# Techno-Economic Feasibility Report for Development of Port at Sagar Island

**23rd January 2016**

# Techno-Economic Feasibility Report for Development of Port at Sagar Island

Prepared for

Ministry of Shipping
Government of India

## Ministry of Shipping / Indian Ports Association

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## EXECUTIVE SUMMARY

## Introduction

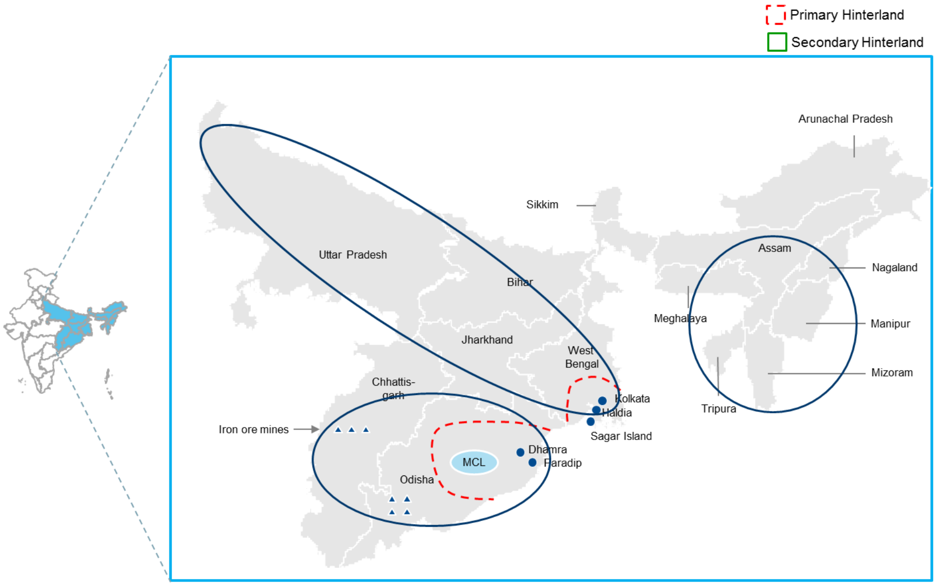
Currently, the Haldia Dock Complex and the Kolkata dock handle cargo traffic of around 41 MTPA, primarily thermal coal, coking coal, POL and general cargo from the hinterland. The ports/docks have been facing the challenges in terms of draft limitations, limited headroom for expansion and efficiency. These serious constraints at the ports of Kolkata & Haldia has necessitated the need to look for a new port nearer to the sea, avoiding long river navigation with limitations in draft due to high dredging costs.

The Sagar Island has been selected for a detailed study for locating a mega port. The Sagar Island is the southernmost Island of the Hooghly Estuary and forms one of the biggest deltas in Sunderban group. It is located 100 km downstream of Kolkata and separated by Muriganga River from mainland. The island is 30 km in length and has a maximum width of 12 km. Presently there is no rail-road connectivity to Sagar Island with the mainland and rail-cum-road bridge across the Muriganga River has been proposed to provide connectivity.

## Traffic Projections for the Proposed Port

A port in Sagar will share the hinterland of the Haldia and Kolkata ports, particularly the power and steel plants in the eastern region, and containers from the eastern parts of India (Western UP, Odisha, Jharkhand, Chhattisgarh, etc.) and neighbouring landlocked countries – Nepal and Bhutan.

**Ports in Eastern hinterland**





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According to the landed-cost analysis of the imported cargo for bulk, the natural ownership of cargo for the Sagar port is limited due to the proximity of the Haldia, Paradip and Dhamra ports to plants in the hinterland and the established evacuation infrastructure as could be seen from the above figure.

Analysis reveals that while Sagar port does not come out as the cheapest port of call for any of the existing steel and upcoming power plants, the landed cost of coking coal/ thermal coal at Sagar port is only marginally expensive in case of a 9 m draft (Sub- panamax vessel). In case of 13.5 m draft Sagar port becomes comparable to Haldia port in landed cost. Thus, Sagar port can become a viable alternative to serve as for spill-over cargo, specifically non-POL bulk from the Haldia dock complex.

Containers will be the major cargo commodity handled at the Sagar port. This is primarily due the paucity of capacity and the inability to expand the Haldia and Kolkata ports, which is causing an overflow of containers that can be handled at the Sagar port.

The traffic for the Sagar port is projected to be around 3.5 MTPA in 2020 increasing to around 27 MTPA in 2035.

## Port Development Plan

It is assessed that at Sagar anchorage an additional draft ranging from 1.4 m to over 2.0 m is available as compared to Haldia and Kolkata Ports respectively. Accordingly the phasing of dredging for Sagar port has been proposed as given below:

**Phase 1 - To handle vessels with draft of 9.0 m with tidal advantage**

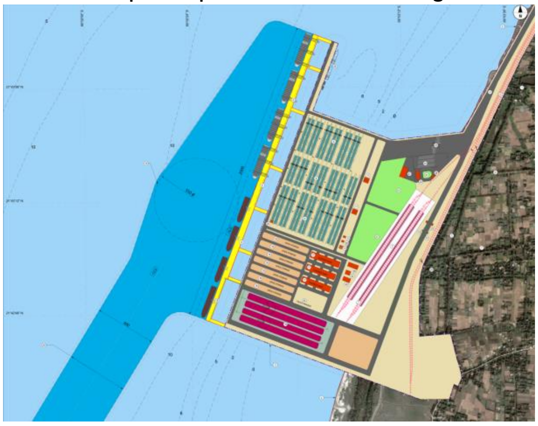
**Ultimate Phase - To handle vessels with draft of 13.5 m with tidal advantage**

The vessel size for Phase 1 is carefully chosen so that no capital dredging is needed in the long eastern approach channel. This would still enable carrying about 30,000 T of parcel size of bulk in panamax ships round the year with minimum waiting time. The recommended port master plan layout is as shown in **Figure** below.

It is imperative that the road bridge is built before the Sagar port is made operational i.e. by year 2020. The rail connectivity is assumed to be provided by Phase 2 development of the port i.e. year 2025.

State of the art material handling system shall be provided to ensure faster turnaround of ships. In the Phase 1 a 600 m quay length is provided which shall go upto 2000 m in the master plan phase.

The recommended port master plan layout is shown in **Figure** below and it shall be developed in various phases as per the built up of traffic. The entire area for port operations and storage shall be created by way of reclamation. It is proposed to reclaim an area of 96 Ha in Phase 1 and that 197 Ha in master plan stage of the port. The engineering for the major port facilities such as dredging and reclamation, Revetment, berths, material handling system has been carried out in compliance with the applicable codes and standards.



The width of eastern channel navigational channel is proposed to be 450 m and that for Sagar channel is proposed as 400 m to allow two-way navigation of ships.

## Cost Estimates

The capital cost of overall port development upto the master plan phase is expected to be INR 5,971 crores. The capital cost for Phase 1 development is expected to be INR 1,161 crores. The major exclusions in cost estimates are Road and Rail Bridge across river Muriganga, External linkages for rail, road beyond river Muriganga, Cost of land acquisition, Financing and Interest Costs.

## Financial Appraisal

The base case traffic of container and break bulk overflow from Kolkata port has been considered to calculate the financial viability of the project. The project IRR was worked out for various scenarios of development and it is observed that the scenario where the port development is limited to Phase 1 works out to be the most financially viable option. It is therefore recommended that only the infrastructure of Phase 1 as suggested in this TEFR is built for now (at total capital investment of INR 1,161 crores) and traffic handling capacity be limited based on the infrastructure developed in Phase 1.

The project is recommended to be developed as per Landlord model, wherein the basic port infrastructure (dredging, reclamation, navigational aids, offsite container yard, external rail/road etc.) will be developed by the Special Purpose Vehicle (SPV) between KoPT and Govt. of West Bengal, at total estimated cost of INR 421.85 crores funded by a multilateral loan at 5% payable over 15 years. PPP concessionaire would be responsible for terminal development comprising of berths, stackyard development, equipment, utilities etc. at an estimated cost of INR 739 crores.

It is assessed that the Concessionaire shall provide the revenue share to SPV to cover debt servicing of multilateral loan (interest and repayment) and O&M costs borne by SPV. With an assumed 70:30 Debt/Equity ratio at 12% cost of debt and 20% VGF, the Concessionaire has an estimated pre-tax equity IRR of about 16.31%.

## Recommendations

It is recommended that initially Phase 1 of the project be built under landlord model as per the details mentioned in financial appraisal in para above.

The following are the key enablers for the success of Sagar Port:

- Limiting Greenfield investments in Haldia port complex; to create overflow for Sagar Port
- No expansion in container handling capacity at Kolkata Dock Systems
- Guaranteed Viability Gap Funding of minimum 20% from the State/Central Govt.
- Road connectivity to the port and bridge at River Muriganga to be constructed before port becoming operational
- Land Acquisition for rail, rail connectivity and offsite rail yard
- Establishment of industrial cluster/hinterland near Sagar port for enabling cargo flow
- Widening of NH-117 for road connectivity
- Expansion of mainland railway connectivity from Kashinagar to main routes

# 1.0 Introduction

## 1.1 Background

The Sagarmala initiative is one of the most important strategic imperatives to realize India's economic aspirations. The overall objective of the project is to evolve a model of port-led development, whereby Indian ports become a major contributor to the country's GDP.

As shown in **Figure 1.1**, the Sagarmala project envisages transforming existing ports into modern world-class ports, and developing new top notch ports based on the requirement. It also aspires to efficiently integrate ports with industrial clusters, the hinterland and the evacuation systems, through road, rail, inland and coastal waterways. This would enable ports to drive economic activity in coastal areas. Further, Sagarmala aims to develop coastal and inland shipping as a major mode of transport for the carriage of goods along the coastal and riverine economic centres.

As an outcome, it would offer efficient and seamless evacuation of cargo for both the EXIM and domestic sectors, thereby reducing logistics costs with ports becoming a larger economy.

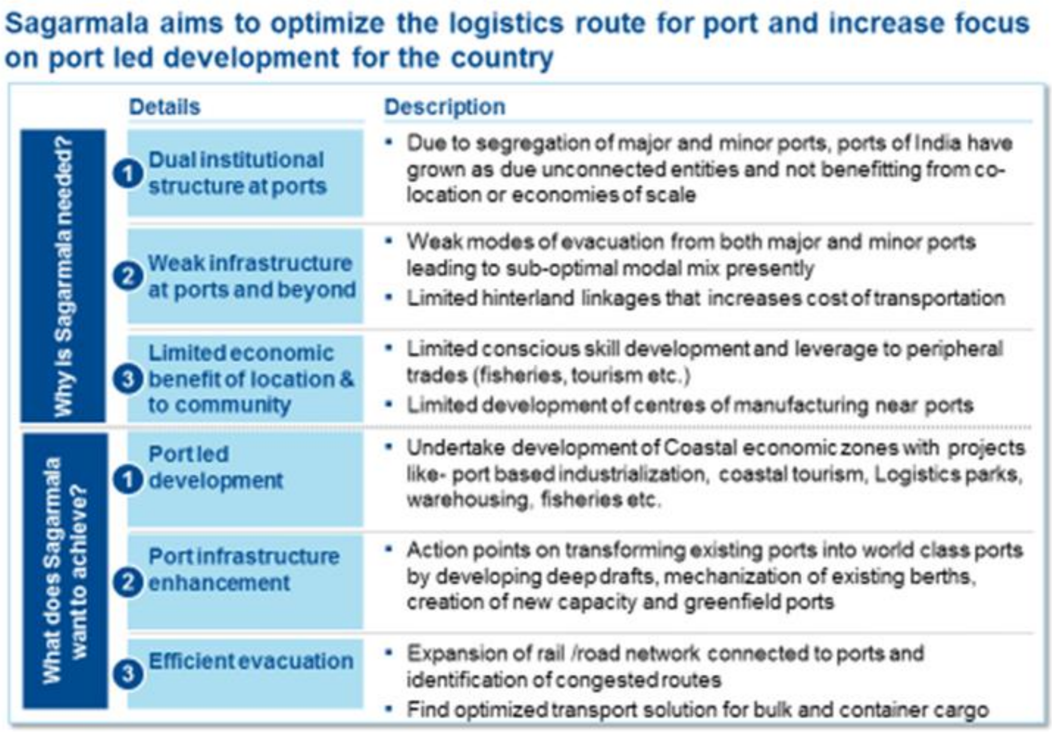



**Figure 1.1 Aim of Sagarmala Development**

In order to meet the objectives, Indian Port Association (IPA) appointed the consortium of McKinsey and AECOM as Consultant to prepare the National Perspective Plan as part of the Sagarmala Programme.

## 1.2 Scope of Work

We have distilled learnings from our experience in port-led development and examined major engagement challenges to develop a set of governing principles for our approach as shown in **Figure 1.2** below.

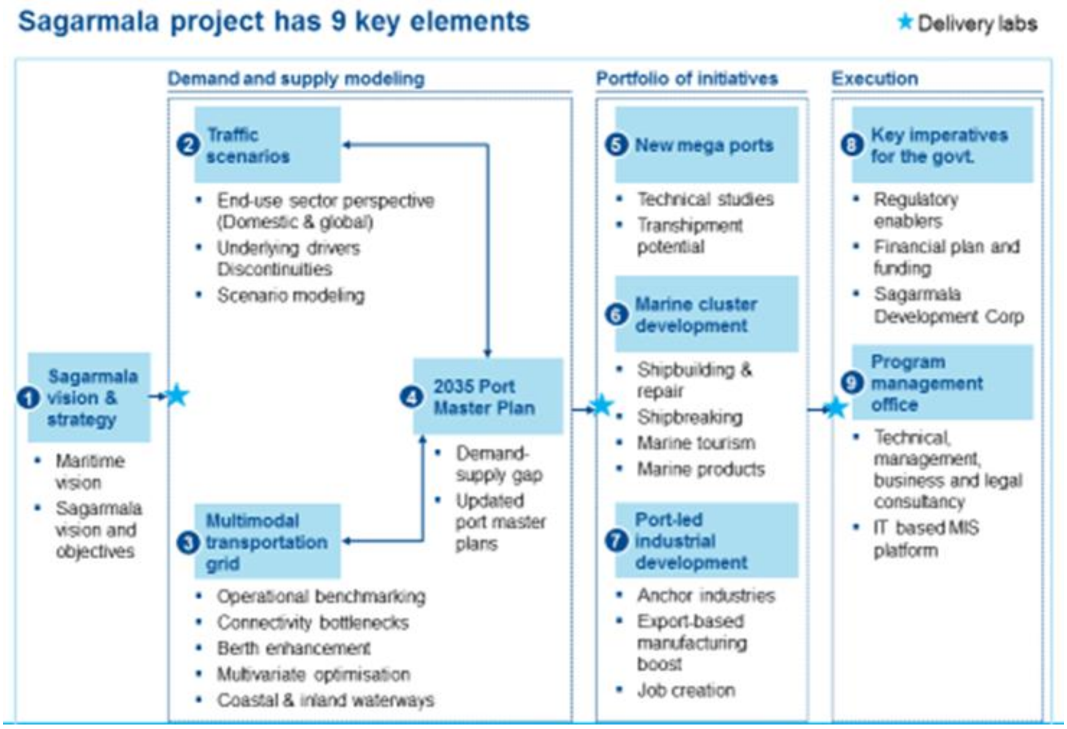



**Figure 1.2 Governing Principles of our Approach**

As indicated above, the origin-destination of key cargo (accounting for greater than 85% of the total traffic) in Indian ports shall be mapped to develop traffic scenarios for a period of next 20 years. The forces and developments that will drive change in the cargo flows shall also be identified. This would lead to the identification of regions along the coastline where the potential for the development of Greenfield port or expansion of existing port exists. These regions shall be further evaluated based on the technical, socio-economic and environmental aspects to arrive at the suitable location of a major port.

The scope of the assignment includes the preparation of development/investment plan for at least 5 mega ports sites based on the technical study, traffic scenarios and constraints in existing ports.

## 1.3 Need for the New Mega Port at Sagar Island

### 1.3.1 General

At present Haldia port and Kolkata port are the only ports in West Bengal handling significant cargo. They share the same navigational facilities and are under the management of KoPT. These ports serve the vast hinterland in northeast India. However, both are riverine ports located along the Hooghly River at a distance of 121 km and 232 km from respectively from the sea. Hence, they are severely constrained by the reduced parcel size of the vessels due to the limited water depths in the long approach channel, which are being maintained after significant annual dredging.

### 1.3.2 Limitations of Haldia/Kolkata Port

The port of Haldia is a Riverine port and the designated berths for bulk cargo are located within the impounded dock system. The entrance to the dock system is controlled by lock gates and the river passage of 70 nautical miles from the sea known as SANDHEADS is governed by the available draft depending on the tide of the day and is negotiated under the guidance of port pilots.

The pilotage distance to Haldia is 121 km comprising 46 km of river and 75 km of sea pilotage. The Port maintains a pilot Vessel/Station at Sagar Roads. The River Pilot embarks on inwards bound vessels at Middleton Point and proceeds up the river. At Haldia the pilot bringing the vessel from Middleton point hands over the vessel at the lock entrance to the Berthing Master but all vessels bound for oil jetties are taken alongside by the same Pilot. The following constraints are notice at the Haldia Port:

- Average river draft gradually falling over the last few years, resulting in reduced parcel size of ships with increased operating costs
- Reduced parcel sizes result in increased number of ships for the same cargo traffic causing congestion at the lock gates
- Port has limitations in handling bigger ships due to navigational constraints and draft limitations.
- High annual maintenance dredging costs for maintaining the channel

Kolkata Port, which is still farther away from the sea, is also facing similar constraints on account of smaller parcel sizes and high costs of maintenance dredging.

### 1.3.3 Need for a New Port

The aforesaid serious constraints at the ports of Kolkata & Haldia has necessitated the need to look for a new port nearer to the sea, avoiding long river navigation with limitations in draft due to high dredging costs.

The idea of a deep-draft port in West Bengal was floated in 2010, and a Feasibility Report was completed by RITES in 2012. Sagar was suggested as a complementary location for Kolkata Port Trust. Subsequently the state government and the Centre for development have signed a memorandum of understanding for a new port in West Bengal.

Accordingly, the Sagar Island has been selected for a detailed study for locating the new port.

## 1.4 Present Submission

The present submission is the Techno-economic Feasibility Report for development of the port at Sagar Island, West Bengal. This report is organised in the following sections:

Section 1 : Introduction
Section 2 : Site Conditions
Section 3 : Traffic Projections for Sagar Port
Section 4 : Design Ship Sizes
Section 5 : Port Facility Requirements
Section 6 : Preparation of Sagar Port Layout
Section 7 : Engineering Details
Section 8 : Environmental Setting and Impact Evaluation
Section 9 : Cost Estimates and Implementation Schedule
Section 10 : Financial Analysis for Sagar Port
Section 11 : Conclusions and Recommendations

# 2.0 Site Conditions

## 2.1 Alternative Sites Considered

Three sites were considered for the proposed new port development in West Bengal.

- Digha
- Rasulpur and
- Sagar

These site locations are as shown in the **Figure 2.1**.

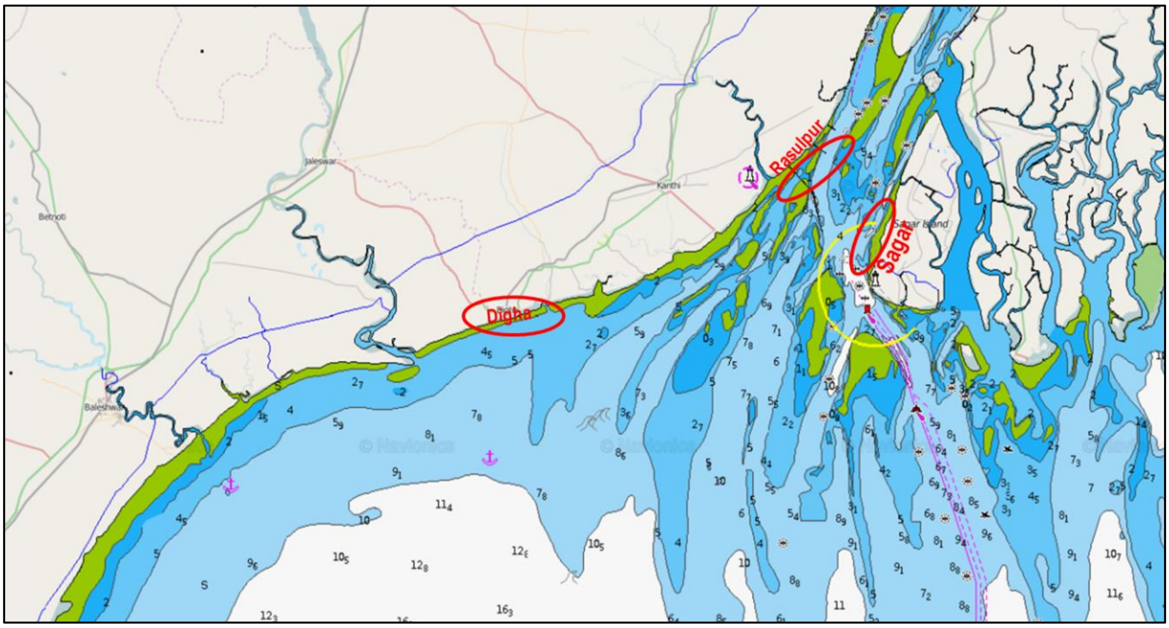



**Figure 2.1 Prospective Site Locations**

These sites were evaluated based on the available site data for the following parameters:

- Technical suitability for port development
- Hinterland connectivity
- Capital and Maintenance costs of development
- Potential for expansion to cater to bigger vessels
- Time for construction
- Environmental aspects

The comparison and site evaluation was carried out considering the various factors and the outcome of the evaluation is given in **Figure 2.2**.

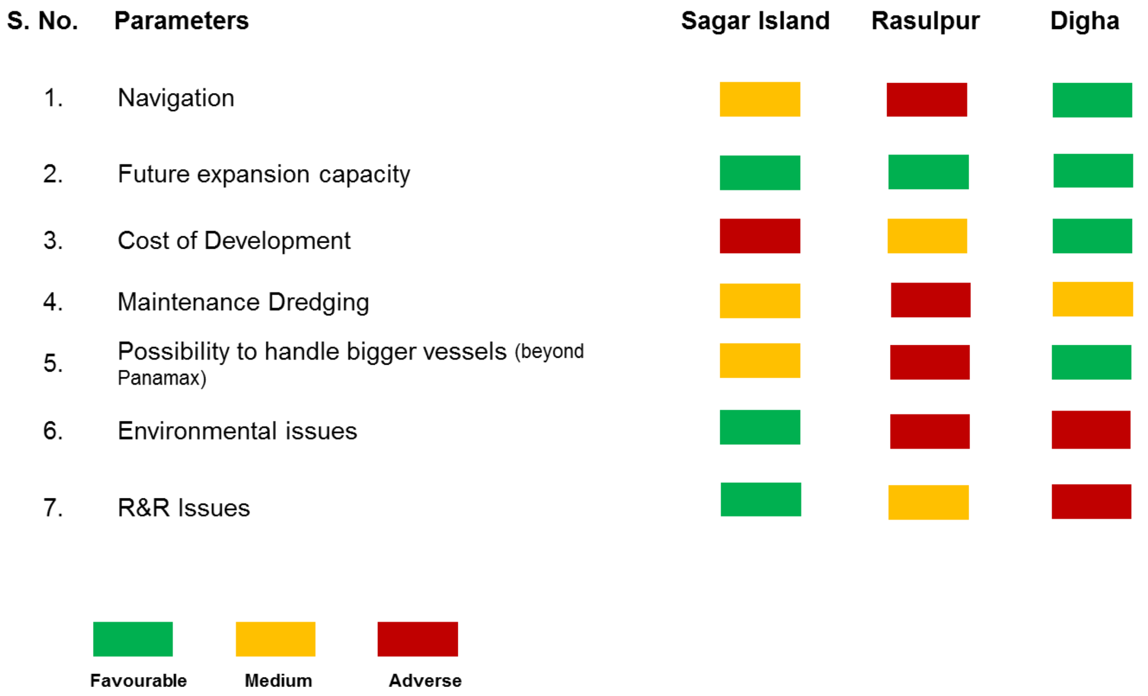



**Figure 2.2 Multicriteria Analysis of Alternative Locations**

While the site at Digha might be better from the technical aspects, due to associated serious environmental and R&R issues it is not preferred site for port development. The port site at Sagar scores better than at Rasulpur and Digha on overall considerations for technical, environmental and financial parameters and thus selected for further detailed evaluation.

## 2.2 Port Location at Sagar Island

The Sagar Island is the southernmost Island of the Hooghly Estuary and forms one of the biggest deltas in Sunderban group. It is located 100 km downstream of Kolkata and separated by Baratola River / channel creek /Buriganga River from main land. On the north is Ghoramara Island. On west side is Bedford channel while on southern side are sand heads of Hooghly River. The Sagar Island can presently be accessed by ferry only from Harwood point to Kachubaria having an approximate distance of 3.5 km. The island is 30 km in length and has a maximum width of 12 km.

The location plan of proposed Sagar Port is shown in **Figure 2.3**.

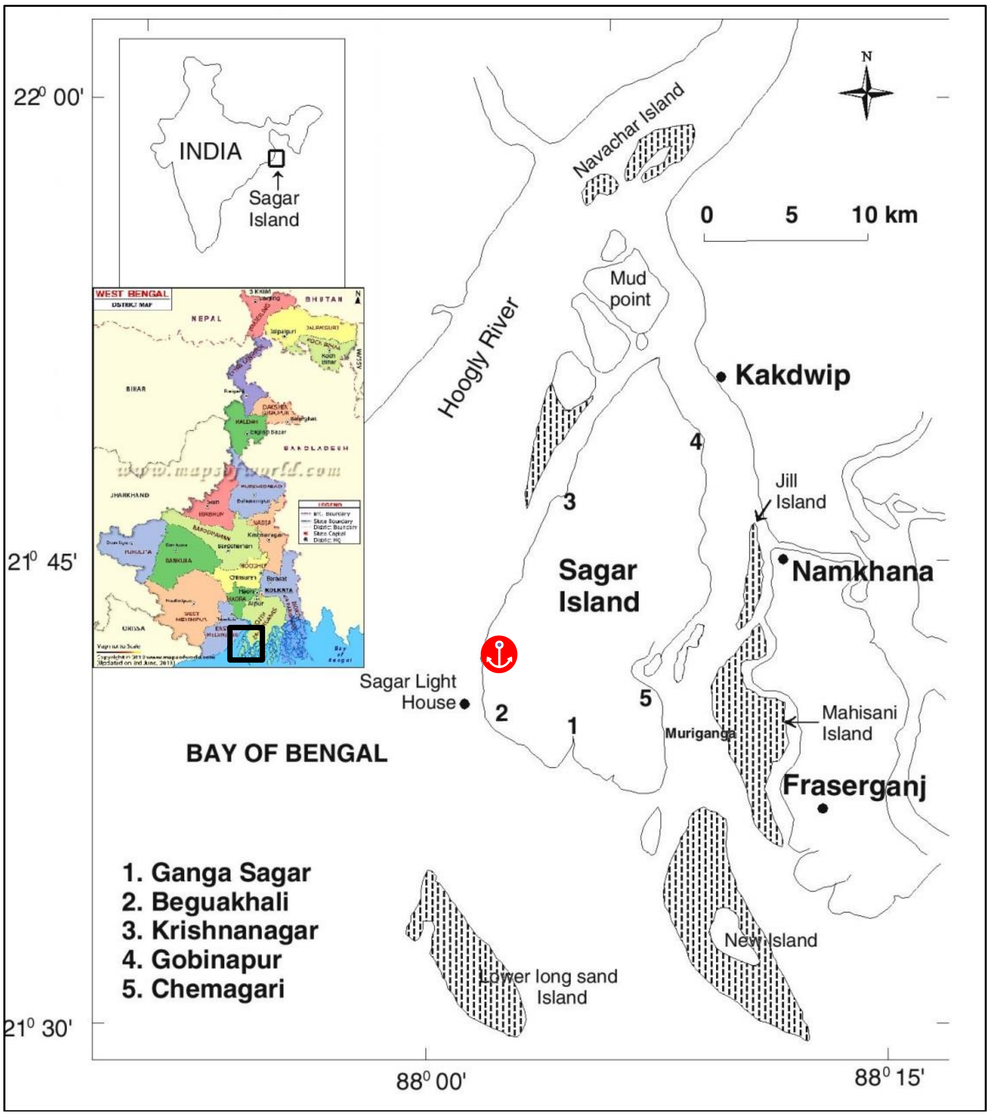



**Figure 2.3 Location of Sagar Island in West Bengal**

Two sites (Site A and Site B) were considered by RITES in their study along the western bank of the island (**Figure 2.4**) to carry out the port site evaluation based on factors such as,

- wave tranquillity,
- availability of adequate back up area for port infrastructure,
- proximity of deep water contour,
- magnitude of tidal window etc.

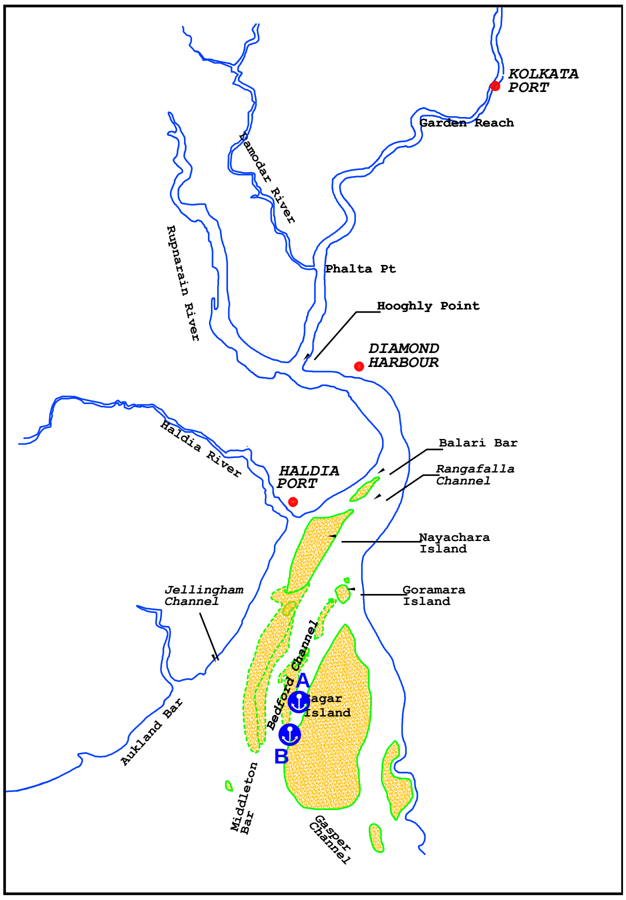
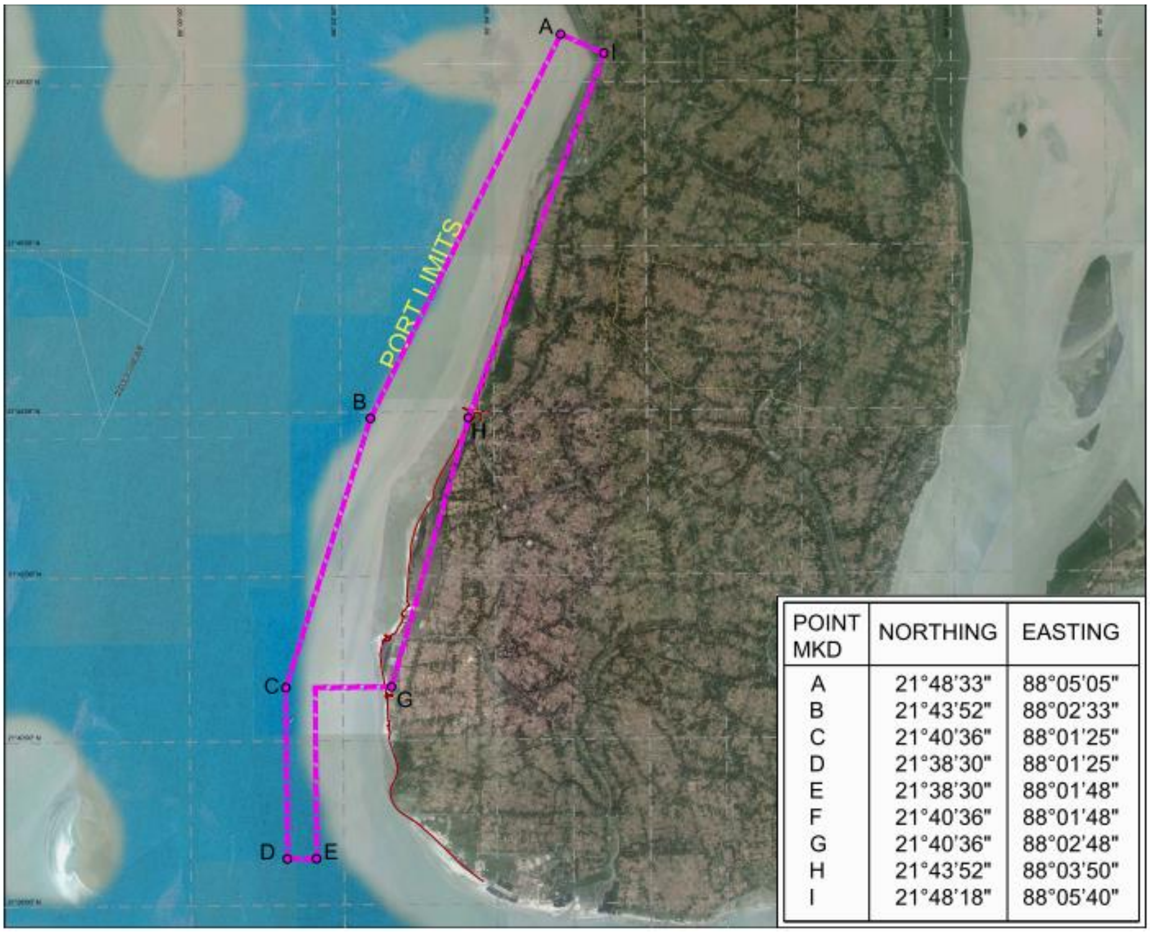



**Figure 2.4 Port Development Locations (Site A & B) at Sagar**

Based on these parameters, the Site B area at the south of Sagar Island was preferred for the port development.

The proposed port limits for Sagar port are as shown below.




| POINT MKD | NORTHING | EASTING |
|---|---|---|
| A | 21°48'33" | 88°05'05" |
| B | 21°43'52" | 88°02'33" |
| C | 21°40'36" | 88°01'25" |
| D | 21°38'30" | 88°01'25" |
| E | 21°38'30" | 88°01'48" |
| F | 21°40'36" | 88°01'48" |
| G | 21°40'36" | 88°02'48" |
| H | 21°43'52" | 88°03'50" |
| I | 21°48'18" | 88°05'40" |

**Figure 2.5 Existing and Proposed Port Limit of Sagar**

## 2.3 Field Survey and Investigations for Sagar Port Development

For planning of the port facilities, RITES in 2011 conducted the following surveys and investigations at Sagar Island as part of the Techno-economic feasibility studies. The following surveys and investigations were conducted both on the western as well as the eastern fringe of the island.

- Hydrographic and Hydraulic survey
- Topographic survey
- Geotechnical Investigation
- Wind and Wave measurements

## 2.4 Onshore Area

Onshore area is proposed to be developed in the intertidal zone. The intention is to locate all port facilities and operational requirements within the reclaimed area without any major land acquisition process. However, minor land acquisition would be required for providing connectivity to the port.

## 2.5 Meteorological Data

### 2.5.1 Wind

Wind data were measured in the months of May, June, July and August in 2011 at the location (21° 37’ 59.53” Lat. and 88° 07’03.50” Long.). The data were analysed and the wind rose diagrams from May 2011 to August 2011 are presented in **Figure 2.6**. Predominant wind directions at the location are from the sector between WNW to SW with average wind speed of about 6m/s to 8m/s.

During southwest monsoon, winds are from SW, SSW and S with maximum speed of 68 km/hr, while northeast monsoon winds are from N, NNE with maximum wind up to 50 km/hr. During non-monsoon season, winds are from SSW, S, SSE and SE with maximum wind speed of 54 km/hr.

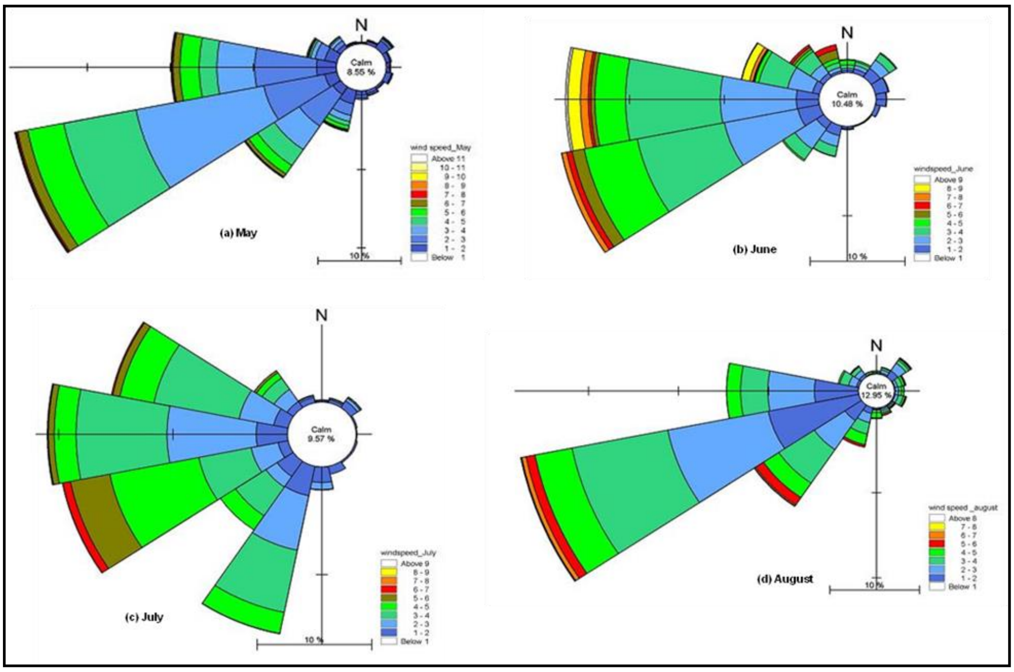



**Figure 2.6 Measured Wind Rose Diagram in May to August 2011**

Sagar Island experiences a mean annual wind speed of 8.24 km/ hr. Maximum wind speed was observed in April (13.2 km/hr), while minimum wind speed was observed in November (4.51 km/hr).

### 2.5.2 Rainfall

As per the study of 1982-2010 data done for Sagar island area, it receives annual rainfall of 1735.9mm. Maximum, minimum and mean rainfall distribution is as per the **Table 2.1** shown below.

**Table 2.1 Rainfall data of Sagar Island 1982-2010**

| Month | Maximum | Minimum | Mean |
|---|---|---|---|
| January | 87.60 | 0.10 | 11.44 |
| February | 72.1 | 1.00 | 20.74 |
| March | 271.7 | 0.40 | 21.39 |
| April | 163.3 | 1.10 | 40.44 |
| May | 471.2 | 1.00 | 121.12 |
| June | 363.3 | 0.80 | 251.24 |
| July | 700.5 | 134.9 | 372.51 |
| August | 380.5 | 101.8 | 303.64 |
| September | 741.8 | 78.8 | 344.27 |
| October | 498.1 | 24.2 | 182.85 |
| November | 307.7 | 0.40 | 61.44 |
| December | 33.2 | 0.10 | 4.84 |

### 2.5.3 Temperature

As per study of climate data between 1982 – 2010, average monthly temperature was highest during May (29.8°C), and lowest in January (20.43°C). Mean (of 29 years) maximum and minimum temperatures recorded were 33°C (in May) and 22°C (in January).

The highest maximum temperature experienced by the island was 43.1°C (June 2010), and the lowest minimum temperature was 11.6°C (January 2010).

### 2.5.4 Relative Humidity

Relative humidity is generally high and rises to about 87% during the monsoons in the month of August.

### 2.5.5 Visibility

Throughout the year visibility is good except during rains and squalls, the visibility deteriorates. While navigation in channel gets affected rarely, berthing of vessels may not be possible for about 10 days in a year.

## 2.6 Site Seismicity

The site is in Zone IV of Indian Map of Seismic zones (IS-1893 Part-1 2002) which is a high risk seismic intensity zone.

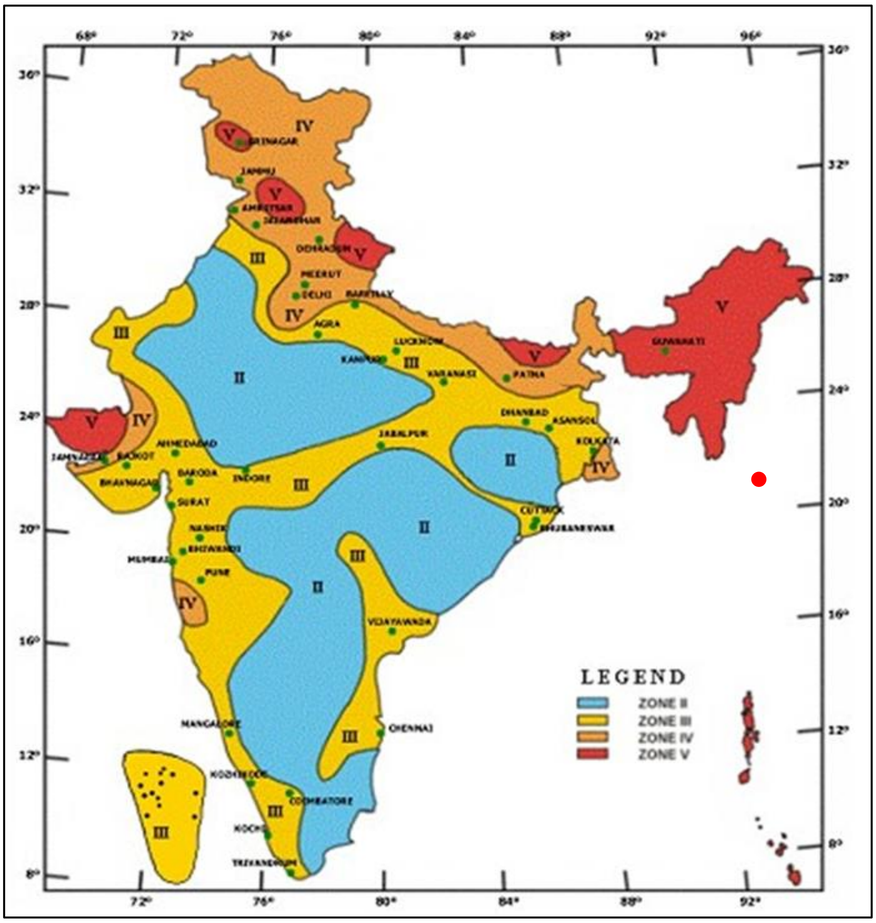



**Figure 2.7 Seismic map of India as per IS-1893 Part 1-2002**

## 2.7 Oceanographic Information

### 2.7.1 Bathymetry

Sagar Island is separated from the mainland by two channels with Jellingham channel on the west and Rangafalla channel on the east. Deep drafts are available along the southern tip and midstream lighterage operation of ships is being carried out at Sagar Anchorage for the last 40 years. Towards the western side of the waterfront of the proposed port location, natural water depth of about 8.0 to 10m below chart datum exists.

