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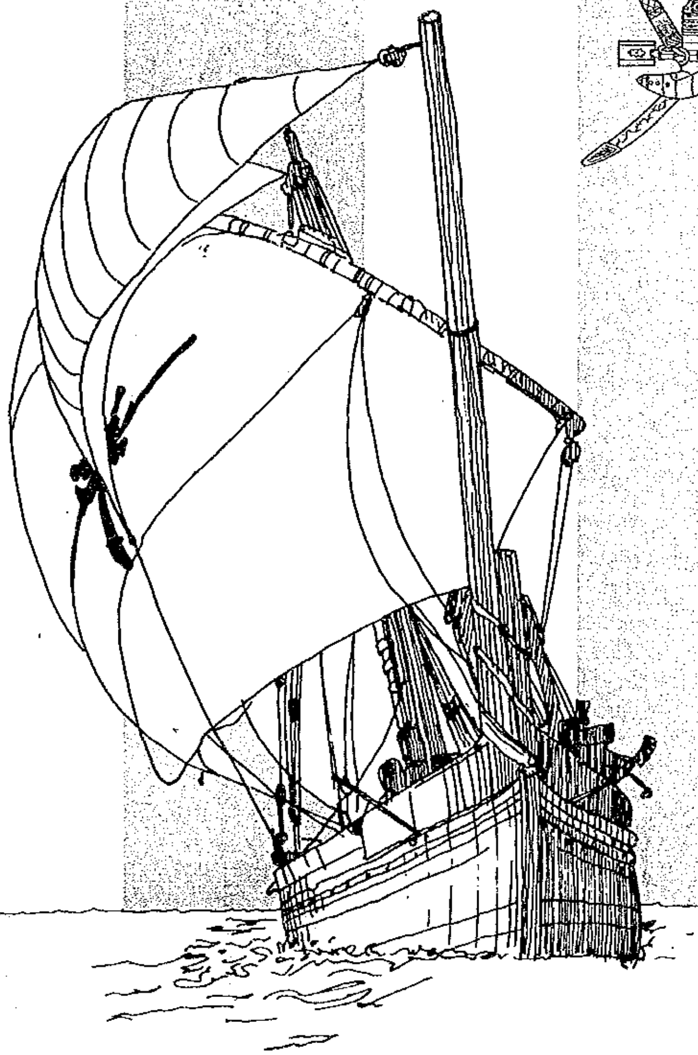
FINAL REPORT

THE STUDY ON THE PORT DEVELOPMENT FOR NORTHERN OMAN

VOLUME (I)



OCTOBER 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

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THE STUDY ON THE PORT DEVELOPMENT FOR NORTHERN OMAN
VOLUME (I)
OCTOBER 1990
J.I.C.A.

FINAL REPORT

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VOLUME (I)

OCTOBER 1990

PREFACE

In response to a request from the Government of the Sultanate of Oman, the Japanese Government decided to conduct a study on Port Development in Northern Oman and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Oman a survey team, headed by Mr. Hideaki Sagara, and composed of members from the Overseas Coastal Development Institute of Japan and Nippon Koie Co.Ltd., four times between September 1989 and September 1990.

The team held discussions with officials concerned of the Government of the Sultanate of Oman, and conducted field surveys. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Sultanate of Oman for their close cooperation extended to the team.

1990

Kensuke Yanagiya

Kensuke Yanagiya
Presdident
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

October 1990

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency

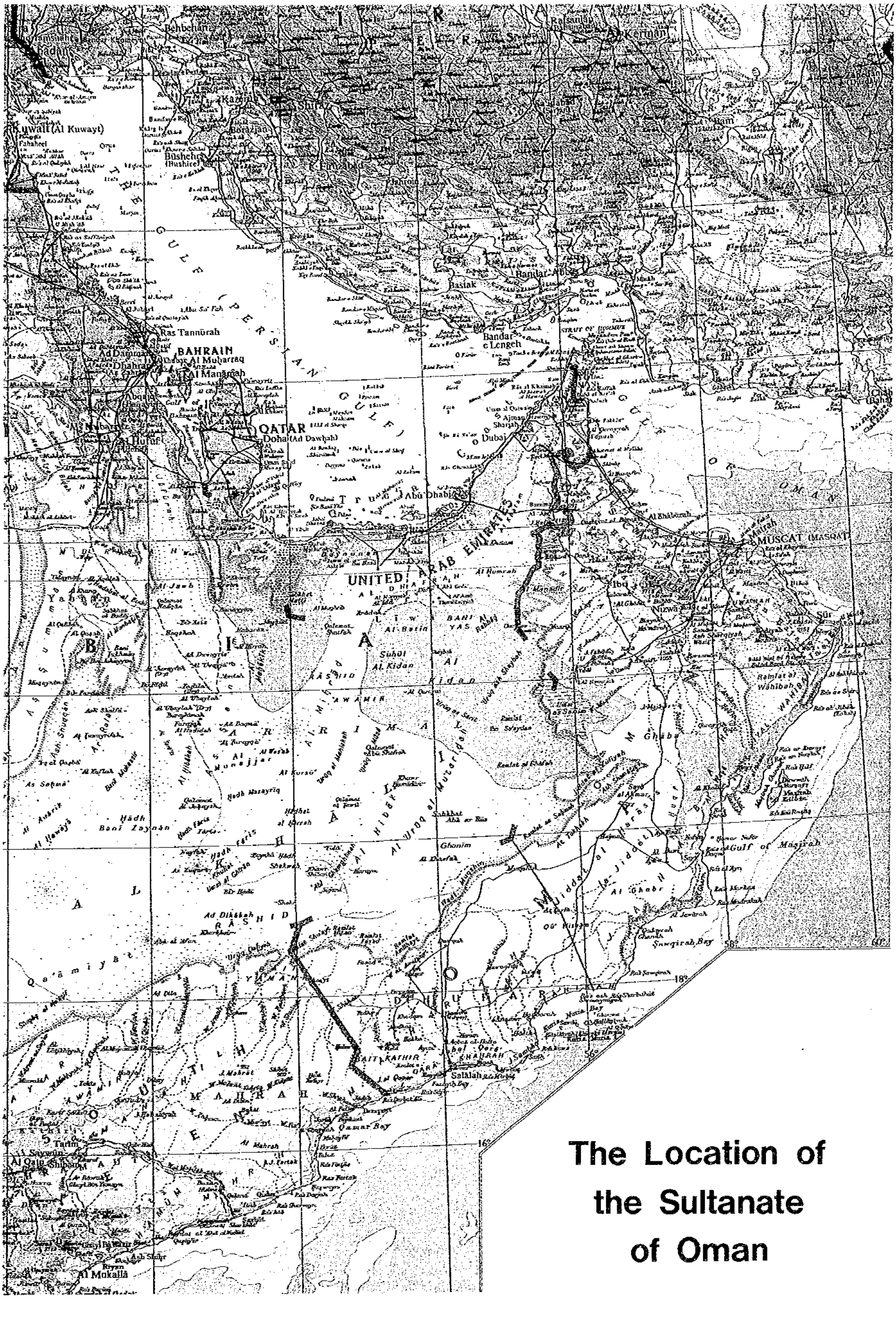
Dear Mr. Yanagiya :

It is may pleasure to submit herewith the Final Report for the Study on the Port Development for the Northern Oman.

The team's acknowledgments to the relevant persons in the Sultanate of Oman appear in the foreword of the volume 1 of the main report, and I wish to take this opportunity to express my sincere gratitude to the Japan International Cooperation Agency, the Ministry of Foreign Affairs, the Ministry of Transport and the Japanese Embassy in Oman for their support.

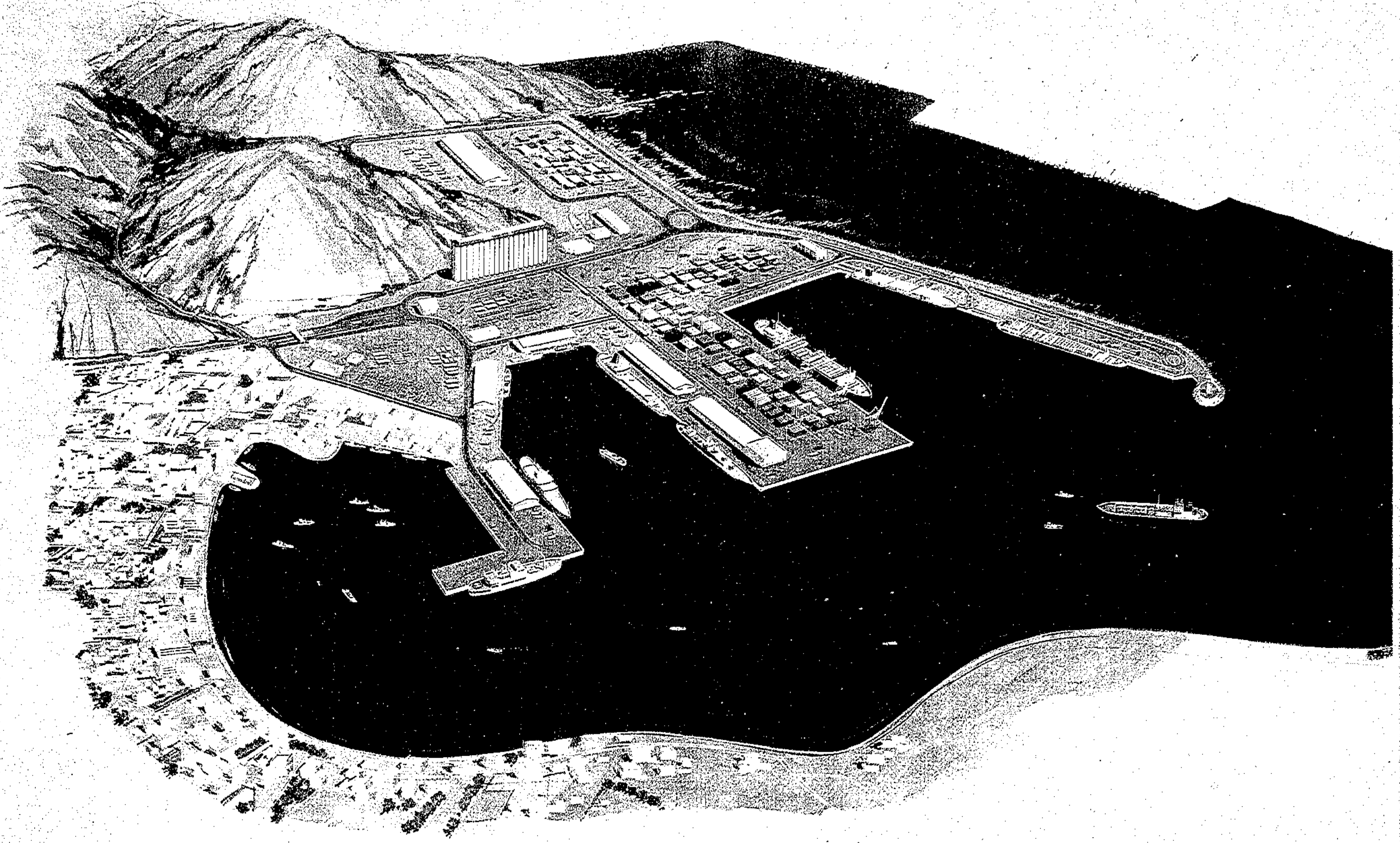
Yours faithfully,

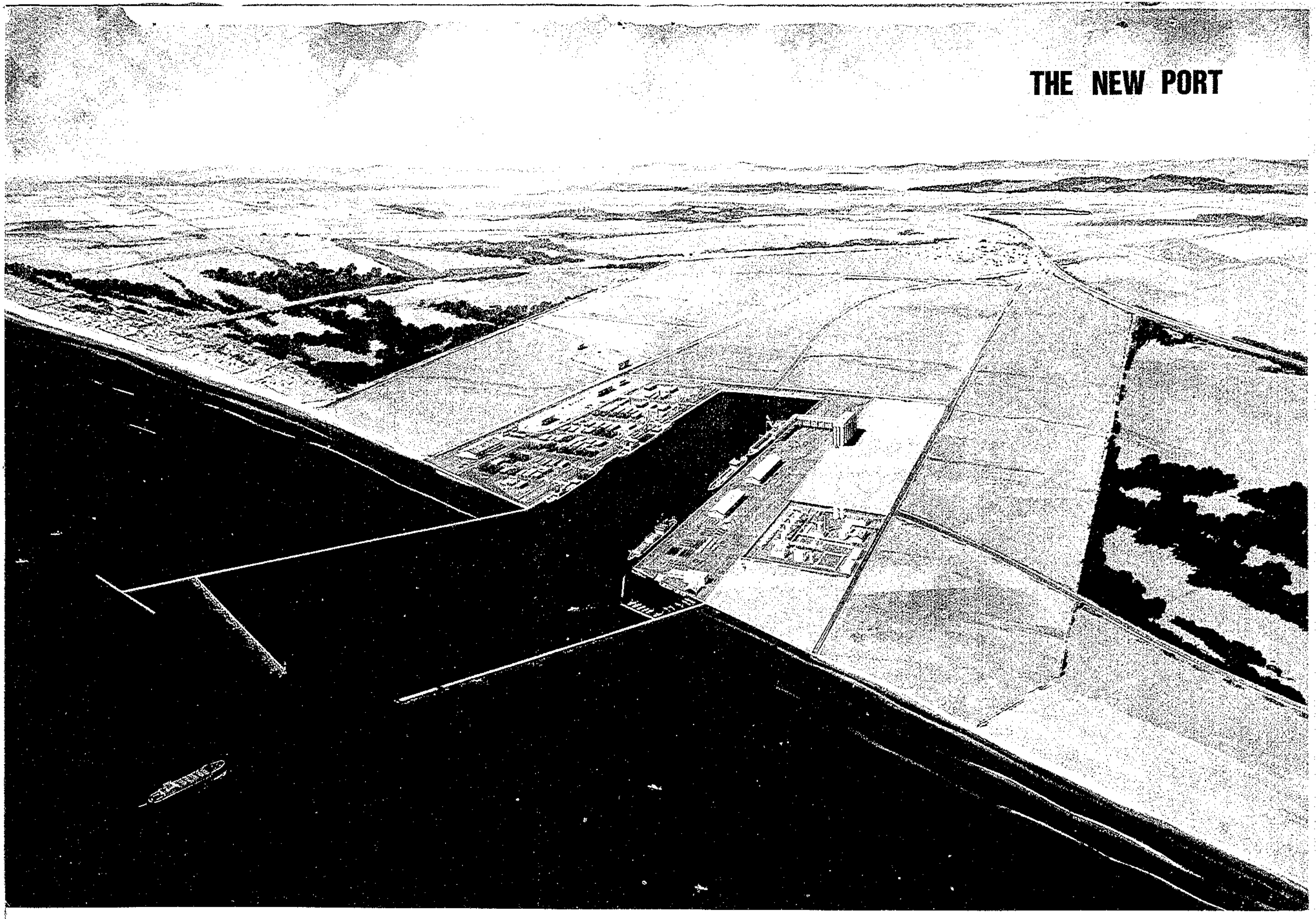
SAGARA Hideaki
Leader
Japanese Study Team for
the Study on the Port Development
for Northern Oman
(Senior Executive Director,
the Overseas Coastal Area
Development Institute of Japan)



The Location of the Sultanate of Oman

MINA QABOOS




THE NEW PORT

THE STUDY ON THE DEVELOPMENT

FOR NORTHERN OMAN

VOLUME I THE STUDY ON THE DEVELOPMENT FOR NORTHERN OMAN

VOLUME II MINA QABOOS DEVELOPMENT PLAN

VOLUME III NEW PORT DEVELOPMENT PLAN IN SOHAR

SUMMARY

ABBREVIATIONS

CA	Capital Area
CD	Chart Datum
CES	Consulting Engineering Service (India) Private Limited
CFS	Container Freight Station
CMA	Compagnie Maritime d'Affretement
CRT	Cathode Ray Tube
CY	Container Yard
DC	The Development Council
DL	Datum Water Level
DWT	Dead Weight Tonnage
FCL	Full Container Load
FTZ	Free Trade Zone
G.C.	General Cargo
GCC	The Gulf Co-operation Council
GDP	Gross Domestic Product
GDP(R)	GDP for Regression Analysis
GNP	Gross National Product
G.S.	Ground Spot
G/T, GRT	Gross Tonnage
H	Wave Height
Ho	Deep Water Wave Height
H1/3	Significant Wave Height
IBRD	International Bank for Development and Reconstruction
IMO	International Maritime Organization
JAFZ	Jebel Ali Free Zone
JICA	The Japan International Cooperation Agency
J¥	Japanese Yen
L	Wave Length
LAT	Low Astronomical Tide
LCL	Less Than Container Load
LNG	Liquid Natural Gas
L.W.L.	Low Water Level
MAF	Ministry of Agriculture and Fishery
M.H.W.L.	Mean High Water Level
MMSCF	Million Standard Cubic Feet

MMSCFD	Million Standard Cubic Feet per Day
M.L.W.L.	Mean Low Water Level
MOC	The Ministry of Communications
MRO	Million Omani Rial
M.S.L.	Mean Sea Level
MT	Empty Container
MTBE	Methyl Tertial Butyl Ether
MTD	Metric Tonnes per Day
MTPA	Metric Tonnes per Annum
MW	Mega Watt
NYK	Nippon Yusn Kabushikigaisha
OBAF	The Oman Bank for Agriculture and Fisheries
OCDI	The Overseas Coastal Area Development Institute of Japan
ORC	Oman Refinery Company
PAMAP	The Public Authority for Marketing Agricultural Produce
PMB	Port Management Body
PSC	The Port Services Corporation
R.O	Omani Rial
Ro/Ro	Roll on/Roll off
SMDS	Shell Middle Distillate Synthesis
SPT	*Standard Penetration Test*
TEU	Twenty-foot Equivalent Unit
TRS	Transshipment
UAE	The United Arab Emirates
US$	The United States Dollars
ϕ	Angle of Internal Friction

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FOREWORD

Foreword

1. The objectives of the study, which appear in "the Scope of Work for the Study on the Port Development for Northern Oman" agreed upon by the Government of Japan and the Government of the Sultanate of Oman, are:

(1) to review and evalute the intermediate development plan of Mina Qaboos,

(2) to recommend a port development strategy for northern Oman,

(3) to formulate a master plan for a new port in northern Oman considering the following:

  (i) Reviewing the completed study for a proposed new port at Quriat,

  (ii) Reviewing a major extension of Mina Qaboos into Shutaify Bay,

  (iii) Examining the present situation at Mina Qaboos, including the recommendations for improvement/development made by the Indian Consultant.

