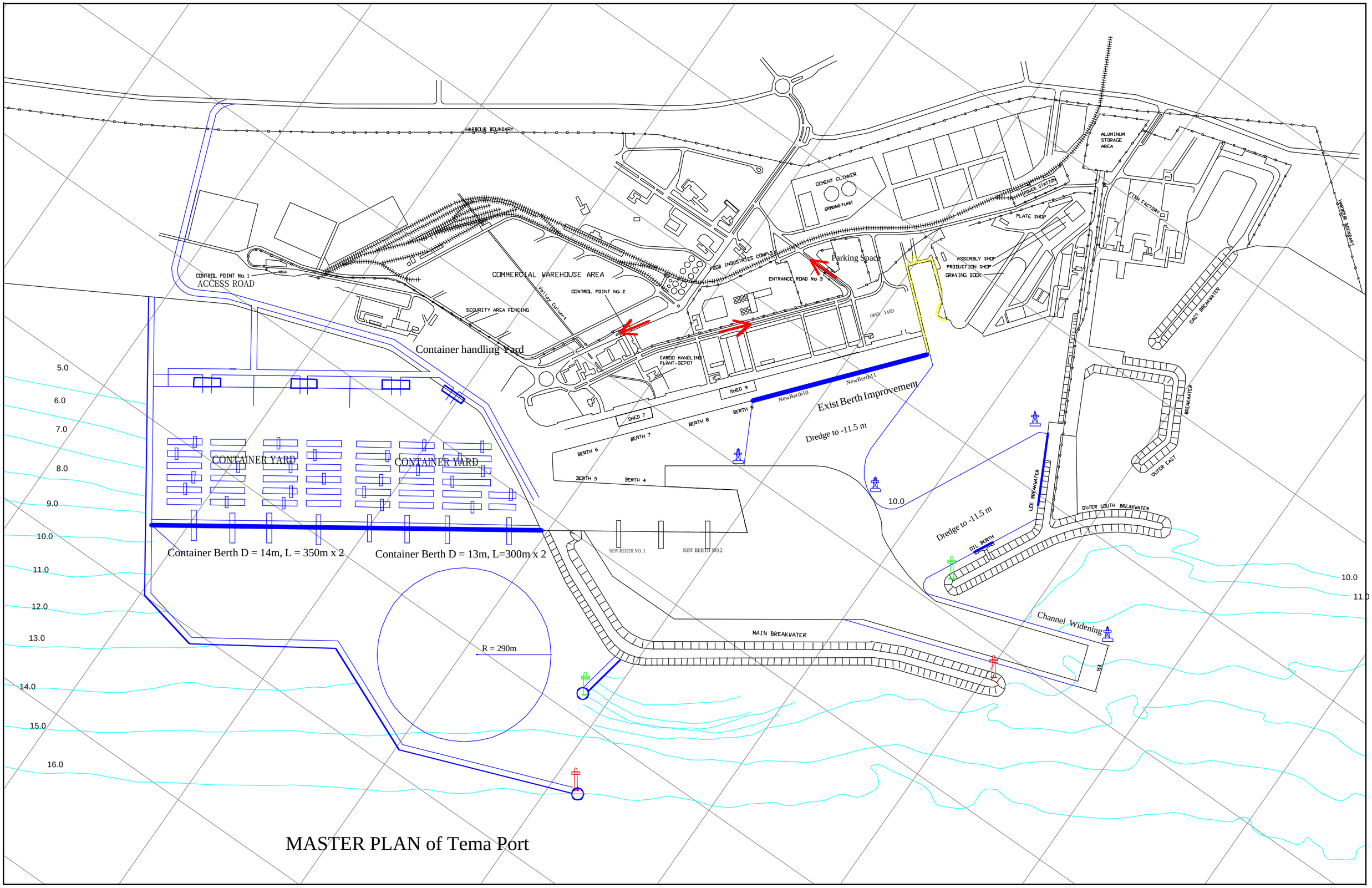
APPENDIX



MASTER PLAN of Tema Port

Appendix

Draft Environmental Impact Statement

for Short-Term Development Plan

of Tema Port

Table of Contents

Chapter 1 Introduction

1.1 Project Background and Objectives

1.1.1 Background

Tema Port construction began in 1954 and opened in 1962 as an outer port for Accra. The original layout of the Tema Port was composed of two breakwaters. A water basin, Quay No. 1 and Quay No. 2 were added between 1970 and 1975, completing the present port. Tema Port was one of the three integral components of the Volta River Project. The other two were the dam at Akosombo and the aluminum smelter at Tema.

Tema Port is located about 30km east of Accra. About 80 % of imported goods to Ghana is handled in Tema Port. The main commodities handled here are crude oil, clinker, oil products, rice, sugar, wheat, alumina, and aluminum. Recently the volume of container cargo has been increasing.

Main port facilities of Tema Port include 14 berths, i.e. 7 berths in Quay No. 1 and 5 berths in Quay No. 2, an Oil Berth and a Valco Berth. There are 11 sheds, one (1) CFS, one (1) container yard, one (1) container devanning areas and one (1) open storage yard. Out of these, four (4) sheds in Quay No. 2 will be demolished during the on-going Quay No. 2 Extension Project. The existing port layout plan of Tema Port is shown in Figure 7.2.1 of the Main Report.

Increasing cargo-handling volume requires a considerable scale of expansion of capacity of the Port. The cargo handling volume will reach to 10 million tons and 18 million tons in 2010 and 2020, respectively, while it remains around 6 million tons at present. In particular, container cargo is estimated to increase 2.5 times and 6.5 times in 2010 and 2020 (see Table 14.1.1).

In order to respond to the increasing demand of cargo volume, the provision of deep berths is indispensable and urgent. At the same time, the space for the cargo-handling operation should be provided considering the requirement from the local residents.

1.1.2 Objectives

JICA Study Team proposed a development plan of Takoradi Port, in response to the request from the Government of Ghana to Government of Japan, to accelerate and support the economic development of Ghana. Based on the Scope of Works signed by JICA and Government of Ghana on July 20th, 2000, the study team carried out an EIA study for a short-term development plan of Tema Port with a target year of 2010.

The short-term development plan of Tema Port comprised of the following components:

- Creation of new berths and a container yard through reclamation of the sea area southwest of the main breakwater
- Construction of new breakwaters sheltering the new berths
- Construction of new access road from the container yard to West Gate Road and Meridian Road
- Container and other cargo-handling operation on the reclaimed land

- Increase in the cargo transportation

In compliance with the Environmental Protection Agency (EPA) Act, Act 490 of 1994, the plan must be registered with the EPA by GPHA, the project proponent. Under the Ghana Environmental Assessment Regulations, 1999 (LI 1652), port expansion projects with the increase of cargo handling volume of 25 % or more fall within the category of Environmental Critical Undertakings for which EIA is mandatory.

The objective of the environmental study in this report is to prepare the technical parts of the EIS for the short-term development plan of Tema Port, which in due course, GPHA will complete for the implementation of the plan.

1.2 Legal, Administrative and Policy Consideration

The relevant policies and the regulatory conditions that must be considered for the successful implementation of the project have been reviewed and are discussed below.

The laws considered include:
- Environmental Protection Agency Act, 1994 (Act 490)
- Environmental Assessment Regulation, 1999 (LI 1652)
- Ghana Ports and Harbours Authority Law, 1986 (PNDC Law 160)
- Merchant Shipping Act, 1963 (Act 183)
- Port Regulations, 1964 (LI 352)
- Ghana Free Zones Act, 1995 (Act 504)

In addition, the followings were considered, though under consideration of the Government of Ghana:
- Draft National Maritime Authority Act, 2000
- Draft Landlord Ports Act, 2000
- Draft Port Regulations, 2000

The Environmental Assessment Regulations, 1999 (LI 1652) enacted under the provisions of the EPA Act, set out the procedures governing EIA in Ghana. Under Schedule 2 Regulation 3 (10) of these regulations, the proposed port development project falls under the undertakings for which EIA is mandatory as it is expected to result in an appreciable increase in port handling capacity.

Section 5 of the Ghana Ports and Harbours Authority Law, empowers the GPHA to build, develop, manage, maintain, operate and control all ports in Ghana. The law also charges the Authority to maintain and deepen as necessary the approaches to the port and also to provide cargo storage/handling facilities such as warehouses etc.

The Ministry of Road and Transport is responsible for Government policy issues related to the Maritime sector. Currently the Merchant Shipping Act, 1963 (Act 183) and the Port Regulations, 1964 (LI 352) have been revised as part of an overall restructuring of the Maritime Administration in Ghana. These revised laws are yet to be approved by Parliament.

Apart from the administrative and policy issues, various legislation and guidelines concerning

safety, pollution etc. have also been considered. Among these are:
- EPA Quality Guidelines (Effluents, Air Quality and Noise)
- Radiation Protection Instrument, 1993 (LI 1559)
- National Oil Spill Contingency Plan
- Various international maritime conventions (MARPOL, SOLAS, OPRC, IMDG codes etc.)

These are discussed in relevant details in the sections later where they are applicable.

1.3 Scope of Study

In prior to the preparation of the short-term plan, the study team made a master plan for Tema Port development (see Interim Report (1)). In accordance with the EIA procedure in Ghana, Scoping work was also done to identify the environmental elements with possible impact, and in due course of the said procedure, TOR for EIA on the master plan prepared (Appendix BB-1).

Here, the Study Team applies the TOR for EIA on the master plan to the EIA on the short-term plan, since the master plan's components of construction work and operational activity entirely contain those of the short-term plan. Hence it can be said that the TOR for EIA on the master plan cares all of the possible environmental impacts of the short-term development plan of Tema Port.

In accordance with the Environmental Assessment Regulations, 1999, the EIA of the Tema Port short-term development plan includes:
- A description of the proposed undertaking and an analysis of the need/reason for the undertaking;
- Objectives of the undertaking;
- Other options for carrying out the undertaking;
- Alternatives to the undertaking;
- A description of the present environment that would be affected, directly, or indirectly;
- A description of the future environment, predicting its condition if the undertaking did not take place;
- Impacts that may be caused to the environment by the undertaking;
- Proposed measures to prevent or mitigate all adverse impacts;
- Evaluation of opportunities and constraints to the environment of the undertaking;
- Proposal for an environmental management program to cover constructional, operational and decommissioning stages of the undertaking;
- Proposal for a program of public information

Chapter 2 Description of Proposed Development Plan

The short-term development plan of Tema Port comprises the following components:

- Creation of new berths and a container yard through reclamation of the sea area southwest of the main breakwater
- Construction of new breakwaters sheltering the new berths
- Construction of new access road from the container yard to West Gate Road and Meridian Road
- Container and other cargo-handling operation on the reclaimed land
- Increase in the cargo transportation

2.1 Preparation Phase

Since GPHA has already owned the necessary areas for the port expansion, it will not need further land acquisition and relocation of facilities.

2.2 Construction Phase

The short-term development plan of Tema Port is drawn as in Figure 24.3.1. The schedule of the construction works is planned as in Figure 26.3.1.

2.2.1 Reclamation for New Container Yard

A coastal sea area neighboring west to the existing port will be reclaimed with materials both dredged to deepen the new port basin and transported from a quarry site. The reclamation of the area of ca. 290,000 m^3 requires 2.3 million $m^3$of filling materials. The reclaimed area will be used for berths and a yard for container handling.

2.2.2 Dredging

The new port basin will be deepened to 13.0 meter to provide deep container berths and a turning basin. The dredging will be carried out by a dredge cutter boat, a pump-dredge boat and a grab-dredge boat.

The dredged materials will be used for the reclamation in the proposed plan. The materials to be dredged is estimated to be about 1.3 million m^3, which accounts for about 50 % of the required filling material volume of 2.3 million m^3.

2.2.3 Construction of Breakwater

New breakwaters will be constructed to provide the new container berths and a turning basin with a calm condition and consequent safe navigation at the port entrance. The structure will be same as the existing breakwater, using rocks that are available from the quarry site.

2.2.4 Demolishing Existing Facility

A small-scale demolition will occur to the existing facilities located on the hinterland of the planned new container yard. This may include the existing two cocoa sheds and parapet and wavewall of the existing breakwater.

2.2.5 Construction of New Access Road

A new access road will be constructed connecting the new container yard to West Gate Road and Meridian Road. The new access road is expected to share the cargo transportation with the existing access roads.

2.3 Operation Phase

2.3.1 Container-Handling at Berth/Yard

The new container berths and yard, which would be constructed through reclamation, will handle around 250,000 TEU of containers. Cranes and other container-handling equipment will be installed. Light facility will also be set up to ensure the safe work and the security. Port workers will also be posted for an efficient container handling.

2.3.2 Cargo Transportation

Increased trucks and trailers will be employed to transported the increased cargoes through port access roads including the planned road. Future cargo volume is estimated to be 10 million tons in 2010, while it remains 6 million tons at present.

2.3.3 Ship Berthing/Navigation

Pilots and tugboats will work properly for navigation in the port area and berthing, as same as at present.

2.4 Demolition Phase

The port structures should be long-life assets and will form the basement for future expansion of the port. Therefore, demolishing port is not reality, though the future port development work may demolish partly some port structure.

Chapter 3 Existing Environmental Condition

3.1 Climate Condition

3.1.1 General

The study area lies within the tropical zone in which each year has rainy and dry seasons and belongs to dry Equatorial climatic region of Ghana. Climate is characterized with constant high temperature and moderate rainfall.

Tema area, which is a part of the Accra Plains, is one of the driest parts of the country. It experiences two rainfall peaks in the months of May/June and September/October. During these periods, the region is affected by the warm moist Southwest (SW) monsoon wind. The dry season occurs in the months of December/January with minimum rainfall. During this period, the region is occasionally affected by the dry Northeast (NE) Trade winds (Harmattan).

3.1.2 Temperature

The hottest periods of the year in Tema are in the months of February and March with daytime temperatures reaching up to 35 ℃. This is the period preceding the onset of the minor rains. The mean monthly temperature during this time is about 29 ℃. July and August are relatively cooler months with mean temperatures of 26 ℃ (Table 3.1.1).

Table 3.1.1 Monthly Average Temperature - Tema (Unit: ℃)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Av.
61-97	30.4	30.8	31.0	31.0	30.5	28.7	27.3	26.7	27.4	29.2	30.5	30.6	29.5
1998	28.2	29.3	30.0	29.7	28.2	27.1	25.8	25.0	26.0	27.4	28.7	28.4	27.8
1999	27.9	28.4	28.4	28.5	28.3	27.4	26.0	25.0	25.3	26.5	28.0	28.3	27.3
2000	27.8	28.4	29.4	28.7	28.1	27.0	25.1	24.8	25.8	26.7	27.7	28.0	27.3

Source: Meteorological Services, Tema

3.1.3 Relative Humidity

The variation in relative humidity in Tema area is minimal and sometimes erratic due to the daily influence of the sea and the land breezes. The values range between 80 % during the night to about 60 % at daytime, and falls to less than 30 % during the dry season (Dec. – Jan.), when the dry North-east Trade winds reach the coastline. The highest humidity is experienced around July - August after the rainy season and the lowest in December (Table 3.1.2).

