Infrastructure Advisory

CRISIL
An S&P Global Company

West Bengal Industrial Development Corporation Limited (WBIDC)

Consultancy services for selection of a private partner and independent engineer for deep sea port at Purba Medinipore, West Bengal

Feasibility Report

Volume 2: Site Selection & Technical Assessment

July 2016

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1. Introduction

1.1 Background of the project

Infrastructure development is a key driver for growth of the Indian economy. Ports play an important role in the development of the nation's trade, contributing about 95% of the country's trade by volume. Development of ports and transportation through waterways has increasingly gained importance considering that the Government of India is committed to bring down the high logistics cost, which currently hovers around 13-14% of GDP, compared to 7-8% of GDP in developed countries.

In spite of a global slowdown, traffic at ports in India has grown at an impressive ~7% CAGR from FY'06 to FY'15. Increase in port traffic is an indication of a booming trade, providing plenty of opportunity to the maritime sector. To leverage India's vast coastline spanning 7,500 km and navigable inland waterways extending 14,000 km, the Government of India wants to double the capacity of ports from 1,400 million tonnes to 3,000 million tonnes by 2025. Pitching for making the country's long coastline an "engine of growth", the Prime Minister of India announced ambitious plans of mobilizing Rs. 1 lakh crore investment in this sector. This is likely to have a multiplier effect on India's economic growth, which has already become the fastest growing economy in the world ahead of China and is likely to continue its position in FY'17 as per IMF estimates.

In line with the vision of the Central Government to boost infrastructure sector in India, the Government of West Bengal has also embarked on various infrastructure projects to propel industrial development in the region. The State is endowed with a mineral rich hinterland, vast stretches of agricultural land and a strategic location as a gateway to Eastern India. Being a power surplus state, the State Government wants to leverage its strategic location and rapidly scale up its connectivity to promote investment in the state. The deep sea port at Rosulpur is one such landmark project aimed at promoting marine connectivity to the state.

Another rationale for the development of the Rosulpur Port at various alternative sites, as formulated by WBIDC, is to revive the pre-eminence of West Bengal as the preferred port of access to the North Indian hinterland, (which has since been overtaken by the Gujarat Ports and JNPT). The proposed port need to cater to the deeper draught vessels that came in to being in World Shipping (post the Suez closure of 1966), which cannot enter the Hugli River owing to draft limitations. It may be recalled that even at the time of Independence of the country, the North Indian hinterland was served by the Ports of Karachi and Kolkata and not by the Port of Mumbai or the Gujarat Ports. It was the loss of the Karachi Port and the deterioration of the Hugli River due to shifting of the head of the Hugli away from the Ganga, which resulted in the North Indian hinterland being captured by Mumbai initially and later by other Gujarat Ports. It is well known that cruise vessels carried passengers and cargo from Kolkata to Allahabad as late as in the early twentieth century, and it is logical that West Bengal should desire to recapture some of the North Indian hinterland.

It is expected that the proposed port would have enough draft to handle vessels, which cannot enter Haldia due to the present draft restriction across the Auckland Bar and the Jellingham Channel which has recently become a shallow bar.

The proposed port at Rosulpur has been proposed to be developed on reclaimed land and as such no major land acquisition would be required. Further, the port has been proposed to be developed through Public Private Partnership (PPP) route and the Private Partner has to be selected through an International Competitive Bidding process.

With this in view, WBIDC circulated an RFP for appointment of the Transaction Advisors to advice on the process and selection of a PPP Partner and Independent Engineer for the Deep Sea Port at Rosulpur.

CRISIL Risk and Infrastructure Solutions Limited (CRIS) have been awarded the Transaction Advisory role and in turn have appointed Zebec Maine Consultants and Services Pvt. Ltd. (ZEBEC) to carry out a technical feasibility study for developing the deep water port.

1.2 Objective of the Feasibility Report:

The objectives of the feasibility report are as follows:

- Conduct techno-economic feasibility study for development of a greenfield port at Rosulpur
- Identify alternate sites in the district and compare the pros and cons of the different sites
- Based on the identified technical and financial parameters, suggest and recommend the best site for construction of the port along with design parameters

1.3 Contents of the feasibility report

The commodity analysis and estimated traffic potential at Rosulpur port have been provided in Volume 1 of the Feasibility Report. This report is the Volume 2 of the Feasibility Report consisting of the site assessment and technical viability and design of the port. The scope of work covered in this volume is as follows:

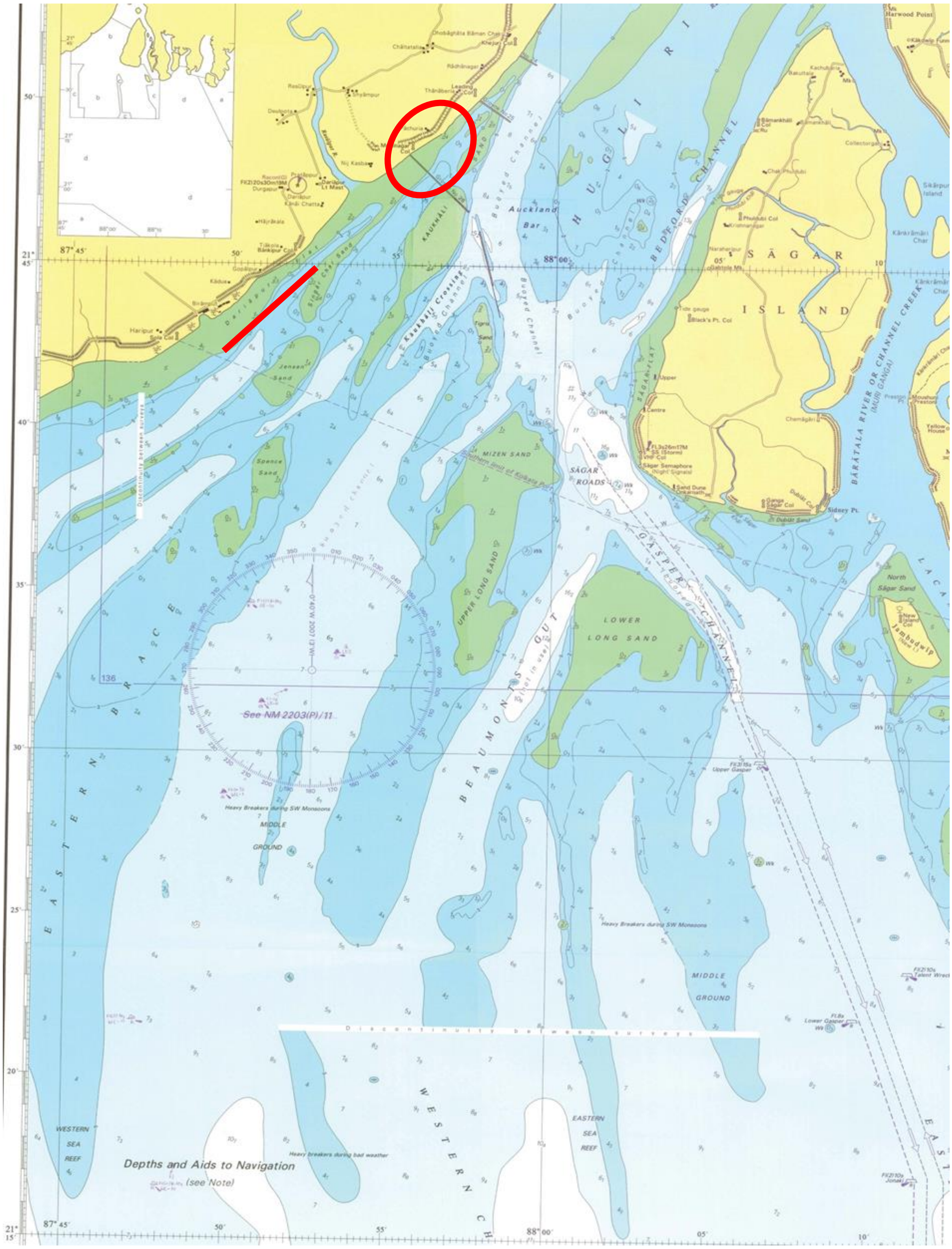
- Examining the site for development of a deep sea water port by considering oceanographic conditions and hinterland road and rail linkages
- Assessing the climatic conditions at the proposed site such as rainfall, temperature, relative humidity and visibility
- Analysis of road and rail connectivity to the port
- Sea side infrastructure planning such as berths, channel, breakwater including indicative/outline drawing preparations
- Equipment and storage area planning
- Estimation of the capital and operating costs for undertaking the financial viability assessment
- Comparative assessment of different sites and recommendation of the preferred location for port development

2. Site Conditions

2.1 Overview of the Site

The project site at Rosulpur which was initially assessed is located in Purba Medinipur District, 35km from Haldia.

Figure 2.1: Rosulpur Port Location – Approaches to Hugli River Chart (Extract from IN 123)



At first glance it appears that there is ample space for developing the port, in the inter-tidal zone to the south of the Rosulpur outfall, to accommodate all the facilities required to handle an estimated 50 million tonnes per annum of bulk and containerized cargo, without acquiring village lands. However, the relatively deep water of 10m is 65 km away from the Rosulpur Outfall in to the Hugli, though there are shallows further downstream. Considering that there may be a need to reclaim land say 2 km wide for the port activities, the deepening of the approaches to the port would provide the necessary fill material. However, the projection of the reclamation into the Hugli, adjacent to the present approach channel to the Haldia Dock Complex could be a deterrent factor in developing the port in this area.

Figure 2.2: Foreshore south of Rosulpur River

The geographical location of the Rosulpur River outfall in to the Hugli (Lat 21°47'44"N Long 87°54'02"E) may be seen from the Naval Hydrographic Chart IN 123 (reproduced here as Fig. 2.1), which incidentally describes this area as the Dariapur Mud Flat.

To the north of the Rosulpur outfall, as seen from Fig. 2.2, the foreshore is sandy, called the Kaukhali Sands. The construction of Groynes 25 and 26 appear to have accelerated deposition of sand in this area making reclamation for construction of port facilities easier, as shown in Google Image Figure 2.3 below. Access to the existing Buoyed Channel (which leads to the Jellingham Channel and Haldia Dock complex) is easier at the area north of the Rosulpur River outfall.

Figure 2.3: Area north of Rosulpur River reclaimed by sand due to Groynes 25 &26

While there is ample room here for locating the greenfield port, the immediate hinterland is heavily wooded and occupied by habitation. Connectivity for this site shall be discussed in another chapter.

As we go further south of the Rosulpur outfall, the open beach at Mandarmoni is seen in Figure 2.4. It may be seen that the beach between Mandarmoni and Silampur is occupied by holiday resorts with surrounding greenery. The beach widens as one approaches Silampur, where there is sparse habitation. The fields and low lying areas behind the beach make it easy to access the road to Contai.

Figure 2.4: Google Image showing Mandarmoni Beach &Contai

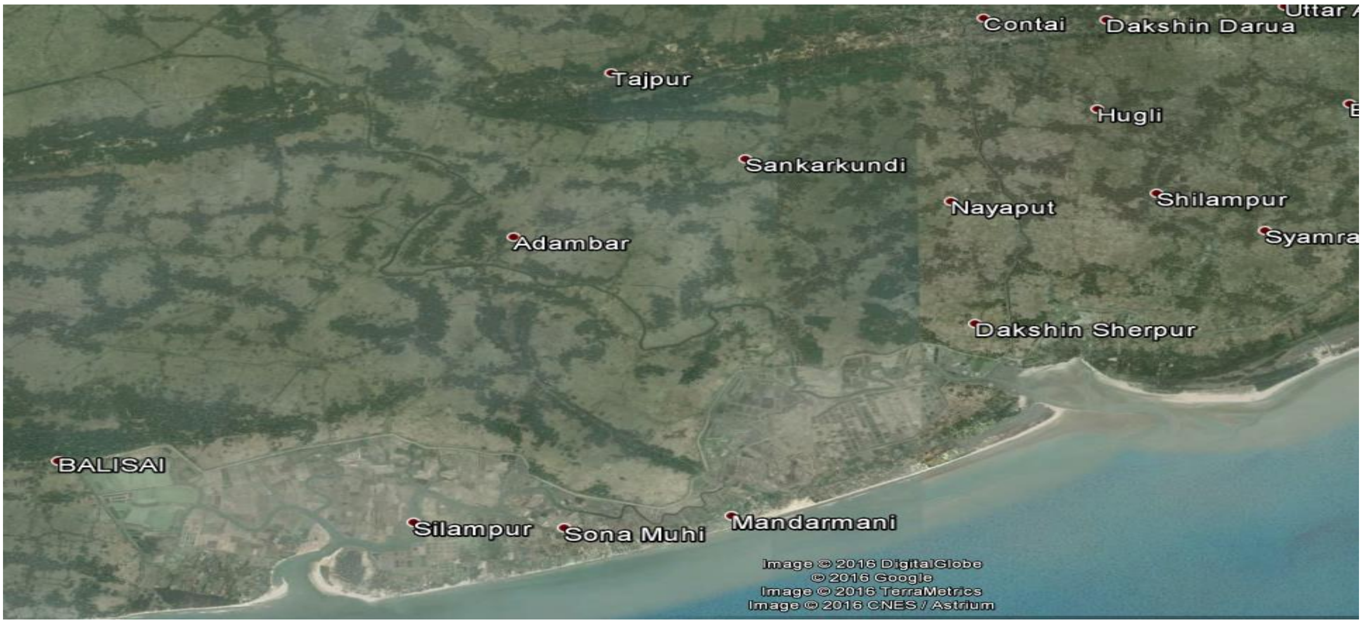


Figure 2.5: Google Image showing Mandarmoni Beach

As would be seen from the overview of the shoreline, from Google Images and available navigation charts, there are several constraints in locating the deep draught sea port, along and south of Rosulpur River. It was therefore decided to undertake a detailed site reconnaissance, the findings of which are given in chapter 3.

The climatic conditions and conditions pertaining to wind, wave, tidal variations and cyclones in the region have been analyzed from a port development perspective and the same have been described in the following section.

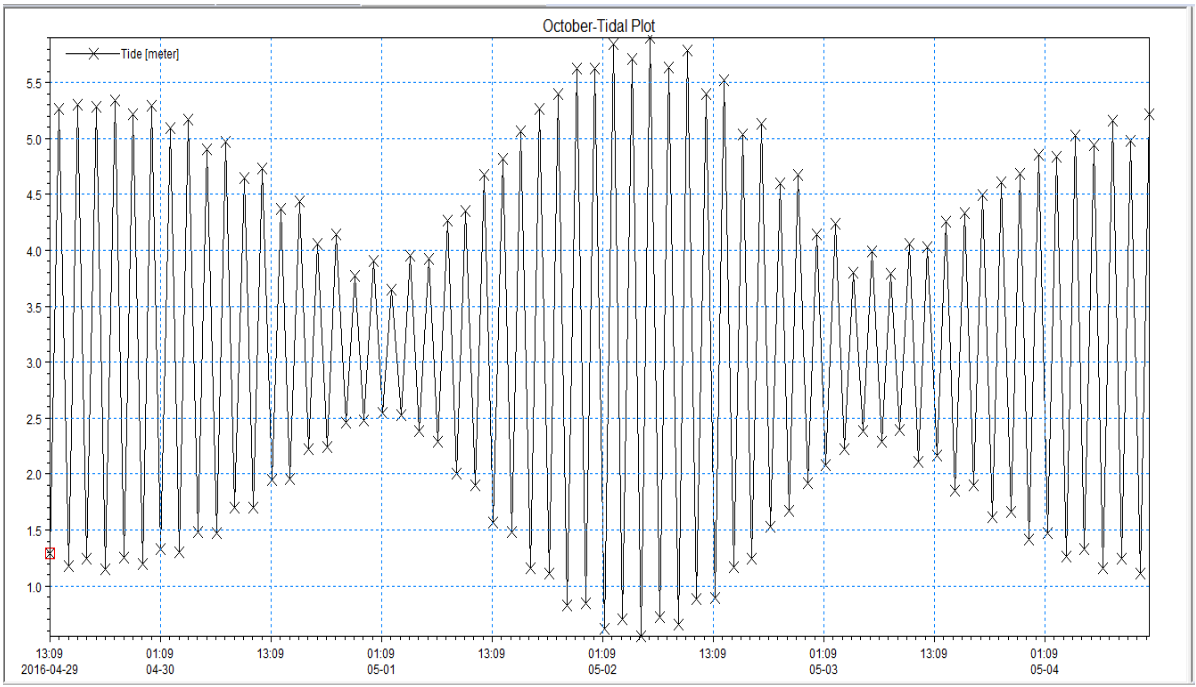
2.2 Tidal Heights

The tidal level referred to Chart Datum for Sagar Island (Lat 21o 39'N and Long 88o03'E) obtained from Approaches to Hugli River (Chart No 123) is as shown below.

Tidal Levels in m CD	Sagar Island
MHWS (Mean High Water Spring)	5.20
MHWN (Mean High Water Neap)	3.90
Mean Sea Level (MSL)	3.00
MLWN (Mean Low Water Neap)	2.20
MLWS (Mean Low Water Spring)	0.90
LAT (Lowest Astronomical Tide) CD	0.00

The tidal plot for a typical month is shown below derived from the Sagar Tide Tables. It may be seen that the tide is semi-diurnal, with little or no diurnal component. There is a strong variation of the tidal range from 1.5 m in neaps to 6 m in springs. Figure 2.6 shows tidal variation during the month of October 2015 relative to Chart Datum

Figure 2.6: Tidal Variation during the month of October 2015 relative to Chart Datum



2.3 Tidal Currents

The Currents in the estuary vary from 1.5 to 2 knots (0.77m/s to1.02m/s) on neaps to 3 to 3.5 knots (1.54m/s to 1.80m/s) on springs.

(Source – Bay of Bengal Pilot)

2.4 Climate:

In absence of data regarding the climatic conditions at the Rosulpur region, the climate data for Sagar Island obtained from Bay of Bengal Pilot has been considered as reference.

2.4.1 Temperature

The temperature over Sagar Island are shown in the table below (Source: Bay of Bengal Pilot)

Temperature (ºC)				
Month	**Mean Daily Max**	**Mean Daily min**	**Mean highest in each month**	**Mean highest in each month**
January	25	16	28	12
February	27	19	30	13
March	30	24	34	18
April	31	26	34	21
May	32	27	33	22
June	32	27	34	24
July	30	27	32	24
August	30	27	32	24
September	30	27	32	24
October	30	25	32	22
November	28	20	30	17
December	25	16	28	13

2.4.2 Rainfall

The annual rainfall in the area is approximately 2000mm.The monthly rainfall data obtained from Bay of Bengal Pilot is listed below:

	Rainfall (mm)	
Month	**Average Fall (mm)**	**No. Of Days 2-5 mm or more**
January	14	1
February	22	2
March	21	2
April	42	3
May	128	6
June	250	12
July	409	17
August	410	17
September	329	14
October	240	9
November	33	2
December	8	1

2.4.3 Humidity

The month-wise average humidity of Sagar Island is listed below.

	Average Humidity	
Month	**0800hrs (%)**	**1700hrs (%)**
January	79	63
February	78	66

Month	Average Humidity	
	0800hrs	1700hrs
	(%)	(%)
March	75	73
April	77	78
May	79	79
June	83	83
July	86	83
August	86	83
September	84	82
October	32	77
November	30	68
December	28	64

2.5 Wind

The climate of Rosulpur is governed by monsoon winds which reverse direction in different seasons. Southeastern regions are also influenced by the interaction of sea and hills with respect to wind direction. Wind speed and direction is not only important for port design but also for ascertaining the local wave conditions. Wind direction and wind speed for Sagar Island obtained from Bay of Bengal Pilot are shown below:

Month	Wind Direction																		Mean Wind Speed(Knots)	
	0,800 Hrs									1700 Hrs										
	N	NE	E	SE	S	SW	W	NW	Calm	N	NE	E	SE	S	SW	W	NW	Calm	0,800	1700
Jan	39	34	4	2	2	5	2	9	3	29	12	1	5	25	18	3	6	1	6	5
Feb	24	19	5	2	9	18	7	12	4	12	7	1	8	43	23	2	3	1	7	8
Mar	11	7	2	2	17	43	9	7	2	3	2	0	10	57	26	1	1	0	9	11
Apr	2	2	1	2	30	55	6	2	0	1	1	0	8	59	29	1	1	0	13	15
May	1	2	3	6	36	48	2	1	1	1	1	1	15	56	25	1	0	0	14	16
Jun	2	4	5	9	30	40	7	2	1	1	1	2	18	45	29	3	1	0	11	13
Jul	3	6	7	9	20	42	9	4	0	1	1	3	16	36	36	6	1	0	13	13
Aug	5	7	7	10	19	37	9	4	2	1	1	3	17	37	37	4	2	2	11	11
Sep	7	11	9	13	21	24	7	5	3	4	3	5	19	27	27	4	2	2	8	8
Oct	25	25	7	5	18	11	6	11	2	18	14	7	10	17	17	4	7	7	7	5
Nov	44	31	5	1	0	2	2	15	0	38	18	2	1	8	8	5	11	5	6	5
Dec	49	31	2	1	1	2	1	12	1	40	15	1	2	12	12	5	8	2	4	5

2.6 Wave Climate

The set of wave data from Daily Weather Reports published by the India Meteorological Department (IMD) and analyzed in a publication by the National Institute of Oceanography, Goa, for the period 1966 – 1984 was used for preparing wave rose diagrams Figure 2.8 and Figure 2.9 obtained from Grid No1 of the NIO Wave Atlas. The all-India data are divided in to various quadrants as shown below in Figure 2.7.

This data enables the design of the harbor for limiting operations for say 2 or 3% of the time when storms are raging. Survival design of protective structures is to be undertaken from cyclonic data mentioned further on in this chapter.

It may be seen from Figure 2.8 that waves from bearing 150 degree (South East) are dominant, the second most frequent direction being from bearing 60 degree (North East). For planning the harbor layout, it would be seen that it is adequate to consider a significant height of 2.5 to 3 m for harbor operations.

From Figure 2.9, it may be seen that the harbor design wave period which is dominant is 10 seconds which is recommended for operational design.

Figure 2.7: Wave Atlas Grid Quadrants- Grid No. 1 considered

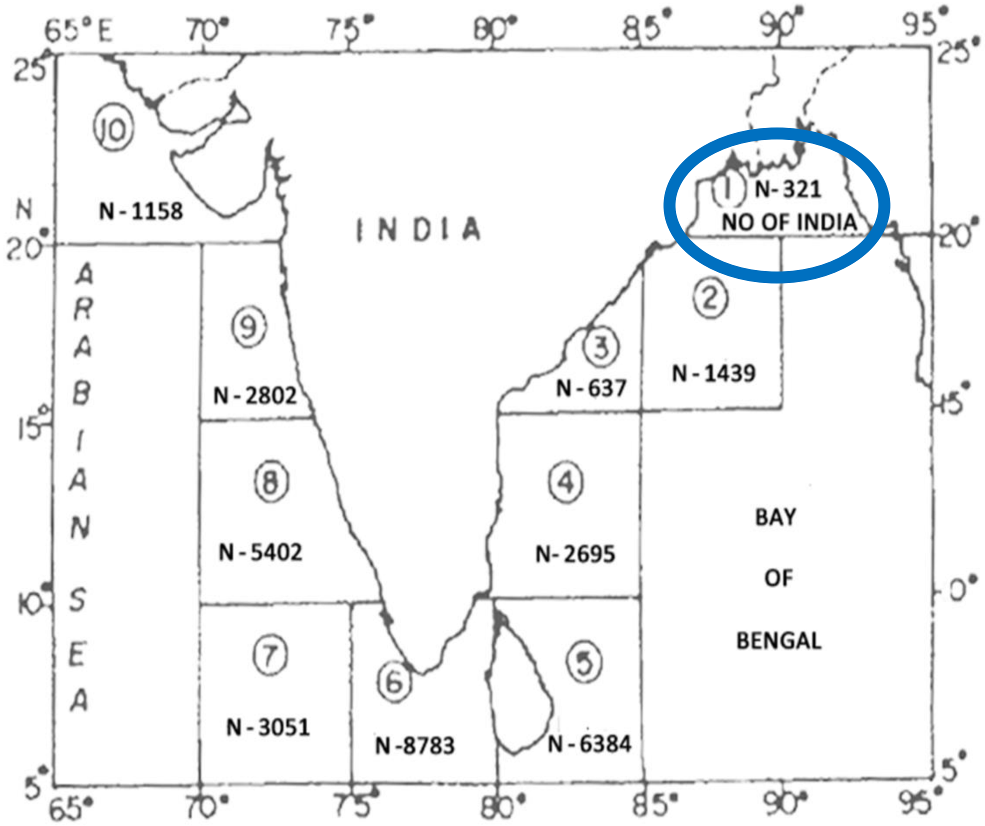


Figure 2.8: Wave Rose Diagram – Wave Height (Source – NIO Wave Atlas Quadrant 1)

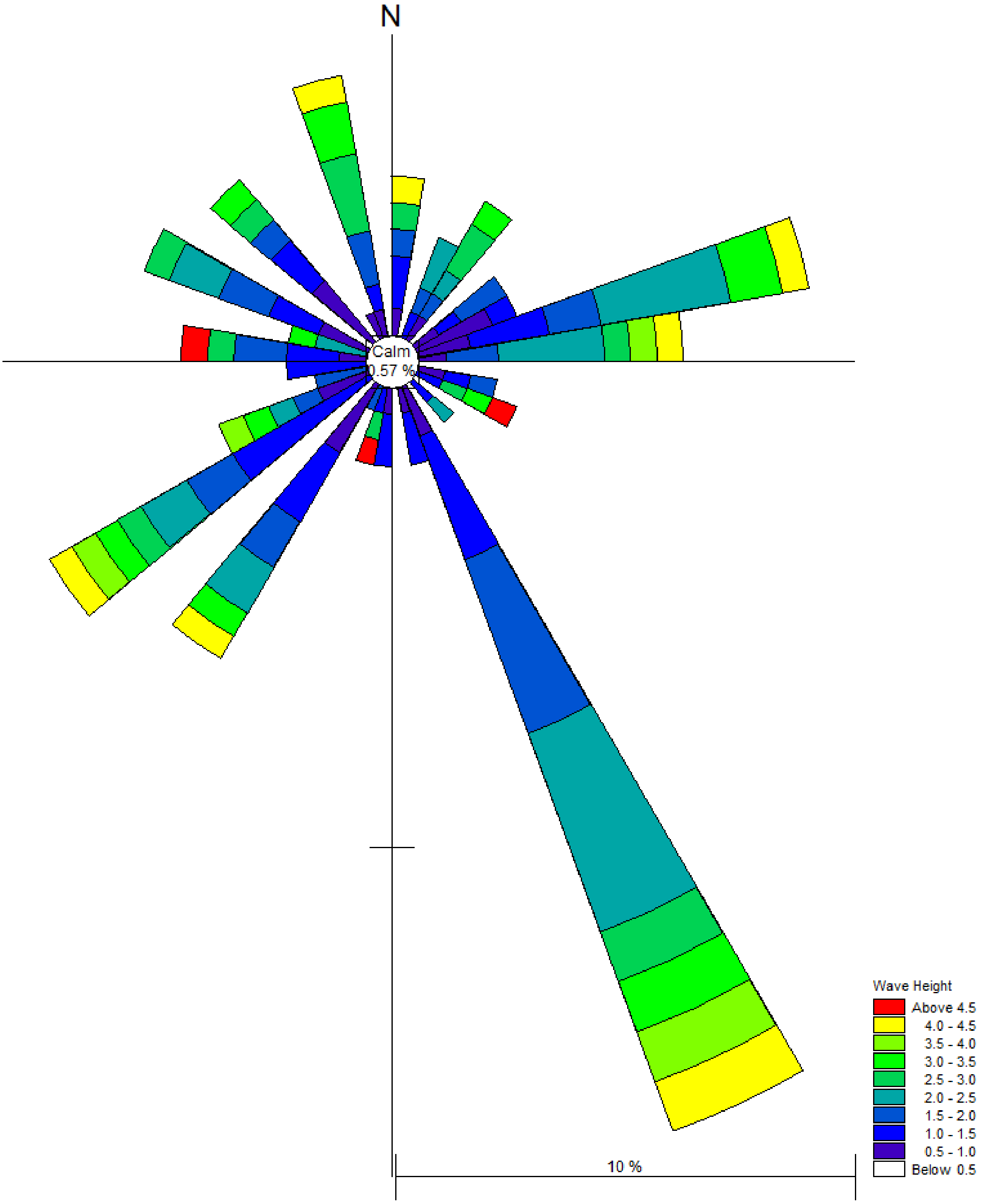
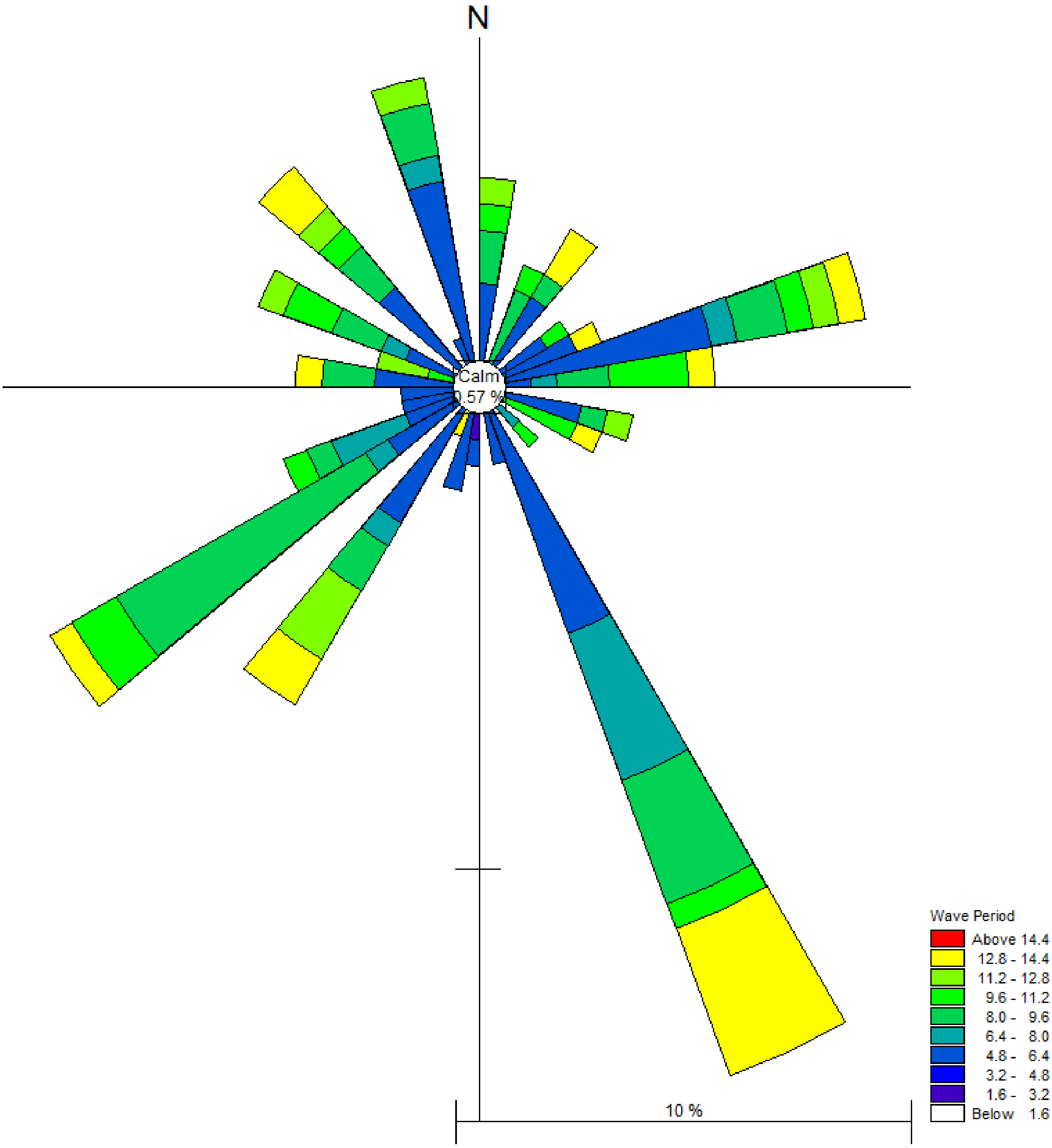


Figure 2.9: Wave Rose Diagram – Wave Period (Source – NIO Wave Atlas Quadrant 1)



The dominant wave period is seen to be10 seconds which is recommended for operational design.

