CHAPTER 5

DESIGN OF THE ACCESS CHANNEL

Chapter 5 Design of the Access Channel

5.1 Ship Traffic Forecast

5.1.1 Port Cargo Forecast

(1) Cargo Volume of Beira Port from 1978 to 1997

Trend of the cargo volume handled in Beira Port from 1978 to 1997 excluding drought relief as a temporary factor is shown in Figure 5.1.1-1. Data of 1997 represents the figure planned by CFM-C. The average growth rate of cargo volume per annum is 5.4 % during 1978-1996.

The cargo tonnage and ratio by type of ship in Beira Port during 1995-1996 including drought relief is shown in Table 5.1.1-1. The actual total cargo volume of Beira Port in 1996 including drought relief was 2,603,300 tons, which consists of Mozambican traffic of 357,100 tons (13.7 %) and transit traffic of 2,246,200 tons (86.3 %).

(2) Demand Forecast on Cargo of Beira Port by SATTC

In February, 1997, the Southern Africa Transport and Communication Commission (SATCC) published expected transit port cargo volume in inter-SADC (Southern Africa Development Community) and extra-SADC in 2002, 2007 and 2017 based on the volume of 1995.

The freight traffic growth factors by country (central-case) are shown in Table 5.1.1-2. As shown in the table, the forecast annual tonnage of Beira Port excluding Petroleum, Oil and Lubricant (POL) is forecast at 1,275,000 tons in 2002, 1,475,000 tons in 2007 and 2,180,000 tons in 2017 based on 964,200 tons in 1995, as shown in Table 5.1.1-3.

The forecast of POL is established by using the growth-rate of import transit cargo in Table 5.1.1-3 and the forecast of the Mozambican traffic was carried out employing the growth rate of Mozambique in Table 5.1.1-2.

Then, Table 5.1.1-4 shows the demand forecast of cargo at Beira Port adopted the central-case forecast derived by SATCC. The total cargo of Beira Port is forecast at 2,976,400 tons in 2002, 3,398,900 tons in 2007 and 4,874,900 tons in 2017. The rate of transit traffic of Beira Port is forecast to increase by 78.6 % in 2002, 79.5 % in 2007 and 81.1 % in 2017. The average growth rate per annum of the total cargo is forecast at 2.6 % in 2002 and 2007 and 3.7 % in 2017,

less than 5.4 % of the actual growth rate per annum during 1978-1996.

(3) Effect by Improvement of Waiting Time of Beira Port

The comparison of tide waiting time of calling ships in Beira Port is shown in Table 5.1.1-5. The channel water depth of Beira Port which was 8.0 m in 1991 decreased to 5.0 m in 1996. As the result, the rate of numbers of tide waiting ships in arrival ships was increased to 69.9 % in 1996 from 11.5 % in 1991 and the tide waiting time increased to 3,043.2 hours (126.8 days) in 1996 from 170.8 hours (7.1 days) in 1991. The annual rate of increase on tide waiting time was 177.9 % during 1991-1996.

Traders of the Beira Corridor Group in Zimbabwe and shipping companies using Beira Port need to shorten the waiting time of the ships to save transportation costs. The transportation route of some of their cargoes are assumed to be shifted from Maputo Port to Beira Port because of less waiting time and shorter transport distance.

The place of production, market and port for trade goods of Zimbabwe in 1996 are shown in Table 5.1.1-6. According to traders of Beira Corridor Group, the exporting sugar refined around Harare near Beira Port and the importing goods with the market centering around Harare have the advantage to use Beira Port originally, thus 25 % of exports and 50 % of imports using Maputo Port in 1995 are assumed to return to Beira Port if the improvement of the Access Channel of Beira Port will be realized.

The cargo volume for the trade goods of Zimbabwe in 2002 changeable to Harare-Beira from Harare-Maputo in transportation route by the improvement of waiting time of the ships at Beira Port is shown in Table 5.1.1-7. As the transit cargo volume of Zimbabwe in Maputo Port was 810,000 tons in 1995 and is forecast to be 870,000 tons in 2002 by SATTC, the shifting tonnage to Harare-Beira route is calculated to be 298,000 tons in 2002. The shifting tonnage to Harare-Beira route is assumed to be transported by container. The forecast during 2000-2025 of this transit container cargo of Zimbabwe to move to Harare-Beira route is as shown in Table 5.1.1-8. These forecast volume should be added to the demand forecast of Table 5.1.1-4, because the demand forecast by SATTC based on 1995 is without consideration of the improvement of waiting time of ships at Beira Port.

(4) Port Cargo Forecast of Beira Port

Table 5.1.1-9 and Figure 5.1.1-2 show the forecast of cargo by traffic type in Beira Port during 2000-2025.

According to the data of CFM, the handling capacity per annum of container of Beira Port is 100,000 TEU and the handling capacity per annum of dry cargo is 2,950,000 tons. As this project is studied on basing the present handling capacity per annum of Beira Port, the forecast volume of container cargo is estimated to amount to 100,000 TEU in 2010 and to be fixed at 100,000 TEU (Twenty footer Equivalent Unit) after 2010 in Tables 5.1.1-8 and 5.1.1-9. Then, Table 5.1.1-9 is the base data in order to calculate the waiting time of calling ships to Beira Port.

The forecast of cargo that does not consider the handling capacity per annum is shown in Table 5.1.1-10 by type of traffic on Beira Port during 2000-2025.

Table.5.1.1-1 Cargo Tonnage and Ratio by Type of Ship at Beira Port during 1995-1996

(unit : tons)

Type of Ship	Container (TEU)		Container (tons		Dry Cargo		Tanker (POL)		Total Tonnage	
Year:Export,Import		Ratio		Ratio		Ratio		Ratio		Ratio
Export	16,916	62%	147,850	62%	281,750	26%			429,600	17%
Import	10,330	38%	90,270	38%	788,130	74%	1,126,900	100%	2,005,300	81%
Cabotage									53,300	2%
Total in 1995	27,246	100%	238,120	100%	1,069,880	100%	1,126,900	100%	2,488,200	100%
Export	19,632	58%	162,160	58%	490,640	42%			652,800	25%
Import	14,204	42%	117,370	42%	690,530	58%	1,089,700	100%	1,897,600	73%
Cabotage									52,900	2%
Total in 1996	33,836	100%	279,530	100%	1,181,170	100%	1,089,700	100%	2,603,300	100%
							Transit Traffic		2,246,200	86.3%
							Mozambican Traffic		357,100	13.7%

Source : CFM

Table.5.1.1-2 Traffic Forecast Factors by SATCC

Country / Year	Population (million)	Population Growth (% per annum)		GDP/head (US $)	GDP/head Growth (% per annum)	
	1995	1995	2010	1995	1995	2010
Zimbabwe	11.3	2.7	1.6	501	5.9	1.1
Malawi	11.2	2.8	1.6	107	6.7	0.4
Zambia	9.5	2.8	1.6	370	6.5	0.2
Botswana	1.5	3.3	2.1	2,682	0.2	1.7
Mozambique	16.0	2.7	2.1	108	0.3	2.4
Total / SADC	49.5	2.7	1.3	1,207	0.7	2.2

Country / Year	Intra-SADC Growth (% per annum)			Extra-SADC Growth (% per annum)		
	2002	2007	2017	2002	2007	2017
Zimbabwe	1.23	1.43	1.94	1.19	1.37	2.09
Malawi	1.22	1.42	1.98	1.23	1.43	2.14
Zambia	1.36	1.84	2.83	1.21	1.38	1.84
Botswana	1.22	1.39	1.76	1.36	1.68	2.54
Mozambique	1.4	1.85	2.85	1.38	1.63	2.38
Total / SADC	1.62	2.3	3.57	1.31	1.59	2.41

Source : SATCC, Transport and Communications Integration Study for Southern Africa , 5.Feb.1997

Table.5.1.1-3 Forecast Annual Tonnage at Beira Port by SATCC

(unit : 1000 tons)	1995	2002		2007		2017	
			2002/1995		2007/1995		2017/1995
Export Transit Cargo	365.3	750	2.0531	870	2.3816	1,304	3.5697
Import Transit Cargo	496.2	525	1.0580	605	1.2193	876	1.7654
Drought Relief Cargo (Import)	102.7	0		0		0	
Transit Cargo (excl. POL) Total	964.2	1,275	1.3223	1,475	1.5298	2,180	2.2609

Source: SATCC, Transport and Communications Integration Study for Southern Africa, 5 Feb. 1997

Table.5.1.1-4 Demand Forecast on Cargo of Beira port by SATCC

(unit : 1,000 metric tons)

	CFM-C Data			Port Cargo Forecast by SATTC		
	Actual	Actual	Plan	Scenario 1 (Central-case)		
Year	1995	1996	1997	2002	2007	2017
1.1.1 Exports	283.0	451.8	586.0	581.0	674.0	1,010.2
1.1.2 Imports(excl.POL)	443.0	479.5	326.0	468.7	540.1	782.1
1.1.3 POL *	986.4	919.3	1,100.0	1,043.6	1,202.7	1,741.4
1.1 Zimbabwe Total	1,712.4	1,850.6	2,012.0	2093.3	2,416.9	3,533.7
2.2.1 Exports	57.3	98.0	96.0	117.6	136.5	204.5
2.2.2 Imports(excl.POL)	46.5	130.9	93.0	49.2	56.7	82.1
2.2.3 POL *	18.9	86.0	15.0	20.0	23.0	33.4
1.2 Malawi Total	122.7	314.9	204.0	186.8	216.2	320.0
2.3.1 Exports	25.0	45.2	57.0	51.3	59.5	89.2
2.3.2 Imports	6.0	15.3	28.5	6.4	7.3	10.6
1.3 Zambia Total	31.0	60.5	85.5	57.7	66.8	99.8
1.4 Botswana(import)	0.7	0.0	1.0	0.7	0.9	1.2
1.5 Drought Relief etc., not separable	102.7	20.2				
1. Transit traffic Total	1,969.5	2,246.2	2,302.5	2,338.6	2,700.8	3,954.7
2.1.1 Exports	64.3	57.8	66.0	70.7	76.6	97.0
2.1.2 Imports(excl.POL)	279.5	162.0	330.0	353.8	387.7	513.5
2.1.3 POL	121.6	84.4	135.0	144.7	158.6	210.1
2.1 International Traffic	465.4	304.2	531.0	569.2	622.9	820.6
2.2 Cabotage	53.3	52.9	64.0	68.6	75.2	99.6
2. Mozambique	518.7	357.1	595.0	637.8	698.1	920.2
Total Cargo of Beira Port	2,488.2	2,603.3	2,897.5	2,976.4	3,398.9	4,874.9
Ratio of Transit Traffic	79.2%	86.3%	79.5%	78.6%	79.5%	81.1%
Average Growth Rate(%) per annum		4.6%	11.3%	2.6%	2.6%	3.7%

Table 5.1.1-5 Comparison of Tide Waiting Time of Calling Ships

year	1991	1996
Channel Water Depth (m)	8.0 m	5.0m
Numbers of Arrival Ships	243	289
Numbers of Tide Waiting Ships	28	202
%	11.50%	69.90%
Tide Waiting Time (hours)	170.8h	3,043.2h
Tide Waiting Time (days)	7.1 days	126.8 days
Rate of increase per annum(%)		177.9% per annum

Table 5.1.1-6 Place of Production, Market and Port for Exporting and Importing Goods in 1996

Exporting and Importing Goods	Place of Production	Place of Market	Port
Granite for export	Northern area	Centering around Harare	Beira
Agricultural products for export	All area	Centering around Harare	Beira
Sugar and Iron for export (25% manufactured, 75% material)	Southern area	25% around Harare	Maputo
		75% around Maputo	Maputo or Durban
Agricultural products for import		Centering around Harare	Beira
Machine for import	More than 50%	Centering around Harare	Maputo or Durban

Source : Data of Finance Ministry of Zimbabwe

Table 5.1.1-7 Cargo Volume for Trade Goods of Zimbabwe via Maputo Port and Expected Shift via Beira Port

(unit : tons)

	Harare-Maputo Route		Expected Share by Harare-Beira Route	
	Cargo Tonnage in 1995	(1)Cargo Tonnage in 2002	(2) Shifting Rate	(1)×(2) Shifting Tonnage
Imports	273,000	322,000	50%	161,000
Exports	537,000	548,000	25%	137,000
Total	810,000	870,000		298,000

Source : SATCC, Transport and Communications Integration Study for Southern Africa , 5.Feb.1997

Table.5.1.1-8 Forecast of Container Cargo at Beira Port in 2000-2025

Trnsit Cargo of Zimbabwe to move from Mapuyo-Harare to Beira-Harare							Forecast of Container Cargo on Beira port in 2000-2025 by SATCC						
	(B) Container Cargo (TEU)			Container Cargo (tonnes)				(A) Container Cargo (TEU)			Container Cargo (tonnes)		
Year	export	import	total	export	import	total	Year	export	import	total	export	import	total
1995	15,592	15,854	31,446	134,250	136,500	270,750	1995	16,916	10,330	27,246	147,850	90,270	238,120
1996	15,638	16,232	31,870	134,639	139,757	274,397	1996	19,632	14,204	33,836	162,160	117,370	279,530
1997	15,683	16,619	32,302	135,031	143,092	278,123	1997	19,565	13,866	33,431	168,451	119,389	287,840
1998	15,728	17,016	32,744	135,422	146,507	281,929	1998	20,324	14,105	34,429	174,986	121,443	296,430
1999	15,774	17,422	33,196	135,815	150,003	285,818	1999	21,112	14,348	35,460	181,775	123,532	305,308
2000	15,820	17,838	33,658	136,209	153,583	289,792	2000	32,442	7,998	40,440	279,322	68,867	348,189
2001	15,866	18,263	34,129	136,604	157,248	293,851	2001	33,700	8,136	41,836	290,159	70,051	360,210
2002	15,912	18,699	34,611	137,000	161,000	298,000	2002	35,008	8,276	43,284	301,416	71,257	372,673
2003	16,304	19,205	35,509	140,379	165,358	305,737	2003	36,056	8,485	44,541	310,443	73,055	383,499
2004	16,706	19,725	36,431	143,842	169,833	313,675	2004	37,136	8,699	45,835	319,741	74,900	394,641
2005	17,118	20,259	37,377	147,390	174,430	321,819	2005	38,248	8,919	47,167	329,317	76,791	406,108
2006	17,541	20,807	38,348	151,025	179,151	330,176	2006	39,394	9,144	48,538	339,180	78,729	417,910
2007	17,973	21,370	39,344	154,750	184,000	338,750	2007	40,574	9,375	49,949	349,342	80,717	430,059
2008	18,673	22,226	40,900	160,776	191,369	352,146	2008	42,239	9,700	51,939	363,678	83,518	447,195
2009	19,400	23,117	42,517	167,038	199,034	366,072	2009	43,972	10,037	54,009	378,601	86,415	465,016
2010	20,504	23,335	43,838	176,537	200,912	377,449	2010	45,777	10,385	56,162	394,138	89,413	483,551
2011	20,504	23,335	43,838	176,537	200,912	377,449	2011	45,777	10,385	56,162	394,138	89,413	483,551
2012	20,504	23,335	43,838	176,537	200,912	377,449	2012	45,777	10,385	56,162	394,138	89,413	483,551
2013	20,504	23,335	43,838	176,537	200,912	377,449	2013	45,777	10,385	56,162	394,138	89,413	483,551
2014	20,504	23,335	43,838	176,537	200,912	377,449	2014	45,777	10,385	56,162	394,138	89,413	483,551
2015	20,504	23,335	43,838	176,537	200,912	377,449	2015	45,777	10,385	56,162	394,138	89,413	483,551
2016	20,504	23,335	43,838	176,537	200,912	377,449	2016	45,777	10,385	56,162	394,138	89,413	483,551
2017	20,504	23,335	43,838	176,537	200,912	377,449	2017	45,777	10,385	56,162	394,138	89,413	483,551
2018	20,504	23,335	43,838	176,537	200,912	377,449	2018	45,777	10,385	56,162	394,138	89,413	483,551
2019	20,504	23,335	43,838	176,537	200,912	377,449	2019	45,777	10,385	56,162	394,138	89,413	483,551
2020	20,504	23,335	43,838	176,537	200,912	377,449	2020	45,777	10,385	56,162	394,138	89,413	483,551
2021	20,504	23,335	43,838	176,537	200,912	377,449	2021	45,777	10,385	56,162	394,138	89,413	483,551
2022	20,504	23,335	43,838	176,537	200,912	377,449	2022	45,777	10,385	56,162	394,138	89,413	483,551
2023	20,504	23,335	43,838	176,537	200,912	377,449	2023	45,777	10,385	56,162	394,138	89,413	483,551
2024	20,504	23,335	43,838	176,537	200,912	377,449	2024	45,777	10,385	56,162	394,138	89,413	483,551
2025	20,504	23,335	43,838	176,537	200,912	377,449	2025	45,777	10,385	56,162	394,138	89,413	483,551

Handling capacity per annum100,000TEU		
Growth-rate % per annum for 1995-2002	0.2901%	2.3863%
Growth-rate % per annum for 2002-2007	2.4665%	2.7066%
Growth-rate % per annum for 2007-2017	3.8943%	3.4691%

Handling capacity per annum100,000TEU		
Growth-rate % per annum for 1996-2002	3.8796%	1.7204%
Growth-rate % per annum for 2002-2007	2.9950%	2.5245%
Growth-rate % per annum for 2007-2017	4.1036%	3.4691%

note-1 : 1TEU=10 tons, Empty rate=13.9% (Actual rate in 1995)

note-2 : Container Cargo after 2000 involves the Shifting Cargo from Maputo-Harare Route to Beira-Harare Route.

note-3 : Handling Capacity per annum of Container is 100,000TEU after 2010.

note-4 : Handling Capacity per annum of Dry Cargo is 2,950,000 tons.

Table.5.1.1-9. Forecast of Cargo by Type of Traffic at Beira Port in 2000-2025

Forecast of Cargo by Type of traffic on Beira port in 2000-2025

year	(A+B) Container Cargo (TEU) export	(A+B) Container Cargo (TEU) import	(A+B) Container Cargo (TEU) total	Container Cargo (tonnes) export	Container Cargo (tonnes) import	Container Cargo (tonnes) total	Dry Cargo export	Dry Cargo import	Dry Cargo total	POL import	Cabotage ①	② export	③ import	①+②+③ total
1995	16,916	10,330	27,246	147,850	90,270	238,120	281,750	788,130	1,069,880	1,126,900	53,300	429,600	2,005,300	2,488,200
1996	19,632	14,204	33,836	162,160	117,370	279,530	490,640	690,530	1,181,170	1,089,700	52,900	652,800	1,897,600	2,603,300
1997	19,565	13,866	33,431	168,451	119,389	287,840	428,971	753,889	1,182,860	1,108,626	55,242	597,422	1,981,904	2,634,567
1998	20,324	14,105	34,429	174,986	121,443	296,430	445,663	764,346	1,210,008	1,127,880	57,687	620,649	2,013,669	2,692,005
1999	21,112	14,348	35,460	181,775	123,532	305,308	463,004	774,948	1,237,952	1,147,469	60,241	644,779	2,045,949	2,750,969
2000	48,261	25,836	74,098	415,531	222,449	637,981	481,021	785,696	1,266,717	1,167,398	62,907	896,552	2,175,543	3,135,003
2001	49,566	26,399	75,965	426,763	227,299	654,062	499,738	796,594	1,296,332	1,187,673	65,692	926,501	2,211,566	3,203,759
2002	50,919	26,975	77,895	438,416	232,257	670,673	519,184	807,643	1,326,827	1,208,300	68,600	957,600	2,248,200	3,274,400
2003	52,360	27,690	80,051	450,823	238,413	689,236	533,936	827,528	1,361,464	1,241,612	69,872	984,739	2,307,553	3,362,183
2004	53,842	28,424	82,267	463,583	244,733	708,316	549,107	847,902	1,397,009	1,275,842	71,167	1,012,690	2,368,477	3,452,335
2005	55,367	29,178	84,544	476,707	251,220	727,927	564,710	868,778	1,433,487	1,311,016	72,487	1,041,417	2,431,014	3,544,918
2006	56,934	29,951	86,886	490,205	257,880	748,086	580,755	890,167	1,470,923	1,347,160	73,831	1,070,961	2,495,207	3,639,999
2007	58,547	30,745	89,293	504,092	264,717	768,809	597,258	912,083	1,509,341	1,384,300	75,200	1,101,350	2,561,100	3,737,650
2008	60,912	31,926	92,839	524,454	274,887	799,341	620,763	943,225	1,563,987	1,425,096	77,343	1,145,217	2,653,208	3,875,768
2009	63,373	33,153	96,526	545,639	285,449	831,088	645,192	975,430	1,620,622	1,487,757	79,547	1,190,331	2,748,636	4,019,014
2010	66,280	33,719	100,000	566,937	288,423	855,360	670,584	1,008,735	1,679,318	1,542,349	81,815	1,237,520	2,839,507	4,158,842
2011	66,280	33,720	100,000	570,675	290,325	861,000	696,974	1,043,177	1,740,151	1,598,945	84,146	1,267,649	2,932,447	4,284,242
2012	66,280	33,720	100,000	570,675	290,325	861,000	724,403	1,078,795	1,803,198	1,657,618	86,544	1,295,078	3,026,738	4,408,360
2013	66,280	33,720	100,000	570,675	290,325	861,000	752,911	1,115,629	1,868,541	1,718,444	89,011	1,323,586	3,124,398	4,536,995
2014	66,280	33,720	100,000	570,675	290,325	861,000	782,542	1,153,721	1,936,263	1,781,501	91,548	1,353,217	3,225,547	4,670,312
2015	66,280	33,720	100,000	570,675	290,325	861,000	813,338	1,193,113	2,006,452	1,846,873	94,157	1,384,013	3,330,311	4,808,481
2016	66,280	33,720	100,000	570,675	290,325	861,000	845,347	1,233,851	2,079,198	1,914,643	96,840	1,416,022	3,438,819	4,951,681
2017	66,280	33,720	100,000	570,675	290,325	861,000	878,615	1,275,980	2,154,595	1,984,900	99,600	1,449,290	3,551,205	5,100,095
2018	66,280	33,720	100,000	570,675	290,325	861,000	913,192	1,319,547	2,232,739	2,057,735	102,439	1,483,867	3,667,607	5,253,913
2019	66,280	33,720	100,000	570,675	290,325	861,000	949,131	1,364,601	2,313,732	2,133,243	105,358	1,519,806	3,788,169	5,413,333
2020	66,280	33,720	100,000	570,675	290,325	861,000	986,483	1,411,194	2,397,677	2,211,521	108,361	1,557,158	3,913,040	5,578,559
2021	66,280	33,720	100,000	570,675	290,325	861,000	1,025,305	1,459,377	2,484,683	2,292,672	111,449	1,595,980	4,042,375	5,749,804
2022	66,280	33,720	100,000	570,675	290,325	861,000	1,065,656	1,509,206	2,574,862	2,376,801	114,625	1,636,331	4,176,332	5,927,288
2023	66,280	33,720	100,000	570,675	290,325	861,000	1,107,594	1,560,736	2,668,330	2,464,017	117,892	1,678,269	4,315,078	6,111,239
2024	66,280	33,720	100,000	570,675	290,325	861,000	1,151,183	1,614,026	2,765,208	2,554,433	121,252	1,721,858	4,458,784	6,301,893
2025	66,280	33,720	100,000	570,675	290,325	861,000	1,196,487	1,669,135	2,865,621	2,648,167	124,707	1,767,162	4,607,627	6,499,496
Handling capacity per annum			100,000TEU			Handling capacity per annum			2,950,000					
Growth-rate % per annum for 1996-2002				2.6595%	2.1788%		3.8912%	1.3870%		1.7368%	4.4267%			
Growth-rate % per annum for 2002-2007				2.8311%	2.6509%		2.8414%	2.4620%		2.7569%	1.8542%			
Growth-rate % per annum for 2007-2017				4.0397%	3.8443%		3.9354%	3.4144%		3.6695%	2.8500%			

note-1 : 1TEU=10 tons, Empty rate=13.9% (Actual rate in 1995)

note-2 : Container Cargo after 2000 involves the Shifting Cargo from Maputo-Harare Route to Beira-Harare Route.

note-3 : Handling Capacity per annum of Container is 100,000TEU after 2010.

note-4 : Handling Capacity per annum of Dry Cargo is 2,950,000 tons.

