TECHNO ECONOMIC FEASIBILITY REPORT FOR DEVELOPMENT OF PORT AT SIRKAZHI

Techno-Economic Feasibility Report for Development of Port at Sirkazhi

Prepared for

Ministry of Shipping / Indian Ports Association

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EXECUTIVE SUMMARY

Introduction

To make best use of economies of scale, increased global trade and to achieve efficient management of supply chain, larger sized ships are being built (cape size vessels for moving bulk cargoes) to ply on international routes and as well as coastal. This benefits the cargo owners with lower freight costs which eventually lead to low cost of final product for the end user. With this in mind, it is envisaged by Ministry of Shipping that all major ports in India shall have infrastructure and equipment capable of handling such large ships that will be at par with their global peer group.

Port at Sirkazhi

Based on judicial directive, Chennai Port has been restrained from handling dirty cargo like coal and iron ore which have been shifted to Kamarajar Port (Ennore). The next coal handling port in Tamil Nadu is Karaikal in the Union Territory of Pondicherry at a distance of 280 km (156 nautical miles). Therefore, the concept of satellite port for Chennai Port has emerged, which aims at providing a Greenfield port along the Tamilnadu coast that serve the requirements of secondary hinterland of ChPT and also overcoming constraints of handling dirty cargo adjacent to the city. The development of satellite port in Sirkazhi would be a catalyst in aiding for speeding development of the region by providing the employment opportunities, industrialisation, cheaper end products to user etc.,

Based on the Origin–Destination studies carried out under Sagarmala assignment, it has been assessed that there is a good potential of about 58 MTPA of traffic for coastal movement of thermal coal from Sirkazhi to power plants located in the North & South Tamilnadu e.g. SRM, IL&FS, NLC, Sindhya & TANGEDCO etc. These industries can be better served by setting up a port close to proximity of the power Plants. In addition to diversion of traffic, Sirkazhi port can also build upon the industrial growth of Tamilnadu, which is considered one of India's most industrialised states, comprising large public sector industrial undertakings as well as privately-owned industries e.g. steel, sugar and textiles. The state has also evolved as the base for some of the largest public sector industries in India.

It is assessed that the proposed port shall cater to the total traffic volumes of 18 MTPA in Phase I and increasing upto 58 MTPA in Master Plan phase (year 2035).

Port Development Plan

It is proposed that the port facilities shall be developed in a phased manner commensurate with traffic growth. Considering that the coal would be the primary commodity for the port, it is proposed that the port facilities will be able to handle capsize vessels upto 200,000 DWT. As the proposed port has to compete with the adjacent port at Karaikal which can currently handle mini-cape size ships of 120,000 DWT (draft 16.5 m), it would be important that the proposed port at Sirkhazi be planned to handle cape size ships at initial stage of development itself.

Under Phase 1 development of the port it is proposed to provide 2 coal berths. In view of the cost economics and minimal impact on shoreline it is proposed to provide only one offshore breakwater initially to provide the required tranquillity. The estimated capital dredging for phase 1 development is about 17.2 Mcum. It is proposed that the coal for NLC power plant shall be directly taken to their power plant. For coal of other power plants stackyard has been proposed in the port boundary from where it shall be loaded into rail wagons through in- motion wagon loading system. Fully mechanised bulk import system shall be provided at the port with 2 × 2400 TPH capacity Grab Unloaders and 4,800 TPH conveyor system at each of the two coal berths.

Additional berths, equipment, other infrastructure and additional breakwater shall be added in staged manner till the ultimate stage development.

The estimated capital cost of Phase 1 port development is INR 2,446 crores. Additional INR 423 Crores would be needed for the rail/road connectivity to the port and land acquisition. Phase 1 of port development would have an implementation time of about 34 months.

It has to be noted that when the port is commissioned, it can readily capture 7 MTPA of thermal coal for TNEB Mettur Power Plant and 4 MTPA of imported coal for IL&FS Parangipettai Power Plant. If NLC power plant is commissioned by that time, an additional 6 MTPA of imported coal will have to be handled.

Assessment and Recommendations

The viability analysis for the project has been carried out considering three alternative models for port development i.e. development by project proponents, by full-fledged concession to private operators and landlord model.

In the project proponent model the project shall be executed by a Special Purpose Vehicle (SPV), which may include ChPT and other government entities. SPV shall arrange funds, manage and operate the port. The IRR for project proponent model works out to 12.5%.

In the second model in which the entire project is given to private developer and costs towards external rail/road connectivity, land acquisition for connectivity and port facilities shall be taken up by the government entities. In this case IRR for the private entity works out to 14.5% considering the private entity does not share the revenue with the government.

In the third model, SPV shall be responsible for providing the entire basic infrastructure for the port including the external connectivity and land acquisition to the port. The cargo handling terminals and associated facilities shall be developed by PPP operator, who shall be responsible for terminal operations & maintenance and also sharing the revenue with the SPV. Limiting the project IRR to 15% for the PPP operator, he can share about 50% of the revenue with the SPV with an overall IRR of 11.5 % for SPV. The estimated IRR for SPV can further improve if SPV can manage debt from the international funding agencies. Further if the external rail and road connectivity to the port could be undertaken by NHAI, Railways and IPRCL, the burden on SPV shall reduce.

From these thorough analyses of the development of port at Sirkazhi, it can be concluded that the port has a great potential and can be developed under Landlord model.

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.

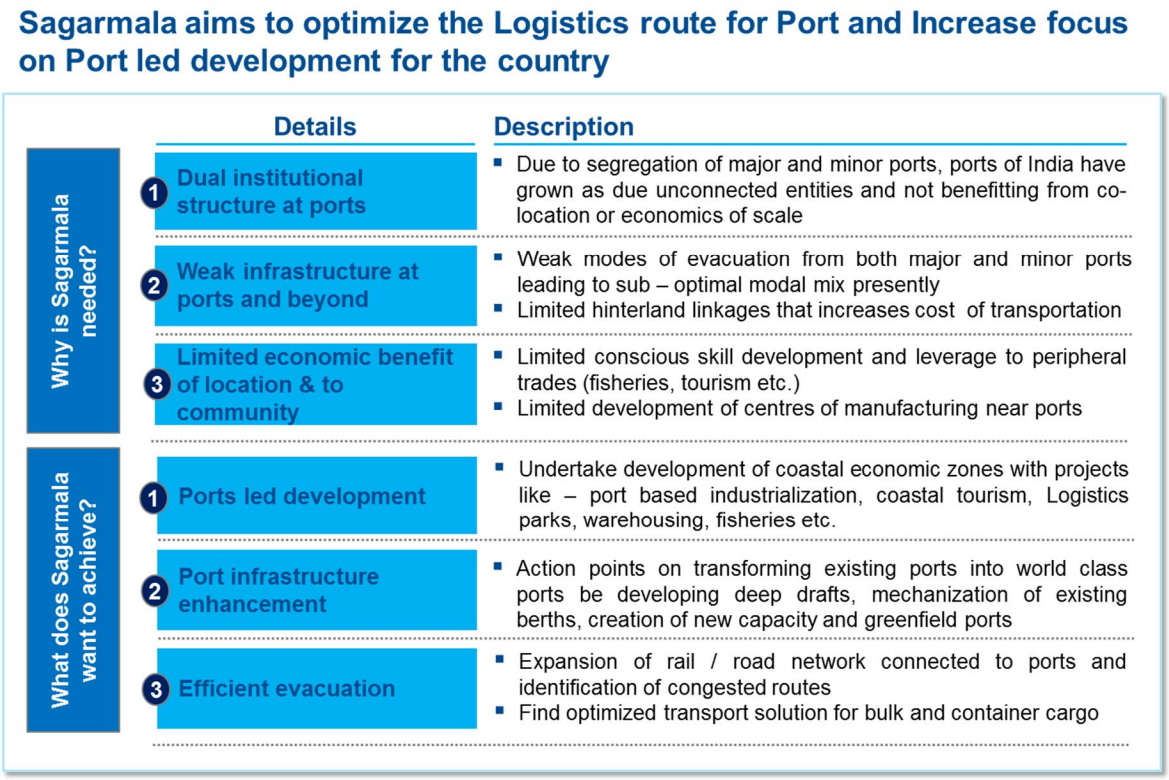


Figure 1.1 Aim of Sagarmala Development

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

The team of McKinsey and AECOM distilled learnings from the experience in port-led development, the major engagement challenge to develop a set of governing principles for our approach is shown in **Figure 1.2**.

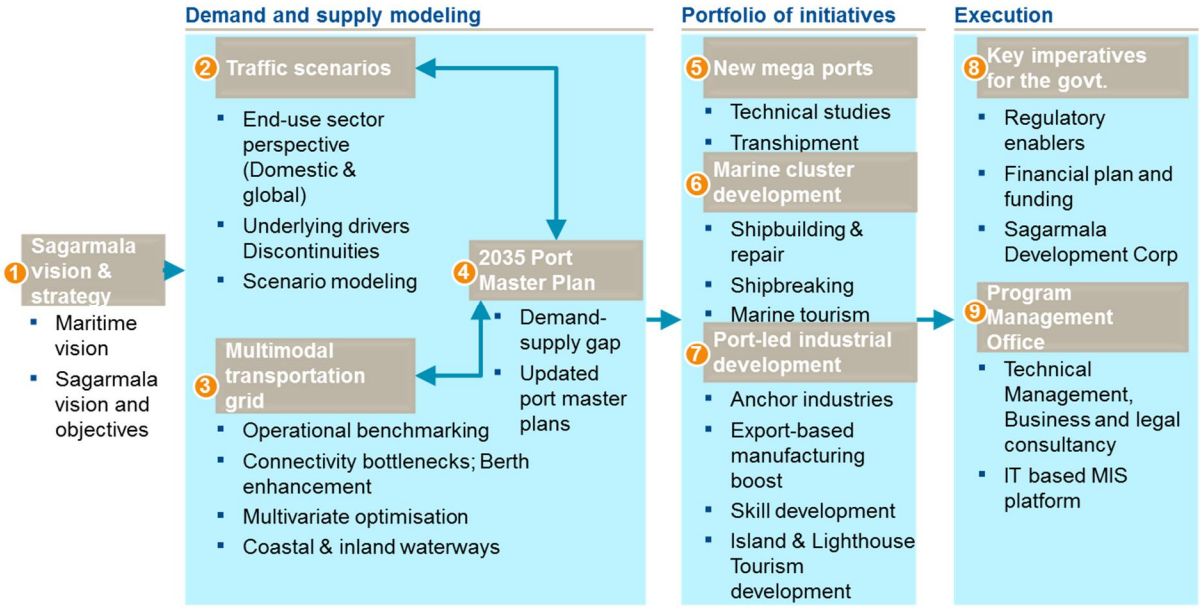


Figure 1.2 Governing Principles of Our Approach

As indicated above, the origin-destination of key cargo (accounting for greater than 85% of the total traffic) in Indian ports have been 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 another Major Port in Tamil Nadu

Based on judicial directive, Chennai Port has been refrained from handling dirty cargo like coal and iron ore which have been shifted to Kamarajar Port (Ennore). The next coal handling port in Tamil Nadu is Karaikal in the Union Territory of Pondicherry at a distance of 280 km (156 nautical miles). Hence, it has been proposed to set up another major port in between Ennore and Karaikal with a focus on handling coal for industries and thermal power plants.

1.4 Present Submission

The present submission is the Techno-economic Feasibility Report for “Development of Port at Sirkazhi”, Tamil Nadu. This report is organised in the following sections:

Section 1 : Introduction
Section 2 : Site Selection
Section 3 : Site Conditions
Section 4 : Traffic Projection for Sirkazhi Port
Section 5 : Design Ship Sizes
Section 6 : Port Facility Requirements
Section 7 : Preparation of Port Layout
Section 8 : Engineering Details
Section 9 : Environmental Settings and Impact Evaluation
Section 10 : Cost Estimates and Implementation Schedule
Section 11 : Financial Analysis for Alternative Means of Project Development
Section 12 : Way Forward

2.0 SITE SELECTION

2.1 Present Status of Ports of Tamil nadu

The ports under the control of Tamil Nadu Maritime Board (TNMB) in Tamil Nadu are shown in **Figure 2.1**.

Figure 2.1 Various Ports in Tamil Nadu

Among these ports, Cuddalore and Nagappattinam are Government ports. All others are captive ports. Among captive ports, Kattupalli, Mugaiyur and Semmbimangalam are for shipyards and ship repair facilities. Thiruchopuram, PY-03 and Thirukkadaiyur are for handling liquid cargo. The rest are linked to power plants and are to handle thermal coal.

The present status of these captive ports is presented hereunder:

- **Panaiyur - Cheyyur Port:- (Gazette Notification Not Yet Issued)**

The Government of India has proposed to develop a 4,000 MW Ultra Mega Power Plant (UMPP) at Cheyyur, near Marakkanam, in Villupuram district. A SPV, namely M/s. Coastal Tamil Nadu Power Limited (M/s. CTNPL) has been established for this purpose. In order to handle the coal required for this power plant, the company has been granted an in-principle approval to establish a port in a location called Panaiyur, south of Mudaliyar kuppam Boat House. ***Till date there is no progress at site.***

- **Parangipettai Port :- (Gazette Notification Issued During May, 2010)**

M/s. IL&FS Ltd. has proposed to develop a Captive Port to handle the coal required for their proposed 4,000 MW Power Plant at Parangipettai, in Cuddalore District. ***Till date no progress at site for the port. However, the 1st Phase of power plant (1200 MW) has been commissioned during October, 2015 and is sourcing coal through Karaikal port.***

- **Kaveri Port: (Gazette Notification Issued During January, 2010)**

M/s. PEL Power Limited had proposed to establish a jetty near Poombuhar in Nagappattinam District for handling coal for their proposed 1,320 MW Power Plant. ***Till date there is no progress at site.***

- **Vanagiri Port: (Gazetted Notification Issued During July, 2009)**

M/s. NSL Power Limited had proposed to establish a jetty in Sirkazhi taluk of Nagappattinam district for handling coal for 1,500 MW Power Plant. However, it is understood that this power plant has been shifted to Odisha. ***Till date there is no progress at site.***

- **Tharangambadi Port (Gazetted Notification Issued During January, 2012)**

Chettinad Tharangampadi Port: M/s. Chettinad Power Corporation Ltd. has proposed to set up a 1,320 MW Thermal Power project at Tharangampadi taluk in Nagappattinam District. ***Till date there is no progress at site.***

- **Thirukkuvalai Port: (Gazetted Notification Issued During April, 2008)**

M/s. Tridem Port and Power Company Private Ltd. had proposed to establish a captive port at Nagappattinam District to handle coal required for proposed 2,000 MW Merchant Power Plant. ***Till date there is no progress at site.***

It is also understood that Neyveli Lignite Corporation Ltd. is planning to set up a thermal power plant of 1,600 MW (2 × 800 MW) at Thirumullaivasal / Vettangudi (Sirkazhi site). This will be further expanded to an ultimate capacity of 4,000 MW (5 × 800 MW). The land for the power plant is understood to have been identified and NLC is taking it up with the State Govt.

Considering the locations of these proposed power plants and their present status, it is suggested that the new major port could be located at a suitable location so that it is able to cater to the needs of these plants as and when they come up. Instead of having many captive jetties along the coast, it is prudent to have a centralised coal handling at a specific area so as to ensure better management of environment.

Another advantage of the proposed port location at Sirkazhi is its proximity to Mettur and Parangipettai where thermal power plants are already in operation.

Mettur Thermal Power Station is operated by TANGEDCO. It has 4 units each of 210 MW and 1 unit of 600 MW which was commissioned recently giving its total capacity as 1,440 MW. Its annual thermal coal requirement is about 7.0 MTPA which is sourced from Mahanadi Coal Fields and routed through Paradip and Kamarajar Ports.

As indicated earlier, IL&FS have recently commissioned their 1,200 MW Power Plant at Parangipettai and they are sourcing their coal from Indonesia and are presently routed through Karaikal port as their captive port has not yet been taken up.

The nearest station to the proposed new port is Sirkazhi. By opting for this new port, both the power plants can reduce their railway haulage by about 100 km each. In fact, Parangipettai is only about 30 km away as compared to Karaikal at about 130 km. The relative locations of Sirkazhi, Parangipettai and Mettur are shown (*blue circle*) in the southern railway map given in **Figure 2.2**.

With this locational advantage, it is possible to kick-start this new port immediately with a starting traffic of about 17 MTPA. It will be a win-win situation for the power plants as well as for the new port.

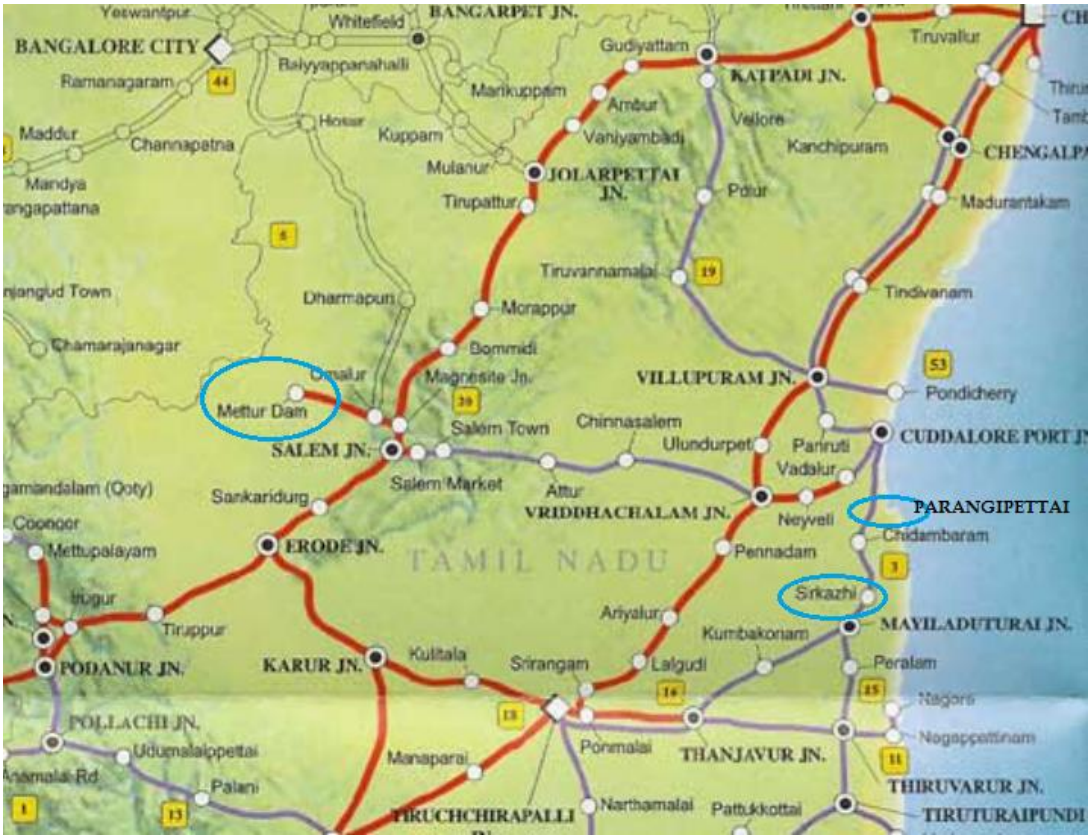


Figure 2.2 Relative Locations of Sirkazhi, Parangipettai & Mettur

2.2 Selection of Port Site

Considering the proposed locations of all these power plants, their capacities and the present status, it is proposed that the new port could be located east of Vettangudi where the power plant of Neyveli Lignite Corporation has been planned. This power plant could be the anchor client to the proposed port. Accordingly the exact location of the proposed port is examined hereunder.

The identified land for the NLC power plant lies almost in between Collidam River and Uppanar River as shown in **Figure 2.3**.

Figure 2.3 Tentative Location Identified for NLC Power Plant

On the northern side (about 7-8 km) at the mouth of Collidam River, there is a well-developed Pazhaiyar fishing harbour with about 400 fishing operational boats. On the southern side approximately 5 km at the mouth of Uppanar River is Thirumullaivasal, where a relatively small fish landing centre is operational. On the eastern side, there is a coastal stretch of about 3 km free of any habitation as marked as 'A' & 'B' in the **Figure 2.3**. A blow up image of this area is as shown in **Figure 2.4**.

Figure 2.4 Proposed Port Location

This coastal stretch has been examined by Chennai Port through the National Centre for Sustainable Coastal Management. It has concluded that this selected stretch is a stable coast. The finding is presented in the **Figure 2.5**.

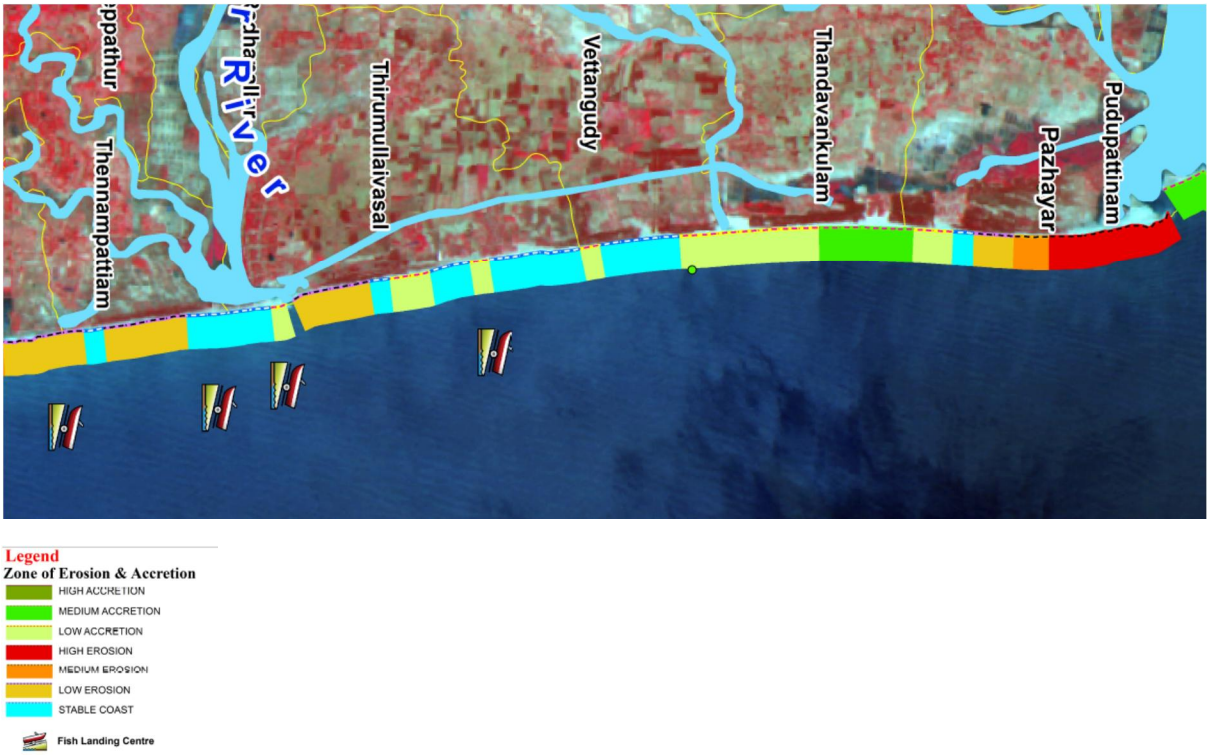


Figure 2.5 Coastal Stability at the Location of Proposed Port

Considering the nearest rail head, this port is proposed to be named as **Sirkazhi Port**.

3.0 SITE CONDITIONS

3.1 Location of Project Site

The Satellite port to Chennai is proposed to be located near Sirkazhi in Tamil Nadu. The port site is 4 km north of Thirumullaivasal (a fishing village) while the latter is 14 km east of Sirkazhi town. All lie with in Nagappattinam District.

The site is bounded by the sea on the eastern side, Buckingham canal on the western side, a canal on the northern side and is about 1 km away from Thoduvaai village on the southern side. There is almost 2 km stretch of stable coastline at this location as discussed in **Chapter 2**. The site is free of habitation and there are casuarina plantations around. The location of the proposed thermal power plant of Neyveli Lignite Corporation is bound by Vettangudi on the west, Kooliyar village on the northern side and Radhanallur on the southern side. The co-ordinates of the site are 11° 18' N and 79° 50' E. Site location is as shown in **Figure 3.1**.

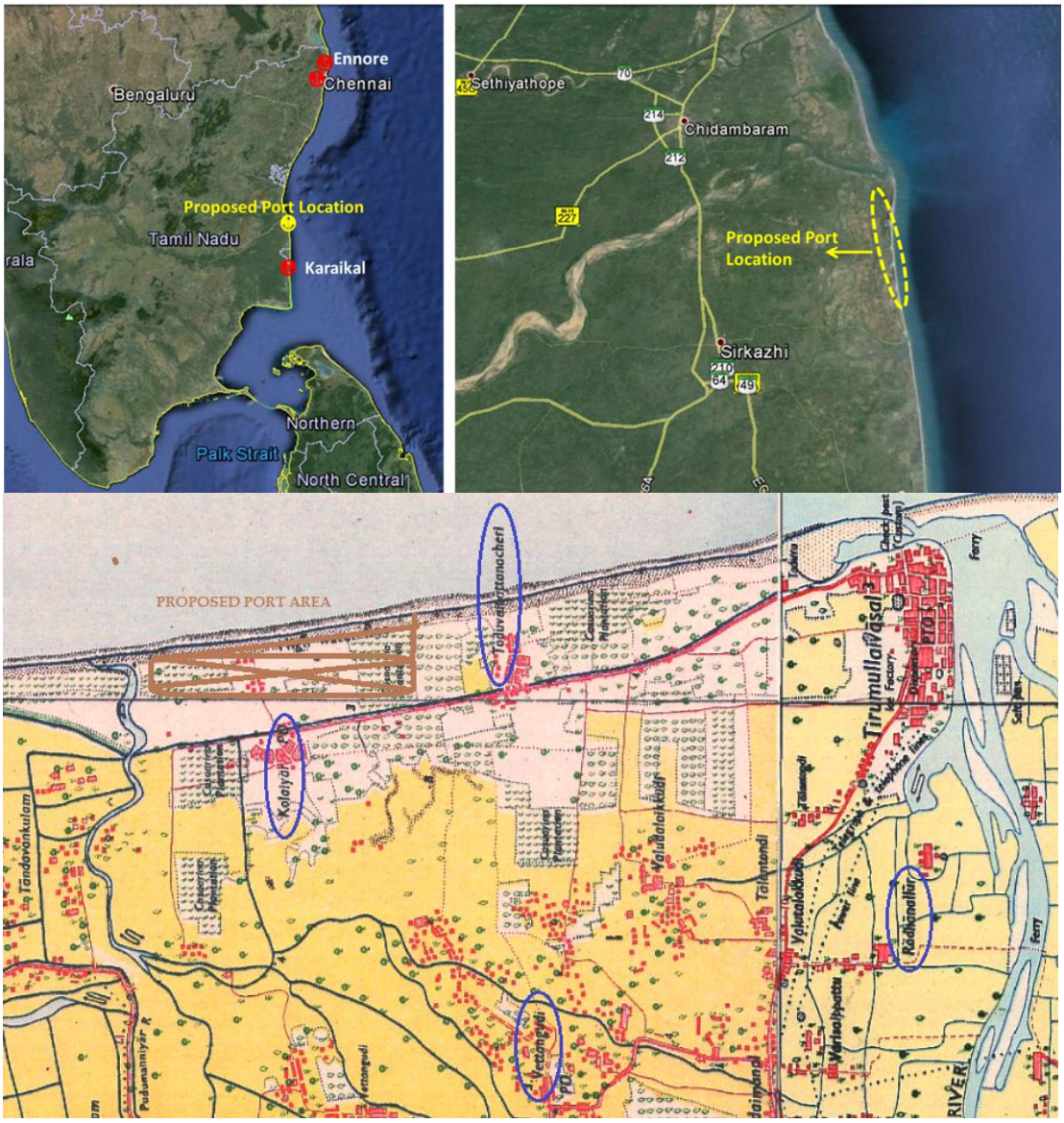


Figure 3.1 Location of Project Site

There is a clear distance about 800 m from the high water line up to the edge of Buckingham canal. This space is sufficient for locating the required port facilities.

Figure 3.2 Area Available for Port Facilities

Approximately 3,000 m of water front area is available for the proposed port development, which can be utilized for handling various cargoes. The port site is endowed with natural depths of 20 m within a distance of approximately 3,600 m from the shore.

The waterfront identified for the development of proposed port has a village named Thoduvaai in the immediate vicinity, while the other village Kooliyar is about 900 m west. The village has got a population of 8,000 and the main occupation involves mostly around small scale fishing and agriculture (rice, groundnut, cashew and mango).

3.2 Meteorological Data

3.2.1 Climate

The climate of the region is characterised by two seasonal monsoons viz. NE and SW. NE monsoon occurs between November and January and is characterised by predominant north-easterly winds. During this period the risk of a tropical storm or cyclones is higher than in most months. SW monsoon extends from June up to September and is characterised by occurrence of rain, with predominantly south-westerly winds.

3.2.2 Rainfall

The annual rainfall is in the order of 1,400 mm, about 65% occurring in the period October to December.

3.2.3 Relative Humidity

The climate of the area is tropical in nature with mean relative humidity around 75% reaching a maximum of almost 100%.

3.2.4 Temperature

March to June is the summer season with maximum temperature touching around 42º C. December to February is the winter season with minimum temperature falling to around 18° C.

3.2.5 Visibility

Throughout the year visibility is good as the fog is infrequent at sea in all seasons.

