Japan International Cooperation Agency (JICA)
Ghana Ports and Harbours Authority

NO.

FINAL REPORT

VOL. 3 SHORT-TERM DEVELOPMENT PLAN FOR TAKORADI PORT

THE DEVELOPMENT STUDY OF GHANA SEA PORTS IN THE REPUBLIC OF GHANA

February 2002

The Overseas Coastal Area Development Institute of Japan (OCDI)
NIPPON KOEI CO.,LTD.

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Short-term Development Plan - Takoradi Port -

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List of Abbreviations

AEC	Assumed Environmental Criteria
ASEAN	Association of Southeast Asian Nations
B/L	Bill of Lading
BOD	Biochemical Oxygen Demand
BOR	Berth Occupancy Ratio
BOT	Built-Operate-Transfer
BRV	Bulk Road Vehicles
BU	Bulk Carrier
C.D	Chart Datum
CEPS	the Customs Exercise and Preventive Service
CFS	Container Freight Station
CIF	Cost, Insurance and Freight
CM	Container/Multipurpose Carrier
CO	Container Cellular Vessel
COD	Chemical Oxygen Demand
CRMS	Computerized Risk Management System
CT	Container Terminal
CY	Container Yard
DO	Dissolved Oxygen
DO	Delivery Order
DR	Dock Receipt
DWT	Dead Weight Tonnage
EDI	Electric Data Interchange
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EPZ	Export Processing Zone
FEU	Forty-foot Equivalent Unit
FOB	Free On Board
GAFCO	Ghana Agro-Food Company
GBC	Ghana Bauxite Company
GC	General Cargo Carrier
GDP	Gross Domestic Product
GEPC	Ghana Export Promotion Council
GFZB	Ghana Free Zones Board
GHATIG	Ghana Trade and Investment Gateway Project
GPHA	Ghana Ports and Harbours Authority
GRC	Ghana Railway Corporation
GT(GRT)	Gross Tonnage
H1/3	Significant Wave Height
HWL	High Water Level
IALA	International Association of Lighthouse Authority
IAPH	International Association of Ports and Harbors
JICA	Japan International Cooperation Agency

KIA	Kotoka International Airport
KN	Kilo Newton (=0.102 tf)
L0	Wave Length
LOA	Length Overall
LWL	Low Water Level
MHWN	Mean High Water Neap
MHWS	Mean High Water Spring
MLWN	Mean Low Water Neap
MLWS	Mean Low Water Spring
MOF	Ministry of Finance
MOFA	Ministry of Food and Agriculture
MOL	Mitsui O.S.K Line
MORT	Ministry of Road and Transport
MPa	Mega Pascal (=N/mm2)
MR	Mate's Receipt
NCA	National Communication’s Authority
NCP	New Container Platform (at Takoradi Port)
NEAP	National Environmental Action Plan
OCDI	Overseas Coastal Area Development Institute of Japan
OECD	Organization for Economic Co-operation and Development
OECF	The Overseas Economic Cooperation Fund
PIANC	International Navigation Association
RO	Ro-Ro Vessel
Ro/Ro	Roll on / Roll off
RTG	Rubber Tyre mounted Gantry crane (= Transfer crane)
S.F.	Safety Factor
SAPS	Special Assistance for Project Sustainability
SO	Shipping Order
SS	Suspended Solids
T1/3	Significant Wave Period
TDC	Tema Development Cooperation
TEU	Twenty-foot Equivalent Unit
TFCC	Tema Food Complex
TG	Tugboat
TK	Tanker
TMA	Tema Municipal Assembly
TOR	Tema Oil Refinery
UNCTAD	United Nations Conference on Trade and Development
VALCO	Volta Aluminium Company Limited
VLTC	Volta Lake Transport Company
VRA	Volta River Authority
WAG	West Africa Gas
WTO	World Trade Organization

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PART IV SHORT-TERM DEVELOPMENT PLAN FOR TAKORADI PORT

Chapter 16 Short-term Development Plan for Takoradi Port

16.1 Planning Requirement for Short-term Development Plan

16.1.1 Need of Strategy for Development

As explained in Chapter 14.1, Takoradi Port has advantages for future development and the port must make the most of its advantages to play its expected role. However, it must be remember that there are some negative factors which could hinder development. Specially, some of main cargoes such as sawn timber and manganese are not expected to increase as rapidly as before, ocean freight to/from the port is higher than that of Tema Port due to imbalance of volume of containerized cargo between import and export and economic activities have been more concentrated in Great Accra Region.

The short-term development plan, when it is implemented, will the first real expansion project since the 1950'. The development of the port from an export-oriented port of traditional goods to a modern comprehensive port depends on the plan. To make the plan practical, development strategy is very important.

Fortunately, as the port has basic cargoes, income from handling such cargoes will continue. Using this advantage, available resources should be concentrated on investment for facilities which are indispensable to future development of the port. As explained in Chapter 14.3.2, the most important project is the new container terminal planned at the inner port area. In the short-term development plan, the priority will be given to the new container terminal.

Dry bulk mining cargoes are also very important to the port. The mining companies are main users of the port and the port and mining companies have become prosperous side by side. Because of facility limitation at the port, mining companies have to endure higher transportation costs. It is beneficial to both the port and mining companies to develop deep bulk berths. Mining companies can save the transportation cost and the port can increase its revenue. And moreover, the appropriate combination of the new container terminal development project and the new deep bulk berth project will reduce the cost savings of both projects and expedite project implementation.

16.1.2 Future Cargo Demand

Future cargo demand was forecasted and the results are summarized in Table 16.1.1 and Table 16.1.2. Main cargoes in which volumes will increase their volumes are clinker, bauxite and container cargo.

Table 16.1.1 Future Cargo Demand Forecast in Takoradi Port

IMPORT	1991	2000	2010
Dry Bulk	413,040	891,815	1,258,530
Clinker	323,538	694,374	991,760
Liquid Bulk	92,284	157,012	224,787
Bagged Cargo	2,514	5,770	51,839
General Cargo	20,868	26,619	222,250
Containerized Cargo	20,610	62,102	509,022
Total	**549,316**	**1,143,318**	**2,266,428**

Export	1991	2000	2010
Dry Bulk	644,310	1,461,732	2,000,000
Bauxite	324,313	503,823	1,000,000
Manganese	319,997	929,296	1,000,000
Liquid Bulk	0	6551	8386
Bagged Cargo	106,772	70,368	21,944
General Cargo	292,888	102,658	37,517
Containerized Cargo	46,182	271,889	789,981
Total	**1,090,152**	**1,913,198**	**2,857,828**
Grand Total	**1,639,468**	**3,056,516**	**5,124,256**

Table 16.1.2 Future Container Cargo Demand Forecast at Takoradi Port

	1991	2000	2010
Import	4,422	15,387	66,894
Export	4,690	24,418	68,098
Transit			1,204
Total	**9,112**	**39,805**	**136,196**

16.2 Facility Requirement for Short-term Development Plan

16.2.1 Berthing Facilities

(1) Cargo Handling Productivity

As explained in chapter 13.4 and the development strategy mention above, new container berths and new bulk berths with deep depth have a higher priority among projects in the master plan. Therefore, the cargo handling productivity at 2010 for cargoes handled at multipurpose berths is set at the same level of that of the year 2000.

