TIDE GAUGE NETWORK ON THE RED SEA

IOC/GLOSS/PERSGA/ISESCO TECHNICAL MISSION TO RED SEA

TIDE GAUGE OPERATING AGENCIES

9-20 DECEMBER 2004

Chérif SAMMARI

Institut National des Sciences et Technologies de la Mer

2025 Salammbô, Tunisia

E-mail : cherif.sammari@instm.rnrt.tn

ANNEX II: AVAILABLE DATA ON PAPER AND IN GRAPHIC FORM AT PORT SUDAN

I. INTRODUCTION

The technical visit was carried out on behalf of the Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) and the Intergovernmental Oceanographic Commission (IOC) Global Sea Level Observing System Programme (GLOSS).

The objective of the technical visit was to: (i) take stock of the sea level observation networks in the Saudi Arabia, Djibouti, Yemen, Sudan and Egypt; (ii) discuss its operating procedures and future development; (iii) to assess data use and historical data holdings; and (iv) assess possible regional areas of intervention and support from PERSGA and the IOC/GLOSS programme. This technical visit took place from 9 to 20 December 2004 in conformity with following programme:

PROGRAMME

Thursday 9 December:	Arrival in Jeddah, visiting PERSGA data base & GIS system
Saturday 11 December:	Meeting tide gauge staff & visiting tide gauge station.
Sunday 12 December:	Travel to Djibouti via Sana'a; meetings & visit the TG station in Djibouti.
Monday 13 December:	Travel to Sana'a from Djibouti.
Tuesday 14 December:	Travel to Hodeidah & visit the TG station & meet with the staff.
Tuesday 14 December:	Travel to Aden from Hodeidah by road.
Wednesday 15 December:	Visit the tide gauge station and meet with the staff.
Wednesday 15 December:	Travel from Aden to Sana'a.
Thursday 16 December:	Travel from Sana'a to Khartoum.
Friday 17 December:	Travel to Port Sudan, meet the TG staff & visit the station
Saturday 18 December:	Travel to Khartoum.
Sunday 19 December:	Travel to Cairo & by road to Suez, visit the TG station and meet

	with people.
Sunday 19 December:	Travel back to Cairo.
Monday 20 December:	Travel back to Tunis

II. PERSGA (source: http://www.jreds.org/persga.htm; see also www.persga.org)

The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) is an intergovernmental organization dedicated to the conservation of the coastal and marine environments in the region. Its legal basis stems from the regional convention for the conservation of the Red Sea and Gulf of Aden environment known as the Jeddah convention and signed in 1982. The PERSGA member countries include Djibouti, Egypt, Jordan, Sudan, and Yemen, Saudi Arabia, Somalia and Palestine: the headquarters are based in Jeddah, Saudi Arabia.

PERSGA is currently executing the strategic action programme (SAP) for the Red Sea and Gulf of Aden. This project is funded by the World Bank, United Nations Development Program (UNDP), the United Nation Environment Programme (UNEP), the Islamic Development Bank (IDB) and other donor organizations. The SAP was prepared following an extensive analysis of regional environmental issues and has been endorsed by the PERSGA council of minister. The SAP provides a cooperatively developed framework for the long-item conservation and management of the coastal and marine resources of the region. A programme of activities is being carried out through seven complementary components: institutional strengthening, reduction of navigation risks and marine pollution, sustainable use of living marine resources, conservation of habitats and biodiversity, the establishment of a network of marine protect areas, support for integrated coastal zone management, and the enhancement of public awareness and participation.

III. THE RED SEA

The Red Sea extends from the Bab el Mandeb (Gulf of Aden) and divides in the North to form the Gulf of Suez and Aqaba (see Map 1). It is an important link between the

Mediterranean Sea, via the Suez Canal, and the Indian Ocean. Eritrea, Sudan, Egypt, Jordan, Israel, Saudi Arabia, Yemen and Djibouti bound the Red Sea.

The Red Sea has a length of approximately 2300 km and a maximum width of 350 km. It reaches depths of 3000 m in the central trough but along the coasts it is relatively shallow (100-500m deep). The climate is equatorial, 35-41°C in average. Water temperature is 18-21°C in winter and 21-26°C in summer. The Red Sea has relatively little water exchange with the Mediterranean Sea and the Indian Ocean, and is regarded as an enclosed sea. As a consequence, the salinity is higher (40-41%) than in the open ocean. The central Red Sea is almost tideless. In other areas the tides are small, rarely exceeding 1 m.

Map 1. The Red Sea and locations of tide gauges (●). Some of them are not operational.

IV. INSPECTED SITES

IV.1. Saudi Arabia

In Saudi Arabia, ARAMCO Petroleum Company has been operating five (5) tide gauges in the Red Sea and twelve (12) in the Arabic Gulf since 1998 (the exact date is unknown). These British brand tide gauges (Sonar Research Ltd) are placed in Jeddah, Rabigh, Yanbua, Jizan and Duba (See figure 1).

