4.8 Computer System

19. Present problems of computer system in relation to the yard activity is noted as follows. In this section problems stipulated are rather in the yard activity which can be improve with the aids of computer system than computer system itself.

4.8.1 Instruction System for Container Location

20. Discharging of containers from a vessel is carried out according to a discharging sequence checklist which is prepared manually by the head planner. Copies of this plan printed out are delivered to key personnel of the operation: that is to say the ship supervisor, the yard supervisor the tally clerks of the PSC and chief officer of the vessel.

The location of the container in the marshaling yard, however, is not scheduled beforehand. It is determined by the yard supervisor in the course of operation. The yard supervisor is responsible for determining the locations of discharged containers according to vacant slots he finds in the marshaling yard and instructs the drivers of top lifters via a yard clerk.

Picking up a container underneath a gantry crane, the top lifter proceeds to the place instructed. At the same time, the yard clerk proceeds to the place and confirms whether the location of the container is correct or not.

If the container is in the correct position, he records and reports the locations at times convenient to the yard planner.

4.8.2 Preparing and Updating the Yard Map (Container Locations)

21. 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

22. 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

23. 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

24. 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

5.1 Socioeconomic Framework

5.1.1 Population

1. In the absence of a census in Oman, the nation's population and its growth rate are not available. Therefore, the Study Team adopted a population estimate of 1,500,000 for 1989 and an annual growth rate of 3.5% for the future, which are used for planning purposes in the Development Council.

5.1.2 Gross Domestic Product (GDP)

2. Under the Second Five-Year Development Plan (1981-85), at the outset of which oil prices skyrocketed to US $40/barrel, GDP in real terms increased at an annual rate of 14.5% and the manufacturing and agriculture/fishery sectors had high growth rates of 34.4% and 13.2%, respectively. However, at the beginning of the Third Five-Year Development Plan (1986-90), oil prices fell to less than US$ 10/barrel and a consequent decline in oil revenues led to critical financial problems in Oman. Between 1985 and 1988, the annual growth rate of GDP in real terms was only 1.7% and nominal GDP showed a minus growth rate of -5.5%.

3. Since the Fourth Five-Year Development Plan is to be published in late 1990 and no authorized figures are available concerning future GDP, the Study Team has estimated that the annual growth rate of the GDP of Oman in current prices will be:

i) 5.1% from 1991 to 1995

ii) 5.0% from 1996 to 2010

4. The estimated results of GDP by sector are shown in Table 5-1-1.

Table 5-1-1 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

5. In this Study, two methods are used to forecast the local trade cargo (imports/exports): one is the "total demand forecast", which forecasts the total volume of cargo as a whole, and the other is the "commodity-wise demand forecast", which forecasts the volume of each major commodity group individually. Concerning transshipment cargo, only the total demand forecast is applied.

6. 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.

5.2.2 Premise

7. In this chapter the combined demand for 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 after the improvement of Mina Qaboos and development of a new port and that those ports will be attractive to port users and be competitive with the major ports in the United Arab Emirates. Port traffic between Mina Qaboos and the new port will be allocated later.

5.2.3 Total Demand Forecast for Import/Export Cargo

8. The total import volume of Oman is forecast first by regression analysis against the GDP of Oman. After assuming that the percentage of imports that will enter through Mina Qaboos and a new port (hereafter "the share of ports") will rise to 75% by the year 2000 from the present figure of about 60%, the cargo volume that will be handled at Mina Qaboos and a new port is forecast.

9. The cargo volume of exports is estimated by a time series correlation analysis. The share of ports is assumed to rise to 50% by the year 2000.

5.2.4 Commodity-wise Demand Forecast

10. After categorizing the major commodity groups into the following groups, the volume of each commodity is forecast individually and the total cargo volume is then calculated by the summation of these volumes.

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

In the process of the analysis the share of ports is assumed to increase for some commodities by the year 2000, taking the present situation of each commodity into consideration.

Checked by the results of the total demand forecast, the cargo volumes obtained by the commodity-wise forecast are adopted for the development plans for Mina Qaboos and a new port in this Study. The results are shown in Table 5-2-1.

5.2.5 Transshipment Cargo

11. The volume of transshipment cargo has been on the rise in recent years and accounted for 37.2% of the total cargo handled at Mina Qaboos in 1988. It is obvious that Oman has an absolute geographical advantage over other Gulf countries as a transshipment base. When Oman has superior ports with enough capacity, high efficiency, price competitiveness and less bureaucratic red tape, there is a great possibility for transshipment throughput to make rapid progress.

12. In the analysis the total container throughput in Oman and UAE ports is forecast first. The Study Team has estimated the annual growth rate of this throughput to be 5% in the future. Since this container movement comprises latent demand for transshipment in Oman, transshipment cargo volume at Mina Qaboos and a new port is forecast by multiplying this forecast container throughput by the share of Mina Qaboos and a new port.

Although it is very difficult to forecast the volume of transshipment cargo on a long term basis, the forecast is made upon the assumption that Mina Qaboos and a new port will get a share of 10%, which is somewhat higher than the present share of 7% at Mina Qaboos.

5.2.6 Results of Demand Forecast

13. The results of the demand forecast are shown in Table 5-2-1 and Fig.5-2-1.

Table 5-2-1 Results of Demand Forecast for Mina Qaboos & New Port

(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
Import 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
Export Total	130.9	231.5	327.3	395.7
Transshipment	977.8	1,560.0	2,541.0	3,243.1
Grand Total	2,531.9	3,695.7	5,688.1	7,079.3

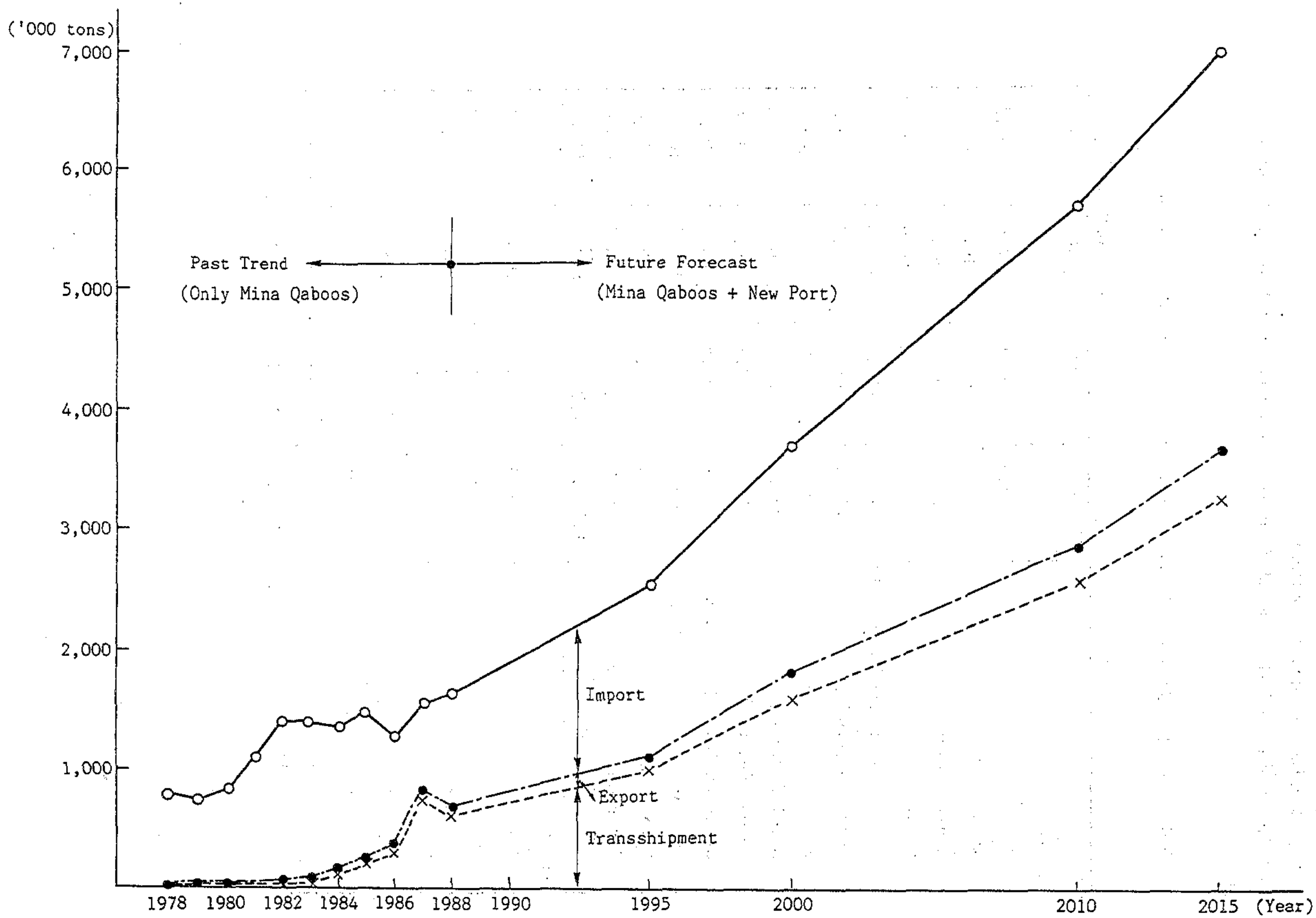

Fig. 5-2-1 Past Trend and Future Forecast of Total Cargo at Mina Qaboos & New Port

5.3 Cargo Volume by Handling Mode

5.3.1 Bulk Cargo

14. Bulk cargo commodities are wheat, other grains, vegetable oil and bitumen in terms of imports, and chromite in terms of exports. The calculation is made based upon the results of the demand forecast for respective commodities.

5.3.2 Container and Break-bulk Cargo

15. Of break-bulk cargo, timber, steel & pipes, vehicles and livestock are not containerizable. Taking into consideration the past trend of the ratio of container cargo volume to containerizable cargo volume, the future ratio of containerization is assumed to be 80% for imports and 90% for exports, which is the maximum limit in Oman's case. The cargo volume of containers is calculated by multiplying the containerizable cargo volume by the ratio of containerization. All the transshipment cargoes are containers.

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.

5.3.3 Results

16. The results of the forecast of cargo volume by handling mode are shown in Table 5-3-1.

Table 5-3-1 Cargo Volume at Mina Qaboos & New Port by Handling Mode

(Unit: '000 tonnes)

	1995	2000	2010	2015
Bulk Grain	204.3	250.3	373.6	456.6
Other Bulk	41.3	89.8	106.0	116.4
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	167.4	223.1	324.9	393.2
Containers (Local Cargo)	726.6	982.6	1,438.4	1,745.5
Containers (Transshipment)	977.8	1,560.0	2,541.0	3,243.1
Total	2,531.9	3,695.7	5,688.1	7,079.3
TEUs of Containers	236,604	348,412	542,078	677,352
Boxes of Containers	177,452	261,309	406,559	508,013

Chapter 6 A NEW PORT CONSTRUCTION AND ITS CHARACTERISTICS

6.1 Necessity of a New Port in the Northern Part of Oman

(1) Present Port Capacity of Mina Qaboos

1. Mina Qaboos handled about 1.62 million tons of cargoes which comprised import, export and transshipment cargoes, in 1988.

The total cargo throughput at Mina Qaboos during these 7 years was almost always around 1.5 million tons. The average waiting time was found to be 0.22 day in 1988 according to the analysis of our own study. Some vessels waited due to the draft restriction and others waited due to the non-availability of suitable berths. Judging from the present average waiting time, present port operation conditions and the annual throughput, the present capacity of Mina Qaboos seems to be around 1.5 million tons.

(2) Future Cargo Demand in the Northern Part of Oman

2. The projected cargo volumes in the Northern Part of Oman are about 3.7 million tons is 2000 and 7.1 million tons in 2015.

(3) Future Port Capacity of Mina Qaboos

3. The cargo handling capacity of Mina Qaboos is estimated to be about 2.6 million tons in 2000 after the economically feasible expansion and improvement which comprise the reclamation in Shutaify Bay and the strengthening of cargo handling equipment and manpower, and the improvement of the operating system including the introduction of an effective 3-shift system. The capacity is defined under the precondition that the average vessels waiting time should be less than 3 hours/vessel. Excessively long waiting times deter container liners, especially liners trading transshipment containers from using Mina Qaboos and eventually the future container throughput would decrease.

6.1.1 A Supplementary Port of Mina Qaboos

4. Comparing the forecast cargo throughput in 2000 with the capacity of Mina Qaboos in 2000, 1.1 million tons of cargo will overflow from Mina Qaboos. The transshipment cargo volume was about 0.6 million tons in 1988. The forecast transshipment cargo volume in 2000 is 1.6 million tons, and even if the transshipment cargo volume remains at the same level as in

1988, the total cargo throughput would be 2.7 million tons in 2000. If Oman intends to increase its handling of transshipment cargoes, the need for a new port in the Northern Part of Oman is clear. Even if Oman stops handling transshipment cargoes, a capacity of 2.6 million tons would seem very small for Oman.

6.1.2 Spearhead to Develop Industries and Regional Development

5. The government of Oman is now promoting the development of non-oil industries in order to diversify the sources of national income to augment and eventually replace oil resources which is said to be exhausted within 20 years. The policy will be fruitful, if strong aggressive strategies are adopted and promoted by the government and the private sector.

