Draft Environmental Impact Assessment

Project Number: 47928
August 2013

IND: Dahej Liquefied Natural Gas Terminal Expansion Phase III

Prepared by Vimta Labs Ltd. for Petronet LNG Limited

EXECUTIVE SUMMARY

for

EXPANSION OF EXISTING LNG IMPORT, STORAGE AND RE-GASIFICATION FACILITIES FROM 10 MMTPA TO 20 MMTPA AT DAHEJ, BHARUCH DISTRICT, GUJARAT

Project Proponent:

PETRONET LNG LIMITED

Petronet LNG Limited
New Delhi

Environment Consultant:

VIMTA LABS
Determining Quality

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April, 2013

1.0 EXECUTIVE SUMMARY

1.1 Introduction

Petronet LNG Limited (PLL) proposes to expand its existing LNG Import, Storage and Re-gasification facilities from 10 MMTPA to 20 MMTPA at Dahej, Bharuch District, Gujarat.

1.1.1 Classification of the project as EIA Notification

As per the Environment Impact Assessment (EIA) Notification dated 14th September 2006, the proposed expansion of LNG Re-gasification Terminal falls under 'Category-A' with project or activity type number '6(a)'. Ministry of Environment & Forests (MoEF) Expert Appraisal Committee (EAC) has prescribed the TORs for undertaking detailed EIA study vide letter F.No. 11-63/2011-IA.III dated 17th February 2012. Present EIA report has been prepared in compliance to the above ToRs and report is being presented for the public consultation process.

1.1.2 CRZ Status of the project

As per the Costal Regulation Zone (CRZ) notification 2011, the proposed project is a permitted activity within CRZ-III zone.

1.2 Importance of Project

Regasified Liquefied Natural Gas (LNG) is having considerable advantage in terms of environmental benefits when compared to fossil fuel like Methylated spirit, High speed diesel, and furnace oil etc.

Honorable Supreme Court of India, on realizing the urgency and importance of protection and improvement of the environment, has given direction to authorities to take immediate steps to tackle the vehicular pollution. On Writ petition no. 939 of 1996, Supreme Court has given judgment on 28/07/1998 for use of Compressed Natural Gas (CNG) in vehicles at New Delhi.

Advantages of CNG/LNG/NG

- 60–90% less smog-producing pollutants
- 30–40% less greenhouse gas emissions
- Less expensive than gasoline

1.3 Brief Description of the Project

The PLL Project facilities would receive and store LNG that is unloaded from ship tankers, and regassify the LNG into natural gas for delivery to a pipeline. The terminal would be expected to operate continuously, with a design capacity of 20 MMTPA.

Existing LNG terminal consists of the following facilities:

A) Marine
- Jetty with unloading platform & unloading arms;
- Trestle; and
- Berthing & mooring dolphins LNG Jetty.

- Stand by jetty (under construction)

B) Onshore
- Storage Tanks
- LP & HP Pumps;
- Vaporizers; and
- Utilities.

Additional facilities required for expansion of LNG Terminal from 10 MMTPA to 20 MMTPA:

A) Onshore
- Storage Tanks;
- LP & HP Pumps;
- Vaporizers; and
- Utilities.

1.3.1 Cost of the Project

The estimated cost of the proposed expansion of LNG Re-gasification Terminal from 10 MMTPA to 20 MMTPA is about Rs.2950 crores (for 5 MMTPA) and estimated to be 2700 crores (for additional 5 MMTPA capacity). This estimate is inclusive of LNG storage tank facilities, re-gasification facilities, project management and project financing cost.

1.3.2 Land Requirement and Status

PLL is having about 16 hectares of land in south side of the existing plot. Additionally about 22.62 hectares of land on south side of existing plot is allocated by Forest Department to PLL and Stage-I clearance is accorded by Forest Department. PLL has also been permitted by Gujarat maritime Board to reclaim 20 hectares of land on west side of the existing plot.

1.4 Project Location

The index map and topographical features of the study area within 10 km radius from the proposed LNG Terminal boundary are shown in **Figure-1** and **Figure-2.**

The environmental setting of study area within 10 km radius from the proposed LNG Terminal boundary are given **Table-1.1.**

TABLE-1.1
ENVIRONMENTAL SETTING AROUND 10-KM RADIUS OF PROJECT SITE

Sr. No.	Particulars	Details		
1	LNG terminal Location			
	Town	Dahej		
	District	Bharuch		
	State	Gujarat		
2	LNG terminal Location Limits (within Sea)	**Project Land Co-ordinates**		
		Code	**Latitude**	**Longitude**

Sr. No.	Particulars	Details
		A — 21° 40' 17.49" — 72°32' 0.05" B — 21° 40' 17.81" — 72°32' 21.43" C — 21° 39' 55.66" — 72° 32' 21.80" D — 21° 39' 53.74" — 72° 32' 13.78" **Land To Be Reclaimed Co-ordinates** **Code — Latitude — Longitude** 1 — 21°40'43.20" — 72°31' 50.91" 2 — 21°40'43.49" — 72°31' 59.60" 3 — 21°40'17.49" — 72°32' 0.05" 4 — 21°40'17.36" — 72°31' 51.36"
3	Site Elevation above MSL	12-14 m above MSL
4	Geographical location in toposheet	Topo sheet No. 46 C/9, C/10
5	Nearest representative IMD station	IMD Surat
6	India Meteorological Dept. (IMD), Data	**IMD-Surat Data (Annual)** Predominant Wind Direction-SW Predominant Wind Speed- 1 to 11 kmph Maximum temperature-37.2°C Minimum Temperature-17.1°C Relative Humidity-32.8-36.6
	Study Period - IMD Meteorological Data	**Winter Season** Predominant Wind Direction-NW Predominant Wind Speed-1 to 5 kmph Maximum Temperature- 34.6°C Minimum Temperature-16.0°C Relative Humidity-36-68% **Pre Monsoon Season** Predominant Wind Direction-SW Predominant Wind Speed-1 to 11 kmph Maximum Temperature- 40.3°C Minimum Temperature- 23.1°C Relative Humidity- 35-72% **Post Monsoon Season** Predominant Wind Direction-NW Predominant Wind Speed- 1-5kmph Maximum Temperature- 35.1°C Minimum Temperature- 20.2°C Relative Humidity- 45.7-79.2%
7	Present land use at the site	Industrial
8	Nearest highway	SH-206 (1.5km, N)
9	Nearest railway station	Baruch(50-km, E)
10	Nearest airport	Vadodara(130-km, E)
11	Nearest rivers	Narmada (2.6 km, ESE)
12	Nearest sea	Arabian Sea (0.3 km, W)
13	Nearest port	Hazira (68.3 km, S)
14	Nearest town	Baruch(50-km,E)
15	Nearest city	Vadodara(130km,NE)
16	Nearest major city with 2,00,000 population	Bharuch (43.7 km, E)
17	Villages within 1 km radius	Luvara (1.5 km, E), Lakhigam (1.9 km, NE)
18	Distance from the sea coast	0.3 km, W

Sr. No.	Particulars	Details
19	Hills/valleys	NIL
20	Nearest tourist place	NIL
21	Archaeologically important places	NIL
22	Protected areas as per Wildlife Protection Act,1972 (Tiger reserve, Elephant reserve, Biospheres, National parks, Wildlife sanctuaries, community reserves and conservation reserves)	NIL
23	Reserved / Protected Forests	Adjacent to project site in southern direction
24	Seismicity	Seismic Zone III
25	Defence Installations	NIL
26	List of Industries	RIL, Birla Copper, GCPTCL

Note: All distances mentioned above are aerial distances
Source: EIA Studies, Vimta Labs Limited, Hyderabad

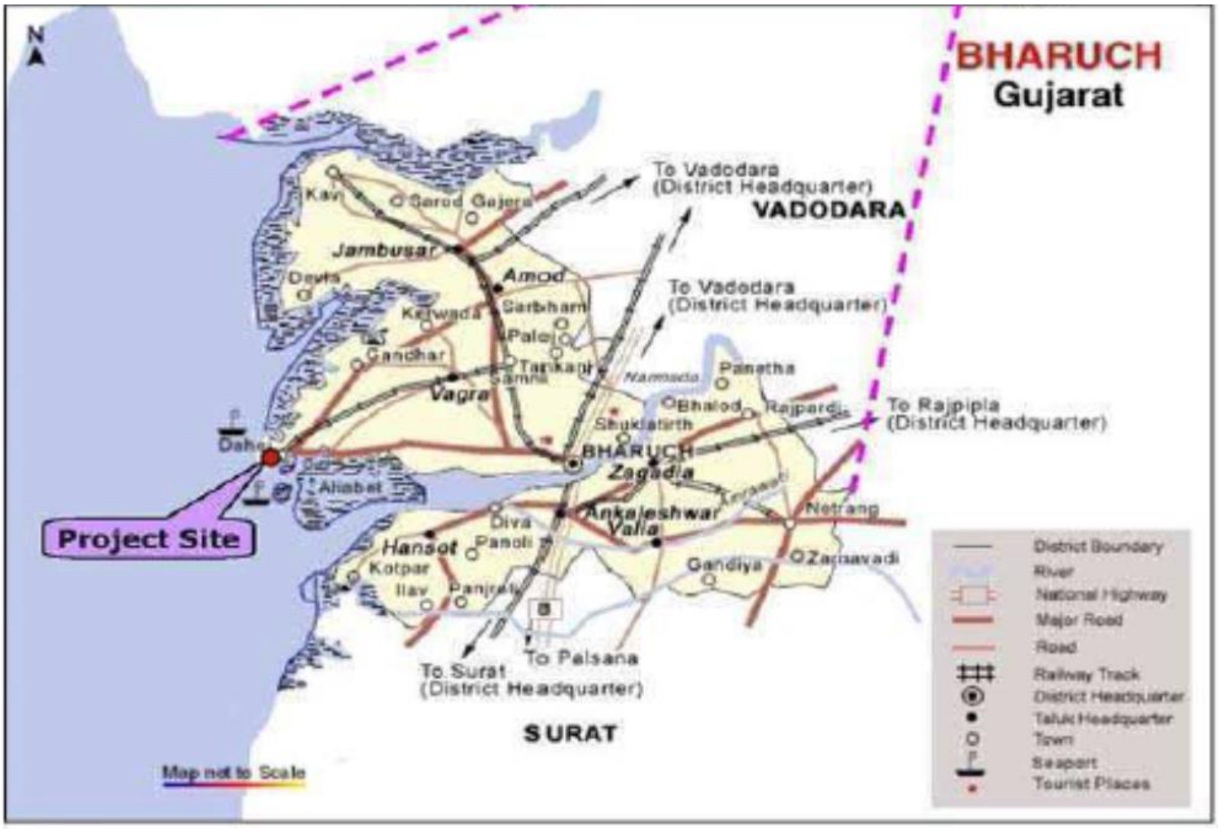

FIGURE-1
INDEX MAP SITE

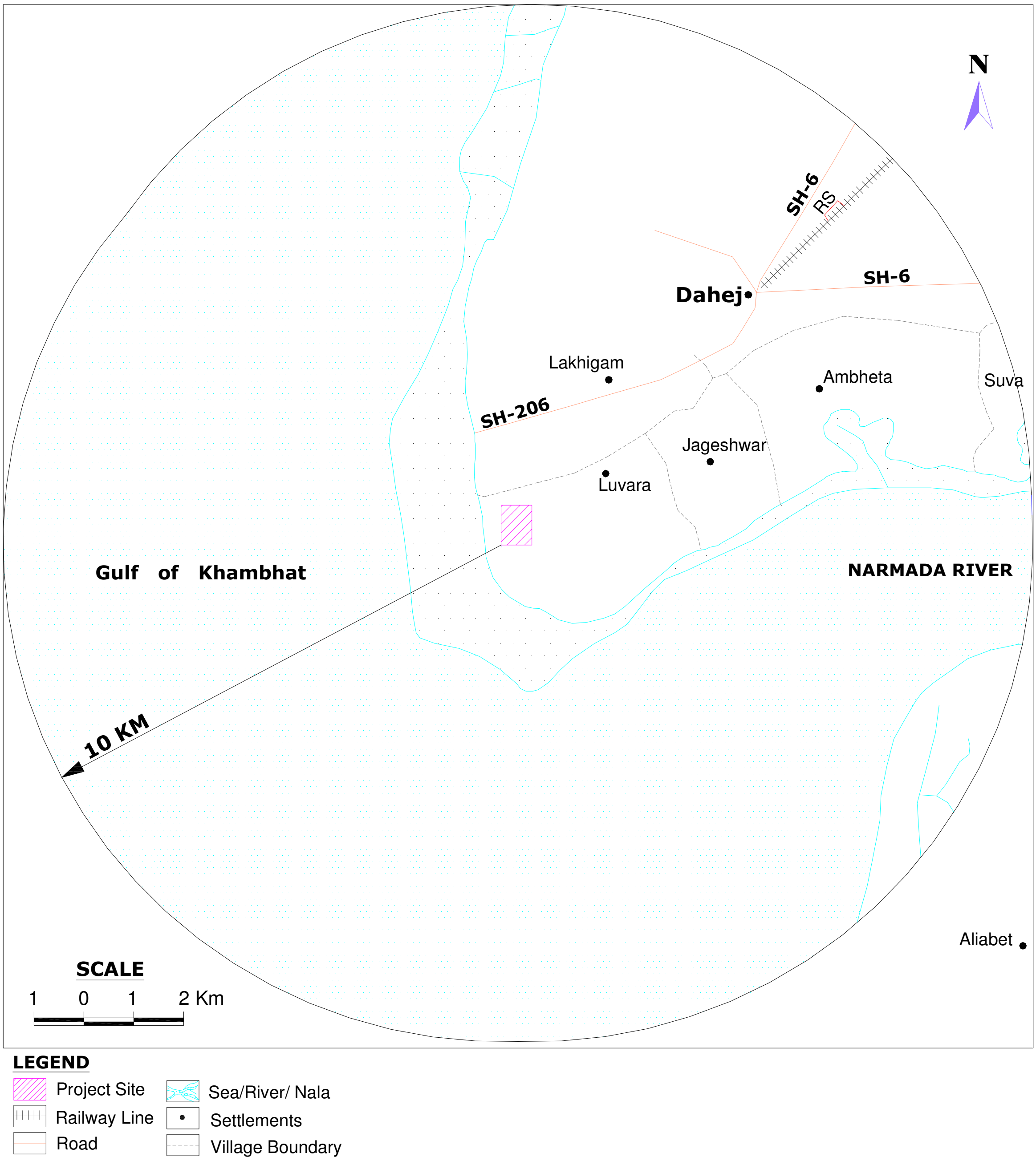

FIGURE-2
STUDY AREA OF THE PROJECT SITE

1.5 Baseline Environmental Status

The existing environmental setting is considered to adjudge the baseline environmental conditions, which are described with respect to climate, hydrogeological aspects, atmospheric conditions, water quality, soil quality, vegetation pattern, ecology, land use and socioeconomic profiles of people.

The comprehensive report incorporates the baseline studies carried out for three seasons covering 2011-2012 (winter, pre-monsoon and post-monsoon) seasons in the various domains of environment. Secondary data collected from various Government and Semi-Government organizations have been also discussed in the following section.

1.5.1 Land Use Studies

The land use pattern around 10 km radius of the proposed expansion of LNG terminal has been studied by District Census Hand Books. It is observed that 5.2% of the land falls under Culturable waste. On the other hand, 19.1% of land falls under un-irrigated land. The area not available for cultivation is about 75.6 % forms the bulk of the land use.

1.5.2 Soil Quality

Eight locations within 10 km radius of the study area were selected for soil sampling. The soil quality at all locations is found to be neutral in nature with moderate to average content of NPK**.**

1.5.3 Meteorology

The recorded temperature at site during study period ranges between 16.0°C and 43.3°C and relative humidity ranges in between 35% to 79.2%. Predominant winds from SW, NE and NW directions were observed during study period.

1.5.4 Ambient Air Quality

Ambient Air Quality Monitoring (AAQM) stations were set up at **Eight** locations during the study period of 2011-2012 (winter, pre-monsoon and post-monsoon) seasons with due consideration to the above mentioned points.

The Ambient air quality at all locations during the study period is presented in **Table-1.2.** All the values are found to be within the limits as per gazette notification GSR 826(E), dated 16th Nov. 2009.

TABLE-1.2
AMBIENT AIR QUALITY RESULTS

Sr.No	Parameter	Ranges in Winter season (December 2011 to February 2012)	Ranges in Pre-monsoon season (March to May 2012)	Ranges in Post monsoon season – (October to November 2012)	NAAQS (National Ambient Air Quality Standards) 24hrs CO, O_3 – 8hrs
1	PM_{10}	33.5-57.9	34.7-65.1	34.1-62.3	100
2	$PM_{2.5}$	8.5-19.4	10.2-23.8	9.4-21.7	60
3	So_2	10.2-19.4	9.1-15.8	9.6-17.8	80
4	Nox	11.4-20.4	10.3-16.5	10.8-19.1	80
5	CO	143-507	132-414	136-473	02
6	O_3	2.2-7.8	2.5-8.0	2.4-7.9	100

All values are given in $\mu g/m^3$

1.5.5 Water Quality

Surface water samples were collected from **two** locations and Ground water samples were collected from **eight** locations during the study period of 2011-2012 (winter, pre-monsoon and post-monsoon) seasons.

The quality of water samples were found to be having high values of hardness. The Ground Water Quality at all locations during the study period is presented in **Table-1.3.**

TABLE-1.3
GROUND WATER QUALITY

Sr. No	Parameter	Units	Ranges in Winter season (December 2011 to February 2012)	Ranges in Pre-monsoon season (March to May 2012)	Ranges in monsoon season (March to May 2012)	Ranges in Post monsoon season – (October to November 2012)	IS:10500 Limits
1	pH	-	7.6-8.3	7.6-8.5	7.7-7.9	7.6-7.9	6.5 -8.5
2	Electrical conductivity	µS/cm	203-2570	214-3160	176-2980	194-3050	$
3	Total Hardness	mg/l	90-940	85-675	73-523	84-565	300 (600)
4	TDS	mg/l	132-1720	142-1390	115-2090	126-1980	500 (2000)
5	Chloride	mg/l	7.1-319	8.2-500	10.1-475	9.7-490	250 (1000)
6	Fluoride	mg/l	0.2-0.7	0.1-0.8	0.2-0.7	0.3-0.6	1.0 (1.5)
7	Nitrate	mg/l	1.2-34.6	1.4-31.4	1.6-31.4	1.2-34.6	45 (NR)

The Surface Water Quality at all locations during the study period is presented in **Table-1.4**

TABLE-1.4
SURFACE WATER QUALITY

Sr. No	Parameter	Units	Ranges in Winter season (December 2011 to February 2012)	Ranges in Pre-monsoon season (March to May 2012)	Ranges in monsoon season (March to May 2012)	Ranges in Post monsoon season – (October to November 2012)	IS:2296 Class 'C' Limits
1	pH	-	7.8-7.9	7.9-8.0	7.6-7.7	7.7-7.9	6.5 to 8.5
2	DO	mg/l	6.2-6.5	6.3-6.4	3.8-4.1	4.9-5.2	4
3	Sulphates	mg/l	189.0-232.4	196-254	164-204	182-210	400
4	Fluoride	mg/l	1.1-1.2	1.1-1.2	1.2-1.3	1.2-1.3	1.5
5	Nitrate	mg/l	3.4-4.5	3.8-4.8	3.1-3.8	3.1-3.5	$

1.5.6 Ambient Noise Levels

The Noise monitoring has been conducted for determination of noise levels at eight locations in the study area. The noise levels at each location were recorded for 24 hrs.

Seasons	Ranges of Day Time Noise Levels (L_{day})	Ranges of Night Time Noise Levels (L_{night})
Ranges in Winter season (December 2011 to February 2012)	37.1-48.1	32.5-43.6
Ranges in Pre-monsoon season (March to May 2012	38.3-47.8	33.7-44.1
Ranges in Post monsoon season – (October to November 2012)	37.5-47.6	32.9-43.9
Standards	Day time	Night time
Industrial Area	75	70
Commercial Area	65	55
Residential Area	55	45
Silence Zone**	50	40

The noise levels are found to be within the limits as per the CPCB gazette notification dated 11th April 1994.

1.5.7 Ecological Environment

Terrestrial Environment

Detailed ecological studies were conducted during winter season in 2011-2012 to identify the floristic composition in and around project area and surrounding villages. To know the presence of any endangered/threatened/endemic plant species in proposed project area and surrounding 10 km radius.

The study area did not record the presence of any critically threatened species. The records of Botanical Survey of India and Forest department also did not indicate presence of any endangered and or vulnerable species in this area.

Avifauna: Many bird species including quails, sand grouses, bayas, sparrows, munias, crows, mynas, parakeets, kites, hawks, doves, bee-eaters, ibis, bulbuls, babblers, larks, ducks, peafowls, lapwings, pigeons, etc are recorded from the study area during the recent survey by VIMTA team. These bird species have composition of raptors, insectivorous and granivorous birds. Occurrence of bird species in good numbers is due to suitable climate and availability of food. Some of the common birds observed during recent survey by state forest departments indicate the presence of bhat titar (Pterocles exuslus), house crow (Corvus splendense), wood pecker (Piecoides nanus), Baya (Ploceus philippinus), kabboter (Columbia livia), owl (Bubo bubo), house sparrow (Passer domesticus), parrot (Psittacula krameri), chil (Falco jugger) and eagle (Corcatus gallicus).

Surroundings of agricultural land and water bodies: The birds like Mynas, Crows, Sparrows, Bulbuls, Babblers and Pigeons are observed in and around villages. In agriculture fields, the grain eating herbivorous species are dominant. These species are Doves, Sparrows, Cattle egrets, Parakeets etc. Insectivorous bird species viz. Bee-eaters, Wagtails, White breasted kingfisher, Egrets, Indian Roller are found around water bodies and in low-lying vegetation areas.

Rare, Endangered and Threatened Fauna in the Study Area:

In the year 1972 Government of India made an Act to provide protection to wild animals, birds and plants and for matters connected therewith which is known as Wild life (Protection) Act, 1972. Under this act Animals are categorized in Schedules to give maximum protection to the wild animals.

No animals and birds are found to be threatened in the study area. However with increasing anthropogenic activities like expansion of agricultural fields and industries there is limited impact on the fauna.

Surface water samples were collected for biological analysis from lentic and lotic water bodies during study period. Biological samples were analysed and estimated diversity index. Plankton diversity Index for phytoplankton and zooplankton varies from 2.56 to 3.14 and 2.45 and 2.84. Physico-chemical, biological parameters and diversity index reveals that the studied water bodies are slightly Oligotrophic in nature.

1.5.9 Socio-Economic Environment

The information on socio-economic aspects of the study area has been compiled from secondary sources, which mainly include census data of 2001.

The total population of the study area is about 14391. The Sex ratio is 812.5. About 64.4% of people are literates. The study area contains about 38.3 % of main workers, 2.6% of marginal workers and 59.1% of non-workers. In the study area about 20.1% population belong to Scheduled Tribes (ST) and 4.5 % Scheduled Castes (SC), thus indicating that there has been no significant change in weaker sections over previous years.

1.6 Impact Assessment

The identification and assessment of impacts over the various environmental attributes in the region due to the proposed expansion of LNG Terminal activities are discussed in the following sections. Suitable mitigative measures and environmental management plan for the potential impacts have also been presented.

1.6.1 Impact on Land Use

The proposed expansion of LNG Re-gasification Terminal will be carried out with in existing LNG terminal at Dahej. PLL is having about 16 hectares of land in south side of the existing plot. Additionally about 22.62 hectares of land on south side of existing plot is allocated to PLL by Forest Department. PLL has also been permitted by Gujarat Maritime Board to reclaim 20 hectares of land on west side of the existing plot.

1.6.2 Impact on Soil

The impact on soil due to project activity is expected on account of changes in soil quality and also due to soil erosion from the project areas. Considering that the proposed project will be implemented within the existing LNG terminal premises and operation causing change in soil quality is not envisaged, the impact of the project on soil quality will be less than significant.

Greenbelt will be developed in phased manner from construction stage onwards. Apart from localized construction impacts at the plant site, no adverse impacts on soil in the surrounding area are anticipated.

1.6.3 Impact on Topography

The proposed project premise is a generally plain land with a general elevation of about 12~13 m above MSL. Most of the buffer zone of the project is undulated land.

It is proposed to level the project area and to use the dredge sand. There will be no tall structures except stacks and storage tanks. Also, the contours of natural drainage will not be disturbed. In view of the above, there will be no major adverse impact on topography of the project site.

1.6.4 Impact on Air Quality

LNG regasification and storage is a clean process and essentially there is no emission from this process. The only sources of pollution in the proposed project are the operation of GTGs and flare. The GTGs are run by the natural gas only and hence the emissions of SO_2 and SPM are negligible as LNG don't contain sulphur. NOx is the only pollutant emitted from GTGs with a guarantee of NOx emissions less than 50 ppm.

Emissions from the flare shall mostly occur at the time of plant upset condition and the emissions will be insignificant under normal condition In the proposed LNG terminal, three (03) No of GTGs are proposed for 15 MMTPA and further two (02) additional GTG for 20 MMTPA terminal operations.

1.6.5 Impact on Surface Water and Groundwater Quality

There is no generation of any liquid effluent from the process area. Existing facilities are adequate to handle additional domestic waste water.

1.6.6 Impact on Noise Levels

The proposed LNG terminal would generate noise due to pumps and compressors. A quantitative prediction was carried out to estimate the cumulative noise levels due to operation of all noise generating source of LNG terminal and found to be within the permissible limits.

1.6.7 Impact on Terrestrial Ecology

The initial construction works at the LNG terminal involves land clearance and reclamation. Greenbelt will be developed in phased manner during construction to improve the aesthetic value in the area and to screen out the fugitive dust generated during construction.

The existing trees will be preserved to the extent possible. Thus, no major adverse impacts are envisaged on terrestrial ecology.

1.7 Environment Management Plan

1.7.1 Environment Management Plan during Construction Phase

Air Quality Management

The activities like site development, grading and vehicular traffic contribute to increase in PM and NOx concentrations. The mitigation measures recommended to minimize the impacts are:

- Dust masks will be provided to construction workers, while carrying out operations that may entails potential for dust generation.
- All vehicles delivering construction materials or removing soil will be covered to prevent escape of dust.
- Water sprinkling in construction area;
- Asphalting the main approach road;
- Proper maintenance of vehicles and construction equipment; and
- Tree plantation in the area earmarked for greenbelt development.

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 camp; and utilizing the wastewater in greenbelt development.

Noise Level Management

Operation of construction equipment and vehicular traffic contribute to the increased noise level. Recommended mitigation measures are:

- Good maintenance of vehicles and construction equipment;
- Restriction of construction activities only to day time;
- Plantation of trees around the plant boundary to attenuate the noise; and
- Provision of earplugs and earmuffs to workers.

Ecological Management

Tree plantation (large size species) should be undertaken at the time of preparation of site so that they would grow to considerable size by time of commissioning of the proposed project.

Socio-economic Environment

Given that the project and related developments like construction camps will be dependent on local resources (power, water), during both construction and operations, the only likely impact on infrastructure would be on the roads. Considering the increased traffic during construction phase an effective traffic management scheme will be developed to avoid congestion on the nearby and local roads.

1.7.2 Environment Management Plan during Operations Phase

Air Quality Management

Only source of emissions in the proposed project are the GTGs. The gas generators installed at PLL Dahej site are based on "Lean–burn" technology and the NOx emissions will be controlled below 50 ppm.

Water Quality Management

There is no generation of any liquid effluent from the process area. Existing facilities are adequate to handle additional domestic waste water.

Rainwater harvesting structures can't be built in the project area as the ground water table is very shallow.

Noise Level Management

The noise may be generated due to operation of pumps and compressors.

The recommended measures to minimize the impacts of noise generated which are as follows:

- Equipment's should be designed to conform to noise levels prescribed by regulatory authorities; i.e 85 dB(A) at 1 m from source;
- Provision of acoustic barriers or shelters in noisy workplaces;

- Provision of hoods to noise generating equipments like pumps;
- Provision of thick greenbelt to attenuate the noise levels;
- Provision of Personal Protective Equipments (PPE) such as earplugs, earmuffs to the workers working in high noise level area; and
- Implementation of greenbelt, landscaping with horticulture at power block areas to reduce noise impacts.

Ecological Management

The measures required to be undertaken to minimize the impact on the ecology are:

- The felling of trees will be kept at minimum; and
- The greenbelt having vegetation density of 2500 trees/ha will be developed in phased manner

Solid Waste Management

On a regular basis, there is no generation of any non-hazardous or inert solid waste from the proposed expansion of LNG terminal. A small quantity i.e. about 0.5 KL/year of hazardous oily waste will be generated from the proposed LNG terminal during periodic maintenance. Hazardous waste will be collected and stored at specific identified area at site. Separate authorization has been obtained under Hazardous Waste Management Rules to handling the hazardous waste generated.

1.8 Environmental Monitoring Program

Recognized agencies are engaged for carrying out the above stated monitoring works.

A centralized environmental monitoring cell has been established for monitoring of important and crucial environmental parameters which are of immense importance to assess the status of environment during LNG Terminal operation.

1.9 Risk Assessment and Disaster Management Plan

The hazard potential of LNG estimation of consequences in case of their accidental release during storage, transportation and handling has been identified and risk assessment has been carried out to quantify the extent of damage and suggest recommendations for safety improvement for the proposed expansion of LNG terminal facilities.

The Risk modelling scenarios considered for the proposed LNG terminal are

- Leakage of pipeline
- Unloading arm failure

1.9.1 Storage Tank

A Full containment LNG storage tank is designed to contain the spill from the inner tank into the containment space of the tank itself. Hence, the chance of leakage from the storage tank is ruled out.

The maximum vulnerable heat radiation will not spread beyond 346-m. Hence, human habitation will not be affected.

An effective Disaster Management Plan (DMP) to mitigate the risks involved has been prepared. This plan defines the responsibilities and resources available to respond to the different types of emergencies envisaged. Training exercises will be held to ensure that all personnel are familiar with their responsibilities and that communication links are functioning effectively.

1.10 Project Benefits

The proposed expansion of LNG Terminal will result in improvement in the social infrastructure in following manner:

- Generation of employment to unskilled people will be during construction phase and skilled people during operational phase of the LNG terminal.
- Improved standard of living;
- Revenue to Government;
- Change in the socio-economic scenario of the area;
- Direct and in direct employment during terminal construction and operation phases. Recruitment for the unskilled and semiskilled workers for the proposed project will be from the nearby villages;
- Development of the basic amenities viz. roads, transportation, electricity, drinking water, proper sanitation, educational institutions, medical facilities.
- Overall the project will change living standards of the people and improve the socio-economic conditions of the area.

ENVIRONMENTAL IMPACT ASSESSMENT

FOR
EXPANSION OF EXISTING LNG IMPORT, STORAGE AND RE-GASIFICATION FACILITIES FROM 10 MMTPA TO 20 MMTPA
AT
DAHEJ, BHARUCH DISTRICT, GUJARAT

REPORT FOR PUBLIC HEARING

Project Proponent:

PETRONET LNG LIMITED

Petronet LNG Limited
New Delhi

Environmental Consultant:

VIMTA LABS
Determining Quality

Vimta Labs Ltd.
Plot No.142,IDA,Phase-II,
Cherlapally, Hyderabad – 500 051

April, 2013

REPORT FOR PUBLIC HEARING

M/s Petronet LNG Limited
New Delhi

ENVIRONMENTAL IMPACT ASSESSMENT
FOR
EXPANSION OF EXISTING LNG IMPORT, STORAGE AND RE-GASIFICATION FACILITIES FROM 10 MMTPA TO 20 MMTPA
AT
DAHEJ, BHARUCH DISTRICT, GUJARAT

For and on behalf of VIMTA Labs Limited

Approved by	:	**E. Shyam Sundar**
Signature	:	
Position	:	**Vice President (Env)**
Date	:	**April 13, 2013**

The report has been prepared in line with the prescribed TOR's issued vide F.No.11-63/2011-IA.III dated 17th February 2012 of Ministry of Environment and Forests, New Delhi.

This report has been prepared by Vimta Labs Limited with all reasonable skill, care and diligence within the terms of the contract with the client, incorporating our General Terms and Conditions of Business and taking account of the resources devoted to it by agreement with the client.

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List of Abbreviations

APHA	American Public Health Association
ALOHA	Area Locations of Hazardous Atmospheres
AWWA	American Water Works Association
BOG	Boil-Off Gas
CRZ	Coastal Regulation Zone
CZMP	Coastal Zone Management Plans
CPCB	Central Pollution Control Board
DMP	Disaster Management Plan
EAC	Expert Appraisal Committee
ERS	Emergency Release System
ESD	Emergency Shut-Down
EIA	Environment Impact Assessment
EC	Environmental Clearance
EMP	Environment Management Plan
FB	Full Bore
FCC	False Color Composite
FSRU	Floating Storage Re-gasification unit
FSU	Floating Storage unit
GTG	Gas Turbine Generators
GW	Glycol Water
GLC	Ground Level Concentrations
GSPCB	Gujarat State Pollution Control Board
HP	High Pressure
HTL	High Tide Line
IMD	India Meteorological Dept. Data
KO	Knock-Out
LAH	Level Alarm High
LAL	Level Alarm Low
LC	Liquid Column
LNG	Liquefied Natural Gas
LNGC	Liquefied Natural Gas Cargo
LP	Low Pressure
LTL	Low Tide Line
MSL	Mean Sea Level
MTPA	Million Ton Per Annum
MoEF	Ministry of Environment and Forests
NAAQ	National Ambient Air Quality Standards
NIHL	Noise Induced Hearing Loss
N/A	Not Applicable
OSHA	Occupational Health and Safety
PAH	Pressure Alarm High
PAHH	Pressure Alarm High
PAL	Pressure Alarm Low
PCV	Pressure Control Valve
PSV	Pressure Safety Valve
STV	Shell and tube type vaporizer
SADA	Shore Area Development Authority
TSS	Total Suspended Solids
WI	WOBBE Index
SCV	Submerged Combustion Vaporizer

1.0 INTRODUCTION

Petronet LNG Limited (PLL) proposes to expand its existing LNG Import, Storage and Re-gasification facilities from 10 MMTPA to 20 MMTPA at Dahej, Bharuch District, Gujarat.

This chapter describes the purpose of the report, identification of the proposed project, project proponent, brief description of nature, size and location of the project and importance to the region and country. This chapter also describes the scope of the study and details of regulatory scoping carried out as per Terms of Reference (TOR) issued by Ministry of Environment and Forests (MoEF), New Delhi.

1.1 Purpose of the Report

As per the Environment Impact Assessment (EIA) Notification dated on 14th September, 2006 and the amendments thereof, the proposed LNG Re-gasification Terminal falls under '**Category-A**' with project or activity type number '6(a)', which require preparation of EIA Report to get Environmental Clearance (EC) from the Ministry of Environment and Forests (MoEF), New Delhi.

The application for prior EC (Form-1) for the proposed project had been submitted to MoEF and was considered in the 108th Expert Appraisal Committee Meeting held on 10th-11th January, 2012 in New Delhi to obtain Terms of Reference (TORs) for the preparation of EIA/EMP report. The Expert Appraisal Committee prescribed the TORs for undertaking detailed EIA study vide letter F.No. 11-63/2011-IA.III dated 17th February 2012. A copy of Terms of Reference (ToR) and its compliance is given in **Annexure-I**.

The existing environmental clearance for LNG terminal and jetty from Ministry of Environmental and Forests is given in **Annexure-II.**

1.2 Identification of Project and Project Proponent

Petronet LNG Ltd (PLL) is an Indian natural gas company formed on the behest of government of India to import liquefied natural gas (LNG) and set up LNG terminals in the country. It is a joint venture company promoted by the Gas Authority of India Limited(GAIL), Oil and Natural Gas Corporation Limited (ONGC), Indian Oil Corporation Limited (IOC) and Bharat Petroleum Corporation Limited (BPCL) with an authorized capital of Rs.1200 crores (US$ 240 million). Each has 12.5% equity share totaling to 50%. In addition, GDF International (GDFI), a wholly owned subsidiary of Gaz de France, a French national gas company, holds 10% and the Asian Development Bank (ADB) holds 5.2% of the equity. The balance of the equity, 34.8%, is held by the public.

The company had signed an LNG sale and purchase agreement with Ras Laffan Liquefied Natural Gas Company Ltd., Qatar and Exxon Mobil, Australia for the supply of LNG to India.

Petronet LNG Ltd. has set up its first LNG terminal at Dahej in Gujarat with the capacity of 10 million metric tons per year. Capacity of Dahej Terminal will expand to 20MMTPA by end of 2020. Another terminal with capacity 5 million tons per year is being set up in Kochi (Kerala) and it is expected to start operations in January 2013. Petronet LNG is planning to set up its third LNG terminal with capacity 10 million tons per year at Gangavaram port Limited, Visakhapatnam, Andhra Pradesh. It is expected that by 2016 Petronet LNG's total operating capacity will be 25 million tons per year.

1.3 Brief Description of the Project

PLL proposes to expand its existing LNG import, storage and regasification facilities from 10 MMTPA to 20 MMTPA at Dahej Bharuch district, Gujarat.

The Project facilities would receive and store LNG that is unloaded from ship tankers, and regassify the LNG into natural gas for delivery to a pipeline.

Existing LNG terminal consists of the following facilities:

A) Marine Jetty with unloading platform & unloading arms
- Trestle
- Berthing & mooring dolphins LNG Jetty,
- Stand by jetty (under construction)

B) Onshore
- Storage Tanks
- LP & HP Pumps
- Vaporizers
- Utilities

Additional facilities required for expansion of LNG Terminal from 10 MMTPA to 20 MMTPA:

A) Onshore
- Storage Tanks;
- LP & HP Pumps;
- Vaporizers; and
- Utilities.

Primary functions of the Terminal Facilities include the following:

- Receive, manoeuvre and moor the LNG carriers,
- Unloading of LNG from LNG carriers to LNG Tanks, and return LNG vapour from LNG Tanks to LNG carriers,
- Store LNG in LNG storage tanks to provide sufficient buffer against flow differences and delays in LNG carrier arrivals,
- Handle vapour generated during unloading and from heat gain during operation without flaring or venting,
- Pump LNG from LNG storage tanks to vaporisers, and discharge as natural gas at suitable pressure to the Gas send-out pipeline,

- Control the pressure and the temperature of natural gas to the send-out pipeline to satisfy customer requirements,
- Meter natural gas flowing to the send-out pipeline,
- Analyse the natural gas quality flowing to the send-out pipeline,
- Maintain supply of gas to the send-out pipeline to satisfy customer requirements at the delivery points during the whole year.
- Jetty facility

1.3.1 Environmental Setting of the Site

The details of environmental setting are given in **Table-1.1**. The index map of the project site is shown in **Figure-1.1**. Similarly, the topographical features of the study area within 10 km radius from the LNG regasification terminal boundary along with site map showing the facilities are shown in **Figure-1.2** and **Figure-1.3**. The photographs of the project site are shown in **Figure-1.4**.

TABLE-1.1
ENVIRONMENTAL SETTING AROUND 10-KM RADIUS OF PROJECT SITE

<table>
<tr><th>Sr. No.</th><th>Particulars</th><th>Details</th></tr>
<tr><td rowspan="4">1</td><td colspan="2">LNG terminal Location</td></tr>
<tr><td>Town</td><td>Dahej</td></tr>
<tr><td>District</td><td>Bharuch</td></tr>
<tr><td>State</td><td>Gujarat</td></tr>
<tr><td>2</td><td>LNG terminal Location Limits (within Sea)</td><td>Project Land Co-ordinates
<table>
<tr><th>Code</th><th>Latitude</th><th>Longitude</th></tr>
<tr><td>A</td><td>21° 40' 17.49"</td><td>72°32' 0.05"</td></tr>
<tr><td>B</td><td>21° 40' 17.81"</td><td>72°32' 21.43"</td></tr>
<tr><td>C</td><td>21° 39' 55.66"</td><td>72° 32' 21.80"</td></tr>
<tr><td>D</td><td>21° 39' 53.74"</td><td>72° 32' 13.78"</td></tr>
</table>
Land To Be Reclaimed Co-ordinates
<table>
<tr><th>Code</th><th>Latitude</th><th>Longitude</th></tr>
<tr><td>1</td><td>21°40'43.20"</td><td>72°31' 50.91"</td></tr>
<tr><td>2</td><td>21°40'43.49"</td><td>72°31' 59.60"</td></tr>
<tr><td>3</td><td>21°40'17.49"</td><td>72°32' 0.05"</td></tr>
<tr><td>4</td><td>21°40'17.36"</td><td>72°31' 51.36"</td></tr>
</table></td></tr>
<tr><td>3</td><td>Site Elevation above MSL</td><td>12-14 m above MSL</td></tr>
<tr><td>4</td><td>Geographical location in toposheet</td><td>Topo sheet No. 46 C/9, C/10</td></tr>
<tr><td>5</td><td>Nearest representative IMD station</td><td>IMD Surat</td></tr>
<tr><td rowspan="2">6</td><td>India Meteorological Dept. (IMD), Data</td><td>IMD-Surat Data (Annual)
Predominant Wind Direction-SW
Predominant Wind Speed- 1 to 11 kmph
Maximum temperature-37.2°C
Minimum Temperature-17.1°C
Relative Humidity-32.8-36.6</td></tr>
<tr><td>Study Period - IMD Meteorological Data</td><td>Winter Season
Predominant Wind Direction-NW
Predominant Wind Speed-1 to 5 kmph
Maximum Temperature- 34.6°C</td></tr>
</table>

Sr. No.	Particulars	Details
		Minimum Temperature-16.0°C Relative Humidity-36-68% **Pre Monsoon Season** Predominant Wind Direction-SW Predominant Wind Speed-1 to 11 kmph Maximum Temperature- 40.3^{0}C Minimum Temperature- 23.1^{0}C Relative Humidity- 35-72% **Post Monsoon Season** Predominant Wind Direction-NW Predominant Wind Speed- 1-5kmph Maximum Temperature- 35.1^{0}C Minimum Temperature- 20.2^{0}C Relative Humidity- 45.7-79.2%
7	Present land use at the site	Industrial
8	Nearest highway	SH-206 (1.5km, N)
9	Nearest railway station	Baruch(50-km, E)
10	Nearest airport	Vadodara(130-km, E)
11	Nearest rivers	Narmada (2.6 km, ESE)
12	Nearest sea	Arabian Sea (0.3 km, W)
13	Nearest port	Hazira (68.3 km, S)
14	Nearest town	Baruch(50-km,E)
15	Nearest city	Vadodara(130km,NE)
16	Nearest major city with 2,00,000 population	Bharuch (43.7 km, E)
17	Villages within 1 km radius	Luvara (1.5 km, E), Lakhigam (1.9 km, NE)
18	Distance from the sea coast	0.3 km, W
19	Hills/valleys	NIL
20	Nearest tourist place	NIL
21	Archaeologically important places	NIL
22	Protected areas as per Wildlife Protection Act,1972 (Tiger reserve, Elephant reserve, Biospheres, National parks, Wildlife sanctuaries, community reserves and conservation reserves)	NIL
23	Reserved / Protected Forests	Adjacent to the project site in southern direction
24	Seismicity	Seismic Zone III
25	Defence Installations	NIL
26	List of Industries	RIL, Birla Copper, GCPTCL

Note: All distances mentioned above are aerial distances
Source: EIA Studies, Vimta Labs Limited, Hyderabad

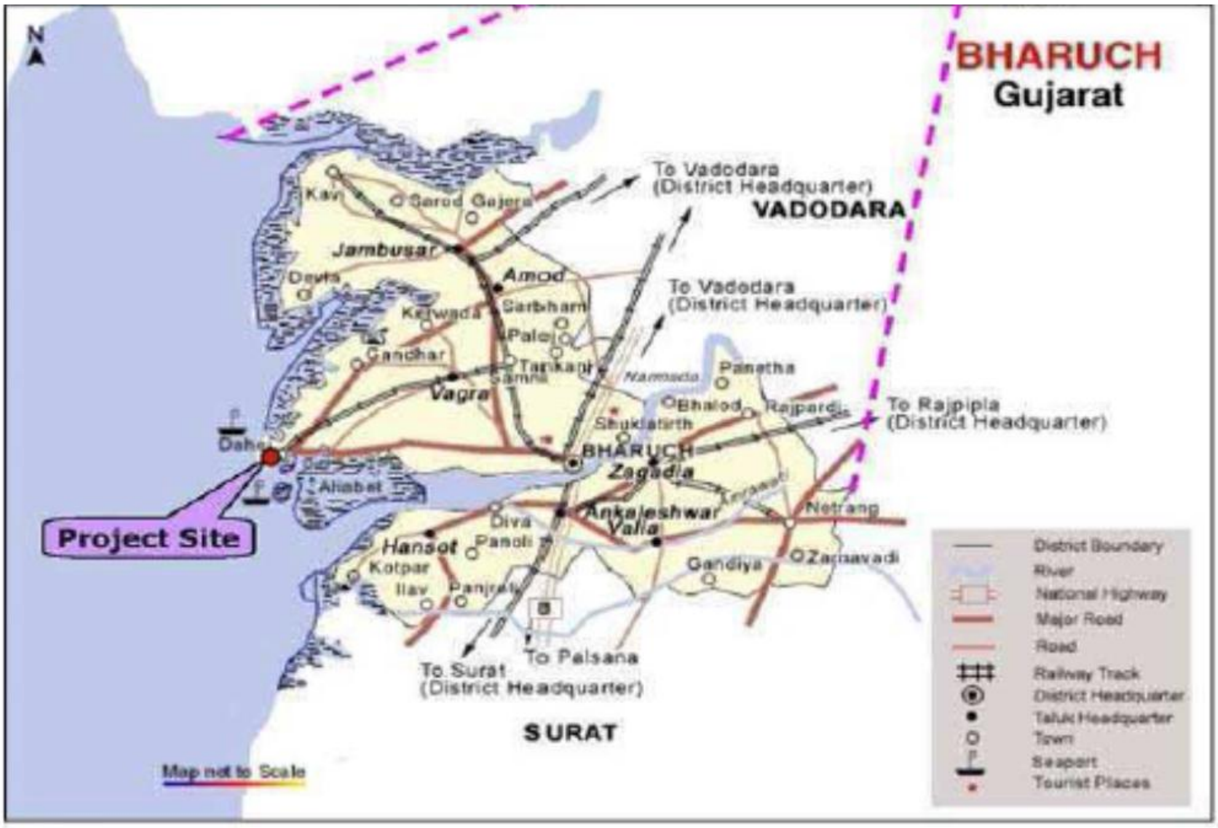
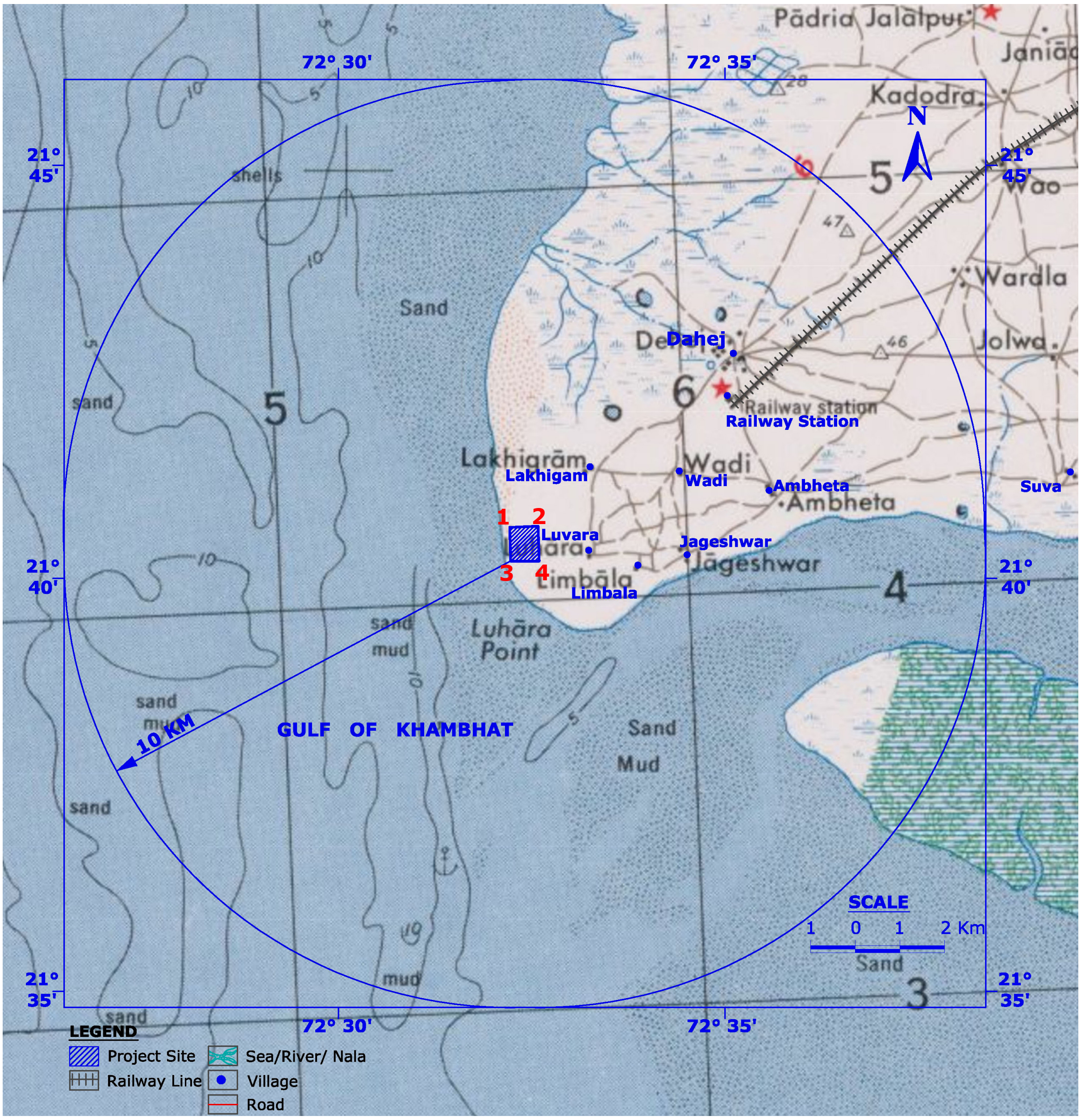


FIGURE-1.1
INDEX MAP SHOWING THE PROJECT SITE



	Latitude	Longitude
1 :	21° 40′ 43.63′′N-	72° 31′ 59.29″ E
2 :	21° 40′ 43.93′′N-	72° 32′ 20.73″ E
3 :	21° 40′ 17.89′′N-	72° 32′ 21.13″ E
4 :	21° 40′ 17.66′′N-	72° 31′ 59.70″ E

FIGURE-1.2
STUDY AREA OF THE PROJECT SITE

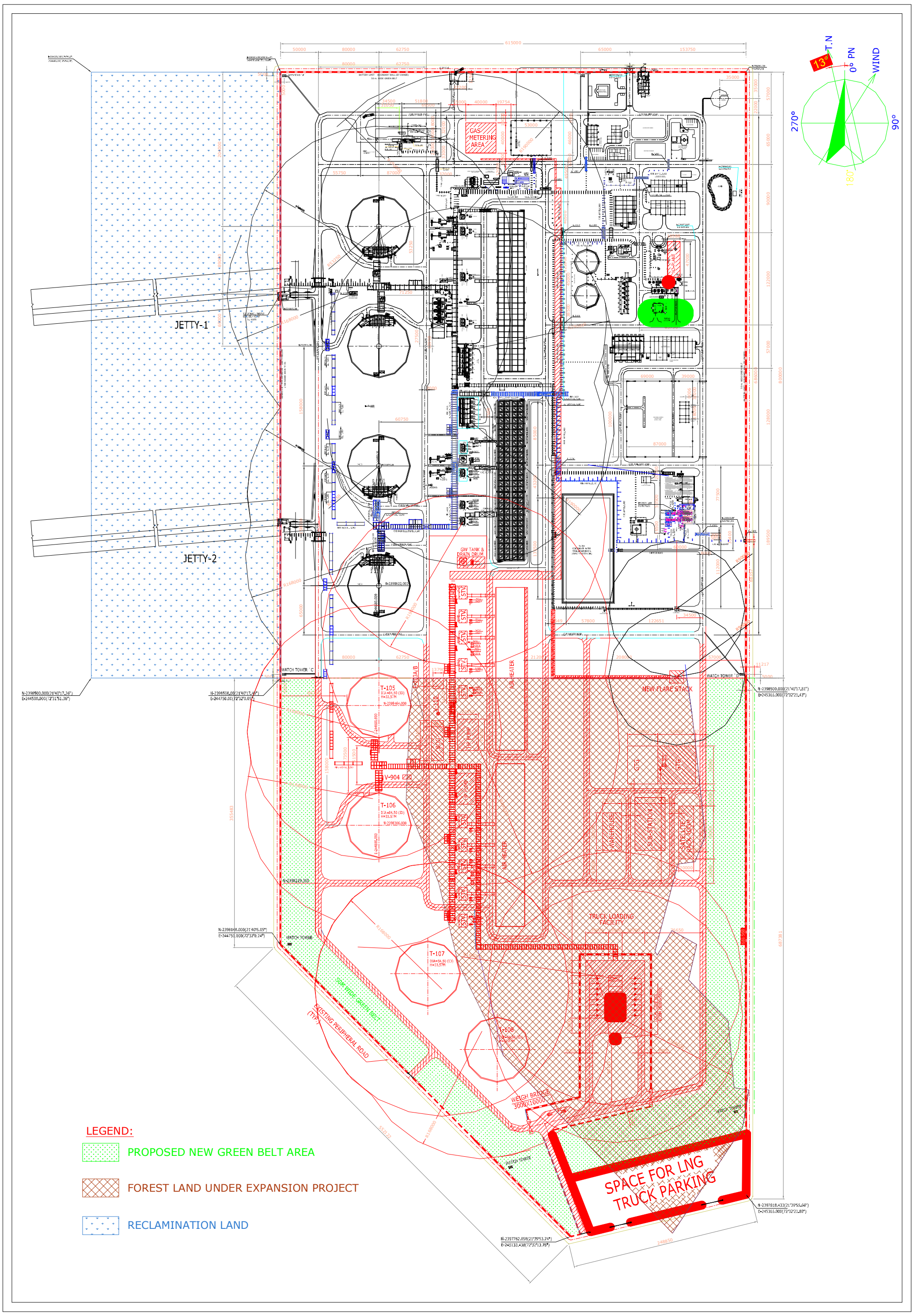


FIGURE-1.3
PROPOSED EXPANSION OF LNG FACLITY - SITE MAP SHOWING FACILITIES

FIGURE-1.4
PHOTOGRAPHS OF THE EXISTING LNG FACILITIES

1.4 Scope of the Study

With a view to assess the environmental impacts arising due to the proposed expansion of 10 MMTPA to 20 MMTPA LNG Import, Storage and Re-gasification facilities at Dahej, **Petronet LNG Limited (PLL)** has retained the services of **M/s Vimta Labs Limited, Hyderabad** to prepare the Comprehensive (Terrestrial & Marine) EIA Report for various environmental components including air, noise, water, land and biological components alongwith parameters of human interest which may be affected and to prepare an Environment Management Plan (EMP) for mitigating adverse impacts.

The one year environmental base line data has been carried out for all three non monsoon seasons (December- 2011 to November 2012). As explained to EAC during the presentation made on 10th-11th January 2012, the three season base line data that has been complied in the present report are as follows:

1. Winter season (December 2011 to February 2012)
2. Pre monsoon Season (March 2012 to May 2012)
3. Post monsoon (September 2012 to November 2012)

1.4.1 Study Area for EIA

In line with the TOR prescribed by Expert Appraisal Committee, study area comprising of 10 km radius around the LNG terminal site is considered as the study area.

1.4.2 Details of the Study

The scope of study broadly includes:

- To conduct literature review and to collect data relevant to the onshore study area;
- To undertake environmental monitoring so as to establish the baseline environmental status of the terrestrial study area;
- To identify various existing pollution loads due to various activities in the ambient levels;
- To predict incremental levels of pollutants in the terrestrial study area due to the proposed expansion of LNG terminal activities;
- To evaluate the predicted impacts on the various environmental attributes in the study area by using scientifically developed and widely accepted environmental impact assessment methodologies;
- To prepare an EMP outlining the measures for improving the environmental quality and scope for future expansions for environmentally sustainable development; and
- To identify critical environmental attributes required to be monitored suggesting a post-project monitoring programme.

The literature review includes identification of relevant articles from various publications, collection of data from various government agencies and other sources. The scope also includes all the conditions outlined in the TOR issued by MOEF.

1.4.3 Methodology of the Study

Reconnaissance survey was conducted by the M/s. Vimta Labs and concerned officials of M/s. Petronet LNG. Sampling locations were identified on the basis of:

- Predominant wind directions in the study area as recorded by India Meteorological Department (IMD) at Surat;
- Existing topography, drainage pattern and location of surface water bodies like ponds, canals, rivers and sea;
- Location of villages/towns/sensitive areas;
- Areas which represent baseline conditions; and
- Collection, collation and analysis of baseline data for various environmental attributes.

The field observations are used to:

- Setup air quality models;
- Identify extent of negative impacts on community/natural resources; and
- Identify mitigation measures and monitoring requirements.

The study also provides framework and institutional strengthening for implementing the mitigation measures. The existing conditions of various environmental attributes have been determined as outlined in **Table-1.2**.

TABLE-1.2
ENVIRONMENTAL ATTRIBUTES AND FREQUENCY OF MONITORING

Sr. No	Environmental Component	Sampling Locations	Sampling Parameters	Total Sampling Period	Sampling Frequency
1	Meteorology	One central location	Temperature, Wind Speed, Wind Direction, Relative Humidity, Cloud Cover, Rainfall	1year	Continuous hourly recording
2	Ambient Air Quality	8 Locations	$PM_{2.5}$, PM_{10}, SO_2, NO_x, CO and HC	Two consecutive days per week for 3 non monsoon seasons	24 hourly samples for $PM_{2.5}$, PM_{10}, SO_2 and NO_x; three 8 hourly samples per day for CO and HC
3	Water Quality	10 Locations	As per IS: 10500	Grab sampling	Once during study period
4	Marine	Project area	Wind storm, waves,	Three	Once during

Sr. No	Environmental Component	Sampling Locations	Sampling Parameters	Total Sampling Period	Sampling Frequency
	Studies/ Marine water Quality/ Sediment analysis		tides, currents, bathymetry and sea bed characteristics/ Physic-chemical and biological analysis	months	study period
5	Noise Monitoring	8 Locations	Sound Pressure Levels	Continuously for 24 hours	Once during study period
6	Soil Analysis	8 Locations	Soil profile, Chemical constituents	Composite sample	Once during study period
7	Ecology	Existing ecological resources within study area	Flora and fauna	Field observations and secondary sources	Once in study period
8	Demography and Socio-economic aspects	Total study area 10 km radius	Demographic profile	Based on District Census Handbook (2001)	
9	Land Use	Total study area 10 km radius	Trend of land use change for different categories	Based on District Census Handbook (2001)	
10	Geology	-	Geological history	Data collected from secondary sources	
11	Hydrology	-	Drainage area and pattern, nature of streams, aquifer characteristics, recharge and discharge rates.	Based on data collected from secondary sources	

Source: Terrestrial EIA Studies by Vimta Labs Limited;

The applicable environmental standards for the project are given in **Annexure-III**. The methodology of monitoring and analysis is given in **Annexure-IV**.

2.0 PROJECT DESCRIPTION

This chapter presents the project information including technical details of the existing and proposed expansion of LNG Receiving, import Storage and Re-gasification Terminal operations, utilities and services, infrastructure facilities.

2.1 Type of the Project

Petronet LNG Limited (PLL) is proposes to expand its existing LNG Import, Storage and Re-gasification facilities from 10 MMTPA to 20 MMTPA at Dahej, Bharuch District, Gujarat.

2.2 Need for the Project

Dahej LNG Terminal is presently operating at its full capacity of 10 Million Tons Per Annum (MMTPA). The plant has one jetty, four LNG tanks, each having a gross capacity of 160,000 cubic meter, regasification facilities along with associated utilities which are sized for handling 10 MMTPA of LNG.

The construction of second Jetty at Dahej LNG Terminal has already commenced and same is expected to be commissioned in the 1st quarter of 2014. Looking at the market scenario and availability of domestic gas, it is felt that in order to meet the increased requirement, the storage and regasification capacity of Dahej LNG Terminal shall be further increased. Some major customers particularly GAIL and GSPC have approached PLL to provide them storage and regas capacities and have also indicated the requirement on firm and long term basis.

In view of the increase demand as above PLL has planned to augment the capacity of Dahej LNG Terminal from 10 MMTPA to 20 MMTPA. The expansion facilities shall be designed to handle additional 10 MMTPA capacity. However, initially the capacity shall be increased from existing 10 MMTPA to 15 MMTPA. The total cost for this capacity enhancement is estimated to be 590 million USD.

Due to the rapid economic growth, the lack of adequate fuel supply alternatives and also more recently for environmental reasons, the demand for natural gas in the country is increasing.

The consumption of gas is primarily constrained by lack of supply and the shortfall in delivery infrastructure. As compared to this demand, the supply is well short. This supply analysis does not consider supplies from any transnational pipeline since a firm supply picture is yet to emerge from the deliberations. The following tables provide an account of the projected gas supplies and the net shortfall on account of the gap between demand and supplies. The segment wise overall demand in the coming years is given in **Table -2.1**.

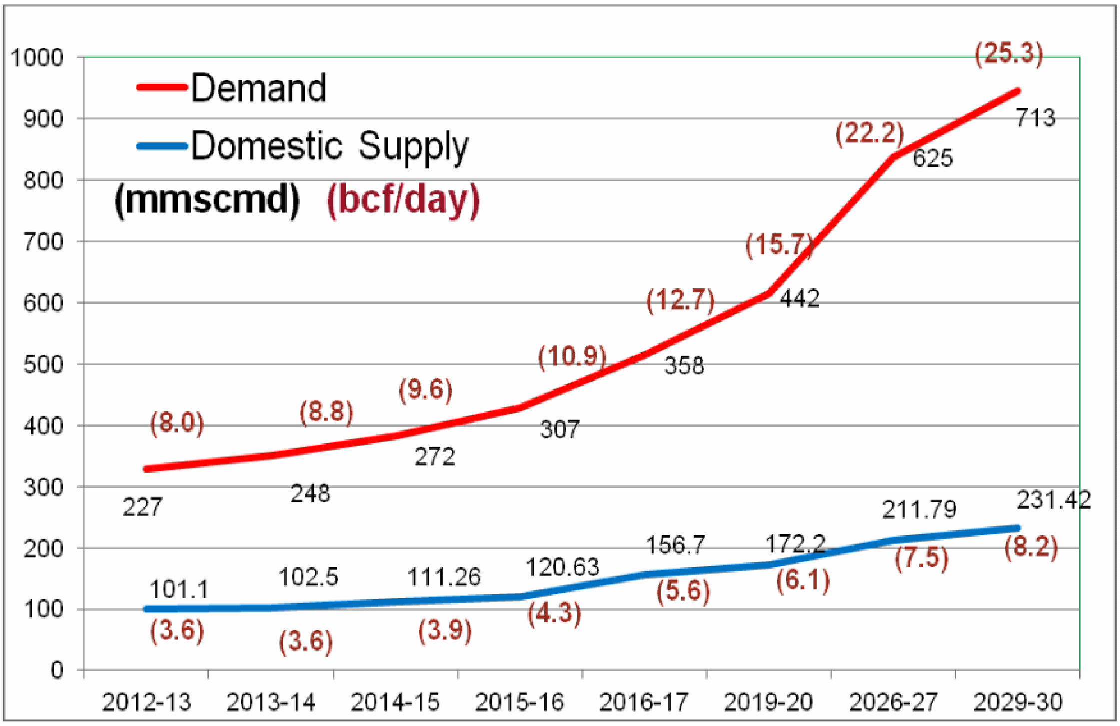
TABLE-2.1
SEGMENT WISE OVERALL DEMAND

Particulars	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Power	80.5	103.4	124.7	146.1	167.5	188.8	210.2	229.1	249.7	272.2
Fertilizer	43.1	44.0	67.7	106.8	113.2	120.0	127.2	134.8	142.9	151.5
Refinery /	46.0	50.8	53.5	56.7	60.1	63.8	67.6	71.6	75.9	80.5

Particulars	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Petrochemical										
City Gas	11.0	13.9	19.2	26.9	37.3	50.6	54.7	59.0	63.7	68.8
Steel	8.7	16.0	23.4	30.7	38.0	45.4	50.2	55.5	61.5	68.0
Others	14.6	15.5	16.4	17.4	18.4	19.6	20.7	22.0	23.3	24.7
Total	203.9	243.7	304.9	384.6	434.6	488.1	530.5	572.1	617.1	665.8

2.2.1 Demand and Supply Gap

Currently, the Indian gas market has a shortfall of approximately 126 MMSCMD. With the projected economic growth and the envisaged growth in the gas infrastructure, market demand is likely to grow. The projected demand–supply gap is shown in **Figure-2.1.**



Source: - Vision 2030, Natural Gas Infrastructure in India

FIGURE-2.1
PROJECTED DEMAND–SUPPLY GAP

2.2.2 Importance of Project

Regasified LNG (Natural Gas) is having considerable advantage in terms of environmental benefits when compared to fossil fuel like MS, HSD and FO etc.

Honourable Supreme Court of India on realizing the urgency and importance of protection and improvement of the environment has given direction to authorities to take immediate steps to tackle the acute problem of vehicular pollution in Delhi.
On Writ petition no. 939 of 1996, Supreme Court has given judgment on 28/07/1998 for use of CNG in vehicles in New Delhi.

Advantages of CNG/LNG/NG

- 60–90% less smog-producing pollutants
- 30–40% less greenhouse gas emissions
- Less expensive than gasoline

2.3 LNG Re-gasification Terminal Location and Layout

The proposed expansion of LNG Re-gasification Terminal will be located contiguous to existing terminal at Dahej, Bharuch District, Gujarat.

Co-ordinates of LNG terminal is given in **Table-2.2** and LNG Terminal Layout of Onshore and Offshore is shown in **Figure**-**2.2.**

TABLE-2.2(A)
PROJECT LAND CO-ORDINATES

Code	Latitude	Longitude
A	21° 40' 17.49"	72°32' 0.05"
B	21° 40' 17.81"	72°32' 21.43"
C	21° 39' 55.66"	72° 32' 21.80"
D	21° 39' 53.74"	72° 32' 13.78"

Source: PLL

TABLE-2.2(B)
CO-ORDINATES OF LAND TO BE RECLAMINED

Code	Latitude	Longitude
1	21°40'43.20"	72°31' 50.91"
2	21°40'43.49"	72°31' 59.60"
3	21°40'17.49"	72°32' 0.05"
4	21°40'17.36"	72°31' 51.36"

Source: PLL

2.3.1 Alternate Site Evaluation

LNG Re-gasification Terminal expansion is proposed contiguous to existing Dahej terminal premises. Since the proposed project is a brown field expansion, no alternatives considered.

2.3.2 Size of the Project

Expansion of 10 MMTPA to 20 MMTPA LNG Import, Storage and Re-gasification facilities will be developed contiguous to existing terminal at Dahej, Bharuch District, Gujarat.

2.3.3 Cost of the Project

The estimated cost of the proposed expansion of LNG Re-gasification Terminal from 10 MMTPA to 20 MMTPA is about Rs.2950 crores (for 5 MMTPA) and estimated to be 2700 crores (for additional 5 MMTPA capacity). This estimate is inclusive of LNG storage tank facilities, re-gasification facilities, project management and project financing cost.

2.4 Resources Requirement for the LNG Terminal

2.4.1 Land Requirement and Status

PLL is having about 16 hectares of land in south side of the existing plot. Additionally about 22.62 hectares of land on south side of existing plot is allocated by Forest Department to PLL and Stage-I clearance is accorded by Forest Department. PLL has also been permitted by Gujarat maritime Board to reclaim 20 hectares of land on west side of the existing plot.

Expansion from 10 MMTPA to 20 MMTPA LNG Import, Storage and Re-gasification facilities will be developed contiguous to existing terminal at Dahej. Allocation of land for LNG Terminal by GMB, GIDC/ Forest Dept. and Dahej SEZ to Petronet LNG Ltd is given in **Annexure-V**. Land use breakup for proposed expansion of LNG re-gasification terminal in **Table-2.3**.

TABLE-2.3
LAND USE BREAKUP FOR PROPOSED EXPANSION OF LNG RE-GASIFICATION TERMINAL

Sr. No	Description	Area (Ha)
1	Process Area	30.78
2	Non-Process Area	8.98

2.4.2 Water Requirement and Source

The existing condensate water reservoir of 10,000 m^3 capacity will help to cater construction water requirements and excess requirement will be met by other sources. Portable water requirement due to this expansion will be met by existing facilities.

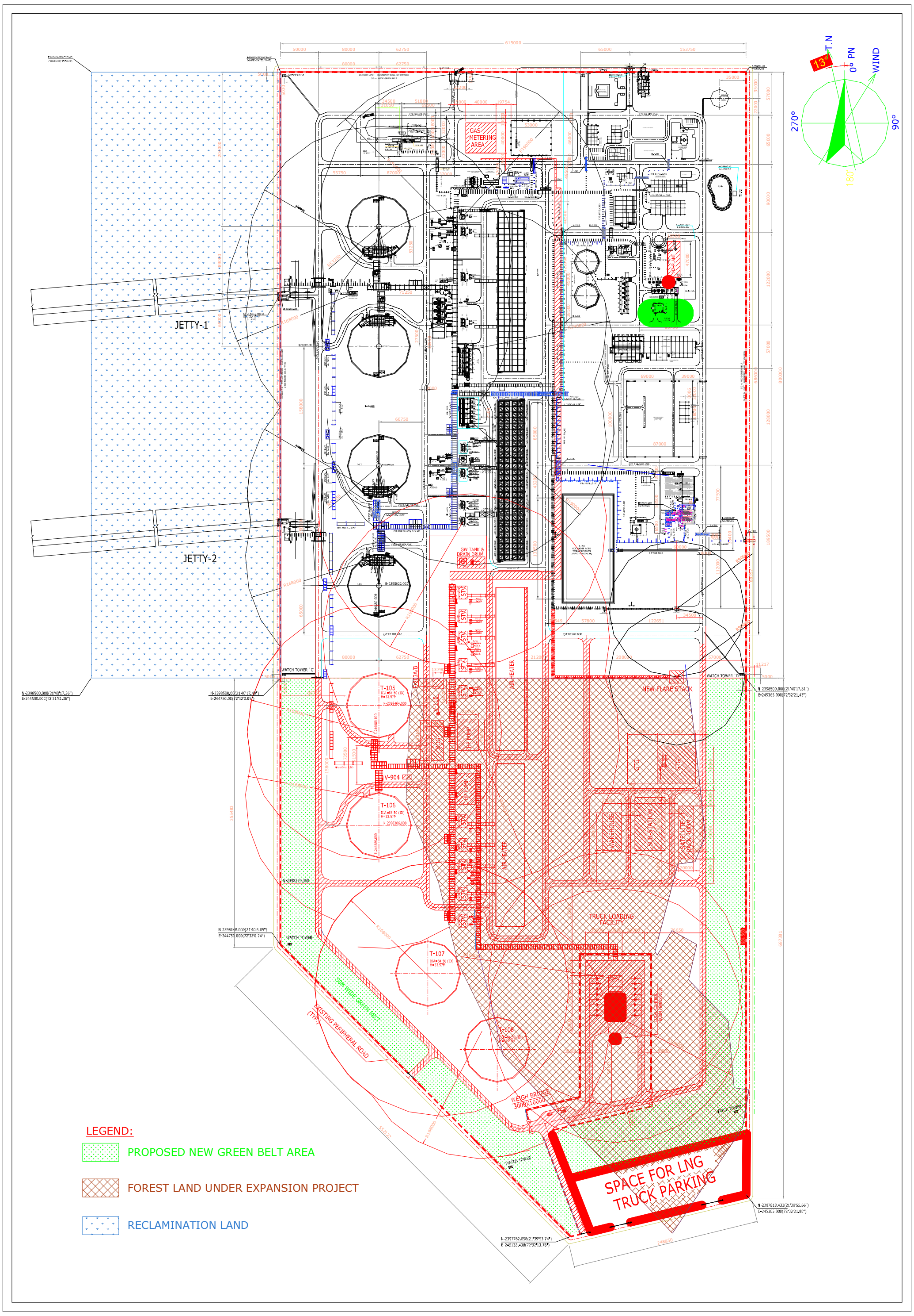


FIGURE-2.2
LNG TERMINAL LAYOUT

2.4.3 Power Requirement

The source of power supply system for existing facilities is as follows:

1. Captive Power Plant (5 X 7.7 MW GTGs)
2. 220 kVA Double feeded from Gujarat Electricity Board (GEB)

The total power requirement for the terminal for handling 10.0 MMTPA LNG with and without ship un-loading is 24,400 kW and 22,200 kW respectively. To achieve this purpose, five GTG's unit of 7.7 MW ISO Rating has been installed along with GEB grid as back up.

For the additional capacity of 5 MMTPA, the estimated power requirement after the Phase-IIIA (10 to 15 MMTPA) expansion with & without ship un-loading are 14,390 KW and 10,815 KW respectively. Accordingly it is proposed to install three additional GTGs, each of 7.18 MW (Minimum, GTG site rating) / 9.5 MW (ISO rating) along with associated facilities (e.g. co-gen heat exchangers, GW/HW exchangers, hot water loop/pumps, GW loop/pumps) for heat recovery in shell and tube vaporiser.

It shall be noted that electrical system shall be designed so that additional two GTGs can be installed in future to meet the requirement of Phase-IIIB (15 to 20 MMTPA).

2.4.4 Manpower Requirement

Based upon PLL experience from building LNG import terminals at Dahej & Kochi, and information from other industry sources on the construction of other similar plants, approximately 2500 person will be working during construction phase, the share of managerial, skilled and unskilled people can be taken to be 20%, 25%, and 55% respectively. This provides the maximum requirement of managerial, skilled and unskilled personnel as 500, 625 and 1375 per during construction period and additional 5 to 10 person will be required during actual terminal operation.

It is understood that sufficient construction laborers (floating, if not locals) are already available in the area. In this regard, maximum utilization of locals, for all types of labour needs of construction will be taken.

The construction phase of the proposed LNG terminal will results in the employment generation of around 500, 625 and 1375 managerial, skilled and unskilled personnel per day respectively for a period of three and a half years. This will result in the reduction in unemployment, thereby improving the standard of living of a section of the society.

2.5 Facilities of LNG Handling Terminal

2.5.1 Existing Facilities in the LNG Terminal

The existing facilities at Dahej LNG terminal were developed in phased manner. Dahej Phase-1 Facilities where installed to handle 5 MMTPA of LNG with provision to handle 10 MMTPA in future. Such facilities included piping manifolds, utilities, marine facilities and flare. The facilities during Phase-2 were installed to enhance the terminal capacity to 10 MMTPA utilizing the provisions that were kept in Phase-1. These facilities mainly included the modular addition of additional equipment's (already identified during Phase-1) and the two LNG Storage Tanks. Both Phase-1 & Phase-2 facilities are given in **Table-2.4**.

TABLE-2.4
EXISTING FACILITIES OF THE DAHEJ LNG TERMINAL

Sr.no	Particulars	Existing facilities	
		Phase-1	Phase-2
1	LNG Unloading Arm	3	-
2	LNG loading Arm	1	-
3	LNG Storage Tank	2	2
4	BOG Compressor	3	-
5	LNG in Tank Pump	6	6
6	LNG HP Pump	5	5
7	BOG Recondenser	1	-
8	HP Shell & Tube Vaporizer	7	7
9	HP Shell & Tube Vaporizer (Heat Recovery)	-	1
10	HP Submerged Combustion Vaporizer	2	2
11	Gas Metering station	1	1
12	Air Heater	16X7	16X7
13	GTG (7.7 ISO Rating)	3	2
14	Utilities (Air, Water, Nitrogen etc)		

2.5.2 Proposed facilities in the Dahej LNG Terminal

For Phase III expansion of the Dahej LNG Terminal, entirely newest of process facilities are required except for the Submerged Combustion Vaporizers. Based on practical experience, it is felt that it may be possible to utilize one of the existing submerged combustion vaporizer (SCV) to meet the total send out requirement during the winter season and at times when the ambient air temperature drops below 13^0C. Also to capitulate on the technological development bigger size shell & tube vaporizers (STVs) are considered to reduce the number of glycol water pumps, valves and fittings. However, initially the facilities, only for 5 MMTPA (Phase-III) of additional LNG will be installed. A summary of the additional process facilities required for handling additional 10 MMTPA (Phase III a & b) of LNG is provided in the **Table-2.5.**

TABLE-2.5
PROPOSED FACILITIES REQUIRED FOR DAHEJ LNG TERMINAL EXPANSION

Sr. No	Additional Equipment/ Facilities	Phase III a (10 to 15 MMTPA)	Phase III b (15 to 20 MMTPA)
1	LNG Storage Tanks (each of 180,000 m^3 gross capacity)	2	2
2	In-Tank Pumps	6	6
3	BOG Compressors	3	1
4	BOG recondensor	01	0
5	HP Pumps	5	5
6	STV	4	4

Sr. No	Additional Equipment/ Facilities	Phase III a (10 to 15 MMTPA)	Phase III b (15 to 20 MMTPA)
7	STV (cogen)	1	1
8	Send out metering	3	3
9	Fuel gas station	1	1
10	Air Heaters	4	4
11	Glycol water pumps	4	4
12	Hot water pumps	2	2
13	GW expansion vessel	4	4
14	GTG	3	2
15	Nitrogen unit	1	1
16	Truck loading facility	4(bay)	4 (bay)
17	Flare Stack	1	Nil

2.5.3 Process Description

LNG at atmospheric pressure and (-)162°C will be transported by sea from LNG exporter by means of specially designed and dedicated LNG vessels of 80,000 to 2,66,000 m^3 capacity at the jetty to be located at Dahej. LNG will be unloaded at the rate of 15,000 m^3 by using unloading arms at the dedicated LNG berth suitable for berthing and unloading from 80,000 m^3 capacity and higher capacity of 2,66,000 m^3 capacity LNG vessels. Annual throughput of LNG at the jetty is expected to be 5~10 MMTPA. The unloaded LNG will be pumped through dedicated pipelines to the LNG storage area. Capacity of LNG storage tanks will be firmed up after detailed engineering of the LNG terminal. Subsequently LNG will be gasified in the regasification area.

After regasification, Natural Gas (NG) will be made available to various NG consumers' e.g., power industry, fertilizer manufacturers, glass industries, steel industry etc. As is evident from the market survey, approximately 75% of the LNG will be utilized for power generation and the rest of it will be utilized by the fertilizer and other industries. It is to be noted that LNG provides the most economical and most environmental friendly option.

As per optimization strategy closed loop waste heat recovery Shell & Tube LNG vaporizers will be installed to recover waste heat from flue gases from gas turbine generator exhaust. Also cold energy from LNG will be utilized for air conditioning of buildings. Typical LNG unloading and regasification facilities process flow is shown in **Figure-2.3**. Process flow diagram of LNG vaporization and send-out facilities is shown in **Figure-2.4**

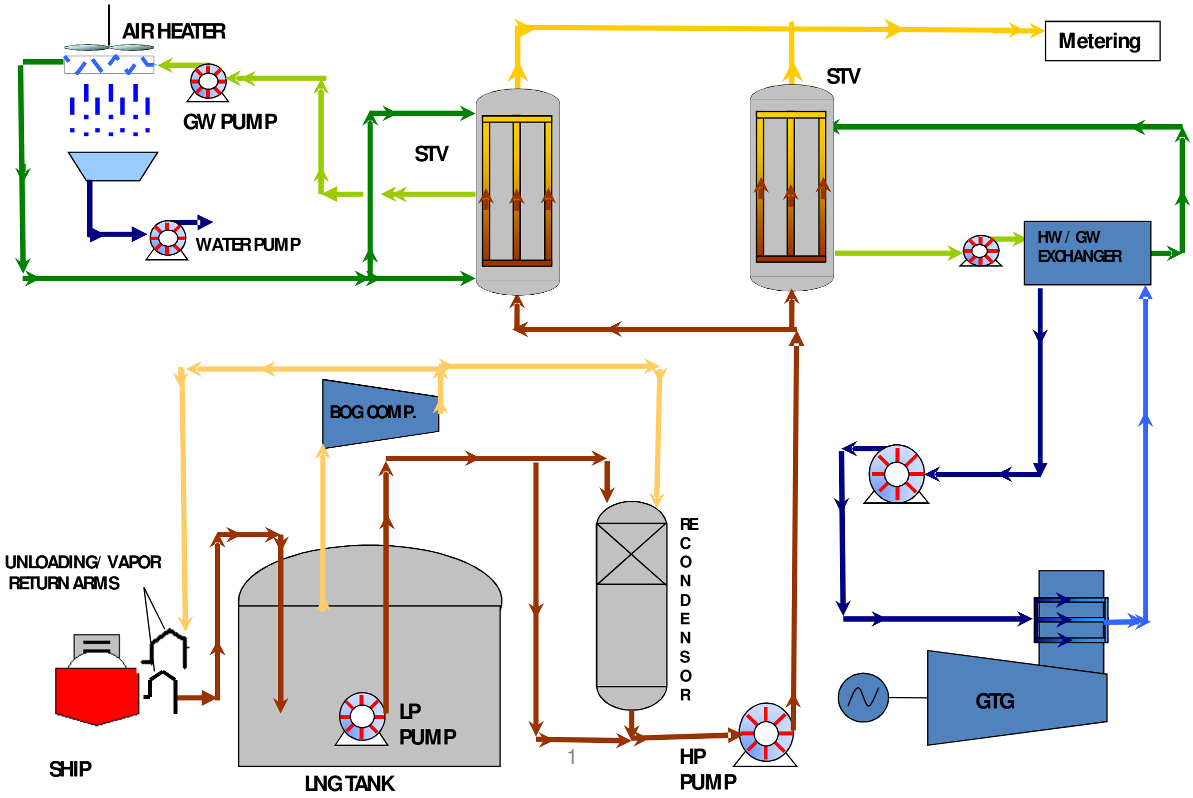


FIGURE-2.3
PROCESS FLOW CHART – LNG TERMINAL

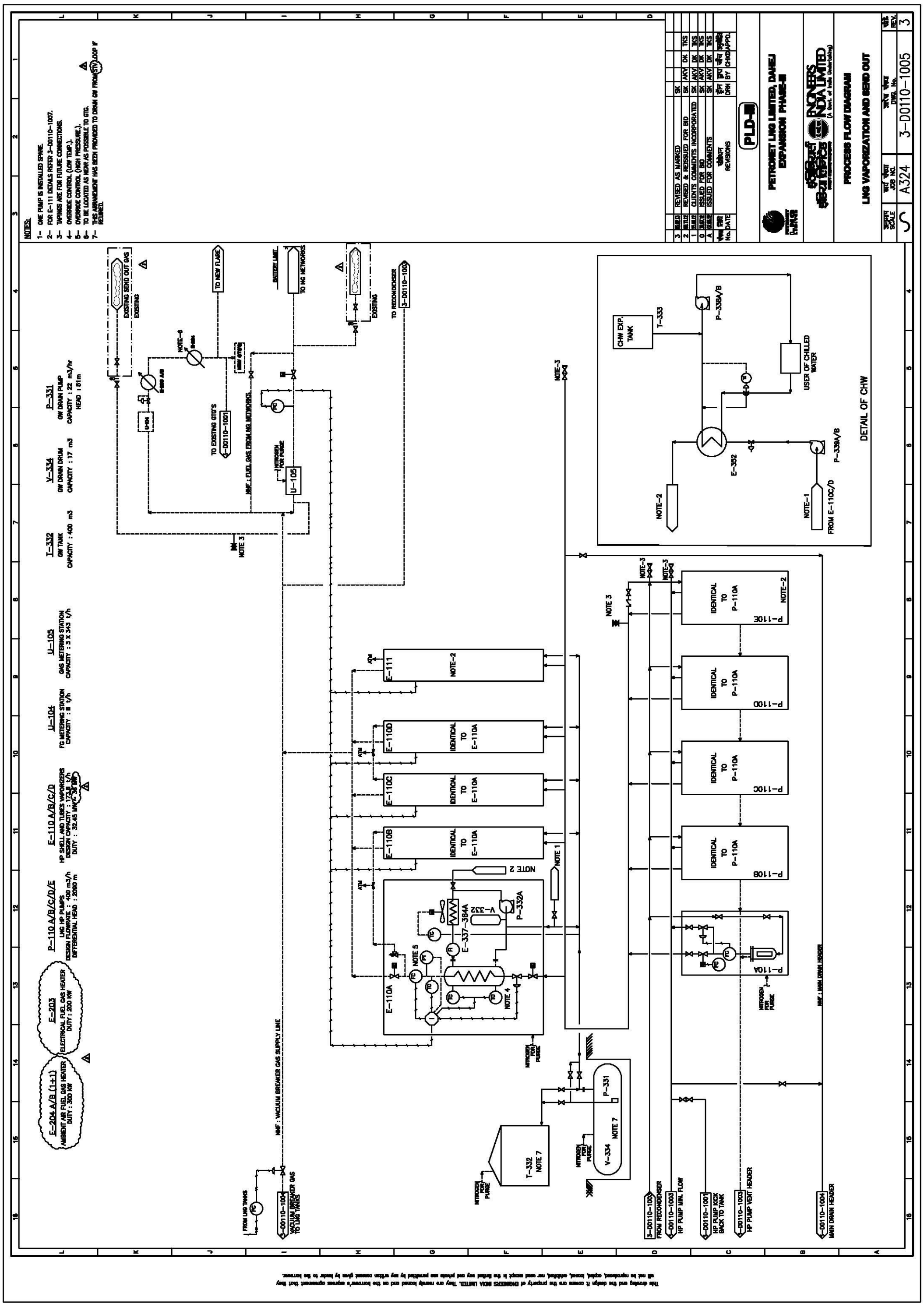


FIGURE-2.4
PROCESS FLOW DIAGRAM OF LNG VAPORIZATION AND SEND-OUT FACILITIES

2.5.4 Utilities

An analysis of the existing utilities indicate that the following facilities /systems (as existing) may be sufficient to cater for the requirement of Phase-III.

- Potable water system;
- Service water system;
- Raw water system;
- Fire water system; and
- Diesel oil system.

However, extension of existing network will be required to meet the Phase-III requirement. Other utilities need either upgradation or the additional facilities. These are briefly described here.

A. Compressed Air System

The existing facilities consist of the following air compressors:

1. Two Screw Compressors, each capacity 950 Nm^3/Hr.

2. Three Reciprocating Compressors, each capacity 950 Nm^3/Hr. (which needs to be discarded)

For the expanded capacity existing capacity is adequate. However, based on existing experience, the three Reciprocating compressors, which are almost 10 years old and are requiring considerable maintenance efforts/costs, are considered for replacement. As this enhancement is being considered as a part of Maintenance reliability program, this is not being considered as the part of the expansion facility.

B. Nitrogen System

The existing nitrogen generation capacity is to generate Gaseous Nitrogen of 135 Nm^3/hr. and Liquid Nitrogen Generation equivalent to 40 Nm^3/hr.

The normal consumption of Nitrogen current and post expansion is 47 Nm^3/hr and 90 Nm^3/hr respectively, which can be met by the existing facilities. The intermittent requirement (during ship un-loading), however is 1250 Nm^3(during ship unloading operation), which cannot be met post expansion, since total liquid Nitrogen generation in-between the two un-loadings is in-sufficient to meet such a demand. Therefore new Nitrogen Generation Unit which can generate sufficient liquid as well as gaseous nitrogen having capacity mentioned as below is proposed using the LNG cold energy.

Gaseous Nitrogen Generation: 160 Nm^3/hr.
Liquid Nitrogen Generation: 105 Nm^3/hr.

No liquid storage bottles are proposed for new facilities.

C. Fuel gas system

The present fuel gas station (consists of pressure reducing valve & ambient air heater etc.) capacity is 11.4ton/hr.

The total fuel gas requirement (i.e. for exiting as well as for expansion) is 18.7 tons/hr. which cannot be met by the existing fuel gas system (capacity 11.4 tons/hr.) and would therefore require a new Fuel Gas System with Conditioning Skid of adequate capacity to meet the requirement of Phase-III.

D. Blow down/flare system

Existing flare header capacity is 80000kg/hr. total flare load for existing facilities is 74300kg/hr. New flare stack of 150,000 kg/hr is proposed to be installed to meet the requirement of PH-III in addition to existing flare.

2.5.5 Instrumentation System

The Distributed Control System (DCS) has been considered to provide basic regulatory control of the process facilities; protective and emergency shutdown of the process facility; custody transfer and process data management. On-line analysis has been considered for monitoring plant performance and computation of energy contents wherever needed for custody transfer. DCS will have interface with ERP system to provide plant operation data for integrated plant information management.

It has been envisaged that additional two number of operator station is required to install in existing control room. Existing Rack room has no space. Rack Room will be located in other place along and will be connected to Existing DCS system through redundant fiber optic cable with necessary hardware

Existing UPS is not capable to take load of phase-III system. For phase-III system load, New UPS has been envisaged in new rack room.

2.5.6 Truck Loading Facilities

Truck Loading Facility (TLF) is provided to dispatch LNG by specially built cryogenic road tankers to various consumers which are not connected with gas pipeline. In the present design only one truck loading bay was provided, to establish the trade. Now that transportation of LNG by road trucks is established it is planned to provide facilities for four trucks loading bays with provision for addition of another four truck loading bays in future. However, for safety and operational considerations, the entire operation of truck loading of LNG shall be moved to a new location. Truck loading facility is shown in **Figure-2.5**

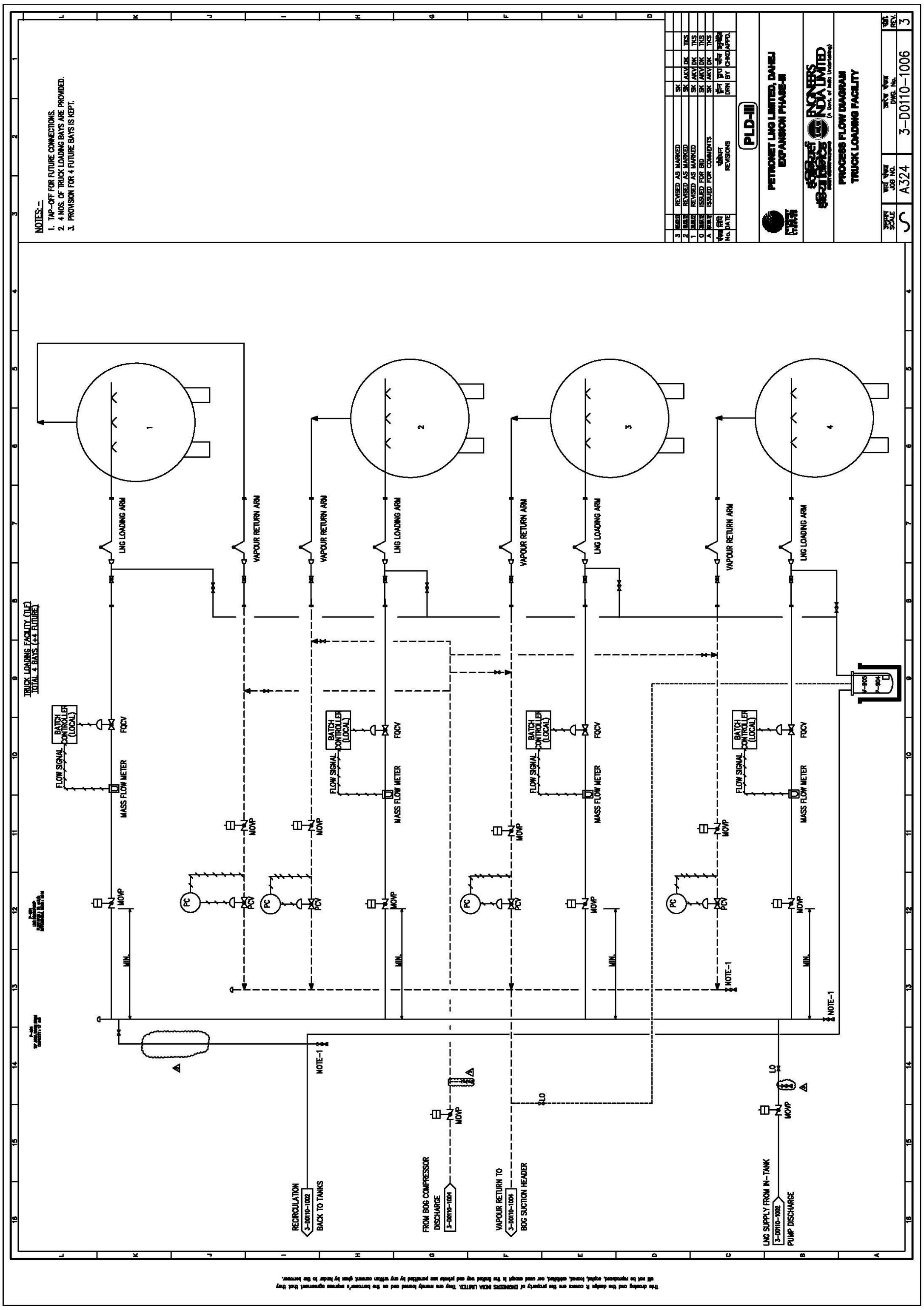


FIGURE-2.5
TRUCK LOADING FACILITY

2.5.6.1 LNG Storage Tanks

The total number of Storage Tanks provided up to Phase-2 are four with cumulative gross Storage Capacity of 640,000m^3. This can accommodate approximately 5 days of delay in ship arrival and 2.5 days of interruption in send out pipeline operation based on the 10 MMTPA terminal capacity.

Further it has been PLL's experience that there have been wide fluctuations in the off–take of RLNG by the off-takers and on many occasions PLL had faced either the tank top situation or the tank empty situation and at time PLL had to encounter the situation of hire floating cargo ships. To account for the delay in ship arrival and fluctuation in the send-out flow rate, for the expanded capacity tow more LNG storage tanks are required.

A further analysis of the existing trend of cost of Storage Tanks vis-à-vis storage capacity indicates that for PLL, at Dahej LNG Terminal, best option could be to go for new tank(s) of gross capacity of about 180,000 cubic meter.

Based on above considerations, it has been decided to consider two additional storage tank of gross capacity 180,000 cubic meter each.

Following berthing, the LNG is pumped ashore via the carrier's pumps through unloading arms to a cryogenic pipeline and on to the storage tanks. For this project, an above-ground, full containment design has been selected. The LNG will be stored near atmospheric pressure and in full-containment LNG tanks that typically consist of the following:

- Primary inside tank - made of a "cryogenic material" such as 9% Nickel steel, aluminium alloy or reinforced pre-stressed concrete; it is now common practice to use 9% Nickel steel for the inner tank in LNG service;
- Insulation – loose insulation material (such as perlite) surrounding the inner nickel steel tank (sides, floor and roof);
- Vapour barrier tank – made of carbon steel to contain the insulation system and vapour pressure of the primary tank;
- Outer tank – reinforced, pre-stressed concrete designed to independently store both the LNG liquid and vapour should the inner wall fail; and,
- Domed roof – reinforced, pre-stressed concrete.
- Base – above ground piles based.

An illustration of typical full containment tank is presented in **Figure-2.6** and LNG receipt and storage facility is shown **Figure-2.7.**

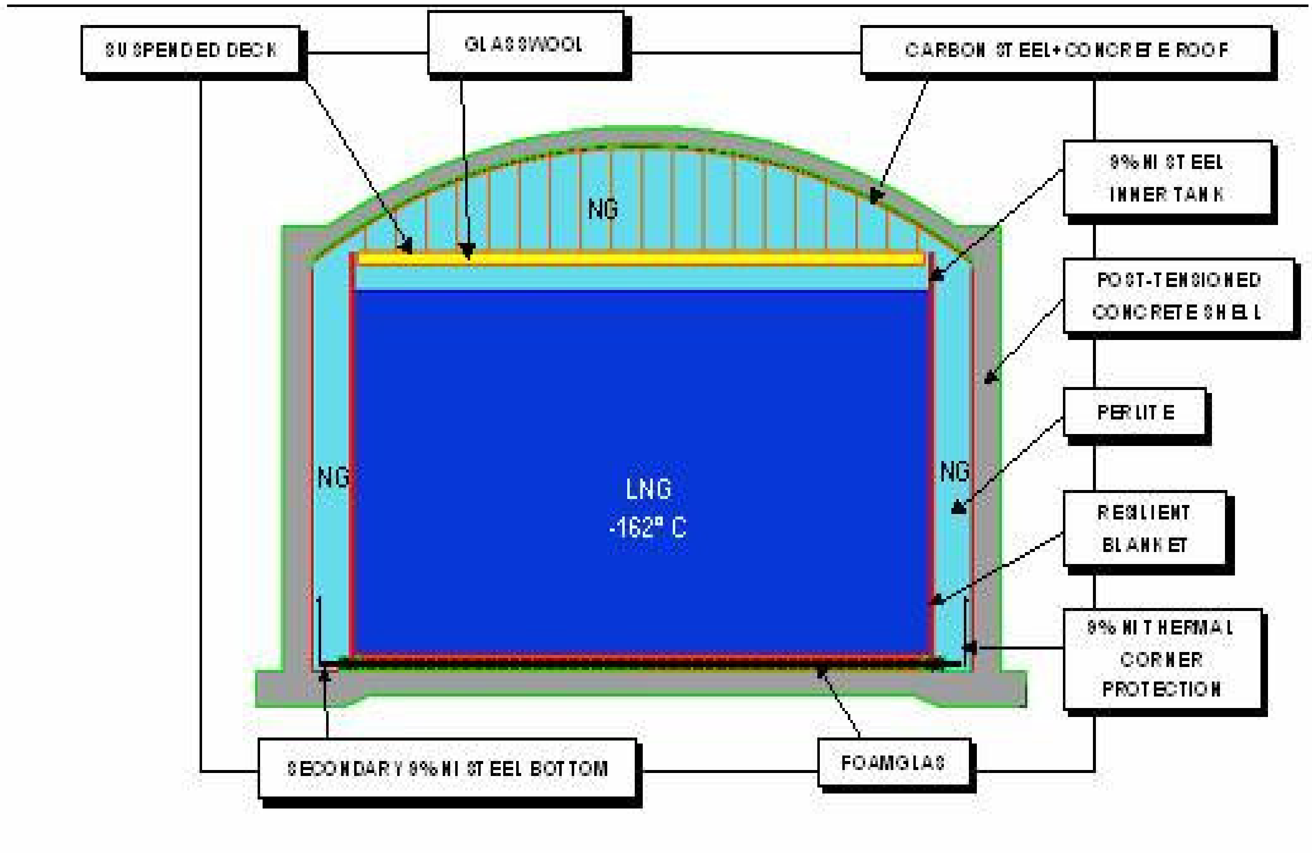


FIGURE-2.6
FULL CONTAINMENT LNG STORAGE TANK

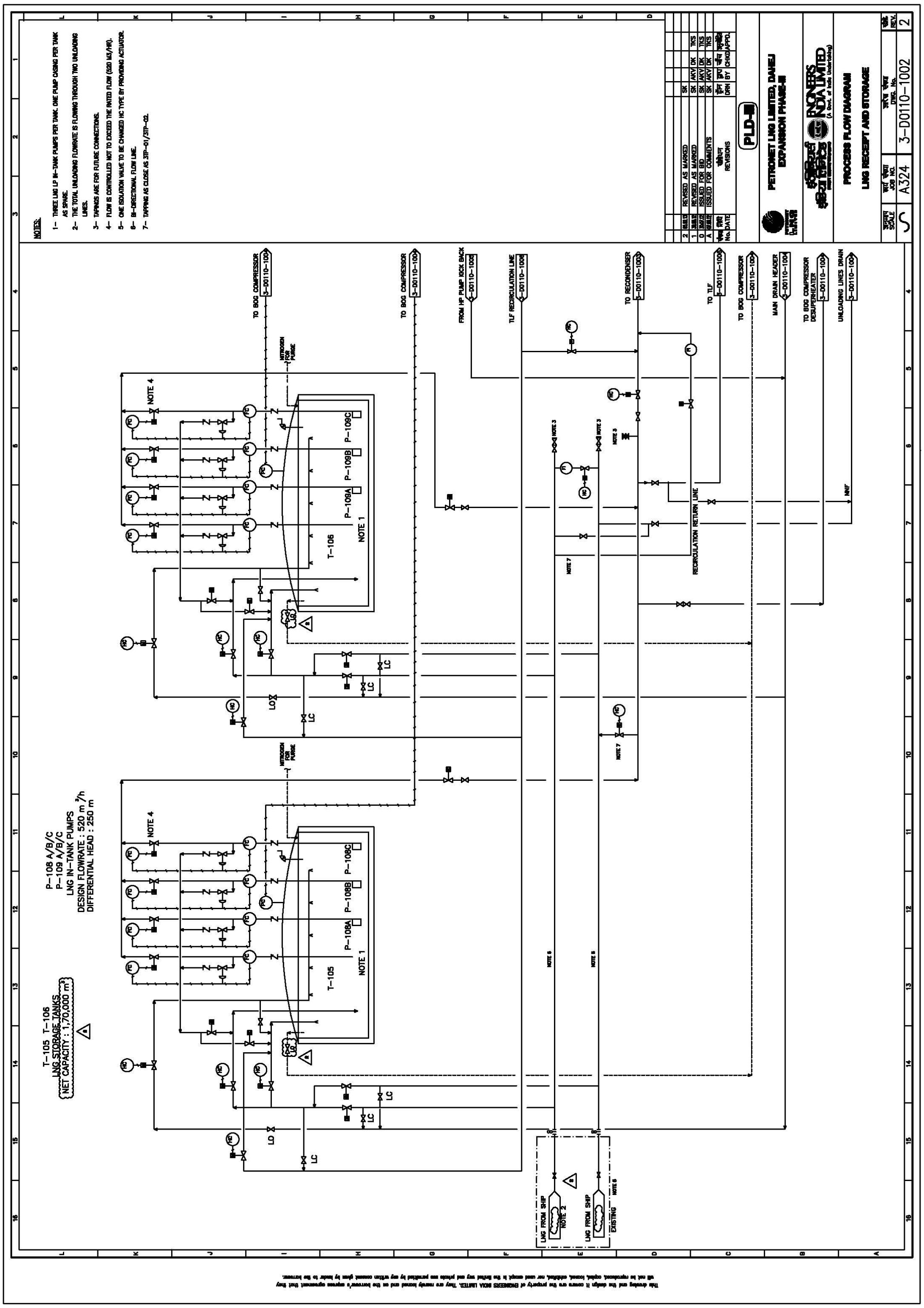


FIGURE-2.7
LNG RECEIPT AND STORAGE FACILITY

LNG tanks are specially designed to contain the LNG at its cryogenic temperature of approximately -162^{0}C near atmospheric pressure. After initial transportation planning, which includes detailed shipping and storage simulation modelling of with regard to LNG volume, minimum inventory, and potential sources of supply and ship sizes, a LNG storage facility comprising four tanks of 180,000 to 200,000 m^3 each is planned.

The LNG tanks have a top entry point for both the loading and unloading operations. Submerged send-out pumps per tank will be suspended from the top of the tank and pump the LNG out of the tanks. All tanks will be designed to simultaneously send out (to the vaporiser units) and to receive LNG (from unloading LNG carriers). The tanks will be fitted with a low-pressure vent, which will provide storage tank overpressure protection if the tank pressure exceeds the maximum operating limit of the LNG storage tank design pressure.

2.5.7 Jetty and Marine

The existing jetty & marine facilities will be utilized for the proposed expansion of LNG terminal. Following are the list of marine facilities existing at LNG Dahej terminal.

- LNG jetty berth (including but not limited to breasting dolphins, mooring dolphins, fenders and catwalks);
- LNG jetty head;
- LNG jetty trestle accommodating pipe rack and access road to the jetty head;
- The mooring hooks and mooring monitoring system;
- Ship berthing system;
- Stand by jetty (under construction)
- The monitoring of meteocean data needed to be available for the ship;
- Any measures to secure the piling of the jetty head, trestle and flare trestle as cathodic protection of piles, etc.;
- Tug berth; and
- Navigational aids.

The jetty shall be designed to accommodate LNG carriers in the size range of 80000 m^3 to 266000 m^3. To accomplish this, the LNG berth will include breasting and mooring dolphins, fender systems, mooring hooks, mooring line tension monitoring system and a LNG carrier docking assistance system.

The second objective of the LNG berth is to provide a platform to support the mechanical equipment required for unloading LNG carriers. The LNG trestle shall provide structural support to the LNG unloading platform for the LNG unloading piping, auxiliary mechanical and utilities, control and electrical systems, and access roadway

2.6 General Criteria for Designing LNG Terminal

2.6.1 LNG Composition Data

LNG will be supplied to the Terminal from the spot market resulting in a wide range of characteristics. The Terminal shall be designed considering the reference LNG composition is given in **Table-2.6**.

TABLE-2.6
LNG COMPOSITIONS

Particulars	Units	Design Case	Check Case N⁰1	Check Case N⁰2
Nitrogen	mol%	0.60	0.37	0.02
Oxygen	mol%	0.00	0.00	0.00
Carbon Dioxide	mol%	0.00	0.00	0.00
Methane	mol%	90.00	86.98	97.21
Ethane	mol%	6.24	9.08	2.49
Propane	mol%	2.19	2.53	0.14
i-Butane	mol%	0.58	0.42	0.09
n-Butane	mol%	0.39	0.62	0.02
i-Pentane		0.01	0.00	0.00
n-Pentane	mol%	0.00	0.00	0.03
Hexane and higher	mol%	0.00	0.00	0.00
Molecular Weight	Kg/kmol	18.02	18.51	16.50
HHV	MJ/kg	53.80	53.81	54.91
LHV	MJ/kg	48.97	49.02	49.85
WOBBE Index (WI)	MJ/kg	68.60	67.70	73.23
Boiling Temperature (BT) (@ 1 bara)	^{0}C	-162.8	-161.7	-161.5
Liquid Density(@ 1 bara & BT)	kg/m^3	463.5	470.8	432.7`

2.7 Vapour Handling Facilities

2.7.1 Designing Vapour Handling Facilities

The vapour handling facilities shall be designed for 10 MMTPA considering the following operating conditions:

- The LNG tank boil-off rate is considered for LNG tanks;
- The design LNG unloading rate is 12750 m^3/h;
- A heat leak of insulating piping of 30 W/m^2 based on external surface of the insulation; and
- The truck loading facilities is fully operated.

2.7.2 Boil-Off Gas Header

A boil-off gas header (low pressure vapour balance line) connects the vapour space of all the LNG storage tanks, the flare, the suction line of the boil-off compressors.

2.7.3 Boil-Off Gas Compressors

BOG compressors are designed considering the design LNG unloading rate (12750 m^3/h), the minimum send-out rate, installed LNG storage tanks and the vapour returned from the LNG trucks at the loading station.

The motors of the BOG compressors shall be sized on the most dense boil-off gas.

The common KO drum located at the suction of the BOG compressors shall be sized for the design BOG rate i.e. considering three compressors in operation.

An in-line desuperheater is provided in the main suction line to maintain the compressors inlet temperature lower than minus 80°C; it shall be designed for three compressors in operation.

2.7.4 BOG Recondenser

Excess vapour generated during LNG unloading into the LNG storage tanks and boil-off gas generated in normal operation are compressed by the boil-off compressors and condensed in sub cooled LNG delivered by the low pressure LNG pumps in a vessel so-called BOG recondenser.

The BOG recondenser has two sections

- The upper section is a packed tower for mixing gas and LNG resulting in the gas to be condensed; and
- The lower section is as buffer vessel for feeding LNG to the high pressure LNG pumps with a net positive suction head (NPSH) above the minimum value required by the HP pump manufacturer.

The LNG required for condensing the vapour is delivered into the upper section of the BOG recondenser while the balanced LNG send-out is flowing directly to the lower section of the BOG recondenser; the LNG coming out from the BOG recondenser is so sub-cooled and provides a medium suitable for being pumped by the high pressure LNG pumps (a safety margin of minimum 2°C below the saturation temperature of the BOG recondenser out-coming LNG shall be considered).

The BOG recondenser shall be designed for the duty envisaged in different operating modes.

2.7.5 Low Pressure LNG Pumps

LP Pump Flow Rate

The LP pumps are designed considering the peak send-out rates
- 5 MMTPA : 685ton/h
- 10 MMTPA : 1370ton/h

All the LP pumps are identical and shall be designed to comply with the above 10 MMTPA LNG flow rate.

2.7.6 High Pressure LNG Pumps

- *HP Pump Flow Rate*

Design of All the HP pumps will be identical. Design of HP pumps will meet conditions given in **Table-2.7.**

TABLE-2.7
DESIGN OF HP PUMPS

Phase	Nominal Send-Out (MTPA)	Peak Send-Out (MTPA)
1	5.0	6.0
2	10.0	12.0

2.7.7 LNG Vaporisers (STV)

LNG will be vaporized in shell and tube type vaporizer (STV) with LNG on the tube side and an ethylene glycol water mixture on the shell side. STV flow rate shall be designed to meet conditions given in **Table-2.8**.

TABLE-2.8
STV FLOW RATE

Phase	Nominal Send-Out (MTPA)	Peak Send-Out (MTPA)
1	5.0	6.0
2	10.0	12.0

- An ethylene glycol water mixture is used as heating medium.
- The ethylene glycol water is heated with air fans.

The atmospheric air conditions are:

- Air temperature: 15°C min. design
  40°C max. design
- Air humidity : 85% design
  95% max.
  0% min.

2.7.8 Metering Station

The metering station, equipped with custody transfer meters, shall be implemented with several metering lines in parallel including, each one, one ultra-sonic type flow meter.

A fiscal metering is required with a gas chromatograph on-line analysis of exported gas from each metering run. In 5 MMTPA, (2+1 spare) metering lines in parallel shall be implemented, each one being capable of 50% of the peak send-out (5+20% MTPA). In 10 MMTPA, (4+1 spare) metering lines in parallel shall be implemented, each one being capable of 50% of the peak send-out (10+20% MTPA).

2.7.9 LNG Truck Loading Station

- A LNG truck loading station shall be implemented consisting in 4 truck loading bays having common weighbridge;
- Each loading bay shall be designed to export 50 m^3/h LNG; and
- The total BOG from the LNG truck loading station (4 bays) will be designed at 3,000 m^3 (n)/h.

2.8 Coastal Regulation Zone (CRZ)

Based on the perusal of the CRZ Notification along with the subsequent amendments, the CZMP of the Bharuch district and the HTL/LTL survey carried out for the project area, the following can be inferred:

- Along the Dahej coast, the stretch in which the Petronet LNG jetty is developed is categorised as CRZ III. The coastal stretch towards north and south of Petronet LNG jetty is also categorised as CRZ III;

- Further, the categorisation of the coastal stretch under CRZ III indicates that the area is rural in nature and developed; and

- As development of Petronet LNG jetty requires waterfront and foreshore facilities, it is a permissible activity under the CRZ notification.

- As per the CRZMA notification 2011, the proposed expansion of LNG terminal project is a permitted activity within CRZ-1 zone.

No ecological sensitive areas such as marine sanctuary, mangroves and national parks etc are present in the study region. The CRZ map of the project site and study area is shown in **Figure-2.8**.

2.9 Sources of Pollution

The various types of pollutions likely to be genrated by the proposed LNG terminal, which can be broadly classified into the following categories which are given in **Table-2.9**.

TABLE-2.9
SOURCES OF POLLUTION

Sr. No	Type of Pollution	Source of Pollution
1	Air pollution	- No_x from proposed GTG's
2	Water & Sewage pollution	- Domestic Sewage
3	Noise Pollution	- Pumps and compressors

- ***Pollution Monitoring and Control Measures***

A Brownfield project of the proposed scale is bound to exert certain adverse as well as beneficial impacts on the immediate surroundings. Primary impact on environment due to installation of a LNG terminal comes from the combustion of gas.

Environmental Management Plant (EMP) is proposed to be established for the LNG terminal to detail out the environmental quality measures to be undertaken during the construction and operational phases. EMP will also discuss the post project monitoring measures to be adopted by the LNG terminal authorities in order to maintain the effluent qualities within the acceptable limits specified by the Gujarat State Pollution Control Board (GSPCB) and the Ministry of Environmental & Forests (MoEF).

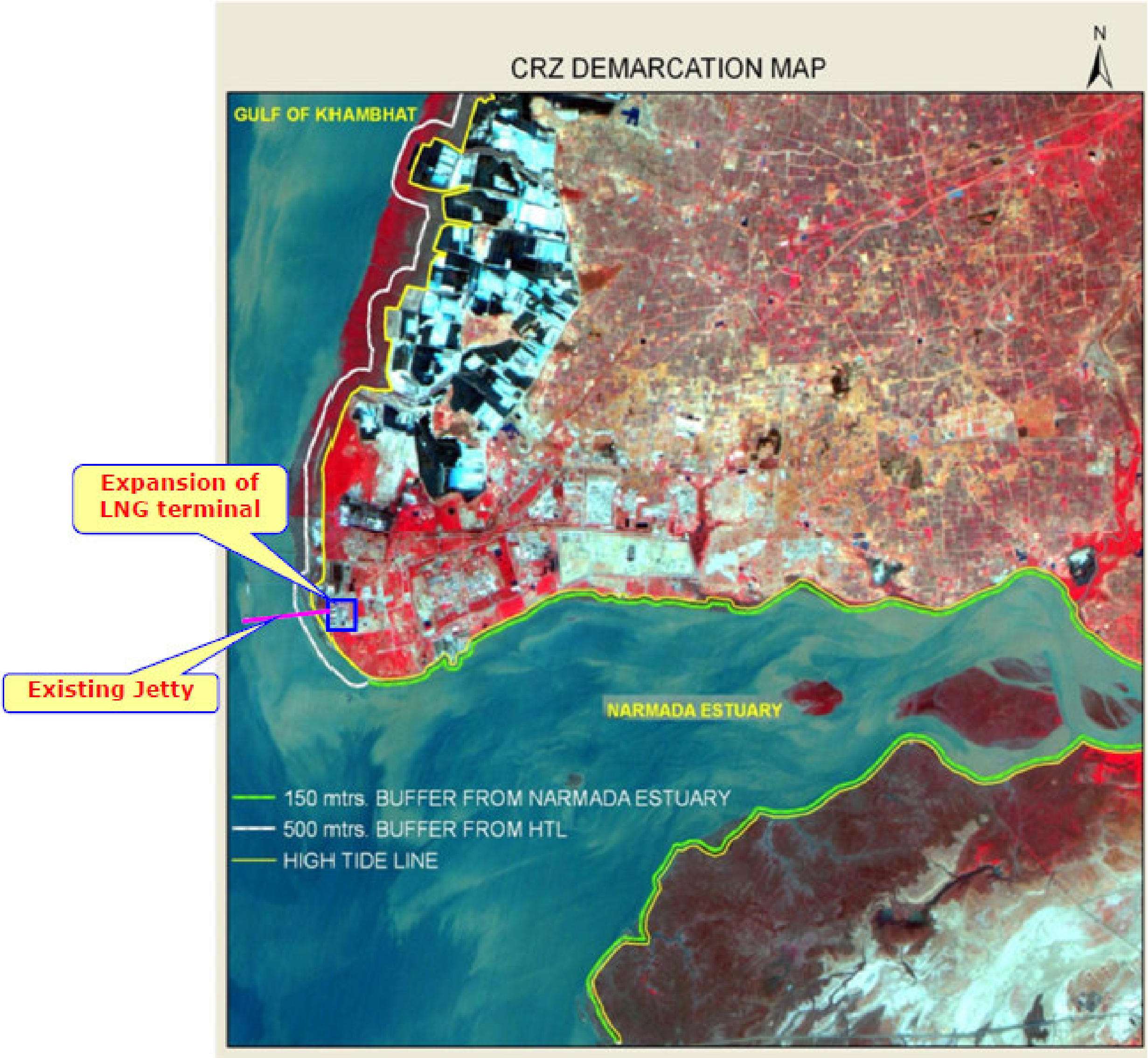


FIGURE-2.8
CRZ MAP OF PROJECT AREA

The environmental monitoring programme will be provided with trained and qualified staff who will monitor the ambient air as well as stack flue gas quality to ensure that the quality of effluents are maintained within the permissible limit. The main stack will be provided with portable monitors to periodically monitor the PM, CO, NOx and SOx constituents in the flue gas on daily basis.