Table 3.1.2 Relative Humidity in Tema (Unit: %)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Av.
61-97	72.8	74.4	74.5	75.5	77.5	80.3	82.2	81.8	79.8	70.8	66.8	65.3	75.1
1998	65.0	77.0	78.0	76.0	81.0	83.0	82.0	80.0	82.0	79.0	76.0	75.0	77.8
1999	83.0	74.0	79.0	79.0	81.0	84.0	87.0	85.0	83.0	78.0	74.0	70.0	79.8
2000	75.0	62.0	71.0	75.0	76.0	81.0	82.0	82.0	79.0	76.0	75.0	74.0	75.7

Source: Meteorological Services, Tema

3.1.4 Rainfall

The minor rainy season begins around March and reaches its peak of about 200 mm in Tema in the month of June, when the region comes under the influence of the moisture-laden Southwest winds. Rainfall figures decline from June to August after which it starts rising to about 60 mm at Tema in October. The monthly average rainfalls figures for the past 25 years and for the recent 3 years recorded at the Tema Meteorological Station are shown in Table 3.1.3.

Table 3.1.3 Monthly Total Rainfall in Tema (Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
61-97	8.3	25.5	48.9	88.0	129.1	203.3	63.9	25.7	45.9	56.5	25.3	12.8	734
1998	0.0	12.6	TR	12.0	135.4	60.9	4.7	2.4	6.9	82.7	5.6	11.7	334
1999	29.2	83.2	13.4	55.7	48.8	169.3	41.7	5.2	28.5	29.7	7.0	3.5	515
2000	TR	0.0	30.0	39.0	146.8	67.7	44.7	4.2	3.4	39.9	25.7	15.3	417

Source: Meteorological Services, Tema

3.1.5 Wind

Wind data compiled by Meteorological Services Department are based on the records for the last 10 years at Tema (Table 3.1.4), and reveal that the mean wind speed is 4 - 6 knots. The Southwest monsoon prevails influencing the project area (Table 3.1.4). In addition, the diurnal change is observed in the wind direction, resulting from the differential heating and cooling of the land and sea. The local breeze is therefore offshore during the daytime, and reverse occurs at night.

Table 3.1.4 Monthly Average Wind Speed and Direction during 1990 – 99, and 2000 in Tema

(Unit: knot)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Av.
Dir.	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
Vel.	5.0	6.1	6.0	5.5	5.1	5.1	5.5	5.9	6.5	6.3	5.2	4.7	5.6
Dir. (2000)	SW	SW	SW	SW	SW	VRB	SW	SW	SW	SW	SW	SW	SW
Vel. (2000)	4.6	4.7	4.7	4.1	3.8	4.9	5.1	5.2	5.4	5.3	4.3	4.3	4.7

Source: Meteorological Services, Tema

3.2 Marine Hydrological Condition

3.2.1 General

The seashore in Ghana is faced on the Guinea Gulf of the Atlantic Ocean. Atlantic Ocean and Monsoon wind directly influence the marine hydrological condition of the Ghana's coast.

3.2.2 Tide Level

Tides are resulted from the rise and fall in seawater levels caused by the pull between the earth and other heavenly bodies, mainly the moon. The relative positions of these bodies determine the level of tide at any particular point. There are normally two high tide levels and two low levels within a day (i.e. semi-diurnal). Ghanaian coast also has the semi-diurnal tide. There is no time difference between Tema and Takoradi Ports. The tide levels of Ports in Ghana are corrected to standard port of Takoradi. Daily tidal predictions are computed and have been published annually by GPHA.

Since the tide level observation stopped one years ago in Tema Port, the Study Team conducted the tide level observation in Tema Port from mid-January to mid-February 2001. The tide level of Tema Port is shown in the Table 3.2.1.

Table 3.2.1 Tide Level of Tema Port (Unit: m)

	MHMS	MHWN	MLWN	MLWS
JICA	1.75	1.20	0.65	0.29
GPHA	1.6	1.3	0.7	0.3

Tema Port: 5 ° 52 ′ N. 0 ° 00 ′

Source: Tide Tables 2001 (GPHA)

3.2.3 Current Flow

Currents in the sea composed of many components including ocean current, wind-driven current, upwelling, tidal current, etc. In the immediate coastal sea area, tidal current plays an important role to transport and disperse materials in the seawater. The velocity of the tidal current is less than 0.1 m/sec. The maximum velocity of tidal current is about 0.5 m/sec which was observed on the day of strong winds.

3.2.4 Wave Condition

There are no wave observation data available locally for Takoradi Port. The wave characteristics during latest 40 years for this study is derived from The Global Wave Statistics publish Maritime Technology.

It is found that the predominant waves flow in the South to Southwest direction (about 60 % of the time). Most of the waves are between 1and 2 meters in height. Wave heights during the rainy season (June-September) when the Monsoon winds predominate may exceed 2 meters more frequently.

The frequency distribution of the concluded wave is shown in Table 3.2.2. South and Southwest waves prevail with a composition rate of nearly 60 % and have relatively large height.

Table 3.2.2 Frequency Distribution of Wave at Offshore of Ghana (1985-1990)

(Unit: %)

Height	N	NE	E	SE	S	SW	W	NW	Total
0.0-1.0	2.45	2.00	1.84	4.38	10.55	10.30	7.48	3.98	42.97
1.0-2.0	1.69	0.84	0.92	5.04	19.85	7.82	2.98	2.84	41.98
2.0-3.0	0.24	0.17	0.19	1.36	6.93	2.15	0.60	0.62	12.44
3.0-4.0	0.07	0.02	0.03	0.22	1.36	0.41	0.08	0.09	2.28
4.0-5.0	0.00	0.00	0.00	0.02	0.19	0.04	0.01	0.01	0.29
5.0-6.0	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.04
Total	4.63	3.04	2.99	11.03	38.92	20.72	11.15	7.54	100.00

Number of Observations: 267,326

Source: "The Global Wave Statistics" publish Maritime Technology

3.3 Pollution

3.3.3 Water quality

Main port basin receives a part of municipal wastewater of Tema City through a drain, together with wastewater originated from port facilities. Field reconnaissance surveys found that the water in the innermost part of the port sometimes brought about odor due to the drained sewage particularly during the low tide.

Based on the above observation, a field survey was carried out in the time zone of the low water on 23rd January 2001 to obtain the worst water quality condition. The location of the sampling is shown in Fig. 3.3.1. The surface water was sampled and brought to a laboratory for chemical analyses. The results are tabulated in Table 3.3.1.

The water quality in and outside the port basin did not show a significant difference in terms of the eutrophication level indicated by DO, BOD, and COD. This is resulted from the highly polluted coastal water that receives a lot of pollutants from Accra and other coastal districts and flow easterly along the shore. Oil and grease revealed higher concentrations in the port basin than outside. Ship-related activities may account for this distribution pattern. Heavy metal concentration also showed no significant difference between sampling stations.

Since Ghana has not established an ambient water quality standards, a series of quality reference value for selected parameters were introduced in Table 3.3.1 as an Assumed Environmental Criteria (AEC). This was tentatively set up based on the examples of criteria for port waters in tropical and subtropical eight (8) countries. This helps the understanding the water quality situation objectively. COD in stations 1 and 4, and oil and grease in stations 1 and 2 showed higher values than AEC.

The water quality in Tema Port was once measured in an EIA study for a Tema Port Development Project – Quay 2 Extension and Devanning area - in May 2000. The obtained data showed high concentration of lead (Pb), and depressed DO concentration, which suggested considerable

contamination from the human activities (Table 3.3.2, Fig. 3.3.2). AEC emphasized that the lead concentration should draw immediate and full attention to cope with.

Table 3.3.1 Result of the Water Quality Analysis of Tema Port

Station	unit	1	2	3	4	AEC*
Date		23 Jan. 2001	23 Jan. 2001	23 Jan. 2001	23 Jan. 2001	
Time		09:33	10:30	11:02	11:39	
Latitude		5°37'16"N	5°37'28"N	5°37'29"N	5°37'16"N	
Longitude		000°00'30"E	000°00'54"E	000°01'16"E	000°01'00"E	
Whether	-	Fine	fine	fine	fine	
Air temp.	℃	31.0	29.5	28.5	29.0	
Wind direction	-	SW	SW	SW	SW	
Wind speed	kt	5	5	5	5	
Depth	m	10.5	12.5	14.0	14.0	
Water color	-	Olive yellowish green	Olive yellowish green	Whitish olive green	Whitish olive green	
Smell	-	No	no	no	no	
Transparency	m	3.2	2.4	2.1	1.9	≧1
Oil film	-	No	no	no	no	
Floatable	-	No	no	no	no	
Surface temp.	℃	29.0	28.0	27.5	28.0	
Salinity	-	35.58	39.02	35.58	37.75	
PH	-	8.0	8.0	8.1	8.1	6.5 - 9.0
DO	mg/L	6.7	7.0	7.2	7.2	≧3
BOD	mg/L	1.3	1.9	1.3	1.3	≦20
COD_{Cr}	mg/L	62.9	15.7	26.0	40.8	≦40
Oil & grease	mg/L	17.0	13.0	6.0	9.5	≦10
SS	mg/L	6.0	6.0	11.0	12.0	
Turbidity	NTU	1.6	1.7	3.6	4.8	
Pb	mg/L	0.002	0.010	0.002	0.002	≦0.05
Cd	mg/L	<0.001	<0.001	<0.001	<0.001	≦0.01
Cu	mg/L	0.004	0.004	0.007	0.002	≦1
Zn	mg/L	0.011	0.057	0.020	0.005	≦2

* "AEC" (Assumed Environmental Criteria) is conveniently cited as a quality reference value derived from "Environmental Assessment Handbook for Port Development Projects." OCDI, 1993.

3.3.4 Bottom Sediment Quality

A field survey on the bottom sediment quality was conducted at the same time as the water quality survey. The sampling locations are also shown in Fig. 3.3.1. Four (4) samples were all collected from the port basin, because a rocky substrate covered the extensive area outside the port basin. The obtained data is shown in Table 3.3.3.

COD and total sulfide (T-S) showed high concentration, which is still higher than those of many polluted port areas in Japan. As for the heavy metal concentration, total chromium (T-Cr) and total mercury (T-Hg) revealed the objectively high values. The comparison of these data with AEC strongly

appeals that dredging and other bottom-disturbing activities, if any, will need the intensive care not to disperse the contaminated bottom sediment.

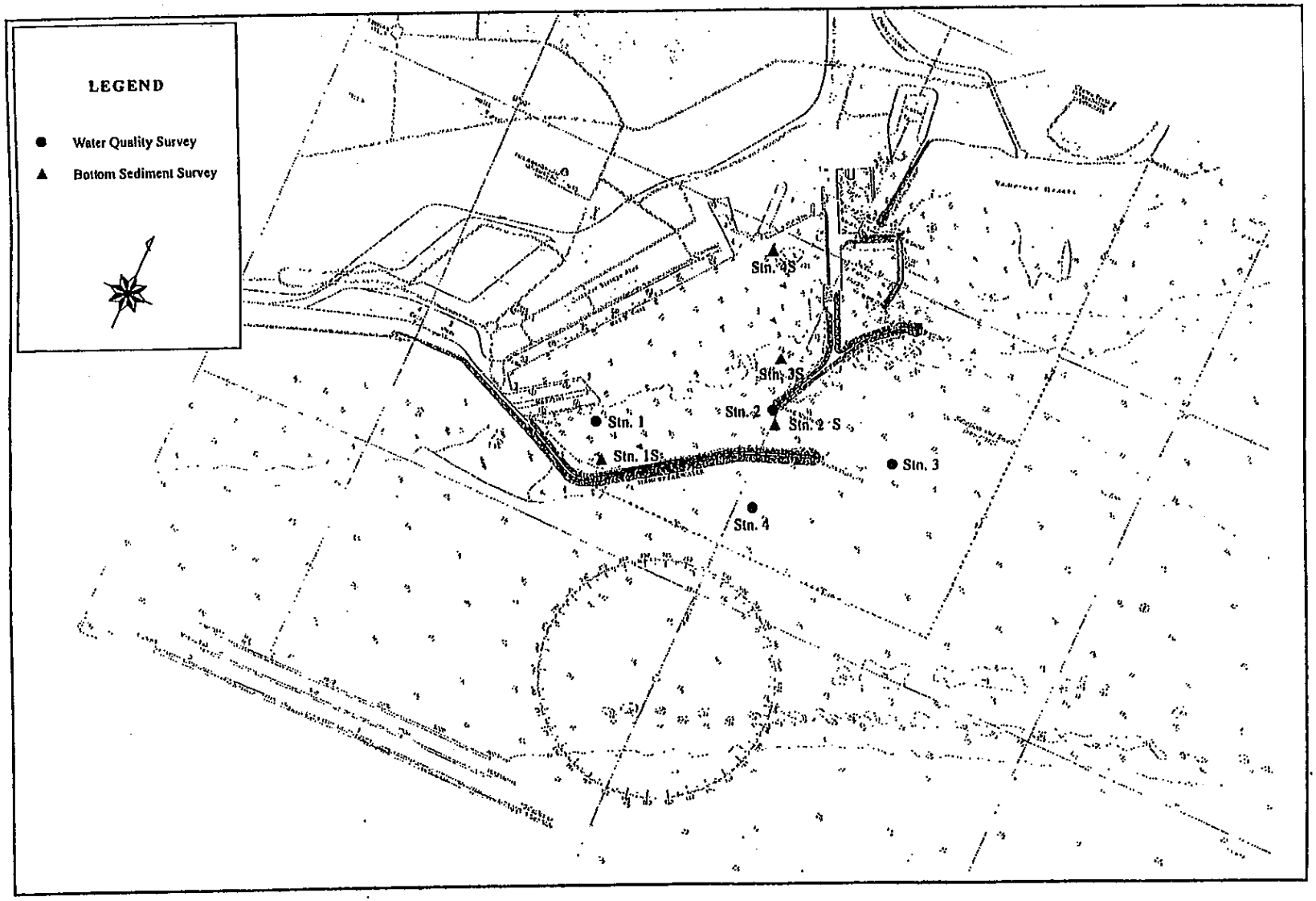


Figure 3.3.1 Locations of Water and Bottom Sediment Sampling in Tema Port (23 Jan. 2001)

