Mumbai Port Trust

Civil Engineering Department

Feasibility Report

for

"Deepening and Widening of Approach Channel to Second Chemical Berth (SCB)" at Pir Pau, Mumbai

Prepared by: Marine Survey Division,
Mumbai Port Trust

FEASIBILTY STUDY FOR DEEPENING AND WIDENING OF APPROACH CHANNEL TO SECOND LIQUID CHEMICAL BERTH AT PIR PAU, MUMBAI

C O N T E N T S

Deepening and Widening of Approach Channel to Second Chemical Berth

(Feasibility Study)

E.0 EXECUTIVE SUMMARY

E.1 INTRODUCTION

The Second Chemical Berth (SCB) was partly commissioned in June 2015 and fully commissioned in January 2016. The Second Liquid Chemical Berth is constructed 650 meter south of existing First Chemical Berth (FCB) off Pir Pau and in the same alignment as that of the FCB. The capacity of the Second Liquid Chemical Berth is of 2MMTPA. It was initially designed for handling tankers of 37,000 DWT. For the Second Liquid Chemical Berth, the berth pocket of 300 m x 60 m is dredged to 13m below Chart Datum and the existing navigational approach channel is widened by about 60m for vessels of 9.00 mt. draft. The SCB is connected to FCB by a approach trestle of 650 m length. The berth structure of SCB consists of -

- 2 Nos. of Breasting Dolphins supported on piles with concrete deck on top. It is provided with fenders and quick release mooring hooks.
- 4 Nos. of Mooring Dolphins on piles with concrete deck and quick release mooring hooks.
- Unloading platform. (The Marine Loading Arms (MLAs) on top of the platform are provided by the Users.)

The dredging & civil works were done by MbPT through its internal resources. The liquid cargo will be unloaded/ loaded by the MLAs and will be transported through extension of product pipelines from FCB to SCB. The expenditure on loading arms & pipelines is borne by the Users. Before completion of the construction of SCB, MbPT decided to check the adequacy of the structure for vessel berthing up to 55,000 DWT. Accordingly MbPT appointed IIT Madras to verify the layout, configuration, analysis and design for 55,000 DWT vessels. M/s IIT Madras vetted the design and accordingly the construction was carried out so that vessels in the range of 15,000 to 55,000 DWT can be accommodated.

E.2 Traffic Study

E.2.1 Past Traffic

Consistent with the domain of study, traffic study was confined to Liquid chemicals and POL Products handled at MbPT in the past and their assessed future incremental traffic. Over the years the share of MbPT in all India Port traffic of Chemicals and POL was around 15%.

The traffic handled in last five years at Pir Pau as under:

Year	2012-13		2013-14		2014-15		2015-16		2016-17		
Category	OPP	FCB	OPP	FCB	OPP	FCB	OPP	FCB	OPP	FCB	SCB
Chemicals	0.44	1.24	0.34	1.42	0.39	1.60	0.49	1.72	0.15	1.33	0.56
Products	0.28	1.10	0.42	0.96	0.56	0.63	0.41	0.87	0.30	0.23	0.90
Total	0.72	2.34	0.76	2.38	0.95	2.23	0.90	2.59	0.45	1.56	1.46
Berth Occupancy	47.43	87.08	33.89	88.14	40.38	84.91	52.34	78.74	20.68	67.35	65.43
Total Traffic	3.06		3.14		3.18		3.49		3.47		

E.2.2 Future Traffic

In order to assess the future potential of Liquid chemicals and POL products traffic at Mumbai Port the following perspective has been taken into account**:**

- Maharashtra & Gujarat accounts for the major share of all India demand of liquid chemicals and products.
- Users have shown preference for further developments in Pir Pau area.
- Improvement of Infrastructural facility at Pir Pau is required to cope with the exim growth in Chemical/ product sector.
- BPCL & HPCL are keen on laying additional pipe lines from SCB which will create additional traffic at Pir Pau.

- Land allotment of the plot previously with RCF is under consideration for development of Tank farm which would create additional traffic at Pir Pau.

Though it is observed that there is sufficient future growth of Chemical and POL products in Maharashtra and Gujarat region, there is not adequate data to assess the exact future traffic at Mumbai Port. In various meetings the Users are pressing for further deepening of SCB channel and berth to handle bigger ships and improve efficiency by minimising the dependence on tide. In order to assess the realistic figure, the future incremental traffic has been worked out based on the present traffic. It is observed that in 2016-17 with berth occupancy of 65.43 % the traffic handled at SCB is 1.46 MT. Out of which Chemical traffic was 0.56 MT and POL traffic 0.90 MT. In the year 2016-17 total 203 no of ships were handled at SCB with average vessel being of 25,713 GRT. By extrapolation, for a berth occupancy of 70%, the SCB berth can handle 220 vessels of average GRT of 25,713 (say 26,000 GRT). Considering the proposed deepening and widening of the channel, 10% increase in no of vessels can be expected.

E.2.3 Vessel Traffic

The existing world fleet of tankers for various types of liquid cargo and the ships normally calling at Indian Ports and in particular at the existing Chemical berths has been considered to arrive at an optimum design vessel size and the deepening and widening parameters of Channel leading to Second Chemical Berth have been worked out accordingly**.** The Design Vessel size considered is as under:

Size of Vessel	55,000 DWT
LOA	230 M
Beam	36 M
Draft	12.8 M

E.3.0 Channel Design

The existing channel leading to FCB and SCB is deepened to 9.0 m below CD. Considering the design vessel characteristics and various environmental parameters and other surrounding restrictions, the optimum channel depth and width have been finalised. The Turning circle has been provided in front of the berth. The proposed widening and deepening is shown below:

Dimensions of the proposed deepening and widening is as under:

Width of the Channel = 300 m

Depth of the Channel = 10.0 m & 10.5 m below CD

Radius of Turning Circle = 460 m

Depth at Berth pocket = 14.0m below CD

The size of the berth pocket does not require modification.

E.4.0 Project Cost

Based on the above proposed dimensions and available soil reports, the soil and rock dredging quantities have been worked out for two

alternatives viz. approach channel with depths of 10.0 m below CD (Alt – I) and 10.5 m below CD (Alt – II). The maintenance dredging quantity has been assumed as 1% of dredging quantity. Accordingly the project costs have been evaluated for the two alternatives as under:

Table 4.1 : Cost Estimate for Alternative I

Sr. No.	Description	Quantity	Rate	Amount Rs (in crores)
1	Soil Dredging	3,90,000 cu.m	Rs.110/cu.m	4.29
2	Rock Dredging	1,45,000 cu.m	Rs 4000/cu.m	58.00
3	Mob + Demobilisation (10 % of dredging cost)	LS		6.23
4.	Procurement of Navigational Aids	LS		0.50
5.	EIA Study and EMP	LS		0.50
			Total (Sr No.1 to 5) :	69.52
			Add 3 % contingencies :	2.09
			Grand Total :	71.61

Say 72 crores

Table 4.2 : Cost Estimate for Alternative II

Sr. No.	Description	Quantity	Rate	Amount Rs (in crores)
1	Soil Dredging	5,25,000 cu.m	Rs.110/cu.m	5.78
2	Rock Dredging	2,15,000 cu.m	Rs 4000/cu.m	86.00
3	Mob + Demobilisation (10 % of dredging cost)	LS		9.18
4.	Procurement of Navigational Aids	LS		0.50
5.	EIA Study and EMP	LS		0.50
			Total (Sr No.1 to 5) :	101.96
			Add 3 % contingencies :	3.06
			Grand Total :	105.02

Say 105 crores

E 5.0 Financial Analysis

The financial analysis have been carried out for two cost alternatives as above to select the optimum alternative. The revenue assessment have been carried out based on the likely incremental traffic due to the project and the existing tariff of MbPT scale of rates 2016. The summary of Project IRR for different cases are tabulated below :

Table 5.1 Financial Internal Rate of Return for Two alternatives

Case.	IRR for Alternative – I	IRR for Alternative – II
Case 1 : Basic	**16.96%**	**12.75%**
Case 2 : Cost more than 10%	**15.45%**	**11.74%**
Case 3 : Traffic less by 10%	**15.09%**	**11.24%**
Case 4 : Cost more than 10% & traffic less by 10%.	**13.72%**	**10.32%**

From the above it can be seen that Alternative I is the most optimum option.

E 6.0 Implementation Schedule

The project requires administrative approval of Board for the cost estimate. The necessary environmental clearance needs to obtained from Ministry of Environment, Forests and Climate Change (MoEF&CC). The completion period of dredging works would be around 7 months.

E 7.0 Conclusions

- Considering the growth of chemical industries in and around Maharashtra and as per the requirement of Users of Pir Pau terminal it is proposed to carry out deepening and widening of SCB Channel.
- From the IRR values indicated in Table 5.1it can be seen that Alternative I is most suitable.
- The work is proposed to be executed through internal resources of Mumbai Port.
- To correlate the seismic survey data few bore holes shall be taken at appropriate places to ascertain the nature of rock strata.

CHAPTER-1
INTRODUCTION

1.0 **Background:**

1.1 The Port of Mumbai has long been the principle Gateway of India located strategically on the west coast of India and blessed by nature with calm and sheltered waters.

Mumbai Harbour is located at latitude 18 deg. 57' N and longitude 72 deg 51' E. It is natural harbour protected by the main land on its east and the Mumbai peninsula to its West. The entrance to the harbour is from the South West between Prong's Reef at the southernmost tip of Mumbai and Thal Reef lying off the main land. The main harbour channel is, for the greater part, a natural channel following the longitudinal axis of the harbour, approaching the Docks & Oil & Chemical berths.

1.2 Initially the existing old pier at Pir Pau was originally built in 1922 for handling of the Petroleum Oil Products (POL) traffic at the Mumbai Port. In the year 1951, the Government of India accorded license for setting up of two Oil Refineries in Trombay and instructions were issued to the Mumbai Port Trust to provide adequate Port facilities for handling of the POL cargo to be generated by these two Refineries. A study then carried out revealed that:

i. The sole pier pier at Pir Pau is not only inadequate; but is too inferior for handling the volume of POL traffic to the two Refineries.

ii. The water-front at Pir Pau is not suitable for the deep- water port facilities required for handling the volume of the POL traffic to be generated by the two Refineries;

iii. A new common user and multiproduct, Marine Oil Terminal (MOT) should be developed at Jawahar Dweep (JD) (formerly known as Butcher Island), for handling the entire POL traffic to be generated by the two Refineries.

1.3. A Marine Oil Terminal (MOT) comprising three berths was original developed at JD and commissioned in phases in 1955. The Facilities have been augmented in 1984 by the commissioning of a fourth berth at JD. After commissioning of the MOT in 1955, the POL traffic shifted to MOT complex at JD and it was expected that the old pier at Pir Pau would, in course of time, become redundant and could be de-commissioned at the end of its service life. In course of time, however, new traffic developed in the "Specialised Grades of POL" (LPG, Lube oils), "Bulk liquid Chemicals" and these could not be handled at the MOT complex, JD, and therefore, the old pier at Pir Pau was retained for this new traffic even though its design life was over. General feasibility studies for the

establishment of marine terminal facilities at and around Pir Pau were carried out during 1965-70 by M/s. Bertlin & Partners (India) as a part of the Master Plan study for the development of the Port of Mumbai. This master plan was reviewed by the same firm in the year 1984 which highlighted the need for an integrated and staged development of Pir Pau and to construct a new marine terminal at Pir Pau for the traffic in bulk liquid chemicals, specialised grades of POL and coal. In 1987-88, M/s Howe India Pvt. Ltd. (HIPL) were engaged to prepare:

i. A Master plan for development of water front at Pir Pau.
ii. A DPR for a new pier for specialised grades of POL and bulk liquid chemicals in replacement of old pier at Pir Pau.

1.4 The Master Plan prepared by HIPL envisaged three berths at Pir Pau – two for "Specialised grades for POL and Bulk liquid chemicals" and one for "Coal", - each to be designed for 30,000 to 35,000 DWT vessels. As envisaged by the Master Plan prepared by M/s. HIPL, the first berth to handle liquid chemicals/ specialised grades of POL in bulk was constructed and commissioned in December 1996. The connecting jetty to the first berth is having provision for 20 Nos. pipelines of 300 mm dia. or equivalent, which are provided on one side of trestle in two tiers. These pipelines are extended from the End block of RCC approach trestle of the old pire. Space is available on the existing pipe trestle for laying, in future pipelines of about t Nos. of 300 mm. dia. or equivalent.