2. Until the midway point of the whole project, the study was carried out by dividing into two parts, i.e., Mina Qaboos and a new port, because the timing of development as well as the contents of the studies are different. However, in the later stage, the study was carried out such that an overall picture of port development in northern Oman could be emerged.

At the outset of the work, the Inception Report was submitted by the team to the Ministry of Communications, the counterpart of the team, on 5th Nov. 1989 at the occasion of the teams' first visit to Oman. Following to the report, five reports, viz. Progress Report (I), Progress Report (II), Interim Report (I), Interim Report (II) and Draft Final were submitted based on the team's findings through discussions, interviews, field reconnaissance of possible new port sites, preliminary investigation of natural conditions and studies of collected data. Of which reports, Progress Report (I) and Interim Report (I) deal with the development of Mina Qaboos, while on the other hand, Progress Report (II) and Interim Report (II) describe the development of a new port.

The Draft Final Report, submitted on 24th August, 1990 consists of three volumes. In Volume I, the team tried to formulate a comprehensive picture of port development policy form now until the year 2015, by amalgamating both Mina Qaboos and a new port aspect. Volumes II and III deal with the expansion of Mina Qaboos and development of a new port, respectively. And these volumes are to a large extent the same as the first and second interim reports with some alterations or additions in the light of discussions or studies thereafter. The reason why the report is presented in this form is that the Volume I quickly describes the whole concept of port development policy in northern Oman, while detailed analyses of each port are left to Volumes II and III, and in this way readers are free to take any of these Volumes according to their needs instead of having to deal with one voluminous report.

3. The substance of the Final Report is virtually same as the Draft Final Report, except insofar as it is amended in accordance with the outcome of meetings at the team's last visit between 23rd Aug. and 4th Sept. 1990. The composition of The Final Report also follows suit, however, for the convenience of users, it is supplemented by the summary of Volume I of the Final Report. Followings are the main content of each volume.

Volume I: Comprehensive strategy for port development of Northern Oman including both Mina Qaboos and a new port.

Volume II: Composite scheme of the development of Mina Qaboos.

Volume III: Master plan for the new Port including its site selection and the short term plan.

Summary of Volume I

4. Launching a new port is a challenging task and expanding Mina Qaboos also involves much difficult work. Although the team tried to pave the way for formulating a development scheme for ports in northern Oman corresponding to the country's stage of economic development, there is still a lot of work to be done before full materialization of the scheme.

The team hopes that this study proves to be a contribution to the development of ports and finally growth of the economy and progress of welfare of the Sultanate of Oman.

5. Acknowledgments

Acknowledgment is made to H.E.Salim Bin Ali Bin Nasser As Siyabi, Undersecretary of Ministry of Communications; Mr. Engr. Moh'd Bin Rajab Ba-Omar, Director General of Finance and Administration, MOC; and the Committee chaired by Mr. Engr. Salim Bin Hameed Al Ghassani, Director

General of Ports and Public Transport, MOC, the members of which are from MOC and the Port Service Corporation (Mina Qaboos), for holding fruitful discussions and making many productive suggestions.

Acknowledgment is also made to Mr. Engr. Majid Bin Saeed Al-Rawahi, Superintendent General, Planning and Studies; Mr. Abbas Bin Khudadat Dostein and his division; and in particular to Mr. Engr. Shahid Hussain Mirza for providing us for useful advice and information.

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The study team conducted many interviews with private companies in various fields such as shipping agents, mining firms, manufacturers, contractors and consultants, and these interviews were very informative.

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and Administration and Mr. Ali Bin Moh'd Bin Ali Al-Tiwany, Director, Services and Public Relations, as well as the Embassy of Japan in Oman.

6. List of the Team Members

Mr. SAGARA Hideaki	leader
Mr. SASAJIMA Hiroshi	co-leader
Mr. UEDA Hiroshi	
Mr. KAWAKITA Hirokazu	
Mr. OHNO Hiroshi	
Mr. MASUNAGA Kunio	
Mr. INOUE Toshihisa	
Mr. MURAI Noboru	
Mr. SAEGUSA Fujio	
Mr. TERASHIMA Takuro	
Mr. EBATA Shizuo	
Mr. LIAN, Fawzi L.,	

H.SAGARA
The Team Leader

CONCLUSION AND RECOMMENDATIONS

Conclusion (Brief)

While detailed conclusion appears in Chapter 12, its brief is as follows:

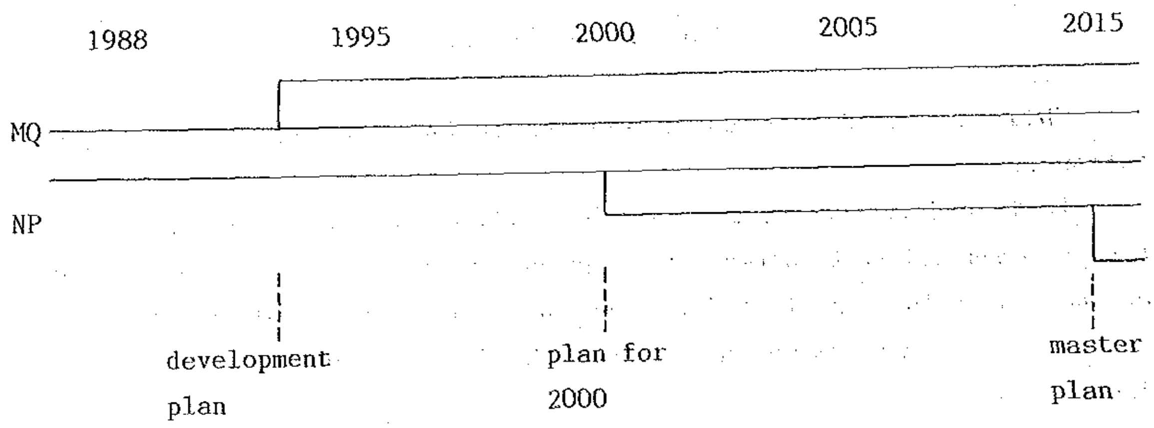
It is widely recognized that Mina Qaboos, which is the only gateway port to Oman and will continue to play an important role in various aspects of the country's economic life, cannot properly adapt itself to the present increasing cargo demand and the technological progress of relevant industries.

In order to meet these circumstances the development work at Mina Qaboos should be expedited. Speedy construction work is also required with a view to saving on financial costs as well as minimizing the unfavourable effects on day-to-day port operations during the construction period.

As far as development of a new port is concerned, the economic internal rate of return (EIRR) based on a cost-benefit analysis is 5.0%. The figure is below the level that is generally considered to be economically feasible in terms of construction of infrastructure.

According to the financial analysis using the financial internal rate of return (FIRR), the project is financially viable in terms of a port management body on the assumption that about 80% of the funds necessary for the project are borne by the government on an interest-free and no-repayment basis. These terms seems to be attainable, because they are similar to the funding arrangement of Mina Qaboos.

There are some other concern regarding the new port project. The Sultanate of Oman attaches great importance on the preservation of the environment. In this regard, at the site selection and actual planning at the selected site, the highest priority is given to keeping the impact of the port development to a minimum. After consideration of alternatives in terms of port development, and taking into account favourable effects of a new port upon the nation's economy, regional development and other factors such as environmenfal aspects, the team came to the conclusion that a new port should be constructed in the vicinity of Sohar. Following figure are the tentative action plan:



Notes: MQ-Mina Qaboos; NP-New Port;
Width of the bars does not indicate cargo handling capacity.

However, the circumstance where the factors for future demand is not entirely clear, the timing of the new port construction should carefully be examined, with the budgetary codition of the time and the progress of relevant development schemes in mind.

Recommendations

(1) The wave conditions have been observed by using marine buoys since 1988. It is desirable to continue this observation because the natural conditions of the Port are important to daily port administration and development.

(2) Due to their lack of length, Berths Nos.1, 1A & 2, Nos.4 & 5, Nos.7 & 8 cannot be considered sets of two independent berths. Therefore, berth allocation should be done carefully in order to maximize the port's capacity. Regarding port capacity, it should be also noted that berth occupancy by non-commercial users is to be expected to some extent even in the future. Port capacity should thus be evaluated considering these factors.

(3) It should be emphasized that the proposed Mina Qaboos development plan is based upon adequate cargo allocation with a new port in the year 2000, and delay in the new port development schedule will bring about a serious shortage of cargo-handling capacity at Mina Qaboos. Hence the development schedule of Mina Qaboos and the new port should be controlled carefully.

(4) In this project, development of multipurpose berth, dredging of water basin and reclamation of Shutaify Bay are very closely related to each other. Therefore, for the efficient use of the multipurpose berth, dredging of the water basin should be implemented at an early stage after completion of the multipurpose berth.

(5) The transfer crane system should be adopted to accommodate the rapidly increasing amount of container traffic in Mina Qaboos. Effective land utilization can be expected only with this system because it enables higher stacking of containers, and a smaller area is needed for containers. The new system requires an appropriate number of tractor-trailer, top lifters and other equipment.

(6) The number of gangs needed for handling conventional cargoes and containers and at CFS is to be increased. At the same time, the productivity of handling cargo is to be improved by mechanization, using

appropriate equipment, training of gang members and recruiting younger labourers.

(7) Computerization should be speeded up to match the new handling system. The new handling system can maintain its function with appropriate support from the integrated computer system. Application of the following systems is indispensable for the introduction of new handling system:

i) Terminal control system
   - Marshalling yard control program
   - Gate control program

ii) Terminal planning system
   - Loading schedule program
   - Discharging schedule program

iii) Program for optimum handling equipment procedure

iv) Documentation

(8) Facility design and evaluation are carried out based on the sub-soil surveys and the existing bore hole data. But more sub-soil surveys should be carried out in the implementation stage, because there are many different sub-soil characteristics in each section of the port area.

(9) Construction work such as dredging, erection of container cranes. etc., should be executed without interfering with regular port activities by ensuring coordination among the administration and operation sections and port users in order to maintain smooth port operations.
Alternative space for normal port operations should be provided during the construction period.

(10) Considering the expandable space of Mina Qaboos and the future demand forecast of cargoes, a new port should be constructed in northern Oman.

(11) The new port should be in Majis, considering the various factors such as space availability, ground surface conditions, locational relation to the existing towns, construction costs and the potential functions of the new port.

(12) With regard to preservation of the environment, the highest priority

is given to minimizing the impact on the environment during both site selection and actual planning of the new port at the selected site. The environmental aspects of the project should be kept in mind in the detailed design and construction stages.

(13) The transfer crane system should be adopted at the container terminal in the new port as well as at Mina Qaboos due to ease of maintenance of equipment, such as obtaining the parts for the equipment, and of operator training.

(14) The management body of the new port may be a corporation, a large portion of the capital of which will be owned by the government but independent from the existing PSC. This is because a large part of investment should be borne by the government, and the PSC cannot bear the huge deficit envisaged at its initial stage, although the body will be self sustaining in the long term.

(15) For the new port, in order to carry out these enormous tasks which have to be done along with the construction, a detailed study of recruitment and training should be carried out. Where difficulty is envisaged in recruiting a sufficient number of experts for higher-ranking officials of the PMB, it may be advisable to hire foreign experts with much port management experience, preferably including a general manager, with a view to assisting in the smooth operation of the port and also to transfer port management expertise in the inauguration period.

(16) The new port should make an intensive effort to "sell" the port. For new comers it is absolutely true that without such efforts the port will not survive. However, it should be emphasized that publicity can only do a little on its own. Reputation accompanied by substance is more effective. Form the customers' viewpoint the best substance is sure and speed cargo movement. To attain this, quick customs, immigration and quarantine (CIQ) procedures are also vital.

(17) The new port and Mina Qaboos should cooperate with each other and coordinate their activities in many fields. It may be advisable to establish a national port council under the Ministry of Communications

consisting of exectives of the PSC (Mina Qaboos) and of the port managing body of the new port with a small secretariat.

(18) Some means of linking all the relevant bodies should be developed. Relevant bodies include municipalities, regional branches of central organizations dealing with housing, education, energy, customs, quarantine and immigration, the industrial estate authority, the governing body of the free trade zone and the petro-chemical factory.

(19) Another study, which may be named as the study for preparation for the new port at Sohar, will be useful in finding solutions to some of the questions including fixing exact timing based upon economic indices forecasts and information regarding related projects at the time. Also, detailed plans of ancillary services and plans for recruitment and training structure may well be a part of the study. Taking into account the time schedule for the new port construction, the study should be concluded by 1997.

Chapter 1 CONTAINER SHIPPING IN THE GULF REGION

1.1 Traffic Trend

1.1.1 Main Liner Services in the Gulf Region

1. The main liner services calling at the ports in the Gulf region can be roughly divided into four groups:

(1) US・Europe/Gulf/Far East Services

The traffic flow in this type of service is shown in Fig. 1-1-1.

- Main international services in the Gulf Region.
- Some of them serve only between Europe and the Gulf.
- Singapore is always the entrance point for the Far East.
- There are other services between Europe and the Far East which call at Jeddah but not at the Gulf ports.

(2) US・Far East/Gulf Services

The traffic flow is shown in Fig. 1-1-2.

- Some serve only between the Far East and the Gulf, with a few serving between the US and the Gulf only or on the US/Gulf/Far East route.
- Singapore is the entrance point for the Far East in every case.
- Japanese shipping lines are prominent in these services.

(3) Australia・New Zealand/Gulf Services

The traffic flow is shown in Fig. 1-1-3.

- Singapore, Bombay, Karachi and Colombo are included in this route.
- All vessels on this route call at Dubai, Damman (Saudi Arabia) Bahrain and Kuwait.

(4) Feeder Services from the Gulf

- Feeder services from the Gulf are mainly from Dubai and most of them are to India (Bombay, Cochin), Pakistan (Karachi) and Sri Lanka (Colombo).
- There are only a few cases where East Africa is served by feeders from the Gulf.
- Mina Qaboos also provides feeder services to India, Karachi and Colombo as well as inter-Gulf ones. Feeder service to East Africa is

via Dubai.

1.1.2 Characteristics of Traffic

2. The characteristics of the traffic in the Gulf region are as follows:

- Most of the vessels entering the Gulf region call at Dubai. The other ports in the UAE and Oman are now becoming mere feeder ports and are patronized only by particular shipping lines as transshipment bases.
- There is a tendency whereby round-the-world services make only one stop in the Gulf.(e.g. Senator Linie of Khor Fakkan)
- Damman, Bahrain and Kuwait are still hub ports, even though in some cases one or two of them are skipped.
- A number of shipping lines have used Dubai as a base for inter-Gulf feeder services which extend to all the other ports in the Gulf. However, there are some cases where Mina Qaboos, Fujairah or Khor Fakkan provide feeder services to other ports, even to Dubai.
- Feeder transport from Dubai to Oman is mainly done by feeder ships, but some commodities such as steel, timber, fresh fruit and fresh vegetables enter Oman by land.
- East Africa is served by feeder services mostly via Jeddah from Europe.
- Most of the feeder shipments to Iran are at present from Dubai.