Table 16.2.1 Gross Cargo Handling Productivity at Takoradi Port in 2000 and 2010

Type	Commodity	Unit	Productivity 2000	Productivity 2010	Equipment 2010
IMPORT					
DB	Clinker/Gypsum	t/hour/vessel	270	600	Grab, Belt conver
DB	Wheat	t/hour/vessel	90	100	Grab, hopper
LB	Petro products	t/hour/vessel	80	80	Pipeline
BC	Rice, Fertilizer	t/hour/vessel	40	50	Multi. Crane/ship gear
GC	Cars, Steel product	t/hour/vessel	70	70	Multi. Crane/ship gear
GC	Chemical	t/hour/vessel	58	60	Multi. Crane/ship gear
RO	RoRo cargo	t/hour/vessel	68	70	RoRo ramp
CO	Container	box/hour/vessel	9	24	Container crane
EXPORT					
DB	Bauxite	t/hour/vessel	190	600	Loader, belt conveyor
DB	Manganese	t/hour/vessel	210	600	Loader, belt conveyor
DB	Cocoa beans	t/hour/vessel	70	100	Belt conver
BC	Cocoa beans	t/hour/vessel	30	50	Multi. Crane/ship gear
GC	S/Timber, Wood product	t/hour/vessel	30	50	Multi. Crane/ship gear
RO	RoRo cargo	t/hour/vessel	68	70	RoRo ramp
CO	Container	box/hour/vessel	9	24	Container crane

Note: Productivity of the year 2000 is calculated from vessel berthing data

(2) Vessel Size at Target Year

Based on analysis explained in Chapter 13.2.1, vessel sizes in the year 2010 are set as described in Table 16.2.2.

Table 16.2.2 Vessel Size at the Target Year 2010 at Takoradi Port

Vessel Type	2000		2010 (Standard Size)		
	Max.DWT (tons)	$DWT_{1/4}$ (tons)	DWT (tons)	Length (m)	Draft (m)
Bulk carrier	51,694	43,685	40,000	200	11.8
Cellular container	31,057	25,375	30,000	218	11.1
RO-RO	31,311	27,601	28,000	210	11.0

Note: $DWT_{1/4}$ means DWT of one fourths largest vessel

(3) Number of Berths Required

Number of berths by berth type required for the short-term development plan to meet future cargo demand is determined by the method explained in Chapter 13.2.1 and is checked by a computer simulation for vessel berthing. The result of required berth number by berth type is shown in Table 16.2.3.

A multipurpose berth with the depth of 12m will be constructed by improving existing Berth No.5, No. 6 and a part of Berth No.4. However, reclamation works for cargo handling area behind the berth will be done in the next stage to reduce the project cost. Even in the assumption of the present cargo handling productivity mentioned in Table 16.2.1 the new multipurpose berth and other conventional berths have the capacity to handle conventional cargoes in 2010 except mineral bulk cargoes and petroleum products.

Table 16.2.3 Scale of New Berths for Short-term Development Plan of Takoradi Port

<table>
<tr><th>Berth</th><th>Commodity</th><th>Number</th><th>Depth</th><th>Length</th></tr>
<tr><td>Manganese Berth</td><td>Manganese</td><td>1</td><td>12m</td><td>200m</td></tr>
<tr><td>Bauxite Berth</td><td>Bauxite</td><td rowspan="2">1</td><td rowspan="2">13m</td><td rowspan="2">230m</td></tr>
<tr><td>Clinker Berth</td><td>Clinker</td></tr>
<tr><td>Container Berth</td><td>Container</td><td>1</td><td>12m</td><td>300m</td></tr>
<tr><td>Multi-purpose Berth</td><td>Break bulk, wheat etc.</td><td>1</td><td>12m</td><td>300m</td></tr>
<tr><td>Total</td><td></td><td>4</td><td></td><td></td></tr>
</table>

16.2.2 Water Facilities

(1) Approach Channel

As explained in the master plan, width of the approach channel is set at 160m and depth is 13m.

(2) Turning Basin

Turning basins are to be located in front of new berths and have a diameter of two times the overall length of design vessel.

16.2.3 Breakwater

The breakwater is extended by 400m to satisfy the criteria that the non-excess probability under 0.7m in wave height be at least 95% in the case of bulk berths. The result of the non-excess probability under 0.7m in wave height in front of the new bulk berth is 95.9 %.

16.2.4 Storage Area

(1) Container Yards and CFS

One container berth with a sufficient container yard will be constructed. This container berth is the first dedicated container berth at the port. Details of the new container terminal are explained in chapter 17.4.

(2) Shed

The required dimensions of sheds were estimated using following formula for the storage of bagged cargoes and paper reels. Required area of sheds is calculated at 3,000 sq.m. As Shed No. 4 has the area of 3,600 m2, new sheds are not planned in the short-term development plan.

$$A = (\lambda \times \delta \times V / T) / (\mu \times (1 - \xi) \times \varepsilon)$$

Where、

V	:	149,611	Annual cargo throughput of conventional cargo (tons)
T	:	363	Annual working days
λ	:	1.5	Peaking factor to the daily average handling demand
δ	:	7	Average dwelling time (days)
μ	:	3.0	Unit load for storage (tons/sq. m)
ξ	:	0.4	Passage ratio
ε	:	0.75	Operational factor
A	:	3,005	Floor space (sq. m)

16.2.5 Road

(1) Access Road

The traffic volume generated by port activities is estimated by applying the following equation.

$$V = \upsilon / 24 \times \sigma / \delta / \varepsilon$$

Where,

υ	1,138	Number of trucks at peak day
σ	2.0	Variation ratio per hour
δ	0.2	Cargo related vehicle ratio
ε	0.5	Ratio of vehicle with load
V	949	Number of vehicles at peak hour

According to the estimated traffic volume, 4 lanes are required. Access Road 1 from the south gate to Axim Road passing by the railway station will be paved and widened for two heavy lorries to pass by each other. The triangular shaped square in front of the post office will be reshaped and traffic light will be installed, if necessary for smooth vehicle movement. As for inner port roads, a new port road will be constructed from the new container terminal to the south gate.