1.5 After the commissioning of the first berth at Pir Pau M/s. Tata Electric Companies (TEC) have started operations from the first berth and presently M/s CTTL, M/s. ACIL, M/s. IOBL are operating from the first berth. However, M/s HPCL and M/s BPCL are still operating from the old pier at Pir Pau and have not shifted their operations to first berth.

1.6 The need was felt for construction of second chemical berth and accordingly, detailed feasibility report was prepared by the Port through the consultant, M/s. Consulting Engineering Services (India) Ltd. in August 1999. The Port accepted the recommendation of the consultant to construct second chemical berth to the north of first chemical berth through private participation on BOT basis with provision that capital dredging and navigational aids will be undertaken by the Port. The Port invited offers for construction of second liquid chemical berth on BOT basis in 2001. Two firms viz. M/s. Adani Port Ltd. and M/s. Aegis Logistics Ltd. were short-listed. However, only M/s. Aegis Logistics Ltd. submitted the proposal, which was not found attractive. The scheme could not be implemented through private participation. Vide T.R.No. 103 of 25.03.1997 Board's sanction was accorded for the acceptance of the offer of TATA Electrical Co. to construct a Coal Berth through BOOT route at Pir Pau south of First Chemical Berth. However they have failed to commence the project

as per the terms of agreement and therefore by T.R.No.58 of 10.5.2005, sanction was accorded to terminate the license. Therefore the location at south of First Chemical berth was available for construction of second chemical berth which had certain advantages in terms of Navigations, Capital Dredging Cost.

Considering the demand from the users and the traffic projections, the Board approved construction of second chemical berth with its own resources to the south of first chemical berth instead of north, as envisaged in the Feasibility Report for navigational convenience.

2. Navigational Channel:

The main Harbour Channel is for the greater part a natural deep water fairway following the longitudinal Axis of the Harbour. Till 2012 the depth of the Channel was 11 meter below CD. With increasing demand for catering to vessels of larger drafts, the deepening and widening of Main Channel was carried out in the year 2012. The channel depth was increased from 11 meter to 14 m below CD in outer channel to facilitate handling vessels of 14 m draft with utilisation of tidal window and the Channel was widened from 325 meter to 370 meter for straight stretches and to minimum 450 meter at bends. The common user Channel of JNPT and MbPT was extended from 21.02 Km to 26.36 Km. Recently JNPT has undertaken further deepening and widening of main navigational (Phase II). The Channel depth at outer section will be increased to (-) 16.20 meter C.D to (-) 15.0 M C.D. The approach Channel to MOT berths (J1 to J3) leaves the main Harbour Channel north east of MOT berth No.4 . The approach to the First Chemical and second Chemical berths is an extension of the Channel leaving off from the MOT berths 1 to 3. The approach Channel to Old Pir Pau is an extension of the Channel leaving off from the First Chemical Berth. The map of Mumbai Harbour is shown in Fig 1.1.

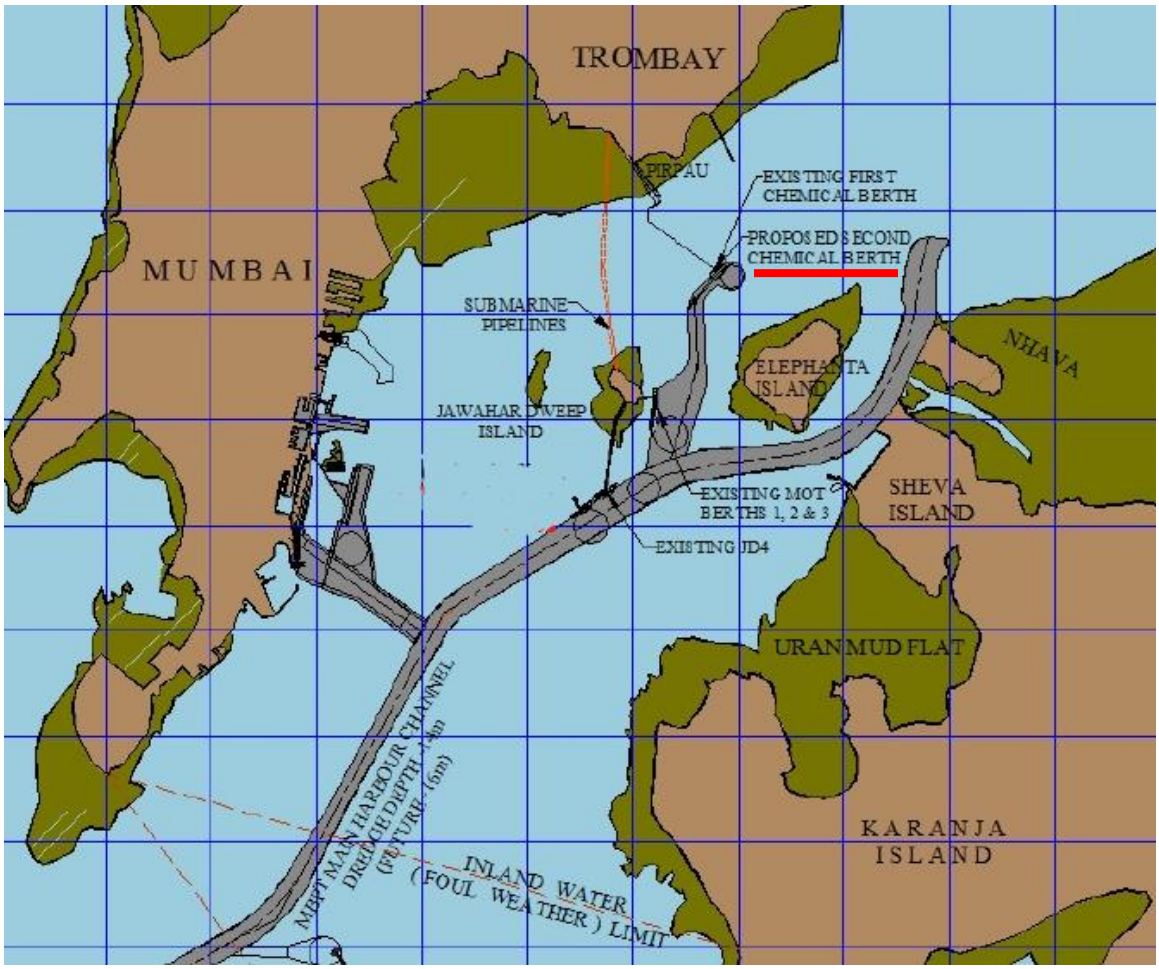


Fig.1.1

3. Development of Second Chemical Berth

The Second Chemical Berth (SCB) was partially commissioned in June 2015 and fully commissioned in January 2016. The SCB is constructed 650 meter on the south of existing First Chemical Berth off Pir Pau and in the same alignment as that of the First Chemical Berth. The capacity of proposed SCB is 2MMTPA and initially it was designed for handling capacity of 37,000 DWT tankers. For the SCB, the berth pocket of 300 m x 63 m is dredged upto –13m below Chart Datum and the existing navigational approach channel is widened by about 60m for vessels of 9.00 mt draft. The SCB is connected to First Chemical Berth by a separate approach trestle of 650 m long. The berth structure consists of

- 2 Nos. of Breasting dolphins of size 15m x 14m supported on bored cast in situ piles and concrete deck with fenders and quick release mooring hooks for berthing and mooring the vessels.
- 4 Nos. of Mooring dolphin of size 11m x 12m supported on bored cast in situ piles and concrete deck with quick release mooring hooks for mooring the vessels.

- Unloading platforms.

The dredging & civil works were done by MbPT through its internal resources. The Chemical cargo will be unloaded/ loaded by the marine loading arms and will be transported through extension of product pipelines from 1st Chemical Berth to 2nd Chemical Berth. The expenditure on loading arm & pipelines is borne by the users.

Before completion of the construction of Second Chemical Berths, MbPT decided to check the adequacy of the structure for vessel berthing up to 55,000 DWT. Accordingly MbPT appointed IIT Madras to verify the layout, configuration, analysis and design for 55,000 DWT vessels. M/s IIT Madras vetted the design and accordingly the construction was carried out so that vessels in the range of 15000 DWT to 55,000 DWT can be accommodated. The location plan diagram of Second Chemical Berth is shown in Fig 2.

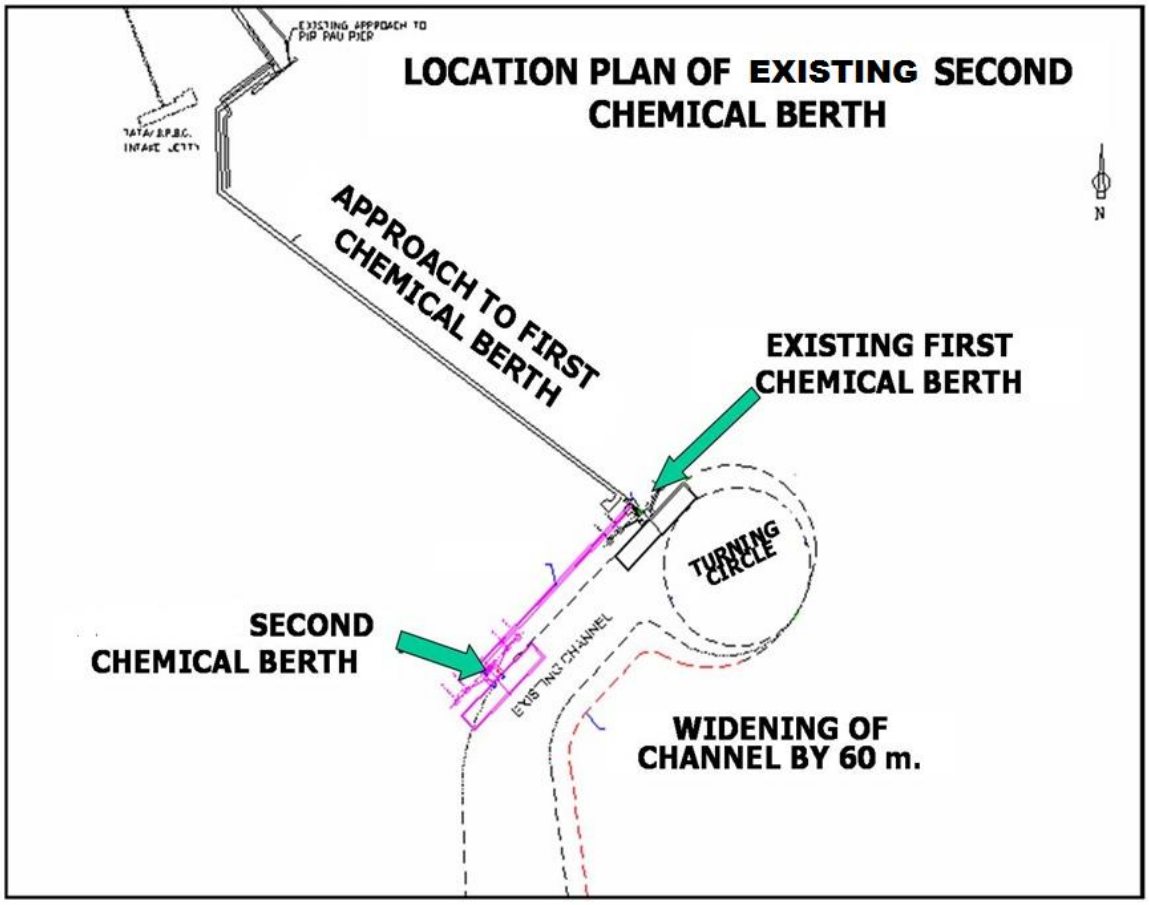


Fig 1.2

CHAPTER 2
SITE EVIRONMENT

2.1 Location

The Mumbai Harbour is a natural deep water harbor, situated, on the west coast of India (Latitude 18^{o} **54**, N, Longitude 72^{o} 49'E) and inside the protected waters of the Mumbai Gulf area. The Mumbai Port area is spread up at serveral places inside the gulf. The wet docks (Indira, Voctroia and Princess) and bunders are on the western side of the Gulf. There are four jetties for handling crude and POL Products which are situated at the Jawahar Dweep (Butcher Island). The first deep draft liquid chemicals/specialised grades of POL berth was commissioned in December, 1996 on the northern side of the Gulf near the explosive vessels anchorage area, about 2.85 km offshore at Pir Pau (WGS Co-ordinate 280995.2E, 2099921.2 N). The Second Liquid Chemical Berth is constructed 650 meter on the south of existing First Chemical Berth Off Pir Pau and in the same alignment as that of the First Chemical Berth (WGS Coordinate of SCB 280522.0E, 2099481.1N)

2.2 Marine / Land Features

2.2.1 Climate

The climate of the region is influenced by two annual monsoon seasons – south-west monsoon (June to September) and north-east monsoon (November to March). The fair weather period is from October to May. Most of the rainfall in the region occurs during south west monsoon with aggregate rainfall 200 to 250 cm. The rainfall during November to March is minimal. Relative humidity is high all-round the year, 85 to 90% during summer months and reducing to 60 to 70% during November to February. Mean day temperature is 25 to 38^{o}C which falls in winter to 20 to 25^{o}C minimum.