3.3 Oceanographic Data

3.3.1 Bathymetry

The Admiralty Chart No. 2069 suggests that 5 m contour is at around 0.7 km while 10 m contour is about 1.5 km and 20 m contour is 3.6 km away from the coast.

3.3.2 Tides

The tides in the region are semi diurnal in nature with two high tides and two low tides in a day. The various tidal levels at Sirkazhi port with respect to Chart Datum (CD) are as follows:

Mean High Water Springs (MHWS)	+ 1.1 m
Mean High Water Neaps (MHWN)	+ 0.9 m
Mean Low Water Neaps (MLWN)	+ 0.6 m
Mean Low Water Springs (MLWS)	+ 0.3 m
Mean Sea Level (MSL)	+ 0.7 m

3.3.3 Currents

The current during the NE monsoon is southwards and during SW monsoon is northwards. The current velocities are in the range of 0.1 m/s to 0.5 m/s.

3.3.4 Wind

The average wind speed does not exceed 20 kmph for almost 90% of the time during a year but during monsoon season, winds of up to 60 kmph speed are experienced. The annual average wind climate exhibits two distinct peaks in its directional distribution, centered approximately on SW and NE. Examination of the seasonal climate tables shows that these corresponds to the (SW) monsoon period and the post-monsoon (also referred to as northeast monsoon) period, respectively. Wind rose diagram for a period of 10 years is as shown in **Figure 3.3**.

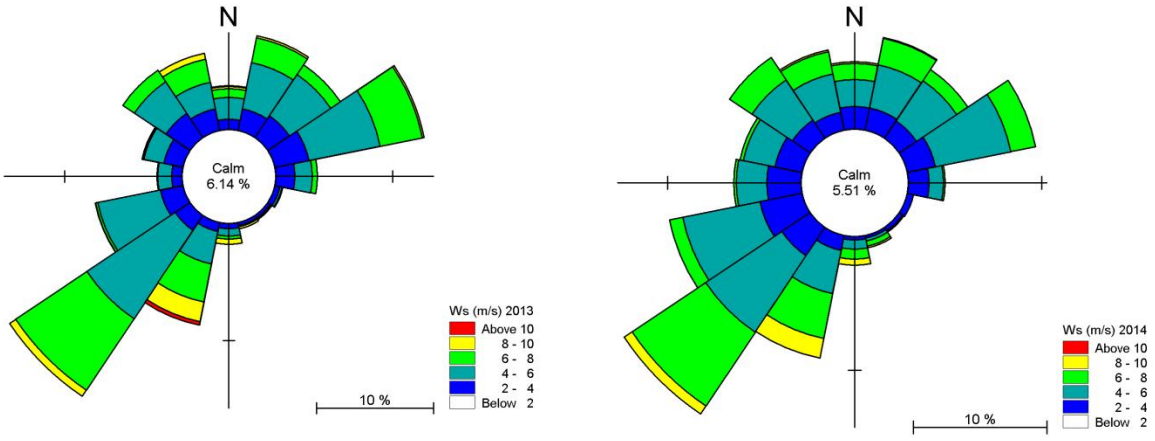


Figure 3.3 Wind Rose Diagram

Non-cyclonic offshore wind speeds for different return periods are as mentioned in **Table 3.1**.

Table 3.1 Non-Cyclonic Extreme Wind Speeds (m/s)

S. No.	Return Period (Years)	N-ENE	ENE-SSE	SSE-WSW	All Directions
1.	1	12.40	9.10	13.50	13.50
2.	50	14.50	11.60	15.50	15.50
3.	100	14.80	12.00	15.80	15.80
4.	200	15.10	12.30	16.10	16.10

3.3.5 Cyclones

East Coast is prone to cyclonic storms round the year but mostly these occur prior to SW monsoon i.e. in May and after SW monsoon i.e. in October and November. Tropical cyclones generated in the Bay of Bengal hit the coast between Nagappattinam and Chennai. The data relating to cyclones which crossed the areas within 200 Km from Sirkazhi between 1975 and 2013 is presented in the **Table 3.2**.

Table 3.2 List of Severe Cyclones Hitting the Site Shoreline

S. No.	Date	Maximum Wind Speed (Knots)	Duration (Days)	Type of Cyclone
1.	27.10.1975	33	1	D
2.	20.10.1976	47	1	SS
3.	29.11.1976	33	1	D
4.	12.11.1978	33	1	D
5.	25.11.1979	47	1	S
6.	18.10.1982	63	2	SS
7.	16.11.1984	47	2	SS
8.	01.12.1984	63	1	SS
9.	12.11.1985	33	1	D
10.	14.12.1985	47	1	S
11.	29.10.1991	33	1	D
12.	14.11.1991	47	1	S
13.	22.11.1993	63	2	SS
14.	04.12.1993	63	1	SS
15.	20.12.1993	33	1	D
16.	31.10.1994	63	1	SS
17.	06.05.1995	33	1	D
18.	14.10.1996	20	1	D
19.	29.11.2000	63	1	SS
20.	10.12.2005	43	1	S
21.	30.12.2011	63	1	SS
22.	16.11.2013	30	1	D
D – Depression; S – Storm; SS – Severe Cyclone				

3.3.5.1 Storm Surge

Surge levels were also assessed for the Thirumullaivasal shoreline. The assessment shows that the wind driven water surge towards the shoreline at shallow waters turns to be higher as shown in **Table 3.3**.

Table 3.3 Surge Levels Based on Extreme Cyclonic Storms (m) wrt CD

S. No.	Return Period (Years)	(-5 m)	(-10 m)	(-15 m)	(-20 m)
1.	1	0.40	0.30	0.30	0.30
2.	50	0.70	0.60	0.50	0.50
3.	100	0.80	0.70	0.60	0.60
4.	200	0.90	0.70	0.70	0.70

3.3.6 Wave

The offshore wave data obtained from secondary sources (UKMO) based on the hindcasting using the synoptic chart and statistical analysis has been considered to Sirkazhi site and is presented in the subsequent tables. The annual average offshore wave rose diagram is shown in **Figure 3.4**.

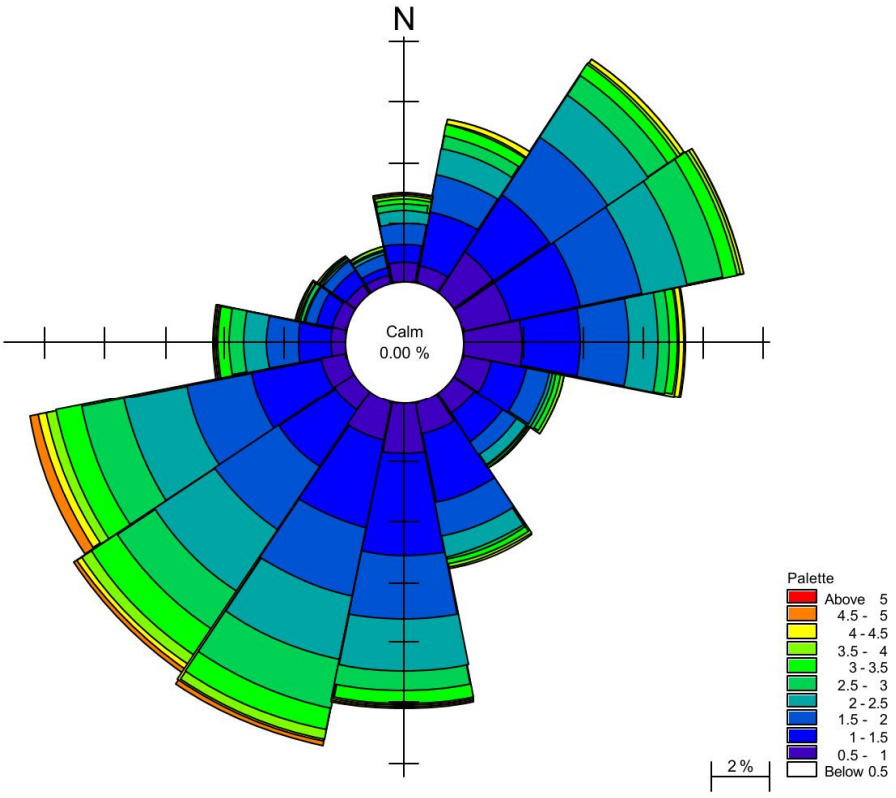


Figure 3.4 Annual Offshore Wave Rose Diagram

3.3.7 Nearshore Wave Transformation

Based on the past records for the offshore wave data mentioned above its respective nearshore transformed wave rose plot is shown in **Figure 3.5**, and nearshore wave characteristics for different return periods are provided in **Table 3.4**.

Table 3.4 Wave Characteristics for Return Periods wrt CD

S. No.	Return Period (Years)	(-5 m)		(-10 m)		(-15 m)		(-20 m)	
		Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)
1.	1	2.6	6.2	2.8	6.1	3.0	6.2	3.0	6.2
2.	50	3.7	8.4	3.9	8.2	4.1	8.2	4.1	8.1
3.	100	3.8	8.9	4.2	8.7	4.3	8.7	4.3	8.6
4.	200	3.8	9.4	4.4	9.3	4.5	9.2	4.5	9.1

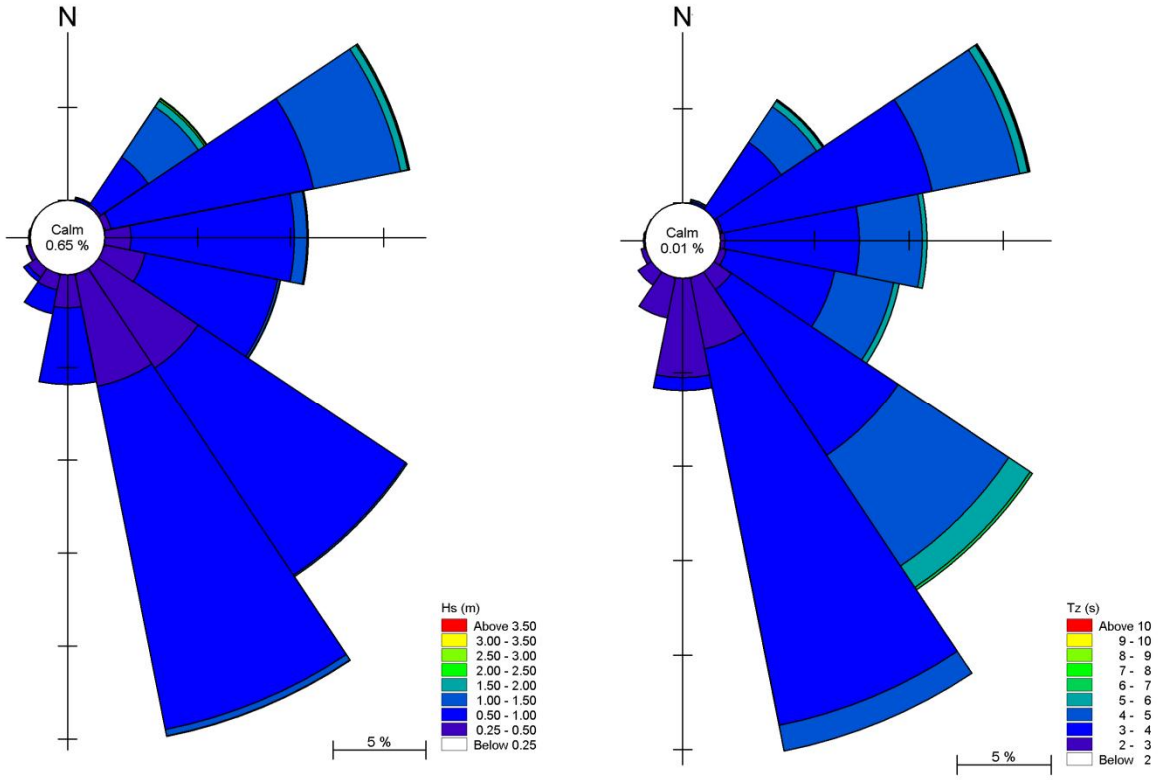


Figure 3.5 Nearshore Wave Rose Diagram

3.3.8 Littoral Drift

The east coast is subjected to the phenomenon of littoral sediment transportation, which is from south to north during SW monsoons and in the reverse direction during NE monsoons. The net annual littoral drift at a particular location depends upon the orientation of the coastline and also the nearshore wave climate at that location. The net drift towards north has been generally observed to increase as one moves up along the coast in the north direction, with values of as high as 0.75 Mcum in Visakhapatnam and 1.0 Mcum in Paradip. However, the observed net drift is much smaller in the ports located towards south such as V.O.Chidambaranar.

The site specific mathematical model studies on siltation were carried out near the proposed site. It has been observed that the gross annual littoral drift towards north and south are quite balanced and are 298,000 cum and 125,000 cum respectively. The net drift works out to only 150,000 cum per annum only towards north.

3.4 Site Seismicity

Sirkazhi is in **Zone II** of Indian Map of Seismic zones (IS-1893 Part-1 2002) which is a moderate risk seismic intensity zone (**Figure 3.6)**.

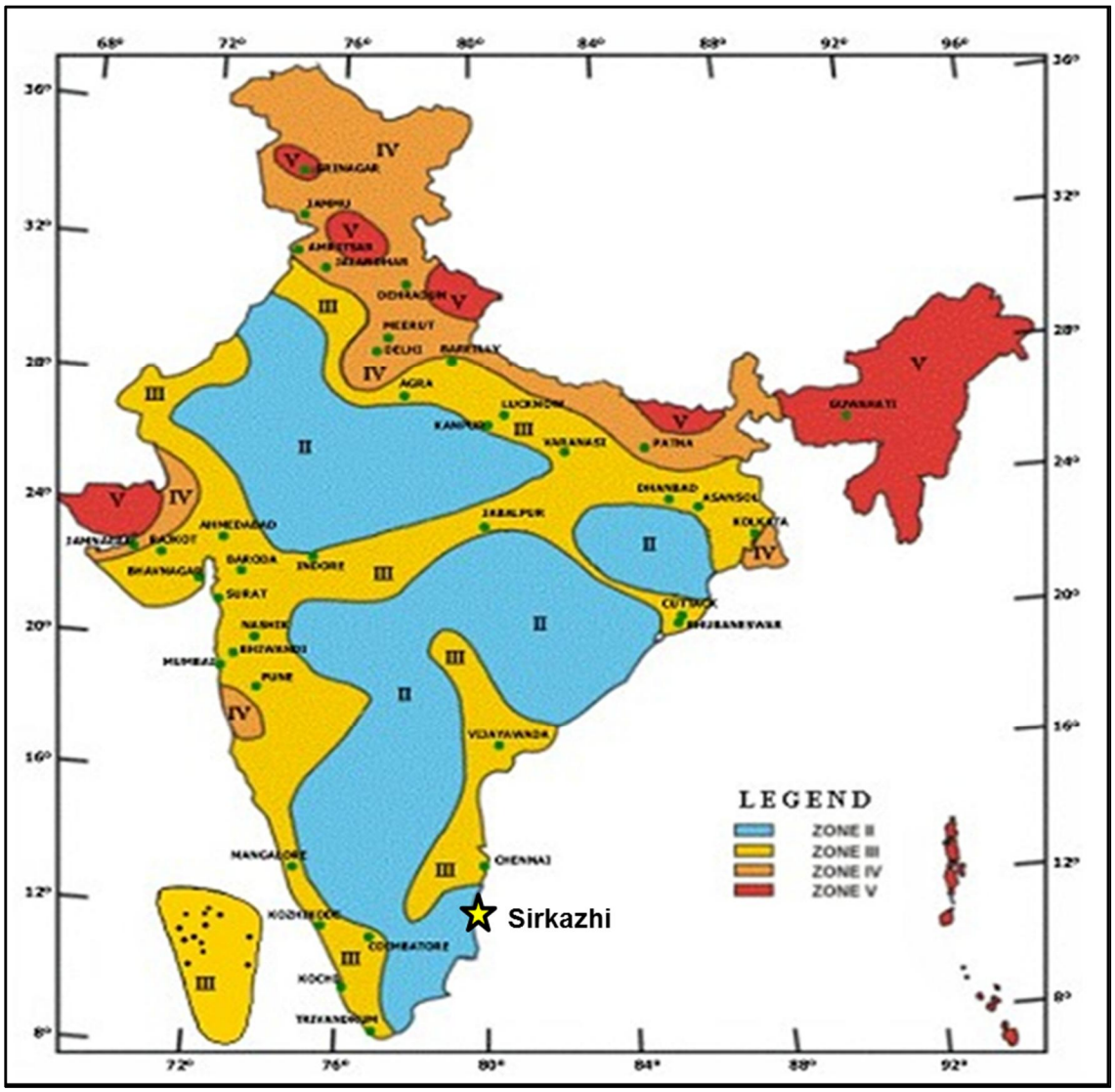


Figure 3.6 Seismic Zoning Map of India as per IS-1893 Part 1 – 2002

3.5 Geotechnical Data

Based on the available site data and information collected during the site visits, the geotechnical data indicates absence of any hard stratum like rock and presence of soft strata like dense fine silty sand along the seabed strata. The top layer is very loose to medium dense silty fine sand with less percentage of clay content. This stratum is followed with the layer of medium dense fine sand with the presence of silt. The depth of this layer varies from 15 m close to the shore. This layer is underlain with dense silty sand followed with the layer of very dense fine to medium course sand.

3.6 Topography

The proposed area for cargo storage and port operations shall be located along the stretch of 3 km of port waterfront area. Along this stretch Casuarina trees were observed along the shoreline covering almost entire 3 km stretch. The topographic details of the onshore area for port operation and storage have been extracted from source like Google Earth and processed through ArcGIS software. This information has been completed using the available land charts of the region. Proposed area of development is mostly flat with average ground elevations of varying from 1 m along the shore to 5 m. An average ground elevation of +1.5 m CD is considered.

The topographic details of the area are as shown in **Figure 3.7**.

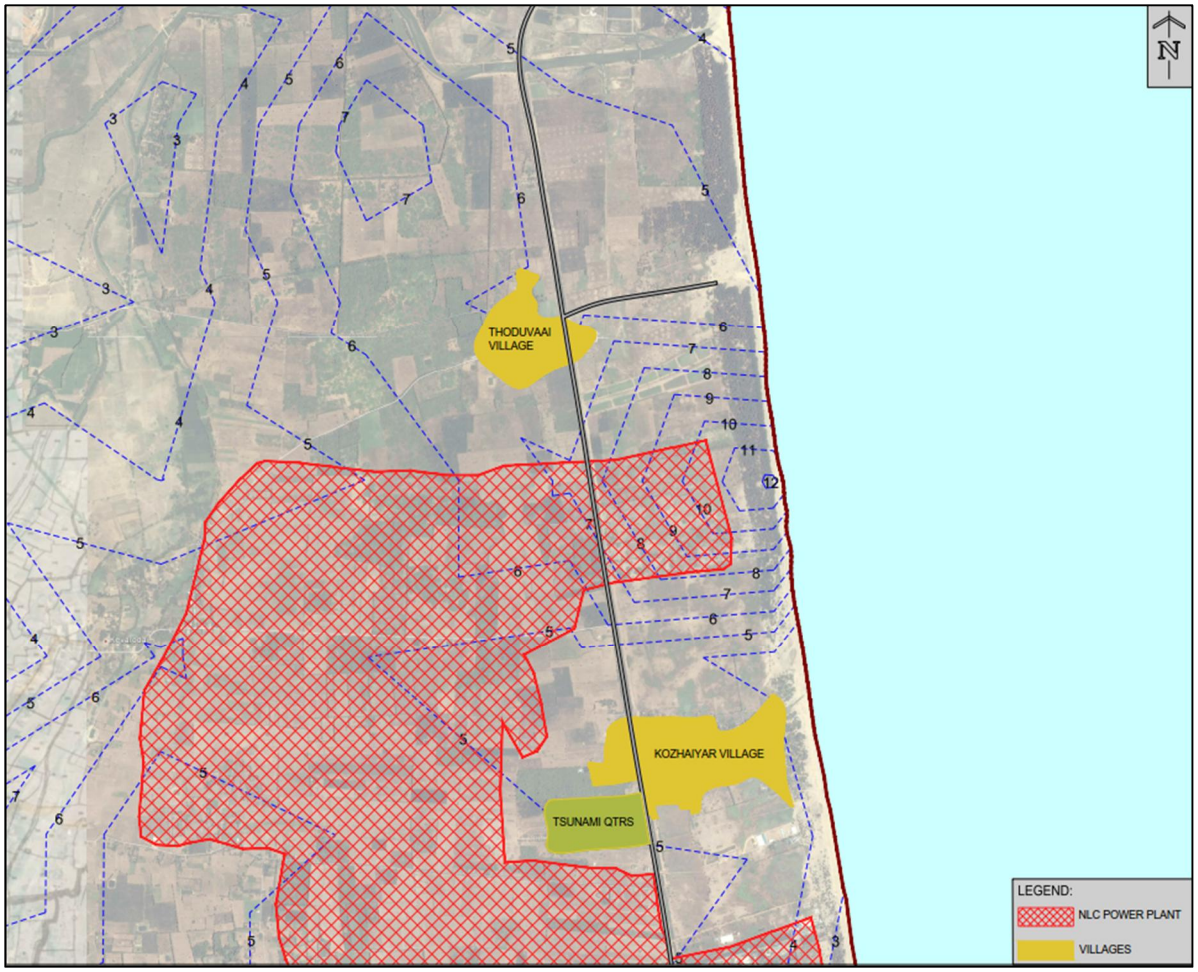


Figure 3.7 Topographic Details of the Proposed Sirkazhi Port Area

3.7 Connectivity of Port Site

3.7.1 Existing Rail Connectivity

The nearest railhead is at Sirkazhi (**Figure 3.8**) at a distance of about 14 km from the proposed port location. This location can be considered for rail head where the railway siding to the port site can be established. The station area shall include a secondary stackyard and siding facilities.

Figure 3.8 Sirkazhi Railway Station at Present

The existing rail network to Sirkazhi area is as shown in **Figure 3.9**

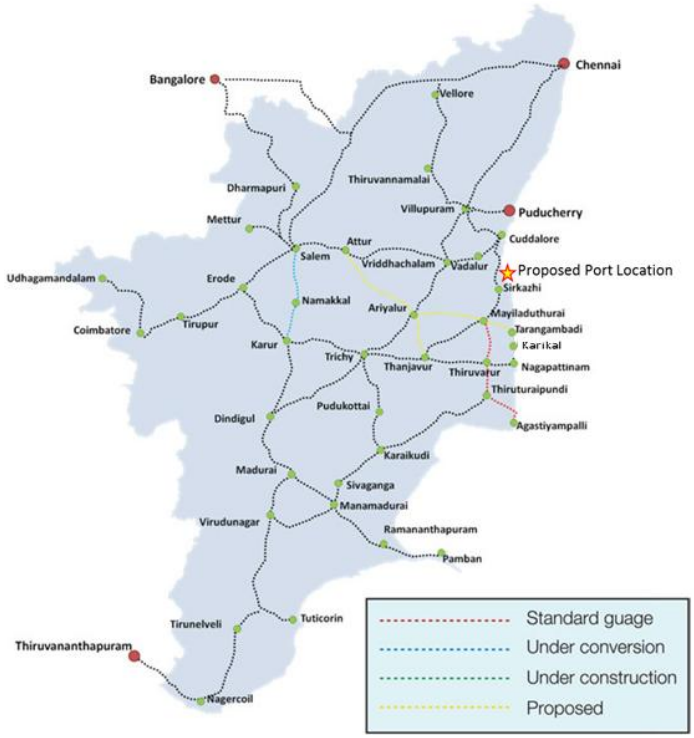


Figure 3.9 Existing Rail Connectivity

3.7.2 Existing Road Connectivity

The proposed port location is approximately 14 km from the East Coast Road (NH-45A), which passes through Cuddalore and links the proposed port to northern hinterland right up till Chennai. In addition to the national highways, a network of state highways connects Sirkazhi to other industrial centres of Tamil Nadu.

NH-67 starting from Nagappattinam (Approx. 60 km from the proposed port location and south of Karaikal) traverses Central Tamil Nadu in a near straight line connecting the major industrial areas such as Thiruchirapalli, Karur and Coimbatore as well as onward linkages to other industrial areas such as Salem, Erode and Mettur.

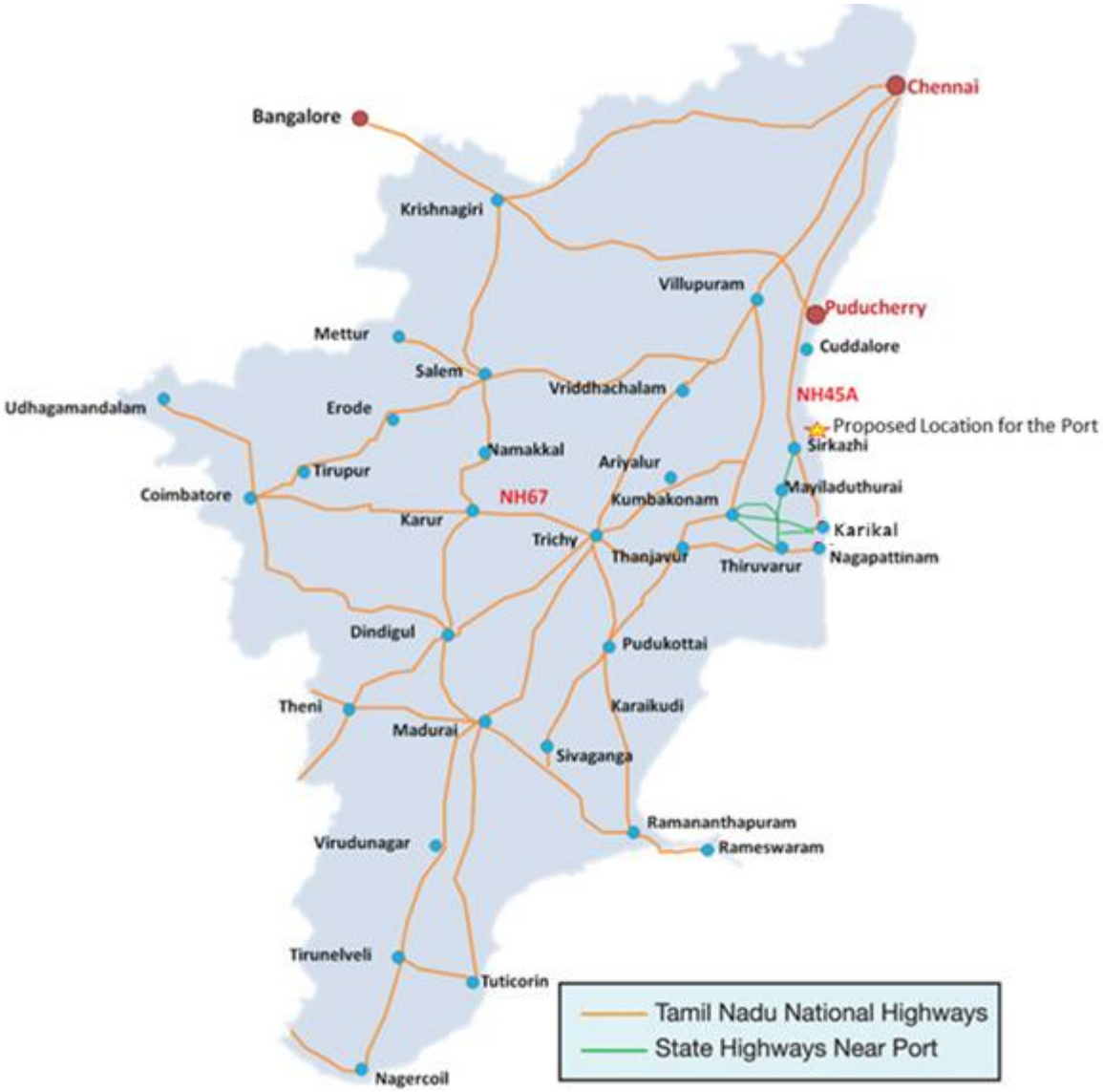


Figure 3.10 Existing Road Connectivity wrt Proposed Port

The proposed port location is connected via single lane road covering a total length of 14 km from Sirkazhi to Thirumullaivasal (about 6 km from proposed port location).

Figure 3.11 Road from Sirkazhi to Thirumullaivasal

3.8 Water Supply

The Madanam and Palaypalayam L&T water supply station supplies water to the adjoining 140 villages in the surrounding area, Thoduvaai also comes under its domain. This pumping station has a pumping capacity of 500,000 liters per day. The pumps are of 20 HP capacity and it is serving Thirumullaivasal village and its surroundings. To this pumping station additional water is pumped from Pannagattakudi borewells near Sithamalli village. Further additional water can be pumped from Collidam River, if required. Ground water table near Thoduvaai is good and available within 20 feet.

Figure 3.12 Existing Water Supply Station

To meet the water demand in the port area during the construction phase, water can be sourced from Collidam River. However, during operational phase of the port the water supply will be from the desalination plant.

3.9 Power Supply

33/11 KV substation is located at Edamanal (**Figure 3.13**) which is about 10 km away from the proposed port location (recently upgraded to HT substation). The substation has got 3 feeder lines which are at Thettai feeder, Kooliyar feeder and Thozilga feeder. The substation is working with 8,000 KVA capacity which can be enhanced suitably as per the requirement.

Figure 3.13 Electrical Substation at Edamanal

4.0 TRAFFIC PROJECTIONS FOR SIRKAZHI PORT

4.1 General

The origin-destination of key cargo for port at Sirkazhi and development of traffic scenarios for a period of 20 years, i.e. upto 2035 has been carried out by **McKinsey & Co.** as mandated for this project.