Table.5.1.1-10 Cargo Tonnage and Ratio by Type of Ship at Beira Port in 2002, in 2007 and in 2017 by SATCC's Forecast

(unit : tons)

Type of Ship / Year:Export,Import	Container (TEU)	Ratio	Container (tons)	Ratio	Dry Cargo	Ratio	Tanker (POL)	Ratio	Total Tonnage	Ratio
Export	50,919	65%	438,416	65%	519,184	39%			957,600	29%
Import	26,975	35%	232,257	35%	807,643	61%	1,208,300	100%	2,248,200	69%
Cabotage									68,600	2%
Total in 2002	77,894	100%	670,673	100%	1,326,827	100%	1,208,300	100%	3,274,400	100%
Export	58,547	66%	504,092	66%	597,258	40%			1,101,350	29%
Import	30,745	34%	264,717	34%	912,083	60%	1,384,300	100%	2,561,100	69%
Cabotage									75,200	2%
Total in 2007	89,292	100%	768,809	100%	1,509,341	100%	1,384,300	100%	3,737,650	100%
Export	81,164	69%	698,822	69%	878,615	41%			1,577,437	30%
Import	36,519	31%	314,432	31%	1,275,980	59%	1,984,900	100%	3,575,312	68%
Cabotage									99,600	2%
Total in 2017	117,683	100%	1,013,254	100%	2,154,595	100%	1,984,900	100%	5,252,349	100%

	Container Cargo		Dry Cargo		POL	Cabotage
	Export	Import	Export	Import	Import	
Growth-rate % per annum for 1996-2002	2.6595%	2.1788%	3.8912%	1.3870%	1.7368%	4.4267%
Growth-rate % per annum for 2002-2007	2.8311%	2.6509%	2.8414%	2.4620%	2.7569%	1.8542%
Growth-rate % per annum for 2007-2017	4.0397%	3.8443%	3.9354%	3.4144%	3.6695%	2.8500%

note-1 : 1TEU=10 tons, Empty Rate=13.9% (Actual Rate in 1995)

note-2 : Container Cargo after 2000 involves the Shifting Cargo from Mapuyo-Harare Route to Maputo-Beira Route.

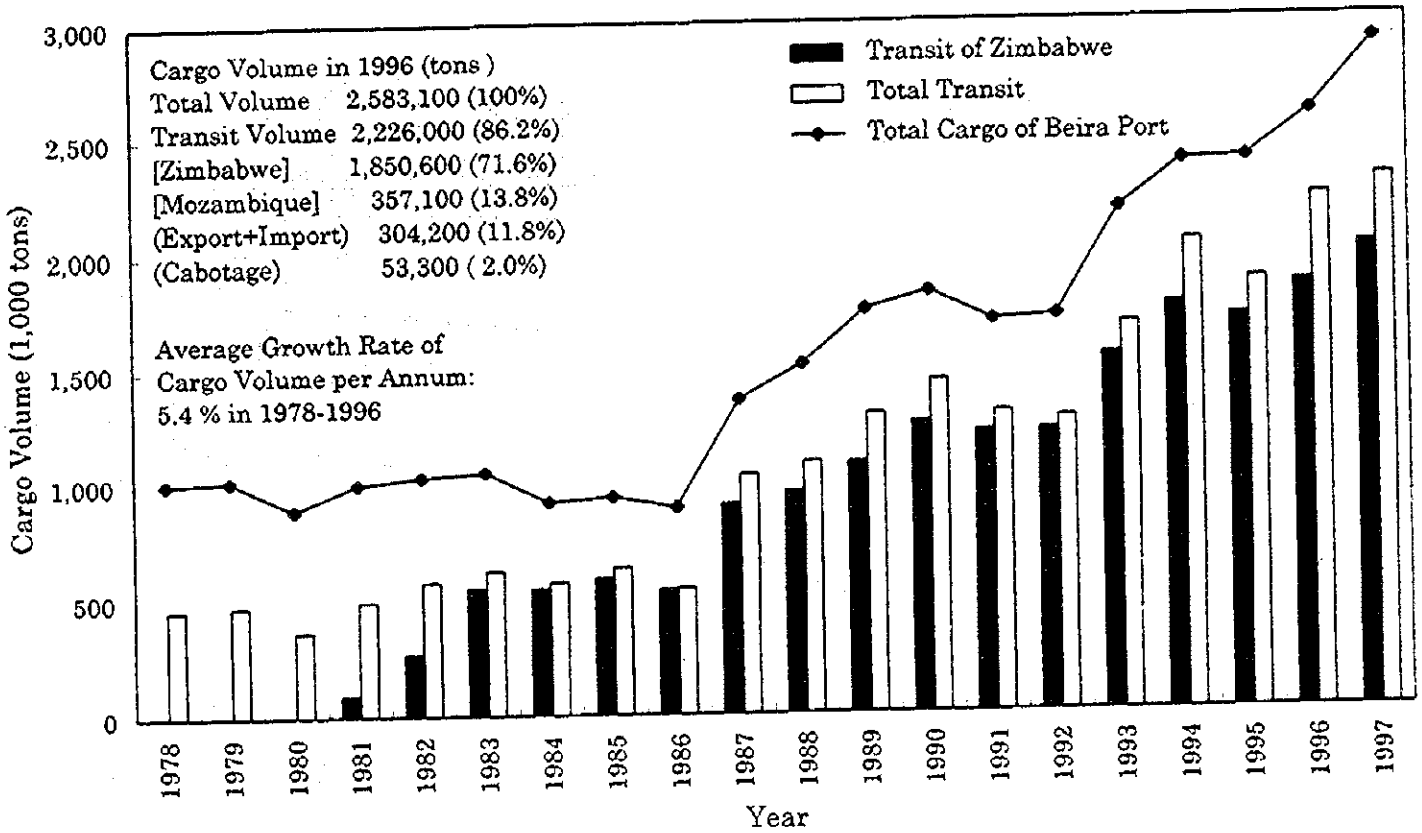

Figure 5.1.1-1 Cargo Volume of Beira Port in 1978 - 1997

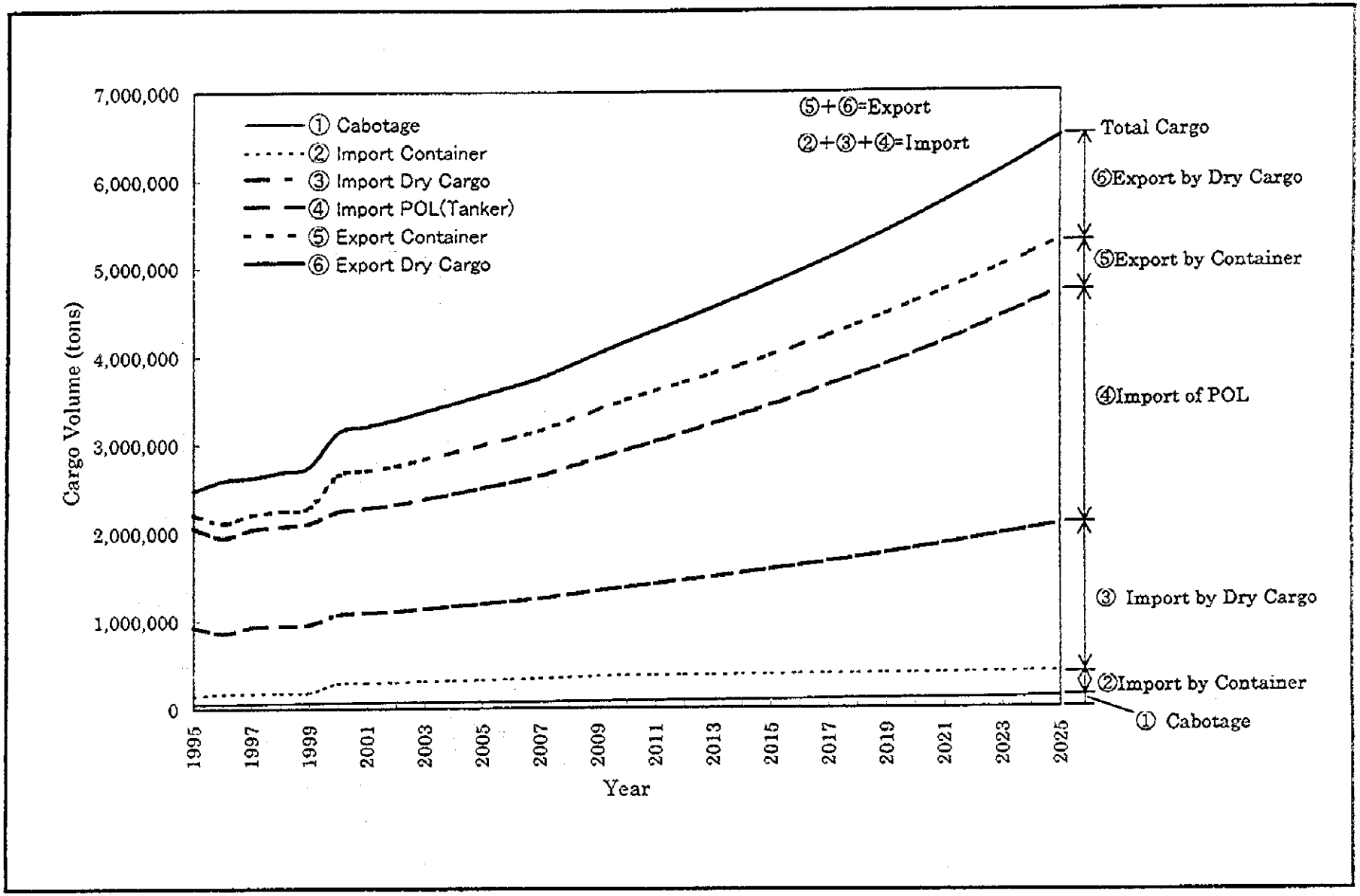

Figure 5.1.1-2 Trend in Cargo Forecast of Beira Port

5.1.2 Ships' Call Forecast

In the previous section, the future cargo volume of each commodity has been forecast. In this section, the future ship traffic volume is derived by converting the forecast cargo volume into a number of ship's calls. Ship's traffic is forecast based on the ship and the cargo volume in 1996 detailed in Chapter 2.2.

(1) Forecast of Ship Size by Ship Type

According to the data on calling ships in 1996, the largest ship is a tanker of 30,611 DWT, while another ship has the longest Loa of 206.1m. The design ship to determine the dimensions of the Access Channel is 30,000 DWT of a tanker or a cargo carrier according to "Beira Port Study, Access Channel Study", of which draft and length between perpendiculars (Lpp) are set at 11.0 m and 200.0 m, respectively. Calling ships are restricted by the dimension of the Access Channel and the port facilities, and regulated below the dimensions of the design ship.

In case of no alteration in the water depth of the Access Channel, 30,000 DWT of tanker or bulk carrier is the maximum sized ship to enter Beira Port. According to restriction of the port facility, it is said that the increasing trend of vessel size has already reached the limit.

Regarding the forecast of ship size, the maximum size of calling ships is the same as the current dimensions due to the restriction of the port facilities and the Access Channel. However, it can be presumed that the number of small size ships operating currently will increase in size and shift to the bigger size as shown in Table 5.1.2-1, where a shear of calling ships of more than 20,000 of DWT has increased from 3.3 % in 1991 to 12.9 % in 1996. The increasing trend in ship size will be accelerated with the improvement of the accessibility and maneuverability at the port as a result of maintenance dredging of the Access Channel.

Table 5.1.2-1 Share of Calling Ships by DWT in 1991 and 1996

DWT (ton)	Number of Calling Ships			
	1991	%	1996	%
DWT>20,000	16	3.3	47	12.9
20,000>DWT>10,000	118	24.0	115	31.6
10,000>DWT	357	72.7	202	55.5
Total	491	100.0	364	100.0

(2) Forecast of Ships' Call by Ship Type

In regard to the forecast of ship's call, a number of calling ships, ship types and cargo volumes in 1996 are used as base data. The increase in a size of calling ship are expected as mentioned in the above. Cargo tonnage of the base year 1996 and forecast cargo tonnage for the years 2000, to 2025 are summarized in Table 5.1.2-2 which is extracted from Table 5.1.1-9. Ratio of the forecast cargo tonnage and the cargo tonnage of the base year 1996 for each category is also tabulated in Table 5.1.2-2. The numbers of ships' call in the years 2000 to 2025 are calculated by multiplying the ships' call of each category of the year 1996 by the respective increment ratios of those forecast years as shown in Table 5.1.2-3 and Figure 5.1.2-1.

Table 5.1.2-2 Cargo Tonnage and Ratio in 1996 to 2025

Year	Tanker		Container		Dry Cargo		Cabotage		Total Cargo	
	Ton	Ratio	Ton	Ratio	Ton	Ratio	Ton	Ratio	Ton	Ratio
1996	1,089,700	1.00	279,530	1.00	1,181,170	1.00	52,900	1.00	2,603,300	1.00
2000	1,167,398	1.07	637,981	2.28	1,266,717	1.07	62,907	1.19	3,135,003	1.20
2002	1,208,300	1.11	670,673	2.40	1,326,827	1.12	68,600	1.30	3,274,400	1.26
2007	1,384,300	1.27	768,809	2.75	1,509,341	1.28	75,200	1.42	3,737,650	1.44
2012	1,657,618	1.52	861,000	3.08	1,803,198	1.53	86,544	1.64	4,408,360	1.69
2017	1,984,900	1.82	861,000	3.08	2,154,595	1.82	99,600	1.88	5,100,095	1.96
2022	2,376,801	2.18	861,000	3.08	2,574,862	2.18	114,625	2.17	5,927,288	2.28
2025	2,648,167	2.43	861,000	3.08	2,865,621	2.43	124,707	2.36	6,499,496	2.50

Table 5.1.2-3 Forecast Number of Ship's Call in 1996 to 2025

Year	1996	2000	2002	2007	2012	2017	2022	2025
Tanker	62	62	69	79	98	112	136	150
Container	152	334	350	403	453	453	453	453
Dry-Cargo	109	113	114	141	176	198	238	259
Cabotage	41	48	53	58	67	78	88	97
Total	364	557	586	681	794	841	915	959

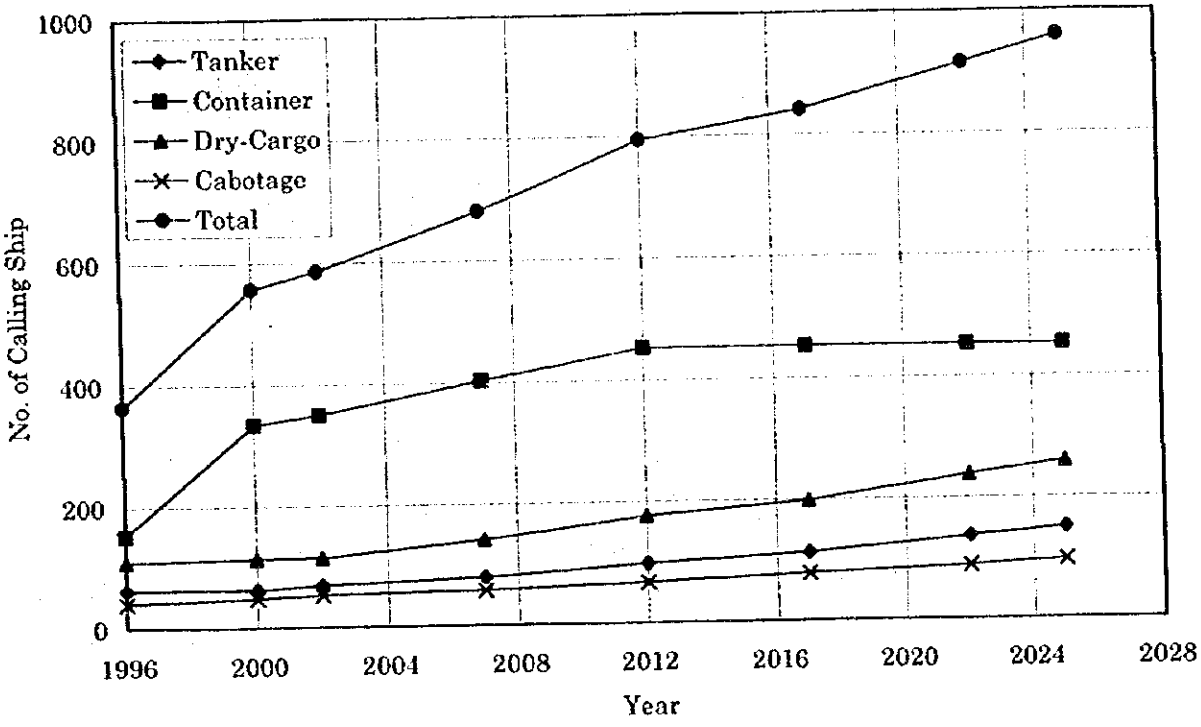

Figure 5.1.2-1 Forecast Number of Ship's Call in 1996 to 2025

5.1.3 Channel Traffic Simulation

The waiting time to enter and to leave the port is estimated using the channel traffic simulation model comprising routine functions of a port predicted with a certain probability. The channel traffic is closely affected by the channel depth which is maintained by economically acceptable dredging. The simulation model is one of the most suitable tool to evaluate economic and financial prospects of maintenance dredging.

(1) Premise of the Model

1) Ship Category

Ships adopted to the simulation model are categorized based on the forecast of cargo potentials and ship types for the years 2000, 2002, 2007, 2012, 2017 and 2025 as mentioned in previous section. The calling ships are categorized into 4 groups such as tanker, container carrier, dry cargo carrier and cabotage vessels with different sizes of draft based on the ship's call forecast from the years 2000 to 2025 as shown in Table 5.1.3-1.

The arrival time of calling ships is modeled by random distributions using the Poisson distributions. Ship arrival of each category is assumed according to its individual schedule.

2) Berthing Rules

The normal procedure in admitting a ship to its specific quay is based on the first come first serve rule within the specific ship group. If a ship arrives at the entrance of the Access Channel in cases that there is no space in its specified quay, non-occupied quay is allocated for berthing. The cargo types and the maximum number of vessels served simultaneously are set forth for each quay in the berthing rules.

3) Cargo handling

In the numerical model applied for Beira Port, cargo handling is set according to the actual cargo flow. The cargo handling time of each category of ships is included in the model based on standardized cargo handling times in 1996 as shown in Section 2.2.2.

Table 5.1.3-1 Categorized Ships' Call in 1996 to 2025

Type	Draft	1996	2000	2002	2007	2012	2017	2022	2025
Tanker	11.0>Draft≧10.0	12	12	12	16	19	22	26	29
	10.0>Draft≧9.0	17	17	19	21	27	30	38	41
	9.0>Draft≧8.0	15	15	17	19	23	27	33	37
	8.0>Draft≧7.0	16	16	18	21	25	29	35	39
	7.0>Draft≧6.0	-	-	-	-	-	-	-	-
	6.0>Draft≧5.0	1	1	1	1	2	2	2	2
	Draft<5.0	1	1	1	1	2	2	2	2
	Sub-total	62	62	69	79	98	112	136	150
Container	11.0>Draft≧10.0	-	-	-	-	-	-	-	-
	10.0>Draft≧9.0	11	24	26	29	33	33	33	33
	9.0>Draft≧8.0	27	59	62	72	81	81	81	81
	8.0>Draft≧7.0	76	166	175	201	225	225	225	225
	7.0>Draft≧6.0	25	56	57	67	75	75	75	75
	6.0>Draft≧5.0	5	11	12	13	15	15	15	15
	Draft<5.0	8	18	18	21	24	24	24	24
	Sub-total	152	334	350	403	453	453	453	453
Dry-Cargo	11.0>Draft≧10.0	4	4	4	5	7	7	9	9
	10.0>Draft≧9.0	33	35	35	43	51	59	73	80
	9.0>Draft≧8.0	15	15	15	19	25	27	33	35
	8.0>Draft≧7.0	15	15	16	20	24	28	32	36
	7.0>Draft≧6.0	12	12	12	15	21	22	26	27
	6.0>Draft≧5.0	12	12	12	16	20	22	26	28
	Draft<5.0	18	20	20	23	28	33	39	44
	Sub-total	109	113	114	141	176	198	238	259
Cabotage	11.0>Draft≧10.0	-	-	-	-	-	-	-	-
	10.0>Draft≧9.0	-	-	-	-	-	-	-	-
	9.0>Draft≧8.0	-	-	-	-	-	-	-	-
	8.0>Draft≧7.0	-	-	-	-	-	-	-	-
	7.0>Draft≧6.0	1	1	1	1	2	2	2	2
	6.0>Draft≧5.0	14	16	18	20	22	26	30	34
	Draft<5.0	26	31	34	37	43	50	56	61
	Sub-total	41	48	53	58	67	78	88	97
Total	11.0>Draft≧10.0	16	16	17	21	26	29	35	38
	10.0>Draft≧9.0	61	76	80	93	111	122	144	154
	9.0>Draft≧8.0	57	89	94	110	129	135	147	153
	8.0>Draft≧7.0	107	197	209	242	274	282	292	300
	7.0>Draft≧6.0	38	69	70	83	98	99	103	104
	6.0>Draft≧5.0	32	40	43	50	59	65	73	79
	Draft<5.0	53	70	73	82	97	109	121	131
	Grand-Total	364	557	586	681	794	841	915	959

4) Navigational Regulation and Control

Accessibility to the Port is limited by draft restriction and traffic regulations. In the model, two components are incorporated: tidal variations in the Access Channel and the possibility for ships to pass each other in the Access Channel. Night navigation is prohibited as one of the safety measures. The velocity of ships sailing along the Access Channel is considered as 8 knots.