(2) Inner Harbour Road

The capacity of a two-lane inner harbour road between the main gate and the multipurpose berth is examined. The traffic volume generated by port activities is estimated by applying the following equation.

$$V = \upsilon / 24 \times \sigma / \delta / \varepsilon$$

Where,

υ	657	Number of trucks at peak day

σ	4.0	Variation ratio per hour
δ	0.7	Cargo related vehicle ratio
ε	0.5	Ratio of vehicle with load
V	313	Number of vehicles at peak hour

Although the estimated traffic volume requires 4-lane road, there is no space to expand the existing road. In the master plan the road will be improved. A new road with two lanes between the new container terminal and the south gate will be constructed.

16.3 Port Facility Layout Plan for Short-term Development Plan

Based on the analysis described above, port facility layout plan is formulated. Fig. 16.3.1 and 16.3.2 show the proposed layout. Table 16.3.1 shows the list of main facilities of the short-term development plan.

Table 16.3.1 List of Main Facilities for Short-term Development Plan of Takoradi Port

Facility	No.	Dimension / Capacity
Container Berth	1	Length 300m, depth 12m
Multipurpose Berth	1	Length 300m, depth 12m
Manganese Berth	1	Length 200m, depth 12m
Bauxite/Clinker Berth	1	Length 260m, depth 13m
Berth for small craft	1	Length 150m, depth 5m
Navigational aids	1	1 Light beacons, 5 Buoys
Tug boat	1	2,420 Hp
New approach channel	1	One way, width 160m, depth 13m
Turning basin 1	1	Radius 220m, depth 12m
Turning basin 2	1	Radius 200m, depth 13m
Container yard	1	10.5 ha
Breakwater extension	1	400m
Revetment	1	480m, 270m, 160m
Access road improvement	1	1 set
Inner harbour road	1	1 set
Container crane	2	45 tons
Multipurpose crane	1	45 tons
Transfer crane	6	40 tons, 1 over 4
Top lifter	3	35 tons, 15 tons
Tractor head	16	For container cargo
Trailer	16	For container cargo