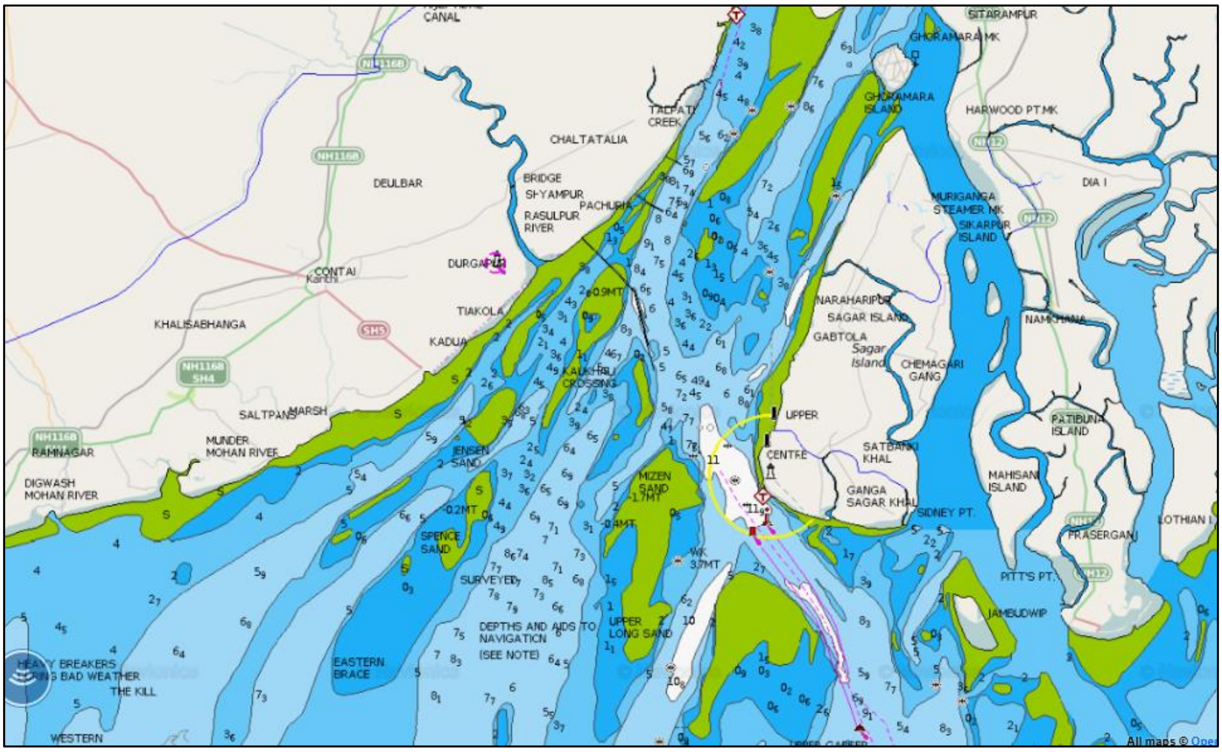



**Figure 2.8** **Sagar Island Bathymetry Information**

The hydrographic survey data for the western fringe of Sagar Island is being collected by Kolkata Port Trust periodically. The hydrographic survey chart is presented in **Figure 2.9**.

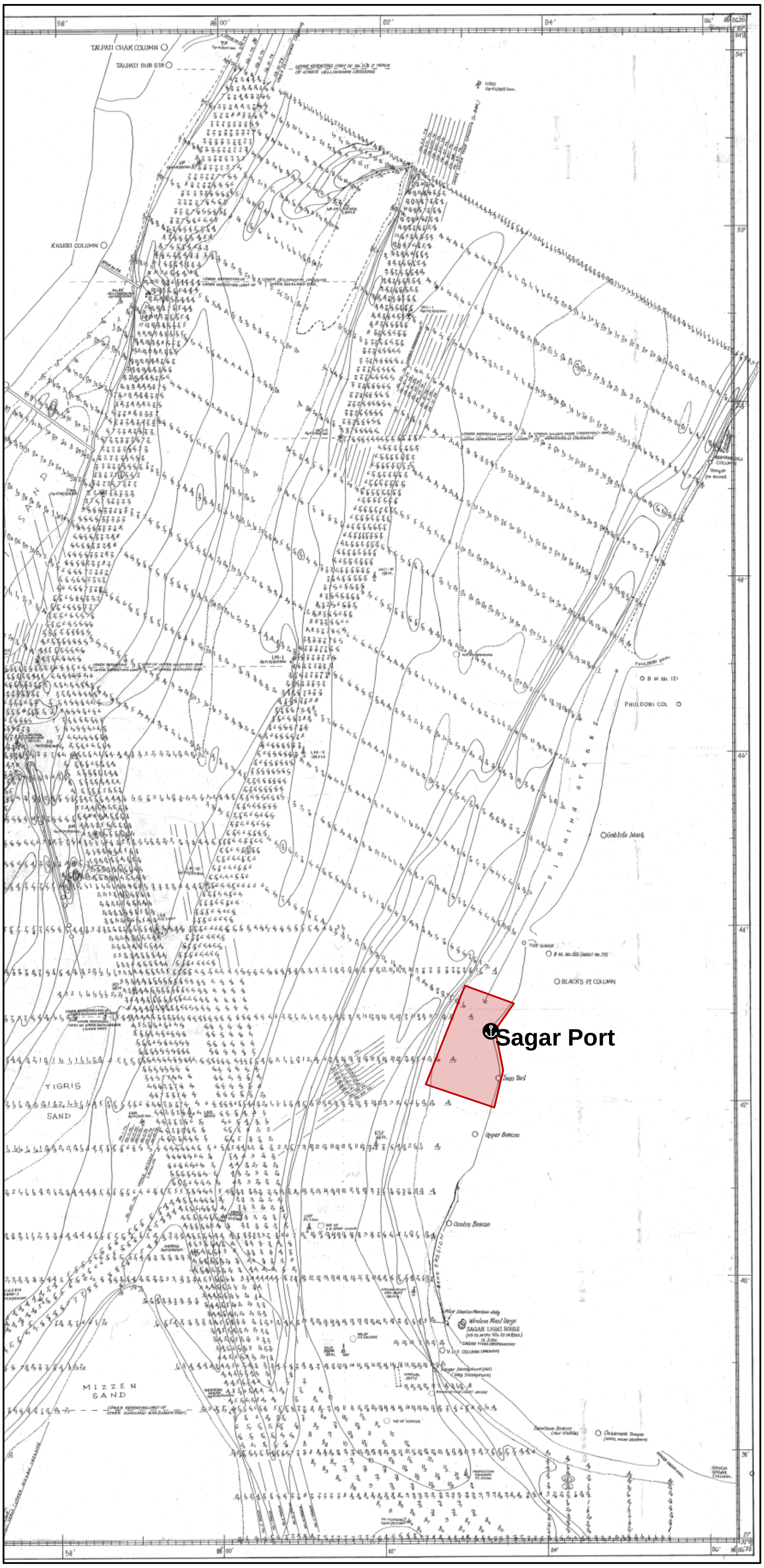



**Figure 2.9 Hydrographic Chart provided by KoPT**

## 2.7.2 Waves

### ***2.7.2.1 Offshore Wave Data***

The offshore wave data reported by India Meteorological Department (IMD) as observed from ships plying in deep waters off Sagar (Latitude 20° N to 25°N, Longitude 85°E to 95°E) for 33 years from 1968 to 2001 were analysed. The frequency distribution of wave heights from different directions during different seasons and entire year for the above offshore data were presented in the form of the wave rose diagrams presented in **Figure 2.10**. It is seen from the deep water data that the predominant wave directions in the deep sea off Sagar are from WSW to SSE. It may be noted that the wave height based on ship observed data closely corresponds to significant wave height, which represents average energy of the random wave train.

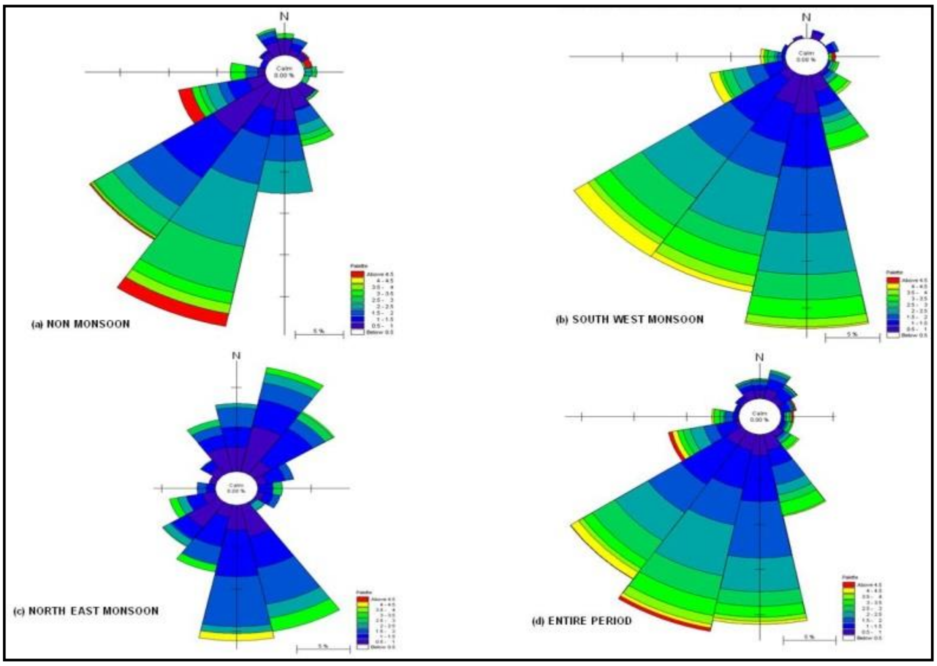



**Figure 2.10 Offshore Wave Rose Diagrams**

### ***2.7.2.2 Measured Wave Data***

The wave data were measured for months of June, July and August 2011. The results are presented in **Table 2.2** below:

**Table 2.2 Percentage Occurrence of Measured Wave Heights (m) during SW Monsoon**

| Month | Significant Wave height (m) | | |
|---|---|---|---|
| | 0.0 - 0.5 | 0.5 - 1.0 | 1.0 - 1.5 |
| June | 82.97 | 17.03 | 0 |
| July | 77.26 | 22.74 | 0 |
| August | 67.77 | 32.08 | 1.14 |

#### *2.7.2.3 Nearshore Wave Transformation*

As waves travel from deep sea to shallow coastal waters, they undergo changes in direction and height due to the processes of refraction and shoaling. MIKE21 SW models is a spectral wind wave model based on unstructured mesh and it simulates the growth, decay and transformation of wind – generated waves and swell in offshore and coastal areas. In the present case, MIKE21 SW was used to assess these transformations of offshore wave conditions to the proposed port location.

The offshore data reported by India Meteorological Department (IMD) as observed from ships plying in deep waters off Sagar (Latitude 20° N to 25° N, Longitude 85° E to 95° E) for 33 years from 1968 to 2001 were analysed and used as input to the model. In addition, wave data collected on the southern tip of Sagar Island for months of June, July and August 2011 was also considered for the study.

The analyses of the offshore data suggested that the predominant wave directions in the deep sea off Sagar are from WSW to SSE (**Table 2.3**).

**Table 2.3 Percentage Occurrence of Wave Height & Direction off Sagar Island for Entire Period (Jan-Dec)**

| Height (m) | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|
| **DIRECTION** | | | | | | | | **CALM** | **%** | **5.47** |
| 22.50 | 1.13 | 1.02 | 0.59 | 0.25 | 0.00 | 0.14 | 0.00 | 0.00 | 0.00 | 3.14 |
| 45.00 | 0.58 | 1.06 | 0.33 | 0.00 | 0.18 | 0.04 | 0.00 | 0.00 | 0.02 | 2.20 |
| 67.50 | 0.18 | 0.74 | 0.36 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.16 | 1.50 |
| 90.00 | 0.00 | 0.31 | 0.00 | 0.18 | 0.31 | 0.18 | 0.00 | 0.00 | 0.18 | 1.16 |
| 112.50 | 0.14 | 0.33 | 0.14 | 0.14 | 0.29 | 0.14 | 0.00 | 0.00 | 0.00 | 1.19 |
| 135.00 | 0.67 | 0.09 | 0.27 | 0.43 | 0.09 | 0.65 | 0.18 | 0.00 | 0.00 | 2.39 |
| 157.50 | 1.64 | 1.78 | 2.01 | 1.04 | 0.82 | 1.38 | 0.11 | 0.00 | 0.00 | 8.78 |
| 180.00 | 2.18 | 4.83 | 5.95 | 3.56 | 1.49 | 1.13 | 0.47 | 0.29 | 0.00 | 19.91 |
| 202.50 | 1.72 | 4.10 | 3.92 | 5.43 | 2.52 | 1.73 | 0.95 | 0.36 | 0.36 | 21.09 |
| 225.00 | 1.72 | 4.99 | 3.55 | 3.55 | 2.5 | 1.02 | 0.47 | 0.85 | 0.04 | 18.69 |
| 247.50 | 0.33 | 1.82 | 1.10 | 1.26 | 0.67 | 0.51 | 0.00 | 0.50 | 0.33 | 6.50 |
| 270.00 | 0.18 | 0.36 | 0.72 | 0.13 | 0.36 | 0.54 | 0.00 | 0.18 | 0.00 | 2.48 |
| 292.50 | 0.14 | 0.29 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.51 |
| 315.00 | 0.43 | 0.31 | 0.02 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.78 |
| 337.50 | 0.99 | 0.49 | 0.4 | 0.00 | 0.16 | 0.05 | 0.00 | 0.00 | 0.00 | 2.09 |
| 360.00 | 0.90 | 0.51 | 0.49 | 0.11 | 0.00 | 0.13 | 0.00 | 0.00 | 0.00 | 2.13 |
| **Total** | **12.94** | **23.02** | **19.92** | **16.08** | **9.47** | **7.64** | **2.18** | **2.18** | **1.08** | **100.00** |

It is evident from the above analysis that about 95% of the time wave height is less than 3m.

Nearshore wave transformation of the offshore wave conditions was carried out and the results were extracted at every 1000 m at 18 locations opposite the waterfront of Sagar Island, as shown in **Figure 2.11** below.

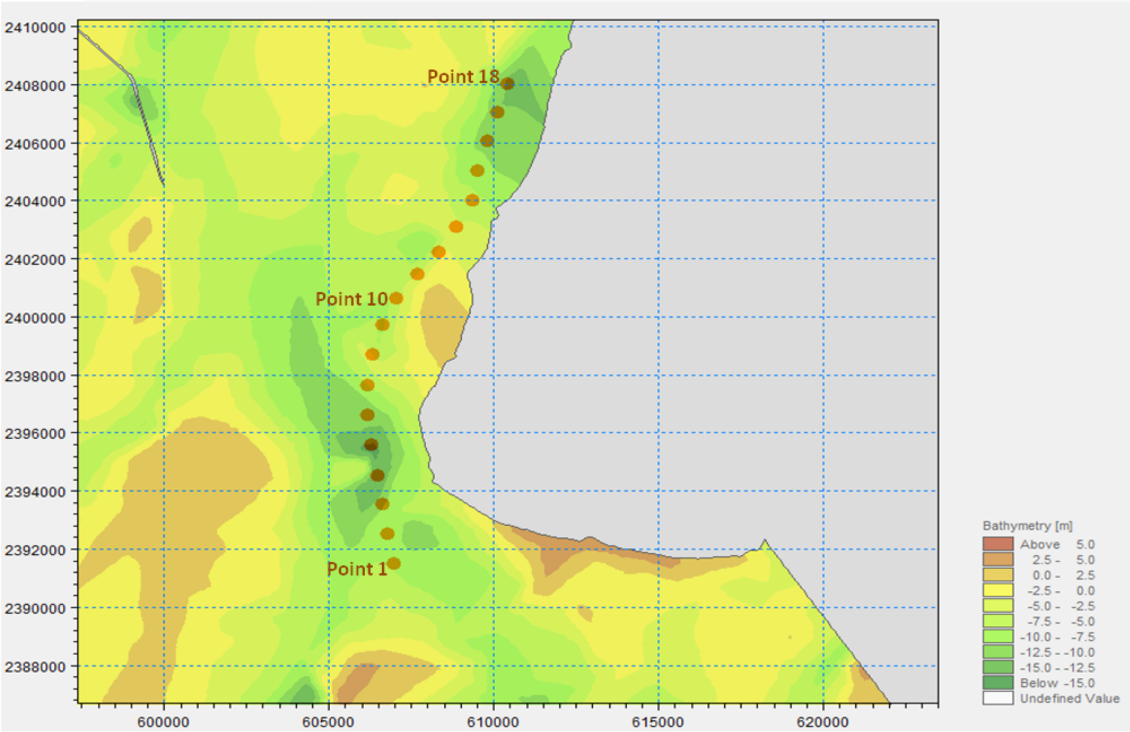



**Figure 2.11 Locations of Extraction of Wave Height along the Approach Channel**

Points 12 to 15 represent the waterfront of the proposed port location at Sagar Island. Nearshore wave transformation studies were carried out for an offshore wave height of 3 m offshore and the resultant wave heights from various incident directions have been arrived at as presented in **Table 2.4,** below:

**Table 2.4 Wave Heights along the Sagar Waterfront with respect to 3 m Offshore Wave Height with High Water from various directions**

| Locations | Incident Wave from SSE | Incident Wave from S | Incident Wave from SSW | Incident Wave from SW |
|---|---|---|---|---|
| 1 | 0.62 | 0.27 | 0.82 | 0.77 |
| 2 | 0.64 | 0.33 | 0.82 | 0.78 |
| 3 | 0.66 | 0.35 | 0.75 | 0.76 |
| 4 | 0.66 | 0.35 | 0.73 | 0.75 |
| 5 | 0.66 | 0.37 | 0.71 | 0.77 |
| 6 | 0.65 | 0.39 | 0.72 | 0.78 |
| 7 | 0.64 | 0.38 | 0.74 | 0.77 |
| 8 | 0.56 | 0.34 | 0.73 | 0.77 |
| 9 | 0.50 | 0.33 | 0.72 | 0.76 |
| 10 | 0.41 | 0.29 | 0.72 | 0.73 |

| Locations | Incident Wave from SSE | Incident Wave from S | Incident Wave from SSW | Incident Wave from SW |
|---|---|---|---|---|
| 11 | 0.32 | 0.22 | 0.67 | 0.66 |
| 12 | 0.27 | 0.16 | 0.60 | 0.59 |
| 13 | 0.26 | 0.14 | 0.59 | 0.57 |
| 14 | 0.25 | 0.13 | 0.58 | 0.56 |
| 15 | 0.25 | 0.14 | 0.57 | 0.55 |
| 16 | 0.24 | 0.13 | 0.59 | 0.54 |
| 17 | 0.23 | 0.13 | 0.58 | 0.55 |
| 18 | 0.22 | 0.13 | 0.57 | 0.54 |

It is concluded that wave heights at the proposed port location remain below the permissible limits for port operations and the weather downtime would be limited to during the cyclonic events only.

### 2.7.3 Tides

Tidal and current measurements were carried out continuously a period of 1 lunar month covering the tidal and current time history for a complete tidal cycle. Also, the bed samples and water samples were also collected in order to establish the characteristics of seabed and suspended silt content in the project area.

Tidal levels at Sagar Island are presented in **Table 2.5** as per the NHO chart 301. The levels mentioned below are with respect to Chart Datum (CD).

**Table 2.5 Tide levels at Sagar Island**

| Description | Tide Levels |
|---|---|
| Mean high water spring | +5.2m CD |
| Mean high water neap | +3.9m CD |
| Mean sea level | +3.0m CD |
| Mean low water neap | +2.2m CD |
| Mean low water level spring | +0.9m CD |

### 2.7.4 Currents

The current measurements have been carried out at 3 locations using FSI 2D-ACM self-recording current meter. The Current meter flow quest ADCP was lowered at location C1 at water depth of 8.7 m, 2DACM Current meter was lowered at location C2 at the water depth of 9.5 m & the Velport 106 was lowered at location C3 at the water depth of 4.9 m in the survey area. The Current speed in the region varies from 0.01 m/s to 1.15 m/s. The surface currents are found to be higher as compared to the velocities near the bottom.

However the recent measurements undertaken by KoPT at the proposed port location indicate the maximum current speed of about 2.5 m/s.

### 2.7.5 Water and Bed Samples

The Seawater samples were collected at 56 locations in the open sea. The water samples were collected using Aqua Trap water sampler. The samples collected were analysed for silt, grain size distribution of suspended load and salinity. The samples tested indicated that the water was slightly acidic with a high concentration of dissolved solids.

The coastal areas prone to tidal floods may have acid sulphate soils. Seabed samples were collected at 20 locations using a Van Veen grab sampler. The collected samples were then tested in the laboratory after being dried and sieved.

## 2.8 Geotechnical Conditions

The field investigations were carried out during June and August 2011 at proposed locations and consist of total 20 nos. of Boreholes. Refer **Figure 2.12** for borehole location map. About 9 boreholes were carried out near the proposed location of the port. The boreholes were terminated at a maximum depth of 30m.

Soil profiles for all the boreholes were developed as shown in **Figure 2.13** and **Figure 2.14** to study the distribution of the sub strata. According to the particle size distribution, the soil in boreholes MBH 1 to 9 consists of mostly silty sand.


**Figure 2.12 Topographic and Geotechnical Survey Locations**

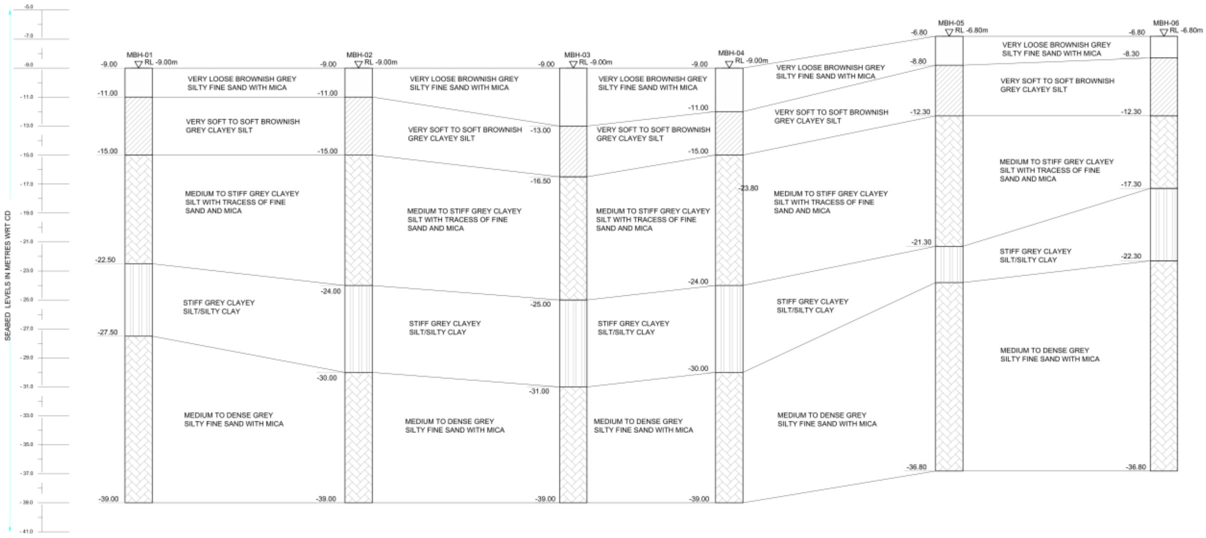



**Figure 2.13 Soil Profiles of Boreholes MBH 1 to MBH 6**

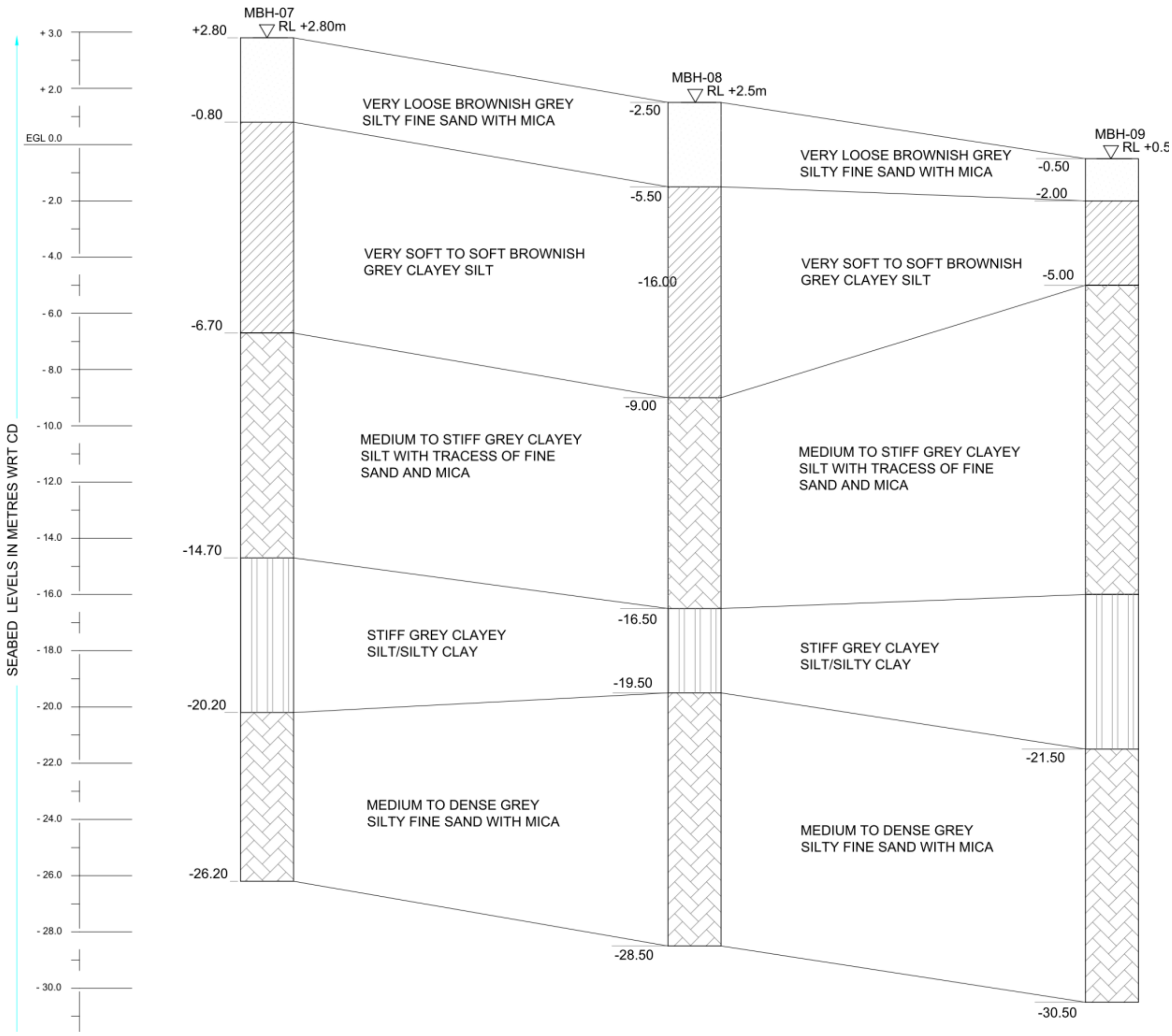



**Figure 2.14 Soil Profiles of Boreholes MBH 7 to MBH 9**

## 2.9 Topographic Information

Topographic survey was carried out at project site, covering an area of 4 $km^2$, by levelling/traversing and mapping. Spot levelling was carried out at a spacing of 50 m.

The topographic survey carried out were presented in the form of topographic survey maps as shown in **Figure 2.15** the elevations are marked WRT, mean sea level, which is (+) 3.00m CD.

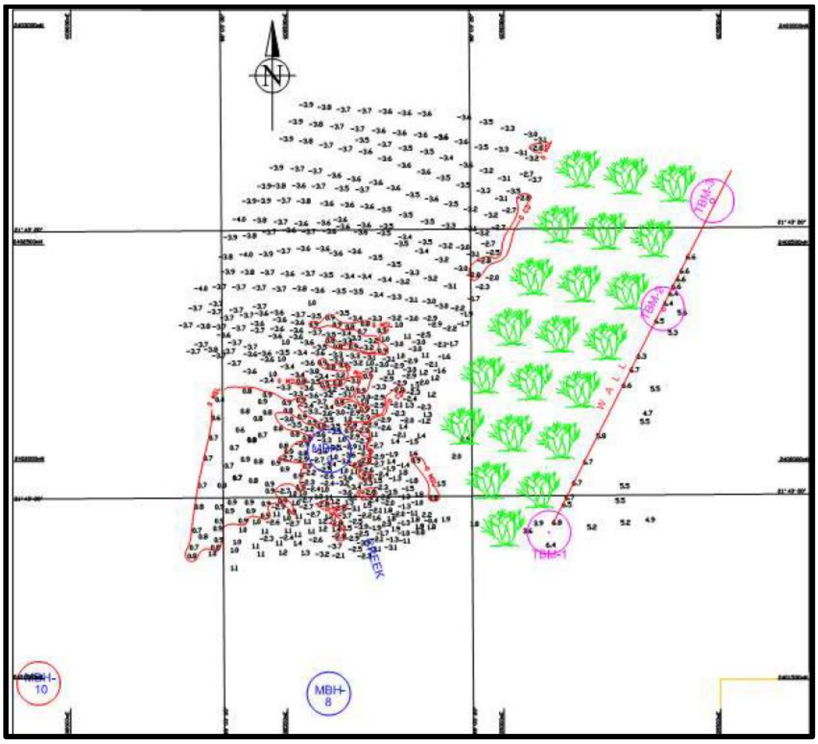



**Figure 2.15 Topographic Survey chart**

## 2.10 Connectivity of Port Site

### 2.10.1 Rail Connectivity

Eastern Railways has taken up the project of Rail connectivity as a feeder route to Eastern Dedicated Freight Corridor (DFC) from Kashinagar to Dankuni. Presently, there is no rail-road connectivity to Sagar Island with the mainland. It will be connected to the mainland by a proposed rail-cum-road bridge across the Muriganga River.

The utilization of the different sections between Dankuni and Namkhana via Dum Dum – Ballygunge - Baruipur and Laxmikantapur, capacity is marginally available between Kankurgachi and Ballygunge section to accommodate additional trains. In rest of the sections the line capacity is saturated and will get further deteriorated in future with the introduction of additional suburban trains. As only EMU rakes are in operation in all the sections, induction of any goods train with higher trailing load shall affect the existing line capacity since suburban trains are quicker in operation. In this context, introduction of any new freight train on this section will require laying of additional tracks throughout the section for carrying the projected traffic generated at the proposed port. Also providing any additional line particularly between Jadavpur and Ballygunge may not be feasible as no spare railway land is available and at the same time the area is thickly populated with residential buildings immediately after the railway boundary. Besides, movement of any additional freight traffic through Dum Dum station may be difficult. Similarly, movement of projected freight trains between Dum Dum and Dankuni may not be possible because no additional track can be laid on this section in view of land constraints and Vivekananda Bridge on river Hooghly. The proposed flyover at Dum Dum shall be mainly used for movement of trains to and from Bongaon section avoiding surface crossing at Dum Dum Junction. Considering these limitations, it would be necessary to plan a new dedicated route for movement of port traffic.

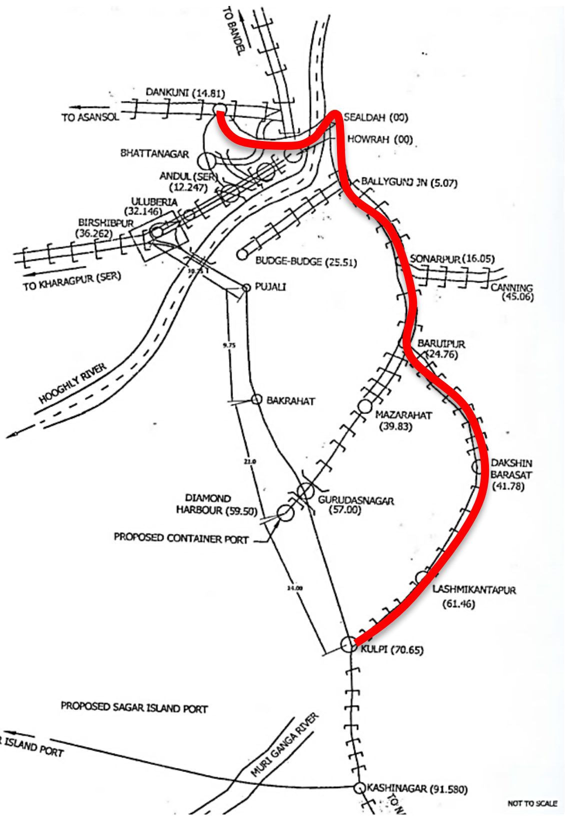



**Figure 2.16** **Currently Operating Alignment**

## 2.10.2 Road Connectivity

NH-117 runs through Kolkata-Diamond harbour – Kulpi – Kakdwip – Namkhana. Sagar Island can be connected with NH-117 near Kakdwip through the proposed bridge across the waterway. Sagar main road which is running from north to south of Sagar Island needs to be widened in order to facilitate the movement of anticipated traffic from/to the Port. In the island, the proposed road connecting the bridge and port location is intersected with Sagar main road, to serve the general public for their movement to main land. **Figure 2.17** shows West Bengal state road connectivity map and Sagar Island location with respect to existing NH-117 alignment.


**Figure 2.17** **NH-117 Connecting Kolkata-Namkhana**

# 3.0 Traffic Projections for Sagar Port

## 3.1 General

A port in Sagar will share the hinterland of the Haldia and Kolkata ports, particularly the power and steel plants in the eastern region, and containers from the eastern parts of India (Western UP, Odisha, Jharkhand, Chhattisgarh, etc.) and neighbouring landlocked countries - Nepal and Bhutan.

This section covers traffic projections for the proposed Sagar Port.

## 3.2 Hinterland Identification and Cargo Potential

Assessment of past traffic at Haldia & Kolkata port, interviews with industry bodies (West Bengal Industrial Development Corporation), and interviews with manufacturing units in the hinterland as well as port authorities have been conducted to assess traffic for Sagar port.

Cargo potential at Sagar has been estimated based on the following sources of information:

1. Assessment of past traffic at Haldia & Kolkata port
2. Landed cost economics analysis for relevant hinterland plants
3. Interviews with industry bodies (West Bengal Industrial Development Corporation)
4. Interviews with Port Authorities

Existing traffic (2014-15 in the eastern region in India is around 132 MTPA (**Figure 3.1**), with coal and POL being the primary commodities along with other general cargo (around 28 MTPA) consisting of limestone, manganese ore, food grains, vegetable oil, agro-products etc.

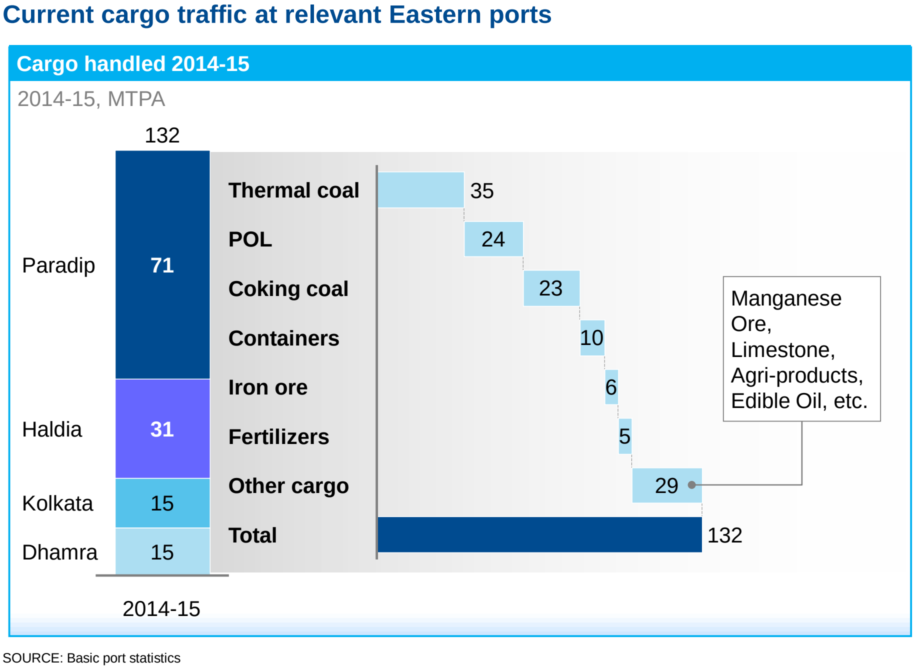



**Figure 3.1 Traffic at Relevent Eastern Ports**

The primary hinterland for the Haldia and Kolkata ports (for containers) is manufacturing units and agri-based cargo in the vicinity; the secondary hinterland is large with , Bihar and Jharkhand, serves the North-Eastern studies of Assam, Meghalaya, Nagaland, Tripura, Mizoram, Arunachal Pradesh and Sikkim as well as parts of Orissa, Chhattisgarh, Uttar Pradesh, Madhya Pradesh and the northeast (**Figure 3.2**).

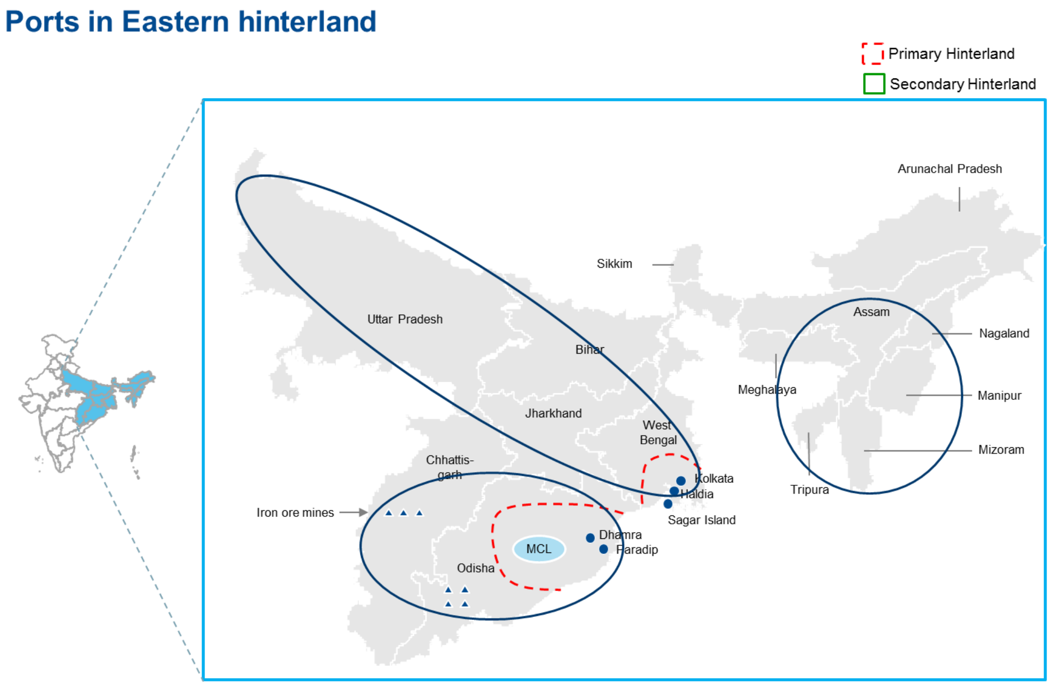



**Figure 3.2** **Hinterland to the Eastern Ports**

Based on the origin-destination analysis of key commodities and industrial growth in the eastern hinterland, cargo is projected to grow up to around 440 MTPA by 2025 (**Figure 3.3**).

### Eastern Hinterland: Kolkata Dock System, Haldia Dock Complex, Paradip, and Dhamra port

| Key commo-dities for the cluster | Current – 2014-15 (MMTPA) | 2020 (MMTPA) | 2025 (MMTPA) | 2035 (MMTPA) | Growth drivers for the next 5-10 years |
|---|---|---|---|---|---|
| Thermal Coal | 35.3 | 129.0 | 196.7 | 291.2 | Uijamala: Paradip and Dharma port to be used as loading ports for coastal shipping |
| Coking Coal | 23.0 | 37.8 | 47.5 | 78.8 | Increased coking coal imports due to capacity expansion of steel plants (Meramandali & Patratu) and greenfield plant at TATA, Kalinganagar |
| Iron Ore | 5.7 | 3.9 | 5.3 | 9.4 | Linear growth in exports/imports due domestic mining regulation and low global export spot prices |
| Fertilizer | 5.4 | 10.0 | 12.6 | 18.9 | Business as usual growth for finished and fertilizer raw material. No major upswing identified |
| POL | 24.1 | 40.1 | 53.4 | 88.5 | Operations start of IOCL Paradip. increasing the volume of crude imports at Paradip |
| Containers (nm. TEU) | 10.1 | 17.2 (1.1) | 26.6 (1.7) | 34.5 (2.3) | Increased containerization, port led development and increased export competitiveness |
| Cement | 0.4 | 8.0 | 30.7 | 50.9 | Coastal shipping of Steel, Creation of New Steel clusters as part of port led development |
| Steel | 0.0 | 8.4 | 20.9 | 34.6 | Coastal shipping of Cement, Creation of New Cement clusters as part of port led development |
| Others | 28.3 | 57.0 | 72.4 | 112.9 | |
| **TOTAL** | **115.6** | **294.2** | **439.5** | **719.0** | |

**Figure 3.3 Projected Traffic in Eastern Hinterland**

**Most of the increase in cargo will be contributed by:**

a) Coastal shipping of thermal coal (around 100 MTPA), **this traffic is relevant only for Paradip and Dhamra**
b) Coking coal (12 MTPA increase) to serve new upcoming plants of Tata Kalinganagar, JSPL Patratu, etc. and capacity expansion projects at SAIL, Bokaro etc.
c) Containers due to a rise in containerization and manufacturing boost
d) Growth in general cargo due to industrial growth in the region

The existing capacity of the four primary ports in the hinterland - Paradip, Dhamra, Haldia and Kolkata is around 190 MTPA. This capacity - meets the current need of the hinterland cargo. However, the future capacity projection based on existing port expansion plans and the headroom available for growth at four port locations will fall short of cargo projections by 2030.

Port capacity combined at all four locations will become equal to capacity available in 2030–2032, as the projected hinterland traffic in 2030 will be around 524 MTPA compared to the available capacity of around 530 MTPA.

While Paradip and Dhamra ports have the potential for expansion due to the availability of waterfront, land and draft (**Figure 3.4**), the Kolkata Dock System and Haldia Dock Complex have limited headroom for expansion. KDS is constrained by limited waterfront availability and HDC will need to create a new lock or new berths.

Thus, an additional deep water port in West Bengal would be required by 2030.

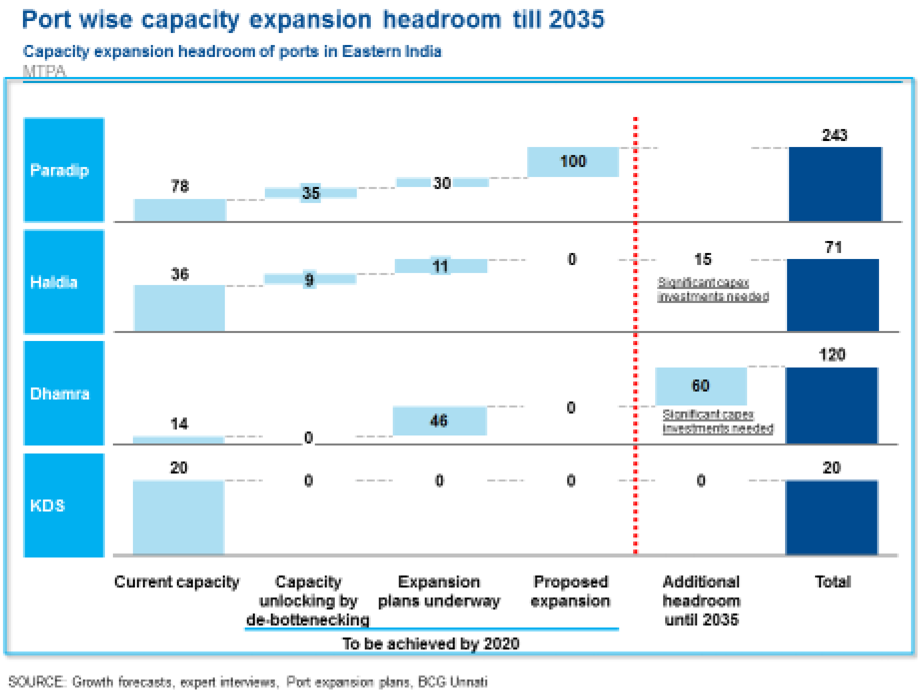



**Figure 3.4 Capacity Expansion Headroom of Eastern Ports**

Paradip and Dhamra ports have a large primary hinterland mostly centred on natural resources and the location of steel and power plants. Logistics costs for bulk cargo for these plants is the lowest through Paradip and Dhamra, hence this cargo is unlikely to shift to the Sagar port.