Tide condition to evaluate the possibility of sailing along the Channel is calculated by the standard tide forecast formula.

(2) Essential Sequences of the Model

The essential sequence of calculations in the simulation model is summarized as below.

1) Random arrivals of ships of different categories at the entrance of the channel are reproduced.
2) In case of night arrival, they have to wait as a night waiting.
3) In case of insufficient water level for sailing at the daytime, they have to wait until the next required high tide. Tide level is calculated to check whether the nautical depth is sufficient or not for channel navigation.
4) As soon as ships arrive at the quay, cargo handling starts.
5) If the water level of the Channel is under the required nautical depth when ships depart, waiting time for high tide is considered.
6) The distance for 30 minutes of sailing is maintained between the ships navigating along the same direction of the Channel.
7) The ships of opposite direction, having draft lesser than 7.0 m, can cross each other in the Channel.
8) To evaluate the variation of waiting time with respect to the channel depth, simulations of the different channel depths are performed.

(3) Computation Results of the Model

Table 5.1.3-2 gives waiting times due to insufficient tide level for sailing in the Access Channel and due to night arrival. Figures 5.1.3-1 to 5.1.3-4 show characteristics of the tide waiting time with respect to the different channel depths for different categories of calling ships . The tide waiting time is affected distinctly by the channel water depth. The waiting times under the condition of 5.0 m and 6.0 m channel water depth are extremely high. The tide waiting times of the channel depth more than 8.0 m are reduced drastically to a small number of hours and become almost allowable.

Table 5.1.3-2 Forecast of Waiting Time of Calling Ships in 2000 to 2025

Channel Depth (m)	Year	2000		2002		2007		2012		2017		2022		2025	
	Ship Type	Night (hrs)	Tide (hrs)	Night (hrs)	Tide (hrs)	Night (hrs)	Tide (hrs)	Night (hrs)	Tide (hrs)	Night (hrs)	Tide (hrs)	Night (hrs)	Tide (hrs)	Night (hrs)	Tide (hrs)
5.0	Tanker	215	6,099	226	6,350	164	7,186	217	8,711	317	10,898	341	13,769	363	15,805
	Container	973	5,167	950	5,656	1,443	6,672	1,329	7,524	1,318	8,209	1,496	8,799	1,394	9,098
	Dry Cargo	413	5,795	413	6,437	513	8,051	597	9,706	743	11,437	752	13,234	749	14,438
	Cabotage	171	377	155	401	178	468	195	521	249	590	254	640	293	704
	Sub Total	1,772	17,438	1,744	18,844	2,298	22,376	2,338	26,463	2,627	31,134	2,843	36,441	2,799	40,045
6.0	Tanker	215	1,663	226	1,755	164	2,026	217	2,592	317	3,453	341	4,593	363	5,430
	Container	973	2,101	950	2,236	1,443	2,535	1,329	2,861	1,318	3,191	1,496	3,549	1,394	3,763
	Dry Cargo	413	1,536	413	1,713	513	2,129	597	2,570	743	3,032	752	3,499	749	3,814
	Cabotage	171	377	155	402	178	488	195	522	249	592	254	642	293	694
	Sub Total	1,772	5,677	1,744	6,106	2,298	7,177	2,338	8,545	2,627	10,268	2,843	12,283	2,799	13,701
7.0	Tanker	215	658	226	703	164	831	217	1,032	317	1,296	341	1,635	363	1,874
	Container	973	1,464	950	1,596	1,443	1,853	1,329	2,144	1,318	2,394	1,496	2,645	1,394	2,767
	Dry Cargo	413	711	413	780	513	955	597	1,164	743	1,410	752	1,694	749	1,901
	Cabotage	171	377	155	402	178	488	195	522	249	592	254	642	293	694
	Sub Total	1,772	3,210	1,744	3,481	2,298	4,127	2,338	4,861	2,627	5,692	2,843	6,616	2,799	7,235
8.0	Tanker	215	332	226	360	164	438	217	530	317	651	341	793	363	884
	Container	973	1,282	950	1,384	1,443	1,579	1,329	1,831	1,318	2,078	1,496	2,340	1,394	2,513
	Dry Cargo	413	599	413	661	513	782	597	911	743	1,046	752	1,187	749	1,281
	Cabotage	171	377	155	402	178	488	195	522	249	592	254	642	293	694
	Sub Total	1,772	2,590	1,744	2,806	2,298	3,287	2,338	3,794	2,627	4,367	2,843	4,961	2,799	5,372
9.0	Tanker	215	218	226	252	164	333	217	401	317	469	341	540	363	584
	Container	973	1,240	950	1,342	1,443	1,550	1,329	1,792	1,318	2,044	1,496	2,270	1,394	2,382
	Dry Cargo	413	407	413	479	513	611	597	738	743	870	752	992	749	1,076
	Cabotage	171	377	155	402	178	488	195	522	249	592	254	642	293	694
	Sub Total	1,772	2,241	1,744	2,475	2,298	2,982	2,338	3,453	2,627	3,975	2,843	4,444	2,799	4,735

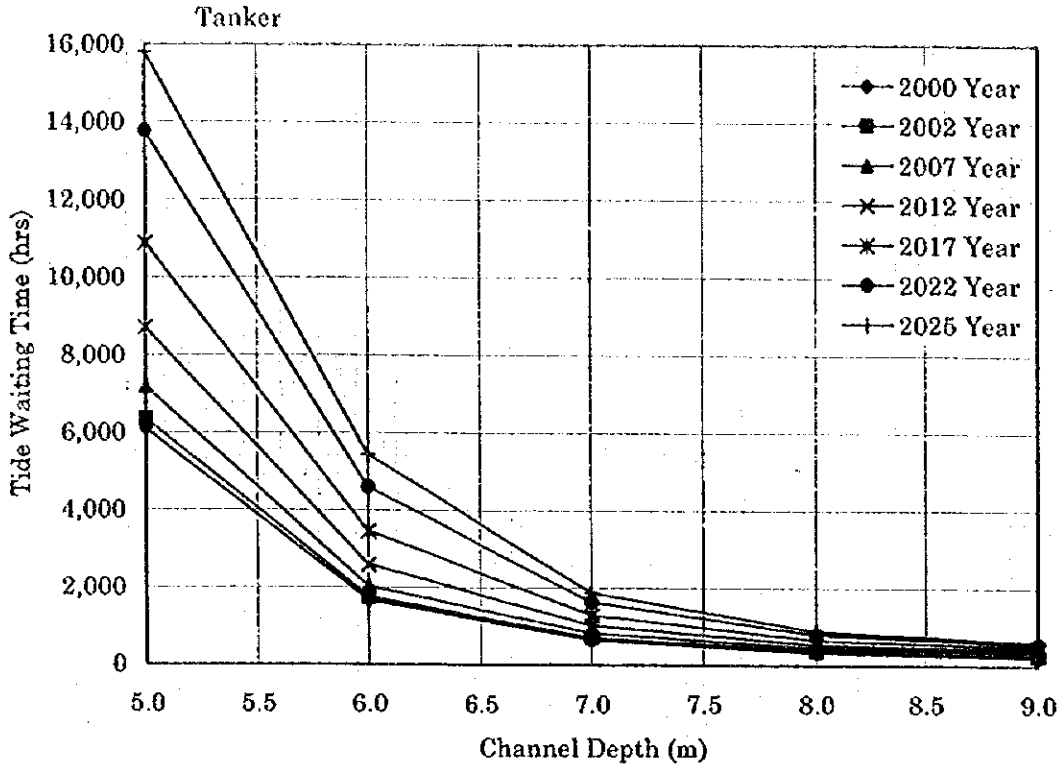

Figure 5.1.3-1 Forecast of Tide Waiting Time of Tanker in 2000 to 2025

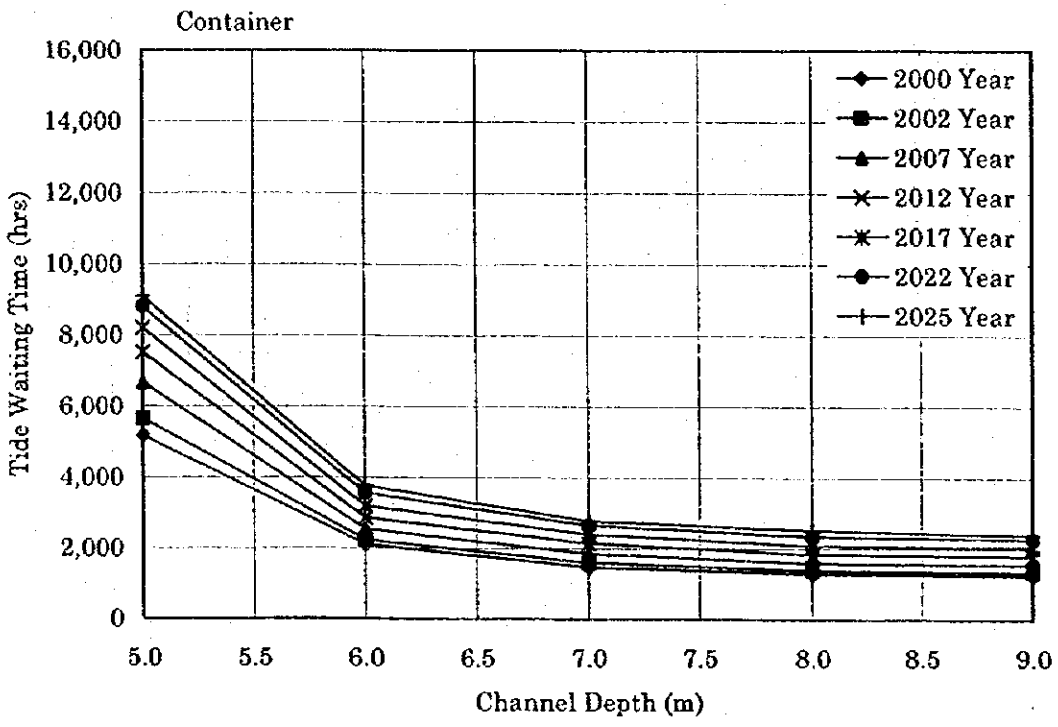

Figure 5.1.3-2 Forecast of Tide Waiting Time of Container in 2000 to 2025

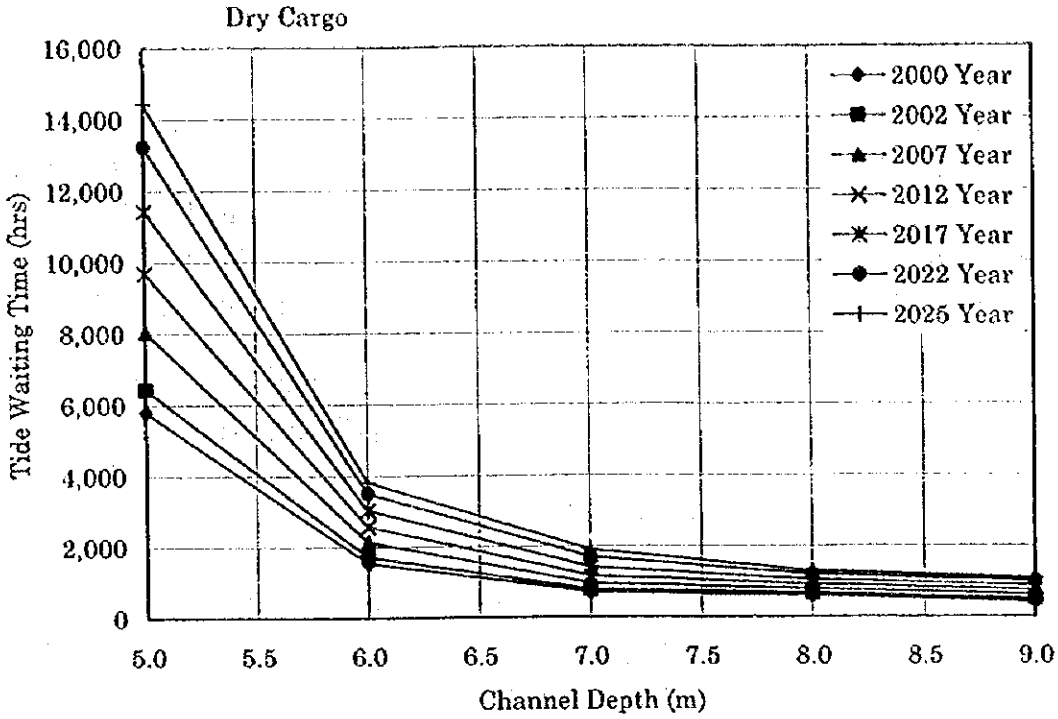

Figure 5.1.3-3 Forecast of Tide Waiting Time of Dry Cargo in 2000 to 2025

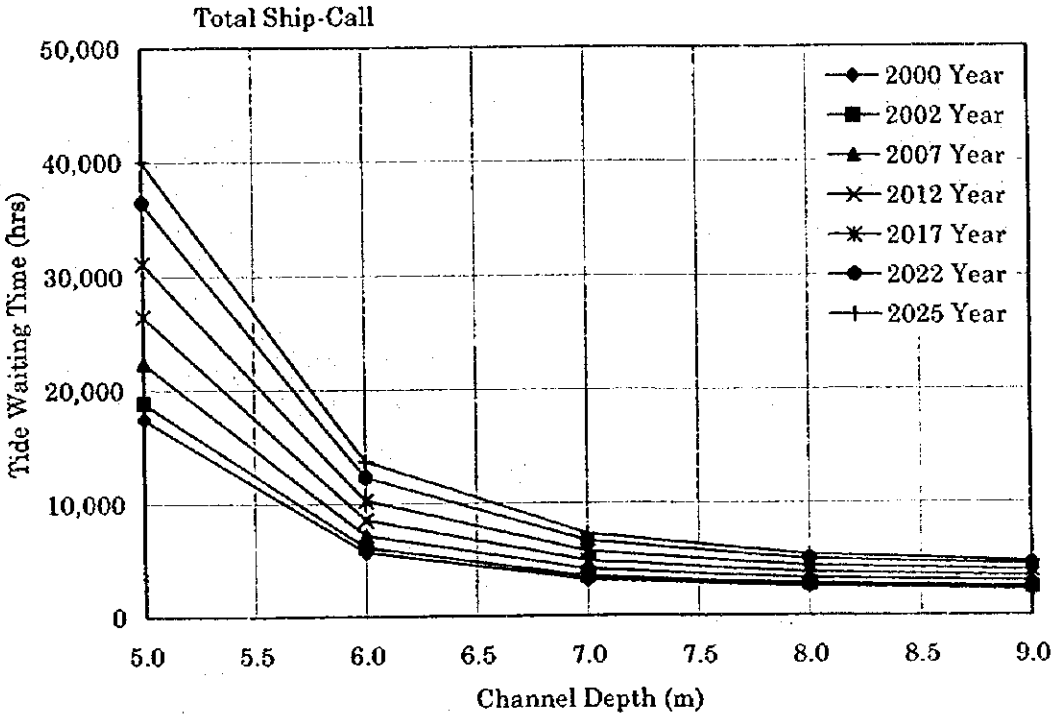

Figure 5.1.3-4 Forecast of Tide Waiting Time of Total Ship's Call in 2000 to 2025

5.2 Improvement Plan of the Access Channel

The most serious problem, which Beira Port currently faces, is a shallow and narrow access channel hampering safe and efficient navigation in the channel. The present study will give a detailed examination on technical and economical feasibility on introduction of a dredger to maintain the channel. The size of dredger, manufacturing schedule, maintenance dredging plan, etc. have been given a thorough consideration.

Improvement plan of the Access Channel is discussed in this section.

5.2.1 Problem and Improvement Policy

An access channel to a port is designed to ensure a safe and efficient entry to and departure from the port. The dimensions of the channel are determined by taking into consideration both construction/maintenance costs and navigational safety/efficiency.

The layout and dimension of the existing channel was given a thorough consideration from various aspects of oceanography, soil conditions, siltation, navigation, construction and maintenance costs, etc. and determined by NEDECO in Beira Port Study before the beginning of the capital dredging in 1989.

The study team has reviewed the original design and proposed the channel with the minimum depth of 8.0 m. The depths of the original channel are designed to be different section by section. While, in the new channel, the upper reach is designed at –8.0 m below CDL, the middle reach at -8.5 m and the outer reach at -8.7 m.

Principal purpose of this Study is to work out an appropriate plan to introduce a dredger to maintain the Access Channel to Beira Port through due consideration of technical and economical feasibility.

The basic direction of maintenance and improvement of the Access Channel of Beira Port in this Project is to restore the existing silted channel to the dimensions which allow safe navigation to the port for the largest ships calling the port. The existing channel was designed in 1989 and such changes occurred thereafter as cargo volume, number of ship's call and ship's size will be given a consideration with up-to-date data.

5.2.2 Original Design of the Access Channel

The original layout of the channel is shown in Figure 5.2.2-1 and its design is discussed in this section.

Improvement of the channel to Beira Port was studied in "Access Channel Study" in 1982 and following the study, "Master Plan Study for the Port of Beira" was carried out by NEDECO to deepen the channel from -6.0 m CDL in 1984. In 1989-90, the deepening works of the Access Channel to Beira Port was implemented to enable the port to receive the largest ship calling the port, oil tankers based on these studies. A maintenance dredging contract was prepared in 1991 but was not done due to financial reason.

Since the completion of this capital dredging work, no full scale maintenance dredging works have been carried out.

The tidal range in Beira is very large at about 7.0 m in spring tide and the existing Access Channel has been, through comparative consideration of cost and benefit, utilized in such a way that large ships with deeper draft have to wait for suitable tide levels.

(1) Design Ship

The ships calling Beira Port are broadly classified into tankers, container carriers, bulk cargo ships, general cargo ships and others. Bulk carriers leave the port fully laden with export coal while tankers enter the port fully loaded with oil. In Master Plan Study, various sizes of ships were examined in phased development plans. The existing channel was deepened according to the first phase development plan with the design ship shown below;

The ship size for designing the channel was determined as below;

Ship Size	Length	Beam	Full Draft	Draft in Ballast
30,000 DWT	200 m	27 m	11 m	7.2 m

(2) Alignment of Access Channel

1) Alternative Alignment of Access Channel

Two alternative layouts of the channel, the Macuti Channel and the Rambler-Portela Channel, were examined in the above study. The Macuti Channel was selected through consideration of mainly construction and

maintenance costs as summarized below;

Capital and Maintenance Volume (million m^3) and Cost (million US$), 30,000 DWT

	Capital Dredging		Maintenance Dredging	
	Volume	Cost	Volume	Cost
Macuti Channel	3.4	7.77	3.55	4.85
Rambler-Portela Channel	10.4	21.40	7.28	6.25

(3) Dimension of Access Channel

1) Channel Depth

The depth of the channel was determined by taking following factors into consideration.

- Tidal levels
- Ship's draft, trim and squat
  Ship speed of 4 m/s was assumed in calculating squat.
- Wave conditions
- Salinity
  Ships navigating in the sea of lower salinity draw deeper draft and 0.2 m is calculated at neap tide in the wet season.
- Keel clearance
  10 % of ship's draft was taken as a keel clearance.

2) Channel Width

The width of the channel was determined at the keel level by taking the followings into account.

- Dimensions and maneuverability of calling ships
- Natural conditions
- Channel layout and navigation aids
- Traffic condition
  Width of lane: 1.8-2.0 x ship's beam, clearance: 1.5 x ship's beam on both sides

3) Side Slope

The side slope of the channel was taken at 1:10 for all non-cohesive and weak cohesive soil, while 1:2 for all strong cohesive soil.

The above consideration on the channel design led to the following dimensions;

Channel Depth and Width (m), ship size 30,000 DWT

	Inner Section	Middle Section	Outer Section 2	Outer Section 1
Depth	8.5	8.8	9.2	9.3
Width	135	155	140	160

According to the above channel design proposed in Beira Port Study, the capital dredging work was designed in December, 1986 as shown in Figure 5.2.2-1 and outlined below;

Channel Depth and Width (m)

Section	E1	E2	E3	E4	E5	E6	E7	E8
Length	1063	645	360	3050	970	2134	2106	2186
Accumulated L				3050		5184	7290	9476
Width	50	50	50	200	200	135	135	135
Depth	9.5	12.0	12.3	8.0	5.5	8.0	8.0	8.0
Remarks	Q6-11	Q2-5	Oil.B		T.Basin			

Section	E9	E10	E11	E12	E13	E14	E15
Length	1614	3394	2428	2224	4375	3700	970
Accumulated L	11090	14484	16912	19136	23511	27211	
Width	250	155	155	140	140	160	150
Depth	8.8	9.2	8.7	8.8	8.5	8.7	7.5
Remarks	Corner						T.Basin

The existing channel is designed in L shape with the inner reach aligned in N-S direction and the outer reach in E-W. The inner reach from Sections E-4 to E-9 is about 12 km long while the outer reach from Sections E-10 to E-14 is about 16 km. The depth and width of the channel vary depending on wave, current and siltation conditions.