In order to develop new industries a new port in the Northern Part of Oman is indispensable.

6. The population of Oman was estimated at 1.5 million in 1989. The population is projected to increase at a rate of 3.5 percent for at least the next 10 years. The government of Oman has a basic policy of giving due attention to local human resources and improving their capabilities of contributing to the national economy in order to prevent consentration to already densely populated urban centers and to promote regional development. In order to promote regional development, a new port in the Northern Part of Oman is indispensable.

7. As of 1988, the export cargo share is now only about 4 percent of the total amount of cargo handled at Mina Qaboos. The government of Oman is now adopting policies to promote non-oil industries and seeking income sources other than oil. The government of Oman has already developed the Rusayle Industrial Estate and is now planning other four Industrial Estates. The industries in the Rusayl Industrial Estate are also export industries as well as import substitute industries. In order to develop new Indusustrial Estates in the area far from Mina Qaboos, a new port in the Northern Part of Oman is also indispensable to export products.

6.2 Timing of New Port Development

6.2.1 Comparison of Expanded Capacity of Mina Qaboos with the Future Cargo Demand in the Northern Part of Oman

8. The forecast cargo demand in the Northern Part of Oman is as follows, according to our own estimation:

Table 6-2-1 Forecast Cargo Demand

(Unit: '000 tonnes)

Year	1988	1995	2000	2010	2015
Imports	951	1,423	1,904	2,820	3,440
Exports	70	131	232	327	396
Sub-total	1,021	1,554	2,136	3,147	3,836
Transshipments	604	978	1,560	2,541	3,243
TOTAL	1,625	2,532	3,696	5,688	7,079

As the capacity of Mina Qaboos is estimated at 2.6 million tons (6.1.1), the forecast cargo volume will be at the upper limit of Mina Qaboos in 1995.

In 2000. Mina Qaboos will not be able to handle the forecast cargo volume, accordingly, a new port must be in operation in 2000 at the latest.

6.2.2 Timing of New Port Development from the Viewpoint of Other Factors

9. From the viewpoint of a spearhead to develop industry and regional development, it is hoped that a new port in the Northern Part of Oman will be in operation as soon as possible, because there is no possible way to develop industries without a port in the area far from Mina Qaboos.

Judging from the amount of construction costs needed to expand Mina Qaboos as presented at Chapter 7.13, and the construction costs of a new port presented in Chapter 6.3.4 the construction of a new port will not be possible between 1991 and 1995.

Judging from the implementation schedule which is presented later in 11.2.4, the required construction period is at least 4 years, so the commission date of a new port would be at the end of 1999 if construction were to start at the beginning of 1996.

Before starting construction, detailed design of the various facilities and detailed site investigation in support of detailed design work must be completed. The budget for implementing the detailed site investigation and detailed design must be taken account of in the next five-year plan in order to ensure the new port is in operation at the end of 1999.

According to the scope of the study, the target year to formulate a master plan of a new port is 2015.

6.3 Potential Functions of a New Port

10. Modern ports can play various roles not only as a node between land and sea transportation but also as a core of regional, socio-economic, industrial and tourism development. In considering the potential functions of a new port, we selected the following port functions and analyzed their respective potentials:

(1) Import Cargo Handling Function
(2) Transshipment Cargo Handling Function
(3) Industrial Port Function
(4) Free Trade Zone Function
(5) Fishery Port Function
(6) Other Functions

6.3.1 Import Cargo Handling Function

11. According to the share of import cargoes by point of entry, the import cargo share of Mina Qaboos was only 58.3 percent of Oman's total import cargoes in 1988. The import cargo share by road occupied 29.6 percent in 1988. This suggests that some portion of import cargoes is handled in Dubai Port and transported by road to the Northern Part of Oman.

According to the Report on the "Batinah Regional Plan" which was conducted by Weidleplan in 1989, the limit of influential area from Dubai in Al-Batinah was shown to be up to Suweiq. This illustrates that there are some potential cargo demands for a new port along the Batinah coast.

The population in Al-Batinah has a big share of the total population and that this will increase in the future. Most of the import cargoes in Oman are consumer's goods. So the area in which population will increase in the future can be said to have good potential for import cargo handling ports.

6.3.2 Transshipment Cargo Handling Function

12. Mina Qaboos handled transshipment cargoes totaling 80,000 TEUs (604,000 tons) in 1988. Port Rashid, located in Dubai, UAE, handled transshipment cargoes totaling 3,069,000 tons between January and October 1989. Compared with transshipment cargo volumes handled at other ports in the Arabian Gulf, Port Rashid has the overwhelming share at present. But Oman occupies a geographically advantageous location as a transshipment base for other ports in the Arabian Gulf. The following table shows the required time for the voyage to various sites from Jeddah and Singapore.

Table 6-3-1 Required Time from Jeddah and Singapore

Hub Port	Vessel Speed	Required Time (Jeddah-Hub Port)	Required Time (Hub Port-Singapore)
Qaboos	17.5knots	4.7days	7.7days
	15.0knots	5.4days	8.8days
Majis	17.5knots	5.0days(+0.3day)	8.0days(+0.3day)
	15.0knots	5.8days(+0.4day)	9.2days(+0.1day)
Haradi	17.5knots	4.8days(+0.1day)	7.8days(+0.1day)
	15.0knots	5.5days(+0.1day)	8.9days(+0.1day)
Dubai	17.5knots	5.5days(+0.8day)	8.4days(+0.7day)
	15.0knots	6.3days(+0.9day)	9.7days(+0.9day)

Mina Qaboos has the locational benefit of a voyage about one day shorter for mother vessels compared with Dubai.

A new port located at Majis or Haradi in the Batinah coast would have a locational benefit of about 0.5 day for mother vessels compared with Dubai. Accordingly, there is a possibility of locating a new port on the Batinah coast as a transshipment base.

13. The locational advantages of the Northern Part of Oman are calculated and summarized as follows:

(1) Even if Mina Qaboos cannot collect container cargoes to the same extent as Dubai, Mina Qaboos could become a Hub Port.

(2) If the difference of collectable container cargoes between Mina Qaboos and Dubai is less than 158 TEUs/vessel, Mina Qaboos could become a Hub Port.

(3) If the difference of collectable container cargoes between a new port in Haradi and Dubai is less than 138 TEUs/vessel, the new port in Haradi could become a Hub Port.

(4) If the difference of collectable container cargoes between a new port in Majis and Dubai is less than 93 TEUs/vessel, the new port in Majis could become a Hub Port.

(5) The collectability of container cargoes in Dubai is greater than other ports in the Arabian Gulf. Efforts to colect cargoes for a new port must be made in order to make the new port a Hub Port. But it is easer for the new port to become a Hub Port than Dubai from the viewpoint of location. Accordingly, there is a possibility of locating a new port in the Batinah coast as a transshipment base.

6.3.3 Industrial Port Function

14. In order to make the economy of the Sultanate more independent of the oil-based economy, the government of Oman has made efforts to promote non-oil industries for the past two decades.

The first policy is to promote import substitution industries, such as a petroleum refinery, and cement factories, while the second policy is to develop industries based on indigenous mineral resources, such as a copper mine. Thirdly, the government has made a plan to develop Industrial Estates to promote the manufacturing sector. In order to make progress in industrialization, the government has commissioned various feasibility studies, but clear conclusions have not yet been obtained.

The developed industries in the Rusayl Industrial Estate import various kinds of materials and even export their products because the market in Oman is not big enough for it to be economical to build factories on a scale that can easily fulfill the domestic market in Oman. So it is very important to develop industries especially in the new Industrial Estates, taking into account both import substitution and export promotion.

15. To develop import substitution industries, materials of half-finished goods must be imported before the related industries can be developed in Oman. Accordingly, it is very important to develop a new port in the vicinity of the envisaged new Industrial Estates.

After the related industries which produce half-finished goods have been well developed in Oman, the need for heavy industries which produce basic products will be considerable. At that stage, feasibility studies to introduce heavy industries should be implemented. The feasibility studies to utilize the minerals available in Oman should be continued, but it is not clear whether they are economically feasible projects. The results of the feasibility study examined by Shell Corporation are not clear to the Team, but they seem to be encouraging, based on our examination.

Other feasible industries are fish-related and light industries.

16. The policy of attracting foreign investors that the government of Oman is now undertaking should be continued and encouraged. The policy will be useful in terms of stimulating foreign investment because industrial investment from overseas will become a leverage for technology transfer and transfer of management skills. The policy to establish free trade zones in the vicinity of port areas is one of the best policies in terms of attracting foreign investment in Oman. The potential for FTZ(Free Trade Zones) shall be examined in the next section

The policy of developing industries in vicinity of some local centers should be continued in future, because the concentration in the capital area of Oman will not only create some problems,such as traffic conggestion and high real estate prices, but also inefficient land utilization in rural areas.

There are many policies and strategies that can be used to convert the economy of the Sultanate of Oman from an oil-dependent economy to one based on various industries. These will also be promoted in the future.

17. Judging from the government's policies and strategies and the on-going projects in Oman, the industrial sectors which should be studies in the future are found to be as follows:

a. Industries Based on Indigenous Mineral Resources

18. The government of Oman is promoting the development of indigenous mineral resources in Oman. In 1990, a world ophiolite seminar was held in Muscat. At the seminar, some reports suggested that there is a

possibility of finding precious mineral depots in Oman. There have been many discoveries of mineral resources in Oman, but most mineral deposits are still at the research level. So far, only industrialized mine is a copper one, and it is estimated that its reserves will be consumed within 10 years at the most. The government is now studying the possibility of developing chromite in the vicinity of the copper mining corporation from the viewpoint of economic viability.

b. Industries Based on Natural Gas Resources

19. The government of Oman commissioned a feasibility study from the Shell Corporation to examine utilizing natural gas resources. The detailed results were not given to the Team but the project to produce fertilizer and methanol, etc., seem viable and also a natural gas separation plant seems necessary.

c. Agro-related Industries

20. The government of Oman intends to upgrade the agricultural and livestock sectors. The other JICA team is now carrying out a study on agricultural development in Oman. The result of their development plan are not yet available to the Team. The fish-processing industry is one of the sectors in Oman for which there are great hopes. Agro-related industries in Oman have good potential. Cooperative organizations such as farmers' and fishermen's co-operatives are recommended in order to upgrade and modernize the agricultural and fishery sectors. It is recommended that distribution centers for agro-related products be located in the vicinity of the new port.

d. Other Industries

21. There are various kinds of traditional industries in Oman. A large number of skilled artisans are scattered all over the country. Their skills could be integrated for the industrialization of Oman. The traditional industries are wearing industries, pottery industries, farming tools manufacturing, blacksmithing, the non-ferrous handicrafts industry, grass mat weaving, wooden handicrafts and wooden shipbuilding.

Metal-working technology is the base of all manufacturing and processing industries. Unless this subsector is developed, industrialization may not be achieved. The potential metal-working industries are the casting industry, the forging and tool-making industries, the metal fabrication industry, the electric appliances repairing industry and the ship repairing industry.

6.3.4 Free Trade Zone Function

22. By introducing free trade zones, the trade potential of export-oriented industries can be expected to increase. The various benefits that are likely to be created in Oman are as follows:

(1) Promotion of Export-Oriented Industries
(2) Diversification of National and Regional Economies
(3) Regional Development
(4) Incresed Employment Opportunities
(5) Improvement of Technical and Managerial Skills
(6) Technology Transfer
(7) Improvement of Accessibility of International Markets
(8) Direct Generation of Wealth such as
  a. Income from Port Charges Including Cargo Handling Charges
  b. Income from Rent of Land and Facilities
  c. Income from Utility Consumption of Electricrty, Gas and Water
  d. Generation of Additional Foreign Exchange Earnings.

But introducing FTZs should be handled very carefully in order not to depress the existing domestic industries. Thus the strategies of giving incentives to potential investers to free trade zones and domestic potential investors should be carefully examined.

23. Although there are lots of issues to be solved, the potential for free trade zones in the Northern Part of Oman might be high because of the following advantagaes:

(1) The Northern Part of Oman is located at the entrance of the Arabian Gulf. It is very convenient for approaching Iran and Iraq.
(2) The Sultanate of Oman is politically stable and there seems to be no risk to investment.
(3) There are not so many export goods compared with the amount of imported consumer goods and space for exports by sea to Europe and the Far East is available at a comparatively low cost.
(4) There is a well-developed international airport and a good highway along the Batinah Coast. It is very easy to approach the airport

within 2 hours.

24. The potential industries in a free trade zone in the Northern Part of Oman are as follows:

1) Entrepot Trade as Transshipment, Re-export

a. Food-Related Production Distribution Centers such as Cereal and Cereal Products and Beverage (Including the Expansion of the Existing Flour Mill)

b. Petroleum Products Distribution Centers

c. Iron and Other Metals distribution Centers

d. Chemical Products Distribution Centers

e. Distribution Centers for Various Kinds of Machinery

2) Export Processing

a. Derivative Petrochemical Industries such as manufacturing Using Synthetic Resins and Rubber

b. Iron and Other Metal Manufacturing

The introduction of free trade zones seems to be very beneficial and Oman has good potential in this respect. A well-developed new port should be equipped with good infrastructure and utilities such as electricity, gas and water.