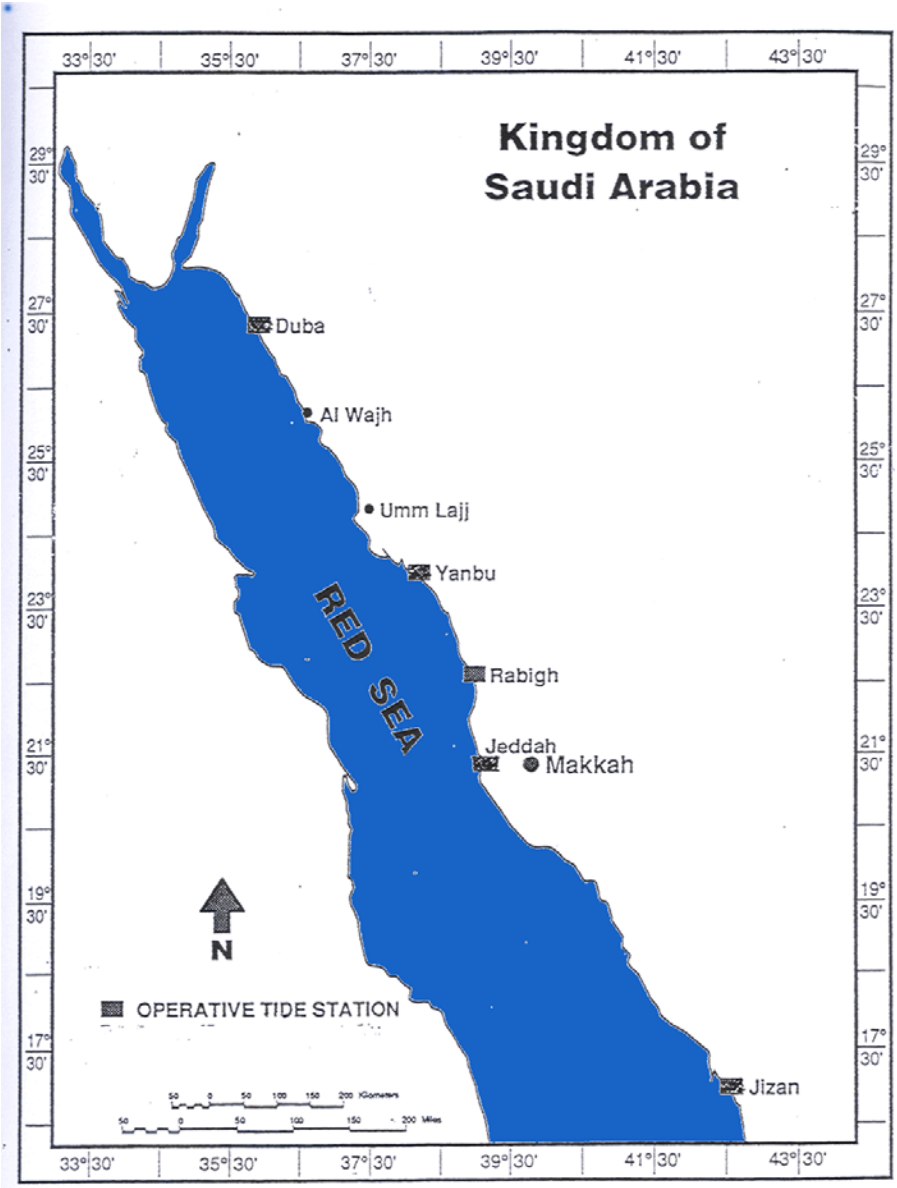

Fig. 1 SAUDI ARAMCO TIDE STATION LOCATIONS

Figure 1.

We visited the one in Jeddah (see figure 2) and had the occasion to discuss with the team in charge of the programme follow up. These discussions brought up the following facts:

Figure 2: Example of a tide gauge deployed by ARAMCO in the Red Sea. Here it is the Jeddah station.

- Data are transmitted in real time to the concerned authority (located in Ras Tannura) where they are archived and processed by established procedures,
- Tides and forecasts tables are published. Yet their dissemination seems to be limited and is received upon a prior application. Figure 3 represents the cover page of the 2004 report,
- Saudi universities may access to these data upon request.

We also met with the Department of Meteorology and Environment Protection (MEPA). The tidal officers informed us that four tide gauges (Sutron 9000 with Aquatrak acoustic sensors and telephone modems for data retrieval) had been deployed during the period from 1992-1993 along the Red Sea at Haql, Al Wedj, Jeddah and Gizzan and that data collected by D. Dixon had been transmitted to the PSMSL (LIVERPOOL).

As of April 2000 the tide gauges at Gizzan Sea Port and Haql Coastguard station were still in operation but had non-operational telephone lines for data retrieval. The gauge at Jeddah had been removed due to construction at the Coastguard station. The gauge at Al Wedj Coastguard harbour was damaged and needed attention.

Data collection at the MEPA/PME Gizzan tide gauge has proved most successful with an uninterrupted span of 1992-4 as analysed by staff at King Abdulaziz University, Jeddah, (Abdelrahman,S.M., 1997).

Geodetic heighting by DGPS of the tide gauge/bench marks is highly recommended to provide an absolute height for each gauge on a common geodetic datum. A maintenance program should be a priority as the gauges are of the highest quality and still represent one of the best systems available today.

Apart from ARAMCO, there is no policy for archiving sea level measurements and that the number of competent persons (researchers, engineers, technicians, etc.) who are adequately trained is very limited. We did not have the impression that the King Abdulaziz University is deeply involved in this process. A comprehensive program should be adopted to remedy such gaps (see Chapter V).

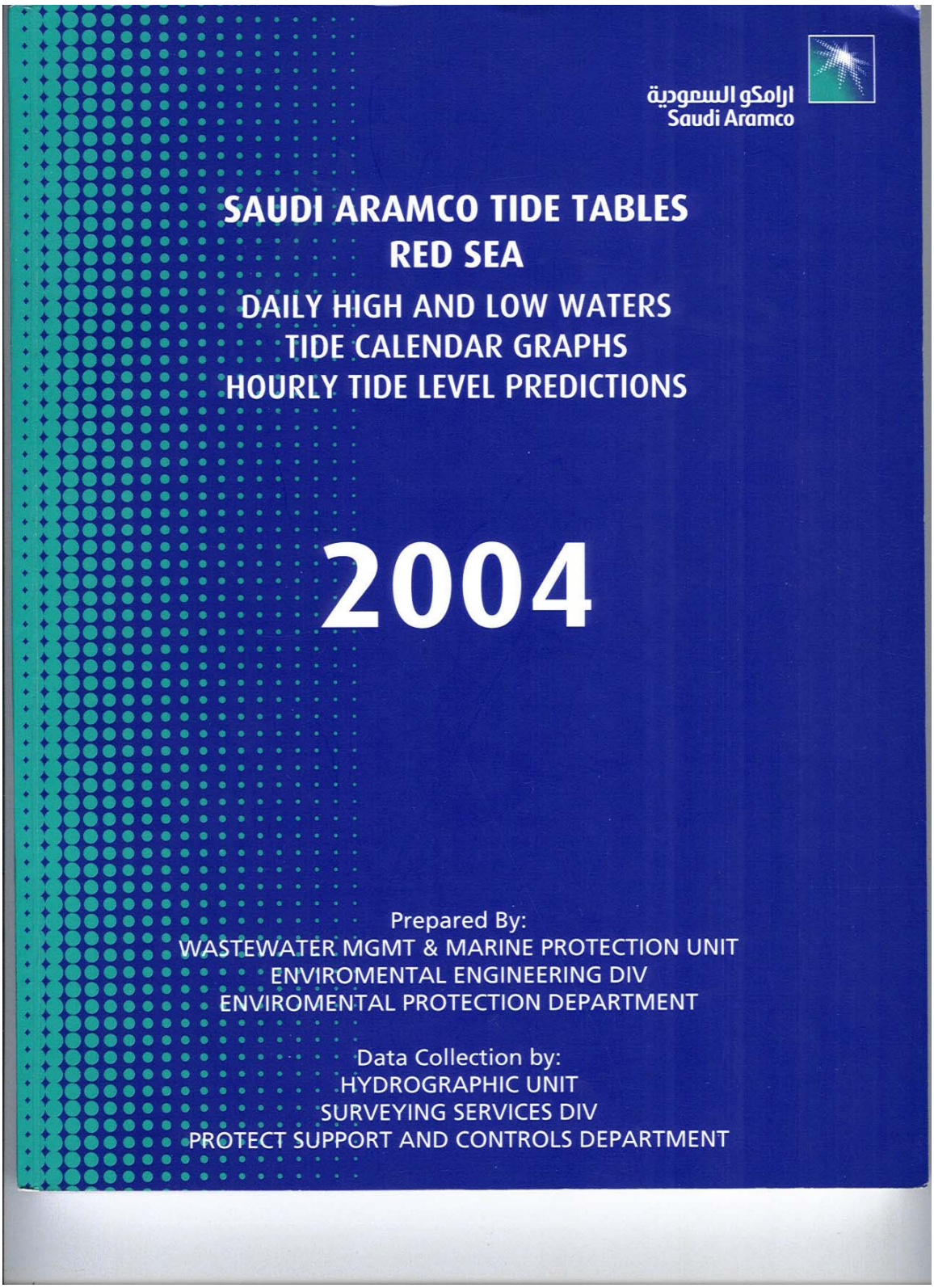
ارامكو السعودية
Saudi Aramco
SAUDI ARAMCO TIDE TABLES
RED SEA
DAILY HIGH AND LOW WATERS
TIDE CALENDAR GRAPHS
HOURLY TIDE LEVEL PREDICTIONS
2004
Prepared By:
WASTEWATER MGMT & MARINE PROTECTION UNIT
ENVIROMENTAL ENGINEERING DIV
ENVIROMENTAL PROTECTION DEPARTMENT
Data Collection by:
HYDROGRAPHIC UNIT
SURVEYING SERVICES DIV
PROTECT SUPPORT AND CONTROLS DEPARTMENT