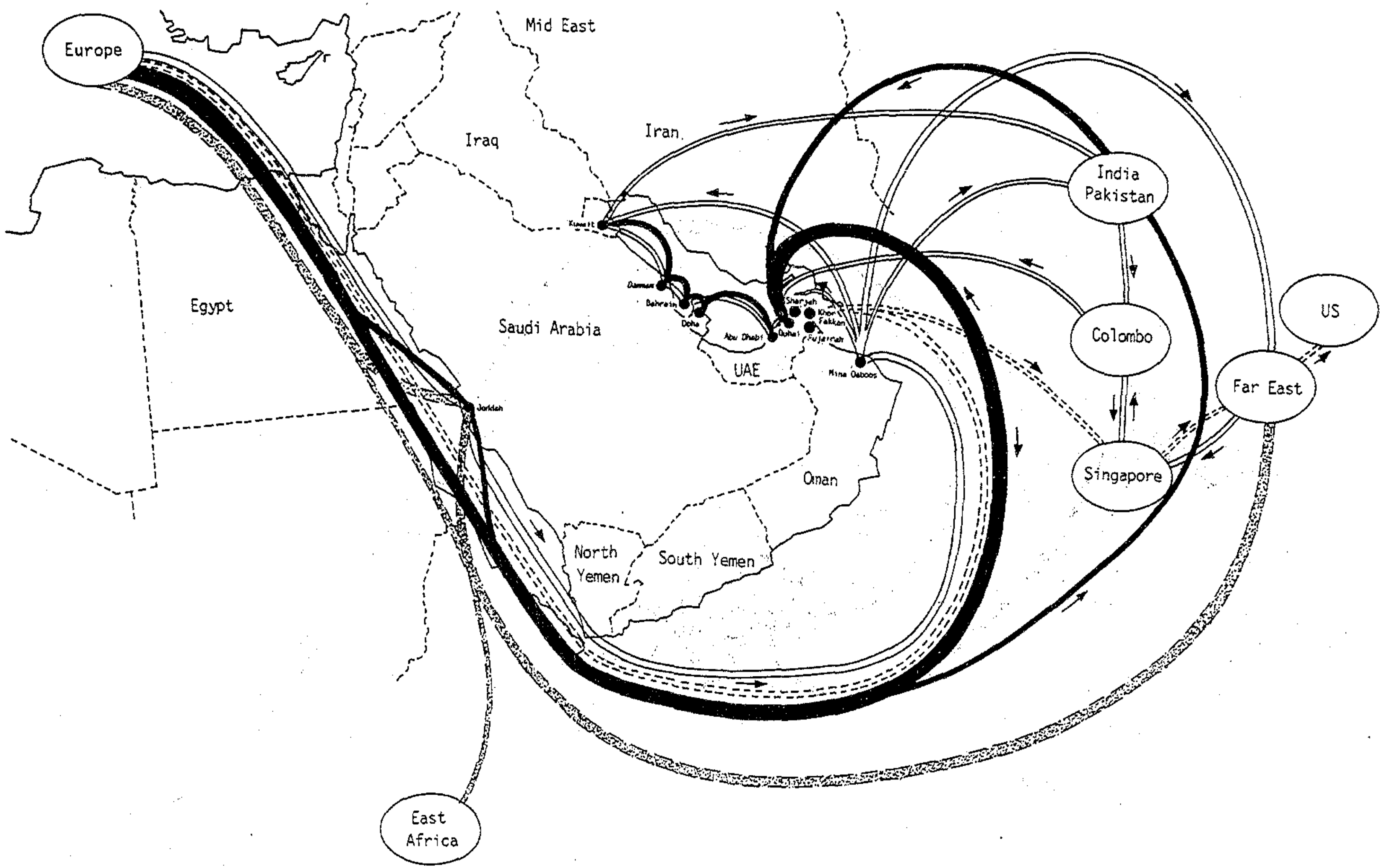


Fig. 1-1-1 US·Europe/Gulf/Far East Route

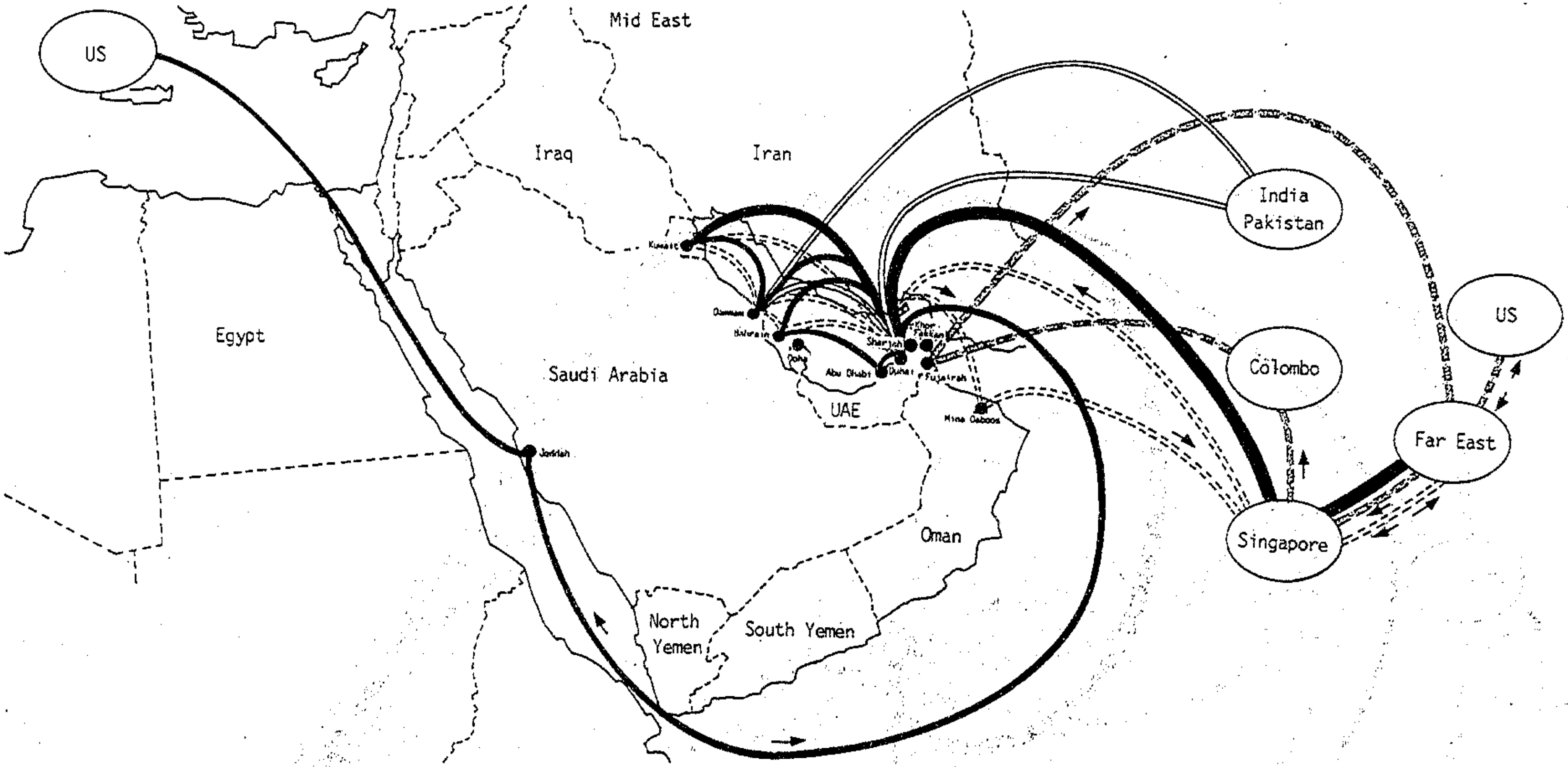


Fig. 1-1-2 US·Far East/Gulr Route

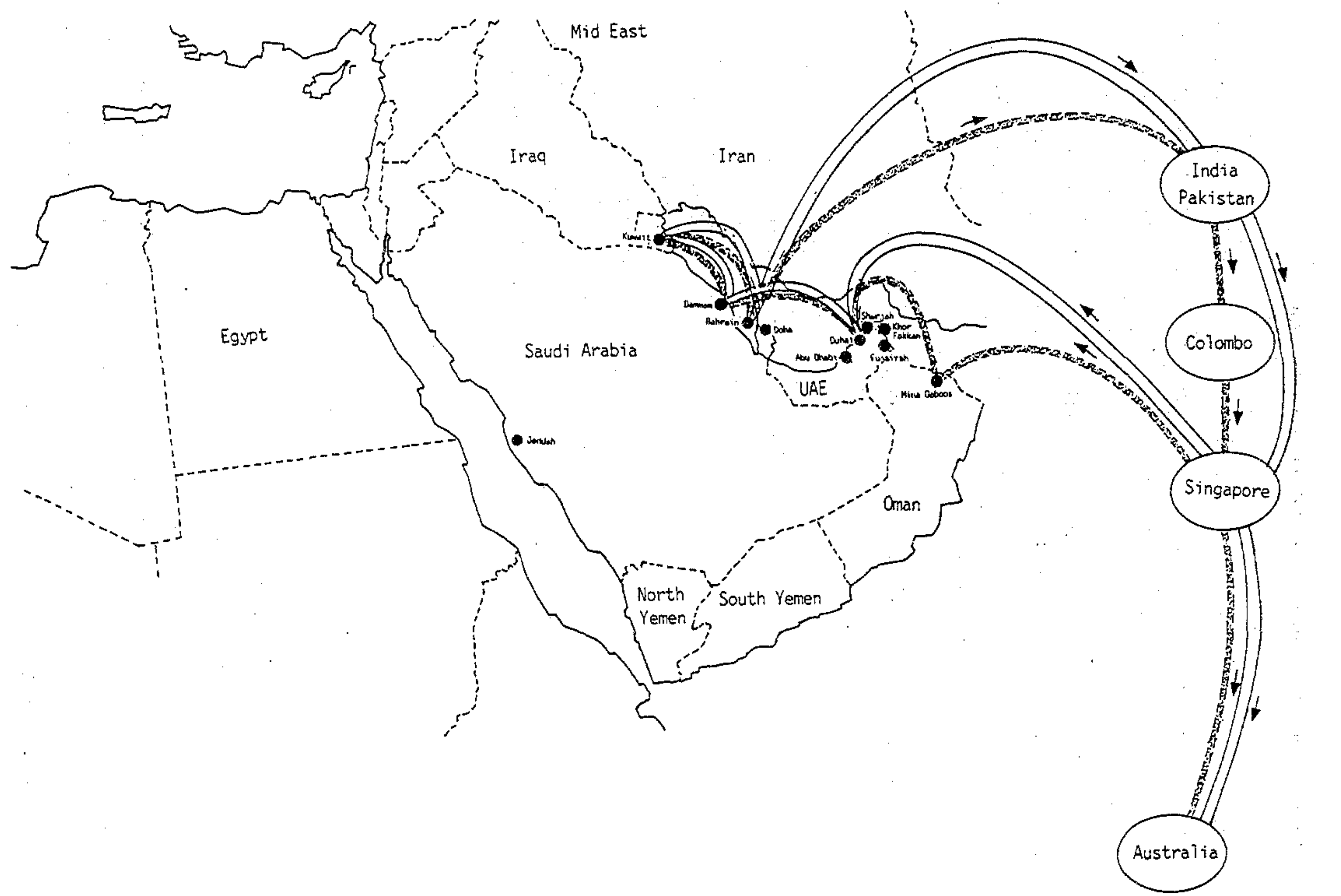


Fig. 1-1-3 Australia New Zealand/Gulf Route

1.2 Characteristics of Calling Ships

1.2.1 World-wide Trend and Ships Calling in the Gulf

3. The average TEUs of vessels deployed on the Middle East route are somewhat smaller than the world average. However, compared with routes such as those to Australia/New Zealand, South America, Africa and India, considerably larger vessels are deployed on this route, while vessels of the largest dimensions are deployed exclusively on routes such as those to the Far East, North America and Europe. Ships of the largest class are not deployed in the Gulf region very often, and ships of the second-biggest class are principally deployed.

1.2.2 Comparison between Mina Qaboos and Dubai

4. There is not a large difference between the two ports in terms of DWT. The ratio of ships of more than 40,000DWT is somewhat larger at Dubai than at Mina Qaboos. The ratio of ships of more than 11.5m in draft at Mina Qaboos is only half that at Dubai. This shows that Mina Qaboos has a certain limitation with respect to draft. Even at Mina Qaboos, ships of more than 9.5m in draft account for more than 75% of all calling ships. The tendency whereby the biggest ships skip Mina Qaboos is most noticeable with respect to length. No ships of more than 230m in length call at Mina Qaboos, while such ships account for more than 10% of those calling at Dubai.

1.3 Role of Mina Qaboos

5. The characteristics of Mina Qaboos can be summarized as follows:
(1) Transshipment base in the Gulf region
(2) Mother port for local Omani cargo
(3) Feeder Port (mainly from Dubai)

While the volume of transshipment cargo has increased in recent years and accounted for nearly forty percent of the total cargo in 1988, Mina Qaboos is becoming a mere feeder port and tends to be skipped by mother vessels with regard to the local Omani cargo.

6. There are some reasons for major shipping lines to skip Mina Qaboos on the main route, even though Oman has an absolute geographical advantage over all other Gulf countries:

- Mina Qaboos faces various problems, such as physical constraints on the dimensions of facilities (in particular, length of the berths), low handling productivity and a lack of handling equipment in good condition.
- Dubai has become so established as a Middle East trading center that it is now more convenient for port users to use Dubai as a distribution center in this region.

7. In order to make Oman's ports attractive for port users and competitive with Dubai, it is necessary not only to solve the above physical problems but also to properly carry out commercial and financial development plans. Once these problems are solved, Mina Qaboos will be able to play a more important role as a hub port in the Gulf, possibly with feeder services to Iran and East Africa as well as the Gulf countries, India, Pakistan and Sri Lanka.

Chapter 2 NATURAL CONDITIONS

2.1 Meteorology

1. The Northern Oman is located in the sub-tropical zone. The monthly average temperature of Seeb varies from 21°C to 36°C and the maxima vary from 25°C and 41°C, and the minima from 17°C to 32°C.

2. Precipitation has been recorded in the Sultanate in every month, but basically, most rainfall in central and northern Oman occurs as a result of synoptic situations of cyclonic or frontal types, and mainly during the winter from November to April.

3. The topographic effect of the northern Oman mountains and Ras Al Jibal results in the highest average rainfall in the Sultanate falling on the mountains. Such rainfall is the principal source of groundwater for the Batinah coast, the Musandam penisula, and the interior.

Annual rainfall is shown in Fig. 2-2-1.

2.2 Seismicity of the Area

4. The interior of the Arabian Peninsula is comparatively stable, its rigidity being determined by the Pre-Cambrian basement, and the influence of this dominates the seismicity of Oman. The map in Figure 2-2-1 shows two areas that have been defined following a study of the limited historical records, instrumental data obtained from the Global seismology Unit in Edinburgh, and knowledge of the tectonics.

5. The regulations in current use make no reference to design earthquakes. The framework and general configuration of most multi-storey buildings may well be found to satisfy such needs. Wide span buildings may require special attention. Consultants working in the Capital Region indicate however that no special allowance is normally made for earthquakes in the design of major structures.

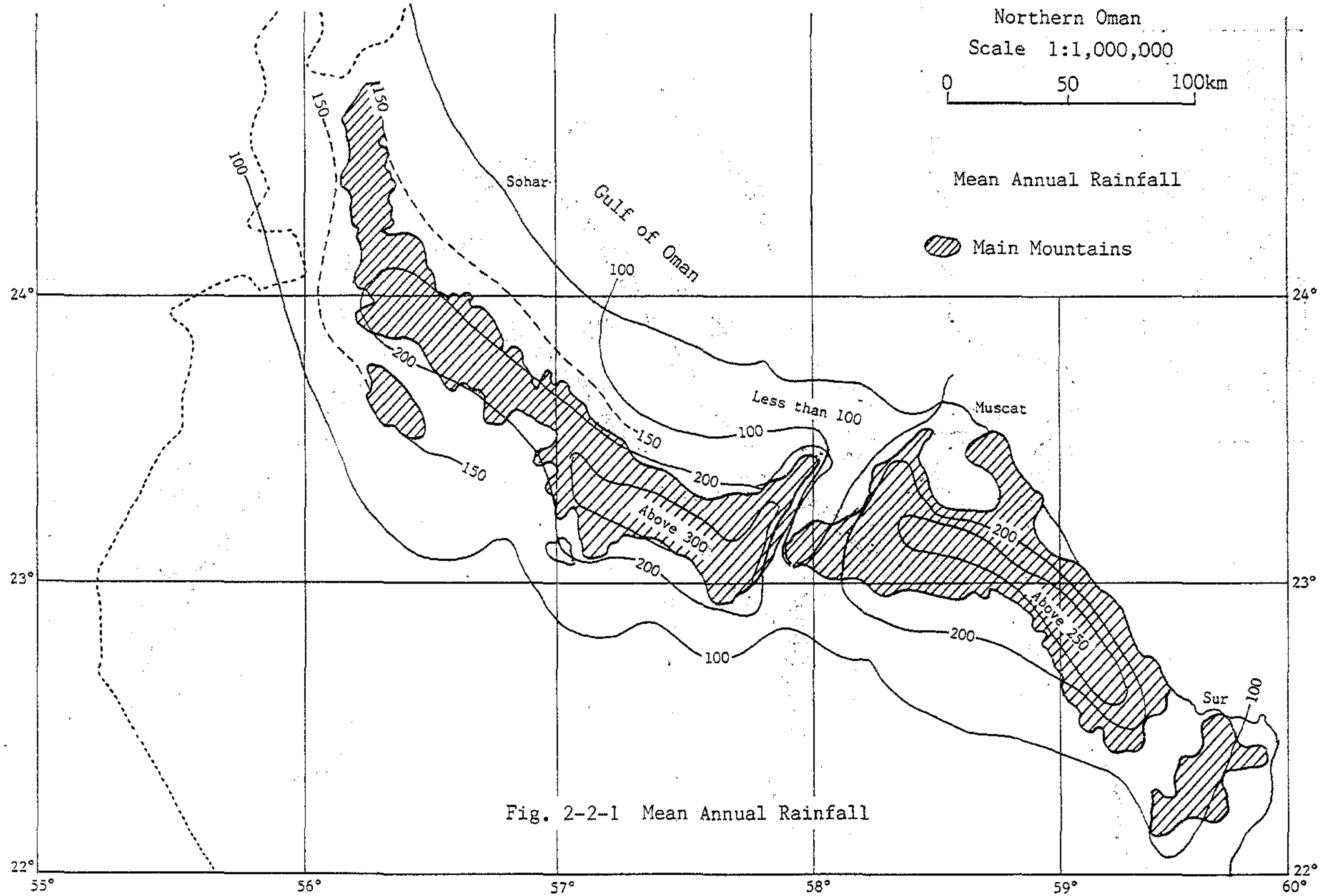


Fig. 2-2-1 Mean Annual Rainfall

Area indicated	intensity (Modified Mercalli 1958)
A (Major event)	VII or greater
B (Minor event)	V or VI

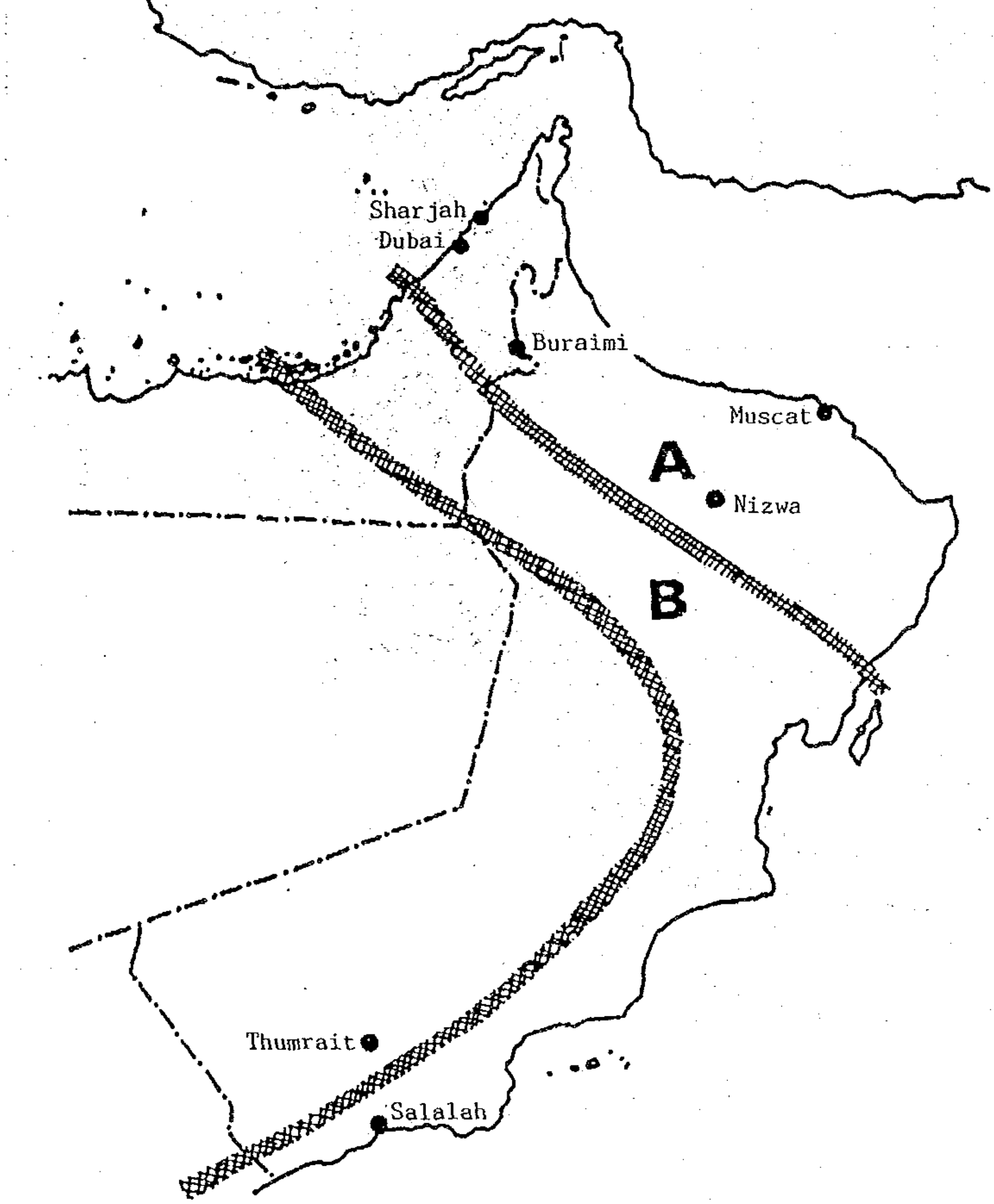


Fig. 2-2-2 Seismicity of the Area

2.3 Geology

6. The location of boreholes at Mina Qaboos and New Port are shown in Fig. 2-3-1 and 2-3-3 respectively.

The cross section of the sub-soil findings including the SPT results relative to Chart Datum at Mina Qaboos, is presented in Fig. 2-3-2, and geological profile at New Port is presented in Fig. 2-3-4.

