8. Natural Conditions Around Port Salalah

General

The Sultanate of Oman occupies the South-Eastern corner of the Arabian Peninsula and is located between Latitudes 16° 40′ and 26° 20′ North and Longitudes 51° 50′ and 59 ° 40′ East.

The coast line extends 1, 700 kilometers from the Strait of Hormuz in the north to the borders of the Republic of Yemen and overlooks three seas—the Arabian Gulf, Gulf of Oman and the Arabian Sea.

The Sultanate of Oman borders Saudi Arabia and the United Arab Emirates in the West, the Republic of Yemen in the South: the Strait of Hormuz in the North and the Arabian Sea in the East. The total land area is approximately 309, 500 km^2 and it is the third largest country in the Arabian Peninsula.

The climate differs from one area to another, it is hot and humid in the coastal areas in summer, while it is hot and dry in the interior with the exception of the higher mountains which enjoy a moderate climate throughout the year. Rainfall is generally light and irregular; although heavy rains and thunderstorms can cause severe flooding.

In the South the Dhofar region has a moderate climate and the pattern of rainfall is more predictable with heavy monsoon rains occurring regularly between May and September.

8.1 Meteorology

The general climate of Salalah is governed by the two monsoons, the NE and SW. Unlike northern Oman, the edge of the SW monsoon influence area just covers the southern part of the Dhofar coastline bringing cool sea breezes, cloudy weather and light rain to the Salalah area between May and September.

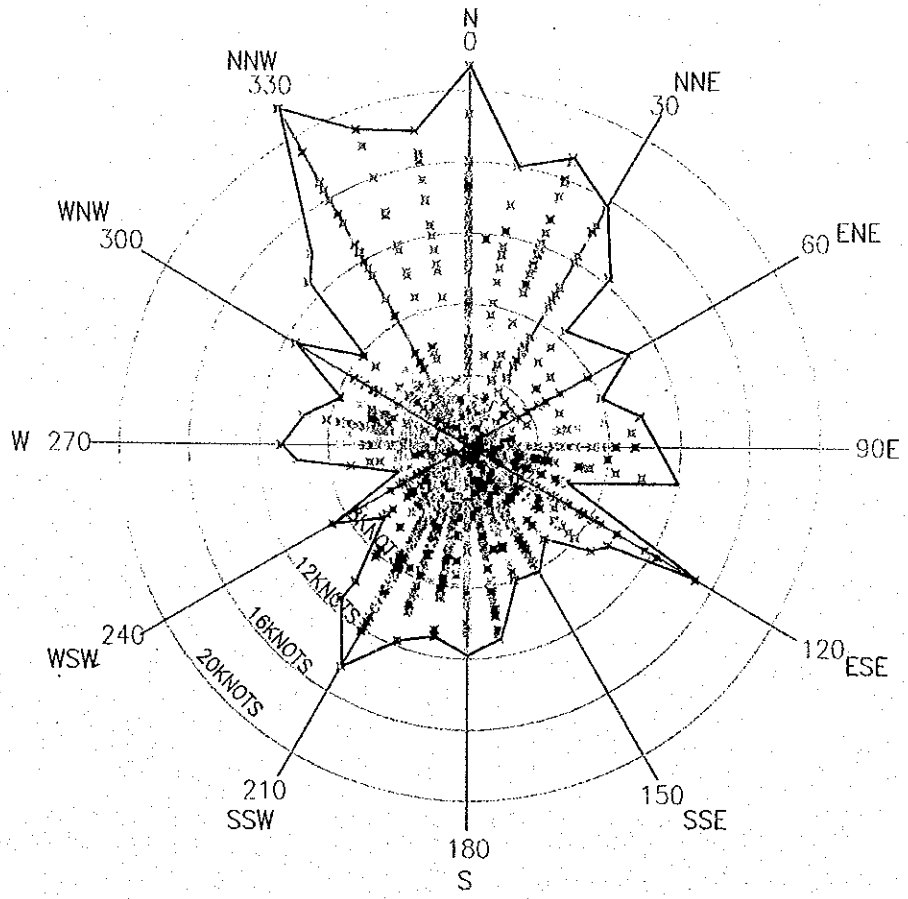
The NE monsoon occurs between November and February and is a dry wind bringing cooler weather but almost no rain. Data collection and analysis of daily weather has been conducted at Salalah Civil Airport and in Salalah Port, namely Temperature, Vapor Pressure, Humidity, Prevailing Winds, Rainfall and Sunshine Data. About 70 government and private establishments were furnished with various climatical data during the year 1998.

The Meteorological data at Salalah are shown in Table 8. 1. 1 and in Fig. 8. 1. 1 .

Table 8.1.1 Monthly Mean for Meteorological Data at Salalah in 1999

Mon.	Air Temp (℃)			Rainfall (mm)			Relative Humidity (%)			Prevailing Winds			
	Mean	Max.	Min.	Total	Mean	Max.	Mean	Max.	Min.	Direction	Mean	Max. Maen	Max. Gust
Jan.	24.1	31.3	16.2	0.0	0.0	0.0	54	90	12	225	6	8	28
Feb.	25.0	34.2	18.2	0.0	0.0	0.0	67	85	15	225	4	6	19
Mar.	25.7	34.7	18.3	0.0	0.0	0.0	61	89	7	210	6	8	28
Apr.	28.0	38.1	20.1	0.0	0.0	0.0	67	96	7	228	5	8	31
May	28.9	34.2	24.0	0.0	0.0	0.0	79	100	59	211	6	9	22
Jun.	27.8	32.6	25.0	0.1	1.2	0.0	85	98	59	185	7	10	22
Jul.	25.2	31.1	22.7	1.0	3.8	0.0	91	99	72	167	5	7	18
Aug.	24.8	29.1	22.4	0.7	4.7	0.0	90	99	71	160	5	8	19
Sep.	26.5	31.4	23.6	0.0	0.5	0.0	84	100	60	199	6	9	22
Oct.	27.3	38.6	20.7	2.2	33.4	0.0	72	98	26	204	5	7	22
Nov.	26.4	33.8	19.7	0.0	0.0	0.0	62	90	18	204	5	7	25
Dec.	25.2	33.4	17.2	0.0	0.0	0.0	44	81	10	200	8	12	28

Source: Salalah Air Port



ANNUAL WIND ROSE

-1	(JAN)	-7	(JULY)
-2	(FEB)	-8	(AUG)
-3	(MAR)	-9	(SEP)
-4	(APR)	-10	(0CT)
-5	(MAY)	-11	(NOV)
-6	(JUNE)	-12	(DEC)

Figure 8.1.1

SALALH PORT

ANNUAL WIND ROSE

YEAR 1999

(1) Rain

The annual rainfall distribution of Salalah is four months of the NE monsoon period are almost dry while the main rainfall period brought by the SW monsoon is May to October, with July and August being by far the wettest months with 25 to 30 mm of rain. The mean annual precipitation is 112 mm, and average fog days per year are between 13 and 14 days.

(2) Wind

During the NE monsoon, wind strengths of between 7 and 17 knots are typical with maximum strength of about 28 knots. During the SW monsoon, wind strengths are typically 17 to 34 knots with a maximum normally less than 48 knots.

(3) Temperature

The annual temperature of Salalah is maximum about 42℃ in April and Minimum about 15℃ in December. The mean temperature through the year is about 25℃ and generally most mild weather in the Arabian Peninsula.

(4) Cyclones

For the years since Salalah Airport rainfall records started, the Airport rainfalls associated with these cyclones have been tabulated in Table 8. 1. 2.

The table shows that a total of 16 cyclones are known to have occurred since the year 1902.

Table 8. 1. 2 Cyclones Recorded in the Vicinity of Salalah (1877～1999)

No.	Year	Month	Max, Rainfall(㎜)		
			1-Day Total	2-Day Total	3-Day Total
1	1902	Oct.	—	—	—
2	1903	Jun.	—	—	—
3	1916	May.	—	—	—
4	1946	Jun.	—	—	—
5	1948	Oct.	48	91	133
6	1951	Apr.	0	0	0
7	1959	May.	81	84	84
8	1960	May.	1	1	1
9	1963	May.	138	198	230
10	1963	Dec.	0	0	0
11	1966	Nov.	186	203	203
12	1977	Jun.	70	111	119
13	1979	Jun.	54	56	56
14	1983	Apr.	127	146	148
15	1996	May.	38	46	47
16	1999	Oct.	33	33	33

Source : Salalah Airport

8. 2 Oceanography

8.2.1 General

The marine waters off the southern coast of Oman are of exceptional biological interest, due to the unusual oceanographic conditions that occur. During the months of June to September a strong upwelling of cold water moves towards the coast, and this causes water temperatures to drop significantly.

In some marine areas the effect is particularly intense, with water temperatures declining, rapidly from June to September. The variation in intensity of the cold current at different points along the southern Oman coast creates a range of habitat types, with corals, brown alga meadows and kelp forests present at different locations.
The record of sea water temperature in vicinity of Salalh is shown in Table 8.2.1.

The inter tidal zone present in the Salalah area includes rocky shores, long wide sandy beaches, coastal cliffs and a limited number of tidal creeks, most of which contain ecologically valuable mangrove or reed bed vegetation.

The southern coast of Oman is also of great importance for fishing, although the wave conditions during the tidal creeks make fishing almost impossible. The productivity of the area is linked to the cold upwelling. A great variety of fish are caught, including sardines and tuna. Sardines are traditionally laid out on the beaches to dry in the sun. The abalone fishery is important and the area is also known as a lobster fishing area.

Very little tidal stream and current data is available within Oman coast; however, the few observations which have been conducted show that with a few notable exceptions, the combined effect of stream and current is generally less than 1 knot.

Table 8. 2. 1 Sea Water Temperature in Vicinity of Salalah

Year	Month	A. M (° C)	P. M (° C)	Average (° C)
1999	Mar.	26. 0	27. 0	26. 5
1999	Apr.	27. 5	27. 7	27. 6
1999	May.	28. 0	26. 2	27. 1
1999	Jun.	25. 1	24. 1	24. 6
1999	Jul.	23. 3	21. 6	22. 4
1999	Aug.	20. 9	19. 3	20. 1
1999	Sep.	20. 6	23. 6	22. 1
1999	Oct.	24. 5	27. 3	25. 9
1999	Nov.	26. 8	27. 0	26. 9
1999	Dec.	26. 8	25. 3	26. 1
2000	Jan.	25. 0	24. 8	24. 9
2000	Feb.	25. 0	25. 7	25. 4

Note : Sea depth of measurement point is CD－3. 0m.

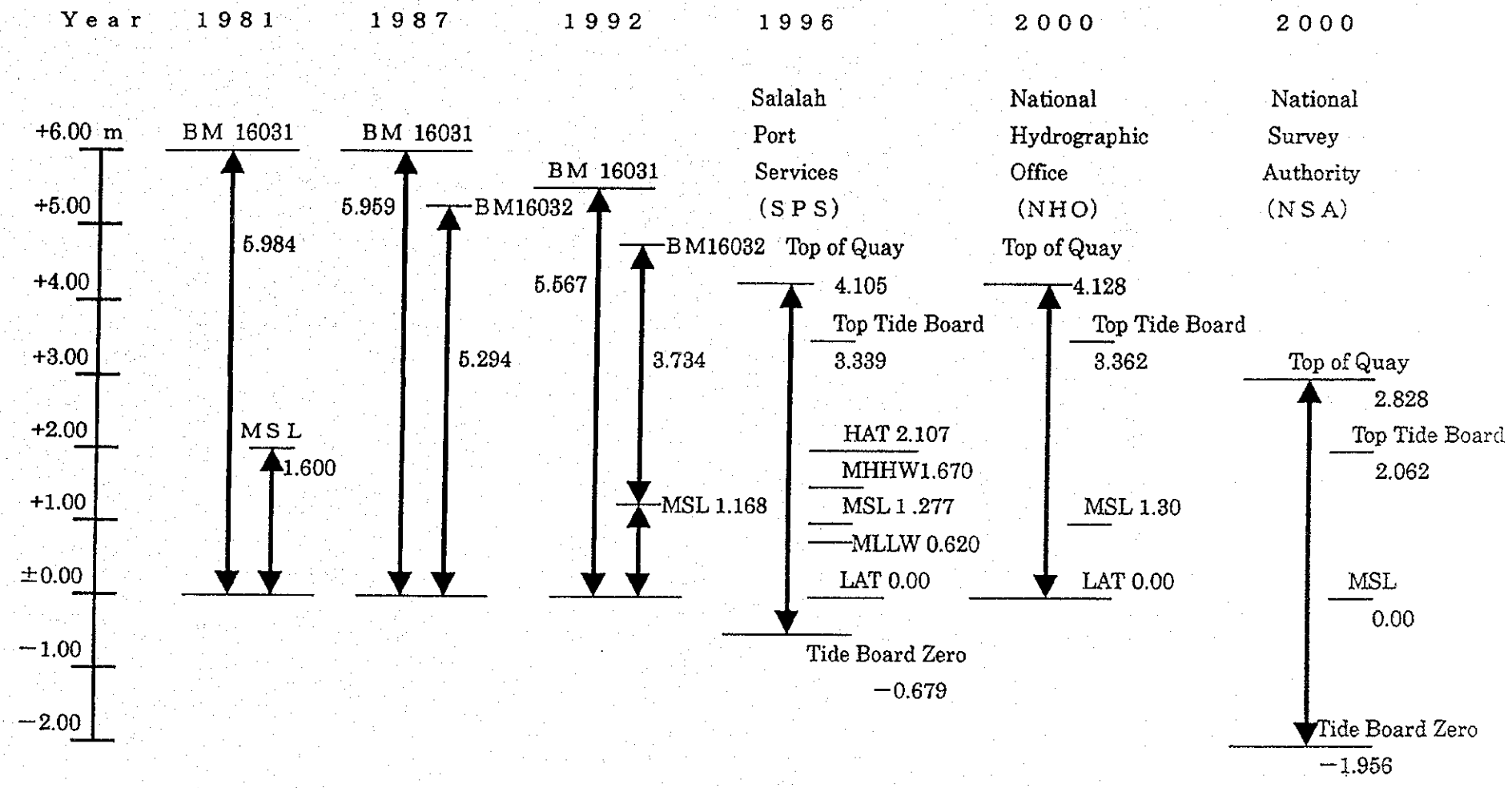


Fig. 8. 2. 1 Tide Information Of Salalah Port

8.2.2 Tide

All astronomically generated tides are composed of both semi-diurnal (twice daily) and diurnal (daily) components. The components of the tide can be represented by a series of pure cosine curves with a certain amplitude (H) and phase lag (g) of the tidal response relative to the Greenwich meridian. By combining these curves together, the height of tide at each site can be calculated for any given time.

The mean spring range in Oman varies from just over a meter near the border with Yemen to almost 2 meters in the northern Gulf of Oman. The predicted ranges from Lowest to Highest Astronomical Tide vary from about 2 meters in the south to 3. 5 meters in the North. Since 1990, Chart Datum has been established at over 40 sites along the coast through observations conducted by or under the supervision of the Royal Navy of Oman Hydrographic Department. There are various tide information of Salalah Port since 1981 from plural sources as shown in Fig. 8.2.1.

The following tidal levels referred to datum of soundings are shown in the latest chart of Port Salalah 1999.

Mean	Higher	High	Water	(MHHW):	1. 68m
Mean	Lower	High	Water	(MLHW):	1. 64m
Mean	Higher	Low	Water	(MHLW):	1. 33m
Mean	Lower	Low	Water	(MLLW):	0. 65m
Lowest	Astronomical Tide			(LAT):	0. 00m

Above tide information will be applied for our proposed basic design of port facilities.

8.2.3 Wave

A substantial amount of wave measurement has taken place at Salalah Port over the years. Originally, during the design and construction of the conventional port in 1977 through 1979, the contractor, Hochtief, obtained wave measurements outside the port using the wave rider buoy. A wave rider buoy measures the up and down motion of the water at particular point. From this information, the wave height and period as well as the wave spectrum can be obtained. However, no information on the direction of the waves can be derived from this information. The data from wave rider buoy had obtained on and off until 1997, but none of information of wave measurements has been done for last three years.

8.2.4 Wave Hindcasting

The wave hindcasting was carried out in the second stage of the study based on the international data base ECMWF(European center for medium-range weather forecast).

The wave characteristics at the entrance of Salalah Port is investigated by means of following method. Fig. 8.2.2 shows the research flow.

1.Selection of offshore wave hindcast data from a global wave hindcast database

A global wave hindcast database is made by using an improved WAM model called the JWA-3G model. This model is based on the latest understanding on ocean wave physics and used a higher order advection scheme in order to improve the accuracy. Surface wind dataset analyzed by ECMWF is used as a wind driving force. Details of this wave hindcast database are as follows.

Time interval: 6 hours
Grid space: 2.5 ° in latitude and longitude
Period :1985-1999
Items :Wave height ,wave period ,wave direction ,
wind direction, wind speed

Values of grid point of the nearest Salalah Port is selected as an offshore wave hindcast data from the database(fifteen years:1985-1999).

2.Transformation of offshore waves by local winds

Offshore waves are transformed by local winds. The local wind wave generation is estimated by the Wilson Ⅳ equation. Schematic figure is shown in Fig.8.2.3.