2.7 Cyclones

2.7.1 Frequency

Cyclones are atmospheric system characterized by the rapid inward circulation of air masses about a low-pressure center, usually accompanied by stormy, often destructive weather.

Cyclones circulate counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere.

The size of a cyclone over Indian seas typically varies from 50 km radius to 2,000 km with an average of 300 -600 km.

On an average, about 5 to 6 tropical cyclones occur in the North Indian Ocean prominently during the pre-monsoon season (March-April-May) and the post-monsoon season (October-November-December). Nearly 7% of the global tropical cyclones form in the North Indian Ocean.

Tropical cyclones more often strike the Odisha-West Bengal coast in October, the coast of Andhra Pradesh in November and the coast of Tamil Nadu in December.

Almost over 60% of the cyclones in the Bay of Bengal make landfall at different parts of the East coast of India, whilst 30% strike the coasts of Bangladesh and Myanmar and about 10% finally lose their ferocity and dissipate over the sea.

The dangers associated with cyclonic storms are generally three fold:

- Storm surge
- Strong wind
- Very heavy rains causing floods

The coastal areas of West Bengal are one of the most vulnerable in the Bay of Bengal that experience very high cyclonic attack. Extreme wave conditions in the region are caused by cyclones travelling westwards across the Bay of Bengal. The path of cyclones is generally from East to West in the proposed location of the port.

The India Meteorological Department has been maintaining climatic data from 1893. The Cyclone Atlas provides a list of disturbances in the Bay of Bengal. A list of selected major historic Depression, Cyclonic Storms and Severe Cyclonic Storm in the proposed area is reproduced below (Source: RMC Chennai – Cyclone E Atlas).

S.No.	Initial Date	Month	Year	Max Intensity	Beginning Position	
					Lat(ºN)	Long(ºE)
1	1	8	1915	Cyclonic Storm	18.88	88.54
2	4	6	1916	Cyclonic Storm	18.52	90.87
3	14	6	1917	Cyclonic Storm	19.07	67.68
4	24	5	1918	Cyclonic Storm	19.84	90.35
5	3	8	1924	Cyclonic Storm	20.58	91.04
6	26	6	1925	Cyclonic Storm	19.53	88.52
7	5	7	1926	Cyclonic Storm	21.52	90.97
8	13	8	1926	Cyclonic Storm	24.28	87.68
9	16	9	1926	Cyclonic Storm	19.94	69.95
10	1	9	1926	Cyclonic Storm	25.26	76.32
11	27	7	1927	Cyclonic Storm	19.45	89.13
12	5	6	1928	Cyclonic Storm	18	89.04
13	17	7	1928	Cyclonic Storm	18.53	92.74
14	23	7	1928	Cyclonic Storm	18.5	88.26

S.No.	Initial Date	Month	Year	Max Intensity	Beginning Position	
					Lat(ºN)	Long(ºE)
15	15	7	1929	Cyclonic Storm	20.48	89.94
16	23	8	1929	Cyclonic Storm	19.23	88.45
17	12	5	1930	Cyclonic Storm	18.05	88.42
18	27	6	1930	Cyclonic Storm	20.01	63.3
19	28	6	1930	Cyclonic Storm	18.81	89.46
20	15	7	1930	Cyclonic Storm	19.96	91.66
21	19	8	1931	Cyclonic Storm	20.39	89.68
22	18	9	1932	Cyclonic Storm	18.55	89.4
23	2	8	1933	Cyclonic Storm	19.07	90.55
24	17	9	1934	Cyclonic Storm	19.76	89.47
25	28	1	1935	Cyclonic Storm	22.53	61.86
26	8	7	1935	Severe Cyclonic Storm	20.09	89.92
27	11	6	1936	Cyclonic Storm	18.9	89.26
28	28	6	1936	Cyclonic Storm	22.21	77.67
29	20	6	1937	Cyclonic Storm	20.84	89.1
30	22	7	1937	Cyclonic Storm	18.98	88.94
31	23	6	1939	Cyclonic Storm	22.19	87.76
32	29	7	1939	Cyclonic Storm	24.53	90.46
33	28	8	1939	Cyclonic Storm	18.39	91.8
34	30	6	1940	Severe Cyclonic Storm	20.51	88.8
35	8	7	1940	Severe Cyclonic Storm	21.05	89.51
36	2	8	1940	Cyclonic Storm	21.24	89.46
37	4	6	1941	Cyclonic Storm	20	87.67
38	6	7	1941	Severe Cyclonic Storm	21.41	88.1
39	15	8	1941	Cyclonic Storm	18.91	92.17
40	8	8	1941	Cyclonic Storm	19.67	89.13
41	8	7	1942	Cyclonic Storm	20.38	90.28
42	24	7	1943	Cyclonic Storm	19.35	90.25
43	10	7	1943	Cyclonic Storm	19.88	88.52
44	22	9	1943	Cyclonic Storm	18.51	89.26
45	23	7	1944	Cyclonic Storm	21.21	90.62
46	28	7	1944	Severe Cyclonic Storm	19.96	89.59
47	14	8	1944	Cyclonic Storm	23.55	84.5
48	18	8	1944	Cyclonic Storm	18.88	89.64
49	15	10	1945	Cyclonic Storm	6.89	91.77
50	24	6	1947	Cyclonic Storm	18.47	90.14
51	10	7	1947	Cyclonic Storm	18.98	90.46
52	9	6	1950	Cyclonic Storm	18.76	90.85
53	12	9	1950	Cyclonic Storm	20.74	89.86
54	4	7	1952	Cyclonic Storm	20.18	88.19
55	2	9	1955	Cyclonic Storm	21.18	90.1
56	29	5	1956	Severe Cyclonic Storm	21.5	89.86
57	19	8	1957	Cyclonic Storm	19.42	90.95
58	18	11	1958	Cyclonic Storm	7.27	92.43
59	25	6	1959	Cyclonic Storm	18.29	71.29

S.No.	Initial Date	Month	Year	Max Intensity	Beginning Position	
					Lat(ºN)	Long(ºE)
60	10	7	1959	Cyclonic Storm	21.01	90.01
61	11	10	1959	Severe Cyclonic Storm	19.38	71.44
62	27	5	1960	Cyclonic Storm	19.73	88.33
63	21	6	1961	Severe Cyclonic Storm	18.79	71.59
64	11	9	1961	Cyclonic Storm	18.65	92.94
65	19	9	1962	Cyclonic Storm	20.2	95.24
66	26	10	1963	Severe Cyclonic Storm	18.4	84.05
67	7	8	1964	Cyclonic Storm	18.85	71.02
68	8	10	1967	Severe Cyclonic Storm	18.49	89.07
69	10	9	1968	Cyclonic Storm	18.78	91.18
70	13	8	1969	Cyclonic Storm	21	89.39
71	9	10	1969	Cyclonic Storm	18.03	86.6
72	7	6	1970	Cyclonic Storm	21.7	89.4
73	2	9	1970	Cyclonic Storm	22.41	86.81
74	4	6	1971	Severe Cyclonic Storm	19.17	87.94
75	27	10	1971	Severe Cyclonic Storm	10.25	19.72
76	13	7	1972	Cyclonic Storm	19.97	91.64
77	15	11	1973	Severe Cyclonic Storm	12.44	89.93
78	29	5	1974	Cyclonic Storm	21.51	89.68
79	13	8	1974	Severe Cyclonic Storm	22.01	90.32
80	27	8	1976	Cyclonic Storm	20.68	82.76
81	6	8	1979	Severe Cyclonic Storm	20.94	90.32
82	7	8	1981	Cyclonic Storm	18.81	88.15
83	2	10	1983	Cyclonic Storm	19.94	86.89
84	14	10	1983	Severe Cyclonic Storm	18.72	91.52
85	13	10	1984	Severe Cyclonic Storm	19.02	90.03
86	15	12	1990	Severe Cyclonic Storm	6.81	88.06
87	15	5	1997	Cyclonic Storm	5.76	90.60
88	19	11	1998	Severe Cyclonic Storm	11.85	92.54
89	16	5	2004	Severe Cyclonic Storm	17.14	91.45
90	21	9	2006	Severe Cyclonic Storm	18.08	66.23
91	25	6	2007	Cyclonic Storm	22.96	68.01

It may be seen that the frequency of cyclones is once a year, excluding weaker depressions. These cyclones have to be analyzed for wave characteristics by hind casting, so that design criteria for the port structures could be derived

2.7.2 Cyclone Tracks– Bay of Bengal Coast

(Source – RMC Chennai)

The tracks of a few typical cyclones passing over the proposed port area are shown in Figures 2.10 to 2.13.

Figure 2.10: 1971-October– Severe Cyclonic Storm

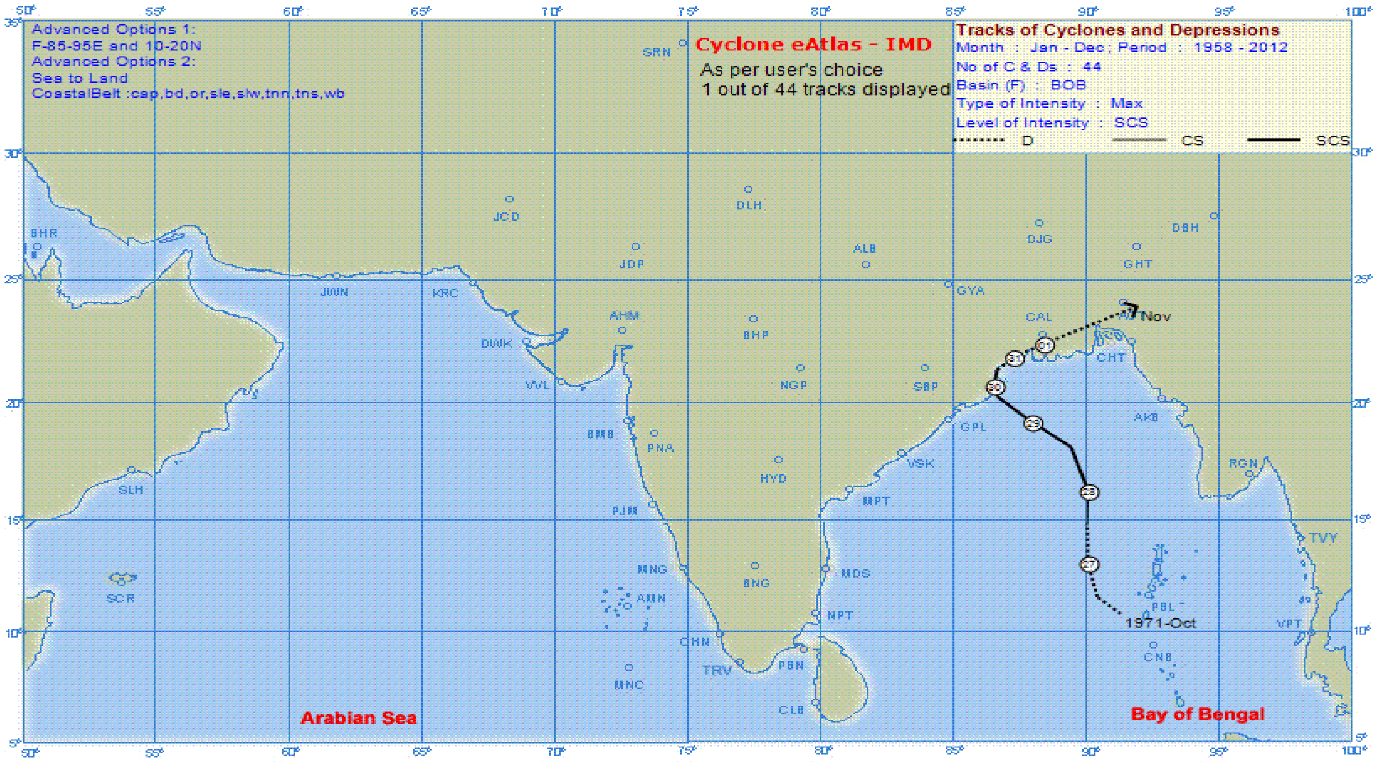


Figure 2.11: 1973-November-Severe Cyclonic Storm

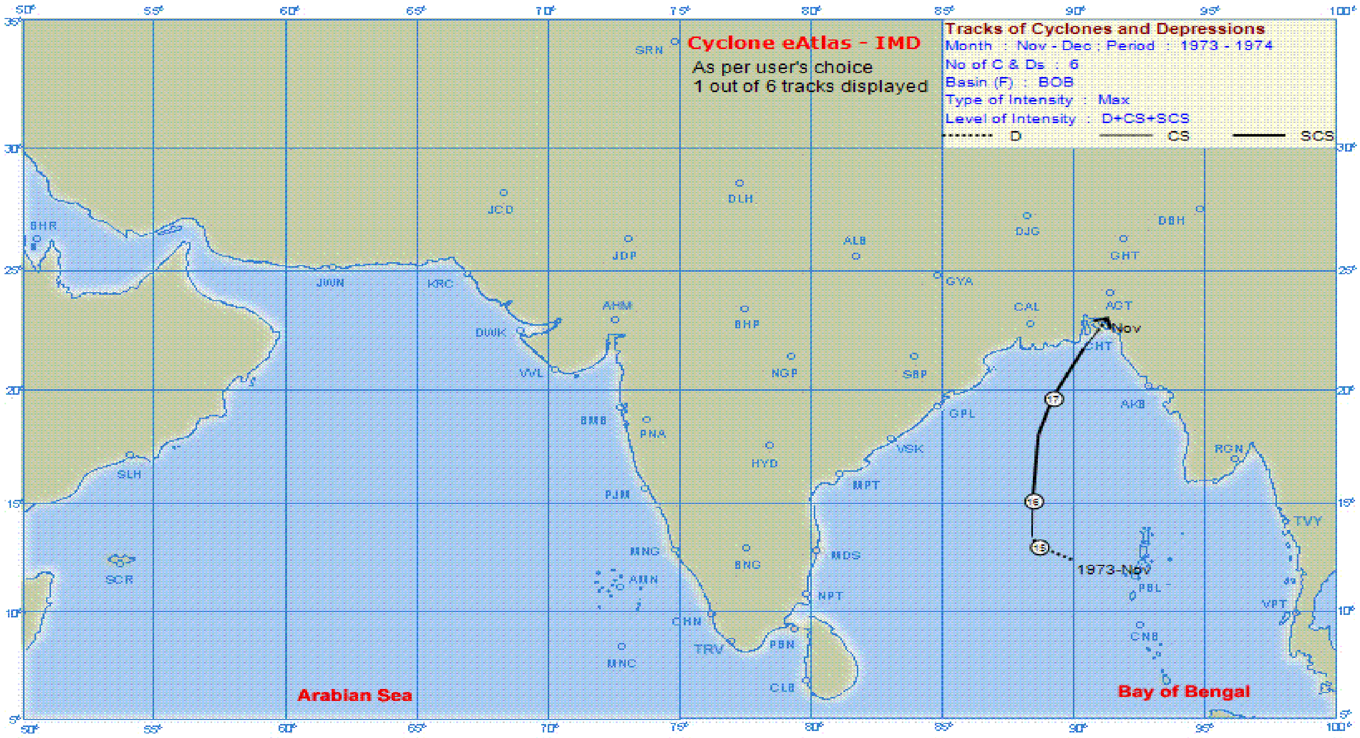


Figure 2.12: 1998-November-Severe Cyclonic Storm

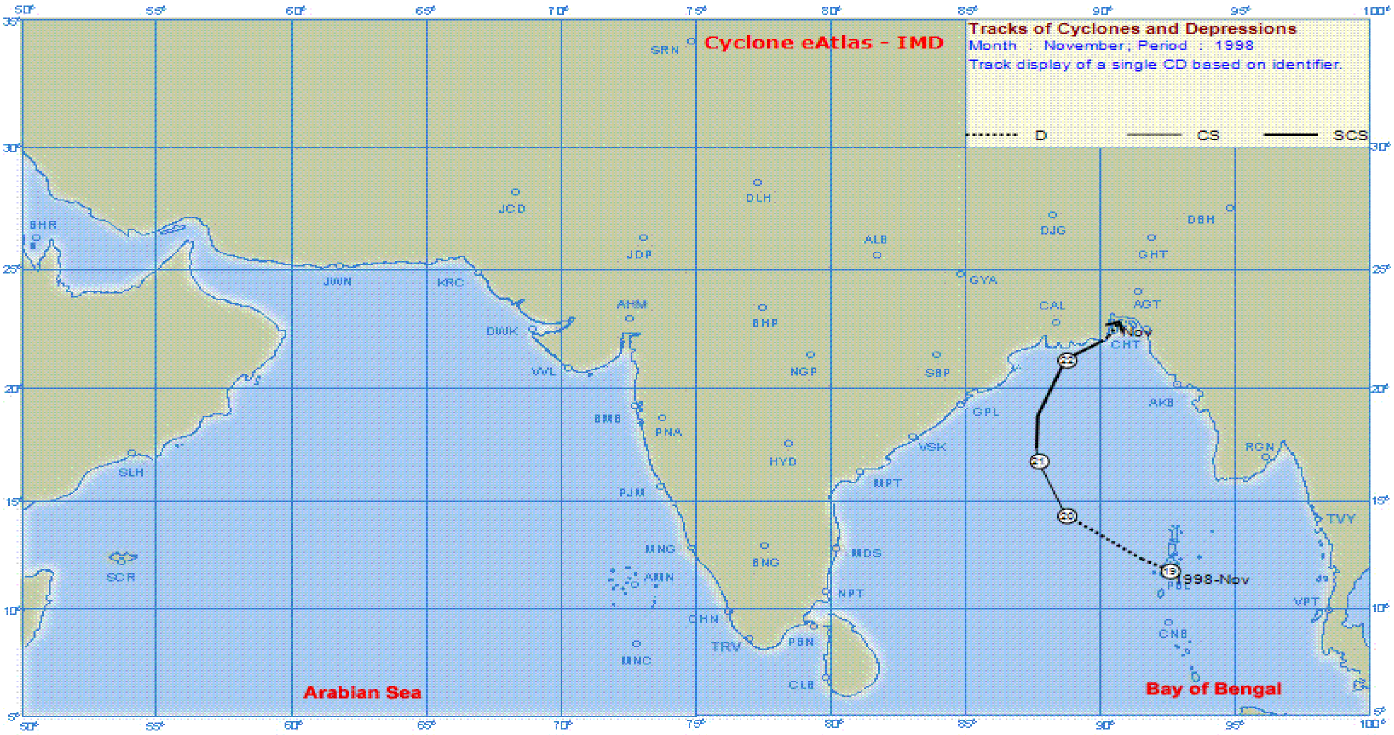
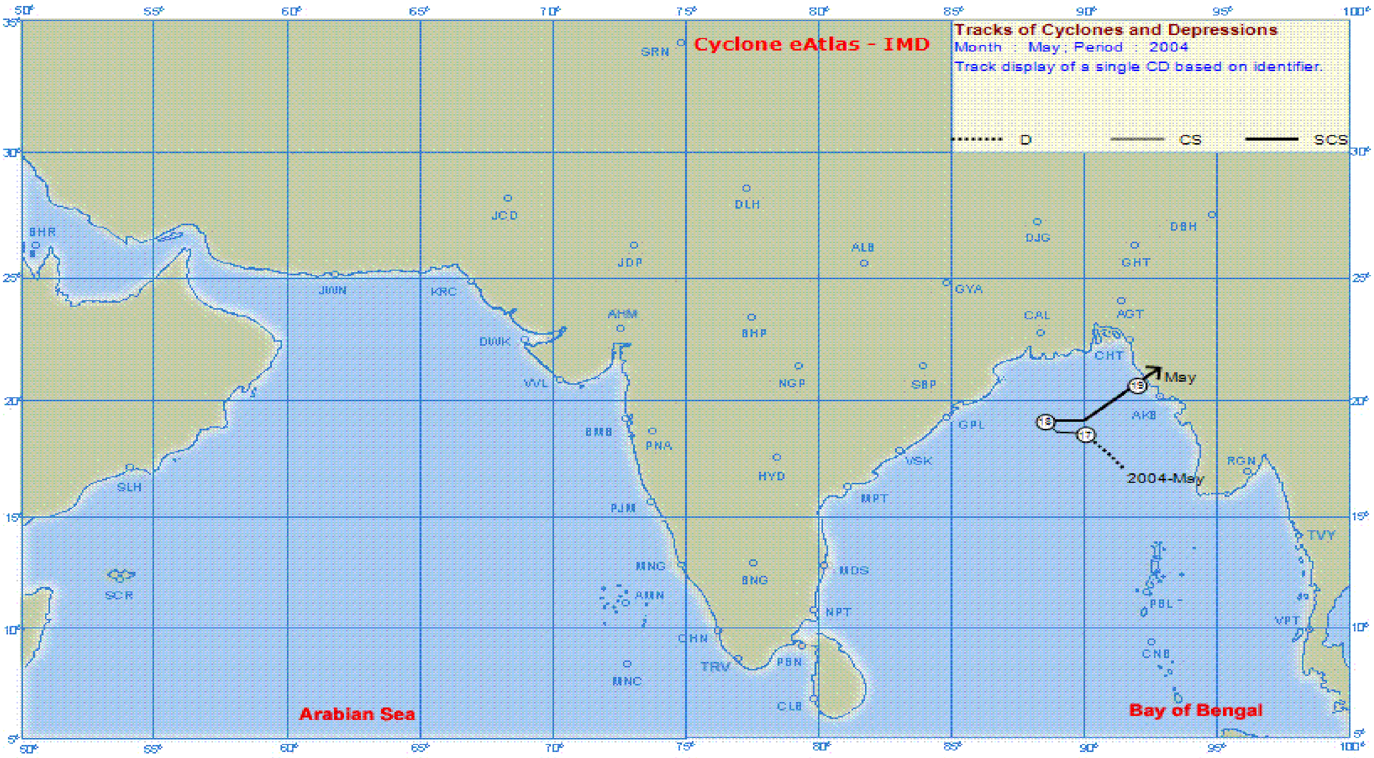


Figure 2.13: 2004 –May- Severe Cyclonic Storm



2.7.3 Cyclonic Isobaric Patterns (Source – IMD Pune)

The calculation of cyclonic wave heights is based first on determining what is called the geostrophic wind speed, obtained by equating the Coriolis force to the pressure gradient, the latter being found from the isobaric patterns given in the following Figure 2.14 to Figure 2.18, for representative storms. The geostrophic wind speed has to be converted to sea surface wind speeds using empirical relationships of the effect of curvature and the air-sea differential temperature and thereafter to the wave height and period in the fetch over which the wind is blowing.