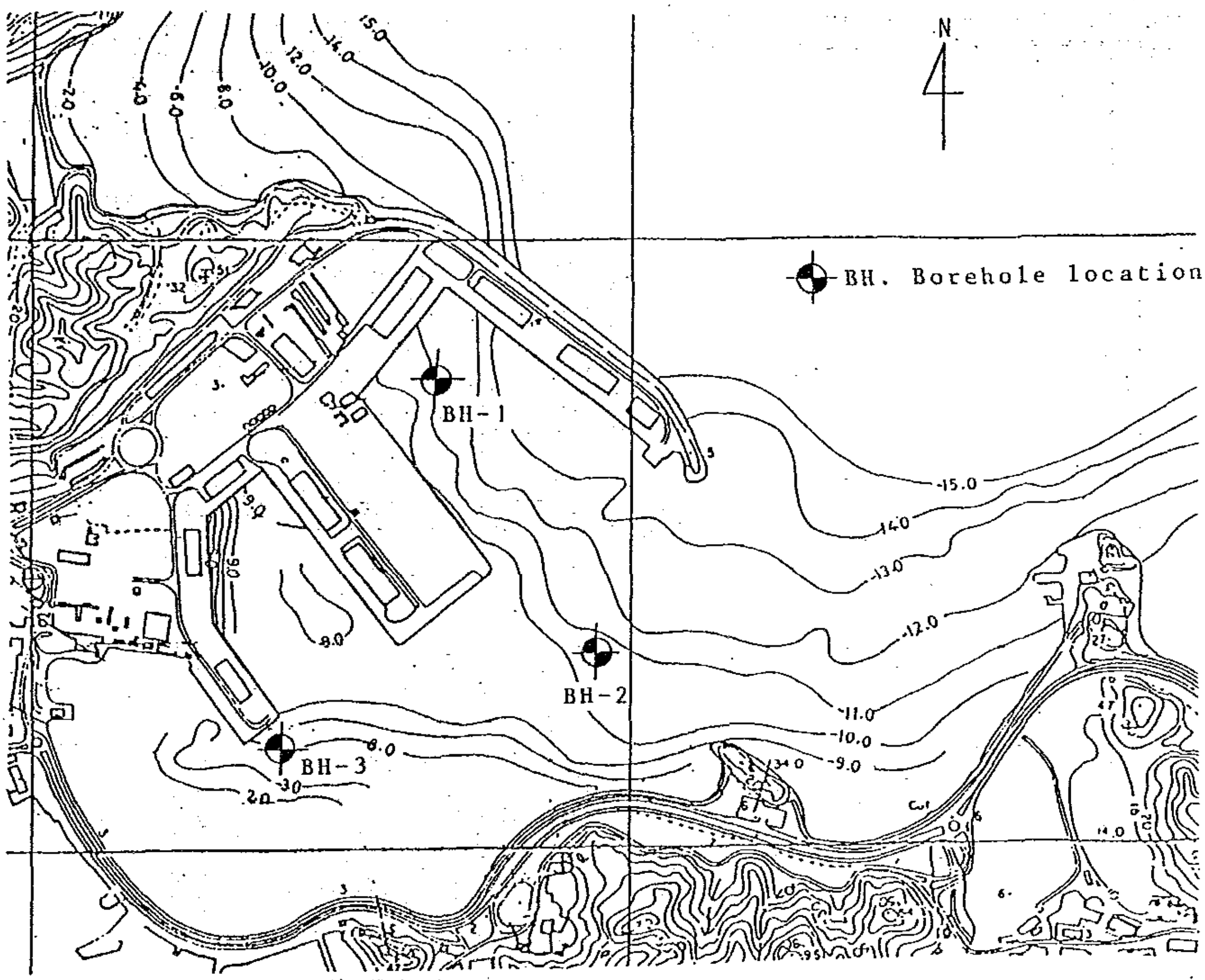


Fig. 2-3-1 The Location of the Boreholes (Mina Qaboos)

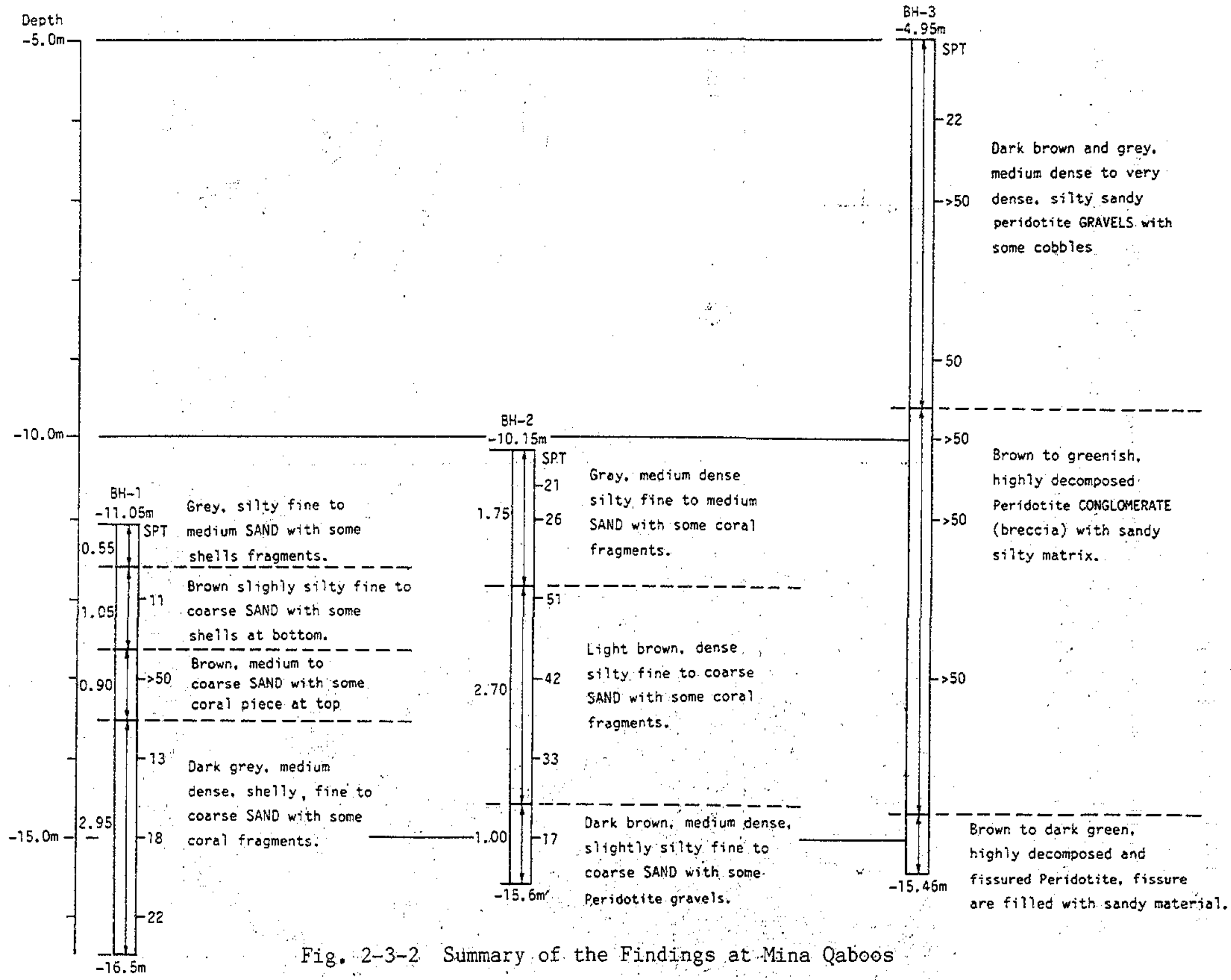


Fig. 2-3-2 Summary of the Findings at Mina Qaboos

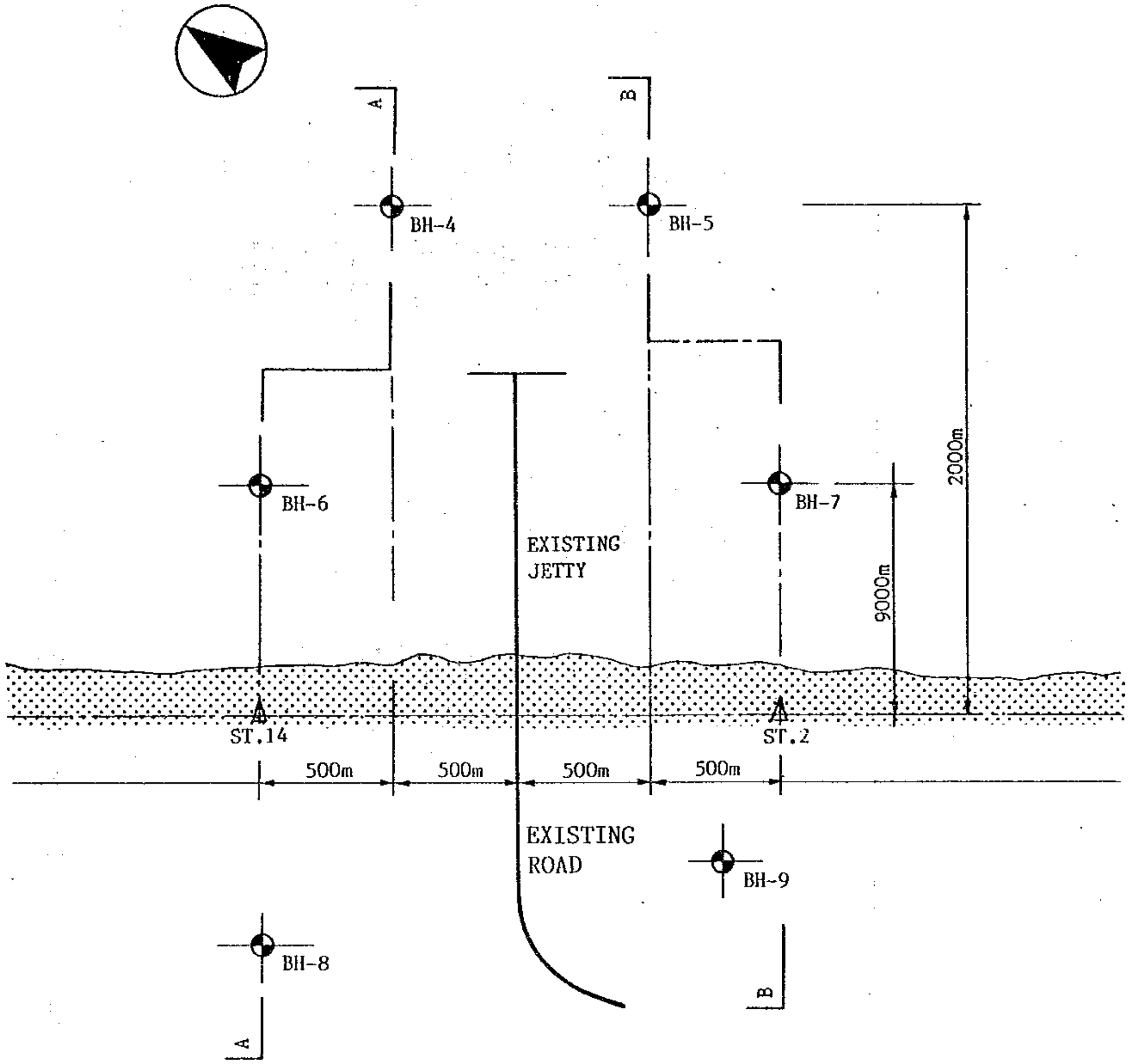


Fig. 2-3-3 The Location of the Boreholes (New Port)

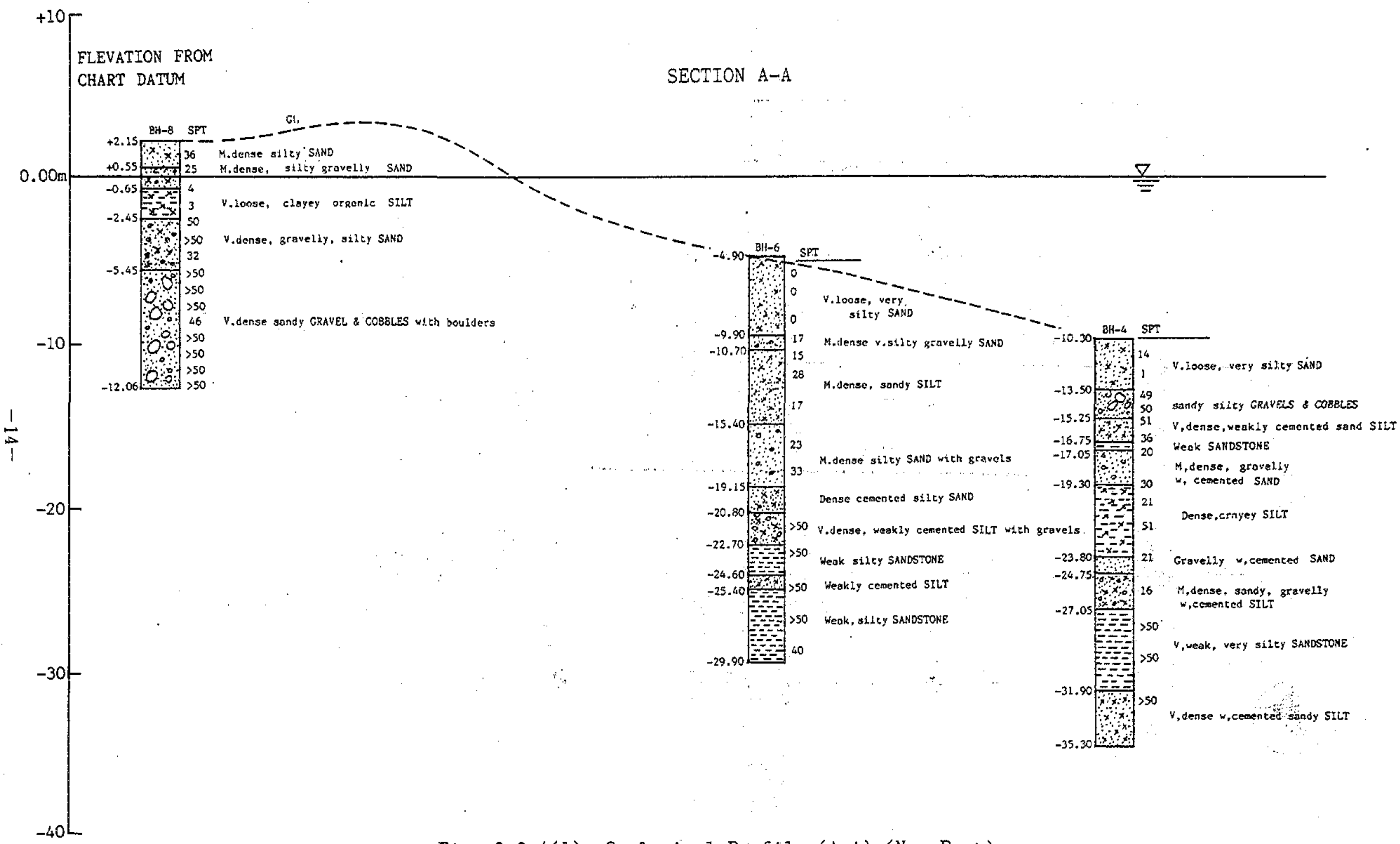


Fig. 2-3-4(1) Geological Profile (A-A) (New Port)