2.2.2 Wind

Predominant wind is from north to west directions with seasonal variations as given in Table 2.1.

TABLE 2.1

WIND DATA

Month	Predominant Direction	Wind Speed (Beaufort scale)
February to May	NW	4 to 6 (Max. 8 to 10)
June to September	WNW	6 to 8 (Max. 8 to 10)
October to January	NNW	2 to 6 (Max. 6 to 8)

2.2.3. Cyclones

The west coast is subjected to occasional severe cyclonic storms. The region experiences very strong winds and heavy wide spread rain in the post-monsoon months of October and November and to a lesser extent in May. The frequency of cyclones is 0.3 per year i.e. about one cyclone in 3 years. During strong winds, the swell can have significant effect but due to channel bathymetry the wave heights are considerably reduced.

The thunder storms occur mainly in May and June and in the late September to the middle of November. On an average thunder storms may occur for about 17 days in a year. The squalls occurs mainly in the monsoon months from June to September. In November-December a squall coming from east and lasting for about half an hour occurs in the evening. During these squall wind force goes upto 6 on Beauforts scale. On as average the squalls may occur for about 15 days in a year. The occurrences of dust storm and fog are very rare.

2.2.4 Special Weather Phenomena

The thunder storms occur mainly in May and June and in the later September to the middle of November. On an average thunder storms may occur for about 17 days in year. The squalls occurs mainly in the monsoon months from June to September. In November – December a squall coming from east and lasting for about half an hour occurs in the evenings. During these squalls wind force goes upto on Beauforts scale. On an average the squalls may occur for about 15 days in a year. The occurrences of dust storm and fog are very rare.

2.2.5. Tides

The tidal variation at Mumbai is mainly diurnal. An automatic tide gauge has been installed at Apollo Bunder, near Gateway of India for regular observation of tides.

Tide levels considered for this report are as under (with reference to chart - datum).

HHW	+ 5.38 M
MHWS	+ 4.42 M
NGWN	+ 3.30 M
MSL	+ 2.50 M
MLWN	+ 1.80 M
MLWS	+ 0.76 M
LLW	- 0.44 M

The statistical studies done in the Master Plan indicate that

i) All high tides exceed + 2.7 m.

ii) About 95%of all highest high tides would be greater than + 3.2 m

iii) About 95% of all lower high tides would be greater than + 2.85m

2.2.6. Currents/Waves

Currents in Mumbai Gulf are caused by tidal ebb and flood flows. Normal maximum current inside the Gulf are about 2 to 3 knots, though ad maximum 4 knots could be expected in the ebb during monsoon spring tide. The DPR for the Pir Pau Marine Terminal (1988) indicated that the flood currents, as they approach the Tromaby Island change dirtection from north to north-east and further beyond tend to become northerly again. The Maximum velocity of the current at the Pir Pau old pier is reported to be 1.0 M/Sec on neap tide.

As regards waves, the Mumbai harbour is not subjected to any abnormal wave conditions. The wave heights reaches a maximum of 1.5 m under normal conditions with wave period ranging from 6 to 10 seconds. The past studies show that waves entering the Mumbai Harbour get substantially attenuated by the time the waves reach the Pir Pau berth and that only 10 percent of waves exceed 0.3 M amplitude at old pier.

The maximum currents of flood and ebb tides are shown in Fig. 2.1 and 2.2.

Hydraulic model/desk studies were carried out at the Central Water and Power Research Station (CWPRS) by MBPT for the Pir Pau Marine Terminal in 1988 (for the First liquid chemical berth), with the following objectives in mind.

1. To assess the tranquility conditions in the harbour at the proposed alternative locations of the (chemicals/POL) berths.
2. To determine the most favorable alignment of the berthing structures with respect to the tidal currents and waves.
3. To study the siltation pattern the rate of siltation per year.
4. To determine the optimum length of the approach bund to ensure that the general circulation patter in the vicinity is not disturbed significantly.
5. To assess the impact of the proposed reclamation, in general, on the surrounding area and specifically on the siltation of erosion pattern of the dredged area. It is proposed to fill the area between the existing and new approach to the existing Pir Pau Jetty.

CWPRS's specific note no. 2509 submitted to MBPT in April 1988 reported for the bulk chemicals/specialised grades of POL berths at Pir Pau are well protected from waves by the Mumbai Island itself. Moreover, the area of the Pir Pau terminal being 16 km from the harbour entrance the wave activity would be low at all locations. Further, the berthing face of jetties in the recommended alternative was well aligned to the tidal flow in this and there was no likelihood of any problem of berthing of berthing and mooring of vessels alongside the berths.

Since the second chemical berth is aligned in the same direction as the existing First chemical berth, it is likely that the proposed second berth also will have no problem of berthing and mooring of vessels.

2.2.7. Sub – sea soil conditions

Soil investigation carried out during October-December, 1989 at the location of Pir Pau Marine Terminal by Mumbai Port Trust. Thereafter in November-December 2007 at the location of SCB soil investigation was carried out along the alignment of SCB Jetty and at the berth pocket. In 2015 sub-bottom profiling survey of the area New Pir Pau channel along with berth locations were carried out. The investigations carried out in this area indicates at certain location in berth pocket the rock level starts at (-) 10.71 M CD and in widening portion of Channel at certain location Rock level exists at less than (-) 9.0 M CD. There are not sufficient data is available for the proposed deepening portion of SCB. From the soil investigation data available, it appears that there is rock dredging involved in the proposed deepening of SCB Channel. Hence it is advisable to carry out few marine boring at these locations to have more realistic information on quantum of rock dredging.

2.2.8. Approach Channel and Navigational Aspects

The approach Channel used by the ships for the first chemical berth would also be used by the Second Chemical berth as envisaged earlier. Presently the approach Channel is maintained at (-) 9.0 M CD. As per the discussion had with the Dy Conservator, for handling bigger ships at SCB the Turning Circle shall be made in front of Berth for ease of navigations and the existing Channel is also need to be deepened and widened. The details designing of proposed approach channel to SCB is covered in later chapter.

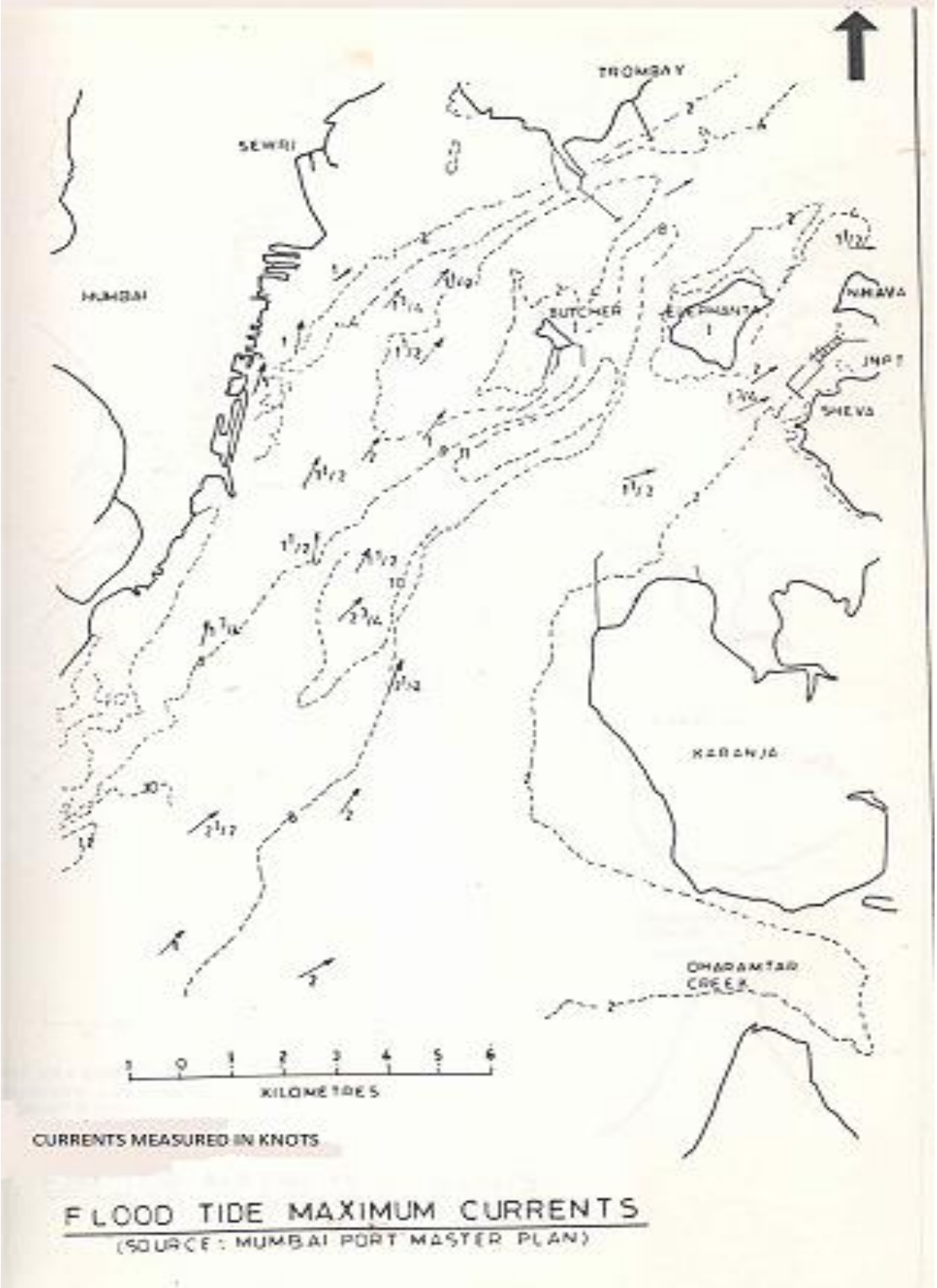

TROMBAY
SEWRI
MUMBAI
BUTCHER
ELEPHANTA
NHAVA
JNPT
SHEVA
KARANJA
DHARAMTAR CREEK
KILOMETRES
CURRENTS MEASURED IN KNOTS
FLOOD TIDE MAXIMUM CURRENTS
(SOURCE : MUMBAI PORT MASTER PLAN)