6.3.5 Fishery Port Function

25. The Oman Gulf is abundant in various kinds of fishes. This is very clear from the fact that Korean fleets are now catching fish in the Oman Gulf.

The Omani fishery industry remains a traditional inshore fishery using small boats. It is necessary to change from traditional fishing to modernized fishing, that is, the introduction of deep-sea fishing would be very beneficial for Oman.

The increase of fish exports, including processed fish, is expected in the future. Increased in frozen fish exports can be expected with the introduction of modern freezing equipment. The potential to establish fish processing plants in the Northern Part of Oman seems very high.

6.3.6 Other Functions

26. We can imagine various other functions for ports. Ship repairing, passenger terminal, berthing facilities for small recreation boats and working vessels, marine promenades and marine parks, a bunkering facility, a water supply for vessels and offshore oil platforms, ship chandlers, etc., are some that come to mind.

1) Ship repairing functions should be taken into account in a small scale. Repairing big ships may not be possible, considering the existing huge ship repairing facilities in Dubai and Bahrain.
   Reparing middle class ships such as 3,000DWT ships may also not be possible, because slipways for small ships can not be used for repairing the middle class ships and dry dock facilities, of which cost amounts to over one million R.O, are required.
   In view of gathering the scattering facilities owned by various Government organizations and fisheries, and taking into account the locational advantage, further consideration should be given to the ship repairing facilities some time in future.

2) Passenger terminals might be possible, considering the close location to Iran. But the relationship between two countries is not still clear. And the passenger terminals should be planned at first at Mina Qaboos, when the demand becomes clear. So this function shall be excluded in the master plan, but space for possible expansion will be taken into consideration.

3) Berthing facilities for small recreational boats and working vessels may be taken into consideration. But the demand forecast for small recreational boats is very difficult to make at present. And the priority for such facilities is with mina Qaboos. So the area for expansion is taken into consideration in a new port. The facilities for working vessels shall be examined.

4) Marine promenades and marine parks shall be treated as part of the environmental aspect of the industrial zone's development.

5) Bunkering facilities and other supply should be taken into consideration. But the supply of offshore platforms will not be taken into consideration, because the feasibility of off-shore oil production is not clear at present.

6.4 Allocation of functions between Mina Qaboos and a New Port

27. The schedule of respective ports is as follows:

(1) 1991 to 1995: This will be the period for the improvement of Mina Qaboos and the preparation of a new port.

(2) 1996 to 2000: This will be the period for the utilization of Mina Qaboos and the construction of a new port.

(3) 2000: The new port will mainly handle the overflow of cargoes from Mina Qaboos. Mina Qaboos will be handling the same kinds of cargoes as present.

(4) 2015: This is the target year of a master plan of a new port. The functions of the respective ports are considered to be as follows:

1) Import cargoes will be handled in both ports.
2) Export cargoes will be also handled in both ports.
3) Transshipment cargoes will also be handled in both ports, but in order to handle more import and export cargoes in Mina Qaboos, a policy of giving up transshipment cargo handling in Mina Qaboos might be considered. Nevertheless, judging from the present combination of container movements for each ship call, the container ships which are carrying only transshipment containers are 3.2 percent of 436 calling ships and 51.7 percent ships are carrying transshipment and import/export containers. So, it is very difficult to allocate only transshipment containers to a new port, some of import/export containers will also be allocated to the new port and the container volume at Mina Qaboos will be half of the allocated volume.
4) Industry-related cargoes will be handled in both ports. But it seems very difficult for Mina Qaboos to handle cargoes generated by heavy industries because of the lack of open space for the development of heavy industry.
5) Cargoes generated for free trade zones shall be allocated to the New Port because there are no available open spaces for free trade zones in the vicinity of Mina Qaboos.
6) There are various kinds of bulk cargoes, as follows:

a. Wheat is handled by the Oman Flour Mill Corporation. They intend to use 50,000 DWT type carriers, but it is impossible to berth 50,000 DWT type carriers at berth No.3 in Mina Qaboos. The Oman Flour Mill Corporation expanded the capacity of the silos in Mina Qaboos in 1989 from 60,000 tons to 120,000 tons. So there are two alternative ways of handling wheat: only at Mina Qaboos or at both ports.

b. Logs are carried by rather large vessels in Mina Qaboos. Logs should be dealt with mainly at the New Port, which has a big space around the port area. But the purpose of log imports is for producing consumer goods, so they will be handled at both ports.

c. Steal is not a bulk cargo, but imports of steel are very much related to the various functions of the new port. It is very important to import steel to upgrade various industries in Oman, such as the industries which have already developed on the Rusayl Industrial Estate. So steel must be handled at both ports, but heavy cargoes should be treated in the new port, which will have deeper berths than Mina Qaboos.

d. Imports of petrochemical products will be handled in both ports, but export cargoes will be handled in the new port.

e. After establishment of a fertilizer plant, imports of fertilizer will decrease. But if imports of fertilizer continues in future, the cargoes will be handled at the new port. Export fertilizer cargoes will be handled in the new port.

f. Bulk cargoes should be handled principally at the new port.

7) Fishery-related cargoes will be handled at both ports. But unloading of fish from the deep sea fishery will be carried out at the new port.

8) The base port of His Majesty's Vessel will continue to be Mina Qaboos, but we will take into account of the usage of the new port by Royal fleets.

9) Large scale ship repairing facilities would not be viable in Oman. But small scale ship repairing facilities should be furnished at the New Port.

10) A passenger terminal for passenger boats and ferry boats between Oman and Iran might be needed in future

Functional allocation between Mina Qaboos and the New Port is summarized in the following table:

Table 6-4-1 Functional Allocation between Mina Qavoos and New Port

Functions	Mina Qaboos	New Port
1)Import Cargo Handling		
a. Break Cargo	X	X
b. Container Cargo	X	X
2)Export Cargo Handling		
a. Break Cargo	X	X
b. Container Cargo	X	X
3)Transshipment		
Mainly Container Cargo	X	X
4)Industry Related Cargo		
a. Light Industry	X	X
b. Heavy Industry		X
5)Free Trade Zone Related Cargo		X
6)Bulk Cargo		
a. Wheat	X	X
b. Log/Timber	X	X
c. Steel(Light)	X	X
(Heavy)		X
d. Petrochemicals(Import)	X	X
(Export)		X
e. Fertilizer(Break Bulk)		X
(Bulk)		X
f. Others		X
7)Fishery-Related Cargo		
a. Coastal Fishery	X	X
b. Deep Sea Fishery		X
8)His Majesty's Vessel	X	X
9)Ship Repairing		
a. Small Craft		X
10)Passenger		
a. Passenger Boats	(X)	(X)
b. Ferry Boats		(X)
11)Small Boat		
a. Working Boats	X	X
b. Recreation Boats	(X)	(X)
12)Bunkering Facilities		
a. Bunker Oil	X	X
b. Supply for Vessels	X	X
c. Offshore Supply		(X)
13)Marine Park etc.	X	(X)

Note: Marks in parentheses show that the functions will not be included in the master plan in 2015 and should be planned when the demand of the functions becomes clear.

6.5 New Port Development Policy

28. 1) Through the analysis of port functions, we have concluded that the new port must be planned by taking account of various functions.

2) As for major functions, the proposed port development policies are as follows:

a. Import Cargo Handling

i. A new port must function as a supplementary port for Mina Qaboos.

ii. Efforts to become independent of UAE ports must be carried out.

b. Transshipment

i. A new port must be equipped with well-developed container facilities to attract regular shipping liners.

ii. Aggresive marketing must be carried out by emphasizing to ship operating corporations the locational benefits of Oman.

c. Industry Port

i. A new port must be equipped with well-developed infrastructures, utilities and land necessary for industrial development.

ii. Efforts to develop the potential industries must be carried out.

iii. Feasibility studies to introduce heavy industries must be carried out.

iv. Import substitution industries must be introduced in the vicinity of the new port area.

v. Not only industries based on indigenous mineral resources but also processing industries must be promoted.

vi. Industries based on natural gas resources must be promoted.

vii. Measures to strengthen the agro-related sector must be carried out.

d. Free-Trade Zone

i. A new port must be equipped with free trade zones.

ii. Efforts to introduce overseas corporations to the free trade zones must be carried out.

iii. The measures to harmonize the corporations in the free trade zone with the domestic industries must be carried out.

e. Fishery Port

i. A new port must be equipped with fishery port facilities necessary for the deep sea fishing and fish processing industries.

ii. Measures to strengthen the fishery sector must be carried out.

6.6 Site Selection of a New Port

29. We selected the following new port development site alternatives at first:

a. Majis

b. Sohar

c. Saham

d. Khaburah

e. Suweiq

f. Masnaah

g. Murayasi

h. Haradi

i. Quriyat

j. Sur

k. Other sites(k.Shinas, l.Liwa, m.Azaiba, n.Bandar Jissah, o.Bandar Khayran and p.As Sifah)

Based upon the criterion of space availability, we excluded the following sites: b.Sohar c.Saham n.Bandar Jissah o.Bandar Khayran p.As Sifah

Based upon the criterion of rock exposure, we excluded the following sites:

e.Suweiq j.Sur

Based upon the criterion of location, we excluded the following sites:

k.Shinas l.Liwa(Too close to UAE)

m.Azaiba(Too close to Muscat)

Other sites that seem to be suitable for new port development are as follows:

a.Majis d.Khaburah f.Masnaah g.Murayashi h.Haradi i.Quriyat

30. The revised cost estimation for Quriyat subject to the construction cost of dredging and 2,500m long quay wall and breakwater is 115.4 million RO. This does not include the cost of the associated road works. The cost for the associated road works is estimated by Maunsell Consultants as 169.9 million RO. The comparable cost for a new port in Quriyat with the above table is 285.3 million RO. Accordingly, the site of Quriyat should be excluded.

From the cost comparison, the cheapest site is Majis, followed by Haradi.

The following table shows the comparison of Majis and Haradi from the future port functions:

a.Import Cargo Handling	Majis is more economical than Haradi.
b.Transshipment	The locational potential of Haradi is a little bit greater than that of Majis. The locational advantage of Majis is still big. The new port in Haradi might become competitive with Mina Qaboos.
c.Industrial Development	The new port in Majis is very effective for regional development. The new port in Haradi can not give incentives to regional development.
d.Free Trade Zone	Both Majis and Haradi have a high potential for being developed as trade free zones. A free trade zone in Majis would provide good incentives to regional development.
e.Fishery Port	Majis has a higher labour force potential than Haradi. Majis has a higher marketing potential than Haradi of raw fish exports.

Therefore, we would like to recommend Majis as the best new port site. The following figure shows the summarization of selecting procedure.

New port development site alternatives	1.Space Availability	2.Rock Exposure	3.Location	4.Cost Comparison	5.Import Cargo Handling	6.Transshipment	7.Free trade zone	8.Fishery port	9.Industrial Development
a.Majis	○	○	○	◎	◎	○	○	◎	○
b.Sohar	×								
c.Saham	×								
d.Khaburah	○	○	○	×					
e.Suweiq	○	×							
f.Masnaah	○	○	○	×					
g.Murayashi	○	○	○	×					
h.Haradi	○	○	○	○	○	◎	○	○	△
i.Quriyat	○	○	○	×					
j.Sur	○	×							
k.Shinas	○	○	×						
l.Liwa	○	○	×						
m.Azaiba	○	○	×						
n.Bander Jissah	×								
o.BanderKhayran	×								
p.As Sifa	×								

Fig. 6-6-1 Site Selection of a New Port

6.7 Environmental Aspect

When a large project, due consideration should be given to environmental aspect, and in this regard frola and fauna should be attached to a particular importance.

The study team visited the proposed site of a natural reservation area on Jun 21st, 1990, and took photographs at the place where is about one km west of the existing jetty. The following photographs show the present situation of the site.

Photo. 6-7-1 Present Situation at Majis

As the photograph apparently shows, there is no mangrove at the project site, and a long jetty exists already. These facts give enough reason to judge that impact to the environment is very small.

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Chapter 7 FUTURE DEVELOPMENT PLAN OF MINA QABOOS

7.1 Development Strategy

1. 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.

7.2 Evaluation of the Existing Development Plan of Mina Qaboos

7.2.1 Review of the Existing Plan

2. 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.

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.

3. 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

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

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

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.

(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.

(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 compared with the expandable quay length. The revised cost estimates are listed in Appendix 6-2-1.

7.3 Zoning

4. It is very apparent that large-scale countermeasures, such as reclamation of water area, are inevitable in terms of overcoming the lack of space of Mina Qaboos. 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

5. Fig. 7-3-1 shows the zoning of the port's land area schematically. In this scheme, the following aspects are taken into consideration:

(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. 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. However, from the perspective of the port's cargo handling capacity, the berths used for the abovementioned 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.