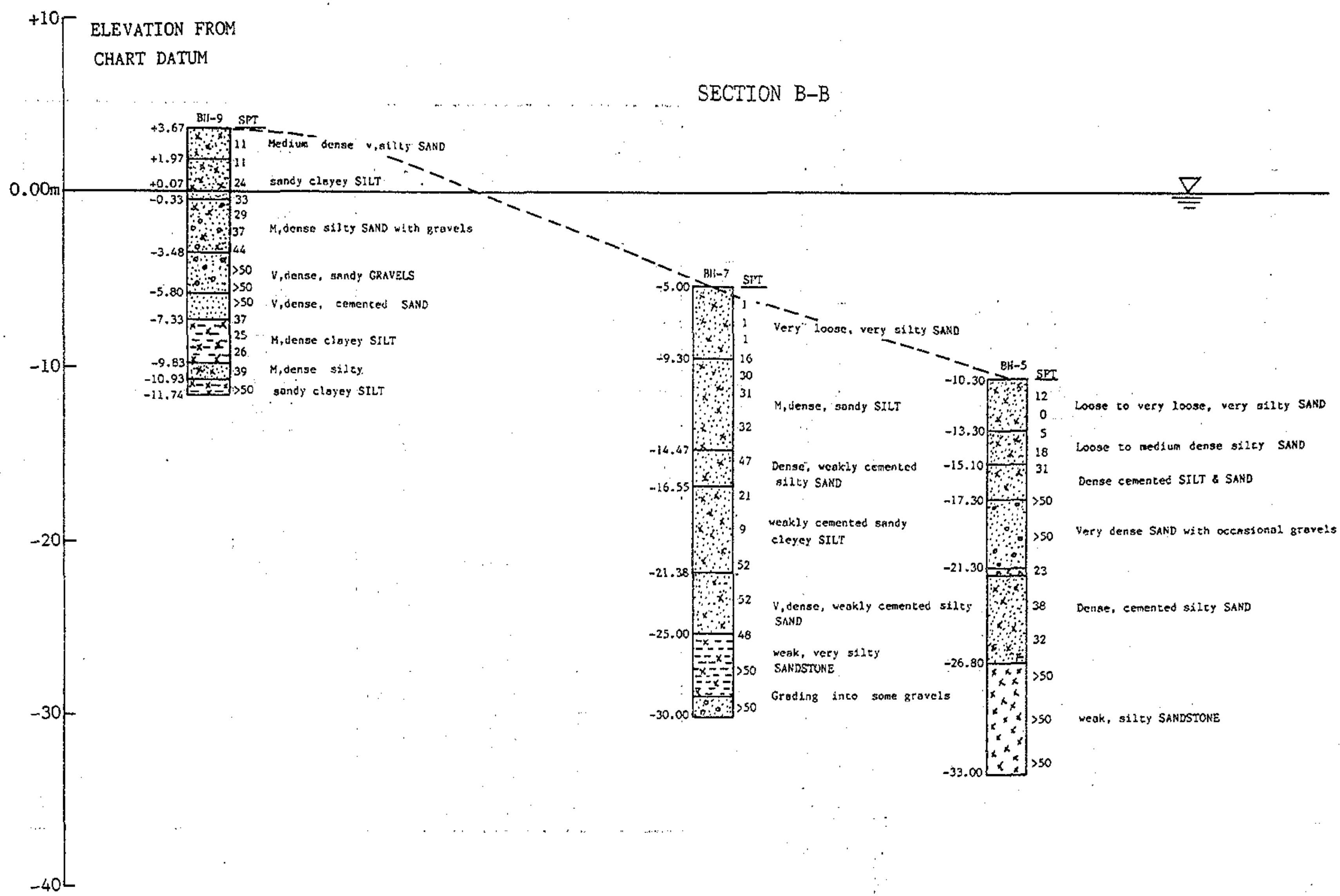


Fig. 2-3-4(2) Geological Profile (B-B) (New Port)

2.4 Hydrography

2.4.1 Tides

7. The predicted tidal levels for Muscat and Majis are as follows:

	Muscat	Majis
Highest astronomical Tide	+ 3.1	--
Mean high water spring	+ 2.7	+ 2.4
Mean high water Neap	+ 2.4	+ 1.9
Mean sea level	+ 1.9	+ 1.5
Mean low water Neap	+ 1.6	+ 1.1
Mean low water spring	+ 0.8	+ 0.9
Lowest astronomical tide	0	--

2.4.2 Waves

8. Significant wave heights and return periods for the Muscat Area and the New Port (deep water) are shown in Table 2-4-1 and 2-4-2.

Table 2-4-1 Significant Wave Height and Return Period for the Muscat Area (Deep Water)

Item / Wave Condition	Return Period in Years		
	10	50	100
Normal Regime Significant Wave Height in Meters. Wave Period in Seconds	 2.9 9	 3.3 10	 3.6 10
Cyclone Significant Wave Height in Meters. Wave Period in Seconds			 6.4 12

Table 2-4-2 Significant Wave Height and Return Period for the New Port (Deep Water)

Item / Wave Condition	Return Period in Years		
	10	50	100
Significant Wave Height in Meters.	4.2	5.3	5.9
Wave Period in Seconds			12

9. The desired service period of the breakwater will be 50 in years. The probability (% risk) of exceedance of design wave height should be less than 50%. Than, return periods of design wave height for breakwater will be 100 years.

10. The wave characteristics at the design depth can be determined by the following procedure:

Design Deep Water Wave

↓

Wave Deformation

↓

Dimensions of Design Waves
1) Significant Waves
2) Highest Waves

11. The dimensions of design waves at the design depth of -10m in Shutaify Bay and -7.5m at the New Port can be estimated based on the hydraulic model tests carried out so far.

The design wave are estimated as follows:

(1) Mina Qaboos

i. Design Deep Water Wave

Wave Direction	:	ENE
Wave Height	:	Ho = 6.4m
Wave Period	:	T = 12.0 sec
Wave Length	:	Lo = 224.6m
Slope of Sea Bottom	:	$\tan\alpha$ = 1/50
H.W.L	:	+ 2.7 m

ii. Equivalent Deep Water Wave Height (Ho')

Ho' = Ho x K•r = 6.4 x 0.88 = 5.6 m

iii. Design Waves

Design Depth	:	h = 12.7 m (10 m + 2.7 m)
Significant Wave Height	:	H1/3 = 5.8 m
Maximum Wave Height	:	Hmax = 9.5 m

(2) New Port

i. Design Deep Water Wave

Wave Direction	:	E
Wave Height	:	Ho = 5.9m
Wave Period	:	T = 12.0 sec
Wave Length	:	Lo = 225m
Slope of Sea Bottom	:	tan α = 1/200
H.W.L	:	+ 2.4 m

ii. Equivalent Deep Water Wave Height (Ho')

Ho' = Ho x Kr = 5.9 x 0.86 = 5.2 m

iii. Design Waves

Design Depth	:	h = 9.9 m (7.5m + 2.4m)
Significant Wave Height	:	H1/3 = 5.2 m
Maximum Wave Height	:	Hmax = 7.7 m

2.4.3 Tidal Current

12. Current observation was carried out to know the current characteristics (velocity an direction) for maneuverability of vessels, port constriction work and siltation. The observation was performed for 15 days continuously by using a selfrecording current meter.

13. Current velocity and direction of observation were shown in Fig. 2-4-1. As shown in this figure, the tidal current velocity was found to be less than 0.1m/sec at about 2m above the seabed. Primary directions of tidal currents are NW and SE. So the influence of tidal current on port construction and operation will be negligible. And the influence of tidal current on siltation will also be small.

2.4.4 Coastal Sediment Aspect

14. The majis coast is characterized by flat beaches and nearshore bottom slopes; and relatively low levels of wave and current energy, which are insufficient to disperse much of the sediment discharged from the mouths of wadis south of the site.

Seabed material sampling was carried out at 30 points and grain size were measured for littoral drift analysis.

15. The diameter of seabed material gradually decreases towards the off shore under the sorting action of the waves whereby the finer material is carried furtherest.

16. The seabed material from 0m to 3m in depth is mostly moved by waves., The seabed material from 4m to 13m in depth is very fine and its medium diameter is almost constant. Therefore, it seems that seabed material from 4m to 13m in depth is not moved so much.

From the report of Majis jetty study it was found that the net rate of movement near the site is about 12,000m^3/yr northwards and 6,000m^3/yr southwards. These are very low rates.

The net littoral drift would be fully trapped by any solid structure likely to be contemplated. The waterline would advance about 100-200m seaward after 50 years.

It was estimated that the maximum recession after 50 years could be 20-30m; that the total length of shore affected might be about 4km in 50 years.

17. At sheltered basins, or dredged areas, finer-grained sediment deposits are likely to be so dispersed that they are not likely to necessitate significant or frequent maintenance. At Wudum port, the existing navigation channel is subjected to deposition rate of about 8 centimeters per year.

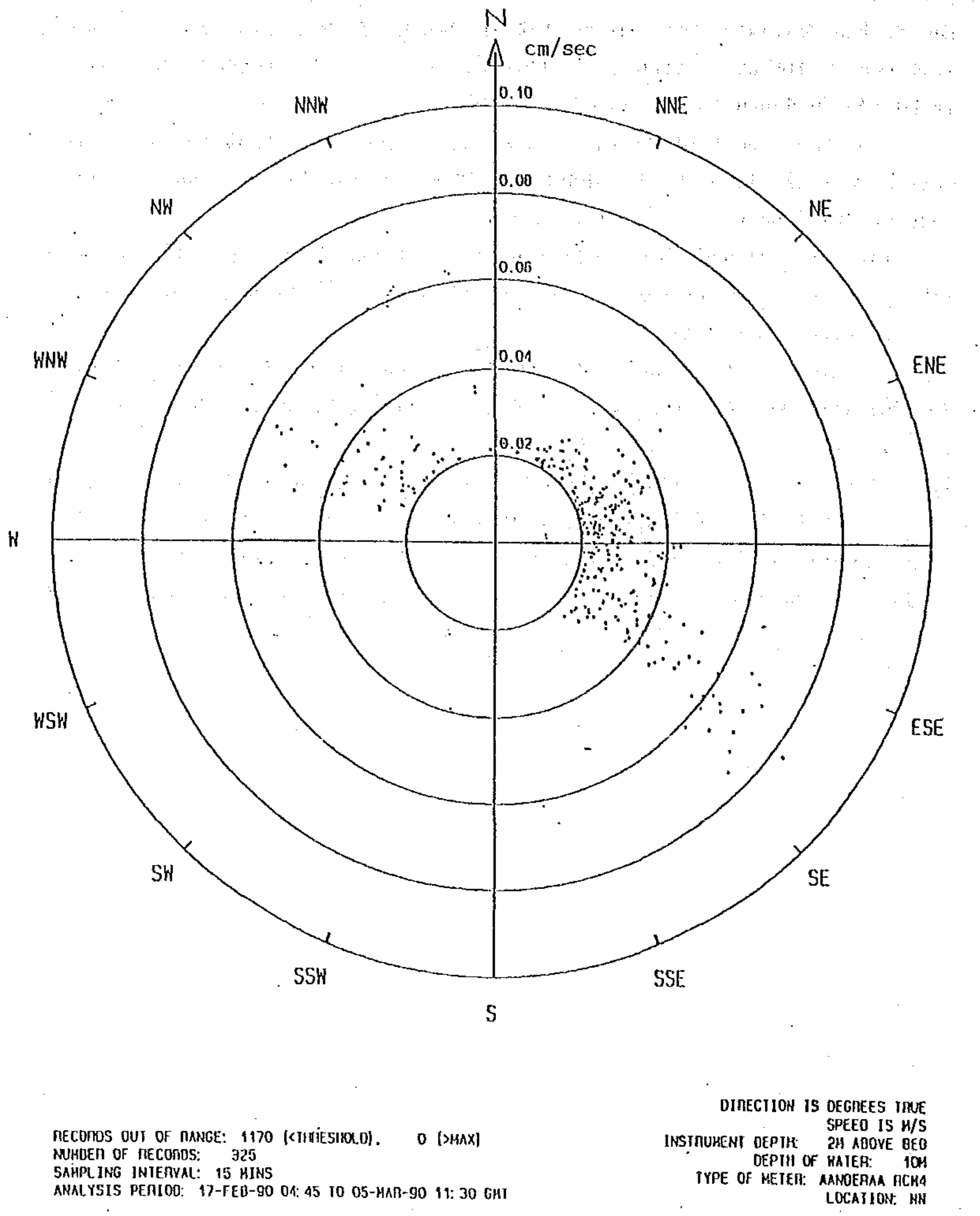


Fig. 2-4-1 Current Velocity and Direction

Chapter 3 PRESENT CONDITIONS OF MINA QABOOS

3.1 Port Facilities

(1) Structure of Breakwater and Quaywall

1. The approximately 700m breakwater is located at the north end of Mina Qaboos. (Fig. 3-1-1).

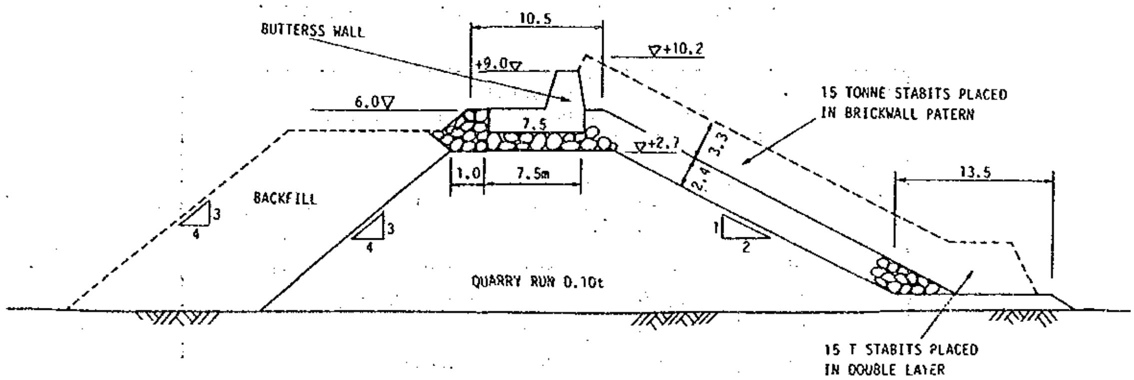


Fig. 3-1-1 Existing Breakwater

2. Typical cross sections of the quay walls of Berths Nos.1 to 13 are shown in Fig. 3-1-2.

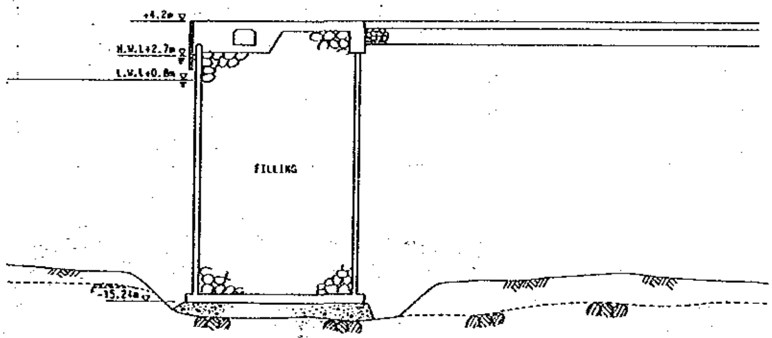


Fig. 3-1-2(1) Existing Quay Wall (Berth No.1A)

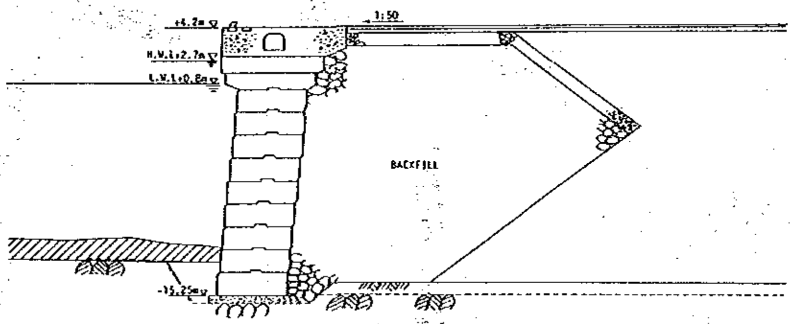


Fig. 3-1-2(2) Existing Quay Wall (Berth No.1, No.2)

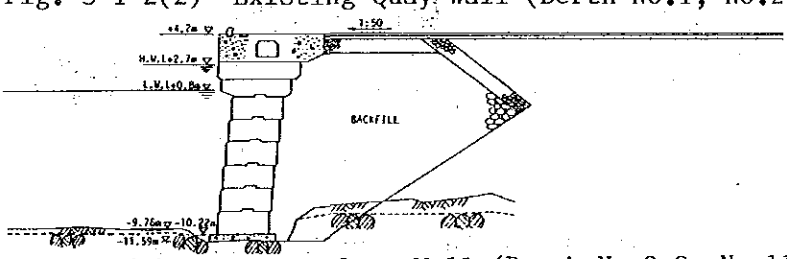


Fig. 3-1-2(3) Existing Quay Wall (Berth No.3-8, No.11)

(2) Length of and Draft at Berths

3. The layout of the port is presented in Fig. 3-1-3.

The length, draft available at Low Astronomical Tide (LAT) and main usage of each berth are given in table 3-1-1 below:

Table 3-1-1 Length of and Draft at Berths

Berth No.	Length (m)	Available Depth below CD (m)	Declared Draft (m)	Remarks
1A	91.5	13.0	10.4	Ro/Ro, Convention
1	183	13.0	10.4	Ro/Ro, Convention
2	183	13.0	10.4	Ro/Ro, Convention
3	228	11.0	9.8	Bulk Grain, Rice
4	183	9.5	9.1	Container
5	183	9.5	9.1	Container
6	198	9.5	9.1	Royal Support Yacht, Convention
7	183	9.5	9.1	Convention, Naval Vessel
8	183	9.5	9.1	Convention, Bitumen
9	122	5.0	4.0	Port Service
10	183	5.0	4.0	Naval, Police Vessel
11	183	9.5	4.0	His Majesty's Vessel
12	76	3.5	3.0	His Majesty's Vessel
13	152	2.5	2.2	Coast Guard Launch

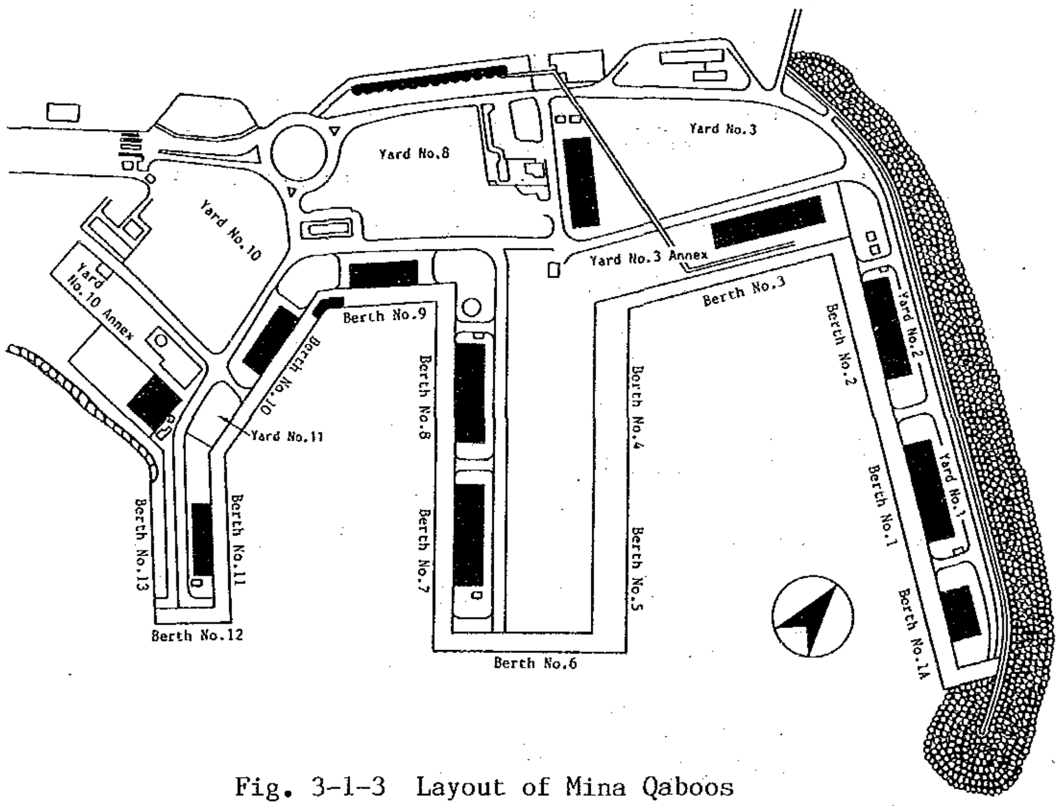


Fig. 3-1-3 Layout of Mina Qaboos

(3) Transit Shed and Open Storage Yard

4. The following transit sheds and open storage yards are available and utilized for the storage of cargoes. Those dimensions are shown in Table 3-1-2.

