# CONSULTANCY SERVICES FOR PREPARATION OF INTEGRATED MASTER PLAN FOR VIZHINJAM PORT

# Integrated Port Master Plan Report - Final

Prepared for

Vizhinjam International Seaport Limited

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# Table of Contents


**Glossary ..... i**

**1 Introduction ..... 1**

1.1 Project ..... 1
1.2 Scope of Works ..... 1
1.3 Previous Studies ..... 2
1.4 Present Submission ..... 3

**2 Site Conditions ..... 4**

2.1 Background ..... 4
2.2 Vizhinjam Port Location ..... 4
2.3 Meteorological and Oceanographic Data ..... 5
2.4 Geotechnical Data ..... 6
2.5 Topographical Data ..... 7
2.6 Existing Transport Linkages ..... 8

**3 Master Planning Process ..... 10**

3.1 Previous planning studies ..... 10
3.2 AECOM Port Planning Process Summary ..... 11
3.3 Port Planning Issues ..... 16
3.4 Green Port Initiatives ..... 244

**4 Functional Requirements ..... 26**

4.1 General ..... 26
4.2 Traffic Forecast ..... 26
4.3 Design Vessels ..... 27
4.4 Length of Berths ..... 31
4.5 Port Capacity Analysis ..... 31
4.6 Functional Requirements ..... 39
4.7 Buildings ..... 47
4.8 Coast Guard ..... 50
4.9 Multipurpose Cargo Terminal ..... 50
4.10 Liquid Bulk Terminal for Bunkering ..... 51

4.11 Fishery Berths....51
4.12 Cruise Terminal....51
4.13 Navigational Requirements....54
4.14 Off-Port Support Facilities....59
4.15 Other Users....63
4.16 Utilities....65
4.17 Port Operation Support Systems....70
4.18 Other facilities....70
**5 Port Master Plan....71**
5.1 Overview....71
5.2 Port Master Plan Alternatives....71
5.3 Master Plan Key Component Options....75
5.4 Evaluation of Master Plan Options....81
5.5 Modification/ Refinement in the Recommended Master Plan Alternative....83
**6 Final Port Master Plan....86**
6.1 Overview....86
6.2 Key Elements....91
**7 Land Use Plan....100**
7.1 General....100
7.2 Land Use Plan....100
**8 Capital Expenditures....102**
8.1 Introduction....102
8.2 Project Preliminaries & Site Development....103
8.3 Dredging & Reclamation....103
8.4 Breakwaters....103
8.5 Berthing Structures....103
8.6 Container Yard....104
8.7 Equipments....104
8.8 Buildings....104
8.9 Utilities....104
8.10 Port Craft & Aids to Navigation....105

8.11 Gate Complex & Terminal Road ..... 105
8.12 Block Cost Estimation Summary ..... 105
**9 Implementation Schedule ..... 107**
9.1 General ..... 107
9.2 Breakwater ..... 107
9.3 Dredging ..... 108
9.4 Reclamation Bund ..... 110
9.5 Reclamation ..... 110
9.6 Berth Construction ..... 110
9.7 Equipment, Pavements, Roads, Rail & Buildings ..... 111
9.8 Summary ..... 112

**Annexure 1 Master Plan Drawings for Port of Vizhinjam**

**Annexure 2 Marine Geotechnical Investigations**

**Annexure 3 Container Transhipment Port Comparison Analysis**

**Annexure 4 Detailed Capital Expenditures (CAPEX) for Vizhinjam Port Master Plan**

# List of Figures

Figure 2-1 Vizhinjam port location with respect to international East-West shipping route....................4
Figure 2-2 Existing Bathymetry at Proposed Port of Vizhinjam......................................................................5
Figure 2-3 Topographic map of the port backup facilities area as provided by VISL ..............................7
Figure 2-4 Road and Rail Connectivity to Vizhinjam Port.............................................................................8
Figure 3-1 Initial Port Master Plan Layout......................................................................................................10
Figure 3-2 Results of Multi-Criteria Analysis.................................................................................................11
Figure 3-3 Vizhinjam Port master planning process elements....................................................................13
Figure 3-4 Opportunities & Constraints map for Vizhinjam port site ........................................................176
Figure 3-5 Vizhinjam port location with respect to international East-West shipping route..................17
Figure 3-6 Temporary road up to the waterfront...........................................................................................18
Figure 3-8 Mulloor Naga Temple located at southern land parcels ...........................................................20
Figure 3-9 View of the Port Waterfront from South .......................................................................................21
Figure 3-10 Location of hard materials within proposed dredge area........................................................22
Figure 4-1 Distribution of Container Vessels by TEU....................................................................................29
Figure 4-2 Vertical window of accessibility for Cruise Vessels...................................................................53
Figure 4-3 Proposed Horizontal Window of Accessibility for Mobile Passenger-Boarding Bridges .....53
Figure 4-4 Sample IALA Buoyage System ......................................................................................................58
Figure 4-5 Schematic layout of ship repair yard by CSL...............................................................................64
Figure 5-1 Vizhinjam Port Master Plan Layout by RH...................................................................................71
Figure 5-2 Master Plan Alternative 1 ................................................................................................................73
Figure 5-3 Master Plan Alternative 2 ................................................................................................................74
Figure 5-4 Master Plan Alternative 3 ................................................................................................................75
Figure 5-5 Cruise Terminal Location along Inner South Breakwater, Option 1 during Initial phase....76
Figure 5-6 Cruise Terminal during Port Master Plan Option 1 ....................................................................76
Figure 5-7 Cruise Terminal location along North Breakwater, Option 2 during Initial Phase...............77
Figure 5-8 Port Layout Option 1 Rail Entry shown in RED and Road Entry shown in GREEN ............78
Figure 5-9 Port Layout Option 2 Rail Entry shown in RED and Road Entry shown in GREEN ...........79
Figure 5-10 Port layout Option 3 Rail Entry shown in RED and Road entry shown in GREEN.............80
Figure 5-11 Layout Iterations Carried on Recommended Master Plan Alternative................................85
Figure 6-1 Final Master Plan for Port of Vizhinjam.........................................................................................88
Figure 6-2 Phase-1 development of Port of Vizhinjam..................................................................................89
Figure 6-3 Phase-2 development of Port of Vizhinjam..................................................................................90
Figure 6-4 Traffic Circulation Pattern for Port of Vizhinjam Master Plan ...................................................93
Figure 6-5 Option 1 for Cruise Terminal and Access .....................................................................................95
Figure 6-6 Option 2 for Cruise Terminal and Access .....................................................................................96
Figure 6-7 Gate Complex for Port of Vizhinjam...............................................................................................97
Figure 6-8 Future Expansion Areas in the Master Plan for Port of Vizhinjam..........................................99
Figure 7-1 Land Use Plan for Port of Vizhinjam ..........................................................................................101

# List of Tables


Table 1-1 Past Studies carried out for Vizhinjam Port....................2
Table 2-1 Meteorological and Oceanographic Data for Vizhinjam Port location....................5
Table 4-1 Traffic Forecast Summary for Vizhinjam Port....................27
Table 4-2 World Fleet of Container Ships and Order books....................28
Table 4-3 Design Container Vessels over Master Plan Horizon....................30
Table 4-4 Characteristics of Port Crafts....................31
Table 4-5 Minimum Berth Lengths....................31
Table 4-6 Phase-wise Berth Capacity Analysis....................33
Table 4-7 Phase-wise Container Yard Capacity Analysis....................35
Table 4-8 Phase-wise Rail Yard Capacity Analysis....................36
Table 4-9 Phase-wise Gate Capacity Analysis....................38
Table 4-10 Phase-wise Development Summary....................39
Table 4-11 Approach Channel Lane Requirement Estimation....................54
Table 4-13 Approach Channel Dredging Depth Estimation....................57
Table 4-14 Navigational Requirement Summary....................58
Table 4-15 Capacity calculations for CFS/Warehousing....................60
Table 4-16 Residential Requirements for Staff and Social Infrastructure....................61
Table 5-1 Rail Road Connectivity Evaluation Matrix....................81
Table 5-2 Multi Criteria Evaluation of Alternative Master Plan Layouts....................82
Table 6-1 Master Plan Phase Wise Container Terminal Capacity....................91
Table 6-2 Phase-wise Container Yard Capacity Over Master Plan Horizon....................92
Table 7-1 Land Use Plan Areas....................100
Table 8-1 Block cost estimates summary....................105
Table 8-2 Block cost estimates split between VISL and Private Port Operator....................106
Table 9-2 Dredging Works Timeframe Calculation....................109
Table 9-3 Marine Works Construction TImeframe Calculation....................111

# Glossary

APFC- Automatic Power Factor Correction

CAPEX- Capital Expenditure

CCTV- Closed Circuit Television

CD- Chart Datum

CFO- Chief Financial Officer

CFS- Container Freight Station

CIRIA- Construction Industry Research and Information Association

CLC- Construction Logistic Centre

COSCO- China Ocean Shipping Company

CRZ- Coastal Regulation Zone

CSS- Compact Substations

CSD- Cutter Suction Dredger

CSL- Cochin Shipyard Limited

CY- Container Yard

DP- Dubai Ports

DPR- Detail Project Report

ECH- Empty Containers Handlers

EDI- Electronic Data Interchange

EIA- Environmental Impact Assessment

EPC- Engineering Procurement Construction

E-RTG- Electric Rubber Tired Gantry

FY- Fiscal Year

GoK- Government of Kerala

GTA- General Terminal Area

Hs- Wave Height Significant

HYSD- High Yield Strength Deformed

HV- High Voltage

IALA- International Association of Marine Aids to Navigation and Lighthouse Authorities

IBC- Inter Box Connector

IFC- International Finance Corporation

IMZ- Inter Modal Zone

INR- Indian National Rupees

IOCL- Indian Oil Corporation Limited

IT- Informational Technologies

IVT- Intra Terminal Vehicle

JCT- Jaya Container Terminal

KLD- Kilo Liter per Day

LNG- Liquefied Natural Gas

LOA- Length Overall

LTR- L&T Ramboll Consulting Engineers Limited

LV- Low Voltage

MARPOL- Marine Pollution, The International Convention for the Prevention of Pollution from Ships

MHHW- Mean Highest High Water

MLLW- Mean Lowest Low Water

MVA- Mega Volt Ampere

NE- North East

NH- National Highway

NOx- Nitrogen Oxide

O&C- Opportunities and Constraints

PCC- Portland Cement Concrete

PIANC- Permanent International Association for Navigation and Congress

PM- Particulate Matter

POV- Personally Owned Vehicles

PPP- Public Private Partnership

PRECAP- Preliminary Capacity

PSA- Port of Singapore Authority

PWD- Public Works Department

QC- Quay Crane

R&R- Relocation & Rehabilitation

RCC- Reinforced Cement Concrete

RDT- Radio Data Transfer

RH- Royal Haskoning

RMG- Rail Mounted Gantry

RMQC- Rail Mounted Quay Cranes

RPM- Radiation Portal Monitor

RS- Reach Stacker

RTG- Rubber Tired Gantry

RVNL- Rail Vikas Nigam Limited

SAGT- South Asia Gateway Terminal

SOx- Sulfur Oxide

SPV- Special Purpose Vehicle

SSW- South-South West

STP- Sewage Treatment Plant

SW- South West

SWAN- Simulating Wave Near Shore

TEU- Twenty-foot Equivalent Unit

TGS- Twenty foot Ground Slot

TOS- Terminal Operating System

TSHD- Trailing Suction Hopper Dredge

UHF- Ultra High Frequency

USA- United States of America

USD- United States Dollar

VAT- Value Added Tax

VDU- Video Display Unit

VISL- Vizhinjam International Seaport Limited

VTMS- Vessel Traffic Management System

WOA- Window of Accessibility

# 1 Introduction

## 1.1 Project

The Government of Kerala (GoK) through its special purpose government company (SPV – Special Purpose Vehicle) Vizhinjam International Seaport Ltd (VISL) is developing a deep water Multipurpose Greenfield Port at Vizhinjam. The VISL has been formed as a nodal agency for implementing the Greenfield port at Vizhinjam in Thiruvananthapuram, capital city of Kerala. The SPV is fully owned by the Government of Kerala.

The proposed project is based on a Landlord Port Model[1], where all the civil work facilities viz., construction of basic infrastructure like breakwater, quay wall, dredging, reclamation, rail and road access to the Port will be developed by VISL. Port Operation will be through the PPP model for an agreed concession time period. Terminal operator(s) will be required to develop the container yard, terminal buildings, and purchase & operate the cargo handling equipments.

In this regard, VISL have engaged AECOM to develop an integrated port master plan and preparation of EPC tender documents for the civil works. This report describes the port master plan.

As per the master plan, the port will be developed in three phases. Once fully developed, the port is envisioned to have,

- Fish landing center with a total berth length of 850m in Phase-1 development.
- Breakwaters of total length 5,160m (north breakwater 3,960m, inner south breakwater 725m to be developed in Phase-1 and south breakwater of length 475m to be developed in Phase-3) to be developed in two phases.
- Total container berth length of 2,000m which would be developed in three phases (800m in Phase-1, additional 400m in Phase-2 and another 800m in Phase-3).
- Container yard commensurate with the quay development in three phases.
- Cruise berths of 600m which would be developed in two phases (300m in Phase-2 and another 300m in Phase-3).
- Port craft berth of 220m and Coast Guard berth of 120m length in Phase-1.

The port is designed to primarily cater to the container transshipment business with provision for a cruise terminal and general/multipurpose cargo area.

## 1.2 Scope of Works

AECOM's primary scope of work related to preparing the integrated landside port master plan was to:

- Determine the functional requirements critical for port operations by phase;
- Carry out capacity analysis of Berth, Container yard, Rail yard and Gate complex;
- Determine the overall land use plan;
- Prepare an integrated master plan indicating the inter connectivity of road and rail;
- Determine the block cost estimate for critical port master plan elements;
- Prepare implementation schedule.

[1] Definition of Landlord Port Model as per VISL: The landlord port is characterized by its mixed public-private orientation. Under this model, the port authority acts as regulatory body and as landlord, while port operations (especially cargo handling) are carried out by private companies. Examples of landlord ports are Rotterdam, Antwerp, New York, and since 1997, Singapore. Today, the landlord port is the dominant port model in larger and medium sized ports.

The content of this report summarizes the findings and AECOM's recommendations on the long term vision for the Port.

## 1.3 Previous Studies

Before the commencement of preparing the Port Master Plan, VISL had carried out the required technical studies, which have become the base of this study. During the preparation of the Port Master Plan, additional studies have also been carried out by other consultants, which have also been sourced and utilized in preparation of the Port Master Plan.

Table 1-1 mentions reports related to Vizhinjam port project and work carried out by previous consultants that have been sourced and referenced in preparation of the Port Master Plan:

Table 1-1 Past Studies carried out for Vizhinjam Port

| S. No. | Description of the Study/Investigations | Agency | Time (Month – Year) |
|---|---|---|---|
| **OCEANOGRAPHIC/GEOTECHNICAL INVESTIGATIONS** | | | |
| 1. | Geotechnical and Geophysical Survey Works | Fugro Geotech Pvt. Limited | May 2011 |
| **MODEL STUDIES** | | | |
| 1. | Wave Modeling Report | Royal Haskoning/IFC | August 2010 |
| 2. | Mathematical Modeling Study Report | L&T-RAMBØLL Consulting Engineers Limited, Chennai (LTR) | March 2012 |
| 3. | Shoreline Modeling Study and Impact of Proposed Port at Vizhinjam on Existing Fishing Harbour, Final Report | L&T-RAMBØLL Consulting Engineers Limited, Chennai (LTR) | September 2012 |
| **TECHNICAL STUDIES** | | | |
| 1. | Preliminary Project Plan Report | Royal Haskoning/IFC | October 2010 |
| 2. | Field Surveys and Investigation Report, May 2004 | L&T-RAMBØLL Consulting Engineers Limited, Chennai (LTR) in association with Rogge Marine Consulting GMBH, Germany (RMC), Rambøll, Hannenmann & Højlund A/S, Denmark (RAMBØLL) and L&T Capital Company Limited, India (LTC). | May 2004 |
| 3. | Detailed Techno-Economic Feasibility Study | L&T-RAMBØLL Consulting Engineers Limited, Chennai (LTR) in association with Rogge Marine Consulting GMBH, Germany (RMC), Rambøll, Hannenmann & Højlund A/S, Denmark (RAMBØLL) and L&T Capital Company Limited, India (LTC). | May 2004, Revision June 2007 |
| 4. | Rapid Environmental Impact Assessment Report | L&T-RAMBØLL Consulting Engineers Limited, Chennai (LTR) | February 2004 |
| **TRAFFIC STUDIES** | | | |
| 1. | Kerala Port PPP – Market Study | Drewry Shipping Consultants Ltd. | November 2010 |

## 1.4 Present Submission

The present submission is the Final Report on the Integrated Master Plan for the development of the Port, which is one of the key deliverables to VISL by AECOM as per the scope of work agreed between AECOM and VISL. This submission consists of:

- Port Master Plan Report
- Annexure 1: Master Plan Drawings
- Annexure 2: Geotechnical Borehole Profiles
- Annexure 3: Trans-shipment Port Comparison Analysis
- Annexure 4: Detailed CAPEX Breakup for Master Plan

# 2 Site Conditions

## 2.1 Background

The data on site conditions for Vizhinjam Port site has been compiled from the various site specific studies / investigations undertaken by various agencies.

The brief outcome of these studies / investigations is referenced appropriately in this report in order to advice the Port Master Plan.

## 2.2 Vizhinjam Port Location

The proposed port at Vizhinjam (Lat 8° 22’ N, Long 76° 57’ E) is located in India in the state of Kerala, at 16 km south of the State Capital, Thiruvananthapuram which falls in a close proximity to the international East-West shipping route. The port location is selected to tap the potential for development of a deep water international container transshipment port that can handle the largest container vessels navigating the East-West shipping route. The proposed port location is just south to the existing fishery harbor of Vizhinjam.


Figure 2-1 Vizhinjam port location with respect to international East-West shipping route

The key advantage of the proposed site location is availability of naturally deep water and proximity to the East-West shipping channel. An overview of the bathymetry reveals that the seabed within the survey area covering the water front of the proposed port and the approach channel is gently sloping down towards south west, i.e. seabed depth contours are perpendicular to the shoreline towards sea. No significant bathymetric undulations are recorded within the survey area for the depths considered for the proposed port. The site is characterized by naturally available deep water depths with 20m contour located at a distance of less than 800m from the shore.

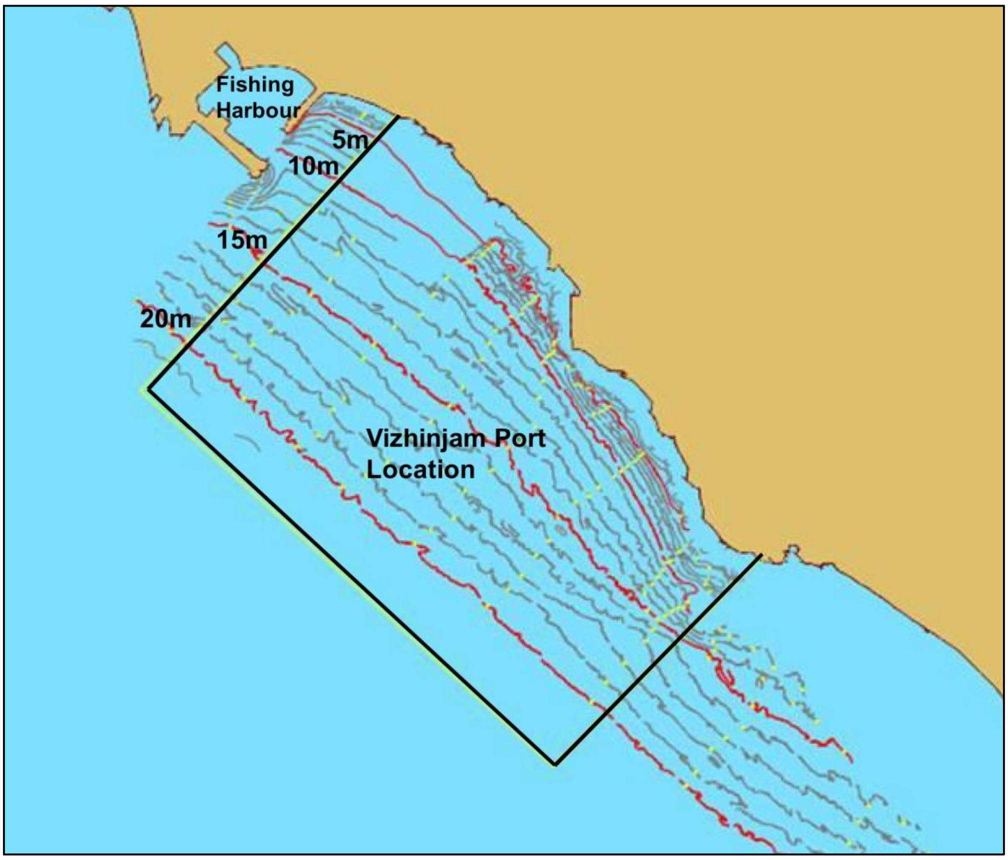



Figure 2-2 Existing Bathymetry at Proposed Port of Vizhinjam

## 2.3 Meteorological and Oceanographic Data

The met-oceanographic data applicable for project region is summarized in Table 2-1.

Table 2-1 Meteorological and Oceanographic Data for Vizhinjam Port location

| Parameters | Unit | | Remarks |
|---|---|---|---|
| Average Annual Rainfall | mm | 1800 | Receives rain from SW monsoon from June to September as well as the NE monsoons which hit the coastal area by October |
| Mean Minimum Temperature | deg | 23.5 | Dec., Jan. and Feb. are the coldest months |
| Mean Maximum Temperature | deg | 30.8 | April and May are the Hottest month |
| Relative Humidity | % | 90 | Maximum Relative humidity is observed in June |
| Maximum Wind speeds | m/s | 15 | Observed during the monsoons |

| Parameters | Unit | | Remarks |
|---|---|---|---|
| Prevailing Wind Direction | deg | 240 & 315 | Between West and North West quadrant |
| Near shore Wave height | m | 1.6 - 2.0 | Near shore wave height at 20m depth contour |
| Prevailing Wave Direction | | SSW | |
| Tidal Variation | m | 0.5 | With the MHHW 0.8m and MLLW at 0.3m. |
| Currents Intensity<br>– During Monsoon<br>– Non Monsoon | Knots | 2.0<br>1.0 | |
| Prevailing Current Direction | | SE | During monsoons |

## 2.4 Geotechnical Data

VISL commissioned the geotechnical investigations through M/s Fugro Geotech Ltd. Mumbai (Fugro) considering the Phase-1 and Master Plan Development of the Port.

Previous soil investigation studies performed in the proposed port area were as follows,

1) Marine Geophysical and Bathymetric surveys, and
2) Onshore and Marine Geotechnical Investigations, performed by Fugro.

Marine geotechnical investigations have already been carried out for the proposed port site. 18 no. of marine borehole investigations were carried out in the harbor area covering the breakwater, berths, turning circle, navigational channel and the reclamation area for the container yard.

The geophysical data at the site reveals that, the subsurface generally consists of marine deposited silty sand for the full depth of exploration in the approach channel area, layers of clay and sand were encountered along the breakwater stretch, while layers of sand and rock were encountered in the terminal area and southern breakwaters.

The outcome of investigations reveals that in general, the stratification in inner approach channel is silty sand over a layer of dense sand, followed by moderately weathered basalt. The stratification in the middle of entrance channel is predominantly silts and sand on weathered rock. The weathered rock levels vary from -26m to -28m Chart Datum (CD) in this stretch.

The stratification in outer channel is predominantly sand followed by weathered rock. The rock levels are mostly lower than -28m CD in this stretch.

The stratification of the port area is loose fine sand, followed by soft to dense sand, underlain by moderately weathered basalt. The rock levels were found to be varying between -22m to -24m CD in the container terminal area and between -26m to -32m CD in the navigational basin.

The general topography of the site shows exposed rock along the coast except at a few locations where beaches are present. The seabed dips relatively steeply towards the sea, with some sudden rises and falls due to the presence of rock outcrops. Detailed borehole profiles are provided in Annexure 2.

### 2.4.1 Seismic Conditions

The Geological Survey of India has identified Thiruvananthapuram district as a moderately earthquake-prone centre and categorized the district in the Seismic III Zone as per Indian Standard Code IS 1983-2002.

## 2.5 Topographical Data

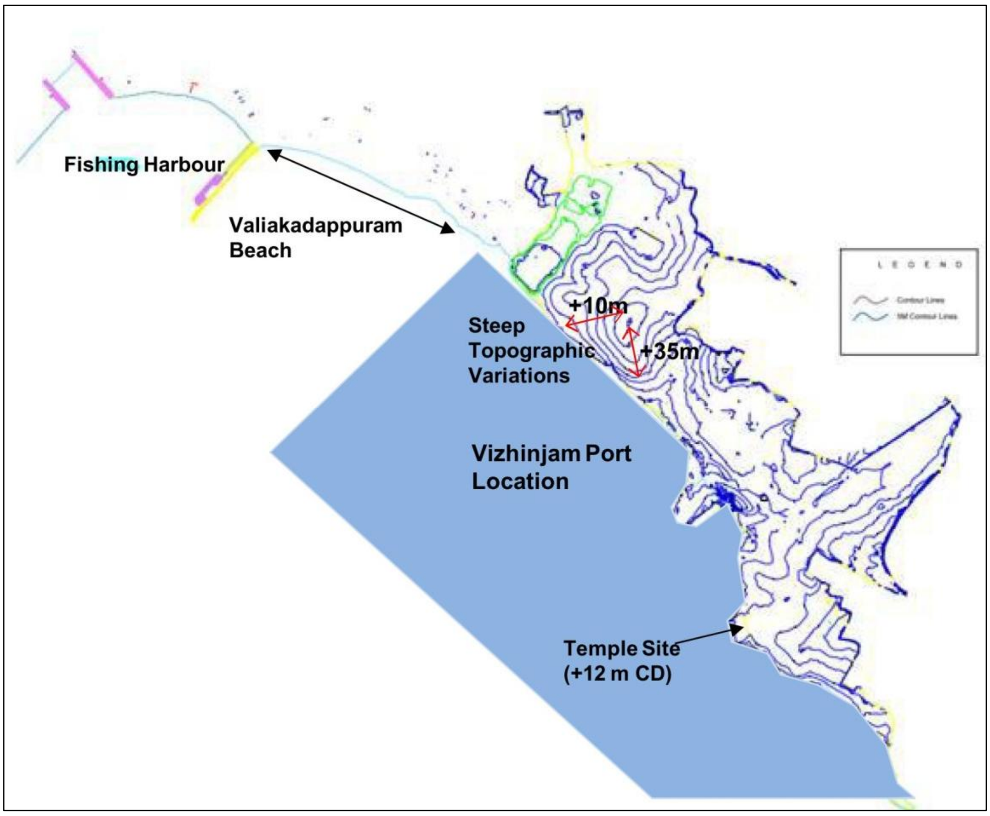



Figure 2-3 Topographic map of the port backup facilities area as provided by VISL

Figure 2-3 shows the topography map of the Vizhinjam port location. The blue lines represent elevation contours in an interval of 5m (10m, 15m, 20m…etc). Topography along the shore is very steep with weathered rock patches and high land areas. General topography of the port back-up land right behind the shoreline varies from +5m CD to up to +35m CD. The red arrows on the figure are showing steepness of the topography. The red arrows are connecting 10m & 35m elevation contours. Mulloor Naga Temple shown in the figure is located at +12m elevation on a high land area.

## 2.6 Existing Transport Linkages

Figure 2-4 shows the existing rail & road connections to the Vizhinjam Port site. The existing road and rail connectivity is further described in the sections below. In addition, the proposed rail access and road corridor for the port are also shown.

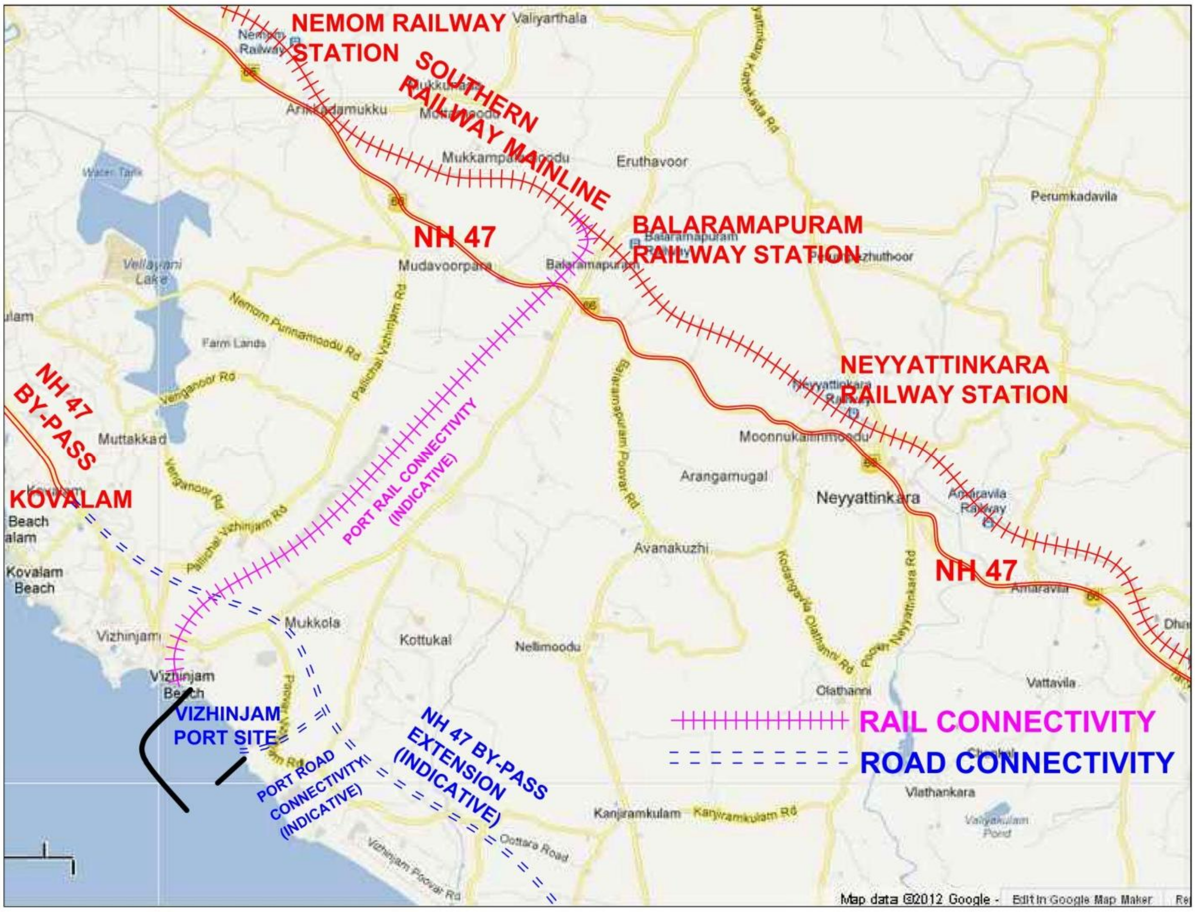



Figure 2-4 Road and Rail Connectivity to Vizhinjam Port

### 2.6.1 Connectivity

#### *2.6.1.1 Road*

The Thiruvananthapuram district is well connected by road, rail and airport to the rest of the country. National highway NH 47 passes through Thiruvananthapuram and is at a distance of approximately 8km and running almost parallel to the shoreline. NH47 connects Salem to Kanyakumari and is connected to Cochin Port through NH 47A. From Cochin to further north it is connected to Mumbai through NH 17. Thiruvananthapuram in North and Nagercoil & Kanyakumari in south are the nearest major urban centers on the NH 47. It is also connected to the major towns such as Thrissur, Palakkad, Kollam, Alappuzha in Kerala; and Coimbatore and Salem in Tamil Nadu. NH 47 is connected to Chennai and the rest of the country through NH 7 and NH 4.

NH 47 bypass road from Thiruvananthapuram extends upto Kovalam and construction works are in progress to extend it up to Parassala.

#### 2.6.1.2 Rail

A railway line runs parallel to the NH 47 and connects major towns such as Thrissur, Palakkad, Kollam and Alappuzha. The existing railway line runs North-South and connects to Mumbai through Konkan Railway. This rail line connects southern part of Tamil Nadu through Nagercoil and Tiruchirapalli as well as to the North-West region of Tamil Nadu through Palakkad and Coimbatore. Neyyatinkara and Balaramapuram railway stations are approximately 10 Km (aerial distance) from the Vizhinjam Port location. The rail line is broad with single line running between Thiruvananthapuram and Kanyakumari. Beyond Thiruvananthapuram towards north, double rail line exists up to Kayamkulam.

# 3 Master Planning Process

## 3.1 Previous planning studies

VISL has undertaken preliminary project planning of water side operations through the study undertaken by Royal Haskoning (RH). RH analyzed various navigational arrangements as well as harbor layouts for the proposed port. Figure 3-1 shows the various options considered for the harbor layout. The selection criteria considered were constructability, nautical accessibility, and operational aspects, planning flexibility, separation of businesses and natural environment & social aspects.

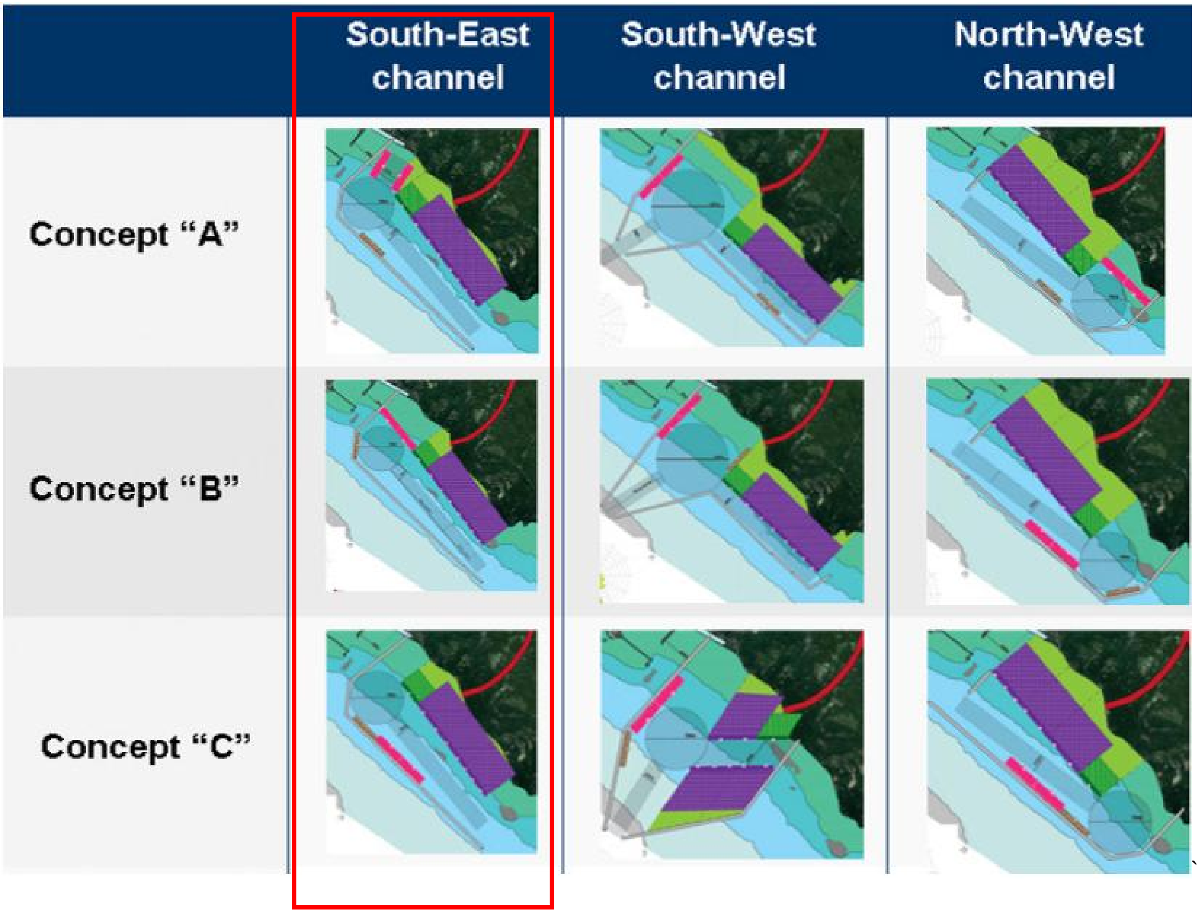



Figure 3-1 Initial Port Master Plan Layout
[Source: Royal Haskoning Report Vizhinjam Port PPP Project, Preliminary Project Plan, 2010]

The port configuration with the South-East channel alignment was recommended by RH because of its minimal impact on the existing fishing harbor, its good protection against waves and it's most economic construction cost. A Multi Criteria Analysis (MCA) was used by RH with factors mentioned above and the South-East channel alignment gave the highest weighted score as well as value of money for Phase-1 and full development. The result of this analysis is reproduced in Figure 3-2.

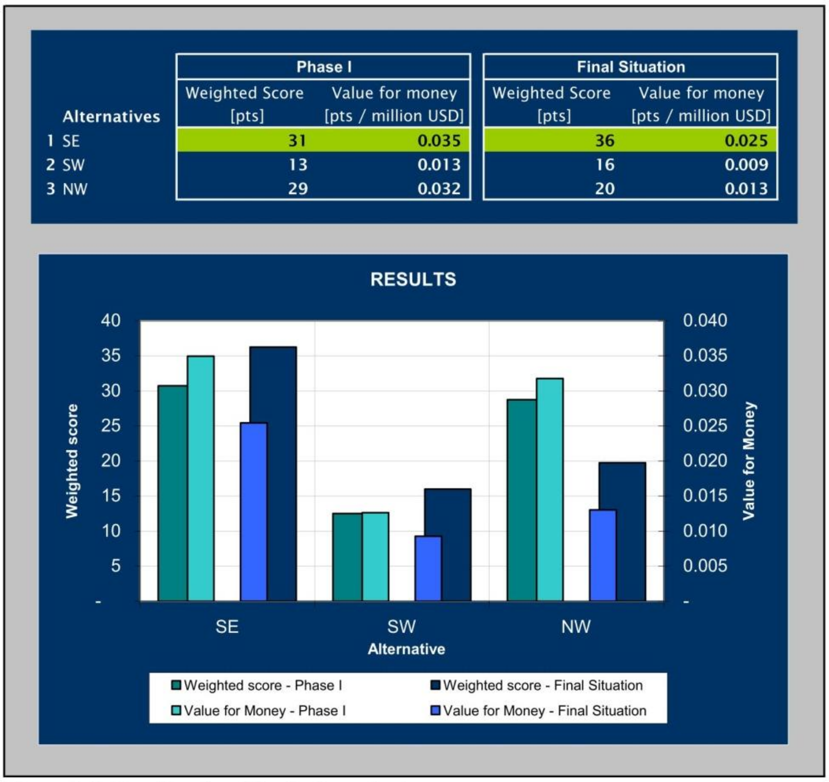



Figure 3-2 Results of Multi-Criteria Analysis
[Source: Royal Haskoning Report Vizhinjam Port PPP Project, Preliminary Project Plan, 2010]

The master plan work by AECOM has been developed based on the recommended RH layout of the port, VISL requirements and market study (anticipated container traffic volumes) carried out by DREWRY.

## 3.2 AECOM Port Planning Process Summary

For preparing the Integrated Master Plan of the Vizhinjam Port, AECOM has employed a collaborative and iterative planning process. Over the 10 months period, the plans and details were developed in diagram form, alternatives were generated, and then these were combined and refined in stages resulting into the final master plan.

VISL's feedback from various review sessions has been integrated into the planning concepts. During each review meeting, AECOM attempted to jointly identify concepts that were not acceptable, identified ways in which presented concepts could be improved, and put forth new concepts for consideration. This process continued until the presented final master plan was evolved.

Preliminary concept development for elements of the planning process started concurrently with the development of the port design criteria based on the traffic forecast. This began with the identification of the physical attributes of the sites being considered and identifying the site Opportunities and Constraints (O&C).

Existing land form, deep water access, adjacent property usage, public access, and other such influences were identified based on discussions with VISL and various project stakeholders.

The O&C map was prepared based on the feedback received from VISL. The O&C map acted as a "foundation roadmap" for integrating the physical design criteria resulting from the capacity analysis. Land use areas were then defined and color coded based upon the evolving design criteria.

Alternative schemes were then developed for the various land use areas being considered, first using simplified diagrams to physically locate them on the site map. These alternatives were then further analyzed, evaluated, and refined based on the master planning design criteria. Several iterations of development and refinement occurred, continually moving the assembly of different schemes into a composite that best met the finalized design criteria and VISL development goals.

As the planning process continued, the initial diagrams were further refined into meaningful plots describing the best land usage for each of the parcels available for development. Costing models for component elements were developed and integrated into the process. The resulting master plan developed as a composite of a multitude of smaller assemblages. As these plans came together, capital budget estimates and phasing considerations for each of the project components were finalized and integrated to produce the recommended project master plan.

Critical elements of the planning process are summarized in a flow chart format in Figure 3-3, followed by a brief description on key elements of the process.

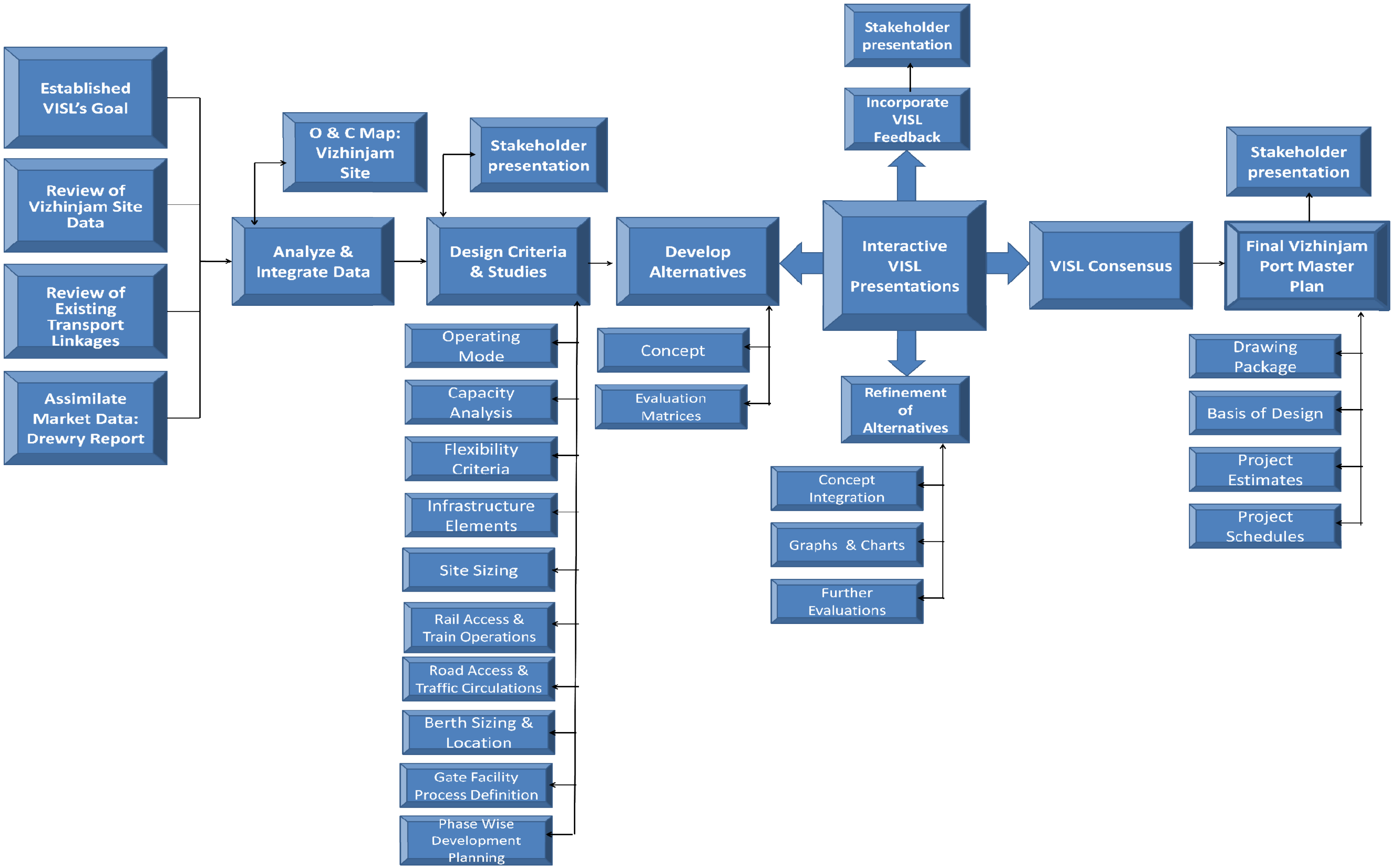



Figure 3-3 Vizhinjam Port master planning process elements

***Opportunities and Constraints:***

Based on the documents provided by VISL on land parcels near the proposed port already under ownership of VISL, land parcels being considered for procurement by negotiated purchase and land that cannot be owned, AECOM has prepared the O&C Map. The O&C Map shows constraints on development and opportunities for utilization of the various properties nearby the proposed port site that can be considered for future port operations, access to the port, or for providing port support facilities. This map was updated for each Project Meeting, as and when the new information became available.

***Throughput & Design Parameters (Capacity Analysis)*:**

Based on the market study carried out by DREWRY, AECOM has established the throughput parameters for preparation of the port master plan. These formed the basis for the design parameters. These sets of parameters were reviewed with and approved by VISL to ensure that they properly support the VISL development goals and formalized into a set of Design Criteria. These criteria were used in the evaluation of the planned marine facilities.

***Container Terminal Operating Mode*:**

AECOM considered various operating modes for the proposed container transshipment terminal, including a traditional diesel operated Rubber Tired Gantry (RTG) cranes, electric Rail Mounted Gantry (RMG) cranes and Electric RTGs. Based on various discussions AECOM had with VISL which established vision of the port being a Green Port, AECOM has recommended the terminal operating mode as Electric RTGs with provision for first phase with Diesel RTGs. The master plan has been carefully planned to leave flexibility for the operator to ultimately select the operating mode. Details of the selected operating mode is discussed later in this report.

***Site Sizing and Configurations***:

Based on the throughput and design parameters, AECOM has analyzed the appropriateness of the current plans for the transshipment terminal and assessed the facility needs including the total length of the wharf, container storage area, number of rail tracks and size of entry/exit gates for various phases of development. Where these were found deficient, AECOM has developed alternative site configurations that meet VISL goals.

These configurations show berths, wharfs, net site boundaries, backland operating areas, entrance and exit gate locations, major building and facility locations, rail yard locations, truck and rail access paths, and general internal circulation patterns.

***Road Access and Traffic Circulation***:

Information on the existing and proposed road access to the proposed port was provided by VISL to AECOM. The port access road has been carried out by the Public Works Department (PWD) and preliminary information from PWD was incorporated in the Port Master Plan. Based on the location of the port access road entering the port boundary, AECOM developed a master circulation mapping covering the site, including general roadway paths and internal terminal circulating patterns. Access for cargo traffic and potential cruise terminal traffic was analyzed and provided in the port master plan.

***Rail Access and Train Operations*:**

Rail Vikas Nigam Limited (RVNL) has prepared the Detail Project Report (DPR) for providing a rail access to the proposed port. Various options and routes for bringing the rail to the port were considered by AECOM. Due to the dense habitation nearby the Port site along the potential rail corridor and very steep site topography, AECOM made adjustments to the port site and configuration in order to accommodate the proposed rail throughput within a confined available space with limited rail access options.

***Berth and Wharf Sizing and Location**:*

AECOM assessed various alternates for phasing of the port development and assignment of berthing space among various proposed uses (container, cruise, petroleum, ship repair, etc.) to produce the most optimum berthing configuration. Ability to service design vessels, continuity of cargo handling operations, proximity to road and rail access for relevant cargo operations, available water depth under operational wind & wave conditions, approach channel length and width, berth length, wharf geometry and other related issues have been analyzed to ensure that overall port configuration and phasing meets the design criteria.

***Entry/Exit Gate Processes***:

As per VISL requirements, appropriate concepts for gate operations, including truck processing and inspection patterns, customs inspections, deployment of labor, and utilization of new technologies for data collection and integrated truck control have been developed by AECOM. Appropriate configurations and sizes have been developed by integrating this data with the capacity and circulation requirements for the transshipment terminal. Provision for non-cargo related traffic including future cruise terminal has been considered.

***Infrastructure Elements***:

AECOM studied the basic infrastructure elements required for each of the marine facilities and the method of local supply. The findings have been summarized in this report for the followings:

- Power Supply and Distribution
- Grading, Drainage, and Paving
- Facility Lighting and Security
- Other Utilities

***Phased Development Planning:***

Phasing plans for each of the marine facilities have been developed based upon the market projections and planned facility capacities.

Following subsequent sections describe key port planning issues encountered during the master plan process.

## 3.3 Port Planning Issues

### 3.3.1 Opportunities & Constraints

Opportunities & Constraints (O&C) map has been prepared by using site maps (Topography, Bathymetry etc) provided by VISL. Key opportunities and constraints are illustrated in Figure 3-4. Opportunities are marked in green color while the constraints are marked in red color.

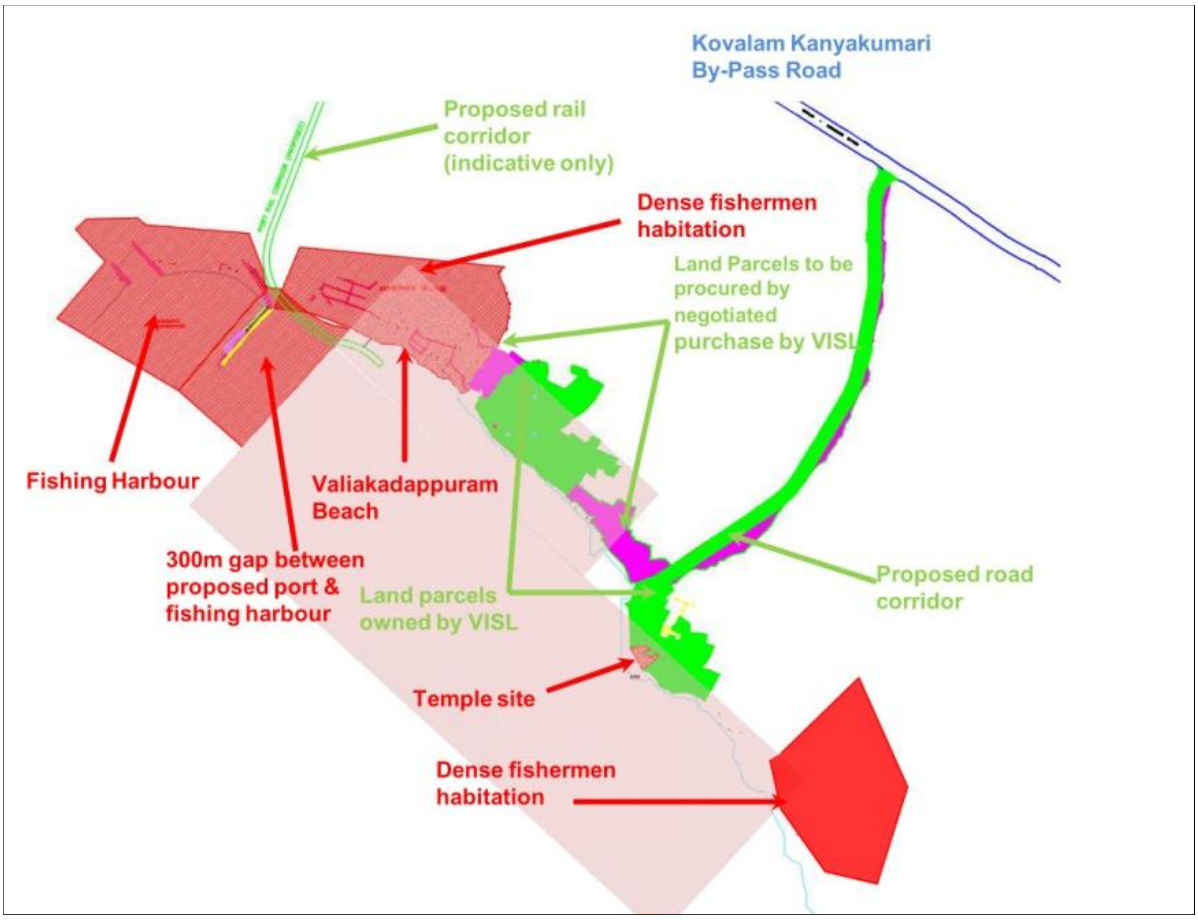



Figure 3-4 Opportunities & Constraints map for Vizhinjam port site

Based on the information collected from various reports provided by VISL and site visit data; key opportunities and constraints are summarized below:

### 3.3.1.1 Opportunities

**1) Proximity to International Shipping Route**


Figure 3-5 Vizhinjam port location with respect to international East-West shipping route

As stated earlier in the report, Vizhinjam has a big geographic location advantage in that it lies within 10 nautical miles from the major international shipping route as shown in Figure 3-5. The port can attract large share of the container transshipment traffic destined or originated to/from India, which is now being diverted primarily through Colombo, Singapore and Dubai.

**2) Favorable Bathymetry**

Bathymetry in Vizhinjam region is very favorable for deep draft port development. The port site is endowed with natural depths of 18m contour within a distance of a mile from the shore. This will result in a minimum need for capital dredging required for berthing and navigational arrangements at the port to handle the largest container vessels (up to 18,000 TEU) being planned to transit the East-West shipping channel with no such deep facility available in the Indian coast.

**3) Availability of Large Waterfront**

A water front area of 2500m is available for the proposed port development, which can be utilized for handling the container, cruise and other cargoes. A continuous long container terminal quay length can optimize transshipment terminal quay side productivity. Also, no active fishing is taking place along the proposed waterfront, which is segregated to the north and the south of the proposed site and has the added advantage of not affecting the activity and the nearby community.

**4) Proposed Road & Rail Connectivity**

The port can be connected to existing National Highway and Railway network. The proposed road and rail connectivity has been shown in the O&C map. Figure 3-6 shows the temporary road connecting to the waterfront. The road will be built up to +5.0m CD when completed.