The environmental standards as prescribed by the Ministry of Environment & Forests (MoEF) and Indian Pollution Control Authorities will be implemented. The pollution control measures proposed to be adopted for the project are summarized as follows:

2.9.1 Air Pollution Management

LNG regasification and storage is a clean process and essentially there is no emission from this process. There will be a small emission from the operation of GTGs and flare. The GTGs are run by the natural gas only and hence the emissions are small in terms of SO_2 and SPM. NOx is only significant pollutant emitted under this condition.

2.9.2 Water Pollution Management

There is no generation of any liquid effluent from the process area. Existing facilities are adequate to handle additional domestic waste water.

2.9.3 Noise Pollution

Pumps and compressors are the high noise generating equipments in the proposed LNG terminal. However, impacts on the working personnel are not expected to be significant on account of the high level of automation of the LNG terminal, which means that workers will be exposed for short duration only and that too intermittently.

The noise generation during operational phase would be restricted at source itself through different measures such as inspection, operation and maintenance at regular intervals. All equipments will be designed for < 80 dB sound level at 1 meter. The noise control measures as described in EMP will be fully followed. The occupational noise exposure to the workers in the form of 8-hourly time weighted average will be maintained well within the prescribed OSHA standards (<90 dB (A)). Hence, the impact on occupational health of workers would be insignificant.

2.9.4 Solid Waste Management

On a regular basis, there is no generation of any non-hazardous or inert solid waste from the proposed LNG terminal. A small quantity i.e. about 0.5 KL/year of hazardous oily waste will be generated from the proposed LNG terminal expansion during periodic maintenance. Hazardous waste will be collected and stored at specific identified area at site. Authorized agency will be hired to dispose the collected Hazardous waste.

2.9.5 Afforestation and Green Belt Development

Extensive afforestation at LNG terminal area is planned which would not only act as lung space in the area but would also improve aesthetics and will be continued in all available space.

3.0 BASELINE ENVIRONMENTAL STATUS

3.1 Introduction

This chapter illustrates the description of the existing environmental status of the study area with reference to the prominent environmental attributes. The study area covers 10-km radius area from the boundary of the LNG handling facilites.

As part of the study, description of biological environment and human environment such as environmental settings, demography & socio-economics, land-use/land cover, ecology & biodiversity have been carried out for entire 10-km radius. The study of physical environmental attributes such as ambient air quality, water quality, soil quality, noise levels, physiography, hydrology, odour, solid waste generation have been studied at selective locations representing various land uses such as industrial, rural/residential, commercial and sensitive locations including the densely populated areas, agricultural lands, forest lands and other ecologically sensitive areas, if any falling within 10-km radius study area.

The existing environmental setting is considered to adjudge the baseline environmental conditions, which are described with respect to climate, hydro-geological aspects, atmospheric conditions, noise levels, water quality, soil quality, ecology (aquatic and terrestrial), land use and socio-economic profiles of people.

A regional background to the baseline data is being presented at the very outset, which will help in better appreciation of micro-level field data generated on several environmental and ecological attributes of the study.

This comprehensive report incorporates the baseline studies were carried out for three seasons covering winter 2011-2012, pre-monsoon and post-monsoon for 2012 in the various domains of environment.

The primary baseline monitoring consists of meteorology, ambient air quality, noise levels, water quality, soil quality and ecology (aquatic and terrestrial). The land use, geology, hydrogeology, demography is based on the secondary data collected from various Government and Semi-Government organizations.

3.2 Geology and Hydrogeology of the Region

3.2.1 Physiography

The study region lies between $21^0$40’17.66” North latitude and $72^0$32’21.13” East longitudes.

The geographical area of the study region falls under Vagra Taluka, Bharuch District of Gujarat. The project site is surrounded by Gulf of Khambhat on west side and followed by Narmada River on East side.

3.2.2 Geology and Hydrogeology

The geology of the present study area broadly falls in Quaternary age consisting of recent alluvial formations. In geologic time, the Quaternary Period (also termed the Anthropogenic Period), the second geologic period in the Cenozoic Era, spans the time between roughly 2.6 million years ago (mya) and present day. On the geologic time scale, Earth is currently in the Quaternary Period of the Cenozoic Era of the Phanerozoic Eon.

During the Quaternary Period, Earth's continents assumed their modern configuration. The fluctuating climatic conditions during both the Tertiary and Quaternary Periods brought about sweeping changes in the landscape evident in modern topographical features.

As the area falls in Gulf of Cambay, the geology of Gulf of Cambay and also the study area is discussed below.

The Gulf of Khambhat is a South to North penetration of the Arabian Sea on the western shell of India between the Saurashtra peninsula and mainland Gujarat. At its Northern end between the Sabarmati and mahi mouths, the Gulf is barely 5 km wide and it opens out south ward like a funnel, reaching its maximum width south of Gopnath point. Its north-south length is approximately 115 km. The gulf is intercepted by several inlets of sea and creeks formed by confluence of major rivers such as Narmada, Tapi, Mahi, Sabarmati, and Shetrunji etc. All the major rivers carry heavy load of suspended sediments into the Gulf.

Thick coastal sediments occupied the entire northern Gulf and eastern coast of Southern Gulp. Bhavnagar district bears Deccan Traps, while alluvium covered most part of Ahmedabad, Kheda, Anand, Baroda, Bharuch and Surat districts. Pleistocene sediments are confined only to Mahuva region.

The local geology of the study area is consisting of coastal alluvium of fine sand and clay. The hydrogeology of the area is a typical alluvial coastal area with high salinity and shallow water tables in the area. The shallow and unconfined aquifers are alluvium with fine clay and silty sand at the top, the movement of groundwater is very slow and prone to very shallow water levels especially in monsoon and prone to water logging. In addition, to the high tide covers all the area, the groundwater very quickly turns saline even in monsoon.

3.3 Land Use Studies

Studies on land use aspects of eco-system play an important role in identifying sensitive issues and taking appropriate actions by maintaining 'Ecological Homeostatic' for development of the region.

3.3.1 Objectives

The objectives of land use studies are:

- Establishment of the existing land use pattern;

- Assessment of the likely impacts due to the proposed project on the land use pattern of the study area; and
- Making recommendations for optimizing the future land use pattern after the project in the study area.

The land use pattern of study area has been studied based on the review of secondary data provided in the 2001 District Census Handbook of Bharuch district of Gujarat State.

3.3.2 Methodology

For the study of land use, literature review of various secondary sources such as District Census Handbooks, regional maps regarding topography, zoning settlement, industry, forest etc were taken. The data was collected from various sources like District Census Handbook (2001), Revenue records, state and central government offices and Survey of India (SOI) Toposheets and also through primary field surveys.

3.3.3 Land use Based on Secondary Data

Based on the census report, 10-km radial distance around proposed project area has been considered in the study. These areas were studied in detail to get the idea of land use pattern in the study area. The land use pattern of the study area is given in **Table-3.3.1** and in detail presented in **Annexure-VI**.

TABLE-3.3.1
LAND USE PATTERN IN THE STUDY AREA

Sr. No	Particulars of Landuse	0-3 km	3-7 km	7-10 km	0-10 km	Area %
1	Forest Land	0	0	0	0	0.0
2	Land under Cultivation					
	a) Irrigation Land	0	0	0	0	0.0
	b) Un Irrigated Land	1018.82	114.11	1087.25	2220	19.1
3	Cultivable Waste Land	212.92	26.63	369	609	5.2
4	Area not Available for Cultivation	722.03	1890.38	6174.27	8787	75.6
	Total Area	**1954**	**2031**	**7631**	**11615**	**100.0**

Note: All values except Percentages are given in Ha; Source: Distric Census Handbook – Baruch District

- ***Land under Cultivation***

The Un-irrigated land covers 2220.18 ha in the study area which is about to be 19.1% of the total land. No irrigated land is found in the study area.

- ***Cultivable Waste***

This category of land mainly consists of the lands suitable for cultivation, which however have not been brought under cultivation at any time. The area under this category works out to be 609 ha i.e. 5.2 % of the general study area.

- ***Land not available for Cultivation***

The areas not covered under any of the above categories of land uses as well as land covered under urban population forms this type of land use. Altogether 8787 ha (75.6%) area in the general study area is classified under this category.

3.4 Soil Characteristics

It is essential to determine the potential of soil in the area and identify the impacts of urbanization and industrialization on soil quality. Accordingly, a study of assessment of the soil quality has been carried out.

3.4.1 Data Generation

For studying soil profile of the region, sampling locations were selected to assess the existing soil conditions in and around the project area representing various land use conditions. The physical, chemical and heavy metal concentrations were determined. The samples were collected by ramming a core-cutter into the soil upto a depth of 90 cm. A total of eight samples within the study area were collected and analyzed. The details of the soil sampling locations are given in **Table-3.4.1** and are shown in **Figure-3.4.1**. The sampling has been carried out once in the each seasons representing winter season for 2011–2012, pre monsoon and post monsoon season for 2012.

TABLE-3.4.1
DETAILS OF SOIL SAMPLING LOCATIONS

Code	Location	Bearing w.r.t Proposed Project	Distance (km) w.r.t Proposed Project Site
S1	Project Site	--	--
S2	Lakhigam Village	NNE	2.9
S3	Near Dahej	NNE	5.8
S4	Ambetha Village	ENE	6.2
S5	Jageshwar Village	ENE	3.6
S6	Luvara Village	E	1.5
S7	SE of Project Site	SE	1.5
S8	Near Aliabet Village	ESE	9.5

Source: Vimta Labs Limited

The soil quality at all the locations during the study period is given in **Table-3.4.2.** The results are compared with standard classification given in **Table-3.4.3.**

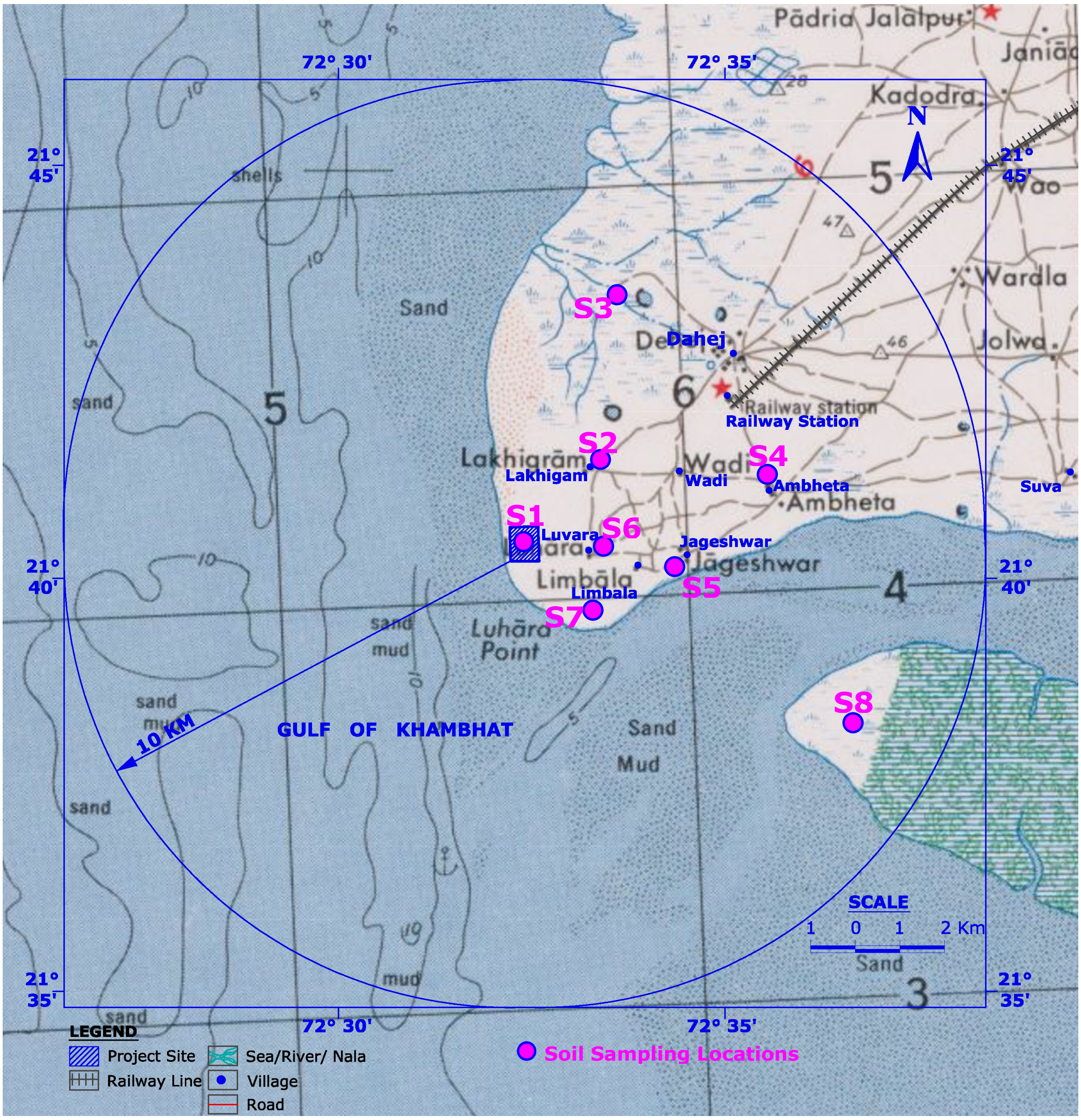


FIGURE-3.4.1
SOIL SAMPLING LOCATIONS

3.4.2 Baseline Soil Status

Winter Season (December 2011 to February 2012)

- It has been observed that the texture of soil is mostly Sandy clay to Sandy clay loam in the study area. The pH of the soil indicating that is slightly alkaline in nature.

- The Electrical conductivity was recorded as 270 µS/cm to 980 µS/cm. Minimum concentration was observed at Jageshwar village (S5) and maximum concentration at near Aliabet village (S8) during the study period.

- The Organic Carbon content in the study area observed as 0.32 % to 0.90 %, which the soil falls under less to sufficient category.

- Available potassium was observed as minimum 184.2 Kg/ha at Dahej village (S3) and maximum observed as 526.2 Kg/ha at at near Aliabet village (S8) indicating that the soil falls under medium to morethan sufficient category.

- Available Nitrogen was observed as 64 Kg/ha to 195 kg/ha. Minimum concentration is observed at Project Site (S1) and the maximum observed concentration observed at near Dahej village (S3) location. Based on the above values the soil falls under less to better category.

- Available phosphorous was observed as 66 kg/ha to 90 kg/ha in the study region. The minimum value observed at Project Site (S1) location and the maximum was observed at near Dahej village (S3) location. It shows the soil falls under sufficient to more than sufficient category.

Pre-monsoon Season (March to May - 2012)

- It has been observed that the texture of soil is mostly Sandy clay in the study area. The pH of the soil indicating that is slightly alkaline in nature.

- The Electrical conductivity was recorded as 312 µS/cm to 960 µS/cm. Minimum concentration was observed at Jageshwar village (S5) and maximum concentration at near Aliabet village (S8) during the study period.

- The Organic Carbon content in the study area observed as 0.42 % to 0.82 %, which the soil falls under medium to sufficient category.

- Available potassium was observed as minimum 196 kg/ha at Dahej village (S3) and maximum observed as 536.4 kg/ha at near Aliabet village (S8) indicating that the soil falls under medium to more than sufficient category.

- Available Nitrogen was observed as 58 kg/ha to 182 kg/ha. Minimum concentration is observed at Project site (S1) and the maximum observed concentration observed at near Dahej village (S3) location. Based on the above values the soil falls under less to better category.

- Available phosphorous was observed as 63 kg/ha to 84 kg/ha in the study region. The minimum value observed at near Aliabet village (S8) location and the maximum was observed at near Ambetha and Ambetha villages (S4 and S5) location. It shows the soil falls under an average sufficient to more than sufficient category.

Post-monsoon Season (October to November - 2012)

- It has been observed that the texture of soil is mostly Sandy clay to Sandy clay loam in the study area. The pH of the soil indicating that is slightly alkaline in nature.

- The Electrical conductivity was recorded as 325 μS/cm to 965 μS/cm. Minimum concentration was observed at Jageshwar village (S5) and maximum concentration at near Ambheta village (S4) during the study period.

- The Organic Carbon content in the study area observed as 0.29 % to 0.80 %, which the soil falls under less to on an avg. sufficient category.

- Available potassium was observed as minimum 216.1 Kg/ha at Dahej village (S3) and maximum observed as 614.0 Kg/ha at at near Aliabet village (S8) indicating that the soil falls under medium to more than sufficient category.

- Available Nitrogen was observed as 62 Kg/ha to 215 kg/ha. Minimum concentration is observed at near Aliabet village (S8) and the maximum observed concentration observed at near Dahej village (S3) location. Based on the above values the soil falls under very less to better category.

- Available phosphorous was observed as 53 kg/ha to 98 kg/ha in the study region. The minimum value observed at Project Site (S1) location and the maximum was observed at near Dahej village (S3) location. It shows the soil falls under on an average sufficient to more than sufficient category.

TABLE 3.4.2(A)
SOIL ANALYSIS RESULTS-WINTER SEASON (DECEMBER 2011 TO FEBRUARY 2012)

Sr.No.	Location	Unit	S1	S2	S3	S4	S5	S6	S7	S8
1	pH	--	7.5	7.6	7.6	7.5	7.4	7.6	7.5	7.4
2	Conductivity	µS/cm	481	451	601	891	270	922	364	980
3	Texture	--	Sandy Clay	Sandy Clay	Sandy Clay	Sandy Clay Loam	Sandy Clay	Sandy Clay	Sandy Clay	Sandy Clay Loam
4	Sand	%	52	48	50	34	49	52	50	32
5	Silt	%	11	10	14	32	15	10	15	38
6	Clay	%	37	42	36	34	36	38	35	30
7	Bulk Density	g/cc	1.1	1.2	1.2	1.3	1.1	1.2	1.2	1.1
8	Exchangeable Calcium as Ca	mg/kg	6953	5165	6399	4989	6759	6214	5726	5468
9	Exchangeable Magnesium as Mg	mg/kg	729	864	629	575	1013	609	928	593
10	Exchangeable Sodium as Na	mg/kg	252.3	191.4	264.0	202.3	172.6	299.2	204.9	386.6
11	Available Potassium as K	kg/ha	192.6	224.6	184.2	454.2	212.4	332.6	267.2	526.2
12	Available Phosphorous as P	kg/ha	66	86	90	80	76	88	77.8	68
13	Available Nitrogen as N	kg/ha	64	158	195	94	99	148	82	68
14	Organic Matter	%	0.96	1.48	1.55	0.88	0.85	1.38	0.56	0.92
15	Organic Carbon	%	0.56	0.86	0.90	0.51	0.50	0.80	0.32	0.54
16	Water soluble chloride as Cl	mg/kg	384	192	450	710	290	673	318	1623
17	Water soluble sulphates as SO_4	mg/kg	46	86	164	84	88	74	62.1	180
18	Sodium Absorption Ratio	--	0.35	0.29	0.38	0.32	0.23	0.43	0.30	0.59
19	Aluminium	%	1.88	1.97	1.75	3.39	3.56	1.98	1.67	3.54
20	Total Iron	%	3.17	3.50	2.20	3.84	3.92	3.27	2.74	4.11
21	Manganese	mg/kg	375	360	312	412	374	356	257	428
22	Boron	mg/kg	19.7	20.2	15.1	41.5	26.1	26.1	15.6	31.8
23	Zinc	mg/kg	48.7	82.2	76.2	94.8	80.1	182.5	54.1	86.6

TABLE 3.4.2(B)
SOIL ANALYSIS RESULTS – PRE-MONSOON SEASON (MARCH TO MAY 2012)

Sr.No.	Location	Unit	S1	S2	S3	S4	S5	S6	S7	S8
1	pH	--	7.4	7.6	7.5	7.4	7.6	7.5	7.4	7.5
2	Conductivity	µS/cm	448	492	624	922	312	874	382	960
3	Texture	--	Sandy Clay	Sandy Clay	Sandy Clay	Sandy Clay Loam	Sandy Clay	Sandy Clay	Sandy Clay	Sandy Clay Loam
4	Sand	%	48	51	52	36	47	50	52	34
5	Silt	%	12	12	13	34	15	11	12	37
6	Clay	%	40	37	35	30	39	39	36	29
7	Bulk Density	g/cc	1.0	1.1	1.2	1.1	1.2	1.1	1.0	1.0
8	Exchangeable Calcium as Ca	mg/kg	6754	5024	6482	5074	6654	6042	5874	5568
9	Exchangeable Magnesium as Mg	mg/kg	704	794	652	546	986	592	904	618
10	Exchangeable Sodium as Na	mg/kg	268.6	204.6	272	218.6	186.4	309.4	218.2	372.4
11	Available Potassium as K	kg/ha	224.2	232.4	196	472.4	244.8	348.6	274.8	536.4
12	Available Phosphorous as P	kg/ha	72	78	82	84	84	82	75.4	63
13	Available Nitrogen as N	kg/ha	58	144	182	92	92	132	86	72
14	Organic Matter	%	0.89	1.27	1.41	0.78	0.92	1.20	0.72	0.75
15	Organic Carbon	%	0.52	0.74	0.82	0.48	0.54	0.70	0.42	0.44
16	Water soluble chloride as Cl	mg/kg	362	184	426	684	276	622	304	1562
17	Water soluble sulphates as SO_4	mg/kg	42	80	158	78	82	68	64.2	162
18	Sodium Absorption Ratio	--	0.37	0.31	0.38	0.32	0.25	0.45	0.30	0.56
19	Aluminium	%	1.72	1.86	1.82	3.42	3.68	1.88	1.74	3.42
20	Total Iron	%	2.92	3.26	2.54	3.74	3.82	3.18	2.78	3.94
21	Manganese	mg/kg	360	472	324	374	436	432	282	418
22	Boron	mg/kg	17.6	23.4	18.4	38.6	27.2	28.6	17.2	28.3
23	Zinc	mg/kg	52.6	74.8	71.4	97.4	83.4	194.4	58.6	82.4

TABLE 3.4.2(C)
SOIL ANALYSIS RESULTS – POST-MONSOON SEASON (OCTOBER TO NOVEMBER 2012)

Sr.No.	Location	Unit	S1	S2	S3	S4	S5	S6	S7	S8
1	pH	--	7.6	7.8	7.8	7.6	7.7	7.7	7.7	7.6
2	Conductivity	µS/cm	520	540	655	965	325	810	435	932
3	Texture	--	Sandy Clay	Sandy Clay	Sandy Clay	Sandy Clay loam	Sandy Clay	Sandy Clay	Sandy Clay	Sandy Clay loam
4	Sand	%	48	51	47	30	52	47	46	29
5	Silt	%	14	08	11	28	13	08	13	26
6	Clay	%	38	41	42	42	35	45	41	45
7	Bulk Density	g/cc	1.0	1.1	1.1	1.2	1.0	1.1	1.1	1.2
8	Exchangeable Calcium as Ca	mg/kg	7120	6190	7320	5190	7196	7024	6114	6124
9	Exchangeable Magnesium as Mg	mg/kg	898	1025	759	698	1125	725	1094	695
10	Exchangeable Sodium as Na	mg/kg	345	245.6	335.9	186.9	215.4	210.9	194	560
11	Available Potassium as K	kg/ha	243.0	312.9	216.1	530	295	416.3	319.2	614.0
12	Available Phosphorous as P	kg/ha	53	75	98	89	94	96	82	74
13	Available Nitrogen as N	kg/ha	71.0	164	215	104	88	136	78	62
14	Organic Matter	%	0.52	0.39	1.26	0.86	0.82	1.04	0.82	0.65
15	Organic Carbon	%	0.29	0.80	0.72	0.49	0.47	0.59	0.47	0.37
16	Water soluble chloride as Cl	mg/kg	415	165	540	664	329	715	422	812
17	Water soluble sulphates as SO_4	mg/kg	53	97	173	92	94	78.0	69.3	196
18	Sodium Absorption Ratio	--	0.46	0.34	0.45	0.29	0.28	0.29	0.27	0.81
19	Aluminium	%	1.21	1.09	1.33	2.67	2.02	1.07	1.26	3.65
20	Total Iron	%	2.69	3.10	2.06	3.39	4.12	4.23	2.96	3.86
21	Manganese	mg/kg	428	445	396	320	489	438	315	512.9
22	Boron	mg/kg	26.1	23.9	18.4	33.9	30.8	34.3	18.4	28.6
23	Zinc	mg/kg	53.9	91.0	82.3	105.6	86.3	193.9	63.4	81.7

TABLE-3.4.3
STANDARD SOIL CLASSIFICATION

Sr. No.	Soil Test	Classification
1	pH	<4.5 Extremely acidic 4.51- 5.50 Very strongly acidic 5.51-6.00 Moderately acidic 6.01-6.50 Slightly acidic 6.51-7.30 Neutral 7.31-7.80 Slightly alkaline 7.81-8.50 Moderately alkaline 8.51-9.00 Strongly alkaline >9.00 Very strongly alkaline
2	Salinity Electrical Conductivity (ppm) (1 ppm =640µmho/cm)	Upto 1.00 Average 1.01-2.00 harmful to germination 2.01-3.00 Harmful to crops (sensitive to salts)
3	Organic Carbon	Upto 0.20: Very less 0.21-0.40: Less 0.41-0.50: Medium, 0.51-0.80: On an avg. sufficient 0.81-1.00: Sufficient >1.00 : More than sufficient
4	Nitrogen (Kg/ha)	Upto 50 Very less 51-100 Less 101-150 Good 151-300 Better >300 Sufficient
5	Phosphorus (Kg/ha)	Upto 15 Very less 16-30 Less 31-50 Medium, 51-65 On an avg. sufficient 66-80 Sufficient >80 More than sufficient
6	Potash (Kg/ha)	0 -120 Very less 120-180 Less 181-240 Medium 241-300 Average 301-360 Better >360 More than sufficient

Source: Hand Book of Agriculture, ICAR, New Delhi

3.5 Meteorology

The meteorological data recorded during the monitoring period is very useful for proper interpretation of the baseline information as well as for input prediction models for air quality dispersion. Historical data on meteorological parameters will also play an important role in identifying the general meteorological regime of the region.

The year may broadly be divided into four seasons:

- Winter season : December to February
- Pre-monsoon season : March to May
- Monsoon season : June to September
- Post-monsoon season : October to November

On-site monitoring was undertaken for various meteorological variables in order to generate the site-specific data. The meteorological station was installed over top of a residential house near to the project site and data was recorded every hour continuously from December 2011 to February 2012 representing winter season, March to May 2012 for pre monsoon season and October to November 2012 for post monsoon season. The generated data are then compared with the meteorological data generated by nearest India Meteorological Department (IMD) station located at Surat. The available meteorological data of IMD, Surat station was collected and analyzed.

3.5.1 Meteorological Data Generated at Site

The meteorological parameters were recorded on hourly basis during the study period and comprises of parameters like wind speed, wind direction (from 0 to 360 degrees), temperature, relative humidity, atmospheric pressure, rainfall and cloud cover. The maximum, minimum and average values for all the parameters except wind speed and direction are presented in **Table-3.5.1**.

3.5.2 Secondary Data Collected from IMD Surat

Secondary information on meteorological conditions has been collected from the nearest IMD station at Surat. The available meteorological data of IMD, Surat has been collected for the period 1999-2009 and analyzed.

3.5.2.1 Meteorological data

The meteorological data is collected from the IMD includes wind speed, wind direction (recorded in sixteen directions), temperature, relative humidity, atmospheric pressure; rainfall and cloud cover over a period of 10 years (1999 to 2009). The monthly maximum, minimum and average values are collected for all the parameters except wind speed and direction. All these parameters are recorded twice a day viz at 0830 and 1730 hours. The collected data is tabulated in **Table-3.5.2**.

TABLE-3.5.1
SUMMARY OF THE METEOROLOGICAL DATA GENERATED AT PROJECT SITE

Month	Temperature (^0C)		Relative Humidity (%)		Rainfall (mm)	Atmospheric Pressure (mb)	
	Max.	Min.	Max.	Min.		Max.	Min.
Winter season 2011-2012							
December, 2011	32.4	16.0	68	45	-	1015.1	1011.7
January, 2012	31.2	15.9	67	42	-	1014.8	1011.5
February, 2012	34.6	19.1	65	36	-	1013.1	1010.4
Range	**16.0-34.6**		**36-68**		**-**	**1010.4-1015.1**	
Pre-monsoon season 2012							
March, 2012	35.3	23.1	68	35	-	1009.6	1006.8
April, 2012	39.8	25.1	69	44	-	1006.2	1003.9
May, 2012	40.3	26.3	72	52	-	1005.7	1003.2
Range	**23.1-40.3**		**35-72**		-	**1003.2-1009.6**	
Post-monsoon season 2012							
October, 2012	35.1	24.3	79.2	56.4	-	1012.3	1010.6
November, 2012	32.6	20.2	68.9	45.7	-	1015.1	1011.4
Range	**20.2-35.1**		***45.7-79.2***		**-**	***1010.6-1015.1***	

TABLE-3.5.2
CLIMATOLOGICAL DATA-STATION: IMD – SURAT (1999-2009)

Month	Temperature (^0C)		Relative Humidity (%)		Rainfall (mm)
	Max	Min	08:30 hr	17:30 hr	
January	30.1	17.1	67.4	39.2	6.4
February	31.9	18.8	65.1	34.1	9.3
March	34.6	21.9	62.3	32.8	5.3
April	36.5	24.3	68.0	42.5	15
May	37.2	25.9	71.3	60.5	45.8
June	33.7	24.4	79.1	70.3	307.1
July	31.0	23.8	84.2	78.1	339
August	30.2	23.3	86.6	79.3	269.3
September	31.5	23.2	84.4	70.1	154.5
October	32.2	21.8	76.7	55.3	95.1
November	31.8	19.7	66.9	44.8	23.7
December	30.7	17.3	68.0	43.3	18.3
Range	**17.1-37.2**		**32.8-86.6**		**1288.8**

3.5.2.2 Wind speed/Direction – IMD- Surat

The IMD wind roses representing winter, pre-monsoon, monsoon and post-monsoon seasons along with annual wind rose are shown in **Figure-3.5.2(A) to Figure-3.5.2(E)** and presented in **Table-3.5.3**.

TABLE-3.5.3
SUMMARY OF WIND PATTERN – IMD SURAT

Season	First predominant Winds in %		Second predominant winds in %		Calm Condition In %	
	0830	1730	0830	1730	0830	1730
Winter	NE (25.3)	NW (39.0)	N (20.4)	N (13.3)	7.6	3.3
Pre-Monsoon	SW (28.0)	SW (36.0)	NW (12.3)	NW (20.3)	9.0	2.3
Monsoon	SW (44.8)	SW (66.0)	W (16.5)	W (10.0)	8.2	2.5
Post Monsoon	SE (20.0)	NW (24.5)	NE (19.5)	SW (11.5)	8.5	8.5
Annual	SW (19.2)	SW (30.7)	NE (13.1)	NW (22.0)	8.3	4.2

Note: Figures in parenthesis indicates % of time wind blows

3.5.3 Site specific Wind Rose

Winter Season – 2011 to 2012

Predominantly winds were from NW direction for 25.9% of the total time. The second predominant wind direction was from NE direction (14.9%). In the N direction, the winds were observed for 13.5% of the total time. In other directions, the percentage frequencies observed as SE (6.7%), NNW (6.4%), W & E (5.3%), SW (5.1%), NNE (2.7%), S (2.3%), WNW (1.6%), ESE (1.2%), SSE (1.1%), SSW (0.8%), WSW (0.3%) and ENE (0.2%). Calm conditions prevailed for 6.7% of the time. The site specific wind rose for the winter season is shown in **Figure-3.5.1(A).**

Pre Monsoon Season - 2012

Predominantly winds were from SW direction for 29.1% of the total time. The second predominant wind direction was from NW direction (18.8%). In the W direction, the winds were observed for 13.5% of the total time. In other directions, the percentage frequencies observed as S (8.3%), SE (4.6%), N (4.3%), WSW (3.7%), SSW (2.9%), NE (2.4%), SSE (1.6%), NNW (1.5%), WNW (1.5%), ESE (0.9%), NNE (0.6%), E (0.6%) and ENE (0.3%). Calm conditions prevailed for 5.4% of the time. The site specific wind rose for the winter season is shown in **Figure-3.5.1(B).**

Post Monsoon Season – 2012

Predominantly winds were from NW direction for 20.2% of the total time. The second predominant wind direction was from NE direction (16.9%). In the E direction, the winds were observed for 12.8% of the total time. In other directions, the percentage frequencies observed as SE (11.9%), N (8.1%), W (7.2%), SW (4.5%), S (3.9%), NNW (1.6%), SSE (1.4%), ENE (1.1%), WSW (1.0%), NNE (0.9%), WNW (0.8%), ESE (0.7%) and SSW (0.5%). Calm conditions prevailed for 6.5% of the time. The site specific wind rose for the winter season is shown in **Figure-3.5.1(C).**

3.5.4 Comparison of Primary and Secondary Data

The India Meteorological Department (IMD) records the data at two times a day viz. 0830 hr and 1730 hr while the site specific data has been recorded at an hourly interval. On comparison of site specific data generated for study period vis-à-vis the IMD data, slight variations were observed. The following observations are brought out:

- The temperature was recorded on site when compared vis-à-vis the IMD data, slight variations was found. The minimum and maximum temperatures recorded at site during study period in winter 16.0^{0}C to 34.6^{0}C; in pre-monsoon seasons were 23.1^{0}C to 40.3^{0}C and in post-monsoon season 20.2^{0}C – 35.1^{0}C. At IMD-Surat during the same period for winter, pre-monsoon and post monsoon period the minimum and maximum temperatures were recorded as 17.1^{0}C to 31.9^{0}C, in the pre-monsoon are 21.9^{0}C to 37.2^{0}C and in the post monsoon season are 19.7^{0}C -32.2^{0}C respectively.

- The Relative Humidity was observed to be in the range of 36-68% in winter, 35-72% during the study period at the site for pre-monsoon season and in the post monsoon season 45.7-79.2%. Whereas according to IMD Surat the Relative Humidity was observed to be in the range of 34.1-68% during the winter season, in pre-monsoon season 32.8-71.3% and in post monsoon 44.8-76.7% respectively.

- No major deviations of site specific met data as compared with regional IMD met data.

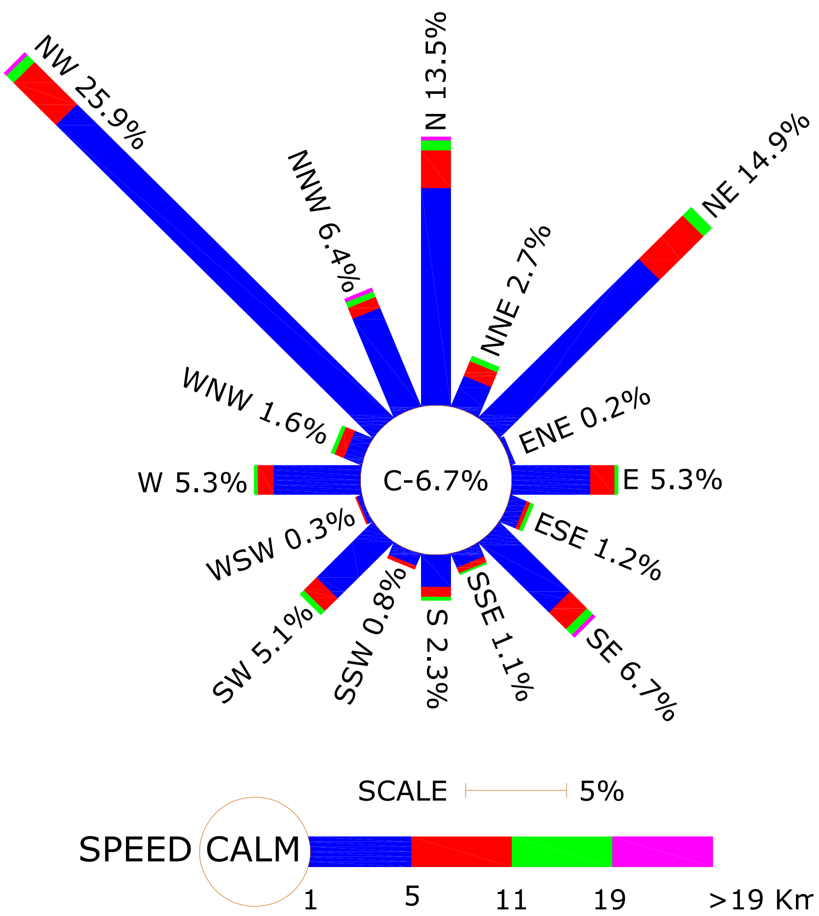


FIGURE-3.5.1 (A)
SITE SPECIFIC WIND ROSE – WINTER SEASON (2011 – 2012)

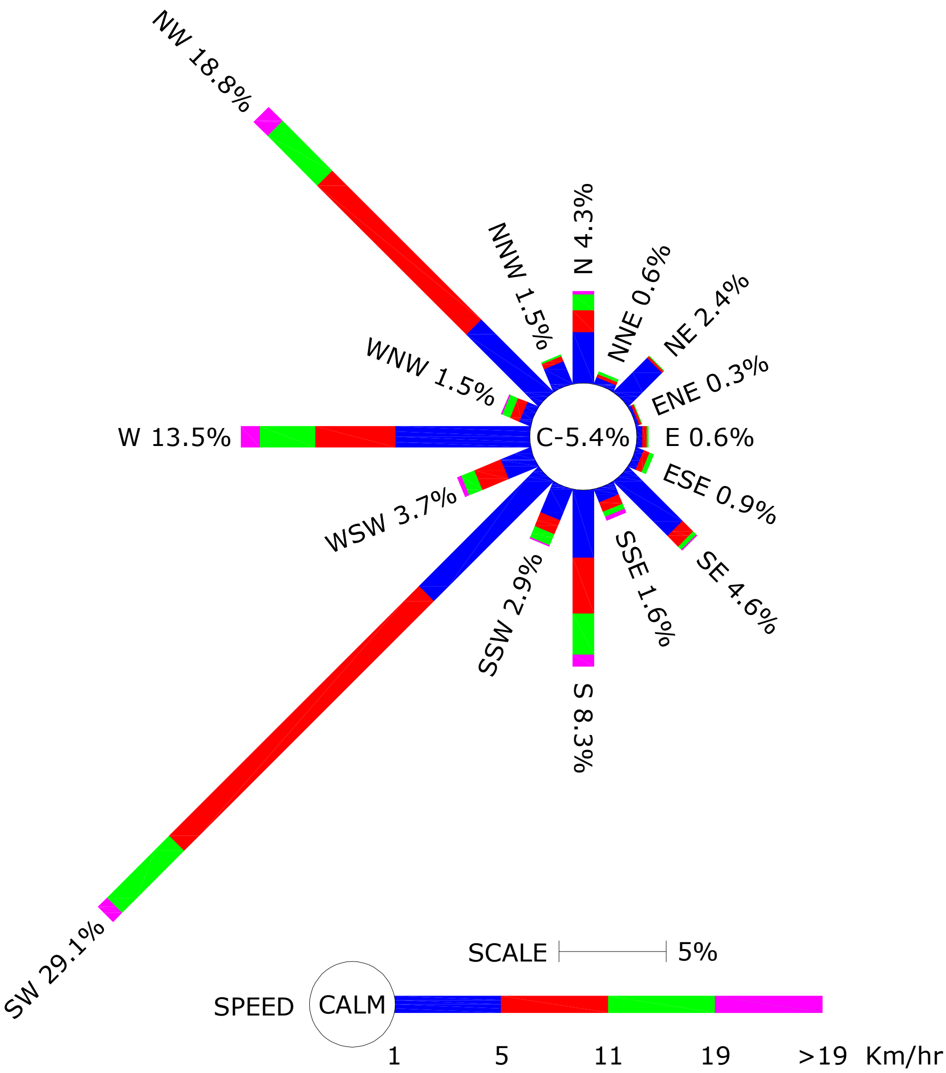


FIGURE-3.5.1 (B)
SITE SPECIFIC WIND ROSE – PRE MONSOON SEASON (2012)

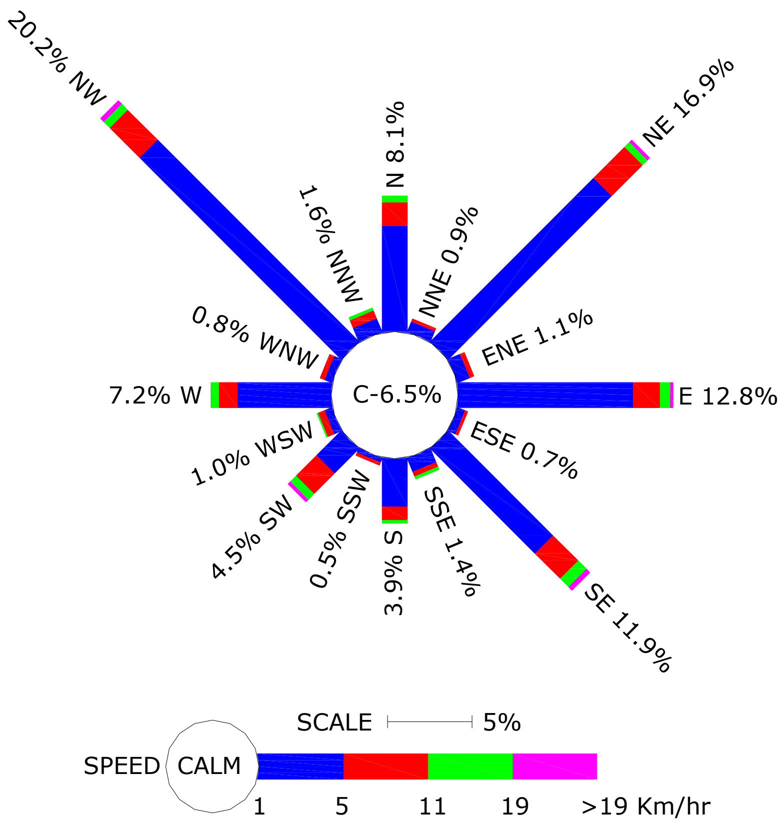


FIGURE-3.5.1 (C)
SITE SPECIFIC WIND ROSE – POST MONSOON SEASON (2012)

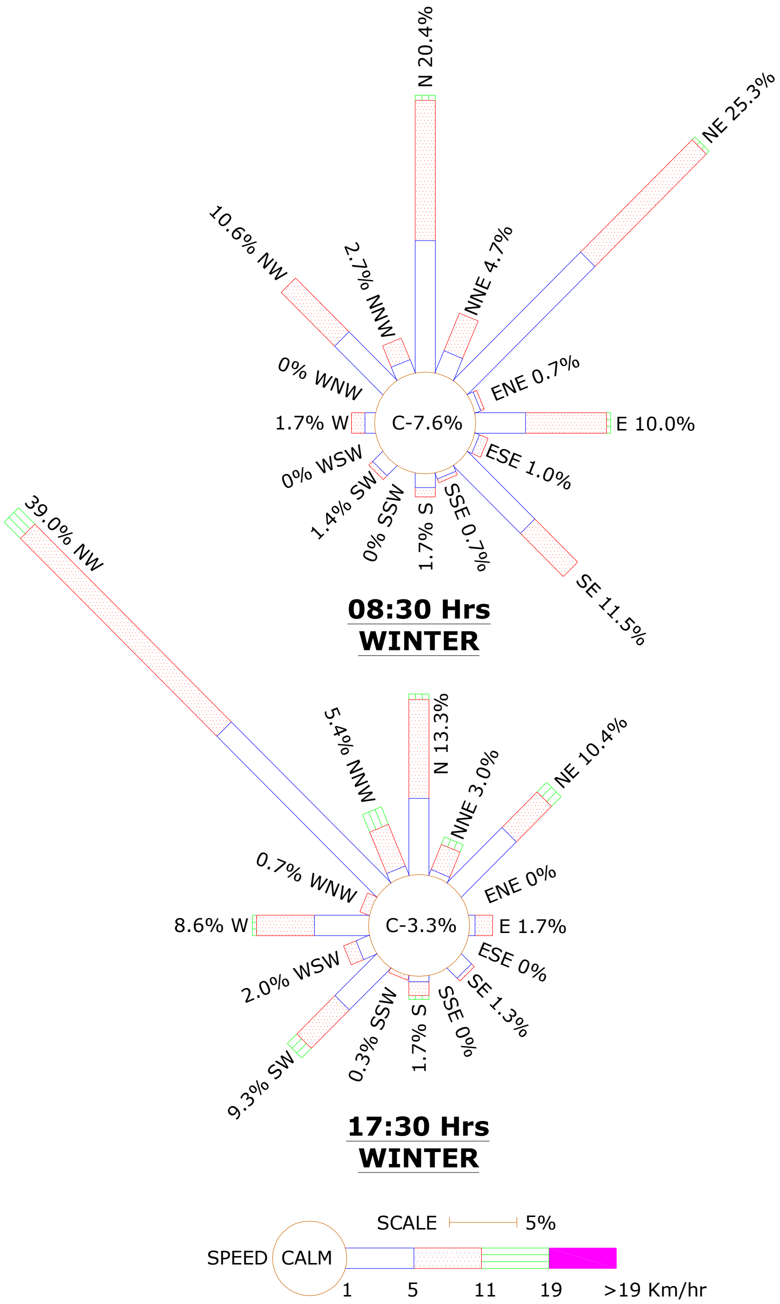


FIGURE-3.5.2 (A)
SEASONAL WINDROSE - IMD SURAT- WINTER SEASON

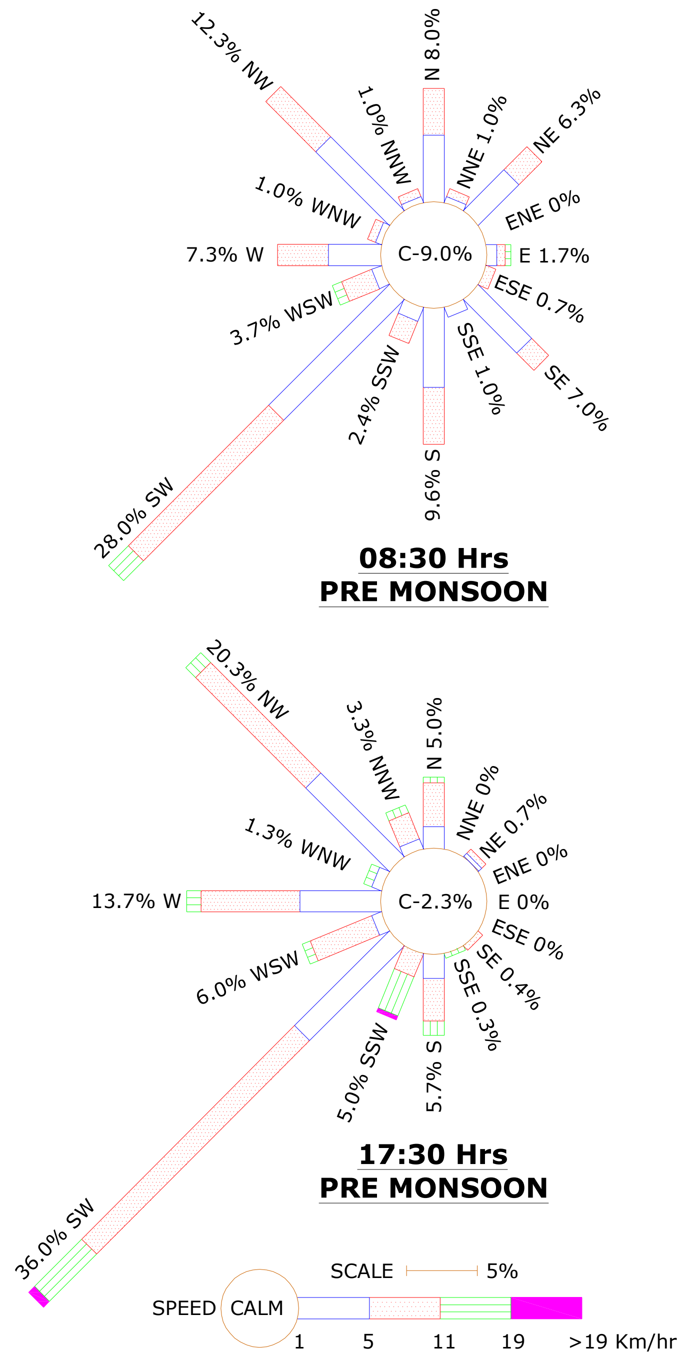


FIGURE-3.5.2 (B)
SEASONAL WINDROSE - IMD SURAT-PRE MONSOON

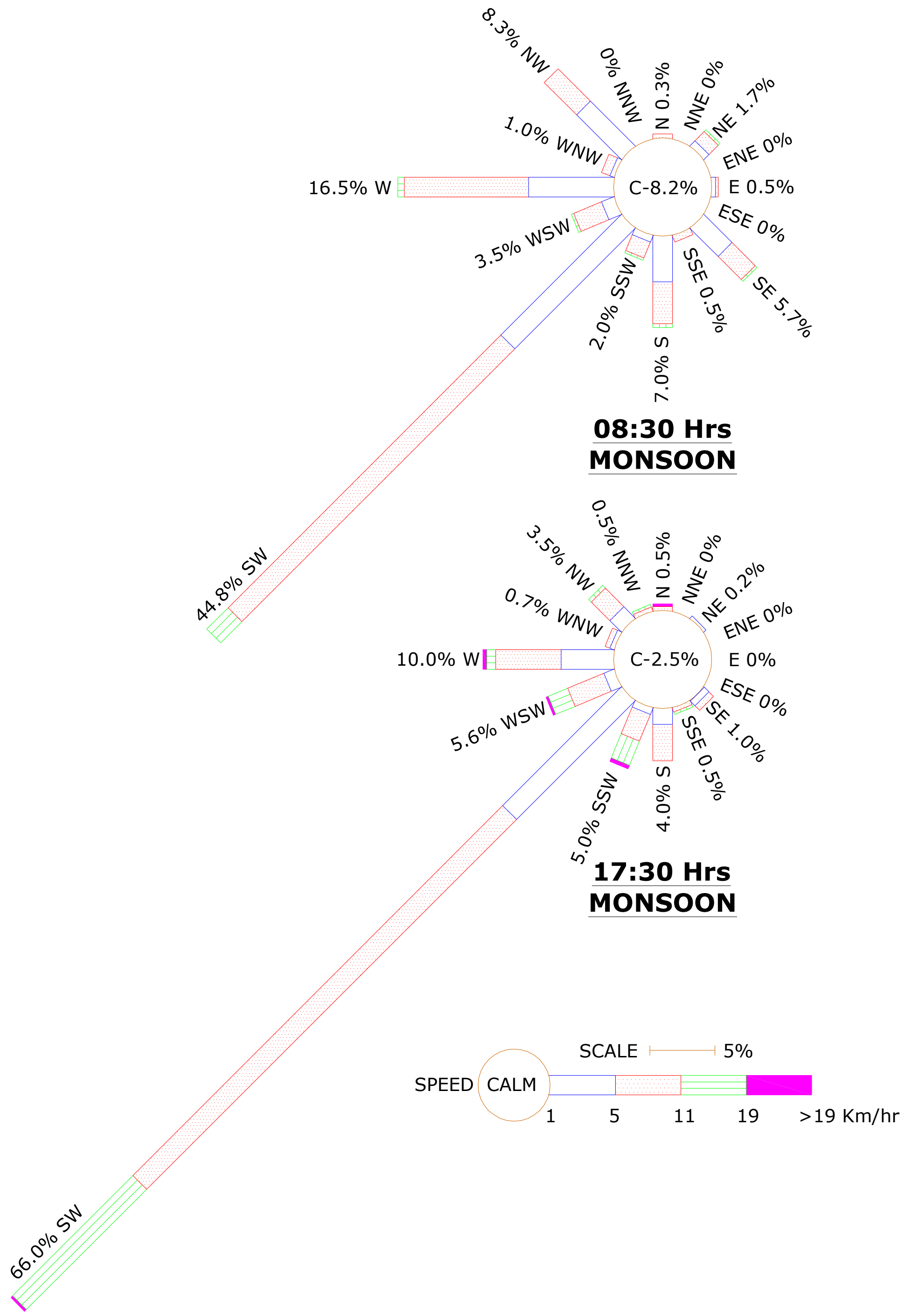


FIGURE-3.5.2 (C)
SEASONAL WINDROSE - IMD SURAT-MONSOON SEASON

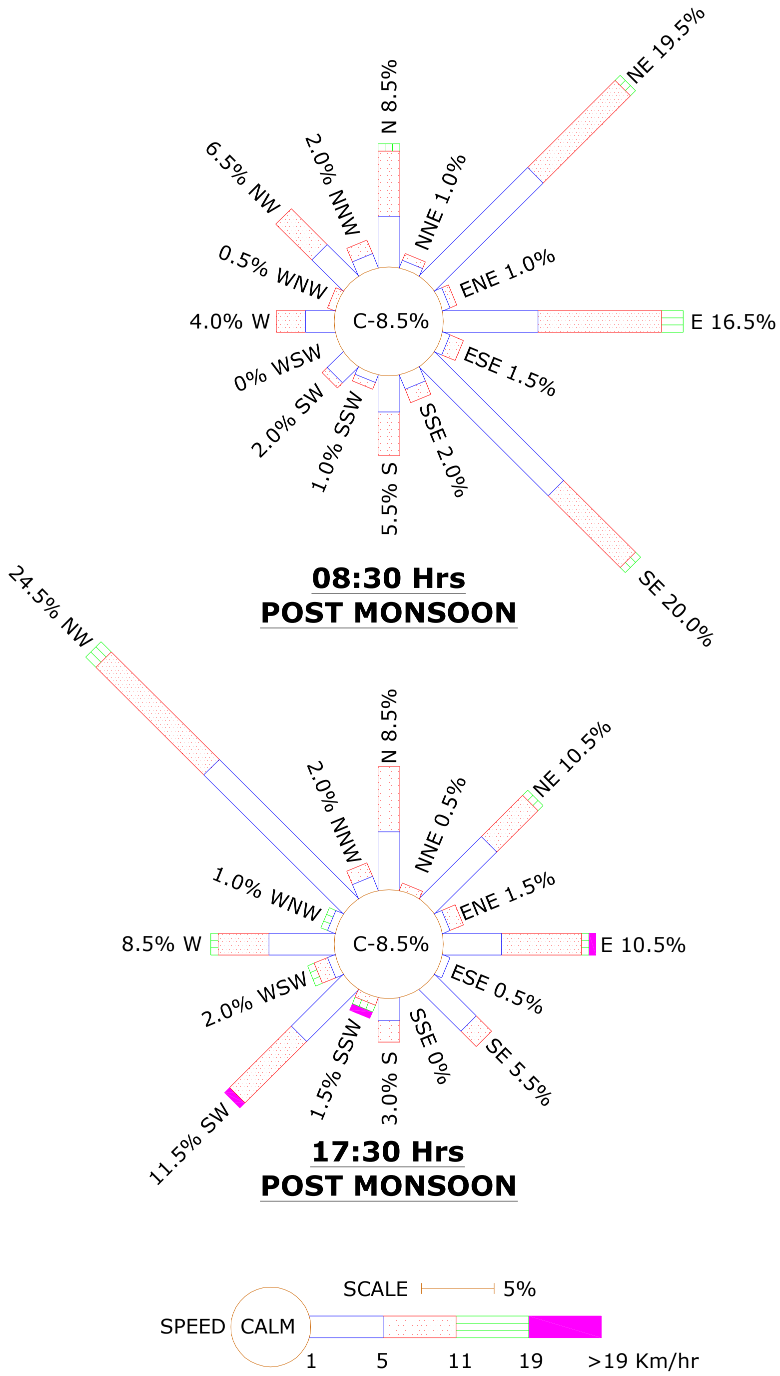


FIGURE-3.5.2 (D)
SEASONAL WINDROSE - IMD SURAT-POST MONSOON SEASON

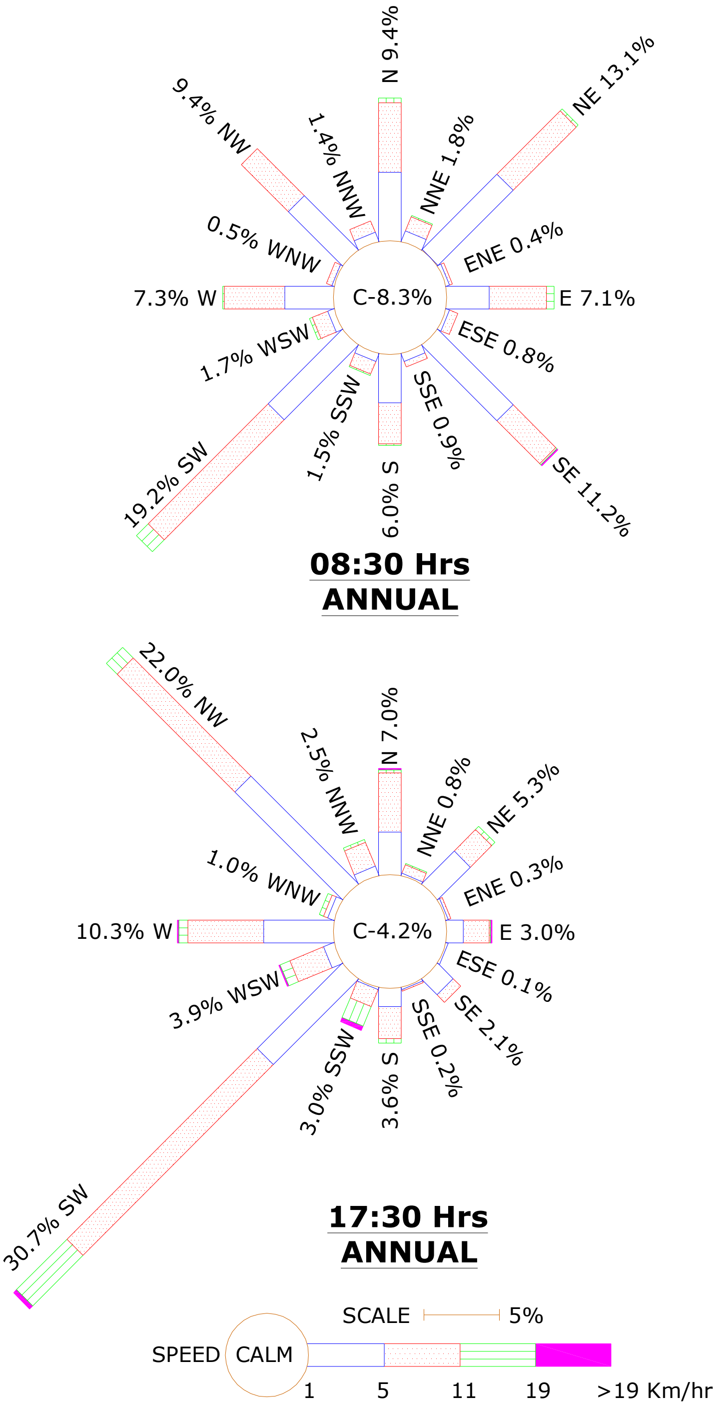


FIGURE-3.5.2 (E)
ANNUAL WINDROSE - IMD SURAT

3.6 Air Quality

The ambient air quality with respect to the study zone of 10-km radius around the proposed project forms the baseline information. The prime objective of the baseline air quality study was to assess the existing air quality of the area. This will also be useful for assessing the conformity to standards of the ambient air quality during the operational phase. The study area represents mostly rural/residential environment.

This section describes the selection of sampling locations, methodology adopted for sampling, analytical techniques and frequency of sampling.

3.6.1 Methodology adopted for Air Quality Survey

Selection of Sampling Locations

The baseline status of the ambient air quality has been assessed through a scientifically designed ambient air quality-monitoring network. The design of monitoring network in the air quality surveillance program has been based on the following considerations:

- Meteorological conditions on synoptic scale;
- Topography of the study area;
- Representatives of regional background air quality for obtaining baseline status; and
- Representatives of likely impact areas.

Ambient Air Quality Monitoring (AAQM) stations were set up at eight locations with due consideration to the above mentioned points. **Table-3.6.1** gives the details of environmental setting around each monitoring station. The locations of the selected stations with reference to the proposed project are given in the same table and depicted in **Figure-3.6.1**.

➢ ***Frequency and Parameters for Sampling***

Ambient Air Quality Monitoring was done at a frequency of two days continuous per week for three season's at all eight monitoring stations during winter 2011-2012, pre monsoon 2012 and post monsoon season 2012. The baseline data of air environment was monitored for parameters mentioned below as per revised MoEF notification dated 16th November 2009:

- Particulate Matter (PM_{10});
- Particulate Matter ($PM_{2.5}$);
- Sulphur dioxide (SO_2);
- Nitrogen dioxide (NO_2);
- Carbon monoxide (CO);
- Ozone (O_3)

TABLE-3.6.1
DETAILS OF AMBIENT AIR QUALITY MONITORING

Station Code	Name of the Station	Distance (km)	Direction
		w.r.t. Proposed project Site	
AAQ1	Project site	--	--
AAQ2	Lakhigam village	2.9	NNE
AAQ3	Near Dahej	5.8	NNE
AAQ4	Ambheta village	6.2	ENE
AAQ5	Jageshwar village	3.6	ENE
AAQ6	Luvara village	1.5	E
AAQ7	SE of project Site	1.5	SE
AAQ8	Near Aliabet village	9.5	ESE

- ***Duration of Sampling***

The sampling duration for Particulate Matter-10, Particulate Matter-2.5, SO_2 and NOx is twenty four hourly continuous samples per day; CO and O_3 are sampled for 8 hours continuous thrice a day. This is to allow a comparison with the present revised standards mentioned in the latest Gazette notification of the Central Pollution Control Board (CPCB) (November 16, 2009).

3.6.2 Presentation of Primary Data

Various statistical parameters like 98th percentile, average, maximum and minimum values have been computed from the observed raw data for all the AAQ monitoring stations. The results of monitoring carried out are presented in **Annexure-VII.** The summary of these results representing winter 2011-2012, pre-monsoon 2012 and post-monsoon season 2012 are given in **Table-3.6.2 to Table 3.6.4** respectively**.** These are compared with the standards prescribed by Central Pollution Control Board (CPCB) for rural and residential zone and Industrial zone.

- Summary of observations

Winter season (December 2011 to February 2012)

PM_{10}

The maximum concentration for Particulate Matter (PM_{10}) observed in eight locations is 57.9 $\mu g/m^3$ recorded at Project site (AAQ1) the minimum concentration is recorded as 33.5 $\mu g/m^3$ at near Aliabet Village (AAQ8) during the study period.

$PM_{2.5}$

Out of the eight locations the maximum concentration for Particulate Matter ($PM_{2.5}$) was observed as 19.4 $\mu g/m^3$ recorded at SE of Project site (AAQ7) with the minimum concentration observed as 8.5 $\mu g/m^3$ recorded at near Aliabet Village (AAQ8) during the study period. All ambient air quality locations the $PM_{2.5}$ levels recorded are within the prescribed standards for Residential and Industrial areas.

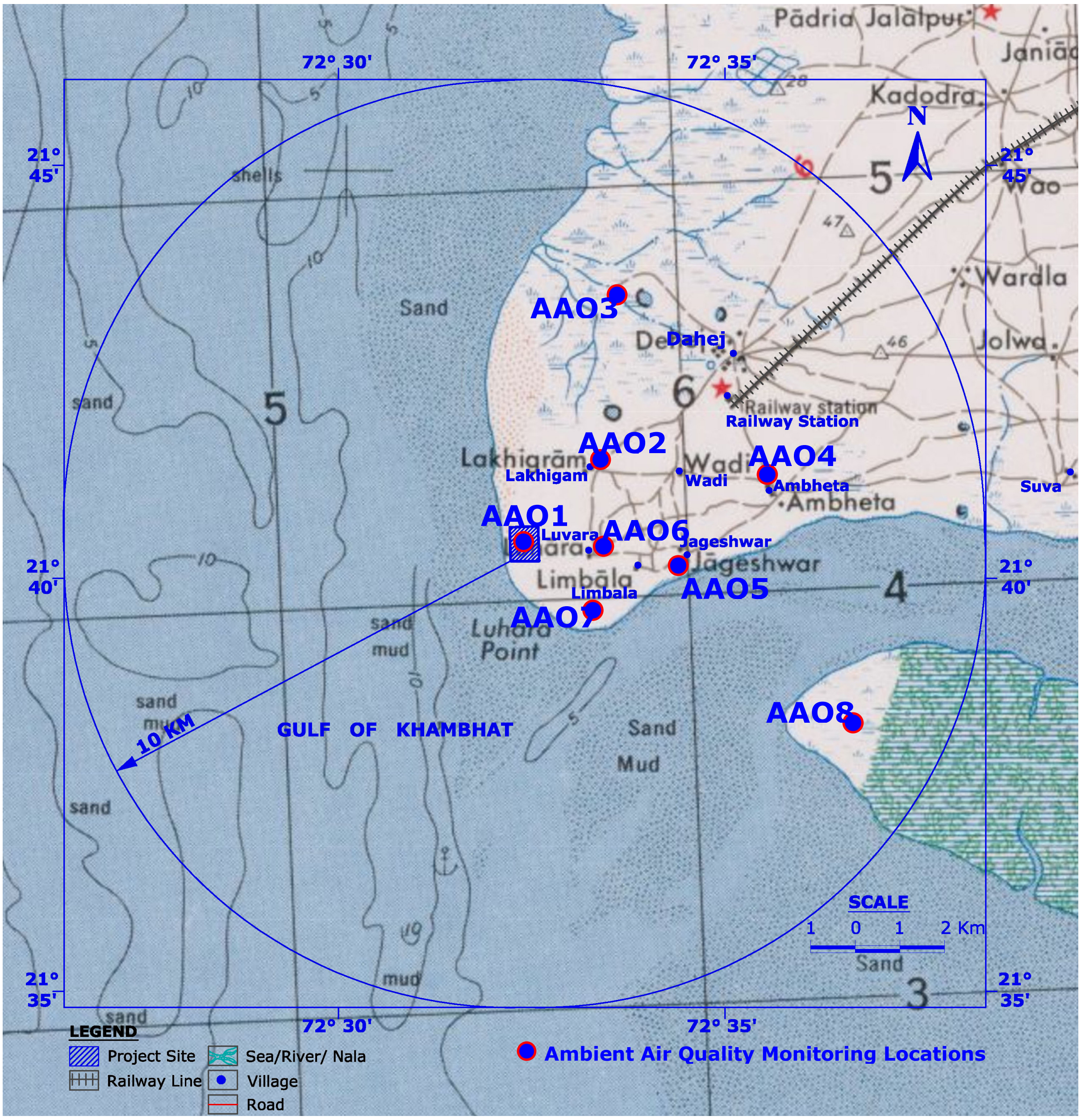


FIGURE-3.6.1
AIR QUALITY SAMPLING LOCATIONS

SO_2

In the eight locations the maximum concentration for Sulphur dioxide (SO_2) was observed as 19.4 $\mu g/m^3$ recorded at SE of project site (AAQ7) and the minimum concentration observed as 10.2 $\mu g/m^3$ recorded at near Aliabet Village (AAQ8) during the study period.

NO_x

Out of the eight locations the maximum concentration for Oxides of Nitrogen (NO_x) was observed as 20.4 $\mu g/m^3$ recorded at SE of project site (AAQ7) and the minimum concentration observed at 11.4 $\mu g/m^3$ recorded at near Aliabet village (AAQ8) during the study period.

CO

In all the eight residential and rural locations the maximum concentration for Carbon Monoxide (CO) was observed as 507 $\mu g/m^3$ recorded at SE of project site (AAQ7) and the minimum concentration observed of 143 $\mu g/m^3$ recorded at near Aliabet village (AAQ8) village during the study period.

O_3

Out of the eight locations the maximum concentration for O_3 was observed as 7.8 $\mu g/m^3$ recorded at project site (AAQ1) with the minimum concentration observed as 2.2 $\mu g/m^3$ recorded at near Aliabet Village (AAQ8) during the study period. All ambient air quality locations the O_3 levels recorded are within the prescribed standards for Residential and Industrial areas.

Pre-monsoon season (March to May 2012)

PM_{10}

The maximum concentration for Particulate Matter (PM_{10}) observed in eight locations is 65.1 $\mu g/m^3$ recorded at project site (AAQ1) the minimum concentration is recorded as 34.7 $\mu g/m^3$ at near Aliabet Village (AAQ8) during the study period.

$PM_{2.5}$

Out of the eight locations the maximum concentration for Particulate Matter ($PM_{2.5}$) was observed as 23.8 $\mu g/m^3$ recorded at Project site(AAQ1) with the minimum concentration observed as 10.2 $\mu g/m^3$ recorded at near Aliabet Village (AAQ8) during the study period. All ambient air quality locations the $PM_{2.5}$ levels recorded are within the prescribed standards for Residential and Industrial areas.

SO_2

In the eight locations the maximum concentration for Sulphur dioxide (SO_2) was observed as 15.8 $\mu g/m^3$ recorded at Project site (AAQ1) and the minimum concentration observed as 9.1 μg/m^3 recorded at near Aliabet Village (AAQ8) during the study period.

NOx

Out of the eight locations the maximum concentration for Oxides of Nitrogen (NOx) was observed as 16.5 μg/m^3 recorded at Project site (AAQ1) and the minimum concentration observed at 10.3 μg/m^3 recorded at near Aliabet village (AAQ8) during the study period.

CO

In all the eight residential and rural locations the maximum concentration for Carbon Monoxide (CO) was observed as 414 μg/m^3 recorded at Project site (AAQ1) and the minimum concentration observed of 132 μg/m^3 recorded at near Aliabet village (AAQ8) village during the study period.

O_3

Out of the eight locations the maximum concentration for O_3 was observed as 8.0 μg/m^3 recorded at project site (AAQ1), near Dahej (AAQ3) and near SE of project site (AAQ7) with the minimum concentration observed as 2.5 μg/m^3 recorded at near Jageshwar village (AAQ5) during the study period. All ambient air quality locations the O_3 levels recorded are within the prescribed standards for Residential and Industrial areas.

Post monsoon season – (October to November 2012)

- **Particulate Matter (PM_{10})**

The maximum concentration for Particulate Matter (PM_{10}) observed in eight locations is 62.3 μg/m^3 recorded at Project site (AAQ1) the minimum concentration is recorded as 34.1 μg/m^3 at near Aliabet Village (AAQ8) during the study period.

- **Particulate Matter ($PM_{2.5}$)**

Out of the eight locations the maximum concentration for Particulate Matter ($PM_{2.5}$) was observed as 21.7 μg/m^3 recorded at Project site (AAQ1) with the minimum concentration observed as 9.4 μg/m^3 recorded at near Aliabet Village (AAQ8) during the study period. All ambient air quality locations the $PM_{2.5}$ levels recorded are within the prescribed standards for Residential and Industrial areas.

- **Sulphur Dioxide**

In the eight locations the maximum concentration for Sulphur dioxide (SO_2) was observed as 9.6 μg/m^3 recorded at Project site (AAQ1) and the minimum concentration observed as 17.8 μg/m^3 recorded at near Aliabet Village (AAQ8) during the study period.

- **Nitrogen Oxide**

Out of the eight locations the maximum concentration for Oxides of Nitrogen (NOx) was observed as 10.8 μg/m^3 recorded at Project site (AAQ1) and the minimum concentration observed at 19.1 μg/m^3 recorded at near Aliabet village (AAQ8) during the study period.

- ***Carbon Monoxide***

In all the eight residential and rural locations the maximum concentration for Carbon Monoxide (CO) was observed as 473 μg/m^3 recorded at Project site (AAQ1) and the minimum concentration observed of 136 μg/m^3 recorded at near Aliabet village (AAQ8) village during the study period.

- ***Ozone***

Out of the eight locations the maximum concentration for O_3 was observed as 7.9 μg/m^3 recorded at project site (AAQ1) with the minimum concentration observed as 2.4 μg/m^3 recorded at near Aliabet village (AAQ8) during the study period. All ambient air quality locations the O_3 levels recorded are within the prescribed standards for Residential and Industrial areas.

TABLE-3.6.2(A)
AMBIENT AIR QUALITY– WINTER SEASON 2011-2012

(All Values are expressed in μg/m^3)

Sr. No	Location	PM_{10}				$PM_{2.5}$			
		Min	**Max**	**Avg.**	**98%**	**Min**	**Max**	**Avg**	**98%**
1	Project site	42.6	57.9	52.1	57.8	12.8	17.8	15.7	17.6
2	Lakhigam village	34.6	55.3	42.7	53.4	11.4	17.2	14.2	17.0
3	Near Dahej	34.4	49.6	39.3	48.4	10.0	16.5	12.8	15.9
4	Ambheta village	34.1	43.7	38.4	43.7	9.2	11.7	10.6	11.7
5	Jageshwar village	33.6	42.1	35.7	40.9	9.5	13.9	11.4	13.7
6	Luvara village	44.1	56.2	48.2	54.3	13.9	17.3	15.8	17.3
7	SE of Project site	49.2	57.4	53.5	57.4	16.2	19.4	17.5	19.2
8	Near Aliabet village	33.5	40.4	35.4	38.9	8.5	11.6	9.7	11.4
	Range	**33.5 - 57.9**				**8.5 - 19.4**			

TABLE-3.6.2(B)
AMBIENT AIR QUALITY– WINTER SEASON 2011-2012

(All Values are expressed in μg/m^3)

Sr. No.	Location	SO_2				NOx			
		Min	**Max**	**Avg.**	**98%**	**Min**	**Max**	**Avg**	**98%**
1	Project site	11.4	17.6	15.7	17.6	12.2	18.5	15.3	18.0
2	Lakhigam village	10.4	13.6	11.8	13.6	11.6	15.7	13.2	15.3
3	Near Dahej	10.3	13.5	11.9	13.2	11.9	16.1	13.4	15.6
4	Ambheta village	10.8	13.1	11.7	12.9	12.1	14.6	13.1	14.6
5	Jageshwar village	11.1	14.3	12.4	13.9	12.7	15.4	13.9	15.3
6	Luvara village	11.2	15.9	12.9	15.7	12.2	17.0	14.0	17.0
7	SE of Project site	11.6	19.4	15.3	18.5	12.5	20.4	16.1	19.5
8	Near Aliabet village	10.2	11.8	11.2	11.8	11.4	13.7	12.7	13.6
	Range	**10.2 - 19.4**				**11.4 - 20.4**			

TABLE-3.6.2(C)
AMBIENT AIR QUALITY– WINTER SEASON 2011-2012

(All Values are expressed in $\mu g/m^3$)

Sr. No.	Location	CO				O_3			
		Min	Max	Avg.	98%	Min	Max	Avg	98%
1	Project site	313	483	396	472	2.5	7.8	4.4	7.7
2	Lakhigam village	235	442	346	437	2.3	7.4	4.3	7.2
3	Near Dahej	238	394	317	386	2.4	7.6	4.3	7.3
4	Ambheta village	206	324	253	301	2.3	7.1	3.9	6.1
5	Jageshwar village	215	334	270	316	2.3	7.3	4.0	6.9
6	Luvara village	305	446	381	433	2.4	7.7	4.4	7.6
7	SE of Project site	313	507	444	497	2.5	7.6	4.4	7.4
8	Near Aliabet village	143	282	215	274	2.2	7.0	3.9	6.4
	Range	**143 - 507**				**2.2 - 7.8**			

TABLE-3.6.3(A)
AMBIENT AIR QUALITY–PRE MONSOON 2012

(All Values are expressed in $\mu g/m^3$)

Sr. No	Location	PM_{10}				$PM_{2.5}$			
		Min	Max	Avg.	98%	Min	Max	Avg	98%
1	Project site	52.3	65.1	59.8	64.9	18.6	23.8	21.7	23.5
2	Lakhigam village	35.6	61.9	46.1	60.8	12.8	19.5	16.0	19.2
3	Near Dahej	36.6	59.0	48.9	58.8	13.2	19.3	16.8	19.3
4	Ambheta village	36.8	52.2	44.8	51.7	11.6	15.3	13.9	15.3
5	Jageshwar village	36.6	45.1	40.2	44.3	11.2	15.7	13.6	15.5
6	Luvara village	49.5	63.1	53.4	60.9	15.1	21.4	17.7	21.0
7	SE of Project site	51.1	63.5	57.8	62.3	17.3	20.4	19.1	20.4
8	Near Aliabet village	34.7	45.3	39.3	44.9	10.2	15.7	12.2	15.2
	Range	**34.7 – 65.1**				**10.2 – 23.8**			

TABLE-3.6.3(B)
AMBIENT AIR QUALITY–PRE MONSOON 2012

(All Values are expressed in $\mu g/m^3$)

Sr. No.	Location	SO_2				NOx			
		Min	Max	Avg.	98%	Min	Max	Avg	98%
1	Project site	10.1	15.8	13.1	15.7	11.1	16.5	14.2	16.3
2	Lakhigam village	9.5	12.9	11.7	12.9	11.2	14.2	12.9	14.2
3	Near Dahej	10.0	12.4	11.2	12.4	10.8	13.8	12.5	13.7
4	Ambheta village	9.3	12.0	10.5	11.9	10.6	13.1	11.6	13.0
5	Jageshwar village	9.5	13.0	10.9	13.0	10.6	14.4	12.3	14.4
6	Luvara village	9.7	13.8	11.5	13.5	10.9	14.9	13.0	14.9
7	SE of Project site	10.0	13.7	10.9	13.4	10.9	15.5	12.4	15.0
8	Near Aliabet village	9.1	10.2	9.8	10.2	10.3	12.0	11.2	12.0
	Range	**9.1 – 15.8**				**10.3 – 16.5**			

TABLE-3.6.3(C)
AMBIENT AIR QUALITY–PRE MONSOON 2012

(All Values are expressed in $\mu g/m^3$)

Sr. No.	Location	CO				O_3			
		Min	Max	Avg.	98%	Min	Max	Avg	98%
1	Project site	267	414	344	405	2.8	8.0	4.8	7.8
2	Lakhigam village	221	352	298	343	2.7	7.9	4.5	7.7
3	Near Dahej	231	373	304	357	2.7	8.0	4.6	8.0
4	Ambheta village	189	297	248	283	2.6	7.3	4.4	6.9
5	Jageshwar village	204	299	262	295	2.5	7.5	4.4	7.2
6	Luvara village	283	384	319	358	2.7	7.9	4.6	7.8
7	SE of Project site	293	411	368	408	2.6	8.0	4.6	7.8
8	Near Aliabet village	132	275	205	256	2.6	7.3	4.3	7.1
	Range	**132 - 414**				**2.5 – 8.0**			

TABLE-3.6.4(A)
AMBIENT AIR QUALITY–POST MONSOON SEASON 2012

(All Values are expressed in $\mu g/m^3$)

Sr. No	Location	PM_{10}				$PM_{2.5}$			
		Min	Max	Avg.	98%	Min	Max	Avg	98%
1	Project site	57.7	62.3	59.2	61.8	16.8	21.7	18.9	21.4
2	Lakhigam village	47.4	53.2	50.2	52.9	12.9	19.5	15.7	19.1
3	Near Dahej	46.6	52.5	49.6	52.2	11.2	17.6	14.5	17.2
4	Ambheta village	40.3	46.7	43.1	46.2	10.9	15.9	12.7	15.4
5	Jageshwar village	38.5	44.6	41.2	44.3	9.9	14.7	12.1	14.3
6	Luvara village	51.9	57.8	54.7	57.4	13.4	20.2	16.4	19.8
7	SE of Project site	55.9	60.6	57.9	60.2	15.3	21.6	17.7	21.2
8	Near Aliabet village	34.1	41.3	36.7	40.6	9.4	13.7	11.3	13.4
	Range	**34.1 – 62.3**				**9.4 – 21.7**			

TABLE-3.6.4(B)
AMBIENT AIR QUALITY–POST MONSOON SEASON 2012

(All Values are expressed in $\mu g/m^3$)

Sr. No.	Location	SO_2				NOx			
		Min	Max	Avg.	98%	Min	Max	Avg	98%
1	Project site	14.1	17.8	15.4	17.5	14.2	19.1	15.9	18.8
2	Lakhigam village	13.3	16.6	14.4	16.3	13.1	18.2	15.9	17.9
3	Near Dahej	12.7	15.9	14.4	15.6	12.8	17.8	15.1	17.6
4	Ambheta village	11.8	14.7	12.9	15.4	12.4	17.3	14.5	16.9
5	Jageshwar village	10.2	13.9	12.1	13.6	11.6	16.9	14.1	16.5
6	Luvara village	9.9	12.7	10.9	12.4	11.2	15.5	13.2	15.2
7	SE of Project site	13.8	17.1	15.1	16.9	13.5	18.6	15.3	18.2
8	Near Aliabet village	9.6	12.5	10.9	12.3	10.8	14.9	12.5	14.5
	Range	**9.6 – 17.8**				**10.8 – 19.1**			

TABLE-3.6.4(C)
AMBIENT AIR QUALITY–POST MONSOON SEASON 2012

(All Values are expressed in µg/m³)

Sr. No.	Location	CO				O_3			
		Min	Max	Avg.	98%	Min	Max	Avg	98%
1	Project site	407	473	433	469	5.7	7.9	6.4	7.4
2	Lakhigam village	331	412	361	405	4.7	6.9	5.8	6.8
3	Near Dahej	316	396	359	389	4.1	6.4	5.3	6.1
4	Ambheta village	287	379	329	375	3.5	5.9	4.7	5.6
5	Jageshwar village	207	333	265	326	3.2	5.4	4.3	5.1
6	Luvara village	175	281	227	275	2.6	4.9	3.7	4.6
7	SE of Project site	371	445	408	441	5.1	7.2	6.2	6.9
8	Near Aliabet village	136	222	169	211	2.4	4.4	3.3	4.1
	Range	**136 - 473**				**2.4 – 7.9**			

3.6.3 Characterization of RSPM

Characterization of RSPM details are given in the **Table 3.6.5**.

TABLE 3.6.5
CHARACTERIZATION OF RSPM

Sr. No	Element	Winter 2011-2012		Pre Monsoon 2012		Post Monsoon 2012	
		Min	Max	Min	Max	Min	Max
		(µg/m³)		(µg/m³)		(µg/m³)	
1	Free Silica	0.44	1.14	0.51	1.12	0.62	1.28
2	Aluminium	2.2	5.2	1.9	6.2	2.6	7.1
3	Calcium	3.2	8.1	3.5	9.1	3.9	7.9
4	Sodium	3.2	9.6	3.6	10.2	2.9	9.4
5	Potassium	2.3	5.3	2.4	5.8	3.2	6.1
6	Magnesium	0.9	4.1	0.8	3.6	1.4	4.4
7	Lead	0.04	0.22	0.05	0.42	0.05	0.34
8	Zinc	4.12	9.7	4.3	10.8	4.3	9.8
9	Vanadium	0.006	0.098	0.008	0.124	0.009	0.092
10	Iron	0.38	1.48	0.42	1.6	0.54	1.7
11	Manganese	0.08	0.94	0.09	0.84	0.12	0.84
12	Boran	3.2	7.6	3.4	8.1	3.8	7.9
13	Cadmium	<0.001	0.046	<0.001	0.064	<0.001	0.068
14	Copper	0.04	0.52	0.06	0.64	0.05	0.69
15	Nickel	0.007	0.072	0.009	0.09	0.007	0.08
16	Cobalt	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
17	Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
18	Arsenic	<0.001	0.018	<0.001	0.024	<0.001	0.018
19	Sulphur	0.64	2.18	0.58	2.76	0.74	2.38
20	Phosphorus	1.1	2.3	1.36	3.4	1.54	3.1
21	Chlorides	1.1	2.7	1.4	4.4	1.6	3.4
22	Chromium	0.006	0.032	0.006	0.042	0.004	0.035

3.7 Water Quality

Selected water quality parameters of ground water and surface water resources within 10-km radius of the study area has been studied for assessing the water environment and evaluate anticipated impact of the proposed LNG storage handling activites. Understanding the water quality is essential in preparation of Environmental Impact Assessment and to identify critical issues with a view to suggest appropriate mitigation measures for implementation.

The purpose of this study is to:

- Assess the water quality characteristics for critical parameters; and
- Predict the impact of water quality by these project and related activities.

The information required has been collected through primary surveys and secondary sources.

Two surface water sources and *eight* groundwater sources covering 10-km radial distance were examined for physico-chemical, heavy metals and bacteriological parameters.

The samples were collected and analysed once during the study period. The samples were analyzed as per the procedures specified in 'Standard Methods for the Examination of Water and Wastewater' published by American Public Health Association (APHA).

3.7.1 Water Sampling Locations

Total ten water samples were collected from different sampling locations for four seasons during winter 2011-2012 to pre monsoon 2012 and post monsoon 2012. These samples were taken as grab samples and were analyzed for various parameters to compare with the standards. The water sampling locations are listed below in **Table-3.7.1** and are depicted in **Figure-3.7.1**. The results of monitoring carried out for the study are presented in **Table-3.7.2.**

TABLE-3.7.1
DETAILS OF WATER SAMPLING LOCATIONS

Sr. No.	Code	Location	Distance	Bearing
			w.r.t. Proposed Project site	
Surface Water				
1	SW1	Sea near Project site (near PLL Jetty)	0.7	SW
2	SW2	Narmada River (near Ambetha)	9.0	E
Ground Water				
1	GW1	Project site	--	--
2	GW2	Lakhigam village	2.9	NNE
3	GW3	Near Dahej	5.8	NNE
4	GW4	Ambetha village	6.2	ENE
5	GW5	Jageshwar village	3.6	ENE
6	GW6	Luvara village	1.5	E
7	GW7	SE of Project site	1.5	SE
8	GW8	Near Aliabet village	9.5	ESE

3.7.2 Presentation of Results

3.7.2.1 Surface Water Quality

The results for the surface water samples analysed for four seasons are presented in **Table 3.7.2** and are compared with the IS-10500 standards.

Winter Season (December 2011 to February 2012)

- The analysis results of surface water samples indicate that the pH value was observed to be 7.8 and 7.9 in SW1 & SW2 respectively which is well within the specified standards of 6.5 to 8.5.

- Electrical conductivity of surface water samples was observed to be very high concentrations because the source of the samples is taken from sea & river surface waters.

- The Dissolved Oxygen was observed about 6.5 & 6.2 mg/l in SW1 & SW2 samples respectively.

- Sulphates were found to be in the range of 232.4 & 189.0 mg/l, and Nitrates were found to be in the range of 4.5 & 3.4 mg/l which are with in the prescribed limits only.

- Fluoride concentration was found to be in the range of 1.2 & 1.1 mg/l in both the samples, which are within the prescribed limits.

- Cyanides and Phenolic compounds found to be less than detection limits.

- Bacteriological studies revealed that the Total Coliform count and E. coli count are well within the prescribed limits of IS 10500.

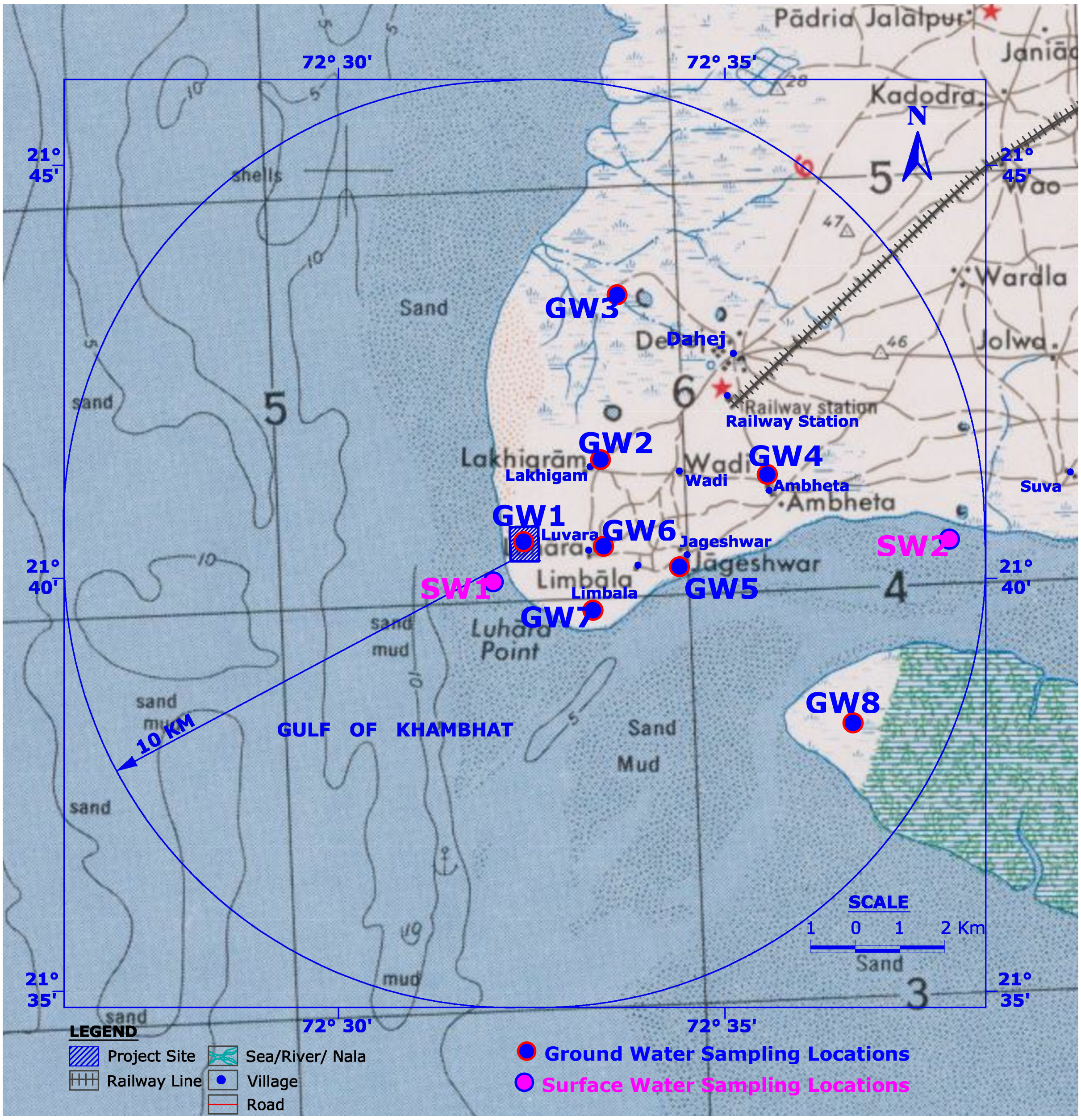


FIGURE-3.7.1
WATER SAMPLING LOCATIONS

Pre-monsoon Season (March to May 2012)

- The analysis results of surface water samples indicate that the pH value was observed to be 7.9 and 8.0 in SW1 & SW2 respectively which is well within the specified standards of 6.5 to 8.5.
- Electrical conductivity of surface water samples was observed to be very high concentrations, because the source of the samples is taken from sea & river surface waters.
- The Dissolved Oxygen was observed about 6.4 & 6.3 mg/l in SW1 & SW2 samples respectively.
- Sulphates were found to be in the range of 254 & 196 mg/l, and Nitrates were found to be in the range of 4.8 & 3.8 mg/l which are within the prescribed limits only.
- Fluoride concentration was found to be in the range of 1.1 & 1.2 mg/l in both the samples, which are within the prescribed limits.
- Cyanides and Phenolic compounds found to be less than detection limits.
- Bacteriological studies revealed that the Total Coliform count and E. coli count are well within the prescribed limits of IS 10500.

Monsoon Season (June to September 2012)

- The analysis results of surface water samples indicate that the pH value was observed to be 7.6 and 7.7 in SW1 & SW2 respectively which is well within the specified standards of 6.5 to 8.5.
- Electrical conductivity of surface water samples was observed to be very high concentrations, because the source of the samples is taken from sea & river surface waters.
- The Dissolved Oxygen was observed about 3.8 & 4.1 mg/l in SW1 & SW2 samples respectively.
- Sulphates were found to be in the range of 204 & 164 mg/l, and Nitrates were found to be in the range of 3.8 & 3.1 mg/l which are within the prescribed limits only.
- Fluoride concentration was found to be in the range of 1.3 & 1.2 mg/l in both the samples, which are within the prescribed limits.
- Cyanides and Phenolic compounds found to be less than detection limits.
- Bacteriological studies revealed that the Total Coliform count and E. coli count are well within the prescribed limits of IS 10500.

Post-monsoon Season (October to November 2012)

- The analysis results of surface water samples indicate that the pH value was observed to be 7.9 and 7.7 in SW1 & SW2 respectively which is well within the specified standards of 6.5 to 8.5.
- Electrical conductivity of surface water samples was observed to be very high concentrations, because the source of the samples is taken from sea & river surface waters.
- The Dissolved Oxygen was observed about 5.2 & 4.9 mg/l in SW1 & SW2 samples respectively.
- Sulphates were found to be in the range of 210 & 182 mg/l, and Nitrates were found to be in the range of 3.5 & 3.1 mg/l which are within the prescribed limits only.
- Fluoride concentration was found to be in the range of 1.2 & 1.3 mg/l in both the samples, which are within the prescribed limits.
- Cyanides and Phenolic compounds found to be less than detection limits.
- Bacteriological studies revealed that the Total Coliform count and E. coli count are well within the prescribed limits of IS 10500.

3.7.2.2 Ground Water Quality

Winter Season (December 2011 to February 2012)

The results for the ground water samples collected during winter season are presented in **Table 3.7.3(A).**

- The analysis results of ground water samples showed the pH in range of 7.6-8.3, which is well within the specified standard of 6.5 to 8.5.
- Colour and Turbidity of the samples ranged from 2-3 Hazens and 3-6 NTU respectively.
- Electrical conductivity of the samples ranged from 203 - 2570 µS/cm except one location having maximum value observed as 9230 µS/cm at GW1 (Project site), and where as the minimum value was observed at GW8 (near Aliabet Village).
- The Total Hardness of the samples ranged from 90 - 940 mg/l. The maximum value was observed at GW1 (Project site) and the minimum value observed at GW8 (near Aliabet village). Whereas the prescribed limit of 300 mg/l.
- Calcium and Magnesium concentrations ranged from 19 – 192 mg/l and 7.3 – 121.5 mg/l respectively.

- The Total Dissolved solids of the samples ranged from 132 - 1720 mg/l except one sample shows the higher value as 6190 mg/l at project site.. The maximum TDS was observed at GW6 (Luvara village) and where as the minimum value observed at GW8 (Aliabet Village).The TDS values are well within the prescribed limit of 2000 mg/l except one sample at (GW1) project site.

- Range of Chlorides and Sulphates concentrations at all the locations 7.1 -319 mg/l, except one sample at project site (GW1) which is having 2411 mg/l. And sulphate concentration as 2.9 – 69.4 mg/l respectively except Project site (GW1) has shown 537.9 mg/l.

- Fluoride concentrations are ranging in between 0.2 – 0.7 mg/l and are found to be within the permissible limits. Similarly, Nitrates are also found to be ranging between 1.1 – 32.2 mg/l.

- Iron concentrations in ground waters varied from 0.02 – 0.18 mg/l. All other metal concentrations are observed to be below detectable limits.

- Bacteriological studies revealed the absence of E.coli in ground waters. The Total Coliform counts is <2 MPN/100 ml in all eight samples against the standard limit of 10 MPN/100 ml.

Based on the above results it is evident that all of the parameters in ground water fairly meet the desirable standard limits of IS: 10500.

<u>Pre-monsoon Season (March to May 2012)</u>

The results for the ground water samples collected during pre-monsoon season are presented in **Table-3.7.3(B).**

- The analysis results of ground water samples showed the pH in range of 7.6-8.5, which is well within the specified standard of 6.5 to 8.5.

- Colour and Turbidity of the samples ranged from 2-3 Hazens and 3-4 NTU respectively.

- Electrical conductivity of the samples ranged from 214 - 3160 µS/cm except one location having maximum value observed as 10140 µS/cm at GW1 (Project site), and where as the minimum value was observed at GW5 (near Jageshwar Village).

- The Total Hardness of the samples ranged from 85 - 675 mg/l. The maximum value was observed at GW1 (Project site) and the minimum value observed at GW8 (near Aliabet village). Whereas the prescribed limit of 300 mg/l.

- Calcium and Magnesium concentrations ranged from 24 – 160 mg/l and 6.1 – 103.3 mg/l respectively.

- The Total Dissolved Solids of the water samples ranged from 142 - 1390 mg/l except two samples shows the higher value as 2150 and 6896 mg/l at GW6 & GW1 respectively. The maximum TDS was observed at GW1 (Project site), and where as the minimum value observed at GW5 (Jageshwar Village). The TDS values are well within the prescribed limit of 2000 mg/l except two samples at (GW1) project site and Luvara village (GW6).

- Range of Chlorides concentrations at all the locations 8.2 - 500 mg/l, except one sample at project site (GW1) which is having 2918 mg/l. And range of sulphate concentration as 2.2 – 113.9 mg/l except Project site (GW1) has shown 708.6 mg/l.

- Fluoride concentrations are ranging in between 0.1 – 0.8 mg/l and are found to be within the permissible limits. Similarly, Nitrates are also found to be ranging between 1.4 – 31.4 mg/l.

- Iron concentrations in ground waters varied from 0.02 – 0.20 mg/l. All other metal concentrations are observed to be below detectable limits.

- Bacteriological studies revealed the absence of E.coli in ground waters. The Total Coliform counts is <2 MPN/100 ml in all eight samples against the standard limit of 10 MPN/100 ml.

Based on the above results it is evident that all of the parameters in ground water fairly meet the desirable standard limits of IS: 10500.

Monsoon Season (June 2012 to September 2012)

The results for the ground water samples collected during monsoon season are presented in **Table 3.7.3(C).**

- The analysis results of ground water samples showed the pH in range of 7.7-7.9, which is well within the specified standard of 6.5 to 8.5.

- Colour and Turbidity of the samples ranged from 2-3 Hazens and 2-5 NTU respectively.

- Electrical conductivity of the samples ranged from 176 - 2980 µS/cm except one location having maximum value observed as 9120 µS/cm at GW1 (Project site), and where as the minimum value was observed at GW5 (Jageshwar Village).

- The Total Hardness of the samples ranged from 73 - 523 mg/l. The maximum value was observed at GW7 (SE of Project site) and the minimum value observed at GW5 (Jageshwar village). Whereas the prescribed limit of 300 mg/l.

- Calcium and Magnesium concentrations ranged from 16.9 – 150.2 mg/l and 5.4 – 75.6 mg/l respectively.

- The Total Dissolved solids of the samples ranged from 115 - 2090 mg/l except one sample shows the higher value as 6340 mg/l. The maximum TDS was observed at GW1 (Project site) and where as the minimum value observed at GW5 (Jageshwar Village).

- Range of Chlorides and Sulphates concentrations at all the locations 10.1 -475 mg/l, except one sample at project site (GW1) which is having 2460 mg/l. And sulphate concentration as 2.5 – 105.5 mg/l respectively except Project site (GW1) has shown 695 mg/l.

- Fluoride concentrations are ranging in between 0.2 – 0.7 mg/l and are found to be within the permissible limits. Similarly, Nitrates are also found to be ranging between 1.6 – 31.4 mg/l.

- Iron concentrations in ground waters varied from 0.03 – 0.16 mg/l. All other metal concentrations are observed to be below detectable limits.

- Bacteriological studies revealed the absence of E.coli in ground waters. The Total Coliform counts is <2 MPN/100 ml in all eight samples against the standard limit of 10 MPN/100 ml.

Based on the above results it is evident that all of the parameters in ground water fairly meet the desirable standard limits of IS: 10500.

Post-monsoon Season (October to November 2012)

The results for the ground water samples collected during post-monsoon season are presented in **Table-3.7.3(D).**

- The analysis results of ground water samples showed the pH in range of 7.6-7.9, which is well within the specified standard of 6.5 to 8.5.

- Colour and Turbidity of the samples ranged from 2-4 Hazens and 3-5 NTU respectively.

- Electrical conductivity of the samples ranged from 194 - 3050 μS/cm except one location having maximum value observed as 9480 μS/cm at GW1 (Project site), and where as the minimum value was observed at GW5 (near Jageshwar Village).

- The Total Hardness of the samples ranged from 84 - 565 mg/l. The maximum value was observed at GW1 (Project site) and the minimum value observed at GW5 (near Jageshwarvillage) whereas the prescribed limit of 300 mg/l.

- Calcium and Magnesium concentrations ranged from 22.3 – 158.4 mg/l and 5.7 – 90 mg/l respectively.

- The Total Dissolved Solids of the water samples ranged from 126 - 1980 mg/l except one sample shows the higher value as 6160 mg/l at GW1. The maximum TDS was observed at GW1 (Project site) and where as the minimum value observed at GW5 (Jageshwar Village). The TDS values are well within the prescribed limit of 2000 mg/l except at (GW1) project site.

- Range of Chlorides concentrations at all the locations 9.7 - 490 mg/l, except one sample at project site (GW1) which is having 2642 mg/l and range of sulphate concentration as 2.4 – 110.6 mg/l except Project site (GW1) has shown 690 mg/l.

- Fluoride concentrations are ranging in between 0.3 – 0.6 mg/l and are found to be within the permissible limits. Similarly, Nitrates are also found to be ranging between 1.2 – 34.6 mg/l.

- Iron concentrations in ground waters varied from 0.02 – 0.12 mg/l. All other metal concentrations are observed to be below detectable limits.

- Bacteriological studies revealed the absence of E.coli in ground waters. The Total Coliform counts is <2 MPN/100 ml in all eight samples against the standard limit of 10 MPN/100 ml.

Based on the above results it is evident that all of the parameters in ground water fairly meet the desirable standard limits of IS: 10500.

TABLE-3.7.2
SURFACE WATER QUALITY – 2011 - 2012

Sr. No.	Parameters	UOM	IS: 10500 Standards	Winter 2011-2012		Pre monsoon - 2012		Monsoon - 2012		Post monsoon - 2012	
				SW-1	SW-2	SW-1	SW-2	SW-1	SW-2	SW-1	SW-2
1	pH	--	6.5 to 8.5	7.8	7.9	7.9	8.0	7.6	7.7	7.9	7.7
2	Color	Hazen	5(25)	6	8	3	4	4	5	6	7
3	Odour	--	U.O	UO	UO	UO	UO	UO	UO	UO	UO
4	Conductivity	µmhos/cm	$	45000	46600	46300	46000	43370	44050	41785	42180
5	Turbidity	NTU	5 (10)	9	10	4	5	4	4	5	4
6	Chemical Oxygen Demand	mg/l	$	140	160	152	168	125	130	120	135
7	Dissolved Oxygen	mg/l	$	6.5	6.2	6.4	6.3	3.8	4.1	5.2	4.9
8	Total Dissolved Solids	mg/l	500 (2000)	30148	31228	30095	29900	28191	28633	27160	27417
9	Total Hardness	mg/l	300 (600)	6300	6350	6100	6220	5755	5770	5340	5480
10	Total Alkalinity	mg/l	200 (600)	145	155	155	190	140	165	155	170
11	Calcium as Ca	mg/l	75 (200)	372	372	360	352	335	325	285	290
12	Magnesium as Mg	mg/l	30(100)	1304.9	1317.1	1263	1297	1195	1205	1125	1156
13	Residual Chlorine	mg/l	0.2 Min	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
14	Boron	mg/l	1	0.20	0.30	0.03	0.02	<0.01	<0.01	<0.01	<0.01
15	Chlorides as Cl	mg/l	250 (1000)	16094	16307	16216	16156	14652	15102	14860	14320
16	Sulfates as SO_4^{2-}	mg/l	200 (400)	232.4	189.0	254	196	204	164	210	182
17	Fluorides as F	mg/l	1.0 (1.5)	1.2	1.1	1.1	1.2	1.3	1.2	1.2	1.3
18	Nitrates as NO_3	mg/l	45 (NR)	4.5	3.4	4.8	3.8	3.8	3.1	3.5	3.1
19	Sodium as Na	mg/l	$	7536	7445	7684	7516	7165	7325	6995	7010
20	Potassium as K	mg/l	$	269	289	284	304	275	255	260	285
21	Phenolic Compounds	mg/l	0.001(0.002)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
22	Cyanides	mg/l	0.05 (NR)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
23	Anionic Detergents	mg/l	0.2 (1.0)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
24	Mineral Oil	mg/l	0.01 (0.002)	<0.01	<0.01	<0.01	<0.01	<1.0	<1.0	<1.0	<1.0
25	Cadmium as Cd	mg/l	0.01 (NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
26	Arsenic as As	mg/l	0.01 (NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
27	Copper as Cu	mg/l	0.05 (1.5)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
28	Lead as Pb	mg/l	0.05 (1.5)	0.02	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
29	Manganese as Mn	mg/l	0.1 (0.3)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
30	Iron as Fe	mg/l	0.3 (1.0)	0.08	0.07	0.12	0.15	0.22	0.16	0.11	0.13
31	Chromium as Cr^{+6}	mg/l	0.05 (NR)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
32	Selenium as Se	mg/l	0.01(NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
33	Zinc as Zn	mg/l	5 (15)	0.01	0.02	<0.01	<0.01	0.07	0..01	0.05	0.02
34	Aluminium as Al	mg/l	0.03 (0.2)	0.06	0.03	0.11	0.19	0.12	0.09	0.11	0.07
35	Mercury as Hg	mg/l	0.001 (NR)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
36	Pesticides	mg/l	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
37	E coli	MPN/100ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
38	Total coliforms	MPN/100ml	10	09	08	08	09	10	08	10	07

**Onsite results, $ Limits not specified as per IS: 10500; OU: Unobjectionable; Ag: Agreeable; NR: No Relaxation*

TABLE-3.7.3(A)
GROUND WATER QUALITY – WINTER 2011 – 2012

Sr. No.	Parameter	Unit	Limits as per IS10500	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8
1	pH	-	6.5-8.5 (NR)	8.0	8.3	8.1	8.0	7.8	8.1	7.6	7.7
2	Colour	Hazen	5(25)	3	3	3	2	2	3	2	2
3	Taste	-	Agreeable	Ag	Ag	Ag	Ag	Ag	Ag	Ag	Ag
4	Odour	-	UO	UO	UO	UO	UO	UO	UO	UO	UO
5	Conductivity	µS/cm	$	9230	286	226	250	252	2570	2319	203
6	Turbidity	NTU	5(10)	6	4	4	3	3	4	3	3
7	TDS	mg/l	500(2000)	6190	198	151	172	152	1720	1572	132
8	Total Hardness as CaCO3	mg/l	300(600)	940	130	95	100	115	915	600	90
9	Total Alkalinity	mg/l	200(600)	595	120	70	105	110	850	595	95
10	Calcium as Ca	mg/l	75(200)	176	32	26	24	26	192	148	19
11	Magnesium as Mg	mg/l	30(100)	121.5	12.2	7.3	9.7	12.2	104.5	55.9	10.3
12	Residual Chlorine	mg/l	0.2 Min	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
13	Boron	mg/l	1	<0.01	<0.01	<0.01	<0.01	<0.01	0.28	<0.01	<0.01
14	Chlorides as Cl	mg/l	250(1000)	2411	11	24	11	18	237	319	7.1
15	Sulphates as SO_4	mg/l	200(400)	537.9	6.7	8.4	3.9	4.0	69.4	64.8	2.9
16	Fluorides as F	mg/l	1.0(1.5)	0.6	0.5	0.5	0.4	0.4	0.7	0.5	0.2
17	Nitrates as NO_3	mg/l	45(NR)	4.2	1.7	2.1	1.8	1.7	31.7	32.2	1.1
18	Sodium as Na	mg/l	$	1502	7.0	9.2	11.8	10.8	88.4	195.6	7.5
19	Potassium as K	mg/l	$	278	1.8	1.6	1.4	1.4	122.8	82.9	0.8
20	Phenolic Compounds	mg/l	0.001(0.002)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
21	Cyanides	mg/l	0.05(NR)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
22	Anionic Detergents	mg/l	0.2(0.1)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
23	Mineral Oil	mg/l	0.01(0.03)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
24	Cadmium as Cd	mg/l	0.01(NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
25	Arsenic as As	mg/l	0.01(NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
26	Copper as Cu	mg/l	0.05(1.5)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
27	Lead as Pb	mg/l	0.05(NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
28	Manganese as Mn	mg/l	0.1(0.3)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
29	Iron as Fe	mg/l	0.3(1.0)	0.03	0.10	0.08	0.18	0.08	0.07	0.02	0.03
30	Chromium as Cr+6	mg/l	0.05(NR)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
31	Selenium as Se	mg/l	0.01(NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
32	Zinc as Zn	mg/l	5(15)	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.01	<0.01
33	Aluminium as Al	mg/l	0.03(0.2)	0.01	0.06	0.06	0.01	<0.01	0.02	0.01	<0.01
34	Mercury as Hg	mg/l	0.001(NR)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
35	Pesticides	mg/l	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
36	E.Coli	MPN/100 ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
37	Total Coliforms	MPN/100 ml	10	<2	<2	<2	<2	<2	<2	<2	<2

**Onsite results, $ Limits not specified as per IS: 10500; OU: Unobjectionable; Ag: Agreeable; NR: No Relaxation*

TABLE-3.7.3(B)
GROUND WATER QUALITY – PRE MONSOON – 2012

Sr. No.	Parameter	Unit	Limits as per IS10500	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8
1	pH	-	6.5-8.5 (NR)	8.0	8.4	8.3	8.5	8.4	8.2	7.7	7.6
2	Colour	Hazen	5(25)	2	2	3	2	2	3	3	2
3	Taste	-	Agreeable	Ag	Ag	Ag	Ag	Ag	Ag	Ag	Ag
4	Odour	-	UO	UO	UO	UO	UO	UO	UO	UO	UO
5	Conductivity	µS/cm	$	10140	250	244	217	214	3160	2150	220
6	Turbidity	NTU	5(10)	3	4	4	3	3	4	4	3
7	TDS	mg/l	500(2000)	6896	174	168	144	142	2150	1390	152
8	Total Hardness as CaCO3	mg/l	300(600)	675	120	110	100	95	550	570	85
9	Total Alkalinity	mg/l	200(600)	370	105	100	100	90	695	565	90
10	Calcium as Ca	mg/l	75(200)	100	30	34	30	26	100	160	24
11	Magnesium as Mg	mg/l	30(100)	103.3	10.9	6.1	6.1	7.3	72.9	41.3	6.1
12	Residual Chlorine	mg/l	0.2 Min	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
13	Boron	mg/l	1	0.02	<0.01	<0.01	<0.01	<0.01	0.87	<0.01	<0.01
14	Chlorides as Cl	mg/l	250(1000)	2918	25	23	20.0	21	500	204	8.2
15	Sulphates as SO_4	mg/l	200(400)	708.6	5.3	7.1	2.2	2.9	113.9	28.6	3.1
16	Fluorides as F	mg/l	1.0(1.5)	0.5	0.4	0.4	0.3	0.4	0.8	0.6	0.1
17	Nitrates as NO_3	mg/l	45(NR)	3.8	2.2	2.4	2.8	2.1	31.4	30.6	1.4
18	Sodium as Na	mg/l	$	2012	12.2	11.9	12.6	11.8	312.3	181	7.2
19	Potassium as K	mg/l	$	82.6	2.0	1.8	1.8	1.7	253.7	88.6	0.6
20	Phenolic Compounds	mg/l	0.001(0.002)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
21	Cyanides	mg/l	0.05(NR)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
22	Anionic Detergents	mg/l	0.2(0.1)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
23	Mineral Oil	mg/l	0.01(0.03)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
24	Cadmium as Cd	mg/l	0.01(NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
25	Arsenic as As	mg/l	0.01(NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
26	Copper as Cu	mg/l	0.05(1.5)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
27	Lead as Pb	mg/l	0.05(NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
28	Manganese as Mn	mg/l	0.1(0.3)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
29	Iron as Fe	mg/l	0.3(1.0)	0.11	0.03	0.08	0.02	0.08	0.20	0.03	0.04
30	Chromium as Cr+6	mg/l	0.05(NR)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
31	Selenium as Se	mg/l	0.01(NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
32	Zinc as Zn	mg/l	5(15)	0.22	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
33	Aluminium as Al	mg/l	0.03(0.2)	0.06	0.09	0.06	0.03	0.06	0.13	0.02	0.01
34	Mercury as Hg	mg/l	0.001(NR)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
35	Pesticides	mg/l	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
36	E.Coli	-	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
37	Total Coliforms	MPN/100 ml	10	<2	<2	<2	<2	<2	<2	<2	<2

**Onsite results, $ Limits not specified as per IS: 10500; OU: Unobjectionable; Ag: Agreeable; NR: No Relaxation*

TABLE-3.7.3(C)
GROUND WATER QUALITY – MONSOON – 2012

Sr. No.	Parameter	Unit	Limits as per IS10500	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8
1	pH	-	6.5-8.5 (NR)	7.8	7.8	7.7	7.8	7.9	7.9	7.8	7.7
2	Colour	Hazen	5(25)	2	2	2	2	3	3	2	3
3	Taste	-	Agreeable	Ag	Ag	Ag	Ag	Ag	Ag	Ag	Ag
4	Odour	-	UO	UO	UO	UO	UO	UO	UO	UO	UO
5	Conductivity	µS/cm	$	9120	185	198	235	176	2980	1979	185
6	Turbidity	NTU	5(10)	3	2	2	3	4	4	3	5
7	TDS	mg/l	500(2000)	6340	120	130	160	115	2090	1330	125
8	Total Hardness as CaCO3	mg/l	300(600)	512	76	85	100	73	517	523	79
9	Total Alkalinity	mg/l	200(600)	350	55	75	95	60	650	495	75
10	Calcium as Ca	mg/l	75(200)	80.4	16.9	25.1	30.0	18.5	95.0	150.2	21.2
11	Magnesium as Mg	mg/l	30(100)	75.6	8.1	5.4	6.1	6.4	67.8	35.8	6.2
12	Residual Chlorine	mg/l	0.2 Min	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
13	Boron	mg/l	1	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
14	Chlorides as Cl	mg/l	250(1000)	2460	19.7	16.4	15.6	20.5	475	265	10.1
15	Sulphates as SO_4	mg/l	200(400)	695	5.9	5.4	2.5	3.0	105.5	45.0	3.4
16	Fluorides as F	mg/l	1.0(1.5)	0.4	0.5	0.5	0.4	0.5	0.7	0.6	0.2
17	Nitrates as NO_3	mg/l	45(NR)	3.4	2.4	2.2	2.4	2.8	31.4	31.2	1.6
18	Sodium as Na	mg/l	$	1865	7.4	9.1	12.6	8.4	296.8	174.5	6.3
19	Potassium as K	mg/l	$	62.9	1.4	1.5	1.8	1.3	245.5	80.2	0.9
20	Phenolic Compounds	mg/l	0.001(0.002)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
21	Cyanides	mg/l	0.05(NR)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
22	Anionic Detergents	mg/l	0.2(0.1)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
23	Mineral Oil	mg/l	0.01(0.03)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
24	Cadmium as Cd	mg/l	0.01(NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
25	Arsenic as As	mg/l	0.01(NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
26	Copper as Cu	mg/l	0.05(1.5)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
27	Lead as Pb	mg/l	0.05(NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
28	Manganese as Mn	mg/l	0.1(0.3)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
29	Iron as Fe	mg/l	0.3(1.0)	0.14	0.09	0.03	0.04	0.03	0.16	0.07	0.04
30	Chromium as Cr+6	mg/l	0.05(NR)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
31	Selenium as Se	mg/l	0.01(NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
32	Zinc as Zn	mg/l	5(15)	0..19	<0.01	0.11	0.09	0.09	0.02	0.09	<0.01
33	Aluminium as Al	mg/l	0.03(0.2)	0.09	0.03	0.07	0.01	<0.01	0.12	<0.01	0.07
34	Mercury as Hg	mg/l	0.001(NR)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
35	Pesticides	mg/l	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
36	E.Coli	-	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
37	Total Coliforms	MPN/100 ml	10	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

**Onsite results, $ Limits not specified as per IS: 10500; OU: Unobjectionable; Ag: Agreeable; NR: No Relaxation*

TABLE-3.7.3(D)
GROUND WATER QUALITY – POST MONSOON 2011 – 2012

Sr. No.	Parameter	Unit	Limits as per IS10500	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8
1	pH	-	6.5-8.5 (NR)	7.8	7.9	7.7	7.6	7.8	7.9	7.9	7.6
2	Colour	Hazen	5(25)	2	2	2	2	2	4	3	2
3	Taste	-	Agreeable	Ag	Ag	Ag	Ag	Ag	Ag	Ag	Ag
4	Odour	-	UO	UO	UO	UO	UO	UO	UO	UO	UO
5	Conductivity	µS/cm	$	9480	210	220	205	194	3050	2010	205
6	Turbidity	NTU	5(10)	4	3	3	3	3	5	3	3
7	TDS	mg/l	500(2000)	6160	137	143	133	126	1980	1307	133
8	Total Hardness as CaCO3	mg/l	300(600)	565	97	98.2	93	84	532	554	86
9	Total Alkalinity	mg/l	200(600)	365	82	86.4	88.4	76.7	680.4	550	87.2
10	Calcium as Ca	mg/l	75(200)	86	24.2	29.6	27.8	22.3	98.6	158.4	23.8
11	Magnesium as Mg	mg/l	30(100)	90	9.1	5.8	5.7	6.8	69.4	38.6	6.4
12	Residual Chlorine	mg/l	0.2 Min	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
13	Boron	mg/l	1	0.03	0.01	<0.01	0.01	0.01	0.01	<0.01	<0.01
14	Chlorides as Cl	mg/l	250(1000)	2642	22.3	18.6	25.6	20.8	490	278	9.7
15	Sulphates as SO_4	mg/l	200(400)	690	5.5	6.4	2.4	3.4	110.6	36.4	2.8
16	Fluorides as F	mg/l	1.0(1.5)	0.3	0.4	0.5	0.4	0.3	0.6	0.5	0.3
17	Nitrates as NO_3	mg/l	45(NR)	3.8	1.9	2.1	2.6	2.5	33.6	34.6	1.2
18	Sodium as Na	mg/l	$	1885	7.9	10.6	14.8	10.2	305.2	178.6	6.8
19	Potassium as K	mg/l	$	76	1.8	1.4	1.6	1.5	240.2	84.4	0.7
20	Phenolic Compounds	mg/l	0.001(0.002)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
21	Cyanides	mg/l	0.05(NR)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
22	Anionic Detergents	mg/l	0.2(0.1)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
23	Mineral Oil	mg/l	0.01(0.03)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
24	Cadmium as Cd	mg/l	0.01(NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
25	Arsenic as As	mg/l	0.01(NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
26	Copper as Cu	mg/l	0.05(1.5)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
27	Lead as Pb	mg/l	0.05(NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
28	Manganese as Mn	mg/l	0.1(0.3)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
29	Iron as Fe	mg/l	0.3(1.0)	0.09	0.03	0.09	0.12	0.09	0.09	0.03	0.02
30	Chromium as Cr+6	mg/l	0.05(NR)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
31	Selenium as Se	mg/l	0.01(NR)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
32	Zinc as Zn	mg/l	5(15)	0..11	0.09	0.03	0.06	0.02	0.09	0.01	0.05
33	Aluminium as Al	mg/l	0.03(0.2)	0.02	0.01	0.07	0.01	<0.01	0.03	0.01	0.06
34	Mercury as Hg	mg/l	0.001(NR)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
35	Pesticides	mg/l	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
36	E.Coli	-	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
37	Total Coliforms	MPN/100 ml	10	<2	<2	<2	<2	<2	<2	<2	<2

**Onsite results, $ Limits not specified as per IS: 10500; OU: Unobjectionable; Ag: Agreeable; NR: No Relaxation*

3.8 Noise Level Survey

The physical description of sound concerns its loudness as a function of frequency. Noise in general is sound which is composed of many frequency components of various types of loudness distributed over the audible frequency range. Various noise scales have been introduced to describe, in a single number, the response of an average human to a complex sound made up of various frequencies at different loudness levels. The most common and universally accepted scale is the A weighted Scale which is measured as dB (A). This is more suitable for audible range of 20 to 20,000 Hz. The scale has been designed to weigh various components of noise according to the response of a human ear.