Fig 2.1

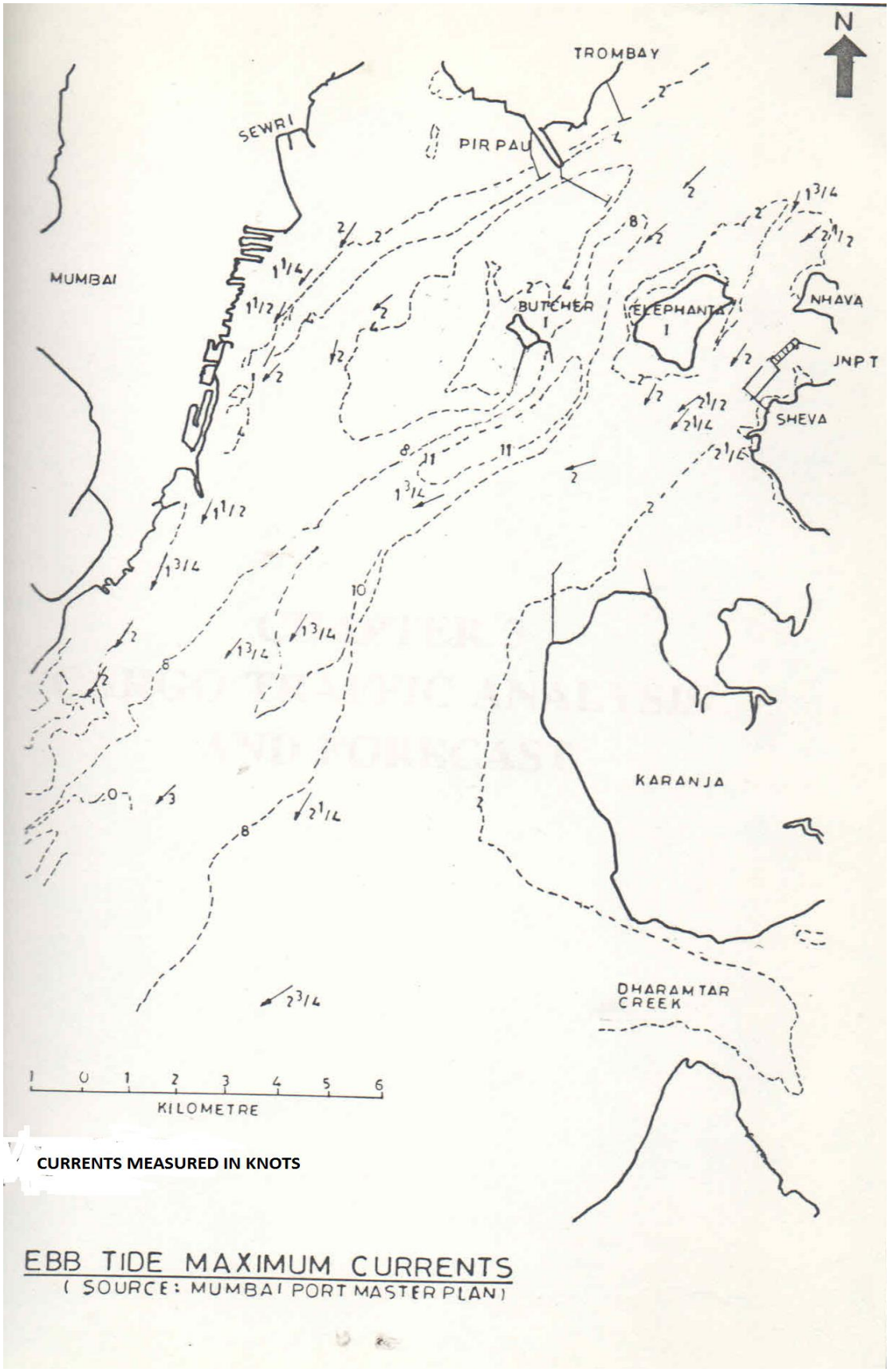

N
TROMBAY
SEWRI
PIR PAU
MUMBAI
BUTCHER
ELEPHANTA
NHAVA
JNPT
SHEVA
KARANJA
DHARAMTAR CREEK
1 0 1 2 3 4 5 6
KILOMETRE
CURRENTS MEASURED IN KNOTS
EBB TIDE MAXIMUM CURRENTS
(SOURCE: MUMBAI PORT MASTER PLAN)

Fig 2.2

CHAPTER 3
CARGO TRAFFIC ANALYSIS AND FORECAST

3.1 Liquid chemical and POL traffic at MbPT

At the initial stage during preparation of feasibility report in 1999, the Consultant had made Traffic projection as under:

TRAFFIC FORECAST
Table 3.1

In million tonnes

Sr. No.	Category	2001	2006	2011	2016
1	Naphtha	0.79	1.299	2.2	2.897
2	Other specialised grades of POL	0.97	1.200	1.598	2.147
3	LPG	0.7	1.40	1.500	1.550
4	Chemicals	1.145	1.267	1.43	1.616
Total in MMT :		3.5	5.2	6.7	8.2

The consultant M/s CES had assessed the capacity of First Chemical Berth and Old Pir Pau as 1.72 MTPA and 0.75 MTPA respectively with an average handling rate of 600 TPH for First Chemical Berth and 200 TPH for Old Berth with 20 hours production basis. The Old Pir Pau is not in structurally sound condition and may be required to be decommissioned or may be used for barges for the construction of MTHL project by the Government of Maharashtra.
MbPT updated the feasibility report (1999) in house in the year 2006. Considering the Chemical traffic scenario of 2005, the traffic of Chemicals and specialised grades of POL for the Second Chemical Berth was forecasted as under:

Table 3.2

(**in MMTPA**)

Year	POL Products	Chemicals	Total Traffic At Pir Pau	Traffic for 2nd/ future berths
2008-09	1.30	1.15	2.45	0.45
2009-10	2.50	1.61	4.11	2.11
2010-11	3.00	1.93	4.93	2.93
2011-12	3.07	2.32	5.39	3.39
2012-13	3.15	2.62	5.82	3.82
2013-14	3.23	3.07	6.30	4.30
2014-15	3.31	3.38	6.69	4.69
2015-16	3.39	3.71	7.11	5.11
2016-17	3.48	3.99	7.47	5.47

The above Traffic projections were worked out based on the discussion held in 2015 with All India Liquid Bulk Importers and Exporter Association (AILBIEA) and Indian Chemical Manufacturer Association (ICMA), when they informed that the traffic at Pir Pau will continue to rise in future.

The actual traffic handled in Pir Pau has been raised from 1.15 MTPA in 2005 to 3.18 MTPA in 2014-15.

3.2 PRESENT TRAFFIC

The traffic handled in last five years at Old and first & second chemical berth and occupancy of the berths are as under:

Table 3.3

(in MMTPA)

Year	2012-13		2013-14		2014-15		2015-16		2016-17		
Category	OPP	FCB	OPP	FCB	OPP	FCB	OPP	FCB	OPP	FCB	SCB
Chemicals	0.44	1.24	0.34	1.42	0.39	1.60	0.49	1.72	0.15	1.33	0.56
Products	0.28	1.10	0.42	0.96	0.56	0.63	0.41	0.87	0.30	0.23	0.90
Total	0.72	2.34	0.76	2.38	0.95	2.23	0.90	2.59	0.45	1.56	1.46
Berth Occupancy	47.43	87.08	33.89	88.14	40.38	84.91	52.34	78.74	20.68	67.35	65.43
Total Traffic	3.06		3.14		3.18		3.49		3.47		

Note: OPP = Old Pir Pau, FCB = First Chemical Berth, SCB = Second Chemical Berth.

3.3 Chemical Industry Products

Presently Chemical Industry plays a major role in the country's economic growth. Some of the useful current information on Chemical Industry is -

- The Chemical Industry holds a significant position in the economy. It comprises 2.11% of National GDP.
- Gujarat and Maharashtra have emerged as most favourite zones. The chemical Industry Infrastructure across India is shown in fig 3.3.
- Chemical Industry expected to clock a growth of 10-13% percent over current years.
- Chemical export from India stood at USD 12.70 billion for the financial year 2014-15 and it is growing at CAGR of 0.9% is shown in fig 3.2.
- Total imports of Chemicals growing from USD 10.1 billion in Financial year 2012-13 to USD 19 billion in Financial year 2014-15 at CAGR of 37.5%. shown in fig 3.1.
- Government allows 100% FDI in chemical Industry. Procedures relating to FDI have been simplified.
- It is expected that in 2025, Chemical Industry is expected to grow and reach USD 403 billion mark.

From above, it can be seen that chemical Industry is growing at high rate including import and export of chemical cargo.

3.4 Petroleum Products

Some of the useful current information on Petroleum products is -

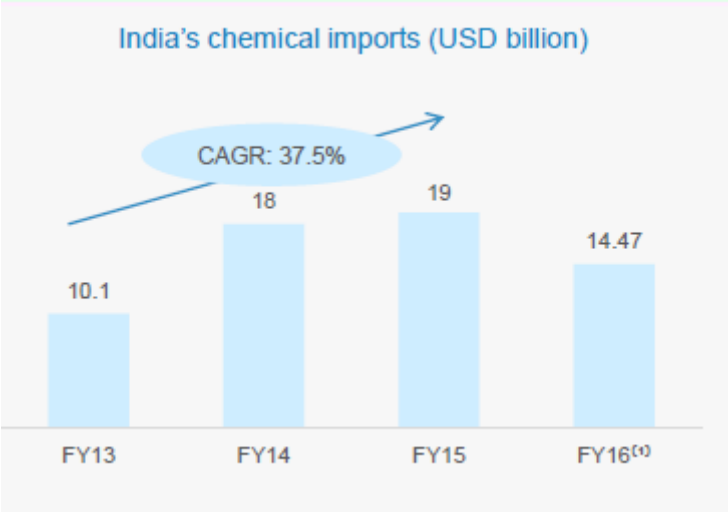
- With increase in refinery capacity, production of petroleum products has increased substantially during last few years. During 2013-14, 67.864 MMT of petroleum products, valued at Rs. 3,68,279 crores were exported. During the previous year 2012-13, export of these products was 63.408 MMT valued at Rs. 3,20,090 crores. Export of petroleum products during 2013-14 was higher by 7.03% in terms of quantity and by 15.05% in terms of value, as compared to the previous year.
- The quantity of petroleum products imported during 2013-14 was 16.718 MMT valued at Rs. 74,605 crore. During 2012-13, imports of these products were 15.774 MMT valued at Rs. 68,363 crore. Imports of petroleum products increased by 5.98% in terms of quantity and increased by 9.13% in value terms, as compared to the previous year.
- During FY15, consumption of petroleum products in India stood at 183.5 MMT. Petroleum products derived from crude oil include light distillates such as LPG, naphtha; middle distillates such as kerosene; and heavy ends such as furnace and lube oils, bitumen, petroleum coke and paraffin wax.
- Light distillates with the highest growth rate grew at CAGR of 4.09 per cent, while middle distillates and heavy end segment witnessed a CAGR of 4.02 per cent and 1.78 per cent respectively, during the year FY08-15. Consumption of petroleum products is shown in fig 3.4.
- During the 12^{th} Five-year Plan period (2012–17), production of petroleum products in India is expected to reach 1195.8 MMT.
- The Government allows 100 per cent Foreign Direct Investment (FDI) in upstream and private sector refining projects.
- The FDI limit for public sector refining projects has been raised to 49% without any disinvestment of domestic equity in the existing PSUs.

From the above it can be seen that the requirement of petroleum products are also growing at high rates which in turns increase the growth rate of import/ export of petroleum products.

3.5 Conclusion:

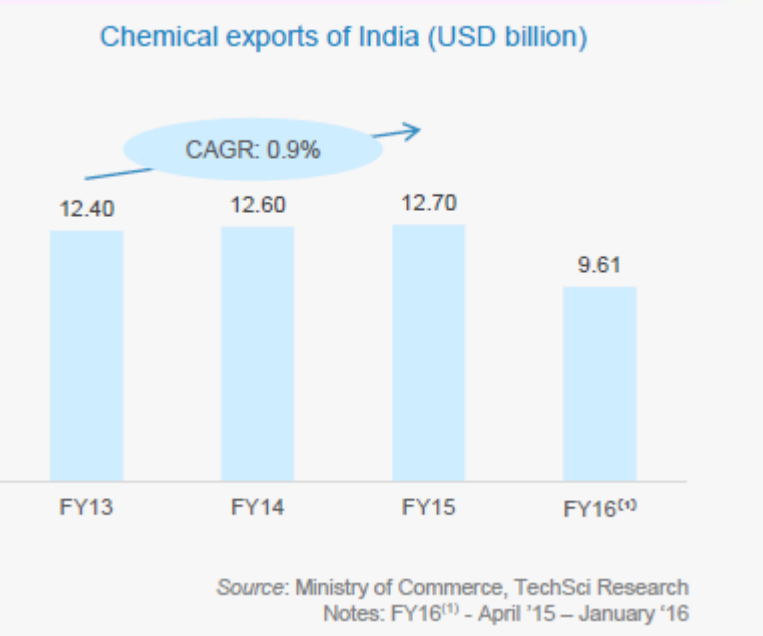
The conclusions and findings emerging out from the previous discussion on Chemical and POL products are as under:

- Maharashtra & Gujarat account for the major share of the all India demand for liquid chemicals and products.
- The traffic assessed at Mumbai Port holds good.
- Users have shown preference for further developments in Pir Pau areas..
- Improvement of Infrastructural facility at Pir Pau areas are required to cope with import / export growth in Chemical / Product sector.
- BPCL & HPCL are keen on laying additional pipe lines from SCB which will create additional traffic at Pir Pau.
- Land allotment of the plot previously with RCF is under consideration for development of Tank farm which would create additional traffic at Pir Pau.