Figure 3-6 Temporary road up to the waterfront

**5) Shoreside Land Parcels procured**

VISL has procured through negotiated purchase a few fragmented and continuous land parcels along the shoreline and near the port area. The parcels which are owned by VISL are shown in green color and the parcels which are yet to be procured and are necessary for the Phase-1 and Phase-2 port operations and connectivity between backup areas are shown in pink color in the O&C map.

**6) Greenfield Port**

The port being a Greenfield project, away from dense urban/city area, and thus can be master planned and shaped as per the needs of VISL into a very efficient, modern and highly productive port.

#### 3.3.1.2 *Constraints*

1) **Steep Land Side Topography**

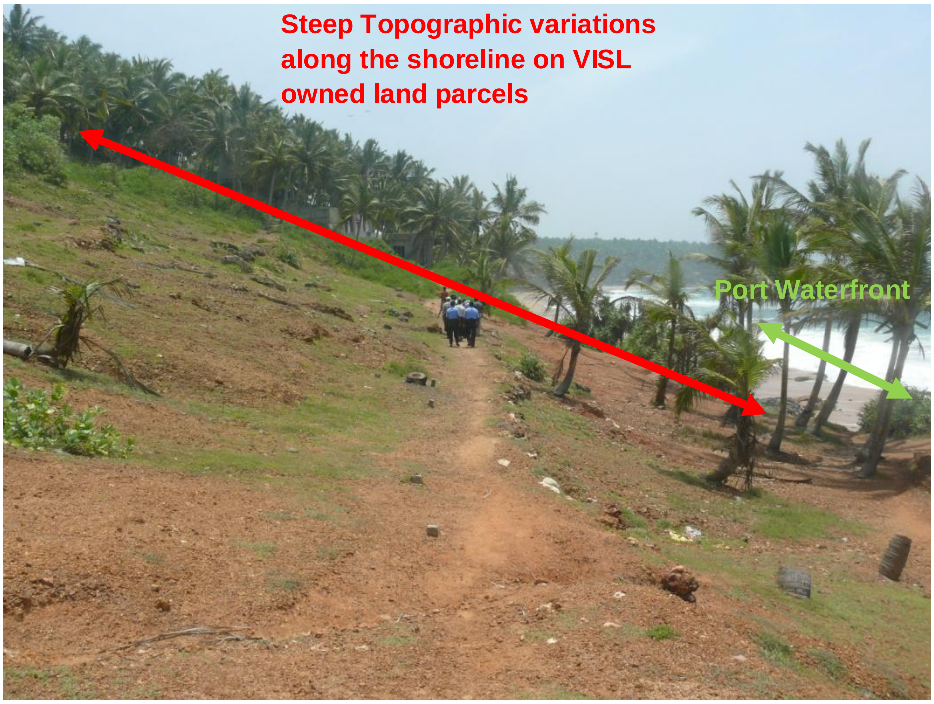



Figure 3-7 Steep topography along the port waterfront

The landside topography at Vizhinjam immediately behind the waterfront (Figure 3-7) is a hilly area with the cliff formation and land levels varying from +15m at the shore to +38m to the hill top. This would require careful planning for the landside development for the port backup facilities as well as approach to these areas. The potential area leveling could result in high Capital Expenditure for the terminal backup area developments. The master plan has been developed by keeping the site topography in mind such that minimum land cutting will be required and thus creating minimum impact to the existing environment and land formation.

2) **Proximity to the Existing Fishing Harbor**

The existing Vizhinjam fishing harbor is just north of the proposed Vizhinjam port site. The first constraint will be to curtain the effects of construction activities of the port on the fishing harbour. As the site is adjacent to the fishery harbor, buffer space would be required between the fishing and the construction activities of the northern breakwater. If the space planned between the proposed port's northern breakwater and existing fishing harbor is less, it is likely to cause turbulence as well as congestion at the entrance of the fishery harbor. Modeling studies have been performed to identify the optimum spacing between the existing fishery harbour and proposed port. These studies have indicated that a gap of around 300m between southern tip of the fishing harbour breakwater and the northern breakwater of the proposed port will improve wave tranquility at the enterance of the fishing harbour and ensure that Valiakadappuram beach is available for social gatherings.

3) **High Dense Habitation at Fishermen Village**

The proposed port site is located south of the fishing harbour and the village of Vizhinjam. There is a highly dense fishing community settled around the fishing harbor which could pose considerable restriction for the port development activity. The fishermen village is as shown in the O&C map. The port development has to be carried out in such a way that it has minimum impact to the people living around and rather creates a positive impact on these settlements in terms of jobs, economic and social benefits.

4) **Existing Ancient Temple just South of the Port Road Entry Point**

With the temple being located at the tip of the protruding hilly outcrop at the southern land parcel owned by VISL, the area surrounding the temple and the approach to the temple cannot be disturbed by the proposed developments. The temple is located at about +12m elevation above CD. Port planning constraint is to keep terminal operation area away from temple land. As the temple is located at a higher elevation compared to terminal elevation of +5m CD, road connectivity to the temple is needed to be planned in such way that it would not interfere with port operations. Figure 3-8 below shows the existing temple. The O&C map shows the temple location.

Figure 3-8 Mulloor Naga Temple located at southern land parcels

**5) Feasibility/Technical issues in Rail connectivity**

The rail access options to the proposed port site are limited and only one option has been considered feasible by RVNL, considering the need for rail tracks inside the port at +5m CD, steep topography of land behind site and settlements nearby the proposed port site. Various options considered for rail access are described later in this report.

**6) Valiakadappuram Beach**

Valiakadappuram beach stretch of about 300m which is just adjacent to the existing fishing harbor will not be used for port development as explained in point 2 above. This beach is being used by the local population for the communal gathering during the festive seasons. The constraint is to avoid intruding into this area adjacent to the fishing harbour.

Figure 3-9 shows the general features around the proposed Vizhinjam port site.

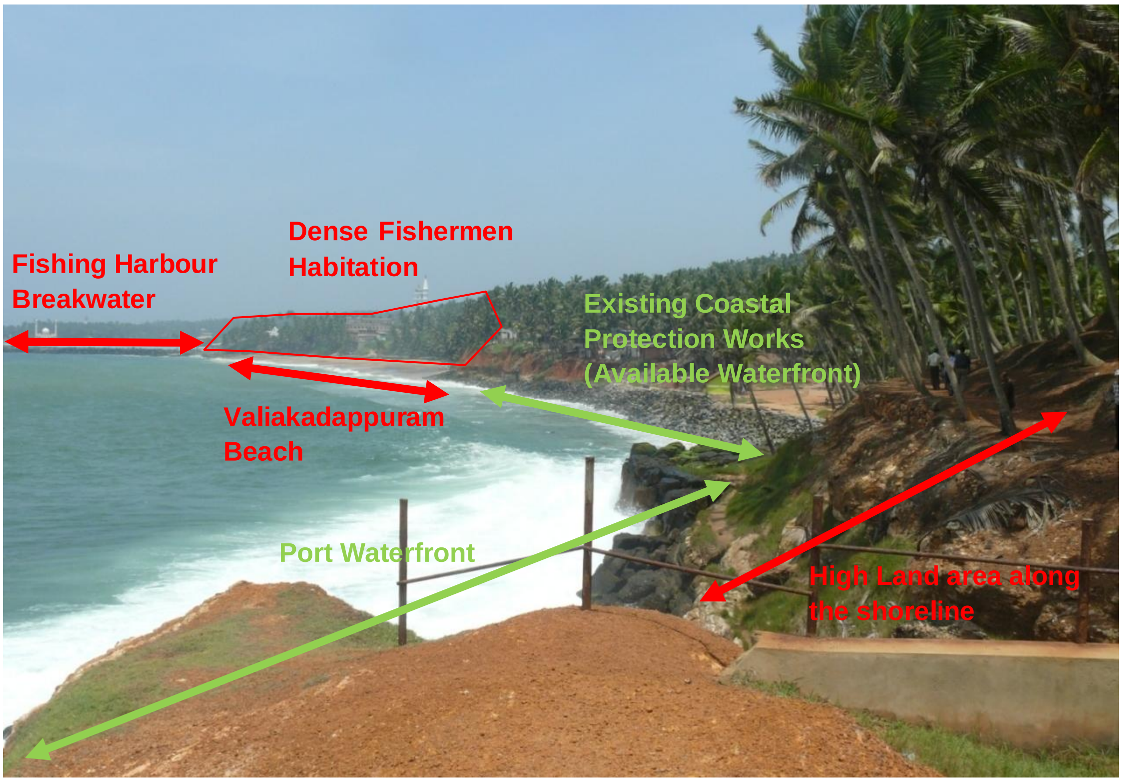



Figure 3-9 View of the Port Waterfront from South

## 3.3.2 Ground conditions

### *3.3.2.1 Background*

One of the key objectives of the master planning is to achieve an optimum balance between dredging required to create navigational facilities as well as utilization of existing/reclaimed land for creation of landside port facilities. Another critical element was to locate the port such that minimum or no rock dredging is required. The geotechnical information available at the site has been explained briefly in Section 2.

The geotechnical investigation borehole data at the site reveals that the subsurface generally consists of marine deposited silty sand for the full depth of exploration in the approach channel area, layers of clay and sand were encountered along the breakwater stretch, while layers of sand and rock were encountered in the terminal area and southern breakwaters. Rock was not encountered during borehole investigations in the proposed dredged area with exception of rock found at a depth of around 25m CD in front of proposed container berths.

The borehole profiles show that the dredge spoils (except the initial surface material up to the depth of approximately 1 m below the existing seabed) comprise of good quality sand and is suitable for reclamation for the development of the onshore facilities.

However, geophysical survey shows that we may encounter a very dense sand layer beyond depth of 22m CD in the outer approach channel. It is also observed that rock can be expected along the container berth face at around 20m CD to 22m CD. Figure 3-10 shows the location of expected dense sand pockets and rock pockets within the dredged area. In other areas, very dense sands or weathered rocks are expected to be found at depths at or below 24m CD.

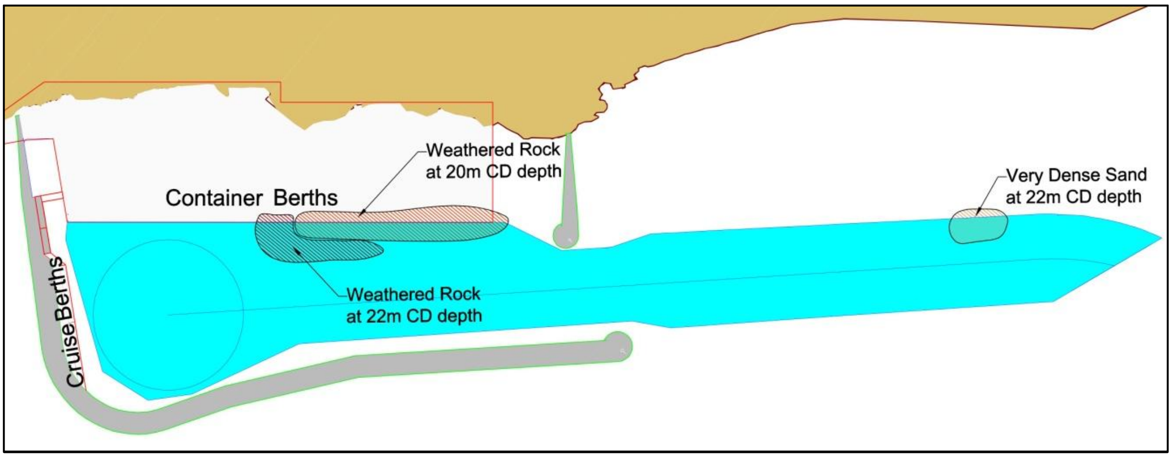



Figure 3-10 Location of hard materials within proposed dredge area

There are no boreholes currently available over existing land. However, considering the topography of the area, it will be safe to assume that underlying strata would mainly consist of rock with a top surface of soil.

#### *3.3.2.2 Reclamation Strategy*

Whilst not part of the master plan process, the development will need to include a strategy for reclamation of land behind the container berths to create container yard and other terminal facilities.

Sourcing of fill for reclamations has always been a major issue, not only for the proposed Port of Vizhinjam but for the other port developments throughout Kerala. It is unlikely that sufficient amount of fill material for full development would be available from dredging within Vizhinjam Port with the location being blessed with natural depths. Therefore, alternate sources of fill need to be investigated. A brief summary of potential sources is:

- Carrying out additional dredging in the proposed dredging area by deepening the harbour and channel to meet the required fill quantity;
- Sourcing the sand from the marine borrow area;
- Major dredging projects within the region;
- There are potential quarry sites to be utilized. The available volumes may suffice the construction requirements; however, this would lead to high transportation costs of the material resulting in the high project cost;
- Major civil and road works projects in the Vizhinjam and Trivandrum Region.

It is expected that the reclamation strategy would include either of the above options or a combination of them.

In addition, suitable rock material needs to be sourced for reclamation protection, bunds and breakwaters. These might comprise:

- Rock from the identified quarry sites at Kadavala and Thottiyodu.
- Alternate man-made protection systems such as concrete armour units (ACCROPODE, CORELOC etc.) may be required instead of rock of large size (which is usually difficult to produce).

#### *3.3.2.3 Design Issues and Risks*

Based on the above and geotechnical information provided in Section 2, the following key geotechnical design issues are to be considered for the development of the proposed Vizhinjam port:

- Proposed dredged areas will need to be limited up to a depth of around 22m CD with berth pockets restricted up to a depth of around 20m CD in order to avoid very dense/weathered rock dredging
- Foundation of container berths is expected to encounter rock at around 20-27m CD and will require hard driving conditions for steel tubular piles or sheet piles if used for berth construction
- Potential long term settlement and consolidation times of the dredged materials
- Potential long term settlements of any future placed sediments
- Differential settlements across the proposed development site if any
- Stability of the backland that may need to be cut for the yard development

- Cutting of the immediate hilly high level areas to the desired ground level for the onshore port backup for the terminal development in due consideration of geology of the area
- Possible dense material levels or rock outcrops in proposed potential dredge areas;

### 3.3.3 Connectivity Issues

#### *3.3.3.1 General*

Land access will play a key role in linking the proposed port to the rest of its supply chain. Ensuring that surface transport links to the Harbour are adequate is crucial in ensuring the efficiency of the overall supply chain. Vizhinjam Port needs to have an efficient “whole of chain” system to maximize the port’s attractiveness to shippers and thus its competitiveness. The future potential for development of the port will call for significant freight operations being carried out from the Port.

Whilst the mode split of cargo to and from the port is going to be largely governed by the transshipment containers; ability to handle the potential gateway traffic will be determined to a large extent by the type of products hauled and the origin/destination of these cargos.

#### *3.3.3.2 External Road Access Issues*

The existing external road link to/nearby the port area has been discussed in the section 2.

As there is no proper direct access for the main entrance to the port from the hinterland (NH 47), the NH 47 bypass Road will be used by all trucks, travelling from the north and south, wishing to access the Vizhinjam port. Consequently, one of the key areas of the study (which is underway by PWD) as part of the Vizhinjam Port project is to assess NH 47 bypass Road to ensure adequate road access capacity is provided.

#### *3.3.3.3 External Rail Access Issues*

The existing external rail link to/nearby the port area has been discussed in the Section 2.

The Port is fortunate in that it enjoys the presence of main rail line facilities connecting to the rest of the hinterland at a distance of approximately 10km from the port site. To handle the potential gateway traffic, the first preference is to provide a direct rail access to the proposed port through a new rail link connecting the port site with the existing main line.

As an alternate, shuttling of the containers to/from the port by trucks to the nearest rail yard along the main line can be also considered in the interim absence of the direct rail access to the port. Shuttling of the cargo to/from port to the mainline terminal will create additional truck traffic accessing the port.

Providing a direct rail access to the port is mainly hindered by the site topography which comprises of highlands between the mainline and the port site.

### 3.3.4 Environmental Considerations

Considerable work has been done by VISL on determining the impact of environmental factors on the proposed port of Vizhinjam. Modeling studies have been performed for waves and currents at the site, impact on shoreline for fishing port, long term shoreline change around the site and impact on beach erosion due to the proposed port.

As mentioned earlier, the breakwater layout of the port as planned by RH was developed after due consideration to various environmental aspects. Some of studies have been performed after the RH layout was finalized.

This master plan has been produced considering that the major elements from RH layout such as navigation channel and breakwater alignments are unchanged. AECOM’s port master planning effort has been primarily focused on the efficient and optimum utilization of marine and land facilities within the RH’s port breakwater footprint in order to meet VISL functional requirements as discussed in detail in the next section.

## 3.4 Green Port Initiatives

Sustainable development is a broad-reaching concept that seeks to provide a good quality of life for today's population while preserving the ability for future generations to maintain their quality of life. At the highest level, it incorporates environmental, social and economic aspects which can be further defined into human, social, manufactured, natural and financial capitals that must be sustained and enhanced.

In the context of development within the built environment, the imperatives of sustainability require schemes that address sustainability concerns and enhance opportunities to improve the quality of life of occupants and the surrounding community. Assessing the extent to which aspirations are achieved can be performed using sustainability appraisal techniques through the duration of the development, or by incorporating sustainability statements against defined criteria as part of the planning process.

The proposed port at Vizhinjam aims to provide long-term commitment, strong policy push, innovation, and alignment of interests and business philosophies along with serious investment in technologies, systems and manpower in order to achieve this objective set out in developing the vision of the port by VISL. These sustainable solutions will range from analysis of climate change risk and resiliency at the planning stage to incorporation of renewable and alternative energy sources, where feasible, to minimize the site carbon footprint and energy costs during the operations phase.

Factors considered and mitigated as appropriate in designing and constructing waterfront structures commonly include, but are not limited to:

- Site selection, design, and configuration: the potential for material reuse, access to rail and multi-modal transportation networks, vulnerability to flooding and sea level rise, storm-water best management practices, impact to marine environment and native species, and impacts on the surrounding community including light and noise pollution.
- Material selection: focus on durability in addition to reuse of dredged materials, use of recycled, re-used, sustainably harvested or locally sourced content where possible; and avoidance of toxic or hazardous materials.
- Emissions reduction strategies: on-terminal or near terminal electric generation (solar, wind), waterborne delivery of construction materials, terminal configuration, equipment selection, and transportation technologies to efficiently handle cargo and reduce emissions and air quality impacts from terminal handling equipment and truck traffic. The proposed port will involve a wide range of mechanized equipment and vehicles used in the loading, unloading, handling, storage and transportation of cargoes.

Some of the specific solutions amongst others include the following:

- Electric RTGs
  It is proposed to utilize fully electrified RTGs at the port in future phases. These RTGs provide significant reduction in fuel consumptions as well as emissions (both air and noise). Several Asian, European and North American ports have either converted from diesel RTGs to electric RTGs or planning to convert over next few years.

- Intra-Terminal Vehicles (ITV)
  The ITV fleet will comprise of a mix of LNG based and efficient low sulphur diesel vehicles. The ITVs comprise the majority of vehicle movement within a container terminal and the proposed port fleet will provide a considerable reduction in emissions compared to a typical diesel engine fleet. In the future, the fleet can also include hybrid and electric vehicles. The hybrid and electric technology is expected to eliminate emissions during idling, which can represent more than half of a yard hostler's duty cycle. Successful projects including this technology have been considered at ports including Port of Los Angeles and Long Beach in California, USA. Several European ports are exploring use of bio-fuels and bio-mass gases as alternate ways to power these vehicles.

- Electric Quay Cranes
  All the quay cranes for the container as well as the future multi-cargo terminals will be fully electrified. The electric quay cranes have been successfully adopted by most of the new port developments

and result in significant reduction in emissions compared to their diesel counterparts in addition to providing higher productivity.

- Bigger Vessels
  The proposed port is capable of handling the world's biggest container vessels of 18,000 TEU. These bigger vessels have fewer emissions compared to smaller vessels (up to 8,000 TEUs currently used in Indian ports) proportionate to their cargo.

- Cold Ironing
  The proposed port can utilize the practice of cold ironing at the berths. This concept avoids the use of ship's engines which burn heavy fuel oil and replaces it with alternative sources of power for a berthed ship. Electrical plug-ins will be provided along the berths for ships while they are berthed.

  It has been observed that this technology has shown an average reduction of 90 percent in nitrogen oxide (NOx), sulfur oxide (SOx), and particulate matter (PM) per vessel call in ports where it is implemented.

- Modern Efficient Operations reduce Emissions & Fuel consumption
  A modern operation at the port utilizing the state of the art IT technologies will avoid bottle-necks and reduce queuing, idling and dwelling of port equipment resulting in significant reduction in emissions and also result in energy saving. A performance evaluation system may also be established as part of maintenance system at the port which will observe and evaluate various port equipments on fuel economy, emissions, and operator baseline performance.

- Storm Water Treatment system
  The proposed port is planned to have its own storm water runoff collection system by providing renewable system to collect and treat the storm water. It will treat oil contaminated rainwater (run-off) from impervious areas, e.g. roads, yard areas and will be spread throughout the port area.

- Waste Management system
  In order to avoid and minimize the potential effects of generated wastes, the port will develop and implement a port waste management plan to provide adequate reception facilities for oil, chemical and garbage wastes, and remove, as far as is practicable, any disincentives to landing waste in the port. As part of this process the port will encourage responsible management of waste, including minimization and recycling, at the point of generation on ships, reception in ports, transportation and disposal, and ensure that port employees and users dispose of garbage and other wastes responsibly in facilities provided and report any spills or large pieces of floating garbage to the port authority.

- Construction Stage
  During construction stage, various sustainable solutions are envisaged for the port. Green additives will be added to our concrete mixtures for almost all specifications. Additives such as fly ash, blast furnace slag, and silica fume are byproducts in the combustion of various materials. The use of these materials offers tremendous potential to alleviate their placement in landfills. In addition, because the carbon emissions generated by fly ash are significantly less than that generated by an equal weight of cement, "greenhouse gas" production is reduced. Moreover, these additives enhance the properties of concrete, including its durability, performance, and resistance to corrosion caused by sulfates and chlorides. Steel buildings are considered green structures because 100% of the material can be recycled once its life cycle has been reached. The Port would also incorporate the use of recycled steel, or steel with recycled content, into construction projects whenever possible.

  The proposed port will require dredging activities and this dredge material will be utilized to the full extent possible for reclaiming the port area and low-lying areas within the port. This will avoid the need for transporting material from far flung areas.

# 4 Functional Requirements

## 4.1 General

A primary objective of preparing the Port Master Plan is to ensure that the progressive development of the port in time will take place based on the long term vision set-out for the port in a sustainable, cost-efficient and optimum manner with ability to meet the underlying market forecast.

The port master plan is generally considered a dynamic document rather than a static document and is required to undergo periodical changes to address the prevailing market conditions.

The Vizhinjam port master plan is prepared to guide the development of the port in phases and identify the most suitable location of the critical infrastructure facilities required to operate the port in a long term. The focus of the master plan has been on the primary cargo (containers) with provision for secondary cargo (cruise, general cargo, bunkering etc.) to allow for flexibility in the port development strategy without affecting the existing fishing harbour and without compromising on the efficiency of the cargo handling operations – a primary objective of the port!

This section outlines the functional requirements to operate the port successfully over the master plan horizon, which are derived based on the market forecast undertaken for the Vizhinjam port. Functional requirements for the number and length of berths, vessel navigational requirements, cargo handling equipments, storage area required for each type of cargo, road and rail access for the receipt and evacuation of cargo, and other utilities and service facilities are discussed in detail in this section.

## 4.2 Traffic Forecast

Traffic forecast are primary underlying assumption used to develop the port master plan. Traffic study for Vizhinjam Port was carried out by the DREWRY Shipping Consultants Ltd. in year 2010. Details of the underlying assumptions and traffic forecast methodology is discussed in detail in the DREWRY report.

Traffic forecast was undertaken for the master plan horizon year 2044 with a starting year of 2014.

Three phases were defined as:

- Phase-1: Years 2014 through 2020
- Phase-2: Years 2021 through 2030
- Phase-3: Years 2031 through 2044

Following cargo types were studied:

- Containers (transshipment and gateway)
- General Cargo (fertilizers, timber, raw cashews, etc.)
- Petroleum products
- Cruise vessels

Summary of DREWRY's forecast by phase is given in Table 4.1.

Table 4-1 Traffic Forecast Summary for Vizhinjam Port

| | Unit | Phase 1 | Phase 2 | Phase 3 |
|---|---|---|---|---|
| | | FY14-20 | FY21-30 | FY31-44 |
| Container terminal | | | | |
| Gateway Container Traffic | [TEU] | 138,459 | 392,371 | 768,904 |
| Transhipment container Traffic | [TEU] | 683,798 | 1,292,842 | 2,054,545 |
| Total | [TEU] | 822,256 | 1,685,212 | 2,823,449 |
| Vessel calls - main liners | [#] | 156 | 312 | 520 |
| Vessel calls - feeders | [#] | 260 | 312 | 468 |
| Multi-purpose terminal | | | | |
| Fertiliser and FRM | [tons] | 20,000 | 180,000 | 540,000 |
| Timber | [tons] | 24,000 | 91,000 | 104,000 |
| Raw cashew (break-bulk) | [tons] | 63,000 | 88,000 | 133,000 |
| Total | [tons] | 107,000 | 359,000 | 777,000 |
| Vessel calls | [#] | n/a | n/a | n/a |
| Liquid terminal | | | | |
| Petro-products | [tons] | 159,000 | 518,000 | 1,051,000 |
| Total | [tons] | 159,000 | 518,000 | 1,051,000 |
| Vessels calls | [#] | n/a | n/a | n/a |
| Cruise terminal | | | | |
| Vessel calls | [#] | 30 | 60 | 120 |

*[Source: Drewry]*

As highlighted in the above table, container traffic constitutes as the primary cargo, a majority of which is transshipment container traffic. Year 2044 base demand forecasted for the container traffic is in the range of 2.8 million TEU, out of which approximately 2.0 million TEU are related to the transshipment traffic. Total demand for general/bulk cargo is less than one million Tons. For liquid petroleum products, the demand is also in the range of one million tons. Cruise vessel calls are forecasted at approximately 120 per year.

## 4.3 Design Vessels

### 4.3.1 General

Seaborne trade and traffic patterns have undergone tremendous change in recent decades due to a number of reasons including changing demand, economies of scale and technological advances. A key trend has been the increase in the vessel sizes.

The size of ships to be expected at Vizhinjam Port will be governed by the following aspects:

- Sailing distances between Vizhinjam port and origin/ destination ports;
- The facilities available at the origin/ destination ports including draft;
- The distribution of container vessel sizes in the world fleet;
- Future availability of vessel on the market including 'trickle down' effects from mainline routes to secondary routes;
- Volumes of annual trade and the likely parcel sizes;
- Overall supply chain cost of transshipping the cargo through Vizhinjam port as compared to other established ports.

On the premises of the traffic forecast, the proposed port at Vizhinjam is being planned to mainly accommodate the container vessels responsible for generating the forecasted transshipment throughput. These vessels will include the mainline vessels traversing through the East-West shipping channel and the feeder vessels supporting the mainline vessels for distribution of the cargo to service the end markets.

Provision is also made for secondary users such as cruise, general cargo and liquid petroleum tankers from navigation in and out of the port.

### 4.3.2 Container Vessels

Since its start in the early sixties, container trade has grown exponentially worldwide, resulting in a significant increase in number of container vessels in the worldwide fleet and their sizes.

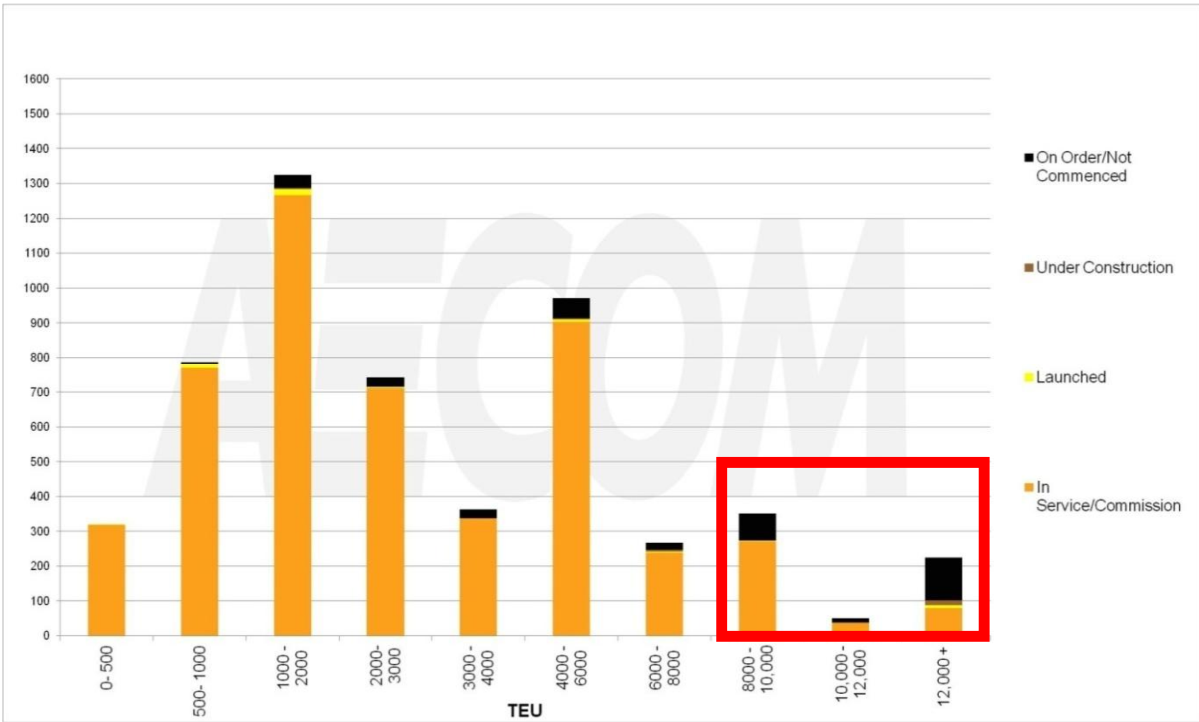
The distribution of world fleet container vessel sizes is shown in Table 4-2 and Figure 4-1.

Table 4-2 World Fleet of Container Ships and Order books

| Container Ship | Year end ('000' TEU) | | | | 2011 | | Order Book & Delivery Schedule | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Fleet (TEUs)** | **2007** | **2008** | **2009** | **2010** | **No** | **'000' TEU** | **No** | **'000' TEU** | **% Fleet** | **2012** | **2013** | **2014** |
| 100-999 | 611 | 664 | 690 | 723 | 1203 | 740 | 6 | 6 | 1% | 5 | 1 | 0 |
| 1,000-1,999 | 1535 | 1705 | 1793 | 1934 | 1400 | 1989 | 22 | 31 | 2% | 24 | 7 | 0 |
| 2,000-2,999 | 1592 | 1760 | 1849 | 1916 | 768 | 1952 | 14 | 38 | 2% | 21 | 16 | 1 |
| 3,000-7,999 | 5419 | 6084 | 6638 | 7304 | 1606 | 7694 | 94 | 505 | 7% | 381 | 124 | 0 |
| 8,000+ | 1228 | 1664 | 1999 | 2685 | 371 | 3678 | 98 | 1117 | 30% | 896 | 167 | 54 |
| **Total Fleet** | **10385** | **11877** | **12969** | **14562** | **5348** | **16053** | **234** | **1697** | **11%** | **1327** | **315** | **55** |

[Source: Lloyds Fairplay Database Jul '11]

Figure 4-1 Distribution of Container Vessels by TEU




*[Source: Lloyds Fairplay Database Jul '11*]

From Table 4-2 and Figure 4-1, it is evident that market share of 8000+ TEU vessel has been growing steadily and majority of the large container vessels which are under construction are having capacity in excess of 8,000 TEU.

There is a continuing trend towards larger container vessels and a number of vessels at the top end of the size range are already on order (*Source: Internet search*) as summarized below:

- 32 no. 12,500 TEU minimum ships ordered for delivery between 2010 and 2012.
- 8 nos. 13,100 TEU ships ordered by Hamburg based Nord Capital group on Hyundai Heavy Industries. Delivery between April 2010 and March 2011.
- A series of 16,000 TEU ships have been ordered from Samsung Heavy Industries.
- Maersk Lines have ordered 20 new 18,000 TEU ships from Daewoo Shipbuilding.

Historically, as the mainline vessel sizes have increased, larger vessels operating in primary routes have 'trickled down' to the second tier routes. It is expected that vessels in the range of 8,000 TEU will 'trickle down' to serve secondary or feeder routes in the future.

In order to establish Vizhinjam port's position as a transshipment port, it will need to be able to handle ships normally in the range of 9,000 to 14,000 TEU with provision for handling even larger vessels of size up to 18,000 TEU.

#### *4.3.2.1 Transshipment Containers*

Based on the projections, the maximum vessel size at the port is likely to be driven by the Transshipment traffic. During Phase-1, it is considered likely that the average exchange will be in the order of 1,500 container moves per ship call and over the master plan horizon, it is expected that the average exchange per vessel call would increase to 2500 moves after accounting for the range of vessel mix including the mainline and feeder. The design vessel considered for Phase-1 is 12,500 TEU with provision to handle up to 18,000 TEU depending on the prevailing market conditions.

#### *4.3.2.2 Import/ Export Container Vessels*

The projected import / export trade through the port hinterland is relatively modest. In this case, it is likely that the vessel sizes for import/ export trade will be driven by the use of the transshipment vessels for carrying the import/export cargo as well. For other direct vessel calls serving the import/export cargo, the design vessels considered are in the range of 1,000 TEU to 6,000 TEU.

### 4.3.3 Summary of Design Vessels

Based on the outcome of ship size analysis for container traffic carried out in the preceding paragraphs, the design ship sizes considered for development of VISL port have been presented in Table 4-3

Table 4-3 Design Container Vessels over Master Plan Horizon

| S. No | Commodity | Average parcel size in moves | Design Ship Capacity | | Overall Length | Beam | Loaded Draft |
|---|---|---|---|---|---|---|---|
| | | Moves | TEU | | (m) | (m) | (m) |
| 1. | Containers (Transshipment) | 2500 | Min | 9,000 | 350 | 46 | 14.5 |
| | | | Max | 18,000 | 400 | 59 | 16 |
| 2. | Containers (Feeder) | 1200 | Min | 1,000 | 175 | 27 | 10 |
| | | | Max | 6,000 | 300 | 43 | 13.5 |

### 4.3.4 Cruise Vessels

As part of the Kerala Port PPP – Market Study, DREWRY Shipping Consultants also studied the potential for developing a cruise terminal at Vizhinjam port and assessed the potential traffic which could be targeted.

Key findings of the study are stated below by taking the reference from the final report of the study:

- Kovalam is a major tourist destination in India. This can be leveraged to attract cruise vessels at Vizhinjam
- High port dues and inadequate cruise vessel and passenger handling facilities are seen as a major deterrent for cruise operators in India
- A marketing and promotion strategy along with world class specialized cruise facilities at competitive port charges can promote cruise tourism at Vizhinjam
- Average passenger spend per port is around USD 100 to 120. This could bring in revenue of around USD 80,000 to 96,000 per vessel call
- Collaborative effort of state government, players in the hospitality industry and cruise operators are a prerequisite

DREWRY estimated following number of cruise vessel calls based on the preliminary study:

- Phase-1: 30 calls per year, 1 cruise berth
- Phase-2: 60 calls per year, 1 cruise berth
- Phase-3 (Master Plan): 120 calls per year, 2 cruise berths

The estimated size of the cruise vessel varied from 1200 passengers in Phase-1 to up to 3000 passengers in the master plan.

Since the cruise market assessment conducted during the planning process projects increasing cruise ship lengths and larger cruise passenger populations on each ship, AECOM has prepared the Port Master Plan to accommodate the requirements of this projected larger fleet.

### 4.3.5 Port Crafts

The typical characteristics of these support crafts are provided in Table 4-4.

Table 4-4 Characteristics of Port Crafts

| S. No | Type of Craft | LOA | Beam | Draft | Freeboard |
|---|---|---|---|---|---|
| | | (m) | (m) | (m) | (m) |
| 1. | Tug | 32.7 | 10.7 | 3.5 | 1.5 |
| 2. | Pilot launch | 24.0 | 4.8 | 1.5 | 1.1 |
| 3. | Mooring launch | 10.3 | 3.2 | 1.2 | 0.8 |

## 4.4 Length of Berths

The berth length needs to be sufficient to accommodate the length of the vessel plus an allowance at either end for mooring and clearances between vessels. The amount of clearance required at either end of the vessel depends upon the vessel size. Minimum single berth lengths for the design vessels are shown in Table 4-5.

Table 4-5 Minimum Berth Lengths

| S. No | Berth Type | Design Ship Size | Phase-1 | Phase-3 (Master Plan) |
|---|---|---|---|---|
| | | | m | m |
| 1. | Container Berths | 12,500 TEU | 360 – 400 | 360 – 400 |
| 2. | Cruise/ Multipurpose Berth | | - | 300 |

## 4.5 Port Capacity Analysis

AECOM used a spreadsheet-based capacity analysis model to determine Vizhinjam port's container terminal throughput capacity, which is defined as the amount of cargo a terminal can handle under given operating parameters. For containerized cargo, the capacity is calculated in either lifts or TEU per year. For general/break-bulk cargoes, the capacity is measured in terms of metric tons.

The total amount of cargo a terminal can handle annually depends on the capacity of four main components: ship operations, yard operations, gate operations, and rail operations. AECOM evaluated each of these terminal-operation components independently to identify elements limiting the overall throughput capacity of Port facilities. If one component of the facility has a much lower throughput capacity than the others, then the entire facility must operate at the capacity of that lower-functioning component.

### 4.5.1 Container Terminal Capacity Analysis

AECOM conducted the VISL Port container terminal capacity analysis using the Preliminary Capacity (PRECAP) spreadsheet analysis model. PRECAP is a static model of terminal capacity that can be used to analyze capacity of the terminal berth, backland storage area (container yard and equipments), rail operations, and gate operations.

The primary outputs from PRECAP are annual capacity of each of these terminal elements, which can then be evaluated as independent features or as linked elements.

An important benefit of this model is its ability to identify the element that is constraining overall terminal capacity and to focus investments where the greatest capacity improvement can be achieved. For example, the model may be used to establish parameters for the container yard and for the gate to match available berth capacity so that the terminal has a balanced capacity across all elements.

The following table summarizes the key inputs to PRECAP for each terminal element.

| Berth | Container Yard | Rail | Gate |
|---|---|---|---|
| – Cargo moved per vessel call<br>– Cranes used per vessel<br>– Crane productivity<br>– Work hours<br>– Non-work time at berth<br>– Seasonal peaking factors<br>– Maximum allowable berth utilization | – Mix of cargo types<br>– Dwell time<br>– Static storage capacity<br>– Inventory peaking factors | – Number of rail cranes in use<br>– Rail crane productivity<br>– Working hours<br>– Switching delay<br>– Static working track capacity | – Gate to vessel move ratio<br>– Hourly arrival pattern<br>– Number of gate stages<br>– Fraction of trucks that visit each stage<br>– Truck processing time at each stage |

AECOM often uses PRECAP to analyze a range of options, such as comparison of high/med/low capacity forecast based on specific input assumptions like crane productivity, or calculation of static density that is expected to increase as a result of a particular project, or evaluation of impacts of statistical factors – like working hours or vessel size – that are expected to change over time due to external trends.

PRECAP has been developed by AECOM over many years of experience at port facilities around the globe in the planning and analysis of dozens of marine terminals. PRECAP is currently used by the Port of Los Angeles, the Port of Long Beach, and Port Metro Vancouver (Canada) as the standard tool for determining their port terminal capacity.

#### *4.5.1.1 Berth Capacity*

Berth capacity is defined as the volume of cargo that can be handled across the berth, without concern for any backland constraints. As with all elements of capacity, berth capacity is not a single fixed number, but a range of plausible values. Higher berth capacity means higher cost (more equipment and more labour cost) and lower levels of service, because some vessels may have to queue for berth space. The potential maximum number of containers handled over the berth (measured in twenty-foot equivalent units or TEU), is primarily dependent on following factors:

*Design Vessel Size:* Size of vessels is increasing day by day to accommodate more number of TEU per vessel call. Considering the order-book of vessels and the vessels under construction, the typical max size of the vessel for direct call at Vizhinjam port in Phase-1 is considered as 12,500 TEU (for capacity analysis).

*Available Berth Length*: The berth length should be optimized to be able to cater to the largest design vessel along with mix of average vessels.

*Container Moves per Vessel Call:* Based on a combination of mainline and feeder vessels, and market data relating to average number of containers handled per vessel call at peer transshipment ports, 1500 container moves per vessel call is used as the maximum average number of containers handled per vessel call in Phase-1, 2000 containers in Phase-2 and 2500 in Phase-3.

*Dock Cranes Assigned per Vessel*: Number of dock cranes deployed per vessel call varies based on the vessel size and number of containers to be handled per vessel call. For the design vessel of size up to 12,500 TEU, up to six dock cranes are being used and for smaller feeder vessels two to three dock cranes will be deployed. On average, four dock cranes per average vessel call is considered for the capacity analysis.

*Productivity per Dock Crane*: As per prevailing practice in India, an average productivity of 25 moves per hour is used for Phase-1, whereas 30 moves per hour is used for Phase-2 and Phase-3 assuming gradual increase in the skill set of crane operators.

*Maximum Practical Berth Utilization*: It is a key subjective variable in a berth capacity analysis. No berth can effectively run at 100% full. Shipping lines expect a certain level of customer service when calling a terminal; they do not want to queue out at sea for too long waiting for a berth to become available. Conversely, shipping lines work on fairly rigid vessel schedules around the world and filling a berth on a given day of the week may prove difficult to accomplish by changing sailing patterns. Due to the variable nature of vessel arrivals (delays at berth, storms, etc.), and the market-driven need to service vessels in a timely manner, the maximum practical berth utilization should be limited to avoid vessel queuing. In some locations, especially in Asia where feeder vessels will in fact queue for berth space, terminals can operate at berth occupancy up to 80%. Longer contiguous berths allow for greater occupancy than shorter berths. Vessels start queuing on a two berth facility when average berth utilization goes over 65%, whereas for a single berth, it happens at around 50% to 60%. At Port of Vizhinjam, berthing length is increasing phase wise so the maximum practical Berth Utilization can also increase without incurring the vessel queuing therefore a value of 60%, 65% and 70% for Phase-1, Phase-2 and Phase-3 respectively is used for the capacity analysis.

*Operational Time*: Being an all weather port, it is assumed that Vizhinjam Port will work seven days a week for 365 days. Further, it is assumed that the port will operate round the clock i.e. three shifts of eight hours each with allowance for one hour break between each shift. This results in an effective working of 21 hours a day used in the capacity analysis.

*Unproductive Time at Berth*: It accounts for ship tie-up and untie time, which represents time where the berth is physically occupied by a vessel (i.e. no other vessel can be in that berth position) but there is no crane activity, excluding breaks which are captured by the work hours per day input. This activity includes mooring, line fastening, unlashing prior to first container move, administrative clearance, etc. These activities are assumed to take, on an average, 4 hours per vessel call.

*Peak/mean Week Seasonal Demand:* It is assumed that a peak week demand of berth will be 20% higher than the average week demand to account for changes in seasonal demand and adjust peak week berth capacity down to an average week berth capacity for calculation of the annual berth capacity.

Table 4-6 describes step-by-step assessment of annual berth capacity for the Port of Vizhinjam Container Transshipment Terminal. The right most column provides formulas along with the variables description.

Table 4-6 Phase-wise Berth Capacity Analysis

| Phase-1 | Phase-2 | Phase-3 | Berth Capacity |
|---|---|---|---|
| 12,500 | 12,500 | 12,500 | Typical Max Vessel Class Size TEUs |
| 1,500 | 2,000 | 2,500 | Container moves (Lifts) per vessel call [a] |
| 4.0 | 4.0 | 4.0 | Dock cranes assigned per vessel [b] |
| 25.0 | 30.0 | 30.0 | Productivity per dock crane (moves/hr) [c] |
| 100.0 | 120.0 | 120.0 | Vessel productivity (moves/hr) [d=b*c] |
| 15.0 | 16.7 | 20.8 | Work hours per vessel call [e=a/d] |
| 4 | 4 | 4 | Unproductive time at berth (hrs) [f] |
| 19.0 | 20.7 | 24.8 | Total vessel time at berth (hrs) [g=e+f] |
| 21 | 21 | 21 | Work hours per day [h] |
| 1.14 | 1.14 | 1.14 | Calendar hrs/ work hour [i=24/h] |
| 21.7 | 23.6 | 28.4 | Total vessel hrs at berth [j=g*i] |

| | | | |
|---|---|---|---|
| 168 | 168 | 168 | Calendar hrs per week [k] |
| 7.74 | 7.11 | 5.92 | Vessel calls per week at 100% berth utilization [l=k/j] |
| 60% | 65% | 70% | Maximum practical peak week berth utilization [m] |
| 4.64 | 4.62 | 4.14 | Maximum practical vessel calls per week [n=l*m] |
| 6,963 | 9,246 | 10,359 | Peak week berth capacity (moves) [o=n*a] |
| 1.2 | 1.2 | 1.2 | Peak/mean week seasonal demand factor [p] |
| 5,802 | 7,705 | 8,632 | Mean week throughput capacity (moves) [q=o/p] |
| 302,000 | 401,000 | 449,000 | Annual unit berth capacity (moves) [r=q*52] |
| 1.5 | 1.5 | 1.5 | TEU per container [s] |
| **450,000** | **600,000** | **670,000** | **Annual unit berth capacity (TEU) [t=r*s]** |
| 2 | 3 | 5 | Number of berths [u] |
| **900,000** | **1,800,000** | **3,350,000** | **Annual total berth capacity (TEU) [v=t*u]** |
| **450,000** | **600,000** | **670,000** | **Capacity Per Berth (TEU)** |
| 75,500 | 100,250 | 112,250 | Annual lifts per dock crane [w=r/b] |
| **800** | **1,200** | **2,000** | **Total berth length (m)** |
| **1,130** | **1,500** | **1,680** | **Annual berth capacity per unit berth length (TEU/m)** |

With two berths of total quay length 800m in Phase-1 Vizhinjam Port can handle approximately 900,000 TEU over the berths. Phase-2 and Phase-3 will add quay length of 400m (one additional berth) and 800m (two additional berths) respectively so the port can handle total 1.8 million TEU and 3.35 million TEU respectively in Phase-2 and Phase-3.

It is estimated that if bigger vessels are calling at the port (such as 18,000 TEU vessels) with higher parcel size per vessel call, additional throughput can be handled from the proposed port. This additional throughput will depend on the actual mix of different vessels calling at the port.

Another important factor in the capacity of a container terminal is the size and operation of the container yard. Ideally, the capacity of the berth and the container yard should be balanced to achieve maximum throughput from the terminal as a whole.

#### 4.5.1.2 Container Yard capacity

Container yard capacity is defined as the potential maximum throughput of containers handled inside the container yard (measured in twenty-foot equivalent units or TEU), is primarily dependent on following factors:

> *Mean Dwell Time:* The number of days a container sits inside the container terminal (dwell), which significantly varies for a transshipment (usually 2 to 3 days) vs. the gateway traffic (varies from 3 to 7 days). For the gateway traffic, it varies by import vs. export vs. empty container. For the capacity calculation, an average of 5 days is used for all phases of development.
>
> *TGS Capacity:* Represents the static storage capacity in terms of total number of twenty feet ground slots (TGS) or net acres available to store those containers inside the container yard.
>
> *Mean Storage Height:* A mean storage height is calculated which takes into account the peak stacking height of the machine and various utilization factors than can be applied. It represents the maximum

overall desired height for grounded operations. Most operators feel that 70-80% of the peak theoretical capacity is a reasonable level for planning purposes in order to account for sufficient empty slots for reshuffling and yard marshaling moves. Mean storage height used for this case is 3.5 for capacity calculations.

*Seasonal Peaking Factor:* It is assumed that a peak week demand of container yard will be 10% higher than the average week demand to account for changes in seasonal demand and adjust peak week container yard capacity down to an average week yard capacity for calculation of the annual container yard capacity.

*Weekly Inventory Peaking Factor*: During a week, when a vessel arrives or departs, there is a sudden surge of inventory of containers that needs to be handled in the container yard, based on the size of the vessel and number of containers handled per vessel call. The factor applied to account for this surge is 10%.

Table 4-7 describes calculation of container yard capacity and formulas used to derive it.

Table 4-7 Phase-wise Container Yard Capacity Analysis

| Phase-1 | Phase-2 | Phase-3 | CY Capacity |
|---|---|---|---|
| 1000 | 1000 | 1000 | Nominal TGS capacity available [a] |
| 3.5 | 3.5 | 3.5 | Mean storage height (containers) [b] |
| 3,500 | 3,500 | 3,500 | TEU static capacity [c=a*b] |
| 5.0 | 5.0 | 5.0 | Mean dwell time (days) [d] |
| 73.00 | 73.00 | 73.00 | Turnovers per year per TEU static capacity [e=365/d] |
| 2,55,500 | 2,55,500 | 255,500 | TEU capacity without peaking [f=c*e] |
| 1.10 | 1.10 | 1.10 | Seasonal throughput peak factor [g] |
| 1.10 | 1.10 | 1.10 | Weekly inventory peak factor [h] |
| 2,10,000 | 2,10,000 | 210,000 | Nominal Annual CY Capacity in TEUs [i=f/g/i] |
| **4,286** | **8,571** | **15,952** | **Required TGS to meet berth capacity** |
| **5,600** | **8,700** | **18,200** | **Available TGS** |
| **1,197,000** | **1,827,000** | **3,822,000** | **Container Yard Capacity TEU/year** |

With available number of TGS in Phase-1, Phase-2 and Phase-3, the Vizhinjam port will be able to handle the berth throughput from the planned container yard. The container yard capacity provided is higher than the berth capacity so, with higher utilization of berth capacity, additional throughput will be also possible from the container yard.

#### *4.5.1.3 Rail Throughput Capacity*

This section describes the methodology that was used to determine the rail throughput capacity which is expressed as number of rail tracks required to handle the forecasted gateway container traffic that can be handled from the port. For capacity calculations, it has been assumed by AECOM that 30% of the gateway traffic will be handled by rail as compared to 70% by truck.

Following factors impact rail throughput capacity:

Track length is taken as 800 m clear length for each track as per the nominal length of container train operated by Indian Railways.

Maximum possible number of cranes working to load/discharge containers from railcars: Based on the shortest track length available at the proposed rail yard, it is assumed that maximum four Reach Stacker/RMG cranes can be deployed to work simultaneously on a group of rail tracks.

*Amount of railcar double cycling:* It is assumed that for 90% of arriving railcars that bring in a container in the port will leave with a container while departing.

*Crane productivity:* For all phases reach stackers are assumed for loading/unloading of train racks over a single or double rail tracks respectively. Handling rate of 12 moves per hour is used for the cranes.

*Work hours per day:* 8 hours per day is assumed for Phase-1 and Phase-2 whereas 16 working hours per day is assumed in Phase-3 for rail yard operation.

*Peaking factors:* It is assumed that the peak month will be 20% higher than the average month and peak day throughput will be 20% higher than the average day throughput.

*Switching time:* It is defined as time between the first set of railcars getting ready to depart from the port rail yard and going to the mainline and a second set of railcars arriving in the port rail yard through the single rail track. For the capacity analysis purpose, the switching time of trains is considered to be 4 hours. This will account for all the delays incurred in bringing the set of rail cars from the mainline to the port.

Table 4-8 describes calculations to determine the number of working tracks to handle the forecasted demand.

Table 4-8 Phase-wise Rail Yard Capacity Analysis

| Phase-1 | Phase-2 | Phase-3 | Rail Capacity |
|---|---|---|---|
| 5% | 7% | 8% | % of Total Container Traffic via Rail (AECOM assumption) |
| 44,611 | 125,729 | 273,690 | Total Rail Throughput Goal (TEU) [a] |
| 1 | 1 | 1 | Nominal Number of Working Tracks [b] |
| 800 | 800 | 800 | Average Length of Each Track (m) [c] |
| 16 | 16 | 16 | m per one well railcar [d] |
| 45 | 45 | 45 | Static capacity (railcars) [e] |
| 2 | 2 | 2 | TEU per railcar at 100% utilization [f] |
| 90% | 90% | 90% | Railcar utilization factor [h] |
| 1.50 | 1.50 | 1.50 | TEU per container [i] |
| 108 | 108 | 108 | Disch + load moves possible w/o switching [j = 2*e*f*g*h/i] |
| 4 | 4 | 4 | Max Rail Yard Cranes in use [k] |
| 12 | 12 | 12 | Moves per hour per RS/RTG [l] |
| 2.25 | 2.25 | 2.25 | Train work time (work-hours) [m = j/(k*l)] |
| 8 | 8 | 16 | Work hours per day [n] |
| 3.0 | 3.0 | 1.5 | Calendar hrs per work hour [o = n/24] |
| 6.8 | 6.8 | 3.4 | Train work time (hours) [p = o*m] |
| 4.0 | 4.0 | 4.0 | Switch time to replenish working tracks (hours) [q] |
| 2.2 | 2.2 | 3.3 | Max turnovers per day [r = 24/(p+q)] |

| | | | |
|---|---|---|---|
| 241 | 241 | 351 | Max rail boxes/day [s = j*r] |
| 120% | 120% | 120% | Peak/mean week throughput [t] |
| 120% | 120% | 120% | Peak/mean day within week for rail [u] |
| 167 | 167 | 244 | Mean rail capacity per day (moves) [v = s/(t*u)] |
| 350 | 350 | 350 | Number of working days per year [w] |
| 60,000 | 60,000 | 90,000 | Annual rail capacity per module year (moves) [x = w*v] |
| 90,000 | 90,000 | 135,000 | Annual on-terminal rail capacity per module (TEU) [y = i*x] |
| 397 | 1,118 | 1,622 | Total working track length required to meet vessel capacity (m) [z = a*y/c] |
| 1 | 2 | 3 | Number of Working Tracks Required (each track of 800 m. length) [a1 = z/c] |
| 1 | 2 | 3 | Number of Working Tracks Provided [b1] |
| **90,000** | **180,000** | **405,000** | **Annual Rail Capacity Provided TEU/year [c1 = y*b1]** |

In order to meet the traffic forecast, one working track will be required in Phase-1 vs. two working tracks in Phase-2, assuming 8 hour working operations. However, three working tracks will be required over the master plan horizon assuming a two shift operations. With three tracks total rail yard capacity will be up to 400,000 TEU per year as compared to approximate 275,000 TEU rail throughput goal, so additional rail throughput will be able to handle from the planned rail yard.

