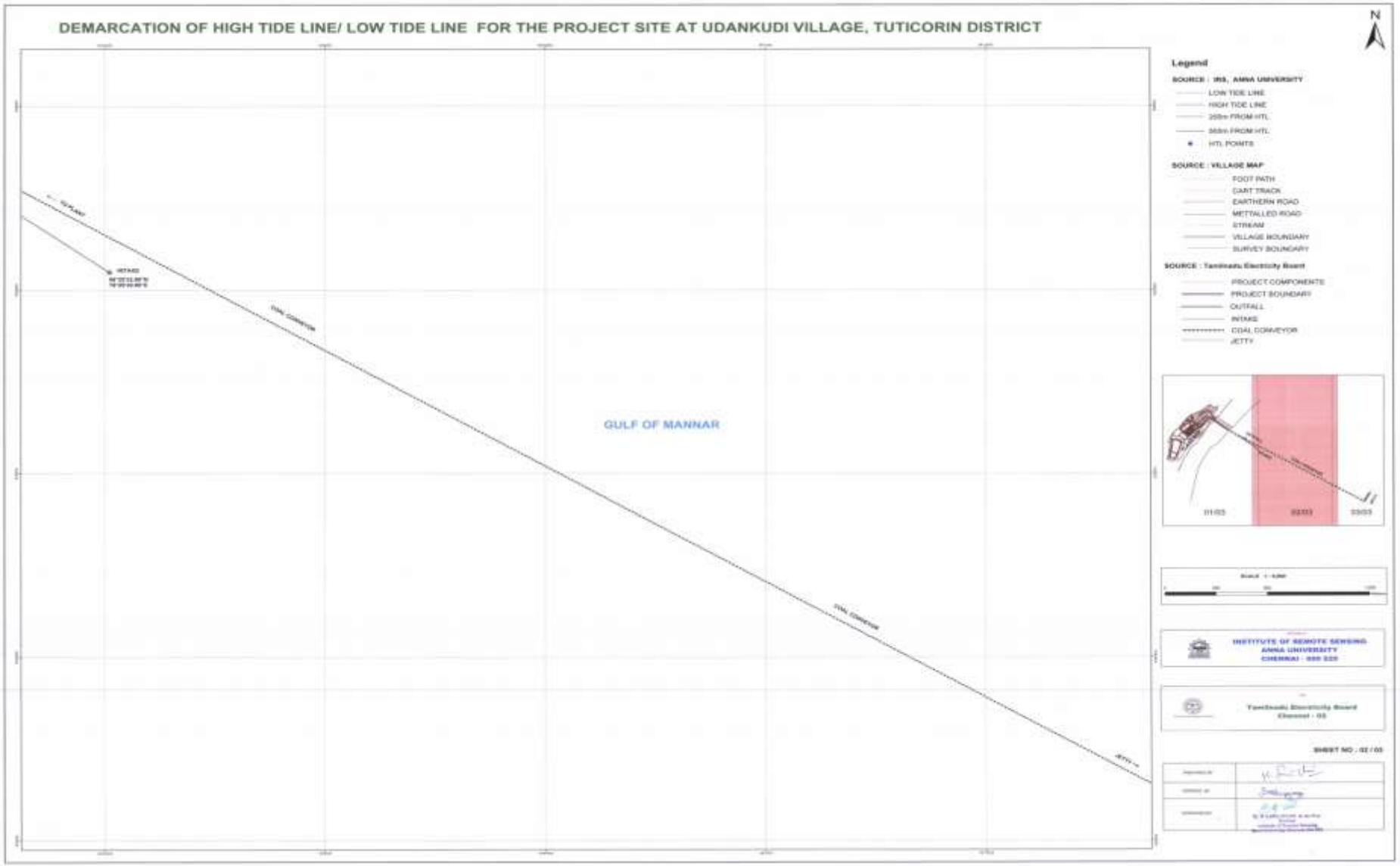

DEMARCATION OF HIGH TIDE LINE/ LOW TIDE LINE FOR THE PROJECT SITE AT UDANKUDI VILLAGE, TUTICORIN DISTRICT
N
Legend
PLANT SITE
GULF OF MANNAR
OUTFALL
INSTITUTE OF REMOTE SENSING
ANNA UNIVERSITY
CHENNAI - 600 025
Tamilnadu Electricity Board
Chennai - 02

AUTHENTICATED MAP OF CRZ DEMARCATION . 2/3



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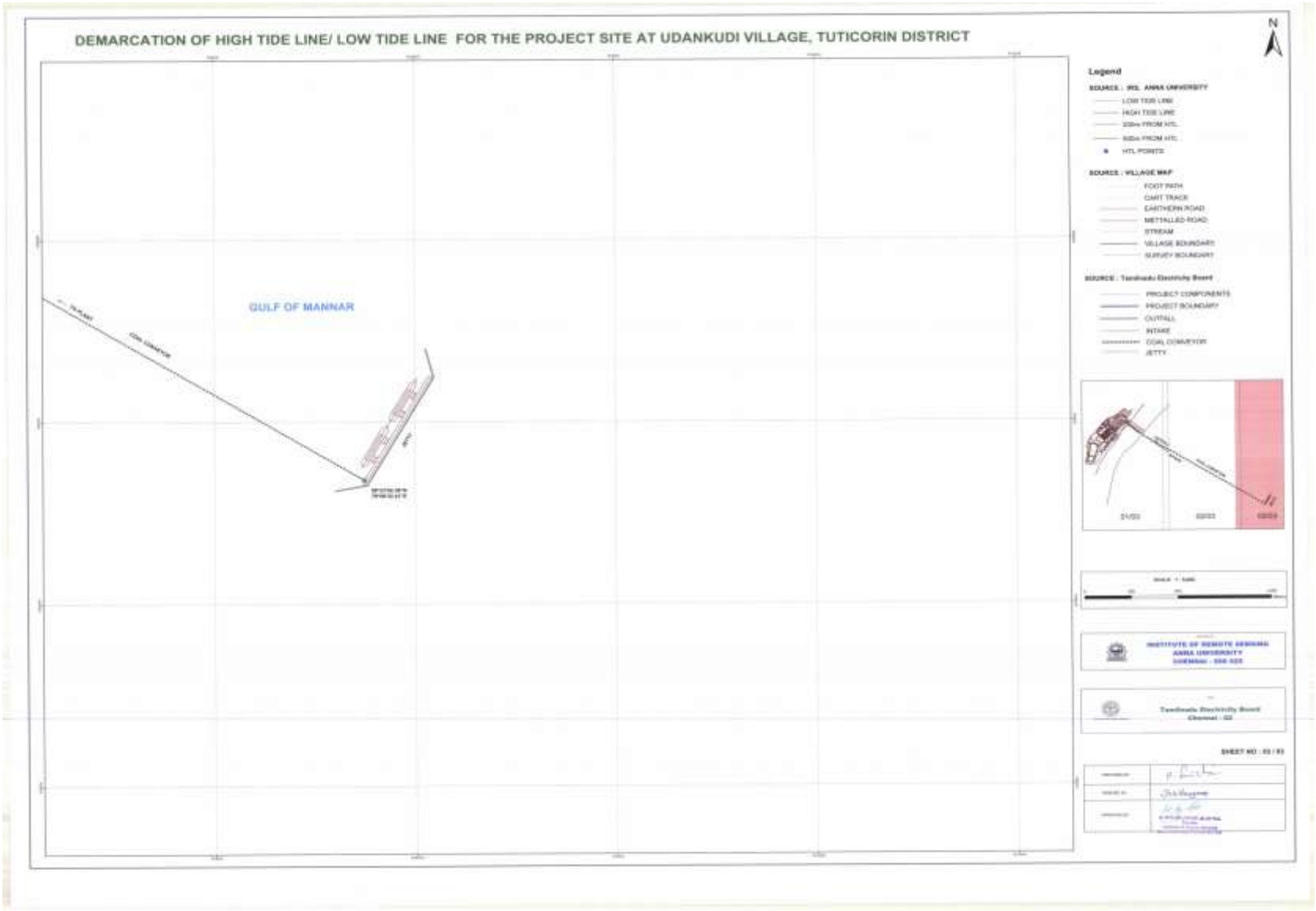


EXECUTIVE SUMMARY

Udangudi Power Corporation Limited, a joint venture of Tamil Nadu Electricity Board (TNEB) and Bharat Heavy Electricals Limited (BHEL)intends to set up 2X800 MW Coal Based Thermal Power Plant at Udangudi Village, Thoothukudi District, Tamil Nadu, with an investment of `9083 Crores. The project is envisaged to strengthen the power availability in the state. This project would be the first 800 MW supercritical thermal power project to be installed in Tamil Nadu. About 939 acres of land for the proposed plant has been identified near Udangudi village, Thoothukudi district.

This project has been located 1.2 km from the shore of the Gulf of Mannar near Kulasekaranpatnam, Thoothukudi District, Tamilnadu. The makeup water for the Cooling water system required for the plant is drawn from the sea and after utilization the sea water is let into the sea. Further a separate captive coal jetty for the project ~~is~~ will be developed in the sea about 7.5 km from shore and coal is transported to the plant through pipe conveyor. Hence a comprehensive Marine Environmental Impact Assessment and Environmental Management Plan for drawing Cooling water from sea for condenser cooling, discharging the same in the sea in accordance with the norms of MOEF and for developing a captive coal jetty in the sea involved for the proposed project was carried out by the Institute for Ocean management, Anna University, Chennai to predict the quality of the environment once the project gets underway. This has been done by:

- Analyzing the current baseline data on air, water and sediment during dry and wet seasons
- Identifying the activities causing the impacts and the risk associated with the proposed development
- Suggesting steps for effective environmental management.

A summary of the findings on baseline survey of the project site are reproduced below

I. Air quality

Ambient air quality monitoring was carried out for dry (May 2009) and wet (December 2009) seasons at two locations to assess the air quality status in this region. At the two sampling stations, the concentration of particulate matter ($PM_{2.5}$ and PM_{10}) as well as gaseous pollutants like sulphur oxides and nitrogen oxides were monitored for 24 hours. The values of all these parameters in the ambient air were found to be within permissible levels specified by CPCB, and in general, ranged as follows.

Air quality parameter	Range (May 2009) $\mu g/m^3$
Nitrogen oxides (NO_x)	11.9 -15.4
Sulphur oxides (SO_x)	16.6 – 17.1
PM_{10}	68.7 - 78.4
$PM_{2.5}$	45.6 – 56.6

Air quality parameter	Range (December 2009) $\mu g/m^3$
Nitrogen oxides (NO_x)	15.9 – 16.6
Sulphur oxides (SO_x)	22.1 – 22.2
PM_{10}	65.1 – 75.9
$PM_{2.5}$	58.1 – 79.5

II. Water quality

The assessment of water quality in the area of 10 km radius seaward from the project site was undertaken during the study period. Selected physico-chemical parameters have been used for describing the baseline status of water environment. The average values of surface seawater temperature and salinity during dry and wet seasons (May and December 2009) varied from 26.5 to 30.7 ^{0}C and 31.8 to 32.9 respectively. The average values of dissolved oxygen (DO) is ranged between 5.7 (May 2009) and 5.2 (December 2009) mg/l and the average values of biochemical oxygen demand is varied from 2.2 (December 2009) and 2.4 (May 2009) mg/l. The average values of dissolved inorganic nitrogen varied between 4.4 (December 2009) and 6.1 (May 2009) µmol l^{-1} and total phosphates varied between 0.6 (December 2009) and 2.6 (May 2009) µmol l^{-1}. The microbial load in terms of total Coliform and faecal Coliform were analysed and the population of total coliform varied from 68 to 136 MPN/100ml and faecal coliform varied from 10 to 67 MPN/100 ml. The values obtained from all sampling locations were within permissible limits as stipulated by CPCB (500/100 ml MPN).

III. Sediment quality

The concentration of heavy metals in the sediments such as copper, zinc, chromium, lead and cadmium were analysed using atomic absorption spectrometry during May and December 2009. Overall, the heavy metal concentrations in the sediments were found to be low, and the concentration is following the pattern of **Cr>Zn>Pb>Cu>Cd.**

IV. Biota

The planktonic diversity in the water samples were analyzed qualitatively and quantitatively for both seasons (May and December 2009). Meiofaunal community was examined for species abundance and composition. The phytoplankton community was composed of 56 species and zooplankton community was represented by 40 species. The Shannon Weiner diversity of the Phytoplankton population ranged between 2.17 and 2.88 and that of zooplankton varied between 2.06 and 2.86.

The hierarchy of dominance observed in the meiofaunal groups following the pattern of **Harpacticoids>Nematodes>Gastrotrichs>Polychaetes>Turbellarians>Ostracods>Arachiannelids>Foraminiferans>Isopods.**The marine hydrographical parameters that were measured in the study of the Udangudi Power Project site indicated healthy conditions. The bed sediments indicated low heavy metal content. Biodiversity was also reasonably high with communities of phytoplankton, zooplankton and meiobenthos being identified. The phytoplankton communities were larger than the zooplankton communities indicating higher primary productivity in the site.

Offshore facilities involved in the project

Coal Jetty

The coal jetty for transportation of coal is located about 7.5km from the shore where more than 16m depth of water is easily available to berth Panamax vessels for unloading the coal. The pipe conveyer is at 6m to 8m height from the sea water and supported by trestles at 30m intervals. The coal berth is about 640m long and 24 m wide.

Cooling Water intake

The proposed location for intake of cooling water is about 2.05 km from high tide line (HTL) where 5.4 m depth of water is available to draw sufficient quantity of sea water up to 21,000 m^3/hr as per NIO, Goa modelling studies. The requirement of sea water for make up the cooling system is about 13,790 m^3/hr for two units. The water is to be drawn through buried pipe conduit of 2m diameter and taken to the cooling water in-take pump house by gravity and then to cooling water fore-bay by pumping. The technical details have been specified in the NIO report.

Cooling Water Outfall

The sea water drawn is circulated through the condenser, cooling tower by forming closed loop system. The cooling water blow down, RO rejects etc., of about 8912 M^3 /hour will be let in to the sea through pipe conduit along the coal conveyor trestles with a length about 1.06 km from shore. The outfall seawater temperature will be maintained so that the cooling water discharged will not be more than 5°C above the ambient seawater temperature as per the CPCB guidelines. The excess temperature of the outfall will be about 1.46°C as per the modeling study conducted by NIO, Goa.

Environmental Management Plan: During plant operation, the following parameters would be continuously monitored and recorded, to ensure that all regulatory stipulations for the operation of the project, particularly the liquid or gaseous releases will be fully complied with CPCB norms.

Sl.No.	Parameter	Sampling frequency
1	Ambient air quality	Monthly monitoring by approved agency in accordance with the environmental clearance order.
2.	Source emission	Monthly monitoring on the performance of ESPs.
3	Ground water quality	Once in a season
4	Wastewater quality	Monthly and weekly monitoring will be carried out for Steam generator blow down, Cooling tower blow down and D.M. Plant effluent.
5	Soil sample	Should be monitored once in a season
6	Non-hazardous waste	Monthly records of fly ash and bottom ash generation, collection, storage and disposal will be maintained as per the Fly Ash Act, 2007.
7	Hazardous waste	Monthly records of each type of hazardous wastes generation, collection, storage and disposal will be maintained as per the Hazardous Wastes (Management and Handling) Amendment Rules, 2003.
8	Ambient Noise Levels	Noise level monitoring will be carried out within the power plant premises once in every month.
9	Occupational Health and safety	Qualified doctors will carry out pre-employment and periodic medical check-up of all the employees.

Coal spillage Management Plan

- A fully mechanized coal unloading system will be employed for the ship-to-shore transfer of coal to ensure spillage to minimum.
- Coal will be handled through closed pipe conveyors where spillage is nil.

- Further dust suppression system will be employed at the Unloaders to prevent any pollution.
- Regular monitoring to avoid the spillage of coal will be enforced. In case of any spillage, the spilled coal will be arranged to be removed by grab cranes from the conveyor deck/Coal Jetty.

Accidental oil spill Management Plan:

For Fuel Oils, Heavy Fuel Oils and Light Diesel Oils, firewater cooling systems and foam facilities as per OISD-117 [Oil Industry Safety Directorate] must be provided.

The oil spill response kits should be installed in key places, and containment booms need to be deployed in case of large spills in marine areas. In the event of an oil spill in the marine environment the following measures should be employed according to the circumstances of the spill and conditions prevailing:

- Notify the Indian Coast Guard as they are the oil spill notification nodal agency
- If possible prevent, control or stop the outflow or release of the oil from the source
- If coastal or marine resources are not threatened or likely to be threatened, monitor the movement and behaviour of the oil
- If coastal and marine resources are threatened, determine whether to begin response operations, either at sea and/or to protect sensitive resources;
- If possible contain the spread of oil; and
- If, due to weather and sea conditions, response at sea or protection of sensitive areas is not feasible, or the foreshores have already been affected, determine appropriate cleanup priorities and other response measures.
- Udangudi Port will provide the necessary oil spill combating equipment like tug with booms and skimmer and sorbent pads within the Port. The required number of such equipment shall be procured prior to commissioning of the Port.

The management Plan in respect of other kind of emergencies like mechanical Emergency plan, Rough weather Plan, Earthquake management Plan , Fire Protection and response plan, Medical Emergency Plan, Special Emergency equipment, Chemical information, Drills/ rehearsing emergency procedures , emergency evacuation plan, of-site emergency plan etc. have been detailed in Chapter 8.14 of this report.

Further the Maintenance Plan in respect of the long approach structures like bridges against man-induced and / or natural forces have also been addressed in detail in Chapter 8.21 of this report and the frequency of maintenance to be followed is detailed in the table below.

Guidelines for frequency of maintenance & remedial measures

1	Cleaning Road surface of all soil, debris, pebbles and metal pieces if any	Continuous process on daily basis
2	Cleaning Expansion joints off any pebbles	Every month or as and when required
3	Cleaning of drainage spout	Every three months and frequency during monsoon or as and when required
4	Cleaning Road surface of all soil, debris, pebbles and metal pieces if any	Continuous process on daily basis
5	Removing nests if any on the structure	Continuous process on daily basis
6	Replacing of expansion Joint	As and when required
7	Bituminous work	
	(a) Repairing of pot holes	Every month or as and when required
	(b) Relaying of layer	After 4 to 5 years for improvement of ridership quality
	(c) Micro seal (Slurry seal)	
8	Cleaning inside deck	
	(a) Box portion	Stagnated water quarterly, Daily after rains
	(b) Vent holes	
	(c) Electrical lights	

CHAPTER 1 – INTRODUCTION

1.1 Purpose of the Report

Power generation is the vital infrastructural requirement for the economic growth of any country. The demand for power increases with growth in economy. Until India's independence, electricity generation in Tamil Nadu was confined to a few tiny plants in tea estates run on water power or hydro electric stations. Real progress in electricity generation was achieved with the constitution of Tamil Nadu Electricity Board (TNEB) under the Electricity Supply Act 1948. The TNEB has presently installed a capacity of 10,214 MW and serving a consumer base of about `2 crore. The TNEB has played a pivotal role in improving the economy of the state of Tamil Nadu by extensive electrification of the villages, large scale energisation of agricultural pump sets and extension of electricity services. TNEB succeeded in placing Tamil Nadu in records as the first state to achieve 100 % village electrification as early as 1992.

Moreover with the aim to achieve Power for all by the year 2012 and considering the high growth rate of economy, the Govt. of India has envisaged capacity addition of 1,00,000 MW in next 6 years. This translates to almost doubling the existing capacity. Considering the fact that at present there is around 13% overall deficit of power availability with the present installed capacity, there is an immediate need to install power projects to achieve the economic growth projection which has been planned to meet the supply and demand equilibrium.

Based on the above and also in order to meet the growing demand of the State to develop technology based infrastructural facilities and to boost the state's economy, the Government of Tamil Nadu has decided to develop a coal based power project through TNEB. Hence, TNEB has proposed to develop 2X800 mega watt (MW) supercritical thermal power project at Udangudi located 12 KM south of Tiruchendur in Thoothukudi District, Tamil Nadu, as a JV with Bharat Heavy Electricals Limited, (BHEL) with an investment of ` 9083 crores in order to enhance the power availability in Tamil Nadu. This project would be the first supercritical power project with 800 MW capacity to be installed in Tamil Nadu. TNEB and Bharat Heavy Electricals Limited (BHEL) signed a joint venture agreement and incorporated the 'Udangudi Power Corporation Ltd' (UPCL) for setting up this 1,600 MW (2X800 MW) coal based thermal power project at Udangudi. The boilers and the turbine generators will be

installed by BHEL in technical collaboration with Alstom and Siemens respectively, who are pioneers in the field of supercritical technology.

Environmental Impact Assessment (EIA) serves as useful tool in prediction of potential impacts on the surrounding environment due to developmental project. It helps to protect the marine environment from the impacts of the development of the project. It guides / recommends the project proponent, impact assessment authorities, regulatory agencies and other stakeholders in understanding the project and mitigation measures, environmental impact and establishing emission requirements and other measures early in the project cycle.

The UPCL engaged Institute for Ocean Management, Anna University, Chennai for carrying out comprehensive Marine Environmental Impact Assessment study for obtaining "Environmental Clearance" from Ministry of Environment and Forests, Government of India. This report describes the project location, facilities in sea for cooling water intake, out fall, coal jetty and coal conveyor, baseline environmental scenario, potential impacts of the marine facilities of the project on the environment and proposed measures for effective environment management during the project cycle (Environmental Management Plan during construction and operation stage of the project).

1.2 Nature and Size of the Project

The proposed power plant will be operated with coal as the main fuel to generate 1600 MW power (2×800 MW) and would be developed with super critical technology to obtain benefits under clean development mechanism (CDM Project). The selection of a supercritical versus a sub-critical power cycle is dependent on many project specific factors including fuel cost, emissions regulations, capital cost, load factor, duty and unit reliability and availability. It is proposed to use blended coal (70% Indian coal from Talcher coal fields of Mahanadi coal fields limited from Orissa and 30% imported Coal from Indonesia, South Africa, Australia, China, etc.) as fuel. The annual consumption of coal for the proposed power plant is estimated as 6.19 million tonnes. The project proposes to have its own captive coal jetty at Udangudi with transportation of coal through pipe conveyor system to the power plant to handle coal up to 10 million tonnes per annum, which is a rare one amongst the thermal power projects in India. IITM, Chennai has studied the feasibility of the coal jetty. Based on the feasibility study by NIO, Goa has finalized the location by model studies. The Govt of Tamilnadu has accorded approval for the development of coal jetty as Udangudi Minor Port by declaring the Port Limits for captive use of UPCL. M/s. L&T Ramboll is the consultant

for the preparation of Detailed Project Report for coal jetty . The coal jetty is located at about 7.5km from shore.

The total water requirement for boiler and cooling water for the proposed Plant would be around 13,790 m^3 hr^{-1} and the source would be from seawater. The NIO, Goa, has finalized the location of the cooling water intake and outfall in sea by conducting the modeling studies. The intake is located at 2.05 km from shore and the outfall is located at 1.06km from shore. Super critical boilers and turbine generators would be installed for the operation of the project. The technical details of the project such as fuel and water requirements, discharge etc. are summarized in Table 3 and the project cost is estimated to be Rs.9083 crores.

1.3 Project Proponent

The TNEB is having installed capacity of 10,214 MW and serving a consumer base of about Rs.2 crores. The TNEB has played a pivotal role in improving the economy of the state of Tamil Nadu by extensive electrification of the villages, large scale energisation of agricultural pump sets and extension of electricity services. TNEB succeeded in placing Tamil Nadu in records as the first state to achieve 100 % village electrification as early as 1992.

In order to meet the growing demand of the State to develop technology based infrastructural facilities and to boost the state's economy, the Government of Tamil Nadu has decided to develop a coal based power project through TNEB. Hence, TNEB has proposed 2X800 mega watt (MW) supercritical thermal power project at Udangudi located near Tiruchendur of Thoothukudi District, Tamil Nadu, with an investment of `9083 crores in order to envisage the strengthening of the power availability in Tamil Nadu. This project would be the first kind of supercritical power project with 800 MW capacity to be installed in Tamil Nadu and the second in major project in India. TNEB and Bharat Heavy Electricals Limited (BHEL) signed a joint venture agreement and incorporated the Joint Venture Company 'Udangudi Power Corporation Ltd' (UPCL) for setting up this 1,600 MW (2X800 MW) coal based thermal power project at Udangudi.

1.4 Project Location

The project site identified by UPCL is near a small village called Udangudi, about 650 km south of Chennai and 45 km from Thoothukudi. The name Udangudi might have been derived from two Tamil words. "Udai" means the thorny firewood tree (Acacia Sp) which is

abundant in that area and "Kudi" refers to a village or a human settlement. The climate of Udangudi area is arid, with an average ambient temperature of 30°C, annual rainfall of 718.2 mm and 65.5 % relative humidity. The village was once known for betel leaves (Vetrilai) and palm jaggery (Karupatti). Udangudi had a population of 19,347 according to the 2001 census. The area allocated for the project is about 939 acres and is located close to the Gulf of Mannar. The nearest railway station is at Tiruchendur which is about 12 km from the project site. The nearest airport is at Vagaikulam, which is about 60 km from the site. The nearest seaport is, Tuticorin which is about 45 km from the site.

The site naturally slopes towards the sea on the eastern side of the power plant and the topography of the site appears almost flat. Anna University has done a detailed study on the drainage of the area and has proposed that filling of 1 to 2m depth is required by fixing finished ground level to +2.45 m above msl. The salient features of the project site are summarized below:

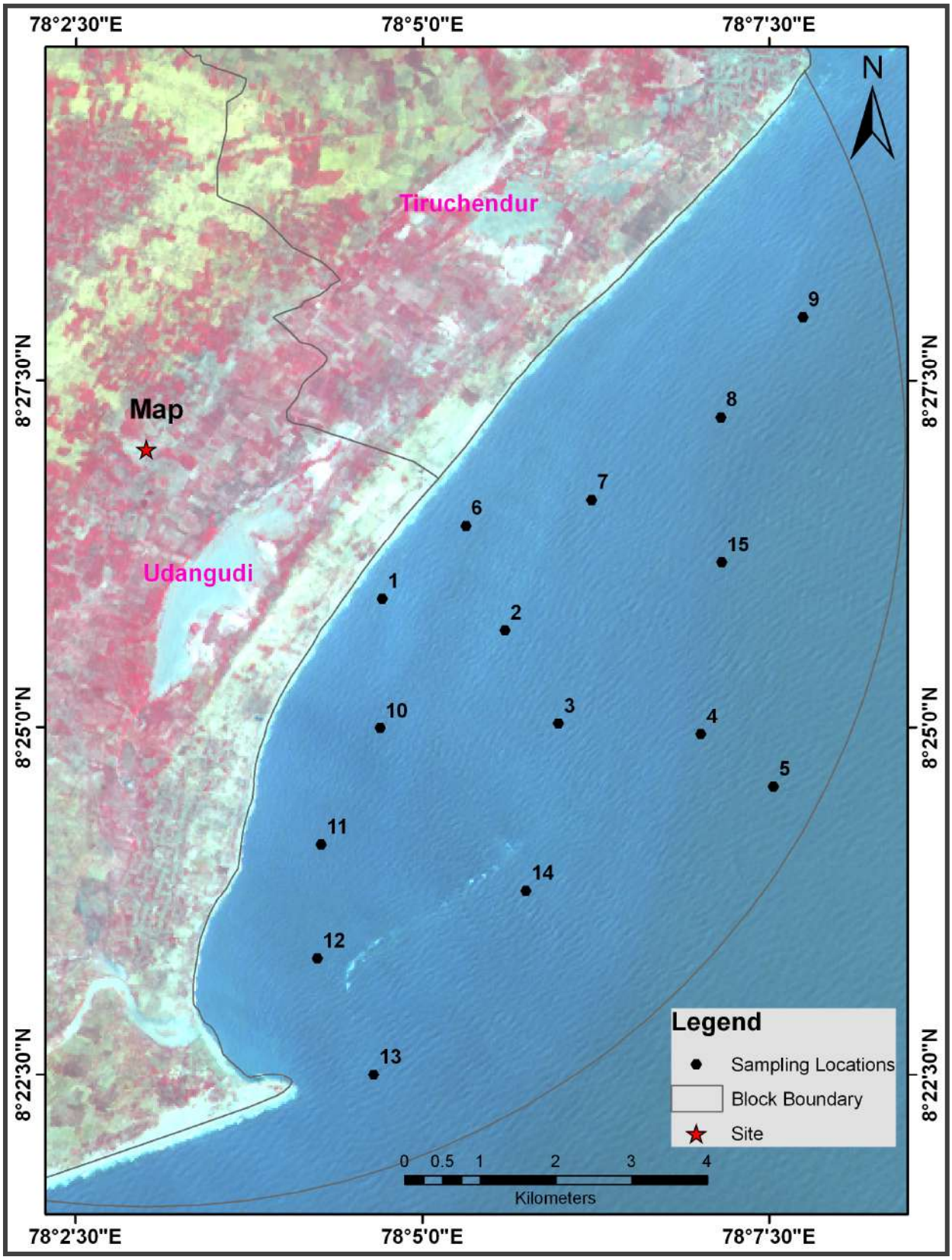
Table 1: Salient features of the Project Site

Village	Udangudi
District & State	Thoothukudi, Tamil Nadu
Latitude	8 ^{0}27' N
Longitude	78^{0}3'E
Road Connectivity	ECR-State Highway (176) passes near the project area
Rail Connectivity	Power House at a distance of 12 Km from Thiruchendur Railway Station
Airport	Vagaikulam which is 60 km from site
Sea Port	Thoothukudi, 45 km from project site
Archaeological/Historically important site	Nil
Sensitive Places	Gulf of Mannar
Sanctuaries/National Parks	Nil
Nearest Industries	Nil

UPCL has located this project on the following advantages:

- **Availability of suitable and adequate land without the need for displacement and rehabilitation of families or hamlets.**
- **Proximity to the sea and hence ready availability of cooling water for the operation of the power plant.**
- **Availability of infrastructural facilities such as road and railway access.**
- **Sufficient distance away from thickly populated town, avoidance of use of forest land, away from sanctuaries and bio reserves.**
- **Minimal issues for right of way for seawater pipeline and coal conveyor system.**

Fig.1. Location map of the project site



1.5 Importance of the Project

The proposed thermal power plant is envisaged

- **to meet the growing electricity demand for the development of the economy of Tamil Nadu and India**
- **to increase access to affordable energy services and**
- **to improve energy sector governance.**

The current power supply scenario in Tamil Nadu and the expected future demand are presented in Tables 2 and 3.

Table 2: Present Power Scenario in Tamil Nadu

Peak Load (MW)				Energy (MU)		
Years	Demand	Met	Deficit (%)	Required	Available	Deficit (%)
2002-2003	7364	7123	3.3	46262	43476	-6.0
2003-2004	7455	7228	3.0	45665	45042	-1.4
2004-2005	7647	7555	1.2	47872	47570	-0.6
2005-2006	9375	8297	11.5	54194	53853	-0.6
2006-2007	8860	8624	2.7	61499	60445	-1.7
2007-2008	10334	8690	15.9	65724	63898	-2.8

Table 3: Future Power Scenario in Tamil Nadu

Years	Peak demand(MW)	Energy requirement (MU)
2011-2012	14,224	87,222
2016-2017	21,976	1,34,755
2021-2022	29,815	1,82,825

The above tables clearly depict the gap between the energy supply and demand in Tamil Nadu. Hence, towards bridging this gap, TNEB has proposed to install the 2X800 MW coal based Power Plant.

1.6 Scope of EIA Study

The Environmental Impact Assessment report has been prepared for the proposed 1600 MW power (2×800 MW) to be set up near a small village called Udangudi in Thoothukudi district, Tamil Nadu by UPCL. It would be developed with super critical technology to obtain benefits under clean development mechanism (CDM Project). Based on the Terms of

Reference prescribed by the Ministry of Environment and Forests, Government of India for the EIA study has been addressed in this EIA report.

Chapter 1. Introduction (This chapter will describe the purpose of the report, Identification of nature, size and location of the project (with latitude and longitude) and its proponent, Description of site and surrounding environment, Location maps, Importance of project to the country and region and finally the Scope of the EIA study, as per TOR approved by MoEF).

Chapter 2. Project Description (This chapter will describe the Type and Need of the project, Magnitude of operation, Schedule for approval and implementation, Land requirement, Water requirement and flow scheme, Technology and Process description, Description of mitigation measures to meet the environmental standards).

Chapter 3. Field Investigations and Methodology for Analysis (This chapter will describe the study area, period of study, components and methodology for valued environmental components of all environmental component like Ambient air quality, Ambient noise quality, Marine water quality and Marine biota).

Chapter 4. Baseline Environment Scenario (This chapter will describe the baseline data for valued environmental components of all environmental component like Ambient air quality, Ambient noise quality, Marine water quality and Marine biota).

Chapter 5. Summary of Baseline Survey (This chapter will describe the summary of baseline data for valued environmental components).

Chapter 6. Anticipated Environmental Impacts and Mitigation Measures (This chapter will describe the details of investigated impacts due to project location, Measures for minimizing and / or offsetting adverse impacts identified, Irreversible and Irretrievable commitments of environmental components, Assessment of significance of impacts and Mitigation Measures).

Chapter 7. Environmental Management Plan (This chapter will describe the administrative aspects of ensuring that mitigation measures are implemented and their effectiveness monitored after approval of the EIA and also describe outcome of Risk Assessment and DMP).

CHAPTER 2: PROJECT DESCRIPTION

2.1 Project Site

The project site identified by UPCL is near a small village called Udangudi, about 650 km south of Chennai and 45 km from Thoothukudi. The climate of Udangudi area is arid, with an average ambient temperature of 30°C, annual rainfall of 718.2 mm and 65.5 % relative humidity. The village was once known for betel leaves (Vetrilai) and palm jaggery (Karupatti). Udangudi had a population of 19,347 according to the 2001 census. The area allocated for the project is about 939 acres and is located close to the Gulf of Mannar. The nearest railway station is at Tiruchendur which is about 12 km from the project site. The nearest airport is at Vagaikulam, which is about 60 km from the site. The nearest seaport is Tuticorin, which is about 45 km from the site.

The site naturally slopes towards the sea on the eastern side of the power plant and the topography of the site appears almost flat. Anna University has done a detailed study on the drainage of the area and has proposed that filling of 1 to 2m depth is required by fixing finished ground level to +2.45 m above msl.

Table 4. Technical details of the proposed project

Parameter	Description
Capacity of the Project	2X800 MW, Total 1600 MW
Source of fuel	Blended coal (Indian coal at 70% - 4.33 Million Tonnes / annum and Imported coal at 30% - 1.86 Million Tonnes / annum)
Fuel requirement	6.19 Million tonnes per annum at a PLF of 85 %.
Coal Transportation	Through Pipe Conveyor from Captive coal jetty to plant
Calorific value	4460 KCal/kg
Average ash content in coal (%-ARB)	29%
Maximum Sulphur content in coal	0.35 %
Water Requirement	The estimated consumption water requirement is 13,790 m^3/hr (including losses & recovery)
Source	Seawater
Cooling Water drawal	Through Pipe Line
Raw water treatment	Water shall be treated in Clarifiers, filters and in DM plant.
Cooling water system	Natural Draft Cooling Tower system
Raw Material	Secondary Fuel : 4500m^3 oil/annum

2.2 Land

The lands to an extent of 939 acres are envisaged for this proposed thermal plant. An extent of 755 acres of government lands have been alienated for the project. A corridor from the

plant boundary to seafront for conveying coal, seawater intake and outfall systems is planned to an extent of about 90 acres of dry-patta land. Adequate private lands required for township and green belt development are under acquisition by the govt.

2.3 Fuel

Udangudi site is located at a distance of about 1.2km from seafront and coal will be transported through a captive jetty at Udangudi and conveyed to the plant site by the belt/pipe conveyors. The blended coal of 70% Indian coal and 30% imported coal will be used as the main fuel for the proposed power plant. The Indian coal from Talcher fields - Mahanadi Coal Fields Limited in Orissa and imported coal from countries like Indonesia, South Africa, China, Australia and other possible sources will be used for the plant.

