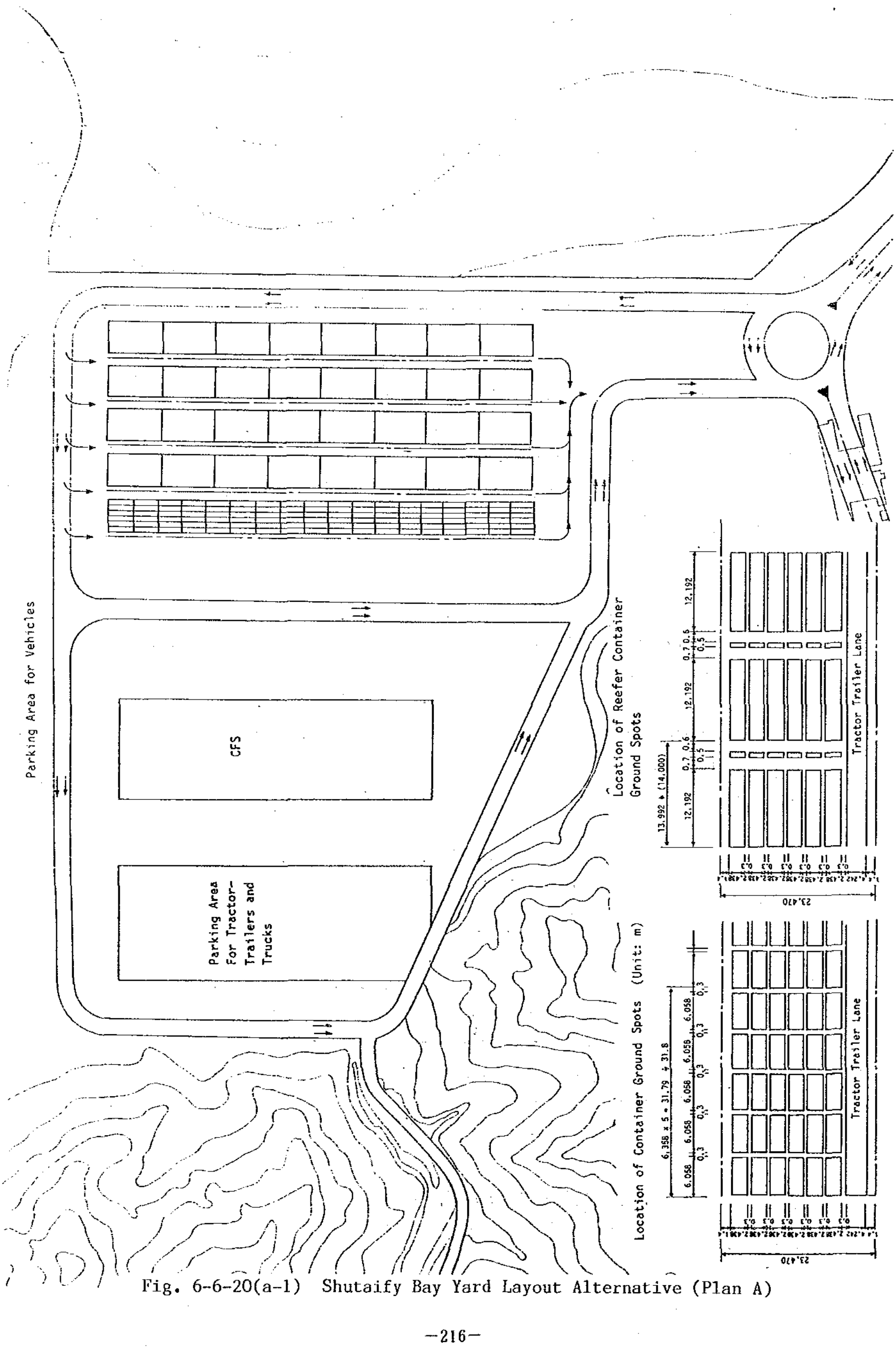


Fig. 6-6-20(a-1) Shutaify Bay Yard Layout Alternative (Plan A)