It should be noted that if the rail yard can be operated 24/7 then only two working tracks will be required over the master plan horizon and additional planned space can be utilized to handle non-containerized cargo from the rail yard area.

Container will be stacked at container yard and brought to railway siding by trucks/terminal tractors. Reach-Stackers will load it on the railway rack. It will be the practice for all phases of the master plan. In Phase-3 E-RTG or RMGs can be used for rail loading/unloading operation.

#### *4.5.1.4 Gate Capacity*

Gate capacity analysis is essential feature to get essence of seamless inward and outward traffic movement including major share of trucks having containers. Following factors impact gate throughput capacity:

*Throughput share handled by trucks:* Share of throughput which is forecasted to be handled by truck is key factor for gate capacity planning. Amount of TEU handled by truck will determine the daily truck traffic at port and the movements at gate complex. For capacity analysis, it is assumed that 70% of the gateway traffic will be moved by trucks as compared to 30% by rail.

*Peak Ratio:* For weekly mean moves 20% peak factor is considered. For daily traffic movement 30% peak in daily traffic is considered. For hourly traffic, 50% peak is considered for mean hourly traffic.

*Working Hours:* working hours of gate directly impacts the gate capacity. For Phase-1 an 8 hour gate shift is assumed, where as for Phase-2, total 16 hours of gate operations are assumed and for Phase-3, three shifts of total 24 hours gate operations are assumed for capacity calculations.

*Moves per Truck visit:* Moves per truck visit reflect the container handling movement per truck. It reflects the number of trucks which come with a container and leave port with a container. The amount of such truck traffic is assumed 10% of total daily truck traffic.

*RPM Capacity:* Radiation Portal Monitors (RPM) are passive radiation detection devices used for the screening of vehicles and cargo for detection of illicit sources at port gates. Number of trucks that can be screened by this device per hour determines its capacity, which is being considered as 120 trucks per hour for capacity calculation. This number can increase with reduction in screening time.

Table 4-9 describes calculations to determine phase wise the fraction of capacity required for seamless container truck traffic movement through the gate.

Table 4-9 Phase-wise Gate Capacity Analysis

| Phase-1 | Phase-2 | Phase-3 | Gate Capacity |
|---|---|---|---|
| 600,000 | 1,200,000 | 2,233,333 | Vessel moves/year [a] |
| 12% | 16% | 19% | % of Total Container Traffic via Truck [b] |
| 69,395 | 195,579 | 425,739 | Total throughput moved through Gate [c = a*b] |
| 1,335 | 3,761 | 8,187 | Moves per mean week [d = c/52] |
| 1.2 | 1.2 | 1.2 | Peak/mean week ratio [e] |
| 1,601 | 4,513 | 9,825 | Peak week moves [f = d*e] |
| 7 | 7 | 7 | Days per week operation [g] |
| 229 | 645 | 1,404 | Mean day moves [h = f/g] |
| 1.3 | 1.3 | 1.3 | Peak/mean day ratio [i] |
| 297 | 838 | 1,825 | Peak day moves [j = i*h] |
| 8 | 16 | 24 | Hours worked per day [k] |
| 37 | 52 | 76 | Moves per mean hour on a peak day [l = j/k] |
| 1.5 | 1.5 | 1.5 | Peak/mean hour factor [m] |
| 56 | 79 | 114 | Peak hour on a peak day moves [n = l*m] |
| 1.1 | 1.1 | 1.1 | Moves per truck visit [o] |
| 51 | 71 | 104 | Peak hour truck entries [p = n/o] |
| 100% | 100% | 100% | Fraction of entries that have a container [q] |
| 51 | 71 | 104 | Trucks per hour at RPM [r = p*q] |
| 30 | 30 | 30 | RPM process incl truck replacement (sec) [s] |
| 120 | 120 | 120 | RPM capacity per hour [t = 3600/s] |
| **1.0** | **1.0** | **1.0** | **RPM lanes required [u = r/t]** |
| 180 | 120 | 80 | Entry pedestal process time (sec) [v] |
| 20 | 30 | 45 | Gate capacity per hour [w = 3600/v] |
| **3.0** | **3.0** | **3.0** | **Gate entry lanes required [x = p/w]** |
| 180 | 120 | 80 | Exit process time (sec) [y] |
| 20 | 30 | 45 | Exit capacity per lane [z = 3600/y] |
| **3.0** | **3.0** | **3.0** | **Exit lanes required [a1 = p/z]** |

It should be noted that truck process time at entry and exit gates have been assumed to be improved over time from Phase-1 to Phase-3 due to stabilizing of the labor and improvement in available gate technology deployment.

Number of required lanes in above calculation relates to container truck traffic only. Additional two lanes are required for each entry and exit gate for the vehicles participating in port operation facilities such as port staff vehicles, vehicles of customs, vehicles for supporting services etc. Therefore, total five lanes each for entry and exit gate will be required over the master plan phase.

It is expected that with the proposed "landlord" port model of VISL, private terminal operator will be responsible for operating the gate. With phased development plans of the port, there may be a need to have standalone gate complexes depending on the number of private operators at the port and contractual agreements between VISL and potential port operators. The master plan has been developed with this need in mind and space provision has been provided for additional gate facilities.

### 4.5.2 Container Terminal Capacity Analysis Summary

The container terminal has been sized so as to meet the market demand predicted by IFC/Drewry in 2010. The following Table 4-10 summarizes the development needs of berths, gate, yard and rail elements for the Port of Vizhinjam. The master plan has been prepared to meet this development needs.

Table 4-10 Phase-wise Development Summary

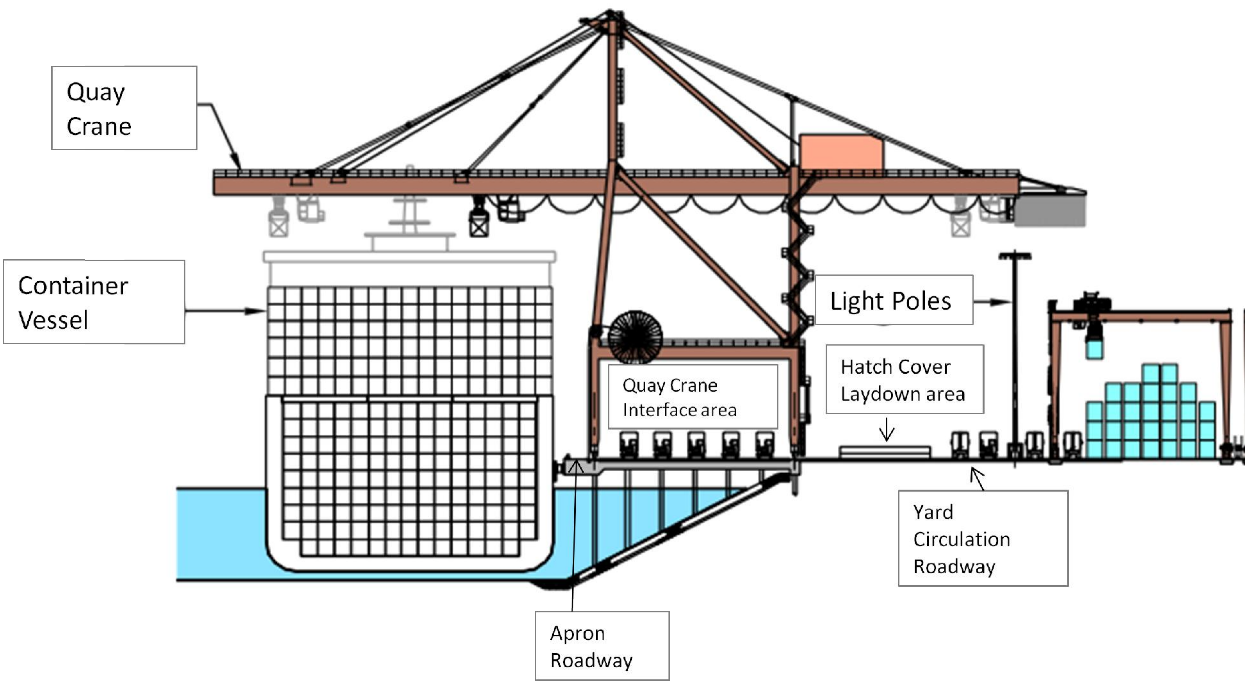
| Port components | Phase-1 | Phase-2 | Phase-3 |
|---|---|---|---|
| Berths (400m each) | 2 | 3 | 5 |
| Container yard storage (TGS) | 5,700 | 8,700 | 18,200 |
| Rail sidings (800m each) | 1 | 2 | 3 |
| Entry/Exit Gate (lanes) | 5 | 5 | 5 |

## 4.6 Functional Requirements

### 4.6.1 Container Berth Area

In preparation of the Port Master Plan and defining the needs for a container transshipment terminal, the direct input on the port operations from a proposed port operator was not available so the port master plan is prepared based on the best industry practice in container handling applicable to the project site.

The primary productive unit of the marine terminal is the combination of quay, quay cranes, and apron. This element of the terminal has been envisioned at a conceptual level to maximize the productivity and safety of the proposed port operations.




The primary elements of this area, which are described in this section, are as follows:

Apron roadway and quay crane interface
Quay cranes
Coning platforms
Hatch cover laydown area
Yard circulation roadway

#### 4.6.1.1 Apron Roadway and Quay Crane Interface

The apron roadway carries all non-container traffic moving onto and off the quay/apron area. This traffic generally includes:

- Vessel crews
- Linesmen
- Vessel service vendors and chandlers
- Quay crane operating crews
- Government officials
- Terminal visitors and customers

Vehicles can only access the apron roadway at either end of the planned container berth for each phase along a secured access road that connects the apron with the terminal yard access roads.

The quay cranes interface with the quay/apron complex along each gantry rail.

The quay crane interface supports the transfer of power and crews between the ground and the moving cranes.

The crane power cable runs in a vertical plane parallel to the crane rail, between the waterside crane rail and the apron road’s landside protective fence.

Crews access the quay crane via a stairway and elevator located at the western waterside leg of each crane. Crews gain access to this system via the apron roadway.

The landside legs of the quay cranes simply ride along their rails, with no power or crew interface. The quay area is to be designed to encourage any pedestrian access to be on the waterside edge, along the apron road.

#### 4.6.1.2 Quay Cranes

At the time of preparation of the master plan, the input from the potential terminal operator (concessionaire) was not available to AECOM. Therefore, the master plan is prepared based on the latest trend observed in the container transshipment terminals in the region such that the proposed project provides a futuristic design.

Depending on the potential terminal operator's preference, details of the quay cranes will need to be specified. The quay designer will have to work with VISL and the concessionaire to correctly design the structural and power interface for the cranes.

For the master plan, AECOM has provided a provision for the quay cranes to be able to service a 22-wide super-post-Panamax container ships of capacity up to 14,000 TEUs with additional provision to service up to 18,000 TEU vessels.

In order to service these container vessels, the quay crane lift capacity will be in the range of 60 to 80 tonnes, with outreach of between 60 to maximum 70 meters. The standard crane gauge (distance between the two crane legs) is currently proposed at 30.5 meters, however depending on the operator's preference it can be extended up to 35m to provide additional truck lanes in between the crane legs. The back reach will be in the range of 20 to 25m with the lift height of up to 45m.

Various drive speeds (hoist, trolley etc) will be selected based on the operator's preference and productivity criteria.

### 4.6.1.3 Coning Operations

On-deck containers on container vessels are connected to one another by inter-box connectors (IBCs), or “cones”, at each corner. Most ships carry semi-automatic IBCs. When a ship is being discharged, on-deck containers come off with an IBC hanging from each corner. These must be removed before containers are set on the terminal tractor for delivery to the container yard.

When a ship is being loaded, containers from the yard are brought to the quay deck by terminal tractors without cones. After they are picked by the quay crane, cones must be inserted and armed before the containers are placed on the ship. Cone removal and insertion has not been widely automated because cones are “ship’s gear”, and vary widely between ships.


The spacing of truck lanes between the quay crane legs is provided such that enough room is provided for coning crew to undertake the coning operations.

### 4.6.1.4 Hatch Cover Laydown Area

Standard cellular container vessels carry large steel hatch covers over the under-deck storage holds. During normal under-deck vessel operations, these hatch covers are stored on the ground in the quay/apron area. The quay crane cannot gantry with these covers. A single hold may have one to four hatch covers, and these will be stacked on the ground, aligned with their hold, during under-deck operations.

The hatch cover area to the landside of the landside quay crane rail holds hatch covers during under-deck operations.

The pavement system shall be designed to accommodate a stack of up to four hatch covers without suffering any damage or deformation. Note that hatch covers can generate very high point loads on the pavement system, depending on the design of the individual container ships.

The waterside edge of the hatch cover area is generally kept 3.0m from the landside crane rail. The hatch cover area is 16.0m wide, extending the full length of the quay. The hatch cover area is served by the quay crane only. The hatch cover area shall be striped to indicate its extent, as shown in the drawings.

#### *4.6.1.5 Yard Circulation Roadway*

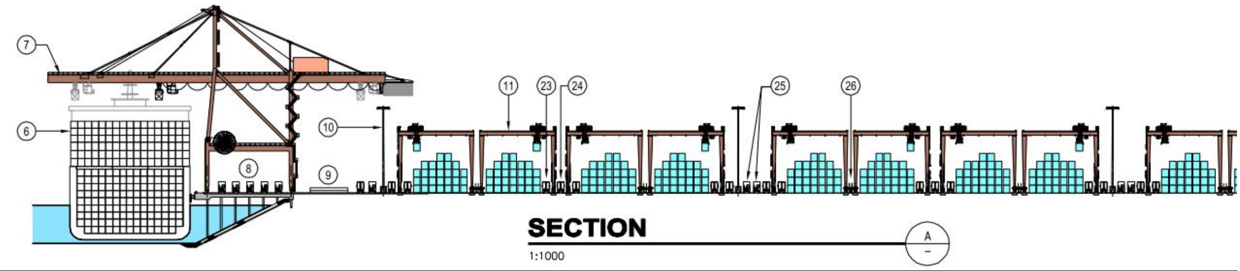
The yard circulation roadway is provided along the length of the quay in between the landside edge of the hatch cover laydown area and the water side leg of the first RTG block to provide uninterrupted longitudinal traffic flow.

### 4.6.2 Container Storage Yard

The primary container storage and marshaling area of the proposed container terminal is planned for grounded container storage in RTG storage rows running parallel to the quay in stacks seven-wide by five-high. Refrigerated container storage is envisioned to be provided in the midsection of the terminal along the north end of the RTG storage rows and served by fixed service racks. Empty container storage is supplied along the far-east edge of the container yard in blocked stacks up to six containers high and serviced by empty container handlers.

#### 4.6.2.1 *Dry Loaded Container Storage*

The phase wise container terminal development plan is configured with storage areas for loaded containers stacked 5-high by 7-wide placed in grounded stacks, serviced by 26.1 meter gage, diesel or electric powered portal frame, RTGs capable of lifting containers one over a five-high stack.




The loaded storage area is designed for high-density random-access container storage and retrieval by RTGs. Container transport is done using diesel powered terminal tractors.

The RTG storage area is provided for approximately following number of twenty-foot-ground slots after discounting the TGS provided for empty containers:

– Phase-1: 4,400 TGS
– Phase-2: 7,500 TGS
– Phase-3 (Master Plan): 17,000 TGS

The empty container storage area for top-pick/side-pick operations has been provided along the rear of the container yard for around 1,200 TGS. The master plan has been kept flexible in the form of space provision along the north boundary of the terminal which can be used for empty container storage as per the market demand.

Stacking areas shall be designed to support five-high storage of fully-loaded containers. RTG crane runway pads shall be designed to support RTG wheel loads established by the RTG manufacturer.

The master plan is prepared such that the loaded container storage area is directly adjacent to the quay area. Containers will be stored in and retrieved from the stacks by RTGs. Containers will be transported by terminal tractors between:

- Quay
- Container stacks
- Empty stacking area buffer
- Rail terminal

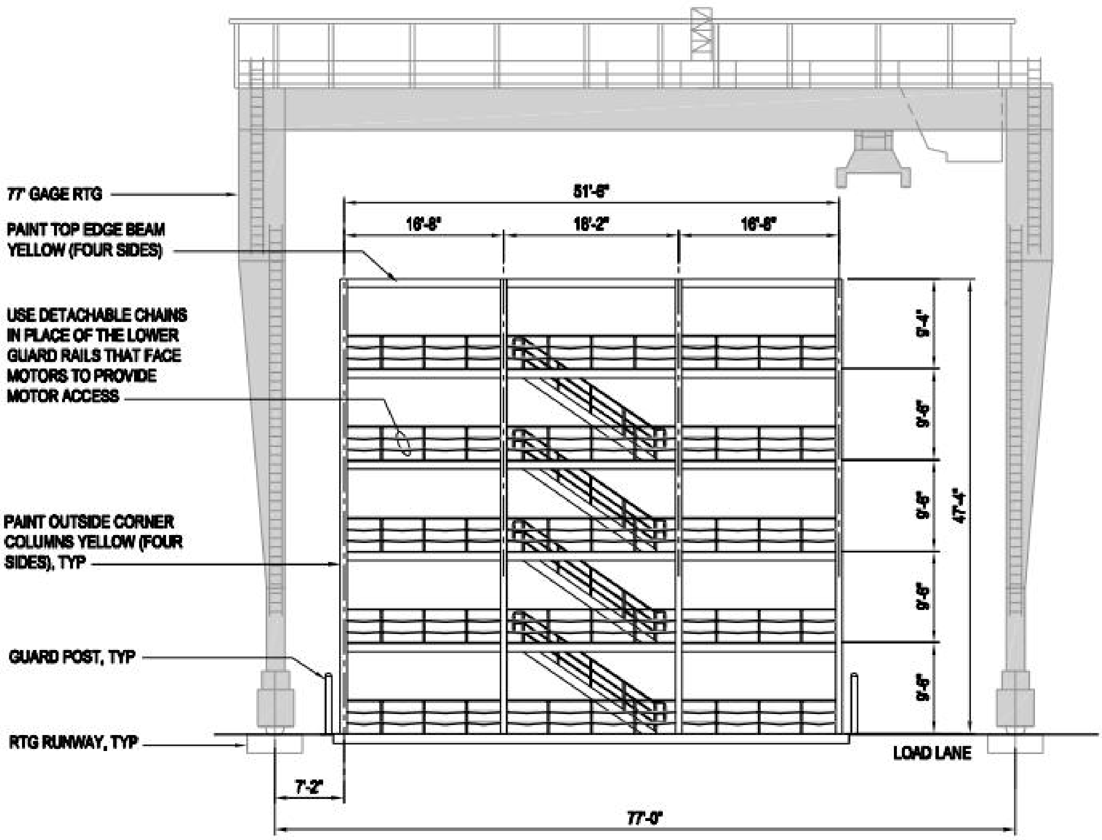
Terminal tractors will also have access to the equipments parking and maintenance and repair area, as well as the peripheral storage areas at each end of the terminal.

Street trucks that will be handling the gateway import/export containers will be permitted access to the RTG and empty container storage area. They will be served by either RTGs or empty handlers depending on the location of the container storage.

Traffic through each RTG row will be one-way and all containers will be stored with the same orientation. The traffic flow will be south to north through the rows, based on having all vessels berthed “port-side-to”. Counter flow circulation traffic roadways are provided, as indicated on the drawings, to expedite traffic flow back to the quay cranes and towards the entry/exit gate. Terminal traffic circulation from the quay through the storage rows will generally be anti-clockwise due to the port-side-to berthing.

#### 4.6.2.2 Reefer Load Container Storage

Refrigerated loaded containers (reefers) are envisioned to be stored either at the north end or a south end of some group of RTG rows, as shown in the conceptual port master plan. 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 terminal tractors.




Reefer racks provides 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.

Empty reefer containers can be stored in designated areas of the empty storage area and/or the RTG container storage rows.

Empty reefers are plugged in and tested (pre-tripped) to confirm their operating condition. Pre-tripping can be done in the grounded reefer stacks.

#### 4.6.2.3 Empty Container Storage

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

ECHs may include, at the discretion of the concessionaire:

- Medium-duty forklift trucks
- Side-pick cranes
- Top-pick cranes
- Reach-stacker cranes

Side-pick Empty Container Handlers are recommended as the primary equipment for ECH operations. See image below. Should the concessionaire elect to do twin-picking of twenty-foot boxes, a twin-pick reach-stacker can be used in the proposed layout.

The dedicated empty storage area is provided at the eastern end of the container terminal between the RTG rows and the container terminal main access road.

ECHs may transport empty containers over short distances to or from the container repair shop or reefer washout area.

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

Traffic through the ECH storage rows can be either unidirectional or bidirectional based on the preference of the operator.

#### *4.6.2.4 Pavement*

The recommended paving system for the container yard storage area may involve the use of pre-cast interlocking concrete paving blocks over a compacted lean mix concrete base with compacted sub base comprised of sand. This system offers the greatest operational flexibility in the container storage yard. An alternate system involves use of concrete beams with container storage over gravel. This system is the most cost-effective and provides better drainage for the yard but provides less operational flexibility. Grading and drainage schemes will need to be fully integrated with terminal operating plans so as not to create impediments to efficient operations.

### 4.6.3 Yard Service and Support

#### *4.6.3.1 Reefer Wash Facility*

A reefer wash facility is used to clean and sanitize the interiors and clean the exteriors of refrigerated containers using manually operated high-pressure hot-spray washing machines.

The number of reefer wash slots required will depend on the operator’s requirement. However, from the land use plan, the Reefer Wash Facility should be located adjacent to the Maintenance and Repair Building at the rear of the terminal.

This area shall be graded and bermed so that water and wash materials will be contained and flow to a reclamation sump equipped with an appropriate water separator and shut-off valves. Grading of the surrounding areas shall cause rain water to drain away from the area.

#### 4.6.3.2 *Yard Equipment Parking*

Yard equipment parking area is provided to allow for consolidated storage of inactive terminal equipments. This area is provided adjacent to mobilization areas with easy access from the entry/exit gate so as not to interfere with terminal operations.

As shown in the terminal plan, this area is provided centrally at the rear of the terminal adjacent to the Maintenance and Repair Facility. Additional yard equipment parking is provided along the landside edge of the terminal adjacent to the terminal POV parking area.

Most powered vehicles will be fueled at the Fuel Station in the parking area. Therefore, the pavement in these areas shall be graded so that spills are contained and flow to special drains and/or sumps provided with oil-water separators and drain shut-off valves.

#### 4.6.3.3 *POV Parking Areas*

Parking spaces for management employees, visitors and other personally owned vehicles (POVs) is provided on the south side of gate entry/exit area, at the rear of the terminal.

It is assumed that the yard personnel will arrive by port-operated bus service or motor cycles. Additional POV parking is not provided for the yard personnel. Motor cycle parking is provided inside the POV parking area.

The port master plan shows the POV parking area of approximately 1 Ha size. The adequacy of these values should be verified, in concert with refined building planning, during the final design process.

Each POV parking stall shall be 2.7 meters wide by 6.1 meters long. An aisle of at least 7.6 meters in width shall serve the parking stalls.

On-terminal bus stops will be required adjacent to each of the terminal buildings and yard equipment parking areas. On-terminal buses are to be used to transport employees to their places of work on the terminal.

## 4.7 Buildings

The port master plan has identified the conceptual foot print and tentative location for various terminal buildings required for the functional port operations.

Typical buildings common to a container terminal includes:

- Administration Building
- Entry/Exit Gate Inspection Canopy
- Security Guard Booths
- Pre-gate and Customs Building
- Maintenance and Repair Building
- Quay Crane Maintenance and Marine Operations Building

Buildings not shown or considered in the master plan include those that may be needed to handle possible general/multipurpose cargo and port operator need based facilities. A provisional location for these buildings is shown on the plan but no additional details are provided to keep the flexibility for future expansion.

### 4.7.1 Administration Building

The administration building will be required to house the terminal operator's management, security, admin and customer service personnel.

The Administration Building is located adjacent to the entrance and exit gate as indicated on the site plans. This facility houses the management and staff functions for container terminal and gate operations.

The building is located on the site plan to allow visual access to the gate complex from the Customer Service Department and the second floor Control Room. Office areas on the third floor will have visual access to the container yard, container ship wharf, rail yard, and all gate areas. The building has been planned in such a way that additional annex can be added in the same location for future phases if needed.

Typical users/uses of the administration building include:

- Terminal Administration
- Customer Service
- Gate Equipment Control
- IT/Server
- Gate Control Clerks
- Offices
- Shipping Lines Offices
- Terminal Security and Communications Hub

The Administration Building generally equips the following systems:

- TOS Computer System
- Container Yard Lighting Controls
- Annunciation and Alarm Systems
- Gate Control and Systems (voice, data, scale, sign bridge etc.)
- Public Address System
- Telecommunications System

### 4.7.2 Entry/Exit Gate Inspection Canopy

The Entry Gate Inspection Canopy is used to process container traffic into the terminal and the Exit Gate Inspection Canopy is used to process container traffic out of the terminal.

Both entry and exit gate canopy will have five lanes each in all of the master plan phases with four booths on each side. As discussed earlier, if different private terminal operators are utilized at the port, they will require separate lanes or even standalone gate complex depending on number of operators at the port and depending on the contractual agreements. Master plan has been developed keeping these eventualities in mind and provides sufficient flexibility. If the whole port (full master plan development) is operated by the same operator, the gate canopy described above will be sufficient. However, in the case of two terminal operators operating at the port with one operator for Phase-1 and Phase-2 development and the second operator for Phase-3 development, there may be a need for an additional gate complex for the Phase-3 operator. Master plan provides space provision for this additional Phase-3 gate.

Each clerk booth needs to be able to house two staff and have 360° visibility of the lanes.

Gate canopies provide weather protection for the gate activities and provide a mounting structure for gate cameras and infrastructure. Any statutory scanning of import as well as export cargo will also take place here.

The Entry/Exit Gate Canopy equipment shall include, but not be limited to the following:

- TOS and Gate Computer Systems
- Gate Camera Controllers
- Cameras with automatic vibration correction
- Sign Bridge Controllers
- Scales and Scale Interface Controls
- Communication antennae and associated hardware

### 4.7.3 Security Guard Booth

Security guard booth will be located at the main entrance of the secured port boundary after crossing the roundabout shown on the layouts. It provides security surveillance at the main gate truck access and exit lanes.

The guard booth serving the main gate should be elevated and provided with sliding windows so that communications with drivers within the truck cabs can be facilitated.

The building is located on the site plan on either side of the road to allow visual access to the gate complex and the public roadway (Port road). The Guard Booth equipment shall include, but not be limited to the following:

- Central Security Monitoring and Annunciation Panels. Panels shall accurately depict the site plan of the terminal.
- CCTV monitors and controls with split screen & view selection capability.

### 4.7.4 Pre-gate Building and Customs Clearance

This facility is provided for the administrative functions of the remote pre-gate facility. The Pre-gate Building houses the Customs and Customer Service Department. The Customer Service Buildings and Kiosks provide facilities for truck drivers to resolve problems they may have with their paperwork, as well as convenience facilities.

The Pre-gate Building is located on the site plan to provide facility for following functions:

- Customs clearance
- Demurrage payment
- Customer service
- Trouble transactions
- Truck driver canteen
- Toilets and washrooms
- Public phone, fax and internet

### 4.7.5 Maintenance and Repair Building

This facility houses maintenance, repair and related activities for RTGs, yard tractors, top-picks, side-picks, truck chassis, and other container terminal operating equipment. It also supports other service areas such as tire changing, and equipment steam cleaning activities.

Typical users/uses for this building include:

- Maintenance Supervisors
- Power and Chassis Repair Mechanics
- Parts Storage and Control
- Mechanics' Lockers
- Genset Repair
- Offices
- Vendors

The building needs to be positioned near the perimeter of the container terminal so as not to interfere with terminal traffic circulation. Parking for service vehicles and bad order equipment needs to be adjacent to the building. Adequate circulation is required to move vehicles to and from the service bays. Roll-up overhead doors are required in the parts room and service bays.

Building location shall allow for the ease of vendor access through the perimeter fence. The building has been planned in such a way that it can be easily expanded if needed. Sufficient area has been provided for additional maintenance and repair building for future phases.

The design shall include bridge cranes, floor loadings from tie-down anchors, and access platform loading in the service bays. Structural systems shall adequately support this equipment.

### 4.7.6 Quay Crane Maintenance and Marine Operations Building

This facility houses ship loading/unloading operations and planning functions as well as break facilities for the ship operations. The building should be multi-leveled.

This building is to be positioned and of sufficient height so that marine operations can have visual oversight of the wharves. Visual contact can be augmented by the use of TV cameras as required.

Typical users/uses of this building include:

- Marine Operations Supervisors
- Labor Breakroom and Restroom Facilities
- Crane Repair Mechanics (Spreaders, Ropes)
- Parts Storage and Control
- Mechanics' Lockers

Sufficient area has been provided for additional quay crane maintenance buildings for future phases or different private operators along the berth as needed by the users. The building equipment shall include, but not be limited to the following:

- TOS Computer System
- TV Supervisory System

### 4.7.7 VISL Port Administration Building

A separate building and land area will be required to provide for functioning of VISL in managing the port operations. This will include but not limit to office building for the VISL management and administration staff, office for government officials, security staff and customs and border protection officers. This will also include the facilities for port maintenance and engineering staff.

## 4.8 Coast Guard

The need for effective coastal security in the present security scenario was highlighted by Coast Guards during the February 2012 workshop held in Trivandrum. The same was communicated to VISL with reference to the letter dated on December, 2011, where Coast Guard had put requirement for development of a station at Vizhinjam.

The Coast Guard requested a dedicated berthing space at Port of Vizhinjam to enable operation of its ships. Presently Coast Guard has no provision to berth Coast Guard ships calling at Vizhinjam. The Coast Guard is planning to have station at Port of Vizhinjam for effective coastal security and monitoring of Sea Lanes of Communication which is located at 10 nautical miles off the south west coast of Trivandrum. It will also help to provide enhanced training to Marine Police.

The Coast Guard at Vizhinjam requested for a dedicated berth having a minimum berthing space of 120m and alongside depth of 8m. It was suggested that the berth has a land parcel of one acre adjacent to berth for ship's support complex, pollution control store and diving cell at Port of Vizhinjam. The cost of land and berth construction will be met by Coast Guard. A land parcel of 6 to 10 acre for construction of accommodation for staff of Coast Guard was also requested outside the CRZ near the Port of Vizhinjam.

## 4.9 Multipurpose Cargo Terminal

The long term demand for general/breakbulk cargo was provided by DREWRY to be in the range of 1 million Tons per year. This can be handled from one dedicated berth and approximate storage area of approximately 3 Ha. Provision for multipurpose cargo terminal can be provided either at the Southern most end of the container terminal in the future expansion area or if Cruise demand is deemed low, one of the cruise berth location can be utilized and area north of port crafts berth be utilized as the terminal area.

## 4.10 Liquid Bulk Terminal for Bunkering

In order to make the proposed transshipment terminal more attractive location for shipping lines traversing through the East-West shipping channel, a provision for bunkering facility can be also provided at the proposed Vizhinjam port. In order to provide for the latest state-of-the art bunkering facilities, following key elements will be required at the port:

- Bunker fuel loading hydrant system along all container berths
- Bunker fuel storage tanks
- Bunker fuel unloading berth

DREWRY forecasted annual demand of approximately 1 million tons of petroleum products to be handled from the proposed port. It equates to approximately 100,000 tons of static storage capacity and one dedicated berth for unloading of the liquid products – if coming by barges or ocean going vessels into the proposed port.

## 4.11 Fishery Berths

A fishing landing centre is a place where the fishing boats are assured safety while in operation or idling. It should be possible to load /unload the contents with minimum handling and within shortest possible time. The facilities to be provided are broadly divided into two categories viz.

a) Waterside facilities
  - Proper access to the landing area from the sea
  - Landing, Outfitting Quay and berthing quay/ jetty
  - Navigational Aids etc

b) Landside facilities
  - Auction hall
  - Administrative building
  - Vehicle parking area
  - Access roads
  - Electric & Water Supply etc.

The proposed port has been planned to have minimal impact on the existing fishing harbour of Vizhinjam. In order to ease the congestion in the existing fishing harbour and provide additional facilities for the local population, it is proposed to provide fishery berths along the sea side of north breakwater of the proposed Vizhinjam port and sea side of the south breakwater of the existing fishing harbour. The modeling studies performed by LTR have shown that these locations will provide adequate protection from waves and hence provide suitable location for additional facilities for the local fishing community.

## 4.12 Cruise Terminal

As per the direction received from VISL, the cruise terminal will not be included in the Phase-1 development. First cruise berth could be developed as a Phase-1A or in Phase-2 and second cruise berth could be developed in the Master Plan phase. Before the details of the terminal phasing are decided, a more in-depth market study will be required for the cruise terminal including a more detail cruise terminal planning.

The cruise terminal will have to be integrated with a long-range wider area transport and tourism plan of the Trivandrum area and will have to be strategically integrated along with local area attractions for its success.

AECOM has prepared the master plan based on the critical functional requirements a large cruise facility needs to provide, in combination with the availability of berthing and landside needs after accounting for the primary container cargo handling needs.

- Safe access for the vessel
- A protected berth
- Intermodal Zone requirements

- General Terminal Area
- Passenger boarding bridges and "Window of Accessibility"
- Shopping (Duty free shops) and recreational facilities
- Transport facilities for excursions
- Ship chandler for supplies.

Each of these elements is briefly discussed below.

### 4.12.1 Safe Access for the Vessel

Navigation facilities like approach & turning circle must provide safe passage for cruise vessels. Since Vizhinjam Port is primarily a container transshipment terminal, the design ship for the port navigation facilities is taken as 12,500 TEUs capacity which has 400m length, 56m beam & 16m draft. As the navigation facilities have been conceptualized for big container vessels, cruise ships with relatively smaller dimensions compared to the mainline container vessels will be able to navigate safely through the approach channel & turning circle.

### 4.12.2 A protected berth

The berth location should have enough tranquility for berthing operations. Limiting wave heights for a cruise ship at berth area should be less than 0.65m. as per IS:4651 (Part V).

From the Royal Haskoning wave tranquility studies it can be concluded that the cruise berth location will have enough tranquility for a cruise ship to berth.

### 4.12.3 Intermodal Zone

A cruise passenger's first and last experience at the cruise terminal is the intermodal zone where buses, taxis, shuttles, and private automobiles load and unload passengers taking the cruise and their baggage to/from the port. Depending on the size of various cruise vessels forecasted to service, the intermodal zone must be expanded to meet the needs of the larger passenger population.

### 4.12.4 Ticketing, Customs/Security Inspection Facilities & Baggage-Handling Areas (General Terminal Area)

General Terminal Area caters to the cruise terminal functions such as ticketing, customs/security inspection and baggage-handling. In terms of the footprint of the cruise terminal, the ticketing, baggage-handling & security checks areas require the largest area for the terminal functionality. Generally, one square meter per passenger is the minimum needed to lay down the baggage. In order to service up to 2 vessels of 3000 passengers capacity, it is estimated that the building foot print will be in the range of 8000 square meters total, after accounting for main circulation aisles, egress, customs inspection requirements, restrooms and vertical circulation elements. Other facilities such as duty free shops, restaurants and recreational facilities can be integrated into this complex or separately around the cruise terminal.

Ideal lcoation for the GTA is directly behind the berth with the intermodal area directly on the other side of the GTA as shown in Figure 4-2.

Depending on the available land directly behind the cruise berth, the GTA can be de-coupled and provided at a distance with provision for passengers to access the cruise berth to/from the GTA through a secured and a safe passenger corridor.

### 4.12.5 Passenger-Boarding Bridges and Window of Accessibility (WOA)

The WOA is defined by both a vertical and a horizontal dimension (see Figure 4-2 and Figure 4-3). The maximum WOA with the greatest range of vertical and horizontal dimension provides access to the largest number of cruise ships in today's fleets and those of the future. Seaports planning cruise terminals cannot predict long-term uses (up to 40 years) of a terminal by a particular ship. Therefore, their terminals must be sufficiently flexible to accommodate the universe of cruise ships that may call at their port in the future.

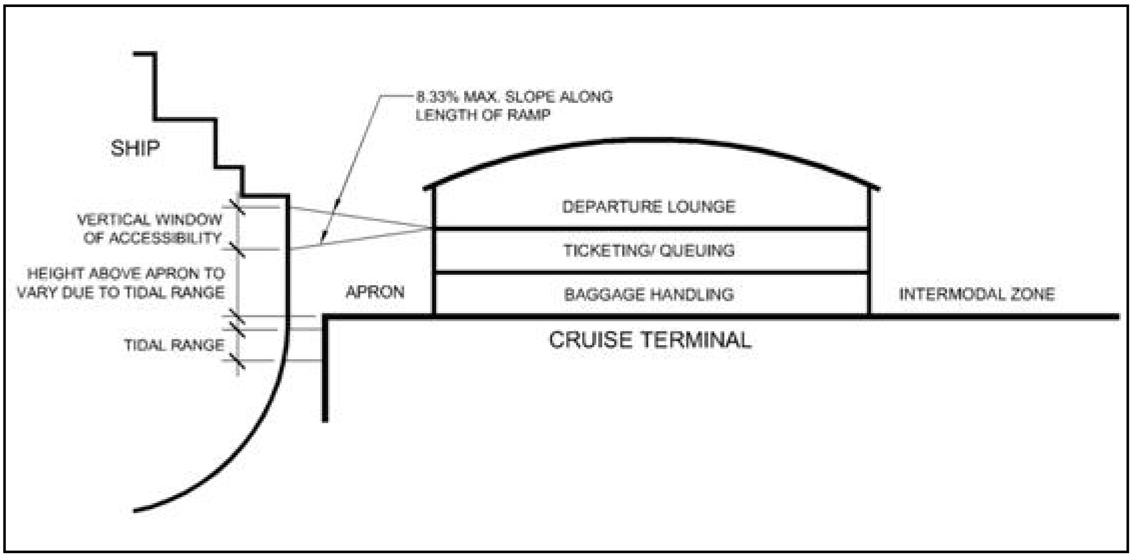



Figure 4-2 Vertical window of accessibility for Cruise Vessels

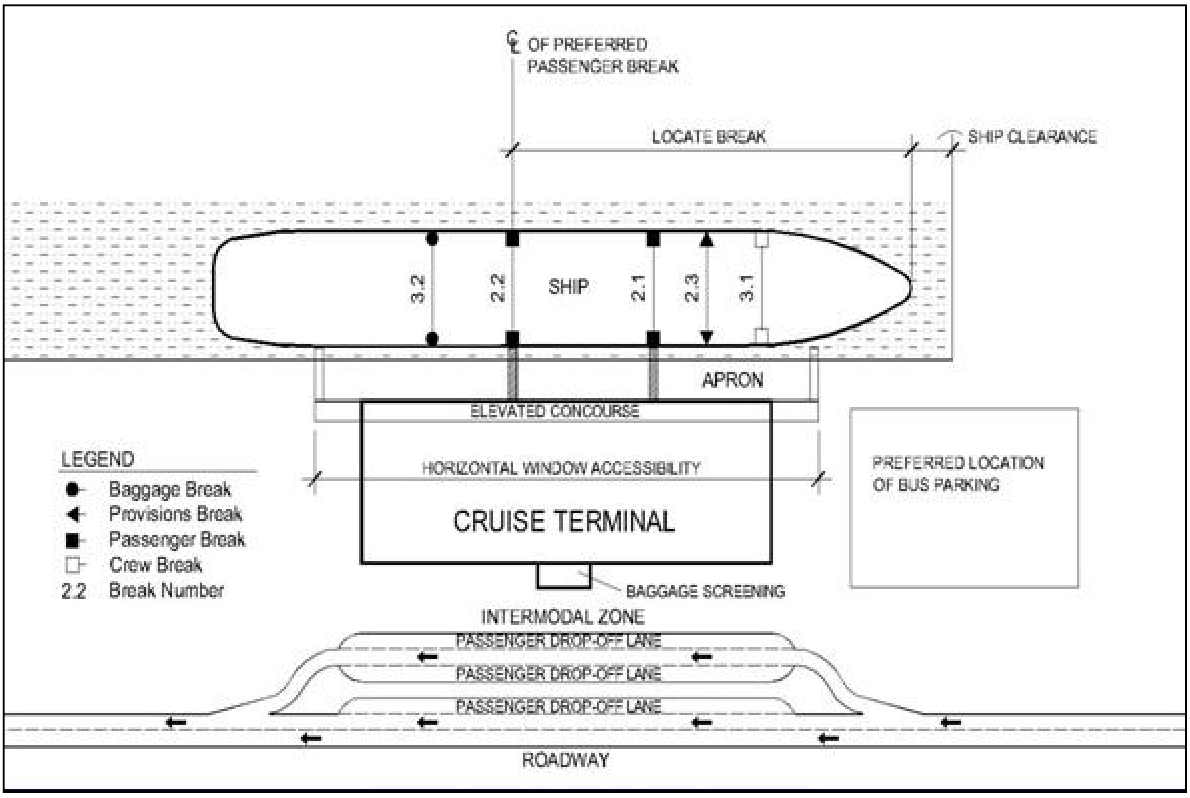



Figure 4-3 Proposed Horizontal Window of Accessibility for Mobile Passenger-Boarding Bridges

The WOA is also determined by the ramp slope of the boarding bridge which must not exceed 1 vertical unit in 12 horizontal units. The WOA is also affected by the tidal range, which determines the vertical height of the passenger access openings (pax breaks) above the apron. The boarding bridge provides the passenger connection to the ship and must be designed to allow for both horizontal and vertical ship movements and be provided with specific safety equipment such as a safety net and devices warning of ship movement.

A cruise terminal must thus maximize the WOA for passengers to enter and leave the new generation of cruise ships. Because all ships have different access locations, which also differ from port side to starboard side on the same ship, and because ships are of different lengths, it is critical to allow access to as many pax breaks as possible on the various cruise ships via the passenger-boarding bridge or bridges. If the GTA is provided away from the cruise berth then mobile passenger boarding bridges can be provided to access the cruise vessels to/from the berth.

## 4.13 Navigational Requirements

### 4.13.1 Navigational Aspects

The navigation channel layout, orientation and breakwater layout was prepared by RH, which has been taken forward by AECOM. The navigation requirements for the proposed port are presented in this section. The channel parameters such as one way or two way channel, channel base width and channel depth required for the port have been calculated based on the design ship size & total number of ship calls expected to be handled by the port.

### 4.13.2 Approach Channel

The port approach channel consists of the two parts: the outer approach channel which is the section of the channel outside the breakwaters area and the inner approach channel, which is the section of the channel from the head of the breakwaters area to the vessel turning area.

The outer approach channel would be unprotected with vessels in transit along this section sailing under their own power without tug assistance. The inner entrance channel would be protected and should be fairly sheltered from wave attacks. Tugs will be able to meet and fasten to the vessel before it enters the turning area and starts to maneuver towards the allocated berth.

The vessels will start slowing down after tugs are attached in the inner approach channel. As per PIANC (1997) guidelines, sheltered inner approach channel should have a around 4-5 times length of the design ship. However considering the capital cost of longer breakwater, it is expected that breakwater will be provided with an effective length of 3-4 times the design vessel length overall for Phase-1 and Phase-2 operations which is deemed adequate. Phase 3 developments will provide the necessary length of inner approach channel for the design vessels up to the turning circle.

### 4.13.3 Approach Channel Lanes

The approach channel can be a single lane or a two lane channel. For busy ports which handle very large throughput and have a large number of vessel calls, it is recommended to have a two way approach channel. In order to establish the approach channel width and number of lanes, AECOM performed a spreadsheet analysis. Based on the operating assumptions made, Table 4-11 shows the impact of vessel traffic on the channel utilization rate for various phases.

Table 4-11 Approach Channel Lane Requirement Estimation

| Parameters | Phase-1 | Phase-2 | Phase-3 |
|---|---|---|---|
| Assumed vessel speed (knots) | 5 | 5 | 5 |
| knots to km | 1.852 | 1.852 | 1.852 |
| Vessel Speed in km/hr | 9.26 | 9.26 | 9.26 |
| Length of the channel in Km | 4 | 4 | 4 |
| Time for transit (Hrs) | 0.43 | 0.43 | 0.43 |
| Time for pilot boarding (Hrs) | 0.25 | 0.25 | 0.25 |
| Time tug fastening (Hrs) | 0.25 | 0.25 | 0.25 |

| | | | |
|---|---|---|---|
| Average time from turning circle to berth (Hrs) | 0.50 | 0.50 | 0.50 |
| Total Channel + Turning Circle Operation Time (Hrs) | 1.43 | 1.43 | 1.43 |
| **Average total operation time (hours)** | **1.50** | **1.50** | **1.50** |
| Number of container berths | 2 | 3 | 5 |
| Number of cruise berths | 0 | 1 | 2 |
| Number of other berths | 0 | 1 | 3 |
| Container vessels per week per berth | 5 | 5 | 5 |
| Cruise vessels per week per berth | 0 | 1 | 2 |
| Other vessels per week per berth | 0 | 0.25 | 0.5 |
| **Total vessel calls per week** | **10** | **16.25** | **30.5** |
| Total number of vessel trips through the approach channel per week | **20** | **32.5** | **61** |
| Number of days per week | 7 | 7 | 7 |
| **Total vessels trips per day** | **2.86** | **4.64** | **8.71** |
| Operating time per day (Hrs) | 20 | 20 | 20 |
| Window of availability for each vessel trip (Hrs) | 7.0 | 4.3 | 2.3 |
| **Channel Utilization in %** | **21%** | **35%** | **65%** |

The parameters considered for channel traffic level analysis are vessel speed (it is assumed that vessels would transit slowly in the approach channel at an average speed of 5 knots), length of the approach channel, time for operation such as pilot boarding, tug fastening and maneuvering operations in turning circle. Traffic parameters (total ship calls) are taken from DREWRY report & AECOM's PRECAP model. Approach channel utilization for Phase-1, Phase-2 and Phase-3 are calculated at 20%, 35% & 65% respectively. With these utilization figures it can be concluded that a single lane, one way channel will be sufficient to serve the expected number of ship calls upto the final phase of development.

### 4.13.4 Approach Channel Width

The width of the single lane approach channel has been estimated considering the design ship beam of 56m. The various factors considering the base width of the channel have been taken from PIANC guidelines. A suitable factor for each parameter is taken and it is multiplied with design ship beam to get the total base width of the channel. Channel width calculations are shown in Table 4-12.

Table 4-12 Approach Channel Width Estimation

| Factor description | Outer Approach | Inner Approach |
|---|---|---|
| Basic Width | 1.5 | 1.5 |
| Vessel Speed | 0 | 0 |
| Prevailing Wind | 0.4 | 0.4 |
| Prevailing Cross Currents | 0.7 | 0.7 |
| Prevailing Long. Currents | 0.1 | 0.1 |
| Sig. Wave Height & Wavelengths | 1.5 | 1 |
| Aid to Navigation | 0 | 0 |
| Bottom Surface | 0.1 | 0.1 |
| Depth of Waterway | 0.1 | 0.1 |
| Cargo Hazard | 0 | 0 |
| Bank Clearance 1 | 0.3 | 0.3 |
| Bank Clearance 2 | 0.3 | 0.3 |
| **Total Factor (One-Way Channel)** | **5** | **4.5** |
| Beam of Design Vessel | 56 | 56 |
| **Channel Width** | **280 m (=56*5)** | **252 m (=56*4.52)** |

From Table 4-12 it can be concluded that as per PIANC guidelines outer approach channel (unsheltered) and inner approach channel (sheltered) will need approximately 280m and 252m of base width respectively. The port has a provision of handling 18,000 TEU ships with a beam of 59m. These ships would require an outer channel width of 295m (59m*5) and inner channel width of 266m (59m*4.5). However, since the navigational requirements of the 18,000 TEU vessels are stricter, it is recommended that outer approach channel width be sized as 400m gradually reducing at the breakwater mouth to an inner approach channel width of 300m.

### 4.13.5 Turning Circle Diameter

As per the PIANC guidelines, diameter of the sheltered turning circle with tug assistance should be 1.75 times length of the design ship. The design ship length is taken as 400m so the turning circle diameter required would be 1.75 times 400m which is 700m.

### 4.13.6 Approach Channel, Turning Circle and Berth Pocket Depth

The depth of the approach channel is a very important parameter in approach channel design. The Vizhinjam port location has a very favorable bathymetry and natural depth. Water depth in the channel region is around 15 to 18m depth below CD. This will minimize the initial capital dredging cost involved. The recommended channel depths have been estimated based on PIANC guidelines for the design ship draft of 12,500 TEU vessels which is 16m. The table below shows the dredge depth calculations.

Table 4-13 Approach Channel Dredging Depth Estimation

| Analysis of Channel Width using PIANC Guidance | |
|---|---|
| **Factors as multiples of the draft of the vessel** | **Depth (relative to CD) for 12,500 TEU Design Ship** |
| Draft of Vessel | 16 m |
| Outer Approach Channel Depth Factor (30% of draft) | 1.3 |
| **Outer Channel Depth (Unsheltered)** | **20.8 m (=16*1.3)** |
| Inner Approach Channel Depth Factor (15% of the draft) | 1.15 |
| **Inner Channel, Harbour Basin & Turning Circle (Sheltered)** | **18.4 m (=16*1.15)** |
| Berths Depth Factor (10% of draft) | 1.1 |
| **Berths Depth** | **17.6 m (=16*1.1)** |

Thus the outer approach channel which will be unsheltered will have a minimum dredging depth of 20.8m, whereas in the inner approach channel area, turning circle and harbor basin, a water depth of 18.4m will be provided. Berthing pockets will have a dredged depth of 17.6m. These dredge depths will also be able to accommodate the 18,000 TEU ships.

It is estimated that the dredge depths prescribed above will provide sufficient material for the reclamation quantity needs of Phase-1 development.

### 4.13.7 Marine Operational Requirements

#### *4.13.7.1 Tug Fastening & Tug Operations*

The tugs, which assist the ship while stopping, turning in the basin and in maneuvering to the berth, normally meet the vessel in protected water, just inside the breakwaters. The limiting wave condition for conventional tugs to fasten to a ship and effectively assist and control the ship varies from Hs = 1.0m to Hs= 1.5m depending the type of tugs used. If a single tug is used in the trail mode, this can control the ships direction and speed if it has the right propulsion system. Trail tugs can connect in waves up to Hs= 3.0m

When an arriving ship reaches the shelter of the breakwater, tugs will be in attendance and will assist in maneuvering to a stop. The distance required to bring a ship to a stop varies with the type of ship, the weather conditions and its speed on entering the harbour. The stopping distance, turning circle diameter, required number and power of the tugs, etc. will be optimized in detailed design stage later by ship navigation studies.

While developing the marine layouts it is considered that adequate number of tugs would be provided to handle the ships using the port. The optimum requirement however will be based on the outcome of navigation simulation studies on the selected design ships.

#### *4.13.7.2 Requirements for Port Craft*

The main activity of harbour tug is providing assistance to vessels entering/ leaving the harbour, turning of the vessel in the harbour and the berthing/ de-berthing operations.

While developing the marine layouts it is considered that the minimum fleet will be four tugs in the initial stages of development. Further in view of the projected ship movements at the master plan stage, it is expected that additional set of tugs will be needed by 2044 to manage the one way channel. The exact requirement however will be based on the outcome of navigation simulation studies on the selected design ship.

#### *4.13.7.3 Pilot Boarding*

Ships arriving and departing the port will generally take on local pilots for the transit between fairway buoy and berths. Pilots will need to board and disembark vessels in the open sea and the limiting wave condition for this will be approximately significant wave height (Hs) of not exceeding 2.5m. The limiting wave heights will depend on factors such as wave period and vessel sizes and will need to be reviewed during preparation of the detailed project report.

When offshore wave conditions exceed Hs = 2.5m, the limit for pilot boarding, ships cannot enter port and will have to wait at outside of the port channel.

### 4.13.8 Navigational Aids

International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) maritime buoyage system as per Region A in which Vizhinjam port falls will be followed. The lateral marks will be red and green colours to denote the port and starboard sides of channel. A total of 10 buoys, which include 6 outer channel buoys i.e. one fairway buoy (3.5m dia.)/light vessel, 3 port side buoys (3m dia.) & 3 starboard buoys (3m dia.) and 5 buoys (2.5m dia.) in the inner channel & harbour basin are required for the navigational purpose. In addition, two sets of transit lights and two sets of mole lights and beacons are also proposed for ensuring adequate safety.

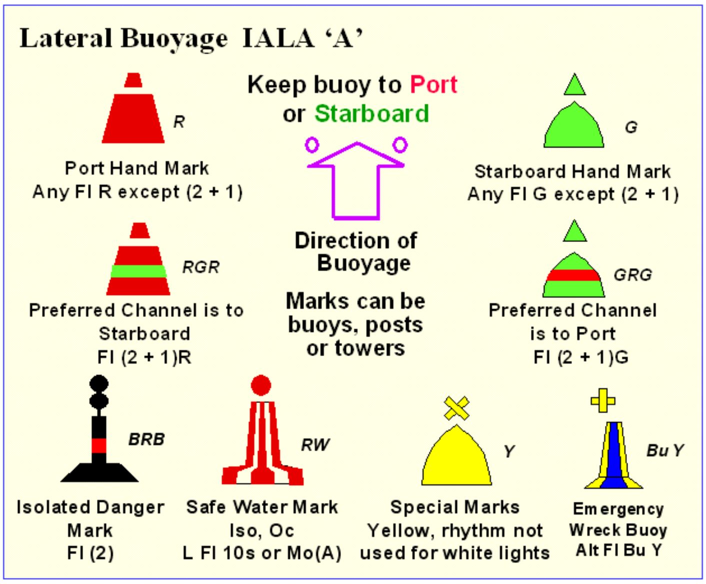



Figure 4-4 Sample IALA Buoyage System

### 4.13.9 Vessel Traffic Management System (VTMS)

An integrated VTM system will be required for marine operations at Vizhinjam Port, which will have to be linked to the PMIS (Port Management and Information System). Together with an automatic update of traffic information, VTMS will provide a powerful tool for programming of safe ship movements and efficient traffic planning within the port and channel areas.