Indian coal having calorific value about 3800 kcal/kg and imported coal having calorific value of about 6000 kcal/kg are blended at a ratio of 70:30 percentage. The blended coal will have an average calorific value of about 4460 kcal/kg. Annual coal requirement is about 6.19 million tonnes. The requirement of Indian coal from Talcher coal field will be about 4.33 million tonnes per annum and imported coal requirement will be 1.86 million tonnes per annum considering a PLF of 85%. The coal jetty is designed to cater the coal handling upto 10 million tonnes.

2.4 Water

Input

The power station will have to depend upon seawater to meet the cooling water requirement due to non-availability of freshwater either from surface water sources or underground sources on a sustained basis. The hourly sea water requirement break-up for the 2 x 800 MW power plant with closed cycle cooling water system and 12 MLD desalination plant is as follows:

Description Flow rate	(m^3/hr)
Desalination plant Feed water	1,560
Cooling water make up	12,230
Total seawater requirement	13,790

Outlet

The RO reject from the desalination plant will be about 26,220 m3 / day. This reject will be diluted by discharging the same into the large quantity of blow down water let into the sea (1, 87,200m^3/day)Thereby the impact of RO reject over the marine ecology is negligible.

2.5 Ash generation

The average annual ash generation from the proposed power plant of 2 X 800 MW considering blended coal at 85% PLF will be as indicated below.

Description	Ash Generation
Total ash generation	241 tph
Annual bottom ash generated	0.36 million tpa
Annual fly ash generated	1.44 million tpa

Ash and Ash water will not be let into the sea.

2.6 Offshore Facilities

2.6.1 Coal jetty

The coal would be transported through pipe conveyer system to the power plant from its own captive coal jetty. The coal jetty is located at about 7.5km from the shore where 16m depth of water is easily available to berth Panamax vessels for unload coal. The pipe conveyer is at 6m to 8m height and supported by trestles 30m intervals. The coal berth is about 640m long and 24 m wide. The feasibility study for the establishment of coal jetty has been carried out by IIT, Madras and the report has been attached herewith as Annexure.

2.6.2 Cooling water intake

The National Institute Oceanography, Goa conducted mathematical model studies and finalized the locations for the intake point of cooling water and outfall point. The intake location of cooling water is about 1.6 km from HTL in the sea where 5.4m depth of water is available to draw sufficient quantity of seawater of about 13,790 m^3 hr^{-1} and the water is drawn through submerged pipe conduit of 2m diameter.

2.6.3 Cooling water outfall

The cooling water after passing through the plant is fed into the cooling towers and then let into the sea through pipe conduit along the coal conveyor trestles with a length about 1.06 km from shore. The RO reject of 26,220 m3 / day from the desalination plant will be diluted by discharging with the large quantity of blow down water (1,87,200 m^3/day). Thereby the impact of RO reject over the marine ecology is negligible.

CHAPTER 3. FIELD INVESTIGATIONS AND METHODOLOGY FOR ANALYSIS

The baseline status and the site-specific data are vital in determining the environmental design considerations for the project and environmental parameters that are likely to be impacted by the project. Hence, as part of the Environmental Impact Assessment, various environmental parameters were studied in ≈ 10 Km radius from the project site, to establish baseline environmental status with respect to various attributes. Major quantifiable parameters such as air, water and sediment that define environmental setting were analyzed. Water and sediment samples were collected from 15 locations (Fig. 1) and air quality was monitored at two locations within and around the project site, during the month of May and December 2009.

Methodology

a. Air quality

Clean air is a basic necessity for sustenance of life. In spite of introduction of cleaner technologies in industry, energy production and transport sectors, air pollution remains a major health risk. Recent epidemiological studies have provided evidence that even low pollution levels increase mortality and morbidity. Air quality standards provide a legal framework for air pollution control. Ambient air quality was monitored at two locations of the proposed power plant site. Respirable Dust Samplers (RDS) were used for this purpose.

Air samples were monitored for 24 hours and samples were analyzed for Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter, (RSPM), Sulphur Oxides (SO_x), and Nitrogen Oxides (NO_x) by using appropriate methods prescribed by the Bureau of Indian Standards and the Central Pollution Control Board. The methods followed for air monitoring in the study site are given in Table 5.

Table 5: Methods followed for air quality monitoring

Air Pollutants	Monitoring Method	Principle
Sulphur Dioxide (SO_2)	Improved West and Gaeke Method (Sodium Tetrachloro mercurate method)	Absorption followed by colorimertic analysis
Nitrogen Dioxide (NO_2)	Modified Jacob Hocchleser Method (Sodium Arsenite Method)	Sampling using High Volume Sampler with an average flow rate of <1.1 m^3 min-1
Particulate Matter ($PM_{2.5}$ and PM_{10})	High Volume Sampling and gravimetric filter method	Sampling using High Volume Sampler with an average flow rate of <1.1 m^3 min^{-1}

b. Water quality

Intensive water quality investigations were done in and around the proposed project site. A total of 15 locations were selected for the proposed work. The water samples were collected from the selected sites (Fig. 1) and were analyzed for various water quality parameters. The samples were collected in one-liter pre-cleaned acid washed polyethylene bottles and were preserved in dry ice and stored in the cold room at 4°C in the laboratory until further analysis. *In situ* measurements were made using a multiprobe, after calibration with appropriate standards. The water samples were filtered through a 0.45 µm Millipore filter and were analyzed for nutrients. Standard procedures and methods were followed [Ramesh and Anbu (1996) and APHA (1995)]. The samples were analyzed for physicochemical parameters such as temperature, salinity, conductivity, turbidity, total dissolved solids, pH, dissolved oxygen, biological oxygen demand and nutrients such as nitrate, nitrite, phosphate and silicate.

c. Sediment quality

Sediments collected from all 10 locations were analyzed for trace metals (Chromium, Iron, Cobalt, Zinc, Copper, Cadmium and Lead) in order to detect the presence of any sediment bound heavy metals. The samples were collected using a Van Veen Sediment Grab sampler.

The sediments were oven dried at 60°C for further analysis and the concentration of heavy metal was estimated using a Perkin Elmer Atomic Absorption Spectrophotometer.

d. Analysis of biota

Analysis of the biota involves (i) assessment of microbial load (ii) quantitative and qualitative study of the plankton (Phytoplankton and Zooplankton) and (iii) Meiobenthic community in the study area and is described in detail below.

○ Assessment of microbial load

Fecal coliforms which are more faecal specific, has been adopted as a standard indicator for contaminations in natural waters. Faecal coliforms are facultative-anaerobic, rod-shaped, gram-negative, non-sporulating bacteria. The presence of fecal coliform in aquatic environments may indicate that the water has been contaminated with fecal material of human or animal origin. Higher numbers of faecal coliform bacteria in water may indicate a higher risk of pathogens being present in the water. Faecal streptococci are bacteria which are also indicators of sewage contamination. The presence of such organisms indicates the presence of faecal material and thus of possible presence of intestinal pathogens. Indicators of faecal pollution thus provide a means of water quality control. The use of normal intestinal organisms as indicators of faecal pollution rather than the pathogens themselves is a universally accepted principle for monitoring and assessing the microbial pollution.

○ Plankton

Plankton are floating or drifting plants and animals that live in the ocean as well as in fresh water. Most can only be seen under a microscope, yet they are remarkably abundant in the world's ocean. It is estimated that phytoplankton, the plant forms of plankton, photosynthesize more than all other land and marine plants combined. This means that they also produce most of the oxygen breathed by humans and other animals. Phytoplankton is also the base of the ocean food chain. They are grazed upon by small zooplankters that are in turn, eaten by small fish and other zooplankton. Plankton has long been used as indicators of water quality.

Seawater samples for plankton studies were collected from all the fifteen locations using plankton net No.20 (100µm mesh size). The net was hauled for 10-15 minutes at each sampling site. The organisms were rinsed from the collection bucket into sampling bottles and preserved with 4 % buffered formalin solution. In the laboratory, the concentrated plankton sample was taken in aliquots of known volumes and identified and enumerated using a phase contrast microscope. The identification keys by Newell and Newell were followed for the analysis. Shannon–Weiner (H) and Evenness indices (E) were used to measure the overall biodiversity of the study site. The advantage of these indices is that it takes into account the number of species and the evenness of the species.

- **Meiobenthos**

Meiobenthos are small benthic invertebrates that can be retained in a mesh that is less than 1 mm and above 45 micron size. These serve as sensitive litmus for environmental change. The methods used for benthic study are standard and widely accepted techniques in coastal ecology. Published reference sources provide detailed instructions regarding these methods (Hauer and Lamberti 1996, APHA 1995, Cuffney et al. 1993). These references often provide multiple methods for sampling a given variable. For meiobenthic identification, a portion of the sediment on the sea floor was collected using Van Veen grab and sieved through standard mesh sized sieves. Organisms from each sample were further transferred into a labeled plastic bag to which approximately 10-15 ml of 10 % formalin was added. In the laboratory, the contents of each sample were spread-out in a white sorting tray and identified. The sorting was accomplished with the aid of a dissecting microscope of 10x magnification. The organisms were then identified to the lowest feasible taxonomic level.

CHAPTER 4: BASELINE ENVIRONMENT SCENARIO

Marine environmental survey was carried out by the team of scientists from IOM, Anna University, Chennai during May and December 2009 and the baseline data was obtained with respect to meteorology, air, water and sediment are briefly discussed in this section.

4.1 Physiography

There are two physiographic features in the coast of Thoothukudi district. That is, in the coastal belt between Vembar to Thiruchendur, there are raised beaches with sand bars parallel to the present coastline. The sand bars show trend towards north - south. In the coastal area between Thiruchendur to Manappad, there are sand dunes and terridunes complexes. The area of study has reached a mature stage of erosion and has gentle slope towards east- southeast towards Gulf of Mannar.

4.2 Geology

The stretch, comprises mainly of archeans, quaternary and recent geological formations. Sedimentary formations are traversed in coastal area, comprising of sand, clay, sandstone, calcareous sand with shell inclusion, laterite, granite gneisses, charnockite, pegmatite and quartzite. The coastal sedimentary beds attain maximum thickness of 50m and width of 15km from the shoreline. The coastal sediments assume different forms along the coastal belts due to neotectonic activities.

4.2.1 Black cotton soil (Typic chromusterts – TCSV)

Soil is clayey and high content of humic acid in vertisols is responsible for their dark tinge. The vertisols (black cotton soils) are impregnated with carbonates of secondary origins called as “Kankar” which occurs in the form of nodular, laminar and massive. The presence of carbonates indirectly indicates excessive evaporation in this part i.e evaporation is more than average rainfall. The genesis of the vertisol is the primary product of the weathering of the charnockite and gneissic rocks in the area. This type of soil is exposed in Ottapidaram taluk and is called as Typic chromusterts. Alkali hazard, poor drainage and erosion affect this soil group. The crops suitable for this type of soil are cotton, chillies, coriander, millets and sunflower.

4.2.2 Shallow red soil (Paralithic ustorthents –Puot)

This soil is red, fine loamy, non-calcareous and well drained with high permeability. This is generally observed on gentle slope and is subjected to erosion. This type of soil is distributed in the taluks of Thoothukudi and Thiruchendur. This soil supports groundnuts, gingelly, sunflower, vegetables and shallow rooted rainfed crops.

4.2.3 Deep red soil (Typic ustipsamments – Tupt)

This soil is red, very deep and non-calcareous sands. They occur as mound of sands, locally called as "Teri" sands. Soil texture ranges from sand to loamy sand. This is also subjected to severe wind erosion due to high permeability. Palm, coconuts, cashew grow in this soil. This is found in Thoothukudi and Thiruchendur taluks.

4.2.4 Alluvium (Aquic Haplustalfs and Fluventic Haplustalfs – Fhsf)

These soils are dark brown, brown, yellowish brown, imperfectly drained calcareous soils. This soil has low permeability. Irregular concretions of $CaCo_3$ are localized. This alluvial soil coverage is found in Thoothukudi and Thiruchendur taluks. Paddy, banana, chillies, vegetables, pulses and sunflower are grown in this soil.

4.2.5 Strong calcareous soil (Calcic ustropepts- Cutp)

This is dark grayish brown, yellowish brown calcareous soil. Moderately deep to deep fine loamy soil occurs on gently slopes subjected to sheet erosion. This soil exhibits elasticity, plasticity and low permeability. The texture of the soil varies from loamy sand to sandy clay. Many types of sea shells are encountered in this group of soils. This is distributed in Thiruchendur taluk.

4.3 Coastal Geomorphology

The coastline from Vembar to Tiruchendur is developed by sediment accretion except for the Thiruchendur and Manappad which have cliffed coast resulting from erosions of mounds of quaternary sediments. South of Thoothukudi, near the mouth of Korampallam backwater, huge sand bar has developed into a northward trending beach cap 4km from the main shore. The south of Thiruchendur coastline is marked by a narrow beach, beyond which extends the coastal ridge from Manapadu to Kudangulam over which sand dunes and beach terraces have developed. The quaternary sandstones are exposed as wave cut platform along the entire coast from Periyatalai to Uvari. The most important coastal features are bays, lagoons, estuaries, cliffs, dunes, backshore, beach and wave cut features.

4.3.1 Headland (Cliff) and Bays

Due to the presence of headlands, the coastal configuration is divided into various types of coastal cells like bays between Manapad and Thiruchendur; Thiruchendur and Kayalpattinam. In these bays, the beach widths are more than normal beaches. The cliff sections in these areas are comprised of sedimentary of quaternary age. The cliff sections act as wave barriers. The confluence of wave generates more energy for erosional activity and so undercutting and toe erosion in the cliff sections are common.

4.4 Coastal Types

The coast in the study area is almost rocky shore. The sandy beaches have broader beach width (50 to 85m) and backshore width (5 to 25m) and well developed dunes with height ranging from 0.5 to 2.5m.

4.4.1 Dunes

Presence of well developed dunes in the coastal zone indicates that the erosional processes do not affect the beaches in that area. Dunes sometimes are covered with vegetation which is thus protected from erosion than the unprotected dunes.

4.4.2 Islands

Four coral islands, out of twenty coral islands in Gulf of Mannar, come under the administrative control of Thoothukudi. These islands are characterized by reef with marked zonation (Patch reef, offshore patch, coral pinnacles etc). A morphological variation study reveals that the islands are reduced in their size and distribution and have migrated about 1.7km towards north-west direction towards the main land.

4.5 Climate and Meteorological Conditions

The factors that influence the climate of this stretch are the two monsoon winds and proximity of the sea. Due to the absence of hill ranges of considerable height, the monsoons do not precipitate heavy showers. The southwest monsoon also brings showers in the months of June and July and this season is locally called as “Saral”**.**

4.5.1 Temperature

During the study period, the temperature minima and maxima were about 26°C to 38°C in dry season and 20°C to 28°C in post monsoon season.

4.5.2 Relative humidity

The lowest and highest values of humidity vary from 61% in dry season to 81% in post monsoon season.

4.5.3 Rainfall

Thoothukudi experiences rain from both southwest and northeast monsoons. The major precipitation occurs during September and March. The average annual rainfall observed over period of 37 years is about 610mm.

4.5.4 Solar radiation

Average solar radiation was seen to be in the range of 191 to 250 Watt/m^2.

4.5.5 Wind speed

The wind speed was 15km/hr during most of the year and 80km/hr during monsoon seasons. The wind direction predominantly varies between 60º to 90º (Northwest) during November to March; 220º to 270º during May to September and 180º in April.

4.5.6 Waves

The peak wave heights are observed during mid May and August of the order of 2.2 m and during December of the order of 1.5 m. The peak wave period is 9 seconds with the wave approaching from south –southeast. The wave directions vary from about 45º (northeast) to 225º (southwest).

4.5.7 Currents

Two types of water masses are known to prevail in the Gulf. There is a strong current from the north flowing southwards from November to March. This direction is reversed from April to October bringing oceanic waters from the southern regions.

4.5.8 Cyclones

Cyclones are not so frequent. Cyclones may occur during northeast monsoon. However, the port experienced a direct hit of a cyclone during November, 1992 when the highest wind speed recorded was 113 km/hour from ESE direction.

4.7 Natural Resources

4.7.1 Water

Dug cum bore wells and shallow tube wells are prominent in this area. The water table has been highly depleted due to extraction of ground water for irrigation.

4.7.2 Mineral

The coastal belt is rich in garnet, ilmenite and monazite sands. Near the mouth of Kallar and Vaipar River mouths concentrations of ilmenite and garnet sands are observed.

4.7.3 Flora and Fauna

From Surangudi to Udangudi, the sea is filled with occasional coral reefs and algal patches. There are submerged huge rocky patches which themselves form an ecosystem of algae, sea fans and pearl oysters. From Thoothukudi to Chinnamuttam the coast is absolutely sandy and is the best nesting ground of sea turtles.

4.8 Marine Environment

4.8.1 Water quality

In a coastal segment, marine water is subjected to several types of uses. Depending on the types of uses and activities, water quality standards have been specified to determine its suitability for a particular purpose. Among the various types of uses there is one use that demands highest level of water quality/purity and that is termed a "designated best use" in that stretch of the coastal segment. Based on this, primary water quality has been specified for five designated best uses as given in Table 6.

Water pollution refers to any change in natural waters that may impair further use of the water, caused by the introduction of organic or inorganic substances or a change in temperature of the water. In power stations, the source of water may be from river, lake, pond or sea and there is a possibility of water being contaminated from the source itself. Further contamination or pollution could be added by the pollutants from the power plant such as inorganic or organic compounds that cause changes in the aquatic environment such as changes of pH, dissolved oxygen, temperature and the species present in the domain. The effects on the marine ecology arising from the operation of coastal thermal power plants are mainly habitat loss in the intertidal and subtidal faunal assemblage.

Table 6. Standards of seawater quality

	Class	"Designated use" of sea water
Sea water	SW-I	Shell fishing, Mariculture and Ecologically Sensitive Zones
Sea water	SW-II	Bathing, Contact water sports and Commercial fishing
Sea water	SW-III	Industrial cooling, Recreation (non-contact) and Aesthetics
Sea water	SW-IV	Harbour
Sea water	SW-V	Navigational and Controlled waste disposal

The primary water quality standards for industrial cooling under SW-III category (CPCB, 1998) are furnished in Table 7.

Table 7. Primary sea water quality (SW-III)

No.	Parameters	Standards
1.	pH	6.5-8.5
2.	DO	3.0 mg/l
3.	Colour and Odour	No noticeable colour or offensive odour
4.	Floating matters	No visible, obnoxious floating debris, oil slick, scum
5.	Fecal Coliform	500/100ml MPN
6.	Turbidity	30 NTU
7.	Temperature	Shall not exceed more than 5°C than the receiving water temperature

Results of the coastal water quality during the survey are given in Table 11 that represents the existing baseline values of the coastal water. In addition to this, baseline studies help us to understand the behavior of the system, which is essential for establishing trends for predicting future conditions with the proposed development.

4.9 Meteorology

Data on meteorological parameters such as wind speed, rainfall, temperature etc are as follows:

Predominant wind direction: East and South East direction.
Wind speed: 16.6 km/hr.
Average temperature: 25.51-36.7 ^{0} C
Humidity: 31-93.43 %
Annual maximum rainfall: 718.2 mm

4.10 Ambient Air Quality

The major air pollution parameters such as Nitrogen oxides (NO_x), Suspended Particulate Matter ($PM_{2.5}$, PM_{10}) and Sulphur oxides (SO_x) were monitored at the proposed project area. High volume air samplers were installed at two locations, one close to the coastal site and the other near the coal dumpsite and samples were collected at every 8 hour interval for a period of 24 hours during May and December 2009. The results of the analysis are furnished in Table 8 and 9.

Table 8. Ambient air quality in the proposed project area (May 2009).

S. No.	Time	PM_{10} µg/m^3	$PM_{2.5}$ µg/m^3	NO_x µg/m^3	SO_x µg/m^3
Location 1: Coastal area					
1	*10 am-6pm*	80.0	62.0	10.3	15.1
2	*6pm-2am*	76.4	69.0	12.8	17.8
3	*2am-10am*	82.0	42.1	10.2	19.5
4	*10am-6 pm*	75.0	46.8	11.8	17.9
5	*6pm-2am*	56.0	25.9	12.9	16.0
6	*2am-10am*	43.0	27.9	13.4	16.2
Average		68.7	45.6	11.9	17.1
Location 2: Project site					
1	*10 am-6pm*	67.0	53.0	11.2	16.8
2	*6pm-2am*	69.0	49.2	15.4	17.1
3	*2am-10am*	74.0	57.2	18.9	18.1
4	*10am-6 pm*	76.8	52.2	13.0	17.9
5	*6pm-2am*	77.3	61.5	13.9	16.6
6	*2am-10am*	82.4	66.4	19.7	13.2
Average		74.4	56.6	15.3	16.6
Annual Average* CPCB limits	Industrial areas	360	120	80	80
	Residential areas	140	60	60	60

Table 9. Ambient air quality in the proposed project area (December 2009).

S. No.	Time	PM_{10} µg/m^3	$PM_{2.5}$ µg/m^3	NO_x µg/m^3	SO_x µg/m^3
Location 1: Coastal area					
1	*10 am-6pm*	87.3	62	11.6	16.3
2	*6pm-2am*	79.2	69	11.9	17.8
3	*2am-10am*	69.3	76	15.3	20.5
4	*10am-6 pm*	60.6	83	17.8	23.2
5	*6pm-2am*	51.6	90	20.3	25.9
6	*2am-10am*	42.6	97	22.8	28.6
Average		68.7	45.6	11.9	17.1
Location 2: Project site					
1	*10 am-6pm*	74.8	58.7	12.5	17.5
2	*6pm-2am*	69.7	52.3	16.4	18.9
3	*2am-10am*	74.4	57.2	18.9	21.6
4	*10am-6 pm*	76.8	52.2	13.7	22.3
5	*6pm-2am*	77.3	61.5	13.9	24.7
6	*2am-10am*	82.4	66.4	19.7	27.9
Average		75.9	58.1	15.9	22.2
Annual Average* CPCB limits	Industrial areas	360	120	80	80
	Residential areas	140	60	60	60

4.10.1 Suspended Particulate matter (PM_{10} and $PM_{2.5}$)

Suspended particulate matter (SPM) arises from the dust generated due to construction and operation activities of the project. The PM_{10} at port area during May 2009 was observed to be 68.7 (Coastal area) to 74.4 (Project area) µg/m^3. Whereas, during December 2009 the concentration varied from 65.1 to 75.9 µg/m^3. The $PM_{2.5}$ concentration in the project site during May and December 2009 averaged between 45.6 and 79.5 µg/m^3 in the coastal site and 58.1 to 56.6 µg/m^3 in the Project site. The observed values of both PM_{10} and $PM_{2.5}$ are well below the prescribed standards of the CPCB.

4.10.2 Nitrogen oxides (NO_x)

Nitrogen oxides, or NO_x, are the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. Many of the nitrogen oxides are colorless and odorless.

In general, NO_x

- react to form nitrate particles, acid aerosols, as well as NO_2, which also causes respiratory problems
- contribute to formation of acid rain
- contribute to nutrient overload that deteriorates water quality
- contribute to atmospheric particles, that cause visibility impairment
- react to form toxic chemicals and
- contribute to global warming

In the present study, the concentration of NO_x during May and December 2009 averaged between 11.9 and 16.6 µg m^{-3} in the coastal site and 15.4 and 15.6 µg m^{-3} in the Project site respectively, which is below the permissible limits of the CPCB[1] (Table 8 and 9) for industrial/residential areas.

4.10.3 Sulphur oxides (SO_x)

Sulphur oxides or SO_2, is the most important of the family of sulphur oxide gases (SO_x). These gases dissolve easily in water.

In general, SO_2

- contributes to respiratory illness, particularly in children and the elderly, and aggravates existing heart and lung diseases.
- contributes to the formation of acid rain, which: damages trees, crops, historic buildings, and monuments; and makes soils, lakes, and streams acidic.
- contributes to the formation of atmospheric particles that cause visibility impairment
- can be transported over long distances.

[1] http://moef.nic.in/downloads/public-information/826.pdf

In the present study, the concentration of SO_x during May and December 2009 is averaged between 17.1–22.1(Coastal site)µg m^{-3} and 16.6–22.2(Project site)µg m^{-3} respectively, which is below the permissible limits of the CPCB[2] (Table 8 and 9) for industrial/residential areas.

4.10.4 Noise Quality

Table 10. Noise monitoring around proposed site

Code	Location	Zone	Noise Level dB(A)	
			L_{Day}	L_{Night}
May 2009				
N1	Project site	Silent	65.1	60.5
N2	Coastal site	Silent	55.6	48.1
December 2009				
N3	Project site	Silent	68.4	62.0
N4	Coastal site	Silent	43.9	36.7

Table 11. Ambient Air Quality standards (CPCB) in respect to noise level

Day time	Area	Noise level (L_{eq})
	Industrial area	75
	Commercial area	65
	Residential area	55
	Silence zone	50
Night time	Industrial area	70
	Commercial area	55
	Residential area	45
	Silence zone	40

The average ambient noise level is ranged from 43.9 to 68.4db during day time and 36.7 to 62 db during night time in the proposed project site during both seasons. The observed values are below the limits for industrial areas as prescribed by CPCB.

4.11 Water Quality

Water pollution refers to any change in natural waters that may impair further use of the water, caused by the introduction of organic or inorganic substances or a change in

[2] http://moef.nic.in/downloads/public-information/826.pdf

temperature of the water. Pollutants could be immediately toxic or those which cause physic-chemical changes in the aquatic environment resulting in the adverse impact on living organisms present in the seawater. The source of pollutants could be point source such as outfalls or non-point source such as runoff from land.

Pathogens

Pathogens are disease causing microorganisms, such as bacteria and viruses that come from the fecal waste of animals and humans. The main sources of pathogenic organisms in India are untreated sewage let into the sea as well as open defecation practiced along shorelines or river banks.

Nutrients

Nutrients such as nitrogen and phosphorus originate from sewage (especially the use of detergents) and agricultural runoff. Large quantities entering seawater can result in eutrophication.

Toxic Contaminants

Toxins are substances that can harm aquatic and human life include heavy metals, pesticides and organic compounds. Organic toxic compounds are resistant to breakdown and like some heavy metals tend to be passed through the food chain and get concentrated in top predators including fish and birds. In a coastal segment, marine water is subjected to several types of uses. Depending on the types of uses and activities, water quality standards have been specified to determine its suitability for a particular purpose. Among the various types of uses there is one use that demands highest level of water quality/purity and that is termed a "designated best use" in that stretch of the coastal segment. Based on this, primary water quality has been specified for five designated best uses as follows (Table. 12). As per amendment to Schedule-1, serial no. 86 of Environment Protection Rules, 1986 dated 22nd December, 1998) and the water utilized for industrial cooling is designated as class SW-III.

Table. 12. Water Quality Standards for Coastal Waters

Seawater	Classification
SW-I	Saltpans, shell fishing, mariculture and Ecologically Sensitive Zones
SW-II	Bathing, contact water sports and commercial fishing
SW-III	Industrial cooling, recreation (non-contact) and aesthetics
SW-IV	Harbour
SW-V	Navigational and controlled waste disposal

4.11.1 Physico-Chemical Parameters

Determination of the physico-chemical characteristics of seawater is important in environmental monitoring. The pollutants released into the marine environment due to anthropogenic activity, enter the aquatic system by direct discharge and through atmospheric inputs and get incorporated into the environment. Physico-chemical parameters such as surface water temperature, dissolved oxygen, pH, Total Dissolved Solids (TDS), Salinity and specific gravity observed during the present investigation are generally within the accepted optimum range for marine organisms (Table 13 and 14).

Table 13. Physicochemical parameters of the coastal waters observed at various locations (May 2009)

Station ID	Long/ Lat	pH	DO (mg/l)	Conductivity (mS)	Turbidity (NTU)	Temp (^{0}C)	Salinity	TDS (mg/l)	BOD (mg/l)
UD1	78° 4' 42.511" E 8° 25' 55.644" N	7.9	5.9	4.8	5.2	31.7	30.8	50.2	1.0
UD2	78° 5' 34.142" E 8° 25' 40.742" N	8.3	5.6	5.0	5.4	31.3	31.8	52.5	1.8
UD3	78° 5' 58.305" E 8° 25' 0.955" N	8.4	5.5	5.0	5.7	31.3	31.9	52.5	1.6
UD4	78° 7' 1.170" E 8° 24' 57.247" N	8.2	5.6	5.0	6.2	31.2	32.0	52.5	1.6
UD5	78° 7' 33.650" E 8° 24' 33.628" N	8.0	5.4	5.0	6.4	31.1	31.9	52.4	2.0
UD6	78° 5' 17.471" E 8° 26' 25.506" N	8.2	5.2	5.0	6.5	31.1	31.9	52.4	2.4
UD7	78° 6' 12.007" E 8° 26' 37.550" N	8.2	5.6	5.0	5.0	31.0	31.9	52.4	2.0
UD8	78° 7' 9.866" E 8° 27' 13.345" N	8.2	5.5	5.0	6.7	30.9	31.9	52.3	1.4
UD9	78° 7' 44.827" E 8° 27' 57.299" N	8.2	5.7	5.0	6.3	30.9	31.9	52.3	1.8
UD10	78° 4' 40.871" E 8° 24' 58.975" N	8.2	5.1	5.0	6.2	31.1	32.0	52.5	2.4
UD11	78° 4' 15.499" E 8° 24' 7.808" N	8.2	6.0	5.0	6.7	30.9	31.9	52.4	0.8
UD12	78° 4' 14.273" E 8° 23' 19.306" N	8.1	6.2	2.6	7.0	30.5	32.0	52.3	0.7
UD13	78° 4' 39.272" E 8° 22' 29.530" N	7.9	6.1	2.6	7.2	29.9	31.8	52.2	0.8
UD14	78° 5' 45.011" E 8° 23' 49.565" N	7.7	5.8	2.6	7.3	29.3	31.6	52.1	0.6
UD15	78° 7' 9.471" E 8° 26' 12.241" N	7.4	5.9	2.6	7.4	28.7	31.4	52.0	0.8
Averag		8.1	5.7	4.3	6.3	30.7	31.8	52.2	1.4

e									
Min		7.4	5.1	2.6	5.0	28.7	30.8	50.2	0.6
Max		8.4	6.2	5.0	7.4	31.7	32.0	52.5	2.4

Table 14. Physicochemical parameters of the coastal waters observed at various locations (December 2009)

Station ID	Long/ Lat	pH	DO (mg/l)	Conductivity (mS)	Turbidity (NTU)	Temp (^{0}C)	Salinity	TDS (mg/l)	BOD (mg/l)
UD1	78° 4' 42.511" E 8° 25' 55.644" N	7.9	4.9	5.04	2.7	27.4	32	51.6	2.1
UD2	78° 5' 34.142" E 8° 25' 40.742" N	7.9	4.6	5.34	2.3	27.7	33.6	55.1	2.8
UD3	78° 5' 58.305" E 8° 25' 0.955" N	7.8	4.8	5.29	1.7	26.8	33.4	54.7	2.6
UD4	78° 7' 1.170" E 8° 24' 57.247" N	7.8	5.4	5.26	1.7	26.5	33.1	54.3	2.6
UD5	78° 7' 33.650" E 8° 24' 33.628" N	7.7	5.6	5.2	1.9	26.9	32.7	53.4	2.0
UD6	78° 5' 17.471" E 8° 26' 25.506" N	7.8	4.8	5.2	2	26.9	33.1	54	1.8
UD7	78° 6' 12.007" E 8° 26' 37.550" N	7.8	5.1	5.3	2.1	26.3	33.4	54.9	2.1
UD8	78° 7' 9.866" E 8° 27' 13.345" N	7.7	4.9	5.3	2.3	26.7	33.5	55	2.4
UD9	78° 7' 44.827" E 8° 27' 57.299" N	7.5	5.2	5.3	1.8	26.4	33.4	54.7	2.8
UD10	78° 4' 40.871" E 8° 24' 58.975" N	7.8	5.3	4.1	2.3	26.8	33.7	54.4	2.6
UD11	78° 4' 15.499" E 8° 24' 7.808" N	7.9	5.2	5.2	2.5	26.9	32.6	53.4	1.8
UD12	78° 4' 14.273" E 8° 23' 19.306" N	7.8	4.9	5.16	3.1	25.9	32.3	52.9	1.7
UD13	78° 4' 39.272" E 8° 22' 29.530" N	7.7	5.3	5.16	3.4	25.7	32.3	53	1.8
UD14	78° 5' 45.011" E 8° 23' 49.565" N	7.7	5.8	2.6	3.3	25.7	32.2	52.8	1.6
UD15	78° 7' 9.471" E 8° 26' 12.241" N	7.7	5.9	2.6	3.7	25.4	32.2	52.8	1.8
Average		7.8	5.2	4.8	2.5	26.5	32.9	53.8	2.2
Min		7.5	4.6	2.6	1.7	25.4	32.0	51.6	1.6

Max		7.94	5.9	5.34	3.7	27.7	33.7	55.1	2.8

Temperature and Salinity

The average surface temperature of coastal waters and 2009 varied from 26.5°C (December 2009) to 30.7°C (May 2009) and the salinity varied between 31.8 (May 2009) and 32.9 (December 2009). High salinity was observed in stations 4, 10 and 12 and low value was observed in station 15 (Fig.2, Fig.3).