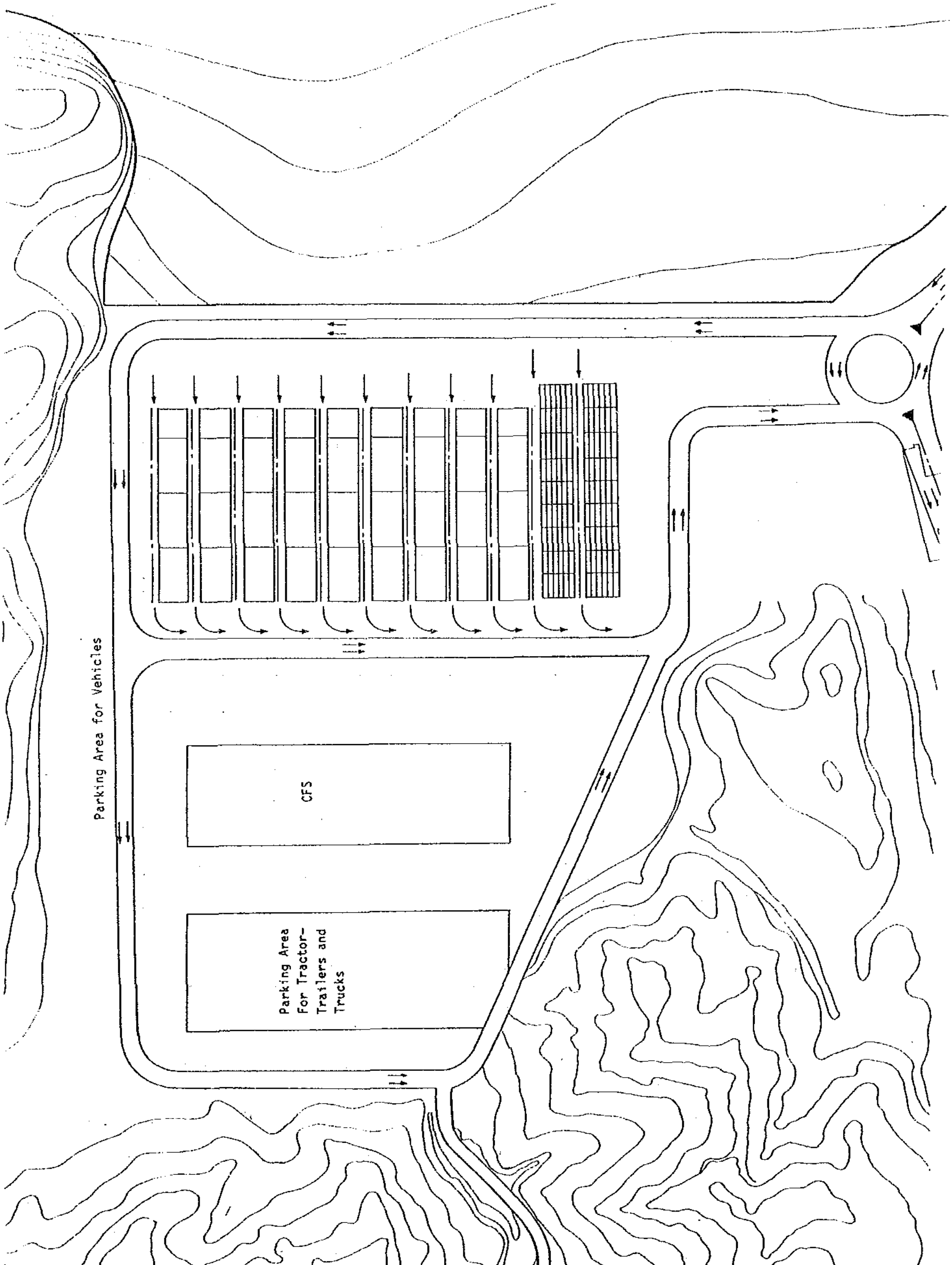


Fig. 6-6-20(b) Shutaify Bay Yard Layout Alternatives (Plan B) factors 4) and 5).

6) Average running distance per cycle

Plan B is considered to be better for average running distance needed to carry the containers between the stack and the container crane. The difference between these plans is less than 3% for the distance of a cycle.

7) Accessibility or interchangeability to and from the main roads

The facility of delivery depends upon the accessibility or interchangeability of the roads in the marshalling yard with the main roads. Plan B is better because it has a shorter distance between the two main roads as well as the length of each stack.