Figure 2.14: 1971-October – Severe Cyclonic Storm

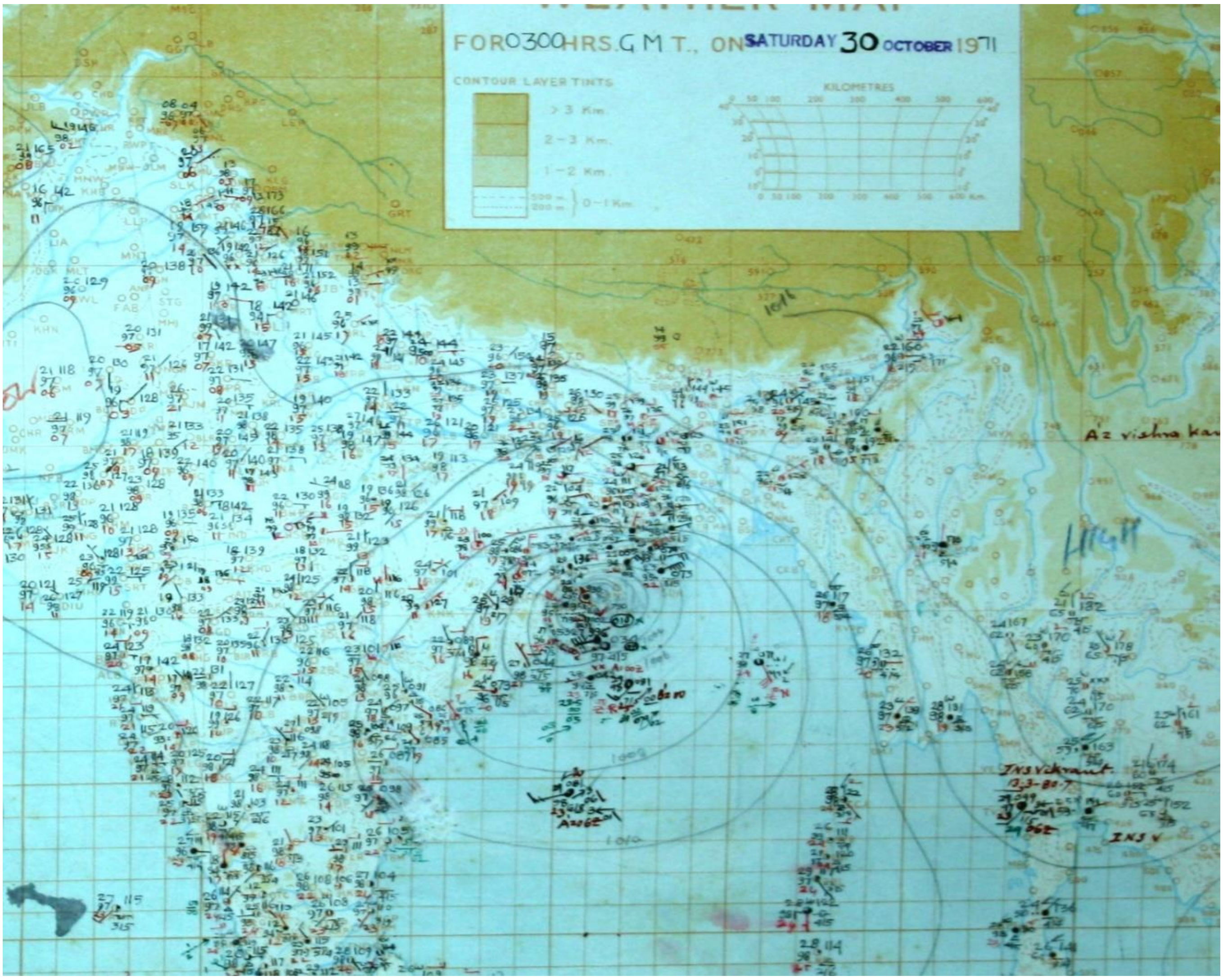


Figure 2.15: 1973 -November – Severe Cyclonic Storm

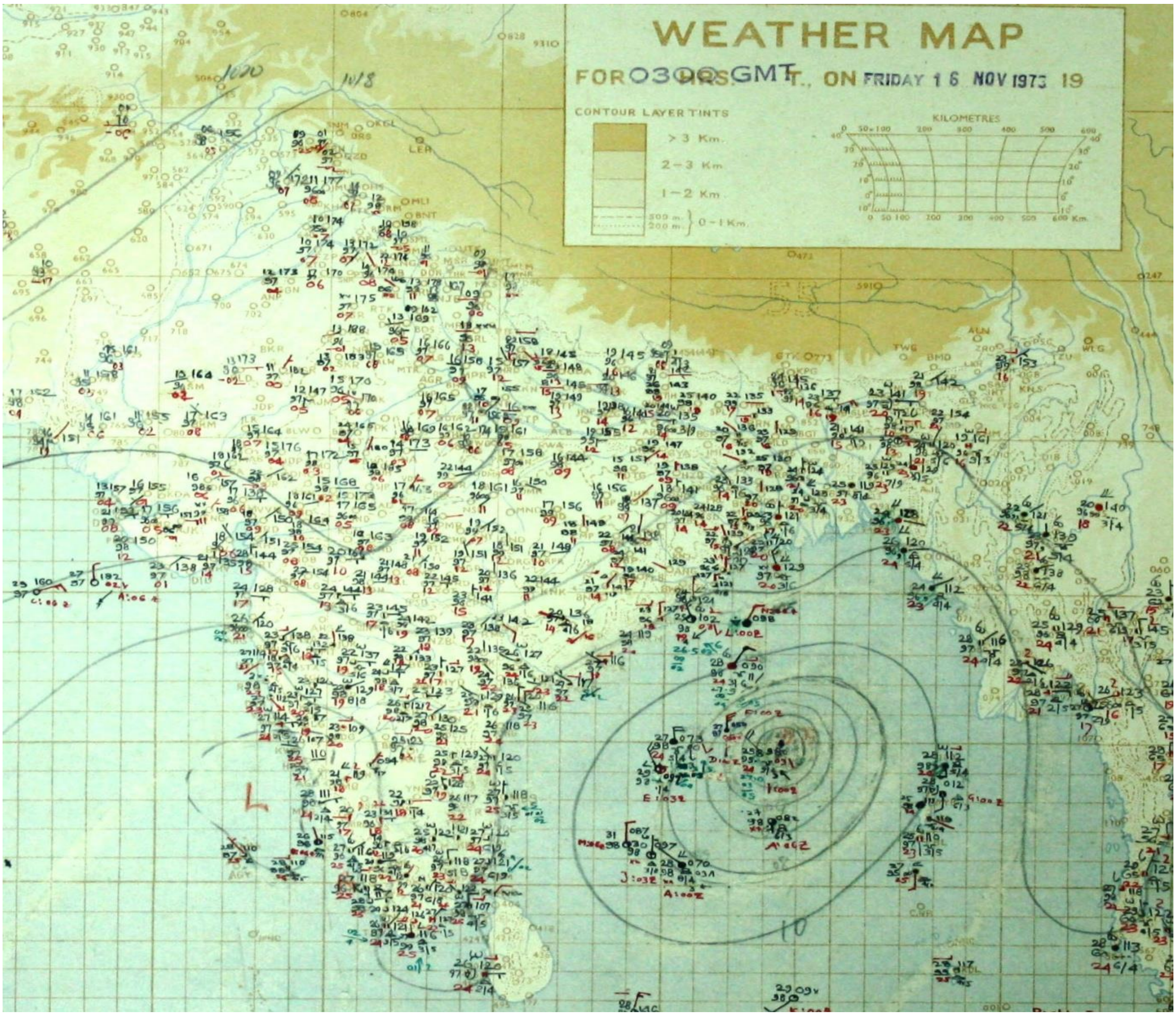


Figure 2.16: 1997-May– Severe Cyclonic Storm

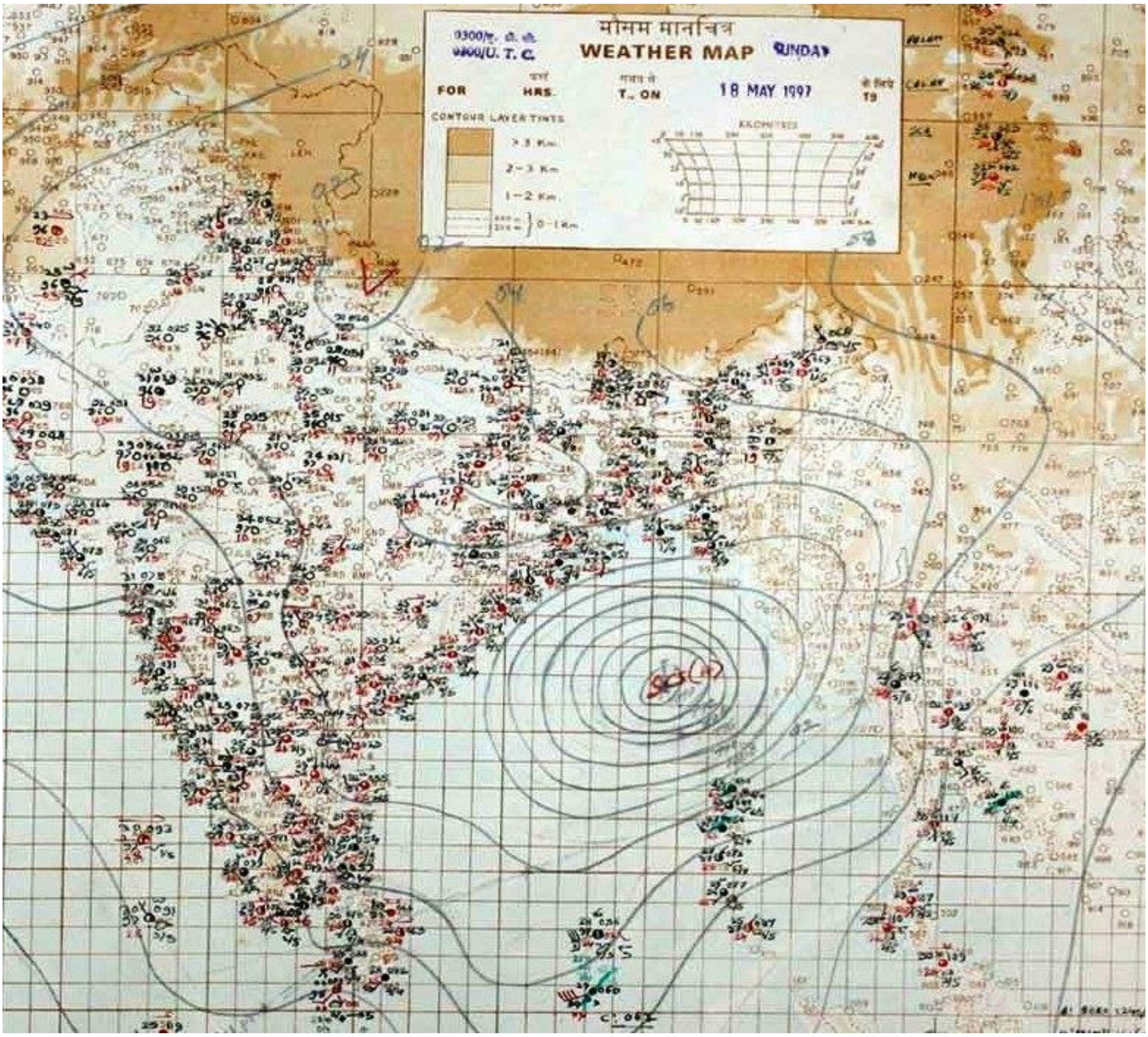


Figure 2.17: 1998-November– Severe Cyclonic Storm

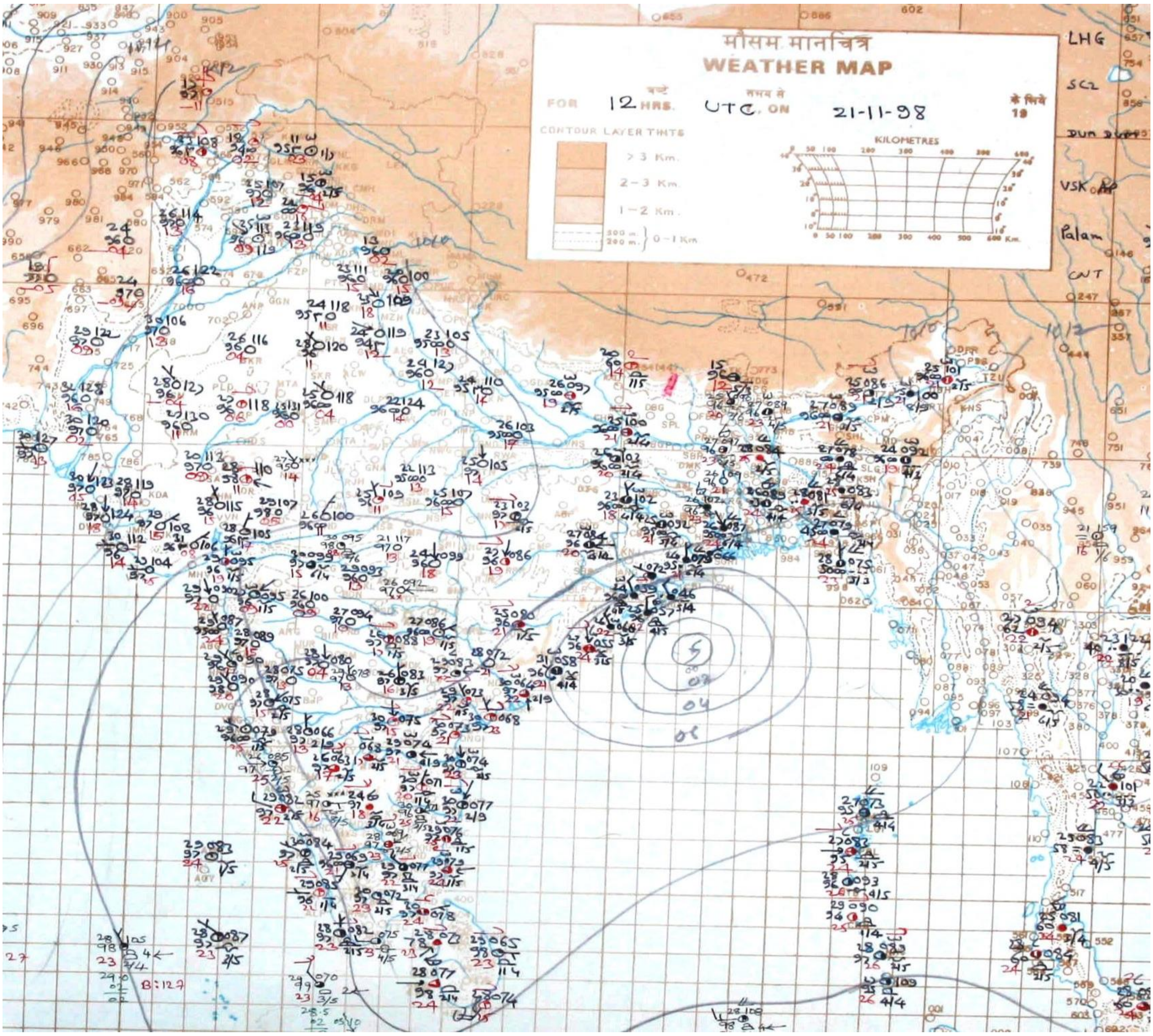
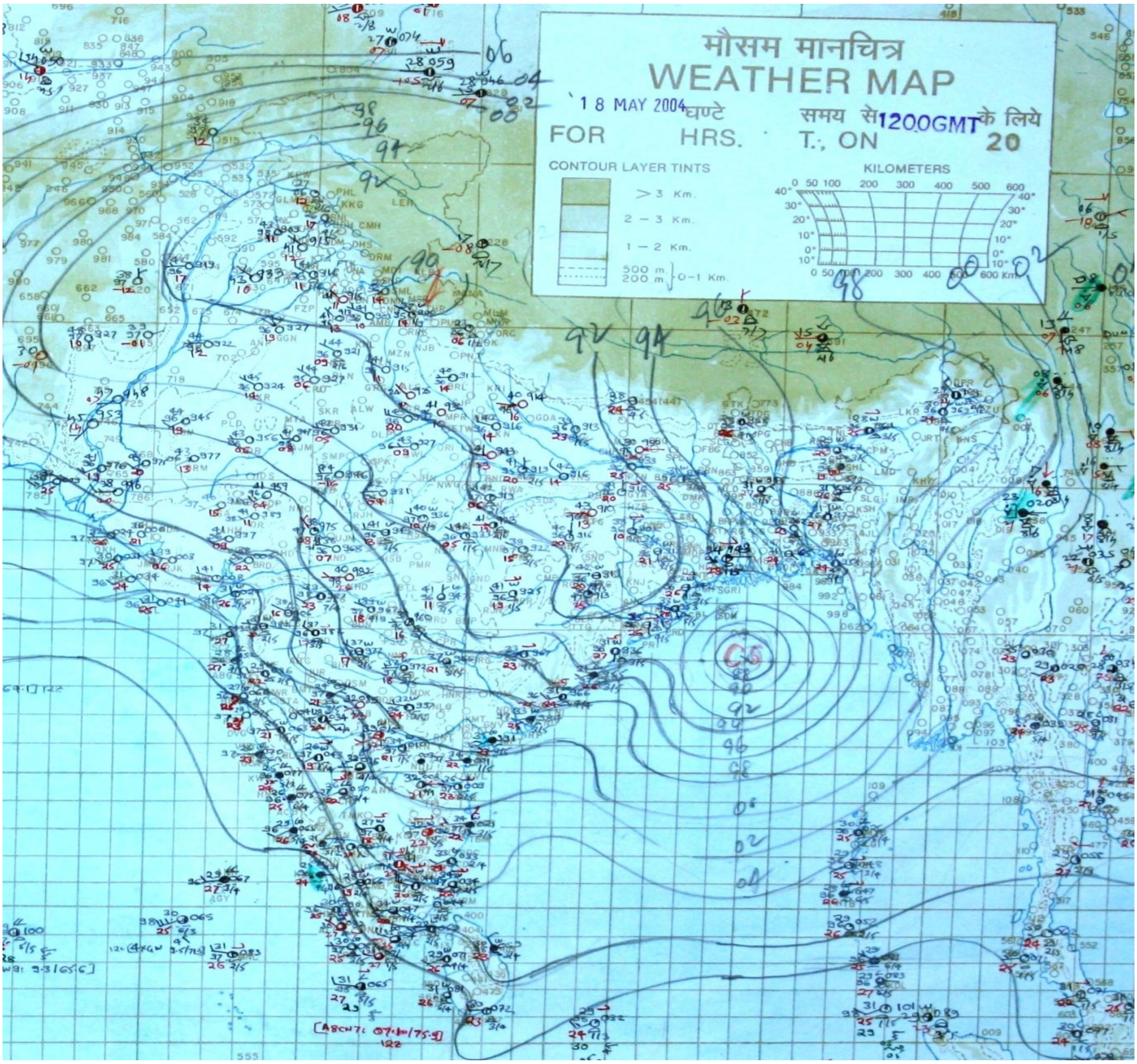


Figure 2.18: 2004-May– Severe Cyclonic Storm



2.7.4 Hindcasting Analysis

Having obtained the wave height and period in the storm area, called the Fetch, the wave is required to travel over some distance to the shore. This distance is called the decay distance over which the wave 'decays' before reaching the shore. Calculations of selected storms are presented in Table below.

Sr.	Date	Isobar Spacing for 2mb	Latitude of Fetch Area	Geostrophic Wind Speed Ug	U/Ug	Surface Wind Speed	Fetch Length	Decay Distance	Wave Condition at the Head of the fetch		Wave Condition at the Site	
		(o Lat)	(Deg)	(m/s)		(m/s)	(km)	(km)	Height (m)	Period (s)	Height (m)	Period (s)
1	17.10.1945	0.55	17	78	0.395	31	170	0	6.7	11	6.7	11
2	18.10.1945	0.37	17	95	0.38	36	100	0	5.8	9.7	5.8	9.7
3	10.07.1947	0.65	18	100	0.39	39	200	260	7.4	11	2.7	14.5
4	21.11.1948	0.96	17	16.5	0.55	9.07	200	250	1.8	5.7	0.9	6.8
5	30.10.1971	0.25	20	180	0.38	68	160	0	7.5	11.5	7.5	11.5
6	16.11.1973	0.37	19	87.5	0.39	34	140	0	6.8	10.5	6.8	10.5
7	03.06.1982	0.56	18	58	0.41	24	150	270	7.4	11	2.3	11.4
8	13.10.1984	1.25	21	22.5	0.5	11.3	150	225	2.1	7.5	1.2	1.1
9	16.12.1990	1.1	17	85	0.39	33	120	0	5.3	10.2	5.3	10.2
10	18.05.1997	0.37	19	87.5	0.39	34	150	0	6.2	10.8	6.2	10.8
11	21.11.1998	0.74	19	110	0.38	42	120	0	7.2	11.8	7.2	11.8
12	17.05.2004	0.55	17	78	0.395	31	160	0	6	10.9	6	10.9
13	18.05.2004	0.37	17	95	0.38	36	130	0	7.1	11	7.1	11

It may be seen that the maximum wave height in the Fetch from the 13 selected storms is 7.5m, though when decay is taken in to account, from the Fetch to the port site is 7.1 m (due to a storm that was directly over the port site, that is, zero decay). For design purposes of a coastal port, a wave height of 7.5 m could be taken. In case offshore structures are contemplated in deep waters, further hindcasting studies would have to be undertaken, together with statistical analysis for 100 and 200 year return periods.

2.7.5 Storm Surge

Storm Surge is rise in water level due to storm and is caused predominantly by large pressure variations between the center of the cyclone and its periphery and wind stress directed from the continental shelf towards shallow water. The importance of surge in harbor design is two-fold. First it indicates the water level above the High Tide Level, which has to be taken in to account when designing the top level of structures such as berths where overtopping is not to be permitted. Second, for breakwater structures, where overtopping may be permitted, the additional wave height that can be sustained in the given depth of water, is to be taken in to account for design of the armour.

The coastal areas of West Bengal are one of the most vulnerable in the Bay of Bengal that experience very high cyclonic storm surge attack. The height of the coastal surge largely depends upon the central pressure in the cyclone, taken together with the wind shear at the sea level. . The surge level is important for determining the Safe Ground Elevation in the harbor reclamation. An accurate calculation of surge takes in to account, not only the barometric pressure, but also the drag effects on a gently sloping beach. An approximate formula is given below:

$$\frac{S}{d_1} = k \frac{U^2 L}{g(d_1)^2 \left(1-\frac{d_2}{d_1}\right)} * \ln\left(\frac{d_2}{d_1}\right)$$

S = Surge (m)

d_1 = depth at shelf edge (m)

d_2 = depth at site (m)

k = 3*10^-6

U = Wind Velocity (m/s)

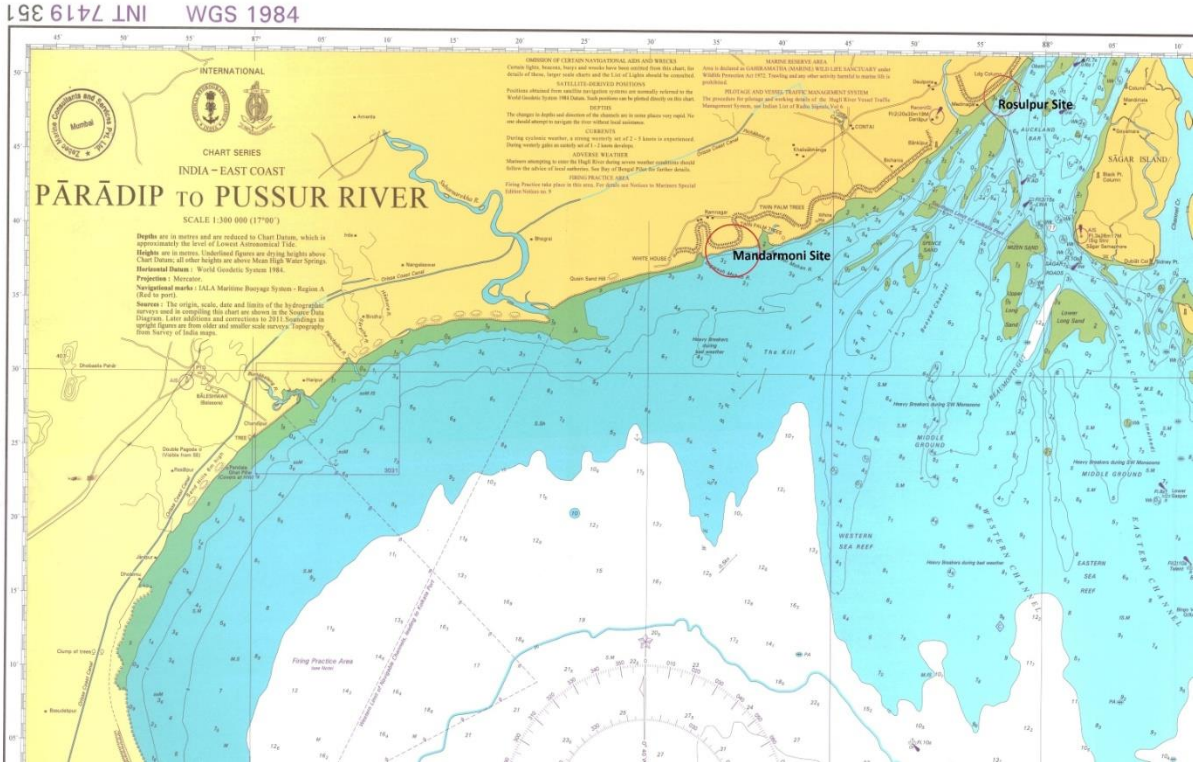
L = Edge of Continental Shelf (km)

The maximum surge level, as a result of the combination of storm surge and inverted barometric pressure is 2m.

3. Site Visit and Port Location

As stated earlier, in addition to the initial site of south of Rosulpur River, further alternative sites were analyzed so as to identify a more favorable site for development of a port. Two site reconnaissance visits were made to explore these alternate sites. These sites are shown in below in Fig. 4.1 from Rosulpur to Mandarmoni.

Figure 4.1: Shoreline beyond Kolkata Port Limits – extracted from NH Chart INT 351



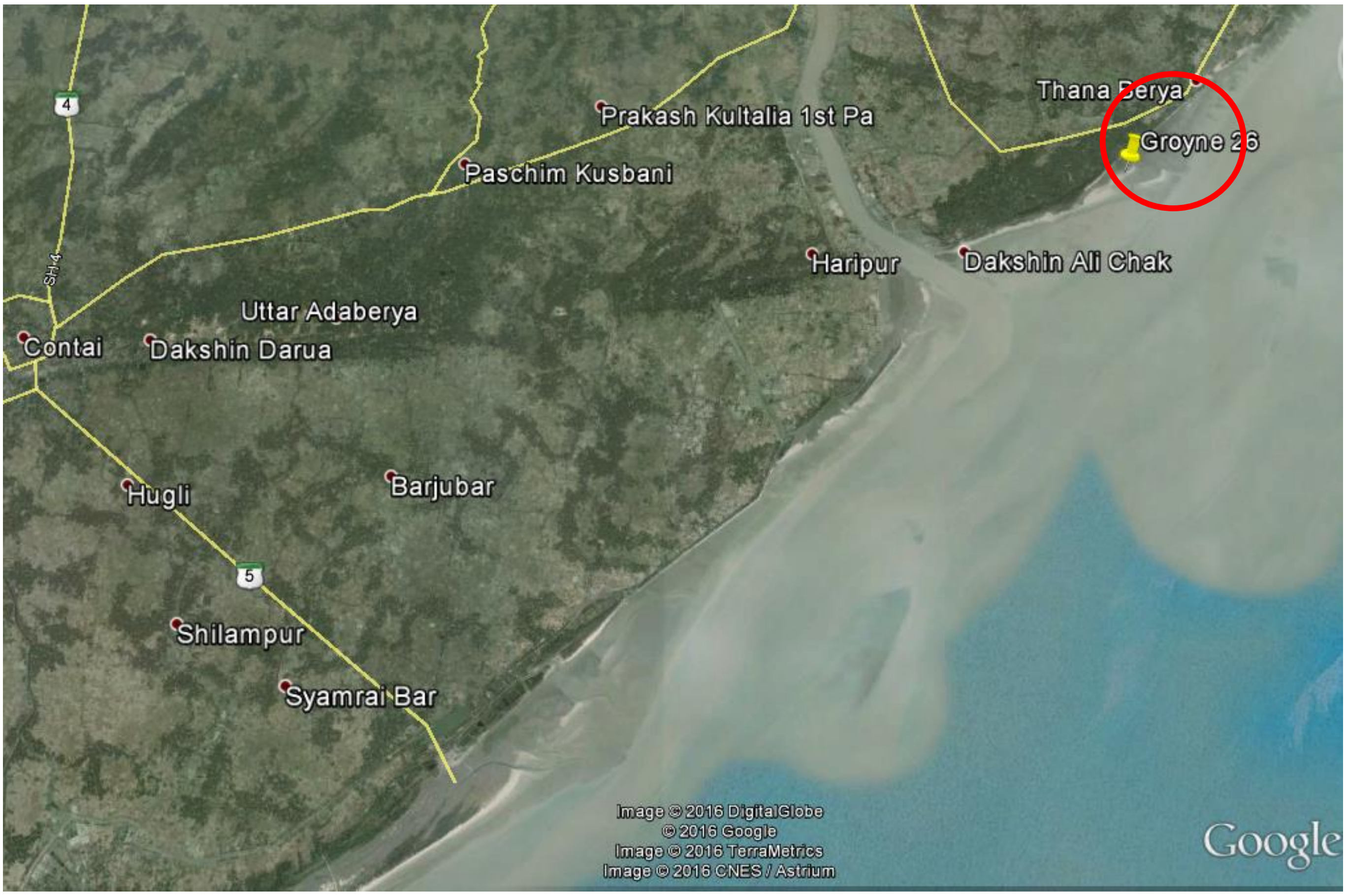
3.1 Rosulpur South Site

As part of our primary survey, a site visit was undertaken from February 21st to the 24th 2016, to the Rosulpur site, south of the river.

It was observed during our visit that there is a ferry crossing the river, about 5.5 km upstream of the mouth (Photo 4.1.1). Further downstream there is the fishing harbor, about 1.2 km from the mouth (Photo 4.1.2). Based on primary interactions, it was understood that approximately 600 boats are currently operating from the fishing harbor.

Along the coast, the proposed deep draught harbor site, shown in Google image below, was noted to have a sandy beach (Photo 4.1.5), which at low tide was observed to be clay (Photo 4.1.6).

Figure 3.1: Proposed harbor site Rosulpur South (Google image)



The major concern was of the deep channel of 6m CD at this location which was about 8km away from the high water line.

The 15m contour as seen from Admiralty Chart 123 was about 43 Nm. (80km) to the South, requiring an unprotected channel to be dredged over this long length, which would have to be maintained.

It was understood that about 6 million tons of maintenance dredging is required per annum in the Jellingham Channel (now a bar).

It was immediately noted that there is a mud flat in this area, called the Dariapur Flat, which being environmentally sensitive, would be difficult to get Environment Clearance (EC) from the Ministry of Environment and Forests. Photos 4.5 and 4.6 at the end of this chapter show the nature of the site. Since it was considered environmentally sensitive, potential for port development at this location seems low.