Table 3-1-2(a) Dimensions of Transit Shed

No.	Dimension	Area	Cargo by traffic mode
No. 1A	55 X 30.5m	1,678 m^2	Conventional
No. 1	110 X 30.5m	3,355 m^2	Conventional
No. 2	110 X 30.5m	3,355 m^2	Conventional
No. 3	131 X 30.5m	3,996 m^2	Conventional
No. 4	95 X 30.5m	2,898 m^2	Container (CFS)
No. 7	110 X 30.5m	3,355 m^2	Conventional
No. 8	110 X 30.5m	3,355 m^2	Conventional
No. 9	76 X 24.0m	1,824 m^2	Container (CFS)
No.10	76 X 24.0m	1,824 m^2	Government use
No.11	76 X 24.0m	1,824 m^2	His Majesty's use
	Total	27,462 m^2	

- Covered storage for conventional cargo: 19,094 m^2
- Covered storage for LCL cargo (CFS): 4,722 m^2
- Covered storage for government use : 3,648 m^2

Table 3-1-2(b) Dimensions of Open Storage Yard

No.	Area	Cargo by traffic mode
No. 1A	2,200 m^2	Conventional
No. 1	2,000 m^2	Conventional
No. 2	2,020 m^2	Conventional
No. 3	28,430 m^2	Conventional/Container
No. 3A	7,180 m^2	Container
No. 4/5	36,900 m^2	Container
No. 8	18,030 m^2	Container
No. 9	1,225 m^2	Conventional
No.10	20,000 m^2	Conventional/Container/Ro/Ro
No.10A	5,250 m^2	Ro/Ro
No.11	2,100 m^2	Container
Total:	125,335 m^2	

- Storage yard for conventional cargo: 39,910 m^2
- Storage yard for containers: 87,425 m^2

Note: Open yard allocation by comodity is illustrated in Fig. 3-1-4.

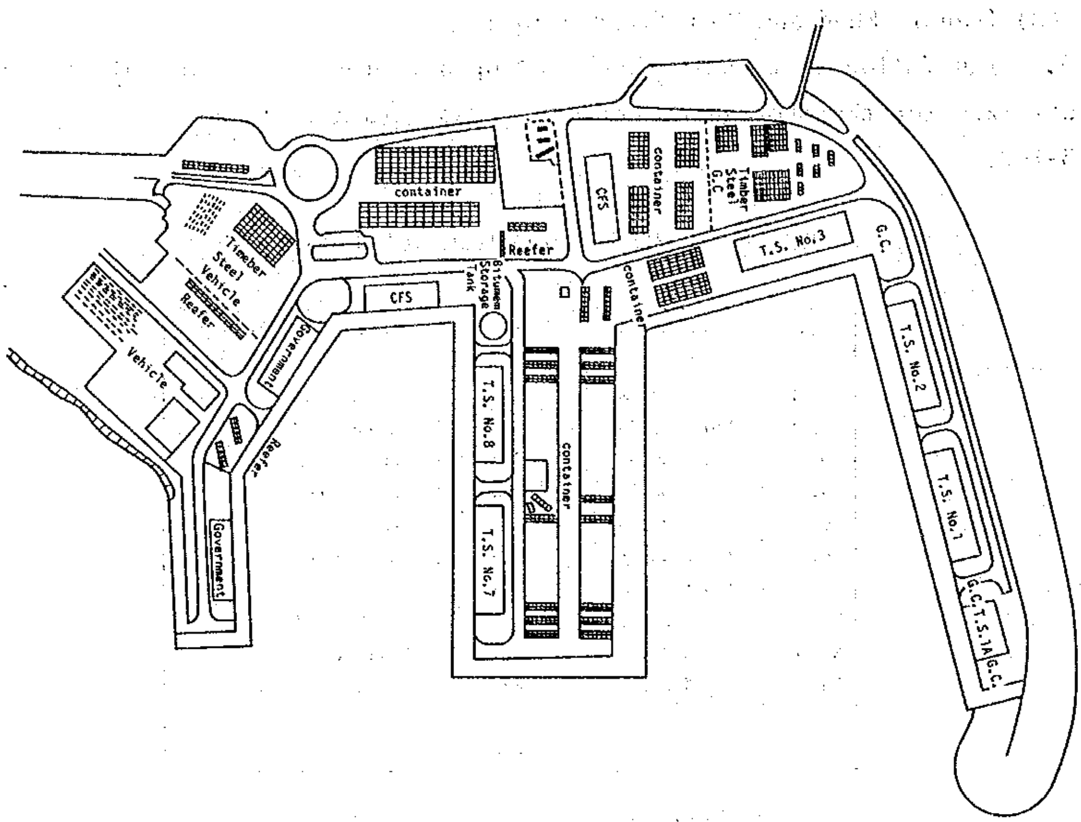


Fig. 3-1-4 Open Yard Allocation

3.2 Handling Equipment

(1) Container Crane

5. Two container cranes are installed on No.4 and 5 berths respectively. These two cranes are at present kept in good operating conditions as a result of good maintenance work by engineering department staff members. Because of this good maintenance, working and maintenance documents show that there are not many cases in which cranes are off work due to major accidents involving the machine.

The average rate of unloading/loading work at each container crane is 25 to 30 containers per hour. But at Mina Qaboos the average unloading/loading rate is lower. It seems that each container crane handles 17 to 20 containers per hour.

Fig. 3-2-1 shows the location of the existing crane rails for gantry cranes.

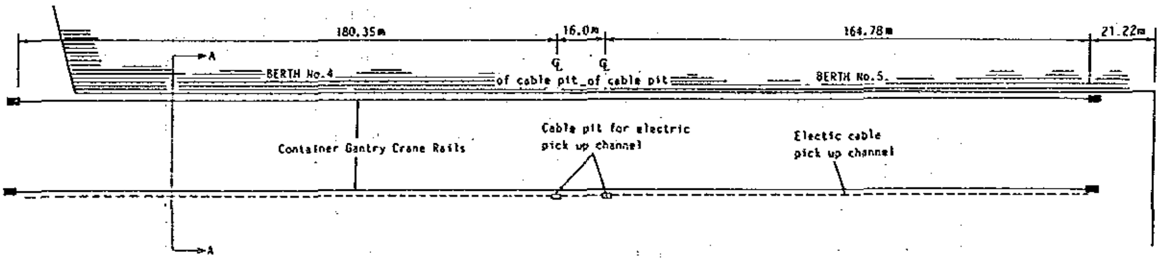


Fig. 3-2-1 Location of Crane Rails

(2) Pneumatic Unloader and Chain Conveyer

6. A pneumatic unloader and a chain conveyer are provided at No.3 berth by Flour Mill Co. Ltd.

According to actual daily reports of the Flour Mill Co. site office, transport tonnages are as follows:

Table 3-2-1 Actual Carrying Capacity of Flour Mill Conveyers

Date	Transport tonnage per 24h	Average (t/h)
Nov. 19/89	4,980	207
Nov. 30/89	5,500	230
Nov. 04/89	3,652	170

This system has improved its carrying capacity from 230 t/h to 250 t/h by replacing the electric motors and reducers in 1984.

(3) Forklift Trucks (Heavy Type)

7. There are eight (8) forklift trucks with a capacity over 25,000kg weight at the port.

3.3 Cargo Movement

8. Table 3-3-1 shows the cargo volume handled at Mina Qaboos between 1978 and 1988. As compared with imports which have declined since 1986, when oil prices fell, transshipments have been on the rise for the last few years. The port owes the constant increase in the total volume of cargo to this upsurge of transshipment.

Table 3-3-1 Cargo Volume Handled at Mina Qaboos

(Unit: '000 tonnes, TEUs)

Year	Cargo Volume (Import)	Cargo Volume (Export)	Cargo Volume (Ex+Im)	Cargo Volume (Tranship)	Cargo Volume (Total)	(Container) TEU
1978	782.2	10.1	792.3	0.0	792.3	
1979	697.7	19.6	717.3	11.8	729.1	
1980	781.9	23.7	805.6	2.2	807.8	
1981	1,088.6	21.6	1,110.2	0.1	1,110.3	
1982	1,352.2	31.8	1,384.0	12.2	1,396.2	14,965
1983	1,318.2	38.8	1,357.0	31.6	1,388.6	44,112
1984	1,195.0	51.1	1,246.1	90.7	1,336.8	65,901
1985	1,207.1	62.0	1,269.1	192.7	1,461.8	90,175
1986	930.4	50.0	980.4	287.4	1,267.8	111,596
1987	777.5	57.7	835.2	713.4	1,548.6	110,635
1988	950.9	67.3	1,018.2	603.7	1,621.9	139,256

Source: PSC

9. Table 3-3-2 shows the import cargo volume by commodity. Cement, which had been the largest import, has fallen sharply since Oman started operating its own cement factories in Rusayl and Salalah. Since the 1986 crisis, most cargoes have been decreased but above all a down trend of in imports of construction materials (steel, timber, other building materials, heavy duty trucks and so forth) is remarkable.

Table 3-3-2 Import Cargo Volume at Mina Qaboos by Commodity

(Unit: '000 tonnes)

Year	Rice	Wheat & Flour	Other Grain	Sugar	Chilled & Frozen Foodstuffs	Other Food-Stuffs	Timber & Plywood	Steel & Pipe
1978	20.5	39.1		10.1	13.5	53.2	42.7	31.6
1979	25.3	62.5		6.1	17.7	47.8	36.5	54.0
1980	20.4	68.7		2.2	24.4	63.6	56.0	51.9
1981	17.7	87.3		4.8	19.3	60.5	67.2	99.7
1982	25.8	80.3		4.3	23.8	69.3	107.3	136.6
1983	48.7	98.8		6.0	29.7	91.5	121.7	140.1
1984	55.7	117.2		19.4	42.6	99.4	130.8	167.6
1985	61.8	100.9		7.5	49.0	86.5	134.3	155.0
1986	60.1	156.4		17.1	48.8	64.5	82.7	63.5
1987	60.5	150.5		16.0	39.4	72.3	60.7	34.2
1988	82.3	105.8	29.7	22.7	44.9	81.8	70.9	149.0

Source: PSC

(Unit: '000 tonnes)

Year	Cement-bagged	Cement-bulk	Other Building Materials	Vehicles	Livestock	General Cargo	Total
1978	382.0	28.7	6.5	26.4	0.6	127.3	782.2
1979	232.6	38.6	7.6	40.6	0.3	128.1	697.7
1980	145.8	118.1	6.1	60.5	0.4	163.8	781.9
1981	300.8	128.0	8.0	69.9	0.4	225.0	1,088.6
1982	261.5	271.1	13.5	88.6	3.1	267.0	1,352.2
1983	96.2	242.9	30.0	94.0	8.1	310.5	1,318.2
1984	43.9	0.0	39.0	98.2	7.0	374.2	1,195.0
1985	34.4	0.0	36.7	83.1	6.5	451.8	1,207.5
1986	25.3	0.0	24.2	27.6	8.2	352.0	930.4
1987	10.4	0.0	22.0	19.1	10.4	282.0	777.5
1988	10.2	0.0	19.5	32.6	14.3	287.2	950.9

Source: PSC

10. Import cargo volume by handling mode is shown in Table 3-3-3. Although less than 15% of rice is containerized, the containerization ratio of all containerizable imports is quite high: 76% in 1987 and 73% in 1988 (containerizable cargo is defined as all non-bulk cargo exclusive of vehicles, livestock timber and steel).

Table 3-3-3 Import Cargo Volume at Mina Qaboos by Handling Mode

(Unit: '000 tonnes)

Year	Bulk Grain	Bulk Cement	Other Bulk	Ro/Ro Live stock	Timber & Plywood	Steel & Pipes	Break bulk Cargo	Container	Total
1981	87.2	128.0	0.0	70.3	67.2	99.7	480.7	155.5	1,088.6
1982	80.2	271.1	13.7	91.7	107.3	136.6	431.7	220.0	1,352.2
1983	98.7	242.9	21.4	102.1	121.7	140.1	269.1	322.1	1,318.2
1984	110.2	0.0	27.6	105.2	130.8	167.6	241.4	412.3	1,195.0
1985	100.8	0.0	40.1	89.6	134.3	155.0	216.7	471.0	1,207.5
1986	156.3	0.0	17.8	35.8	82.7	63.5	157.7	416.6	930.4
1987	150.3	0.0	31.0	29.5	60.7	34.2	111.5	360.3	777.5
1988	135.4	0.0	18.8	46.9	70.9	149.0	144.4	385.9	950.9

Source: PSC

11. Tables 3-3-4 and 3-3-5 provide the information about export cargo. Major export commodities handled at Mina Qaboos are copper, fish, scrap and provisions but the quantity of exports is quite small compared with imports. The ratio of containerized export cargo has reached more than 90%, utilizing a lot of empty containers which have brought import cargoes.

Table 3-3-4 Export Cargo Volume at Mina Qaboos by Commodity

(Unit: '000 tonnes)

Year	1986	1987	1988
Copper	15.5	14.2	11.6
Fish	10.8	11.6	10.5
Scrap	4.2	11.7	3.2
Provisions	0.9	2.2	10.3
Vehicles	4.8	5.8	2.8
Dates	0.2	0.1	0.0
Other Cargo	13.6	12.1	28.9
Total	50.0	57.7	67.3

Source: PSC

Table 3-3-5 Export Cargo Volume at Mina Qaboos by Handling Mode

(Unit: '000 tonnes)

Year	Container	Break Bulk	Bulk	Total
1981	2.8	18.8	0.0	21.6
1982	6.3	25.5	0.0	31.8
1983	12.3	26.5	0.0	38.8
1984	34.5	10.7	5.9	51.1
1985	32.3	28.6	1.1	62.0
1986	43.5	1.6	4.9	50.0
1987	50.5	7.2	0.0	57.7
1988	60.2	7.0	0.1	67.3

Source : PSC

12. Table 3-3-6, 3-3-7, 3-3-8 show the container traffic of imports, exports and transshipments, respectively. The proportion of 20ft. containers and 40ft. containers is nearly fifty-fifty in terms of TEU (this means that the ratio is about 2:1 in terms of boxes).

Table 3-3-6 Import Container at Mina Qaboos

Year	With Cargo (TEU)	%	Empty (TEU)	%	Total ① (TEU)	Boxes of 20ft. ②	Boxes of 40ft.	② / ① %	Boxes of Container
1981	14,925								
1982	21,379	98.0%	446	2.0%	21,825	15,169	3,328	69.50%	18,497
1983	31,412	97.7%	727	2.3%	32,139	19,609	6,265	61.01%	25,874
1984	40,044	98.4%	646	1.6%	40,690	22,874	8,908	56.22%	31,782
1985	47,146	97.6%	1,154	2.4%	48,300	25,518	11,391	52.83%	36,909
1986	39,422	97.2%	1,116	2.8%	40,538	20,996	9,771	51.79%	30,767
1987	30,619	96.9%	972	3.1%	31,591	17,393	7,099	55.06%	24,492
1988	32,701	96.8%	1,091	3.2%	33,792	17,494	8,149	51.77%	25,643

Source: PSC

Table 3-3-7 Export Container at Mina Qaboos

Year	With Cargo (TEU)	%	Empty (TEU)	%	Total ① (TEU)	Boxes of 20ft. ②	Boxes of 40ft.	② / ① %	Boxes of Container
1981	305								
1982	772	3.7%	20,307	96.3%	21,079	14,665	3,207	69.57%	17,872
1983	1,342	4.4%	28,917	95.6%	30,259	19,427	5,416	64.20%	24,843
1984	2,409	6.1%	36,824	93.9%	39,233	22,075	8,579	56.27%	30,654
1985	2,833	6.0%	44,487	94.0%	47,320	25,254	11,033	53.37%	36,287
1986	4,115	9.8%	37,947	90.2%	42,062	21,650	10,206	51.47%	31,856
1987	4,939	16.1%	25,782	83.9%	30,721	16,847	6,937	54.84%	23,361
1988	5,610	16.2%	28,978	83.8%	34,588	18,134	8,227	52.43%	26,361

Source: PSC

Table 3-3-8 Transshipment Container at Mina Qaboos

Year	With Cargo (TEU)	%	Loaded (TEU)	%	Total ① (TEU)	Boxes of 20ft. ②	Boxes of 40ft.	② / ① %	Boxes of Container
1981	20	50.0%	20	50.0%	40	24	8	60.00%	32
1982	604	50.0%	604	50.0%	1,208	964	122	79.80%	1,086
1983	1,752	50.0%	1,751	50.0%	3,503	1,777	863	50.73%	2,640
1984	5,145	50.2%	5,107	49.8%	10,252	5,716	2,268	55.75%	7,984
1985	8,008	50.1%	7,968	49.9%	15,976	12,086	1,945	75.65%	14,031
1986	14,318	51.1%	13,717	48.9%	28,035	21,109	3,463	75.30%	24,572
1987	38,613	50.2%	38,331	49.8%	76,944	43,386	16,779	56.39%	60,165
1988	39,801	50.1%	39,701	49.9%	79,502	45,355	17,073	57.05%	62,428

Source: PSC

13. In Mina Qaboos, there are four different types of container cargo movement, namely, the movement of import containers, export containers (loaded), export containers (empty) and transshipment containers. There are various kinds of combinations of container shipments in Mina Qaboos, as shown in Fig. 3-3-1, and among these, five combinations dominate. From this figure, it is understood that in most cases, transshipment cargoes are transported with other kinds of containers, except for 3.2% of all combinations.