8) The number of transfer cranes

In other words, this refers to the efficiency of the transfer crane. It takes a long time for the transfer crane to change lanes. This disturbs cargo handling and is disadvantageous in terms of effective operation. The difference in the efficiency of the transfer crane is significant in comparing plan A and plan B. Plan B requires more transfer cranes to obtain the handling efficiency on the level as that of plan A. Plan A is apparently better than plan B.

9) Cost of constructing the marshalling yard

There is no significant difference between either plans. Plan A, however, is somewhat cheaper than plan B because the area of plan A to be paved especially firmly is smaller than that of plan B.

There is no significant difference between plan A and plan B except for factors 7), 8) & 9). Factor 8) is considered to be the most important, hence plan A is appropriate for the layout of the marshalling yard at Shutaify Bay. Summary of comparison is shown in Table 6-6-8.

Table 6-6-8 Comparison of Layout Alternatives

Factors	Plan A	Plan B
1) Number of ground spots	1068	1080
2) Maximum annual container throughput to be stowed	normal	good
3) Easiness to identify stacked containers handling mode	normal	good
4) Safety of transportation in the marshalling yard	good (to a slight extent)	normal
5) Simplicity of transportation in the marshalling yard	good (to a slight extent)	normal
6) Average running distance per cycle	normal	normal (somewhat better)
7) Accessibility or interchange ability to and from the main roads	normal	good
8) Number of transfer cranes	good	normal
9) Costs of constructing the marshaling yard	good	normal

(3) Allocation of container stacks

The number of ground spots allocated for each container handling mode is worked out taking into consideration various factors, such as dwelling time, stacking height, stacking efficiency, annual working days, and peak period factors. These factors have been investigated minutely. The stacking capacity of each stack is summarized in Table 6-6-9.

Table 6-6-9 Summary of Stacking Capacity

Unit (TEU)

No.of stack	application	g.spot	dwell time (day)	stack height	efficiency	peak fact.	serv. day (day)	through-put (capacity)
Reefer stack	reefer E&I	108	10.0	2.0	0.75	1.4	365.0	4224
No.1	import	90	8.6	3.0	0.75	1.4	365.0	6139
	import	90	8.6	3.0	0.75	1.4	365.0	6139
	import	60	8.6	3.0	0.75	1.4	365.0	4093
No.2	transship	90	6.9	4.0	0.80	1.4	365.0	10882
	transship	90	6.9	4.0	0.80	1.4	365.0	10882
	transship	60	6.9	4.0	0.80	1.4	365.0	7255
No.3	export(e)	90	21.0	4.0	0.80	1.4	365.0	3576
	export(e)	120	21.0	4.0	0.80	1.4	365.0	4767
	import	30	8.6	3.0	0.75	1.4	365.0	2046
No.4	export(e)	90	21.0	4.0	0.80	1.4	365.0	3576
	export(e)	120	21.0	4.0	0.80	1.4	365.0	4767
	export(1)	30	7.0	4.0	0.80	1.4	365.0	3576
sum		1068						71920

Note: Ground spots for reefer containers are designed for 40-foot containers.

The allocation for each handling mode is shown in Table 6-6-10.

Table 6-6-10 Allocation of Each Handling Mode

No. of stack	No. of grand sport	Application
Reefer stack	108	Import and export reefer containers to be stacked
No.1 stack	240	Almost all import containers to be stacked
No.2 stack	240	All transshipment containers to be stacked
No.3 stack	210 30	Export empty containers to be stacked Some import containers to be stacked
No.4 stack	210 30	Export empty containers to be stacked Export loaded containers to be stacked

(4) Layout of the Yard

The layout of container-related functions described above is shown in Fig.6-6-20(a-2), 6-6-21. Besides these container-related functions, a car park area is also planned in this yard.