The Sagar port will share the hinterland cargo currently being serviced by the Haldia and Kolkata ports. Looking at the profile of cargo being handled at Haldia & Kolkata port the likelihood of cargo types spilling over from Haldia/Kolkata is the following (**Figure 3.5**)

- **Petroleum, Oil & Lubricants:** The products/crude imported at Haldia port currently is consumed within a radius of 100-300 km. Most of the consumption centres are already connected to the Haldia refinery and dock based storage through existing pipeline infrastructure. Thus it is unlikely that this cargo would shift to Sagar.
- **Coal:** A detailed analysis of relevant steel plants (SAIL, TATA, JSPL and others) and thermal plants on the basis of landed logistics cost, from Australia (coking coal) and Indonesia (thermal coal) has been undertaken. The data reveals that only SAIL, Durgapur will have comparable cost savings (~48 INR /tonne), for all the other plants in the hinterland Dhamra port and Paradip port will have natural ownership of the coking coal cargo. Thus, this will not shift to Sagar port.
- **Containers:** Apart from traffic originating in the immediate hinterland, the KDS and HDC handle container traffic from Bihar, Orissa, North-East, part of Uttar Pradesh and NCR besides the neighbouring Countries of Nepal and Bhutan. Capacity at HDC can reach 0.3-0.4 million TEU. At KDS current capacity is 0.8 million TEU but headroom for further expansion is limited. As the container traffic volume increases, overflow traffic from KDS could potentially move to Sagar.
- **Iron Ore:** The volume of Iron Ore exports has been on a decline and as per the origin-destination study conducted the Iron Ore volumes will remain muted and hence, the probability of shifting to Sagar port is low.
- **Fertilizers**: The imported fertilizers finished products and fertilizer raw materials, moved by rail travels to various locations in the hinterland such as Birgunj, Birbhum/ Burdwan/ Murshidabad, and Eastern UP and Bihar-Gorakhpur, Samstipur, Darbhanga, etc. for

processing and consumption. Haldia dock complex currently has the business environment and set –up for relevant processing units hence only spill over cargo can move to Sagar port.

- **Other Cargo:** Most of the other cargo (Vegetable oil, Manganese Ore, Limestone etc.) is generated or consumed within 100-300 km of the existing port and thus, has an established business environment; Interviews conducted with manufacturing units in the vicinity of Haldia confirm that handling this cargo in Sagar would result in significantly higher costs and would not be economically viable.

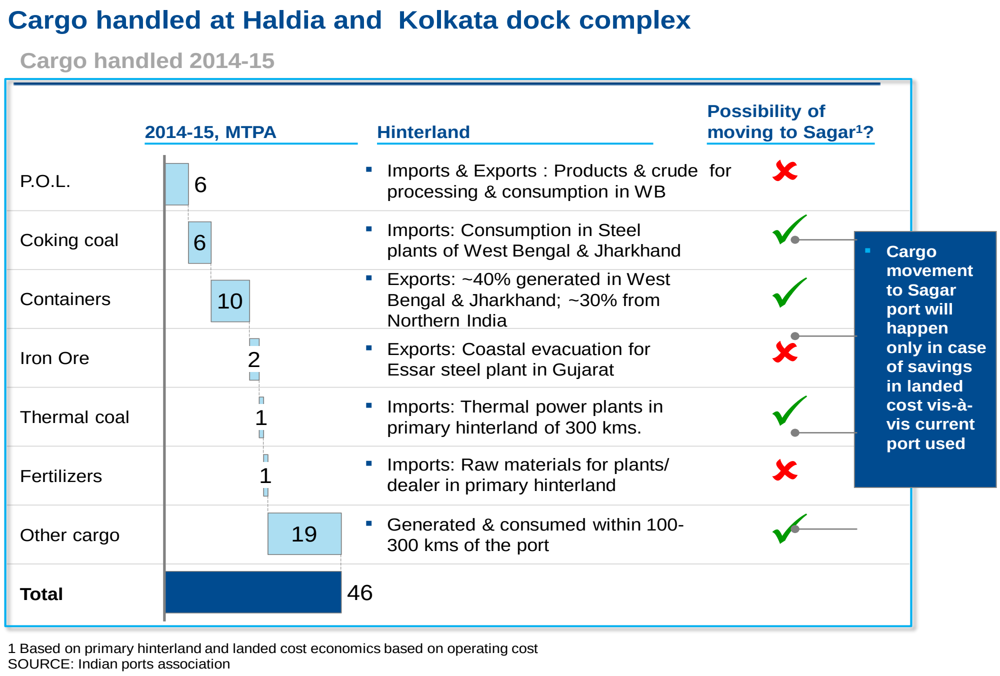



**Figure 3.5 Cargo handled at Haldia and Kolkata Dock Complex**

Also, the Sagar port does not have a natural hinterland and ownership of any cargo due to limited levels of industrialisation in eastern West Bengal and Ganga Sagar Island. We have conducted interviews with West Bengal Industrial Development Corporation, which confirmed that there are no existing plans for establishing an industrial zone for the Ganga Sagar Island. Thus, the potential for growth in cargo from Sagar Island remains muted, Also, Eastern West Bengal the level of industrialization and presence of manufacturing units is low to generate enough for Sagar port.

## 3.3 Competitive Analysis and Possible Diverted Cargo

An end-to-end landed-cost analysis for around 20 relevant steel and power plants in the hinterland was conducted to ascertain the natural cargo ownership of the Sagar port.

**For importing cargo, any plant in the hinterland has six choices across four ports:**

- Importing through the Haldia port with a sub-Panamax vessel or a part-load Panamax vessel;
- Importing through a cape-sized vessel and conducting transloading at the Paradip anchorage using a 10,000–15,000 DWT vessel from anchorage to the Haldia dock;
- Importing at the Dhamra port in a Panamax vessel in case of a smaller throughput (<2 MTPA);
- Importing at the Dhamra port in a cape-sized vessel in case of a bigger throughput (>2 MTPA);
- Importing at the Sagar port in a Panamax/Sub- Panamax vessel, and
- Importing at the Paradip port in a Panamax vessel.

The components of landed cost have been taken as:

a) Ocean freight (from Australia in case of coking coal and Indonesia in case of thermal coal) and
b) Railway freight, based on actual rail kilometres.

Analysis reveals that the Dhamra port is economical for most plants, as it is able to handle cape-sized vessels in case of an annual cargo throughput more than 2 MTPA (**Table 3.1**). Further, as per the proposal, the Paradip port would also start constructing an outer harbour for handling cape size ships, thus reducing the landed cost at the Paradip port as well with enabling a cape- size vessel.

The Sagar port can attract around 1.9 MTPA of coking coal cargo for the SAIL Durgapur plant currently. Although, while Sagar port does not come out as the cheapest port of call for any of the existing steel and upcoming power plants, the landed cost of coking coal/ thermal coal at Sagar port is only marginally expensive in case of a 9 m draft (Sub- panamax vessel). In case of 13.5 m draft Sagar port becomes comparable to Haldia port in landed cost (**Table 3.1** and Figure 3.6).

Thus, Sagar port can become a viable alternative to serve as for spill-over cargo, specifically non-POL bulk from the Haldia dock complex.

**Table 3.1 Ocean Freight Analysis to Eastern Ports**

| | | Types of Ship | Lightered Panamax | Capesize/ Panamax | Sub-Panamax | Panamax |
|---|---|---|---|---|---|---|
| Commodity | Volumes (MMTPA) | Points in hinterland | Haldia | Dhamra | Sagar | Paradip |
| | 6.20 | TISCO | 1,407 | 1,079 | 1,544 | 1,535 |
| | 2.40 | SAIL, Bokaro | 1,564 | 1,241 | 1,627 | 1,697 |
| | 2.50 | SAIL, IISCO | 1,502 | 1,179 | 1,516 | 1,635 |
| | 3.32 | SAIL, Rourkela | 1,627 | 1,299 | 1,746 | 1,521 |
| | 1.90 | SAIL, Durgapur | 1,490 | 1,513 | 1,452 | 1,683 |
| | 0.60 | Bhushan steel, Sambalpur | 1,791 | 1,479 | 1,867 | 1,370 |
| | 6.80 | Tata steel, Kalinganagar, Orissa | 1,525 | 721 | 1,670 | 1,060 |
| Coking Coal | 1.70 | Bhushan steel, Meramandali | 1,715 | 1,194 | 1,808 | 1,085 |

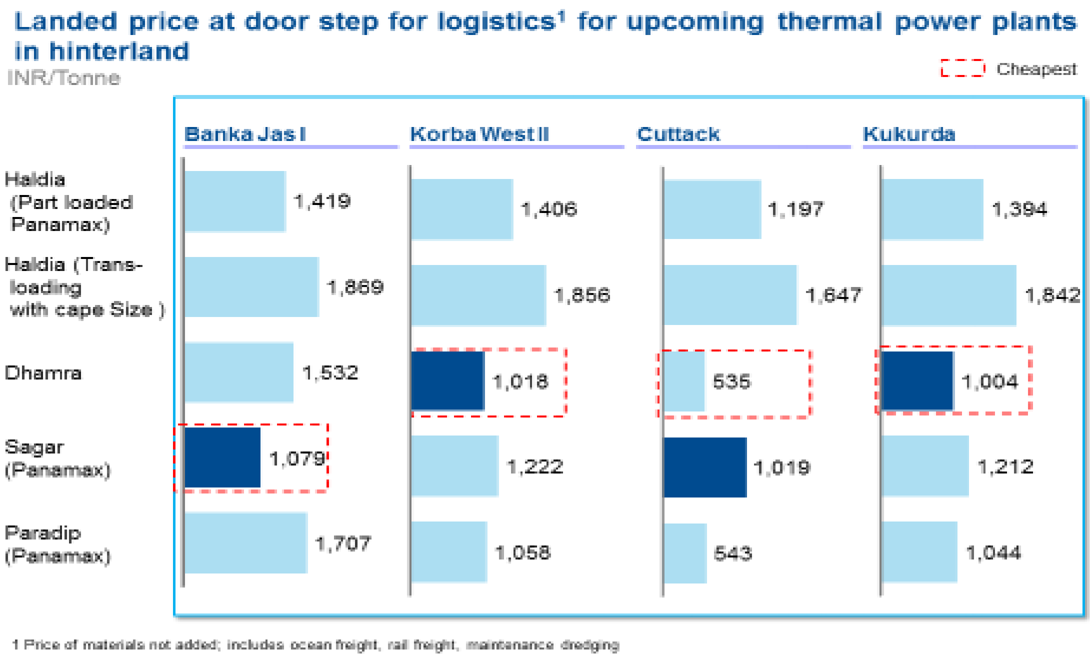



**Figure 3.6 Logistics Cost for the upcoming Power Plant**

Landed cost includes ocean freight, rail freight, handling cost and in the case of trans-loading, trans-loading charge and extra barging cost.

## 3.4 Haldia Port Capacity Expansion Scenario

Haldia port has a lock based system with an estimated capacity of 30 MTPA, with lock gate being the main limiting factor currently in increasing capacity further. There is potential to further expand the capacity outside the lock either by creating another lock or through use of Trans-loading systems with barge handling berths outside the lock and additional riverine jetties.

The port is currently operating at only ~24 MTPA within the lock due to low productivity operations on the berth. As part of Project Unnati, a detail set of initiatives have been proposed to unlock the capacity and enable the port to reach 34 MTPA capacity. Basis this analysis, it looks quite feasible to increase cargo throughput from 24 MTPA to 34 MTPA without significant incremental capex.

Also, currently the port has 3 berths outside the locks for handling oil cargo. These berths currently handle 7 MTPA of oil cargo. There are plans to develop additional riverine jetties outside the lock and it is expected that the port will be able to handle about 50 MTPA of cargo.

In order to further expand capacity, the port will need to make investments in building new berths / jetties at Shalukhali. They will also have to establish road / rail linkages with the current port network.

A detail analysis will be required to estimate the maximum capacity can be created through this route, though a total port capacity of > 60 MTPA should be feasible. Alternatively, in case of Greenfield investments the port can also explore the possibility of creating another lock system basis commercial feasibility and this can take the port capacity beyond 60 MTPA.

For container traffic the Haldia Dock Complex has a current capacity of 0.6 Mn. TEU which cannot be extended beyond that in the existing complex. Thus, in order to cater to container cargo other than 0.6

Mn. TEU Haldia port complex will need to make a Greenfield capex investment of around INR 2,000-2,500 crores in Haldia – II, which will offer a draft of 6-8 m compared to 9 m (in Phase 1) at Sagar port.

Thus, for Sagar port to generate any traffic from Haldia cargo spill over, a decision on whether Greenfield investments in Haldia should be continued has to be made.

## 3.5 Final Traffic Forecast Figures adopted for Port Planning

As it is clear from the preceding analysis, Sagar port does not have a natural hinterland or ownership of cargo. Most of the bulk cargo will continue to move through the existing four ports in the eastern region until such time that the ports run out of capacity. A new hinterland could develop for Sagar through increased industrial activity in West Bengal but as of now, there are no confirmed plans from the state government.

Any cargo from the hinterland of the Dhamra or Paradip ports will not shift to the Sagar port, due to relative distance and increased landed cost. The Dhamra and Paradip ports serve the evacuation of natural resources and import of raw materials for plants in the hinterland. The Sagar port is around ~200-270 km away from both the ports and thus, cargo evacuation through Paradip and Dhamra is the economical choice.

For traffic projections of the Sagar port, we have considered **container and non-POL bulk overflow from Kolkata and Haldia port**: The Kolkata Dock System cannot handle/expand more than its current capacity of 0.8 Mn. TEU's due to water front constraints although the container traffic in the Eastern Ports cluster (Paradip, Dhamra, Kolkata, Haldia) etc. is projected to be ~2.3 Mn. TEU. Thus, the growth of container cargo generated in the hinterland will be evacuated from Sagar port. (**Table 3.2**)

The Kolkata port currently handles around 0.54 Mn. TEU and according to the hinterland growth of around 8 percent would reach capacity (0.8 Mn. TEU) by 2020 and hence the overflow of containers will start to Sagar port. It may be noted, that at Haldia port, with the current plans of floating jetties outside the lock, the non POL bulk capacity can potentially reach 50-55 MTPA. With this capacity, the spill over of non POL bulk from Haldia is only expected after 2035.

**Table 3.2 Base Case - Container and Bulk Cargo for Sagar Port**

| Base Case | Cargo overflow from Kolkata Port Trust - Containers & Break Bulk | | |
|---|---|---|---|
| Year | Total Traffic (in MT) | Container (in MT) | Break Bulk (in MT) |
| 2020-21 | 3.42 | 0.52 | 2.90 |
| 2021-22 | 4.09 | 0.71 | 3.38 |
| 2022-23 | 5.44 | 1.55 | 3.89 |
| 2023-24 | 7.41 | 2.99 | 4.42 |
| 2024-25 | 9.53 | 4.55 | 4.98 |
| 2025-26 | 11.14 | 5.81 | 5.33 |
| 2026-27 | 12.84 | 7.15 | 5.69 |
| 2027-28 | 14.64 | 8.57 | 6.07 |
| 2028-29 | 16.52 | 10.07 | 6.45 |

| Base Case | Cargo overflow from Kolkata Port Trust - Containers & Break Bulk | | |
|---|---|---|---|
| **Year** | **Total Traffic (in MT)** | **Container (in MT)** | **Break Bulk (in MT)** |
| 2029-30 | 18.52 | 11.67 | 6.85 |
| 2030-31 | 20.05 | 12.80 | 7.25 |
| 2031-32 | 21.64 | 13.97 | 7.67 |
| 2032-33 | 23.29 | 15.19 | 8.11 |
| 2033-34 | 25.00 | 16.45 | 8.55 |
| 2034-35 | 26.78 | 17.77 | 9.01 |
| 2035-36 | 26.78 | 17.77 | 9.01 |

# 4.0 Design Ship Sizes

## 4.1 General

The size of ships that would call at any port will generally be governed by the following aspects:

- The trading route
- Availability of a suitable ship in the market
- Available facilities mainly navigational channel and manoeuvring areas including the draft
- The available facilities for loading & unloading
- Volume of annual traffic to be handled and the likely parcel size as per the requirements of the users.

The following main cargo commodities for the proposed Sagar Port have been identified:

- Dry Bulk - Coal
- Break Bulk - Steel, Non Metallic Minerals, Engineering Goods
- Containers

## 4.2 Dry Bulk Ships

Dry bulk carriers are generally classified into the following groups, viz.

| | | |
|---|---|---|
| Handysize | : | 10,000–40,000 DWT |
| Handymax | : | 40,000–60,000 DWT |
| Panamax | : | 60,000–80,000 DWT |
| Cape | : | 80,000–120,000 DWT |
| Super cape | : | Over 120,000 DWT with the largest carrier being 322,000 DWT |

While selecting the design ship size, in addition to ascertaining the freight advantage of larger vessels, it is essential to study the origin/destination ports and the facilities available there for handling large carriers.

Considering the draft limitations on account of the likely maintenance dredging required at the proposed port at Sagar, the size of the dry bulk ships is proposed to be limited to Panamax carrier (80,000 DWT).

## 4.3 Break Bulk Ships

### 4.3.1 General Cargo

The general cargo commodities such as non-metallic minerals, heavy machine goods etc. are likely to be imported / exported in ships, which range from 10,000 DWT to 40,000 DWT. For planning purposes 40,000 DWT is recommended as the maximum design size of general cargo ships.

### 4.3.2 Steel Products

Generally, steel, steel products etc. are exported mainly through general cargo ships. At the Indian ports, ship sizes carrying steel products are 20,000 DWT on an average, though there have been occasions when ships of about 40,000 DWT have also called. Considering these facts it is recommended to adopt the design ship size as 40,000 DWT.

## 4.4 Container Ships

Container ships are classified into six broad categories viz. Feeder, Feeder Max, Handy, Sub-Panamax, Panamax and Post-Panamax. The following table, which has been compiled through data from the Shipping Register of Lloyds Fairplay database, gives a broad outline of the principal dimensions of the ships under the different categories. The **Table 4.1** gives the dimensions of the smallest and the largest ship in each category. This will help in planning the layout of the container terminal and the other facilities.

**Table 4.1 Dimensions of the Smallest and Largest Ship**

| Parameters | 1000 TEU | 2000 TEU | 4000 TEU | 6000 TEU | 9000 TEU | 14500 TEU | 15000 TEU | 16000 TEU | Triple E | 18300 TEU |
|---|---|---|---|---|---|---|---|---|---|---|
| **Nominal Capacity** | 1000 | 2000 | 4000 | 6000 | 9000 | 14500 | 15000 | 16000 | 18000 | 18300 |
| **LOA (m)** | 160 | 200 | 290 | 320 | 350 | 365 | 397 | 400 | 400 | 400 |
| **Beam (m)** | 22 | 32 | 32 | 42 | 45 | 50 | 56 | 54 | 59 | 59 |
| **Loaded Draft (m)** | 10.0 | 11.0 | 13.5 | 14.0 | 15.0 | 16.0 | 15.5 | 15.5 | 15.0 | 15.5 |

[Source: Lloyds Fairplay Database]

Considering the location of Sagar Island, only feeder ships will call. However, provision should be made to handle larger direct-call ships (4000 TEUs) at a later date.

## 4.5 Design Ship Sizes

The principal dimensions of the ships considered for the preparation of the layouts and design of marine structures for the proposed Sagar port are presented in **Table 4.2** below:

**Table 4.2 Parameters of Ship Sizes**

| Commodity | Design Ship Sizes (DWT) | Maximum Parcel Size (T) | Overall Length (m) | Beam (m) | Loaded Draft (m) |
|---|---|---|---|---|---|
| Coal | 80,000 | 72,000 | 240 | 32 | 13.5 |
| Break Bulk | 10,000 | 9,000 | 125 | 19 | 8.1 |
| | 20,000 | 18,000 | 160 | 25 | 10.0 |
| | 40,000 | 200 | 200 | 28 | 11.3 |
| Containers | 1000 TEUs | 700 TEUs | 160 | 22 | 10.0 |
| | 4000 TEUs | 1,200 TEUs | 290 | 32 | 13.5 |

# 5.0 Port Facility Requirements

## 5.1 General

The layout of any port will be based on the requirements in terms of number of berths, navigational requirements, material handling equipment, storage area for each type of cargo, road and rail access for the receipt and evacuation of cargo, and other utilities and service facilities. These requirements have to be worked out for development in a phased manner to enable preparation of the port's master plan.

Presently, ships going to Haldia and Kolkata are brought through the eastern channel. The daily draft forecast for every month, for vessels going to Haldia dock, Kolkata port and Sagar Roads is intimated by KoPT in advance so that appropriate scheduling of vessel could be made. Analysing this data it has been observed that for vessels going to Sagar roads an additional draft ranging from 1.4 m to over 2.0 m is available as compared to Haldia and Kolkata Ports respectively. This information has been utilised to propose the phasing of dredging for Sagar port as given below:

**Initial Phase - To handle vessels with draft of 9.0 m with tidal advantage**

**Ultimate Phase - To handle vessels with draft of 13.5 m with tidal advantage**

The vessel size for Phase 1 is carefully chosen so that no capital dredging is needed in the long eastern approach channel. This would still enable carrying about 30,000 T of parcel size of bulk in Panamax ships round the year with minimum waiting time.

It may further be noted that in Phase 1 itself, for about 109 days in a year, it would be possible to navigate vessels with draft of over 9.5 m.

The dredging of the eastern channel and Sagar Channel could be undertaken in phased manner so as to achieve adequate water depths to handle the design draft of 13.5 m, as per the trade requirements.

## 5.2 Berth Requirements

### 5.2.1 General

The required number of berths depends mainly on the cargo volumes and the handling rates. While considering the handling rates for various commodities it must be ensured that they are at par or better as compared to the competing facilities so as to be able to attract more cargo. Allowable berth occupancy, the number of operational days in a year and the parcel sizes of ships are other main factors that influence the number of berths.

### 5.2.2 Cargo Handling Systems

Considering the project throughput and the competiveness requirements, the handling systems assumed for various commodities are described below:

#### ***5.2.2.1 Containers***

Considering the projected traffic for containers, it is proposed to provide state of the art equipment as well as the best international operational practice. It is proposed to equip the container terminal with post panamax Rail Mounted Quay Gantry Cranes (RMQC) on berths. For handling at the container yard suitable number of Rubber Tyred Gantry Cranes (RTGCs) shall be provided. At the railway yard Rail Mounted Gantry Cranes (RMGCs) shall be provided to enable faster turnaround of rakes.

#### ***5.2.2.2 Dry Bulk Import***

For dry bulk import of cargo like thermal and coking coal, ore, FRM etc. the fully mechanised system of comprises of gantry type unloaders at berth, connected conveyor system from berth to yard, stacker and reclaimer at yard and wagon loading system.

However, considering the minimal traffic of bulk import commodities in Phase 1, it is proposed to handle this cargo at the multipurpose berths using mobile harbour cranes. Although the traffic is limited, it is proposed to provide mobile hoppers with the connected conveyor system at the multipurpose berth and stackers at the stackyard in the subsequent phases. The rail loading of bulk cargo is proposed to be through front end loaders only.

#### ***5.2.2.3 Break Bulk cargo***

The forecast of other dry bulk cargoes at Sagar Port comprise of iron and steel, non-metallic goods, Sugar etc. Mostly geared ships are used for carrying these cargos. However, it is proposed to provide two mobile harbour cranes at each berth to achieve higher handling rates. Support dumpers/ trailers shall be provided to match the handling rates at berth. At storage areas adequate number of front end loaders, mobiles cranes would be provided.

### 5.2.3 Cargo Handling Rates

The following cargo handling rates have been assumed as mentioned in **Table 5.1** below:

**Table 5.1 Cargo Handling Rates**

| S. No. | Commodity | Average Handling Rate (tonnes per day per berth) | | | |
|---|---|---|---|---|---|
| | | 2020 | 2025 | 2030 | 2035 |
| 1. | Coal and ore | 12,000 | 15,000 | 15,000 | 15,000 |
| 2. | Other Bulk | 12,000 | 15,000 | 15,000 | 15,000 |
| 3. | Fertilizer, Food Grain, Sugar | 8,000 | 8,000 | 8,000 | 8,000 |
| 4. | Iron and Steel | 8,000 | 8,000 | 8,000 | 8,000 |
| 5. | Containers (TEUs per day per Berth) | 1,200 | 1,500 | 2,000 | 2,000 |

### 5.2.4 Operational Time

As the proposed site has adequate wave tranquillity, round the year operations are possible. The effective number of working days is taken as 350 days per year, allowing for 15 non-operational days due to weather. Further, it is assumed that the port will operate round the clock i.e. three shifts of eight hours each. This results in an effective working of 20 hours a day.

### 5.2.5 Time Required for Peripheral Activities

Apart from the time involved in loading / unloading of cargo, additional time is required for peripheral activities such as berthing and de-berthing of the vessels, customs clearance, cargo surveys, positioning and hook up of equipment, waiting for clearance to sail, etc. An average of 4 hours per vessel call has been assumed for these activities.

### 5.2.6 Allowable Levels of Berth Occupancy

Berth occupancy is expressed as the ratio of the total number of days per year that a berth is occupied by a vessel (including the time spent in peripheral activities) to the number of port operational days in a year. High levels of berth occupancy will result in bunching of ships resulting in undesirable pre-berthing detention.

In order to be competitive, it is important that the ships calling at the port should have minimal pre-berthing detention. At the same time the investment at the port infrastructure has to be kept at optimal level. Keeping these in consideration, it is proposed to limit berth occupancy of 60% for 1 berth and that 65% for 2 berths for similar commodity. This shall reduce the pre-berthing detention of ships and offer reduced logistics cost to the shippers.

### 5.2.7 Berths Requirements for the Master Plan

Based on the above criteria, the berth requirements for different cargo have been worked out. A summary of the estimated berths over master plan horizon is presented in **Table 5.2** below:

**Table 5.2 Estimated Berths at the Sagar Port**

| S. No. | Type | Total Berths Needed | | | |
|---|---|---|---|---|---|
| | | 2020 | 2025 | 2030 | 2035 |
| 1 | Multipurpose Berths | 2 | 3 | 4 | 5 |
| 2 | Container Berths | 1 | 2 | 3 | 4 |
| | **Total Berths** | **3** | **5** | **7** | **9** |

The requirements of subsequent stages would depend on how best the proposed port is able to meet the requirements of the customers. Therefore while preparing the master plan it shall be ensured that the proposed initial port facilities could be expanded so as to meet the traffic beyond the master plan phase.

### 5.2.8 Port Crafts Berth

For the initial stage development, the port would require 4 tugs with a capacity of 40 T bollard pull, 3 pilot launches and 2 mooring launches.

It is proposed to utilise one end of the main berths for berthing of port crafts initially. An exclusive berth for the port crafts could be provided in the later phases.

### 5.2.9 Length of the Berths

Length of a single berth for a commodity depends on the LOA of the largest vessel of that commodity expected to use that berth. However in case of multiple berths of a same commodity it is possible to optimise the total length based on the average LOA of the ships visiting that berth.

Therefore for planning the berths, the profile of vessels visiting the Kolkata port and Haldia ports were analysed and maximum, minimum and average vessel sizes for the various commodities were compiled. The berth lengths for the initial phase were worked out on that basis. As for subsequent phases when deepening of Sagar port would take place in phased manner it is assumed that average LOA of the ships using the port would also go up and accordingly the berth lengths for future phases have been worked out.

Based on site conditions a continuous quay is proposed for all commodities which enable optimal utilisation of total berth length. It may be noted that due to contiguity of berths, flexibility is provided to utilise any berth for loading/unloading operations based on its availability.

The proposed berth lengths for various phases of port development are presented in **Table 5.3** below.

**Table 5.3 Total Berth Length**

| | Phase of Port Development | | | |
|---|---|---|---|---|
| | 2020 | 2025 | 2030 | 2035 |
| **Total Berth Length (m)** | **600** | **1100** | **1500** | **2000** |

## 5.3 Storage Requirements

The storage requirement at port for a particular commodity is mainly determined by the dwell time of the cargo at port. It is a common practice to assume a dwell time of;

- 30 days for imported bulk cargo,
- 20 days for export bulk cargo,
- 5 days for containers on an average.

It should also be ensured that the storage capacity at the port for a particular cargo is at least 1.5 times the parcel size so as to allow faster turnaround of the ship.

Other factors to be taken into account in determining the size of the storage areas are stacked densities, angle of repose, maximum and average stacking height, aisle space, reserve capacity factor, peaking factor, etc.

Based on the above criteria the storage areas have been worked out for various cargos. The Phase 1 storage area works out to about 15 Ha increasing to 65 Ha over the master plan horizon.

## 5.4 Buildings

Sufficient buildings as per their functional requirements shall be provided in the port area. The following buildings are generally envisaged:

### 5.4.1 Terminal Administration Building

It will be a 4 storied building housing the following:

- Administrative offices of various operational departments including documentation space
- Canteen
- First aid post
- Central control room for terminal operations
- A VIP floor on top floor to have an overall view of the terminal

### 5.4.2 Signal station

A signal station with radar and VHF communication facilities will be provided at a suitable location near the water front to communicate with the ships calling at the port and control their movements.

### 5.4.3 Customs office

An office building inside the port area at an appropriate location to accommodate the customs officials who are required to inspect the ships and give clearance for movement of cargo in and out of the bonded area.

### 5.4.4 Gate complex

This will be a single storied building for security personnel and shall be provided near the port entrance.

### 5.4.5 Substations

Two substations are envisaged to be provided, one each for container and coal terminals, apart from the main receiving substation at the terminal boundary.

### 5.4.6 Worker's Amenities Building

This shall provide locker and store rooms. It will also include bath and lavatory facilities. Separate buildings for container and bulk terminals are envisaged.

### 5.4.7 Maintenance Workshops

This shall comprise of a workshop plus store room, and an annex building to provide space for offices of the workshop foremen, mechanics, electricians, technicians and the storekeepers and rooms for off duty operational personnel and maintenance labour.

### 5.4.8 Other miscellaneous buildings

The following miscellaneous buildings shall also be provided in the port area:

- Fire Station to house firefighting equipment, fire tenders, etc.
- Dispensary buildings to be located near the operational areas and provide minimum first aid services.

- Other miscellaneous utility sheds as per requirements of a particular terminal
- Port Users Building for allocation to Banking, C&F Agents' offices
- A fuelling station shall be provided to cater to the requirements of ITV's and other vehicles used.

## 5.5 Receipt and Evacuation of Cargo

### 5.5.1 General

For the efficient functioning of a port, the essential pre-requisite is the rail and road connectivity for the effective movement of cargo in and out of the port.

Currently there is a proposal to provide only a two lane road bridge across river Muriganga. This has to be ready before the first phase of the proposed port is commissioned i.e. by year 2020. Along with Road Bridge, the widening of NH117 shall also be taken up from bridge location till Kolkata. It is also assumed that the work for Rail Bridge shall be undertaken in the next phase i.e. by year 2025. These form the key assumptions while arriving at the traffic forecast for Sagar Port and planning of the port facilities.

Based on the market assessment and the infrastructure constraints, it is envisaged that the key cargo shall follow the evacuation pattern from Sagar port, as shown in **Table 5.4**.

**Table 5.4 Evacuation Pattern for Various Cargo**

| S. No. | Commodity | 2020 | | 2025 | | 2030 | | 2035 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Road Share | Rail Share | Road Share | Rail Share | Road Share | Rail Share | Road Share | Rail Share |
| | | % | % | % | % | % | % | % | % |
| 1. | Thermal Coal | 100% | 0% | 5% | 95% | 5% | 95% | 5% | 95% |
| 2. | Other Bulk | 100% | 0% | 5% | 95% | 5% | 95% | 5% | 95% |
| 3. | Fertilizer | 100% | 0% | 75% | 25% | 65% | 35% | 50% | 50% |
| 4. | Iron and Steel | 100% | 0% | 75% | 25% | 65% | 35% | 50% | 50% |
| 5. | Containers | 100% | 0% | 75% | 25% | 65% | 35% | 50% | 50% |

### 5.5.2 Port Access Road

The access road from bridge across Muriganga till the proposed port shall be the only means for receipt and evacuation of cargo during Phase 1. However, subsequently with the construction of a rail bridge the evacuation of key cargo shall also be by rail. Based on the traffic forecast the total PCU movement are estimated to be about 4,000 per day increasing to about 11,000 per day over the master plan horizon, which indicates adequacy of two lane access road to port.

### 5.5.3 Rail Connectivity

Similar to above, the assessment of rail movements in the port has been carried out for different phases of the project. Total daily incoming and outgoing rakes are estimated to be 6 in the initial phase (from the offsite rail yard) increasing to 36 over the master plan horizon.

In the absence of any rail bridge across river Muriganga in the Phase 1 development of port, an offsite rail yard for the port shall be located near Kashinagar railway station and adequate rail sidings shall be provided at that location. Subsequently this yard shall be utilised as an R&D yard for the port.

## 5.6 Water Requirements

Water would be needed at the port for use of port personnel, dust suppression, firefighting and miscellaneous uses.

It is estimated that the average water requirement for the initial development will be around 0.1 MLD increasing to about 0.3 MLD in the long term.

## 5.7 Power Requirements

HT and LT power supply at the port would be required for Handling Equipment, Lighting of the Port Area, Offices and Transit Sheds etc.

The electrical load demand for the proposed port for the initial phase development is about 3.5 MVA increasing to about 10.5 MVA in the master plan stage. The major requirement is on account of the proposed mechanised cargo handling system at various berths.

# 6.0 Preparation of Sagar Port Layout

## 6.1 Layout Development

The key considerations that are relevant for the establishment of a Greenfield port and its layout are given below:

- Potential Traffic;
- Techno-economic Feasibility;
  - Design ship size
  - Geotechnical Characteristics at site
  - Protection from waves and swell to create tranquillity at berths
  - Availability of material for Reclamation and Breakwater construction
  - Adequate manoeuvring area and Channel for the design ships
  - Scope for expansion beyond the initial development
  - Suitability for development in stages
  - Optimum capital cost of overall development and especially of initial phase
- Land Availability;
  - Availability of adequate back-up land for storage of cargo and port operations
  - Rail and Road Connectivity to the Hinterland
- Environmental issues related to development.

## 6.2 Brief Descriptions of Key Considerations

The following sub-sections briefly discuss the relative importance and implication of each of the above factors in relation to the Greenfield port development at Sagar Island.

### 6.2.1 Potential Traffic

The potential traffic that a new port could attract forms the first and foremost requirement of the project. In case there is significant traffic that could be captive to the port e.g. coal for the nearby power plant or cargo from nearby SEZ /industrial areas, the viability of the port increases. According to the landed-cost analysis of the imported cargo for bulk, the natural ownership of cargo for the Sagar port is limited due to the proximity of the Haldia. Containers will be the major cargo commodity handled at the Sagar port. This is primarily due the paucity of capacity and the inability to expand the Haldia and Kolkata ports beyond a certain limit, which is causing an overflow of containers that can be handled at the Sagar port.

### 6.2.2 Techno-Economic Feasibility

#### ***6.2.2.1 Design Ship Size***

The selection of design ship size is a key input for the port development as the required depths and the size of the navigational and manoeuvring area of the harbour as well as the cargo handling infrastructure are dependent on this. The ship size has direct implication on the cost of the port development and therefore has impact on the viability. Considering the site conditions, it is proposed to increase the draft at port in phases so as to phase the capital investment with growth in traffic.

#### ***6.2.2.2 Geotechnical Characteristics of the Site***

The geotechnical characteristics of the site could be a key factor in capital cost of port development. The rock levels at the site will impact the selection of marine layout because of the potentially very high cost of dredging in rock. Similarly very soft soil at the location would also have impact on capital cost as ground improvement works will have to be resorted to support the structures. At Sagar port the soil comprises silty sand and silty clay for a depth of about 22m below bed level followed by a layer of stiff/ dense silty clay up to 30m. This soil condition allows carrying out dredging at competitive rates as well as moderate cost of building the structures.

#### ***6.2.2.3 Protection from Waves and Swell***

The location of the port has to be evaluated in terms of the shelter available from the direct attack of waves. The locations which are in naturally protected zones do not require expensive breakwaters for protection from waves for round the year operations. As per the analysis of wave conditions at Sagar Port site it is observed that the location remain tranquil round the year under normal conditions.

#### ***6.2.2.4 Availability of Construction Material***

Transportation cost of the borrowed fill and rock from longer distance forms the major component of the overall cost of reclamation. The availability of these materials at a nearby location is favourable to economise the capital cost of port development. At Sagar, it is assessed that most of the material for reclamation could be obtained from the capital dredging. However, rock would have to be brought from Pakur, which is about 350 Km from the port site. Similarly other construction material would also have to be brought from mainland through boats/barges as the bridge connecting the Sagar Island with mainland would not be ready during the port construction phase.

#### ***6.2.2.5 Adequate Manoeuvring Area and Channel for Design Ships***

This consideration requires provision of adequate channel width, stopping distance and the manoeuvring area for the design ship, as per the best international practices. The potential of marine accidents of the ships hitting the berth structure and approach trestle should be eliminated. The width of the channel would be based on the design ship size as well as requirement for one way or two way channel.

#### ***6.2.2.6 Scope for Expansion over the Initial Development***

With the costly basic infrastructure like dredged basin, channel, hinterland connectivity in place, addition of more berths will not be so capital intensive. This is a likely incentive for investors to create additional cargo handling capacity by building new berths/ terminals in future. Therefore the port location and layout should allow for the flexibility for expansion to allow additional berths, storage and evacuation.

#### ***6.2.2.7 Flexibility for Development in Stages***

The site should allow a development plan such that it is capable of being developed in stages, if needed for phase wise induction of cargo handling facilities.

#### ***6.2.2.8 Optimum Capital Cost of Overall Development and Especially for the Initial Phase***

Capital cost is clearly the primary consideration while evaluating a port location. The cost of development of initial phase takes precedence. Therefore it is proposed to limit the draft of design ship so as to minimise the cost.

### 6.2.3 Land Availability

#### ***6.2.3.1 Availability of Backup Area for Storage of Cargo and Port Operations***

Adequate land must be available along the waterfront for an efficient cargo storage and port operations. Acquiring the land for this purpose may lead to protests from local residents resulting in abandoning of the project or involving significant cost towards land acquisition. At Sagar, it is therefore proposed that backup area of cargo storage and port operations be planned on reclaimed area in the intertidal zone.

Another aspect which needs to be considered carefully is that only a two lane road bridge across river Muriganga shall be built initially and the rail bridge shall be built in later phases. Therefore suitable land parcel for off-site rail yard would also need to be identified at mainland preferably near Kashinagar station (from where the rail connectivity to Sagar shall be provided in future). This land parcel shall need to be adequately sized so as to provide sufficient storage space for transit cargo, loading unloading facilities and rail lines.

#### ***6.2.3.2 Provision for Rail and Road Connectivity***

The onshore cargo storage area should have good connectivity to the external rail and road linkages for faster evacuation of cargoes with minimum capital investment and minimum rehabilitation and resettlement. In this particular case of Sagar the Bridge across river Muriganga is a prerequisite for the port construction.

### 6.2.4 Environmental Issues Related to Development

The environmental issues such as deforestation, rehabilitation and resettlement would need special consideration while arriving at the suitable port location or suitable layout of port.

## 6.3 Planning Criteria

### 6.3.1 Limiting wave conditions for port operations

#### ***6.3.1.1 Pilot Boarding***

Ships arriving at the port will take on a pilot to guide it to the designated berth inside the port. The pilot will normally board the ship at the outer anchorage. Since the pilot has to board the vessel in the open sea through rope ladder along the ship side, the limiting condition is that the significant wave height ($H_S$) should not exceed 2.5 m. As in the present case the pilots shall be boarding at Sagar Roads and then take the ship to the port location through Sagar Channel.

#### *6.3.1.2 Tug Fastening & Tug Operations*

The tugs, which assist the ship while stopping, turning in the basin and manoeuvring to the berth, normally meet the vessel in protected water, just inside the breakwaters. The limiting wave condition for tugs to fasten to a ship and effectively assist and control the ship varies from Hs=1.0m to Hs=1.5m depending the type of tugs used.

#### *6.3.1.3 Tranquillity Requirements for Cargo Handling Operations*

For carrying out cargo handling operations at the berths, it has to be ensured that there are no excessive movements of the ships due to wave action that will hamper the ship-shore handling operations. This limit varies with the handling system for the different types of cargoes. Hence, the breakwater configuration and the overall port layout should ensure adequate tranquillity at the berths so that cargo handling may continue even when the offshore wave climate exceeds the limit for ships' movement in and out of the harbour.

The maximum acceptable wave conditions for cargo handling operations at the berth are dependent on ship size, the type and method of cargo handling and the direction of the wave attack. Beam waves cause the vessel to roll and affect the cargo handling operations more than head waves. The limiting wave height ($H_s$) from different wave directions for cargo handling operations are stipulated in PIANC bulletin - "Criteria *for movements of moored ships in Harbours – a Practical Guide (1995)".* An extract is summarised in **Table 6.1** below:

**Table 6.1 Limiting Wave Heights for Cargo Handling**

| **Type of ship** | **Limiting wave height ($H_s$)** | |
|---|---|---|
| | **Head or Stern ( 0°)** | **Quadrant (45°- 90°)** |
| **Dry bulk Carriers** | | |
| - loading | 1.5 – 2.0 m | 1.0 – 1.5 m |
| - unloading | 1.0 –1.5 m | 0.5 - 1.0 m |
| **Break-bulk Ships** | 1.0 m | 0.8 m |
| **Liquid Carriers** | 1.5 m | 1.0 m |
| **Containers** | 0.5 m | 0.5 m |

### 6.3.2 Breakwater

The mathematical studies on the nearshore wave transformation studies reveal that the proposed port site is naturally protected to allow round the year operations and there is no need for breakwater protection.

### 6.3.3 Berths

The estimated berths and the total quay length for the various phases of development have been worked out and are presented in **Table 5.3**.

### 6.3.4 Navigational Channel Dimensions

The dimensions of the navigation channel to the terminal are dependent on the vessel size, the behaviour of the vessel when sailing through the channel, required tidal access, the environmental maritime conditions (winds, waves, currents) and the channel bottom conditions.

#### ***6.3.4.1 Channel Width and Length***

The channel width has been calculated from the latest PIANC Guidelines “Harbour Approach Channels – Design Guidelines: Report No. 121 – 2014”. The detailed calculations are shown in attached **Table 6.2**.