### 4.13.10 Navigational Requirement Summary

The Navigational requirements summary over the master plan horizon is shown in Table 4-14 below.

Table 4-14 Navigational Requirement Summary

| Navigational Parameters | Phase-1 | Phase-3 (Master Plan) |
|---|---|---|
| **Outer Channel** | | |
| Length (m) | 2,800 | 1,900 |
| Width (m) | 400m | 400m |

| | | |
|---|---|---|
| Required Dredge Depth (-CD) | 20.8m | 20.8m |
| **Inner Channel** | | |
| Length (m) | 1,200 | 2,100 |
| Width (m) | 300m | 300m |
| Required Dredge Depth (-CD) | 18.4 | 18.4 |
| **Turning Circle** | | |
| Diameter (m) | 700m | 700m |
| Required Dredge Depth (-CD) | 18.4m | 18.4m |

The length of the outer approach channel in Phase-1 is longer than Master Plan because of the extension of north breakwater. After the extension, a part of the outer approach channel will be categorized as inner approach channel as that part will be in protected water. The extent of the channel is the same but the corresponding difference in outer channel length is reflected in the increase in length of inner approach channel.

## 4.14 Off-Port Support Facilities

### 4.14.1 Container Freight Station, Truck Terminal and Warehousing/Distribution Center

Container Freight Station (CFS) services the cargo owners in transferring the cargo to/from domestic trucks to international shipping containers. For cargo owners who ships partial container loads or does not have their own packing/ de-packing facilities utilizes the CFS. CFS is used for receipt of cargo to be packed into containers for cargo export and unpacking of cargo from containers in case of import cargo and temporary storage. It is a custom bound area.

General activities carried out in a CFS are as under:

- Container packing and unpacking
- Customs bonded warehouse storage/cold storage
- Container storage/stacking
- Container repairs and maintenance
- Storage of reefer cargo
- Hazardous cargo handling
- Empty containers storage

Containers stuff in CFS area are cleared by custom procedures within the CFS boundary and sent to the port with custom seal on it. Containers will be sent to port after custom sealing under ownership or on responsibility of the CFS operator. Warehouse / cold storage are part of CFS area for storing loose cargo before stuffing or after opening of container.

Land parcel earmarked for the proposed CFS required at Vizhinjam port is identified in the land parcel owned by VISL at the eastern end of the port access road near the junction of port road to NH 47. Based on the DREWRY traffic forecast, it is estimated that approximately 27% of the total traffic in the Master Plan phase will be gateway traffic. We have assumed a split of 30% vs. 70% for the gateway traffic moving through rail vs. truck. This would result in an approximately 19% of traffic moving by trucks in the master plan phase.

Not all gateway traffic will need the services of the CFS. Most of the containers going long distance from the port would use the cargo owner's own CFS facilities and may not need the CFS. Based on the general trend on the use of CFS in India, we have assumed maximum 20% of the gateway truck traffic will avail the near Port CFS facilities. Based on this assumption, the port master plan provides a location for future expansion of the required CFS/ Warehouse area to cater to approximately 80,000 moves per year throughput through the proposed CFS.

The Table 4-15 shows the calculations for arriving at an approximate functional area for the CFS/Warehousing activity related to the Vizhinjam Port.

Table 4-15 Capacity calculations for CFS/Warehousing

| Master Plan | CFS Capacity Calculations |
|---|---|
| 1,825 | Peak day moves for gateway traffic [a] |
| 20% | % of traffic coming to CFS/Warehousing area [b] |
| 365 | Peak day moves at CFS/Warehousing area [c = a*b] |
| 1.5 | TEU per Move [d] |
| 3 | Mean storage height for loads and empties [e] |
| 7.00 | Average container dwell time in days [f] |
| 1,277 | Total Twenty Feet Ground Slots (TGS) required [g = c*d*f/e] |
| **5** | **Required Area for stacking yard (Ha) [h = g/(2.47*100)** |
| 6 | Stuffing/de-stuffing time per Container in hrs [i] |
| 20 | Hours of operation per day [j] |
| 110 | **Required number of container bays [k = c*i/j]** |
| **3** | **Required area for container bay and Warehousing (Ha) [l]** |
| **3** | **Required area for office buildings and vehicle movement (Ha) [m]** |
| **11** | **Total area required (Ha) [n = h+l+m]** |

Total land requirement for CFS/Warehousing area for the master plan phase will be approximately 11ha. Based on the discussions with VISL, it is proposed to allocate the land for the CFS/Warehousing area at the eastern end of the Port Access road in the VISL owned land of approximately 20ha.

Following describes key functional facilities to be incorporated in the proposed CFS/Warehousing area:

a) Most modern facility with paved yard
b) Office building for customs, staff and user agencies with basic amenities
c) Warehousing with separation for Import / export / bonded goods / confiscated goods / hazardous cargo
d) Basic fire fighting arrangements
e) Gate complex with separate entry and exit
f) Adequate parking facility
g) Access roads to the facility and service roads within the facility
h) Boundary wall to the satisfaction of the customs commissioner
i) Electronic weighbridge
j) EDI linkage for customs and users

In future, if additional CFS/Warehousing facilities are needed, they can be provided at the Southern Eastern land parcel owned by VISL – in the range of 40ha.

### 4.14.2 Commercial Development Facilities

As a long term strategy, port based industrial units will be housed over an additional area beyond the port complex. These functional units will avail the port infrastructure facility thereby generating additional cargo for the port and vice versa. As part of the port development, VISL may consider providing the following units for commercialising and business support to the port activities:

- Warehousing services – Transhipment terminal, tank farms, Warehouses
- International bunkering terminal
- Engineering activities – Container repair and reconditioning, ship repair
- Processing and repacking units
- Tourism related services such as hotels, resorts, excursion facilities, tours and travel services, and providing ayurvedic medical spas and treatments (for which Kerala is known worldwide).
- Commercial and Institutional facilities
- Industrial units comprising of automobile, light engineering, apparel and readymade garments
- Social infrastructure - Educational, sports, hospitals, parks
- Integrated industrial township and residential complexes

The port Master Plan provides due consideration to the above and relevant land parcels from VISL owned land have been identified.

### 4.14.3 Residential Requirement for Staff and Social Infrastructure

A residential colony is proposed for the administrative and operational personnel of the Vizhinjam Port. The housing accommodation would depend upon the deployment of staff at the port and would need to be augmented over the master plan horizon. In addition to the residential colony other social infrastructure such as primary school, hospital, convenient shopping centers, play grounds etc. need to be provided. The physical infrastructure comprising of a sewage treatment plant, water distribution system, roads, power and water supply would also need to be provided. Based on the assessment of the port personnel over the master plan horizon, it is assessed that an area of 4ha would be required in the Phase-1 increasing to about 11ha over the master plan horizon for the port housing and social infrastructure. The detailed estimation of the residential requirements is as shown in the table below.

Table 4-16 Residential Requirements for Staff and Social Infrastructure

| **Category of Housing Units** | | | | **Estimated Port Personnel (Number of Housing Units) Over Master Plan Horizon** | | |
|---|---|---|---|---|---|---|
| **S** | **Category of Housing Units** | **Plinth Area ($m^2$)** | **Floors** | **Phase-1** | **Phase-2** | **Phase-3** |
| 1 | Type - I | 48.75 | Ground + 8, 4 houses per floor | 250 | 488 | 651 |
| 2 | Type - II | 52.95 | Ground + 8, 4 houses per floor | 307 | 599 | 799 |
| 3 | Type - III | 72.4 | Ground + 8, 4 houses per floor | 70 | 137 | 182 |
| 4 | Type - IV | 101.1 | Ground + 2, 2 houses per floor | 5 | 10 | 13 |
| 5 | Type -V | 196.3 | Duplex unit with Garage and Servant quarters | 1 | 2 | 3 |
| **Housing** | | | | | | |
| **S. No.** | **Category of Housing Units** | **Plinth Area ($m^2$)** | **Floors** | **Built up Area for Type of Houses ($m^2$)** | | |
| 1 | Type - I | 48.75 | Ground + 8, 4 houses per floor | 12,188 | 23,797 | 31,730 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2 | Type - II | 52.95 | Ground + 8, 4 houses per floor | 16,256 | 31,741 | 42,321 |
| 3 | Type - III | 72.4 | Ground + 8, 4 houses per floor | 5,068 | 9,896 | 13,194 |
| 4 | Type - IV | 101.1 | Ground + 2, 2 houses per floor | 506 | 987 | 1,316 |
| 5 | Type -V | 196.3 | Duplex unit with Garage and Servant quarters | 196 | 383 | 511 |
| **Total Built-up Area Of Houses** | | | | **34,213** | **66,804** | **89,073** |

| **Housing** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Category of housing units** | | | | **Number of towers required** | | | | **Land for each type** | | |
| | **Category of Housing Units** | **Plinth Area ($m^2$)** | **Floors** | **Phase 1** | **Phase 2** | **Phase 3** | **Area of each floor** | **Phase 1** | **Phase 2** | **Phase 3** |
| 1 | Type I | 48.75 | 8 floors with 4 units in a floor | 8 | 15 | 20 | 195 | 1,524 | 2,975 | 3,966 |
| 2 | Type II | 52.95 | 8 floors with 4 units in a floor | 10 | 19 | 25 | 212 | 2,032 | 3,968 | 5,290 |
| 3 | Type III | 72.4 | 8 floors with 4 units in a floor | 2 | 4 | 6 | 290 | 634 | 1,237 | 1,649 |
| 4 | Type IV | 101.1 | 2 floors with 2units in a floor | 2 | 3 | 4 | 202 | 404 | 607 | 809 |
| 5 | Type V | 196.3 | Duplex unit with garage & servant quarters | 1 | 2 | 3 | 196 | 196 | 393 | 589 |
| **Total Land Area (sqm)=** | | | | | | | | **4,790** | **9,178** | **12,303** |

| **Primary School (nursery to 5th)** | **Note** | **Built up Area of School ($m^2$)** | | | |
|---|---|---|---|---|---|
| Number of students per standard | Approximately 80 to 100 children per 100 residential units. Assumed an average of 15 children in one Class per hundred housing units & 2.67 $m^2$ /student | 95 | 185 | 247 | No. |
| Area Required for Class Rooms = | | 1,521 | 2,970 | 3,960 | $m^2$ |
| Other Proposed Area = | In Addition to the class room, one activity room, principal room, teaching staff room toilets and store has been proposed (50% over the class room) | 761 | 1,485 | 1,980 | $m^2$ |
| **Total School Area** | | **2,282** | **4,455** | **5,940** | **$m^2$** |

| Shopping Centre | Note | Built up Area of Shopping Centers ($m^2$) | | | |
|---|---|---|---|---|---|
| No. of shopping center assumed for given staff = | One shopping center for 100 units with 8 shops is assumed to have a area = 150 $m^2$ | **6** | **12** | **16** | No. |
| **Total Shopping center Area =** | | **950** | **1,854** | **2,472** | **$m^2$** |

| Hospital | Note | Built up Area of Hospital ($m^2$) | | | |
|---|---|---|---|---|---|
| No. of Bed assumed = | For 100 unit 2 bed general hospital has considered with the area of 225 $m^2$ | 13 | 25 | 33 | No. |
| **Total Hospital Area =** | | **1,424** | **2,781** | **3,708** | **$m^2$** |

| | | | | | |
|---|---|---|---|---|---|
| **Petrol filling Station** | Petrol filling Station with service Bay (37 X 31 M) | 1 | 1 | 2 | No. |
| | | **1147** | **1147** | **2294** | $m^2$ |

| | | | | |
|---|---|---|---|---|
| **Total Built up Space =** | **10,592** | **19,416** | **26,718** | $m^2$ |
| **Township area after considering open space, roads and Parking =** | **42,368** | **77,662** | **1,06,870** | **$m^2$** |
| | **4** | **8** | **11** | **Ha** |

This colony should be located close to the port but outside the port limits. The suitable location has been identified by VISL and is shown in the land use section later.

## 4.15 Other Users

As per information provided by VISL, VISL has got proposals from various organizations for providing land parcels within VISL premises. The suitable land parcels requested under different proposals have different requirement as land parcels having water front and outside CRZ etc. Details of proposals are mentioned as under.

**Indian Oil Corporation Limited (IOCL)**

VISL has received the letter from IOCL dated on 8th December for the requirement of land for petroleum storage depot at Vizhinjam. IOCL would like to have a suitable land parcel for setting up a storage facility for petroleum products at Trivandrum. IOCL has proposed to have a storage facility for bunker fuels for the vessels calling at Port of Vizhinjam along with the storage of other petroleum products for supplies to Trivandrum area. IOCL has requested VISL to provide 40 to 50 acres of land at VISL with access to Railway line. The requested land should have good road approach for movement of heavy vehicles and there may not be high tension power lines and canals/natural streams passing through the land as IOCL has to setup storage tanks and allied infrastructure.

Because of the scarcity of land suitable for a tank farm development inside the port, this request has not been accommodated as per IOCL's request. However, a provision for a liquid berth and bunker fuel storage has been made in the master plan to cater to the organic need of bunkering facilities for servicing the transshipment vessels.

**Cochin Shipyard Limited**

As per attachment named The Location Study Report for New Greenfield shipyard submitted by Cochin Shipyard Limited (CSL) of letter dated 27th December, 2011 from Secretary to Government, Fisheries & Port Department, Government of Kerala; Port of Vizhinjam has potential for a shipyard. Minimum requirements for the Greenfield Shipyard are (a) land parcel of approximately 100 acres with about 1.5 Km of waterfront and (b) basic infrastructure like road, rail, electricity, water etc to be made up to side by the State Government. The assessment for the three sites Azhikkal, Poovar and Vizhinjam was carried out for a Greenfield Shipyard. CSL has shown interest in establishing a ship repair facility at Vizhinjam as a good business proposition due to the following factors:

- Proximity to international shipping route and Vizhinjam transshipment container terminal
- Water depth up to 20m is available about 700m from shore
- Dredging requirement is minimum
- Ship repair and ship building being labour intensive industry, it creates high employment potential
- Possibility of development of ancillaries

Schematic layout for ship repair yard prepared by CSL is shown in Figure 4-5 .

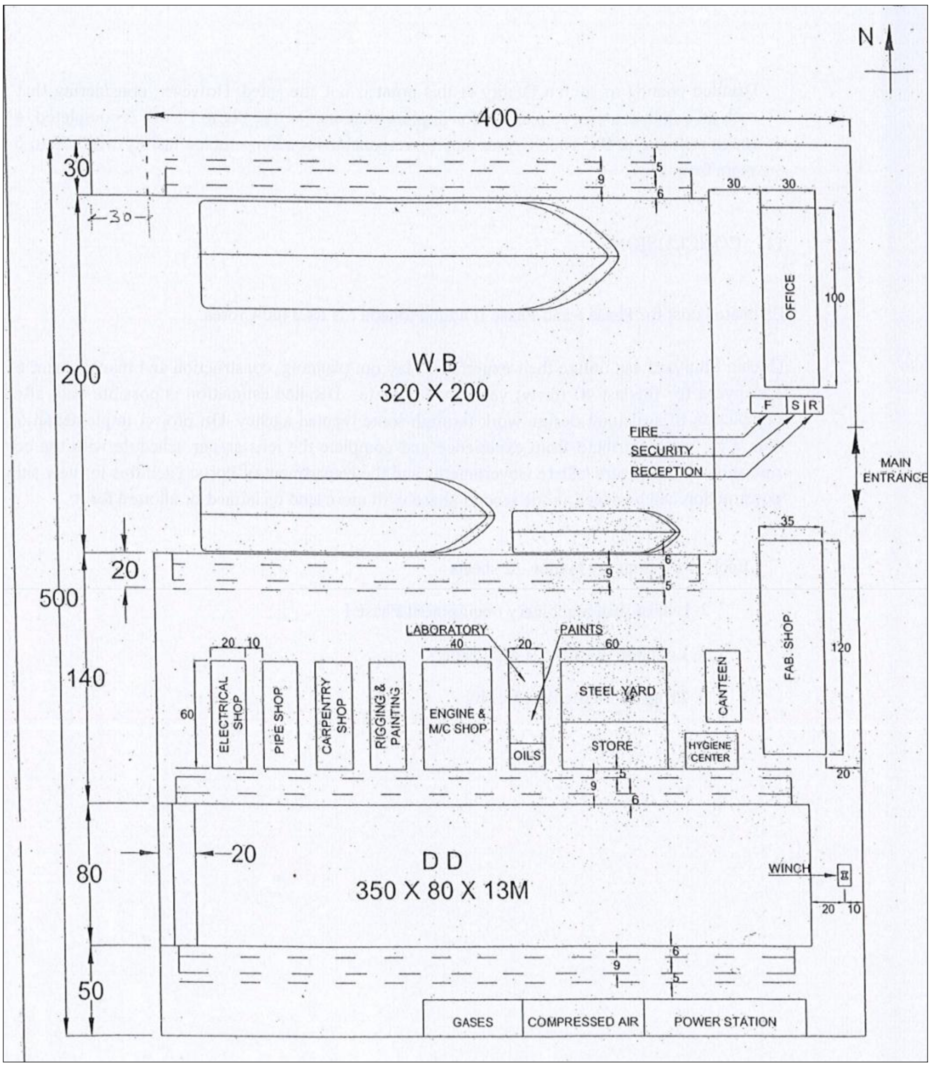



Figure 4-5 Schematic layout of ship repair yard by CSL

In the current master plan, a shipyard facility is not shown due to the lack of required water front area and back-up land for proper establishment of the shipyard facility. However, master plan provides a provision for such a facility if the forecasted container transshipment business is lower than forecasted. In that case, the proposed shipyard/ship repair facility can be planned in the area earmarked for Phase-3 container development, plus the additional area south of it.

## 4.16 Utilities

### 4.16.1 General

This section deals with the supporting infrastructure requirements for the port master plan. The main infrastructure includes the following components.

- Water Supply System
- Storm Water Drainage System
- Sewerage/Waste Water System
- Power/Electrical Supply System
- Telecommunication Network System
- Piped Gas/Fuel Supply System
- Solid Waste Management
- Fuel Bunkering System
- Fire Fighting System
- Environment Management System (Pollution Control Measures)

These basic infrastructures and supporting amenities would play very important role from the day one of port operations. Considering these would further increase with the expansion plan of the port, it is important to plan these basic infrastructure and supporting amenities during the master planning process. The advance planning of supporting infrastructure with their future demand would facilitate coordination between working agencies on a particular sector including their expansion phases. The advance planning of supporting infrastructure would also help in procuring necessary resource and manage them for efficient output.

### 4.16.2 Water Supply System

Total water demand is broadly classified in the following categories:

- Potable water for consumption of port personnel
- Water for fire fighting
- Potable water for passengers using Cruise terminal
- Other uses like gardening etc.

Based on the cargo and passenger handling requirements of berths over the master plan horizon, it is expected that the water demand at the port would be about 1.5 million liters per day in the year 2044. The exact water demand shall be governed by the type of terminals provided for the master plan horizon. Based on this, suitable size of underground and overhead storage tanks will be provided at appropriate places. The water supply system connecting to the port is already under construction from Overhead tank and ground level sump near Panavilacode. The water supply system within the port will be designed for optimum services to all the port areas such cruise area, container area, housing areas etc.

### 4.16.3 Storm Water Drainage System

Storm Water Drainage will be through a system of underground covered drains provided to discharge the collected runoff from port surfaces. The main storm water drains will run parallel to the port roads and its branches will serve to port components as container yard, wharf area, supporting complexes etc.

An oil /sediment in-line unit in areas such as reefer wash-down area is recommended to provide basic treatment to the storm water before discharging to the sea. A gravity drainage system with outfalls would be required for the proposed port. The system will need to be designed for catering to a suitable storm event. Rainwater harvesting is also proposed at the port site.

### 4.16.4 Sewerage/Waste Water System

Suitable drainage arrangement will required to be provided in the port area. These drains in turn will be connected to Sewage Treatment Plant (STP). The amount of sewage water will be approximately 80% of the total water supply, so it will be of 1.2 million liters per day in the year 2044. It is assumed that ships will not be allowed to discharge their sewage within the port boundary. As per industry convention, the ships have an STP on board. In the initial phase of development, no STP has been planned in the port complex.

The sewerage system is limited to the areas wherever office buildings, canteens, and other operational buildings are constructed. For the isolated buildings where the quantity is negligible, it is proposed to construct septic tanks connected to soak pits for disposal. In the later phase, it is proposed to provide an STP of 200 KLD capacity in the utility area north of the gate complex. The treated sewage fulfilling discharge norms as per the guidelines shall be discharged to the main drainage network. The sludge from the treatment plant will be processed and converted into Biomass used as manure.

### 4.16.5 Power/Electrical Supply System

The required electrical system for the project will consist of:

- The incoming electrical supply at 11 kV.
- A substation containing transformers, switchboards, control equipment, etc. to allow the distribution of electrical supply to the various parts of the site at the required voltage levels.
- Monitoring and control systems.
- Power cabling and fibre optic communications from the substation to the quay cranes at 11 kV.
- Power cabling from the substation to the reefer area. The cables should be run at medium tension with step-down transformers installed beneath reefer platforms in the reefer areas.
- Provision of power cabling to the buildings and gate complex.
- Provision of power cabling to terminal light towers.

The port will be supplied through a 220KV main receiving station located near the truck terminal through dedicated 11kV lines. The proposed new container terminal development will contain all the features of a modern first class terminal, and as such will require a reliable power supply system. Consideration of future electrical requirements of the terminal shall also be taken into account, and all necessary provisions shall be made in the design and installation of the electrical system, to take account of future requirements. This applies to switchboards, transformers, underground conduits and the likeThe following energy requirements have been considered when defining the electrical supply requirements.

#### *4.16.5.1 High Voltage Supply*

It is understood that the supply voltage to the site will be at 11kV. It is envisaged that High Voltage (HV) supply at 11 kV will be provided from the nearest substation to each installation with Ring Main System to have better redundancy. The HV power requirements for the container yard and terminal support facilities include:

- Power Supply to Quay cranes
- Power Supply to future eRTGs for yard operations
- Power Supply to future RMGCs for rail operations

#### *4.16.5.2 Low Voltage Supply*

It is envisaged that Low Voltage (LV) supply at 415V will be provided from the substation to each installation. LV requirements for the wharf and access include lighting, the operation of the fire pump house and miscellaneous LV power services. The LV power requirements for the container yard and terminal support facilities include:

- Reefer Points,
- Yard Lighting,
- Miscellaneous LV power Requirements, and
- Power Supply to the Gate Complex and Terminal Buildings.

#### 4.16.5.3 Power Cables/Controls and Power Factor Improvement

Appropriate Power Cables for the voltages of 11kV and other service requirements with sufficient current carrying capacity for the power demands of power transformers; with due consideration of the effect of position/installation of cables and other ambient de-rating factors will be provided.

The 220 kV main receiving station as well as 11 kV substation at the port; will be controlled through a dedicated large screen Video Display Unit (VDU) in the main receiving station with an additional VDU in the plant control room.

Suitable rated capacitors or capacitor banks will be provided to improve and maintain the system power factor over and above 0.95 with Automatic Power Factor Correction (APFC) relay system to take care of the basic load as well as to compensate peak loads.

#### 4.16.5.4 Emergency Power Requirements

The diesel generator in the substation as well as installed at different locations shall have sufficient capacity to provide power for the following functions in the event of an interruption to power from the supply authority:

- The security, fire fighting and communication system.
- 25% of lighting in the Administration Building.
- 25% of lighting in the Workshop Offices.
- Computers of key staff as nominated by the Client.
- Computer system main server and back-up server UPS.
- All gates functions.
- All Operations Team functions.
- The slow operation of 1 or 2 cranes acting simultaneously, for the purpose of installing back the vessel hatch covers.
- 25% of terminal floodlighting.
- Compact Substations (CSS) of Reefer Plug Points.

In addition, appropriate electrical connections shall be provided at the reefer area to allow the RTGs, acting as electrical generators, to supply power to all reefers stacked at the terminal.

#### 4.16.5.5 Terminal Area Lighting

The container terminal area lighting will be provided with suitable 30 or 40 Mtr. high light masts with compliance of the required average lighting levels at the different areas as follows:

- Substation/Control Room: 300 lux
- Reefer Platforms: 100 lux
- Wharf/Jetty: 50 lux
- Yard Area: 50 lux
- Gates Area: 50 lux
- Workshop Perimeter: 50 lux
- Car Parking/Road: 20 lux

In the lighting calculations, an allowance shall be made for 20% deterioration in the performance of each luminaire over time. This shall be taken into account when final illumination measurements are taken, with lux levels on site to be 20% higher than the design levels nominated above. Each Terminal Yard light tower shall have separate circuits – a Main Lighting Circuit and an Emergency Lighting Circuit. Each light tower shall have a lightning rod at its top and have a separate lightning conductor connected to an earth pocket.

Based on the requirements of berths over the Master plan horizon, it is expected that the power demand at the port shall be about 16 MVA in the year 2044. The exact requirement will have to be governed by the facilities proposed mainly in terms of handling system. The suitable electrical distribution system in the port area will have to be accordingly planned.

### 4.16.6 Telecommunication Network System

Telecommunication Network System will be planned in close association with the relevant service provider. A standalone system should be considered in order to integrate all the services which would serve as global network management system. After ascertaining the requirements, planning of distribution network up to end users/areas would be done including type and capacity of exchange, type of network media for communication system (copper /fiber optics), etc. The system should be modular to suit both the expansion and services. Main Distribution System frame should be located and underground optical fiber cable routing, network cables, network connection should be studied by the service provider till the end consumer/area. Control panel room location should be identified based on the master plan and suitable network system connecting to all the common area should be provided. Both the normal condition and emergency condition action plan should be considered based on the requirement.

The port has the following functional requirements for communications:

- Access Control System (biometric, proximity, turnstile and barriers)
- Intruder Detection System - motion or ground detection
- Telephone Network (Emergency)
- UHF/Tetra Mobile Radio System - for reliable communications
- Vehicle Monitoring System (Automatic Number Plate Recognition and Optical Character Recognition) if needed
- Crane Monitoring cable connected to Crane Maintenance Facility
- Container Scanning Capability (Gamma-Ray, X-Ray etc.)
- IT systems for:
  - Ship-to-shore loading and discharge control
  - Yard planning, gate delivery and receipt control•
  - Ship planning and dispatch including a vessel stowage planning module
  - Electronic Data Interchange (EDI) abilities
  - Radio Data Transfer (RDT) abilities
  - Payment status and service billing
  - Management information reports and statistics
  - Linking to shipping lines/

### 4.16.7 Solid Waste Management System

The solid waste generation will be basically from 2 sources – cargo handling and the garbage/ human waste. The cargo envisaged at the port is primarily container cargo. The garbage and human waste generation will be minimal and is proposed to be disposed off using the normal measures (Vermin-compost, plastic separation and granuling, paper recycling etc.). The garbage will be carried through covered trucks and disposed at the designated dumping grounds in the locality. Two Incinerators will be required in Vizhinjam Port to dispose the solid waste.

### 4.16.8 Fuel Bunkering System

As Vizhinjam port is developing as container transshipment port the fuel bunkering facilities will be required for fueling of vessels. The bunkering tank farm will also serve fuel to port crafts and port vehicles/equipments. Fuel bunkering facility is not planned for Phase-1, but it will be a part of the master plan. It is proposed that in Phase-1, vessels are supplied bunker fuel through trucks bringing the fuel from outside the terminal and directly feeding the vessels.

Estimated throughput of 1 million tons per year will mainly require the space for bunker fuel storage, fuel hydrant system from tanks to berths, and unloading berth. It is estimated that approximately 100,000 tons of static storage capacity will be able to meet the annual throughput needs. These tanks may be supplied by the unloading berth or using rail. Based on various types of tanks, provision for 2ha land is provided in the port master plan in the future expansion area east of rail tracks and north of gate complex. The vessels will be supplied bunker fuel from fuel tanks through the fuel hydrants on the berth using trucks.

### 4.16.9 Fire Fighting System

A centralized fire station will be provided for attending to all calls which will house 2 mobile fire tenders, with one snorkel-attached fire tender. In addition, separate fire fighting systems are proposed at the various terminals. The Fire Hydrant System shall be designed to give adequate fire protection for the facility based on Indian Standard or equivalent International Standard and shall conform to the provisions of the Tariff Advisory Committee's fire protection Manual.

The fire hydrant system at the container terminal will be seawater-based. This fire-fighting system shall consist of an underground ring main with spur lines to cover the facilities in the yard and other port areas. Hydrants shall be provided at 60m spacing. The main fire fighting pumps will be provided in the pump house located at the northern end of the berth. In addition jockey pumps will be provided to maintain the minimum pressure of 3.5 $kg/cm^2$ in the remotest hydrant.

### 4.16.10 Environment Management System (Pollution Control Measures)

The pollution control measure in the form of suitable facilities for the reception and treatment of oily wastes from the vessels calling at the port shall be provided as per the MARPOL regulations. Container booms, skimmer, dispersant sprayer, oil absorbing booms, vulcanizing machine are some of the equipments that would be deployed to control the pollution at berths.

### 4.16.11 Security

Security measures at the port will be provided to perform the primary functions of deterrence, detection, assessment, delay and response by security personnel. Detection of threats should occur as far from the port facilities as is reasonably possible. To further enhance the overall security, the Vizhinjam Port physical security system will employ protection-in-depth. Protection-in-depth means attackers will need to avoid or defeat a number of protective devices in sequence to reach their target.

Fencing will be placed around the port to establish a physical barrier to entry of persons, vehicles, and vessels into the port except through designated entry points (i.e. gates). Surveillance cameras will be mounted along all boundaries between the secure port area and land or sea. Access controls will be provided to help prevent entry of unauthorized vehicles and personnel into the port and detect any weapons, explosives and other contraband through a system of screening, and/or searching all trucks, cars and persons including inspection of carried bags.

Access controls and inspection procedures will also be implemented to screen and/or inspect all inbound and outbound containers passing through the port. In order to achieve this level of coverage, high speed scanning equipment will be used at the gate in combination with physical inspection techniques.

### 4.16.12 Health and Safety

The value of Health and Safety policies, plans and systems is well understood and common business practice. VISL and the potential private port operator will be developing H&S plans for Vizhinjam Port in relation to port operations. It is envisaged that a risk register will be prepared following the methodology and definitions given in SP125 Control of Risk : A Guide to the Systematic Management of Risk From Construction published by the Construction Industry Research and Information Association (CIRIA) of the UK or similar document.

It is stressed that the risk register should be reviewed and revised at regular intervals to ensure that new circumstances have not led to new hazards. As far as possible, contractors and the port operator should be involved in both the identification and assessment of hazards with reviews carried out at regular intervals. All parties should make safety training a core part of their corporate culture and ensure as far as possible that this culture extends right through their organizations.

## 4.17 Port Operation Support Systems

### 4.17.1 Harbour Crafts

The Harbour Crafts envisaged for the Phase-1 and Master Plan Development of Vizhinjam Port is as below:

Table 4-17 Harbour Crafts Requirement

| S. No | Port Crafts | Unit | Quantity | |
|---|---|---|---|---|
| | | | Phase-1 | Master Plan |
| 1. | Tugs | No. | 5 | 8 |
| 2. | Mooring Launch | No. | 3 | 4 |
| 3. | Pilot Launch | No. | 1 | 2 |

## 4.18 Other facilities

### 4.18.1 Construction Logistic Centre (CLC)

CLC is required to be provided very near to the port as it will provide the logistics support to the port during the project phase and also provide temporary logistics service during initial phase of the port operations. Facilities such as casting yard, crushers, batching plant etc. will be located here. CLC has been located towards the west end of the main port access road just before entering through the security guard booths and to the north of it. Figure 4.6 shows a schematic of areas that can be used for CLC (area 6, 15, 20 and 26).

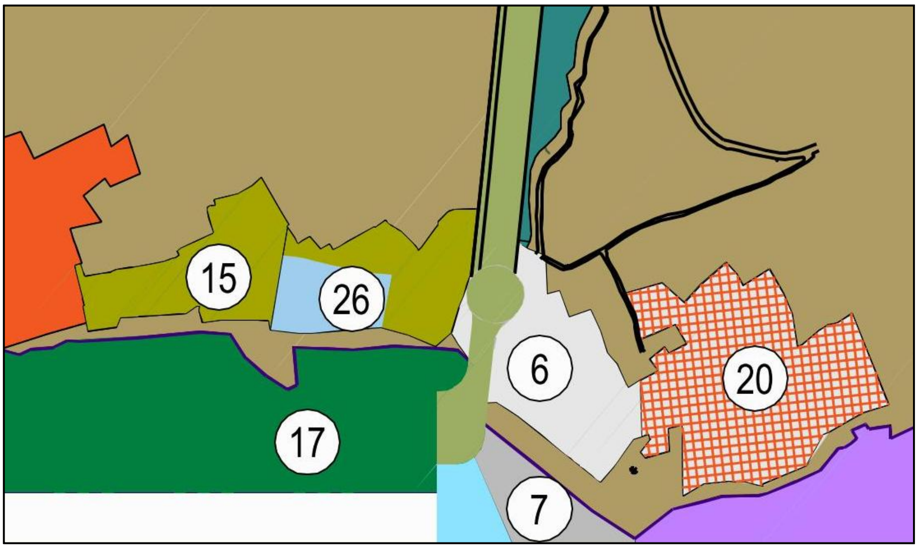



Figure 4-6 Proposed Location of Construction Logistics Center (CLC)

# 5 Port Master Plan

## 5.1 Overview

The Port Master Plan development process initiated with the initial inputs taken from IFC/ Royal Haskoning Report (Vizhinjam Port PPP Project, Preliminary Project Plan, 2010). Royal Haskoning considered different layouts of approach channel (i.e. South-East channel, South-West channel & North-West Channel) and different harbor layouts. Different layouts were then analyzed by RH as explained in Section 3 out of which a South-East Channel alignment was chosen. Royal Haskoning came up with the port master plan as shown in Figure 5.1 below, which is used as the base plan for the further development and refinement of the Port Master Plan.

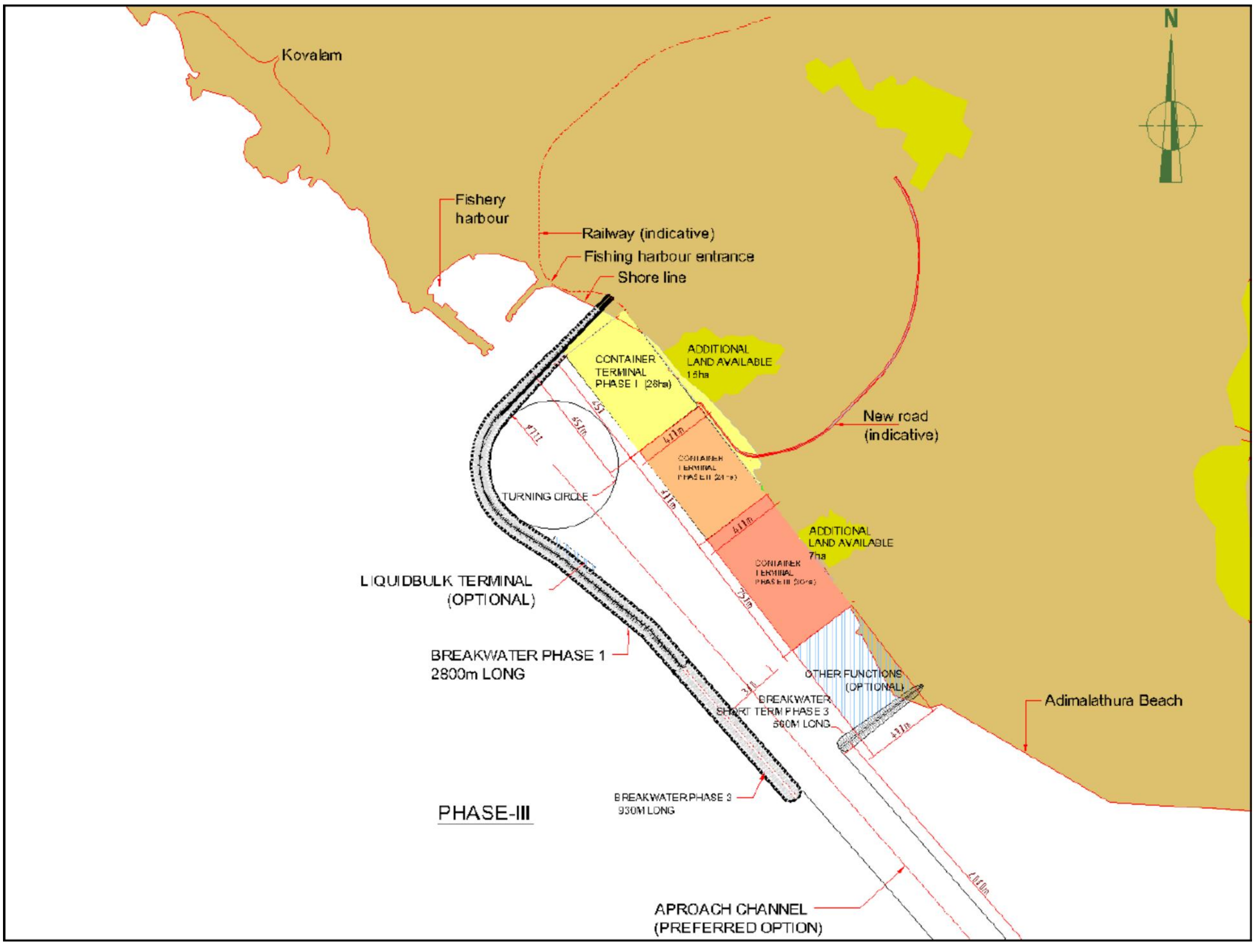



Figure 5-1 Vizhinjam Port Master Plan Layout by RH
*[Source: Royal Haskoning Report Vizhinjam Port PPP Project, Preliminary Project Plan, 2010]*

## 5.2 Port Master Plan Alternatives

### 5.2.1 General

AECOM has prepared the port master plan based on the recommended RH port master plan layout, VISL requirements and market study (anticipated container traffic volumes) carried out by DREWRY. The Port Master Plan layout was further developed using the RH layout by incorporating additional critical elements of the port planning such as layout of berthing facilities (for container, cruise ships, port crafts etc), fishery berth for social and economic well being of the region, road & rail connectivity, and minimizing the social and environmental impacts of the port.

Since rail connectivity is a vital aspect of the development of container terminal, various alternatives of rail road connectivity were considered in order to arrive at the most optimum alignment to the port for the smooth operations and minimal hindrance to the local community.

### 5.2.2 Master Plan Development Options

The Master Plan for Vizhinjam Port has been developed considering the master plan layout prepared by RH as the base plan for further detailing and refinement. The Master Plan has been based on the base case scenario with provision to meet high case also, i.e., even if the base case forecasts are realized in 2044, there will be room for expansion beyond 2044.

This section details the Master Plan development options considered. These options have been evolved with due consideration to various parameters like environmental aspects, geotechnical data, navigational aspects, adequacy of back up area, operational efficiency, the number of berths along the water area and development phasing strategy, which has been discussed under each of these options herein.

All these layouts have been developed based on the following primary functional requirements over the master plan horizon

- 5 container berths to service design vessels
- Container yard area to handle the berth throughput
- Fishery Berths
- Liquid Bunker Fuel Berth
- Rail terminal
- Gate complex
- Cruise/ Multipurpose Terminal

#### *5.2.2.1 Master Plan Alternative 1*

The container terminal is planned with 5 berths of a total length of 2,000m (see Figure 5-2). The container quay arrangement is provided such that the backup area of about 600m width is available to accommodate the storage for the containers, approach corridors, rail yard and port admin requirements. This Master Plan alternative has the provision for additional berthing space of approximately 400m east of the development either for containers/ multipurpose /cruise terminal as per the traffic realization and requirements. It is important that the channel be wide enough to allow:

- ships to turn at any point with a safe clearance from ships moored at the berths
- arriving and departing ships to pass each other within the length of the berth in the port basin.

The scheme comprises a large area of confined water with the long breakwater arrangement at the north, an inner south breakwater to cater to Phase-1 & 2 requirements and an outer southern most breakwater to cater to the master plan (Phase-3) requirements. This option involves dismantling of the inner breakwater over the master plan horizon to maintain the contiguity of the berths and the yard. The harbour is aligned so as to avoid breakwater into deep waters and this option is developed much into the land so as to reduce the quantum of reclamation and breakwater quantity which if provided in deep waters can significantly increase the capital cost. However, this option would involve considerable amount of backup land cutting to provide the required yard and other port facilities. This kind of landside arrangement would hinder the master plan development due to presence of the temple near the inner south breakwater thereby impacting the flexibility of terminal development.

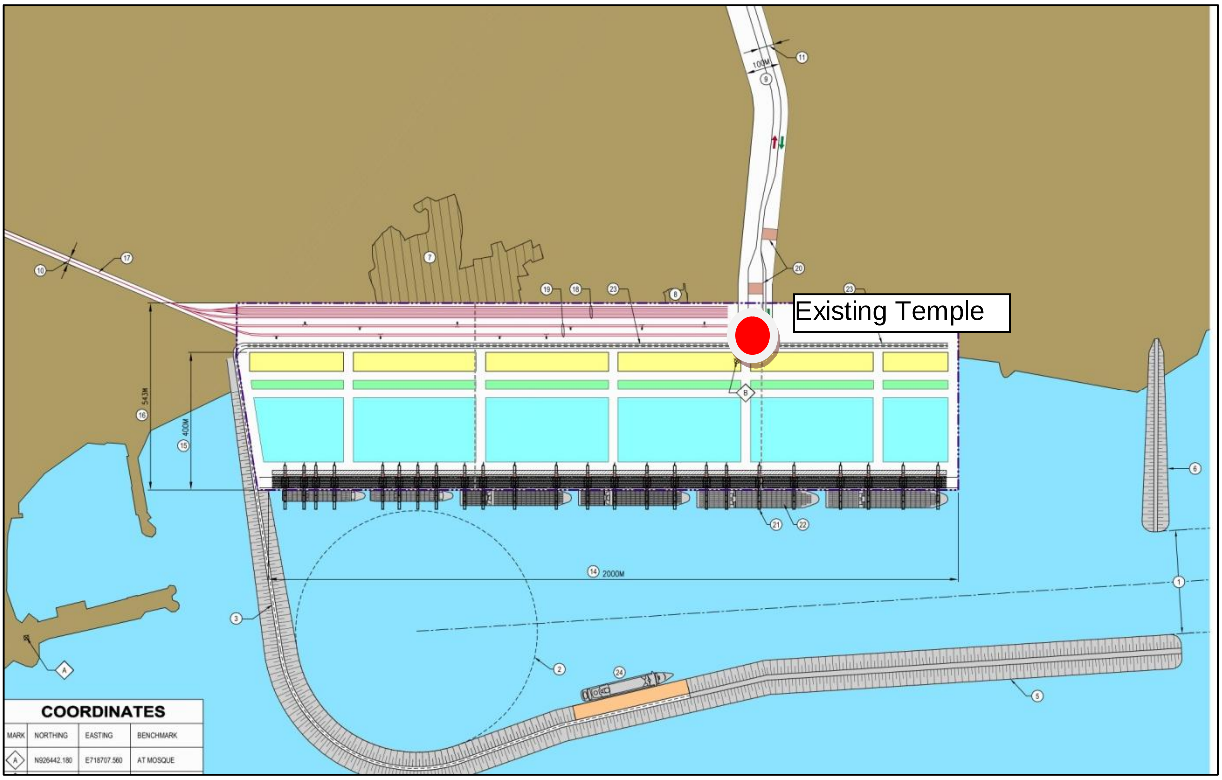



Figure 5-2 Master Plan Alternative 1

The rail connectivity is proposed from the north of the port which passes through the dense local population (Kottapuram village with greater than 450 families) and settlements. The access road to the port is from the east during the Phase-1 with the access corridor of 45m width to suffice the road capacity over the master plan horizon.

The road and rail corridors along each side take into account the need for:

- extensive rail sidings;
- a six or eight lane road outside the port boundary for access to the port ;
- internal perimeter roads to each terminal;
- corridors for power lines and infrastructure for services;

Sensitivity on rail road alignment was carried out by providing the rail road corridor from the east. However, this option was discarded based on the following issues:

- The corridor involved huge amount of land cutting for the corridor to maintain the required gradient especially for rail;
- The rail line connecting the main line involved tunneling which had direct impact on the overall project construction cost;
- The corridor was passing through the settlement areas and also the land cutting would separate the local community which is usually unacceptable for any project development.

#### *5.2.2.2 Master Plan Alternative 2*

This option (see Figure 5-3) comprises of two container terminals separated by docks at right angles to a channel and parallel to the inner south breakwater. It provides two cruise berths on either side of the inner breakwater in addition to the 3 container berths incorporated in the Phase-1 expansion, for a total of 5 container berths. This alternative has the provision for liquid bulk handling facility on the lee side on northern breakwater. The facility for the tug berth is provided at the end of the container terminal of Phase-1 expansion. However, this option does not have provision for any further expansion to cater to other cargoes.

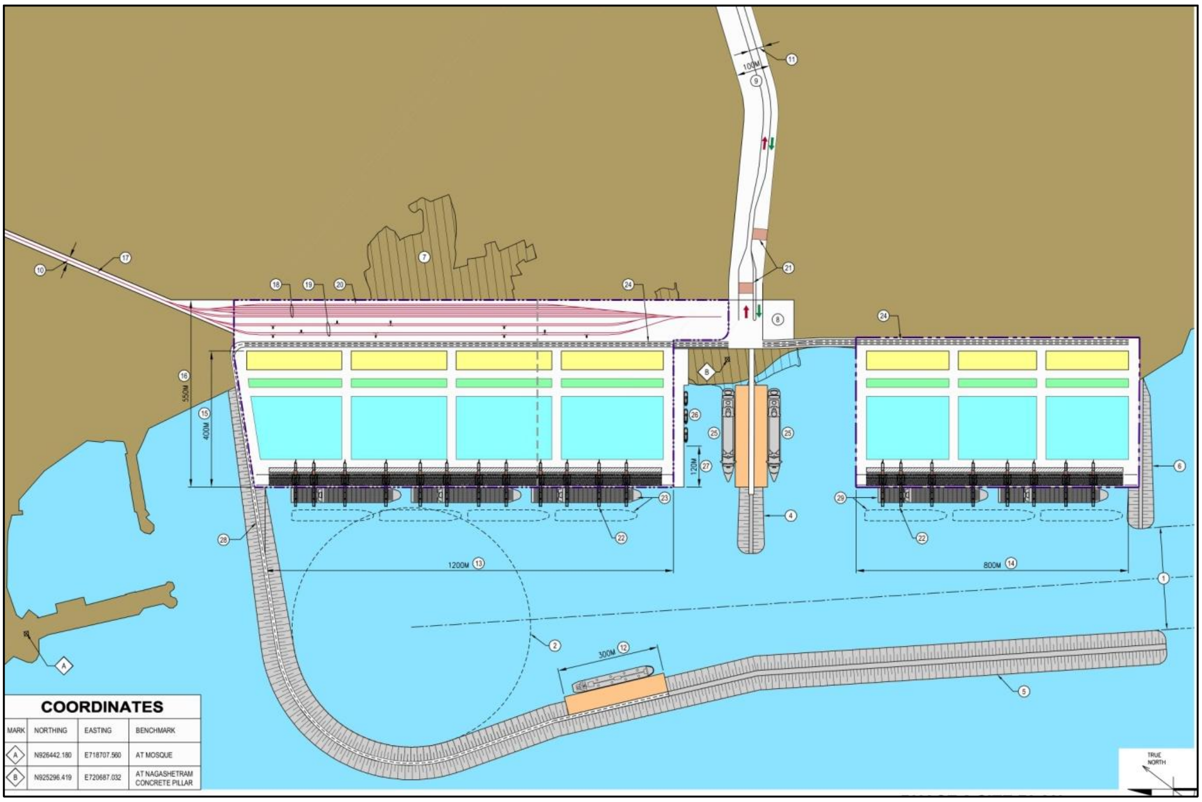



Figure 5-3 Master Plan Alternative 2

This option does not impact the temple and provides access to cruise berths directly from the VISL owned land near the temple. The intermediate breakwater to be built in Phase-1 can be utilized for the cruise berth construction by building berths (sheetpile or similar structure) using the breakwater and won't be required to be dismantled completely.

However, Alternative 2 is not as flexible in its long term development as Alternative 1, as it is divided into terminals of a pre-determined size. Navigationally it has some disadvantages in that ships turning into the cruse berths will impede ships proceeding to or from other berths.

Rail access to each terminal is relatively difficult to provide and the land usage is less efficient.

#### *5.2.2.3 Master Plan Alternative 3*

This option (see Figure 5-4) comprises a contiguous wharfage area for 5 container berths apart from 2 additional berths for cruise cum multipurpose berth, tug berth area and provision for coast guard berth to the north on the lee of the northern breakwater.

The navigation aspects are good in that ships can maneuver to all the respective berths and therefore will not interfere with other cargo operation. The approach channel is 300m wide with the turning circle of 700m dia. resulting in a wide continuous basin so that ships can turn at any position and additional maneuvering space can be provided in front of the berths.

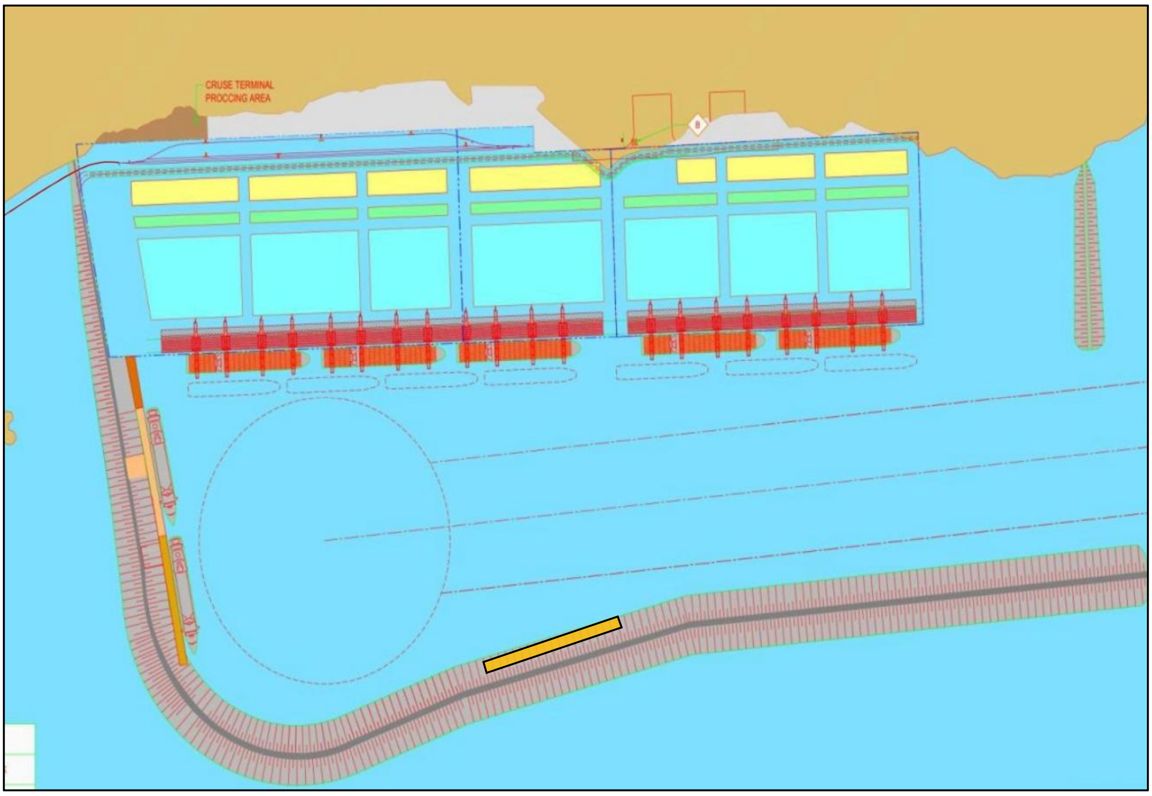



Figure 5-4 Master Plan Alternative 3

This option provides a total of about 5 container berths and 2 cruise cum multipurpose berths and provision for liquid bulk berth along the northern breakwater just south of the turning basin as and when required. This layout will suffice the year 2044 throughput demand for the base case scenario with the provision to cater the high case scenario and beyond.

Rail access to the yard will be provided on the north side of the yard. This would require the road to the container yard to be from the east side of the port so as not to interfere with the rail. This arrangement will suffice the Phase-1 development needs as well as future phase expansion requirements.

This option could be implemented without interference with the operations of Phase-1.

## 5.3 Master Plan Key Component Options

### 5.3.1 Cruise Terminal

To promote tourisms in the region, VISL has envisaged a world-class, first of its kind cruise terminal facility to be developed over the master plan horizon of the port project. The key requirements of a world-class cruise terminal is to provide a high comfort high capacity passenger entry/exit processing terminal area, car/truck lane corridor to the cruise berthing facility and berthing facility for cruise ships. This section explores the options for berthing location to be provided. The other land side requirements have been explained in Land Use Planning section.

AECOM considered two options to accommodate cruise terminal as described below. These options were used to develop the overall port master plan as discussed in the master plan options.

**Option 1 Cruise Berthing Facility along the Inner South Breakwater**

In this layout, the berthing facility is to be provided along the inner south breakwater as shown in Figure 5-5 and Figure 5-6. Cruise terminal location is highlighted in red box.