The proposed port site of Sirkazhi lies on the Southern coast of India in Tamil Nadu. It has operational major ports of Chennai and Ennore on the north and major port of Tuticorin on the south. Tamil Nadu would be the primary hinterland of the port. Considering the location of the proposed site and the presence of other ports in proximity, Sirkazhi port would have to compete for the same hinterland with ports of Ennore, Chennai, Karaikal, Tuticorin and Katupalli.

4.2 Major Commodities and their Projections

Thermal coal, coking coal, POL and containers would be the key commodities that can be catered to by the proposed port. Thermal coal, which is the major commodity for the port, would be diverted away from the existing ports of Ennore and Tuticorin. It has to be noted that all identified traffic is only potential and traffic commitments may be needed for final go-ahead.

4.2.1 Coal

The port is expected to divert part of the traffic currently handled by Ennore and Tuticorin ports. Neyveli Lignite Corporation, IL&FS and Mettur (TANGENCO) would be the key plants in the hinterland ideally placed to take supplies through the Sirkazhi port. These plants are closer to Sirkazhi port as compared to Ennore and Tuticorin ports.

In the case of IL&FS, as Sirkazhi cuts distance to the plant by 100 km, it is reasonable to expect this traffic at Sirkazhi port. In addition, Mettur plant can take coal from the proposed Sirkazhi port as it is also ~100 km nearer as compared to the next nearest port.

In 2020, it is also understood that Neyveli Lignite Corporation Ltd. is planning to set up a thermal power plant of 1,600 MW (2 × 800 MW) at Thirumullaivasal / Vettangudi (Sirkazhi site). As the proposed Sirkazhi port is the nearest port, it is expected that incremental ~6.6 MTPA of coal will be handled at Sirkazhi port in 2020.

In 2025, setting up of a power plant by SRM Energy in Cuddalore can also result in incremental traffic of ~6.1 MTPA for the proposed port. In the 2025 optimistic case, ~10 MTPA of coal traffic for upcoming plants of Patel Energy (Tirumalai) and 2 power plants of Sindhya Power at Nagappattinum has been accounted for in the projections. In addition, the 2025 optimistic case also assumes IL&FS to handle its coal traffic at the Sirkazhi port considering the port is the nearest to its power plants.

In 2035, the port is expected to handle, 6.1 MTPA of traffic for Mettur plant, 6.1 MTPA of traffic for SRM energy plant, ~10 MTPA of traffic for the plants of Patel energy and Sindhya power. In addition going forward in 2035, Phase II expansion of Neyveli Lignite Corporation can add an incremental traffic of ~6.7 MTPA. The 2035 optimistic case also assumes IL&FS to handle its coal traffic at the Sirkazhi port considering the port is the nearest to its power plants.

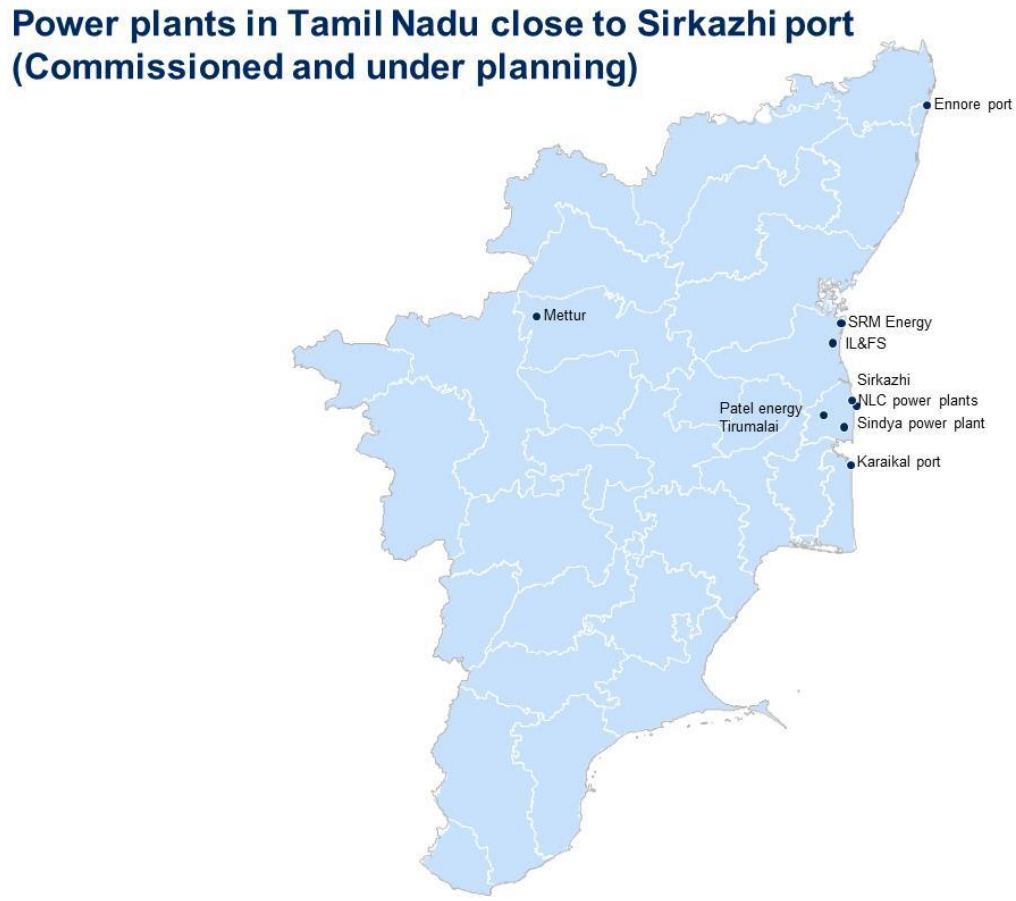


Figure 4.1 Location of Power Plants Close to Sirkazhi Port

Also, JSW Salem plant with a capacity of 1 MTPA is expected to add traffic of ~0.7 MTPA of coking coal to the proposed port.

4.2.2 Containers

The proposed port is expected to attract traffic of ~60,000 TEUs by 2020 primarily from the hinterlands of central Tamil Nadu. This traffic would be diverted mainly from the ports of Ennore and Chennai on the north and Tuticorin in the south. This traffic is expected to be generated from the hinterlands of Namakkal, Karur and Salem. The GDP of these hinterlands are expected to grow at a CAGR of 9-11% resulting in estimated traffic of ~80-97,000 TEUs by 2025.

In the case of a new transhipment hub coming up on the Southern tip of the country the potential traffic is expected to significantly decline owing to the fact that part of the Tamil Nadu containers will go directly to the transhipment hub.

4.2.3 POL

Tamil Nadu is expected to face a deficit of around 10 MTPA of MS/HSD deficits in the next 10 years. This deficit is proposed to be met by coastal shipping of product from Cochin refinery or other refineries on east coast of India (Vizag, Paradip etc.). The proposed port would be best positioned to serve the demand arising from the closest hinterland districts of Cuddalore, Ariyalur, Perarbelur etc. in the longer term it is proposed that a Greenfield refinery be set up in Central Tamil Nadu. Hence it has been assumed in the optimistic case, that a 10 MTPA Greenfield refinery will come up in Central Tamil Nadu and the refinery will use the port to meet its crude demand. The refinery capacity is proposed to go up to 20 MTPA by 2035 in order to meet the demand and consequently the crude traffic at port is expected to go up to 15-20 MTPA by 2035 in optimistic case.

4.2.4 Other Cargo

Other than the above mentioned commodities, break bulk and coastal cargo is expected to form a significant share of the total traffic owing to the rich hinterland of the proposed port site. Cuddalore, Ariyalur, Perarbelur, Tiruchirapalli, Salem, Namakkal, Karur and Erode are the key districts in the primary hinterland of the port. Proposed port of Sirkazhi is ideally located to serve the break bulk requirements of these districts. Consequently, the break bulk and coastal cargo traffic is expected to be ~2.7 MTPA by 2020 and 4-7.6 MTPA by 2025.

The overall commodity wise projections for the port are as shown in **Table 4.1**.

Table 4.1 Traffic Projection of Sirkazhi Port

Units: MMTPA (except Containers)

Sirkazhi Port - Traffic Projections

xx Base Scenario xx Optimistic Scenario

Commodity	2020	2025		2035	
Dry and Break Bulk Cargo					
Thermal Coal (Unloading)	22.5	28.6	38.6	45.4	45.4
Coking coal	0.7	0.7	0.7	0.7	0.7
Containers and other Cargo					
Containers ('000 TEUs)	57.6	79.5	97.2	188.3	275.9
Others	2.7	3.9	7.6	7.6	10.8
Liquid cargo					
POL	1.5	1.5	10	2	15
Total (MMTPA)	**28.3**	**35.9**	**58.4**	**58.5**	**76.0**

Conversion Factor Used for Containers Projections: 1 TEU = 15 Tons

The others cargo split are given in **Table 4.2**.

Table 4.2 Other Cargo Split - Traffic Projection of Sirkazhi Port

Units: MMTPA (except Containers)

Sirkazhi Port - Traffic Projections (Others)

xx Base Scenario xx Optimistic Scenario

Commodity	2020	2025		2035	
Others cargo					
Steel	0.4	0.5	0.5	1.0	1.0
Cement	0.3	0.4	1.9	0.9	2.3
Fertiliser	0.1	0.1	0.1	0.2	0.2
Food grains	0.6	0.7	0.7	1.0	1.0
Break bulk[1]	1.4	2.1	4.4	4.5	6.3
Total (MMTPA)	**2.7**	**3.9**	**7.6**	**7.6**	**10.8**

1 Break bulk assumes 10% of overall cargo

4.3 Cargo Considered for Proposed Port at Sirkazhi

For planning of Port at Sirkazhi, the phase wise traffic as shown in **Table 4.3** has been considered.

Table 4.3 Projected Cargo for Port at Sirkazhi

Cargo Handled	I/E	Projected Traffic (MTPA)		
		2020	2025	2035
Coal	I	17.7	28.6	46.1
Breakbulk & Containers	I/E	0.0	5.1	10.4
POL	I	0.0	1.5	2.0
Total		**17.7**	**35.9**	**58.5**

As the port would be developed primarily for handling coal and other traffic like breakbulk and containers may take to get built up, it is proposed that phase 1 be planned only for coal traffic. This would minimise the initial capital investment. Depending upon the user requirements other facilities could be added in later phases of development.

5.0 DESIGN SHIP SIZES

5.1 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

Coal is the main commodity to be handled at the proposed Sirkazhi Port. However, there will also be some potential for handling breakbulk and containers.

5.2 Dry Bulk Ships

Coal being the main cargo commodity proposed to be handled at the proposed port at Sirkazhi. 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.

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 400,000 DWT

Presently, the coastal shipping of thermal coal to southern states is carried out using ship sizes limited to Panamax. However, more and more facilities are being built in the southern states to receive vessels up to cape size and ports further north can handle vessels of 200,000 DWT. The coastal shipping in cape size carrier offer additional cost advantage for many of the users and it would be prudent, if the proposed port should also have unloading facilities for cape size ships.

5.3 Containers

Container ships are classified into six broad categories viz. Feeder, Feedermax, Handy, Sub-Panamax, Panamax and Post-Panamax. The following **Table 5.1**, which has been compiled through the Shipping Register of Lloyds Fairplay database, gives a broad outline of the principal dimensions of the ships under the different categories. The **Table 5.1** 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 its other facilities.

Table 5.1 Dimensions of the Smallest and Largest Ship

Parameters	1,000 TEU	2,000 TEU	4,000 TEU	6,000 TEU	9,000 TEU	14,500 TEU	16,000 TEU	Triple E	20,000 TEU
Nominal Capacity	1000	2000	4000	6000	9000	14500	16000	18000	20000
LOA (m)	160	200	290	320	350	365	400	400	400
Beam (m)	22	32	32	42	45	50	54	59	59
Loaded Draft (m)	10.0	11.0	13.5	14.0	15.0	16.0	15.5	16.0	16

[Source: Lloyds Fairplay database]

In view of its location, the port at Sirkazhi is expected to handle feeder vessels only and therefore the design ship size for container is likely to be limited to 4,000 TEUs.

5.4 POL

The liquid cargo mainly involve the product handling facility, the berth may be required to handle small tankers on exigencies. Hence, for laying out jetty the ship size ranging from 20,000 DWT to 80,000 DWT is considered for planning purpose.

5.5 Break Bulk Ships

The general cargo commodities such as steel, fertilizers, food grains, cement etc. are likely to be handled in ships, which range from 10,000 DWT to 65,000 DWT.

5.6 Design Ship Sizes

The principal dimensions of the ships considered for the preparation of the layouts and design of marine structures for the proposed port is presented in **Table 5.2**.

Table 5.2 Parameters of Ship Sizes

Commodity	Design Ship Sizes (DWT)	Maximum Parcel Size (T)	Overall Length (m)	Beam (m)	Loaded Draft (m)
Dry Bulk	80,000	72,000	240	32	14.5
	120,000	110,000	260	40	16.5
	200,000	200,000	300	50	18.3
Container	1,000 TEUs	700 TEUs	160	22	10.0
	4,000 TEUs	1,200 TEUs	290	32	13.5
POL	60,000	54,000	230	32	12.5
Break Bulk	65,000	60,000	240	32	14.5

[Source: Lloyds Fairplay database]

6.0 PORT FACILITY REQUIREMENTS

6.1 General

The layout of the master plan of any port should be based on the expected traffic at different timelines, size of ships, facility requirements in terms of number and length of berths, navigational requirements, material handling system, storage area required for each type of cargo, road and rail access for the receipt, evacuation of cargo, and other utilities and service facilities. The layout of the proposed port at Sirkazhi is prepared based on these.

The vessel size for Phase 1 needs to carefully chosen so that the capital investment commensurate with the traffic forecast. Accordingly, it is proposed to consider the following options for phasing of depths in approach channel and harbour basin:

1. Initial development for panamax size ships having draft of 14.5 m.
2. Initial development for cape size ships of draft up to 18.3 m.
3. Initial development for panamax size ships and deepening of the channel and harbour basin to handle cape size ships in phase-wise manner as per the market demand.

As the proposed port has to compete with adjacent port at Karaikal which can currently handle mini-cape size ships and can be deepened further upto -18.0 m dredged depth to handle 120,000 DWT cape size ships (draft 16.5 m), it would be Prominent that the port be planned to handle cape size ships at initial stage of development itself.

6.2 Berth Requirements

6.2.1 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.

6.2.2 Cargo Handling Systems

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

6.2.2.1 Dry Bulk Import

For bulk cargo, it is proposed to provide a fully mechanised coal handling system comprising of gantry type coal unloaders, conveyor system, stacker, reclaimers and in motion wagon loading system etc. It is expected that with the proposed handling arrangement about 45,000 T coal can be unloaded per day at one berth on an average.

6.2.2.2 Breakbulk and Containers

It is proposed to be handled through mobile harbour cranes with spreader arrangement. For handling at the container yard, suitable number of Rubber Tyred Gantry Cranes (RTGC's) shall be provided. At the railway yard reach stacker shall be provided for loading and unloading of rakes.

6.2.2.3 POL

The POL products are unloaded from the tankers by means of marine unloading arms and transferred to the tank farms through the pipelines. The unloading rates mainly depend upon the capacity of the on-board ships provided the matching capacity of unloading arms and pipelines are provided. The average handling rates achieved at berth for POL products is about 8,000 TPD.

6.2.3 Operational Time

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.

6.2.4 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.

6.2.5 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, 65% for 2 berths and higher for 3+ berths for similar commodity. This shall reduce the pre-berthing detention of ships and offer reduced logistics cost to the shippers.

6.2.6 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 6.1**:

Table 6.1 Berths Estimates for Port at Sirkazhi

S. No.	Berth Type	Commodities to be Handled	Import (I) / Export (E)	Total Berth Provided		
				2020	2025	2035
1.	Bulk Import	Coal	I	2	3	4
2.	Multipurpose Terminal	Break Bulk/ Containers	I/E	0	3	5
3.	POL	Liquid	I	0	1	1
	Total			**2**	**7**	**10**

6.2.7 Port Crafts Berth

For the initial stage development, the port would require 4 tugs (3 operational + 1 standby) with a capacity of 50 T bollard pull, 2 pilot launches and 2 mooring launches.

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

6.2.8 Length of the Berths

Length of a single berth for a commodity depends upon 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.

The proposed length of isolated berth for the different design ships are presented in **Table 6.2**.

Table 6.2 Total Berth Length

Berth Type	Design Ship Size	Design Ship's LOA (m)	Minimum Berth Length (m)
Bulk Berths	80,000 DWT	240	290
	120,000 DWT	260	310
	200,000 DWT	300	350
Breakbulk/ Containers	4,000 TEUs	250	300
	65,000 DWT	240	290

6.3 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.

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 per berth so as to allow faster turnaround and/or avoid delays to unloading of the ship.

For containers, the dwell time at port is a deciding factor. However, for some of the cargo, the annual throughput is relatively small as compared to the parcel sizes and hence the frequency of vessel calls will be low to moderate. This will, most likely allow for the clearance of the stored cargo prior to the arrival of the next shipment. Further, during cargo handling operations at the multi-purpose berths, part of the cargo is likely to be directly evacuated without passing through the storage area. Under these circumstances, the storage areas could be optimised at least for the initial stages of development. As far as thermal coal is concerned the main requirement is for the power plants in the near vicinity. It is therefore expected that this cargo would be moved out of the port through direct conveyor system or dedicated rail corridor.

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 16 Ha increasing to 85 Ha over the master plan horizon. This does not take into account the area of coal stackyard required for the proposed NLC power plant, which shall be located within the power plant boundary itself.

6.4 Buildings

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

6.4.1 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

6.4.2 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.

6.4.3 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.

6.4.4 Gate Complex

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

6.4.5 Substations

One substation is envisaged to be provided for coal terminal, apart from the main receiving substation at the terminal boundary.

6.4.6 Worker's Amenities Building

This shall provide locker and store rooms. It will also include bath and lavatory facilities. Separate buildings are envisaged based on various terminals to be developed.

6.4.7 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.

6.4.8 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

6.5 Receipt and Evacuation of Cargo

6.5.1 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.

Based on the market assessment and the infrastructure constraints, it is envisaged that the key cargo shall follow the evacuation pattern from Sirkazhi, as shown in **Table 6.3**.

Table 6.3 Cargo Evacuation Pattern from Proposed Port at Sirkazhi

S. No.	Commodity	2020		2025		2035	
		Road Share	Rail Share	Road Share	Rail Share	Road Share	Rail Share
		%	%	%	%	%	%
1.	Bulk Import*	0%	100%	0%	100%	0%	100%
2.	Breakbulk & Container	100%	0%	100%	0%	80%	20%
3.	POL	100%	0%	100%	0%	100%	0%

* This does not include coal for NLC, which shall be directly evacuated from berth to the power plant through conveyor

6.5.2 Port Access Road

The port would need to be connected to national highway for evacuation of the cargo by at least a 4 lane road initially. The width of the road shall be increased once the throughput picks up.

6.5.3 Rail Connectivity

The port shall be connected to the nearest rail link for effective evacuation of cargo.

6.6 Water Requirements

Water would be needed at the port for use of port personnel's, potable water for ships calling at this port, dust suppression, firefighting and miscellaneous uses.

It is estimated that the average water requirement for the initial phase development will be around 0.71 MLD increasing to about 2.10 MLD in the master plan phase.

6.7 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 12 MVA increasing to about 33 MVA in the master plan stage. The major requirement is on account of the proposed mechanised cargo handling system at coal berths.

6.8 Land Area Requirement for Port at Sirkazhi

Large backup area has always been a prime requirement for major port development anywhere in the world. Therefore, especially in the case of a completely new port, it will be prudent if a large area is specifically reserved for the long term development of the port, so that the port facilities which are so vital to the growth of the Nation can be developed easily to cater to its growing needs.

The land area required for the purpose of cargo handling, storage, port operations, rail and road connectivity, greenery etc. has been worked out as shown in **Table 6.4**.

Table 6.4 Land Area Requirement for Port at Sirkazhi

S. No.	Commodity	Allocated Area (sqm)		
		2020	2025	2035
1.	Storage Space for various Cargoes	1,59,629	4,89,967	8,51,211
2.	Internal Roads and Circulation Space in Storage areas @ 25%	39,907	1,22,492	2,12,803
3.	Rail and Road Corridor	1,97,000	6,04,673	10,50,487
4.	Port Building Complexes including parking	5,000	11,630	16,652
5.	Landscaping, Green belt and other for Expansion	1,32,507	4,05,491	7,03,281
	Total Land Area (Sqm)	**5,34,044**	**16,34,254**	**28,34,434**
	Total Land Area (Acres)	**132**	**404**	**700**
	Total Land Area (Hectares)	**53**	**163**	**283**

The master plan details have been worked out based on traffic studies only up to 2035. However, ports are normally planned for 50 to 70 years of growth and hence there is need to provide at least double the area over the area requirement assessed for the year 2035.

7.0 PREPARATION OF PORT LAYOUT

7.1 Layout Development

The key considerations that are relevant for the establishment of layout for the proposed port at Sirkazhi 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
  - Ability to cater for Littoral Drift
  - 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
  - Flexibility to Expand Beyond Master Plan Horizon
- Land Availability;
  - Availability of adequate back-up land for storage of cargo and port operations
  - Rail and Road Connectivity to the Hinterland
- Environmental and R&R issues related to development.

7.2 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 Sirkazhi.

7.2.1 Potential Traffic

The potential traffic that the proposed port could attract forms the first and foremost requirement of the project. Considering the site conditions and initial investment needed for creation of the basic port infrastructure, the projected traffic for the initial phases of development would govern the viability of Port development at Sirkazhi.

As indicated earlier, Sirkazhi port will immediately cater to the needs of three power plants, viz. Parangipettai (IL&FS), Mettur (TANGEDCO) & Vettangudi (NLC). Therefore, there is assured cargo in the Phase 1 port development itself.

7.2.2 Techno-Economic Requirements

7.2.2.1 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. The Karaikal port which is a potential competitor located towards south is close to this port location and can cater to small cape size ships, it would be important that the proposed port at Sirkazhi be designed for handling cape size ships.

7.2.2.2 Geotechnical Characteristics of the Site

The geotechnical characteristics of the site could be a key factor in capital cost of port development. Based on the information available, the seabed strata mainly comprise of loose to medium dense silty fine sand. Only part of the suitable dredged material shall be used for site grading and reclamation. The sea bed level indicates good founding strata for piled foundations. Therefore the geotechnical conditions at the proposed site are considered favourable for preliminary design purposes, but to be verified by marine SI in the later stages.

7.2.2.3 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. The ports located along east coast are subject to waves from NE direction during NE monsoons and that from SE direction during SW monsoon period. The orientation of the breakwaters would need to be decided accordingly.

7.2.2.4 Ability to Cater for Littoral Drift

The phenomenon of littoral drift of sediments along the east coast of India is well known. The drift of sediments along the coast is caused by the action of waves impinging on the coastline at an angle, and this slowly drives the material in the direction of the waves. This is predominantly from south to north along the east coast of India, but there is some reverse drift in the NE monsoon season.

7.2.2.5 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 and breakwater. The availability of these materials at a nearby location is favourable to economise the capital cost of port development. As per the information obtained during site visits, there are no quarries available for breakwater rock in Nagappattinam district and rock have to be brought from at least over 150 km away from Villupuram district. Any additional sources of rock shall need to be identified during detailed study.

7.2.2.6 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 operation.

7.2.2.7 Scope for Expansion Over the Initial Development

With the costly basic infrastructure like breakwaters, 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.

7.2.2.8 Flexibility for Development in Stages

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

7.2.2.9 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. This aspect shall be duly kept into consideration while deciding the design ship size for Phase 1 development so as to minimise the cost of capital dredging. Same is the case for reducing the area required to be reclaimed in the initial phase.

7.2.2.10 Flexibility for Expansion Beyond Master Plan Horizon

An important and sometimes forgotten aspect of Master Planning is to consider what may happen after the end of the immediate time horizon of the Master Plan study. The traffic projections for a 20 year period inevitably have more inbuilt uncertainty than the more immediate 5 year projections. Therefore the requirements in 2035 may be more than, or less than, or different from, what can be predicted now. Furthermore, the port traffic will not stop growing beyond 2035. Therefore in comparing the merits of different alternatives for Master Plan layout, preference should be given to those that allow space for further development.

7.2.3 Land Availability

7.2.3.1 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.

The area demarcated for the NLC power plant is as shown in **Figure 7.1**.

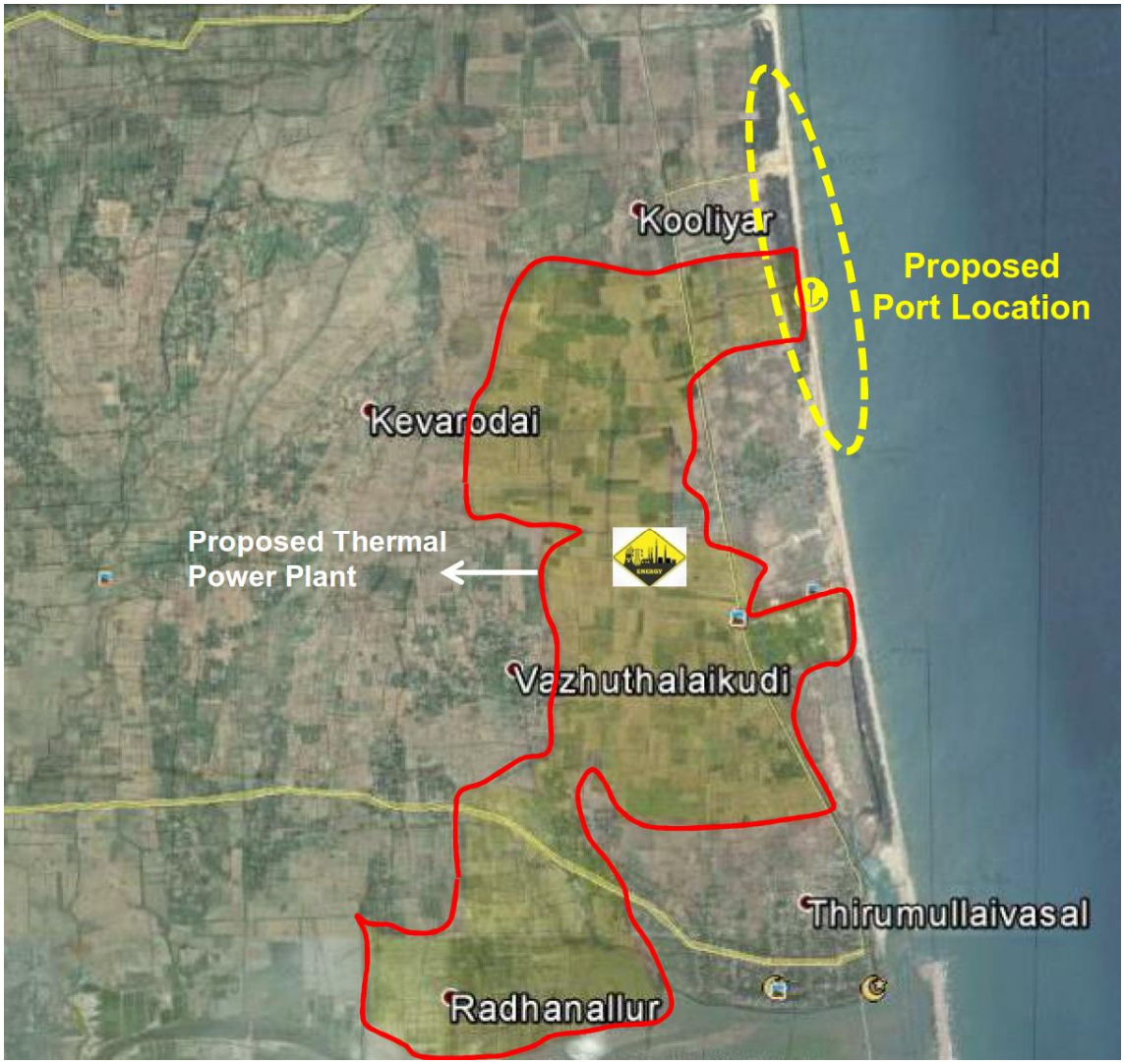


Figure 7.1 Land Area Demarcation of Proposed Neyveli Thermal Power Plant and Port

The area to the north of the power plant area along the coastal stretch of about 3 km is free of any habitations. The backup land of this area shall be utilised for locating the onshore facilities for the port. At the same time it shall also be ensured that the land acquisition is kept to minimal.

7.2.3.2 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. It shall be ensured that the road and rail alignment be selected in such a manner so as to minimise the need for any land acquisition and avoid conflicts with local traffic (if any).

7.2.4 Environmental Issues

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

7.3 Planning Criteria

7.3.1 Limiting Wave Conditions for Port Operations

7.3.1.1 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 seawards of the navigational channel then take the ship to the harbour or at the outer anchorage if it has to wait for a berth. 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.

7.3.1.2 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 H_s=1.0 m to H_s=1.5m depending on the type of tugs used.

7.3.1.3 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 ships due to wave action that will hamper the ship-shore handling operations. This limit varies with the handling system for 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 wave conditions exceed 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) for different wave directions for coal unloading operations are summarised in **Table 7.1**.

Table 7.1 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
Containers	0.5 m	0.5 m
Break bulk	1.0 m	0.8 m

7.3.2 Breakwaters

In view of the two monsoon seasons, it is possible to get the required tranquillity in the open sea for a limited period in a year only. This is determined by wave exceedance studies in the mathematical model. Handling the required number of ships during the limited number of operational days would require vast storage area to allow for the period of downtime. Hence there is a need for breakwaters to ensure the port is operable throughout the year.