3.2 Rosulpur North

A second extensive site visit was made between May 7 and May 10, 2016, to locate a suitable site for development of a greenfield port in the Purba Medinipur District. Since the site south of the Rosulpur River was a mud flat, it was decided to examine a site to the north, where river training works carried out by the Kolkata Port Trust, for improving depths on the Auckland Bar, had resulted in a large deposition of fine sand which could be fruitfully developed for the storage of materials and containers in a greenfield port. Further reclamation in this area by deepening the adjacent channel would make this site an ideal one for development. However, the impact of such an extensive reclamation to the area on the upstream, where the Jelllingham Channel is located (access to the Haldia Dock complex) would need to be examined. A Google Earth Image of the area is shown below in Figure 3.2:

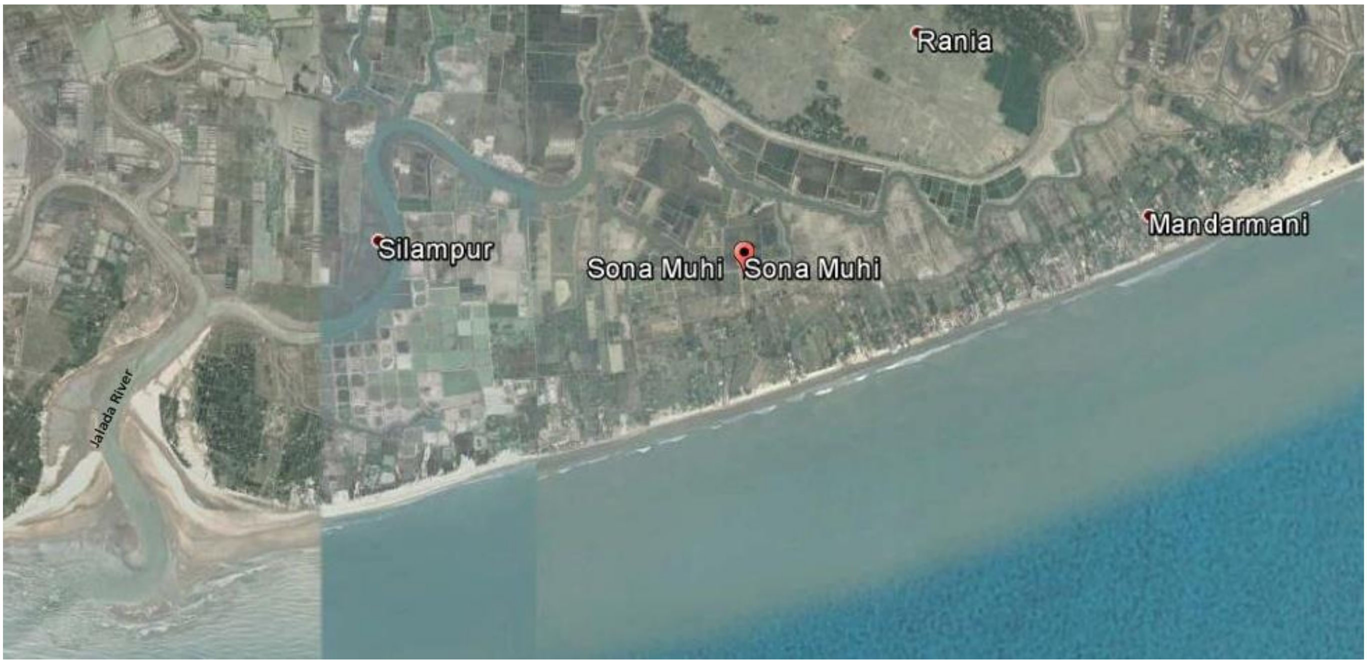
Figure 3.2: Google Image of Rosulpur North showing reclaimed sandy beach

To the immediate north of the Rosulpur River outfall, the beach is clayey, indicating deposits from the Rosulpur catchment. Photo 4.2.1 shows this area which has been systematically planted with mangroves by the Forest Department. However, further north, a wide sandy beach has been formed, as shown in Photos 4.2.2 to 4.2.4, as a result of the river training Groynes constructed by the Kolkata Port Trust. It may be noticed that the foreshore has been planted by the Forest Department with Casurina trees. Photo 4.2.5 shows the limited access through the Mazaar Dakshin Ali. Photo 4.2.6 shows a wider road lined with Casurina trees towards the National Highway.

3.3 Mandarmoni North

The Mandarmoni Beach extends, from Mandar Muhana towards the north to Jalada River mouth in the south. The area offers a wide intertidal beach which could be fruitfully reclaimed for the port storage and other utilities. A Google Image of the site is shown below in Figure.

Figure 3.3: Google Image of Mandarmoni North Beach

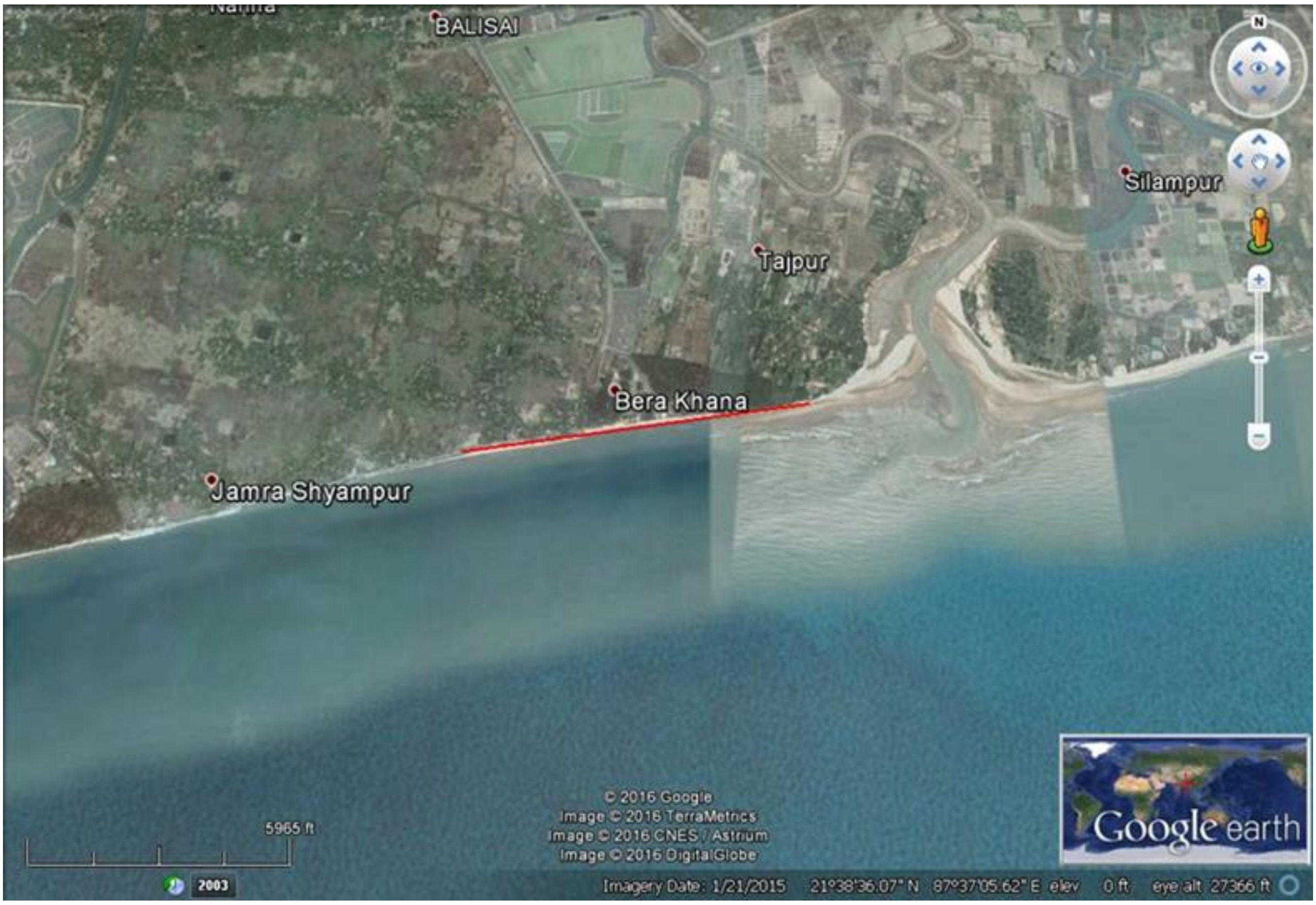


3.4 Mandarmoni South

The area south of the Jalada River mouth referred to as Mandarmoni South is shown below in Figure 3.4 taken from a Google Imagery. The area between Shankarpur-Tajpur is subject to wave attack, unlike Mandarmoni North. A concrete seawall has been built by the Irrigation and Waterways Department, to protect the adjacent lands from erosion and submergence during high tides. Further near the Jalada mouth a timber pile seawall was built, with rubble filling between two rows of piles. The vertical face offered to the wave action has resulted in scour and consequent damage to the structure. A Google Image of the site is given below in Figure.

It may be seen that the immediate hinterland is sparsely populated compared to Mandarmoni North. The fact that there is erosion in the area is an opportunity for the port to protect these vulnerable areas and also reclaim land for development of the port.

Figure 3.4: Google Image of Mandarmoni South showing erosion area by red line

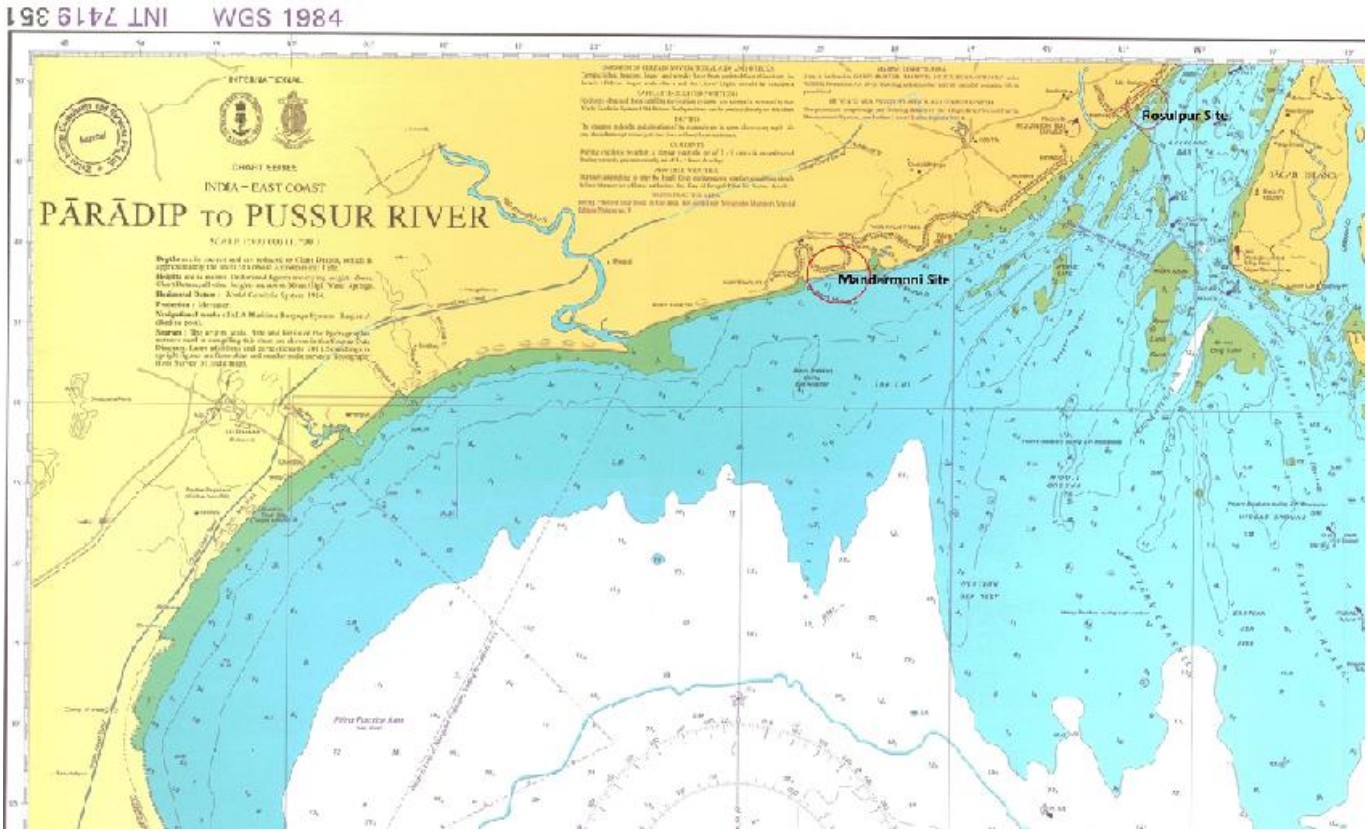


The present erosion and protection measures adopted are shown in Photos 4.4.1 to 4.4.6. The failure of vertical sea walls at Tajpur is apparent in comparison to the sloping seawalls at the Shankarpur end. The issue being one of deficient bypassing would of course hardly protect the area in the long run, which the port would enable by trapping the drift moving offshore and nourishing the northern beach.

The photographs clearly show the vacant low lying areas behind the seawalls, which could be reclaimed for purposes of providing adequate area for an Industrial Estate or even an SEZ, which would be to the mutual benefit of the Port and also the industry, which may require an access to imports and exports

The present coastal road from Tajpur to Shankarpur, shown in Photo 4.4.7 would need to be improved so that port connectivity to the hinterland via Shankarpur-Tajpur region is easily established.

Figure 3.5: Location of alternate sites for development of the port



3.5 APPENDIX to Chapter 3 - Photos from Site Visit

A 4 – 1: Photos South Rosulpur

Photo 4.1.1.: Ferrycrossing across the Rosulpur River

Photo 4.1.2. : Fishing Harbor at Petuaghat, Rosulpur River

Photo 4.1.3 : Slipway construction at Petuaghat

Photo 4.1.5.: Inter Tidal Zone South Bank of Rosulpur River

Photo 4.1.6: Soil Condition – Mud – South Bank of Rosulpur River

A 4 –2: Photos North Rosulpur

Photo 4.2.1: Mangrove Plantation on North Bank of Rosulpur River

Photo 4.2.2 : Sandy Beach North of Rosulpur River

Photo 4.2.3: Sandy Beach looking north towards Groyne 26

Photo 4.2.4: North of Rosulpur Intertidal Zone – Rosulpur Shore looking south.

Note sandy beach and shoreline afforestation

Photo 4.2.5 Present Road Connectivity from NH 116B to Dakshin Ali Chak

Photo 4.2.6 Access Road to Rosulpur North – Note afforestation

A 4 – 3: Photos –Mandarmoni North

Photo 4.3.1: Flat Beach – looking south from MandarmoniBeach

Photo 4.3.2: Inter-Tidal Zone – MandarmoniBeach looking North

A 4 – 4 Photos from Shankarpur to Tajpur

Photos 4.4.1. : Images of Seawall –Shankarpur Coastline

Photo 4.4.2 Shankarpur Seawall

Photo 4.4.3 Southern end of Shankarpur Seawall

Photo 4.4.4 Close-up of the southern end of Shankarpur Seawall

Photo 4.4.5 Friction Blocks on Sloping Face of Shankarpur Seawall

Photo 4.4.6 Another view of Friction Blocks

Photo 4.4.7 Waves breaking on Shankarpur Seawall at Low Tide

Photo 4.4.8: Shankarpur Seawall – Looking North from Tajpur

Photo 4.4.9 Low Lying Area behind Shankarpur Seawall

Photo 4.4.10 Seawall at Tajpur in dilapidated condition

Photo 4.4.11 Seawall at Tajpur showing rubble fill between timber piles

Photo 4.4.6 Shore Protection by pitching behind Timber pile seawall

Photo 4.4.12 Present Coastline Connectivity road from Tajpur to Shankarpur

4. Connectivity

4.1 Connectivity for the proposed location

Performance of a port depends not only on the infrastructure and facilities provided at the port but also on its connectivity to the hinterland consumption and production centers. While assessing the connectivity of the port, it is imperative to consider factors like speed, capacity and quality of transportation available. For example, a port may not have cargo moving and storage services nearby, thus having connection to the broad-gauge rail network or multi-lane road with the hinterland will not suffice to increase the efficiency of the port. Conversely, having cargo moving services and storage facilities available but no proper rail-road connectivity would not improve the overall port-hinterland efficiency. The ports like JNPT, Mundra, Pipavav and Kandla on the west coast of India have flourished only after hinterland connectivity was established.

A better rail connectivity is a boost to the performance of the port; it offers faster evacuation, lesser CO emissions and optimum utilization of the storage. With this in mind, the Government of India has begun the construction of the Dedicated Freight Corridors. There are two routes proposed, namely Western DFC and Eastern DFC, of which Eastern DFC connects important cities between Delhi and Kolkata and of importance for this project. The Eastern DFC is expected to boost the movement of raw materials required for power plants, steel and cement industries, which are necessary for economic growth in Eastern India. The proposed junction of Dankuni (end-point of Eastern DFC) is 151 km away from Rosulpur South. Similarly, Kharagpur railway junction, which is the nodal junction of the two newly announced railway freight corridors (Kharagpur-Mumbai, Kharagpur-Vijayawada), is located approximately 127 km from the Rosulpur South. The Kharagpur-Mumbai and Eastern DFC routes are expected to be completed by 2022.

Dankuni and Kharagpur Distance	
Dankuni to Rosulpur North	151 km
Dankuni to Rosulpur South	167 km
Dankuni to Mandarmoni North	229 km
Dankuni to Mandarmoni South	217 km
Kharagpur to Rosulpur North	134 km
Kharagpur to Rosulpur South	127 km
Kharagpur to Mandarmoni North	121 km
Kharagpur to Mandarmoni South	119 km

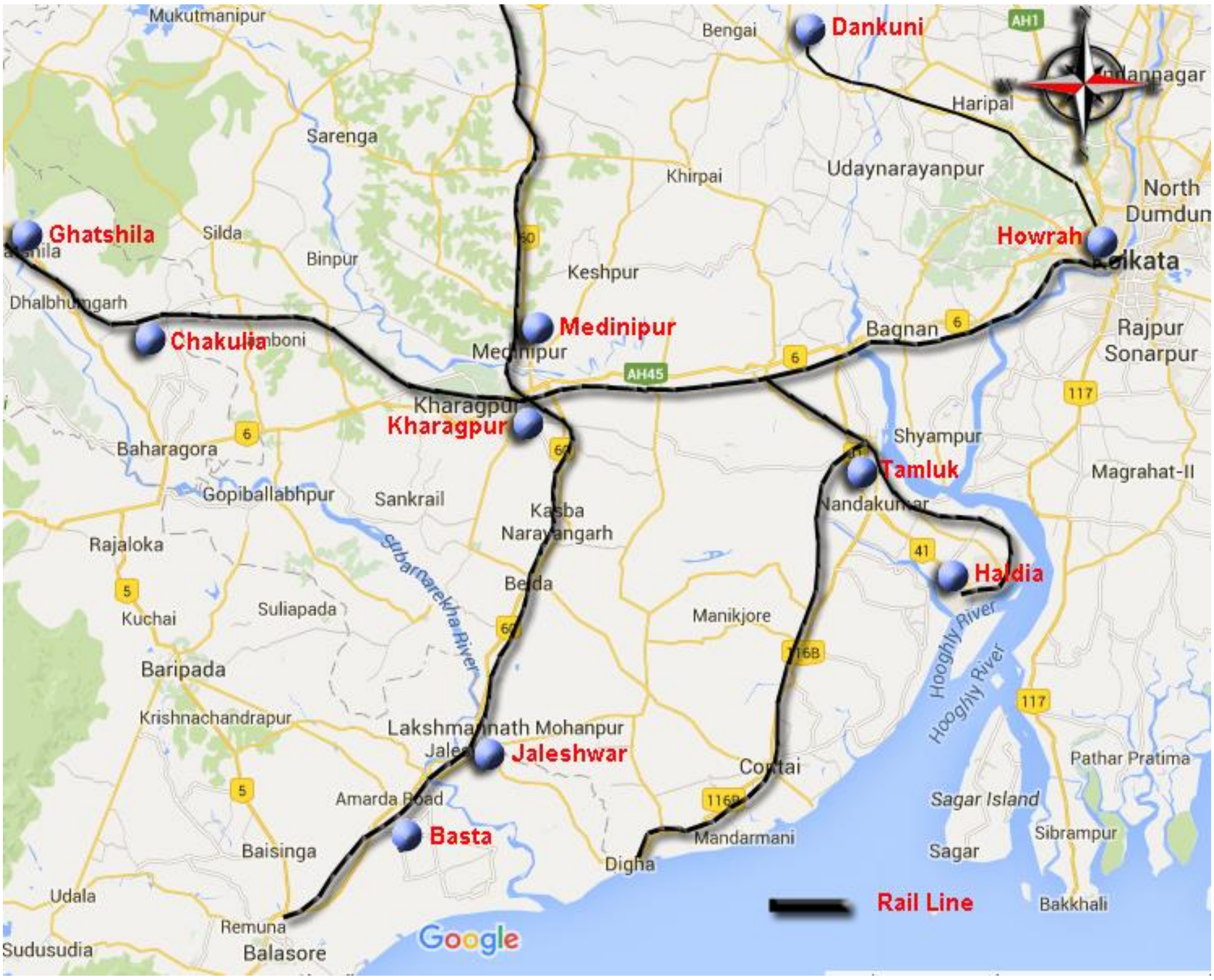
India has the second largest road network in the world, but is still behind the U.S. and China with regard to the percentage of paved roads and national highways/expressways. National and State Highways between them constitute less than 6% of the total road network, but they account for almost 80% of the road traffic. The shortage of multi-lane highways, coupled with poor road conditions cause congestion, accidents, break-downs, and high maintenance costs of roads and vehicles. The repercussion of these conditions are high congestion time, break downs and stoppage delays.

There are many initiatives undertaken by the Ministry of Road Transport and Highways regarding the widening of roads in Western and Eastern corridors; and along main National Highways connecting the states to decongest the present traffic on roads; but the pace of growth of road networks is at present only 4% CAGR in the last 5 years[1], which needs to be doubled.

The present Rail and Road network around the proposed Rosulpur Port is shown below:

[1] *Source: Transport Corporation of India report, 2013*

Figure 4.1: Rail Road Connectivity



4.2 Rail

Digha is connected to Contai through a single rail line transiting the Tamluk junction where it merges with the Haldia to Howrah rail route thereby connecting to all other major rail networks.

The rail route from Digha to Tamluk being under-utilized is therefore proposed as a good candidate facility for usage for the proposed port.

With time and increase in traffic the number of rail tracks could be increased substantially as land acquisition is already done by the railways.

4.3 Road

In order to evacuate the various goods and commodities it is necessary to have suitable roads to transport these items in a fast and efficient manner. At present the road from the proposed port to the state highway comprises of a single narrow lane. This is inadequate and will lead to very heavy traffic congestions. It is therefore recommended that the proposed port be connected by a 4 lane road to the state highway **SH 116B**. Furthermore **SH 116B** should be converted from an existing 2 lane highway to at least 4 or 6 lane highways to expedite cargo movement to the hinterland.

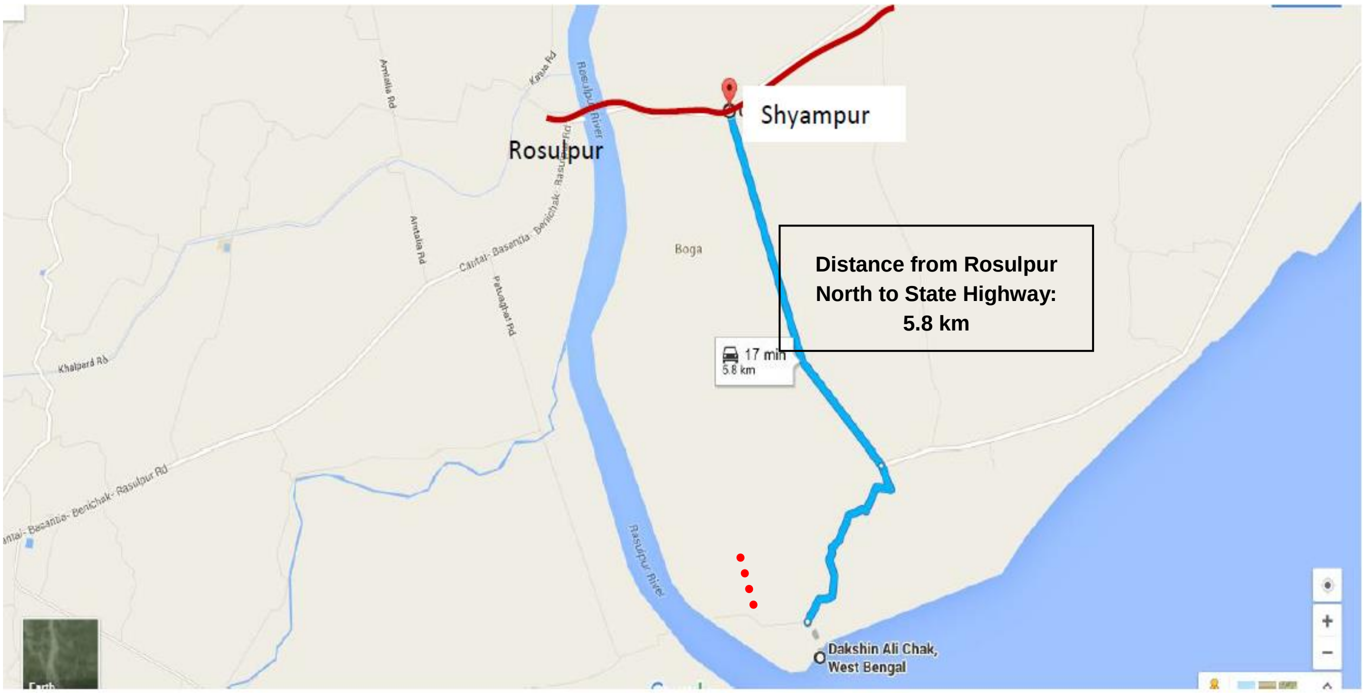
4.4 The Micro Network

The micro or local connectivity to the State/National Highways is now examined, with reference to possible difficulties in land acquisition. As mentioned in Chapter 1, the Scope of the investigations was widened to consider alternate sites as may be necessary. The Rosulpur site has two options, on either bank of the Rosulpur River. Similarly the Mandarmoni site also has two options on either bank of the Jalada River. These are separately discussed below.

4.4.1 Rosulpur North

The site at Rosulpur North is accessed from State Highway 116 B at Shyampur. There is a rural road having a length of 5.8 km, up to Boga Bus stop, after which there is a kuchcha road shown in dotted line below.

Figure 4.2: Local Road from State Highway 116B at Shyampur to Dakshin Ali Chak



The alignment from Boga Bus stop to the harbor site at Dakshin Ali Chak (Rosulpur North) would have to be re-routed as the present kuccha alignment has no scope for widening. A suitable alignment would have to be chosen after examining the village maps of Mehdinagar, Nonapata and Nichkosba. The access road would also have to be cut through Forest Plantation, for which clearance of the Forest Department would have to be taken.

4.4.2 Rosulpur South

The shoreline south of the Rosulpur River near Kanai Chatta and further south towards Biramput and Dakshin Sherpur is protected by an embankment to protect the low lying areas from storm surge. This site provides access to the National Highway through the Rosulpur – Basantia – Contai Road or even through Dakshin Sherpur – Contai Road, where scope for widening is available. However, as pointed out in Chapter 2, the Dariapur Mud Flats in the area preclude development of a port facility here.

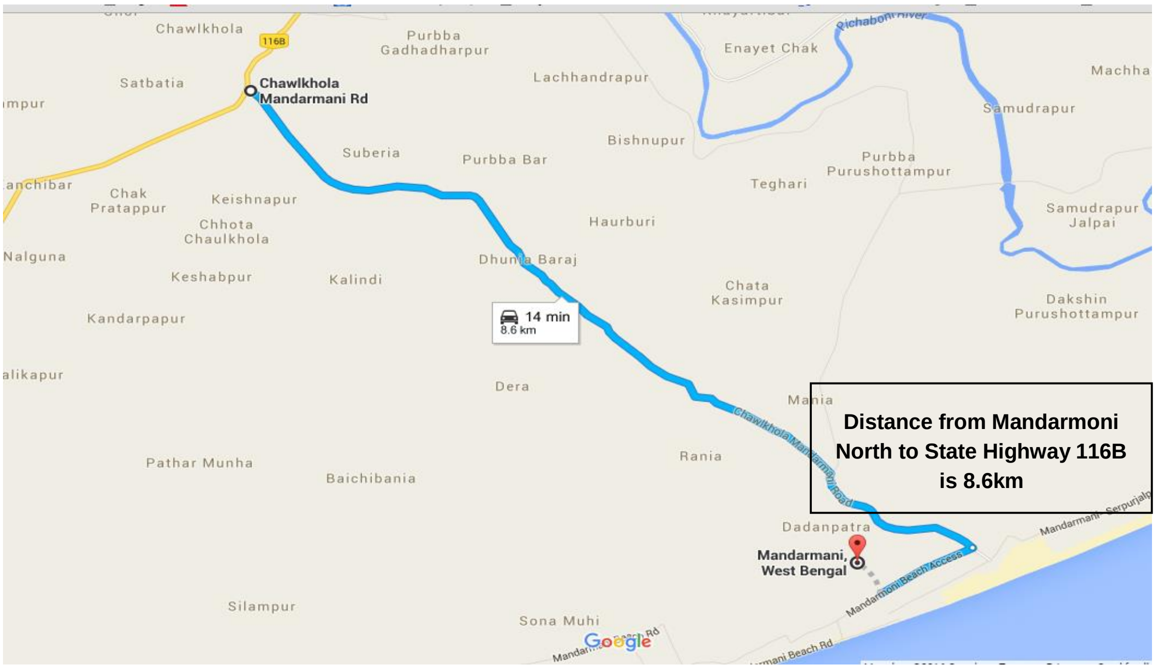
Figure 4.3: Local Connectivity from State Highway 116 B to Kanai Chatta

It may be seen that the existing road is about 10 km long to the Rosulpur South side, which if permitted from an environmental point of view, would require widening and improvement by acquiring land which appears fallow and undeveloped today.

4.4.3 Mandarmoni North of Jalada Outfall

Considering the difficult access to the Rosulpur North and South sites, it was decided to scout the areas further south towards the State Border at Mandarmoni. The access road from State Highway 116B, shown in Figure 4.4 below from Google Maps, is 8.6 km. The road at present is quite narrow and traffic is heavy as there are several beachfront hotels and holiday resorts.