3.Calculation of shallow water effect

Due to refraction and shoaling, the offshore waves are significantly transformed. This shallow water effect is estimated by using the shallow water transformation method ,in which the energy balance equation model is used as a fundamental equation. Transformation coefficients are obtained for following conditions.

Wave direction : ENE～WSW(clockwise)
Wave period:4,6,8,10sec
Wave height:2m
Smax:25

The estimated transformation coefficients are shown in Table 8.2.2.

4.Calculation of wave data at the entrance of the Salalah Port

Wave data at the entrance of the Salalah Port are obtained by multiplying offshore waves by transformation coefficients (Table 1).

5.Frequency distribution of wave data at the entrance of the Salalah Port

Frequency distribution of wave data is investigated about the annual, monsoon seasons and non-monsoon seasons. The most frequent classes are as follows.

(1)Annua(1985-1999)

Wave height – period :1.00-1.49m,7.1-8.0sec(10.7%)
Wave height – direction:1.00-1.49m,SE(18.7%)
Wave period – direction:6.1-7.0sec,S(24.2%)

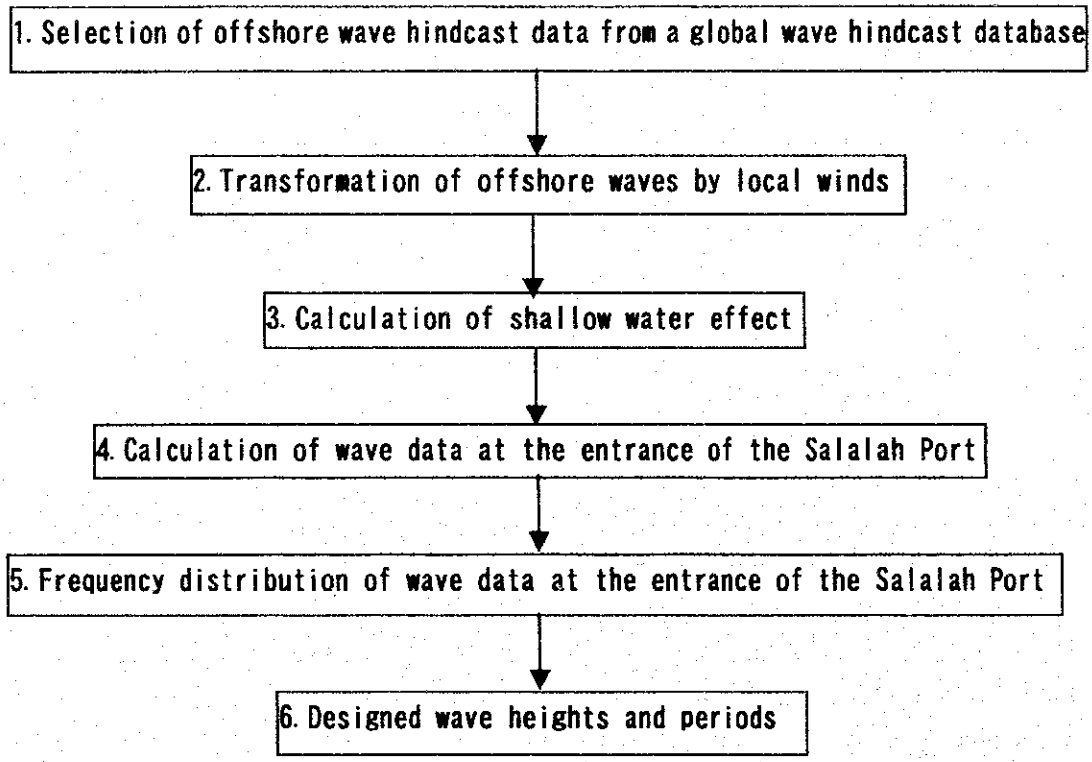


Fig. 8.2.2 Research Flow

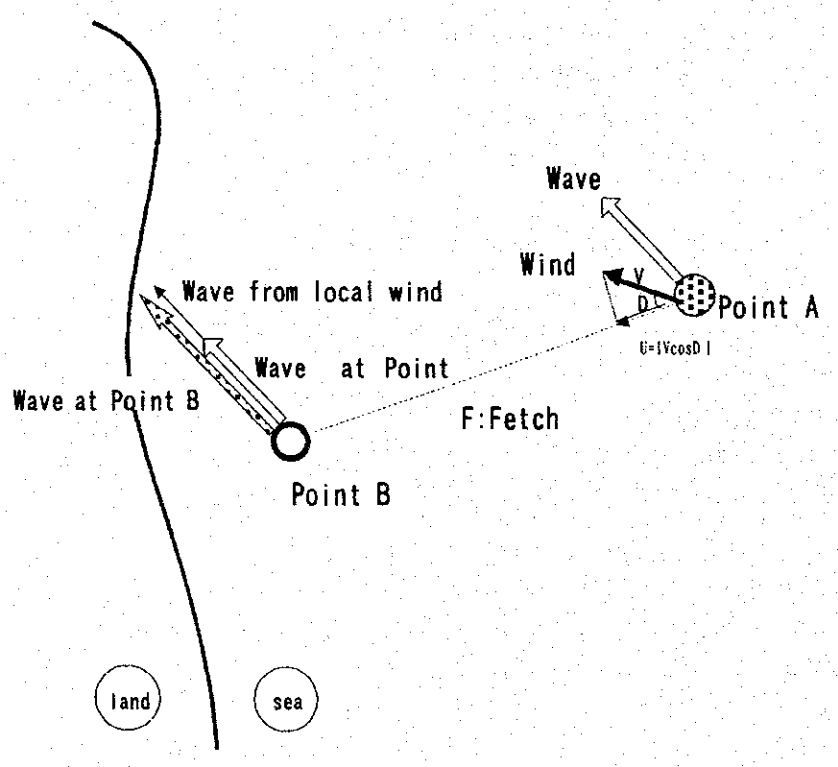


Fig. 8.2.3 Schematic figure of wind wave

(2)Monsoon season(1985-1999)

Wave height – period :2.50-2.99m,6.1-7.0sec(14.0%)

Wave height – direction:2.50-2.99m,S(19.1%)

Wave period – direction:6.1-7.0sec,S(50.5%)

(3)Non-Monsoon season(1985-1999)

Wave height – period :1.00-1.49m,7.1-8.0sec(14.8%)

Wave height – direction:1.00-1.49m,SE(27.5%)

Wave period – direction:5.1-6.0sec,SE(13.5%)

6.Designed wave heights and periods

Designed wave heights and periods are estimated for 10,30,50 years, which are shown in Table 8.2.3.

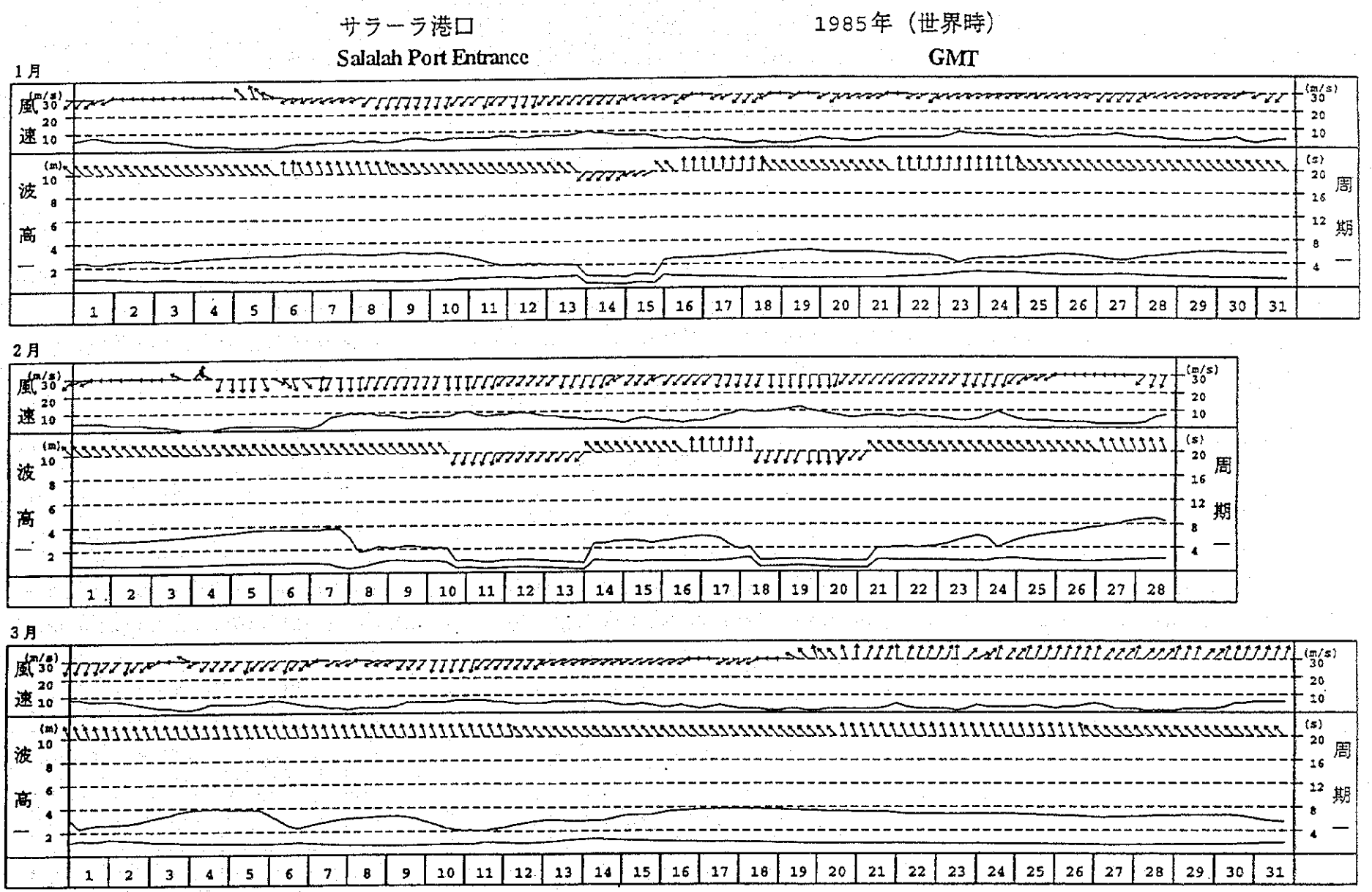
The wave hindcasting data example is shown in Fig.8.2.4 and the probability of wave exceedance is shown in Fig.8.2.5.

Table 8.2.2 Shallow water effect coefficient

Wave direction	Period 4sec			Period 6sec			Period 8sec			Period 10sec		
	KH	KT	DD	KH	KT	DD	KH	KT	DD	KH	KT	DD
ENE	0.68	0.96	-12.4	0.57	0.91	-24.8	0.53	0.92	-37.2	0.54	0.98	-43.4
E	0.87	0.98	0.0	0.74	0.94	-12.4	0.67	0.94	-24.8	0.68	1.00	-31.0
ESE	0.97	0.99	0.0	0.88	0.97	-6.2	0.83	0.97	-12.4	0.85	1.01	-12.4
SE	0.91	1.01	0.0	0.85	0.99	0.0	0.82	1.00	0.0	0.84	1.03	-6.2
SSE	0.94	1.01	0.0	0.88	0.99	0.0	0.86	1.00	6.2	0.86	1.02	6.2
S	0.92	1.00	0.0	0.86	0.98	6.2	0.84	0.99	12.4	0.85	1.02	18.6
SSW	0.79	0.99	6.2	0.72	0.97	12.4	0.70	0.90	24.8	0.72	1.02	31.0
SW	0.49	0.93	24.8	0.45	0.91	31.0	0.46	0.96	37.2	0.52	1.03	43.4
WSW	0.26	0.85	37.2	0.25	0.85	49.7	0.27	0.93	55.9	0.32	1.03	62.1

Table 8.2.3 Designed wave height and period

	10years			30years			50years		
Wave Direction	Hs(m)	Ts(sec)	±ΔH(m)	Hs(m)	Ts(sec)	±ΔH(m)	Hs(m)	Ts(sec)	±ΔH(m)
ENE	1.01	3.3	0.16	1.17	3.6	0.22	1.24	3.7	0.25
E	1.54	4.8	0.48	1.88	5.6	0.68	2.02	5.9	0.77
ESE	2.21	5.0	0.27	2.54	5.1	0.39	2.68	5.2	0.44
SE	2.48	7.1	0.17	2.72	7.5	0.25	2.82	7.7	0.29
SSE	4.73	8.4	0.93	5.48	8.7	1.28	5.79	8.9	1.43
S	5.99	7.8	0.63	6.70	8.2	0.92	7.00	8.4	1.05
SSW	3.15	5.7	0.71	3.48	5.7	1.01	3.62	5.7	1.14



Note: Month(月), Year(年), Wind Velocity(風速), Wave Height(波高), Period(周期)

Fig. 8.2.4 Wave Hindcasting Data Example.

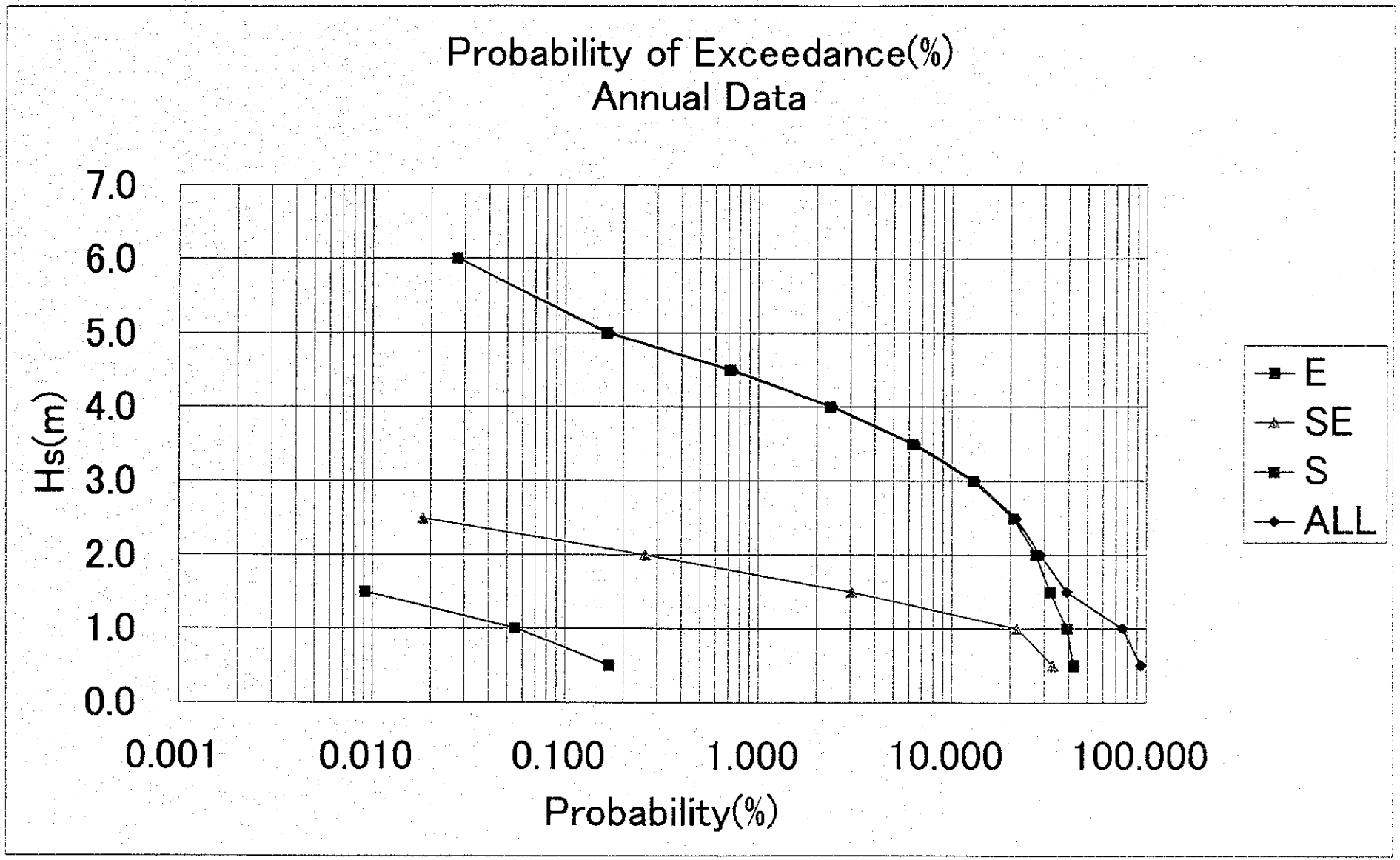


Fig. 8. 2. 5 Probability Of Wave Exceedance

8.3 Topography

8.3.1 General

The Dhofar region lies in the extreme south of Oman, 460 miles south west of Muscat by sea and 1, 040 kilometers south of Muscat by road and one hour fifteen minutes by air from Seeb International Airport. The region is naturally divided into three main areas.