The purpose of breakwater is to provide tranquil conditions inside the port under normal wave conditions. Breakwater is to be planned for predominant waves coming from southeast, east and northeast direction. This would require a south breakwater to protect harbour from the waves coming from southeast direction and a north breakwater to protect the harbour from North east waves. Final length and alignment of the breakwaters has to be decided based on the mathematical model studies for harbour tranquillity and the length shall be kept minimum, to limit the overall capital expenditure.

7.3.3 Navigational Channel Dimensions

The dimensions of the navigation channel to the terminal are dependent on the vessel size, and 1 or 2 way operation, the behaviour of the vessel when sailing through the channel, required tidal advantage, the environmental maritime conditions (winds, waves, currents) and the channel bottom conditions.

7.3.3.1 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 7.2**.

Table 7.2: Calculation of Channel Width based on PIANC Recommendations

PIANC Recommendations					
Basic Lane Width W_{bm} (multiple of ship beam B)	Vessel Speed	Outer Channel Exposed to Open Water	Inner Channel Protected Water	Channel	
				outer	inner
vessel manoeuvrability					
- good	all	1.3	1.3		
- 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		
(b) Prevailing cross wind (knots)					
- mild ≤ 15 (≤ Beaufort 4)	fast	0.1	0.1		
	mod	0.2	0.2		
	slow	0.3	0.3		
- moderate > 15 - 33	fast	0.3	0.3		
(> Beaufort 4 - Beaufort 7)	mod	0.4	0.4	0.4	0.4
	slow	0.6	0.6		
- severe >33 - 48	fast	0.5	0.5		
(> Beaufort 7 - Beaufort 9)	mod	0.7	0.7		
	slow	1.1	1.1		
(c) Prevailing cross current (knots)					
- negligible < 0.2	all	0.0	0.0		
- low 0.2 - 0.5	fast	0.2	0.1		
	mod	0.25	0.2		
	slow	0.3	0.3	0.3	0.2
- moderate >0.5 - 1.5	fast	0.5	0.4		
	mod	0.7	0.6		
	slow	1.0	0.8		
- strong > 1.5 - 2.0	fast	1.0	-		
	mod	1.2	-		
	slow	1.6	-		
(d) Prevailing longitudinal current (knots)					
- low ≤ 1.5	all	0.0	0.0	0.0	0.0
- moderate > 1.5 - 3	fast	0.0	0.0		
	mod	0.1	0.1		
	slow	0.2	0.2		
- strong > 3	fast	0.1	0.1		
	mod	0.2	0.2		
	slow	0.4	0.4		
(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	all	0.5			0.5
- H_s > 3 and l > L	all	1.0		1.0	
(f) Aids to Navigation					
- excellent with shore traffic control		0.0	0.0		
- good		0.2	0.2	0.2	0.2
- moderate		0.4	0.4		
(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
- 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	0.2		0.2
- < 1.25T (outer waterway)		0.2	0.4	0.2	
(i) Cargo Hazard Level					
- low		0.0	0.0	0.0	0.0
- medium		0.5	0.4		
- high		1.0	0.8		

PIANC Recommendations					
Basic Lane Width W_{bm} (multiple of ship beam B)	**Vessel Speed**	**Outer Channel Exposed to Open Water**	**Inner Channel Protected Water**	**Channel**	
				outer	**inner**
TOTAL ADDITIONAL MANOEUVRING WIDTH FACTOR W_i				**2.2**	**1.6**
PIANC Table 5.4 - Additional Width for Bank Clearance					
- Gentle underwater Channel slopw (<1:10)	fast	0.2			
	mod	0.1			
	slow	0.0			
- sloping channel edges and shoals	fast	0.7			
	mod	0.5		0.5	0.5
	slow	0.3			
- steep and hard embankments and structures	fast	1.3			
	mod	1.0			
	slow	0.5			
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	1.8		
	mod	1.6	1.4	1.6	1.4
	slow	1.2	1.0		
additional width for traffic encounter density					
- light	all	0.0	0.0	0.0	0.0
- moderate	all	0.2	0.2		
- heavy	all	0.5	0.4		
TOTAL EXTRA FOR STRAIGHT CHANNEL TWO-WAY TRAFFIC W_p				**1.6**	**1.4**
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)	
Cape Size Bulker	**50**
Panamax Size Bulker	**32**

	Channel Width	
	outer	**Inner**
one way straight channel		
Cape Size Bulker	**235**	**205**
Panamax Size Bulker	**150**	**131**
one way curved channel		
Cape Size Bulker	**244**	**214**
Panamax Size Bulker	**156**	**137**
two way straight channel		
Cape Size Bulker +Panamax Size Bulker	396	340
two Panamax Size Bulker	320	275
two way curved channel		
Cape Size Bulker +Panamax Size Bulker	**410**	**355**
two Panamax Size Bulker	**332**	**287**

The calculated channel width for various design ship sizes is summarised below in **Table 7.3**.

Table 7.3 Particulars of Navigational Channel for Design Ships

Design Ship Size (DWT)	Beam (m)	Channel Width (m)				Loaded Draft (m)
		Straight Channel		Curved Channel		
		One Way	Two Way	One Way	Two Way	
2,00,000	50	240	400	250	410	18.3
80,000	32	150	320	160	330	14.5

The channel length for handling 2,00,000 DWT ships works out to approximately 3.4 km and therefore the transit time of the ships in the channel will be about 0.3 hours at 8 knots speed. Allowing for time required for tugs attachment, manoeuvre and tug return for next ships as 1.3 hour, maximum of 18 ship movements per day (9 in and 9 out) could be accommodated with one set of tugs. Taking an average of about 16 ship movements per day in the channel, a one way channel can handle about 2,920 ship calls per year using one set of tugs. Considering the projected traffic and consequent ship movements, one way channel would be adequate for the proposed port.

7.3.3.2 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 as calculated in **Table 7.4**:

Table 7.4 Dredged Levels at Port for the Design Ships

Ship Size	Draft (m)	Approach Channel Outside Breakwater (m CD)	Inner Channel and Manoeuvring Area (m CD)	At Berths (m CD)
80,000 DWT	14.5	16.7	16.0	16.0
2,00,000 DWT	18.3	21.0	20.1	20.1

It may however be noted that above values are arrived at considering the design ship navigates the channel and harbour basin during low water levels and therefore without the advantage of tide. There is a opportunity to reduce the dredging quantity at the implementation stage.

7.3.4 Elevations of Backup Area and Berths

Considering the mean high water level as +1.1 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 proposed as +4.5 m CD. The finished levels of onshore areas will be kept at around +4.0 m CD.

7.4 Alternative Marine Layouts

Two basic layouts for the port development have been considered for the Port at Sirkazhi, keeping in view various considerations discussed above. These are discussed below:

Alternative Layout 1 involves offshore harbour option where the harbour area is located away from the shore. The master plan and Phase 1 development of this is alternative are shown in **Drawings DELD15005-DRG-10-0000-CP-SRK1001** and **SRK1002** respectively. The breakwater in this alternative extends up to 15 m contour. This alternative involves higher cost for breakwaters but less for dredging. Also the berths are away from shore resulting in higher cost of approach trestle and conveyor system. It is proposed to provide only a south breakwater with two berths in its lee for Phase 1 development. This arrangement is likely to provide adequate protection to the berths and harbour area for round the year operations. The root of south breakwater is located towards the southern boundary of the NLC plot. The channel orientation at harbour entrance is from NNE direction and after some distance from entrance it take a turn towards ENE direction to minimise the length to reach 20 m contour.

Alternative Layout 2 is a coastal harbour option with berths located closer to the shore as compared to alternative layout 1. The breakwater extends only up to 11 m contour and therefore shorter in length. However, dredging quantity would be higher. The master plan and Phase 1 development of this is alternative are shown in **Drawings DELD15005-DRG-10-0000-CP-SRK1003** and **SRK1004** respectively. The channel orientation is similar to that in alternative 1. The port location in this layout is shifted towards north by about 2 km to check its suitability as compared to location in alternative 1. Therefore root of the south breakwater is located towards northern boundary of the NLC plot and the onshore and reclaimed back-up areas are better integrated.

7.5 Evaluation of the Alternative Port Layouts

7.5.1 Cost Aspects

One of the key considerations for the layouts evaluation is that it should be able to handle the project throughput in phased manner keeping the capital cost of development especially that of Phase 1 development as optimum. It is to be noted that the items such as Berths, approach trestle and Equipment are of minor cost difference while some of the items such as Stacking areas, Internal Roads and Railway, Port Crafts, Navaids, Utilities, Buildings etc. are of negligible cost difference for both alternative layouts. Therefore, for cost comparison for these two alternative port layouts, items of major cost difference need to be considered, as presented in **Table 7.5**.

Table 7.5 Cost Differential (Rs. in Crores) of Key Items for Alternative Layouts

Item	Phase 1 Development		Master Plan Development	
	Layout 1	Layout 2	Layout 1	Layout 2
Breakwaters	832	505	1208	711
Dredging*	75	180	465	477
Reclamation	92	92	195	182
Total	**1000**	**778**	**1868**	**1371**

* In above table it is assumed that dredging for cape size ships shall be carried out for master plan layout. However in case dredging is carried out for cape size ships in phase 1 development the cost of dredging would be Rs. 177 crores and Rs. 344 crores respectively for layout 1 and 2.

7.5.2 Fast Track Implementation of Phase 1

It is anticipated that the breakwaters construction would be on the critical path for the port development. The quantities of rock in the breakwaters and the estimated breakwater construction time are calculated approximately as given **Table 7.6**.

Table 7.6 Estimated Rock Quantity and Construction Time of Breakwater

Alternate	Estimated Rock Quantity (MT)	Estimated Construction Time (months)
Alternative 1	5.4	45
Alternative 2	3.2	34

7.5.3 Available Land for Phased Development

The selected port layout should be able to expand in a phased manner to meet the market demand. Considering a patch of state government land right opposite the waterfront, it is required that limited land could be reclaimed utilising the suitable dredged material for the required cargo storage and operational areas.

7.5.4 Expansion Potential

It is observed that alternative layout 1 offer higher number of berths as compared to alternative 2. However, considering the traffic projections, the number of berths available in alternative 2 are considered adequate.

7.6 Multi Criteria Analysis of Alternative Port Layouts

The above alternative port layouts were evaluated using a Multi-Criteria-Analysis. The comparison of these layouts is presented in the **Table 7.7**.

Table 7.7 Multi-Criteria Analysis of Alternative Layouts

S. No.	Factor Description	General	Alternative 1	Alternative 2
1.	**Soil Profile**	The soil characteristic would dictate the cost of dredging and marine structures.	The soil comprises of loose to medium dense silty sand and thus easy to dredge. Also it provides a reasonable founding strata for breakwaters and piled foundation	Same as Alternative 1.
2.	**Material for Reclamation Fill**	The borrowed fill material would be costly due to distant location of quarries.	Part of the dredged material could be used for reclamation.	Same as Alternative 1.
3.	**Protection to the Berths from Waves and Swell**	The predominant wave direction is from ENE and ESE	The proposed breakwaters provide adequate tranquility to the berths	Same as Alternative 1.
4.	**Ability to Cater to Littoral Drift**	The scheme should be able manage littoral transport so as to minimize the shoreline changes	Sand trap could be provided along the south breakwater to manage littoral drift	Same as Alternative 1.
5.	**Suitable Location of back-up Land for Storage of Cargo and Port Operations**	The storage area should located close to the berths so as to provide faster receipt / evacuation of cargo and also provide separation between dirty and clean cargo	Storage area much further from the bulk berths, requiring longer conveyors. Clear segregation of cargo.	Effective utilization of backup area. Clear segregation of cargo.
6.	**Provision for Rail and Road Connectivity**	The port layout should be such so as to be able to be connected to the main road and rail networks	Suitable rail and road connectivity can be provided in the land proposed to be acquired for port development	Same as Alternative 1.
7.	**Environmental issues Related to Development**	Pitchavaram Mangroves forest	Proper EMP needs to be prepared to avoid any impact of proposed development.	Same as Alternative 1.
8.	**Potential Reclamation Area**	The higher reclamation area could be used to meet the storage and operation requirements of master plan stage	Reclamation area has to be minimum to reduce the cost. Already adequate land required for storage and port operations in phase 1 is available.	Same as Alternative 1.

S. No.	Factor Description	General	Alternative 1	Alternative 2
9.	**Capital Cost of Phase 1 Development**	Optimized capital cost for the initial phase development so as to increase the project viability	Base case	Lower than alternative 1
10.	**Expansion Potential**	Maximum number of berths possible in the harbour so as to meet the demand at least for master plan horizon	Total 11 berths possible with potential for more berths	Only 9 berths would be possible

7.7 Proposed Port Master Plan Layout

Based on above assessment it is observed that alternative 2 involving shorter breakwaters involves lower capital investment and implementation time and therefore recommended to be taken up. The recommended port master plan layout is shown in Drawing **DELD15005-DRG-10-0000-CP-SRK1006**.

7.8 Recommended Phase 1 Layout

From **Table 7.5**, it may be noted that the difference of cost of dredging for panamax and capesize facilities is only Rs. 164 Cr, it is recommended to develop capesize facilities in Phase 1 itself in order to be competitive with the neighbouring ports.

Drawing **DELD15005-DRG-10-0000-CP-SRK1007** presents, Phase 1 layout of the recommended master plan layout of the port. In this recommended alternative, it is suggested that only offshore portion of the south breakwater be built first. This will have the following advantages:

1. The rock quantity required to build the breakwater will reduce resulting in some cost reduction.
2. The breakwater not being connected to shore will not block the littoral movement of the sediments and hence minimise any shoreline changes.
3. The harbour area being sufficiently away from shore the sedimentation would be very much limited and also shadow effect (Tombola effect) due to offshore breakwater is not expected.

7.9 Phasing of the Port Development

The key port facilities that shall be developed in the phased manner over the master plan horizon are indicated in **Table 7.8**.

Table 7.8 Phasewise Port Development over Master Plan Horizon

Description	Total Port Facilities in Each Phase	
	Phase 1 Year 2020	Master Plan - Year 2035
Maximum Ship Size		
Number of Berths (Total length of berths in meters)		
• *Dry Bulk (DWT)*	*200,000*	*2,00,000*
• *Breakbulk (DWT)*	*0*	*65,000*
• *Containers (TEUs)*	*0*	*4,000*
• *POL (DWT)*	*0*	*60,000*
Navigational Areas		
• *Bulk Berths*	*2*	*4*
• *Multipurpose berths*	*0*	*4*
• *POL berths*	*0*	*1*
Breakwaters		
• *Length of Approach Channel (m)*	*3.4*	*3.4*
• *Width of Approach Channel (m)*	*240*	*240*
• *Diameter of Turning Circle (m)*	*600*	*600*
Design Draft of the Ship (m)	18.3	18.3
• *South Breakwater (m)*	*1700*	*3400*
• *North Breakwater (m)*	*0*	*1200*
Dredged Depths at Port (m below CD)		
• *Approach Channel*	*21.0*	*21.0*
• *Manoeuvring Areas*	*20.1*	*20.1*
• *Berths*		
o *Bulk*	*20.1*	*20.1*
o *Breakbulk/Containers*	*0*	*14.5*
o *POL*	*0*	*14*
Incremental Dredging Quantity (million cum)	*17.2*	*6.7*
Incremental Reclamation Quantity (million cum)	*4.6*	*4.5*
Total Reclamation Area (Ha)	*0*	*70*

8.0 ENGINEERING DETAILS

8.1 Mathematical Model Studies on Marine Layout

8.1.1 Model Inputs

MIKE 21 BW based on the Boussinesq's equation is applied to carry out the wave agitation study, which determines the tranquillity inside the harbour. MIKE 21 BW is a non-linear wave model and it simulates in the time domain the propagation of irregular, directional waves into the harbour taking into account all important effects like shoaling, depth refraction, diffraction, bottom friction, partial and full reflection, and transmission through porous structures.

The model bathymetry was created using the breakwater configuration and the approach channel shown in **Figure 8.1**. All the numerical simulations of the wave agitation were carried out with a water level corresponding to the Chart Datum (CD).

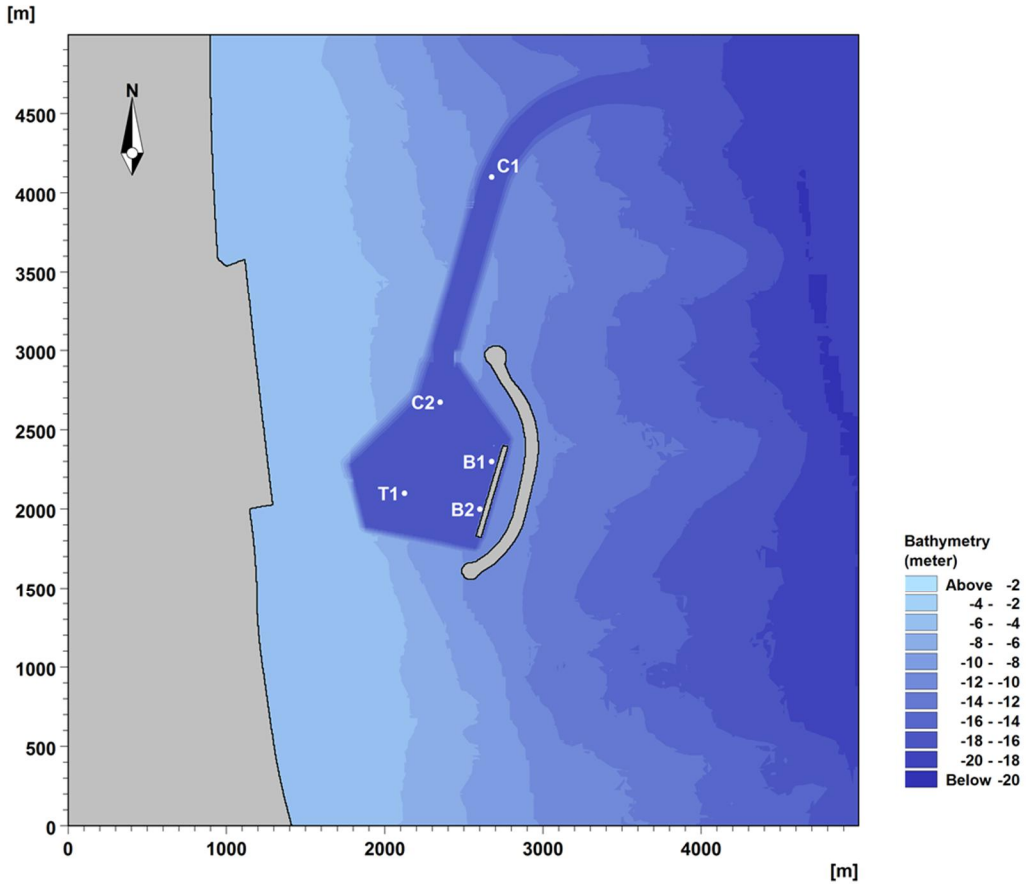


Figure 8.1 Bathymetry Used for the BW

The waves in the numerical model were generated along the open boundaries and to avoid reflection on the boundaries of the model thus so-called sponge layers (layers which smoothly absorb all wave energy entering the layers) were introduced along the open boundaries of the model. Sponge layers were also introduced at the land and closed boundaries (**Figure 8.2)**.

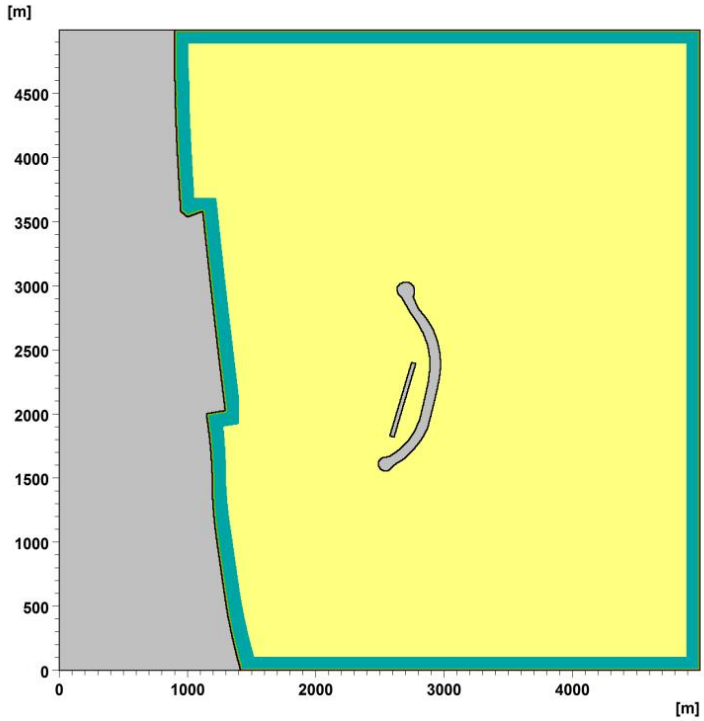


Figure 8.2 Sponge Layers (in Green) along the Non-Reflecting Boundaries

Various structural components of the port like Breakwaters, riveted banks, sheet piles, and vertical block works etc. have their own wave absorption capacity and reflectivity. In order to reproduce the structures in the model, different reflection and absorption coefficients are provided in the model as porosity layers (**Figure 8.3**). For the present study, the porosity coefficient for the breakwater has been taken as 0.5 while that for berths a value of 0.8 has been considered.

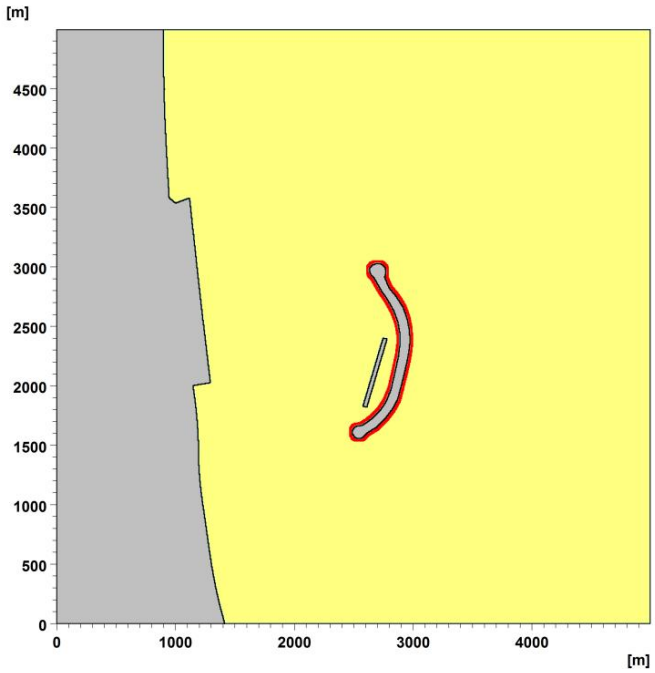


Figure 8.3 Porosity Layers (in Red) along the Port Structures

The proposed layout provides effective protection from E, SE, SSE and partially from the NE and NNE. Thus the partially protected directions were chosen to carry out wave agitation simulations. The input wave heights were taken as 1.0 m with peak wave period of 6.5 s.

8.1.2 Model Results

Figure 8.4 to **Figure 8.6** provides wave diffraction patterns after encountered within the breakwater from NNE, NE, E, SE and SSE directions respectively. In order to access the wave impact on entire breakwater the grid is been tilted about 45 degrees for the above mentioned respective directions except E direction.

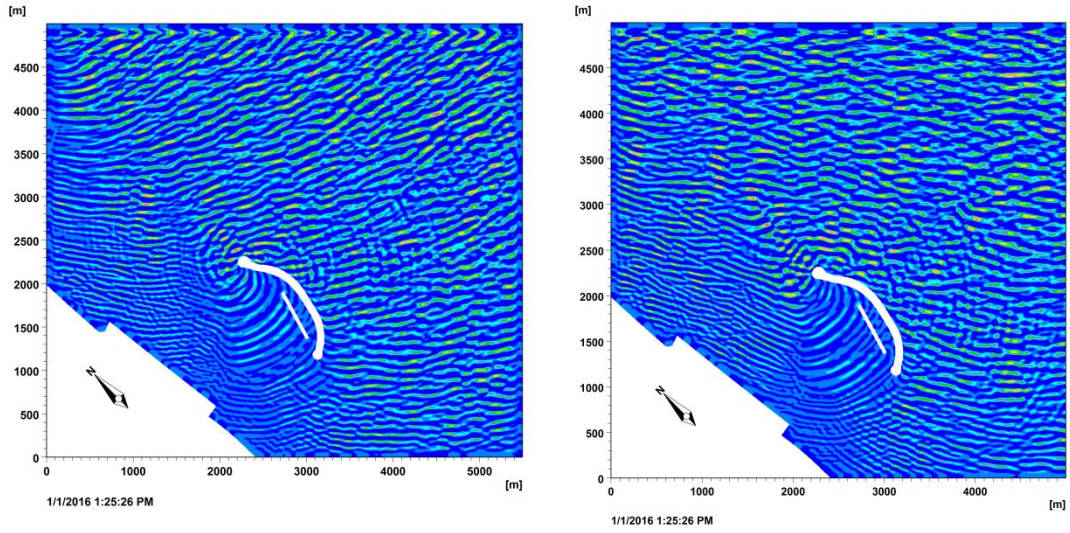


Figure 8.4 Wave Diffraction Patterns after Breakwater from NNE (Left) and NE (Right)

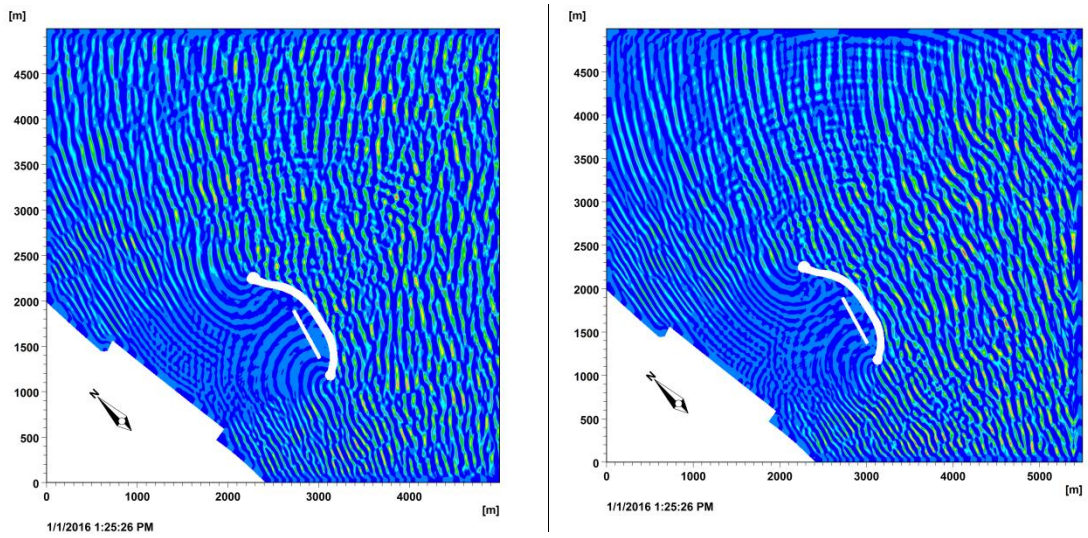


Figure 8.5 Wave Diffraction Pattern after Breakwater from SE (Left) and SSE (Right)

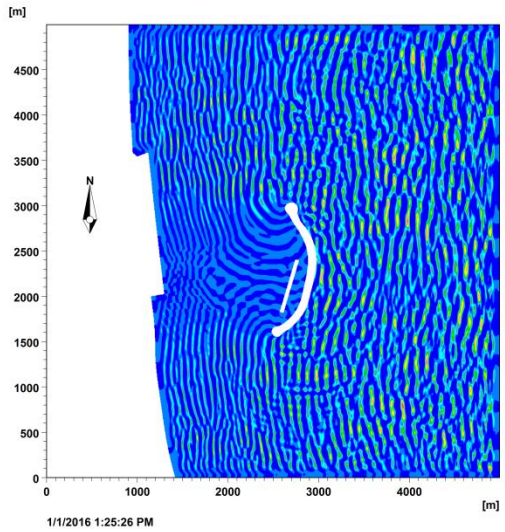


Figure 8.6 Wave Diffraction Pattern after Breakwater from E

Figure 8.7 to **Figure 8.11** provides wave height that may be encountered within the harbour under the impact of 1 m waves from NNE,NE, E, SE and SSE directions respectively. It may be observed that the wave entering the harbour have maximum impact at the berth locations and turning circle, while NE, E, SE and SSE waves are attenuated at the breakwater.