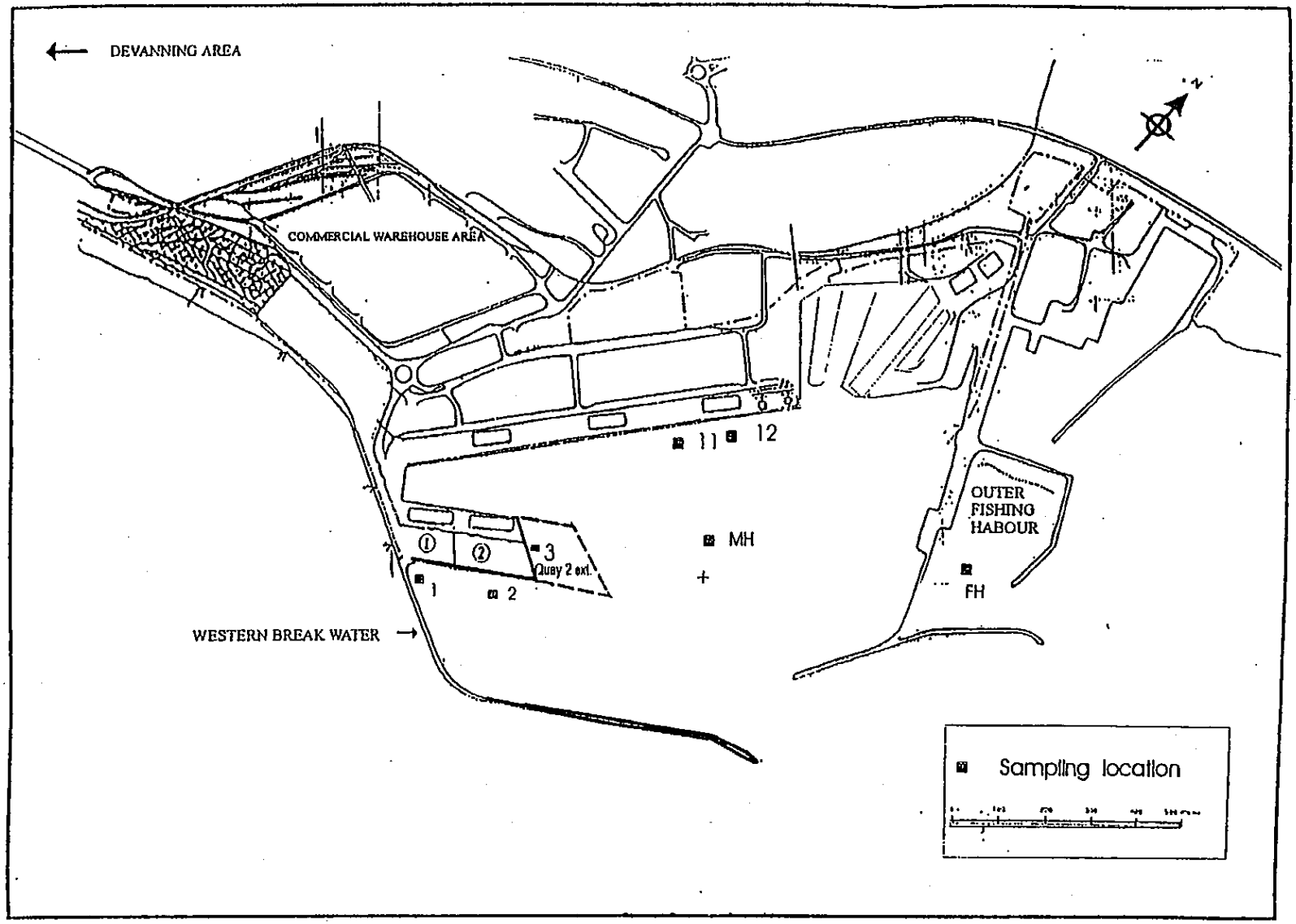


Figure 3.3.2 Water and Bottom Sediment Quality Sampling Locations (May 2000)

Table 3.3.2 Water Quality Data Obtained in Tema Port in May 2000.

Site	Unit	Berth 1	Berth 2	Berth 3	Berth 11	Berth 12	Main harbor	Fishing harbor	AEC*
PH	-	8.0	8.0	8.0	8.0	8.0	8.0	7.2	
Cond.	μS/cm	51,400	51,700	51,300	50,800	51,600	50,900	59,000	
Turb.	NTU	1.0	1.0	2.0	1.0	1.0	1.0	2.0	
Sal.	-	33.9	34.1	33.8	33.2	33.5	33.5	32.1	
DO	mg/L	4.29	5.25	4.84	4.83	4.80	4.90	3.92	≧3
Temp.	℃	28.4	28.0	28.3	28.2	28.4	28.1	29.0	
Oil & Gr.	mg/L	nd	nd	nd	nd	nd	nd	4.0	≦10
Pb	mg/L	0.43	0.42	0.41	0.43	0.46	0.43	0.40	≦0.05
Zn	mg/L	0.08	0.09	0.08	0.28	0.19	0.14	0.13	≦2
Cu	mg/L	0.04	0.02	0.04	0.03	0.02	0.03	0.05	≦1
Cd	mg/L	<dl	<dl	<dl	<dl	<dl	<dl	<dl	≦0.01
Hg	mg/L	<dl	<dl	<dl	<dl	<dl	<dl	<dl	≦0.005

nd: not detected, <dl: below detection limit

* AEC: see Table 3.3.1.

source: modified from "Proposed Tema Port Development Project – Quay 2 Extension and Devanning area -. Environmental Impact Statement, GPHA. 2000.

Table 3.3.3 Result of Sea Bottom Sediment Analysis in Tema Port

Station	Unit	1S	2S	3S	4S	AEC*
Date		23 Jan. 2001	23 Jan. 2001	23 Jan. 2001	23 Jan. 2001	
Time		10:05	10:50	11:25	11:58	
Latitude		5°37'12"N	5°37'28"N	5°37'40"N	5°37'53"N	
Longitude		000°00'34"E	000°00'54"E	000°01'00"E	000°00'46"E	
Color		Grayish black	Grayish black	Grayish black	Grayish black	
Smell		no	no	no	no	
Grain size		Fine sand	Silt	Coarse sand	Medium sand	
COD_{Cr}	mg/g dry	129	92	174	174	
T-S	mg/kg dry	12.0	45.0	23.0	27.0	
I. L.	%	12.6	14.3	20.3	15.6	
Pb	mg/kg dry	55.80	24.38	66.21	59.74	≦100
Cd	mg/kg dry	0.18	0.13	0.26	0.39	≦2.5
As	mg/kg dry	3.96	5.39	9.27	18.26	≦30
T-Cr	mg/kg dry	181.1	155.5	310.4	187.4	
T-Hg	mg/kg dry	0.86	7.66	4.98	4.18	≦1.0
Mg	mg/kg dry	38.11	34.66	61.40	40.42	

AEC: see Table 3.3.1.

The heavy metal concentration of bottom sediment taken by the past investigation in May 2000 also showed some data on the chemical condition (Table 3.3.4, Fig. 3.3.2). Since it, however, did not explain the unit of the concentration, the interpretation and the evaluation of the bottom sediment condition has not been done. Still it showed the bottom contamination extends to the entire port basin.

Table 3.3.4 The Metal Concentrations of Sediment in Tema Port (May 2000)

Site	Unit (unknown)	Berth 1	Berth 2	Berth12	Main harbor	Fishing harbor	AEC* (mg/kg dry)
Pb		0.58	0.62	0.49	0.46	0.71	≦100
Zn		0.63	0.82	0.74	0.49	0.46	≦350
Cu		0.12	0.19	0.26	0.10	0.09	≦68
Cd		0.0070	0.0074	0.0123	0.0087	0.0126	≦2.5
Hg		0.01	0.01	0.05	0.1	0.07	≦1.0

*AEC: see Table 3.3.1.

source: modified from "Proposed Tema Port Development Project – Quay 2 Extension and Devanning Area -. Environmental Impact Statement. GPHA, 2000."

3.3.5 Air Quality

Tema has been built as an industrial city and many of the major industries in Ghana are located there. The operations of these industries generate atmospheric pollutants like oxides of carbon, sulfur and nitrogen as well as short chain hydrocarbons, lead, and particulates. Because of its location, Tema is exposed to the wind all year long and gets rid of the stagnant of air pollutants. The air quality in Tema Port measured in May 2000 showed no serious air pollution problem in general (Table 3.3.5, Fig. 3.3.3). The growing port activity, industries and consequent transportation activity, however, require careful monitoring of the state of air quality.

Table 3.3.5 Air Quality Data within the Tema Port (May 2000)

Site No.	Location	SO_2 μgm^{-3}	NO_2 μgm^{-3}	CO mgm^{-3}	PM_{10} μgm^{-3}	TSP μgm^{-3}
1	Shed 6 (A)	28	10	2	23	10
2	Shed 6 (B)	34	11	1	23	13
3	Shed 6 (C)	37	11	2	25	13
4	Shed 8 (A)	56	26	3	20	42
5	Shed 8 (B)	45	23	4	31	44
6	Berth 2	92	67	5	15	13
7	Berth 3	81	48	5	21	23
8	Berth 11	87	55	6	17	19
9	Berth 12	87	54	4	19	19
EPA Guidelines		900 as averaging time of 1 hr	400 as averaging time of 1 hr	100 as averaging time of 15 min.	70 as averaging time of 8 hrs	230 as averaging time of 24 hrs

The wind direction was almost SW. The wind speed was 5.4 – 6.8 m/sec.

source: "Proposed Tema Port Development Project – Quay 2 Extension and Devanning Area -. Environmental Impact Statement. GPHA, 2000."

Thus, the Study Team carried out a field survey in August 2001 focussing on both the dust and gas concentrations at locations in Figure 3.3.3. Two Paschal 9000 – dust monitor and an Accuro 2000 sampler with dragger tubes were employed for the fieldwork. Detailed methodology is described in Appendix BB-2. Table 3.3.6 shows the result of the survey. Obtained concentrations were low enough to satisfy the Environmental Quality Standards in Ghana.

Table 3.3.6(1) Ambient Air Quality (1 hr value) Measured in August 2001.

(Unit: μg/m^3)

	TSP				PM_{10}			
Site No.	9 Aug.	10 Aug.	11 Aug.	Mean	9 Aug.	10 Aug.	11 Aug.	Mean
1	16	21	9	15.3	1.5	2.1	2.0	1.87
2	35	47	29	37.0	4.0	3.2	2.1	3.10
3	10	12	6	9.3	2.1	2.6	1.7	2.13
4	8	12	6	8.7	4.0	3.3	1.4	2.90
5	120	98	62	93.3	5.0	3.6	0.8	3.13
6	7	10	6	7.7	3.0	3.2	3.0	3.07
7	10	18	14	14.0	2.0	3.2	0.4	1.87
8	5	10	7	7.3	1.0	1.2	0.2	0.80
9	15	9	6	10.0	1.0	1.0	0.1	0.70
EQS*	Industrial area 230 for 24 hrs 75 for 1 year		Residential area 150 for 24 hrs 60 for 1 year		70 for 24 hrs, regardless of the type of area			

*: National Environmental Quality Standards (draft), EPA

Table 3.3.6(2) Ambient Air Quality (8 hr value) Measured in August 2001.

(Unit: μg/m^3)

	SO_2				NO_2			
Site No.	9 Aug.	10 Aug.	11 Aug.	Mean	9 Aug.	10 Aug.	11 Aug.	Mean
1	12.5	14.8	12.5	13.27	2.2	1.2	n.d.	1.13
2	6.25	6.25	2.5	5.00	1.3	0.8	n.d.	0.70
3	3.6	3.2	1.9	2.90	1.2	0.9	n.d.	0.70
4	3.2	3.3	0.9	2.47	0.6	0.9	n.d.	0.50
5	2.1	4.7	0.3	2.37	1.3	1.0	2.0	1.43
6	2.5	2.5	1.25	2.08	0.2	n.d.	n.d.	0.07
7	11.9	9.5	6.2	9.20	1.5	0.9	0.3	0.90
8	1.3	2.0	0.4	1.23	n.d.	n.d.	n.d.	n.d.
9	0.9	0.5	0.6	0.67	0.4	0.2	0.2	0.27
EQS*	Industrial area 900 for 1 hour 150 for 24 hrs 80 for 1 year		Residential area 700 for 1 hour 100 for 24 hrs 50 for 1 year		Industrial area 400 for 1 hour 150 for 24 hrs		Residential area 200 for 1 hour 60 for 24 hrs	

*: National Environmental Quality Standards (draft), EPA

3.3.6 Noise

The major sources of noise within the Tema Port are associated with vehicular traffic, ships and other marine craft, equipment movement, human/operational activities (loading and unloading, opening of containers and inspection of cargoes), sea waves as well as some ongoing maintenance work.

The Study Team carried out a field survey on noise at locations in Fig. 3.3.3, using a Castle 1800 Type 19-a noise meter. Detailed methodology and obtained field data are introduced in Appendices BB-2 and 3, and the summarized results in Table 3.3.7.

Measurement sites from Sts. 1 to 7 were located in the port area or the commercial/industrial area neighboring the Port, while St. 8 was on the boundary of the residential area, and St. 9 in Sakumo

Ramsar Site. Obtained values showed high level that did not meet the Environmental Quality Standards (EQS) value in Ghana occasionally.

Table 3.3.7 Summary of Noise Measured in August 2001.

(Unit: dB(A))

Site No.	$L_{Aeq}=L_{50}+(L_{10}-L_{90})^2/57$			
	9 Aug.	10 Aug.	11 Aug.	EQS's Permissible Noise Level
1	65.4	64.8	61.5	
2	75.3	60.3	67.0	Predominantly Commercial Areas
3	67.4	70.1	67.4	75 in daytime (0600 – 2200)
4	65.4	71.4	71.8	65 at night (2200 – 0600)
5	76.5	70.8	68.1	
6	62.0	62.5	64.0	
7	79.0	76.0	65.4	Residential Areas
8*1	67.4	65.9	66.8	55 in daytime (0600 – 2200)
9*1	64.1	60.6	75.1	48 at night (2200 – 0600)

*1: to be categorized to Residential Areas, while others to Predominantly Commercial Areas

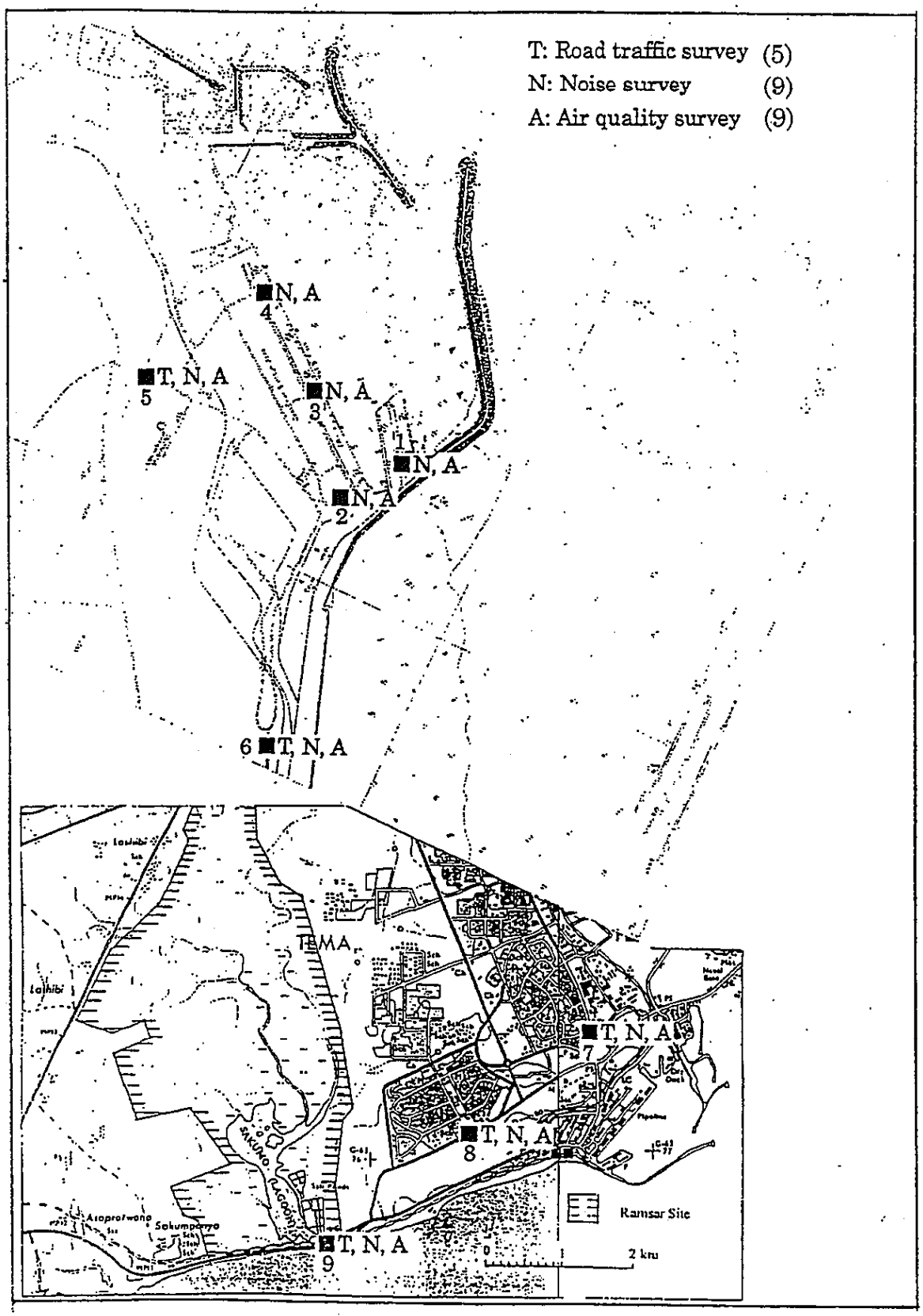


Figure 3.3.3 Sampling and Monitoring Sites for Air Quality, Noise and Road Traffic (9 – 11 August 2001)

3.3.5 Odor

The odor caused by a wastewater outlet was detected during the field reconnaissance. The odor extinguished when the flood tide submerged the outlet beneath the sea level.