Figure 3.

IV.2. Djibouti

Only one tide gauge is deployed in the Djibouti harbour (43° 08’ 28’’ N; 11° 36’ 48’’). It is an OTT R 20 float gauge (see figure 4).

Figure 4.

In Djibouti where the tide is at a diurnal character, this tide gauge was installed by the Institute for Earth’s Physics (IPG) in the University of Paris VII (FRANCE). It has been functional since 1995. Data are retrieved every two weeks in graphic form (See figure 4), and are digitised by the ARTA observatory team (a department coming under IPG). A copy is transmitted to the Djibouti Centre for Studies and Researches (CERD) and another copy to the IPG.

Maintenance and calibration operations are regularly carried out by the ARTA observatory team. Nonetheless, the harbor’s hydrographer (Aden Awaleh Meraneh) who met with us was unable to tell us more about the tide gauge. Tide predictions for Djibouti (see figure 5) are published by the SHOM which appear to have access to the data *via* the IPG.

2004

DJIBOUTI

Heures UT + 3h — HEURES ET HAUTEURS DES PLEINES ET BASSES MERS — Lat. 11° 35' N Long. 43° 09' E

JUILLET 2004

	Heures h min	Haut. m		Heures h min	Haut. m
1	0 50	0,4	**16**	1 34	0,8
	8 04	2,4		8 43	2,2
J	12 32	1,9s	V	13 19	1,9
	18 10	2,8s		18 28	2,5
2	1 40	0,3	**17**	2 06	0,7s
	8 52	2,4s		9 09	2,2s
V	13 43	1,9	S	13 58	1,8s
PL	19 05	2,8s	*NL*	19 06	2,5s
3	2 31	0,2s	**18**	2 37	0,7s
	9 39	2,5		9 35	2,3
S	14 46	1,8s	D	14 37	1,8
	20 00	2,8s		19 44	2,5s
4	3 21	0,3	**19**	3 08	0,7s
	10 24	2,5s		10 02	2,3s
D	15 45	1,8	L	15 18	1,7s
	20 53	2,7s		20 23	2,5
5	4 08	0,4s	**20**	3 39	0,8
	11 06	2,6		10 29	2,4
L	16 43	1,7	Ma	16 02	1,7
	21 47	2,5s		21 04	2,4s
6	4 53	0,6s	**21**	4 07	0,9
	11 46	2,6		10 57	2,4s
Ma	17 43	1,6s	Me	16 48	1,6s
	22 42	2,3s		21 46	2,3s
7	5 34	0,9s	**22**	4 34	1,0
	12 24	2,6		11 24	2,5
Me	18 47	1,6	J	17 37	1,5s
	23 46	2,1		22 35	2,1s
8	6 12	1,2	**23**	4 59	1,1s
	13 03	2,6		11 52	2,5s
J	19 55	1,5	V	18 31	1,4s
				23 38	2,0
9	1 11	1,9	**24**	5 24	1,3s
	6 46	1,4s		12 23	2,6
V	13 41	2,5s	S	19 30	1,3
DQ	21 08	1,4			
10	2 57	1,8	**25**	1 12	1,8s
	7 18	1,7		5 53	1,5s
S	14 20	2,4s	D	13 01	2,6
	22 18	1,3	*PO*	20 35	1,1s
11	7 01	1,8s	**26**	3 33	1,8
	8 02	1,8s		6 31	1,7s
D	15 01	2,4	L	13 49	2,6
	23 13	1,1s		21 41	0,9s
12	7 35	2,0	**27**	5 30	1,9s
	9 17	1,9s		8 11	1,9
L	15 45	2,3s	Ma	14 50	2,6
	23 52	1,0s		22 47	0,7s
13	7 48	2,0s	**28**	6 40	2,1
	10 30	2,0		9 59	2,0
Ma	16 30	2,3s	Me	16 02	2,6
				23 48	0,6
14	0 26	0,9s	**29**	7 24	2,2s
	8 00	2,1		11 25	1,9s
Me	11 38	2,0	J	17 12	2,7
	17 12	2,4			
15	1 01	0,8s	**30**	0 45	0,4s
	8 19	2,2		8 03	2,3s
J	12 34	1,9s	V	12 44	1,9
	17 51	2,4s		18 13	2,7s
			31	1 35	0,3s
				8 40	2,4s
			S	13 47	1,7s
			PL	19 09	2,8