**Table 6.2: Calculation of Channel Width based on PIANC Recommendations**

| PIANC Recommendations | | | | | Channel | |
|---|---|---|---|---|---|---|
| Basic Lane Width $W_{bm}$ (multiple of ship beam B) | | Vessel Speed | Outer Channel Exposed to Open Water | Inner Channel Protected Water | outer | inner |
| **vessel manoeuvrability** | | | | | | |
| | - good | all | 1.3 | 1.3 | 0.0 | 0.0 |
| | - moderate | all | 1.5 | 1.5 | 1.5 | 1.5 |
| | - poor | all | 1.8 | 1.8 | | |
| **TOTAL BASIC MANOEUVRING LANE $W_{bm}$** | | | | | **1.5** | **1.5** |
| **PIANC table 5.2 - Additional Width for Straight Channel Sections (multiple of ship beam B)** | | | | | | |
| **(a)** | **vessel Speed (knots)** | | | | | |
| | - fast >12 | | 0.1 | 0.1 | | |
| | - moderate >8 - 12 | | 0.0 | 0.0 | 0.0 | 0.0 |
| | - slow 5 - 8 | | 0.0 | 0.0 | 0.0 | 0.0 |
| **(b)** | **Prevailing cross wind (knots)** | | | | | |
| | - mild ≤ 15 (≤ Beaufort 4) | all | 0.0 | 0.0 | | |
| | - moderate > 15 - 33 | fast | 0.3 | - | | |
| | (> Beaufort 4 - Beaufort 7) | mod | 0.4 | 0.4 | | |
| | | slow | 0.5 | 0.5 | 0.0 | 0.5 |
| | - severe >33 - 48 | fast | 0.6 | - | | |
| | (> Beaufort 7 - Beaufort 9) | mod | 0.8 | 0.8 | | |
| | | slow | 1.0 | 1.0 | 1.0 | |
| **(c)** | **Prevailing cross current (knots)** | | | | | |
| | - negligible < 0.2 | all | 0.0 | 0.0 | | |
| | - low 0.2 - 0.5 | fast | 0.1 | - | | |
| | | mod | 0.2 | 0.1 | | |
| | | slow | 0.3 | 0.2 | 0.0 | 0.0 |
| | - moderate >0.5 - 1.5 | fast | 0.5 | - | | |
| | | mod | 0.7 | 0.5 | 0.7 | 0.5 |
| | | slow | 1.0 | 0.8 | 0.0 | 0.0 |
| | - strong > 1.5 - 2.0 | fast | 0.7 | - | | |
| | | mod | 1.0 | - | | |
| | | slow | 1.3 | - | | |
| **(d)** | **Prevailing longitudinal current (knots)** | | | | | |
| | - low ≤ 1.5 | all | 0.0 | 0.0 | | |
| | - moderate > 1.5 - 3 | fast | 0.0 | - | | |
| | | mod | 0.1 | 0.1 | | |
| | | slow | 0.2 | 0.2 | 0.2 | 0.2 |
| | - strong > 3 | fast | 0.1 | - | | |
| | | mod | 0.2 | 0.2 | | |
| | | slow | 0.4 | 0.4 | 0.0 | 0.0 |
| **(e)** | **Significant wave height $H_s$ and length l (m)** | | | | | |
| | - Hs ≥ 1 and l ≥ L | all | 0.0 | 0.0 | | |
| | - 3> $H_s$ > 1 and l = L | fast | 2.0 | | | |
| | | mod | 1.0 | | 1.0 | |
| | | slow | 0.5 | | 0.0 | 0.0 |
| | - $H_s$ > 3 and l > L | fast | 3.0 | | | |
| | | mod | 2.2 | | | |
| | | slow | 1.5 | | | |
| **(f)** | **Aids to Navigation** | | | | | |
| | - excellent with shore traffic control | | 0.0 | 0.0 | | |
| | - good | | 0.2 | 0.1 | 0.2 | 0.1 |
| | - moderate with infrequent poor visibility | | 0.5 | 0.2 | | |
| | - moderate with frequent poor visibility | | 0.5 | 0.5 | | |
| **(g)** | **Bottom Surface** | | | | | |
| | - if depth ≥ 1.5T | | 0.0 | 0.0 | | |
| | - if depth < 1.5T then | | | | | |
| | - smooth and soft | | 0.1 | 0.1 | 0.1 | 0.1 |
| | - smooth or sloping and hard | | 0.1 | 0.1 | | |
| | - rough and hard | | 0.2 | 0.2 | | |
| **(h)** | **Depth of Waterway** | | | | | |
| | - ≥ 1.5T (inner and outer waterway) | | 0.0 | 0.0 | | |
| | - 1.5T - 1.25T (outer waterway) | | 0.1 | | | |
| | - < 1.25T (outer waterway) | | 0.2 | | | |
| | - < 1.5T - 1.15T (outer waterway) | | | 0.2 | 0.2 | 0.0 |
| | - < 1.15T (inner waterway) | | | 0.4 | 0.0 | 0.4 |
| **(i)** | **Cargo Hazard Level** | | | | | |
| | - low | | 0.0 | 0.0 | 0.0 | 0.0 |
| | - medium | | 0.5 | 0.4 | | |
| | - high | | 1.0 | 0.8 | 0.0 | 0.0 |
| **TOTAL ADDITIONAL MANOEUVRING WIDTH FACTOR $W_i$** | | | | | **3.4** | **1.8** |
| **PIANC Table 5.4 - Additional Width for Bank Clearance** | | | | | | |
| | - sloping channel edges and shoals | fast | - | | | |
| | | mod | 0.5 | | 0.5 | 0.5 |
| | | slow | 0.3 | | 0.0 | 0.0 |
| | - steep and hard embankments and structures | fast | - | | | |
| | | mod | 1.0 | | | |
| | | slow | 0.5 | | | |

| PIANC Recommendations | | | | | |
|---|---|---|---|---|---|
| | | | | Channel | |
| Basic Lane Width $W_{bm}$ (multiple of ship beam B) | Vessel Speed | Outer Channel Exposed to Open Water | Inner Channel Protected Water | outer | inner |
| TOTAL BANK CLEARANCE FACTOR $W_{br}$ or $W_{bg}$ | | | | **0.5** | **0.5** |
| **PIANC Table 5.3 - Additional Width for Passing Distance for Two-Way Traffic** | | | | | |
| **additional width for traffic speed** | fast | 2.0 | - | | |
| | mod | 1.6 | 1.4 | 1.6 | 1.4 |
| | slow | 1.2 | 1.0 | 0.0 | 0.0 |
| **additional width for traffic encounter density** | | | | | |
| - light | all | 0.0 | 0.0 | 0.0 | 0.0 |
| - moderate | all | 0.2 | 0.2 | 0.2 | 0.2 |
| - heavy | all | 0.5 | 0.4 | | |
| **TOTAL EXTRA FOR STRAIGHT CHANNEL TWO-WAY TRAFFIC $W_p$** | | | | **1.8** | **1.6** |
| **Curved Channel Width Factor $W_c$ - PIANC Figure 5.9** | | | | | |
| assume rudder angle 20 deg, W/D ratio 1.1, therefore Ws/B = 1.18 | all | 0.18 | 0.18 | **0.18** | **0.18** |

**Required channel width**

| ship beam (m) | | Channel Width | |
|---|---|---|---|
| Panamax Size Bulker | 32 | | |
| Container Ship | 32 | | |
| | | **outer** | **Inner** |
| **one way straight channel** | | | |
| Panamax Size Bulker | | **189** | **138** |
| Container Ship | | **189** | **138** |
| **one way curved channel** | | | |
| Panamax Size Bulker | | **195** | **143** |
| Container Ship | | **195** | **143** |
| **two way straight channel** | | | |
| Panamax Size Bulker +Container Ship | | 403 | 294 |
| two Container Ship | | 403 | 294 |
| **two way curved channel** | | | |
| Panamax Size Bulker +Container Ship | | **415** | **306** |
| two Container Ship | | **415** | **306** |

The calculated channel width for various design ship sizes is indicated below in **Table 6.3**.

**Table 6.3 Particulars of Navigational Channel for Design Ships**

| Design Ship Size | Beam | Outer Channel Width | | Inner Channel width | |
|---|---|---|---|---|---|
| | | One way Channel | Two way Channel | One way Channel | Two way Channel |
| 80,000 - Bulk Carrier | 32 | 200 | 415 | 150 | 310 |
| 4,000 - TEUs Container Carrier | 32 | 200 | 415 | 150 | 310 |

The eastern channel has natural water depths available to receive the 9.0m draft vessels planned for Phase 1 and is wide enough to allow two way passage of the design ships. However, in the ultimate stage when 13.5 m draft vessels are proposed to be handled, significant dredging would need to be carried out over a width of about 450 m to allow two way passage of design ships.

As regards to the Sagar Channel, it is fully protected and therefore it is proposed to provide a channel width of 400 m to allow two way movements of 32 m beam ships.

#### ***6.3.4.2 Dredged Depths***

The depth in the channel is determined by the vessel's loaded draught; trim or tilt due to loads within the holds; ship's motion due to waves, such as pitch, roll and heave; character of the sea-bottom, soft or hard; wind; influence of water level and tidal variations; and the sinkage of the vessel due to squat or bottom suction.

The dredged depths at the port entrance channel and manoeuvring areas will be governed by the designed draft of the largest ship. The calculated values are given in **Table 6.4** below:

**Table 6.4 Dredged Depths in Approach Channel to Sagar Port**

| Location | Vessel Size | Design Draft of vessel (m) | Depth of Channel Required (m below CD) | Tidal Advantage (m) | Design Dredged Depth (m below CD) |
|---|---|---|---|---|---|
| **Sagar Channel** | **Phase 1 2020** | 9.00 | 9.90 | 3.00 | 6.90 |
| | **Phase 2 2025** | 11.70 | 12.87 | 3.00 | 9.87 |
| | **Phase 3 2030** | 12.50 | 13.75 | 3.00 | 10.75 |
| | **Phase 4 2035** | 13.50 | 14.85 | 3.00 | 11.85 |
| **Eastern Channel** | **Phase 1 2020** | 9.00 | 10.35 | 3.50 | 6.85 |
| | **Phase 2 2025** | 11.70 | 13.46 | 3.50 | 9.96 |
| | **Phase 3 2030** | 12.50 | 14.38 | 3.50 | 10.88 |
| | **Phase 4 2035** | 13.50 | 15.53 | 3.50 | 12.03 |

Considering the above it is recommended that in the initial phase the eastern channel should be utilised in the present condition, with no capital dredging. However, the Sagar channel shall be dredged to a level of -8.0 m CD to allow for navigation of about 10.0 m draft vessels (which may be possible during few days in a year) and berth pockets shall be dredged to -11.0 m CD. The structural design of berths shall be carried out to the design dredged level of -15.0 m CD to cater to fully loaded Panamax ship.

### 6.3.5 Elevations of Backup Area and Berths

Considering the mean high water springs as +5.2 m CD and allowing for the operational wave height of 1.0 m and thus crest height of 0.7 m and height of the structure as 1.5 m, the deck elevation of berths is arrived at +8.5 m CD. It is proposed to keep the finished levels of onshore areas also at +8.50 m CD.

## 6.4 Recommended Master Plan Layout

Based on the traffic projections, port facility requirements and the technical requirements, the master plan layout of the Sagar Port has been developed as shown in **Drawing DELD15005-DRG-10-0000-CP-WBP1001**. It may be noted that the master plan layout is based on the traffic projections but there is significant scope for expansion of port facilities.

The ideal capacity of phase 1 of port development is assessed as **5.75 MTPA** and that for the proposed master plan at year 2035 is assessed as **26.0 MTPA**, as presented in **Table 6.5**.

**Table 6.5 Berth Capacity Assessment**

***Capacity at Phase 1 Development***

| Berth Type | Commodities to be Handled Using Common Material Handling System | Import (I) / Export (E) | Handling Rate TEUPD/TPD | Average Parcel Size T | Maximum Parcel Size T | Year 2020 | | | | | | Allowable Berth Occupancy | Berth Capacity (MTPA) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Annual Throughput MTPA | Ship Calls/ Annum | Berth Days Required | Total Berth Occupancy | Berths Provided | Combined Berth Occupancy | | |
| Multi Purpose Berth | Thermal Coal | I | 12,000 | 30,000 | 70,000 | 0.33 | 11 | 29 | 105% | 2 | 53% | 65% | 0.41 |
| | Other Bulk | I/E | 8,000 | 25,000 | 50,000 | 0.00 | 0 | 0 | | | | | 0.00 |
| | Fertilizer, Food Grain, Sugar | I/E | 8,000 | 25,000 | 50,000 | 2.52 | 101 | 332 | | | | | 3.11 |
| | Iron and Steel | I/E | 8,000 | 20,000 | 50,000 | 0.05 | 3 | 7 | | | | | 0.06 |
| | **Total** | | | | | **2.90** | **114.30** | **368.18** | | | | | **3.58** |
| Berth- Containers | Containers | I/E | 1,200 | 500 | 1,000 | 0.52 | 87 | 55 | 16% | 1 | 16% | 65% | 2.16 |
| | **Total** | | | | | **0.52** | **87** | **55** | | | | | **2.16** |
| GRAND TOTAL | | | | | | **3.42** | **200.97** | **422.90** | | **3** | | | **5.75** |

***Capacity at Master Plan Development***

| Berth Type | Commodities to be Handled Using Common Material Handling System | Import (I) / Export (E) | Handling Rate TEUPD/TPD | Average Parcel Size T | Maximum Parcel Size T | Year 2035 | | | | | | Allowable Berth Occupancy | Berth Capacity (MTPA) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Annual Throughput MTPA | Ship Calls/ Annum | Berth Days Required | Total Berth Occupancy | Berths Provided | Combined Berth Occupancy | | |
| Multipurpose Berth | Thermal Coal | I | 15,000 | 60,000 | 70,000 | 1.01 | 17 | 70 | 318% | 5 | 64% | 65% | 1.03 |
| | Other Bulk | I/E | 8,000 | 30,000 | 50,000 | 0.00 | 0 | 0 | | | | | 0.00 |
| | Fertilizer, Food Grain, Sugar | I/E | 8,000 | 30,000 | 50,000 | 7.83 | 261 | 1023 | | | | | 7.99 |
| | Iron and Steel | I/E | 8,000 | 25,000 | 50,000 | 0.16 | 6 | 21 | | | | | 0.16 |
| | **Total** | | | | | **9.00** | **284** | **1114** | | | | | **9.19** |
| Berth- Containers | Containers | I/E | 2,000 | 1,200 | 2,000 | 17.77 | 1234 | 943 | 269% | 4 | 67% | 65% | 17.15 |
| | **Total** | | | | | **17.77** | **1234** | **943** | | | | | **17** |
| GRAND TOTAL | | | | | | **27** | **1518** | **2057** | | **9** | | | **26** |

The capacities calculated above are based on the optimal berth occupancy of 65%. However with the same berthing facilities it is possible to handle additional cargo beyond the capacity e.g. phase 1 of the port development can also handle 7.5 MTPA cargo at a berth occupancy of about 85%. However this may result in higher waiting time for ships and thus reducing competitiveness of the port in long run.

## 6.5 Phasing of the Port Development

The development of port shall be taken up in phases. The key port facilities that shall be developed in the phased manner over the master plan horizon are indicated in **Table 6.6** below.

**Table 6.6 Phasewise Port Development over Master Plan Horizon**

| Description | Total Port Facilities in Each Phase | | | |
|---|---|---|---|---|
| | Phase 1 - Year 2020 | Phase 2 - Year 2025 | Phase 3 - Year 2030 | Master Plan - Year 2035 |
| **Maximum Ship Size** | | | | |
| • *Dry Bulk (DWT)* | *80,000* | *80,000* | *80,000* | *80,000* |
| • *Containers (TEUs)* | *2,000* | *3,000* | *4,000* | *4,000* |
| **Total length of berths in meters** | | | | |
| • *Multipurpose and Container berths* | *600* | *1100* | *1500* | *2000* |
| **Navigational Areas** | | | | |
| • *Length of Sagar Channel (m)* | *6500* | *6500* | *6500* | *6500* |
| • *Width of Approach Channel (m)* | *400* | *400* | *400* | *400* |
| • *Diameter of Turning Circle (m)* | *500* | *500* | *550* | *550* |
| • *Minimum Width of Sagar Channel (m)* | *400* | *400* | *400* | *400* |
| • *Minimum Width of Eastern Channel (m)* | *450* | *450* | *450* | *450* |
| **Design Draft of the Ship (m)** | *9.0* | *11.7* | *12.5* | *13.5* |
| **Dredged Depths at Port (m below CD)** | | | | |
| • *Approach Channel* | *6.9* | *9.9* | *10.8* | *11.9* |
| • *Manoeuvring Areas* | *6.9* | *9.9* | *10.8* | *11.9* |
| • *Berths* | *10.0* | *13.0* | *14.0* | *15.0* |
| • *Incremental Dredging Quantity (million cum)* | *1.2* | *45.2* | *25.8* | *36.8* |
| **Incremental Reclamation Quantity (million cum)** | *6.6* | *6.6* | *1.9* | *1.3* |
| **Total Reclamation Area (Ha.)** | *96* | *170* | *186* | *197* |

The phase wise development plan of the Sagar port is indicated in **Drawings DELD15005-DRG-10-0000-CP-WBP1002** to **WBP1004**. It is assumed that Rail Bridge across river Muriganga would be in place by Phase 2 development i.e. by year 2025 and accordingly Rail sidings are proposed within the port area at that phase.

# 7.0 Engineering Details

## 7.1 Mathematical Model Studies on Marine Layout

### 7.1.1 General

The mathematical model studies have already been conducted for the port development at Sagar Island by CWPRS. The findings of model study are presented in following sections.

### 7.1.2 Wave Transformation Studies

The site being naturally protected there is no requirement to provide the breakwater for wave tranquillity. Therefore the wave penetration studies are not required. As mentioned in section 2.7.2.3 the proposed location is suitable for round the year port operations under normal wave conditions.

### 7.1.3 Hydrodynamics/ Flow Modelling

The two dimensional mathematical model MIKE21 HD was used to examine the flow conditions at the berths along the western bank of Sagar Island and in the approach channel. The truncated portion of estuary from Kulpi to Sagar Roads including part of Eastern and Western channels near sand heads was included in the model. The Muriganga (Baratola) channel was also included for the study. Water levels were applied as boundary conditions at the southern boundary while the observed discharge at Kulpi was specified for Northern boundary.

To represent the conditions of the proposed developments, berths and channel, bathymetry was modified and used as an input to the model.

The hydrodynamic model simulation was calibrated for current observations at Middleton Fairway Buoy, southwest of Sagar Island observed during 03/05/2011 to 02/06/2011 (**Figure 7.1**).

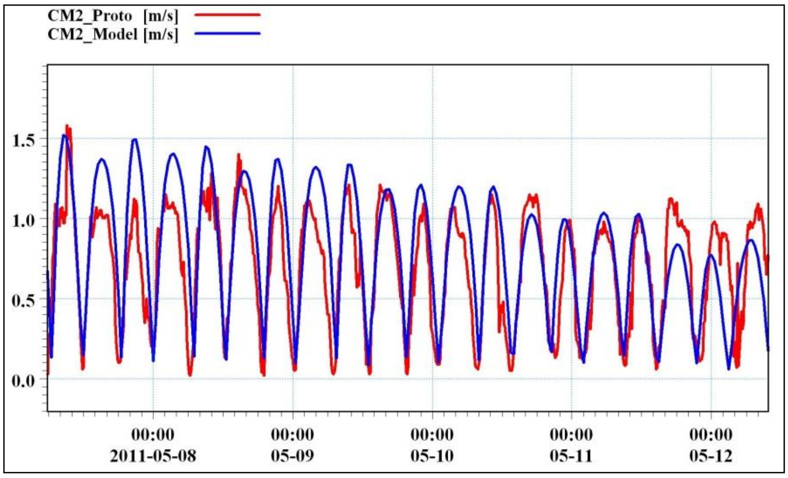



**Figure 7.1 Calibration of Current**

The model results i.e. current speed in the entire domain is provided as **Figure 7.2** and **Figure 7.3**. Higher magnitude current may be observed at the southern end of the Sagar Island during both ebb and flood tide. The figures clearly show that proposed berthing area and channel have higher current velocities.

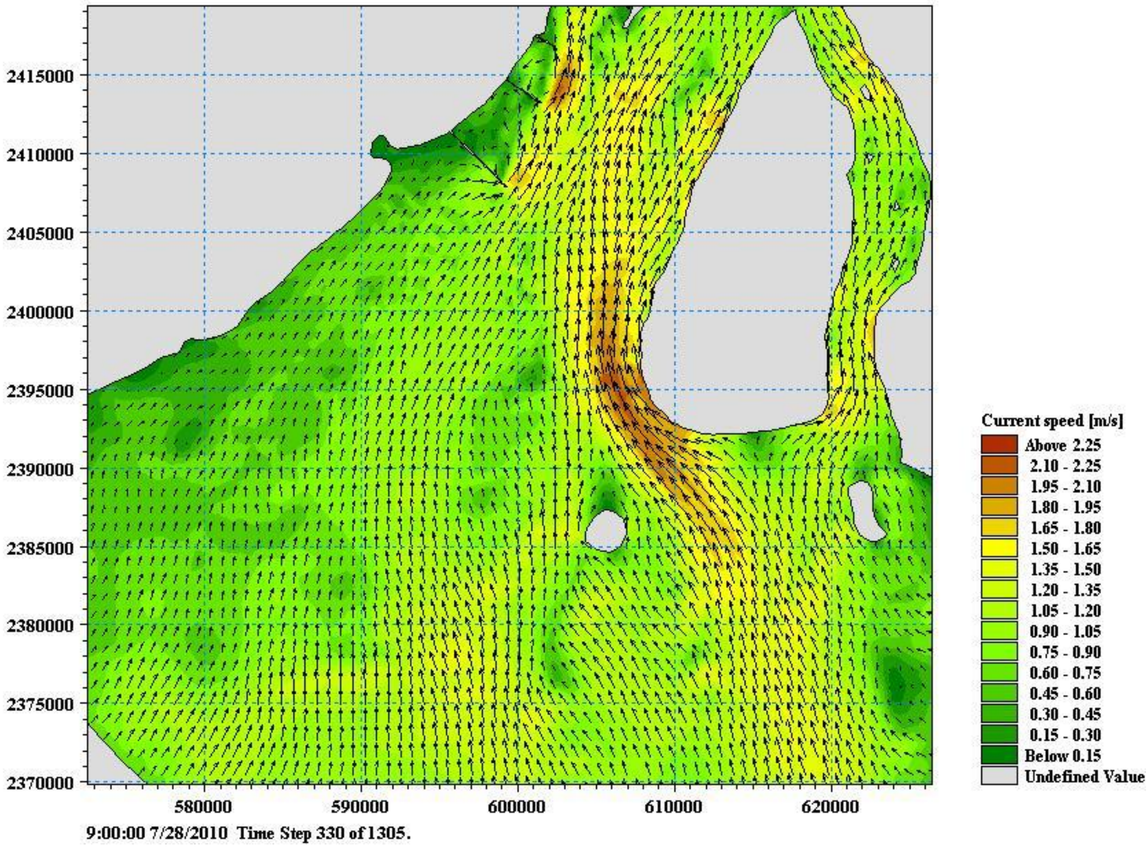



**Figure 7.2 Location of Peak Flood Currents Southwest of Sagar**

The current profiles were extracted from the model results at all berth locations and in the channel (Figure 7.3). At berth locations, flood currents were found to vary between 1.2 m/s and 1.4 m/s, while during ebb currents were between 0.82 and 1.08 m/s.

Similarly, current profiles were extracted at 23 locations in the channel (**Figure 7.4**). At outer channel, high current values were noticed as compared to the current strength in the inner channel and turning circle. During flood conditions, currents in the channel were found to vary between 1.2 to 2.3 m/s.

It is important to note that current profiles with the proposed channel dredging were also quite same as in existing condition at most of the locations.

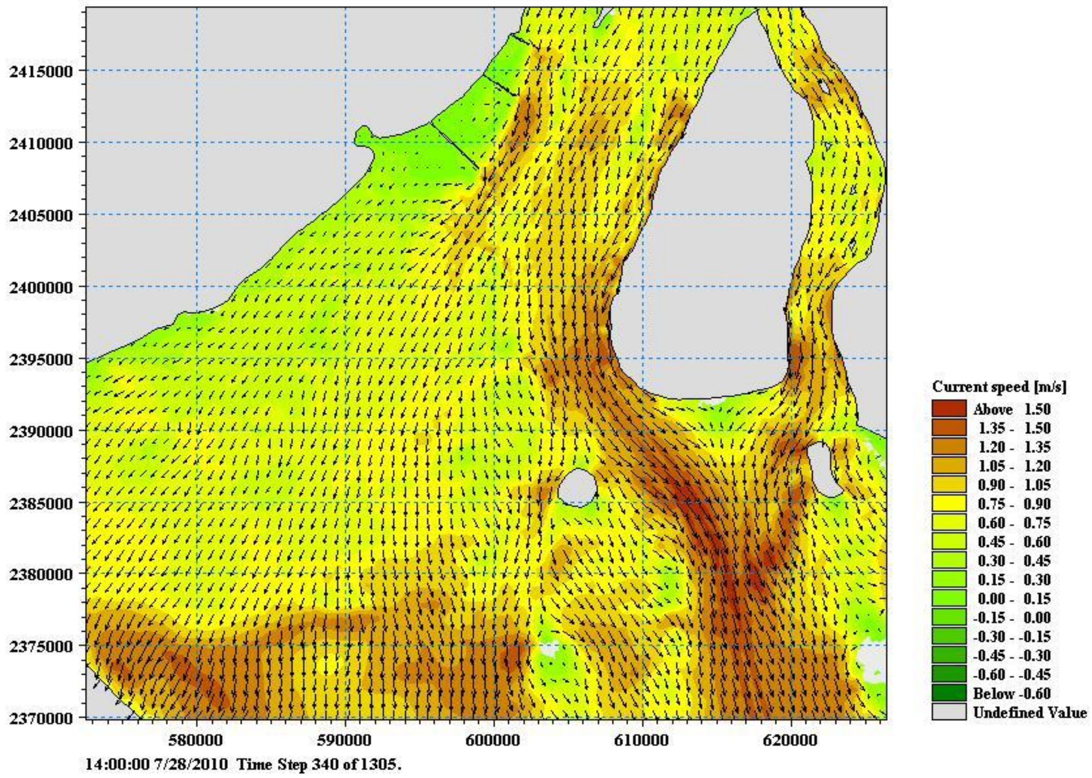



**Figure 7.3 Location of peak Ebb Currents south of Sagar**

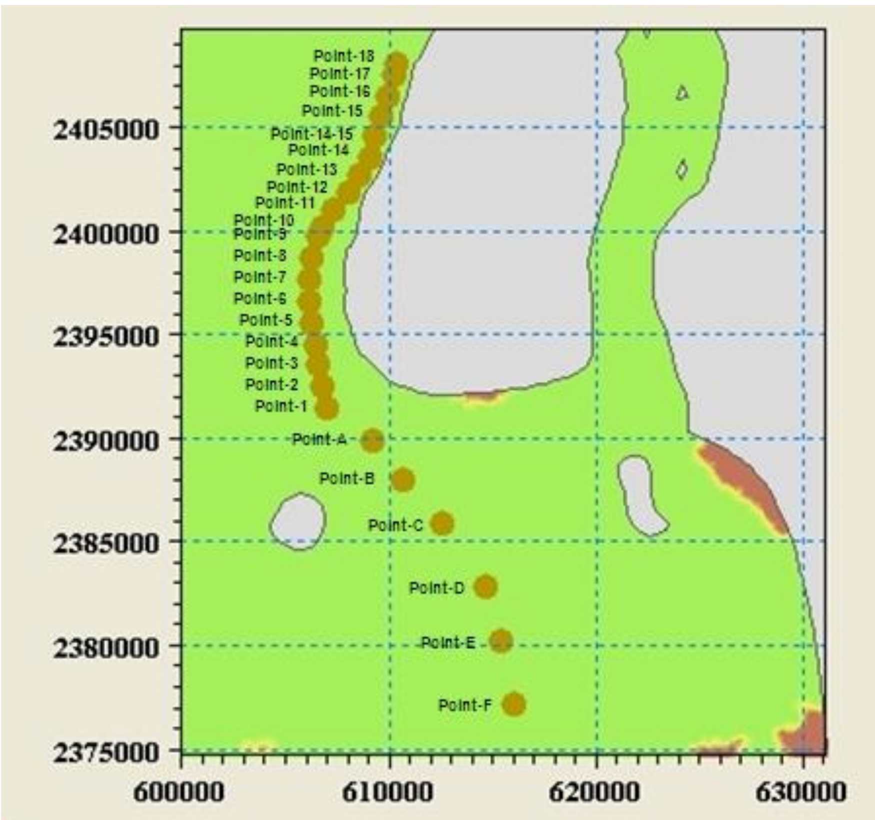



**Figure 7.4 Locations of Extraction of Current along the Approach Channel**

**Table 7.1 Maximum current at berth locations for ebb and flood conditions, m/s**

| | Point 17 | Point 15 | Point 13 | Point 11 | Point 9 | Point 7 | Point 5 | Point 3 | Point 1 | Point A | Point B | Point C | Point D | Point E | Point F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Current magnitude for existing conditions** | | | | | | | | | | | | | | | |
| **Ebb Tide** | 1.08 | 1.00 | 0.92 | 1.15 | 1.25 | 1.20 | 1.30 | 1.30 | 1.15 | 1.30 | 1.40 | 1.60 | 1.65 | 1.50 | 1.60 |
| **Flood Tide** | 1.44 | 1.40 | 1.20 | 1.60 | 1.80 | 2.00 | 2.30 | 2.20 | 1.85 | 2.30 | 2.25 | 2.00 | 1.85 | 1.70 | 1.65 |
| **Current magnitude with proposed channel / dredging** | | | | | | | | | | | | | | | |
| **Ebb Tide** | 1.00 | 0.92 | 0.88 | 1.20 | 1.20 | 1.20 | 1.30 | 1.30 | 1.15 | 1.30 | 1.45 | 1.60 | 1.50 | 1.50 | 1.50 |
| **Flood Tide** | 1.44 | 1.28 | 1.20 | 1.60 | 1.80 | 2.00 | 2.30 | 2.20 | 1.85 | 2.30 | 2.25 | 2.10 | 1.85 | 1.80 | 1.80 |

The results of model study corroborated that the restricted flow at lower stages of tide near the Sagar bank and the shallow Bedford sands might be helping in maintaining the depths in that region. After dredging of turning circle, berthing basin and the approach channel the flow in the region did not show any significant change in the magnitude of the flood and ebb currents.

### 7.1.4 Morphological Model Simulations

The MIKE21 ST module was used for simulation of sediment transport for assessing the morphological changes and likely siltation in the vicinity of the proposed berthing area and the approach channel. The hydrodynamic input was taken from the 2-D hydrodynamic model and morphological simulation was done for one month covering the monsoon period.

The model predictions provided the zones of potential siltation and erosion along the channel as shown in **Figure 7.5**.

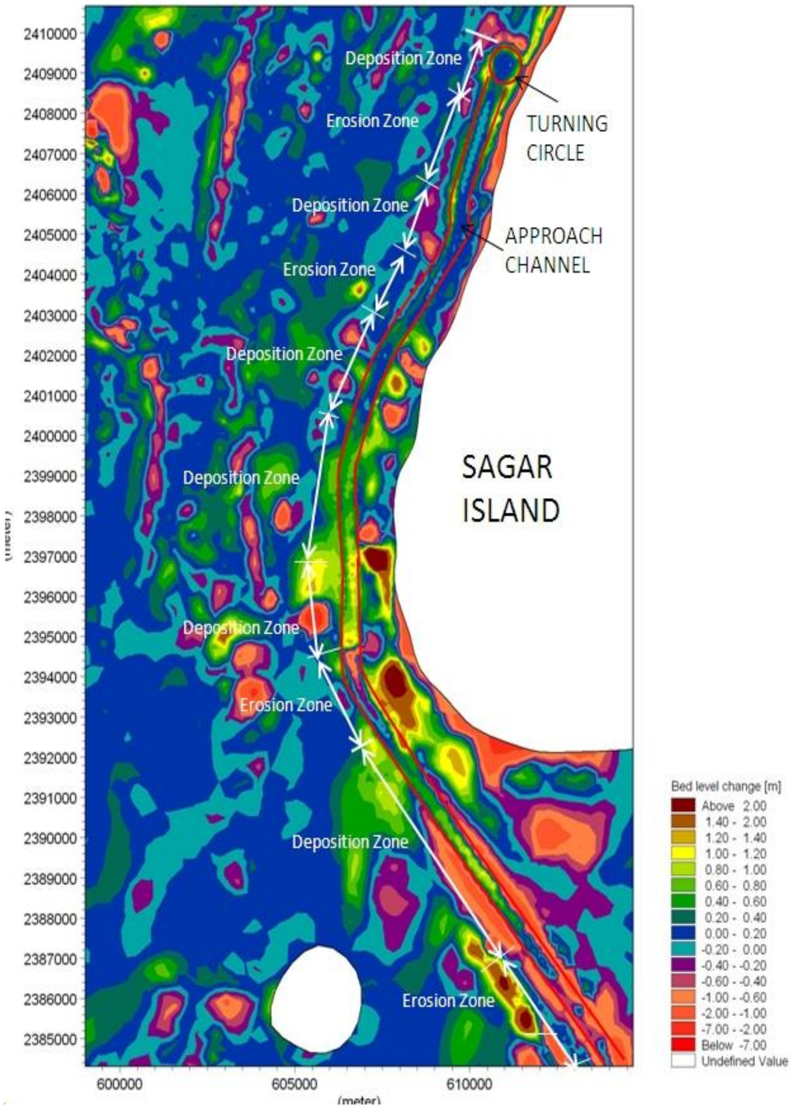



**Figure 7.5** **Results of Sediment Transport Model**

The Upper Channel extending from turning circle to the Middleton Fairway Buoy (Ch. 0.0 to 16.0) generally observed to have siltation with a very small pocket of erosion zone in between, i.e. near the berths area.

In the Lower Channel, which extends from Ch. 16.0 to Ch. 48.0, siltation was observed in the entire channel except the end reaches where erosion was prominent.

Based on the model study results, the siltation was extrapolated for annual yield. It was observed that the overall sedimentation was about 5% of the capital dredging carried out.

The capital dredging volumes being 1.2 million cum in Phase 1, the annual maintenance dredging is expected to be 0.06 million cum only. For ultimate stage development, where the total capital dredging is calculated as 103 million cum, the annual maintenance dredging is taken as about 5.2 million cum.

### 7.1.5 Model Studies for Ship Manoeuvring

A numerical model NAVIGA developed at CWPRS was executed to ascertain the adequacy of the width of the channel for navigating the ship safely under the prevailing winds, waves and currents at the site. The model is based on Abkowitz (1964) formulation and upgraded based on the latest literature on ship hydrodynamics and its tracks of the centre of gravity, heading angle and the required rudder action in small time steps. The model accounts for the influence of winds, waves and currents. The wind, waves and current forces the ship to deviate from the desired path. In order to maintain the course under the influence of winds, waves and currents and also in channels having bends, proper steering actions are necessary.

For the purpose of this study, a container vessel with 210 m LOA and 30 m beam was considered. Simulations were carried out for various limiting conditions of wave, wind and currents. It was observed that channel width of 208 m would be adequate for such vessel under the critical section of the channel.

As indicated in section 6, it is proposed to provide a channel width of 400 m in Sagar channel and that 450 m in the eastern channel to allow for two way passage of design ships, as per the PIANC guidelines.

## 7.2 Onshore Facilities

The main consideration, in locating the facilities has been to minimise the land acquisition. Therefore the onshore facilities have been located in the reclaimed land. The areas for cargo handling and port operations have been segregated. The administrative building and other buildings catering to port users, amenities etc. are placed outside the port compound and close to the gate. They are planned as a single complex because of their inter-related functions.

While arriving at the layout it has been ensured that adequate space has been earmarked for the railway lines to be provided within the port area once the rail bridge across river Muriganga is built.

## 7.3 Revetment

### 7.3.1 Basic Data for Revetment Design

#### *7.3.1.1 Extreme Wave Conditions at Site*

Wave transformation studies were carried out at site for the operational wave conditions. Based on that it has been observed that reduction factor of waves at port location vs the offshore waves is about 25%. Analysis of cyclonic wave data observed in the region indicated that the offshore wave height could reach about 8 m in deep waters. Using the same reduction factor on a conservative side, the design significant wave height at the port location shall be around 2.0 m.

#### *7.3.1.2 Design Water levels*

Storm surges, the meteorological conditions causing the rise in water levels, occur sometimes but not always the same as those causing maximum wave attacks. In some cases the two conditions will act as independent variables; and in some other cases they can be positively or negatively related. The probability of the design wave height at structure occurring along with maximum storm surge is considered to be negligible. Therefore storm surge is generally added to MHWS to arrive at the design water level. No significant storm surge has been reported in the region and no reliable data on storm surge is available. Therefore it is proposed to use the +5.4 m CD (mean high water spring) as the design water level.

### 7.3.2 Revetment Cross Sections

Hudson formula is used for calculating the weight of armour unit

$$W = \frac{e_s H^3}{K_D \left( \frac{e_s}{e_w} - 1 \right)^3 \times \cot \alpha}$$

| | | | |
|---|---|---|---|
| where | W | = | weight of armour unit |
| | $e_s$ | = | Mass density of armour unit |
| | H | = | Design Wave height |
| | $K_D$ | = | Stability Coefficient |
| | $e_w$ | = | Mass density of water |
| | cot α | = | Armour slope (H/V) |

The values for $K_D$ considered for design of revetment is 2.8.

Based on this, the assessment of revetment section would comprise of 1 to 1.5 T rock in the armour layer laid over core fill comprising of 0.5 kg to 200 kg stones. The cross section of revetment is as shown in **Drawing DELD15005-DRG-10-0000-CP-WBP1005**.

### 7.3.3 Rock Quarrying and Transportation

#### ***7.3.3.1 Location of Quarries***

It is understood that the rock for the construction works in the mainland opposite Sagar Island is brought from Pakur to Farakka by road and from Farakka it is taken to various marine sites through barges.

#### ***7.3.3.2 Transport to Site***

The viable option for rock quarrying and transportation which is socially acceptable, environmentally and technically feasible, and economical is transportation of rocks to the site through barges.

The proposed quarry site is located at about 30 km from Farakka. Considering the quantum of rock needed it may work out to be economical that rock be brought through the river to the proposed port site where a temporary jetty shall be built to receive the construction material. The location of quarry sites is as shown in **Figure 7.6**.

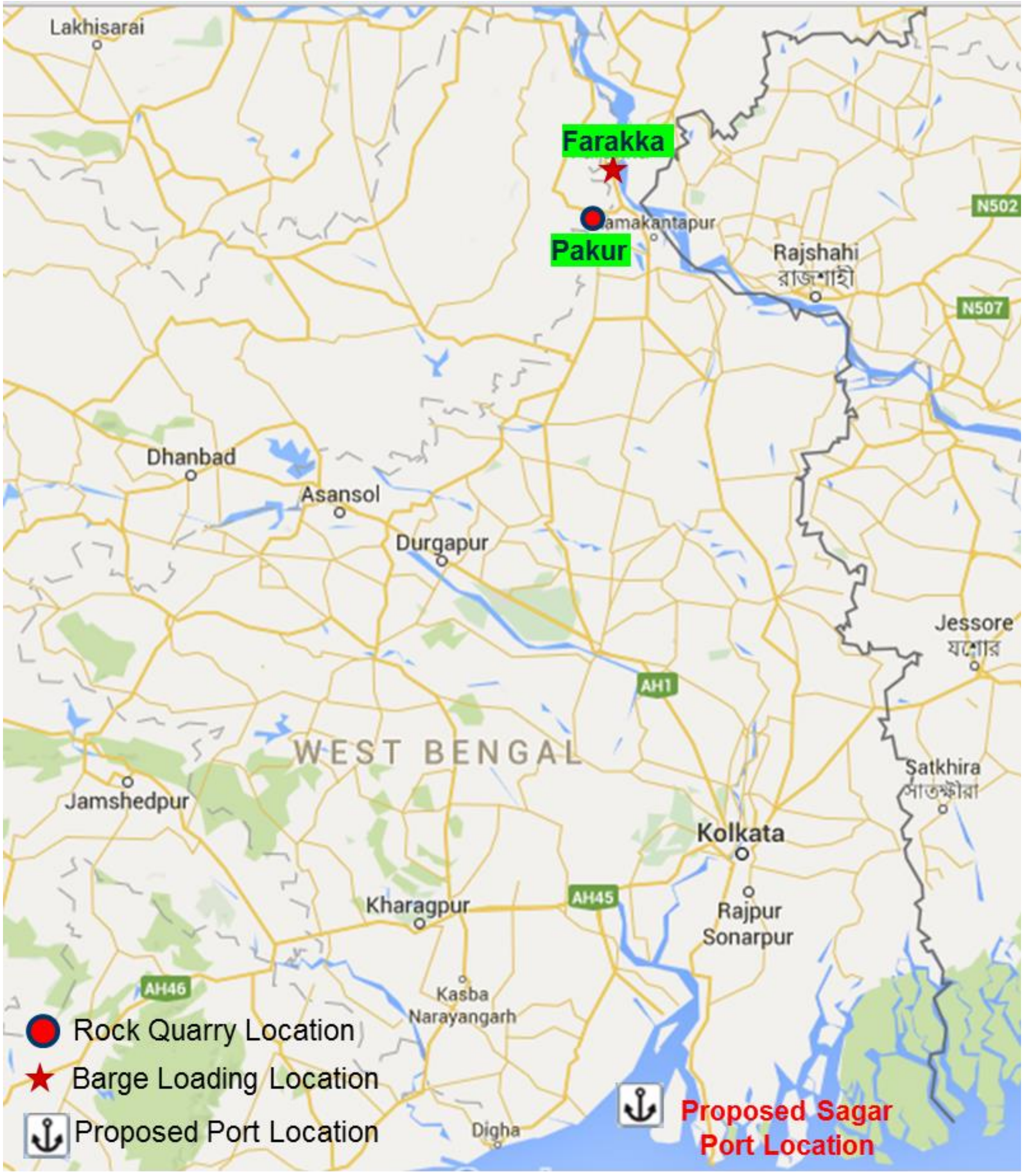



**Figure 7.6 Location of Quarry Site**

**Figure 7.7** describes the transportation process assumed for rock required for armour layer of revetment.


**Figure 7.7 Logistics Flow diagram from Quarry to Port Site**

## 7.4 Berthing Facilities

### 7.4.1 Location and Orientation

The location and orientation of the proposed berths is shown **Drawing DELD15005-DRG-10-0000-CP-WBP1002**. Ideally the Container and Multipurpose berths should be built contiguous to the land for ease of handling operations, whereas the bulk berths could be located away and connected to shore by means of an approach trestle. However, considering the soil conditions and also the requirement to carry out deepening of berth pockets in stages, it is proposed that all berths shall be located away from backup area to which the connection shall be by approach trestles provided at intervals along the quay length.

### 7.4.2 Deck Elevation

The deck elevation of the berths has been fixed at +8.50m CD. This deck elevation will prevent the waves slamming the deck during cyclones. This deck level will also ensure adequate clearance to the deck during operational wave conditions.

### 7.4.3 Design Criteria

#### *7.4.3.1 Design Ships*

The structural design of the multipurpose berths shall be carried out for the maximum size of the ships expected to be handled at these berths at the ultimate phase. The details of design ship sizes are given in **Table 7.2** below:

**Table 7.2 Characteristics of Design Ships**

| Commodity | Design Ship Size (DWT) |
|---|---|
| Coal* | 80,000 |
| Multipurpose** | 80,000 |
| Containers | 4000 TEUs |

* The berth designed for fully loaded Panamax ship can also cater to the loads of light loaded cape size ships.

** It may be noted that the multipurpose berths shall be designed such that during later stages, there is a flexibility to convert these to container berths.

#### *7.4.3.2 Design Dredged Level*

The structural design of the berths shall be carried out for design dredged level of -15.0 m CD.

#### *7.4.3.3 Geotechnical Criteria for Design of Berth Piles*

The preliminary design of the berths' foundation has been carried out based on the subsoil profiles discussed in section 2.

#### *7.4.3.4 Design Loads*

- **Dead Loads** comprising the self-weight of the structure plus superimposed loads of permanent nature shall be considered as per IS: 875 (Part-I) 1987.

- **Live Load** on the deck slab shall be 5 T/$m^2$

- **Vehicle and Crane Loads** as per details below
    - *Mobile Harbour Cranes LMH400 or equivalent*
    - *Single train of IRC class AA vehicle or Loads due to mobile crane of 70 T lifting capacity*
    - *Loads due to Container Gantry cranes with rail centres at 30 m c/c (except for the exclusive bulk berth)*

- **Seismic Loads** on the structures shall be computed in accordance with the seismic code of India IS: 1893.

- **Wind Loads** on the structures shall be calculated using a basic wind speed of 50 m/s as per the Indian standards. However, wind speed during the operational conditions shall be limited to 20 m/s only.