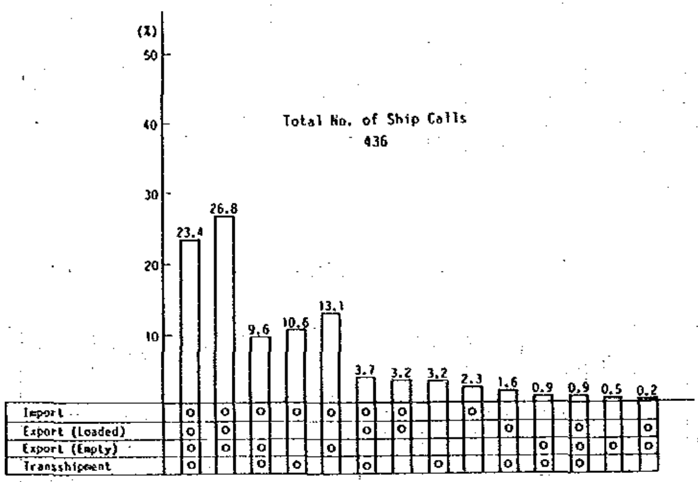
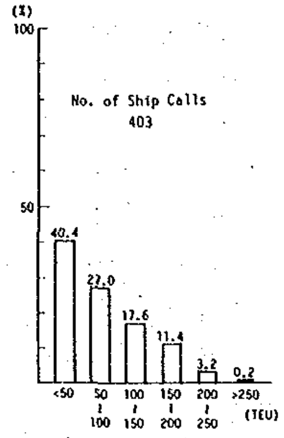
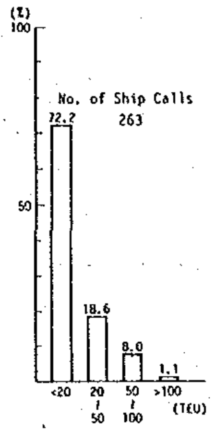


Fig. 3-3-1 Combination of Container Movements for Each Ship Call (1987)

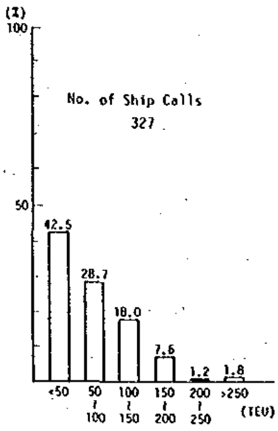
14. The number of containers discharged/loaded for each ship call is shown in Fig. 3-3-2, and some specific features are revealed here. Reflecting the total throughput for each type of container, the number of transshipment container handled is by far the largest, with more than 1000 TEUs at one ship call. In contrast, the number of export containers (loaded) handled is very small and concentrated in a range of less than 20 TEUs at one ship call. Import containers and export containers (empty) show almost the same characteristics. This information is very helpful in planning the locations an areas of container stocking yards.



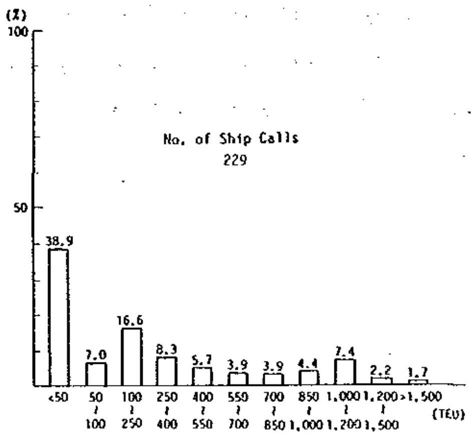
(a) Import Containers



(b) Export Containers (Loaded)



(c) Export Containers (Empty)



(d) Transshipment Containers

Fig. 3-3-2 Number of Containers per One Dischange/Loading (1987)

Source: PSC data

3.4 Calling Ships

15. The total number of ships calling at Mina Qaboos amounted to 1,056 in 1988. Among these, the number of container ships was by far the largest, about 40% of all calling ships. Other types of ships calling often were conventional ships, Ro/Ro ships and livestock ships. Details of the characteristics of calling ships are shown in Table 3-4-1. Maximum arrival drafts and tonnages (GRT) are shown in Table 3-4-2. This table shows most of the largest ships for each ship type exceeded 10 meters in arrival draft. In Mina Qaboos, declared draft is at most 10.4 meters, even for berths No.1, 1A and 2, due to the limited depth of the approach channel. In the case of container berths, Berths No.4 and 5, the declared draft is only 9.1 meters. This situation means many ships have been utilizing Mina Qaboos with the aid of tides. Table 3-4-3 show the dimensions of container ships calling at Mina Qaboos. It is obvious most of these ships cannot call at Mina Qaboos with its maximum draft under usual conditions. Hence some of them call utilizing tides and some of them use Mina Qaboos as the last port on their itinerary.

Table 3-4-1 Number of Calling Ships (1988)

Ship Type Size	Berth Numbers																Total
	1	2	2A	2B	3	4	5	6	7	7A	7B	8	8A	8B	10	11	
11	6	5	1	1	12	16	2	1	9	1		12	1	2	3		72
12	4	3			2			2	7	1		6	2			1	28
13	5	14			11		1	3	16	2		17					69
14	10	26			1			5	3								45
21						1											1
22		1				39	21					1					62
23	1	2				102	43	1									149
24	1					129	62										192
31	1	3			3	5											12
32		1			2	2	4		1			1					11
33	2	1				10	3	1									17
34	1	4				6	2										13
41																	0
42		1			1				2	1		1	1				7
43		1			4							1					6
44					4												4
51																	0
52																	0
53					2												2
54																	0
61																	0
62	3				1		2	2	2								10
63	1	2							3			1					7
64																	0
71																	0
72	7	2				1		2									12
73	71	4				2	5	11	1								94
74	39	1				2	3	3									48
81																	0
82	1						1										2
83	7																7
84	13						1										14
91	5				15		1	7	10		4	34	3	1	7		87
92	5	1			2		1	7	8	1		9			3	10	47
93	6							15	1			2				3	27
94	2						2	5	2								11
Total	191	72	1	1	60	315	154	65	65	6	4	85	7	3	13	14	1056

Source: PSC

Table 3-4-2 Min/Max Draft/Gross Tonnage of Calling Ships (1988)

Ship Type Size	Draft		Tonnage	
	Minimum	Maximum	Minimum	Maximum
11	0.9	6.1	147	996
12	3.0	6.9	1000	4633
13	5.0	10.4	5084	12750
14	5.6	10.2	15041	28005
21	3.4	3.4	984	984
22	4.0	7.3	1223	4999
23	5.2	8.8	5332	13107
24	4.2	10.6	15122	33761
31	1.8	1.8	258	795
32	3.1	7.4	1000	4633
33	6.0	9.2	5575	11941
34	6.8	10.3	15122	33761
41				
42	4.3	7.2	1223	4548
43	8.2	10.1	7083	14440
44	9.6	9.8	16023	18622
51				
52	5.3	9.2	8844	9315
53				
54				
61				
62	3.9	8.2	1599	4412
63	6.0	10.3	5266	14418
64				
71				
72	4.3	8.1	1000	4046
73	7.0	9.3	7050	14660
74	7.2	10.0	15673	53578
81				
82	6.0	6.0	3369	3761
83	7.0	8.2	8269	12079
84	7.2	10.7	16222	34082
91	2.0	3.8	147	750
92	4.5	8.1	1200	4609
93	6.0	8.5	5000	12359
94	6.3	10.3	16000	30645

Ship Code	Ship Type GRT
11	Conventional < 1000
12	Conventional 1000 - 5000
13	Conventional 5000 - 15000
14	Conventional > 15000
21	Full Container < 1000
22	Full Container 1000 - 5000
23	Full Container 5000 - 15000
24	Full Container > 15000
31	Semi Container < 1000
32	Semi Container 1000 - 5000
33	Semi Container 5000 - 15000
34	Semi Container > 15000
41	Grain Carrier < 1000
42	Grain Carrier 1000 - 5000
43	Grain Carrier 5000 - 15000
44	Grain Carrier > 15000
51	Dry Bulk Carreir < 1000
52	Dry Bulk Carrier 1000 - 5000
53	Dry Bulk Carrier 5000 - 15000
54	Dry Bulk Carrier > 15000
61	Liquid Carrier < 1000
62	Liquid Carrier 1000 - 5000
63	Liquid Carrier 5000 - 15000
64	Liquid Carrier > 15000
71	Ro-Ro Ship < 1000
72	Ro-Ro Ship 1000 - 5000
73	Ro-Ro Ship 5000 - 15000
74	Ro-Ro Ship > 15000
81	Livestock Carrier < 1000
82	Livestock Carrier 1000 - 5000
83	Livestock Carrier 5000 - 15000
84	Livestock Carrier > 15000
91	Visit/Other Ship < 1000
92	Visit/Other Ship 1000 - 5000
93	Visit/Other Ship 5000 - 15000
94	Visit/Other Ship > 15000

Source: PSC

Table 3-4-3 Container Vessels Calling at Mina Qaboos

Name of Owner	Maximum LOA (m)	Maximum Arrival Draft (m)
CMA	188	10.7
Norasia Line	180	10.0
Bule Star Line	188	10.5
Mitsui O S K Line	212	10.0
Nippon Yusen Kaisha (Far East)	215	8.8
Nippon Yusen Kaisha (Aus/NZ)	151	8.0
Lloyd Triestino	150	8.5
Seacrest Shipping	115	6.0
P & OCL	215	10.5
CMB	209	10.5
NCHP	205	10.5
Jugolinija	146	9.0
Maersk Line	241	11.0
Maersk Line (Feeder Vessels)	128.5	6.8
Maersk Line (Feeder Vessels)	137.1	6.4
Showa	216	
Ellerman	216	
Ceylon Shipping Corporation	129	7.5
DSR	150	7.0
Nedlloyd	230	10.5
Happag Lloyd	226	10.5
UASC	211	10.8
Y.S. Line (Last Port)	227	9.0
K Line (Last Port)	227	9.0
Sealand	151	7.8
OOCL	221	9.3
APL	202	9.5
Merzario	192	7.4

Note: LOA stands for Overall Length
Source: PSC

16. Concerning conventional ships, more than 40% of such ships are concentrated in a small size range of less than 2,000 GRT, with large ships of more than 20,000 GRT accounting for only 5% of all ships. The distribution of container ships depicts one conspicuous feature, that is the existence of two different size groups, one being the group of less than 10,000 GRT and the other comprising ships of more than 18,000 GRT. This can be interpreted as meaning the small ships group represents feeder ships and the large-ship group represents main line ships. Most grain carriers transport wheat from Australia. Among these, large ships call at Mina Qaboos half loaded due to the limited depth at Berth No.3. Concerning Ro/Ro ships, no draft limits are expected, due to its structural characteristics. Even for maximum-sized ship of 53,578 GRT, the draft is only 8.1 meters. For Ro/Ro ships, their overall length is a more important factor regarding the use of berths. Twelve calls were made by such ships with lengths of more than 200 meters.

3.5 Cargo Operation

3.5.1 Storage Facility and Cargo Throughput

17. The import/export cargo handled at Mina Qaboos can be calculated according to delivery/storage mode as follows:

- Total Import Throughput 950,900 tons
  - Container Cargo = 385,900 tons
  - Conventional Cargo = 565,000tons
    - Direct Delivery Cargo : 220,830 tons
    - Covered Storage Cargo : 62,925 tons
    - Open Storage Cargo : 281,245 tons
- Total Export Throughput 67,300 tons
  - Container Cargo : 60,200 tons
  - Break Bulk : 7,000 tons
  - Bulk : 100 tons

18. The area inside the port is currently allocated according to storage mode as follows:

Cargo mode	Throughput (Import)	Area allocated
Container cargo	385,900 tons	87,425 m^2
Open storage cargo	281,245 tons	39,910 m^2
Covered storage cargo	62,925 tons	19,072 m^2

Note: Transit shed Nos.4 & 9 are mainly utilized for CFS and excluded from the covered storage area for conventional cargo.

3.5.2 Productivity of Cargo Handling

(1) Conventional Cargo

19. The productivity of cargo handling discharge was calculated for major commodities transported by several typical vessels. The results are as follows:

(a) Steel in bars and pipes

Maximum	: 26.8 tons/G/Hr.
Minimum	: 17.0 tons/G/Hr.
Average	: 23.2 tons/G/Hr. (out of 5 specific vessels)

(b) Timber (In bundles, poles, crates etc.)

Maximum	: 49.3 tons/G/Hr. (poles)
Minimum	: 12.0 tons/G/Hr.
Average	: 23.9 tons/G/Hr. (out of 7 specific vessels)

(c) Rice (in bags)

Maximum	: 13.4 tons/G/Hr.
Minimum	: 10.6 tons/G/Hr.
Average	: 12.2 tons/G/Hr. (out of 4 specific vessels)

(d) Reefer cargo

Maximum	: 7.5 tons/G/Hr.
Minimum	: 4.2 tons/G/Hr.
Average	: 6.1 tons/G/Hr. (out of 5 specific vessels)

(e) General cargo (mixed, such as cement, timber, pipes, drums Cables, etc.)

Maximum	: 30.2 tons/G/Hr.
Minimum	: 9.4 tons/G/Hr.
Average	: 18.9 tons/G/Hr. (out of 15 specific vessels)

The productivity for loading is generally less than that of discharging, approximately 80% or less.

(2) Container Cargo

20. We picked 24 vessels at random and calculated the productivity of container per crane per hour.

From the calculation we obtained the following results:

a) Rates of discharging : Maximum: 27.5 Box/Hr/Crane
Minimum: 13.5 Box/Hr/Crane
Average: 20.2 Box/Hr/Crane

b) Rates of loading : Maximum: 28.7 Box/Hr/Crane
Minimum: 12.6 Box/Hr/Crane
Average: 16.8 Box/Hr/Crane

c) The loading rates are generally lower than those for discharging. The difference is approximately 17%.

3.5.3 Labour Force and Work Hours

21. The labour force, their constitution and work hours were indicated by the PSC and were noted as follows:

(1) Gangs for Handling General Cargo

i) Number of gangs:
Gangs for day shift: 7 gangs
Gangs for night shift: 5 gangs

ii) Work hours:
day shift : 0700 - 1500
night shift: 1500 - 2300

iii) Constitution of gangs
Foreman: 1 person
Tindale: 2 persons
Labourers on ship : 8 persons
Labourers on shore: 4 persons

In addition to the gangs, one supervisor is stationed on each vessel.

(2) Gangs for Handling Containers

i) Number of gangs

1) Sea/side for loading/discharging
1st shift: 1 gang
2nd shift: 1 gang
3rd shift: 1 gang

2) Land side for CFS
1 gang is deployed for the day shift

ii) Work hours

1) Sea/side operation

Round the clock service is provided for the sea/side.

2) Land side operation

1st shift: 0600 - 1400

2nd shift: 1400 - 2200

3rd shift: 2200 - 0600

3) CY Operation (Delivery/Receiving)

1st shift: 0700 - 1500

2nd shift: 1500 - 2300

4) CFS operations

Day shift only: 0700 - 1500

As well, ship side gangs can be deployed for CFS operations if the CFS operation is very busy and also if there are no vessels at the berth.

iii) Constitution of gangs

1) Sea side (shipside) gangs

Foreman: 1 person

Winchman: 2 persons

Labourers: 13 persons

In case of 2 cranes being in service, the gang is divided into 2 groups for operations with each crane.

2) CFS gang

Foreman: 1 person

Tally clerk: 2 persons

Marker boy: 1 person

Labourers: 8 persons

Forklift drivers: 3 persons

In addition to the above, one supervisor conducts the CFS operation.

3.5.4 Dwelling Time of Cargo

22. In order to estimate the appropriate land area, an investigation into the dwell time of cargo and the peak factor of operation is essential. Dwell time of container was analyzed by the PSC's staff for a total of 41,282 units and the results were submitted to the Study Team.

The summary of dwelling times is as follows:

Summary of Dwelling Times

Import FCL Container	20 Ft.	9.42 days
	40 Ft.	7.76 days
Import LCL Container	20 Ft.	2.74 days
	40 Ft.	3.13 days
Import TRS Container	20 Ft.	7.86 days
	40 Ft.	8.92 days
Export MT from FCL	20 Ft.	11.51 days
	40 Ft.	10.99 days
Export MT from LCL	20 Ft.	13.44 days
	40 FT.	13.40 days

Note: MT = empty container

23. Table 3-5-1 shows the calculated dwelling time for the principal conventional cargoes based on three month's data provided by PSC. This result shows that dwelling times are around one week for principal conventional cargoes and two weeks for general cargoes.

Table 3-5-1 Average Dwelling Time

(Days)

Commodity	OCT 88	NOV 88	DEC 88
Steel/Pipes	8	6	7
Rice	48	7	
Timber/Plywood	8	7	9
Vehicles	5	5	6
Others	14	12	12

3.5.5 Shore Side Operations

24. We investigated the shore side operations by processing the records of daily container movements.

The records show the number of containers daily delivered, received, grounded and shifted to the CFS. The records we used were those of July 1988.