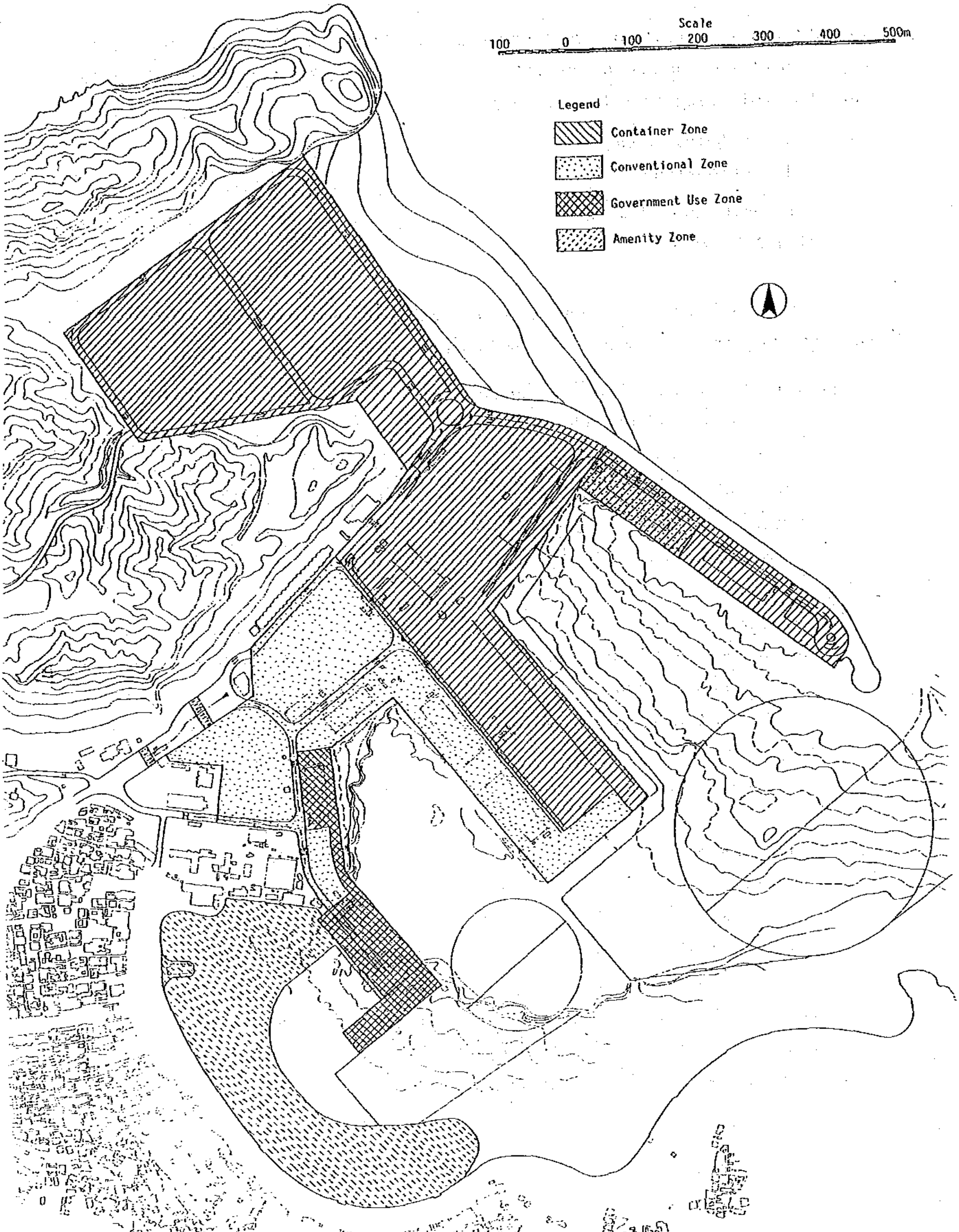


Fig. 7-3-1 Zoning of Mina Qaboos

7.4 Berth Use Plan

7.4.1 Cargo and Berth Characteristics

6. The result of commoditywise traffic demand forecast are shown in Table 7-4-1. 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 2 should be converted to multipurpose berths, as shown later, to respond to these situations.

Table 7-4-1 Result of Commoditywise Traffic Demand Forecast

Year / Commodity	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)	1,156.2 ('000Ton)
	236,646 (TEUs)	348,524 (TEUs)

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.

7. 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 more in detail in 7.6.6.

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.

7.4.2 Berth Use Allocation

(a) Cargo Allocation

8. Cargoes in 1995 and 2000 are allocated to each berth as shown in Tables 7-4-2 and 7-4-3, respectively. 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

Table 7-4-2 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		400.0	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	61,000.0	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	69,700.0	300.0	229	76.0	1	3	8	1,824.0	0.1	0.2	68.6	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	400.0	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		400.0	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		400.0	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		400.0	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		400.0	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		400.0	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		400.0	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	108,500.0	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	68.6	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	400.0	38	61.0	1	3	8	1,464.0	0.1	0.3	15.7	365	0.5
	G. Cargo	209,700.0	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 7-4-3 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	70,560.0	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	29.0	365	8.2
	Timber	40,800.0	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	10.7	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	35.0	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	10.7	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	184549	276.0	668	25.0	2	3	8	1,200.0	0.1	0.21	293.9	365	18.0
	Other Use	0.0		0										9.4
	(Total)			1,326										34.5

※ Only cargo-related berth occupancy is shown.

cannot be evaluted as two different berths because large ships cannot berth simultaneously due to the shortness of these berths. And also, a considerable amount of berth occupancy by non-commercial ships 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.

(b) Queuing Simulation

9. 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. 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. Table 7-4-4 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.

(c) Berth Use Allocation in 1995 and 2000

10. 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. Hence cargo allocation between Mina Qaboos and the New Port is set as shown in Table 7-4-5. Berth use allocations in 1995 and 2000 are already shown in Tables 7-4-2, 7-4-3, 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 Bulk Grains carriers and 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 7-4-2 and 7-4-3.

After making a shift of royal fleets from Berth No.6 to a new berth, the berth occupancy rates 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.

Table 7-4-4 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 7-4-5 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)

7.5 Land Use Plan

7.5.1 Land Use of Existing Area

11. In terms of total available land area, about 5,600m^2 of area will increase, as shown in Table 7-5-1. 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 7-5-1 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

7.5.2 Required Land Area in 1995 and 2000

(a) Characteristics of Cargo Movement

12. 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 7-5-2, based on the analysis of Mina Qaboos' cargo data.

Table 7-5-2 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%

(b) Required Land Area

13. The area required for each storage mode is shown below. Formula and data for calculation are appeared in Vol. II. 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 7-5-3. 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.

Table 7-5-3 Relation between Required Area and Available Area

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

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

7.5.3 Reclamation of Shutaify Bay

14. 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.

7.6 Facility Plan

7.6.1 Cargoes and Calling Ships

(a) Cargoes

15. 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 7-4-5

(b) Calling Ships

(1) Conventional ships

16. 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. Therefore, in this study it is assumed that the distribution of conventional ships will not change by the year 2000.

(2) Container Ships

17. 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

18. In this Study, it is assumed that the distribution of bulk grain carrier ships, Ro/Ro ships and livestock carrier ships, will not change in the future.

7.6.2 Traffic Flow in Port Land Area

19. The road alignment in Mina Qaboos is shown in Fig.7-6-1. 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.

7.6.3 Water Basin

20. The required dimension of dredging for channel, turning basin and slips are shown in Fig.7-6-2. The reasons for the requirement of each dredging operation are as follows:

(a) Dredging to -13m Depth

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.

Taking 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.

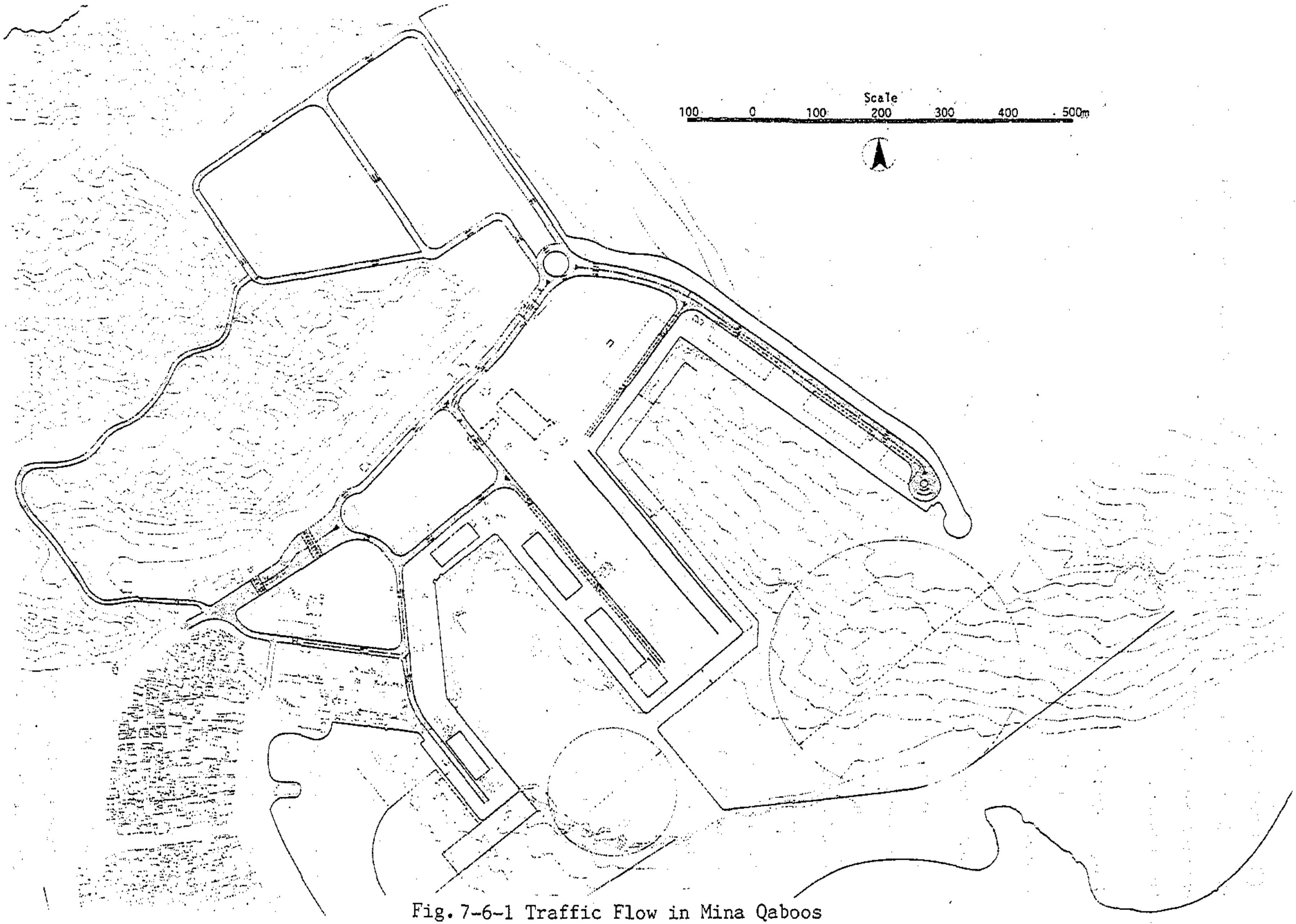


Fig. 7-6-1 Traffic Flow in Mina Qaboos

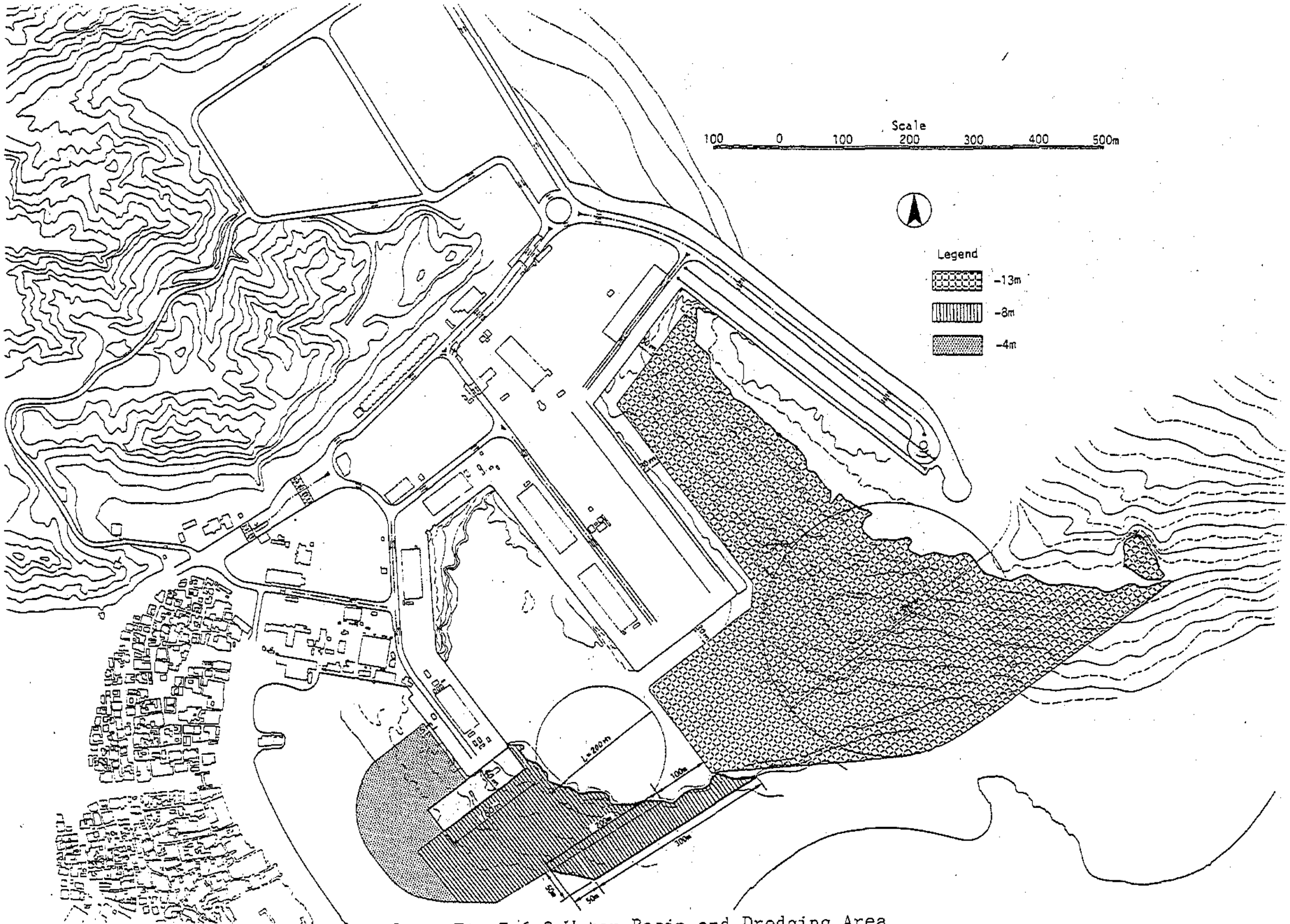


Fig.7-6-2 Water Basin and Dredging Area

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.7-6-2. Turning basin is dredged in order to accommodate ships with a maximum length of 260 meters. Hence with this dredging, Mina Qaboos will no longer be limited in terms of turning basin area.