Fig.2. Variations in temperature in surface waters (May 2009)

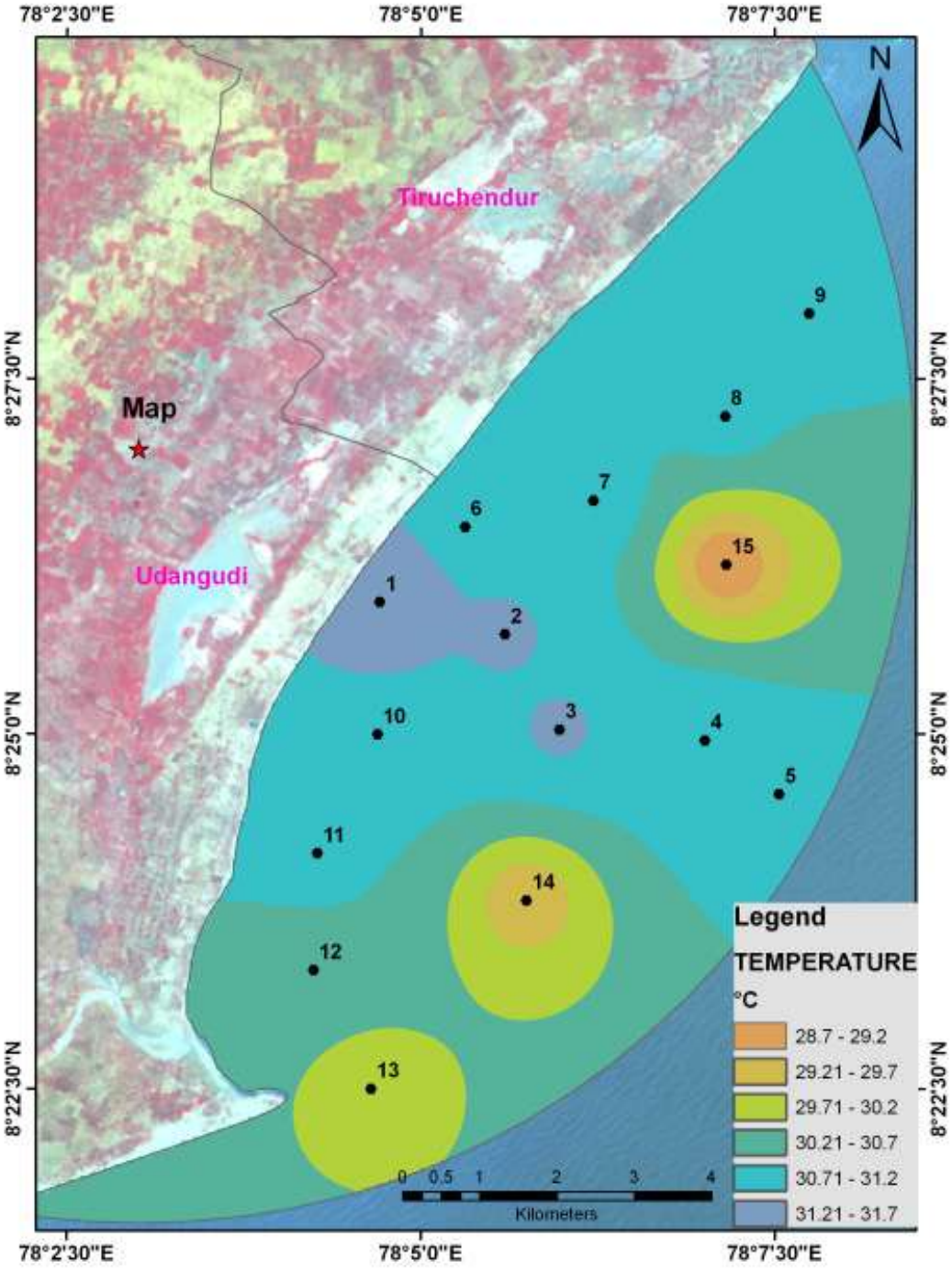
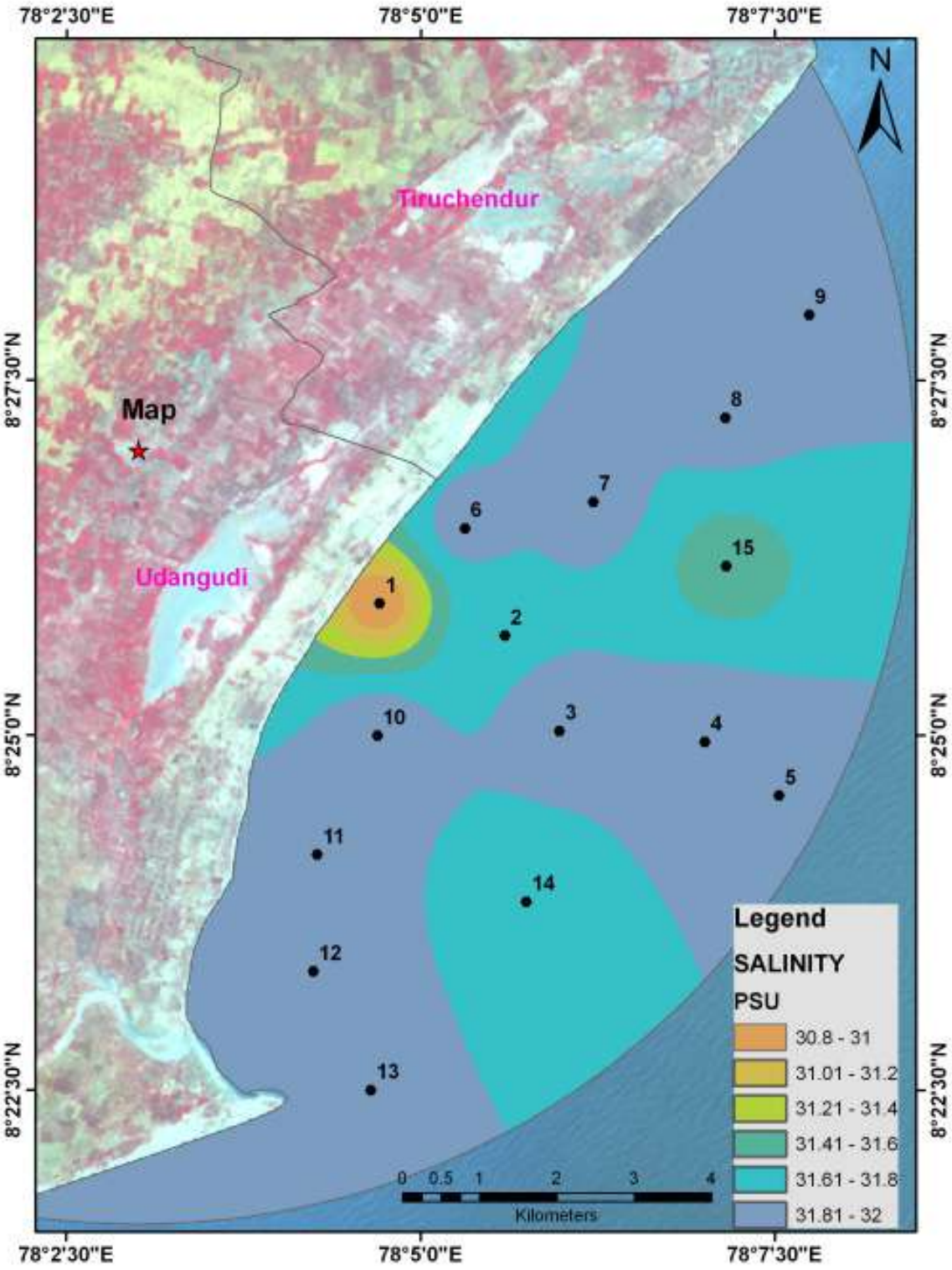


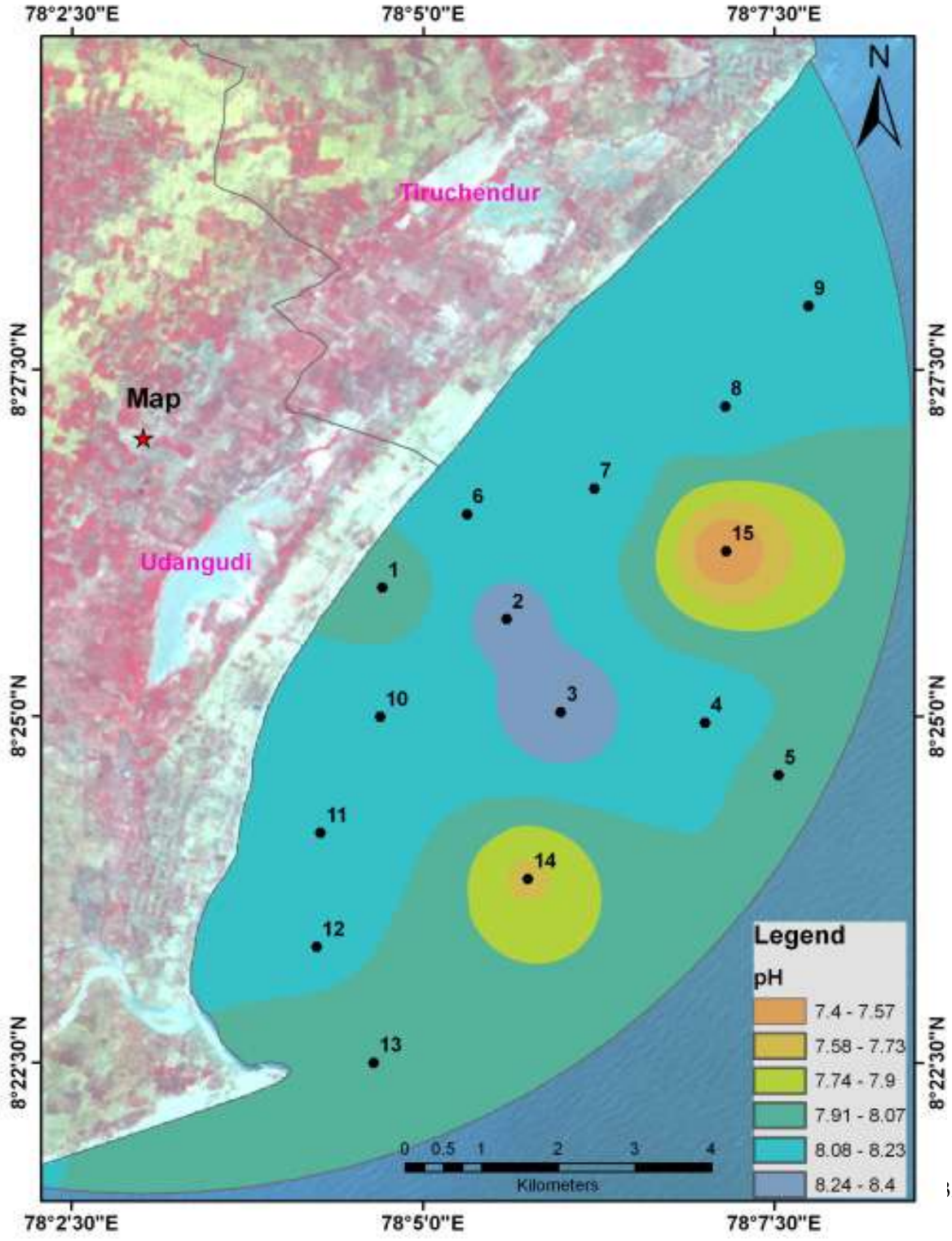
Fig. 3. Variations in salinity in surface waters (May 2009)



pH

The average values of pH in both seasons ranged between 7.8 (December 2009) and 8.1 (May 2009) (Fig.4).The range of pH is in agreement with the values reported from the other areas in the Gulf of Mannar.

Fig. 4. Variations in pH in the study site



Electrical Conductivity (EC) and Total Dissolved Solids (TDS)

The Electrical conductivity (EC) of water is a measure of the ability of water to conduct an electrical current. EC is transported by the ions in solution; the conductivity increases as the ions increases. The values of electrical conductivity in both surveys averaged from 4.3 (May 2009) to 4.8 mS (December 2009). TDS is an important indicator of water quality as it has an impact on the mobility of metals and ionizable chemicals, particularly in the present study area. The average TDS values during both seasons averaged between 52.2 mg/l (May 2009) to 53.8 mg/l (December 2009) (Fig.5).

Dissolved Oxygen

Dissolved oxygen is a measure of the ability of a system to support aquatic life. Generally the oxygen concentration of seawaters is influenced by processes such as diffusion and photosynthesis which add oxygen to the water or deplete it (e.g., by assimilation of organisms, organic decomposition and nitrification, or diffusion into the atmosphere). Dissolved oxygen (DO) level is also controlled by factors such as temperature and salinity. With increase in salinity and temperature, DO decreases. Introduction of organic carbon into the ecosystem leads to intense bacterial activity and since the bacteria consume oxygen in their respiratory process the DO levels are affected. Though the response of different marine fauna to reduction in DO level varies, DO levels of less than 2 mg l^{-1} is highly injurious and levels between 2 to 4 mg l^{-1} will impart considerable stress. Dissolved oxygen measured in the coastal waters of the project site during averaged between 5.2 (December 2009) and 5.6 (May 2009) mg l^{-1} respectively, indicating healthy nature of the surface waters (Fig.6).

Fig.5. Variations in TDS in the study site (May 2009)

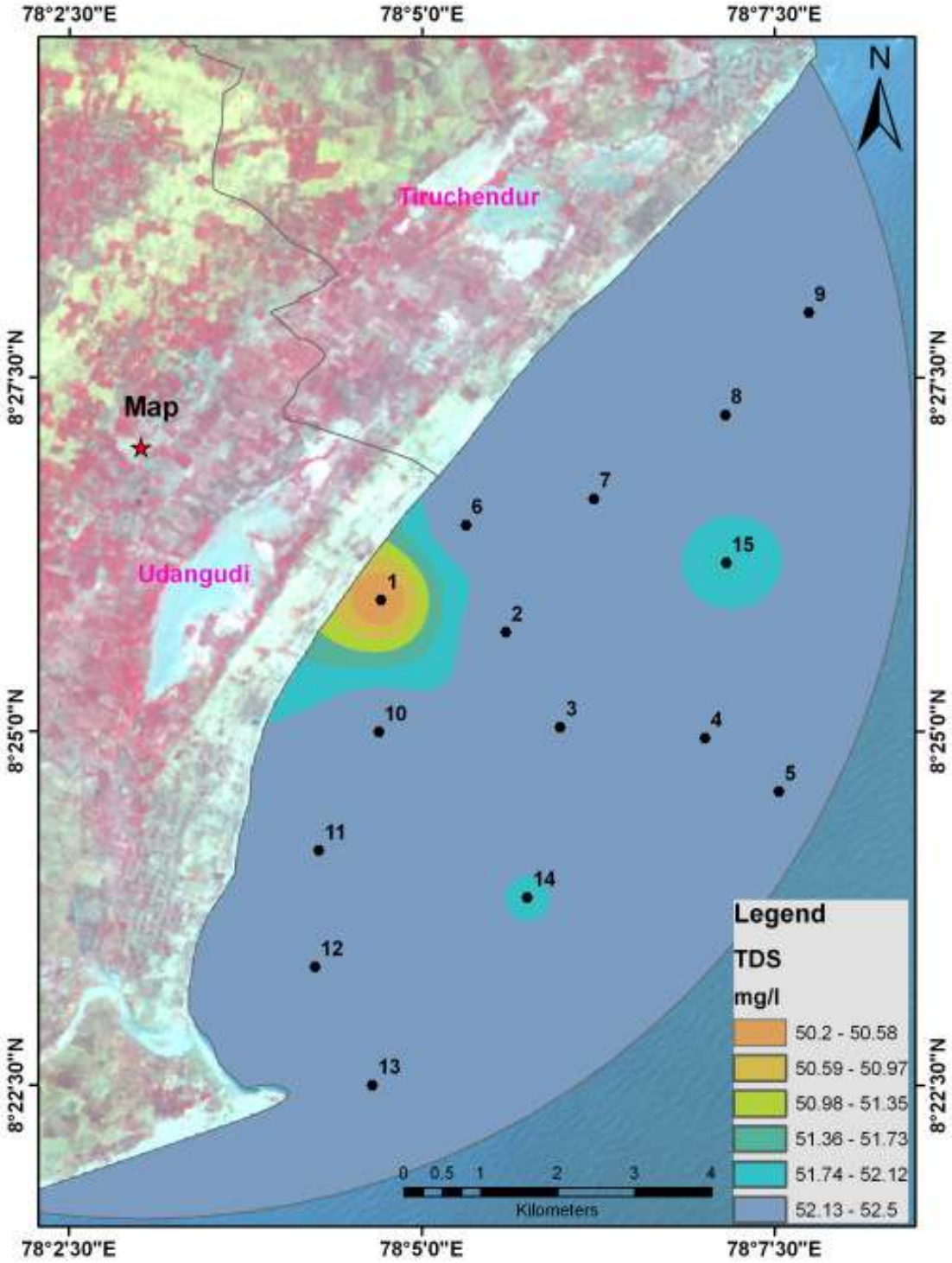
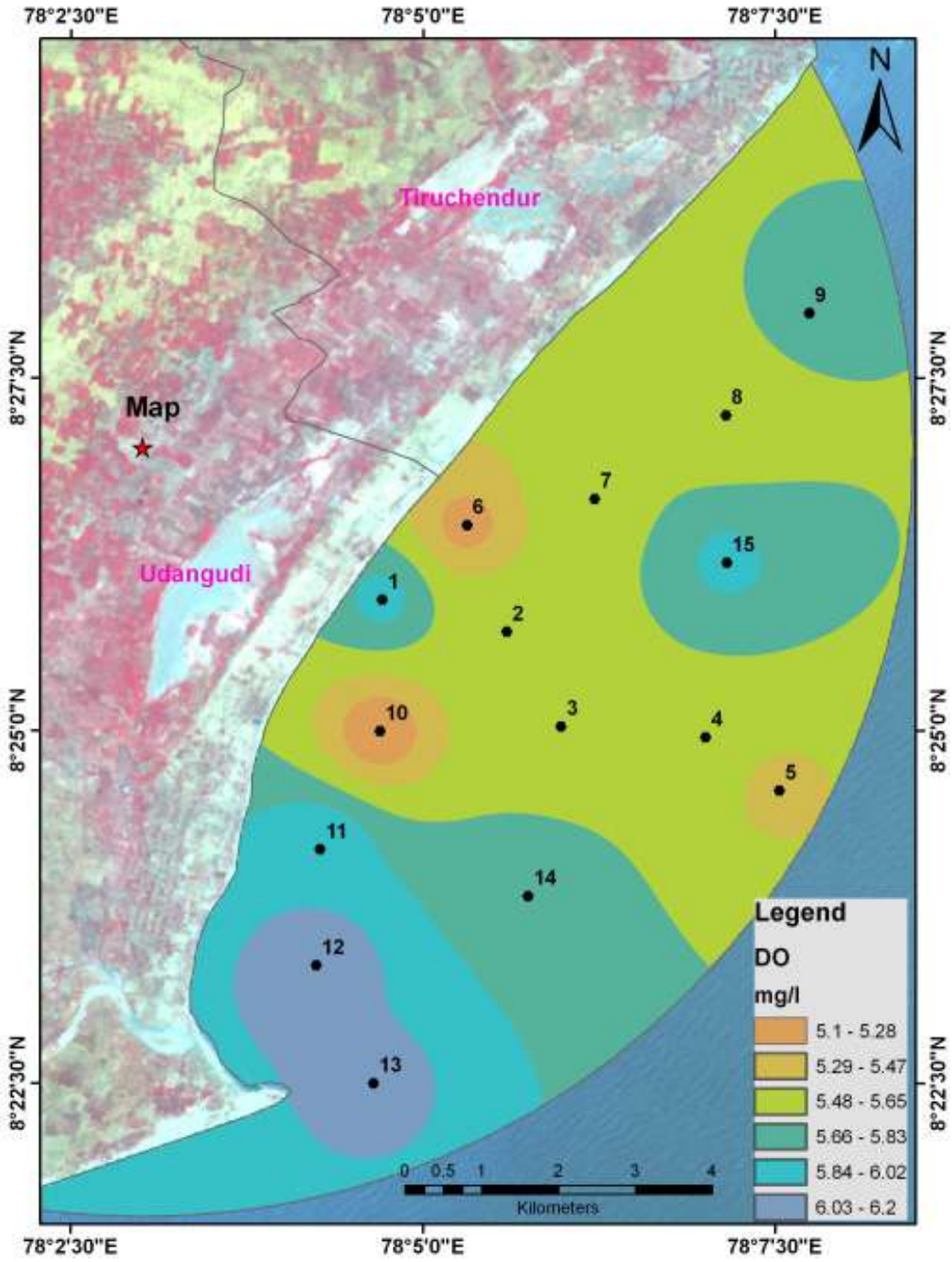


Fig. 6. Dissolved oxygen concentration in the study site (May 2009)



Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand (BOD) is a chemical procedure for determining how fast biological organisms use up oxygen in a body of water. It is used as a measure of the level of

organic matter in a water body. Table below gives the range of BOD concentrations correlated with the water quality. The more organic material is in the water, the higher the BOD. Higher BOD is indicative of low levels of oxygen available for other biota such as fish living in the water.

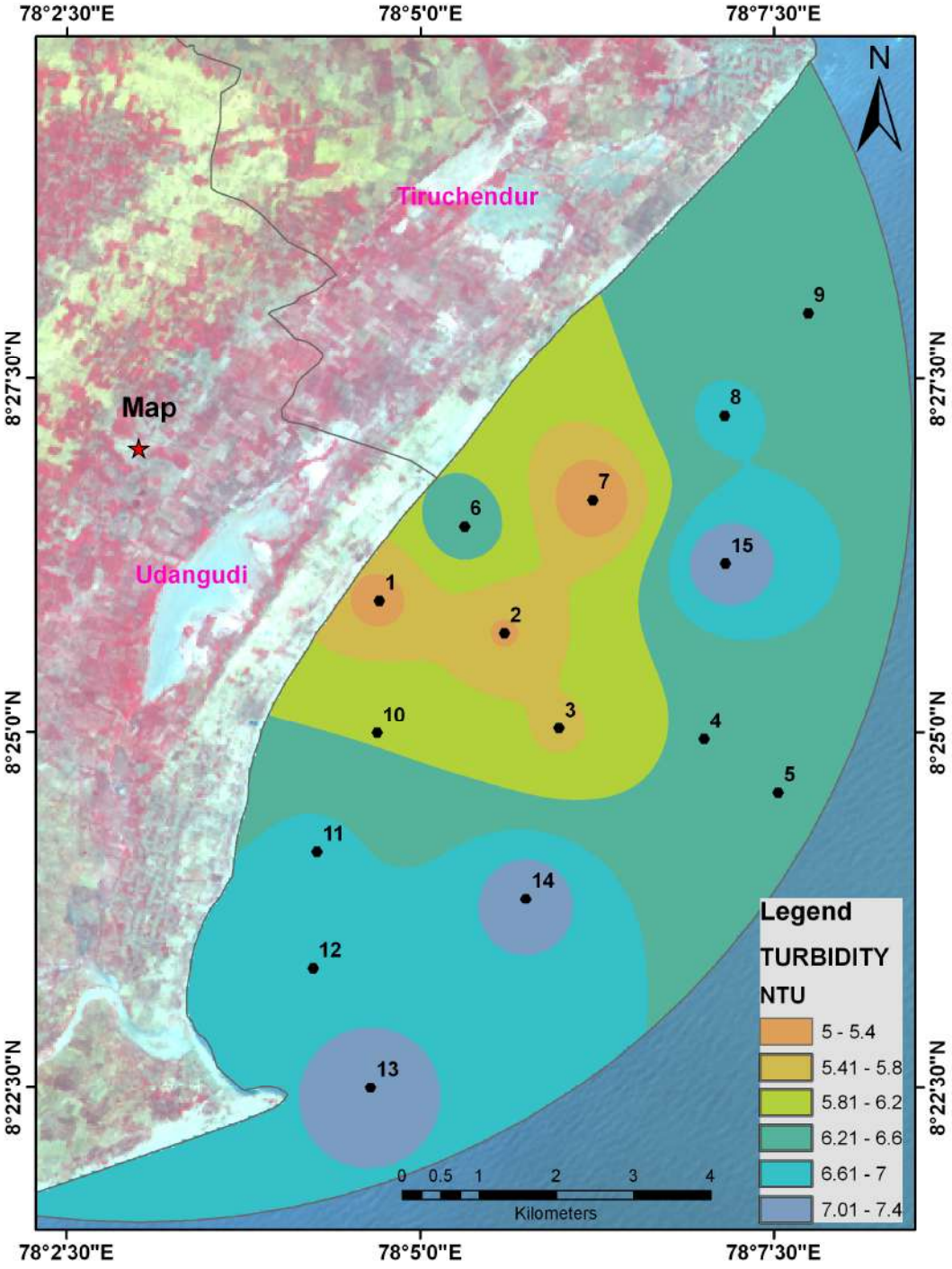
BOD Level ***(in ppm)***	**Water Quality**
1 – 2	Very good There will not be much organic waste present in the water supply.
3 – 5	Fair: Moderately Clean
6 – 9	Poor: Somewhat Polluted Usually indicates organic matter is present and bacteria are decomposing this waste.
100 or greater	Very Poor: Highly Polluted Contains organic waste.

The BOD values measured in both sampling survey averaged between 1.4 (May 2009) to 2.2 mg l^{-1} (December 2009), indicating minimal pollution.

Turbidity

Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates. Turbidity is considered as a good measure of the quality of water. The suspended particles absorb heat from the sunlight, making turbid waters become warmer, and so reducing the concentration of oxygen in the water (oxygen dissolves better in colder water). Some organisms also cannot survive in warmer water. The suspended particles scatter the light, thus decreasing the photosynthetic activity of plants and algae, which contributes to lowering the oxygen concentration even more. Turbidity of the coastal waters of the project site in both surveys ranged from 2.5 (December 2009) to 6.3 (May 2009) NTU (Fig.7).

Fig.7. Turbidity profile in the study site (May 2009)



Nutrients

Nutrients such as nitrates and phosphates are used by phytoplankton during photosynthesis. The analytical results indicate that the coastal waters of proposed project site are moderately rich in nutrients in both seasons (Table 15 and 16).

Table 15.Concentration of nutrients in the waters of the Project site during May 2009 (µmol l^{-1})

Sample ID	NH_4	NO_2	NO_3	DIN	PO_4
UD1	3.2	0.2	1.0	4.4	2.2
UD2	3.6	0.2	1.4	5.2	1.9
UD3	3.8	0.3	4.3	8.4	3.1
UD4	3.0	0.3	3.1	6.4	3.0
UD5	12.9	0.2	2.2	15.3	2.3
UD6	2.3	0.3	1.0	3.6	2.3
UD7	3.3	0.4	5.0	8.7	3.0
UD8	2.7	0.3	1.0	4.0	2.7
UD9	3.4	0.3	1.2	4.9	2.1
UD10	2.6	0.2	1.4	4.2	2.7
UD11	3.4	0.1	0.7	4.2	3.2
UD12	8.1	0.2	0.6	8.9	3.1
UD13	3.4	0.4	1.0	4.8	2.4
UD14	4.7	0.4	0.3	5.4	3.2
UD15	2.6	0.2	0.5	3.3	2.4
Average	4.2	0.3	1.6	6.1	2.6
Min	2.3	0.1	0.3	3.3	1.9
Max	12.9	0.4	5.0	15.3	3.2

Table 16.Concentration of nutrients in the waters of the Project site during December 2009 (µmol l^{-1})

Sample ID	NH_4	NO_2	NO_3	DIN	PO_4
UD1	3.5	0.8	2.6	6.8	0.8
UD2	2.6	0.5	2.4	5.5	0.7
UD3	2.2	0.4	1.5	4.1	0.6
UD4	2.2	0.4	1.4	3.9	0.5
UD5	2.1	0.3	1.3	3.7	0.4
UD6	1.8	0.4	1.4	3.6	0.5
UD7	1.8	0.5	1.5	3.8	0.5
UD8	1.9	0.5	1.8	4.3	0.6
UD9	2.5	0.6	2.4	5.4	0.6
UD10	2.9	0.7	2.5	6.0	0.7
UD11	2.5	0.6	2.4	5.6	0.7
UD12	2.0	0.5	2.0	4.5	0.6
UD13	1.7	0.2	1.4	3.2	0.5
UD14	1.5	0.1	1.2	2.9	0.4
UD15	1.4	0.1	1.1	2.5	0.4
Average	2.2	0.4	1.8	4.4	0.6
Min	1.4	0.1	1.1	2.5	0.4
Max	3.5	0.8	2.6	6.8	0.8

In addition to the natural sources, agricultural source, sewage and industrial effluents released into the water bodies directly or through rivers contribute to the nutrient content of the sea. The level of nutrients should not exceed the threshold limits, though they are essential. Eutrophication results when the level of nutrients released into the aquatic system is high leading to the excessive growth of certain species and the depletion in numbers of others.

Nitrogen

Nitrogen exists in nature in multiple forms (nitrates, nitrites, ammonia etc) and there are reactions commonly that go both to and fro in different forms. Nitrification, the oxidation of ammonia and nitrite to nitrate, consumes oxygen in the water column and in sediments. Ammonia and nitrate are also important nutrients for the growth of algae and other plants.

The average concentration of dissolved inorganic nitrogen (NH_4^+, NO_3^- and NO_2^-) varied from 4.4 (December 2009) to 6.1 (May 2009) µmol l^{-1} respectively. The average concentration of nitrate (NO_3^-) varied between 1.6 (May 2009) and 1.8 (December 2009) µmol l^{-1} in both seasons studied (Fig.10).

Phosphate

Phosphate is a key nutrient for the growth of phytoplankton. Total Phosphate includes all forms of P, dissolved ortho-phosphate and phosphate that is organically bound to suspended solids. After assimilation in plant and algal growth, microbial breakdown and other processes such as mineralization may transform organic and complexed phosphate forms through various steps into the readily available inorganic phosphate form. Most of the total phosphorus is transported by processes such as runoff, stream flow groundwater flow etc, and sometimes, through wind (transports components of total phosphorus around the landscape). The average values of soluble reactive phosphorous concentration in both seasons varied from 0.6 (December 2009) to 2.6 (May 2009) µmol l^{-1}. High total phosphate levels together with high total nitrogen levels, in conjunction with other necessary nutrients and favorable physical characteristics of aquatic environs, can result in plant and algal blooms.

Fig.8. Variations of Ammonium content in surface waters (May 2009)

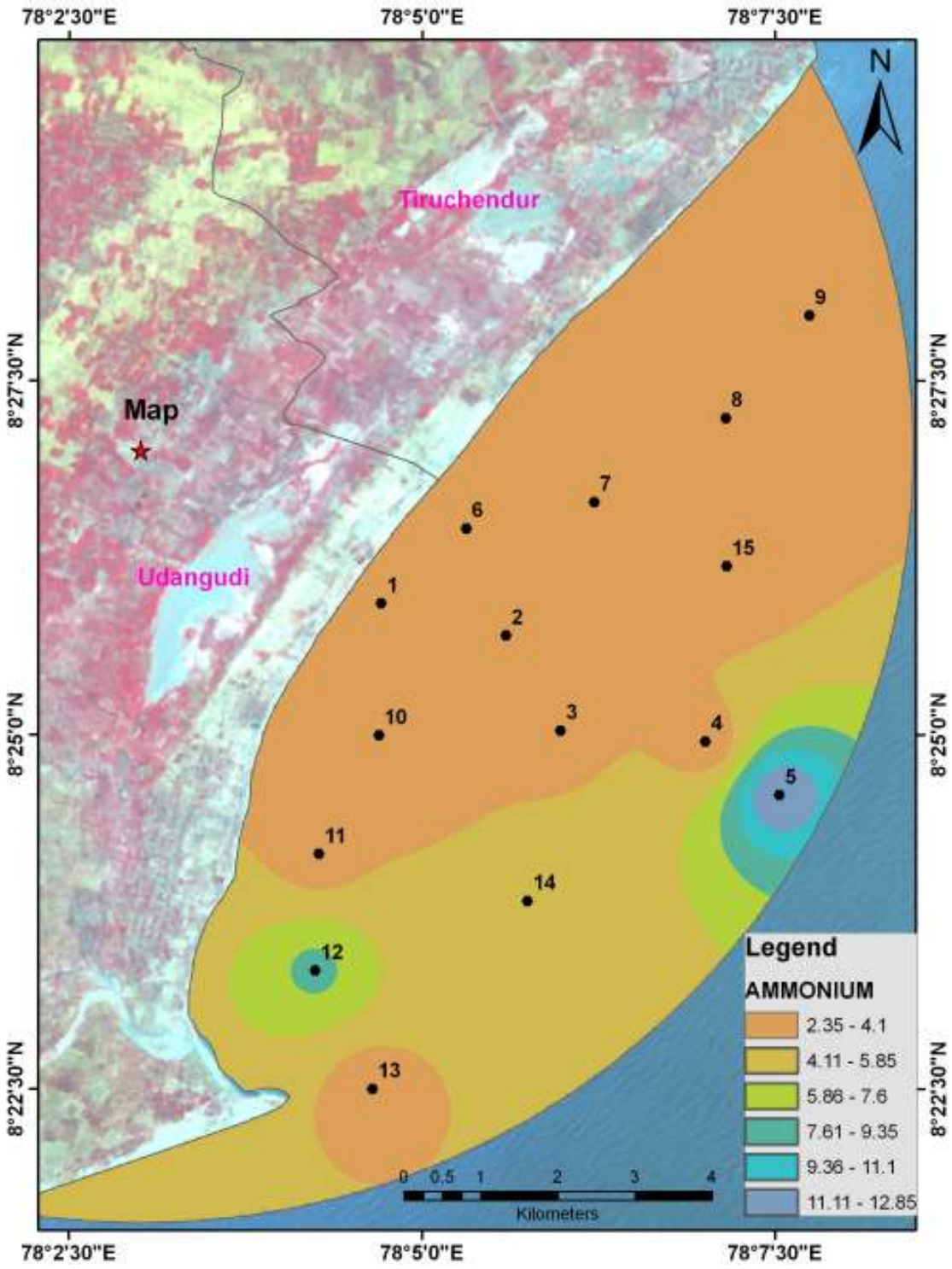


Fig.9. Variations of Nitrite content in surface waters (May 2009)

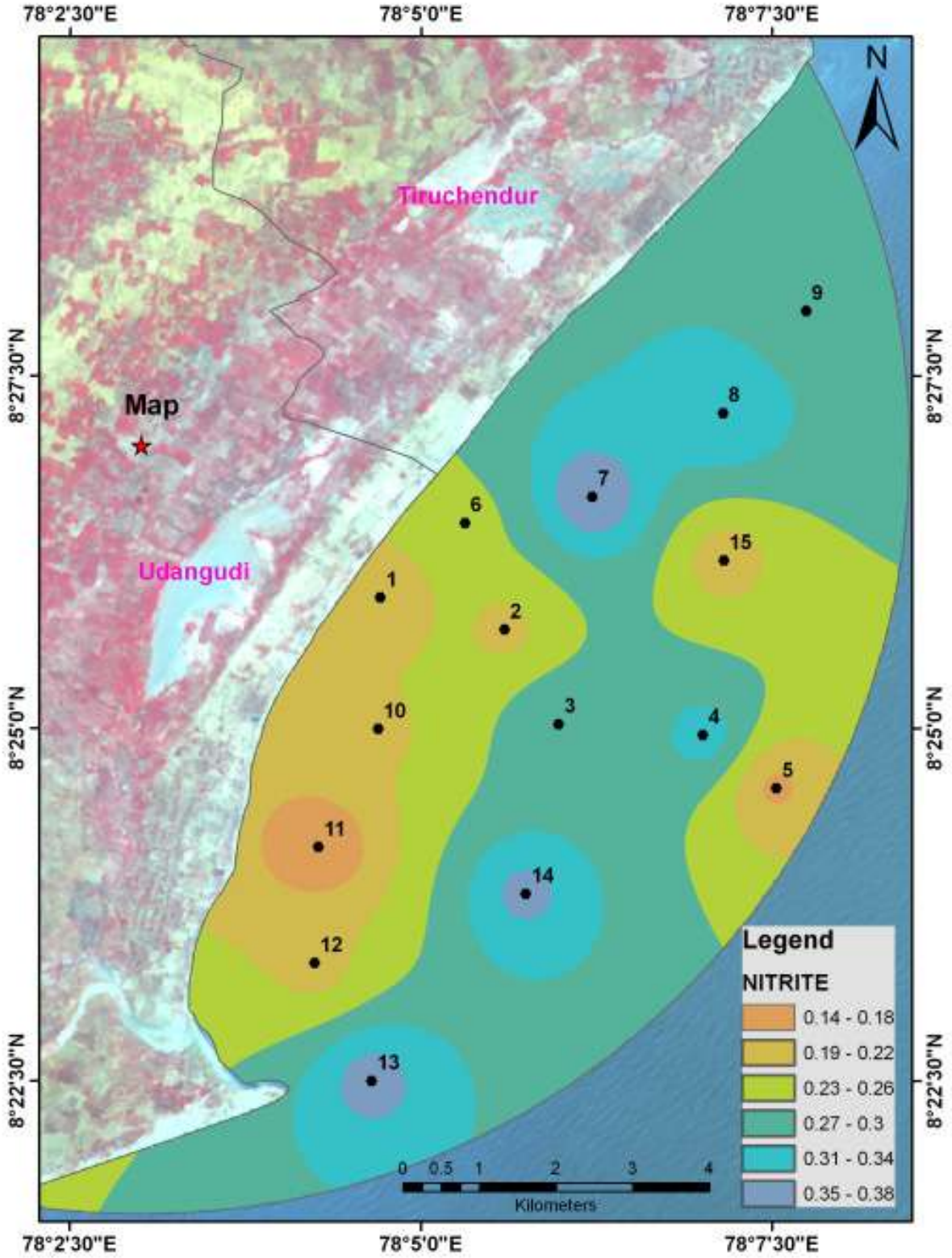


Fig.10. Nitrate content in the surface waters (May 2009)