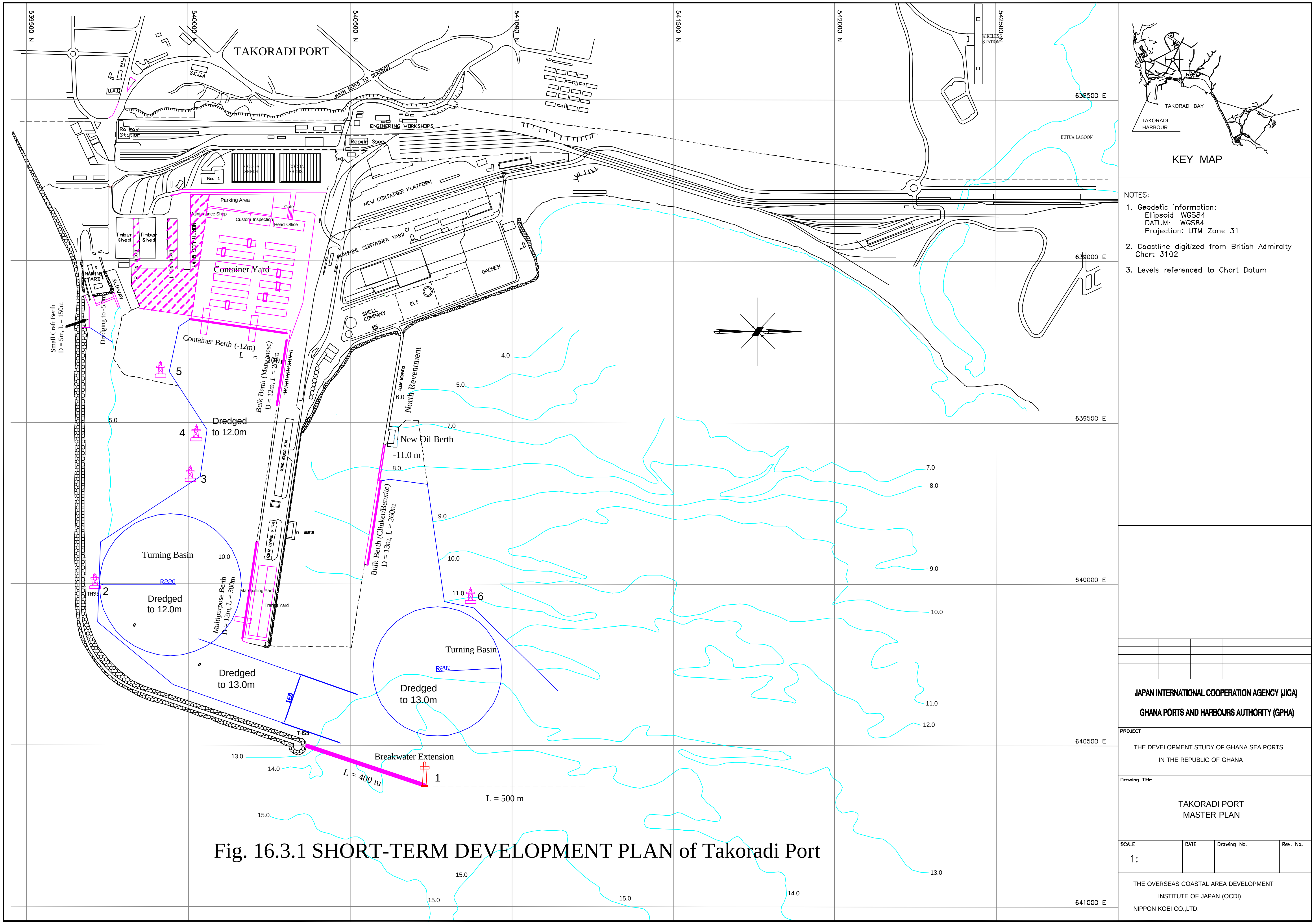

Fig. 16.3.1 SHORT-TERM DEVELOPMENT PLAN of Takoradi Port

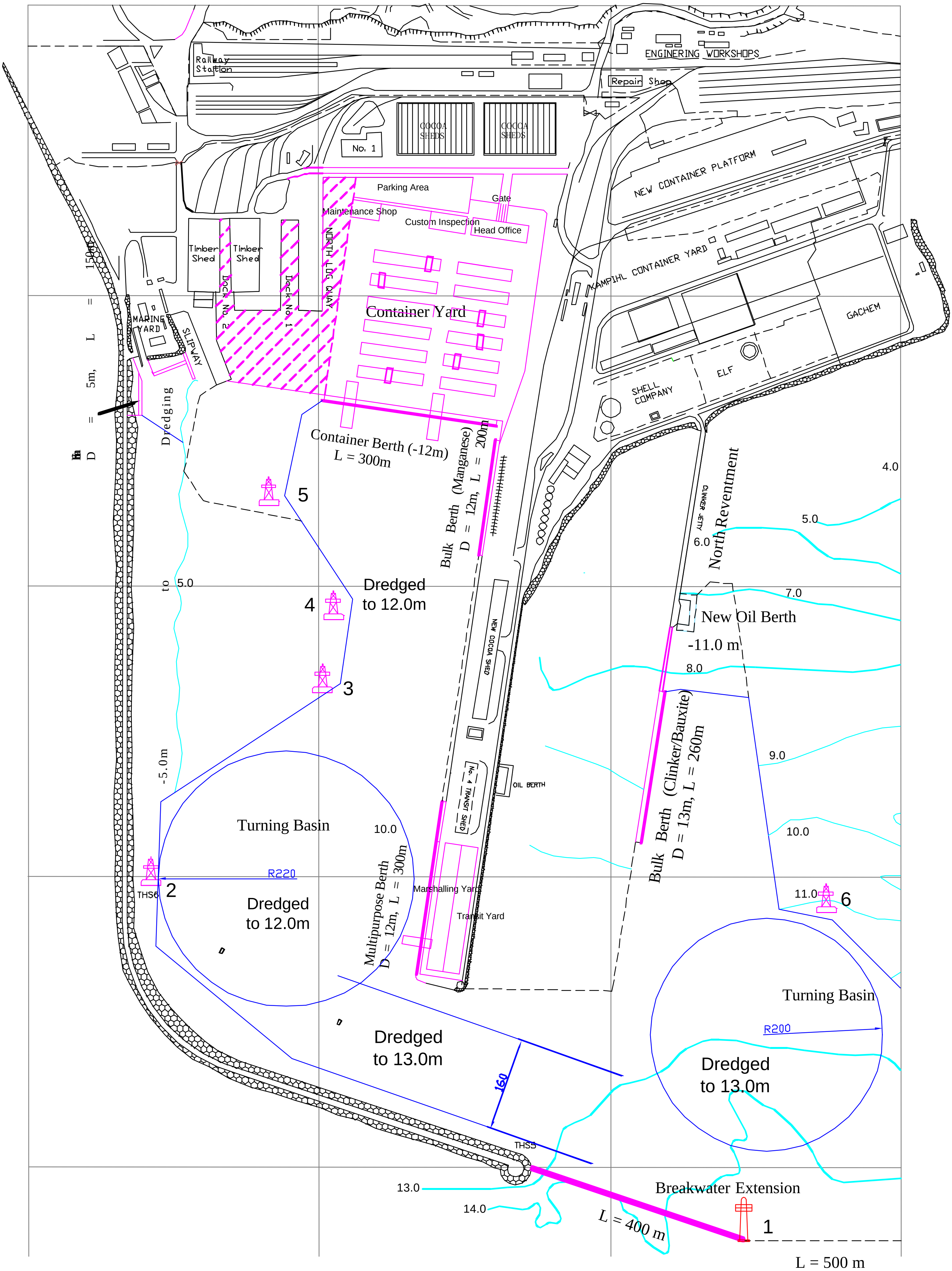

Fig. 16.3.2 SHORT-TERM DEVELOPMENT PLAN of Takoradi Port (Main Facilities)

16.4 Other Facilities

16.4.1 Navigational Aids

It is proposed that buoys be installed as shown Fig. 16.3.1 so as to allow vessels to enter and departure from the port even at nighttime. The list of navigational aids is shown in Table 16.4.1.

Table 16.4.1 Proposed Navigational Aids

No	Position	Kind	Color	Light	Top-mark
1	North end of main B.W.	Lateral Mark Light Beacon	Red	Flashing	Single red cylinder
2	South end of turning basin 1	Light Bouy	White	Flashing	-
3	Boundary of basin	Light Bouy	White	Flashing	-
4	Boundary of basin	Light Bouy	White	Flashing	-
5	Boundary of basin	Light Bouy	White	Flashing	-
6	West end of turning basin 2	Light Bouy	White	Flashing	-

16.4.2 Tugboats

The maximum thrust is required when moving a mother vessel athwart direction, and an empirical formula on the thrust based on vessels' deadweight and external force (mainly by wind force) is shown in Fig. 16.4.1.

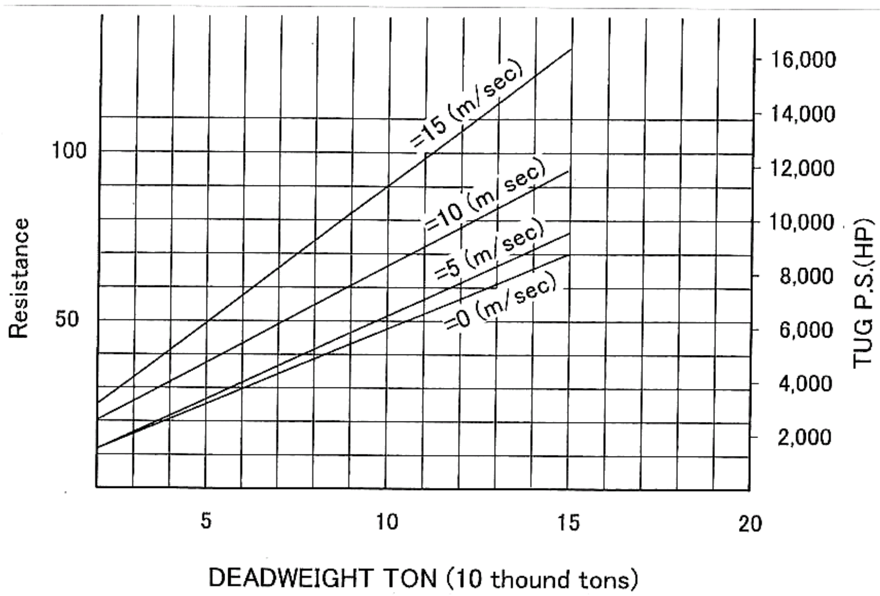

Fig. 16.4.1 Necessary Tug Boat(s) Thrust against Vessel's DWT and Winds

According to Fig. 16.4.1, assisting a 40,000 DWT mother vessel against a wind of 10 m/s (probability of exceeding 10 m/s at Takoradi is less than 1%) requires a total of 3,600 hp (2 tugs 1,800 hp each). There are three tugboats at Takoradi Port with respective hp's of 1,240, 1,250 and 2,420. The oldest tugboat (built in 1977) which has hp of 1,240 will be replaced by a new tugboat with 2,420 hp, which means hp of any pair of two tugboats exceeds 3,600 hp.

16.5 Proposal for Efficient Port Operation

16.5.1 Container Cargo

Basic policy of container handling in the short-term development plan is described below.