1) The Coastal Plain
2) The Mountains
3) The Desert

It is bordered by the Al Wusta region in the east, the Arabian Sea in the south, the Republic of Yemen in the south west and the Kingdom of Saudi Arabia across the Rub Al Khali, the Empty Quarter, in the north west.
The study team has conducted observation trip from Salalah to Al Mazyunah near Yemen border by 4WD vehicle, one way 5 hours trip including 4 hours track road. The topographic condition of this area is hilly with spot bush and desert.

The study team also conducted route survey trip from Salalah to Muscat by Oman National Transport Co. Express Bus during daytime. The travel time was 11 hours with two bus stops namely, Hayma and Adam. Average speed of Express Bus is about 100 km except mountain area near Salalah. The topographic condition of along road area is as follows.

1) Salalah－Thumrayt	Mountain and hilly district with wadi.
2) Thumrayt－Hayma	Flat desert with spot bush and wadi.
3) Hayma－Adam	Flat desert with spot bush and wadi.
4) Adam－Nizwa	Hilly district with grass and wadi.
5) Nizuwa－Muscat	Hilly and Mountain district with plant and wadi.

8.3.2 Hinterland of Salalah Port

The hinterland of Salalah Port is generally wide and flat open area except south-west direction. The elevation gradually changes from MSL 0m Coast to 15m Airport, and average gradient is 0. 4 percent.

The distance from the coast to Airport is about 4 km and from Airport to the foot of mountain is about 5 km. Total distance of 9 km north-west and 20 km of north-east is almost flat area with plant, grass and wadi. The mountain is existing about 11 km from the sea shore with about 500 m top elevation.

8.4 Bathymetry

8.4.1 General

The bathymetric survey of Salalah port was carried out by the WGS 84 system by satellite fixing from 1992 by following survey companies, namely, Nortech Surveys of Canada in 1992 and Fugro Survey Middle East in 1996.

The survey vessel was equipped with an echo sounder with automatic digitizing and position fixing receivers. The latest Chart of Salalah port has been published by National Hydrographic Office of Oman in 1999.

8.4.2 Salalah Port

The gradient of sea bottom in north side of Salalah port is about 1 percent. The chart indicates the following information of Salalah port (Oman 250, Scale 1 : 12500)

Location:	1)	Latitude	16° 56′ N
	2)	Longitude	54° 00′ E
Datum:	1)	MHHW	1.68
	2)	MLHW	1.64
	3)	MHLW	1.33
	4)	MLLW	0.65
	5)	LAT	0.00
Depth:	1)	Entrance Channel	Dredged to 16.5m (1998)
	2)	Turning Basin	Dredged to 16.0m (1998)
	3)	Container Terminal	Dredged to 16.0m (1998)
	4)	Edge of East Breakwater	Dredged to 13.5m
	5)	Oil Pier	Dredged to 12.0m
	6)	Berth 1, 2, 3	Dredged to 9.5m
	7)	Berth 4	Dredged to 8.0m
	8)	Berth 5, 6, 7, 8	Dredged to 4.6m
	9)	Berth 9	Dredged to 3.0m
	10)	Multipurpose Berth	Dredged to 16.0m

8.5 Siltation and Shoreline

8.5.1 Silation

In 1979, Hochtief, GmbH conducted the bathymetric survey at Salalah port to determine the as-built bottom contours of the port. In 1996 bathymetric survey was performed by Fugro Survey Middle East for confirmation of harbor depth of new container terminal construction project. The level of accuracy of the two surveys is similar approximately 17 years interval by HPA report.

The maintenance dredging record does not exist since 1973, and the soil material in the port area is sand, gravel and limestone in accordance with the soil investigation report of previous studies. This port has experienced almost no accumulation of sediment during long time.

In 1999, a new container terminal was completed and the shape of Salalah port was drastically changed. Therefore, periodical measurement of the sea depth throughout the port, the harbor entrance in particular, is recommended from now on.

There are two wadis that discharge into the port area, namely Wadi Adawnib and Wadi Nar. Sediment discharges from these wadis during flood period are estimated some volume in long term basis
In accordance with the result of soil tests by offshore boring points in the study, sand, gravel, cobble layer has been confirmed as surface layer.

8.5.2 Shoreline

The shoreline of Salalah city is about 20 km from the existing container terminal to Holiday Inn Hotel. A road stretches along the coastline, however, two parts of the road was damaged by wave forces between the Palace and Holiday Inn. Shore protection works are under way for the damaged parts of existing temporary concrete wall.
The beach material is very fine powder sand with light density compared with normal quartz sand.
The coastal erosion surveys was carried out from May to Jun, 2000 for the simulation study of beach line variation, concerning the coastal erosion impacts that a master plan will have on the adjacent coastal area.

(1)Scope of Works

The scope of works is summarized as follows.

- To conduct a topographical survey from the north end of Salalah Port near Holiday Inn for about 20 km along the strand line as depicted in the drawing.
- Survey cross sections at approximately 100m intervals.

- Section : between DL-01.0m and high tide shore line.
- Bottom sediment sampling every 1 km along the strand line.
- Prepare drawings showing the topography along the strand line.

(2)Equipment

Following survey equipment was employed for each survey items.

- LEICA TC 1010 Total Station No.374446 with WILD accessories.
- WILD Tripods
- WILD reflector poles.
- WILD reflector prisms.
- WILD REC GRE 10 Recording modules.
- CASIO FX 880 P computer,
- CASIO FX 602P programmable calculator.
- Grab Sampler

(3)Survey method

- High tide shore line was determined by observation.
- Permanent Survey Marks (PSM) were established at approx. 500-800m intervals closer to the high tide line and on the land side of it.
- The PSM's were traversed and closed on the NSA survey stations available in the vicinity. Two (2) inter related control traverses were surveyed and control established for use in the survey.
- All natural and man made features falling in the project area were surveyed.
- Cross sections were surveyed at 100m intervals and 10-15m lateral intervals.
- Beach sand sampling material was collected using grab sampler.
- The 21 samples were taken to the ISO 9002 accredited testing laboratory for analysis.
- Sea bottom sediment samples were tested in laboratory for particle size distribution and density / specific gravity.

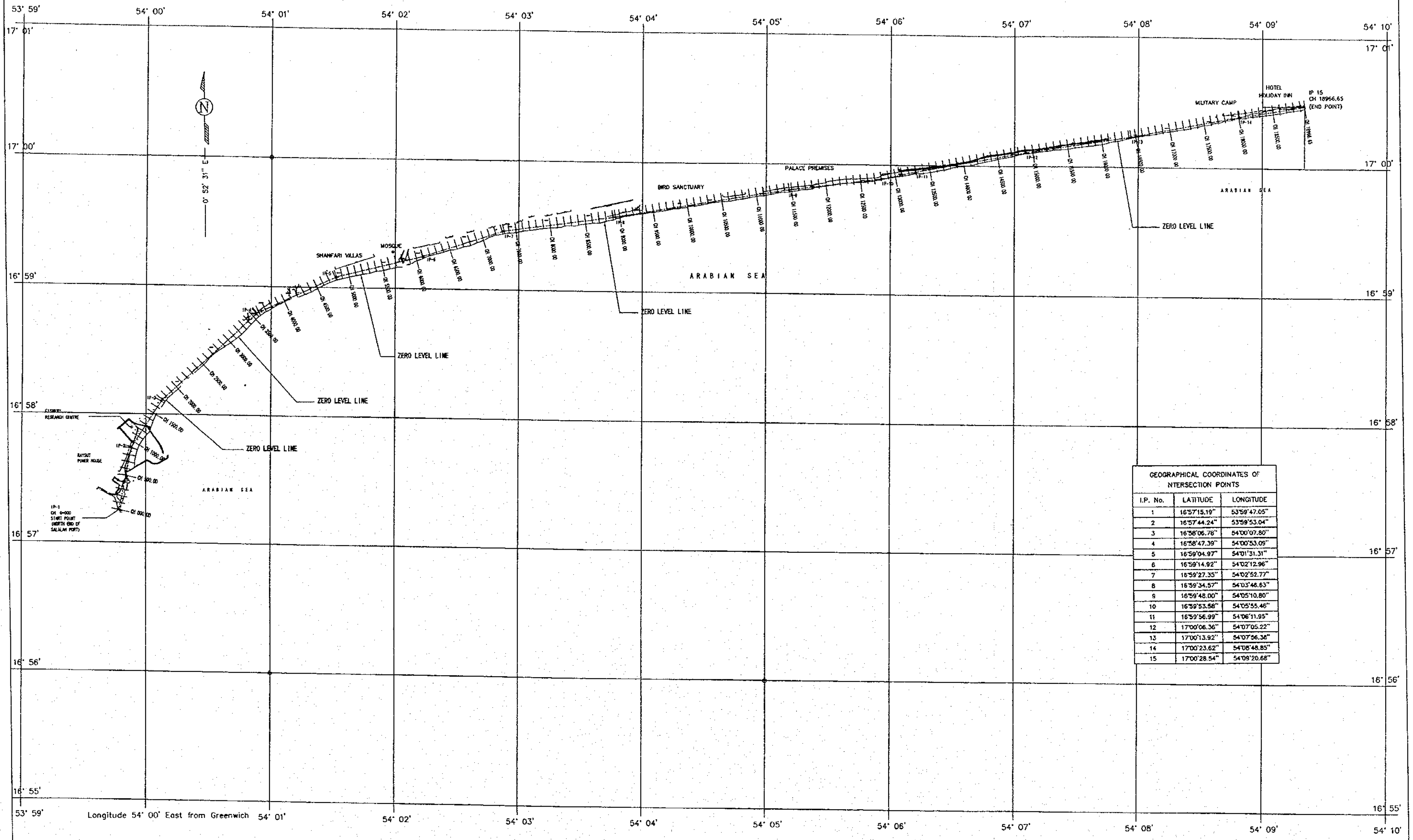
(4)Survey results

a. The average size and density of sea bottom sediment particles are as follows.
   Average size of particles : Diameter 0.25mm fine sand
   Average density of particles: 2.70 Mg/cm3 fine sand.

b. Any special sediment could not find out for the mouse of wadi in whole survey area.
   The volume of sediment from flood time of wadi is not significant for short term basis.

c. The whole survey area and strand line are shown in Fig.8.5.1. and the typical survey cross sections are shown in Fig.8.5.2.

d. The result of simulation study for coastal erosion will be described in this report Part 4.



GEOGRAPHICAL COORDINATES OF NTERSECTION POINTS		
I.P. No.	LATITUDE	LONGITUDE
1	16°57'15.19"	53°59'47.05"
2	16°57'44.24"	53°59'53.04"
3	16°58'06.78"	54°00'07.80"
4	16°58'47.39"	54°00'53.09"
5	16°59'04.97"	54°01'31.31"
6	16°59'14.92"	54°02'12.96"
7	16°59'27.35"	54°02'52.77"
8	16°59'34.57"	54°03'46.63"
9	16°59'48.00"	54°05'10.80"
10	16°59'53.58"	54°05'55.46"
11	16°59'56.99"	54°06'11.95"
12	17°00'06.36"	54°07'05.22"
13	17°00'13.92"	54°07'56.38"
14	17°00'23.62"	54°08'48.85"
15	17°00'28.54"	54°09'20.68"

Fig. 8. 5. 1 Plan of Entire Survey Area

LEGEND:

NOTES	ASSOCIATED DRAWINGS	NO.	REVISIONS	DATE	BY
REF. DATUM: HOR – U.T.M. WGS 84		A	COORDINATES OF I.P. 1 TO 15 & ZERO LEVEL LINE ADDED	16.07.00	LB
DATE SURVEYED: 30 MAY TO 12 JUNE, 2000					
DATE PLOTTED: 30 JUNE 2000					
CAD FILE NAME: C:\99159B\99159B03B.DWG					

SURVEYED: SUNIL
DRAWN: LAKY
CHECKED: SUNIL & SANATH
APPROVED: HBS
DATE: 28.06.00

AUSCON & PARTNERS ENG. CONSULTANTS llc.

CLIENT: SANYO TECHNO MARINE (STM), INC.
PROJECT: COASTAL EROSION SURVEY OF SALALAH PORT
TITLE: TOPOGRAPHICAL SURVEY KEY PLAN SHEET 1 OF 1
SCALE 1:25,000
DWG NO. 99/159B/028

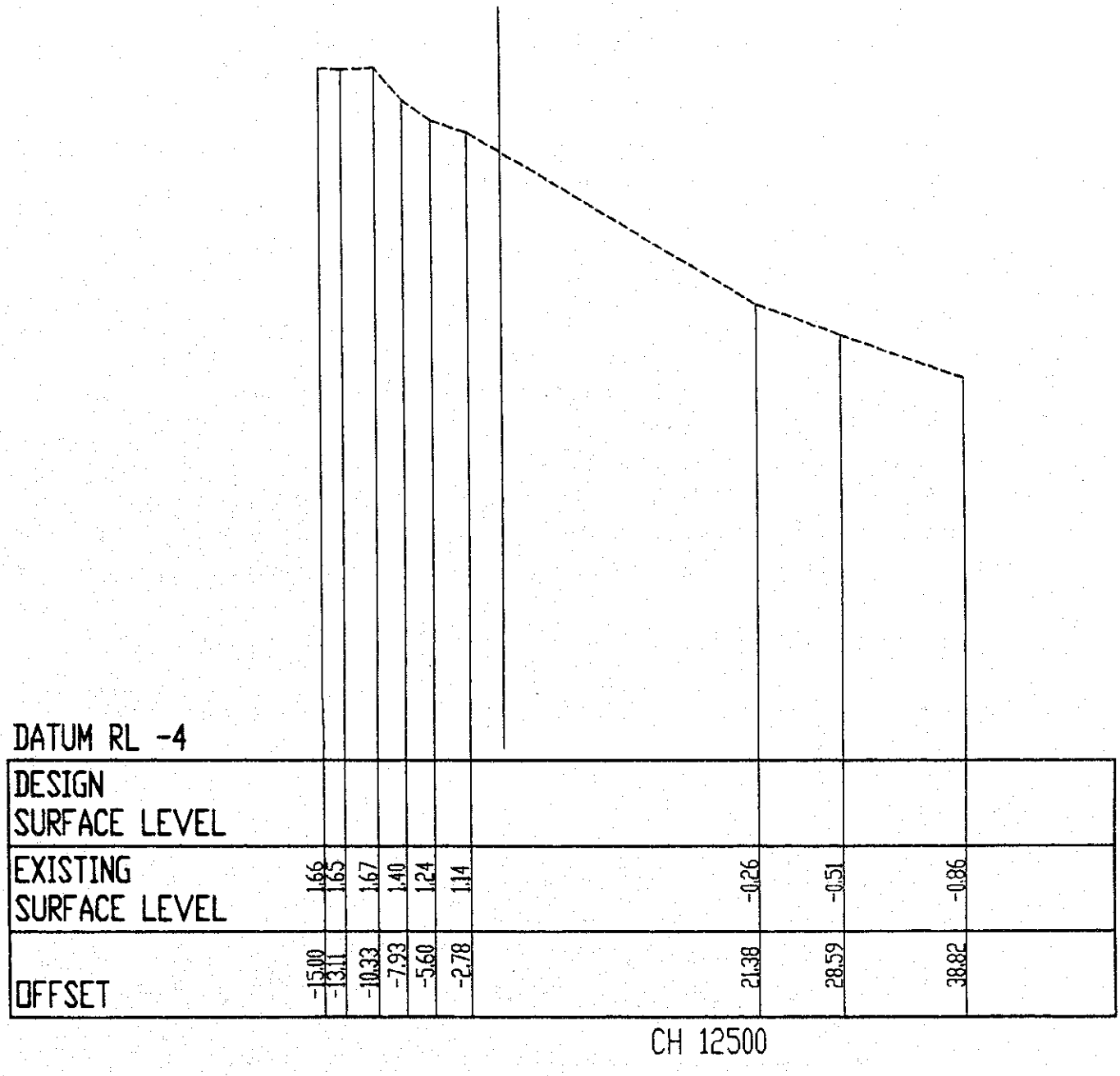


Fig. 8. 5. 2 Typical Cross Section of Survey Area

8.6 Geophysical Surveys

8.6.1 General

The Salalah port area lies on the western perimeter of a gravel plain underlain by limestones of the Taqah Formation with the Jibal Dhofar mountain area rising to the north. The Geological Map shows three major geological provinces. (See Fig.8.6.1) An offshore boring program was carried out to define the rock and sand profiles in the existing port areas.

The Study Team conducted following geophysical site survey works in northern offshore of Salalah port from the end of January to middle of February 2000.

8.6.2 Scope of Works

The scope of works for Geophysical Surveys is summarized as follows.

- Acquisition of bathymetric data reduced to Chart Datum, through utilization of a dual frequency, single beam, echo sounder.
- Acquisition of analogue seismic sub bottom profiler data.
- Acquisition of current data at various pre－determined locations near to the port Salalah.
- Acquisition of water samples at various pre－determined locations near to the port Salalah.
- Acquisition of seabed （grab） samples at the same pre-determined locations.