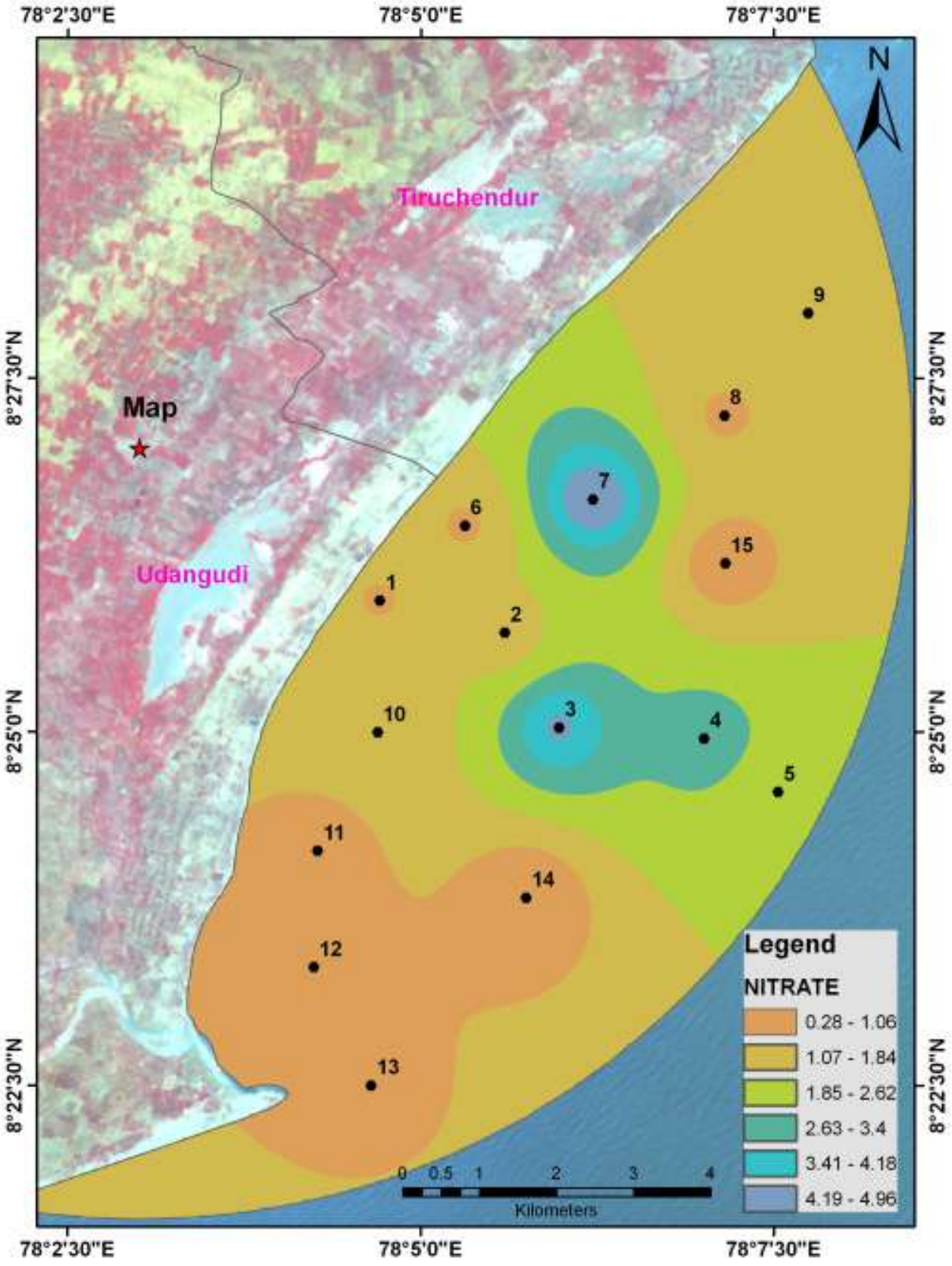
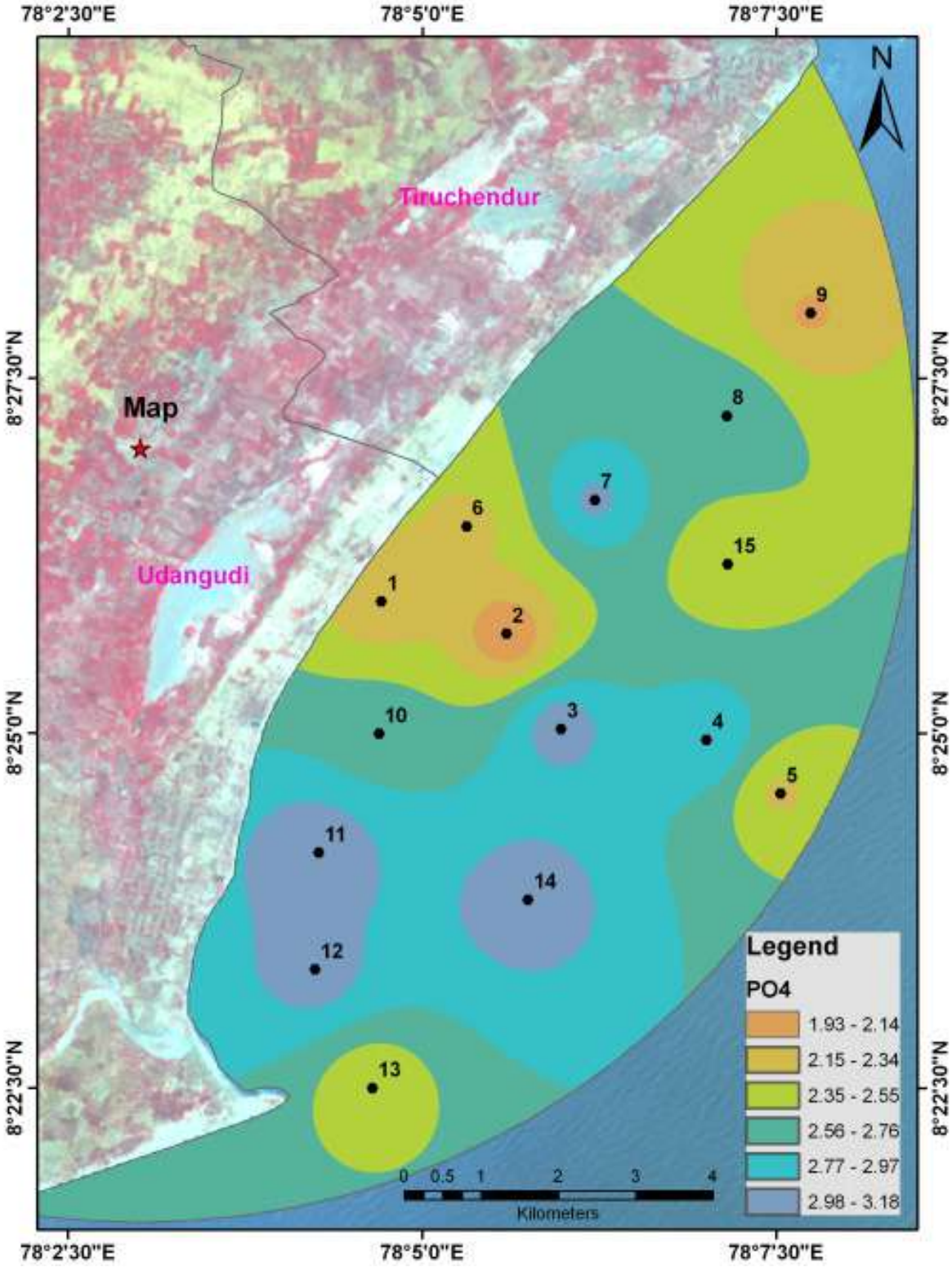


Fig.11. Phosphate content in the surface waters (May 2009)



4.11.2 Sediment Quality

The quality of sediment serves as a crucial indicator to assess any impact caused to the environment due to various activities. Coastal sediments constitute a reservoir of trace metals in aquatic environments and the distribution of metals among specific components in sediments largely determines the fate of sediment bound metals. Metal accumulation on sediment particles mainly depends on the adsorptive bonding on fine-grained materials, precipitation of the element in discrete compounds, co-precipitation of the element with hydrous Fe and Mn-oxides and carbonates, association with organic compounds and incorporation in crystalline material and moreover the enrichments of metal in mainly due to the surface adsorption and ionic attraction in clay/silt fractions. Sediments serve as a sink for several trace metals through a process of hydrolysis and adsorption by suspended particles. Thus coastal marine sediments act as the most concentrated physical pool of inorganic chemical constituents, particularly metals in the aquatic environment. High metal concentrations in sediments would also release these metals into the dissolved phase when in suspension. Hence, sediment quality was assessed for presence of important heavy metals such as Copper, Cadmium, Mercury, Lead, Chromium, Nickel and Mercury.

In general, heavy metal concentrations in the sediments were found to be within the permissible limit and cadmium was below detectable limits (BDL). The average values of the heavy metals following the sequential order of **Cr > Zn > Pb > Cu > Cd** and the values are within permissible limits.

Table 17. Average values of heavy metals (mg/kg) in the sediments samples from the proposed project site during May and December 2009

May 2009

Sample Id	Zn	Cu	Cr	Pb	Cd
1	22.1	3.7	28.6	14.9	BDL
2	45.5	3.5	80.4	13.4	BDL
3	35.4	3.2	45.3	14.9	BDL
4	34.6	5.2	48.9	12.3	BDL
5	24.6	4.7	35.4	13.3	BDL
6	33.6	6.4	48.6	11.4	BDL
7	37.6	3.6	63.1	17.8	BDL
8	38.6	5.4	48.9	13.8	BDL
9	37.6	6.2	52.4	14.2	BDL
10	41.4	4.7	58.9	16.1	BDL
11	30.1	5.7	45.4	15.8	BDL
12	27	6.2	39.8	15.3	BDL
13	27.8	7.8	36.2	15.8	BDL

14	49.6	5.7	77	16.4	BDL
15	27.5	7.2	37.9	13.2	BDL
Average	34.2	5.28	49.787	14.573	BDL
Min	22.1	3.2	28.6	11.4	BDL
Max	49.6	7.8	80.4	17.8	BDL

December 2009

Sample Id	Zn	Cu	Cr	Pb	Cd
1	39.9	17.4	21.6	30.0	BDL
2	33.6	16.8	24.7	25.4	BDL
3	28.8	12.9	26.2	25.3	BDL
4	35.8	19.4	30.4	25.5	BDL
5	28.0	12.1	24.4	28.4	BDL
6	31.4	12.8	27.3	17.4	BDL
7	71.2	29.8	21.3	29.3	BDL
8	22.7	11.8	39.7	27.2	BDL
9	23.6	27.3	33.7	22.8	BDL
10	20.6	10.4	33.0	22.8	BDL
11	32.4	24.2	32.2	19.8	BDL
12	20.6	26.0	21.5	22.6	BDL
13	33.4	27.7	29.3	27.9	BDL
14	31.8	24.2	30.0	17.6	BDL
15	28.6	25.1	30.8	219.6	BDL
Average	32.2	19.9	28.4	37.4	BDL
Min	20.6	10.4	21.3	17.4	BDL
Max	71.2	29.8	39.7	219.6	BDL

4.11.3 Biota

Assessment of biota covers four major components viz, the microbes, phytoplankton, zooplankton and benthos.

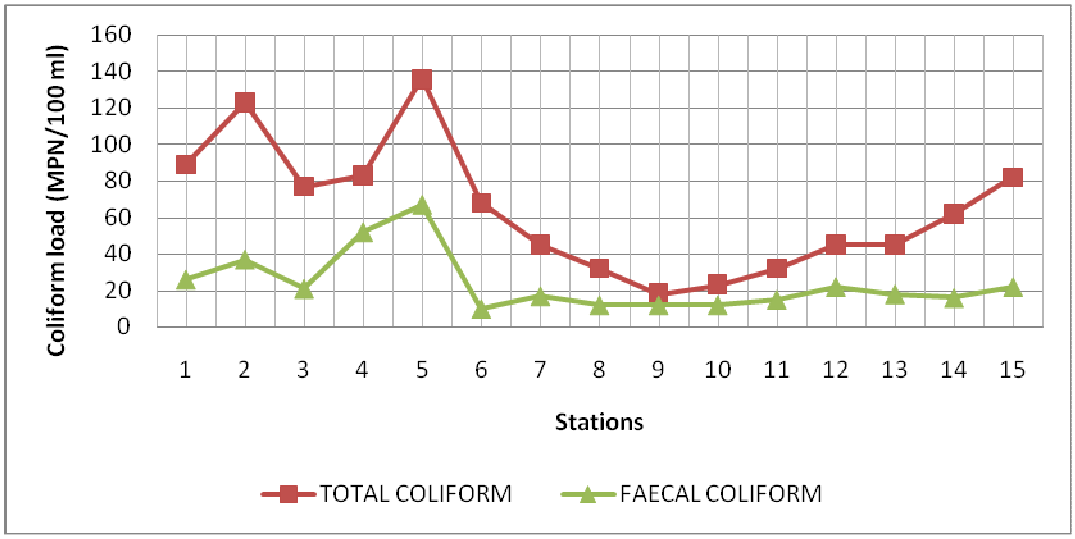
a. Microbial load

Faecal coliform which is more specific for faecal contamination has been adopted as a standard indicator of contamination in natural waters. Both total coliforms (TC) and faecal coliforms (FC) numbers are used as tools to assess the extent of pollution. Faecal coliforms (sometimes fecal coliforms) are facultatively-anaerobic, rod-shaped, gram-negative, non-sporulating bacteria. The presence of fecal coliform bacteria in aquatic environments may indicate that the water has been contaminated with the fecal material of human or animal origin.

Faecal streptococci are bacteria which are also indicators of sewage contamination. The presence of such organisms indicates the presence of faecal material and thus the possible

presence of intestinal pathogens. Use of such indicators of faecal pollution thus provides a means of water quality control anda universally accepted principle for monitoring and assessing the microbial pollution. In the proposed project site, during May 2009, the population of total coliform varied from 68 to 136 MPN/100ml and faecal coliform from 10 to 67 MPN/100 ml and during December 2009 the total coliform varied from 41 to 164 MPN/100 and Faecal Coliform from 19 to 134 MPN/100 ml (Fig.12). The values obtained from all the stations were within permissible limits stipulated by CPCB (500/100 ml MPN).

Fig.12. Distribution of coliforms in coastal waters of proposed project site



b. Phytoplankton

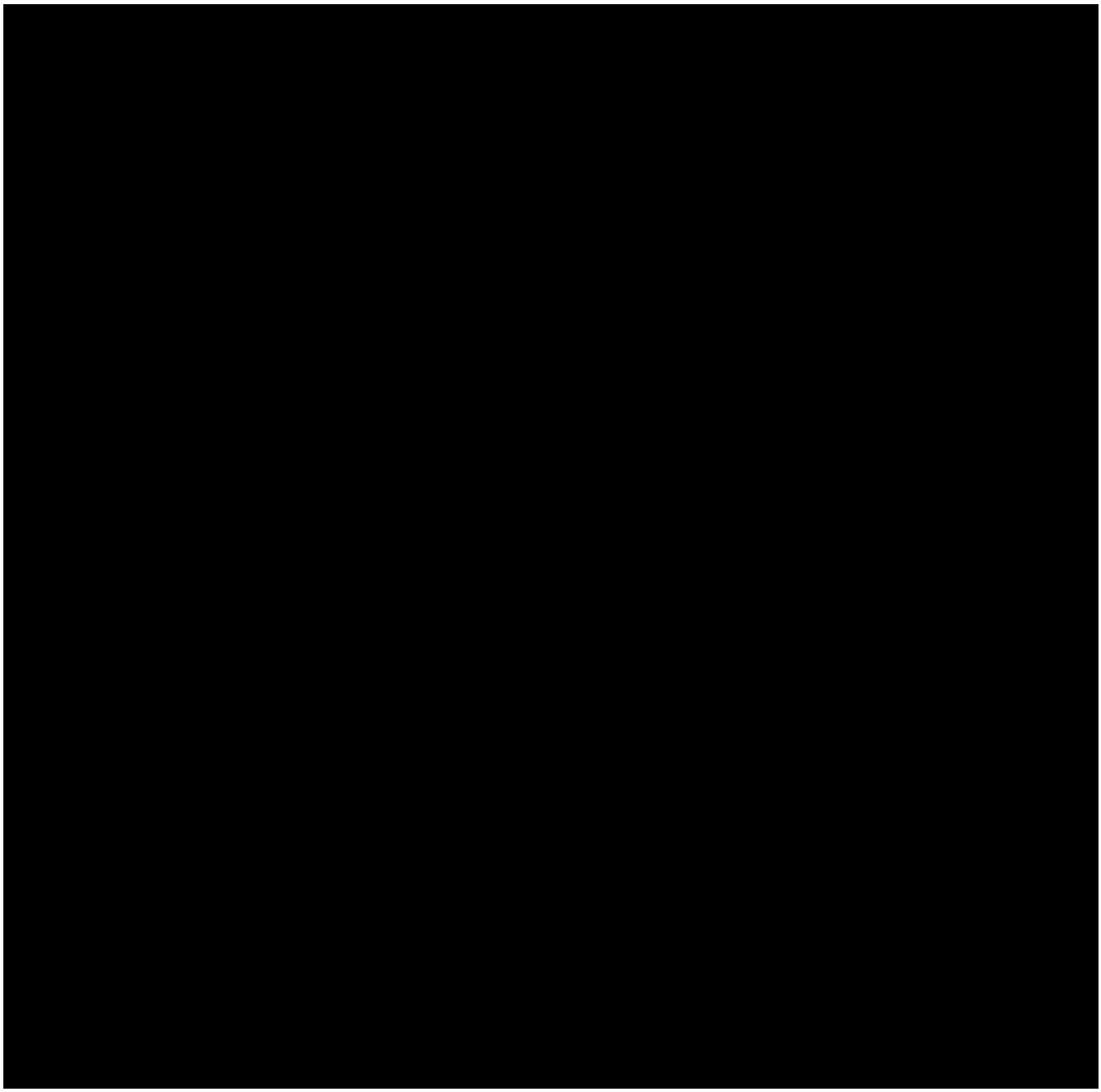
The average population of phytoplankton recorded from the 15 locations of the project site during May and December 2009, comprised of 56 species from four major groups namely

- **Diatoms (Bacillariophyceae)**
- **Dinoflagellates (Dinophyceae)**
- **Blue green algae (Cyanophyceae) and**
- **Green algae (Chlorophyceae)**

Diversity

A total of fifty six species comprised the phytoplankton population in the sampling sites (Table 18). Of these, 44 species belonged to Bacillariophyceae, 10 species to Dinophyceae and 1 species each represented Cyanophyceae and Chlorophyceae.

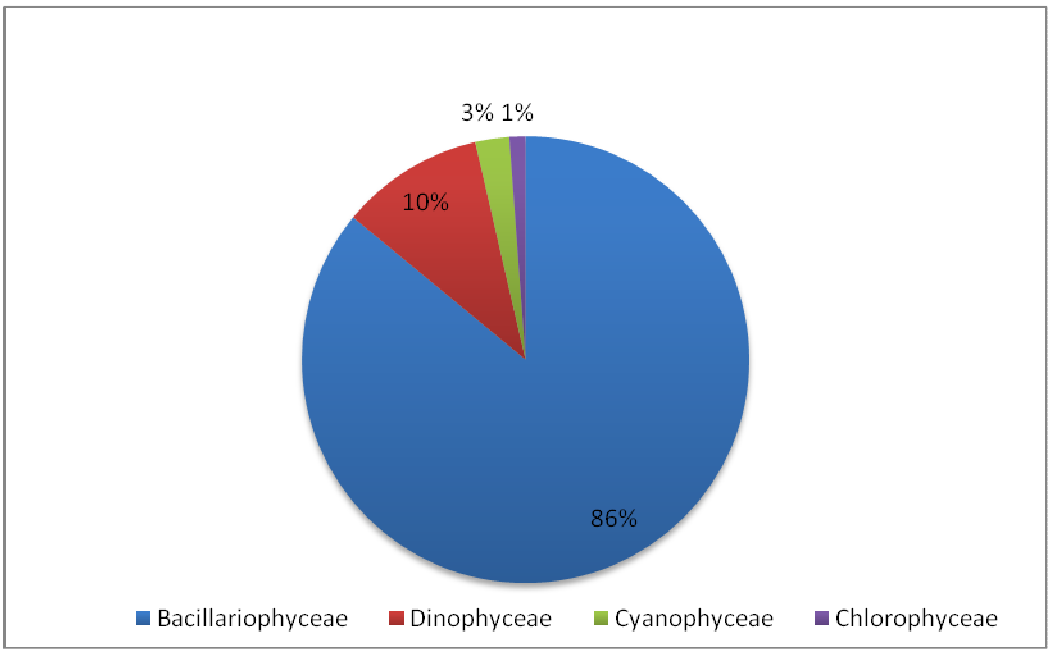
Table 18. Phytoplankton diversity (average cell counts/l) in the coastal waters



Abundance

The overall percentage composition of phytoplankton for the 15 locations revealed that the Bacillariophyceae was the dominant group (86%) followed by Dinophyceae (10%), Cyanophyceae (3%) and Chlorophyceae (1%).

Fig.13. Percentage abundance of phytoplankton population in the project site



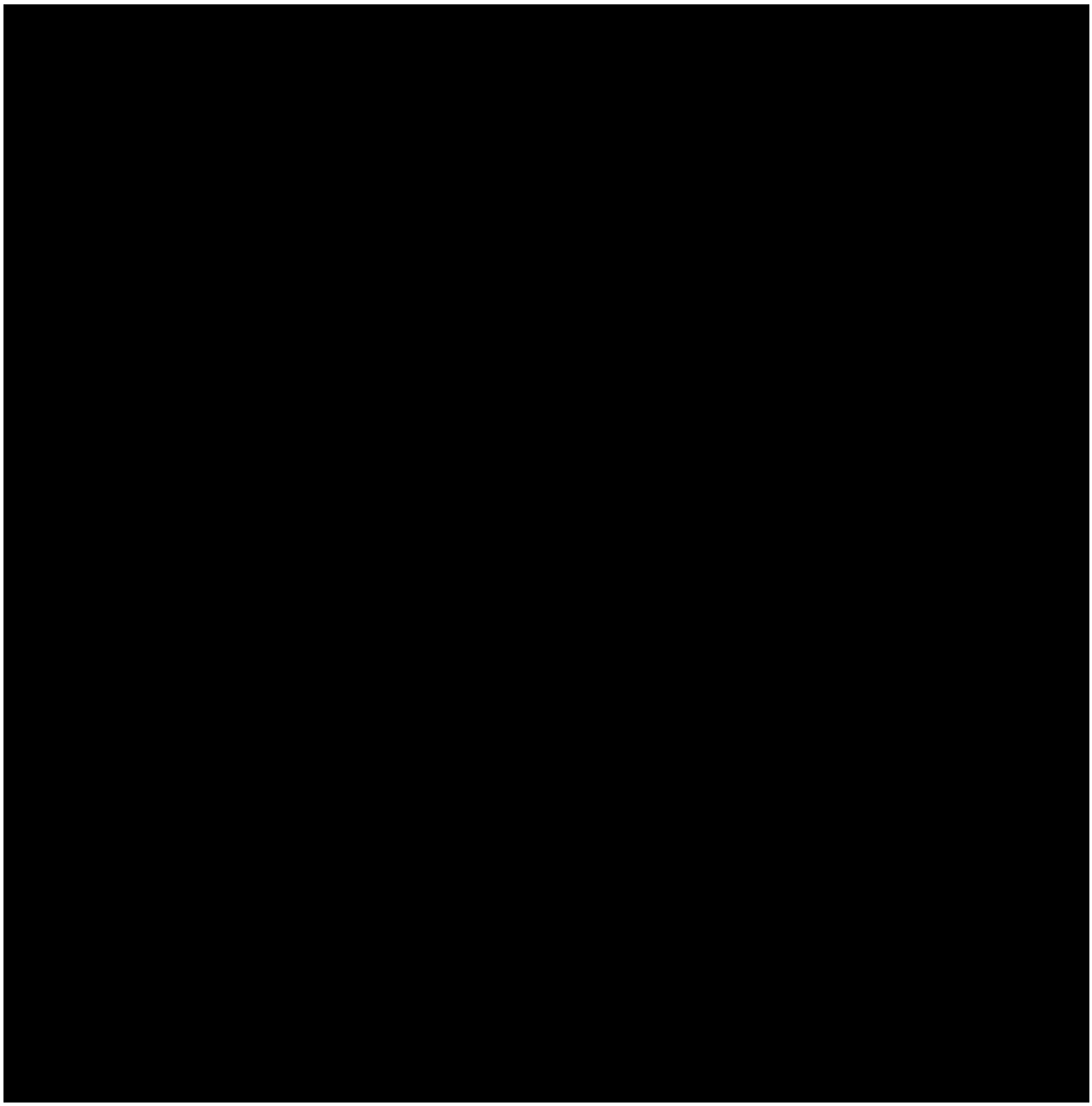
The Hierarchy observed in the samples collected, is as follows:

Bacillariophyceae > Dinophyceae > Cyanophyceae > Chlorophyceae

c. Zooplankton

Zooplankton recorded from the 15 locations, were composed of species from the groups/orders such as Foraminifera, Radiolaria, Tintinnida, Copepoda (Calanoida, Cyclopoda, Harpacticoda), Sagittoida, Mysidopsida, Larvacae and eggs and larval forms (Table 19).

Table 19. Zooplankton diversity observed in various stations



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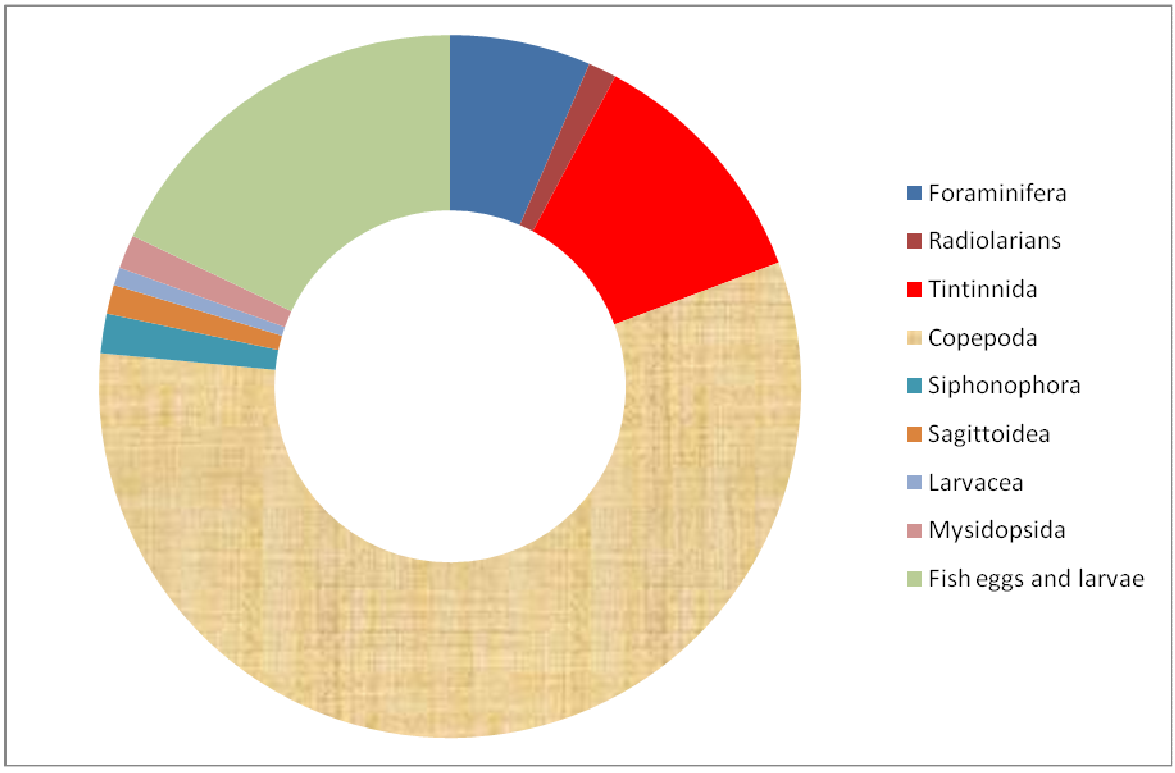
Abundance

A total of 41 species were recorded from the 15 field locations. The percentage composition for zooplankton of all the 15 stations revealed that the copepods (57.23%) were the most dominant group followed by eggs and larval forms (17.94 %), tintinnids (11.47%), foraminiferans (6.48%), siphonophores (1.82%), Mysidopsids (1.56%), sagittoids (1.34%), radiolarians (1.3%) and larvacea (0.82%) (Fig.14).

Fig.14. Percentage abundance of Zooplankton population in the project site



The hierarchy of the species groups is as follows:

Copepoda (Cyclopods>calanoids>harpacticoids) > larval forms > tintinnids> foraminiferans > siphonophores >mysdopsida >sagittoids >radiolarians > larvacea.

Plankton biomass

All the sampling sites were moderately rich in biodiversity. The phytoplankton biomass registered highest count of 49,163 cells/l in station 7 and lowest in station 14 (29940 cells/l). Maximum biomass of zooplankton was recorded as 34,000 organisms/l in station 15 and minimum of 10,421 organisms/l in station 1. Overall, the phytoplankton density was found to be higher in all the stations than the zooplankton indicative of higher primary productivity.

Diversity index measurement for plankton populations in the project site

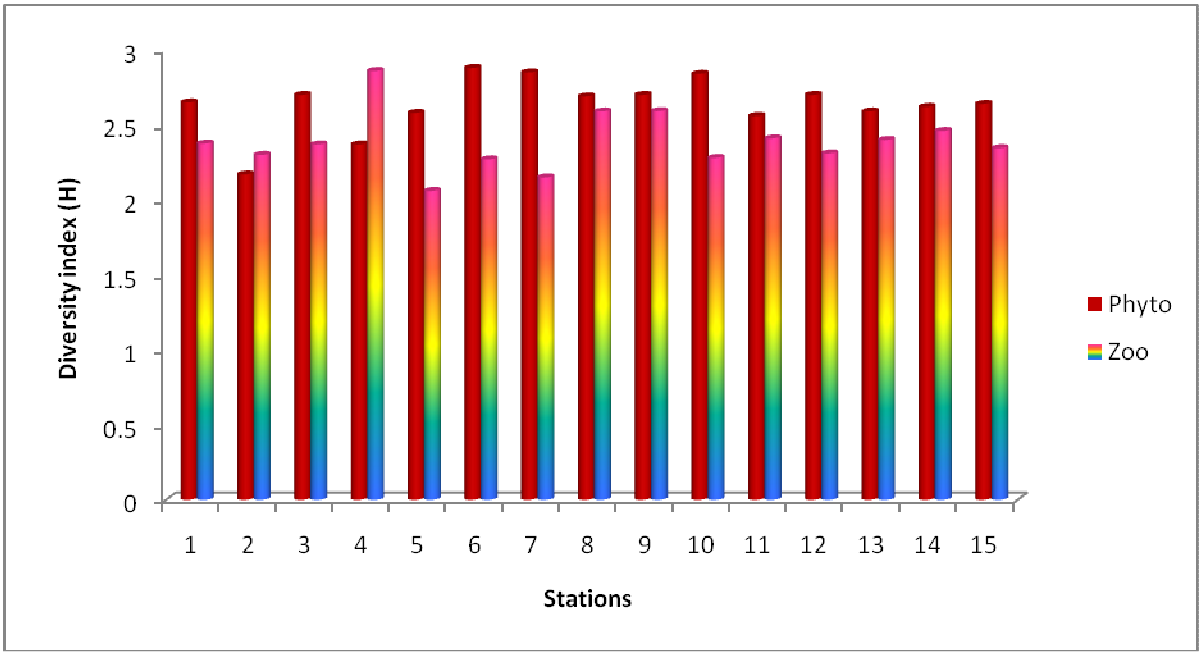
Measure of diversity has been of historical significance, given the obvious declines in habitat quality in almost every ecological system. The Shannon-Weiner diversity index is one such measure that summarizes the species composition at each station. The index utilizes taxa richness and their relative abundance. This index is an important aspect for indicating the distribution of phytoplankton and their relation to pollution.

It combines two quantifiable measures the:

- species richness (the number of species in the community) and
- species equitability (how evenly distributed among the classes are the numbers of individuals of each species)

The Shannon Weiner Index for phytoplankton and zooplankton abundance in the coastal waters of the project area was determined and the results are presented in Fig.15. According to Boyd, Shannon-Weiner Index of >2 indicates that the coastal surface waters are less polluted. The Shannon-Weiner index varies approximately from 1-5, where 1 is less diverse and 5 is more diverse. The index calculated in the present study site for phytoplankton varies between 2.1 and 2.8; and for zooplankton, it varies between 2.0 and 2.8 which reveal that the waters are not much polluted.

Figure.15. Diversity index (H) of plankton communities

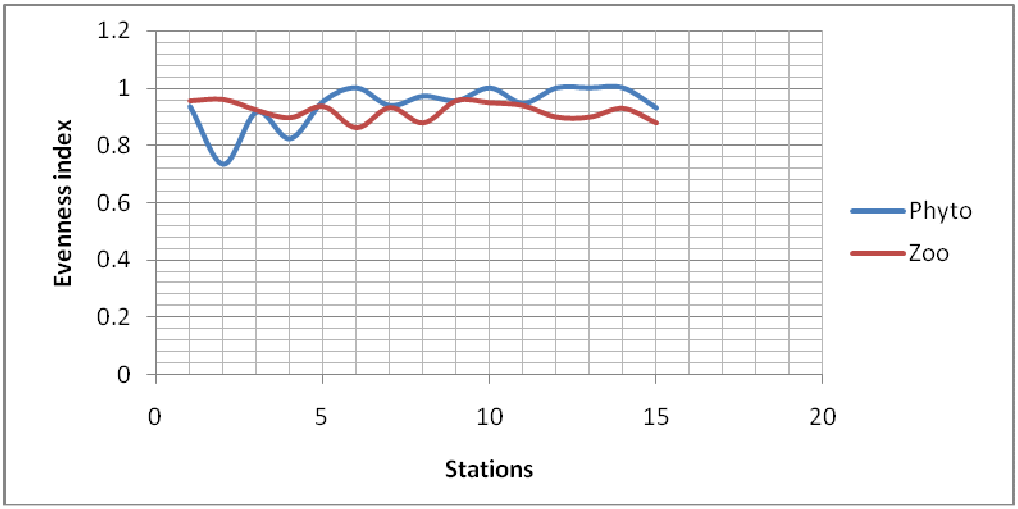


Measure of Evenness

Using species richness (S) and the Shannon-Wiener index (H), the measure of evenness was computed. A comparison of one or all of these measures of biodiversity can illustrate changes in water quality conditions within a local community. Water quality parameters like light penetration, dissolved oxygen and salinity can have dramatic impacts on levels of biodiversity. Species evenness of both phytoplankton and zooplankton populations is depicted in Fig.16.

Evenness index for the phytoplankton and zooplankton E = H/ln (S)

Fig.16. Evenness index (E) of plankton communities



Lowest evenness of phytoplankton population (0.73) was observed in station 2 and highest (1) was observed in stations 6, 10, 12, 13 1nd 14. Zooplankton population showed the peak evenness index in station 2 (0.96) and lowest (0.88) in station 8 and 15.

d. Meiobenthos density

The overall percentage composition of meiobenthos in the sampling sites is depicted in Fig.17. Meiobenthic community from all the sites was dominated by copepod group (Harpacticoids). Station 2 was observed to be rich in meiofauna and station 15 registered low or poor faunal density. The hierarchy of dominance observed in the meiofaunal groups is as follows:

Harpacticoids>Nematodes>Gastrotrichs>Polychaete>Turbellarians>Ostracods>Arachiannelids>Foraminiferans>Isopods

CHAPTER 5: SUMMARY OF BASELINE SURVEY

5.1 Air quality

Nitrogen oxides:	11.9-16.6 µg/m^3
Sulphur oxides:	16.6-22.2 µg/m^3
PM_{10}:	65.1- 78.4 µg/m^3
$PM_{2.5}$:	45.6- 79.5 µg/m^3

Concentration of SO_x, NO_x, PM_{10} and $PM_{2.5}$ are within the limits specified by the CPCB

5.2 Water quality

Physicochemical characteristics

Temperature	26.5 – 30.7^0 C
Salinity	31.8-32.9
pH	7.1-8.0
Electrical conductivity	4.3 –4.8 mS
Total Dissolved Solids	52.2-53.8 g/l
Dissolved oxygen	5.2-5.7 mg/l
Biological oxygen demand	1.4-2.2 mg/l

Nutrients concentration

Ammonium	2.2-4.2 µm/l
Nitrite	0.3-0.4 µm/l
Nitrate	1.6-1.8 µm/l
Phosphate	0.6-2.6 µm/l

5.3 Sediment quality

Heavy metal content

Cu	5.2 –19.9 mg/kg
Zn	32.2-34.2 mg/kg
Cr	28.4-49.7 mg/kg
Pb	14-37.4 mg/kg
Cd	BDL

In general, heavy metal concentrations in the surface sediments were found to be low, the concentration pattern following the sequential order of: Cr>Zn>Pb>Cu>Cd.