- **Current Loads** on the structure shall be applied on the submerged parts of the structure considering the maximum current velocity as 3.0 m/s.

- **Wave Loads** shall be computed considering maximum wave height of 3.6 m (~ 1.8*2.0) for the design of the berths on a conservative side.

- **Mooring *Loads*** shall be calculated considering 150 T bollard pull.

- **Berthing Loads**
  The berthing loads have been calculated as per relevant Indian standards. Considering the tidal range at the site and also the variation in the sizes of vessels to be handled at the jetty, the fendering system is designed such that sufficient contact area between the hull of the ship and the fender face is ensured at all tidal levels, for all possible size of ships expected to be berthed at the jetty. Based on these criteria it is proposed to use fenders with a frontal frame reaching down to the lowest water level at all the berths.

  It is observed that the berthing energy of the fully loaded 80,000 DWT ships would govern the design. Basis this selection of suitable fender has been made has been and the Corresponding design reaction force has been worked out based on the standard fender design catalogues. The details are provided below:

**Table 7.3 Details of Berthing Energy, Fender and Berthing Force applied at Berths**

| Parameters | Value |
|---|---|
| Berthing Energy | 153 Tm |
| Fender | Trellborg Cell Type Fenders SCK 2000 or equivalent |
| Berthing Force | 174 T |

In addition a longitudinal force equal to the 25% of above transverse berthing force is also applied simultaneously on the fender point to account for the friction between the ship's hull and the fender. The parameters of the fender need to be confirmed after getting the exact details from the supplier during the detailed engineering stage.

#### ***7.4.3.5 Load Combinations***

The above loads with appropriate load combinations, as per IS 4651 (Part 4) shall be applied on the different components of the berths.

#### ***7.4.3.6 Materials and Material Grades***

Concrete of grade M40 and high corrosion resistant thermo-mechanically treated bars of Fe 500 grade shall be used for berth construction.

### 7.4.4 Proposed Structural Arrangement of Berths

#### ***7.4.4.1 Dry Bulk Berth/ Multipurpose Berth***

The berth shall have a provision to provide a conveyor system, to be provide in future if required, for carrying the dry bulk from the berth and transfer to the conveyor provided over the approach trestle. **Drawing DELD15005-DWG-10-0000-CP-WBP1006** presents the general arrangement of Phase 1 berths. **Drawing DELD15005-DWG-10-0000-CP-WBP1007** presents the cross section of multipurpose berth and approach trestle.

The minimum width of the berth, keeping in view the rail span of the coal unloaders (only future provision), service ducts and the end clearances should be about 25m.

In view of the above arrangement of berth and its location, founding strata, piled foundation is considered as best option for the structural system.

The proposed structural scheme consists of four rows of vertical bored cast-in-situ RCC piles of 1.2 m diameter, spaced at 8 m c/c in the longitudinal direction. The piles will be founded at a level of -40 m CD.

In the transverse direction, main beams are provided supported over the piles, which in turn support beams in the longitudinal direction. The longitudinal beams, at the front row and the fourth row, are designed for loads due to ship unloaders. A 450 mm thick deck slab will be provided supported over the intermediate longitudinal beams.

Bollards and rubber fenders will be provided @ 24 m c/c along the berthing face. A service trench will be provided on the berthing side to accommodate cables/utilities. The crane rails are provided at a spacing of 20 m c/c to match the rail span of the ship unloaders. The conveyor supports are provided in the rear side of the berth at a spacing not exceeding 25 m.

The bulk berth is connected to the shore by means of 105 m long and 16 m wide approach trestle to back up area. The approach trestle shall be supported over three rows of 1.0 diameter bored cast in situ piles. The structural arrangement of the approach trestle would be similar to that of the bulk berth.

#### *7.4.4.2 Container and Multipurpose Berths*

The container and multipurpose berths are connected to land by means of approach trestle. Due to the requirement of placing the ship's hatch covers on the berths the width of the berth is taken as 40 m.

The structural arrangement of the berth is based on the design criteria. The proposed scheme consists of five rows of vertical bored cast-in-situ piles of 1.2 m diameter, spaced at 7 m c/c in the longitudinal direction. The piles will be founded at a level of -45.0 m CD.

In the transverse direction, main beams are provided supported over the piles, which in turn support beams in the longitudinal direction. The longitudinal beams, at the front row and the third row, are designed for crane loads. A 500 mm thick deck slab will be provided supported over the intermediate longitudinal beams.

Bollards and rubber fenders will be provided @ 24 m c/c along the berthing face. A service trench will be provided on the berthing side to accommodate cables/utilities.

The berth is connected to the shore by means of 90 m long and 16 m wide approach trestle to back up area. The approach trestle shall be supported over three rows of 1.1 m diameter bored cast in situ piles. The structural arrangement of the approach trestle would be similar to that of the container and multipurpose berth.

**Drawing DELD15005-DWG-10-0000-CP-WBP1008** presents the cross section of container and multipurpose berths.

## 7.5 Dredging and Disposal

### 7.5.1 Capital Dredging

Considering the design draft of the ships chosen for Phase 1 development, no capital dredging in the eastern channel is required to be carried out. The entire capital dredging for Phase 1 development shall be limited to the Sagar Channel only and is estimated to be around 1.2 million cum only. The phase wise incremental capital dredging quantity is indicated in **Table 7.4** below:

**Table 7.4 Estimated Quantity of Capital Derdging (cum)**

| S. No. | Location | 2020 | | 2025 | | 2030 | | 2035 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Design draft of Ship | Capital Dredging | Design draft of Ship | Capital Dredging | Design draft of Ship | Capital Dredging | Design draft of Ship | Capital Dredging |
| 1 | Eastern Channel | 9.00 | - | 11.70 | 42,056,093 | 12.50 | 23,998,113 | 13.50 | 33,320,091 |
| 2 | Sagar Channel | 9.00 | 1,072,398 | 11.70 | 2,025,641 | 12.50 | 1,079,610 | 13.50 | 2,024,920 |
| 3 | Harbour Area | 9.00 | 108,000 | 11.70 | 816,309 | 12.50 | 692,034 | 13.50 | 1,143,033 |
| | **Total Incremental (Phase Wise)** | | **1,180,398** | | **44,898,042** | | **25,769,758** | | **36,488,043** |

Most of the dredging in the approach channel and harbour basin shall be carried out using trailing suction hopper dredger. It is anticipated that about 0.9 million cum of material could be utilised for reclamation and balance shall be dumped offshore at the designated disposal area.

The dredging for subsequent phases shall be undertaken as per the demand of the users and cost benefit analysis.

### 7.5.2 Maintenance Dredging

Based on the outcome of model studies the expected annual maintenance dredging volumes are estimated to be about 60,000 cum only for Phase 1. The maintenance dredging volumes being minimal it is suggested that maintenance dredging to be carried out on annual basis by deploying suitable trailing suction dredgers. However, in the subsequent phases with the deepening of water depths significant maintenance dredging is anticipated. At the master plan stage development with dredged depths adequate to receive the fully loaded Panamax ships the annual maintenance dredging is expected to be about 6.0 million cum.

## 7.6 Reclamation

### 7.6.1 Areas to be reclaimed

The backup area for the proposed berth shall be reclaimed using the suitable dredged material and also the borrowed fill.

### 7.6.2 Reclamation Process

The reclamation process comprises creating bunds in the reclamation areas of suitable heights to receive the dredged material. Considering that most of the fill will be placed in intertidal zone and it could be undertaken without the requirement of reclamation bunds, except behind the proposed locations of berths.

As the required reclamation quantity of 6.6 Mcum in phase 1 development is significantly higher than the suitable material available from dredging the Sagar channel, borrowed fill would be needed. Currently, over 9.0 million cum dredging is being carried out in Auckland bar to maintain the navigational route to Kolkata and Haldia ports. Instead of disposing the material at offshore disposal site, the suitable material could be brought to the proposed port site. The material shall be disposed off by TSHD using rain bowing technique. Alternatively the dredger may discharge material using pipeline to reclamation area for which a temporary jetty with connecting pipelines and couplers would be provided. The dredged material being silty sand, ground improvement shall be carried out using band drains.

## 7.7 Material Handling System

### 7.7.1 Bulk Import System

#### ***7.7.1.1 General System Description***

Due to low throughput a partly mechanized ship unloading system is planned at one of the multipurpose berths (bulk berth).

The major components of the mechanized bulk import system are:

- Mobile Harbour Crane(s)
- Mobile Hoppers
- Stackers at stackyard
- Connected Conveyor system

### *7.7.1.2 Mobile Harbour Cranes*

Mobile harbour crane is versatile equipment and can be used to handle variety of cargo ranging from bulk, breakbulk, containers etc. utilising different attachments like grab, sling or spreader. For unloading the bulk cargo it is proposed to provide two cranes at one of the multipurpose berths (bulk berth). These cranes shall unload the bulk from ships and transfer to the mobile hopper. The mobile hoppers are rail mounted and provided over conveyor placed at ground level at berth for carrying the material to stackyard. The system details are shown in **Figure 7.8**.

**Figure 7.8 Typical Mobile Harbour Cranes with Mobile Hoppers**

### *7.7.1.3 Conveyor System*

The material unloaded from the ship will need to be conveyed to the stackyard. The ship-unloading rate typically peaks during initial operation of a ship, when the cargo holds are full and conditions are favourable for "cream digging". The conveying system will be rated for such operations and short-term surges, as anticipated. However, the required conveying capacity will reduce as the ship is progressively emptied. The designed capacity of the connected conveyor is 2000 TPH.

The conveyor galleries will be covered, for environmental protection. At road crossings, the conveyor galleries will have a clear height of at least 6 m.

### *7.7.1.4 Stacking*

It is proposed to provide two stackers at the stackyard. This equipment shall be used to receive coal from the ship and stacking in the yard.

The stacker will have limit switches and controls to restrict the stockpiles to their planned boundaries. The equipment shall be used to stack coal to 12 m height.

#### 7.7.1.5 Reclaiming and Wagon Loading

Due to very limited cargo throughput it is proposed to use front end loaders for cargo reclaiming from stackyard and loading the wagons. Should the throughput goes up reclaimer in the stackyard with conveyor to rapid loading system shall be provided.

### 7.7.2 Container Handling System

#### 7.7.2.1 Ship-to-Shore Handling Facility (Rail Mounted Quay Cranes - RMQCs)

These are rail mounted travelling cranes on quay provided as a ship-to-shore handling facility. They will have an outreach of up to 42 m. It is not envisaged to stack any containers on the quay except in emergency situations. The cranes will be provided with telescopic twin lift spreaders. Typical details of RMQCs are shown in **Figure 7.9**.

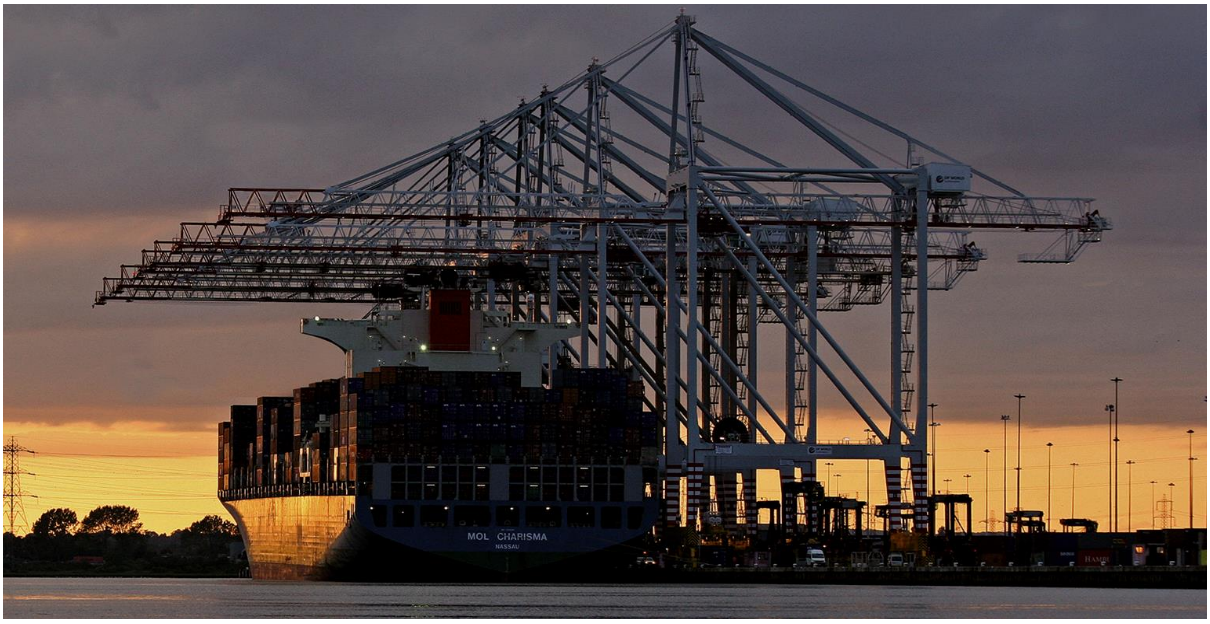



**Figure 7.9 Typical RMQCs Operating at Berth**

#### 7.7.2.2 RTGs (Rubber Tired Gantry Cranes)

RTG cranes have long been the most common mode of operating worldwide in a container yard. As the name implies, these machines operate on rubber tires and can roam anywhere in the container yard. They typically run on reinforced concrete runways to minimize the rutting that can take place along the RTG travel paths.

Although, RTGs have traditionally been diesel powered, there is a major trend in the container handling industry to shift to electrically powered RTGs. RTGs can be powered from a cable reel but the most common electrical solution is an above ground bus bar power system.

Taking due care of the green nature of the proposed port, spatial provisions are provided in the planned development for E-RTGs (Electric RTGs) for container yard handling. It will run with zero emission compared to a diesel-powered RTG, a greenhouse gas emission free container yard operation and saving in energy costs on long run. Local NOX, PM, CO emissions can be reduced at greater level with use of E-RTGs. **Figure 7.10** shows an E-RTG in operation.


**Figure 7.10 Typical E-RTG for Yard Operation**

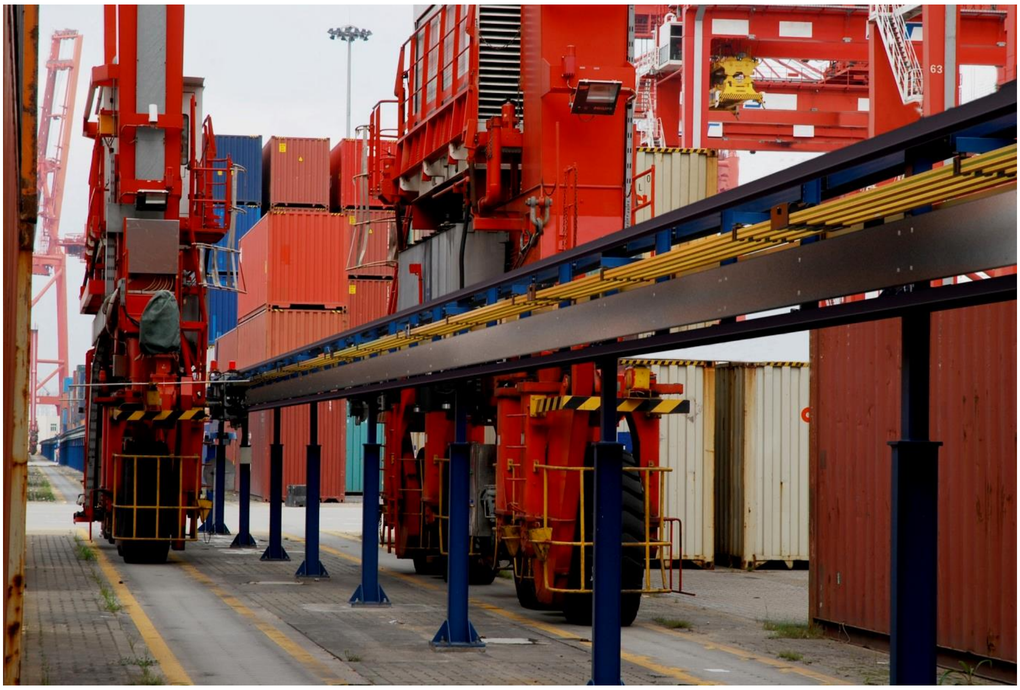


**Figure 7.11 Typical Details of Electric Buss Bar Arrangement for E-RTG**

### *7.7.2.3 RMGCs (Rail mounted gantry Cranes)*

RMGCs are deployed at the rail yard for loading unloading the rakes. They move on a straight rail track slightly longer than the length of the rake. These equipment have cantilevers at both end through which the containers are lifted from trailers and then loaded to wagons and vice versa.

### *7.7.2.4 Reefer Load Container Storage*

The reefers will be stored for access via multi-level reefer racks, stacked to a maximum of five containers high. The racks will provide power and maintenance access. Reefers will be delivered and retrieved by ITVs.


**Figure 7.12 Typical Details of Reefer Stacks**

Reefer racks provide grounded storage for reefers. Multi-level reefer racks are provided to allow mechanics access to plug and unplug units, to check reefer machinery status, and to perform low level maintenance and repair. Refrigerated loads are plugged into power receptacles, located on the reefer racks, to maintain temperature while stored in the container yard.

### *7.7.2.5 Empty Container Handlers*

Empty containers will be block-stowed in grounded rows with containers stacked up to eleven-wide by six to seven high. Empty Container Handlers (ECHs) will service these rows.

**Figure 7.13 Snapshot of Typical Side-pick Handling**

Containers will be transported between the quay and the empty storage areas by ITVs.

### *7.7.2.6 Reach Stackers*

Reach Stacker is the equipment used for handling containers within container yard and intermodal operation of the containers. It is able to transport containers for short distances and stack them in various rows depending on its access. In small to mid-size ports reach stackers are also used in the yard operation for stacking containers. Reach stacker has gained ground in container handling in rail yard because of its flexibility and ability to stack across rail tracks.


**Figure 7.14 Snapshot of Typical Reach Stacker Handling**

Considering the throughput of the import export containers of gateway traffic, it is proposed to provide two numbers of Reach Stackers for train loading/unloading.

#### *7.7.2.7 Internal Transfer Vehicles (ITVs)*

These are the vehicles used for cargo movement within the terminal area from berth to storage area and storage area to rail yard or vice-versa. Generally trucks with a forty feet long trailer are used for container handling and dumper trucks are used for bulk cargo.


**Figure 7.15 Typical ITV for Handling Containers**

### 7.7.3 Break Bulk Handling System

#### *7.7.3.1 Steel Products*

Major share of steel products is likely to be steel coils each weighing about 25 T. Other steel products for export shall be in the category of rods, pipes, angles, channels, beams etc. of various sections. All such cargo shall be in bunches, duly tied and slinged. Such steel products in the storage area shall be loaded on to trailers by heavy duty Fork Lift Trucks (FLT) or Mobile Cranes of adequate capacity. At the berth MHCr shall lift the pre-slinged cargo directly from trailers with the help of cargo beam/hooks for loading on to the vessel at planned sequence.

Terminal facilities and equipment required for handling the aforesaid cargo for aggregation, transfer and loading on the vessel are:

- Open storage area/covered storage shed of adequate capacity for the purpose of cargo aggregation.
- Fleet of trailers for cargo transfer from storage area to the berth.
- Heavy Duty FLTs (35 T) and a Mobile Crane.
- MH Cranes at berth for vessel loading
- Cargo loading accessories like cargo beam, wire rope net slings of adequate capacity and size

#### *7.7.3.2 General Cargo*

General cargo shall be aggregated in covered storage shed before arrival of vessel. The terminal facilities and handling equipment required for handling general cargo are as follows:

- Dumpers / trucks for cargo transfer from shed to the jetty during vessel operation.
- Sufficient numbers of net slings of proper size and capacity to ensure cargo loading in the hatches with the help of MHCr or ship's derrick in case of geared vessels.

#### *7.7.3.3 Other Dry Bulk Cargo*

The small quantities of the dry bulk cargo shall be handled at the multipurpose terminal using mobile harbour cranes. While unloading the material shall be unloaded onto the mobile hoppers through which it shall be transferred to the dumpers underneath, which shall move to the bulk stackyard for dumping the cargo in allocated stockpile.

The typical section of container and bulk yard is as shown in **Drawing DELD15005-DRG-10-0000-CP-WBP1009** and **DELD15005-DRG-10-0000-CP-WBP1010**.

## 7.8 Port Infrastructure

### 7.8.1 External Rail Connectivity

#### *7.8.1.1 Proposed New Rail Alignment*

A subcommittee was constituted by Chief Secretary, Govt. of West Bengal to finalise the railways alignment connecting the future Sagar port to the dedicated freight corridor. The final unanimously recommended route by the committee is as under:

1. *Sagar Port – Kasinagar : New Line*
2. *Kasinagar – Kulpi : Existing Line*
3. *Kulpi – Gurudasnagar – (Diamond Harbour) – Bakrahat – Chak Gopalpur – Nangi : New Line*
4. *Nangi – Majerhat : Existing Line*
5. *Majerhat – Kidderpore – Takta Ghat : Existing Line (Circular Railways)*
6. *Takta Ghat – Shalimar : New Line on new bridge over the Hoogly river*
7. *Shalimar – Santragachi – Dankuni : Existing Line*

The railway alignment, consisting of existing rail corridors and proposed new lines, has to be capacity augmented to cater to the DFC standards. A schematic diagram of the railway alignment is presented in **Figure 7.16**.

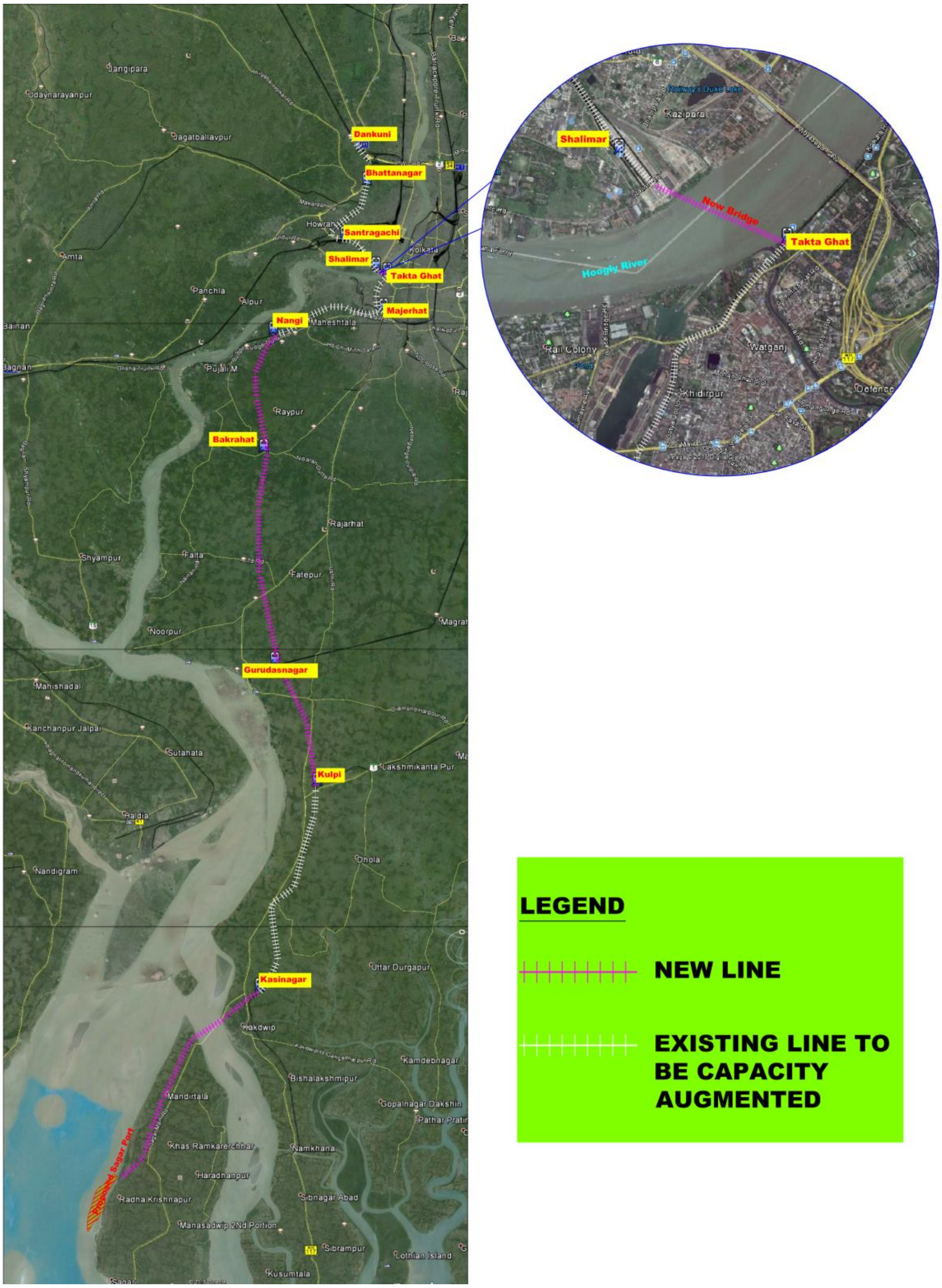



**Figure 7.16 Proposed New Rail Alignment till Dhankuni**

#### *7.8.1.2 Offsite Rail Yard*

As mentioned in section 7.8.1, an offsite rail yard shall be built near Kashinagar railway station from where a branch rail line is taken to the yard. Initially three sidings shall be built in the yard for loading and unloading of the cargo.

The cargo between the port and the offsite rail yard shall be transferred by means of tractor–trailers /dumpers/trucks. Adequate storage space shall be provided in the offsite yard for storage of transit cargo. The typical layout of the offsite rail yard is shown in **Figure 7.17**.

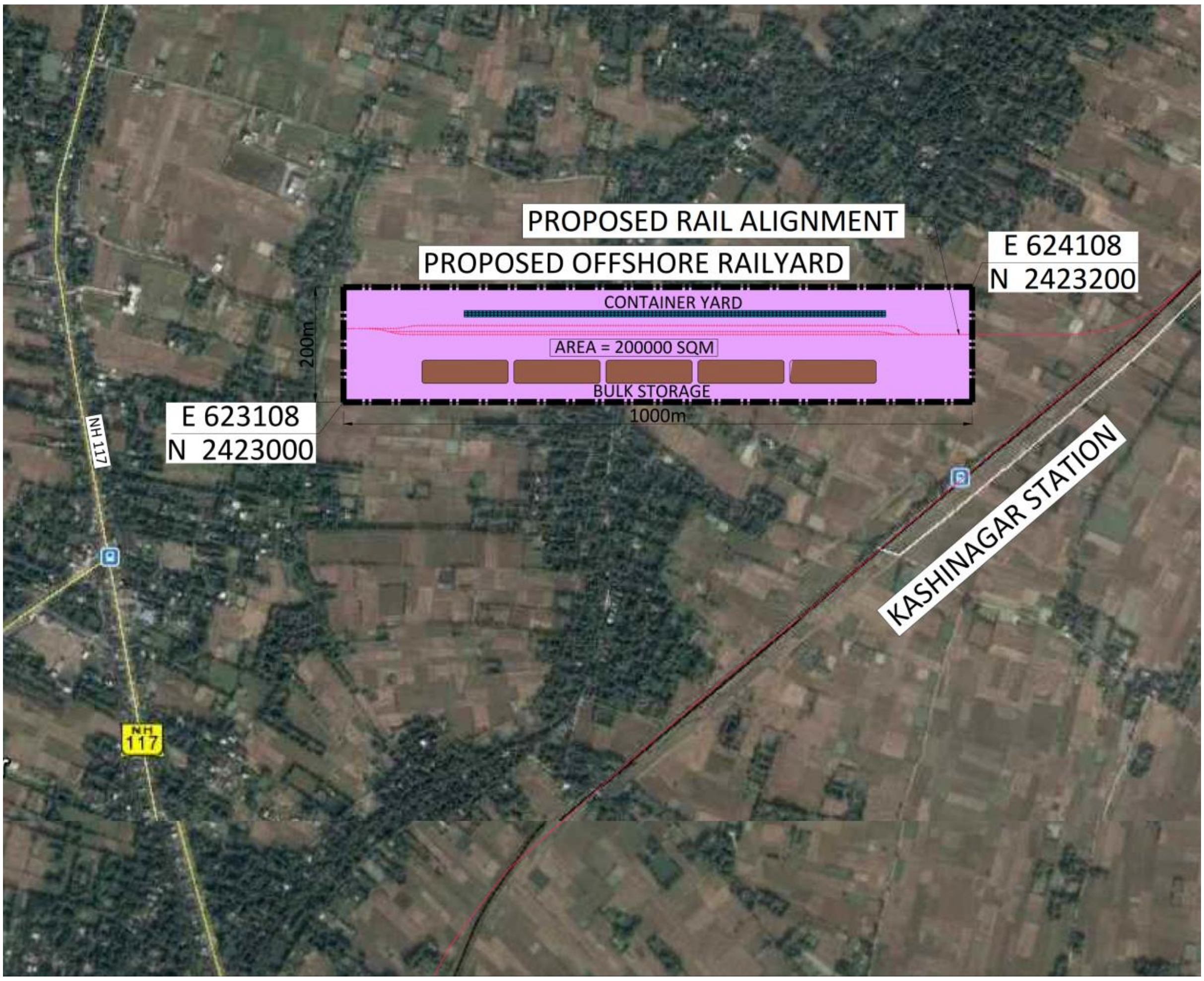



**Figure 7.17 Typical Layout of Offsite Rail Yard**

#### *7.8.1.3 Take off station for Rail Connectivity*

The rail bridge across river Muriganga is expected to be built by the year 2025 and then port shall be connected to main railway network. The main line of broad gauge that passes through Kakdwip – Kashinagar – Kulpi – Laxmikantapur – Dakshin Barasat – Sealdah – Dankuni is approximately 25 km from the Sagar Port location. It is proposed to take off a rail link from the Kashinagar station for the proposed port.

#### *7.8.1.4 R&D Yard*

Since block loads of trains or point to point trains are proposed to be run to and from the port, only a Receipt & Despatch (R&D) yard is required to be provided. Provision for a separate siding for sick wagons needing repairs and a loco shed for attending to minor repairs of shunting locomotives with fuelling arrangement is also required.

It is proposed that the offsite railyard be used as R&D yard. In the ultimate stage it would have about 6 full length lines, out of which one line will be kept exclusively for engine movement. Apart from this, a loco line of short length for parking locomotives and another short siding for detaching sick wagons will be provided.

### 7.8.2 Internal Rail links

The internal rail lines will be developed to the various cargo terminals. It shall be ensured that their location does not obstruct the movement of port vehicles. For containers the rail sidings shall be taken till the rear of the container yard. At the bulk import yard two rail sidings shall be provided including one engine escape line. One silo for in motion wagon loading shall be located at the main rail track.

### 7.8.3 External Road Connectivity

#### *7.8.3.1 Introduction*

The road connectivity at Sagar is as discussed in section 2.10.2. Once the road bridge on river Muriganga is constructed, the island can be connected to the mainland and thereafter to NH 117, which runs through Kolkata-Diamond harbour – Kulpi – Kakdwip – Namkhana.

#### *7.8.3.2 Road Connectivity between Sagar Port to Muriganga Bridge*

Sagar main road which is running from north to south of Sagar Island needs to be widened in order to facilitate the movement of anticipated traffic from/to the Port.

For the rail and road connectivity from future Sagar port, KoPT has already initiated the land acquisition process for around 102 Ha of land as per RITES alignment (schematically presented in **Figure 7.18**) and hence further option study in this regard is not envisaged.


**Figure 7.18 Road Alignment between Sagar Port and Muriganga Bridge**

However, the following few important points have to be ratified during preparation of detailed design of the road corridor:

- The spur connecting the Kasinagar Stackyard (approximate length – 0.85km) to the junction of NH-117 and the road to Lot no. 8, was not part of the RITES report. Hence the alignment option study in this regard has to be done during detailed design stage.
- The land width being acquired is 25m for new alignment and 15m for existing alignment, which is not adequate as per 4 lane standards. However, the projected traffic is only 8000 PCU after 20 years, which is well within the traffic capacity of 15,000 PCU for 2 lane roads. Hence, since the proposed dualisation is only for traffic safety enhancement, the 4 lane road can be accommodated within the 25m RoW, with some deviations from standard cross sectional elements. The proposed cross sectional elements in this regard are as under :
  - Median : 1.5m
  - Carriageway with Kerb Shyness : 7.5m
  - Earthen Shoulder : 1.5m

  However, detailed analysis of all parameters has to be done during the detailed design phase to finalise the road cross sectional elements.

- Since the road is located in the vicinity of the Bay of Bengal and the area was severely affected by the cyclonic storm "Aila" in May 2009, detailed investigations and analysis have to be done while finalising the road design to ensure sustainable connectivity to the future port.

#### *7.8.3.3 Road Connectivity between Muriganga Bridge to Offsite Railway Yard*

#### *Option 1*

The proposed connectivity option is about 3.48 km. It follows existing road and get connected with the Railway yard with a level crossing at NH 117. The road capacity augmentation will be required.

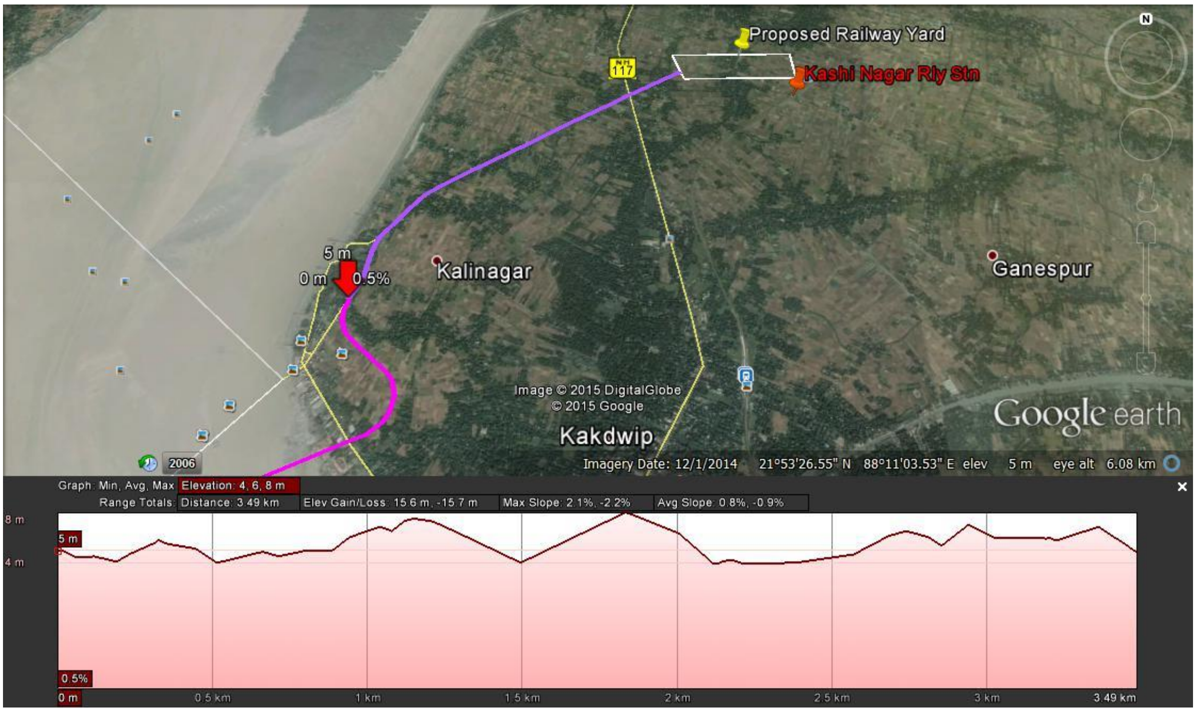



**Figure 7.19 Option 1 – Road Connectivity to Proposed Rail Yard from Muriganga Bridge**

#### *Option 2*

The proposed connectivity option is about 4.46 km and a Greenfield Alignment. It will also have a flyover over NH 117. But it will have more social and environmental issues.

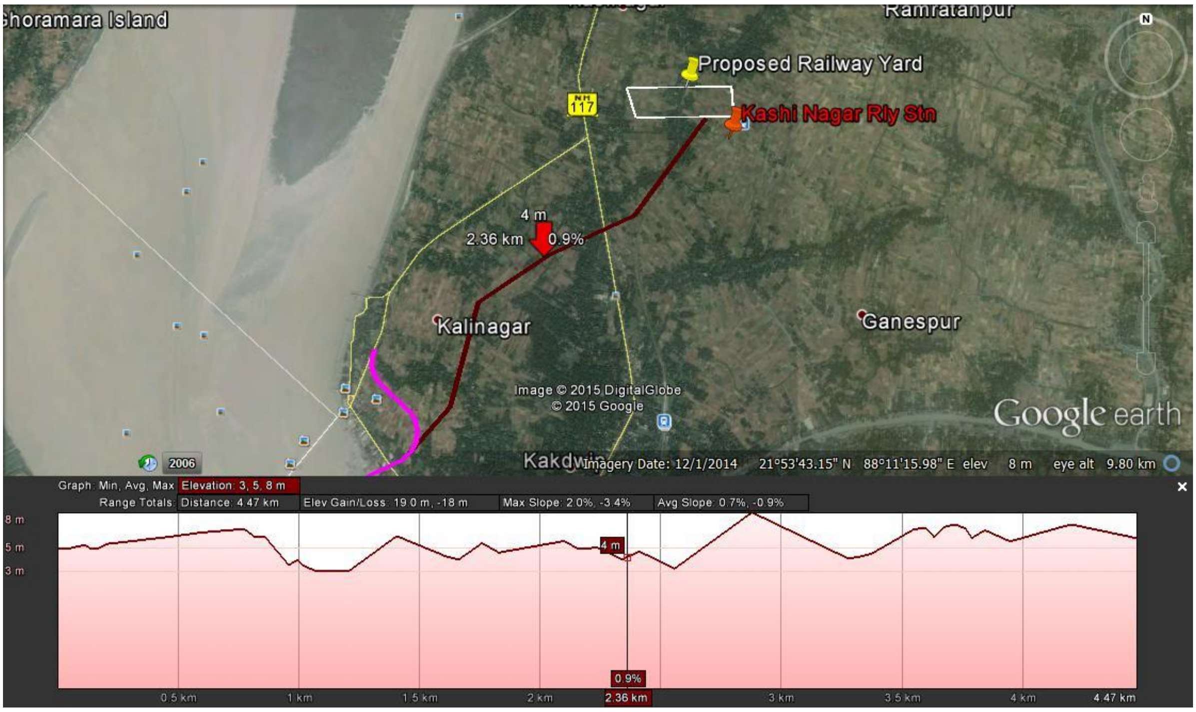



**Figure 7.20 Option 2 – Road Connectivity to Proposed Rail Yard from Muriganga Bridge**

***Preferred Alignment***

**Option 1** is preferred as the project length is less and is following the existing road.

## 7.8.4 Rail cum Road Bridge across Muriganga

The bridge across river Muriganga has to be taken up separately by a government agency and the above options are indicated to help in decision making process.

However, AECOM carried out assessment of various options of development of Rail cum Road Bridge for a span of 3 km across Muriganga. The following were the options which were considered from cost point of view.

- **Option 1**: Extradosed Bridge (2 Track + 4 lane Road)
- **Option 2**: Steel Truss (2 track + 3 lane)
- **Option 3A**: Fully welded Steel composite Truss (2 track +3 Lane)
- **Option 3B**: Fully welded Steel composite Truss (2 track + 4 Lane)
- **Option 4**: Fully welded Steel composite Truss (1 track + 2 Lane) Sub structure for double track and 4 lane Road with Super structure provision
- **Option 5A**: Steel Truss (1 track + 2 Lane)
- **Option 5B**: Fully welded Steel composite Truss (1 track + 2 Lane)

Following are the assumptions for the determination of Block cost

- The span length for the main bridge is considered 125m
- Foundation is assumed to be well

Table below summarises cost comparison of different options.

**Table 7.4 Rail-Road Bridge Option Comparison**

| Options | Bridge Type | Cost (INR in Crores) |
|---|---|---|
| **Option 1** | Extradosed Bridge (2 Track + 4 lane Road) | **1,841** |
| **Option 2** | Steel Truss (2 track + 3 lane) | **2,494** |
| **Option 3** | **A:** Fully welded Steel composite Truss (2 track +3 Lane) | **3,203** |
| | **B:** Fully welded Steel composite Truss (2 track + 4 Lane) | **3,417** |
| **Option 4** | Fully welded Steel composite Truss (1 track + 2 Lane) Sub structure for double track and 4 lane Road with Super structure provision | **2,221** |
| **Option 5** | **A:** Steel Truss (1 track + 2 Lane) | **1,746** |
| | **B:** Fully welded Steel composite Truss (1 track + 2 Lane) | **1,922** |

These costs include the cost of elevated approach to the bridge at both the ends.

### 7.8.5 Internal Roads

The main approach road to the port shall be located parallel to the rear of the backup area. The road leading to container terminal shall widen out near the terminal gates where security checks will be undertaken. Within the terminals internal roads shall be planned based on the cargo handling and storage plans.

### 7.8.6 Electrical Distribution System

#### ***7.8.6.1 Introduction***

The handling systems for containers are power intensive and hence require considerable high tension electrical power for their operation. The terminal development will contain all the features of a modern first class terminal, and as such will require a reliable power supply system.

Similarly the mechanised coal unloading, conveying and stock piling system would also need considerable electrical power. This apart the illumination of the terminal areas, stacking areas, storage sheds, roads and auxiliary services viz., dust suppression system, firefighting system and port buildings would all require considerable HT and LT power.

#### ***7.8.6.2 Estimation of Electrical Load***

Based on the proposed port facilities the total installed power load for the proposed Phase 1 development are estimated to be around 3.5 MVA. This is expected to go up to 10.5 MVA over the proposed master plan horizon.

#### ***7.8.6.3 Source of Power Supply***

Power supply to Sagar Island is being managed by West Bengal Electricity Distribution Company. Currently, transmission line carrying power at 33 KV is passing near the proposed port location. The power shall be tapped from Rudranagar Electric Substation 33/11 KV which is approximately 5km from the proposed port site.

#### 7.8.6.4 Incoming Supply – System Requirements

The HT power shall be brought at 33 KV till the port boundary, where the main receiving substation shall be located. This outdoor switch yard will have two numbers of 33 KV transformers with 15 MVA rating and convert the power at the secondary voltage of 11 KV. This outdoor switch yard will have SF 6 type circuit breakers and will have necessary lightening arresters, current transformers etc. required for protection and metering. The outgoing cables from the two transformers are designed to be of 300 sq mm size leading to the indoor switching station.

The power from the 33/11 kV switch yard is drawn through twin 11 kV feeders each of 3 core XLPE cables to the substation.

All the low tension loads meant for illumination, office buildings etc. are drawn through a 11 KV/415 V transformers.

#### 7.8.6.5 Distribution of Power

Two no. of 33 KV / 11 KV, 5 MVA, HT transformers will be installed at the main receiving substation. Of the two transformers, one will be main and the second will be a stand by and each transformer is designed is to cater to 100% of the maximum demand of the port for the initial phase.

11 KV feeders from main receiving substation will feed to two secondary substations; one for bulk terminal and other for container terminal. The distribution of power in the respective terminals shall be through these secondary substations.

Both the substations will be equipped with a 11KV /0.415 KV transformer of suitable capacity to cater to LT loads of different buildings for illuminations, area lighting, street/road lighting, firefighting, water supply system, etc. The substation shall be equipped with capacitor banks for automatic power factor correction and for maintaining a PF of not less than 0.9.

#### 7.8.6.6 Standby Power Supply

It is proposed to install one diesel generator of 1 MVA each in container and bulk handling substations. These would serve as standby to provide power backup for lighting and emergency loads during failure of mains.