3.4 Biophysical Environment

3.4.1 Erosion

The West African coast extending from Cape Palmas to The Niger Delta generally has an accretion tendency in the western section up to Cape Three Points in Ghana and an erosion tendency in the east.

Shoreline recession has been recorded at various locations along the eastern Coast of Ghana. The worst hit areas are found in Atorkor and Ada. The shoreline was reported to have receded about 10 m in some areas, and erosion of another area was about 7 m in Ada.

The effect of the littoral drift is not obvious in and around Tema Port. Hard rock substrate forms the sea bottom surface of most part of the port basin, and the sand composed of the bottom sediment very little.

3.4.2 Fauna/Flora

(1) Aquatic Biota

Field reconnaissance surveys found that filamentous green algae dominated the aquatic flora on the quay wall of the Port, indicating the deteriorated water quality condition. Balanoids, limpets, snails, isopods, and crabs were also found on the quay wall of various locations.

The composition of fish community in the Port appeared poor at low tides, composed of fry and small pelagic fish.

(2) Terrestrial Biota

Tema has been built as an industrial city. The vegetation of Tema area, therefore, has been affected over the years by human factors as well as climatic changes. There is very little significant natural vegetation around the Tema Port, because the City and the Coastal Savannah surround it.

A field survey on the terrestrial fauna and flora conducted in May 2000 found out 5 species of trees and shrubs, 16 species of grass and herbs, 3 species of mammals, 3 species of birds, 3 species of lizards, and 3 species of snakes. There was no species designated as of special needs to be conserved.

It should be noted, however, that Sakumo Lagoon that has been registered as a Ramsar Site forms a distinct ecosystem at 2 – 3 km west to the Port (Fig. 3.4.1). This is a conservation area for, especially, waterfowl habitats designated by the Convention of Wetlands of International Importance Especially as Water Fowl Habitat (Ramsar Convention, in short). In addition, sea turtles, which are endangered, have been reported to occur on the sandy beach of Sakumo.

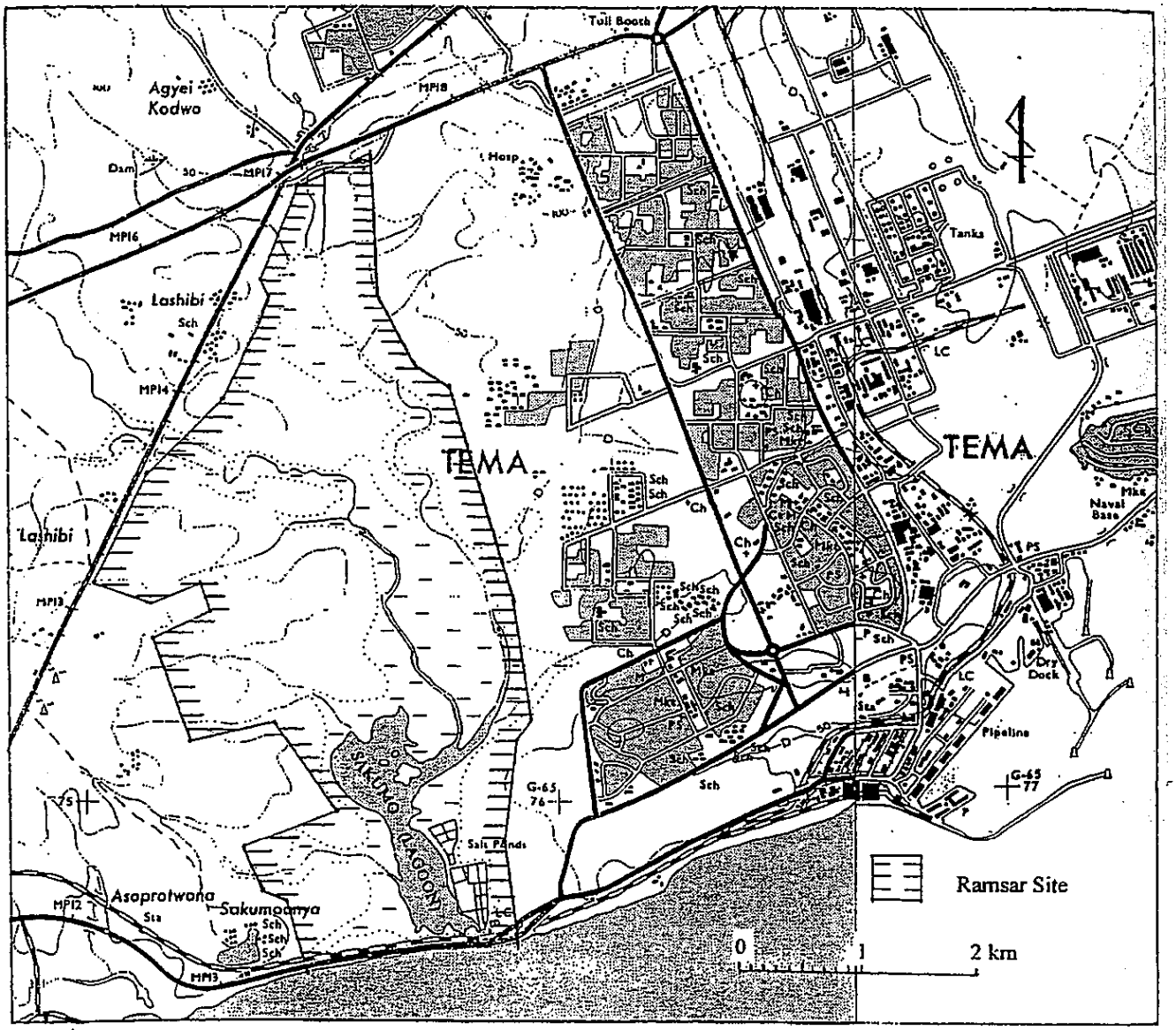


Figure 3.4.1 Location of Sakumo Ramsar Site

Source: Ntiamoa-Baidu, Y. & C. Gordon, 1991. Coastal Wetlands Management Plans: Ghana

3.5 Social Environment

3.5.1 Population Distribution

Tema in 1951 was a small village with a population of about 2000. With the construction of the Port, Tema grew into a sub-urban area and in 1960 had a population of 25223. Expansion of commercial and industrial activities caused accelerated population growth in the township by about 13.4 % over the 1960 figure to 101000 in 1970. The estimated population of Tema, according to a census as of December 1988, stood at 302815 (Table 3.5.1).

Table 3.5.1 Tema Municipal Population distribution (1988)

	Tema	Ashaiman	Tema Manhean	Tema Rural	Total	%
Ch. 0-11 months	6293	3279	2057	484	12113	4
Ch. 12-23 months	6293	3279	2057	484	12113	4
Ch 24-60 months	18879	9836	6170	1453	36338	12
Ch. 5-14 years	42477	22130	13884	3268	81759	27
m. 15-49 years	31464	16393	10285	2421	60563	20
f. 15-49 years	31464	16393	10285	2421	60563	20
m/f. 50-60 years	14586	7857	814	968	24225	8
m/f 60+	7866	4099	2571	605	15141	5
Total	159322	83266	48123	12104	302815	100

source: 5 yr Dev. Plan for Tema ch: children m: males f: females

Based on the census in 1988 above, population in 2000 was estimated assuming growth rates of 4.5 % and 3.5 % for urban Tema (Tema Township and Ashaiman) and rural Tema (Tema Manhean and Tema Rural) respectively. This is because the results of the 2000 population census have not been released yet. The higher growth rate than the national average of 3.2 % (1992 – 2000) is attributed to rural-to-urban migration. The estimated population in 2000 is shown in Table 3.5.2.

Table 3.5.2 Estimated Population in 2000

Settlement	1988	2000
Tema Township	159,322	270,191
Ashaiman	83,266	141,209
Tema Manhean	48,123	72,717
Tema Rural	12,104	18,290
Total	302,815	502,408

The population studies of 1992 revealed that the following density patterns for the main settlements in Tema Municipal area:

- Tema Township 100 inhabitants/hectare
- Tema Manhean 285 inhabitants/hectare
- Ashaiman 300 inhabitants/hectare

Most of the population is concentrated in the urban part of the Municipality comprising of Tema

Township, Adenta, Ashaiman and Tema Manhean. Urban Tema with about 90 % of the population covers about 15 % of the total land area while Rural Tema has 10 % of the population occupying the remaining 85 % of the land area.

3.5.2 Ethnicity and Religion

(1) Composition of Ethnic Groups

Tema is land for the indigenous Gas, however presently almost all the ethnic groups are represented in the city. Among the major ethnic groups are the Ga-Adangbe, Akan, Ewe, Guan, Mole-Dagbani, Gurma, etc. In terms of size, the Gas constitute the majority, followed by the Akans, and the Ewes, as the rest follow suit. There is also a sizeable group of immigrants, Non-Ghanaian Africans, Europeans and Asians. The bulk of the African group of immigrants is mainly from the neighbouring West African countries.

The present population figure used by the Tema Municipal Assembly in the planning and provision of facilities for the municipality is 550,000 people.

(2) Conflicts Between Ethnic Groups

According to the Public Relations Officer of the Police Service (Tema Harbour Police Station) in Tema, there are no records of conflicts between the ethnic groups in Tema. All the representatives of the relevant organisations, with regards to this survey, could not recall, in their lifelong experience, any ethnic disturbances taking place in Tema.

3.5.3 Existence of Slums and Illegally Occupied Areas

Sites 2, 5 and 12 of Community One, New Town, Sakumono Village and Ashaiman, could be considered as slums. The TMA officials preferred to refer to Ashaiman as a town whose growth preceded infrastructure development, and that a face-lifting programme, dubbed URBAN 4, consisting of road networks, refuse collection systems and drainage construction, is being presently implemented.

With regards to Sites 2, 5 and 12 of Community One, the officials of TMA explained that these Sites are very old communities, which have barely enjoyed any maintenance since their construction, and have therefore deteriorated over the years. New Town and Sakumono Village are indigenous fishing communities, which are similar to other such communities along the coastal belt of the country.

With reference to the illegally occupied areas, both the Tema Development Corporation (TDC) and the Tema Municipal Assembly (TMA), custodians of the bulk of Tema land, usually demolish any illegally erected structure in the Metropolis. The land and building laws are strictly enforced in Tema with the help of a well co-ordinated task force, and this has prevented illegally occupied areas in the Metropolis.

3.5.4 Economic Activity

Tema Port is the Ghana's major seaport accounting for more than 80 % of the country's imports. Life of local people have closely tied with port activities and port-related activities, such as transportation services, repairing of machines, sales of daily consumables, etc.

Tema is an industrial city with many factories located in its industrial zone. Industries located in this zone include Textile, Food Processing, Iron, Steel, and Aluminium Smelting, Wood Processing, Paper Processing, Leather Manufacturing, Paints Manufacturing, Pharmaceuticals Processing, Cement Processing, Petroleum Refinery, Salt processing, Cable Manufacturing, Jewellery, Footwear Manufacturing, Ice Block Manufacturing, etc. The industrial sector in Tema, which consists of over 185 manufacturing and industrial organisations, represents the most important productive sector in terms of local revenue generation. It is also a major source of employment for the urban population.

There is also a large number of small-scale and informal sector manufacturers, especially in the wood processing, metal fabrication, food production, and textiles industries.

Qualified, skilled and semi-skilled manpower from the Accra-Tema Metropolis are employed in the above-mentioned sector.

3.5.5 Infrastructure

(1) Water Supply System

The urban settlements in Tema have access to pipe-borne water provided by Ghana Water Company, from the Kpong water works. However, in the rural parts of the Municipality some settlements still lack this basic facility and depend on water from boreholes and wells.

Tema Township presently consumes an average of 818 million litres of treated water per month. This value is only for domestic or residential consumption. The industries and the commercial entities consume an average of 308 million litres per month. The highest consumer of treated water in the Metropolis is Ghana Textiles Printing Company Limited (GTP). The second highest water consumer is the Ghana Ports and Harbours Authority (GPHA). The water consumption per month by these two companies averages 12 million gallons.

As at December 2000, the customer growth rate and the water consumption growth rate with regards to the previous year were 10% and 5.8% respectively.

(2) Sewerage

A central sewage system was installed in Tema during the construction of the township in the early 1960's. The system comprises of the following:

- pumping stations
- inverted siphons
- gravity sewers
- detention basins

- submarine out-fall

Sewage is collected by gravity into a pumping station located at the lowest point in each drainage area. Domestic sewage is pumped to a treatment plant located at Community 3, from where the treated water is discharged through a marine out-fall at the western end of Tema.

Industrial sewage is pumped into a detention basin near VALCO which discharges by gravity into the sea through a submarine out-fall located at the eastern end of Tema. The discharge pipe from the detention basin crosses the Gao lagoon at Tema Manhean and extends 3.5 km across the canoe-landing beach into the sea.

The new settlements of Communities 13 - 20 are not connected to this centralised sewage system and rely on septic tanks that are siphoned by mobile facilities and discharged at Manhean.

(3) Other Infrastructure

Adequate provision has been made for the supply of electricity for the urban community. There are, however, a few rural settlements that are yet to be provided with this service. Industries in Tema consume the largest part of all electric power generated in Ghana.