- New container terminal (length 300m x 1 berth, depth 12m) will be constructed at the inner port area. This is the first dedicated container terminal at Takoradi Port with sufficient container yards and sophisticated cargo handling equipment.
- Berths 5-6 will be redeveloped as a multipurpose berth (length 300m) for container and Ro-Ro vessels with a depth of 12m.
- Until container yard behind the new multipurpose berth is constructed, users of the new multipurpose berth have priority to utilize New Container Platform (NCP) and GPHA's new container yard (KAMPIHL Container Yard).
- Seventy percent of container cargo will be handled at the new container terminal, and the rest (30%) will be handled at the new multipurpose berth.

Table 16.5.1 Estimated Storage Area for Container Cargo

Port of Takoradi		2000	2010	unit
Volume of Container Cargo		39,966	136,196	TEU
Volume of Container Cargo		31,469	107,241	Box
Productivity		9	24	box/hour/vessel
Working day		365	365	day
Cargo throughput in a day		109	373	TEU/day
Average Dwell Time(Target)		12	6	day
Peak Ratio		1.3	1.3	
		2000	2010	
Required Capacity Volume for Container storage		1,700	2,909	TEU
Required Area for Container Storage	2 tiers	21,255	36,368	m2
	3 tiers	14,170	24,245	m2
	4 tiers	**10,628**	**18,184**	**m2**

Size of 20ft Container	
Length(l)	6.058 m
Widgh(w)	2.438 m
Height(h)	2.438 m
Bottom Area(=l x w)	15 m2
Area for 1slot	
(+ 50cm space on each side)	
lengh + 50cm x 2(ls)	7.058 m
widgh + 50cm x 2(ws)	3.438 m
Bottom Area(=ls x ws)	25 m2

(1) New Container Terminal

In the short-term plan, new container terminal (length 300m x 1 berth, depth 12m) is proposed to be constructed at the inner port area. For the most efficient use of this area, transfer crane method is recommended to handle the maximum volume of container cargoes.

At Takoradi Port, the forecasted volume of container cargo in 2010 is 136,196 TEUs. It is assumed that 70% of the forecasted volume of container cargo will be handled at the new container terminal, and the rest (30%) will be handled at the new multipurpose berth. Container handling volume at the new container terminal is calculated in Table 16.5.2.

Table 16.5.2 Estimated Storage Area for New Container Terminal

		70%				
Port of Takoradi (New Cont.T)	2000	2010	unit		Size of 20ft Container	
Volume of Container Cargo	0	95,338	TEU		Length(l)	6.058 m
Volume of Container Cargo	0	75,069	Box		Widgh(w)	2.438 m
Productivity	9	24	box/hour/vessel		Height(h)	2.438 m
Working day	365	365	day		Bottom Area(=l x w)	15 m2
Cargo throughput in a day	0	261	TEU/day			
Average Dwelling Time(Target)	12	6	day		Area for 1slot	
Peak Ratio	1.3	1.3			(+ 50cm space on each side)	
	2000	2010			lengh + 50cm x 2(ls)	7.058 m
Required Capacity Volume	0	2,036	TEU		widgh + 50cm x 2(ws)	3.438 m
for Container storage					Bottom Area(=ls x ws)	25 m2
Required Area 2 tiers	0	25,448	m2			
for Container Storage 3 tiers	0	16,965	m2			
4 tiers	**0**	**12,724**	**m2**			

Dairy container handling volume at new container terminal
= 136,196 x 70% / 365 = 261 TEUs/day
Average dwelling time = 6 days (as target value in 2010)
Container storage capacity at the new container terminal = 261 x 6 x 1.3 = 2,036 TEUs
Minimum area for container storage = (2,036/4) x $25m^2$ = 12,724 m^2
(4 tiers high, 1TEU=$25m^2$)

- The layout of the new container terminal is envisioned in Figure 16.5.3. The storage capacity under this layout is 3,120 TEUs and is sufficient to meet the demand.
- Two gantry cranes are proposed to be installed in the new container berth.

- The required number of transfer cranes for the new container terminal (Ntc) is estimated as below.

Ntc = Nqsc x 2 + A/(T x Ptc x E) +Ntc-backup
= 4 + 0.43 + 1 = 5.43 → 6 units

Nqsc = Number of quay side gantry cranes	2 units
A = Annual throughput in TEUs	95,337 TEUs
T = Maximum available working hours for the year	8,760 hours/year
Ptc = Net productivity of transfer cranes	20 boxes/hour/crane
E = Conversion rate (TEU/box)	1.27 TEUs/Box
Ntc-backup = Number of transfer crane for backup	1 unit

- Between quay side and marshalling yard, container cargo will be carried by yard tractor-trailers. The required number of yard tractor-trailers for each gantry crane Nytt is estimated as below.

Nytt = (Ttr＋Lytt/(Vytt/60)) / Tqsc + Nbackup
= 2.33 + 1 = 3.33 → 4 units

Ttr = Handling time under transfer crane: 3 minutes/cycle
Lytt = Average travelling length of yard tractors (1km): 1 km/cycle
Vytt = Average travel speed of yard tractor-trailers: 15 km/h
Tqsc = Handling time under quay-side crane: 3 minutes/cycle
Nbackup = Number of yard tractor-trailer for backup: 1 unit

Therefore, the required number of yard tractor-trailer is estimated at 8 units for 2 gantry cranes.

Total required equipment for the new container berth:

Quay side gantry crane:	2 units
Transfer crane:	6 units
Yard tractor trailer:	8 units
Storage capacity:	3,120 TEUs