5.4 Biota

Microbial load within CPCB limits

Phytoplankton

Average Population density	High
Species Diversity:	Moderate
No: of species observed:	56
Diversity index:	2.1-2.8

Zooplankton

Population:	Moderate
Faunal Diversity:	Moderate
No:of species observed:	41
Diversity index:	2.0-2.8

Meiobenthos

Population:	Moderate

Overall assessment of the biota indicates moderate natural biodiversity in the proposed project site.

5.5 Conclusion

A detailed marine EIA study of the proposed Udangudi super critical thermal power project indicated that the waters are not much polluted. The marine hydrographical parameters were measured in this study indicated healthy conditions. The bed sediments indicated low heavy metal content. The coastal marine environment is moderately rich in its biodiversity. A variety of phytoplankton, zooplankton and meiobenthos have been identified. The phytoplankton communities were much higher than the zooplankton indicating a high primary productivity in the site.

CHAPTER 6. ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

The environmental impacts during the construction stage will be short term, temporary in nature and will be confined very close to project sites. The impacts that would be caused due to the project during construction and operation phases may be categorized as follows:

- Impact on air quality
- Impact on water quality
- Impact on land/soil
- Impact on biota
- Impact on socioeconomic aspect

6.1 Impact on air quality

Construction Phase

The main sources of emission during the construction period are the movement of equipment at the project site and dust emitted during the leveling, grading, earthwork and foundation works. Exhaust emissions from vehicles and equipment deployed during the construction phase is likely to result in marginal increase in the levels of SO_x, NO_x, and suspended particulate matter. The impact will be for short duration and confined within the project boundary and is expected to be negligible outside the plant boundaries. Proper maintenance of vehicles and construction equipment will help in controlling the gaseous emissions. Water sprinkling on roads and construction site will prevent fugitive dust. Electrostatic precipitators of high efficiency shall be provided for the coal fired boilers to ensure better dispersion of air pollutants.

Operational Phase

When coal is unloaded from ships at the jetty there is a chance of emission of coal dust in the air. The coal dust shall be suppressed by sprinkling of water continuously while unloading of coal into hopper. Separate arrangement for water sprinkling shall be made. Coal is to be transported from the jetty to the plant by pipe conveyor and hence transporting of coal from coal jetty to the power plant there will be minimum air pollution due to coal dust.

6.2 Impact on water quality

During construction time around 10 m^3/day waste water will be generated from the toilets & canteen. This water will be sent to septic tank followed by soak pits. While constructing the sea water Intake pipe line, core cutting dredging will be adopted instead of the blast dredging

to minimize the impact. The dredged material will be properly refilled in the intake trench after the erection of intake pipe in the trench and balance materials if any shall be deposited in the low lying area of the plant. The outfall pipeline is aligned along the coal conveyor trestles and there will not be any dredging involve it. However, outfall and intake well will be constructed with minimum excavation.

In the operation phase about 2,13,900 m^3 /day of waste water will be generated (i.e)

(1) 1,87,200 m^3 /day from cooling water blow down.

(2) 26,220 m^3 /day from RO plant reject.

(3) 480 m^3 / day from RO-DM plant neutralization pit

As there is no chemical is added by the project proponent in the above two operation the water quality will remain same except minor change in temperature and conducting due to evaporation loss and RO process in RO plant. The RO reject of 26220 m3/day is diluted with large quantity of 1,87,200 m^3 /day cooling water blow down sea water and let in to the sea and hence the impact on the marine ecology is negligible. The sea water discharged back in to the sea shall maintain a temperature difference of 5^OC as per MoEF norms. This can be archived by the project proponent by suitably designing the cooling tower so that the temperature at the outlet of cooling tower is around ambient temperature and the temperature difference between the inlet and outlet sea water is less than 5^OC.The observed excess temperature as per the modeling study conducted by NIO is around 1.46°C and the excess salinity is around 4.82 psu. Around 480 m^3 /day waste water will be generated at DM plant this water will be treated at neutralisation pit and this treated water will be further diluted by cooling tower blow down and discharged into sea.

Coal handling system runoff shall be clarified in the coal pile run off pit and at central monitoring basin and reutilised. The storm water in the project area shall be collected through the storm water drain and shall be diverted to rain water harvesting pits and overflow if any will be mixed with cooling tower blow down water and let out into sea. No ash or ash water is let into the sea. Overall no marine organisms would be affected due to the establishment of coal jetty and constructed of intake and out fall. Also there will not be any temperature stress in marine biota.

6.3 Impact on land/soil

The land identified for the proposed 2 X 800 MW power plant is about 939 acres. The proposed plant land is mostly barren land and there is no forest or ecological sensitive areas

within proposed site. No residential or habitation areas are proposed to be acquired, hence no displacement of residential areas. All major construction activities tend to create certain changes in the soil of the area. Excavation denudes the topsoil and makes it loose. Destruction of topsoil leads to reduction of fertility and removal of vegetation cover with associated hazards of the soil erosion. During storms, some of the excavated soil and construction material such as sand etc. would be blown up in the air and dispersed around the project site, some would also tend to be driven into the soil and clog inter-granular spaces. Greenbelt will be developed in a phased manner during construction to improve the aesthetic value in the area and to screen out the fugitive dust generated during construction.

The major solid waste to be generated from the proposed coal based power plant is bottom ash and fly ash. Bottom ash and fly ash can be collected in dry form in Ash Silos andwill be transported outside by Tippers.. Fly ash can be utilized for cement production and brick manufacturing industries, concrete mixing and in road construction projects. The sludge generated from effluent treatment plan can be used as manure for greenbelt development.

6.4 Impact on biota

The release of effluent from R.O. and D.M. plants amounting to 40 m^3 / hour into the local water bodies though mixed with large quantity of outfall water of about 7800 m^3 per hour can marginally affect the aquatic biota by decreasing the primary productivity and in turn can influence the survival of plankton and fishes. This impact can be controlled by adopting the following measures:

- Continuous attempt to optimize/reduce the use of water in plant;
- Continuous attempt to avoid wastage and leakage of water;
- Regular record of level and flow of surface water sources;
- Raw water quality shall be checked on regular basis for essential parameters under BIS: 10500 before and after treatment;
- Drainage system that shall be used for carrying the wastewater to the plant shall be periodically checked for any leakage; and
- Treated wastewater at inlet and outlet shall be monitored on regular basis.

Regular monitoring of temperature, pH and other environmentally important parameters will be monitored before the water let into the sea using online water quality probe.

6.5 Socio-economic Impacts

The major economic impacts during the construction and operation phase are that of, increased availability of direct and indirect employment. Local people would be benefited after commissioning of the proposed project in terms of petty to major contractual jobs and associated business establishments and overall improvement of infrastructure.

CHAPTER 7. ENVIRONMENTAL MANAGEMENT PLAN

The data collected on baseline studies indicate that the marine water quality at the project site is moderately good. The project operations are likely to impact coastal waters leading to short or long term change in temperature and salinity parameters around the outfall. These changes can be minimized by evolving proper environmental management plan so that the developments prove beneficial. Adequate preventive and control measures can be introduced wherever required and monitoring programmes can be initiated to measure the environmental parameters. The EMP is proposed for the thermal power plant mainly focus mainly on air, noise, water quality and ecological management.

7.1 Air Quality Management

The activities like site development, grading and vehicular traffic contribute to deterioration of ambient air quality due to increased air pollution and noise pollution. The mitigation measures recommended to minimize the impacts are:

- Suppression of dust by water sprinkling in construction area;
- Suppression of dust by water sprinkling in the coal jetty and coal yard.
- Separate arrangement for water sprinkling shall be made. In addition, pollution due to vehicles and construction equipment shall be mitigated by:
- proper maintenance of vehicles and construction equipment; and
- tree plantation in the area earmarked for greenbelt development.

For effective dispersion of SO_x once the plant is commissioned, as per MoEF norms, minimum stack height of 275 m must be provided to the proposed boilers. Since transportation of coal from coal jetty to the power plant is to be by means of pipe conveyor system, there will be minimum air pollution due to coal dust. Necessary arrangements shall be taken to curb the coal spillage into the sea by providing plates in the hoppers.

7.2 Water Quality Management

The mitigation measures recommended to minimize the impacts are sedimentation tank to retain the solids from run-off water; oil and grease trap at equipment maintenance centre; septic tanks to treat sanitary waste at labour colony; and utilizing the wastewater in greenbelt development. The temperature of outfall water shall be maintained not more than 5° C over the ambient temperature. Only the treated water from the Effluent Treatment Plant amounting 20 m^3 hr^{-1} shall be let into the sea along with the blow down water outfall. The brine water amounting to 1090 m^3/hour shall be diluted with more than 7802 m^3 / hour of outfall water before letting in to the sea.

7.3 Noise Level Management

Operation of construction equipment and vehicular traffic contribute to the increased noise level. Recommended mitigation measures include good maintenance of vehicles and construction equipment and restriction of construction activities to day time only. Plantation of trees around the plant boundary will be done to attenuate the noise. Provision of earplugs and earmuffs to workers shall be made.

7.4 Ecological Management

During construction, vegetation in the plant premises, if any, is required to be cleared. The felling of trees will be kept at minimum. Transplantation of existing matured trees will be undertaken and transplanted in the area earmarked for greenbelt development.

7.5 During Construction phase

During construction phase, trenching work shall be entrusted to a specialist agency. Trenches shall not be too deep. Lighter machinery shall be used and the trenches shall be refilled with native sediments only. The blast dredging shall be avoided while establishing cooling water intake trench. Instead core cutting dredging shall be made. The dredge material will be properly refilled in the intake trench after the erection intake pipe in the trench and the balance materials, if any, shall be used for land filling and deposited in the low lying area of the plant.

7.6 Effluent disposal

Treatment and disposal facilities for warm water shall be completed prior to commissioning the plants. Trained personnel shall be engaged for operating and maintaining intake, outfall and discharge equipment. They shall be motivated on the need to avoid human errors. All critical parameters such as sea surface temperature, salinity and suspended sediment shall be monitored periodically and a laboratory shall be set up for this purpose

7.7 Safety Measures

In order to minimize any operational hazards, trained personnel shall be appointed to oversee all safety requirements. Periodic training programmes will be conducted for all relevant personnel.

7.8 Post project environmental monitoring

Post project monitoring shall be carried out in order to ensure that the environmental stresses are low. Trained staff shall be employed to take up the monitoring work or this job shall be assigned to any research institute having expertise in collection and analysis of sea water and sediment samples in the offshore and intertidal region. Any changes in the water quality shall be immediately noted and measures initiated to restore the original condition.

7.9 Sampling site

Site selection for sample collection shall be decided depending on the dispersion pattern of the discharge. The sampling station shall cover the discharge point as well as other close by locations covering 5 to 15 km offshore within around 25 sq km area. The intertidal region along the Udangudi shoreline shall also be periodically sampled to know the impact on beach fauna and flora.

7.10 Frequency of monitoring

Monitoring programme shall include proper baseline data collection after the project activities are initiated and regular periodic monitoring after the project is fully operational.

1st monitoring: Before the operation stage of the project
2nd monitoring: 6 months after operation
3rd monitoring: 12 months after operation
Periodic monitoring: Once in a year

7.11 Parameters to be monitored

Water and sediment samples shall be monitored for the following parameters:

Water quality- water samples shall be obtained from 3 depths if the water depth exceeds 10 m. Parameters to be analysed are: temperature, pH , salinity, dissolved oxygen, biological oxygen demand, nutrients (nitrate, nitrite, phosphate, ammonia) and petroleum hydrocarbons and sediment quality parameters such as grain size, total organic carbon, total phosphorus, cadmium, lead, mercury and petroleum hydrocarbons are to be monitored.

Biological characteristics - water samples will be analysed for primary productivity, chlorophyll and phytoplankton population; zooplankton shall be collected for population and group diversity; benthos from sediments shall be obtained for benthic samples for biomass and group diversity and fish quality.

Bioassays - waste water released shall be tested for static bioassay tests to ascertain that the effluents are not harmful to the marine organisms. Fishes from the nearby coastal areas shall be used for the bioassay tests.

In addition to the above mentioned aspects, regular monitoring of the parameters listed below, would serve to nullify the effects if any caused to the environment.

Sl.No.	Parameter	Sampling frequency
1	Ambient air quality	Monthly monitoring by approved agency as accordance with the Environmental Clearance Order.
2.	Source emission	Monthly monitoring and continuous check on the performance of ESP
3	Ground water quality	Once in a season
4	Wastewater quality	Monthly monitoring and Weekly monitoring will be carried out for monitoring of the Steam generator blow down, Cooling tower blow down , RO reject and D.M. Plant effluent.
5	Soil sample	Should be monitored once in a season
6	Non-hazardous waste	Monthly records of fly ash and bottom ash generation, collection, storage and disposal will be maintained as per the Fly Ash Act, 2007.
7	Hazardous waste	Monthly records of each type of hazardous wastes generation, collection, storage and disposal will be maintained as per the Hazardous Wastes (Management and Handling) Amendment Rules, 2003.
8	Ambient Noise	Noise level monitoring will be carried out within the power plant premises once in a month
9	Occupational Health and safety	Qualified doctors will carry out pre-employment and periodical medical check-up of all the employees.

Coal spillage Management Plan

- A fully mechanized coal unloading system will be employed for the ship-to-shore transfer of coal to ensure spillage to minimum.
- Coal will be handled through closed pipe conveyors where spillage is nil.
- Further dust suppression system will be employed at the Unloaders to prevent any pollution.
- Regular monitoring to avoid the spillage of coal will be enforced. In case of any spillage, the spilled coal will be arranged to be removed by grab cranes from the conveyor deck/Coal Jetty.

Accidental oil spill Management Plan:

For Fuel Oils, Heavy Fuel Oils and Light Diesel Oils, firewater cooling systems and foam facilities as per OISD-117 [Oil Industry Safety Directorate] must be provided.

The oil spill response kits should be installed in key places, and containment booms need to be deployed in case of large spills in marine areas. In the event of an oil spill in the marine environment the following measures should be employed according to the circumstances of the spill and conditions prevailing:

- Notify the Indian Coast Guard as they are the oil spill notification nodal agency
- If possible prevent, control or stop the outflow or release of the oil from the source
- If coastal or marine resources are not threatened or likely to be threatened, monitor the movement and behaviour of the oil
- If coastal and marine resources are threatened, determine whether to begin response operations, either at sea and/or to protect sensitive resources;
- If possible contain the spread of oil; and
- If, due to weather and sea conditions, response at sea or protection of sensitive areas is not feasible, or the foreshores have already been affected, determine appropriate cleanup priorities and other response measures.
- Udangudi Port will provide the necessary oil spill combating equipment like tug with booms and skimmer and sorbent pads within the Port. The required number of such equipment shall be procured prior to commissioning of the Port.

The spillage of coal and oil will be controlled by using appropriate methods as mentioned above.

The management Plan in respect of other kind of emergencies like mechanical Emergency plan, Rough weather Plan, Earthquake management Plan , Fire Protection and response plan, Medical Emergency Plan, Special Emergency equipment, Chemical information, Drills/ rehearsing emergency procedures , emergency evacuation plan, of-site emergency plan etc. have been detailed in Chapter 8.14 of this report.

Further the Maintenance Plan in respect of the long approach structures like bridges against man-induced and / or natural forces have also been addressed in detail in Chapter 8.21 of this report and the frequency of maintenance to be followed is detailed in the table below.

Guidelines for frequency of maintenance & remedial measures

1	Cleaning Road surface of all soil, debris, pebbles and metal pieces if any	Continuous process on daily basis
2	Cleaning Expansion joints off any pebbles	Every month or as and when required
3	Cleaning of drainage spout	Every three months and frequency during monsoon or as and when required
4	Cleaning Road surface of all soil, debris, pebbles and metal pieces if any	Continuous process on daily basis
5	Removing nests if any on the structure	Continuous process on daily basis
6	Replacing of expansion Joint	As and when required
7	Bituminous work	
	(d) Repairing of pot holes	Every month or as and when required
	(e) Relaying of layer	After 4 to 5 years for improvement of ridership quality
	(f) Micro seal (Slurry seal)	
8	Cleaning inside deck	
	(d) Box portion	Stagnated water quarterly, Daily after rains
	(e) Vent holes	
	(f) Electrical lights	

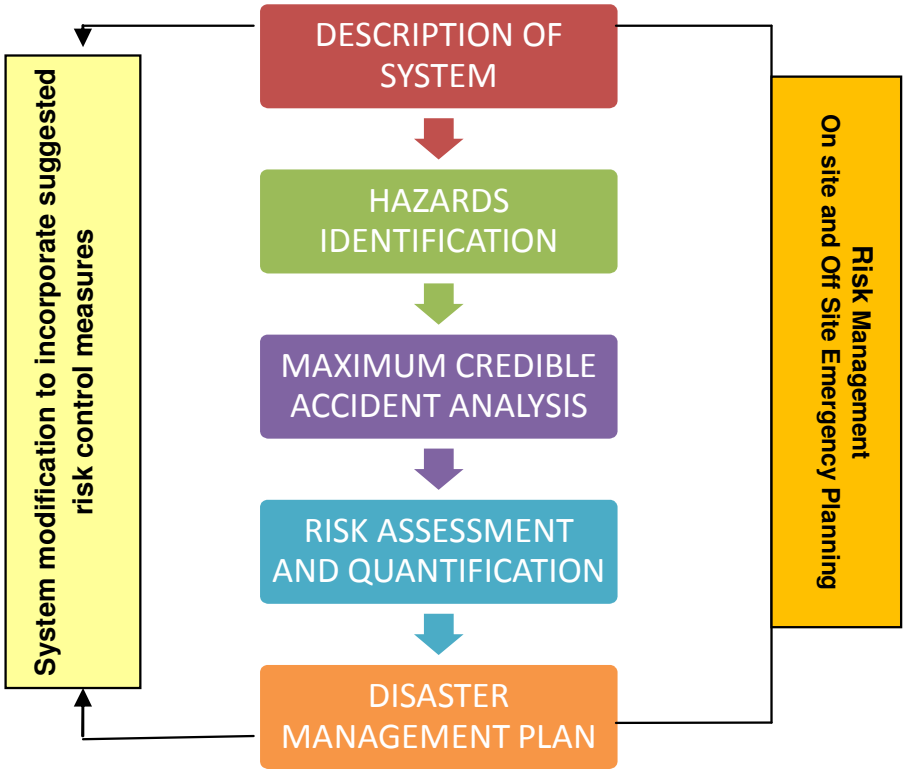
CHAPTER 8: DISASTER MANAGEMENT PLAN: UDANGUDI – CAPTIVE COAL JETTY

8.1 Introduction

A Risk Assessment Study and Disaster Management Plan including emergency evacuation during natural and manmade disasters for the coal jetty project for M/s Udangudi ~~Thermal~~ Power Corporation has been asked for. The DMP will be based on the identification of various potential hazards during the construction and operational stages of the project and assessing the kinds of risks possible. The DMP includes procedures for emergency evacuation during natural and man-made disasters.

The proposed coal jetty is to be developed as an artificial deep sea, all weather facility. The proposal consists of pipe conveyor, conveyor and road. The pipe conveyor for coal will be on a trestle of length 7.5 km and main jetty will be of length 640m by width 24m. The number of personnel at any given time on the jetty area is not likely to be more than ten plus the personnel on board the coal carrier (if berthed at the jetty) as the activities are unloading of coal from the ship and conveying the same through the pipe conveyor to the power plant site on land. Figure 1 gives the flow chart for the procedure to identify and manage risks at the coal jetty.

Figure 17. Flow Chart for Hazard Identification and DMP



8.2 Objective

The aim is to examine the activities in the coal jetty during construction and operation activities to identify hazards, estimate the risk due to the various hazards and prepare a Disaster Management Plan (DMP) to enable mitigation of a hazard as well as react in case of an incident due to the hazard. It recognizes that accidents are possible. The DMP deals with anticipating impacts of hazards, responses to alerts, deciding on the emergency procedures to be used and the actions (both on-site and off-site) that need to be carried out in case of an emergency. Thus, it aims at

- Protecting project personnel and nearby general public
- Protecting project property as well as minimizing damage to the environment
- Rendering help to person at site to provide him/her relief in the case of accidents
- Restoring the affected area as soon as possible
- Reviewing the event and strengthen the DMP and response for future emergencies

The DMP aims to describe the company's preparedness to deal with different kinds of emergencies and the organizational structure to be deployed at the shortest possible time. There are thus three main objectives:

- Minimizing risk and impact of the event/accident
- Rapid control and containment of hazardous situation
- Effective prevention of damage to personnel and property

This requires

- Following proper safety procedures
- Reliable Early Warning Systems
- The command, co-ordination and response organization structure along with availability of efficient trained personnel.
- Resources allocated for handling emergencies
- Effective notification and communication strategies
- Training and mock drills
- Regular updating of DMP

Before a DMP is prepared, a maximum credible accident analysis has to be done. In other words, the major hazards have to be identified and the risk posed by the existence of these hazards has to be assessed. Subsequently, a management plan has to be put in place to ensure

that there is mitigation of the identified hazards and coping capacity to react in case of an emergency is built.

8.3 Definitions

For the sake of conformance to norms, the following definitions have been taken from "The Disaster Management Act of 2005" [1] as published by the Government of India.

(*a*) "affected area" means an area or part of the country affected by a disaster;

(*b*) "capacity-building" includes—

(*i*) Identification of existing resources and resources to be acquired or created;

(*ii*) Acquiring or creating resources identified under sub-clause (*i*);

(*iii*) Organization and training of personnel and coordination of such training for effective management of disasters;

(*c*) "Central Government" means the Ministry or Department of the Government of India having administrative control of disaster management;

(*d*) "disaster" means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or man made causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area;

(*e*) "disaster management" means a continuous and integrated process of planning, organising, coordinating and implementing measures which are necessary or expedient for—

(*i*) prevention of danger or threat of any disaster;

(*ii*) mitigation or reduction of risk of any disaster or its severity or consequences;

(*iii*) capacity-building;

(*iv*) preparedness to deal with any disaster;

(*v*) prompt response to any threatening disaster situation or disaster;

(*vi*) assessing the severity or magnitude of effects of any disaster;

(*vii*) evacuation, rescue and relief;

(*viii*) rehabilitation and reconstruction;

(*f*) "District Authority" means the District Disaster Management Authority constituted under sub-section (*1*) of section 25;

(*g*) "District Plan" means the plan for disaster management for the district prepared under section 31;

(*h*) "local authority" includes panchayati raj institutions, municipalities, a district board, cantonment board, town planning authority or Zila Parishad or any other body or authority, by whatever name called, for the time being invested by law, for rendering essential services or, with the control and management of civic services, within a specified local area;

(*i*) "mitigation" means measures aimed at reducing the risk, impact or effects of a disaster or threatening disaster situation;

(*j*) "National Authority" means the National Disaster Management Authority established under sub-section (*1*) of section 3;

(*k*) "National Executive Committee" means the Executive Committee of the National Authority constituted under sub-section (*1*) of section 8;

(*l*) "National Plan" means the plan for disaster management for the whole of the country prepared under section 11;

(*m*) "preparedness" means the state of readiness to deal with a threatening disaster situation or disaster and the effects thereof;

(*n*) "prescribed" means prescribed by rules made under this Act;

(*o*) "reconstruction" means construction or restoration of any property after a disaster;

(*p*) "resources" includes manpower, services, materials and provisions;

(*q*) "State Authority" means the State Disaster Management Authority established under sub-section (*1*) of section 14 and includes the Disaster Management Authority for the Union territory constituted under that section;

(*r*) "State Executive Committee" means the Executive Committee of a State Authority constituted under sub-section (*1*) of section 20;

(*s*) "State Government" means the Department of Government of the State having administrative control of disaster management and includes Administrator of the Union territory appointed by the President under article 239 of the Constitution;

(*t*) "State Plan" means the plan for disaster management for the whole of the State prepared under section 23.

8.4 Report Flow

This report has been prepared in a manner as to serve as a blue print for the actual Disaster Management Plan. The report identifies the various components for the DMP and provides the logic behind the need. The report has standardized certain terms and data which should be used in the DMP. The definitions are used as per the norms as defined by the Government of

India. The actual DMP will have to be based on the actual equipment to be used on the site and other such details and has to be done by the designated person.

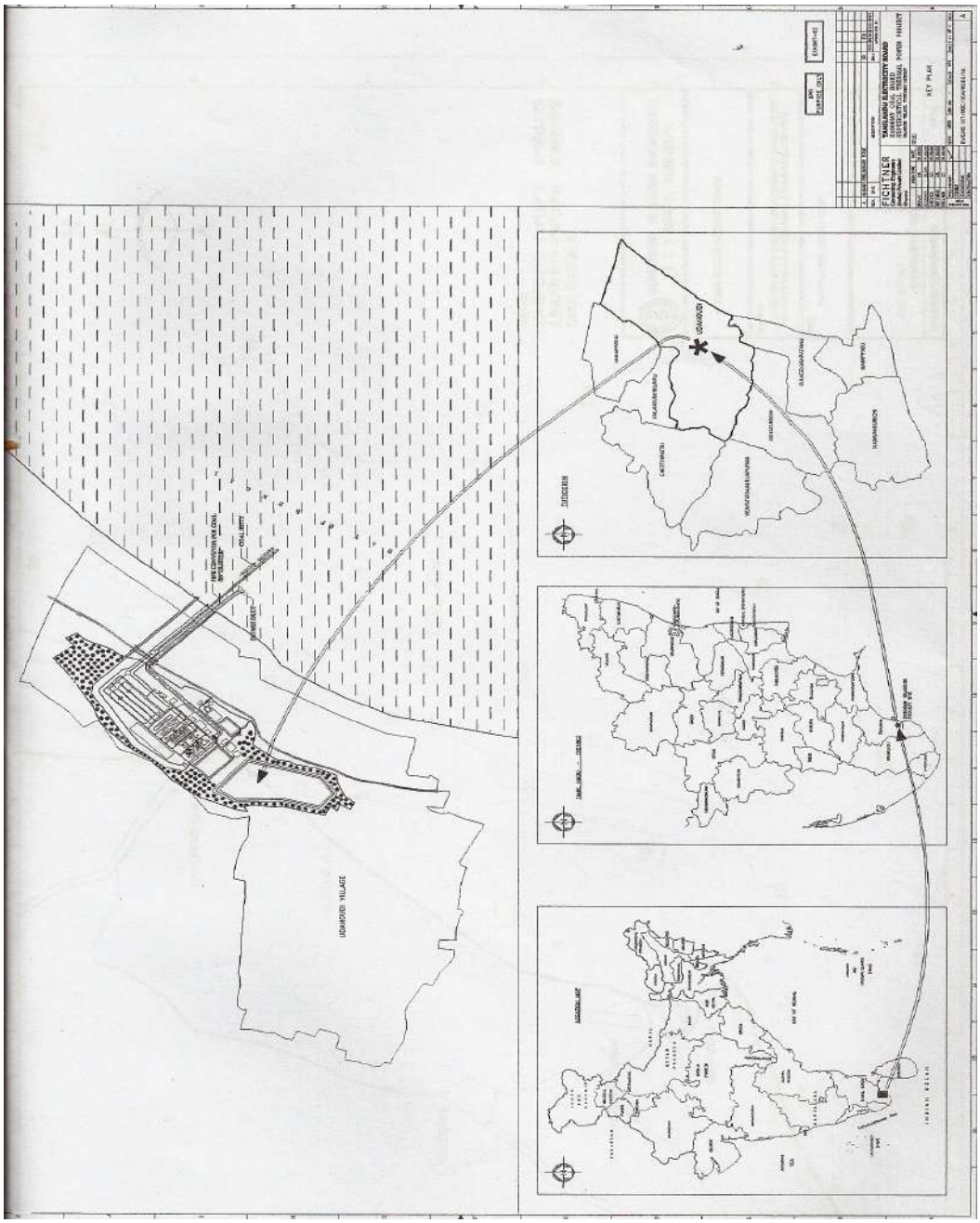
8.5 Site Information

Risk assessment and Disaster Management Plan is site specific even if general plans can be used as a templa**te. Basic information on the proposed coal jetty is given in this section.**

8.5.1 Site Location

The coal jetty is located off shore of the proposed super critical thermal power ~~plant~~ project at Udangudi, Thoothukudi district in Tamil Nadu. The location is shown in the sketch in Figure 18.

Figure 18: Site Location



8.5.2 Basic Details about Site

The basic data required for due consideration while assessing hazards was taken from the report entitled "Feasibility study for the Development of coal jetty for 2x800MW / Udangudi super critical Thermal power project in Thoothukkudi district" [2]. This report contains access, environmental and details of sea conditions.

8.5.3 Equipment

Only general data regarding the type of equipment is given in the feasibility study. The data needs to be gathered on the types of equipments actually present at the site which will be available only after the tendering process and other activities are completed. The manufacturers of the chosen equipments must provide the safety procedure for the safe operation of the machinery. They must also provide the maintenance cycle data to ensure safe and continuous operation. They must also provide the safety equipment that must be used while operating these machines and operating training in safe handling. As part of the DMP, the data on anticipated failure of this equipment (as per their design) must be provided by the manufacturer. The mean time between failures must also be recorded and methods to mitigate the failure by periodic maintenance activities should be clearly and specifically provided.

8.6 Hazards Identification

For the coal jetty, Table 20 gives a potential summary of hazards that could impact the project.

Table 20. Summary of Potential Hazards for the Udankgudi Coal Jetty Project

POTENTIAL HAZARD	PROBABLE IMPACTS
MAN MADE	
Berthing accidents	Impact on jetty (mooring, structure)
Carrier running aground	Oil Spills, wreckage
Fuel/oil spills, leaks	Impact on aquatic (marine) environment
Break/leak in coal conveyor pipeline	Asphyxation/breathing problems due to fine dust in the air; shutting down of operations
Coal unloading – breakdown of grab unloader;	Failure of grab unloader may result in coal being deposited on seabed
NATURAL	
Tropical Storms, Cyclones, Heavy Rain	Rough seas during particular seasons during which carrier berthing is not possible; accidents due to collision with jetty
Earthquake / tsunami	Damage buildings and equipment, inundation of jetty
OTHERS	
Fire	Fire outbreaks can vary in size and location, can cause extensive damage
Medical	Can occur at any time especially due to falling debris during construction; operational procedures

8.7 Natural Hazards

Tropical storms which can intensify into cyclones form regularly in the Gulf of Mannar.However, since the project site Udangudi is located below the 10º N latitude, the site is considered to be free from the regular effect of storms. The region falls under the 'moderate' zone in the Cyclone, Wind and storm surge hazard maps as shown in the Figures 3 and 4 from the Building Materials & Technology Promotion Council (BMTPC) Vulnerability atlas for India. Most of the rainfall is during the North East monsoon period between October and December each year for Thoothukudi district.

The major hazard therefore is likely to be due to high waves during the monsoon. According to the consultant for the coal jetty project, the recommended tranquility conditions of 1.2 – 1.5m may not occur for about 20% of the time during the monsoon season. Hence, the jetty operator as well as emergency coordinator should obtain regular updates from the India Meteorological Department (IMD) about the weather status to ensure that no ship operations are carried out under unfavourable conditions.