Communication systems have improved greatly in the past decade. There are various systems including the followings:

- Telephones over 26,000 lines in Tema Township and over 28,000 mobile phones
- Internet 17 internet cafes, 130 communication/business centres
- Post office 8 post offices in Tema Metropolis

3.5.6 Road Traffic

The transportation of cargo to and from the port involves considerable vehicular movements. The port is provided with three (3) main accesses. The trucks enter by the eastern gate near the Cement factory and exit from the central gate and the eastern gate. The western gate is used mainly for delivery of imported vehicles.

The results of a field survey on the traffic volume carried out in August 2001 are shown in Table 3.5.3. The locations of traffic count were set up on the map in Figure 3.3.3 (see Appendix BB-4).

Data for three (3) days was averaged by the time zone and shown in Table 3.5.3. Inbound traffic showed more volume in the morning than in the afternoon, while outbound traffic had a peak in the late afternoon. This suggests the noise caused by the road traffic may bring about a nuisance for residents at late afternoon and night.

Table 3.5.3 Summary of Road Traffic Survey, 9 – 12 August 2001 (Trailer and Truck)

Hour	Inbound						Outbound					
	St.5	St.6	St.7	St.8	St.9	Total	St.5	St.6	St.7	St.8	St.9	Total
00-01	7.0	2.0	4.7	0.3	3.7	17.7	19.3	21.0	1.7	0.3	1.3	43.7
01-02	5.0	16.0	0.3	0.0	4.3	25.7	10.0	5.3	0.0	0.0	0.3	15.7
02-03	5.0	6.0	1.0	0.0	3.0	15.0	5.0	5.3	7.0	0.0	0.0	17.3
03-04	7.3	4.0	0.0	0.7	3.7	15.7	5.3	6.7	8.3	1.3	2.0	23.7
04-05	18.3	2.3	0.3	1.3	3.3	25.7	4.7	3.0	10.7	3.0	8.0	29.3
05-06	32.7	22.0	5.0	1.0	33.7	94.3	18.0	13.0	6.0	3.3	1.0	41.3
06-07	33.0	15.7	86.7	14.3	27.7	177.3	89.7	4.7	75.0	1.3	9.3	180.0
07-08	61.7	24.7	80.7	10.3	48.3	225.7	55.7	5.7	96.0	3.0	7.3	167.7
08-09	79.3	28.0	139.7	15.0	53.7	315.7	80.7	6.0	91.3	7.0	15.0	200.0
09-10	90.0	12.7	105.0	18.3	38.3	264.3	117.7	3.7	129.3	8.7	17.3	276.7
10-11	70.3	20.3	79.7	15.3	47.0	232.7	101.0	11.0	109.3	9.0	25.0	255.3
11-12	63.7	13.0	49.7	17.0	50.0	193.3	110.0	9.7	105.7	24.0	32.0	281.3
12-13	67.7	14.0	124.7	12.7	41.7	260.7	69.7	5.7	131.7	13.0	29.3	249.3
13-14	57.7	9.0	131.7	11.7	39.7	249.7	65.3	9.3	170.3	8.0	29.7	282.7
14-15	73.3	10.3	138.3	12.3	27.0	261.3	78.0	8.7	95.7	12.3	36.0	230.7
15-16	65.0	6.7	83.0	9.0	28.7	192.3	80.7	11.3	90.0	9.0	34.3	225.3
16-17	67.7	10.0	95.7	7.3	27.0	207.7	108.0	11.7	91.7	8.0	32.0	251.3
17-18	72.7	1.7	79.0	10.3	20.7	184.3	116.7	13.0	48.7	10.0	33.3	221.7
18-19	110.7	34.0	20.0	14.0	62.3	241.0	90.7	12.0	120.0	4.3	52.0	279.0
19-20	86.3	21.7	16.7	9.7	56.7	191.0	71.0	12.7	101.0	4.3	21.7	210.7
20-21	53.0	16.7	9.3	11.3	31.7	122.0	46.0	1.7	87.3	2.0	14.3	151.3
21-22	50.0	8.7	5.7	6.0	40.7	111.0	12.3	2.7	94.0	0.3	9.0	118.3
22-23	18.0	7.3	5.7	3.0	17.3	51.3	17.0	4.3	61.7	2.7	8.7	94.3
23-00	17.0	41.0	5.0	0.7	12.0	75.7	12.0	2.7	34.3	0.7	1.0	50.7
Total	1212.3	347.7	1267.3	201.7	722.0	3751	1384.3	190.7	1766.7	135.7	420.0	3897.3
*[1]Daily ave. transportation (A)				318.7								
*[2]Daily peak transportation (B)				541								
β (B/A)				1.7								

*1 and 2: The values were calculated through the addition of the total of inbound and outbound traffic.

3.5.7 Waste

Port activities generate considerable wastes of various forms both from the ships and from shore operations. The common wastes generated are:

- Solid wastes
  packing wastes (paper, wood, metals, plastics), damaged cargoes (various types), empty sacks, spilled cargoes (rice, sugar, wheat), etc.
- Liquid wastes
  mainly from spills and leakage from cargoes of oils, paints chemicals, solvents, beverages etc. Liquid wastes may also arise from ort equipment and cargo handling machinery.

International Maritime regulations (MARPOL Protocols) require that wastes from ships in port are either retained onboard or discharged to shore facilities. Such wastes are usually domestic wastes and oily wastes from machinery spaces.

Tema Port has waste collection bins located at various points within the port. Special trucks lift these twice daily and dispose off at the Kpone landfill site located about 5 km from the port. This overage landfill site has been rehabilitated by a World Bank project. Besides this, a waste treatment facility construction project is ongoing also supported by the WB.

Tema Port generates an average of 972.5 tons of solid waste per month. This waste is recollected at about 5 tons per refuse truck at an average number of 6.5 trips per day. More solid waste is recollected during the weekdays than the weekends. The solid waste is sent to the Kpone Final Refuse Dump of the Tema Waste Unit of the Tema Municipal Assembly (TMA). The TMA charges ¢ 15000 per each trip by the refuse truck.

About 12.5 tons on the average, of solid wastes per day, out of the above mentioned refuse quantities, emanate from the vessels that dock at the port. It must be mentioned that part of the solid wastes, consisting of wood packaging and paper cartons, are usually evacuated by labourers of the port or the truck drivers and their assistants to be re-used.

Domestic liquid waste generated at the port, from workers, enters the Tema centralised sewage system. An average of 1740 people enters the harbour (fishing and commercial) everyday. The estimated minimum amount of liquid waste generated by these persons is 3480 gallons per day.

With regards to the sewage from the vessels, the GPHA makes an average of 4 trips per month at the request of the vessels' officials. The waste is siphoned into cistern trucks and sent to the Tema Manhean (Paradise Beach) Liquid Waste Dumping Site. Each trip evacuates an average of 2 tons, and the TMA charges ¢ 15000 per trip.

There are no reception facilities for handling waste oil and oily bilge water from ships. This has led to oily waste waters being discharged by ships into the harbour waters and this is particularly significant in the fishing harbour. Occasionally waste oils from ships are collected by local contractors for use ashore in preparation wood preservatives.

3.5.8 Fishing Industry

There is also a fishing harbour located east of the main (commercial) harbour. The fishing harbour caters for both inshore boats and large fishing trawlers and purse seine vessels. The Tema fishing harbour until recently, practically handled all the country's fish imports and exports. Presently part of the country's fish imports is handled by the Sekondi (Bosomtwi Sam) Fishing Harbour.

The following information on the fleet provides an indication of the number of people involved in this type of business.

The Ghanaian marine fishery is classified in four sectors: canoe (artisan) fisheries, inshore fisheries, distant water fisheries and the tuna bait-boat fisheries. The artisanal sector of the industry accounts for over 70 % of marine fish production annually and has dominated the Ghanaian fishing industry over the decades. There are over 8000 of these canoes in Ghana. In the Tema sector there are over 1800

canoes, of which approximately half are motorised by low powered out-board engines, operated by over 3800 fishermen.

The inshore fishery consists of medium to large sized motorised vessels of between 8 and 30 meters. The majority of these semi-industrial boats are wooden, built locally, and fitted with inboard engines of up to 400 hp. They are dual-purpose vessels (purse seine/trawler) and are used for purse seining, mainly during the months of July to September, which coincide with the up welling period, and trawling for the remaining part of the year.

There are presently approximately 48 semi-industrial vessels involved in this sector of the fishing industry. Industrial or distant water vessels of the marine fisheries use imported steel vessels for fishing.

The tuna fishery fleet comprises about 30 vessels. Their target species are mainly the skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacores*) and big-eye (*Thunnus obesus*).

Exploitation of these resources is mainly offshore and anchovy is commonly used by the bait-boats to capture the tunas. Purse seining is also employed in tuna fishing.

Subsistence and commercial fishing is a significant activity along the Ghanaian coast with the Tema district being of prominence.

The major fishing harbour within the district and the industrialised township has enabled the fishing activities and other ancillary trades such as boat building and repair, fish processing plants and small-scale trading as means of employment to thrive satisfactorily. The Tema district comprises three major fishing villages namely Kpone to the East, Tema in the central, and Sakumono to the West. Fishermen number approximately 4800 within the district. This district contributes approximately 27 % of the national fish production with the artisan sector contributing about 20 % in the Greater-Accra region.

3.5.9 Land Use

GPHA has already owned the extensive land area for the port development. The immediate coastal land area provides space for port-related activities, such as storage and car parking in the west to the Port. On the eastern side of the Port, i.e. neighbouring to the fishing harbour, there is an extensive beach that is being used as a fish dry field by local fishermen. Residential area and the industrial zone appear immediately beyond the boundary of the Port area.

Chapter 4 Assessment of Impact

Fourteen (14) environmental elements needed to be assessed on the impacts, as shown in the TOR for EIA. The impacts on these elements were identified for every phase of the project, i.e. preparation phase, construction phase and operation phase. Every activity likely to have impacts on the environment was listed up and its environmental impacts were evaluated. The result is summarized in Table 4.1.1.

It is not realistic for the port development to assume demolishing port structure. When demolition becomes necessary, it will be to implement the further development of the port. In the present study, therefore, the demolition phase was not considered. Instead, impacts of the demolition of existing facilities during the construction phase were taken into account.

In Table 4.1.1, the significance of the environmental impact was evaluated from the viewpoint of "Importance" and "Magnitude". "Importance" was classified into five (5) ranks positively or negatively (second row of Table 4.1.1). The classification was based on the following points of view:

- How local people and/or port workers value the environmental element to be affected.
- Whether or not the environmental element has a value of national/regional/global level which the local people are not aware of.
- Whether or not improving the situation of the environmental element leads the poverty reduction in the local community.

Thus, "Importance" is the property of the environmental elements for local people, port workers and other relevant persons/parties/organizations, regardless of the contents and scale of the development activity involved.

"Magnitude" was also classified into five (5) ranks (top of each cell of Table 4.1.1). Criteria for the classification include the followings:

- Degree and/or scale of the impact on the environmental element
- Whether the impact is temporal, residual or permanent.
- Whether the impact is reversible or irreversible.

Thus, "Magnitude" is determined through the extent of the environmental alteration by the proposed development activity.

Finally, the evaluation of the significance of the environmental impact was made multiplying "Importance" by "Magnitude". The obtained values were put on the bottom of each cell of Table 4.1.1.

Justification on the ratings for each element is shown below.

- Progress of air pollution (AP): Although, Ghana has an Environmental Quality Standard for air quality, air pollution is still causing various health hazards and nuisance and is a major concern for the local people.
- Progress of water pollution (WP): Despite the poor water quality in the Tema port basin and the surrounding coastal waters, no Environmental Quality Standards for recipient water has yet

been established in Ghana. Local people do not show the concern on the seawater quality.

- Bottom sediment pollution (SP): Though the local people might be unaware of sediment pollution, high concentration of heavy metal substances have been recorded in the port area, which could potentially have an adverse affect on the health of local residents through biological accumulation.
- Noise generation (Noi): Noise is not a major concern for the local people as yet, with GPHA receiving no noise complaints so far. However, noise level in the port area occasionally exceeded the Ghana Environmental Quality Standards.
- Odor generation (Odr): Odor-related complaints from local residents and port workers are uncommon, though odor is obviously detectable when a lot of wastewater flows into the existing port basin..
- Progress of Erosion (Ero): Tema Port is located in the active littoral drift zone facing the open ocean.
- Deterioration of Fauna/Flora (F/F): A Ramsar site (Sakumo Ramsar Site) has been set up neighboring west to Tema Port. This lagoon should be of regional value.
- Promotion of Economic Activities (EA): The livelihood of the local people is intimately linked to the presence of the port. The local people are engaged in various forms of port related activities, which could either be directly or indirectly related. Indirect port related activities include manufacturing, repairing, transportation and fishing. Increased port activity will lead to the poverty reduction in Tema.
- Resettlement (RES): Resettlement of port facilities could disturb the efficiency of port workers.
- Development of Infrastructure (INF): With many unpaved roads and inadequate sewage systems, improvement of infrastructure is a key issue among the local people. Improvement in the infrastructure will lead to the poverty reduction.
- Promotion of Fisheries (Fsh): Fisheries is an important industry for Tema and has contributed to the poverty reduction. A strong interest in fisheries exists among the local people.
- Rational Land Use (LU): Tema is a planned city and has a perspective of the future land use. Change in Land use should be under the control of local government.
- Waste generation (Wst): The importance of waste management is strongly emphasized in the Ghana EIA guideline, since many disposal sites are approaching its full capacity.
- Promotion of Public Health and Safety (HS): There is a strong interest in Public Health and Safety among the local people, but poverty reduction is their first priority.

Table 4.1.1 Environmental Impact Matrix

Element	AP	WP	SP	Noi	Odr	Ero	F/F	EA	Res	Inf	Fsh	LU	Wst	HS
Importance	-3	-1	-3	-1	-1	-2	-3	+5	-3	+5	+2	+1	-3	+2
Activity														
Preparation Phase (no activity)														
Construction Phase														
Dredging & other marine works		2 -2	0 0	1 -1							0 0		1 -3	
Construction machines, and vehicles/vessels	1 -3	0 0		1 -1				2 +10			0 0		1 -3	-1 -2
Reclamation	1 -3	1 -1					0 0				0 0		-1 +3	
Demolition of existing facilities	1 -3			1 -1					0 0				1 -3	
Employing construction workers		1 -1						3 +15					2 -6	
Operation Phase														
Altered port configuration		0 0	2 -6			1 -2					0 0			
Increased ship-call		0 0						2 +10			0 0		2 -6	
Increased cargo-handling	0 0	0 0		2 -2	0 0			2 +10					2 -6	0 0
Increased port workers		0 0						3 +15					2 -6	
Port-associated development										2 +10				
Rearrangement of facilities							0 0					0 0		
Increased land transportation	1 -3			3 -3			2 -6	2 +10						-1 -2
Demolition Phase (not applicable)														

AP: Progress of air pollution

WP: Progress of water pollution

SP: Bottom sediment pollution

Noi: Noise generation

Odr: Odor generation

Ero: Progress of Erosion

F/F: Deterioration of Fauna/Flora

EA: Promotion of Economic Activities

Res: Resettlement

Inf: Development of Infrastructure

Fsh: Promotion of Fisheries

LU: Rational Land Use

Wst: Waste generation

HS: Promotion of Public Health and Safety

top: Magnitude of impact

bottom: Significance of impact

(importance × magnitude)

4.1 Air Quality

Since Tema area has an intensively accumulated industrial area, it has suffered from air pollution resulted from gas emission and dust generation. The evaluation of impact on the air quality, therefore, was done on the concentrations of gas and dust by port construction and operation activities.