Source: Ministry of Commerce, DGCI&S, TechSci Research
Notes: FY16(1) - Data is for April '15 – January '16
CAGR - Compound Annual Growth Rate

Fig 3.1



Source: Ministry of Commerce, TechSci Research
Notes: FY16(1) - April '15 – January '16

Fig 3.2

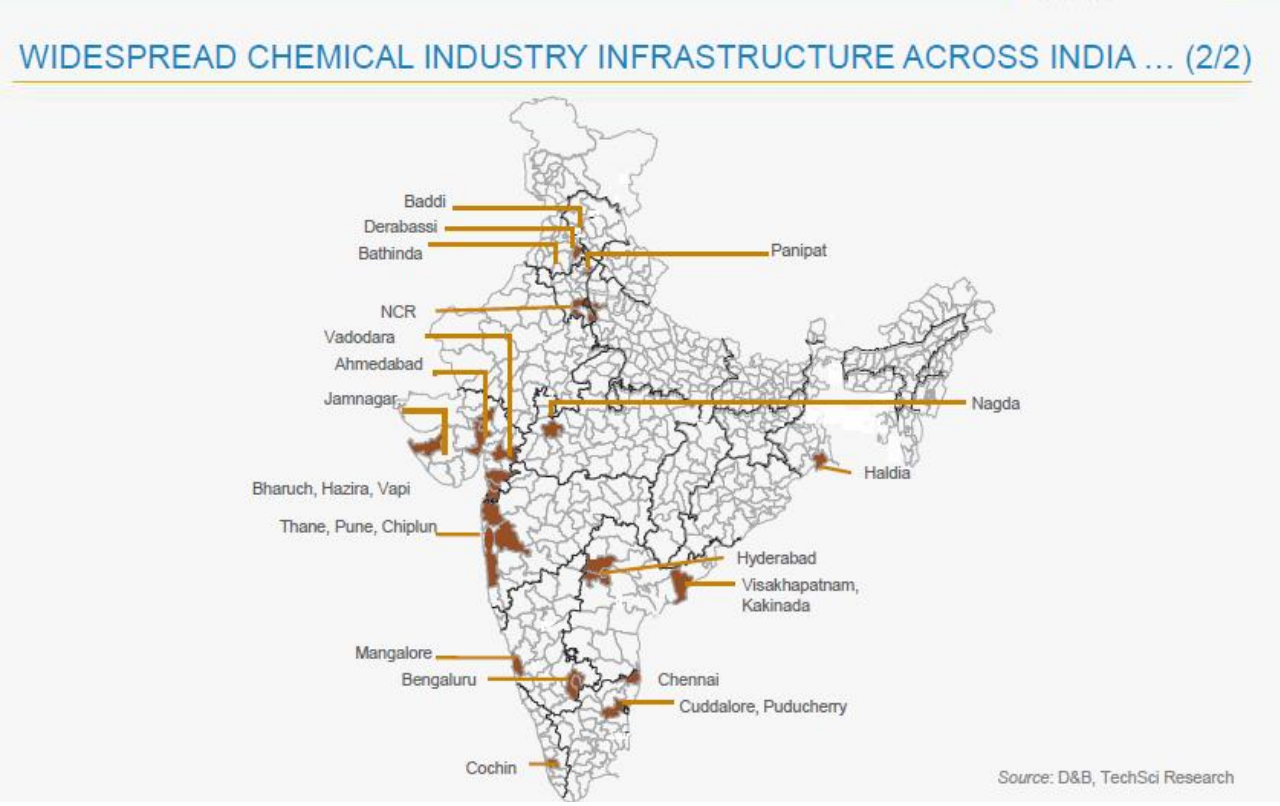

WIDESPREAD CHEMICAL INDUSTRY INFRASTRUCTURE ACROSS INDIA … (2/2)
Baddi
Derabassi
Bathinda
Panipat
NCR
Vadodara
Ahmedabad
Jamnagar
Nagda
Haldia
Bharuch, Hazira, Vapi
Thane, Pune, Chiplun
Hyderabad
Visakhapatnam, Kakinada
Mangalore
Bengaluru
Chennai
Cuddalore, Puducherry
Cochin
Source: D&B, TechSci Research

Fig 3.3

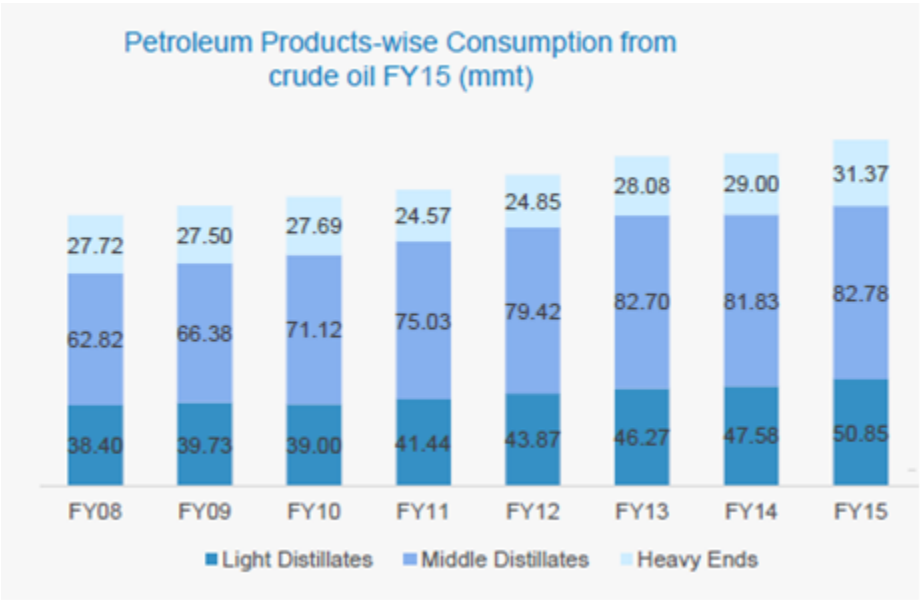

Petroleum Products-wise Consumption from crude oil FY15 (mmt)
27.72
62.82
38.40
27.50
66.38
39.73
27.69
71.12
39.00
24.57
75.03
41.44
24.85
79.42
43.87
28.08
82.70
46.27
29.00
81.83
47.58
31.37
82.78
50.85
FY08
FY09
FY10
FY11
FY12
FY13
FY14
FY15
Light Distillates
Middle Distillates
Heavy Ends

Fig 3.4

CHAPTER 4
VESSEL TRAFFIC ANALYSIS & FORECAST

4.1 Vessel Traffic analysis:

M/s Consulting Engineer Services (CES) in their DPR of 1999 had observed that 88% of world fleet for chemical tankers were up to 30000 DWT. The feasibility report prepared by CES was updated in 2006 and enquiries with largest tanker operators in the world revealed the largest vessels as follows.

Table 4.1

Sr. No.	Vessel Name	DWT	Draft in m	LOA in m	Displacement in Tonnes
1.	Montana Blue	40,077	11.22	176.00	49,454
2.	Stolt Creativity	37,186	11.68	176.75	49,845
3.	Stolt Aquamarine	38,719	12.23	176.80	50,238

Considering the draft requirement at that time, the design Vessel size of 37,000 DWT was considered and the particulars of Design Vessel was as under:

Size of vessel : 37,000 DWT
LOA : 210 M
Beam : 28 M
Draft : 10.8 M

Based on the above design vessel size, the construction of Jetty structure (SCB) and dredging works started. However before completion of the construction of Second Chemical Berth, MbPT decided to check the adequacy of the structure for vessel berthing up to 55,000 DWT. Accordingly MbPT appointed IIT Madras to verify the layout, configuration, analysis and design for 55,000 DWT vessels. M/s IIT Madras vetted the design and accordingly the construction was carried out so that vessels in the range of 15,000 to 55,000 DWT can be accommodated. The max. design vessel size particulars that the civil structure can accommodate is as under:

Dead Weight Tonnage : 55,000 (DWT)
Displacement Tonnage : 72,600 (MT)
Length Overall (LOA) : 230 m
Beam (B) : 36.0 m
Draft : 12.8 m

In view of the time lapse fresh enquiries have been made and the details of few largest chemical tanker vessels available in the market is as under:

Table 4.2

Sr. No.	Vessel Name	DWT
1.	Stolt Breland	43,476
2.	Stolt Sneland	44,080
3.	Stolt Facto	46,105
4.	Stolt Gulf Mishref	46,089

From the above it can be seen that over the years the vessel size of chemical tankers have not been increased much and the design vessel size of 55,000 DWT is on higher side as present scenario for handling chemicals.

4.2 Pir Pau Berths

Presently at Pir Pau, three berths i.e. Old Pir Pau (OPP), New Pir Pau (FCB) and the newly constructed Second Chemical Berth (SCB) are operational. Since the Old Pir Pau berth may not handle ships due to implementation of Mumbai Trans Harbour Link (MTHL) project the same is not considered for analysis. The various performance parameters at Pir Pau berths are as under.

Table 4.3

Year	2012-13	2013-14	2014-15	2015-16	2016-17
Average time spent at berth (Days)	1.12	1.02	1.01	1.11	0.97
Average Pre-berthing detention on Port Account (Days)	0.83	1.30	0.87	20.46 (Hrs)	4.67 (Hrs)
Average Turn-round time (Days)	2.03	2.41	1.97	2.04	1.25
Idle Time at berth (%)	32.18	29.36	31.30	34.99	33.77

Berth Occupancy of Old Pir Pau, First & Second Chemical Berths are as under:

Year	2012-13	2013-14	2014-15	2015-16	2016-17
Old Pir Pau (OPP)	47.43	33.89	40.38	52.34	20.68
New Pir Pau (FCB)	87.08	88.14	84.91	78.74	67.35
Second Chemical (SCB)	---	---	---	---	65.43

4.3 Capacity Augmentation

From the above section, it is seen that average time spent at berth by the vessel and idle time at berth have not improved much even after the construction of SCB. There is reduction in pre-berthing detention time of vessels. After SCB is operational the berth occupancy at FCB & SCB is 67.35% & 65.43%. The productivity is not increased.

The main factor affecting the productivity are as under.
The average time spent at berth. Idle time at berth has not improved and is on higher side. As a result it restricts reduction in turn-around-time. One of the reason for more time spent by the vessel at the berth is lesser tidal window available for the vessels for both FCB & SCB. At the Pir Pau berths most of the ships unload the cargo and leave the berth with light draft while ships arriving at the berths, depending on the sizes, need to wait for suitable high tide. Further ships berthed at SCB need to use Turning circle in front of FCB. This affects movements of vessels at both the places. Certain big ships have to wait longer time for berthing for the availability of the requisite high tide.

Considering this current scenario at Pir Pau, the Marine Survey Division is of the opinion that if the tidal window of vessels for SCB is reduced by further deepening the approach channel and providing separate Turning circle in front of SCB alongwith widening of channel at certain locations for easy manoeuvring, the idle time at berth and turnaround time can be reduced. This will improve the efficiency of the chemical terminals.

Further the Oil Industry Users are keen on laying additional pipe lines from SCB which will result in effective capacity augmentation of the Pir Pau berths. For capacity augmentation at SCB and improvement of vessel operations and management it is proposed to deepen the approach channel leading to SCB. The details of proposed Channel design will be dealt in the next Chapter.

CHAPTER 5
CHANNEL DESIGN & DREDGING VOLUME

5.1 Channel Design

The dimensions of the navigational areas such as approach channel, maneuvering areas are based on the vessel envisaged to visit the Pir Pau areas with prevailing environmental conditions, traffic density and safe navigational practice as per the standards.