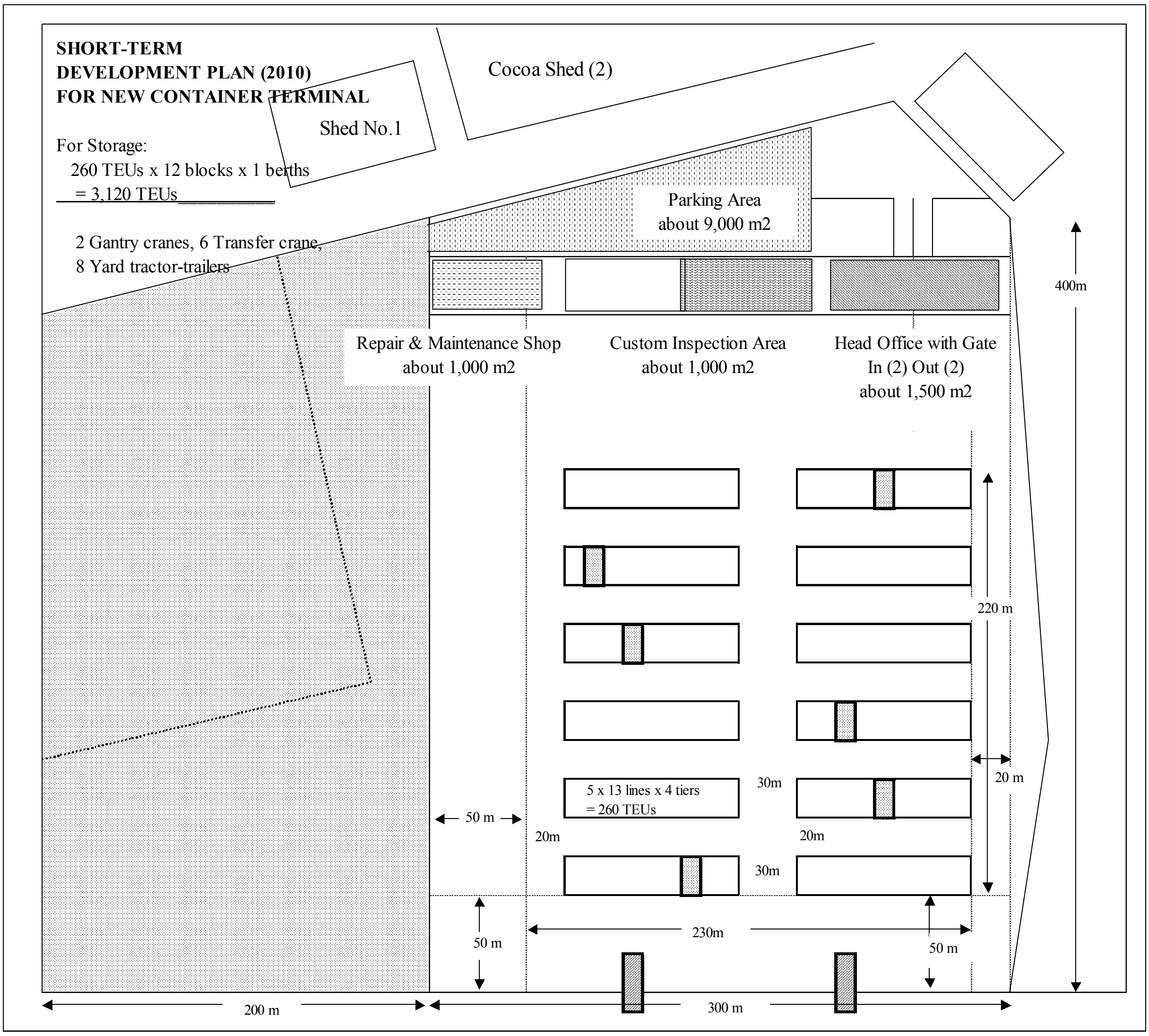

Figure 16.5.3 Layout of New Container Terminal at 2010

・New computer system for container operation will be installed in the new container terminal. For efficient operation with gantry cranes and transfer cranes, rapid control of their operation is required and this work is difficult to do without computers. Operation control system by computers will be also connected to port EDI system or some system of shipping companies for rapid information exchange for operation control. Following operation works will be done by computer system.

- Vessel Operation（Loading/Discharging Operation Control）
- Gantry Crane Allocation
- Transfer Crane Allocation
- Yard Planning
- Container Inventory Control
- Container Delivery/Receiving Control（Gate Operation）

(2) New Multipurpose Berth

・Top-lifter method is the most convenient for container handling in the new multipurpose berth because it is easier to change the cargo handling layout.
・In the short-term plan, one gantry crane with multi-use-attachment is proposed to be installed for container handling and other heavy cargoes.
・Most ports in West Africa do not have quay side cranes. Therefore, most container ships have their own ship gear for container handling. When ship gears are utilized together with the quay side cranes at the new multipurpose berth, the productivity of container handling will be enhanced.
・At Takoradi Port, the forecasted volume of container cargo in 2010 is 136,196 TEUs. It is assumed that 30% of the forecasted volume of container cargo will be handled at the new multipurpose berth, and the rest will be handled at the new container terminal. The container yard area behind the new multipurpose berth is calculated as Table 16.5.4.

Table 16.5.4 Estimated Storage Area for New Multipurpose Berth

30%

Port of Takoradi (Multipurpose)		2000	2010	unit
Volume of Container Cargo		39,966	40,858	TEU
Volume of Container Cargo		31,469	32,172	Box
Productivity		9	24	box/hour/vessel
Working day		365	365	day
Cargo throughput in a day		109	112	TEU/day
Average Dwelling Time(Target)		12	6	day
Peak Ratio		1.3	1.3	
		2000	2010	
Required Capacity Volume		1,700	874	TEU
for Container storage				
Required Area	2 tiers	21,255	10,920	m2
for Container Storage	**3 tiers**	**14,170**	**7,280**	**m2**
	4 tiers	10,628	5,460	m2

Size of 20ft Container	
Length(l)	6.058 m
Widgh(w)	2.438 m
Height(h)	2.438 m
Bottom Area(=l x w)	15 m2
Area for 1slot	
(+ 50cm space on each side)	
lengh + 50cm x 2(ls)	7.058 m
widgh + 50cm x 2(ws)	3.438 m
Bottom Area(=ls x ws)	25 m2

Dairy container handling volume at the new multipurpose berth

= 136.196 x 30% / 365 = 112 TEUs/day

Average dwelling time = 6 days (as target value at 2010)

Container storage capacity at the new multipurpose berth = 112 x 4 x 1.3 = 874 TEUs

Minimum area for container Storage = (874/3) x 25 m^2 = 7,280 m^2

(3 tiers high for top lifter method, 1 TEU = 25 m^2)

- The layout of the new container yard behind the new multipurpose berth is envisioned in Figure 16.5.5. As the storage capacity under this layout is about 200 TEUs, container cargo has to be removed to other container yards such as NCP (New Container Platform, storage capacity is about 800 TEUs) and KAMPIHL Container Yard (opened in August 2001 and storage capacity is 786 TEUs). These two container yards can be utilized for the new multipurpose berth and GPHA should give priority to utilize these yards to users of the new multipurpose berth.