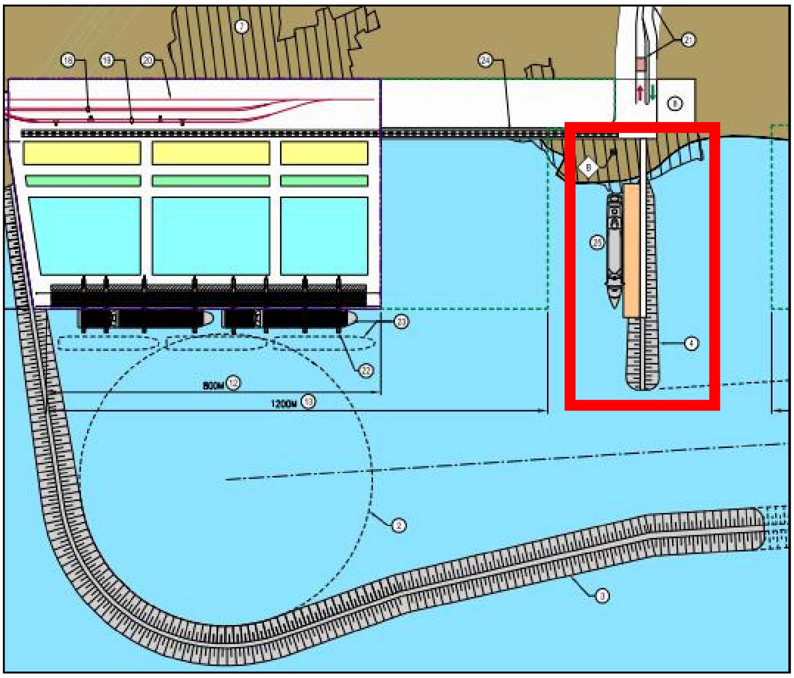


Figure 5-5 Cruise Terminal Location along Inner South Breakwater, Option 1 during Initial phase

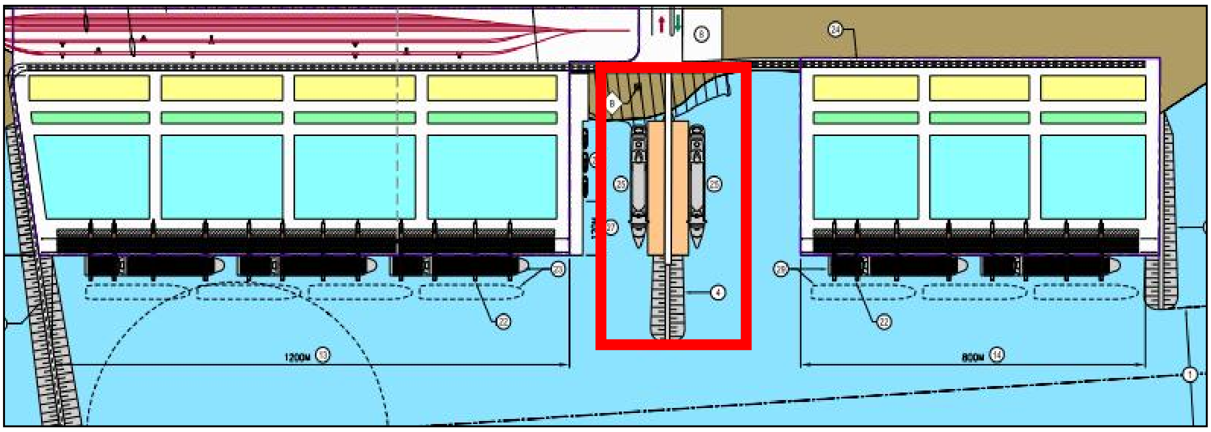


Figure 5-6 Cruise Terminal during Port Master Plan Option 1

The key advantages of this option are as below:

- Proximity of the cruise passenger processing area near to the existing temple site, creating a tourist environment without impacting the temple site;
- Isolation of the cruise terminal operations from the container terminal activities;
- Separate entry/exit corridor for the cruise passenger through the port gate.

Disadvantages:

- Once the cruise terminal facility is developed. The expansion of the container terminal facility would be discontinuous. This would lead to lower berth utilization and expansion flexibility for container operations.

**Option 2 Cruise Berthing Facility along the North Breakwater**

Another alternate layout considered was the cruise facility along the major breakwater as shown in Figure 5-7.

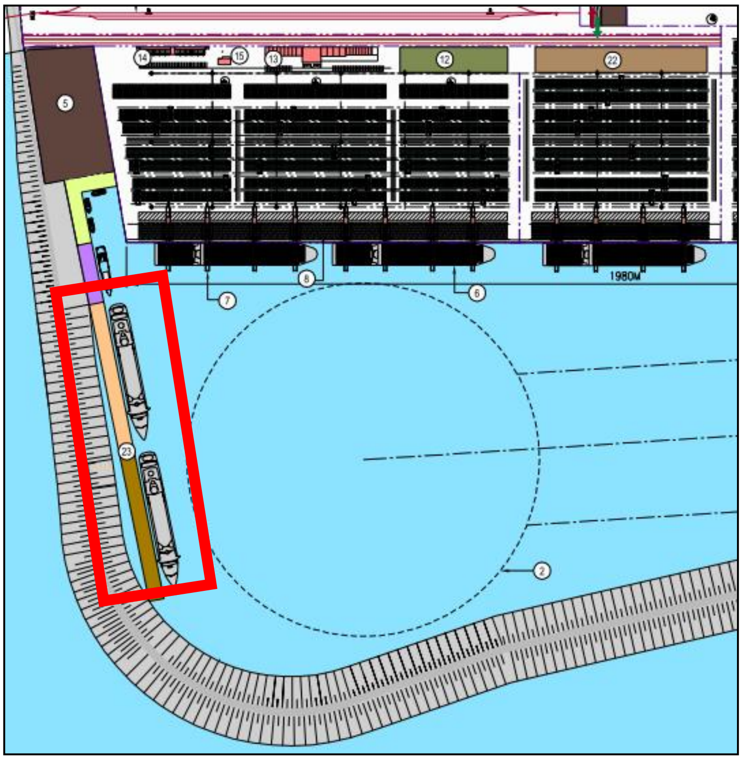


Figure 5-7 Cruise Terminal location along North Breakwater, Option 2 during Initial Phase

The key advantages of this option are as below:

- Cruise passenger processing area would be provided in the backup land allowing for a dedicated passenger recreation and processing area;
- Cruise terminal berthing operations would be isolated from container terminal berthing space;
- Phase wise expansion of the cruise terminal can be done independently as per the traffic requirement;
- One or two cruise berths can be accommodated without disturbing the container terminal facility;
- Allows for a continuous container terminal quay development unlike the previous option of discontinuous container quay.

Disadvantages:

- Need for a separate overhead corridor for passenger transport to avoid interference with container terminal rail operations & road movement.

By considering the advantages & disadvantages of the above mentioned options, Option 2 found to be suitable. The major drawback of the Option 1 is that it would lead to a discontinuous container terminal.

Option 2 offers flexibility in planning and development of cruise facility independent of container terminal development. By considering the similar constraints that of cruise facility, the proposed coast guard berth, marine craft berthing facility & provisional liquid cargo terminal are also considered along the north breakwater. Multi-purpose cargo can also be handled at the cruise berths if needed in future considering the proximity of these berths to the rail.

### 5.3.2 Hinterland Connectivity

For the efficient functioning of a port, the connectivity to the hinterland is the essential pre-requisite for the effective movement of cargo in and out of the port. As part of the Port Master Planning and Integration of the port with the hinterland, three options were considered for the port hinterland connectivity through rail and road that would impact the operations over the master plan horizon.

**Option 1: Rail connectivity to the Port site from North & Road Connectivity from East direction**

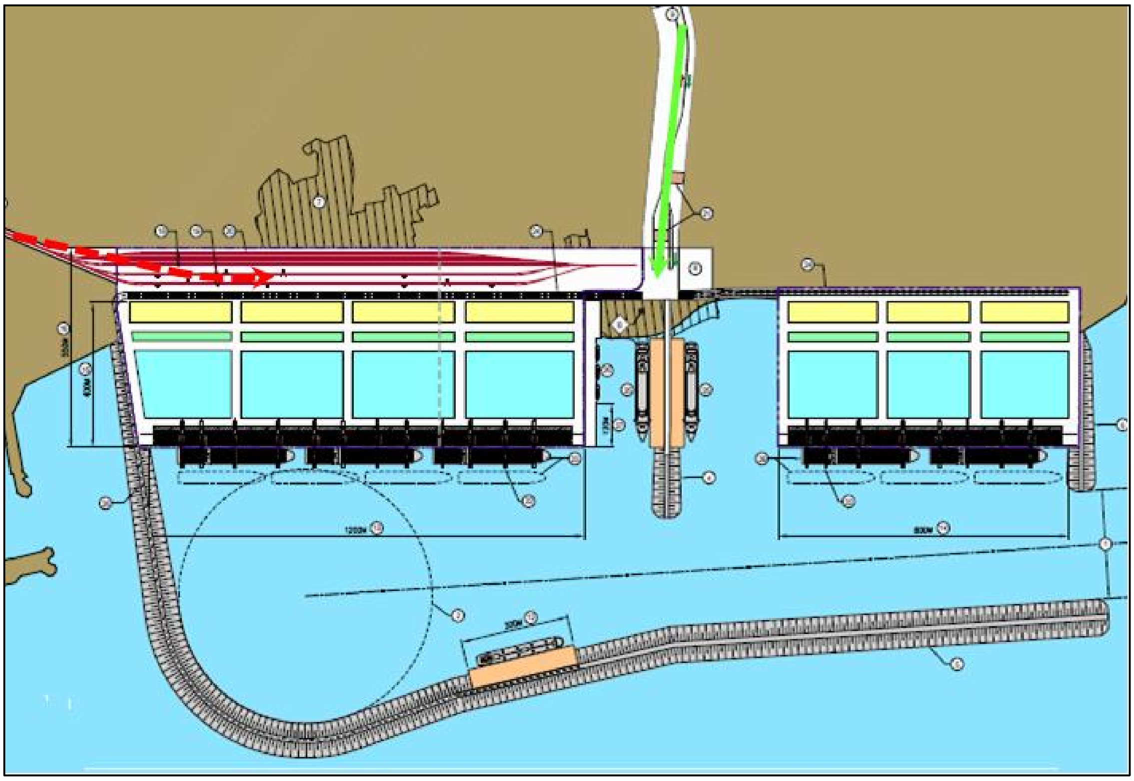


Figure 5-8 Port Layout Option 1 Rail Entry shown in RED and Road Entry shown in GREEN

In this option (Figure 5-8), the rail enters the port from the north without making any steep S curve while the road entry is from the east. This option has the following advantages:

- The proposed rail alignment would provide smooth conditions for rail operations, inside the port if it can be brought into the terminal at +5m CD, the same level as the container terminal

This option has the following disadvantages

- The rail alignment passes through the dense population settlement area (Kottappuram village with more than 450 families) resulting in large amount of resettlement thereby increasing the overall project cost and social impact of the project.
- The rail alignment involves huge amount of land cutting (greater than 45m) or tunneling to maintain the gradient level with that of the port.

**Option 2:** **Rail & Road connectivity to the port site from East direction through a single rail-Road Corridor**

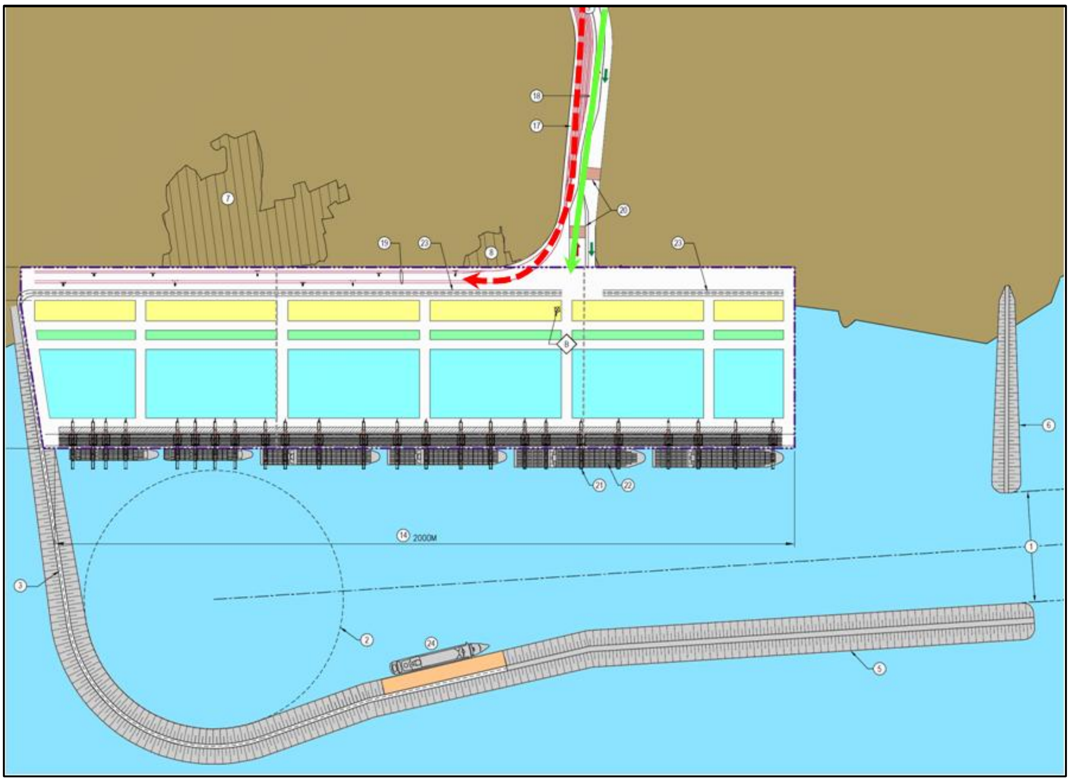


Figure 5-9 Port Layout Option 2 Rail Entry shown in RED and Road Entry shown in GREEN

In this option (Figure 5-9), the rail and road alignment enters the port from the east. This option has the following advantages:

- The proposed rail road alignment is through a single corridor which is advantageous from land procurement point of view.
- Additional rail sidings can be provided outside of the port for rail car storage.

This option has the following disadvantages

- This alignment would involve large amount of land cutting to maintain the required gradient with the ground level in the port impacting the overall cost of the project.
- Tunneling will be required for rail due to steep gradient from east to west
- Social resistance to this rail alignment as it would impact the existing settlement along the proposed alignment and will have a significant cost of land acquisition
- Connecting to the mainline network poses challenges.

**Option 3:** **Rail Entry to the yard from the North with a permissible degree of S-curve and the road connectivity from East direction.**

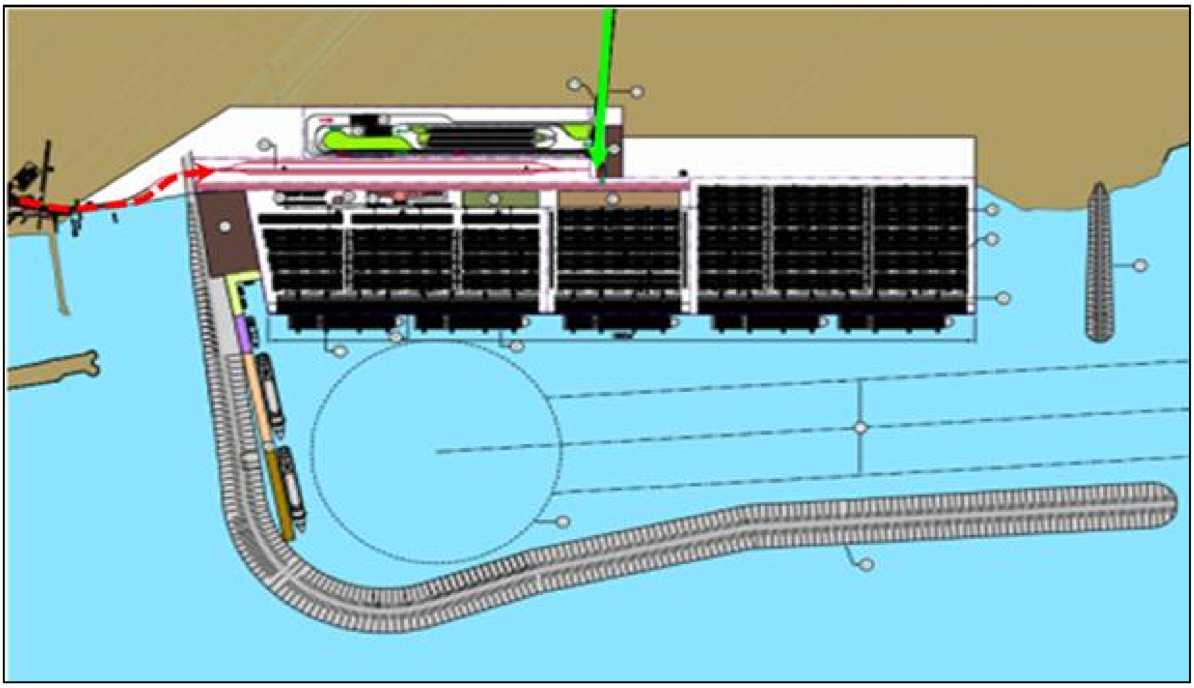


Figure 5-10 Port layout Option 3 Rail Entry shown in RED and Road entry shown in GREEN

In this option (Figure 5-10), the rail alignment is similar to that in Option 1 except that rail would enter the port with the S curve (reverse curve) through the sea while the road alignment is same as in Option 1. This option has the following advantages:

- The proposed rail alignment would be free from any interference from the local community by avoiding the settlements and thereby maintaining degree of curvature i.e. less than 8° for the smooth operations. This would be cost-effective compared to resettlement and land cutting costs of other options.

This option has the following disadvantages:

- This alignment would involve construction of an overland rail bridge to maintain the required gradient with the ground level in the port and need to cut through the northern breakwater impacting the overall cost of the project.

The parameters which have been considered while selecting port road & rail connectivity layout are as follows:

- Flexibility for Expansion
  The impact on the terminal planning process & flexibility due to rail-road connectivity has been considered. Ideally the layout should offer flexibility in planning for future expansion.

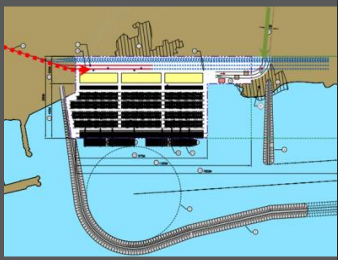
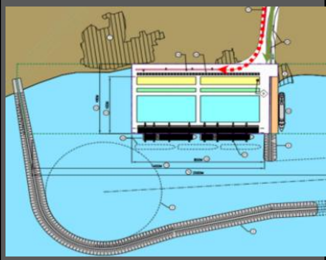
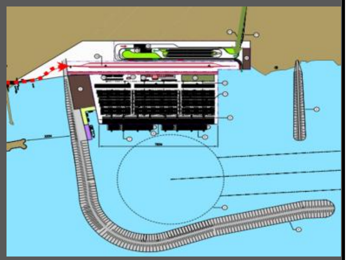
- Minimum Social Impact
  The social cost involved in the project related to Relocation & Rehabilitation (R&R), land acquisition & displacement of local community has been considered and compared.

- Technical Feasibility
  Technical barriers such as unfavorable topography, tunneling, S curve connectivity to rail yard etc. have been considered and compared.

- Impact on Port Costing
  The impact on the total construction cost of the proposed layouts has been compared.

Table 5-1 shows the matrix wise comparative analysis of the different road-rail connectivity layout options.

Table 5-1 Rail Road Connectivity Evaluation Matrix

| Parameters | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| |  |  |  |
| **Planning Flexibility** | **Moderate :** Flexibility in rail yard planning | **High:** highest level of flexibility in planning as the proposed road & rail connectivity would be expandable with port | **Low:** layout offers the lowest flexibility in planning due to the rail yard entry constraints because of "S" curve of the rail line |
| **Social Impact** | **High:** Social cost would be high due to the displacement, R&R of local community | **Medium:** Social cost would be overcoming the resistance of the local community due to the rail corridor physically dividing the land adjacent to the rail. | **Low:** Social cost would be minimal as the proposed rail corridor will be through the existing drainage so displacement of local community would be minimal |
| **Technical Feasibility** | **Difficult:** due to the unfavorable topography | **Very Difficult:** rail connectivity will need tunneling & land cut to overcome steep grading and highly unfavorable topography | **Moderate:** Technical difficulty to be overcome for the last mile connectivity (sharp "S" curve) which will be an elevated structure & yard entry has to be through the northern breakwater |
| **Impact on Port Costing** | **High** economic cost involved in Land Acquisition, R&R for the rail corridor | **High** economic cost involved due to the tunneling requirement for rail corridor | **Moderate** economic cost involved in providing an elevated structure for the last mile rail connectivity |

Due to the limited options available for the rail and road access to the proposed port and significant cost involved in land acquisition and R&R for Option 1 and Option 2, the Option 3 was considered and taken forward for the final master plan.

## 5.4 Evaluation of Master Plan Options

The above alternative master plan options were evaluated using Multi-criteria-analysis as presented in Table 5-2. While comparing the capital cost of the development it may be noted that for all the options the cost of breakwater, berth structure, equipments is comparable except with the infrastructure facilities in terms of rail road alignment and smooth terminal operations.

Table 5-2 Multi Criteria Evaluation of Alternative Master Plan Layouts

| Sr. No. | Criteria | Alternative 1 | Alternative 2 | Alternative 3 |
|---|---|---|---|---|
| 1. | **Total Number of Berths Possible** | A total of 5 berths with a provision of 2 additional berths for other cargos and liquid bulk | A total of 5 berths, 2 cruise berths, tug berth with a provision for an additional berths for liquid bulk | A total of 5 berths, 2 cruise berth, a coast guard and tug berth with a provision of 2 additional berths for other cargos and liquid bulk |
| 2. | **Space to accommodate Types of Berths Required in Master Plan Horizon** | All the berths are capable of being developed as deep water container berths | All the berths are capable of being developed as deep water container berths | All the berths are capable of being developed as deep water container berths |
| 3. | **Environmental/Social Issues** | Moderate | Moderate | Low |
| 4. | **Navigational Aspects** | Good. However, requires due confirmation from ship navigation studies in regard to the channel alignment being parallel to the shore | Good. However, requires due confirmation from ship navigation studies in regard to the channel alignment being parallel to the shore | Good. However, requires due confirmation from ship navigation studies in regard to the channel alignment being parallel to the shore |
| 5. | **Flexibility in Implementing as Staged development** | The layout is very much suitable for staged expansion except that the terminal operations would be impacted by the cultural activities in the vicinity | The layout is very much suitable for staged expansion except that the container terminal are not contiguous affecting the smooth operations | The layout is very much suitable for staged expansion |
| 6. | **Adequate Back-up Area** | Not sufficient | Not sufficient | Sufficient |
| 7. | **Rail and Road Connectivity** | Rail connectivity, a challenge | Rail connectivity, a challenge | Rail connectivity feasible |
| 8. | **Operational Flexibility** | This layout provides good operational flexibility with the container terminal being contiguous | This layout does not provide operational flexibility as the container terminal is not contiguous | This layout provides good operational flexibility with the container terminal being contiguous |
| 9. | **Capital Cost of Development** | Option capital cost per berth is comparable | Option capital cost per berth is comparable | Option capital cost per berth is comparable |

| Sr. No. | Criteria | Alternative 1 | Alternative 2 | Alternative 3 |
|---|---|---|---|---|
| 10. | **Capital Cost of the Phased Expansion** | Breakwater construction can be done as per the staged expansion | Breakwater construction can be done as per the staged expansion | Breakwater construction can be done as per the staged expansion |
| 11. | **Operation and Maintenance Costs of Phased Expansion** | As a base case | As a base case | As a base case |
| 12. | **Provision of Separate Access Road to Cruise Terminal** | Can be readily provided at the lee of northern breakwater | Must pass through the port operational area | Provided at the lee of northern breakwater and does not interfere with the port operations |
| 13. | **Impact to the temple** | Yes | No | No |
| 14. | **Recommended** | No | No | Yes |

Based on Multi-Criteria Evaluation Matrix presented in the section above, Alternative 3 would present the biggest advantage as it has the minimum social and environmental impact and it is technically most feasible. It was decided in conjunction with VISL to further refine this alternative and develop it into the master plan.

## 5.5 Modification/ Refinement in the Recommended Master Plan Alternative

### 5.5.1 Master Plan Refinements over the selected port layout

After finalizing the master plan alternative, several iterations were done to optimize & refine the layout as per the VISL requirements. The modifications carried out to the master plan are as listed below and shown in Figure 5-11:

- Shifting the terminal layout towards Sea by 90m
- Terminal layout rotated by 2° (anticlockwise)
- Shifting back the port layout by 40m towards landside
- Shifting the layout to south along the Coast
- Shifting container berth to south by 100m

#### *5.5.1.1 Shifting the Terminal Layout towards Sea by 90m – Step 1*

Based on the layout developed by RH, the port layout needed ample space for on-shore backup area for container terminal operations including the container storage and rail operations. The various factors which required shifting of the terminal are listed as below:

- The high backup terrain topography which is very steep, and will involve large amount of excavation/soil cutting (rock blasting in some area) in order to bring the terminal area at +5m CD;
- Presence of the temple area which is of the cultural importance for the local community;

- Space requirement for rail entry at the port boundary maintaining the limiting degree of curvature;
- Suffice the area requirement for contiguous container yard, rail yard;
- Providing ample clearance between the dredged channel and toe of the breakwater for safe maneuverability.

However, shifting the site by 90m into the sea ocean pushed the breakwaters in deeper water thereby increasing the cost of the project. The layout still did not provide enough clear length without intruding in the existing temple site for the proposed rail sidings and the limiting degree of curvature of the rail entry into the port.

#### *5.5.1.2 Terminal Layout Rotated by 2° (anticlockwise) – Step 2*

In order to gain more length for the proposed rail sidings without impacting the existing temple site and to maintain the degree of curvature for the rail entry (from North), the terminal layout was rotated in anti-clockwise direction in 1° increments up to 6°, in order to test the impact of each degree of rotation.

After comparing the pros and cons of each degree rotation layout, a two degree rotation of the layout was freezed which gave the minimum shifting of the breakwater in deeper water while providing for the sufficient clearance for the rail line from the temple site at an agreeable S-degree curve.

#### *5.5.1.3 Shifting back the port layout by 40m towards landside- Step 3*

To optimize the breakwater cost meeting the above requirements, the port layout was shifted towards the landside by 40m, without jeopardizing the benefit gained from the 2 degree rotation.

#### *5.5.1.4 Shifting the layout to South along the Coast – Step 4*

Due to the presence of north breakwater there is the possibility of turbulence at the entrance of the fishing harbour which would create undesirable conditions for navigation of the fishing boats. In order to maintain the port requirement without disturbing the surroundings, model studies were conducted to assess the favorable conditions at the fishing harbour entrance. Based on the outcome of the model studies it was recommended to provide a gap of 300m between the face of the north breakwater and the fishing harbour breakwaters. In order to maintain the required gap, the overall port was shifted by 80m to the south. The space between the breakwaters will be used for expansion of the fishing harbour along with maintaining the 400m beach stretch undisturbed.

#### *5.5.1.5 Shifting container berth to south by 100m – Step 5*

The container berths were shifted to south by 100m to suffice the area space requirement for the port craft, coast guard and cruise cum multipurpose terminal. This resulted in additional space for back up area for Coast Guard to the east of the coast guard berths.

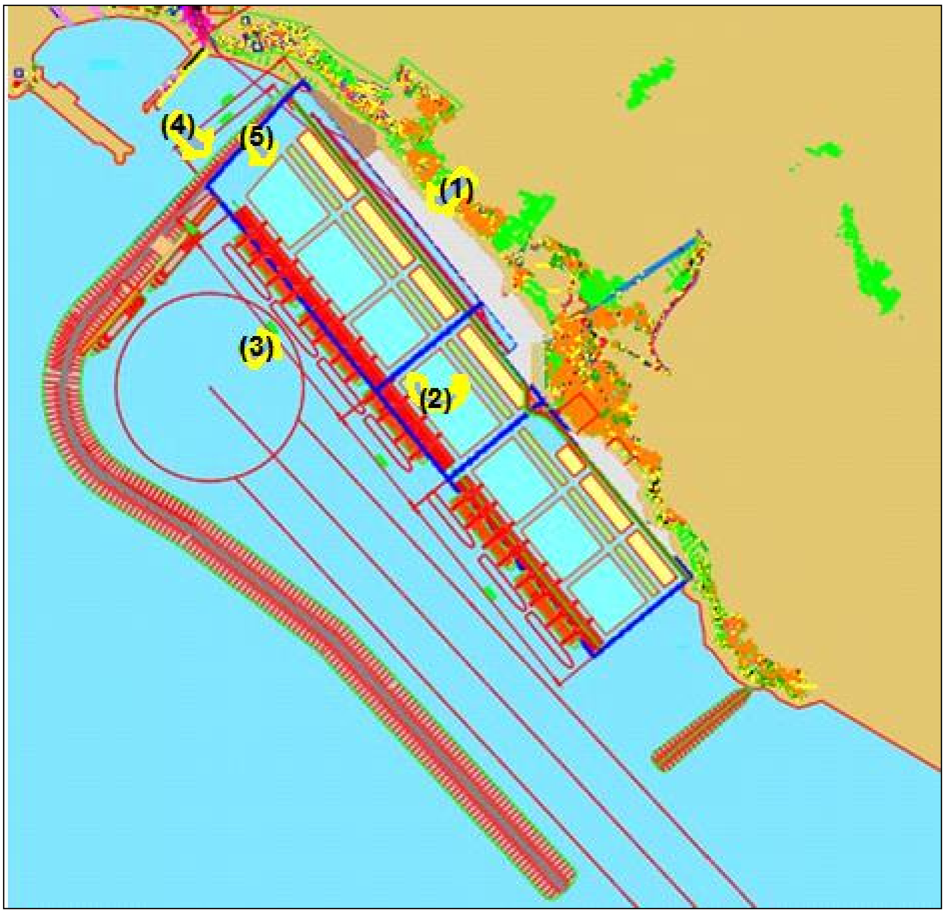



Figure 5-11 Layout Iterations Carried on Recommended Master Plan Alternative

# 6 Final Port Master Plan

## 6.1 Overview

This section summarizes Final Master Plan for the proposed port at Vizhinjam. The factors leading up to the development of the final plan have been described in earlier sections. Later sections describe the estimated capital costs for the phased development of the master plan.

The final Master Plan (also referred to as Phase-3) as shown in Figure 6-1 results from identifying the infrastructure needed to achieve the projected market demand over the 30-year planning horizon for the Port's two core commodities: containerized cargo and cruise. This is based on the traffic projections in the IFC/DREWRY 2010 report, and considering the limited / utilizable shore length of 2.5 Km at Vizhinjam. This infrastructure includes:

- Ability to berth fully laden 12,500 20-foot equivalent container units (TEU) vessels in Phase-1 itself with provision to handle up to 18,000 TEU vessels.
- Ability to handle 3,000 passenger capacity cruise ships.
- Additional fishery berths on the sea side but sheltered section of north breakwater.
- Liquid bunker fuel berth in Master Plan.
- Container Yard on reclaimed land.
- Rail line to port and the railway yard.
- Other support and ancillary facilities.

The AECOM team applied the site-specific physical constraints, based on the infrastructure assessment, to identify the master plan while keeping VISL objectives in mind. These constraints include proximity to an existing fishing harbor and fishermen settlements in the north; a temple in the middle (Phase-2 end); a fishing village with long beach (*Adimalathura*) in the south (Phase-3 end) and steep topography of the backup area.

In summary the Master Plan addresses four main factors:

- **Market:** The master plan is based on the traffic analysis performed by IFC/Drewry (2010) and is planned to accommodate the 2044 high case scenario. In addition, expansion potential of the master plan will allow to port to expand beyond 2044. The master plan is flexible enough to accommodate various types of cargoes depending on the market situation (cruise, multi-purpose cargo). Based on the market forecast, it is recommended that Port of Vizhinjam be developed in three phases with Phase-3 bringing it up to the final master plan development. Figure 6-2 and Figure 6-3 show the Phase-1 and Phase-2 development plan respectively. Figure 6-1 shows the Phase-3 development bringing the port to full master plan development.

- **Technical**: The master plan presents the most technically sound option after taking into due consideration the physical constraints at the site and providing a futuristic world class efficient facility with green design concepts.

- **Environmental**: The master plan takes into account various environmental aspects such as:
  - Provides a 300m clearance between the existing fishing harbor to avoid disturbing the existing facilities due to proposed port;
  - Minimizes the land cutting with efficient arrangement of terminal facilities
  - Minimizes tree uprooting in the backland by locating terminal facilities away from existing shoreline
  - Provides flexibility to incorporate green initiatives
- **Social:** The Master Plan has been carefully arrived at to minimize impact on the adjoining population, some of the factors considered are:
  - Fishing community near the proposed port site

- Additional fishery berths are provided for the fishing community
- Rail access has been planned for minimal impact on the adjoining village;
- Tourism industry to improve through cruise vessels and the proposed land use will match the current land use in the cruise terminal area;
- Master plan preserves the existing Mulloor Naga temple and provides for unimpeded access to it.

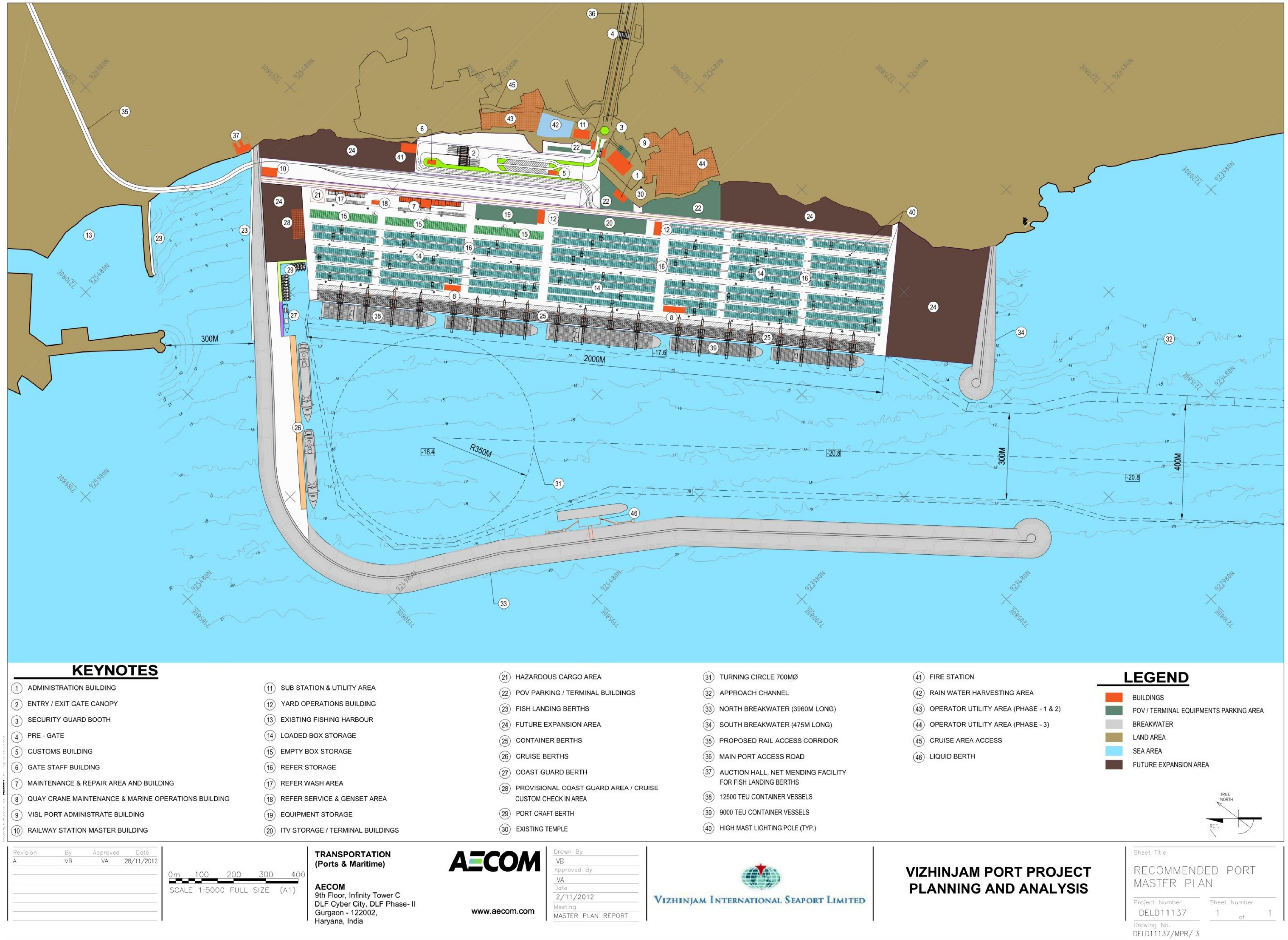



Figure 6-1 Final Master Plan for Port of Vizhinjam

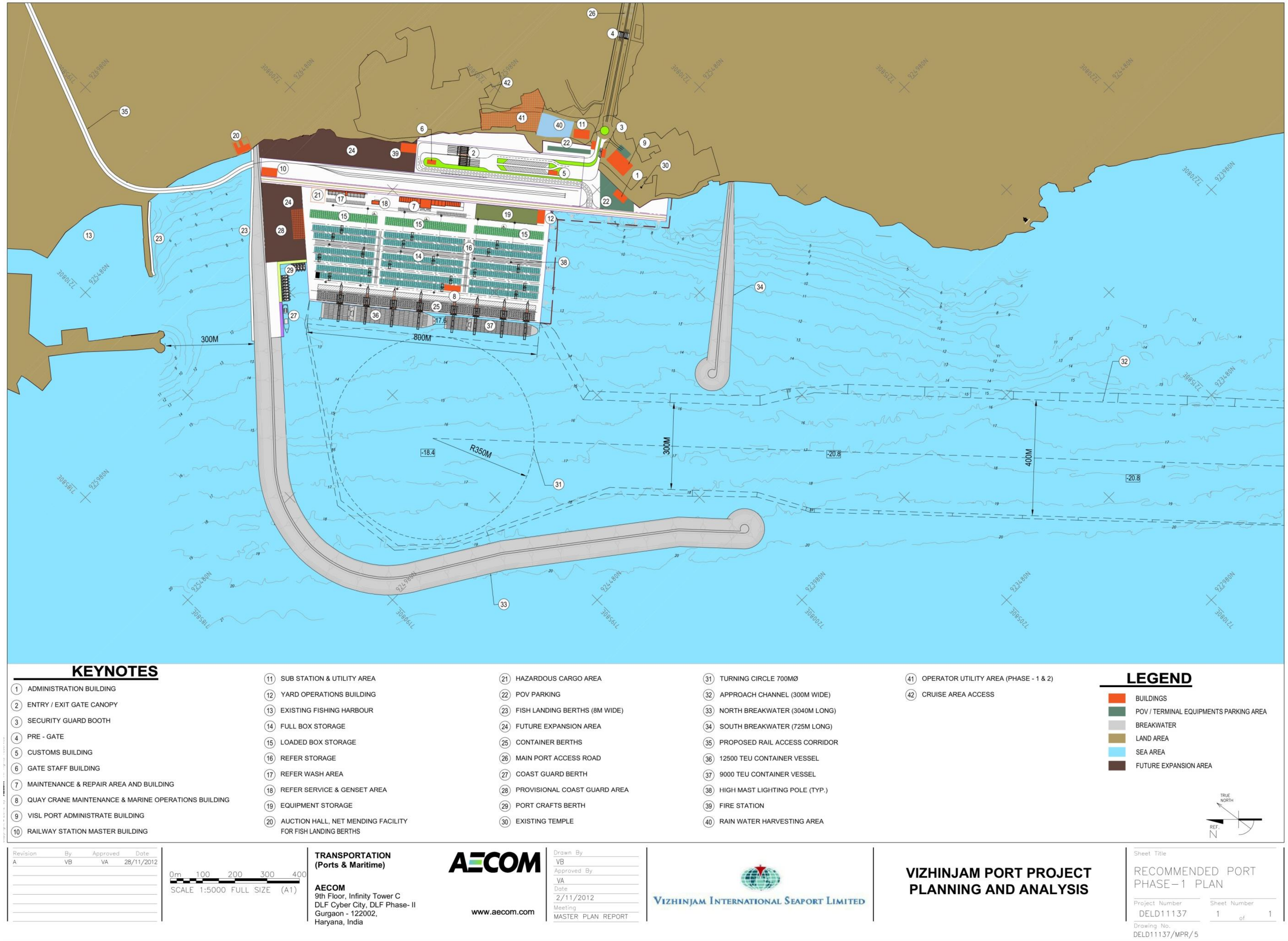
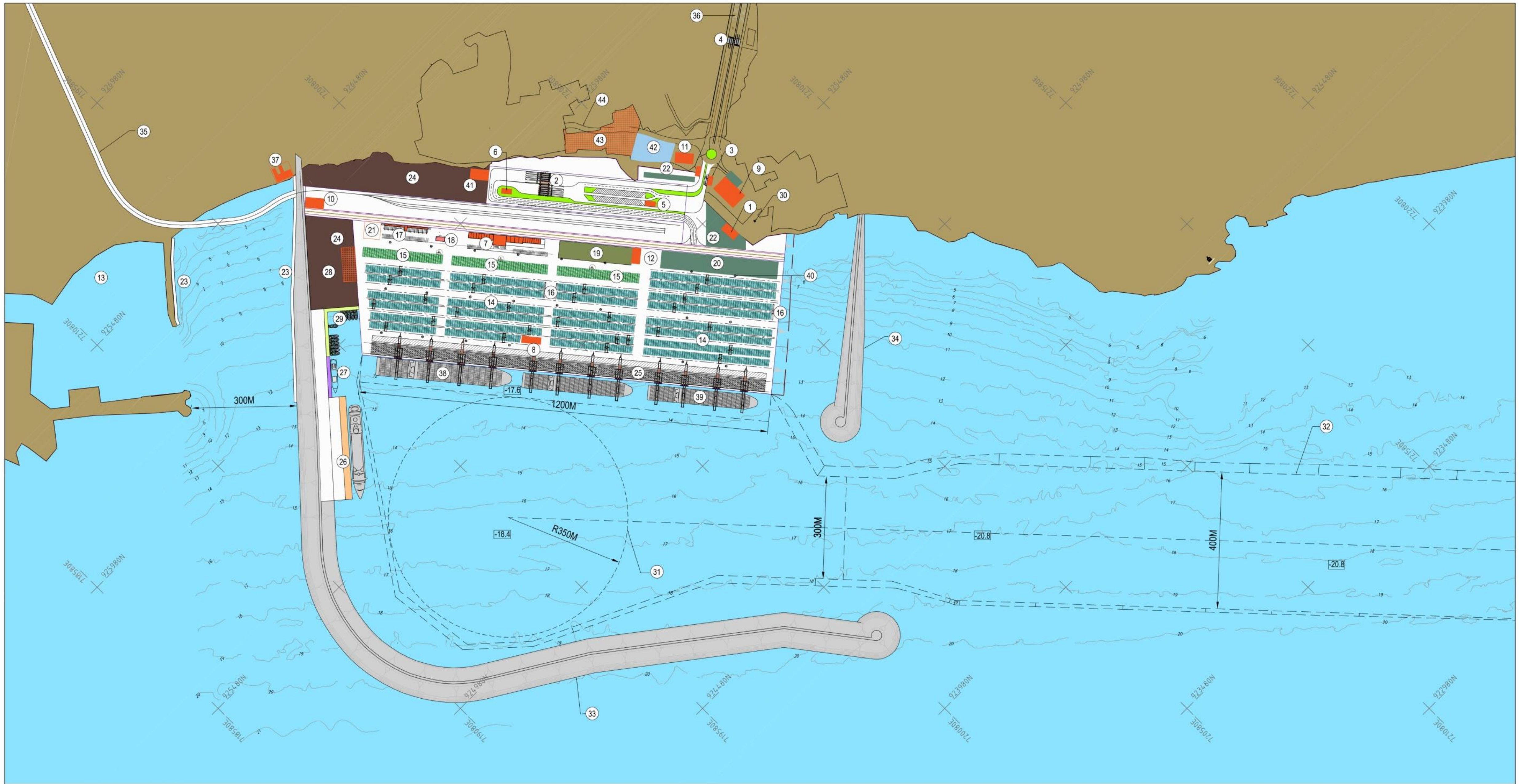



Figure 6-2 Phase-1 development of Port of Vizhinjam




## KEYNOTES

1. ADMINISTRATION BUILDING
2. ENTRY / EXIT GATE CANOPY
3. SECURITY GUARD BOOTH
4. PRE - GATE
5. CUSTOMS BUILDING
6. GATE STAFF BUILDING
7. MAINTENANCE & REPAIR AREA AND BUILDING
8. QUAY CRANE MAINTENANCE & MARINE OPERATIONS BUILDING
9. VISL PORT ADMINISTRATE BUILDING
10. RAILWAY STATION MASTER BUILDING
11. SUB STATION & UTILITY AREA
12. YARD OPERATIONS BUILDING
13. EXISTING FISHING HARBOUR
14. LOADED BOX STORAGE
15. EMPTY BOX STORAGE
16. REFER STORAGE
17. REFER WASH AREA
18. REFER SERVICE & GENSET AREA
19. EQUIPMENT STORAGE
20. ITV STORAGE
21. HAZARDOUS CARGO AREA
22. POV PARKING
23. FISH LANDING BERTHS (8M WIDE)
24. FUTURE EXPANSION AREA
25. CONTAINER BERTHS
26. CRUISE BERTHS
27. COAST GUARD BERTH
28. PROVISIONAL COAST GUARD AREA
29. PORT CRAFTS BERTH
30. EXISTING TEMPLE
31. TURNING CIRCLE 700MØ
32. APPROACH CHANNEL (300M WIDE)
33. NORTH BREAKWATER (3040M LONG)
34. SOUTH BREAKWATER (725M LONG)
35. PROPOSED RAIL ACCESS CORRIDOR
36. MAIN PORT ACCESS ROAD
37. AUCTION HALL, NET MENDING FACILITY FOR FISH LANDING BERTHS
38. 12500 TEU CONTAINER VESSELS
39. 9000 TEU CONTAINER VESSELS
40. HIGH MAST LIGHTING POLE (TYP.)
41. FIRE STATION
42. RAIN WATER HARVESTING AREA
43. OPERATOR UTILITY AREA (PHASE - 1 & 2)
44. CRUISE AREA ACCESS

## LEGEND

- BUILDINGS
- POV / TERMINAL EQUIPMENTS PARKING AREA
- BREAKWATER
- LAND AREA
- SEA AREA
- FUTURE EXPANSION AREA

TRUE NORTH
REF. N

| Revision | By | Approved | Date |
|---|---|---|---|
| A | VB | VA | 28/11/2012 |

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**TRANSPORTATION (Ports & Maritime)**

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Approved By: VA
Date: 2/11/2012
Meeting: MASTER PLAN REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

**VIZHINJAM PORT PROJECT PLANNING AND ANALYSIS**

Sheet Title: RECOMMENDED PORT PHASE-II PLAN
Project Number: DELD11137
Sheet Number: 1 of 1
Drawing No. DELD11137/MPR/6

Figure 6-3 Phase-2 development of Port of Vizhinjam

## 6.2 Key Elements

The following section describes the key elements incorporated in the master plan. Salient features and phase-wise development plan for each element are explained below.

### 6.2.1 Harbour and Breakwater Alignment

The harbour and breakwater alignment has been maintained from the RH report as it was arrived at after due consideration and studies. However, some alterations have been made such as maintaining the distance between the existing fishing harbor and the proposed port to be 300m considering the improved tranquility conditions of the fishing harbor as observed from the mathematical modeling studies.

The shape/ layout of the northern breakwater have been designed in such a way that bunkering vessels can also be berthed in future. The port design has been made futuristic by considering 12,500+ TEU vessels as the design vessel in Phase-1 itself (as against 9,000 TEU vessels considered in the RH 2010 report) with a turning circle of 700m diameter, to cater to tug assisted rotation of even futuristic vessels of 400+ m length. Considering that about 18m draft is naturally available at Vizhinjam (which will be deepened to about 21m), 14,000+ TEU and other bigger vessels (18,000 TEU like MAERSK EEE class) can also be berthed if needed with the berths designed for these bigger vessels.

### 6.2.2 Container Berths and Quay

The master plan provides for a total of five, four hundred meters container berths. Phase-1 development will have a total of 800m berth length to accommodate two 12,500 TEU container vessels. Phase-2 development will add another 400m berth to have a total of 1200m berth length to accommodate up to three 12,500+ TEU container vessels. Phase-3 will add two additional 400m berths to have a total of 2000m berth length to accommodate up to five 12,500+ TEU container vessels. The berths have been planned so as to meet the traffic forecast. These berths will be designed and also be able to berth 18,000 TEU vessels.

Each berth will be equipped with four quay container cranes. Table 6-1 provides a summary of key container berth elements.

The Quay apron area has been planned to accommodate the crane rail (upto 35m rail gauge), circulation lanes as well as hatch cover laydown area. The apron area has been planned for a width of 70 meters.

Table 6-1 Master Plan Phase Wise Container Terminal Capacity

| Development Phase | Total Berths | Berth Length (m) | Terminal Capacity (TEUs) |
|---|---|---|---|
| **Phase-1** | 2 | 800 | 900,000 |
| **Phase-2** | 3 | 1200 | 1,800,000 |
| **Phase-3** | 5 | 2000 | 3.350,000 |

### 6.2.3 Fishery Berths

The master plan provides for additional fishery berths for the local fishing community. A total berth length of around 850m is provided for along the sheltered sea-ward side of the proposed north breakwater and sea-ward side of existing fishery harbour's south breakwater. The access to the fishery berths will be provided from outside of the container port and the proposed operations at the new port will not cause interference to the fishery berth access. Adequate landside facilities in terms of auction hall etc. are also planned for at the root of the new north breakwater as shown in Figure 6-1.

### 6.2.4 Cruise Berths

In the master plan, cruise berths are programmed to be constructed along the northern breakwater, in order to optimize the container cargo handling berths and provide flexibility for phasing the cruise berths on a need basis without interrupting the cargo operations.

The master plan provides for two dedicated berths for Cruise vessels (300m length each in Phase-2 and Phase-3) along the northern breakwater. The depth required for maneuvering and berthing of cruise ships is naturally available at the proposed location and will not involve any capital dredging. The berths are located on the lee-side of the breakwater so as to utilize the structure and provide a wide area behind the berths.

### 6.2.5 Coast Guard & Port Craft Berths

A dedicated 120m coast guard berth will be provided in Phase-1 itself. A total of 220m of berth length will be provided for port crafts such as tugs. The 220m berth will be able to accommodate up to ten port crafts. The location of these coast guard and port craft berth has been carefully chosen so as to provide a sheltered location as well as at an optimum distance from all berthing areas, and having a provision for coast guard/pilot office area adjacent to the berths.

### 6.2.6 Liquid Berth

A provision has been provided in the master plan for a dedicated liquid berth. This berth will be used to import bunker fuel for the vessels calling at the Vizhinjam port. The berth will be connected to the storage tanks through pipelines passing along the north breakwater. A provision for 250m long berth has been provided and will be able to berth a 60,000 DWT liquid bulk tanker. The berth will be located along the north breakwater just south of the turning circle as shown in Figure 6-1. This location would cause minimum interference between liquid berth operations with any other port vessel operations.

### 6.2.7 Container Yard

The master plan provides for around 100 hectares of Container Yard and support facilities. The container yard is located adjacent to the berths allowing for the efficient transfer of containers from the yard to the apron. The container yard has been planned for efficient handling operations providing for dedicated areas for full, empty and reefer containers. Dedicated circulation lanes have also been provided for quay to yard as well as within yard circulation. The mode of operation for the container yard will be Rubber Tired Gantry (RTG) Cranes in Phase-1 with provision for up gradation to Electric RTG's in Phase-2 and Phase-3. Top Pick / Side Pick cranes will be utilized for handling empty containers. Master Plan provides flexibility with adequate space provision for terminal operator to choose a different container handling operating mode such as RMG.

The numbers of ground slots have been provided so as to be able to meet the peak berth capacity. Storage for equipments and Inter-Terminal Vehicle (ITV) has been provided along the northern side of the container yard. The master plan provides for 2.5 hectare for this parking. Figure 6-4 shows the proposed circulation pattern within the container yard. Most of the terminal roads will have two-way traffic. The truck lanes under the RTG as well as under the quay crane will have one-way traffic. The quay apron - yard movement will be anti-clockwise whereas the yard – gate/ railyard movement will be clockwise.

In addition, the yard has been planned such that the trans-shipment cargo stays closer to the berths than the gateway cargo. The container yard as planned has a width of around 400m and has a total of 18,200 Twenty Foot Ground Slots (TGS) in order to match the required storage capacity. Table 6-2 shows the phase-wise distribution of storage capacity.

Table 6-2 Phase-wise Container Yard Capacity Over Master Plan Horizon

| Development Phase | Total TGS |
|---|---|
| **Phase-1** | 5,600 |
| **Phase-2** | 8,700 |
| **Phase-3** | 18,200 |

Figure 6-4 Traffic Circulation Pattern for Port of Vizhinjam Master Plan

Utility routes have been planned and incorporated into the yard to allow for minimal disruption during phased development as well as easy upgradation of diesel RTGs to ERTGs. A dedicated area has been provided for reefer support operations such as Reefer Wash Down, Reefer Service and Genset repair Building.

### 6.2.8 Cruise Terminal

Due to a very limited available land area inside the port boundary, cruise passenger accessibility constraints and port security constraints; it will not be possible to provide intermodal zone within the secured port boundary limits – which is primarily located on the reclaimed land.

Having the intermodal zone outside of the port boundary, access of the cruise passengers to the cruise berth will have to be planned as per the cruise terminal operator's needs. The approach to the intermodal zone from outside will be through a common port approach road and then a diversion will be given through the roundabouts located just east of the security guard booth.

From there onwards, the final approach to intermodal zone will be a two lane road. It is envisioned that multiple resorts, shopping complex and tourism facilities can be provided along the road to the intermodal zone.

Ideally, cruise passengers need to be able to directly approach to the berth without interfering with the cargo handling operations of the port and jeopardizing the port security rules. It will not be ideal to have cruise passengers directly approach the cruise berth without proper escort and through a regulated shuttle-drop off service, just like being implemented at many airports.

In order to provide cruise passenger a safe access to the cruise berths, following two options have been considered:

**Option 1:** General Terminal Area (GTA) is provided outside of Port entry next to the intermodal zone as shown in Figure 6-5. After all check-in formalities are done, passengers will be transported by a dedicated shuttle service which will take the cruise passengers to the cruise berth through the terminal road (a 4 Lane road which is adjacent to the rail yard). After the security booth, the shuttle service will not be required to go through the entry/exit gate complex. This option will not require crossing the rail yard.

**Advantages:**

1) Simple & easy to implement.
2) No additional cost for shuttle service road corridor
3) No rail crossing required.