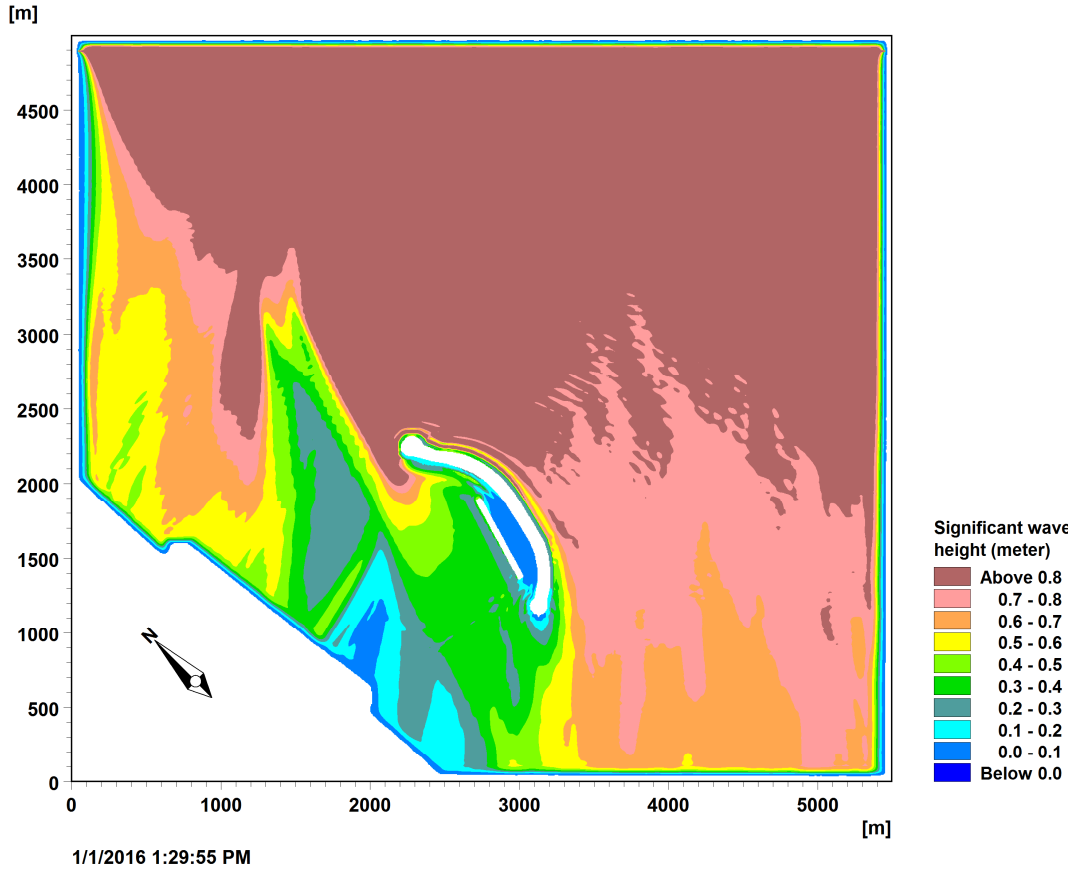


Figure 8.7 Wave Tranquility Assessment for Waves from NNE Direction

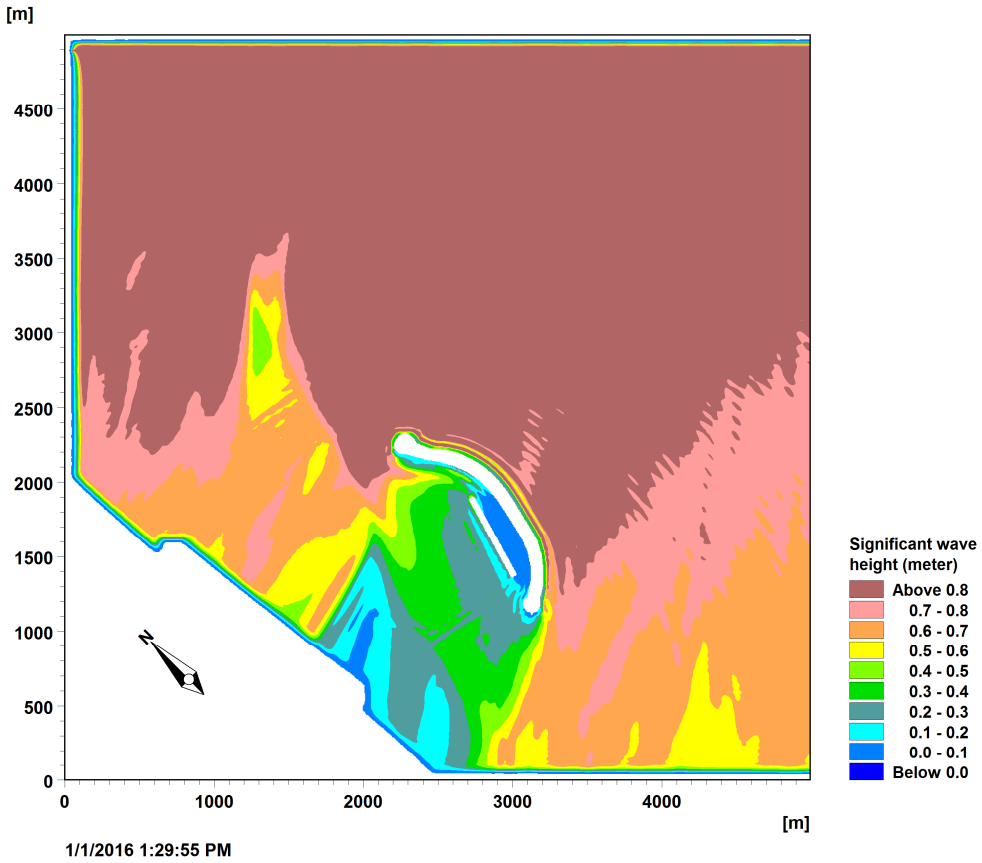


Figure 8.8 Wave Tranquility Assessment for Waves from NE Direction

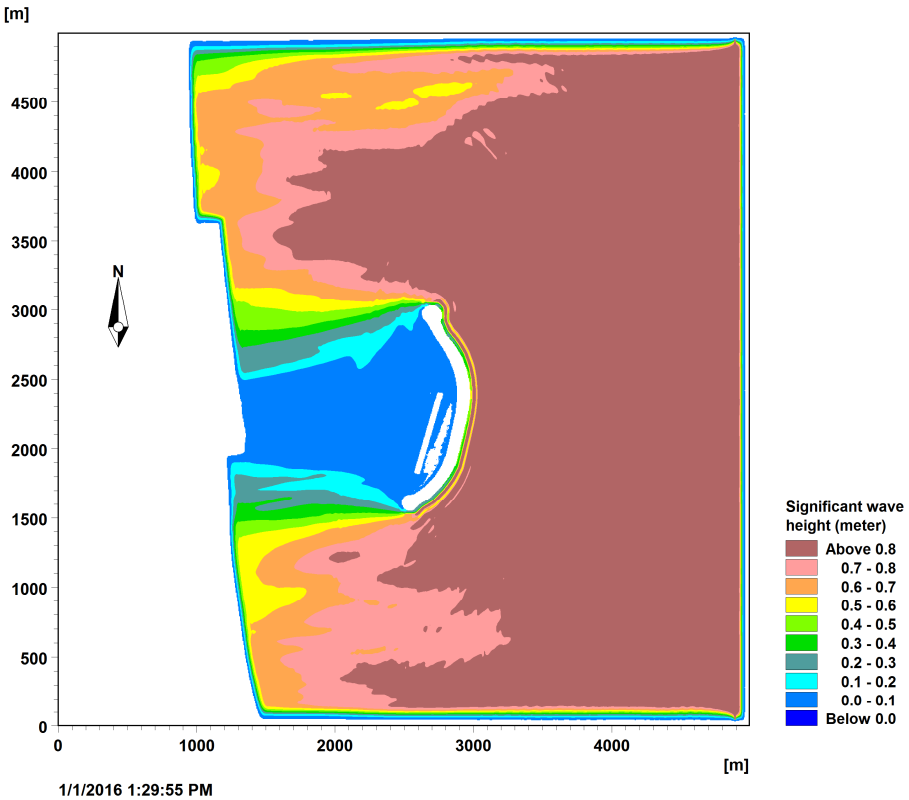


Figure 8.9 Wave Tranquility Assessment for Waves from E Direction

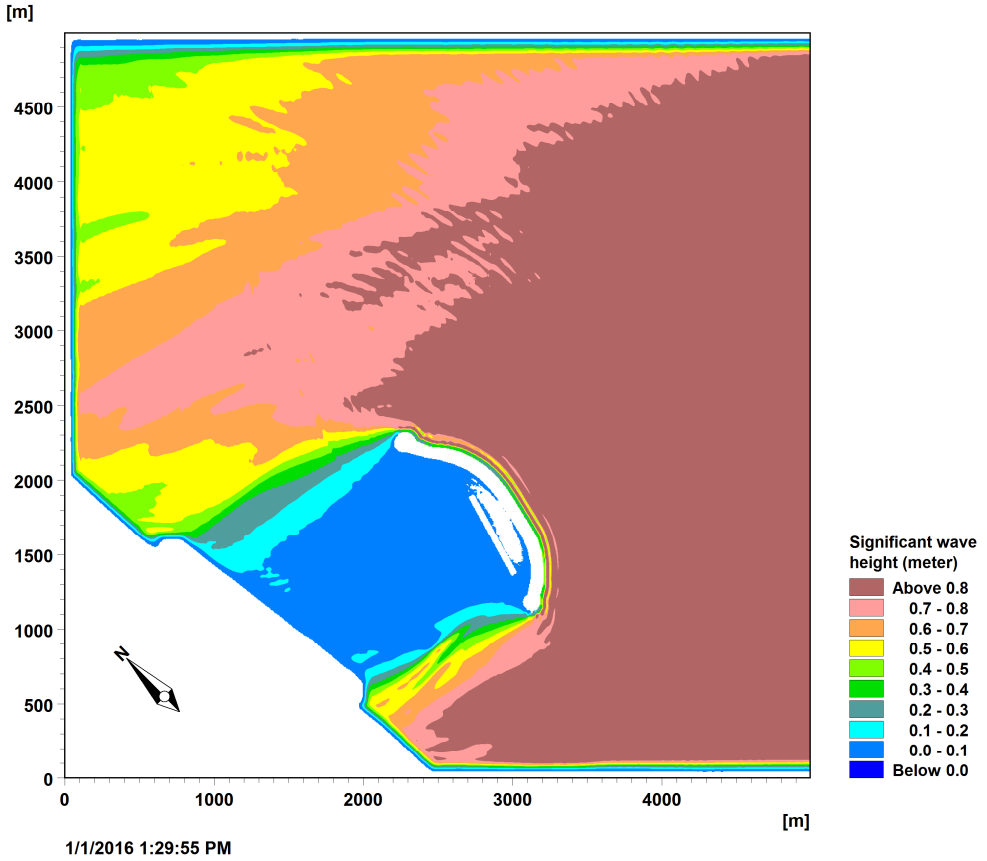


Figure 8.10 Wave Tranquility Assessment for Waves from SE Direction

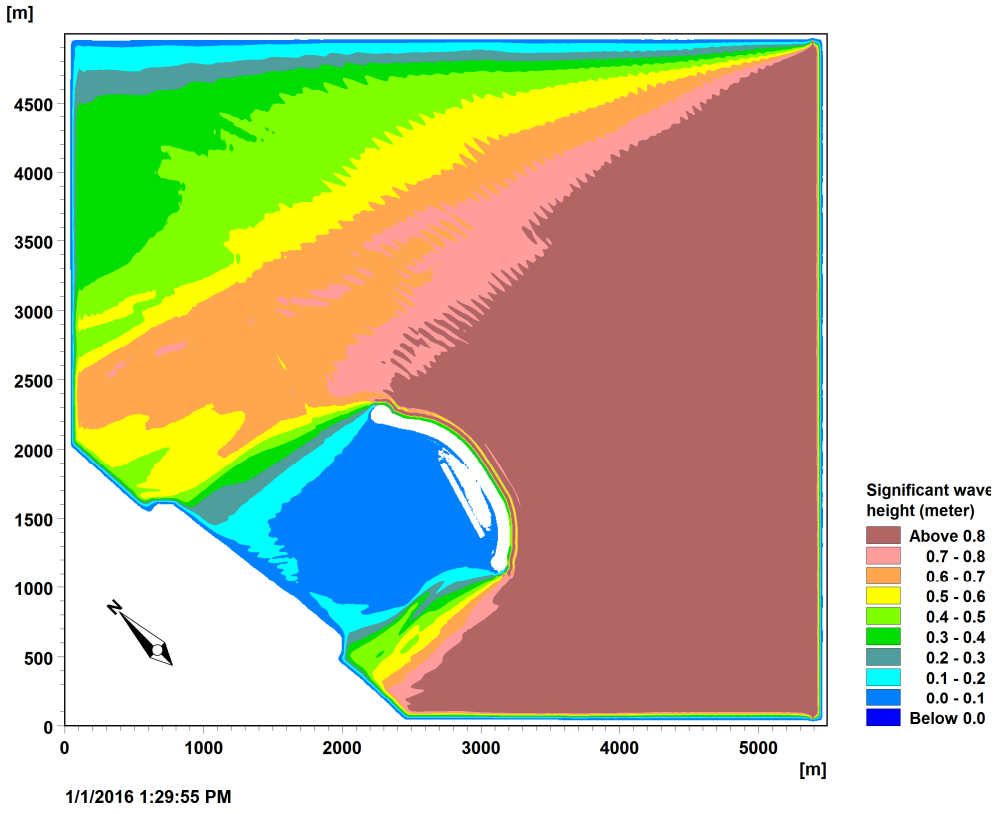


Figure 8.11 Wave Tranquility Assessment for Waves from SSE Direction

Based on the model runs carried out for the above conditions the wave disturbance coefficients i.e. ratio of H_{mo} (Site)/H_{mo} (incoming), are calculated at the locations of proposed berths and turning circle (**Table 8.1**).

Table 8.1 Wave Disturbance Coefficients

Label	Description	NNE	NE	E	SE	SSE
C1	Outer Channel	0.6	0.6	0.9	0.8	0.6
C2	Inner Channel	0.6	0.5	0.1	0.04	0.04
T1	Turning Circle	0.4	0.3	0.1	0.1	0.04
B1	Berth 1	0.2	0.2	0.03	0.03	0.02
B2	Berth 2	0.2	0.2	0.05	0.03	0.02

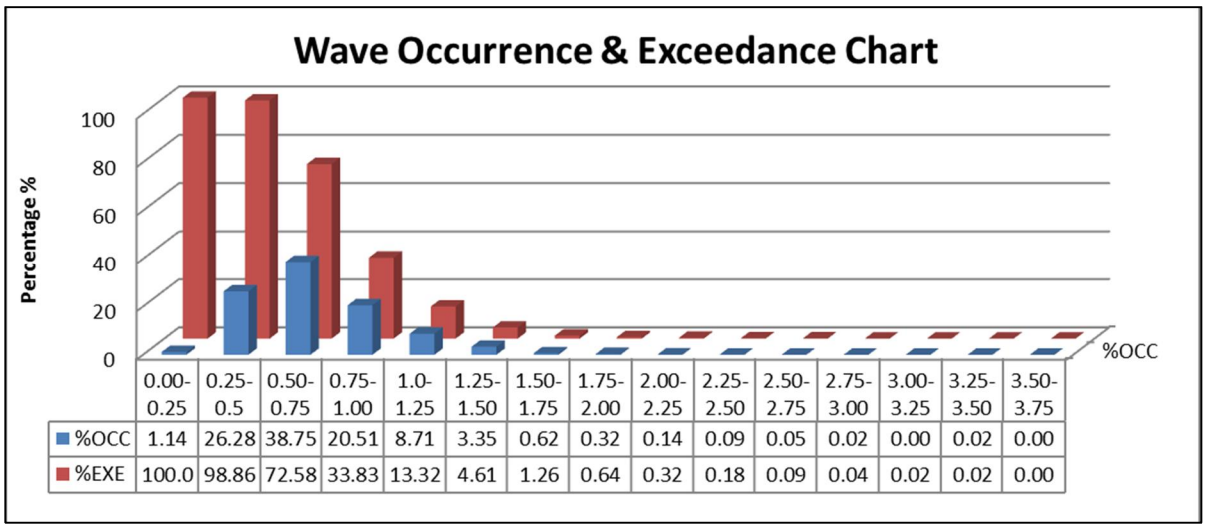
Using these coefficients, a representative mean significant wave height (Hm0, mean) can be estimated by multiplication of the wave disturbance coefficient of the area with the incident significant wave height (Hm0) outside. As may be seen from the **Table 8.1** above, coefficient of only 0.2 reaches location B1 if incident wave of 1 m approach the port from NE direction.

8.1.3 Outcome of Model Studies

Considering that the berths under consideration are for handling bulk cargo, cargo handling operations can be effectively undertaken for a significant wave height of 1.0 m, which corresponds to an offshore incident wave height of more than 2.5 m.

Based on the percentage exceedance of waves at 20 m contour (**Table 8.2**), it is assessed that waves exceeding even 2m are negligible and hence it may be safely concluded that downtime at the port with proposed layout is practically nil under the normal wave conditions.

Table 8.2 Percentage of Wave Occurrence and Exceedance



	0.00-0.25	0.25-0.5	0.50-0.75	0.75-1.00	1.0-1.25	1.25-1.50	1.50-1.75	1.75-2.00	2.00-2.25	2.25-2.50	2.50-2.75	2.75-3.00	3.00-3.25	3.25-3.50	3.50-3.75
%OCC	1.14	26.28	38.75	20.51	8.71	3.35	0.62	0.32	0.14	0.09	0.05	0.02	0.00	0.02	0.00
%EXE	100.0	98.86	72.58	33.83	13.32	4.61	1.26	0.64	0.32	0.18	0.09	0.04	0.02	0.02	0.00

8.2 Onshore Facilities

The main consideration, in locating the facilities has been to minimise the land acquisition. Therefore, while the initial onshore facilities have been located on a narrow strip of land along the shoreline, the land needed for future expansion has been located on reclaimed land.

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.

8.3 Breakwater

8.3.1 Basic Data for Design of Breakwater

8.3.1.1 Design Wave Height

The probable significant wave heights off Sirkazhi coast for different return periods have been discussed in **Section 3**.

AECOM analysed the historic cyclone data close to project site. Extreme values associated with cyclone events viz. the wind speeds, significant wave heights and peak periods were predicted by fitting a Weibull probability distribution to the results of historical storms.

8.3.1.2 Design Wave Height

The wave heights to be considered for the breakwaters design would depend upon the extreme wave conditions for 1 in 10, 1 in 50 and 1 in 100 years return periods for the respective depths in which breakwaters are located from considerations of over topping and section design respectively.

The estimates derived from the extreme value analyses of wave height during cyclonic conditions were found to be about 5.5 m at 10 m contour. Thus, the significant wave height for the breakwater design is taken as 6.0 m in the offshore section and 4.0 m for nearshore sections or the breaking wave height whichever is lesser.

Considering the extreme wave heights, their return periods, depths in which the breakwaters are located, the importance of the breakwaters (i.e. functional requirements) and the judgment for allowing the risk factor, the following design conditions are adopted for the south as well as north breakwaters:

- No damage for actual predicted wave heights
  Or
- Corresponding breaking wave height in that water depth, whichever is critical

8.3.1.3 Design Water Levels

The storm surge of 0.7 m is expected at this site based on the mathematical model study. With storm surges the meteorological conditions causing the rise in water levels are sometimes but not always the same as those causing maximum wave attacks. In some cases the two conditions will be independent variables; in others they can be positively or negatively related. The combined probability of the storm causing design wave height at structure along with maximum storm surge is considered to be negligible. It is therefore proposed to use +1.8 m CD (Mean High Water Springs i.e. +1.1 m CD plus 0.7 m storm surge), as the design high water level for the breakwater design.

- Other Design Assumptions
- Stones up to 5.0 T are economically available with density of 2.6 T/m^3
- The minimum density of concrete armour units will be 2.4 T/m^3
- Concrete slab with a parapet will be provided at the crest of the breakwater
- The design life of the breakwater is 100 years.
- The breakwater construction will be by end-on dumping method and that there will be no restriction/ limitations of crane for laying armour units. However where ever possible construction shall by carried out by Barge dumping also.

8.3.1.4 Crest Width and Elevation

The primary purpose of the breakwaters at the port is to provide the required tranquillity conditions in the manoeuvring areas and berths. The required minimum crest height of the breakwater is determined by the allowable wave penetration by overtopping during extreme conditions.

The crest level has been decided based on the limiting the overtopping discharge to 50 l/s/m. The crest width is determined after allowing a 2 way roadway for the maintenance of breakwater.

8.3.1.5 Armour Units

For the armour units following options have been considered:

- Rock as armour layer
- Accropodes as Concrete Armour Units

While evaluating the above options, the major factor under consideration will be the cost of breakwaters and the implementation schedule. It is expected that at the present site conditions, the placement of rock for breakwater construction, will be limited on an average to about 10,000 T/day by end on dumping method. An additional 3,000 to 5,000 T/day of rock could be placed by using the barge dumping also.

Wherever possible, rock would be utilised as armour layer. However, concrete armour units would be used once the rock size increases beyond 5 T. The present base case design has been undertaken considering accropodes as armour units but during detailed engineering a decision could be taken to adopt other armour units such as Core-loc or Xblock.

8.3.2 Breakwater 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 design wave height is taken as follows:

- 1 in 100 years return period significant wave height at the corresponding location or the breaking wave height at that location, whichever is severe, when using the concrete armour units.
- $H_{1/10}$ (i.e. 1.27 times Hs) for 100 year return period at the corresponding location or the breaking wave height at that location, whichever is severe, when using rock as armour unit.

The values for K_D considered (under non breaking conditions) are as follows:

Stones (in double layer) K_D = 2.8 for head portion
K_D = 4.0 for trunk portion

Table 8.3 K_D Values for Accropodes

Breakwater Portion	K_D values for Accropodes
Trunk	15
Head	12

The typical cross section of the breakwater is presented in **Drawing DELD15005-DRG-10-0000-CP-SRK1008**.

8.3.3 Geotechnical Assessment of Breakwaters

The breakwaters would be built on existing sea bed, so dredging areas need to be sufficiently far away to avoid endangering the foundations, allowing for the cape size depths.

The seabed level at the proposed offshore breakwater increases from -10 m CD to a maximum of -11 to -12.0m CD level. The crest level at the maximum depth is about +9.0 m CD.

The stability of the breakwater foundation needs to be analysed for the subsoil conditions. This would be more relevant for the sections in deeper water. Based on the subsoil data observed along the coast, the top layer of soil could be loose to medium dense sand for which breakwater toe may have to be wider for safety. At this stage it is assumed that there will not be any requirement of soil replacement which would increase the cost for breakwater significantly. However, any shortfall in the stability found at the detailed engineering stage could be managed by increasing the toe width and/or toe depth while maintaining a safe distance from the adjacent dredged area, allowing for future design depth.

8.3.4 Rock Quarrying and Transportation

8.3.4.1 Location of Quarries

It is understood that there are no suitable quarries are located for breakwater construction in Nagappattinam district. The rock for the construction of breakwater works need to sourced out from the quarries located at distant places in Villupuram district, which are approximately 150 km from the proposed site.

AECOM visited various quarry sites as shown in **Figure 8.12**. Considering the requirement of stones for the proposed breakwater, the quarries close to the proposed port site are located in Villipuram district.

Three different quarries are available at Kunnam near Thindivanam in Villupuram district. Two quarries are located in Kunnam which are at a distance of 3 km from Perumpakkam and one quarry in Perumpakkam itself of Thindivanam taluka in Villupuram district. The total distance from the proposed site to the quarry is about 146 km.

The approach to these quarry sites is through the WBM road which meets NH-45A. The distance of the quarry from the highway is about 2 km. The port site can be reached through NH-45A from Kunnam – Pondicherry – Cuddalore – Pudupettai. As far as rail link is concerned, the nearest place from the quarry site is Kutteripattu which is at a distance of 18 km.

The quarry is located by the side of the state highway which joins NH 45 at a distance of 19 km.

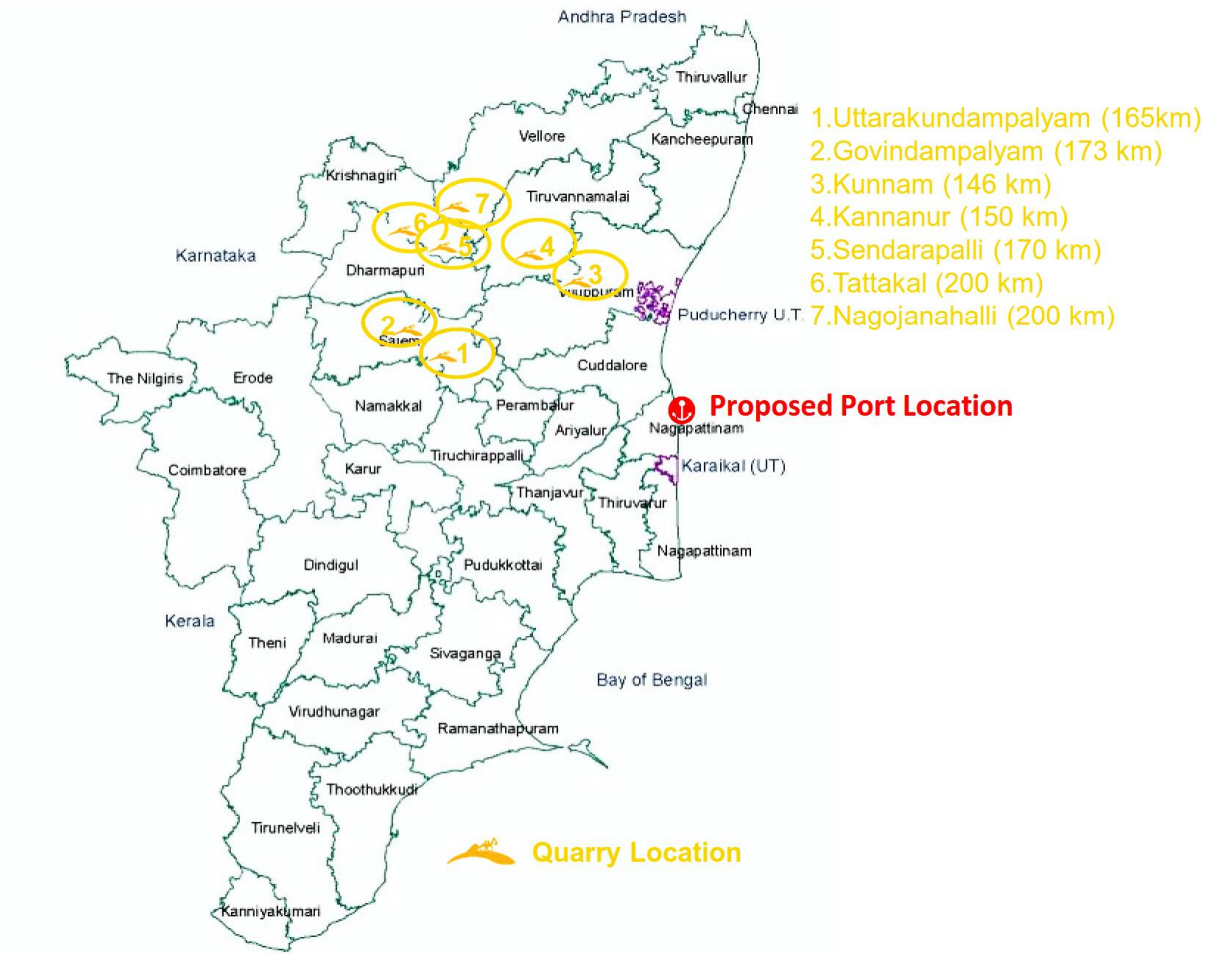


Figure 8.12 Location of Quarry Sites

Figure 8.13 Quarries at Villipuram

8.3.4.2 Transport to Site

These quarry sites are well connected to the proposed port through road network. The approach to the port site is well connected to the NH 45. The quarry material will have to be transported in through dumpers. Some localised road improvement measures will need to be undertaken near the quarries and near the project site to enable moving of the large quantity of stones by road using trucks.

8.4 Berthing Facilities

8.4.1 Location and Orientation

The location and orientation of the proposed berths is shown **Drawing DELD15005-DRG-10-0000-CP-SKZ1007**. The bulk berths are located away towards south of the harbour and connected to shore by means of an approach trestle. The multipurpose berths proposed to be provided in later phases are located in the lee of north breakwater and are located close to shore.

8.4.2 Deck Elevation

The deck elevation of the berths has been fixed at +4.5 m CD. This deck elevation will prevent the waves slamming the deck during cyclones. This level will also ensure adequate clearance to the deck during operational wave conditions.

8.4.3 Design Criteria

8.4.3.1 Design Ships

The structural design of the bulk berths shall be carried out for the maximum size of the ships expected to be handled at these berths at the ultimate phase.

The structural design of the bulk berths shall be carried out for 200,000 DWT ships.

8.4.3.2 Design Dredged Level

Structural design of the berths shall be carried out for design dredged level of -21 m CD.

8.4.3.3 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:
    - *Loads due to Gantry type unloaders with rail centres at 20 m c/c on bulk berth*
    - *Class AA or 70R vehicle loads on deck of berth and approach trestle*
- **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 55 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 1.0 m/s.

- **Wave Loads** shall be computed considering maximum wave height of 4.5 m (~ 1.8 × 2.5m) for the design of the berths on a conservative side.

- **Mooring *Loads*** shall be calculated considering 200 T bollard pull.

- **Berthing Loads**

The berthing loads have been calculated as per PIANC 2002 guidelines and 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 200,000 DWT ships would govern the design for the bulk berths. 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 8.4 Details of Berthing Energy, Fender and Berthing Force Applied at Berths

Parameters	Bulk Berth
Berthing Energy	2975 kNm
Fender	Trelleborg Cell Type Fenders SCK 2500H E1.1 or equivalent
Rated Berthing Force	2711 kN

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.

8.4.3.4 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.

8.4.3.5 Materials and Material Grades

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

8.4.4 Proposed Structural Arrangement of Berths

The access from the coal berths to the backup area is provided through a 13 m wide approach trestle. The berth shall be provided with a conveyor system which will carry the coal from the berth and transfer to the conveyor provided over the approach trestle.