The impact of noise sources on surrounding community depends on:

- Characteristics of noise sources (instantaneous, intermittent or continuous in nature). It can be observed that steady noise is not as annoying as one which is continuously varying in loudness;

- The time of day at which noise occurs, for example high noise levels at night in residential areas are not acceptable because of sleep disturbance; and

- The location of the noise source, with respect to noise sensitive landuse, which determines the loudness and period of exposure.

The environmental impact of noise can have several effects varying from Noise Induced Hearing Loss (NIHL) to annoyance depending on loudness of noise. The environmental impact assessment of noise from the project operations, construction activity, and vehicular traffic can be undertaken by taking into consideration various factors like potential damage to hearing, physiological responses, and annoyance and general community responses.

The main objective of noise monitoring in the study area is to establish the baseline noise levels and assess the impact of the total noise generated by the project operations around it.

3.8.1 Identification of Sampling Locations

A preliminary reconnaissance survey has been undertaken to identify the major noise generating sources in the area. Noise at different noise generating sources has been identified based on the activities in the village area, ambient noise due to traffic and the noise at sensitive areas like hospitals and schools.

The noise monitoring has been conducted for determination of noise levels at eight locations in the study area. The noise level survey was conducted for three seasons i.e., winter season-2011-2012, pre monsoon-12 and post monsoon-2012 the noise levels at each location were recorded for 24 hours. The environment setting of each noise monitoring location is given in **Table-3.8.1** and depicted in **Figure-3.8.1**.

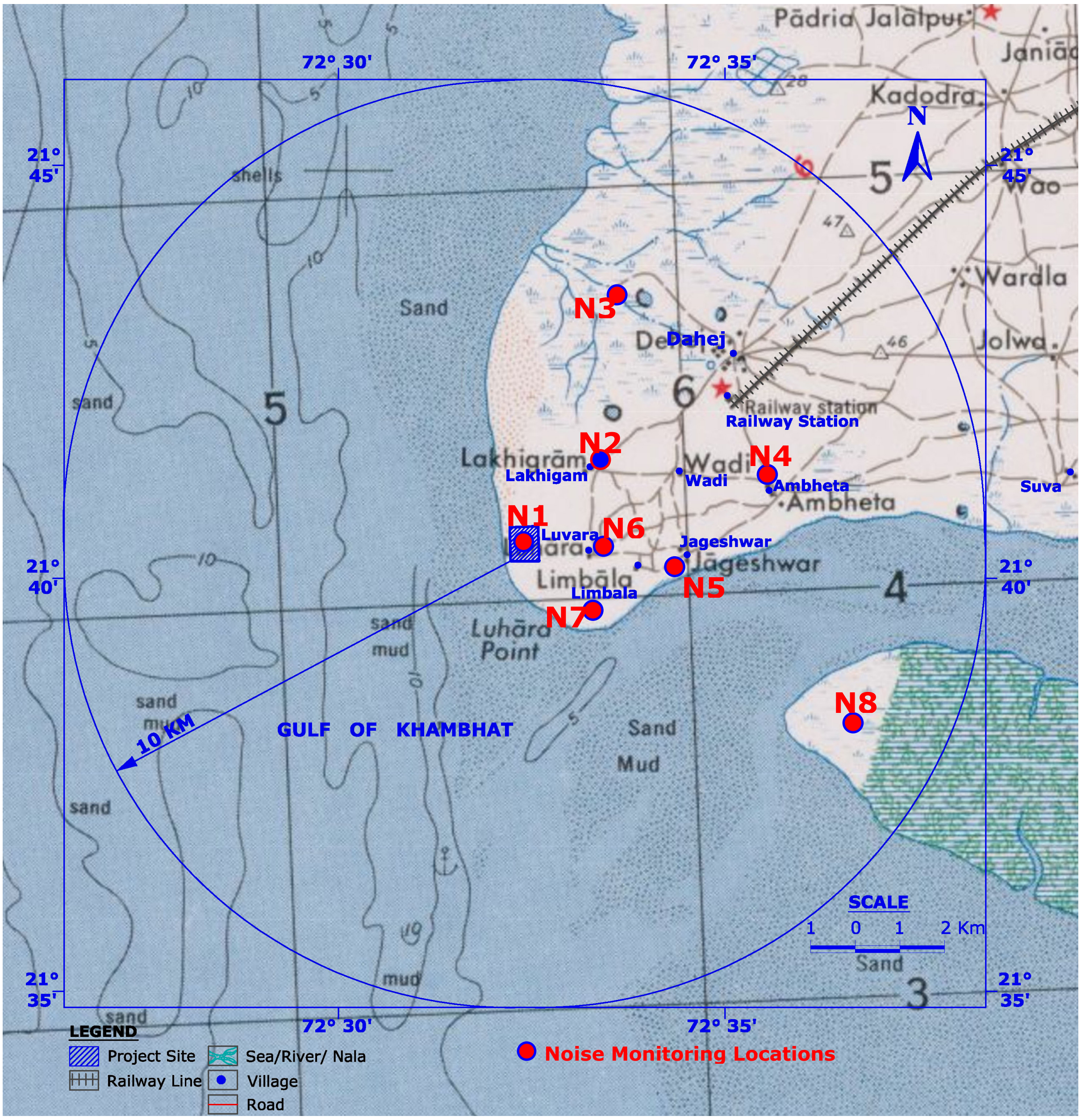


FIGURE-3.8.1
NOISE MONITORING LOCATIONS

TABLE-3.8.1
DETAILS OF NOISE MONITORING LOCATIONS

Location Code	Location	Distance (km)	Direction	Zone
		w.r.t. Proposed Project site		
N1	Project site	--	--	Industrial area
N2	Lakhigam village	2.9	NNE	Rural/Residential area
N3	Near Dahej	5.8	NNE	Rural/Residential area
N4	Ambheta village	6.2	ENE	Rural/Residential area
N5	Jageshwar village	3.6	ENE	Rural/Residential area
N6	Luvara village	1.5	E	Rural/Residential area
N7	SE of Project site	1.5	SE	Rural/Residential area
N8	Near Aliabet village	9.5	ESE	Rural/Residential area

3.8.2 Method of Monitoring

Sound Pressure Level (SPL) measurements were measured at all locations. The readings were taken for every hour for 24 hours. The day noise levels have been monitored during 6 am to 10 pm and night levels during 10 pm to 6 am at all the locations covered in 10 km radius of the study area.

3.8.3 Presentation of Results

The statistical analysis is done for measured noise levels at eight locations during study period. The parameters are analyzed for L_{day}, L_{night}, and L_{dn}. These results are tabulated in **Table-3.8.2(A)** to **Table-3.8.2(C).** The standard noise limits are listed in the **Table 3.8.3.**

3.8.4 Observation of Results

Winter Season (December 2011 to February 2012)

a) Day Time Noise Levels (L_{day})

The day time (L_{day}) noise levels at all the residential locations are observed to be in the range of 37.1 dB (A) to 48.1 dB (A). The maximum noise level of 48.1 dB (A) was observed at SE of project site (N7) and the minimum noise level of 37.1 dB (A) was observed at near Aliabet Village (N8). It is observed that the day time noise levels are in accordance to the prescribed limit of 55 dB (A) in the residential area.

b) Night Time Noise Levels (L_{night})

The night time (L_{night}) noise levels at all the residential locations were observed to be in the range of 32.5 dB (A) to 43.6 dB (A). The maximum noise level of 43.6 dB (A) was observed at Project site (N1) and the minimum noise level of 32.5 dB (A) was observed at near Aliabet Village (N8). As per the standards night time noise levels are in accordance 45 dB (A) at the residential area and 70 dB (A) at industrial area.

TABLE-3.8.2(A)
NOISE LEVELS IN THE STUDY AREA – WINTER – 2011-2012

Code	Location	L_{10}	L_{50}	L_{90}	L_{eq}	L_{day}	L_{night}	L_{dn}
N1	Project site	49.1	45.6	41.8	46.5	47.3	43.6	50.8
N2	Lakhigam Village	47.6	43.1	39.7	44.1	46.1	41.2	48.7
N3	Near Dahej	46.5	42.6	38.9	43.6	44.4	40.8	47.9
N4	Ambheta Village	40.4	36.6	32.8	37.6	38.8	34.9	42.1
N5	Jageshwar Village	43.3	39.1	35.2	40.2	41.2	36.8	44.2
N6	Luvara Village	48.8	45.0	41.2	46.0	47.6	43.3	50.6
N7	SE of Project site	49.6	44.8	41.2	46.0	48.1	42.3	50.2
N8	Near Aliabet Village	39.1	35.2	31.3	36.2	37.1	32.5	39.9

TABLE-3.8.2(B)
NOISE LEVELS IN THE STUDY AREA – PRE MONSOON - 2012

Code	Location	L_{10}	L_{50}	L_{90}	L_{eq}	L_{day}	L_{night}	L_{dn}
N1	Project site	49.6	46.1	42.3	47.0	47.8	44.1	51.3
N2	Lakhigam Village	48.3	43.8	40.4	44.8	46.8	41.9	49.4
N3	Near Dahej	48.2	44.3	40.6	45.3	46.1	42.5	49.6
N4	Ambheta Village	41.2	37.4	33.6	38.4	39.6	35.7	42.9
N5	Jageshwar Village	46.9	42.7	38.8	43.8	44.8	40.4	47.8
N6	Luvara Village	48.2	44.4	40.6	45.4	47.0	42.7	50.0
N7	SE of Project site	47.9	43.1	39.5	44.3	46.4	40.6	48.5
N8	Near Aliabet Village	40.3	36.4	32.5	37.4	38.3	33.7	41.1

TABLE-3.8.2(C)
NOISE LEVELS IN THE STUDY AREA – POST MONSOON - 2012

Code	Location	L_{10}	L_{50}	L_{90}	L_{eq}	L_{day}	L_{night}	L_{dn}
N1	Project site	49.4	45.9	42.1	46.8	47.6	43.9	51.1
N2	Lakhigam Village	48.1	43.6	40.2	44.6	46.6	41.7	49.2
N3	Near Dahej	47.2	43.3	39.6	44.3	45.1	41.5	48.6
N4	Ambheta Village	40.9	37.1	33.3	38.1	39.3	35.4	42.6
N5	Jageshwar Village	45.4	41.2	37.3	42.3	43.3	38.9	46.3
N6	Luvara Village	48.4	44.6	40.8	45.6	47.2	42.9	50.2
N7	SE of Project site	48.9	44.1	40.5	45.3	47.4	41.6	49.5
N8	Near Aliabet Village	39.5	35.6	31.7	36.6	37.5	32.9	40.3

TABLE-3.8.3
AMBIENT NOISE STANDARDS

Area Code	Category of Area	Noise Levels (dB (A) Leq (Limits)	
		Day time	Night time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone	50	40

Pre-monsoon Season (March to May 2012)

a) Day Time Noise Levels (L_{day})

The day time (L_{day}) noise levels at all the residential locations are observed to be in the range of 38.3 dB (A) to 47.8 dB (A). The maximum noise level of 47.8 dB (A) was observed at Project site (N1) and the minimum noise level of 38.3 dB (A) was observed at near Aliabet Village (N8). It is observed that the day time noise levels are in accordance to the prescribed limit of 55 dB (A) in the residential area and 75 dB (A) at industrial area.

b) Night Time Noise Levels (L_{night})

The night time (L_{night}) noise levels at all the residential locations were observed to be in the range of 33.7 dB (A) to 44.1 dB (A). The maximum noise level of 44.1 dB (A) was observed at Project site (N1) and the minimum noise level of 33.7 dB (A) was observed at near Aliabet Village (N8). As per the standards night time noise levels are in accordance 45 dB (A) at the residential area and 70 dB (A) at industrial area.

Post-monsoon Season (October to November 2012)

a) Day Time Noise Levels (L_{day})

The day time (L_{day}) noise levels at all the residential locations are observed to be in the range of 37.5 dB (A) to 47.6 dB (A). The maximum noise level of 47.6 dB (A) was observed at Project site (N1) and the minimum noise level of 37.5 dB (A) was observed at near Aliabet Village (N8). It is observed that the day time noise levels are in accordance to the prescribed limit of 55 dB (A) in the residential area and 75 dB (A) in industrial area.

b) Night Time Noise Levels (L_{night})

The night time (L_{night}) noise levels at all the residential locations were observed to be in the range of 32.9 dB (A) to 43.9 dB (A). The maximum noise level of 43.9 dB (A) was observed at Project site (N1) and the minimum noise level of 32.9 dB (A) was observed at near Aliabet Village (N8). As per the standards night time noise levels are in accordance 45 dB (A) at the residential area and 70 dB (A) in Industrial area.

3.9 Flora and Fauna Studies

3.9.1 Introduction

The Convention on Biological Diversity (CBD), the Ramsar Convention, and the Convention on Migratory Species (CMS) recognize Environmental Impact Assessment (EIA) as an important decision making tool to help plan and implement development with biodiversity "in mind." The Conventions require Signatories ("Parties") to apply EIA. According to the International Association for Impact Assessment (IAIA), Impact Assessment provides opportunities to ensure that biodiversity values are recognized and taken into account in decision-making. Importantly, this involves a participatory approach with people who might be affected by a proposal.

The main aim of Conservation of Biodiversity is to ensure "No Net Loss" of any biological species whether big or small. The biodiversity-related Conventions are based on the premise that further loss of biodiversity is unacceptable. Biodiversity must be conserved to ensure it survives, continuing to provide services, values and benefits for current and future generations. The following approach has been chosen by the IAIA to help achieve 'no net loss' of biodiversity:

1. Avoidance of irreversible loss of biodiversity

2. Seeking alternative solutions to minimize biodiversity losses

3. Use of mitigation to restore biodiversity resources

4. Compensation for unavoidable loss by providing substitutes of at least Similar biodiversity value

5. Looking for opportunities for enhancement

This approach can be called "positive planning for biodiversity." It helps achieve no net loss by ensuring the safety and survival of Rare or Endangered or Endemic or Threatened (REET) species.

3.9.2 Study area and Sampling locations

The ecological study was conducted in winter season 2011-2012 for the expansion of LNG handling facility from 10 MMTPA to 20 MMTPA LNG terminal fat Dahej, District Bharuch, Gujarat. The study area is around 10 km radial distance from the proposed project site taking as center.

The study area around the proposed project site mainly comprises of terrestrial ecosystem (agricultural land, wasteland and barren land) and aquatic ecosystem (Rivers and Coastal ecosystem etc.). Vegetation around the proposed project area comprises of mainly coastal vegetation type. Most of the vegetation is aggregated on agricultural boundaries, road side plantations of various industries and social forest area. Some salt pans are also observed during the field study.

Selection of sampling locations was made with reference to topography, land use, vegetation pattern, etc. The observations were taken on village forest and non-forest area (Agricultural field, Catchment area, on hills, in plain areas, village wasteland, etc.) as per the objectives and guidelines of MoEF for Environmental Impact Assessment. All observations were taken in and around sampling locations for quantitative representation of different species. The list of Terrestrial sampling locations are given in **Table-3.9.1** and depicted in **Figure-3.9.1.**

TABLE-3.9.1
DETAILS OF TERRESTRIAL ECOLOGICAL SAMPLING LOCATIONS

Station Code	Name of the Station	Distance w.r.t. site (km)	Direction w.r.t. site
TE1	Vegetation near Project site	0.3	SSW
TE2	Vegetation near Luvara	1.5	ENE
TE3	Vegetation near Lakhigam	2.9	NNE
TE4	Vegetation near Ambheta	6.2	ENE
TE5	Vegetation near Aliabet	8.7	SE

Source: Vimta Labs Limited

3.9.3 Terrestrial Ecological Studies

3.9.3.1 Objectives of Ecological Studies

The present study was undertaken with the following objectives:

- To assess the nature and distribution of vegetation in and around the project site;
- To assess the distribution of animal life spectra;
- To understand the productivity of the water bodies;
- To assess the biodiversity and to understand the resource potential; and
- To ascertain migratory routes of fauna and possibility of breeding grounds.

3.9.3.2 Methodology adopted for the Survey

To achieve the above objectives a detailed study of the area was undertaken in 10 km radius area from proposed project site boundary as centre. The different methods adopted were as follows:

- Generation of primary data by undertaking systematic ecological studies in the area;
- Discussion with local people so as to elicit information about local plants, animals and their uses; and
- Gathering data for ethno botany

❖ ***Forest Lands in Study Area***

About 22.36 ha forest land is required for proposed expansion of LNG Project site

3.9.3.3 Observations

As the LNG facility already exists, the proposed expansion will be carried out by ecology friendly means.

(A) Plant Diversity

Vegetation diversity of the area:

Secondary data was collected from Forest Department on flora and fauna which reveals that vegetation in the study area falls under tropical moist mixed deciduous and tropical dry mixed deciduous types as per the Champion and Seth's revised classification based on phenological pattern like evergreen, semi-evergreen and deciduous.

The most dominant trees in this region are *Prosopis julifera, Azadiracta indica, Albizia lebbeck* are found in co-association and phytosociological order with *Acacia nilotica*. On wasteland the vegetation cover consisting *of Pongamia pinnata, Ficus sp, Jatropha gosifolium* and *Leucaea leucocephala* were observed. The shrubs consist of *Zizyphus mauritiana, Xanthium stromarium, Tridax procumbens, Tephrosia hamiltonii, Lantana camara, Calotrops gigantea* etc. Species of bamboo and grasses like *Dendrocalamus strictus, Cynodon dactylon, Cymbopogon martini* etc. were also observed during the field survey.

Floristic Structure and Composition:

The phyto-ecological structure of vegetation found in Buffer zone shows three different strata i.e. Top, Middle and Ground. Top storey covered by *Albizzia sp., Bauhinia sp., Bombax malabaricum, Ficus religiosa, Syzygium cumini, Cocos nucifera, Azadiracta indica, Terminalia cattapa etc*. Middle storey in this region comprises *Adhatoda vasica, Capparis spinosa, Emblica officinalis*, *Lantana camara etc.* The dominant herbs in ground vegetation are *Aegeratum conyzoides*, *Argemone mexicana, Indigofera tinctoria, Tridax procumbens, Alternantera sisesselis* etc.

Near the shore mangrove species are found in Hansud. Mainly six species of mangrove are commonly found in this area are *Avicenia marina, A. alba, A. officinalis, Ceriops species, Rhizophora mucronata and Aegiceros corniculata*. The area near coastal villages has poor vegetation as compared to other places. Trees species like *Coccos nucifera, Prosopis julifera* and *Azadiracta indica* along with are observed in some places. Herbs are abundant only during monsoon. The area is dominated with tree members as compared to shrubs and herbs. *Cocos nucifera* is the dominant tree species. Density and diversity of plants is different with change in places.

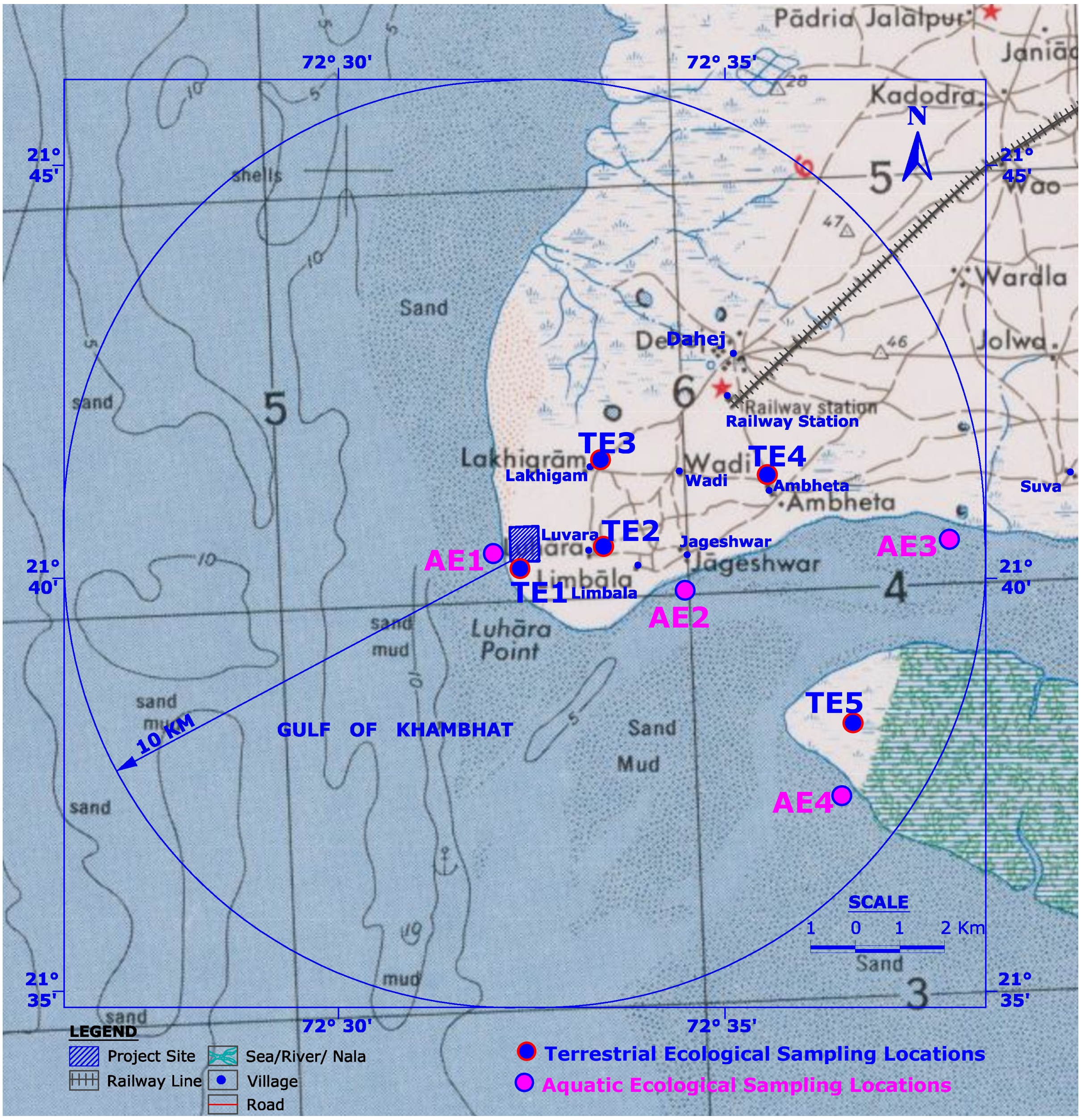


FIGURE-3.9.1
TERRESTRIAL ECOLOGICAL SAMPLING LOCATIONS

Comments on the types of Plant Community

A plant community is governed by several factors like climatic, edaphic, topographic and biotic. Even local variations in environment affect components of plant community.

Presence of large number of trees and shrubs and herbaceous vegetation indicates tropical vegetation structure.

Grasses and sedges were found to be significant in the area. These indicate fertile and wet soil in upper layer of soil profile. Aquatic plants were present in both the seasonal and perennial water bodies.

Cryptogamic Vegetation

The area shows many algae, fungi, bryophytes and ferns. Algae are present in aquatic bodies or in marshy places. Fungi, particularly from ascomycetes and basidiomycetes are located on ground or epiphytically. Lichens of crustose, foliose and fruticose types are present on different substrates (Lichens, Ascomycetes and Basidiomycetes could be observed near hilly terrain). Bryophytes occur in wet areas and occasionally on barks of trees and old walls of houses. The commonly observed bryophtes in this area are *Funaria sp* and *Polypodium sp.* Fern flora of the study area is insignificant. The aquatic weeds *Hydrilla sp, Chara sp,* and *Salvinia* were observed in small ponds in agricultural fields.

During field survey, maximum 199 number of plant species (except algae, fungi and bryophytes) were recorded from the study area. Out of 199 plant species, only 10 species were recorded from the core area. The list of plants (trees, shrubs and herbs) reported is depicted in **Table-3.9.2**.

TABLE-3.9.2
LIST OF FLORA OBSERVED IN BUFFER ZONE AREA TAKING PROJECT SITE AS CENTRE

Sr. No.	Local Name	*Botanical Name*	Family
A. Tree			
1	Acacia/ Sunajhari	*Acacia auriculiformis*	Mimosaceae
2	Akasmali / Akas nim	*Mellingtonia hortensis*	Bignoniaceae
3	Amba/Am	*Mangifera indica*	Anacardiaceae
4	Ambta	*Bauhinia recemosa*	Fabaceae
5	Amla/ Aunla	*Ernblica officinalis*	Euphorbiaceae
6	Ankula	*Alangium lamarckii*	Alangiaceae
7	Aswatha/ Peepal/ Osta	*Ficus religiosa*	Moraceae
8	Babul	*Acacia nilotica*	Mimosaceae
9	Bahada	*Terminalia belerica*	Combretaceae
10	Bana Ruar	*Aegialitis rotundifolia*	Plumbaginaceae
11	Banakapasia	*Kydia calycina*	Malvaceae
12	Bandari	*Bruguiera gymonbiza, Bruguiera sexangula*	Rhizophoraceae
13	Bandhan / Tinsa	*Ougeinia oojeinensis*	Fabaceae
14	Baniah / Baniya	*Hibiscus tiliaceus*	Malvaceae
15	Bara	*Ficus bengalensis*	Moraceae
16	Barabakulia/Dhoben	*Dalbergia paniculata*	Fabaceae
17	Barada	*Bauhinia purpurea*	Caesalpinaceae
18	Barkoli	*Ziziphus mauritiana*	Rhamnaceae

Sr. No.	Local Name	Botanical Name	Family
19	Baula	*Mimusops elengi*	Sapotaceae
20	Bel	*Aegle marmelos*	Rutaceae
21	Bheru	*Chloroxylon swietenia*	Rutaceae
22	Cashew	*Anacardimum occidentale*	Anacardiaceae
23	Chakunda	*Cassia siamea*	Ceasalpinaceae
24	Champa	*Michelia champaca*	Annonaceae
25	Chara	*Buchanania lanzan*	Anacardiaceae
26	Chhatian	*Alstonia scholaris*	Apocynaceae
27	Chikini/Kalchua	*Glochidion zeylanicum*	Euphorbiaceae
28	Churunda	*Lumnitzera racemosa*	Combretaceae
29	Damgurubu	*Gardenia latifolia*	Rubiaceae
30	Debadaru	*Polyalthia longifolia*	Annonaceae
31	Dhalabani	*Avicennia alba*	Verbeneceae
32	Dhalasiris	*Albizia procera*	Mimosaceae
33	Dhaman	*Grewia tiliifolia*	Tiliaceae
34	Dhaura	*Anogeissus latifolia*	Combretaceae
35	Dimiri	*Ficus lanceolata*	Moraceae
36	Dot	*Bruguiera parviflora*	Rhizophoraceae
37	Eucalyptus/ Nilagiri	*Eucalyptus sp.*	Myrtaceae
38	Gambhari	*Gmelina arborea*	Verbenaceae
39	Gandha palas	*Miliusa velutina*	Annonaceae
40	Ganga siuli	*Nyctanthes arbortristis*	Oleaceae
41	Garh khair	*Acacia Ienticularis*	Mimosaceae
42	Garth	*Ceriops roxburghiana*	Rhizophoraceae
43	Gando baval	**Prosopis julifera*	mimosaceae
44	Ghontol (Gotha)	*Ziziphus xylocarpus*	Rhamnaceae
45	Ghoralanjia	*Albizia chinensis*	Mimosaceae
46	Ghurudu	*Gardenia gummifora*	Rubiaceae
47	Giringa	*Pterospermum canescens*	Sterculiaceae
48	Gohira	*Acacia leucophloea*	Mimosaceae
49	Habali	*Thespesia populnea*	Malvaceae
50	Haldu/kurum	*Adina cordifolia*	Rubiaceae
51	Harkach	*Acanthus illicifolius, Acanthus volubilis*	Acanthaceae
52	Jamu/Jambu	*Syzygium cumini*	Myrtaceae
53	Jhaun	*Casuarina equisetifolia*	Casurinaceae
54	Kadam/Kadamba	*Anthocephalus cadamba*	Rubiaceae
55	Kaitha	*Limonia acidissima*	Rutaceae
56	Kalabani	*Avicennia offtcinalis*	Verbenaceae
57	Kalasiris	*Albizia lebbeck*	Mimosaceae
58	Kaliachua	*Bruguiera cylindrical*	Rhizophoraceae
59	Kamlagundi	*Mallotus philippinensis*	Euphorbiaceae
60	Kanchan	*Bauhinia variegata*	Fabaceae
61	Kandhia	*Citrus aurantium*	Rutaceae
62	Kapasia	*Kydia calycina*	Malvaceae
63	Karada/Karla	*Cleistanthus collinus*	Euphorbiaceae
64	Karanja	*Pongamia pinnata*	Fabaceae
65	Kathabadam	*Terminalia catappa*	Combretaceae
66	Katranga/Domkurudu	*Gardenia latifolia*	Rubiaceae
67	Kekra	*Bruguiera caryophylloides*	Rhizophoraceae
68	Keruhan	*Sonaretia appittela*	Sonneratiaceae
69	Khair	*Acacia catechu*	Mimosaceae
70	Kharsi	*Aegiceras corniculatum*	Myrsinaceae
71	khijdo,samdo	**prosopis cineraria*	mimosaceae
72	Krushanchuda	*Delonix regia*	Caesalpiniaceae
73	Kusum	*Schleichera oleosa*	Sapindaceae

Sr. No.	Local Name	*Botanical Name*	Family
74	Lanka badhial	*Annona reticulate*	Annonaceae
75	Latasundari	*Brownlowia tersa, Brownlowia lanceolata*	Tiliaceae
76	Lemur Mai/ Raj Mai	*Bursera penicellata*	Burseraceae
77	Mahanimba	*Ailanthus excelsa*	Simarubaceae
78	Mai	*Lannea coromandelica*	Anacardiaceae
79	Miriga	*Salvadora persica*	Salvadoraceae
80	Mohul	*Madhuca indica*	Sapotaceae
81	Mundi/Mitkania	*Mitragyna parviflora*	Rubiaceae
82	Neem/Limbo	*Azadirachta indica*	Meliaceae
83	Oau	*Dillenia indica*	Dilleniaceae
84	Orua	*Sonneratia casolaris, Sonneratia alba*	Sonneratiaceae
85	Palas/Phalas	*Butea monosperma*	Fabaceae
86	Paldhua	*Etythrina indica*	Fabaceae
87	Panas	*Artocarpus integrifolia*	Moraceae
88	Panigambhari/Tabhar	*Trewia nudiflora*	Euphorbiaceae
89	Panikusum/Pitakusum	*Aphanamixis polystachya*	Meliaceae
90	Panipatuli	*Lagerstroemia speciosa*	Lythraceae
91	Piasal/Bija	*Pterocarpus marsupium*	Fabaceae
92	Radhachuda	*Peltophorum ferrutgineum*	Caesalpiniaceae
93	Rai (Mangrove)	*Rhizophora condelaria Rhizophora murcronate*	Rhizophoraceae
94	Saguan	*Tectona grandis*	Verbenaceae
95	Sajana	*Moringa pterigosperma*	Moringaceae
96	Salap	*Caryota urens*	Palmae/ Arecaceae
97	Siju	*Euphorbia neriifolia*	Euphorbiaceae
98	Simal/Simili	*Bombax ceiba*	Bombacaceae
99	Sindhika	*Kandelia candal*	Rhizophoraceae
100	Singalbani	*Avicennia maringa*	Verbenaceae
101	Sissoo	*Dalbergia sissoo*	Fabaceae
102	Sissoo / Rosewood	*Dalbergia latifolia*	Fabaceae
103	Sunari	*Cassia fistula*	Caesalpinaceae
104	Tala	*Borassus flabelliformis*	Palmae/ Arecaceae
105	Tambal	*Ficus hispida*	Moraceae
106	Tava	*Citrus grandis*	Rutaceae
107	Telkuruma/Bhuinkuruma	*Ixora arborea*	Rubiaceae/Fabaceae
108	Tentra	*Albizzia procera*	Mimosaceae
109	Tentuli/Kania	*Tamarindus indica*	Caesalpinaceace
B. Bamboo			
1	Daba bans/kanta bans	*Bambusa arundinacea*	Poaceae
2	Salia/Hill bamboo	*Dendrocalamus strictus*	Poaceae
C. Shrubs / Herbs			
1	Agnijal/Bana jalangi	*Vernonia cinerea*	Asteraceae
2	Amiri/ Raipani	*Ipomia fistula*	Convolvulaceae
3	Anantmula	*Hemidesmus indicus*	Asclepidaceae
4	Anantmula	*Tylophlora indica/ Tylophlora tenuis*	Asclepidaceae
5	Ankarati	*Solanum xanthocarpum*	Solanaceae
6	Ankhukoli	*Carrissa opaca*	Apocynaceae
7	Ankula	*Alangium salvifolium*	Ajangiaceae
8	Arakha	*Calotropis gigantean*	Asclepiaceae
9	Ata	*Annona squamosa*	Annonaceae
10	Badianla	*Phyllanthus fraternus*	Euphorbiaceae
11	Baigaba	*Jatropha gossypifolia*	Euphorbiaceae
12	Baincha koli	*Flacourtia indica*	Flacourtiaceae
13	Bajramuli	*Sida spinosa*	Malvaceae

Sr. No.	Local Name	Botanical Name	Family
14	Ban soris	*Cleome viscosa*	Capparaceae
15	Banchkunda	*Cassia tora*	Fabaceae
16	Bani	*Avicennia officinalis*	Verbenaceae
17	Bankadaii	*Musa sapientum*	Musaceae
18	Bankhajuri/Pinokhajuri	*Phoenix sylvestris*	Palmaceae
19	Bantulasi	*Ocimum basilicum*	Lamiaceae/labiatae
20	Barkoli	*Zizyphus mauritiana*	Rhamnaceae
21	Begunia	*Vitex negundo*	Verbenaceae
22	Bhains dera	*Strobilanthus auricunatus*	Acanthaceae
23	Bhersunga / Bhugsang	*Murrya koenigii*	Rutaceae
24	Bhuin Anla	*Phyllanthus niruri*	Euphorbiaceae
25	Bhuin-neem	*Andrographis paniculate*	Acanthaceae
26	Bichuati	*Tragia involucrate*	Euphorbiaceae
27	Bisalyakarani	*Tridax procumbens*	Asteraceae
28	Chiani	*Clerodendron inermes*	Verbcnaceae
29	Dhatiki	*Woodfordia fruticosa*	L.ythraceae
30	Dhatura	*Datura fastuosa*	Solanaceae
31	Giliri/gilira	*Indigofera cassioides*	Fabaceae
32	Gohirakanta	*Dalbergia spinosa*	Apilionaceae
33	Gotha	*Croton oblongifolius*	Euphorbiaceae
34	Iswarjata	*Celosia cristata*	Amaranthaceae
35	Jagula	*Tamrix troupii/ Tamrix dioica/ Tamrix gallica*	Tamricaceae
36	Jatijatia saru	*Urena repanda*	Malvaceae
37	Jatjatiamota	*Urena cinnata*	Malvaceae
38	Jhumpuri	*Phyllochlamys spinosa*	Moraceae
39	Kantamaul	*Ventilago denticulate*	Rhamnaceae
40	Kantasiju	*Euphorbia nivulia*	Euphorbiaceae
41	Kathamanjuati	*Lawsonia inermis*	Lithraceae
42	Ketakikia	*Pandanus fascicularis*	Pandanaceae
43	Khajuri	*Phoenix dactylifera*	Arecaceae
44	Kharal	*Gardenia turgida*	Rubiaceae
45	Kharkhari	*Clerodendrum viscosum*	Verbenaceae
46	Khirkoli	*Manilkara hexandra*	Sapotaceae
47	Kurei/kher	*Holarrhena antidysenterica*	Apocynaceae
48	Kuruda/Ghurudu	*Gardenia gummifera*	Rubiaceae
49	Laj wanti/Lajkulilata	*Mimosa pudica*	Mimosaceae
50	Lantana/Bholupadi /Nagairi	*Lantana camara*	Verbenaceae
51	Lunikia	*Pandanus foetidus*	Pandanaceae
52	Masundi	*Croton oblongifolius*	Tiliaceae
53	Mayurachulia	*Celosia argenta*	Amaranthaceae
54	Mirgichra/Barenga	*Grewia elastica*	Tiliaceae
55	Mula	*Raphanus sativas*	Brassicaceae
56	Muraphal/ muri muri	*Helicteres isora*	Sterculiaceae
57	Tinakoli	*Ziziphus rugosa*	Rhamnaceae
58	Tuls	*Ocimum sanctum*	Lamiaceae
59	Urguna	*Cycas circinatis*	Cycadaceae
D. Climbers & Lianes			
1	Agnisikha	*Gloriosa superb*	Liliaceae
2	Asadhua	*Capparis zeylanica*	Capparidaceae
3	Atundi	*Combretum decandnan*	Combretaceae
4	Baidank	*Mucuna pruriens*	Fabaceae
5	Bhudel/Latapalas	*Butea superba*	Fabaceae
6	Bichhuati	*Tragia involucrate*	Euphorbiaceae
7	Kaincha	*Abrus precatorius*	Fabaceae
8	Kunjalata	*Ipomoea quamoclit*	Convolvulaceae
9	Nirmuli	*Cuscuta reflexa*	Convolvulaceae

Sr. No.	Local Name	Botanical Name	Family
10	Noipalas/Latapalas	*Butea parviflora*	Fabaceae
11	Porta (Grah)	*Dalbergia candenatensis/ Dalbergia spinosa*	Fabaceae
12	Satabari	*Aspargus racemosus*	Liliaceae
13	Siali, Sualoi	*Bauhinia vahlii*	Fabaceae
14	Smilax/ Muturi species	*Smilax zeylanica*	Liliaceae
E. Grasses			
1	Bena	*Vetiveria zizaniodes*	Poaceae
2	-	*Acrachne recemosa*	Poaceae
3	-	*apluda mutica*	Poaceae
4	Dabholu	*aristida adscensionis*	Poaceae
5	samo	*echinocloa colonum*	Poaceae
6	Adhen nasli	*Eleusine indica*	Poaceae
7	Chano	*Setaria etalica*	Poaceae
8	Chepti	*Evolvulus alsinoides*	Convolvulaceae
9	Chhana	*Imperata arundinaceae*	Poaceae
10	Dhanidhana	*Porteresia coarctata*	Poaceae
11	Dhanwantary/Khara	*Cymbopogon martini*	Poaceae
12	Duba	*Cynodon dactylon*	Poaceae
13	Keuti	*Cyperus corymbosis*	Cyperaceae
14	Panighasa	*Eragrostis japonica*	Poaceae
15	Sinkhola	*Heteropogon contortus*	Poaceae

**observed during field survey*

Endangered Plants

Floristic studies were conducted during winter season in 2011-2012, to know the presence of any endangered/threatened/endemic plant species in proposed project area and surrounding 10 km radius. The study area did not record the presence of any critically threatened species. The records of Botanical Survey of India and Forest department also did not indicate presence of any endangered and or vulnerable species in this area.

(B) Animal and Bird Diversity

National Park/Sanctuary

As per Ministry of Environment Notifications and local forest notifications reveals that no Wildlife sanctuaries, National parks/biospheres in 10km radius from study area.

Primary Survey

Since animals are capable of moving from one place to another, this makes their study entirely different. Therefore, specific methods were adopted for counting these animals in the field. For finding the bird population of migratory and local categories random sampling readings were taken at every location and for observing mammals, amphibians and reptiles were done by noting their calls, droppings, burrows, pugmarks and other signs.

The on-site information (observation and interview with local people) collected during survey was further enriched by the information collected from different secondary sources.

Wild Animals: The diversity in fauna basically depends upon density and diversity of flora. The richer the diversity among the flora better will be the diversity in fauna. The study area has tropical moist mixed deciduous vegetation. Present conditions of the area do not support higher mammals. There are animals like neelgai, hare, mouse, langur, jackal and squirrels. The mammalian elements commonly reported in the study area are presented in **Table-3.9.3**.

Reptiles: Garden lizards and monitor lizards were seen during the survey. In snakes Dhaman, Python and Cobra, Monitor lizard was noted during personal interviewing with local peoples.

TABLE-3.9.3
LIST OF FAUNA OBSERVED IN BUFFER ZONE (5-10 KM) AREA TAKING PROJECT SITE AS CENTRE

Sr. No.	Article I. Scientific Name	Common Name	Schedule of WPA-1972
Article II.	**I. Mammals**		**Article III.**
1.	*Canis laureus*	Jackal	Schedule II: Part –II
2.	*Baselaphus tragocamelus*	Nilgai	Schedule III
3.	*Funambulus pennati*	Squirrel	Schedule IV
4.	*Herpestes edwardsii*	Mongoose	Schedule II: Part –II
5.	*Lepus nigricollis*	Hare	Schedule V
6.	*Micro chiroptera*	Bat	Schedule V
7.	*Presbytis entellus*	Common Langur	Schedule II: Part –I
Article IV.	**II.Birds**		**Article V.**
1	*Accipiter badius*	The Shikara	Schedule IV
2	*Acridotheres ginginianus*	Bank Myna	Schedule IV
3	*Acridotheres tristis*	Common Myna	Schedule IV
4	*Aloedo atthis*	Small Blue Kingfisher	Schedule IV
5	*Anas clypeatea*	Shoveller Duck	Schedule IV
6	*Andea alba*	Large Egret	Schedule IV
7	*Anhinga rufa*	Darter	Schedule IV
8	*Anthropoides virgo*	The Demoiselle Crane	Schedule IV
9	*Ardea cinere*	Grey Heron	Schedule IV
10	*Ardeola grayii*	Pond Heron	Schedule IV
11	*Athene brama*	Spotted Owlet	Schedule IV
12	*Bubulcus ibis*	Cattle Egret	Schedule IV
13	*Ceryle rudis*	Pied Kingfisher	Schedule IV
14	*Columba livia neglecta*	Blue Rock Pegion	Schedule IV
15	*Coracias benghalensis*	Indian Roller	Schedule IV
16	*Corvus macrorhynchos*	Jungle Crow	Schedule IV
17	*Corvus splendens*	House Crow	Schedule V
18	*Cypsiurus parvus*	The Palm Swift	Schedule IV
19	*Dicrurus adsimillis*	Black Drongo	Schedule IV
20	*Egreta garzetta*	Little Egret	Schedule IV
21	*Egretta gularis*	Reef Heron	Schedule IV
22	*Elanus caeruleus*	Blackwinged Kite	Schedule IV
23	*Eudynamys scolopacea*	Koel	Schedule IV
24	*Francolinus pondicerianus*	Grey Partridge	Schedule IV
25	*Haliastur Indus*	Brahminy Kite	Schedule IV
26	*Himantopus himantopus*	Blackwinged Stilt	Schedule IV
27	*Hydrophasianus*	Pheasant tailed Jacana	Schedule IV
28	*Larus argentatus*	Herring Gull	Schedule IV
29	*Motacilla alba dukhuensis*	White Wagtail	Schedule IV
30	*Motacilla cincerea*	Grey Wagtail	Schedule IV

Sr. No.	Article I. Scientific Name	Common Name	Schedule of WPA-1972
31	*Mycteria leucorodia*	Painted Stork	Schedule IV
32	*Nectarinia asiofica brevirostris*	Purple Sunbird	Schedule IV
33	*Parus major*	Grey Tit	Schedule IV
34	*Pelecanus qnocrotalus*	Rosy Pelican	Schedule IV
35	*Perdicula asiatica*	The Jungle Bush Quil	Schedule IV
36	*Phalacrocorax niger*	Little Cormorant	Schedule IV
37	*Phalacrocorax qarbo*	Large Cormorant	Schedule IV
38	*Phoenicopterus roseus*	The Flamingo	Schedule IV
39	*Platalea leucorodia*	The Spoonbill	Schedule IV
40	*Pluvialis squatarola*	Grey Plover	Schedule IV
41	*Podiceps raficollis*	Little Grebe	Schedule IV
42	*Pseudibis papillosa*	Black Ibis	Schedule IV
43	*Psittacula krameri*	The Roseringed Parakeet	Schedule IV
44	*Saxicoloides fulicata*	Indian Robbin	Schedule IV
45	*Sterna aurantia*	River Tern	Schedule IV
46	*Strebopelia decaocto*	Ring Dove	Schedule IV
47	*Strebopelia senegalensis*	Little Brown Dove	Schedule IV
48	*Sturnus pagodarum*	Brahminy Myna	Schedule IV
49	*Threskiornis aethiopica*	White Ibis	Schedule IV
50	*Tringa tetanus*	Redshank	Schedule IV
51	*Turdoides striatus*	The Jungle Babbler	Schedule IV
52	*Vanellus indicus*	Redwattled Lapwing	Schedule IV
III. Reptiles			
1.	**Varanus bengalensis*	Monitar Lizzard	Schedule II: Part –II
2.	*Ptyas mucosus*	Rat snake	Schedule II: Part –II
3.	*Naja naja*	Indian cobra	Schedule II: Part –II
4.	*Bungarus caeruleus*	Common Indian Krait	Schedule II: Part –II
5.	*Vipera russelli*	Russell's Viper	Schedule II: Part –II
6.	**Calotes versicolor*	Garden lizard	-

**Observed during field survey*

Avifauna: Many bird species including quails, sand grouses, bayas, sparrows, munias, crows, mynas, parakeets, kites, hawks, doves, bee-eaters, ibis, bulbuls, babblers, larks, ducks, peafowls, lapwings, pigeons, etc are recorded from the study area during the recent survey by VIMTA team. These bird species have composition of raptors, insectivorous and granivorous birds. Occurrence of bird species in good numbers is due to suitable climate and availability of food. Some of the common birds observed during recent survey by state forest departments indicate the presence of bhat titar (Pterocles exuslus), house crow (Corvus splendense), wood pecker (Piecoides nanus), Baya (Ploceus philippinus), kabboter (Columbia livia), owl (Bubo bubo), house sparrow (Passer domesticus), parrot (Psittacula krameri), chil (Falco jugger) and eagle (Corcatus gallicus).

Surroundings of agricultural land and water bodies: The birds like Mynas, Crows, Sparrows, Bulbuls, Babblers and Pigeons are observed in and around villages. In areas with agriculture fields, the grain eating herbivorous species are dominant. These species are Doves, Sparrows, Cattle egrets, Parakeets etc. Insectivorous bird species viz. Bee-eaters, Wagtails, White breasted kingfisher, Egrets, Indian Roller are found around water bodies and in low-lying vegetation areas.

Rare, Endangered and Threatened Fauna in the Study Area:

In the year 1972 Government of India made an Act to provide protection to wild animals, birds and plants and for matters connected therewith which is known as Wild life (Protection) Act, 1972. Under this act Animals are categorized in Schedules to give maximum protection to the wild animals.

No animals and birds are found to be threatened in the study area. However with increasing anthropogenic activities like expansion of agricultural fields and industries there is an intense pressure on the fauna.

3.9.4 Aquatic Ecosystems

Protecting the environment and making efficient use of natural resources are two of the most pressing demands in the present stage of social development. The task of preserving the purity of the atmosphere and water basins is of both national and global significance since there are no boundaries to the propagation of anthropogenic contaminants in the water. An essential pre requisite for the successful solution to these problems is to evaluate ecological impacts from the baseline information and undertake effective management plan. So the objective of aquatic ecological study may be outlined as follows:

- To characterize water bodies like fresh waters;
- To understand their present biological status;
- To characterize water bodies with the help of biota;
- To understand the impact of industrial and urbanization activities; and
- To suggest recommendations to counter adverse impacts, if any on the ecosystem.

To meet these objectives following methods were followed:

- Generating data by actual field sampling and analysis in these areas through field visits during study period;

- Discussion with local people to get the information for aquatic plants and aquatic animals; and

To fulfill these objectives and to understand the present status of aquatic ecosystem, samples were collected from different coastal salty water system.

In order to get a clear picture and to assess the various parameters of water, four sampling locations were identified for sampling. Samples were collected during winter season.

Methodology Adopted for Aquatic Studies

Aquatic ecosystem close to the project area was considered for a detailed study. Water samples were considered for their physico-chemical characteristics. Plankton, aquatic plants, fish fauna of water bodies, and their associated fauna were collected, identified and estimated. The sampling locations for the aquatic study are given in **Table-3.9.4**.

TABLE-3.9.4
DETAILS OF AQUATIC SAMPLING LOCATIONS

Sr. No.	Code	Locations	Distance w.r.t. Site (km)	Direction w.r.t. Site
1	AE1	Near project site	0.4	W
2	AE2	Near Jageshwar	3.8	E
3	AE3	Near Suva	9.4	E
4	AE4	Near Aliabet village	9.1	SE

Source: Vimta Labs Limited

Phytoplankton

Phytoplankton group reported from four locations are basillariophyceae, chlorophyceae, myxophyceae and euglenophyceae members. About 24 species of phytoplankton were reported from four locations. Density of phytoplankton group among the four locations was highest in coastal ecosystem (AE-2) and lowest in (AE-1). The density of phytoplankton group ranged from 17 - 26 organisms/ml in all of the studied samples. Dominance of *Bacillariophyceae* members followed by myxophyceae was observed in all the locations. The highest percentage was *Ankistrodesmus falcatus and Anabeana sp* and the lowest percentage was *Euglena sp* during study period was observed. The Shannon weinners index for phytoplankton varies between 2.56 to 3.14.

Zooplankton

Daphnia, Asplancha, Ceriodaphnia is predominant animal species in studied samples Shannon weinners index for zooplankton varies between 2.45 and 2.84. The standards of Shannon weinners index are given in **Table-3.9.5**.

TABLE 3.9.5
STANDERDS OF SHANNON WEINNER DIVERSITY INDEX FOR AQUATIC COMMUNITY

Sr. No.	(SWDI) Value	Type of impacts
1	0 .0 - 1.0	Eutrophic
2	1.0-2.0	Mesotrophic
3	2.0-3.0	Oligotrophic

❖ ***Conclusions on Aquatic Ecology***

Surface water samples were collected for biological analysis from lentic and lotic water bodies during study period. Biological samples were analysed and estimated diversity index. Plankton diversity Index for phytoplankton and zooplankton varies from 2.56 to 3.14 and 2.45 and 2.84. Physico-chemical, biological parameters and diversity index reveals that the studied water bodies are slightly Oligotrophic in nature.

3.10 Demography and Socio-Economics

The growth of industrial sectors and infrastructure developments in and around the agriculture dominant areas, villages and towns is bound to create its impact on the socio-economic aspects of the local population. The impacts may be positive or negative depending upon the developmental activity.

To assess the impacts on the socio-economics of the local people, it is necessary to study the existing socio-economic status of the local population, which will be helpful for making efforts to further improve the quality of life in the area of study.

To study the socio-economic aspects of people in the study area around the proposed project site, the required data has been collected from various secondary sources and supplemented by the primary data generated through the process of a limited door to door socio-economic survey.

3.10.1 Methodology Adopted for the Study

The methodology adopted for the study is based on the review of secondary data, such as District Census Statistical Handbooks-2001 and the records of National Informatics Center, New Delhi, for the parameters of demography, occupational structure of people within the general study area of 10-km radius around the proposed plant.

3.10.2 Review of Demographic and Socio-Economic Profile-2001

The sociological aspects of this study include human settlements, demography, social such as scheduled castes and scheduled tribes and literacy levels besides infrastructure facilities available in the study area. The economic aspects include occupational structure of workers. The village wise demographic data as per 2001 census is presented in **Annexure-VIII**. The salient features of the demographic and socio-economic details are described in the following sections.

3.10.3 Demographic Aspects

3.10.3.1 Distribution of Population

As per 2001 Census the study area consisted of 14391 persons inhabited. The distribution of population in the study area (10 km radial distance from the proposed Project site) is given in **Table-3.10.1.**

3.10.3.2 Average Household Size

The study area has a family size of 4.6 as per 2001. The decrease of family size could be attributed to a high degree of urbanization with migration of people with higher literacy levels who generally opt for smaller family size with family welfare measures and also due to the prevalence of single member families.

TABLE-3.10.1
DISTRIBUTION OF POPULATION IN THE STUDY AREA

Particulars	0-3 km	3-7 km	7-10 km	0-10 km
No. of Households	916	639	1551	3106
Male Population	2628	1556	3756	7940
Female Population	2122	1239	3090	6451
Total Population	4750	2795	6846	14391
Male Population (0-6 years)	378	255	582	1215
Female Population (0-6 years)	364	219	563	1146
Total Population (0-6 years)	742	474	1145	2361
Average Household Size	5.2	4.4	4.4	4.6
% of males to the total population	55.3	55.7	54.9	55.2
% of females to the total population	44.7	44.3	45.1	44.8
Sex Ratio (no of females per 1000 males)	807.5	796.3	822.7	812.5

Source: Bharuch District Census Statistics-2001

3.10.3.3 Population Density

The density of population reveals that the study area has an overall density of 124 persons per km^2 as per 2001 census reports.

3.10.3.4 Sex Ratio

The configuration of male and female indicates that the males constitute to about 55.2% and females to 44.8% of the total population as per 2001 census records. The sex ratio i.e. the number of females per 1000 males indirectly reveals certain sociological aspects in relation with female births, infant mortality among female children and single person family structure, a resultant of migration of industrial workers. The study area on an average has 812 females per 1000 males as per 2001 census reports.

3.10.4 Social Structure

In the study area, as per 2001 census, 4.5 % of the population belongs to Scheduled Castes (SC) and 20.1 % to Scheduled Tribes (ST), thus indicating that there has been no significant change in weaker sections over previous years. This indicates that, the study area is inhabited predominantly by tribal population. The distribution of population in the study area by social structure is shown in **Table-3.10.2.**

TABLE-3.10.2
DISTRIBUTION OF POPULATION BY SOCIAL STRUCTURE

Particulars	0-3 km	3-7 km	7-10 km	0-10 km
Schedule caste	160	117	365	642
% To the total population	3.4	4.2	5.3	4.5
Schedule Tribes	1226	274	1398	2898
% To the total population	25.8	9.8	20.4	20.1
Total SC and ST population	1386	391	1763	3540
% To total population	29.2	14.0	25.8	24.6
Total population	4750	2795	6846	14391

Source: Bharuch District Census Statistics-2001

3.10.4 Literacy Levels

The study area experiences a very moderate literacy rate of 64.4 % (2001). The distribution of literate and literacy rate in the study area is given in **Table-3.10.3.** The male literacy rate to total population was found in the study area as 40.2%. The female literacy rate to total population is observed to be only 24.1% as per 2001 census records. Percentage of sex ratio and literacy rate in the study area is given in **Figure-3.10.1.**

TABLE-3.10.3
DISTRIBUTION OF LITERATE AND LITERACY RATES

Particulars	0-3 km	3-7 km	7-10 km	0-10 km
Male Population	2628	1556	3756	7940
Female Population	2122	1239	3090	6451
Total Population	4750	2795	6846	14391
Male literates	1926	1131	2734	5791
Female literates	1028	625	1818	3471
Total literates	2954	1756	4552	9262
Male literacy rate (%)	65.2	64.4	60.1	62.5
Female literacy rate (%)	34.8	35.6	39.9	37.5
Average Male Literacy to the total population (%)	40.5	40.5	39.9	40.2
Average female Literacy to the total population (%)	21.6	22.4	26.6	24.1
Total Literacy rate (%)	62.2	62.8	66.5	64.4

Source: Bharuch District Census Statistics-2001

3.10.4 Occupational Structure

The occupational structure of residents in the study area is studied with reference to main workers, marginal workers and non-workers.

As per the 2001 census records main workers works out to be 38.3% of the total population. The marginal workers and non-workers constitute to 2.6% and 59.1% of the total population respectively. The distribution of workers by occupation indicates that the non-workers are the predominant population. The occupational structure of the study area is shown in **Table-3.10.4.** Distribution of work participation rate in the study area is depicted in **Figure-3.10.2.**

TABLE-3.10.4
OCCUPATIONAL STRUCTURE

Particulars	0-3 km	3-7 km	7-10 km	0-10 km
Total Population	4750	2795	6846	14391
Total workers	2185	1014	2688	5887
Work participation rate (%)	46.0	36.3	39.3	40.9
Total main workers	2070	921	2524	5515
% of main workers to total population	43.6	33.0	36.9	38.3
Marginal workers	115	93	164	372
% of marginal workers to total population	2.4	3.3	2.4	2.6
Non-workers	2565	1781	4158	8504
% of non-workers to total population	54.0	63.7	60.7	59.1

Source: Bharuch District Census Statistics-2001

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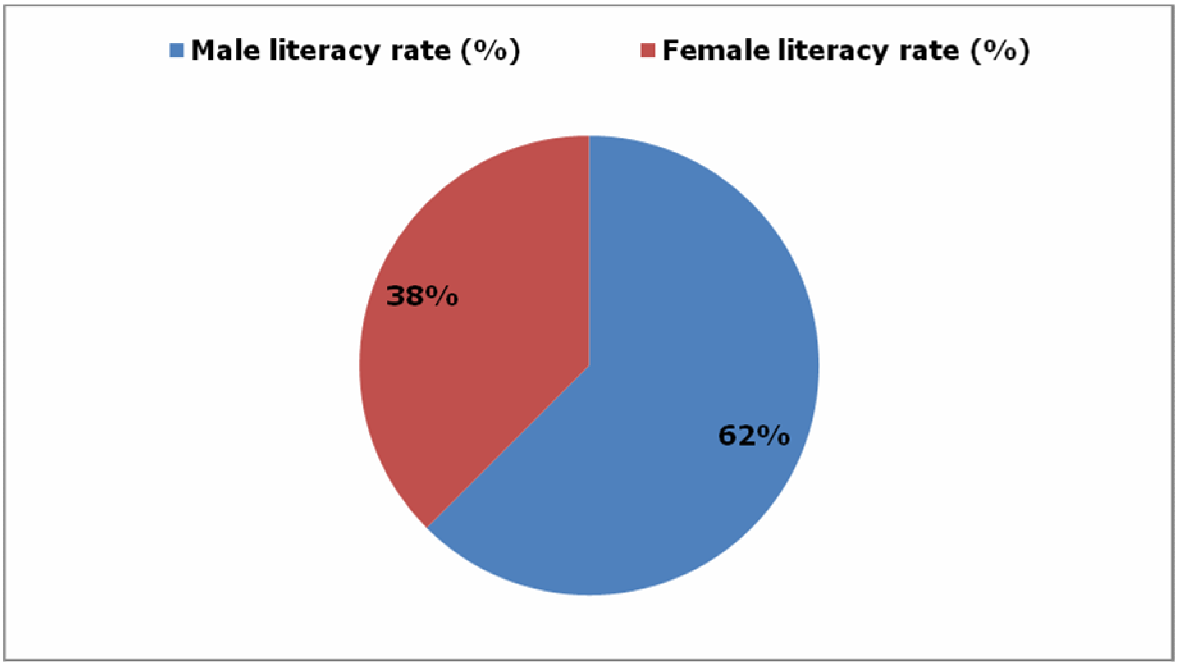

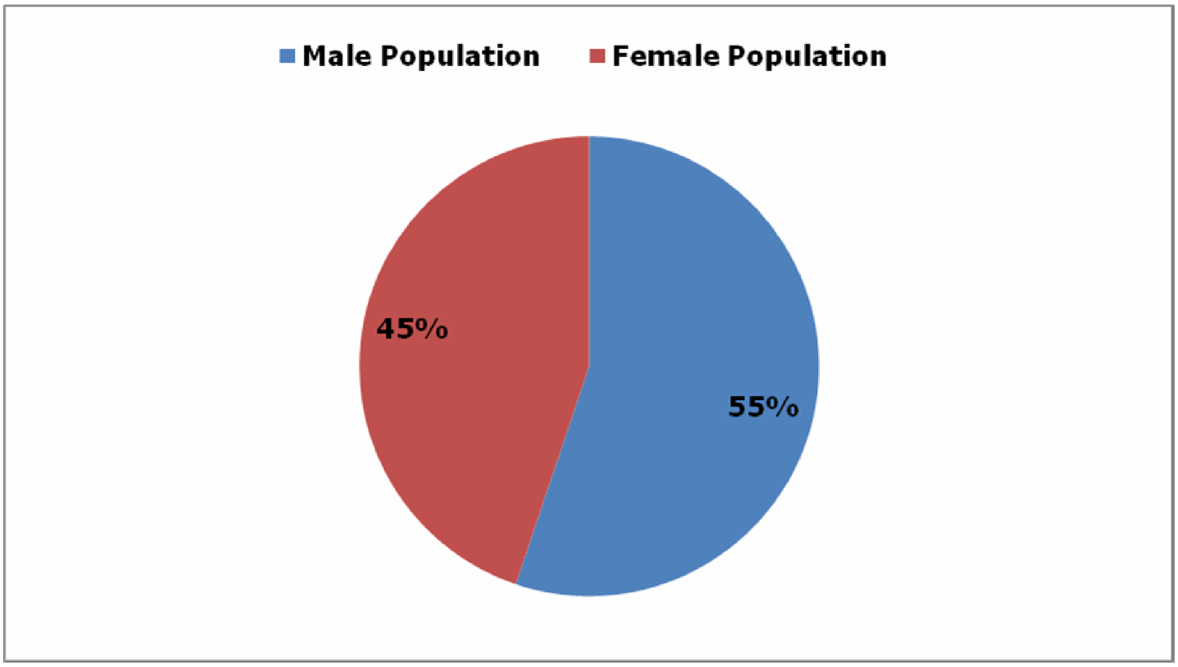

FIGURE-3.10.1
PERCENTAGE OF SEX RATIO AND LITERACY RATE IN THE STUDY AREA

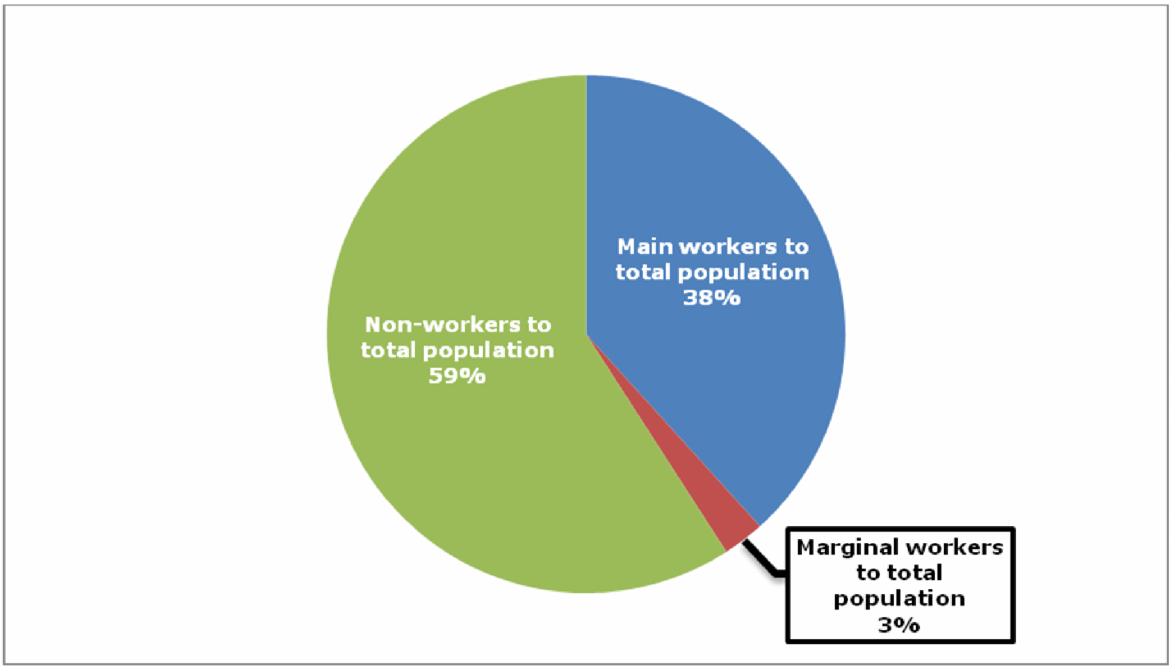

FIGURE-3.10.2
DISTRIBUTION OF WORK PARTICIPATION RATE (%) IN THE STUDY AREA

4.0 ANTICIPATED IMPACT ASSESSMENT AND MITIGATION MEASURES

4.1 Introduction

The chapter presents identification and appraisal of various impacts due to the proposed expansion of LNG terminal during construction and operational phases. The environmental impacts are categorized as primary or secondary. Primary impacts are those, which are attributed directly to the project and secondary impacts are those, which are indirectly induced and typically include the associated investment and changed pattern of social and economic activities by the proposed action.

The mitigation measures proposed for minimizing the impacts have also been discussed in this chapter. Environment Management Plan (EMP) is developed to minimize adverse impacts and to ensure that the environment in and around the project site is well protected. The EMP has been prepared for both construction and operation phases of the proposed facilities and presented in chapter 5.

The impacts have been assessed for the LNG terminal assuming that the pollution due to the existing activities has already been covered under baseline environmental monitoring and continue to remain same till the operation of the project.

The construction and operational phase of the proposed project comprises various activities each of which may have an impact on some or other environmental parameters. Various impacts during the construction and operation phase on the environment have been studied to estimate the impacts on the environmental attributes and are discussed in the subsequent sections.

4.2 Impacts during Construction Phase

This includes the following activities related to land acquisition, leveling of site, construction of related structures and installation of related equipment.

4.2.1 Impact on Land Use

The proposed expansion of LNG Re-gasification Terminal is contiguous to existing LNG terminal at Dahej PLL is having about 16 hectares of land in south side of the existing plot. Additionally about 22.62 hectares of land on south side of existing plot is allocated to PLL by Forest Department. PLL has also been permitted by Gujarat Maritime Board to reclaim 20 hectares of land on west side of the existing plot.

4.2.2 Impact on Soil

The impact on soil due to project activity is expected on account of changes in soil quality and also due to soil erosion from the project areas. Considering that the proposed project will be implemented in contiguous to existing LNG terminal premises and operation causing change in soil quality is not envisaged, the impact of the project on soil quality will be less than significant.

Greenbelt will be developed in phased manner from construction stage onwards. Apart from localized construction impacts at the plant site, no adverse impacts on soil in the surrounding area are anticipated.

4.2.3 Impact on Topography

The proposed project premise is a generally plain land with a general elevation of about 12~14 m above MSL. Most of the buffer zone of the project is undulated land.

It is proposed to level the project area for implementation of project. There will be no erection of tall structures except stacks and storage tanks. Also, the contours of natural drainage will not be disturbed. In view of the above, there will be no major adverse impact on topography at the project site.

4.2.4 Impact on Air Quality

The main sources of emission during the construction period are the movement of equipment at site and dust emitted during the leveling, grading, earthwork, foundation works and exhaust emissions from vehicles and equipment deployed during the construction phase is also likely to result in marginal increase in the levels of SO_2, NOx, PM and CO. The impact will be for short duration and confined within the project boundary and is expected to be negligible outside terminal boundaries. The impact will, however, be reversible, marginal and temporary in nature. 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.

4.2.5 Impact on Water Quality

Impact on water quality during construction phase may be due to non-point discharges of solids from soil loss and sewage generated from the construction workforce stationed at the site. Further, the construction will be more related to mechanical fabrication, assembly and erection; hence the water requirements would be small. The construction water required will be obtained from existing facilities within the present LNG terminal site.

The major source of water pollution in the construction phases is the sewage generated by the workers. During construction phase about 35 m^3/day of wastewater is expected to be generated. Temporary sanitation facilities (septic tanks and soak pits) will be set-up for disposal of sanitary sewage generated by the workforce.

The overall impact on water environment during construction phase due to proposed expansion of LNG terminal is likely to be short term and insignificant.

4.2.6 Impact on Noise Levels

Heavy construction traffic for loading and unloading, fabrication and handling of equipment and materials are likely to cause an increase in the ambient noise levels.

The areas affected are those close to the site. However, the noise will be temporary and will be restricted mostly to daytime.
The noise control measures during construction phase include provision of caps on the equipment and regular maintenance of the equipment.

4.2.7 Impact on Terrestrial Ecology

The initial construction works at the LNG terminal regasification involves land clearance and reclamation. Greenbelt will be developed phase wise during construction to improve the aesthetic value in the area and to screen out the fugitive dust generated during construction.

The removal of vegetation from the soil and loosening of the topsoil generally causes soil erosion. However, such impacts will be confined to the project site and will be minimized through paving and regular water sprinkling.

There are not many existing matured trees in the site. However, greenbelt will be developed surrounding the project site. Thus, no major adverse impacts are envisaged on terrestrial ecology.

4.3 Impacts during Operational Phase

The proposed expansion of LNG terminal operation after phase-III (a & b) will involve 33-36 MW of power generation (including operations for 20 MMTPA). The following activities related to the operational phase will have varying impacts on the environment and are considered for impact assessment:

- Air environment;
- Water resources and quality;
- Land use;
- Soil quality;
- Solid waste;
- Noise levels;
- Terrestrial and aquatic ecology;
- Demography and socio-economics; and
- Infrastructural facilities.

4.3.1 Impact on Air Quality

LNG regasification and storage is a clean process and essentially there are no significant emission from the process. There will be a small emission from the operation of GTGs and flare. The GTGs are run by the natural gas only and hence the emissions are negligible in terms of SO_2 and SPM. NOx is only significant pollutant emitted under this condition.

The proposed project has the gas generators based on "Lean – burn" technology. In this technology, each burner and flame tube installation consists of six burner assembly, each consisting of main and pilot burner and six flame tubes. The top end of the flame tube is secured to a main burner and the grooved bottom end carries two support rings and piston rings which located in a transition fuel this provide a controlled supply of fuel in a form suitable for the efficient operation of the combustion system. The combustion is considered "Lean" when excess air is introduced into the engine along with the fuel. This produces two positive effects first, the excess air reduces the temperature of the combustion process and this reduces the amount of oxides of nitrogen (NOx) produced by nearly half, compared to a conventional natural gas engine. Second, since there is also excess oxygen available, the combustion process is more efficient and more power is produced with the same amount of fuel. In this new lean-burn engine, the combustion process is enhanced by pre-mixing the air and fuel upstream of the turbo charger before introduction into the cylinder. Break Mean Effective Pressure (BMEP) against Air Excess (Lambda), the operating window is a very narrow band where efficiency peaks and where NOx is near its minimum.

One of the results of this technology is significantly reduced emission in the exhaust. The gas engine generators have NOx emissions as low as 0.85 grams/BHP-hr and produce low amounts of hydrocarbons (HC), carbon monoxides (CO) and particulate matter (PM). Emission from the proposed GTGs shall be controlled using the similar technology.

Emissions from the flare shall mostly occur at the time of plant upset condition and the emissions will be insignificant under normal condition. In the proposed LNG terminal, three (03) No of GTGs are proposed for 15 MMTPA and further two (02) additional GTG for 20 MMTPA terminal operations.

The various measures proposed to minimize the pollution from the LNG terminal are as follows:

The NOX emission from the GTG's will be controlled by controlling combustion measures, which will be approached by way of low NOX burners

Air Pollution Modeling

Prediction of impacts on air environment has been carried out employing mathematical model based on a steady state Gaussian plume dispersion model designed for multiple point sources for short term. In the present case, **Industrial Source Complex Short Term [ISCST3]** 1993 dispersion model has been used developed by United States Environmental Protection Agency [USEPA].

The options used for short-term computations are:

- The plume rise is estimated by Briggs formulae, but the final rise is always limited to that of the mixing layer;
- Stack tip down-wash is not considered;
- Buoyancy Induced Dispersion is used to describe the increase in plume dispersion during the ascension phase;
- Calms processing routine is used by default;
- Wind profile exponents is used by default, 'Irwin';
- Flat terrain is used for computations;
- It is assumed that the pollutants do not undergo any physico-chemical transformation and that there is no pollutant removal by dry deposition;
- Washout by rain is not considered;
- Cartesian co-ordinate system has been used for computations; and
- The model computations have been done for 10 km with 1000-m interval.

Emission calculations are enclosed as **Annexure-IX**.

4.3.1.1 Model Input Data

The air pollution modeling has been carried out representing the worst case scenario. The stack details considered for model computations are summarized in **Table-4.1**.

TABLE-4.1
PROPOSED STACK DETAILS

Sr. No.	Parameters	Units	Phase-I&II	Phase-III (Tentative figures)
1	Stack Height	m	**30**	**30**
2	Stack diameter	m	1.66	1.66
3	Exit velocity	m/s	21	21
5	Flue gas temperature	°K	160+273	160+273
7	Gas Consumption	TPH	8 (max)	8 (max)
8	Oxides of Nitrogen	g/sec	0.5 (max)	0.5 (max)

Source: PLL

- ***Meteorological Data***

The hourly meteorological data recorded at site is converted to the mean hourly meteorological data as specified by CPCB and the same has been used in the model.

- ***Stability Classification***

Hourly stability is determined by wind direction fluctuation method as suggested by Slade (1965) and recommended by CPCB (PROBES/70/1997-1998).

$$\sigma_\theta = \mathbf{Wd/6}$$

σ_θ, is standard deviation of wind direction fluctuation, Wd is the overall wind direction fluctuation or width of the wind direction in degrees. The table for stability classes is given as under. The percentage occurrence of stability class used for model is given in **Table 4.2.**

TABLE-4.2
STABILITY CLASSIFICATION

Stability Class	σ_θ Degree
A	>22.5
B	22.4-17.5
C	17.4-12.5
D	12.4-7.5
E	7.4-3.5
F	<3.5

- ***Mixing Heights***

Hourly mixing heights are taken from the "Atlas of hourly mixing height and Assimilative capacity Atmosphere in India" by Indian meteorological department 2008 New Delhi has been used. The meteorological data of the post monsoon season is used for modifying.

4.3.1.2 Presentation of Results

The model simulations were carried out for winter, pre-monsoon and post monsoon season. For the short-term simulations, the Ground Level Concentrations (GLCs) were estimated around 1200 receptors to obtain an optimum description of variations in concentrations over the site in 10 km radius covering 16 directions. The predicted ground level concentration isopleths for NOx during normal operations are given in **Figure-4.1** to **Figure-4.3**.

The maximum incremental ground level concentrations and resultant concentrations for PM, SO_2 and NOx are given in **Table-4.3** and **Table-4.4** respectively. Similarly, the isopleths for various pollutant concentrations are enclosed.

TABLE-4.3
PREDICTED 24-HOURLY SHORT TERM INCREMENTAL CONCENTRATIONS

Season	Maximum Incremental GLCs NOx (μ/m^3)	Distance (km)	Direction
Winter Season	8.28	2	SE
Pre Monsoon	6.3	1.4	E
Post Monsoon	6.75	2	SE

TABLE-4.4
RESULTANT CONCENTRATIONS DUE TO INCREMENTAL GLC's (WORST CASE SCENARIO)

Season	Maximum Baseline Concentration ($\mu g/m^3$)	Incremental Concentrations due to Proposed Project ($\mu g/m^3$)	Maximum Resultant Concentration ($\mu g/m^3$)	NAAQ Standards 2009
Winter Season	20.4	8.28	28.68	80
Pre Monsoon	16.5	6.3	22.8	80
Post Monsoon	19.1	6.75	25.85	80

4.3.1.3 Discussions on Results

Even though, the incremental and resultant concentrations of NOx and are marginally higher than the baseline values, they are well within the NAAQ limits and hence, the AAQ levels after implementation of the proposed 36 MW (ISO rated) GTG's will remain within the permissible limits.

It is also to be noted that the above concentrations are for worst case scenario of operations only. Hence, it can be stated that the AAQ of the area will be within the permissible limits of respective zones.

A perusal of pervious section reveals that the maximum incremental short-term 24 hourly resultant ground level concentrations for NO_x likely to encountered in the operation of proposed LNG terminal is 8.28 µg/m^3 occurring at a distance of 2.0 km in the west direction. The resultant concentration is well within the limits when compare with NAAQM standards.

This small increase will be substantially offset by the overall improvement in regional air quality as Natural Gas will eventually replace other polluting fuel inputs in the various industries. Natural gas is an extremely important source of energy for reducing pollution and maintaining a clean and healthy environment. Natural gas is the cleanest of all the fossil fuels. Composed primarily of methane, the main products of the combustion of natural gas are carbon dioxide and water vapor, the same compounds we exhale when we breathe.

4.3.2 Impact on Water Resources and Water Quality

Water required for various LNG terminal operations will be sourced from existing LNG terminal resources. For meeting the water requirements during construction and operational stage of the LNG terminal the same source will be utilized.

4.3.2.1 Impact on Water Resources

There is no tapping of ground water during construction stage. Hence no impacts on groundwater resources is envisaged.

4.3.2.2 Impact on Water Quality

There is no generation of any liquid effluent from the process area. Existing facilities are adequate to handle additional domestic waste water.

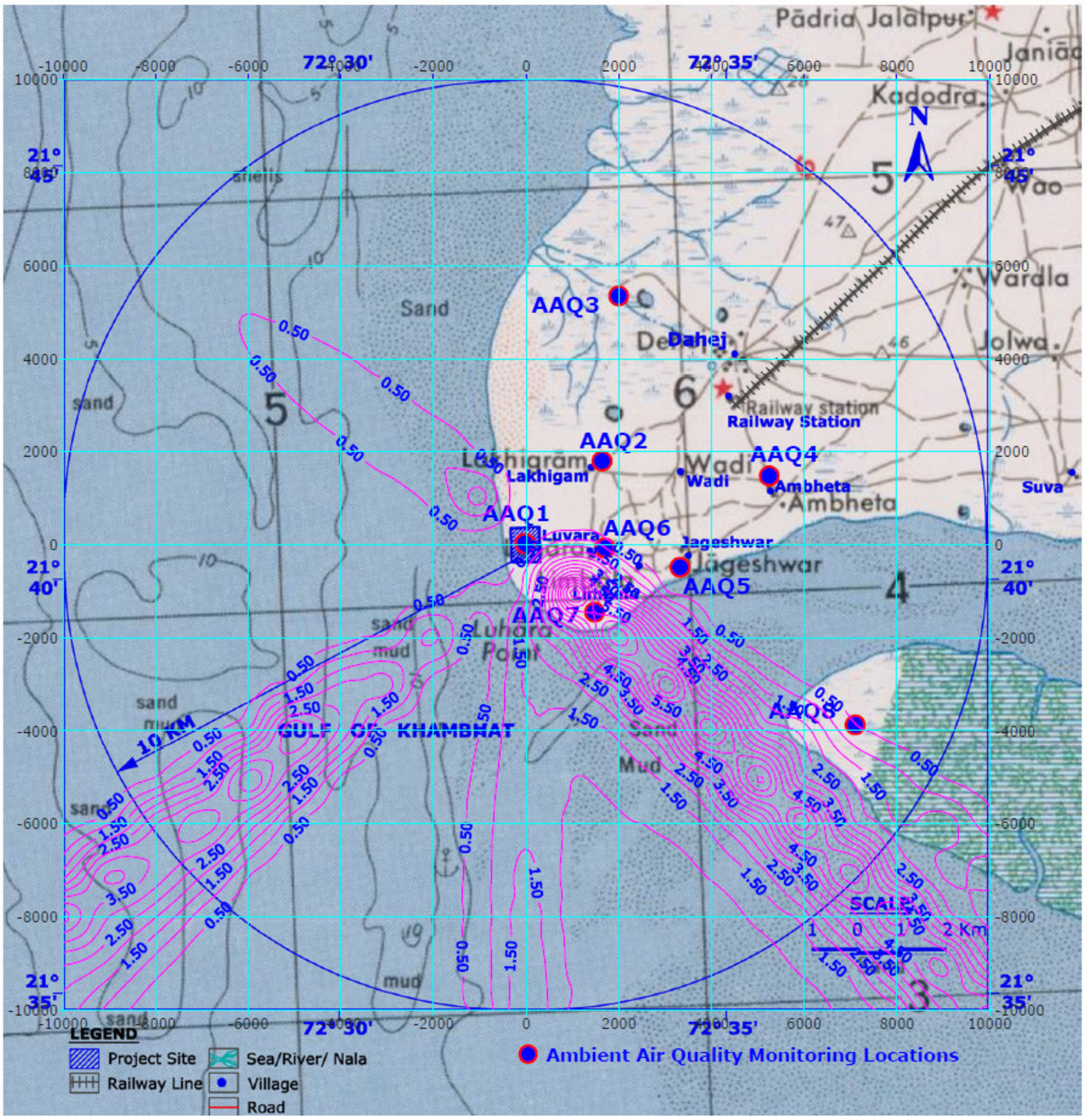

FIGURE-4.1
SHORT TERM 24 HOURLY INCREMENTAL GLCs of NOx – WINTER SEASON

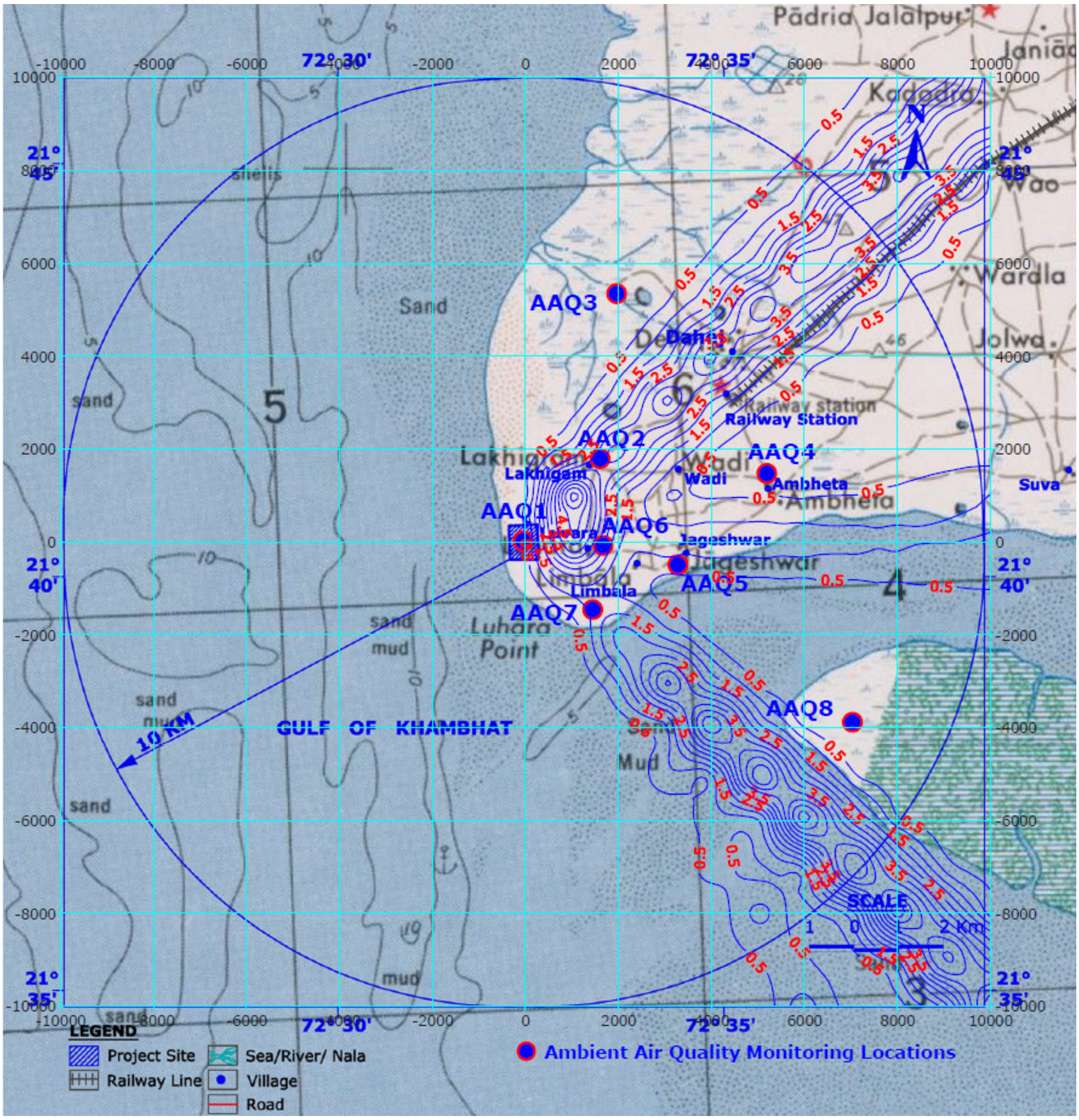

FIGURE-4.2
SHORT TERM 24 HOURLY INCREMENTAL GLCs of NOx - PRE MONSOON

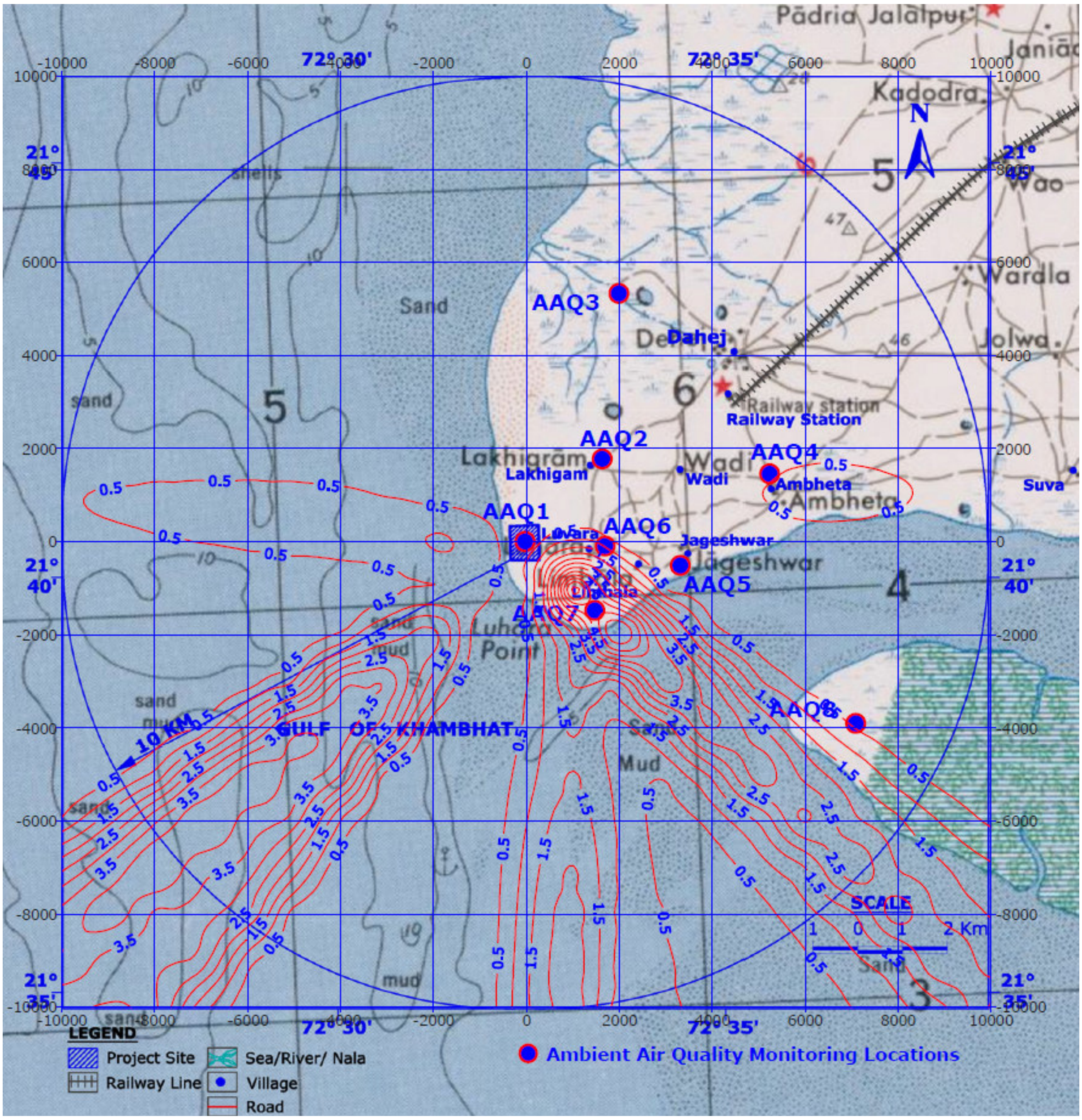

FIGURE-4.3
SHORT TERM 24 HOURLY INCREMENTAL GLCs of NOx - POST MONSOON

4.3.3 Modeling of Flow Regime for the Proposed Development

Marine modeling studies for the proposed expansion of LNG terminal at Dahej has been carried out by **M/s Environ Software Pvt. Ltd. Bangalore.**

Based on the modeling study carried out to evaluate the flow regime and sedimentation processes due to the proposed development of marine facilities (installing a standby LNG Jetty south of the existing LNG jetty) at Dahej, the following conclusions can be drawn:

Hydrodyn-FLOSOFT and SEDSOFT modules have been used for predicting the impact on flow dynamics, morphological changes and coastline changes due to marine facility development.

Hydrodynamic Modeling:

- The model generated tides are comparable to actual observations at the vicinity of proposed development at PETRONET LNG Jetty.
- The model has been run for various tidal conditions to study the hydrodynamic behavior and flow regime in and around the proposed development.
- For all the tidal conditions and with the proposed development considered, the impact on the flow regime is minimal and there seems to be no significant difference in the tides and velocities in the domain due to proposed development.
- The changes in the flow regime for various tidal conditions before and after the proposed development are found to be negligible.

Sediment Transport Modeling:

- Minor changes in the sedimentation processes for all tidal conditions seem to be present due to the proposed development.
- The accumulation of sand/silt/mud predicted in the vicinity of proposed LNG jetty is around 3 to 5 cm over a period of 15 days.
- The changes in the sedimentation processes for all tidal conditions due to the development activities are not significant enough to cause any appreciable change in the bed levels and sediment concentration in other parts of the domain except at the proposed LNG jetty
- The development activities do not seem to affect the flow regime and morphology in the rest of the study area in general.

The report of marine modeling study carried out for the proposed expansion of LNG terminal is given in **Annexure-X.**

4.3.4 Impact on Land Use

PLL is having about 16 hectares of land in south side of the existing plot. Additionally about 22.62 hectares of land on south side of existing plot is allocated by Forest Department to PLL and Stage-I clearance is accorded by Forest Department. PLL has also been permitted by Gujarat maritime Board to reclaim 20 hectares of land on west side of the existing plot.

After commissioning of proposed expansion of LNG terminal, land use of the additional land required for expansion of LNG terminal will change to industry category. The greenbelt proposed will have a positive impact on land. There will be minimum changes in land use during the operational phase of the LNG terminal. Hence, no major impacts are envisaged during operational phase of the project.

4.3.5 Impact on Soil

Most of the impacts of LNG terminal project on soils are restricted to the construction phase, which will get stabilized during operational phase. The impact on the topsoil will be confined to the proposed expansion of main terminal area only. Further, the greenbelt proposed will have a very positive impact on soil quality.

The impact of project activity is expected on account of changes in soil quality and also due to soil erosion from the project areas. Considering that the proposed project will be implemented within the existing LNG Terminal and operation causing change in soil quality is not envisaged, the impact of the project on soil quality will be less than significant.

The airborne fugitive dust from the proposed expansion LNG terminal is likely to be deposited on the topsoil in the immediate vicinity of the terminal boundary. However, the fugitive emissions are likely to be controlled to a great extent through proposed control measures like water sprinkling and development of greenbelt development.

Hence, no major impact is envisaged on soil quality of the project site.

4.3.6 Impact of Solid Waste

On a regular basis, there is no generation of any non-hazardous or inert solid waste from the proposed LNG terminal. A small quantity i.e. about 1.0 KL/year of hazardous oily waste will be generated from the proposed expansion of LNG terminal during periodic maintenance. Hazardous waste is being collected and stored at specific identified area at site. Authorized agency will be hired to dispose the collected Hazardous waste.

4.3.7 Biological Environment (Coastal and Marine Ecology)

4.3.7.1 Potential Impact Due to LNG terminal Location

The location of a proposed expansion of LNG terminal may affect aquatic fauna and flora through changes of water quality, coastal hydrology and bottom contamination. Land reclamation from the sea may damage bottom habitat and displaces fishery resources. Terrestrial fauna and flora may also be altered by the location of a LNG terminal.

Diminution of bottom biota is usually linked to a reduction of fishery resources, and occasionally to an increase of undesirable species. Deterioration of water quality usually gives rise to changes in aquatic biota, a decrease in the number of species, and an increase in the quantity of one or two specific species.

Diminution of plants in a shore zone within enclosed water may degrade its aeration capability and cause water pollution.

4.3.7.1.1 Mitigation Measures

Careful survey of the ecological characteristics of a project area has been carried out and appropriate measures are proposed for their conservation. Planting of green plants in and around the LNG terminal is being done as an effective means to mitigate adverse effects on terrestrial habitat.

Greenbelt proposal has been prepared and being implemented in the LNG terminal premises as per the guidelines of Central Pollution Control Board.

4.3.7.2 Potential Impact Due to the LNG terminal Construction

➢ ***Organic Matter and Nutrients***

The release of organic rich sediments during dredging can result in the localized removal of oxygen from the surrounding water. Depending on the location and timing of the dredge this may lead to the suffocation of marine animals and plants within the localized area or may deter migratory fish or mammals from passing through. However, it is important to stress that the removal of oxygen from water is only temporary, as tidal exchange would quickly replenish the oxygen supply. Therefore, in most cases where dredging is taking place in open coastal waters this localized removal of oxygen has little, if any, effect on marine life.

The resuspension of sediments during dredging may also result in an increase in the levels of organic matter and nutrients available to marine organisms. This can result in two main effects:

- In certain cases, such as environments adapted to low nutrient conditions or sensitive to the effects of eutrophication which can simply be described as nutrient enrichment leading to the formation of algal blooms. These blooms can reduce the surrounding water quality by causing the removal of oxygen as the blooms break down or occasionally by the release of toxins which may disturb marine life; and

- In other cases, increased organic material, nutrients and algal growth may provide food for zooplankton and higher organisms, thereby increasing the productivity of the marine ecosystem.

➢ ***Impact on Terrestrial Ecology***

The initial construction works at the project site involves land clearance. During construction activities vegetation may be disturbed which can be considered insignificant. In LNG terminal, a good number of *casuarinas equisitfolia* plants are planted by government as a part of shore protection and maximum extent these plants have been retained as a part of green belt or shore protection barrier. In addition greenbelt development plan has been initiated from before the construction activity of existing LNG terminal, which in turn has improved the aesthetic value in the area and helps in screening out the fugitive dust generated. The greenbelt development will be continued after construction of proposed expansion of LNG terminal also. The removal of vegetation from the soil and loosening of the topsoil generally causes soil erosion. However, such impacts will be confined to the project site and will be minimized through paving and water spraying.

4.3.7.2.1 Mitigation Measures

➢ ***Ecological Aspects***

During construction period, there could be clearing of vegetation in order to prepare the site for construction. However, this will be mitigated by proper landscaping and extensive plantation along with the construction of the additional LNG terminal facilities. Similarly, aquatic life observed in the nearby streams is common in nature and these do not harbor any endangered species. A comprehensive green belt programme is being implemented which will help in improving the ecological condition of the region.

The damage to native species is not envisaged and the genetic diversity of the area will not be disturbed.

4.3.7.3 Potential Impact Due to the LNG Terminal Operations

4.3.7.3.1 Potential Impacts on Marine and Coastal Ecology

➢ ***Oil Spill***

During towing and berthing of the ships, owing to natural calamity or piloting errors, there can be remote possibility of mishap of one to one ship collusion or ship hitting against the wharf or ship getting grounded. During such events, the ship may sink/break and lead to oil spill inside the jetty basin or in the vicinity.

It is difficult to assess the effect of oil in the marine environment because of the large variation in sources, quantities, and nature of the oil, also the physical, chemical and biological conditions of the environments involved. The majority of research relating to the effects of the oil on the marine environment relate to major oil spill events, usually from shipping accidents and groundings, the environmental effects of which are well known by all, particularly the associations with oiled birds and mammals. However, very little literature describes the effects of chronic discharges from run off or numerous small discharges of oil which are common in port and harbour areas.

Some of the potential effects of oil pollution are as follows:

- Marine animals and plants tend to be tolerant of low level concentrations of oil in sediments from chronic or small discharges, however this is not always the case;

- Prolonged exposure to major or minor oil spills can lead to mass mortality of benthic communities, fish, mammals and birds;

- In sediments, as it is organic, oil will be broken down relatively quickly by microorganisms which may result in the localized removal of oxygen from the sediments and surrounding water with possible effects on marine life;

- The persistent toxic constituents of oil, such as heavy metals, can become stored in the sediments, and taken up into the food chain. Therefore, following large oil spills, even where animals recover in diversity and density, they may continue to suffer physiological and behavioural disorders which can result in reduction in growth and reproduction and in the worst cases, death; and

- The breakdown of oil tends to be slowest in intertidal areas, which leads to the highest concentration and longest residence times.

4.3.7.4 Impact on Noise Levels

The proposed expansion of LNG terminal would generate noise due to pumps and compressors. A quantitative prediction was carried out to estimate the cumulative noise levels due to operation of all noise generating source of LNG terminal. An in-house propagative modeling was undertaken to estimate the resultant noise level. The typical noise level generated from these sources are given in **Table-4.5.**

TABLE 4.5
TYPICAL NOISE LEVELS OF EQUIPMENTS DURING THE OPERATION PHASE

Sr. No	Particulars	Noise Level dB(A)
1	Pump	**70**
2	Compressor	**< 80 at 1 mtrs**

- **Propagative Modelling**

A propagation model has been devised to predict the noise levels at various distances around a single or multiple sources. Propagation and attenuation of noise pressure wave is dependent on many factors important amongst them being the medium of travel and the ambient conditions. The model uses the following formula as a basis for such predictions.

$$(L_{ob}) = (L_r) - (L_{Div}) - (L_{Atm})$$

Where

(L_{ob}) = Observed noise level at distance R from source.
(L_r) = Noise level of source measured at reference distance r.
(L_{Div}) = Loss due to divergence at Distance R from source.

The three terms are further defined as :

$(L_{Div}) = 20 \text{ Log } (R/r)$

Where,

R = Distance at which noise level is to be computed.
(L_{Atm}) = Attenuation due to atmosphere at distance R from source
$= \alpha \times R/100$
Where α is atmospheric attenuation coefficient in dB (A)/100m.

The total impact (L_{ob}) of all the sources at particular place is then estimated by adding as the contribution of noise from each of the following sources, as follows:

Where n = total number of sources.

The calculated noise levels are further superimposed (logarithmically) on the background noise levels. The model assumes that the noise spectrum is mainly centred around a spectrum of 1000 Hz and does not account for attenuation due to building materials.

Noise Modelling

Major sources of noise emission during operation phase have been identified as additional pumps and compressors. Noise emission from these sources have been included in the noise modelling and their impact has been predicted as discussed below.

Based on the above, noise propagation modeling was carried out to assess the post project noise scenario using in-house "NOISE" model. The result of the model was superimposed on the baseline noise levels representing the operation of proposed expansion of LNG terminal plant to predict the resultant noise level. The resultant noise level represents the conservative estimate of the cumulative impact of the operation of the LNG terminal including the proposed expansion of LNG terminal. This resultant noise level within the battery limit of the terminal has been evaluated vis-à-vis damaged risk criteria for hearing as enforced by OSHA and Ambient Air Quality Standards in respect of Noise specified under Noise Pollution (regulation and control) Rules, 2000 at the battery limit.

The model considered for monitoring background noise level of the terminal site for two periods i.e. day time and night time. Within the terminal site, model results shows that the noise level gets attenuated rapidly and at the plant battery limit and there will be negligible impact (<1 dBA) in the baseline noise level. Considering the baseline monitored noise level of the operation of existing terminal shows noise level as well within the regulatory standard, the impact of the operation of proposed expansion on Noise Environment shall be less then significant, reversible and long term. Major noise generating sources are given in **Table-4.6.**

TABLE-4.6
MAJOR NOISE GENERATING SOURCES

Sr. No.	Sources	Noise Level in dB(A)	Nature of Noise
1	Pump	70	Continuous
2	Compressor	85	Continuous

4.3.7.4.1 Presentation of Results

The incremental noise levels are computed at proposed project site at 100-mX100-m grid intervals over an area of 10-km x 10-km study area. The predicted results of incremental noise levels at each grid points are used to draw noise contours. The predicted noise contours around proposed sources are shown in **Figure-4.4**.

4.3.7.4.2 Impact on Work Zone

Pumps and compressors are the high noise generating equipment's in the proposed expansion of LNG terminal. However, impacts on the working personnel are not expected to be significant on account of the high level of automation of the LNG terminal, which means that workers will be exposed for short duration only and that too intermittently.

The noise generation during operational phase would be at source itself through different measures such as inspection, operation and maintenance at regular intervals. The noise control measures as described in EMP will be fully followed. The occupational noise exposure to the workers in the form of 8-hourly time weighted average will be maintained well within the prescribed OSHA standards (<90 dB (A)). Hence, the impact on occupational health of workers would be insignificant.

4.3.7.3 Impact on Community

As per the location of LNG terminal, the minimum distance available between proposed major noise sources and the outer periphery of the project site would be more than 500-m. The cumulative incremental impact of all noise sources at boundary will range in between 45-50 dB (A).

The nearest human habitations are located at about 1.5 km from the boundary and the cumulative noise impacts would be insignificant.

4.3.7.4 Prediction of Impacts on Socio-Economics

The requirement of unskilled manpower will be met from nearby villages during construction phase. The project will also help in generation of the indirect employment apart from direct employment. This will be a positive socio-economic development for the region. There will be a general upliftment of standard of living in the region.

4.3.7.5 Impacts on Public Health and Safety

The discharge of waste materials (stack emission, wastewater and solid wastes) from process operations may have potential impact on public safety and health.

The domestic waste water generated will be treated and used in green belt. Only storm water will be drained outside. It is proposed to reuse the wastewater to the maximum extent. Since, the adverse impacts on ambient air and soil quality are predicted to be low it is anticipated that the impact on public health will be minimum.

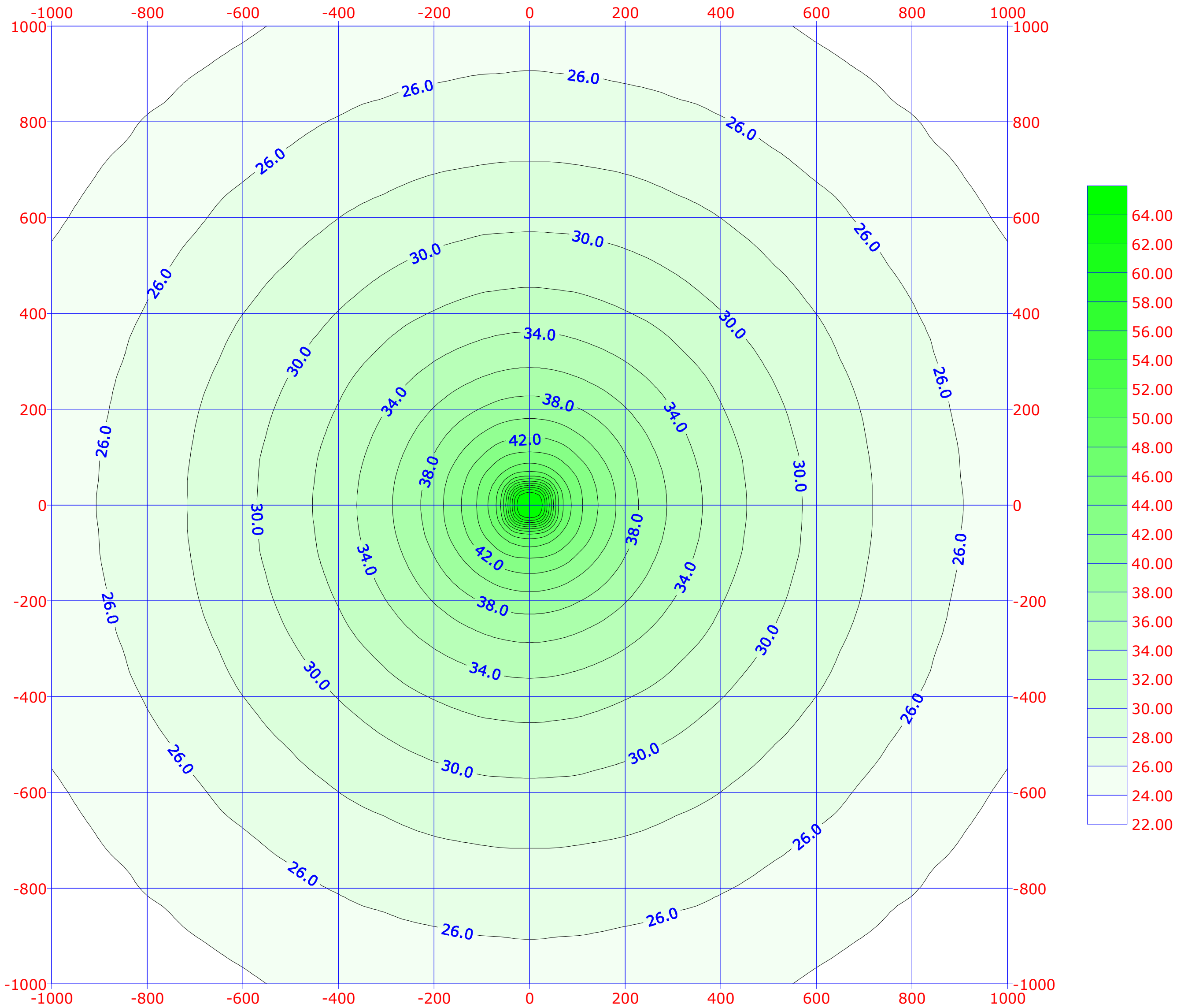

FIGURE-4.4
PREDICTED NOISE DISPERSION CONTOURS

5.0 ENVIRONMENT MANAGEMENT PLAN

5.1 Environment Management Plan during Construction Phase

During construction phase, the construction activities like site leveling, grading, transportation of the construction material cause various impacts on the surroundings. However, the constructional phase impacts are temporary and localized phenomena except the permanent change in local landscape and land use pattern of the proposed expansion of LNG terminal project site.

Since the construction activities shall be carried out by the EPC contractor, an effective contractor plan must be developed to reflect the overall environmental policy of the project.

As a part of Construction Environmental Management Plan, Construction contractor’s plan shall identify specific techniques, practices and measures that will be utilized to minimize any adverse environmental impact during construction of the facility including those specified under mitigation measures and Environmental Management Plan. Specific issues to be addressed shall include the following:

- Protection of marine and ground water quality during all construction work;
- Minimization fugitive dust emissions from construction and site preparation as per the mitigation plan;
- Minimize the quantity of erosion;
- Containment, collection and disposal of waste materials from construction activities. Dumping at sea and burning will be strictly prohibited. Maintain disposal records (quantities, disposal facility, dates etc.);
- Collection and disposal of construction site domestic waste;
- Noise control of vehicles and construction equipment;
- Vehicle traffic congestion on access roads to and from the construction site;
- Construction site storage, handling and dispensing of vehicle and equipment fuel and lubricants. Specify spill containment, clean-up and disposal methods;
- Containment of airborne paint particles from spray painting operations;
- Disposal of waste or unused liquid concrete (non-solidified concrete). Include clean-up procedure for tools, boots, equipment, truck chutes;
- Soil contamination must be prevented;
- Disposal of contaminated soil;
- Disposal of hazardous materials; and
- Establish good relationships with local community administration offices and residents.

5.1.1 Land Environment Management

PLL is having about 16 hectares of land in south side of the existing plot. Additionally about 22.62 hectares of land on south side of existing plot is allocated by Forest Department to PLL and Stage-I clearance is accorded by Forest Department. PLL has also been permitted by Gujarat maritime Board to reclaim 20 hectares of land on west side of the existing plot.

Preparation of site will involve excavations and fillings. The earthen material generated during excavations and site grading periods, shall be properly dumped and slope stabilization shall be taken. The topsoil generated during construction shall be used for filling of low laying areas required for the proposed expansion of LNG terminal and reused for plantations.

No perennial nallas are present in the LNG terminal site. However, natural drainage pattern shall not be disturbed as far as possible.

The existing approach road to project site shall be appropriately strengthened to facilitate vehicular movement.

The greenbelt area shall be delineated before start-up of earthwork and tree plantation shall be taken up during and after construction stage itself.