(b) 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.7-6-2.

7.6.4 Container berth

(a) Layout Alternatives

21. With a view to laying out the effective container yard, we have studied the merits and demerits of three plans, namely, A, B and C on the basis of a transfer crane system.

A summary of the comparison is shown in Table 7-6-1. Economically, plan C is considered to be the best; there will be no difference between plan A and plan B.

The selected container allocation plan is illustarated in Fig.7-6-3.

Table 7-6-1 Comperison 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

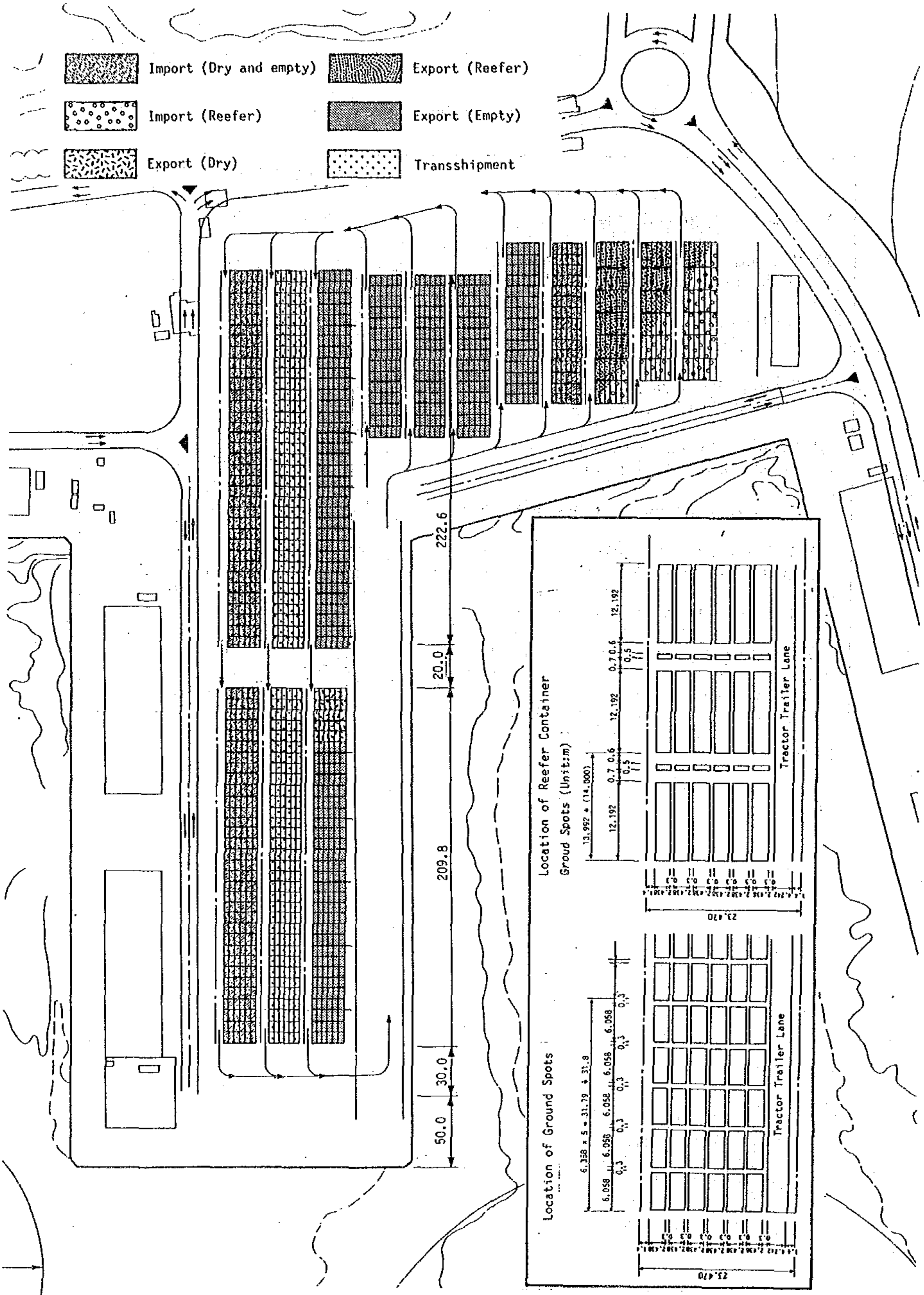


Fig. 7-6-3 Allocation of Containers

(b) Allocation of Container Stacks

(1) Number of containers to be stored

22. 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. The summary of these numbers is shown in Table 7-6-2.

Table 7-6-2 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.

(c) Marshalling Yard behind Berths Nos.3, 4 & 5

(1) Required Slots and Storage Capacity

23. 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 7-6-3 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.

Table 7-6-3 Storage Capacity of Berth Nos.4 & 5

	storage capa(TEUs)	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 capa(TEUs)	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 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

24. The number of ground spots allocated for each container handling 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 7-6-4.

Table 7-6-4 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.

(d) Layout of Container Yard

25. Cross-sections are illustrated in Fig. 7-6-4 and 7-6-5. 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 arranged in parallel 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.

7.6.5 Multipurpose Berth

(a) Concept of Facility Layout

26. 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. In order to use the yard space efficiently for on 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 because of its limited land area and the container stockyard for this Berth will be developed on Shutaify Bay. The layout of the facilities at the multipurpose berth is shown in Figs. 7-6-6, 7-6-7.

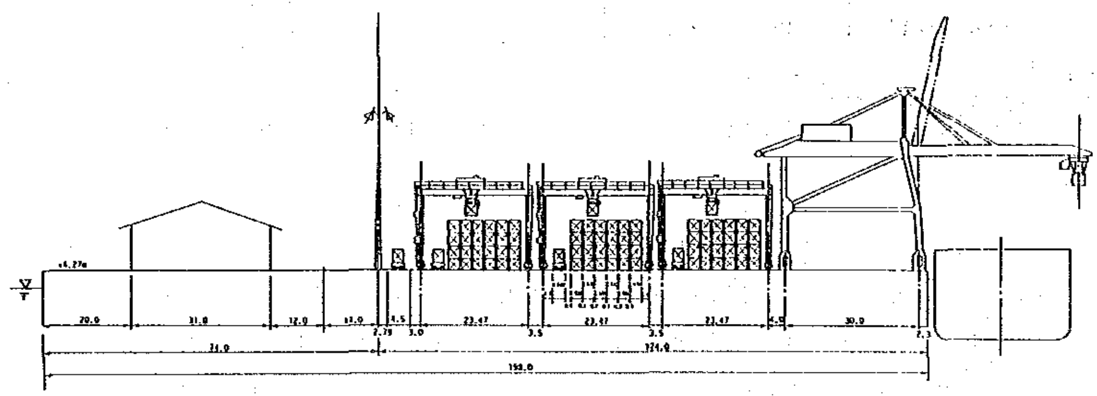


Fig. 7-6-4 A Cross Section of No.4, 5 Berth and No.7, 8 (Unit: m)

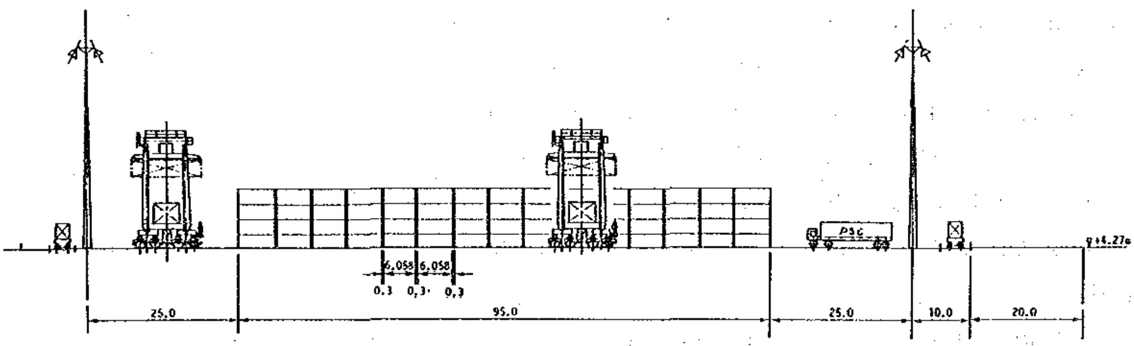


Fig. 7-6-5 A Cross Section of No.3 Container Berth (Unit: m)

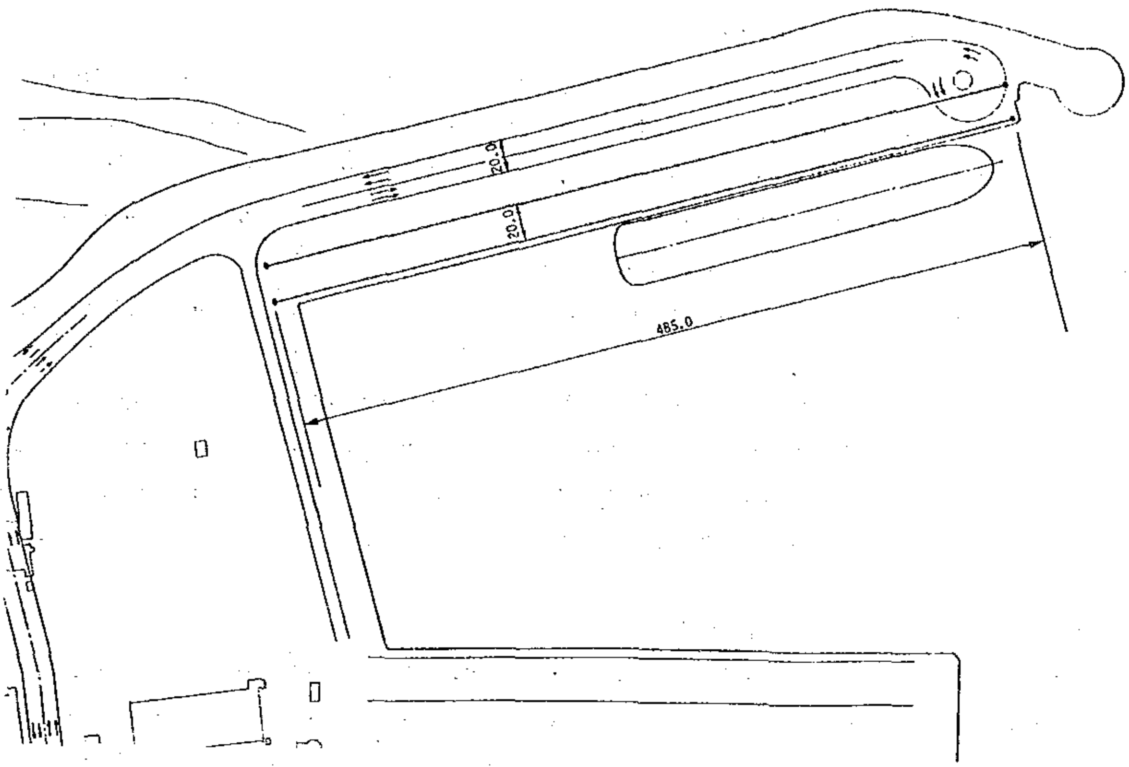


Fig. 7-6-6 Multipurpose Berth (Unit: m)