The minimum width of the berth, keeping in view the rail span of the coal unloaders, service ducts and the end clearances should be about 30 m. The total length of the two bulk berths provided is 600m on the assumption that two cape size ships may not berth simultaneously. If required a mooring dolphin on either end could be provided at a later stages.

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 6.0 m c/c in the longitudinal direction. The piles will be founded in the substrata at levels beyond -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 300 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 conveyor supports are provided in the rear side of the berth at a spacing not exceeding 24 m. The typical cross section of Bulk berth is as shown in **Drawing DELD15005-DRG-10-0000-CP-SRK1009**.

8.5 Dredging and Disposal

8.5.1 Capital Dredging

The capital dredging for Phase 1 of the port development is estimated to be around **17.2 Mcum**. Only part of the suitable dredged material shall be used for site grading during Phase 1 development and balance shall be disposed of at a suitable location offshore at about 30 m contour.

8.5.2 Maintenance Dredging

Based on the mathematical model studies on siltation, only 50,000 cum per annum of siltation is expected at the channel entrance and the harbour basin. This material is expected to be primarily silt and will have to be disposed of at the offshore dumping ground after carrying out periodic maintenance dredging.

As in the initial phase only offshore breakwater is proposed there is unlikely to be any accretion or erosion along the coastline. Also as the harbour basin and berths are located beyond 5m contour, there is unlikely to any sedimentation in the harbour area as a result of littoral movement of sediments.

However, once the north breakwater is built in the later stages of development there would be an accretion towards its south. The accreted material being sand shall be suitable for creating the reclaimed land to provide backup area for proposed multipurpose berths. Along-with the north breakwater built for the port, a groyne towards north of the mouth of canal shall also be built to prevent closure of mouth due to deposition of littoral sediments.

It is expected that annually about 150,000 cum of material shall be accredited towards south, which would need to be periodically removed by way of excavation/dredging and bypassing to the northern side of the port by means of a pipeline and a booster pump to nourish the beach.

8.6 Site Grading

The existing average ground level at the project site is about +1.5 m CD and there would be a need to raise the formation level at site to about +4.0 m CD to allow for planning of better drainage system at site and also for protection against flooding due to the raised water levels during storms.

It is proposed that this area shall be raised to provide the space for transit storage and area along the shore line to create the backup area for storage and operation. The ground level is proposed to be +4.0 m CD and the total quantity of fill is estimated as **4.6 Mcum** which can be sourced through suitable material from capital dredging.

8.7 Material Handling System

8.7.1 Coal Handling System

The principal components of the coal handling system are:

- Ship unloaders
- Conveyors
- Stackyard
- Stacker cum Reclaimers
- Railway sidings with silos for in-motion wagon loading for evacuation

Each of these components is described hereunder.

8.7.1.1 Ship Unloaders

Gantry grab type ship unloaders: This is a versatile type of unloader suitable for all types of materials whether lumpy or powdery and materials of different bulk densities. The machine is easy to maintain and have a large population in India. The grabs are easy to maintain and the operational skills are well available. But they can cause spillage if not properly operated and maintained. Their initial cost is competitive as compared to the other type of unloaders and is manufactured by a number of competing companies. The gantry grab type unloaders can be fitted with grabs of different sizes to suit different materials of varying bulk densities. The disadvantage with this type of unloading system is that the percentage of material that can be unloaded by prime digging is less as compared to continuous unloaders. In other words the amount of material that needs to be accumulated using pay loaders after prime digging inside the hatch is more. As such the downstream conveyor system will carry more material during cream digging operation and less later.

The gantry grab type unloaders shall be designed for unloading different types of thermal coal with a bulk density of 0.8 T/m^3 and with moisture content up to 12%. They shall have a rated capacity of 2000 TPH each and a free digging capacity of 2400 TPH.

There will be two unloaders for each berth. The capacity of the unloaders shall ensure an average unloading rate of 45,000 TPD on a sustained basis and a peak unloading rate of not less than 60,000 TPD of thermal coal with the two unloaders in operation together.

Figure 8.14 Typical Gantry Type Ship Unloader

8.7.1.2 Conveyor System – Berths to Shore

As has been indicated earlier, the coal from the berths will have to be sent to three Power Plants – one on the shore and two farther away. While the coal for the on-shore Power Station will be directly transported to the plant stockyard, the coal for the other two Power Stations will have to pass through the transit stockyard within the port limits. Hence the conveyor system will be designed and provided in such a way that the coal can either be directly conveyed to the on-shore Power Station or conveyed to the port transit stockyard. For this purpose, there will be two streams of conveyors for the two berths so as to ensure flexibility in operation. The coal unloaded by the two gantry grab unloaders will be discharged into two streams of jetty conveyors proposed for the two coal berths. Since both the berths will be in line, the orientation of the berth conveyors will follow the berth alignment.

The berth conveyors will be ground level conveyors and will be located within the gantry track. Also these will run horizontally for the entire length of the two berths without any elevation and each conveyor will be designed to cater to coal unloaded by two gantry grab unloaders. Thus each of the two jetty conveyors will have a nominal capacity of 4000 TPH and a designed capacity of 4800 TPH.

While running along the approach trestle, the conveyors will run on an elevated closed structure to avoid pollution of the environment.

A junction tower will be provided at the landfall point which will be a junction point of the cross country conveyor to the power plant and the stockyard conveyor. Whenever required, the coal from the ship will be diverted to the stockyard at this junction tower.

8.7.1.3 Stackyard

Out of the total traffic of 17.0 MTPA during the 1st Phase, 5.5 MTPA required for the Vettangudi Power station will be taken directly to the plant stackyard through conveyors. 7.0 MTPA required for the Mettur Power Station and 4.5 MTPA for the Parangipettai Power station will have to move through the port stockyard and evacuated through rail. This will later increase to 14.0 MTPA for Parangipettai and 7.0 MTPA for Mettur during the 2nd Phase. The direct transfer to Vettangudi will also increase to 14.0 MTPA. Hence the port stockyard at the foreshore will be initially designed to handle about 12.0 MTPA during the 1st Phase and 21.0 MTPA during the 2nd Phase. The stockpiles have to be segregated for these two power stations.

It is proposed to plan the storage at port equivalent to 15 days of throughput. This would mean that in the initial phase about 0.5 MT and in the final phase about 0.9 MT of coal would need to be stored at port. The layout of stackyard and its dimensions have been planned accordingly.

8.7.1.4 Stackers & Reclaimers

The stackyard shall be provided with stackers cum reclaimer units for receipt and despatch of coal through conveyor system. Total 4 units shall be provided initially and shall be augmented to commensurate the traffic in the later stages of development. This will ensure independent operations for receipt from the ship as well evacuation through rail. The stacker will have 4000 TPH capacity capable of stacking up to 15 m high. The reclaimer will also have 4000 TPH capacity and capable of operating with stacks of 15 m high. The typical stacker cum reclaimer unit is presented in **Figure 8.15**:

Figure 8.15 Typical Stacker cum Reclaimer

8.7.1.5 Railway Sidings with Silos for In-Motion Wagon Loading

As indicated earlier, the coal for Mettur and Parangipettai will be moved through railways. Accordingly, about 7 rakes for Mettur and about 5 rakes for Parangipettai have to be handled daily during the 1st Phase. Presently, Indian Railways permit a free time of 5 hours for turning around a rake. However, it is understood that they are actively contemplating to reduce it to 3 hours. In such an eventuality, the actual loading time should be less than 1.5 hours as about 1.5 hours will be required for peripheral activities like placement of empty rake at the loading station and for rehauling it to the yard after loading. This could be done only with a rapid wagon station with a silo.

Accordingly, the proposed system will consist of a concrete silo of about 2000 T holding capacity and fitted with a rapid loading chute with electronic pre-weighing bins, sensors and a cascade chute. Prior to the placement of the rake below the silo, the silo will be preloaded to its capacity so that at least half a rake of material is already available and once the loading from silo starts, the conveyor system feeding the silo is started and filling carried out to be in line with the commensurate requirement. As the first wagon of the rake in-motion is positioned under the silo, the flood loading starts and each wagon gets filled in less than a minute. The only consideration is that the locomotive that propels the full rake has to move in a fairly controlled speed.

A typical rapid wagon loading system is presented in the **Figure 8.16** hereunder.

Figure 8.16 Typical Rapid Loading System

For this purpose, it may be necessary to have three railway sidings with two provided with rapid loading silos and the third for engine escape. The total length of the sidings will be minimum 1400 m each with the silos located at the centre.

8.7.2 Container Handling System

8.7.2.1 Mobile Harbour Crane

This port is primarily being developed as a bulk handling port. However, in the later stages of the port, the port is expected to cater breakbulk and containers as well. Based on the forecasted traffic, the expected traffic at the port is around 188,000 TEU. In view of the limited throughput for container, it is proposed to handle the containers using Mobile Harbour Cranes (MHCr) fitted with the spreader attachment which is a well proven arrangement for the efficient handling of containers.

Figure 8.17 Mobile Harbour Crane with Spreader Arrangement

This arrangement will have benefit in the sense that the cranes can also be used to handle breakbulk cargo using appropriate grab or hook attachment.

8.7.2.2 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 8.18** shows an E-RTG in operation.

Figure 8.18 Typical E-RTG for Yard Operation

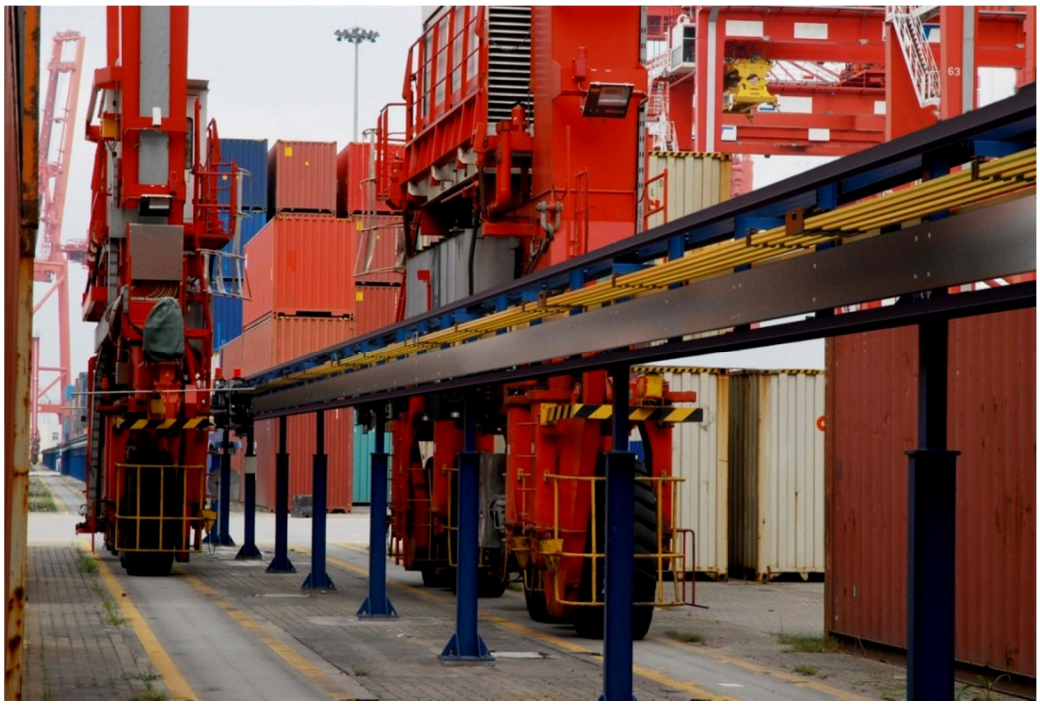


Figure 8.19 Typical Details of Electric Buss Bar Arrangement for E-RTG

8.7.2.3 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 8.20 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.

8.7.2.4 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 8.21 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.

8.7.2.5 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 8.22 Typical ITV for Handling Containers

8.8 Road Connectivity

8.8.1 External Road Connectivity

The proposed port location is approximately 14 km away from the East Coast Road (NH-45A) which passes through Cuddalore and links the proposed port to northern hinterland right up till Chennai. In addition to the national highways, a network of state highways connects Sirkazhi to other industrial centres in Tamil Nadu.

NH-67 starting from Nagappattinam (Approx. 60 Km away from the proposed port location) traverses Central Tamil Nadu in a near Straight line connecting the major industrial areas such as Thiruchirapalli, Karur and Coimbatore as well as onward linkages to other industrial areas such as Salem, Erode and Mettur.

From Sirkazhi, the port location is accessed through Thirumullaivasal and Thoduvaai villages. These roads are shown in the **Figure 8.23**.

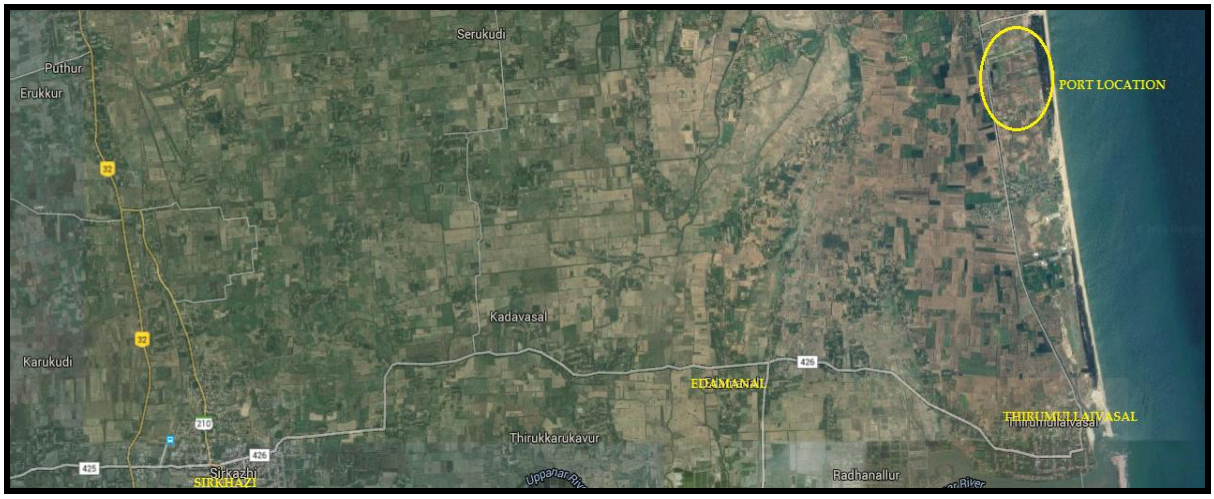


Figure 8.23 Connectivity between Sirkazhi and the Port location

8.8.2 Internal Roads

The main approach road to the port shall be located parallel to the backup area. Within the terminal internal roads shall be planned based on the cargo handling and storage plans with 1 way circulations to avoid any criss crossings.

8.9 Rail Connectivity

8.9.1 External Rail Connectivity

The rail connectivity to the port site could be achieved either through Sirkazhi Railway Station or through Kollidam Railway Station. The total distance from Sirkazhi will be about 18 km and that from Kollidam will be about 14 km. The railway routes are marked in the **Figure 8.24** and they pass through open cultivable lands. Considering that the Power Stations at Mettur and Parangipettai are both to the north, it will be advantageous to get the connectivity through Kollidam Railway Station.

Figure 8.24 Proposed Rail Connectivity

8.9.2 Internal Rail Links

The internal rail lines will be developed so that the rakes for bulk cargo could be taken to the wagon loading system. It shall be ensured that their location does not obstruct the movement of port vehicles. Two rail sidings shall be provided including one engine escape line during the initial phase of port development.

8.10 Port Infrastructure

8.10.1 Electrical Distribution System

8.10.1.1 Introduction

The handling systems for bulk loading and unloading are power intensive and hence require considerable high tension electrical power for their operation. 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. The various terminals within port will contain all the features of a modern first class terminal, and as such will require a reliable power supply system.

8.10.1.2 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 12 MVA. This is expected to go up to 33 MVA over the proposed master plan horizon.

8.10.1.3 Source of Power Supply

Power supply to port at Sirkazhi can be tapped from the 33/11 KV substation located at Edamanal (about 10 km from port site) having a current capacity of 8 MVA which can be enhanced as per the requirement. It is proposed that the transmission lines be tapped off and extended up to the proposed location of the main receiving substation.

8.10.1.4 Incoming Supply – System Requirements

The HT power shall be brought at 33 KV till the boundary of the proposed port, where the main substation shall be located. This outdoor switch yard will have two numbers of 33 KV transformers with 13 MVA rating and convert the power at the secondary voltage of 11 KV. 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.

8.10.1.5 Distribution of Power

11 KV feeders from main receiving substation will feed to secondary substation for the bulk terminal. The distribution of power shall be through this secondary substation.

The substation will be equipped with 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.

8.10.1.6 Standby Power Supply

It is proposed to install one diesel generator of 3 MVA at the substation. This would serve as standby to provide power backup for lighting and emergency loads during failure of mains.

8.10.1.7 Illumination

The illumination level in various areas will be maintained as per the industry standards and shall generally be as in **Table 8.5** below:

Table 8.5 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
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 m 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.

8.10.1.8 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.

8.10.1.9 Earthing & Lightning 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.

8.10.1.10 Power Factor Improvement

Suitable rating HT capacitors with automatic power factor correction arrangement will be installed to maintain the overall power factor correction to 0.97.

8.10.2 Communication System

8.10.2.1 General

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

8.10.2.2 Telephone System

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

8.10.2.3 Radio Communication

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

8.10.2.4 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.

8.10.3 Computerized Information System

8.10.3.1 Overall Objectives

The computerised information system proposed for Port at Sirkazhi 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.

8.10.3.2 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

8.10.3.3 Technology Infrastructure

The IT Infrastructure of Port at Sirkazhi 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.

8.10.4 Water Supply

8.10.4.1 Water Demand

The water demand for the Port at Sirkazhi has been worked out in the **Table 8.6** below:

Table 8.6 Estimated Water Demand for Port at Sirkazhi

S. No.	Consumer	Water Demand (KLD)	
		Phase 1	Master Plan
1.	Raw Water (KLD)	673	1,976
2.	Potable Water (KLD)	39	129
Total Water Demand at Port (KLD)		**712**	**2,105**

8.10.4.2 Sources of Water Supply

The water requirement for port at Sirkazhi shall be sourced from Collidam River. Alternatively providing a desalination plant at the port can also be explored during the implementation stage.

8.10.4.3 Storage of Water

The water supply from the main header shall be fed to the underground water tank of 1500 cum located at the port boundary which is equivalent to about 2 day consumption.

The water from the main sump would be pumped to secondary sump of 1000 cum capacity located near the stackyard. The sump shall be split into three compartments of 600 cum, 100 cum and 300 cum. The compartment of 600 cum will retain water permanently for firefighting; the compartment of 100 cum will be used for water supply to buildings, ships, where a small filtration unit shall be provided. The third compartment of 300 cum will provide water for dust suppression system and greenery.

8.10.5 Drainage and Sewerage System

8.10.5.1 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 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.

8.10.5.2 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.

8.10.6 Floating Crafts for Marine Operations

8.10.6.1 Tugs

For berthing / un-berthing of the design vessels four harbour tugs of 50 T bollard pull capacity are required initially, including tug for standby/ emergency.

8.10.6.2 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. It is proposed to provide two pilot vessels including one standby vessel.

8.10.6.3 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.

8.10.6.4 Harbour Crafts

The requirements of Harbour Crafts for the Phase 1 development of port of Sirkazhi are given in **Table 8.7** below.

Table 8.7 Harbour Craft Requirements

S. No.	Harbour Craft	Number
1.	Tugs 50 T bollard pull	4
2.	Pilot cum Security Vessels	2
3.	Mooring Boats	2

8.10.7 Navigational Aids

8.10.7.1 General

It is envisaged that navigation will be carried out throughout the year, by day and night, except during cyclonic weather, when rough seas, high wind speeds, and negative storm surge may result in low/inadequate draft. 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 port. These aids are such as fairway buoys, port and starboard buoys, leading / transit lights, beacons and Vessel Traffic Management Information System (VTMIS) etc., which are installed on land or in water for guidance to all vessels for safe and regulated navigation in channels, anchorages, and berths. VTMIS will have the requisite communication, Radar system integrated into it.

8.10.7.2 Buoys

The approach channel has a total length of about 4 km from the breakwater head which require 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 to mark the limits of the harbour basins. IALA maritime buoyage system as per region A, in which Sirkazhi port falls, will be followed. The lateral marks will be red and green colours to denote the port and starboard sides of channel.

8.10.7.3 Leading / Transit lights

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

8.10.7.4 Beacons / Mole lights

Two Beacons at each end of offshore breakwater are proposed to be provided.

8.10.7.5 Vessel Traffic Management System (VTMS)

The purpose of the VTMS is to provide a clear and concise real time portrayal of vessel movements and interaction in the Vessel Traffic Service (VTS) area. For Sirkazhi Port, the service area will be the approach channel, the anchorage area, the harbour basin etc. This system will be used for marine operations and will also be linked to the PMIS (Port Management and Information System). The information provided by VTMS system allows the operator or user of the system to:

- Provide the required level of VTS: Information, Assistance or Organisation
- Enhance safety of life and property
- Reduce risks associated with marine operations
- Enhance efficiency of vessel movements and port marine resources
- Distribute VTS related information
- Provide Search and rescue assistance
- Provide VTS data for administrative purposes, analysis of incidents and planning

The VTS in recent years has changed from Traffic Monitoring to Traffic Planning by introduction and interconnection of databases and expert systems. It allows access of static and dynamic information about ships, their cargo and port service requirements. Together with an automatic update of traffic information the VTMS provides a powerful tool for programming of traffic movement within the surveillance area. Operators can associate tracked targets with vessels registered in the database, which makes the data readily available and allows the system to automatically provide pertinent voyage information to other port service providers.

8.10.8 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.

8.10.9 Firefighting System

8.10.9.1 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.

8.10.9.2 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
- Conveyors galleries

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.

8.10.10 Pollution Control

8.10.10.1 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

8.10.10.2 Dust Suppression

Dust control equipment is proposed for efficient control of dust pollution to the environment during storage and handling of 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.

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.

9.0 ENVIRONMENTAL SETTINGS AND IMPACT EVALUATION

9.1 Introduction

This section presents environmental conditions in and around the proposed port location at Sirkazhi. It briefly describes general environmental conditions of the project area, i.e., physical environment, flora and fauna; identifies environmental issue that may arise due to the considered project and its components, suggests mitigation measures to minimise adverse impacts. This section also details environmental policies and legislation to highlight the permissions and clearances required for the project.

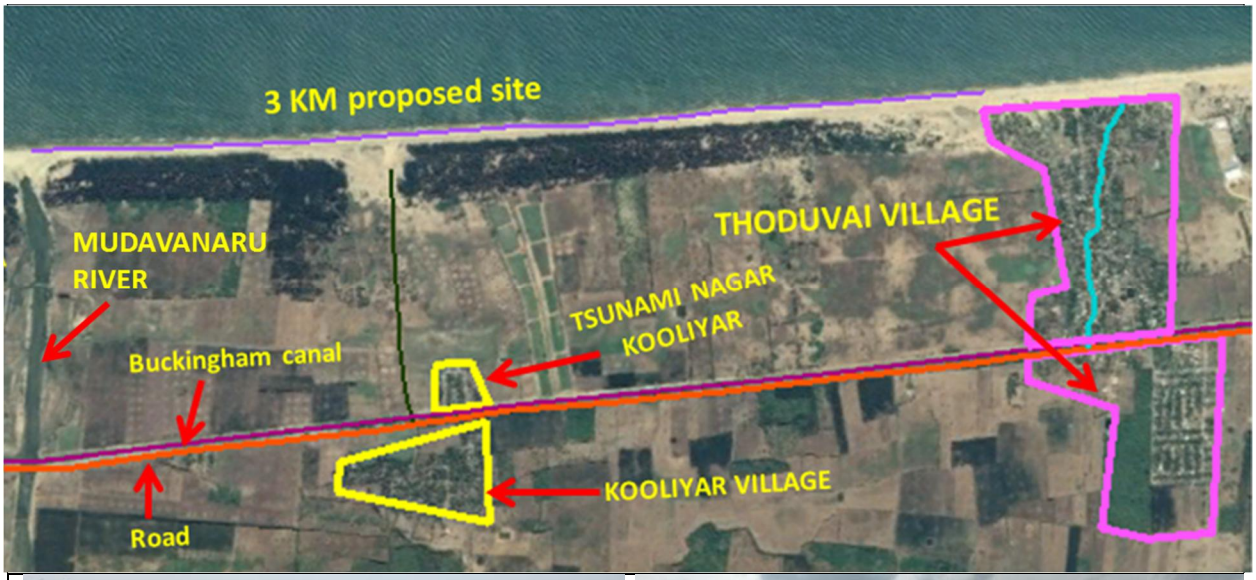
The section is largely based on the review of literature, available secondary data and information gathered during the site visits.

9.2 Site Setting

A Greenfield port is planned to be developed on the coast near Thoduvaai fishing village. A 3 km long coast line was found to be suitable for this development (**Figure 9.1**).

Around 1500 household were situated in the Thoduvaai village with a population of 8000 has been reported. The villagers are mainly involved in small scale fishing and agriculture. Rice and Groundnut are cultivated predominantly along with Cashew and Mango.

Casuarina plantation was observed all along the coast line covering almost 3 km stretch. River Mudavanaru is flowing on the North of the proposed site while Buckingham canal runs parallel to coast on the west at a distance of about 1 km.



Mudavanaru river

Casuarina Plantation

Fishing Activities at Thoduvaai

Fishing Activities at Thoduvaai

Figure 9.1 Location of the Proposed Site

9.3 Environmental Policy and Legislation

Table 9.1 presents Environmental regulations and legislations relevant to this project, along with the details of the competent authority for implementation.

Table 9.1 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 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 • Permission for tree felling	No forest land is involved in the project.	MoEF&CC; Department of Forest, GoTN
3.	Wild Life (Protection) Act, 1972	• To protect wildlife in general and National Parks and Sanctuaries in particular • Permission for working inside or diversion of sanctuary land	-	Chief Conservator of Wildlife, Wildlife Wing, Forest Department, GoTN; 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 • 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	Tamil Nadu 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 • 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	Tamil Nadu Pollution Control Board
6.	Noise Pollution (Regulation and Control) Rules, 1990	• Standard for noise	Yes, construction machinery to conform to noise standards	Tamil Nadu Pollution Control Board
7.	The Motor Vehicle Act, 1988 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. • Issuance of Pollution Under Control (PUC) certificate to vehicles used in	Yes, all vehicles shall comply with these provisions	State Motor Vehicle Department

S. No.	Act/Rule/ Notification, Year	Relevance	Applicability	Implementing Agency
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 • Issuance of authorisation for all above mentioned activities.	Yes, NOC to handle any hazardous waste, i.e., waste oil from machineries etc.	Tamil Nadu 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, GoTN
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.

9.4 Anticipated Environmental Impacts and Mitigation Measures

Potential impacts on environment due to the proposed port project have been summarized in **Table 9.2**. 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 9.2 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 • Construction of road and rail • Clearing of site and land levelling • Dumping of liquid and solid waste from labour camps, stack yards, workshops etc.	• Change in land use • Loss of trees/vegetative cover hence increase in soil erosion • Soil contamination due to dumping of solid waste (municipal and construction) and spillage of hazardous waste, i.e., oil or other chemicals.	• Dumping of liquid and solid waste from labour camps, stack yards, workshops etc. • Spillage of cargo and hazardous material/waste	• Contamination due to spillage
Impact on Water Environment	• Construction of road and rail • Setting up of Labour camps • Dredging and construction	• Change in natural drainage • Water Pollution from labour camps • Increase in turbidity due to dredging and construction activities • Contamination due to spillage of chemicals used during pile diving.	• Handling and Storage of cargo such as coal, iron ore etc. • Sewage generation • Oily effluent from maintenance area • Discharge of bilge and ballast water • Maintenance dredging	• Change in marine water quality due to wastewater from stack yards, sewage, bilge and ballast. • Oil spill from vessels serving port • Increase in turbidity
Impact on Air Environment	• Operation of vehicles and construction machinery • Fuel burning at labour camps	• Dust emissions due to construction activities and vehicle movement • Emissions from labour camps, vehicles, machinery and DG sets	• Vehicle movement • Cargo Handling	• Vehicular pollution • Emission from ore and coal handling
Impact on Noise Environment	• Operation of vehicles and construction machinery • Quarrying and transportation of material to the site.	• Increased noise levels from heavy machinery and increased human activities	• Operation of vehicles and machinery Including stand-by generators and ship engines	• Increase in noise • Health impacts on workers

Environmental Aspects	Pre-construction/ Land Acquisition/Construction		Operation	
	Activities	**Potential Impacts**	**Activities**	**Potential Impacts**
Impact on Ecology	• Quarrying for fill material • Construction of road and rail • Clearing of site and land levelling • Reclamation and dredging	• Loss of vegetation due to site clearing including mangroves • Loss of habitat to birds and small animals • Impact of dredging and dumping of dredged material on marine flora and fauna	• Cargo Handling • Maintenance dredging	• Impact of dredging and dumping of dredged material on marine flora and fauna.
Impact on Socio-economic	• Construction activities • Traffic Movement • Influx of outside workers/ population • Land acquisition	• Hindrance in the fishing activities • Discomfort to nearby communities due to noise, air and water pollution • Loss of land/ livelihood in case of rail and road development • Relocation of CPR and utilities for rail and road development • Increased traffic movement	• Operations • Traffic movement	**Negative Impacts** • Discomfort to nearby communities due to noise, air and water pollution • Restrictions to the fishing activities • Reduction in fish catch. **Positive Impacts** • Increased Jobs • Increased Business opportunities • Better roads • Community development programs

9.5 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.