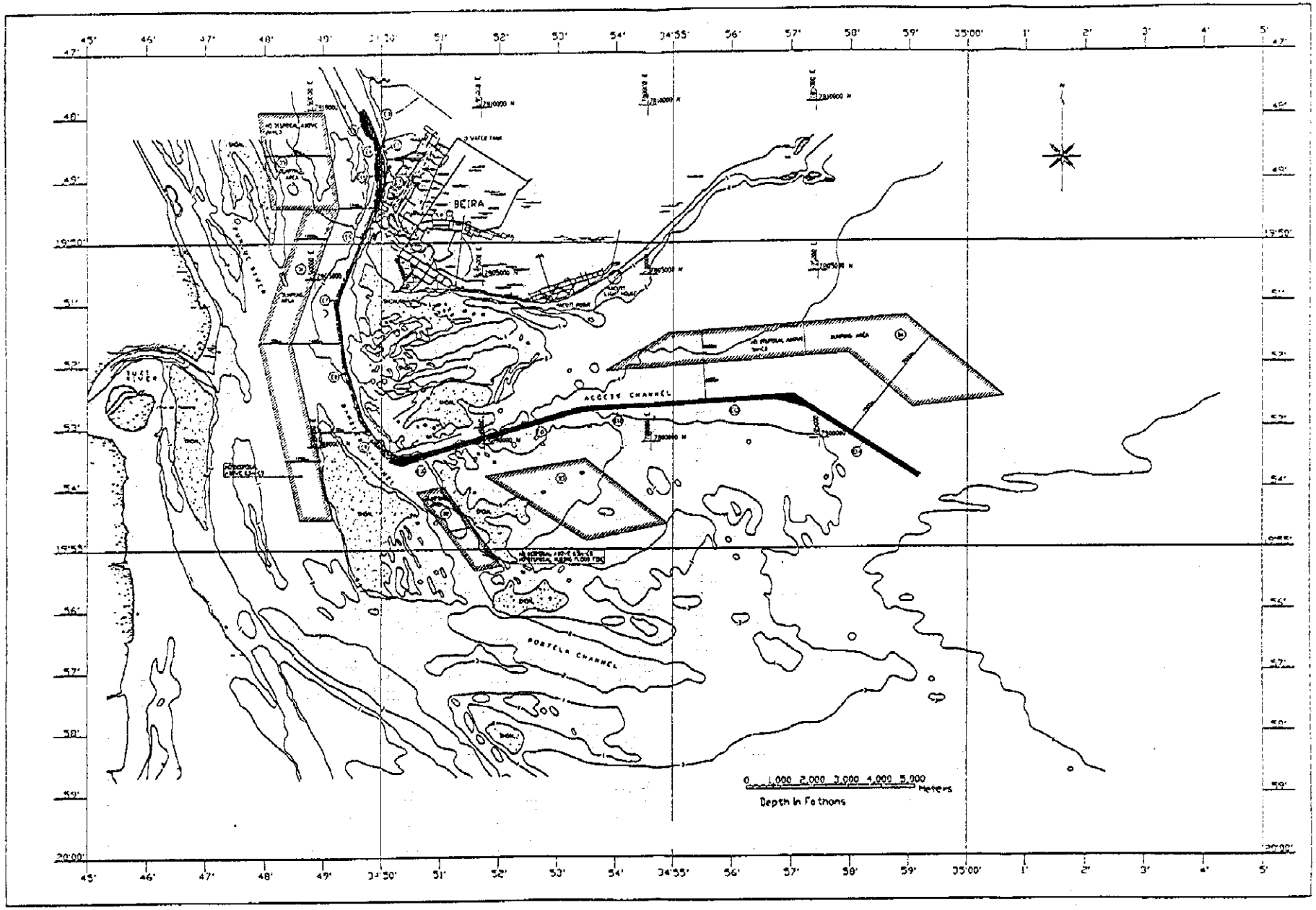

Figure 5.2.2-1 Layout of the Access Channel

5.2.3 Design of the Access Channel

The design depth and width of the Access Channel is examined on the basis of the size of calling ships and the capacity of the port quay facilities as well as the additional tidal benefit of a very wide excursion range to the channel depth.

(1) Capacity of Port Quay Facilities

Allowable ship sizes of the port quay facilities are estimated by the dimensions of the water depth detailed in Chapter 2.1. The ship size of the New Oil Terminal is stated on the document published by CFM-C. Table 5.2.3-1 gives the allowable sizes of each quay. The dead weight tonnage (DWT) of 30,000 tons of a cargo carrier is the maximum size for the quays of the Multipurpose and Container Terminal. Regarding the liquid cargo, the New Oil Terminal caters for a 50,000 DWT tanker at maximum.

Table 5.2.3-1 Dimensions of Port Quay Facilities

	Quay	Length	Depth	Size of Ship
Multipurpose and Container Terminal	Quay 2 - 5	645.9 m	12.0 m	DWT 30,000 ton Cargo Carrier *
General Cargo Terminal	Quay 6 - 10	858.0 m	10.0 m	DWT 10,000 ton Cargo Carrier *
Oil Terminal	Quay 11	128.5 m	10.0 m	DWT 15,000 ton Tanker *
New Oil Terminal	Quay 12	260.0 m	13.5 m	DWT 50,000 ton Tanker **

*) Ship size estimated by quay depth **) Ship size stated in CFM-C document

(2) Design Ship for Original Access Channel

As mentioned in the previous section, the design ship of the original access channel is 30,000 DWT tankers or cargo carriers sized as follows.

Dimensions of 30,000 DWT Tanker and Cargo Carrier

Length Perpendicular (Lpp) = 200.0 m
Length Overall (Loa) = 210.0 m
Breadth (B) = 27.0 m
Full Load Draft (D) = 11.0 m

For reference to the ship size, Table 5.2.3-2 shows standard dimensions of Length Overall, Moulded Breadth and Full Load Draft by ship type stipulated in "Technical Standards of Port and Harbour Facilities in Japan". The full load draft of tankers and cargo carriers give the same number of 10.9 m, which is almost equivalent to the full load draft applied for the original design of the Access Channel.

Table. 5.2.3-2 Standard Size of Ships

Type	Tonnage DWT(ton)	Length Overall (m)	Moulded Breadth (m)	Full Load Draft (m)
Oil Tanker	1,000	61	9.8	4.0
	2,000	77	12.2	5.0
	3,000	88	13.8	5.6
	5,000	104	16.2	6.5
	10,000	130	20.1	8.0
	15,000	148	22.8	9.0
	20,000	162	24.9	9.8
	30,000	185	28.3	10.9
	40,000	204	30.9	11.8
	50,000	219	33.1	12.7
	60,000	232	35.0	13.6
Cargo Carrier	1,000	64	10.4	4.2
	2,000	81	12.7	4.9
	3,000	92	14.2	5.7
	5,000	109	16.4	6.8
	8,000	126	18.7	8.0
	10,000	137	19.9	8.5
	15,000	153	22.3	9.3
	30,000	186	27.1	10.9
	40,000	201	29.4	11.7
	50,000	216	31.5	12.4
	70,000	235	33.8	13.4
Container Carrier	20,000	201	27.1	10.6
	30,000	237	30.7	11.6
	40,000	263	33.5	12.4
	50,000	280	35.8	13.0

Source: Technical Standards for Port and Harbour Facilities in Japan

(3) Tide Condition

Tide condition at Beira Port described in "Admiralty Tide Tables, the Hydrographer of the Navy, 1997" is as follows. The tidal excursion range is extremely wide at Beira Port, so that calling ships enter the port with a tidal benefit in addition to the water depth of the Access Channel. The tidal ranges of the mean spring tide and the mean neap tide are 5.6 m (MHWS - MLWS) and 1.5 m (MHWN - MLWN), respectively.

HAT (Highest Astronomical Tide)	CDL +7.3 m
MHWS (Mean High Water Spring Tide)	CDL +6.5 m
MHWN (Mean High Water Neap Tide)	CDL +4.2 m
MSL (Mean Sea Level)	CDL +3.5 m
MLWN (Mean Low Water Neap Tide)	CDL +2.7 m
MLWS (Mean Low Water Spring Tide)	CDL +0.9 m
LAT (Lowest Astronomical Tide)	CDL +0.2 m
CDL (Chart Datum Level)	CDL 0.0 m

Figure 5.2.3-1 shows the accumulated percentage of the annual occurrence days of high tide, which means the percentage of days not exceeding the certain tide level. The accumulated percentage of the tide level of MHWN (CDL +4.2 m) indicates 0.0 %, in other words the tide level reaches MHWN every day throughout the year. The number of days in which the tide level does not exceed MHWS (CDL +6.5 m) is 87 %, which means that the days when the tide level becomes over MHWS account for 47 throughout the year.

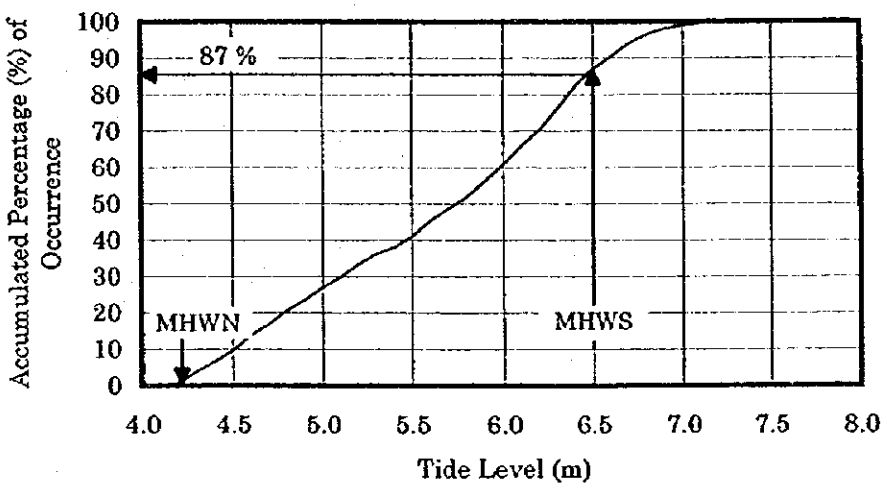

Figure 5.2.3-1 Accumulated Percentage of High Tide Occurrence Days

(4) Calculation of Water Depth of the Access Channel

The water depth of the Access Channel is calculated as follows. The definitions and the relevant components of the water depth of the Access Channel are shown in Figure 5.2.3-2.

As mentioned above, the design ships of the Access Channel are determined as 30,000 DWT of cargo carriers and 50,000 DWT of tankers. Full load drafts of 30,000 DWT cargo carriers and 50,000 DWT tankers are set respectively as 10.9 m and 12.7 m as described in Table 5.2.3-2.

Design Water Depth = Required Water Depth + Tolerance for Siltation, Ripples and Survey Inaccuracy (5.2.3-1)

where;

Required Water Depth = Allowable Nautical Depth - Water Level (5.2.3-2)

Allowable Nautical Depth = Nautical Vessel Depth + Allowance (5.2.3-3)

Nautical Vessel Depth = Draft + Tolerance for Squat, Trim and Wave Motion (5.2.3-4)

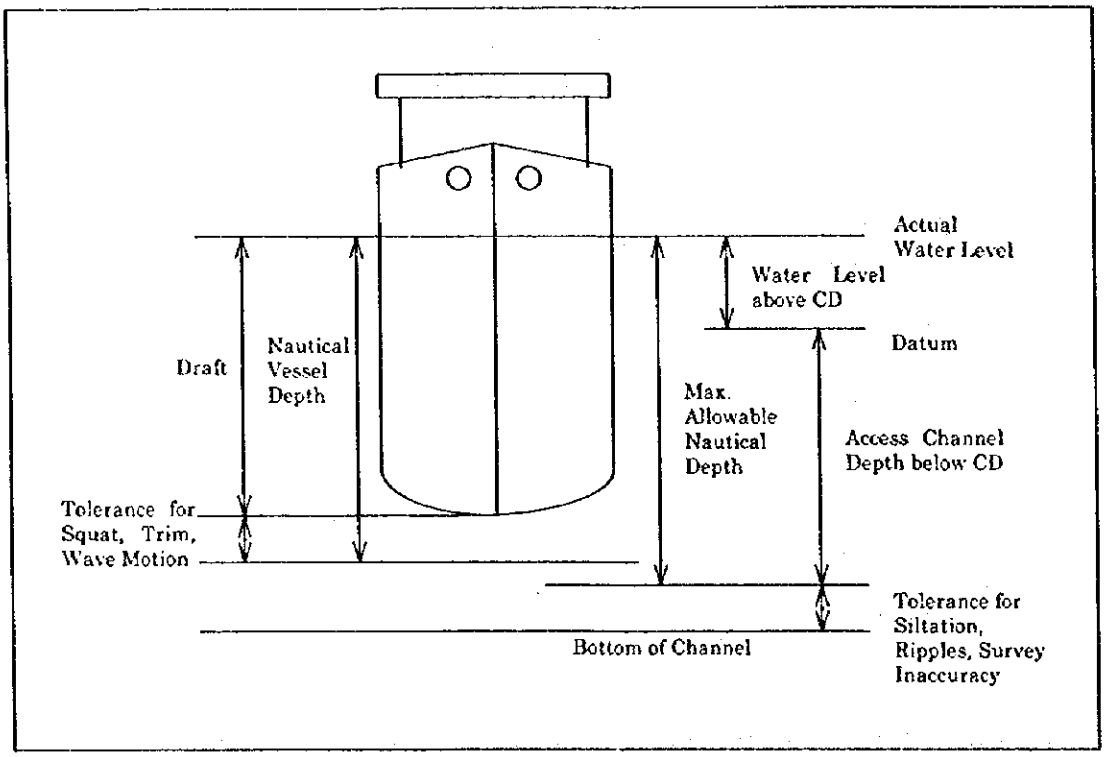

Figure 5.2.3-2 Definition of Water Depth Components of the Access Channel

By reference to Figure 5.2.3-2, the nautical vessel depth of 30,000 DWT of cargo carriers and 50,000 DWT of tankers obtained above are calculated as in Table 5.2.3-3 with a tolerance for squat, trim and wave motion of ship set as 10 % of a full load draft. And a required channel depth is obtained by subtracting the water level of MHWN (CDL +4.2 m), expected daily occurrence throughout a year,

from the nautical vessel depth, which means that the aforementioned design ships are enabled to enter or leave the port every day through the year.

Table 5.2.3-3 Required Water Depth of the Access Channel

Ship Size (DWT)	Full Load Draft (1)	Tolerance (1) x 0.1	Nautical Vessel Depth	Allowable Nautical Depth	Water Level (MHWN)	Required Channel Depth
30,000 t	10.9 m	1.1 m	12.0 m	12.2 m	CDL +4.2 m	CDL -8.0 m
50,000 t	12.7 m	1.3 m	14.0 m	14.2 m	CDL +4.2 m	CDL -10.0 m

The required water depths for 30,000 DWT cargo carriers and 50,000 DWT tankers are determined respectively at CDL -8.0 m and CDL -10.0 m with a tolerance for squat, trim and wave motion in a normal wave condition equivalent to 10 % of the full load draft and allowance of 0.2 m.

(5) Evaluation of Water Depth of the Access Channel

Water depth of the Access Channel is determined from the view points of accessibility of the design ships, annual maintenance dredging volume and tide waiting time.

1) Maintenance Dredging Volume

The annual maintenance dredging volume is examined in Section 4.3.2 and is estimated for different water depth of the Access Channel as shown in Table 5.2.3-4. A difference of the maintenance dredging volume between the channel depth of CDL -8.0 m and CDL -9.0 m is 1,000,000 m^3 per year, which results an considerable increase of the maintenance cost of the order of some million US$ or more.

Table 5.2.3-4 Comparison of Maintenance Dredging Volume

Access Channel Depth	Annual Maintenance Dredging Volume
CDL -7.0 m	1,700,000 m^3
CDL -8.0 m	2,500,000 m^3
CDL -9.0 m	3,500,000 m^3

2) Accessibility of the Access Channel

In order to evaluate accessibility of the Access Channel, an accessible time for calling ships to enter or leave the Port is calculated considering the full load draft of ships and annual tide level occurrence in hour required for sailing through the Channel.

As shown in Table 5.2.3-5, a 50,000 DWT tanker of the design ship of the New Oil Terminal is not allowed to sail through the Access Channel of CDL -7.0 m through the year and needs more water depth to enter or leave the Port. Other bigger sized ships such as 30,000 DWT bulk carriers of the design ship of the Multipurpose and Container Terminal are also obliged to wait for considerable time until tide level rises to sail the channel. In case of CDL -8.0 m channel depth, the 50,000 DWT tanker can enter the Port several days a month and other ships expected to call can easily access the Port without long tide waiting time. Particularly, container ocean liners of frequent visit ranged from 10,000 to 20,000 DWT which are requested a timely arrival and departure can easily call the Port every day with occasionally short tide waiting. Accessibility of the channel depth of CDL -9.0 m is sufficiently improved with very short tide waiting which is adjustable by sailing schedule of ship call.

Table 5.2.3-5 Comparison of Annual Navigable Time

			Access Channel Depth		
Ship Type	DWT	Full Load Draft	CDL -7.0 m	CDL -8.0 m	CDL -9.0 m
Tanker	50,000 t	12.5 m	None	451 hrs	1,619 hrs
	30,000 t	10.9 m	1,619 hrs	3,354 hrs	5,101 hrs
	10,000 t	8.0 m	2,063 hrs	8, 468 hrs	8,768 hrs
Container Carrier	30,000 t	11.6 m	642 hrs	1,887 hrs	3,745 hrs
	20,000 t	10.6 m	2,063 hrs	3, 910 hrs	4,612 hrs
	10,000 t	9.6 m	4,074 hrs	4, 823 hrs	7,529 hrs
Bulk Carrier	30,000 t	10.9 m	1,619 hrs	3,354 hrs	5,101 hrs
	10,000 t	8.5 m	5,246 hrs	7782 hrs	8,729 hrs

1 year = 8,760 hours

3) Tide Waiting Time

The tide waiting time is obtained by the channel traffic simulation model in Chapter 5.1.3, in which a total of the annual tide waiting time is calculated for future ship calls of each ship type and different water depth of the Access Channel as shown in Table 5.2.3-6. Water depth change of the Access Channel from CDL -7.0 m to CDL -8.0 m is more significant than that from CDL -8.0m to CDL -9.0 m, which means that the channel depth of CDL -8.0 m is reasonable and efficient from a view point of tide waiting time.

Table 5.2.3-6 Comparison of Tide Waiting Time of Calling Ships

	Annual Total Tide Waiting Time		
Channel Depth	2000	2007	2025
CDL -7.0 m	3,210 hrs	4,127 hrs	7,235 hrs
CDL -8.0 m	2,590 hrs	3,287 hrs	5,372 hrs
CDL -9.0 m	2,241 hrs	2,982 hrs	4,735 hrs

4) Evaluation of Channel Depth

Evaluation results of the channel depth in terms of the maintenance dredging volume, the accessibility of the Access Channel and the tide waiting time of calling ships are summarized in Table 5.2.3-7. The water depth of CDL -8.0 m is concluded technically to be more appropriate and reasonable for Beira Port.

Table 5.2.3-7 Evaluation of Channel Depth

	Access Channel Depth		
Items	CDL -7.0 m	CDL -8.0 m	CDL -9.0 m
M. Dredging Volume	◎	○	△
Accessibility	△	○	◎
Tide Waiting Time	△	○	◎
Total Evaluation		1 st	

◎: Better ○: Good △: Fair

(6) Water Depth along the Access Channel

The design water depth of the Access Channel is calculated by a tolerance for siltation, ripples and survey accuracy in addition to the required water depth mentioned above.

In case of a maintenance dredging on a contract basis, a tolerance for siltation, ripples and survey accuracy must be included in the design water depth, because of the interval until the next expected dredging works and availability of dredging equipment. However, on condition that Beira Port will has a dredger for its own exclusive use, any area in the Access Channel necessary for a maintenance dredging would be dredged timely and smoothly by a dredger on standby basis at the Port. Taking the availability of a dredger into account, the tolerance for siltation, ripples and survey accuracy is excluded from the design depth along the Access Channel.

The design water depth along the Access Channel is determined with an additional tolerance for wave motion at the sections from E9 to E14, where the channel section is severely affected by direct wave intrusion. The water depth and the additional tolerance of each channel section are determined as shown in Table 5.2.3-8.

Table 5.2.3-8 Design Water Depth along the Access Channel

	Design Water Depth		
Channel Section	E6, E7, E8	E9, E10, E11	E12, E13, E14
Location	Near Port	Bending Point	Near Entrance
Required Water Depth	8.0 m	8.0 m	8.0m
Additional Tolerance	---	0.5 m	0.7 m
Design Water Depth	8.0 m	8.5 m	8.7 m

(7) Width of the Access Channel

The width of the Access Channel is determined as the same as the original design width stipulated in "Beira Port Study, Access Channel Study, NEDECO". The required width along the Access Channel is examined by the following factors in the study.

* Dimensions and maneuverability of design vessels,
* Environmental conditions with respect to wind, waves and currents,
* Influence of depth and width restriction on the maneuverability,
* Alignment,
* Traffic situation,
* Ability of pilots and helmsmen and
* Effectiveness of aid to navigation.

The required channel width is set on conditions of one-lane traffic for the largest vessels in consideration of the design traffic situation and the design vessel of fully laden bulk carriers leaving the port.

The width of the maneuvering lane depending on the maneuvering of the vessels at the prevailing water depth, the ability of pilots and helmsmen and the navigation aids can be supposed to be a width of between 1.8 and 2.0 times of the ship's breadth.

To prevent ships from being hampered by bank suction effects, a bank clearance of 1.5 time of the ship's breadth on both sides of the maneuvering lane is employed. The channel width of the standard area is obtained by following equations as illustrated in Figure 5.2.3-3.

Channel Width = Width of Maneuvering Lane (1.8B, 2.0B) +
2 x Bank Clearance (1.5 B) = 4.8 B, 5.0B (4.2.3-5)
B = Breadth of Vessel
(27.0m of 30,000 DWT tanker and Cargo Carrier)

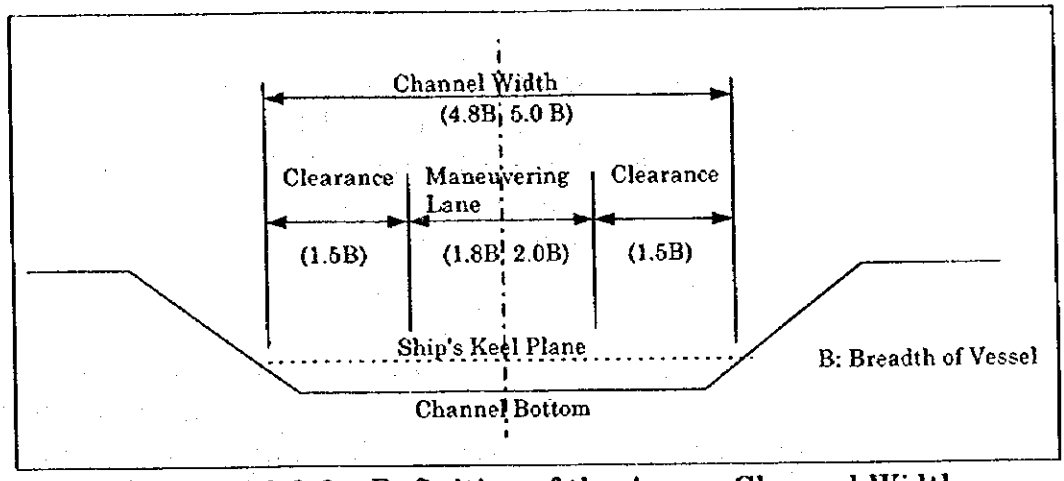

Figure 5.2.3-3 Definition of the Access Channel Width

As the result of it, channel widths are presented in Table 5.2.3-9. These widths should be available in the ship's keel plane.