Figure 19. Cyclone Frequency and Wind Hazard Map of India

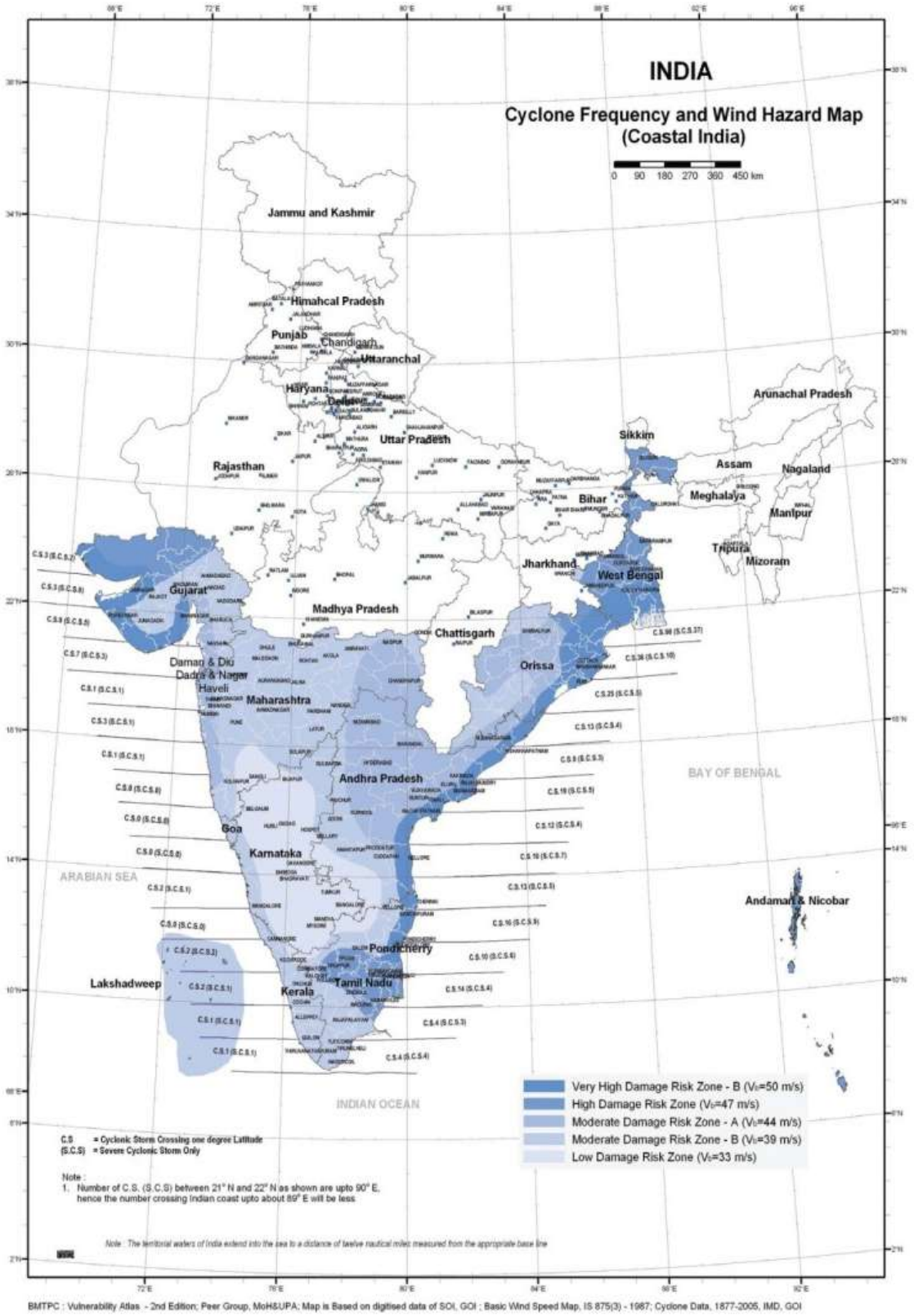
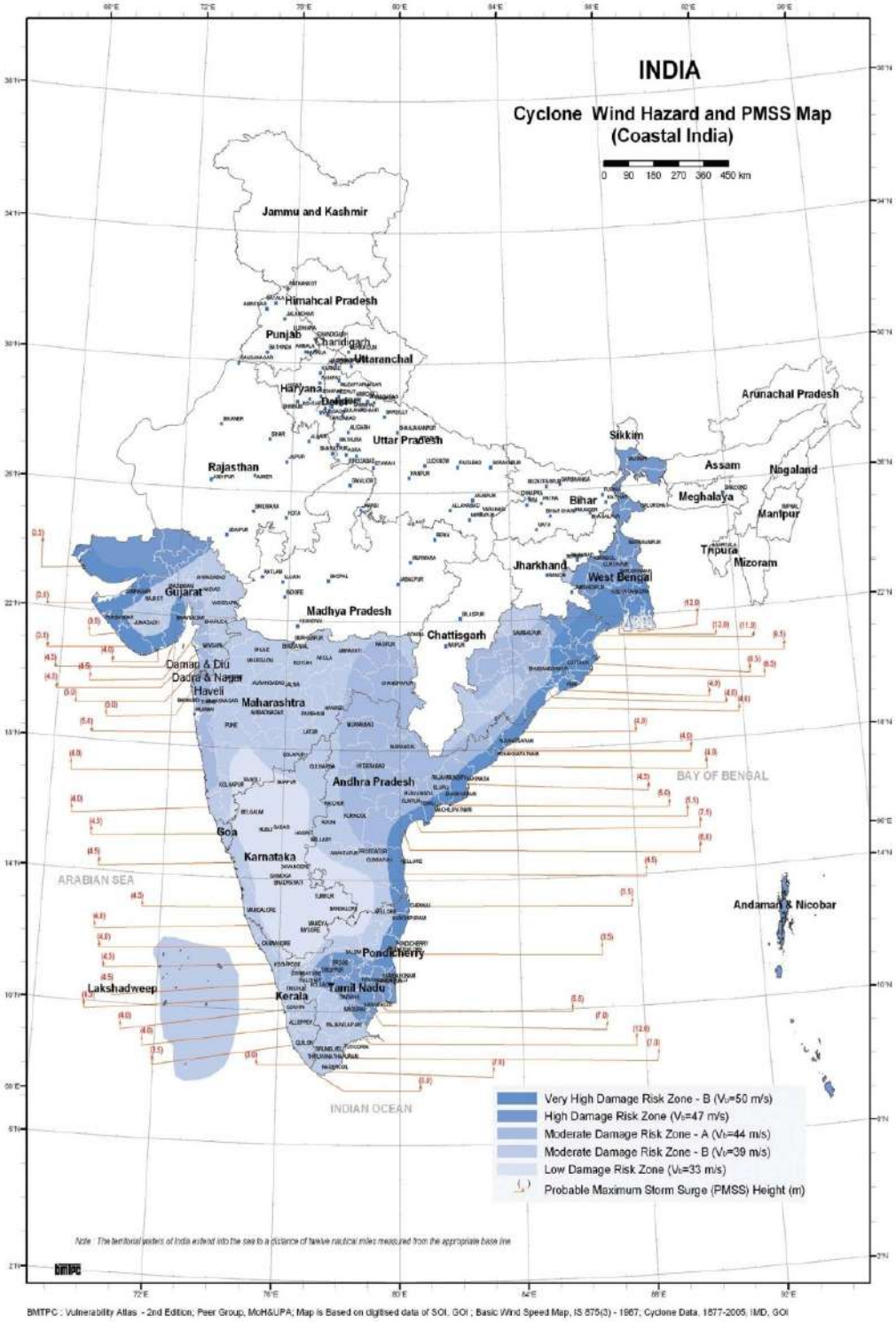


Figure 20. Cyclone Wind Hazard and PMSS Map of India



During such conditions, the following emergency situations may occur and need to be monitored and attended to:

- **Carrier collision / grounding:** Especially during rough weather, carrier collision with jetty / grounding of carrier is possible mainly because of uneven distribution of cargo in the carrier. If such events take place, immediate alert and action especially for saving crew as well as jetty personnel must be given out. A lifeboat must be kept moored with all first aid facilities near the work site both during construction phase and operation phase. Since the facilities on land will be about 7-10 km away, this is essential. Life buoys should be kept available at all times.
- **Fuel / Oil spills:** Because of carrier collisions/grounding or even during routine operations, spilling or leak of fuel /oils from carriers as well as from storage facilities (if any) on the jetty are possible. The oil spill contingency plan as described in the next section needs to be activated during such an event.
- **Inundation:** During periods of heavy rain and rough weather, wave heights can be high enough to cause various degrees of flooding of the jetty.

8.8 Man Made Hazards

Under this section are covered hazards due to human error as well as mechanical failure of equipment. Some of the most important activities that could result in emergency situations include the following:

- **Berthing:** The coal jetty is to have two coal berths (one side unloading). Berthing has to be done properly following the requisite safety precautions as specified by the IMO (International Maritime Organization). One of the most common problems is collision between the carrier and jetty which can happen if proper procedures are not followed as well as in rough weather when there are swells.
- **Unloading:** Four shore unloaders of 2000TPH are to be provided. There must be proper synchrony between the ship and the unloading area to avoid spills and any other accidents. The operation of unloaders is a mechanical repetitive task and hence fatigue can set in the operators resulting in errors that may translate into accidents. The next section lists some of the precautions to be followed to ensure safe unloading of bulk materials such as coal.

- **Handling and Transfer by pipelines:** The coal after unloading from the coal carrier has to be loaded into the pipe conveyor for transfer to the mainland. Mechanical breakdown of the pipe conveyor could result in blockage of coal transfer and may also result in coal getting dumped into the sea.

8.9 Maximum Credible Accident Analysis

Hazard analysis involves the identification and quantification of the various hazards (unsafe conditions) that exist in any operations. Risk analysis follows an extensive hazard analysis. It involves the identification and assessments of risks the jetty personnel as well as general public are exposed to as a result of hazards present. This requires a thorough knowledge of failure probability, credible accident scenario, vulnerability of population etc. Hence, this deals with the recognition and computation of risks that the equipment in the coal jetty and personnel are prone to due to accidents resulting from the hazards whose origin may be natural or man-made, including equipment and human failure. Maximum Credible Accident Analysis (MCAA) is one of the methods of risk assessment. Essentially, this concept says that the situation cannot be worse than the "maximum credible accident". Therefore, the safety systems designed are always done with sufficient margin to contain such extreme situations. In the case of the coal jetty the areas listed under man made hazards are covered under the maximum credible accident analysis. The actual risk analysis can be done only based on the equipment that is proposed to be used at the site. To reduce the probability of such events happening, mitigation activities must be undertaken.

8.10 Mitigation Activities

Disaster preparedness is essential to ensure that all manner of precautions are taken so that in case of an emergency, there is minimum harm to personnel and equipment. Key precautions include:

- Manufacturers of all equipment must provide MTBF (Mean Time Between Failures) and failure frequency data. These are normally decided prior to designing such equipment. Maintenance procedures – frequency of replacement of parts with routine wear and tear – should also be cited here.
- During construction of the jetty, relevant building and construction codes must be followed. During construction and operation, all workers should follow safety procedures

such as wearing of life jackets while working near the water's edge, safety rope lines, non-slippery shoes and helmets; ear muffs while working in noisy areas such as during pile driving; face masks during working in areas with high dust.

- During construction, excavation of sand and controlled blasting of rocks in the seabed may be carried out. During this time, all safety precautions as are deemed necessary and given in the guidelines for such operations, must be followed.
- During operation, all requisite safety precautions to be followed for mooring, berthing, loading and unloading coal/ fly-ash; fine spray of water to be used to maintain low ambient dust levels.
- In the interests of safety close cooperation between the ship and the terminal is called for on all matters relating to loading/unloading of bulk cargoes. The "Code of Practice for Safe Loading and Unloading of Bulk Carriers", published by the International Maritime Organisation (IMO Sales No.266E), may be referred to for detailed operational guidance, including the responsibilities of the master and the terminal representative in the cargo operations.
- Regular schedule of maintenance to be maintained based on the best available information.
- Consistent weather forecasting service to be maintained during transfer of coal from carriers.
- All terminal crew to have minimum certification as per the IMO's STCW Convention (International Maritime Organization – International Convention on Standards of Training, Certification and Watch keeping for Seafarers, 1978). For example, the Tamil Nadu Maritime Academy at Thoothukudi is conducting five STCW-95 courses namely "Personal Survival Techniques", "Elementary First Aid", "Personal Safety and Social Responsibility", "Oil Tanker Familiarization" and "Fire Prevention and Fire Fighting".
- Marker buoys to be positioned near intake and outfall points

8.11 Disaster Management Plan

The impact of a hazard may result in an emergency situation or a disaster. A major emergency in industry is one which has the potential to cause serious injury or loss of life. It may cause extensive damage to property and serious disruption in work inside and outside the premises. It would normally require the assistance of emergency services to handle it

effectively. It is necessary therefore to be aware of and be prepared for various kinds of emergencies that arise out of the impact of different kinds of hazards. For this, a Disaster Management Plan is required to be in place at all times. The essential requirement for any disaster management is assigning duties to specific personnel and this is discussed first.

8.11.1 Key Personnel & Emergency Room

This section deals with the personnel who are to be positioned in charge in case an emergency situation arises. The general role that is played by the key persons in an DMP as well as specific actions to be taken in case of an emergency are given in the following sections.

Emergency coordinator

The Emergency Coordinator would be someone in a senior position designated by the authority operating the jetty. The emergency coordinator has to prepare a detailed DMP based on the locations of the various activities on site and the space available for storage of emergency equipment including lifebuoys, life jackets, safety ropes as well as the mooring of the lifeboat; and regularly update the DMP based on changing activities and learning from any accidents. He/she has to ensure that requisite resources are always available to tackle an emergency situation. The emergency coordinator will have to create a chain of command for response during an emergency. He/she has to liaise with the environmental management unit, authorities on the shore, the Coast Guard and hospitals/trauma care centres on shore. The emergency coordinator has to identify suitable personnel who will act as the various emergency coordinators such as rescue, fire-fighting, medical, transport etc.

Incident Controller

The Incident Controller would be designated by the Emergency Coordinator and would have requisite training in safety procedures. He/she would conduct regular safety audits and report any deficiencies to the Emergency Controller. In case of any incident on site, the incident controller has to take charge and issue the needed orders to cope with the emergency. He/she will liaise with the coast guard in case of oil spills or any personnel / ship related accidents at sea. He/she will keep themselves regularly updated especially during the rough weather season to ensure that no adverse incident takes place and all precautions are taken at the appropriate time.

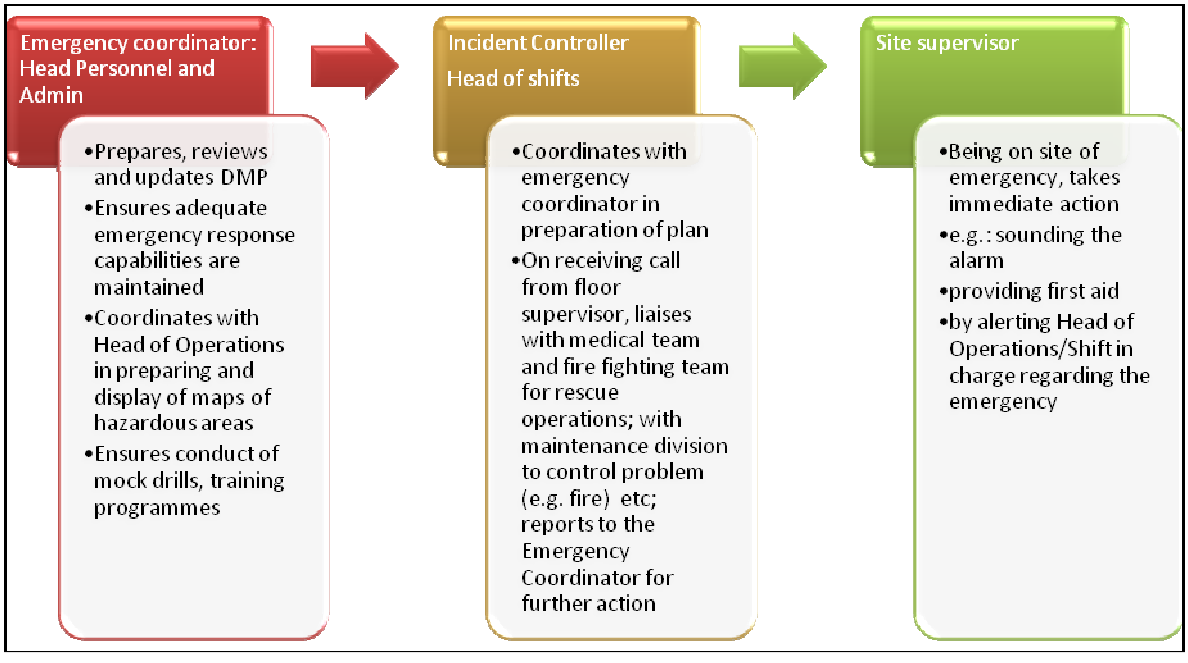
Emergency control room

- The emergency control room is a centre for emergency works and is staffed by personnel as identified in the DMP. The control room will have the following:
- Regular as well as emergency communication systems,
- Telephone numbers of all essential services including speedboat/ lifeboat pilots, doctor and paramedics, ambulance, fire services, police, district collector etc.
- Detailed muster roll of employees and personnel on site,
- Information about arrival-departure schedules of ships, tugs and other craft,
- Detailed layout plan of the site including identified hazardous areas and evacuation routes,
- Medical (first-aid) treatment facilities
- Canned food material, water, equipment for making hot water
- Safety equipment, additional fire-extinguishing materials
- Material Safety Data sheets, personnel protective equipment, medical first aid facilities, evacuation plans etc. The emergency control room is not always manned.
- Designated employees will move into the control room in case of an emergency. The emergency control room should be located in a safe area.

8.11.2 Lines of action in an Emergency

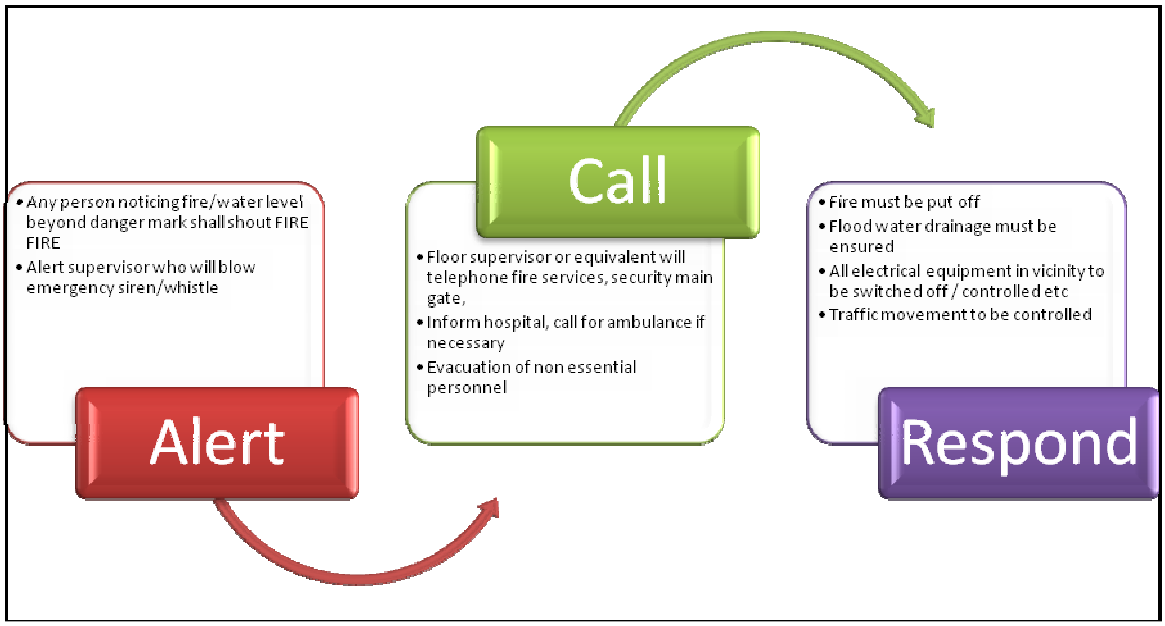
Depending on the emergency, the appropriate contingency plan to be prepared in detail in the DMP for the site to be prepared by the Emergency Coordinator is to be activated. The key people responsible for disaster management and their functions are represented in Figure 20.

Figure 21. Key Personnel in Disaster Management



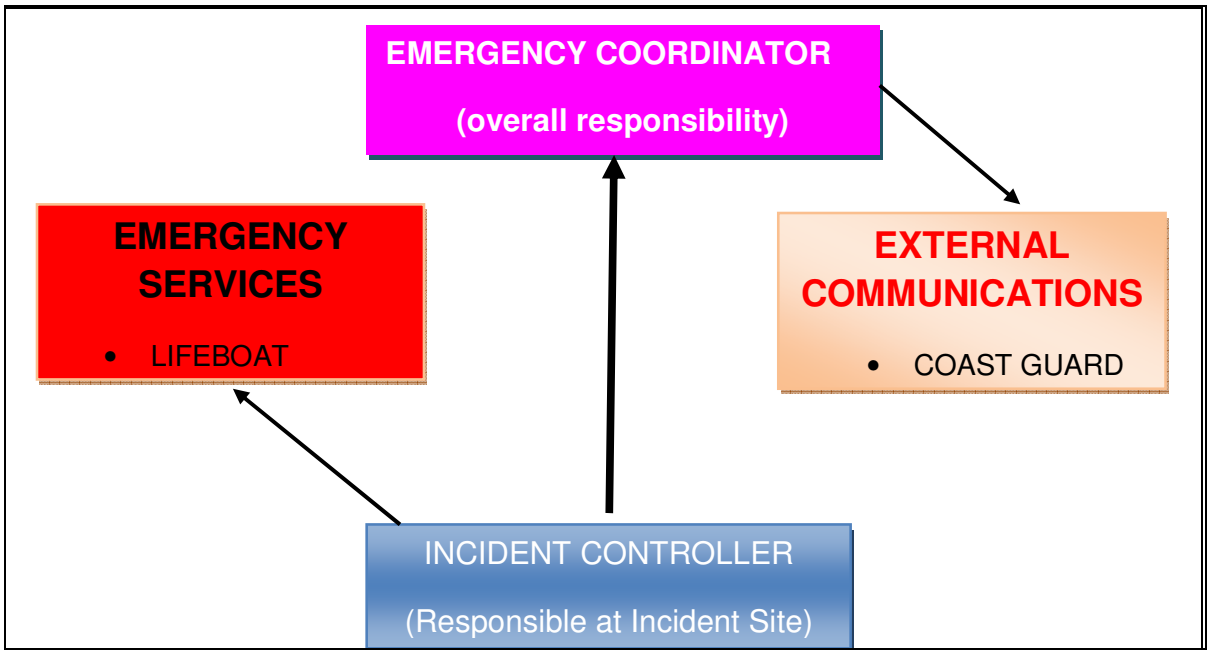
The Line of action will follow approximately the path indicated in Figure 21.

Figure 22. Line of Action to an Emergency Situation



The command structure in an emergency situation is expected to follow the form given in Figure 21.

Figure 23. Emergency Operational Command Structure



8.12 Responsibilities of key personnel in an emergency

In case of an emergency, the responsibilities of the key personnel would be as given below:

Emergency Coordinator

On receiving information about emergency, he/she would rush to Emergency Control Center (ECC) and take charge of ECC and the situation. The responsibilities would be as indicated below:

- Assessment of the magnitude of the situation on the advice of Incident Controller and takes decision on:
  - Whether the affected area needs to be evacuated;
  - Whether activities on the coal jetty have to be shut down;
- Declares state of Emergency;
- Organizes announcement by public address system about location of emergency;
- Assesses which areas are likely to be affected, or need to be evacuated or are to be alerted;
- Maintains a continuous review of possible development and assesses the situation in consultation with Incident Controller and other Key Personnel as to whether shutting down the activities on the coal jetty or any section of the jetty is required and if evacuation of persons is required;
- Directs personnel for rescue, rehabilitation, transport, fire, brigade, medical and other designated mutual support systems locally available, for meeting emergencies;
- Calls for speedboat to be readied and directs the personnel to go to the jetty;
- Controls evacuation of affected areas, if the situation is likely to go out of control, informs the Coast Guard, Port Authorities, District Collector, Police, Hospital and seeks their intervention and help;
- Informs Inspector of Factories, Deputy Chief Inspector of Factories, Pollution Control Board, and other statutory authorities; Gives a public statement, if necessary;
- Keeps record of chronological events and prepares an investigation report and preserves evidence; and
- On completion of On Site Emergency and restoration of normalcy, declares all clear and orders for all clear warning.

Incident Controller (Port operations Manager or his nominee)

- Assembles the incident control team;
- Directs operations such as fire fighting and evacuation within the affected areas with the priorities for safety to personnel, minimizing damage to the plant, property and environment and minimizing the loss of materials;
- Directs the shutting down and evacuation of plant/operations and areas likely to be adversely affected by the emergency;
- Ensures that key personnel help is sought;
- Provides advice and information to the Fire and Security Officer and the Local Fire Services as and when they arrive;
- Ensures that all non-essential workers/staff of the affected areas are evacuated to the appropriate assembly points, and the areas are searched for casualties;
- Has regard to the need for preservation of evidence so as to facilitate any inquiry into the causes and circumstances, which caused or escalated the emergency;
- Co-ordinates with emergency services at the site;
- Provides tools and safety equipment to the team members;
- Keeps in touch with the team and advises them regarding the method of control to be used; and
- Keeps the Site Controller of Emergency informed of the progress being made.

Coordinator - Rescue, Fire Fighting (Port Fire & Safety Officer or his nominee)

- On knowing about emergency, rushes to ECC;
- Organizes the speed boat with medical supplies and doctor/trained paramedics and ensures that ambulance service is readily available on the shore
- Helps the Incident Controller in containment of the emergency;
- In case of possible fire, ensure fire pumps are in operating condition and instructs pump house operator to ready for any emergency with standby arrangement;
- Guides the fire fighting crew i.e. firemen, trained plant personnel and security staff;
- Organizes shifting the fire fighting facilities to the emergency site, if required;
- Takes guidance of the Incident Controller for fire-fighting as well as assesses the requirements of outside help;

- Arranges to control the traffic at the gate and the incident area;
- Directs the security staff to the incident site to take part in the emergency operations under his guidance and supervision;
- Evacuates the people in the plant or in the nearby areas as advised by Site Controller;
- Searches for casualties and arranges proper aid for them;
- Assembles search and evacuation team;
- Arranges for safety equipment for the members of this team;
- Decides which paths the evacuated workers should follow; and
- Maintains law and order in the area, and if necessary seeks the help of police.

Coordinator-Medical, Mutual Aid, Rehabilitation, Transport and Communication

- In the event of failure of electric supply and thereby internal telephone, sets up communication point and establishes contact with the ECC;
- Organizes medical treatment to the injured and if necessary will shift the injured to nearby hospitals;
- Mobilizes extra medical help from outside, if necessary;
- Keeps a list of qualified first aid providers and seeks their assistance;
- Maintains first aid and medical emergency requirements;
- Makes sure that all safety equipment is made available to the emergency team;
- Assists Site Controller with necessary data to coordinate the emergency activities;
- Assists Site Controller in updating emergency plan, organizing mock drills, verification of inventory of emergency facilities and furnishing report to Site Controller;
- Maintains liaison with Civil Administration;
- Ensures availability of canteen facilities and maintenance of rehabilitation center.
- Liaises with Site Controller/Incident Controller;
- Ensures transportation facility;
- Ensures availability of necessary cash for rescue/rehabilitation and emergency expenditure;
- Controls rehabilitation of affected areas on discontinuation of emergency; and
- Makes available diesel/petrol for transport vehicles engaged in emergency operation.

Coordinator - Essential Services

- Assists Site Controller and Incident Controller;
- Maintains essential services like Diesel Generator, Water, Fire Water, Compressed Air/Instrument Air, power supply for lighting;
- Plans alternate facilities in the event of power failure, to maintain essential services such as lighting, etc;
- Organizes separate electrical connections for all utilities and emergency services so that in the event of emergency or fires, essential services and utilities are not affected;
- Gives necessary instructions regarding emergency electrical supply, isolation of certain sections etc. to shift in-charge and electricians; and
- Ensures availability of adequate quantities of protective equipment and other emergency materials, spares etc.

Other employees / personnel

Those personnel involved in operating equipment must shut down the systems safely as early as possible and attend to any assigned emergency duty. They should assemble in the safe area for evacuation if necessary. They should not panic or spread rumours. They should assist the emergency coordinator and incident coordinator in carrying out the disaster management plan. Those employees who have obtained training as life guards must indicate so to the ECC so that their services are utilized in an emergency as this is for an offshore unit.

8.13 Communication Systems in Disaster Management

In case of incident, communication is essential to control the incident and to ensure timely help to personnel affected as well as to minimize losses.

The following communication system may be provided in the coal jetty area:

- Walkie-Talkie for communication between the personnel on duty at any time on
- the jetty since the number is small
- Telephone(internal & external- to the shore office).
- Cell phone: The strength and stability of the signal from the shore needs to be monitored and based on this, the service provider may be chosen

Since the coal jetty is more than 7km from the mainland, it is essential to have a direct HOTLINE to the shore. In other words, there should be no need for personnel to dial a number. Instead, the pressing of a single button on a phone would result in the alarm being sounded in the emergency control room and at the desk of the emergency coordinator on the shore. Such a device would have to work even when there is no power supply. A HF/VHF/satellite communication system may also be considered.

8.14 On-site Emergency Plans

8.14.1 Mechanical Emergency Plan

Coal unloading: The coal jetty has a layout to provide open berthing with waves for ships upto 75,000 tonnes capacity (PANAMAX class). The coal will be unloaded using grab unloaders. Because of the increased demand for speed in performing exacting, repetitive tasks, operators of manually controlled grab unloaders are subject to fatigue. Operator fatigue can result in error, accidents and compromised efficiency. This aspect must be dealt with in detail when the equipments to be used at the coal jetty are finalized. Training for the operators is essential and regular maintenance of the grab unloaders has to be done. A plan of action to be activated in case of such mechanical failures must be part of the detailed localized DMP to be prepared by the emergency coordinator.

Coal spillage Management Plan

Break/leak in coal conveyor pipe system: According to the proposed plan, coal is to be off loaded from carrier ships in the coal jetty and transferred by closed pipeline to land over a distance of about 7.5 km. Coal, unlike LNG for example, does not undergo spontaneous ignition. Hence if there is an accident to the conveyor belt, and coal gets deposited on seafloor, it will not be a fire hazard but will create environmental problems. However, fine coal dust can cause respiratory problems and in the case of relatively large releases of fine dust due to a leak in the conveyor system, there could be problems of asphyxiation which means that personnel working in those areas must wear masks or requisite breathing apparatus.

- A fully mechanized coal unloading system will be employed for the ship-to-shore transfer of coal to ensure spillage to minimum.
- Coal will be handled through closed pipe conveyors where spillage is nil.
- Further dust suppression system will be employed at the Unloaders to prevent any pollution.

- Regular monitoring to avoid the spillage of coal will be enforced. In case of any spillage, the spilled coal will be arranged to be removed by grab cranes from the conveyor deck/Coal Jetty.

8.14.2 Rough Weather Plan

The major hazard therefore is likely to be due to high waves during the monsoon. According to the consultant for the coal jetty project, the recommended tranquility conditions of 1.2 – 1.5m may not occur for about 20% of the time during the monsoon season. Hence, the jetty operator as well as emergency coordinator should obtain regular updates from the IMD about the weather status to ensure that no ship operations are carried out under unfavourable conditions. During such conditions, the following emergency situations may occur and need to be monitored and attended to:

- **Carrier collision / grounding:** Especially during rough weather, carrier collision with jetty / grounding of carrier is possible mainly because of uneven distribution of cargo in the carrier. If such events take place, immediate alert and action especially for saving crew as well as jetty personnel must be given out. A lifeboat must be kept moored with all first aid facilities near the work site both during construction phase and operation phase. Since the facilities on land will be about 7-10 km away, this is essential. Life buoys should be kept available at all times.
- **Fuel/Oil spills:** Because of carrier collisions/grounding or even during routine operations, spilling or leak of fuel /oils from carriers as well as from storage facilities (if any) on the jetty are possible. The oil spill contingency plan as described in the next section needs to be activated during such an event.
- **Inundation:** During periods of heavy rain and rough weather, wave heights can be high enough to cause various degrees of flooding of the jetty.

During the pre monsoon period (August-September), the Emergency Coordinator will liaise with the maintenance division to ensure that all storm water drains and other areas where flooding may occur are kept clear to ensure free drainage of water. During the monsoon, the Emergency Coordinator will ensure a system for regular updating of weather information especially rainfall forecasts from the IMD and will monitor wave heights so that decisions can be taken regarding berthing of carriers and unloading/loading cargo. In addition, during periods of heavy rain/swells, whoever notices water in places where there should not be any water or water above the danger marks if so marked, they should take immediate action and

also follows the line of action to communicate to the emergency coordinator for additional action.

8.14.3 Earthquake Management Plan

In case of a building collapse, three major problems can be envisaged – people getting trapped under debris, outbreak of fire, and flooding due sea swells as well as due to bursting of water pipes. When such an event happens, immediate evacuation of the place must be ensured by ringing the alarm bell/activating the hotline to the shore, and personnel should assemble in the safe assembly zone. Rescue of people trapped under debris must be immediately attempted and fire and rescue services must be called for assistance and further action. Maintenance division must check to ensure safety from outbreak of fire and any burst/damaged water pipes. Once the emergency is past, the emergency coordinator with the assistance of other staff must document damage (especially by photography) to ensure necessary repair works are undertaken.

8.14.4 Oil Spill Contingency Plan

Accidental oil spill: For Fuel Oils, Heavy Fuel Oils and Light Diesel Oils, firewater cooling systems and foam facilities as per OISD-117 [Oil Industry Safety Directorate] must be provided. The DMP detailed by the Emergency Coordinator should have a schedule for regular inspection of piping and other equipment for corrosion and damage in the jetty area. Firefighting equipment as well as information about safety precautions to be followed in these areas must be given in sufficient detail in the form of posters in and around the vulnerable areas.

Due to ship activities in the vicinity of the jetty, oil spills can happen because of different causes such as unintended leaks, collision with jetty/another ship/ grounding. The oil spill contingency plan aims to

- Ensure the safety of the personnel in the event of an oil spill
- Minimize the environmental impact of an oil spill
- Minimizing business disruption
- Minimizing harm to the people

Oil spill Management Plan

Cleaning of shore-line is usually carried out in two stages:

Primary phase: It consists of removal of floating oil and heavy contamination as soon as possible in order to avoid further pollution.

Final cleaning phase: It is to removal the final traces of oil and oil stains.

The procedure of containment and recovery is as follows:

- Identification of the oil spill.
- Containment (boom deployment).
- Recovery (skimmers).
- Temporary waste storage (on-deck storage, barges etc.).
- Waste transport and onshore waste receiving facility.

The oil spill response kits should be installed in key places, and containment booms need to be deployed in case of large spills in marine areas In the event of an oil spill in the marine environment the following measures should be employed according to the circumstances of the spill and conditions prevailing:

- Notify the Indian Coast Guard as they are the oil spill notification nodal agency
- If possible prevent, control or stop the outflow or release of the oil from the source;
- If coastal or marine resources are not threatened or likely to be threatened, monitor the movement and behaviour of the oil;
- If coastal and marine resources are threatened, determine whether to begin response operations, either at sea and/or to protect sensitive resources;
- If possible contain the spread of oil; and
- If, due to weather and sea conditions, response at sea or protection of sensitive areas is not feasible, or the foreshores have already been affected, determine appropriate cleanup priorities and other response measures.
- Udangudi Port will provide the necessary oil spill combating equipment like tug with booms and skimmer and sorbent pads within the Port. The required number of such equipment shall be procured prior to commissioning of the Port.

8.14.5 Fire prevention and response plan

The fire prevention and response plan will focus on the possibility of a fire and any fire outbreak, whether large or small, that might occur. It is therefore important to consider its likelihood and with this in mind, the development will develop a response plan aimed at addressing the awareness and the mechanism necessary for its response. The DMP should indicate all possible fire hazard areas and also evacuation route to the safe assembly area.

Relevant Firefighting equipment should be kept ready in all hazard prone areas and training should be imparted on the use of the equipment. Normally sea water is used for fire emergencies in jetties and ports. Tugboats with firefighting equipment should be made available.

The action should follow approximately the following procedure:

- Shout FIRE FIRE, Sound the alarm
- Use an extinguishing media preferably a fire extinguisher to fight the fire.
- Do not fight a large fire with a fire extinguisher.
- Remove any combustible material if possible
- Evacuate personnel in the area, if necessary to the safe assembly point
- Check to see that the fire is completely extinguished.
- Inspect the fire area and assess for damages.
- Close off the area for safety purposes.
- Alert the fire services if external fire tender / firefighting equipment/materials are required

A report of the incident should be prepared by the Emergency Coordinator and should be submitted to the Emergency Committee for assessment.

8.14.6 Medical Emergency Plan

A medical emergency is an injury or illness that poses an immediate threat to a person's life or long term health. Depending on the severity of the emergency, and the quality of any treatment given, it may require the involvement of multiple levels of care, from a first-aider to an emergency physician through to specialist surgeons. This response plan will cater to basic first aid health care only and any emergency transportation to a recognized health institution such as a hospital or health center.

The 3 main aims of first aid, commonly referred to as the “3 Ps” are:

- Preserve life
- Prevent further injury
- Promote recovery

First aid kits must be made available at key points and personnel must undergo basic training to react to simple emergencies. Since this is an offshore site, a lifeboat with first aid and other necessary emergency medical equipment should be always kept in readiness at a mooring

point in the jetty to ensure rapid transportation to land in case of an accident. Contact must be maintained with the nearby hospital / trauma care centres, immediate transportation of injured personnel should be ensured

8.14.7 Special Emergency Equipment

Special emergency equipment in the form of lifebuoys, lifejackets, safety ropes, non slippery shoes, helmets etc as well as appropriate fire fighting systems and chemicals and equipment to control oil spills must be kept available. As mentioned earlier, a lifeboat should always be stationed near the working area to enable immediate relief/rescue activities in case of accidents. It would be advisable for the port operator to ensure that tugs that are deployed have appropriate firefighting equipment.

8.14.8 Chemical Information

Coal and fly ash will be the main items stored / transported. In addition, other chemicals may be used during construction and operation. MSDS for such chemicals as well as for the fuels used in the jetty must be made available with the Emergency Control Room.

8.14.9 Drills/Rehearsing Emergency Procedures

The emergency coordinator is responsible for conducting drills and rehearsing emergency procedures on a regular basis so that personnel response to any disaster situation is quick and efficient entailing minimum loss. Regular mock drills to check preparedness of people as well as the functioning of all emergency equipment must be carried out.

8.15 Emergency Evacuation Plan

The coal jetty is an offshore site located about ~~7~~7.5 km from the shore. The number of personnel on the jetty at any given time will be limited to the personnel on duty manning the pipe conveyor and the grab unloaders. There will also be the crew of the ship(s) berthed. Under normal circumstances, it would take more than half an hour from the shore to reach the coal jetty. In case of any emergency (e.g. accident) in the coal jetty, the persons on shift will have to be evacuated to the mainland. It is suggested that a boat jetty about 1.5 km into the sea from the shore along the pipe conveyor trestle be created so that speedboat(s) and lifeboat(s) with life saving equipment can be moored. This will enable speedier response to any emergency on the coal jetty.

In addition, the emergency coordinator must maintain regular contact with the coast guard as well as with the authorities of the nearest port to enable quick response and action in case of

any contingency. The telephone numbers and contact details of the specific officers in charge at the Coast Guard and Port must be kept in readiness and a procedure for informing them and requesting their help should form part of the detailed DMP to be prepared by the Emergency Coordinator. Contact should also be maintained with fishermen in the local area to request help in an emergency.