4.1.1 Construction Phase

The construction activities that give rise to gas and dust generation include the followings:
- Activity of dump truck, bulldozer and other machines
- Landfill
- Demolition of wharves and docks

At the peak time of the construction work, it is presumed that three (3) dump trucks, three (3) bulldozers and a few other machines will be operated at the same time. The presumed impact of these machines will be small, and considering the present situation of the dust concentration (Table 3.3.6), it will meet the permissible level of Environmental Quality Standards.

Landfill and demolition of existing facilities would have a smaller impact of dust generation. Because landfill will use dredged wet materials, it will result in small amount of dust. Demolition will generate dust only momentarily.

4.1.2 Operation Phase

(1) Methodology

Impact of the future port activity on the air quality was evaluated using the method shown in Figure 4.1.1. In this analysis, all the impacts caused by increased ship-call, cargo-handling and land transportation were considered together.

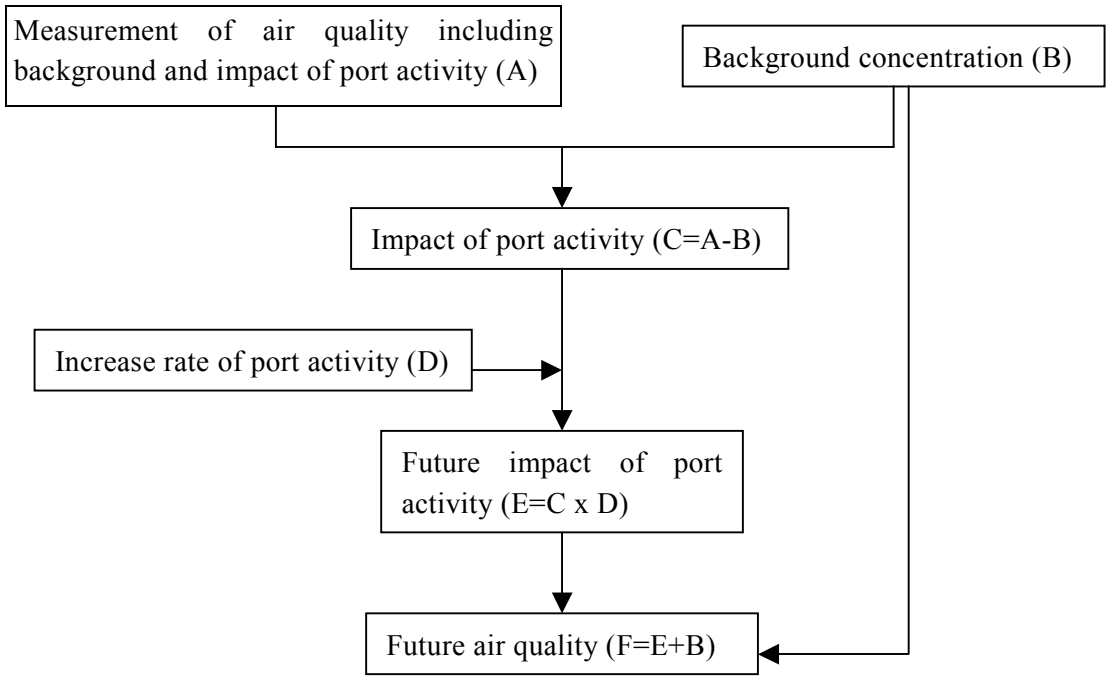


Figure 4.1.1 Flow chart of air quality modeling

1) Measurement at survey site (A). Background concentration also measured at a site with no impact of port activity (B).
2) Present impact of port activity on air quality calculated by subtracting the background concentration from the measured air quality value (C).
3) Future impact of port activity on air quality then estimated by multiplying the rate of emission increase to the magnitude of impact obtained in 2) (E).
4) Future air quality concentration obtained by adding the value in 3) to the background concentration (F).
5) Figures of annual cargo-handling volume were used to obtain (D).

(2) Application of Air Quality Model to Tema Port

(a) Present Impact of Port Activity on Air Quality

Present impact of port activity on the air quality was calculated by subtracting the background concentration from the measured air quality value (see Table 3.3.6). The value of St. 9 was set as the background concentration. Present impact of port activity was obtained as shown in Table 4.1.2.

Table 4.1.2 Present Impact of Port Activity on Air Quality in Tema Port

($\mu g/m^3$)

Site	1	2	3	4	5	6	7	8	9 (BG)
TSP(1hr)	5.3	27	-	-	83.3	-	4	-	10
PM_{10} (1hr)	1.17	2.4	1.43	2.2	2.43	2.37	1.17	0.1	0.70
SO_2 (8hr)	12.6	4.33	2.23	1.8	1.7	1.41	8.53	0.56	0.67
NO_2 (8hr)	0.86	0.43	0.43	0.23	1.16	-	0.63	-	0.27

BG: Background Concentration

2) Increase Rate of Future Activity

Based on the annual cargo volume, intensity of future port activity was estimated by the following formula.

$I = (Vf / Vp) \times \alpha \times \beta$

Where, I: Increase rate
Vf: Annual cargo volume in 2010
Vp: Annual cargo volume in 2000
α : Monthly change rate (monthly peak transportation / monthly average transportation
β : Daily change rate (daily peak transportation / daily average transportation)

Vf / Vp = 10,126,771 tons / 6,001,643 tons = 1.69 (see Table 14.1.1 of Main Report)
α = 589,709 / (5,980,403 / 12) = 1.18 (Table 4.1.3)
β = 541 / 318.7 = 1.70 (see Table 3.5.3)
I = 1.69 x 1.18 x 1.70 = 3.39

For β , road traffic data of trailers/trucks (Table 3.5.3) were used as an indicator of diurnal fluctuation of port activity.

Table 4.1.3 Monthly Change Rate (α) of Transportation in Tema Port

Months	Monthly Transportation (Ton)
January	505,366
February	365,351
March	434,592
April	589,709
May	465,183
June	532,855
July	496,892
August	583,077
September	525,809
October	459,283
November	467,852
December	554,434
Total	5,980,403
Monthly ave. transportation (A)	498,367
Monthly peak transportation (B)	589,709
α (B/A)	1.18

Source: GPHA

Increase rate of 3.41 was applied for all eight (8) survey points in the estimation of the air quality.

3) Future Impact of Port Activity

Future impact of port activity on air quality was estimated by multiplying the increase rate and present impact obtained in Table 4.1.2. Calculated future impact is shown in Table 4.1.4.

Table 4.1.4 Future Impact of Port Activity on Air Quality in Tema Port

($\mu g/m^3$)

	1	2	3	4	5	6	7	8
TSP(1hr)	17.97	91.53	-	-	282.39	-	13.56	-
PM_{10} (1hr)	3.97	8.14	4.85	7.46	8.24	8.03	3.97	0.34
SO_2 (8hr)	42.71	14.68	7.56	6.1	5.76	4.78	28.92	1.9
NO_2 (8hr)	2.92	1.46	1.46	0.78	3.93	-	2.14	-

4) Future Air Quality Concentration

Rising gas and dust concentration may have an adverse impact to port workers. Estimated ambient air quality in 2010 is shown in Table 4.1.5. Environmental Quality Standards (EQS) has set the TSP and PM_{10} values for industrial area as 24-hr value or 1-yr value, and SO_2 and NO_2 values for 1-hr value or 24-hr value. The estimation is based on the 1-hr value for particles and 8-hr value for gases, thus immediate comparison is not reasonable. Considering the fact that the ratio of 1-hr value to 24-hr value falls into 3:1 to 4:1 and 8-hr value to 24-hr value of 2:1 in most cases of environmental standards of various countries, the assumed EQS (1 hr) would be as follows: TSP: about 700 $\mu g/m^3$, PM_{10}: about 250 $\mu g/m^3$, SO_2: about 300 $\mu g/m^3$, NO_2: 200 – 250 $\mu g/m^3$. All the

obtained air quality (1-hr or 8-hr) values will meet the EQS.

Table 4.1.5 Estimated Air Quality in Tema Port (2010)

(μ g/m^3)

	1	2	3	4	5	6	7	8
TSP(1hr)	27.97	101.53	-	-	292.39	-	23.56	-
PM_{10} (1hr)	4.67	8.84	5.55	8.16	8.94	8.73	4.67	1.04
SO_2 (8hr)	43.38	15.35	8.23	6.77	6.43	5.45	29.59	2.57
NO_2 (8hr)	3.19	1.73	1.73	1.05	4.20	-	2.41	-

4.2 Water Quality

4.2.1 Construction Phase

The following activities will affect the water quality in and around the port area:
- Dredging and other marine works will generate turbid water.
- Work boats will discharge bilge and other waste water.
- Reclamation work will squeeze turbid water to the receipt water area.
- Construction workers will generate waste water through the daily life.

Among these, dispersion of turbid water caused by dredging activity seemed to have the most significant impact. The suspended solid (SS) concentration, therefore, was predicted using hydrodynamic and diffusion modeling.

(1) Methodology

Tidal currents of Tema Port are modeled by numerical model of hydrodynamics. The model describes time-varying water levels and depth-averaged circulation of seawater. This type of model is appropriate for Tema Port area because vertical gradients of physical properties are relatively small. The basic equations of the model are:

<Equation of Continuity>

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0 \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (1)$$

<Equation of Motion>

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial z}-fv=-\frac{1}{\rho_0}\frac{\partial p}{\partial x}+\frac{\partial}{\partial z}\left(K_M\frac{\partial u}{\partial z}\right)+F_X \quad \cdots\cdots\cdots\cdots \quad (2)$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial v}{\partial z}+fu=-\frac{1}{\rho_0}\frac{\partial p}{\partial y}+\frac{\partial}{\partial z}\left(K_M\frac{\partial v}{\partial z}\right)+F_Y$$

Transport and diffusion of contaminants are modeled by numerical model of diffusion. The diffusion model describes the movement of contaminants based on the current field obtained by the hydrodynamic model. The basic equation of the model is:

<Equation of Diffusion>

$$\frac{\partial S}{\partial t}+u\frac{\partial S}{\partial x}+v\frac{\partial S}{\partial y}+w\frac{\partial S}{\partial z}=\frac{\partial}{\partial z}\left(K_H\frac{\partial S}{\partial z}\right)+F_S \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (3)$$

where,

x, y, z	: right hand coordinate
u, v, w	: x, y, z component of currents [cm/s]
p	: pressure [g/cm/s^2]
f	: Coriolis parameter[1/s]
ρ_0	: representative density [g/cm^3]
K_M	: eddy viscosity [cm^2/s]
K_H	: eddy diffusivity [cm^2/s]
F_X, F_Y	: other forces [cm/s^2]
S	: concentration [mg/L]
F_S	: loads [mg/s]

(2) Application of Hydrodynamic Model to Tema Port

Hydrodynamic model was applied to Tema Port for the present condition and Y2010 condition. The data used for the model are shown below.

- Model area: 8000 m by 6000 m (see Figure 4.2.1)
- Grid size: 100 m
- Bathymetry: Bathymetry was set up based on the marine chart updated in Y2000. Present condition is shown in Figure 4.2.2 and Y2010 condition is shown Figure 4.2.3. Y2010 condition adds two changes to the present condition. They are 1) new construction of container yard and 2) remove and new construction of breakwaters.
- Boundary conditions:
  1) Water levels on open boundaries were forced by semidiurnal oscillation (M_2) of 49 cm observed in Tema (Admiralty Tide Tables Vol. 2, 1999).
  2) River discharges and surface runoff were set as shown in Figure 4.2.4 estimated from the average precipitation.
  3) Wind frictions were included in F_X, F_Y based on the average summer wind condition of SW 6.0 knot (Meteorological Services, Tema, 1990-99).

(3) Results of Hydrodynamic Model

Current vectors are shown in Figure 4.2.5 for the present condition and in Figure 4.2.6 for Y2010 condition. Eastward or northward currents dominated in both rising tide and ebb tide due to SW wind conditions. Tidal currents were relatively small and dominantly found near the mouth of Tema Port due to water exchange between breakwaters. Validation of the results by field survey data is expected if the data are available.

(4) Application of Diffusion Model to Dredging Impact Assessment

Dredging impacts to suspended solid (SS) concentrations during dredging works were predicted by the diffusion model.

Pollution loads of SS by dredging works were estimated based on the following conditions.

- 200,000 m^3 of sediment is dredged per month. 400,000 m^3 as a total of two months.
- 24 hour operation everyday
- One suction dredger of 3,000 to 6,000 horsepower operates
- Silt screen is used to reduce impacts

Based on the conditions, pollution loads were estimated as 8,014 kg/day referencing unit loads of similar dredger in Japan. Settling velocities were estimated for three ranges by Stokes law based on grain size distributions obtained at sampling locations in Figure 3.3.1. The grain size distributions are shown in Figure 4.2.7. The estimated settling velocities are shown in Table 4.2.1.

Table 4.2.1 Settling Velocities

Range	Grain size (mm)	Settling velocity (m/h)
Range 1	0.01 to 0.1	0.28
Range 2	0.1 to 1.0	28
Range 3	1.0 to 10.0	2800

(5) Results of Diffusion Model on Dredging Impacts

Predicted SS distributions are shown in Figure 4.2.8. The result suggested the impacts would be very limited to nearby dredging points mainly due to large settling velocities of the sediments. The mud particle to be diffused, however, is contaminated with heavy metals (lead and mercury). This requires special attention to minimize the diffusion.

Other impact than dredging would be smaller taking the situation of severely polluted seawater in the coastal area into account.

4.2.2 Operation Phase

In the operation phase, increased ship-call, cargo-handling and port workers will give more pollution load to the sea than the present. Altered port configuration may also effect on the water quality distribution. Considering all these imapcts, a diffusion model was employed to predict the future water quality distribution, based on the results of the hydrodynamic model introduced in the previous section.

(1) Application of Diffusion Model to Impact Assessment of Port Extension

Impacts of port extension to key water quality parameter, COD, were predicted by the diffusion model. Two cases were considered to estimate impacts: 1) present condition and 2) Y2010 condition. Impacts were expressed by difference of the two cases.

Pollution loads of COD from coasts were estimated as below based on field reconnaissance in the study and existing statistics. Discharge location numbers correspond to those in Figure 4.2.4.

Table 4.2.2 Pollution Loads of COD (unit: kg/day)

Location	Present	Y2010
Sakumo Lagoon	4,299	4,299
River in North	730	730
Port Area	413	466
East Area	45.4	45.4

(2) Results of Diffusion Model on Impacts to COD

Predicted COD distributions are shown in Figure 4.2.9 for the present condition and in Figure 4.2.10 for Y2010 condition. Field survey data in the study are plotted in Figure 4.2.9 for comparison. The data ranged more than 200 % within 1 km and showed lower values (15.7 mg/L) inside the port and close to the coast. This suggested the possibility of polluted water from offshore. The simulated distribution corresponded such trend.