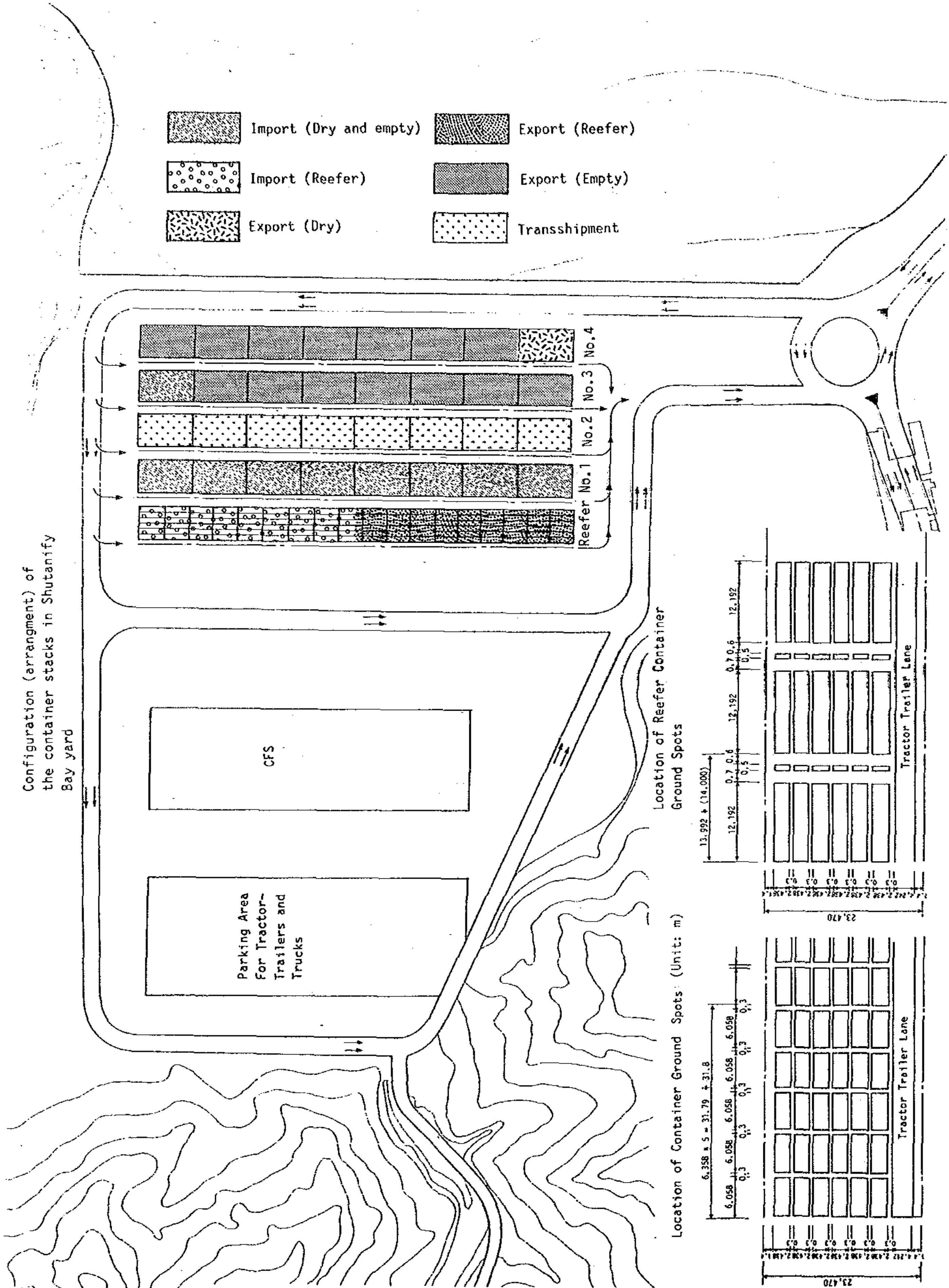


Fig. 6-6-20(a-2) Allocation of Containers

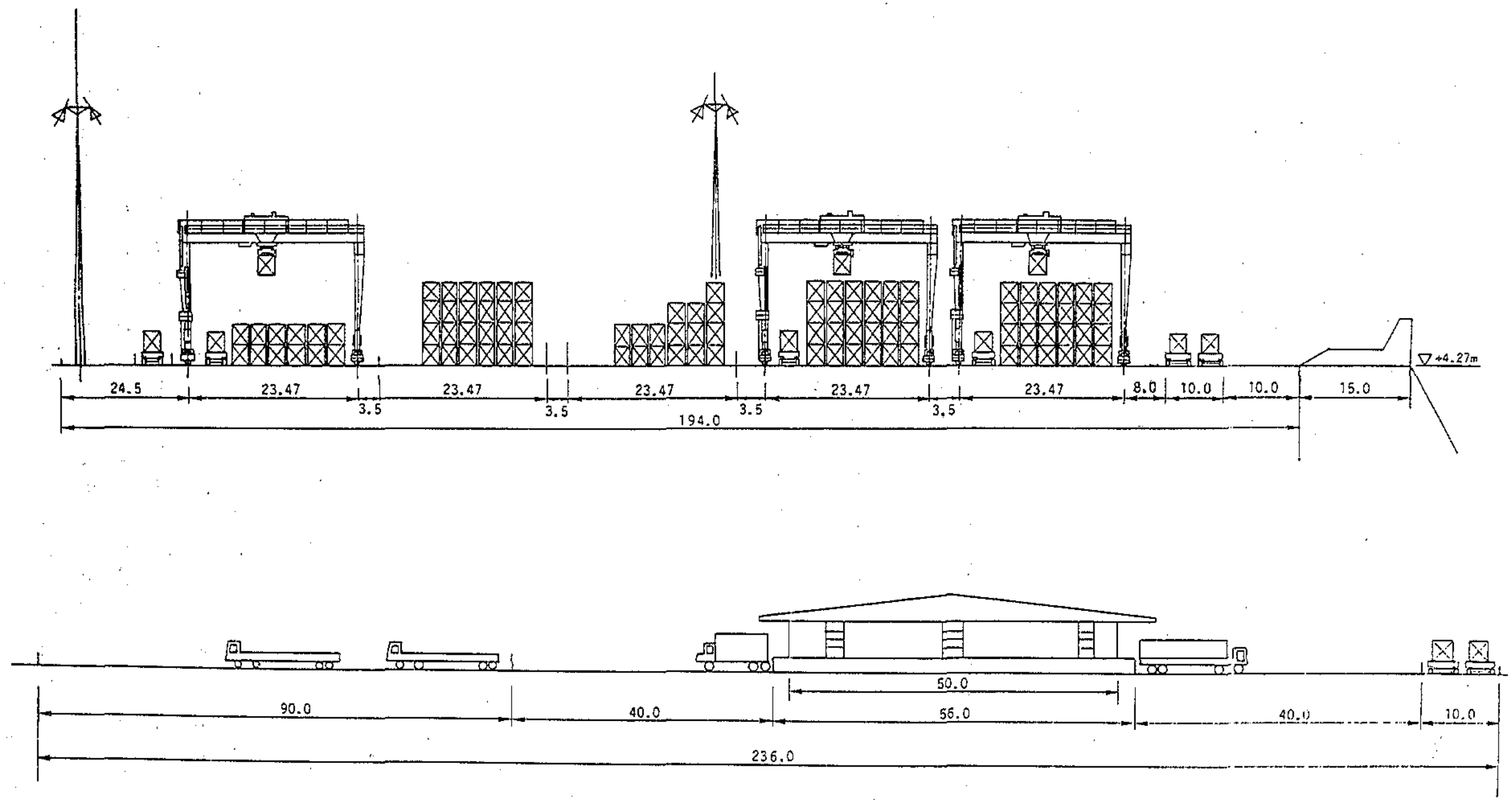


Fig. 6-6-21 A Cross Section of Shutaify Bay Yard (Unit: m)

6.6.6 New Berth for the Royal Yacht

6.6.6.1 Background

Berth No.6 is currently used mainly by the Royal Support Yacht and a small amount of cargoes are handled only when the yacht is out of Mina Qaboos. However, in view of security, safety and convenience of the Royal Services, it may be better for all the Royal vessels to positioned in one place. From this viewpoint, the west pier which is now used for non commercial purpose is the most suitable place for the Royal Fleet. This shift is also recommendable because the Royal procession can go through the southern gate which is shorter distance than No.6 berth without hindered by the flow of commercial lorries. Moreover, topographical features of Mina Qaboos make impossible to expand its physical functions economically on a large scale. Nevertheless, the future traffic demand for Mina Qaboos will most probably exceed the capacity of the port. On the other hand, Berth No.6 is well furnished as a commercial berth in terms of its length, depth and location. Hence, one of the most effective ways to increase the port capacity is to make Berth No.6 fully available for commercial cargo use. Therefore it is necessary to find a new place for the establishment of a new berth to accommodate the Royal Support Yacht at Mina Qaboos.