Figure 4.4: Road Access from State Highway 116 B to Mandarmoni



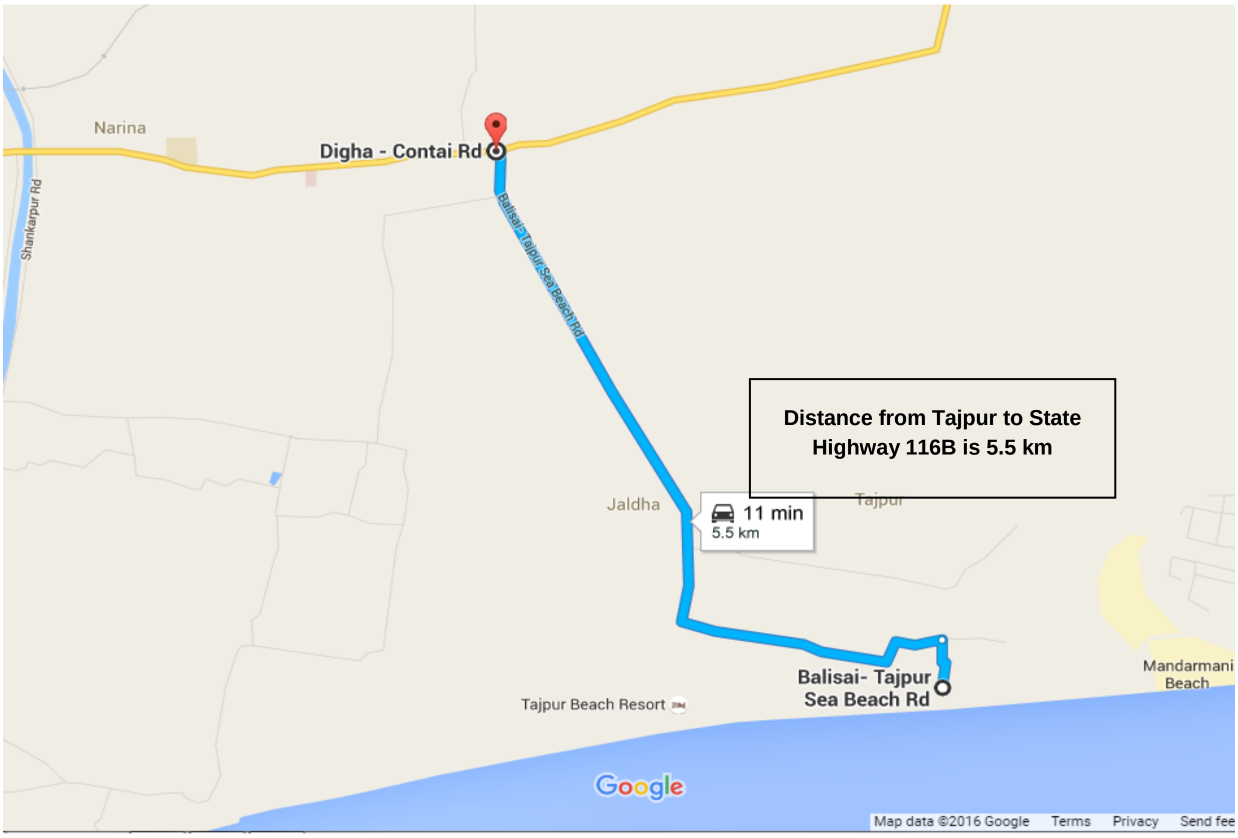
The Mandarmoni Beach is today fully occupied by Beachfront Hotels over a distance of 5 km up to the mouth of the Jalada River, shown in Figure 4.5 below:

Figure 4.5: Google image of the Mandarmoni Beach up to Jalada mouth

4.4.4 Mandarmoni South

Considering the occupancy of the beachfront north of the Jalada mouth, the shoreline south of the Jalada has been examined. Figure 4.6 shows the access from State Highway 116B.

Figure 4.6: Access from State Highway 116B to Tajpur

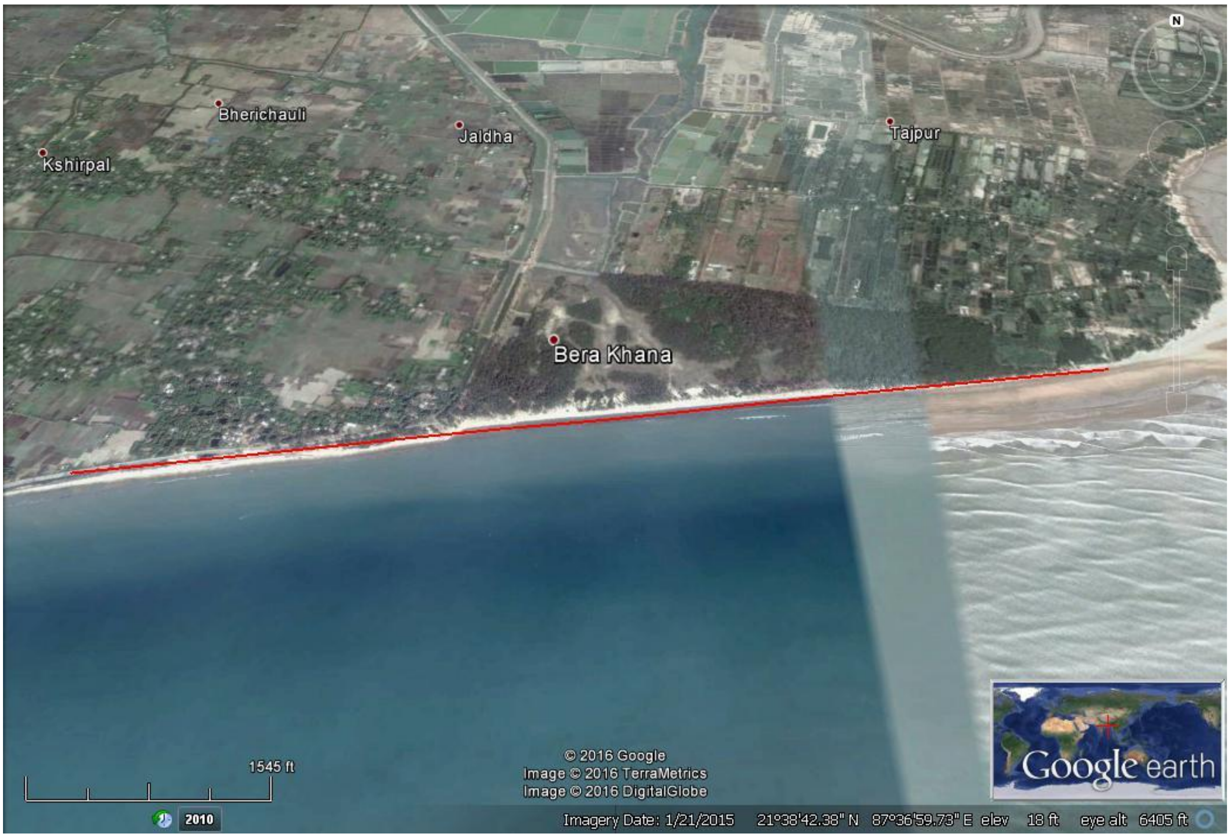


This area is subject to erosion, unlike Mandarmoni North, and a seawall has been constructed up to Shankarpur. Moving south from Tajpur, there is a seawall, about a kilometer long, constructed by dumping of boulders between timber piles. Because of the vertical face offered to the oncoming waves, toe erosion has caused this seawall to be damaged. Further south a sloping concrete seawall has been constructed which remains in better condition.

From	To State Highway	Distance (km)
Rosulpur-North	116 B	5.80
Rosulpur -South	116 B	10.00
Mandarmoni-North	116 B	8.60
Mandarmoni-South	116 B	5.50

There is another alternate route seen to this area between Tajpur and Shankarpur, as seen from the Google Image below (Figure 4.7):

Figure 4.7: Eroding beach about 3 km long



The eroding beach from Tajpur to Shankarpur, 3 km long, presents a unique opportunity for development of a coastal harbor, which would not only provide protection from erosion but would be a surge barrier to the area between the beach and the State Highway 116 B.

Of all the four sites assessed above, the Mandarmoni South site appears the most attractive for development as it presents the least difficulty in terms of land acquisition (based on visual inspection) and has the shortest distance to the State Highway.

A comparison of the distances of the four sites to the nearest State Highway (SH-116B) is shown below:

5. Traffic Analysis

The traffic assessment for the proposed port has been provided in Volume I of the Feasibility Report: Report on Market Assessment.

6. Selection of Suitable Design Vessel

6.1 General

A very important parameter which has a large bearing on the port layout and selection of the material handling equipment are the various commodities that shall transit through the proposed port. An equally important parameter is identifying the size of different vessels that shall call on the port. A combination of both these parameters shall decide the port layout, approach channel design, type of material handling units required. Needless to mention these shall directly have an impact on the capital expenditure.

The type and size of vessel that are envisaged to call at the proposed port shall be dependent upon;

- Current market scenario with respect to commodities being traded
- The routes that ships utilize for trading
- Approach channel design (depth & width)
- The capability of the port to handle various parcel sizes and throughputs
- Transportation cost benefits

In the first phase of development of the proposed port (Phase – I) facilities for the following have been planned based on the outcome of the traffic analysis.

- Container berth
- Dry bulk cargo
- Break bulk cargo

6.2 Categorization of Projected Commodities

Cargo to be handled at the proposed port has been identified as per the traffic analysis for the port covered in Volume 1 of the Feasibility Report. As per the traffic forecast, the commodities envisaged to be handled at the port are categorized in to three types. The following cargo handling facilities are envisaged to be developed at the proposed port.

Table 6.1: Categorization of Projected Cargo

Cargo Category	Commodities	Type of Terminal Envisaged	Remark
Category 1: Dry Bulk	Thermal Coal Coking Coal	Dedicated fully mechanized coal import terminal	Projected Coal import throughput is sufficient enough to justify a mechanized coal terminal
Category2: General Cargo and Break-bulk	Iron Ore (E), Thermal Coal (Coastal) Limestone, Other General Break-bulk Cargo	Multi cargo terminal with Harbor Mobile Crane arrangement at berth – Manual Handling	As volume of Iron ore (Export) and thermal coal (Coastal) are not sufficient enough to justify a dedicated terminal, it is proposed to handle these commodities at the Multi-cargo terminal along with other General cargo and Break bulk

Cargo Category	Commodities	Type of Terminal Envisaged	Remark
Category 3: Container	Containerized cargo	Dedicated container terminal with RMQC at berth	Projected container volumes are sufficient enough to justify a dedicated container berth. However the deployment of RMQC & RTGC has to be phased in as the container throughput ramps up.

It is preferable to look for a modern port with deep draft for handling of large parcel sizes and with modern mechanical handling equipment which will ensure faster turnaround of vessels. However, to reduce the project developmental cost requirement, it is preferable to optimize the facilities required.

6.3 Selection of Vessel Size

The large vessels have generally stopped calling at Haldia Dock. The restriction for navigation of larger vessel due to the falling draft in the channel has led to increase in the operating costs. The vessel size at Haldia Dock and Paradip can be analyzed to estimate the vessel size to be called at the present proposed port.

6.3.1 Vessel Size Distribution nearest Operational Port

The vessel call at the nearest port of Paradip, Kolkata and Haldia Dock for the year 2014-15 has been considered for analysis. The vessel call data has been taken from IPA Year Book and is tabulated below:-

Table 6.2: Vessel Call at nearest Ports - 2014-15

Vessel size in DWT	Containers			Dry Bulk			Break Bulk		
	Kolkata Nos	Haldia Nos	Paradip Nos	Kolkata Nos	Haldia Nos	Paradip Nos	Kolkata Nos	Haldia Nos	Paradip Nos
Up to 10000	160	33		28	6	30	194	13	7
10001 to 20000	514	146	16	9	2	15	44	5	14
20001 to 30000		9	2	9	26	20	5	16	1
30001 to 40000				11	25	27	6	10	1
40001 to 50000				8	72	93	3	2	
50001 to 80000				51	462	756	20	8	
80001 to 100000				1	157	127			
Above 100000						1			
Total	**674**	**188**	**18**	**117**	**750**	**1069**	**272**	**54**	**23**

**Source: IPA Yearbook 2014-15*

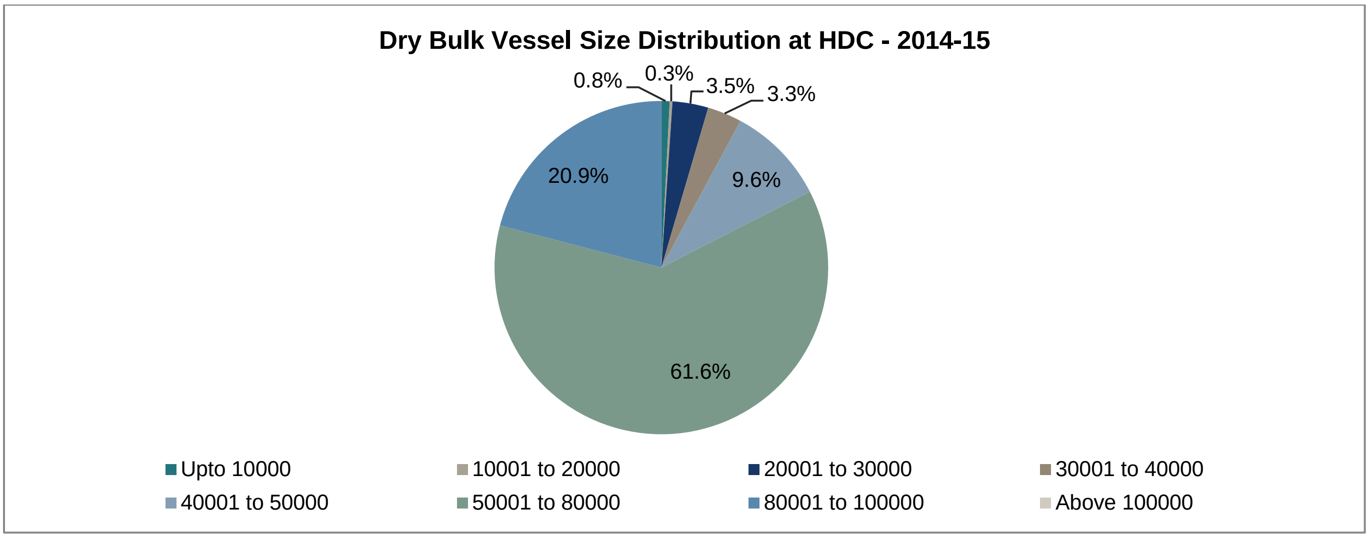
Two aspects are worthy of note in the above Table 6.2.

First, the number of container vessels calling at Kolkata and Haldia is quite large, implying that there is a demand. Paradip on the other hand hardly has any container traffic, implying that the demand from the hinterland is limited and the fact that the port has concentrated on bulk cargoes. A proper comparison of container traffic has to take in to account the new upcoming ports in Odisha as contenders for the container traffic to and from the hinterland of Eastern and Northern India.

The second aspect to be noted is the large number of bulkers above 50,000 DWT calling at Paradip, due to its deep approach channel, which is further being deepened to attract Cape size vessels. The fact that a substantial number of bulkers proceed to Haldia and Kolkata can be misleading as they carry only part loads (lower draft). Nevertheless the numbers certainly indicate the demand of the trade for import and export of bulk cargoes from the hinterland.

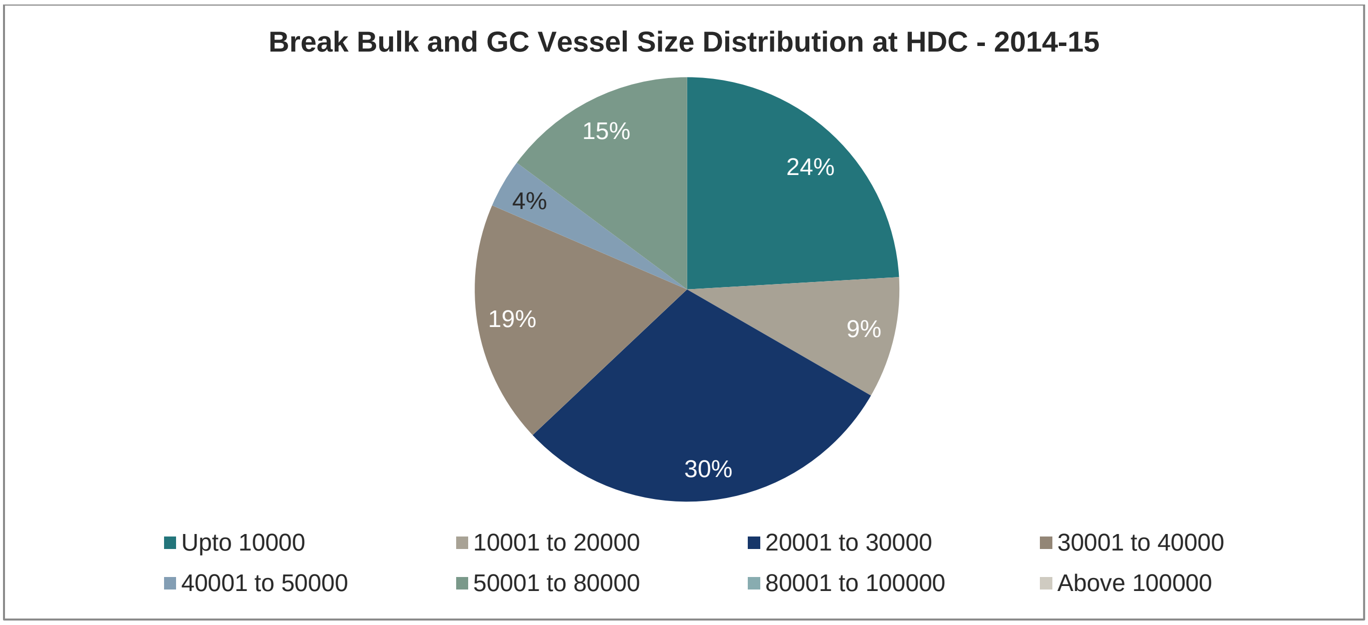
It is therefore proposed to analyze the vessel call data for the Paradip Port and Haldia Dock Complex further to identify the design vessel for the proposed Port at Rosulpur.

Figure 6.1: Vessel Size Distribution at HDC – Dry Bulk 2014-15 (IPA Data)



Thus, it can be observed that 61 % of the vessels that called at the Haldia Dock Complex is in the range of 50,000 to 80,000 DWT bulk carriers. However, the average parcel size when it comes to bulk cargo is around 24,000 DWT. It indicates that the vessels which are being called at Haldia are not fully loaded. Hence, it is evident the present Haldia approach channel is not adequate in terms of available depth to accommodate navigation of 60,000 DWT fully loaded panamax vessels and more. The average parcel size at Paradip Port is around 52,000 tonnes for Dry Bulk Cargo.

Figure 6.2: Vessel Size Distribution at HDC – Break Bulk 2014-15 (IPA Data)



When it comes to General Cargo, it can be observed that 85% of the vessels that called at Haldia Dock are below 40,000 DWT, whereas the average parcel size the vessels are carrying is around 5,187 tonnes.

Figure 6.3: Vessel Size Distribution at HDC – Container 2014-15 (IPA Data)

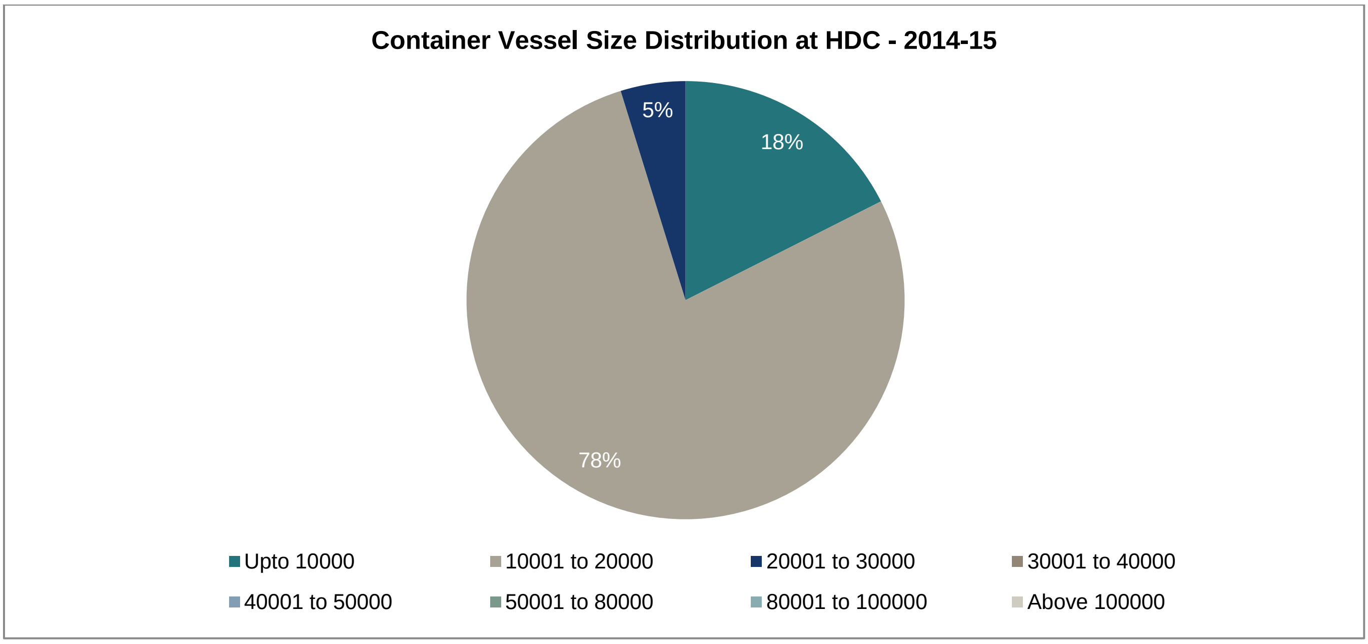
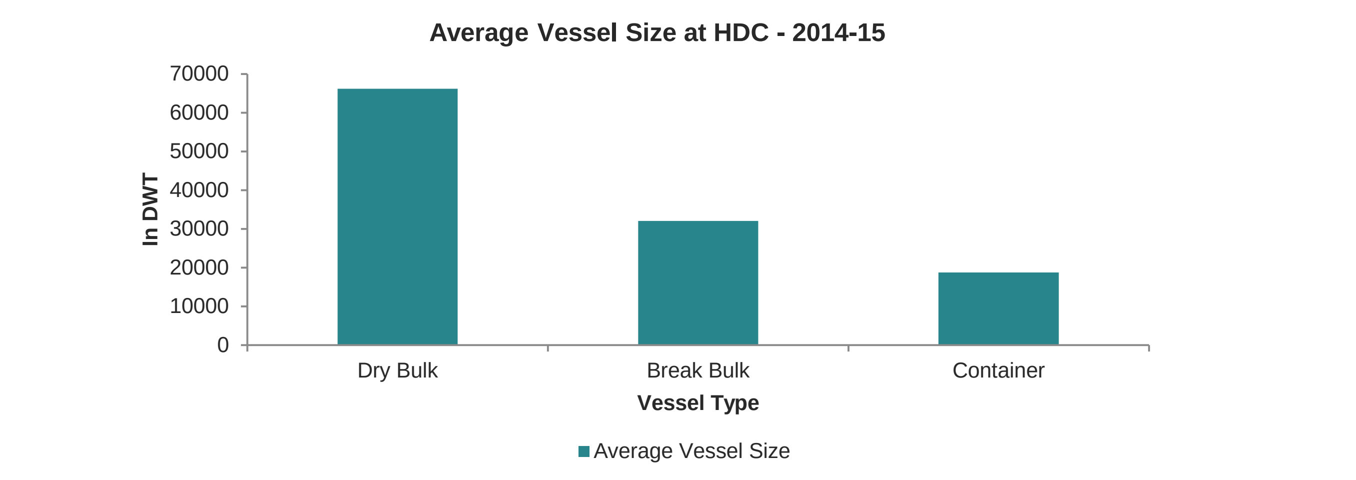


Figure 6.4: Average Vessel Size at HDC – 2014-15 (IPA Data)



6.3.2 Design Vessel for proposed Deep Draft Port

It is suggested that Phase-I development of the proposed port will be planned for the frequent berthing of Cape size Dry Bulk Carriers , berthing of Panamax size General Cargo (GC) and Break Bulk (BB) cargo vessel up to 40,000 DWT and Container Vessels up to 20,000 DWT. However, sufficient depth will be provided at berths to accommodate occasional berthing of larger vessels

Table 6.3: Vessel Size for Proposed Port – Operation Point of View

Parameters	Design Vessel – Phase 1 Development			Design Vessel - Phase2			Design Vessel - Master Plan		
	Dry Bulk	GC and BB	Container	Dry Bulk	GC and BB	Container	Dry Bulk	GC and BB	Container
Size, in DWT	Upto 100,00	30000	20000 DWT 1500 TEU	100000	60000	50000 DWT 4000 TEU	220000	60000	120000 9000 TEU
Displacement	74000	41000	27000	121000	74000	68000	250000	74000	130000
LOA, M	220	188	174	255	220	267	300	220	300
Beam, m	33.5	27.7	26.2	39	33.5	32.2	52	33	45
Loaded Draft, m	12.8	11.3	9.2	15.3	12.8	12.2	18	12.8	15

The above recommendation for the Design Vessel is based on an analysis of traffic figures at neighboring ports for the Year 2014 – 2015, as shown in Table 6.2. The new Greenfield port would come in to being around 2020. It is worth speculating here whether the above Table 6.3 is too conservative since it depends on the Traffic Forecast as seen today. The economics of Cape size ore carriers has not been felt at present, probably owing to the global recession. It may be noted that Paradip Port is already in the process of deepening its Approach Channel to accommodate larger vessels. It is therefore necessary to consider here whether the proposed vessel size for Phase 2 should be advanced to Phase 1 and that of the Master Plan, given above, advanced to Phase 2.

Fortunately, the impact of vessel size on the CAPEX of the project is restricted only to the dredged depth, which can be easily evaluated. This aspect will be further considered in Chapter 8.

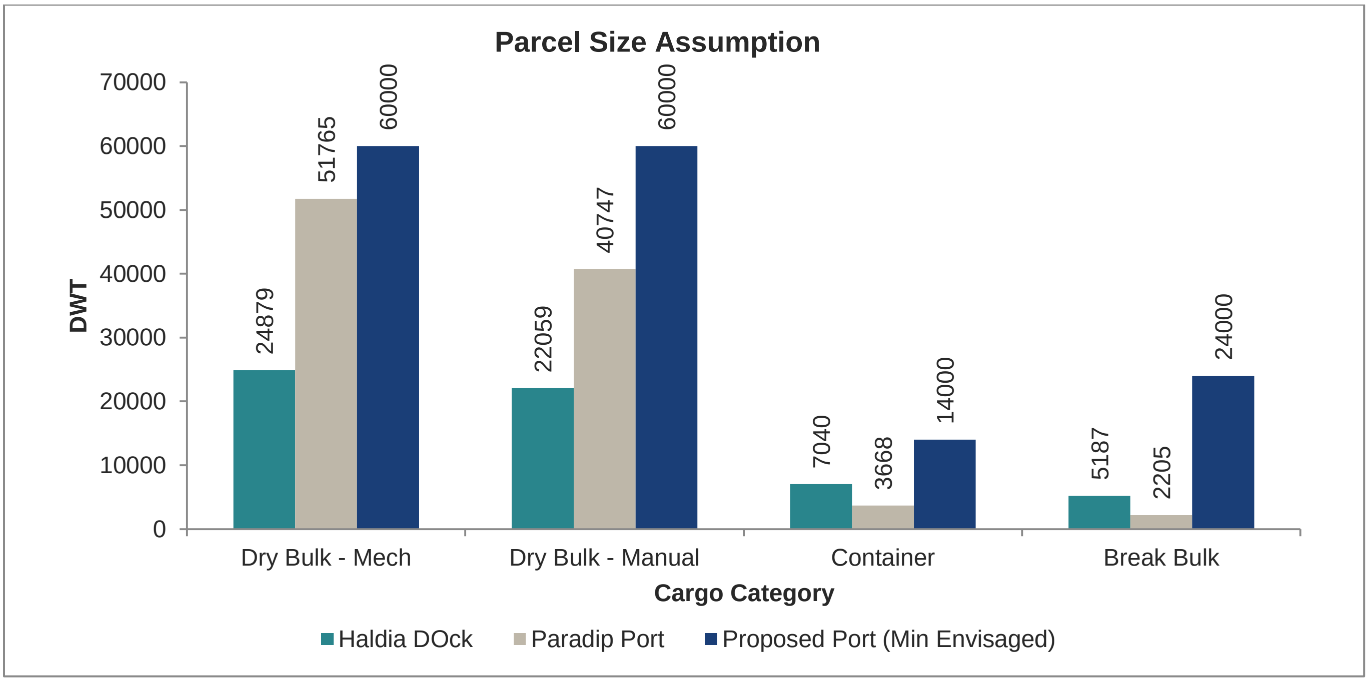
6.3.3 Parcel Size for the Proposed Port

Category-wise average parcel size at Haldia Dock and Paradip Port has been analyzed to justify the average parcel size assumed for the present proposed port. The parcel size considered for the proposed deep water port is as tabulated below.