AOÛT 2004

	Heures h min	Haut. m		Heures h min	Haut. m
1	2 21	0,3s	**16**	2 16	0,7s
	9 16	2,5s		8 58	2,4
D	14 42	1,6s	L	14 25	1,6s
	20 01	2,7s	*NL*	19 43	2,5
2	3 05	0,4s	**17**	2 42	0,8
	9 51	2,6		9 19	2,4s
L	15 34	1,5s	Ma	15 02	1,5
	20 51	2,6s		20 23	2,5
3	3 45	0,6	**18**	3 09	0,8s
	10 24	2,6s		9 41	2,5s
Ma	16 25	1,4s	Me	15 41	1,4
	21 42	2,5		21 06	2,4
4	4 22	0,8s	**19**	3 34	1,0
	10 55	2,6s		10 03	2,6
Me	17 15	1,4	J	16 22	1,3
	22 36	2,3		21 53	2,3
5	4 55	1,1	**20**	3 57	1,1s
	11 26	2,6		10 27	2,6s
J	18 07	1,3s	V	17 06	1,2
	23 35	2,1		22 47	2,1s
6	5 21	1,3s	**21**	4 17	1,3s
	11 56	2,5s		10 53	2,6s
V	19 00	1,3	S	17 54	1,1
				23 51	2,0
7	0 47	1,9	**22**	4 36	1,5s
	5 26	1,6		11 23	2,6
S	12 26	2,4s	D	18 50	1,0s
	19 59	1,3			
8	2 14	1,8	**23**	1 23	1,8s
	4 30	1,7s		4 53	1,7
D	12 58	2,3	L	12 03	2,5s
DQ	21 06	1,2s	*PQ*	19 56	1,0
9	13 44	2,2s	**24**	13 02	2,4s
	22 25	1,2		21 13	0,9
L			Ma		
10	14 56	2,2	**25**	6 59	2,0s
	23 33	1,1		8 40	2,0s
Ma			Me	14 29	2,4
				22 35	0,8
11	7 46	2,0s	**26**	6 54	2,2
	10 22	2,0		10 28	2,0
Me	16 06	2,2	J	16 08	2,4s
				23 44	0,6s
12	0 16	1,0	**27**	7 15	2,3
	7 50	2,1		12 01	1,8s
J	11 53	1,9s	V	17 22	2,5s
	17 03	2,2s			
13	0 51	0,9	**28**	0 38	0,5s
	8 02	2,1s		7 41	2,4s
V	12 42	1,8s	S	12 58	1,7
	17 49	2,3s		18 19	2,6s
14	1 21	0,8	**29**	1 21	0,5
	8 19	2,2s		8 09	2,5s
S	13 18	1,8	D	13 45	1,5s
	18 28	2,4s		19 11	2,7
15	1 49	0,7s	**30**	2 01	0,5s
	8 38	2,3		8 37	2,6s
D	13 51	1,7	L	14 30	1,4
	19 05	2,5	*PL*	20 00	2,6s
			31	2 38	0,7
				9 04	2,7
			Ma	15 13	1,2s
				20 48	2,5s

SEPTEMBRE 2004

	Heures h min	Haut. m		Heures h min	Haut. m
1	3 12	0,9	**16**	2 32	1,1
	9 30	2,7		8 43	2,6s
Me	15 54	1,1s	J	15 12	1,0
	21 37	2,4		21 12	2,4
2	3 43	1,1s	**17**	2 59	1,2s
	9 56	2,6s		9 06	2,7
J	16 35	1,1	V	15 51	0,8s
	22 27	2,2s		22 03	2,3
3	4 09	1,3s	**18**	3 24	1,4s
	10 19	2,5s		9 31	2,7
V	17 15	1,1	S	16 32	0,8
	23 19	2,1		22 58	2,2
4	4 24	1,5s	**19**	3 46	1,6
	10 40	2,4s		9 59	2,6s
S	17 57	1,1s	D	17 20	0,8
5	0 19	1,9s	**20**	0 02	2,0s
	4 11	1,7		4 05	1,7s
D	10 52	2,3s	L	10 33	2,5s
	18 48	1,2		18 17	0,8s
6	1 30	1,8s	**21**	1 39	1,9s
	3 40	1,8		4 16	1,9
L	10 56	2,2s	Ma	11 19	2,4s
DQ	19 55	1,2s	*PO*	19 29	0,9s
7	11 06	2,1s	**22**	6 09	2,0s
	21 24	1,2s		7 28	2,0s
Ma			Me	12 38	2,3
				20 53	0,9s
8	7 38	2,0	**23**	6 01	2,1s
	8 13	2,0		9 28	2,0
Me	11 25	2,0s	J	14 36	2,2s
	22 56	1,2		22 22	0,9
9	7 07	2,0s	**24**	6 16	2,3
	11 44	1,9s		11 29	1,8s
J	15 42	2,0s	V	16 26	2,3
	23 48	1,1		23 28	0,8s
10	7 11	2,1s	**25**	6 37	2,4
	12 12	1,8s		12 17	1,6s
V	16 56	2,1s	S	17 33	2,4
11	0 23	1,0	**26**	0 15	0,8
	7 21	2,2s		7 00	2,5s
S	12 39	1,7s	D	12 56	1,4s
	17 46	2,3		18 26	2,5
12	0 51	0,9	**27**	0 54	0,8s
	7 35	2,3		7 23	2,6s
D	13 07	1,6	L	13 33	1,2s
	18 26	2,4		19 14	2,5
13	1 16	0,9	**28**	1 29	0,9s
	7 50	2,4		7 46	2,7
L	13 34	1,4s	Ma	14 08	1,0s
	19 04	2,4s	*PL*	20 01	2,5
14	1 41	0,9	**29**	2 02	1,1
	8 06	2,5		8 08	2,7
Ma	14 04	1,3	Me	14 42	0,9s
NL	19 43	2,4s		20 46	2,4s
15	2 06	1,0	**30**	2 33	1,3
	8 23	2,6		8 29	2,6s
Me	14 36	1,1s	J	15 15	0,9
	20 26	2,4s		21 30	2,3s

Figure 5.

IV.3. Yemen

IV.3.1 Hodeïda

In Hodeïda, we visited a SLM-2B tide gauge (see figure 6) which was deployed in 2001 but only operated properly for one year. The malfunctioning was due to electric problems and no maintenance and/or repairing was carried out because of an obvious lack of trained technicians.

Data are available on paper at the Hydrographic Department in the Harbour Authority which does not use it at all.