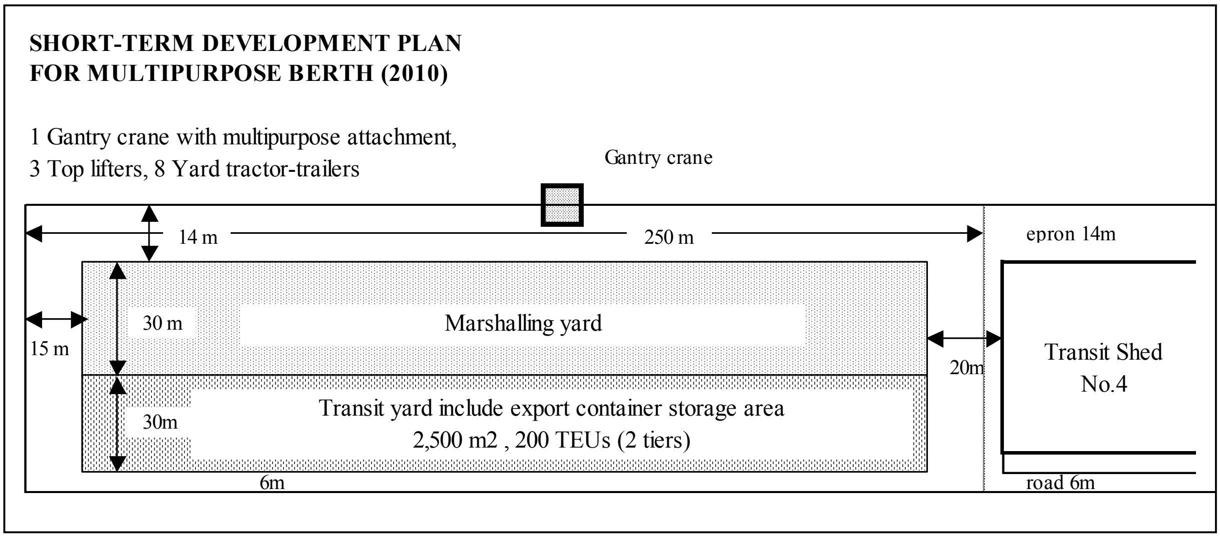

Figure 16.5.5 Layout for New Multipurpose Berth at 2010

- For container handling at the new multipurpose berth, 3 top lifters are required for 1 crane (1 for import, 1 for export, 1 for container relocation and backup).

- Until the opening of the container yard behind the new multipurpose berth in the master plan stage, container cargoes are required to be shifted to the new proposed container terminal and NCP and KAMPIHL Container Yard. Between the new multipurpose berth and NCP or KAMPIHL Container Yard, container cargo would be carried by yard tractor-trailers. The average traveling speed of yard tractor-trailers is about 15 km/hour (250 m/minute) and the distance between the new multipurpose berth and GPHA's yard is about 3,500 meters.
  The required number of yard tractor-trailers for one quay side crane Nytt is estimated as below.

$$Nytt = (Ttp \times 2 + Lytt/(Vytt/60)) / Tqsc + Nbackup$$
$$= 6.67 + 1 = 7.67 \rightarrow 8 \text{ units}$$

Ttp = Handling time under top lifter	3 minutes / cycle
Lytt = Average travelling length of yard tractor trailers	3.5 km/cycle
Vytt = Average travel speed of yard tractor-trailer	15 km/hour
Tqc = Handling time under quay-side crane	3 minutes/cycle
Nbackup = Number of yard tractor-trailer for backup	1 unit

・As for container loaded/discharged by ship gears, the present cargo handling equipment is utilized. These containers are also required to be shifted to the new proposed container terminal, NCP or KAMPIHL Container Yard. Between the new multipurpose berth and NCP or KAMPIHL Container Yard, container cargo would be carried by existing yard tractor-trailers.

・Therefore, before the opening of the container yard behind the multipurpose berth, the required number of yard tractor-trailers (Nytt) is estimated as 8 units for one quay-side crane.
After the opening, the required number of yard tractor-trailers is estimated as 8 units for two quay-side gantry cranes (refer to Chapter 13.5.2-(1)-(d)), so the required yard tractor-trailers in the short-term plan will be transferred to the new container yard behind the new multipurpose berth.

Total required equipment for the new multipurpose berth in the short-term plan;

Quay side gantry crane:	1 unit
Top lifter:	3 units
Yard tractor trailer:	8 units

16.5.2 Manganese

In the short-term plan, manganese berth (Berth No.1) will be reinforced and deepened. With these improvements, manganese will be loaded to vessels directly at the manganese berth. The forecast volume of manganese is shown in Table 16.5.6. The required bulk storage area is also estimated in Table 16.5.6. A storage area with capacity of 40,000t is already provided behind the Manganese Berth, and this is sufficient for the estimated storage volume of manganese (35,644 ton).

After the improvement of the manganese berth, about 25,000-40,000t of manganese will be loaded directly to one vessel, thereby eliminating the double-handling problem. Manganese handling works then be able to complete in 4-7 day.

Table 16.5.6 Estimated Storage Area for Bulk Cargoes

MINERAL BULK CARGO VOLUME AT TAKORADI			2000	2010
Manganese	(ton)		929,296	1,000,000
Bauxite	(ton)		503,823	1,000,000
Clinker	(ton)		694,374	991,760
Productivity		Manganese	208	600
	(ton/hour/vessel)	Bauxite	194	600
		Clinker	269	600
Working Day	(day)		365	365
Cargo throughput		Manganese	2,546	2,740
in a day		Bauxite	1,380	2,740
	(ton/day)	Clinker	1,902	2,717
Average Dwelling Time		Manganese	14	14
		Bauxite	35	28
	(day)	Clinker	14	14
Estimated Required Capacity		Manganese	35,644	38,356
		Bauxite	48,312	76,712
	(ton)	Clinker	26,634	38,040
Required Storage Capacity		Manganese	**40,000**	40,000
***2000: present capacity**		Bauxite	**120,000**	120,000
	(ton)	Clinker	**80,000**	80,000