Table 6.4: Parcel Size Consideration for the Proposed Deep Water Port Phase 1

2013-14	Haldia Dock	Paradip Port	Remark
Dry Bulk -Mech	24879	51765	60000 and above Fully Loaded Vessel
Dry Bulk -Manual	22059	40747	60000 and above Fully Loaded Vessel
Container(DWT)	7040	3668	14000 - 70 % of the vessel capacity
	-	-	1000 TEU - 70 % of the vessel capacity
BB (DWT)	5187	2205	24000 & Above - 80 % of the Vessel Capacity

Figure 6.5: Parcel Size Assumption for Proposed Deep Water Port



The following are the design vessels considered for the design of various facilities at the proposed port.

Table 6.5: Consideration for Design of Various Facilities

Components	Phases of Development of the Proposed Port	
	Phase - I	Phase-II
Approach Channel	To be designed for frequent one Way Plying of 100,000 DWT Dry Bulk Vessels utilizing the advantage of available tidal window (Mean High Water Neaps (+) 3.9 m CD).	To be maintained for frequent one Way Plying of 100,000 DWT Dry Bulk Vessels utilizing the advantage of available tidal window (Mean High Water Neaps (+) 3.9 m CD).

Components	Phases of Development of the Proposed Port	
	Phase - I	**Phase-II**
Turning Circle	To be designed for frequent one Way Plying of 100,000 DWT Dry Bulk Vessels utilizing the advantage of available tidal window (Mean High Water Neaps (+) 3.9 m CD).	To be maintained for frequent one Way Plying of 100,000 DWT Dry Bulk Vessels utilizing the advantage of available tidal window (Mean High Water Neaps (+) 3.9 m CD).
Dock	Depth at dock to be designed for berthing of 100,000 DWT vessels irrespective of tidal advantage.	Depth at dock to be designed for berthing of 100,000 DWT vessels irrespective of tidal advantage.
Barge Maneuvering Area	To be maintained at (-) 8 m CD for maneuvering of barges for transshipment via Inland Waterway.	To be maintained at (-) 8 m CD for maneuvering of barges for transshipment via Inland Waterway.
Dock Structural Design	Structurally the Berthing structures are to be designed for 100,000 DWT bulk vessels.	Structurally the Berthing structures are to be designed for 100,000 DWT bulk vessels.

7. General Considerations for Port and Harbor Design

7.1 General Concepts

A port is essentially a location on the interface between the deep sea and the land, for loading and unloading cargo. Therefore the first consideration in the planning of a greenfield port is the volume of the intended cargo. This aspect has been covered in the traffic assessment for the proposed port.

The second consideration is whether the port is expected to operate only seasonally or throughout the year. If the port is expected to operate throughout the year, meaning thereby throughout the monsoon, except for a few days a year, only then may it be called a harbor. Seasonal ports have vanished with time, except in name, and are only referred to when all-season greenfield port is to be considered.

7.2 Predicted Volume of Cargo

Cargo is the raison d'etre of a greenfield port and therefore the first consideration in the planning and design of the port. The type and volume of cargo to be handled per annum determines the vessel size and the number of calls in a year. This in turn determines the number of berths required. If the cargo to be catered to is small, a single berth is provided. In order to ensure that there is little or no demurrage being incurred due to vessels having to wait for a vacant berth, it is recommended that the berth occupancy shall not exceed 70% for a single berth.

The number of berths also depends on the possibility or otherwise of a berth being shared for different types of cargo. For example the requirement to handle containers is generally kept separate from berths which handle dry bulk cargoes, from an environmental point of view.

On the above basis, the number of berths required to cater to the projected cargo is determined, and the largest vessel is considered as the "Design Vessel".

7.3 Two Major Elements that go into the Capital Cost of a Greenfield Port

The interface between the land and the sea is a waterline, which may vary with the tide. Obviously to bring a deep draught vessel alongside to load/unload cargo has to be effected by dredging an access channel. The quantum of capital dredging forms a major component of the capital cost of the project. The length of the approach channel is therefore a major consideration in the selection of a greenfield port site, as does the maintenance of the channel to the operation cost of the facility.

The other major factor in the capital cost of a greenfield port is the need to provide protection to vessels berthed alongside the loading/unloading facility. Such protection is offered in three ways: first, locating the harbor in a sheltered estuary such as the Hugli (a design losing popularity due to heavy maintenance costs for deep draught vessels); second, locating the harbor in a lagoon (natural or artificial); and third along the coast, duly protected by long breakwaters. These aspects are discussed in a separate chapter with reference to Rosulpur.

Examples of the estuarine ports in India are of course Kolkata-Haldia and the Tapi and Narmada estuaries in Gujarat. Examples of lagoon harbors are the Inner harbor at Visakhapatnam, Paradip, Kochi, and New Mangalore. Coastal harbors are today the most popular for greenfield ports, examples being the Outer Harbor at Visakhapatnam, Gangavaram, Kattupalli, Ennore, the Madras Outer Harbor, and on the west coast at Jaigadh, Porbandar, Outer Hazira and Muldwarka. The popularity of coastal harbors has been due to intensely populated coastal areas where land acquisition is difficult, and the need to cater to very deep draught vessels, which may not be possible in riverine and lagoon ports.

7.4 Approach Channel and Tidal Entry

Where the cargo to be handled, particularly in the initial years is small, consideration is given to vessels entering and leaving the port at high tide. This may entail a vessel waiting for the tide for a few hours before entry. This is the present practice for the Kolkata – Haldia Complex and the same design principle could be adopted for the Greenfield port at Rosulpur. A reference to the tidal pattern in a given month, as shown in Chapter 2, Figure 2.6 would show the tremendous advantage in terms of depth of the dredged approach channel and its length. As cargo picks up and the trade requires it, the channel depth can be increased after say a period of 10 years. The importance of reduction in initial capital cost cannot be underestimated, as it could make an unviable project viable.

7.5 Waves Swell and Wind

Waves and swell (long period waves) play an important role in the design of the port, in that they govern the design of the breakwater system, particularly for coastal harbors. The Port layout has to be prepared in a manner such that sufficient tranquility is obtained at berth as well as in the harbor basin for the operational design conditions, which has an exceedance level of up to 3% for an all-weather harbor. The length and alignment of the breakwater is to be so designed so as to ensure that the attenuated wave height in different parts of the harbor are less than 0.6m at the berths and up to 1.20 m in the turning basin. The berths are therefore to be located in areas which are best protected from wave disturbance and away from the disturbance incident upon the harbor entrance.

The alignment of the berth should also take in to account the direction of the wind, so that mooring stresses are minimized on berthed vessels.

7.6 Maneuvering Area and Channel Dimensions for the Design Vessel

The channel width to be provided as per Indian Standards 4651-V is 5 to 8 times the beam of the design vessel for one lane and two lane channels. A maneuvering area, called a Turning Circle as required for vessels to be comfortably turned around, is required to be provided with a minimum of two ship lengths. Furthermore, in a protected harbor, there should be a stopping distance of 5 to 7 times the vessel length between the nose of the breakwater and the berth (Ref British Standards 6349).

7.7 Space to Accommodate Berth Requirements up to Master Plan

The layout should cater to the projected maximum requirement of the port in the future. Therefore the future traffic should also be taken into account while estimating the jetty requirements for the ultimate phase. With the basic infrastructure like breakwaters and dredged basin and channel in place, providing the additional barge berths will not be that capital intensive. This in future is likely to attract investors to create additional traffic handling capacity by building new berths. Therefore the layout should allow for the flexibility to accommodate additional berths.

8. Planning of Port Layout

8.1 General Aspects of the Port

Normally the feasibility of a greenfield port is undertaken on a pre-selected site. In the instant case the canvas is wider, due to various reasons, dominant amongst which is the limited shoreline of the State of West Bengal outside the delta of the Ganga, in this case the Hugli. As mentioned in Chapter 1, the scope of the feasibility study was widened to identify the best location within the Purba Medinipur District, south of and including the outfall of the Rosulpur River. An assessment of the various sites studied is presented in this Chapter.

8.2 Comparative Assessment of Sites and Site Selection

As mentioned in Chapters 2, 3 and 4, four sites were considered, viz. Rosulpur North, Rosulpur South, Mandarmoni North and Mandarmoni South. The pros and cons of each site were discussed in the respective chapters, pertaining to archival site conditions, findings at the site and connectivity. In order to undertake a comparative assessment of the sites, key parameters were identified which are crucial from a port development perspective and the sites have been evaluated and ranked on a scale of 1 to 5 against each of the parameters.

The assessment of the sites against the parameters are represented below.

1: Poor   2: Average   3: Satisfactory   4: Good   5: Very Good

Criteria	**Rosulpur North**	**Rosulpur South**	**Mandarmoni North**	**Mandarmoni South**
Availability foreshore for reclamation	3	3	4	5
Capital Dredging	1	1	3	4
Maintenance Dredging	1	1	4	4
Navigation	2	2	4	4
Breakwater	3	3	2	2
Environmental Acceptability	3	1*	2	5
Forest Clearance	1	4	4	5
KoPT Acceptability	1	1	4	5
Rail/Road Connectivity	1	3	2	4
Fallow land behind shoreline available	1	4	3	5
Social Compatibility	1	3	2	5

** High Risk: May be rejected by MOEF due to the Dariapur Mud flats.*

Thus, it may be thus noted that Mandarmoni South is clearly the best choice for the proposed Port site out of the four possible site options.

8.3 Traffic

Based on the traffic projections for the port, it is proposed that the greenfield port provides for one coal berth and one berth for iron ore and limestone as part of the bulk handling part of the proposed harbor during the first phase of development, say in the first five or ten years. A container berth is also recommended in the first phase considering a high rate of growth in the container volume expected in this region aided by infrastructural developments.

8.4 Channel Depths

Assuming that the design vessel in the Port would be restricted to a draught of 14.1 m, it appears prudent to cater to such a vessel taking advantage of the tide, which shows a value of 3.9 m for Mean High Water Neaps, suggesting a channel depth of 12.1m Chart Datum.

It may be emphasized here that all the planning with regard to channel depths and dredging have been based on Indian Navy Navigation Charts No. 123 and 351. These charts, besides being to a very small scale provide a sparse sounding, which in addition provides only the least depth in the surrounding area. A closer set of soundings is required for proper design of the approach channel during the DPR stage.

8.5 Channel Alignment

The alignment of the approach channel for the proposed port has been shown in the below diagram for both the sites i.e. Rosulpur and Mandarmoni. The alignment of channel has been carried out referring the Naval Hydrographic Chart. The alignment of channel is to be further subjected to mathematical modeling studies so as to optimize from dredging, current flow and sedimentation point of view.

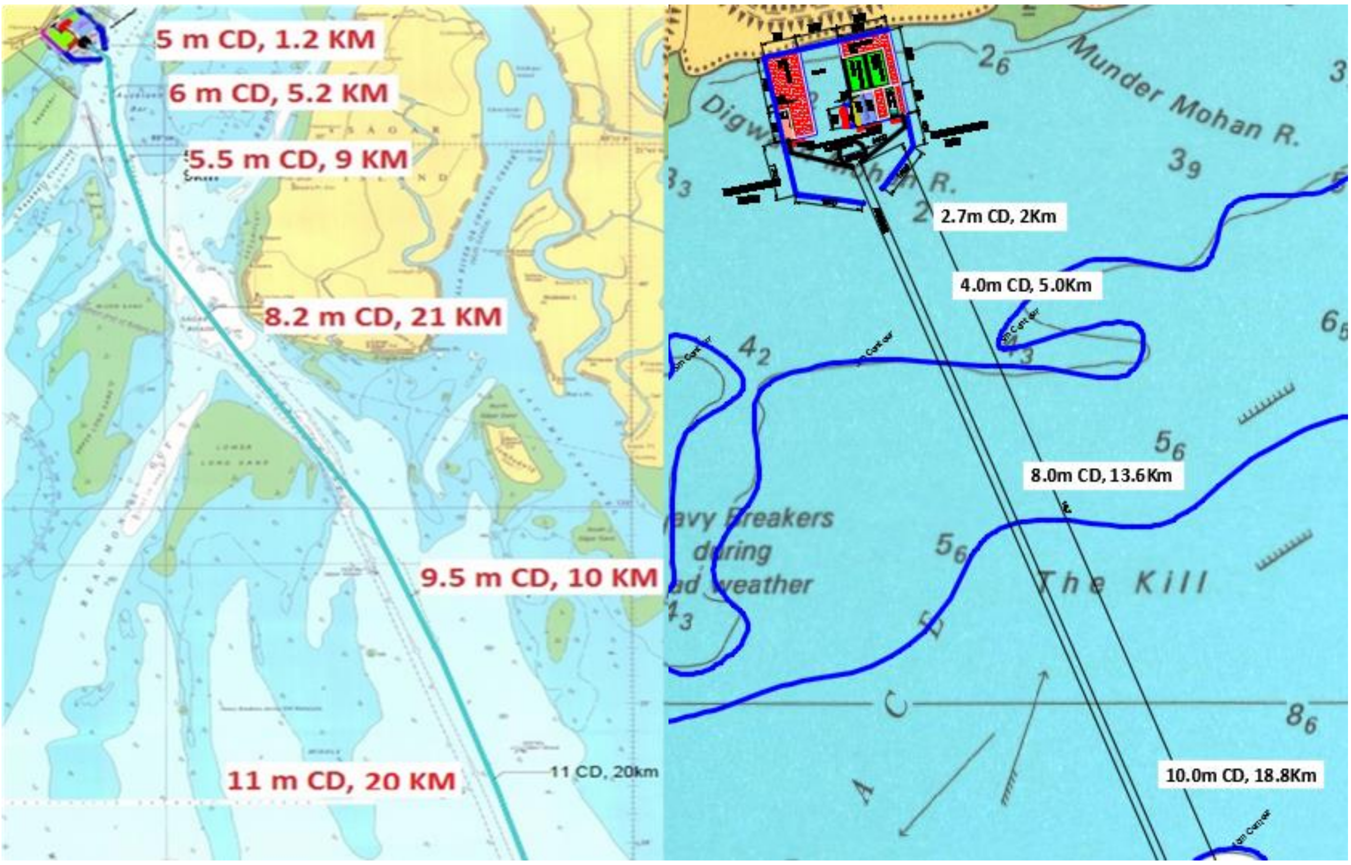
Rosulpur Site:

The approach channel for the proposed port at Rosulpur and the vessels calling for Rosulpur have to navigate through the existing Gasper and eastern channel which is presently used for navigation of vessels to calling at Haldia Dock. The length of the channel from the proposed site at Rosulpur to the VTMS (Existing Chanel) is around 93 km. The average depth at the existing channel varies from 6 to 10 m as shown in the Naval Hydrographic Chart.

Mandarmoni Site:

The length of the channel from the proposed site at Mandarmoni to the 10 m contour is around 18.8 km. The existing sea bed level at along the channel varies from 2 to 8 m below CD.

Figure 8.1: Proposed Channel Alignment for Rosulpur (L) and Mandarmoni (R) - Indicative



8.6 Breakwater Protection

The Rosulpur area is reasonably protected from storm waves by numerous shoals and islands in the area. However, waves up to 3 m have been reported, which would require protection to be provided for a port at Rosulpur. The protection has to be in the form of training walls, so that adverse flow conditions are not generated for vessels heading to and from Haldia. This implies longer training walls as that would provide the requisite shelter to the port.

At Mandarmoni, the shoreline is more exposed, but the strong tidal currents experienced in the Hugli, at Rosulpur are not experienced here. The breakwater alignment has therefore to be as normal as possible to the dominant wave directions during cyclonic weather.

A preliminary layout is given below in Figure 8.2. It may be noted that the contours have been shown notionally based on the few soundings given in IN Chart 351. The south breakwater has been restricted to the 3 m contour. The final layout would require a closer spaced hydrographic chart.

It may be seen that the container berth is kept at the southern end, upwind from the bulk berths, so that dust is avoided in the container storage area. It may be mentioned that screw type continuous unloaders have been provided, so that the bulk cargo is contained in a closed environment and stored in covered storage areas. Nevertheless, the container yard is kept upwind of the bulk cargoes.

Figure 8.2: Proposed port layout phase-1

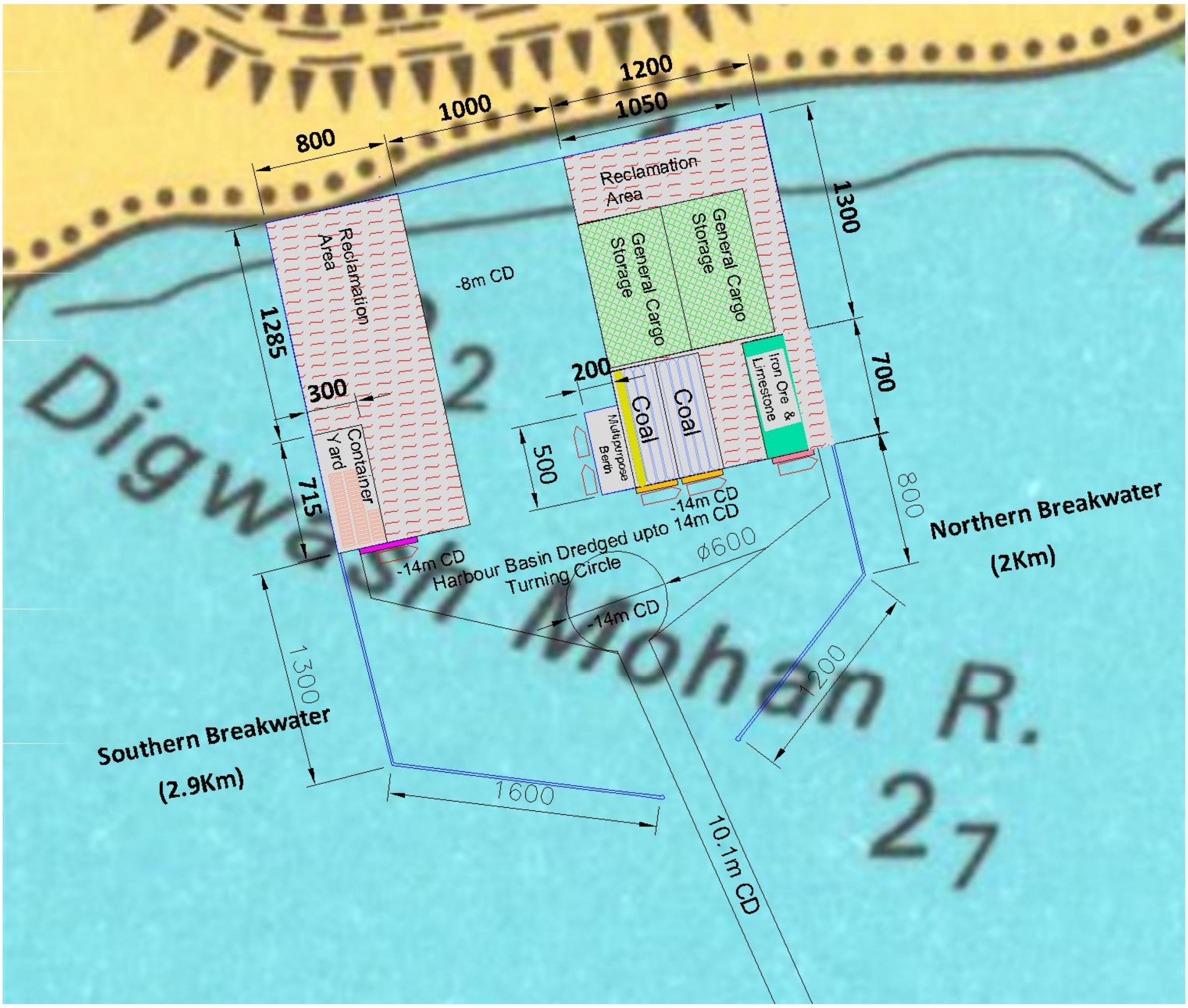


Figure 8.3: Proposed port layout phase-2

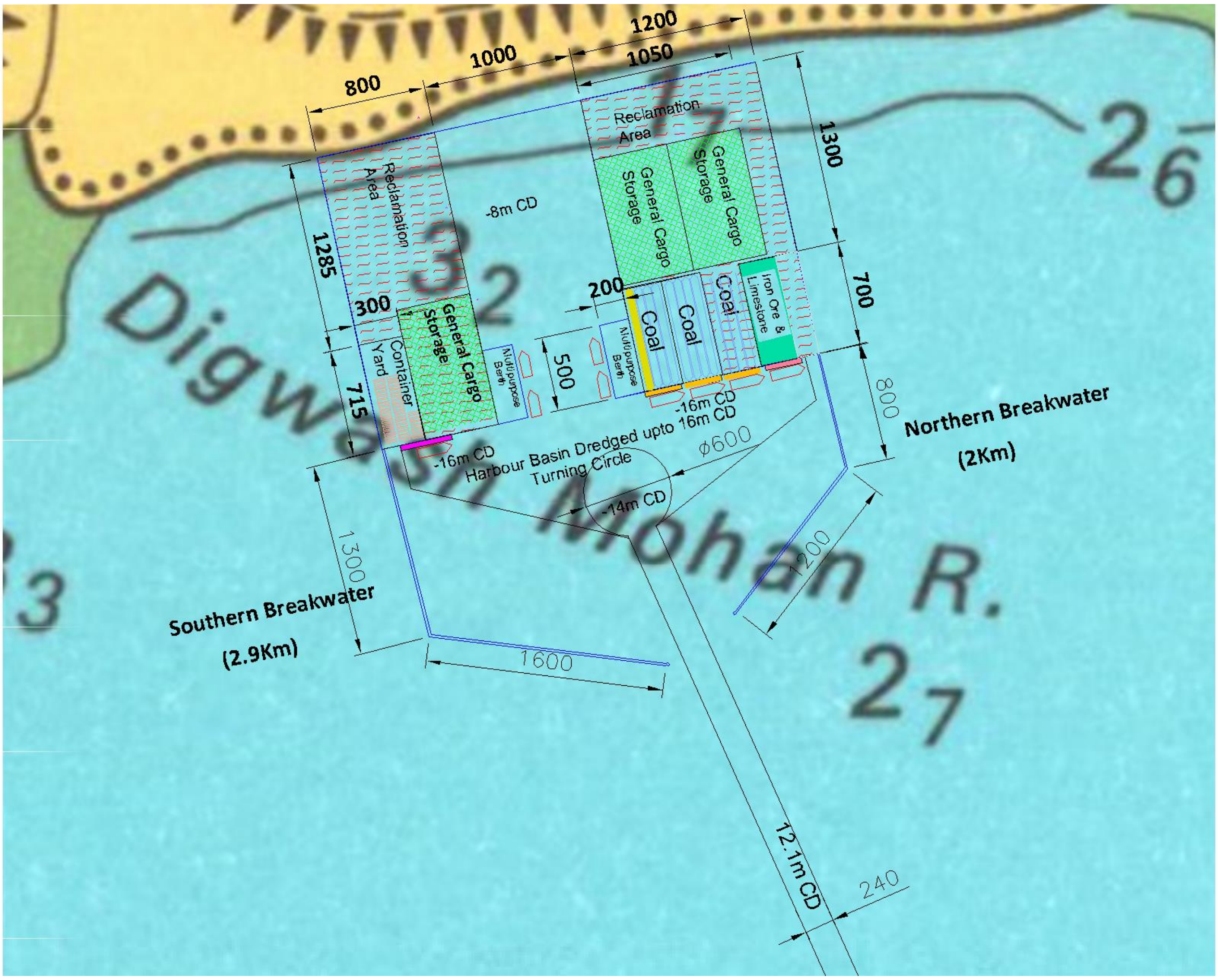
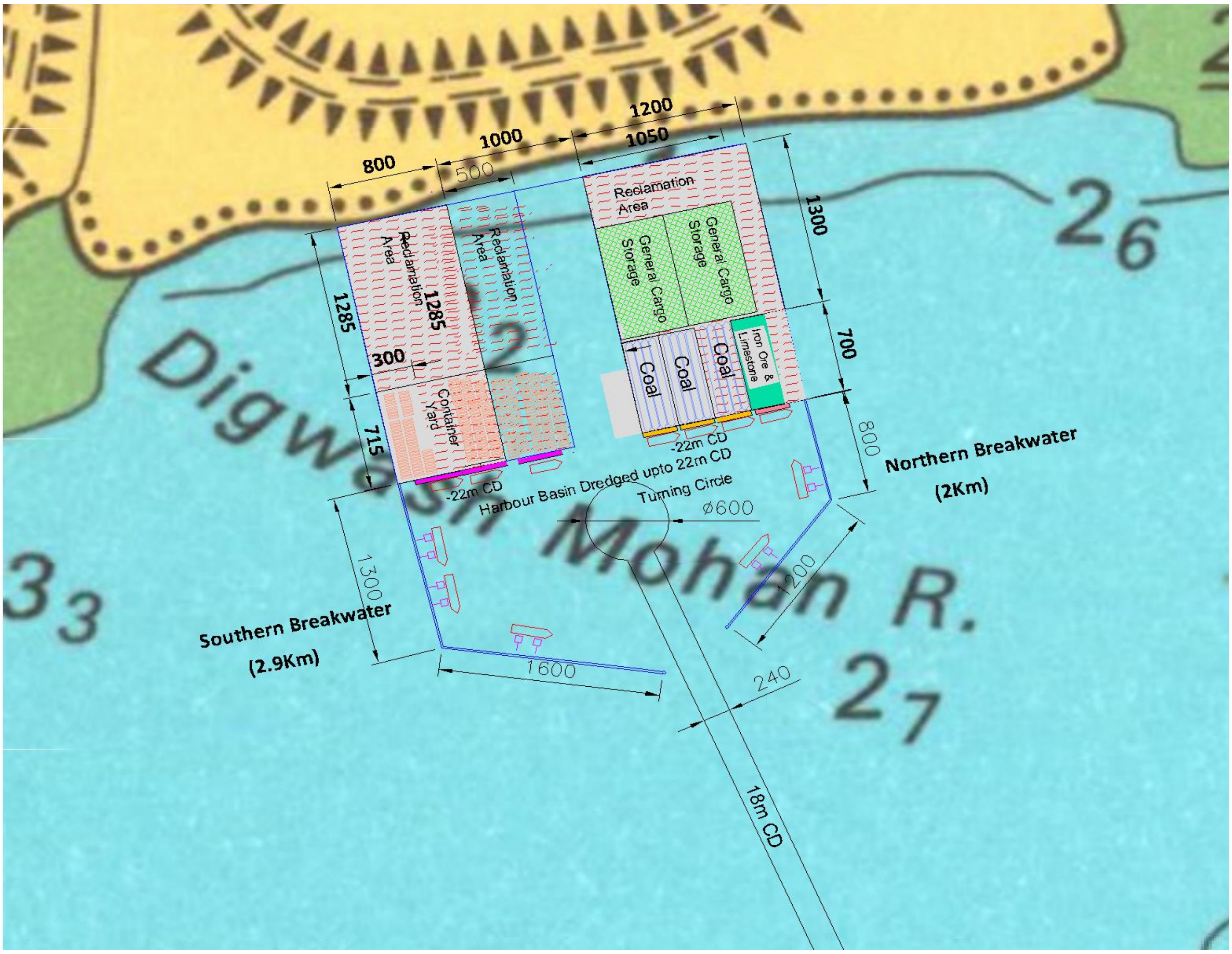


Figure 8.4: Proposed Layout Master Plan (Showing Oil Berths along the breakwater)



8.7 Dredging and Reclamation

8.7.1 Capital and maintenance dredging

Based on the channel design and the layout, the dredging quantity has been estimated and is shown below.

Table 8.1 Dredging Quantity Estimation Phase – 1 & 2

	Proposed Port at Mandarmoni		Proposed Port at Rosulpur river	
	Phase 1	**Phase 2**	**Phase 1**	**Phase 2**
Channel Depth (m)	12.1	12.1	12*	14*
Capital Dredging (Mil m^3)	62	0	175	142
Maint. Dredging (Mil m^3/y)	1.5	1.5	9	

** Due to lower tidal advantage in a longer Approach Channel*

As pointed out in Para 8.4, there is a case for deepening the channel, as soon as larger vessels begin to call at this port say 4 years down the line. Taking this into consideration it would require an early infusion of capital in phase 1, which would be justified by the growth in traffic.

As and when the traffic picks up, the channel could be deepened to 16 or 18m as part of a Master Plan, which could then accommodate as many as 25 berths. The volume of dredging would have to go up to as much by as another 90 mil m^3, so that 7 or 8 liquid berths could be accommodated alongside the breakwaters, and another 10 to 12 solid bulk berths in the Dock.

8.7.2 Reclamation

The dredged material is a resource which should be utilized in harbor construction by reclamation. Not only does it reduce the cost of reclamation by bringing in fill from land sources, but is environment friendly. The dredged material may not have the desired characteristics to take the loads of storage or transfer equipment, but technology of improving soil characteristics has advanced so far today that it is economical to consider all dredged material to be accommodated in the port reclamation. This obviates the necessity of obtaining environmental permissions for identifying suitable offshore “dumping grounds”.

In the instant case, the harbor design has been kept liberal with a 3 km protected shoreline area for future development. An attempt has been made to match the quantities of dredging and reclamation in each phase. It may be seen that there is a small deficit of 15% in the dredging quantity and the same can be adjusted by reclaiming only that portion as may be required in the beginning. Depending on the dredging rate at the time of construction, the possibility of deepening the channel beyond 12.1 m C.D. (as proposed in para 8.3) could be considered, in order to fully match the reclamation requirement.

The reclamation will be carried out by constructing two reclamation bunds/revetments on both side at 3 km apart. The Length of the revetment will be around 2 km and almost perpendicular to the shore. The reclamation will also require several sacrificial bunds to hold the dumped dredge material.