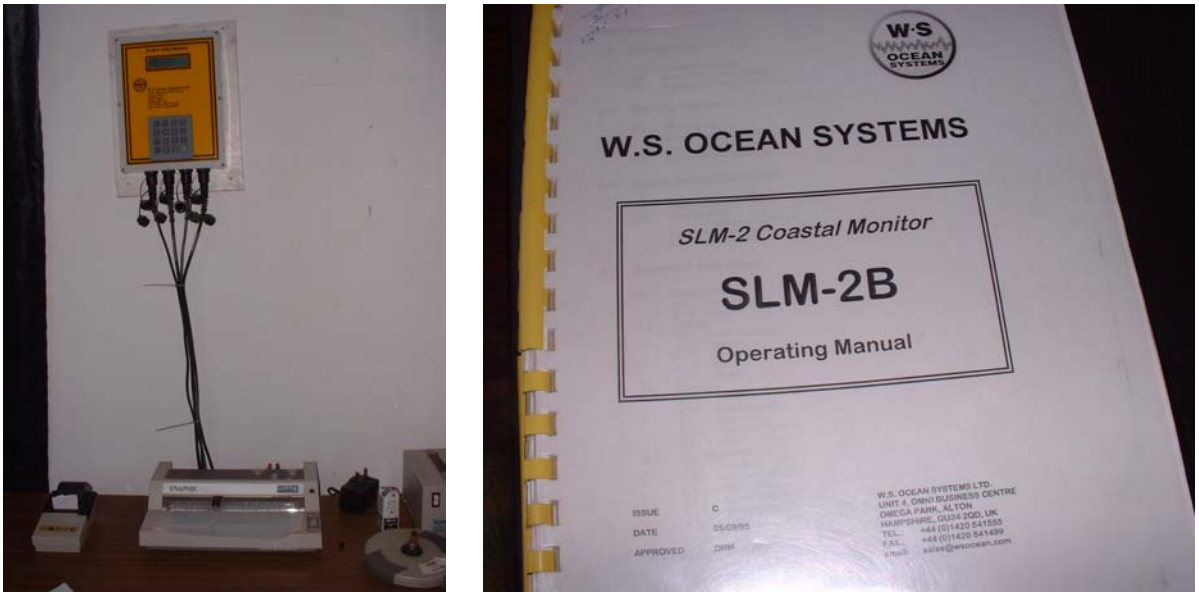

Figure 6.

The tide gauge deployed within the Hodeïda harbour is under the responsibility of the General Department of Maritime Affairs reporting to the General Authority of Maritime Affairs. This Authority does not have close ties with the Department of the Environment Protection which is the focal point of PERSGA in Yemen.

IV.3.2 Aden

The same type of tide gauge as the one deployed in Hodeïda is operating without any major problems since 2001 (figure 7). Yet, no calibration operation was carried out and no data retrieval or processing or archiving system is in use. Data are available on paper but no graphical is available because of a printer breakdown. The harbour technician just moves the paper.

Figure 7.

Within Aden Harbour, a level gauge was deployed in 1969 by the UK (figure 8). This instrument had, reportedly, operated well up till 1994. (Note from Dr Philip Woodworth, Director of PSMSL: The PSMSL has data for Aden from 1879 to 1969. In the early days the Aden gauge was operated by the Survey of India. But when the British left in 1969 we stopped getting data. There have been some communications in recent years e.g. with Captain Roy Facey who is harbour master but no data appear to have been sent from Aden since 1969).

Figure 8. Tide gauge hut in Aden Harbour where a tide gauge appear to have been installed in 1969.

Data, or a part of it, were transmitted to PSMSL. Nonetheless, the persons we were talking to were unable to give us a copy of these documents and promised to look for a copy and inform us as soon as they get hold of it. In this context, the GLOSS program and the IOC may be able to assist with the retrieval and digitisation of this information.

During our meetings in Aden, we inquired about tide gauges installed at Socotra Island but no gauge is presently installed. We were informed that the General Department of Civil Aviation and Meteorology in beginning of December 2004 installed a tide gauge at the entrance of Aden Harbour. This new generation tide gauge is equipped with other sensors and data are transmitted in real-time through VHF to a processing unit located near the Aden International airport.

IV.4. Sudan

In the harbour of Sudan, we visited the Institute of Marine Research which since 1998 has been responsible for a tide gauge provided by PERSGA. This SML-2B tide gauge (see figure 9) was installed by a British expert but was never functional despite a second visit in 2000 (funded by PERSGA). It appears that a manufacturing fault is at the origin of this breakdown.

Figure 9.

In the harbour of Sudan, we also inspected a second float tide gauge (see figure 10) which was deployed in 1961 by the “Survey Department”.

Figure 10.

There were no available data on its calibration but it seems that the instrument operated in a correct way up till 1997. We tried to trace back its data and obtained the following information:

- From 1961 to 1985 data were transmitted to the PSMSL,
- From 1986 to 1994 data are available in a graphic form (see figure 11) and a copy was perhaps transmitted to the PSMSL,
- From 1994 to 1997, data are available on paper and even in poor quality graphics but yet retrievable (figure 12).

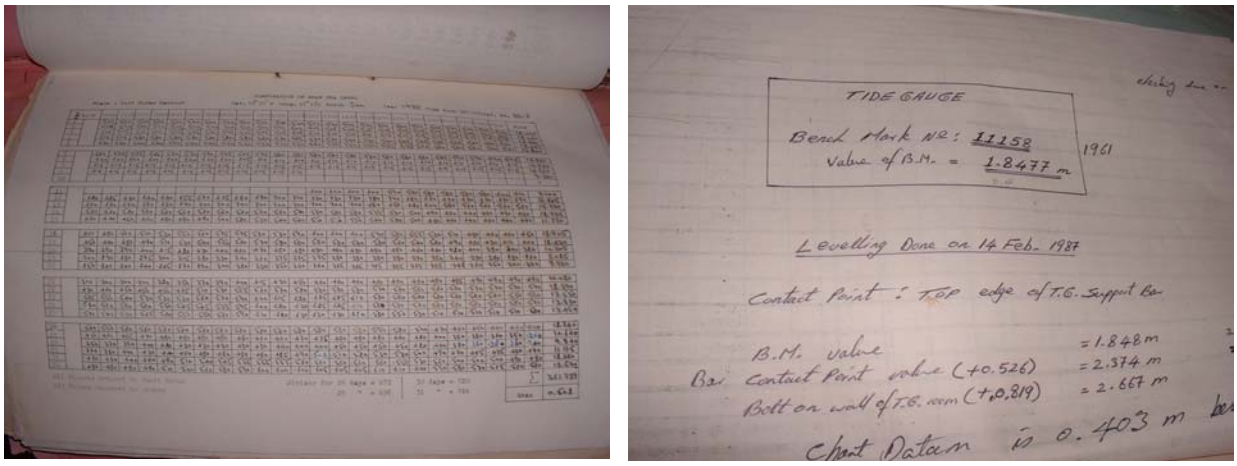

Figure 11.