Table 5.2.3-9 Design Width of the Access Channel

Channel Section	E6, E7, E8, E9	E10, E11	E12, E13	E14
Design Width	135 m	155 m	140 m	160 m

5.2.4 Maintenance Works of the Access Channel

In general, maintenance dredging work is a fundamental countermeasure for maintenance of a navigation channel suffering from severe shoaling such as the Access Channel of Beira Port. In order to reduce a maintenance dredging volume, supplementary countermeasures such as a retaining wall, a sand trap and over dredging would be installed according to a sedimentation condition of the channel, efficiency and applicability of the countermeasures.

(1) Sedimentation Condition of the Access Channel

Sedimentation condition of the Access Channel is categorized into 4 groups in terms of predominant sedimentation factors as shown in Figure 5.2.4-1.

Group I : Silty material of the river bed sediment is suspended by strong tidal currents in addition to river currents and is transported to the Access Channel. Group I is an area where a deposition of silty material provided by river predominantly causes shoaling of the Channel.

Group II: Sand drift along the Macuti Coast and through the Macuti Shoal and other shallow area are suspended by wave action and are transported to the Access Channel by alongshore currents in addition to the sediment discharged from the river. Group II is an area affected simultaneously by river sedimentation and littoral sand drift of the adjacent beach and shoal.

Group III: Predominant shoaling factor of group III is regarded as littoral sand drift transported by alongshore current through the adjacent shallow area, such as the Macuti Shoal and the Rambler Shoal.

Group IV: An area of Group IV is situated at the entrance of the Access Channel where the water depth is CDL -8.0 m or more. Wave action and current force for sediment transport is relatively small and deposition of fine silt discharged from the river is presumed to be a predominant factor of the channel shoaling in this area.

The following supplementary countermeasures in addition to the maintenance dredging are considered to be applicable to ease the siltation in the Access Channel.

(a) Retaining Wall: Groins, Jetties and Submerged Breakwater
(b) Sand Trap
(c) Over Dredging

Taking the sedimentation condition along the Access Channel and safety of sailing ships into account, appropriate and applicable maintenance works for channel siltation are selected for each group area as shown in Table 5.2.4-1.

Table 5.2.4-1 Applicable Maintenance Works of Siltation

Maintenance Works	Group I	Group II	Group III	Group IV
Groin and Jetty		○		
Submerged Breakwater		○	○	
Sand Trap	○	○	○	
Over Dredging	○	○	○	○

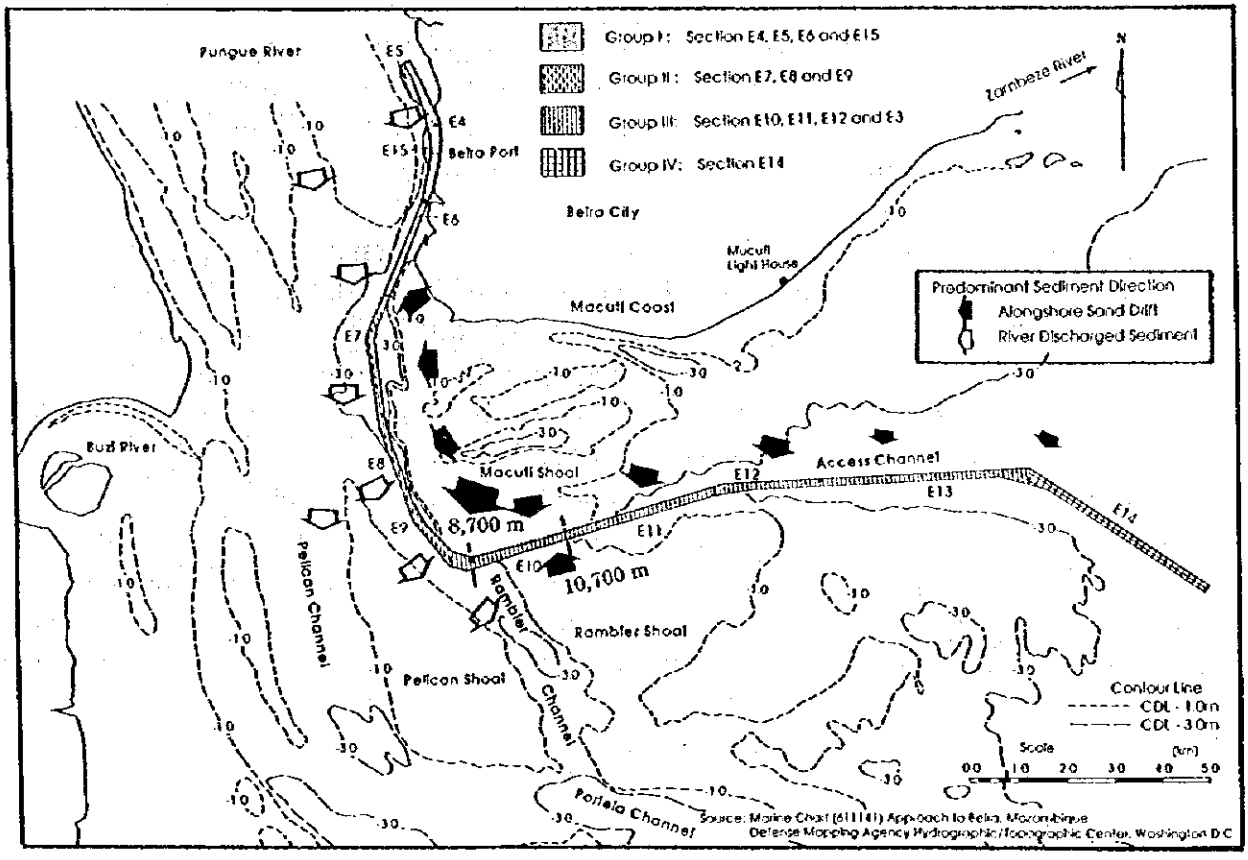

Figure 5.2.4-1 Sedimentation Condition of the Access Channel

(2) Groin and Jetty

A series of Groin are coastal structures of a few hundred meters or less in length constructed perpendicularly or obliquely to a beach line for the purpose of preventing beach erosion. Currently, a groin system installed along the Macuti Coast in the extension of about 5 km from the river mouth of the Pungue River along the Macuti Coast so that some part of the alongshore sand transport is prevented from entering the Access Channel. But, the distance between the Macuti beach and the area of Group II and III suffering from severe shoaling of the Access Channel is 3 to 4 km and the length of groins is relatively short, so that its effect against the Macuti Channel is restricted in very local portion adjacent to the beach and is regarded as substantially negligible. The groin system of relatively short extension added besides the Macuti Coast is concluded not to be effective for the channel siltation.

A jetty sized much bigger and longer is a structure prolonged seawards from the coast line, taking its crown above the sea level. The location suitable for a jetty installation is the west end of the Macuti Coast in the vicinity of the river mouth of the Pungue River, from which it would be extended parallel to the Access Channel of Group II area. This kind of large scaled maritime structure plays a role not only for the ease of siltation in the Channel, but also affecting the sea condition such as wave, current and bottom conditions which give some impact on environmental conditions of the adjacent area.

A cross section of the rubble mound type jetty is as shown in Figure 5.2.4-2. A crown height of the jetty structure is set as 7.0 m above CDL, which is required to be more than CDL +6.5 m of the mean high water spring tide level. The surface of the jetty body is covered by armor stones with sufficient wave stability weighing 1 to 2 tons. The construction cost for different water depth depending on the construction area is estimated preliminary for a nearshore area constructed from land and an offshore area of maritime construction as shown in Table 5.2.4-2 and Figure 5.2.4-3. Such a jetty of a rubble mound type will cost in the order of ten thousand US dollars per meter. The cost of the necessary extension until the end of E10 to cover the section E9 and E10 of Group II area suffering from the most severe shoaling with sand intruded from the Macuti Shoal. Considering the site condition of the Access Channel, a construction of the jetty is economically unfeasible as a supplementary maintenance work.

(3) Submerged Breakwater

The submerged breakwater is a structure of a rubble mound type as shown in Figure 5.2.4-3, taking its crown height at some meters above the sea bottom,

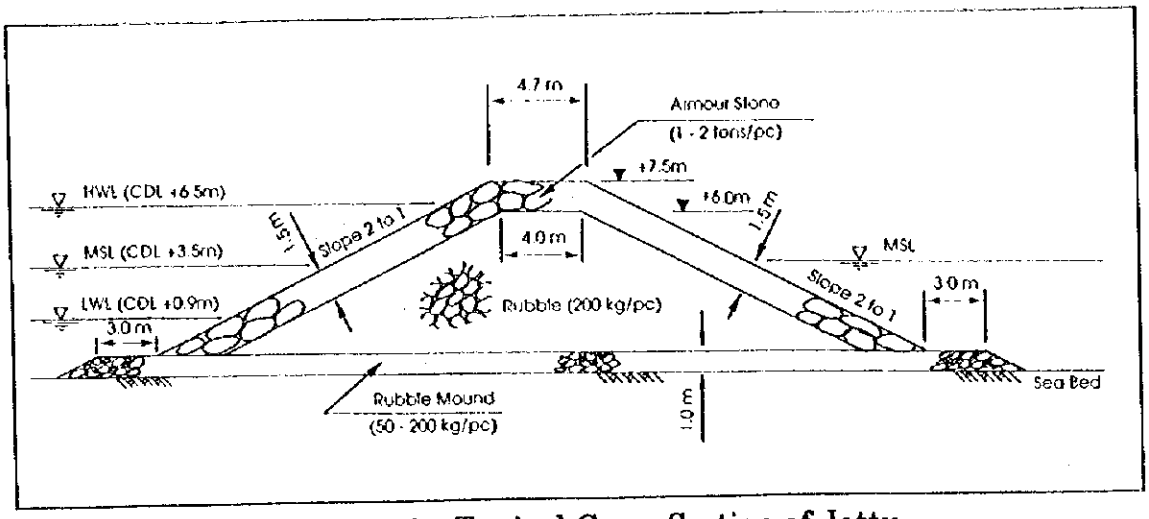

Figure 5.2.4-2 Typical Cross Section of Jetty

Table 5.2.4-2 Construction Cost of Jetty

(US$/100m)

Water Depth	Nearshore Area	Offshore Area
CDL ±0.0 m	1,200,000	1,400,000
CDL -1.0 m	1,400,000	1,600,000
CDL -2.0 m	1,700,000	1,900,000
CDL -3.0 m	2,000,000	2,300,000

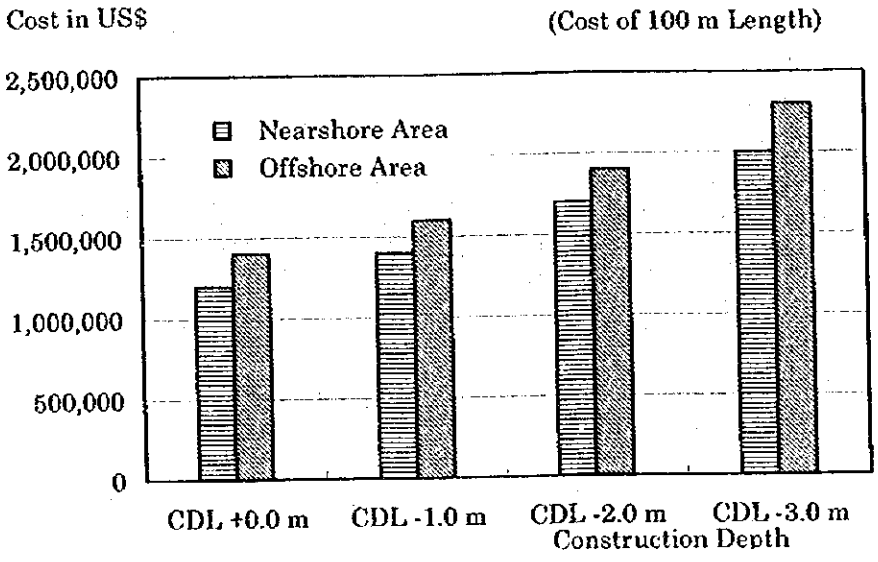

Figure 5.2.4-3 Construction Cost of Jetty

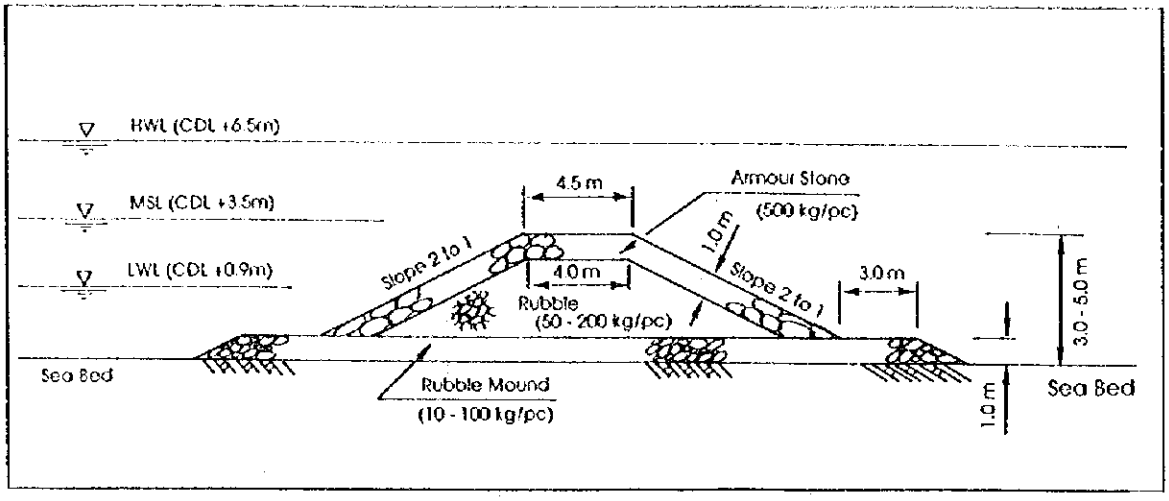

Figure 5.2.4-4 Typical Cross Section of Submerged Breakwater

Table 5.2.4-3 Construction Cost of Submerged Breakwater

(US$/100m)

Body Height	Submerged Breakwater
3.0 m	520,000
4.0 m	720,000
5.0 m	960,000

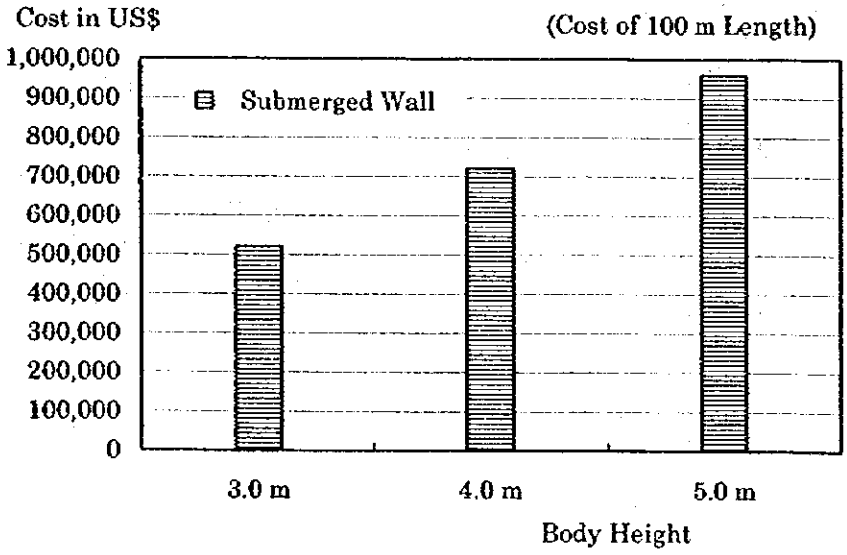

Figure 5.2.4-5 Construction Cost of Submerged Breakwater

and is utilized to prevent bed load moving on sea bottom surface. A submerged breakwater is an alternate countermeasure to control the sedimentation along E8, E9 and E10 in the area of Group II so that the amount of sand entering the Access Channel from the Macuti Shoal would be decreased up to a certain proportion depending on the body height and extension of the submerged breakwater.

The construction cost for different body heights determined by sand trap efficiency is estimated preliminary on the basis of maritime construction as shown in Table 5.2.4-3 and Figure 5.2.4-5. The submerged breakwater also is not recommendable as a countermeasure of the Access Channel to Beira Port, because of the high construction cost estimated as several thousand US dollars per meter and maritime safety of ship traffic in the Channel.

(4) Sand Trap

Where a source of sediment materials intruding into the mooring basin or a navigation channel is clear, a sand trap placed upstream of the sediment flow is an alternate countermeasure to prevent sand deposition before invasion of the sediment material into a basin and a access channel. For instance of an estuary port located along a river mouth, a certain portion of upper stream side of basins or channels is deepened more than other area in order to trap sediment materials transported by river flow before entering the basin. The sand trap method is effective where bed load is predominant and a tidal range is small. In case of the Pungue River where Beira Port is located along, a bed load is less predominant than suspended load, as well as tidal range is quite wide, so that the sand trap is not effective in the upper stream side of the section E4 of Group I.

On the other hand, in the most severe shoaling sections E9 and E10 of Group II, a sand trap method seems to be more effective, because shoaling phenomena occurring in the area indicates that a bed load is predominant for the channel siltation so as for the channel slope shifting into the channel due to a severe bed load, as described in Section 4.1.1(2).

As mentioned in Chapter 5.2.2, the channel width in the vicinities of the bending part of the Access Channel is widened to 250 m in access portion and 400 m in the bending point as shown in Figure 5.2.4-6. Comparing that the channel width of E8 and E11 is respectively 135 m and 155 m, the width near the bending corner has more excessive width for ships traffic, even taking into consideration the deviation of ships sailing through the center of the channel. This surplus is playing a role to serve as a buffer space for sand trap.

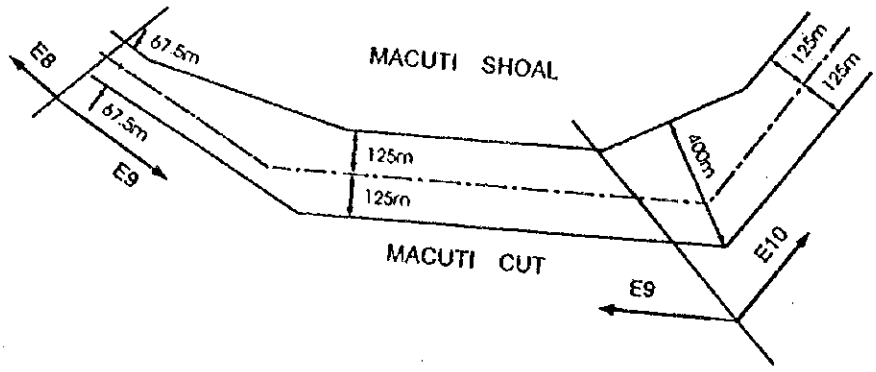

Figure 5.2.4-6 Channel Width Near The Bending Corner

Figure 5.2.4-7 shows a time history of the point of CDL -5.0 m deep on the side slope plotted by its distance from the sectional center of the channel as obtained by the cross section of Figure 4.1.1-4. Deviation curves of the land side slope at the distance of 8,700 m in the Figure shows that the slope moved inside about 150 m during 3 years from April 1993 to April 1996, corresponding to 50 m per year. The annual deviation rate of 50 m occurring under the condition of 10 m channel depth could be converted the rate under the condition of 8.5 m recommended channel depth in the study as follows.

$$50 \text{ m/ year} \times 10 \text{ m} / 8.5 \text{ m} \fallingdotseq 60 \text{ m/year} \qquad (5.2.4\text{-}1)$$

The channel width at the distance of 8,700 m is 250 m in the original design of the Access Channel would be reduced by sediment deposition to 190 m in one year without maintenance dredging. The channel width of 190 m corresponds to more than half of ship length of 30,000 DWT, which means that the design channel width of 250 m has sufficient siltation buffer against the shoaling for one year.

Regarding the curve of the distance 10,700 m, the deviation rate of the sea side slope of the channel is about 20 m per year. The deviation rate under the recommended channel depth of 8.5 m is converted by same manner as follows.

$$20 \text{ m/ year} \times 10 \text{ m} / 8.5 \text{ m} \fallingdotseq 25 \text{ m/year} \qquad (5.2.4\text{-}2)$$

The channel width is 155 m at the distance of 10,700 m is also reduced to 130 m without maintenance dredging during for one year, which means that the channel width of the original design includes one year siltation buffer.

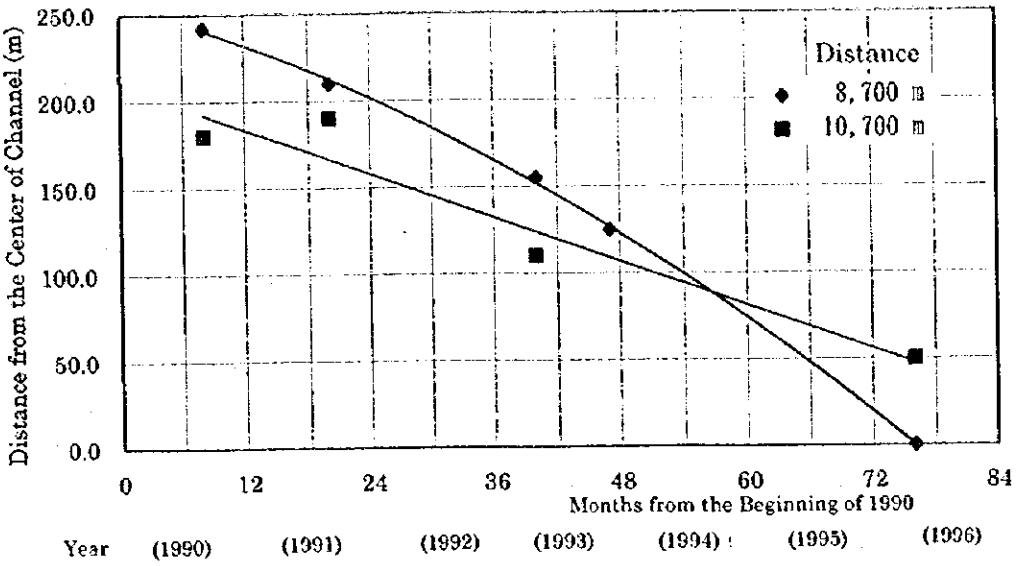

Figure 5.2.4-7 Time History of Deviation of Channel Slope

(5) Over Dredge

In the capital dredging, the over dredge of more than 1 m was taken for a sedimentation tolerance throughout the Access Channel. For the expected maintenance dredging, the over dredge does not seem to be necessary as follows.