6.6.6.2 Dimensions of Ships

According to the information from the MOC, the dimensions of the Royal Support Yacht and the Royal Dhow are as follows:

(a) Royal Support Yacht
   i) Length 136m
   ii) Draft -6.0m

(b) Royal Dhow
   i) Length 55m
   ii) Draft -3.5m

6.6.6.3 Location and Layout of New Berth

(1) Location

A new berth is needed at Mina Qaboos because of its functions. At Mina Qaboos, Berths Nos.1 to 8 have to be continue to be used as commercial berths, and the shallow water area is not adequate for a new berth because its allow depth would necessitate a large amount of dredging. Moreover, this area should be kept as it is as an amenity zone. Hence the only feasible location for a new berth is the area in the vicinity of Berth No.12.

(2) Wave Conditions

The Water basin at Mina Qaboos is protected from waves by a breakwater. The calmness conditions in the water basin are estimated based upon the wave data for 1988. Calculation results already listed in Chapter II show that 99.7% of wave height throughout the year is estimated to be less than 0.5m around Berth No.12. Hence wave conditions in the vicinity of Berth No.12 are very good. Detailed results are shown in Chapter 2.

(3) Layout of Berth

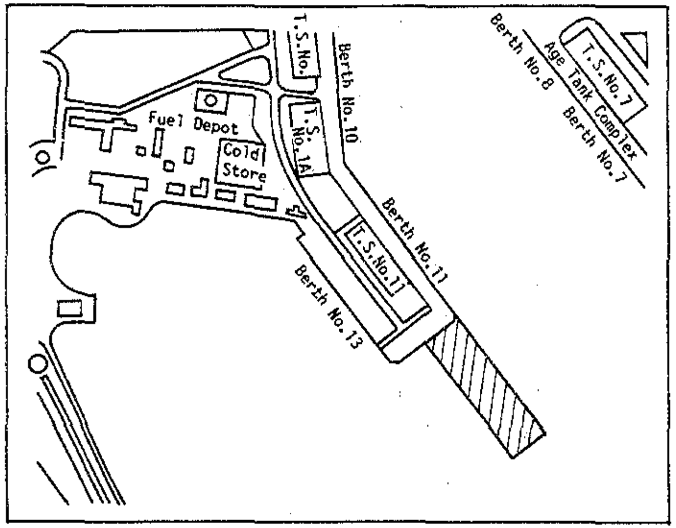
Fundamentally, only two alternatives are considerable concerning the layout of a new berth, as shown in Fig. 6-6-22(a). Comparison of these alternatives is shown in Table 6-6-11. Except for item 1 of this table, no significant differences are found between these alternatives. Regarding item 1, namely wave condition, the difference is obvious, and this factor is very important for the Royal Yacht berth. Thus alternative B is chosen for the new berth.

(4) Dimensions of New Berth

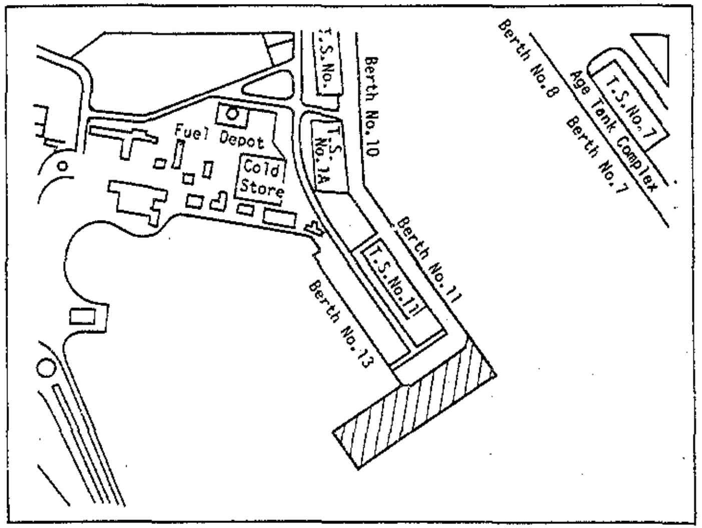
Because existing Berth No.12 is to be demolished, a berth for the Royal Dhow must be built. Considering the dimensions of the Royal Yachts, which have already been explained, two berths are planned, as shown in Fig. 6-6-22(b). These berths are named Berth No.12A for the Royal Support Yacht and Berth No.12B for the Royal Dhow. Concerning the drafts for these yachts, the water basin will be dredged up to -8m for the Royal Support Yacht basin area and -4m for the Royal Dhow basin area.