Compared with the simulated present distribution, the predicted Y2010 distribution changed in east of the port. This is considered due to the dominant eastward currents shown in Figures 4.2.5 and 4.2.6.

To highlight impacts of port extension, the difference between the simulated present values and Y2010 values (Y2010 - present) was obtained as shown in Figure 4.2.11. COD values decreased in western side of the extended breakwater and increased offshore although pollution loads from the coast increased in Y2010. This suggested the extension of the breakwater would reduce the

intrusion of offshore water of high COD concentration and prevent the port basin from the progress of the water pollution.

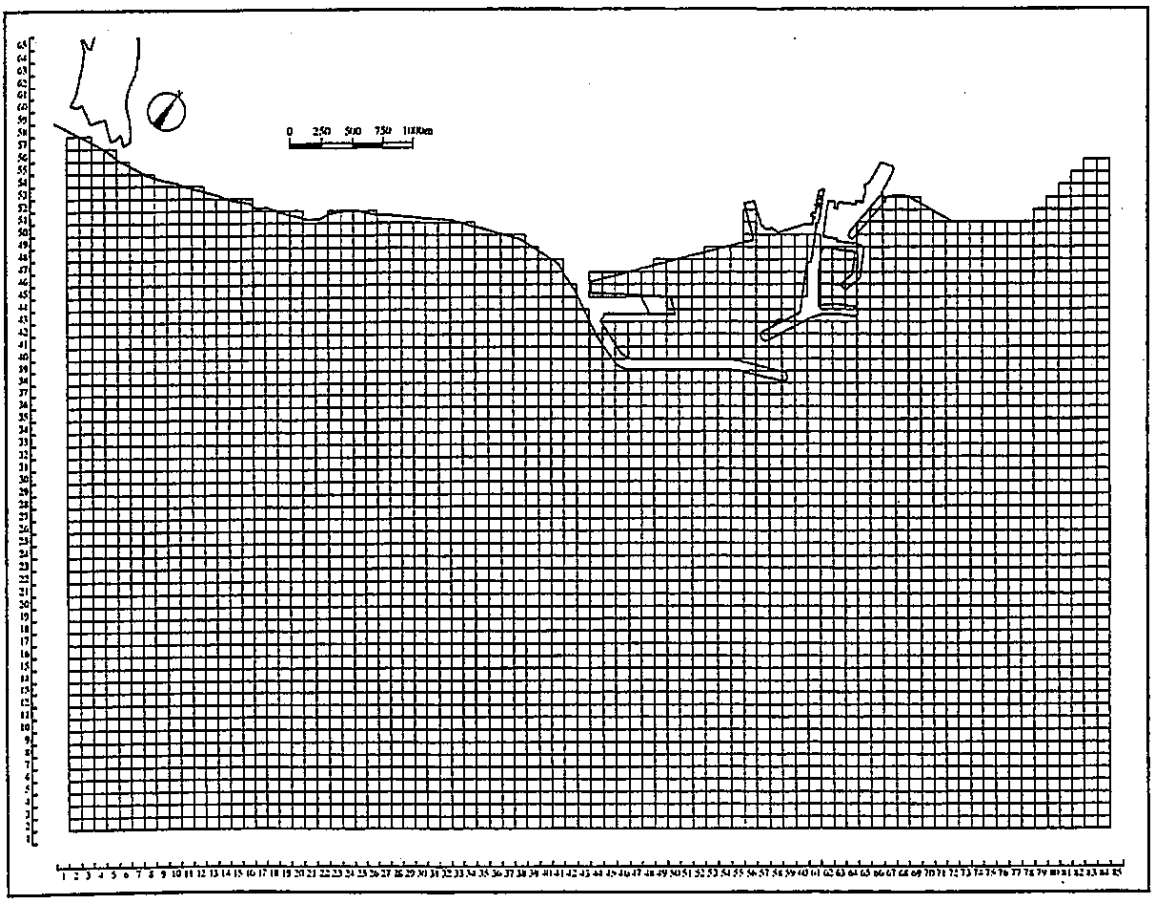


Figure 4.2.1 Model Area

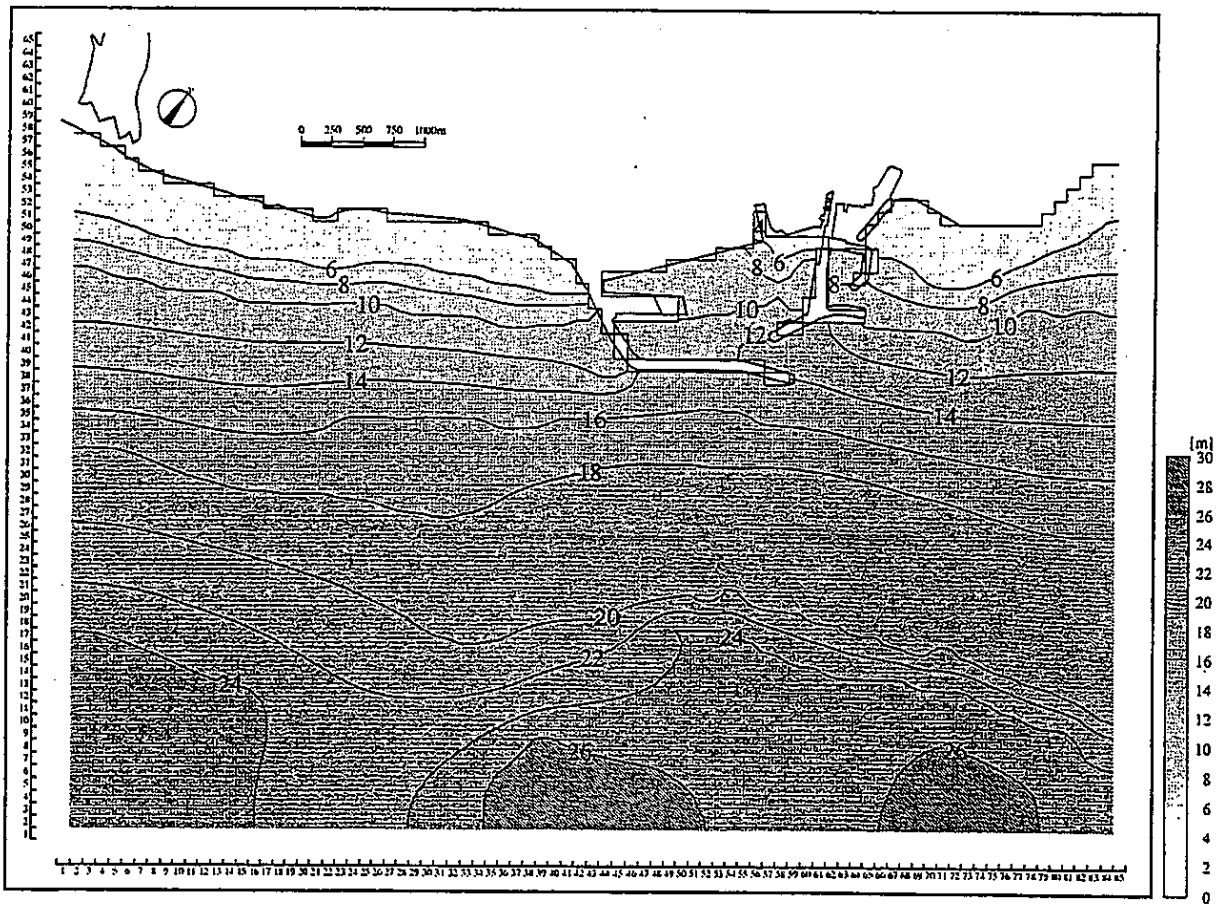


Figure 4.2.2 Bathymetry (Present)

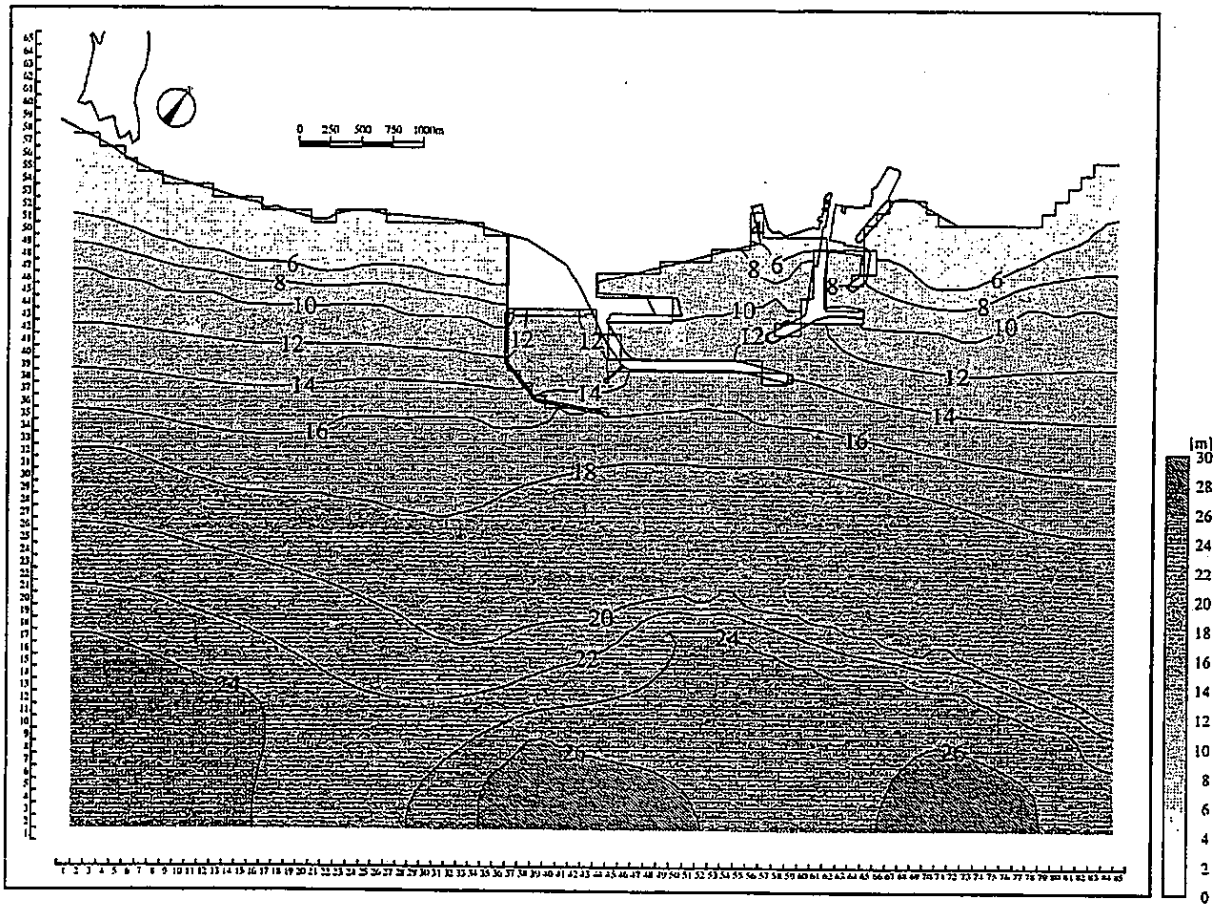
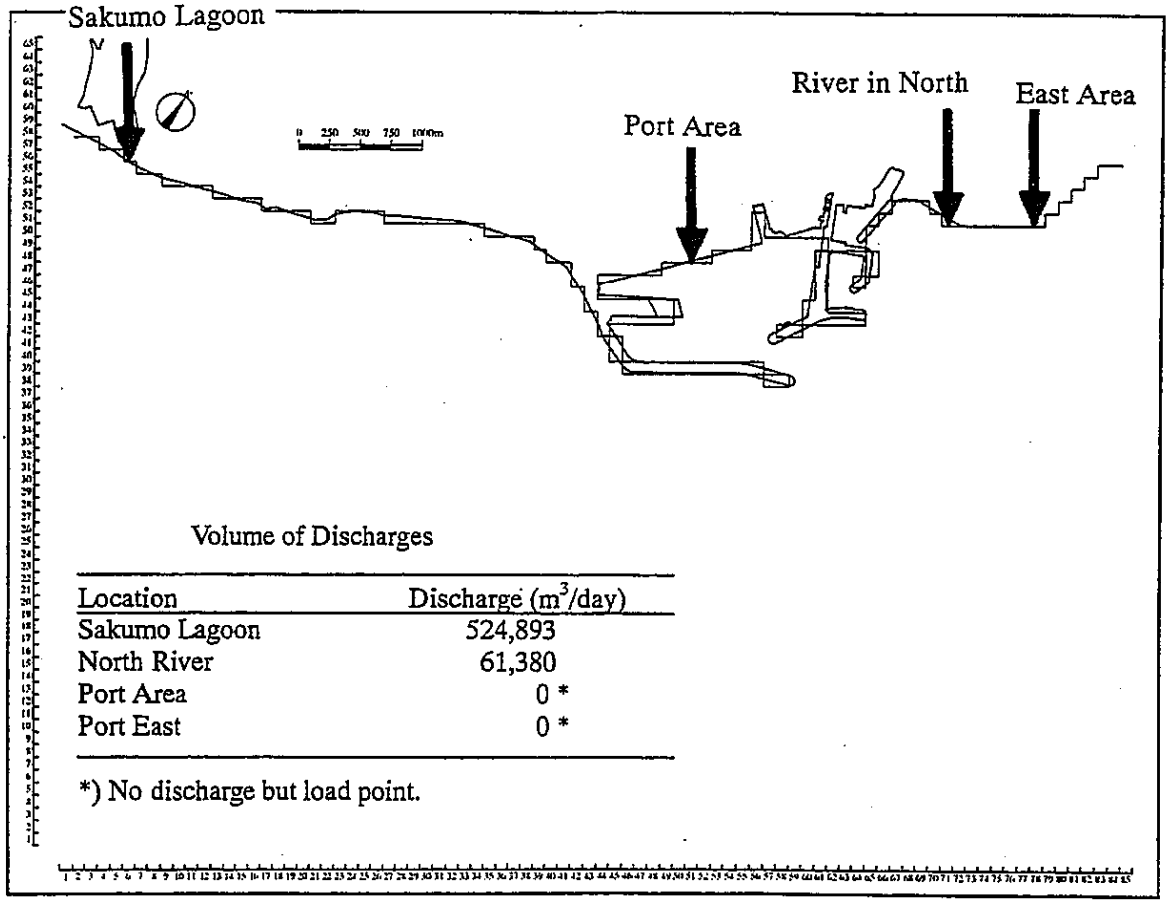


Figure 4.2.3 Bathymetry (Y2010)



Volume of Discharges

Location	Discharge (m^3/day)
Sakumo Lagoon	524,893
North River	61,380
Port Area	0 *
Port East	0 *

*) No discharge but load point.