5.1.2 Air Quality Management

Construction phase will generate air pollution due to operation of construction machinery as well as vehicular emissions. Some measures can be considered for mitigation purpose

- In the unpaved Roads, apply chemical stabilizers or apply water twice per hour during active operation;
- In Earthmoving operation, maintain soil moisture content to a minimum of 12 percent when earthmoving;
- Conduct watering as necessary to restrict the dust emission within the active cut area; and
- In the disturbed surface areas, apply dust suppression in sufficient quantity and frequency to maintain a stabilized surface. Any areas, which cannot be stabilized as evidenced by wind driven fugitive dust. If applying chemical stabilizers, apply within five working days of grading completion.
- Proper maintenance of vehicles and construction equipment; and
- Tree plantation in the area earmarked for greenbelt development.

With regard to NOx emissions, the contractors shall implement the following measures to reduce daily NOx emissions associated with construction activities.

- All equipment shall be properly tuned and maintained in accordance with manufacturer's specifications; and
- General contractors shall maintain and operate construction equipment so as to minimize exhaust emissions. During construction, trucks and vehicles in loading and unloading queues would be kept with their engines off, when not in use, to reduce vehicle emissions. Construction emissions should be phased and scheduled to avoid emissions peaks.

5.1.3 Water Quality Management (site pls advise)

The major source of water pollution in the construction phases is the sewage generated by the workers. During construction phase about 10 m^3/day of waste is expected to be generated. The sewage generated shall be routed to soak pits and tanks and will be transferred regularly through authorized agencies.

5.1.4 Noise Level Management

The project construction is likely to increase the vehicular traffic in the area However, there are no settlements near the project site and thus adverse impacts on noise levels due to increased vehicular movements are not anticipated. During construction phase, the noise may be generated due to operation of various construction equipment's. Efforts need to be made to reduce the noise generated by the various construction equipment's which are as follows:

- Chassis and engine structural vibration noise can be dealt with by isolating the engine from the chassis and by covering various sections of the engines
- Noise levels from the drillers can be reduced by fitting of exhaust mufflers and the provision of damping on the steel too.
- Good maintenance of vehicles and construction equipment;
- Restriction of construction activities to day time only;
- Plantation of trees around the plant boundary to attenuate the noise; and
- Provision of earplugs and earmuffs to workers.

5.1.5 Ecological Management

During construction, the measures required to be undertaken to minimize the impact on the ecology are:

- The felling of trees will be kept at minimum; and
- The greenbelt having vegetation density of 2500 trees/ha will be developed.

5.1.6 Social community Management

Constructional activities will generate employment to about 2500 workers. For construction work force, temporary sanitation facilities (septic tanks and soak pits) will be set-up for disposal of sanitary sewage. Similarly, rest rooms and canteen facilities will be provided for truck drivers during construction as well as operation phase of LNG terminal.

5.2 Environment Management Plan during Operation Phase

During operation phase, the impacts on the various environmental attributes should be mitigated using appropriate pollution control equipment. The Environment Management Plan prepared for the proposed expansion of LNG terminal aims at minimizing the pollution at source.

PLL will enhance the existing Health, Safety, Environment (HSE) department to ensure safe and environment friendly practices during operations. HSE department is corporate mandate to achieve these objectives and establish PLL organization as safety and health conscious, environment friendly, and conscious of its social obligations and commitments.

HSE functions are dealt with team of competent professionals. This team also includes engineers qualified in Environmental Engineering. Coordination on environmental sample analysis done by Lab team experienced in environmental sampling and analysis. PLL, Lab, will be equipped with analyzers having state-of-the art technology to ascertain the composition on LNG/ RLNG as well as to meet other analytical requirements of process of LNG regasification & various analytical requirements pertaining to environment. There will be one marine chemist also to take care of quality of sea water. Work permit management system will be developed and being followed to carry out all kind of maintenance activities inside the project premises in a safe and environment friendly manner. Work permit system also covers environmental issues like good housekeeping and all types of waste disposal & management.

PLL will enhance and utilize the existing Occupational Health Centre with basic facilities and round the clock medical assistants & Industrial doctor for 2 days a week. PLL will lineup with nearest hospital for emergency which cannot be handled by PLL medical assistants.

The primary role of OHC is to protect the health of the employee in their Work Zone environment and to ensure that everyone is medically and physically fit to carry out the job that they are employed to do. OHC will conduct periodic medical checkup of all employees working at site.

HSE department is equipped with noise meter, Lux meter for regular monitoring of noise levels and illumination levels in the terminal area.

The proposed expansion of LNG terminal shall be within the existing LNG terminal area and existing environment management system shall be extended.

5.2.1 Air Pollution Management

Only source of emissions in the proposed expansion of LNG terminal project are the GTGs. The gas generators installed at PLL Dahej site are based on "Lean – burn "technology. This controls pollution generation by firstly, reducing the temperature of the combustion process by introducing excess air thereby reducing the amount of oxides of nitrogen (NOx) produced by nearly half, compared to a conventional natural gas engine. Secondly, improving the efficiency of the combustion process and more power by introducing excess oxygen. In this new lean-burn engine, the combustion process is enhanced by pre-mixing the air and fuel upstream of the turbo charger before introduction into the cylinder. Break mean Effective Pressure (BMEP) against Air Excess (Lambda), the operating window is a very narrow band where efficiency peaks and where NOx is near its minimum. One of the results of this technology is significantly reduction in emission in the exhaust. The gas engine generators have NOx emissions as low as 0.85 grams/BHP-hr and produce low amounts of hydrocarbons (HC), carbon monoxides (CO) and particulate matter (PM). This allows the generator sets to meet the most stringent air quality regulations without after –treatment devices in the exhausts stream.

Fugitive and stack emissions from the LNG terminal will contribute to increase in concentrations of NOx pollutants. The mitigative measures recommended in the Terminal are:

- 30 m tall stack will be provided to ensure wider dispersion of pollutants
- Appropriate system to control NOx emissions to 50 PPM will be provided
- Asphalting of the roads within the project area;
- Developing of greenbelt around the project to arrest the fugitive emissions;
- Design of control equipment to meet the standards stipulated by CREP;
- Use of Personnel safety devices by the workers should be strictly enforced.
- Online flue gas monitors as well as flue gas flow rates and temperature measurement shall be provided for all stacks; and

To control fugitive hydrocarbon emissions, the following measures shall be adopted:

- Provision and periodic inspections of mechanical seals in pumps;
- Preventive maintenance of valves, flanges, joints, roof vents of storage tanks; and
- Submerged filling of liquid fuel storage tanks.

5.2.2 Water Pollution 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 camp; and utilizing the wastewater in greenbelt development. The wastewater from labour colony will contribute to higher BOD concentrations.

The domestic sewage generated shall be routed to soak pits and tanks and will be transferred regularly through authorized agencies.

5.2.3 Noise Pollution Management

In the process, various equipments like pumps, cooling tower, compressors etc generate the noise. The recommendations to mitigate higher noise levels are:

- Equipments should be designed to conform to noise levels prescribed by regulatory authorities;
- Provision of acoustic barriers or shelters in noisy workplaces;
- Provision of hoods to noise generating equipments like pumps;
- Provision of thick greenbelt to attenuate the noise levels;
- Provision of Personal Protective Equipments (PPE) such as earplugs, earmuffs to the workers working in high noise level area; and
- Implementation of greenbelt, landscaping with horticulture at power block areas to reduce noise impacts.

5.2.4 Solid Waste Management

On a regular basis, there is no generation of any non-hazardous or inert solid waste from the proposed expansion of LNG terminal. A small quantity i.e. about 0.5 - 1.0 KL/year of hazardous oily waste will be generated from the proposed expansion of LNG terminal during periodic maintenance. Hazardous waste will be collected and stored at specific identified area at site. Authorized agency will be hired to dispose the collected Hazardous waste. Like existing hazardous waste, additional waste shall be handled similarly.

5.3 Greenbelt Development

With rapid industrialization and consequent deleterious impact of pollutants on environment, values of environmental protection offered by trees are becoming clear. Trees are very suitable for detecting, recognizing and reducing air pollution effects. Monitoring of biological effects of air pollutant by the use of plants as indicators has been applied on local, regional and national scale. Trees function as sinks of air pollutants, besides their bio-esthetical values, owing to its large surface area.

The greenbelt development not only functions as foreground and background landscape features resulting in harmonizing and amalgamating the physical structures of the project with surrounding environment, but also acts as pollution sink. Thus, implementation of afforestation program is of paramount importance. It will also check soil erosion, make the ecosystem more complex and functionally more stable and make the climate more conducive.

Greenbelt with a width of 10-m to 50-m has been developed around the project site outside the LNG handling area.

5.3.1 Various Species planted by Petronet LNG Limited, Dahej

The following plants species are planted in greenbelt for the aesthetic importance and into various patches. All the species are planted as per standard green belt design. They are given in **Table-5.1** to **Table-5.6** respectively. Three grass species like *Cynodon sp, Cymbopogon martini and Cyperus rotundus* planted in lawn. Most of the species are exotic and have very little role for the attenuation of environmental pollution

TABLE-5.1
BOTANICAL NAME OF FRUIT TREES

Sr No	Botanical Name of Fruit Trees	Common Name
1	*Musa paradisiaca*	*Banana*
2	*Punica granatum*	-
3	*Cocos nucifera*	*Coconut*
4	*Acrhrus sapota*	*Sapota*
5	*Mangifera indica*	*Mango*
6	*Psidium gauvava*	*Guavava*
7	*Sygygium cumini*	*Jamun*
8	*Ziziphus jujube*	*Ber*
9	*Terminalia catapa*	*Ashoka tree (hybrid)*

TABLE-5.2
BOTANICAL NAME OF PALM TREES

Sr No.	Botanical Name of Palm Trees	Common Name
1	*Areca catechu*	*Kattha*
2	*Areca palm ornamental*	*Palm*
3	*Roystonia regia*	-
4	*Caryota mitis*	-
5	*Caryota urenis*	-
6	*Washingtonia filifera*	-
7	*Bismarckia sp*	-
8	*Lantana sp - Yellow*	*Lantana*
9	*Lantana sp - Red*	-
10	*Raphis excelsa*	
11	*Travenella medagascarensis*	
12	*Cycas revoluta*	*Cycas*
13	*Cycas circinalis*	-
14	*Phoenix robellenii*	*Sindi*

TABLE-5.3
BOTANICAL NAME OF ORNAMENTAL TREES

Sr No	Botanical Name of Ornamental Trees	Common Name
1	*Azadirachta indica*	*Neem*
2	*Melia azadirachta*	*Mahaneem*
3	*Cassia siamea*	*Cassia*
4	*Cassia fistula*	*Amaltash*
5	*Cassia biflora*	-
6	*Lagerstroemia indica*	-
7	*Spathodia companulata*	-
8	*Kegilia pinnata*	*Kajali*
9	*Leaucena leaucocephala*	*Subaool*
10	*Pongamia pinnata*	*Karanj*
11	*Terminalia catapa*	*Badam*
12	*Erythrina indica*	-
13	*Samanea saman*	*Indian rain tree*
14	*Saraca indica*	*Askoka (wild)*
15	*Polyalthia longifolia*	*Askoka (hybrid)*
16	*Polyalthia pendula*	-
17	*Bahunia blackia*	-
18	*Bahunia purpurea*	*Apata*
19	*Callistemon lanceolatus*	-
20	*Gravillea robusta*	*Indian ghost tree*
21	*Alstonia scholaris*	-
22	*Peltophorum ferrugenium*	-
23	*Schlechera oliosa (Kusum)*	*Kusum*
24	*Thespesia populnea*	
25	*Molsari sp*	-
26	*Ficus bengalensis*	*Baragad*
27	*Ficus religiosa*	*Pipal*
28	*Ficus infectoria*	-
29	*Dalbergia sissoo*	*Shisam*
30	*Delonix regia*	*Gulmohar*
31	*Tecoma stans*	-
32	*Tebubia rosea*	-
33	*Michelia champaca*	*Champa*
34	*Bambusa vulgaris*	*Bamboo*
35	*Casuarina equisitifolia*	*Suru*
36	*Couroupita guianensis*	-

TABLE-5.4
BOTANICAL NAME OF SHRUB SPECIES

Sr No	Botanical Name of Shrub Species	Common Name
1	*Hibiscus rosasinensis*	*Jasvand*
2	*Hibiscus malavicus*	-
3	*Hibiscus double*	*Jasvand*
4	*Calliandra sp*	*Callendra*
5	*Golden duranta*	*Peela kaner*
6	*Duranta broad leaved*	*Duranta*
7	*Ixora singapuriensis*	*Ixora*
8	*Thevetia peruviana*	-
9	*Ficus panda*	-
10	*Caesalpinia pulicherrima*	*Yellow gulmohar*
11	*Mussanda sp*	-
12	*Acalypha hyspida*	-
13	*Acalypha sp*	-
14	*Amaranthus virdis*	*Chaulai*
15	*Adenium obesum*	-
16	*Lantana camara*	*Lantana*
17	*Lantana sellowviana*	-
18	*Ocimum sanctum*	*Tulasi*
19	*Allamanda cathartica*	-
20	*Verbina*	-
21	*Taberna –e-montena*	*Safed Chkri*
22	*Dracena cordilyne*	-
23	*Draceana indica*	-
24	*Draceana fragrance*	-
25	*Draceana light yellow*	-
26	*Polyscia variegata*	-
27	*Aralia sps.*	-
28	*Agloenema*	-
29	*Asparagus sprengeri*	*Asparagus*
30	*Asparagus meyers*	-
31	*Syngonium sp*	-
32	*Diffenbachia sp*	
33	*Coaedium petra*	-
34	*Coaedium narrow leaved*	-
35	*Coaedium sp*	-
36	*Lagerstromia indica*	-
37	*Bougainvillea spectabilis*	*Bougainvillea*
38	*Russalia juncia*	-
39	*Russalia equisitifolia*	-
40	*Taberna dwarf*	-
41	*schefflera arboricola compacta*	-
42	*Oleander*	-
43	*Hibiscus rosasinensis*	*Jasvand*

TABLE-5.5
BOTANICAL NAME OF HEDGES AND EDGES

Sr No	Botanical Name of Hedges	Common Name
1	*Clerodendron inermi*	*Clerodendron*
2	*Duranta golden*	-
3	*Duranta broad leaved*	-
4	*Amaranthus narrow leaved*	-
5	*Amaranthus broad leaved*	-
6	*Acalypha hyspida*	-
7	*Acalypha java*	-
8	*Acalypha copper*	-
9	*Acalypha red*	-
10	*Acalypha wilkisia green*	-
11	*Acalypha wilkisia copper*	-
12	*Acalypha twisted*	-
13	*Lantana camara*	*Lantana*
14	*Lantana yellow*	-
15	*Lantana sellowiana blue*	-
16	*Lantana sellowiana white*	-
17	*Lantana pink*	-
18	*Ficus panda*	-
19	*Bougainvillea specabilis*	*Bougainvillea*
20	*Hibiscus rosasinensis*	*Jasvand*
21	*Tradescantia sps*	-

TABLE-5.6
BOTANICAL NAME OF CREEPERS AND GROUND COVER

Sr No	Botanical Name of Creepers	Common Name
1	*Ipomea sps.*	*Lotus*
2	*Quisqualis indica*	*Chameli*
3	*Allamanda species*	-
4	*Vernonia elaegnifolia*	-
5	*Petria volubilis*	-
6	*Passiflora*	*Passin flower*
7	*Clerodendron inermi*	*Clerodendron*
8	*Ipomea species*	-
9	*Wodelia sps.*	-
10	*Asparagus sprengeri*	*Khus*
11	*Asparagus meyers*	-

Grass Species

1. Cynodon dactylon
2. Cyperous rotundous
3. *Cymbopogon* sp. (lemongrass)

5.3.2 Recommended species for Plantation

The species proposed will have broad leaves. Trees will be selected based on the type of pollutants, their intensity, location, easy availability and suitability to the local climate. They have different morphological, physiological and bio-chemical mechanism/ characters like branching habits, leaf arrangement, size, shape, surface (smooth/hairy), presence or absence of trichomes, stomatal conductivity proline content, ascorbic acid content, cationic peroxides and sulphite oxidize activities etc to trap or reduce the pollutants. Species to be selected will fulfill the following specific requirements of the area:

- Tolerance to specific conditions or alternatively wide adaptability to eco-physiological conditions;
- Rapid growth;
- Capacity to endure water
- Stress and climate extremes after initial establishment;
- Differences in height and growth habits;
- Pleasing appearances; and
- Providing shade.

Based on the above, the recommended species for greenbelt and plantation are given in **Table-5.7**. Further, the already existing/native species will be given preference.

Based on climate and soil characteristics of the study area, some species are recommended for plantation. In order to have a ground cover, some fast growing species, wider soil adaptability have been recommended for mass plantation. For protecting the environment from dust, temperature, chemicals, emissions, the following species have been recommended:

TABLE-5.7
RECOMMENDED PLANTS FOR GREENBELT

Note: S: Small, M: Medium, L: Large

Sr. No.	Species	Type
1	*Acacia auriculoformis*	Tree
2	*Acacia catechu*	Tree
3	*Acacia nilotica*	Tree
4	*Aegle marmelos*	Tree
5	*Albizia lebbeck*	Tree
6	*Albizia procera*	Tree
7	*Anona squamosa*	Tree
8	*Azadirachta indica*	Tree
9	*Bridelia squamosa*	Tree
10	*Butea monosperma*	Tree
11	*Callistemon citrinus*	Tree
12	*Ceiba pentandra*	Tree
13	*Cassia symea*	Tree
14	*Caesalpinia pulcherima*	Tree
15	*Dalbergia sisoo*	Tree
16	*Delonix regia*	Tree
17	*Eucalyptus sp*	Tree
18	*Ficus benghalensis*	Tree
19	*Ficus glomerata*	Tree

Sr. No.	Species	Type
20	*Ficus religiosa*	Tree
21	*Gardenia asminoides*	Tree
22	*Gardenia resinifera*	Tree
23	*Polyalthia longifolia*	Tree
24	*Prosopis chilensis*	Tree
25	*Mangifera indica*	Tree
26	*Pithocellobium duci*	Tree
27	*Syzygium cumini*	Tree
28	*Tamarindus indica*	Tree
29	*Zizyplus mauritiana*	Tree
30	*Pongamia pinnata*	Tree
31	*Plameria rubra*	Tree
32	*Polyalthia longifolia*	Tree
33	*Duranta repens*	Shrub
34	*Caesalpinia pulcherima*	Shrub
35	*Hibiscus rose-sinensis*	Shrub
36	*Ixora coccinea*	Shrub
37	*Clerodendrum sp*	Shrub
38	*Lantana camara*	Shrub
39	*Lawsonia inermis*	Shrub
40	*Peltophoram sp*	Shrub
41	*Nerium indicum*	Shrub
42	*Abutilon indicum linn*	Shrub
43	*Bambusa arundinecia*	Shrub
44	*Bambusa vulgeris*	Shrub
45	*Bougainvillea spectabilis*	Shrub

The plantation schedule will be completed within five years from the construction period of the project. PLL will also associate with State Forest Department for plantation and forestation project in the state.

5.3.3 <u>Post Project Monitoring</u>

Regular monitoring of environmental parameters is of immense importance to assess the status of environment during project operation. With the knowledge of baseline conditions, the monitoring programme will serve as an indicator for any deterioration in environmental conditions due to operation of the project, will enable the management to take up suitable mitigatory steps in time to safeguard the environment. Monitoring is as important as that of control of pollution since the efficiency of control measures can only be determined by monitoring.

Usually, as in the case of the study, an Impact Assessment study is carried over short period of time and the data cannot bring out all variations induced by the natural or human activities. Therefore, regular monitoring programme of the environmental parameters is essential to take into account the changes in the environmental quality.

5.4 Environmental Monitoring and Reporting Procedure

Monitoring shall confirm that commitments are being met. This may take the form of direct measurement and recording of quantitative information, such as amounts and concentrations of discharges, emissions and wastes, for measurement against statutory standards, consent limits or targets. It may also require measurement of ambient environmental quality in the vicinity of a site using ecological/biological, physical and chemical indicators. Monitoring may include socio-economic interaction, through local enquiry.

Contract will been awarded to GPCB approved agency to carry out environmental monitoring as per GPCB consent requirements. Details of environmental monitoring plan undertaken by PLL is given below

5.4.1 Objectives of Monitoring

The objectives of environmental post-project monitoring are to:

- Verify effectiveness of planning decisions;
- Measure effectiveness of operational procedures;
- Confirm statutory and corporate compliance; and
- Identify unexpected changes.
- Opportunity to utilise the feedback for the corrective measures.

5.5 Monitoring Schedule

Environmental monitoring schedules are prepared covering various phases of project advancement, such as constructional phase and regular operational phase.

5.5.1 Monitoring Schedule during Construction Phase

The construction activities require clearing of vegetation, mobilisation of construction material and equipment. The construction activities are expected to last for four years.
The generic environmental measures that need to be undertaken during project construction stage are given in **Table-5.8**.

TABLE-5.8
ENVIRONMENTAL MONITORING DURING PROJECT CONSTRUCTION STAGE

Sr. No.	Potential Impact	Action to be Followed	Parameters for Monitoring	Frequency of Monitoring
1	Air Emissions	All equipments are operated within specified design parameters.	Random checks of equipment logs/ manuals	Periodic
		Vehicle trips to be minimized to the extent possible	Vehicle logs	Periodic during site clearance & construction activities
		Maintenance of DG set emissions to meet stipulated standards	Gaseous emissions (SO_2, HC, CO, NOx)	Periodic emission monitoring
		Ambient air quality within the premises of the proposed facility to be monitored.	The ambient air quality will conform to the standards for PM_{10}, $PM_{2.5}$, SO_2, NO_x and CO	As per CPCB/ GPCB requirement or on monthly basis whichever is earlier
2	Noise	List of all noise generating	Equipment logs,	Regular during

Sr. No.	Potential Impact	Action to be Followed	Parameters for Monitoring	Frequency of Monitoring
		machinery onsite along with age to be prepared. Equipment to be maintained in good working order.	noise reading	construction activities
		Night working is to be minimized.	Working hour records	Daily records
		Generation of vehicular noise	Maintenance of records of vehicles	Daily records
		Noise to be monitored in ambient air within the project premises.	Spot Noise recording	As per CPCB/GPCB requirement or on quarterly basis whichever is earlier
3	Wastewater Discharge	No untreated discharge to be made to sea, groundwater or soil.	No discharge hoses shall be in vicinity of watercourses / sea.	Periodic during construction activities
4	Soil Erosion	Protect topsoil stockpile where possible at edge of site.	Effective cover in place.	Periodic during construction activities
5	Drainage and effluent Management	Ensure drainage system and specific design measures are working effectively. The design to incorporate existing drainage pattern and avoid disturbing the same.	Visual inspection of drainage and records thereof	Periodic during construction activities
6	Waste Management	Implement waste management plan that identifies and characterizes every waste arising associated with proposed activities and which identifies the procedures for collection, handling & disposal of each waste arising.	Comprehensive Waste Management Plan should be in place and available for inspection on-site. Compliance with MSW Rules, 1998 and Hazardous Wastes (Management and Handling Rules), 2003	Periodic check during construction activities
7	Non-routine events and accidental releases	Plan to be drawn up, considering likely emergencies and steps required to prevent/limit consequences.	Mock drills and records of the same	Periodic during construction activities
8	Health	Employees and migrant labour health check ups	All relevant parameters including HIV	Regular check ups
9	Environmental Management Cell/ Unit	The Environmental Management Cell/Unit is to be set up to ensure implementation and	Responsibilities and roles will be decided before the commencement of	During construction phase

Sr. No.	Potential Impact	Action to be Followed	Parameters for Monitoring	Frequency of Monitoring
		monitoring of environmental safeguards.	work.	
10	Loss of flora and fauna	Re-vegetation as per Forest guidelines	No. of plants, species	During site clearance phase

5.5.2 Monitoring Schedule during Operational Phase

During operational stage, continuous air emissions from GTG's, wastewater, non-hazardous and hazardous wastes ash and oily wastes are generated.

The following attributes based on the environmental setting and nature of project activities merit regular monitoring are listed below:

- Source emissions and ambient air quality;
- Groundwater Levels and ground water quality;
- Water and wastewater quality (water quality, effluent & sewage quality etc);
- Solid and hazardous waste characterisation (oily wastes, used and waste oil);
- Soil quality;
- Noise levels (equipment and machinery noise levels, occupational exposures and ambient noise levels); and
- Ecological preservation and afforestation.

The following routine monitoring programme as detailed in **Table-5.9** shall be implemented at site. Besides to this monitoring, the compliances to all environmental clearance conditions and regular permits from GPCB/MoEF shall be monitored and reported periodically.

TABLE-5.9
ENVIRONMENTAL MONITORING DURING OPERATIONAL PHASE

Sr. No.	Potential Impact	Action to be Followed	Parameters for Monitoring	Frequency of Monitoring
1	Air Emissions	Stack emissions from GTG to be optimized and monitored	Gaseous emissions (SO_2, CO, NOx and	Continuous monitoring using on-line equipment during operation phase
		Stack emissions from DG set to be optimized and monitored	Gaseous emissions (SO_2, HC, CO, NOx)	Periodic during operation phase
		Ambient air quality within the premises of the proposed unit and nearby habitations to be monitored. Exhaust from vehicles to be minimized by use of fuel efficient vehicles and well maintained vehicles having PUC certificate.	SPM, RPM, SO_2, NO_x, CO and HC. Vehicle logs to be maintained	As per CPCB/ GPCB requirement or on weakly basis whichever is earlier

Sr. No.	Potential Impact	Action to be Followed	Parameters for Monitoring	Frequency of Monitoring
		Measuring onsite data of Meteorology	Wind speed, direction, temp., relative humidity and rainfall.	Continuous monitoring using on-line weather station during operation phase
		Vehicle trips to be minimized to the extent possible	Vehicle logs	Daily records
2	Noise	Noise generated from operation of Pumps and compressor to be optimized and monitored Noise generated from operation of DG set to be optimized and monitored Compressor to generate less than 80 dB(A) Leq at 1-m from the source	Spot Noise Level recording; Leq(night), Leq(day), Leq(dn)	Periodic during operation phase
		Generation of vehicular noise	Maintain records of vehicles	Periodic during operation phase
3	Wastewater Discharge	No untreated discharge to be let to surface water, groundwater or soil.	Regular check ups	Periodic during operation phase
		Take care in disposal of wastewater generated such that soil and groundwater resources are protected	Discharge norms for effluents	Periodic during operation phase
		Compliance of wastewater discharge to standards	pH, TSS, TDS, BOD, COD & Temperature	Once in a week during operation phase
		Compliance of treated sewage to standards	Comprehensive as per GSR 422(E)	Once in a season
4	Drainage and effluent Management	Ensure drainage system and specific design measures are working effectively. Design to incorporate existing drainage pattern and avoid disturbing the same.	Visual inspection of drainage and records thereof	Periodic during operation phase
5	Water Quality and Water Levels	Monitoring used water quality, groundwater quality around project site and ground water levels	Comprehensive monitoring as per IS:10500 Groundwater level in meters bgl	Periodic during operation phase
		River water quality downstream to discharge	As per IS:10500	Once in a week
6	Work zone air contamination	Contaminants such as VOCs to be reduced by providing adequate ventilation	Monitoring of indoor air contaminants such as CO, CO_2 and VOCs.	As per CPCB/ GPCB requirement
7	Emergency preparedness,	Fire protection and safety measures to take care of	Mock drill records, on site emergency	Periodic during operation phase

Sr. No.	Potential Impact	Action to be Followed	Parameters for Monitoring	Frequency of Monitoring
	such as fire fighting	fire and explosion hazards, to be assessed and steps taken for their prevention.	plan, evacuation plan	
8	Maintenance of flora and fauna	Vegetation, greenbelt / green cover development	No. of plants, species	Periodic during operation phase
9	Waste Management	Implement waste management plan that identifies and characterizes every waste arising associated with proposed activities and which identifies the procedures for collection, handling & disposal of each waste arising.	Records of solid waste generation, treatment and disposal	Periodic during operation phase
10	Soil quality	Maintenance of good soil quality	Physico-chemical parameters and metals.	Periodical monitoring at ash pond site
11	Health	Employees and migrant labour health check ups	All relevant parameters including HIV	Regular check ups

5.6 Monitoring Methods and Data Analysis of Environmental Monitoring

All environmental monitoring and relevant operational data will be stored in a relational database. This will enable efficient retrieval and storage and interpretation of the data. Regular data extracts and interpretive reports will be sent to the regulator.

5.6.1 Air Quality Monitoring and Data Analysis

5.6.1.1 Stack Monitoring

The emissions from all the stacks shall be monitored regularly. The exit gas temperature, velocity and pollutant concentrations shall be measured. Any unacceptable deviation from the design values shall be thoroughly examined and appropriate action shall be taken.

5.6.1.2 Workspace Monitoring

The concentration of air borne pollutants in the workspace/work zone environment shall be monitored periodically. If concentrations higher than threshold limit values are observed, the source of fugitive emissions shall be identified and necessary measures taken. Methane and non-methane hydrocarbons shall be monitored in oil storage area once in a season. If the levels are high suitable measures as detailed in EMP shall be initiated.

5.6.1.3 Ambient Air Quality Monitoring

The ground level concentrations of PM_{10}, $PM_{2.5}$, SO_2 and NO_X in the ambient air shall be monitored at regular intervals. Any abnormal rise shall be investigated to identify the causes and appropriate action shall be initiated. Greenbelt shall be developed for minimising dust propagation. The ambient air quality data should be transferred and processed in a centralised computer facility equipped with required software. Trend and statistical analysis should be done.

5.6.2 Water and Wastewater Quality Monitoring and Data Analysis

To ensure a strict control over the water consumption, flow meters shall be installed for all major inlets. All leakages and excess shall be identified and rectified. In addition, periodic water audits shall be conducted to explore further possibilities for water conservation.

Methods prescribed in "Standard Methods for Examination of Water and Wastewater" prepared and published jointly by American Public Health Association (APHA), American Water Works Association (AWWA) is recommended.

5.6.2.1 Monitoring of Wastewater Streams

All the wastewater streams in the project area shall be regularly analysed for flow rate and physical and chemical characteristics. Such analysis is carried out for wastewater at the source of generation, at the point of entry into the wastewater treatment plant and at the point of final discharge. These data shall be properly documented and compared against the design values for any necessary corrective action.

5.6.3 Noise Levels

Noise levels in the work zone environment such as compressor/pump area shall be monitored. The frequency shall be once in three months in the work zone. Similarly, ambient noise levels near habitations shall also be monitored once in three months. Audiometric tests should be conducted periodically for the employees working close to the high noise sources.

5.7 Reporting Schedules of the Monitoring Data

It is proposed that voluntary reporting of environmental performance with reference to the EMP should be undertaken.

The environmental monitoring cell shall co-ordinate all monitoring programmes at site and data thus generated shall be regularly furnished to the state regulatory agencies.

The frequency of reporting shall be on six monthly basis to the local state pollution control board officials and to Regional office of MoEF. The Environmental Audit reports shall be prepared for the entire year of operations and shall be regularly submitted to regulatory authorities.

5.8 Infrastructure for Monitoring of Environmental Protection Measures

A well-equipped laboratory with consumable items shall be provided for monitoring of environmental parameters in the site. Alternatively, monitoring can be outsourced to a recognized reputed laboratory.

The following equipment and consumable items shall be made available in the site for environmental monitoring or alternatively the monitoring can be outsourced by engaging a reputed authorised environmental laboratory.

Air Quality and Meteorology

Respirable dust sampler, stack monitoring kit, personal dust sampler, central weather monitoring station, spectrophotometer (visible range), single pan balance, flame photometer, relevant chemicals as per IS:5182.

Water and Wastewater Quality

The sampling shall be done as per the standard procedures laid down by IS: 2488. The equipments and consumables required are:

BOD incubator, COD reflex set-up, refrigerator, oven, stop watch, thermometer, pH meter, distilled water plant, pipette box, titration set, dissolved oxygen analyser, relevant chemicals.

Noise Levels

Noise monitoring shall be done utilising an integrating sound level meter to record noise levels in different scales like 'A-weighting' with slow and fast response options.

6.0 ENVIRONMENTAL MONITORING PROGRAMME

6.1 Implementation Schedule of Mitigation Measures

The mitigation measures suggested in Chapter-5 shall be implemented so as to reduce the impact on environment due to the operations of the proposed expansion of LNG terminal project. In order to facilitate easy implementation of mitigation measures, the priority of implementation is given in **Table-6.1**.

TABLE-6.1
IMPLEMENTATION SCHEDULE

Sr. No.	Recommendations	Time Requirement	Schedule
1	Air pollution control measures	Before commissioning of respective units	Immediate
2	Water pollution control measures	Before commissioning of the expanded Terminal (Phase-III A)	Immediate
3	Noise control measures	Along with the commissioning of the LNG terminal activities	Immediate
4	Ecological preservation and up gradation	Stage wise implementation	Immediate & Progressive

Source: Vimta Labs Limited, Hyderabad

6.2 Environmental Monitoring

The environment monitoring for the proposed expansion of LNG Terminal operations shall be conducted as follows:

- Air quality;
- Water and wastewater quality;
- Noise levels;
- Soil Quality; and
- Greenbelt Development.

A centralized environment monitoring cell will be established for proposed expansion of LNG terminal. Monitoring of important and crucial environment parameters is of immense importance to assess the status of environment during operation of LNG terminal. With the knowledge of baseline conditions, the monitoring program can serve as an indicator for any deterioration in environment conditions due to operation of the LNG terminal and suitable mitigatory steps could be taken in time to safeguard the environment. Monitoring is as important as that of control of pollution since the efficiency of control measures can only be determined by monitoring. The following routine monitoring program will be implemented under the post-project monitoring in the LNG terminal complex. The monitoring program for implementation is given below.

- ***Air Pollution and Meteorological Aspects***

Both ambient air quality and meteorology will be monitored. The ambient air will be monitored twice in a week in line with the guidelines of Central Pollution Control Board and GPCB.

Meteorological parameters like wind speed, wind direction, temperature, relative humidity and rainfall will be recorded continuously at LNG terminal complex.

- ***Surface Water Quality Monitoring***

Marine water and sediment quality monitoring and ground water quality will be being monitored at two locations in and around the LNG terminal. The analysis of physico-chemical and bacteriological parameters will be done on a monthly basis. The parameters and frequency of monitoring will be as per stipulation of Gujarat Pollution Control Board (GPCB) and Environment Clearance from Ministry of Environment and Forests.

- ***Ground Water Quality Monitoring***

Ground water sampling shall be conducted in two location per month.

Marine Water and Sediment Quality Monitoring

Marine water sampling shall be conducted in two location per month..

- ***Noise Levels***

Noise levels in the work zone environment and ambient will be monitored regularly. The frequency of noise monitoring will be once in a month in the work zone. The ambient noise levels in the surrounding villages will be monitored once in six months.

- ***Soil Sampling***

Soil samples will be tested before plantation/vegetation of the area. The environment monitoring cell will co-ordinate all monitoring programs at site and data thus generated will be regularly furnished to the regulatory agencies.

The parameters and frequency of monitoring are given in **Table-6.2**.

TABLE-6.2
MONITORING SCHEDULE FOR PROPOSED LNG TERMINAL

Sr. No.		Particulars	Monitoring Frequency	Duration of Sampling	Important Monitoring Parameters
1	**Air Pollution and Meteorology**				
	Air Quality				
	A	Ambient Air Quality Monitoring			
		Selected 4 locations in and around LNG terminal specified by GPCB	Twice in a week	24 hr continuously	PM_{10}, $PM_{2.5}$, SO_2, NOx and CO
	B	Stack gas analysis in GTG's & all major stacks	Once in a month	Grab sampling	Specified as per Gujarat Pollution Control Board/ Flue gas temp., Exit velocity, flow, PM,

Sr. No.		Particulars	Monitoring Frequency	Duration of Sampling	Important Monitoring Parameters
					SO_2, NOx
	Meteorology				
	A	Meteorological data to be monitored at LNG terminal	Daily	Continuous Monitoring	Wind speed, direction, temperature, relative humidity and rainfall.
2	**Water and Wastewater Quality**				
	A	Marine water quality			
	1	Two locations - Marine water (Low Tide/High Tide)	Monthly	Grab sampling	DO, BOD, Oil & Grease, Nitrate, Nitrite, Sulphate, Phosphate, Chloride, Coliform count, Iron, Manganese, Cadmium, Chromium, Mercury, Zinc
	B	Industrial/Domestic			
	1	Sewage treatment plant	Daily	24 hr composite	As per CPCB/ GPCB norms
	C	Water quality in the study area			
	1)	Ground Water quality	Half yearly	Grab	As per the parameters specified under IS:10500-1991
	2)	Surface Water	Half yearly	Grab	Parameters specified under IS:10500-1991
3	**Industrial Noise Levels**				
	1)	Major noise generating sources (Pumps, compressors & generator areas)	Every fortnight	24 hr continuous with 1 hr interval	Noise level in dB(A)
	Ambient Noise Levels				
		4 Locations around LNG terminal	Monthly	24 hr continuous with one hr interval	Noise levels in dB(A)
4.	**Soil Characteristics**				
	1.	Selected 10 locations in core and buffer zone in nearby villages	every season	One Grab sample	Colour, textural class, grain size, distribution, pH, Electrical Conductivity, Bulk Density, Porosity, Infiltration rate, Moisture retention capacity, Wilting Co-efficient, Organic matter Na, N, K, PO_4, SO_4, SAR, Base Exchange Capacity, Pb, Cu, Zn, Cd, Fe.

6.3 Monitoring Methods and Data Analysis

All environment monitoring and relevant operational data will be stored in a relational database. Regular data extracts and interpretive reports will be sent to the regulator.

6.3.1 Air Quality Monitoring and Data Analysis

The concentration of air borne pollutants in the workspace / work zone environment will be monitored periodically. If concentrations higher than threshold limit values are observed, the source of fugitive emissions will be identified and necessary measures taken. If the levels are high suitable measures as detailed in EMP shall be initiated.

The ground level concentrations of PM_{10}, $PM_{2.5}$, SO_2, NO_X and CO in the ambient air will be monitored at regular intervals. Any abnormal rise will be investigated to identify the causes, and appropriate action will be initiated. Greenbelt shall be developed for minimising dust propagation. The ambient air quality data should be transferred and processed in a centralised computer facility equipped with required software. Trend and statistical analysis should be done.

6.3.2 Water and Wastewater Quality Monitoring and Data Analysis

Methods prescribed in "Standard Methods for Examination of Water and Wastewater" prepared and published jointly by American Public Health Association (APHA), American Water Works Association (AWWA) and Water Pollution Control Federation (WPCF); Manual on Water and Wastewater Analysis published by NEERI, Nagpur are recommended.

6.4 Monitoring Equipment and Consumables

A well-equipped laboratory with consumable items will be provided for monitoring of environment parameters. Alternatively, monitoring can be outsourced to a recognized laboratory.

a) Air Quality and Meteorology

Following equipment and consumable items will be made available with the environment cell to meet the monitoring frequency and to implement the monitoring program.

- Respirable Dust Samplers and fine dust samplers
- Personal sampler
- CO Monitor
- Weather station (automatic recording)
- Spectrophotometer (visible range)
- Single pan balance
- Relevant chemicals as per IS:5182
- Chemical/Glass ware

b) Water and Waste Water Quality

The sampling should be done in jerry cans as per the standard procedures laid down by IS: 2488. Following equipments are recommended to be available with the environment cell:

- BOD incubator;
- Refrigerator;
- Oven;
- Stop watch;
- Thermometer;
- pH meter;
- Distilled water plant;
- Spectrophotometer; and
- Relevant chemicals and Glassware's.

c) Noise Levels

The environment cell shall have sound level meter to record noise levels in different scales like A, B and C with slow and fast response options and vibration meter. Further, any recognized agency can also be engaged for carrying out the above stated monitoring works.

6.5 Occupational Health and Safety

Occupational health and safety is very closely related to productivity and good employer-employee relationship. To avoid any adverse effects on the health of workers due to dust, heat, noise and vibration, sufficient measures have been proposed in the project.

These include:

- Provision of personal protection devices to the workers;
- Rotation of workers exposed to noise premises;
- Dust suppression of road; and
- First-aid facilities with ambulance in the LNG terminal complex.

Occupational Health Survey of the employees will be carried out at regular intervals. QHSE policy of Petronet LNG is given in **Annexure-XI.**

6.6 Budgetary Allocation for Environment Protection

As environment protection will be monitored and implemented by a centralized environment management cell. The capital cost of the proposed project will be Rs. 5650 crores (2950 crores for 5 MMTPA and 2700 crores for additional 5 MMTPA). The details of investment for procuring the equipments for efficient control and monitoring of pollution along with total annual recurring cost are given in **Table-6.3.**

TABLE-6.3
COST OF ENVIRONMENTAL PROTECTION MEASURES

Sr. No.	Description of Item	Cost (Rs in Crores)	Recurring cost Rs (Crores)per Annum
1	Fire Fighting System	20.25	1.2
2	Fire Tendor, ambulance etc	3.4	0.6
3	Occupational Health Centre	2.2	0.2
4	Water conservation and wastewater treatment	0.3	0.05
5	Environment Lab	13.2	0.2
6	Green belt	7	0.50
	Total	**46.35**	**2.75**

7.0 ADDITIONAL STUDIES

This chapter_describes the public consultation for the proposed expansion of LNG terminal, Risk Assessment and Disaster Management Plan, occupational health and safety issues.

7.1 Public Consultation

Public Consultation refers to the process by which the concerns of local affected persons and others who have plausible stake in the environmental impacts of the project or activity are ascertained with a view to taking into account all the material concerns in the project or activity design as appropriate. All Category 'A' and Category 'B' projects or activities under Schedule II of the EIA Notification, dated 14th September 2006 shall undertake public consultation.

The proposed expansion of LNG terminal falls under '**Category-A**' with project or activity type number '6(a)', which requires EIA studies as well as public consultation.

The public consultation shall ordinarily have two components comprising of public hearing at the site or in its close proximity- district wise, to be carried out in the prescribed manner and obtaining responses in writing from other concerned persons having a plausible stake in the environmental aspects of the project or activity.

This report is being submitted to Gujarat Pollution Control Board for conducting public hearing/consultation. After completion of the public consultation, PLL shall address all the material environmental concerns expressed during this process, and make appropriate changes in the draft EIA and EMP. The final EIA report, so prepared, shall be submitted by PLL to MoEF to complete EC process.

7.2 Risk Assessment

7.2.1 Introduction

The proposed expansion of LNG Re-gasification terminal at the existing LNG terminal shall optimize the existing facilities and design, construct and operate for unloading, storage and re-gasification of LNG equivalent to 20 MMTPA. Facility shall mainly comprise of

- Jetty & Marine Facilities for handling LNG ships
- Full Containment LNG Storage tanks,
- High Pressure LNG Re-gasification facilities
- Boil off Compressors & Re-condenser,
- Truck loading and small LNG ship loading facilities,
- RLNG and LNG Metering facilities
- Gas Turbine Generators, Utilities, Cold Heat Recovery, Condensate Water Storage etc.

The salient features of the proposed in the expansion of LNG Re-gasification Terminal are presented in **Table-7.1.**

TABLE-7.1
SALIENT FEATURES OF THE PROPOSED LNG RE-GASIFICATION TERMINAL

Sr. No	Details	Particulars
	Ship capacity range	
1	LNG import	From 80,000 m^3 to 265 000 m^3
	Heat In-Leak	
2	Ship tank	0.08% vol./d (methane)
3	LNGC manifold	220 kw
4	Unloading arms (3X20")	240 kw (for 3 unloading arms)
	LNG Pressure	
5	Saturation pressure when unloading	Maximum 130 m barg (vapour space)
6	LNG pressure at manifold	120 m LC shall be considered for hydraulic calculation of the LNG unloading line(s) at 15000 m^3 LNG flow rate.
7	Height of LNGC main fold	20 m above minimum sea level

Source: Project Report,

7.2.2 Objectives of Risk Assessment Study

The objectives of the Risk Assessment are as follows:

- To identify all credible hazardous scenarios associated with storage, handling and operation of the LNG facility, which has potential to cause fatalities;
- To carry out the QRA expressing population risks in both individual and societal terms;
- To compare the individual and societal risks at the proposed development sites with the NFPA Guidelines;
- To identify and assess practical and cost effective risk mitigation measures as appropriate;
- To identify all LNG leakage scenarios and propose a safety management system for the operational phase of the project with an aim to contain any accidental leakage in short notice and to prevent and/or minimize any leakage.
- Suggestions of risk mitigation measures and delineation of Approach to Disaster Management Plan (DMP).

Standard industry practices of risk assessment are considered in the project. Maximum Credible Accident analysis is carried out to arrive at the hazard distance for the worst case scenario. The consequences of all the scenarios are computed and hazard distances are worked out and listed for proposed expansion of LNG and possible explosion effects.

7.3 Maximum Credible Accident (MCA) Analysis

MCA stands for Maximum Credible Accident or in other words, an accident with maximum damage distance, which is believed to be probable. MCA analysis does not include quantification of the probability of occurrence of an accident. In practice, the selection of accident scenarios for MCA analysis is carried out on the basis of engineering judgement and past accident analysis.

Risk involves the potential occurrence of some accident consisting of an event or sequence of events. Accidental release of LNG to the atmosphere from storage tank or regasification equipment is studied by visualising scenarios on the basis of their properties and the impacts are computed in terms of damage distances. A disastrous situation is the outcome of fire or explosion of the released gas in addition to other natural causes, which eventually leads to loss of life, damage to property and/or ecological imbalance.

Depending on the effective hazardous attributes and their impacts, the maximum effect to the surroundings could be assessed.

7.3.1 Methodology of MCA Analysis

The MCA analysis involves ordering and ranking various sections in terms of potential vulnerability. Following steps are involved in the general MCA analysis:

- Review of Past accident data
- Identification of potential hazardous sections and representative failure cases for the wells and various equipments **(HAZID)**
- Visualisation of release scenarios with recourse to **consequence analysis**
- Damage distance computations for the released cases **(Damage Effects)**

7.3.1.1 Past Accident Data Analysis

Analysis of events arising out of the unsafe conditions is one of the basic requirements for ensuring safety in LNG terminal. The data required for such an analysis has either to be generated by monitoring and/or collected from the records of the past occurrences. This data, when analysed, helps in formulation of the steps towards mitigation of hazards faced commonly. Trends in safety of various activities can be evaluated and actions can be planned accordingly, to improve the safety.

Data analysis helps in correlating the causal factors and the corrective steps to be taken for controlling the accidents. It is, therefore, of vital importance to collect the data methodically, based on potential incidents, sections involved, causes of failure and the preventive measures taken. This helps to face future eventualities with more preparedness.

Release frequencies have been derived from generic data on loss of containment events. Reference has been made to a number of sources. A summary is presented in **Table-7.2**.

The frequency of various outcomes following a loss of containment event is estimated using an event tree model. The various outcomes considered include pool fire, jet fire, flash fire and vapour cloud explosions for liquid releases, jet fire and flash fire for continuous gas releases and fireball and flash fire for instantaneous gas releases.

TABLE-7.2
LNG RELEASE EVENT FREQUENCIES

Equipment	Release Scenario	Release Phase	Release Frequency	Unit
Process Vessels	i) 10 & 25 mm hole	Liquid	1.00 E-05	Per year
	ii) 50 & 100 mm hole	Liquid	5.00 E-06	
	iii) Full bore rupture	Liquid	1.00 E-06	
Pumps	i) Leak	Liquid	1.00 E-04	Per year
	ii) Full bore rupture	Liquid	1.00 E-05	
Unloading arm	i) leak	Liquid/Gas	4.05 E-03	Per year
	ii) Full bore rupture	Liquid/Gas	4.05 E-05	
Pipe Size 600 mm to 750 mm	i) 10 & 25 mm hole	Liquid/Gas	1.00 E-07	Per meter Per year
	ii) 50 & 100 mm hole	Liquid/Gas	7.00 E-08	Per meter Per year
	iii) Full bore rupture	Liquid/Gas	3.00 E-08	Per meter Per year
Pipe size 150 mm to 500 mm	i) 10 & 25 mm hole	Liquid/Gas	3.00 E-07	Per meter Per year
	ii) 50 & 100 mm hole	Liquid/Gas	1.00 E-07	Per meter Per year
	iii) Full bore rupture	Liquid/Gas	5.00 E-08	Per meter Per year
LNG Storage Tank	i) Rupture	Liquid	1.00 E-08	Per tank - year

Classification of annual probabilities of event occurrence is given in **Table-7.3** and categorization of consequences by number of people suffering injuries is given in **Table-7.4.**

TABLE-7.3
CLASSIFICATION OF ANNUAL PROBABILITIES OF EVENT OCCURRENCE

Probability Class	Occurrence Frequency per year
1	$<10^{-1}$
2	10^{-2} to 10^{-1}
3	10^{-3} to 10^{-2}
4	10^{-4} to 10^{-3}
5	10^{-5} to 10^{-4}
6	10^{-6} to 10^{-5}
7	$<10^{-6}$

TABLE-7.4
CATEGORIZATION OF CONSEQUENCES BY NUMBER OF PEOPLE SUFFERING INJURIES

Consequence Category	1	2	3	4	5
Number of injuries	>100	10 to 100	1 to 10	0.1 to 1	<0.1

7.3.1.2 Hazard Identification (HAZID)

A Hazard Identification (HAZID) Study was conducted to identify all hazards, both generic and site specific. A review of literature and accident databases was also undertaken. These formed the basis for identifying all hazardous scenarios for the RA Study

Hazards from LNG Handling

LNG is an extremely cold, non-toxic, non-corrosive and flammable substance. As LNG is released from a temperature-controlled container, it will likely contact warm surfaces and air that transfer heat into the liquid. The heat input begins to vaporise some of the liquid, returning the liquid to the gaseous phase. The relative proportions of liquid and gaseous phases immediately following a release depend on the release conditions. The liquid phase will form an LNG pool on the ground which will begin to "boil", due to heat input from the surrounding environment.

Immediately following vaporisation, the gas is colder and heavier than the surrounding air and forms a vapour cloud. As the gas disperses, it mixes with the surrounding air and warms up. The vapour cloud will only ignite if it encounters an ignition source while concentrated within its flammability range. Downstream of the vaporisers the natural gas will be in the gas phase. A release from this piping and equipment will result in a gaseous phase release directly.

Several hazards which involve or influence the occurrence of initiating events are:

- Unloading and transfer files
- Corrosion of dissimilar metals in systems and foreign material induced corrosion
- Collision of transport vehicles
- Vaporization system failure
- Fires and explosion
- Gas air vapor cloud dispersion
- Temperature extremes
- Personnel exposure (Cryogenic temperatures and flames)
- Human factors
- Reactivity of cryogens

7.3.1.3 Consequence Analysis

Quantification of the damage can be done by means of various models, which can then be translated in terms of injuries and damage to the exposed population and buildings. LNG may be released and result into jet fire & less likely unconfined vapour cloud explosion causing possible damage to the surrounding areas. Extent of the damage depends upon the nature of release. The release of flammable material and subsequent ignition results in heat radiation, pressure wave or vapour cloud depending upon the flammability and its physical state.

It is important to visualise the consequence of the release of such substances and the damage caused to the surrounding areas. An insight into physical effects resulting from the release of hazardous substances can be quantified by means of various models.

7.3.1.4 Damage Affects of Various Heat Loads

Damage affects of various heat loads and pressure loads are detailed in **Table-7.5** to **Table-7.7**.

TABLE-7.5
DAMAGE CRITERIA FOR HEAT LOAD

All values are given in KW/m^2

Exposure time	t = 10 seconds		t = 30 seconds		t = 60 seconds	
	With protection	Without protection	With protection	Without protection	With protection	Without protection
1% lethal injury	21.2	16.5	9.3	7.3	5.5	4.3
First degree burns	8.5	6.9	4.0	3.0	2.2	1.8

Reference: Effects of Heat Radiation, 2nd edition, Loss Prevention in Chemical Industries, by FP LEES

TABLE-7.6
DAMAGE CRITERIA FOR A PRESSURE WAVE

Peak Overpressure (bar)	Type of Damage
0.30	90% of houses seriously damaged
0.10	10% of houses seriously damaged
0.03	Damage by flying fragments of glass
0.01	Windows smashed

Reference: Effects of Heat Radiation, 2nd edition, Loss Prevention in Chemical Industries, by FP LEES

TABLE-7.7
DAMAGE CAUSED AT VARIOUS HEAT LOADS

Heat Load (kW/m^2)	Type of Damage
37.5	Sufficient to cause damage to process equipment
25.0	Minimum energy required to ignite wood infinitely long exposure (non-piloted)
16.5	1% lethality, if exposed for 10 seconds
12.5	Minimum energy required for piloted ignition of wood, melting plastic tubing
6.9	First degree burns if exposed for 10 seconds
4.0	Sufficient to cause pain to personnel if unable to reach over within 20 seconds; however, blistering of skin (1st degree burns) is likely
1.6	Will cause no discomfort to long exposures

Reference: Effects of Heat Radiation, 2nd edition, Loss Prevention in Chemical Industries, by FP LEES

Hazard Effects

In the event of an accidental release of LNG from piping or equipment, the characteristics of the possible hazardous effects are described below.

Pool Fire

A pool fire occurs when a flammable liquid is spilt onto the ground and ignited. A pool formed from the release of liquid LNG will initially spread due to the gravitational and surface tension forces acting on it. As the pool spreads, it will absorb heat from its surroundings causing evaporation from the pool surface. Ignition of this vapour leads to a pool fire.

Jet Fire

Jet fires result from ignited releases of pressurised flammable gas or superheated/pressurised liquid. The momentum of the release carries the materials forwards in a long plume entraining air to give a flammable mixture. Jet fires only occur where the LNG is being handled under pressure or when handled in gas phase and the release is unobstructed.

Flash Fire

Following an LNG release, a large proportion of the liquid will evaporate immediately to form a cloud of methane, initially located around the release point. If this cloud is not ignited immediately, it will move with the wind and be diluted as a result of air entrainment. Similarly, a gas release may not be ignited immediately and will disperse in the air.

The dispersing vapour cloud may subsequently come in contact with an ignition source and burn rapidly with a sudden flash. If the source of material which created the cloud is still present, then the fire will flash back to the source giving a pool fire, or if under pressure, a jet fire. Direct contact with the burning vapours may cause fatalities but the short duration of the flash fire means that thermal radiation effects are not significant outside the cloud and thus no fatalities are expected outside of the flash fire envelope.

Vapour Cloud Explosion

A flash fire is the most likely outcome upon ignition of a dispersing vapour cloud from an LNG release. If ignited in open (unconfined) areas, pure methane is not known to generate damaging overpressures (explode). However, if the gas is ignited in areas where there is significant degree of confinement and congestion, such as the process areas, an explosion may result.

Fireball

Immediate ignition of releases caused by a rupture in a gas piping may give rise to a fireball upon ignition. Fireballs have very high thermal radiation, similar to jet fires although the duration of the event is short.

To summarise, a liquid phase release may result in a flash fire, vapour cloud explosion, pool fire or jet fire. A gas phase release can result in a flash fire, fireball or jet fire.

- **Modes of Failure**

There are various potential sources of large leakage, which may release hydrocarbon into atmosphere. This could be in the form of small gasket failure in a flanged joint, or a bleeder valve left open inadvertently, or an instrument tubing giving way or a guillotine failure of a pipeline, or any of many other sources of leakage. Operating experience can identify lots of these sources and their modes of failure.

- **Damage Due to Explosion**

Explosion is a sudden and violent release of energy accompanied by the generation of pressure wave and a loud noise. The rate of energy release is very large and has potential to cause injury to the people, damage the plant and nearby property etc. The effect of over-pressure can directly result in deaths to those working in the direct vicinity of the explosion. The pressure wave may be caused by a BLEVE (Boiling Liquid Expanding Vapour Cloud) or Vapour Cloud explosion.

- **BLEVE - Fireball**

BLEVE is sometimes referred to as a fireball; a BLEVE is a combination of fire and explosion with an intense radiant heat emission within a relatively short time interval. This phenomenon can occur as a result of overheating of a pressurized vessel by a primary fire. If a pressure vessel fails as a result of a weakening of its structure the contents are instantaneously released from the vessel as a turbulent mixture of liquid and gas expanding rapidly and dispersing in air as a cloud. When this cloud is ignited a fireball occurs causing enormous heat radiation intensity within a few seconds. This heat intensity is sufficient to cause severe skin burns and deaths at several hundred meters from the vessel, depending on the quantity of gas involved. A BLEVE can therefore be caused by a physical impact on a vessel or a tank, which is already overstressed.

- **Vapour Cloud Explosion**

Explosion can be confined and unconfined vapour cloud explosions. Confined explosions are those, which occur within some sort of containment such as a vessel or pipeline. Explosions in buildings also come under this category. Explosions, which occur in the open air, are referred to as unconfined explosions and produce peak pressures of only a few kPa. The peak pressures of confined explosions are generally higher and may reach hundreds of kPa.

Hazard Assessment and Evaluation

Preliminary hazards analysis is based on the philosophy "PREVENTION IS BETTER THAN CURE". Safety is relative and implies freedom from danger or injury. But there is always some element of danger or risk in anything we do or build. When a chemical process facility is considered safe, this calls for identification of hazards, quantification of risk and further suggest hazard mitigating measures, if necessary.

The purpose of the preliminary hazards analysis is to identify early in the design process the potential hazards associated with, or inherent in a process design, thus eliminating costly and time consuming delays caused by design changes made later. This also eliminates potential hazard points at design stage itself.

Hence preliminary hazards analysis is more relevant when a plant is at design/construction stage. This technique, applied early in the project life cycle, helps to eliminate hazards and, thus to avoid costly design modifications later. This analysis fortifies the proposed process design by incorporating additional safety factors into the design criteria.

7.3.2 Scenarios Considered for MCA Analysis

Fuel Storage

In case of tank or fuel released in the dyke area catching fire, a steady state fire will ensue. Failures in pipeline may occur due to corrosion and mechanical defect. Failure of pipeline due to external interference is not considered as this area is licensed area and all the work within this area is closely supervised with trained personnel.

7.3.2.1 Chemical Storage

The gas or vapour released from chemical storage either instantaneously or continuously will be spread in the surrounding area under the influence of the atmospheric turbulence. In the case of gas dispersion, a distinction must be made between neutral gas dispersion and heavy gas dispersion. The critical concentrations of the gas released in the surrounding area can be calculated by means of dispersion models. These concentrations are important for determining whether, for example, an explosive gas cloud can form or whether injuries will occur in the case of toxic gases.

7.3.2.2 Modeling Scenarios

The modeling scenario considered for the proposed expansion of LNG terminal are

- Leakage of pipeline
- Leakage of tank

Storage Tank

A Full containment LNG storage tank is designed to contain the spill from the inner tank into the containment space of the tank itself. Hence, the chance of leakage from the storage tank is ruled out.

LNG release is modeled for its gaseous dispersion after its release (which is likely to result in flash boiling) using the model **ALOHA** – "Area Locations of Hazardous Atmospheres" a model developed by NOAA and USEPA. Aloha predicts the rate at which chemical vapors may escape into the atmosphere from broken gas pipes, leaking tanks and evaporating puddles.

The critical conditions modeled are:

Distance to LEL from location of spill to determine the maximum threat distance with in which the cloud can ignite;

Distances to radiation intensities from pool fire burning or fire ball; Radiation levels considered are 10.0 kw/m^2, 5.0 kw/m^2 and 2.0 kw/m^2

Weather Conditions

The following weather conditions were considered for modeling each of the scenarios considered

- 2A – Worst Weather Case, Wind speed of 2 m/s with atmospheric stability class A as per Pasquill-Gifford classification.

- 5D – Most likely scenario, Wind speed of 5 m/s with Neutral atmospheric conditions (D stability class) as per Pasquill-Gifford classification.

Ambient conditions considered are:

- Ambient temperature: 40^0c
- Relative humidity: 70%
- Surface type : Open waters

Results of Modeling Using ALOHA

Leakage of Pipeline

For a 20 meter long and a 3 inch diameter pipe with a rupture of 0.5 inch rupture is considered as the worst case scenario.

Hazard distances for Pipeline leakage are given in **Table-7.8.** Threat zone distances on worst case scenario for pipeline leakage at 2A weather condition is shown in **Figure-7.1** and Threat zone for pipeline leakage at 5D is shown in **Figure-7.2**.

TABLE-7.8
HAZARD DISTANCES FOR PIPELINE LEAKAGE

Weather Conditon	Hazard Condition Distances (meters)								
	Thermal Radiation (kW/m^2)			Flammable Area(PPM)			Overblast (PSI)		
	10	5	2	44000	26400	4400	8.0	3.5	1.0
2A	10	10	16	85	108	262	LOC never exceeds		68
5D	10	10	18	49	67	141			41

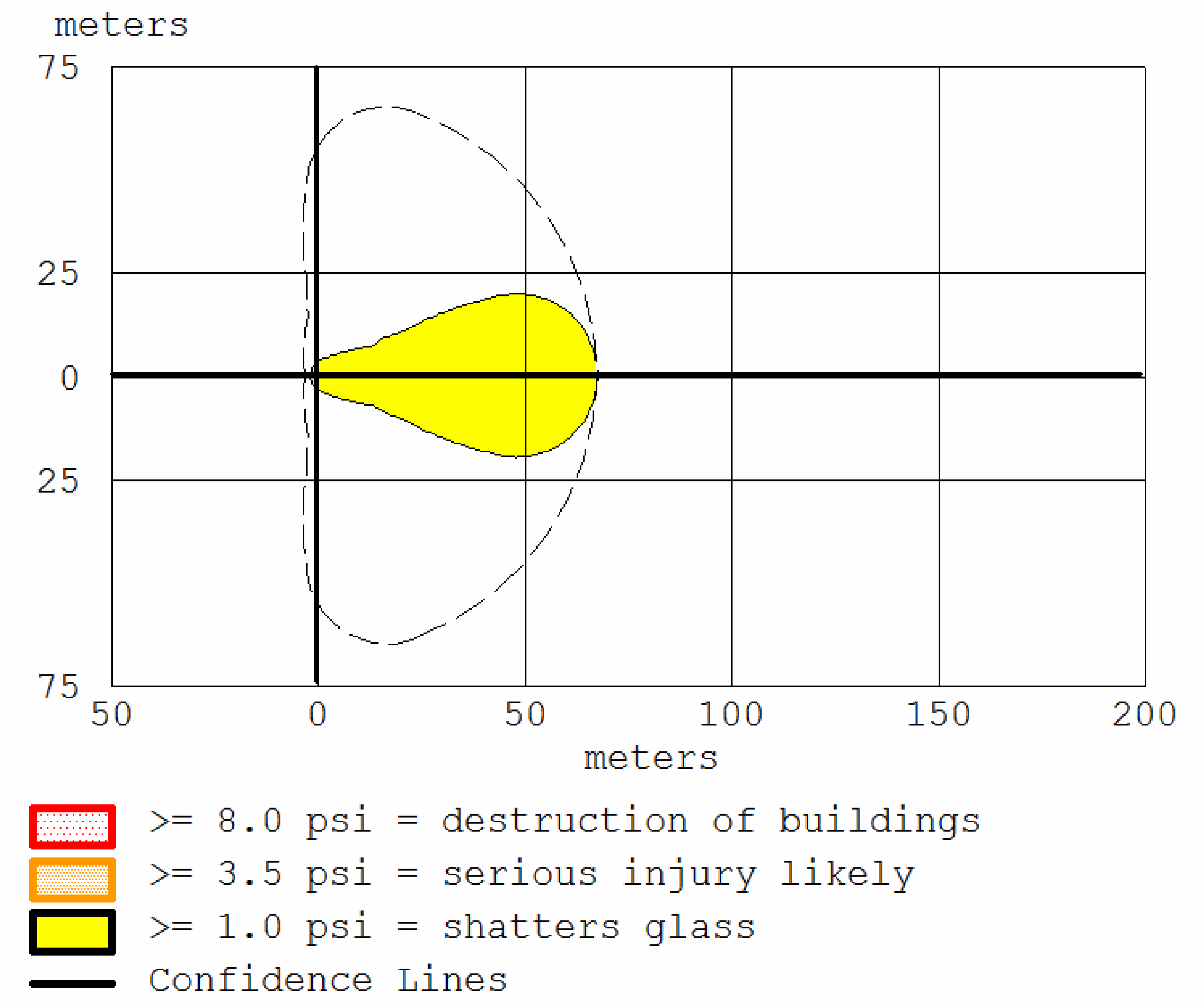

FIGURE-7.1
THREAT ZONE FOR PIPELINE LEAKAGE (2A)

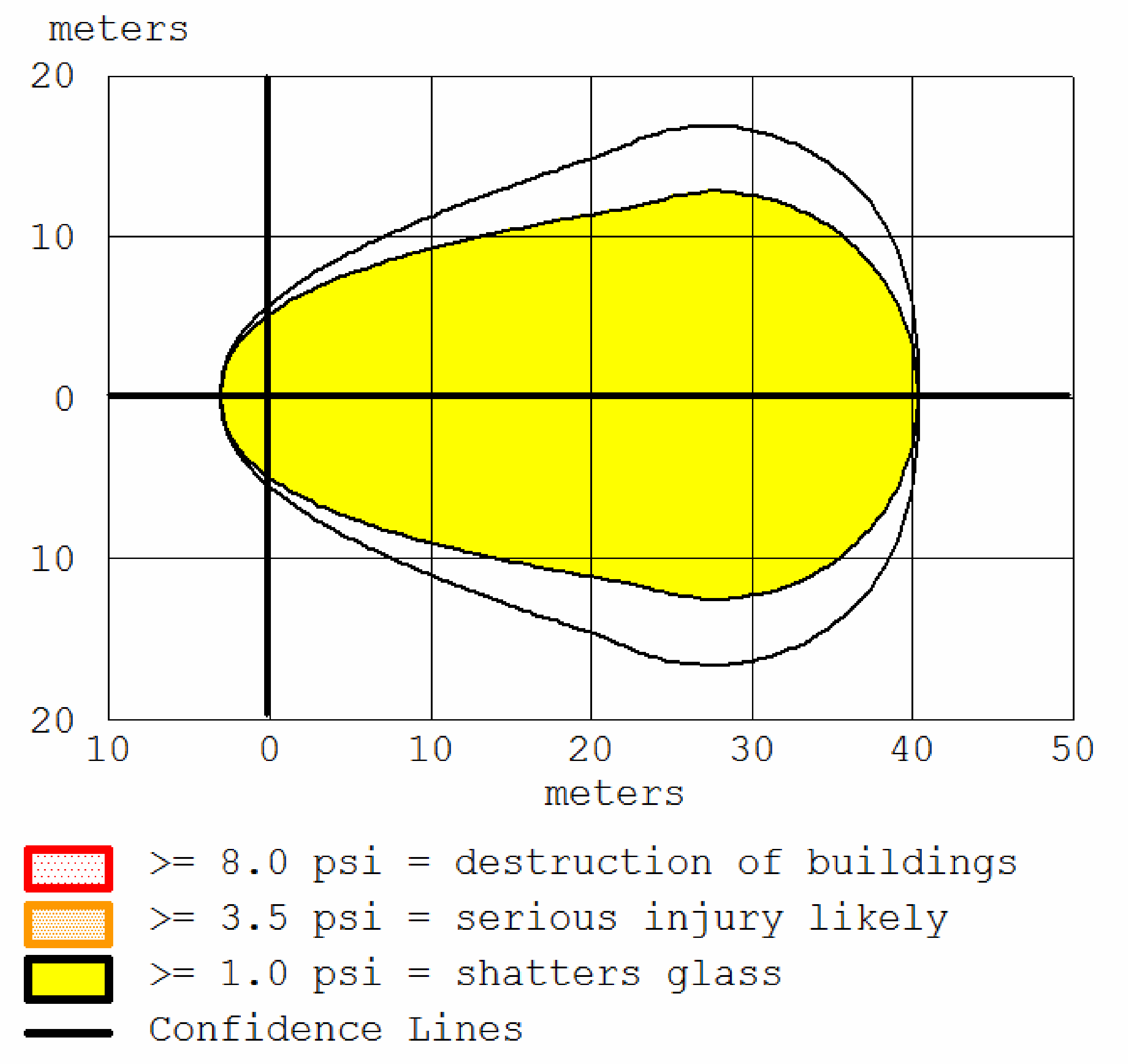

FIGURE-7.2
THREAT ZONE FOR PIPELINE LEAKAGE (5D)

Leakage of Storage Tank

For a pipeline, a catastrophic failure spilling the contents of the storage tank considered as the worst case scenario. For a 40 meter wide and 80 meter height tank, the total quantity contained in the tank would be 125,000 m^3.

Hazard distances for tank leakage are given in **Table-7.9.** Threat zone at weather condition (2A) is shown in **Figure-7.3** and Threat zone for weather condition (5D) is shown in **Figure-7.4**.

TABLE-7.9
HAZARD DISTANCES FOR FAILURE OF STORAGE TANK

Weather Conditon	Hazard Condition Distances (meters)								
	Thermal Radiation (kW/m^2)			Flammable Area(PPM)			Overblast (PSI)		
	10	5	2	44000	26400	4400	8.0	3.5	1.0
2A	10	11	20	114	145	346	LOC never exceeds		122
5D	10	13	21	67	86	234			72

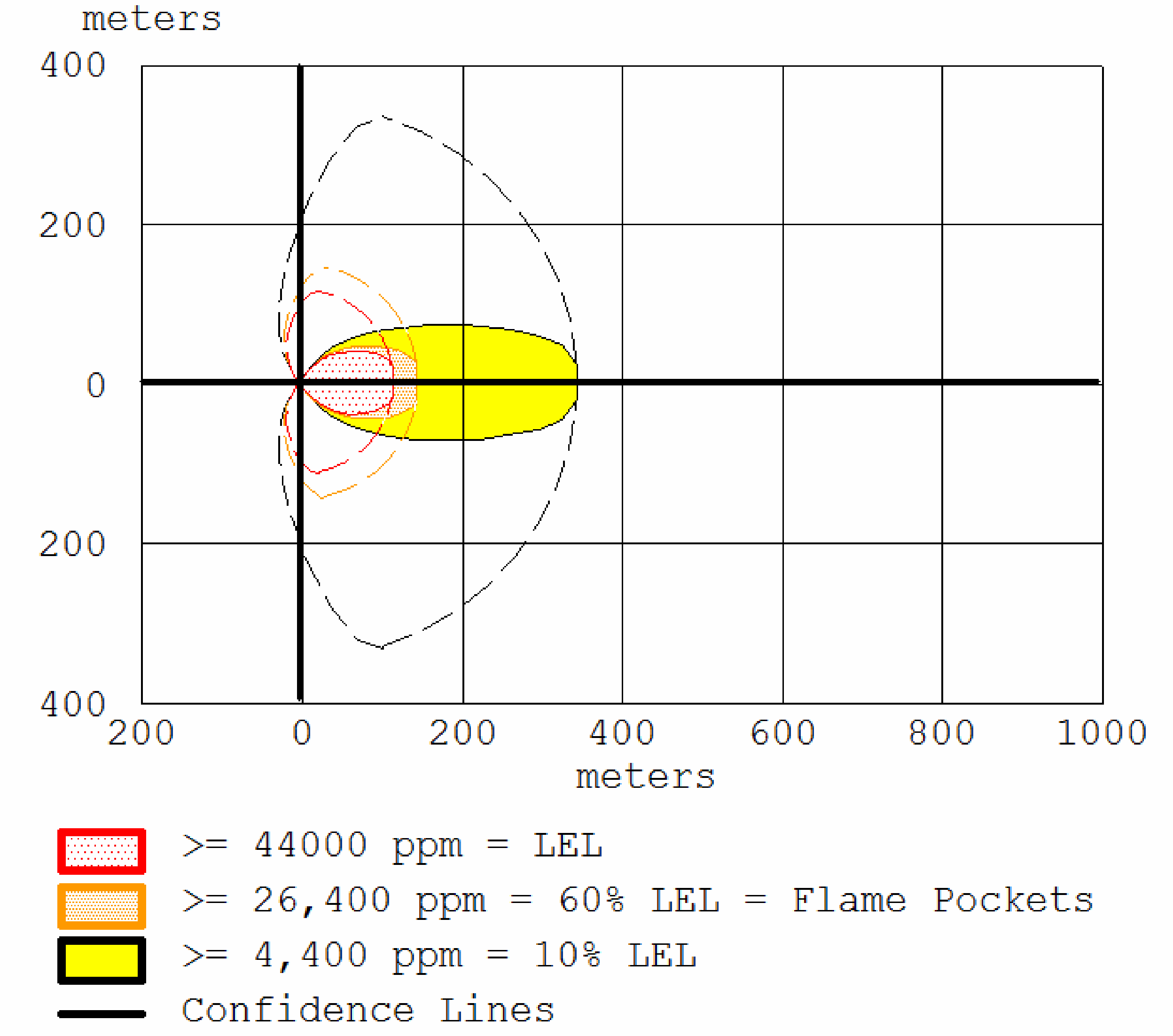

FIGURE-7.3
THREAT ZONE FOR TANK LEAKAGE (2A)

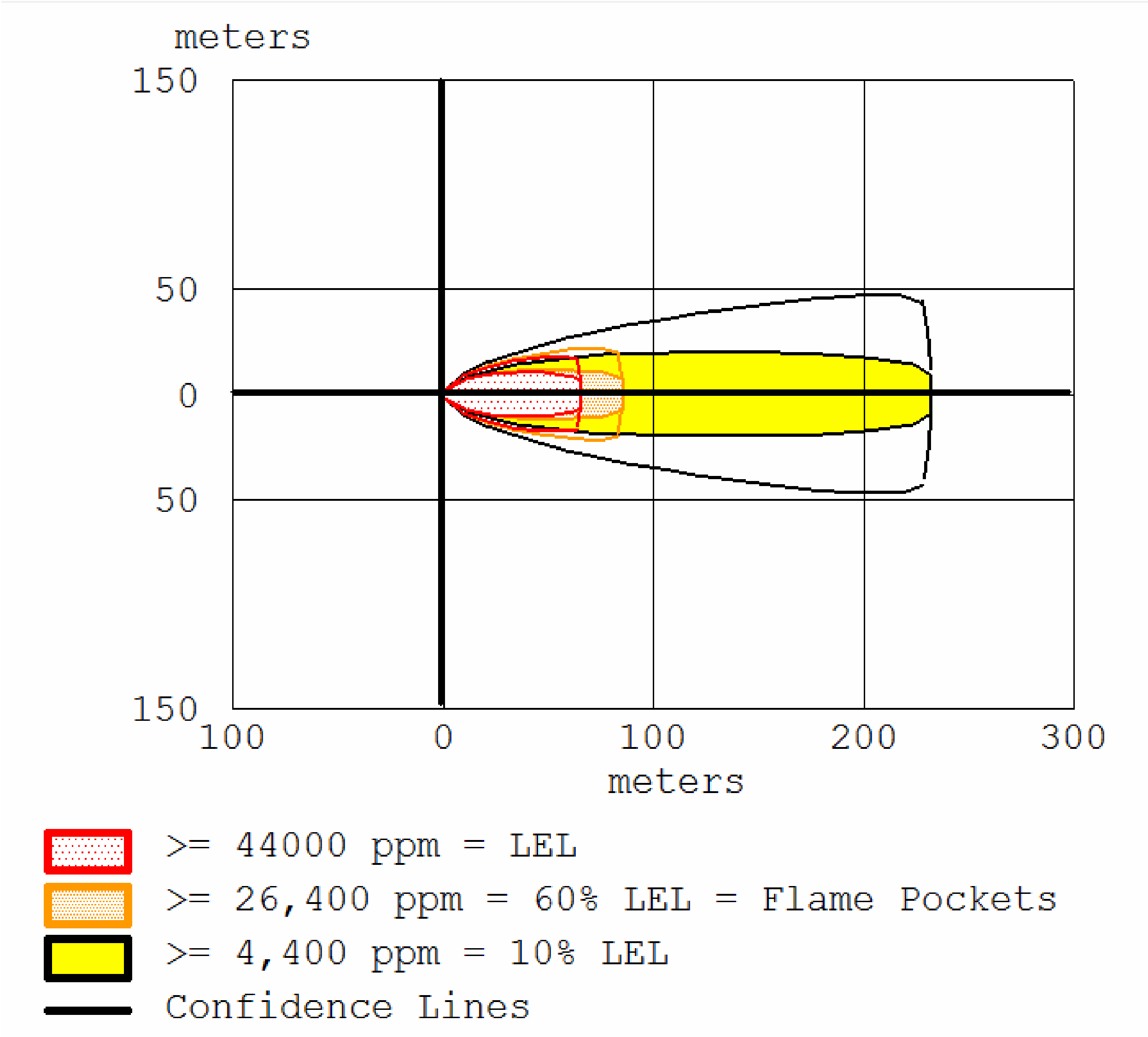

FIGURE-7.4
THREAT ZONE FOR TANK LEAKAGE (5D)

7.4 Emergency Preparedness & Response

7.4.1 Introduction

Disaster is considered as a sudden, low probability incident with dire consequences for the surrounding environment (community) requiring unusual to be taken. An incident may be considered a major environmental disaster if it causes long-term damage to rare or valuable features of the natural or man-made environment, or there is wide spread environmental damage. This chapter outlines measures and facilities necessary to prevent and mitigate potential releases during transfer operations in the marine areas.

7.4.2 Risk and Safety measures imbibed into Plant design

LNG storage tanks are the of risk is large volumes of LNG will be stored. The following are the design criteria considered while constructing the tanks, so that risk due to leakages are kept nil.

7.4.2.1 Container Spacing

The minimum separation distance between any type of LNG container of 70,000 gal (265 m^3) water capacity or less, single containment constructed LNG containers of greater than 70,000 gal (265 m^3) water capacity, or tanks containing flammable refrigerants and exposures shall be in accordance with **Table-7.10** or with the approval of the authority having jurisdiction at a shorter distance from buildings or walls constructed of concrete or masonry but at least 10 ft (3.0 m) from any building openings.

TABLE-7.10
DISTANCES FROM CONTAINERS AND EXPOSURES

Container Water Capacity		Minimum Distance from Edge of Impoundment or Container Drainage system to property lines that can be built upon		Minimum Distance between storage Containers	
Gal	m^3	ft	m	ft	m
<125*	<0.5	0	0	0	0
125-500	≥0.5-1.9	10	3	3	1
501-2000	≥1.9-7.6	15	4.6	5	1.5
20001-18000	≥7.6-63	25	7.6	5	1.5
18001-30000	≥63-114	50	15	5	1.5
30001-70000	≥114-265	75	23	-	-
>70000	>265	0.7 times the container diameter but not less than 100 ft (30 m)		¼ of the sum of the diameter of adjacent containers	

Reference:-**NFPA 59A,** ***Standard for the production, Storage and Handling of Liquefied Natural Gas (LNG)***

Full and double construction LNG storage containers of greater than 70,000 gal (265 m^3) water capacity shall be separated from adjoining LNG storage containers such that a fire in one container or impoundment will not cause loss of containment from adjacent containers. This shall be accomplished by ensuring that no part of the adjacent storage container roof, walls, or its impoundment structure reaches a temperature at which the strength of the material of the container roof, wall, or its impoundment is reduced to a level where the LNG tank, roof, or impoundment loses its structural integrity.

The application of engineering analyses shall be used to determine this temperature by including the following conditions in the analyses:

1) The analyses shall be performed for the following

(a) A fire involving the complete loss of containment of a container to an impoundment area

(b) A fire over the whole surface of the liquid contained in the tank, assuming the roof is completely lost

2) The analyses shall account for the following:

(a) The duration of the fire, the radiant heat. emission characteristics of the fire, and the physical attributes of the fire under the anticipated atmospheric conditions

(b) The atmospheric conditions producing the maximum separation distances shall be used except for conditions that occur less than 5 percent of the time based on recorded data for the area and using a LNG fire model

(c) Active or passive systems to reduce thermal heat flux incident on the surface or to limit the surface temperature

(d) The materials, design, and methods of construction of the target LNG tank being analyzed

7.4.3 Stationary LNG Storage Containers

The following information will be specified for each LNG container

1 Maximum allowable working pressure, indicating a margin above the normal operating pressure

2 Maximum allowable vacuum

Those parts of LNG containers that normally are in contact with LNG and all materials used in contact with LNG or cold LNG vapor (vapor at a temperature below -20^{0}F (-29^{0}c) will be physically and chemically compatible with LNG and intended for services at -270^{0}F (-168^{0}C)).

Container piping will include all piping internal to the container, with insulation spaces and within insulation spaces and within void spaces and external piping attached or connected to the container up to the first circumferential external joint of the piping.

Piping that is part of a an ASME LNG container, including piping between the inner and outer container, will be in accordance with either the ASME Boiler and Pressure Vessel

All LNG containers will be designed for both top and bottom filling unless other means are provided to prevent stratification.

Any portion of the outer surface area of an LNG container that accidentally could be exposed to low temperatures resulting from the leakage of LNG or clod vapor from flanges, valves, seals, or other non-welded connections will be designed for such temperature or otherwise protected from the effects of low-temperature exposure.

Where two or more containers are sited in a common dike, the container foundations will be capable of withstanding contact with LNG or will be protected against contact with an accumulation of LNG that might endanger structural integrity.

The density of liquid will be assumed to be the actual mass per unit volume at the minimum storage temperatures, expect that the minimum density for design purposes will be 29.3 lb/ft (470 kg/m^3). Provisions will be made for removal of the container from service.

The LNG container and its impounding system will be designed for the following two levels of seismic ground motion

- The safe shutdown earthquake (SSE)
- The operating basis earthquake (OBE)

The SSE Will be represented by a ground motion response spectrum in which the spectral acceleration at any period, T, will be equal to the spectral acceleration of the MCE ground motion.

The OBE ground motion will be the motion represented by an acceleration response spectrum having a 10 percent probability of exceedance with in a 50 year period (mean return interval of 475 years).

The two levels of ground motion will be used for the earthquake-resistant design of the following structures and systems

- An LNG storage and its containment system.
- System Components required to isolate the LNG container and maintain it in a safe guard shutdown condition
- Structures or systems, including fire protection systems, the failure of which could affect the integrity

The structure and system will be designed to remain operable during and after an OBE. The OBE will be designed for

- The structures and systems will be designed to remain operable during and after an OBE.
- The OBE design will be based on an elastic response spectrum. Where used, response reduction factors applied in the OBE design will be demonstrated not to reduce the performance criteria.
- The SSE design will provide for no loss of containment capability of the primary container, and it will be possible to isolate and maintain the LNG container during and after the SSE. Where used, response reduction factors applied in the SSE design will be demonstrated not to reduce the performance criteria.

7.4.4 Wind, Flood, and Snow Loads

The wind, flood, and snow loads for the design of LNG storage containers will be determined using ASCE 7. Design Loads for Buildings and Other Structures. Where a probabilistic approach is used, A 1OO-year mean occurrence interval will be used.

7.4.5 Container Insulation

Exposed insulation will be noncombustible, will contain or inherently will be a vapor barrier, will be water free, and will resist dislodgment by fire hose streams.

(A) Where an outer shell is used to retain loose insulation, the shell will be constructed of steel or concrete.

(B) Exposed weatherproofing will have a flame spread index not greater than 25.

The space between the inner tank and the outer tank will contain insulation that is compatible with LNG and natural gas and that is noncombustible.

(A) A fire external to the outer tank will not cause reduction of the insulation thermal conductivity due to melting or settling.

(B) The load-bearing bottom insulation will be designed and installed so that cracking from thermal and mechanical stresses does not jeopardize the integrity of the container.

(C) Only materials used between the inner and outer tank bottoms (floors) will not be required to meet the combustibility requirements, where the material and the design of the installation comply with all of the following:

(1) The flame spread index of the material will not exceed 25, and the material will not support continued progressive combustion in air.

(2) The material will be of such composition that surfaces that would be exposed by cutting through the material on any plane will have a flame

spread index not greater than 25 and will not support continued progressive combustion.

(3) It will be shown by test that the combustion properties of the material do not increase significantly as a result of long-term exposure to LNG or natural gas at the anticipated service pressure and temperature.

(4) The materials in the installed condition will be demonstrated to be capable of being purged of natural gas.

(5) The natural gas remaining after purging will not be significant and will not increase the combustibility of the material.

7.4.6 Filling Volume

Containers designed to operate at a pressure in excess of 250 mBarg will be equipped with a device(s) that prevents the container from becoming liquid full or from covering the inlet of the relief device(s) with liquid when the pressure in the container reaches the set pressure of the relieving device(s) under all conditions.

7.4.7 Foundations

LNG containers will be installed on foundations designed by a qualified engineer and constructed in accordance with recognized structural engineering practices.

Prior to the start of design and construction of the foundation, a subsurface investigation will be conducted by a soils engineer to determine the stratigraphy and physical properties of the soils underlying the site. The bottom of the outer tank will be above the groundwater table or protected from contact with groundwater at all times. The outer tank bottom material in contact with soil will meet one of the following requirements

(1) Selected to minimize corrosion

(2) Coated or protected to minimize corrosion

(3) Protected by a cathodic protection system

Where an outer tank is in contact with the soil, a heating system will be provided to prevent the 32°F (0°C) isotherm from penetrating the soil.

(A) The heating system will be designed to allow functional and performance monitoring.

(B) Where there is a discontinuity in the foundation, such as for bottom piping, attention and separate treatment will be given to the heating system in this zone.

(C) Heating systems will be designed, selected, and installed so that any heating element and temperature sensor used for control can be replaced after installation.

(D) Provisions will be incorporated to prevent moisture accumulation in the conduit.

If the foundation is designed to provide air circulation in lieu of a heating system, the bottom of the outer tank will be of a material compatible with the temperatures to which it can be exposed.

A tank bottom temperature monitoring system capable of measuring the temperature on a predetermined pattern over the entire surface area in order to monitor the performance of the bottom insulation and the tank foundation heating system (if provided) will be installed.

The system to conduct a tank bottom temperature survey 6 months after the tank has been placed in service and annually thereafter, after an OBE, and after the indication of an abnormally cool area.

7.4.8 <u>Safety Procedures</u>

The first step to minimize risk would be to ensure efficient and safe operations at the various stages of transfer operations. This can be achieved by adhering to strict inspection and routine maintenance schedule of the various components of the transfer system.

7.4.9 <u>Checklist for Jetty monitoring and transfer operations</u>

The scope of inspection schedule and frequency of individual components shall be determined by the PLL. The schedule shall be based on the best available information concerning the sea conditions at the site. It is essential that the schedules are followed and work logs maintained. The schedule can be modified as needed on the basis of the actual operating experience. While the following list gives general guideline, specific details to conform to the manufacturer manuals. The following schedules enable reduction of component failure.

- The pre-berthing inspection comprises inspection of mooring connections, hatches, lights, telemetry systems and signs of damage.

- Terminal operations during transfers shall comprise inspection of gas detection and safety shutdown systems.

- LNG unloading systems and docks are equipped with LNG Vapour detection, fire detection and associated safety shutdown systems that shut down pumping operations and close valve s to isolate the transfer lines.

  - The shutdown operations can be actuated by the ship's crew or LNG terminal personnel.

- In most cases, these systems also respond automatically to any detection of LNG in the atmosphere by shutting down pumping operations and closing valves to isolate the LNG transfer lines.

- Inspection of emergency release couplings of the unloading arms: LNG terminals have emergency release coupling that are fitted between the ship's cargo manifold and the receiving station. These couplings are designed to release if vessel movement exceeds predetermined limits. If the coupling release, the resulting LNG loss to the atmosphere is designed to be very negligible.

- Inspection of LNG carrier deck for protection with materials suitable for withstanding LNG exposure, as LNG is a cryogenic liquid that can cause severe embrittlement of steel structures.

7.4.10 Operational Requirements

- Cargo transfer operations shall be suspended at the jetty when heights in excess of 2.5 meters significant and/or wind velocities exceed 20m/s (39 knots).

- Tankers shall disengage from the jetty when wave heights exceed 4 meters significant and / or wind velocities exceed 30m/s (58knots) and

- It is recommended to have a consistent weather forecasting service during LNG transfers.

- The terminal crew shall have minimum training equivalent to those specified LNG carrier crews in the IMO-STCW Convention, (International Convention on Standards of Training, Certification and Watch keeping for Seafarers, 1978).

- Development of safety and environment policies, along with assignment of responsibilities, development of procedures, periodic audits and reviews for responding to LNG releases and situations like fire as per ISM Code (International Management Code for the Safe Operations of Ships and Pollution Prevention adopted by the IMO Resolution A.741 (18)-1994)

- The marine security plans shall address:
  - Security administration and organization of the facility
  - Personal training
  - Records and exercises
  - Response to change in security level
  - Procedures for interfacing with vessels
  - Declaration of security (DoS)
  - Communications
  - Security systems and equipment maintenance
  - Security measures for access control, restricted areas, handling cargo, delivery of vessel stores and bunkers and monitoring
  - Security incident procedures
  - Audits and security plan amendments

7.4.11 Release Response System

While the LNG industry traditionally focuses on release prevention, it is essential that release response systems exist to help mitigation in the event of releases. The primary aim is to protect human health and safety, minimize environmental impacts and to restore the environments, as nearly as practicable, to pre-release conditions. The response system at the marine terminal includes gas detection, safety shutdown and fire protection systems. The other elements of response system comprise:

- Safety and security zones
- Ship and facility emergency response plan
- Coordination with GMB and local emergency responders
- Evacuation plans and procedures

7.4.12 Emergency Response Planning (ERP)

Handling Major Releases

- On noting release transfer operations shall be suspended immediately.

- The onsite personnel at the marine facility shall indicate the position and cause of release to onshore control room. The onsite personnel shall also indicate the probable size of the release.
- The site main controller shall assist the designated release response team/ Coast Guard reach the site of release and mobilize release combating equipment to the site depending on the size of the release.

- The responsibility of the main controller is also to inform all statutory authorities, i.e., Gujarat Maritime Board, GPCB, Coast Guard, Superintendent of Police, and Local Customs etc.

- The spills shall be contained as per the National Oil Spill Disaster Contingency plan with PLL providing the necessary equipment and manpower assistance.

The operational command structure can be similar to **Figure-7.5.**

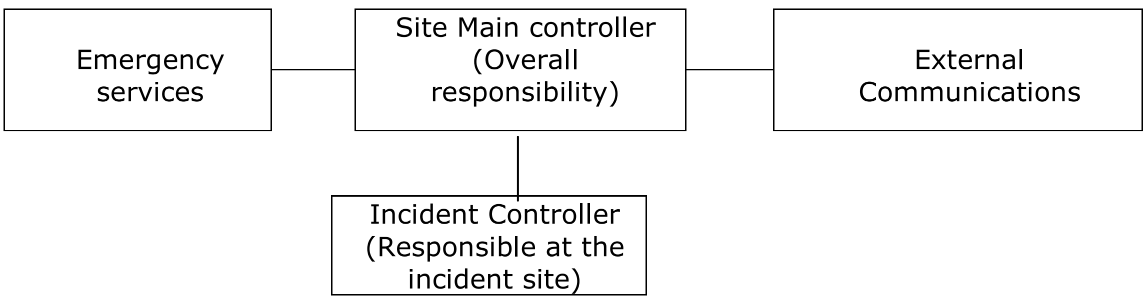

FIGURE-7.5
TYPICAL COMMAND STRUCTURE FOR EMERGENCY RESPONSE

7.4.13 Handling Unignited Release

The unignited vapours could accumulate or move to a vulnerable area where any ignition source would produce an explosion with even more dramatic consequences. In this case, the emergency responders may involve law enforcement or other public resources to help notify personnel in the downwind direction to take action and move away from the hazard.

7.4.14 Handling Fire and Explosion Emergencies

The general strategy that can be used to deal with a fire emergency comprises three steps, namely:

- Information gathering and accident assessment
- Decision Making
- Implementation of the response actions
  The types of actions to be implemented will depend on the first two steps, and can be summarized in three possible courses of actions, i.e.
- Attacking fire
- Controlling the fire without attempting to put it out, or
- Complete withdrawal

Step1: Information gathering and Accident Assessment

- Determine whether casualties have occurred, and whether rescue operations would be required
- Identify the materials involved in the incident. It is possible that more than one material is involved in the accident. It is possible that more than one material is stored in the same location.

  - Use the MSDS for the material involved
  - Appropriate extinguishing agents for the material

- Determine weather conditions such as wind direction and speed, temperature, humidity, and precipitation.

- Determine available resource in terms of manpower, equipment and supplies. Also determine what additional resources could be mobilized and how soon.

Step2: Decision Making

After all this information has been collected, a decision should be made as to the type of action to take. Rescue of casualties should, of course, be the first task. However, even this task will depend on the overall accident assessment, on the resources available, and on the alternatives implementable.

In general, three possibilities should be considered,

- Attack the fire
- Control the fire without attempting to put it out
- Withdrawal of emergency response panel

The choice of one of these actions will depend on the accident assessments and the materials involved. Putting out the fire could sometimes introduce even greater hazards due to dispersion of the unignited cloud and therefore, the other alternative can be sometimes be to let the fire burn, thus limiting the exposure of personnel.

The duties of the fire and rescue team leader include:

- Overall in-charge of the fire fighting operations
- Inform the Main Controller if external fire tender/ firefighting equipment/ materials/ Mutual Aid are required.
- Maintaining adequate supplies for the fighting equipment and facilities.

7.4.15 Roles and Responsibilities

Contingency plans backed up by adequate and well-maintained equipment, detailed procedures, necessary supplies of products for treatment, and personnel trained to deal with spills are essential to ensure an effective response. The following section defines the roles and responsibilities of the various agencies involved in combating oil pollution in the event of spillage or in the event of a disaster.

- Provision of safety and security zones for LNG carriers to reduce the likelihood of collisions or the need for an LNG vessel to try to avoid other post traffic.
- Identify releases: Location, size and intimate site main controller at PLL Plant
- Inform statutory bodies, Coast Guard about releases
- Establish crisis management group an define roles and responsibilities
- Coordination on quick and safe handling of tankers
- Provide for training of personnel involved in operation
- Organization of periodic exercise and mock drills under the guidance of the regional Coast Guard to keep equipment and personnel in constant readiness.
- Identification of suitable means for treatment and disposal of debris, emulsions etc.

7.4.16 Regional Coast Guard Commander

- Coordination of activities of Regional Communication Center
- Receive reports of oil pollution and mobilize Coast Guard resources to support On-Scene Commander (OSC) action at spill area.
- Provision of administrative and infrastructure to the Regional Communication Centre (RCC) to conduct routine and operational tasks.
- Maintain a list and assess available resources including local, regional, national and international groups, and the scale of spillage at which they should be contacted
- Conduct periodical exercises of combating oil pollution equipment and material
- Provide assistance to local groups in implementation of Local Action Plan.

7.5 Disaster Management Planning (DMP) by PLL

PLL has a Disaster Management Plan (DMP) in place that is professionally addressed & duly weighed. PLL had engaged an experienced Port Operator to provide various services that include Hazard Prevention, and Health, Safety & Environment services on the waterfront. PLL are taking care of HSE & Hazard prevention activities on the waterfront with the assistance of Port Operator. The DMP prepared by PLL is fully effective for preventing and managing any incidents or accidents in and around the Facilities, the existing LNG terminal and the waterfront and for ensuring their safety. Detailed Disaster Management Plan for PLL LNG terminal at Dahej is given in **Annexure-XII**.

8.0 PROJECT BENEFITS

Petronet LNG Limited (PLL) proposes for expansion of existing LNG Import, Storage and Re-gasification facilities from 10 MMTPA to 20 MMTPA at Dahej, Bharuch District, Gujarat.

The proposed developmental activities in this region will result in improvement of infrastructure as well upliftment of social structure in the area. The people residing in the nearby areas will be benefited indirectly. It is anticipated that the proposed development will provide benefits for the locals in two phases i.e. during construction phase as well as during operational stage.

8.1 Construction Phase

8.1.1 Employment

The major benefit due to the proposed expansion of LNG terminal will be in the sphere of generating temporary employment for substantial number of personnel. The construction phase of the proposed expansion of LNG terminal is expected to span over a period of 42~ 48 months. Approximately 2500 persons would be required for the construction work, most of whom would be unskilled workers, although the LNG terminal construction requires few skilled personnel as well. These construction workers will be taken from the study area to the extent possible. Hence, the proposed expansion of LNG terminal project will benefit locals to some extent.

8.1.2 Community Services

PLL shall employ local people to the extent possible in order to reduce the need for additional infrastructure. In addition, PLL will develop necessary infrastructure like water supply, sewerage, medical facility, etc. for catering to the needs of the project personnel and their families. The local people have been indirectly benefited by these developments.

8.1.3 Transportation

The proposed expansion of LNG terminal site is well connected with roads and local transport.

8.2 Operational Phase

8.2.1 Population

During the operational phase, additional (site to advise) 20~30 people shall be employed. Considering that most of the skilled personnel and unskilled/ semiskilled personnel shall be from within the study area, the proposed project result in better scope for direct employment etc. The developmental activities will cause least increase in the local population and hence any extra strain on the infrastructure, education etc.

8.2.2 Education

Unskilled people and limited skilled people (depending on availability) shall be hired from local population. People expected to come to the study area from outside are expected to be educated and especially skilled. In addition, some secondary developments like opening of new schools, shops may take place in view of the increased family population due to the proposed employment. These factors will be beneficial to locals residing in the study area.

8.2.3 Employment

The man power requirements for the operational phase of the proposed expansion of LNG terminal project shall be about 20 ~ 30 persons. Many of these persons, however shall be skilled people and possibly shall come from outside the study area. Need of unskilled people shall be satisfied from local population.

In addition to the direct employment mentioned above, there will be indirect employment of local people by utilizing their expertise in different areas like horticulture, site clearing, LNG terminal development activities like reclamation and construction. Also, due to secondary development in the study area, employment opportunities will be generated.

8.3 Corporate Social Responsibility

Petronet LNG, as responsible Corporate/Community/Government Citizens, will undertake Socio-Economic Development Programme to supplement the efforts to meet priority needs of the community with the aim to help them become self-reliant. These efforts would be generally around our work centres mostly in the areas of Education, Civil Infrastructure, Healthcare, Sports & Culture, and Entrepreneurship in the Community. Petronet LNG shall also support Water Management and Disaster Relief in the country thereby helps to bolster its image with key stakeholders.

8.4 Social Philosophy

Petronet LNG shall promote community projects selected on the following parameters in the focus areas:

- Shared resource contribution by Petronet with Government, credible partners and the Community;
- Sustainable impact of the projects on the well-being & self-reliance of the community; and
- Process credibility to enhance the corporate image – projectised working, critical evaluation of success in meeting the desired objectives & documentation.

Support National causes in the focus areas, and

Create enduring Values, Satisfactions and Recognitions

8.5 Work Centre Level

At the Work Centre level, the focus areas are Education with thrust on Information Technology, Health care including Drinking Water, Environment and Entrepreneurship Projects. The distribution of budget allocation in these areas will be on the following lines:

i.	Education	-	25%
ii.	Healthcare including Drinking water	-	30%
iii.	Entrepreneurship Schemes	-	15%
iv.	Environment	-	15%
v.	Others	-	15%

NOTE: The Schemes will be developed in collaboration with State Agencies like District Administration, District Industries Centres, District and Government agencies, NGOs, local districts/village level authorities, Professional bodies etc.

8.6 Existing CSR Activities

Following are the Existing CSR activities carried out Petronet LNG at Dahej. Photos of CSR activities are shown in **Figure-8.1**

1. PLL has constructed a temple at the site for the local people and has contributed towards infrastructure in the area for roads and drinking water.

2. Community development and welfare measures are taken. Village Luwara has been jointly adopted along with another nearby industry, as directed by PCPIR Welfare Society. Separate fund allocated for CSR.

3. Some of the schemes completed/under progress are Health Center (construction & operation), drainage and provision of street lights at Village Luwara. Rupees 75 lakh contributed to PCPIR Welfare Society. Two ladies from Luwara village sponsored for nursing course at Vidhyadeep Community college, Bharuch. Sponsored construction of Sanitation scheme at village Muller. Active participation in other Government initiated community development programs.

4. Installed 10 nos. Emergency solar lighting at prominent places in village Luwara. Donated Rs.1 lac for Bharuch District Civic centre development. Participated in Govt. scheme on Kanya Kelvani. Installation of drainage crossings to remove accumulated water at 4 locations within the village Luvara at a cost of Rs. 0.8 lacs. Construction of approach road in village Lakhigaon, Dahej.

5. PLL has sponsored 'Mataria Talav drinking water project' of the Bharuch Municipality Corporation. This project is for the supply of sweet drinking water from the Narmada River to the residents of Bharuch city. MD&CEO handed over cheque for Rs. 25 Lacs to the Collector, Bharuch on 13/06/2011.

6. PLL installed 50 nos. Emergency solar lighting at prominent places in village Luwara & 10 nos. Emergency solar lighting at prominent places in village Lakhigam of Vagra Taluka in Bharuch District. Provided School Bus to Primary School at Lakhigam Village and also running Primary Health Center at Luvara Village.

FIGURE-8.1
PHOTOS Of EXISTING CSR ACTIVITIES

9.0 ADMINISTRATIVE ASPECTS

9.1 Institutional Arrangements for Environment Protection and Conservation

The proposed expansion of LNG Terminal complex will be supervised and controlled by the unit head, supported by HOD (Terminal operations) and adequate team of technically and statutorily qualified personnel apart from the operating staff of skilled, semi skilled, unskilled and other categories.

Environment management cell will be headed by HOD-Environment plant and will be supported by multi disciplinary professionals. The HOD-Environment will be responsible for regular environment management activities in LNG Terminal and CPP.

The organizational structure of environment management for LNG Terminal is presented in **Figure-9.1**

The Environmental Engineer will be responsible for monitoring activities in the LNG terminal. As conscious of this, PLL will create a department consisting of officers from various disciplines to co-ordinate the activities concerned with the management and implementation of the environmental control measures in all sphere of activities.

Basically, this department will supervise the monitoring of environmental pollution levels viz. ambient air quality, water and effluent quality, noise level either departmentally or by appointing external agencies wherever necessary.

In case the monitored results of environmental pollution are found to exceed the allowable limits, the environmental management cell will suggest remedial action and get these suggestions implemented through the concerned authorities.

The environmental management cell will also co-ordinate all the related activities such as collection of statistics of health of workers and population of the region, afforestation and green belt development.

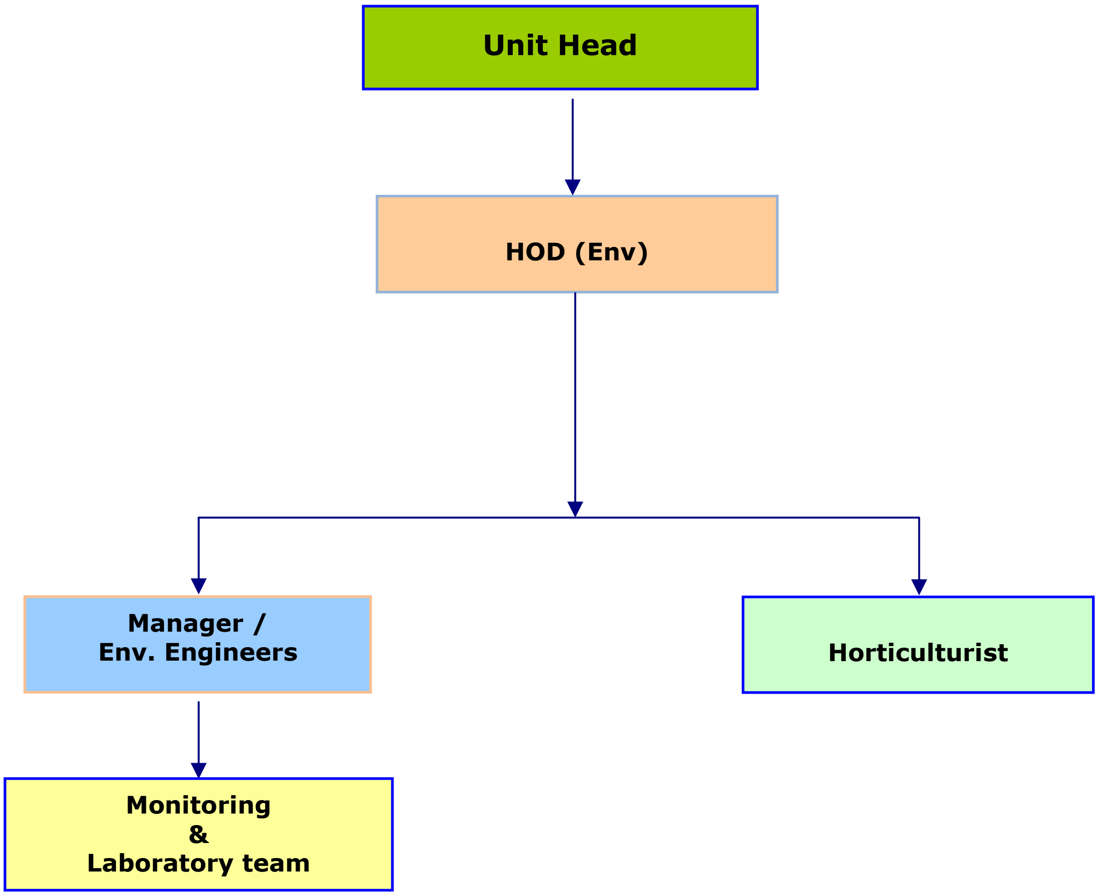

FIGURE-9.1
ORGANIZATIONAL STRUCTURE OF ENVIRONMENT MANAGEMENT

10.0 SUMMARY AND CONCLUSIONS

Petronet LNG Limited (PLL) proposes for expansion of existing LNG Import, Storage and Re-gasification facilities from 10 MMTPA to 20 MMTPA at Dahej, Bharuch District, Gujarat.

As per the Environment Impact Assessment (EIA) Notification dated 14th September 2006, the proposed expansion of LNG Re-gasification Terminal falls under 'Category-A' with project or activity type number '6(a)', The present draft EIA Report is prepared for Public Hearing/Consultation purpose, considering the TOR conditions received from MoEF.

10.1 Location Details of the Project

The proposed expansion of LNG Re-gasification Terminal will be located within existing terminal at Dahej, Bharuch District, Gujarat.

10.2 Importance of the Proposed Project

The gas consumption in power generation and fertilizer industries are the major consumers for nearly 65% of the consumption of natural gas in India. The power and fertilizer sectors together are expected to consume more than 80% of the total natural gas consumed in the country. Apart from power and fertilizer the other prominent demand segment include industries like steel and CGD. Although the availability of gas has expanded, its demand has continuously been outstripping supply. Currently, the Indian gas market has a shortfall of approximately 45 MMSCMD. However there is large latent demand that is unserved. Sectors like power could require as much as 100 MMSCMD additionally during the 12th Plan period (source: CEA). With the projected economic growth and the envisaged growth in the gas infrastructure, market demand is likely to grow.

10.3 Alternate Site Evaluation

LNG Re-gasification Terminal expansion is proposed within existing Dahej terminal premises. Since the proposed project is a brown field expansion, no alternatives are considered.

10.4 Size of the Project

Expansion of existing LNG Import, Storage and Re-gasification facilities from 10 MMTPA to 20 MMTPA capacity within the existing terminal at Dahej, Bharuch District, Gujarat.

10.5 Cost of the Project

The estimated cost of the proposed expansion of LNG Re-gasification terminal from 10 MMTPA to 20 MMTPA is about Rs.2950 crores (for 5 MMTPA Phase-III A) and estimated to be 2700 crores (for additional 5 MMTPA capacity Phase-III B)

10.6 Baseline Environmental Status

The existing environmental setting is considered to adjudge the baseline environmental conditions, which are described with respect to climate, hydrogeological aspects, atmospheric conditions, water quality, soil quality, vegetation pattern, ecology, land use and socioeconomic profiles of people.

The comprehensive report incorporates the baseline studies were carried out for three seasons covering winter 2011-2012, pre-monsoon and post-monsoon for 2012 in the various domains of environment. Secondary data collected from various Government and Semi-Government organizations have been also discussed in the following section.

10.6.1 Land Use Studies

The land use pattern of the proposed expansion of LNG terminal has been studied by District Census Hand Books. It is observed that 5.2% of the land falls under Culturable waste. On the other hand, 19.1% of land falls under un-irrigated land. The area not available for cultivation is about 75.6 % forms the bulk of the land use.

10.6.2 Soil Quality

Winter Season (December 2011 to February 2012)

- It has been observed that the texture of soil is mostly Sandy clay to Sandy clay loam in the study area. The pH of the soil indicating that is slightly alkaline in nature.
- The Electrical conductivity was recorded as 270 µS/cm to 980 µS/cm. Minimum concentration was observed at Jageshwar village (S5) and maximum concentration at near Aliabet village (S8) during the study period.
- The Organic Carbon content in the study area observed as 0.32 % to 0.90 %, which the soil falls under less to sufficient category.
- Available potassium was observed as minimum 184.2 Kg/ha at Dahej village (S3) and maximum observed as 526.2 Kg/ha at at near Aliabet village (S8) indicating that the soil falls under medium to morethan sufficient category.
- Available Nitrogen was observed as 64 Kg/ha to 195 kg/ha. Minimum concentration is observed at Project site (S1) and the maximum observed concentration observed at near Dahej village (S3) location. Based on the above values the soil falls under less to better category.

- Available phosphorous was observed as 66 kg/ha to 90 kg/ha in the study region. The minimum value observed at Project site (S1) location and the maximum was observed at near Dahej village (S3) location. It shows the soil falls under sufficient to more than sufficient category.

Pre-monsoon Season (March to May - 2012)

- It has been observed that the texture of soil is mostly Sandy clay in the study area. The pH of the soil indicating that is slightly alkaline in nature.

- The Electrical conductivity was recorded as 312 µS/cm to 960 µS/cm. Minimum concentration was observed at Jageshwar village (S5) and maximum concentration at near Aliabet village (S8) during the study period.

- The Organic Carbon content in the study area observed as 0.42 % to 0.82 %, which the soil falls under medium to sufficient category.

- Available potassium was observed as minimum 196 kg/ha at Dahej village (S3) and maximum observed as 536.4 kg/ha at near Aliabet village (S8) indicating that the soil falls under medium to more than sufficient category.

- Available Nitrogen was observed as 58 kg/ha to 182 kg/ha. Minimum concentration is observed at Project site (S1) and the maximum observed concentration observed at near Dahej village (S3) location. Based on the above values the soil falls under less to better category.

- Available phosphorous was observed as 63 kg/ha to 84 kg/ha in the study region. The minimum value observed at near Aliabet village (S8) location and the maximum was observed at near Ambetha and Ambetha villages (S4 and S5) location. It shows the soil falls under an average sufficient to more than sufficient category.

Post-monsoon Season (October to November - 2012)

- It has been observed that the texture of soil is mostly Sandy clay to Sandy clay loam in the study area. The pH of the soil indicating that is slightly alkaline in nature.

- The Electrical conductivity was recorded as 325 µS/cm to 965 µS/cm. Minimum concentration was observed at Jageshwar village (S5) and maximum concentration at near Ambheta village (S4) during the study period.

- The Organic Carbon content in the study area observed as 0.29 % to 0.80 %, which the soil falls under less to on an avg. sufficient category.

- Available potassium was observed as minimum 216.1 Kg/ha at Dahej village (S3) and maximum observed as 614.0 Kg/ha at at near Aliabet village (S8) indicating that the soil falls under medium to more than sufficient category.

- Available Nitrogen was observed as 62 Kg/ha to 215 kg/ha. Minimum concentration is observed at near Aliabet village (S8) and the maximum observed concentration observed at near Dahej village (S3) location. Based on the above values the soil falls under very less to better category.

- Available phosphorous was observed as 53 kg/ha to 98 kg/ha in the study region. The minimum value observed at Project site (S1) location and the maximum was observed at near Dahej village (S3) location. It shows the soil falls under on an average sufficient to more than sufficient category.

10.6.3 Meteorology

The recorded temperature at site during study period ranges between 16.0°C and 43.3°C and relative humidity ranges in between 35% to 79.2%. Predominant winds from SW, NE and NW directions were observed during study period.

10.6.4 Ambient Air Quality

Winter Season (December 2011 to February 2012)

PM_{10}

The maximum concentration for Particulate Matter (PM_{10}) observed in eight locations is 57.9 $\mu g/m^3$ recorded at Project site (AAQ1) the minimum concentration is recorded as 33.5 $\mu g/m^3$ at near Aliabet Village (AAQ8) during the study period.

$PM_{2.5}$

Out of the eight locations the maximum concentration for Particulate Matter ($PM_{2.5}$) was observed as 19.4 $\mu g/m^3$ recorded at SE of project (AAQ7) with the minimum concentration observed as 8.5 $\mu g/m^3$ recorded at near Aliabet Village (AAQ8) during the study period. All ambient air quality locations the $PM_{2.5}$ levels recorded are within the prescribed standards for Residential and Industrial areas.

SO_2

In the eight locations the maximum concentration for Sulphur dioxide (SO_2) was observed as 19.4 $\mu g/m^3$ recorded at SE of project (AAQ7) and the minimum concentration observed as 10.2 $\mu g/m^3$ recorded at near Aliabet Village (AAQ8) during the study period.

NO_x

Out of the eight locations the maximum concentration for Oxides of Nitrogen (NO_x) was observed as 20.4 $\mu g/m^3$ recorded at SE of project (AAQ7) and the minimum concentration observed at 11.4 $\mu g/m^3$ recorded at near Aliabet village (AAQ8) during the study period.

CO

In all the eight residential and rural locations the maximum concentration for Carbon Monoxide (CO) was observed as 507 µg/m^3 recorded at SE of Project (AAQ7) and the minimum concentration observed of 143 µg/m^3 recorded at near Aliabet village (AAQ8) village during the study period.

O_3

Out of the eight locations the maximum concentration for O_3 was observed as 7.8 µg/m^3 recorded at project site (AAQ1) with the minimum concentration observed as 2.2 µg/m^3 recorded at near Aliabet Village (AAQ8) during the study period. All ambient air quality locations the O_3 levels recorded are within the prescribed standards for Residential and Industrial areas.

Pre-monsoon Season (March to May 2012)

PM_{10}

The maximum concentration for Particulate Matter (PM_{10}) observed in eight locations is 65.1 µg/m^3 recorded at Project site (AAQ1) the minimum concentration is recorded as 34.7 µg/m^3 at near Aliabet Village (AAQ8) during the study period.

$PM_{2.5}$

Out of the eight locations the maximum concentration for Particulate Matter ($PM_{2.5}$) was observed as 23.8 µg/m^3 recorded at Project site (AAQ1) with the minimum concentration observed as 10.2 µg/m^3 recorded at near Aliabet Village (AAQ8) during the study period. All ambient air quality locations the $PM_{2.5}$ levels recorded are within the prescribed standards for Residential and Industrial areas.

SO_2

In the eight locations the maximum concentration for Sulphur dioxide (SO_2) was observed as 15.8 µg/m^3 recorded at Project site (AAQ1) and the minimum concentration observed as 9.1 µg/m^3 recorded at near Aliabet Village (AAQ8) during the study period.