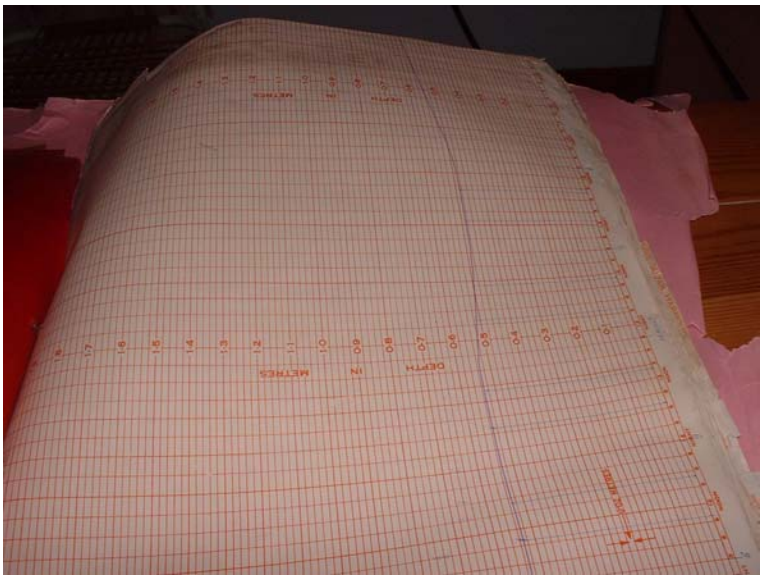

Figure 12.

We asked for and obtained a detailed list all available data on paper and in graphic form (see Annexe II). We did suggest that a request be filed to the GLOSS programme to ask for assistance in retrieving and digitising these data.

In Sudan, Yemen and Djibouti, training is still the only way to master this topic.

IV.5. Egypt

In Egypt, my visit was arranged by the Coastal and Marine Zone Management Authority which is the PERSGA focal point in Egypt. After much research, it turned out that the Suez Canal Authority (SCA) is the only body deploying tide gauges along the canal. I travelled to Suez to meet with the experts responsible for the use of water level data. These interviews brought out the following:

- The SCA has established 8 tide gauges which are located along the canal. Figure 13 shows one type of deployed tide gauge,

- This equipment has been functioning since 1980 and is correctly used by a competent technical team in charge of digitizing, using (tide forecasts and publishing tide tables) and archiving data.
- Concerning, archiving, only data relating to the last five years are available in a computerized form. Other data relating to other periods are available only in graphics (see figure 13)
- A new instrument (WTR9/Aanderaa) was recently acquired and is now being tested in order to possible replace all old instruments
- There is no partnership with collaboration with research institutes and/or universities such as the Suez University.

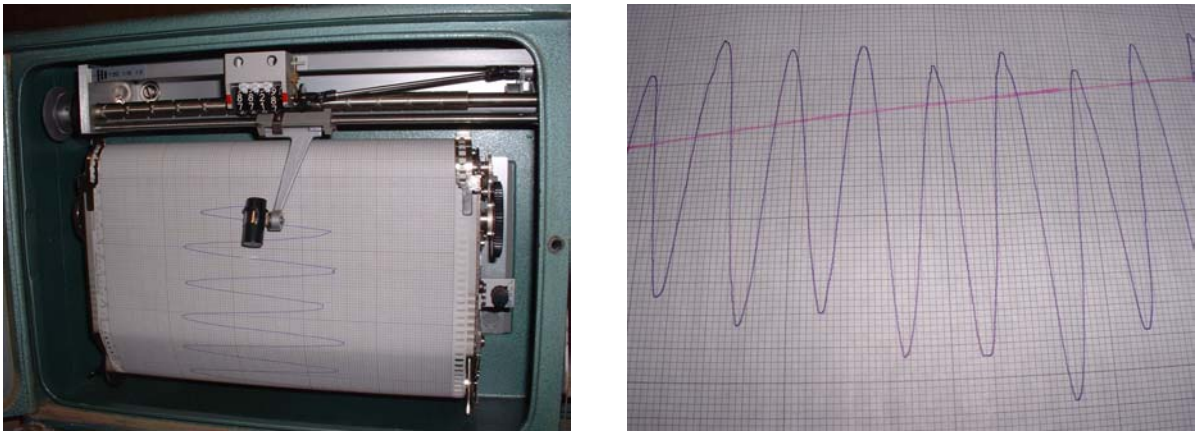

Figure 13.

During the meeting with the PERSGA focal point in Egypt, I learned that the National Water Research Centre is deploying tide gauges in the Mediterranean Sea and that the Red Sea Port Authority is probably deploying one tide gauge near Hurgada city (Red Sea).

V. SUMMARY OF SITE VISITS

V.1. Human Resources

In Saudi Arabia and Egypt, tide gauges are deployed and correctly used by highly qualified individuals. In both countries, tide gauges come under the responsibility of two big companies (ARAMCO and the Suez Canal Authority). Data is exclusively used for

safe navigation. In other countries the lack of qualified human resources is obvious. Even tide gauges deployed within the framework of regional and/or international projects are not correctly used.

Training is therefore a high priority. It has to cover all levels, from technicians to engineers and researchers.

V.2. Maintenance and Calibration

Data registered by a tide gauge (whatever the type is) are reliable only if calibration and levelling operations are correctly and regularly carried out. Moreover, each tide gauge shall be linked to the benchmark located close to it. These levelling procedures are observed in Egypt and in Saudi Arabia but are not respected at other visited sites. As an example, I witnessed a calibration operation carried at the Jeddah harbour sea level gauges out by an ARAMCO technician who rigorously followed well-established standard procedures.

V.3. Available Data and Data Base

In Saudi Arabia, (digital) data are correctly used and carefully archived by an ARAMCO department which is exclusively in charge of this task. In Egypt, data are available in graphic form dating back to 1982. The data relating to the last five years are available in digital form. It should be mentioned that the use of data in Egypt is limited to the calculation of the tide's fundamental parameters (***HH, MH, M, ML and L***).

In Sudan a new tide gauge was installed in 1998 but it never operated. A second one deployed in 1961 operated correctly up till 1997. Some data are available in the PSMSL and other data are available in a graphic form and may be digitized. Nevertheless, special attention should be paid to their reliability and strict quality control should be carried out. In this context, we noted down the details of the benchmark (see figure 11).

In Yemen, sea level measurements registered throughout one year are available in graphic form for Hodeïda. In Aden, we identified two sources of data. The first source is

paper copies of observations from a tide gauge deployed in 2001. Other data obtained from a limnograph set up in 1969 may be available. However, there are no signs of these data on site.

Finally, In Djibouti, data exist and are of a good quality but are accessible only from the IPG or SHOM (FRANCE).

In all these countries there is no database on sea level measurements. Moreover we did not notice any collaboration with universities and data does not appear to be used for research purposes.

V.4.Quality Control

Except for Saudi Arabia, all visited sites did not have quality control data and records.

V.5. Data Analysis

Only the time series registered at the 5 Saudi Arabian stations are correctly analyzed (harmonic analysis and tide forecasts, tide tables published and American experts are using it for research purposes). High quality publications are drafted on the basis of these data, yet their dissemination is still limited but accessible upon request by writing. In other countries, sea level measurements are either subjected to a limited analysis, such as Egypt or no analysis at all such as Sudan and Yemen and Djibouti to a lesser degree.