(a) The deeper the Channel is dredged, the more shoaling occurs, which results in increasing the maintenance dredging cost.

(b) In this Project, the new dredger is exclusively engaged in Beira Port. Therefore, in case that some part become shallower than the design depth, immediate dredging will be executed by the new dredger on standby basis at the Port.

However, when the ship calling of fully loaded 30,000 DWT tanker or other equivalent carriers become frequent in the future, some over dredge of the Access Channel towards the channel depth should be considered.

(6) Dredgers

Taking into consideration that materials deposited in the Access Channel is silty and sandy material, a suction dredger is suitable. A suction pump dredger, in general, is not used for maintenance dredging of an active navigation channel, because it is necessary to install discharged pipe lines in addition to anchorage

wiring or spuds during the dredging operation, which would be an obstacle for the ship traffic through the Channel. A grab dredger is too small in dredging capacity and is used mainly for small scaled dredging such as a short navigation channel, an anchorage basin and a spot dredging of structure foundations.

In conclusion, a trailing suction hopper dredger should be appropriate for the maintenance works of the Access Channel without any of the supplemental works mentioned above, although a kind of sand trap installed within the width of the Access Channel is applicable. This type of dredger is self navigable at a speed of 2 or 3 knots, stocking suctioned materials in the hopper and discharging from the hull bottom. A trailing suction hopper dredger is utilized widely for the maintenance works of active navigation channels throughout the world.

CHAPTER 6

MAINTENANCE DREDGING PLAN

Chapter 6 Maintenance Dredging Plan

6.1 Design of Dredger

6.1.1 Basic Design Criteria

In order to make the design of the dredger for maintenance dredging of the Access Channel to Beira Port, the following design criteria are established.

(1) Type of Dredger

In selecting and designing the most suitable type for the intended purpose of this Project from among various types of dredgers, full consideration should be given to the conditions and requirements of the Project and to the functions and features of each type of dredger.

Since the dredger to be planned under this Project is intended to engage in the maintenance dredging of the Access Channel of the Port, it must be able to carry out the dredging work without hindering navigation of incoming/outgoing vessels and also to maintain her own safe navigation and to avoid such marine risks as collision without any difficulty. To comply with such requirements, it should be taken into due consideration that the dredger shall have a maneuvering function not only to enable to make a quick turning but also be manned by qualified crew on board.

Therefore, such concept design has been worked out that the dredger shall be of a self-propelling trailing suction type that is capable to change easily her direction by means of twin sets of propulsion engine, propeller and rudder, each installed at port and starboard sides respectively, for independent control of propulsive power of each side in emergencies, load the dredged soil into her own hopper and then dump them in the prescribed dump sites by shuttling between the dredging sites and the dump sites.

A self-propelling trailing suction type dredger can be classified in two types by hull form, i.e. a conventional type hull form and a split type one.

A split type can be deemed to be more advantageous in a quicker dumping performance and in a shallower working draft for dumping work.

In this report, however, a conventional type hull form has been adopted as the concept design in view of any possible operational risk for a split type due to

EMODRAGA's lack of familiarity with such a type of dredger.

Selection of a self-propelling trailing suction type can also be justified from the viewpoint of its operation as the most suitable for EMODRAGA, considering that the existing dredger is of the same type.

(2) Basic Data from Siltation Analysis and Dredging Plan

Necessary data for setting up the concept of the dredger, the following design conditions are adopted.

1) Soil volume to be dredged per annum;		2 ,500,000 m^3
	Silt	(1,125,701 m^3)
	Sand	(1,374,298 m^3)
2) Maximum dredging depth at light load condition;		21.0 m
3) Distance from dredged point to dumping area;		average 10.54 km
4) Minimum water depth at dredging area and sailing route; (including bottom clearance of 0.5 m)		6.0 m
5) Minimum water depth at dumping point; (including bottom clearance of 0.5 m)		7.0 m
6) Maximum speed against current velocity during dredging work;		3.5 knots
7) Days per annum encountering with wind of more than 10 m/sec and wave of more than 2 m high ;		less than 10 day/year
8) Loading rate of dredged soil in hopper	Silt	55 %
	Sand	75 %

(3) Conditions for the Dredging Work Schedule

The dredging work schedule is established according to the following work conditions.

Working days per week	5 days
Leave from base on Monday morning and return on Saturday morning	
Saturday: Ship's condition check and maintenance work day	
Sunday: Rest day	
Working weeks per annum	44 weeks (220 days)
Non-working weeks per annum	8 weeks
Docking for maintenance of underwater part	4 weeks
Repairing, replacing of consumable, greasing, etc.	3 weeks
Non-working days due to bad weather	1 week

Binding hours of a day	24 hours
Actual expected working hour (working ratio 0.8)	19.2 hours
Manning schedule of dredging works	3-gangs, each 24 persons

2-gangs will be on board the ship at the same time (2 sift system)
Each gang works 2 weeks continuously, 9.6 hours per day
Every Monday, 1-gang alternates with the other gang

(4) Design Conditions Given by "Maintenance Dredging Plan"

The following design conditions are required by the Maintenance Dredging Plan for the dredger.

Total dredging cycle per annum		1,940 times
	for silt	(1,024 times)
	for sand	(916 times)
Cycle time (average)		approx. 2.11 hours
Hopper capacity		2,000 m^3

(5) Other Conditions

1) Maximum Allowable Ship's Breadth 15.0 m
(restricted by dimensions of the dry dock of BEIRANAVE)

2) Overflow work for silt and sand dredging

6.1.2 Concept of Dredger

Concepts of the dredger necessary for maintenance dredging works in the Beira Port are as follows.

(1) Principal Dimensions

Length overall (Loa)	about 83.0 m
Length between perpendiculars (Lpp)	80.0 m
Breadth, moulded (B)	15.0 m
Depth, moulded (D)	6.2 m
Designed fully loaded draft, extreme(d)	5.5 m

(2) Outline Arrangement of the Ship (refer to Figure 6.1.2-1)

1) Single decker with forecastle and poop
2) Hopper tank for dredged material; midship
3) Dredge pump room; forward
4) Propulsion engine room; aft
5) Accommodation space; above propulsion engine room
6) Operation bridge; above accommodation space
7) Bottom gate of hopper tank; total 14 both sides hinged doors
8) Drag arm; 1-side starboard arm system
   Maximum dredging depth at light load condition
   with drag arm inclination of 45 degrees
9) Hoisting system of drag arm; 3-points hoisting system by using
   drag head davit, intermediate joint davit and
   trunnion davit
10) Overboard discharge system; tilting type discharge pipe located
   on dredge pump room top
11) Bow thruster; provided
12) Deck crane; installed at forecastle aft end

(3) Deadweight at Fully Loaded Draft	about 3,650 tons
(4) Cargo Weight at Fully Loaded Draft	about 3,200 tons
(5) Hopper Capacity (for Dredged Soil)	about 2,000 m^3
(6) Class Notation	BV, I 3/3 E +, Hopper Dredger, Coastal Waters or NK, NS* Hopper Dredger, Coastal Service, MNS*

(7) Speed

Free running speed on full load condition at about 80 % of maximum output of main engines	10.2 knots
Free running speed on empty hopper condition at about 80 % of maximum output of main engines	10.8 knots
Maximum capable dredging speed on fully loaded condition at max. output of main engines without sea margin	6.5 knots

(8) Accommodation

Cabins	for 48 persons
Mess room	2 rooms
Galley	1 room
Offices	2 rooms

(9) Machinery

1) Twin propulsion plant
   (2-main engines, 2-screw fixed pitch propellers)
2) Twin rudder
3) 1-Bow thruster
4) 1-Deck crane
5) 1-Work boat
6) 2-Main generating plant
7) 1-Harbor use generating plant
8) Air conditioning plant
9) Provision refrigerator

(10) Electrical Equipment

Supply system;	Power source	AC 380V x 50 Hz 3-phase system
	In-ship supply	AC 220V x 50 Hz 1-phase system
	DC 24V	

(11) Dredging Apparatus

1) Dredge pump;	1 set, direct drive system by diesel engine
2) Jet pump;	1 set
3) Drag arm;	1 set
4) Hopper door;	Hinge type, hydraulic cylinder driven
5) Drag arm hoisting davit;	Drag head davit, Intermediate joint davit and Trunnion davit each 1 set (hydraulic driving)
6) Swell compensator;	1 set

7) Overboard discharge system; provided
8) Dredging instrument (installed in bridge);
   Dredge pump vacuum and delivery pressure indicator
   Drag arm remote control console desk
   Drag arm position indicator
   Draught and load indicator

Dredging operation remote control desk
Ship's positioning equipment

(12) Automation and Remote Control

1) For main engine
Remote speed control from bridge
Start and stop operation at machine side

2) For bow thruster
Remote start and stop, and propeller pitch control from bridge

3) For other auxiliary machinery
Automatic stop of fuel oil transfer pump
Automatic start and stop of main air compressor
Automatic start and stop of fresh water pump and sanitary water pump

4) For dredge pump
Remote speed control of dredge pump engine from bridge
Start and stop of dredge pump engine at machine side
Engage and disengage of clutch of dredge pump engine at machine side

5) For drag arm
Remote hoist and lower from bridge
Start and stop of hydraulic pump at machine side

6) For dredge valve and overboard discharge valve
Remote open and shut from bridge
Start and stop of hydraulic pump at machine side

7) For hopper door
Remote open and shut from bridge
Start and stop of hydraulic pump at machine side

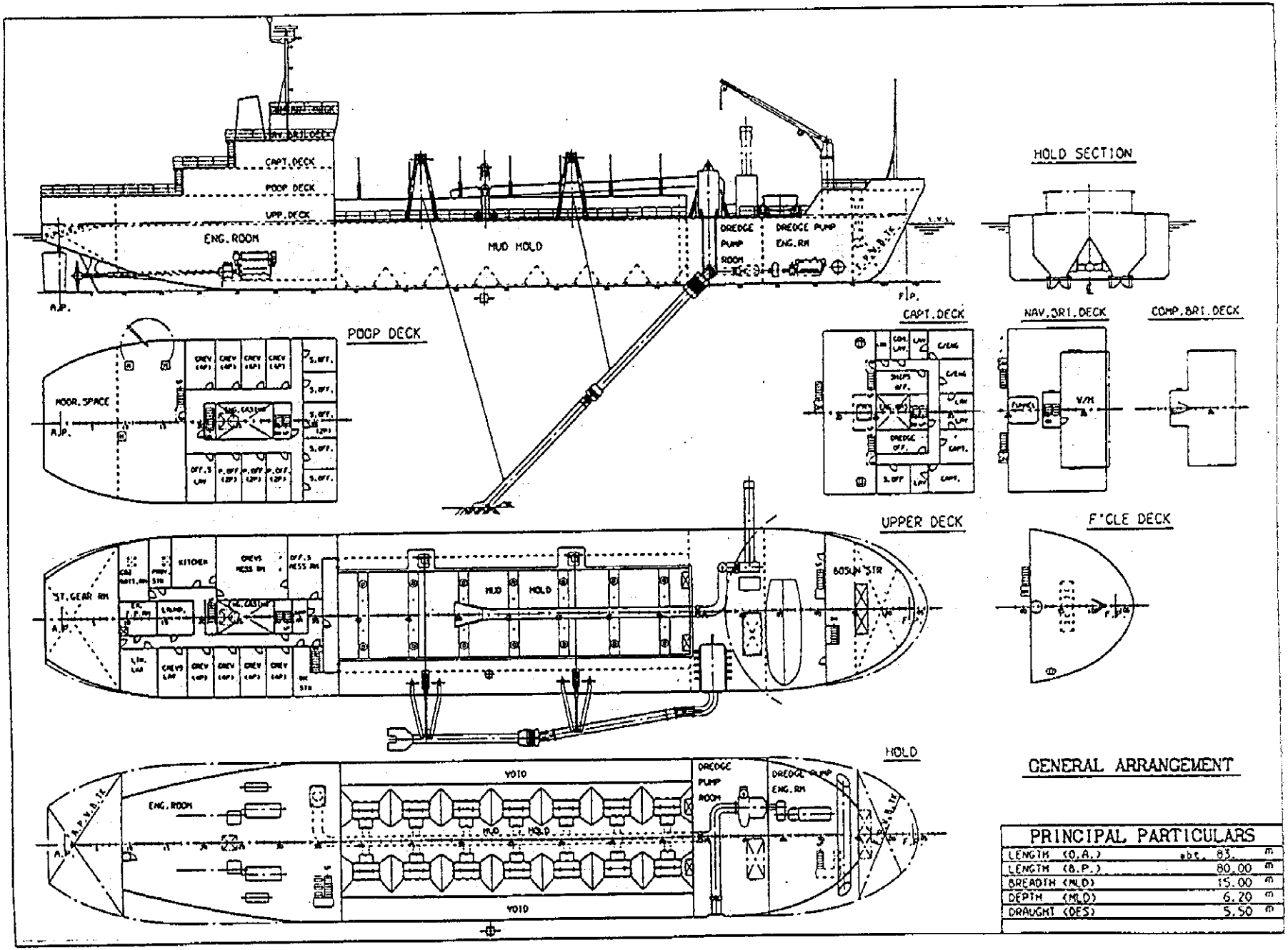

Figure 6.1.2-1 Outline Arrangement of New Dredger

6.1.3 Cost of Dredger

The preliminary costing of the dredger was roughly estimated under the following conditions;

1) The ship will be built by Japanese Shipbuilder.
2) Delivery of the ship will be at the end of 1999.
3) Exchange rate is 116.8 ¥en/US$

Estimated Cost (unit: 1,000 US$)	
Material Cost	13,105
Labor Cost	9,116
Expenses and Charges	2,030
Spare Parts	1,140
Total	US$ 25,391

6.2 Maintenance Dredging Plan

The channel depth is set at -8.0 m CDL based on which a siltation analysis by computer has been conducted to estimate future annual siltation rate. And thereafter, based on the estimated siltation rate, the required capacity of dredger has been determined, the maintenance dredging plan has been worked out and then an economic feasibility of the Project will be appraised.

6.2.1 Siltation and Dredging Works

(1) Dredging Area and Dredger

1) Access Channel

The trailing suction hopper dredger with the specifications detailed in the previous section is considered to be an optimal option for the purpose of maintaining the Access Channel of Beira Port at the depth of 8.0 m with dredging volume of 2.5 million m^3.

The efficiency of the dredging operation largely depends upon time required for the dumping operation and is, in Beira Port, largely governed by the sailing distance to/from the dumping area and the draft of dredger as well.

The proposed dredger is of a hopper capacity of 2,000 m^3 and draws a full draft of 5.5 m requiring a depth of 7.0 m at the dumping area. The minimum depth at the dumping area is of about 4.0 m not allowing dumping operations at low tide. A small dredger with a shallower draft has an advantage of less influence from low tide. In this regard, though it is obviously not economical due to higher running cost, in order to achieve a higher operational efficiency accruing from shallower draft, a combination of 2 dredgers with the same total hopper capacity, eg. 2 dredgers of 1,000 m^3 hopper, can be an alternative option.

Dredging fleet formations of one dredger with hopper capacity of 2000 m^3 and two 1000 m^3 dredgers are compared below;

	1 x 2,000 m^3 dredger	2 x 1,000 m^3 dredgers
Full draft	5.5 m	4.0 m
Time affected by low Tide	40 %	10 %
Maneuverability/safety	Good	Excellent

Purchase/introduction	One time	Can be phased
Docking/repair downtime	Inevitable	Avoidable

The dredging fleet formation of two 1,000 m^3 dredgers is not recommended due solely to higher capital and running costs.

However, besides an economic viewpoint, a 1,000 m^3 dredger has such essential and valuable advantages as the possibility of phased purchase/ introduction, lower effect to operation by low tide, thereby higher efficiency and safety of dredging/dumping operations and higher flexibility of docking/repair scheduling. Phased introduction is to allow a lower financial and managerial burden, while shallower draft permits higher productivity and safety in dredging works.

Therefore, in case any difficulty or delay in financial and personnel arrangements is expected, the fleet formation of two 1,000 m^3 dredgers shall be given a thorough consideration from the economic, financial and operational aspects.

2) Front Area of Quay

The area of immediate frontage of the existing quays is silted at an annual rate of about 100,000 m^3. The area is not accessible by a trailing suction hopper dredger and the dredging work there is assumed to be done by the grab dredger owned by EMODRAGA as per the present arrangement. The dredging fleet of one grab dredger, 3 soil barges and 2 tug boats are available in Beira Port for this purpose. The annual dredging capacity is estimated at about 120,000 m^3. The conversion of the soil barges to trailing suction hopper dredgers and the introduction of a bed leveler were recommended by the Netherlands mission but not realized. The maintenance dredging plan, 1997 of "Lurio", EMODRAGA is presented in Appendix A-4.

(2) Dredging Volume

1) Backlog

The existing channel has been silted up with the minimum water depth of less than 5.0 m. The dredging volume required to deepen the channel to the depth of 6.0, 7.0 and 8.0 m from the depth sounded in April 1996 is shown in Table 6.2.1-1.

Table 6.2.1-1 Dredging Volume Required for Deepening (m^3)

Section/ Depth	8.0 m	%	7.0 m	%	6.0 m	%
E5	274203	7	144009	8	27802	4
E15	211237	5	111566	7	20895	3
E4	204023	5	8000	0	0	0
E6	200149	5	36725	2	0	0
E7	292870	7	26675	2	0	0
E8	469125	11	180406	11	3510	0
E9	559454	14	296799	17	172158	22
E10	1130064	28	820660	48	561792	71
E11	154493	4	5421	0	0	0
E12	4946	0	0	0	0	0
E13	71407	2	0	0	0	0
E14	510060	12	76124	4	0	0
Total	4082031	100	1706385	100	786157	100

As shown in the above table, two Sections E9 and E10 at the channel bend occupy a large dredging volume especially in deepening work to 6 and 7 m. Interim dredging shall concentrate on the sections at the bend in the first stage and then on the sections upstream from the bend.

2) Maintenance Dredging Volume

Besides the above, the channel is under continuous siltation at various rates increasing with increase in depth as shown in Table 6.2.1-2.

Table 6.2.1-2 Maintenance Dredging Volume for Various Depths (m^3)

Section/Depth	8.0 m	%	7.0 m	%	6.0 m	%
E5	120488	5	57593	3	13374	2
E15	187005	7	89388	5	20758	3
E4	276146	12	131998	8	30652	4
E6	113057	5	54041	3	12549	2
E7	128696	5	61517	4	14285	2
E8	148823	6	71137	4	16519	2
E9	287820	12	232559	14	177009	24
E10	614958	25	496886	29	378199	52
E11	101051	4	81649	5	62146	9
E12	30637	1	24755	1	0	0
E13	62313	2	50349	2	0	0
E14	429005	17	346636	20	0	0
Total	2499999	101	1698508	98	725491	100

The above table shows a similar distribution pattern of siltation along the channel as backlog. The highest siltation rate occurs at E9 and E10 of Macuti corner and a relatively higher siltation is estimated at innermost and outermost parts of the channel.

(3) Dumping Area

Along the channel, five dumping sites for dredged soil were designated in the capital dredging work PA1 within the distance of less than 3 km from the channel as shown in Figure 5.2.2-1 and the minimum depths up to which dumping operations are allowed are indicated for each dumping site as below:

Area, Minimum Depth and Distance of Dumping Site

Dumping Site	D1	D2	D3	D4	D5
Area (km^2)	9.9	2.9	8.8	24.1	6.8
Minimum Depth (m)	-0.5	-0.5	+2.0	-5.0	+2.0
Dumping Distance (km)	1.8	2.7	2.4	1.6	2.5

The dumping distance is an approximate distance to a center of dumping area from the channel. Dumping during flood tide is not allowed for dumping site D2. Dumping area D1 for the N-S reach of the channel is very shallow, thus not allowing efficient dumping operation.

In this study, the above dumping sites and locations have been reviewed and determined as below, based on the latest sounding survey carried out in the course of this study.

Dumping Site	Location	Current Depth
D1	southernmost part only	4 m
D2	northern half area only	5 m
D3	not used due to insufficient depth	
D4	widened to west	6 m
D5	not used due to insufficient depth	

The location and depth of dumping sites are key factors governing the efficiency of dredging operation and a sounding survey covering a wide area shall be carried out to evaluate the appropriateness of current sites and find better alternative sites based on the results of the natural condition survey.

6.2.2 Dredging Schedule

As discussed in the previous sub-section, the dredging work required in Beira Port include a backlog dredging and a maintenance dredging. These two dredging works are discussed below.

(1) Interim Dredging

CFM planed to restore the channels in Beira, Maputo and Quilimane ports to the original depth in three years from 1997 as detailed in Appendix and summarized below.

Interim Dredging Plan (million m^3)

	1997	1998	1999	Total	
Beira					
Channel	3.3	3.3	3.3	9.9	(by a chartered dredger)
Berth	0.1	0.1	0.1	0.3	(by Lurio)
Maputo					
Channel	1.5	1.5	1.5	4.5	(by Rovuma)
Berth	0.15	0.15	0.15	0.45	(by Tembe)
Quilimane	0.15	0.15	0.15	0.45	(by Lurio)
Total	5.2	5.2	5.2	15.6	

The total dredging cost is estimated at about 31 million US$ and 70 % of the dredging cost shall be funded by CFM and 30 % by the Government of Mozambique. The dredging work will be done under joint venture between EMODRAGA and Selmer with equal shares by leasing a dredger from overseas and using the existing EMODRAGA's fleet.

The interim dredging is to include a backlog and annual siltation as well. The volume of backlog required to restore the channel from the depth in April 1996 to the depths of 6.0, 7.0 m and 8.0 m is calculated as 0.8 million m^3, 1.7 million m^3 and 4.1 million m^3, respectively. Siltation rates for various depths are assumed according to the results of computer simulation and analysis on the past sounding charts as below;

Channel depth (m)	5.0	6.0	7.0	8.0	9.0
Siltation rate (000 m^3/y)	522	725	1,699	2,500	3,483

The existing channel of Beira Port was planned to be restored to the original

depth of 8.0 m under the above interim dredging plan with an annual dredging volume of 3.3 million m^3 for 3 years from 1997 and from 2000 onward the dredging work will move to a phase of periodical maintenance of constant volume of 2.5 million m^3 a year.

The above original plan of interim dredging was not implemented due to financial reason, and the plan has been changed as 0.5 million m^3 to be dredged in 1997 and 1.5 million m^3 in 1998/99. This change has led to a situation in which the new dredger has to be put in a backlog dredging in addition to the maintenance dredging.