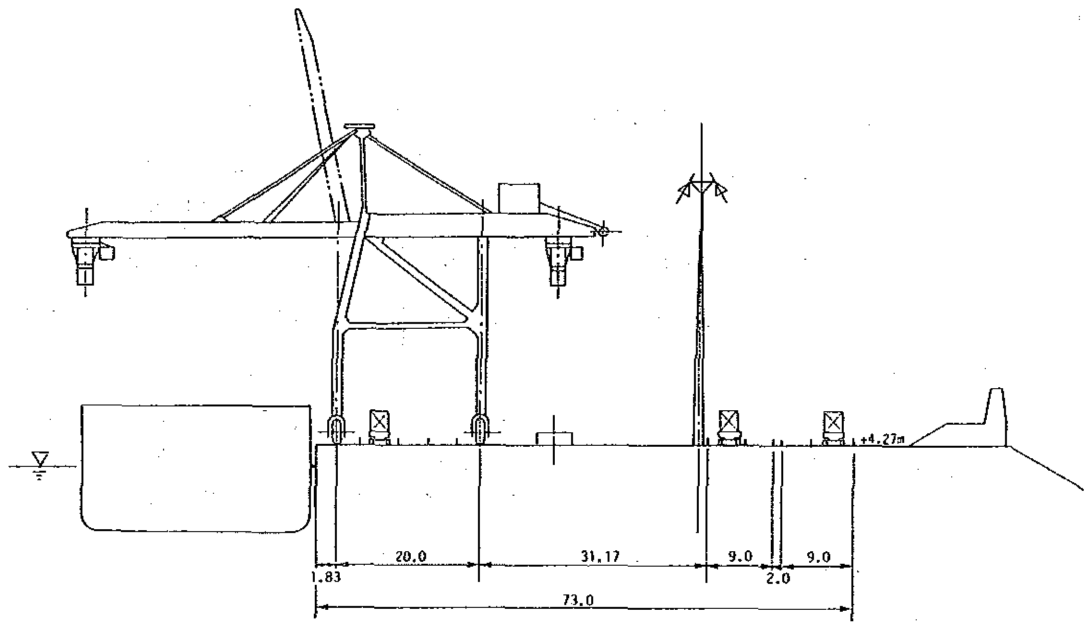


Fig. 7-6-7 A Cross Section of No.1 & 1A Berth (Unit: m)

(b) Container Freight Station

27. 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. 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. Import FCL containers to be unstuffed in the port are delivered to the consignees but are grounded and will stay in the port area until all the consigments are unstuffed, which are called as grounded containers.

(1) Expected Container Throughput at CFS.

According to gate control data in 1988, the available data base for 1989 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 containers. We assume these percentages will not significantly change until 2000. Estimated container and cargo throughput are summarized in Table 7-6-5.

Table 7-6-5 Estimatd 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

(2) Area and Dimension of CFS Area

a. CFS shed

Based on the cargo throughput and following specifications, we calculated the CFS shed area and found it to be 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 of the CFS becomes 50m x 113m.

b. CFS area inclusive of the shed and adjacent area

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.

c. Area reserved for grounded containers

On the other hand, 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

d. Comprehensive consideration

In the case of ground service containers being 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 other hand, 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.

(3) Type of CFS shed

As regards the type of CFS shed, there are ground and platform systems. Based on the recent CFS trend showing that terminals where straddle carriers are not used mostly adopt platform system, a platform system is recommended for this port.

(c) 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 will be set in the reefer container stacks for two high stacking. The following Table 7-6-6, shows the annual volume estimated to be handled in 1995 and 2000 at multipurpose berth, 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 illustrated in Figs. 7-6-8 and 7-6-9.

Table 7-6-6 Required and Available Ground Spots

summary	storage capa(TEUs)	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

summary	storage capa(TEUs)	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

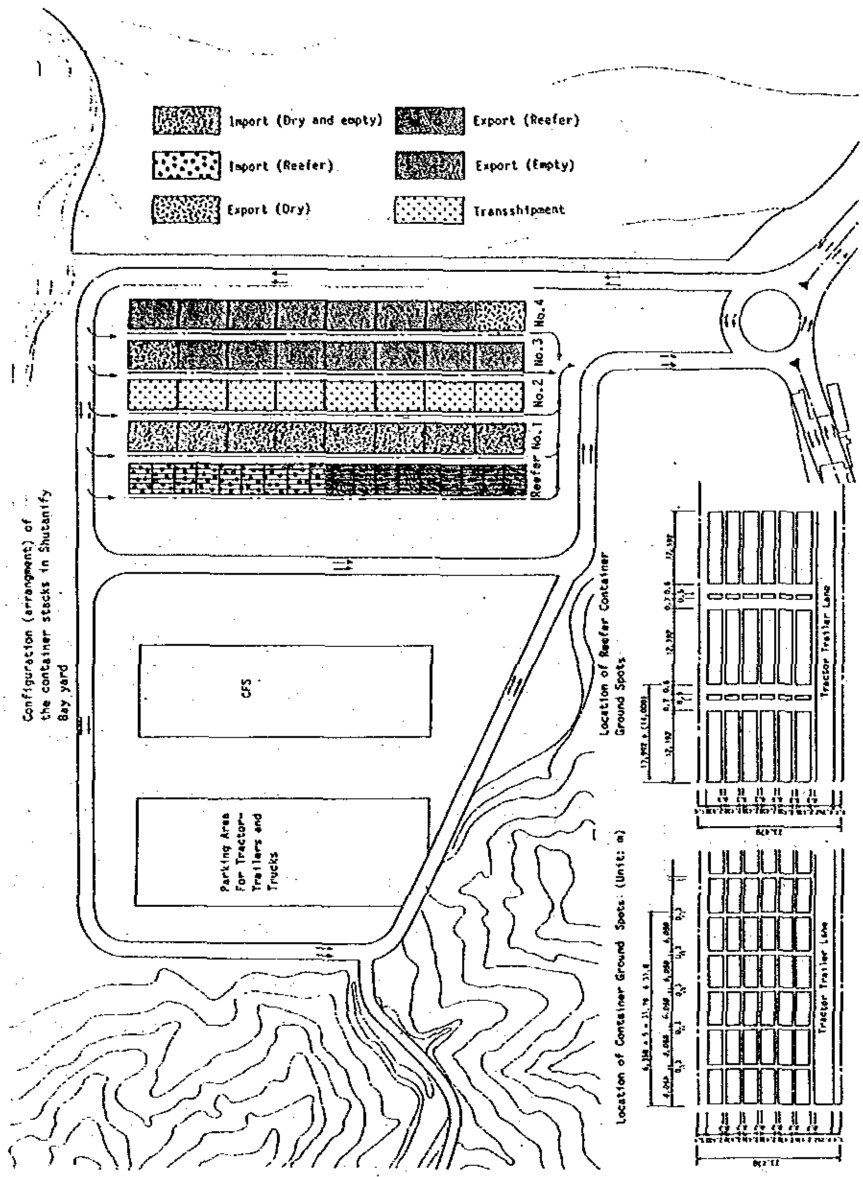


Fig. 7-6-8 Allocation of Containers

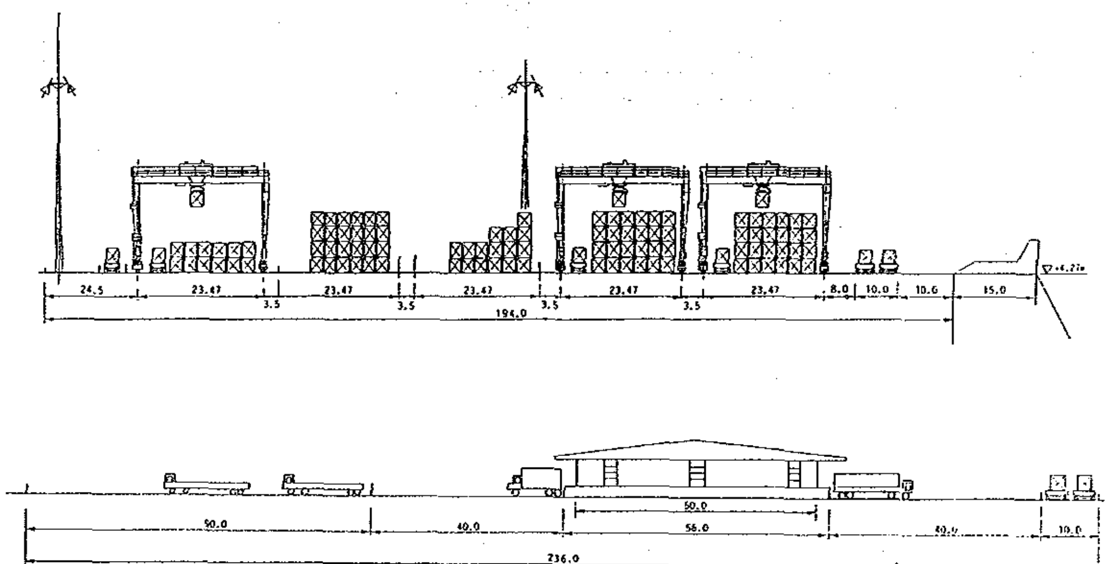


Fig. 7-6-9 A Cross Section of Shutaify Bay Yard (Unit: m)

(2) Allocation of container stacks

29. 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 7-6-7.

Table 7-6-7 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.

7.6.6 New Berth for the Royal Yacht

(a) Background

30. Royal Fleets are using Berth No.6, 11 and 12 at present. However, in view of the safety, security and convenience of the Royal Services. It may be better for all the Royal vessels being positioned in one place. In this respect, all the Royal fleet should be berthed the west pier which is now exclusively used for non-commercial purpose. This shift is also recommend able from points because it facilitates more orderly and effective land use plan proposed by the Report and the Royal procession can go through the southern gate in shorter distance without impeded by the flow of commercial lorries.

(b) Dimensions of Ships

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

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

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

(c) Location and Layout of New Berth

(1) Location

32. *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

33. 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

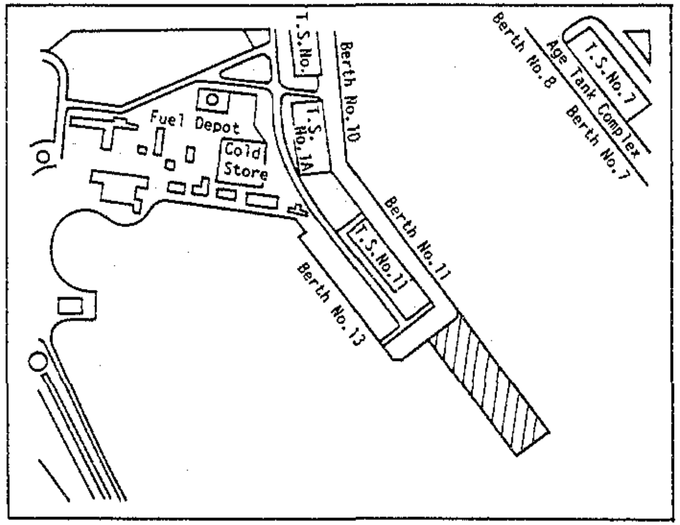
2 show that 99.7% of wave height throughout the year is estimated to be less than 0.5m around Berth No.12. Hence wave conditions in the vicinity of Berth No.12 are very good. Detailed results are shown in Chapter 2.

(3) Layout of Berth

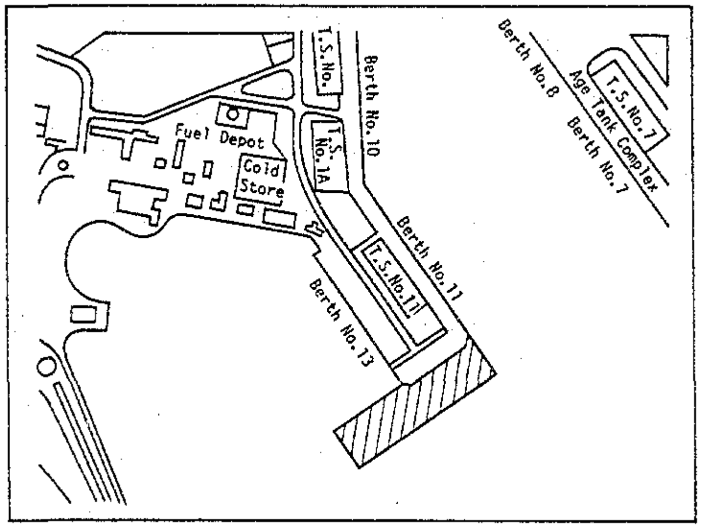
34. Fundamentally, only two alternatives are considerable concerning the layout of a new berth, as shown in Fig. 7-6-10(a). Comparison of these alternatives is shown in Table 7-6-8 . Except for item 1 of this table, no significant differences are found between these alternatives. Regarding item 1, namely 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.