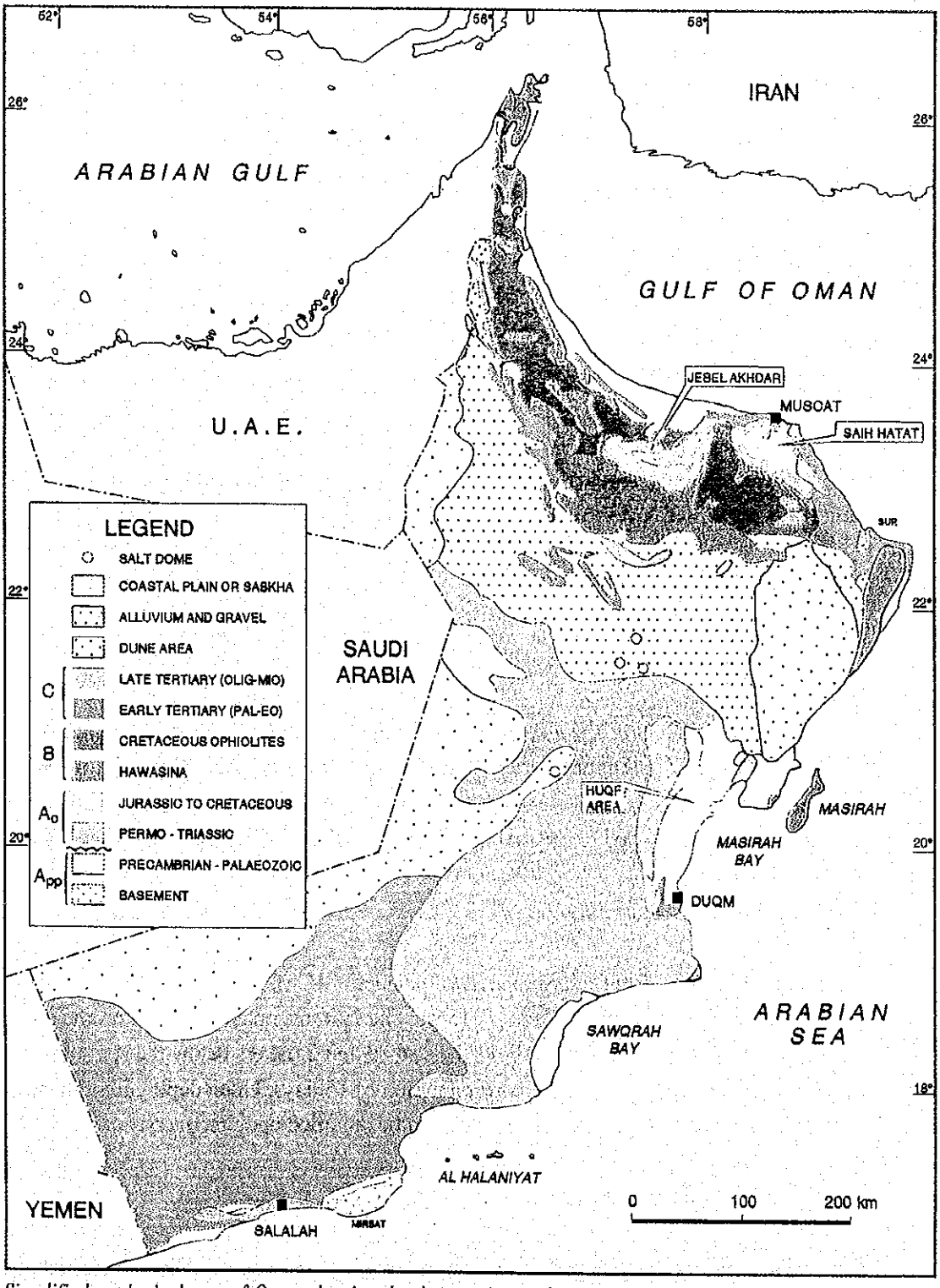
The survey was carried out in two locations, Area A and Corridor B(See Fig, 8.6.2).

Area A measured approximately 3, 000m×2, 000m, whilst corridor B measures 5, 000m× 500m.

8.6.3 Equipment

Following survey equipment was employed for each survey items.

- Positioning and Navigation - Fugro Starfix-Spot DGPS system
- Navigation and Data Logging System－PC Computer, PC Nav. and PC Map Software.
- Bathymetric Suite
  - Atlas Deso 20　Echo Sounders, TSS 320 Heave Compensator, Bar Check
- Sub Bottom Profiler
  - Geo Acoustics 5430A Transceiver, Pinger Array, TSS 360 Seismic Processor



Simplified geological map of Oman showing the three major geological provinces, the Oman mountains in the north (including the Musandam Peninsula), the Huqf area west of Masira Island and the Dhofar mountains.

Figure 8.6.1 Geological Map of Oman

8.6.4 Method of Operation

All personnel and equipment were mobilized on to a small fiber glass launch "Kismet" and all necessary system and checks were undertaken in Salalah port or at a designated Geodetic point, prior to sailing, in accordance with the DGPS systems verification.

Test and calibration will consist of the following.

- DGPS Health Check
- Echo Sounder wet test
- SBP wet test
- Tide Gauge wet test
- Current meter wet test

The DGPS positioning system was verified either alongside the quay in Salalah, at the Tide Gauge or at a national survey monument, NSA 5187 opposite the port entrance.

8.6.5 Survey Method

- Tide Gauge

  Prior to commencing the geophysical surveys, a Valeport 720 seabed tide gauge was installed at a depth of approximately 8 meters following a Harbor Master Permission.
  Data from this tide gauge was recovered with the unit upon completion of 15 days survey period and downloaded to a PC where the data was backed up immediately.

- Long Term Current Meters

  A current meter "string" comprising two Aanderra RCM 7 current meters were installed at the proposed location with depth −15 m. The current meters were set on the string such that a unit suspended 2 meters above the seabed and 2 meters below the sea surface. This current meter string was deployed for a period of 15 days. Upon deployment the time, date and location were logged. This shall also be recorded upon recovery.

- Direct Reading Current Meters

  Surrounding the Salalah port , five pre-designated locations have been assigned as points where direct reading current measurements were undertaken. The purpose of this survey is to check the current condition adjacent to the port, to provide base data for IEE. In a water depth of 10 meters, observations were undertaken at 1 meter intervals upon a level equivalent to 1 m above the seabed. The sampling cycle was 25 hours continuously.

- Bathymetric Survey and Sub Bottom Profiling

Area A is an area to the North of the existing container terminal, banked by the shoreline to the west and the water depths within this area are expected to be between 0 and 15m.

The area was surveyed on a grid basis, with primary lines running in an East／West direction spaced apart at 100 meters. Secondary cross lines were run in a North／South direction spaced 200 meters apart. The survey vessel was taken inshore as far as the vessel helmsman considers safe, taking into account swell, tide, current, maneuverability and the geology at shore.

Corridor B is an area to the East of the existing container terminal extending parallel to and encompassing the existing dredged channel and the water depths within this areas are expected to range between 16 and 23 meters ACD.

For both Area A and Corridor B, the Echo Sounder and Sub Bottom Profiler was run on all lines simultaneously. The higher 210 KHZ frequency of the echo sounder was used as the primary frequency for depth observation. The sub bottom profiler was operated at a frequency between 1. 5 KHZ to 10 KHZ to produce the best quality records. The tuning of the equipment was at the discretion of the Geophysicist and Engineer.

8.6.6 Summary of Survey Results

1) General

This preliminary report describes some of the findings of the survey.

Figure 8.6.2 shows the survey area and Figure 8.6.3 shows the survey run line diagram for the bathymetric survey and sub bottom profiling, respectively. The survey was conducted based on this survey run line.

Figure 8.6.4 through 8.6.6 show the survey results of the bathymetric survey and sub bottom profiling. These figures represent the bathymetric chart, the isopatch of uncemented sediment, and the tack chart, respectively.

Figure 8.6.7 and Figure 8.6.8 show the survey record samples of the bathymetry and the sub bottom profiling.

The configuration of the survey system and general arrangement of the survey equipment for the bathymetric survey and sub bottom profiling are shown in Figure 7.1.15 and Figure 8.6.10

Figure 8.6.11 through Figure 8.6.16 and Table 8.6.1 through Table 8.6.5 show the results of the 15 days current observations and tide observation.

2) Survey Results

a) Bathymetry

Water column depths have been reduced to Admiralty Chart Datum (ACD) by the simplified harmonic method of tidal prediction. References is made to the Admiralty Tide Table for the Indian Ocean and South China Sea, NP 203-00 Vol. No. 3 (Table 15).

Maximum water depth of 16 meters was confirmed at the South Eastern corner of Area A. On the other hand, Corridor B was found to have a depth of 16.5 meters at the harbor entrance. The Eastern extent of the corridor, which is 5 km from the harbor entrance, has a water depth of 26 meters.

Area A

The seabed Area A generally slopes down from the beach and across the entire site between gradients of 1: 50 and 1: 300 in an easterly direction of 110 degrees. Depths at the Eastern limit of this survey area ranges from 10 meters in the North Eastern corner to 16 meters in the South Eastern corner.

Corridor B

Corridor B encompasses a 300 meter wide approach channel, which has been dredged to -16.5 meters at the harbor entrance. The dredged area is therefore limited by the 16.5 meter contour, which is about 700 meters from the harbor entrance.

The Corridor seabed generally deepens beyond this point at a gradient of 1: 100 in a South Easterly direction of 150. The last 2 kilometers of the corridor slopes down to a maximum depth of 26 meters at gradients between 1: 70 and 1: 400 in a Southerly direction of 170° .

The coastline including the container terminal shown on the charts has been digitized from the National Hydrographic Office of the Sultanate of Oman chart No. 250.

Echo sounder records indicate a hard uneven seabed surface as shown in a sample records in Figure 8.6.7.

b) Sub-bottom Sediments

The Pinger data shows the thickness of uncemented sediments comprising sands and gravels with cobbles and boulders.

Over most of the survey area, the sediments are cemented Calcarenties, which are not penetrated by the Pinger. Some of the areas, however, was found to be pockets of loose or only partially cemented sediments.

Area A

The sediments are the same as Corridor B and arte made up of sands and gravels with cobbles and boulders infilling depressions in a mainly hard cemented Calcarenite seabed. The thickness of the loose sediments increases to the South West reaching up to 5.4 meters along the edge of the container terminal.

This area is the outwash from the Wadis and the greater thickness of loose sediments in this area seems to represent a great volume of flood transported material.

In the South Western corner of the area, numerous pinnacles with a height up to 1-1.5 meters were observed and are thought to be old coral heads or boulders.

To the South Eastern corner of the survey area are a series of old reef like structures with relief of up to 5 meters. These features run South West to North East and extend for up to 300 meters.

To the North East of the area, cliff in the calcarenite seabed display relief of up to 2 to 3 meters.

Pinger records are shown in Figure 8.6.8.

Corridor B

Areas of loose sediments exist with thickness of up to 2 meters although the seabed is mainly cemented Calcarenite. In the approach to the Salalah Container Port, the sediments have been dredged and shear cliffs of relief up to 4 to 5 meters have been produced. The edge of the dredged channel has been plotted on the Isopatch Chart.

Within the channel, some loose sediments were recorded with a maximum thickness of 1.5 meters.

These sediments probably represent recent sedimentation resulting from re-deposit of suspended material during the dredging operations.
To the North and to a lesser extent to the South of the dredged channel, loose sediments were found. Up to 1.3 meters of loose sands and gravels were found over cemented calcarenites to the South of the channel.

To the North of the channel, the loose sediments are thicker reaching up to 3.3 meters at the harbor entrance, these seem to represent flood transported materials from the wadis.

Two coral-reef like structure were also noted on the Pinger data in the Corridor B at coordinates E 183 270 m, N1 876 060m and E184 060m, N 1 876 450m with relief of 1m and 2m, respectively.

GENERAL LOCATION DIAGRAM

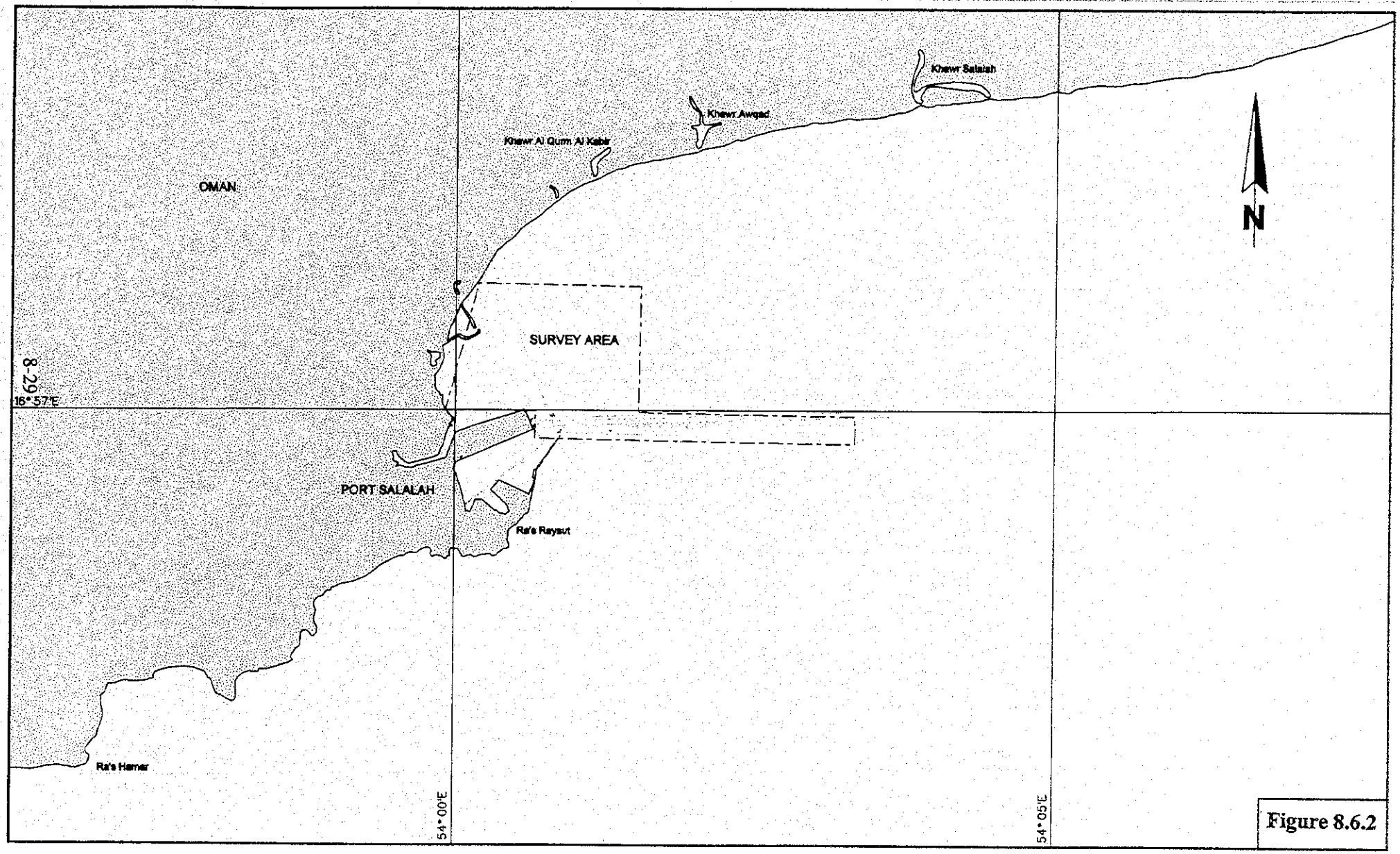
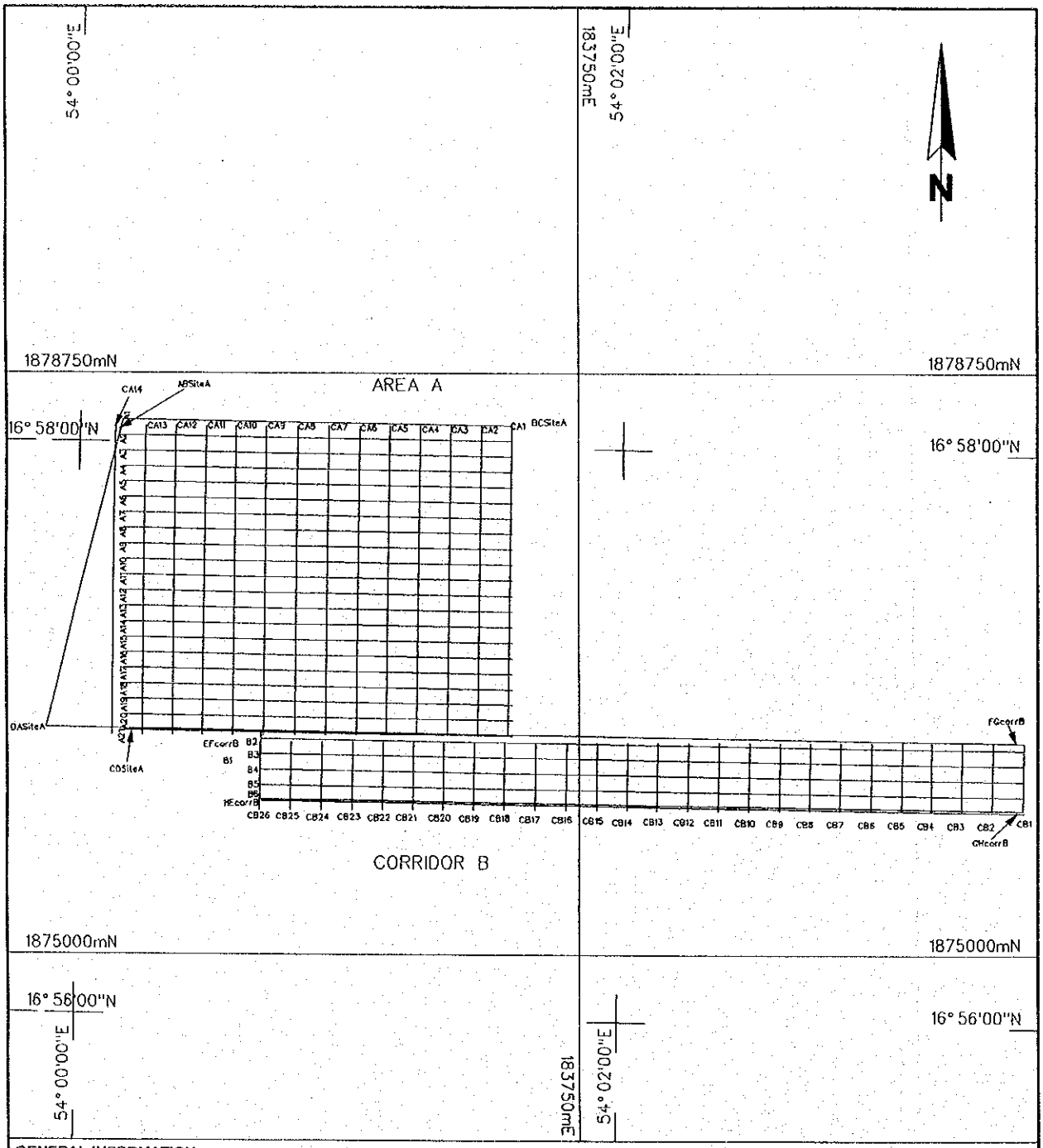