Table 6-6-11 Comparison of Layout Alternatives

Items	Alternative A	Alternative B
1. Wave conditions alongside Berth	×	○
2. Flexible Use with Berth No.11	○	△
3. Berth Length	○	△
4. Influence on Small Ships to Shallow Area	△	○
5. Influence on Turning Basin	△	○
6. Cost	○	○



Alternative A



Alternative B

Fig. 6-6-22(a) Layout Alternatives of Royal Yacht Berth

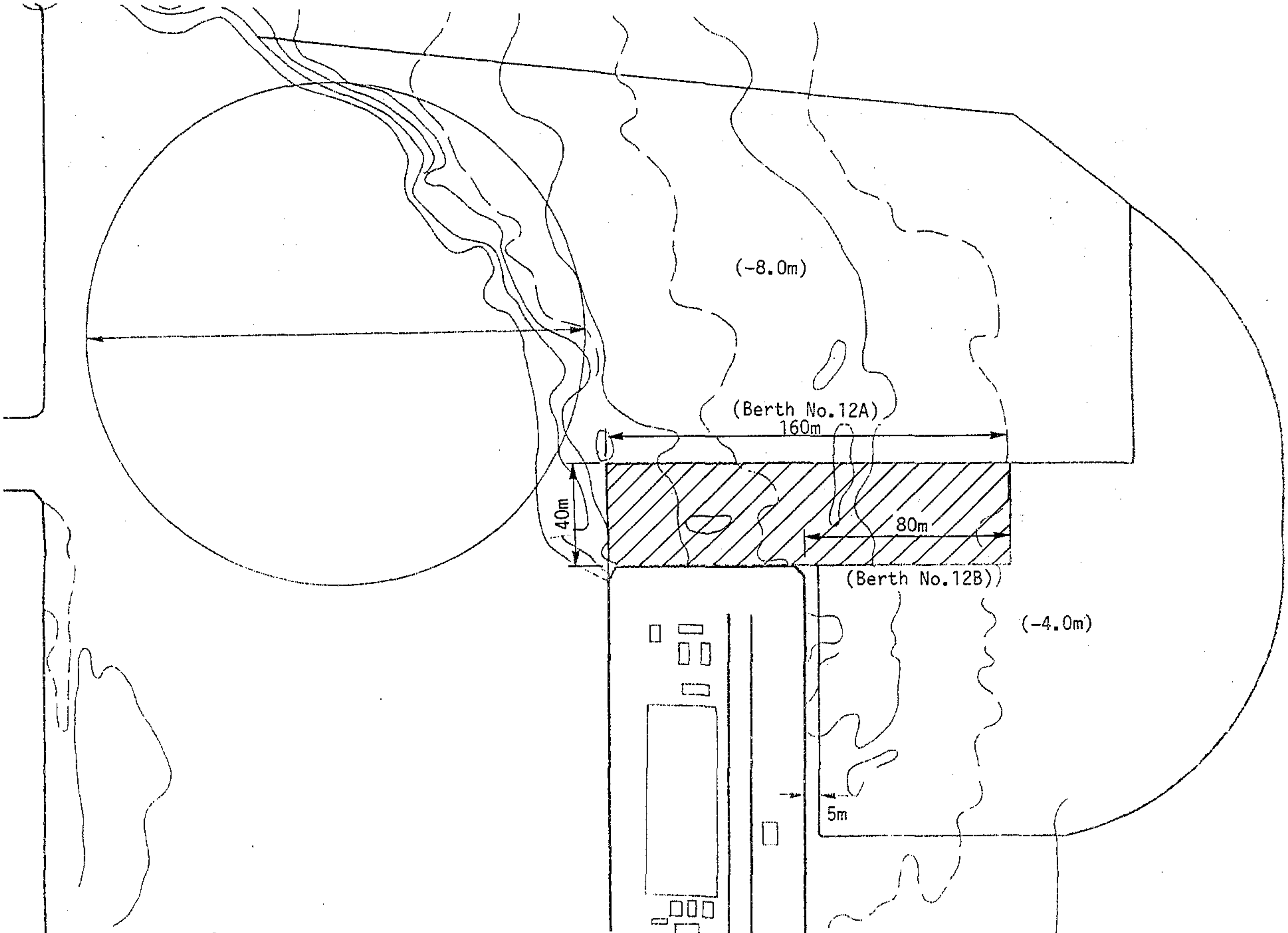


Fig. 6-6-22(b) Layout of Royal Yacht Berth