#### 7.8.6.7 Illumination

The illumination level in various areas will be maintained as per the industry standards and shall generally be as in **Table 7.5** below:

**Table 7.5 Illumination Level**

| Area | Lux Level |
|---|---|
| Gate houses, Buildings | 50 |
| Transfer House | 150 |
| Substation, pump houses and fire houses | 250 |
| Workshops | 200-300 |
| External illumination (Road Lightings), Parking | 15-20 |

| Area | Lux Level |
|---|---|
| Stock pile areas and open storage areas | 20-30 |
| Berths | 50 |
| Conveyor galleries | 50 |

For transfer house, high-pressure sodium vapour fixtures (SON) will be provided. For illumination of street, road, and conveyor galleries poles of suitable height with HPSV fittings will be installed. Power supply will be made available from suitably located feeder pillars. For illumination of roads 9 metre high steel tubular type pole with 250 W HPSV street light fixtures shall be provided. For stackyard area high mast (30 m) and for berth area high mast (40 m) with HPSV (SON) will be installed.

#### ***7.8.6.8 Cables***

To meet the HT load requirement 11 KV XLPE aluminium armoured cables will be used. Cables will be laid on cable trays, ducts, directly buried in ground and in trenches, etc. as per site requirement.

LT power distribution to various services such as illumination, firefighting, air conditioning water supply etc. will be done through 1.1 kV grade PVC insulated aluminium armoured power cables. Laying of cables will be done as per site requirement.

Internal wiring to be done in recessed UPVC conduit or on surface with GI conduit and single core PVC insulated FRLS copper wire to be done in case of transfer towers, conveyors, workshops, substations, pump house, fire house, etc.

#### ***7.8.6.9 Earthing & Lighting Protection***

Suitable lightning protection system will be installed as per the guide lines of the IS: 2309. An efficient earthing and lightning protection system will be designed to ensure protection of men & material in worst of the weather conditions.

#### ***7.8.6.10 Power Factor Improvement***

Suitable rating HT capacitors with automatic power factor correction arrangement will be installed to maintain the overall power factor correction to 0.95.

### 7.8.7 Communication System

#### ***7.8.7.1 General***

The Communication system comprising Radio Communication units, Telephone System and PA system of suitable capacities will be provided to suit the port operation requirement.

#### ***7.8.7.2 Telephone System***

To meet the total port requirement, an EPABX of 100 lines capacity will be installed. Suitable telephone instruments to suit the site requirement with adequate protection will be provided.

#### ***7.8.7.3 Radio Communication***

A radio communication system will be installed for transfer of information between various operational areas of port like mobile harbour cranes, shore side duties, control room, terminal engineering services, operational management, supervision etc.

#### ***7.8.7.4 Public Address System***

The public address system will supplement the above two systems. The central control for the system will be kept with the control room located at top floor of the administrative building.

Distribution type public address system will provide a comprehensive paging system for oral communication and announcement by loud speakers and handset stations with built-in amplifiers covering all working areas of the port terminal. The loud speakers will be mounted on purpose built supports provided on permanent structures. The exterior speakers will be weather proof. One number master control station with microphone to zone selection and all call facility will also be provided at control room.

### 7.8.8 Computerized Information System

#### ***7.8.8.1 Overall Objectives***

The computerised information system proposed for Sagar Port will have the following objectives:

- Establish one common IT infrastructure that is based on large scale operations in order to deliver services of high quality.
- Enable centralized control of the Infrastructure to ensure effective management and security.
- Ensure mobility of users located at different office premises by providing the necessary services to ensure connectivity from anywhere.
- Utilize best practices for technology selection and implementation.

#### ***7.8.8.2 Terminal Operating System***

Terminal handling equipment will have control systems to maintain and manage bulk terminal operations. These control systems will be interfaced with BI systems for reporting and MIS. Terminal Operating systems will be deployed for handling the following processes:

- Berth Planning
- Terminal Planning, Monitoring and Execution processes
- Operations Equipment Control (OEC)
- Cargo Control (CC)
- Yard Planning, gate delivery and receipt control
- Landside planning processes
- Enterprise Resource Planning

#### ***7.8.8.3 Technology Infrastructure***

The IT Infrastructure of Sagar Port like hardware, software, network etc. will be implemented according to a long-term strategic plan. The capacity plan includes the necessary infrastructure for the IT strategy development as well as to support the general day-to-day IT requirements (anticipated capacity growth etc.)

### 7.8.9 Water Supply

#### ***7.8.9.1 Water Demand***

The water demand for the Sagar Port has been worked out in the **Table 7.6** below:

**Table 7.6 Estimated Water Demand at Sagar Port**

| S. No. | Consumer | Water Demand (KLD) | |
|---|---|---|---|
| | | Phase 1 | Master Plan |
| 1. | Raw Water (KLD) | 38 | 223 |
| 2. | Potable Water (KLD) | 15 | 42 |
| **Total Water Demand at Port (KLD)** | | **53** | **265** |

#### ***7.8.9.2 Sources of Water Supply***

It is understood that ground water is being utilised to meet the requirements of local population. As the water requirements for the proposed port are very much limited, bore wells shall be installed for the receipt ground water and transferred to an underground reservoir located near the port entrance. This water after chlorination shall be distributed for potable purposes.

#### ***7.8.9.3 Storage of Water***

It is proposed to provide an underground water tank of 250 cum at the port boundary. Water from this tank shall be treated in the water treatment plant, consisting of chlorination, filtration and softening units (depends on the water quality test). Potable water shall be stored in the underground domestic water tank of 50 cum capacity for potable use. For this purpose a small filtration plant is provided at this place. This treated water will be stored in a sump adjoining the main sump for the raw water. The water treatment plant must ensure that it produces water of acceptable quality as per the provisions of IS 10500: 1991

The water from the main sump would be pumped to secondary sumps of 300 cum capacity each located near the multipurpose terminal and bulk terminal. The secondary sump at bulk terminal shall be split into three compartments of 100 cum, 100 cum and 100 cum. The compartment of 100 cum will retain water permanently for firefighting, the compartment of 100 cum will be used for water supply to buildings and greenery. The third compartment of 100 cum will provide water for dust suppression system in the bulk import terminal. The secondary sump for the container/multipurpose terminal shall be split into two compartments i.e. one to retain water permanently for firefighting and other for water supply to buildings and greenery.

### 7.8.10 Drainage and Sewerage System

#### ***7.8.10.1 Drainage System***

Storm Water Drainage at the port will be through a system of underground covered drains provided to discharge the collected runoff. At the bulk import stackyard, the drainage system would comprise of open drains for taking the discharge to the settling pond. Before discharging the collected storm water into the main drainage system of the port it would be passed through the necessary filters for further reduction of PPM.

Surface drainage system shall be provided in the container yard through which water shall be diverted to the secondary covered drains, which shall ultimately discharge to the main drain.

#### ***7.8.10.2 Solid Waste Management***

For the buildings complex having administration building and port user buildings, a small sewage treatment plant of 20 KLD capacity is proposed. The treated sewage shall be discharged to the main drainage network. The sludge from the treatment plant will be processed and converted into Biomass used as manure.

For the isolated buildings where the quantity is negligible, it is proposed to construct septic tanks and connect the septic tank outlets to soak pits for disposal.

There will be very little sewage water generated at the quay walls and hence separate treatment proposals are not contemplated.

### 7.8.11 Floating Crafts for Marine Operations

#### ***7.8.11.1 Tugs***

For berthing / un-berthing of the design coal carriers a minimum of three harbour tugs of 40 T bollard pull capacity are required initially. In addition, a tug is also required for standby/ emergency.

#### ***7.8.11.2 Pilot cum Security Vessels***

These vessels are required for the pilots to travel to and fro between the port and boarding point, where the port's pilot will embark/disembark the ship. Though Sagar Port has a short channel, the vessel arrival and departure shall take place during high water time and hence queueing of vessels is expected. Therefore at least two pilot vessels would be required. In addition one standby vessel is proposed. This will also take care of requirements of routine maintenance and emergency break down/ repairs as well as security purposes.

#### ***7.8.11.3 Mooring Boats***

These boats will be required to carry the lines from the ships and pass it to the required points during berthing and un-berthing operations. Two boats are required per vessel for berthing and un-berthing operations. Considering the frequency of the ships, two mooring boats are considered adequate for Phase 1.

#### ***7.8.11.4 Harbour Crafts***

The requirements of Harbour Crafts for the first phase of the Sagar Port development are given in **Table 7.7** below.

**Table 7.7 Harbour Craft Requirements**

| S. No. | Harbour Craft | Number |
|---|---|---|
| 1. | Tugs 40 T bollard pull | 4 |
| 2. | Pilot cum Security Vessels | 3 |
| 3. | Mooring Boats | 2 |

## 7.8.12 Navigational Aids

### ***7.8.12.1 General***

It is envisaged that navigation will be carried out throughout the year, by day and night, except during cyclonic weather. Navigation aids are required for ensuring safe navigation of ships entering and leaving the port through the approach channel as well as berthing / un-berthing requirements inside the docks. These aids are such as fairway buoys, port and starboard buoys, leading / transit lights for safe and regulated navigation in channels, anchorages, berths and docks. It is proposed to use the existing VTMIS at Sagar Island for this port as well.

The aids to navigation proposed to be provided at port are shown in **Drawing DELD15005-DRG-10-0000-CP-WBP1011** and are detailed below:

### ***7.8.12.2 Buoys***

The approach channel is short but for the safe navigation and pilotage it is necessary to mark the channel with suitable number of navigational buoys by following the IALA zone 'A' code. Considering the need to provide adequate assistance for safe navigation of the ships, it is recommended to provide paired buoys at a spacing of 1 nautical mile. In addition some buoys are proposed in the respective berthing area as well. IALA maritime buoyage system as per region A, in which Sagar Port falls, will be followed. The lateral marks will be red and green colours to denote the port and starboard sides of channel.

### ***7.8.12.3 Leading / Transit Lights***

Considering the channel being very short and being adequately marked with navigational buoys, it is not proposed to install any leading / transit lights to guide the ships through the channel.

## 7.8.13 Security System Complying with ISPS

Security system of the port is required to provide sufficient protection against:

- Sabotage
- pilferage and thefts
- encroachments by unauthorised persons
- trespassers and antisocial elements

The security system must comply with the requirements of ISPS Code.

Keeping in view the importance of various areas in the port, the following proposals are made:

- The custom bound area will be provided with a rubble masonry wall 2.4 m high with barbed wire fencing of 1 m high over the wall.
- A security office and check post at the entrance to the terminals.
- Provision of watch towers at suitable intervals for manual monitoring with night vision binoculars for use during nights.
- Adequate isolated area would be allocated for storage of dangerous goods
- The lighting in the port area shall be to the acceptable standards
- Close circuit Television system (CCTV) to capture activities at all vantage, vulnerable and sensitive locations.

The security arrangements proposed would have to be to the approval of the Director General of Shipping who is the designated authority under the ISPS code.

## 7.8.14 Fire Fighting System

### *7.8.14.1 General*

The firefighting system shall be designed to be capable of both controlling and extinguishing fires. The firefighting system for berths and terminal areas will be a fresh water system with a separate pump house with pumps which will draw water from the respective fresh water tanks.

A centralised fire station will be provided for attending to all calls which will house two mobile fire tenders. One fire tender will be provided with snorkel attachment.

### *7.8.14.2 Dry Bulk Berths and Stackyard*

It is proposed to install Fire Hydrant System, which shall be designed to give adequate fire protection for the facility based on Indian Standard or equivalent and shall conform to the provisions of the Tariff Advisory Committee's fire protection Manual.

Fire hydrant system is proposed at the following areas, which are classified as ordinary hazard areas.

- Berths
- Stackyards
- Wagon Loading Station
- All galleries of Coal Conveyors

The fire hydrant system shall be designed to ensure that adequate quantity of water is available at all times, at all areas of the facility where a potential fire hazard exists. Each hydrant connection shall be provided with suitable length of hoses and nozzles to permit effective operation.

### *7.8.14.3 Container and Multipurpose Terminal*

The firefighting system shall be designed to give suitable fire protection for the containerised/breakbulk cargo and container handling facilities in the terminal and shall conform to the provision of Tariff Advisory Committee’s fire protection manual. The firefighting system shall be a combination of water hydrants, fire alarm system and fire extinguishers.

## 7.8.15 Pollution Control

### *7.8.15.1 General*

One of the essential regulatory functions of a Port Authority is to ensure that the port waters are free from pollution. To this end, pollution control assumes a significant role in any port operations. The main sources of pollution during operations in the port are:

- Discharge of oil by ships / crafts.
- Discharge of bilge by ships / crafts.
- Discharge of dirty / contaminated ballast by ships.
- Discharge of cargo overboard.
- Spillage of cargo during unloading / loading operations.
- Discharge of garbage, sweepings, sewage, etc.

- Discharge of industrial effluents.
- Municipal sewage and drainage.
- Dust from cargo.
- Smoke from ships, vehicles.
- Noise from vehicles, machinery.
- Accidents

#### ***7.8.15.2 Dust Suppression***

Dust control equipment is proposed for efficient control of dust pollution to the environment during storage and handling of coking coal / thermal coal at the berth and stackyard. An efficient dust suppression system will contain dust particles before it becomes airborne.

A system consisting of pumps, storage tank, nozzles for dust suppression at discharge / feeding points of belt conveyors have been proposed at each transfer tower for efficient dust control. In addition to above suitable spray system shall also be provided at ship unloader, coal stackyard and wagon loading station.

Each unit of the proposed dust control system shall consist of plain water tank to store the plain water, chemical tank for chemical storage, plain water pump, metering pump sprinklers & nozzles and piping network. Both the tanks shall be provided with low level and high level switches for control and safety of the pumps. This makes the pump fully automatic and does not require manual monitoring.

The water pumping system shall be designed to operate only when it is required thus saving energy. The spray in dust generation area shall operate only when material is being handled in that location.

# 8.0 Environmental Settings and Impact Evaluation

## 8.1 Environmental Setting

Sagar Island is one of the largest river island and is 30 km long and 12 km wide. The major coastal geomorphological landforms identified around the island during the field survey were barrier beaches, spits, bars, tidal flats, mud flats, sand dunes, and marshy and swampy zones.

The site for the development of Greenfield port is proposed at Chandipur Village on the South-West side of the island. The selected site has about 500 m of tidal flats beyond which sparse habitation and paddy fields may be observed (**Figure 8.1**). On the shoreline some tree plantation was observed which was reported to be under afforestation program.


| **Tidal flat** | **Habitation near the selected site** |
|---|---|

**Figure 8.1 Landside area behind proposed Port Site**

The prime activity in the vicinity was observed to be agriculture, where rice is the main crop. Coconut plantation is also practised widely. No fishing or aquaculture activities were observed near the proposed site.

The region is found to have good provisions of electricity and drinking water.

## 8.2 Environmental Policies and Legislation

**Table 8.1** presents Environmental regulations and legislations relevant to this project, along with the details of the competent authority for implementation.

**Table 8.1 Summary of Relevant Environmental Legislations**

| S. No. | Act/Rule/Notification, Year | Relevance | Applicability | Implementing Agency |
|---|---|---|---|---|
| 1. | Environment Impact Assessment Notification and amendments made thereafter, 2006 | For environmental clearance to new development activities following environmental impact assessment | Yes, Category A For port having cargo more than 5MTPA. | MoEF & CC |
| 2. | Indian Forest Act, 1927<br>Forest (Conservation) Act, 1980 | • Conservation of Forests, Judicious use of forestland for non-forestry purposes; and to replenish the loss of forest cover by Compensatory Afforestation on degraded forestland and non-forest land<br>• Permission for tree felling | No, no forest land is involved in the project | MoEF & CC; Department of Forest, GoWB |
| 3. | Wild Life (Protection) Act, 1972 | • To protect wildlife in general and National Parks and Sanctuaries in particular<br>• Permission for working inside or diversion of sanctuary land | No. | Chief Conservator of Wildlife, Wildlife Wing, Forest Department, GoWB; National/State Board for Wildlife |
| 4. | The Water (Prevention and Control of Pollution) Act, 1974 | • CPCB/ SPCB to establish water quality and effluent standard; monitor water quality; prosecute offenders<br>• Issuance of Consent to Establish (CTO) and Consent to Operate (CTP) | Yes, Consent required to establish and not to pollute water during construction and operation | West Bengal Pollution Control Board |
| 5. | The Air (Prevention and Control of Pollution) Act, 1981 | • CPCB/ SPCB to establish air quality and emission standard; monitor air quality; prosecute offenders<br>• Issuance of Consent to Establish (CTO) and Consent to Operate (CTP) | Yes, Consent required to establish and not to pollute air during construction and operation | West Bengal Pollution Control Board |
| 6. | Noise Pollution (Regulation and Control) Rules, 1990 | • Standard for noise | Yes, construction machinery to conform to noise standards | West Bengal Pollution Control Board |
| 7. | The Motor Vehicle Act, 1988<br><br>Central Motor Vehicle Rules, 1989 | • Licensing of driving of motor vehicles, registration of motor vehicles, with emphasis on road safety standards and pollution control measures, standards for transportation of hazardous and explosive materials. | Yes, All vehicles shall comply with these provisions | State Motor Vehicle Department |

| S. No. | Act/Rule/Notification, Year | Relevance | Applicability | Implementing Agency |
|---|---|---|---|---|
| | | • Issuance of Pollution Under Control (PUC) certificate to vehicles used in | | |
| 8. | The Explosive Act (& Rules), 1884 | • Regulations with regard to the usage of explosives and suggests precautionary measures while blasting and quarrying | Yes, If new quarrying activity needs to be undertaken for construction material | Chief Controller of Explosives. |
| 9. | Public Liability and Insurance Act, 1991 | • Protection to general public from the accidents due to hazardous material | Yes, Any hazardous material used as raw material or waste for activities | District Collector |
| 10. | Hazardous Wastes (Management and Handling Rules), 1989 | • Guidelines for generation, storage, transport and disposal of Hazardous waste<br>• Issuance of authorisation for all above mentioned activities. | Yes, NOC to handle any hazardous waste, i.e., waste oil from machineries etc. | West Bengal Pollution Control Board |
| 11. | Mines and Minerals (Regulation and Development), Act, 1952, 1996 | • Permission of mining of aggregates and sand | Yes, mining of borrow material to be undertaken. | Department of Mines, GoWB |
| 12. | The building and other construction workers (regulation of employment and conditions of services) Act, 1996 | • Employing labour/ workers | Yes, as construction workers will be appointed | District Labour Commissioner |

Apart from the environmental stipulations mentioned above, other acts applicable for the project are Child Labour (Prohibition and Regulation) Act, 1986; The Factories Act, 1948 and The Minimum Wages Act, 1948.

## 8.3 Anticipated Environmental Impacts and Mitigation Measures

Potential impacts on environment due to the proposed port project have been summarized in Table 8.2. The impacts due to the project location are generally irreversible and cannot be mitigated through environmental enhancement measures. However, impacts related to construction are normally short term, which can be off-set to a large extent by observing a set of precautionary measures. The impacts during operation phase are permanent and can be mitigated following environment management plan provided in next section strictly.

**Table 8.2 Potential Environmental Impacts**

| Environmental aspects | Pre-construction/ Land Acquisition/Construction | | Operation | |
|---|---|---|---|---|
| | **Activities** | **Potential Impacts** | **Activities** | **Potential Impacts** |
| **Impact on Land & Soil Environment** | • Quarrying for fill material<br>• Construction of road and rail<br>• Clearing of site and land levelling<br>• Dumping of liquid and solid waste from labour camps, stack yards, workshops etc. | • Change in land use<br>• Loss of trees/vegetative cover hence increase in soil erosion<br>• Soil contamination due to dumping of solid waste (municipal and construction) and spillage of hazardous waste, i.e., oil or other chemicals | • Construction of break water<br>• Dumping of liquid and solid waste from labour camps, stack yards, workshops etc.<br>• Spillage of cargo and hazardous material/waste | • Shoreline changes<br>• Contamination due to spillage |
| **Impact on Water Environment** | • Construction of road and rail<br>• Setting up of Labour camps<br>• Dredging and construction | • Change in Natural drainage<br>• Water Pollution from labour camps<br>• Increase in turbidity due to dredging and construction activities | • Storage of cargo such as coal, iron ore etc.<br>• Sewage generation<br>• Oily effluent from maintenance area<br>• Discharge of bilge and ballast water<br>• Maintenance dredging | • Change in marine water quality due to wastewater from stack yards, sewage, bilge and ballast.<br>• Oil spill from vessels serving port<br>• Increase in turbidity |
| **Impact on Air Environment** | • Operation of vehicles and construction machinery<br>• Fuel burning at labour camps | • Dust emissions due to construction activities and vehicle movement<br>• Emissions from labour camps, vehicles, machinery and DG sets | • Vehicle movement<br>• Cargo Handling | • Vehicular pollution<br>• Emission from ore and coal handling |
| **Impact on Noise Environment** | • Operation of vehicles and construction machinery | • Increased noise levels from heavy machinery and increased human activities | • Operation of vehicles and machinery | • Increase in noise |
| **Impact on Ecology** | • Quarrying for fill material<br>• Construction of road and rail<br>• Clearing of site and land levelling<br>• Reclamation and dredging | • Loss of vegetation due to site clearing<br>• Loss of habitat to birds and small animals<br>• Impact of dredging and dumping of dredged material on marine flora and fauna | • Cargo Handling<br>• Maintenance dredging | Impact of dredging and dumping of dredged material on marine flora and fauna |
| **Impact on Socio-economic** | • Construction activities<br>• Traffic Movement<br>• | • Discomfort to nearby communities due to noise, air and water pollution<br>• Loss of land/ | • Operations<br>• Traffic movement | **Negative Impacts**<br>• Discomfort to nearby communities due to noise, air and |

| | | | | |
|---|---|---|---|---|
| | | livelihood in case of rail and road development<br>• Relocation of CPR and utilities for rail and road development<br>• Increased traffic movement<br>• Occupation health issues | | water pollution<br>**Positive Impacts**<br>• Increased Jobs<br>• Increased Business opportunities<br>• Better roads<br>• Community development programs |

## 8.4 Impacts during Construction Phase

The construction phase, in general, has adverse influence on all the components of environment. Most of these impacts are short lived and reversible in nature, hence proper care is must to minimize the disturbance so as to the restoration of natural and ecological services.

### 8.4.1 Impacts on Land and Soil

The proposed port is planned on reclaimed land between low and high water line. It does not have much of vegetation except some afforestation carried out by forest department. The present vegetation in the areas is planned to act as wind breakers and as a shield during cyclonic conditions. Moreover, this plantation also protects erosion of the shoreline. Thus, vegetation clearing may lead to erosion.

Soil contamination may be caused from roadside litter, oil spillage form machinery, sanitation and waste disposal, spillage of hazardous chemicals etc. Any soil contamination will also impact marine water as the site is located in the intertidal region.

**Mitigation Measures**

Considering the activities and their impact on land and soil the following mitigation measures are discussed below.

- Vegetation clearance shall be confined to the minimum area required for the project.
- Re-plantation shall be taken up followed by construction in another identified area.
- All the waste has to be collected and nothing to be dumped on land or water.
- The contactor will be held responsible to clean all debris before leaving the construction site and also to make necessary arrangements with scrap dealers to sell off the waste scraps.
- The waste from labour camps and administrative activities during construction will all be disposed off through municipal facility.

### 8.4.2 Impacts on Water Quality

Impacts on water resource are two-fold, one increased water demand and disposal of waste water. Additional water demand due to this project is anticipated towards construction activities and drinking water needs for labours and employees. The water will be sourced from the ground and treated to be used for port activities. Thus, water availability to the locals from the existing Rudrapur water supply plant will not be impacted.

It is generally assumed that 80% of the domestic consumption is generated as sewage, which if discharged, untreated will act as a source of water pollution. During construction phase, sewage of 20 KLD is expected to be generated.

Other sources of contamination are accidental disposal of construction debris and spillage of oil and grease from the vehicles and construction machineries.

The construction activities have potential influence on the water resources within the activity area. The pile driving and dredging will cause high turbidity, removal of nutrient due to dredging, which would ultimately affect the marine flora and fauna.

Natural drainage may be impacted due to the provision of the road network and hence it needs careful planning.

**Mitigation Measures**

In order to mitigate negative impacts on water that are expected from the project, the following measures need to be implemented:

- Bore wells, if required to source water during construction phase will be drilled after an exhaustive historical study of the region and after obtaining necessary permission and approvals from the state water board or Central Ground water Authority. Water cess shall also be paid to relevant authority;
- The embankments of any surface water bodies will be raised to prevent contamination from run-off;
- Workers shall be provided proper sanitation facilities including mobile toilets or 'Sulabh Shauchalayas' (community toilets).
- All the waste water will be collected and treated using soak pits and sludge from soak pits will be cleaned.
- The construction site and camp will be provided with temporary drainage; Avoid water stagnation/ ponding near work and camp sites to curb vector borne diseases;
- Fuel/ oil storage will be sited away from any watercourses; leakage of oil wastes from oil storage and vehicles shall be avoided in order to prevent potential contamination of streams or ground water;
- Surface runoff from machine operations, oil handling areas/devices will be treated for oil separation before being discharged into the river;
- Waste Oil/ grease/ lubricants are categorized by MoEF as Hazardous Wastes. All such waste will be collected and stored at a protected place and sold to a vendor authorized by WBPCB or MoEF.
- No construction activity will be undertaken during monsoon period.
- Use of silt curtains is recommended to confine areas of high turbidity during dredging and pile driving.
- To avoid impacts from dumping of dredged material the following measures shall be adopted:
  - Dredged disposal site shall be identified beyond 20 m depths in the sea.
  - Areas with high fish yield or used by locals for fishing shall be avoided.
  - Dumping activity shall not be carried out during monsoon season.
  - To reduce the potential for error on the part of the contractor, efforts should be made to monitor regularly the activities during dredging and disposal of spoils.
  - Where appropriate, disposal vessels should be equipped with accurate positioning systems. Disposal vessels and operations should be inspected regularly to ensure that the conditions of the disposal permit are being complied with and that the crews are aware of their responsibilities under the permit.

### 8.4.3 Impact of Air Quality

Air emissions due to construction activities, fuel burning, vehicle movement, machinery and DG sets are the most significant sources of air pollution during construction phase.

Air pollution can cause significant impacts on the environment, and subsequently on humans, animals, vegetation and materials. It primarily affects the respiratory, circulatory and olfactory systems in humans. In most cases, air pollution aggravates pre-existing diseases or degrades health status, making people more susceptible to other infections or the development of chronic respiratory and cardiovascular diseases.

**Mitigation Measures**

- Power supply from State Electricity Board shall be sourced for electrically operated construction machinery/equipment and this arrangement shall continue to reduce the consumption of diesel;
- The use of DG set would be limited to backup during power failure;
- Dust suppression systems (water spray) will be used near the earth handling sites, asphalt mixing sites and other excavation areas to reduce the wind-blown fugitive dust emissions.
- Earth moving equipment, such as bulldozer with a grader blade and ripper will be used for excavation work.
- Excess idling of construction equipment as well as vehicles to be prohibited.
- The labours shall be provided with clean fuel so that they neither cut the trees for fuel wood nor burn firewood.
- Vehicles and construction equipment will be fitted with internal devices i.e. catalytic converters to reduce CO and HC emissions.
- All stationary machines/ DG sets / construction equipment emitting the pollutants will be inspected weekly for maintenance and shall be fitted with exhaust pollution control devices;
- Vehicles and machineries will be regularly maintained to conform to the emission standards stipulated under Environment (Protection), Rules 1986.
- “No Objection Certificate (NoC)” for setting up of crusher, hot-mix plant and DGs will be obtained from West Bengal Pollution Control Board;
- Ensure that all vehicles must possess Pollution under Control (PUC) Certificate and shall be renewed accordingly;
- All the roads in the vicinity of Port site and the roads connecting quarry sites to construction sites will be paved to minimize the fugitive emissions.
- If any of the road stretches are not paved due to some reason, then adequate arrangements will be made to spray water on such stretches of the road.

### 8.4.4 Impacts on Noise Quality

During construction phase, there could be high noise levels due to operation of various construction equipment and increased number of vehicles supplying man and material to the site. It is known that continuous exposure to high noise levels above 90 dBA affects the hearing acuity of the workers/operators or residents and hence, require mitigation planning.

**Mitigation Measures**

- The construction works will be carried out during the day time. The work hours should be limited depending on convenience of the local people.
- Noise levels of machineries used shall conform to relevant standards prescribed in Environment (Protection) Rules, 1986. Workers shall not be exposed to noise level more than permitted for industrial premises, i.e. 90 dBA (Leq) for 8 hours;

- Exposure of workers near the high noise levels areas can be minimized. This can be achieved by job rotation/automation, use of ear plugs, etc.
- Labour camps shall be established away from high noise generating area. Workers exposed to high noise level shall use ear plugs or ear muffs;
- Regular maintenance of all vehicles and machinery shall be made mandatory to keep noise under check;
- Nearby communities will be notified of the construction schedule and construction works shall be structured to daylight working hours;
- Any 'High Noise Area' shall be posted with warning signs and will have restricted access.
- Noise from air compressors could be reduced by fitting exhaust mufflers and intake mufflers.
- Chassis and engine structural vibration noise can be dealt with by isolating the engine from the chassis and by covering various sections of the engines.
- Crushers, if any, will be fitted with rock lining to act as natural sound insulator during the crushing process;
- Noise levels from the construction equipment can be reduced by fitting of exhaust mufflers and the provision of damping on the steel tool.
- It is proposed to develop a greenbelt within the port premises including along the road stretches.
- Noise from the DG set should be controlled by providing an acoustic enclosure or by treating the enclosure acoustically.
- Regular monitoring and maintenance of all the equipment and DG sets shall be taken up to keep a note on noise levels and to take corrective actions.

### 8.4.5 Impacts on Ecology

As discussed earlier the proposed site is devoid of any vegetation except the small area where Afforestation has been carried out by forest department. Thus, impact of terrestrial ecology is limited.

Pile driving, deposition of rubble, sand compaction and other construction work in water may cause increase in sediment concentration in the Hoogly river, which may also reduce sunlight penetration. Disturbance from construction activities may cause displacement of fishery resources and other mobile bottom biota.

However, it is well documented that sediment concentration of the Hoogly river is quite high and thus is categorised as low productive region in terms of presence of marine life forms. No fishing activity is been observed near the proposed location. Thus, damage to marine life due to the increase of turbidity would be minor, localized, temporary and reversible.

**Mitigation Measures**

- All care shall be taken that trees shall be protected as far as possible while site clearing.
- Detailed ecological survey shall be conducted during detailed EIA study to assess the impacts.
- No construction activity will be allowed during the monsoon season so as to avoid breeding period of fishes.
- Use of silt curtains is recommended to confine areas of high turbidity during dredging and pile diving.
- Controlled dumping of the dredged material will be carried out beyond 20 m depths in the sea as a designated site. Areas with high fish yield or used by locals for fishing shall be avoided.

### 8.4.6 Impact on Social conditions

During the site visit no major settlement were seen at the proposed site. In addition, no major social impacts associated with the proposed port like loss of land and associated lively hood activities is anticipated as proposed port will be developed utilising wide intertidal plain.

However, limited acquisition of land and loss of livelihood is anticipated for the provision of rail and road connectivity.

**Mitigation Measures**

- Detail survey will be undertaken to ascertain land losers, properties etc. falling within the area. Each stakeholder will be adequately compensated as per government regulations.
- A Rehabilitation and Resettlement (R&R) plan has also been put forth to take up activities for wellbeing of affected families and panchayats.

## 8.5 Impacts during Operation Phase

### 8.5.1 Impact on Water Quality

The most likely impacts from the operation phase of the project will be on the marine water, primarily due to (a) effluent from coal stack yard; (b) oily wastes such as bilge water, washing water, lubricant oil and other residues from vessels and machineries (c) sewage; (d) cargo spillage. All these may lead to odour and degradation of water quality.

**Mitigation Measures**

- An aerated lagoon is proposed to be provided for treatment of effluent from domestic sources and the settled sludge will be dried in sludge drying beds and then used as manure for local use.
- Effluent generated from coal stackyard will be treated in a settling tank. The sludge produced will be mainly coal dust, which will be dried on sludge drying beds.
- The effluent from workshops, oil storage, etc. will contain oil and grease particles which shall be treated in an oil skimmer. The collected oily matter is stored in cans and disposed off at through authorised waster recycler.
- To combat oil pollution near the port, inflatable type containment boom with oil skimmers will be provided at the berth. A clean sweep oil recovery unit consisting of a power pack and the recovery unit mounted on a system will also be deployed for this purpose.
- Any kind of spill, release and other pollution incidents is to be reported promptly to the nearby port authorities and coastguard personnel are informed to take appropriate actions.
- Strom water drain shall be made to collect run off from rain but care shall be taken that it is not contaminated.
- The ships will not be allowed to discharge their sewage in the port complex. As per MARPOL convention, the ships are now required to have STP on board.
- The International Convention Guidelines for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL, 73/78) will be strictly adhered to in Sagar Port area for prevention of marine pollution.

### 8.5.2 Impact on Air Quality

Vehicle traffic to service cargo at the port, emissions from port equipment, cargo handling (Coal, iron ore, etc.) and fuel burning at labour camps are the major source of air pollution during operation phase.

The coal stock pile is another potential source for entrainment of fugitive coal dust.

**Mitigation Measures**

- As such, a system consisting of pumps, storage tank, nozzles for dust suppression at discharge feeding points of belt conveyors will be provided at each transfer tower for efficient dust control.
- In addition to above, a suitable spray system will also be provided at ship unloader, coal stackyard & wagon loading station. The effluent generated by washing from coal terminal will be treated in a settling tank and sludge so produced dried on sludge drying beds.
- All vehicles shall have a valid PUC certificate and regular maintenance shall be mandated.
- All the roads in the vicinity of the project site will be paved or black topped to minimize the entrainment of fugitive emissions.
- If any of the road stretches cannot be blacktopped or paved due to some reason or the other, then adequate arrangements will be made to spray water on such stretches of the road.
- For wind generated dust, a windshield with a wire mesh fencing with fast growing creepers up to a height of 10 m around the stockyard shall be installed.
- In addition to all the above measures, a 10 m wide greenbelt will be developed for dust arresting proposes.
- No unauthorized labour settlement shall be allowed in the vicinity of the port.
- It will be a responsibility of labour contractors to provide for clean fuel to the labours.

### 8.5.3 Impact on Noise Quality

As discussed in construction phase, noise due to equipment and vehicles and human activities will be chief sources. Noise from vehicles can be attributed to the engine, vibration, friction between tyres and the road, and horns. Increased levels of noise depend upon volume of traffic, road condition, vehicle condition, vehicle speed and congestion of traffic and the distance of the receptor from the source.

**Mitigation Measures**

- Noise levels of port equipment used shall conform to relevant standards prescribed in Environment (Protection) Rules, 1986. Workers shall not be exposed to noise level more than permitted for industrial premises, i.e. 90 dBA (Leq) for 8 hours;
- Exposure of workers near the high noise levels areas can be minimized. This can be achieved by job rotation/automation, use of ear plugs, etc.
- Labour camps shall be established away from high noise generating area. Workers exposed to high noise level shall use ear plugs or ear muffs;
- Regular maintenance of all vehicles and machinery shall be made mandatory to keep noise under check;
- Any ‘High Noise Area’ shall be posted with warning signs and will have restricted access.
- It is proposed to develop a greenbelt within the port premises including along the road stretches.
- Noise from the DG set should be controlled by providing an acoustic enclosure or by treating the enclosure acoustically.

- Regular monitoring and maintenance of all the equipment and DG sets shall be taken up to keep a note on noise levels and to take corrective actions.

### 8.5.4 Impact on Ecology

Once port is in operation, major impacts are anticipated from vessel movement, cargo handling, waste water discharge and disturbance due to maintenance dredging. Release of heavy metals and other chemicals and compounds from the spilled cargo in long run may cause bioaccumulation of these substances in sediment as well as marine flora and fauna.

The constituents of oil are toxic to marine life and release of oil contents on to water will result in formation of a shining film on the surface of water which prevents dissolution of oxygen across the surface of water. Moreover, oil gets accumulated on the body of the small species of fish or invertebrates and coat feathers and fur, reducing birds' and mammals' ability to maintain their body temperatures.

**Mitigation Measures**

The following actions shall be taken to avoid any major damage due to oil spill:

- Indian Coast Guard (CG) is the Central Coordinating Authority for Oil Spill Response, so in case of any such event CG shall be informed immediately.
- All the measures shall be taken according to the “Guidelines and Policy for use of OSD in Indian Waters” issued in 2002 and in consent with CG.
- Booms, skimmers and dispersant inventory shall be maintained to contain spill at the port location.
- All recovered oily material shall be disposed-off properly. Either to waste oil dealers or dumped in secured landfill sites.
- Role and responsibility of personnel taking part in oil spill emergency shall be clearly spelled out.
- Regular drill for oil spill containment shall be conducted and any lag shall be recorded and corrected.

### 8.5.5 Impact on Socio-economic Conditions

It is envisaged that during operation stage impacts are mostly positive in nature. Once the project is operational, the project has several benefits to the immediate affected community and society in large. The following positive impacts envisaged from the project:

- Employment generation for locals
- Development of road and rail connectivity
- Business opportunity due to ware-housing, cargo handling (stevedoring), transport requirements.

In addition, under Corporate Social Responsibility initiatives will be undertaken in consultation with the local administration and local population to benefit local population and environment. The key thrust areas for CSR activities will be:

- Environment
- Primary Education
- Health Care
- Employment Skill and Job Trainings
- Environmental Services and climate resilience.

## 8.6 Environmental Monitoring Plan

This section presents the environmental monitoring framework for the project where parameters, frequency and locations for the environmental monitoring are suggested in **Table 8.3** below:

**Table 8.3 Environmental Monitoring Plan**

| Environmental Components | Parameters | Frequency of Monitoring | Location |
|---|---|---|---|
| Air | PM2.5, PM10,SO2,NOx,CO , HC | Continuous monitoring, 2 times a week for 24 hours | 03-Apr |
| Surface water / Marine water | pH, DO, BOD, O&G, Salinity, Electrical Conductivity, TDS, Turbidity, Phosphates, Nitrates, Sulphates, Chlorides and heavy metals (Zinc, Lead, Cadmium, Mercury) | Once every months | 03-Apr |
| Ground water | Comprehensive monitoring as per IS : 10,500:2012 | Once every months | 5 – 8 |
| Noise | Leq (Night), Leq (day), Leq (24 hourly) | Once every month | 8 – 10 |
| Ecological Environment (Coastal) | No. of species and density:<br>• Phytoplankton<br>• Zooplankton<br>• Benthos<br>• Fisheries<br>Invasion of new plant species and plant communities, increased habitat diversity, invasion of new species | Once a year | 3 – 4 |
| Bed Sediment | Texture, size, O&G, Heavy Metals (Zinc, Lead, Cadmium, Mercury) | Once every six months | 04-May |

## 8.7 Environmental Management Cost

A site specific Environmental Management Plan (EMP) shall be prepared for avoiding, mitigating, monitoring the adverse impacts envisaged on various environmental components during construction and operational phase of the project. About 1% of the project cost is estimated to be earmarked for environmental management activities.

In addition about 1% of average net profits of last 3 years will be spent on Corporate Social Responsibility (CSR) activities each year during operational phase (Companies Act, 2013). The CSR activities may be formulated to deal with hunger and poverty; promoting public health; supporting education; addressing gender inequality; protecting the environment; and funding cultural initiatives and the arts.

# 9.0 Cost Estimates and Implementation Schedule

## 9.1 Capital Cost Estimates

### 9.1.1 General

The capital cost estimates prepared for the project are based on the project descriptions and drawings given under the relevant sections of the present report. The drawings were prepared after carrying out basic engineering of various components of the project. The quantities have been calculated from the drawings for cost estimation purpose. The basis of the costing is as follows:

- The cost estimates of civil works have been prepared on the basis of current rates for various items of work prevailing in the region and also on the past costs for similar works elsewhere.
- The costs of equipment and machinery are based on budgetary quotations and discussions held with the manufacturers and also in-house data. The costs include all taxes, duties, insurance freight etc.
- The price level used for the estimates is as of the third quarter of 2015.
- All costs towards overheads, labour, tools, materials, insurance, financing costs, etc., are covered in the rates for individual items.
- The costs towards plant and machinery include manufacture, supply, transport, installation and commissioning of the respective items.
- The exchange rate has been assumed as 1 US $ = INR 65/-
- Provision towards engineering and establishment has been included separately.

These site information and assumptions are subject to many factors that are beyond the control of the consultants; and the consultants thus make no representations or warranties with respect to these estimates and disclaim any responsibility for the accuracy of these estimates.

### 9.1.2 Capital Cost Estimates for Phased Development

The capital cost of phased development of port, as per the proposed phasing as per **Table 6.6** has been worked out as furnished below in **Table 9.1**. The costs given for each phase are for the facilities created during that particular phase only.

**Table 9.1 Block Capital Cost Estimates**

| S. No. | Item | 2020 | 2025 | 2030 | 2035 |
|---|---|---|---|---|---|
| 1. | PROJECT PRELIMINARIES AND SITE DEVELOPMENT | 6 | 3 | 3 | 3 |
| 2. | DREDGING AND RECLAMATION | 313 | 1,136 | 587 | 797 |
| 3. | BERTHS | 256 | 176 | 162 | 151 |
| 4. | BUILDINGS | 72 | 24 | 7 | 5 |
| 5. | STACKYARD AND OTHER BACKUP AREA | 69 | 94 | 46 | 54 |
| 6. | ROADS AND RAILWAY | 66 | 70 | 23 | 14 |
| 7. | EQUIPMENTS | 230 | 332 | 411 | 305 |
| 8. | UTILITIES AND OTHERS | 93 | 88 | 41 | 50 |
| 9. | PORT CRAFTS AND AIDS TO NAVIGATION | 2 | 0 | 0 | 0 |
| 10. | Total (1+2+3+4+5+6+7+8+9) | **1,106** | **1,923** | **1,279** | **1,379** |
| 11. | Engineering and Project Management @ 5% | 55 | 96 | 64 | 69 |
| **Incremental Capital Cost (Rs. In Crores)** | | **1,161** | **2,019** | **1,342** | **1,448** |

These capital cost estimates do not include the following:

- Road and rail bridge across river Muriganga, which shall be provided by Government agency.
- External linkages for rail, road from port to river Muriganga and beyond to hinterland
- Cost of land acquisition for rail/road corridors, offsite rail yard/exchange yard
- Port crafts, as these are proposed to be leased out
- Contingencies, Financing and Interest Costs

## 9.2 Operation and Maintenance Costs

### 9.2.1 General

Operation and maintenance costs have been calculated under various heads as described in the subsequent paras.

These costs do not include the following items:

- Lease rent to the state government
- Maintenance of Infrastructure outside the port boundary

### 9.2.2 Repair and Maintenance Costs

The following norms have been used for estimating the annual maintenance and repair costs:

- 3% of Quay Cranes and Gantries
- 7% of ITVs, Reach Stackers and FLTs
- 5% of other Mechanical equipment and Electrical Works
- 1% of Civil Works
- 3% of Utilities and Other Works

For dredging, the actual cost based on the maintenance dredging volume estimated from model studies is taken into account.

### 9.2.3 Manpower Costs

The estimated manpower for the initial phase of development is about 325 increasing to about 900 in the ultimate stage of development. The manpower costs have accordingly been calculated considering the number and types of personnel deployed.