NOx

Out of the eight locations the maximum concentration for Oxides of Nitrogen (NOx) was observed as 16.5 µg/m^3 recorded at Project site (AAQ1) and the minimum concentration observed at 10.3 µg/m^3 recorded at near Aliabet village (AAQ8) during the study period.

CO

In all the eight residential and rural locations the maximum concentration for Carbon Monoxide (CO) was observed as 414 µg/m^3 recorded at Project site (AAQ1) and the minimum concentration observed of 132 µg/m^3 recorded at near Aliabet village (AAQ8) village during the study period.

O_3

Out of the eight locations the maximum concentration for O_3 was observed as 8.0 µg/m^3 recorded at project site (AAQ1), near Dahej (AAQ3) and near SE of project (AAQ7) with the minimum concentration observed as 2.5 µg/m^3 recorded at near Jageshwar village (AAQ5) during the study period. All ambient air quality locations the O_3 levels recorded are within the prescribed standards for Residential and Industrial areas.

Post monsoon Season – (October to November 2012)

- **Particulate Matter (PM_{10})**

The maximum concentration for Particulate Matter (PM_{10}) observed in eight locations is 62.3 µg/m^3 recorded at Project site (AAQ1) the minimum concentration is recorded as 34.1 µg/m^3 at near Aliabet Village (AAQ8) during the study period.

- **Particulate Matter ($PM_{2.5}$)**

Out of the eight locations the maximum concentration for Particulate Matter ($PM_{2.5}$) was observed as 21.7 µg/m^3 recorded at Project site (AAQ1) with the minimum concentration observed as 9.4 µg/m^3 recorded at near Aliabet Village (AAQ8) during the study period. All ambient air quality locations the $PM_{2.5}$ levels recorded are within the prescribed standards for Residential and Industrial areas.

- **Sulphur Dioxide**

In the eight locations the maximum concentration for Sulphur dioxide (SO_2) was observed as 9.6 µg/m^3 recorded at Project site (AAQ1) and the minimum concentration observed as 17.8 µg/m^3 recorded at near Aliabet Village (AAQ8) during the study period.

- **Nitrogen Oxide**

Out of the eight locations the maximum concentration for Oxides of Nitrogen (NOx) was observed as 10.8 µg/m^3 recorded at Project site (AAQ1) and the minimum concentration observed at 19.1 µg/m^3 recorded at near Aliabet village (AAQ8) during the study period.

- ***Carbon Monoxide***

In all the eight residential and rural locations the maximum concentration for Carbon Monoxide (CO) was observed as 473 µg/m^3 recorded at Project site (AAQ1) and the minimum concentration observed of 136 µg/m^3 recorded at near Aliabet village (AAQ8) village during the study period.

- ***Ozone***

Out of the eight locations the maximum concentration for O_3 was observed as 7.9 µg/m^3 recorded at project site (AAQ1) with the minimum concentration observed as 2.4 µg/m^3 recorded at near Aliabet village (AAQ8) during the study period. All ambient air quality locations the O_3 levels recorded are within the prescribed standards for Residential and Industrial areas.

10.6.5 Water Quality

Surface Water Quality

Winter Season (December 2011 to February 2012)

- The analysis results of surface water samples indicate that the pH value was observed to be 7.8 and 7.9 in SW1 & SW2 respectively which is well within the specified standards of 6.5 to 8.5.
- Electrical conductivity of surface water samples was observed to be very high concentrations because the source of the samples is taken from sea & river surface waters.
- The Dissolved Oxygen was observed about 6.5 & 6.2 mg/l in SW1 & SW2 samples respectively.
- Sulphates were found to be in the range of 232.4 & 189.0 mg/l, and Nitrates were found to be in the range of 4.5 & 3.4 mg/l which are with in the prescribed limits only.
- Fluoride concentration was found to be in the range of 1.2 & 1.1 mg/l in both the samples, which are within the prescribed limits.
- Cyanides and Phenolic compounds found to be less than detection limits.
- Bacteriological studies revealed that the Total Coliform count and E. coli count are well within the prescribed limits of IS 10500.

Pre-monsoon Season (March to May 2012)

- The analysis results of surface water samples indicate that the pH value was observed to be 7.9 and 8.0 in SW1 & SW2 respectively which is well within the specified standards of 6.5 to 8.5.
- Electrical conductivity of surface water samples was observed to be very high concentrations, because the source of the samples is taken from sea & river surface waters.
- The Dissolved Oxygen was observed about 6.4 & 6.3 mg/l in SW1 & SW2 samples respectively.
- Sulphates were found to be in the range of 254 & 196 mg/l, and Nitrates were found to be in the range of 4.8 & 3.8 mg/l which are within the prescribed limits only.
- Fluoride concentration was found to be in the range of 1.1 & 1.2 mg/l in both the samples, which are within the prescribed limits.

- Cyanides and Phenolic compounds found to be less than detection limits.
- Bacteriological studies revealed that the Total Coliform count and E. coli count are well within the prescribed limits of IS 10500.

Monsoon Season (June to September 2012)

- The analysis results of surface water samples indicate that the pH value was observed to be 7.6 and 7.7 in SW1 & SW2 respectively which is well within the specified standards of 6.5 to 8.5.
- Electrical conductivity of surface water samples was observed to be very high concentrations, because the source of the samples is taken from sea & river surface waters.
- The Dissolved Oxygen was observed about 3.8 & 4.1 mg/l in SW1 & SW2 samples respectively.
- Sulphates were found to be in the range of 204 & 164 mg/l, and Nitrates were found to be in the range of 3.8 & 3.1 mg/l which are within the prescribed limits only.
- Fluoride concentration was found to be in the range of 1.3 & 1.2 mg/l in both the samples, which are within the prescribed limits.
- Cyanides and Phenolic compounds found to be less than detection limits.
- Bacteriological studies revealed that the Total Coliform count and E. coli count are well within the prescribed limits of IS 10500.

Post-monsoon Season (October to November 2012)

- The analysis results of surface water samples indicate that the pH value was observed to be 7.9 and 7.7 in SW1 & SW2 respectively which is well within the specified standards of 6.5 to 8.5.
- Electrical conductivity of surface water samples was observed to be very high concentrations, because the source of the samples is taken from sea & river surface waters.
- The Dissolved Oxygen was observed about 5.2 & 4.9 mg/l in SW1 & SW2 samples respectively.
- Sulphates were found to be in the range of 210 & 182 mg/l, and Nitrates were found to be in the range of 3.5 & 3.1 mg/l which are within the prescribed limits only.
- Fluoride concentration was found to be in the range of 1.2 & 1.3 mg/l in both the samples, which are within the prescribed limits.
- Cyanides and Phenolic compounds found to be less than detection limits.

- Bacteriological studies revealed that the Total Coliform count and E. coli count are well within the prescribed limits of IS 10500.

10.6.5.1 Ground Water Quality

Winter Season (December 2011 to February 2012)

- The analysis results of ground water samples showed the pH in range of 7.6-8.3, which is well within the specified standard of 6.5 to 8.5.

- Colour and Turbidity of the samples ranged from 2-3 Hazens and 3-6 NTU respectively.

- Electrical conductivity of the samples ranged from 203 - 2570 µS/cm except one location having maximum value observed as 9230 µS/cm at GW1 (Project site), and where as the minimum value was observed at GW8 (near Aliabet Village).

- The Total Hardness of the samples ranged from 90 - 940 mg/l. The maximum value was observed at GW1 (Project site) and the minimum value observed at GW8 (near Aliabet village). Whereas the prescribed limit of 300 mg/l.

- Calcium and Magnesium concentrations ranged from 19 – 192 mg/l and 7.3 – 121.5 mg/l respectively.

- The Total Dissolved solids of the samples ranged from 132 - 1720 mg/l except one sample shows the higher value as 6190 mg/l at project site.. The maximum TDS was observed at GW6 (Luvara village) and where as the minimum value observed at GW8 (Aliabet Village).The TDS values are well within the prescribed limit of 2000 mg/l except one sample at (GW1) project site.

- Range of Chlorides and Sulphates concentrations at all the locations 7.1 -319 mg/l, except one sample at project site (GW1) which is having 2411 mg/l. And sulphate concentration as 2.9 – 69.4 mg/l respectively except Project site (GW1) has shown 537.9 mg/l.

- Fluoride concentrations are ranging in between 0.2 – 0.7 mg/l and are found to be within the permissible limits. Similarly, Nitrates are also found to be ranging between 1.1 – 32.2 mg/l.

- Iron concentrations in ground waters varied from 0.02 – 0.18 mg/l. All other metal concentrations are observed to be below detectable limits.

- Bacteriological studies revealed the absence of E.coli in ground waters. The Total Coliform counts is <2 MPN/100 ml in all eight samples against the standard limit of 10 MPN/100 ml.

Based on the above results it is evident that all of the parameters in ground water fairly meet the desirable standard limits of IS: 10500.

Pre-monsoon Season (March to May 2012)

- The analysis results of ground water samples showed the pH in range of 7.6-8.5, which is well within the specified standard of 6.5 to 8.5.

- Colour and Turbidity of the samples ranged from 2-3 Hazens and 3-4 NTU respectively.

- Electrical conductivity of the samples ranged from 214 - 3160 µS/cm except one location having maximum value observed as 10140 µS/cm at GW1 (Project site), and where as the minimum value was observed at GW5 (near Jageshwar Village).

- The Total Hardness of the samples ranged from 85 - 675 mg/l. The maximum value was observed at GW1 (Project site) and the minimum value observed at GW8 (near Aliabet village). Whereas the prescribed limit of 300 mg/l.

- Calcium and Magnesium concentrations ranged from 24 – 160 mg/l and 6.1 – 103.3 mg/l respectively.

- The Total Dissolved Solids of the water samples ranged from 142 - 1390 mg/l except two samples shows the higher value as 2150 and 6896 mg/l at GW6 & GW1 respectively. The maximum TDS was observed at GW1 (Project site), and where as the minimum value observed at GW5 (Jageshwar Village). The TDS values are well within the prescribed limit of 2000 mg/l except two samples at (GW1) project site and Luvara village (GW6).

- Range of Chlorides concentrations at all the locations 8.2 - 500 mg/l, except one sample at project site (GW1) which is having 2918 mg/l. And range of sulphate concentration as 2.2 – 113.9 mg/l except Project site (GW1) has shown 708.6 mg/l.

- Fluoride concentrations are ranging in between 0.1 – 0.8 mg/l and are found to be within the permissible limits. Similarly, Nitrates are also found to be ranging between 1.4 – 31.4 mg/l.

- Iron concentrations in ground waters varied from 0.02 – 0.20 mg/l. All other metal concentrations are observed to be below detectable limits.

- Bacteriological studies revealed the absence of E.coli in ground waters. The Total Coliform counts is <2 MPN/100 ml in all eight samples against the standard limit of 10 MPN/100 ml.

Based on the above results it is evident that all of the parameters in ground water fairly meet the desirable standard limits of IS: 10500.

Monsoon Season (June 2012 to September 2012)

The results for the ground water samples collected during monsoon season.

- The analysis results of ground water samples showed the pH in range of 7.7-7.9, which is well within the specified standard of 6.5 to 8.5.

- Colour and Turbidity of the samples ranged from 2-3 Hazens and 2-5 NTU respectively.

- Electrical conductivity of the samples ranged from 176 - 2980 µS/cm except one location having maximum value observed as 9120 µS/cm at GW1 (Project site), and where as the minimum value was observed at GW5 (Jageshwar Village).

- The Total Hardness of the samples ranged from 73 - 523 mg/l. The maximum value was observed at GW7 (SE of Project) and the minimum value observed at GW5 (Jageshwar village). Whereas the prescribed limit of 300 mg/l.

- Calcium and Magnesium concentrations ranged from 16.9 – 150.2 mg/l and 5.4 – 75.6 mg/l respectively.

- The Total Dissolved solids of the samples ranged from 115 - 2090 mg/l except one sample shows the higher value as 6340 mg/l. The maximum TDS was observed at GW1 (Project site) and where as the minimum value observed at GW5 (Jageshwar Village).

- Range of Chlorides and Sulphates concentrations at all the locations 10.1 -475 mg/l, except one sample at project site (GW1) which is having 2460 mg/l. And sulphate concentration as 2.5 – 105.5 mg/l respectively except Project site (GW1) has shown 695 mg/l.

- Fluoride concentrations are ranging in between 0.2 – 0.7 mg/l and are found to be within the permissible limits. Similarly, Nitrates are also found to be ranging between 1.6 – 31.4 mg/l.

- Iron concentrations in ground waters varied from 0.03 – 0.16 mg/l. All other metal concentrations are observed to be below detectable limits.

- Bacteriological studies revealed the absence of E.coli in ground waters. The Total Coliform counts is <2 MPN/100 ml in all eight samples against the standard limit of 10 MPN/100 ml.

Based on the above results it is evident that all of the parameters in ground water fairly meet the desirable standard limits of IS: 10500.

Post-monsoon Season (October to November 2012)

The results for the ground water samples collected during post-monsoon season.

- The analysis results of ground water samples showed the pH in range of 7.6-7.9, which is well within the specified standard of 6.5 to 8.5.

- Colour and Turbidity of the samples ranged from 2-4 Hazens and 3-5 NTU respectively.

- Electrical conductivity of the samples ranged from 194 - 3050 μS/cm except one location having maximum value observed as 9480 μS/cm at GW1 (Project site), and where as the minimum value was observed at GW5 (near Jageshwar Village).

- The Total Hardness of the samples ranged from 84 - 565 mg/l. The maximum value was observed at GW1 (Project site) and the minimum value observed at GW5 (near Jageshwarvillage) whereas the prescribed limit of 300 mg/l.

- Calcium and Magnesium concentrations ranged from 22.3 – 158.4 mg/l and 5.7 – 90 mg/l respectively.

- The Total Dissolved Solids of the water samples ranged from 126 - 1980 mg/l except one sample shows the higher value as 6160 mg/l at GW1. The maximum TDS was observed at GW1 (Project site) and where as the minimum value observed at GW5 (Jageshwar Village). The TDS values are well within the prescribed limit of 2000 mg/l except at (GW1) project site.

- Range of Chlorides concentrations at all the locations 9.7 - 490 mg/l, except one sample at project site (GW1) which is having 2642 mg/l and range of sulphate concentration as 2.4 – 110.6 mg/l except Project site (GW1) has shown 690 mg/l.

- Fluoride concentrations are ranging in between 0.3 – 0.6 mg/l and are found to be within the permissible limits. Similarly, Nitrates are also found to be ranging between 1.2 – 34.6 mg/l.

- Iron concentrations in ground waters varied from 0.02 – 0.12 mg/l. All other metal concentrations are observed to be below detectable limits.

- Bacteriological studies revealed the absence of E.coli in ground waters. The Total Coliform counts is <2 MPN/100 ml in all eight samples against the standard limit of 10 MPN/100 ml.

Based on the above results it is evident that all of the parameters in ground water fairly meet the desirable standard limits of IS: 10500.

10.6.6 Ambient Noise Levels

Winter Season (December 2011 to February 2012)

a) Day Time Noise Levels (L_{day})

The day time (L_{day}) noise levels at all the residential locations are observed to be in the range of 37.1 dB (A) to 48.1 dB (A). The maximum noise level of 48.1 dB (A) was observed at SE of project (N7) and the minimum noise level of 37.1 dB (A) was observed at near Aliabet Village (N8). It is observed that the day time noise levels are in accordance to the prescribed limit of 55 dB (A) in the residential area.

b) Night Time Noise Levels (L_{night})

The night time (L_{night}) noise levels at all the residential locations were observed to be in the range of 32.5 dB (A) to 43.6 dB (A). The maximum noise level of 43.6 dB (A) was observed at Project site (N1) and the minimum noise level of 32.5 dB (A) was observed at near Aliabet Village (N8). As per the standards night time noise levels are in accordance 45 dB (A) at the residential area and 70 dB (A) at industrial area.

Pre-monsoon Season (March to May 2012)

a) Day Time Noise Levels (L_{day})

The day time (L_{day}) noise levels at all the residential locations are observed to be in the range of 38.3 dB (A) to 47.8 dB (A). The maximum noise level of 47.8 dB (A) was observed at Project site (N1) and the minimum noise level of 38.3 dB (A) was observed at near Aliabet Village (N8). It is observed that the day time noise levels are in accordance to the prescribed limit of 55 dB (A) in the residential area and 75 dB (A) at industrial area.

b) Night Time Noise Levels (L_{night})

The night time (L_{night}) noise levels at all the residential locations were observed to be in the range of 33.7 dB (A) to 44.1 dB (A). The maximum noise level of 44.1 dB (A) was observed at Project site (N1) and the minimum noise level of 33.7 dB (A) was observed at near Aliabet Village (N8). As per the standards night time noise levels are in accordance 45 dB (A) at the residential area and 70 dB (A) at industrial area.

Post-monsoon Season (October to November 2012)

a) Day Time Noise Levels (L_{day})

The day time (L_{day}) noise levels at all the residential locations are observed to be in the range of 37.5 dB (A) to 47.6 dB (A). The maximum noise level of 47.6 dB (A) was observed at Project site (N1) and the minimum noise level of 37.5 dB (A) was observed at near Aliabet Village (N8). It is observed that the day time noise levels are in accordance to the prescribed limit of 55 dB (A) in the residential area and 75 dB (A) in industrial area.

b) Night Time Noise Levels (L_{night})

The night time (L_{night}) noise levels at all the residential locations were observed to be in the range of 32.9 dB (A) to 43.9 dB (A). The maximum noise level of 43.9 dB (A) was observed at Project site (N1) and the minimum noise level of 32.9 dB (A) was observed at near Aliabet Village (N8). As per the standards night time noise levels are in accordance 45 dB (A) at the residential area and 70 dB (A) in Industrial area.

10.6.7 Ecological Environment

Terrestrial Environment

Detailed ecological studies were conducted during winter season in 2011-2012 to identify the floristic composition in and around project area and surrounding villages. To know the presence of any endangered/threatened/endemic plant species in proposed project area and surrounding 10 km radius.

The study area did not record the presence of any critically threatened species. The records of Botanical Survey of India and Forest department also did not indicate presence of any endangered and or vulnerable species in this area.

Avifauna: Many bird species including quails, sand grouses, bayas, sparrows, munias, crows, mynas, parakeets, kites, hawks, doves, bee-eaters, ibis, bulbuls, babblers, larks, ducks, peafowls, lapwings, pigeons, etc are recorded from the study area during the recent survey by VIMTA team. These bird species have composition of raptors, insectivorous and granivorous birds. Occurrence of bird species in good numbers is due to suitable climate and availability of food. Some of the common birds observed during recent survey by state forest departments indicate the presence of bhat titar (Pterocles exuslus), house crow (Corvus splendense), wood pecker (Piecoides nanus), Baya (Ploceus philippinus), kabboter (Columbia livia), owl (Bubo bubo), house sparrow (Passer domesticus), parrot (Psittacula krameri), chil (Falco jugger) and eagle (Corcatus gallicus).

Surroundings of agricultural land and water bodies: The birds like Mynas, Crows, Sparrows, Bulbuls, Babblers and Pigeons are observed in and around villages. In areas with agriculture fields, the grain eating herbivorous species are dominant. These species are Doves, Sparrows, Cattle egrets, Parakeets etc. Insectivorous bird species viz. Bee-eaters, Wagtails, White breasted kingfisher, Egrets, Indian Roller are found around water bodies and in low-lying vegetation areas.

Rare, Endangered and Threatened Fauna in the Study Area:

In the year 1972 Government of India made an Act to provide protection to wild animals, birds and plants and for matters connected therewith which is known as Wild life (Protection) Act, 1972. Under this act Animals are categorized in Schedules to give maximum protection to the wild animals.

No animals and birds are found to be threatened in the study area. However with increasing anthropogenic activities like expansion of agricultural fields and industries there is limited impact on the fauna.

Surface water samples were collected for biological analysis from lentic and lotic water bodies during study period. Biological samples were analysed and estimated diversity index. Plankton diversity Index for phytoplankton and zooplankton varies from 2.56 to 3.14 and 2.45 and 2.84. Physico-chemical, biological parameters and diversity index reveals that the studied water bodies are slightly Oligotrophic in nature.

10.6.8 Socio-Economic Environment

The information on socio-economic aspects of the study area has been compiled from secondary sources, which mainly include census data of 2001.

The total population of the study area is about 14391. The Sex ratio is 812.5. About 64.4% of people are literates. The study area contains about 38.3 % of main workers, 2.6% of marginal workers and 59.1% of non-workers. In the study area about 20.1% population belong to Scheduled Tribes (ST) and 4.5 % Scheduled Castes (SC), thus indicating that there has been no significant change in weaker sections over previous years.

10.7 Impact Assessment

The identification and assessment of impacts over the various environmental attributes in the region due to the proposed expansion of LNG Terminal activities are discussed and mitigative measures and environmental management plan for the potential impacts have also been presented.

10.7.1 Impact on Land Use

The proposed expansion of LNG Re-gasification Terminal is contiguous to existing LNG terminal at Dahej PLL is having about 16 hectares of land in south side of the existing plot. Additionally about 22.62 hectares of land on south side of existing plot is allocated to PLL by Forest Department. PLL has also been permitted by Gujarat Maritime Board to reclaim 20 hectares of land on west side of the existing plot.

10.7.2 Impact on Soil

The impact on soil due to project activity is expected on account of changes in soil quality and also due to soil erosion from the project areas. Considering that the proposed project will be implemented within the existing LNG terminal premises and operation causing change in soil quality is not envisaged, the impact of the project on soil quality will be less than significant.

Greenbelt will be developed in phased manner from construction stage onwards. Apart from localized construction impacts at the project site, no adverse impacts on soil in the surrounding area are anticipated.

Impact on Topography

The proposed project premise is a generally plain land with a general elevation of about 12~14 m above MSL. Most of the buffer zone of the project is undulated land.

It is proposed to level the project area and to use the dredge sand. There will be no tall structures except stacks and storage tanks. Also, the contours of natural drainage will not be disturbed. In view of the above, there will be no major adverse impact on topography of the project site.

10.7.3 Impact on Air Quality

LNG regasification and storage is a clean process and essentially there is no emission from this process. There will be a small emission from the operation of GTGs and flare. The GTGs are run by the natural gas only and hence the emissions are small in terms of SO_2 and SPM. NOx is only significant pollutant emitted under this condition.

The proposed project has the gas generators based on "Lean – burn" technology. In this technology, each burner and flame tube installation consists of six burner assembly, each consisting of main and pilot burner and six flame tubes. The top end of the flame tube is secured to a main burner and the grooved bottom end carries two support rings and piston rings which located in a transition fuel this provide a controlled supply of fuel in a form suitable for the efficient operation of the combustion system. The combustion is considered "Lean" when excess air is introduced into the engine along with the fuel. This produces two positive effects first, the excess air reduces the temperature of the combustion process and this reduces the amount of oxides of nitrogen (NOx) produced by nearly half, compared to a conventional natural gas engine. Second, since there is also excess oxygen available, the combustion process is more efficient and more power is produced with the same amount of fuel. In this new lean-burn engine, the combustion process is enhanced by pre-mixing the air and fuel upstream of the turbo charger before introduction into the cylinder. Break Mean Effective Pressure (BMEP) against Air Excess (Lambda), the operating window is a very narrow band where efficiency peaks and where NOx is near its minimum.

One of the results of this technology is significantly reduced emission in the exhaust. The gas engine generators have NOx emissions as low as 0.85 grams/BHP-hr and produce low amounts of hydrocarbons (HC), carbon monoxides (CO) and particulate matter (PM). Emission from the proposed GTGs shall be controlled using the similar technology.

Emissions from the flare shall mostly occur at the time of project upset condition and the emissions will be insignificant under normal condition. In the proposed LNG terminal, three (03) No of GTGs are proposed for 15 MMTPA and further two (02) additional GTG for 20 MMTPA terminal operations.

The various measures proposed to minimize the pollution from the LNG terminal are as follows:

The NOX emission from the GTG's will be controlled by controlling combustion measures, which will be approached by way of low NOX burners

10.7.4 Impact on Surface Water and Groundwater Quality

There is no generation of any liquid effluent from the process area. Existing facilities are adequate to handle additional domestic waste water.

10.7.5 Impact on Noise Levels

Heavy construction traffic for loading and unloading, fabrication and handling of equipment and materials are likely to cause an increase in the ambient noise levels. The areas affected are those close to the site. However, the noise will be temporary and will be restricted mostly to daytime.

The noise control measures during construction phase include provision of caps on the equipment and regular maintenance of the equipment.

The proposed LNG terminal would generate noise due to pumps and compressors. A quantitative prediction was carried out to estimate the cumulative noise levels due to operation of all noise generating source of LNG terminal.

As per the location of LNG terminal, the minimum distance available between proposed major noise sources and the outer periphery of the project site would be more than 500-m. The cumulative incremental impact of all noise sources at boundary will range in between 45-50 dB (A).

The nearest human habitations are located at about 1.5 km from the boundary and the cumulative noise impacts would be insignificant.

10.7.6 Impact on Terrestrial Ecology

The initial construction works at the LNG terminal involves land clearance and reclamation. Greenbelt will be developed phase wise during construction to improve the aesthetic value in the area and to screen out the fugitive dust generated during construction.

The removal of vegetation from the soil and loosening of the topsoil generally causes soil erosion. However, such impacts will be confined to the project site and will be minimized through paving and water sprinkling.
However, greenbelt will be developed surrounding the project facilities. The existing trees will be preserved to the extent possible.

Thus, no major adverse impacts are envisaged on terrestrial ecology.

10.8 Environment Management Plan

10.8.1 During Construction Phase

During construction phase, the construction activities like site leveling, grading, transportation of the construction material cause various impacts on the surroundings. However, the constructional phase impacts are temporary and localized phenomena except the permanent change in local landscape and land use pattern of the LNG terminal project site.

Land Environment Management

PLL is having about 16 hectares of land in south side of the existing plot. Additionally about 22.62 hectares of land on south side of existing plot is allocated by Forest Department to PLL and Stage-I clearance is accorded by Forest Department. PLL has also been permitted by Gujarat maritime Board to reclaim 20 hectares of land on west side of the existing plot.

Preparation of site will involve excavations and fillings. The earthen material generated during excavations and site grading periods, shall be properly dumped and slope stabilization shall be taken. The topsoil generated during construction shall be used for filling of low laying areas required for the proposed expansion of LNG terminal and reused for plantations.

No perennial nallas are present in the LNG terminal site. However, natural drainage pattern shall not be disturbed as far as possible.

The existing approach road to project site shall be appropriately strengthened to facilitate vehicular movement.

The greenbelt area shall be delineated before start-up of earthwork and tree plantation shall be taken up during and after construction stage itself.

Air Quality Management

Construction phase will generate air pollution due to operation of construction machinery as well as vehicular emissions. Some of measures can be considered for mitigation purpose

- In the unpaved Roads, apply water during active operation.
- In Earthmoving operation, maintain soil moisture content to a minimum of 12 percent when earthmoving.
- Conduct watering as necessary to restrict the dust emission within the active cut area.
- In the disturbed surface areas, apply dust suppression in sufficient quantity and frequency to maintain a stabilized surface. Any areas, which cannot be stabilized as evidenced by wind driven fugitive dust, must have an application of water for 80 percent of the unstabilized area. If applying chemical stabilizers, apply within five working days of grading completion.
- Proper maintenance of vehicles and construction equipment; and
- Tree plantation in the area earmarked for greenbelt development.

With regard to NOx emissions, the contractors shall implement the following measures to reduce daily NOx emissions associated with construction activities.

- All equipment shall be properly tuned and maintained in accordance with manufacturer's specifications.

- General contractors shall maintain and operate construction equipment so as to minimize exhaust emissions. During construction, trucks and vehicles in loading and unloading queues would be kept with their engines off, when not in use, to reduce vehicle emissions. Construction emissions should be phased and scheduled to avoid emissions peaks.

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 camp; and utilizing the wastewater in greenbelt development. The wastewater from labour colony will contribute to higher BOD concentrations.

The major source of water pollution in the construction phases is the sewage generated by the workers. During construction phase about 35 m^3/day of waste is expected to be generated.

The sewage generated shall be routed to soak pits and tanks and will be transferred regularly through authorized agencies.

Noise Level Management

The project construction is likely to increase the vehicular traffic in the area However, there are no settlements near the project site, thus, adverse impacts on noise levels due to increased vehicular movements are not anticipated. During construction phase, the noise may be generated due to operation of various construction equipment's. Efforts need to be made to reduce the noise generated by the various construction equipment's which are as follows:

- Chassis and engine structural vibration noise can be dealt with by isolating the engine from the chassis and by covering various sections of the engines.
- Noise levels from the drillers can be reduced by fitting of exhaust mufflers and the provision of damping on the steel too.
- Good maintenance of vehicles and construction equipment;
- Restriction of construction activities to day time only;
- Plantation of trees around the project boundary to attenuate the noise; and
- Provision of earplugs and earmuffs to workers.

Ecological Management

During construction, the measures required to be undertaken to minimize the impact on the ecology are:

- The felling of trees will be kept at minimum; and
- The greenbelt having vegetation density of 2500 trees/ha will be developed.

Social community Management

Constructional activities will generate employment to about 2500 workers. For construction work force, temporary sanitation facilities (septic tanks and soak pits) will be set-up for disposal of sanitary sewage. Similarly, rest rooms and canteen facilities will be provided for truck drivers during construction as well as operation phase of LNG terminal.

Environment Management Plan during Operation Phase

During operation phase, the impacts on the various environmental attributes should be mitigated using appropriate pollution control equipment. The Environment Management Plan prepared for the proposed expansion of LNG terminal aims at minimizing the pollution at source.

As a policy, PLL will establish Health, Safety, Environment (HSE) department to ensure safe and environment friendly practices during operations. HSE department is corporate mandate to achieve these objectives and establish PLL organization as safety and health conscious, environment friendly, and conscious of its social obligations and commitments.

<u>Air Pollution Management</u>

Only source of emissions in the proposed project are the GTGs. The gas generators installed at PLL Dahej site are based on "Lean – burn" technology. This controls pollution generation by firstly, reducing the temperature of the combustion process by introducing excess air thereby reducing the amount of oxides of nitrogen (NOx) produced by nearly half, compared to a conventional natural gas engine. Secondly, improving the efficiency of the combustion process and more power by introducing excess oxygen. In this new lean-burn engine, the combustion process is enhanced by pre-mixing the air and fuel upstream of the turbo charger before introduction into the cylinder. Break mean Effective Pressure (BMEP) against Air Excess (Lambda), the operating window is a very narrow band where efficiency peaks and where NOx is near its minimum. One of the results of this technology is significantly reduction in emission in the exhaust. The gas engine generators have NOx emissions as low as 0.85 grams/BHP-hr and produce low amounts of hydrocarbons (HC), carbon monoxides (CO) and particulate matter (PM). This allows the generator sets to meet the most stringent air quality regulations without after –treatment devices in the exhausts stream.

Fugitive and stack emissions from the LNG terminal will contribute to increase in concentrations of NOx pollutants.

<u>Water Pollution Management</u>

The domestic sewage generated shall be routed to soak pits and tanks and will be transferred regularly through authorized agencies.

<u>Solid Waste Management</u>

On a regular basis, there is no generation of any non-hazardous or inert solid waste from the proposed LNG terminal. A small quantity i.e. about 0.5 KL/year of hazardous oily waste will be generated from the proposed LNG terminal during periodic maintenance. Hazardous waste will be collected and stored at specific identified area at site. Separate authorization has been obtained under Hazardous

Waste Management Rules to handling the hazardous waste generated. Like existing hazardous waste, additional waste shall be handled similarly.

10.9 Environmental Monitoring Program

The environment monitoring for the proposed LNG Terminal operations shall be conducted as follows:

- Air quality;
- Water and wastewater quality;
- Noise levels;
- Soil Quality; and
- Greenbelt Development.

Sr. No.		Particulars	Monitoring Frequency	Duration of Sampling	Important Monitoring Parameters
1	**Air Pollution and Meteorology**				
	Air Quality				
	A	Ambient Air Quality Monitoring			
		Selected 4 locations in and around LNG terminal specified by GPCB	Twice in a week	24 hr continuously	PM_{10}, $PM_{2.5}$, SO_2, NOx and CO
	B	Stack gas analysis in GTG's & all major stacks	Once in a month	Grab sampling	Specified as per Gujarat Pollution Control Board/ Flue gas temp., Exit velocity, flow, PM, SO_2, NOx
	Meteorology				
	A	Meteorological data to be monitored at LNG terminal	Daily	Continuous Monitoring	Wind speed, direction, temperature, relative humidity and rainfall.
2	**Water and Wastewater Quality**				
	A	Marine water quality			
	1	Two locations - Marine water (Low Tide/High Tide)	Monthly	Grab sampling	DO, BOD, Oil & Grease, Nitrate, Nitrite, Sulphate, Phosphate, Chloride, Coliform count, Iron, Manganese, Cadmium, Chromium, Mercury, Zinc
	B	Water quality in the study area			
	1)	Ground Water quality	Half yearly	Grab	As per the parameters specified under IS:10500-1991
	2)	Surface Water	Half yearly	Grab	Parameters specified under IS:10500-1991
3	**Industrial Noise Levels**				
	1)	Major noise generating sources (Pumps,	Every fortnight	24 hr continuous with 1 hr interval	Noise level in dB(A)

Sr. No.	Particulars		Monitoring Frequency	Duration of Sampling	Important Monitoring Parameters
		compressors & generator areas)			
	Ambient Noise Levels				
		4 Locations around LNG terminal	Monthly	24 hr continuous with one hr interval	Noise levels in dB(A)
4.	**Soil Characteristics**				
	1.	Selected 10 locations in core and buffer zone in nearby villages	every season	One Grab sample	Colour, textural class, grain size, distribution, pH, Electrical Conductivity, Bulk Density, Porosity, Infiltration rate, Moisture retention capacity, Wilting Co-efficient, Organic matter Na, N, K, PO_4, SO_4, SAR, Base Exchange Capacity, Pb, Cu, Zn, Cd, Fe.

10.10 Risk Assessment and Disaster Management Plan

The hazard potential of LNG estimation of consequences in case of their accidental release during storage, transportation and handling has been identified and risk assessment has been carried out to quantify the extent of damage and suggest recommendations for safety improvement for the proposed facilities.

The Risk modelling scenarios considered for the proposed LNG terminal are

- Leakage of pipeline
- Unloading arm failure

Storage tank

A Full containment LNG storage tank is designed to contain the spill from the inner tank into the containment space of the tank itself. Hence, the chance of leakage from the storage tank is ruled out.

The maximum vulnerable heat radiation will not spread beyond 346 m. Hence, human habitation will not be affected.

An effective Disaster Management Plan (DMP) to mitigate the risks involved has been prepared. This plan defines the responsibilities and resources available to respond to the different types of emergencies envisaged. Training exercises will be held to ensure that all personnel are familiar with their responsibilities and that communication links are functioning effectively.

10.11 Project Benefits

The proposed developmental activities in this region will result in improvement of infrastructure as well upliftment of social structure in the area. The people residing in the nearby areas will be benefited indirectly. It is anticipated that the proposed development will provide benefits for the locals in two phases i.e. during construction phase as well as during operational stage.

PPL shall employ local people to the extent possible in order to reduce the need for additional infrastructure. In addition, PPL will develop necessary infrastructure like water supply, sewerage, medical facility, etc. for catering to the needs of the project personnel and their families. The local people have been indirectly benefited by these developments.

10.12 Administrative Aspects of Implementation of EMP

The LNG Terminal complex will be supervised and controlled by the unit head, supported by HOD (Terminal operations) and adequate team of technically and statutorily qualified personnel apart from the operating staff of skilled, semi skilled, unskilled and other categories.

Environment management cell will be headed by HOD-Environment project and will be supported by multi disciplinary professionals. The HOD-Environment will be responsible for regular environment management activities in LNG Terminal and CPP.

10.13 Conclusions

The proposed expansion of LNG terminal project has certain level of marginal impacts on the local environment. However, the proposed project has significant beneficial impact/effects in terms of providing the employment opportunities and various CSR practices to be followed by PLL. Growth and development, in harmony with the environment, has always been the approach of PLL.
The conclusions of EIA are:

- The proposed project meets the compliance requirements of various environmental regulations;
- Adoption of environmental friendly Best Management Practices results in minimising the impacts on environment;
- Community impacts of the project will be beneficial, as the project will generate significant economic benefits for the region; and
- With the effective implementation of the Environment Management Plan (EMP) during the planning, design, construction and operation phases, the development and production project can proceed without significant negative impact on the environment.

NABET

National Accreditation Board
for Education and Training

July 26, 2010

Mr. M. Janardhan,
Vice President
Vimta Labs Limited,
142, IDA, Phase – II,
Cherlapally, Hyderabad – 500 051

Dear Sir,

<u>QCI – NABET Scheme for Accreditation of EIA Consultant Organization</u>

This is with reference to your application for QCI – NABET Accreditation as EIA Consultant Organization.

We are pleased to inform you that based on Document & Office Assessments **Vimta Labs, Hyderabad** are hereby accredited as an EIA Consultants as per the scope given in Annexure I (A & B). Please confirm the correctness of spellings of the names of the experts mentioned in Annexure I B. The detailed terms and conditions are mentioned in Annexure II. You are also advised to check the QCI website for the Minutes of the Accreditation Committee Meeting held on June 24, 2010 for observations related to your application or any decisions with respect to Scheme/ assessment process and take necessary action for compliance.

The accreditation of your organization will be for three year period starting May 18, 2010. The annual renewal of the accreditation will be confirmed after surveillance assessment every year. Surveillance assessments will be conducted to ensure compliance with NABET Scheme and the details mentioned in your Quality Manual.

May we request for an early payment of the annual fees and your confirmation of acceptance of the terms and conditions attached. This will enable us to issue you the requisite accreditation certificate which will be valid for one year duration.

We thank you for your esteemed support in making this scheme successful and for your participation in this national cause.

Thanks and best regards,

Yours sincerely,

Vipin Sahni
Director

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30 JUL 2010
VIMTA LABS LTD.
VLL

QUALITY COUNCIL OF INDIA

Institution of Engineers Building, 2nd Floor, Bahadur Shah Zafar Marg, New Delhi - 110 002, India
Tel : +91-11-2337 9321, 2337 8057 Fax : +91-11-2337 9621 email : nabet@qcin.org Website : www.qcin.org

Annexure I-A

Name of the Consultant: VIMTA LABS LIMITED

142, IDA, Phase – II,
Cherlapally, Hyderabad – 500 051

Sectors Approved – 20 Nos.

Sl. No.	Sector No.	Name of Sector	Category A/B
1	**1**	Mining of minerals including Opencast / Underground mining	A
2	**2**	Offshore and onshore oil and gas exploration, development & production	A
3	**4**	Thermal Power Plants	A
4	**6**	Coal washeries	A
5	**7**	Mineral beneficiation including pelletisation	A
6	**8**	Metallurgical industries (ferrous & non ferrous) – both primary and secondary	A
7	**9**	Cement plants	A
8	**10**	Petroleum refining industry	A
9	**11**	Coke oven plants	A
10	**12**	Asbestos milling and asbestos based products	A
11	**21**	Synthetic organic chemicals industry (dyes & dye intermediates; bulk drugs and intermediates excluding drug formulations; synthetic rubbers; basic organic chemicals, other synthetic organic chemicals and chemical intermediates)	A
12	**22**	Distilleries	A
13	**24**	Pulp & paper industry excluding manufacturing of paper from wastepaper and manufacture of paper from ready pulp without bleaching	A
14	**27**	Oil & gas transportation pipeline (crude and refinery/ petrochemical products), passing through national parks/ sanctuaries/coral reefs /ecologically sensitive areas including LNG terminal	A
15	**29**	Air ports	A
16	**31**	Industrial estates/ parks/ complexes/areas, export processing Zones(EPZs), Special Economic Zones(SEZs), Biotech Parks, Leather Complexes	A
17	**34**	Highways, railways, transport terminals, mass rapid transport systems	A
18	**38**	Building and large construction projects including shopping malls, multiplexes, commercial complexes, housing estates, hospitals,	A

QUALITY COUNCIL OF INDIA

		institutions	
19	**39**	Townships and Area development projects	A
20	**40 (i)**	Automobile and Auto Components	A

Total = 20 Sectors*

Sectors allocated to individual EIA Coordinators are mentioned in Annexure I-B

Vipin Sahni
Director
NABET

QUALITY COUNCIL OF INDIA

11.0 DISCLOSURE OF CONSULTANTS

11.1 Introduction

The Environmental Impact Assessment (EIA) and Environment Management Plan (EMP) report has been prepared by carrying out various scientific studies. Studies have been carried out by engaging scientists/engineers/experts of Vimta Labs Limited, India and its associates. The list of experts involved in different studies is given below:

Sr. No.	Study	Consultants
1	Environmental Impact Assessment study including Environment Management Plan	Vimta Labs Limited., Hyderabad, India
2	Marine Modeling Studies	Environ Software Pvt. Ltd. Bangalore.

The profile of the Consultants is given below:

11.2 Vimta Labs Limited - Environment Consultant

Vimta Labs Limited is a leading multi-disciplinary testing and research laboratory in India. VIMTA provides contract research and testing services in the areas of environmental assessment, analytical testing, clinical research, pre-clinical (animal) studies, clinical reference lab services, advanced molecular biology services and research & development studies.

The **Environment Division** has been in the forefront of its vision to provide better environment through guiding and assisting the industry for sustainable development. A stalwart in the mission to protect and preserve the natural resources on earth for future generations, it offers extensive research and consultancy services in the field of environment. With its rich experience, multi-disciplinary expertise and with the support of its state-of the-art analytical equipment, the services offered by the division are wide ranging and encompasses entire gamut of environment management and monitoring services. With its emphasis on quality services over the years, it has evolved itself into a single reference point in India for comprehensive environmental services.

11.2.1 The Quality Policy

- VIMTA is committed to good professional practices and quality of operations in its testing, validation and research services;
- VIMTA shall ensure customer satisfaction by maintaining independence, impartiality and integrity in its operations;
- VIMTA shall provide the services in accordance with national and international norms;
- VIMTA shall implement quality systems as per ISO/IEC 17025 and applicable Good Laboratory Practices (GLPs) & Good Clinical Practices (GCPs), to generate technically valid results/data; and

- VIMTA shall ensure that all its personnel familiarize with the policies and procedures of the quality system and implement the same in their work.

11.2.2 Major Milestones and Accreditations

- 1984 - Registered with an initial investment of Rs.200,000=00
- 1985 - Recognized by ISI (now known as Bureau of Indian Standards)
- 1987 - Qualified by the criteria of Ministry of Environment and Forests, India and was notified as one of the first 14 Standard Environmental Laboratories published in the Gazette of India
- 1988 - Licensed for carrying out tests on Drugs and Pharmaceuticals
- 1991 - Accredited by NCTCF, DST, Government of India (the forerunner of NABL)
- 1995 - Accredited by NABL, India under its revised scheme, certified by Standards Australia, Quality Assurance Services as per ISO/IEC Guide 25 and ISO 9002
- 1996 - GLP Compliance
- 1998 - Accreditation by GOSSTANDART and joint venture for certification of Food Exports with ROSTEST, Russia
- 1998 - World Bank Recognition
- 2002 - ANVISA Brazil Certification
- 2003 - USFDA accepts Vimta Bioequivalence study report. Showcased Vimta at AAPS (USA) and ICSE-CPHI (Germany)
- 2003 – Recognized by Saudi Arabian Standards Organization
- 2004- Enters Gulf market - Executes a contract for environmental consultancy in Kuwait
- 2006 –Expands its overseas activities. Undertakes environmental assignment in Saudi Arabia
- 2006 – Undertakes environmental impact assignment in Tanzania, Africa
- 2008 – Has been Pre-Qualified by World Health Organization (WHO)
- 2008- Undertaken environmental impact assessment studies in Cameroon, Africa
- 2010 – Accredited by Quality Council of India/NABET for Environmental Consultancy Division

11.2.3 Services Offered

Spread over 70,000 sq.ft lush green garden premises at Cherlapally, Hyderabad (India), the scientifically designed and meticulously groomed infrastructural facility of the Central Laboratory of **VIMTA** has the most sophisticated instruments backed by an excellent team of professionals.

Over 150,000 sq. ft. of world class research laboratory is also under operation at Biotech Park-Genome Valley, Hyderabad (India). Having all the facilities under one roof is perhaps the only one of its kind in South Asia in the contract testing and research sector.

VIMTA Central Laboratory, Cherlapally, Hyderabad

VIMTA Life Sciences, Genome Valley, Hyderabad

Vimta offers services under the following specializations:

- Environment;
- Analytical;
- Clinical Reference Lab;
- Clinical Research;
- Preclinical;
- Molecular Biology; and
- Research and Development.

The environment division of VIMTA Labs Limited (VLL) has its presence all over India and other countries including a strong association with international consultants like Japan Bank for International Cooperation (JBIC), Kennametal Inc. - USA, Rudal Blanchard – UK, E&E Solutions – Japan, NAPESCO & Kuwait National Petroleum Corporation – Kuwait, Marafiq and Haif Consultants – Saudi Arabia and others. Vimta Labs Limited has the following credentials:

- Recognition by BIS, India;
- Recognition by Ministry of Environment and Forests, Govt. of India and various State Pollution Control Boards (wherever applicable) ;
- Recognition by Department of Science & Technology, Govt. of India (NABL) ;
- Recognition by Ministry of Defence, Govt. of India;
- Recognition by APEDA, Ministry of Commerce, Govt. of India;
- Recognition by Saudi Arabia Standard Organization (SASO), Saudi Arabia;
- Recognition from NEMC, Tanzania;
- Accreditation by NCTCF;
- Certification from Standard Australia;
- Recognition from ANVISA Brazil;
- Recognition from USFDA;
- Quality Assurance Services as per ISO/IEC 17025;
- Quality Assurance Services as per ICH Guidelines; and
- Recognition by World Health Organization (WHO).

NABET

National Accreditation Board for Education and Training

NABET/EIA/SA044/0413 **April 22, 2013**
The Head & Vice President (Environment)
Vimta Labs Limited
142, IDA, Phase-II, Cherlapally,
Hyderabad-500051
(Kind Attention: **Shri M. Janardhan**)

Dear Sir,

Sub: Surveillance Assessment

This has reference to the Surveillance Assessment (SA) carried out for your organization. Based on the SA, the Accreditation Committee has recommended continuation of conditional accreditation of your organization under the QCI-NABET Accreditation Scheme for EIA Consultant Organizations as per the following details:

1. Annexure I - Scope of accreditation
2. Annexure II - List of experts with approved sectors/ ~~functional~~ areas
3. Annexure III - Non-Conformances/ Observations/ Alerts (NCs/ Obs./ Alerts)
4. Annexure IV - Observations on Quality Management System (QMS)
5. Annexure V - Terms and conditions of accreditation
6. Annexure VI - Result of assessment
7. Annexure VII - Guidelines for addressing Non-Conformances/ Observations/ Alerts

Non-Conformances/ Observations/ Alerts (NCs/ Obs./ Alerts) applicable to your organization as per SA are also posted on QCI website vide minutes of the Accreditation Committee meetings held on December 21, 2012 and February 15, 2013. You are requested to take necessary actions to close the NCs/ Obs. as per guidelines and timeframe mentioned in Annexure VII of this letter.

You are required to make all payments to NABET as applicable, within one month of receipt of this letter. Continuation of accreditation of your organization is subject to the clearance of all dues by your organization and satisfactory compliance to Annexure III and V.

With best regards,

Yours sincerely,

(Vipin Sahni)
C.E.O.

2013/4/26. VP-Env/Sr. Mgr QA.

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VIMTA LABS LTD
VLL

Institution of Engineers Building, 2nd Floor, Bahadur Shah Zafar Marg, New Delhi - 110 002, India
Tel. : +91-11-2337 9321, 2337 8057 Fax : +91-11-2337 8678 e-mail : nabet@qcin.org Website : www.qcin.org

QCI Scheme for Accreditation of EIA Consultant Organizations NABET

Scope of Accreditation Annexure I

NAME OF THE CONSULTANT ORGANIZATION: **Vimta Labs Limited**
142, IDA, Phase-II, Cherlapally,
Hyderabad-500051

Sl. No.	Sector No.	Name of Sector	Category A/B
1.	1	Mining of minerals including Opencast/ Underground mining	A
2.	2	Offshore and onshore oil and gas exploration, development & production	A
3.	4	Thermal power plants	A
4.	6	Coal washeries	B
5.	8	Metallurgical industries (ferrous & non ferrous) – both primary and secondary	A
6.	10	Petroleum refining industry	A
7.	12	Asbestos milling and asbestos based products	A
8.	21	Synthetic organic chemicals industry (dyes and dye intermediates; bulk drugs and intermediates excluding drug formulations; synthetic rubbers; basic organic chemicals, other synthetic organic chemicals and chemical intermediates)	A
9.	27	Oil & gas transportation pipeline (crude and refinery/ petrochemical products), passing through national parks, sanctuaries/ coral reefs/ ecologically sensitive areas including LNG terminals	A
10.	29	Air ports	A
11.	31	Industrial estates/ parks/ complexes/ areas, export processing zones (EPZs), special economic zones (SEZs), biotech parks, leather complexes	A
12.	38#	Building and large construction projects including shopping malls, multiplexes, commercial complexes, housing estates, hospitals, institutions#	B#
13.	39	Townships and Area development projects	B
14.	40 (i)	Automobile and Auto components	-

Total = 14 Sectors*

**Sectors allocated to individual EIA Coordinators are mentioned in Annexure II*

#At present, the ACO is lacking FAE for EB out of 8 essential Functional areas. Final approval of newly proposed sector (38) is subject to approval of EB FAE by QCI (refer MoM dated Oct. 19, 2012)

(Vipin Sahni)
C.E.O.

Vimta Labs Limited, Hyderabad Page 2 of 19

11.2.3 Environment Division

Environment essentially being a multi-disciplinary science, the range of services offered by the division are also comprehensive and caters to the needs of industry, pollution control agencies, regulatory authorities and in a larger pursuit of a green globe. The services under environment include:

- Site selection and liability studies;
- Environmental impact assessments;
- Environment management plans;
- Carrying capacity based regional studies;
- Environmental audits;
- Solid and hazardous waste management;
- Risk assessment (MCA,HAZON,HAZOP) & disaster management plans;
- Occupational health and safety, industrial hygiene;
- Environmental monitoring for air, meteorology, water, soil, noise, ecology and socio-economics;
- Industrial emission source monitoring;
- Offshore sampling and analysis of marine water and sediments;
- Marine ecological studies;
- Marine impact assessment;
- Rehabilitation and resettlement studies;
- Forestry and ecological studies;
- Geological and hydro-geological studies;
- Land use /land cover studies based on remote sensing;
- Socio-economic studies;
- Due diligence studies;
- Industrial epidemiological studies;
- Wasteland management studies; and
- Study on bio-indicators.

The services under Environmental Chemistry include:

- Analysis of water, wastewater, soil, solid waste, hazardous waste as per international codes;
- Source emissions and work zone air/noise quality monitoring;
- Analysis of SVOCs, VOCs, PAH, BTEX, AOX, PCB's, TCLP metals, TOC etc.;
- Categorization of hazardous waste; and
- Pesticide residue analysis.

11.2.4 Acilities of Environment Division

Vimta-Environment Division is located in scientifically designed Central Laboratory with the state-of-the-art modern facilities to offer vide range of services in indoor and outdoor monitoring and analytical characterization in the field of Environment. Further, it is ably supported by highly skilled and experienced team of professionals in the fields of science, engineering, ecology, meteorology, social planning, geology & hydro-geology and environmental planning.

Besides the regular monitoring equipment such as Fine Dust Samplers, Respirable Dust Samplers (RDS), automatic weather monitoring stations, stack monitoring kits, personal samplers, noise meters, portable water kits etc, the other major specialized equipment include:

- Monostatic Sodar–Designed by National Physical Laboratory, GOI;
- Integrated Noise Level Meters–Quest, U.S.A;
- Flue Gas Analyzers–Testo, Germany;
- 113-A Gravimetric Dust Sampler-Casella, London;
- ICP AES– Varian, USA;
- Gas Liquid Chromatographs with FID, ECD & pFPD–Varian, USA;
- Gas Chromatograph with Mass Detector–Varian, USA;
- Atomic Absorption Spectrometer [AAS]–Varian, USA;
- PAS-AFC-123 instrument;
- High Performance Liquid Chromatograph (HPLC);
- Laser Particle Size Analyzer;
- Bomb Calorimeter;
- Polarographs;
- X-ray Fluorescent Spectrometer;
- Flame Photometer;
- Carbon Sulphur Analyzer;
- Computerized Fatigue Testing Machine;
- Electronic Universal Testing Machine;
- Fourier Transmission Infrared Spectroscope; and
- Water Flow Current Meter – make Lawrence & Mayo.

HIGH RESOLUTION GAS CHROMATOGRAPHS

11.2.5 Quality Systems

The basic fact that environment division and its supporting site laboratories are accredited by NABL (IS0-17025) and Ministry of Environment and Forests, India and by other international bodies stand testimony to its emphasis on Quality Systems.

11.2.6 Achievements

Being the first laboratory to be recognized under Environment Protection (EP) Act by Government of India (GOI), environment division with its best mind power and industrial knowledge competency that allows it to compare with the best in the business.

- The environment division till date has executed about 600 environmental impact assessment and environment management studies with risk assessment and disaster management plans for various spectrum of industries and obtained statutory approvals;
- Supported by the strong modern laboratory and experienced hands, environment division is well equipped in conducting due diligence, phase-I and phase-II studies;
- Undertaken specialized studies such as regional environmental impact assessment on carrying capacity principle; upper air meteorological studies using monostatic SODAR for major industrial complexes;
- Associated with prestigious studies such as environmental pollution monitoring around Taj Trapezium (India), pre and post satellite launch studies for Indian Space Research Organisation (ISRO) and monitoring for offshore oil & gas exploration for deep-sea water and sediment sampling;
- The services offered include vide spectrum of industries covering power, chemical, cement, mining, steel & alloys, metallurgical, aluminium refining & smelting, dye & intermediates, bulk drugs, pesticides, agro-chemicals, petro-chemicals, refineries, pulp & paper, oil & gas exploration & production, asbestos, infrastructure such as highways, seaports and airports, river valley, foundries etc;
- Undertaken environmental consultancy for pipeline layout and up gradation of API oil-water separators of various crude oil depots and petrol filling stations of Kuwait National Petroleum Corporation, Kuwait;
- Undertaken performance evaluation and capacity expansion of sewage treatment plant and industrial wastewater treatment Plant for Marafiq, Saudi Arabia; and
- Undertaken environmental impact assessment studies for pulp and paper mill expansion of Mufindi Paper Mills, Tanzania, Africa.

The details of the persons involved in the preparation of present EIA/EMP report is presented below:

DETAILS OF PERSONNEL INVOLVED IN CURRENT EIA/EMP STUDY – VIMTA LABS LTD

Sr. No.	Name	Qualification	Position	Contribution	Experience
1	Mr. M.Janardhan	M.Tech (Env. Engg)	Vice President & Head (Env)	Co-ordination	About 20 years of experience in the field of environmental management and environmental engineering
2	Mr. E.Shyam Sundar	M.Sc., M.Phil (Chem) PGDES	Vice President (Env)	Co-ordination	About 19 years of experience in the field of environmental chemistry and monitoring
3	Dr. B. Chandra Sekhar	M.Sc., Ph.D	Sr. Manager	Co-ordination	About 13 years of experience in the field of environmental management and modeling
4	Mr. G.V.Raghava Rao	M.Tech (Env)	Group Leader	Expert	About 12 years of experience in the field of environmental management and environmental engineering
5	Ms.Durga Bhavani	MSC (Env Science)	Env Scientist	Expert	About 8 years of experience in the field of Environmental Management and Environmental Chemistry
6	Mr. S.Kishore Kumar	M.Tech (Env)	Env Engineer	Expert	About 3 years of experience in the field of environment management and engineering
7	Mr. G. Mallikarjuna Murthy	M.S (Env. Engg), Dip Ind. Safety	Env Engineer	Expert	About 3 years of experience in the field of environment management and engineering
8	Mr. M. Raja Manohar	M.Tech (Env)	Env Engineer	Expert	About 3 years of experience in the field of environment management and engineering
9	Dr. Ranga Rama Seshan	M.Sc., Ph.D	Scientist	Expert	About 3 years of experience in the field of Environmental Management and Environmental Chemistry
10	Dr. Santosh Kumar Yadav	M.Sc., Ph.D	Scientist	Expert	About 7 years of experience in the field of Environmental Sciences and Environmental Management
11	Ms. Sri Lakshmi	M.Sc.,	Scientist	Expert	About 3 years of experience in the field of Environmental Management and Environmental Chemistry
12	Mr. S. Saravanan	M.Tech	Engineer	Expert	About 2 years of experience in the field of environment management and engineering
13	Mr. M. Pratapnath	M.S.	Env Scientist	Expert	About 1 years of experience in the field of Environmental Sciences
14	Mr. Ch. Narendra	M.S.W	Scientist	Expert	About 1 year of experience in the field of Social Impact Assessment Studies
15	Mr.Indurkar	MSC (Ecology)	Env Scientist	Expert	About 5 years of experience in ecological and biodiversity studies
16	Mr. P. Niranjan Babu	B.Com	Asst Manager	Secretarial Support	About 21 years of experience in the field of environmental monitoring and secretarial support
17	Mr. P. Krishna	I.T.I (Civil)	Sr. Draftsman	Cartography	About 12 years experience in the field of environmental management and civil drawings
18	Mr. J. Rama Krishna	I.T.I (Civil)	Sr. Draftsman	Cartography	About 11 years experience in the field of environmental management and civil drawings

ANNEXURE-I
TERMS OF REFERENCE LETTER AND COMPLIANCE

तार :
Telegram : PARYAVARAN,
NEW DELHI
दूरभाष :
Telephone : 2436 8526
टेलेक्स :
Telex : W-66186 DOE IN
FAX : 4360678

भारत सरकार
पर्यावरण एवं वन मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF ENVIRONMENT & FORESTS
पर्यावरण भवन, सी. जी. ओ. कॉम्पलेक्स
PARYAVARAN BHAVAN, C.G.O. COMPLEX
लोदी रोड, नई दिल्ली-110003
LODHI ROAD, NEW DELHI-110003

F.No.11-63/2011-IA.III **Dated: 17th February, 2012**

To
Director (Technical),
M/s Petronet LNG Ltd.,
World Trade Centre, First Floor,
Babar Road, Barakhamba Lane,
New Delhi – 110 001

Subject: Finalisation of ToR for installation of terminal facilities to handle 10 MMTPA of additional LNG at PLL, Dahej by M/s Petronet LNG Ltd - Reg.

Dear Sir,

Kindly refer to your above proposal submitted to this Ministry. The proposal involves installation of terminal facilities to handle 10 MMTPA of additional LNG at Petronet LNG Ltd, Dahej Dahej LNG Terminal is presently operating at its full capacity of 10 Million Tonnes Per Annum (MMTPA). The plant has one jetty, four LNG tanks (each having a gross capacity of 160,000 cubic meter) and regasification facilities along with associated utilities (sized for handling 10 MMTPA of LNG). In view of the market scenario and availability of domestic gas an to meet the increased requirement, PLL has planned to augment the capacity of Dahej LNG Terminal from 10 MMTPA to 20 MMTPA (Phase III expansion). Total installed capacity shall be 20 MMTPA after expansion, with provisions to carry out the same in a phased manner, Phase-IIIa (10 to 15 MMTPA) estimated to be completed by end 2016 and Phase-IIIb (15 to 20 MMTPA) by end 2020. Utilities and other associated facilities shall be installed for 20 MMTPA capacity in Phase-III.

The Major additional equipment/facilities proposed are LNG Storage Tanks (each of 180,000 cbm gross capacity), In-Tank Pumps, BOG Compressors, BOG recondensor, HP Pumps, STV, STV (cogen), Send out metering, Fuel gas station, Air heaters, Glycol Water pumps, Hot water pumps, GW expansion vessel, GTG, Nitrogen unit etc.

The above proposal was considered in the 108th EAC meeting held on 10th – 11th January, 2012. The details as presented by the project proponents and after discussions, the following "Terms of Reference" were finalized to be suitably added to those furnished by the project proponent.

ANNEXURE-I
TERMS OF REFERENCE LETTER AND COMPLIANCE

(i) Submit the status of compliance of various conditions of Environmental clearance and Consent orders.

(ii) The proposal indicates the acquisition of forest land 28 ha. Necessary prior permission shall be obtained from the Forest Department.

(iii) Submit the details of safety regulations applicable and its compliance.

(iv) Submit details of Risk Assessment, Disaster Management Plan including emergency evacuation during natural and man-made disaster like floods, cyclone, tsunami and earth quakes etc.

(v) Submit the recommendations of Gujarat CZMA.

(vi) Submit a copy of layout superimposed on the HTL/LTL map demarcated by an authorized agency on 1:4000 scale.

(vii) Submit details of safety aspects associated with handling of LNG vis a vis other cargo in other facilities within the port.

(viii) Submit details of storage and regasification, distribution network etc and vulnerability of human habitation vis a vis LNG associated risks.

(ix) Type of LNG carriers proposed taking into account the future growth in vessel sizes beyond the present day market trend and the handling aspects of such vessels from environmental considerations.

(x) A comprehensive EIA based on 3-season data and actual field measurements, appropriate modeling study etc shall be carried out.

(xi) Submit details of Environmental Management Plan and Environmental Monitoring Plan with parameters and costs.

(xii) Submit the details of court cases, if any.

eral Guidelines

(i) The EIA document shall be printed on both sides, as for as possible.

(ii) The status of accreditation of the EIA consultant with NABET/QCI shall be specifically mentioned. The consultant shall certify that his accreditation is for the sector for which this EIA is prepared.

ANNEXURE-I
TERMS OF REFERENCE LETTER AND COMPLIANCE

(iii) On the front page of EIA/EMP reports, the name of the consultant/consultancy firm along with their complete details including their accreditation, if any shall be indicated. The consultant while submitting the EIA/EMP report shall give an undertaking to the effect that the prescribed TORs (TOR proposed by the project proponent and additional TOR given by the MoEF) have been complied with and the data submitted is factually correct (Refer MoEF office memorandum dated 4th August, 2009).

(iv) While submitting the EIA/EMP reports, the name of the experts associated with/involved in the preparation of these reports and the laboratories through which the samples have been got analysed should be stated in the report. It shall clearly be indicated whether these laboratories are approved under the Environment (Protection) Act, 1986 and the rules made there under (Please refer MoEF office memorandum dated 4th August, 2009). The project leader of the EIA study shall also be mentioned.

(v) All the TOR points as presented before the Expert Appraisal Committee (EAC) shall be covered.

Public hearing to be conducted for the project as per provisions of ironmental Impact Assessment Notification, 2006 and the issues raised ne public should be addressed in the Environmental Management Plan.

A detailed draft EIA/EMP report should be prepared as per the above tional TOR and should be submitted to the Ministry as per the fication.

The prescribed ToRs would be valid for a period of two years for nission of the EIA/EMP Repots, after public consultation.

Yours faithfully,

(Lalit Kapur)
Director (IA-III)

y to:
he Member Secretary, Gujarat Pollution Control Board, Paryavaran Bhavan, Sector 10-A, Gandhinagar, -382010

ANNEXURE-I
TERMS OF REFERENCE LETTER AND COMPLIANCE

Sr. No	Particulars of Recommendations in TOR	Report Reference
1	Submit the status of compliance of various conditions of Environmental clearance and Consent orders.	Compliance of Environmental clearance and consent orders are enclosed in **Annexure-II**
2	The proposal indicates the acquisition of forest land 28 ha. Necessary prior permission shall be obtained from the Forest Department.	Approached Forest department for Forest clearance which is under progress
3	Submit the details of safety regulations applicable and its compliance.	Terminal will be constructed majorly in accordance with the following standards: 1. NFPA 59 A :- Standard for the Production, storage and handling of Liquefied Natural Gas(LNG) 2. OISD-194:- Standard for Storage and Handling of LNG 3. EN1473: Installation and Equipment for Liquefied Natural Gas- Design of Onshore Installations Details of the safety futures incorporated into the project, as per the above safety guidelines, have been detailed in Section- 7.3.2, Chapter-7
4	Submit details of Risk Assessment, Disaster Management Plan including emergency evacuation during natural and man-made disaster like floods, cyclone, tsunami and earth quakes etc.	Risk assessment and Disaster Management Plan is given in Section-7.2 and Section-7.4 of Chapter-7 Detailed Disaster Management Plan for PLL LNG terminal at Dahej is given in **Annexure-XII**
5	Submit the recommendations of Gujarat CZMA.	SCZMA will accept the application after Public hearing.
6	Submit a copy of layout superimposed on the HTL/LTL map demarcated by an authorized agency on 1:4000 scale.	HTL/LTL map is shown in Figure-2.14 of Chapter-2
7	Submit details of safety aspects associated with handling of LNG vis a vis other cargo in other facilities within the port.	Safety aspects associated with handling of LNG is given in section-7.3.8 of chapter-7

ANNEXURE-I
TERMS OF REFERENCE LETTER AND COMPLIANCE

Sr. No	Particulars of Recommendations in TOR	Report Reference
8	Submit details of storage and regasification, distribution network etc and vulnerability of human habitation vis a vis LNG associated risks.	The storage and regasification process along with the layout has been detailed in Section –2.5.3 of Chapter-2 The nearest habitation to the proposed LNG handling terminal is Luvara village which is located at 1.5 -km in the E direction. The maximum vulnerable heat radiation will not spread beyond 346-m. Hence, human habitation will not be affected.
9	Type of LNG carriers proposed taking into account the future growth in vessel sizes beyond the present day market trend and the handling aspects of such vessels from environmental considerations.	Vessel size shall be from 185,000 m^3 to 260,000 m^3 are considered for the future operations. These vessels do not use sea water or discharge in sea when in the port.
10	A comprehensive EIA based on 3-season data and actual field measurements, appropriate modeling study etc shall be carried out.	Base line monitoring data of 1. Winter season (December 2011 to February 2012) 2. Pre monsoon Season (March 2012 to May 2012) 3. Post monsoon (September 2012 to November 2012) is given in Chapter -3
11	Submit details of Environmental Management Plan and Environmental Monitoring Plan with parameters and costs.	Environmental Management plan is given in chapter-5 and Environmental Monitoring plan is given in chapter-6
12	Submit the details of court cases, if any.	-Nil-

PETRONET LNG LIMITED

Petronet LNG Limited

GIDC Industrial Estate, Plot No. 7/A, Dahej,
Taluka : Vagra, Dist. Bharuch (Gujarat) - 392130 (India)
Tel. : 02641-257004-7
Fax : 02641-300310 / 300306

PLL/DHJ/MoEF/003 April 05th, 2013

The Director (Environment)
Forests & Environment Department,
Government of Gujarat,
Block No. 14, 8th Floor, Sachivalaya,
Gandhinagar – 382 010
(Fax No.: 079-23252156)

Kind Attn.: Shri Hardik Shah

Subject: Half-yearly Compliance Report with respect to conditions stipulated by Ministry of Environment & Forests, Govt. of India and Department of Forests, Govt. of Gujarat for Construction of LNG Import Terminal (Phase-I) at Dahej, District Bharuch in Gulf of Khambhat, Gujarat as on 31st December, 2012

Ref : (a) J-17011/11/2000-IA-III Dated 27th December, 2000
(b) ENV-10-2000-181-PI Dated 29th September, 2000

Dear Sir,

The Compliance report as on December 31st, 2012 with respect to conditions stipulated by Ministry of Environment & Forests, Govt. of India and Department of Forests, Govt. of Gujarat for Construction of LNG Import Terminal (Phase-I) at Dahej, District Bharuch in Gulf of Khambhat, Gujarat is enclosed.

With regards,

Baitalik
5/4/13

S. Baitalik
General Manager (Projects)

Encl.: As above

Copy to:-

Director,
Ministry of Environment & Forest,
Paryavaran Bhawan,
CGO Complex, Lodhi Road,
New Delhi – 110 003

Joint Director (S)
Ministry of Environment & Forests,
Regional Office, Western Region,
Kendriya Paryavaran Bhavan,
Link Road No. 3,
Bhopal – 462 016

Regd. Off. :
World Trade Centre, First Floor, Babar Road.
Barakhamba Lane, New Delhi - 110 001 (INDIA)
Tel.: 011 - 23472525, 23411411 Fax : 23472550

Kochi Site :
Survey No. 347, Puthuvypu
P.O. 682508, Kochi (INDIA)
Tel.: 0484 - 2502268

ANNEXURE - I

COMPLIANCE REPORT TO THE CONDITION MENTIONED IN MOE&F LETTER NO. J-17011/11/2000-1A-III DATED 27TH DECEMBER, 2000

(A) SPECIAL CONDITIONS

1) Necessary approval for diversion of 10.5 ha forest land involved in project shall be obtained under the provisions of the forest (conservation) act, 1980 and a copy furnished to this ministry prior to commencement of construction site.

   Complied.

   The compliance report submitted vide our letter no.PLL/ND/D7/2K1 dated 6th September 2001.

2) The plant layout shall be so planned to ensure that no portion of LNG storage and re-gasification facilities fall within CRZ I (1). The final layout plan along with demarcation of CRZ area and their classification shall be submitted to this ministry commencement of construction site.

   Complied.

   Facilities such as LNG storage and re-gasification construction completed and plant is under operation since April-2004. Layout plan submitted with our letter no. PLL/ND/D-7/2K1 dated 16th August 2001.

3) No change in the scope of work shall be made without prior approval of this ministry.

   Noted. Construction works completed without any change in the scope of works.

4) No dredging (capital or maintenance) shall be carried out in the project. If at any stage, necessary of dredging is felt, specific approval for the same shall be obtained.

   No dredging has been carried out or planned to be carried out in the near future.

5) A proper location map clearly showing the various project activities with respect to high tide line (duly demarked by one of the authorized agencies) and the corresponding CRZ classification of the area shall be furnished within one month.

The location map, prepared by M/s National institute of Oceanography, showing various project with respect to high tide line and the corresponding CRZ classification of the area was submitted vide our letter No PLL/ND/D-7/2K1 Dated 16th August 2001.

6) A quantitative risk analysis of the LNG terminal associated facilities shall be carried out taking into account the worst case scenario and based on firmed up engineering design. The report should be submitted within 6 months. The central control room should be located well outside the risk zone.

The quantitative risk analysis (QRA) report submitted vide our letter No PLL/ND/D-7/2K2 dated 18th January 2002. The control room is located outside the risk zone.

7) Based on risk analysis, Disaster Management plan should be prepared and submitted to this ministry within 6 months.

The disaster management plan was submitted vide our letter no PLL/ND/D-7/2K2 dated 18th January 2002.

8) A classification may be obtained from state pollution control board to the effect that the NOC issued by them is for entire project and not restricted to two storage tanks. This may be provided within one month.

Gujarat Pollution Control Board (GPCB) vide their letter no BRCK-NOC-S/40(1948)6721 dated 15th February, 2001 have clarified that the NOC granted by the Board is in respect of the entire LNG project (LNG receipt, storage, re-gasification) including the following components :-

(i) Construction of Jetty & Break Water
(ii) LNG Storage Tanks (2 Nos.)
(iii) Pumping & re-gasification facilities
(iv) Utilities

GPCB have been further informed vide their letter no PC/BRCH-CCA-611 that the NOC granted by them is also for two additional storage tank in Phase-II

9) The details of the facilities to be provided by the company to the local population may be furnished within one month.

The details were provided vide our letter no PLL/ND/D-7/2K2 dated 18th January 2002.

Aaitalik

10) The project proponent should be make specific arrangement for rainwater harvesting in the project design and the rainwater so harvested should be optimally utilized.

The LNG terminal has been set-up very near to the coastline at Dahej, Where water table is very high. Moreover the seawater is brackish in that area. Investigations indicates that it might not be feasible to carry out rainwater harvesting in this area,

The process water requirement in LNG terminal at Dahej is NIL. The sanitary water is being recycled for irrigation of green belt.

11) All the conditions stipulated by the Forest and Environment Department of Gujarat vide their letter no.ENV-10-2000-181-P1 dated 29th September 2000 should be effectively implementer.

Compliance status is enclosed at Annexure –II.

12) All the conditions stipulated by Gujarat Pollution Control Board in their NOC should be effectively implemented.

Noted and complied. Consolidated consent and authorization obtained under Act 1974, Air act 1981 and Environment (Protection) Act vide GPCB consent order No 3936 dated 28th September 2004.

13) The jetty will be constructed on piles to enable the free flow of water across the jetty.

The confirmation regarding construction of jetty on piles has already been sent vide letter no. PLL/ND/D-7/2K2 dated 18th January 2002.

14) The construction of material shall be obtained only from approved quarries. In case new quarries need to opened up specific approval for the same shall be obtained.

Noted and complied.

(B) GENERAL CONDITION

1) Construction of the proposed structures should be undertaken meticulously confirming to the exiting central/local rules and regulations including CRZ notification 1991 & its amendments. All the construction designs / drawings relating to proposed construction activities must have approval of the concerned state government department /agencies.

Complied.

The construction and commissioning of the facilities at Dahej completed and the plant is operational since April-2004..

2) The proponent shall ensure that a result of the proposed construction, ingress of the saline water in to the ground water does not take place. Piezometer for this purpose at appropriate locations on the project site.

Complied.

During construction no water was drawn from ground & no ingress of saline water took place.

3) Handling, manufacturing, storage and transportation of all hazardous chemicals should be carried out in accordance with MSIHC rule 1989 and subsequent amendments. All the approvals from state & central nodal agencies including OISD chief controller of explosives, chief inspectorate of factories must be obtained. A comprehensive contingency plan in collaboration with the concerned authorities must be formulated before commissioning of the project to meet any eventuality in case of an accident.

Noted.

All relevant approvals of state and central nodal agencies, CCOE, CIF for construction and operation of the facilities are in place. Emergency response plan is in place.

4) A well equipped laboratory with suitable instruments to monitor the quality of air and water shall be set up so as to ensure that the quality of ambient air and water conforms to prescribed standards. The will also equipped with qualified manpower including a marine biologist so that marine water quality is regularly monitored in order to ensure that the marine life is not adversely affected as a result of implementation of the said project. The quality of ambient air and water shall be monitored periodically in all seasons and the results should be properly maintain and for the inspection of the concerned pollution agencies. The periodic monitoring reports at least once in 6 months must be sent to this ministry (Regional office at Bhopal) and SPCB.

Noted.

Environment monitoring is being carried out through GPCB approved outsourcing agencies.

Conventional LNG terminal use sea water for vaporization of LNG. Owing to the poor quality (Presence of suspended particles) of sea water, at Dahej sea water is not being used for vaporizers and instead air heater with glycol water mixture was used for vaporizing the LNG. Since there is no intake of sea water and out flow of water in to the sea, hence it is felt that a marine biologist may not be required.

5) Adequate provisions for instrumentation facilities such as water supply, fuel for cooking, sanitation etc. must be provided for the laborer during the construction period to avoid the damage to the environment. Colonies for the laborers should not be located in the CRZ area. It should also be ensured that the construction workers do not cut trees including mangroves for fuel wood purpose.

Noted.

The construction and commissioning of the facilities at Dahej completed and plant is already operational since April-2004.

6) To prevent discharge of sewage and other liquid wastes into the water bodies, adequate system for collection and treatment of wastes must be provided. No sewage and other liquid wastes without treatment should be allowed to enter in to water bodies.

Complied.

7) Appropriate facility should be created for the collection of solid & liquid wastes generated the barges/ vessels and their safe treatment and disposal should be ensured to avoid possible contamination of the water bodies.

Contracts for engaging the vessel stipulate that the vessels comply with these requirements including MARPOL. Besides LNG vessel is berthed for only 24 hours only and it is equipped with incinerator and sewage treatment.

8) Necessary navigational aids such as channel markers should be provided to prevent accidents. Internationally recognized safety standards shall be applied in case of barge/ vessel movement.

Complied.

Necessary navigational aids have been provided and all safety measures as per international standards are being followed in case of vessel movement.

9) The project authorities should take appropriate community development and welfare measures for the villagers in the vicinity of the project site, including drinking water facilities. A separate fund should be allocated for this purpose.

PLL has constructed a temple at the site for the local people and has contributed towards infrastructure in the area for roads and drinking water.

Community development and welfare measures are taken. Village Luwara has been jointly adopted along with another nearby industry, as directed by PCPIR Welfare Society. Separate fund allocated for CSR.

Some of the schemes completed/under progress are Health Center (construction & operation), drainage and provision of street lights at Village Luwara. Rupees 75 lakh contributed to PCPIR Welfare Society. Two ladies from Luwara village sponsored for nursing course at Vidhyadeep Community college, Bharuch. Sponsored construction of Sanitation scheme at village Muller. Active participation in other Government initiated community development programs.

Installed 10 nos. Emergency solar lighting at prominent places in village Luwara. Donated Rs.1 lac for Bharuch District Civic centre development. Participated in Govt. scheme on Kanya Kelvani. Installation of drainage crossings to remove accumulated water at 4 locations within the village Luvara at a cost of Rs. 0.8 lacs. Construction of approach road in village Lakhigaon, Dahej.

PLL has sponsored 'Mataria Talav drinking water project' of the Bharuch Municipality Corporation. This project is for the supply of sweet drinking water from the Narmada River to the residents of Bharuch city. MD&CEO handed over cheque for Rs. 25 Lacs to the Collector, Bharuch on 13/06/2011.

PLL installed 50 nos. Emergency solar lighting at prominent places in village Luwara & 10 nos. Emergency solar lighting at prominent places in village Lakhigam of Vagra Taluka in Bharuch District. Provided School Bus to Primary School at Lakhigam Village and also running Primary Health Center at Luvara Village.

10) The quarrying material required for the construction purposes shall be obtained only from the approved quarries/borrow areas. Adequate safeguard measures shall be taken to ensure that the overburden and rocks at quarry site do not find their way into water bodies.

Noted

11) The dredging operation to be undertaken with the prior approval of the ministry, shall be executed with appropriated safeguard measures to prevent turbidity conditions in consultation with the expert agencies such CWPRS/NIO.

No dredging has been carried or planned to be carried out in near future.

12) For employing unskilled, semiskilled and skilled workers for the project, preferences shall be given to local people.

PLL has recruited fair number of local people. For ancillary and support functions as security services, fire fighting, and green belt maintenance etc. PLL is giving preference to local people. Housekeeping contract has been awarded to local Lakhigam village contractor.

13) The recommendation made in the environment management plan and disaster management plan, as contained in the EIA and risk analysis reports of the project shall be effectively implemented.

Noted

14) A separate environment management cell with suitably qualified staff to carry out various environment related functions should be set up under the charge of senior executive who will report directly to the chief executive of the company.

Complied. Health safety and environment management cell exists at site.

15) The project affected people, if any should be properly compensated and rehabilitated

Complied

16) The funds earmarked for environment protection measures should be maintained in the separate account and there should be no diversion of these funds for any other purpose. A year-wise expenditure on environmental safeguards should be reported to the ministry.

Noted for compliance.

Rs. 105 Lac spent for development of Green Belt during the year 2004-05.

Rs. 33.22 Lac spent for development of Green Belt and Mangrove Plantation during the year 2009-10.

Rs. 50 Lac spent for development of Green Belt and Mangrove Plantation during the year 2010-11.

Rs 93.31 Lacs spent for development of Green belt. /Mangrove plantation during the year 2011-2012

Rs. 146 Lac budgeted for development of Green Belt and Mangrove Plantation during the year 2012-13.

17) Full support should be extended to the officers of this ministry's regional office at Bhopal and the officers of the central and state pollution control boards by the project proponents during their inspection for monitoring purposes, by furnishing full details and action plans including the action taken reports in respect of mitigative measures and other environmental protection activities.

Noted and Agreed

18) In case of deviation or alteration in the project including the implementing agency, a fresh reference should be made to the ministry or modification in the clearance conditions or impositions of new ones for ensuring environmental protection. The project pronouncements should be responsible for implementing the suggested safeguard measures.

Noted and Agreed

19) The ministry reserves the right to revoke this clearance, if any of re condition stipulated or not complied with to the satisfaction of this ministry.

Noted and Agreed

20) This ministry or any other competent authority may stipulate any other additional conditions subsequently, if deemed necessary, for environmental protection which shall be complied with.

Noted and Agreed

21) The project proponent should advertise at least in two local newspapers widely circulated in the region around the project, one of which shall be in the vernacular language on the locality concerned informing that the project has been accorded environmental clearance and copies of clearance letters are available with state pollution control board and may also been at web site of the ministry of environment & forest at http://www.envfor.nic.in

Baitalia

Noted and complied.

22) The project proponents should inform the regional office as well as the ministry the date of financial closure and final approval of the project by the concerned authorities and the date of start of the land development work.

Complied. Project is now completed. Plant is under operation since April-2004.

ANNEXURE II

Response to Department of Forest & Environment Letter No. ENV-10-2000-181-P1, Dated 29th September, 2000

1. No activity shall be commenced before obtaining the necessary permissions under the forest (Conservation) Act.

   Complied

2. The applicant shall not tap the groundwater in any case.

   Complied

3. The applicant shall implement all the suggestions/recommendations given by the NIO in their rapid Marine Environment Impact Assessment Report.

   Agreed & complied

4. The applicant shall appear and submit the comprehensive Marine EIA report including the study for the long term impacts due to construction of breakwater and jetty, before commencing the project activities.

   The clarifications were provided vide our letter ref PLL/ND/D-7/2KI dated 5TH February 2001.

5. The applicant shall implement all the suggestions/recommendations given by the ONGC and the WAPCOS in their comprehensive EIA Report.

   Agreed

6. The applicant shall submit the detailed Risk assessment Report containing the worst case scenario and detailed Oil Spill Contingency Plan before commissioning the project and shall implement all the suggestions/recommendations given in the report.

   Complied

7. The applicant shall adhere to the provisions of National Oil Spill and Disaster Management Plan and shall install all necessary facilities and equipment for controlling and combating the oil spill, before commissioning the operation.

   Complied

8. The applicant shall participate financially for the Regional Environment Impact Assessment of the Dahej region.

   Agreed

9. The applicant shall bear the cost of the external agency appointed by this department for carrying out supervisor and/or monitoring of the construction and/or operation activities.

   Agreed

10. The applicant shall ensure that the construction labors do not cut the mangroves for the fuel etc. Necessary amenities, including fuel, water supply and sanitation would be provided to the construction labors.

    Complied. The construction has been completed and the terminal commenced commercial operations from 9th April 2004.

11. The camps of the construction labors shall be kept outside the CRZ area.

    Complied

12. The applicant shall ensure that free flow of water is not hampered due to any project activities.

    Complied

13. The applicant shall ensure that there will be no disposal of sullage and sewage generated from construction camps, surface run-off from construction sites, and grease spillage from construction equipment into the sea or the CRZ area.

    Complied

14. The applicant shall carry out mangrove plantation in consultation with forest department.

    Agreed

15. The applicant shall carry out the monitoring of the various environmental parameters in consultation with Gujarat pollution control Board/Forest and Environment Department.

    Agreed

16. The Gujarat Maritime Board shall prepare the detailed Traffic Control Management Plan for the Dahej port and the gulf of Khambhat in consultation with respective port companies including PLL, Indian Petrochemicals Corporation Limited and would made effective before commissioning of the activities of the PLL.

    PLL will participate in Traffic Control Management Plan to be prepared by Gujarat Maritime Board.

17. The applicant shall actively participate in the vessel Traffic Management System (VTMS) to be developed for the Gulf of Khambhat.

    Agreed

18. The applicant shall implement socio-economic up-liftment programme in consultation with District Collector/DDO.

    Agreed

19. No construction activities shall be commenced before obtaining all necessary clearances under various acts/ rules from different Govt. department /agencies.

    Noted

20. Any other conditions as may be stipulated by this department from time to time

    Agreed

PETRONET LNG LIMITED

Petronet LNG Limited

GIDC Industrial Estate, Plot No. 7/A, Dahej,
Taluka : Vagra, Dist. Bharuch (Gujarat) - 392130 (India)
Tel. : 02641-257004-7
Fax : 02641-300310 / 300306

PLL/DHJ/MoEF/002 April 05th, 2013

The Director (Environment)
Forests & Environment Department,
Government of Gujarat,
Block No. 14, 8th Floor, Sachivalaya,
Gandhinagar – 382 010
(Fax No.: 079-23252156)

Kind Attn.: Shri Hardik Shah

Subject: Half-yearly Compliance Report with respect to conditions stipulated by Ministry of Environment & Forests, Govt. of India and Department of Forests, Govt. of Gujarat for Expansion of LNG Terminal (Phase-II) at Dahej, District Bharuch in Gulf of Khambhat, Gujarat as on 31st December, 2012

Ref : (a) J-17011/11/2000-IA-III dated 23rd Nov, 2005
(b) ENV-10-2004-117-P dated 28th Dec, 2005

Dear Sir,

The Compliance report as on December 31st, 2012 with respect to conditions stipulated by Ministry of Environment & Forests, Govt. of India and Department of Forests, Govt. of Gujarat for Expansion of LNG Terminal (Phase-II) at Dahej, District Bharuch in Gulf of Khambhat, Gujarat is enclosed.

With regards,

Baitalik 5/4/13
S. Baitalik
General Manager (Projects)

Encl.: As above

Copy to:-

Director,
Ministry of Environment & Forest,
Paryavaran Bhawan,
CGO Complex, Lodhi Road,
New Delhi – 110 003

Joint Director (S)
Ministry of Environment & Forests,
Regional Office, Western Region,
Kendriya Paryavaran Bhavan,
Link Road No. 3,
Bhopal – 462 016

Half-yearly Compliance Report with respect to conditions stipulated by Ministry of Environment & Forests, Govt. of India and Department of Forests, Govt. of Gujarat for Expansion of LNG Terminal at Dahej as on 31.12.2012

COMPLIANCE REPORT TO THE CONDITION MENTIONED IN MOE&F LETTER NO. J-17011/11/2000-IA-III DATED 23rd NOVEMBER 2005

(A) *Specific conditions*

1) All the conditions stipulated by the Ministry vide Ministry's letter of even number dated 27.12.2000 and also Forest and Environment department, Government of Gujarat vide their letter No.ENV-10-2004-117-P dated 28.07.2005 should be effectively implemented.

   Noted.

2) All the conditions stipulated by GPCB in their NOC No.PC/BRCH_CCA _611/28337 dated Nil should be effectively implemented.

   Noted.

3) Quantitative risk analysis of the LNG terminal and associated facilities should be carried out taking into account the worst case scenario and based on formed up engineering design. The report should be submitted within 6 months. The central control room should be located well outside the risk zone.

   The Quantitative Risk Analysis (QRA) report for Phase I Project was submitted vide our letter no. PLL/ND/D-7/2K2 dated 18th January 2002.

   The Coarse Quantitative Risk Analysis (QRA) report for the entire terminal including the Expansion Facilities submitted vide letter no. PLL/ND/D-7/2K7 dated 8th June 2007. The control room is located outside the risk zone.

4) Based on the risk analysis, Disaster Management Plan should be prepared and submitted to this Ministry within 6 months.

   Complied.

5) The details of the facilities to be provided by the company to the local population may be furnished within one month.

   The details have been provided vide our letter no. PLL/ND/D-7/2K2 dated 18th January 2002.

6) The construction material shall be obtained from the approved quarries. In case new quarries need to be opened up, specific approval for the same should be obtained.

   Complied.

Bartalik

7) No change in scope of work should be made without prior approval of this Ministry.

Noted.

8) It should be ensured that no project activities including pipeline shall fall within CRZ-I (i).

Complied.

9) Expansion of existing service road into Coastal Regulation Zone – I(i) areas is strictly prohibited.

Noted and complied.

10) The construction design relating to the project should be reviewed to ensure their safety keeping in view the seismic potential of the area.

Complied.

11) No ground water should be used for the project.

Complied.

12) The projects proponents should make specific arrangement for rain water harvesting in the project design and the rain water so harvested should be optimally utilized.

The LNG terminal is being set up very near to the coast line at Dahej where water table is very high. Moreover the sea water is brackish in that area. Preliminary investigation indicates that it might not be feasible to carry out rain water harvesting in this area. The process water requirement in LNG terminal at Dahej is NIL. The sanitary waste water is being used for green belt purpose.

13) The project proponent will undertake mangrove a forestation in consultation with Forest department, Government of Gujarat in the adjacent area abutting the site. A detailed plan should be worked out in this regard and submitted to this Ministry within 3 months.

Following Mangrove Plantation Completed/under progress along the Gujarat Coast in consultation with GEC & Forest Dept.:

a. Completed	:	**356 Hectares (2008-09, 2009-10, 2010-2011, 2011-2012)**
b. Under Progress	:	**200 Hectares (2012-2013) in consultations with GEC** **100 Hectares (2012-2013) in consultations with Forest Dept.**
c. Proposed	:	**100 Hectares (2013-2014) in consultations with Forest Dept.** **100 Hectares (2014-2015) in consultations with Forest Dept.**

14) The budget allocated for environment safeguarding measures shall not be diverted for any other purposes.

Noted for Compliance.

(B) *GENERAL CONDITION*

1) Construction of the proposed structures should be undertaken meticulously conforming to the existing central / local rules and regulations including CRZ notification, 1991 & its amendments. All the construction designs / drawings relating to the proposed construction activities must have approvals of the concerned State Government Departments/ Agencies.

Complied.

The construction work is completed for expanding the facilities at Dahej (i.e. Phase II) and necessary approvals obtained. Phase-II is commissioned in April 2009. The phase I is operational since April 2004.

2) The proponent shall ensure that as a result of the proposed constructions, ingress of the saline water into the ground water does not take place. Piezometers shall be installed for regular monitoring for this purpose at appropriate locations on the project site.

Noted & Complied. Ground water quality is analyzed regularly. During construction, no water is drawn from ground and no ingress of saline water is taking place.

3) Handling, manufacturing, storage and transportation of all hazardous chemicals should be carried out in accordance with MSIHC Rules, 1989 and subsequent amendments. All approvals from state and central nodal agencies including OISD, Chief Controller of Explosives, and Chief Inspectorate of Factories must be obtained. A comprehensive contingency plan in collaboration with the concerned authorities must be formulated before commissioning of the project to meet any eventuality in case of an accident.

Complied

4) A well–equipped laboratory with suitable instruments to monitor the quality of air and water shall be set up so as to ensure that the quality of ambient air and water conforms to the prescribed standards. The laboratory will also be equipped with qualified manpower including a marine biologist so that the marine water quality is regularly monitored in order to ensure that the marine life is not adversely affected as a result of implementation of the said project. The quality of ambient air and water shall be monitored periodically in all the seasons and the results should be properly maintained for inspection of the concerned pollution control agencies. The periodic monitoring reports at least once in 6 months must be sent to this Ministry (Regional Office at Bangalore) and SPCB.

Noted for Compliance.

Environment monitoring is being carried out through GPCB approved outsourcing agencies.

Owing to the poor quality (presence of suspended particles) of sea water at Dahej, Sea water is not being used for vaporizers or any other purpose. Instead, air heaters with glycol water mixture is used for vaporizing the LNG. Since there is no intake of sea water and out flow of water into the sea, hence it is felt that a marine biologist may not be required.

5) Adequate provisions for infrastructure facilities such as water supply, fuel for cooking, sanitation etc. must be provided for the laborers during the construction period in order to avoid damage to the environment. Colonies for the laborers should not be located in the CRZ area.

Complied.

6) To prevent discharge of sewage and other liquid wastes into the water bodies, adequate system for collection and treatment of the wastes must be provided. No sewage and other liquid wastes without treatment should be allowed to enter into the water bodies.

Complied.

7) Appropriate facility should be created for the collection of solid & liquid wastes generated by the barges / vessels and their safe treatment and disposal should be ensured to avoid possible contamination of the water bodies.

Contracts for engaging the vessel stipulate that the vessels comply with these requirements including MARPOL. Besides LNG vessel is berthed for only 24 hours only and it is equipped with incinerator and sewage treatment plant.

8) The project authorities should take appropriate community development and welfare measures for the villagers in the vicinity of the project site, including drinking water facilities. A separate fund should be allocated for this purpose.

Community development and welfare measures are taken. Village Luwara has been jointly adopted along with another nearby industry, as directed by PCPIR Welfare Society. Separate fund allocated for CSR.

Some of the schemes completed/under progress are Health Center (construction & operation), drainage and provision of street lights at Village Luwara. Rupees 75 lakh contributed to PCPIR Welfare Society. Two ladies from Luwara village sponsored for nursing course at Vidhyadeep Community college, Bharuch. Sponsored construction of Sanitation scheme at village Muller. Active participation in other Government initiated community development programs.

Installed 10 nos. Emergency solar lighting at prominent places in village Luwara. Donated Rs.1 lac for Bharuch District Civic centre development. Participated in Govt. scheme on Kanya Kelvani. Installation of drainage crossings to remove accumulated water at 4 locations within the village Luvara at a cost of Rs. 0.8 lacs. Construction of approach road in village Lakhigaon, Dahej.

PLL has sponsored 'Mataria Talav drinking water project' of the Bharuch Municipality Corporation. This project is for the supply of sweet drinking water from the Narmada River to the residents of Bharuch city. MD&CEO handed over cheque for Rs. 25 Lacs to the Collector, Bharuch on 13/06/2011.

PLL installed 50 nos. Emergency solar lighting at prominent places in village Luwara & 10 nos. Emergency solar lighting at prominent places in village Lakhigam of Vagra Taluka in Bharuch District. Provided School Bus to Primary School at Lakhigam Village and also running Primary Health Center at Luvara Village.

9) The quarrying material required for the construction purposes shall be obtained only from the approved quarries / borrow areas. Adequate safeguard measures shall be taken to ensure that the overburden & rocks at the quarry site do not find their way into water bodies.

Noted and Complied.

10) For employing unskilled, semiskilled and skilled workers for the project, preferences shall be given to local people.

Complied.

11) The recommendation made in the environment management plan and Disaster Management Plan, as contained in the EIA and risk analysis reports of the project shall be effectively implemented.

Noted for Compliance.

12) A separate environment management cell with suitably qualified staff to carry out various environmental studies/analysis should be set up under the charge of a Senior Executive who will report directly to the Chief Executive of the Company.

Complied.
Health, Safety and Environment management cell exists at site.

13) The project affected people, if any should be properly compensated and rehabilitated.

Complied.

14) The funds earmarked for environment protection measures should be maintained in the separate account and there should be no diversion of these funds for any other purpose. A year–wise expenditure on environmental safeguards should be reported to the ministry.

Noted for compliance.

Baitalik

Rs. 33.22 Lac spent for development of Green Belt and Mangrove Plantation during the year 2009-10.

Rs. 50 Lac spent for development of Green Belt and Mangrove Plantation during the year 2010-11.

Rs 93.31 Lacs spent for development of Green belt. /Mangrove plantation during the year 2011-2012

Rs. 146 Lac budgeted for development of Green Belt and Mangrove Plantation during the year 2012-13.

15) Full support should be extended to the officers of this ministry's regional office at Bhopal and the officers of the central and state pollution control boards by the project proponents during their inspection for monitoring purposes by furnishing full details and action plans including the action taken reports in respect of mitigate measures and other environmental protection activities.

Noted & Agreed.

16) In case of deviation or alteration in the project including the implementing agency, a fresh reference should be made to the ministry or modification in the clearance conditions or impositions of new ones for ensuring environmental protection. The project proponents should be responsible for implementing the suggested safeguard measures.

Noted & Agreed.

17) The Ministry reserves the right to revoke this clearance, if any of the conditions stipulated are not complied with to the satisfaction of this ministry.

Noted & Agreed.

18) This Ministry or any other competent authority may stipulate any additional conditions subsequently, if deemed necessary, for environmental protection, which shall be complied with.

Noted & Agreed.

19) The project proponent should advertise at least in two local newspapers widely circulated in the region around the project, one of which shall be in the vernacular language of the locality concerned informing that the project has been accorded environmental clearance and copies of clearance letters are available with the state pollution control board and may also been at web site of the ministry of environment & forest at http://www.envfor.nic.in. The advertisement should be made within 7 days from the date of issue of clearance letter and a copy of the same should be forwarded to the Regional office of this Ministry at Bhopal.

Complied.

20) The project proponents should inform the regional office as well as the ministry the date of financial closure and final approval of the project by the concerned authorities and the date of start of land development work.

Noted and Complied.

Expansion project is completed and the plant is operational.

Compliance to conditions as conveyed by Department of Forests & Environment, Govt. of Gujarat, Letter No. ENV-10.2004-117-P dated 28th December, 2005

As on 31.12.2012

1. The provisions of CRZ notification of 1991 and subsequent amendments issued from time to time.

   Noted

2. The PLL shall obtain necessary permissions from different Government Departments / Agencies before commencing the expansion activities.

   The construction work is completed for expanding the facilities at Dahej (i.e. Phase II) and necessary approvals obtained. Phase-II is commissioned in April 2009. The phase I is operational since April 2004.

3. No effluent or sewage shall be discharged into the sea / creek or in the CRZ area and shall be treated to confirm the norms prescribed by the Gujarat Pollution Control Board and would be reused / recycled within the plant premises.

   Noted

4. All the recommendations and suggestion given by the NIOT and WAPCOS in their Environment Impact Assessment reports shall be implemented strictly.

   Noted.

5. The PLL shall be paid the cost of the external agency that may be appointed by this department for supervision / monitoring of the project activities during construction / operational phases.

   Noted.

6. The PLL shall contribute financially for any common study or project that may be proposed by this Department for environmental management / conservation / improvement for the Gulf of Khambhat or for Dahej region.

   Agreed.

7. The construction debris and any other type of waste shall not be discharged into the sea / creak or in CRZ areas. The debris shall be removed from construction site immediately after construction is over.

   Agreed.

8. The construction camps shall be located outside the CRZ area and the construction labor shall be provided with necessary amenities, including sanitation, water supply and fuel and it shall be ensured that the environmental conditions are not deteriorated by construction labor

   Noted & complied.

9. The PLL shall prepare and regularly update their Local Oil Spill Contingency and Disaster Management Plan in consonance with the National Oil Spill and Disaster Contingency Plan.

   Complied.

10. The Gujarat Maritime Board shall initiate for the Vessel Traffic Management system for the Gulf of Khambhat and would work out the modus operandi for cost sharing by the different players in the Gulf including the PLL. The PLL shall contribute for the same as may be decided by the Gujarat Maritime Board.

    Noted.

11. The PLL shall bear the cost of the external agency that may be appointed by this Department for supervision / monitoring of proposed activities and the environmental impacts of the proposed activities.

    Noted.

General Conditions:

12. The ground water shall not be tapped to meet with the water requirements in any case.

    Complied.

13. The PLL shall take up massive mangrove plantation activities as well as greenbelt development activities in consultation with the Gujarat Institute of Desert Ecology / Forest department.

    Following Mangrove Plantation Completed/under progress along the Gujarat Coast in consultation with GEC & Forest Dept.:

Completed	:	**356 Hectares (2008-09, 2009-10, 2010-2011, 2011-2012)**
Under Progress	:	**200 Hectares (2012-2013) in consultations with GEC**
		100 Hectares (2012-2013) in consultations with Forest Dept.
Proposed	:	**100 Hectares (2013-2014) in consultations with Forest Dept.**
		100 Hectares (2014-2015) in consultations with Forest Dept.

14. The PLL shall have to contribute financially for taking up the socio-economic upliftment activities in this region in consultation with the Forest and Environment Department and the District Collector / District Development Officer.

    Community development and welfare measures are taken. Village Luwara has been jointly adopted along with another nearby industry, as directed by PCPIR Welfare Society. Separate fund allocated for CSR.

    Some of the schemes completed/under progress are Health Center (construction & operation), drainage, provision of street lights at Village Luwara. Rupees 75 lakh contributed to PCPIR Welfare Society. Two ladies from Luwara village sponsored for nursing course at Vidhyadeep Community college, Bharuch. Sponsored construction of Sanitation scheme at village Muller. Active participation in other Government initiated community development programs.

    Installed 10 nos. Emergency solar lighting at prominent places in village Luwara. Donated Rs.1 lac for Bharuch District Civic centre development. Participated in Govt. scheme on Kanya Kelvani. Installation of drainage crossings to remove accumulated water at 4 locations within the village Luvara at a cost of Rs. 0.8 lacs/ Construction of approach road in village Lakhigaon, Dahej.

    PLL has sponsored 'Mataria Talav drinking water project' of the Bharuch Municipality Corporation. This project is for the supply of sweet drinking water from the Narmada River to the residents of Bharuch city. MD&CEO handed over cheque for Rs. 25 Lacs to the Collector, Bharuch on 13/06/2011.

    PLL installed 50 nos. Emergency solar lighting at prominent places in village Luwara & 10 nos. Emergency solar lighting at prominent places in village Lakhigam of Vagra Taluka in Bharuch District. Provided School Bus to Primary School at Lakhigam Village and also running Primary Health Center at Luvara Village.

15. Environmental Audit report indicating the changes, if any with respect to the baseline quality, in the coastal and marine environmental shall be submitted every year.

    Noted

16. The PLL shall have to contribute financially to support the National Green Corps Scheme being implemented in Gujarat by the GEER Foundation, Gandhinagar, in consultation with Forests and Environment Department.

    Noted.

17. A six monthly report on compliance of the conditions mentioned in this letter shall have to be furnished by the PLL on regular basis to this Department.

    Noted for compliance.

18. Any other condition that may be stipulated by this Department from time to time for environmental protection / management purpose shall also have to be complied with by the PLL.

    Noted.

PETRONET LNG LIMITED

Petronet LNG Limited

GIDC Industrial Estate, Plot No. 7/A, Dahej,
Taluka : Vagra, Dist. Bharuch (Gujarat) - 392130 (India)
Tel. : 02641-257004-7
Fax : 02641-300310 / 300306

PLL/DHJ/MoEF/001

Date: 15th January, 2013

The Director (Environment)
Forests & Environment Department,
Government of Gujarat,
Block No. 14, 8th Floor, Sachivalaya,
Gandhinagar – 382 010
(Fax No.: 079-23252156)

Kind Attn.: Shri J.K.Vyas

Subject: Half-yearly Compliance Report with respect to conditions stipulated by Ministry of Environment & Forests, Govt. of India and Department of Forests, Govt. of Gujarat for Setting up of Standby LNG jetty at Dahej, District Bharuch in Gulf of Khambhat, Gujarat as on 31st December 2012

Ref : (a) J-17011/11/2000-IA-III dated 14th Nov, 2008
(b) ENV-10-2004-117-E dated 05th Sep, 2008

Dear Sir,

The Compliance report as on December 31, 2012 with respect to conditions stipulated by Ministry of Environment & Forests, Govt. of India and Department of Forests, Govt. of Gujarat for Setting up of Standby LNG jetty at Dahej, District Bharuch in Gulf of Khambhat, Gujarat is enclosed.

With regards,

Baitalik
15/1/13

S. Baitalik
General Manager (Projects)

Encl.: As above

Copy to:-

Director,
Ministry of Environment & Forest,
Paryavaran Bhawan,
CGO Complex, Lodhi Road,
New Delhi – 110 003

Joint Director (S)
Ministry of Environment & Forests,
Regional Office, Western Region,
Kendriya Paryavaran Bhavan,
Link Road No. 3,
Bhopal – 462 016

Half Yearly Compliance Report with respect to conditions stipulated by Ministry of Environment & Forests, Government of India and Department of Forests, Government of Gujarat for setting up of standby LNG jetty at Dahej, District Bharuch in Gulf of Khambhat, Gujarat as on 31.12.2012

COMPLIANCE REPORT TO THE CONDITION MENTIONED IN MOE&F LETTER NO. J-17011/11/2000-IA-III, DATED: 14TH NOVEMBER, 2008.

(A) Specific Conditions:

i) Adequate safety measures for the offshore structure and ship navigation shall be taken in view of the high current in the area.

Noted.

ii) The shore line changes in the area shall be monitored periodically.

Noted.

iii) The recommendation of the Scour study shall be incorporated in the design.

Incorporated in Design.

iv) The recommendations of the risk assessment shall be implemented. Any change in the design of the project shall come before the committee for seeking necessary approval.

Implemented.

v) Mangrove plantation to be done in consultations with the GEER/GEC of Forest Department, a detailed plan shall be submitted within six months from the date of receipt of this letter.

Following Mangrove Plantation Completed/under progress along the Gujarat Coast in consultation with GEC & Forest Dept.:

a. Completed : 356 Hectares (2008-09, 2009-10, 2010-2011, 2011-2012)
b. Under Progress: 200 Hectares (2012-2013) in consultations with GEC
100 Hectares (2012-2013) in consultations with Forest Dept.
c. Proposed : 100 Hectares (2013-14) in consultations with Forest Dept.

vi) It shall be ensured that during construction and post construction of the proposed jetty the movement fishermen vessels of the local communities are not interfered with.

Agreed.

vii) Relocation of the fishermen community shall he done strictly in accordance with the norms prescribed by the State Government. The relocated fishermen community shall be provided with all facilities including health care. education, sanitation and livelihood.

Noted.

Baitalia
15/1/13

viii) Marine ecology monitoring shall be done regularly during construction of Breakwater and dredging operation.

Construction of break water / Dredging operation is not envisaged

ix) Regular monitoring of air quality shall be done in the settlement areas around the project site and appropriate safeguard measures shall be taken to ensure that the population is not subjected to higher levels of air pollution.

Noted & complied.

x) Sewage arising in the port area shall be disposed off after adequate treatment to conform to the standards stipulated by Gujarat State Pollution Control Board and shall be utilized/re-cycled for gardening, plantation and irrigation.

Agreed.

xi) Adequate plantation shall be carried out along the roads of the Port premises and a green belt shall be developed.

Agreed.

xii) There shall be no withdrawal of ground water in CRZ area, for this project.

Noted & complied.

xiii) Specific arrangements for rain water harvesting shall be made in the project design and the rain water so harvested shall be optimally utilized. Details in this regard shall be furnished to this Ministry's Regional Office at Bhopal within 3 months.

The LNG terminal is being set up very near to the coast line at Dahej where water table is very high. Moreover the sea water is brackish in that area. Preliminary investigation indicates that it might not be feasible to carry out rain water harvesting in this area. The process water requirement in LNG terminal at Dahej is NIL. The sanitary waste water in being used for green belt purpose.

xiv) Land reclamation shall be carried out only to the extent that it is essential for this project.

Noted.

xv) No product other than those permissible in the Coastal Regulation Zone Notification, 1991 shall be stored in the Coastal Regulation Zone area.

Noted.

Baitalik
15/1/13.

B. General Conditions:

(i) Construction of the proposed structures, if any in the Coastal Regulation Zone area shall be undertaken meticulously conforming to the existing Central/local rules and regulations including Coastal Regulation Zone Notification 1991 & its amendments. All the construction designs / drawings relating to the proposed construction activities must have approvals of the concerned State Government Departments / Agencies.

Agreed.

(ii) Adequate provisions for infrastructure facilities such as water supply, fuel, sanitation etc. shall be ensured for construction workers during the construction phase of the project so as to avoid felling of trees/mangroves and pollution of water and the surroundings.

Noted for compliance.

(iii) The project authorities must make necessary arrangements for disposal of solid wastes and for the treatment of effluents by providing a proper wastewater treatment plant outside the CRZ area. The quality of treated effluents, solid wastes and noise level etc. must conform to the standards laid down by the competent authorities including the Central/State Pollution Control Board and the Union Ministry of Environment and Forests under the Environment (Protection) Act, 1986, whichever are more stringent.

Noted for compliance.

(iv) The proponent shall obtain the requisite consents for discharge of effluents and emissions under the Water (Prevention and Control of Pollution) Act, 1974 and the Air (prevention and Control of Pollution) Act, 1981 from the Gujarat Pollution Control Board before commissioning of the project and a copy of each of these shall be sent to this Ministry.

Noted for compliance.

(v) The sand dunes, corals and mangroves, if any, on the site shall not be disturbed in any way.

Agreed.

(vi) A copy of the clearance letter will be marked to the concerned Panchayat / local NGO, if any, from whom any suggestion/representation has been received while processing the proposal.

Noted.

Baitalin.
15/1/13.

(vii) The funds earmarked for environment protection measures shall be maintained, in a separate account and there shall be no diversion of these funds for any other purpose. A year-wise expenditure on environmental safeguards shall be reported to this Ministry's Regional Office at Bhopal and the State Pollution Control Board.

Complied.

Rs 33.22 Lacs spent for development of green belt and mangrove plantation during the year 2009-2010.

Rs 50 Lacs spent for development of Green belt and Mangrove plantation during the year 2010-2011

Rs 93.31 Lacs spent for development of Green belt. /Mangrove plantation during the year 2011-2012

Rs 146 Lacs budgeted for development of Green belt. /Mangrove plantation during the year 2012-2013

(viii) Full support shall be extended to the officers of this Ministry's Regional Office at Bhopal and the officers of the Central and Sate Pollution Control Boards by the project proponents during their inspection for monitoring purposes. by furnishing full details and action plans including the action taken reports in respect of mitigate measures and other environmental protection activities.

Agreed.

(ix) In case of deviation or alteration in the project including the implementing agency, a fresh reference shall be made to this Ministry for modification in the clearance conditions or imposition of new ones for ensuring environmental protection.

Noted & Agreed.

(x) This Ministry reserves the right to revoke this clearance, if any of the conditions stipulated are not complied with to the satisfaction of this Ministry.

Noted & Agreed.

(xi) This Ministry or any other competent authority may stipulate any other additional conditions subsequently, if deemed necessary, for environmental protection, which shall be complied with.

Noted & Agreed.

Baitalik
15/1/13

(xii) The project proponent shall advertise at least in two local newspapers widely circulated in the region around the project, one of which shall be in the vernacular language of the locality concerned informing that the project has been accorded environmental clearance and copies of clearance letters are available with the State Pollution Control Board and may also be seen at Website of the Ministry of Environment & Forests at littp://www.envfornic.in. The advertisement shall be made within 7 days from the date of issue of the clearance letter and a copy of the same shall be forwarded to the Regional Office of this Ministry at Bhopal.

Complied.

(xiii) The Project proponents shall inform the Regional Office at Bhopal as well as the Ministry the date of financial closure and final approval of the project by the concerned authorities and the date of start of Land Development Work.

Noted for compliance.

(xiv) Any appeal against this environmental clearance shall lie with the National Environment Appellate Authority, if preferred, within a period of 30 days as prescribed under Section 11 of the National Environment Appellate Act, 1997.

Noted.

Compliance to conditions as conveyed by Department of Forests & Environment, Govt. of Gujarat, Letter No. ENV-10-2004-117-E, dated: September 5, 2008.

1. The provisions of CRZ notification of 1991 and subsequent amendments issued from time to time shall be strictly adhered to by PLL.

   Noted.

2. All necessary permissions from different Government Departments / Agencies shall be obtained by PLL before commencing the expansion activities.

   Noted.

3. No effluent or sewage shall be discharged into the sea / creek or in the CRZ area and shall be treated to confirm the norms prescribed by the Gujarat Pollution Control Board and would be reused / recycled within the plant premises.

   Noted.

4. All the recommendations and suggestion given by the NIOT and WAPCOS in their Environment Impact Assessment reports shall be implemented strictly.

   Noted.

Baitalik. 17/1/13.

5. The cost of the external agency that may be appointed by this department for supervision / monitoring of the project activities during construction / operational phases shall be paid by PLL.

   Noted.

6. The PLL shall have to contribute financially for any common study or project that may be proposed by this Department for environmental management / conservation / improvement for the Gulf of Khambhat or for Dahej region.

   Agreed.

7. The construction debris and any other type of waste shall not be discharged into the sea / creak or in CRZ areas. The debris shall be removed from construction site immediately after construction is over.

   Agreed.

8. The construction camps shall be located outside the CRZ area and the construction labor shall be provided with necessary amenities, including sanitation, water supply and fuel and it shall be ensured that the environmental conditions are not deteriorated by construction labor

   Noted & complied.

9. The PLL shall prepare and regularly update its local oil Spill Contingency plan and Disaster Management Plan in consonance with National Oil Spill and Disaster Contingency Plan

   Complied for operation of Existing LNG Terminal facilities.

10. The Gujarat Maritime Board shall initiate for the Vessel Traffic Management System for the Gulf of Khambhat and would work out the modus operandi for cost sharing by different players in the Gulf including PLL. The PLL shall contribute for the same as may be decided by Gujarat Maritime Board.

    Agreed

15/1/13

General Conditions:

11. The ground water shall not be tapped to meet with the water requirements in any case.

    Agreed

12. The PLL shall take up massive mangrove plantation activities in 100 ha. of area on Gujarat Coast line as well as greenbelt development activities in consultation with the Gujarat Institute of Desert Ecology / Forest department.

    Following Mangrove Plantation Completed/under progress along the Gujarat Coast in consultation with GEC & Forest Dept.:

    a. Completed : 356 Hectares (2008-09, 2009-10, 2010-2011, 2011-2012)
    b. Under Progress: 200 Hectares (2012-2013) in consultations with GEC
    100 Hectares (2012-2013) in consultations with Forest Dept.
    c. Proposed : 100 Hectares (2013-14) in consultations with Forest Dept.

13. The PLL shall have to contribute financially for taking up the socio-economic upliftment activities in this region in consultation with the Forest and Environment Department and the District Collector / District Development Officer.

    Noted.

14. Environmental Audit report indicating the changes, if any with respect to the baseline quality, in the coastal and marine environmental shall be submitted every year.

    Noted.

15. A six monthly report on compliance of the conditions mentioned in this letter shall have to be furnished by the PLL on regular basis to this Department.

    Noted for compliance.

16. Any other condition that may be stipulated by this Department from time to time for environmental protection / management purpose shall also have to be complied with by the PLL.

    Noted.

18/1/13

ANNEXURE-III
APPLICABLE ENVIRONMENT STANDARDS

1.0 Ambient Air Quality Standards

National Ambient Air Quality Standards for ambient air has been prescribed by the Environment (Protection) Seventh Amendment Rules, 2009 dated 16th November 2009. The prescribed Standards are given below in **Table-1**.