As detailed in the following section, the new dredger with a hopper capacity of 2,000 m^3 has an annual dredging capacity of 2.5 million m^3 with a total annual working time of 4,224 hours under the working condition of 5 days a week, 44 weeks a year and a working efficiency of 0.8. The dredging capacities in the case of increased working hours are calculated as follows;

6 days a week, 44 weeks a year:	3.232 million m^3/y
6 days a week, 46 weeks a year:	3.379 million m^3/y

The interim dredging is planned below, assuming that the new dredger will be operated 6 days a week and 44 weeks a year.

Dredging Volume (x 1,000m^3)

Year	Channel Depth before Dredging	Dredging Volume	Channel Depth after Dredging
1997	5.0 m	0.500	5.0 m
1998	5.0 m	1,500	5.8 m
1999	5.8 m	1,500	6.1 m
2000	6.1 m	3,232	6.9 m
2001	6.9 m	3,232	7.2 m
2002	7.2 m	3,232	7.5 m
2003	7.5 m	3,232	7.8 m
2004	7.8 m	3,232	8.0 m
2005	8.0 m	2,500	8.0 m

As shown in the above, the new dredger has to work 6 days a week for the first 5 years to clear the backlog up and from 2005 onward the channel will be maintained to the depth of 8.0 m with constant annual volume of 2.5 million m^3. In case it is operated 6 days a week and 46 weeks a year, the depth of the channel

will reach up to 8.0 m one year earlier.

The interim dredging and backlog dredging shall be implemented as quickly as possible to provide the port users with a better service.

(2) Maintenance Dredging by New Dredger

The Access Channel will be restored to the depth of 8.0 m after the interim dredging for 3 years by EMODRAGA and for 5 years by the new dredger. The past bathymetric charts have been analyzed to obtain an annual siltation rate and a siltation analysis by a computer simulation has been conducted to estimate the annual siltation rate in the channel at different depths. The results of the computer simulation and the analysis of the past bathymetric charts give the characteristics and distribution of siltation along the channel and appropriate locations of dumping area.

The maintenance dredging plan is worked out based on these results and summarized in Tables 6.2.2-1 to 6.2.2-4. As shown in the tables, a trailing suction hopper dredger with hopper capacity of 2,000 m^3 meets the dredging requirements for Beira Port.

The maintenance dredging plan is described below.

1) Annual Siltation Rate

The annual siltation rates for twelve sections along the Access Channel have been estimated totaling 2.5 million m^3/year (in situ volume). The most upstream three Sections, E5, E15 and E4, occupy 23 %, two Sections, E9 and E10, at the bend 37 % and E14 at the channel entrance 17 %. While two Sections, E12 and E13, near the entrance account for only 1 and 2 %, respectively due mainly to the flushing effect of tidal current flowing in these sections.

The siltation rate in terms of thickness of the sedimentation layer is calculated by dividing the siltation volume by the area of each section in the channel. Three Sections, E15, E9 and E10, exceed annual rate of 1 m. While two Sections, E12 and E13, are silted at an annual rate of about 10 cm requiring maintenance dredging work, say every 5 years.

The siltation rate in the wet season is reported to be three times higher than that in the dry season. This seasonal difference should be taken into consideration in planning monthly maintenance dredging operations and docking schedules.

It should be noted that the siltation pattern at Sections E9 and E10 at Macuti Corner is different from that at the other sections, i.e. these two sections are silted width sand falling from either slope of the channel resulting in a reduction in the channel width rather than reduction of the depth like in the other sections. This phenomenon shall be taken into consideration in planning dredger operation.

2) Characteristics of Soil

The soil silted along the channel is classified according to the location of each section based on the results of soil investigation presented in Chapter 3. The siltation consists of 45 % of silt mainly in the berth area and 55 % of sand in the remaining middle and outer reaches. Since it is impossible to take an undisturbed sample of soil from the seabed, in situ bulk density can not be measured. In situ bulk densities of silt and sand are determined according to the results of laboratory tests of seabed materials over the estuary area.

Bulk Density of Soil (t/m^3)

Soil	In situ	In hopper (after overflow)
Silt	1.50	1.29
Sand	1.80	1.60

The soil to be dredged is a mixture of silt and sand and as detailed in Appendix A-4, the efficiency of dredging operations of silty soil is highly affected by the length of the overflow time. On board tests of dredged soil shall be undertaken at each section in order to maximize the productivity of dredging work.

3) Dredging and Turning Time

The time required for dredging is estimated at 1.0 hour for silty seabed material and 1.25 hours for sand including overflow to obtain the above bulk density in hopper based on the past dredging records with similar soil characteristics in Japan. The time for turning a dredger to sail to a dumping area after dredging is estimated at 0.25 hours.

In the case of dredging soft clay, it can be, as detailed in Appendix A-4, more economical to reduce the dredging time and thereby increase number of cycle. The most efficient dredging time schedule shall be worked out by analyzing port

dredging records. On board test shall be done in sections with different characteristics involving such simultaneous measurements as ship speed, drag head contact pressure, pump revolutions, pump pressure in/out, pump discharge, soil content, soil volumes pumped/loaded, ship's draft, water level in hopper, soil laboratory test, etc. The results of tests give optimum operating conditions of the dredger to maximize the efficiency of the dredging work for various types of soil along the channel.

The total dredging and turning time a year is calculated at 2,654 hours accounting for 68 % of the total working hours.

4) Soil Volume in Hopper

The soil loaded in a hopper increases in volume when dredged from seabed due to a bulging effect by disturbance and a 2,000 m^3 hopper fully loaded with dredged soil is assumed to contain 1,500 m^3 of sand in situ (75 % of hopper capacity) and 1,100 m^3 of silt in situ (55 % of hopper capacity), respectively. The annual average volume of soil in hopper is calculated at 1,280 m^3.

5) Dumping Area

Five dumping areas were provided in the capital dredging work PA1 as shown in Figure 5.2.2-1. Of these dumping areas, D5, the upper part of D1 and D3 are planned not to be used in this study due to current insufficient depths leaving three dumping areas at the lower part of D1, D2 and D4. The dumping area D1, 4.0 m deep below CDL, is used for dumping dredged soil from the upper reach of the channel up to E8, D2, 5.0 m deep for E9 and E10 and D4, 6.0 m deep for E11 to E14. Mean Low Water Spring Tide is +0.9 m above CDL in Beira Port, which means the water level over the channel area is one meter deeper than the figure indicated in a sounding chart almost all the time throughout the year. Extreme low water levels of +0.2 to +0.3 occur several times in Spring or Autumn and should be taken into consideration in planning dumping operations.

The dumping areas D1 and D2 can not be used due to draft restriction at low tide, and D4 is used when the dredger can not dump dredged soil with full draft.

Draft of the dredger is 5.5 m when fully loaded with 3,200 tons of sand and 5.0 m for 2,570 tons of silt. The required depth at the dumping area is calculated as the sum of a full draft, 5.5 m, the swing reach of opening hopper doors, 1.0 m and the under keel clearance of 0.5 m.

The restriction of dumping work due to low tides is analyzed for each section for all the dredging cycles in two weeks of annual average tide. The results are presented in Figures 6.2.2-1 and 6.2.2-2 and summarized below;

D1 (CDL -4.0 m): Silt and sand can be dumped with full load for 75 % and 60 % of working time, respectively and D4 has to be used for the remainder.

D2 (CDL -5.0 m): Sand can be dumped with full load for 80 % of working time and D4 has to be used for the remainder.

D4 (CDL -6.0 m): Silt and sand can be dumped with full load at any tide.

Two options can be adopted for dredging work in the sections from E5 to E10 at low tide. For example, section E4 can be worked in two different ways as follows;

	Tide	Dredging Area	Dumping Area	Dumping Distance	Sailing Time
i)	High	E4	D1	9.7 km	0.99 hr
	Low	E4	D4	15.5 km	1.60 hr
ii)	High	same as i)			
	Low	E11~E14	D4	1.5 km	0.16 hr

As shown above, in the case of dredging (not sticking E4) one of the Sections from E11 to E14 which are close to the deeper dumping area D4, the sailing time can be saved by about 1.5 hours per cycle. The dredging operation of option ii) is detailed in Table 6.2.2-4. As shown in the tables, the annual working hours are reduced from 4,087 hours in option i) to 3,921 hours in option ii) saving 166 hours or 7 days. Dredging work for the sections E11 to E14 requires about 850 hours (20 % of the total working hours) and can absorb all the working hours at low tide for Sections E5 to E10. Option i) is simpler in planning and operating but does not give the maximum productivity. "Rovuma" was operated using option ii) and in this study, option ii) is taken as the dredging method.

According to option ii), dredged soil is to be dumped to each dumping area as follows:

Volume of Dumped Soil (m^3)

D1	D2	D4
974,215	902,778	623,006
39 %	36 %	25 %

The dumping area D1 receives the largest volume of soil but it is shallow in depth and its depth shall be checked periodically.

As mentioned previously, a combination of 2 dredgers with hopper capacity of 1000 m^3 has merit of less effect accruing from low tide. The dredging plan of a 1000 m^3 dredger is examined in the same way as a 2000 m^3 dredger and the results are presented in Appendix A-4.

Water depths of the dumping areas are changing all the time due to such various natural causes as tidal current, waves, river current, etc. and as a matter of course dumped soil resulting from dredging work. Therefore, frequent sounding surveys along the channel and dumping areas shall be conducted in order to obtain the latest depth data for the planning of dredging work as well as providing update information of channel depth to port users.

6) Sailing Distance

The sailing distance between a dumping area and each section of the channel is a controlling factor for dredging efficiency and varies from 16.8 km to 1.5 km as shown in Table 6.2.2-2. The sailing time to a dumping area is longer than the sailing time from the dumping area due to different load conditions of full (ship speed: 10.2 knots) and empty (10.8 knots). For the uppermost sections, the sailing time is almost the same (90 %) as the dredging and turning time and appropriate selection of dumping areas is a controlling factor for efficiency in the dredging operation. For the entire reach of the channel, the sailing time counts for 23 % of total working hours. The reduction of non-productive time for sailing to/from the dumping area shall be given thorough consideration.

7) Dumping Time

The dumping time of silt is assumed as 0.15 hours, being shorter than that of sand, 0.25 hours due to higher fluidity of silt.

8) Cycle Time

One complete cycle of a dredging operation consists of dredging, turning, sailing to a dumping area, dumping and sailing back to the dredging site. The annual average cycle time is calculated as 2.02 hours.

9) Required Number of Cycle

The required annual cycle number of dredging operations for each section is given by dividing the annual siltation volume by the soil volume in hopper. The annual total number of cycles is calculated as 1940.

10) Annual Working Time

The annual working time of each section is given by multiplying the required annual cycle number of dredging operations by the cycle time. A remarkable feature of the dredging operation in terms of working time is the very high share of about 37 % in the berth area and 35 % in Sections E9 and E10 at the channel bend.

The total annual working hours is 4,224 hours and the required annual working time for the trailing hopper suction dredger of 2,000 m^3 hopper capacity totals 3,921 hours, giving a ratio of 0.93 less than 1.0, which means the hopper capacity of 2,000 m^3 is appropriate for dredging work of 2.5 million m^3 with an acceptable allowance.

Table 6.2.2-1 Maintenance Dredging Plan (1)

(soil to be dumped at a distant site at low tide)

Hopper Capacity = 1800 m3
Ship speed full 10.2 kt.

Dredging Time Silt 1.00 hr Sand 1.25 hr

Turning Time 0.25 hr

ballast 10.8 kt

Section	E5		E15		E4		E6		E7		E8		E9		E10		E11	E12	E13	E14	Total
Siltation Vol m^3/y	120,488		187,005		276,146		113,057		128,696		148,823		287,820		614,958		101,051	30,637	62,313	429,005	2,499,999
Siltation Vol %	5		7		11		5		5		6		12		25		4	1	2	17	100
Silt'n Thickness m/y	0.78		1.20		0.57		0.33		0.38		0.43		1.11		1.13		0.26	0.09	0.09	0.72	
Soil: Silt or Sand	Silt		Silt		Silt		Silt		Sand		Sand		Sand		Sand		Sand	Sand	Sand	Silt	
Dred'g/Turn'g Time hr	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.25	
Soil in Hopper %	55		55		55		55		75		75		75		75		75	75	75	55	
Soil in Hopper m3	990		990		990		990		1,350		1,350		1,350		1,350		1,350	1,350	1,350	990	
Dumping Area	D1(75%)	D4	D1(75%)	D4	D1(75%)	D4	D1(75%)	D4	D1(60%)	D4	D1(60%)	D4	D2(85%)	D4	D2(85%)	D4	D4	D4	D4	D4	
Sailing Distance km	11.0	16.8	9.2	15.0	9.7	15.5	6.9	12.8	4.9	10.7	3.0	8.5	2.7	6.4	1.7	4.3	1.8	1.5	1.5	1.5	
Sailing Time to DA hr	0.58	0.89	0.48	0.79	0.51	0.82	0.37	0.68	0.26	0.57	0.16	0.45	0.14	0.34	0.09	0.23	0.10	0.08	0.08	0.08	
Dumping Time hr	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.15	
Sailing Time fm DA hr	0.55	0.84	0.46	0.75	0.48	0.78	0.35	0.64	0.24	0.54	0.15	0.43	0.14	0.32	0.08	0.21	0.09	0.08	0.08	0.08	
Cycle Time hr	2.53	3.13	2.34	2.95	2.39	3.00	2.11	2.71	2.25	2.85	2.06	2.63	2.03	2.41	1.92	2.19	1.94	1.90	1.90	1.55	
Av Cycle Time hr	2.68		2.49		2.54		2.26		2.49		2.29		2.09		1.96						
Required No of Cycle	122		189		279		114		95		110		213		456		75	23	46	433	2155
Req'd Working Hour hr	326.0		471.0		709.8		258.3		237.4		252.0		444.6		892.9		144.9	43.2	87.9	673.6	4,542
Working Hour Ratio %	7.2		10.4		15.6		5.7		5.2		5.5		9.8		19.7		3.2	1.0	1.9	14.8	100.0
T.Dred/Turn'g Time hr	152.1		236.1		348.7		142.7		143.0		165.4		319.8		683.3		112.3	34.0	69.2	541.7	2,948.3
Sailing Time hr	155.6		206.5		319.3		98.4		70.6		59.1		71.5		95.7		13.9	3.5	7.1	67.0	1,168.3
Dumping Time hr	18.3		28.3		41.8		17.1		23.8		27.6		53.3		113.9		18.7	5.7	11.5	65.0	425.1
																				Total	4,541.7

Silt/Sand Ratio %
Silt 45
Sand 55

Average Cycle Time
2.11 hr

Annual Working Hours
Week 44
Day 5
Hour 24
Efficiency 0.8
4,224 hr

Annual Required Working Hours

Dred'g/Turn'g Time	2,948 hr	65%
Sailing Time	1,168 hr	26%
Dumping Time	425 hr	9%
Total	4,542 hr	100%

Required Working Hours
4,542 hr

Required/Annual Working Hours Ratio 108 %

Table 6.2.2-2 Maintenance Dredging Plan (2)

(soil to be dumped at a distant site at low tide)

Hopper Capacity = 2000 m3 Dredging Time Silt 1.00 hr Sand 1.25 hr Turning Time 0.25 hr

Ship speed full 10.2 kt. ballast 10.8 kt

Section	E5		E15		E4		E6		E7		E8		E9		E10		E11	E12	E13	E14	Total
Siltation Vol m^3/y	120,488		187,005		276,146		113,057		128,696		148,823		287,820		614,958		101,051	30,637	62,313	429,005	2,499,999
Siltation Vol %	5		7		11		5		5		6		12		25		4	1	2	17	100
Silt n Thickness m/y	0.78		1.20		0.57		0.33		0.38		0.43		1.11		1.13		0.26	0.09	0.09	0.72	
Soil: Silt or Sand	Silt		Silt		Silt		Silt		Sand		Sand		Sand		Sand		Sand	Sand	Sand	Silt	
Dred'g/Turn'g Time hr	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.25	
Soil in Hopper %	55		55		55		55		75		75		75		75		75	75	75	55	
Soil in Hopper m3	1,100		1,100		1,100		1,100		1,500		1,500		1,500		1,500		1,500	1,500	1,500	1,100	
Dumping Area	D1(75%)	D4	D1(75%)	D4	D1(75%)	D4	D1(75%)	D4	D1(60%)	D4	D1(60%)	D4	D2(85%)	D4	D2(85%)	D4	D4	D4	D4	D4	
Sailing Distance km	11.0	16.8	9.2	15.0	9.7	15.5	6.9	12.8	4.9	10.7	3.0	8.5	2.7	6.4	1.7	4.3	1.8	1.5	1.5	1.5	
Sailing Time to DA hr	0.58	0.89	0.48	0.79	0.51	0.82	0.37	0.68	0.26	0.57	0.16	0.45	0.14	0.34	0.09	0.23	0.10	0.08	0.08	0.08	
Dumping Time hr	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.15	
Sailing Time fm DA hr	0.55	0.84	0.46	0.75	0.48	0.78	0.35	0.64	0.24	0.54	0.15	0.43	0.14	0.32	0.08	0.21	0.09	0.08	0.08	0.08	
Cycle Time hr	2.53	3.13	2.34	2.95	2.39	3.00	2.11	2.71	2.25	2.85	2.06	2.63	2.03	2.41	1.92	2.19	1.94	1.90	1.90	1.55	
Av Cycle Time hr	2.68		2.49		2.54		2.26		2.49		2.29		2.09		1.96						
Required No of Cycle	110		170		251		103		86		99		192		410		67	20	42	390	1940
Req'd Working Hour hr	293.4		423.9		638.9		232.4		213.7		226.8		400.1		803.6		130.4	38.9	79.1	606.3	4,087
Working Hour Ratio %	7.2		10.4		15.6		5.7		5.2		5.5		9.8		19.7		3.2	1.0	1.9	14.8	100.0
T.Dred/Turn'g Time hr	136.9		212.5		313.8		128.5		128.7		148.8		287.8		615.0		101.1	30.6	62.3	487.5	2,653.5
Sailing Time hr	140.1		185.9		287.4		88.5		63.6		53.2		64.3		86.2		12.5	3.2	6.4	60.3	1,051.4
Dumping Time hr	16.4		25.5		37.7		15.4		21.4		24.8		48.0		102.5		16.8	5.1	10.4	58.5	382.6
																				Total	4,087.5

Silt/Sand Ratio %

Silt	45
Sand	55

Average Cycle Time 2.11 hr

Annual Working Hours

Week	44
Day	5
Hour	24
Efficiency	0.8
	4,224 hr

Annual Required Working Hours

Dred'g/Turn'g Time	2,654 hr	65%
Sailing Time	1,051 hr	26%
Dumping Time	383 hr	9%
Total	4,087 hr	100%

Required Working Hours 4,087 hr

Required/Annual Working Hours Ratio 97 %

Table 6.2.2-3 Maintenance Dredging Plan (3)

(soil to be dumped at a distant site at low tide)

Hopper Capacity = 2200 m3 | Dredging Time Silt 1.00 hr | Sand 1.25 hr | Turning Time 0.25 hr

Ship speed full 10.2 kt. | ballast 10.8 kt

Section	E5		E15		E4		E6		E7		E8		E9		E10		E11	E12	E13	E14	Total
Siltation Vol m^3/y	120,488		187,005		276,146		113,057		128,696		148,823		287,820		614,958		101,051	30,637	62,313	429,005	2,499,999
Siltation Vol %	5		7		11		5		5		6		12		25		4	1	2	17	100
Silt'n Thickness m/y	0.78		1.20		0.57		0.33		0.38		0.43		1.11		1.13		0.26	0.09	0.09	0.72	
Soil: Silt or Sand	Silt		Silt		Silt		Silt		Sand		Sand		Sand		Sand		Sand	Sand	Sand	Silt	
Dred'g/Turn'g Time hr	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.25	
Soil in Hopper %	55		55		55		55		75		75		75		75		75	75	75	55	
Soil in Hopper m3	1,210		1,210		1,210		1,210		1,650		1,650		1,650		1,650		1,650	1,650	1,650	1,210	
Dumping Area	D1(75%)	D4	D1(75%)	D4	D1(75%)	D4	D1(75%)	D4	D1(60%)	D4	D1(60%)	D4	D2(85%)	D4	D2(85%)	D4	D4	D4	D4	D4	
Sailing Distance km	11.0	16.8	9.2	15.0	9.7	15.5	6.9	12.8	4.9	10.7	3.0	8.5	2.7	6.4	1.7	4.3	1.8	1.5	1.5	1.5	
Sailing Time to DA hr	0.58	0.89	0.48	0.79	0.51	0.82	0.37	0.68	0.26	0.57	0.16	0.45	0.14	0.34	0.09	0.23	0.10	0.08	0.08	0.08	
Dumping Time hr	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.15	
Sailing Time fm DA hr	0.55	0.84	0.46	0.75	0.48	0.78	0.35	0.64	0.24	0.54	0.15	0.43	0.14	0.32	0.08	0.21	0.09	0.08	0.08	0.08	
Cycle Time hr	2.53	3.13	2.34	2.95	2.39	3.00	2.11	2.71	2.25	2.85	2.06	2.63	2.03	2.41	1.92	2.19	1.94	1.90	1.90	1.55	
Av Cycle Time hr	2.68		2.49		2.54		2.26		2.49		2.29		2.09		1.96						
Required No of Cycle	100		155		228		93		78		90		174		373		61	19	38	355	1763
Req'd Working Hour hr	266.7		385.3		580.8		211.3		194.3		206.2		363.8		730.6		118.5	35.4	71.9	551.2	3,716
Working Hour Ratio %	7.2		10.4		15.6		5.7		5.2		5.5		9.8		19.7		3.2	1.0	1.9	14.8	100.0
T.Dred/Turn'g Time hr	124.5		193.2		285.3		116.8		117.0		135.3		261.7		559.1		91.9	27.9	56.6	443.2	2,412.3
Sailing Time hr	127.3		169.0		261.3		80.5		57.8		48.3		58.5		78.3		11.4	2.9	5.8	54.8	955.8
Dumping Time hr	14.9		23.2		34.2		14.0		19.5		22.5		43.6		93.2		15.3	4.6	9.4	53.2	347.8
																				Total	3,715.9

Silt/Sand Ratio %
Silt 45
Sand 55

Average Cycle Time
2.11 hr

Annual Working Hours
Week 44
Day 5
Hour 24
Efficiency 0.8
4,224 hr

Annual Required Working Hours

Dred'g/Turn'g Time	2,412 hr	65%
Sailing Time	956 hr	26%
Dumping Time	348 hr	9%
Total	3,716 hr	100%

Required Working Hours
3,716 hr

Required/Annual Working Hours Ratio 88 %

Table 6.2.2-4 Maintenance Dredging Plan (4)

(Sections E11-E14 to be dredged at low tide)

Hopper Capacity = 2000 m3 Dredging Time Silt 1.00 hr Sand 1.25 hr Turning Time 0.25 hr

Ship speed full 10.2 kt. ballast 10.8 kt.