9.5.1 Impacts on Land and Soil

The proposed port is planned along the narrow strip of land along the coast and this land is being planned to be acquired by Chennai port. This land is devoid of any habitation and used primarily for agricultural purposes. Additional land for rail and road connectivity will also be required.

The anticipated impact of the project are soil contamination that may be caused from roadside litter, oil spillage from 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 contractor 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 of at designated solid waste collection point.
- Appropriate R&R will be drafted for land acquisition will be drafted.

9.5.2 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 Collidam River, for which all the required permissions from the state authorities will be sought.

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 m^3/day 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, rock cutting 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 projects, the following measures will be implemented:

- Bore wells, if required to source water for 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 10 '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 stored 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 sea or 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 TNPCB or MoEF.
- No construction activity will be undertaken during monsoon period in the sea or near coast.
- 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:
    - Most of the quantity of dredged material will be used as reclamation material and for revetments.
    - Limited material, which will not be suitable for reclamation, will be disposed off at an identified site 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, the activities during dredging and disposal of spoils should be monitored regularly.
    - 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.

9.5.3 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.
- 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.
- 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 Andhra Pradesh 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.
- The labours shall be provided with clean fuel so that they neither cut the trees for fuel wood nor burn firewood.

9.5.4 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.

9.5.5 Impacts on Ecology

The core area of Pitchavaram, one of the biggest mangrove reserved forest, is more than 10 km North of the site and this project is not envisaged to cause any disturbance to that area. However, exact boundaries of the Pitchavaram must be ascertained during the detailed EIA report.

The land requirement for rail and road connectivity will require careful planning to avoid sensitive locations (habitation, vegetation etc.). Tree cutting is inevitable at this location for infrastructure development.

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

Mitigation Measures

- All care shall be taken that trees shall be protected as far as possible while site clearing and infrastructure development.
- In consultation with Forest Department, more than twice number of the trees will be planted in lieu of trees removed.
- Detailed ecological survey shall be conducted during detailed EIA study to assess the impacts.
- No construction activity will be allowed during the monsoon season within sea or near coast 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.
- All care shall be taken to avoid mangroves vegetation while construction activity. It is also proposed to plan and develop mangroves in the area identified and suggested by Forest Development.

9.5.6 Impact on Social Conditions

Loss of livelihood is anticipated for few households as about 120 ha of agricultural land will be acquired for port development. During the site visit no settlement were seen at the proposed site. However, acquisition of land and loss of livelihood is anticipated on account pf port development as well as for connectivity.

Mitigation Measures

- It is proposed that existing roads will be strengthened wherever possible and as far as possible government land will be used for rail and road alignment.
- Detail survey of the land 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 well-being of affected families and panchayats.

9.6 Impacts during Operation Phase

9.6.1 Impact on Land and Shoreline

An offshore breakwater is proposed for the project at 10 and 11 m depth in the sea. This offshore breakwater will not hinder the littoral drift at this location. Thus no impact on accretion and deposition patter is anticipated at the coast line, which is designated as stable (refer **Figure 2.5**).

Mitigation Measures

- Regular monitoring of the coast line shall be carried out so as to assess any changes.

9.6.2 Impact on Water Quality

Water required during operation phase will be sourced from sea, which will be treated in a desalinisation plant for consumption.

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

- Location of sea water intake shall be planned so that it does not affect the flow and sediment pattern in the region.
- 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 stack yard 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 through authorised waste 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 coastguard personnel to take appropriate actions.
- Storm 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 and ballast water 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 at proposed Port area for prevention of marine pollution.

9.6.3 Impact on Air Quality

Vehicle traffic to service cargo at the port, emissions from port equipment, cargo handling (Coal) 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 stack yard & 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, 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.
- It will be a responsibility of labour contractors to provide for clean fuel to the labourers.

9.6.4 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 shall 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.

9.6.5 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.

Due to maintenance dredging, some quantity of dredged disposal is anticipated.

Once the project is operation, a green belt will be developed around the ports site and shoreline.

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.

9.6.6 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 & Job Trainings
- Environmental Services and climate resilience.

9.7 Environmental Monitoring Plan

This section presents the environmental monitoring framework for the project where parameters, frequency and locations for the environmental monitoring are suggested (**Table 9.3**).

Table 9.3 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	3 - 4
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	3 - 4
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: • Phytoplankton • Zooplankton • Benthos • Fisheries • Mangroves 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	4 - 5

9.8 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.

10.0 COST ESTIMATES AND IMPLEMENTATION SCHEDULE

10.1 Capital Cost Estimates

10.1.1 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 preliminary 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 first quarter of 2016.
- 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 contingencies, engineering and establishment has been included separately.

The 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.

10.1.2 Capital Cost Estimates for Phased Development

The capital cost of phased development of port, as per the proposed phasing as per **Table 7.8** has been worked out. The same is furnished below in **Table 10.1**. The capital costs given for each phase are for the facilities created during that particular phase only.

Table 10.1 Block Capital Cost Estimates (INR in Crores)

A. Port Development Cost Only

S. No.	Item	2020	2035	Total
1.	Project Preliminaries and Site Development	60	40	100
2.	Dredging	344	297	641
3.	Reclamation	75	670	745
4.	Breakwater	459	252	711
5.	Berths	298	578	876
6.	Buildings	29	159	188
7.	Stackyard and Other Backup Area	47	92	139
8.	Internal Roads and Railway	43	40	83
9.	Equipment	584	884	1,467
10.	Utilities and Others	181	146	326
11.	Navigational Aids	7	0	7
12.	Total (1+2+3+4+5+6+7+8+9+10+11)	**2,127**	**3,157**	**5,284**
13.	Contingencies @ 10%	213	316	528
14.	Engineering and Project Management @ 5%	106	158	264
Incremental Capital Cost (Rs. In Crores)		**2,446**	**3,631**	**6,076**

B. Total Cost Including External Rail, Road Connectivity and Land Acquisition

S. No.	Components	2020	2035	Total
1.	**Port Development Cost**	**2,446**	**3,631**	**6,076**
2.	**Cost of land acquisition for backup area of port**	**80**	-	**80**
3.	**External connectivity including land acquisition**			
	Rail	**175**	-	**175**
	Road	**168**	-	**168**
Total Cost (INR in Crores)		**2,869**	**3,631**	**6,499**

These capital cost estimates does not include the following:

- Port crafts, as these are proposed to be leased out
- Financing and Interest Costs

10.2 Operation and Maintenance Costs

10.2.1 General

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

10.2.2 Repair and Maintenance Costs

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

- 5% of 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.

10.2.3 Manpower Costs

The estimated manpower for the initial phase of development is about 230 increasing to about 770 in the ultimate stage of development. The manpower costs have accordingly been calculated considering the number and types of personnel deployed.

10.2.4 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. 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

10.2.5 Annual Operation and Maintenance Costs

Based on the various criteria discussed above, the annual operation and maintenance cost for various phases of development of Port at Sirkazhi are summarised below in **Table 10.2**:

Table 10.2 Annual Operation and Maintenance Costs (INR in Crores)

S. No.	Item	2020	2035	Total
1.	REPAIR AND MAINTENANCE COSTS	50.2	67.0	**117**
2.	OPERATION COSTS	57.4	124.0	**181**
3.	**TOTAL**	**108**	**191**	**299**
4.	Contingencies (Rites, @ 10%-Aecom)	10.8	19.1	**30**
5.	Administrative Expenses @ 5%	5.4	9.6	**15**
Incremental O & M Costs (Rs. In Crores) per annum		**124**	**220**	**343**

The above O&M cost does not include the repair and maintenance of external rail and road connectivity.

10.3 Implementation Schedule for Phase 1 Port Development

10.3.1 General

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

10.3.2 Construction of Breakwaters

The construction of the breakwaters is considered as the most critical item in the project implementation schedule, as the other marine works like berths construction, dredging have to be synchronised carefully with the progressive construction of breakwaters.

It is estimated that about 2.3 million tonnes of rock is required for the construction of breakwaters. The major quantity of rock required for armour and sub armour layers would be obtained from identified quarry sites located about 150 km from site.

Being offshore the breakwater shall be built using the marine equipment viz. self-propelled side dumping and/or bottom opening barges of approximately 500 T to 1000 T capacity.

The floating equipment can be used for dumping of filter and core upto a certain level, below high water only. The balance section would need to be built up deployment of floating cranes using dumb barges which is a slow process and likely to involve higher weather downtime. It is envisaged that about 5,000 T stones can be placed per day. This would mean that the construction of breakwaters could be completed in a period of about 30 months duly accounting for weather downtime.

10.3.3 Dredging and Reclamation

The overall dredging quantity is estimated to be about 17.2 Mcum. Once the offshore breakwater construction is half way through, the dredging activity of the harbour basin and channel can commence and reclamation bunds shall be built to receive the suitable material from the dredging operations. The overall duration of the dredging and reclamation is expected to be 18 months.

10.3.4 Berths

As berths are not proposed to be contiguous to the land, construction of berths would be independent of the dredging. The construction of berths could be started by launching the gantries from the shore along the trestle. However, adequate breakwater shelter would be needed to avoid any downtime in construction.

The construction of berths would commence after the dredging in the berth pockets has been completed and adequate shelter to the berth area is provided by the completed portion of breakwater. As the berths and approach trestle are continuous, it is possible to construct the piles using travelling gantries from the shore. The superstructure would be mainly built using precast concrete elements to avoid soffit shuttering. This would also enable the construction of superstructure on the piles already completed. The construction of berths is expected to take about 24 months.

10.3.5 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.

10.3.6 Implementation Schedule

The construction time of Phase 1 development of port at Sirkazhi is likely to take over 60 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 Port at Sirkazhi is shown in **Table 10.3**.

Table 10.3 Implementation Schedule for Development of Port at Sirkazhi

S.No.	Task Description	2016 Aug	Sep	Oct	Nov	Dec	2017 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2018 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2019 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2020 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2021 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
A	**Appointment of Consultant for DPR Preparation**	Zero Date																																																														
1	Preparation of DPR																																																															
2	Prepration of Tender Documents																																																														
3	Prepration of EIA Report and Approvals																																																														
B	**Tendering Activity of Common Infrastructure to be developed by SPV**																																																														
1	Tendering Period																																																														
2	Evaluation, Negotiations and Award of Contracts																																																														
3	Financial Closure																																																														
C	**Construction Activity of Common Infrastructure**																																																														
1	Establishment at Site by Contractor																																																														
2	Approach Roads																																																														
3	Breakwaters																																																														
4	Dredging																																																														
5	Reclamation Bund																																																														
6	Reclamation																																																														
7	Rail and Road Connectivity																																																														
D	**Terminal Construction by BOT Operator(s)**																																																														
1	RFP to selected bidders, Evaluation and Selection of Concessionaire for Terminals																																																														
2	Detailed Engineering by Concessionaire																																																														
3	Tendering and Selection of Contractor by Concessionaire																																																														
4	Financial Closure																																																														
5	Berths																																																														
6	Storage Yard and Pavement																																																													
7	Supply and Installation of Mechanical Equipment																																																													
8	Buildings																																																													
9	Onshore Infrastructure																																																												
10	Commissioning of Port Facilities																																																											

11.0 FINANCIAL ANALYSIS FOR ALTERNATIVE MEANS OF PROJECT DEVELOPMENT

11.1 Assumptions for Financial Assessment

As the coal is the assured cargo which shall kick start the project it is proposed that the financial analysis be carried out for a scenario where the port is developed only to handle coal, projected for the initial phase i.e. only for proposed phase 1 development until it reaches it capacity. With basic infrastructure in place for phase 1 development, any expansion for additional cargo could be carried out at much lower investment and thus would improve the project viability further.

The following assumptions are made while carrying out the financial assessment:

- Based on the profiling of competing ports tariff for handling coal has been assumed as Rs. 225 per tonne
- For NLC, as there is no requirement for coal storage and evacuation from port by rail, the tariff considered is Rs. 175 per tonne.
- The cost of Debt is assumed as 11% for PPP operator.
- The cost of Debt for the SPV, in case of Landlord model, is assumed at 4%.

11.2 Option 1 – By Project Proponents

In this option a Special Purpose Vehicle (SPV) shall be formed comprising of public sector entities i.e. (Chennai Port Trust, NLC and/or State Government/TNMB, SDC), who shall execute this project. They shall also be responsible to arrange funds for the project financing, manage and operate the port.

The financial analysis has been carried out considering the overall capital investment of Rs. 2,869 crores for Phase 1 port development. The project IRR in this scenario works out to about **12.5 %**.

11.3 Option 2 – Full Fledged Concession to Private Operator

In this option, the entire project is allocated to a private developer like in case of Mundra, Gangavaram, Krishnapatnam ports on revenue share basis.

In this case the costs towards External Rail and Road Connectivity to port and land acquisition for connectivity and port facilities shall be borne by the government entities like NHAI, IPRCL and state government.

The financial analysis has been carried out considering the capital investment of Rs. 2,446 crores for Phase 1 port development. The project IRR for developer in this scenario works out to about **14.5 %**.

11.4 Option 3 – Landlord Model

In this option an SPV shall be formed in the similar fashion as in case of Option 1. The exact composition of SPV and the % share of the entities could be decided once the decision to go ahead with the project is taken. The following shall be modalities for development under this option:

1. The basic infrastructure in terms of Breakwaters, capital dredging, reclamation, access rail and road, water and power connection, harbour crafts etc. shall be arranged by SPV. Apart from that the SPV shall also be responsible providing external rail and road connectivity to port including any land acquisition for connectivity and port development. In addition SPV shall also be 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 authorities and administering subleases for the various marine terminals leased to users, terminal operators as applicable.

2. The cargo handling terminals and associated facilities comprising of berths, stackyard development, equipment, utilities etc. will be developed with private participation on PPP mode. PPP Concessionaire would be responsible for terminal operations and maintenance and sharing of its revenue with SPV as per the concession agreement.

In the proposed implementation model the cost split between the project proponents and the terminal operators is estimated as below in **Table 11.1**.

Table 11.1 Estimated Cost Split

A. Port Development Cost Only

S. No.	Item	SPV	Concessionaire	Total
1.	Project Preliminaries and Site Development	40	20	60
2.	Dredging	344	-	344
3.	Reclamation	69	6	75
4.	Breakwater	459	-	459
5.	Berths	-	298	298
6.	Buildings	20	9	29
7.	Stackyard and Other Backup Area	-	47	47
8.	Internal Roads and Railway	18	25	43
9.	Equipment	-	584	584
10.	Utilities and Others	100	81	181
11.	Navigational Aids	7	-	7
12.	Total (1+2+3+4+5+6+7+8+9+10+11)	**1,058**	**1,069**	**2,127**
13.	Contingencies @ 10%	106	107	213
14.	Engineering and Project Management @ 5%	53	53	106
Capital Cost of Phase 1 Port Development (Rs. In Crores)		**1,216**	**1,229**	**2,446**

B. Total Cost Including External Rail, Road Connectivity and Land Acquisition

S. No.	Components	SPV	Concessionaire	Total
1.	**Port Development Cost**	**1,216**	**1,229**	**2,446**
2.	**Cost of land acquisition for backup area of port**	**80**	-	**80**
3.	**External connectivity including land acquisition**			
	Rail	**175**	-	**175.00**
	Road	**168**	-	**168.00**
Total Cost (INR in Crores)		**1,639**	**1,229**	**2,869**

To achieve the project IRR of 15% the PPP operator can even share 50% of revenue with the SPV. Based on the revenue earned the project IRR for the SPV works out to about 11.5%, which being much higher than the cost of capital to SPV makes the investment attractive. The project IRR to SPV can improve if SPV can manage debt from the international funding agencies. Further if the external rail and road connectivity to the port could be undertaken by NHAI, Railways and IPRCL, the burden on SPV shall further reduce.

11.5 Conclusions and Recommendations

The proposed port development project at Sirkazhi is technically and financially suitable to be taken up for development. In terms of its ability to provide modern handling facilities and capacity to handle fully loaded capesize ships, it has a potential to attract customers.

Considering the significant traffic potential for this port to cater to the nearby power plants the project needs to be taken up on priority so as not to lose the market share to its competitors. The Landlord model as per option 3 appears to be most suitable for development.

12.0 WAY FORWARD

The following action plan is recommended for implementation of the project:

1. Formation of SPV for development of the project
2. Appointment of consultant for preparation of detailed project report, which shall use the present TEFR as a base document and detail it further by:
   a. Carrying out detailed site specific studies and investigations to provide a database for detailed design of port facilities
   b. Real Time Ship Navigational Studies to confirm the dimensions of channel and navigational areas
   c. Engineering of the Marine Structures, material handling system and onshore infrastructure to further refine the cost estimates
   d. Two and three dimensional model studies for design of breakwaters.
   e. Mathematical model studies on the final layout for further optimisation. Apart from that model studies for dispersal of dredged plume at the proposed disposal site would be needed as per the requirement of MoEF.
   f. Updated financial analysis
3. Appoint a transaction advisor for project structuring and preparation of tender documents
4. Coordination with the NHAI and Indian railways for providing road and rail connectivity to site.
5. Coordination with state government for land acquisition
6. Approvals from SFC/ EFC/ PIB/ PPPAC/ CCEA
7. Appointment of consultant for Preparation of EIA report and approval of MoEF
8. Coordination with various agencies for getting project approvals as mentioned in **Figure 12.1.**

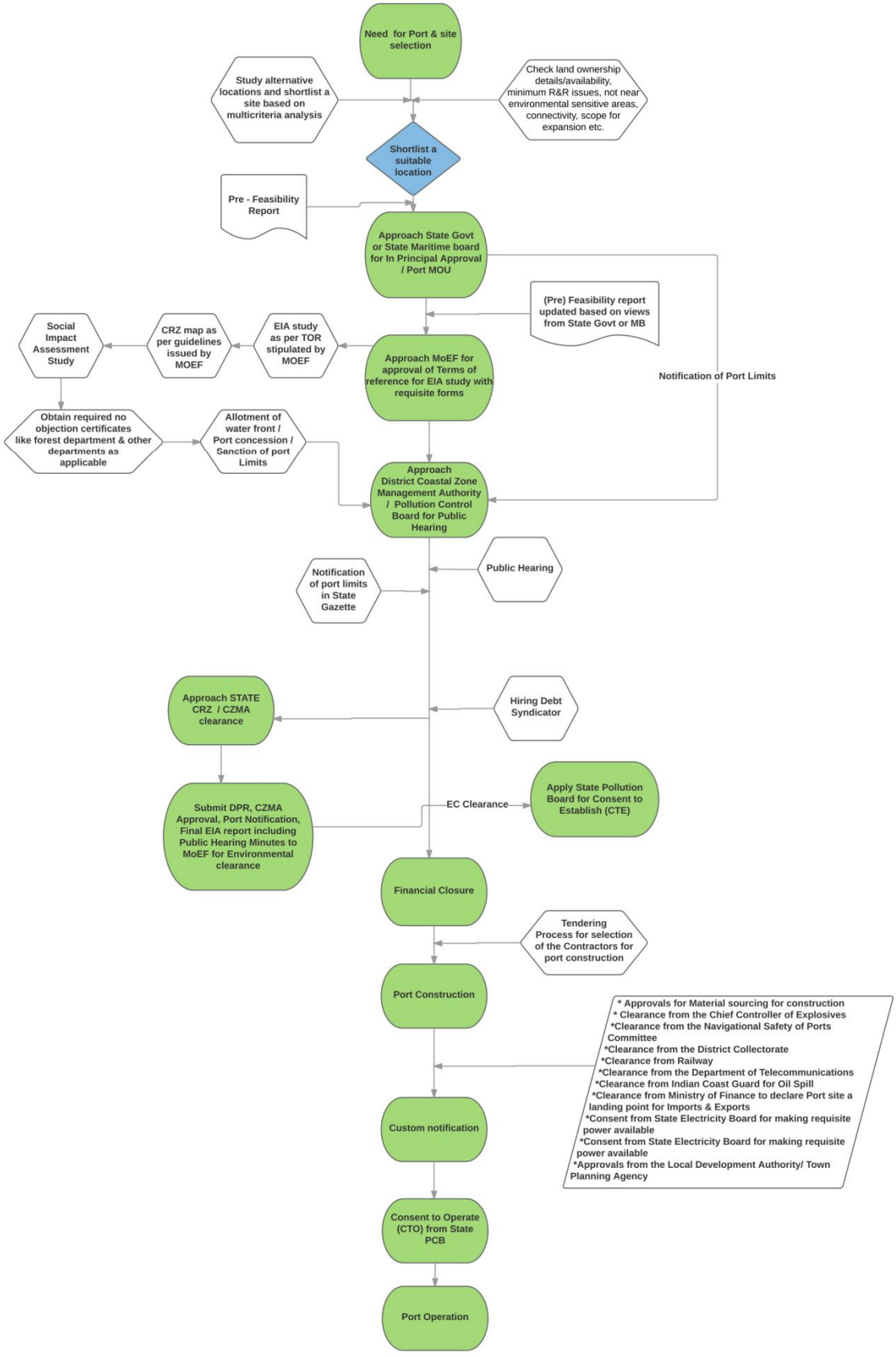
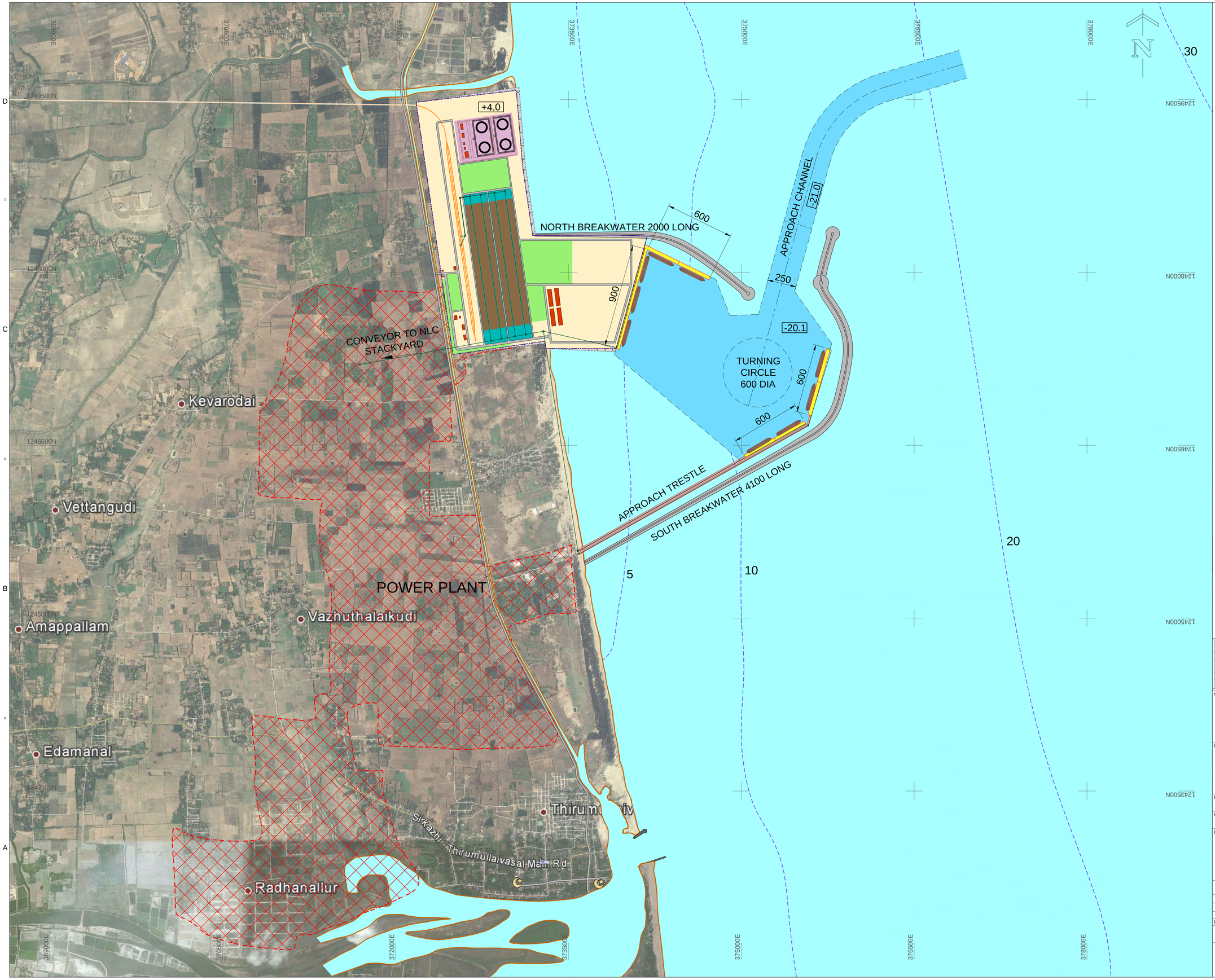


Figure 12.1 Process for the Greenfield Port Development

Drawings



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CLIENT/OWNER:

Ministry of Shipping
Government of India

PROJECT:

SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT SIRKAZHI

PART/DISCIPLINE:

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PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

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ALTERNATIVE 1
MASTER PLAN

SHEET 1 OF 1

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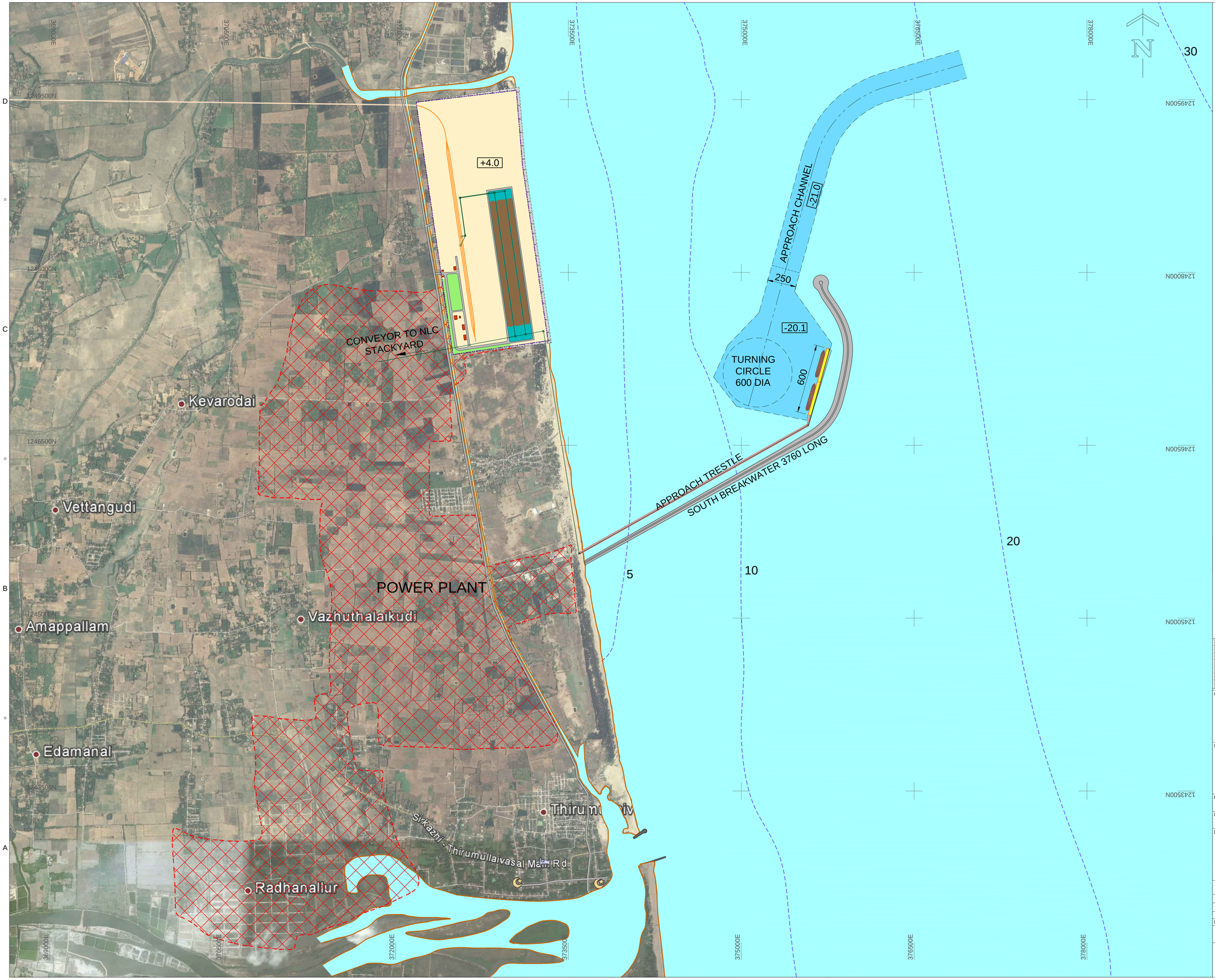