V.6 Data Centre and Data Exchange

There is no data exchange policy, neither at the national level nor at the regional or international level. As a rough guide, there is no operational oceanographic data centre and no links with other international centres. In some countries, the GLOSS programme is not known.

It is suggested that data be made more widely available to a regional centre. PERSGA has established a database system at its headquarters in Jeddah and this system could host a regional sea level databank for the Red Sea and Gulf of Aden Region. As such PERSGA could take on a coordinating role in establishing regional sea level network that could

develop into operational real-time information system that could be of use for safe navigation/marine service and for research.

VI. SUGGESTIONS FOR A REGIONAL SEA LEVEL OSERVING PROGRAMME

Considering the above mentioned facts, we suggest a strategy for an efficient, optimal and productive intervention of the GLOSS programme in this region. This strategy shall be based on following main items:

VI.1. Measurement Sites and Pilot Sites

Deploying a tide gauge depends on several criteria and may have various objectives and uses. In the Red Sea, no study was conducted to define the number of tide gauges required to carry out local and/or regional studies. Were all deployed tide gauges functional, it would have represented an invaluable database which could be of multiple use (i.e. tides, operational modelling, coastal engineering, research). Meanwhile, I think that the most urgent problem to be tackled concerns the lack of trained human resources.

Two pilot sites could be selected to host new generation tide gauges (i.e. complying with the GLOSS standards) under the direct supervision of the GLOSS programme and the IOC. These tide gauges could be used as “best practice sites” for the training of tide gauge operators and researchers.

VI.2 Training

Both mentioned tide gauges should be installed by international experts (selected by the IOC) with the participation of two representatives from each country of the Red Sea area (one technician and one engineer or researcher). Under the supervision of a renowned international expert, the representatives of each country would take part in all the process stages i.e. from the deploying of tide gauges, analysing and quality controlling the measurements, to predicting tides to data archiving. In this context, a regional centre under the responsibility of PERSGA should be set up and dedicated to water level data.

Regular training cycles (at least one cycle each six months) should be organized and based on the use of data, their quality control and archiving at the above mentioned regional centre according to international standards. After two years, country representatives are supposed to be able to carry on the programme by their own using their respective national resources.

VI.3 Using New Technologies

Technologies of water level observations are progressing rapidly. A strategy should be adopted to allow national experts from Red Sea countries to measure in near-real time and make data easier accessible at the regional and the global level. Adapting to new technologies also comes through the participation in seminars and workshops on sea level measurements and sea level science. We can mention here the annual sessions held by ESEAS and/or GLOSS which are an excellent opportunity to exchange information and knowledge. Moreover, it is imperative that measurements and tide gauge types be harmonized within the Red Sea region.

VI.4. Management and exchange of data

Knowing the changes in water level has admittedly local, regional and global use. Data management should be carried out in a harmonized way and mainly in compliance with an international protocol. The GLOSS programme has the required know-how and holds regular training workshops and seminars on the management and exchange of data. Special attention should be paid to the countries which still do not have sufficient information to participate in the international sea level community. We should mention here the need for harmonized tide analysis and forecasts software as well as other statistical tools in the Red Sea region.

VII. PERSPECTIVES

The forthcoming regional action based on the measuring of water level is as follows:

VII.1. Short-term action: To set up a consistent network for the observation of water level which will be maintained and calibrated by national experts.

To benefit from the international cooperation in order to train national experts and technicians and make them able to use correctly, for local purposes, the time series produced by this network.

VII.2. Medium-term action: To develop forecast hydrodynamic models and open up sea level observations from the region to scientific marine researches. Opening up to universities and marine research institutes is imperative as it guarantees a deeper exploitation of water level time series.

VII.3. Long Term Action: Be part of a global sea level community promoting the exchange of data, the contribution to international research programmes, and also the use in regional oceanography for a better understanding of variations of the sea level and its various socioeconomic impacts.

VIII. CONCLUSIONS

The Red Sea holds a strategic position overlooking the Indian Ocean and the Mediterranean Sea (via the Suez Canal) with a relatively easy access. Yet, regional actions have never been undertaken in this region to measure water levels against international standards. Scattered localized actions are carried out on and off but are not enough to tackle issues having direct and /or indirect links with the regional variation of water level. The IOC/GLOSS program can, thanks to its know-how and experience, contribute to the lessening of such gaps. The success of any planned action depends directly from the know-how acquired by nationals. In this connection, a plan should be drafted and implemented in order to make national experts able to undertake the important regional actions as suggested in this report.

THANKS

My sincere thanks and gratitude go to Professors Philip Woodworth and Geoff Brundurit and to Dr. Thorkild Aarup (IOC/GLOSS) who entrusted me with this technical mission. David Dixon provided useful comments about installed gauges in Saudi Arabia and Dr

Khalid M. Zubier provided some additional references for the bibliography. I would like also to thank Dr. Dirar Nasr (PERSGA) for his substantial contribution to the success of my mission. I also thank all the persons who accepted to meet with me and share their knowledge on the subject matter of my mission.

Bibliography

Abdelrahman, S.M., (1997): Seasonal fluctuations of mean sea level at Gizzan, Red Sea. Journal of Coastal Research. 13(4), 1166-1172.

Ahmad, F. and Sultan, S. A. S., 1993. "Tidal and Sea Level Changes at Jeddah, Red Sea". Pakistan Journal of Marine Science, 2 (2), 77-84.

Browell, A. (1987): Report on Tide Gauges Stations in Egypt and the Sudan. 1987. UNESCO Contract Obligation No. 240-609-7. 22 pp

Maghrabi, S. O., 2004. "Variations of Mean Sea Level in the Red Sea". M.Sc. Thesis, King Abdulaziz University.

Osman, M. M., 1984. "Varaition of Sea Level at Port Sudan". Int'l. Hydrographic Reviews, Monaxo LXI, 137-144.

Osman, M. M., 1984. "Seasonal and Secular Variations of Sea Level at Port Sudan". Journal of the Faculty of Marine Science, 4, 15-25.

PERSGA/ALECSO-IOC/GLOSS-GOOS Training Workshop on Sea -level Data Analysis for the Red Sea and Gulf of Aden Region. Jeddah, Kingdom of Saudi Arabia 15-19 April 2000. IOC Training Course Reports No. 57.

Rady, M. A., 1994. "Tide-Surge interaction in the Gulf of Suez,Egypt". Marine Geodesy, 17, 45-62.

Sultan, S. A. R., Ahmad, F. and El-Hassan, A., 1995a. "Seasonal Variations of the Sea Level in the Central Part of the Red Sea". Estuarine, Coastal and Shelf Science, 40, 1-8.