TABLE-1
NATIONAL AMBIENT AIR QUALITY STANDARDS

Sr. No.	Pollutant	Time Weighted Average	Concentration in Ambient Air		
			Industrial, Residential, Rural and other Area	Ecologically Sensitive Area (notified by Central Government)	Methods of Measurement
(1)	(2)	(3)	(4)	(5)	(6)
1	Sulphur dioxide (SO_2), µg/m^3	Annual*	50	20	-Improved West and Gaeke -ultraviolet fluorescence
		24 Hours**	80	80	
2	Nitrogen Dioxide (NO_2), µg/m^3	Annual*	40	30	-Modified Jacob & Hochheiser (Na-Arsenite) -Chemiluminesence
		24 Hours**	80	80	
3	Particulate Matter (Size less than 10µm) or PM_{10} µg/m^3	Annual*	60	60	-Gravitmetric -TOEM -Beta attenuation
		24 Hours**	100	100	
4	Particulate Matter (Size less than 2.5µm) or $PM_{2.5}$ µg/m^3	Annual*	40	40	-Gravitmetric -TOEM -Beta attenuation
		24 Hours**	60	60	
5	Ozone (O_3) µg/m^3	8 hours **	100	100	-UV photometric -Chemiluminiscence -Chemical Method
		1 hour **	180	180	
6	Lead (Pb) µg/m^3	Annual*	0.50	0.50	-AAS /ICP method after sampling on EPM 2000 or equivalent filter paper -ED-XRF using Teflon filter
		24 Hours**	1.0	1.0	
7	Carbon monoxide (CO) mg/m^3	8 Hours	02	02	-Non Dispersive Infra Red (NDIR)
		1 Hour**	04	04	
8	Ammonia (NH_3) µg/m^3	Annual*	100	100	-Chemiluminiscence -Indophenol blue method
		24 Hours**	400	400	
9	Benzene (C_6H_6) µg/m^3	Annual*	05	05	-Gas chromatography based continuous analyzer -Adsorption and Desorption followed by GC analysis
10	Benzo(α) Pyrene (BaP)- particulate phase only ng/m^3	Annual*	01	01	-Solvent extraction followed by HPLC/GC analysis

ANNEXURE-III
APPLICABLE ENVIRONMENT STANDARDS

Sr. No.	Pollutant	Time Weighted Average	Concentration in Ambient Air		
			Industrial, Residential, Rural and other Area	Ecologically Sensitive Area (notified by Central Government)	Methods of Measurement
11	Arsenic (As) ng/m^3	Annual*	06	06	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper
12	Nickel (Ni) ng/m^3	Annual*	20	20	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper

Note:

* *Annual arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform intervals.*

** *24 hourly or 8 hourly or, 01 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, the may exceed the limits but not on two consecutive days of monitoring.*

2.0 Ambient Noise Standards

Ambient standards with respect to noise have been notified by the Ministry of Environment and Forests vide gazette notification dated 26th December 1989 (Amended on January, 2010), Noise Pollution (Regulation and Control) Rules, 2010. It is based on the A weighted equivalent noise level (L_{eq}). The standards are presented in **Table-2.**

TABLE-2
AMBIENT NOISE STANDARDS

Area Code	Category of Area	Noise Levels dB(A) eq	
		Day time*	Night Time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone**	50	40

Note: - 1. Day time shall mean from 6.00 a.m. to 10.00 p.m.
2. Night time shall mean from 10.00 p.m. to 6.00 a.m.
3. Silence zone is an area comprising not less than 100 metres around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority.
4. Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority.

* dB(A) Leq denotes the time weighted average of the level of sound in decibels on scale A which is relatable to human hearing.

A "decibel" is a unit in which noise is measured.
"A",in dB(A) Leq, denotes the frequency weighting in the measurement of noise and corresponds to frequency response characteristics of the human ear.
Leq: It is an energy mean of the noise level over a specified period.

ANNEXURE-III
APPLICABLE ENVIRONMENT STANDARDS

3.0 Noise Standards for Occupational Exposure

Noise standards in the work environment are specified by Occupational Safety and Health Administration (OSHA-USA) which are being enforced by Government of India through model rules framed under Factories Act. These are given in **Table-3** below.

TABLE-3
STANDARDS FOR OCCUPATIONAL EXPOSURE

Total Time of Exposure per Day in Hours (Continuous or Short term Exposure)	Sound Pressure Level in dB(A)
8	90
6	92
4	95
3	97
2	100
3/2	102
1	105
¾	107
½	110
¼	115
Never	>115

Note:

1. No exposure in excess of 115 dB(A) is to be permitted.

2. For any period of exposure falling in between any figure and the next higher or lower figure as indicated in column (1), the permissible level is to be determined by extrapolation on a proportionate scale.

ANNEXURE-IV
METHODOLOGY ADOPTED FOR SAMPLING AND ANALYSIS

1.0 Meteorology

The methodology adopted for monitoring surface observations is as per the standard norms laid down by Bureau of Indian Standards (IS:8829) and India Meteorological Department (IMD).

1.1 Methodology of Data Generation

The Central Monitoring Station (CMS) equipped with continuous monitoring equipment was installed at site at a height of about 10 m above ground level to record wind speed, direction, relative humidity and temperature. The meteorological monitoring station was located in such a way that it is free from any obstructions and as per the guidelines specified under IS:8829. Cloud cover was recorded by visual observation. Rainfall was monitored by rain gauge.

The continuous recording meteorological instrument of Dynalab, Pune (Model No.WDL1002) has been used for recording the met data. The sensitivity of the equipment is as given in **Table-1**.

TABLE-1
SENSITIVITY OF METEOROLOGY MONITORING STATION

Sr. No.	Sensor	Sensitivity
1	Wind speed Sensor	± 0.02 m/s
2	Wind direction Sensor	± 3 degrees
3	Temperature Sensor	± 0.2°C

Hourly maximum, minimum and average values of wind speed, direction and temperature were recorded continuously with continuous monitoring equipment. All the sensors were connected to filter and then logged on to datalogger. The readings were recorded in a memory module, which was attached to datalogger. The memory module was downloaded in computer through Dynalab software. The storage capacity of memory module was 256 KB. Data was downloaded every fortnight into the computer. The data was recorded continuously. The recovery of data was about 98%. The rest of 2 % data gaps were filled by referring to IMD data and daily weather reports in the local newspapers. However, Relative Humidity and Rainfall were recorded manually.

1.2 Ambient Air Quality

The air samples were analyzed as per standard methods specified by Central Pollution Control Board (CPCB), IS: 5184 and American Public Health Association (APHA).

The techniques used for ambient air quality monitoring and minimum detectable level are given in **Table-3.**

ANNEXURE-IV
METHODOLOGY ADOPTED FOR SAMPLING AND ANALYSIS

TABLE-3
TECHNIQUES USED FOR AMBIENT AIR QUALITY MONITORING

Parameters	Test Method [as per GSR 826(E), Sch-VII]	Minimum Detectable Limit ($\mu g/m^3$)
Particulate Matter, PM10	Gravimetric Method	1.0
Particulate Matter, PM2.5	Gravimetric Method	1.0
Sulphur dioxide (SO_2)	Improved West and Gaeke Method	4.0
Nitrogen dioxide (NO_x)	Modified Jacob and Hochheiser Method	4.0
Carbon Monoxide (CO) (3 x 8 hr)	Gas Monitor	12.5
Ozone (O_3) (3 x 8 hr)	Spectroscopic analysis	0.01 ppm /20 $\mu g/m^3$
Ammonia, NH_3	Indophenol Blue method	4.0
Benzene, C_6H_6	Solvent extraction followed by GC analysis	0.001
Benzo(a)pyrene in Particulate phase	Solvent extraction followed by GC analysis	0.0001
Heavy metals in particulate phase for Arsenic (As), Nickel (Ni), Lead (Pb)	AAS/ICP method	0.0001

1.3 Water Analysis

Samples for chemical analysis were collected in polyethylene carboys. Samples collected for metal content were acidified with 1 ml HNO_3. Samples for bacteriological analysis were collected in sterilized glass bottles. Selected physico-chemical and bacteriological parameters have been analyzed for projecting the existing water quality status in the study area. Parameters like temperature, Dissolved Oxygen (DO) and pH were analyzed at the time of sample collection.

The methodology for sample collection and preservation techniques was followed as per the Standard Operating Procedures (SOP) mentioned in **Table-4**.

TABLE-4
STANDARD OPERATING PROCEDURES (SOP) FOR WATER AND WASTEWATER SAMPLING

Parameter	Sample Collection	Sample Size	Storage/ Preservation
pH	Grab sampling Plastic /glass container	50 ml	On site analysis
Electrical Conductivity	Grab sampling Plastic /glass container	50 ml	On site parameter
Total suspended solids	Grab sampling Plastic /glass container	100 ml	Refrigeration, can be stored for 7 days
Total Dissolved Solids	Grab sampling Plastic /glass container	100 ml	Refrigeration, can be stored for 7 days
BOD	Grab sampling Plastic /glass container	500 ml	Refrigeration, 48 hrs
Hardness	Grab sampling Plastic /glass container	100 ml	Add HNO_3 to pH<2, refrigeration; 6 months
Chlorides	Grab sampling Plastic /glass container	50 ml	Not required; 28 days
Sulphates	Grab sampling	100 ml	Refrigeration; 28 days

ANNEXURE-IV
METHODOLOGY ADOPTED FOR SAMPLING AND ANALYSIS

Parameter	Sample Collection	Sample Size	Storage/ Preservation
	Plastic /glass container		
Sodium, Potassium	Plastic container	100 ml	Not required; 6 months
Nitrates	Plastic containers	100 ml	Refrigeration; 48 hrs
Fluorides	Plastic containers only	100 ml	Not required; 28 days
Alkalinity	Plastic/ glass containers	100 ml	Refrigeration; 14 days
Ammonia	Plastic/ glass containers	100 ml	Add H_2SO_4 to pH>2, refrigeration, 28 days
Hexavalent Chromium, Cr^{+6}	Plastic/ Glass rinse with 1+1 HNO_3	100 ml	Grab sample; refrigeration; 24 hrs
Heavy Metals (Hg, Cd, Cr, Cu, Fe, Zn, Pb etc.)	Plastic/ Glass rinse with 1+1 HNO_3	500 ml	Filter, add HNO_3 to pH>2; Grab sample; 6 months

Source: Standard Methods for the Examination of Water and Wastewater, Published By APHA, AWWA, WEF 19th Edition, 1995

1.3.1 Analytical Techniques

The analytical techniques used for water and wastewater analysis is given in the **Table-5**.

TABLE-5
ANALYTICAL TECHNIQUES
FOR WATER AND WASTEWATER ANALYSIS

Parameter	Method
pH	APHA-4500-H^+
Colour	APHA-2120 C
Odour	IS: 3025, Part-4
Temperature	APHA-2550 B
Dissolved Oxygen	APHA-4500 O
BOD	APHA-5210 B
Electrical conductivity	APHA-2510 B
Turbidity	APHA-2130 B
Chlorides	APHA-4500 Cl^-
Fluorides	APHA-4500 F^-
Total dissolved solids	APHA-2540 C
Total suspended solids	APHA-2540 D
Total hardness	APHA-2340 C
Sulphates	APHA-4500 SO_4^{-2}
Arsenic	APHA-3120 B/ APHA-3114 B/ APHA-3500 As
Calcium	APHA-3120 B/ APHA-3500 Ca
Magnesium	APHA-3120 B/ APHA-3500 Mg
Sodium	APHA-3120 B/ APHA-3500 Na
Potassium	APHA-3120 B/ APHA-3500 K
Manganese	APHA-3120 B/ APHA-3500 Mn
Mercury	APHA-3112 B/ APHA-3500 Hg
Selenium	APHA-3120 B/ APHA-3114 B/ APHA-3500 Se
Lead	APHA-3120 B/ APHA-3500 Pb
Copper	APHA-3120 B/ APHA-3500 Cu
Cadmium	APHA-3120 B/ APHA-3500 Cd
Iron	APHA-3120 B/ APHA-3500 Fe
Zinc	APHA-3120 B/ APHA-3500 Zn
Boron	APHA-4500 B
Coliform organisms	APHA-9215 D
Alkalinity	APHA-2320 B

ANNEXURE-IV
METHODOLOGY ADOPTED FOR SAMPLING AND ANALYSIS

1.4 Soil Quality

At each location, soil samples were collected from three different depths viz. 30 cm, 60 cm and 90 cm below the surface and are homogenized. This is in line with IS: 2720 & Methods of Soil Analysis, Part-1, 2nd edition, 1986 of (American Society for Agronomy and Soil Science Society of America). The homogenized samples were analyzed for physical and chemical characteristics. The soil samples were collected and analyzed once in each season.

The samples have been analyzed as per the established scientific methods for physico-chemical parameters. The heavy metals have been analyzed by using Atomic Absorption Spectrophotometer and Inductive Coupled Plasma Analyzer.

The methodology adopted for each parameter is described in **Table-6**.

TABLE-6
ANALYTICAL TECHNIQUES FOR SOIL ANALYSIS

Parameter	Method (ASTM number)
Grain size distribution	Sieve analysis (D 422 – 63)
Textural classification	Chart developed by Public Roads Administration
Infiltration capacity	Infiltrometer
Bulk density	Sand replacement, core cutter
Porosity	Void ratio
Sodium absorption ratio	Flame colourimetric (D 1428-82)
PH	pH meter (D 1293-84)
Electrical conductivity	Conductivity meter (D 1125-82)
Nitrogen	Kjeldahl distillation (D 3590-84)
Phosphorus	Molybdenum blue, colourimetric (D 515-82)
Potassium	Flame photometric (D 1428-82)
Copper	AAS (D 1688-84)
Iron	AAS (D 1068-84)
Zinc	AAS (D 1691-84)
Boron	Surcumin, colourimetric (D 3082-79)
Chlorides	Argentometric (D 512-81 Rev 85)
Fluorides	Fusion followed by distillation and estimation by Ion selective electrod.

1.5 Noise Levels

1.5.1 Method of Monitoring

Noise level monitoring was carried out continuously for 24-hours with one hour interval starting at 0030 hrs to 0030 hrs next day. The noise levels were monitored on working days only and Saturdays, Sundays and public holidays were not monitored. During each hour L_{eq} were directly computed by the instrument based on the sound pressure levels. Lday (Ld), Lnight (Ln) and Ldn values were computed using corresponding hourly Leq of day and night respectively. Monitoring was carried out at 'A' response and fast mode.

Parameters Measured During Monitoring

For noise levels measured over a given period of time interval, it is possible to describe important features of noise using statistical quantities. This is calculated using the percent of the time certain noise levels exceeds the time interval. The notation for the statistical quantities of noise levels is described below:

- Hourly L_{eq} values have been computed by integrating sound level meter.
- L_{day}: As per the CPCB guidelines the day time limit is between 07:00 hours to 22.00 hours as outlined in Ministry of Environment and Forest Notification S.O. 123 (E) dated 14/02/2000.
- L_{night}: As per the CPCB guidelines the night time limit is between 22:00 hours to 07.00 hours as outlined in Ministry of Environment and Forest Notification S.O. 123 (E) dated 14/02/2000.

A rating developed by Environmental Protection Agency, (US-EPA) for specification of community noise from all the sources is the Day-Night Sound Level, (L_{dn}).

L_{dn}**:** It is similar to a 24 hr equivalent sound level except that during night time period (10 PM to 07 AM) a 10 dB (A) weighting penalty is added to the instantaneous sound level before computing the 24 hr average. This nighttime penalty is added to account for the fact that noise during night when people usually sleep is judged as more annoying than the same noise during the daytime.

The L_{dn} for a given location in a community may be calculated from the hourly L_{eq}'s, by the following equation.

$$L_{dn} = 10Log \frac{[\sum_{i=1}^{15} 10^{(L_{eq}i/10)} + \sum_{i=1}^{9} 10^{(L_{eq}i+10/10)}]}{24}$$

GMB/N/PVT/183(10)/ 557-9686 **GUJARAT MARITIME BOARD**
November 3, 2011

5

To,
Mr R K Garg,
Sr, VP-Fin. & Company Secretary
Petronet LNG Limited
World Trade Centre, First floor
Babar Road,
Baramhamba Lane
New Delhi-110 001

Sub: ***Land on waterfront at Dahej LNG Terminal.***

Sir,

Please refer your letter No: PLL/GMB/DHJ-006 dated April 18, 2011 submitting consent on reclaimed land proposal submitted to GMB on June 12, 2009.

In view of this, the Board of GMB resolved to grant In – Principle approval to M/s PLL for reclamation of land admeasuring 800x250 mt adjacent to the waterfront allotted for LNG facilities at Dahej subject to following conditions.

1. M/s PLL shall have to obtain necessary approvals/clearance from the concerned authorities of Government of Gujarat and Government of India including Environment Clearance & CRZ Clearance prior to the commencement of reclamation of the proposed land.
2. M/s PLL shall have to take approval of GMB under section 35(1) of GMB Act 1981 prior to the commencement of reclamation of the proposed land after the receipt of necessary approvals/clearances including Environment Clearance & CRZ Clearance.
3. Detailed Design Drawings for protection, bunding & reclamation shall have to be submitted to GMB by M/s PLL along with the Detailed Project Report for the proposed reclamation for the approval of GMB.
4. The proposed reclamation shall not create any hindrance in the navigational channel.
5. The mitigation of the adverse impact, if any, arise due to the proposed reclamation shall be sole responsibility of M/s PLL.
6. M/s PLL shall have to submit quarterly progress report to Head Office, GMB under intimation to Port Officer, Dahej, GMB.

Head Office : Sector 10-A, "Chh" Road, Opp. Air Force Station, Gandhinagar - 382010. Gujarat (INDIA)
Phone : (91-079) 23238346/47/48/51, Fax : (91-079) 23234704, Tele-Fax : 079-23234705,
E-mail : gmbad1@sancharnet.in **Website : www.gmbports.org**

7. The ownership of all the land to be reclaimed as proposed by M/s PLL shall vest with GMB
8. M/s PLL shall have to submit an undertaking on judicial stamp paper that the proposed reclaimed land shall not form a part of contract assets and therefore, no compensation shall be payable at the end of the concession period or on termination, as the case may be prior to commencement of reclamation of the proposed land.
9. A separate supplementary lease & possession agreement for the proposed reclaimed land shall have to be executed with GMB by M/s PLL for the period in concurrent with Concession Agreement executed between GMB and M/s PLL subject to the approval of the GoG, and terms and conditions as may be decided by the GoG for the allotment of proposed reclaimed land will be binding upon M/s PLL.

Yours' faithfully

Advisor
Privatisation Cell.

Copy to: The Port Officer, Gujarat Maritime Board, Station Road Bharuch. - for information & necessary action.

GOVERNMENT OF GUJARAT

Forest & Environment Department,
14/8, Sardar Bhavan, Sachivalaya, Gandhinagar-382010.
Ph.079-23251071 Fax 079-23252156

No. FCA-1012/10-13/(11)/S.F-31/F **Date:** 26 APR 2012

To,
The Chief Conservator of Forests(Central)
Ministry of Environment & Forest,
Regional Office, Western Region,
Kendriya Paryavaran Bhavan,
Link Road No.3, E-5, Arera Colony,
BHOPAL(M.P.)-462016

અધિક અગ્ર મુખ્ય વન સંરક્ષક
ગુજરાત રાજ્ય, ગાંધીનગર
આવક ક્રમાંક 1588
તારીખ 27-4-12
શાખા ક્રમાંક T-29

Subject: Diversion of 22.62 ha. Forest land for the Construction of LNG Tanks, Regassification, Truck loading facility and associated utilities at village Luvara, Ta. Vagra, Dist.Bharuch in favour of Petronet LNG Limited.

Sir,

Please refer to the proposal submitted by Sr.VP(Projects),Dahej LNG Terminal, Petronet LNG Limited. At.Dahej,Ta. Vagra, Dist: Bharuch. The details of the proposal are as under.

Sr.No.	Name of road	**Total Area Sq.m.**
1	S.No.215 Village Luvara,Ta. Vagara Dist:Bharuch	22.62
	Total	22.62

The area involved has been declared as a Protected Forest vide Government of Gujarat Notification No.AKH-144/FLD-1665/73387-P dt. / /1965.

3100 trees are required to be cut in the demanded area. Girth class wise list of trees is enclosed.

T-29
27-4-12

The Scheme of Compensatory Afforestation has been prepared for raising plantation in 28.38 ha.(Revised 22.62 ha.) pt.15.7601 ha land at Village:Sanala S. No.258/2pt.1/7,8,S.No.258 pt.3,S.No.258pt.2 Ta. Plitana,Dist.Bhavnagar and 13.1758 ha. land at Village :Ratanpura S.No.63/1 pt. Ta. Mahuva,dist:Bhavanagar Compensatory afforestation scheme is enclosed.

The user agency has given an undertaking to pay the cost of Compensatory Afforestation and NPV and has also given an undertaking that in case of upward revision of NPV they will pay the difference. The requisite information in the prescribed profroma, Maps etc. is enclosed.

In view of above, I request you to approve the proposal under the Forest (Conservation) Act, 1980.

Yours Faithfully,

PMChristian

(P.M.Christian)
Joint Secretary to the Government,
Forest & Environment Department.

copy to:-

1. The Nodal officer (FCA), Pr. Chief Conservator of Forest's office, Gujarat State, **'Aranya Bhavan' Sector-10/A,** Gandhinagar, for information.

2, **Sr. VP(Project),**
Pertonet LNG Limited, Dahej LNG Terminal,
GIDC Industrial Estate, Plot No: 7?A,Dahej.
Ta.Vagara, Dist.Bharuch. Pin No.392 130

3. The Select File.

ANNEXURE-VI
LANDUSE PATTERN

Sr. No.	Name of Village	Forest Land	Total Irrigated Land	Un-Irrigated Land	Cultivable Waste Land	Area not Available for Cultivation	Total
0-3 km	**Vagra Taluka**						
1	Lakhigam	0.00	0.00	698.82	204.22	160.28	1063.32
2	Luvara	0.00	0.00	320.00	8.70	561.75	890.45
	Sub-Total	**0**	**0**	**1018.82**	**212.92**	**722.03**	**1953.77**
3-7 km	**Vagra Taluka**						
3	Jageshwar	0.00	0.00	18.00	10.21	486.83	515.04
4	Ambheta	0.00	0.00	96.11	16.42	1403.55	1516.08
	Sub-Total	**0**	**0**	**114.11**	**26.63**	**1890.38**	**2031.12**
7-10 km	**Vagra Taluka**						
5	Dahej	0.00	0.00	1087.25	369.00	6174.27	7630.52
	Sub-Total	**0**	**0**	**1087.25**	**369**	**6174.27**	**7630.52**
	Grand Total	**0**	**0**	**2220.18**	**608.55**	**8786.68**	**11615.41**

ANNEXURE-VII
AMBIENT AIR QUALITY LEVELS

PETRONET LNG, DAHEJ (WINTER DEC 2011 TO FEB 2012)											
	AAQ1:PLANT SITE										
Sr.No	**Monitoring Date**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**NOx**	**CO**			**O_3**		
						I	**II**	**III**	**I**	**II**	**III**
1	01/12/2011	55.3	16.2	14.6	15.2	384	412	379	3.4	6.6	2.7
2	02/12/2011	57.6	16.8	13.2	14.4	426	456	389	3.9	7.8	3.3
3	08/12/2011	56.1	16.5	12.5	12.9	459	483	446	3.2	5.3	2.8
4	09/12/2011	55.3	16.0	11.6	12.2	366	395	384	3.5	7.5	2.9
5	15/12/2011	53.1	17.3	13.6	14.2	452	469	447	4.5	6.2	4.2
6	16/12/2011	51.3	16.3	11.4	12.4	425	459	435	4.1	6.6	3.4
7	22/12/2011	52.6	17.3	12.8	13.6	389	394	374	4.2	7.1	3.9
8	23/12/2011	53.8	16.1	14.9	15.2	342	362	344	3.3	7.5	3.1
9	29/12/2011	54.2	16.3	13.5	14.2	406	421	412	4.2	5.0	3.4
10	30/12/2011	55.6	17.1	14.9	16.2	421	456	429	3.5	5.5	3.9
11	05/01/2012	56.8	17.8	16.2	17.5	412	436	416	3.8	6.1	2.5
12	06/01/2012	57.6	17.3	15.2	16.3	356	389	371	4.1	6.5	3.6
13	12/01/2012	54.2	16.3	13.2	14.2	368	383	362	4.4	5.5	3.8
14	13/01/2012	50.4	15.7	14.6	15.6	344	385	351	3.9	6.5	3.2
15	19/01/2012	47.2	14.0	15.9	16.3	332	357	346	3.5	7.3	3.1
16	20/01/2012	49.5	15.1	14.3	15.4	368	394	379	3.4	4.9	2.8
17	26/01/2012	44.3	13.8	15.2	16.9	334	385	363	3.5	6.1	3.2
18	27/01/2012	42.6	12.8	13.5	14.6	359	384	351	3.9	7.6	3.4
19	02/02/2012	43.9	13.4	14.6	15.4	364	386	380	3.8	4.2	2.8
20	03/02/2012	46.8	14.0	16.8	17.5	346	356	313	4.0	5.2	3.2
21	09/02/2012	47.6	13.3	17.6	18.5	342	372	349	3.8	7.3	3.5
22	10/02/2012	49.2	14.9	14.9	16.3	376	394	384	3.7	7.8	2.7
23	16/02/2012	51.2	15.7	13.9	15.4	376	412	394	3.6	6.3	2.9
24	17/02/2012	53.6	16.6	15.3	16.3	422	443	416	3.8	7.5	2.8
25	23/02/2012	55.8	15.7	13.7	15.7	439	456	432	3.2	5.3	3.0
26	24/02/2012	57.9	16.0	14.9	15.4	451	476	446	3.9	4.4	3.2
	Min	**42.6**	**12.8**	**11.4**	**12.2**		**313**			**2.5**	
	Max	**57.9**	**17.8**	**17.6**	**18.5**		**483**			**7.8**	
	Avg	**52.1**	**15.7**	**14.3**	**15.3**		**396**			**4.4**	
	98th	**57.8**	**17.6**	**17.2**	**18.0**		**472**			**7.7**	
	All the values are given in µg/m3										
	AAQ2 : LAKHIGAM VILLAGE										
Sr.No	**Monitoring Date**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**NOx**	**CO**			**O_3**		
						I	**II**	**III**	**I**	**II**	**III**
1	01/12/2011	55.3	16.5	10.6	11.6	339	362	329	3.3	4.9	2.9
2	02/12/2011	51.4	15.7	11.2	12.5	310	336	311	3.6	6.5	2.7
3	08/12/2011	50.8	17.2	10.9	12.6	325	365	319	3.1	4.3	2.7
4	09/12/2011	49.6	16.7	10.7	12.4	349	392	375	3.7	6.2	3.0
5	15/12/2011	48.3	16.0	11.6	13.1	362	405	386	3.5	6.3	2.4
6	16/12/2011	46.2	14.7	12.7	13.6	379	428	406	4.0	5.6	3.4
7	22/12/2011	45.3	14.6	13.5	14.2	412	435	398	2.7	7.1	2.4
8	23/12/2011	42.9	13.1	11.3	12.8	408	442	398	4.1	5.3	3.0
9	29/12/2011	44.9	14.3	11.8	12.7	413	440	429	4.6	6.4	3.4
10	30/12/2011	43.1	15.6	10.5	13.5	398	432	401	3.4	7.1	3.1
11	05/01/2012	41.8	14.7	11.3	14.1	359	412	389	5.0	6.9	2.7
12	06/01/2012	45.6	14.3	10.9	12.4	276	345	298	3.5	7.0	3.5
13	12/01/2012	44.2	13.8	11.7	12.9	296	345	312	4.3	6.2	3.1
14	13/01/2012	42.6	14.1	12.5	14.2	308	356	334	2.8	6.9	2.3
15	19/01/2012	41.9	15.2	13.3	14.8	298	361	324	3.5	6.4	3.0
16	20/01/2012	40.8	14.5	11.9	13.4	264	316	296	3.3	6.1	2.3
17	26/01/2012	39.4	13.6	12.6	14.2	291	315	305	3.7	5.6	2.9
18	27/01/2012	37.1	12.9	13.2	15.7	372	416	384	5.7	7.4	3.2
19	02/02/2012	35.2	12.6	13.3	14.3	321	376	341	3.7	6.6	2.8
20	03/02/2012	35.4	12.1	13.6	14.6	264	326	284	4.5	7.0	3.4
21	09/02/2012	34.6	12.4	12.4	13.4	235	284	268	2.9	4.1	2.8
22	10/02/2012	35.8	11.4	10.6	11.7	238	274	253	4.4	7.2	2.5
23	16/02/2012	35.6	12.2	11.6	12.6	264	332	301	3.2	6.0	2.6
24	17/02/2012	38.9	13.9	10.4	12.5	295	348	326	3.8	5.5	2.5
25	23/02/2012	40.1	13.4	10.9	11.7	320	359	333	4.0	5.8	3.3
26	24/02/2012	42.2	14.6	11.2	12.4	356	426	398	4.6	7.2	3.5
	Min	**34.6**	**11.4**	**10.4**	**11.6**		**235**			**2.3**	
	Max	**55.3**	**17.2**	**13.6**	**15.7**		**442**			**7.4**	
	Avg	**42.7**	**14.2**	**11.8**	**13.2**		**346**			**4.3**	
	98th	**53.4**	**17.0**	**13.6**	**15.3**		**437**			**7.2**	
	All the values are given in µg/m3										

ANNEXURE-VII
AMBIENT AIR QUALITY LEVELS

Sr.No	Monitoring Date	PM_{10}	$PM_{2.5}$	SO_2	NOx	CO			O_3		
	AAQ3 : NEAR DAHEJ VILLAGE										
						I	II	III	I	II	III
1	01/12/2011	38.5	13.1	10.3	12.0	295	324	302	3.6	5.9	2.9
2	02/12/2011	37.2	12.5	12.1	13.7	284	301	297	3.8	6.9	2.8
3	08/12/2011	38.3	12.6	10.8	11.9	274	291	286	3.2	4.7	2.8
4	09/12/2011	37.1	13.1	11.6	13.0	294	334	316	3.9	5.1	3.2
5	15/12/2011	36.4	12.5	11.5	12.3	312	375	334	3.4	6.0	2.7
6	16/12/2011	35.1	11.3	12.7	13.9	328	394	356	3.9	7.0	3.4
7	22/12/2011	34.6	11.5	12.2	13.1	376	391	381	3.8	5.3	2.8
8	23/12/2011	34.9	10.6	11.8	13.0	334	375	362	4.0	5.6	3.2
9	29/12/2011	35.8	11.2	12.7	13.8	321	349	326	3.8	6.7	2.6
10	30/12/2011	34.4	10.3	12.7	13.9	334	359	320	3.7	7.2	2.7
11	05/01/2012	36.5	11.6	10.8	12.0	304	349	337	3.9	7.2	2.4
12	06/01/2012	34.6	10.0	11.4	12.8	345	375	352	3.2	4.7	2.7
13	12/01/2012	36.7	10.3	12.0	12.9	324	357	341	3.5	6.9	2.9
14	13/01/2012	34.8	11.5	12.8	13.6	308	368	342	4.5	5.6	4.2
15	19/01/2012	36.9	11.2	12.1	13.0	289	324	295	4.1	7.3	3.4
16	20/01/2012	38.4	13.1	12.5	13.6	279	312	296	3.5	6.7	3.1
17	26/01/2012	39.1	13.9	12.9	14.6	284	315	305	3.4	4.9	2.8
18	27/01/2012	40.5	13.1	11.4	13.1	296	338	249	3.5	5.5	3.2
19	02/02/2012	41.6	13.2	13.5	16.1	272	297	286	3.8	5.5	2.5
20	03/02/2012	42.7	14.3	12.5	14.6	264	291	274	4.1	7.4	3.6
21	09/02/2012	44.1	15.1	11.5	12.8	238	294	259	4.4	7.6	3.8
22	10/02/2012	45.6	14.6	10.7	13.9	249	276	264	3.9	7.2	3.2
23	16/02/2012	46.3	15.3	12.1	15.1	264	296	276	4.2	6.5	2.4
24	17/02/2012	44.6	14.1	11.6	12.5	295	348	326	3.3	6.9	2.9
25	23/02/2012	47.2	15.3	11.8	13.9	320	359	333	4.2	6.0	3.4
26	24/02/2012	49.6	16.5	12.4	14.1	356	374	323	3.5	4.9	3.2
	Min	**34.4**	**10.0**	**10.3**	**11.9**	**238**			**2.4**		
	Max	**49.6**	**16.5**	**13.5**	**16.1**	**394**			**7.6**		
	Avg	**39.3**	**12.8**	**11.9**	**13.4**	**317**			**4.3**		
	98th	**48.4**	**15.9**	**13.2**	**15.6**	**386**			**7.3**		
	All the values are given in µg/m3										
	AAQ4 : AMBHETA VILLAGE										
Sr.No	**Monitoring Date**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**NOx**	**CO**			**O_3**		
						I	II	III	I	II	III
1	01/12/2011	38.4	10.2	10.8	12.4	221	264	246	3.5	5.8	3.3
2	02/12/2011	36.4	10.0	11.2	13.1	246	284	261	3.8	5.1	3.5
3	08/12/2011	40.4	11.7	12.5	13.5	221	248	234	3.1	4.1	3.0
4	09/12/2011	41.1	11.6	13.1	14.6	238	263	249	3.8	4.9	2.6
5	15/12/2011	43.7	11.5	12.6	13.4	240	279	268	2.9	4.0	2.5
6	16/12/2011	42.1	10.9	11.6	12.5	246	269	251	3.6	4.6	2.3
7	22/12/2011	43.6	9.2	11.1	14.6	254	286	264	3.2	4.9	2.7
8	23/12/2011	42.5	10.3	11.5	12.1	243	261	246	3.9	5.2	3.1
9	29/12/2011	40.4	10.9	12.2	14.2	252	273	235	4.2	5.5	3.4
10	30/12/2011	41.6	11.1	11.4	13.4	221	234	224	3.9	5.6	3.5
11	05/01/2012	39.4	10.4	10.8	12.6	242	259	213	4.1	5.1	3.3
12	06/01/2012	37.7	11.0	11.4	13.1	232	243	215	3.8	4.8	2.9
13	12/01/2012	35.6	10.5	11.9	12.9	221	260	245	3.4	4.5	2.5
14	13/01/2012	39.4	11.2	11.7	12.4	256	286	275	4.1	7.1	3.0
15	19/01/2012	38.4	9.4	11.3	13.3	226	259	235	3.9	6.5	2.6
16	20/01/2012	37.6	10.7	11.1	12.6	212	234	206	3.5	5.2	2.5
17	26/01/2012	34.1	10.5	11.8	13.1	225	239	219	3.9	5.8	3.0
18	27/01/2012	38.5	10.8	12.4	13.9	256	267	251	3.6	5.6	2.9
19	02/02/2012	36.9	10.6	12.1	12.8	248	276	257	3.7	5.4	2.6
20	03/02/2012	35.4	10.5	11.6	13.5	264	294	289	3.5	4.6	2.4
21	09/02/2012	34.8	9.5	11.1	12.8	279	324	310	3.7	5.1	2.6
22	10/02/2012	35.1	10.1	11.8	12.3	240	267	254	3.9	5.5	2.7
23	16/02/2012	34.2	10.6	12.6	14.2	275	294	284	2.9	4.4	3.1
24	17/02/2012	36.5	10.2	11.1	12.1	256	273	249	3.3	5.2	2.3
25	23/02/2012	37.3	10.8	11.8	12.7	220	258	246	3.5	5.6	3.0
26	24/02/2012	36.7	10.5	12.1	13.3	251	281	262	4.0	5.4	3.2
	Min	**34.1**	**9.2**	**10.8**	**12.1**	**206**			**2.3**		
	Max	**43.7**	**11.7**	**13.1**	**14.6**	**324**			**7.1**		
	Avg	**38.4**	**10.6**	**11.7**	**13.1**	**253**			**3.9**		
	98th	**43.7**	**11.7**	**12.9**	**14.6**	**301**			**6.1**		
	All the values are given in µg/m3										

ANNEXURE-VII
AMBIENT AIR QUALITY LEVELS

	AAQ5 : JAGESHWAR VILLAGE										
Sr.No	Monitoring Date	PM_{10}	$PM_{2.5}$	SO_2	NOx	CO			O_3		
						I	II	III	I	II	III
1	01/12/2011	39.6	13.5	11.7	12.7	242	264	256	3.7	6.5	3.1
2	02/12/2011	42.1	13.9	12.1	13.1	251	276	264	3.5	6.7	2.4
3	08/12/2011	37.4	12.1	12.7	13.6	275	312	294	3.3	6.4	3.0
4	09/12/2011	36.1	11.3	11.4	13.4	259	271	235	3.1	6.3	2.7
5	15/12/2011	35.3	12.1	12.5	13.9	256	279	268	2.9	5.7	2.3
6	16/12/2011	34.5	12.8	13.5	14.6	246	269	251	2.7	5.5	2.5
7	22/12/2011	35.1	11.1	11.9	13.1	275	295	256	3.4	5.5	2.8
8	23/12/2011	33.9	11.5	11.8	13.5	265	281	258	3.5	6.7	2.3
9	29/12/2011	35.1	11.1	13.0	14.9	294	316	285	3.9	5.8	2.7
10	30/12/2011	36.8	9.5	12.1	13.5	284	297	264	3.7	5.0	2.6
11	05/01/2012	34.5	10.6	11.6	14.2	268	285	258	3.2	6.5	2.8
12	06/01/2012	36.7	10.2	12.5	13.4	256	269	215	3.8	7.3	3.3
13	12/01/2012	35.4	11.2	12.1	13.8	221	260	245	3.5	4.7	3.2
14	13/01/2012	36.1	12.2	12.4	15.0	256	286	275	3.8	5.9	2.8
15	19/01/2012	34.8	11.5	11.5	13.5	245	259	264	4.5	6.2	4.0
16	20/01/2012	38.1	10.2	12.1	14.6	234	245	216	3.5	5.0	2.5
17	26/01/2012	33.9	10.6	12.7	13.8	235	256	249	4.2	5.3	2.6
18	27/01/2012	35.1	9.8	11.1	13.8	256	267	275	3.7	5.8	2.3
19	02/02/2012	34.5	11.8	12.4	14.3	248	276	257	4.1	5.7	2.7
20	03/02/2012	35.8	10.5	12.1	12.8	264	294	289	3.6	4.8	2.4
21	09/02/2012	33.6	11.3	12.6	13.8	281	304	294	3.2	6.2	2.8
22	10/02/2012	33.7	11.8	13.4	14.9	249	294	276	3.5	5.5	3.0
23	16/02/2012	34.8	10.4	12.1	12.8	275	305	284	4.4	7.1	3.6
24	17/02/2012	34.8	12.3	12.7	13.9	294	334	312	3.2	4.9	2.4
25	23/02/2012	35.6	12.0	13.4	15.1	259	289	243	2.9	4.7	2.5
26	24/02/2012	36.1	11.7	14.3	15.4	275	316	289	2.8	5.6	2.6
	Min	**33.6**	**9.5**	**11.1**	**12.7**		**215**			**2.3**	
	Max	**42.1**	**13.9**	**14.3**	**15.4**		**334**			**7.3**	
	Avg	**35.7**	**11.4**	**12.4**	**13.9**		**270**			**4.0**	
	98th	**40.9**	**13.7**	**13.9**	**15.3**		**316**			**6.9**	
	All the values are given in µg/m3										

	AAQ6 : LUVARA VILLAGE										
Sr.No	Monitoring Date	PM_{10}	$PM_{2.5}$	SO_2	NOx	CO			O_3		
						I	II	III	I	II	III
1	01/12/2011	56.2	17.3	12.1	13.1	375	402	389	3.2	6.6	2.6
2	02/12/2011	52.3	16.2	11.5	12.2	394	412	388	3.6	7.6	2.8
3	08/12/2011	51.2	16.4	13.0	14.1	401	429	403	3.8	5.8	2.7
4	09/12/2011	50.1	17.3	11.8	12.7	406	426	416	3.1	7.2	2.4
5	15/12/2011	47.9	16.8	11.2	12.2	398	428	399	3.3	6.3	2.5
6	16/12/2011	46.8	16.1	12.1	13.5	394	418	411	3.7	6.7	2.6
7	22/12/2011	46.2	15.9	11.2	12.4	368	412	396	4.1	7.2	2.8
8	23/12/2011	45.2	14.9	11.8	13.0	376	436	416	3.3	5.1	2.9
9	29/12/2011	44.6	15.3	13.0	13.5	389	409	398	4.6	7.5	3.6
10	30/12/2011	46.2	16.4	12.2	13.0	412	446	430	3.5	6.2	2.5
11	05/01/2012	47.3	15.4	13.8	14.5	406	421	402	3.4	6.9	2.7
12	06/01/2012	48.1	14.8	15.0	16.2	349	394	363	3.9	6.5	2.9
13	12/01/2012	49.6	15.6	15.5	16.9	336	391	379	3.6	5.9	2.7
14	13/01/2012	50.2	16.2	15.9	17.0	359	378	365	3.8	7.0	2.8
15	19/01/2012	47.2	15.6	15.5	15.9	354	391	371	4.5	6.0	3.2
16	20/01/2012	45.3	13.9	12.8	14.2	378	412	377	4.1	6.8	2.7
17	26/01/2012	44.1	14.6	12.1	13.0	339	384	360	2.8	3.9	2.4
18	27/01/2012	46.9	15.1	11.5	13.5	353	399	380	3.7	7.5	3.1
19	02/02/2012	48.2	16.3	12.2	14.0	323	388	356	3.9	7.7	2.6
20	03/02/2012	49.3	15.4	13.2	14.0	334	401	358	3.5	7.1	2.5
21	09/02/2012	50.6	15.9	12.5	13.0	322	346	332	3.6	5.9	2.8
22	10/02/2012	51.6	16.2	11.9	13.2	335	398	370	4.1	7.0	2.4
23	16/02/2012	49.6	16.8	14.9	16.5	305	370	315	4.4	7.6	3.4
24	17/02/2012	47.3	15.3	13.8	14.9	313	387	366	3.5	6.9	2.6
25	23/02/2012	46.1	14.9	13.0	13.7	325	368	359	3.5	6.9	2.9
26	24/02/2012	44.3	15.4	12.4	13.4	359	397	388	3.9	5.3	2.7
	Min	**44.1**	**13.9**	**11.2**	**12.2**		**305**			**2.4**	
	Max	**56.2**	**17.3**	**15.9**	**17.0**		**446**			**7.7**	
	Avg	**48.2**	**15.8**	**12.9**	**14.0**		**381**			**4.4**	
	98th	**54.3**	**17.3**	**15.7**	**17.0**		**433**			**7.6**	
	All the values are given in µg/m3										

ANNEXURE-VII
AMBIENT AIR QUALITY LEVELS

	AAQ7 : SE OF PLANT										
Sr.No	Monitoring Date	PM_{10}	$PM_{2.5}$	SO_2	NOx	CO			O_3		
						I	II	III	I	II	III
1	01/12/2011	55.3	17.3	11.6	12.5	414	476	432	4.2	7.1	3.5
2	02/12/2011	51.4	16.5	12.5	13.2	428	494	465	3.6	4.8	3.0
3	08/12/2011	50.8	16.9	13.6	14.2	454	507	489	4.0	5.9	3.2
4	09/12/2011	49.6	16.5	14.4	15.2	442	494	472	3.8	6.7	3.1
5	15/12/2011	52.6	16.8	15.9	16.3	409	459	436	3.6	5.8	2.8
6	16/12/2011	53.9	17.0	13.7	14.2	436	497	475	3.9	5.1	3.0
7	22/12/2011	54.8	17.4	16.2	17.3	442	486	469	4.0	6.3	3.1
8	23/12/2011	51.8	16.2	14.1	15.3	436	465	465	3.9	6.8	3.3
9	29/12/2011	50.9	16.6	15.9	16.4	412	449	406	3.4	6.0	2.6
10	30/12/2011	49.2	17.4	17.6	18.5	431	475	432	5.0	6.5	4.0
11	05/01/2012	51.8	18.4	19.4	20.4	442	482	460	4.6	7.6	3.6
12	06/01/2012	52.6	17.3	17.6	18.2	426	497	451	3.7	7.3	3.0
13	12/01/2012	54.7	19.4	16.3	17.2	437	479	449	3.7	5.9	2.9
14	13/01/2012	55.8	18.2	17.5	18.6	416	476	436	3.5	6.9	2.9
15	19/01/2012	57.3	18.6	14.6	15.3	445	462	441	3.7	6.2	2.7
16	20/01/2012	54.2	16.8	13.5	14.4	461	481	453	3.5	6.5	2.5
17	26/01/2012	52.3	17.9	15.6	16.4	436	459	426	3.4	5.7	2.8
18	27/01/2012	55.6	18.6	17.2	18.2	453	459	426	4.2	7.1	3.1
19	02/02/2012	56.1	18.9	16.4	17.2	435	462	429	3.6	7.5	2.6
20	03/02/2012	57.4	17.6	15.9	16.4	451	462	452	3.5	4.9	2.5
21	09/02/2012	55.9	17.5	17.2	17.9	459	476	434	3.7	5.1	2.9
22	10/02/2012	56.8	18.6	15.6	16.2	430	472	451	4.3	6.3	2.5
23	16/02/2012	54.2	17.3	13.4	14.5	455	472	424	4.0	6.6	2.9
24	17/02/2012	51.8	17.1	12.8	13.4	313	359	334	3.5	5.2	3.0
25	23/02/2012	52.3	16.5	14.7	15.9	361	416	397	4.1	6.3	2.9
26	24/02/2012	51.4	16.6	15.2	15.9	386	423	394	3.6	6.7	2.7
	Min	**49.2**	**16.2**	**11.6**	**12.5**		**313**			**2.5**	
	Max	**57.4**	**19.4**	**19.4**	**20.4**		**507**			**7.6**	
	Avg	**53.5**	**17.5**	**15.3**	**16.1**		**444**			**4.4**	
	98th	**57.4**	**19.2**	**18.5**	**19.5**		**497**			**7.4**	
	All the values are given in µg/m3										
	AAQ8 : NEAR ALIABET VILLAGE										
Sr.No	Monitoring Date	PM_{10}	$PM_{2.5}$	SO_2	NOx	CO			O_3		
						I	II	III	I	II	III
1	01/12/2011	33.9	8.5	11.6	13.4	246	282	259	3.9	5.9	3.3
2	02/12/2011	34.4	9.3	11.3	13.7	232	256	245	3.4	5.1	2.9
3	08/12/2011	35.6	9.1	11.0	12.7	220	237	212	3.6	5.0	3.0
4	09/12/2011	35.2	9.9	10.2	12.0	195	235	221	3.5	5.1	3.0
5	15/12/2011	36.6	8.6	10.9	12.3	241	254	224	3.2	5.2	2.7
6	16/12/2011	37.4	10.8	11.2	12.4	224	269	245	3.3	5.0	3.1
7	22/12/2011	36.4	9.2	11.4	12.7	207	248	221	4.0	7.0	2.7
8	23/12/2011	35.4	10.2	11.6	13.0	196	232	172	3.6	6.6	3.0
9	29/12/2011	36.6	10.0	10.8	13.0	172	199	185	3.0	5.4	2.6
10	30/12/2011	34.3	10.5	11.3	12.7	213	251	234	3.6	5.1	2.3
11	05/01/2012	37.1	11.6	11.0	13.0	208	245	223	3.4	5.2	3.0
12	06/01/2012	40.4	10.7	11.2	12.7	251	263	237	3.5	5.4	2.7
13	12/01/2012	35.6	9.5	10.7	12.5	224	245	235	3.6	5.5	2.7
14	13/01/2012	36.4	8.7	11.0	12.7	201	231	195	3.7	5.7	3.1
15	19/01/2012	34.4	9.2	11.5	13.0	176	198	159	3.4	6.2	2.5
16	20/01/2012	35.5	9.4	11.2	12.5	156	186	143	3.8	5.5	3.0
17	26/01/2012	34.1	10.5	11.7	12.7	186	205	173	3.5	5.4	2.6
18	27/01/2012	35.4	11.1	10.9	12.0	157	169	175	3.8	5.5	3.0
19	02/02/2012	33.8	10.2	10.7	11.4	143	165	151	3.5	5.9	2.8
20	03/02/2012	34.4	9.1	11.2	12.7	152	195	173	3.4	5.3	2.9
21	09/02/2012	33.5	9.5	11.5	12.5	177	193	168	3.2	4.4	2.7
22	10/02/2012	35.3	8.7	11.8	12.7	227	258	214	3.9	4.9	2.2
23	16/02/2012	34.2	8.6	11.4	13.5	251	279	264	3.3	5.4	2.5
24	17/02/2012	35.9	9.6	11.0	13.0	225	253	224	4.2	5.1	3.1
25	23/02/2012	33.8	9.1	11.2	12.7	212	251	234	3.7	6.0	2.5
26	24/02/2012	34.3	9.9	10.9	12.5	221	235	229	3.3	5.4	2.7
	Min	**33.5**	**8.5**	**10.2**	**11.4**		**143**			**2.2**	
	Max	**40.4**	**11.6**	**11.8**	**13.7**		**282**			**7.0**	
	Avg	**35.4**	**9.7**	**11.2**	**12.7**		**215**			**3.9**	
	98th	**38.9**	**11.4**	**11.8**	**13.6**		**274**			**6.4**	
	All the values are given in µg/m3										

ANNEXURE-VII
AMBIENT AIR QUALITY LEVELS

PETRONET LNG, DAHEJ (PRE-MONSOON, MARCH TO MAY 2012)											
	AAQ1:PLANT SITE										
Sr.No	**Monitoring Date**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**NOx**	**CO**			**O_3**		
						I	**II**	**III**	**I**	**II**	**III**
1	01/03/2012	60.8	22.6	14.9	16.1	324	368	289	4.6	6.7	3.4
2	02/03/2012	63.0	20.5	14.2	15.5	338	352	289	4.2	6.4	3.6
3	08/03/2012	65.1	21.4	12.4	12.8	278	331	306	3.4	6.5	3.2
4	09/03/2012	61.4	23.0	15.3	15.7	301	367	328	3.8	7.1	3.5
5	15/03/2012	62.8	23.1	14.1	15.4	356	384	326	4.0	7.3	3.6
6	16/03/2012	64.0	23.8	15.5	16.1	319	355	280	3.6	6.7	3.4
7	22/03/2012	54.3	21.4	12.1	12.8	323	363	297	3.7	7.5	3.5
8	23/03/2012	52.3	20.8	12.4	13.1	351	390	354	4.2	6.6	3.5
9	29/03/2012	55.1	20.5	11.9	12.7	306	317	312	4.5	7.2	3.6
10	30/03/2012	57.2	21.1	13.4	14.8	321	370	353	3.6	6.5	3.4
11	05/04/2012	61.4	21.6	10.1	13.8	328	389	371	3.6	7.5	3.1
12	06/04/2012	58.5	21.4	12.4	13.7	289	344	317	3.9	7.1	2.9
13	12/04/2012	54.4	20.3	13.1	14.8	286	360	306	4.0	7.7	3.3
14	13/04/2012	53.2	20.7	12.5	13.8	315	387	367	3.9	6.8	2.8
15	19/04/2012	59.9	22.8	10.5	12.6	283	297	289	3.9	8.0	3.5
16	20/04/2012	62.5	22.0	10.3	11.5	359	384	364	3.6	7.9	3.4
17	26/04/2012	60.3	23.3	11.3	11.7	364	414	388	3.9	5.9	3.7
18	27/04/2012	62.5	20.0	12.5	14.7	339	394	366	3.8	6.3	3.5
19	03/05/2012	64.8	22.4	11.1	12.2	331	388	377	4.2	6.8	3.8
20	04/05/2012	63.3	21.1	14.2	15.0	352	388	370	3.5	6.6	2.9
21	10/05/2012	64.2	22.4	15.3	16.5	305	384	375	4.7	7.1	4.4
22	11/05/2012	59.8	23.3	15.8	16.0	327	408	389	3.6	5.8	3.4
23	17/05/2012	61.3	22.1	14.1	15.8	327	390	388	3.5	6.5	2.8
24	18/05/2012	59.2	20.4	13.4	14.1	288	357	267	4.0	6.1	3.9
25	24/05/2012	56.4	18.6	14.9	15.8	362	392	381	4.5	7.5	3.5
26	25/05/2012	58.4	22.8	13.2	14.7	336	403	316	4.9	7.2	4.5
	Min	**52.3**	**18.6**	**10.1**	**11.5**	**267**			**2.8**		
	Max	**65.1**	**23.8**	**15.8**	**16.5**	**414**			**8.0**		
	Avg	**59.8**	**21.7**	**13.1**	**14.3**	**344**			**4.8**		
	98th	**64.9**	**23.5**	**15.7**	**16.3**	**405**			**7.8**		
	All the values are given in µg/m3										
	AAQ2 : LAKHIGAM VILLAGE										
Sr.No	**Monitoring Date**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**NOx**	**CO**			**O_3**		
						I	**II**	**III**	**I**	**II**	**III**
1	01/03/2012	35.6	12.8	10.6	12.3	285	333	279	3.2	7.0	3.0
2	02/03/2012	38.5	13.5	9.5	11.2	284	316	288	3.1	7.4	2.9
3	08/03/2012	40.1	13.3	11.2	12.0	310	334	299	3.5	7.6	3.1
4	09/03/2012	37.0	14.0	10.9	11.5	301	336	286	3.8	7.3	3.1
5	15/03/2012	38.5	15.7	11.3	13.4	290	341	275	3.4	7.4	3.2
6	16/03/2012	39.0	14.5	10.5	12.9	289	336	295	3.1	6.1	3.0
7	22/03/2012	57.6	18.8	11.4	12.4	311	352	315	3.2	6.9	2.7
8	23/03/2012	49.9	19.5	12.3	12.9	305	343	303	4.0	7.0	3.2
9	29/03/2012	50.1	17.3	11.1	11.8	309	334	296	3.8	7.7	2.8
10	30/03/2012	53.2	17.8	11.6	12.5	298	329	284	3.4	6.4	3.1
11	05/04/2012	50.9	16.9	12.9	13.7	276	320	289	3.1	7.3	2.9
12	06/04/2012	49.6	16.3	12.9	13.4	274	326	268	3.2	7.3	2.7
13	12/04/2012	47.7	17.0	12.3	13.4	298	310	276	3.5	7.3	2.9
14	13/04/2012	47.0	16.5	11.8	12.5	292	312	274	3.8	7.5	3.7
15	19/04/2012	48.1	16.8	11.7	13.9	315	336	291	3.3	6.0	2.9
16	20/04/2012	49.0	17.0	12.9	14.2	310	343	280	3.7	7.9	3.3
17	26/04/2012	59.6	16.7	12.5	13.5	298	325	286	3.4	7.2	3.0
18	27/04/2012	61.9	15.9	12.3	12.9	296	330	291	3.7	7.4	3.2
19	03/05/2012	50.6	15.1	11.9	13.2	296	326	280	3.5	7.5	3.1
20	04/05/2012	51.9	17.1	12.2	13.8	310	336	291	3.5	7.7	2.8
21	10/05/2012	48.6	17.7	12	13.1	300	315	283	3.6	7.0	2.8
22	11/05/2012	37.9	15.1	12.5	13.4	279	300	276	3.6	7.7	3.5
23	17/05/2012	40.1	14.5	11.1	12.9	221	253	235	3.2	7.4	3.0
24	18/05/2012	40.6	15.1	11.9	12.8	241	269	238	3.4	7.1	2.7
25	24/05/2012	39.0	16.5	11.5	12.6	269	298	266	3.1	6.2	3.0
26	25/05/2012	37.5	14.1	11.4	14.1	283	339	271	2.9	7.6	2.7
	Min	**35.6**	**12.8**	**9.5**	**11.2**	**221**			**2.7**		
	Max	**61.9**	**19.5**	**12.9**	**14.2**	**352**			**7.9**		
	Avg	**46.1**	**16.0**	**11.7**	**12.9**	**298**			**4.5**		
	98th	**60.8**	**19.2**	**12.9**	**14.2**	**343**			**7.7**		

ANNEXURE-VII
AMBIENT AIR QUALITY LEVELS

	All the values are given in µg/m3										
	AAQ3 : NEAR DAHEJ VILLAGE										
Sr.No	**Monitoring Date**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**NOx**	**CO**			**O_3**		
						I	**II**	**III**	**I**	**II**	**III**
1	01/03/2012	48.4	15.9	11.8	12.3	279	298	271	3.9	6.6	3.0
2	02/03/2012	51.6	16.7	11.6	13.6	290	339	299	4.2	8.0	3.2
3	08/03/2012	52.7	18.9	12.4	13.0	284	323	278	3.2	7.4	2.8
4	09/03/2012	53.5	19.2	12.0	13.8	310	354	308	3.1	6.9	2.8
5	15/03/2012	56.6	18.9	11.1	12.9	293	318	288	4.4	6.9	3.2
6	16/03/2012	59.0	19.3	11.7	12.4	289	326	281	3.8	7.7	2.8
7	22/03/2012	51.4	17.8	10.8	13.2	280	330	278	3.4	7.8	2.9
8	23/03/2012	48.9	17.9	11.3	12.1	294	347	298	3.1	6.5	2.7
9	29/03/2012	58.5	18.9	11.6	12.4	273	324	284	3.2	7.3	2.9
10	30/03/2012	57.6	18.8	12.0	13.4	290	324	286	4.0	7.4	3.1
11	05/04/2012	55.6	19.1	11.7	13.1	310	340	301	3.8	7.5	3.0
12	06/04/2012	51.3	19.3	11.0	12.7	314	350	318	3.4	6.8	2.8
13	12/04/2012	55.2	18.8	10.8	12.1	308	323	280	3.6	8.0	2.9
14	13/04/2012	57.1	18.7	12.2	13.3	293	340	313	3.9	7.1	3.2
15	19/04/2012	46.2	14.6	10.3	13.1	310	338	323	3.7	7.7	2.9
16	20/04/2012	44.5	13.4	10.1	10.8	299	321	279	4.1	7.9	3.6
17	26/04/2012	43.4	15.3	10.3	11.7	283	310	277	3.1	6.4	2.8
18	27/04/2012	45.2	15.7	10.0	11.6	267	314	261	3.4	6.8	2.9
19	03/05/2012	40.3	14.9	10.9	12.2	287	318	299	3.4	7.6	2.7
20	04/05/2012	38.6	14.7	10.6	11.8	297	325	288	3.7	7.8	2.9
21	10/05/2012	46.3	15.8	10.4	11.9	231	286	239	3.5	7.9	2.8
22	11/05/2012	40.7	14.3	11.0	11.5	246	294	274	3.5	6.6	2.9
23	17/05/2012	39.4	13.4	10.0	12.0	318	360	332	3.6	7.4	3.0
24	18/05/2012	36.6	13.2	10.2	11.5	322	373	332	3.6	8.0	3.2
25	24/05/2012	45.8	17.1	12.0	13.3	329	340	310	3.2	7.8	2.7
26	25/05/2012	47.3	16.2	12.3	13.2	287	307	278	3.4	7.5	2.9
	Min	**36.6**	**13.2**	**10.0**	**10.8**	**231**			**2.7**		
	Max	**59.0**	**19.3**	**12.4**	**13.8**	**373**			**8.0**		
	Avg	**48.9**	**16.8**	**11.2**	**12.5**	**304**			**4.6**		
	98th	**58.8**	**19.3**	**12.4**	**13.7**	**357**			**8.0**		
	All the values are given in µg/m3										
	AAQ4 : AMBHETA VILLAGE										
Sr.No	**Monitoring Date**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**NOx**	**CO**			**O_3**		
						I	**II**	**III**	**I**	**II**	**III**
1	01/03/2012	37.5	12.5	9.6	10.6	253	270	259	4.8	6.2	3.0
2	02/03/2012	36.8	11.6	9.3	11.1	267	297	283	4.3	6.5	2.7
3	08/03/2012	50.2	14.2	9.8	11.1	250	261	246	4.7	6.6	3.1
4	09/03/2012	51.0	15.1	9.6	10.6	228	270	238	4.2	5.7	2.8
5	15/03/2012	43.8	14.3	10.5	11.1	239	245	238	3.8	7.1	3.1
6	16/03/2012	42.7	13.9	10.3	11.5	232	256	251	4.1	6.4	3.4
7	22/03/2012	45.8	14.9	10.9	12.1	251	265	246	4.5	6.3	3.4
8	23/03/2012	45.3	14.8	10.8	11.9	248	259	245	3.8	5.8	2.8
9	29/03/2012	43.6	14.2	10.5	11.8	238	246	240	3.7	5.6	2.8
10	30/03/2012	42.2	13.7	10.3	11.4	229	251	242	2.9	5.5	2.6
11	05/04/2012	51.2	14.3	12.0	12.8	239	263	252	3.5	5.9	2.9
12	06/04/2012	47.3	14.4	11.7	13.1	241	275	254	3.1	5.2	2.6
13	12/04/2012	46.9	15.3	11.1	12.5	257	284	270	3.9	6.4	3.4
14	13/04/2012	45.3	14.8	10.8	12.1	248	282	261	3.7	6.0	2.7
15	19/04/2012	45.6	13.6	10.9	11.8	250	264	256	3.5	6.1	2.7
16	20/04/2012	43.7	12.8	10.5	11.8	238	258	251	3.3	6.4	2.8
17	26/04/2012	42.0	12.6	10.2	11.4	228	247	241	4.0	6.4	3.2
18	27/04/2012	43.0	13.2	10.4	11.1	234	257	243	3.8	5.6	2.7
19	03/05/2012	42.5	13.8	10.3	11.3	231	252	236	4.5	6.7	3.1
20	04/05/2012	44.3	14.4	10.6	11.2	242	267	258	4.3	5.9	3.0
21	10/05/2012	49.3	15.0	11.3	11.6	252	266	265	3.2	6.5	2.8
22	11/05/2012	48.4	15.3	11.7	12.3	258	264	253	4.4	6.4	3.7
23	17/05/2012	39.2	12.6	9.7	12.4	232	253	224	4.8	6.2	3.6
24	18/05/2012	38.4	12.1	10.1	11.6	225	231	221	4.4	6.1	3.2
25	24/05/2012	52.2	14.2	9.5	11.0	238	257	205	5.1	7.3	4.4
26	25/05/2012	47.0	13.6	9.8	11.4	189	218	194	3.3	6.8	2.9
	Min	**36.8**	**11.6**	**9.3**	**10.6**	**189**			**2.6**		
	Max	**52.2**	**15.3**	**12.0**	**13.1**	**297**			**7.3**		
	Avg	**44.8**	**13.9**	**10.5**	**11.6**	**248**			**4.4**		
	98th	**51.7**	**15.3**	**11.9**	**13.0**	**283**			**6.9**		
	All the values are given in µg/m3										

ANNEXURE-VII
AMBIENT AIR QUALITY LEVELS

	AAQ5 : JAGESHWAR VILLAGE										
Sr.No	**Monitoring Date**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**NOx**	**CO**			**O_3**		
						I	**II**	**III**	**I**	**II**	**III**
1	05/03/2012	41.4	14.0	10.6	12.1	243	269	236	4.6	6.4	2.5
2	06/03/2012	45.1	15.3	13.0	14.4	262	299	266	4.3	7.5	3.3
3	12/03/2012	42.6	15.7	12.3	13.3	275	292	259	4.9	7.2	3.5
4	13/03/2012	39.5	13.3	10.6	11.8	276	284	266	3.6	5.7	2.9
5	19/03/2012	37.9	12.8	10.4	11.4	263	274	237	3.9	6.3	3.0
6	20/03/2012	39.0	13.2	10.1	11.7	258	288	269	3.7	5.5	2.7
7	26/03/2012	40.5	13.7	10.4	12.3	262	268	249	3.5	6.0	2.6
8	27/03/2012	39.8	14.2	10.7	11.8	253	299	260	3.8	6.1	2.6
9	02/04/2012	42.4	14.3	12.5	13.3	264	288	256	4.3	5.4	3.4
10	03/04/2012	42.3	14.3	13.0	14.4	280	285	276	4.4	6.9	3.2
11	09/04/2012	43.4	14.7	12.4	13.3	264	266	258	3.4	5.1	2.5
12	10/04/2012	40.6	14.9	12.6	13.6	263	282	259	3.8	6.4	2.7
13	16/04/2012	43.4	14.7	11.7	12.5	256	284	269	3.7	6.9	2.9
14	17/04/2012	42.4	14.3	10.7	12.3	277	278	267	5.3	6.7	2.7
15	23/04/2012	41.4	14.0	10.6	11.7	261	286	272	3.8	6.8	2.6
16	24/04/2012	39.4	13.3	10.2	12.2	282	265	250	4.6	6.0	3.1
17	30/04/2012	36.8	13.7	9.7	11.9	266	269	259	3.1	6.7	2.5
18	01/05/2012	38.4	13.4	9.5	10.6	250	274	255	3.8	6.2	3.0
19	07/05/2012	39.3	13.3	10.8	12.2	212	241	229	3.6	5.9	3.0
20	08/05/2012	41.7	13.7	10.4	11.9	265	287	269	4.0	5.4	2.9
21	14/05/2012	36.7	11.9	9.8	11.2	226	242	215	6.0	7.2	3.2
22	15/05/2012	37.9	11.8	10.0	10.9	223	246	204	4.0	6.4	2.8
23	21/05/2012	36.6	11.2	9.7	11.4	268	286	266	4.8	6.8	3.4
24	22/05/2012	37.4	12.4	10.4	11.0	230	269	243	3.6	5.1	2.8
25	28/05/2012	38.0	12.8	10.9	12.2	262	271	235	4.7	7.0	3.3
26	29/05/2012	40.5	13.7	11.6	13.2	248	274	257	3.5	5.8	2.5
	Min	**36.6**	**11.2**	**9.5**	**10.6**	**204**			**2.5**		
	Max	**45.1**	**15.7**	**13.0**	**14.4**	**299**			**7.5**		
	Avg	**40.2**	**13.6**	**10.9**	**12.3**	**262**			**4.4**		
	98th	**44.3**	**15.5**	**13.0**	**14.4**	**295**			**7.2**		
	All the values are given in µg/m3										

	AAQ6 : LUVARA VILLAGE										
Sr.No	**Monitoring Date**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**NOx**	**CO**			**O_3**		
						I	**II**	**III**	**I**	**II**	**III**
1	05/03/2012	54.9	19.1	11.2	12.6	313	325	319	3.5	7.2	3.2
2	06/03/2012	50.1	18.5	12.1	14.1	319	340	307	3.8	6.6	3.2
3	12/03/2012	52.7	17.7	11.9	13.1	325	345	312	4.0	7.8	3.1
4	13/03/2012	54.1	19.1	11.5	12.8	312	329	304	3.6	7.7	3.3
5	19/03/2012	51.4	17.7	10.3	11.6	299	320	295	3.6	7.3	2.9
6	20/03/2012	50.1	16.1	10.8	12.2	312	325	310	3.9	6.0	3.1
7	26/03/2012	54.2	16.8	10.2	11.5	322	341	319	3.2	7.2	2.7
8	27/03/2012	51.7	18.7	10.5	10.9	291	317	288	3.6	7.9	3.0
9	02/04/2012	50.3	17.0	11.0	11.9	290	305	294	3.6	7.0	2.8
10	03/04/2012	53.0	16.2	11.6	12.7	303	326	309	3.7	6.3	3.3
11	09/04/2012	52.4	17.0	12.0	13.5	285	314	283	3.5	7.4	2.9
12	10/04/2012	56.0	17.7	12.4	14.2	326	384	334	3.4	7.7	3.0
13	16/04/2012	50.3	16.8	11.8	13.7	320	354	326	3.9	6.8	3.2
14	17/04/2012	52.1	17.4	11.3	12.9	325	336	321	3.5	6.4	3.0
15	23/04/2012	49.5	15.1	11.6	12.8	337	349	325	3.6	5.3	2.7
16	24/04/2012	51.3	15.2	11.5	13.6	300	332	308	3.9	7.6	3.3
17	30/04/2012	63.1	21.4	11.9	14.8	305	314	297	3.4	7.7	2.9
18	01/05/2012	58.6	20.5	11.6	14.2	307	346	308	3.2	6.1	2.7
19	07/05/2012	55.0	18.8	11.4	13.5	319	344	322	3.5	6.4	2.8
20	08/05/2012	52.2	16.6	12.2	12.9	310	362	299	3.9	7.6	3.0
21	14/05/2012	55.8	18.9	12.4	13.4	342	355	334	4.2	7.3	3.8
22	15/05/2012	56.6	18.1	11.6	11.9	293	314	290	3.8	6.3	3.5
23	21/05/2012	53.1	18.7	13.8	14.9	315	329	322	3.9	7.9	3.2
24	22/05/2012	54.8	16.6	13.1	14.4	322	346	326	3.6	7.6	2.9
25	28/05/2012	53.6	17.8	10.8	12.3	325	337	314	3.2	6.1	2.7
26	29/05/2012	50.5	15.7	9.7	11.0	300	320	289	4.0	6.6	3.2
	Min	**49.5**	**15.1**	**9.7**	**10.9**	**283**			**2.7**		
	Max	**63.1**	**21.4**	**13.8**	**14.9**	**384**			**7.9**		
	Avg	**53.4**	**17.7**	**11.5**	**13.0**	**319**			**4.6**		
	98th	**60.9**	**21.0**	**13.5**	**14.9**	**358**			**7.8**		
	All the values are given in µg/m3										

ANNEXURE-VII
AMBIENT AIR QUALITY LEVELS

	AAQ7 : SE OF PLANT										
Sr.No	**Monitoring Date**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**NOx**	**CO**			**O_3**		
						I	**II**	**III**	**I**	**II**	**III**
1	05/03/2012	54.2	17.9	10.1	10.9	369	399	351	3.6	7.6	2.7
2	06/03/2012	57.8	19.2	10.7	12.3	374	382	359	3.7	6.9	2.9
3	12/03/2012	59.5	20.3	10.9	12.5	349	387	336	3.9	7.5	3.0
4	13/03/2012	56.1	18.7	10.0	10.9	339	366	326	4.1	6.9	2.9
5	19/03/2012	55.7	17.3	10.5	12.6	384	407	373	3.6	6.4	2.9
6	20/03/2012	57.5	19.1	10.3	12.0	369	391	359	3.5	6.6	2.8
7	26/03/2012	63.5	20.2	10.5	11.5	351	382	338	4.1	7.6	2.9
8	27/03/2012	60.7	19.9	10.2	12.0	344	381	333	3.5	7.2	2.7
9	02/04/2012	61.0	20.3	10.9	11.9	366	391	356	4.1	7.0	3.3
10	03/04/2012	59.6	20.0	10.1	12.2	365	401	351	3.9	7.3	3.1
11	09/04/2012	60.6	19.1	10.8	12.0	375	397	357	3.8	7.8	2.9
12	10/04/2012	58.9	19.6	10.5	11.6	322	340	319	4.0	8.0	3.1
13	16/04/2012	57.6	18.4	10.3	11.9	310	328	293	3.8	6.5	2.8
14	17/04/2012	61.1	20.4	10.9	12.5	370	408	350	3.6	7.5	2.6
15	23/04/2012	55.8	18.5	12.6	14.5	364	396	346	4.6	6.2	3.7
16	24/04/2012	56.0	17.7	12.1	13.9	363	398	350	4.2	7.7	2.9
17	30/04/2012	53.2	18.7	10.0	12.1	365	411	359	3.6	7.3	2.6
18	01/05/2012	51.1	19.4	10.6	11.8	368	394	356	3.5	4.9	2.7
19	07/05/2012	57.5	19.1	10.3	11.5	360	376	351	3.6	6.1	2.7
20	08/05/2012	59.2	19.7	10.6	11.6	351	368	334	3.9	6.1	3.0
21	14/05/2012	56.3	19.6	11.8	13.0	379	406	359	4.2	7.0	3.1
22	15/05/2012	60.0	20.1	11.2	12.9	350	403	346	4.3	7.2	3.3
23	21/05/2012	57.0	18.0	10.2	11.7	356	397	343	4.0	7.8	2.7
24	22/05/2012	59.4	19.4	10.6	12.5	363	376	347	4.3	7.1	2.7
25	28/05/2012	56.8	18.9	13.1	14.5	370	391	359	4.0	7.5	3.1
26	29/05/2012	55.5	18.1	13.7	15.5	366	408	349	4.3	6.6	2.9
	Min	**51.1**	**17.3**	**10.0**	**10.9**	**293**			**2.6**		
	Max	**63.5**	**20.4**	**13.7**	**15.5**	**411**			**8.0**		
	Avg	**57.8**	**19.1**	**10.9**	**12.4**	**364**			**4.6**		
	98th	**62.3**	**20.4**	**13.4**	**15.0**	**408**			**7.8**		
	All the values are given in µg/m3										
	AAQ8 : NEAR ALIABET VILLAGE										
Sr.No	**Monitoring Date**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**NOx**	**CO**			**O_3**		
						I	**II**	**III**	**I**	**II**	**III**
1	05/03/2012	36.6	11.6	9.7	10.8	208	226	203	3.2	6.7	2.7
2	06/03/2012	37.7	12.6	9.5	11.1	206	235	194	3.5	6.2	3.2
3	12/03/2012	39.3	13.2	9.4	11.3	225	247	220	3.2	5.8	2.8
4	13/03/2012	36.2	11.4	10.2	11.0	220	237	216	3.5	6.5	3.1
5	19/03/2012	34.7	11.0	10.1	11.3	210	236	208	3.6	6.5	3.0
6	20/03/2012	36.6	12.9	9.9	11.8	189	205	171	3.2	6.1	2.7
7	26/03/2012	40.3	14.7	9.4	10.4	185	219	180	3.9	6.8	3.1
8	27/03/2012	36.8	11.2	9.8	10.6	195	220	190	3.4	6.7	2.9
9	02/04/2012	37.1	11.5	9.9	11.1	191	229	186	3.8	6.8	2.6
10	03/04/2012	36.0	12.4	10.1	11.5	193	208	186	3.3	5.9	2.8
11	09/04/2012	44.5	15.7	9.4	11.8	135	156	132	3.6	7.3	2.7
12	10/04/2012	43.7	12.5	9.7	11.0	142	189	146	3.2	6.6	2.9
13	16/04/2012	45.3	12.6	10.1	11.6	220	250	211	3.9	6.5	3.2
14	17/04/2012	41.5	14.5	9.7	11.7	225	249	222	3.2	6.0	2.7
15	23/04/2012	40.4	14.5	10.1	11.5	200	239	198	3.3	5.8	2.8
16	24/04/2012	40.0	13.4	9.9	11.0	179	215	175	3.5	7.1	3.1
17	30/04/2012	44.4	12.5	10.1	11.0	199	221	180	3.4	7.0	3.0
18	01/05/2012	39.6	11.3	9.4	11.4	189	199	180	3.2	7.2	2.7
19	07/05/2012	40.4	11.1	10.1	11.6	206	225	199	3.4	6.5	2.9
20	08/05/2012	39.6	10.9	10.0	12.0	208	232	203	3.9	6.6	3.3
21	14/05/2012	37.7	10.5	9.6	11.0	186	215	175	3.3	6.8	2.9
22	15/05/2012	40.4	11.3	10.1	11.9	184	216	177	3.4	6.6	2.8
23	21/05/2012	37.3	10.2	9.1	11.0	208	225	203	3.1	6.6	2.7
24	22/05/2012	39.5	10.5	9.5	10.9	202	220	199	3.2	6.4	2.8
25	28/05/2012	35.1	10.2	9.7	10.3	236	275	232	3.6	6.9	3.0
26	29/05/2012	40.6	12.4	9.9	10.8	220	262	219	3.4	6.1	2.9
	Min	**34.7**	**10.2**	**9.1**	**10.3**	**132**			**2.6**		
	Max	**45.3**	**15.7**	**10.2**	**12.0**	**275**			**7.3**		
	Avg	**39.3**	**12.2**	**9.8**	**11.2**	**205**			**4.3**		
	98th	**44.9**	**15.2**	**10.2**	**12.0**	**256**			**7.1**		
	All the values are given in µg/m3										

ANNEXURE-VII
AMBIENT AIR QUALITY LEVELS

	PTRONET- LNG (Post Monsoon - Oct-Nov 2012)										
	AAQ1:PLANT SITE										
Sr.No	**Monitoring Date**	**PM10**	**PM2.5**	**SO2**	**Nox**		**CO**			**O3**	
		μg/m3	**μg/m3**	**μg/m3**	**μg/m3**	**μg/m3**	**μg/m3**	**μg/m3**	**μg/m3**	**μg/m3**	**μg/m3**
						I	**II**	**III**	**I**	**II**	**III**
1	01/10/2011	59.3	16.8	15.6	14.6	413	436	422	5.8	6.5	6.2
2	02/10/2011	57.7	17.2	15.1	14.2	407	448	436	6.1	6.9	6.5
3	08/10/2011	58.4	19.3	16.2	15.6	411	452	424	6.6	7.9	7.2
4	9/10/2011	59.1	20.7	14.9	16.3	422	469	441	5.7	6.4	6.1
5	15/10/2011	60.7	18.2	15.3	14.2	441	473	453	6.2	7.1	6.6
6	16/10/2011	59.4	17.8	16.1	15.3	416	455	421	6.5	7.4	6.9
7	22/10/2011	62.3	16.9	14.7	16.7	431	469	446	5.9	6.9	6.2
8	23/10/2011	60.1	18.4	15.2	14.2	419	452	431	5.7	6.3	6.1
9	29/10/2011	58.5	19.3	14.1	14.9	409	441	424	6.1	6.7	6.4
10	30/10/2011	57.7	21.7	14.9	15.5	411	436	419	6.2	7.1	6.6
11	05/11/2012	59.1	20.3	15.2	17.3	422	462	443	5.9	6.9	6.2
12	06/11/2012	60.4	20.9	15.5	18.3	419	431	424	5.7	6.4	6.1
13	12/11/2012	60.9	19.3	14.3	19.1	421	449	431	5.8	6.7	6.2
14	13/11/2012	58.4	17.3	15.7	17.4	409	422	414	6.2	7.2	6.9
15	19/11/2012	57.7	18.3	16.9	16.5	417	431	429	5.7	6.8	6.1
16	20/11/2012	58.1	19.9	15.4	14.8	426	456	443	5.9	6.4	6.1
17	26/11/2012	58.6	20.3	17.8	15.7	431	462	451	6.2	7.1	6.7
18	27/11/2012	59.3	16.9	14.8	16.3	414	441	426	5.9	6.9	6.4
	Min	**57.7**	**16.8**	**14.1**	**14.2**		**407**			**5.7**	
	Max	**62.3**	**21.7**	**17.8**	**19.1**		**473**			**7.9**	
	Avg	**59.2**	**18.9**	**15.4**	**15.9**		**433**			**6.4**	
	98th	**61.8**	**21.4**	**17.5**	**18.8**		**469**			**7.4**	
	AAQ2 : LAKHIGAM VILLAGE										
Sr.No	**Monitoring Date**	**PM10**	**PM2.5**	**SO2**	**NO2**		**CO**				
		μg/m3	**μg/m3**	**μg/m3**	**μg/m3**	**μg/m3**	**μg/m3**	**μg/m3**			
1	01/10/2011	49.3	13.8	14.5	17.2	342	366	357	6.1	6.8	6.4
2	02/10/2011	50.2	14.6	14.1	15.3	345	356	348	5.8	6.5	6.1
3	08/10/2011	51.4	16.3	15.2	14.1	339	361	350	5.4	6.2	5.9
4	9/10/2011	52.4	18.2	13.8	15.9	352	378	361	5.1	5.8	5.3
5	15/10/2011	53.2	19.5	14.7	14.5	341	361	355	5.8	6.4	6.1
6	16/10/2011	51.1	17.4	14.2	16.9	336	356	346	6.2	6.9	6.5
7	22/10/2011	50.7	15.3	13.8	17.4	346	366	354	5.5	6.3	5.9
8	23/10/2011	48.3	14.2	13.3	16.4	361	389	371	5.1	5.9	5.4
9	29/10/2011	47.4	13.9	15.8	18.2	348	364	355	5.3	5.7	5.5
10	30/10/2011	48.8	12.9	14.7	16.7	339	352	346	5.5	6.1	5.9
11	05/11/2012	50.6	13.5	13.9	17.1	341	366	352	4.9	6.4	5.3
12	06/11/2012	49.1	16.7	15.2	14.3	354	379	361	5.2	6.6	5.7
13	12/11/2012	48.4	18.3	14.9	15.4	356	386	374	4.8	6.2	5.4
14	13/11/2012	50.8	17.2	13.6	17.2	351	391	372	4.7	6.7	5.1
15	19/11/2012	51.3	15.2	16.6	16.4	364	406	389	5.2	6.4	5.6
16	20/11/2012	52.1	13.7	14.2	15.3	359	412	392	5.5	6.8	5.9
17	26/11/2012	50.7	16.8	13.8	14.9	346	395	367	5.2	6.6	5.5
18	27/11/2012	48.1	14.2	13.3	13.1	331	374	351	4.9	6.2	5.7
	Min	**47.4**	**12.9**	**13.3**	**13.1**		**331**			**4.7**	
	Max	**53.2**	**19.5**	**16.6**	**18.2**		**412**			**6.9**	
	Avg	**50.2**	**15.7**	**14.4**	**15.9**		**361**			**5.8**	
	98th	**52.9**	**19.1**	**16.3**	**17.9**		**405**			**6.8**	
	AAQ3 : NEAR DAHEJ VILLAGE										
Sr.No	**Monitoring Date**	**PM10**	**PM2.5**	**SO2**	**NO2**		**CO**				
		μg/m3	**μg/m3**	**μg/m3**	**μg/m3**	**μg/m4**	**μg/m5**	**μg/m6**			
1	01/10/2011	48.2	15.6	15.1	13.5	333	356	342	5.3	6.1	5.8
2	02/10/2011	49.7	16.3	15.9	14.2	329	364	355	4.5	5.3	4.9
3	08/10/2011	51.2	17.6	14.2	15.9	334	356	346	4.9	5.9	5.5
4	9/10/2011	52.5	14.2	14.6	17.8	342	375	354	4.6	5.4	5.1
5	15/10/2011	50.7	15.3	13.2	15.8	351	381	362	4.9	5.7	5.3
6	16/10/2011	50.1	16.1	14.8	15.1	362	389	371	4.7	6.1	5.4
7	22/10/2011	49.2	14.2	15.1	13.2	371	396	382	4.4	6.4	5.8
8	23/10/2011	47.4	12.9	13.7	12.8	355	378	367	4.8	5.7	5.3
9	29/10/2011	46.6	11.2	12.7	13.7	361	385	371	4.1	5.5	4.9
10	30/10/2011	48.2	13.8	13.1	14.6	342	361	356	5.1	5.9	5.6
11	05/11/2012	50.7	15.6	14.5	15.8	354	376	364	4.8	5.7	5.2
12	06/11/2012	51.3	13.7	13.3	16.2	361	389	372	5.3	6.1	5.8
13	12/11/2012	50.9	12.8	15.1	15.3	358	384	361	4.7	5.8	5.2
14	13/11/2012	50.1	11.6	14.7	14.1	344	371	356	4.4	5.5	5.1
15	19/11/2012	51.6	13.9	12.9	13.7	323	364	352	4.9	6.1	5.2
16	20/11/2012	49.3	15.8	13.4	15.4	326	385	371	5.3	5.9	5.5
17	26/11/2012	47.1	16.3	14.6	16.9	316	373	355	4.7	5.3	5.1
18	27/11/2012	48.7	14.8	13.2	17.1	322	362	341	5.1	6.1	5.5
	Min	**46.6**	**11.2**	**12.7**	**12.8**		**316**			**4.1**	
	Max	**52.5**	**17.6**	**15.9**	**17.8**		**396**			**6.4**	

ANNEXURE-VII
AMBIENT AIR QUALITY LEVELS

	Avg	**49.6**	**14.5**	**14.1**	**15.1**		**359**			**5.3**	
	98th	**52.2**	**17.2**	**15.6**	**17.6**		**389**			**6.1**	
	AAQ4 : AMBHETA VILLAGE										
Sr.No	**Monitoring Date**	**PM10**	**PM2.5**	**SO2**	**NO2**		**CO**				
		µg/m3	**µg/m3**	**µg/m3**	**µg/m3**	**µg/m4**	**µg/m5**	**µg/m6**			
1	01/10/2011	45.3	11.6	11.9	17.3	325	379	334	4.7	5.5	5.1
2	02/10/2011	44.7	12.8	12.3	15.2	338	365	346	4.9	5.9	5.4
3	08/10/2011	42.1	13.9	12.8	14.1	312	345	329	4.5	5.6	5.2
4	9/10/2011	40.3	11.6	13.4	13.7	303	339	312	4.2	5.1	4.8
5	15/10/2011	41.8	13.8	14.7	14.6	301	356	342	3.9	4.9	4.5
6	16/10/2011	42.7	12.4	13.1	15.4	295	342	331	3.5	4.7	4.1
7	22/10/2011	43.8	11.3	12.4	13.2	287	334	327	3.9	5.1	4.7
8	23/10/2011	45.1	10.9	11.8	12.4	312	353	346	4.6	5.5	5.2
9	29/10/2011	46.7	12.8	13.4	14.5	326	361	352	4.2	5.2	4.9
10	30/10/2011	44.8	13.7	12.7	15.2	314	342	325	4.1	4.8	4.4
11	05/11/2012	44.1	11.4	12.2	16.1	301	339	321	3.8	4.6	4.2
12	06/11/2012	42.8	12.8	11.9	15.9	295	331	315	4.1	4.9	4.3
13	12/11/2012	40.9	13.7	13.4	15.2	302	346	324	4.3	5.1	4.8
14	13/11/2012	41.7	14.3	13.9	14.6	291	352	338	4.8	5.4	5.1
15	19/11/2012	40.3	15.9	12.8	14.1	301	369	345	4.2	5.1	4.7
16	20/11/2012	42.8	13.4	11.9	13.9	292	375	331	4.5	5.3	4.8
17	26/11/2012	41.4	11.2	13.4	13.2	313	356	328	3.6	4.8	4.3
18	27/11/2012	43.6	10.9	13.9	12.5	287	341	319	3.9	5.1	4.7
	Min	**40.3**	**10.9**	**11.8**	**12.4**		**287**			**3.5**	
	Max	**46.7**	**15.9**	**14.7**	**17.3**		**379**			**5.9**	
	Avg	**43.1**	**12.7**	**12.9**	**14.5**		**329**			**4.7**	
	98th	**46.2**	**15.4**	**14.4**	**16.9**		**375**			**5.6**	
	AAQ5 : JAGESHWAR VILLAGE										
Sr.No	**Monitoring Date**	**PM10**	**PM2.5**	**SO2**	**NO2**		**CO**				
		µg/m3	**µg/m3**	**µg/m3**	**µg/m3**	**µg/m4**	**µg/m5**	**µg/m6**			
1	01/10/2011	40.6	10.6	13.9	16.9	244	279	262	4.4	5.4	4.8
2	02/10/2011	38.9	12.7	13.1	14.6	238	284	251	4.1	4.9	4.5
3	08/10/2011	42.6	13.5	12.4	15.3	251	296	274	3.8	4.4	4.1
4	9/10/2011	43.8	14.7	11.3	14.7	242	303	286	3.5	4.1	3.9
5	15/10/2011	44.6	13.2	10.8	13.2	298	323	304	3.7	4.6	4.2
6	16/10/2011	42.9	12.6	11.3	13.9	285	314	294	4.1	4.9	4.5
7	22/10/2011	40.7	12.1	12.4	14.6	274	326	311	4.2	5.1	4.7
8	23/10/2011	38.6	11.3	12.9	15.3	261	333	317	3.9	4.7	4.3
9	29/10/2011	39.4	12.1	13.1	13.7	255	304	294	3.5	4.4	4.1
10	30/10/2011	38.5	9.9	12.1	11.6	243	289	264	4.2	4.9	4.6
11	05/11/2012	40.7	11.2	11.6	13.7	231	275	254	4.1	5.1	4.4
12	06/11/2012	41.3	11.7	10.8	14.3	212	261	242	4.2	4.8	4.7
13	12/11/2012	42.9	13.4	12.7	15.2	207	274	237	3.9	4.5	4.1
14	13/11/2012	43.1	13.1	13.1	12.4	239	269	255	3.5	4.2	3.9
15	19/11/2012	41.1	11.2	10.2	11.9	221	254	242	3.7	4.7	4.2
16	20/11/2012	40.3	10.7	12.9	13.2	216	249	236	3.2	4.3	3.8
17	26/11/2012	39.1	12.2	11.5	15.8	238	256	241	3.8	4.7	4.0
18	27/11/2012	41.8	11.3	10.9	14.2	221	248	232	3.9	5.1	4.4
	Min	**38.5**	**9.9**	**10.2**	**11.6**		**207**			**3.2**	
	Max	**44.6**	**14.7**	**13.9**	**16.9**		**333**			**5.4**	
	Avg	**41.2**	**12.1**	**12.1**	**14.1**		**265**			**4.3**	
	98th	**44.3**	**14.3**	**13.6**	**16.5**		**326**			**5.1**	
	AAQ6 : LUVARA VILLAGE										
Sr.No	**Monitoring Date**	**PM10**	**PM2.5**	**SO2**	**NO2**		**CO**				
		µg/m3	**µg/m3**	**µg/m3**	**µg/m3**	**µg/m4**	**µg/m5**	**µg/m6**			
1	01/10/2011	54.2	15.3	12.7	15.5	205	267	241	3.9	4.6	4.2
2	02/10/2011	55.3	16.8	11.3	13.2	212	257	226	3.6	4.4	3.9
3	08/10/2011	57.8	18.2	10.8	12.7	198	238	212	4.2	4.9	4.6
4	9/10/2011	55.9	20.2	9.9	14.3	202	248	226	3.5	4.2	3.9
5	15/10/2011	56.7	18.8	10.4	13.8	216	256	242	3.2	3.9	3.5
6	16/10/2011	55.4	16.7	10.9	11.2	242	275	261	3.6	3.6	3.8
7	22/10/2011	53.3	15.6	11.3	11.9	213	258	242	3.1	3.7	3.3
8	23/10/2011	52.8	14.3	9.9	13.3	209	247	237	3.3	4.1	3.7
9	29/10/2011	51.9	13.4	10.4	14.1	189	237	221	3.5	4.3	3.9
10	30/10/2011	53.7	15.8	11.5	13.9	175	225	216	3.9	4.6	4.2
11	05/11/2012	55.4	17.3	10.3	11.3	204	246	222	3.3	4.2	3.8
12	06/11/2012	56.1	18.6	9.9	14.2	186	253	212	3.1	3.9	3.5
13	12/11/2012	55.2	15.3	10.4	13.3	175	261	232	3.8	4.4	4.1
14	13/11/2012	53.8	13.9	11.9	12.4	208	281	241	3.2	4.1	3.8
15	19/11/2012	52.7	14.2	10.7	14.5	216	251	223	2.9	3.7	3.4
16	20/11/2012	54.3	15.7	11.6	13.4	204	243	219	2.6	3.5	3.1
17	26/11/2012	56.7	16.2	11.1	12.6	179	236	204	2.9	3.8	3.2
18	27/11/2012	54.2	18.9	10.3	11.8	182	257	221	2.8	3.5	3.1
	Min	**51.9**	**13.4**	**9.9**	**11.2**		**175**			**2.6**	
	Max	**57.8**	**20.2**	**12.7**	**15.5**		**281**			**4.9**	

ANNEXURE-VII
AMBIENT AIR QUALITY LEVELS

	Avg	**54.7**	**16.4**	**10.9**	**13.2**	**227**			**3.7**		
	98th	**57.4**	**19.8**	**12.4**	**15.2**	**275**			**4.6**		
	AAQ7 : SE OF PLANT										
Sr.No	**Monitoring Date**	**PM10**	**PM2.5**	**SO2**	**NO2**	**CO**					
		µg/m3	**µg/m3**	**µg/m3**	**µg/m3**	**µg/m4**	**µg/m5**	**µg/m6**			
1	01/10/2011	58.3	16.8	14.3	13.9	371	405	382	6.3	7.2	6.8
2	02/10/2011	59.1	17.3	15.7	15.2	385	421	396	6.1	6.8	6.5
3	08/10/2011	60.6	19.2	16.2	14.3	391	429	412	5.9	6.5	6.2
4	9/10/2011	57.9	20.4	14.3	13.8	402	435	421	6.1	6.7	6.3
5	15/10/2011	58.1	21.6	13.8	14.2	411	429	431	5.7	6.3	6.1
6	16/10/2011	57.3	17.2	14.9	13.5	399	401	384	6.1	6.6	6.3
7	22/10/2011	55.9	18.3	15.3	15.2	407	416	396	5.7	6.4	6.0
8	23/10/2011	56.8	16.1	13.8	16.3	391	428	412	5.3	6.1	5.6
9	29/10/2011	58.4	15.9	15.9	13.5	404	431	421	5.8	6.6	6.2
10	30/10/2011	57.2	17.3	13.9	14.8	374	419	397	6.1	6.8	6.4
11	05/11/2012	58.4	19.4	14.3	14.1	398	423	411	5.7	6.4	6.1
12	06/11/2012	57.4	16.8	13.8	15.6	382	437	409	5.5	6.7	6.3
13	12/11/2012	55.9	18.3	14.7	16.9	371	416	394	5.8	6.5	6.1
14	13/11/2012	58.1	19.4	15.3	17.4	382	428	407	5.4	6.6	6.2
15	19/11/2012	59.4	16.3	16.4	15.3	411	439	423	5.3	6.4	5.9
16	20/11/2012	58.1	15.3	17.1	17.1	401	445	417	5.1	6.2	5.7
17	26/11/2012	57.3	17.8	15.6	18.6	394	425	402	5.9	6.7	6.4
18	27/11/2012	58.4	15.9	15.9	14.8	373	419	394	5.7	6.6	6.2
	Min	**55.9**	**15.3**	**13.8**	**13.5**	**371**			**5.1**		
	Max	**60.6**	**21.6**	**17.1**	**18.6**	**445**			**7.2**		
	Avg	**57.9**	**17.7**	**15.1**	**15.3**	**408**			**6.2**		
	98th	**60.2**	**21.2**	**16.9**	**18.2**	**441**			**6.9**		
	AAQ8 : NEAR ALIABET VILLAGE										
Sr.No	**Monitoring Date**	**PM10**	**PM2.5**	**SO2**	**NO2**	**CO**					
Units		**µg/m3**	**µg/m3**	**µg/m3**	**µg/m3**	**µg/m4**	**µg/m5**	**µg/m6**			
1	01/10/2011	35.6	9.4	10.3	12.3	175	196	182	3.1	3.9	3.5
2	02/10/2011	36.1	10.8	11.2	14.9	162	184	176	2.4	3.6	3.1
3	08/10/2011	37.9	11.4	11.9	10.8	154	172	161	2.8	3.5	3.1
4	9/10/2011	34.1	10.9	12.5	11.4	141	168	152	3.1	3.9	3.5
5	15/10/2011	35.6	12.7	10.3	12.7	136	159	143	2.4	3.4	3.1
6	16/10/2011	36.7	13.7	9.6	13.6	139	175	151	2.9	3.6	3.3
7	22/10/2011	37.2	10.8	9.9	12.4	186	222	209	3.1	3.9	3.5
8	23/10/2011	39.1	11.3	11.2	13.2	164	209	195	3.3	4.4	3.8
9	29/10/2011	37.4	12.8	10.3	12.8	152	211	184	2.8	3.7	3.3
10	30/10/2011	41.3	10.7	10.9	11.3	141	198	172	2.7	3.4	3.1
11	05/11/2012	37.1	9.9	11.2	10.8	152	176	161	3.1	3.9	3.5
12	06/11/2012	38.4	11.6	11.7	12.6	136	162	153	3.4	4.1	3.9
13	12/11/2012	36.7	12.3	10.4	13.7	155	179	162	2.9	3.8	3.2
14	13/11/2012	35.2	10.3	11.1	12.1	148	184	172	2.4	3.3	2.9
15	19/11/2012	37.2	12.7	10.4	13.5	136	167	176	2.8	3.6	3.2
16	20/11/2012	36.9	11.8	9.6	12.8	142	199	182	2.4	3.4	3.1
17	26/11/2012	34.6	10.6	11.2	11.3	138	176	165	2.9	3.9	3.5
18	27/11/2012	34.1	9.4	11.8	12.8	156	194	181	2.5	3.6	3.2
	Min	**34.1**	**9.4**	**9.6**	**10.8**	**136**			**2.4**		
	Max	**41.3**	**13.7**	**12.5**	**14.9**	**222**			**4.4**		
	Avg	**36.7**	**11.3**	**10.9**	**12.5**	**169**			**3.3**		
	98th	**40.6**	**13.4**	**12.3**	**14.5**	**211**			**4.1**		

ANNEXURE-VIII
DEMOGRAPHIC DETAILS

Sr. No.	Name of Village	No. of House Holds	Total Population	Total Male	Total Female	Population Below 6 Agegroup	Male Below 6 Agegroup	Female Below 6 Agegroup	SC Population	ST Population	Total Literates	Male Literates	Female Literates	Total Workers	Main Workers	Marginal Workers	Non Workers
0-3 km	**Vagra Taluka**																
1	Lakhigam	640	3357	1939	1418	485	249	236	79	434	2204	1472	732	1629	1618	11	1728
2	Luvara	276	1393	689	704	257	129	128	81	792	750	454	296	556	452	104	837
	Sub-Total	**916**	**4750**	**2628**	**2122**	**742**	**378**	**364**	**160**	**1226**	**2954**	**1926**	**1028**	**2185**	**2070**	**115**	**2565**
3-7 km	**Vagra Taluka**																
3	Jageshwar	346	1465	861	604	242	135	107	23	75	855	593	262	609	552	57	856
4	Ambheta	293	1330	695	635	232	120	112	94	199	901	538	363	405	369	36	925
	Sub-Total	**639**	**2795**	**1556**	**1239**	**474**	**255**	**219**	**117**	**274**	**1756**	**1131**	**625**	**1014**	**921**	**93**	**1781**
7-10 km	**Vagra Taluka**																
5	Dahej	1551	6846	3756	3090	1145	582	563	365	1398	4552	2734	1818	2688	2524	164	4158
	Sub-Total	**1551**	**6846**	**3756**	**3090**	**1145**	**582**	**563**	**365**	**1398**	**4552**	**2734**	**1818**	**2688**	**2524**	**164**	**4158**
	Grand Total	**3106**	**14391**	**7940**	**6451**	**2361**	**1215**	**1146**	**642**	**2898**	**9262**	**5791**	**3471**	**5887**	**5515**	**372**	**8504**

ANNEXURE-IX
EMISSION CALCULATIONS

1.1 Emission Calculations

1.1.1 General Calculations

Area Calculations

$$\text{Area}(m^2) = \frac{3.142 \quad x \quad (\text{Top Stack Diameter})^2}{4}$$

$$= 3.14 \text{ X } (1.66)^2/4 = 2.16 \text{ m}^2$$

Temperature Correction

Temperature correction is calculated based on standard ambient temperature of 25° C.

$$Temperature \quad Corection = \frac{273 + 25^0 \ C}{273 + Stack \ Temperature^0 \ C}$$

$$= [273 + 25]/ [273 + 160] = 0.68$$

Volumetric Flow Rate

$$\text{Volumetric flow} \left(\frac{Nm^3}{s}\right) = \text{Area} (m^2) \text{ x Exit Velocity} (m / s) \text{ x Temperature Correction}$$

$$= 2.16 \text{ X } 21 \text{ X } 0.68 = 31.26 \text{ Nm}^3/\text{s}$$

1.1.2 Emission Calculations - Oxides of Nitrogen Emissions (NO_x)

Only NO_x emissions have been considered from the proposed gas based CPP project. NO_x emission is calculated based on limit of 50 ppm.

NO_x Emission (mg/Nm^3) = 50 x 2.05 mg/Nm^3
= 102.5 mg/Nm^3

NO_x Emission (mg/sec/stack) = NO_x (mg/Nm^3) x Volumetric Flow (Nm^3/sec)
= 102.5 x 31.26
= 3204.15 mg/sec
= 3.2 g/sec

MODEL STUDIES FOR FLOW REGIME AND WATER QUALITIES DUE TO THE PROPOSED EXPANSION OF LNG JETTY FACILITIES OF PETRONET LNG LTD AT DAHEJ, GULF OF KHAMBAT

REPORT ON MATHEMATICAL / HYDRAULIC MODELING STUDIES FOR FLOW REGIME AND WATER QUALITIES

For

VIMTA LABORATORIES LTD.
HYDERABAD

Draft Report
January 2013

By

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Contents

ANNEXURE-X
MARINE MODELING STUDIES

ANNEXURE-X
MARINE MODELING STUDIES

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ERROR: stackunderflow
OFFENDING COMMAND: ~

STACK:
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EXECUTIVE SUMMARY

Petronet LNG Limited (PLL) operates at Dahej (Bharuch District, Gujarat), one LNG terminal called Dahej LNG terminal to import and handle LNG received by ships. This complex is presently having a 2.4 km long jetty with unloading platform and unloading arms as a part of the marine facilities apart from other related facilities of storage etc. on shore / ground. PLL is now proposing to expand, under phase III, their unloading and processing facilities and planning to build another jetty (termed as proposed standby jetty) with unloading platform and unloading arms to the south of the existing jetty.

Dredging will be carried out for construction / maintenance of the navigational channel in the Narmada Estuary for the proposed new (standby) Jetty in the Gulf of Khambat.

PLL planned to get modeling studies carried out for predicting the hydraulic behavior, morphological changes and water quality, if any due to the above development. The study has to predict the seasonal behavior of the estuary in terms of hydraulics, morphological changes and water quality based on the available data and to predict the future changes interpolated on behavior of the river and the proposed development. The studies are to predict the current flow regime, morphology and water qualities in terms of sedimentation transport and settling in the area before and after the development for various meteorological and hydrological conditions.

The studies will essentially predict the seasonal behavior of the estuary in terms of hydraulics, morphological changes and predict the future changes interpolated on the behavior of the river and modifications carried out due to development. The studies would also predict the current flow regime and morphology in the area before and after development for various meteorological and hydrological conditions. The governing factor in carrying out the study is to ensure that the modifications carried out should not substantially change the flow regime in the domain.

The details of studies carried out are summarized below:

Flow Modeling studies

Under various hydrological, oceanographic and meteorological conditions of the proposed site in the Gulf of Kambhat, the basic oceanographic field data pertaining to tides and tidal currents has been made available for carrying out the modeling studies. Hydrodyn-FLOSOFT, developed by M/s. Environ Software (P) Ltd. (ESPL), Bangalore has been used for predicting the tides and currents in the model. The model has been run with the available data of tide and currents for various tidal conditions to predict the effects on flow regime due to proposed development of new jetty facilities. The results show that there is no significant change in the flow dynamics due to the proposed development. The software has been run for 15 days continuously for pre-monsoon and post-monsoon periods and calculated the flow patterns for various hydrological conditions. Results of FLOSOFT show that there is no significant impact on the marine environment due to the proposed development.

Sediment Transport Modeling Studies

The software Hydrodyn-SEDSOFT is used to predict the cohesive and non-cohesive sediment transport for various hydrological, oceanographic and geomorphologic conditions for 15 days period during pre-monsoon and post-monsoon seasons. The software has been run continuously for 15 days to calculate the rate of erosion/deposition and also to predict the changes in the bed levels due to proposed development.

Results of SEDSOFT show that there is a certain change in the sedimentation processes after proposed development. There is certain increase in sediment deposition rates in parts of the study domain specifically at the existing and proposed standby LNG jetty head areas; but the variations are very insignificant. It is estimated that the increase in the bed levels will be of the order of 3 cm to 5 cm over a period of fifteen days at the vicinity of the jetty head. It was deduced from the SEDSOFT results that apart from the areas mentioned, there is no significant impact on the marine environment in the rest of the area due to the development.

Approach strategy and final conclusions:

"Hydrodyn-FLOSOFT" and "Hydrodyn-SEDSOFT" software modules have been used to study the flow regime changes and morphological changes due to the proposed development facility. The advanced scientific simulation software is a proven tool used to simulate the flow and sediment transport in the coastal waters having complex geometry with high order precision numerical computations and has been used extensively to predict the same in creeks, seas and estuaries. It solves the conservation equations for mass, momentum and energy of flow and pollutant transport on 3D BFC (Body-Fitted-Coordinate) grid system with generalized flow boundaries. BFC maps exactly the physical features of the domain to be modeled.

The results of the present study for various hydrological and oceanographically conditions follow:

Hydrodynamic Modeling:

The model generated tides are comparable to actual observations at the vicinity of proposed development.

The model has been run for various tidal conditions to study the hydrodynamic behavior and flow regime in and around the proposed development.

For all the tidal conditions and different proposed facilities considered the impact on the flow regime seem to be not significant difference in the flow system due to proposed development.

Flow regime changes for various tidal conditions before and after the proposed development seem to be negligible.

Sediment Transport Modeling:

The changes in the sedimentation processes for all tidal conditions seem to be present due to the proposed standby LNG Jetty.

The accumulation of sand/silt/mud predicted in the vicinity of jetty is around 3 to 4 cm over a period of 15 days at the existing LNG jetty and 3 to 5 cm at the proposed standby LNG jetty.

PROJECT TEAM OF ENVIRON SOFTWARE (P) LTD

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Varun.B.M	Member
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RESOURCE PERSONS OF Vimta Laboratories Ltd.

E Shyam Sundar	Vice President
Raj Manohar	

1. INTRODUCTION

1.1 Back ground

Petronet LNG Limited (PLL) is already operating the Dahej LNG Terminal with the commissioning of phase 1 (5 MMTPA capacity) since April, 2004. The capacity was increased to 10 MMTPA with the commissioning of the phase II in July 2009. The existing facilities at Dahej include:

- 2.4 km long jetty, unloading platform with unloading arms etc.
- 4 LNG tanks, each of 160,000 m^3 gross storage tank capacity
- Shell & tube vaporizer
- Submerged combustion vaporizers
- Boil off compressor and re-condenser
- Send out facilities and gas metering
- Utilities, power generation and distribution
- Fire fighting & safety
- Control room and other instrumentation

Dahej LNG terminal, now operating at 10 MMTPA and with all the gas evacuated through major trunk pipelines, is meeting about 24% of the total gas consumption of the country.

PLL is now proposing to expand the capacity of the Dahej LNG terminal to 20 MMTPA under phase III to be carried out in two phases : phase III 3A (from 10 to 15 MMTPA) to be completed by the year 2016 and phase IIIB (from 15 to 20 MMTPA) to be completed by the year 2020. Utilities and other facilities shall be for 20 MMTPA capacity and will be completed in phase IIIA itself.

As a part of this expansion, PLL is proposing a new LNG jetty. This proposed standby LNG jetty will be on trestles and will be located on the south side of the existing jetty. This development activity would call for a study of its impact on the marine environment. It is necessary to carryout modeling studies to predict the impact due to the proposed standby LNG jetty on the flow conditions and sedimentation processes in the region.

2. SCOPE OF STUDY

Vimta Laboratories Ltd has requested Environ Software (P) Ltd, to carry out the mathematical modeling studies for the hydrodynamic behavior as well as the water quality studies due to the phase III expansion of the Dahej LNG terminal project of Petronet LNG Ltd., Dahej. The expansion includes installation of a new jetty for unloading of LNG to the south of the existing jetty.

Objectives

The following are the main objectives and scope of the present study.

1. Hydrodynamic studies

- Simulate the flow conditions prevailing at the site based on the bathymetry and tidal conditions.
- Predict the flow conditions at site considering the installation of the new jetty. Establishing the flow regime before and after installation the new jetty and identify any changes in the flow regime for various seasons.

2. Sedimentation Modeling Studies:

- Numerical runs will be carried for various tide conditions for predicting morphological changes due to the proposed marine developments.
- Numerical modeling studies for erosion, deposition and shoreline changes at the existing as well as proposed standby Jetty.
- Modeling studies for predicting the impact on flow dynamics, bed morphology and marine environment due to the existing and proposed standby jetty.

3. MODELING OF FLOW REGIME FOR THE PROPOSED DEVELOPMENT

3.1 Introduction

In order to obtain better accuracy in the prediction of flow regime changes due to the proposed development of marine facilities (provision of standby LNG Jetty), a finer mesh is adopted to represent the study area for modeling purpose. Computational runs have been carried out on this model domain.

The study domain selected is between the geographical coordinates given below:

Long: 72° 29' 08.9" E - 72° 32' 30.9" E
Lat : 21° 38' 19.4" N - 21° 43' 43.2" N

Location of the existing LNG jetty and other existing jetties / facilities and the proposed development (standby jetty) are taken into account in this domain.

The terrain features of the domain before the development are shown in Fig.A1.3. The terrain features of the domain after the development (with the proposed marine facilities in place) are shown in Fig.A1.4.

The model domain is divided into several computational blocks (160 x 100) and generated grids in x and y directions respectively. The size of the grid varies from 30m to 80m. Fig.A1.5 and Fig.A1.6 show the computational grid for the domain before and after the development. The computational grid is the same for both conditions.

The bathymetry is selected from the measured hydrographic chart data. Figs.A1.7 and A1.8 show the interpolated bathymetric depth contours before and after the development respectively. From the figures, it can be seen that the maximum depth contour is 26 m.

3.2 Bed roughness

The bottom roughness in the domain varies according to bed sediment grain sizes. The bed consists of various sizes of clay, sand and silt. Depending upon bed configuration and sediment sizes, the d_{50} size varies from 0.0001m to 0.005m. In the present study constant Manning's roughness coefficient is selected based on the validation and the same is used for carrying out various computational runs for the prediction of hydrodynamic parameters in the study region flow field system. The software has been run for various sets of Manning roughness coefficient till the discrepancy is minimum in the prediction of tides and currents. From the series of computational runs, the Manning coefficient found to be best for model calibration is selected. The bed roughness contours (Chezy's bed roughness coefficient) have been calculated based on this Manning roughness and water depth and are shown in Figs.A1.9 and A1.10 for the condition before and after development, respectively. It can be observed that the roughness coefficient varies from 0 to 27. The model has been run for various inputs using the same roughness coefficient in the prediction of tide and currents in the domain under study.

3.3 Initial and boundary conditions

The initial conditions for the model are selected based on still water conditions. The vertical density gradients due to salinity variation have been neglected since the water column is well mixed. The BFC technique has been adopted to take care of shoreline shape and make fine mesh near the coastline. The grid is non-uniform both in x and y directions and it is a fine mesh. Fig.A1.11 shows the boundary tides taken for the model. The selected computational domain has been calibrated with the observed tide and currents and the calibration graphs are shown in Fig.A1.12 and Fig.A1.13. The computational runs have been made for a period of 15 days covering spring and neap tide conditions to obtain an insight into the basic hydrodynamic behavior of the study domain.

A no. of observation points have been located around the proposed standby LNG jetty head area to predict the changes in the flow before and after development. The location of the observer points is shown in Fig.A1.14.

3.4 Modeling of flow regime

The study has been carried out to predict the changes in flow regime and circulation pattern due to the proposed development activities at the PETRONET LNG jetty location for various hydrodynamic conditions.

The model clearly reproduces the tidal variation at various locations in the study area. The typical tidal elevations and velocities for Low Water (LLW), High Water (HHW), Peak Flood (PF) and Peak Ebb (PE) for pre-monsoon (March 2012), and winter (November 2012) have been generated and are discussed in the following sections.

3.4.1 Flow regime before and after proposed development during pre-monsoon (March 2012)

The software has been run for 15 days continuously representing spring and neap tide conditions for both the cases of before development as well as after development and the predicted results are discussed below:

a). Neap tide condition-slack-1(LLW)

The tides during slack-1 for neap tide condition before and after proposed development are shown in Fig A2.1 and Fig.A2.2 respectively. The maximum water level is about 3.44 m at the existing LNG jetty head and no significant change in the water levels after development is noticed during lowest low water condition.

The currents during slack-1 for neap tide condition before and after proposed development are shown in Fig A2.3 and Fig.A2.4 respectively. It can be seen that the maximum current speed is about 0.36 m/sec at the existing LNG jetty head and no significant change in the flow regime after development during lowest low water condition.

Fig.A2.33 shows the difference in current speed before and after proposed development. It can be observed that there is an increase in current speed of the order of 0.04 m/s to 0.16 m/s across the proposed standby LNG jetty head location.

b). Neap tide condition-peak flood (PF)

The tides during neap tide PF condition before and after proposed development are shown in Fig A2.5 and Fig.A2.6 respectively. It can be seen that the maximum water level is about 4.82 m at the existing LNG jetty head and no significant change in the water levels is observed after development during peak flood water condition.

The currents during neap tide PF condition before and after proposed development activities are shown in Fig A2.7 and Fig.A2.8 respectively. It can be observed that flow is towards north direction. It can be seen that the maximum current speed in the basin is about 0.75 m/sec after the development and there is no significant change in the flow regime.

Fig.A2.34 shows the difference in current speed due to proposed development activities. It can be seen that there is an increase in current speed of the order of 0.04 m/s to 0.16 m/s across the proposed standby LNG jetty head location due to the development.

c). Neap tide condition- highest high water (slack-2) (HHW)

The tides during slack-2 for neap tide HHW condition before and after proposed development are shown in Fig A2.9 and Fig.A2.10 respectively. It can be seen that the maximum water level is about 6.17 m at existing LNG jetty head and no significant change in the water levels after development during lowest low water condition.

The currents during slack-2 for neap tide HHW condition before and after proposed development activities are shown in Fig.A2.11 and Fig.A2.12 respectively. It can be seen that the maximum current speed is about 0.45 m/sec at the existing LNG jetty head and the flow direction is north.

Fig.A2.35 shows the difference in current speed due to proposed dredging activities near existing LNG jetty head. It can be observed that there is an increase in current speed of the order of 0.04 m/s to 0.16 m/s across the proposed standby LNG jetty head location due to the development.

d). Neap tide condition- peak ebb (PE)

The tides during neap tide PE condition before and after proposed development are shown in Fig A2.13 and Fig.A2.14 respectively. It can be seen that the maximum water level is about 5.23 m at existing LNG jetty head and no significant change in the water levels is observed after development.

The currents during neap tide PE condition before and after proposed development are shown in Fig.A2.15 and Fig.A2.16 respectively. It can be observed that the flow pattern is towards south direction with a slight tilt towards east. It can be seen that the maximum current speed is about 0.6 m/sec at the existing LNG jetty head after development.

Fig.A2.36 shows the difference in current speed due to proposed development activities. It can be observed that there is an increase in current speed of the order of 0.04 m/s to 0.16 m/s across the proposed standby LNG jetty head location due to the development.

e). Spring tide condition-slack-1(LLW)

The tides during slack-1 for spring tide condition before and after proposed development in the area are shown in Fig A2.17 and Fig.A2.18 respectively. It can be seen that the maximum water level is about 3.365 m at existing LNG jetty head and no significant change in the water levels after development during lowest low water condition.

The currents during slack-1 for spring tide condition before and after proposed development are shown in Fig.A2.19 and Fig.A2.20 respectively. It can be seen that the maximum current speed is about 0.18 m/sec at the existing LNG jetty head and no significant change in the flow regime after development activities during lowest low water condition. The current direction is northwards.

Fig.A2.37 shows the difference in current speed between before and after development activities. It can be observed that there is an increase in current speed of the order of 0.04 m/s to 0.16 m/s across the proposed standby LNG jetty head location due to the development.

f). Spring tide condition-peak flood (PF)

The tides during spring tide PF condition before and after proposed development are shown in Fig A2.21 and Fig.A2.22 respectively. It can be seen that the maximum water level is about 6.01 m at existing LNG jetty head and no significant change in the water levels after development during lowest low water condition.

The currents during spring tide PF condition before and after proposed development are shown in Fig.A2.23 and Fig.A2.24 respectively. It can be observed that flow is towards north direction. It can be seen that the maximum current speed in the proposed dredged area is about 0.57 m/sec after the development and there is no significant change in the flow regime around Existing LNG jetty head.