Table 7-6-8 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. 7-6-10(a) Layout Alternatives of Royal Yacht Berth

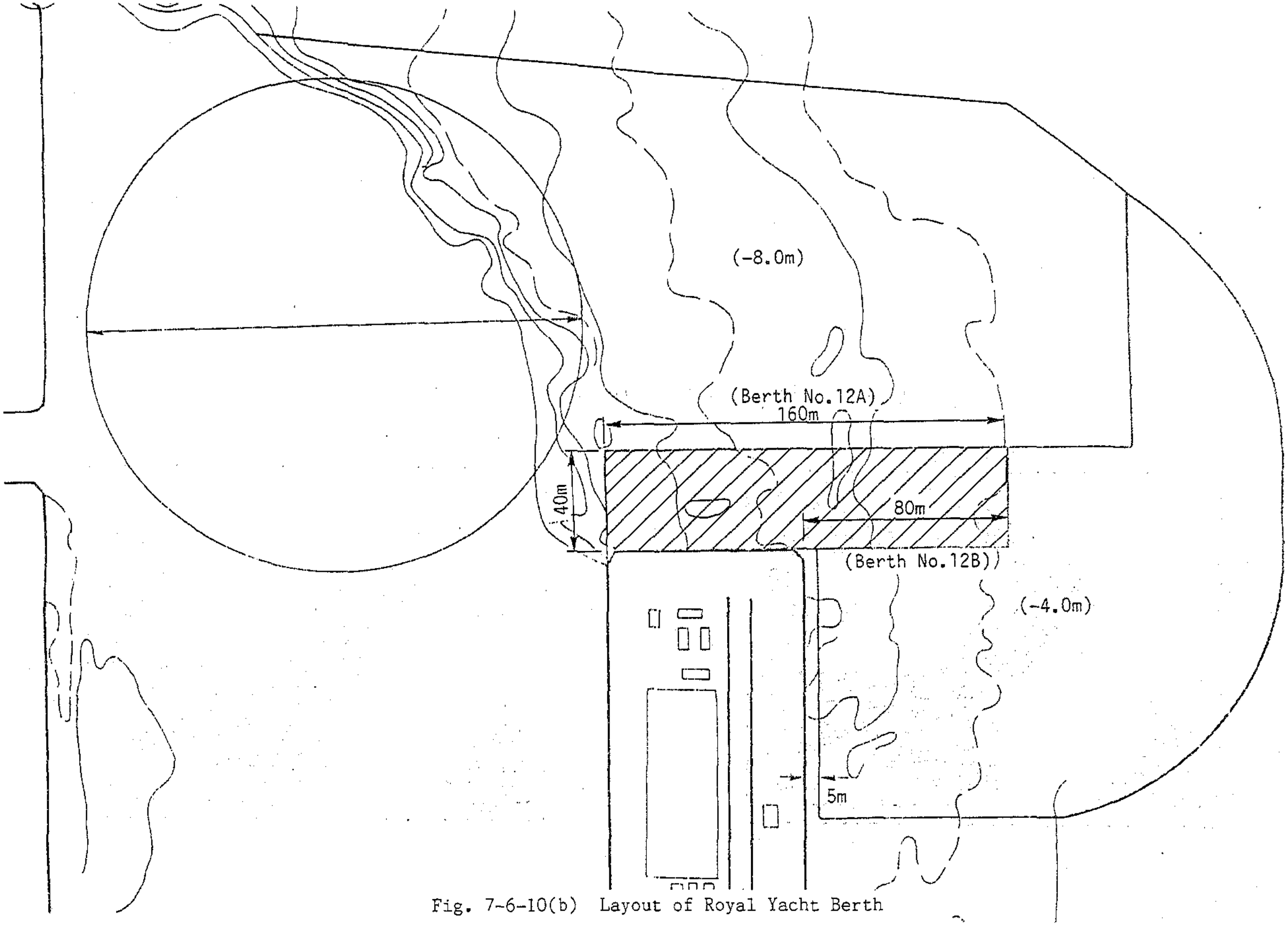


Fig. 7-6-10(b) Layout of Royal Yacht Berth

(4) Dimensions of New Berth

35. 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. 6-6-10(b). These berths are named Berth No.12A for the Royal Support Yacht and Berth No.12B for the Royal Dhow. For the dredging of waer basins, see 7.6.3(b).

7.6.7 Other Facilities

(a) Conventional Berths

(1) Berth No.3

36. Berth No.3 is to be used mainly by grain ships, however berth occupancy ratio of grain ships is not so high as shown in 7.4.2. Hence remaining capacity is available for the use of non-commercial ships. In CES report, extension of conveyer to Berth No.2 is proposed, however that plan is not proposed in this report because of following reasons;

(i) Multipurpose berth is fully used by container ships and larger size conventional ships, RO/RO ships and live stock ships. As already stated, there is no enough capacity to accommodate grain ships.

(ii) According to the demand forecast, the amount of grains is only 250,000 tons even in 2000, and expected number of ships is only about 18.

(2) Berth No.6

Berth No.6 is to be used for conventional cargoes as discussed in 7.6.6. In this berth, cargo handling yard and open yard are reserved as shown in Fig. 7-6-3.

(3) Demolition of Covered Storages

For the future use of land area, Transit Sheds Nos.1A, 1, 2, 3 and 4 are to be demolished.

(b) Cold Storage

37. According to the future demand forecast, the amount of chilled & frozen food stuffs will be 75,000 tons and 112,400 tons in 1995 and 2,000 respectively.

The area required is 2,350m^2, hence a cold storage facility with two stories (40m x 40m) is adequate to accommodate the above mentioned chilled & frozen food stuffs. This cold storage facility is to be built on the space next to Transit shed No.7. (see Fig. 7-6-3)

(c) Administration Office Building

38. For the staff members of the PSC, an administration building should be constructed including a yard control tower. Mina Qaboos consists of a conventional cargo area and a container area, and the building should be constructed where container movement can best be seen as well as in such a location as not to disturb cargo and container movement in the port area. The building should be equipped with a computer system and serve as a concentrated control center for any operation in the terminal. Furthermore, amenity facilities for staff members working in the port should be provided in place of the demolished rest house. The best site for the building is considered to be behind Berth No.3 near the corner of Berth Nos.2 and 3, with a 20m width and 40m length with three floors.

(d) Gate Facility

39. At the gate, documents necessary for handling containers and/or custody transfer are delivered, visual inspection of the containers and weight measurement are conducted, and at the same time, the drivers are instructed to which container stack they should go. In order to carry out this work smoothly, the gate must be separated for incoming and outgoing and the lanes needed should be prepared for the respective gates.

The number of lanes needed at the gate is shown in Table 7-6-9 below.

Table 7-6-9 Gate Capacity

	1995	2000
Max. daily throughput	263 boxes	248 boxes
Working hours	8 hr.	8 hr.
Gate capacity	10 boxes	10 boxes
Number of lanes for containers	4 lanes	4 lanes
Number of lanes for conventional cargo	2 lanes	2 lanes
	6 lanes	6 lanes

For the gate, functionally subdivided into incoming and outgoing it is necessary to arrange six lanes: four lanes for container traffic and two lanes for conventional cargo traffic, each equipped with a truck scale. At the gate, a computer work station operated on line with the control center should be installed. The gate clerk requests and/or is informed of necessary data on line from the control center through this work station.

(e) Electrical Power Station

40. There are three-sub stations on Berths Nos.2, 3 and 4 in the container zone. The electric power station should be moved to the foremer maintenance shop site.

(f) Lighting

41. Lighting must be provided to keep a brightness of an average 20 lux in the container zone to ensure for safety and smooth operations.

Future development plan of Mina Qaboos is shown in Fig.7-6-11.

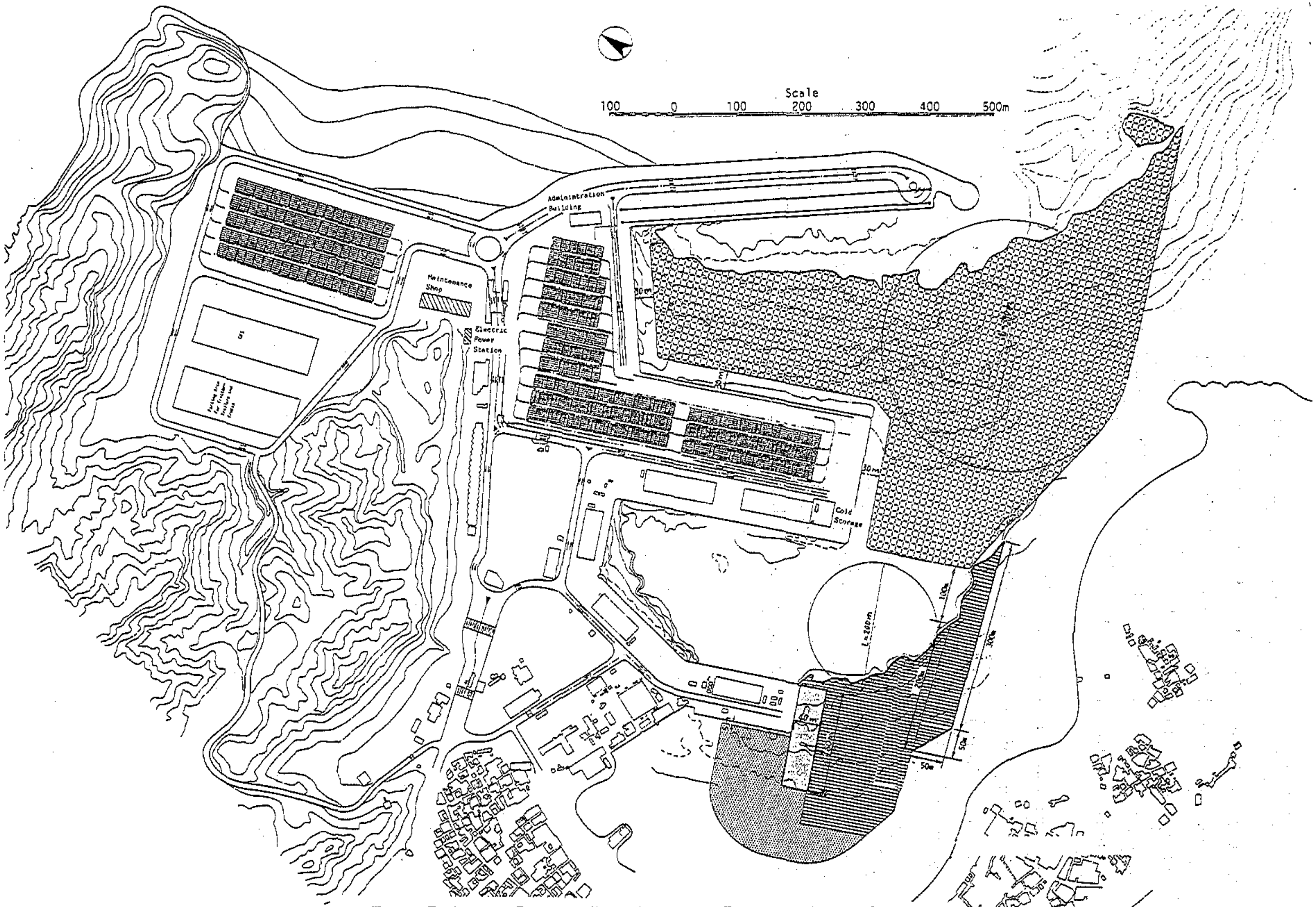


Fig. 7-6-11 Future Development Plan of Mina Qaboos

7.7 Operation System

7.7.1 Handling System

42. Chassis, straddle carrier and transfer crane systems are the handling systems now used in container yards but the chassis system is impracticable for Mina Qaboos Yard and we have studied the merits and demerits of other two systems as shown in Table 7-7-1.

From this analysis as well as the actual circumstances at Mina Qaboos, we consider a transfer crane system to be appropriate.

Table 7-7-1 Comparison of Handling Systems

	Transfer Crane Sytem	Straddle carrier System
(1) Maneuverability	normal	good
(2) Efficiency of container crane	normal	good
(3) Height of stack/land utilization	good	normal
(4) Facility of handling containers	normal	good
(5) Damage ratio of containers	good	normal
(6) Maintenance of machinery	good	normal
(7) Automation of operation	good	normal
(8) Training of drivers	good	normal
(9) Amount of investment (machinery)	good	normal
(10) Amount of investment(yard)	normal	good
(11) Kind/type terminal for which systm is best suited	more than 100,000 TEU mainly for LCL/empty containers	around 100,000 TEU LCL/FCL well balanced

7.7.2 Computer System

(a) Outline of Computerization

43. As mentioned in 3.5.11, planning of the container handling operations is still processed manually. Among these processes, LCL handling in the CFS is difficult area for computerization due to its mixture of containers and general cargo. On the other hand, Yard Location Planning and Stowage Planning are both popular in many container terminals in different ports of

the world. The target of stage III, Empty Container Movement, is therefore, to automate the selection of suitable locations for empty containers while stage IV, Shipping Operations, aims at computerizing planning for loading operations. However, possibility of expanding the present computer based container handling system to the greatest extent should be taken into consideration in order to maximize the utilization of existing system and streamline the present procedures such as sequencing of discharging and calculation of stevedoring charges before further development of system.

Despite of the abovementioned factors, the need for computerization of the container terminal will become more acute as container traffic increases. The container traffic in the port is increasing phenomenally. Thus deployment of a new container handling system is being seriously studied as a way of counteracting the extremely small amount of storage space, so that the port can accommodate the increased traffic volume. From the historical view, the degree and extent of computerization has generally been as shown in table 7-7-2 below.