### 9.2.4 Operation Costs

The operation costs include the fuel, water and power costs. These have been considered as below:

- Power - INR 4.50 per unit plus INR 225 per kVA of demand rate per month
- Water Charges - INR 50 per kilolitre
- Diesel - INR 50 per litre

The operation costs for the equipment run by electrical power have been calculated based on the maximum throughput and utilisation of the equipment. Similarly the operation cost of major equipment like RTGCs and ITVs run by diesel has been worked out based on the utilisation level for the annual throughput. Further the operation costs of the following items have been estimated as a percentage of their capital cost, as given below:

- Diesel Driven Equipment (minor) - 5% per annum
- Other Works such as Firefighting & Pollution Control - 3% per annum

### 9.2.5 Annual Operation and Maintenance Costs

Based on the various criteria discussed above, the annual operation and maintenance cost for various phases of development of Sagar Port are summarised below in **Table 9.2** below:

**Table 9.2 Annual Operation and Maintenance Costs**

| S. No. | Item | 2020 | 2025 | 2030 | 2035 |
|---|---|---|---|---|---|
| 1. | REPAIR AND MAINTENANCE COSTS | 21.9 | 26.4 | 27.2 | 21.8 |
| 2. | OPERATION COSTS | 49.8 | 66.1 | 47.4 | 57.5 |
| **3.** | **TOTAL** | **71.7** | **92.5** | **74.7** | **79.3** |
| 4. | Contingencies @ 10% | 7.2 | 9.3 | 7.5 | 7.9 |
| 5. | Administrative Expenses @ 5% | 3.6 | 4.6 | 3.7 | 4.0 |
| **Incremental O & M Costs (Rs. In Crores) per annum** | | **82** | **106** | **86** | **91** |

## 9.3 Implementation Schedule for Phase 1 Port Development

### 9.3.1 General

The main components for the Development of Sagar Port comprises of capital dredging for approach channel and manoeuvring basin, reclamation of the terminal areas, construction of berths, supply and installation of material handling equipment, onshore infrastructure and marine support systems. The implementation schedule of the critical project items is discussed below.

### 9.3.2 Berths

The construction of berth shall be commenced on priority. The berths being offshore the contractor would need to build some bunds perpendicular to the shore till the berth side boundary of backup area so as to move the construction equipment and piling gantries. The berth piling would be commenced using piling gantries installed from the bunds. The superstructure would be mainly built using precast concrete elements to avoid soffit shuttering. The construction of berths is expected to take about 30 months.

### 9.3.3 Dredging

The dredging quantity for Phase 1 is only about 1.2 million cum and could be completed within a time frame of less than six months. The dredging may need to be carried out with the deployment of one trailing suction and if required a one cutter suction dredger for dredging the shallow areas. Considering the low volumes it is proposed to carry out dredging activity to match with the commissioning of the project.

### 9.3.4 Reclamation

For berth construction, the contractor would need to create bunds perpendicular to the shoreline on which the piling gantries shall be launched. The reclamation activity will be commenced subsequently with the disposal of dredged material within the reclamation bund. It is anticipated that the material obtained from the maintenance dredging in Auckland bar would be utilised for the reclamation purposes and therefore this activity shall take about 2 years. The top layers of the backup area shall be made by borrowed fill. The reclamation fill shall be placed in layers of small thickness and compacted before placement of next layer.

### 9.3.5 Revetment

The reclaimed land would need protection from wave attack under the cyclonic conditions. For this purpose an armour layer of rock shall need to be laid all over the boundary of the reclamation fill. This shall be undertaken once the backup area is fully reclaimed but before start of the yard development and onshore utilities.

### 9.3.6 Equipment and Onshore Development

It is envisaged that the delivery and installation of equipment and the development of onshore works can be carried out to match the implementation schedule of the project.

### 9.3.7 Implementation Schedule

The construction of Phase 1 development of the Sagar port is estimated to take about 39 months. This has been worked out taking into account all the items of the project, the various activities involved and the duration of each activity. The project implementation schedule for the Phase 1 Development of the Sagar Port is shown in **Table 9.3**.

## Table 9.3 Implementation Schedule for Development of Port at Sagar Island

| S.No. | Task Description |
|---|---|
| A | **Appointment of Transaction Advisor** (Zero Date) |
| 1 | EOI Preparation, Receipt, Evaluation and Shortlisting |
| 2 | RFP to selected bidders, Evaluation and Selection of Concessioner |
| B | **Engineering & Tendering by Concessioner** |
| 1 | DPR Preparation |
| 2 | EIA Studies and Approvals |
| 3 | Engineering and Tender Preparation |
| 4 | Tendering Period |
| 5 | Evaluation, Negotiations and Award of Contracts |
| 6 | Financial Closure |
| C | **Construction Activity** |
| 1 | Establishment at Site by Contractor |
| 2 | Detailed Engineering by Consultant/EPC contractor |
| 3 | Approach Roads |
| 4 | Reclamation Bund |
| 5 | Dredging |
| 6 | Reclamation |
| 7 | Berths and Approach Trestle |
| 8 | Yard and Pavement |
| 9 | Offsite rail yard with rail and road connectivity |
| 10 | Buildings |
| 11 | Supply and Installation of Mechanical Equipment |
| 12 | Road Access to Port from Muriganga Bridge |
| 13 | Onshore Infrastructure |
| 14 | Commissioning of Port Facilities |

# 10.0 Financial Analysis for Sagar Port

## 10.1 Introduction

A profitability analysis for the proposed development has been carried out with the following objectives:

- To establish a realistic and reasonable tariff, comparable to those available for similar cargoes at nearby ports, that provide adequate returns after meeting all the costs
- To assess the viability of the project in terms of Financial Internal Rate of Return (FIRR) considering the revenue generated at the proposed tariff and the costs of operations including the investments costs and debt service charges.

## 10.2 CAPEX Plan

The capex spending for entire phase 1 development has been planned over 4 years with phasing of investment as 9 percent (first year), 25 percent (second year), 32 percent (third year) and 34 percent (fourth year). For other phases the implementation time is assumed to be 2 years and investment phasing assumed as 50% each year.

The incremental capital cost over master plan horizon is given in **Table 10.1**.

**Table 10.1 Incremental Cost (INR in Crores) Over the Master Plan Horizon**

| Item | 2020 | 2025 | 2030 | 2035 |
|---|---|---|---|---|
| Incremental Capital Cost | **1,161** | **2,019** | **1,342** | **1,448** |
| Incremental Capital Cost – Without increasing draft beyond 9 m | **1,161** | **1,115** | **826** | **712** |

## 10.3 OPEX Estimates

The operations and maintenance cost has been ascertained based on industry standards and includes maintenance dredging needed for the port (**Table 10.2**).

**Table 10.2 Incremental O&M Costs (INR in Crores) Over the Master Plan Horizon**

| Item | 2020 | 2025 | 2030 | 2035 |
|---|---|---|---|---|
| Incremental O&M Costs | **82** | **106** | **86** | **91** |
| Incremental O&M Costs – Without increasing draft beyond 9 m | 82 | 61 | 60 | 54 |

## 10.4 Sagar Port Tariff

Fixing proper tariff and port charges is one of the critical components of the financial analysis since the success of the project depends on the competitiveness and acceptability of the tariff to be charged to the users.

The rationale underlying the fixation of tariff for Sagar is as follows:

- Prevailing tariff levied by East coast ports, specifically Haldia and Kolkata Dock complex
- Competitiveness/Cost advantage compared to East Coast ports
- Adequate revenue to meet the debt service requirement, operation and maintenance costs including revenue share and lease rent to be paid to the Government and generate cash surplus for payment of dividend to the shareholders and funds for additional capacity expansion when required.

Though the aforementioned rationale is useful in determining a competitive tariff, in order to arrive at the desired tariff the following points should also be considered.

- Port Tariff is generally revised every 3 years due to escalation in cost of materials and the effect of the wage revision for the port employees.
- Prevailing rates should merely be limited to serve as a guideline. The new port should be able to charge a premium for the facilities superior to the competing ports.
- Tariff for newer ports should be higher than old ports, as an older port can afford to charge less owing to their comparative low investment and the fact that over the years it has paid for itself. However the tariff has to be competitive so as not to lose the share of traffic that has been projected to be handled at the new port.

It is therefore proposed that Sagar port charges ~INR 300 per Metric tonne of cargo (current prices), which is comparable to the port tariff charged by Haldia and Kolkata Ports as well as Paradip Port.

## 10.5 Financial Viability of the Project

The base case traffic of container and break-bulk overflow from Kolkata port has been considered to calculate the financial viability of the project (**Table 10.3**).

The pre-tax IRR has been calculated for 28 years i.e. 15 years from the last tranche of capex spending.

Also, since the profile of cargo anticipated at the port has containers- which are feedered to Colombo for transhipment and around 60 percent of general cargo, the parcel size of each commodity will be anticipated at 15,000-25,000 tonnes and hence, while dredging might enable Panamax ships to call at the port, most of the cargo can be evacuated by Sub-panamax ships, thus, the port can function without the dredging for draft of 13.5 m.

**Table 10.3 Base Case Traffic Overflow from Kolkata Dock System**

| Base Case | Cargo overflow from Kolkata Port Trust - Containers & Break Bulk | | |
|---|---|---|---|
| Year | Total Traffic (in MT) | Container (in MT) | Break Bulk (in MT) |
| 2020-21 | 3.42 | 0.52 | 2.90 |
| 2021-22 | 4.09 | 0.71 | 3.38 |
| 2022-23 | 5.44 | 1.55 | 3.89 |
| 2023-24 | 7.41 | 2.99 | 4.42 |
| 2024-25 | 9.53 | 4.55 | 4.98 |

| Base Case | Cargo overflow from Kolkata Port Trust - Containers & Break Bulk | | |
|---|---|---|---|
| **Year** | **Total Traffic (in MT)** | **Container (in MT)** | **Break Bulk (in MT)** |
| 2025-26 | 11.14 | 5.81 | 5.33 |
| 2026-27 | 12.84 | 7.15 | 5.69 |
| 2027-28 | 14.64 | 8.57 | 6.07 |
| 2028-29 | 16.52 | 10.07 | 6.45 |
| 2029-30 | 18.52 | 11.67 | 6.85 |
| 2030-31 | 20.05 | 12.80 | 7.25 |
| 2031-32 | 21.64 | 13.97 | 7.67 |
| 2032-33 | 23.29 | 15.19 | 8.11 |
| 2033-34 | 25.00 | 16.45 | 8.55 |
| 2034-35 | 26.78 | 17.77 | 9.01 |
| 2035-36 | 26.78 | 17.77 | 9.01 |

While building scenarios for financial modelling, following parameters have been taken as variables:

1. The cost of bridge is not considered in the capital cost of port development.
2. No VGF vs VGF of 20% or 40% on the Phase 1 CAPEX only
3. Tariff per tonne of INR 300 or INR 325 or INR 350
4. Both the revenue and OPEX are grown at 5% annually in the model and the inflated CAPEX at the time of investment is considered

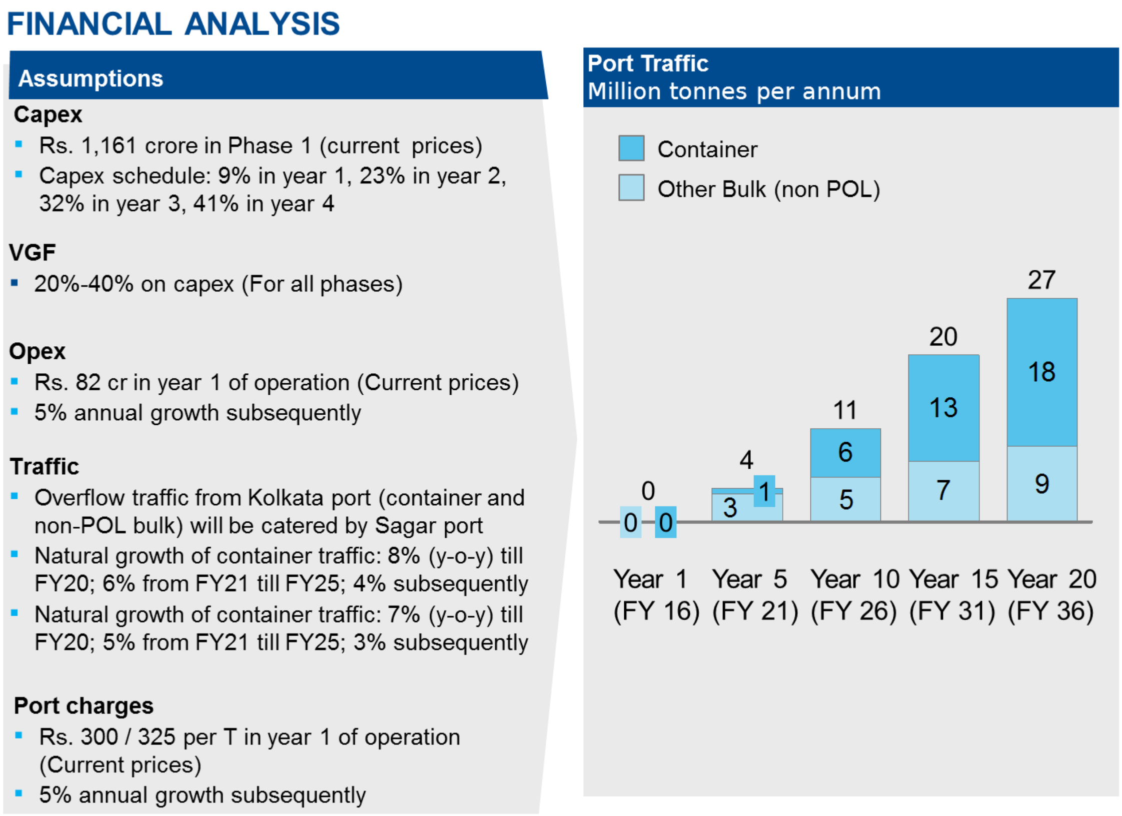



**Figure 10.1 Sagar Port Financial Analysis details**

The project IRR has been evaluated for various scenarios as mentioned below:

1. Scenario – 1: The port is developed as per the phase-wise development details considered in the report with incremental increase in the design draft.
2. Scenario – 2: Same as scenario 1 but design draft of the ships limited Phase 1 draft only i.e. 9.0 m, over master plan horizon
3. Scenario – 3: In this scenario it is assumed that the port development shall be limited to the facilities created in Phase 1 only. The traffic growth at the port shall be capped at a point when the berth occupancy goes upto 85% (i.e. about 7.5 MTPA).

The matrix of the project IRR calculations is presented in Table 10.4 below:

**Table 10.4 Project IRR for Various Scenarios**

| %of VGF | No VGF | | | 20% VGF | | | 40% VGF | | |
|---|---|---|---|---|---|---|---|---|---|
| **Scenario** | **Tariff @300/T** | **Tariff @325/T** | **Tariff @350/T** | **Tariff @300/T** | **Tariff @325/T** | **Tariff @350/T** | **Tariff @300/T** | **Tariff @325/T** | **Tariff @350/T** |
| Scenario 1 (Base Case) - Design Draft of Ship increases from 9.0 m to 13.5 m in phased manner | **6.20%** | **7.60%** | **8.90%** | **6.60%** | **8.10%** | **9.40%** | **7.00%** | **8.60%** | **10.00%** |
| Scenario 2 - Design Draft of Ship remains at 9.0 m for all phases | **12.45%** | **13.75%** | **14.96%** | **13.35%** | **14.74%** | **16.05%** | **14.45%** | **15.97%** | **17.40%** |
| Scenario 3 - No port development beyond Phase 1 excluding the incremental bridge cost | **12.56%** | **13.88%** | **15.11%** | **14.84%** | **16.31%** | **17.67%** | **18.25%** | **199.97%** | **21.57%** |

The equity IRR for pre-tax and post-tax can be worked out once the mode of funding is decided but these would not have any impact on the viability projections of the project.

The scenario 3 presented in **Table 10.4** above has project IRR of 16.31% with tariff of Rs. 325/- per tonne and VGF of 20%.

It may be noted that the project IRR improves to 17.67% with a tariff of Rs. 350 per tonnes, which is still considered competitive considering the draft advantage offered by Sagar Port as compared to Haldia and Kolkata docks.

## 10.6 Alternative Means of Project Development

### 10.6.1 Option 1 – SPV Model

In this option the entire project shall be executed by the Special Purpose Vehicle (SPV) between KoPT and Govt. of West Bengal, who shall also arrange funds for the project financing.

### 10.6.2 Option 2 – Full PPP Model

In this option the project shall be executed through the partnership of SPV and one or more private sector companies.

In this option the private party provides the project and assumes substantial financial, technical and operational risk in the project. SPV contributions to a PPP may be in the form of transfer of land, creating transport linkages etc. In some other cases, the government may support the project by providing revenue subsidies, including tax breaks or by removing guaranteed annual revenues for a fixed time period.

While the port is suitable for development under this model as the SPV's investment in the project would be minimal. However there could be potential competitive issues in a situation where KoPT is fully saturated.

### 10.6.3 Option 3 – Landlord Model

In this option the basic infrastructure in terms of capital dredging, reclamation, access rail and road, water and power connection to port, harbour crafts etc. shall be arranged by SPV. The cargo terminal facilities would be leased out to the various operators who shall be responsible for its construction, operations and maintenance. However SPV will still be directly responsible for:

- Appointing a Harbour Master and conservator of the port.
- Navigation in the port by having qualified and licensed pilots to pilot ships with aids like tugs etc., attending to berthing and de-berthing of ships calling at the port.
- Providing and maintaining the basic infrastructure.
- Payment of lease-rent for areas leased to it and other payments to the State Government as may be contained in the agreement.
- Furnishing management information to the appropriate authority on port operations including cargo-handling activities at the various marine terminals, whether operated directed by it or by subleased to others.
- Co-ordinating with the Collectorate of customs within whose jurisdiction the port falls, for proper accounting of ships entering the port and cargo unloaded or loaded into them.
- Administering subleases for the various marine terminals leased to users, terminal operators as applicable.
- Co-ordinating all port activities, monitoring port performance by individual terminal operators and ensuring optimal performance and collecting necessary management information and furnishing the same to the Government authorities as required.
- Safety and security, pollution control and environmental protection, water supply, power supply.

### 10.6.4 Recommended Option

The project is recommended to be developed as per Landlord model, wherein the basic port infrastructure (dredging, reclamation, navigational aids, offsite container yard, external rail/road etc.) will be developed by the SPV. PPP Concessionaire would be responsible for terminal development comprising of berths, stackyard development, equipment, utilities etc.

## 10.7 Financial Analysis of Recommended Option

Based on the roles and responsibilities of the SPV and the Concessionaire, the breakup of cost estimates for the Phase 1 of the project development is worked out as shown in **Table 10.5**.

**Table 10.5 Cost Split Between SPV and Concessionaire**

| Cost (Rs. In Crores) | SPV | Developer |
|---|---|---|
| **Capital Costs** | 421.85 | 739.01 |
| **O&M Costs** | 31.84 | 50.59 |

| Phasing of CAPEX | Cost (Rs. In Crores) | Cost (Rs. In Crores) |
|---|---|---|
| Year 1 | 103.41 | 5.07 |
| Year 2 | 188.40 | 72.56 |
| Year 3 | 101.01 | 250.23 |
| Year 4 | 29.03 | 411.15 |

It is assumed that the basic port infrastructure (dredging, reclamation, navigational aids, offsite container yard, external rail/road etc.) will be developed by the SPV at total estimated cost of Rs. 421.85 crores funded by a multilateral loan at 5% payable over 15 years. PPP concessionaire would be responsible for terminal development comprising of berths, stackyard development, equipment, utilities etc. at an estimated cost of Rs. 739 crores.

The summary of the financial appraisal for the concessionaire is provided below:

**IRR sensitivity for Sagar port : Landlord model**

**Assumptions**

**Capex**
- Basic infrastructure to be provided by government – dredging, reclamation, navigational aids (701 Crs) – ADB loan at 5%
- Terminal development comprising of berths, stackyard development, equipment, utilities etc. shall be developed by the concessionaire (833 Crs)

**VGF**
20% on capex to be invested by operator (166 Crs

**Opex**
- 31.8 Crs by government , 50.59 crs by concessionaire (Current prices)
- 5% annual growth subsequently

**Revenue share**
- Government share varies from 34%-40% depending on the port charges; share determined on the basis on generating an IRR of ~5% for the loan payback ( government)

**Tenure**
Loan tenure and IRR calculation based on 15 years of operation

| | 300 | 325 | 350 |
|---|---|---|---|
| **Project IRR** | 12.2% | 15.3% | |
| **Pre tax equity IRR** | 14.1% | 17.7% | |
| **Post tax equity IRR** | 10.2% | 13.5% | |

# 11.0 Conclusions and Recommendations

## 11.1 Conclusions

The proposed port site at the Sagar Island along the coastline of West Bengal is technically suitable for development of a port. Considering its advantageous position over Haldia and Kolkata ports in terms of draft, it has a potential to attract customers for using this port for import and export of their cargo.

It is recommended that the project be taken up as per Landlord model. Initially phase 1 of the project shall be taken up i.e. a quay length of 600 m (suitable to handle 2 or 3 ships simultaneously), required backup area, associated infrastructure and dredging to handle 9 m draft ships.

The Sagar Port development shall involve the following broad activities as mentioned in paragraphs below. The process of port development is outlined in **Figure 11.1** attached.

## 11.2 Project Enablers

Given the borderline economics of Sagar Port substantial government interventions would be needed for generating private participation. The following are the key factors to make the Sagar Port successful:

- Limiting Greenfield investments in Haldia port complex; to create over flow for Sagar
- No expansion in container handling capacity at Kolkata Dock Systems
- Guaranteed Viability Gap Funding of minimum 20% from the State/Central Govt.
- Road connectivity to the port and bridge at River Muriganga to be constructed before port becoming operational
- Land Acquisition for rail, rail connectivity and offsite rail yard
- Establishment of industrial cluster/hinterland near Sagar port for enabling cargo flow
- Widening of NH-117 for road connectivity
- Expansion of mainland railway connectivity from Kashinagar to main routes

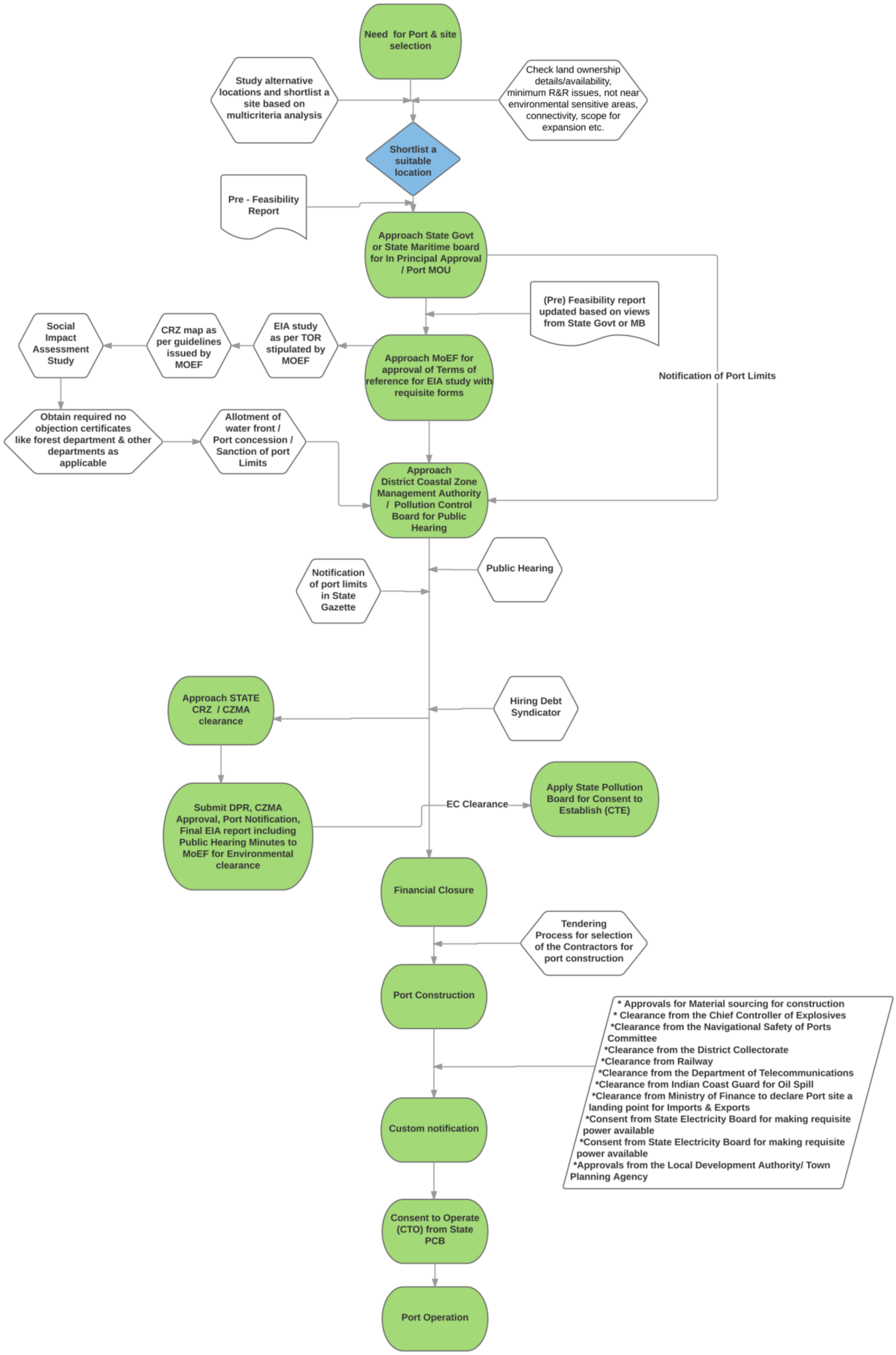



**Figure 11.1 Process for the Greenfield Port Development**

## 11.3 Way Forward

The action plans for the Sagar Port development project are as follows:

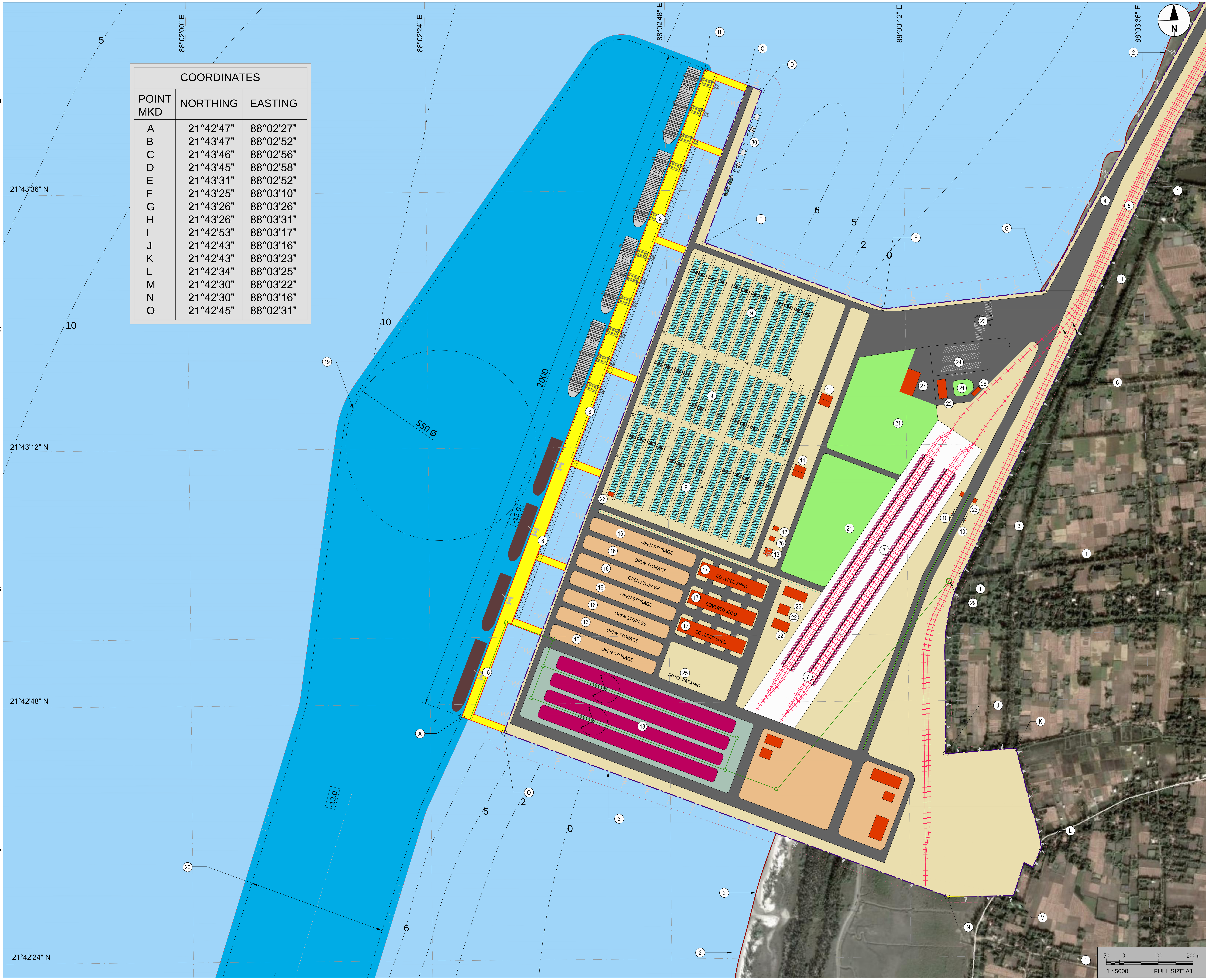
1. Appointment of Transaction Advisor for the Project
2. Preparation of tender documents for selection of private entity for the terminal development and operations as per the landlord model.
3. Tender documents (either EPC contract or Item rate contract basis) for selection of the contractor for the development of basic port infrastructure would also need to be prepared alongwith associated engineering works.
4. Appointment of consultant for EIA studies and approval of MoEF
5. Simultaneously award the work for construction of bridge across river Muriganga and upgrading the rail road connectivity in the hinterland.
6. The selected operator shall take the following actions for project development:
    a. Appointment of consultant for preparation of detailed project report for terminal development
    b. Coordination with state government for external infrastructure linkages like water, power, rail, road and also land needed for the offsite rail yard.
    c. On receipt of DPR, coordination with financial institutions for financial closure.
    d. Appointment of consultant for detailed engineering/EPC tendering for construction of terminal facilities
    e. Appointment of contractor(s) for construction of terminal facilities
    f. Coordination with various agencies for getting project approvals as mentioned in **Figure 11.1**.

# Drawings

AECOM

ISO A1 594mm x 841mm

Approved: SG Checked: AM Designer: SV Project Management Initials:




| COORDINATES | | |
|---|---|---|
| POINT MKD | NORTHING | EASTING |
| A | 21°42'47" | 88°02'27" |
| B | 21°43'47" | 88°02'52" |
| C | 21°43'46" | 88°02'56" |
| D | 21°43'45" | 88°02'58" |
| E | 21°43'31" | 88°02'52" |
| F | 21°43'25" | 88°03'10" |
| G | 21°43'26" | 88°03'26" |
| H | 21°43'26" | 88°03'31" |
| I | 21°42'53" | 88°03'17" |
| J | 21°42'43" | 88°03'16" |
| K | 21°42'43" | 88°03'23" |
| L | 21°42'34" | 88°03'25" |
| M | 21°42'30" | 88°03'22" |
| N | 21°42'30" | 88°03'16" |
| O | 21°42'45" | 88°02'31" |

NOTES:-

1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.
2. ALL LEVELS ARE IN METRES AND WITH RESPECT TO CHART DATUM.
3. ALL COORDINATES ARE IN WGS84

## KEYNOTES

1. SAGAR ISLAND
2. SHORE LINE
3. BUND
4. MAIN ROAD ACCESS TO THE PORT
5. MAIN RAIL LINE TO THE PORT
6. RAILWAY LINES
7. RAILWAY YARD AREA
8. CONTAINER CUM MULTIPURPOSE BERTHS 2000m
9. CONTAINER YARD AREA
10. WEIGH BRIDGE
11. RTG MAINTENANCE AREA
12. HAZARDOUS CONTAINER AREA
13. FUEL STATION
14. CONVEYORS
15. BULK BERTHS 300M LONG
16. OPEN STORAGE AREA
17. COVERED SHEDS
18. BULK STORAGE YARD
19. TURNING CIRCLE 550MØ
20. APPROACH CHANNEL 400M WIDE
21. GREEN AREA
22. OFFICE BUILDINGS
23. GATE COMPLEX
24. POV PARKING
25. PARKING AREA
26. SUBSTATION
27. MAIN SUBSTATION (RECEIVING)
28. PORT USERS BUILDING
29. SILO (PROVISION)
30. TUG BERTHS

| REV. | DATE | DESCRIPTION | DR. | CH. | APR. |
|---|---|---|---|---|---|
| | | | | | |

REVISION DETAILS

CLIENT/OWNER: Ministry of Shipping Government of India; Indian Ports Association

PROJECT: SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT SAGAR ISLAND

PART/DISCIPLINE:

DIMENSIONS ARE IN: METRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE: RECOMMENDED PORT MASTER PLAN LAYOUT

SHEET 1 OF 1

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|---|---|---|
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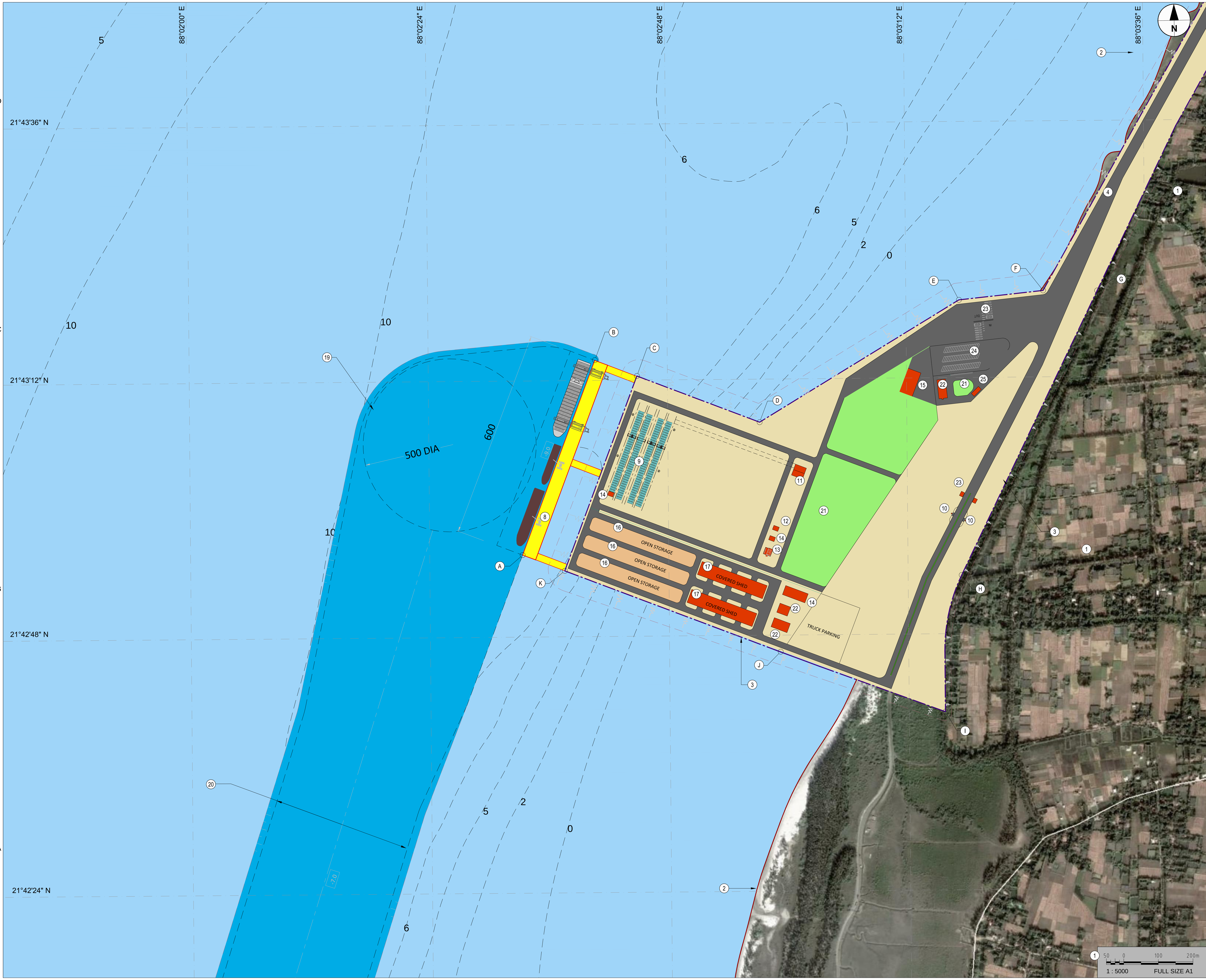


NOTES:-

1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.
2. ALL LEVELS ARE IN METRES AND WITH RESPECT TO CHART DATUM.
3. ALL COORDINATES ARE IN WGS84

## KEYNOTES

1. SAGAR ISLAND
2. SHORE LINE
3. BUND
4. MAIN ROAD ACCESS TO THE PORT
5. NOT USED
8. CONTAINER CUM MULTIPURPOSE BERTHS
9. CONTAINER YARD AREA
10. WEIGH BRIDGE
11. RTG MAINTAINANCE AREA
12. HAZARDOUS CONTAINER AREA
13. FUEL STATION
14. SUBSTATION
15. MAIN SUBSTATION (RECEIVING)
16. OPEN STORAGE AREA
17. COVERED SHEDS
19. TURNING CIRCLE 500mØ
20. APPROACH CHANNEL 400m WIDE
21. GREEN AREA
22. OFFICE BUILDINGS
23. GATE COMPLEX
24. POV PARKING
25. PORT USERS BUILDING

| POINT MKD | NORTHING | EASTING |
|---|---|---|
| A | 21°42'56" | 88°02'33" |
| B | 21°43'14" | 88°02'41" |
| C | 21°43'12" | 88°02'45" |
| D | 21°43'08" | 88°02'57" |
| E | 21°43'19" | 88°03'17" |
| F | 21°43'20" | 88°03'26" |
| G | 21°43'20" | 88°03'31" |
| H | 21°42'53" | 88°03'17" |
| I | 21°42'41" | 88°03'16" |
| J | 21°42'46" | 88°02'59" |
| K | 21°42'54" | 88°02'38" |

REVISION DETAILS

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|---|---|---|---|---|---|

CLIENT/OWNER: Ministry of Shipping Government of India; Indian Ports Association

PROJECT: SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT SAGAR ISLAND

PART/DISCIPLINE:

DIMENSIONS ARE IN: METRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE: RECOMMENDED PHASE 1 PORT LAYOUT

SHEET 1 OF 1

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NOTES:-

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2. ALL LEVELS ARE IN METRES AND WITH RESPECT TO CHART DATUM.
3. ALL COORDINATES ARE IN WGS84

## KEYNOTES

1. SAGAR ISLAND
2. SHORE LINE
3. BUND
4. MAIN ROAD ACCESS TO THE PORT
5. MAIN RAIL LINE TO THE PORT
6. RAILWAY LINES
7. RAILWAY YARD AREA
8. CONTAINER CUM MULTIPURPOSE BERTHS
9. CONTAINER YARD AREA
10. WEIGH BRIDGE
11. RTG MAINTENANCE AREA
12. HAZARDOUS CONTAINER AREA
13. FUEL STATION
14. CONVEYORS
15. BULK BERTHS 300m LONG
16. OPEN STORAGE AREA
17. COVERED SHEDS
18. BULK STORAGE YARD
20. TURNING CIRCLE 500mØ
21. APPROACH CHANNEL 400m WIDE
22. GREEN AREA
23. OFFICE BUILDINGS
24. GATE COMPLEX
25. POV PARKING
26. SUBSTATION
27. MAIN SUBSTATION (RECEIVING)
28. PORT USERS BUILDING
29. SILO (PROVISION)

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REVISION DETAILS

CLIENT/OWNER: Ministry of Shipping, Government of India; Indian Ports Association

PROJECT: SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT SAGAR ISLAND

PART/DISCIPLINE:

DIMENSIONS ARE IN: METRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE: RECOMMENDED PHASE 2 PORT LAYOUT

SHEET 1 OF 1

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3. ALL COORDINATES ARE IN WGS84

## KEYNOTES

1. SAGAR ISLAND
2. SHORE LINE
3. BUND
4. MAIN ROAD ACCESS TO THE PORT
5. MAIN RAIL LINE TO THE PORT
6. RAILWAY LINES
7. RAILWAY YARD AREA
8. CONTAINER CUM MULTIPURPOSE BERTHS 1500m LONG
9. CONTAINER YARD AREA
10. WEIGH BRIDGE
11. RTG MAINTAINANCE AREA
12. HAZARDOUS CONTAINER AREA
13. FUEL STATION
14. CONVEYORS
15. BULK BERTHS 300m LONG
16. OPEN STORAGE AREA
17. COVERED SHEDS
18. BULK STORAGE YARD
19. TURNING CIRCLE 500mØ
21. APPROACH CHANNEL 400m WIDE
22. GREEN AREA
23. OFFICE BUILDINGS
24. GATE COMPLEX
25. POV PARKING
26. SUBSTATION
27. MAIN SUBSTATION (RECEIVING)
28. PORT USERS BUILDING
29. SILO (PROVISION)

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|---|---|---|---|---|---|

REVISION DETAILS

CLIENT/OWNER:

Ministry of Shipping Government of India

INDIAN PORTS ASSOCIATION

PROJECT:

SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT SAGAR ISLAND

PART/DISCIPLINE:

DIMENSIONS ARE IN: METRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE:

RECOMMENDED PHASE 3 PORT LAYOUT

SHEET 1 OF 1

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REV. 1

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Designer: SV
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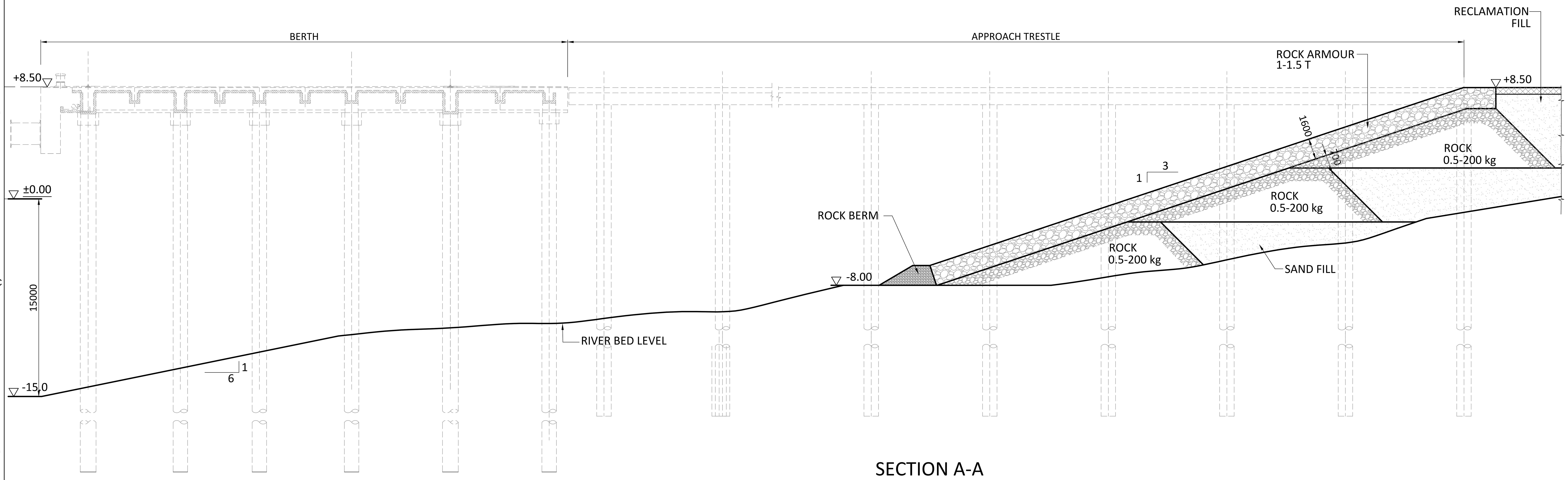
2. ALL LEVELS ARE IN METRES AND RELATED TO CHART DATUM.