**Disadvantages:**

1) Bus shuttle service to use terminal road thus interfering with container/rail yard operations.
2) Cruise passengers exposed to terminal operations, pollutions & noise

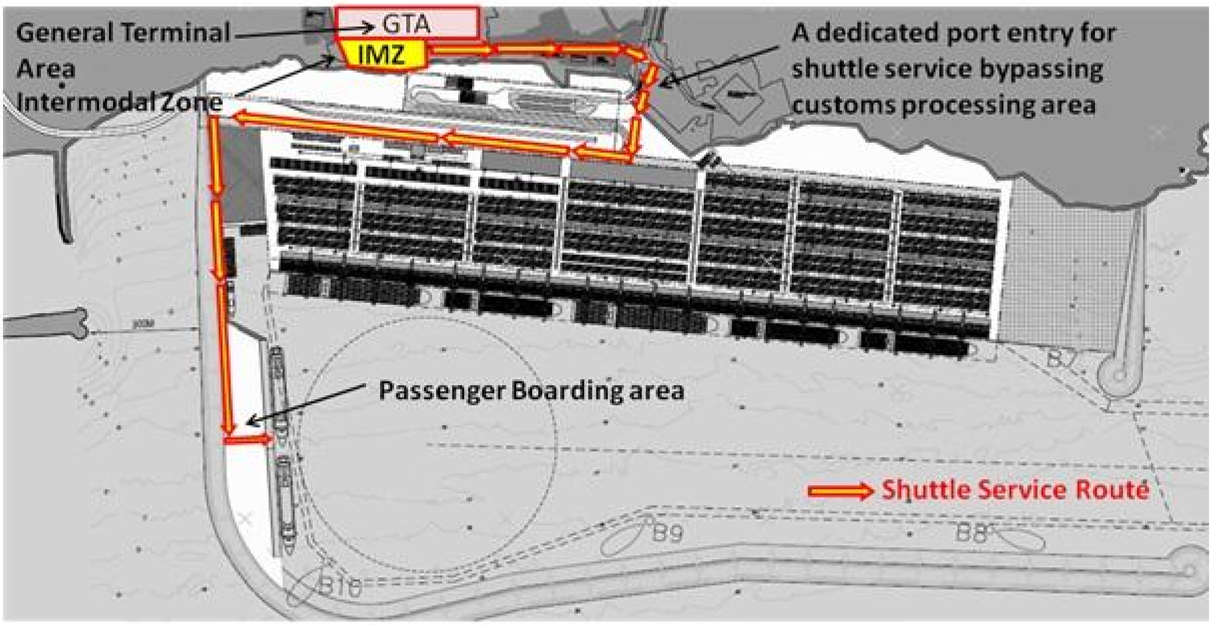


Figure 6-5 Option 1 for Cruise Terminal and Access

**Option 2:** An elevated road corridor from the passenger processing area directly to the cruise berth shown in Figure 6-6.

An elevated corridor can be constructed from the general terminal area directly to the cruise berth location crossing over the rail tracks. As this option will need rail yard crossing, an elevated corridor is the only option available because rail crossing at ground level will cause huge operational difficulties. This elevated corridor will start from the general terminal area (elevation of +15m to +20m CD) and will land on the cruise berthing backup area which will be at an elevation of +5m CD.

**Advantages:**

1) Cruise shuttle service & passengers completely isolated from terminal operations, noise & pollution.
2) Passenger will able to see natural scenic beauty of the location from an elevated corridor

**Disadvantages:**

1) Technically difficult to implement due to the unfavorable topography.
2) High cost involved in constructing an elevated corridor.

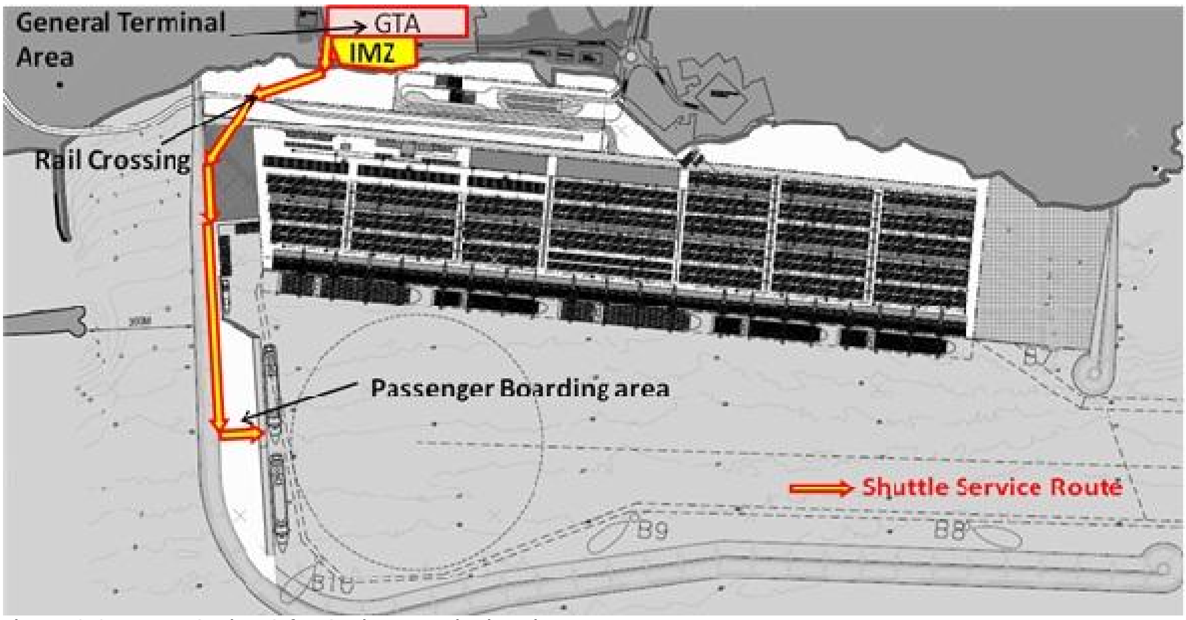


Figure 6-6 Option 2 for Cruise Terminal and Access

The type of cruise vessel likely to be serviced at the Vizhinjam port is not fixed, so to allow for the maximum flexibility, AECOM has considered using the rail and mobile type passenger-boarding bridges which provides a larger WOA.

AECOM recommends not building any large permanent civil structure behind the cruise berth backup area. VISL may also explore the feasibility of berthing general cargo ships along the planned cruise berths to handle break bulk, project cargo or Ro-Ro cargo depending upon demand conditions. Free backup area behind the berth will give that level of flexibility to handle other cargo and also it will be located close to the rail yard.

### 6.2.9 Railway Connectivity/Yard

So as to facilitate the smooth entry of the proposed rail into the Port from the north end with less than eight degree curve (as required by the Indian Railways); to avoid large displacement of fishermen settlement in the 'Valiakadappuram' stretch, and to exclude the temple at Mulloor end, the Port layout (as depicted in the Royal Haskoning 2011 report) was shifted by about 50m into the sea and rotated anticlockwise by two degrees as explained in Section 6.

Rail connection to the port has been planned by Rail Vikas Nigam Limited (RVNL) from the north breakwater side in the form of a coastal bridge. Electrified railway lines (with two live & three service lines, one service line each in Phase-1, 2 and 3) with container handling facilities using Reach Stackers in Phase-1 and Phase-2, upgradable to RTG's or Rail Mounted Gantry's (RMG's) in Phase-3 have been planned. The proposed port is essentially a transshipment container terminal with around 30% of gateway container traffic. The split of gateway traffic coming through rail is assumed to be 30%. The number of rail lines has been sized to accommodate this traffic.

Space has been provided west of the service lines for container stacking. The port will provide for switching and yard services within the railway yard. Railway station master building has been provided south-west of the rail tracks.

In future, the proximity of the planned cruise berths to the rail yard can also be utilized to handle the multipurpose/ bulk cargo from the cruise berths using rail for landside transfer.

Provisional future expansion space east of rail yard and north of the gate complex can be also used for bunker fuel storage, which can also avail the proximity of rail yard, for bringing in the liquid petroleum products in the port by rail.

## 6.2.10 Entry/Exit Gate Complex

The entry/exit gate has been planned as a two-step gate. A pre-gate will be constructed on the main terminal road which will have parking and facilities for truckers. Only drivers will be allowed to leave the pre-gate area and enter the main terminal gate. The main terminal gate has been provided at the east end of the port. It will consist of a gate canopy with three entry and three exit lanes with one bypass lane in each side. It is planned that, gate operations in Phase-1 will consist of single shift increasing to two and three shifts in Phase-2 and Phase-3 respectively. The proposed port is essentially a transshipment container terminal with around 30% of gateway container traffic. The split of gateway traffic coming through road trucks is assumed to be 70%. The gate lanes have been sized to accommodate this traffic. Adequate queuing space has been planned for in the gate complex. Space has been provided for customs and other regulatory processes near the gate complex. Container scanning if needed can be accommodated within the gate complex itself. Users other than the container trucks such as coast guard, cruise traffic, port staff etc. has been provided a dedicated lane in the gate complex. Figure 6-7 shows a detailed view of the proposed gate complex.

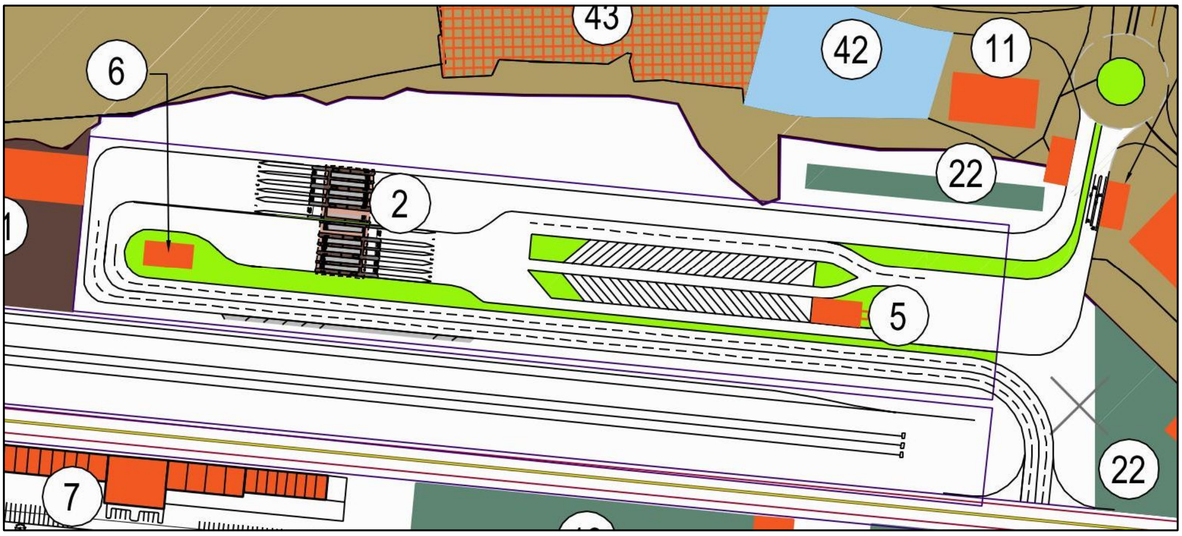



Figure 6-7 Gate Complex for Port of Vizhinjam

As discussed earlier in Section 4, master plan has been kept flexible for the eventuality of multiple private terminal operators for different phases of container terminal development. The gate complex shown above can be used for upto two terminal operators by demarcating two entry and two exit lanes for each operator. If there are more than two terminal operators, it is suggested that an additional gate complex be created in the future expansion area along north-east of the terminal.

Each container gate lane will be equipped with a weigh bridge that is used to measure and assess truck axle weights for enforcement of axle load highway rules.

## 6.2.11 Maintenance Area

Maintenance area has been planned on the northern side of the container yard so as not to interfere with terminal traffic circulation. It will comprise of maintenance, repair and related activities for RTGs, yard tractors, top-picks, side-picks, truck chassis, and other container terminal operating equipment. It also supports other service areas such as tire changing, and equipment steam cleaning activities.

Parking for maintenance vehicles has been provided adjacent to the building. Adequate circulation is provided to move vehicles to and from the service bays. Roll-up overhead doors are planned in the parts room and service bays.

The maintenance area has been planned so as to be able to expand for phased development of the port.

### 6.2.12 Administration Area

The administration area has been planned along the north side of the port adjacent to the entrance. The main Administration building will house the terminal operator's management, security, admin and customer service personnel. This facility houses the management and staff functions for container terminal and gate operations. The building is located on the site plan to allow visual access to the gate complex from the Customer Service Department and the second floor Control Room. Office areas on the third floor will have visual access to the container yard, container ship wharf, rail yard, and all gate areas.

VISL Port administration building will be located east of the main Administration building. Since VISL intends to operate on the land-lord model, VISL staff in charge of the maintenance and day-to-day functioning of the port will be housed in this building.

Parking has been provided in the administration area for management employees, visitors and other personally owned vehicles (POVs) on the south side of gate entry/exit area. The port master plan provides for POV parking area of approximately 2 hectares. Areas have also been earmarked for future expansion of POV parking or other administration functions.

Gate staff has been provided a small building along the western edge of the gate complex that will provide canteen, toilets and other such services to them.

Marine Operations staff has been provided a couple of buildings along the berth apron. This facility houses ship loading/unloading operations and planning functions as well as break facilities for the ship/quay operations. This building is to be positioned and of sufficient height so that marine operations can have visual oversight of the wharves. Visual contact can be augmented by the use of TV cameras as required.

### 6.2.13 Road Connectivity

The road entry has been planned from the Mulloor end and the main terminal access is planned along the middle of the terminal from east. The land for proposed route of the 45m road corridor (six-lane road already under construction) is under the ownership of VISL.

### 6.2.14 Future Expansion Area

The Master Plan provides a lot of flexibility within the terminal in terms of future expansion area. The proximity to the berths of these areas will allow for efficient cargo transfer and minimize interaction between containerized cargo and other cargoes.

The future expansion area identified in the Master Plan is 3 hectare parcel (1) located between the north breakwater root and container yard, a 5 hectare parcel (2) located along the north boundary of the port- north of container gate; a 6 hectare parcel (3) east of south end of the container yard; and a 13 hectare parcel (4) south of container yard along the south breakwater. There is also a provision for creation of a 300m berth along parcel 4. The berth can be used for container, bulk or shipyard facilities depending on the future requirements. Please refer to Figure 6-8 for the locations of these expansion areas.

These future expansion parcels can be used for various purposes but not limited to:

- Parcel 1: Used for cruise terminal or multi-purpose cargo storage
- Parcel 2: Liquid bulk storage tanks, multi-purpose cargo storage
- Parcel 3: Expansion of terminal buildings/container terminal or storage of empty containers or oversize/project cargo or additional gate facilities
- Parcel 4: Container or multipurpose cargo terminal or shipyard facilities

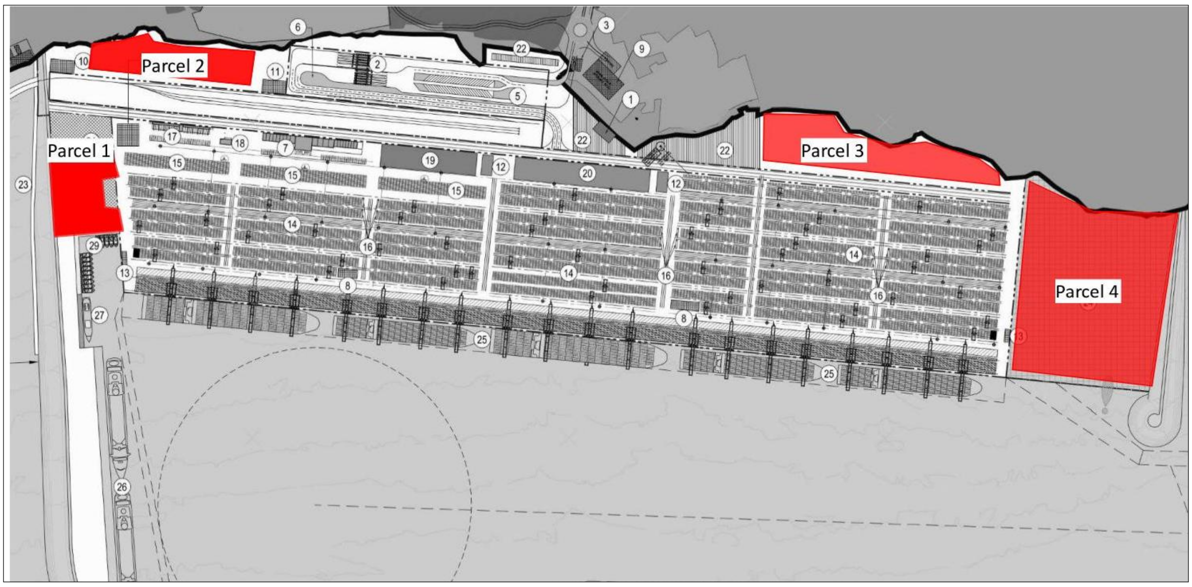



Figure 6-8 Future Expansion Areas in the Master Plan for Port of Vizhinjam

# 7 Land Use Plan

## 7.1 General

The area for future development of port would be available to the south of the Phase-1 development. Hence the Master Plan for the expansion must integrate seamlessly with the Phase-1 facilities and with the planned expansion of Phase-1. The Master Plan must be capable of being implemented in incremental stages without interference with the operation of Phase-1 and in such a way that each stage does not interfere with the operation of any preceding stage. The Master Plan must furthermore be capable of being adapted to changing circumstances in the pattern of shipping, cargoes or cargo handling methods. Like any Master Plan, it must provide a firm plan for the general allocation of space for various activities but it must be reviewed before any development stage in the light of changing circumstances.

## 7.2 Land Use Plan

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, without interfering with the nearby social development.

After identifying the land required for the port for various purposes a land use plan has been prepared over the master plan horizon based on the recommended port layout over the Master plan horizon. The allocation of land over the master plan horizon is presented in Figure 7-1. It is estimated that the total existing land area required by VISL is around 137 hectares out of which around 97.7 hectares is to be procured by negotiated purchase. Table 7-1 lists out various areas considered in the Land Use plan.

Table 7-1 Land Use Plan Areas

| Land Use Plan Areas | Area (Hectares) |
|---|---|
| Container Yard Phase -1 | 33 |
| Container Yard Phase -2 | 16 |
| Container Yard Phase -3 | 30 |
| Future Expansion Area | 30 |
| Breakwater Area | 3.3 |
| Area Reserved for VISL Port Building and Other Uses | 2.1 |
| Terminal Administrative Area | 1 |
| Truck Terminal/Fuel Filling & Other Utilities | 13.5 |
| Rail Corridor Within Port | 6.8 |
| Harbour Area Within Breakwaters | 167 |
| Port Based SEZ, Additional Warehousing & Commercial Facilities | 38 |
| Road Access Corridor | 11.7 |
| Port Operators Colony | 4.9 |
| Area To Be Procured for Port Operator Utility for Phase-1 and 2, Rain Water Harvesting & Treatment Area & Sub-station | 6.1 |
| Proposed Resort/Cruise Area | 7.5 |
| Terminal Gate Area | 7.5 |
| Cruise Berthing Area | 5.5 |
| Pre-Gate Area | 1.3 |
| Port Operator Utility Area for Phase-3 | 4 |
| VISL Colony Area | 9 |
| VISL 220KV Sub-station | 1.2 |
| Coast Guard Area | 1.5 |
| FLC Expansion | 0.14 |
| Rain Water Harvesting Area | 0.8 |
| **Total** | **402** |

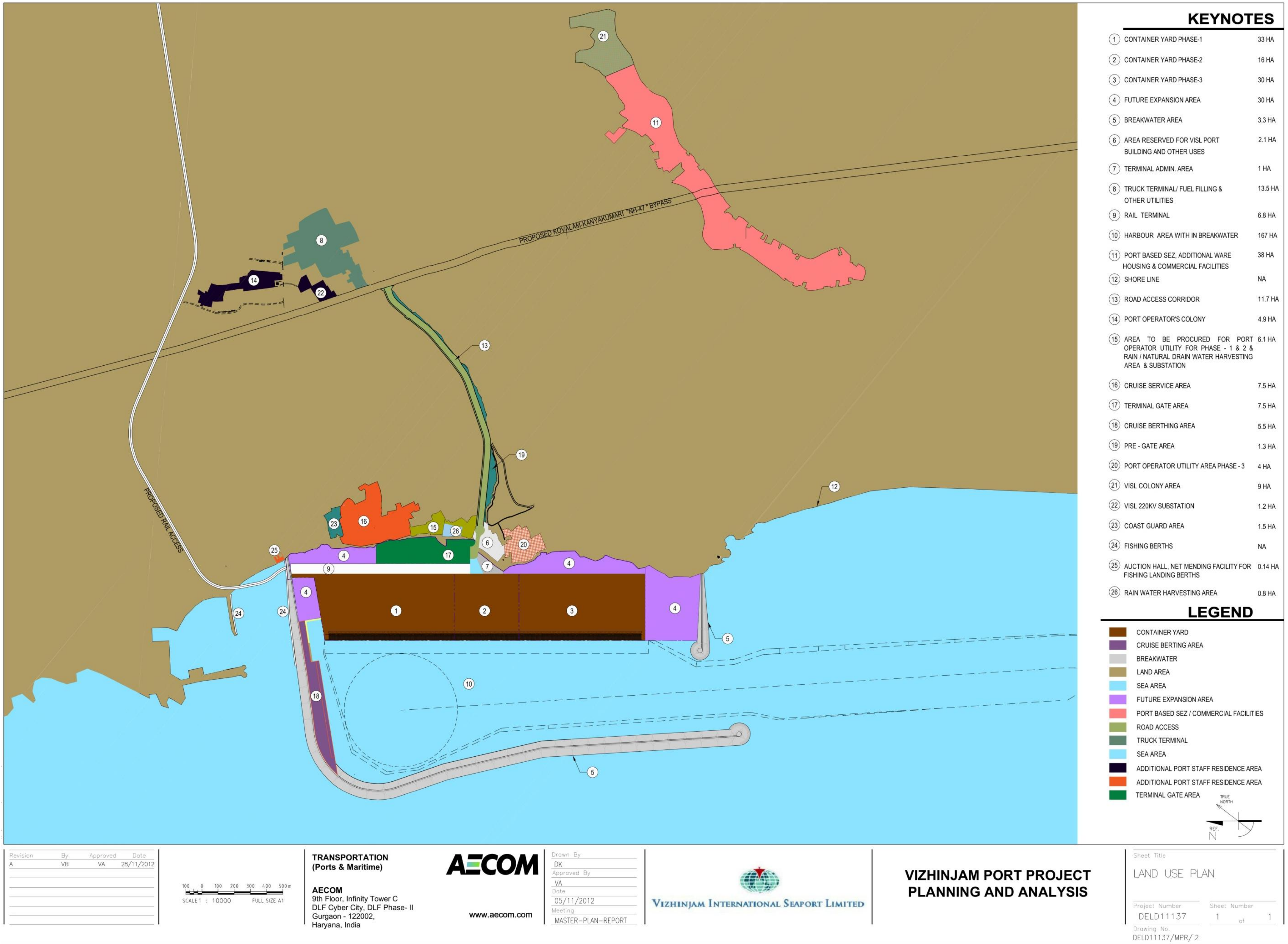



Figure 7-1 Land Use Plan for Port of Vizhinjam

# 8 Capital Expenditures

## 8.1 Introduction

A preliminary CAPEX (**Cap**ital **Ex**penditure) estimate has been summarized for the master plan. The preliminary development budget estimates are provided for reference only, and represent a professional opinion based on a “macro” cost level and available site information. Actual costs may vary significantly from the provided cost estimates, depending on the construction timeline, changed market conditions, availability of materials, change of policy and other unlisted factors. Therefore, these budget cost estimates are not guaranteed figures for financing or carrying out any transactions.

The cost is divided into major components such as Project Preliminaries & Site Development, Dredging & Reclamation, Breakwaters, Berthing Structures, Buildings, Container Yard, Equipments, Utilities, Port Crafts & Aids to Navigation and Gate Complex etc. For each major component, based on its functional requirements, cost has been estimated as per the capacity and phase wise development. For berthing structures, dredging & reclamation, breakwaters the cost estimation has been done by considering the preliminary engineering as per the Vizhinjam Port site and environmental conditions. The unit rates have been taken based on the past projects carried out by AECOM in India and current market rates obtained from ongoing projects and vendors.

The calculations used to create the estimates reflect current construction costs (2012), as well as estimated allocation of funds for construction contingencies and planning/design costs. Refer to Annexure 4 for the detailed estimates for the master plan development. A comparison of capital cost with RH calculated cost is provided in Annexure 4. The difference in cost compared to RH cost is mostly explained by change in scope of this study for e.g. longer berth length in Phase-1 (800m) compared to RH layout (650m) amongst others.

The following assumptions were used during the development of these estimates:

- The capital cost estimates are based on the project descriptions and drawings which were prepared after carrying out basic engineering of various components of the project. These will need to be developed, revised, and refined during the detailed design phase, and, therefore, some quantities shown in the cost estimates may undergo revision.
- A 10% planning, design and construction administration contingency has been included.
- A 20% overall contingency has been included.
- All cost estimates are represented in 2012 USD.
- All mobilization costs are included in respective entities.
- Only cruise berth costs are included. Cruise terminal facility including processing building and connectivity to berth etc. is not included as they are dependent on the option to be chosen by VISL and potential cruise terminal operator.
- The estimate provided only covers components of the port within the secured boundary and does not include components that are responsibility of VISL or RVNL (Rail Vikas Nigam Limited) such as VISL Building, Rail Yard and connectivity etc.
- A construction methodology has been assumed based on experience of similar structures and utilized for costing provided in this section.
- Costs for environmental studies and potential mitigation will be estimated by others as part of the EIA process.

The following exclusions were used during the development of these estimates:

- No taxes such as Service Tax, VAT etc. are included.
- The costs to furnish buildings and operate the facility are not included.
- General administrative supplies are not included.
- No costs associated with the liquid berth are included
- Cost doesn't include land acquisition cost, port approach road corridor development, and rail yard development cost.
- External infrastructure and linkages for road, rail, water, power and other utilities are not included.

## 8.2 Project Preliminaries & Site Development

This includes the cost involved in site preparation & development for construction activities, pre-operative expenses, initial surveys & project studies.

## 8.3 Dredging & Reclamation

Dredging & reclamation is one of the major costing parameter for any port project. Based on the bathymetry contours provided by VISL & as per the proposed phase wise development plan, the dredging & reclamation quantities have been estimated.

It is estimated that reclamation quantity required for Phase-1 development will be met by dredging needs as explained in Section 4.13. Phase-2 will require minimal dredging and hence the reclamation sand quantity is assumed to be taken from marine sand borrow location. Phase-3 will also require marine sand borrow for achieving sand balance for reclamation. The marine borrow location sites will be selected in the future phases as needed and for now, the unit rate for dredging cum reclamation from marine borrow site is taken by inflating the earlier dredging cum reclamation unit rate. The unit cost increment for dredging cum reclamation will be due to the booster pump requirements to pump sand to the reclamation area from marine sand borrows location.

The initial reclamation bund & stone pitching protection costs have been included. The ground improvement costs are estimated over the complete gross reclaimed area of the port.

## 8.4 Breakwaters

As per the near shore wave climate studies carried out by RH, basic engineering has been done for the breakwaters considering the design wave height recommended by RH. The breakwater is considered to have a single layer concrete armor (ACCROPODE) unit & crest elevation enough to restrict wave overtopping to minimal. The cost estimation has been done for the breakwater based on estimated Bill of Quantities (BOQ) of armor units, crown wall, rubble requirements for secondary layer, bedding and toe protection. The basic cross section design of the breakwater is based on CIRIA guidelines.

Phase wise construction of breakwater has been considered. It is to be noted that the final phase of development (Phase-3) will require removal/relocation of Inner South Breakwater and further extension of the North Breakwater.

## 8.5 Berthing Structures

Cost estimated for the berthing structures includes container terminal berths (35m crane rail gauge ), cruise terminal (20m apron), Coast Guard and Port craft berths (10m apron width); and Fishery berths (8m apron width). The cost estimates are done considering the basic design of an open pile berthing structure with stone pitching underneath the berth. These include costs for piles, crane rails, fenders, bollards, in-situ and pre-cast concrete works.

Master plan provides a provision for a liquid berth along the north breakwater. The capital costs for this would comprise of berth costs (breasting and mooring dolphins, unloading arm, platform etc.), pipelines connecting storage to berth and storage farm. Space provisions have been allocated along the north breakwater to be able to carry the pipelines connecting the berth to the storage area. As stated in the exclusions above, the liquid berth cost has not been included as they are very dependent on the approach of the chosen operator.

## 8.6 Container Yard

Major items included in the cost estimate for container yard development are site grading, pavement and RTG beams.

## 8.7 Equipments

Costs for required equipments as discussed in section 4 have been considered for phased development. Major equipments are Rail Mounted Quay Cranes (RMQC), Rubber Tire Gantry (RTG for container yard), Reach Stackers, Diesel locomotive & Intra Terminal Vehicles (ITV).

## 8.8 Buildings

Major buildings included in the cost estimate include

- Administrative Building including Port Users
- Port Marine Operations Building
- Yard Operations Building
- Crane Maintenance Building
- Maintenance & Repair Building
- Trouble Kiosk & Restrooms
- Longshoremen Restrooms
- Reefer Shop & Genset
- Gate Canopy
- Canteen
- Fire Station
- Utilities Building
- Electric Substation
- Guard booth (Entry & Exit Gate)
- Fuel Station
- Fish Landing Center Buildings
    - Auction Hall
    - Management Office
    - Net Mending Shed
    - Fuel Station
- Other Miscellaneous Buildings

## 8.9 Utilities

The following within the terminal utilities have been included in the cost estimate:

- Electric supply & distribution including high mast lighting for container yard
- Fire fighting
- Lighting & Earthing
- Water supply
- Drainage & sewerage
- Communication & IT (including Terminal Operating System)
- Compound wall for land side port area
- Workshop equipments

- Security infrastructure.

## 8.10 Port Craft & Aids to Navigation

The terminal will need tug boats for berthing, stopping & turning maneuvers for the container & cruise ships. As in the Phase -1 and Phase-2, the stopping procedure of the ship will be initiated in sheltered waters inside breakwater protected area, harbour tugs have been considered. The other port crafts include mooring launch and pilot cum survey launch. Aids to Navigation (A to N) requirements have been assessed as per the IALA guidelines.

## 8.11 Gate Complex & Terminal Road

The gate complex, customs processing area and main terminal road (4 lane road along the container yard) costs have been included.

## 8.12 Block Cost Estimation Summary

The cost estimates have been summarized in Table 8-1. The Phase-1 development is estimated to cost USD 642 millions. Phase-2 development is estimated to coast additional USD 190 million. Phase-3 development is estimated to cost another USD 455 million. Please refer to Annexure 4 for detailed breakup of the quantities.

Table 8-1 Block cost estimates summary

| S. No. | Item | Capital Cost (USD Millions) | | |
|---|---|---|---|---|
| | | Phase-1 | Phase-2 | Phase-3 (Master Plan) |
| 1. | Project Preliminaries and Site Development | 2 | 1 | 1 |
| 2. | Dredging and Reclamation | 74 | 34 | 61 |
| 3. | Breakwaters | 175 | - | 71 |
| 4. | Berths | 56 | 35 | 58 |
| 5. | Buildings | 5 | 2 | 4 |
| 6. | Container Yard | 21 | 11 | 24 |
| 7. | Equipments | 117 | 56 | 113 |
| 8. | Utilities and Others | 8 | 4 | 7 |
| 9. | Port Crafts and Aids to Navigation | 26 | 5 | 11 |
| 10. | Gates Complex & Road Development | 9 | 0 | 1 |
| | **Total** | **494** | **147** | **351** |
| | Contingencies @ 20% | 99 | 29 | 70 |
| | Engineering and Project Management @ 10% | 49 | 15 | 35 |
| | **GRAND TOTAL** | **642** | **191** | **457** |

Based on the "landlord" port model, Table 8-2 lists out the estimated capital cost split between VISL and private terminal operator(s) on the basis of discussions with VISL and AECOM's experience and understanding of the market. It is assumed that VISL will provide all civil costs associated with the project including breakwaters, dredging and reclamation, berths, port crafts and navigation aids. Some buildings such as VISL Admin, security guard booth, fish landing center will be provided by VISL. Private operator will provide all container terminal and gate complex development costs as well as equipment costs. It is also assumed that VISL will provide utilities to an agreed upon "hand-shake" point and the private terminal operator will be providing the utilities for the rest of the container terminal.

For Phase-1 development, it is estimated that VISL will incur USD 436 million whereas the private operator will incur around USD 206 million. It is estimated that VISL will incur USD 98 million whereas the private operator will incur around USD 93 million for Phase-2 development. Phase-3 development cost split will be USD 265 million and USD 192 million between VISL and private operator respectively. These cost numbers are in 2012 dollars and may vary depending on actual contractual agreements between VISL and potential terminal operators.

Table 8-2 Block cost estimates split between VISL and Private Port Operator

| S. No. | Item | Capital Cost (in Million USD) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Phase 1 | | Phase-2 | | Phase-3 (Master Plan) | |
| | | VISL | Private Operator | VISL | Private Operator | VISL | Private Operator |
| 1. | Project Preliminaries and Site Development | 2 | 0 | 1 | 0 | 1 | 0 |
| 2. | Dredging and Reclamation | 74 | 0 | 34 | 0 | 61 | 0 |
| 3. | Breakwaters | 175 | 0 | 0 | 0 | 71 | 0 |
| 4. | Berths | 56 | 0 | 35 | 0 | 58 | 0 |
| 5. | Buildings | 1 | 4 | 0 | 2 | 1 | 3 |
| 6. | Container Yard | 0 | 21 | 0 | 11 | 0 | 24 |
| 7. | Equipments | 0 | 117 | 0 | 56 | 0 | 113 |
| 8. | Utilities and Others | 1 | 7 | 0 | 3 | 1 | 7 |
| 9. | Port Crafts and Aids to Navigation | 26 | 0 | 5 | 0 | 11 | 0 |
| 10. | Gates Complex & Road Development | 0 | 9 | 0 | 0 | 0 | 1 |
| | **Total** | **335** | **158** | **75** | **72** | **204** | **148** |
| | Contingencies @ 20% | 67 | 32 | 15 | 14 | 41 | 30 |
| | Engineering and Project Management @ 10% | 34 | 16 | 8 | 7 | 20 | 15 |
| | **GRAND TOTAL** | **436** | **206** | **98** | **93** | **265** | **192** |

# 9 Implementation Schedule

## 9.1 General

At the time of preparation of the Master Plan report, as per the project timelines defined by VISL, it is estimated that the EPC works will commence from November 2013.

The following sections describe significant construction elements in the development of port at Vizhinjam. Construction timeframes are described further based on BOQs and construction schedule for **Phase-1** development is provided below. It is anticipated that depending on the market conditions, Phase-2 and Phase-3 developments will have a similar construction schedule.

It should be noted that the timeframes have been estimated based on an assumed construction methodology. The EPC contractor may choose a different construction methodology depending on their capability and understanding and this may change the calculations presented below.

## 9.2 Breakwater

The breakwater construction is proposed to be the foremost activity as it is needed to provide shelter for other activities such as reclamation and berth construction to commence. It is intended to construct the rubble mound breakwaters using plant based on land and at sea.  Due to the size of the North Breakwater and a tight completion timeframe for Phase-1 development, it is believed it would be economical to incorporate both methods and work on two fronts or more. The typical sequence of construction is as follows:

- Bed preparation
- Core placing
- Toe construction
- Under-layer
- Armour- seaward and leeward sides and
- Crest structure.

### 9.2.1 Quarry

It is estimated that majority of the material will be supplied through barges from identified quarry sites. It is proposed that core of the breakwater be formed up to say -5.0m CD through bottom dumping from barges. The rest of the breakwater profile can be constructed by dump trucks from land. Both marine and land plants could be used for placement of under-layer and armour layers. It is expected that breakwater construction through marine plant will be halted for around 4 months during the monsoon season whereas construction through land plant will experience considerable downtimes. It is also acknowledged that some rock will be lost in the monsoon.

An allowance has been made in the development of the preliminary schedule covering the construction phase for downtime due to adverse weather. There will be a need to perform a detailed assessment of the potential for downtime during construction planning in order to derive the optimum solution in terms of working fronts, equipment selection and so on for the likely conditions at the site. It is expected that breakwater construction will be very crucial for completion of the project in time. This will involve careful analysis of the logistics chain. Table 9-1 shows a calculation to assess breakwater construction schedule.

Table 9-1 Breakwater Construction Timeframe Calculation

| **Breakwater Construction** | | | | |
|---|---|---|---|---|
| | **North** | | **South** | |
| Length | 3,040 | | 725 | Meters |
| Core | 86,41,243 | Tons | 10,14,998 | Tons |
| Stone | 17,55,307 | Tons | 2,70,959 | Tons |
| ACCROPODE | 19,760 | No. | 5,064 | No. |
| **Supply Needed** | | | | |
| Rock/Core (Total) | 46,07,230 | Tons | | |
| ACCROPODE (Total) | 24,918 | No. | | |
| **Rock/Core** | | | | |
| Transport by barge | 22,000 | Tons per day | | |
| **For 7 day week, expected duration of core/rock placing** | **18** | **Months** | | |
| **ACCROPODE** | | | | |
| Placing rate | 8 | Min. each | | |
| No. placed per day | 67 | Per 9 hour day | | |
| Days placing time | 389 | Days, inc 5% for peaks | | |
| **For 7 day week, expected duration of armour placing** | **16** | **Months** | | |

## 9.3 Dredging

There are various types of dredging equipment available for executing capital dredging works out of which 'trailing suction hopper dredger (TSHD)' and 'cutter suction dredger (CSD)' are the most common types.

The TSHD is a sea going self propelled vessel which is equipped with a suction pipe, designed to trail over the side of the vessel. The suction pipe terminates, at the lower end, in a drag head which is designed to draw in the maximum amount of sea bed material and discharge it into a hopper in the vessel. It is a very versatile dredging unit. These types of dredgers are best used in relatively unrestricted areas.

It can work in busy navigation channel and can discharge its load in various ways. It can dredge material ranging from gravel, sand, silt and soft to medium clay. One of the main advantages of a TSHD is that it can operate in exposed locations with wave heights up to 3 m.

The CSD comprises a rotating cutter head mounted at the end of suction and connected to a dredging pump in the main body of the dredger. The dredger pivots around a spud located at the rear of the dredger by using a system of anchor wires and winches. The cutter head cuts the material on the sea bed and then the material is sucked up through the suction pipe by the dredger pump and discharge through a pipeline.

It is usually deployed on capital dredging works and can dredge a variety of different types of soils, ranging from clay and silt to sand and weak rock. It is very sensitive to wave condition and therefore is usually deployed in sheltered locations. CSD can operate in significant wave heights up to 1.0 m dependent on the associated wave period. Long waves and swell usually govern the safety and effectiveness of operation of the dredger.

Considering the site conditions prevailing at proposed Vizhinjam Port, it is recommended to deploy TSHD for undertaking capital dredging works in the approach channel. This enables dredging operation to start before the construction of breakwater. It is further recommended that CSD be used for dredging within the basin including the turning circle and berth pockets.

*Table 9-2* shows calculation for calculating dredging completion time for Phase-1 capital dredging. The dredging work using TSHD is estimated to take 16 months whereas dredging using CSD inside the harbour is estimated to take 12 months.

Table 9-2 Dredging Works Timeframe Calculation

| Dredging Calculations | Unit | Quantity |
|---|---|---|
| Average Production Rate (per Hr) | Cum | 800 |
| Number of Dredgers | | 1 |
| Hours Per Day | | 20 |
| Working Days per Month | | 25 |
| **Trailer Suction Hopper Dredge (TSHD)** | | |
| Efficiency | | 80% |
| Production per Day | Cum | 12,800 |
| Production per Month | Cum | 3,20,000 |
| Approach Channel Dredging Qty. | Cum | 44,73,943 |
| Working Months Needed | Months | 13 |
| Monsoon delay | Months | 3 |
| **Total Approach Channel Dredging Time** | **Months** | **16** |
| **Cutter Suction Dredge (CSD)** | | |
| Efficiency | | 85% |
| Production per Day | Cum | 13,600 |
| Production per Month | Cum | 3,40,000 |
| Turning Circle Dredging Qty | Cum | 18,23,500 |
| Harbour Basin+ Berth Pockets Dredging Qty | Cum | 10,63,100 |
| Working Months Needed | Months | 10 |
| Monsoon delay | Months | 2 |
| **Total Basin Time** | **Months** | **12** |

## 9.4 Reclamation Bund

The reclaimed ground will be protected by providing rubble mound bund on all sides. This reclamation bund will be designed for a design life of 50 years. The methodology provided in the Construction Industry Research and Information Association (CIRIA) manual (manual on use of rock in coastal and shoreline engineering) has been followed.

The reclamation bund will comprise of quarried rock / stones from a suitable source. It will include a geotextile membrane on the rear face to enhance its fill retention properties. The outer face will be protected against wave action with suitable protection. The stones required for the construction of bund could be supplied by local quarry through barges and road trucks similar to breakwater construction.

The rock bund and revetment capital works are proposed to be performed in advance of the reclamation work in order to provide the containment necessary for the reclamation material.

Assuming similar supply and placement rates as for the breakwater construction, it is estimated that reclamation bund will take approximately 6 months for construction.

## 9.5 Reclamation

The design of the reclamation areas is governed by the sub-soil conditions and the superimposed loads likely to occur on the filled up ground. It is required to keep the settlement within an acceptable limit.

During Phase-1 the fill material is expected to vary between -13m and 5m. It is assumed for preparation of implementation schedule that all fill material for reclamation will come from dredging of the basin and the channel. Analysis of borehole data at the site shows that dredge spoils will consist of around 80-90% of decent quality sand which could be utilized as reclamation material. It is recommended that reclamation be carried out with dredge spoils consisting of sand duly compacted in layers. It is likely to be placed in a loose condition below the water table. Above the water table drainage through the fill may have a significant compacting effect and, depending on the grading of the fill, densities as high as 'dense' might be achieved. Reclamation fill above the water level, consisting of coarse to medium sands, shall be compacted to at least 95% of the maximum dry density established in the laboratory (i.e. the modified proctor test).

It is assumed that reclamation can start after one month delay from construction of reclamation bund and continues for the duration of dredging activities.

## 9.6 Berth Construction

The container and cruise berths will be formed from steel or concrete piles socketed into rock beneath the seabed supporting a suspended concrete slab for the quay apron. For the container berths, behind the concrete quay apron will be a combination of sheet pile and block work wall on the reclamation bund that will contain the fill material for container yard. The cruise berth will utilize the leeward slope of the breakwater to create the platform behind the quay.

*Table 9-3* provides a calculation for estimating timeframe of completion for Phase-1 berth construction. It is estimated that container berths will be completed within 18 months. It is estimated that fishery berths will take around 12 months for construction. The cruise berths are estimated to take around 15 months. However, the timing of cruise berth construction is not currently fixed with assumption that it may be part of the Phase-2 development. For the implementation plan, cruise berth is shown to be under construction at the same time as container berths for depiction only and in reality the timing will not be the same. It is assumed that construction activity will be impacted during monsoon and 50% of the time will be lost. It is important to note that breakwater will provide significant sheltering for the marine works. The contractor may optimize this construction schedule based on equipment availability.

Table 9-3 Marine Works Construction TImeframe Calculation

| S. No | Description | Container Berths | | Cruise Berths | | Fishery Berths | |
|---|---|---|---|---|---|---|---|
| | | Quantity | Unit | Quantity | Unit | Quantity | Unit |
| 1. | Total Length | 800 | m | 600 | m | 850 | m |
| 2. | Spacing of piles | 8 | m | 8 | m | 5 | m |
| 3. | Bends/Piles per Week | 1.5 | | 3 | | 6 | |
| 4. | Number of Working Weeks Reqd. | 71 | Weeks | 27 | Weeks | 28 | Weeks |
| 5. | No. of Simultaneous Operation | 2 | | 1 | | 2 | |
| 6. | Efficiency of Operation | 80% | | 85% | | 85% | |
| 7. | Effective Schedule with 80% Efficiency | 44 | Weeks | 33 | Weeks | 18 | Weeks |
| 8. | Pre-Cast Works Lag | 12 | Weeks | 12 | Weeks | 8 | Weeks |
| 9. | In-Situ Works Lag | 12 | Weeks | 12 | Weeks | 12 | Weeks |
| 10. | Monsoon Delay | 2 | Months | 2 | Months | 2 | Months |
| | **Total Work Completion** | **20** | **Months** | **17** | **Months** | **12** | **Months** |

## 9.7 Equipment, Pavements, Roads, Rail & Buildings

The container terminal operating equipment and other equipment will need to be procured in such a manner that they are ready for commissioning in time of finish of construction. Due consideration will need to given to longer lead time equipment such as quay cranes and items such as terminal operating system requiring significant training times.

Open spaces/storage areas will be paved with a variety of surfacing as follows:

- Container terminal areas: block paving;
- Fish Landing Center (FLC) buildings and infrastructure;
- Access roads: asphalt paving;
- Gate complex and parking areas: asphalt concrete; and
- Truck parking: Portland cement concrete pavement

It is planned for the pavements of open/storage areas to commence after soil stabilization within reclamation areas has been completed. Provisions of required utilities such as electric, power, potable water, water main and communication etc. will also commence after the soil stabilization works.

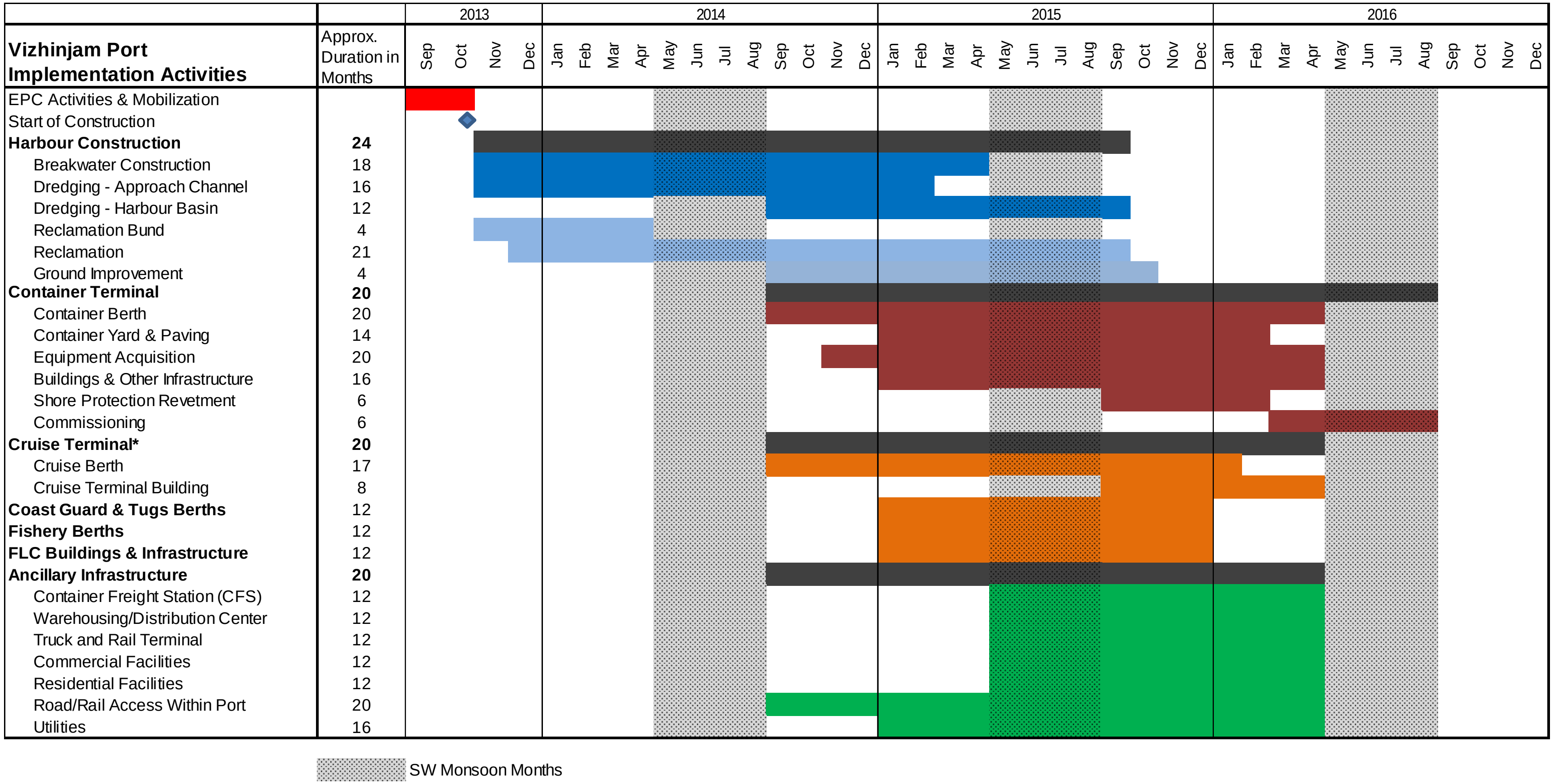
All the buildings shall have RCC framed structure. Structures on the reclaimed land shall be provided with pile foundations to avoid settlement. All other structures can be founded on isolated footings. The buildings will start construction after the reclamation areas are stabilized. It is expected that works on pavement, utilities and buildings will be done concurrently with the berth and other site works.

## 9.8 Summary

Figure 9-1 shows the implementation schedule and timeframes for various construction elements for Phase-1. According to our calculations, Phase-1 construction is supposed to commence in November 2013 and will take approximately two and a half years. Commissioning of port is expected to take around 4 additional months. This would enable the port to be operational in the fourth quarter of 2016. It is expected that other phases will follow similar construction timeframes.

Phase-2 will provide an additional 400 meters container berth with associated land development and infrastructure. It is estimated that this will take around a year.

Phase-3 will provide additional 800 meters of container berth with associated land development and infrastructure. This is expected to take around two years.