5.1.1 Existing Channel

The existing common user main channel is 26.4 km long with widths of 370 m along straight stretches and 450 m at bends. The layout of existing harbor channel is shown below.

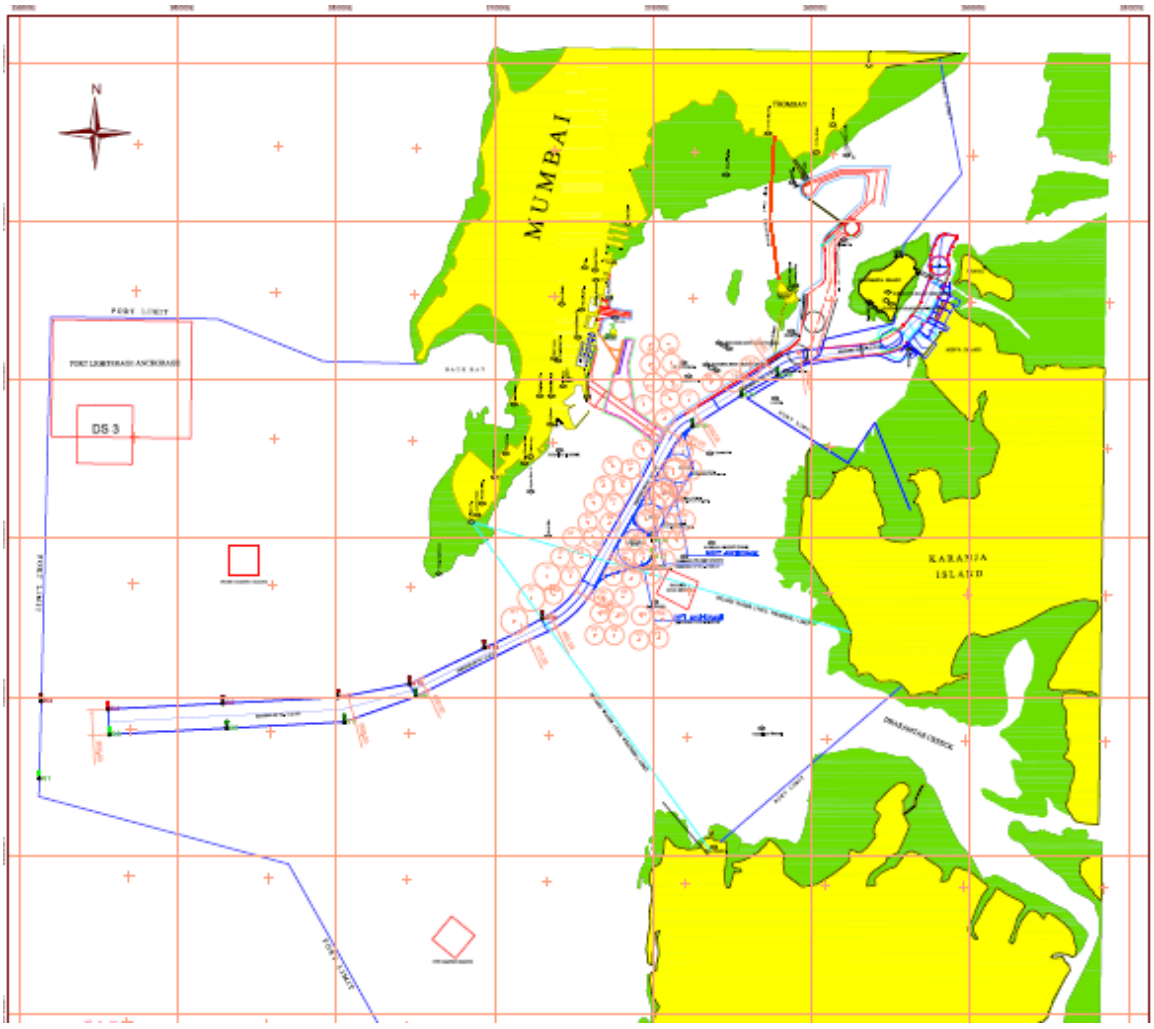


Fig 5.1

The existing design depth of main channel at outer section is 14.2 m below CD and design depth of main channel near JD4 is 13.2 m below CD. M/s JNPT has undertaken further deepening of main harbor channel under Phase II under which existing depth of 14.2 m will be increased to 16.00 m below CD & 13.2 m will be increased to 15.0 m below CD. The common user main harbour channel ends at 4th Oil berth. After the 4th Oil berth, the main harbor channel bifurcates into the "Y" junction – one channel leading to Jawahar Dweep / Pir Pau areas and other channel leading to JN Port. The Channel leading to Jawahar Dweep is maintained at 10.5 m below CD for vessels being handled at JD Berth No.s 1, 2 & 3. The design depth at JD berth Nos.1 & 3 is 11.6 m below CD while design depth at JD Berth No. 2 is 11.0 m below CD. The approach channel to SCB/FCB is an extension of the channel leaving off from the MOT berths 1 to 3 (JD 1, 2 & 3). The existing channel leading to FCB and SCB is deepened to 9.0 m below CD. The depths available at various sections for approaching FCB/SCB as under:

Table 5.1

Sr. No.	Channel Area	Length	Depth below CD
1	Main Harbour (outer section upto JD4)	26.34 Km	14.0 m to 13.2 m
2	Channel Approach to JD 1, 2 & 3.	2.53 Km	10.5 m
3	Approach Channel to FCB/SCB	2.1 Km	9.0 m
4	Approach Channel to OPP	3.53 Km	4.5 m

5.1.2 Channel Design Parameters

The parameters primary influencing the design of approach channel are vessel characteristics and environmental parameters such as tide, wave, current etc and surrounding conditions.

5.1.2.1 Design Vessel Characteristics

The design vessel size considered are 37,000 DWT for which the SCB Jetty was designed and 55,000 DWT for which the SCB Jetty was verified by IITM. The vessel particulars are as under.

Table 5.2: Design Vessel Size Dimensions

Sr. No.	Vessel size	LOA (m)	Beam (m)	Draught (m)
1	37,000 DWT	210	28	10.8
2	55,000 DWT	230	36	12.8

5.1.2.2 Environmental parameters

(i) Tidal Window

The tide in the region is semi-diurnal in nature. As indicated in Chapter 2 of this report, all high tides exceed +2.7 m CD. Hence currently the minimum water depth available in the channel during all stages of high tide is 11.7 m (9m channel depth + 2.7m min high tide). As per the statistical evaluation of the tidal levels carried out by M/s Bertlin & Partners while preparing the master plan for Mumbai Port, the tidal height 3 hours before/after the lowest water would be a minimum of (+) 2.2m CD. In MbPT recently OCT channel has been designed for tidal window of 2.5m. The mean low water springs and the lowest low water neap are + 0.76 m CD and + 1.3 m CD respectively.

The tidal window selected for designing the proposed approach channel under consideration of deepening is summarised below.

Table 5.3

Tide I	Tide II	Tide III
(+) 2.5 m	(+) 1.3 m	(+) 0.76 m

(ii) Wave height

While carrying out feasibility of deepening & widening of main harbor channel M/s JNPT has studied wave heights at different locations along the main harbor channel. The significant wave heights as calculated by CWPRS near JD4 is 1.0 m and it can be expected that the wave height will not be exceed 1.0m at Pir Pau channel.

(**iii) Currents**

The currents in the navigational channel are predominantly tidal currents. The maximum tidal currents of 2 knots have been observed in Pir Pau area. Generally the current is maximum during monsoon periods and the movement of ships is restricted during monsoon period. It is observed that ebb currents are stronger than the flood currents.

(iv) Wind Speed

It is observed that wind speed is less than 20m/s (40 Knots) for 96% of the time and the maximum wind speed is 30 m/sec (60 Knots). Therefore for all practical purposes, a wind speed of 30 knots shall be taken as limiting wind speed for safe navigation in channel.

5.3 Design of Approach Channel

The design of approach channel comprises of determining the channel alignment, width, depth. Considering vessel size & various channel design parameters and the existing surrounding conditions, the most suitable alternative is evaluated .

5.3.1 Channel Alignment

Since this is a brownfield expansion, with approach channel already in place and deepened to 9.0 m, it is considered prudent to maintain the present alignment and modify only widths and depths of the channel.

5.3.2 Channel Depth

For determining the depth required in the approach channel to SCB, the use of optimal tidal window and the depth available just prior to entering approach channel to SCB i.e. JD channel needs to be considered for providing the most economical/feasible solution. The components to be evaluated for determination of the channel depth are as follows:

- Static draft of the design ship
- Under keel clearance required for various environmental parameters
- Allowance for siltation
- Optimisation based on the depth of approach channel to JD1, 2 &3.

5.3.2.1 Determination of Approach Channel Depth

Two alternatives have been considered for determining the Channel depth and tabulated below.

Table 5.4 Channel depth evaluation for Tidal window of 2.5 m

Vessel Size	37,000 DWT	55,000 DWT
Static Draft	10.8 m	12.8 m
Under keel clearance (10% of Static draft)	1.08 m	1.28 m
Siltation Allowance	0.3 m	0.3 m
Net Channel Depth	12.18 m	14.38 m
Tidal Window	2.5 m	2.5 m
Rounded depth of channel required	9.7 m below CD	11.9 m below CD

Table 5.4 Channel depth evaluation for Tidal window of 1.3 m

Vessel Size	37,000 DWT	55,000 DWT
Static Draft	10.8 m	12.8 m
Under keel clearance (10 % of Static draft)	1.08 m	1.28 m
Siltation Allowance	0.3 m	0.3 m
Net Channel Depth	12.18 m	14.38 m
Tidal Window	1.3 m	1.3 m
Rounded depth of channel required.	10.9 m below CD	13.1 m below CD

Table 5.4 Channel depth evaluation for Tidal window of 0.76 m

Vessel Size	37,000 DWT	55,000 DWT
Static Draft	10.8 m	12.8 m
Under keel clearance (10 % of Static draft)	1.08 m	1.28 m
Siltation Allowance	0.3 m	0.3 m
Net Channel Depth	12.18 m	14.38 m
Tidal Window	0.76 m	0.76 m
Rounded depth of channel required	11.4 m below CD	13.6 m below CD

From the Table 4.2 it can be seen that the largest average size of chemical tanker is of 45,000 DWT. The design vessel size of 55,000 DWT is not calling very often to Indian Ports and if they do call at Mumbai Port, the channel depth could be provided such that they can come at High Water Spring tides. Therefore the Channel depth predominantly is decided based on the 37,000 DWT vessel.

Further it is also to be noted that the JD channel which is between the Pir Pau channel and the Main Channel is maintained at 10.5m below CD. Further deepening of Approach Channel to JD berths (1 to 3) will serve no purpose as the max. depth at the JD berth (pocket) is 11.6 m and no further deepening of these berths is envisaged.

It is therefore proposed to restrict the channel depth to 10.5 m at approach channel to Pir Pau. With the channel depth of 10.5 m, a 37,000 DWT vessel can come at a tidal window of 1.7 m (12.2 m -10.5m). If Channel depth is kept as 10.0 m, then the 37,000 DWT vessel would require a tidal window of 2.2 m which

is also reasonably alright. Based on the quantum of rock dredging involved and financial analyses the channel depths will be decided.

5.2.3 Channel Width

Assessment of the channel width required for safe navigation for all expected vessels at SCB involves evaluation of a multitude of parameters such as ship sizes, nature of cargo & prevailing environmental conditions.

The basic components of approach channel depend on the manoeuvring lanes, bank clearance and ship passing clearance lane. Allowance must be given in designing the width of channel to account for the following factors –

1. Speed of the ship
2. Prevailing cross wind
3. Prevailing Cross Current
4. Longitudinal current
5. Depth/Draft ratio
6. Wave Action
7. Quality of Navigational Aids
8. Nature of the bottom surface of the channel
9. Cargo hazard level

The vessel expected to be handled at Pir Pau are of liquid cargo. All components and various allowances have been considered as per PIANC guidelines. The designed single and two way navigable width of approach channel is estimated based on the above considerations and is presented below.