The entire land required for the project will be reclaimed utilizing the dredged material from the channel and the harbor area. The Land can be developed in two phases. As given in the table below, in Phase 1 FY 2025 the land requirement is estimated to be 170 Ha and in Phase 2 FY 2045 and requirement is 288 Ha. As the dredging material volume is much more, the entire area can be filled during Phase 1 construction stage. However, development of area beyond 170 Ha i.e. Phase 2 stack yard, pavement and other facilities can be taken up in FY 2045.

Description	FY'21	FY'25	FY'30	FY'35	FY'40	FY'45	FY'47
Total Area (in Ha)	59	170	170	249	249	288	288

8.8 Mechanical Equipment

The containerized cargo has a slow take-off, and it is recommended that two Rail Mounted Quay Cranes (RMQC) could be considered based on best practices followed in the industry.

With regard to bulk unloading, the traditional method has been to use grab unloaders, which are low in cost but a source of pollution. Many coal ports in Gujarat have received closure orders for this reason and have been given time by the National Green Tribunal to rectify matters. It is recommended here that the Greenfield Port could be developed as an environment friendly port and could utilize continuous unloaders which are environment friendly.

9. Design of Breakwater System

9.1 General

The purpose of a breakwater system is to permit round the year loading and unloading of cargo, except for a few days a year, when there is stormy weather. The wave climate at the proposed port has been analyzed in Chapter 2 and presented in Fig. 2.8. It is seen therefrom that the major direction of approach of the waves is from SSE, where less than 2% of the waves are between 2.5 and 3 m. Secondary directions of relevance are from the East and ENE. The wave height of 2.5 m to 3 m over the three directions is less than 4%.

Several ports have been designed on the basis of such wave rose diagrams with the harbor operational design being kept at 97%. It is the experience over the years that such designs provide 99% workability for cargo operations.

Before coming to the alignment of breakwater protection works, one has to ascertain the nearshore wave direction which has to consider the *refraction* of waves from the directions given in Fig. 2.8

9.2 Refraction of Waves from offshore to near shore

Refraction is a process of wheeling around of waves as they approach shallow waters, enabling the angle of approach to become more normal to the contours and the shoreline, This is caused by the lower velocity of the wave front in shallower waters.

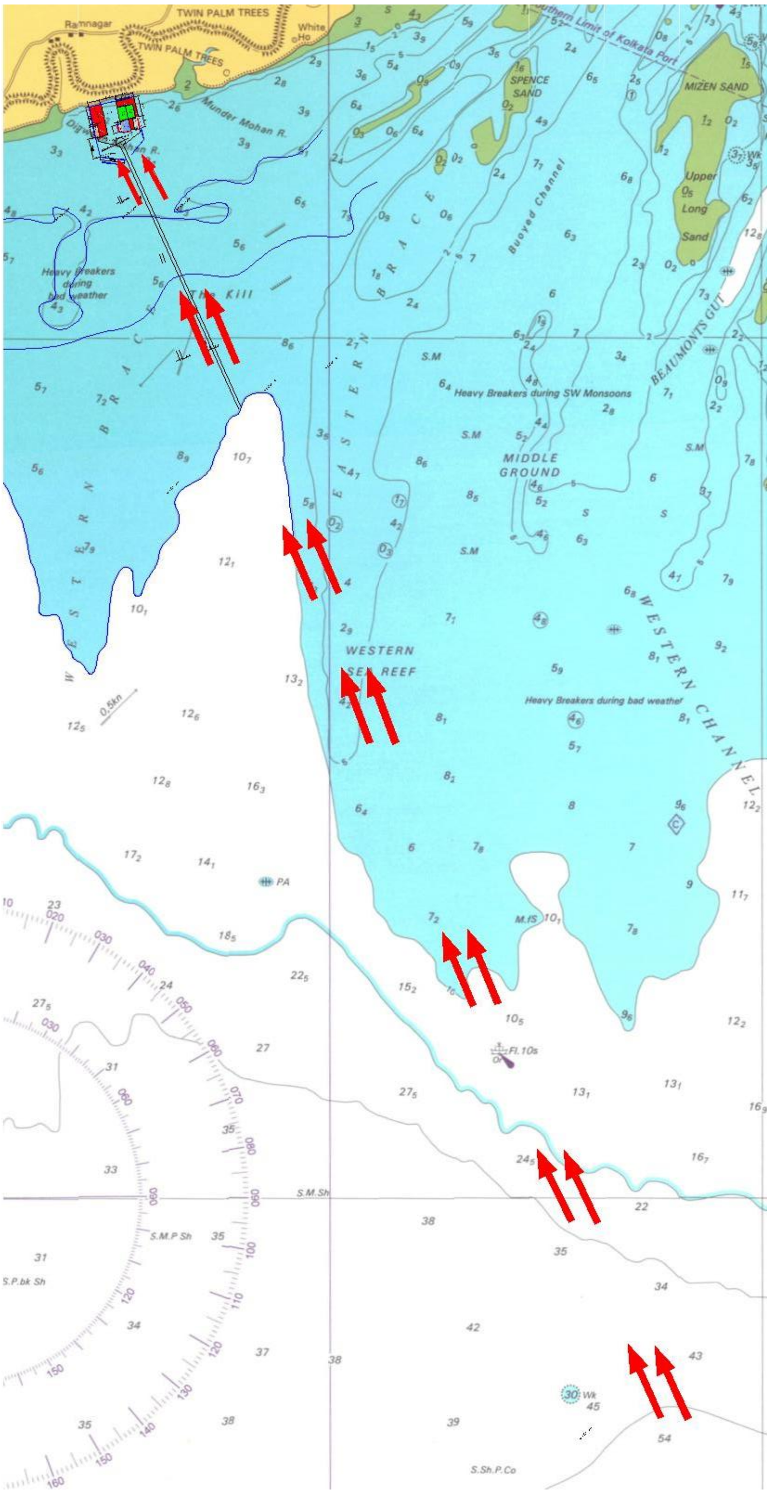
The refraction diagram shown below in Fig. 9.1 shows that there is only a 7^0 rotation of the SSE waves as they approach the shoreline. This minimal refraction is due to the fact that the SSE direction is almost normal to the shoreline. Because of the small refraction, the wave spreading is minimal and the external wave height at the harbor remains unchanged.

9.3 Diffraction of Waves around Harbor Opening

The purpose of breakwaters is to block the waves at the harbor entrance so that the loading and unloading of cargo is not affected due to wave-induced ship motions. In particular, cargo operations are affected by the rolling motion of ships which should be avoided throughout the year except for the very few days when there is stormy weather. While the breakwater system essentially blocks out the wave energy, some energy enters through the harbor entrance and *diffracts around* the nose(s) of the breakwater system. This process of energy transfer along the wave crest is similar to the diffraction of light as would be seen in a dark room, with a small window.

The breakwater alignment has to be so chosen that the diffracted wave height at the berth is acceptable for the cargo being handled. The tranquility desired in a harbor is mentioned in various Standards.

Figure 9.1 Wave refraction Pattern from SSE direction towards Shankarpur-Tajpur Shoreline



IS : 4651 (Part V) - 1980

5.4.1 *Waves* — As a general rule the wave disturbance within the harbour should not exceed the following tranquility condition:

	Maximum Significant Wave Height in m		
	At berth	Turning basin	Offshore mooring
General cargo	0·65	0·90	1·50
Bulk cargo	0·90	1·20	1·50 for berthing 2·50 for operation
Container cargo	0·65	1·20	—
Passenger vessel	0·65	—	—
Trawler and fishing boats	0·60-0·90	—	—

The breakwaters shown in Fig. 8.2 for the first phase are designed to provide tranquility of 0.3 m at the container berth and the coal berth, and 0.6 m at the General Cargo and Other Bulk Berths. These conditions are better than those required under Indian Standards and compare to other global standards.

9.4 Breakwaters

9.4.1 Design parameters

The design parameters, procedures and results for the proposed breakwaters and coastal protection works are briefly explained in this section. The breakwater designs have been carried out in accordance with BIS 4651 and US Army Coastal Engineering Manual (2011).

As mentioned in para 2.7.4, a wave height of 100 or 200 year return period is generally considered in designing the breakwaters. The design, in the instant case, is however governed by waves of a smaller wave height as would break in the given depth. Overtopping is permitted since the berths are not in the immediate lee of the breakwater.

9.4.2 Design procedure

It is presumed that the quarries in the nearby hills are capable of producing armour stones of up to 5 to 6 tonnes with modern blasting/rock splitting techniques. As long as the rock armour size required is well within the quarriable size, rock is proposed be used as primary armour. If the sizes are impracticably large, it is proposed to resort to the adoption of concrete armour blocks of high stability coefficient, such as Accropodes.

The proposed breakwaters are designed using the Hudson formula and the stability (K_D) values for breaking waves are taken into account for obtaining the weight of armor blocks.

$$W_{50} = \frac{W_r H^3}{K_D (S_r - 1)^3 \cot\theta}$$

Where,

W_{50} is the weight of the armour unit,

γ is the weight density of armour unit,

H is the design wave height and denotes,

$$H_{\frac{1}{10}} \left(H_{\frac{1}{10}} = 1.27\, H_S \right)$$

K_D is the stability coefficient

Δ is the specific gravity of armour unit relative to sea water,

Cot α is the breakwater structure side slope (H/V).

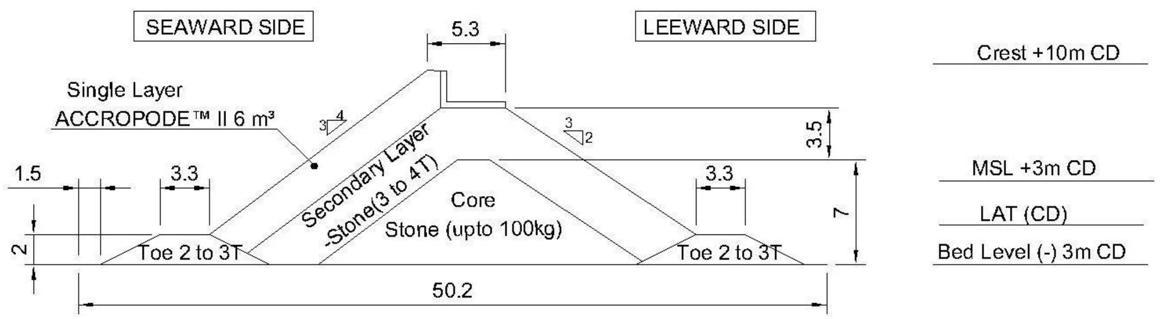
Both southern and northern breakwaters are designed considering nominal overtopping measured and recorded account during the construction phase of breakwaters.

Based on the design criteria for breakwater, cross-sections of Southern and Northern breakwater were worked out.

9.4.3 Design of the South Breakwater

The design of the armor for the trunk section of the South Breakwater is given here as an example. The design has to take in to account the wave height that can be sustained in the given depth of water, or the cyclonic wave height determined in Chapter 2, whichever is less. The spring tide high water level is + 5.2 m CD, giving a depth of water of 8.2 m at the 3 m contour. The breaking wave that can be sustained in this depth is 6.4 m, which has been taken as the design wave height. In shallower waters, the design wave height is suitably reduced. A typical section at the 3 m contour is given below.

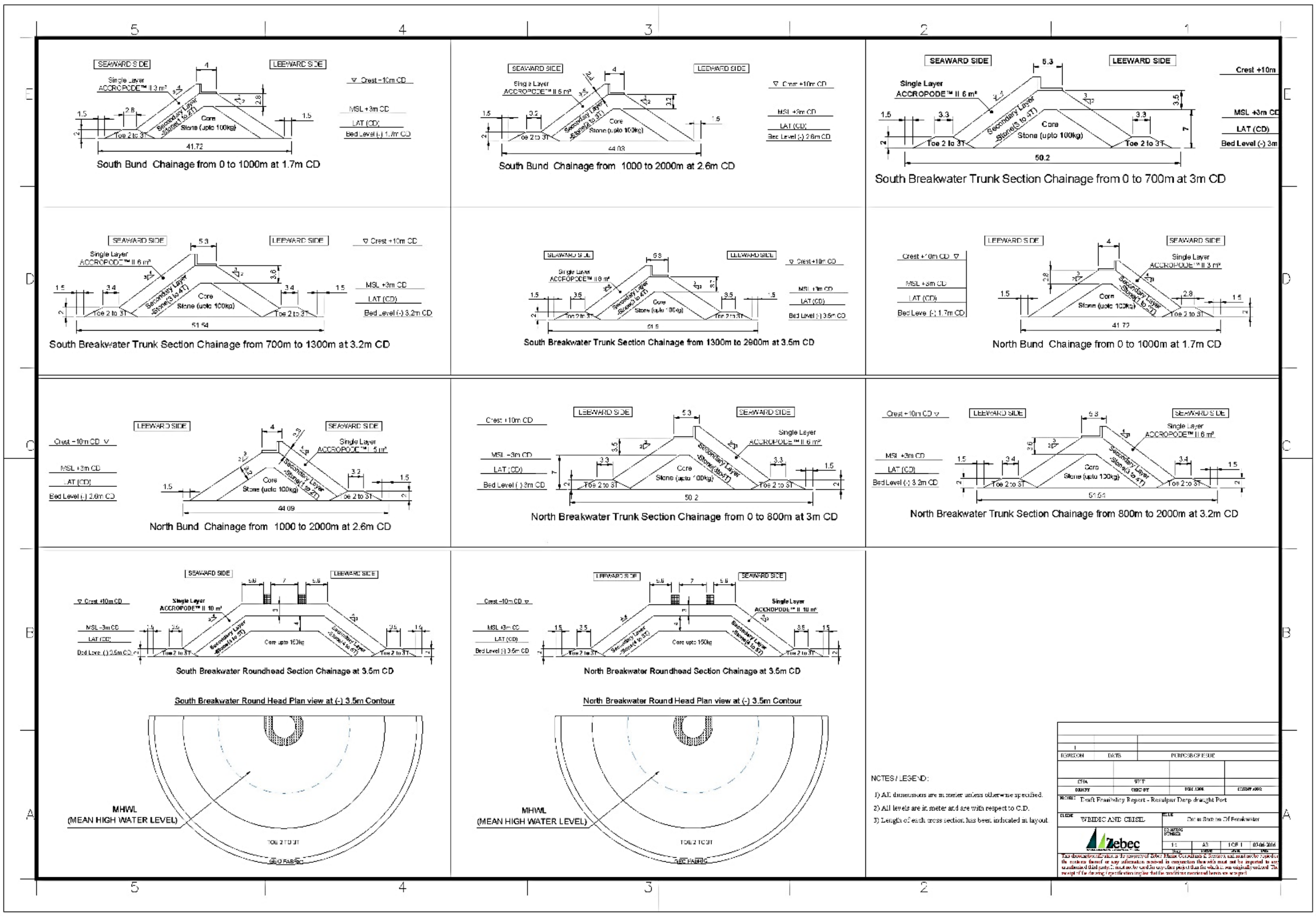
Figure 9.1: Design of the Trunk Section of the South Breakwater at the 3 m contour



South Breakwater Trunk Section Chainage from 0 to 700m at 3m CD

Other sections are given in the attached plate.

Figure 9.2: Breakwater Cross-sections



9.4.4 Littoral Drift

Waves in deeper waters are oscillatory in nature, meaning thereby that there is no mass transport towards the shore. However, as the waves approach shallow water, breaking occur, whereby there is a translator movement towards the shore, thus generating what is called a littoral current. As the wave height increases, the current carries the beach sand parallel to the shore, called littoral drift.

The phenomenon of littoral drift is most visible on the east coast of India, where the drift increases from about 0.5 million m^3 at Chennai to about 2 million m^3 per annum at Paradip. As one proceeds further north from Paradip, the shoreline turns eastward, until it is nearly normal to the direction of waves, which are dominantly from the Southeast. The angle of approach at Shankarpur is almost normal, about 83^0 to the shoreline, as a result of which it is estimated that the littoral drift is less than 100,000 m3/y.

The construction of a structure, such as a breakwater normal to the shore blocks the littoral movement, as a result of which erosion is experienced to the downdrift. It is therefore necessary, in order to ensure stability of the shoreline, to make arrangements to bypass the drift. Hitherto bypassing plants have not been very successful due to the quick breakdown of the propellers. Hence bypassing has had to be undertaken by dredgers, physically moving the dredged material by sailing from the up drift side to the downdrift side of the harbor to transfer the hindered littoral drift. Recently however, sand pumps have been developed in the United States, that have been successful for bypassing arrangements, and it is proposed to allow for the import of the pumps, together with the expert support, while framing the CAPEX. This is considered necessary, even though the littoral drift has been calculated to be insignificant, so that the neighboring Mandarmoni Beach is not affected in any manner.

10. Infrastructure and Facility Requirement

10.1 General

Infrastructure and the facility requirement of the proposed port would entail land reclamation, dredging of approach channel and harbor basin, provision of civil structures, material handling equipment, electrical power supply, and utilities such as water, lighting, sewage handling, etc. The dredged material from the approach channel, harbor basin and along the berths shall be utilized as material for reclamation. In order to optimize the alignment/ orientation of the approach channel and dock alignment, hydrographic survey would be required during the DPR stage.

Basis of facility requirement estimation:

Basis the traffic projection for the proposed port the facilities that are required to handle projected annual throughput are shown below categorized as seaward side facilities and landside facilities respectively.

Table 10.1: Various facilities required

No.	Sea Side Facilities	Land Side Facilities
1	Navigation Channel	Breakwater
2	Turning Circle	Berthing Structure
3	Harbor Basin – Maneuvering Area	Material Handling Equipment at Berth
4	Navigational Aids	Storage Facilities – Land to be reclaimed
5	Tugs and Pilot Launch	Material Handling Equipment at Stockyard
6	-	Evacuation of cargo
7	-	Connectivity – External
8	-	Electrical Power Supply
9	-	Utilities, Power Supply, Fire Fighting, Buildings, Security, IT, VTMS, Etc.

10.2 Projected Annual Throughput

The table below shows the projected traffic for the proposed port.

Table 10.2: Projected Throughput for Proposed Port - MMTPA/MTEU

MTPA	FY21	FY25	FY30	FY35	FY40	FY45	FY47
Thermal Coal (I)	1.3	7.1	8.1	8.5	8.9	9.4	9.6
Thermal Coal (E)	0.1	0.4	0.4	0.4	0.5	0.5	0.5
Coking coal (I)	1.9	10.1	11.9	14.1	16.7	19.7	21.0
Iron Ore (E)	0.2	1.5	2.5	3.1	3.5	3.8	4.0
Limestone (I)	0.5	2.7	3.2	3.8	4.5	5.3	5.7
Limestone (E)	0.2	1.2	1.4	1.6	1.9	2.3	2.4
Other Cargo (Dry bulk and Break bulk) - I	0.6	3.8	5.5	6.5	7.2	8.1	8.4
Other Cargo (Dry bulk and Break bulk) - E	0.3	1.6	2.4	2.8	3.1	3.5	3.6
Total (excluding containers)	5.1	28.4	35.4	40.9	46.3	52.5	55.2
Containers (in MTEU) - I	0.02	0.13	0.26	0.35	0.41	0.47	0.50
Containers (in MTEU) - E	0.02	0.13	0.26	0.35	0.41	0.47	0.50

Based on the nature of cargo, handling method, and projected volume the commodities envisaged to be handled at proposed port has been categorized as given in the below table.

Table 10.3: Categorization of Cargo envisaged for Proposed Port

Cargo Category	**Commodities**	**Type of Terminal Envisaged**
Category 1: Dry Bulk (Coal)	Thermal Coal, Coking Coal	Dedicated fully mechanized coal import terminal
Category 2: Other Dry Bulk (Iron Ore), General Cargo and Break-bulk	Iron Ore (E), Thermal Coal (E),Limestone, Other General and Break-bulk Cargo	Multi cargo terminal with Harbor Mobile Crane arrangement at berth – Manual Handling
Category 3: Container	Containerized cargo	Dedicated container terminal with RMQC at Berth

**Coastal movement to power plants in TN/AP*

Table 10.4: Projected Annual Throughput - Categorization Based –MMTPA/MTEU

Commodities (in MTPA)	**FY21**	**FY25**	**FY30**	**FY35**	**FY40**	**FY45**	**FY47**
Category 1: Dry Bulk (Thermal Coal, Coking Coal) – Import							
Thermal Coal (I)	1.28	7.13	8.08	8.49	8.93	9.38	9.57
Coking coal (I)	1.92	10.00	11.82	13.97	16.51	19.51	20.86
Total	3.20	17.12	19.90	22.46	25.44	28.90	30.43
Category 2: Other dry bulk, General Cargo and Break-bulk (Iron Ore (E), Thermal Coal (E),Limestone, Other General and Break-bulk Cargo)							
Iron Ore (E)	0.2	1.5	2.5	3.1	3.5	3.8	4.0
Limestone (I+E)	0.74	3.89	4.59	5.43	6.42	7.58	8.11
Thermal Coal (E)	0.07	0.38	0.43	0.45	0.47	0.49	0.50
Other Cargo (Dry bulk and Break bulk) - I + E	0.87	5.39	7.78	9.23	10.24	11.39	11.89
Total	1.88	11.08	15.26	18.17	20.51	23.20	24.39

Commodities (in MTPA)	FY21	FY25	FY30	FY35	FY40	FY45	FY47
Category 3: Container (Containerized cargo)							
Containers in MTEU (I + E)	0.03	0.27	0.53	0.70	0.81	0.94	1.00
Containers in MMTPA (I +E)	0.46	3.71	7.39	9.79	11.35	13.16	13.96
Total Projected Annual Throughput							
Total Traffic (MMTPA) – Except Container	5.08	28.20	35.15	40.63	45.95	52.10	54.82

10.3 Water side Facilities

10.3.1 Navigation Channel

With the type and dimensions of the design ship identified, and by considering the environmental and physical ocean parameters, the preliminary design of the approach channel has been carried out. On the basis of which a 200 m channel is provided in Phase 1 and 240 m in Phase 2.

10.3.2 Turning Circle

The dimension of the turning circle is taken as 600 m based on two ship lengths of the largest vessel. There is scope for widening the same as and when longer vessels are expected in the Master Plan stage.

10.3.3 Harbor Basin – Maneuvering Area

The harbor area will be utilized for the maneuvering the larger container and dry bulk cargo vessels. It shall also be used as a temporary short term waiting area for incoming/ outgoing traffic.

The inner basin is to be utilized for the maneuvering of the barges for transshipment of cargo via Inland Waterways Barges. The width in Phases 1 and 2 is more than required, and would reduce to 500 m in The Master Plan stage.

10.3.4 Navigational Aids

The proposed development involves creating channel and breakwater. To identify the channel and the turning area, marker buoys are to be provided.

In addition port facility with breakwater lights and berth corner lights will be provided.

10.3.5 Tugs & Pilot Launch

Based on traffic three tugs and 1 launch is required in Phase 1 and to be increased to 5 Tugs and 2 Pilot launches in Phase 2. To handle the proposed vessel size, it will be necessary to have three tugs of 50 t bollard pull, one of which will be installed with fire-fighting arrangements, to act as a fire float in case of any emergency. Also, the tug shall have pollution control equipment on board.

10.4 Terminal Facilities

10.4.1 Cargo Handling Rate

The following cargo handling rates has been considered for the planning of berths for the proposed port.

Cargo Category	Commodities	Type of Terminal	Vessel Size 60000 DWT and Above	30000 – 60000 DWT	Up to 30000 DWT
			Parcel Size		
Category 1: Dry Bulk	Thermal Coal, Coking Coal	Mechanized	35000 – 40000 TPD	25000 – 35000 TPD	-
Category 2: General Cargo and Break-bulk	Iron Ore (E)	Manual - HMC	35000 – 45000 TPD	25000 - 35000 TPD	-
	Thermal Coal (E)		30000 – 35000 TPD	25000 - 30000 TPD	-
	Limestone, Other General and Break-bulk Cargo		-	12000 – 16000 TPD	12000 TPD
Category 3: Container	Containerized cargo	Mechanized	-	-	-

10.4.2 Mechanical Handling Equipment – Dry Bulk Terminal

10.4.2.1 Continuous Screw Unloaders

The coal terminal in the proposed port will be an import terminal. The coal will be unloaded with the help of continuous mechanical screw type unloaders and will be transported through conveyors system to a covered stockyard. The coal will be evacuated mainly through rails to the end users. For the proposed port, the coal unloaded will be evacuated by Rail, Road and Inland Waterways. The percentage of coal to be evacuated by various modes is assumed as tabulated below:

Table 10.5: Mode of Evacuation of Coal – Percentage Split

Evacuation Mode	Rail	Road	Inland Waterway
Percentage coal	65	15	20

Continuous screw unloaders has the utility of unloading enormous bulk cargo in docks and has the main features of big unloading capacity and of being able to unload various cargoes

Figure 10.1: Continuous Screw Unloaders

10.4.2.2 Stacker Reclaimer

The unloaded coal shall be conveyed from the berth to stack yard via a belt conveyor system.

The coal to be unloaded at the berth will be conveyed to the stackyard by troughed belt conveyor for staking. The major portion of the coal will be evacuated by rail apart from evacuation via road and inland waterway. The cargo from the stackyard will be reclaimed and loaded in to wagon. Suitable stackers and reclaimers are to be provided at the stackyard for efficient operation.

Figure 10.2: Stacker – Reclaimer with covered shed

(Source: Image courtesy Sandvik Mining)

10.4.2.3 Rapid Rail Loading System (RRLS)

A Rapid Rail loading System shall be provided for efficient loading into wagons which shall subsequently be transferred to rail wagons. A dedicated conveyor system is provided for loading coal from the jetty conveyor to the

Rapid Rail Loading System (RRLS).Coal can be fed to the RRLS through multiple conveyors at any point of time. Considering coal will be fed to the RRLS with two numbers of conveyors during peak time, RRLS with average loading capacity of 4000 TPH has been considered.

Figure 10.3: Rapid Rail Loading System

Source: Image courtesy Tenova TAKRAF

10.4.2.4 Truck Loading System

A dedicated loading station for trucking of cargo can be provided to cater for movement of smaller coal parcels to nearby users. A connected type conveyor system shall carry the coal to the loader.

Sheltered storage area for stacking of coal has been envisaged to avoid dust pollution.

10.4.3 Mechanical Handling Equipment – Multi Cargo Terminal

10.4.3.1 Harbor Mobile Cranes - Multi-cargo terminal

The multi cargo berth will be equipped with Level Luffing Wharf Cranes or HMC and these cranes can also be utilized for loading unloading of containers, if required.

The cargo shall be stowed with the help of fork lifts in covered sheds and mobilized to the end user vide rail, road or via the Indian water ways.

Figure 10.4: Level Luffing Wharf Cranes and Sling Arrangements

10.4.3.2 Equipment at Stackyard

Following are the equipment required at the terminal for handling of the cargo. Major of the cargo are envisaged to be evacuated by road. However it is also envisaged that the evacuation of the cargo can also be carried out vial rail and inland waterway.

- HMC : 50 tons
- Fork Lift : 5 Ton x 2 Nos.
- Pay Loaders : 10 Tons
- Dumpers : 15 - 25 tons

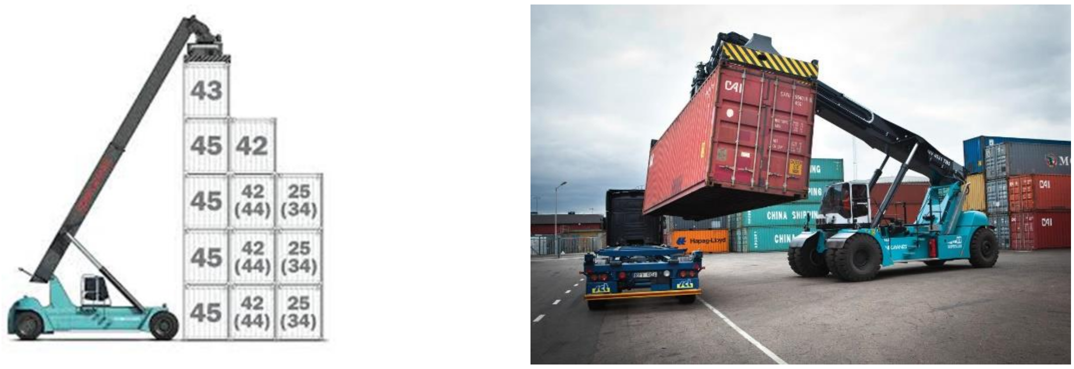
10.4.4 Mechanical Handling Equipment – Container Terminal

As the container annual through put projected is around 0.3 m TEU in 2025, the terminal can be provided with RMQC for the handling of containers. The deployment of RMQC can be phased out in line to the increase in the annual throughput. The Container throughput as projected is sufficient enough to justify a dedicated container terminal equipped with RTG at the stack yard. Major number of containers is expected to be evacuated by Rail while some will be evacuated by road and inland water way also.

Stockyards will also be equipped with adequate numbers of other container handling equipment's e.g. tractors, trailers, empty handlers, reach stackers etc. The container will be loaded into long haul trains using RMGC for further evacuation. The equipment at the stack yard and Rail loading area can also be phased to cater to the increase in container annual throughput.