8.16 Off-site Emergency Plans

Since the coal jetty is located offshore, it is necessary to have offsite emergency plan also. This is especially important in the case of oil spills that can move towards the shoreline and coal dust / fly ash plumes as they can be hazardous to human health. Since the coal conveyor belt discharges coal on the power plant site, constant interaction between the coal jetty operator and the site in charge on land is required to ensure smooth operations, especially in periods of rough weather during the monsoon. The conveyor belt has to be maintained properly to ensure no accidents due to negligence happen. Plant area – coal jetty communications must be constantly maintained to ensure smooth operations of regular activities. The same communication system becomes vital in the case of any accident either on the plant site on the shore or the coal jetty site offshore. Either way, there may be need to shut down the plant or activate emergency systems. Communications to fire-fighters on land, the Coast Guard as well as ambulance services need to be maintained at all times. Suitable communication systems need to be installed for this.

Emergency contact details must be available with the Emergency Coordinator and Emergency Control Room. As mentioned in the previous section, it is essential for a hotline communication system to be installed in the coal jetty so that in case of an emergency, the mere pressing of a button would alert the emergency coordinator. In addition, in case there is an emergency on the land, the same should be communicated immediately to the personnel stationed on the coal jetty and they need to be advised on action to be taken by them. Communications with the meteorological department (IMD) should be constantly maintained to get regular updates on the weather as well as with INCOIS for other sea (wave) related information and with the nearest port (Thoothukudi) for other weather related warnings.

8.17 District level Emergency Committee

At the District Level, the apex body for disaster management is Chaired by the District Collector with the District Revenue Officer/Additional Collector as the Vice Chairman. The main function of the Committee is to coordinate the activities of various departments during

the time of emergency in the district. The collector acts as the nodal officer for disaster management coordination activities during the period of emergency. The emergency coordinator must liaise with the Collector and keep him/her informed of any accident/emergency situation, should the need arise. The emergency coordinator must also keep the telephone contact numbers of the following for immediate use in the case of emergency:

		Distance from plant
Police Station:		
Police Station is at Kulasekarapattinam	-	4 Km
Fire Station :		
Fire Station is at Tiruchendur	-	14 Km
Fire station proposed inside plant area		
Hospital Facility :		
The following hospitals are available in the area.		
Primary health Centre is available at Kulasekarapattinam	-	4 Km
Government General Hospital is available at Udangudi	-	8 Km
Government General Hospital is available at Tiruchendur	-	12 Km
Proposed dispensary at plant	-	-

Important Telephone Numbers:

Fire Station at Tiruchendur	-	04639-242301
Police Station at Kulasekarapattinam	-	04639-250286
Government General Hospital at Udangudi	-	04639-251110
Government General Hospital at Tiruchendur	-	04639-242242
Primary Health Centre at Kulasekarapattinam	-	04639-291897
District Magistrate Court at Thoothukudi	-	0461-2340600
State Pollution Control Board at Thoothukudi	-	0461-2341298

Coast Guard:

Coast Guard Headquarters, New Delhi

Telephone: : +91-11-23384934

FAX: +91-11-23383196

E-mail: vprotect@bol.net.in

Deputy Director General (Operations & Coastal Security)

Inspector General VSR Murthy, TM

Tel : +91-11-23387237

In the unforeseen event of any accidents happening on the jetty site, arrangements must be made by the jetty operator / power plant authorities for appropriate humanitarian arrangements. In addition, claims, as appropriate may be made based on the Public Liability Insurance Act and Rules as described in the following section.

8.18 Public Liability Insurance Act

The Public Liability Insurance Act of 1991 is an Act to provide for public liability insurance for the purpose of providing immediate relief to the persons affected by accidents occurring while handling any hazardous substances and for matters connected therewith or incidental thereto. Under this act every owner shall take out, before he starts handling any hazardous substance, one or more insurance policies providing for contracts of insurance whereby he is insured against liability to give relief under the following:

Where death or injury to any person (other than a workman) or damage to any property has resulted from an accident, the owner shall be liable to give such relief as is specified in the schedule for such death, injury or damage.

According to the Public Liability Insurance Rules, in the event of an accident, an application for claim for relief shall be made to the (District) Collector in Form I with appropriate documentation.

8.19 Public Information

It is advisable for a formal press release by the Emergency Coordinator in case of any accidents on site. This will help in controlling any spread of rumours and ensure that transparency in action is maintained. In the case of events such as oil spills or coal spills, the local fishing community must also be informed to enable them to assist in clean up operations if possible, and to avoid coming in contact with any materials of toxic nature.

8.20 Updating DMP

After every disaster/emergency, a detailed follow up including photographic documentation must be done. The important points from this report are to be used in updating the DMP and overcoming any deficiencies that have been noted/identified. The photographic documentation to be done with digital photographs helps in ensuring that the date of the

incident is embedded in the picture especially for insurance and other claims. The detailed photographs of damage will be required for repair purposes as well.

8.21 Maintenance plan

Approach Bridge

The Approach Trestle connects the Jetty with the land. It also serves as a supporting platform for the pipe-conveyor trestle and the vehicle carriageway. The width of the Approach Trestle is arrived as below:

Approach Dimensions

Thus the width of the approach trestle for Option-1 is fixed as follows:

Width for a single way movement	-	4.25m
Width for conveyor trestle	-	5.40m
Kerb	-	0.30m
Thus, **Total Width required**	**-**	**9.95m**

Approach Deck Level required Off-shore:

To facilitate the movement of Fishing Vessels under the Approach Bridge, a vertical clearance of **6m** from the Highest High Water Level has to be maintained. Thus the bottom of the deck structure for the bridge is fixed as below:

Highest High Water Level	-	(+) 1.026 m CD
Clearance required for fishing vessel passage	-	6.0 m
Thus, the Bottom level for Deck Structure	**-**	**(+) 7.026 m CD**
		Say (+) 7.25m

The bottom of the approach Bridge is fixed at (+) 7.25m CD. Thus the deck top for the Approach Bridge is fixed at **(+)9.0m CD.**

Since the Berth is at (+) 7m CD, the approach bridge will require a transition zone where the approach will have a slope in the longitudinal direction upto (+)9m CD. Hence from the Berth, the Approach takes off at a gradient of 1 in 100 along the direction of the vehicular movement, such that the Approach Deck reaches the level of (+)9m CD. From this point upto

the Shore line the Approach deck maintains the same deck level of (+)9m CD, which can provide uninterrupted access for Fishing vessel movement underneath.

Inspection

The Berth and Approach Bridge is the only connectivity for the Jetty with the shoreline Regular inspection and routine inspection is therefore, very essential to avoid any traffic bottlenecks due to temporary shutdown of the berth and Approach Bridge.

Inspecting Personnel/Officer

Status and Qualification of the Inspecting Officer:

A competent qualified Engineer not below the rank of an Executive Engineer shall inspect the Berth and Approach Bridge. He must be thoroughly familiar with design and construction features of the Berth and Approach Bridge to interpret properly what is observed and know what is to be reported. He must be able to recognise any structural deficiency, assess its seriousness and take appropriate action necessary to keep the Berth and Approach Bridge in safe condition. He must also recognise the areas of the Berth and Approach Bridge where a problem is incipient so that preventive maintenance can be properly programmed.

Seldom will one individual have experience sufficient to qualify him as an expert in the entire specialised field of Engineering, which are parts of Berth and Approach Bridge science. The individual should be aware of any limitation imposed by his lack of knowledge or experience in any area of the work. He should therefore never hesitate to utilise the specialised knowledge and skills of Associate Engineers in such fields, as Structural Design, Construction Materials, Maintenance, Electrical Equipment, Machinery, Hydrodynamic, Soil Technology or Emergency repairs.

Responsibility of the Inspecting Officer:

The Berth and Approach Bridge Inspecting Officer shall be responsible for the thoroughness of the field inspection, the analysis of all findings ascertained by the inspection and the subsequent recommendations for corrections of defects, posting for restricted load and/or speed, any other recommendations deemed necessary.

Co-ordinating Officer:

It is recommended that a single Officer should be nominated for co-ordinating the maintenance and inspection activities. All relevant documents, tools/tackles and accessories

should be in the custody of this officer. The co-ordinating officer should also arrange for the Inspecting Officer's visit and arrange for all the labour force and assistance that is to be provided to the Inspecting Officer.

Time Period/Frequency of Inspection

For maintenance of the Berth and Approach Bridge, regular and periodic inspection should be carried out for different elements of the Berth and Approach Bridge. In general three types of inspection are required to be carried out:

Routine regular inspections at close time intervals, say, every month

Periodic Detailed inspection at longer time intervals, twice in a year

Special or occasional inspection after special time events such as accidents, earthquake, and major weakness noticed during routine or detailed inspection, unusual settlement of foundations, substantial changes in traffic pattern, etc.

Type of Inspection

Routine Visual Inspection

The Berth and Approach Bridge should be inspected once a month from outside as well as from inside by the following different routes:

- By walking on the Carriageway on top of the deck to inspect the top portion of the deck, crash barrier, kerb, central verge, expansion joint, wearing coat, etc. This inspection will be very useful and can be carried out easily. Visual inspection is not just looking for a more overview but should be detailed and should include noting down any structural cracks more than 0.3 mm width and any signs of deterioration and distress.
- By walking around each pier and examining the pier cap, pedestals and bearing for any deficiencies.

Detailed Visual Inspection

This inspection may be carried out twice a year. On this the external surface of the superstructure should be inspected from below using powerful binoculars. The observations made during earlier routine inspections shall be taken a benchmark for detailed inspections. Close inspection of each compartment of the Berth and Approach Bridge both by visual aids and by special instruments in case of distress is observed if necessary.

The following table (

Tabl) of frequency needs to be followed for carrying out routine inspection of the various elements of bridge.

Table: Frequency of Inspection

Sl. No.	Description	Routine inspection in months	Detailed Inspection in Months
1	Inspection of Concrete Surfaces		
a)	Superstructure	1 Month	6 months
b)	Substructure (Pile)	1 Month	6 months
c)	Substructure (Pile cap)	1 Month	6 months
d)	Crash Barrier and Central Verge	1 Month	6 months
2	Drainage Spout	1 Month	6 months
3	Bearing and Bearing Pedestals	1 Month	6 months
4	Expansion Joints	1 Month	6 months
5	Wearing Course	1 Month	6 months
6	Review of Observations	1 Month	6 months

Special

This shall be undertaken in the event of unusual occurrences such as strong earthquake, accidents, and passage of unusual loads, major weakness not found during routine or preliminary inspection, unusual settlement of foundations and substantial changes in traffic pattern.

Inspection procedure and Report

The inspection procedure shall be as per the guidelines for inspection and maintenance of Bridges as per IRC SP-35. Forms as given in annexure shall be used.

Checks to be made while inspecting various Berth and Approach Bridge components

Wearing coat

- To be checked for cracks, spalling, disintegration, potholes, streaking, deformation, corrugation, showing, shallow depression, stripping, widening of gap between joints.
- Check for patches of different colours and cracks.
- Check for riding quality at expansion joints.

Superstructure

- Inspect for cracks, spalls, scaling, disintegration, honeycombing, exposed reinforcement, corrosion or reinforcement, leaching, excessive vibrations, exclusive deflection.
- Sound concrete with a Mason's hammer to detect de lamination or deterioration hollow sound or dull thud is a warning signal
- Check elements for diagonal cracks especially at their supports.
- Note any spalls and indicate size and depth of spalling, if anywhere reinforcement steel is exposed.
- Note the cracks of width especially, which are wider than 0.2mm.
- Check whether the drains are open and functioning properly.
- Check damages if any due to moving of the vehicles.
- Check interior faces of flanges and webs for cracking, excessive accumulation of water and debris.

Pre-stressed concrete members

- The Pre-stressed concrete members shall be examined for excessive spalling disintegration, honey combing, exposed reinforcement, reinforcement corrosion, deflection, distress due to bucking, cracking and deterioration of concrete, cracking or spalling in the area around the bearings and at cast in place diaphragms where creep and humping of the girders may have an effect must be looked for.
- Where cracking is found, location and size shall be noted and tell-tales installed to watch their future development.
- The end anchorages shall be examined for water tightness and corrosion of pre-stressing bars.
- Blister and Guide cone should be in proper shape and size.

Care to be taken

- All joints should be checked in the interval of six months. If any joint is open it should be filled with epoxy.
- Inside the segments sealing of tendon should be checked.
- Checking of guide cone and blister should be carried out in every six months.
- Water stagnation should not be there.

Pedestals

- Check for cracks, spalls scales or stains, deformation, exposed reinforcement, reinforcement corrosion.
- Check for position of Centreline of bearing with respect to the centreline of pedestals in both directions.

Bearings

- Check whether there is smooth movement of sliding bearing or not.
- Check for any damage to the bearings.
- Check for rusting, cleanliness, seizing of plates, silting, peeling off of epoxy paint etc.
- Check if there is any excessive movement, tilting, jumping of guides and undue rotation of bearings.
- Check for any damage by miscreants.

Expansion Joints

- Check if the joints are free of stones and any other debris.
- Check for cracks/fissures, splitting, oxidation, creep, flattening
- Check for freedom of movement existence of normal gap, excessive noise etc..
- Check for water tightness and any other stains of water leakage under the deck slab.
- Check for alignment and clearance.
- Check for any cracks in the Deck slab adjacent to the joints.
- Check for any damage by miscreants.
- Check for seal

Piles

- Check for verticality by Plumb Bob any deviation may indicate uneven settlement of foundations.
- Inspection for cracks, spalls, scaling or stains, tilting, disintegration, decay etc.

Pile Cap

- Inspection for cracks, spalls, scaling or stains, tilting, disintegration etc.

Crash Barrier

- The RCC crash Barrier shall be inspected for cracks, spalling, scaling, deterioration in the concrete and any damage due to traffic.
- Examination shall also be made of the reinforcement in areas where they are exposed due to damage or spalling of the concrete. Often rust stains on the concrete are indicative of corrosive action on the steel inside the concrete and shall be noted.

Road Kerbs

- Check the impact damage and misalignment.
- Check for cracks, spalls, scales and disintegration.

Central Verge

- Check for impact damage and misalignment
- Check for adequacy of Central Verge
- Check for cracks, spalls, scales and disintegration

Drain Spout

- Observe whether flow of water within the drain spout is smooth.
- Check for Blockage of drain due to debris
- Check for possible failure of drain spout.
- Check for deterioration and damage

Approach Slab

- Check settlement, cracks and movements etc.

Follow up action

This Berth and Approach Bridge is to be maintained as per the maintenance manual. Any minor points or shortcomings noticed during inspection shall be immediately attended to. In case of any important or major shortcomings/distress noticed either during routine inspection or detailed visual inspection, the matter shall be reported to the higher authority to decide further line of action.

Remedial Measures

In this section general details of the various possible remedial measures available for the various components of the Berth and Approach Bridge are given. It is recommended that for any serious distress observed, a proper agency should be appointed UPCL to determine the causes of the distress and to recommend suitable remedial measures. It is suggested that the following table (

Table) need to be followed for taking up regular maintenance as per the frequency listed therein.

Replacement of Bearings

For replacement of bearings the following procedure shall be adopted:

- The frequency of maintenance shall be as per
- Table.
- The area for placement of jack will be adjacent to the Bearing Pedestal.
- The jacks shall be lifted up to a maximum height of 6mm so that the bearings can be removed. The above restriction is for jacking at a single pier only. In case it is necessary to jack the superstructure more, the same shall be achieved by maintaining a differential lift or not more than 6 mm between two adjacent piers, i.e. jacking up shall be carried out at the adjacent piers too to achieve the maximum differential lift of 6 mm.

- For pulling out the bearing, the bond between the top plate of bearing and the bottom of the End diaphragm shall be broken. The bearing shall be removed out by pulling it out of its position. Ratchet type pulling device may be used if required.
- The old epoxy mortar shall be removed if necessary along with the bolt, from top of the pedestal by breaking and the surface shall be properly levelled by means of a carborandum stone.
- The bolt shall be replaced and properly secured to the pedestal/End diaphragm bottom by means of a suitable Epoxy Mortar. When the bolts are secured properly, the top and bottom plates of the bearing shall be placed. The bolts shall be properly grouted with a good epoxy mortar.
- The jacks shall be lowered once the mortar sets.

Maintenance of Drainage Spout

- Prior to every monsoon, the drainage spout shall be cleaned properly so that water logging on the deck can be avoided.
- During the rainy season, the drain spout shall be inspected every week and if necessary cleaning of debris shall be carried out.
- If water gets logged inside the expansion joint, it shall be removed every alternate day else there are chances of deterioration of the same.

Table: Guidelines for frequency of maintenance & remedial measures

1	Cleaning Road surface of all soil, debris, pebbles and metal pieces if any	Continuous process on daily basis
2	Cleaning Expansion joints off any pebbles	Every month or as and when required
3	Cleaning of drainage spout	Every three months and frequency during monsoon or as and when required
4	Cleaning Road surface of all soil, debris, pebbles and metal pieces if any	Continuous process on daily basis
5	Removing nests if any on the structure	Continuous process on daily basis
6	Replacing of expansion Joint	As and when required
7	Bituminous work	
	(g) Repairing of pot holes	Every month or as and when required
	(h) Relaying of layer	After 4 to 5 years for improvement of ridership quality

	(i) Micro seal (Slurry seal)	
8	Cleaning inside deck	
	(g) Box portion	Stagnated water quarterly, Daily after rains
	(h) Vent holes	
	(i) Electrical lights	

CONCLUSION

The proposed 2x800 MW Coal based Thermal Power Plant at Udangudi, of UPCL, would be an eco friendly unit as the plant as well as coal jetty, coal conveyor , cooling water intake and outfall arrangements in sea are designed to meet the norms of MoEF and CPCB for environmental protection. The project would lead to provision of infrastructural facilities, increase in job opportunities and overall, will lead to the socio economic upliftment of the people residing in that area. The project will have minimum impact on the flora and fauna as the study area is devoid of any natural forest reserve.

Modelling study for the intake and outfall of cooling water system for super critical thermal power project at Udangudi, Tuticorin Dist., Tamil Nadu

Sponsored by
Udangudi Power Corporation Limited, Chennai

August 2009

National Institute of Oceanography
(Council of Scientific & Industrial Research)
Dona Paula - 403 004
Goa

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PROJECT TEAM

MT Babu	Project Leader
P Vethamony	
V Sanil Kumar	
K Sudheesh	
R Manimurali	
PS Pednekar	
Siddharth Ghatkar	
R Rashmi	
Jyoti Khalap	

EXECUTIVE SUMMARY

- M/s Udangudi Power Corporation Ltd, (UPCL) Chennai, Ltd., is planning to develop a power project to generate 2x800 MW power at Udangudi in Tuticorin Dist., Tamil Nadu. This project proposes to draw sea water for cooling purpose and the warm water from the cooling plant will be discharged into a suitable location off Udangudi. M/s UPCL approached NIO to identify a suitable location off Udangudi for installing the marine outfall and intake facilities. Accordingly, NIO has taken up this project.
- This report describes the hydrodynamics, temperature and salinity of the coastal waters off Udangudi. The field data available for the region has been used to setup the numerical model for simulating hydrodynamics and dispersion of thermal and saline plumes.
- The currents observed off Tuticorin and Kulasekarapattinam exhibited northeastward and southwestward directions, alternating with tidal reversals. A maximum speed of 0.27 m/s was observed during the measurement period.
- Surface elevations at Tuticorin and Kulasekarapattinam have been predicted using the four major constituents M2, S2, K1 and O1, available for the tide gauge stations at Tuticorin and Kulasekarapattinam. The maximum water level obtained during spring tide is 1.19m.
- MIKE21 Model has been used to simulate water levels, currents and thermal plume dispersion off Udangudi during September 2008. Model validation experiments showed that surface elevations are in good agreement with the tides predicted for Udangudi and the components of currents showed good agreement with the measured values.
- Three experimental locations were tested for fixing the outfall positions: outfall-1 is located at 250m offshore, outfall-2 is at 360m offshore and outfall-3 is 1060, respectively at depths of 3.80m, 3.90m and 5. 0m below CD. Based on model results it is recommended that outfall-3 is suitable for warm water discharge and the intake-2 located off 2050m from the shore line is suitable for drawing sea water.

- The intake pipeline corridor extends to the sea 2050m off the coastline. The intake and outfall pipeline will travel offshore along the sea bed. Though the discharge temperature will be nearly the same as the ambient sea water temperature, as an extreme case an outfall temperature of +5°C above ambient temperature is considered with a source salinity of 50 psu and maximum flow rate of 13,500 m^3/h for model studies.
- Under the prevailing currents, the advection of warm water released from the proposed outfall-3 is southwestwards and northeastwards, parallel to the shoreline, associated with reversing tidal currents and it did not exhibit any recirculation towards the intake-2 location.
- Model results indicate that impact of high saline, warm water released into the coastal sea is very negligible as the net excess temperature at the outfall-3 is 1.46°C and excess salinity 4.82 psu. The warm and high salinity waters are confined to a radial distance of 200 m from the discharge location and there will not be any change in the water quality in the coastal environment.
- No recirculation of warm water has been noticed during spring tide, neap tide, calm period, and northeastward current or southwestward current except minor advection of saline waters (+2 PSU) for brief periods during spring tide.

1 Introduction

1.1 Background

M/s Udangudi Power Corporation Limited (UPCL), Chennai, is planning to develop 2X800 MW coal-based super critical thermal power plant at Udangudi in Tuticorin Dist., Tamil Nadu. It is a joint venture project of Tamil Nadu Electricity Board (TNEB) and Bharat Heavy Electricals Limited (BHEL). The project proposes to have a cooling plant for which sea water will be drawn from an offshore location using an intake pipeline. The warm water from the cooling plant will be discharged into the coastal sea at a suitable depth off Udangudi coast. M/s Udangudi Power Corporation Limited approached NIO to identify suitable locations off Udangudi for installing the marine outfall and intake facilities. Accordingly, NIO has taken up this project to find out whether (i) there would be sufficient dilution of thermal and effluent discharges near the discharge region and (ii) any possibility of recirculation of the discharged warm water around the intake point. We have used the marine environmental data available for the Tuticorin coastal region as well as the bathymetry survey data of the intake-outfall corridor provided by M/s UPCL to setup the model domain and grid file required for mathematical modelling of the region.

1.2 Objectives

The objectives of the study are as follows:

a) to find out a suitable location for placing a marine outfall in order to facilitate the release of warm and high saline water into the coastal sea off Udangudi, Tuticorin.
b) to find out a suitable location for placing the marine intake point in such a way that there is no recirculation from the outfall towards intake point.

1.3 Scope of work

i. Compilation of available oceanographic data on physical characteristics of the coastal waters off Udangudi, pertaining to this project at specified locations between Tuticorin and Kulasekarapattinam.
ii. Identification of a suitable location for the proposed outfall.
iii. Modelling study includes the following components:

a) Flow modelling – numerical simulation of the flow patterns in the project area over a horizontal grid covering over 10 Km^2 to generate currents in the study area
b) Thermal plume modelling –simulation of thermal plume around the proposed outfall location
c) Saline plume modeling – simulation of saline plume around the proposed outfall location

d) Optimization of the outfall distance from the coast and from the intake location using recirculation studies

The study envisages conducting numerical experiments to decide the distance between the outfall and intake locations in such a way that the warm water gets dispersed within a reasonable distance from the outfall location and no recirculation takes place at the intake location.

2 Physical aspects of coastal waters

Detailed site-specific information on physical characteristics of the prevailing marine environment is a pre-requisite to set up marine facilities such as sea water intake and outfall and to study recirculation, if any. The field data collected off Tuticorin during September 2008, covering both spring and neap phases of the tide have been used in the study for estimating the currents prevailing in the region during calm season of the year. Calm season is specifically selected to study the dispersion of the warm/saline water discharge because of less advection/dispersion rates and maximum impact on coastal waters. The area of study and locations of marine facilities are shown in Fig.1a & 1b.

2.1 Predicted tides

Surface elevations at Kulasekarapattinam and Tuticorin have been predicted using the harmonic constituents available for these tide gauge stations. The surface elevations have been predicted using the four major constituents M2, S2, K1 and O1 for September 2008.

These predicted tides are applied to run the large scale model to simulate hydrodynamics of the coastal region, lying between Kulasekarapattinam (located to the south of Udangudi) and Tuticorin, Fig. 1a. The surface elevations required at the offshore boundaries of the high-resolution domain (Fig. 1b) were extracted from the model results of the large model domain and these surface elevations are applied to drive the high resolution model. The water level variations prescribed along the southern and northern boundary of the model are given in Fig. 2.

2.2 Bathymetry

Hydrographic survey data supplied by M/s UPCL has been used to prepare bathymetry grid required for modelling the hydrodynamics and temperature-salinity plumes. The bathymetry data required for the model has been obtained from the NHO hydrographic charts (Naval Hydrographic Office, Dehra Dun) and C-MAP hydrographic charts. The depth contours given in these hydrographic charts, are digitized and the digital bathymetry maps are prepared in UTM coordinates. Later, this bathymetry has been updated with C-MAP hydrographic charts (DHI, Denmark) and survey data supplied by UPCL. For setting up the model, measured bathymetry of the study area, initial and boundary conditions of water level variations in the model domain and at the boundaries have been used. Atmospheric parameters such as wind speed, wind direction, air temperature and humidity are needed to estimate the heat flux. Initial and boundary temperature conditions, source and sink characteristics and locations, discharge properties (quantity, flow rate, temperature), heat dissipation, decay and heat exchange are also provided as input parameters.

2.3 Model domain and input parameters

In order to simulate currents off Tuticorin – Kulasekarapattinam coastal region, MIKE21 nested hydrodynamic model was set up using tidal elevations along the open boundaries. MIKE21 modelling software has been applied in EIA projects related to industrial and tourism development activities in the coastal waters and to deduce conclusions, which are helpful for sustainable planning development of the marine and coastal environment. MIKE21 NHD Flow model is a 2-D, hydrodynamic (HD) modeling system used for the simulation of currents, water level variations, water quality, temperature-salinity fields and sediment transport in lakes, estuaries, bays, coastal areas and seas. Specific modules used in the present study are the nested hydrodynamics (NHD) module and Advection-Dispersion module (AD). HD results form the basic requirement to run all other modules as the hydrodynamic properties of the system influence all other processes in the marine environment. MIKE21 can accommodate high-resolution grid for simulation of water level variations, currents and all other related parameters. It solves 2-dimensional shallow water momentum and continuity equations on a vertically integrated and incompressible mode. The vertical acceleration of the flow is assumed to be much smaller than the pressure gradient.

A large scale model was used to simulate currents and water level variations between Kulasekarapattinam and Tuticorin. The NHD large scale model with 150m x 150 m square grid is used to simulate water level variation and currents present in the study area. Further, a Cartesian coordinate system is used in the model with high resolution grid (50m x 50m) to accommodate the proposed intake and outfall system. Both the model domains were used for simulation. The large scale model domain used for simulation is given in Fig. 1a.

Case – 1 : ***Larger model domain***

The nearest coastal tidal stations, situated to the south and north of this domain are Kulasekarapattinam and Tuticorin, respectively. These tidal stations are separated by a distance of ~49 km; this large area (30 X 49 sq. km) was divided into 150 x 150 m grids. The depth values have been interpolated to provide at the grid points. A Cartesian coordinate system has been selected with x-axis = 30 km and y-axis = 49 km, thereby dividing the model domain into 200 X 325 square grids ($\Delta x = \Delta y = 150$m). The offshore boundary extends upto 28.65 km along the south and 17.85 km along the north. The model domain has a maximum depth of 23.5 m.

Case -2: High resolution model domain

The inner model domain includes the study area, off Udangudi with high resolution bathymetry grid of 50m x 50m. The model domain includes an area of ~16.20 X 10.40 sq. km, and it has been selected in such a way that the proposed landfall, outfall and intake points are located in the central part of the model domain. A Cartesian coordinate system has been selected with x-axis = 16.20 km and y-axis = 10.40 km, thereby dividing the model domain into 325 X 215 square grids ($\Delta x = \Delta y = 50$ m). The offshore boundary extends

up to 15.5 km along the south and 8.5 km along the north. The model domain has a maximum depth of 19.95 m. The model domain and the bathymetry are shown in Fig.1b.

In addition to the surface elevations, wind data available for the region also have been used to drive the model hydrodynamics. Surface elevations at Kulasekarapattinam (78° 3′ E: 08° 24′N) in the south and Tuticorin (78° 10′ E: 08° 48′ N) in the north have been predicted using the harmonic constituents available for these tide gauge stations and using these values the tides along the open boundary are generated for the period 18 September – 3 October 2008. MIKE21 toolbox utilities are used for predicting the surface elevations from major constituents such as M2, S2, K1 and O1 at these coastal tidal stations. The variations of predicted water levels at Kulasekarapattinam and Tuticorin are given in Fig. 2 and the maximum and minimum of predicted water levels in Table1. The tide elevations required along the open eastern model boundary are interpolated and used to drive the model. The model was run for a period of 15 days. From these results, surface elevation and velocity components have been generated.

Table 1. Maximum and minimum values of predicted water levels at Kulasekarapattinam and Tuticorin for during September

Station	Water level (m) for September 2008	
	Min	Max
Tuticorin	0.26	1.19
Kulasekarapattinam	0.22	1.10

Table 2. Maximum and minimum values of measured and model simulated water level variations during 18 September – 3 October 2008

Type of data	Water level (m)	
	Min	Max
Measured	0.14	1.16
modelled	0.27	1.18

3 Results

3.1 Model validation

The model runs made for the period 18 September – 3 October 2008 have been used for the validation of surface elevation and velocity components.

3.1.1 Tides

A comparison between measured and model simulated tides is given in Fig. 3. The measured and model simulated tide elevations vary from 0.14 to 1.16m, and 0.27 to 1.18m respectively during 18 September – 3 October 2008. Measured and model simulated high and low water levels are given in Table 2. The model results show good agreement with the measurements.

3.1.2 Currents

In order to understand the zonal and meridional component of the currents in the Gulf of Mannar, the measured currents were resolved into U (east-west) and V (north-south) components. Comparison between measured and model simulated current velocity components and current speed is given in Figs. 4 & 5. The maximum and minimum of east-west (U) and north-south (V) velocity components and current speed of measured and model are given in Table 3.

Measured currents off Tuticorin have been used for validation of the modelled currents. The measured and model simulated maximum current speeds are 0.26 and 0.27 m/s. The measured U and V velocity components vary from -0.15 to 0.21 m/s and -0.14 to 0.20 m/s. The corresponding model values are in the range of -0.26 to 0.13 m/s and -0.14 to 0.14 m/s. The comparison shows that model predicted values match very well with the measured values. This gives the confidence to use these hydrodynamic model results further for thermal and saline plume modeling.

Results obtained from the model results show reversal of currents associated with the tides. Typical flood currents present at 0000 h on 24 September 2008 is shown in Fig. 6 and typical ebb currents at 0300 h on 30 September is shown in Fig. 7.

Table 3. Comparison between measured and modeled velocity components during 18 September – 3 October 2008.

Parameter	Measured (m)		Modelled (m)	
	Min	Max	Min	Max
U-Component	-0.15	0.21	-0.26	0.13
V-Component	-0.14	0.20	-0.14	0.14
Speed	0.00	0.26	0.00	0.27

Table 4. Details of discharge quantity and locations of outfall/intake points

	Discharge/intake Quantity (m^3/h)	Location Lat/Long	Distance from shore	Depth (m) -CD
Outfall-1	13,500	8° 26.28'N 78° 4.85'E	250m	-3.80
Outfall-2	13,500	8° 26.22'N 78° 4.88'E	360m	-3.90
Outfall-3	13,500	8° 25.95'N 78° 5.157'E	1060m	-5.00
Intake-1	21,000	8° 25.70'N 78° 5.43'E	1600m	-5.40
Intake-2	21,000	8° 25.548'N 78° 5.511'E	2050 m	-5.40

3.2 Simulation of Thermal and saline plume.

MIKE 21 Hydrodynamic model (HD) has been used to study the circulation of sea water discharged into coastal waters off Udangudi. Three experimental outfall locations have been tested. Outfall-1 is placed at a depth of -3.80m, outfall-2 3.90m and Outfall-3 is 5.0m. These locations are respectively located at 250m, 360m and 1060 m offshore. The intake point-1 is at 5.40m below CD, located 1600m offshore and intake-2 below -5.40 m located at 2050 m from the landfall point. The locations of intake and outfall points are shown in Fig.1b and details of intake, effluent quantities and position coordinates are given in Table 4.

MIKE21 advection-dispersion (AD) has been used to simulate temperature of the warm water discharge at the outfall location. Though the temperature of the discharged water will be almost same as the ambient seawater temperature, an extreme case scenario has been modelled keeping the source temperature 33.5^0C, .i.e 5^oC above the ambient temperature of 28.5ºC. Keeping these conditions, thermal plume simulation experiments have been carried out to simulate the plume advection-dispersion pattern for outfall locations, i.e outfall-1 and outfall-2. The thermal plume dispersion pattern obtained at the outfall-3 during neap and spring currents are shown in Figs. 8a and 9a. An average increase of 2.4°C is noticeable in temperature at the outfall-1, 1.96°C at outfall-2 and 1.46°C at outfall-3. Under the prevailing currents, the plume exhibited a net northeastward advection and the maximum temperature increase is confined to an area of ~200 sq.m around the outfall. The temperature variation

around the both the intake-1 and intake-2 are shown in Fig. 8c and the salinity variations are shown in Fig 9c.

Salinity plume has been modeled assuming a source salinity of 50.0 psu. The ambient salinity measured off Tuticorin is 34.0 psu. Model runs have been carried out and the plume patterns obtained during neap and spring currents, and maximum salinity events are shown in Figs. 8b & 9b. An average increase of 8.6 psu is seen in the salinity at outfall-1 and 6.6 psu at outfall-2. However at outfall-3 , due to more dilution, the mean excess salinity reduced to 4.82 psu and mean excess temperature to 1.46°C. The results showed that both the plumes plume exhibited a net northeastward or southwestward advection under the northeasterly or southwesterly currents respectively. Therefore, outfall-3 is suitable for warm water release as the plume is away from the shoreline and there is no recirculation towards the intake point-2 located at 2050 m from the shoreline.

4. Summary and conclusions

The outfall/intake pipeline corridor considered for this study extends to the sea upto 2050m offshore, normal to the coastline. The pipeline will traverse offshore along the sea bed and the impacts, if any, will be associated with laying of the pipelines onshore and offshore areas only. Though the temperature of the discharge will be nearly the same as the ambient sea water temperature, as an extreme case an outfall temperature of +5°C above ambient

temperature is considered with a source salinity of 50 psu with maximum flow rate of 13,500 m^3/h.

Model results indicate that the water released into the sea exhibited an excess temperature of 1.46ºC and an excess salinity of 4.82 psu around outfall-3. The high salinity and temperature fields are confined to an area of 200 sq.m around the outfall and the spreading and advection of the warm, high saline plume is in northeast-southwest direction, parallel to the coastline. When the warm, high saline water is released at outfall-1, the model results indicate that there is a possibility of the discharge come within the reach of the shoreline. This can be avoided by choosing the location at outfall-3. The warm/saline water discharge attained higher dilution at outfall-3 which is reflected in lowering of ex temperature

Model results suggest that there is no re-circulation of warm water discharged from the outfall area into the intake point during spring tide, neap tide or calm period and high salinity and high temperature events. As the influence of warm/saline water is confined to a very small region, there will not be any change in the water quality in the coastal environment in the vicinity of the outfall.

Therefore, the outfall-3 location situated at 1060m from the shore is recommended for discharge of the warm water. The intake point (intake-2) located at 2050m from the coast would be suitable, as there is no recirculation of the warm water from outfall-3 towards this point and also this location has sufficient water depth of 5.4m.