Table 5.5: Design Width Estimation of Approach Channel

Sl. No.	Allowances given	Assumed data	Two way Channel		One Way channel	
			Allowance	Magnitude	Allowance	Magnitude
1	Maneuvering lane	Good	2 * 1.5 B	3.0 B	1.5 B	1.5 B
2	Ship Clearance	Moderate	1.8 B	1.8 B	-	-
3	Bank clearance	Moderate	2 * 1.0 B	2.0 B	2 * 1.0 B	2.0 B
4	Cross winds	Moderate/ Good	2 * 0.4 B	0.8 B	0.4 B	0.4 B
5.	Cross current	Moderate/ Good	2 * 0.7 B	1.4 B	0.7 B	0.7 B
6.	Wave action	Hs ≤ 1 m	0.0	0.0	0.0	0.0
7.	Quality of Navigational Aids	Good	2 * 0.1 B	0.2 B	0.1 B	0.1 B
8.	Nature of cargo hazard level	medium	2 * 0.5 B	1.0 B	0.5 B	0.5 B
			Total	10.2 B		5.2 B

Based on the selected allowances for the components of the approach channel width, the estimated channel width for various design vessels is presented below.

Table 5.6 : Width of Approach Channel for Various Design Vessel

Design Vessel	Width (m)	Estimated Width	
		Two Way	One Way
37,000 DWT	28	10.2 x 28 = 285.6 m	5.2 x 28 = 145.6 m
55,000 DWT	36	10.2 x 36 = 367.2 m	5.2 x 36 = 187.2 m

. However the channel in front of SCB berth is not adequate and the same will be suitably widened while designing separate Turning Circle for SCB. The existing channel width of approach channel up to SCB berth is 300 m which is adequate for two way lane of 37,000 DWT vessel. Hence no change in width of the channel is proposed

5.2.4 Design of Channel Bends

In the existing Channel alignment there is a bend near the Second Chemical berth. Channels with bends are more difficult to navigate compared with straight stretches. At the bends when vessel takes a turn the vessel control is reduced and the width of swept path is naturally greater than the beam of the vessel. Therefore additional width is provided at bends. The navigation of vessels at Pir Pau channel will be assisted by tugs, so vessel movement is controlled. However the following equation developed from the Dave Taylor Model Basin studies is used to calculate the increase in channel width required in bends:

$$\Delta W = 0.9144 \, \phi \, V_s^2 \, L^2 \, F / (R_t \, C_c \, S)$$

ΔW= Increase in ship width lane (m)

ϕ = angle of turn, degrees (assumed value = 45º)

V_s= speed of ship in channel (kts) (assumed value : 8 Knots)

L= ship Length = 230 m.

R_t = turning Radius (m) (assumed value 500 m)

C_c = coefficient of vessel manoeuvrability (assumed value 2)

F = 1.0 for one way traffic.

S = unobstructed sight distance from the bridge of the ship.

As per Panama canal study the minimum sight distance required is 2446m. Since in MbPT the vessel will be guided by tugs, this same value is adopted here.

Accordingly $\Delta W = (0.9144 \times 45 \times 8^2 \times 230^2 \times 1)/(500 \times 2 \times 2446)$
$= 56.95$ m (say 60 m)

Hence Channel width required at bend for 55,000 DWT vessel is = (187.2 + 60) = 247.2 m.

5.2.5 Design of Berth Pocket

The dredged depth required in berth pocket is bigger than the rest of the channel as the ship have to lie alongside the berths at all states of tide and advantage of tidal window cannot be taken. For ship of 37,000 DWT & 55,000 DWT, the required depths of pocket alongside of the berth are as under:

Table 5.7 : Depth of Berth Pocket for the two design vessels

Components for Design	**37,000 DWT**	**55,000 DWT**
Static draft of Vessel	10.8 m	12.8 m
Allowance for trim of Vessel	0.3 m	0.3 m
Safety clearance	0.3 m	0.3 m
Allowance for lowest low water	0.3 m	0.3 m
Allowance for siltation	0.3 m	0.3 m
Allowance for sinkages due to density changes	0.1 m	0.1 m
Depth required at berth pocket	12.1 m below CD	14.1 m below CD

The width and length of berth pocket are evaluated and the dimensions of berth pocket to be dredged are given in table below:

Table 5.7 : Width of Berth Pocket for various design vessel

Design Vessel	Beam of Ship	Allowance of 0.5B	Total Width (m)
37,000 DWT	28 m	14 m	42 m
55,000 DWT	36 m	18 m	54 m

Table 5.7 : Length of Berth Pocket for various design vessel

Design Vessel	Length of Ship	Total length of Pocket (1.2 x LOA)
37,000 DWT	210 m	252 m
55,000 DWT	230 m	276 m

Hence existing length & width of 300 m x 60 m is sufficient for 55,000 DWT vessel. Hence plan dimensions of berth pocket do not need modification.

As regards depth, the existing depth of berth pocket is 13 m below CD which is sufficient for 37,000 DWT vessel. For handling fully loaded 55,000 DWT vessels the depth of berth pocket required is 14.1 m. By restricting handling 55,000 DWT ships in monsoon or having better control on other allowances 14 m below CD at Berth pocket can be considered for handling 55,000 DWT vessel. The deepening by additional 1m at berth pocket will have to be carried out either by cutter suction dredger or under controlled blasting to avoid damage to existing pile structures.

5.2.6 Design of Turning Circle

As per IS 4651, the diameter of Turning circle shall be 1.7 to 2 times the length of largest ship. Accordingly diameter of Turning circle is proposed as 460 m (230 m x 2).

5.3 Dredging Volume Estimation

The area where Capital Dredging required for deepening & widening of the approach channel to SCB shown hatched in the figure 5.2 below.

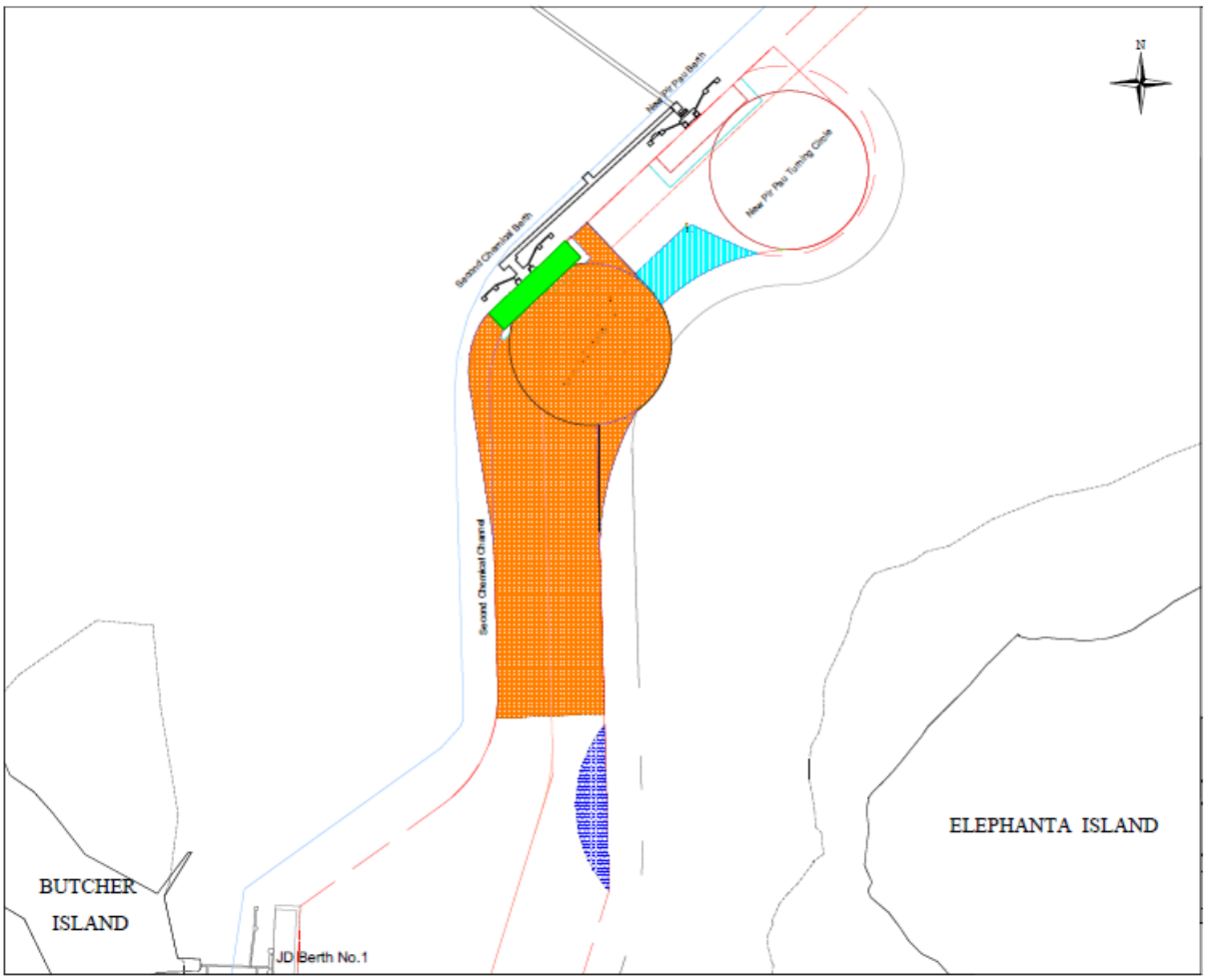


Fig 5.2 Proposed deepening & widening of SCB Channel (shown hatched)

The proposed design layout for deepening & widening of SCB Channel is show in **Annexure**

The volume of capital dredging required both soil and rock for various alternative depths have been computed based on the existing and proposed dredged levels.

5.3.1 Bathymetry Data

The post monsoon bathymetry of channel and berth is shown in Annexure__. The same has been considered for estimation of dredging quantity.

5.3.2 Sub soil Data

The soil Investigation data in the proposed widening portion is not available at present. In 2015 sub-bottom profiler survey of the New Pir Pau channel area was carried out. The seismic survey contour data indicating the hard level is presented in Annexure__. This data has been used for computation of rock volumes. Tenders for carrying out soil investigation have been received. It is proposed to take few bore holes in the channel portions to correlate seismic survey data and confirm the rock dredging volumes.

5.3.3 Estimation of dredging volumes:

The quantity of dredging have been worked out using Hy-Pack software Tin model**.** The channel area & berth pocket area as shown hatched in fig 5.2 has been considered for volume computation**.**

The rock quantity is estimated from the seismic survey data with respect to proposed design depth model. Then the total dredged quantity (i.e. rock + soil) has been estimated from the existing bathymetry survey with respect to proposed design depth model and a tolerance of 0.3 m. Thereafter the soil dredging quantity is worked out from the difference between the two quantities. As stated in Section 5.2.2.1, the quantity of soil & rock dredging have been worked out for two alternatives depths and furnished below:

A) Alternative I

Channel Depth 10m and Berth Pocket depth 14 m (below CD)

Total quantum of dredging = 5,35,000 cu.m.
Total quantum of rock dredging = 1,45,000 cu.m.
Total quantum of Soil Dredging = 5,35,000 - 1,45,000 = 3,90,000 cu.m

B) Alternative II

Channel Depth 10m and Berth Pocket depth 14 m (below CD)

Total quantum of dredging = 7,40,000 cu.M
Total quantum of rock dredging = 2,15,000 cu.M
Total quantum of Soil Dredging = 7,40,000 - 2,15,000 = 5,25,000 cu.m

CHAPTER 6
ENVIRONMENTAL ISSUES

6.1 Environment Clearance Process

The EIA notification 2006 published by Ministry of Environment, Forest and Climate Change (MoEF&CC) states that, construction of new projects or the expansion or modernisation of existing projects entailing capacity addition with change in process or technology, shall be undertaken in any part of India only after the prior environmental clearance is obtained, from the Central Govt. in case of projects falling under Category A or from the State Environment Impact Assessment Authority (SEIAA) in case of Category "B" projects.

This proposed dredging project falls under Category "A" which are appraised by the Expert Appraisal committee (EAC) at MoEF, New Delhi. An online application seeking prior environmental clearance will be required to be made in the prescribed Form 1 along with the proposed Terms of Reference and prefeasibility report.

The EAC determines the detailed Terms of Reference (ToR) addressing all relevant environmental concerns for the preparation of EIA report in respect of the project for which prior environmental clearance is sought.