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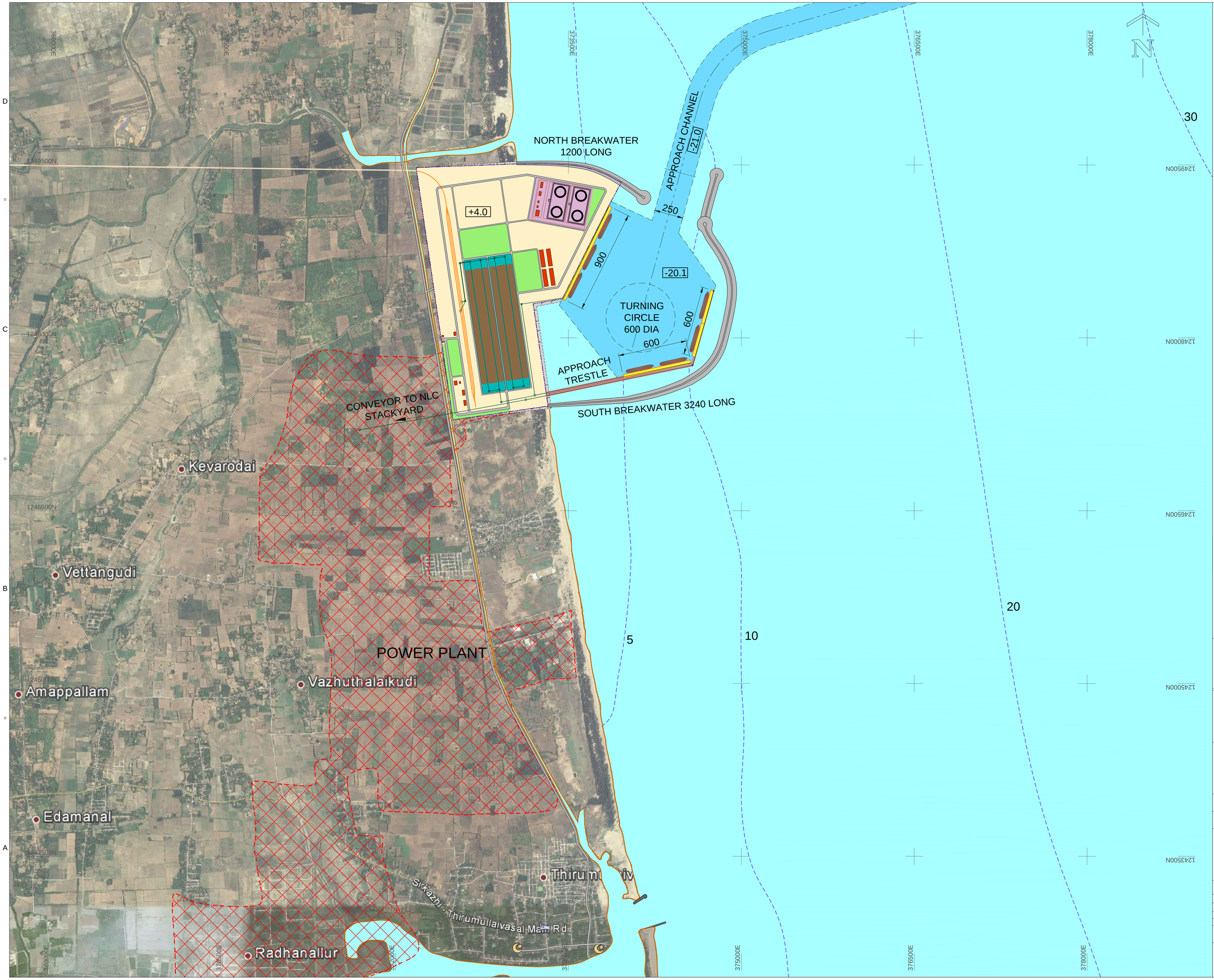

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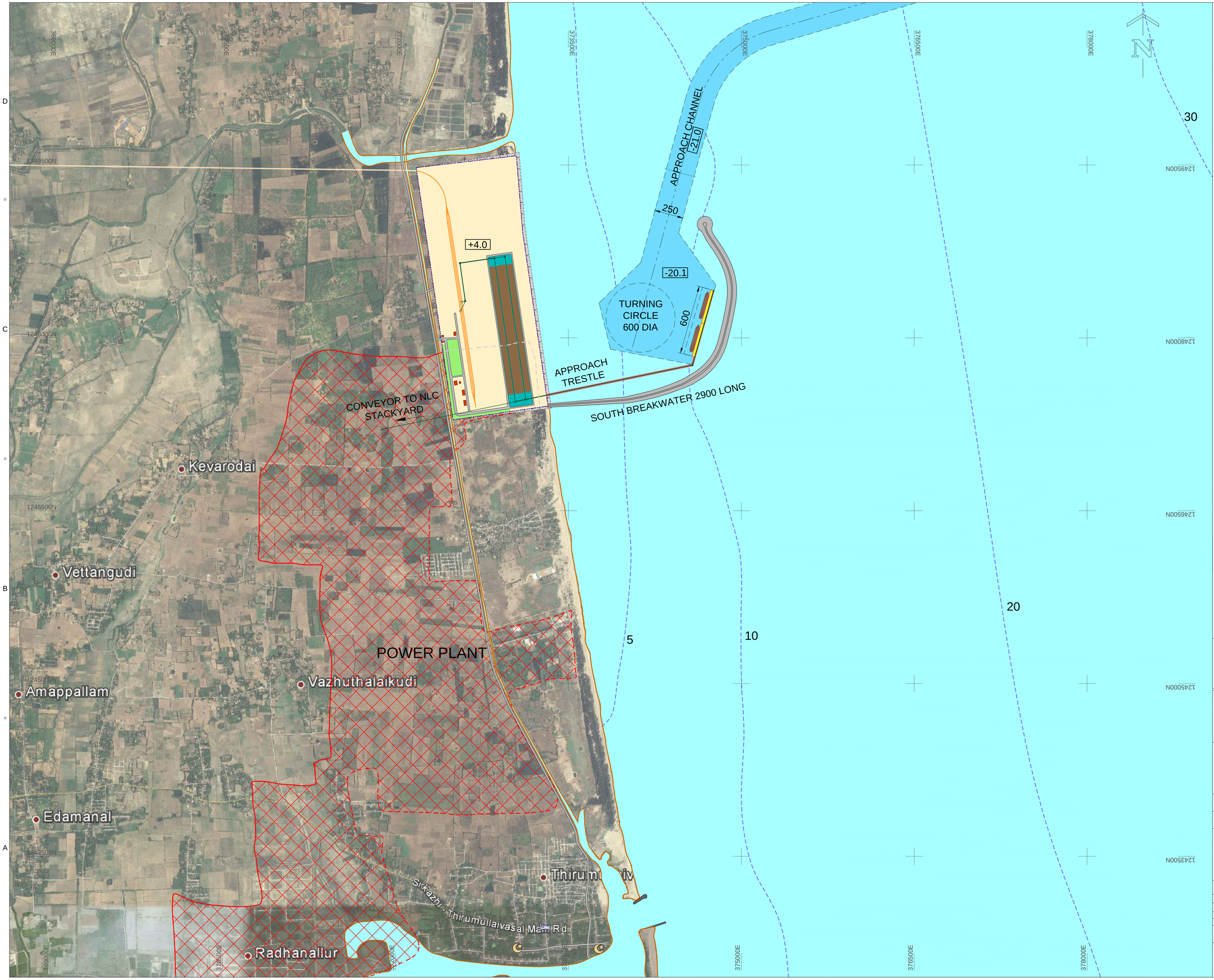

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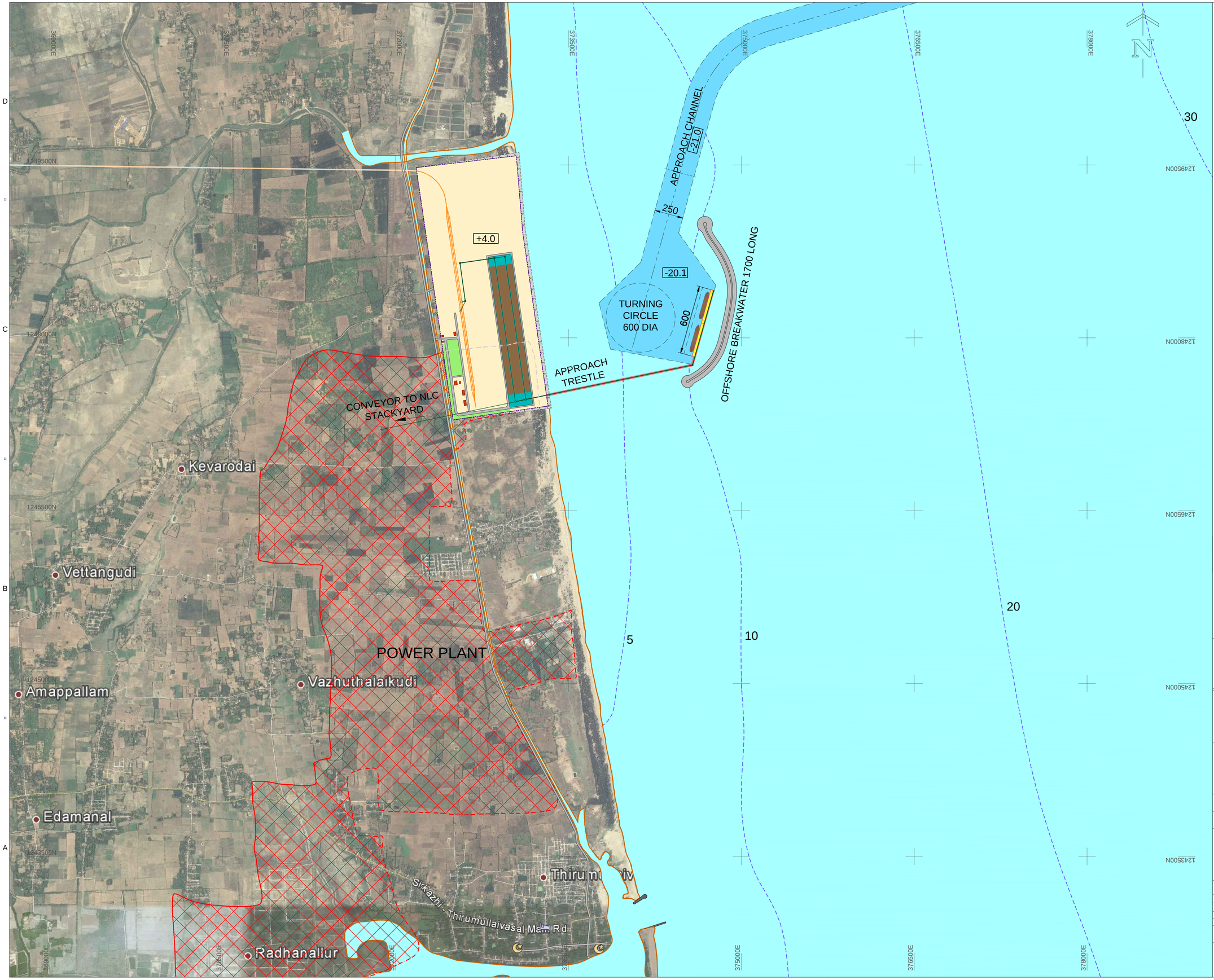

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NORTH BREAKWATER
1200 LONG

APPROACH CHANNEL
-21.0

250

900

+4.0

-20.1

TURNING
CIRCLE
600 DIA

600

600

APPROACH
TRESTLE

SOUTH BREAKWATER 3400 LONG

CONVEYOR TO NLC
STACKYARD

POWER PLANT

Kevarodai

Vettangudi

Amappallam

Vazhuthalaikudi

Edamanal

Thirumullaivasal

Sirkazhi - Thirumullaivasal Main Rd

Radhanallur

30

20

10

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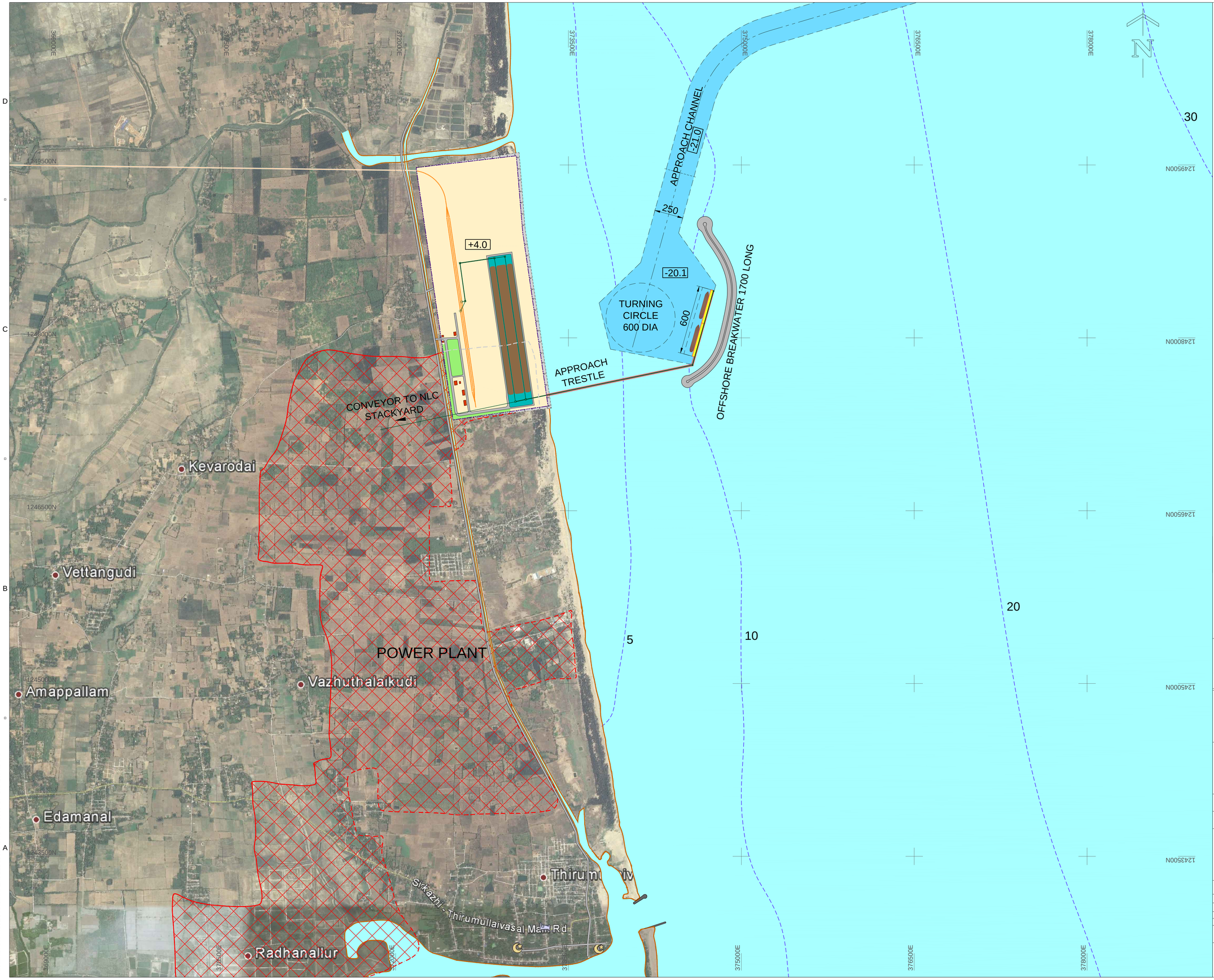

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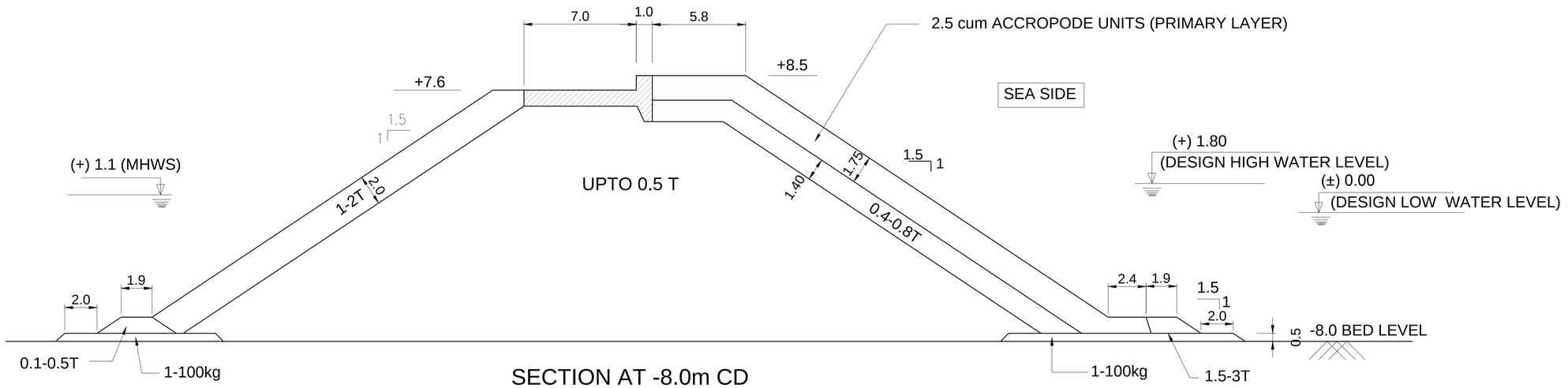

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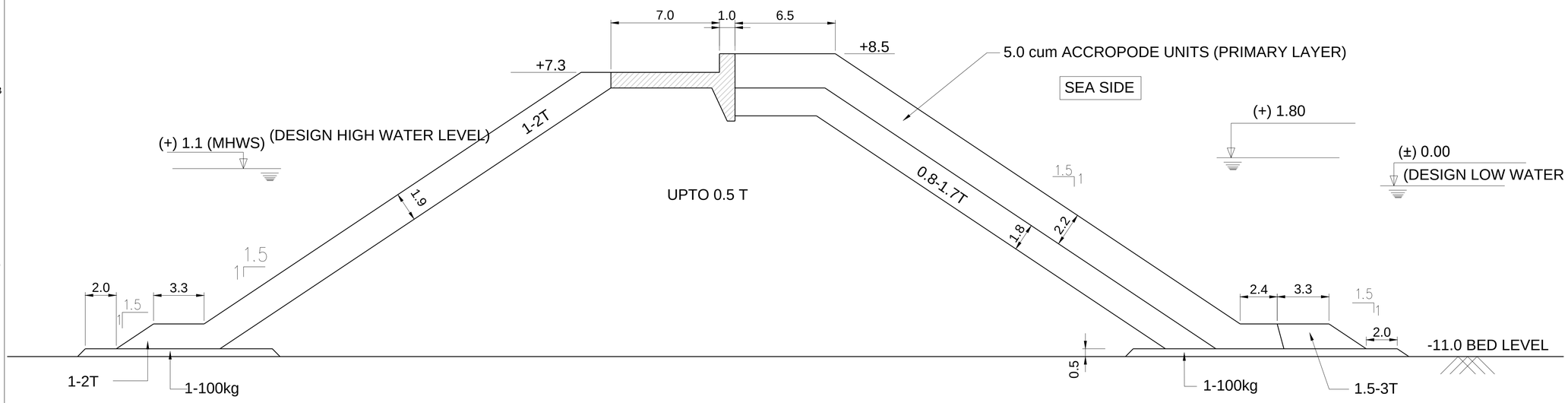

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Ministry of Shipping Government of India

INDIAN PORTS ASSOCIATION

PROJECT:

SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT SIRKAZHI

PART/DISCIPLINE:

DIMENSIONS ARE IN:

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE: TYPICAL CROSS SECTIONS OF BREAKWATER

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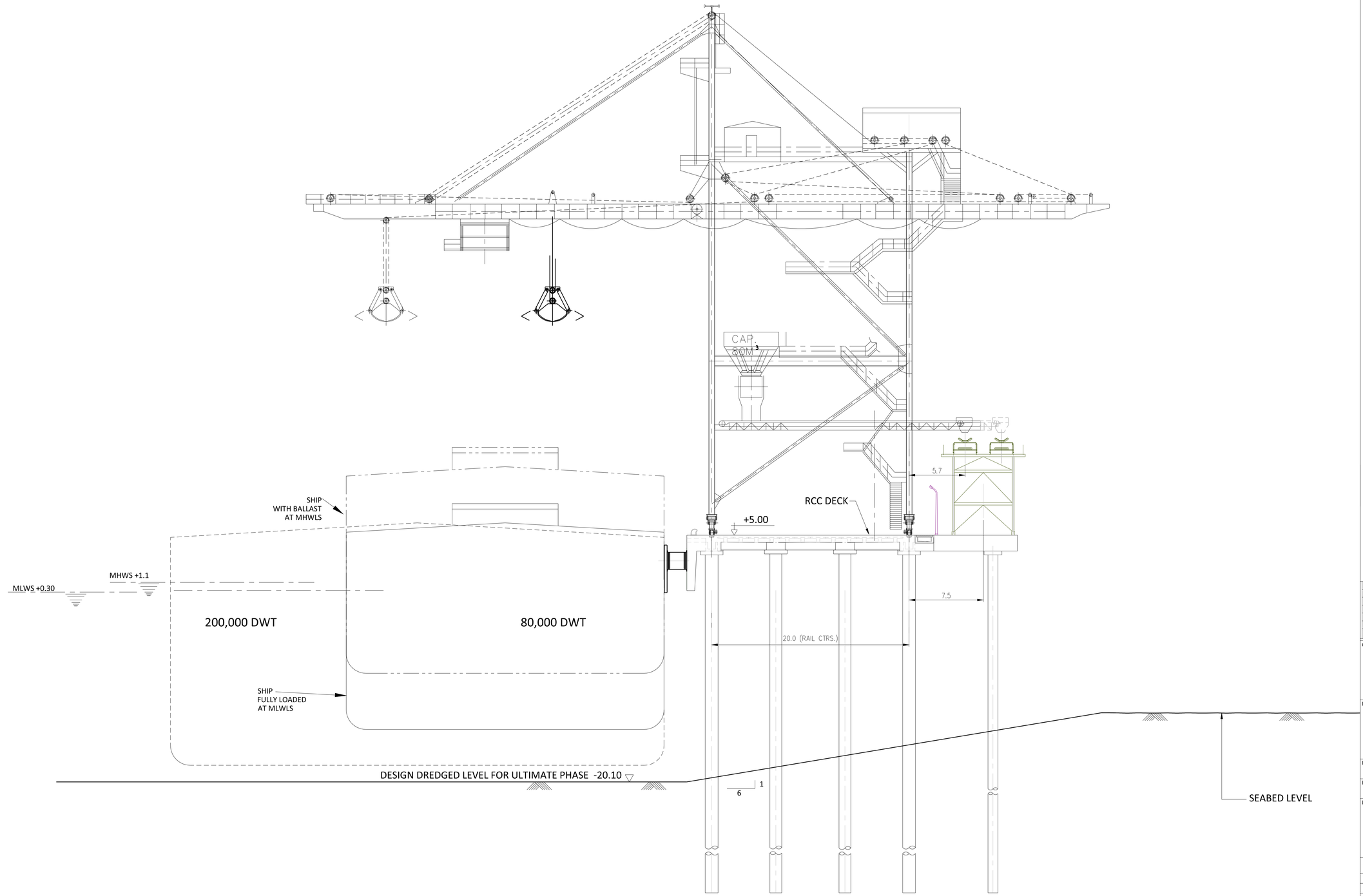

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Ministry of Shipping
Government of India

PROJECT:

SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT SIRKAZHI

PART/DISCIPLINE:

DIMENSIONS ARE IN:

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE:

TYPICAL CROSS SECTION OF BULK BERTH

SHEET 1 OF 1

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Checked: AM
Designer: SV
Project Management Initials:

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S/R
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SILO-2
RAIL SIDINGS
SUBSTATION
WATER TANK
WORKSHOP
CANTEEN
ADMIN BUILDING
GATE HOUSE
ENTRY/EXIT
BUCKINGHAM CANAL
ROAD TOWARD THODUVAI VILLAGE & THIRUMULLAIVASAL
CONVEYOR TO NLC STACKYARD
N

STACKER CUM RECLAMER
STACKER CUM RECLAMER
℄ OF ROAD
℄ OF ROAD
15000
45000
12000
80000
12000
45000
194000

SECTION 1-1

NOTES:-

1 ALL DIMENSIONS ARE IN MILLIMETERS UNLESS NOTED OTHERWISE.

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

REV.	DATE	DESCRIPTION	DR.	CH.	APP.
1					

REVISION DETAILS

CLIENT/OWNER:

Ministry of Shipping
Government of India

INDIAN PORTS ASSOCIATION

PROJECT:

SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT SIRKAZHI

PART/DISCIPLINE:

DIMENSIONS ARE IN:

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE:

TYPICAL CROSS SECTION OF BULK YARD

SHEET 1 OF 1

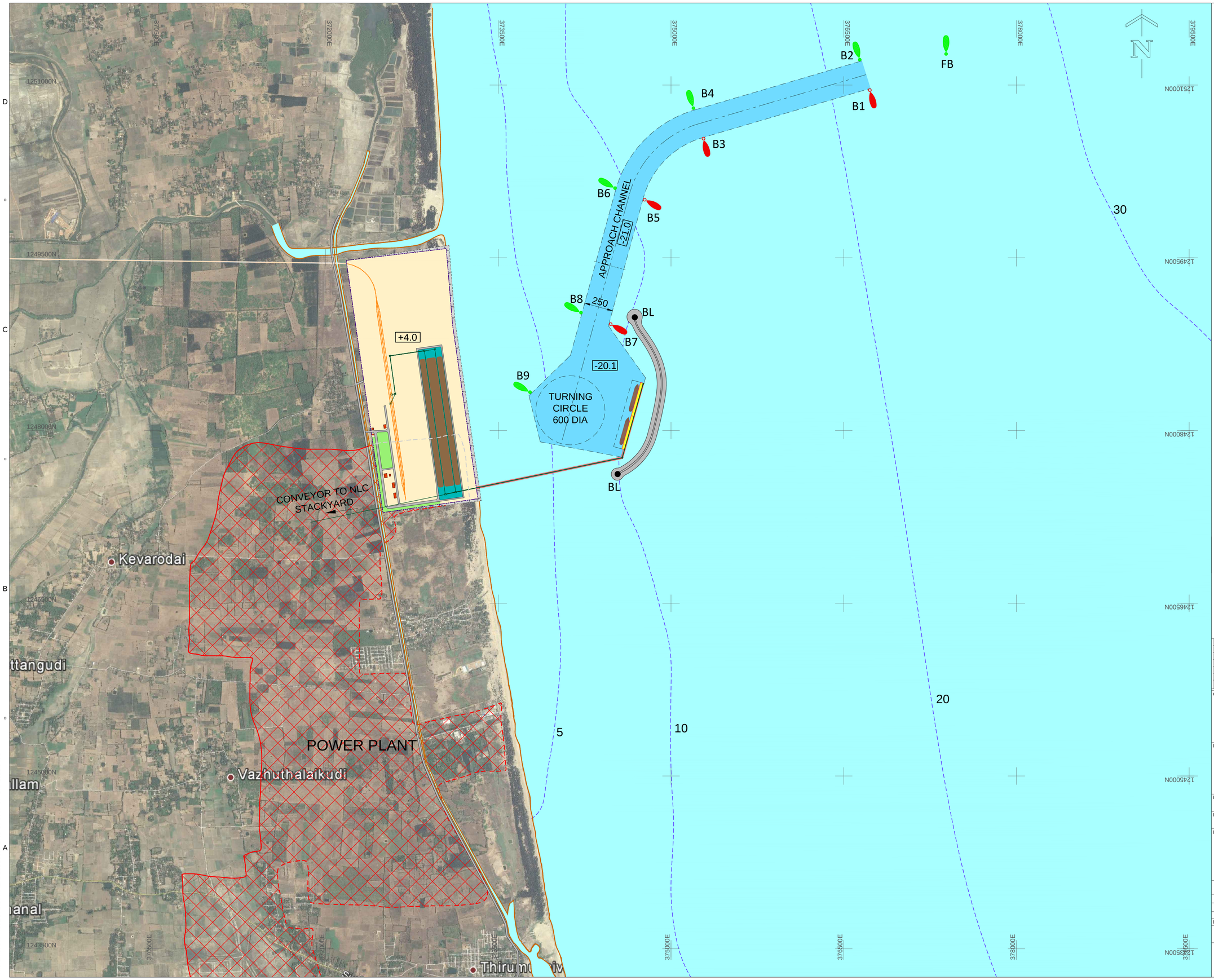
Sign:	Sign:	Sign:
Date: 30-06-2016	Date: 30-06-2016	Date: 30-06-2016
Name: SV	Name: AM	Name: SG
Designed by	Checked by	Approved by

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-SRK1009 REV. 0

AECOM India Pvt. Ltd.

Last saved by: VERMAS2(2016-07-15) Last Plotted: 2015-10-29
Filename: D:\PROJECTS\SIRKAZHI\DELD15005-DRG-10-0000-CP-SRK1010.DWG

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



NOTES:-

1 ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.

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

LEGEND:

- FB — FAIR BOUY
- B1... — CHANNEL MARKING BUOY
- BL — BEACON LIGHT

REV.	DATE	DESCRIPTION	DR.	CH.	APR.
1					

REVISION DETAILS

CLIENT/OWNER:

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Government of India

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PROJECT:

SAGARMALA - TEFR FOR DEVELOPMENT OF PORT AT SIRKAZHI

PART/DISCIPLINE:

DIMENSIONS ARE IN:

PURPOSE: TECHNO ECONOMIC FEASIBILITY REPORT

DRAWING TITLE:

LAYOUT OF NAVIGATIONAL AIDS

SHEET 1 OF 1

Designed by	Checked by	Approved by
Sign:	Sign:	Sign:
Date: 30-06-2016	Date: 30-06-2016	Date: 30-06-2016
Name: SV	Name: AM	Name: SG

DRAWING NUMBER: DELD15005-DRG-10-0000-CP-SRK1011 REV. 0

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