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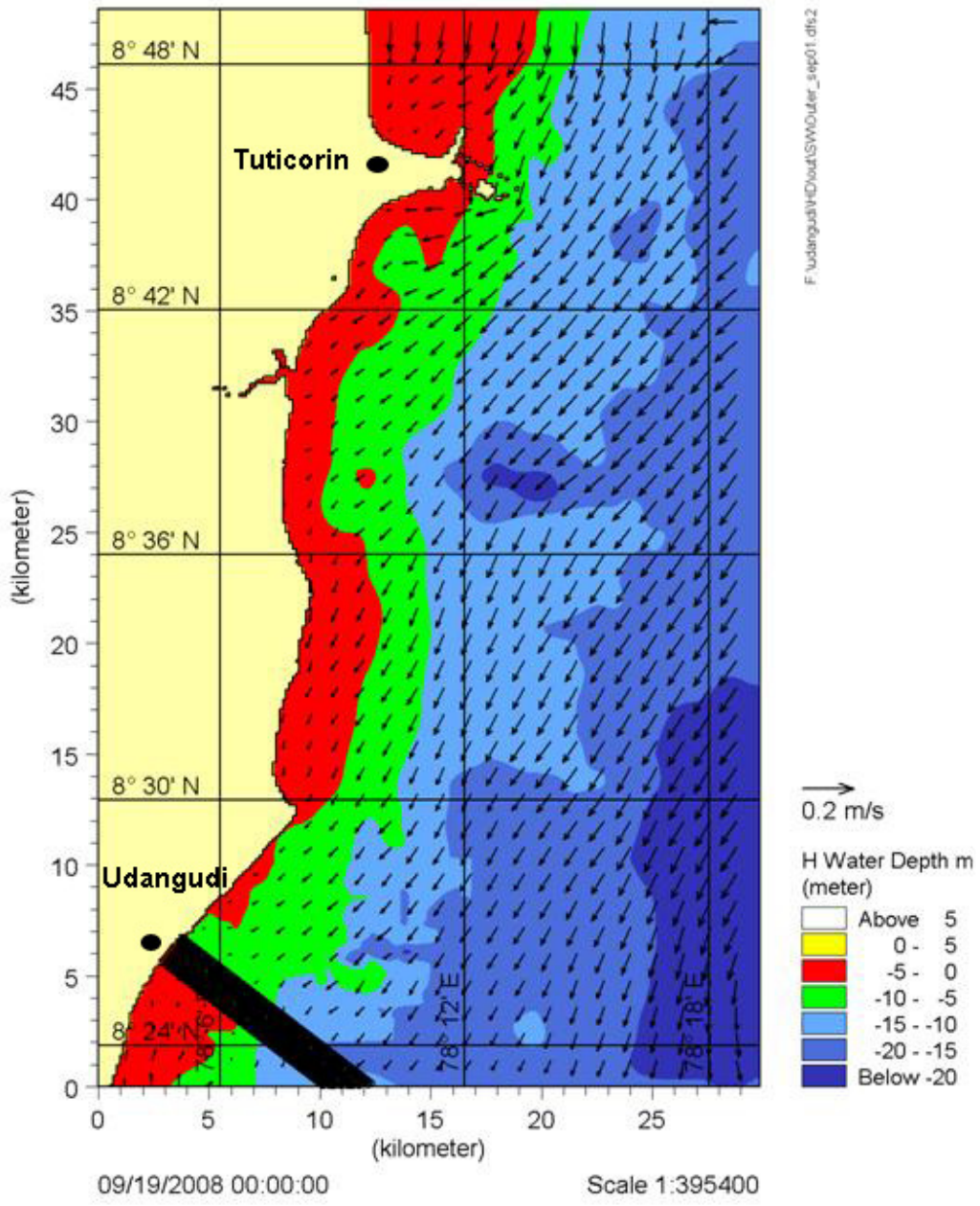


Fig.1a. Large Model domain with depth contours and typical current pattern between Tuticorin (in the north) and Kulasekarapattinam lying along the southern boundary. (Tracks indicate the lines of bathymetry survey conducted off Udangudi)

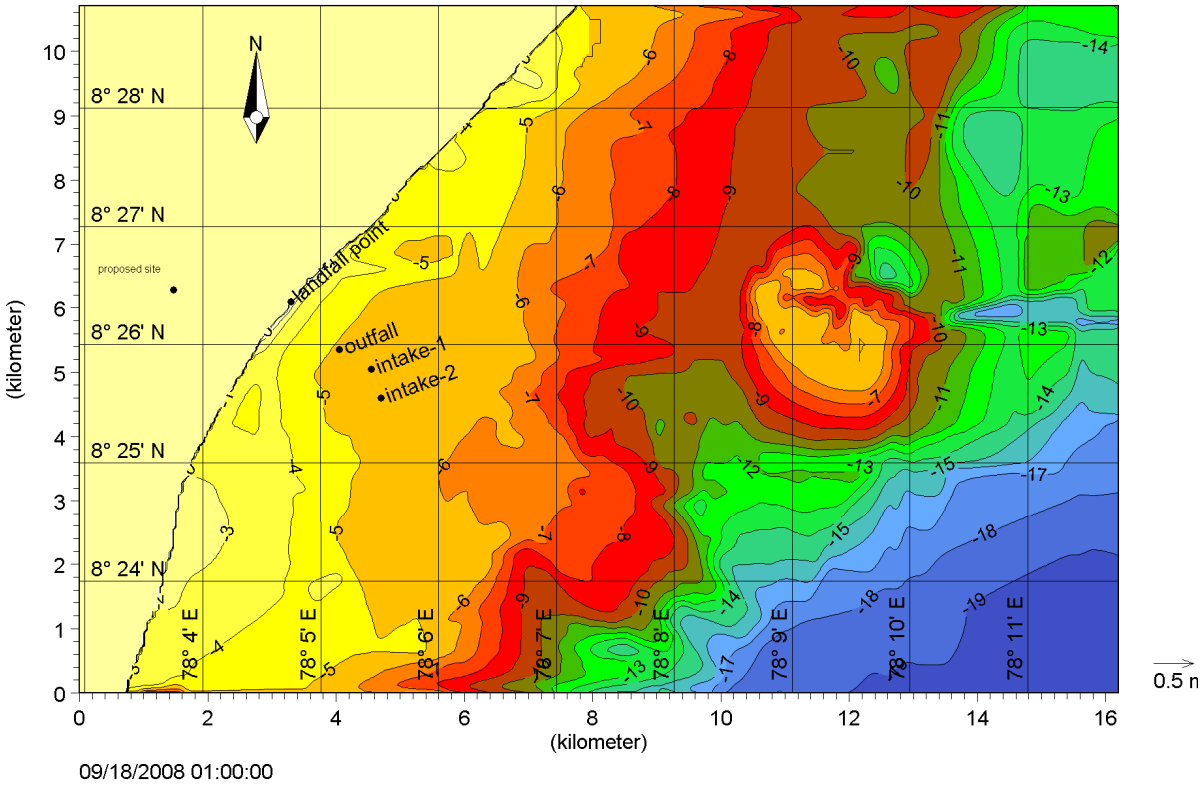


Fig.1b. Proposed Udangudi Power Corporation Ltd (UPCL) project site and outfall-intake locations.

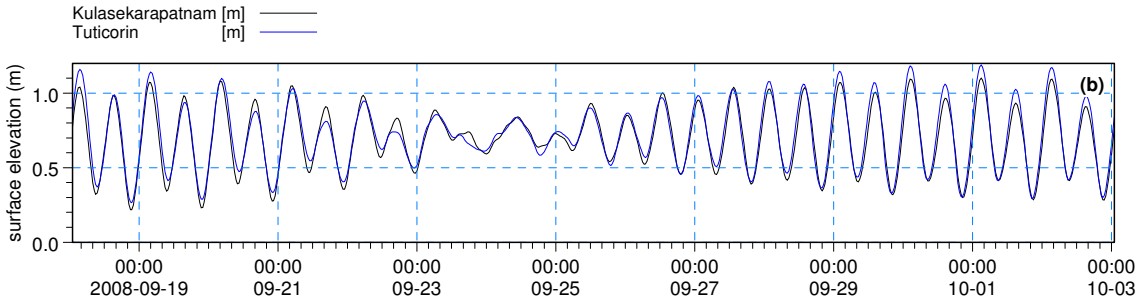


Fig. 2. Input tides applied at the open boundaries (Kulasekarapattinam and Tuticorin) during September 2008.

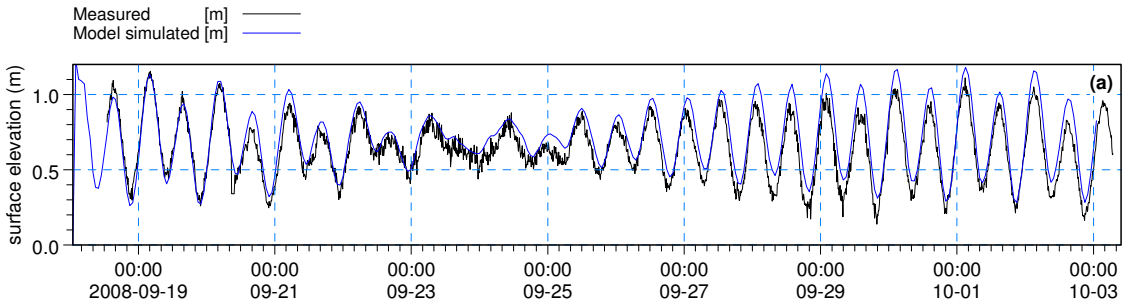


Fig. 3. Comparison between measured tides and model simulated tides at Tuticorin.

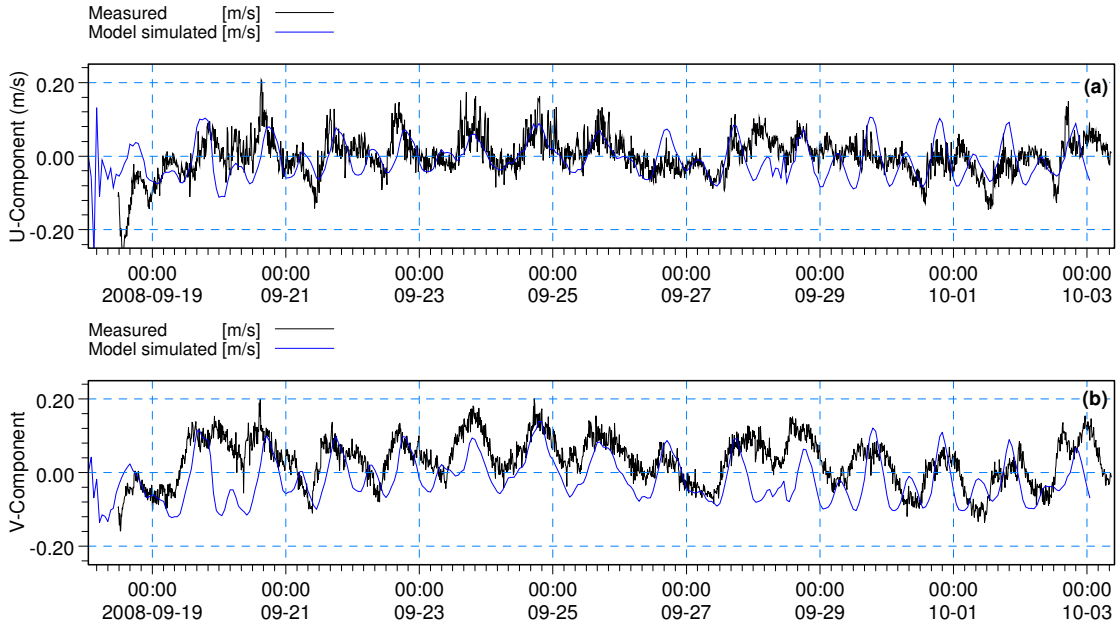


Fig. 4. Comparison between measured and model simulated (a) crossshore and (b) alongshore current velocity components off Tuticorin

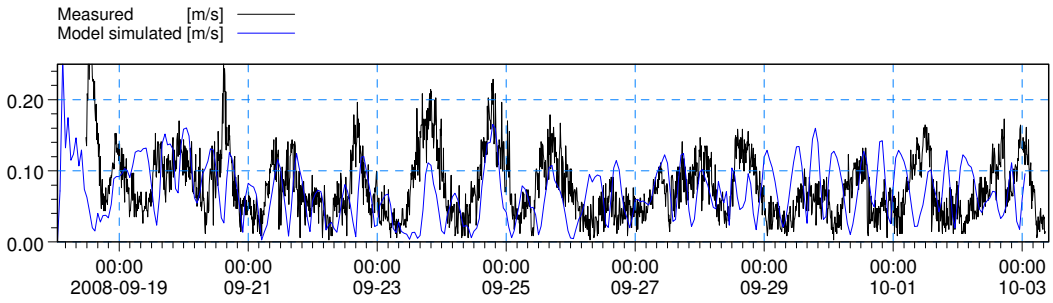


Fig. 5. Comparison between measured and model simulated current speeds off Tuticorin

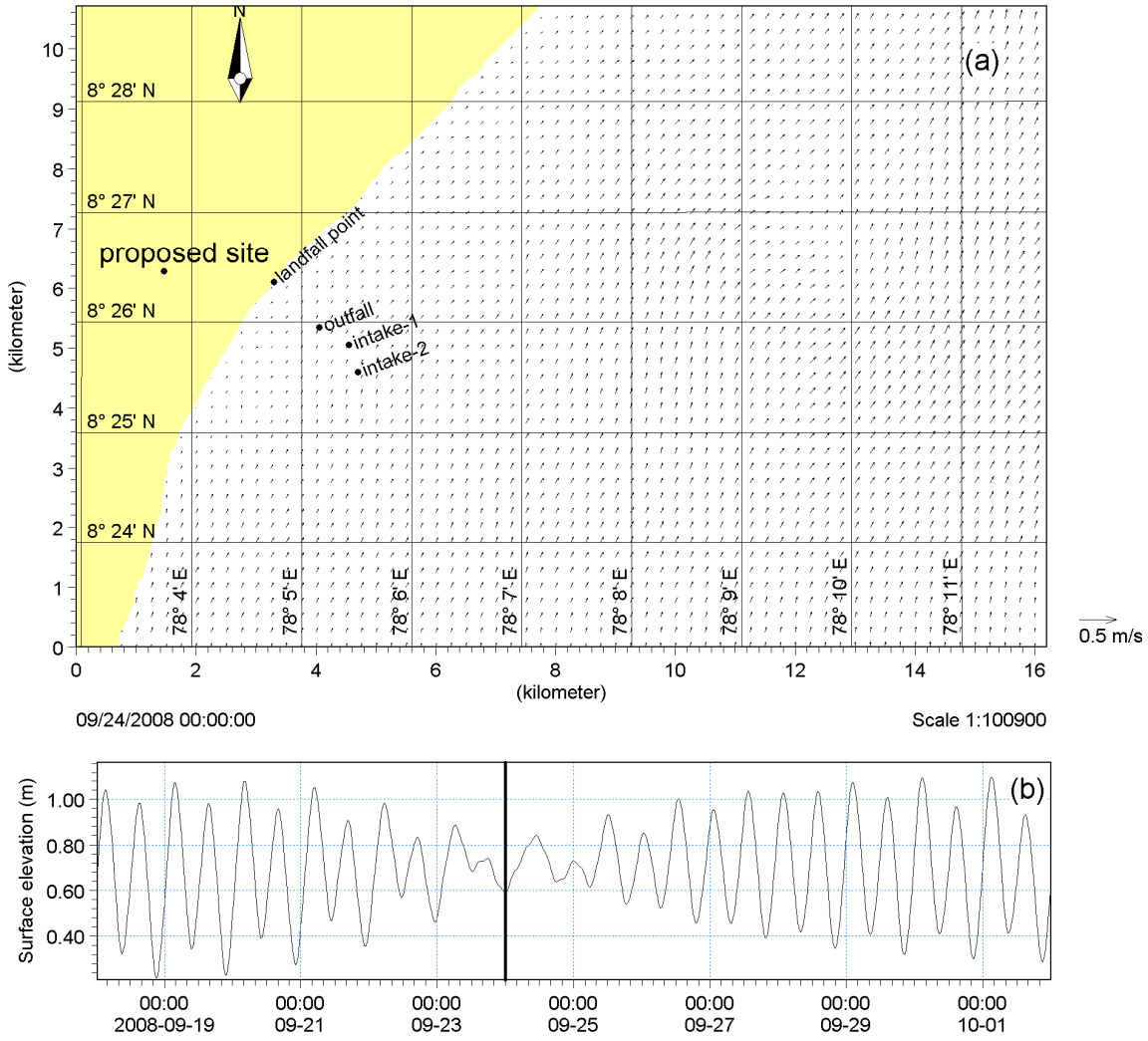


Fig. 6 (a) Typical current pattern during neap tide and (b) surface elevation off Udangudi.

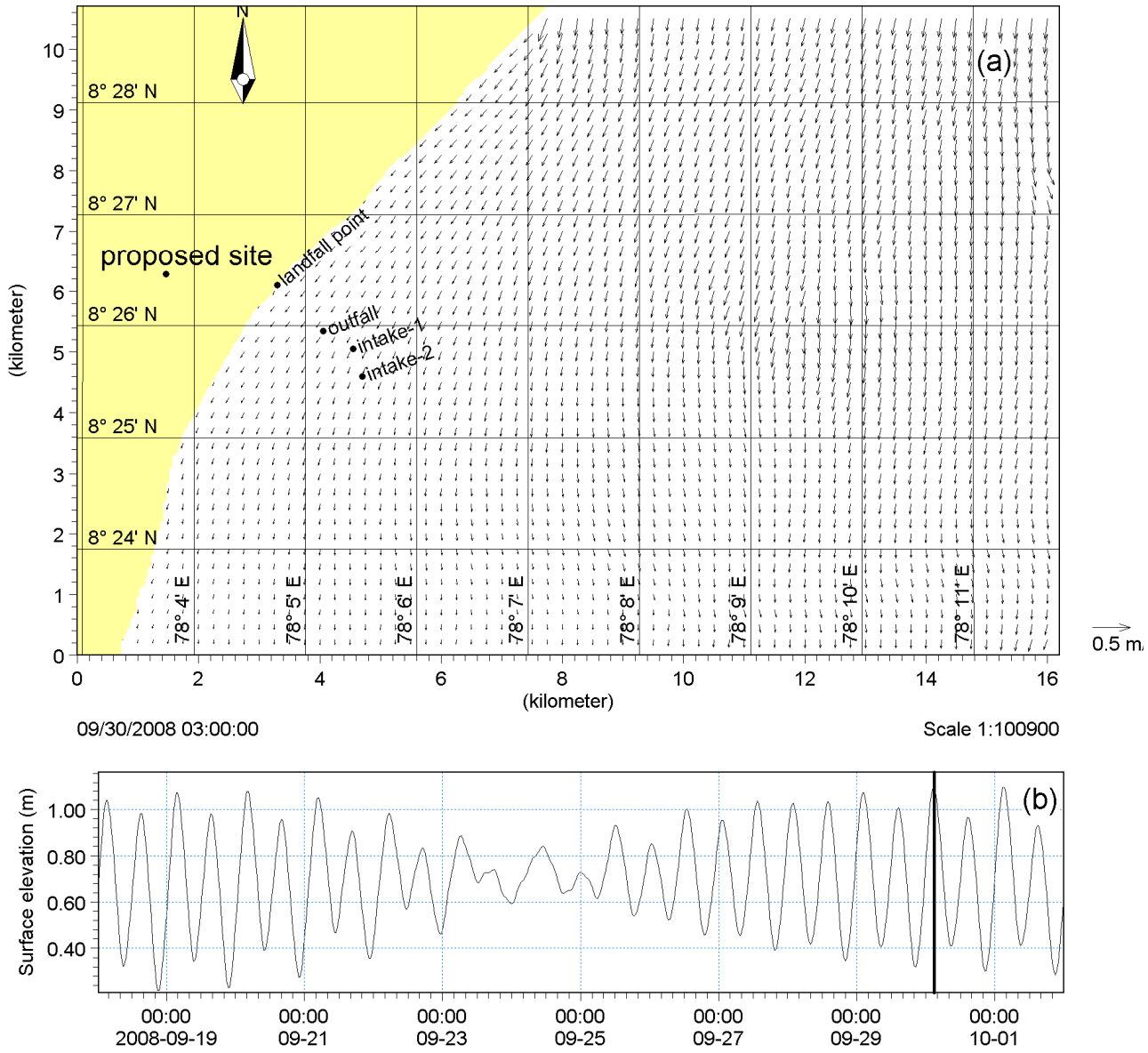
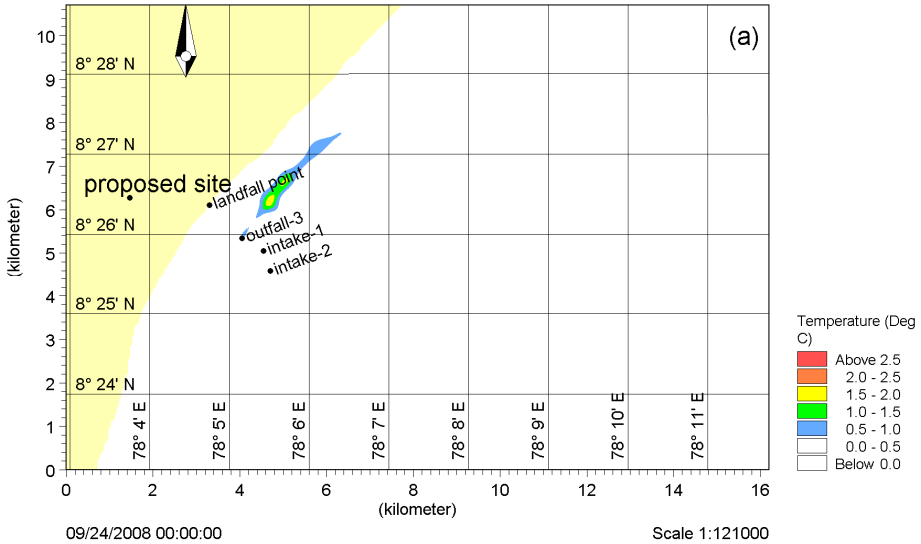
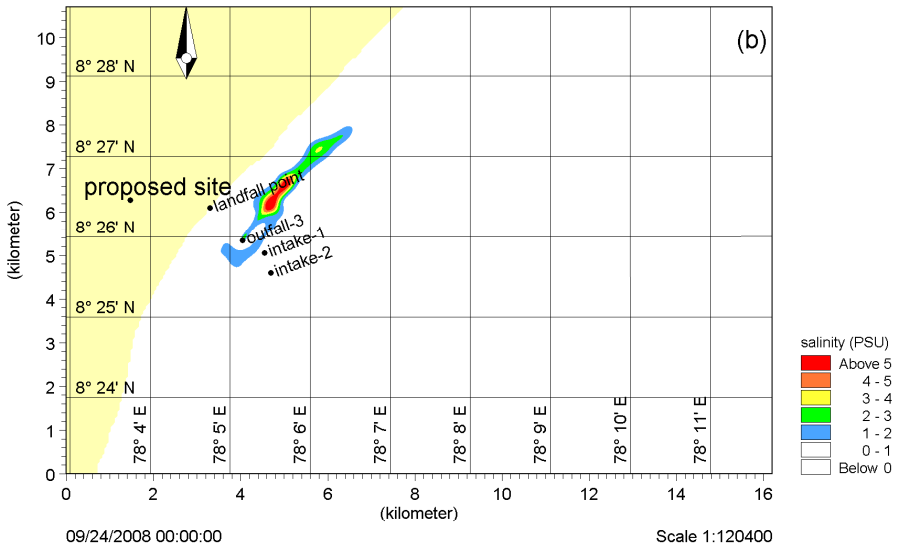


Fig. 7 (a) Typical current pattern during spring tide and (b)surface elevation off Udangudi.





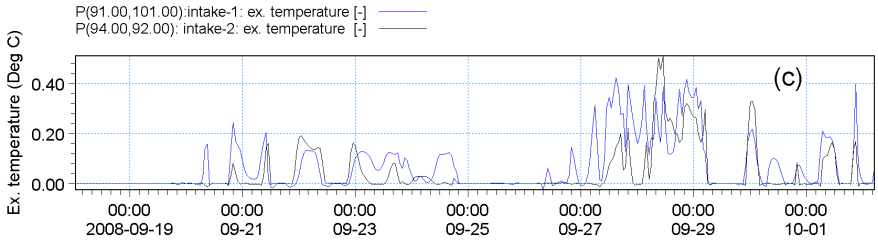


Fig. 8. Spreading of (a) thermal plume and (b) salinity plume around outfall-2 during neap currents, and (c) the variation of excess temperature at intake-1 and intake-2 during the simulation period.

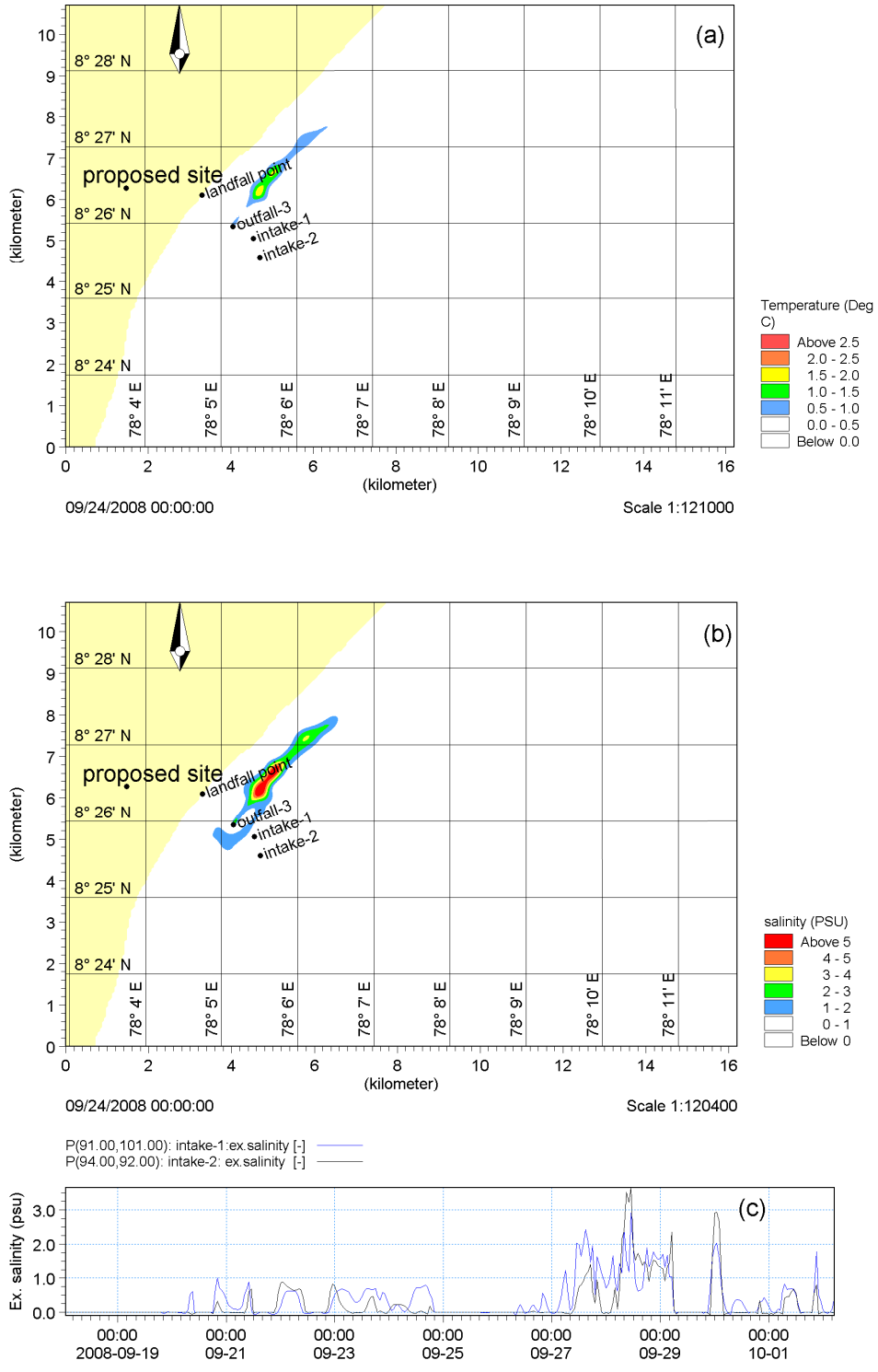
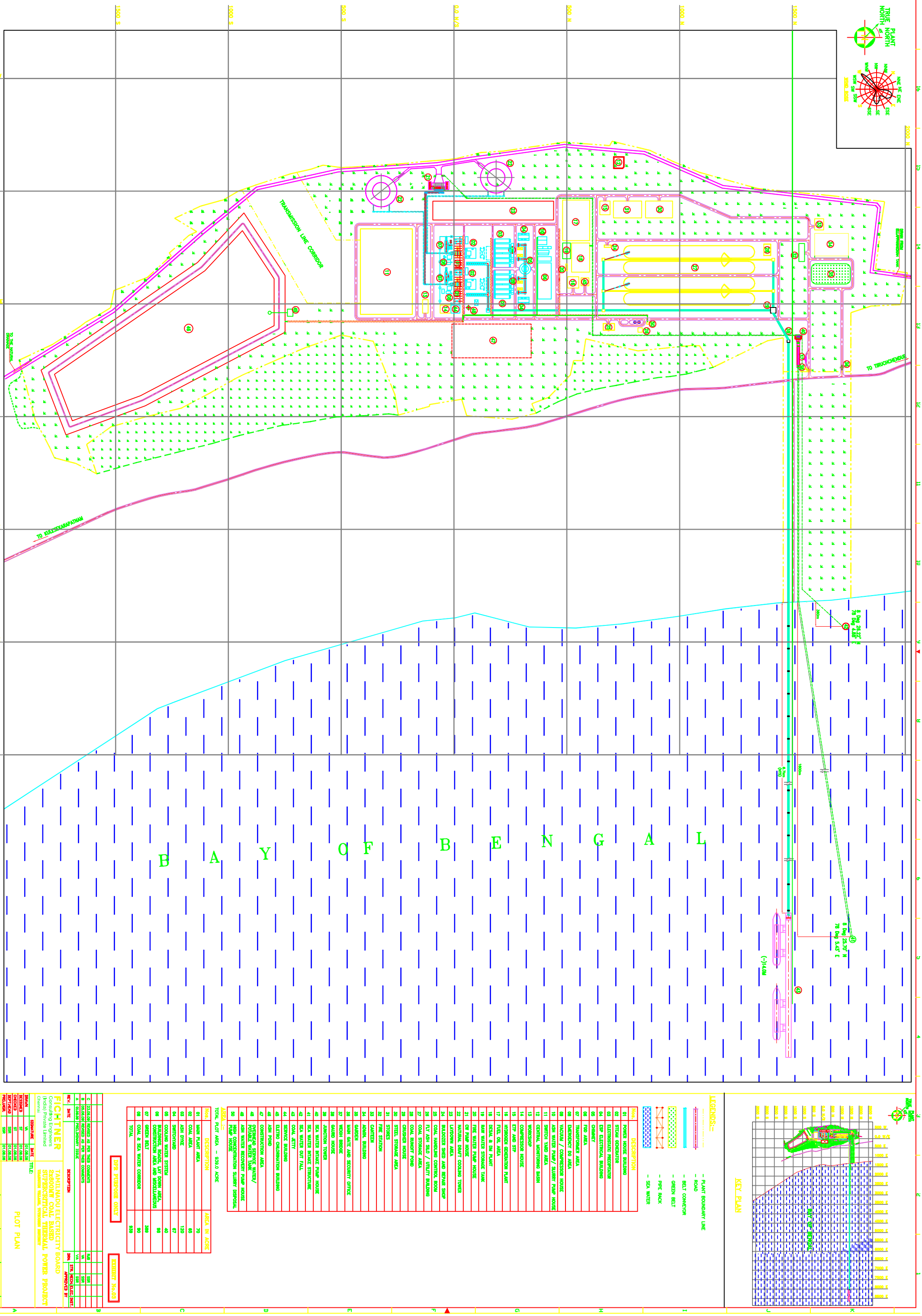


Fig. 9. Spreading of (a) thermal plume and (b) salinity plume around outfall-2 during spring currents, and (c) the variation of excess salinity at the intake-1 and intake-2 during the simulation period.



Nos.	DESCRIPTION
01	POWER HOUSE BUILDING
02	STEAM GENERATOR
03	ELECTROSTATIC PRECIPITATOR
04	ESP ELECTRICAL BUILDING
05	CHIMNEY
06	FGD AREA
07	TRANSFORMER AREA
08	EMERGENCY DG AREA
09	VACUUM / COMPRESSOR HOUSE
10	ASH WATER PUMP / SLURRY PUMP HOUSE
11	SWITCH YARD AREA
12	CENTRAL MONITORING BASIN
13	WORKSHOP
14	COMPRESSOR HOUSE
15	ETP AND STP
16	HYDROGEN GENERATION PLANT
17	FUEL OIL AREA
18	DESAL & DM PLANT
19	RAW WATER STORAGE TANK
20	FIRE WATER PUMP HOUSE
21	CW PUMP HOUSE
22	NATURAL DRAFT COOLING TOWER
23	LAYDOWN AREA
24	BULDOZER SHED AND REPAIR SHOP
25	COAL HANDLING CONTROL ROOM
26	FLY ASH SILO / UTILITY BUILDING
27	COAL STORAGE AREA
28	COAL RUNOFF POND
29	CRUSHER HOUSE
30	STEEL STORAGE AREA
31	STORES
32	FIRE STATION
33	CANTEEN
34	ADMIN. BUILDING
35	GARDEN
36	MAIN GATE AND SECURITY OFFICE
37	WEIGH BRIDGE
38	GAURD HOUSE
39	JUNCTION TOWER
40	SEA WATER INTAKE PUMP HOUSE
41	SEA WATER INTAKE STRUCTURE
42	SEA WATER OUT FALL
43	COAL JETTY
44	SEEPAGE BUILDING
45	ELETRO CHLORINATION BUILDING
46	ASH POND
47	CONSTRUCTION AREA
48	POTABLE WATER / DURABLE WATER TANK
49	ASH WATER RECOVERY PUMP HOUSE
50	HIGH CONCENTRATION SLURRY DISPOSAL PUMP HOUSE

AREA :-

TOTAL PLOT AREA - 939.0 ACRE

Nos.	DESCRIPTION	AREA IN ACRE
01	MAIN PLANT AREA	70
02	COAL AREA	65
03	ASH DYKE	130
04	SWITCHYARD	67
05	COOLING WATER SYSTEM	40
06	BUILDINGS, ROADS, LAY DOWN AREA, CONSTRUCTION AREA AND MISCELLANEOUS	98
07	GREEN BELT	369
08	COAL & SEA WATER CORRIDOR	90
	TOTAL	939

DEPE PURPOSE ONLY

Annexure No.03

FICHTNER
Consulting Engineers
(India) Private Limited
Chennai

TAMILNADU ELECTRICITY BOARD
2x800MW COAL BASED
SUPERCRITICAL THERMAL POWER PROJECT
KUDANKULAM VILLAGE, TIRUNELVELI DISTRICT

PLOT PLAN

DRAWN	VA	01.09.09	REVISED AS PER TNEB COMMENTS	C	23.09.09
DESIGNED	ST	01.09.09	REVISED AS PER TNEB COMMENTS	B	06.06.09
CHECKED	ST	01.09.09	PRELIMINARY ISSUE	A	02.02.09
ACCEPTED	SSR	01.09.09	DESCRIPTION	REV.	DATE
PRELIMINARY	SSR	01.09.09			

DRWN.	VA	01.09.09	
DESIGNED	ST	01.09.09	
CHECKED	ST	01.09.09	
ACCEPTED	SSR	01.09.09	
PRELIMINARY	SSR	01.09.09	

DRWN.	AJB	SSR	
DESIGNED	VA	SSR	
APPROVED BY	MECH	ELEC.	INST.

RELEASED FOR	PRELIMINARY		DEPT.	MECH	JOB NO. -
	TENDER	✓			
	ENGINEERING				
	CONSTRUCTION				

SCALE: 1:5000 | SHEET 1 OF 1 | REV. C

DWG.NO. -