Section	E5	E15	E4	E6	E7	E8	E9	E10	E11	E12	E13	E14	Total
Siltation Vol m^3/y	120,488	187,005	276,146	113,057	128,696	148,823	287,820	614,958	101,051	30,637	62,313	429,005	2,499,999
Siltation Vol %	5	7	11	5	5	6	12	25	4	1	2	17	100
Soil: Silt or Sand	Silt	Silt	Silt	Silt	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Silt	
Dred'g/Turn'g Time hr	1.25	1.25	1.25	1.25	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.25	
Soil in Hopper %	55	55	55	55	75	75	75	75	75	75	75	55	
Soil in Hopper m3	1,100	1,100	1,100	1,100	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,100	
Dumping Area	D1	D1	D1	D1	D1	D1	D2	D2	D4	D4	D4	D4	
Sailing Distance km	11.0	9.2	9.7	6.9	4.9	3.0	2.7	1.7	1.8	1.5	1.5	1.5	
Sailing Time to DA hr	0.58	0.48	0.51	0.37	0.26	0.16	0.14	0.09	0.10	0.08	0.08	0.08	
Dumping Time hr	0.15	0.15	0.15	0.15	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.15	
Sailing Time fm DA hr	0.55	0.46	0.48	0.35	0.24	0.15	0.14	0.08	0.09	0.08	0.08	0.08	
Cycle Time hr	2.53	2.34	2.39	2.11	2.25	2.06	2.03	1.92	1.94	1.90	1.90	1.55	
Av Cycle Time hr													
Required No of Cycle	110	170	251	103	86	99	192	410	67	20	42	390	1940
Req'd Working Hour hr	276.9	398.3	601.0	217.0	193.0	204.3	389.2	787.1	130.4	38.9	79.1	606.3	3,921
Working Hour Ratio %	7.1	10.2	15.3	5.5	4.9	5.2	9.9	20.1	3.3	1.0	2.0	15.5	100.0
T.Dred/Turn'g Time hr	136.9	212.5	313.8	128.5	128.7	148.3	287.8	615.0	101.1	30.6	62.3	487.5	2,653.5
Sailing Time hr	123.6	160.3	249.6	73.1	42.9	30.7	53.4	69.7	12.5	3.2	6.4	60.3	885.4
Dumping Time hr	16.4	25.5	37.7	15.4	21.4	24.8	48.0	102.5	16.8	5.1	10.4	58.5	382.6
												Total	3,921.4

Silt/Sand Ratio %	
Silt	45
Sand	55

Average Cycle Time

Annual Working Hours	
Week	44
Day	5
Hour	24
Efficiency	0.8

Annual Required Working Hours		
Dred'g/Turn'g Time	2,654 hr	68%
Sailing Time	885 hr	23%
Dumping Time	383 hr	10%
Total	3,921 hr	100%

Required Working Hours 3,921 hr

Required/Annual Working Hours Ratio 93 %

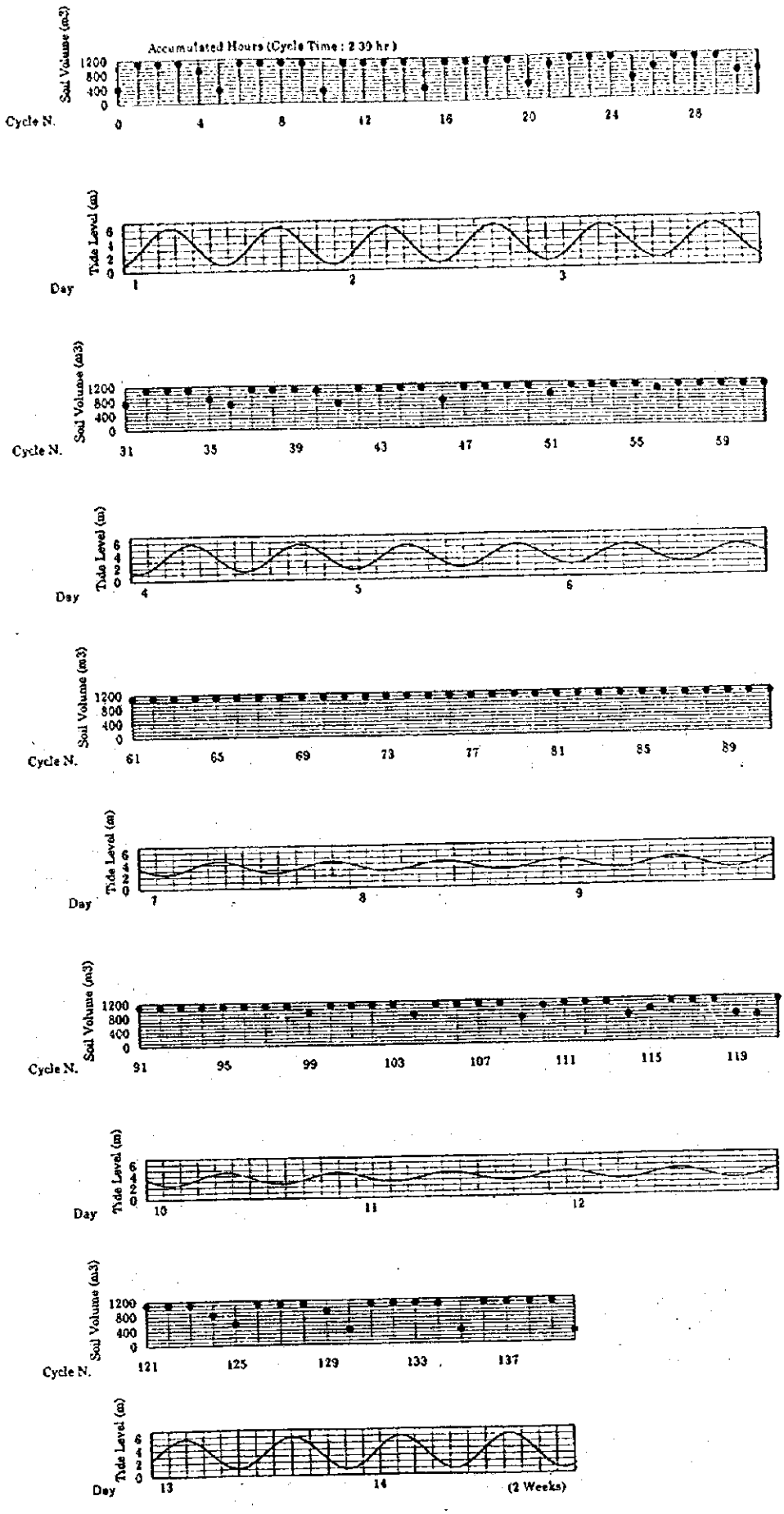

Figure 6.2.2-1 Hopper Load vs Tidal Level, Section E4 (silt)

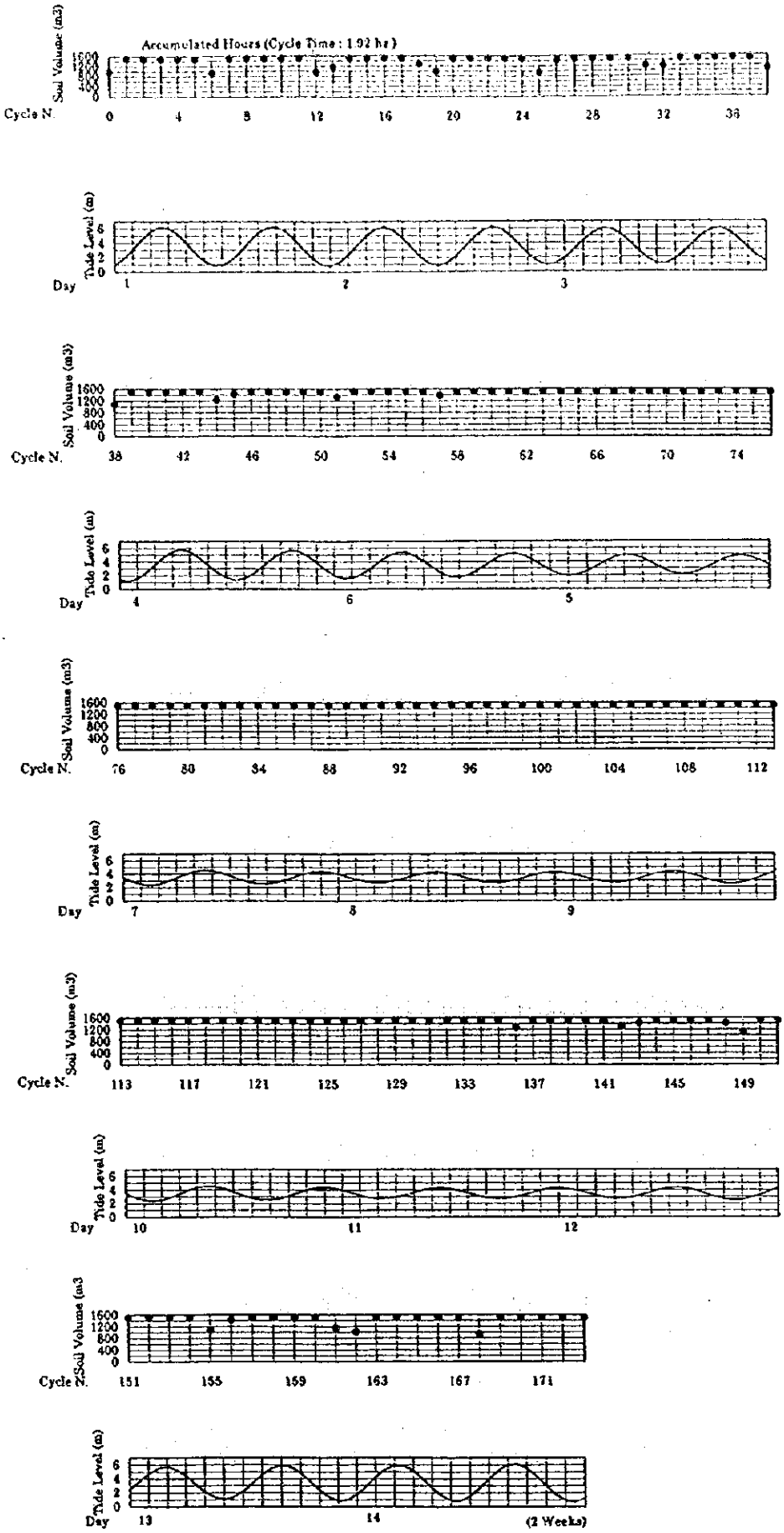

Figure 6.2.2-2 Hopper Load vs Tidal Level, Section E7 (sand)

6.2.3 Dredging Cost

The dredging cost is estimated by adding up such expenses as depreciation of the dredger, insurance, repair and periodical maintenance, fuel and lubricant, salaries and support to crew, surveys and administration, etc.

The dredging cost of a foreign contractor is likely to vary between 3.0 and 4.0 US$/m^3 (in situ), which indicates the economic viability of the dredging works to be conducted by EMODRAGA. The current preliminary estimate suggests the maintenance dredging cost of EMODRAGA being less than 2.0 US$/m^3 as outlined below:

Annual Dredging Cost (US$)

Crew	384,840
Fuel & Lubricant	943,680
Maintenance	500,000
Overhead	672,600
Depreciation	900,000
Total	3,401,120 (1.36 US$/m^3)

6.3 Operation and Management

6.3.1 Proposed Organization

(1) Existing Organization

During the colonial period, all the dredging works were carried out by the dredging service department under direct control of the colonial government. In 1980, EMODRAGA was established under the Ministry of Transport and Communications. In 1987, EMODRAGA moved its head office from Maputo to Beira where an administration office, a workshop and a wide storage yard were provided.

In 1982, the Governments of Netherlands and Mozambique agreed on a technical and financial assistance project for efficient dredging services to be rendered by EMODRAGA.

In May 1989, the Government of Mozambique transferred the ownership and management responsibility of the ports and railways system to CFM State Enterprise. CFM established four regional Executive Directorates, Executive Directorate CFM-South, Executive Directorate CFM-Center, Executive Directorate CFM-Zambezia and Executive Directorate CFM-North. The Executive Directorate CFM-Center is in charge of the administration of Beira Port. CFM is fully responsible for the management and operation of all the ports. It is a contracting party of maintenance dredging works and the related costs are payable through its own revenues. The Beira Corridor Authority supported CFM in various projects implemented for Beira Port until its dissolution in 1995.

In 1997, EMODRAGA moved its office to the building that previously accommodated the Beira Corridor Authority (BCA).

The current organization chart of EMODRAGA is shown in Figure 2.2.5-2. The job description of each division is outlined below.

1) The Production Division is responsible for the planning and control of dredging works, with 35 engineers.

2) The Maintenance Division is responsible for the repair and maintenance work for EMODRAGA's dredging fleet, with 40 engineers.

3) The Administration Division is responsible for all the matters related to accounting and management, with 23 staff members.

The total number of crew operating "Rovuma" is 28 consisting of Captain, Engineer, Dredge Master, First Engineer, First Mate, Second Engineer, Dredge Operator, Electrician, Sailor, Greaser and Others.

(2) Required Reinforcement

To operate a new dredger, an additional dredging crew is required. Onshore management and maintenance staff and survey team can take on new duties on the new dredger with nominal reinforcement. Substantial reinforcement shall be effected to the dredging crew running the new dredger. When the interim dredging is implemented under the joint venture between EMODRAGA and Selmer, EMODRAGA will have a good opportunity to recruit and train dredging crew in addition to the crew of "Rovuma".

The tentative plan of crew formation of the new dredger is shown below:

Work Shift : 3 gangs (24 crew each), total working 12 hour 2 shifts with 2 gangs on board for continuous 1 week with 1 gang out of 2 to be replaced every week end with the third gang on holiday onshore. Dredge masters are readily available from the existing crew of "Rovuma" and the captains from the shipping market.

Crew	No. (per 3 gangs)
Captain	3
Engineer	3
Dredge Master	3
First Engineer	3
First Mate	3
Second Engineer	3
Dredge Operator	3
Electrician	3
Sailor	20
Greaser	20
Other	8
Total	72 crew

6.3.2 Proposed Operation and Management

(1) Efficient Operation

The efficiency of the dredging work depends upon various factors like an adequate dredging plan, the technical level of dredging, location and depth of the dumping area, tide and wave conditions, soil conditions, seasonal change of siltation, down time due to holiday and docking for periodical maintenance and repair, etc.

1) Onboard Test of Dredging Operation

Onboard tests of dredging operation shall be conducted at an early stage after introducing the new dredger to obtain the characteristics of the dredging performance which is affected by various factors like ship's speed, contact pressure of drag head, soil property, pump discharge, overflow, etc. Based on the results of the on board tests, an efficient dredging plan can be worked out.

2) Dumping Area

The location and depth of the dumping area is one of the most important factors controlling dredging efficiency and periodical sounding surveys over all the dumping areas as well as the channel and wide estuary area of 20x30 km^2 shall be conducted. The depth of the dumping area will become shallow with large quantities of dumped soil and shall be periodically sounded to avoid grounding of the dredger. The sounding survey of the wide area on both sides of the channel gives information on the new deep area which can be advantageously used.

3) Overflow

The efficiency of overflow depends on soil condition (sand, silt or clay) and sailing time to/from a dumping area and the optimal working condition shall be sought through daily dredging record. Laboratory tests of dredged soil shall be conducted together with other dredging tests to improve the dredging efficiency. Agitation dredging can be efficient especially for the dredging of soft clay in a section remote from a dumping site and shall be examined for its feasibility.

Agitation dredging is one of the dredging methods, employed in removing soft silt. In this method, pumped soil overflows and is carried away from the dredging area before it settles down to the bottom. This method could be employed in Section E14 at ebb tide.

4) Seasonal and Monthly Dredging Schedule

The change of siltation in dry and wet seasons shall be given thorough consideration, when planning the annual dredging schedule. The siltation rate in the wet season is three times higher than that in the dry season. Periodical docking and major repair work are to be adequately scheduled in consideration of dredging efficiency in each month due to weather and sea conditions, dock availability, crew convenience, etc.

5) Natural Condition Survey

a) General

In order to clarify the oceanographic phenomenon of the Access Channel and its surroundings, the following surveys shall be carried out in Beira Port, the Access Channel and dumping area, for an effective dredging plan.

- Bathymetric Survey
- Bottom Sediment Survey

The bathymetric survey area will be the Access Channel, dumping area D1, dumping area D2 and dumping area D4. Sampling stations of bottom sediment will be installed at 2 stations at each section of the Access Channel. For an accurate positioning of the survey area or stations, DGPS or radio positioning system will be necessary.

The typical survey schedule is described in Figure 6.3.2-1.

b) Bathymetric Survey

Seasonal surveys will be carried out in March and September of every year to determine siltation conditions at the Access Channel and dumping areas. On the other hand an annual survey before and after dredging at a certain dredging area will be required for accurate progress control. All survey results shall be printed out after processing the survey data.

c) Bottom Sediment Survey

The sampling will be from dredged material on the boat. Analyze item will include sieve analysis, D(50), moisture content, bulk density, dry density and void ratio. The results of these analyses are important for the review of the dredging plan.

6) Berthing Facility

Facilities for berthing and maintenance shall be appropriately arranged and well organized. The outer berth at the fishery port is in an adequate location and planned to be allocated to the new dredger.

7) Dredging in front of Berths

Dredging work along the immediate frontage of berths is planned to be executed by Lurio with two soil barges.

(2) Appropriate Management

Efficient management can be achieved with adequate arrangement and provision of personnel, facilities and budget.

1) Personnel

The new dredger is operated by three gangs 72 crews. Recruitment and training of new crew and shift of existing experienced crews shall be planned and implemented well before the introduction of the new dredger. Survey and engineering sections that will work out an appropriate and efficient dredging plan shall be established. The existing management staff have already acquired necessary knowledge required for the dredging operations and can take on an increase of duties brought about by the introduction of the new dredger. The crew required for the interim dredging to be executed by EMODRAGA can be advantageously transferred to the new dredger.

2) Facilities

Facilities for office, maintenance, storage, etc. are already available and a berthing facility shall be secured and improved as required. A survey boat for sounding the depth of the channel and dumping areas is indispensable equipment for planning adequate maintenance dredging and securing safety of channel navigation.

3) Budget

The annual operating cost of the new dredger is estimated at about 3.5 million US$ which exceeds the current budget of EMODRAGA. CFM shall allocate this operating cost to EMODRAGA. Improvement of the channel by the new dredger is to bring significant benefits to port users and CFM could increase port tariff to cover the costs.

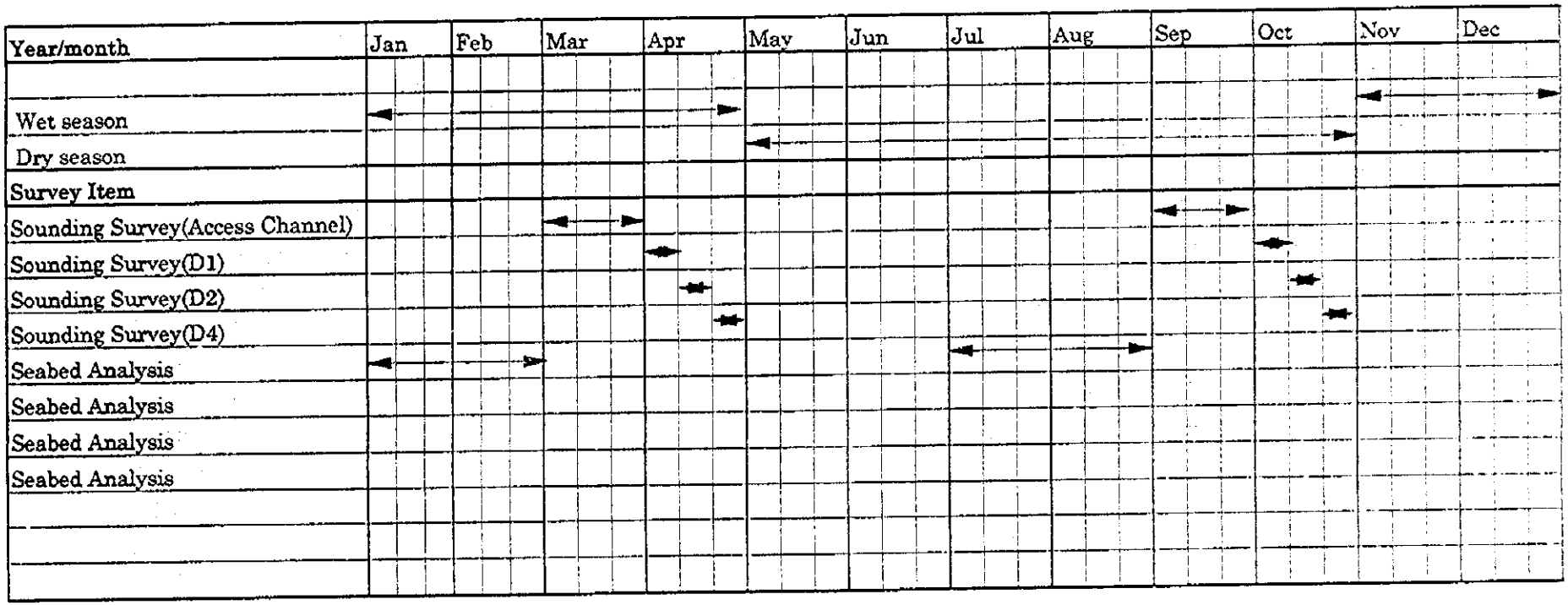

Figure 6.3.2-1 Recommended Schedule of Natural Condition Survey

6.3.3 Training Program

Since EMODRAGA has sufficient staff with experiences acquired through dredging works carried out under its own management and operations using various types of trailing hopper suction, cutter suction, grab and backhoe dredgers, primary training for basic dredging operations is not necessary. Instead, to further improve the efficiency of dredging works, training at advanced level courses like periodical sounding survey, siltation analysis based on the surveys, soil investigation, planning of optimal and efficient dredging and dumping works through detailed examination of siltation and soil characteristics, improvement of dredging methods, (e.g. agitation dredging, study of overflow, dredging speed, pumping rate, drag head pressure, etc.), overseas training for the crew and training by expatriate staff, scheduling of repair and docking, etc. is required. The existing training school in Maputo can be efficiently used for this purpose. Special training for a dredge master and mechanics is essential and in addition to that an on-site training during building works of the dredger will be very useful in acquiring practical knowledge for mechanics.