* Cruise Terminal construction shown to start with Phase-1 for depiction only, actual start will be different

Figure 9-1 Vizhinjam Port Implementation Schedule

# Annexure 1

## Master Plan Drawings for Port of Vizhinjam

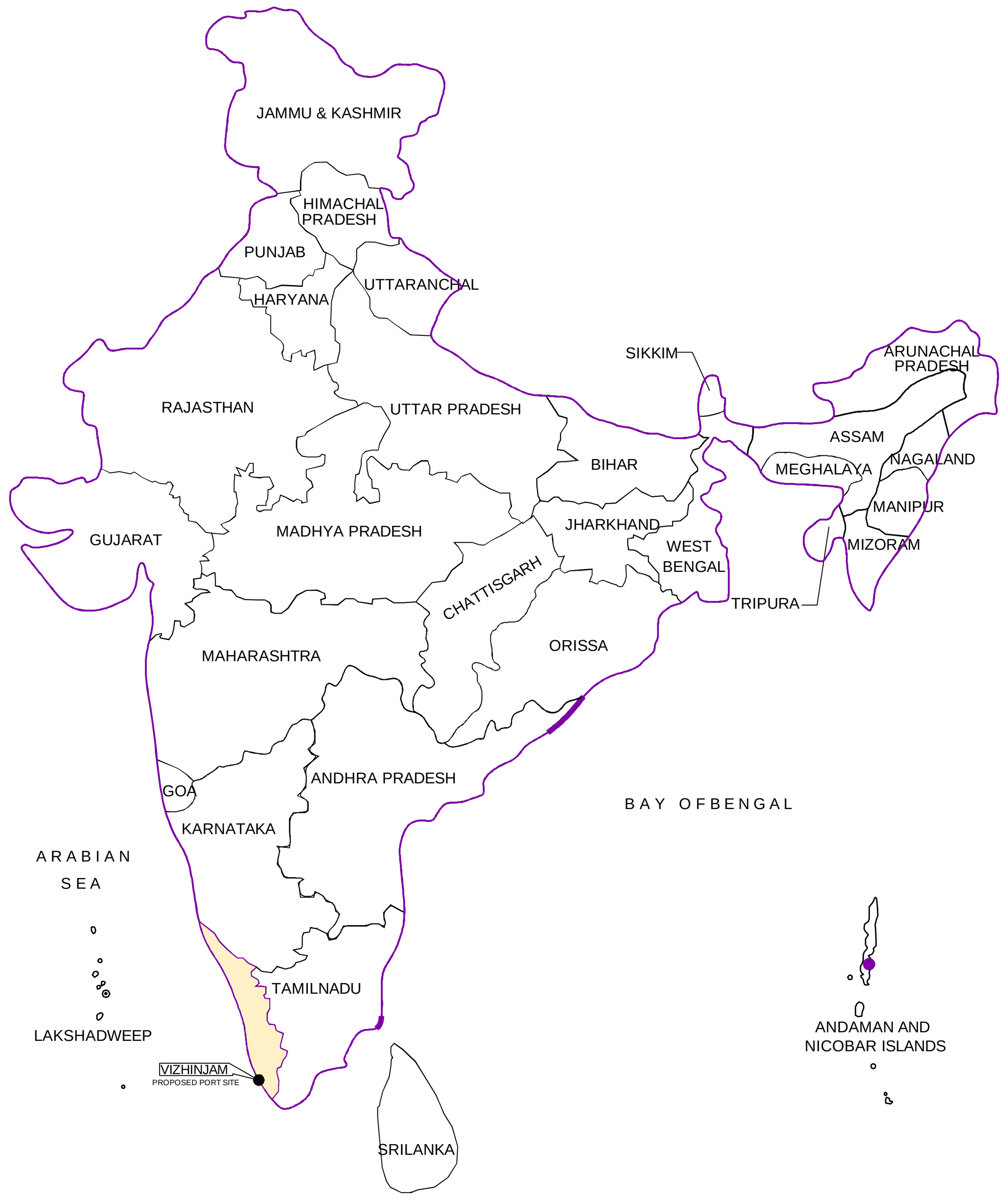
Prepared for

Vizhinjam International Seaport Limited (VISL)

Prepared by

**AECOM India Private Limited**

November 2012



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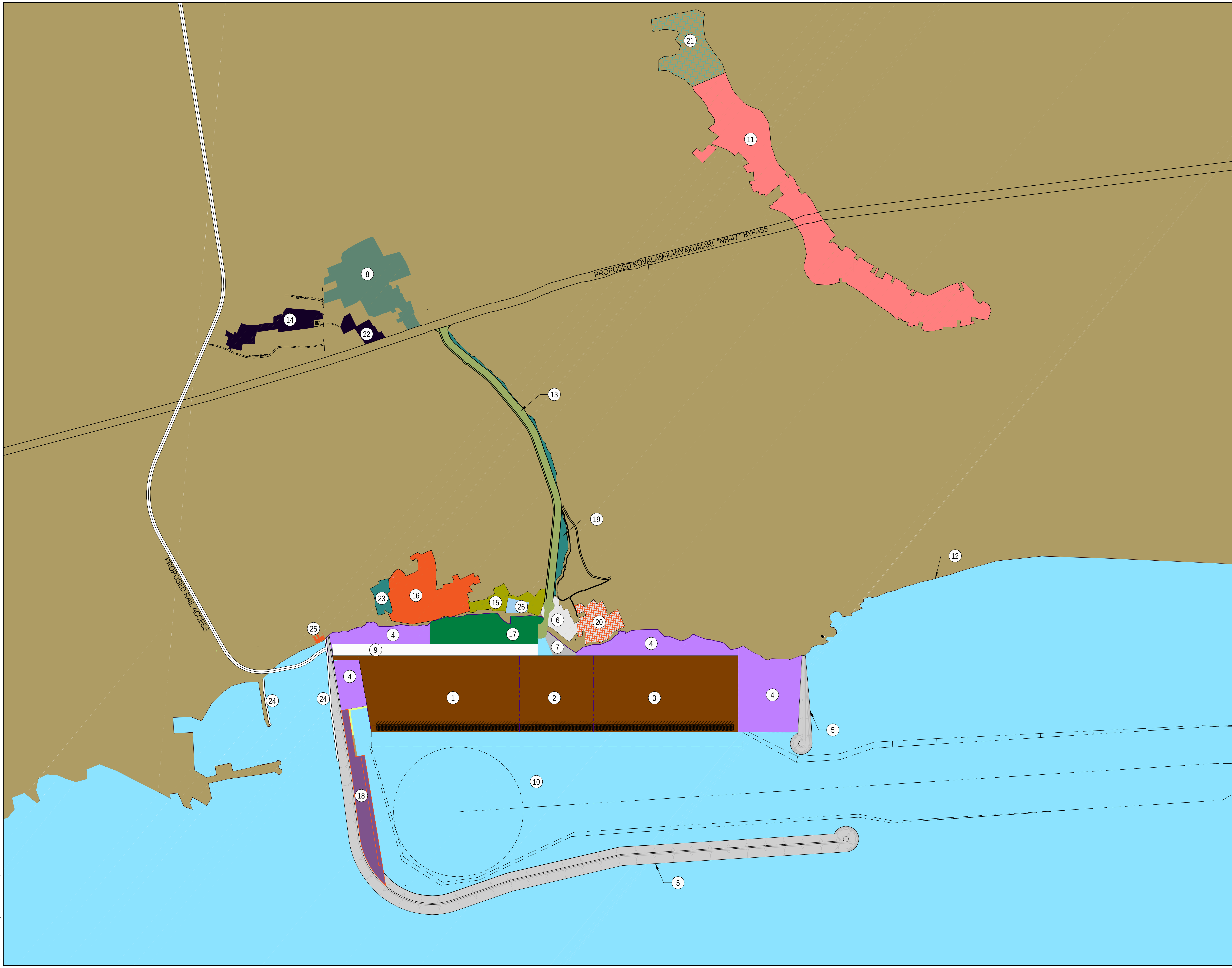
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

**VIZHINJAM PORT PROJECT**
**PLANNING AND ANALYSIS**

Sheet Title: SITE LOCATION MAP

Project Number: DELD11137
Sheet Number: 1 of 1
Drawing No.: DELD11137/MPR/1






## KEYNOTES

| | | |
|---|---|---|
| 1 | CONTAINER YARD PHASE-1 | 33 HA |
| 2 | CONTAINER YARD PHASE-2 | 16 HA |
| 3 | CONTAINER YARD PHASE-3 | 30 HA |
| 4 | FUTURE EXPANSION AREA | 30 HA |
| 5 | BREAKWATER AREA | 3.3 HA |
| 6 | AREA RESERVED FOR VISL PORT BUILDING AND OTHER USES | 2.1 HA |
| 7 | TERMINAL ADMIN. AREA | 1 HA |
| 8 | TRUCK TERMINAL/ FUEL FILLING & OTHER UTILITIES | 13.5 HA |
| 9 | RAIL TERMINAL | 6.8 HA |
| 10 | HARBOUR AREA WITH IN BREAKWATER | 167 HA |
| 11 | PORT BASED SEZ, ADDITIONAL WARE HOUSING & COMMERCIAL FACILITIES | 38 HA |
| 12 | SHORE LINE | NA |
| 13 | ROAD ACCESS CORRIDOR | 11.7 HA |
| 14 | PORT OPERATOR'S COLONY | 4.9 HA |
| 15 | AREA TO BE PROCURED FOR PORT OPERATOR UTILITY FOR PHASE - 1 & 2 & RAIN / NATURAL DRAIN WATER HARVESTING AREA & SUBSTATION | 6.1 HA |
| 16 | CRUISE SERVICE AREA | 7.5 HA |
| 17 | TERMINAL GATE AREA | 7.5 HA |
| 18 | CRUISE BERTHING AREA | 5.5 HA |
| 19 | PRE - GATE AREA | 1.3 HA |
| 20 | PORT OPERATOR UTILITY AREA PHASE - 3 | 4 HA |
| 21 | VISL COLONY AREA | 9 HA |
| 22 | VISL 220KV SUBSTATION | 1.2 HA |
| 23 | COAST GUARD AREA | 1.5 HA |
| 24 | FISHING BERTHS | NA |
| 25 | AUCTION HALL, NET MENDING FACILITY FOR FISHING LANDING BERTHS | 0.14 HA |
| 26 | RAIN WATER HARVESTING AREA | 0.8 HA |

## LEGEND

- CONTAINER YARD
- CRUISE BERTING AREA
- BREAKWATER
- LAND AREA
- SEA AREA
- FUTURE EXPANSION AREA
- PORT BASED SEZ / COMMERCIAL FACILITIES
- ROAD ACCESS
- TRUCK TERMINAL
- SEA AREA
- ADDITIONAL PORT STAFF RESIDENCE AREA
- ADDITIONAL PORT STAFF RESIDENCE AREA
- TERMINAL GATE AREA

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# VIZHINJAM PORT PROJECT PLANNING AND ANALYSIS

Sheet Title: LAND USE PLAN

Project Number: DELD11137

Sheet Number: 1 of 1

Drawing No. DELD11137/MPR/ 2


## KEYNOTES

1. ADMINISTRATION BUILDING
2. ENTRY / EXIT GATE CANOPY
3. SECURITY GUARD BOOTH
4. PRE - GATE
5. CUSTOMS BUILDING
6. GATE STAFF BUILDING
7. MAINTENANCE & REPAIR AREA AND BUILDING
8. QUAY CRANE MAINTENANCE & MARINE OPERATIONS BUILDING
9. VISL PORT ADMINISTRATIVE BUILDING
10. RAILWAY STATION MASTER BUILDING
11. SUB STATION & UTILITY AREA
12. YARD OPERATIONS BUILDING
13. EXISTING FISHING HARBOUR
14. LOADED BOX STORAGE
15. EMPTY BOX STORAGE
16. REFER STORAGE
17. REFER WASH AREA
18. REFER SERVICE & GENSET AREA
19. EQUIPMENT STORAGE
20. ITV STORAGE / TERMINAL BUILDINGS
21. HAZARDOUS CARGO AREA
22. POV PARKING / TERMINAL BUILDINGS
23. FISH LANDING BERTHS
24. FUTURE EXPANSION AREA
25. CONTAINER BERTHS
26. CRUISE BERTHS
27. COAST GUARD BERTH
28. PROVISIONAL COAST GUARD AREA / CRUISE CUSTOM CHECK IN AREA
29. PORT CRAFT BERTH
30. EXISTING TEMPLE
31. TURNING CIRCLE 700MØ
32. APPROACH CHANNEL
33. NORTH BREAKWATER (3960M LONG)
34. SOUTH BREAKWATER (475M LONG)
35. PROPOSED RAIL ACCESS CORRIDOR
36. MAIN PORT ACCESS ROAD
37. AUCTION HALL, NET MENDING FACILITY FOR FISH LANDING BERTHS
38. 12500 TEU CONTAINER VESSELS
39. 9000 TEU CONTAINER VESSELS
40. HIGH MAST LIGHTING POLE (TYP.)
41. FIRE STATION
42. RAIN WATER HARVESTING AREA
43. OPERATOR UTILITY AREA (PHASE - 1 & 2)
44. OPERATOR UTILITY AREA (PHASE - 3)
45. CRUISE AREA ACCESS
46. LIQUID BERTH

## LEGEND

- BUILDINGS
- POV / TERMINAL EQUIPMENTS PARKING AREA
- BREAKWATER
- LAND AREA
- SEA AREA
- FUTURE EXPANSION AREA

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Sheet Title: RECOMMENDED PORT MASTER PLAN
Project Number: DELD11137
Sheet Number: 1 of 1
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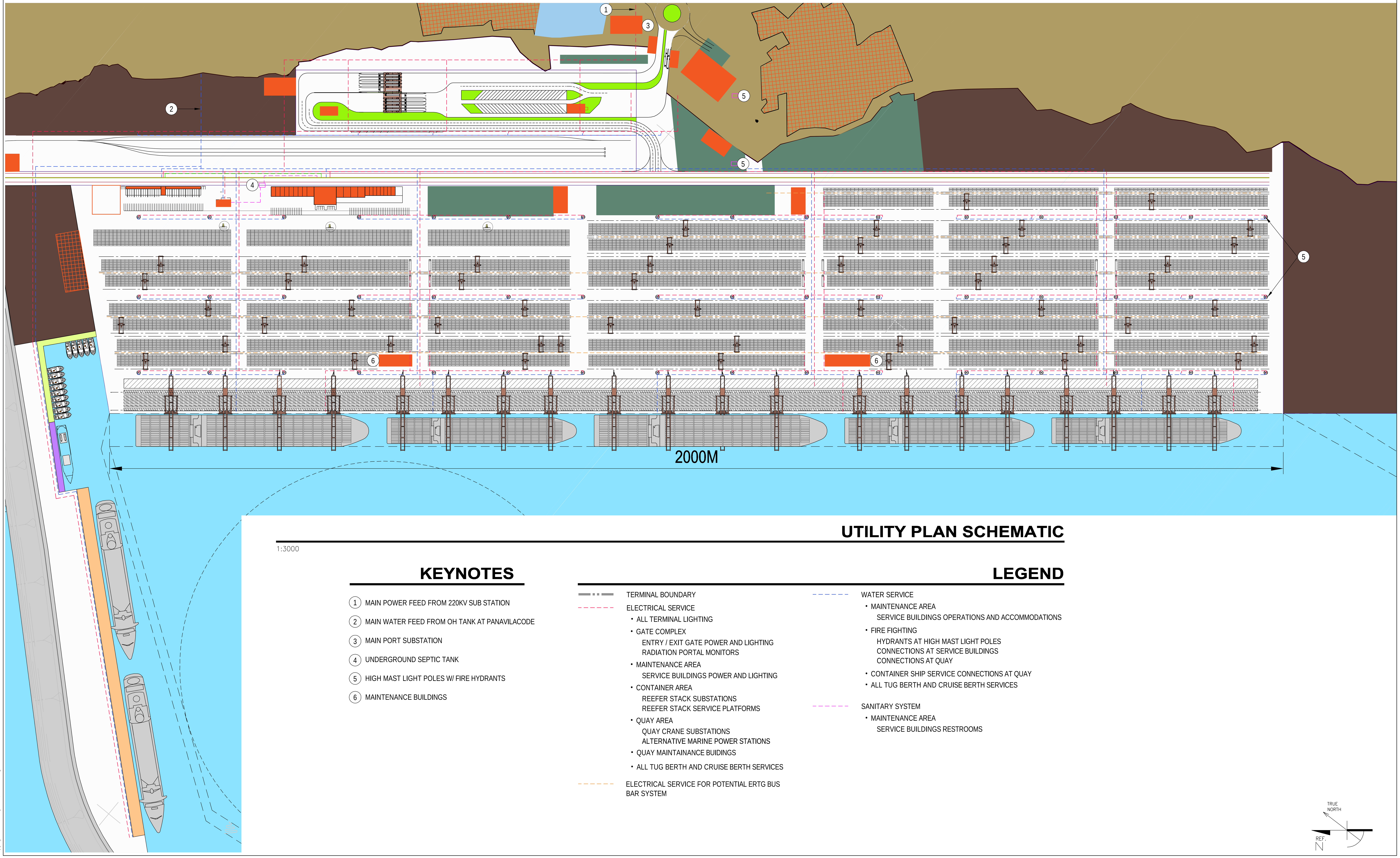


## UTILITY PLAN SCHEMATIC

1:3000

### KEYNOTES

1. MAIN POWER FEED FROM 220KV SUB STATION
2. MAIN WATER FEED FROM OH TANK AT PANAVILACODE
3. MAIN PORT SUBSTATION
4. UNDERGROUND SEPTIC TANK
5. HIGH MAST LIGHT POLES W/ FIRE HYDRANTS
6. MAINTENANCE BUILDINGS

### LEGEND

TERMINAL BOUNDARY

ELECTRICAL SERVICE
- ALL TERMINAL LIGHTING
- GATE COMPLEX
  - ENTRY / EXIT GATE POWER AND LIGHTING
  - RADIATION PORTAL MONITORS
- MAINTENANCE AREA
  - SERVICE BUILDINGS POWER AND LIGHTING
- CONTAINER AREA
  - REEFER STACK SUBSTATIONS
  - REEFER STACK SERVICE PLATFORMS
- QUAY AREA
  - QUAY CRANE SUBSTATIONS
  - ALTERNATIVE MARINE POWER STATIONS
- QUAY MAINTAINANCE BUIDINGS
- ALL TUG BERTH AND CRUISE BERTH SERVICES

ELECTRICAL SERVICE FOR POTENTIAL ERTG BUS BAR SYSTEM

WATER SERVICE
- MAINTENANCE AREA
  - SERVICE BUILDINGS OPERATIONS AND ACCOMMODATIONS
- FIRE FIGHTING
  - HYDRANTS AT HIGH MAST LIGHT POLES
  - CONNECTIONS AT SERVICE BUILDINGS
  - CONNECTIONS AT QUAY
- CONTAINER SHIP SERVICE CONNECTIONS AT QUAY
- ALL TUG BERTH AND CRUISE BERTH SERVICES

SANITARY SYSTEM
- MAINTENANCE AREA
  - SERVICE BUILDINGS RESTROOMS

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Sheet Title: CONCEPTUAL UTILITIES MASTER PLAN

Project Number: DELD11137

Sheet Number: 1 of 1

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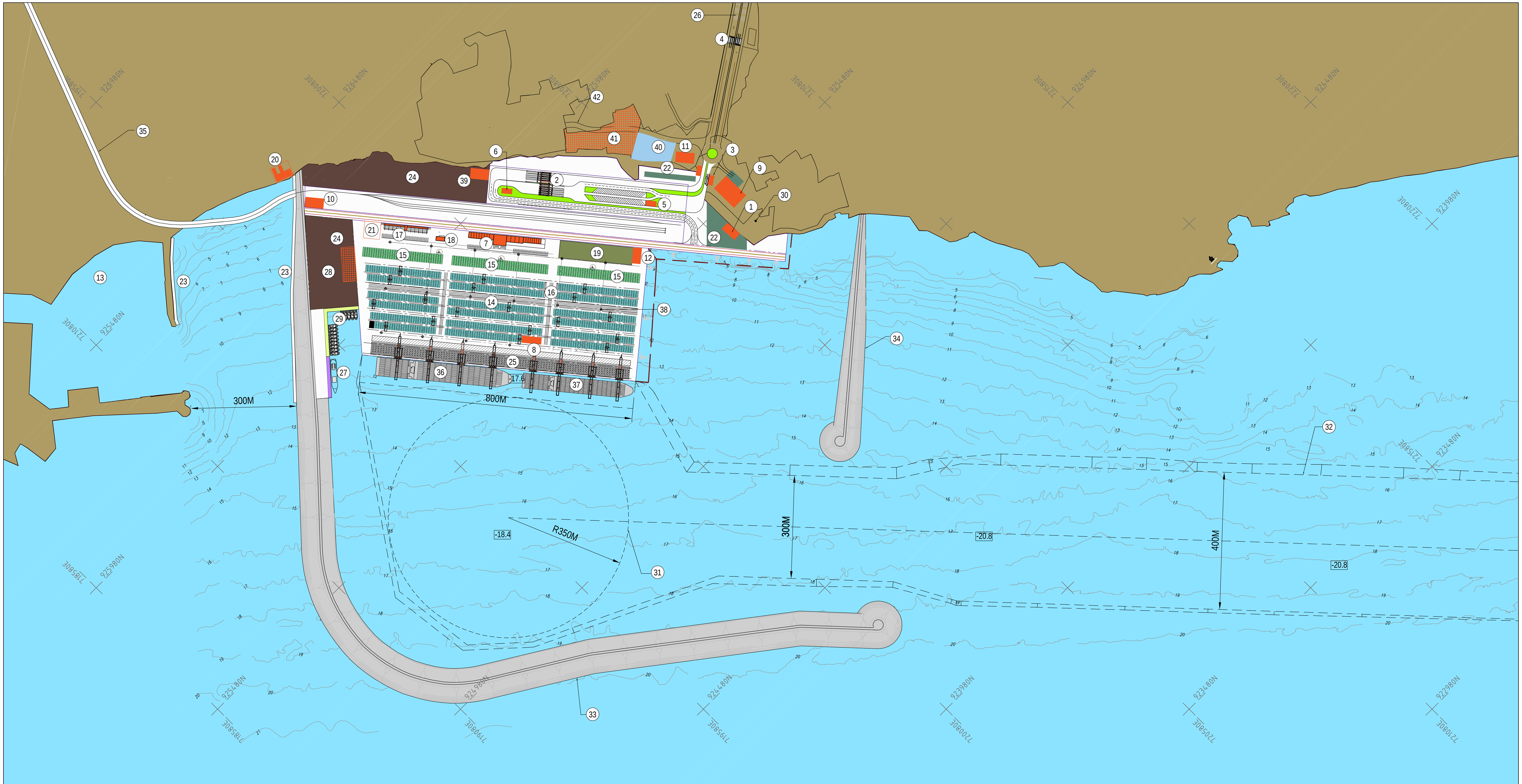


## KEYNOTES

1. ADMINISTRATION BUILDING
2. ENTRY / EXIT GATE CANOPY
3. SECURITY GUARD BOOTH
4. PRE - GATE
5. CUSTOMS BUILDING
6. GATE STAFF BUILDING
7. MAINTENANCE & REPAIR AREA AND BUILDING
8. QUAY CRANE MAINTENANCE & MARINE OPERATIONS BUILDING
9. VISL PORT ADMINISTRATIVE BUILDING
10. RAILWAY STATION MASTER BUILDING
11. SUB STATION & UTILITY AREA
12. YARD OPERATIONS BUILDING
13. EXISTING FISHING HARBOUR
14. FULL BOX STORAGE
15. LOADED BOX STORAGE
16. REFER STORAGE
17. REFER WASH AREA
18. REFER SERVICE & GENSET AREA
19. EQUIPMENT STORAGE
20. AUCTION HALL, NET MENDING FACILITY FOR FISH LANDING BERTHS
21. HAZARDOUS CARGO AREA
22. POV PARKING
23. FISH LANDING BERTHS (8M WIDE)
24. FUTURE EXPANSION AREA
25. CONTAINER BERTHS
26. MAIN PORT ACCESS ROAD
27. COAST GUARD BERTH
28. PROVISIONAL COAST GUARD AREA
29. PORT CRAFTS BERTH
30. EXISTING TEMPLE
31. TURNING CIRCLE 700MØ
32. APPROACH CHANNEL (300M WIDE)
33. NORTH BREAKWATER (3040M LONG)
34. SOUTH BREAKWATER (725M LONG)
35. PROPOSED RAIL ACCESS CORRIDOR
36. 12500 TEU CONTAINER VESSEL
37. 9000 TEU CONTAINER VESSEL
38. HIGH MAST LIGHTING POLE (TYP.)
39. FIRE STATION
40. RAIN WATER HARVESTING AREA
41. OPERATOR UTILITY AREA (PHASE - 1 & 2)
42. CRUISE AREA ACCESS

## LEGEND

- BUILDINGS
- POV / TERMINAL EQUIPMENTS PARKING AREA
- BREAKWATER
- LAND AREA
- SEA AREA
- FUTURE EXPANSION AREA

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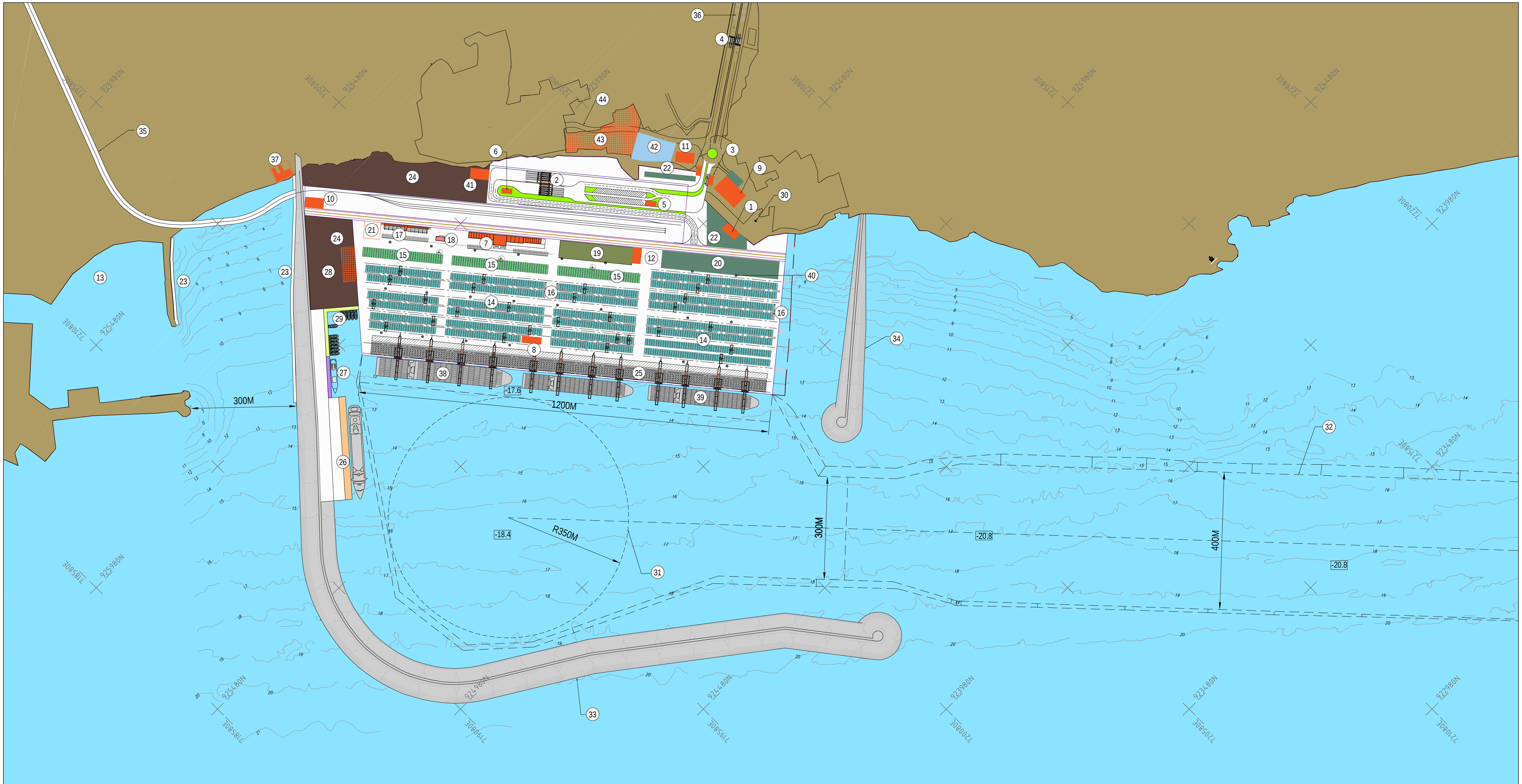
Sheet Title: RECOMMENDED PORT PHASE-1 PLAN

Project Number: DELD11137

Sheet Number: 1 of 1

Drawing No.: DELD11137/MPR/5




## KEYNOTES

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4. PRE - GATE
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6. GATE STAFF BUILDING
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44. CRUISE AREA ACCESS

## LEGEND

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- POV / TERMINAL EQUIPMENTS PARKING AREA
- BREAKWATER
- LAND AREA
- SEA AREA
- FUTURE EXPANSION AREA

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Sheet Title: RECOMMENDED PORT PHASE–II PLAN
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Sheet Title
RECOMMENDED PORT MASTER PLAN OVERVIEW

Project Number
DELD11137

Sheet Number
1 of 1

Drawing No.
DELD11137/MPR/ 7

# Annexure 2

## Marine Geotechnical Investigations

Prepared for

Vizhinjam International Seaport Limited (VISL)

Prepared by

**AECOM India Private Limited**

November 2012

# Marine Geotechnical Investigations

Marine geotechnical investigations were undertaken by M/s. Fugro Geotech Pvt. Ltd. The location plan of marine boreholes conducted at site is presented in Figure A2.1.

Specific borehole data has been utilised to prepare soil profiles to study the distribution of the sub strata and assess the geotechnical conditions of the particular component. The various soil profiles along the important components of the port are shown in FigureA2.2 to FigureA2.5 respectively

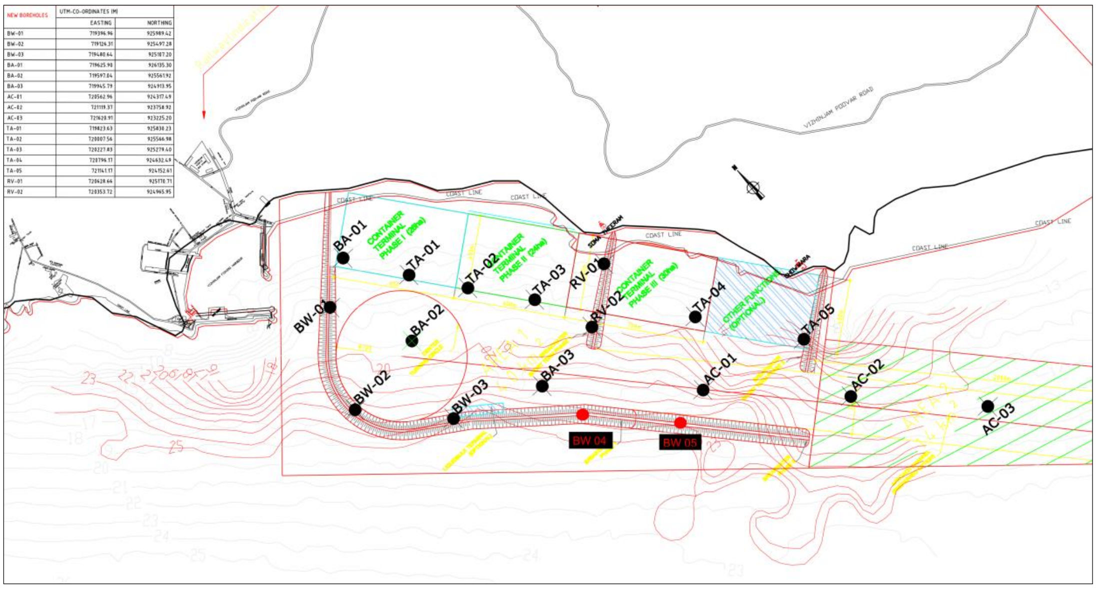



**Figure A2.1** **Borehole locations for Marine geotechnical investigations**

**Soil Profile 1:** Along Northern Breakwater (BW 02, 03, 04, 05)

The top layer is loose to medium dense silty sand with shell fragments. The depth of this layer varies from 5 m at the north to 21 m along the south of the breakwater. This layer is underlain immediately by a layer of very dense clayey sand. This layer is underlain with very dense sand with gravels in In borehole BW 02. The dense sub soil layer of very dense silty clayey sand is observed in all the profile boreholes which continue up to the termination depth of the borehole. The profile boreholes were terminated at an average depth of -50 m CD.

**Soil Profile 2:** Along Basin and Approach channel (BW 01, BA 02, BA 03, AC 01, AC 02, AC 03)

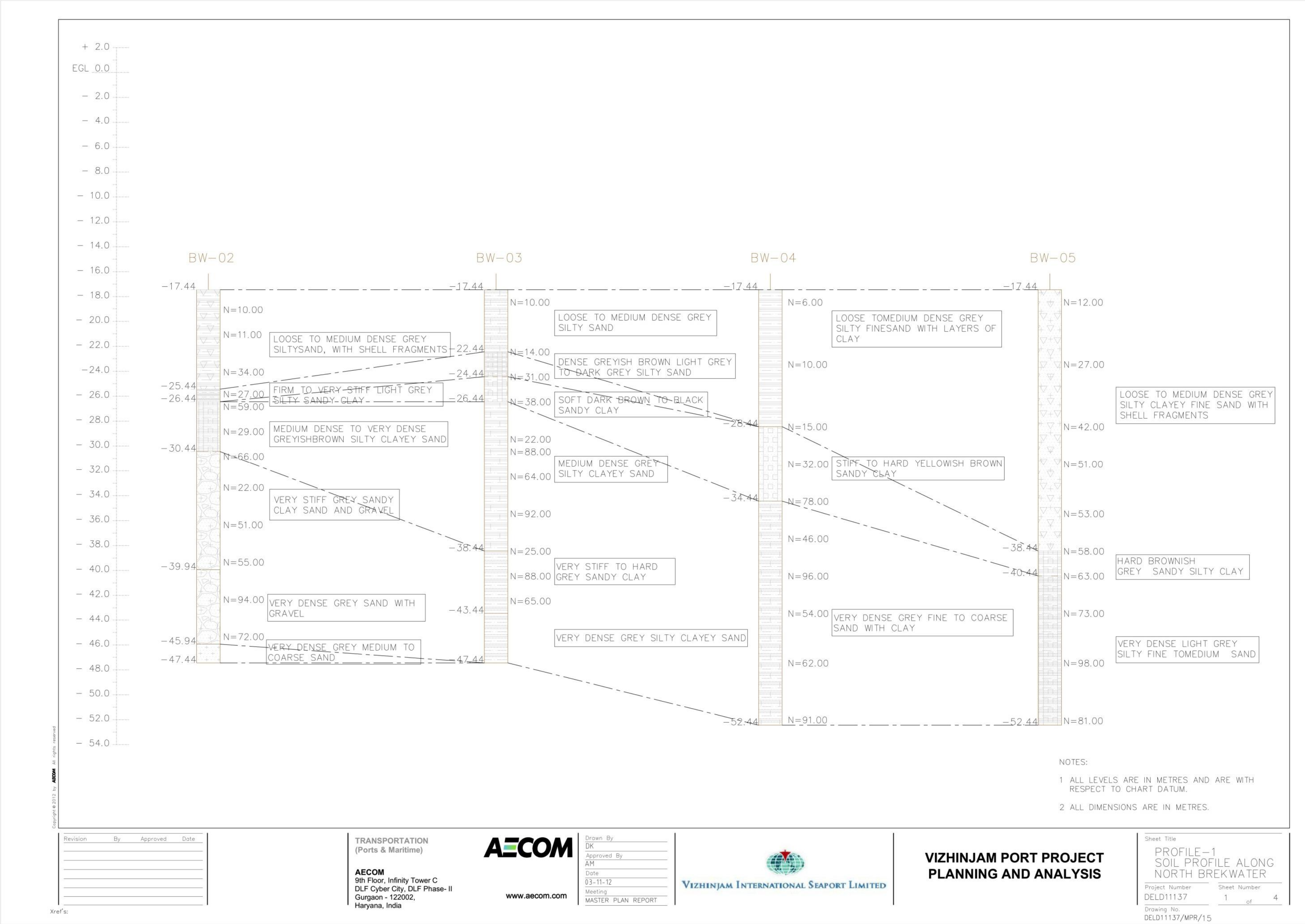
The top layer of all the boreholes along this profile is loose to very dense grey silty fine sand with shell fragments. This layer is followed with the layer of stiff to very dense silty clayey sand which continues up to the termination depth in BW 01. The borehole was terminated at the depth of -47m CD while rest of the other boreholes in the channel were terminated at an average depth of -24m CD.

**Soil Profile 3:** Along Container Berths (BA 01, TA 01, TA 02, TA 03, TA 04, TA 05)

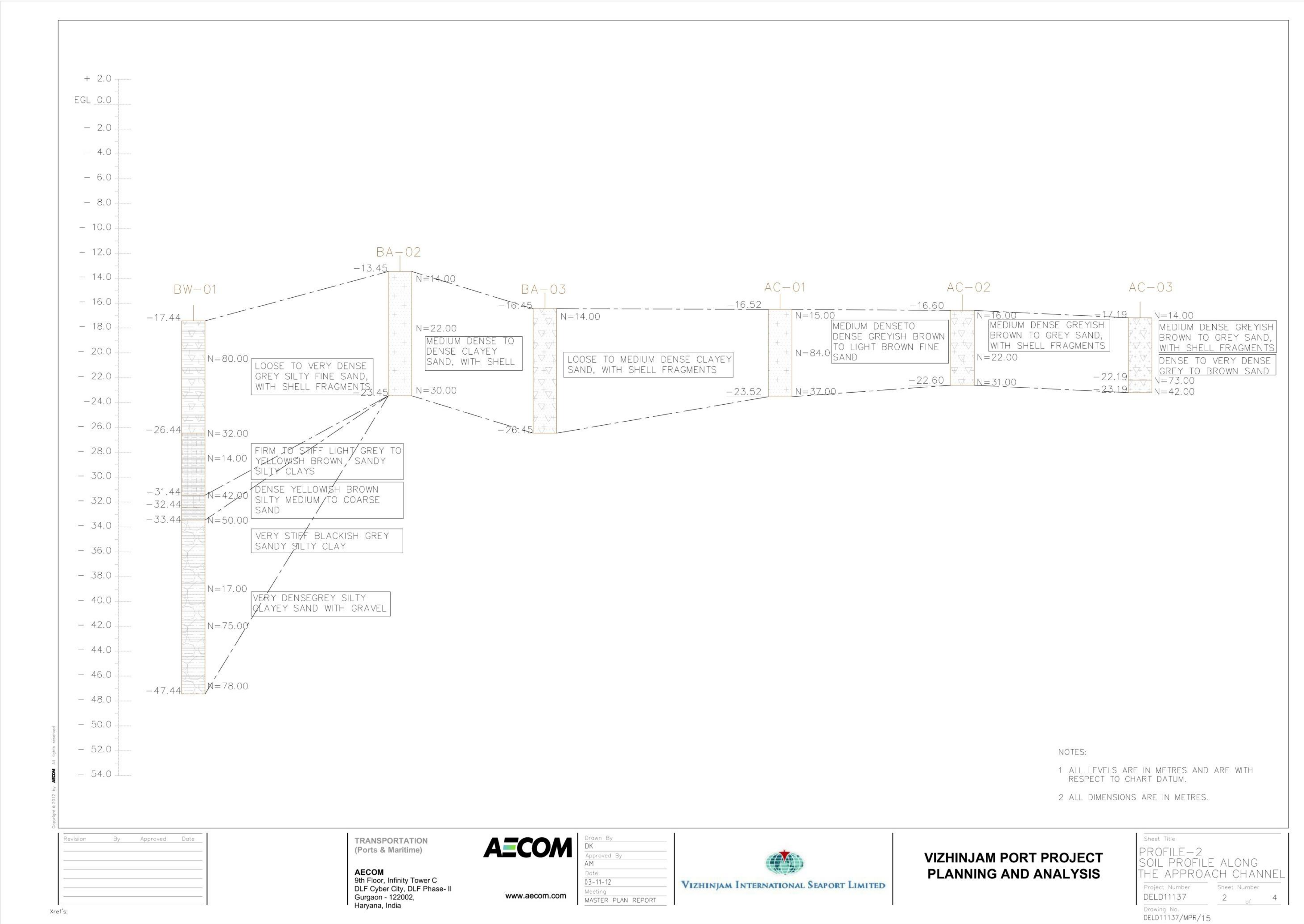
The top layer in this profile is loose to medium dense clayey sand with the shell fragments as well as some portion of weathered rock fragments. The subsequent layer in this profile is of whethered charnockite ranging from weak to strong in nature. Hard rock in the form of Gneiss and Khandalite is encountered in borehole TA 04. Borehole TA 02, 03 and 04 were terminated at an average depth of -50m CD where the refusal layer was encountered while in the other borehole the termination depth were at -30m CD.

**Soil Profile 4:** Along the Inner Southern Breakwater (RV 01, RV 02)

The top layer along this profile is of silty sand. The depth of this layer varied from 2m close to the shore to 12m near the tip of the breakwater. A layer of weathered moderately strong rock of gneiss is sandwiched between the top layer and the layer of moderately weathered rocky layer of Khandolite which continues up to the borehole termination depth. RV 01 was terminated at -31m CD while RV 02 was terminated at -52m CD where the refusal layer was encountered.




**FigureA2.2** **Soil Profile 1**




FigureA2.3 Soil profile 2

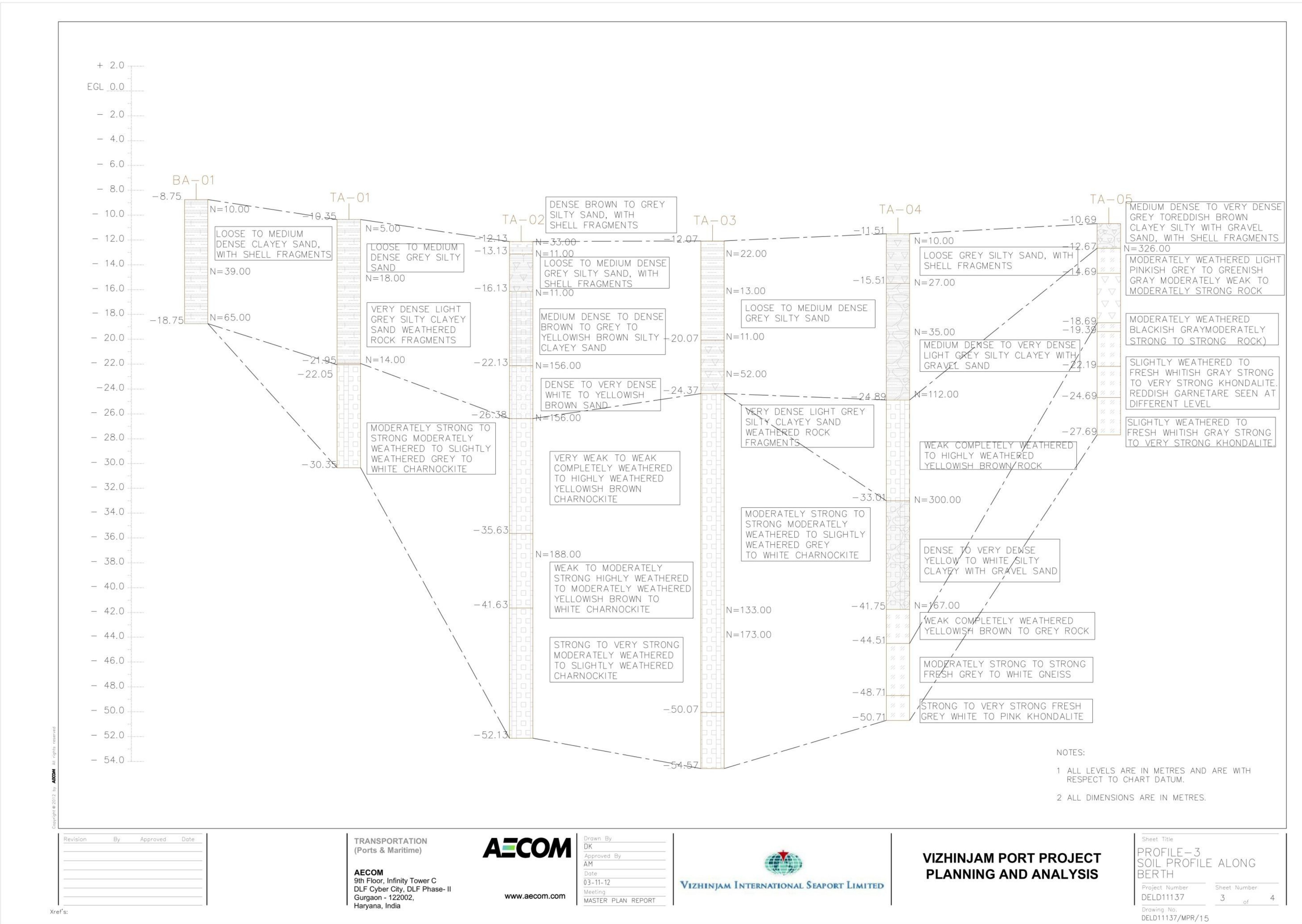
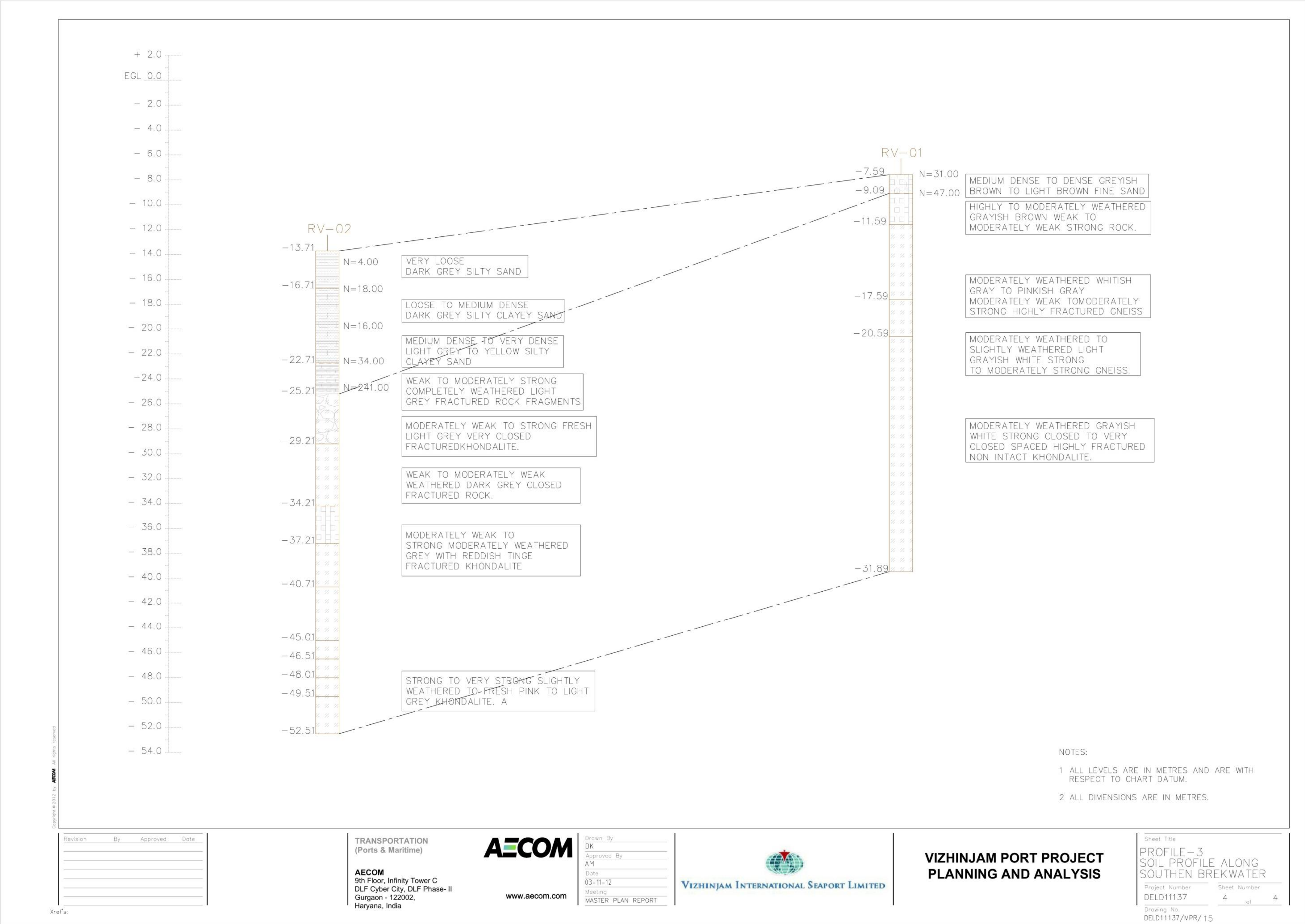



**Figure A2.4** Soil profile 3




**FigureA2.5** **Soil profile 4**

# Annexure 3

## Container Trans-shipment Port Comparison Analysis

Prepared for

Vizhinjam International Seaport Limited (VISL)

Prepared by

**AECOM India Private Limited**

November 2012

# Container Trans-shipment Port Comparison Analysis

The Port of Vizhinjam is coming up with the container transshipment business vision. It is necessary to carryout study for vital parameters such as productivity, throughputs, capacity, etc for benchmarking it with the existing transshipments facilities in the nearby region. The practice adopted by the container transshipment terminals/ports and their operational behavior in vicinity of Port of Vizhinjam, with direct business or competition needs to be studied. Port of Vizhinjam is falling very near to the International Marine Trade Route comparing any other Indian ports which gives the direct opportunity to develop as transshipment terminal to it. The International Marine Route is shown in Figure A3. 1.

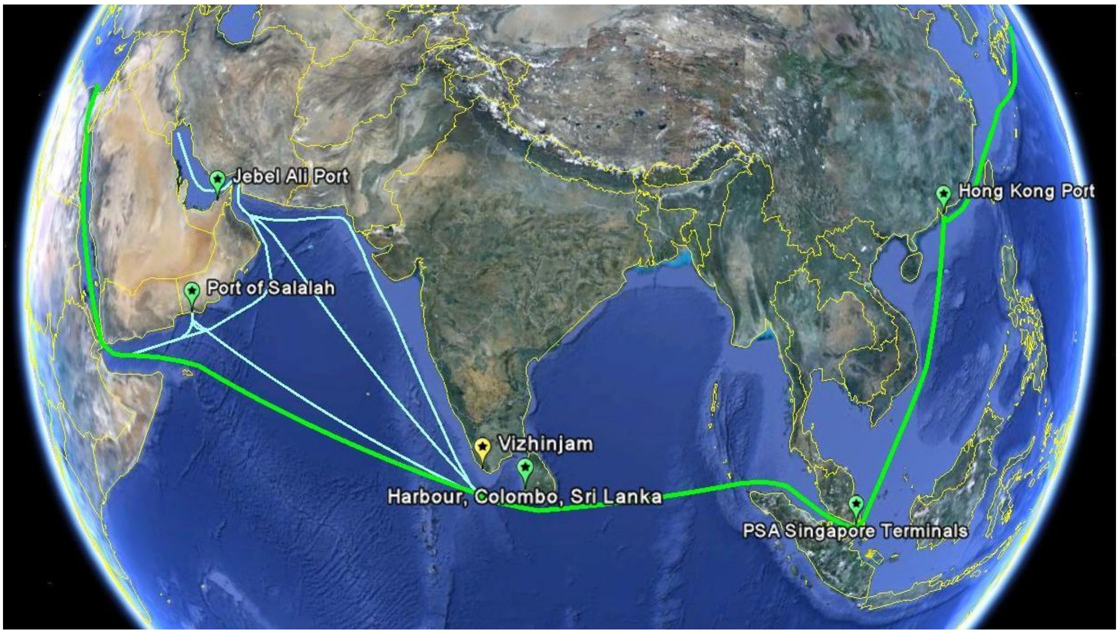



Figure A3. 1 Route map of International Marine Route (Google Earth)

This figure is showing the International Marine Routes and the major Container Transshipment Terminals/Ports. The GREEN Route indicates main marine route connecting East to West via Suez Canal and Sky-Blue Routes indicate the container transshipment handled by Ports in the Gulf and later merge to main marine route. The locations of Port of Vizhinjam and other transshipment terminals are indicated.

The comprehensive study of the surrounding terminals/ports have been taken up, selected terminals/ports are:

- Jebel Ali Port, Dubai
- Port of Salalah, Oman
- Colombo, Shri Lanka
- PSA Terminals
- Singapore and Hong Kong Port.

The major transshipment terminals/ports discussed above were studied for various terminal parameters ranging from terminal dimensions to terminal operations. The observed parameters are as under:

1) **Quay crane type and total numbers:**
   This data gives idea about the type of quay crane and average number of quay cranes per vessel operation.

2) **Total berths and berth details:**
   Number of Berths, the Length of the birth and berth operation for either mainline vessels and/or feeder vessels

3) **Maximum size container vessel which can be called at that port:**
   This is one of the most important parameter in benchmarking. Ports infrastructure limits the maximum size container vessel which can be called by that port. Size of maximum TEU capacity ship is constraint by its length, draft and beam. Port should have sufficiently large turning basin to turn big main line container vessels. Dredged depth alongside berths and approach channel limits draft of a vessel. From the quay side facilities, berths should have long reach quay cranes to handle wide beam modern container ships.

4) **Dredged depth alongside berth:**
   This gives an idea about current maximum draft available for vessel which can be handled by the terminal.

5) **Total terminal area:**
   This shows the dedicated gross terminal area for a container terminal. It represent the terminal capacity indirectly.

6) **Annual throughput (approx.):**
   Quay site container throughputs for major container terminals have been referred and analysed for different transshipment terminals. It is important to note that throughputs of major transshipment terminals which mainly handle transshipment traffic with gateway traffic at smaller percentage size to the total volume of container handling are highly inflated, due to the fact that a transshipment container is handled twice which is counted as two for throughput estimation.

7) **Total berth length:**
   Total berth length gives an idea about total quay side available in a terminal. It includes combined feeder plus mainline vessel berths.

8) **Average berth length per berth:**
   There is no general guide line for it but it is generally represented by dividing the total quay length by number of berths. It also gives the idea of terminal planning and future provision and capability to accommodate larger size vessels.

9) **Annual throughput per Quay Crane (TEU/QC):**
   This productivity factor is calculated by dividing total throughput by total number of Quay Cranes (QC) deployed at the terminal. It is indirectly represents the crane efficiency. So the higher ratio represents the higher efficiency of vessel operation.

10) **Annual throughput per gross acre (TEU/acre):**

Annual throughput per gross acre is estimated by dividing total throughput by total gross terminal area. This parameter gives an idea about area wise capacity ulitisation of a particular container terminal. It also gives indirect idea about the container yard capacity. Higher ratio of this parameter represents the higher terminal operation efficiency.

11) **Annual throughput per berth length (TEU/meter):**
Annual throughput per berth length is obtained by dividing total throughput by total berth length. This figure illustrates quay size facilities utilization for a particular container terminal.

From the parameters discussed above the first eight parameters represents the terminal characteristics as capacity of the terminal infrastructure and rest three parameters give idea about efficiency of terminal operations.

Following provides a brief description of each port used in the comparison. Various benchmarking data of each port was sourced by doing online search and reviewing respective port website. The operation parameters for the Vizhinjam port are based on the AECOM PRECAP model discussed in Section 4.

**Port of Colombo, Shri Lanka:**

The Port of Colombo is the largest and busiest port in Sri Lanka as well as in South Asia. Located in Colombo, on the southwestern shores on the Kelani River, it serves as an important terminal in Asia due to its strategic location in the Indian Ocean. Colombo port container terminals will be the direct competition to VISL container terminal. The Colombo Port currently has three container terminals: Jaya Container Terminal (JCT), South Asia Gateway Terminal (SAGT - operated by John Keells Holdings) and Unity Container Terminal (UCT). UCT mainly handles small feeder vessels. Transshipment containers are being handled by JCT and SAGT. For the benchmarking study parameters from JCT and SAGT are used.

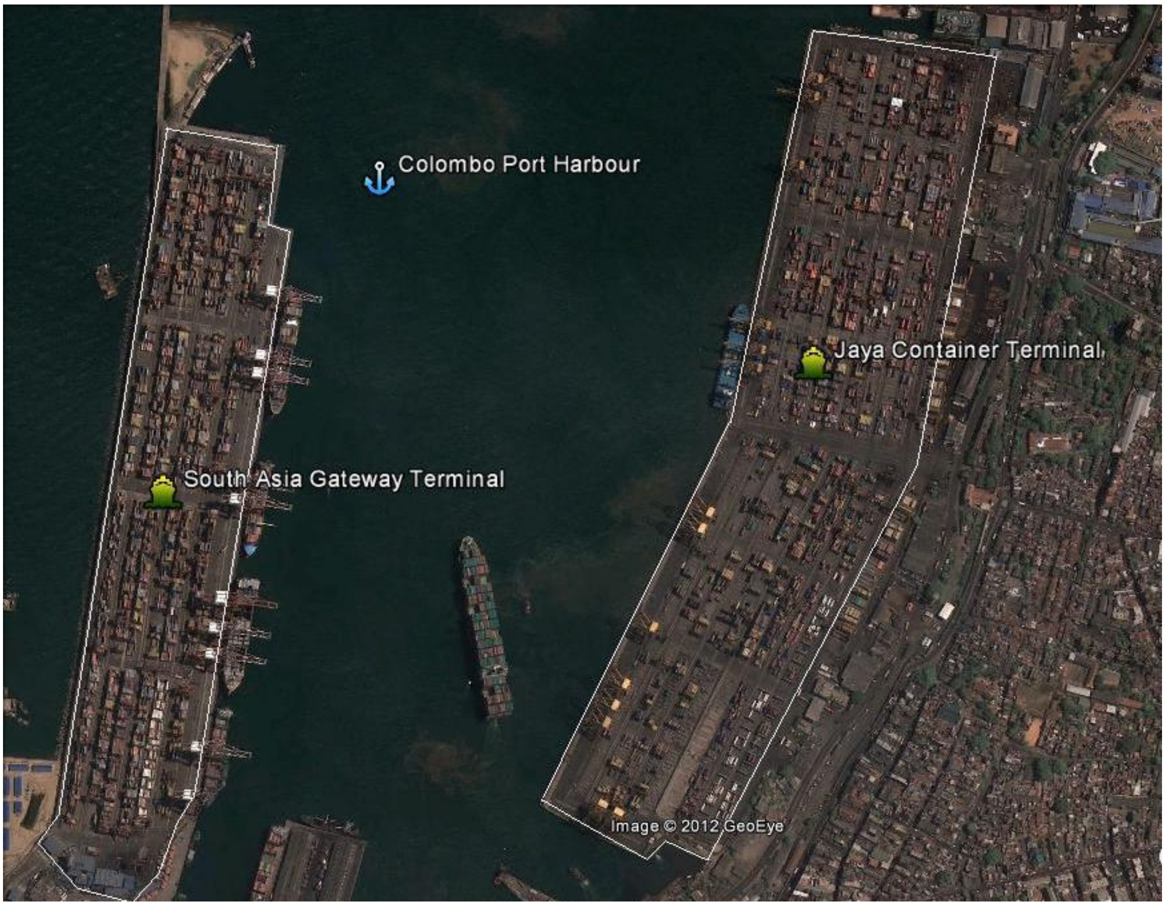



Figure A3 . 2 Colombo Port Container Terminals, Image Source: Google Earth

**Jebel Ali,Dubai,UAE:**

Jebel Ali Port is DP World’s largest flagship port, the world’s largest manmade harbour and the largest container port between Rotterdam and Singapore. Located 35 kilometres to the southwest of Dubai, the Port is situated at the gateway between the East and the West, and strategically positioned to be a natural hub for the global shipping industry that provides access to a market of 1.5 billion people.