Figure 4.2.4 River Discharges and Surface Runoff

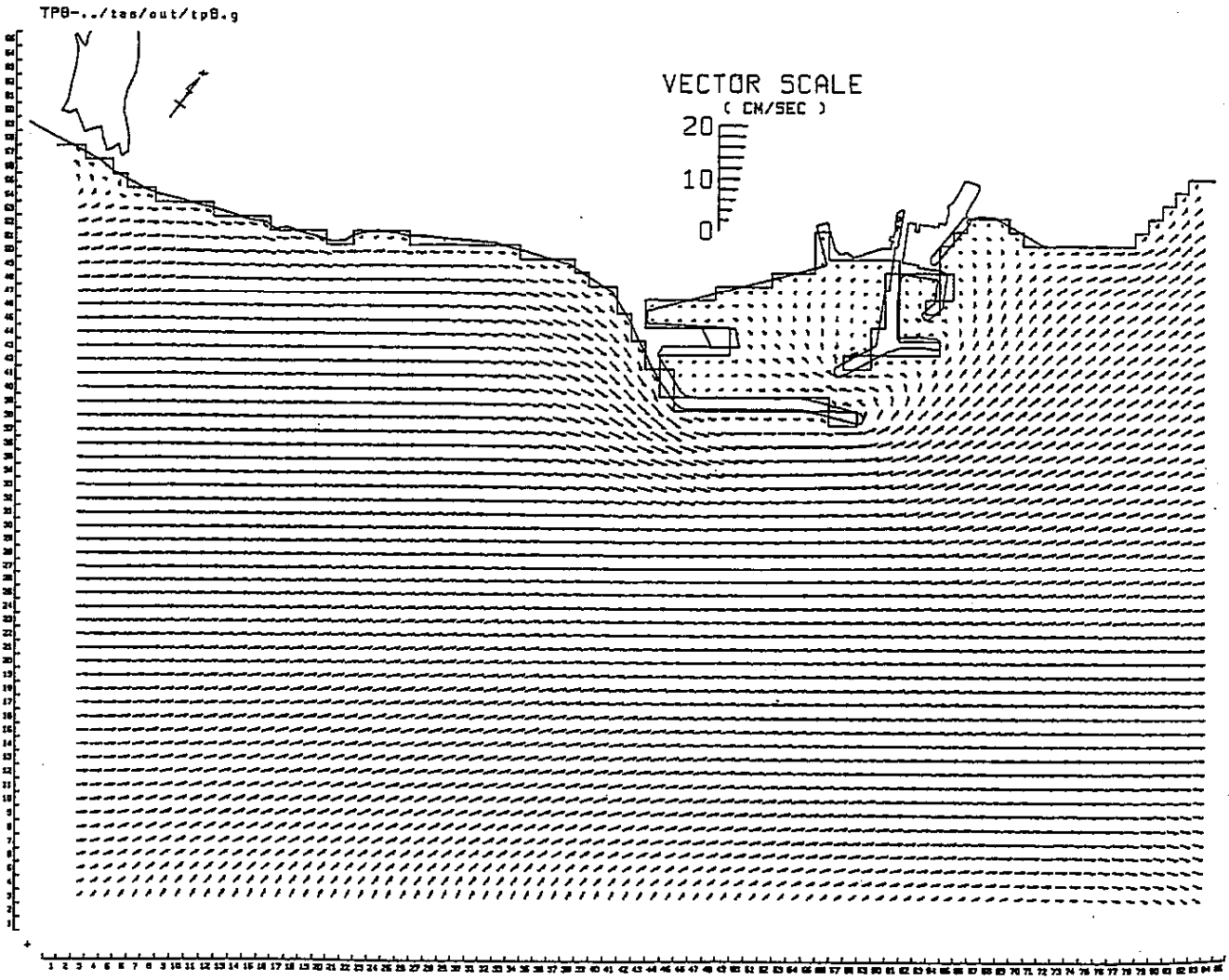


Figure 4.2.5(1) Simulated Current Vectors of Rising Tide (present)

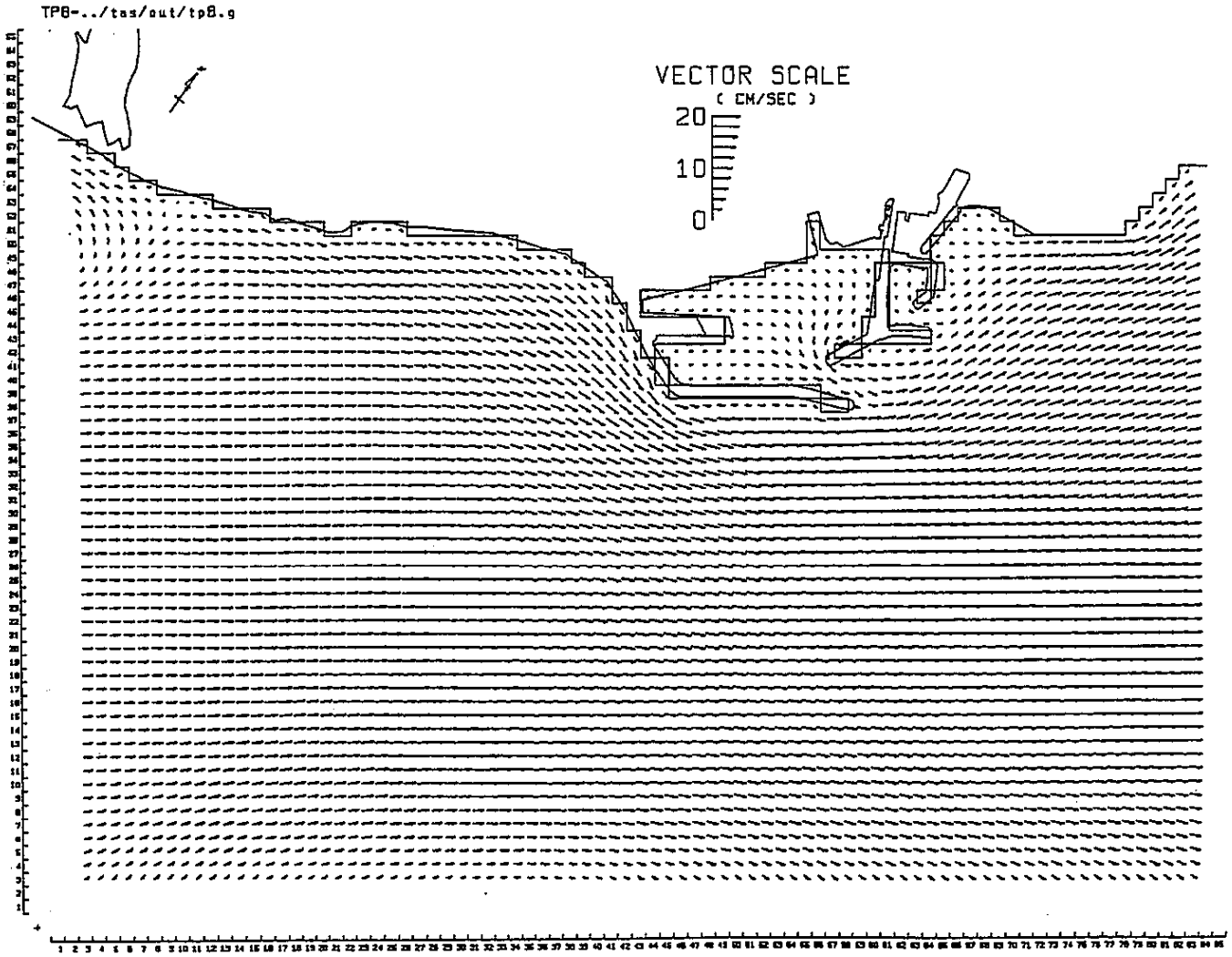


Figure 4.2.5(2) Simulated Current Vectors of Ebb Tide (present)

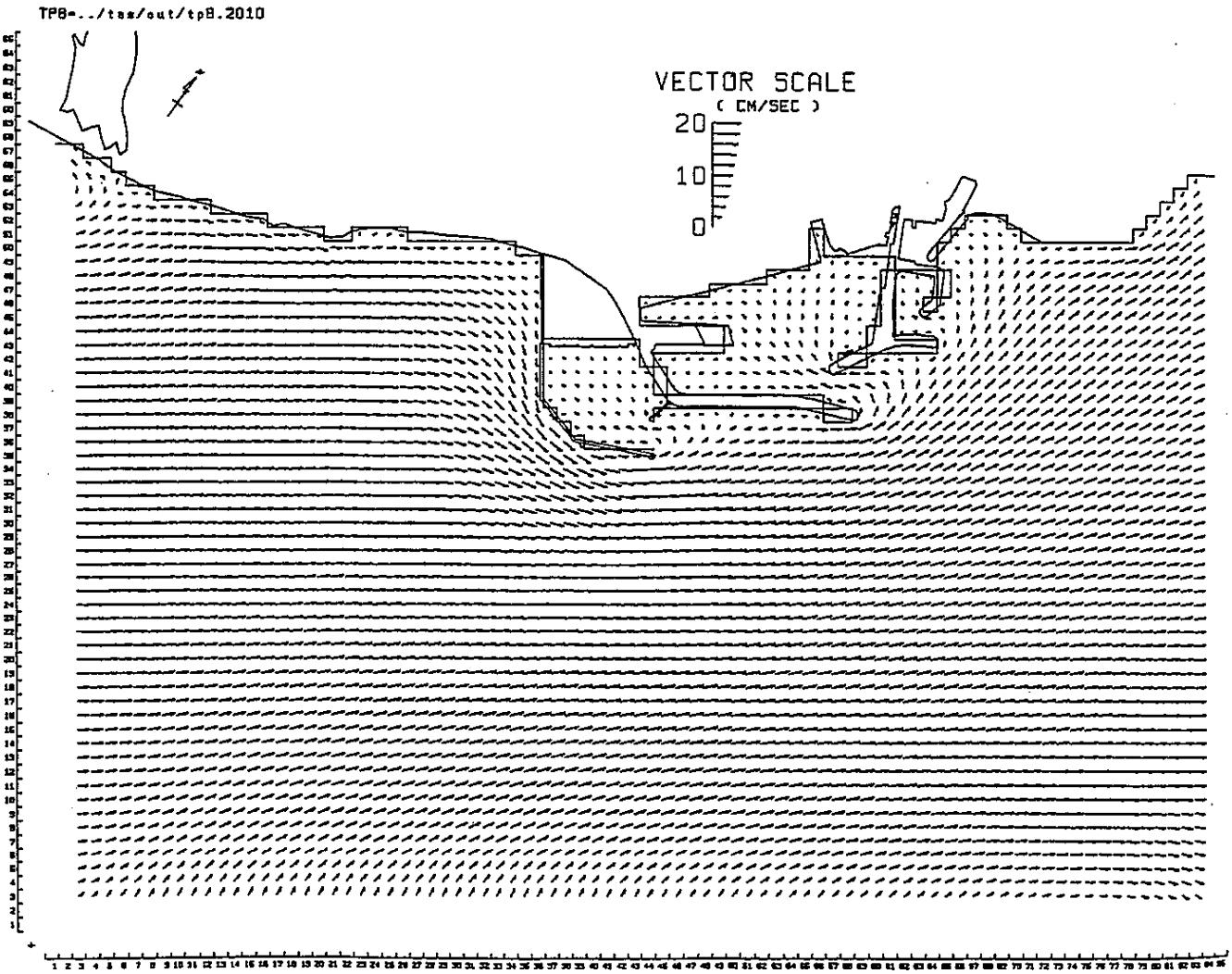


Figure 4.2.6(1) Predicted Current Vectors of Rising Tide (Y2010)

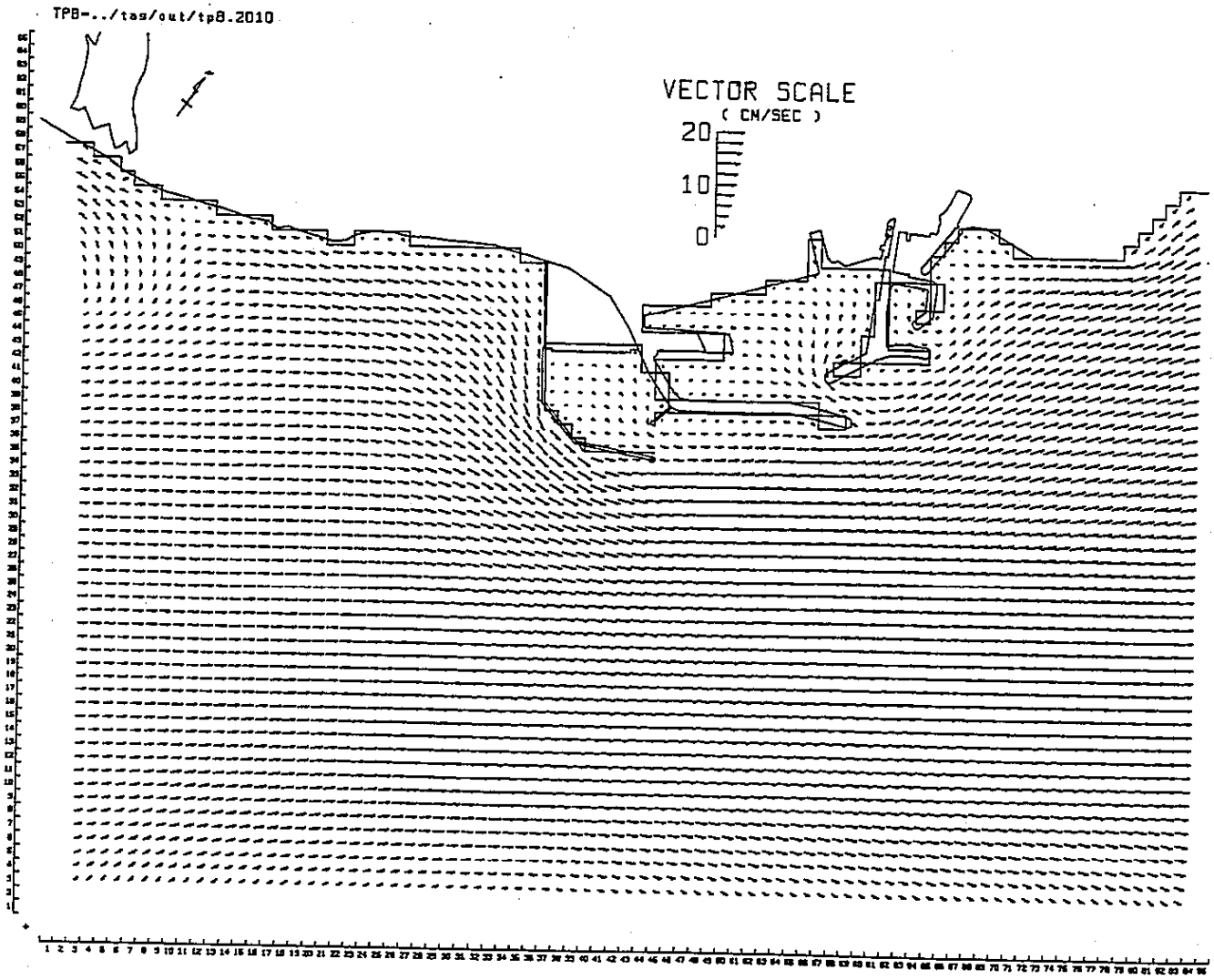


Figure 4.2.6(2) Predicted Current Vectors of Ebb Tide (Y2010)