Fig.A2.38 shows the difference in current speed due to proposed development activities. It can be observed that there is an increase in current speed of the order of 0.04 m/s to 0.16 m/s across the proposed standby LNG jetty head location due to the development.

g).Spring tide condition-highest high water (slack-2) (HHW)

The tides during spring tide HHW condition before and after proposed development are shown in Fig A2.25 and Fig.A2.26 respectively. It can be seen that the maximum water level is about 8.55 m at existing LNG jetty head and not much significant change in the water levels after development during HHW condition.

The currents during slack-2 for spring tide condition before and after proposed development are shown in Fig.A2.27 and Fig.A2.28 respectively. It can be seen that the maximum current speed is about 0.83 m/sec at the jetty head after development and the flow direction is north.

Fig.A2.39 shows the difference in current speed due to proposed development activities. It can be observed that there is an increase in current speed of the order of 0.04 m/s to 0.16 m/s across the proposed standby LNG jetty head location due to the development.

h). Spring tide condition-peak ebb (PE)

The tides during spring tide PE condition before and after development are shown in Fig A2.29 and Fig.A2.30 respectively. It can be seen that the maximum water level is about 6.75 m at jetty head and no significant change in the water levels after development during PE water condition.

The currents during spring PE condition before and after development are shown in Fig.A2.31 and Fig.A2.32 respectively. It can be observed that the flow pattern is changed and the flow is towards south direction. It can be seen that the maximum current speed is about 1.9 m/sec at the jetty after the proposed development activities.

Fig.A2.40 shows the difference in current speed due to proposed development. It can be observed that there is an increase in current speed of the order of 0.04 m/s to 0.16 m/s across the proposed standby LNG jetty head location due to the development.

i). Impact on flow regime and flow circulation in the proposed basin

The model has been run for 15 days continuously for predicting the impact on flow regime and circulation for various hydrodynamic tidal conditions due to the proposed development / augmentation of marine facilities. Fig.A2.41 (a) and Fig.A2.41 (b) show the variation of currents at different locations (Fig.A1.14) in the region around the LNG jetty heads before and after proposed development activities. It can be seen that there is very little (insignificant) impact on current regime in general. The changes in the flow regime (in the values of currents) are mainly local as discussed at length in the above sections.

3.4.2 Flow regime before and after proposed development during post-monsoon (November 2011)

a). Neap tide condition-slack-1(LLW)

The tides during neap tide LLW condition before and after development are shown in Fig A3.1 and Fig.A3.2 respectively. It can be seen that the maximum water level is about 3.82 m at existing LNG jetty head and not much significant change in the water levels after development during LLW tide condition.

The currents during slack-1 for neap tide condition before and after development are shown in Fig.A3.3 and Fig.A3.4 respectively. It can be seen that the maximum current speed is about 0.32 m/sec in the existing LNG jetty head area and there is no significant change in the flow regime after the development during lowest low water condition. The flow direction is northwards.

Fig.A3.33 shows the difference in current speed between before and after development. It can be observed that there is increase in current speed of the order of 0.1 m/s to 0.2 m/s at the proposed standby LNG jetty head area due to the proposed development activities.

b). Neap tide condition-peak flood (PF)

The tides during neap tide PF condition before and after development are shown in Fig A3.5 and Fig.A3.6 respectively. It can be seen that the maximum water level is about 6.03 m at existing LNG jetty head and no significant change in the water levels after development during PF water condition.

The currents during neap tide PF condition before and after development are shown in Fig.A3.7 to Fig.A3.8 respectively. It is observed that flow is towards north direction. The maximum current speed at the existing LNG jetty head region is about 0.5 m/sec after the development and there is no significant change in the flow regime due to the proposed development.

Fig.A3.34 shows the difference in current speed due to proposed development and augmentation of marine facilities. It can be observed that there is increase in current speed of the order of 0.1 m/s to 0.2 m/s at the proposed standby LNG jetty head area due to the proposed development activities.

c). Neap tide condition- highest high water (slack-2) (HHW)

The tides during neap tide HHW condition before and after development are shown in Fig A3.9 and Fig.A3.10 respectively. It can be seen that the maximum water level is about 5.27 m at existing LNG jetty head and no significant change in the water levels after development during HHW water condition.

The currents during slack-2 for neap tide condition before and after development are shown in Fig.A3.11 to Fig.A3.12 respectively. It can be seen that the maximum current speed is about 0.42 m/sec in the existing LNG jetty head region and the direction remains northwards.

Fig.A3.35 shows the difference in current speed due to proposed development activities around the Existing LNG jetty head. It can be observed that there is increase in current speed of the order of 0.1 m/s to 0.2 m/s at the proposed standby LNG jetty head area due to the proposed development activities.

d). Neap tide condition-peak ebb (PE):

The tides during neap tide PE condition before and after development are shown in Fig A3.13 and Fig.A3.14 respectively. It can be seen that the maximum water level is about 4.96 m at existing LNG jetty head and no significant change in the water levels after development during PE water condition.

The currents during neap tide PE condition before and after development are shown in Fig.A3.15 to Fig.A3.16 respectively. It can also be observed that the flow pattern has changed and flow is towards south direction. It can be seen that the maximum current speed is about 1.5 m/sec after development.

Fig.A3.36 shows the difference in current speed due to proposed development activities around the existing LNG jetty head. It can be observed that there is increase in current speed of the order of 0.1 m/s to 0.2 m/s at the proposed standby LNG jetty head area due to the proposed development activities.

e). Spring tide condition-slack-1(LLW):

The tides during spring tide LLW condition before and after proposed dredging activities are shown in Fig A3.17 and Fig.A3.18 respectively. It can be seen that the maximum water level is about 3.57 m at existing LNG jetty head and no significant change in the water levels after development during LLW water condition.

The currents during slack-1 for spring tide condition before and after proposed development are shown in Fig.A3.19 to Fig.A3.20 respectively. It can be seen that the maximum current speed is about 0.32 m/sec at the existing LNG jetty head. It is also evident that there is no significant change in the flow regime after development during lowest low water condition and the flow direction is northwards.

Fig.A3.37 shows the difference in current speeds before and after proposed development. It can be observed that there is increase in current speed of the order of 0.1 m/s to 0.2 m/s at the proposed standby LNG jetty head area due to the proposed development activities.

f). Spring tide condition-peak flood (PF)

The tides during spring tide PF condition before and after development are shown in Fig A.5.21 and Fig.A3.22 respectively. The maximum water level is about 5.95 m at existing LNG jetty head and there is no significant change in the water levels after development during PF water condition.

The currents during spring tide PF condition before and after proposed development are shown in Fig.A3.23 to Fig.A3.24 respectively. It can be observed that flow remains towards north direction. It can be seen that the maximum current speed in the basin is about 0.63 m/sec after the development. It can be seen that there is no significant change in the flow regime after development.

Fig.A3.38 shows the difference in current speed due to the development proposed. It can be observed that there is increase in current speed of the order of 0.1 m/s to 0.2 m/s at the proposed standby LNG jetty head area due to the proposed development activities.

g). Spring tide condition- highest high water (slack-2) (HHW)

The tides during spring tide HHW condition before and after development are shown in Fig A3.25 and Fig.A3.26 respectively. The maximum water level is about 7.55 m at the exisiting LNG jetty head and no significant change in the water levels observed after development during HHW water condition.

The currents during slack-2 for spring tide condition before and after development are shown in Fig.A3.27 to Fig.A3.28 respectively. It can be seen that the maximum current speed is about 0.6 m/sec in the existing LNG jetty head area and the flow direction remains northwards. There is no significant change in the currents due to development in the region.

Fig.A3.39 shows the difference in current speed due to proposed developments. It can be observed that there is increase in current speed of the order of 0.1 m/s to 0.2 m/s at the proposed standby LNG jetty head area.

h). Spring tide condition-peak ebb (PE)*:*

The tide levels during spring tide PE condition before and after development are shown in Fig A3.29 and Fig.A3.30 respectively. It can be seen that the maximum water level is about 6.42 m at the existing LNG jetty head area and no significant change in the water levels after development during PE water condition.

The currents during spring tide PE condition before and after development are shown in Fig.A3.31 to Fig.A3.32 respectively. It can be observed that the flow direction is towards south. It can be seen that the current speed is about 0.66 m/sec att he existing LNG jetty head area and no significant change in the currents observed in the region.

Fig.A3.40 shows the difference in current speed due to proposed development. It can be observed that there is increase in current speed of the order of 0.1 m/s to 0.2 m/s at the proposed standby LNG jetty head area due to the proposed development activities.

i). Impact on flow regime and flow circulation in the proposed basin

The model has been run for 15 days continuously for predicting the impact on flow regime and circulation for various hydrodynamic tidal conditions due to the proposed development / augmenting of marine facilities. Fig.A3.41 (a) and Fig.A3.41 (b) shows the variation of currents at different observation location points (Fig.A1.14) in the region before and after development. It can be seen that there is no impact on current regime in general. The changes in the flow regime are local and do not have any significant effect on the overall domain.

4. SEDIMENT TRANSPORT MODELING

4.1 Numerical approach to sediment (cohesive and non-cohesive) transport modeling studies

This chapter presents the setting up of sediment transport model and simulation of the existing sediment transport conditions for estimating the sediment deposition for various hydro-dynamic and oceanographic conditions.

As with the flow modeling described in the previous chapter, a critical step in applying a numerical model of sediment transport is the process of model verification. Whereas data sets against which to calibrate and validate the flow model are relatively straightforward to obtain, collection of data to validate a sediment transport model is typically more difficult. The sediment transport studies are aimed at indicating the likely tendency in the bed levels (i.e. erosion and/or deposition) as a result of the engineering developments rather than the quantities involved. This approach is, however, still valid for confirming the sediment erosion/deposition at various locations.

The principal aim of these studies was to assess the total (Cohesive and Non-Cohesive) sediment load getting deposited in the study area and to find out any changes in these values due to the proposed development. Accordingly the simulation runs were carried out with a sand/fine silt/mud transport which was appropriate for the conditions in these areas.

4.2 Available data pertaining to the morphological assessment

Data which was made available in the present study to provide input to the morphological studies comprised the following:

- Bathymetry data for the domain
- Suspended sediment concentration in the river
- Bed sediment grain size and settling velocities.

This information was used to specify the initial distribution of sand/silt/mud (limiting it to the intertidal areas) in the numerical modeling simulations.

4.3 Sediment transport simulation

Simulation of sediment transport in the study area (Fig.A2.1) was carried out with the Hydrodyn-SEDSOFT model for various tide conditions during pre-monsoon (March 2012) and post-monsoon (November 2012) seasons. Hydrodyn-SEDSOFT is a 2D sediment transport model (Cohesive and non-Cohesive) and predicts the process of erosion, transport and deposition of sediment.

Hydrodyn-SEDSOFT was driven with the neap and spring tide hydrodynamic flow file and using standard parameters which describe the erosion and settling characteristics of the sediment. Simulation runs were carried by specifying sediment composition in the shallower (intertidal) zones where the tide induced bed shear stress was relatively low.

Following simulation of the sediment transport under existing conditions, the model was adjusted to include the effects of the bathymetry changes due to proposed development.

4.3.1 Sediment erosion before and after development during pre-monsoon (Mar 2012)

The model results for instantaneous rate of sediment erosion before and after development for pre-monsoon (March 2011) are presented in Fig.A4.1 - Fig.A4.16. The figures represent the predicted erosion values for different tidal condition, viz. lowest low water (LLW), peak flood (PF), highest high water (HHW) and peak ebb (PE) of neap and spring tides. Fig.A4.17 to Fig.A4.24 show the difference in the rate of erosion for various seasons before and after development during LLW, PF, HHW and PE condition of neap and spring tides respectively. The results are discussed in subsequent sections below.

4.3.1.1 Neap tide condition-slack-1 (LLW)

The rate of erosion for neap tide LLW water condition before development (as existing) and after development are shown in Fig.A4.1 & Fig.A4.2 respectively. From the figures, it can be seen that the maximum erosion rate at the existing LNG jetty head area is of the order of 0.028 kg/m^2-sec both before and after development.

Fig.A4.17 shows the difference in the instantaneous rate of sediment erosion before and after proposed development. It can be observed that there is an increase in rate of sediment erosion of the order of 0.005 kg/m^2-sec to 0.015 kg/m^2-sec at the proposed standby LNG jetty head location.

4.3.1.2 Neap tide condition-peak flood (PF)

The rate of erosion for neap tide PF water condition before and after development is shown in Fig.A4.3 & Fig.A4.4 respectively. It can be seen that the maximum erosion rate is 0.110 kg/m^2-sec before and after development during the neap tide PF condition at the existing LNG jetty head area.

Fig.A4.18 shows the difference in the instantaneous rate of sediment erosion before and after proposed development. It can be observed that there is an increase in rate of sediment erosion of the order of 0.005 kg/m^2-sec to 0.03 kg/m^2-sec at the proposed standby LNG jetty head location.

4.3.1.3 Neap tide condition-highest high water (HHW)

The rate of erosion for neap tide HHW water condition before and after development is shown in Fig.A4.5 & Fig.A4.6 respectively. It can be seen that the maximum erosion rate at the existing LNG jetty head area head is 0.080 kg/m^2-sec before and after development

Fig.A4.19 shows the difference in the instantaneous rate of sediment erosion before and after proposed development during neap tide HHW condition. It can be observed that there is an increase in rate of sediment erosion of the order of 0.01 kg/m^2-sec to 0.03 kg/m^2-sec at the proposed standby LNG jetty head location.

4.3.1.4 Neap tide condition-peak ebb (PE)

The rate of erosion for neap tide PE water condition before and after development is shown in Fig.A4.7 & Fig.A4.8 respectively. From the figures it can be seen that the maximum erosion rate at the existing LNG jetty head area head is 0.08 kg/m^2-sec before and after development.

Fig.A4.20 shows the difference in the instantaneous rate of sediment erosion before and after proposed development during neap tide peak ebb condition. It can be observed that there is an increase in rate of sediment erosion of the order of 0.01 kg/m^2-sec to 0.03 kg/m^2-sec at the proposed standby LNG jetty head location while area away from jetty head has shown a slight decrease in the sediment erosion rates.

4.3.1.5 Spring tide condition-slack-1 (LLW)

The rate of erosion for spring tide LLW water condition, before and after development is shown in Fig.A4.9 & Fig.A4.10 respectively. It can be seen that the maximum erosion rate at the existing LNG jetty head area head is 0.02 kg/m^2-sec before development and 0.014 kg/m^2-sec after development.

Fig.A4.21 shows the difference in the instantaneous rate of sediment erosion before and after proposed development during spring tide LLW condition. It can be observed that there is an increase in rate of sediment erosion of the order of 0.005 kg/m^2-sec to 0.01 kg/m^2-sec at the proposed standby LNG jetty head location.

4.3.1.6 Spring tide condition-peak flood (PF)

The rate of erosion for spring tide PF water condition, before and after development is shown in Fig.A4.11 & Fig.A4.12 respectively. The maximum erosion rate is about 0.21 kg/m^2-sec before and after development at the existing LNG jetty head area.

Fig.A4.22 shows the difference in the instantaneous rate of sediment erosion before and after proposed development during spring tide PF condition. It can be observed that there is an increase in rate of sediment erosion of the order of 0.01 kg/m^2-sec to 0.03 kg/m^2-sec at the proposed standby LNG jetty head location.

4.3.1.7 Spring tide condition-highest high water (HHW)

The rate of erosion for spring tide HHW water condition, before and after development is shown in Fig.A4.13 & Fig.A4.14 respectively. It can be seen that the maximum erosion rate in the existing LNG jetty head area is of the order of 0.2 kg/m^2-sec before and after development.

Fig.A4.23 shows the difference in the instantaneous rate of sediment erosion before and after proposed development during spring tide HHW condition. It can be observed that there is an increase in rate of sediment erosion of the order of 0.03 kg/m^2-sec at the proposed standby

LNG jetty head location.

4.3.1.8 Spring tide condition-peak ebb (PE)

The rate of erosion for spring tide PE water condition, before and after development is shown in Fig.A4.15 & Fig.A4.16 respectively. From the figures it can be seen that the maximum erosion rate is 0.21 kg/m^2-sec before and after development at the existing LNG jetty head area.
Fig.A4.24 shows the difference in the instantaneous rate of sediment erosion before and after proposed development during spring tide PE condition. It can be observed that there is an increase in rate of sediment erosion of the order of 0.03 kg/m^2-sec at the proposed standby LNG jetty head location.

It can be seen that there is no change in the rate of erosion at the existing LNG jetty head area but the changes are around the proposed standby LNG jetty head and its alignment. It is more pronounced comparatively during LLW and PE condition of the tides. The comparison of sediment erosion before and after the development at different locations around the existing LNG jetty head area is shown in Fig.A4.25 (a) and Fig.A4.25 (b). (The location points are shown in Fig.A1.14). Though there is a slight variation in the erosion values at and around the proposed standby LNG jetty head area, the phenomena seem to be very much localized and there is no significant change observed in the whole domain.

4.3.2 Sediment deposition before and after development during pre-monsoon (Mar 2012)

The model results for instantaneous rate of sediment deposition for pre-monsoon before and after development are presented in Fig.A5.1 - Fig.A5.16. The figures represent the deposition values for different tidal condition, viz. lowest low water (LLW), peak flood (PF), highest high water (HHW) and peak ebb (PE) of neap and spring tides. Fig.A5.17 - Fig.A5.24 show the difference in rate of deposition for various tidal condition before and after development during LLW, PF. HHW and PE of neap and spring tide conditions respectively. The results are discussed in detail below.

4.3.2.1 Neap tide condition-slack-1 (LLW)

The rate of deposition for neap tide LLW water condition before and after development is shown in Fig.A5.1 & Fig.A5.2 respectively. It can be seen that the deposition rate is minimum and is in the range of 0 - 0.0132 kg/m^2-sec at the existing as well as proposed standby LNG jetty head areas before and after development.

4.3.2.2 Neap tide condition-peak flood (PF)

The rate of deposition for neap tide PF water condition before and after development is shown in Fig.A5.3 & Fig.A5.4 respectively. It can be seen that the deposition rate is minimum / negligible in the region of existing LNG jetty head area and is in the range of 0 - 0.009 kg/m^2-sec at the proposed standby LNG jetty head area after development.

4.3.2.3 Neap tide condition-highest high water (HHW)

The rate of deposition for neap tide HHW water condition before and after development is shown in Fig.A5.5 & Fig.A5.6 respectively. The deposition rate in the existing LNG jetty head area is observed to be nil where as it is about 0.009 kg/m^2-sec at the proposed standby LNG jetty head area after development.

4.3.2.4 Neap tide condition-peak ebb (PE)

The rate of deposition for neap tide PE water condition, before and after development is shown in Fig.A5.7 & Fig.A5.8 respectively. It can be seen that the deposition rate in the existing LNG jetty head area and at the proposed standby LNG jetty head area is minimum and is of the order of 0.01 kg/m^2-sec both before and after development.

4.3.2.5 Spring tide condition-slack-1 (LLW)

The rate of deposition for spring tide LLW water condition before and after development is shown in Fig.A5.9 & Fig.A5.10 respectively. The deposition rate in the existing LNG jetty head area and at the proposed standby LNG jetty head area is observed to be small and is about

0.012 kg/m^2-sec.

4.3.2.6 Spring tide condition-peak flood (PF)

The rate of deposition for springtide PF water condition before and after development is shown in Fig.A5.11 & Fig.A5.12 respectively. It can be seen that the deposition rate at the proposed standby LNG jetty head area is about 0.01 kg/m^2-sec where as the existing LNG jetty is unaffected.

4.3.2.7 Spring tide condition-highest high water (HHW)

The rate of deposition for spring tide HHW water condition before and after development is shown in Fig.A5.13 & Fig.A5.14 respectively. The deposition rate in the existing LNG jetty head area is nil where as at the proposed standby LNG jetty head area it is about 0.011 kg/m^2-sec after development.

4.3.2.8 Spring tide condition-peak ebb (PE)

The rate of deposition for spring tide PE water condition before and after development is shown in Fig.A5.15 & Fig.A5.16 respectively. It can be seen that the deposition rate is minimum and is in the range of 0 - 0.0132 kg/m^2-sec both before and after development.

Fig.A5.17 – Fig.A5.24 show the difference in rate of deposition before and after development. It can be seen that there is a change in the deposition rate due to the proposed development specifically at the existing LNG jetty head area. The comparison of sediment deposition before and after development at different location points (given in Fig.A1.14) in the area is shown in Fig.A5.25 (a) and Fig.A5.25 (b). It can be seen that, though there is a slight increase in rate of deposition in some areas in the domain, it is very much localized and no significant change in deposition over the larger domain is noticed.

4.3.3 Sediment erosion before and after development during post-monsoon (Nov 2012)

The model predicted values for the rate of erosion during post-monsoon (November 2012) are discussed below.

4.3.3.1 Neap tide condition-slack-1 (LLW)

The rate of erosion for neap tide LLW condition before and after development is shown in Fig.A6.1 & Fig.A6.2 respectively. It can be seen that the erosion rate in the existing LNG jetty head area is about 0.040 kg/m^2-sec both before and after development.

4.3.3.2 Neap tide condition-peak flood (PF)

The rate of erosion for neap tide PF water condition before and after development is shown in Fig.A6.3 & Fig.A6.4 respectively. It can be seen that the erosion rate in the existing LNG jetty head area is varying between 0.03 to 0.11 kg/m^2-sec both before and after development.

4.3.3.3 Neap tide condition-highest high water (HHW)

The rate of erosion for neap tide HHW water condition before and after development is shown in Fig.A6.5 & Fig.A6.6 respectively. It can be seen that the erosion rate in the existing LNG jetty head area is of the order of 0.0980 kg/m^2-sec both before and after development. There is no significant change in the rates of erosion after development.

4.3.3.4 Neap tide condition-peak ebb (PE)

The rate of erosion for neap tide PE water condition before and after development is shown in Fig.A6.7 & Fig.A6.8 respectively. It can be seen that the erosion rate in the existing as well as proposed standby LNG jetty head areas is varying between 0.0 to 0.090 kg/m^2-sec both before and after development.

4.3.3.5 Spring tide condition-slack-1 (LLW)

The rate of erosion for spring tide LLW water condition before and after development is shown in Fig.A6.9 & Fig.A6.10 respectively. It can be seen that the erosion rate in the existing LNG jetty head area is about 0.0350 kg/m^2-sec both before and after development. A similar erosion rate is observed at the proposed standby LNG jetty head area also after the development.

4.3.3.6 Spring tide condition-peak flood (PF)

The rate of erosion for spring tide PF water condition before and after development is shown in Fig.A6.11 & Fig.A6.12 respectively. It can be seen that the instantaneous rate of erosion in the existing LNG jetty head area is about 0.230 kg/m^2-sec; both before and after development. A similar erosion rate is observed at the proposed standby LNG jetty head area also after the development.

4.3.3.7 Spring tide condition-highest high water (HHW)

The rate of erosion for spring tide HHW water condition before and after development is shown in Fig.A6.13 & Fig.A6.14 respectively. It can be seen that the instantaneous rate of erosion in the existing LNG jetty head area is about 0.180 kg/m^2-sec; both before and after development. A similar erosion rate is observed at the proposed standby LNG jetty head area also after the development.

4.3.3.8 Spring tide condition-peak ebb (PE)

The rate of erosion for spring tide PE water condition before and after development is shown in Fig.A6.15 & Fig.A6.16 respectively. It can be seen that the instantaneous rate of erosion in the existing LNG jetty head area varies between 0.02 to 0.170 kg/m^2-sec both before and after development. A similar erosion rate is observed at the proposed standby LNG jetty head area also after the development.

Fig.A6.17 - Fig.A6.24 show the erosion difference before and after development respectively for different tidal conditions. It can be seen that there is a change in the rate of erosion after development at the proposed standby LNG jetty head area. The comparison of sediment erosion before and after development at different location points (Fig.A1.14) around the existing and proposed standby LNG jetties is shown in Figs.A6.25 (a) and (b). It can be seen that the variations are small in magnitude and can be considered not very significant and the variations are very much localized and do not affect the larger domain.

4.3.4 Sediment deposition before and after development during post-monsoon (Nov 2012)

The model predicted values for the rate of deposition during post-monsoon (November 2012) are discussed below.

4.3.4.1 Neap tide condition-slack-1 (LLW)

The rate of deposition for neap tide LLW water condition before and after development is shown in Fig.A7.1 & Fig.A7.2 respectively. It can be seen that the deposition rate in the existing as well as proposed standby LNG jetty head areas is varying between 0.0 to 0.009 kg/m^2-sec both before and after development.

4.3.4.2 Neap tide condition-peak flood (PF)

The rate of deposition for neap tide PF water condition before and after development is shown in Fig.A7.3 & Fig.A7.4 respectively. It can be seen that the deposition rate in the existing LNG jetty head area has not changed. The rate of deposition at the proposed standby LNG jetty head area is of the order of 0.0176 kg/m^2-sec after development.

4.3.4.3 Neap tide condition-highest high water (HHW)

The rate of deposition for neap tide HHW water condition before and after development is shown in Fig.A7.5 & Fig.A7.6 respectively. It can be seen that the deposition rate in the existing LNG jetty head area is varying between 0.0 to 0.0132 kg/m^2-sec before and after development. The rate of deposition at the proposed standby LNG jetty head area is of the order of 0.0132 kg/m^2-sec after development.

4.3.4.4 Neap tide condition-peak ebb (PE)

The rate of deposition for neap tide PE water condition before and after development is shown in Fig.A7.7 & Fig.A7.8 respectively. It can be seen that the deposition rate in the existing LNG jetty head area is varying between 0.0088 to 0.0132 kg/m^2-sec both before and after the proposed development. The rate of deposition at the proposed standby LNG jetty head area is of the order of 0.0132kg/m^2-sec after development.

4.3.4.5 Spring tide condition-slack-1 (LLW)

The rate of deposition for spring tide LLW water condition before and after development is shown in Fig.A7.9 & Fig.A7.10 respectively. It can be seen that the deposition rate in the existing LNG jetty head area is varying between 0.0 to 0.0132 kg/m^2-sec both before and after development. The rate of deposition at the proposed standby LNG jetty head area is of the order of 0.0132 kg/m^2-sec after development.

4.3.4.6 Spring tide condition-peak flood (PF)

The rate of deposition for spring tide PF water condition before and after development is graphically shown in Fig A7.11 & Fig.A7.12 respectively. It can be seen that there is no change in deposition rate in the existing LNG jetty head area before and after development. The rate of deposition at the proposed standby LNG jetty head area is of the order of 0.0132 kg/m^2-sec after development.

4.3.4.7 Spring tide condition-highest high water (HHW)

The rate of deposition for spring tide HHW water condition before and after development is shown in Fig.A7.13 & Fig.A7.14 respectively. It can be seen that there is no change in the deposition rate in the existing LNG jetty head area before and after development. The rate of deposition at some parts of the proposed standby LNG jetty head area is of the order of 0.0132 kg/m^2-sec after development.

4.3.4.8 Spring tide condition-peak ebb (PE)

The rate of deposition for spring tide PE water condition before and after development is shown in Fig.A7.15 & Fig A7.16 respectively. It can be seen that the deposition rate in the existing LNG jetty head area and channel area is varying between 0.0 to 0.0132 kg/m^2-sec both before and after development. The rate of deposition at the proposed standby LNG jetty head area is of the order of 0.0132 kg/m^2-sec after development.

Fig.A7.17 – Fig.A7.24 show the deposition difference between before and after proposed development at the existing as well as proposed standby LNG jetty head areas. It can be seen that there is a change in the instantaneous rate of deposition in the area after the proposed development. No significant change in the rate of deposition noticed in the rest of the domain. The comparison of the rates of sediment deposition before and after development at different location points around the existing LNG jetty head area (Fig.A1.14) is shown in Fig.A7.25 (a) and (b).
From the figures it can be seen that there is some impact on flow/sediment dynamics after proposed development but it is not very significant and mostly of localized nature.

The actual degree of erosion that would occur over a length of time will depend on the net rate of erosion/deposition over that time. Hence, the exact quantity of erosion or deposition may not be predicted accurately from the instantaneous rates. However, the bed level changes calculated based on the summation of instantaneous rates of erosion/deposition in the domain due to the proposed development indicate the likely scenario of changes in the domain.

4.4 Morphological changes

The model has been run continuously for 15 days taking account of neap and spring tide conditions for various seasons and the morphological changes due to erosion and deposition in the domain after the proposed development. The results are shown graphically.

Fig.A8.1 gives the bed level after 15 days before development and Fig.8.2 gives the bed level after development in the pre-monsoon period (March 2012).

Fig.A8.3 gives the difference in the bed levels before and after development in the domain. It can be seen that the bed level changes are limited to the proposed standby jetty location only due to the development.

Figs.A8.4 (a) and (b) give the comparison of bed levels before and after development at various observation location points set up around the existing as well as proposed standby LNG jetties. Here again it can be observed that there is no significant difference in the bed level changes due to the development in the domain and it is mostly localized to the proposed standby LNG jetty only.

The variation of bed level -- resultant of erosion and deposition over 15 days – is found to be a maximum value of the order of 0.04 m to 0.05 m in the vicinity of proposed standby LNG jetty head area during this pre-monsoon period (March 2012)

Fig.A9.1 gives the bed level after 15 days before development and Fig.9.2 gives the bed level after fifteen days after development in the post-monsoon period (November 2012).

Fig.A9.3 gives the difference in the bed levels before and after development in the domain. Here also, it can be seen that the bed level changes are limited to the proposed standby jetty location only due to the development.

Figs.A9.4 (a) and (b) give the comparison of bed levels before and after development at various observation location points set up around the existing as well as proposed standby LNG jetties. Here again it can be observed that there is no significant difference in the bed level changes due to the development in the domain and it is mostly localized to the proposed standby LNG jetty only.

The variation of bed level -- resultant of erosion and deposition over 15 days – is found to be a maximum value of the order of 0.03m to 0.04 m in the vicinity of proposed standby LNG jetty head area during this post monsoon period (November 2012)

5. CONCLUSIONS AND RECOMMENDATIONS

Based on the modeling study carried out to evaluate the flow regime and sedimentation processes due to the proposed development of marine facilities (installing a standby LNG Jetty south of the existing LNG jetty) at Dahej, the following conclusions can be drawn:

Hydrodyn-FLOSOFT and SEDSOFT modules have been used for predicting the impact on flow dynamics, morphological changes and coastline changes due to marine facility development.

Hydrodynamic Modeling:

- The model generated tides are comparable to actual observations at the vicinity of proposed development at PETRONET LNG Jetty.
- The model has been run for various tidal conditions to study the hydrodynamic behavior and flow regime in and around the proposed development.
- For all the tidal conditions and with the proposed development considered, the impact on the flow regime is minimal and there seems to be no significant difference in the tides and velocities in the domain due to proposed development.
- The changes in the flow regime for various tidal conditions before and after the proposed development are found to be negligible.

Sediment Transport Modeling:

- Minor changes in the sedimentation processes for all tidal conditions seem to be present due to the proposed development.
- The accumulation of sand/silt/mud predicted in the vicinity of proposed standby LNG jetty is around 3 to 5 cm over a period of 15 days.
- The changes in the sedimentation processes for all tidal conditions due to the development activities are not significant enough to cause any appreciable change in the bed levels and

sediment concentration in other parts of the domain except at the proposed standby LNG jetty

- The development activities do not seem to affect the flow regime and morphology in the rest of the study area in general.

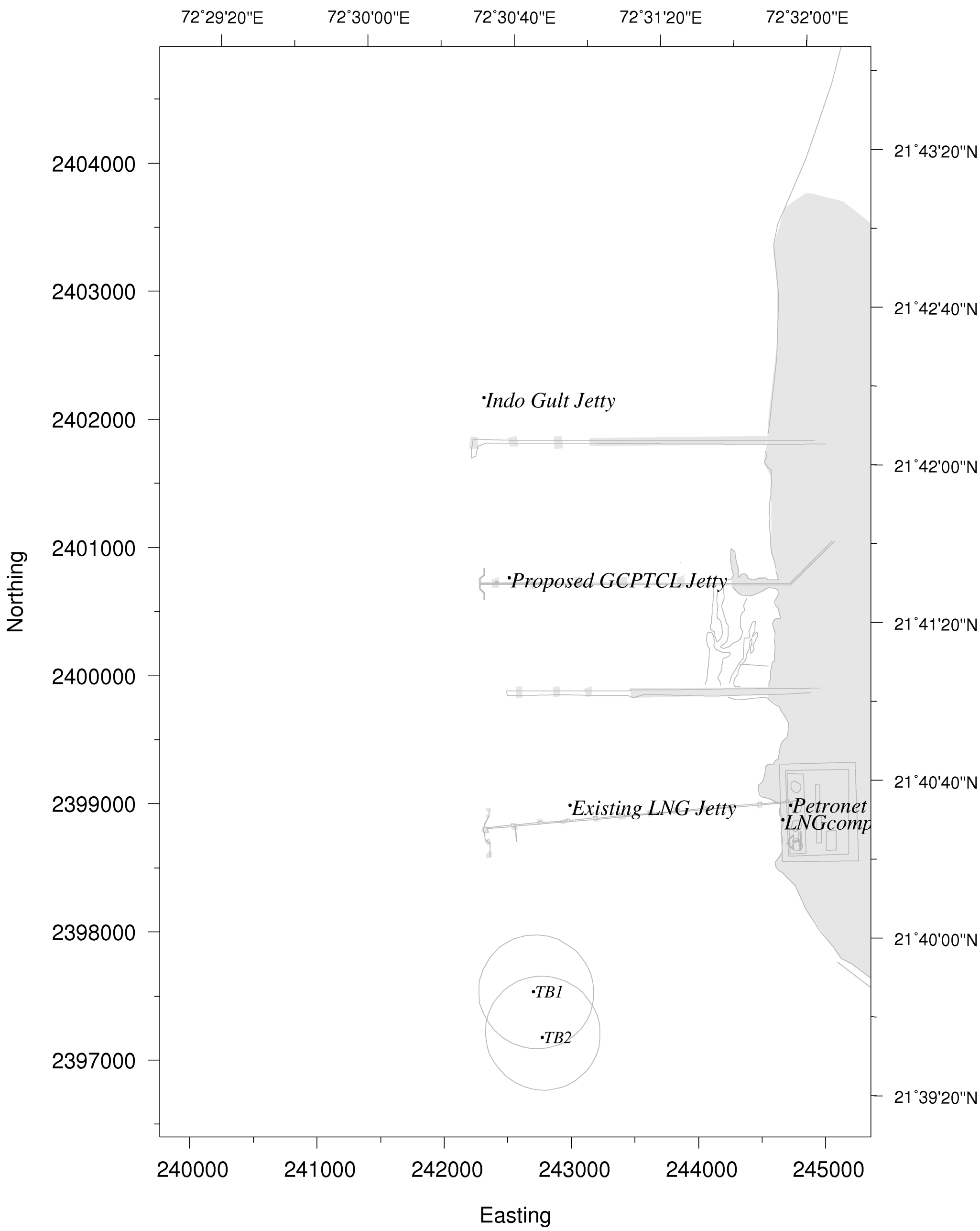


Fig.A1.1: Study domain showing existing LNG jetty and other installations in the study domain - (before development)

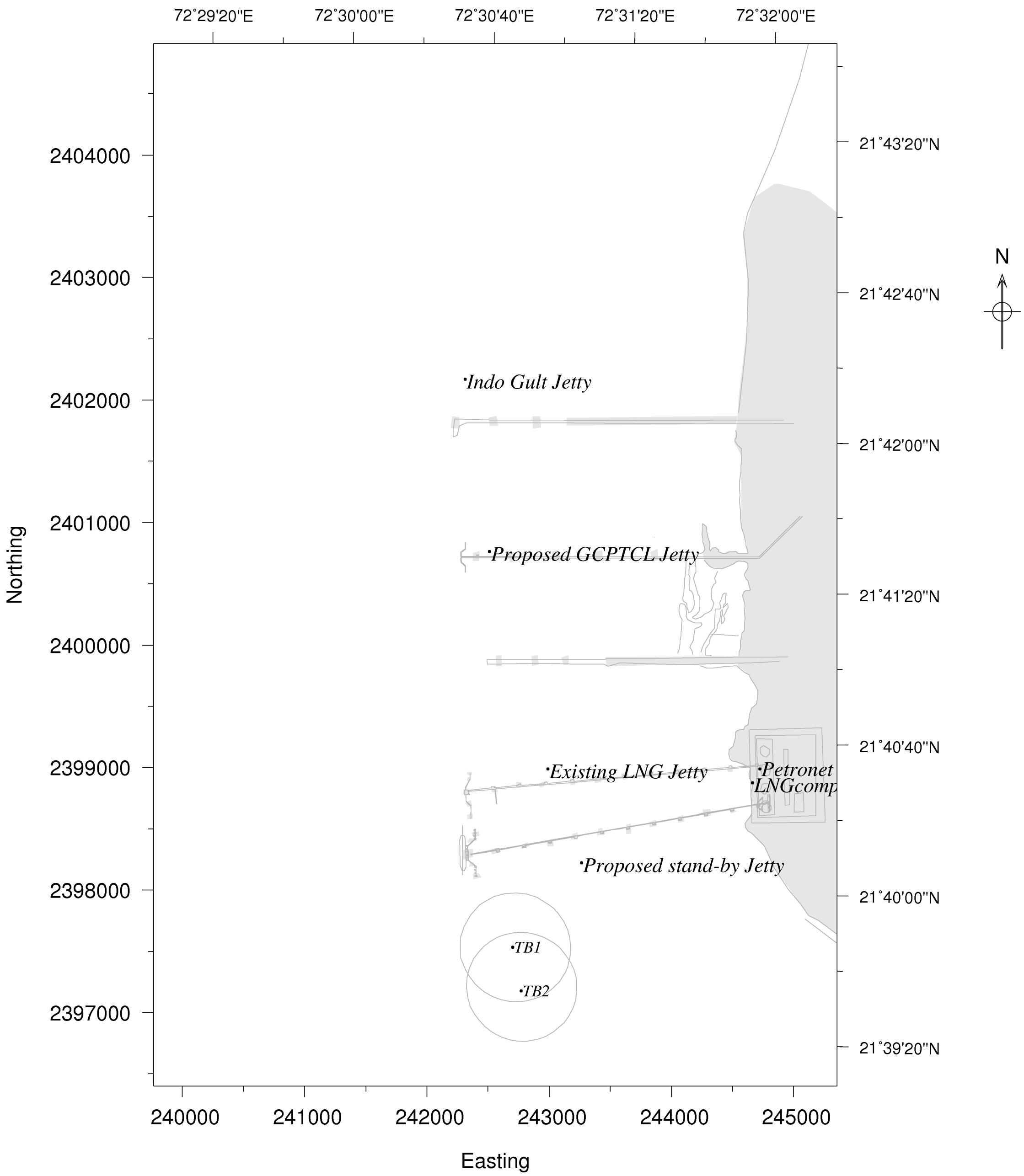


Fig.A1.2: Study domain with the proposed standby LNG jetty and other existing installations in the study domain - (after development)

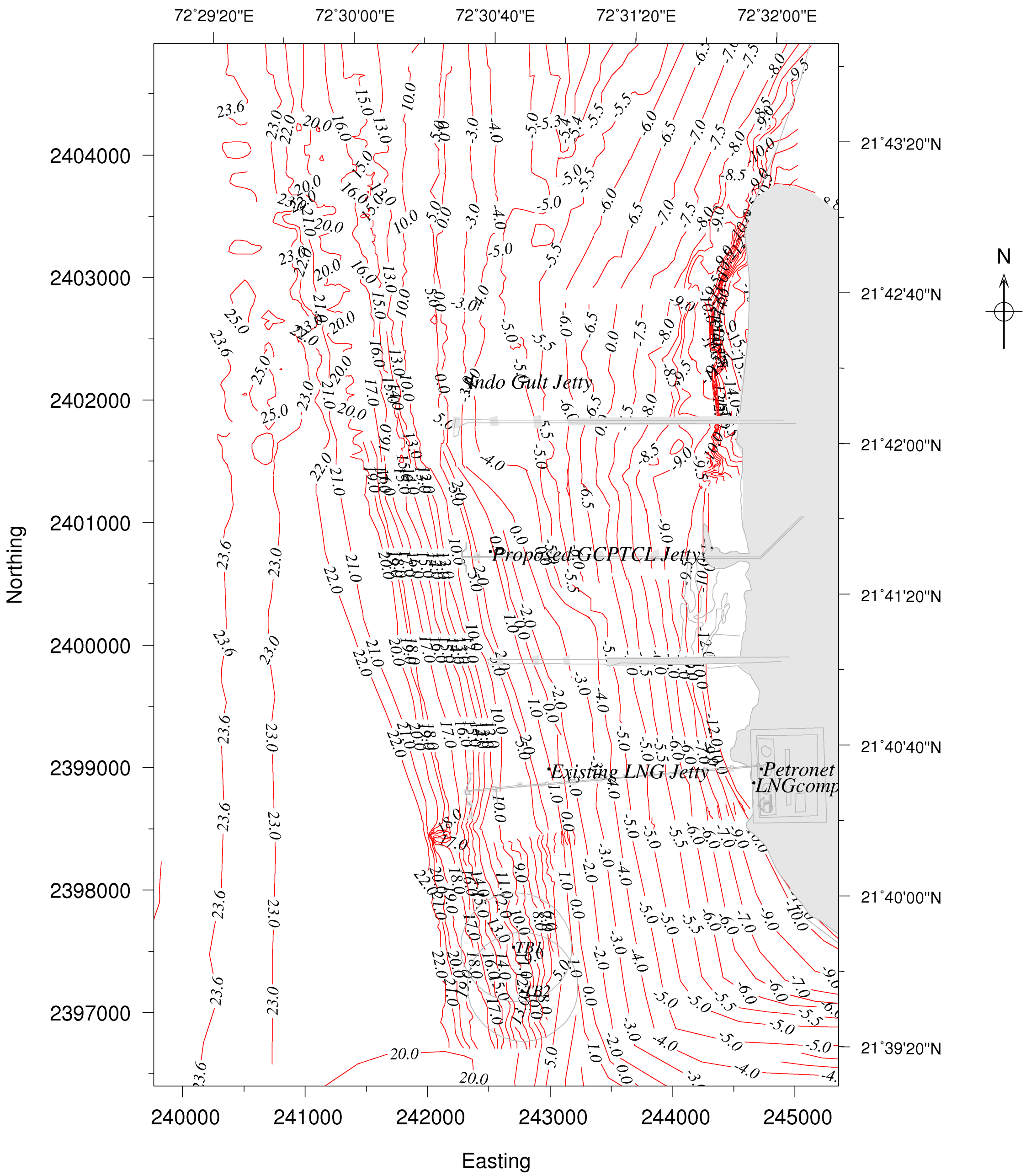
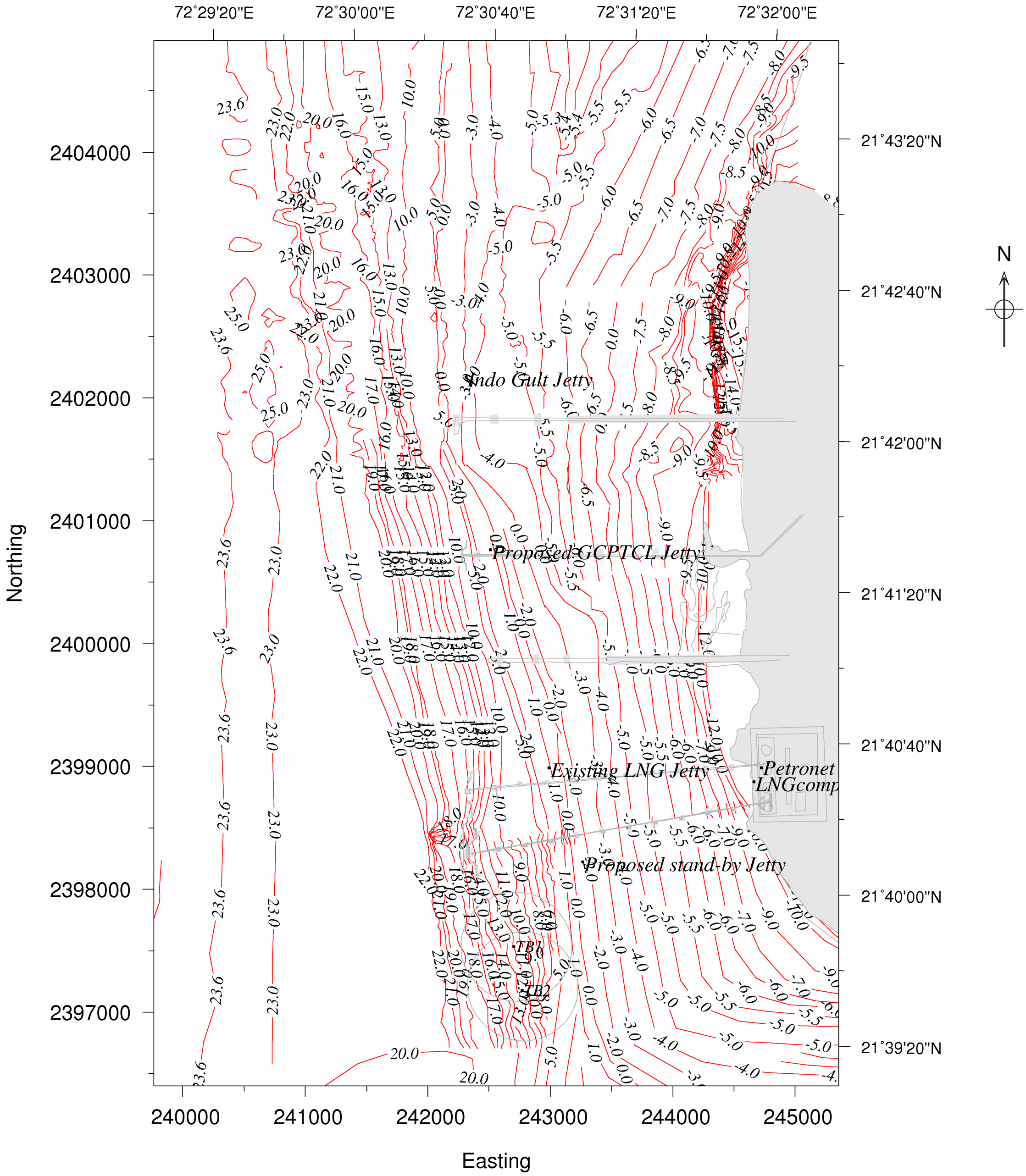


Fig.A1.3: Terrain features of the study domain (Before development)



72°29'20"E
72°30'00"E
72°30'40"E
72°31'20"E
72°32'00"E
21°43'20"N
21°42'40"N
21°42'00"N
21°41'20"N
21°40'40"N
21°40'00"N
21°39'20"N
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Petronet
LNGcomp
Proposed stand-by Jetty
TB1
TB2

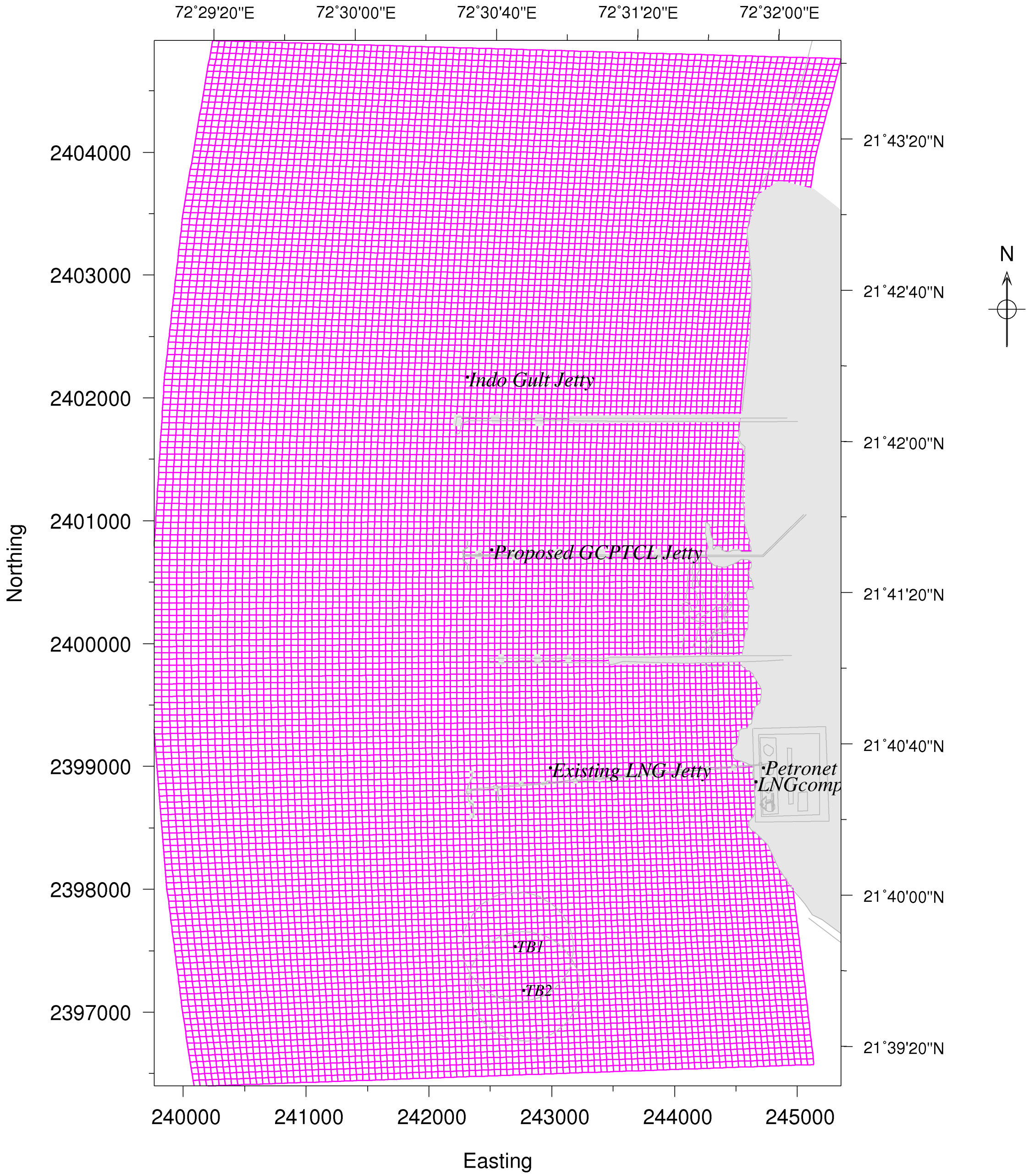


Fig.A1.5: Computational grid of the study domain – (Before development)

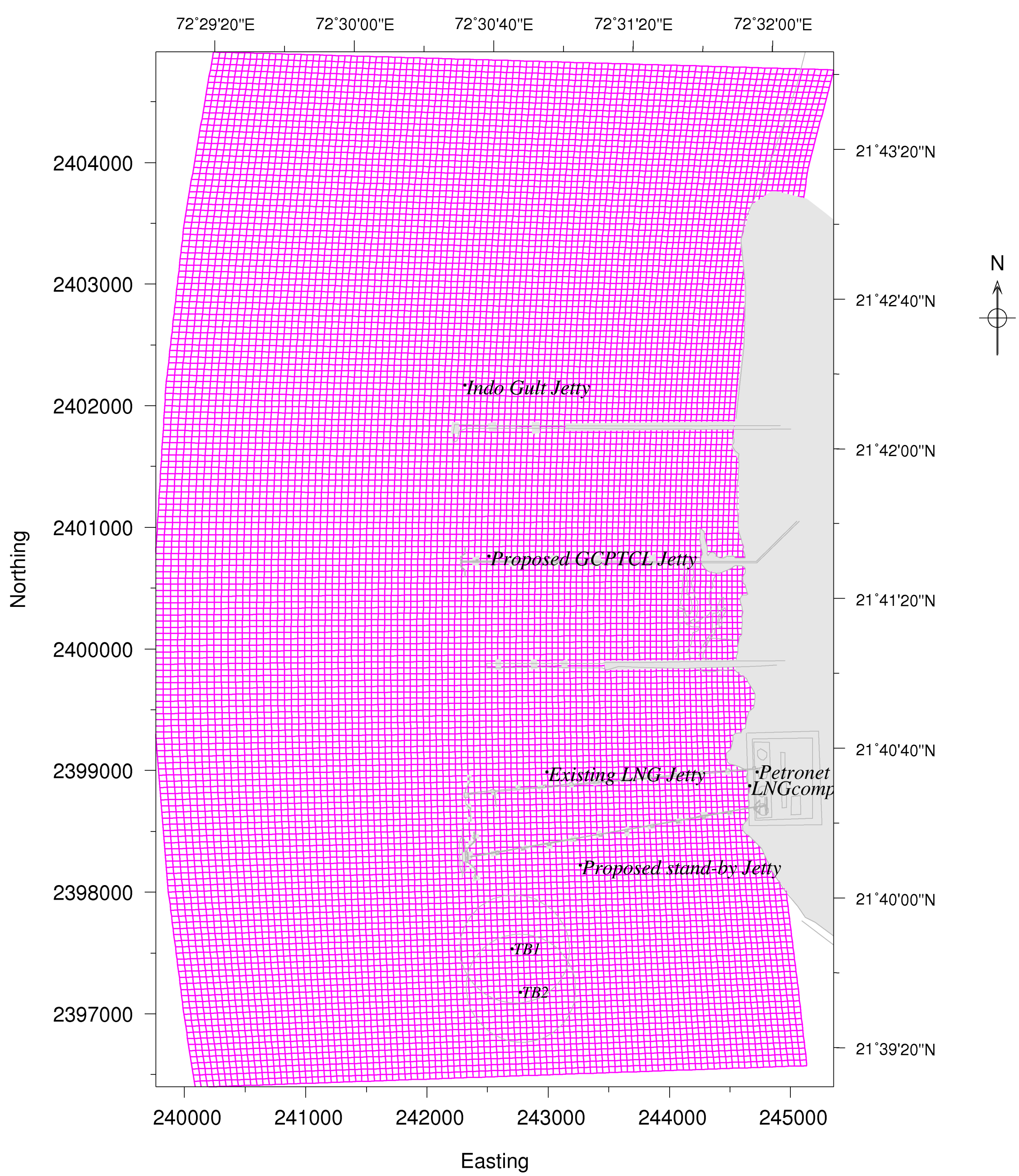


Fig.A1.6: Computational grid of the study domain – (After development)

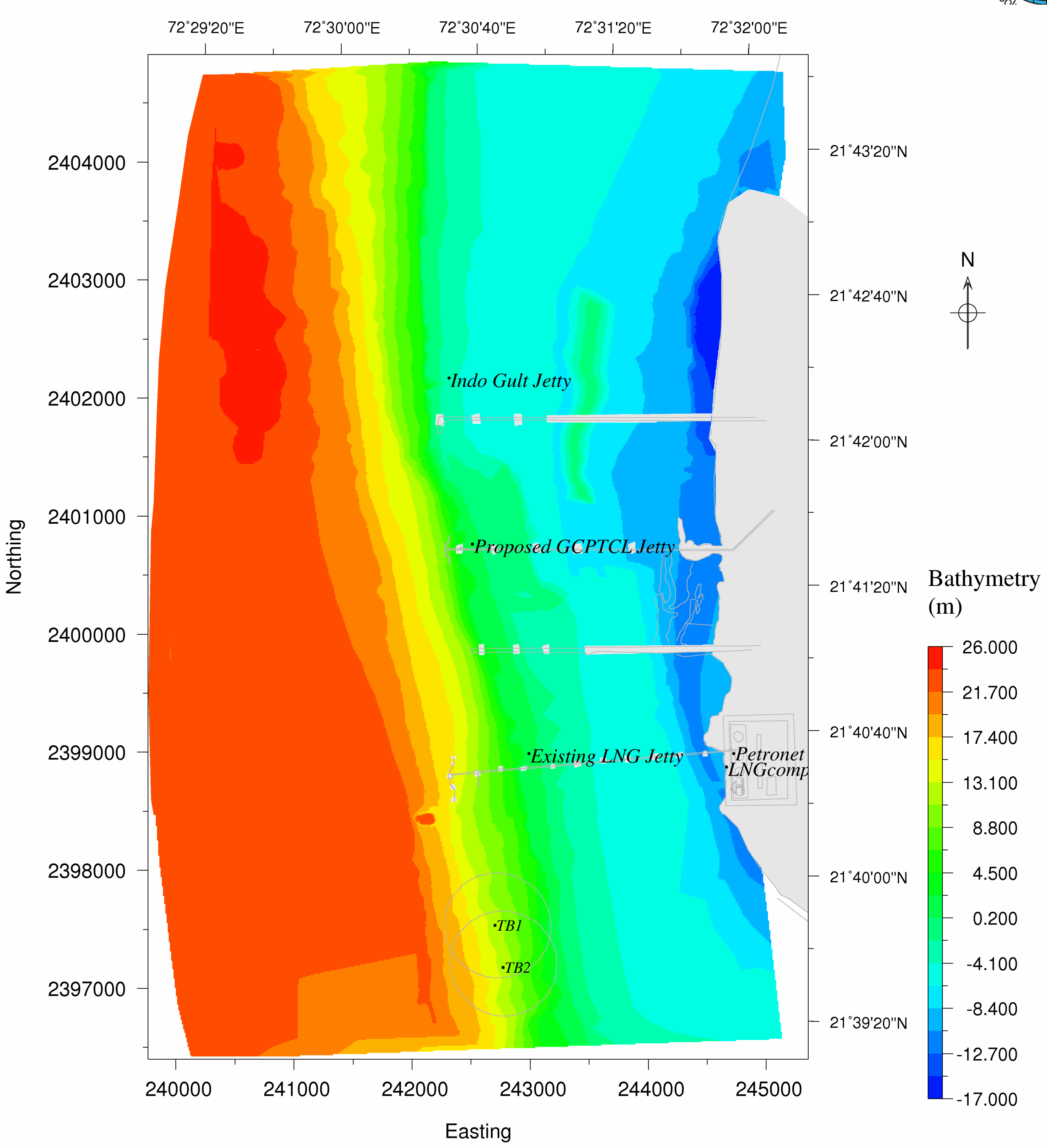


Fig.A1.7: Interpolated depth contours – (Before development)

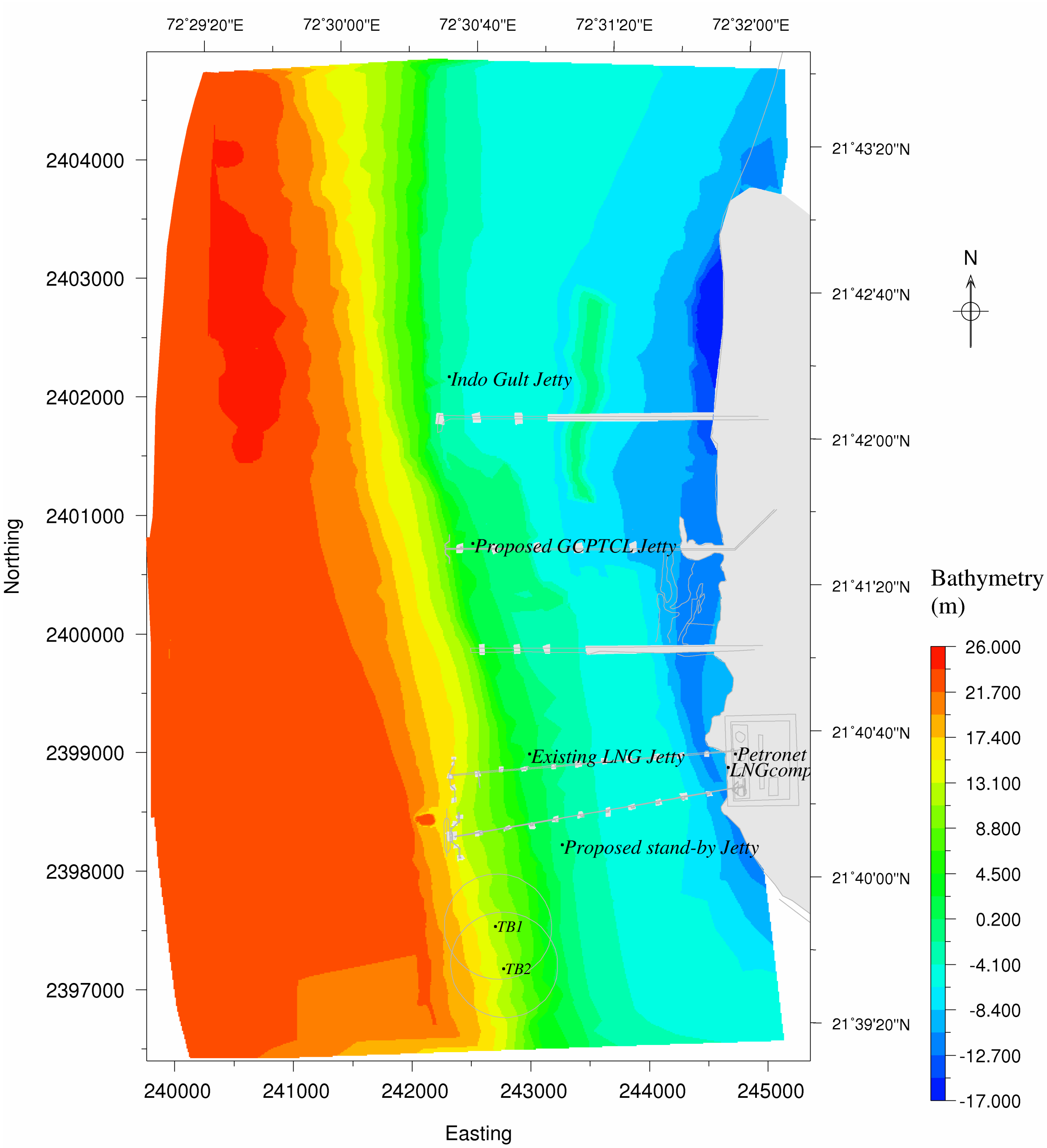


Fig.A1.8: Interpolated depth contours – (After development)

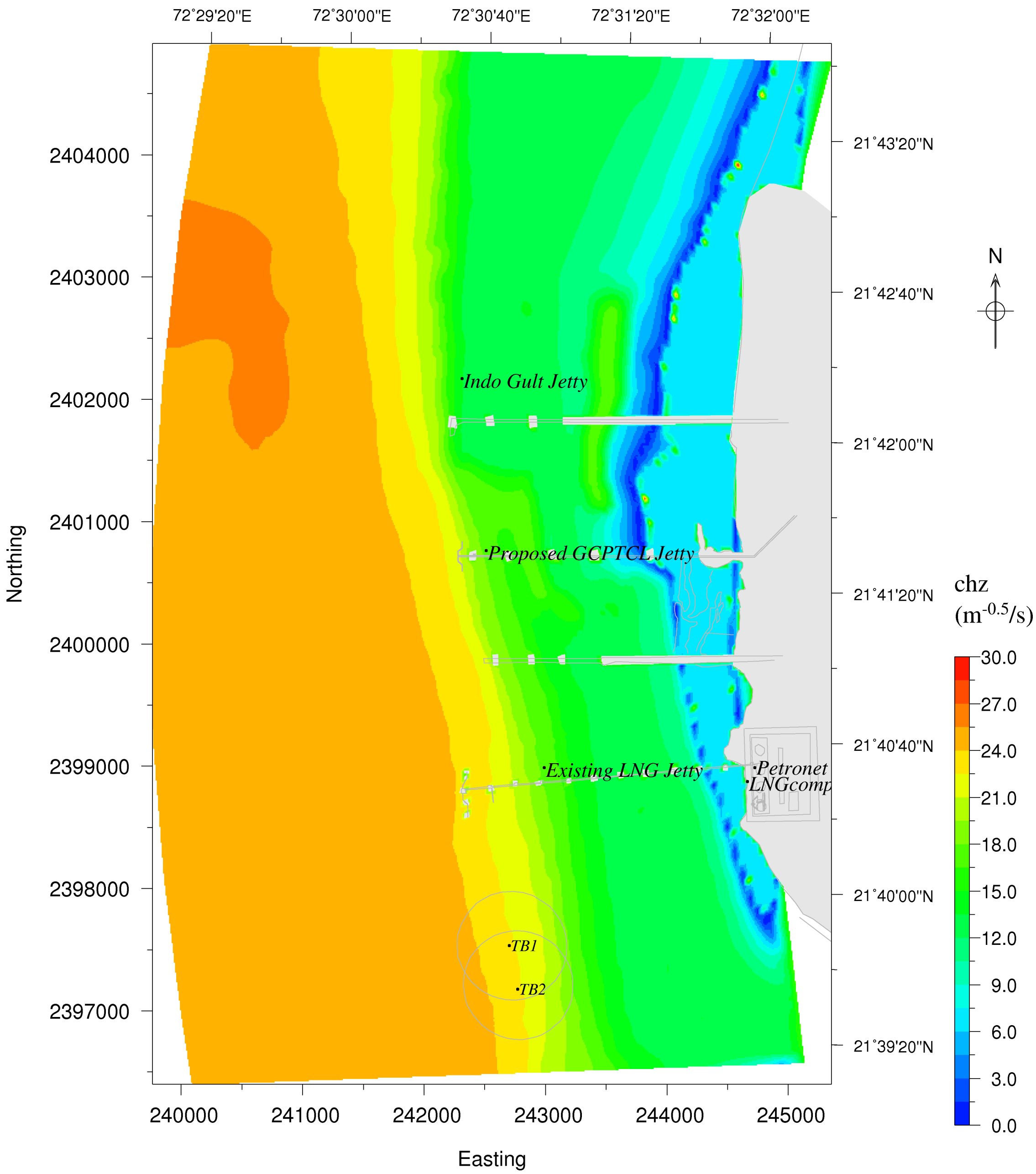


Fig.A1.9: Chezy's coefficients - (Before development)

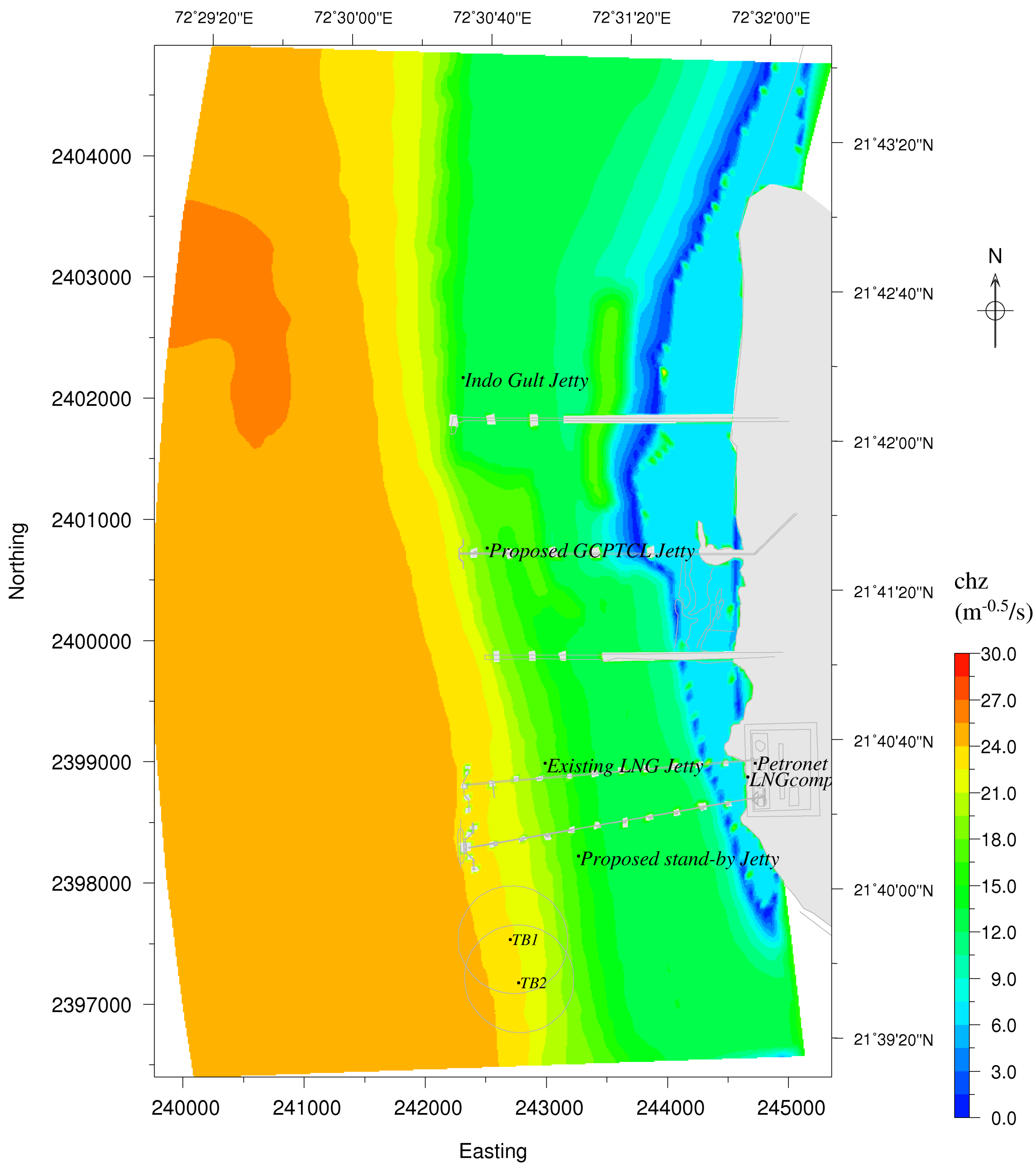
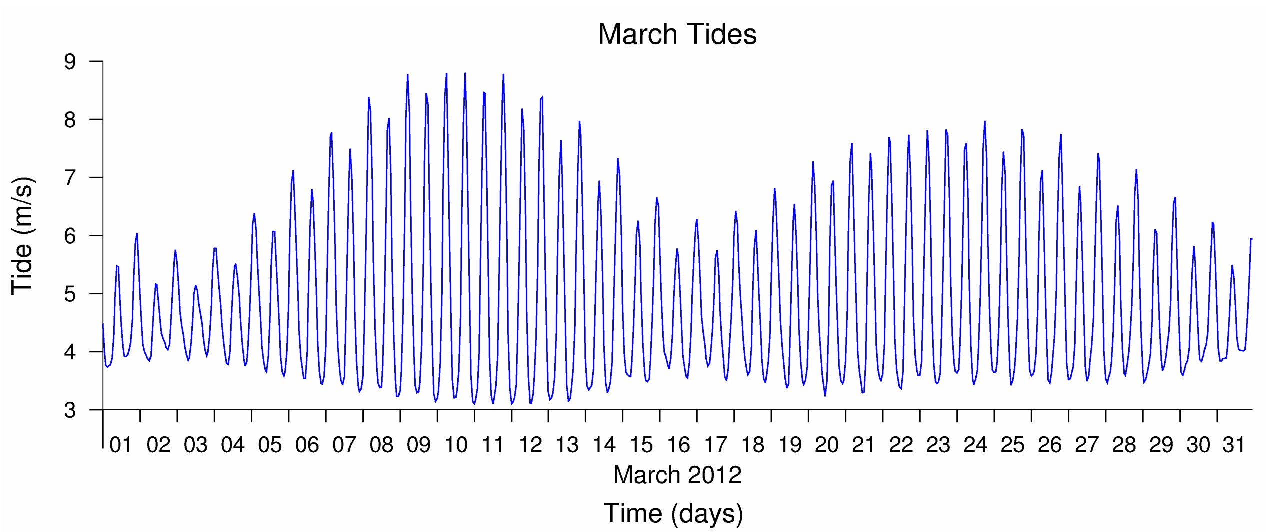


Fig.A1.10: Chezy's coefficients - (After development)



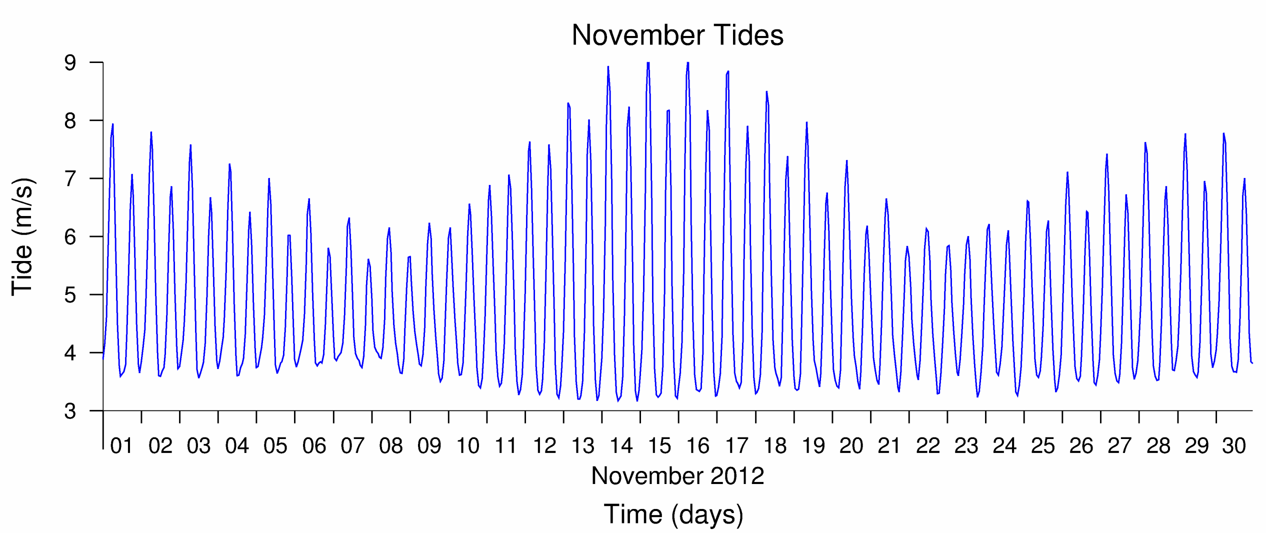


Fig.A1.11:Boundary tides

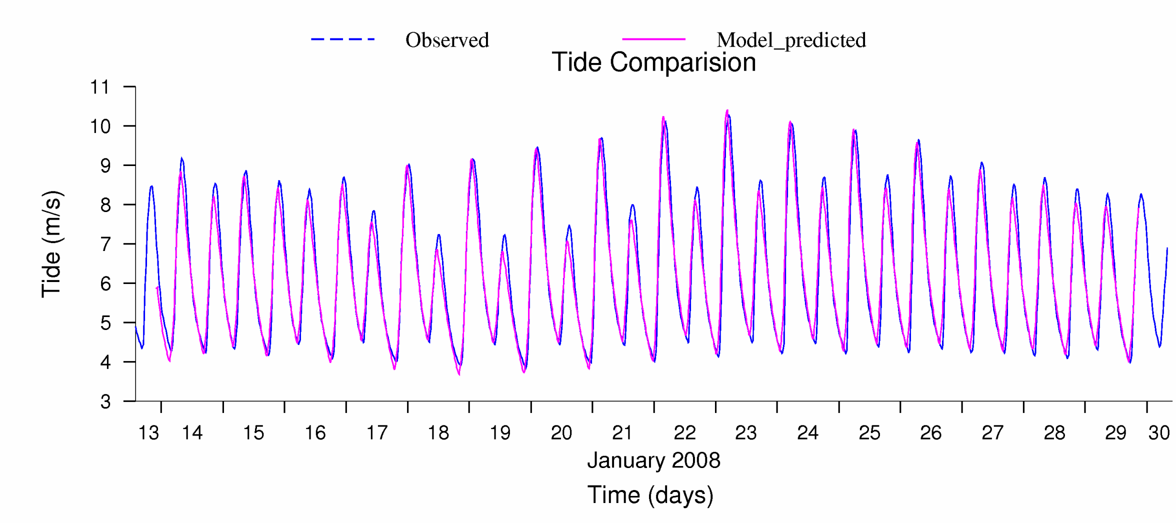


Fig.A1.12: Comparison of predicted and observed tides.

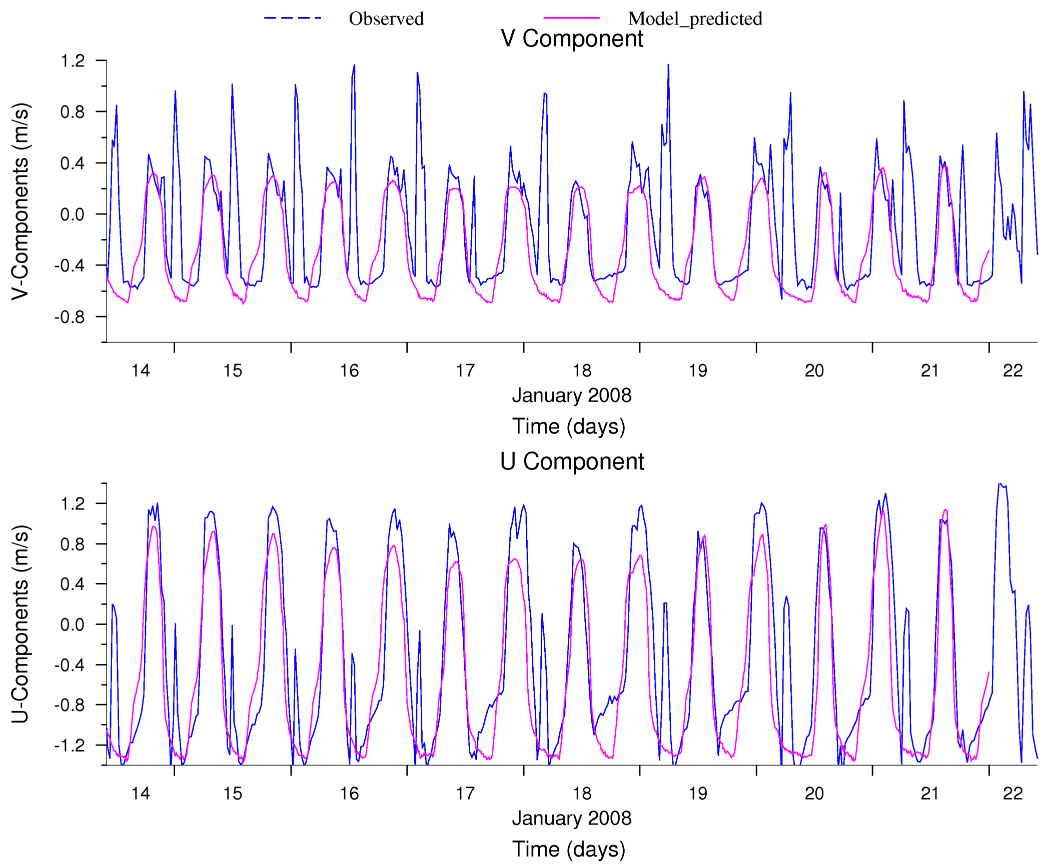


Fig.A1.13: Comparison of predicted and observed currents.

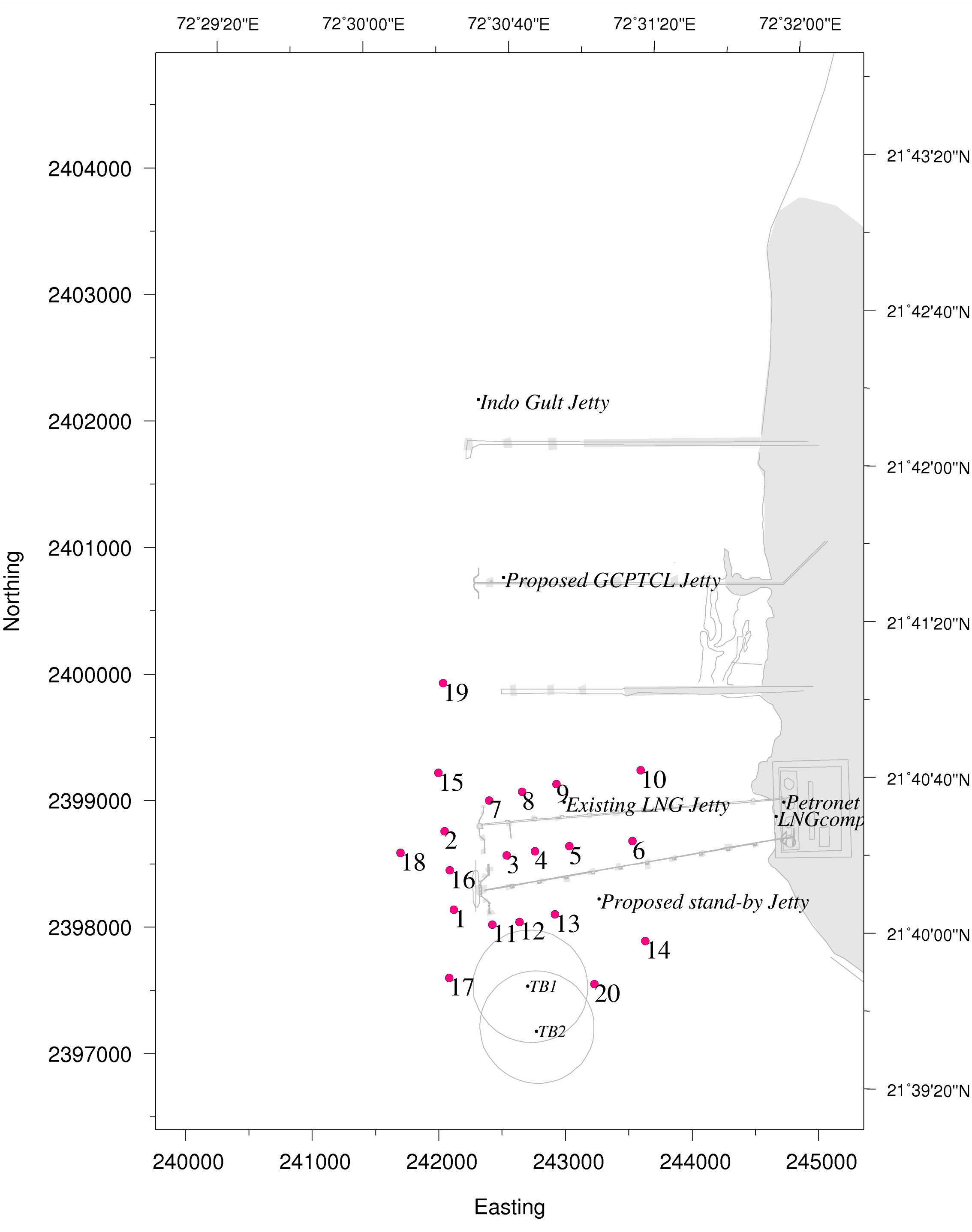


Fig.A1.14: Location of observation points around the proposed breakwater

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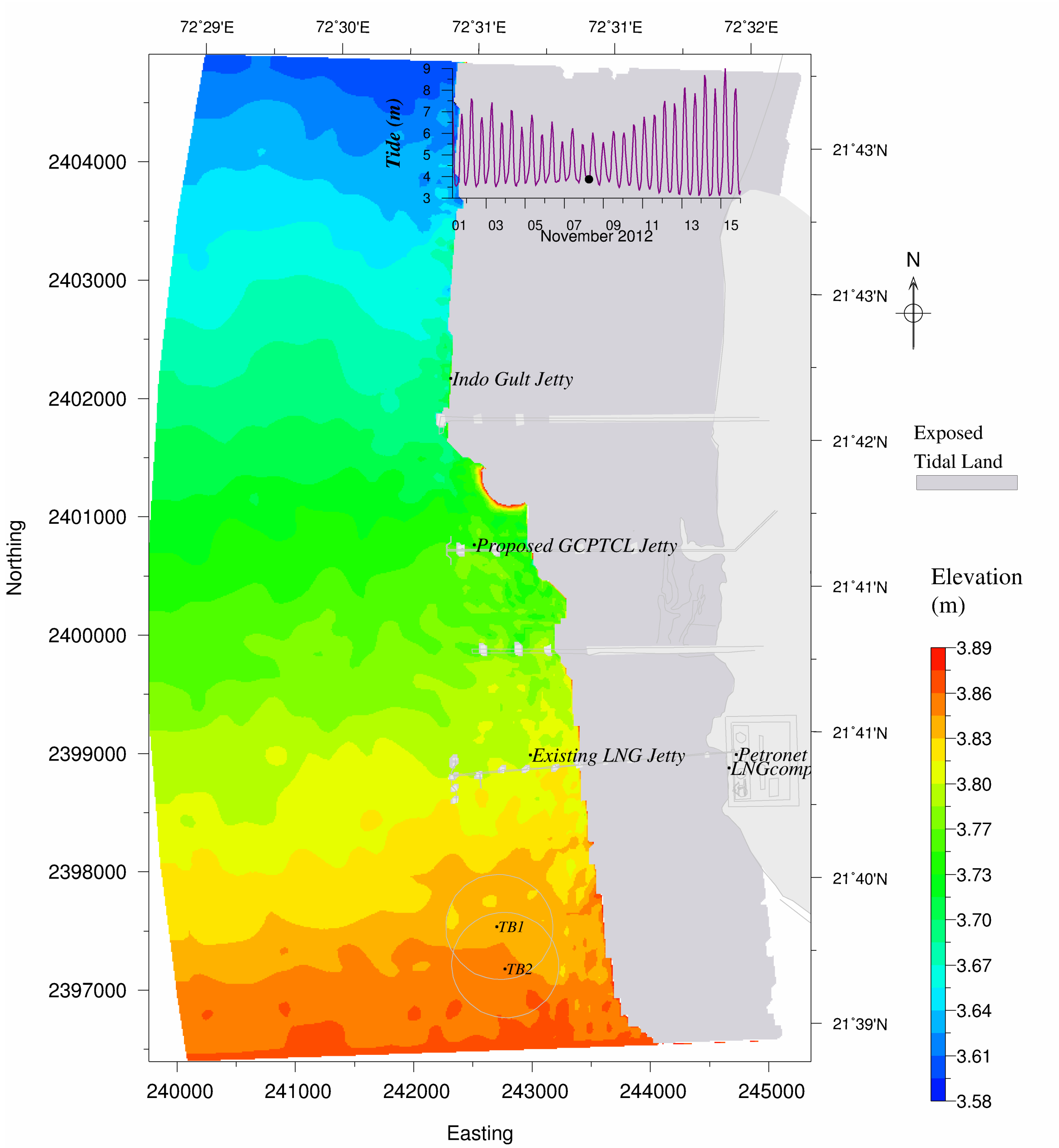


Fig.A3.1 Simulated tides before development (at 08/11/2012 06:00hr) during neap tide (LLW)

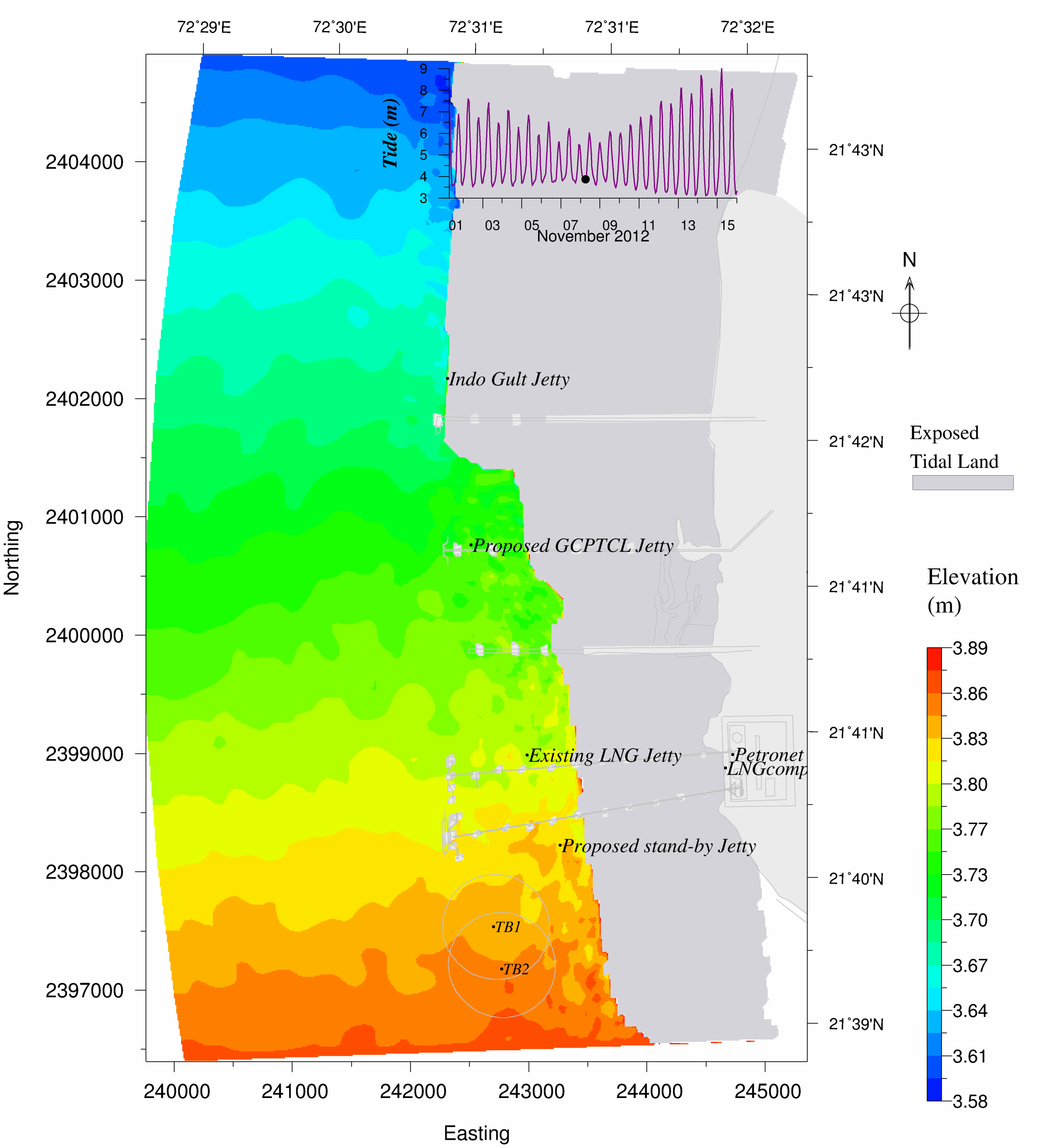


Fig.A3.2 Simulated tides after development (at 08/11/2012 06:00hr) during neap tide (LLW)

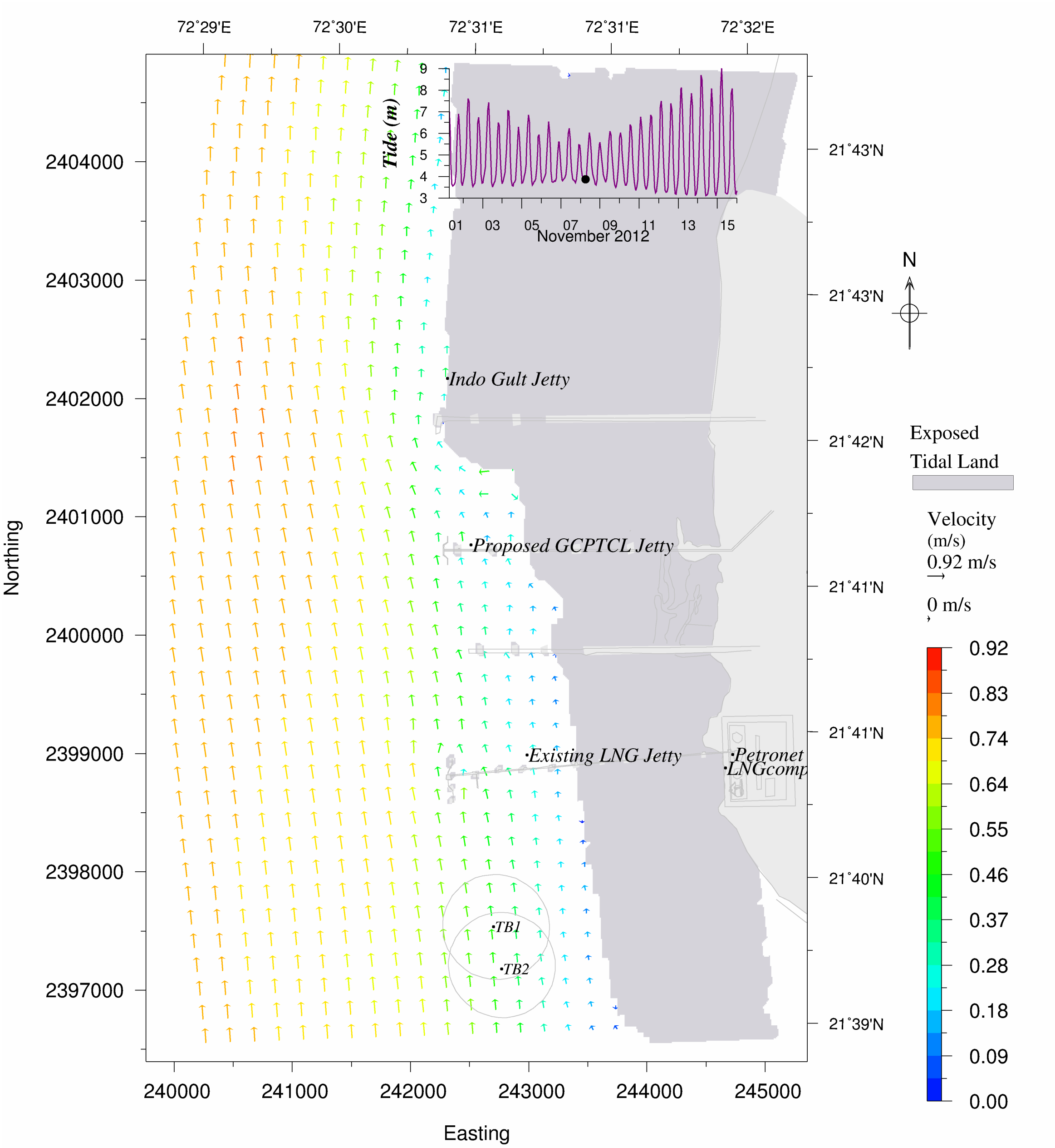


Fig.A3.3 Simulated currents before development (at 08/11/2012 06:00hr) during neap tide (LLW)

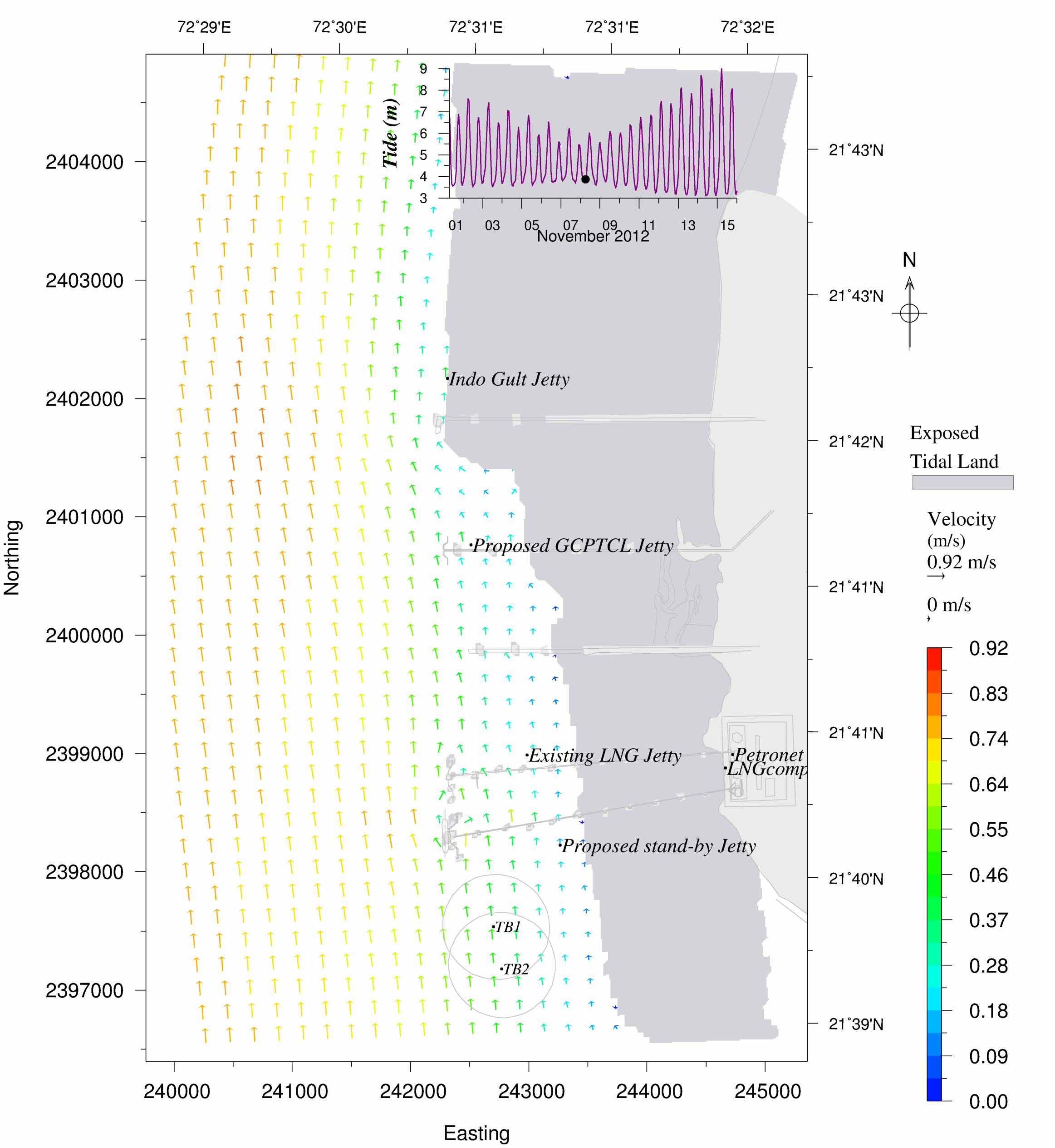


Fig.A3.4 Simulated currents after development (at 08/11/2012 06:00hr) during neap tide (LLW)

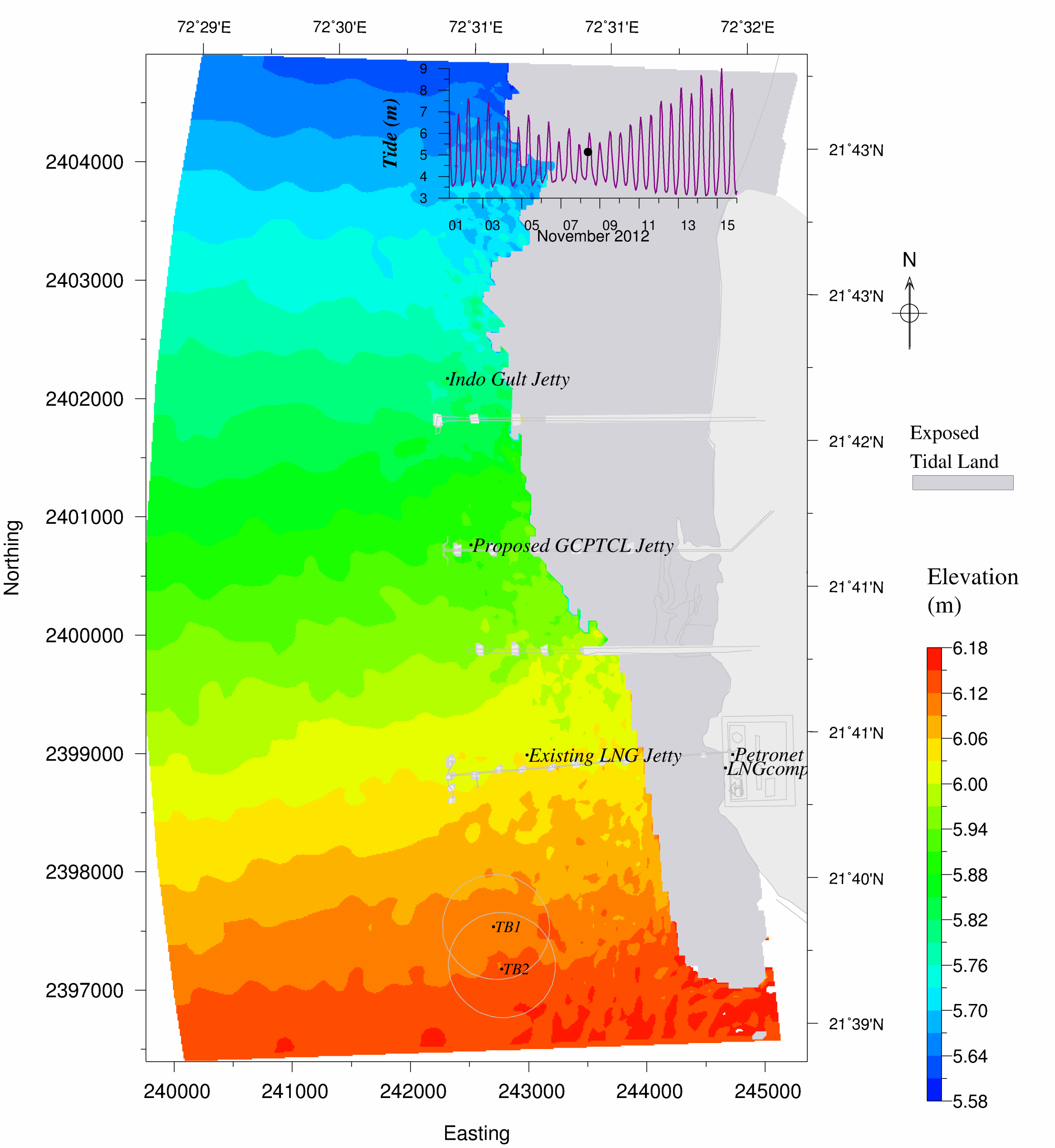


Fig.A3.5 Simulated tides before development (at 08/11/2012 09:00hr) during neap tide (Peak Flood)

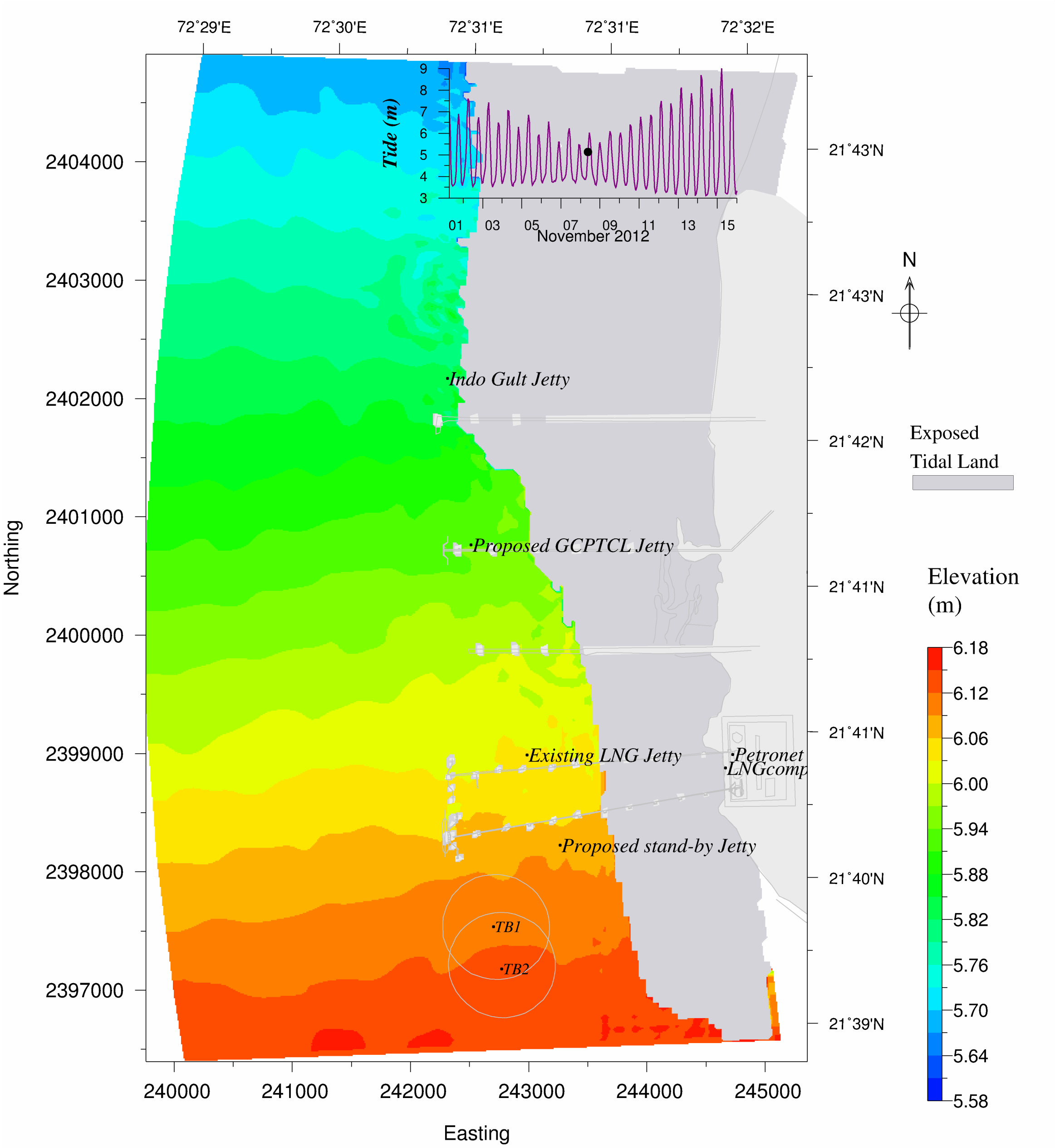


Fig.A3.6 Simulated tides after development (at 08/11/2012 09:00hr) during neap tide (Peak Flood)

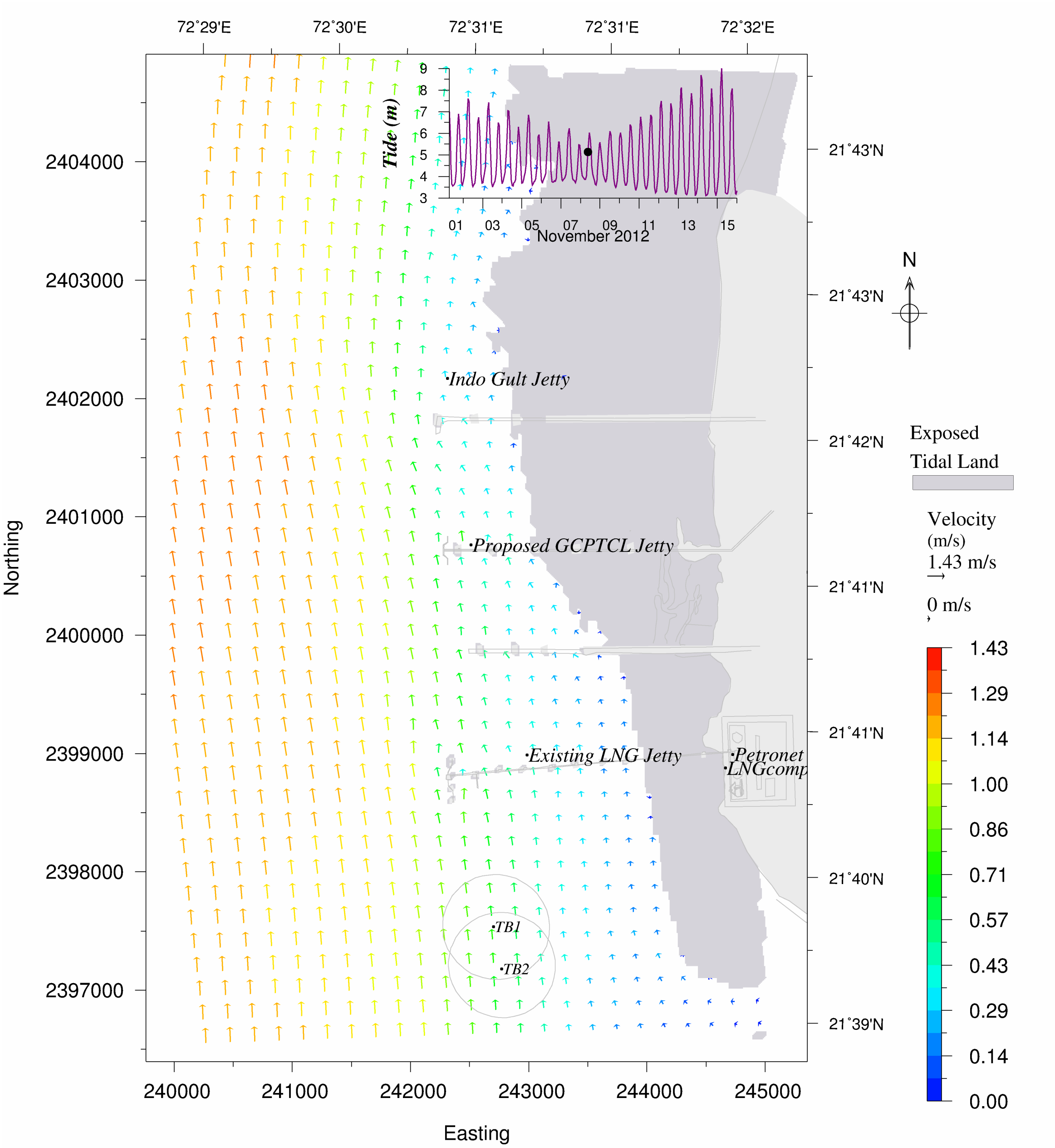


Fig.A3.7 Simulated currents before development (at 08/11/2012 09:00hr) during neap tide (Peak Flood)

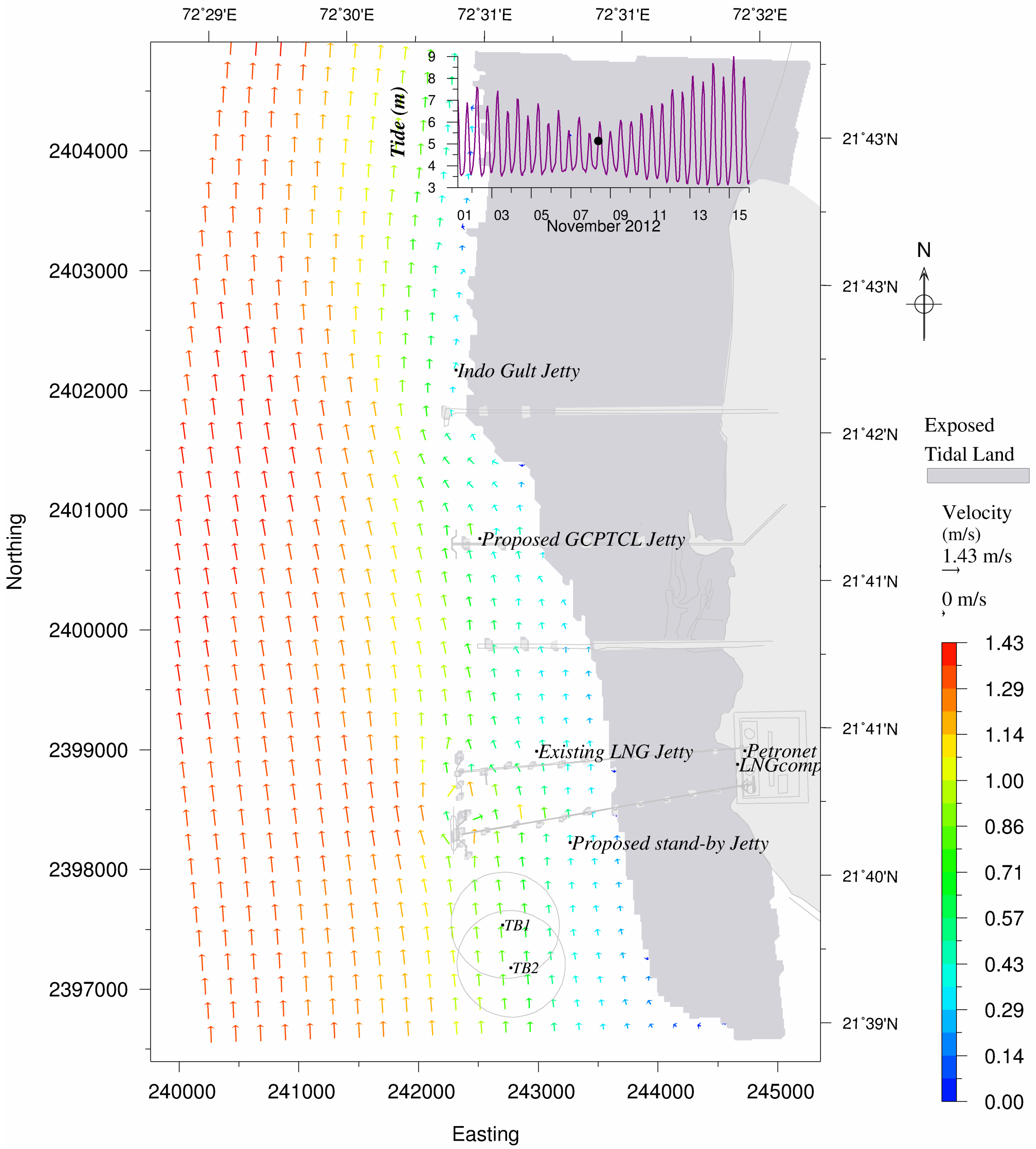


Fig.A3.8 Simulated currents after development (at 08/11/2012 09:00hr) during neap tide (Peak Flood)