Figure 10.5: Rail Mounted Quay Cranes (RMQC) & Rubber Tyre Gantry Crane(RTGC)

Figure 10.6: Empty Container Handler and Reach Stacker



10.4.5 List of Mechanical Handling Equipment's

Based on the above assumption, the required capacity and numbers of mechanical handling equipment's at the berth and stack yard has been estimated and is as tabulated below:-

Table 10.6: Summary – Mechanical Handling Equipment's required

Equipment's	Spec	Unit	FY21	FY25	FY30	FY35	FY40	FY45	FY47
Coal Terminal – Mechanized Import Terminal									
Number of Berths	24 m width	Nos	1	2	2	2	3	3	3
Unloaders - Continuous	2000 TPH	Nos	1	2	2	4	4	4	4
Jetty Conveyor – 2 rows	2000 TPH	Mtr	550	1111	1068	1063	1570	1570	1570
Junction House - Jetty		Nos	1	2	2	2	3	3	3
Drive House - Jetty		Nos	1	2	2	2	3	3	3
Stacker/Reclaimer	2000 TPH		2	2	2	4	4	4	4
Conveyor Belt	2000 TPH	Mtr	2450	4900	4900	4900	7350	7350	7350
Junction House - Stack yard		Nos	4	8	8	8	12	12	12
Drive House - Stack yard		Nos	2	4	4	4	6	6	6
RRLS	4500 TPH	Nos	1	2	2	2	3	3	3
RRLS Conveyor – 2 rows	2200 TPH	Mtr	800	1600	1600	1600	2400	2400	2400
Truck Loader		Nos	1	2	2	2	3	3	3
Pay Loader/Dozers		Nos	4	8	8	8	12	12	12
MC Terminal									
Number of Berths	38 m width	Nos	1	2	3	3	4	4	4
HMC	50 tons	Nos	2	2	2	2	4	4	4
Fork Lift	5 Ton	Nos	4	4	4	4	6	6	6
Pay Loaders	10 Tons	Nos	3	3	3	3	9	9	9
	Dumpers	NOs	2	6	8	10	10	12	12
Container Terminal									
Number of Berths	60 m width	Nos	1	1	1	1	1	1	1
RMQC	Panamax	Nos	0	2	2	3	4	4	4
RTGC		Nos	0	8	8	11	14	14	14
RMGC		Nos	0	2	2	4	6	6	6
Reach Stackers		Nos	0	2	2	3	4	4	4
TTU		Nos	0	18	18	26	34	34	34

10.5 Storage Facility

A one month storage capacity of import and/or export commodity is the norm. By efficient mechanization and speedy evacuation of the commodity by rail or a suitable conveying system, this storage capacity can be optimized and reduced.

10.5.1 Bulk Cargo Storage

Angle of repose, stack height, stack density, peak factor are some criteria that are considered for sizing of the area required for storing bulk commodities. Sufficient buffer area should be considered for various conveyor trestles, workshops, utility arrangements, stacker reclaimer rails.

Table 10.7: Storage Area Calculation for Dry Bulk Terminal (coal)

Description	Unit	FY21	FY25	FY30	FY35	FY40	FY45	FY47
Annual Throughput	MMTPA	3.27	17.50	20.32	22.91	25.91	29.39	30.94
Number Of Berths		1	2	2	2	3	3	3
Coal Density	Ton/cum	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Coal Stockpile Base Width	m	50	50	50	50	50	50	50
Stockpile Height	m	10	10	10	10	10	10	10
Stacking Density	Ton/Sqm	5.96	5.96	5.96	5.96	5.96	5.96	5.96
Turn Over Ratio		18	18	18	18	18	18	18
Plot utilization for stockpile	%	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Area Required for Stackyard, Ha	Ha	5.3	30.9	35.9	40.5	45.7	51.9	56.0
Phasing	Ha	17	35	35	45	45	55	55

10.5.2 Storage for Container

For containers it is important to consider the stack height, ground slot numbers for computing the storage requirements.

The assumptions are given below:-

Table 10.8: Average Transit Time & Stack Height Assumption

Description	Container Split		Avg. Transit Time in Days		Max Stack Height
	Import (51 %)	Export (49%)	Import	Export	
Full Container	80 %	80 %	4	4	5
Empty	15 %	15 %	6	6	6
Reefer	5 %	5 %	3	3	3

- Reefer containers stacked 2 high (max ht. 3), loaded containers 3 high (max ht. 5), empty containers 4 high (max ht. 6) have been considered.
- Ground slot area of approximate 37 sq. m. inclusive of distance between 2 containers has been considered for TTU movement and RTG track.

Table 10.9: Storage Area Calculation for containers

Description	Unit	FY21	FY25	FY30	FY35	FY40	FY45	FY47
Annual Throughput	MTEU	0.03	0.27	0.53	0.70	0.81	0.94	1.00
Number Of Berths	Nos.	0	1	1	1	1	1	1
RMQC Phasing	Nos.	0	2	2	3	4	4	4

Description	Unit	FY21	FY25	FY30	FY35	FY40	FY45	FY47
Area Required for Stackyard, Ha	Ha	0	4.0	8.0	10.6	12.3	14.3	15.6
Phasing of Area	Ha	0	8	8	12.5	12.5	16	16

10.5.3 Storage for General Cargo/Break Bulk

As discussed in the earlier chapter, it is envisaged to handle few amount of thermal coal export and iron ore export from the multi cargo terminal. Apart from this limestone and other break bulk cargo are envisaged to be handle in this terminal.

Coal, iron ore and lime stone will be provided with sheltered stack yard. Shed structures will be provided for other General Cargo. Reinforced concrete column supported steel structures can be provided for storage. The height inside the storage shed can be around 12 m. The shed has to be provided with doors on both sides.

Part of cargo unloaded at port of Rosulpur is likely to be directly evacuated through rail or road without passing through transit shed. Hence the storage area can be optimized during project execution stage. The area required for multicargo terminal is as estimated below:-

Table 10.10: Storage Area Calculation for Multi Cargo Terminal

Description	Unit	FY21	FY25	FY30	FY35	FY40	FY45	FY47
Annual Throughput	MTPA	0.87	5.39	7.78	9.23	10.24	11.39	11.89
Number Of Berths	Nos.	1	2	3	3	4	4	4
Area Required for Stack yard	Ha	9	56.5	80	95	107	121	131
Phasing of Area	Ha	10	80	80	110	110	130	130

10.5.4 Summary of Area Requirement

The development of stack yard area for cargo storage and operation can also be phased in to Phase 1 and Phase 2. FY 2025 can be considered as phase 1 development in line to development of other infrastructural facilities such as berth, breakwater, channel etc. In FY 2025, the total area requirement has been estimated to be 170 Ha, whereas it has to be increased to 290 Ha in FY 2035. FY 2035 can be considered as phase 2 developmental stage of the project.

Table 10.11: Summary of Storage Area Requirement

Description	Unit	FY21	FY25	FY30	FY35	FY40	FY45	FY47
Phasing - Area Required for Coal Stack yard, Ha	Ha	17	35	35	45	45	55	55
Phasing - Area Required for Container Stack yard, Ha	Ha	0	8	8	12.5	12.5	16	16
Phasing - Area Required for Multi cargo Stack yard, Ha	Ha	10	80	80	110	110	130	130
Total Area To Be Provided	Ha	27	123	123	167.5	167.5	201	201
Area Required for Evacuation, Rail, Road, Utilities, and Other ancillary facilities								
Area for Rail, Road, Terminal Access Road (at back of the stackyard)	Ha	17.5	17.52	17.52	35.04	35.04	35.04	35.04
Area between Jetty and Stackyard for access and cargo movement – 50 m	Ha	6.0	6.0	6.0	12.0	12.0	12.0	12.0

Description	Unit	FY21	FY25	FY30	FY35	FY40	FY45	FY47
Area for Barge Berth Cargo Operation - 70 m	Ha	4.9	4.9	4.9	9.8	9.8	9.8	9.8
Area for Buildings, Utilities, Truck Parking, Work Shops, Electrical Installations etc. @15 %	Ha	4.1	18.5	18.5	25.1	25.1	30.2	30.2
Total Area Requirement, HA	**Ha**	**59**	**170**	**170**	**249**	**249**	**288**	**288**

10.6 Buildings

The following buildings are envisaged to be provided;

- Administrative, Operational Offices
- Canteen Facilities
- Security Gate House
- Workshop For Maintenance
- Power Sub Stations
- Fire Station
- Onsite Medical First aid Clinic

10.7 Evacuation of Cargo

Good connectivity with the hinterland and efficient movement of the cargo will increase the efficiency of the port. Connectivity shall comprise of road, rail and inland waterways.

Table 10.12: Proportion of Commodities and evacuation mode

Cargo Type	Evacuation Mode Proportion			Capacity		
	Rail (%)	Road (%)	Inland Waterway (%)	Truck	Rail(Full Rake)	Barges
Coal	65	15	20	-	3300 ton	2000 – 4000 Ton
Container	50	40	10	1 – 2 TEU	180 TEU	8 - 16 TEU
GC and BB	20	75	05	10	2100 ton	800 Ton

10.7.1 Port Access Road

It is envisaged that a four lane road width 14.4 m with 2.5 m paved shoulders on either side is adequate for the Phase – 1 development of the proposed port. This will be expandable during Phase -2 expansion plan. Also initially a double line rail will be provided for evacuation of cargo from the port. A 100 m corridor will be required to accommodate the Phase - 2 rail road expansion.

The rail link to the proposed port will have automatic signaling to ensure that the trains can be moved efficiently.

10.8 Utilities

10.8.1 Water Requirement

Total water demand can be broadly classified in to the following broad categories.

- Potable water for consumption or port personnel
- Potable water for ships calling at port
- Water for dust suppression at coal stockyard
- Water for fire fighting
- Water for gardening

Underground and overhead tanks can be provided at appropriate places.

10.8.2 Power Requirement

The power is required at the port for the following activities.

- Mechanized cargo handling systems
- Lighting of the port area
- Offices and transit sheds
- Miscellaneous

11. Capex and Opex

This section covers the estimation of capital expenditure (CAPEX) of the project and concludes with the investment requirements of the proposed port at the recommended site at Mandarmoni South.

The estimation of the CAPEX covers investments made for development of the civil infrastructure and procurement and installation of the port equipment.

For CAPEX related calculations, assumptions associated with civil infrastructure were made on basis of several in-depth discussions with experts from various fields such as marine construction, dredging. Sufficient references to infrastructure development reports were made to further ensure accuracy of the assumptions. The cost assumptions related to port equipment were built by referring to various product catalogues obtained from the respective vendors.

To estimate the future CAPEX the current values were escalated by making necessary growth rate assumptions. Statistical analysis of historical data was made to arrive at the escalations.

The facility planning is done on the basis that the cargo traffic will ramp up in time. This necessitates the requirement of the phasing of capital investment. The necessary assumptions have been considered while deriving the phase-wise infusion of the capital investment. The common facilities like the breakwater in particular have not been phased and are recommended to be built in phase-1 itself before the port becomes operational. For phase-1 the infrastructure and equipment requirement is calculated on basis of traffic to be handled at port in 2025.The channel dredging has also been done in phased manner so as to keep the capital cost at optimum level. The second phase is ramping up of the port facilities, reclamation of land and dredging based on traffic projected on year 2048.

The estimated investment for the proposed port development at Purba Medinipur is given below:

	PHASE-1				PHASE-2			
Description	**Unit**	**Quantity**	**Rate/ Unit (INR)**	**Amount (INR Cr.)**	**Unit**	**Quantity**	**Rate/ Unit (INR)**	**Amount (INR Cr.)**
Port's Common Infrastructure Works other than Terminal area								
Break Water- Northern and Southern Breakwater)								
Length of the breakwater								
Northern Breakwater	m	4,000		511	m			0
Southern Breakwater	m	4,800		698	m			0
			Total	**1209**			**Total**	**-**
Dredging								
Dredging	cum	6,20,00,000	300	1,860	cum	-	-	-
			Total	**1,860**			**Total**	**-**
Navigational Aids								
Channel Marker Buoys	Nos.	10	15,00,000	1.50	Nos.		15,00,000	-
Beacons	Nos.	6	85,000	0.05	Nos.		85,000	-
Sector Lights	Nos.	2	10,00,000	0.20	Nos.		10,00,000	-
Breakwater lights	Nos.	2	50,000	0.01	Nos.		50,000	-

Description	PHASE-1				PHASE-2			
	Unit	Quantity	Rate/ Unit (INR)	Amount (INR Cr.)	Unit	Quantity	Rate/ Unit (INR)	Amount (INR Cr.)
VTMS- Procurement Installation and Commissioning)	LS		10,00,00,000	10.00	LS		-	-
			Total	**11.76**			**Total**	**-**
Port Craft								
Pilot launches	Nos.	2	5,50,00,000	11	Nos.		5,50,00,000	-
Tug - 60T Capacity	Nos.	3	30,00,00,000	90.00	Nos.	3	30,00,00,000	90
			Total	**101**			**Total**	**90**
Reclamation (up to +10m CD)								
Reclamation (Dredged fill)	Sq m	36,00,00 0			Sq m		-	-
Reclamation - (fill from Quarry)	cum	18,00,00 0	350	63.00	cum		350	-
Ground Preparation	sum	36,00,00 0	150	54.00	sum		150	-
			Total	**117.00**			**Total**	**-**
Berths Structure								
Container Berth								
Berth- (300 L x 52 B)	sqm	15,600	85,000	132.60	sum		85,000	-
Coal Berth								
Berth - (750 L x 15 B)	sqm	7,500	85,000	63.75	sqm	3,750	85,000	31.88
Lime stone & Iron ore Berth								
Berth	sqm	3,375	85,000	28.69	sum		85,000	-
Multipurpose Berth								
Berth- (1000 L x 40 B)	sqm	20,000	85,000	170.00	sum	20,000	85,000	170.00
			Total	**395.04**			**Total**	**201.88**
Container Terminal								
Site work								
Reefer access platform	LS			0.50				
			Total	**0.50**				
Equipment's								
Rail mounted Quay Cranes - Super Post Panamax	Nos.	2	35,00,00,000	70.0	Nos.	2	35,00,00,000	70.00
Reach Stacker	Nos.	2	2,00,00,000	4.0	Nos.	2	2,00,00,000	4.00
Rubber Tyre Gantries (RTG) - 45 T capacity	Nos.	8	7,00,00,000	56.0	Nos.	6	7,00,00,000	42.00
Fork Lifts	Nos.	2	10,00,000	0.2	Nos.	-	10,00,000	-
ECH	Nos.	2	10,00,000	0.2	Nos.	2	10,00,000	0.20

Description	PHASE-1				PHASE-2			
	Unit	Quantity	Rate/ Unit (INR)	Amount (INR Cr.)	Unit	Quantity	Rate/ Unit (INR)	Amount (INR Cr.)
Tractors/Trailers set	Nos.	18	22,00,000	4.0	Nos.	16	22,00,000	3.52
			Total	**134.36**			**Total**	**119.72**
Coal Terminal								
Site work								
Foundation for Equipment's	m	2,400	50,000	12.0	m	-	50,000	-
			Total	**12.00**			**Total**	**-**
Equipment's								
Mobile Hoppers	Nos.	3	10,00,000	0.3	Nos.	1	10,00,000	0.10
Jetty conveyor 2000 TPH	m	1,111	1,00,000	11.1	m	459	1,00,000	4.59
Front End Loaders	Nos.	8	50,00,000	4.0	Nos.	4	50,00,000	2.00
Conveyor Transfer Towers	Nos.	4	10,00,000	0.4	Nos.	-	10,00,000	-
Unloaders - Continuous 2000 TPH	Nos.	2	35,00,00,000	70.0	Nos.	2	35,00,00,000	70.00
Junction House - Jetty	Nos.	2	10,00,000	0.2	Nos.	1	10,00,000	0.10
Drive House - Jetty	Nos.	2	10,00,000	0.2	Nos.	4	10,00,000	0.40
Stacker/Reclaimer-2000TPH	Nos.	2	20,00,00,000	40.0	Nos.	2	20,00,00,000	40.00
Conveyor Belt - 2000 TPH	m	4,900	1,00,000	49.0	m	2,450	1,00,000	24.50
Junction House – Stack yard	Nos.	8			Nos.	4		
RRLS -4500 TPH	Nos.	2			Nos.	1		
RRLS Conveyor- 2200 TPH	m	1,600	1,00,000	16.0	m	800	1,00,000	8.00
			Total	**191.21**			**Total**	**149.69**
Buildings & Utilities								
IN Motion Rail Weigh Bridge	Nos.	LS	50,00,000	0.50	Nos.	LS	-	-
			Total	**0.50**			**Total**	**-**
Limestone & Iron Ore - Equipment's								
Unloaders - Continuous 1000 TPH	Nos.	1	25,00,00,000	25.0	Nos.		25,00,00,000	
Conveyor Belt - 1000 TPH	m	4,900	1,00,000	49.0	m		1,00,000	-
Junction House – Stack yard	Nos.	8	10,00,000	0.8	Nos.		10,00,000	-
Mobile Hoppers	Nos.	3	10,00,000	0.3	Nos.		10,00,000	-
Front End Loaders	Nos.	8	50,00,000	4.0	Nos.		50,00,000	-

Description	PHASE-1				PHASE-2			
	Unit	Quantity	Rate/ Unit (INR)	Amount (INR Cr.)	Unit	Quantity	Rate/ Unit (INR)	Amount (INR Cr.)
Conveyor Transfer Towers	Nos.	2	10,00,000	0.2	Nos.		10,00,000	-
Junction House - Jetty	Nos.	2	10,00,000	0.2	Nos.		10,00,000	-
Drive House - Jetty	Nos.	2	10,00,000	0.2	Nos.		10,00,000	-
			Total	**79.70**			**Total**	**-**
Multipurpose Terminal								
Equipment's								
Mobile Harbour Cranes	Nos.	2	15,00,00,000	30.00	Nos.	2	15,00,00,000	30.00
Backhoes/ Pay loaders 10 tons	Nos.	3	50,00,000	1.50	Nos.	6	50,00,000	3.00
Fork Lift Trucks 5 tons	Nos.	4	24,00,000	0.96	Nos.	2	24,00,000	0.48
Trucks (OUTSOURCED)	Nos.	-	20,00,000	-	Nos.		20,00,000	-
			Total	**32.46**			**Total**	**33.48**
Common infrastructure (Including sand bypassing)								
External Connectivity								
Roads - Approximately 15km Long - 4 Lane Wide complete with Drainage	Esq.	2,10,000	3,500	73.50	sum	-	3,500	-
Railways - INCLUDING MINOR CULVERTS	m	15,000	60,000	90.00	m	-	60,000	-
			Total	**163.50**			**Total**	**-**
Internal Connectivity								
Roads	sum	1,000	2,750	0.28	sum	1,000	2,750	0.28
Rail line in Terminal area		2,700	15,000	4.05		2,700	15,000	4.05
	m		**Total**	**4.33**	**m**		**Total**	**4.33**
Buildings & Utilities								
Administrative / Office Building	sum	500	24,000	1.20	sum		24,000	-
Control Tower	sum	200	28,000	0.56	sum		28,000	-
Customs	sum	400	24,000	0.96	sum		24,000	-
Canteen & Other amenities	sum	100	22,000	0.22	sum		22,000	-
Health Centre	sum	250	24,000	0.60	sum	-	24,000	-
Sub-Stations (4 Nos.each 455sqm)	sum	1,213	4,500	0.55	sum	607	4,500	0.27
Power Supply system - Power Distribution, Control Systems, Transformers, Lighting, etc.)	LS			80.00	LS			-

Description	PHASE-1				PHASE-2			
	Unit	Quantity	Rate/ Unit (INR)	Amount (INR Cr.)	Unit	Quantity	Rate/ Unit (INR)	Amount (INR Cr.)
Water Supply system	LS			12.50	LS			-
Fire fighting system	LS			10.00	LS			-
Drainage & Sewerage system - complete with Drains, pipelines, Manholes, etc...	LS			10.00	LS			-
Pollution Control	LS			10.00	LS			-
Green Belt Development	LS			2.00	LS			-
Shunting Engine	Nos.	1	1,50,00,000	1.50	Nos.	-	1,50,00,000	-
Fuel Station(Port equipment's and Tractor Trailers)	LS			1.10	LS			-
Fire Station	LS			1.10	LS			-
Workshop (Common for Coal and Container)	LS			2.00	LS			-
			Total	**134.29**			**Total**	**0.27**
Gate Complex - Port Entrance (4 - IN + 4 - OUT)	sum	2,750	4,500	1.24	sum	2,750	4,500	1.24
For Power Connectivity from EB to Receiving Sub- Station at Port	LS			12.00	LS			-
Common Facilities								
Weigh Bridge at Gate House	Nos.	2	15,00,000	0.15	Nos.	2	15,00,000	0.15
IN Motion Rail Weigh Bridge	Nos.	1	50,00,000	0.50	Nos.	1	50,00,000	0.50
Watch Tower	Nos.				Nos.			
			Total	**0.65**			**Total**	**0.65**
			Total Cost	**4,447**			**Total Cost**	**600**
Others Cost								
Engineering, Project Management and other Administrative Expenses @5%	%	5%		222.0	%	5%		30.0
Insurance cost	%	-		-	%	-		-
CSR Activity	%	1%		22.0	%	1%		3.0
Contingency	%	5%		222.0	%	5%		30.0
GRAND TOTAL (INR in CR.)				**4,914**				**663**

OPEX

Sr.	Item	CAPEX	Percentage	Amount (INR Cr.)
1	Breakwaters	1208	1%	12.08
2	Dredging			45.00
3	Civil Works	430	1%	04.30
4	Navigation Facilities	113	8%	09.04
5	Mechanical Equipment	525	10%	52.50
6	Common Infrastructure	280	2%	05.60
7	Salaries			25.00
	TOTAL			**153.52**

12. Conclusions

Based on the analysis provided in our feasibility report, a detailed hydrographic survey, assessment of nature of dredged material and sub soil parameters is recommended during the DPR stage.

The approaches to Haldia from the deep water contours at Sand heads are changing with time as the morphology of the estuary responds to dredging. It should further be noted that the maintenance dredging costs are known to be very high in the Hugli estuary. Presently the channel below Rosulpur has minimal dredging amounting to less than 3 mil m3/y. The depths in this area below Rosulpur are more than the controlling bars further upstream. The maintenance dredging now proposed will undoubtedly increase the maintenance of the bars below the Rosulpur River outfall several fold.

Again the impact of dredging in one area of the estuary has been found to transfer to another area, which may affect other users of the estuary. Detailed morphological studies would be required during DPR stage to assess the impact of the proposed project on the approaches to Haldia.

Sub soil characteristics of the port area also need to be investigated.

With the above provisos, a comparative evaluation of the two sites is given below.

12.1 Comparison of Sites

For the development of the deep sea port, two different sites were analyzed in terms of technical feasibility and developmental cost i.e. Rosulpur and South of Mandarmoni. The table below shows the comparison of the two sites in terms of associated technical aspects for the development.

Technical Parameter	Shankarpur-Tajpur	Rosulpur
Breakwater	For tranquility, two numbers of breakwaters has been proposed. The length of the north breakwater is 4 KM whereas the south breakwater is 4.9 km.	For assessing the protection works for the Rosulpur river sites separate morphological studies need to be carried out to ascertain any impacts on the Haldia Channel.
Dredging – Approach Channel, Dock, Harbor Basin	• As per the design vessel of 60000 DWT in Phase 1, the channel depth required is (-) 12.1 m CD utilizing 3.9 m of tidal advantage. • The length of the channel from the proposed site to the 10 m contour is around 18.7 km. • The dredging quantity including approach channel, dock and Harbor basin has been estimated to be **62 mil m^3.**	• As per the design vessel of 60000 DWT in Phase 1, the channel depth required is (-) 10.1 m CD utilizing 3.9 m of tidal advantage. • Vessels calling at Rosulpur have to navigate through the existing Gasper and eastern channel which is presently used for navigation of vessels calling Haldia Dock. • The length of the channel from the proposed site at Rosulpur to the VTMS (Existing Channel) is around 93 km. The average depth at the existing channel varies from 6 to 10 m as shown in the Naval Hydrographic Chart. • The dredging quantity including approach channel, dock and Harbor basin has been estimated to be **175 mil m^3**. • Further during the phase 2 development, the channel will have to be further deepened up to (-) 12.1 utilizing the available tidal window of 3.9 m. The additional dredging quantity has been estimated to be **142.3 M m^3**
Traffic Projection	The potential cargo for the development of a deep draft port in the Hugli area has been estimated and is as given below.	

<table>
<tr><th>Technical Parameter</th><th>Shankarpur-Tajpur</th><th>Rosulpur</th></tr>
<tr><td></td><td colspan="2">
<table>
<tr><td>Cargo Projection</td><td>FY21</td><td>FY25</td><td>FY30</td><td>FY35</td><td>FY40</td><td>FY45</td><td>FY47</td></tr>
<tr><td>Total Traffic (MMTPA) excluding containers</td><td>5.08</td><td>28.20</td><td>35.15</td><td>40.63</td><td>45.95</td><td>52.10</td><td>54.82</td></tr>
<tr><td>Containers (MTEU) - I + E</td><td>0.03</td><td>0.27</td><td>0.53</td><td>0.70</td><td>0.81</td><td>0.94</td><td>1.00</td></tr>
</table>
</td></tr>
<tr><td>Civil Infrastructure</td><td colspan="2">The civil Infrastructure requirement has been estimated considering the cargo throughput projection and is as tabulated below. The facilities required are not dependent on the site.
<table>
<tr><th>Berths Description</th><th>Phase 1 FY 2025</th><th>Phase 2 FY 2047</th></tr>
<tr><td>Thermal + Coking Coal (Mechanized) (I+E)</td><td>2</td><td>3</td></tr>
<tr><td>Multipurpose (GC + BB) (I+E)</td><td>2</td><td>4</td></tr>
<tr><td>Iron Ore (E) + Lime Stone (I+E)</td><td>1</td><td>1</td></tr>
<tr><td>Container Terminal</td><td>1</td><td>1</td></tr>
<tr><td>Total berths</td><td>6</td><td>9</td></tr>
</table>
The project layout has been discussed in Chapter 8. Berthing structures for barges has also been provided in adequate numbers for cargo movement through inland waterways. The harbor will be protected by two breakwaters for tranquility.</td></tr>
<tr><td>Area Requirement</td><td colspan="2">The storage area with regards to the annual throughput has been estimated. Regardless of the site, the area required for the storage is estimated as given below:-
<table>
<tr><td>Storage Area (Area in Ha)</td><th>Phase 1 FY 2025</th><th>Phase 2 FY 2047</th></tr>
<tr><td>Dry Bulk Berth – Coal Mechanized Import Stack yard</td><td>35</td><td>55</td></tr>
<tr><td>Multi Cargo / GC Stack yard</td><td>8</td><td>16</td></tr>
<tr><td>Container Stack yard</td><td>80</td><td>130</td></tr>
<tr><td>Other (Evacuation Corridor, Terminal Access Roads, Barge Access Area, Buildings, Utilities, Etc.)</td><td>47</td><td>87</td></tr>
<tr><td>Total Area (Ha)</td><td>170</td><td>288</td></tr>
</table>
Note: The area as estimated above will be reclaimed from the sea. The land acquisition will only be required for external port connectivity.</td></tr>
<tr><td>Mechanical Handling Equipment</td><td colspan="2">The mechanical handling equipment are estimated and given in chapter 7. The mechanical handling equipment only depend on the annual throughput envisaged to be handled at the port and operation. To handle the projected cargo, both the site will require similar type of handling equipment.</td></tr>
<tr><td>Reclamation</td><td colspan="2">The area required for the development of port facilities will be reclaimed except the area required for port connectivity. As mentioned above, 170 Ha of area will be reclaimed in Phase 1 and 288 Ha will be reclaimed in Phase 2.</td></tr>
</table>

12.2 Cost Comparison

	Shankarpur-Tajpur		Rosulpur North	
	Phase 1	Phase 2	Phase 1	Phase 2
Description	**Amount (INR Cr)**	**Amount (INR Cr)**	**Amount (INR Cr)**	**Amount (INR Cr)**
Port's Common Infrastructure Works other than Terminal area				
Break Water- Northern and Southern Breakwater)	1,209	0	540	0
Dredging	1,860	0	5,250	4,269
Navigational Aids	12	0	12	0

Description	Shankarpur-Tajpur		Rosulpur North	
	Phase 1	Phase 2	Phase 1	Phase 2
	Amount (INR Cr)	Amount (INR Cr)	Amount (INR Cr)	Amount (INR Cr)
Port Craft	101	90	101	90
Reclamation (upto +10m CD)	117	0	515	0
Berths Structure	395	202	395	202
Container Terminal	135	120	135	120
Coal Terminal	204	115	204	115
Limestone & Iron ore	80	0	80	0
Multipurpose Terminal	32	33	32	33
Common infrastructure (Including sand bypassing)	299	2	299	2
Capex total in INR Cr.	**4,447**	**600**	**7,562**	**4,831**
Others Cost				
Engineering, Project Management and other Administrative Expenses @5%	222	30	378	242
Insurance cost	0	0		
CSR Activity (1%)	22	3	76	48
Contingency (5%)	222	30	378	242
Other Cost Total	**467**	**63**	**832**	**531**
GRAND TOTAL (INR Cr.)	**4,914**	**663**	**8,394**	**5,363**

Hence, based on our analysis, the region Shankarpur-Tajpur has more potential for development of a greenfield port.

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