Figure 8.6.2

RUN LINE DIAGRAM



GENERAL INFORMATION	
Location	SALALAH, OMAN
Centre co-ordinates	182 032.85 mE, 1 877 178.20 mN
Plot scale	1:37500
Datum	ITRF 93
Spheroid	WGS 84
Grid projection	UTM
Central meridian	57.0° East (Zone 40)
Equipment deployed	Echo sounder & Sub Bottom Profiler
Vessel	Kismet
Date of Survey	Mar 2000

Figure 8.6.3

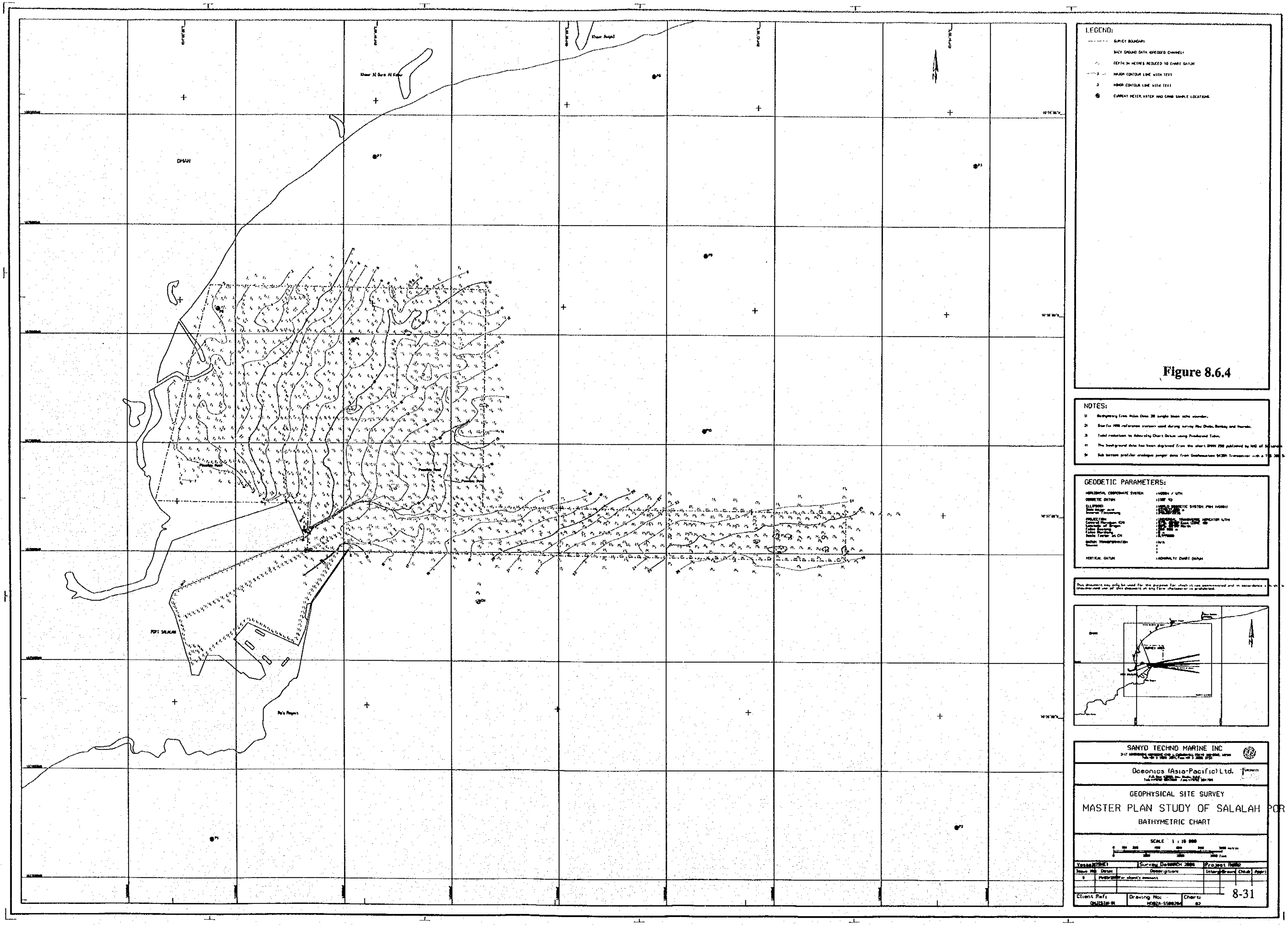

LEGEND:
NOTES:
GEODETIC PARAMETERS:
DHAN
PORT SALALAH
SANYO TECHNO MARINE INC
Oceonics (Asia-Pacific) Ltd.
GEOPHYSICAL SITE SURVEY
MASTER PLAN STUDY OF SALALAH POR
BATHYMETRIC CHART
SCALE
Client Ref:
Drawing No:
Chart:

Figure 8.6.4

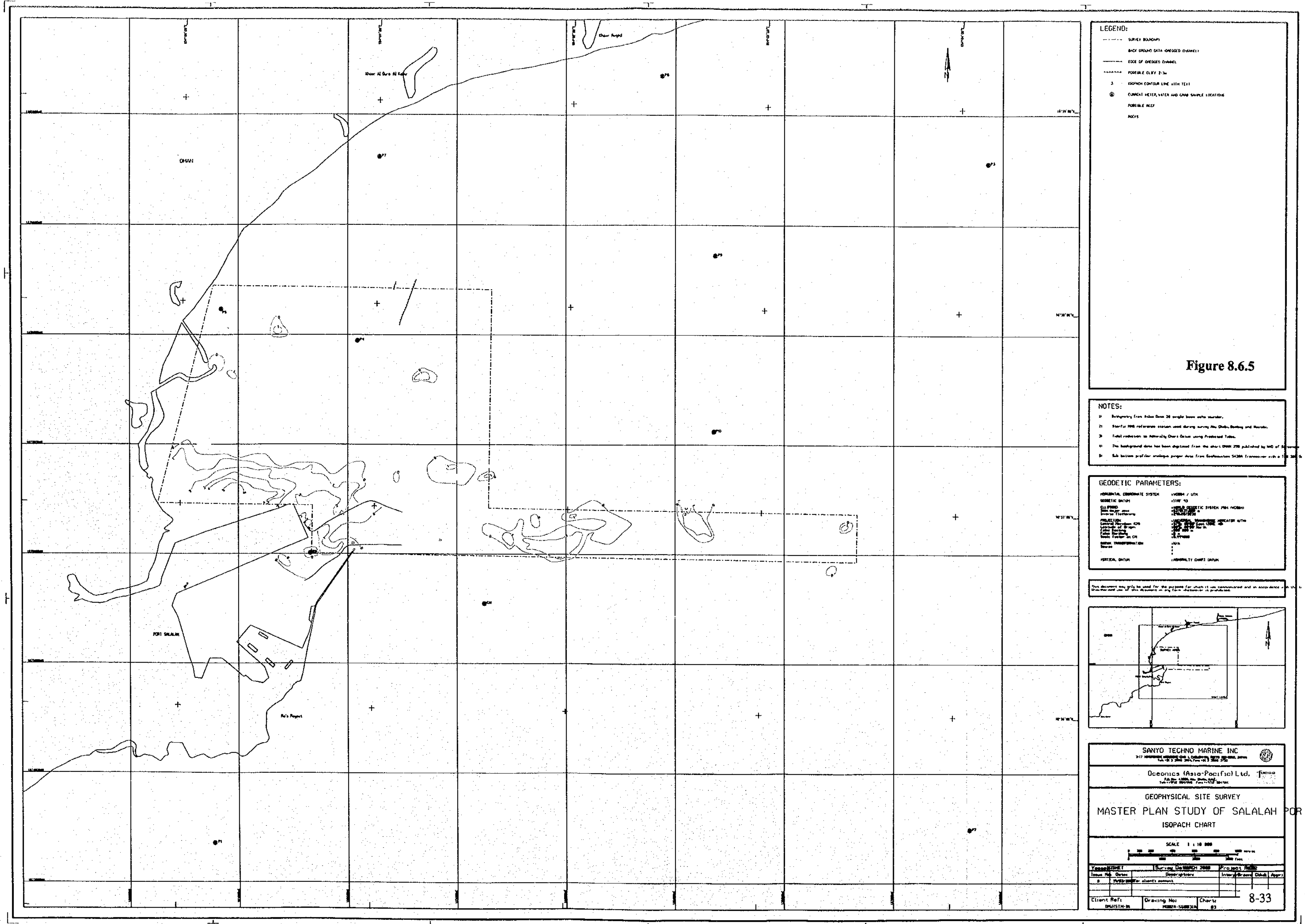
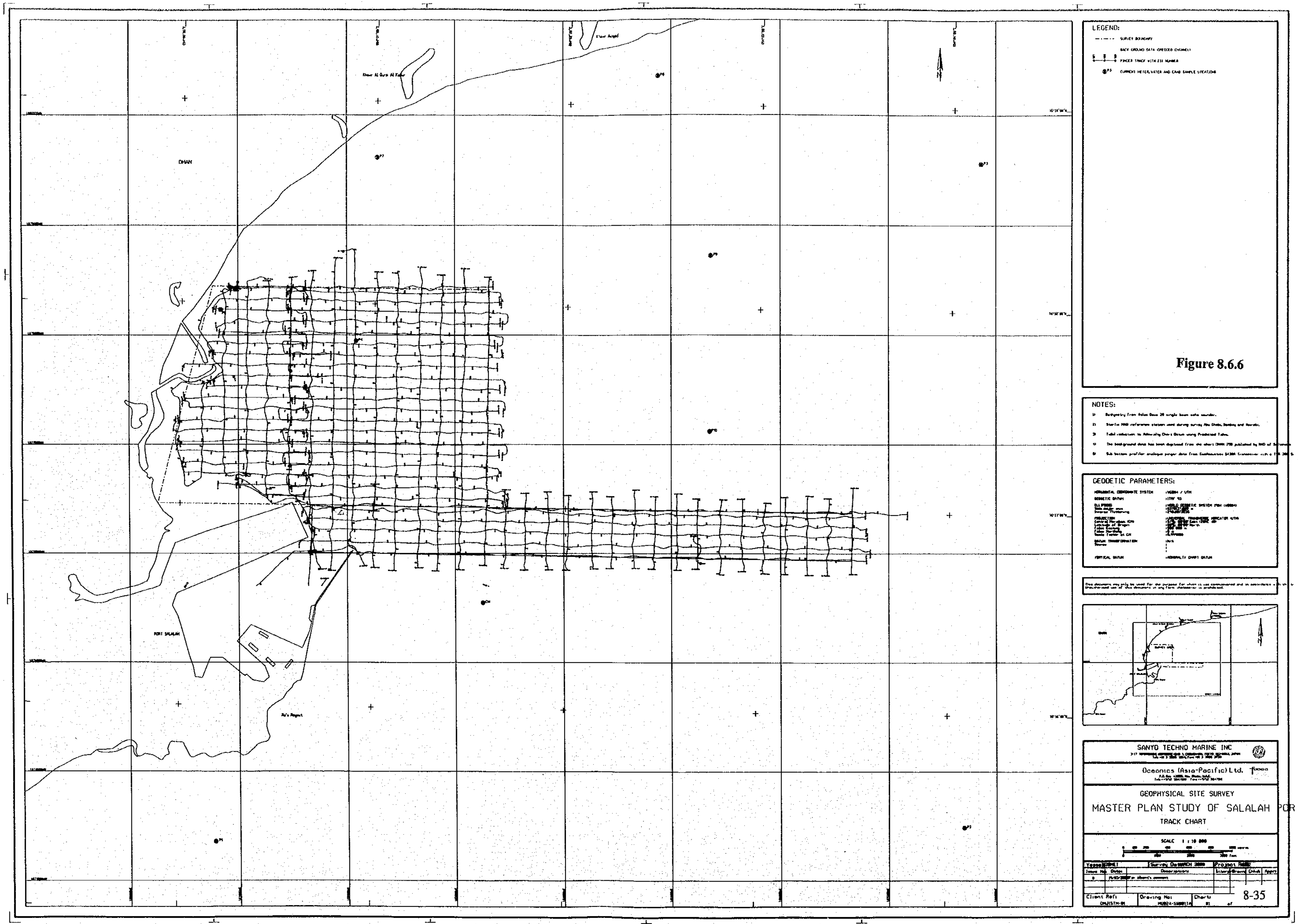

LEGEND:
NOTES:
GEODETIC PARAMETERS:
OMAN
PORT SALALAH
SANYO TECHNO MARINE INC
Oceonics (Asia-Pacific) Ltd.
GEOPHYSICAL SITE SURVEY
MASTER PLAN STUDY OF SALALAH POR
ISOPACH CHART
Client Ref:
Drawing No:
Chart:

Figure 8.6.5

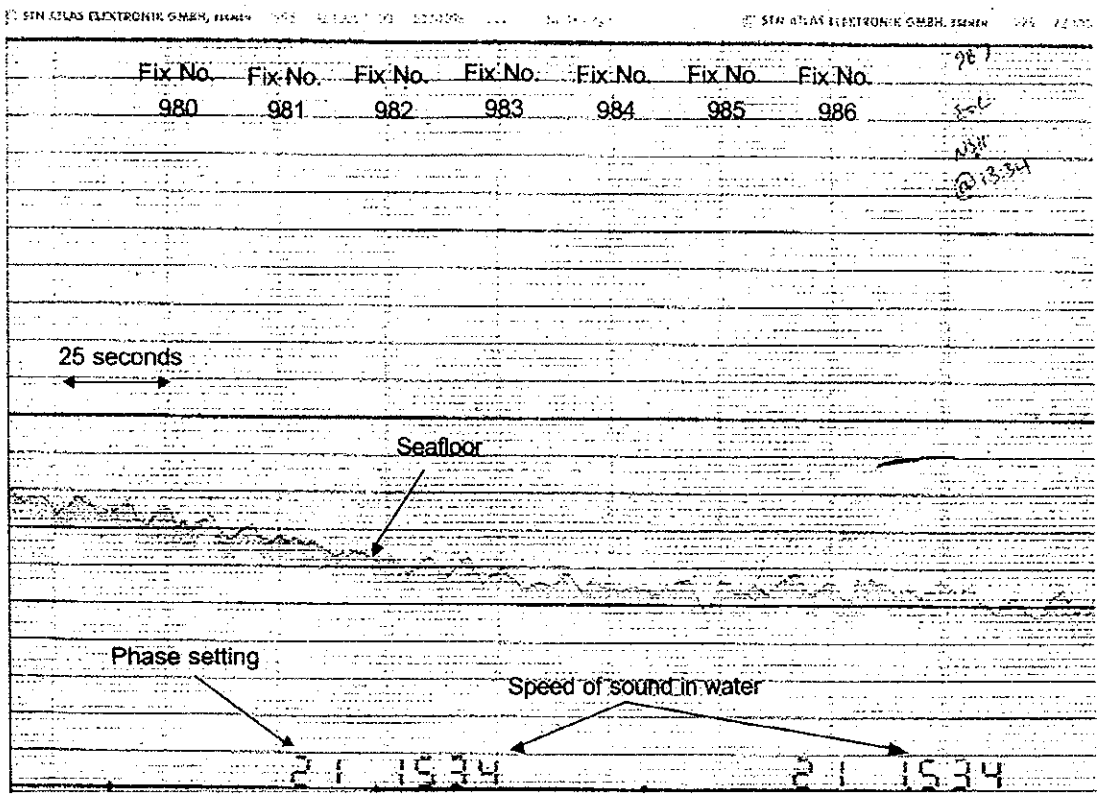


DHAN
PORT SALALAH
LEGEND:
NOTES:
GEODETIC PARAMETERS:
SANYO TECHNO MARINE INC
Oceanics (Asia-Pacific) Ltd.
GEOPHYSICAL SITE SURVEY
MASTER PLAN STUDY OF SALALAH POR
TRACK CHART
SCALE
Client Ref:
Drawing No:
Chart:

Figure 8.6.6

SURVEY RECORD EXAMPLE

IMAGE	Route / Site	Line No. / Direction	SURVEY
Atlas Deso 20 Echo Sounder Example No. 1	Corridor B Project No. MO02	NS_11 / 180 deg KP No. N/A	Geophysical Site Survey

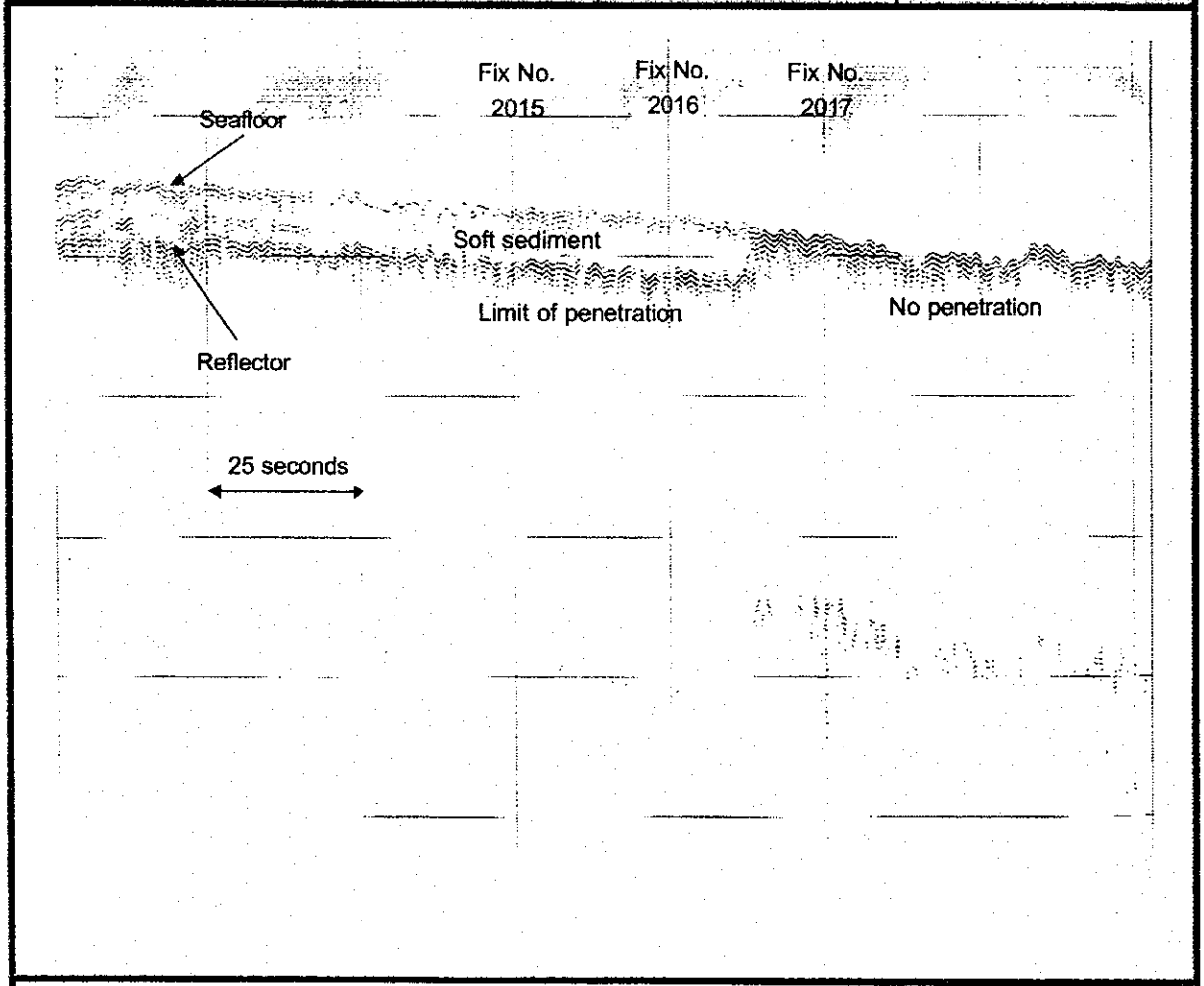


GENERAL INFORMATION	
Date of Survey:	March 2000
Vessel:	MV Kismet
Area of operations;	Salalah Port, Oman
Survey Equipment:	Atlas Deso 20 Dual Frequency Echo Sounder
Recording Medium:	Atlas Deso 20 Recorder and PCNav Computer
Scaling:	Image is by 'scanning' the Hardcopy. Example is not to scale
Frequency:	210 kHz
Range setting:	10 - 30 metres
Velocity of Sound in Water:	1534 m/s

Figure 8.6.7

SURVEY RECORD EXAMPLE

IMAGE	Route / Site	Line No. / Direction	SURVEY
GeoAcoustics 5430A Sub-bottom Profiler Example No. 2	Area A Project No. MO02	EW_21 / 90 deg KP No. @ Fix No. 2016	Geophysical Site Survey



GENERAL INFORMATION	
Date of Survey:	March 2000
Vessel:	MV Kismet
Area of operations;	Salalah Port, Oman
Survey Equipment:	GeoAcoustics 5430A Transceiver with a TSS 360 Seismic Processor
Recording Medium:	Thermal image recorder and PCNav Computer
Scaling:	Image is by 'scanning' the Hardcopy. Example is not to scale
Frequency:	1.5 - 10 kHz

Figure 8.6.8

EQUIPMENT LAYOUT DIAGRAM

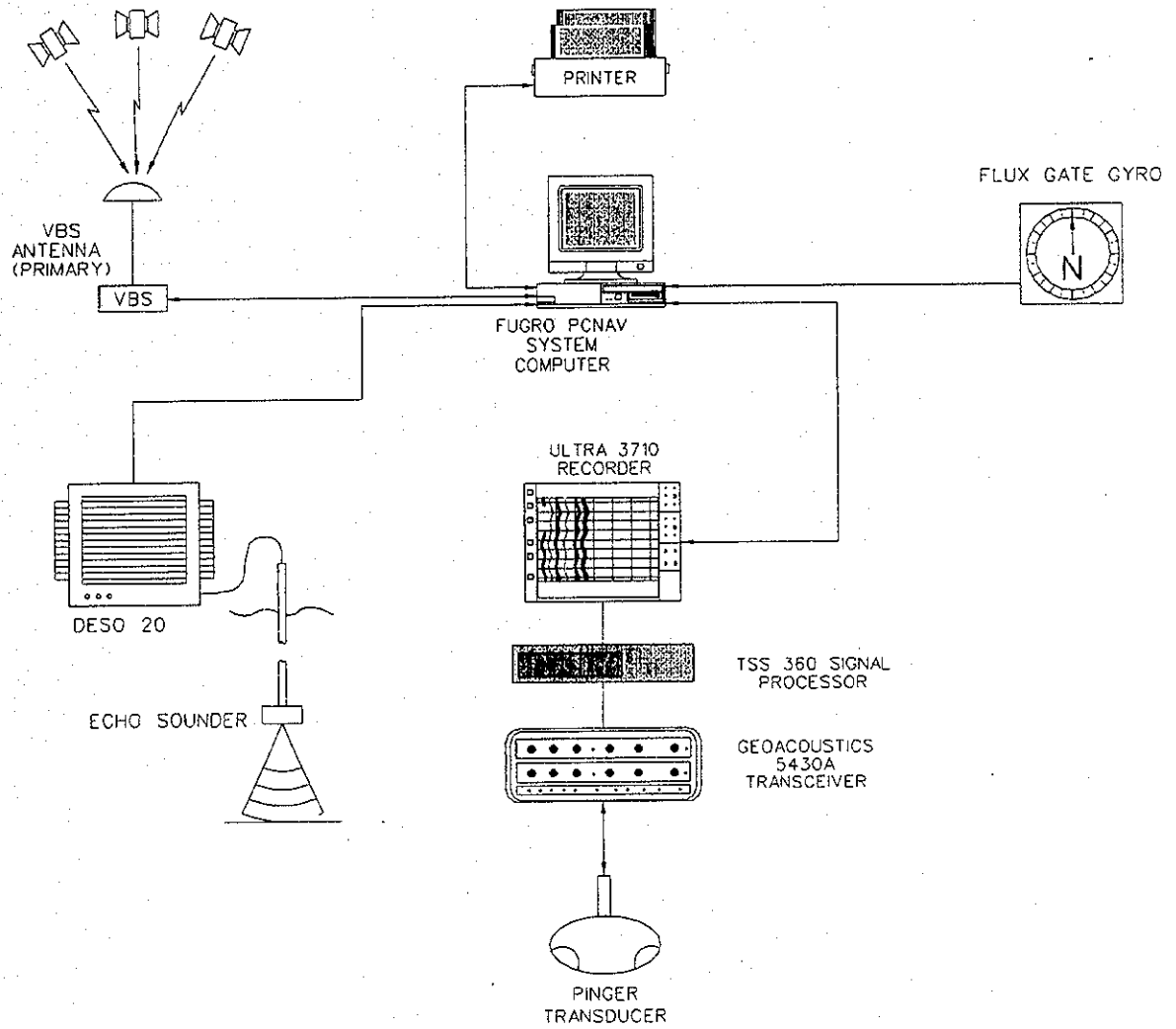
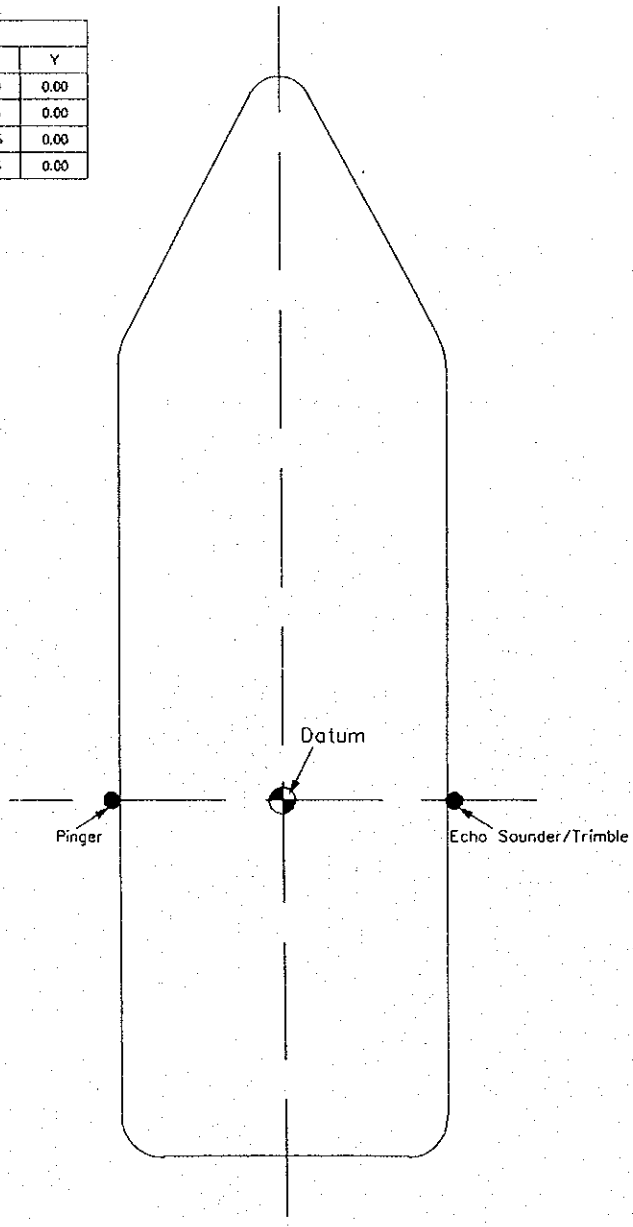


Figure 8.6.9

VESSEL OFFSET DIAGRAM

CLASSIFICATION:	VESSEL NAME:
VESSEL	KESMIT

M.V.Kesmit Offsets In metres		
Offset Name	X	Y
DATUM	0.00	0.00
ECHO SOUNDER	1.65	0.00
PINGER	-1.65	0.00
TRIMBLE	1.65	0.00



GENERAL INFORMATION	
Name of owner:	SAM HARAM DIVING AND SPORTS CENTRE
Name of operator:	SIMON BRACEY
Tonnage-Gross	-
Draft:	0.7m
Length:	10m
Accommodation:	5 person
Engines/propellors:	Twin Volvo Diesels
Deck Space:	N/A
Crane Tonnage:	N/A
Other:	-

Figure 8.6.10

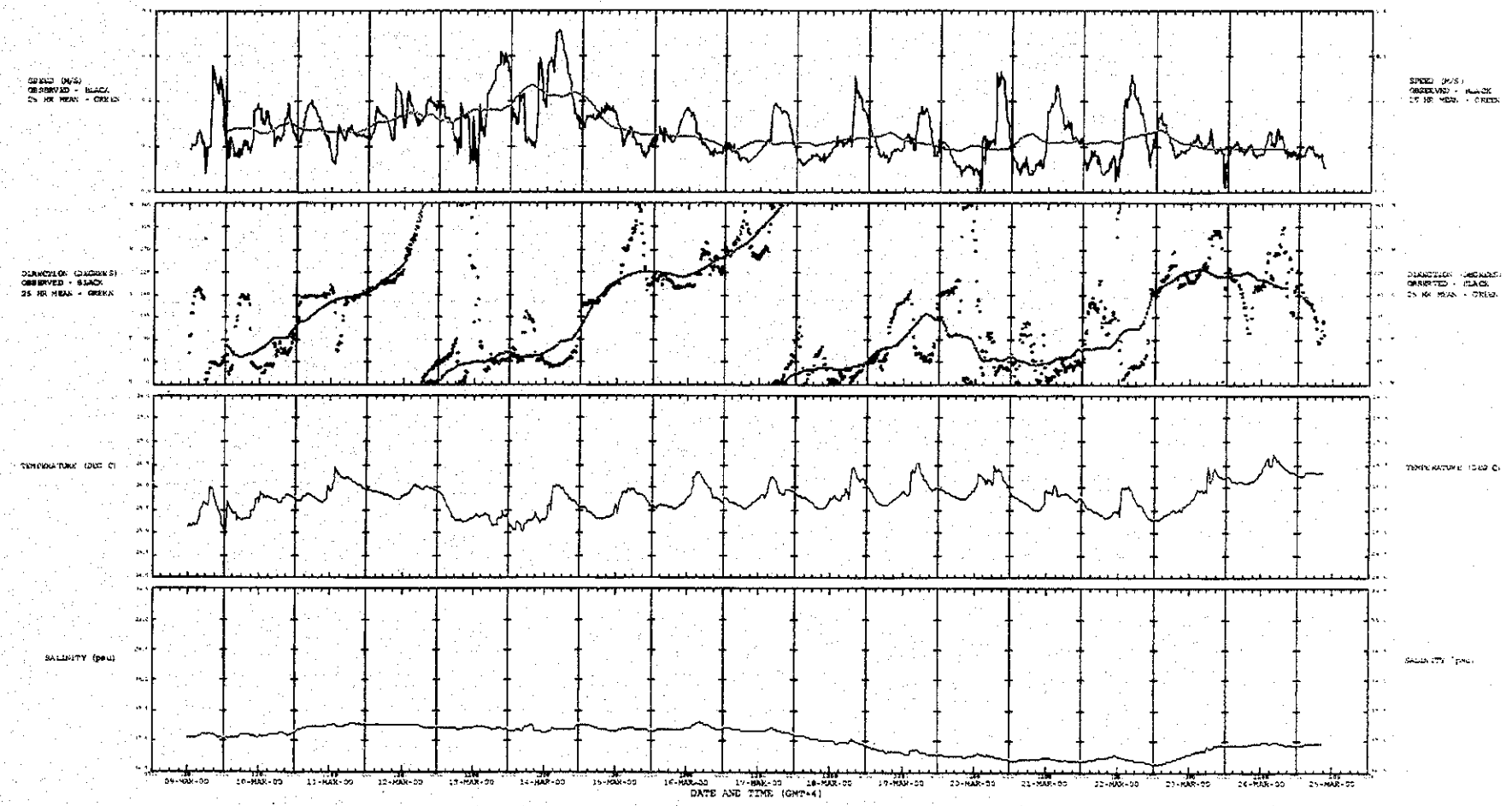


Figure 8.6.11

NOTES:

POSITION:	16 56 31.8N, 054 01 34.2E
WATER DEPTH:	21m
INSTRUMENT DEPTH:	2m BELOW MSL
INSTRUMENT TYPE:	VALEPORT 208
SERIAL NO:	12503
MOORING NAME:	CM
SAMPLING INTERVAL:	20 MINS

OCEANICS (ASIA-PACIFIC) LTD

SALALAH PORT CURRENT & TIDE MEASUREMENTS

CM TOP CURRENT METER (15DAY)