The results obtained is as follows:

i) Total number of containers delivered: 1813 Boxes (58 Boxes/day)
ii) Total number of containers received: 1858 Boxes (60 Boxes/day)
iii) Total number of containers grounded: 234 Boxes (8 Boxes/day)
iv) Total number of unloaded LCL containers: 143 Boxes (5 Boxes/day)
v) Ratio of LCL containers: 6.5% (import)
vi) Ratio of FCL containers grounded: 11% (import)
vii) Daily handling rate at shore side: 144 Boxes/day
(grounded and CFS containers were counted twice)

3.5.6 FCL Grounded Containers

25. From the container movement report, we found that many FCL container are treated as grounded container. This means FCL containers are unloaded within the port area. The unloading area is not pre determined and so we found the operation being carried out here and there. The service is provided to consignee who don't have proper premises, but this interfered with the rotation of containers and effective land use. The grounding service makes FCL containers' dwelling time longer to some extent and occupies some area with on-tier stacking. Because some consignees use containers as a substitute for warehouses and keep them in the port area with cargo in one-tier stacking for some time, they can stay at the port for a long time. The PSC cannot shift them into one place and stack them in tiers.

3.5.7 Present Situation of Computer-based Container Terminal Operation

26. At Mina Qaboos, the development program for a computer-based container terminal operations has been divided into the following four stages.

Stage I : Vessel Operations (Discharging/Loading)
Stage II : Full Container Movement
Stage III : Empty Container Movement
Stage IV : Shipping Operation

At present, Stages I and II have been already introduced to daily terminal operations and Stage III and IV, are in the proposal stage.

27. The outline of the processing system of Stage I and Stage II is summarized as follows:

(1) Manifest

A manifest is submitted to the Cargo Documents Office (CDO) by a shipping agent prior to the vessel's arrival. Prior to data input at CDO, the Rotation Number of the vessel in question is determined by the Harbour Master, and an Index Number is given according to the number of B/Ls by the CDO. Based upon these, data processing is carried out on screen. The CDO inputs such items as Container Agent Code, Consignee Name, Vessel Name, B/L Number, Container Number, ISO Code, deiscription of Goods and so on.

(2) Stowage Plan

The Stowage Plan of the vessel is submitted to the Control Centre. The Head Planner manually arranges a sequencing schedule of each container for dischaging and sequence numbers are input.

(3) Discharging Working List/Tally Sheet

These lists are distributed to the ship's supervisor, the berth supervisor, and tally clerks.

(4) Discharging

During the discharging operations, Tally Clerks record the seal number of each container, and triplicate Container Inspection Reports. The Original Report is delivered to the agent and the inspection details and the result of tallying are input.

(5) Discharge List (Actual)/Discrepancy List

After completion of discharging, the Discharge List (Actual) and

Discrepancy List are printed out. The Actual Discharge List is sent to the Agent and the Discrepancy List to the CDO of the Finance Department. Such reports as the Ship's Supervisor Report, Stevedoring Report and Service Render Report are sent to the Account Section.

(6) Stacking and Movement

LCLs are stacked in blocks and wait for the arrangement of CFS operations. TRS are segregated by port, weight, size, IMO and type. Regarding Local containers, there are three ways of handling them, i.e. FCL Delivery, Direct Delivery and Grounding. Grounding containers are unstuffed inside the port area by the consignee with their labourers and equipment. When each container is stacked, a Stacking Slip is made out and based upon this Slip, the location of each container is input. Tracking of containers is done by Stacking Slip from the berth to the Marshaling Yard. FCLs are moved before delivery for the purpose of Quarantine and Customs Inspections. In order to track such movement, Container Movement Slip is made out to identify the present location of the container inside the port.

From the view point of flow of the containers and the activity in the yard we noted as follows: Containers discharged from a vessel are stored in the marshalling yard according to the instructions of the yard clerk who is in charge of recording and reporting container locations regularly to a yard planner in the terminal office. On the basis of the yard clerk's report, the yard planner to the computer inputs the container location with their specifications and prepares a yard map and data base for stored containers.

The yard map and data base are available when a consignee comes to receive his container, a gate clerk can give the specific container location to drivers of yard top lifters and issue a gate pass.

After the issuance of a gate pass, the location of the container is automatically deleted from the file.

(7) CCRO

After completion of the necessary procedure of the authorities, Delivery Order together with Customs certificate are submitted to the CDO. The CDO prints out Cargo Charges and Removal Order (CCRO). Then the CCRO is presented at the Control Centre, where Gate Pass-cum-Delivery Orders are issued in triplicate. The Order distributed to the consignee is used as a Gate Pass when the container is returned empty to the gate.

(8) Loading

Exporters obtain an Export Shipping Notes from the CDO. A duly completed Export Shipping Note with endorsements from the Agent and custom is presented to the CDO for registration prior to cargo delivery inside the port.

The Note and the Gate Pass are submitted at the gate for Full Container Export.

Chapter 4 CURRENT MAJOR PROBLEMS IN MINA QABOOS

4.1 General

1. As a gateway port of the Sultanate of Oman, Mina Qaboos has been playing an important role since 1974. Especially since 1982, Mina Qaboos has served as a container transshipment base to connect European countries with Asian countries due to its geographically favorable location. However, Mina Qaboos faces various kinds of problems, such as physical constraints on the dimensions of its facilities, low cargo handling productivity, and a lack of good cargo handling equipment in good condition.

By carrying out an investigation over two months, several major problems of Mina Qaboos have been identified based upon a series of discussions and analyses of relevant port data. In this chapter, these problems are discussed in detail.

4.2 Limited Land Area

2. In Mina Qaboos, the land area is extremely limited. Originally this port was developed as conventional type port, so the layout of its facilities and the site are not adequately designed for handling a considerable number of containers. Because of increasing demand for container use, Mina Qaboos has been changing its operations forwards container handling step by step, leaving already occupied areas as it is. Hence, container related areas are dispersed over the whole port area together with conventional cargo areas. For container cargo handling especially, dispersed land use should be avoided. Some countermeasures are necessary to ensure efficient use of the port's land area.

4.3 Dimensions of Berthing Facilities

3. Insufficient available depth is one of the most serious problems Mina Qaboos faces. As already mentioned, the declared depth for Berths Nos. 1, 1A and 2, which have been mainly used by large conventional ships, RO/RO ships and livestock ships, is 10.4 meters, and the depth for container berths, Berth No.4 and 5, is only 9.1 meters. Although maneuvering conditions in Mina Qaboos are excellent due to its calm wave and wind conditions, calling ships with arrival drafts of more than 10 meters and 9

meters for Berths No.1, 1A, 2 and No.4, 5 respectively, should be considered as having limited maneuverability to some extent.

According to the statistics of calling ships in 1988, about 30 calls of conventional, RO/RO and livestock ships are with its draft more than 10 meters and about 110 calls of container ships are with more than 9 meters drafts. These ships seem to wait and use tides to call at Mina Qaboos or at least required extremely careful maneuvering in the port. This fact must have a negative impact on Mina Qaboos, which has been experiencing severe competition from neighboring ports, especially in terms of container services. Hence countermeasures should be given to priority.

4.4 Berth Use Allocation

4. Because of its status in this country, Mina Qaboos has been expected to exercise various kinds of functions not only as a gateway for foreign trade but also as a base port for many different kinds of vessels and even as a marketplace for citizens. Table 4-4-1 shows the characteristics of berth use by ship type. In this figure, ship types are categorized into 9 types and type 90 (other ships), includes fishing trawlers, Navy vessels, the Royal yacht and other small craft. Table 4-4-2 shows working time ratio using the same categories as Table 4-4-1.

5. These figures describe clearly the current berth use allocation at Mina Qaboos. Concerning principal cargoes such as general cargoes, container cargoes, grains, vehicles and livestock, basic berth allocation based upon priority uses of these principal cargoes are organized. Namely, berths Nos. 1, 1A, and 2 are used primarily for general cargoes, vehicles and livestock; Berth No.3 for Grains; Berth No.4 and 5 almost exclusively for container cargoes; Berths No.7 and 8 for general cargoes, and so on. However, it is also true that the share of berth occupancy for type 90 ships is very significant. Hence, it is very important to find some countermeasures for this situation in order to improve the port capacity of Mina Qaboos together with other measure to respond to the increasing level of demand for the port's services.

Table 4-4-1 Berth Occupancy (1988)

(%)

Ship* Type	Berth Numbers 1	2	2A	2B	3	4	5	6	7	7A	7B	8	8A	8B	10	11
Whole	55.6	60.9	0.7	0.3	68.3	69.7	32.1	62.0	58.8	6.2	9.2	74.8	6.2	2.7	7.9	40.7
10	22.3	51.1	0.7	0.3	26.8	8.7	2.1	9.7	37.1	3.5		27.9	2.1	1.6	0.3	0.8
20	0.5	0.5				53.4	25.7	0.1				0.5				
30	2.8	5.5			3.6	7.3	0.9	0.1				0.1				
40		1.9			20.1				3.7	1.7		1.9	1.9			
50					2.1											
60	0.6	0.2			0.1		0.4	0.3	0.7		0.2					
70	11.8	1.6				0.3	0.4	1.9	0.2							
80	4.2						0.3									
90	14.4	0.1			15.6		2.4	49.7	16.9	1.1	9.2	44.3	2.2	1.1	7.6	39.9

* Ship type : 10 Conventional, 20 Full Container, 30 Semi Container, 40 Grain Carrier, 50 Dry Bulk Carrier,
60 Liquid Carrier, 70 RO/RO Ship, 80 Livestock Carrier, 90 Visit/Other Ship

Table 4-4-2 Working Time Ratio by Berth (1988)

Ship** Type	Berth Numbers 1	2	2A	2B	3	4	5	6	7	7A	7B	8	8A	8B	10	11
Whole	17.4	36.2	0.4	0.2	16.3	26.4	17.8	6.4	20.1	2.8	0.0	15.5	1.9	0.8	0.0	0.3
10	8.5	30.0	0.4	0.2	9.7	0.2	1.4	5.5	18.1	2.0		12.2	1.0	1.0	0.0	0.3
20	0.3	0.2				24.4	15.6	0.1				0.4				
30	1.0	2.0			0.8	1.6	0.5	0.1	0.1			0.1				
40		3.1			5.8				1.8	0.8		2.8	1.0			
50					0.0											
60	0.0	0.0			0.0		0.0	0.0	0.0			0.0				
70	5.4	1.0				0.2	0.4	0.5	0.0							
80	2.2															
90	0.0	0.0			0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

** See Table 4-4-1

4.5 Land Use Allocation

4.5.1 General Cargo

6. The area allocated for general cargo is some 4 ha for open storage yard and 1.9 ha for covered storage. Of the 4 ha for the open storage yard, 1.2 ha is a small area beside the transit sheds, that is to say 2000 m^2 or less. The remaining 2.8ha, is actually used as open storage area and is equivalent to the area required by the present level of cargo throughput. The open storage yard consists mainly of yards Nos. 3 & 10. Yard No. 10 is located apart from the other berths, which results in increased cargo traffic within the port area.

On the other hand, the covered storage area of some 1.9 ha should be much larger than that required by the present cargo volume as well as that in future. Therefore, certain measures should including re-allocation of land between the open storage yard and the covered storage area be taken in order to accomodate the increased future cargo traffic volume.

4.5.2 Containers

7. The area allocated for container stacking consists of 4 areas (8.7 ha). The area required by container traffic in 1988 is estimated to be 10 ha. The present container handling system in the yard, a forklift truck system, requires a large vacant space for passage & maneuvering area between stacking bays, although a bay, consisting of 2 rows, required a width of only 16 - 18 feet. Furthermore, the passage must be some 50 feet wide for one passage of 40 feet container movement. These makes land utilization less efficient and this lack of stacking area increases the intrusion into the open storage yard of general cargo, resulting in disordered stacking in whatever places are available. The lack of stacking area for increased container traffic is very apparent, consequently fundamental measures, including a change in handling system, expansion of new land and so on are crucial.

4.6. Productivity of Cargo Handling

4.6.1 General Cargo

8. The productivity of cargo handling including major commodities at Mina Qaboos has been found to be generally less than that normally expected.

For example:

Productivity at Mina Qaboos (data based on certain ships calling in 1988 & 1989)		Productivity normally expected
Steel	23.3 ton/G/H	30 - 50 ton/G/H
Timber	23.9 ton/G/H	30 - 50 ton/G/H
Rice (in bags)	12.2 ton/G/H	30 - 40 ton/G/H
General cargo	18.9 ton/G/H	25 - 30 ton/G/H

From the above figures and the increase in cargo volume in future, productivity should be improved significantly. The number of gangs should also be increased. Detailed analyses in this point, taking into account seasonal factors and other aspects, will be described in Chapter 7.7

4.6.2 Container Cargo

1) Shipside Operation

9. The rate of container handling varies according to the vessel, yard congestion, readiness of the back-up system and other factors. The average rate of 20.2 box/H/crane for discharge and 16.8 box/H/crane for loading is however, rather small than the potential of gantry crane and the record achieved in UAE ports. In our interviews with shipping agents it was said to be from 30 up to 40 in UAE ports such as Port Rashid and Fujairah. It is not known whether the figures for UAE ports were calculated using net hours or gross hours.

10. As for productivity at Mina Qaboos, it should be increased to at least 25 Box/H/crane or more in terms of gross hours. The fact that the figures achieved at Mina Qaboos are rather small in terms of crane potential might be attributable to a wide range of management problems. The difference of loading and discharging is, however, attributable to the improper back up system, i.e., insufficient number of forklift trucks, improper stacking and so on.

2) Land Side Operation

11. The present container stacking system has a major demerit for import cargoes, especially in terms of deliveries to consignees. The system causes a lot of inefficient handling. When a given container under over-stacked containers has to be delivered quickly, the overstacked containers must be removed and stacked in an other place temporarily, then later put back in their original place. Replacement of containers in the same place is necessary, because the computer program used to manage container storage is based on their remaining in one location. This greatly increases the frequency of container handling, as shown in the following table:

Stacking height	Handling frequency/number of container delivered (without replacing)	(with replacing)
1 tier	1.0	1.0
2 tiers	1.5	2.0
3 tiers	2.0	3.0

12. Thus, the present system increases container handling frequency up to 3 times in terms of the number of containers delivered. Numbers of container daily handled were 60 boxes/day for receiving, 59 boxes/day for delivery, 8 boxes/day for grounding and 5 boxes/day for CFS. Applying the handling frequency ratio, that is, 3 times, the maximum number of boxes that can be handled is calculated to be 289. Assuming that the land side operation continues for 12 hours and the container handling ration is 10 – 15 boxes/hour, 2 – 3 top lifters are required for the land side operation. Although the number of top lifters provided for the land side operation is said to be 2, according to our interview with the PSC officials, only 1 unit is actually available.

4.6.3 Required Quantity of Container Equipment

13. Assuming that a gantry crane handles some 65,000 TEU per anumm, the number of major container handling equipment units both at ship side and shore side for a gantry crane is normally described as follows:

	Top lifter	Straddle carrier	Rubber tyred g.c.
Ship side	2	3 - 4	1
Shore side	1 - 2	2	1
Maintenance	1	2	
Sum	4 - 5	7 - 8	2

14. Tractor trailers are deployed in combination with top lifters and the rubber-tyred transfer crane at shipside.

Tractor - T	4		4
Maintenance	1		1
Sum	5		5

15. Applying the above figures to the present situation of Mina Qaboos, required machineries are as follows:

	Required	Present
Annual throughput	147,882 TEU	147,882 TEU
Gantry crane	2 units	2 units
Top lifter at sea side	6 - 8 units	4 units
Forklift at sea side		1 units
Top lifter at shore side	2 units	2 units
Maintenance	2 - 3 units	2 units
Sum	10 - 13 units	9 units

16. The number of back up machines seems to be nearly sufficient, however, it is actually insufficient because of a lack of good assistance by tractor-trailers and a streamlined traffic system due to the deployment of top lifters.

From the above, the number of top lifters and heavy forklift trucks provided for the operation at the moment is marginal or obviously insufficient, taking into consideration downtime and/or maintenance time.

4.7 Equipment Utilization

17. The operating hours of the forklift trucks are shown in Table 4-7-1.

Table 4-7-1 Equipment Utilisation in Three Months

(August 1989)

Srl. No.	Day/s Stopped	Hours worked in August	Srl. No.	Day/s Stopped	Hours worked in August
Forklifts					
15	4	31	51	2	100
16	6	32	52	2	58
17	4	61	53	2	19
18	3	22	54	4	19
19	8	26	55	1	33
20	9	58	*57	5	202
21	2	26	*58	Awtg.spares	---
22	2	36	*59	13	167
23	1	16	*60	5	230
24	1	19	61	1	176
25	2	64	62	4	155

(September 1989)

Srl. No.	Day/s Stopped	Hours worked in September	Srl. No.	Day/s Stopped	Hours worked in September
Forklifts					
15	–	43	51	3	147
16	3	35	52	3	74
17	2	39	53	1	34
18	1	14	54	1	26
19	–	05	55	1	18
20	1	53	*57	3	238
21	7	27	*58	Awtg.spares	---
22	7	23	*59	16 (A/S)	110
23	4	10	*60	2	241
24	4	11	61	26	28
25	1	61	62	3	210

(October 1989)

Srl. No.	Day/s Stopped	Hours worked in October	Srl. No.	Day/s Stopped	Hours worked in October
Forklifts					
15	9	17	51	9	87
16	–	16	52	20	21
17	1	16	53	4	24
18	2	18	54	–	24
19	1	29	55	2	37
20	2	57	*57	2	213
21	–	18	*58	Awtg.spares	---
22	1	24	*59	Awtg.spares	---
23	3	16	*60	6	209
24	2	17	61	2	179
25	–	44	62	3	142
26	15	23	64	3	163

* Over 25,000 kg heavy capacity forklift
Source: PSC

These heavy capacity forklift trucks of Srl. Nos. 57, 58, 59 & 60 have more non-working days than small forklifts Srl. No. 15 to 25.

18. The main reasons of the above mentioned are

1) Long carrying distance and nearly full loads,
2) Insufficient road paving conditions,
3) Resulting damage to drive shaft on wheel axle,
4) The PSC's & dealers' storehouses do not keep large & expensive spare parts, and
5) Lengthy insurance procedures.

As a result, these forklift cannot work properly and maintenance staff member could not repair them effectively.