Sultan, S. A. R., Ahmad, F. and El-Ghribi, N. M., 1995b. "Sea Level Variability in the Central Red Sea". Oceanological Acta, 18 (6), 607-615.

Sultan, S. A. R., Ahmad, F. and Nassar, D., 1996. "Relative Contribution of External Sources of Mean Sea-Level Variations at Port Sudan, Red Sea". Estuarine, Coastal and Shelf Science, 42, 19-30.

Wyrtki, K. (1981): Plan for a network of sea level gauges for the Red Sea and Gulf of Aden. 1981. A study prepared by UNESCO, Divison of Marine Sciences. Submitted to the Red Sea and Gulf of Aden Environment Programme (PERSGA). 20pp

Information about the GLOSS programme and its training activities can be found at:
http://www.pol.ac.uk/psmsl/programmes/gloss.info.html
http://www.pol.ac.uk/psmsl/training/index.html

Information about Permanent Service for Mean Sea Level (PSMSL) can be found at:
http://www.pol.ac.uk/psmsl/

Information about the European Sea Level Service (ESEAS) can be found at:
http://www.eseas.org/

Other examples of regional sea level observing networks:

MedGLOSS (Mediterranean)	http://medgloss.ocean.org.il/
Baltic Operational Observing Systen	http://www.boos.org/

ANNEX I

CONTACT ADDRESSES

SAUDI ARABIA

- Dr Dirar Nasr

PCU Co-ordinator / PERSGA

Tel: 966 2 6573224 / Fax: 966 2 6521901

E-mail: dirar.nasr@persga.org

- Captain TURKI M. AL-SHIHRI

Pollution Control Foreman / Saudi Aramco

Tel: 966 2 4275669 / Fax: 966 2 427 5574

E-mail: turki.shihri@aramco.com

- SAMI A. SA'ATI

Saudi Aramco Affairs

Wp-Dept

Tel: 966 2 4271312 / Fax: 966 2 4276061

E-mail: sami.saati@aramco.com.sa

- EISAA AL. HIJJI

Technician

Tel: 219021 / 6732291 / Fax: 6733488

E-mail: ehijji@yahoo.com

YEMEN

- MAHMOUD M.SHIDIWAH

Chairman / Environment Protection Authority

Tel: 967 1 207816 / Fax: 967 1 207327

E-mail: epa-yemen@yemen.net.ye ; environment@yemen.net.ye

- ABDULLAH HAMOD A ABO AL-FUTOOH

National Expert I C Z M / Environment

Protection Authority

Tel/Fax: 967 1 470247

E-mail: alfotooh@yahoo.com ; alfotouh@hotmail.com

- MOH'D A.M BIN AIFAN

General Manager / Maritime Affairs Authority

Tel: 967 02 206243 / 967 73791684

E-mail: MAA.ADEN@y.net.ye

- FAYÇAL MOHAMED MOREE SALEM

Telecommunication Engineer / Maritime Affairs Authority

Tel: 967 02 206247 / Fax: 967 02 206245

E-mail: faisal_moree_1@yahoo.com

SUDAN

- Dr. MAHGOUB HASSAN

Director / Marine environment Protection Administration

Tel: 249311824754 / Fax: 249311831778

E-mail: mepasudan@yahoo.com / mahgoubhassan@hotmail.com

- Dr. MOHAMED E. HAMZA

Dean of the Faculty of Mar. Sci. & Fisheries

Tel: 249 311833551 / Fax: 249 311827778

E-mail: mohamedamin3@yahoo.ca

- Prof. ABDEL GADIR DAFALLA ELHAG

Director Institute of Marine Research / Red Sea University

Tel: 249 311822509 / Fax: 249 31127778

- BAHA AHMED ABD ALLA

Engineer, Red Sea State

Tel: 249 912913351 / Fax: 249 311824431

E-mail: bahmed4447@hotmail.com

DJIBOUTI

- NASSER DJAMA ABDI

Coordinateur National du PAS- Biologiste Marin

PERSGA

Tel / Fax: 253 250186

E-mail : nasserdjama@yahoo.fr

- ADEN AWALEH MERANEH

Officier de Port

Tel: 253 352331/ 253 819639

E-mail : Aden.Awalehm@port.dj

EGYPT

- MAGED H. ELARESI

Eng in Hydraulic section

Research Center

Suez Canal Authority

- Dr. EZZAT M.ELSADEK

Head of Research Center

Studies department

Suez Canal Authority

ANNEX II: AVAILABLE DATA ON PAPER AND IN GRAPHICS SUPPORTS AT PORT SUDAN

Type: Sea-level tide - gauges

C O: Latitude 19^{O} 37′ Longitude 37^{O} 13′

Bench Mark 1.848 M

Years	Months	Days	Hours (No. of days *24)
1986	*January*	27	648
	March	30	720
	April	30	720
	May	17	408
	June	14	336
	July	23	552
	August	28	672
	September	30	720
	October	31	744
	November	30	720
	December	31	744
1987	*January*	31	744
	February	28	672
	March	24	576
	April	29	696
	May	31	744
	June	30	720
	July	31	744
	August	27	648
	September	30	720
	October	31	744
	November	30	720
	December	31	744
1988	*January*	30	720
	February	29	696
	March	31	744
	April	30	720
	May	18	432

	June	27	648
	July	31	744
	August	31	744
	September	30	720
1988	*October*	30	720
	November	30	720
	December	31	744
1989	*January*	31	744
	February	26	624
	March	16	384
	April	13	312
	May	15	360
	June	29	696
	August	31	744
	September	30	720
	October	31	744
	November	30	720
	December	31	744
1990	*January*	31	744
	February	28	672
	March	31	744
	April	30	720
	May	31	744
	June	30	720
	July	31	744
	August	31	744
	September	30	720
	October	31	744
	November	30	720
	December	29	696
1991	*January*	31	744
	February	28	672
	March	31	744
	April	30	720
	May	31	744
	June	30	720
	July	27	648
	August	26	624
	September	30	720
	October	31	744
	November	30	720

	December	31	744
1992	*January*	31	744
	February	29	696
	March	31	744
	April	30	720
	May	31	744
	June	30	720
	July	31	744
	September	24	576
	October	31	744
	November	30	720
	December	31	744
1993	*January*	31	744
	February	28	672
	March	31	744
	April	30	720
	May	31	744
	June	30	720
	July	31	744
	August	31	744
	September	30	720
	October	31	744
	November	30	720
	December	31	744
1994	*January*	31	744
	February	28	672
	March	31	744
	April	30	720
	May	31	744
	June	30	720
	July	31	744
	August	31	744
	September	30	720
	October	31	744
	November	30	720
	December	31	744
1996	*January*	21	504
	February	21	504
1997	*April*	30	720
	May	31	744
	June	15	360