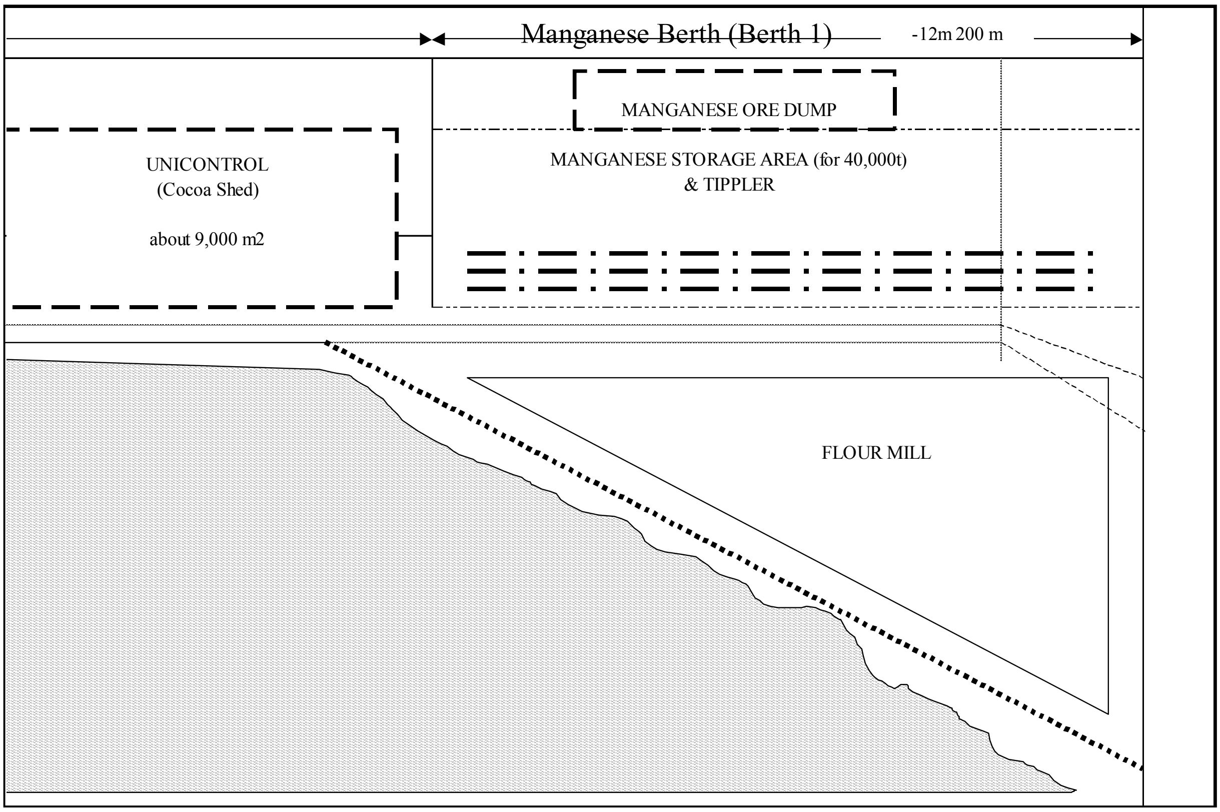

Figure 16.5.7 Layout of Improved Manganese Berth

16.5.3 Bauxite and Clinker

(1) New Bulk Berth

Bauxite and clinker will be handled at new bulk berths with the depth of 13m. Bauxite will be loaded to vessels and clinker will be discharged from vessels directly at the new bulk berth. The location of new bulk berth is shown in Figure 14.3.1. In this plan, conveyor belt system for bauxite and clinker will be extended from present position to the new bulk berths. These extension works will be done by mining companies.

(2) Bauxite

Bauxite volume forecasted in 2010 at Takoradi Port is shown in Table 16.5.6. The required storage area for bauxite is also estimated in Table 16.5.6. At present, storage capacity of bauxite provided in the port area is 400,000t and it is sufficient to cope with future cargo. Present conveyor belt system for bauxite is expected to be extended for direct handling to vessels. Present productivity of conveyor belt for bauxite is 300-400 t/hour by a single belt and improvement of conveyor belt is under implementation (the improved efficiency will be 400-500 t/hour). For direct loading to vessels, conveyor belt is planned to be extended to the new bulk berths and raised to a level that will allow loading onto larger vessels. The belt higher than vessels' height for loading.

At the storage area, the Tippler system is utilized for discharging bauxite from wagons. Ghana Bauxite Company (GBC) has an improvement plan for the Tippler system which it intends to implement soon. Therefore, planned conveyor system will be utilized for the new bulk berths.

With these improvements, double-handling problem will be solved and bauxite handling for one vessel will be finished in 3 days. These improvement works will be done by Ghana Bauxite Company.

(3) Clinker

Clinker volume forecasted in 2010 at Takoradi Port is shown in Table 16.5.6. The required storage area for clinker is also estimated in Table 16.5.6. At present, storage area for clinker provided in the port area is 80,000t and it is sufficient for future cargo. Present productivity of conveyor belt system for clinker is 700t/hour and it is sufficient for the future demand. To discharge clinker from vessels directly, conveyor belt will be extended to the new bulk berths and unloader or grab bucket for clinker is supposed to be introduced with the productivity of 600-700t/hour (270t/hour at present).

With these improvements, clinker handling by lighter will be replaced to direct handling with vessels at the new bulk berths. These implementation works will be done by Ghana Cement Company Limited (GHACEM).

16.5.4 Ro-Ro Cargo

Ro-Ro Cargo (sawn timber, paper reel, vehicle etc.) is mainly handled at berth 6 because it is the deepest berth with marshalling yard. Most of Ro-Ro vessels needs sufficient area for cargo handling and too larger to accommodate berths 2-4. As in the short-term plan, the construction of additional cargo handling yard behind berths 2-6 is not planned. Seventy percent of container cargo handled at the port will be shifted to the new container terminal. At the new multipurpose berth, Ro-Ro cargo is mainly handled, and 15% of container cargo in Ro-Ro vessels and general cargo vessels will be also handled. The layout of the new multipurpose berth is shown as Figure 16.5.5. The marshalling yard is about 6,500 m^2 and the transit area is also about 6,500 m^2, the same as at present.

Before introduction of sufficient storage and vanning area behind berths 2-6 at 2020, Ro-Ro cargo should be loaded or discharged as soon as possible, and then transferred to the container yard or shed immediately to avoid congestion in the marshalling yard. Yard tractor and trailer are important equipment for Ro-Ro cargo handling.

One gantry crane with multi-use-attachment is proposed to be installed at the new multipurpose berth for container and heavy cargo handling. Cargo handling productivity of Ro-Ro vessels which don't have ship gears will be increased by using the quay side crane. As for Ro-Ro vessels with ship gears, even if ship gears are broken down, cargo handling activity can be continued using quay side crane.

Sawn timber is handled as general cargo (by Ro-Ro) and handled by combinations of the forklifts and trailers in the yard and apron. Some sawn timber is also handled as container cargo and vanning operations of sawn timbers is carried at berth 6 and it causes some congestion. These vanning activities are required to be done at a timber shed or transit shed.

16.5.5 Other Cargo

Dry bulk cargo, General cargo and bagged cargo such as wheat, sugar, rice, steels, and machinery are handled at berths 2-6. In the short-term plan, existing sheds such as Transit shed No.4 and UNI CONTROL shed will be utilized for cargo handling and storage. Before sufficient storage and vanning area is provided behind berth 2-6 at the master plan stage, these cargoes are required to be transferred to the shed immediately to make yards free.

Wheat is imported as a grain bulk and handled at berth 2-6. Vessels for wheat usually accommodate to berths 2-4 and wheat is discharged using ship gears and hoppers (loading to trucks). In the short-term stage, wheat handling should concentrate to berths 2-4 to avoid congestion with other cargo. Discharged wheat is desired to carry out to the Silo or shed as soon as possible.

For efficient handling of general cargo and bagged cargo, cargo handling works should be separated. For example steels are usually discharged from vessels directly on the bed of trucks. It is difficult to perform such precise work with ship gears. If these works were divided into "discharging to the berth by ship gear" and "loading to the trucks by forklift", the efficiency would be increased.