09-MAR-00 TO 25-MAR-00

REF. NO: 10460/2068

FIGURE NO: 2.1

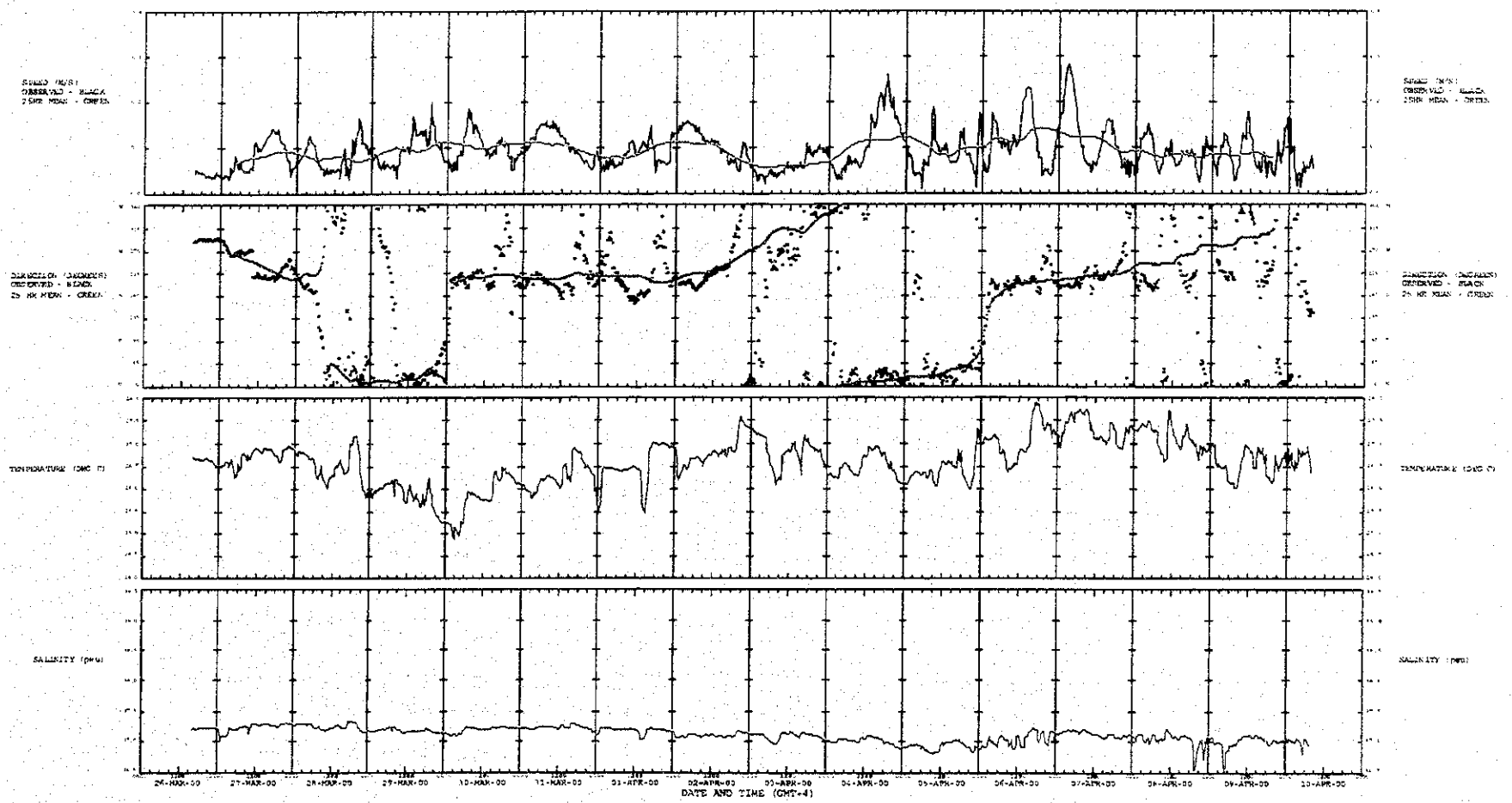


Figure 8.6.12

NOTES:

POSITION:	16 56 31.8N, 054 01 34.2E
WATER DEPTH:	21m
INSTRUMENT DEPTH:	2m BELOW MSL
INSTRUMENT TYPE:	VALEPORT 208
SERIAL NO:	12523
MOORING NAME:	CM
SAMPLING INTERVAL:	20 MINS

OCEANICS (ASIA-PACIFIC)LTD	
SALALAH PORT CURRENT & TIDE MEASUREMENTS	
CM TOP CURRENT METER (15 DAY)	
26-MAR-00 TO 10-APR-00	
REF. NO:	10463/2068
FIGURE NO:	2.2.1

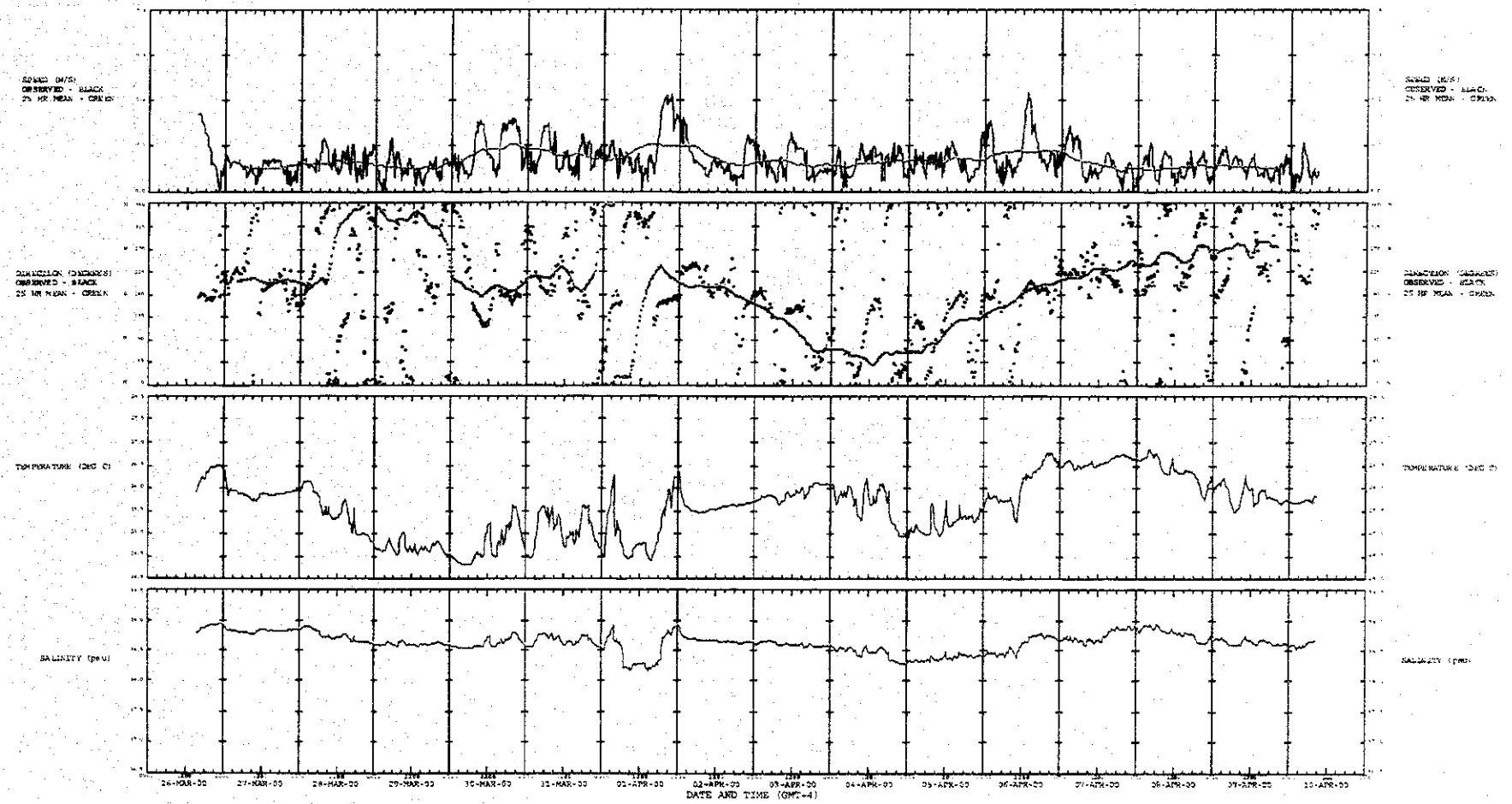


Figure 8.6.13

NOTES:

POSITION:	16 56 31.8N, 054 01 34.2E
WATER DEPTH:	23m
INSTRUMENT DEPTH:	2m ABOVE SEA BED
INSTRUMENT TYPE:	VALEPORT 308
SERIAL NO:	12524
MOORING NAME:	CM
SAMPLING INTERVAL:	20 MINS

OCEONICS (ASIA-PACIFIC) LTD

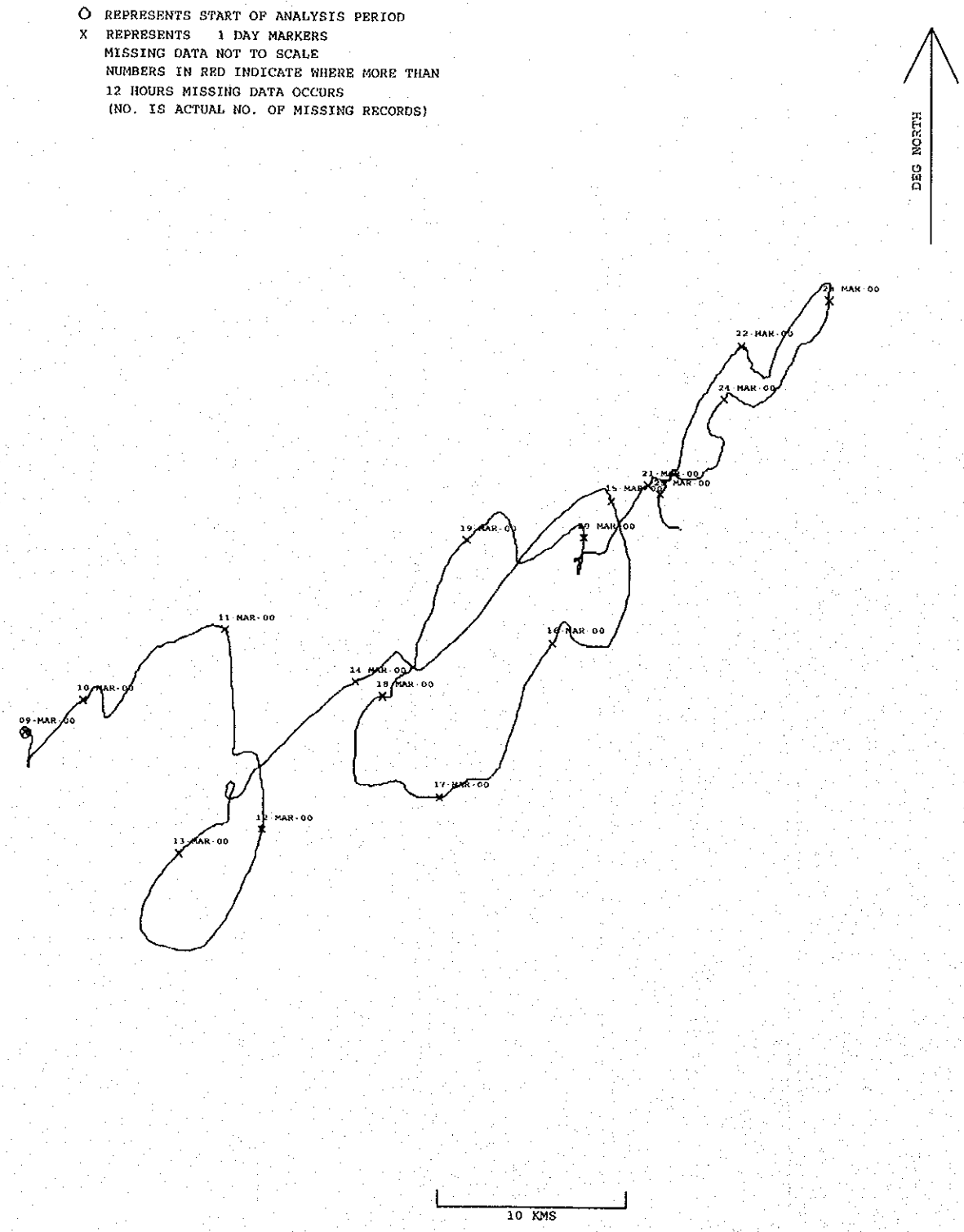
SALALAH PORT CURRENT & TIDE MEASUREMENTS

CM BOTTOM CURRENT METER (15DAY)

26-MAR-00 TO 10-APR-00

REF. NO:	10463/2068
FIGURE NO:	2.2.2

O REPRESENTS START OF ANALYSIS PERIOD
X REPRESENTS 1 DAY MARKERS
MISSING DATA NOT TO SCALE
NUMBERS IN RED INDICATE WHERE MORE THAN
12 HOURS MISSING DATA OCCURS
(NO. IS ACTUAL NO. OF MISSING RECORDS)



MISSING RECORDS: 0
NUMBER OF RECORDS: 1143
SAMPLING INTERVAL: 20 MINS
ANALYSIS PERIOD: 09-MAR-00 11:57 TO 25-MAR-00 08:37 GMT+4

INSTRUMENT HEIGHT: 19M ABOVE BED
DEPTH OF WATER: 21M
TYPE OF METER: VALEPORT 308
POSITION: 16 56 31.8N, 054 01 34.2E

OCEONICS LTD CURRENT & TIDE MEASUREMENTS

OBSERVED CURRENT PROGRESSIVE VECTOR PLOT

SALALAH PORT - TOP CURRENT METER

REF NO 10463/2068

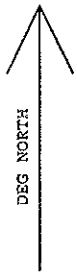
FIG NO 3.1

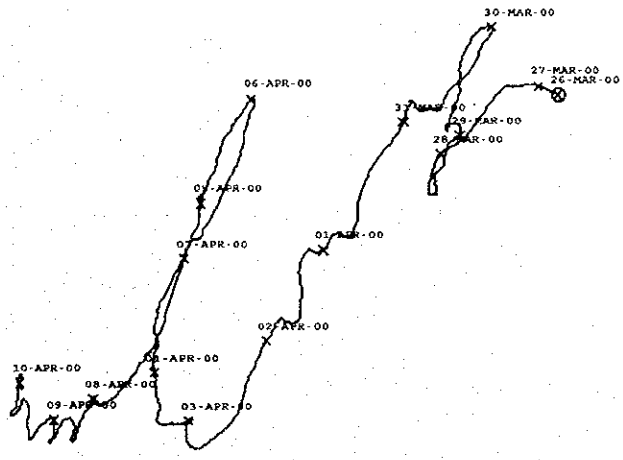
PLOT DATE: 4-MAY-00

FILE: CHIDEP1TOPPVC

Figure 8.6.14

O REPRESENTS START OF ANALYSIS PERIOD
X REPRESENTS 1 DAY MARKERS
MISSING DATA NOT TO SCALE
NUMBERS IN RED INDICATE WHERE MORE THAN
12 HOURS MISSING DATA OCCURS
(NO. IS ACTUAL NO. OF MISSING RECORDS)





10 KMS

MISSING RECORDS: 0
NUMBER OF RECORDS: 1056
SAMPLING INTERVAL: 20 MINS
ANALYSIS PERIOD: 26-MAR-00 15:59 TO 10-APR-00 07:39 GMT+4

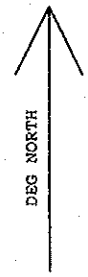
INSTRUMENT HEIGHT: 19M ABOVE BED
DEPTH OF WATER: 21M
TYPE OF METER: VALEPORT 308
POSITION: 16 56 31.8N, 054 01 34.2E

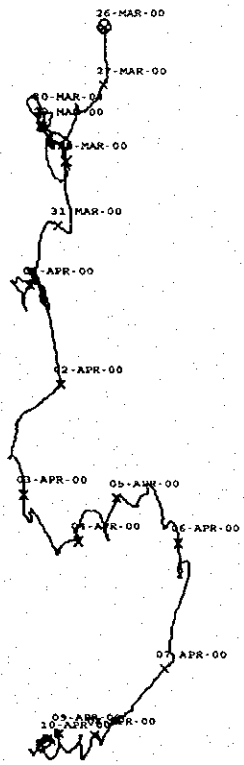
FUGRO GEOS	OCEONICS LTD CURRENT & TIDE MEASUREMENTS OBSERVED CURRENT PROGRESSIVE VECTOR PLOT SALALAH PORT - TOP CURRENT METER	REF NO 10463/2068 FIG NO 3.2.1

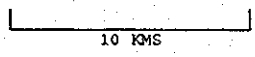
PLOT DATE: 4-MAY-00 FILE: CMADEP2TOPPVC

Figure 8.6.15

○ REPRESENTS START OF ANALYSIS PERIOD
X REPRESENTS 1 DAY MARKERS
MISSING DATA NOT TO SCALE
NUMBERS IN RED INDICATE WHERE MORE THAN
12 HOURS MISSING DATA OCCURS
(NO. IS ACTUAL NO. OF MISSING RECORDS)