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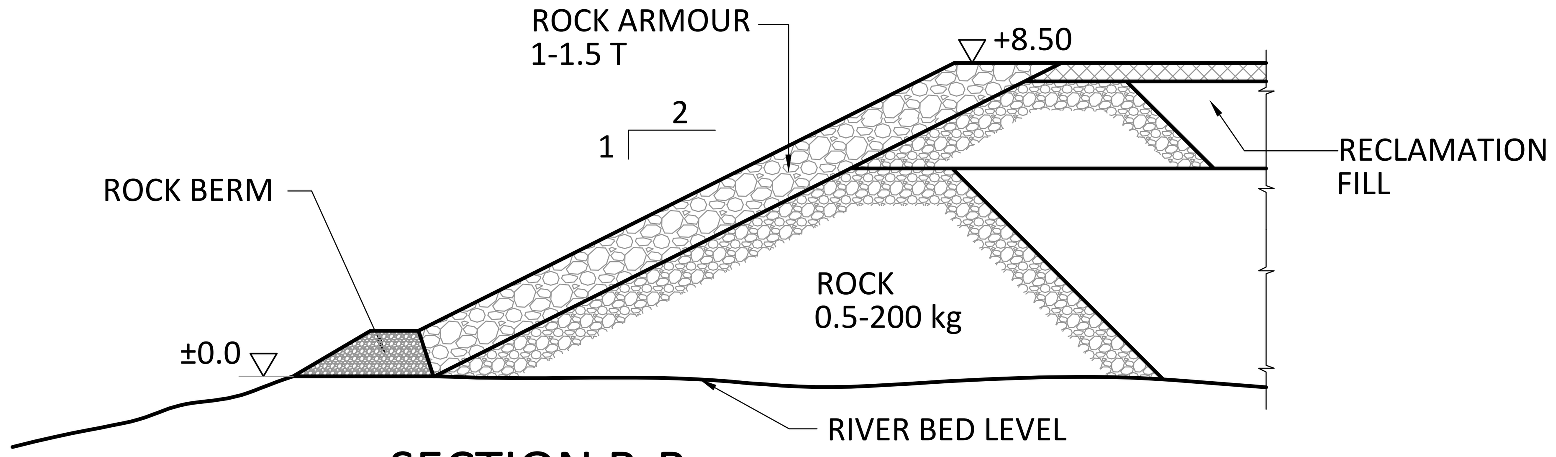


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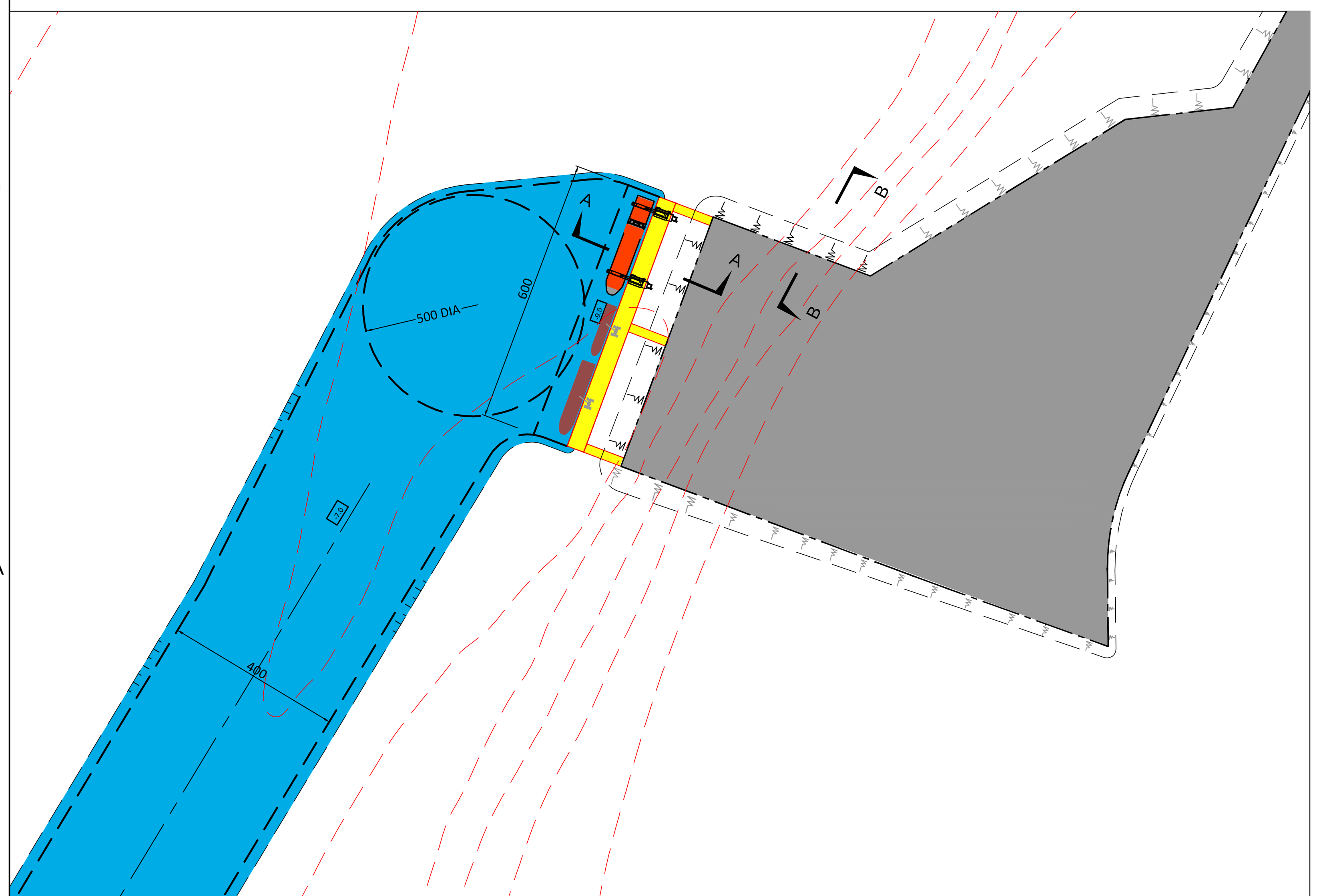


KEY PLAN

| REV. | DATE | DESCRIPTION | DR. | CH. | APR. |
|---|---|---|---|---|---|

REVISION DETAILS

CLIENT/OWNER:
Ministry of Shipping Government of India
INDIAN PORTS ASSOCIATION

PROJECT:
SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT SAGAR ISLAND

PART/DISCIPLINE:
DIMENSIONS ARE IN: MILLIMETRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE:
TYPICAL CROSS SECTION OF RECLAMATION BUND

SHEET 1 OF 1

| Sign: | Sign: | Sign: |
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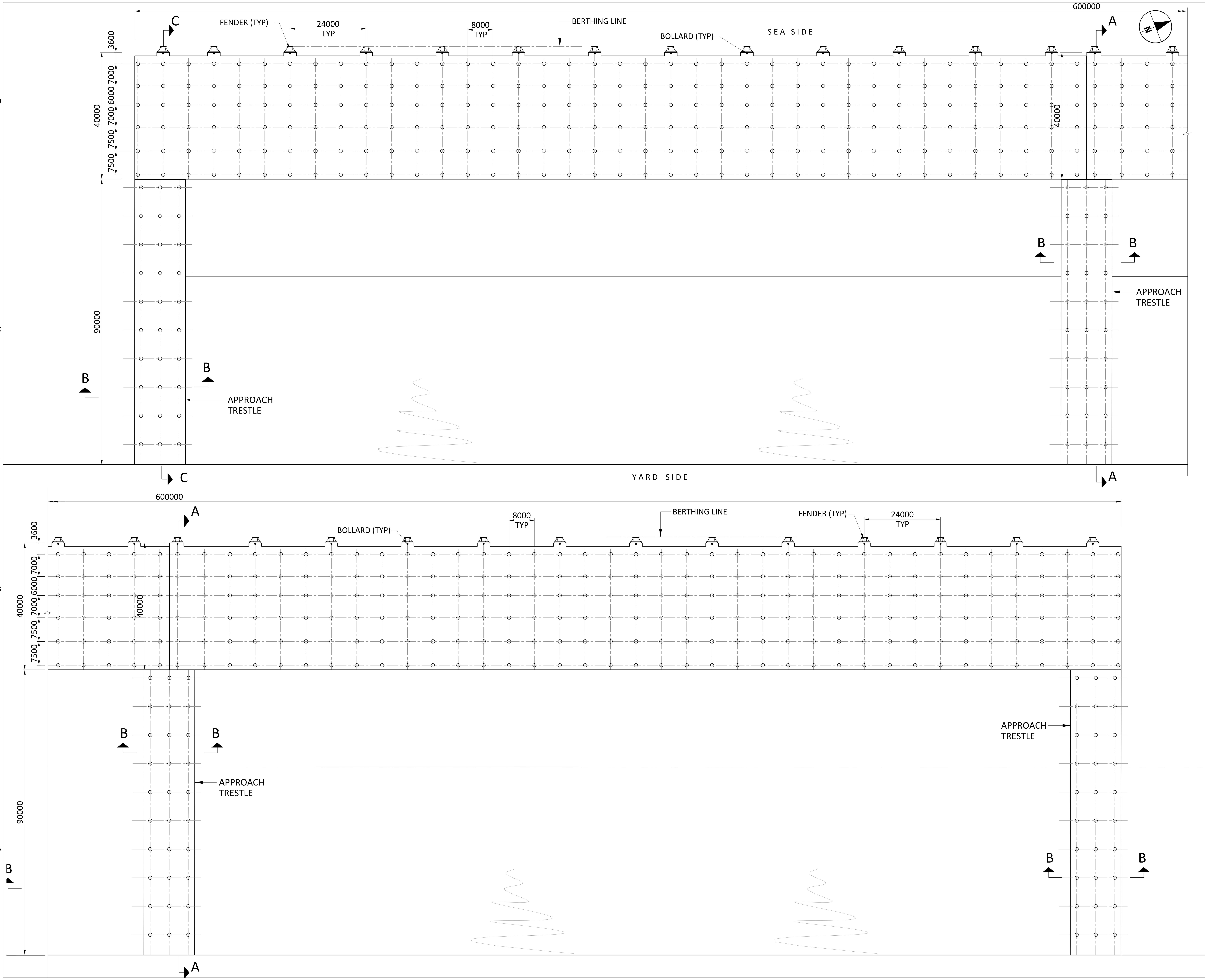


NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. ALL LEVELS ARE IN METRES AND RELATED TO CHART DATUM.

| REV. | DATE | DESCRIPTION | DR. | CH. | APR. |
|---|---|---|---|---|---|

REVISION DETAILS

CLIENT/OWNER: Ministry of Shipping, Government of India; Indian Ports Association

PROJECT: SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT SAGAR ISLAND

PART/DISCIPLINE:

DIMENSIONS ARE IN: MILLIMETRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE:

# PILE LAYOUT OF PHASE 1 BERTHS

SHEET 1 OF 1

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|---|---|---|
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DRAWING NUMBER: DELD15005-DRG-10-0000-CP-WBP1006

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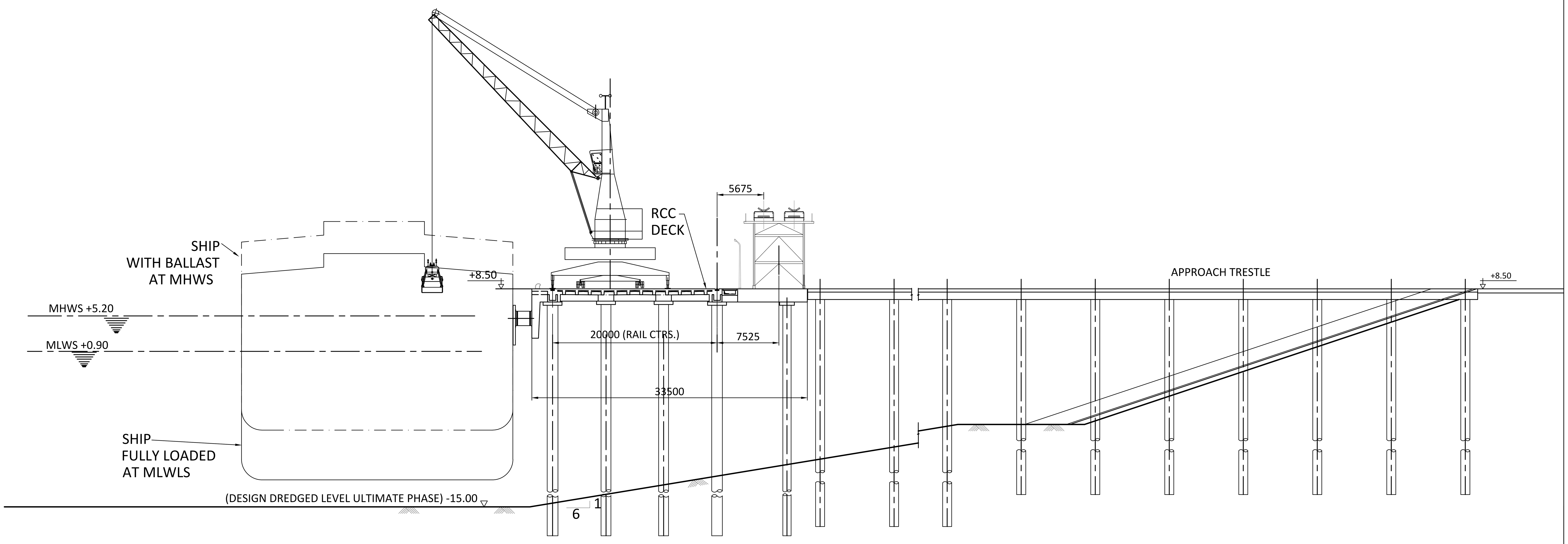
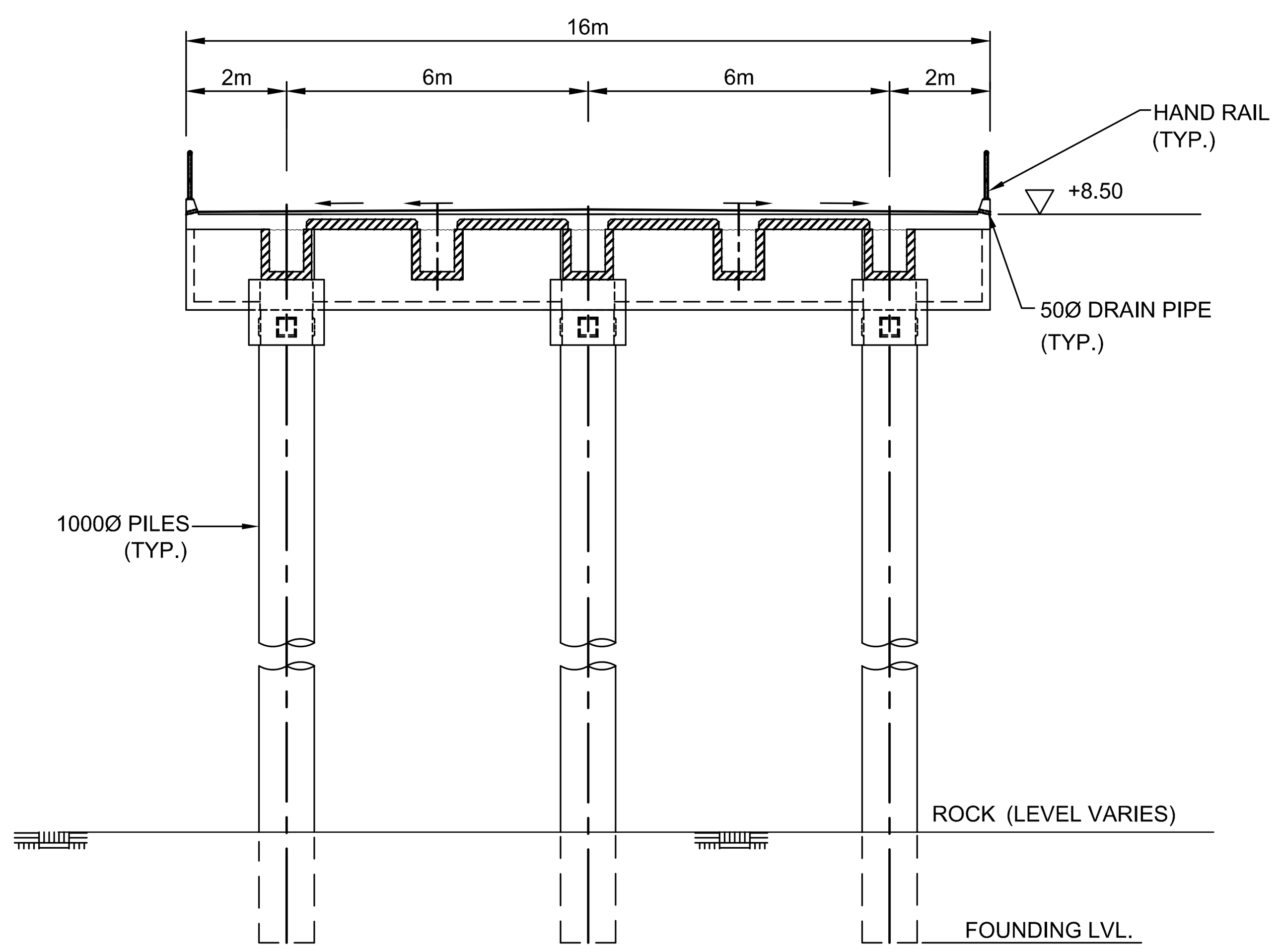



SECTION B-B

NOTES:-

1 ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.

2 ALL LEVELS ARE IN METRES AND RELATED TO CHART DATUM.

| REV. | DATE | DESCRIPTION | DR. | CH. | APR. |
|---|---|---|---|---|---|

REVISION DETAILS

CLIENT/OWNER: Ministry of Shipping Government of India; Indian Ports Association

PROJECT: SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT SAGAR ISLAND

PART/DISCIPLINE:

DIMENSIONS ARE IN: MILLIMETRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE: TYPICAL CROSS SECTION OF DRY BULK IMPORT BERTH

SHEET 1 OF 1

| Sign: | Sign: | Sign: |
|---|---|---|
| Date: 28-10-2015 | Date: 28-10-2015 | Date: 28-10-2015 |
| Name: | Name: AM | Name: SG |
| Designed by | Checked by | Approved by |

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-WBP1007 REV. 1

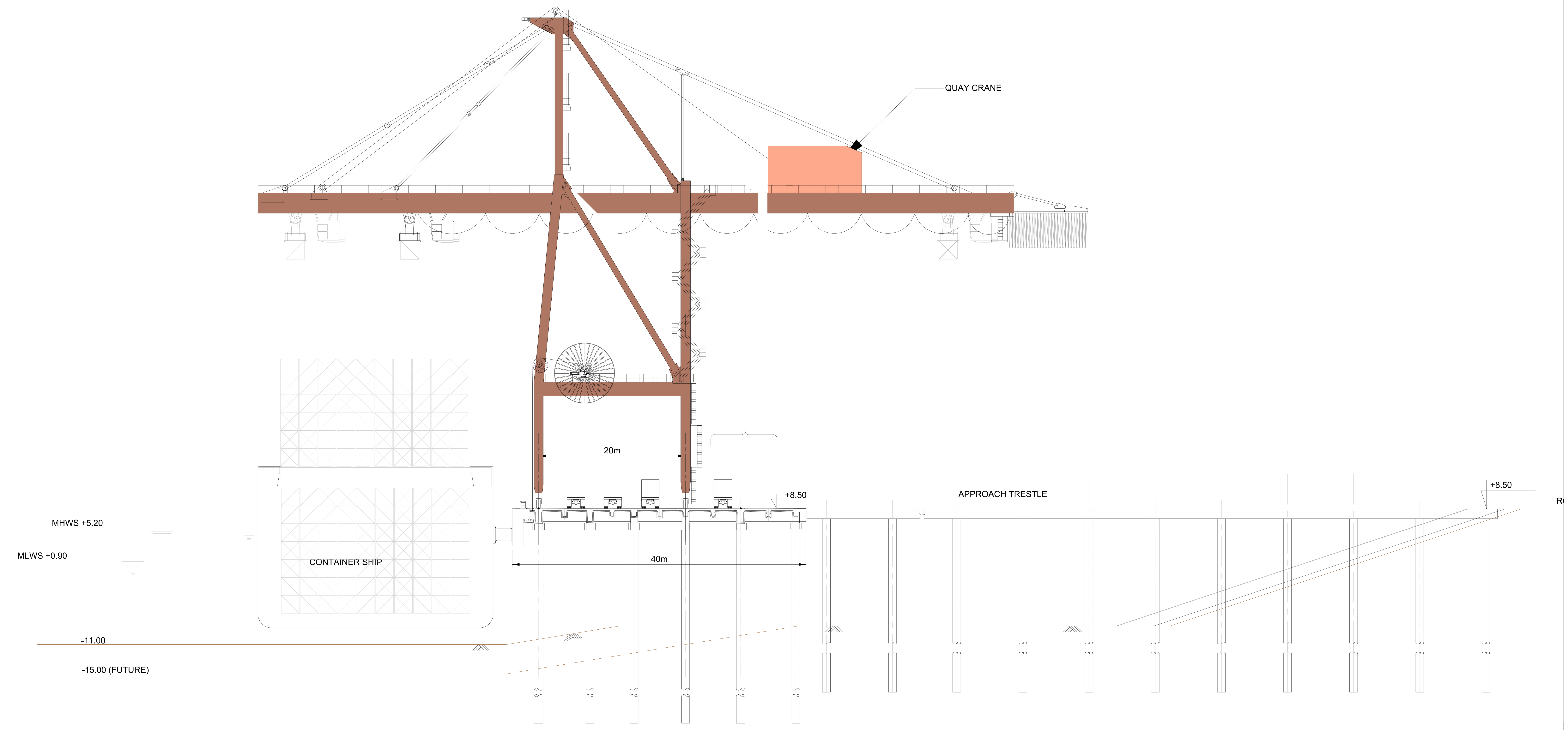
AECOM
AECOM India Pvt. Ltd.

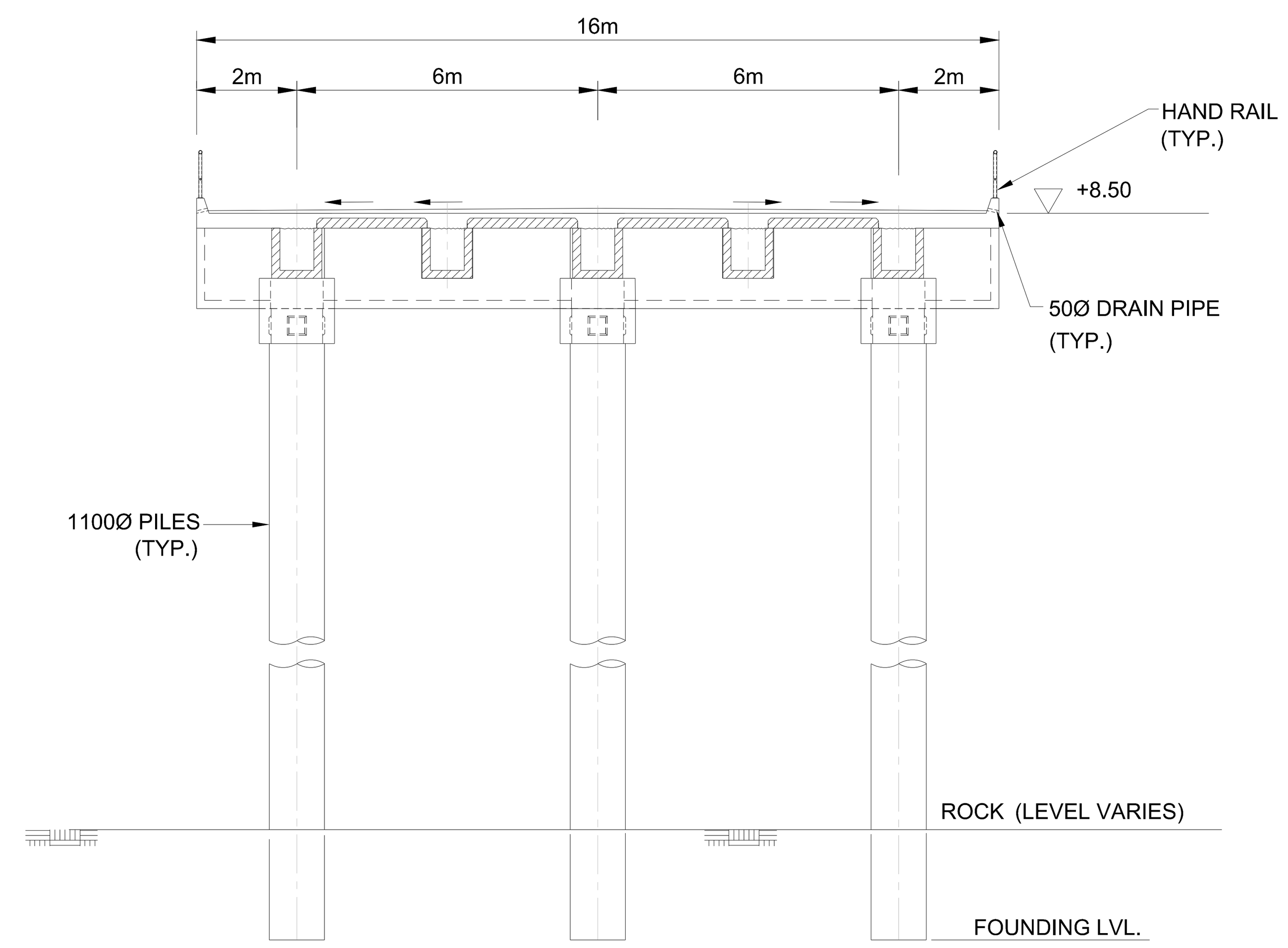


ISO A1 594mm x 841mm
Approved: SG
Checked: AM
Designer: SV
Project Management Initials:
Last saved by: VERMAS2(2015-12-10) Last Plotted: 2015-10-29
Filename: D:\PROJECTS\HUGLI\DELD15005-DRG-10-0000-CP-WBP1007_R1.DWG

NOTES:-

1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.
2. ALL LEVELS ARE IN METRES AND RELATED TO CHART DATUM.




SECTION B-B

| REV. | DATE | DESCRIPTION | DR. | CH. | APR. |
| --- | --- | --- | --- | --- | --- |

REVISION DETAILS

CLIENT/OWNER: Ministry of Shipping, Government of India; Indian Ports Association

PROJECT: SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT SAGAR ISLAND

PART/DISCIPLINE:

DIMENSIONS ARE IN: METRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE: TYPICAL CROSS SECTION OF CONTAINER BERTH AND APPROACH TRESTLE

SHEET 1 OF 2

| Sign: | Sign: | Sign: |
| --- | --- | --- |
| Date: 28-10-2015 | Date: 28-10-2015 | Date: 28-10-2015 |
| Name: | Name: AM | Name: SG |
| Designed by | Checked by | Approved by |

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-WBP1008

REV.: 1

AECOM

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ISO A1 594mm x 841mm

Approved: SG  Checked: AM  Designer: SV  Project Management Initials:

Last saved by: VERMAS2(2015-12-10)  Last Plotted: 2015-10-29
Filename: D:\PROJECTS\HUGLI\DELD15005-DRG-10-0000-CP-WBP1008_SH1_R1.DWG

Project Management Initials: Designer: SV Checked: AM Approved: SG ISO A1 594mm x 841mm

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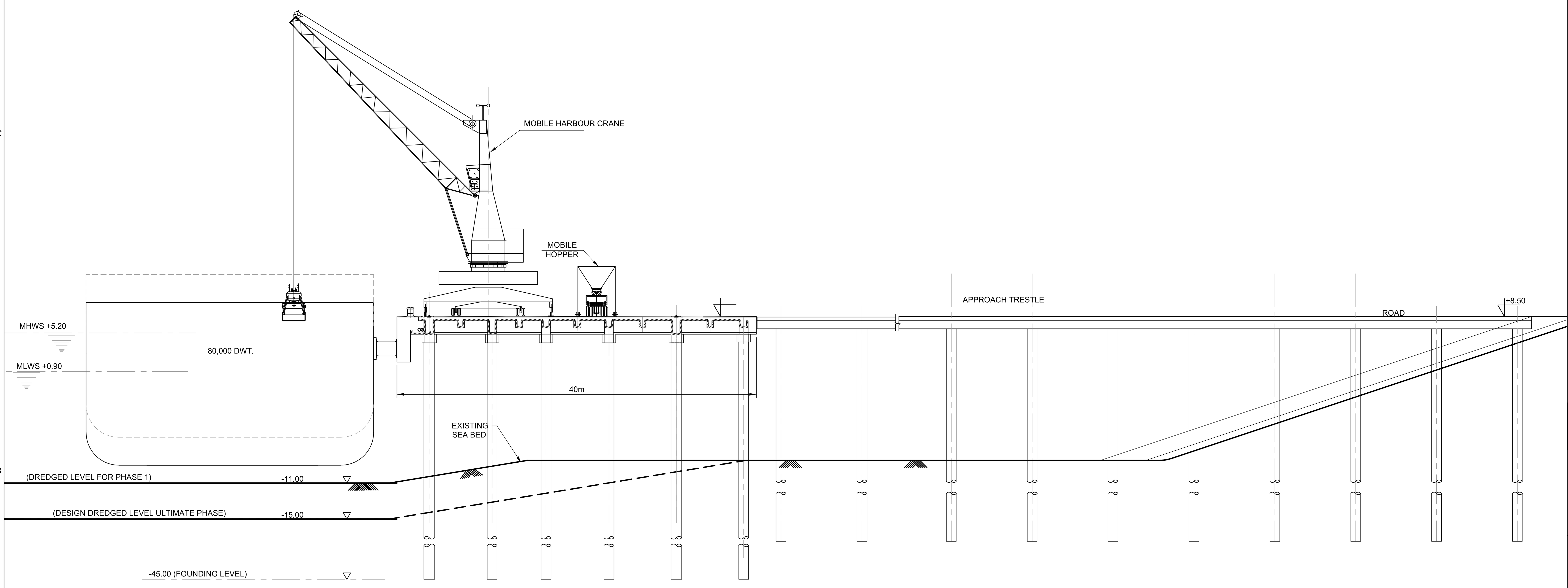


NOTES:-

1 ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.

2 ALL LEVELS ARE IN METRES AND RELATED TO CHART DATUM.

| REV. | DATE | DESCRIPTION | DR. | CH. | APR. |
|---|---|---|---|---|---|

REVISION DETAILS

CLIENT/OWNER:

Ministry of Shipping
Government of India

PROJECT:

SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT SAGAR ISLAND

PART/DISCIPLINE:

DIMENSIONS ARE IN: METRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE:

TYPICAL CROSS SECTION OF MULTIPURPOSE BERTH

SHEET 2 OF 2

| Sign: | Sign: | Sign: |
|---|---|---|
| Date: 28-10-2015 | Date: 28-10-2015 | Date: 28-10-2015 |
| Name: | Name: AM | Name: SG |
| Designed by | Checked by | Approved by |

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-WBP1008

REV.: 1

AECOM India Pvt. Ltd.

ISO A1 594mm x 841mm
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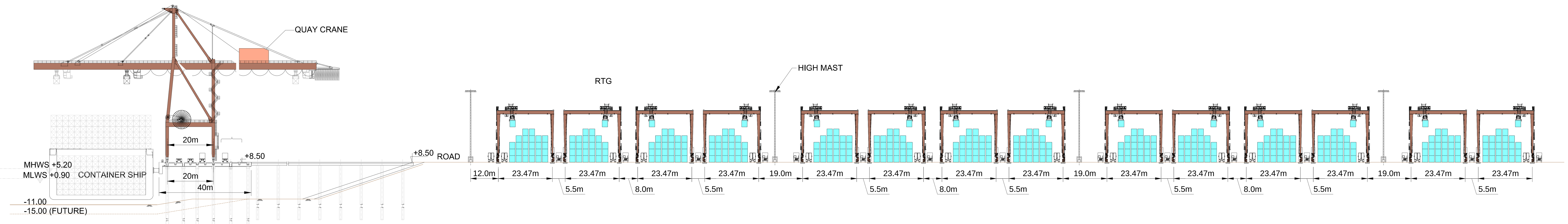
Checked: AM
Designer: SV
Project Management Initials:
Last saved by: VERMAS2(2016-01-14) Last Plotted: 2015-10-29
Filename: D:\PROJECTS\HUGLI\DELD15005-DRG-10-0000-CP-WBP1009_R1.DWG

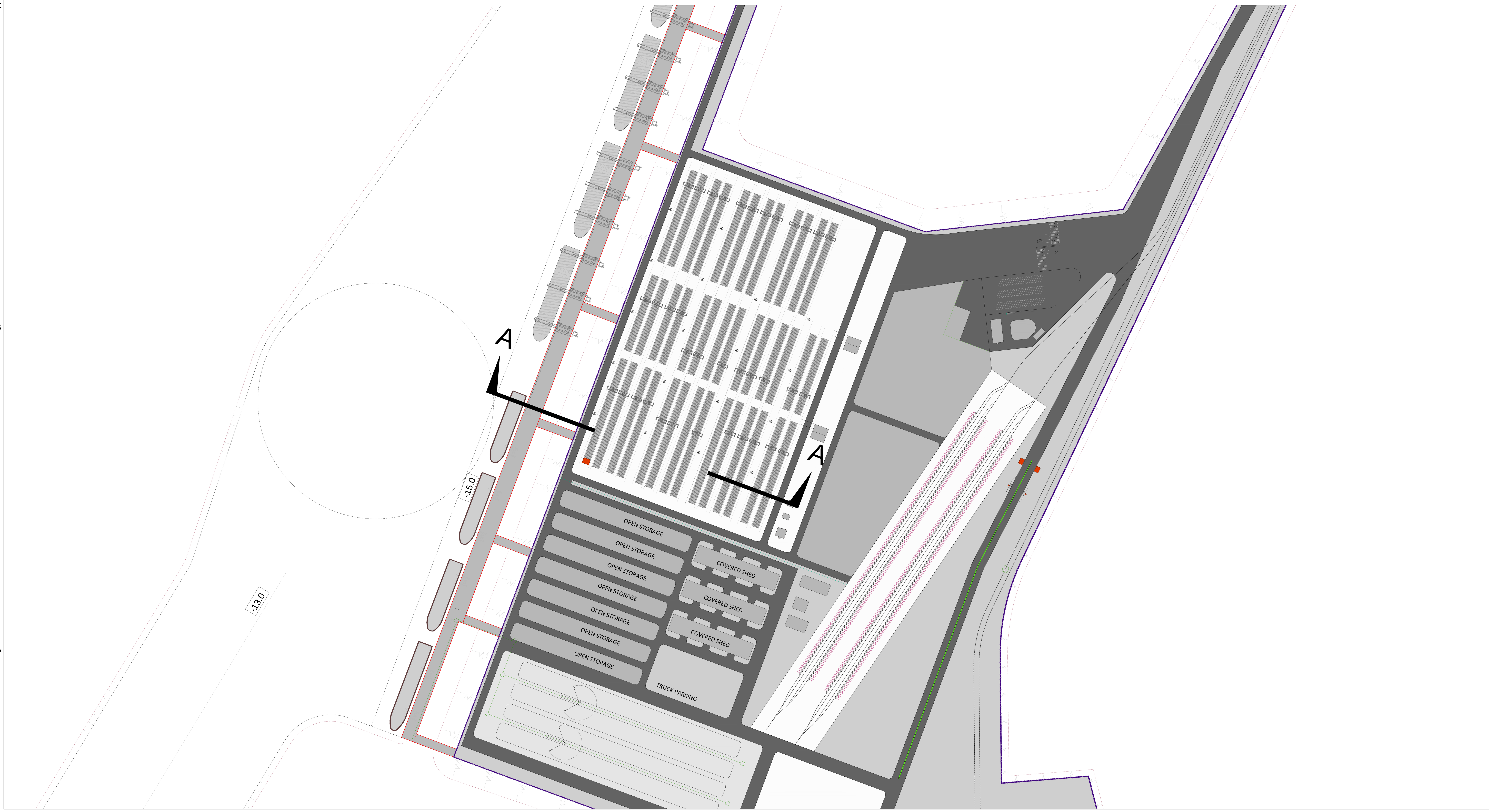
NOTES:-

1 ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.

2 ALL LEVELS ARE IN METRES AND RELATED TO CHART DATUM.




SECTION AT A-A




| REV. | DATE | DESCRIPTION | DR. | CH. | APR. |
|---|---|---|---|---|---|

REVISION DETAILS

CLIENT/OWNER: Ministry of Shipping Government of India; Indian Ports Association

| | | |
|---|---|---|
| PROJECT: | SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT SAGAR ISLAND | |
| PART/DISCIPLINE: | | DIMENSIONS ARE IN: METRES |
| PURPOSE: | TECHNO ECONOMIC FEASIBILITY REPORT | |
| DRAWING TITLE: | TYPICAL CROSS SECTION OF CONTAINER YARD | SHEET OF |
| Sign: Date: 28-10-2015 Name: VB Designed by | Sign: Date: 28-10-2015 Name: AM Checked by | Sign: Date: 28-10-2015 Name: SG Approved by |
| DRAWING NUMBER: DELD15005-DRG-10-0000-CP-WBP1009 | | REV. 1 |

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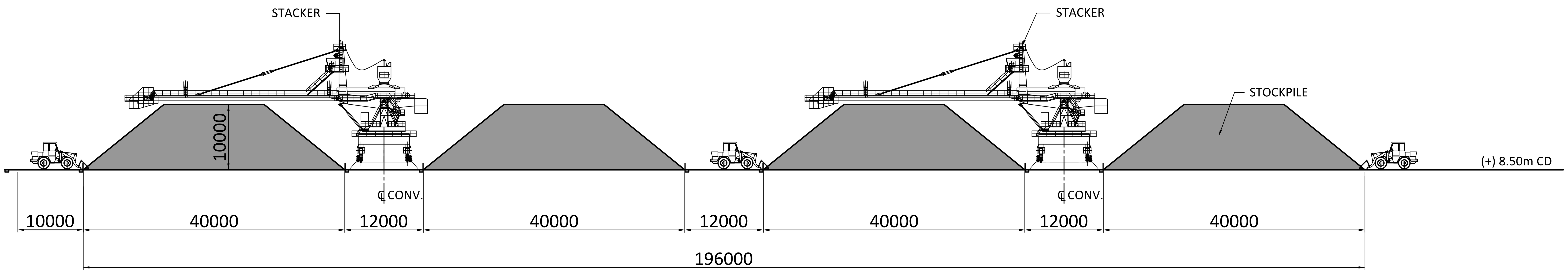


NOTES:-

1 ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.

2 ALL LEVELS ARE IN METRES AND RELATED TO CHART DATUM.

| REV. | DATE | DESCRIPTION | DR. | CH. | APR. |
|---|---|---|---|---|---|

REVISION DETAILS

CLIENT/OWNER: Ministry of Shipping, Government of India; Indian Ports Association

PROJECT: SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT SAGAR ISLAND

PART/DISCIPLINE:

DIMENSIONS ARE IN:

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE: TYPICAL CROSS SECTION OF COAL STACKYARD

SHEET 1 OF 1

| Sign: | Sign: | Sign: |
|---|---|---|
| Date: 28-10-2015 | Date: 28-10-2015 | Date: 28-10-2015 |
| Name: VB | Name: AM | Name: SG |
| Designed by | Checked by | Approved by |

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-WBP1010

REV. 1

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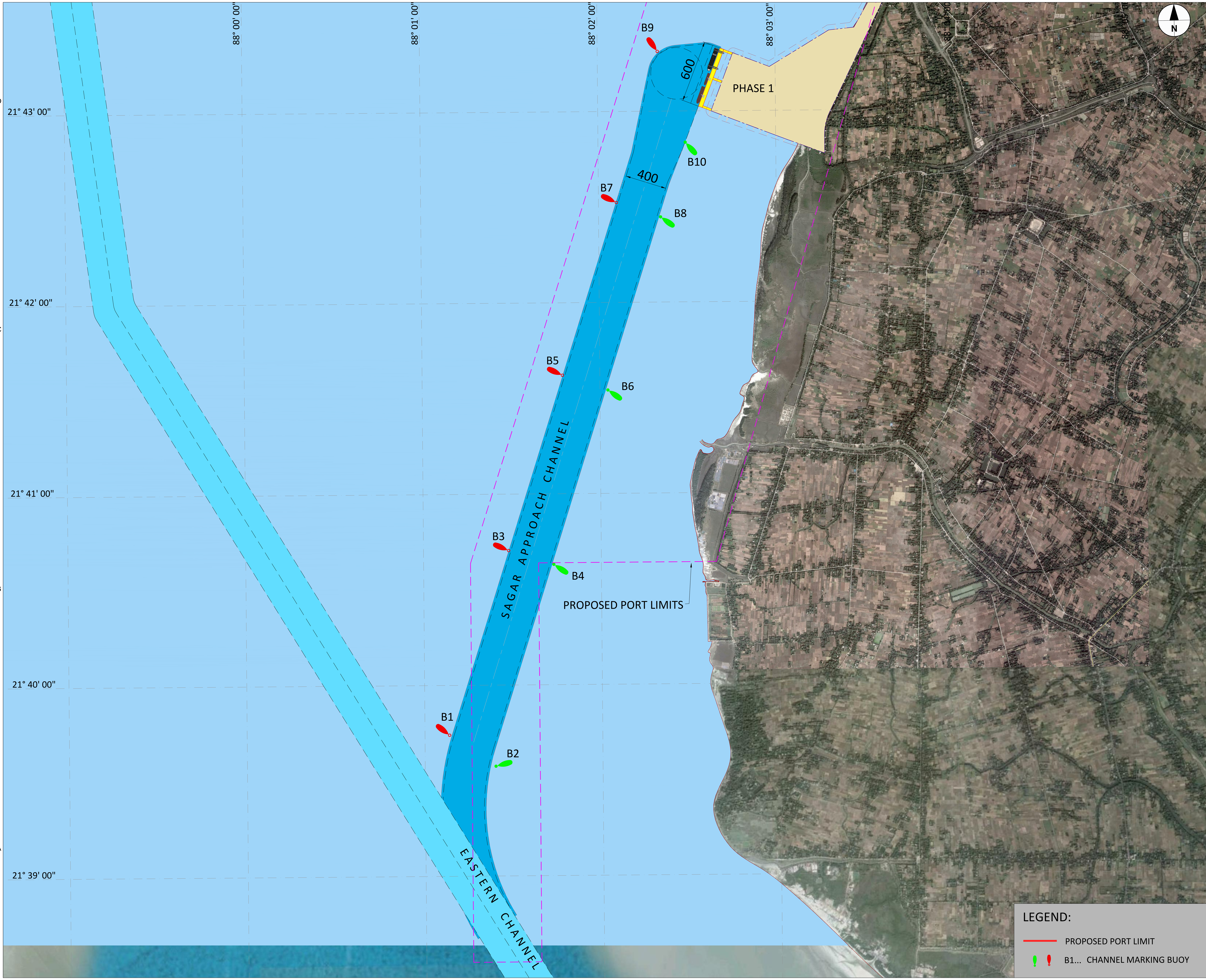


NOTES:-

1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.
2. ALL LEVELS ARE IN METRES AND WITH RESPECT TO CHART DATUM.
3. ALL COORDINATES ARE IN WGS84

| REV. | DATE | DESCRIPTION | DR. | CH. | APR. |
|---|---|---|---|---|---|

REVISION DETAILS

CLIENT/OWNER:

Ministry of Shipping Government of India

INDIAN PORTS ASSOCIATION

PROJECT:

SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT SAGAR ISLAND

PART/DISCIPLINE:

DIMENSIONS ARE IN: METRES

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE:

LAYOUT OF NAVIGATIONAL AIDS

SHEET 1 OF 1

| Sign: | Sign: | Sign: |
|---|---|---|
| Date: 28-10-2015 | Date: 28-10-2015 | Date: 28-10-2015 |
| Name: SV | Name: AM | Name: SG |
| Designed by | Checked by | Approved by |

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-WBP1011

REV. 1

AECOM India Pvt. Ltd.



ISO A1 594mm x 841mm

Approved: SG Checked: AM Designer: SV Project Management Initials:

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