Figure A3 . 3 Jebel Ali Port, Source: Google Earth

**Port of Salalah, Oman:**

Port of Salalah is a transshipment hub in the West Central Asia Region. Situated right at the major East-West shipping lanes, Salalah enjoys an attractive strategic location in the heart of the Indian Ocean Rim and caters to some of the world's largest ocean going vessels. Situated at the major East-West shipping lane, the Port of Salalah provides the location in order to access the Middle East the Indian Subcontinent, East Africa and the Indian Ocean Island with over 2.5 billion consumers.

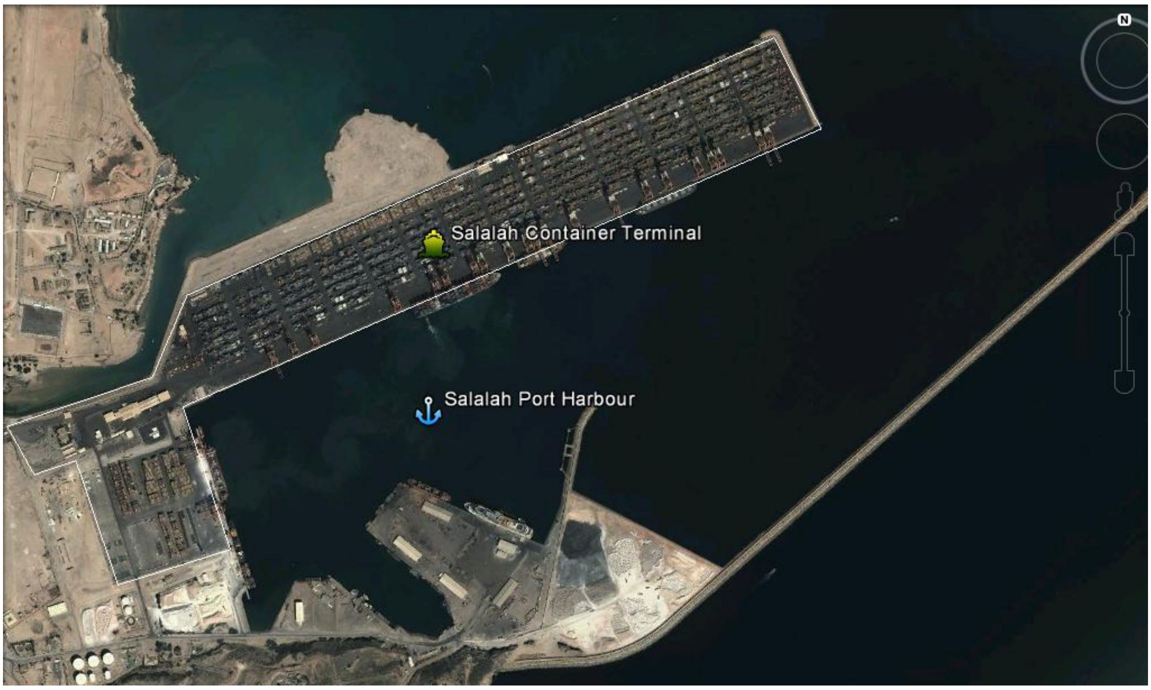



Figure A3 . 4 Salalah Port container terminals, Image Source: Google Earth

**PSA Singapore Terminals at Port of Singapore:**

The Port of Singapore refers to the collective facilities and terminals that conduct maritime trade handling functions in Singapore's harbours and which handle Singapore's shipping.

In Singapore, PSA Singapore operates five container terminals at Tanjong Pagar, Keppel, Brani and Pasir Panjang, with a total of 54 container berths.

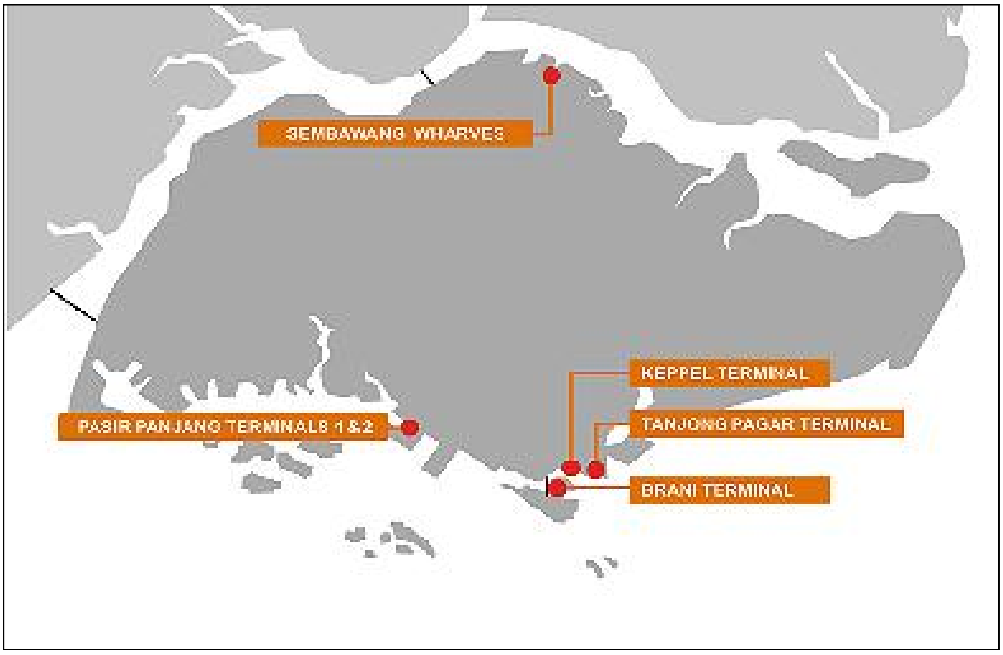



Figure A3 . 5 PSA Singapore container terminals, Source: PSA Webpage

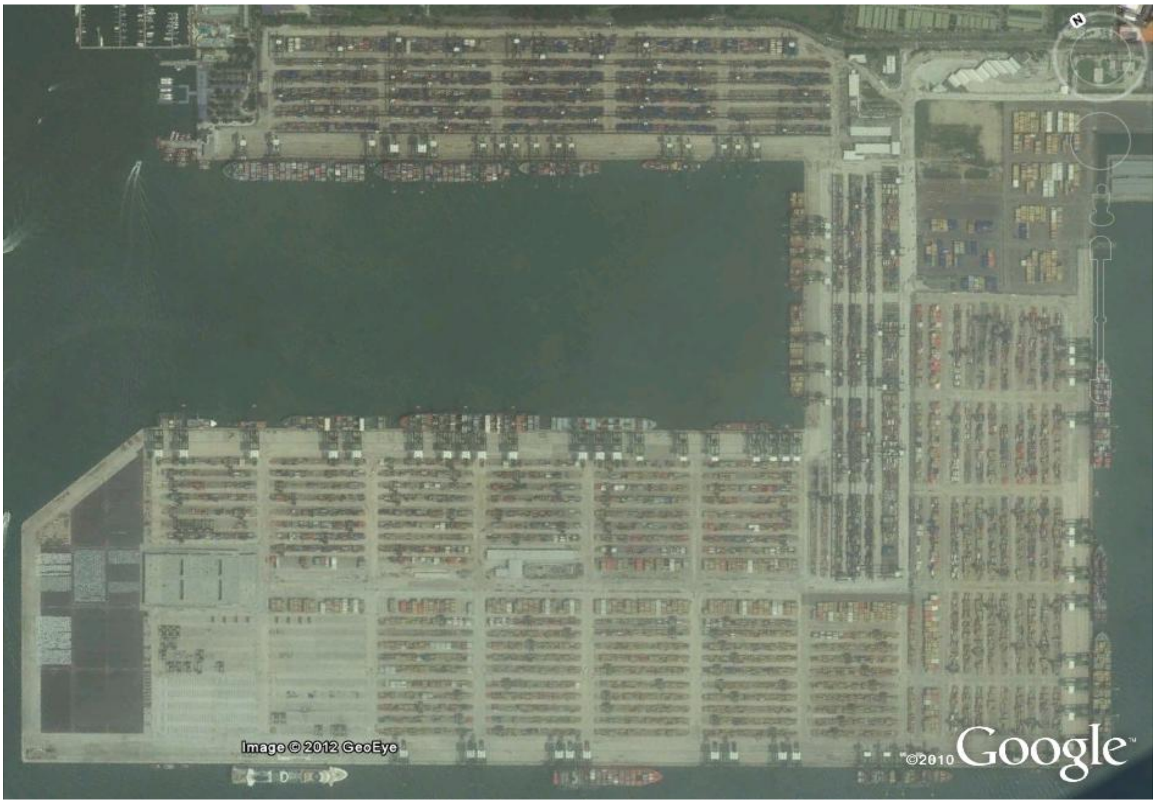


Figure A3 . 6 Pasir Panjang Container Terminal, PSA, Singapore; Image Source: Google Earth

Figure A3 . 7 (a) Keppel Terminal, (b) Tanjong Pagar Terminal, (c) Brani Terminal; Singapore Port; Image Source: Google Earth

**Hong Kong Port, Kwai Tsing Container Terminals:**

The Port of Hong Kong, located by the South China Sea, is a deepwater seaport dominated by trade in containerised manufactured products, and to a lesser extent raw materials and passengers. A key factor in the economic development of Hong Kong, the natural shelter and deep waters of Victoria Harbour provide ideal conditions for berthing and handling all types of vessels. It is one of the busiest ports in the world, in the three categories of shipping movements, cargo handled and passengers carried.

Kwai Tsing Container Terminals is the main port facilities in the reclamation along Rambler Channel between Kwai Chung and Tsing Yi Island, Hong Kong.

The port consists of 9 container terminals and they are operated by Modern Terminals Limited, DP International Limited, Hong Kong International Terminals Limited, COSCO and Asia Container Terminal Limited.

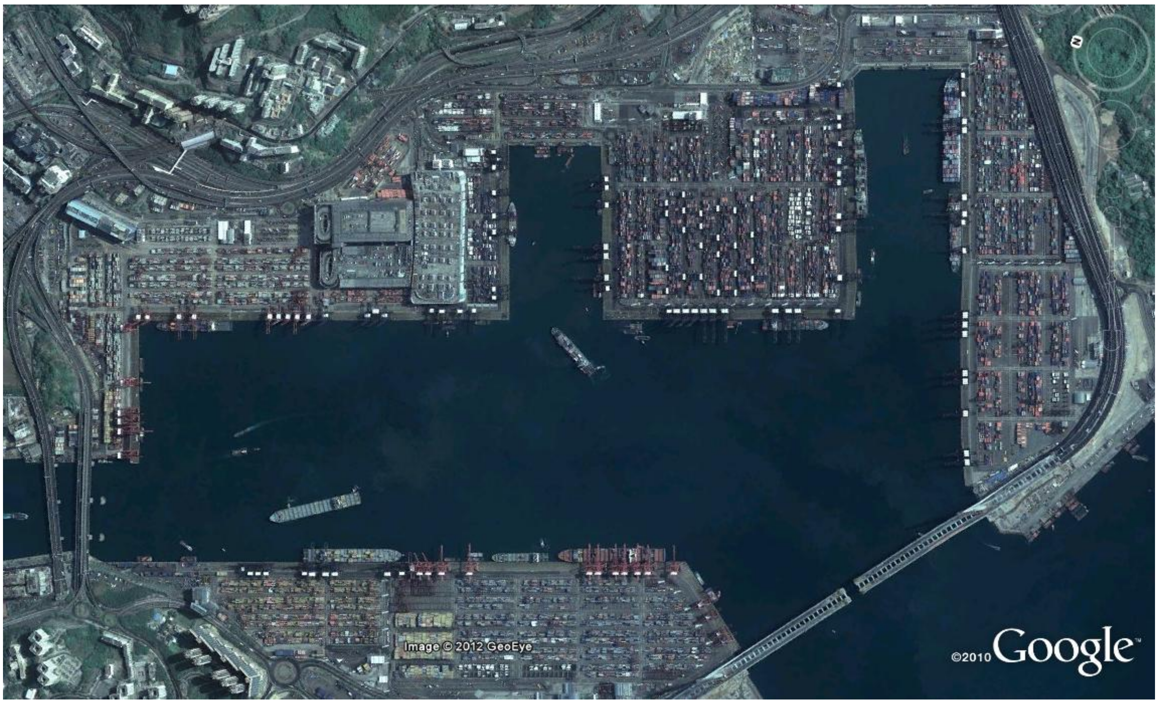



Figure A3 . 8 Hong Kong Port, Kwai Tsing Container Terminals, Image Source: Google Earth

Table A3 . 1 Container Transhipment Port Benchmarking Parameters

| Port Study Parameters | SAGT - Colombo | JCT - Colombo | Colombo Port - Total | Jebel Ali (Dubai) | PSA Singapore Combined | Salalah Port - Oman | Kwai Tsing Container Terminals - Hongkong | VISL Phase I | VISL Phase II | VISL Phase III |
|---|---|---|---|---|---|---|---|---|---|---|
| **Quay Crane Type and Numbers** | 10 QC | 20 QC | 30 QC | 79 QC | 192 QC | 25 QC | 104 QC | 8 QC | 12 QC | 20 QC |
| **Maximum Vessel Size in TEU, Draft (m), LOA(m)** | 10,000 TEU | 10,000 TEU | 10,000 TEU | 12,500 TEU* | 12,500 TEU* | 12,500 TEU* | 12,500 TEU* | 18,000 TEU | 18,000 TEU | 18,000 TEU |
| **Total Berths** | 3 | 6 | 9 | 22 | 52 | 7 | 37 | 2 | 3 | 5 |
| **Berth Datails** | 3 | 4 Main + 2 Feeder | 7 Main + 2 Feeder | 22 | 52 | 7 | 25 main + 12 Barge | 2 Container Berths | 3 Container Berths | 5 Container Berths |
| **Dredged Depth (m)** | 15 | 12 to 15 | 12 to 15 | 11 to 17 | up to 16.7 | 16 to 18 | up to 15.5 | 18 | 18 | 18 |
| **Total Terminal Area (acre)** | 68 | 104 | 176 | 815 | 1482 | 276 | 722 | 80 | 119 | 197 |
| **Estimated Throughput ('000 TEU)** | 1,950 | 2,000 | 3,950 | 13,000 | 29,370 | 3,500 | 17,416 | 900 | 1,800 | 3,350 |
| **Berth Length (m)** | 940 | 1,642 | 2,582 | 7,475 | 16,000 | 2,428 | 11,056 | 800 | 1,200 | 2,000 |
| **Average Berth Length (m/berth)** | 313 | 274 | 287 | 340 | 308 | 347 | 299 | 400 | 400 | 400 |
| **Berth Length (m) per QC** | 94 | 82 | 86 | 95 | 87 | 97 | 106 | 100 | 100 | 100 |
| **Annual throughput per quay crane ('000 TEU/QC)** | **195** | **100** | **132** | **165** | **153** | **140** | **167** | **113** | **150** | **168** |
| **Annual throughput per gross acre ('000 TEU/QC)** | **29** | **19** | **22** | **16** | **20** | **13** | **24** | **8** | **11** | **14** |
| **Annual throughput per berth length (TEU/meter)** | **2,074** | **1,218** | **1,530** | **1,739** | **1,836** | **1,442** | **1,575** | **1,130** | **1,500** | **1,680** |

*** Maximum vessel size as per Emma Mersk E Class container ship calls**

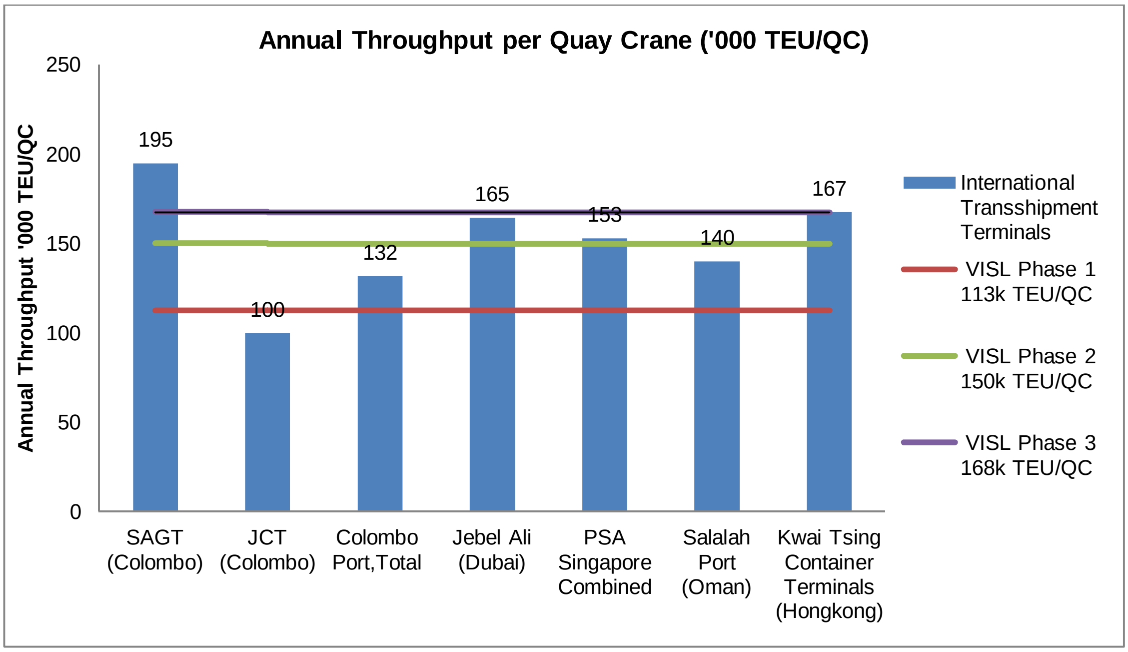



Figure A3 . 9 Graph of International Transshipment Terminal Annual Throughput V/S Quay Crane

Annual throughput per quay crane is shown in Figure A3 . 9.

Achieved throughput is varying from 100,000 TEU/QC to 195,000 TEU/QC. Colombo has achieved the highest throughput per QC based on 2011 year throughput handled. For the other transshipment terminals, it’s ranging from 131,000 to 167,000 per QC. For Vizhinjam port Phase 1, annual throughput per QC will be 113,000 TEU and for Phase 3 it will be 168,000 TUE/QC which is comparable to existing transshipment facilities in Colombo, Dubai, Singapore and Salalah.

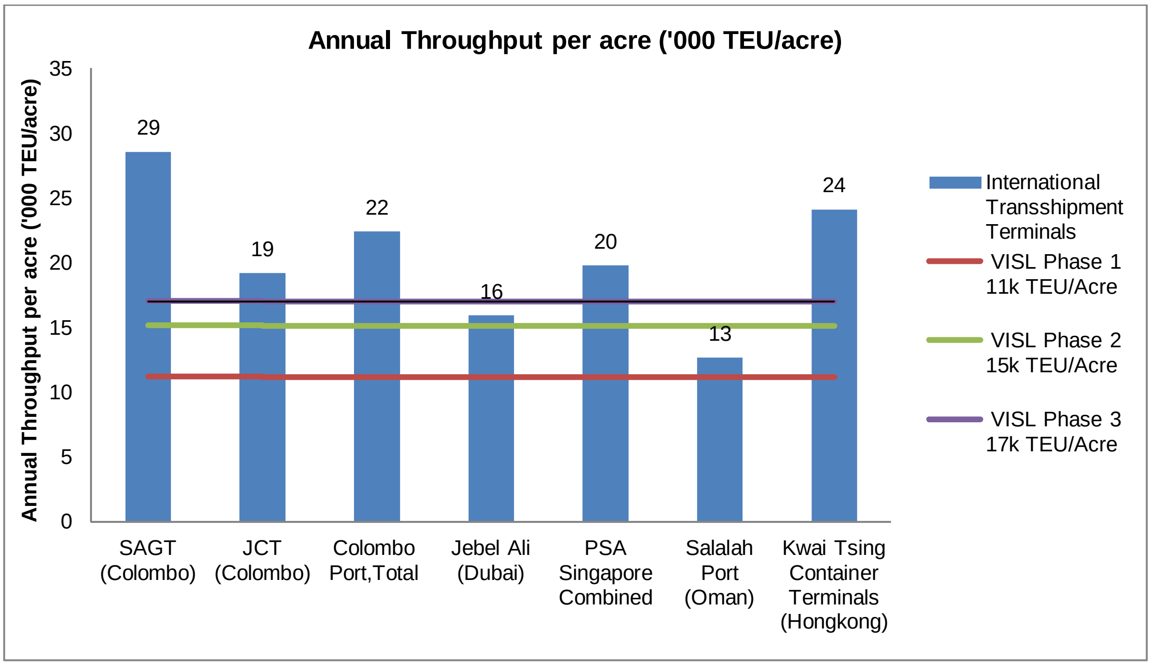



Figure A3 . 10 Graph of International Transshipment Terminal Annual Throughput V/S Terminal Area

Annual throughput achieved per gross terminal area is shown in Figure A3 . 10. Throughput per acre for major international terminals is around 20,000 TEU/acre. Colombo and Kwai Tsing Container Terminals have handled very high throughputs per acre terminal gross area. Other terminals such as Jebel Ali and Salalah are in expansion phase and their throughput volumes per acre of terminal area are expected to grow. For Vizhinjam port, initial throughput per acre is planned at 11,000 TEU for Phase 1 and it will grow upto 17,000 TEU/Acre in Phase 3, which will be comparable to the existing transshipment facilities in Salalah Port and Jebel Ali Port.

It should be noted that, planned storage capacity at Vizhinjam Port is based on a 5 days of dwell time. If this dwell time can be reduced even by 20% in future, Vizhinjam Port can also achieve similar TEU/Acre as being done by Colombo and Hongkong.

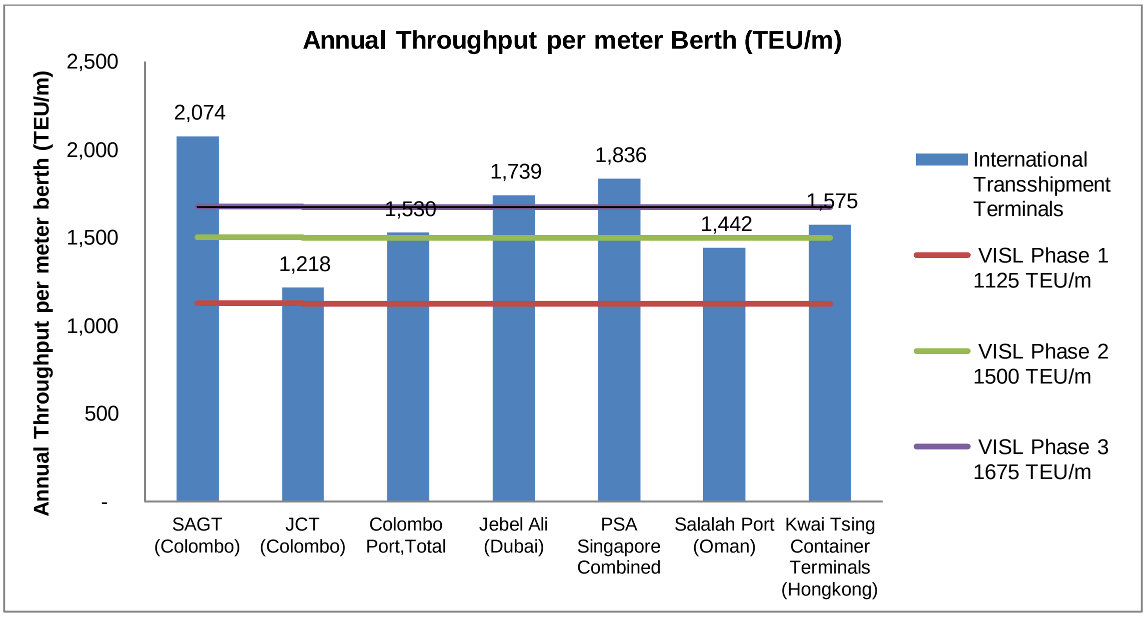



Figure A3 . 11 Graph of International Transshipment Terminal Annual Throughput V/S Berth Length

Annual Throughput per meter Berth in TEU/m is shown in Figure A3 . 11. Annual throughput per meter berth gives an idea about terminals berth side productivity. For all major international terminals its ranging from 1,200 TEU/m upto 2,000 TEU/m. SAGT Colombo terminal has achieved the highest throughput of 2074 TEU/m. The other two terminals with high throughput per meter berth are PSA Singapore and Jebel Ali, Dubai with throughput of 1,836 TEU/m and 1,739 TEU/m respectively. In Phase 1 Vizhinjam port is expected achieve 1125 TEU/m of berth productivity, which will increase up to 1,675 TEU/m in Phase 3.

The low berth productivity is attributed to gaining new market share with lower parcel size and new labour force. With time, these factors will be improved to bring VISL at position with comparing port.

# Annexure 4

## Detailed Capital Expenditures (CAPEX) for Vizhinjam Port Master Plan

Prepared for

Vizhinjam International Seaports Limited (VISL)

Prepared by

**AECOM India Private Limited**

November 2012

## Annexure 4: Detailed Capital Cost Estimates - Master Plan

### Exchange rate used 1 USD= INR 54

| S. No. | ITEM | | QUANTITY | | | UNIT | RATE | AMOUNT (USD) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | PHASE 1 | PHASE 2 | PHASE 3 | | (USD) | PHASE 1 | PHASE 2 | PHASE 3 |
| 1. | PROJECT PRELIMINARIES AND SITE DEVELOPMENT | | | | | | | | | |
| | 1.1 | Project Studies and Surveys | | | | LS | | 9,25,926 | 3,70,370 | 3,70,370 |
| | 1.2 | Preliminary and Preoperative Expenses | | | | LS | | 9,25,926 | 3,70,370 | 3,70,370 |
| | 1.3 | Site Clearing | | | | LS | | 3,70,370 | 1,85,185 | 1,85,185 |
| | 1.4 | Temporary Construction Fencing | | | | LS | | 1,85,185 | 1,85,185 | 1,85,185 |
| | | | | | | | | | | |
| | Total (1) | | | | | | | **24,07,407** | **11,11,111** | **11,11,111** |
| 2. | DREDGING AND RECLAMATION | | | | | | | | | |
| | 2.1 | Dredging & Reclmation of Sand | 73,60,543 | 1,24,200 | 2,34,600 | Cum | 7.9 | 5,79,30,196 | 9,77,500 | 18,46,389 |
| | 2.2 | Dredging & Reclmation from Marine Borrow Area | - | 24,70,151 | 46,70,461 | Cum | 10.2 | - | 2,51,58,948 | 4,75,69,515 |
| | 2.3 | Reclamation bund (Core Material) | 7,90,450 | 3,90,000 | 6,09,375 | Cum | 16.7 | 1,31,74,167 | 65,00,000 | 1,01,56,250 |
| | 2.4 | Stone Pitching for bund protection other than berth | 45,275 | 20,580 | 23,152 | m | 27.8 | 12,57,639 | 5,71,654 | 6,43,111 |
| | 2.5 | Ground Improvement (Gross Reclaimed Area) | 62 | 17 | 48 | Ha. | 18,519 | 11,48,148 | 3,05,556 | 8,88,889 |
| | | | | | | | | | | |
| | Total (2) | | | | | | | **7,35,10,150** | **3,35,13,658** | **6,11,04,154** |
| 3. | BREAKWATERS (Mob-Demob Cost included in material cost) | | | | | | | | | |
| | 3.1 | North Breakwater (Length in meters) | 3,040 | - | 920 | | | | | |
| | | a. ACCROPODE ($m^3$ units) | | | | | | | | |
| | | 14 | 504 | | 504 | No. | 3,111 | 15,68,000 | - | 15,68,000 |
| | | 12 | 16,212 | | 5,971 | No. | 2,667 | 4,32,30,915 | - | 1,59,21,898 |
| | | 10 | 1,100 | | - | No. | 2,222 | 24,44,689 | - | - |
| | | 4 | 1,944 | | - | No. | 889 | 17,28,333 | - | - |
| | | 2 | - | | - | No. | 444 | - | - | - |
| | | b. Rock | - | | - | | | - | - | - |
| | | 3 to 6 T | 1,04,634 | | 32,064 | Cum | 65 | 67,81,833 | - | 20,78,222 |
| | | 2.5 to 4.5 T | 13,385 | | 13,385 | Cum | 56 | 7,43,611 | - | 7,43,611 |
| | | 2.0 to 4.0 T | 5,28,425 | | 1,91,060 | Cum | 56 | 2,93,56,944 | - | 1,06,14,444 |
| | | 1.5 to 3.5 T | 26,730 | | - | Cum | 46 | 12,37,500 | - | - |
| | | 0.7 to 1.4 T | 1,944 | | - | Cum | 28 | 54,010 | - | - |
| | | 0.35 to 0.7 T | - | | - | Cum | 19 | - | - | - |
| | | c. Core and Bedding | - | | - | | | | - | - |
| | | 0.1 to 0.5 T stones (core) | 32,00,766 | | 11,63,906 | Cum | 17 | 5,33,46,100 | - | 1,93,98,433 |
| | | 0.4 to to 0.8 T stones (bedding) | 1,22,789 | | 38,149 | Cum | 22 | 27,28,644 | - | 8,47,756 |
| | | d. Crown Wall | 36,220 | | 12,790 | Cum | 259 | 93,90,347 | - | 33,15,903 |
| | | | | | | | | | | |
| | **3.2** | South Breakwater (Length in meter) | 725 | - | 475 | | | | - | |
| | | a. ACCROPODE ($m^3$ units) | | | | | | | - | |
| | | 10 | 2,609 | | 1,880 | No. | 2,222 | 57,98,678 | - | 41,78,311 |
| | | 4 | 2,454 | | 1,466 | No. | 889 | 21,81,667 | - | 13,03,333 |
| | | 2 | - | | - | No. | 444 | - | - | - |
| | | b. Rock | - | | - | | | - | - | - |
| | | 3 to 6 T | 24,146 | | 16,669 | Cum | 65 | 15,65,019 | - | 10,80,366 |
| | | 1.5 to 3.5 T | 56,584 | | 40,104 | Cum | 46 | 26,19,630 | - | 18,56,667 |
| | | 0.7 to 1.4 T | 23,485 | | 14,030 | Cum | 28 | 6,52,361 | - | 3,89,722 |
| | | 0.35 to 0.7 T | - | | - | Cum | 19 | - | - | - |
| | | c. Core and Bedding | | | | | | | | |
| | | 0.1 to 0.5 T stones (core) | 3,60,349 | | 2,38,079 | Cum | 17 | 60,05,817 | - | 39,67,983 |
| | | 0.4 to to 0.8 T stones (bedding) | 30,035 | | 53,278 | Cum | 22 | 6,67,444 | - | 11,83,944 |
| | | d. Crown Wall | 11,745 | | 8,995 | Cum | 259 | 30,44,977 | - | 23,32,014 |
| | | e. Inner Breakwater Removal | | | | LS | | - | - | ``` |
| | | | | | | | | | | |
| | Total (3) | | | | | | | **17,51,46,521** | **-** | **7,07,80,609** |
| 4. | BERTHS | | | | | | | | | |
| | 4.1 | Container Berths (Quay Length in meters) | 800 | 400 | 800 | | | | | |
| | | a. Piled Foundation | | | | | | | | |
| | | 1.2 m Diameter Piles | 606 | 303 | 606 | No. | 39,039 | 2,36,57,926 | 1,18,28,963 | 2,36,57,926 |
| | | b. RCC in Superstructure | 32,000 | 16,000 | 32,000 | Sqm | 440 | 1,40,89,618 | 70,44,809 | 1,40,89,618 |
| | | c. Fixtures and Accessories | | | | | | | | |
| | | Fenders | 26 | 13 | 26 | No. | 46,296 | 12,03,704 | 6,01,852 | 12,03,704 |
| | | Bollards | 26 | 13 | 26 | No. | 4,630 | 1,20,370 | 60,185 | 1,20,370 |
| | | Others | 1 | 1 | 1 | LS. | 13,10,926 | 13,10,926 | 6,55,463 | 13,10,926 |
| | | d. Block Work behind the berth (5x5) | 1 | 1 | 1 | LS. | 29,62,963 | 29,62,963 | 14,81,481 | 29,62,963 |
| | | e. Stone pitching underside the berth | 1 | 1 | 1 | LS. | 11,90,410 | 11,90,410 | 5,95,205 | 11,90,410 |
| | | f. Miscellaneous Items | 1 | 1 | 1 | LS. | 23,65,793 | 23,65,793 | 11,82,896 | 23,65,793 |
| | | | | | | | | | | |
| | 4.2 | Port Craft Berths (Quay Length in meters) | 270 | | | | | | | |
| | | a. Piled Foundation | | | | | | | | |
| | | 1.0 m Diameter Piles | 70 | | | No. | 21,022 | 14,60,998 | - | - |
| | | b. RCC in Superstructure | 2,700 | | | Sqm | 438 | 11,82,919 | - | - |
| | | c. Fixtures and Accessories | | | | | | | | |
| | | Fenders | 9 | | | No. | 18,519 | 1,74,769 | - | - |
| | | Bollards | 9 | | | No. | 1,852 | 17,477 | - | - |
| | | Others | 1 | | | LS. | 4,98,918 | 4,98,918 | - | - |
| | | d. Stone pitching underside the berth | 1 | | | LS. | 1,40,948 | 1,40,948 | - | - |
| | | e. Mob-Demob Cost | 1 | | | LS. | 1,46,100 | 1,46,100 | - | - |
| | | | | | | | | | | |

| S. No. | | ITEM | QUANTITY | | | UNIT | RATE | AMOUNT (USD) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | PHASE 1 | PHASE 2 | PHASE 3 | | (USD) | PHASE 1 | PHASE 2 | PHASE 3 |
| | 4.3 | Coast Gaurd Berth (Quay Length in meters) | 120 | | | | | | | |
| | | a. Piled Foundation | | | | | | | | |
| | | 1.0 m Diameter Piles | 32 | | | No. | 21,022 | 6,72,690 | - | - |
| | | b. RCC in Superstructure | 1,200 | | | Sqm | 533 | 6,39,159 | - | - |
| | | c. Fixtures and Accessories | | | | | | | | |
| | | Fenders | 5 | | | No. | 27,778 | 1,31,944 | - | - |
| | | Bollards | 5 | | | No. | 2,778 | 13,194 | - | - |
| | | Others | 1 | | | LS. | 4,97,616 | 4,97,616 | - | - |
| | | d. Block Work behind the berth (5x5) | 1 | | | LS. | 4,44,444 | 4,44,444 | - | - |
| | | e. Stone pitching underside the berth | 1 | | | LS. | 62,644 | 62,644 | - | - |
| | | f. Mob-Demob Cost | 1 | | | LS. | 67,269 | 67,269 | - | - |
| | | | | | | | | | | |
| | 4.4 | Cruise Berth (Quay Length in meters) | | 300 | 300 | | | | | |
| | | a. Piled Foundation | | | | | | | | |
| | | 1.2 m Diameter Piles | | 116 | 116 | No. | 31,208 | - | 36,04,508 | 36,04,508 |
| | | b. RCC in Superstructure | | 6,000 | 6,000 | Sqm | 681 | - | 40,83,327 | 40,83,327 |
| | | c. Retaining Wall | | | | LS. | | | 24,65,000 | 24,65,000 |
| | | d. Fixtures and Accessories | | | | | | | | |
| | | Fenders | | 14 | 14 | No. | 37,037 | - | 5,00,000 | 5,00,000 |
| | | Bollards | | 14 | 14 | No. | 3,704 | - | 50,000 | 50,000 |
| | | Others | | 1 | 1 | LS. | 5,18,565 | - | 5,18,565 | 5,18,565 |
| | | e. Mob-Demob Cost | | 1 | 1 | LS. | 3,60,451 | - | 3,60,451 | 3,60,451 |
| | | | | | | | | | | |
| | 4.5 | Fishery Berth | | | | | | | | |
| | | a Landing Outfitting & Berthing Quay 300m Long 15m wide | | | | | | | | |
| | | Piled Foundation | | | | | | | | |
| | | 0.45 m Diameter Piles | 537 | | | No. | 3,637 | 19,53,144 | - | - |
| | | RCC in Superstructure | 2,040 | | | Cum | 356 | 7,27,222 | - | - |
| | | Fixtures and Accessories | | | | | | | | |
| | | Rubber Fenders | 214 | | | No. | 148 | 31,630 | - | - |
| | | Mooring Rings | 214 | | | No. | 28 | 5,931 | - | - |
| | | Ladder, Handrails etc. | | | | LS | | 12,426 | - | - |
| | | b Approach Trestle -100 m long | | | | | | | | |
| | | Piled Foundation | | | | | | | | |
| | | 0.45 m Diameter Piles | 66 | | | | 2,083 | 1,37,464 | - | - |
| | | RCC in Superstructure | 240 | | | | 356 | 85,556 | - | - |
| | | Ladder, Handrails etc. | | | | LS | | 1,852 | - | - |
| | | c Mob-Demob Cost | 10% | | | 1 | | 2,95,522 | - | - |
| | | | | | | | | | | |
| | Total (4) | | | | | | | **5,63,03,543** | **3,50,32,705** | **5,84,83,560** |
| **5.** | **BUILDINGS** | | | | | | | | | |
| | 5.1 | Administrative Buildings | | | | | | - | - | - |
| | | a. VISL Administrative Building | 800 | 400 | 800 | Sqm | 556 | 4,44,444 | 2,22,222 | 4,44,444 |
| | | b. Private Operator Administrative Building | 800 | 400 | 800 | Sqm | 556 | 4,44,444 | 2,22,222 | 4,44,444 |
| | 5.2 | Port Marine Operations Building | 630 | 310 | 620 | Sqm | 556 | 3,50,000 | 1,72,222 | 3,44,444 |
| | 5.3 | Yard Operations Building | 300 | - | 200 | Sqm | 556 | 1,66,667 | - | 1,11,111 |
| | 5.4 | Crane Maintenance Building | 830 | 410 | 820 | Sqm | 463 | 3,84,259 | 1,89,815 | 3,79,630 |
| | 5.5 | Maintenance & Repair Building | 3,400 | 1,600 | 3,300 | Sqm | 463 | 15,74,074 | 7,40,741 | 15,27,778 |
| | 5.6 | Trouble Kiosk & Restrooms | 60 | 60 | 60 | Sqm | 278 | 16,667 | 16,667 | 16,667 |
| | 5.7 | Longshoremen Restrooms | 60 | 60 | 60 | Sqm | 278 | 16,667 | 16,667 | 16,667 |
| | 5.8 | Reefer Shop w/ Genset | 330 | 170 | 330 | Sqm | 648 | 2,13,889 | 1,10,185 | 2,13,889 |
| | 5.9 | Canteen | 100 | 50 | 100 | Sqm | 278 | 27,778 | 13,889 | 27,778 |
| | 5.1 | Fire station | 100 | 50 | 100 | Sqm | 463 | 46,296 | 23,148 | 46,296 |
| | 5.11 | Utility Building | 400 | 200 | 400 | Sqm | 463 | 1,85,185 | 92,593 | 1,85,185 |
| | 5.12 | Electrical Sub Stations | 400 | 200 | 400 | Sqm | 556 | 2,22,222 | 1,11,111 | 2,22,222 |
| | 5.13 | Security Booth - Entry Gate | 30 | 15 | 30 | Sqm | 370 | 11,111 | 5,556 | 11,111 |
| | 5.14 | Security Booth - Exit Gate | 30 | 15 | 30 | Sqm | 370 | 11,111 | 5,556 | 11,111 |
| | 5.15 | Other Misc. Buildings | 200 | 100 | 100 | Sqm | 370 | 74,074 | 37,037 | 37,037 |
| | 5.16 | Fuel Station | 100 | 50 | 100 | Sqm | 556 | 55,556 | 27,778 | 55,556 |
| | 5.17 | Center Buildings | | | | Sqm | | | | |
| | | a Auction Hall | 300 | | | Sqm | 333 | 1,00,000 | | |
| | | b. Fishery Administrative Office | 200 | | | Sqm | 333 | 66,667 | | |
| | | c Net Mending Shed | 250 | | | Sqm | 222 | 55,556 | | |
| | | d Fuel Station | 300 | | | Sqm | 370 | 1,11,111 | | |
| | | e Toilet Block | 45 | | | Sqm | 222 | 10,000 | | |
| | Total (5) | | | | | | | **45,87,778** | **20,07,407** | **40,95,370** |
| **6.** | **CONTAINER YARD** | | | | | | | | | |
| | 6.1 | Yard Pavement | | | | | | | | |
| | | Precast paving blocks on 25mm sand bed | 2,72,720 | 1,30,480 | 2,73,200 | Sqm | 14 | 37,87,778 | 18,12,222 | 37,94,444 |
| | | Grade M45 in-situ concrete | 1,09,088 | 52,192 | 1,09,280 | Cum | 102 | 1,11,10,815 | 53,15,852 | 1,11,30,370 |
| | | Granular sub-base for road | 81,816 | 39,144 | 81,960 | Cum | 19 | 15,15,111 | 7,24,889 | 15,17,778 |
| | | | | | | | | | | |
| | 6.2 | RTGS Beams | | | | | | | | |
| | | HYSD Reinforcement for Structures above 16mm dia | 1,728 | 1,152 | 2,880 | T | 1,389 | 24,00,000 | 16,00,000 | 40,00,000 |
| | | Grade M30 in-situ concrete | 17,280 | 11,520 | 28,800 | Cum | 102 | 17,60,000 | 11,73,333 | 29,33,333 |
| | | Pavement Type-1 (PCC) | 160 | 80 | 160 | Cum | 28 | 4,444 | 2,222 | 4,444 |
| | | Granular sub-base for RTGC Runway | 480 | 240 | 480 | Cum | 19 | 8,889 | 4,444 | 8,889 |
| | | Striping & Signage | 20,000 | 10,000 | 20,000 | m | 4 | 74,074 | 37,037 | 74,074 |
| | 6.3 | Miscellaneous items | | | | LS. | | 3,70,370 | 1,85,185 | 3,70,370 |

| S. No. | ITEM | | QUANTITY | | | UNIT | RATE | AMOUNT (USD) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | PHASE 1 | PHASE 2 | PHASE 3 | | (USD) | PHASE 1 | PHASE 2 | PHASE 3 |
| | 6.4 | Terminal Fencing wall | 1,600 | | 900 | m | 222 | 3,55,556 | - | 2,00,000 |
| | 6.5 | Excavation & Disposal | 17,280 | 11,520 | 28,800 | Cum | 6 | 96,000 | 64,000 | 1,60,000 |
| | | | | | | | | | | |
| | **Total (5)** | | | | | | | **2,14,83,037** | **1,09,19,185** | **2,41,93,704** |
| **7.** | **EQUIPMENTS** | | | | | | | | | |
| | 7.1 | Container Terminal | | | | | | | | |
| | | a. RMQC | 8 | 4 | 8 | No. | 92,59,259 | 7,40,74,074 | 3,70,37,037 | 7,40,74,074 |
| | | b. Reach Stackers | 8 | 4 | 4 | No. | 3,70,370 | 29,62,963 | 14,81,481 | 14,81,481 |
| | | c. RTG (Yard) | 24 | 12 | 24 | No. | 11,11,111 | 2,66,66,667 | 1,33,33,333 | 2,66,66,667 |
| | | d. RMG (Rail Yard) | - | - | 2 | No. | 18,51,852 | - | - | 37,03,704 |
| | | e. ITVs | 50 | 10 | 5 | m | 81,481 | 40,74,074 | 8,14,815 | 4,07,407 |
| | | f. Diesel Locomotive | 1 | - | - | No. | 25,92,593 | 25,92,593 | - | - |
| | | g. Maintenance Vehicles | 2 | 1 | 2 | No. | 27,778 | 55,556 | 27,778 | 55,556 |
| | | h. Workshop Equipments | | | | LS | | 9,25,926 | 5,55,556 | 9,25,926 |
| | 7.2 | Spares @ 5% | | | | | | 55,67,593 | 26,62,500 | 53,65,741 |
| | | | | | | | | | | |
| | **Total (7)** | | | | | | | **11,69,19,444** | **5,59,12,500** | **11,26,80,556** |
| **8.** | **UTILITIES AND OTHERS** | | | | | | | | | |
| | 8.1 | Electric Supply and Distribution lines | | | | LS | | 18,51,852 | 9,25,926 | 18,51,852 |
| | 8.2 | Lighting & Earthing | | | | LS | | 1,85,185 | 1,85,185 | 1,85,185 |
| | 8.3 | Fire Fighting | | | | LS | | 7,40,741 | 3,70,370 | 7,40,741 |
| | 8.4 | Internal Water Supply Service Lines | 6,000 | 2,000 | 4,000 | m | 28 | 1,66,667 | 55,556 | 1,11,111 |
| | | a. Water Storage | | | | | | | | |
| | | Underground | 5,000 | 2,500 | 4,000 | Cum | 130 | 6,48,148 | 3,24,074 | 5,18,519 |
| | | Overhead | 1,500 | 500 | 1,000 | Cum | 278 | 4,16,667 | 1,38,889 | 2,77,778 |
| | | b. Pipeliines, Accessories and Pumps | | | | LS | | 5,55,556 | 1,85,185 | 3,70,370 |
| | 8.5 | Drainage and Sewerage | | | | LS | | 9,25,926 | 3,70,370 | 7,40,741 |
| | 8.6 | Communication and IT | | | | LS | | 11,11,111 | 5,55,556 | 11,11,111 |
| | 8.7 | Workshop equipment | | | | LS | | 2,77,778 | 2,77,778 | 2,77,778 |
| | 8.8 | High mast lighting | 29 | 6 | 21 | No. | 37,037 | 10,74,074 | 2,22,222 | 7,77,778 |
| | 8.9 | Terminal Security | | | | LS | | 2,77,778 | | 2,77,778 |
| | 8.10 | Utilities for Fish Landing Center (Electric, Water & Drainage) | | | | LS | | 1,00,000 | | |
| | **Total (8)** | | | | | | | **83,31,481** | **36,11,111** | **72,40,741** |
| **9.** | **PORT CRAFTS AND AIDS TO NAVIGATION** | | | | | | | | | |
| | 9.1 | Port Crafts | | | | | | | | |
| | | a. Tug Boats | 5 | 1 | 2 | No. | 46,29,630 | 2,31,48,148 | 46,29,630 | 92,59,259 |
| | | b. Pilot-cum-Survey Launches | 1 | - | 1 | No. | 9,25,926 | 9,25,926 | - | 9,25,926 |
| | | c. Mooring Launch | 3 | - | 1 | No. | 3,70,370 | 11,11,111 | - | 3,70,370 |
| | | | | | | | | | | |
| | 9.2 | Aids to Navigation | | | | | | | | |
| | | a. Channel Marking Buoy | 6 | - | - | No. | 14,815 | 88,889 | - | - |
| | | b. Fairway Buoy | 1 | - | - | No. | 37,037 | 37,037 | | |
| | | c. Manoeuvring Area buoys | 4 | - | - | No. | 14,815 | 59,259 | - | - |
| | | d. Leading and Transit Lights | 2 | - | - | sets | 1,48,148 | 2,96,296 | - | - |
| | | e. Breakwater Lights | 2 | - | 2 | No. | 18,519 | 37,037 | - | 37,037 |
| | | f. Racon | 1 | - | - | No. | 1,01,852 | 1,01,852 | - | - |
| | | g. VTMS | 1 | - | - | Unit | 2,40,741 | 2,40,741 | - | - |
| | | h. Fish Landing channel buoys | 2 | | | Unit | 1,852 | 3,704 | | |
| | **Total (9)** | | | | | | | **2,60,50,000** | **46,29,630** | **1,05,92,593** |
| **10.** | **GATES COMPLEX & ROAD DEVELOPMENT** | | | | | | | | | |
| | 10.1 | Road (Customs + Terminal Area 4 Lane road) | 63,000 | | 19,800 | Sqm | 52 | 32,66,667 | - | 10,26,667 |
| | 10.2 | Inspection/Canopy (Entry + Exit Gate) | 2,800 | - | - | Sqm | 370 | 10,37,037 | - | - |
| | 10.3 | Weigh Bridge (Entry + Exit Gate) for Trains | 1 | 1 | 1 | No. | 20,370 | 20,370 | 20,370 | 20,370 |
| | 10.4 | Weigh Bridge (Entry + Exit Gate) for Trucks | 6 | - | - | No. | 12,963 | 77,778 | - | - |
| | 10.5 | Fish Landing Center approach road | 3,000 | | | | 1,550 | 46,50,000 | | |
| | **Total (10)** | | | | | | | **90,51,852** | **20,370** | **10,47,037** |
| | | | | | | | | | | |
| | **Total (1+2+3+4+5+6+7+8+9+10)** | | | | | | | **49,37,91,213** | **14,67,57,678** | **35,13,29,434** |
| | **Contingencies @ 20%** | | | | | | | 9,87,58,243 | 2,93,51,536 | 7,02,65,887 |
| | **Engineering and Project Management @ 10%** | | | | | | | 4,93,79,121 | 1,46,75,768 | 3,51,32,943 |
| | **GRAND TOTAL** | | | | | | | **64,19,28,577** | **19,07,84,981** | **45,67,28,264** |
| | | **Exchange Rate USD to INR used** | **54** | | | | | | | |

*Disclaimer*

*The capital cost estimates prepared for the present assignment has been arrived at based upon site information, appropriate assumptions, wherever required, and the database available with the AECOM for the similar projects. These site information and assumptions are subject to many factors that are beyond the control of the AECOM and AECOM thus make no representations or warranties with respect to these estimates and disclaim any responsibility for the accuracy of these estimates.*

| | | | Phase I | | | | | | Phase II | | | | | | Phase III | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | AECOM | | | RH | | | AECOM | | | RH | | | AECOM | | | RH | | |
| Sr. No. | Costing Block Parameters | Benchmarking Parameters | Cost (Mil. USD) | Quantity | Rate | Cost (Mil. USD) | Quantity | Rate | Cost (Mil. USD) | Quantity | Rate | Cost (Mil. USD) | Quantity | Rate | Cost (Mil. USD) | Quantity | Rate | Cost (Mil. USD) | Quantity | Rate |
| 1 | PROJECT PRELIMINARIES AND SITE DEVELOP | LS Cost | 2 | | | 2 | | | 1 | | | 1 | | | 1 | | | 1 | | |
| 2 | DREDGING AND RECLAMATION | Gross Reclmation Area in Ha | 74 | 62 | 1 | 47 | 26 | 2 | 34 | 17 | 2 | 38 | 24 | 2 | 61 | 48 | 1 | 48 | 30 | 2 |
| 3 | BREAKWATERS | Cost per Length in m | | | | | | | | | | | | | | | | | | |
| 3.1 | North Breakwater | | 153 | 3,040 | 0 | 155 | 2,710 | 0 | 0 | 0 | | | | | 54 | 920 | 0 | 63 | 910 | 0 |
| 3.2 | South Breakwater | | 23 | 725 | 0 | 23 | 630 | 0 | 0 | 0 | | | | | 16 | 475 | 0 | 21 | 630 | 0 |
| 4 | BERTHS | Cost per Quay Length in m | | | | | | | | | | | | | | | | | | |
| 4.1 | Container Berth | | 47 | 800 | 0 | 39 | 650 | 0 | 23 | 400 | 0 | 36 | 600 | 0 | 47 | 800 | 0 | 45 | 750 | 0 |
| 4.2 | Port Craft Berth | | 4 | 270 | 0 | | | | 0 | 0 | | | | | 0 | | | | | |
| 4.3 | Cruise Berth | | | | | | | | 12 | 250 | | | | | 12 | | | | | |
| 4.5 | Coast Guard Berth | | 3 | 120 | 0 | | | | 0 | 0 | | | | | 0 | | | | | |
| 4.5 | Fish Landing Berth | | 3 | | | | | | 0 | | | | | | 0 | | | | | |
| 5 | BUILDINGS | Total Cost | 5 | | | | | | 2 | | | | | | 4 | | | | | |
| 6 | CONTAINER YARD | Cost per Gross Yard Area in Ha | 21 | | | 34 | | | 11 | | | 27 | | | 24 | | | 34 | | |
| 7 | EQUIPMENTS | Cost per Quay Length in m | 117 | 800 | 0 | 73 | 650 | 0 | 56 | 400 | 0 | 60 | 600 | | 113 | 800 | 0 | 73 | 750 | 0 |
| 8 | UTILITIES AND OTHERS | Total | 8 | | | 8 | | | 4 | | | 8 | | | 7 | | | 8 | | |
| 9 | PORT CRAFTS AND AIDS TO NAVIGATION | Total | 26 | | | 23 | | | 5 | | | 23 | | | 11 | | | 23 | | |
| 10 | GATES COMPLEX & ROAD DEVELOPMENT | Total | 9 | | | 3 | | | 0 | | | 3 | | | 1 | | | 1 | | |
| | Total (Excluding Preliminaries, Contingencies, Engineering & Project Management | Total | 494 | | | 407 | | | 147 | | | 197 | | | 351 | | | 317 | | |