Table 7-7-2 Degree and Extent of Computerization

	Approximate annual throughput	Terminal office operation	Yard operation
Level 1	～60000 TEU	manual	manual
Level 2	60000～150000TEU	computerized	manual
Level 3	150000TEU～	computerized	partly computerized
Level 4	～	computerized	computerized

Almost all the container terminals in the world fall under Level 2. Some in Europe, the U.S.A, and Japan have been proceeding toward Level 3. Mina Qaboos is now at Level 2. The basic concept of this level is that computerization of the terminal office operation should be developed inclusive of:

1) Yard control, container status control, gate control
2) Various planning/sequencing operations concerning container movement
3) Documentation

While the berth or yard operation is still manually carried out. Below we describe a typical framework for computerization of a terminal to Level 2.

(b) Terminal Control System

44. This system includes the following two major programs:

a) Marshalling yard control program

Function: Determination of export container locations
Determination of import container locations
Determination of change of locations, instruction and revision of them
Storage container list inclusive of container locations and status

b) Gate control program

Function: Inbound container control
Outbound container control

For maintenance and the computer file, yard planners input the data into the computer system based on booking lists, stowage plans and other documents that are sent by the shipping company and/or obtained at the time of delivery or receipt of containers at the gate. According to this data, yard planners using this system can allocate spaces in the marshalling yard for containers according to their specifications; numbers, kinds, dimensions, ports of destination weight, etc. Once these files, on container location and status are established in the system, it is easy for yard planners to output required information and instruct all personnel concerned by means of an on line computer system and/or a yard communication system.

(c) Terminal Planning System

45. This system includes the following three major programs:

a) Loading schedule program

Function: Inputting and filing the number of loading containers and their status for a specific vessel. Preparing preliminary plans, a bay plan, a stowage plan, a schematic plan, a sequence checklist, etc. Finalization/revision of preliminary plans. Calculation of weight, height of center

of gravity of the ships and cargo combinations and monitoring and others.
Monitoring of operation.

b) Discharging schedule program
Function: Inputting and filing the number of containers discharged and their status from a specific vessel. Preparing preliminary plans, a schematic plan, a sequence checklist and rehandling list. Finalization/revision of preliminary plans.
Monitoring of operation.

c) Program for optimal handling equipment procedure.

46. The loading schedule plan is prepared on the basis of the information in relation to the export container location in the marshalling yard which can be generated by the concerned program as well as by the stowage plan sent by the shipping company. Discharging container information is also important because of the spaces occupied by such containers are usually scheduled to be loaded. A stowage plan is prepared with program a) on the basis of specifications for containers such as their dimensions, kinds, ports of destination, weight etc., and a check of the ship's stability is simultaneously carried out, using a related program. Optimal procedures of yard handling equipment will be decided on the basis of stowage plan and export container location. Bay plans, sequence of handling equipment and other necessary plans are prepared using related programs. The sequence checklist is printed out and distributed to key personnel. A terminal operator monitors the operation with the necessary plans displayed on a CRT. The drivers of each piece of equipment report on the completion of each sequence using the yard communication system. The discharging schedule is prepared in the same way as the loading schedule.

(d) Documentation System
47. The system finalizes all the information processed and/or developed in the systems described previously. Preparing documentation to submit to the parties concerned and filing the necessary information for port statistics can be carried out with this system.

The outline of the total computer system in each area and the whole area can be referred in Fig 7-7-1.

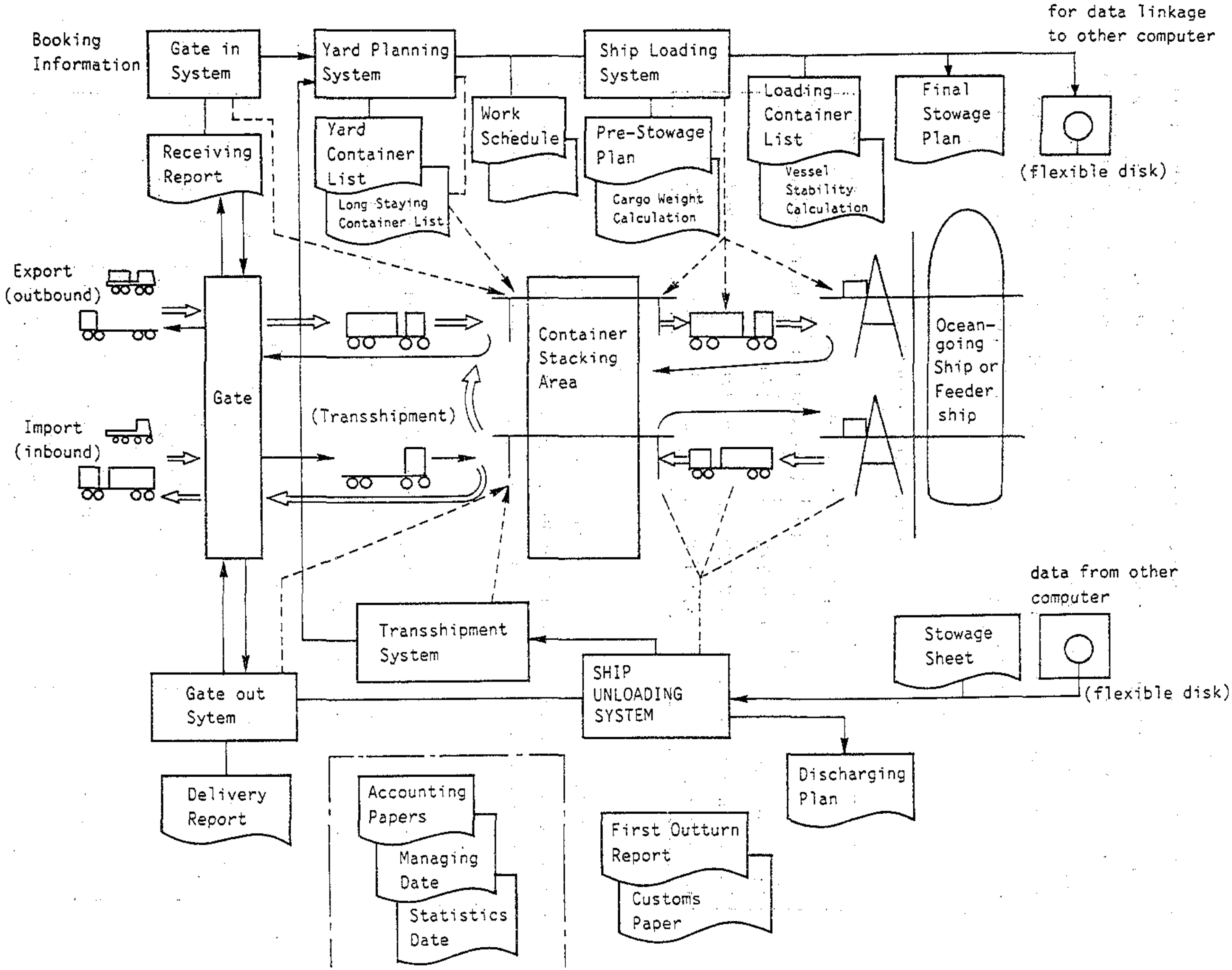


Fig. 7-7-1 Out Line of Total Computer System of a Terminal

7.7.3 Man Power

7.7.3.1 Conventional Cargo Operation

(a) Productivity

48. At present, on the shift-day, 7 gangs are available, and on the shift-night, 5. The make-up of each gang was mentioned in 3.5.3. One gang's handling capability per hour is reported in 3.5.2. On the other hand, with a view to limiting the waiting time of incoming vessels within an acceptable time, improvement of handling capability is absolutely necessary. The following are the targets in respect of three kinds of cargo:

Table 7-7-3 Targets of Productivity

	Productivity expected in 1995		
	Present rate	Expected rate	Improvement ratio
Steel and pipes	23.3 T/H	30 T/H	29%
Timber and plywoods	23.9 T/H	30 T/H	29%
General Cargo	18.9 T/H	25 T/H	32%

The need for an increase in the number of gangs also stems from the need to change port's working hours, since it is necessary to provide round-the-clock service instead of the present 2-shift-service over 16 hours.

(b) Number of gangs required corresponding to the berth capacity

49. Table 7-7-4 below shows the application of gangs, the operation ratio and the number of calling ships.

Table 7-7-4 Application of Gangs

Berth	2			6			7			8		
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
Steel	9	8.5	26	9	7.2	22	9	8.0	24	9	8.0	24
Timber	9	7.5	26	9	2.1	7	9	2.2	8	9	2.2	8
General cargo	9	5.3	31	9	10.7	62	9	10.9	63	9	10.9	63
	9	21.3	83	9	20	91	9	21.1	95	9	21.1	95

Where (a): reserved gangs (b): operating ratio(%)
(c): number of calling ship

The optimum number of gangs should be determined with regard to the entire cargo work in the port, since this should and can be carried out comprehensively, supplementing each other. An appropriate operation ratio is considered to the 50% for the expected cargo. An 80% net operation ratio is considered to be the marginal ratio for an organization that keeps its gangs in good working condition. On the basis of the above reasons, the number of gangs required will be 17 in 1995.

(c) Annual volume of handling and the number of gang

50. Annual throughput recorded 1988 and forcasted in 1995 and 2000 is noted in the following table.

Table 7-7-5 Annual Cargo Throughput

	1988	1995	2000	* 2000
Steel and Pipe	149,000 ton	230,200 ton	220,200 ton	*361,400 ton
Timber and Plywood	70,900 ton	100,500 ton	70,000 ton	*124,000 ton
General Cargo	170,300 ton	208,700 ton	171,700 ton	*313,100 ton
Total	390,200 ton	539,400 ton	461,900 ton	*798,500 ton

Note: * is the aggregate of the volumes handled in Mina Qaboos and the New Port in 2000.

General cargo handled in Mina Qaboos increases as above but from 1995 to 2000, the new port will start servicing with the result that the volume handled at Mina Qaboos in 2000 will be less than the volume in 1995.

Supposing that the volume at the peak is the average of that in 1995 and that in 2000 (presuming that the new port will not contribute to handling general cargo), the annual volume in 1997 - 1998 will be 670,000 tons. The number of gang in proportion to the volume estimated to be handled will be as follows:

Table 7-7-6 Number of Gangs

	1988	1995	1997-1998	2000	2000*
Cargo throughput (tons)	390,200	539,400	670,000	461,900	798,500
Number of gang	12(G)	17(G)	21(G)	14(G)	25(G)

According to the tables above, we note that:

(1) 17 gangs will be necessary for Mina Qaboos for five years around 1995.

(2) The volume at the around 1997 will be 24% higher than the volume in 1995, which cannot be covered by an improvement of efficiency (only 10% may be expected at best), and thus some other steps should be taken.

(3) A maximum of 25 gangs will be necessary in case there is no allocation of cargo handling to the new port up to 2000, but 14 gangs will be sufficient if allocation is feasible as expected.

From the above analysis, it is considered necessary to increase the number of gangs to 17 until 1995, thereafter adjusting the number depending upon the extent of allocation of cargo handling to the new port.

7.7.3.2 Container Cargo Operations

51. Shipside operations at the container terminal must be carried out for on a 24-hour, 365-day a year basis. In addition to berths Nos.4 and 5, container vessels must also be berthed at Berths Nos.1 and 2 thus more gangs will be necessary.

Container handling gangs

Common ship supervisors	:	1 man
Head planners	:	1 man
Planners	:	2 men
Inspection clerks	:	2 men(1 man/crane)
Foremen or gang leaders	:	2 men(1 man/crane)
Winchmans	:	2 men(1 man/crane)
Laborers	:	12 men(6men/crane)
Total	:	22 men/shift/gang/2 cranes

This formation of container gangs is appropriate even in future. 3 gangs, totaling 66 men, will be arranged before service starts at Berths Nos.1 and 2.

7.7.3.3 Gangs for the CFS Operation

52. Small lot cargoes stripped from the container for delivery and brought

into the CFS to be stuffed are dealt with by the gangs engaged in the CFS operation. The cargo volume handled daily is expected to be 520 tons and 501 tons in1995 and 2000, respectively. On the assumption that the productivity of the gang for general cargo handled in the CFS is the same as the figure of the gangs for the conventional cargo, that is, 18.9 tons/hr./gang, the number of cargo-handling gangs needed will be more than 3. However, this can be reduced due to mechanization of the handling using many forklift trucks. Normally one forklift truck is provided for every two or three laborers with one tally clerk, hence productivity can be improved to from twenty five to thirty tonnes. Accordingly, the number of gangs required for the CFS operation will be more than two; approximately 3 gangs. The number of small fork lift truck needed will be nine. The gangs for the CFS operation now consists of the following personnel. This type of gang composition is does not need to be changed:

Foremen	: 1 man
Tally clerks	: 2 men
Marker boys	: 1 man
Laborers	: 8 men
Forklift truck drivers	: 3 men

7.7.3.4 Summary

53. Based on the above investigation, the recommended increase in the number of gangs by 1995 and onward is shown in table 7-7-7. The number of gangs needed to handle conventional cargo, however, should increase more than the figures indicated in the table, if cargo is not allocated between Mina Qaboos and the New Port. In such a case, the other gangs would still sufficient in number because the berth capacity will reach its limit first.

Table 7-7-7 Required Number of Gangs

	Present	1995	2000
Conventional	12	17	14
Container	3	6	6
CFS	$1+\alpha$	3	3

Note: The make-up of each gang is unchanged.