MISSING RECORDS: 0
NUMBER OF RECORDS: 1059
SAMPLING INTERVAL: 20 MINS
ANALYSIS PERIOD: 26-MAR-00 15:56 TO 10-APR-00 08:36 GMT+4

INSTRUMENT HEIGHT: 2M ABOVE BED
DEPTH OF WATER: 21M
TYPE OF METER: VALEPORT 308
POSITION: 16 56 31.8N, 054 01 34.2E

GEOS	OCEONICS LTD CURRENT & TIDE MEASUREMENTS OBSERVED CURRENT PROGRESSIVE VECTOR PLOT SALALAH PORT - BOTTOM CURRENT METER	REF NO 10463/2068 FIG NO 3.2.2

PLOT DATE: 4-MAY-00 FILE: CRIDEP2BOTPVC

Figure 8.6.16

Table 8.6.1

OCEONICS (ASIA-PACIFIC) LTD SALALAH PORT CURRENT & TIDE MEASUREMENTS							
CURRENT METER	DEPTH BELOW MSL (m)	HEIGHT ABOVE BED (m)	CURRENT SPEED (ms^{-1}) (Max)	(Mean)	DIRECTION OF CURRENT MAX (° TRUE)	DATE AND TIME MAX CURRENT (GMT+4)	% DATA RETURN
TOP	2	19	0.36	0.13	038	14-Mar-00 15:57	100
BOTTOM	19	2	NO DATA	NO DATA	NO DATA	NO DATA	0

TABLE 1.1 Summary Statistics of Measured Current, 09-Mar-00 11:57 to 25-Mar-00 08:37 (GMT+4)

Notes:

POSITION: 16° 56' 31.8"N, 054° 01' 34.2"E
SAMPLING INTERVAL: 20 MINS
ANALYSIS PERIODS: 09-Mar-00 11:57 to 25-Mar-00
LOCATION: SALALAH PORT

INSTRUMENT DEPTH: 2m BELOW MSL
WATER DEPTH: 21m
SERIAL NUMBER: 12523
INSTRUMENT TYPE: VALEPORT 308

OCEONICS (ASIA-PACIFIC) LTD SALALAH PORT CURRENT & TIDE MEASUREMENTS							
CURRENT METER	DEPTH BELOW MSL (m)	HEIGHT ABOVE BED (m)	CURRENT SPEED (ms^{-1}) (Max)	(Mean)	DIRECTION OF CURRENT MAX (° TRUE)	DATE AND TIME MAX CURRENT (GMT+4)	% DATA RETURN
TOP	2	19	0.28	0.09	201	07-Apr-00 02:59	100
BOTTOM	19	2	0.22	0.07	196	06-Apr-00 13:16	100

TABLE 1.2 Summary Statistics of Measured Current
Top Current Meter, 26-Mar-00 15:59 to 10-Apr-00 07:39 (GMT+4)
Bottom Current Meter, 26-Mar-00 15:56 to 10-Apr-00 08:36 (GMT+4)

Notes:

POSITION: 16° 56' 31.8"N, 054° 01' 34.2"E
SAMPLING INTERVAL: 20 MINS
ANALYSIS PERIODS: 26-Mar-00 to 10-Apr-00
LOCATION: SALALAH PORT

INSTRUMENT DEPTH: 2m BELOW MSL / 2M ABOVE BED (TOP / BOTTOM)
WATER DEPTH: 21m
SERIAL NUMBER: 12523 / 12524 (TOP / BOTTOM)
INSTRUMENT TYPE: VALEPORT 308

Table 8.6.2

TABLE ENTRIES ARE PERCENTAGE OCCURRENCE

OBSERVED CURRENT DIRECTION (DEG)	0.0–0.1	0.1–0.2	0.2–0.3	0.3–0.4	0.4–0.5	0.5–0.6	0.6–0.7	0.7–0.8	PERCENTAGE OCCURRENCE
360	0.1	0.7	0.4	0.8					2.0
	0.2	0.4	0.3	0.2					1.1
315	0.3	1.6	1.0	0.3					3.1
	0.1	1.0	1.2	0.3	0.1				2.7
270		2.3	2.3	0.1	0.3				4.9
		2.0	1.2	0.1					3.3
225	0.1	2.5	5.2	1.4	0.5				9.8
		3.7	4.2	3.3					11.2
180	0.3	2.7	4.5	3.3	0.1				10.9
	0.3	2.2	0.8						3.3
135	0.4	2.0	1.0	0.1					3.5
	0.3	1.8	1.3						3.4
090	0.2	1.9	1.8	0.5					4.5
	0.2	2.7	3.0	3.9	1.2	1.5	0.1		12.6
045	0.1	1.7	4.0	4.5	2.8	1.8	0.8	0.3	16.1
	0.3	2.1	1.0	2.7	1.2	0.2			7.5
000									
PERCENTAGE OCCURRENCE	2.8	31.4	33.3	21.5	6.2	3.5	0.9	0.3	NUMBER OF SAMPLES
PERCENTAGE EXCEEDENCE	100.0	97.2	65.8	32.5	10.9	4.7	1.2	0.3	1143

OBSERVED CURRENT SPEED (M/S)

NUMBER OF RECORDS: 1143
RECORDS OUT OF RANGE: 0 (<MIN), 0 (>MAX)
NUMBER OF MISSING RECORDS: 0
SAMPLING INTERVAL: 20 MINS
ANALYSIS PERIOD: 09-MAR-00 11:57 TO 25-MAR-00 08:37 GMT+4

INSTRUMENT DEPTH: 2.0M BELOW MSL
DEPTH OF WATER: 21.0M
TYPE OF METER: VALEPORT 308
SERIAL NO.: 12523

OCEONICS LTD CURRENT & TIDE MEASUREMENTS

OBSERVED CURRENT OCCURRENCE TABLE

TOP CURRENT METER PORT SALALAH

REF NO 10463/2068

TABLE 2.1

PLOT DATE: 2-MAY-00

FILE: CMIDEPITOPTAB

Table 8.6.3

TABLE ENTRIES ARE PERCENTAGE OCCURRENCE

OBSERVED CURRENT DIRECTION (DEG)	0.0–0.1	0.1–0.2	0.2–0.3	0.3–0.4	0.4–0.5	0.5–0.6	0.6–0.7	0.7–0.8	PERCENTAGE OCCURRENCE
360	0.7	3.3	1.8						5.8
	0.8	1.8	0.5						3.0
315	1.8	1.9	0.1						3.8
	2.4	3.9	0.4						6.6
270	1.7	4.1	0.3						6.1
	1.2	5.7	2.8	0.1					9.8
225	1.4	7.0	9.3	2.7	0.7				21.1
	0.5	4.8	5.9	1.6	0.6	0.7			14.0
180	0.4	0.9	0.8						2.1
	0.3	1.2							1.5
135	0.3	0.2							0.5
	0.1	0.5							0.6
090	0.6	0.6							1.1
	0.7	1.2	0.3						2.2
045	0.4	2.9	3.2	0.9	0.8	0.1			8.2
	0.4	6.9	4.1	1.9	0.3				13.5
000									
PERCENTAGE OCCURRENCE	13.4	47.0	29.4	7.2	2.3	0.8	0.0	0.0	NUMBER OF SAMPLES
PERCENTAGE EXCEEDENCE	100.0	86.6	39.6	10.2	3.0	0.8	0.0	0.0	1056

OBSERVED CURRENT SPEED (M/S)

NUMBER OF RECORDS: 1056
RECORDS OUT OF RANGE: 0 (<MIN), 0 (>MAX)
NUMBER OF MISSING RECORDS: 0
SAMPLING INTERVAL: 20 MINS
ANALYSIS PERIOD: 26-MAR-00 15:59 TO 10-APR-00 07:39 GMT+4

INSTRUMENT DEPTH: 2.0M BELOW MSL
DEPTH OF WATER: 21.0M
TYPE OF METER: VALEPORT 308
SERIAL NO.: 12523

OCEONICS LTD CURRENT & TIDE MEASUREMENTS

OBSERVED CURRENT OCCURRENCE TABLE

PORT SALALAH

REF NO 10463/2068

TABLE 2.2.1

PLOT DATE: 2-MAY-00

FILE: CMIDEP2TOPTAB

Table 8.6.4

TABLE ENTRIES ARE PERCENTAGE OCCURRENCE

OBSERVED CURRENT DIRECTION (DEG)	0.0 - 0.1	0.1 - 0.2	0.2 - 0.3	0.3 - 0.4	0.4 - 0.5	0.5 - 0.6	0.6 - 0.7	0.7 - 0.8	PERCENTAGE OCCURRENCE
360	1.7	6.2	0.1						8.0
	1.4	4.7	0.4						6.5
315	1.1	2.6	0.2						4.0
	1.7	0.8							2.5
270	3.0	0.3							3.3
	3.5	2.8	0.7						7.0
225	4.2	5.9	1.4	0.2	0.1				11.8
	3.4	6.8	2.3	0.6	0.1				13.1
180	1.2	6.2	3.1	2.4	0.5				13.4
	1.1	3.3	2.5	0.2					7.1
135	0.5	3.2	0.7	0.1					4.4
	1.3	1.2							2.5
090	1.8	1.4							3.2
	1.9	0.4	0.1						2.4
045	3.1	1.4	0.3						4.8
	2.5	3.3	0.1						5.9
000									
PERCENTAGE OCCURRENCE	33.4	50.8	11.7	3.4	0.7	0.0	0.0	0.0	NUMBER OF SAMPLES
PERCENTAGE EXCEEDENCE	100.0	66.6	15.8	4.1	0.7	0.0	0.0	0.0	1059

OBSERVED CURRENT SPEED (M/S)

NUMBER OF RECORDS: 1059
RECORDS OUT OF RANGE: 0 (<MIN), 0 (>MAX)
NUMBER OF MISSING RECORDS: 0
SAMPLING INTERVAL: 20 MINS
ANALYSIS PERIOD: 26-MAR-00 15:56 TO 10-APR-00 08:36 GMT+4

INSTRUMENT DEPTH: 2.0M ABOVE BED
DEPTH OF WATER: 21.0M
TYPE OF METER: VALEPORT 308
SERIAL NO.: 12524

TUCKER GEOS	OCEONICS LTD CURRENT & TIDE MEASUREMENTS OBSERVED CURRENT OCCURRENCE TABLE PORT SALALAH	REF NO 10463/2068 TABLE 2.2.2

PLOT DATE: 2-MAY-00 FILE: CH1DSP2BOTTAB

Table 8.6.5

HARMONIC TIDAL ANALYSIS

TIDAL ELEVATION

Location: SALALAH PORT

Constituent time zone: GMT

Analysis period: 04-FEB-00 15:51 to 20-FEB-00 20:51 GMT+4.
Analysis interval: 10.0 Minutes
Number of records: 2335

Datum name:

Constituent name		Period (hours)	H (metres)	g (degrees)
Z0			0.000	000
MSF		354.367	0.001	249
2Q1		28.006	0.008	320
SIG1	(R)	27.848	0.010	319
Q1	(R)	26.868	0.036	352
RO1	(R)	26.723	0.007	352
O1		25.819	0.190	350
PI1	(R)	24.132	0.008	344
P1	(R)	24.066	0.131	344
S1	(R)	24.000	0.004	344
K1		23.934	0.395	344
PSI1	(R)	23.869	0.003	343
PHI1	(R)	23.804	0.006	343
J1	(R)	23.098	0.022	025
OO1		22.306	0.012	022
2N2	(R)	12.905	0.024	149
MU2		12.872	0.029	149
N2	(R)	12.658	0.060	145
NU2	(R)	12.626	0.011	145
M2		12.421	0.311	143
L2	(R)	12.192	0.009	141
T2	(R)	12.016	0.007	173
S2		12.000	0.126	173
K2	(R)	11.967	0.034	172
M3		8.280	0.002	066
M4		6.210	0.002	258
MS4		6.103	0.001	254
S4		6.000	0.003	283
M6		4.140	0.001	295
2MS6		4.092	0.002	053
2SM6		4.046	0.002	038
M8		3.105	0.002	100

(R) denotes related constituent.

Fugro GEOS Ltd., Hargreaves Road, Swindon, U.K.

8.7 Geotechnical Surveys

8.7.1 General

Geotechnical information for existing port facilities were obtained from previous boring program, namely, Yahya Costain Report in 1996 and Fugro International Report in 1993. These soil profiles for existing port clearly show the three layers, namely, sand and gravel, gravel and cobble and weak to medium rock from upper to lower layer .

8.7.2 Field Work

A program of marine investigation, performed at the site under second site survey period by the Study Team, included the following :

- Exploratory boreholes
- Continuous coring in rock .
- Regular split-spoon sampling during Standard Penetration Tests(SPTs)in soils and poor recovery rock zones .

A total of 10 points offshore boring field work was carried out using top drive rotary rig, Diamec 260, from Fugros modular, 4－legged jackup platform, 「Hercules」, which has a deck area of 9m×15m, and leg lengths extendable to a maximum of about 25m beneath deck level .
Drilling operations were generally performed on a 12hour／single shift basis, subject to weather conditions .

The field work was performed by experienced geotechnical personnel under the full time supervision of a suitably experienced marine operations supervisor .
The works were performed in general accordance with the BS-5930, 「Code of practice for site investigations」.

Borehole locations are indicated on Fig.8.7.1 relative to the proposed site layout and existing features . Field test results and observations are presented in Fig.8.7.3～8.7.7.

8.7.3 Exploratory Boreholes

A total of ten(10)boreholes were drilled to depths ranging from 6 .0 to 18 .5m beneath seabed level using rotary drilling rig .
Rotary coring techniques were used in underlying rock formations using double tube rotary core barrel, producing a nominal core diameter of 76mm.

8.7.4 Surveying of Borehole Locations

The ten(10)borehole locations were set out using Fugro Global DGPS System 「Seastar」. Borehole coordinates and levels are summarised on Table 8.7.1 below .

Table 8 .7 .1 Coordinates and Elevations of Borehole Locations

Borehole Location	Coordinates Easting(m)	Coordinates Northing(m)	Seabed Elevation(mCD)
MBH 1	182 380	1875 825	−16 .15
MBH 2	182 666	1875 673	−17 .80
MBH 3	181 801	1876 296	−9 .70
MBH 4	182 313	1876 535	−13 .10
MBH 5	182 811	1876 513	−15 .00
MBH 6	181 539	1876 950	−7 .60
MBH 7	181 634	1877 522	−7 .00
MBH 8	182 398	1877 417	−10 .85
MBH 9	181 355	1877 265	−5 .60
MBH 10	181 920	1878 105	−6 .40

8.7.5 Laboratory Testing

The laboratory testing was performed on selected samples of soil and rock obtained during the field work . Test results have been used to assist with classifications, and determinations of relevant physical properties of the samples .The following laboratory testing has been performed in accordance with International Standard procedures .

(1) Atterberg Limits
(2) Particle Size Distribution
(3) Particle Density
(4) Unconfined Compressive Strength
(5) Point Load Tests
(6) Carbonate Content

8.7.6 Subsurface Conditions

The subsurface profiles encountered are illustrated diagrammatic with graphic log presentations in Fig.8.7.3.～8.7.4.
The borehole logs reveal varying near-surface conditions, across the site, which can be generally categorised into following three zones .

(1) On the southern side of the port channel, in the deepest section of the site, boreholes

MBH 1 and MBH 2 reveals coarse, alluvial, wadi gravel deposits from seabed to the depths investigated(−25m).

The gravel particles are predominantly coarse(to cobble and boulder size)、well rounded, and strong to very strong. The fringes of these deposits appear to extend to the northern side of the channel, where similar seabed deposits(generally less than 2m)have been noted at other borehole locations.

(2) At borehole locations MBH 3 to MBH 5, in water depths of about 10 to 15m, on the northern side of the channel, predominantly weak to moderately weak carbonate sandstone(calcarenite)was encountered beneath relatively thin wadi gravel deposits and seabed sediments. The calcarenite layer generally extends from about −16m to the depth of investigation (−25m). Locally, it is thinly interbedded with calcisiltite and chalky limestone. At MBH 3, the layer is separated from the near-surface alluvial deposits by a 4m thick layer of hard, cemented clayey silt.

(3) Further to the northwest, in the vicinity of boreholes MBH 6 to MBH10, where seabed elevations range from about −5 to −11m, a chalky limestone formation was encountered from near-seabed to the depth of investigation(-25m). At MBH 6, the limestone was observed to overly calcarenite at –22 .6m. The strength of the limestone appears to decrease generally with elevation, from moderately strong to weak, as indicated on Fig.8.7.3. The formation is locally interbedded with thin calcisitite, and appears to be locally dolomitised.

Plots of intact rock strength, interpreted from unconfined compression test and point load test results, are shown on Fig.8.7.5.～7., for the above three zone.

With respect to the area south of the port channel, it should be noted that the plotted results relate to gravel／cobble／boulder particle strength rather than rock strength. The rock quality, as a measure of the rock mass fracture condition, appears to vary considerably between borehole locations. The general fracture condition varies from closely fractured and broken, with a typical Rock Quality Designation(RQD)of 0 to 30%、to medium and widely fractured, with RQD typically ≧50%.