6.2 Preparation of EIA Report

For this the project proponent has to collect primary baseline date in the project area as well as the area falling within 5 km from the proposed project boundary and secondary data within 15 kms aerial distance from the project boundary, as mentioned at part 9 (III) of Form I of EIA Notification.

Environmental components to be considered in general for projects such as the present proposed project are with respect to - (a) Land (b) Water - ground water, surface water (c) Marine (d) Air and meteorological (e) Noise (f) Biological (g) Socio-economic and occupational health (h) solid waste and (i) public utilities. One Season baseline data (3 months except rainy season) is required for Rapid EIA.

Based on the aforesaid investigations, the magnitude and sensitivity of the direct and the indirect environmental impacts likely to result from the proposed project can be determined. The EIA will include an Environment Management Plan (EMP), suggesting mitigative measures to control the adverse impacts, and also formulate post-project environmental programme.

6.3 Environmental Management Plan (EMP) :

The impact on environment could be either preventive or minimised by incorporating necessary corrective or preventive measures clearly delineated in

the EMP. The EMP & monitoring programmes during and after the completion of the dredging project shall include following:

- Water Quality monitoring & management
- Air and Noise Quality Monitoring
- Dredged Material management plan
- Beneficial use of dredged material
- Assessment of off-shore disposal

6.4 Dredged Material Management Plan

The Dredged Material Management Plan (DMMP) is intended for the environmental acceptability of dredged material management alternatives. Two management alternatives may be considered for dredged material as below:

- Confined disposal (Reclamation)
- Offshore disposal

6.4.1 Reclamation

The subsoil strata in the proposed area of dredging mainly silty clay followed by weathered rock. Owing to the poor Engineering property of the silty clay material, it cannot be used for reclamation.

However the dredged rock material has good engineering value. It can be used for reclamation of the area at Butcher Island or any shore protection works.

6.4.2 Offshore Disposal

The site identified for the disposal of dredged material DS3, is already an existing dumping ground and will not have any adverse effect on the surrounding area. The quantum of dredging involved is small and therefore no separate study is envisaged for dumping of dredged material at DS3 location.

CHAPTER 7
CAPITAL COST ESTIMATE & FINANCIAL ANALYSIS

7.1 Capital Cost Estimates

The quantity of soil and rock dredging has been estimated in the previous Chapter (No. 5). The same have been used for the detailed cost estimates.
In addition to the direct dredging cost, the other additional costs that have been considered in detailed cost estimates are as under:

a) Mobilisation and Demobilsation Cost

The mobilisation and demobilisation costs of equipment have been assumed as 10% of the Total dredging cost.

b) Procurement of Navigational Aids

The procurement of Navigational cost have been kept nominal for marking of Turning circles and at the bend locations over the existing navigational aids.

c) Environmental Management Plan

The cost involved is for activities stated in section 6.3 above.

7.2 Cost Estimate for Alternative I (Channel depth : 10 m)

Sr. No.	Description	Quantity	Rate	Amount Rs (in crores)
1	Soil Dredging	3,90,000 cu.m	Rs.110/cu.m	4.29
2	Rock Dredging	1,45,000 cu.m	Rs 4000/cu.m	58.00
3	Mob + Demobilisation (10 % of dredging cost)	LS		6.23
4.	Procurement of Navigational Aids	LS		0.50
5.	EIA Study and EMP	LS		0.50
			Total (Sr No.1 to 5) :	69.52
			Add 3 % contingencies :	2.09
			Grand Total :	71.61

Say Rs 72 crores

7.3 Cost Estimate for Alternative II

Sr. No.	Description	Quantity	Rate	Amount Rs (in crores)
1	Soil Dredging	5,25,000 cu.m	Rs.110/cu.m	5.78
2	Rock Dredging	2,15,000 cu.m	Rs 4000/cu.m	86.00
3	Mob + Demobilisation (10 % of dredging cost)	LS		9.18
4.	Procurement of Navigational Aids	LS		0.50
5.	EIA Study and EMP	LS		0.50
			Total (Sr No.1 to 5) :	101.96
			Add 3 % contingencies :	3.06
			Grand Total :	105.02

Say Rs. 105 crores

7.4 Cost Estimate for Maintenance Dredging

Presently the rate of siltation at Approach channels leading to Pir Pau berths FCB and SCB is around 25,000 cu.m and it is dredged once every two years. Due to deepening of SCB berth and Channel there will be increased in siltation. Assuming siltation of 1% of total dredging quantity the Maintenance dredging cost for two alternatives are as under:

Description	Quantity	Rate(Rs/cu.m)	Amount Rs (in lakhs)
Alternative I	55,000 cu.m	110	60.50
Alternative II	75,000 cu.m	110	82.50

CHAPTER 8
FINANCIAL ANALYSIS

8.1 Projected Traffic

The projected incremental traffic is calculated for financial analysis purpose.
Traffic at SCB comprises Chemical & POL products.
It is observed that in 2016-17 with berth occupancy of 65.43 % -

- the traffic handled at SCB was 1.46 MMT out of which Chemical traffic was 0.56 MMT.
- total 203 ships were handled at SCB with average size of vessel being 25,713 GRT.

By extrapolation, for a berth occupancy of 70%, the SCB berth can handle 220 vessels of average GRT of 25,713 (say 26,000 GRT).
During preparation of feasibility report in 2006, the average GRT of vessel was assumed as 32,000 GRT.
Considering the deepening and widening proposed in the previous chapters, 10% increase in no of vessels can be expected. Accordingly increment in no of vessels works out to 22. Further with the improved depths we can consider increase in the average GRT of the Vessel. For analysis incremental increase of 3000 GRT is considered.
Accordingly total increment in average GRT in a year is as under

22 Nos x 29,000 GRT = 6,38,000 GRT
220 Nos x 3000 GRT = 6,60,000 GRT
Total GRT = 12,98,000 GRT

Accordingly total increment in cargo traffic calculated as under:
12,98,000 x 0.277 = 3,59,546 T [14,60,000 / (203 x 26000) = 0.277]
Say 0.36 MMTPA (increment)

8.2 Assessment of Revenue generation

The revenue will be generated for traffic handled as per the tariff fixed by the TAMP. For the purpose of revenue assessment, the tariff has been taken from Dock scale of Rates 2016 for following:

I. Port dues
II. Composite Pilotage-cum-Towage Charge
III. Pier Dues
IV. Wharfage Charges

The revenue for incremental traffic only has been worked out as under:

I. Port dues.

As per DSR dated 27.6.2016 Clause 2.16

Port dues for one year = 12,98,000 GRT x 0.2856 $

= 12,98,000 x 0.2856 x 65 (Assume 1$= Rs 65)

= Rs 2,40,96,072

II. Composite Pilotage-cum-Towage Charge.

(Ref : DSR dated 27.6.2016 Clause 2.1)

Pilotage-cum-Towage Charge for one year = 12,98,000 GRT x 0.8455 $

= 12,98,000 x 0.8455 x 65

= Rs 7,13,34,835

III. Pier Dues.

As per DSR dated 27.6.2016 Clause 2.20

Pier Dues at Pir Pau for one year = 12,98,000 GRT x 0.0183 $ per hour

Average time spent at berth in 2016-17 is 0.97 days. Assuming reduction in time by 10%, the berthing time can be assumed as 0.87 days

Hence Pier Dues for one year = 12,98,000 x 0.0183 x 65 x 0.87 x 24

= Rs 3,22,38,114.50

IV. Wharfage Charges.

(Ref : DSR dated 27.6.2016 Clause 3.10)

At per present traffic at SCB,

Chemical = 0.56 MMT

POL Products = 0.90 MMT

Hence percentage of Chemical Traffic= 38.36 %

Percentage of POL Products= 61.64 %

As Oil companies have requested for laying additional pipeline from SCB, it can be assumed that there will be increase in POL products in comparison to chemical traffic.

Therefore it is assumed that incremental traffic would comprise :

30% chemicals and 70% POL products.

Accordingly Average Wharfage rate = 0.30 x 62.34 + 0.7 x 76.44

= Rs 72.21 per Tonne

Hence Wharfage for one year = 3,60,000 x 72.21 = Rs 2,59,95,600

Hence incremental revenue at SCB

= 2,40,96,072 + Rs 7,13,34,835 + Rs 3,22,38,114.50 + Rs 2,59,95,600

= Rs.15,36,64,621.50

Say 1500 lakhs.

In case of deepening the approach channel to 10.5 m further increment in traffic may not be achieved. Further when any loaded deep drafted vessel approaches Pir Pau berths in rising tides, she has to move across the JD channel first and by the time it reaches the approach channel to Pir Pau, due to time lag it gets advantage of increased tide while entering the approach channel to Pir Pau. So there will not be much advantage of deepening the channel to 10.5 m below CD.

However assuming further increment of maximum 10%, the total incremental revenue due to deepening of channel to 10.5 m below CD will be Rs 1650 lakhs per year.

8.3 Financial Results

The Project IRR has been worked out for two cost alternatives as proposed in Chapter 7**.** Other than the maintenance dredging cost, there will be additional expenditure due to deployment of Tugs, manpower etc. On these account an outgo of Rs 100 lakhs has been considered in the financial analysis**.** The project IRR has been worked out for three different cases. The details are shown in Annexure___. The summary of Project IRR for different cases are tabulated below:

Table 8.1 Financial Internal Rate of Return for Two alternatives.

Case.	**IRR for Alternative – I**	**IRR for Alternative – II**
Case 1 : Basic	**16.96%**	**12.75%**
Case 2 : Cost more than 10%	**15.45%**	**11.74%**
Case 3 : Traffic less by 10%	**15.09%**	**11.24%**
Case 4 : Cost more than 10% & traffic less by 10%.	**13.72%**	**10.32%**

Conclusion:

The following are the conclusions of the study**:**

- Considering the factor that Maharashtra & Gujarat account for the major share of all India demand of liquid chemicals and products, the traffic assessed at Mumbai Port holds good.
- Users have shown preference for further developments in Pir Pau areas. Improvement of Infrastructural facility at Pir Pau are required to cope with exim growth in Chemical/product sector**.**
- The expected increment in vessel traffic at SCB is more than 10%.
- The project IRR in base case of Alternative I works out to 16.96 % and project IRR in base case of Alternative II works out to 12.75%. In worst case scenario i.e. project cost increases by 10% & projected increment in traffic decreases by 10%, the project IRR for Alternative I works out to 13.72% and for Alternative II it works out to 10.32%. **Hence Alternative I is most suitable.**
- The project is only part of the entire Mumbai Port Channel, therefore execution of this portion channel only through PPP model is not useful.
- The work is proposed to be executed through internal resources of Mumbai Port.

The Project Implementation is presented in the next Chapter.

CHAPTER 9
PROJECT IMPLEMENTATION

The project implementation schedule has been drawn up by considering Administrative & Statutory approvals required before commencement of work and the deployment of suitable types and capacities of dredgers thereafter with optimum deployment to complete the work in the shortest possible time within the one fair season.

9.1 Administrative & Statutory Approval

As per the enhanced delegation of power, the approval of Cost estimate is within the competence of the Board. The environmental clearance and CRZ clearance is required for the project from MoEF&CC.

9.2 Selection of Dredging Equipment

The most suitable types of dredgers to complete the dredging work of this nature in shortest possible time is Trailing Suction Hopper Dredger (TSHD) and Cutter Section Dredger (CSD). From the available bore hole data at berth pocket it can be seen that nature of strata is weathered rock which can be dredged with powerful cutter suction dredger. If the rock is sound/hard, it may not be economical to dredge with CSD. The most effective and productive process comprises the drilling and blasting technique. The blasting technique shall normally be avoided at berth pocket due to presence of existing berthing structure. However in case dredging in berth pocket requires blasting, very controlled blasting need to be carried out at this location. However the contractor shall be free to select their equipment and working method, as long as the safety, quality and project schedule is maintained.

9.3 Time required for dredging activity

The total quantum of soil dredging involved is 3.9 lakh cu.m. and rock dredging involved is 1.45 lakh cu.m. The critical activity is rock dredging and delay may occur for the permission required for blasting from various authorities. However it should be possible to complete the entire dredging activity in one fair season i.e from October to April.

Based on the above, the schedule implementation programme in the form of a Bar Chart is enclosed as Annexure.