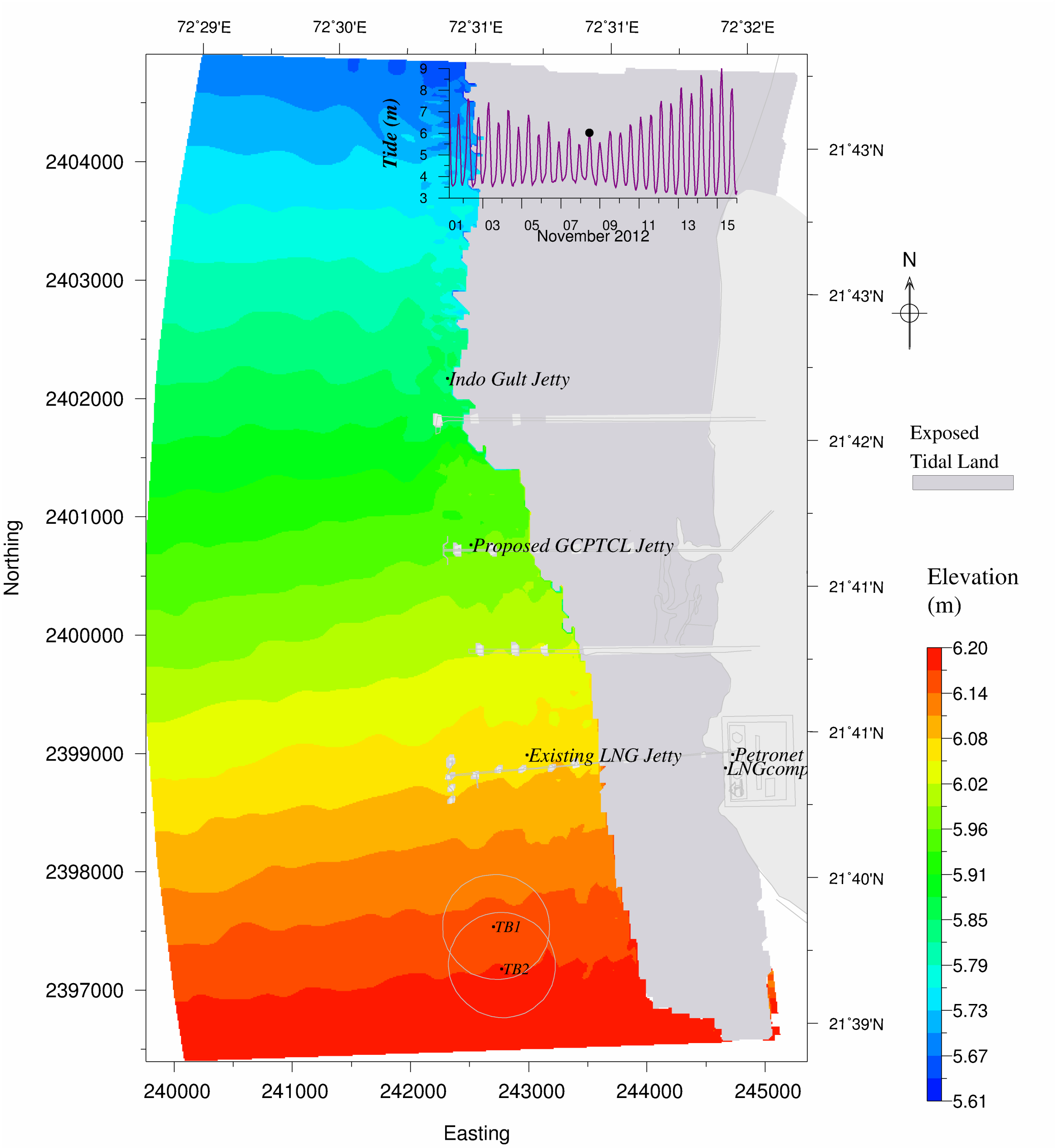


Fig.A3.9 Simulated tides before development (at 08/11/2012 11:00hr) during neap tide (HHW)

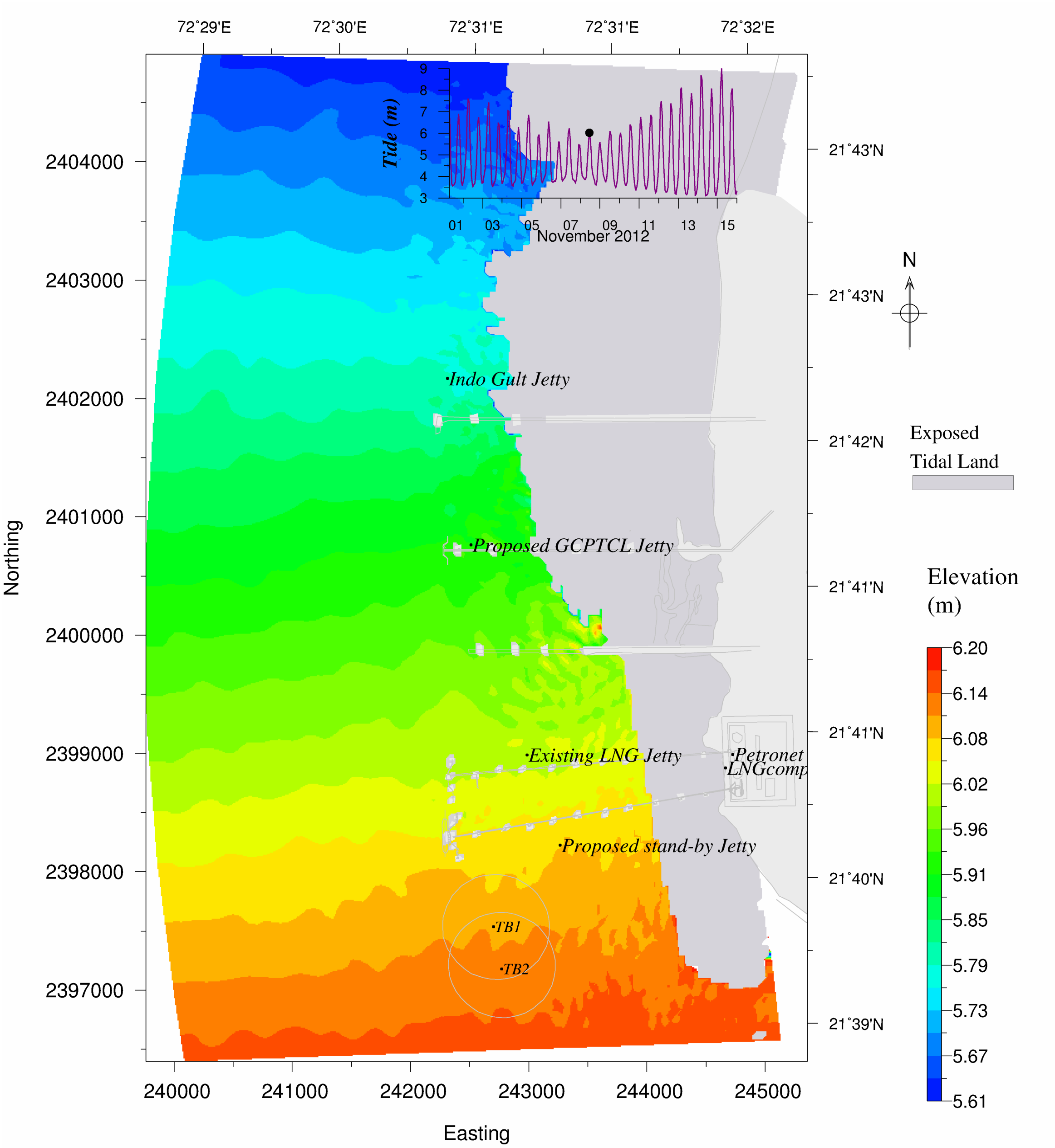


Fig.A3.10 Simulated tides after development (at 08/11/2012 11:00hr) during neap tide (HHW)

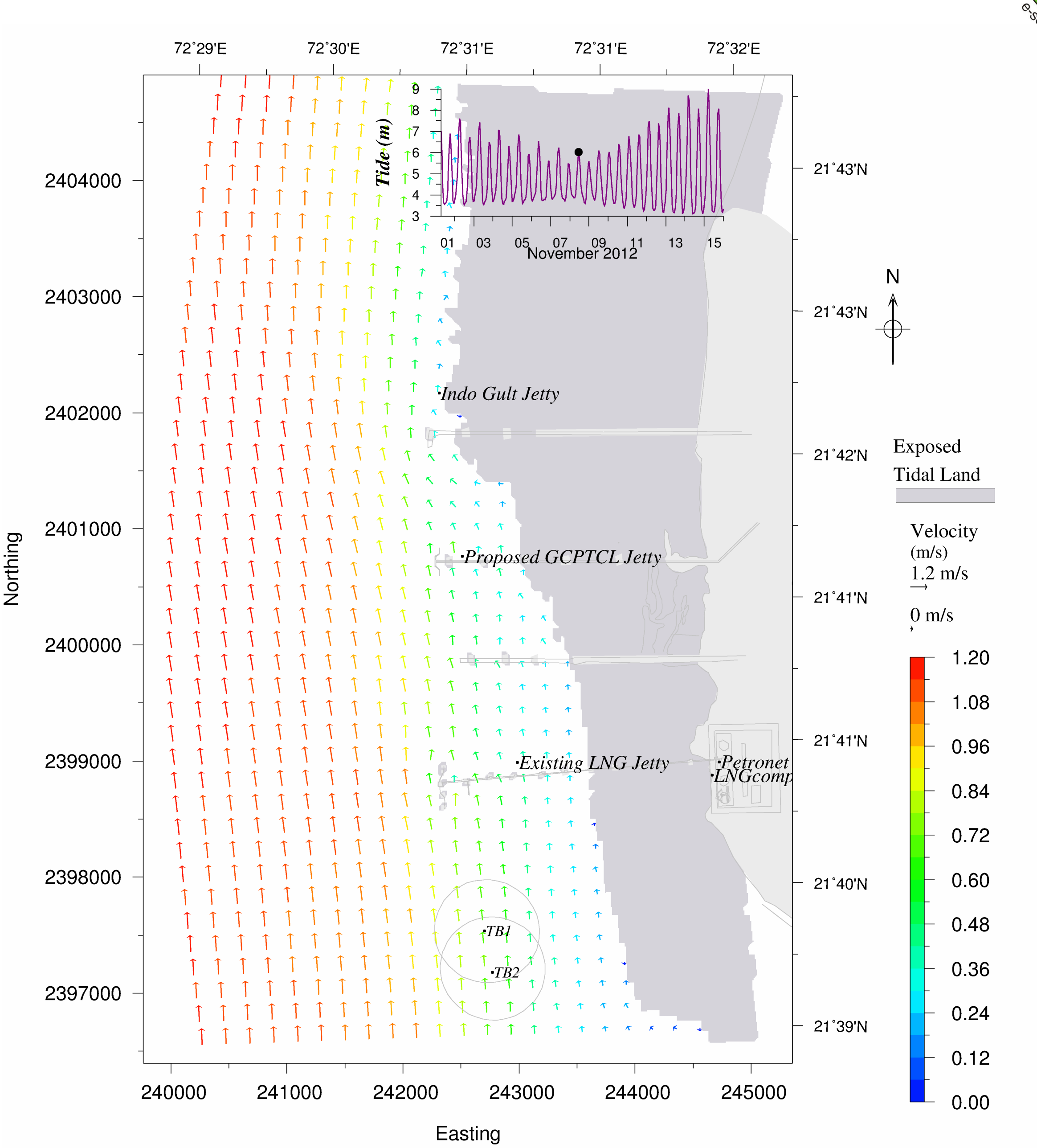


Fig.A3.11 Simulated currents before development (at 08/11/2012 11:00hr) during neap tide (HHW)

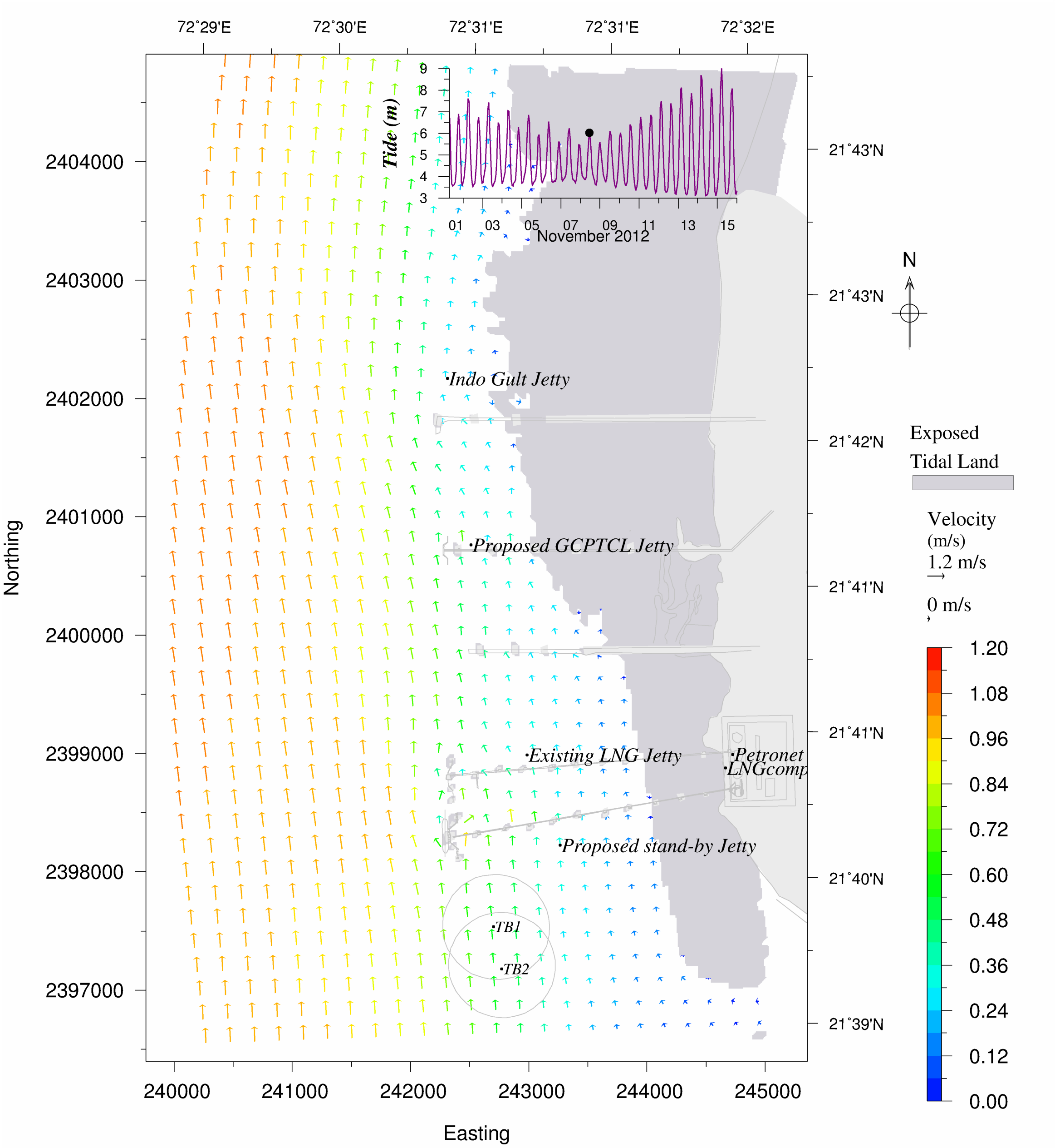


Fig.A3.12 Simulated currents after development (at 08/11/2012 11:00hr) during neap tide (HHW)

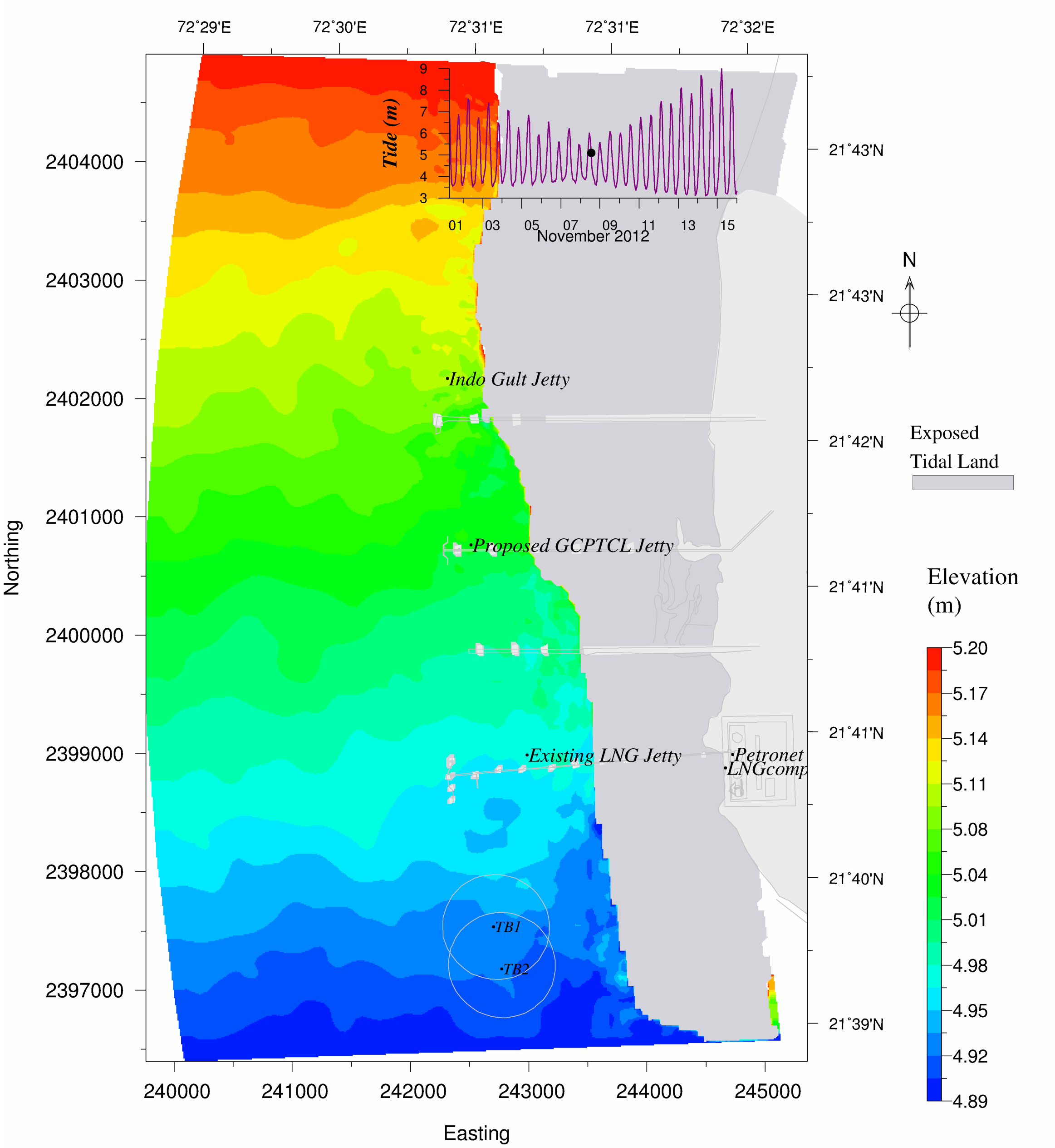


Fig.A3.13 Simulated tides before development (at 08/11/2012 14:00hr) during neap tide (Peak EBB)

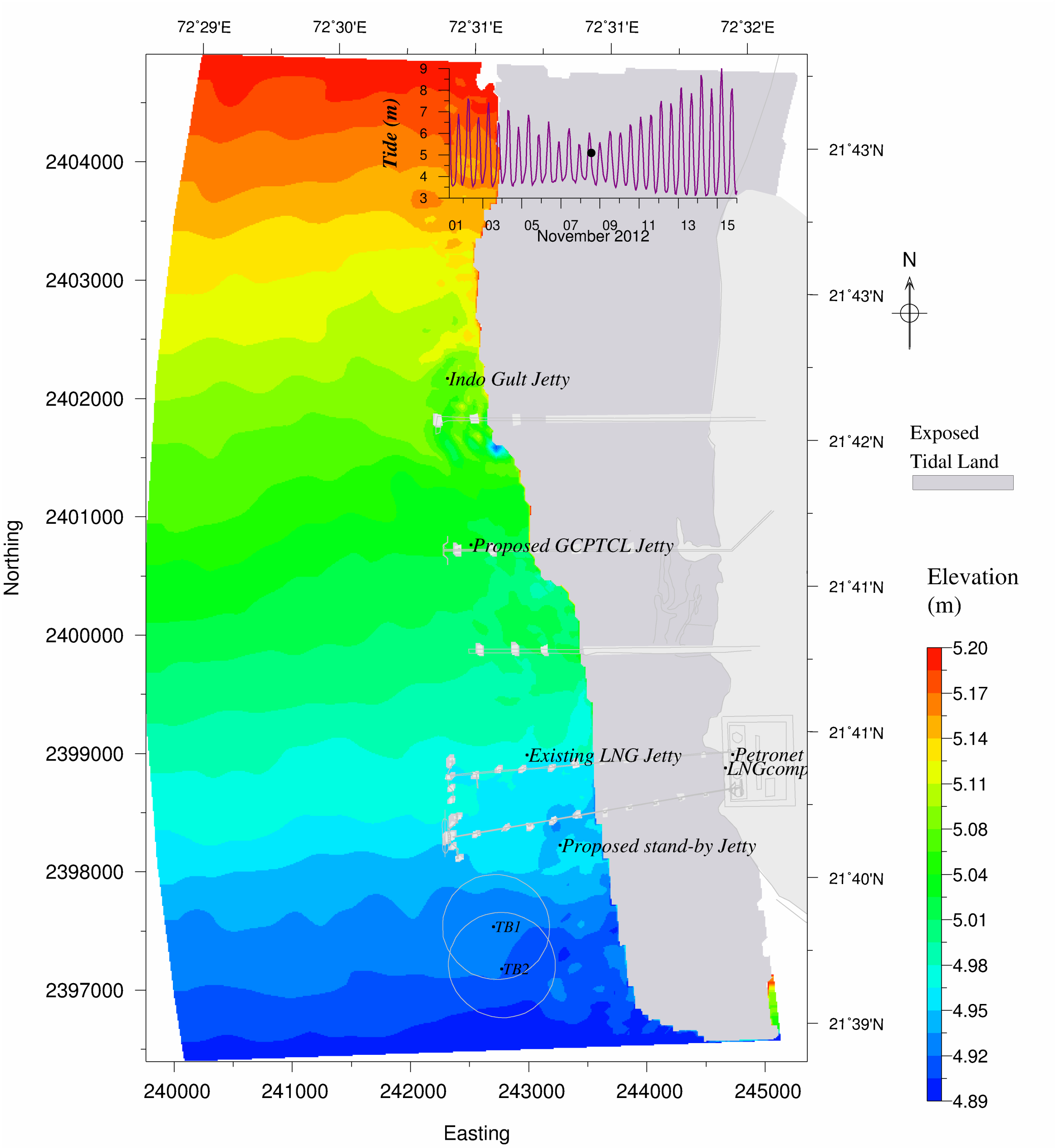


Fig.A3.14 Simulated tides after development (at 08/11/2012 14:00hr) during neap tide (Peak EBB)

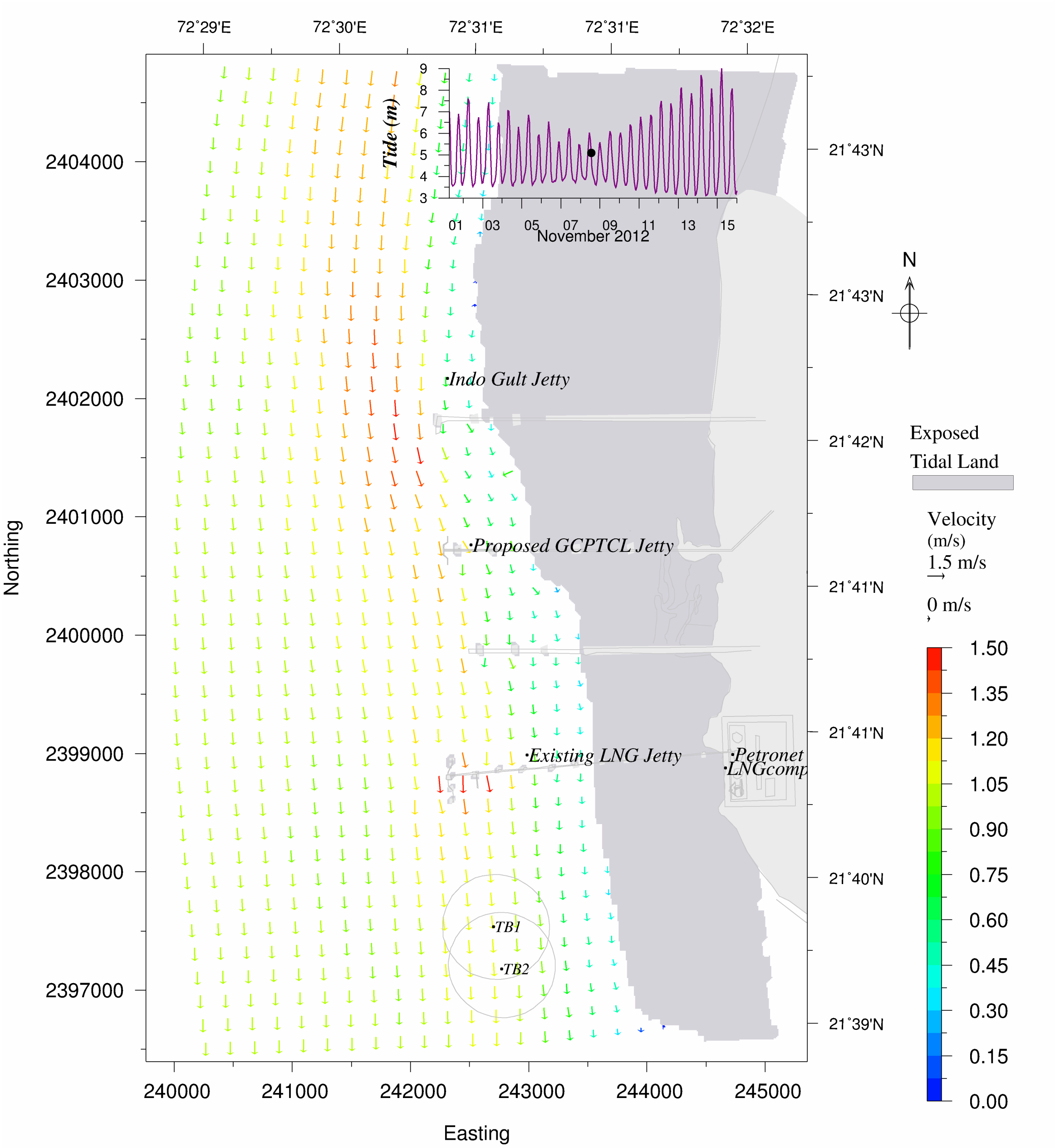


Fig.A3.15 Simulated currents before development (at 08/11/2012 14:00hr) during neap tide (Peak EBB)

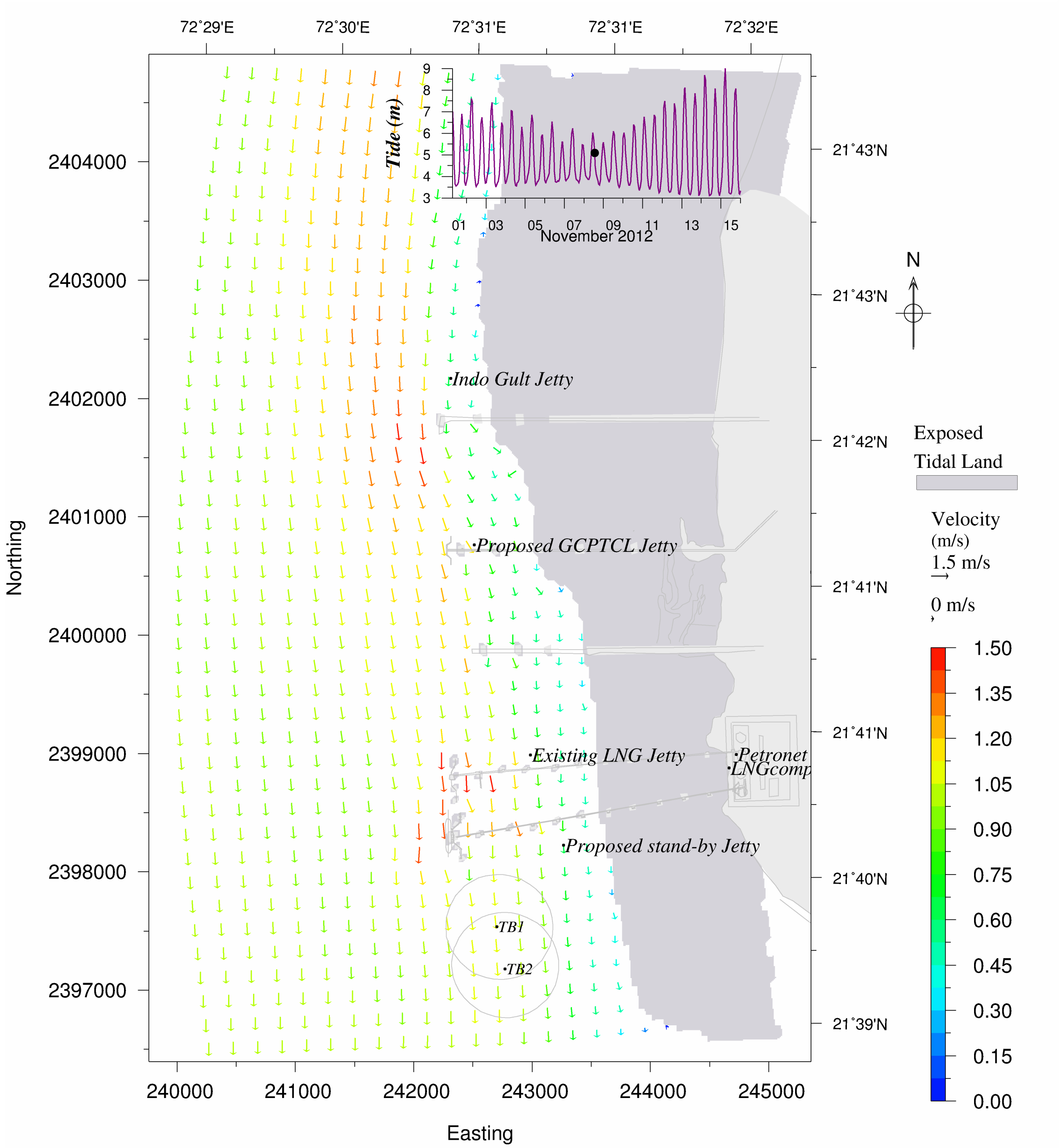


Fig.A3.16 Simulated currents after development (at 08/11/2012 14:00hr) during neap tide (Peak EBB)

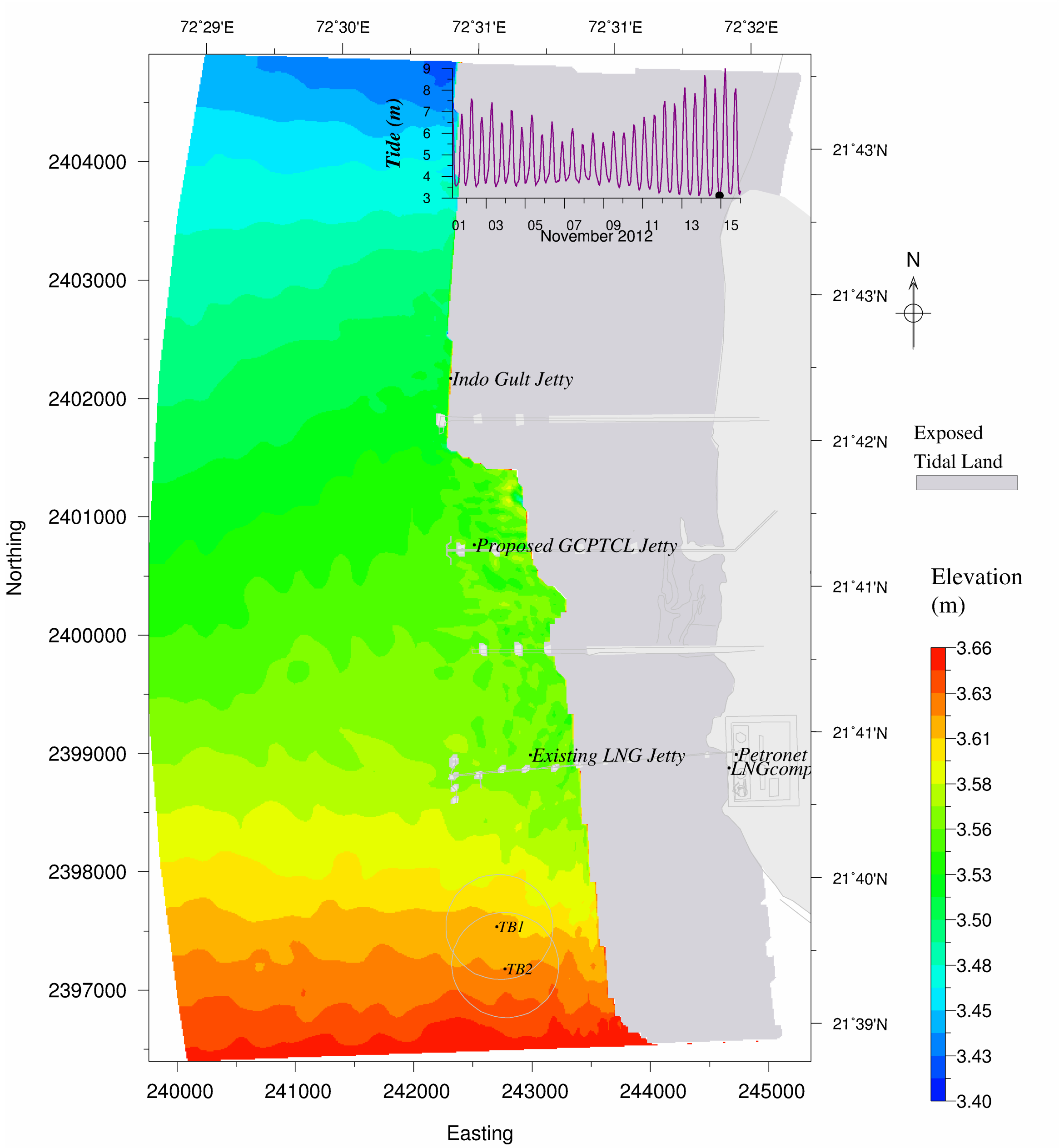


Fig.A3.17 Simulated tides before development (at 14/11/2012 22:00hr) during spring tide (LLW)

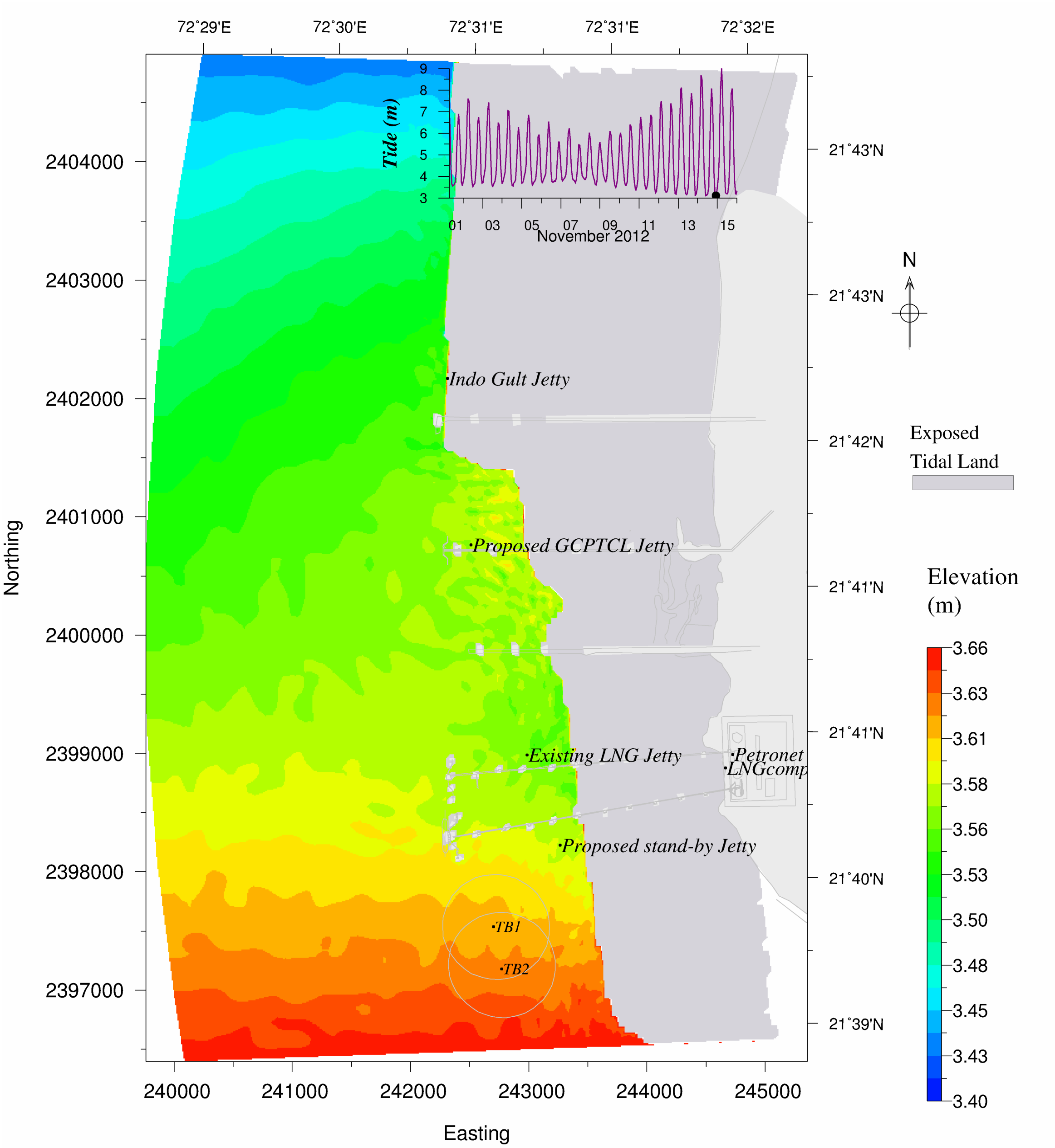


Fig.A3.18 Simulated tides after development (at 14/11/2012 22:00hr) during spring tide (LLW)

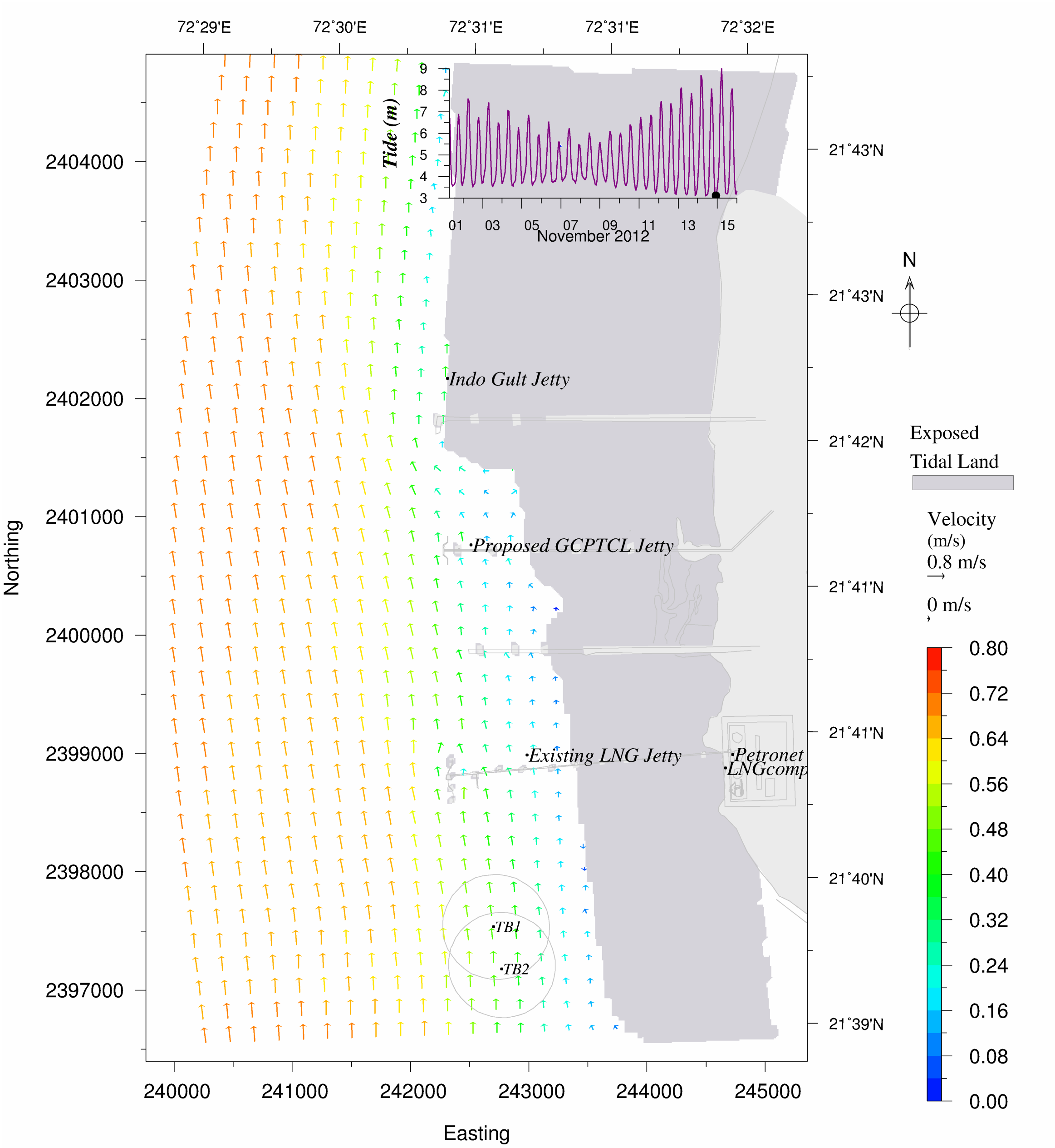


Fig.A3.19 Simulated currents before development (at 14/11/2012 22:00hr) during spring tide (LLW)

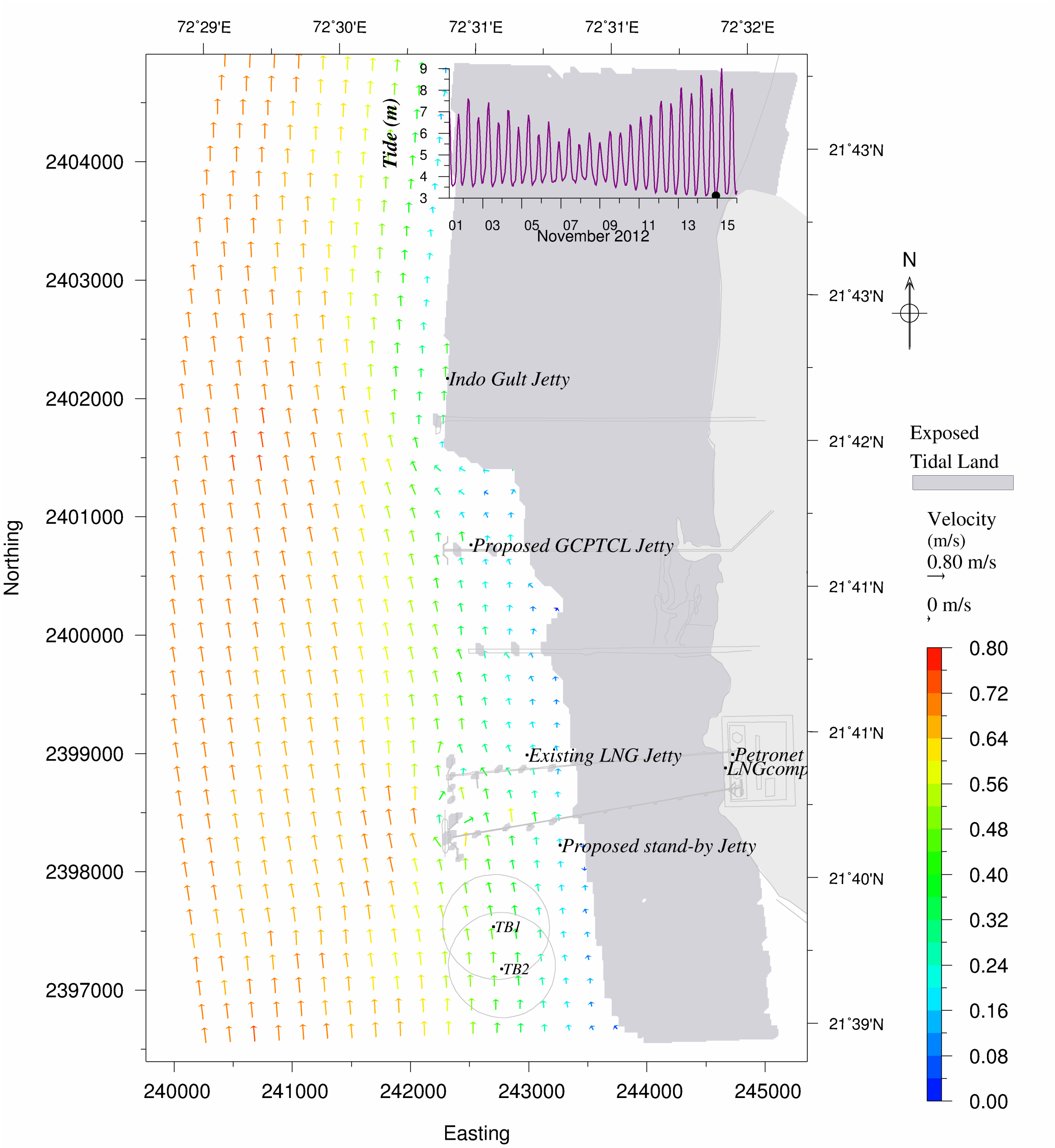


Fig.A3.20 Simulated currents after development (at 14/11/2012 22:00hr) during spring tide (LLW)

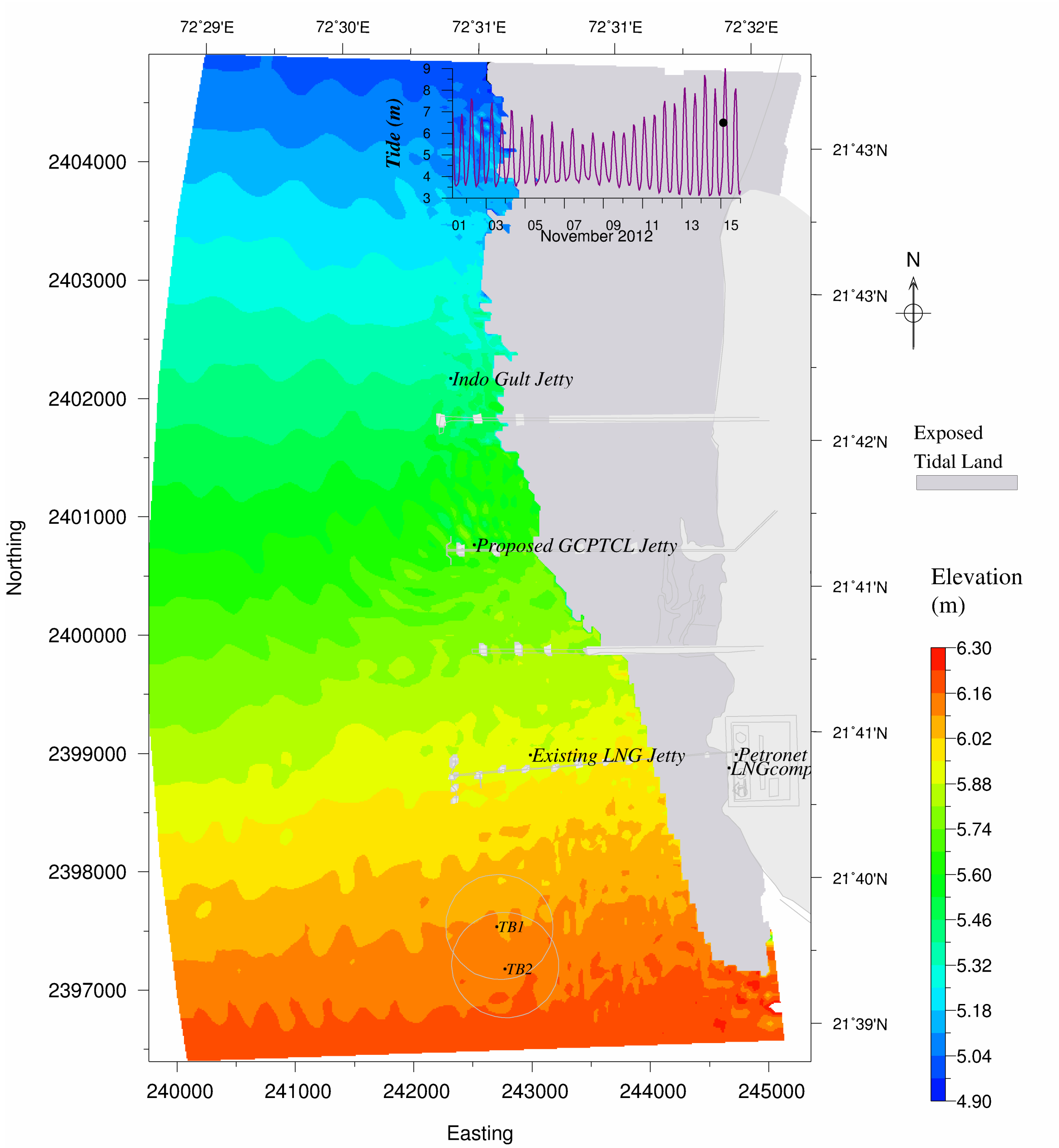


Fig.A3.21 Simulated tides before development (at 15/11/2012 03:00hr) during spring tide (Peak Flood)

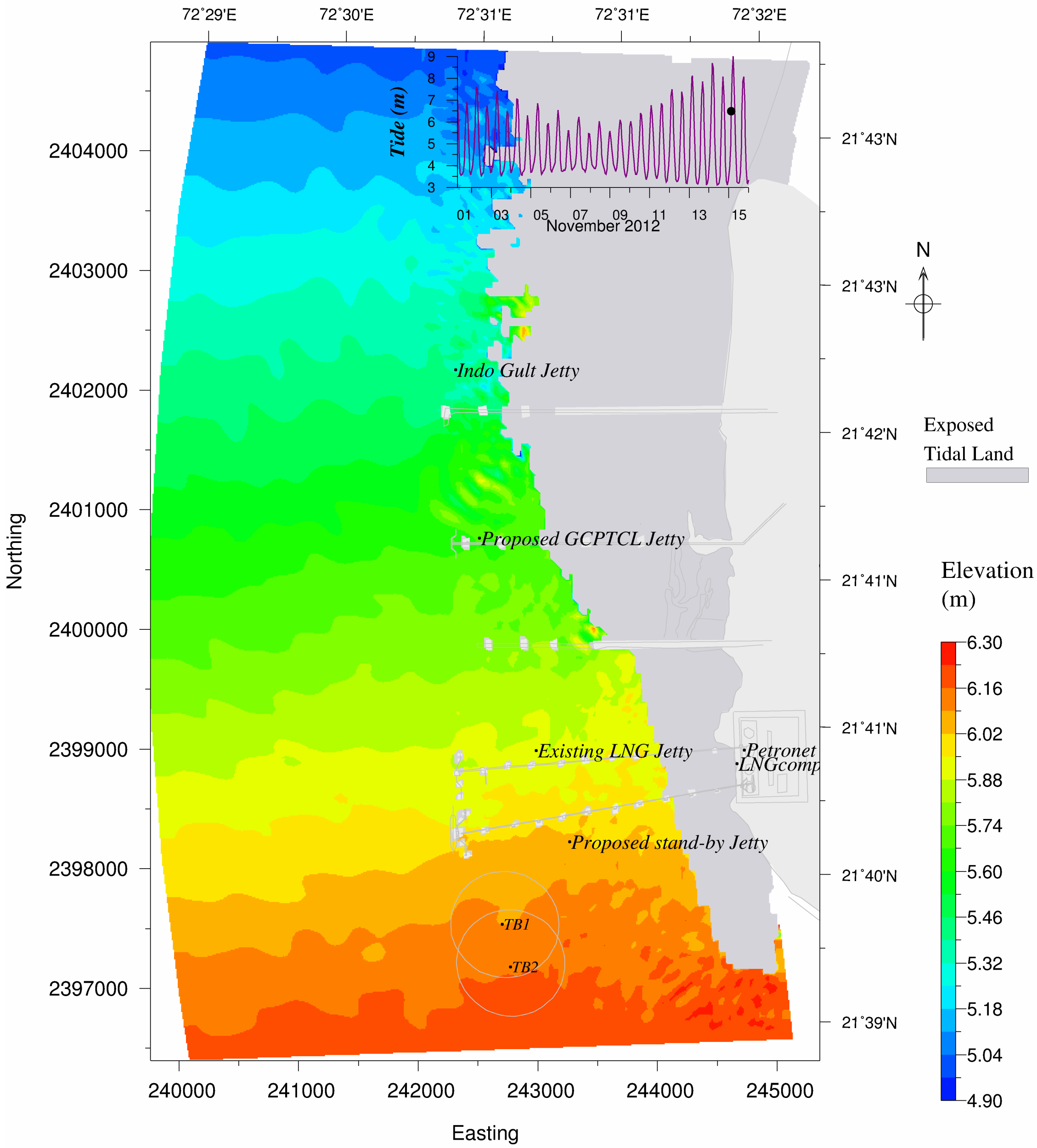


Fig.A3.22 Simulated tides after development (at 15/11/2012 03:00hr) during spring tide (Peak Flood)

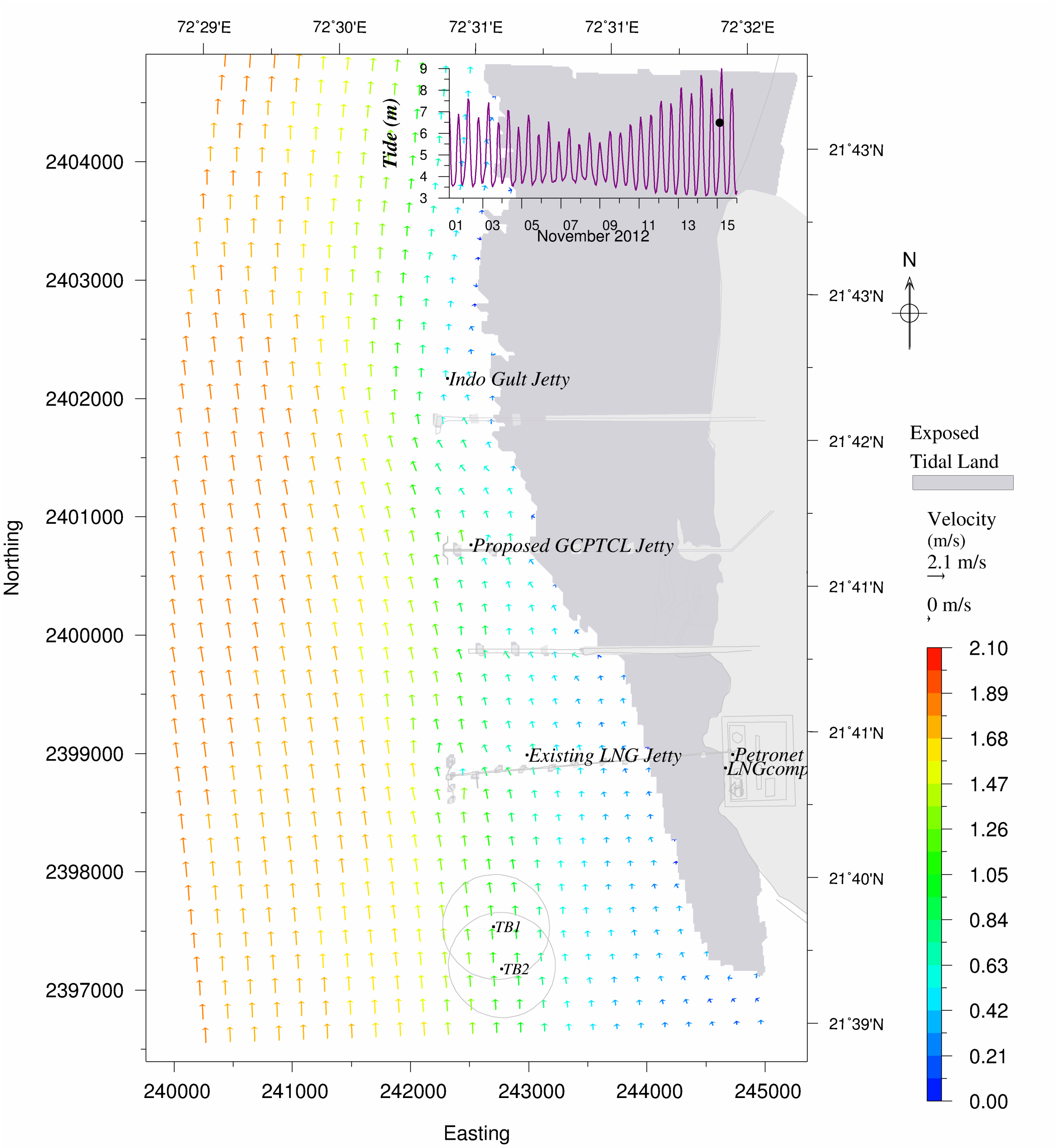


Fig.A3.23 Simulated currents before development (at 15/11/2012 03:00hr) during spring tide (Peak Flood)

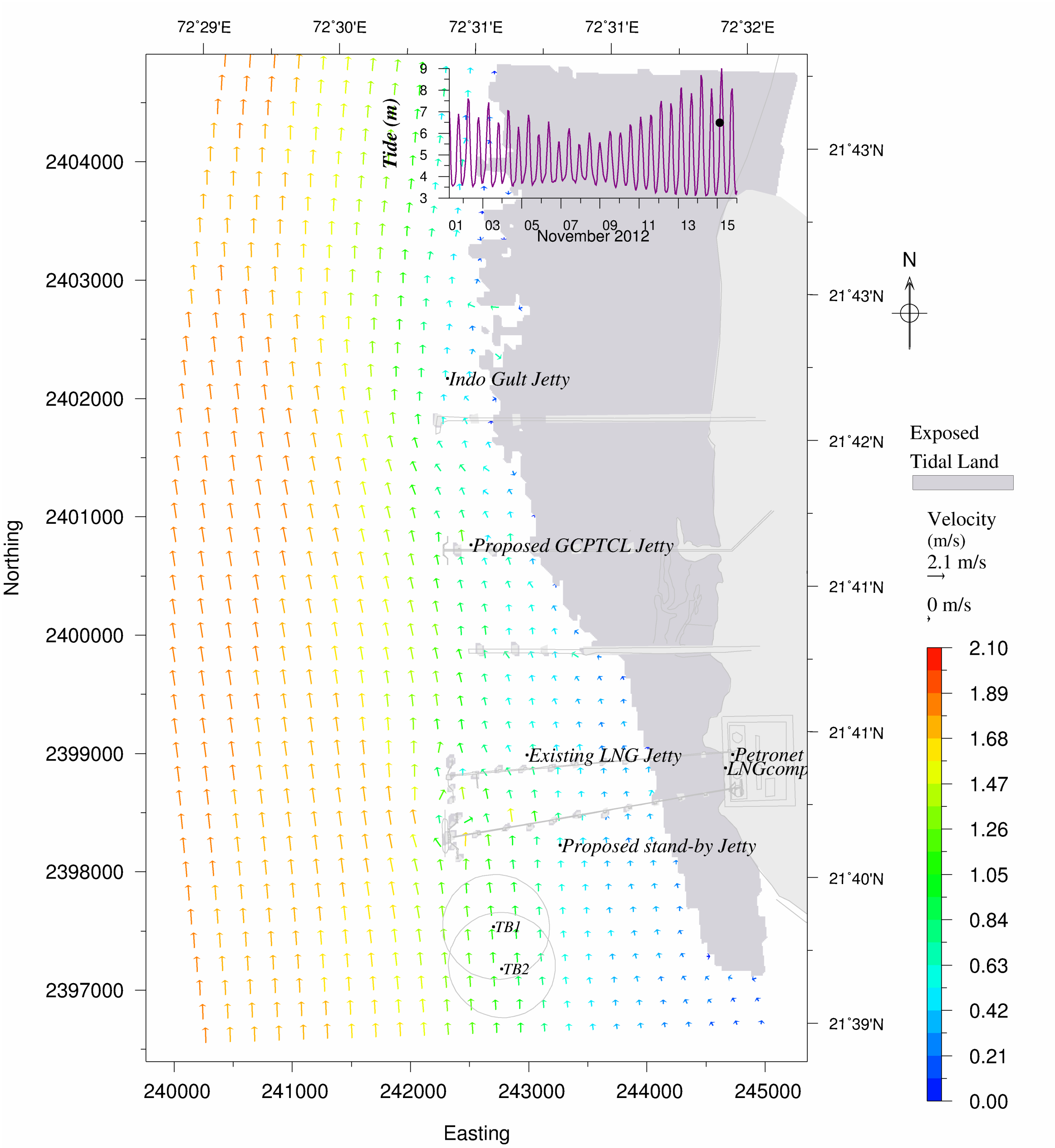


Fig.A3.24 Simulated currents after development (at 15/11/2012 03:00hr) during spring tide (Peak Flood)

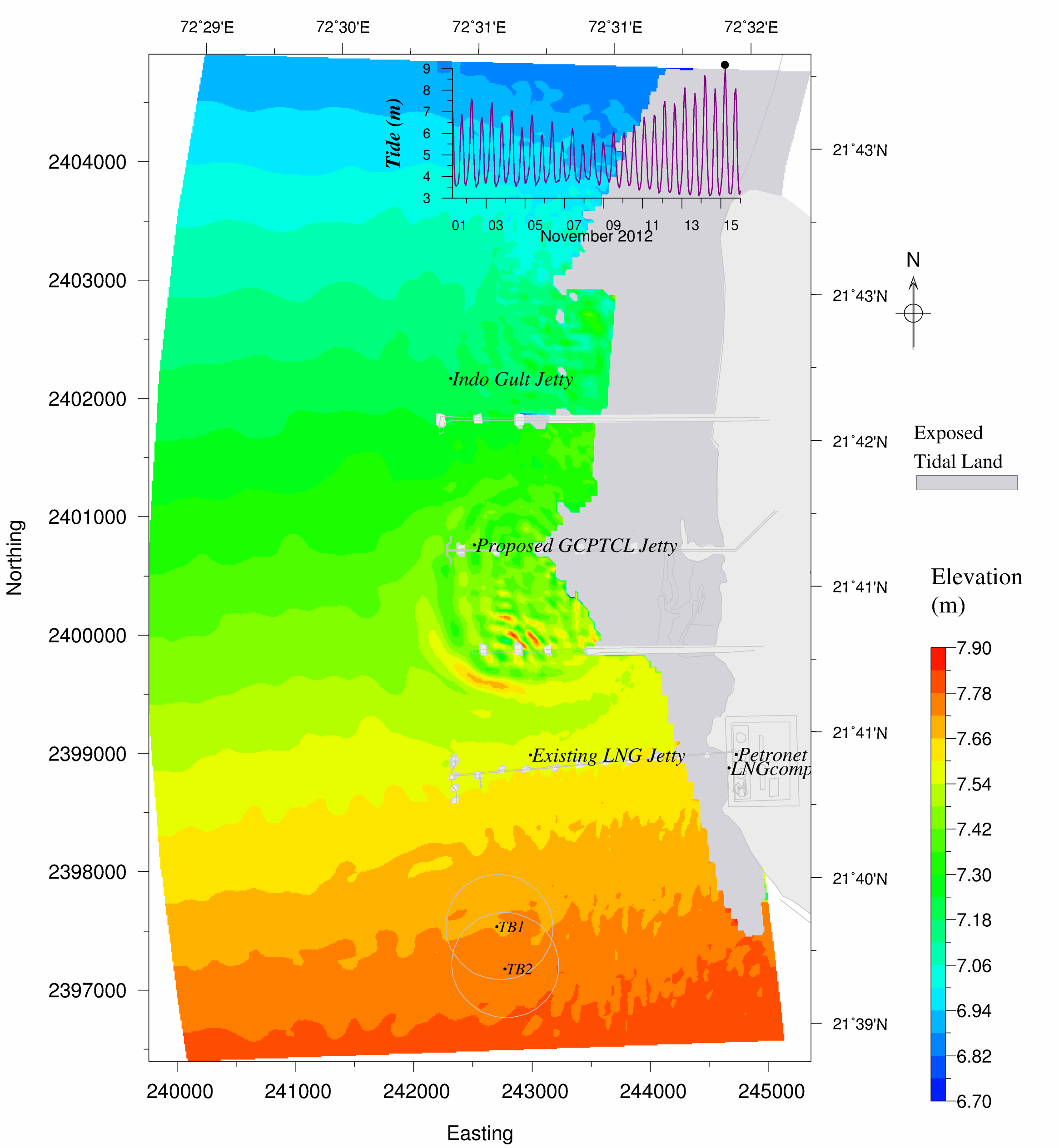


Fig.A3.25 Simulated tides before development (at 15/11/2012 05:00hr) during spring tide (HHW)

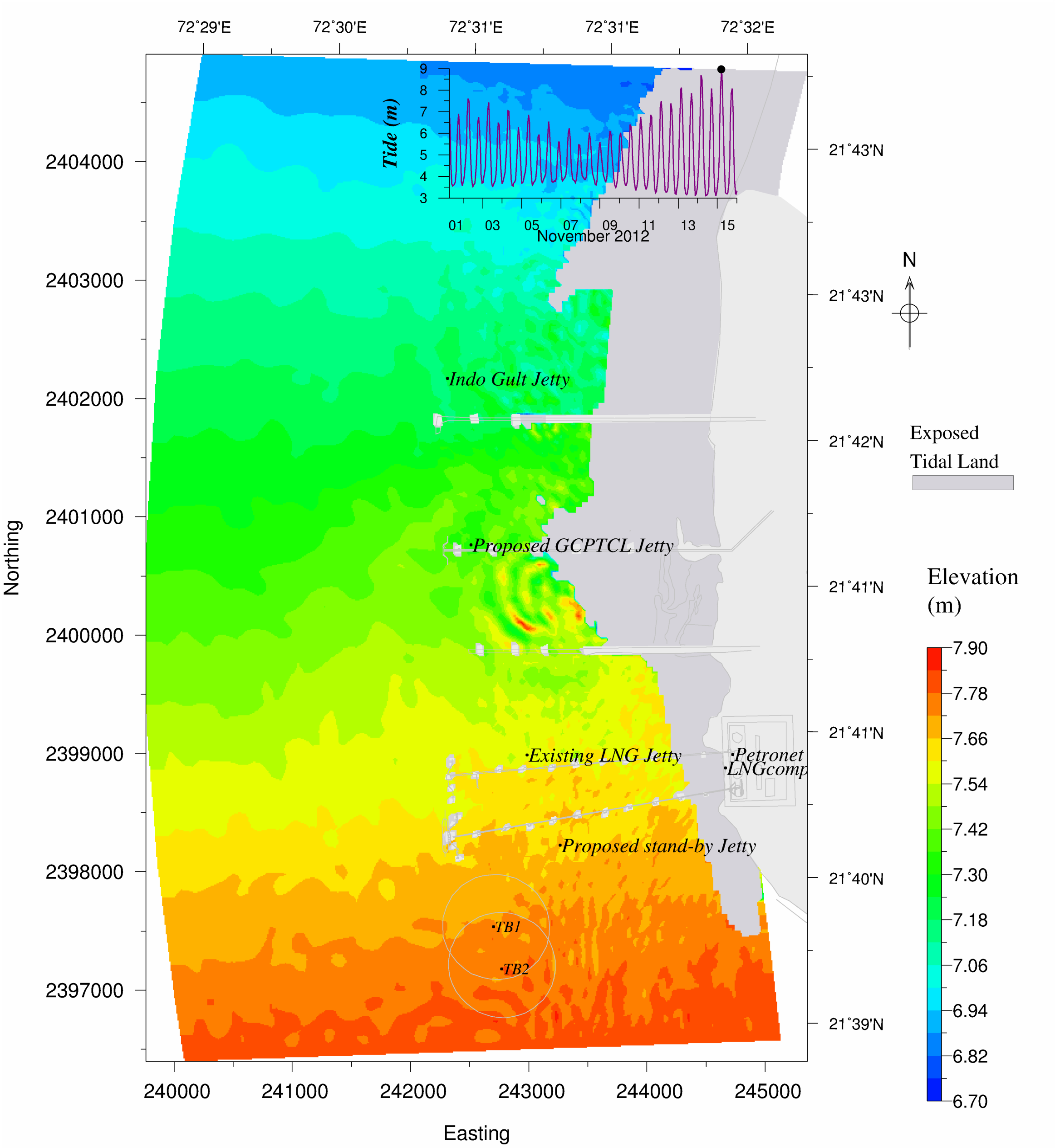


Fig.A3.26 Simulated tides after development (at 15/11/2012 05:00hr) during spring tide (HHW)

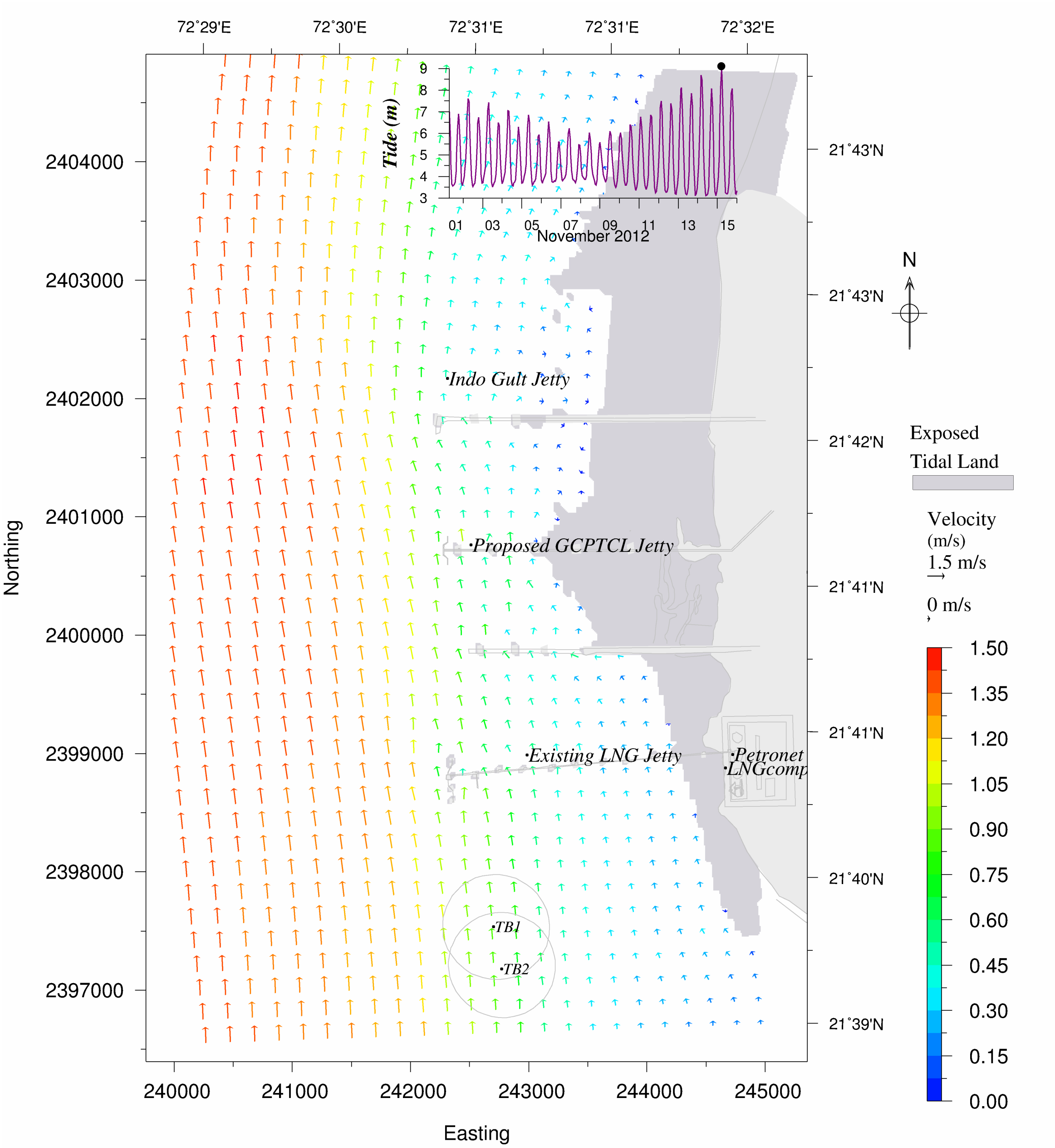


Fig.A3.27 Simulated currents before development (at 15/11/2012 05:00hr) during spring tide (HHW)

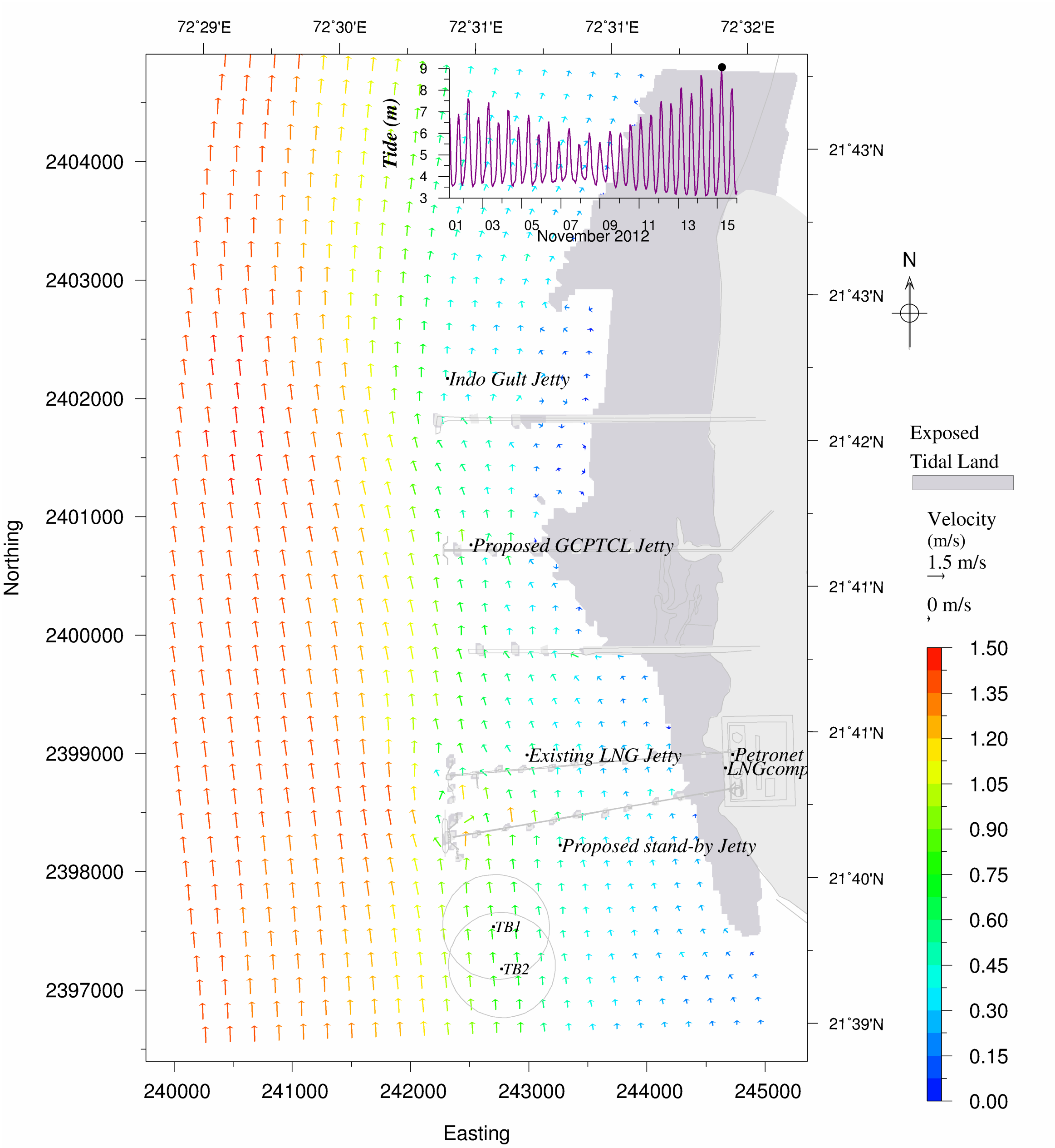


Fig.A3.28 Simulated currents after development (at 15/11/2012 05:00hr) during spring tide (HHW)

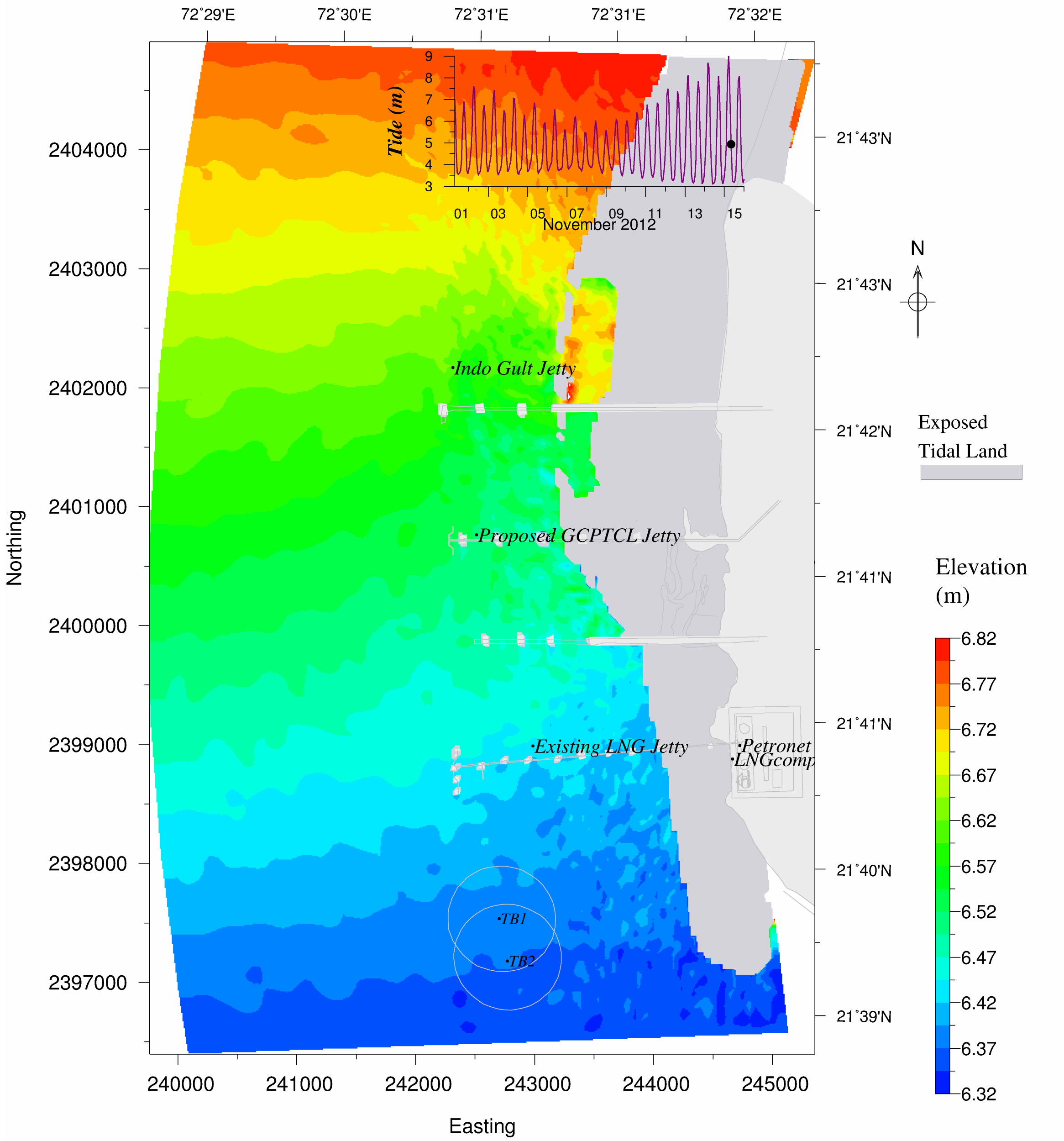
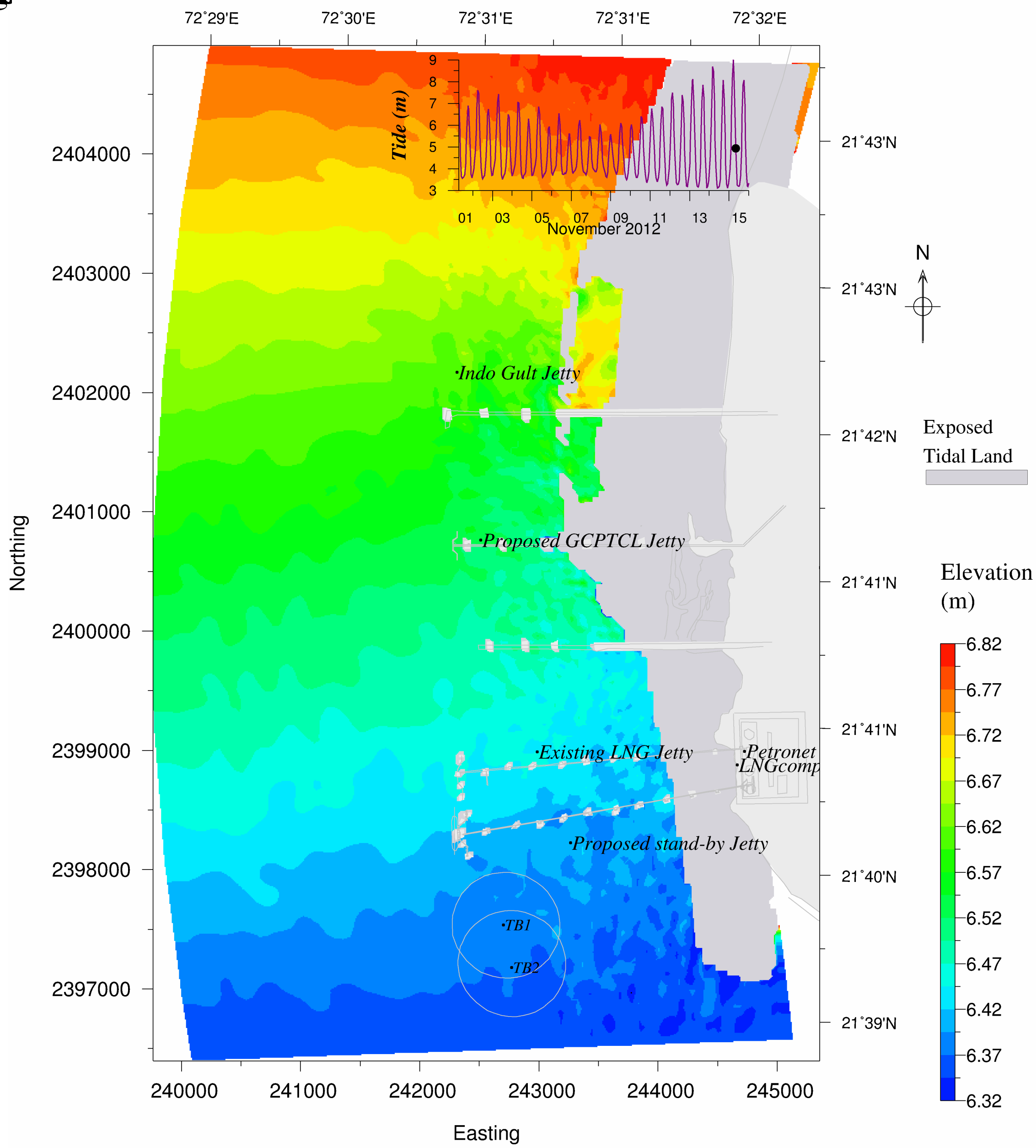


Fig.A3.29 Simulated tides before development (at 15/11/2012 08:00hr) during spring tide (Peak EBB)


72°29'E
72°30'E
72°31'E
72°31'E
72°32'E
Tide (m)
9
8
7
6
5
4
3
01
03
05
07
09
11
13
15
November 2012
2404000
2403000
2402000
2401000
2400000
2399000
2398000
2397000
Northing
21°43'N
21°43'N
21°42'N
21°41'N
21°41'N
21°40'N
21°39'N
N
Indo Gult Jetty
Proposed GCPTCL Jetty
Existing LNG Jetty
Petronet
LNGcomp
Proposed stand-by Jetty
TB1
TB2
240000
241000
242000
243000
244000
245000
Easting
Exposed
Tidal Land
Elevation
(m)
6.82
6.77
6.72
6.67
6.62
6.57
6.52
6.47
6.42
6.37
6.32

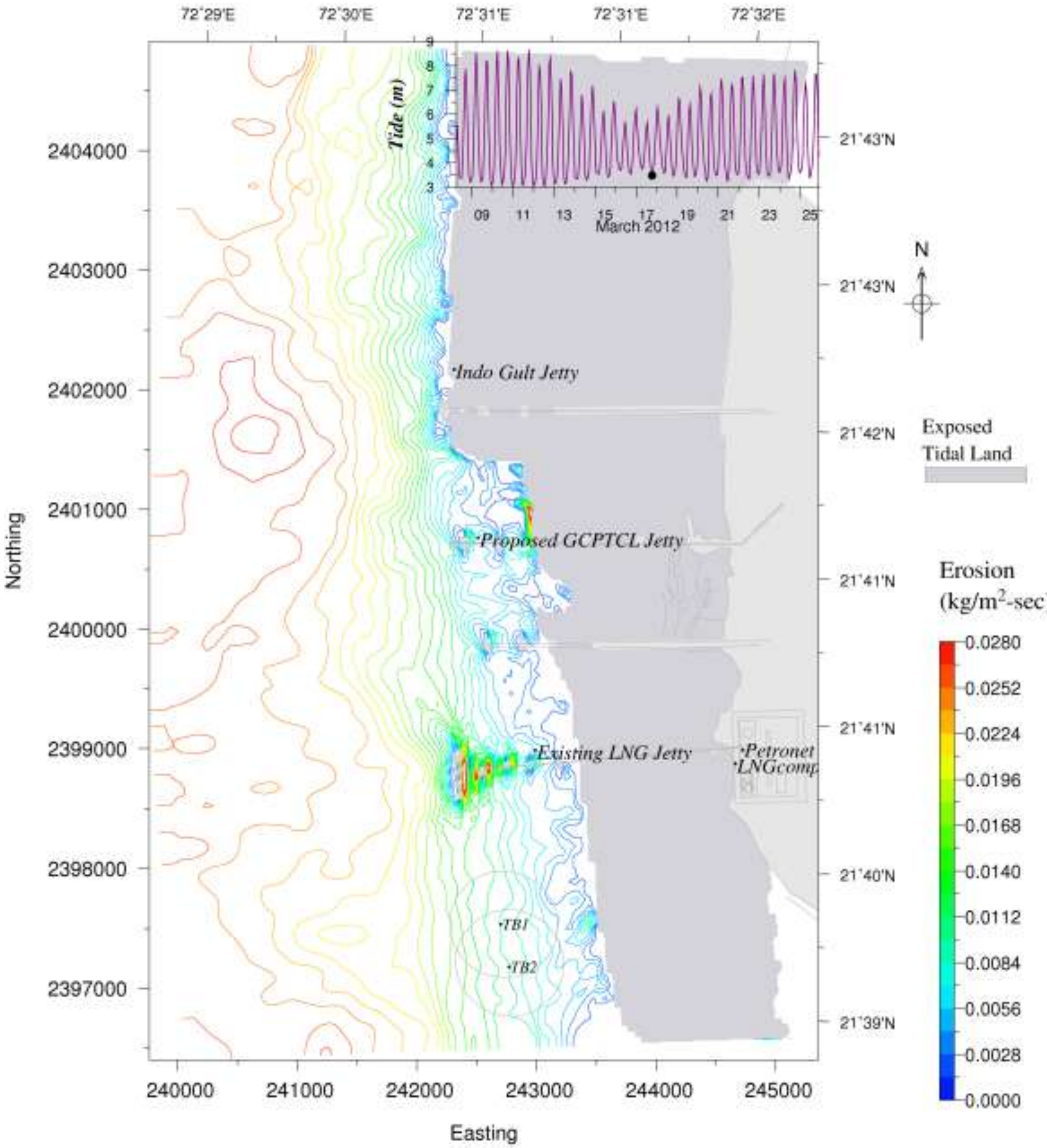


Fig.A4.1 Instantaneous rate of sediment erosion before development (at 17/03/2012 19:00hr) during neap tide (LLW)

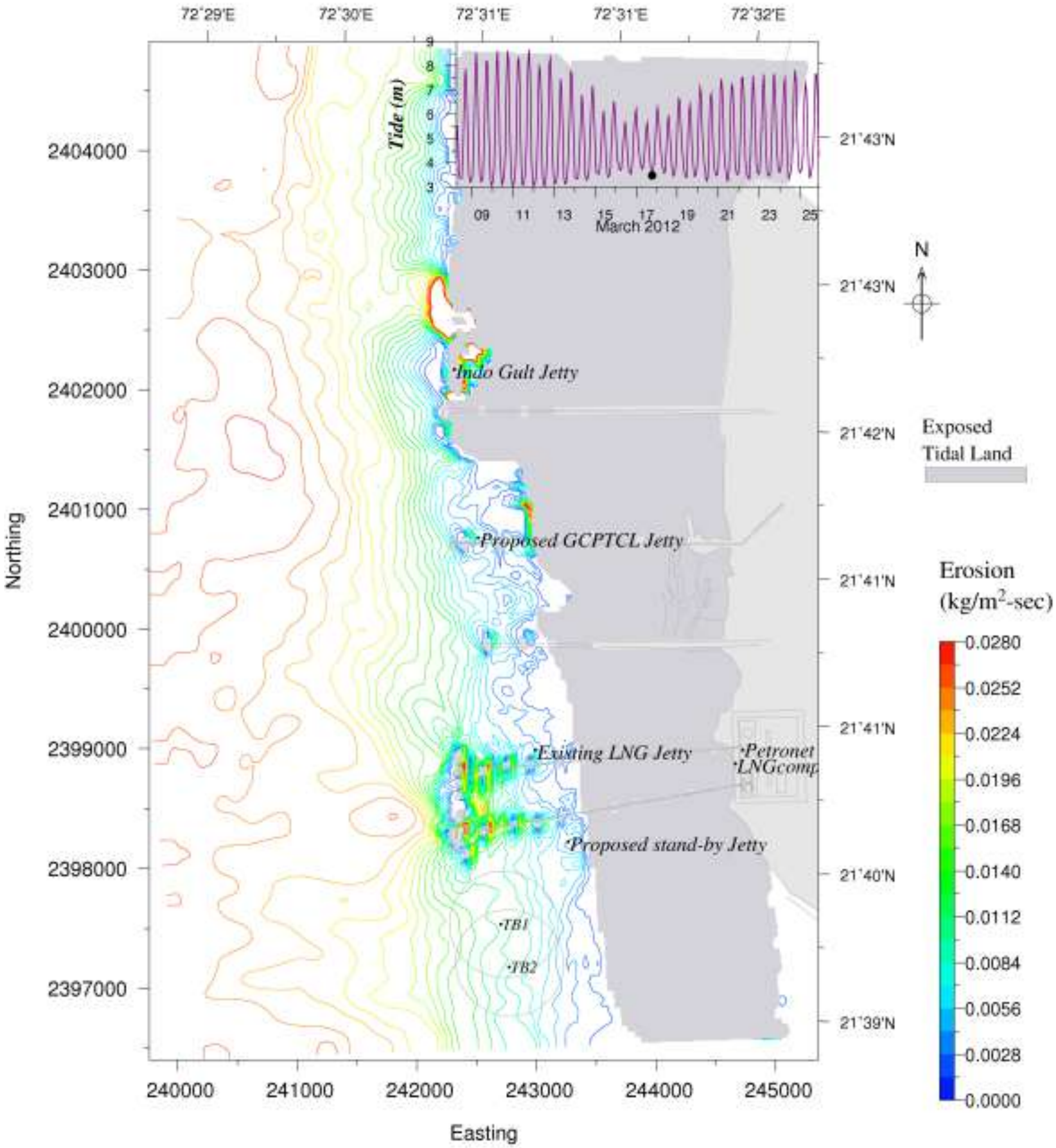


Fig.A4.2 Instantaneous rate of sediment erosion after development (at 17/03/2012 19:00hr) during neap tide (LLW)

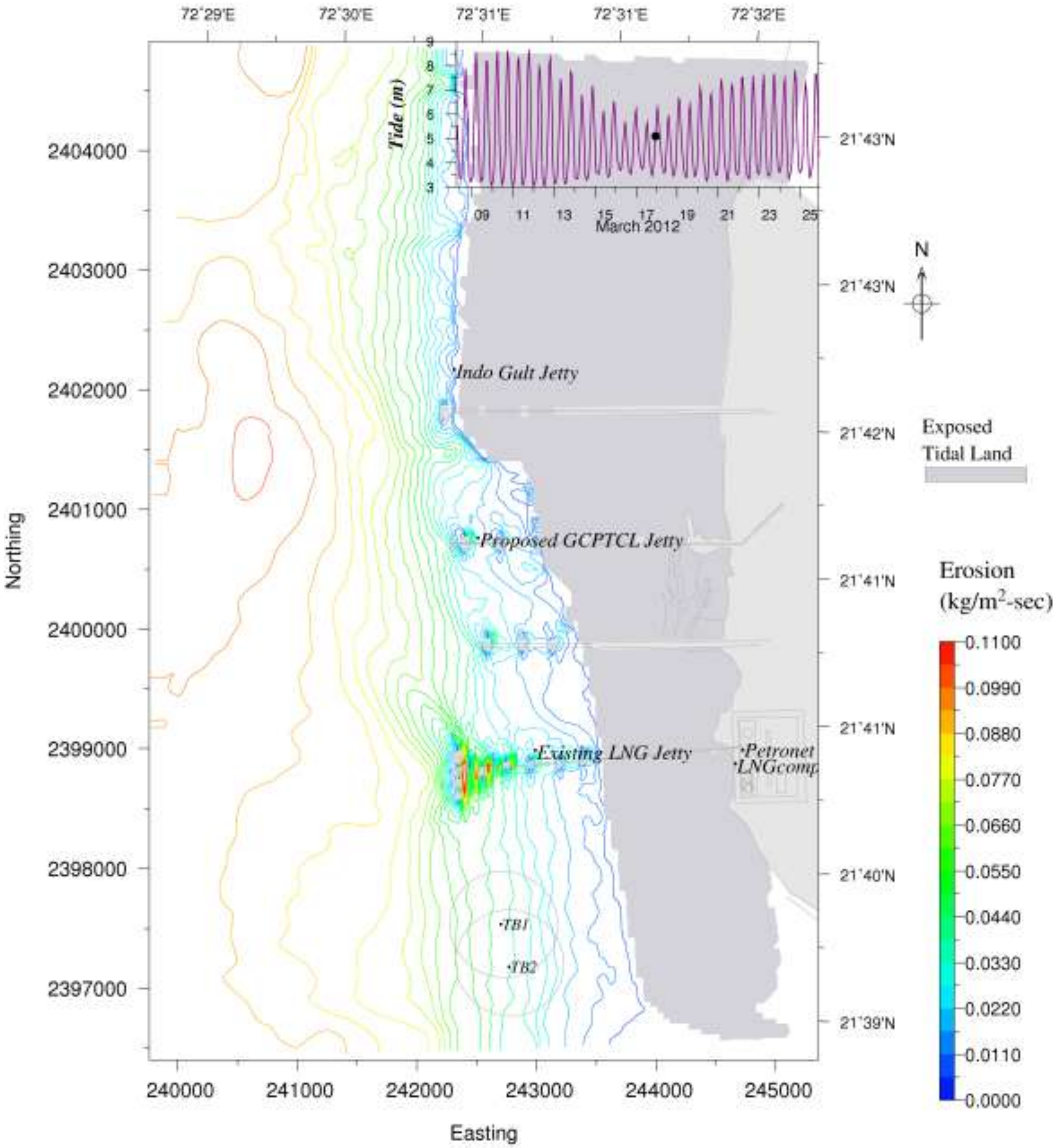


Fig.A4.3 Instantaneous rate of sediment erosion before development (at 17/03/2012 23:00hr) during neap tide (Peak Flood)

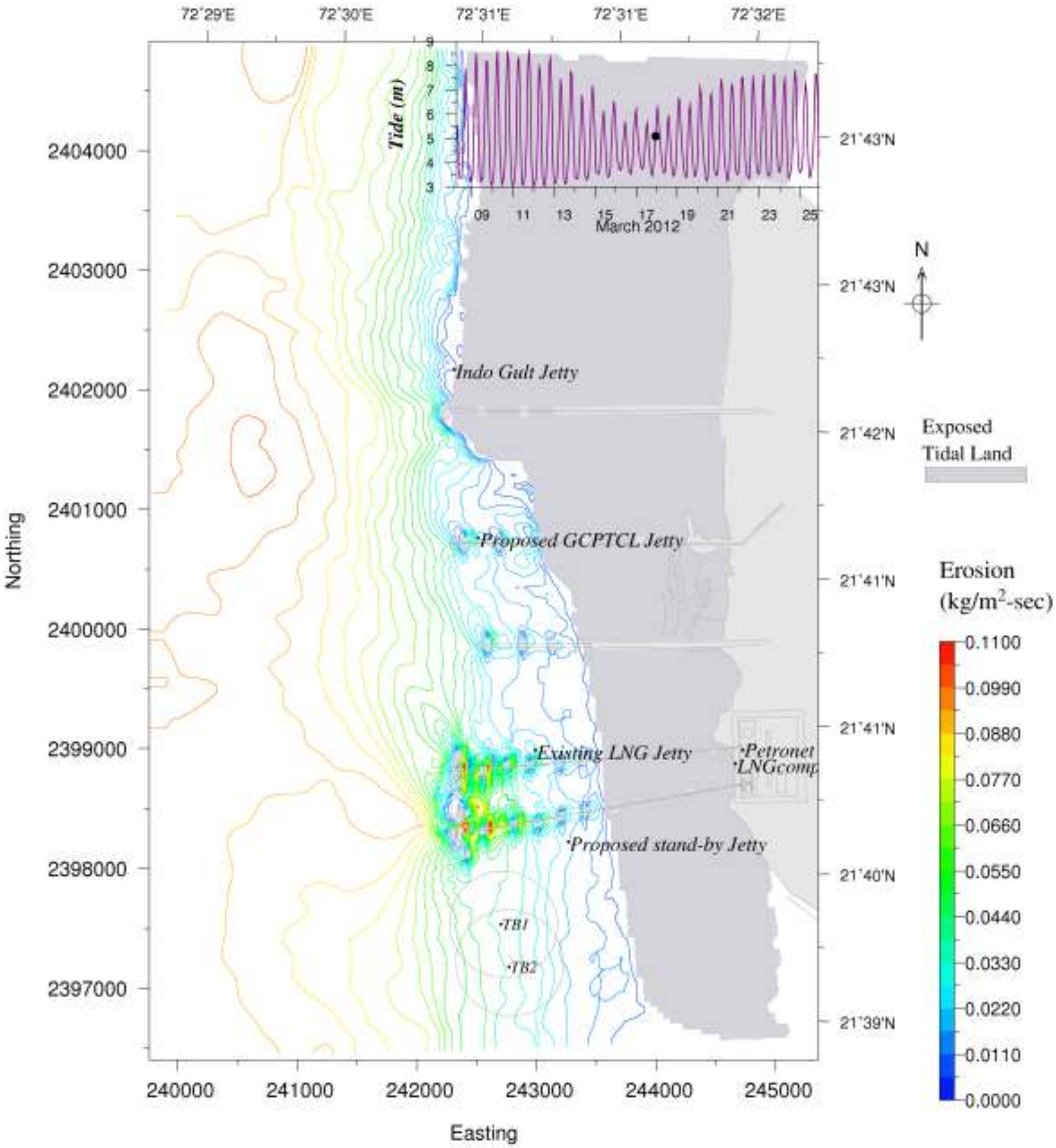


Fig.A4.4 Instantaneous rate of sediment erosion after development (at 17/03/2012 23:00hr) during neap tide (Peak Flood)

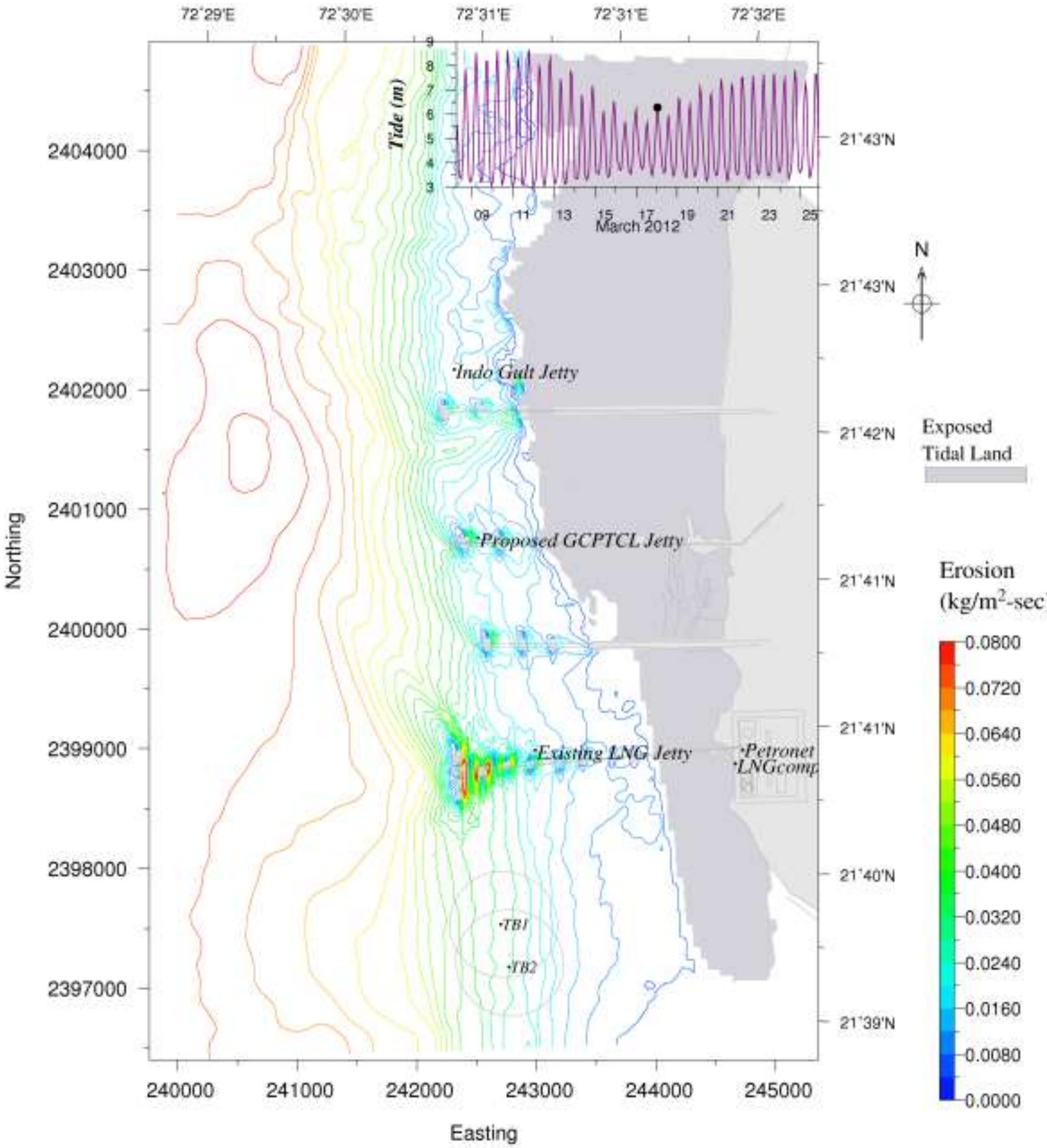


Fig.A4.5 Instantaneous rate of sediment erosion before development (at 18/03/2012 01:00hr) during neap tide (HHW)

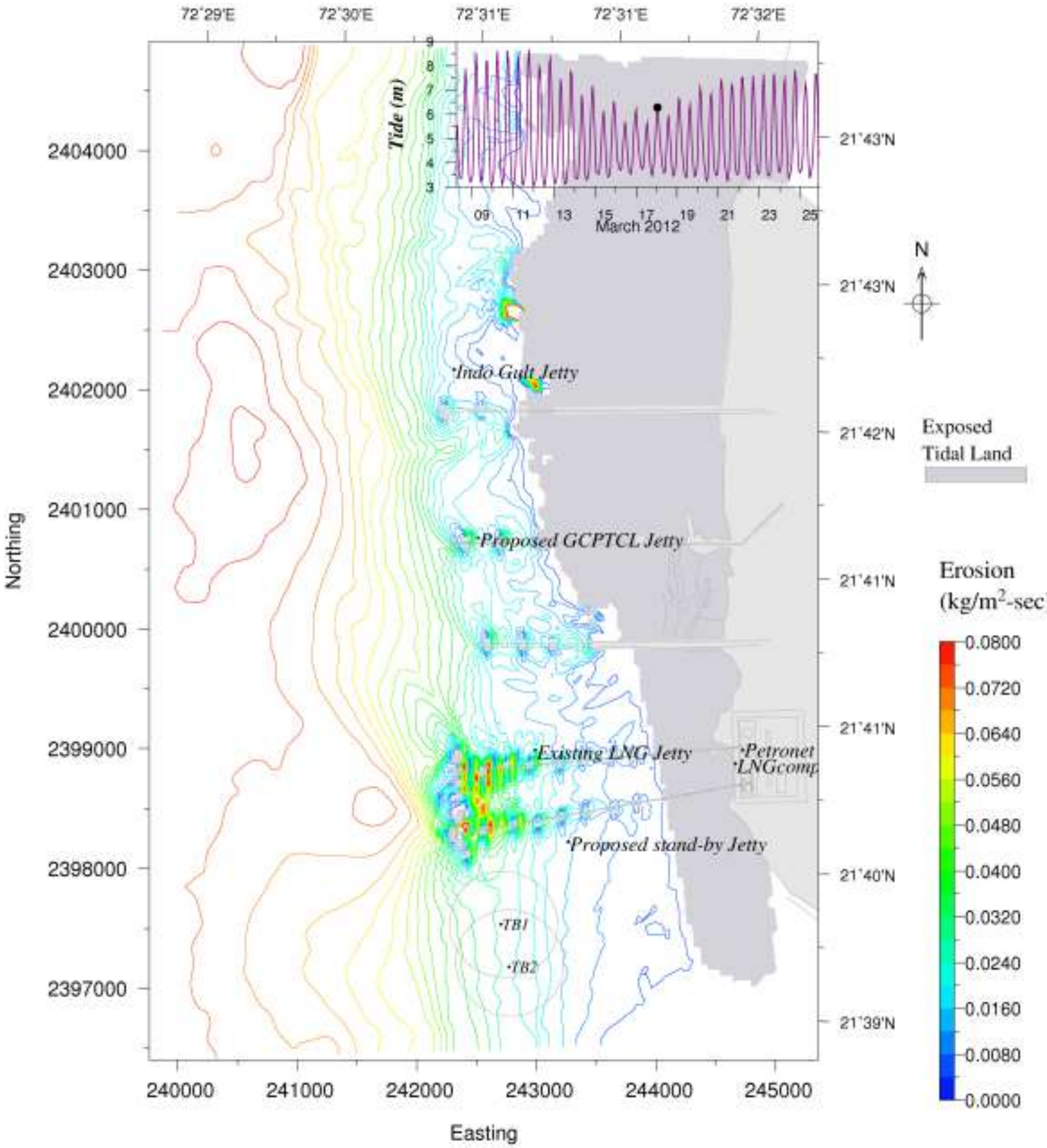


Fig.A4.6 Instantaneous rate of sediment erosion after development (at 18/03/2012 01:00hr) during neap tide (HHW)

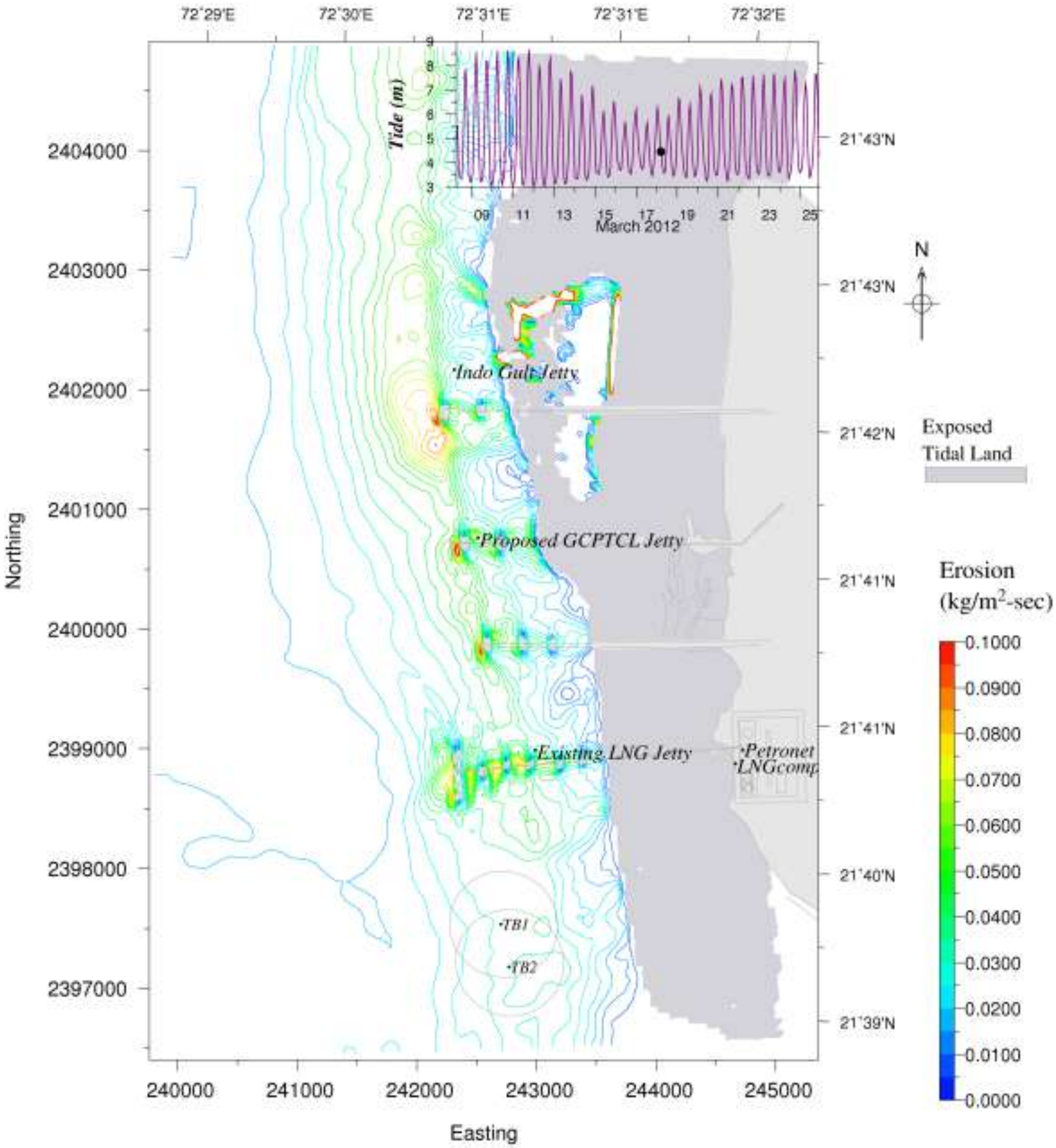


Fig.A4.7 Instantaneous rate of sediment erosion before development (at 18/03/2012 05:00hr) during neap tide (Peak EBB)

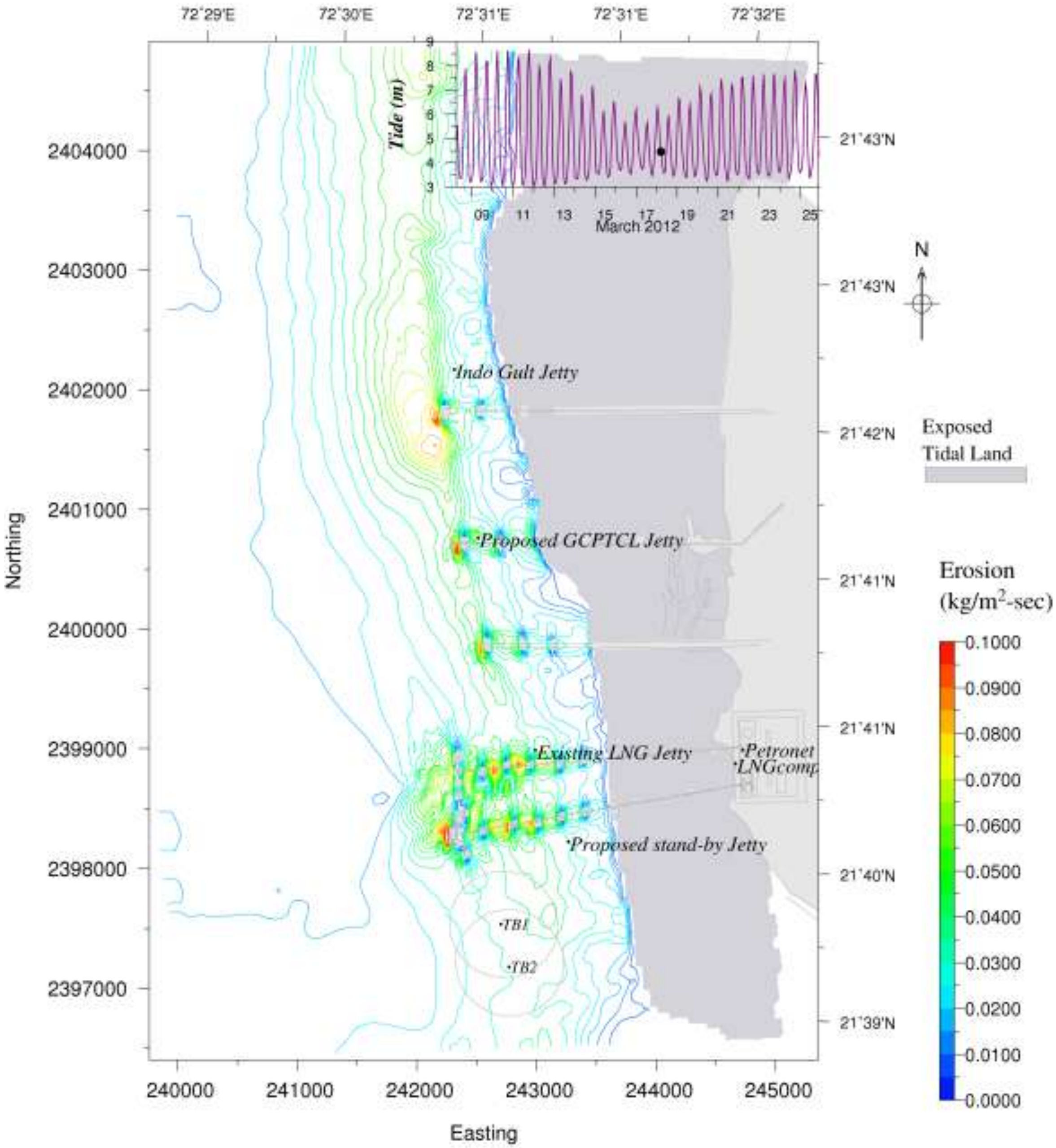


Fig.A4.8 Instantaneous rate of sediment erosion after development (at 18/03/2012 05:00hr) during neap tide (Peak EBB)

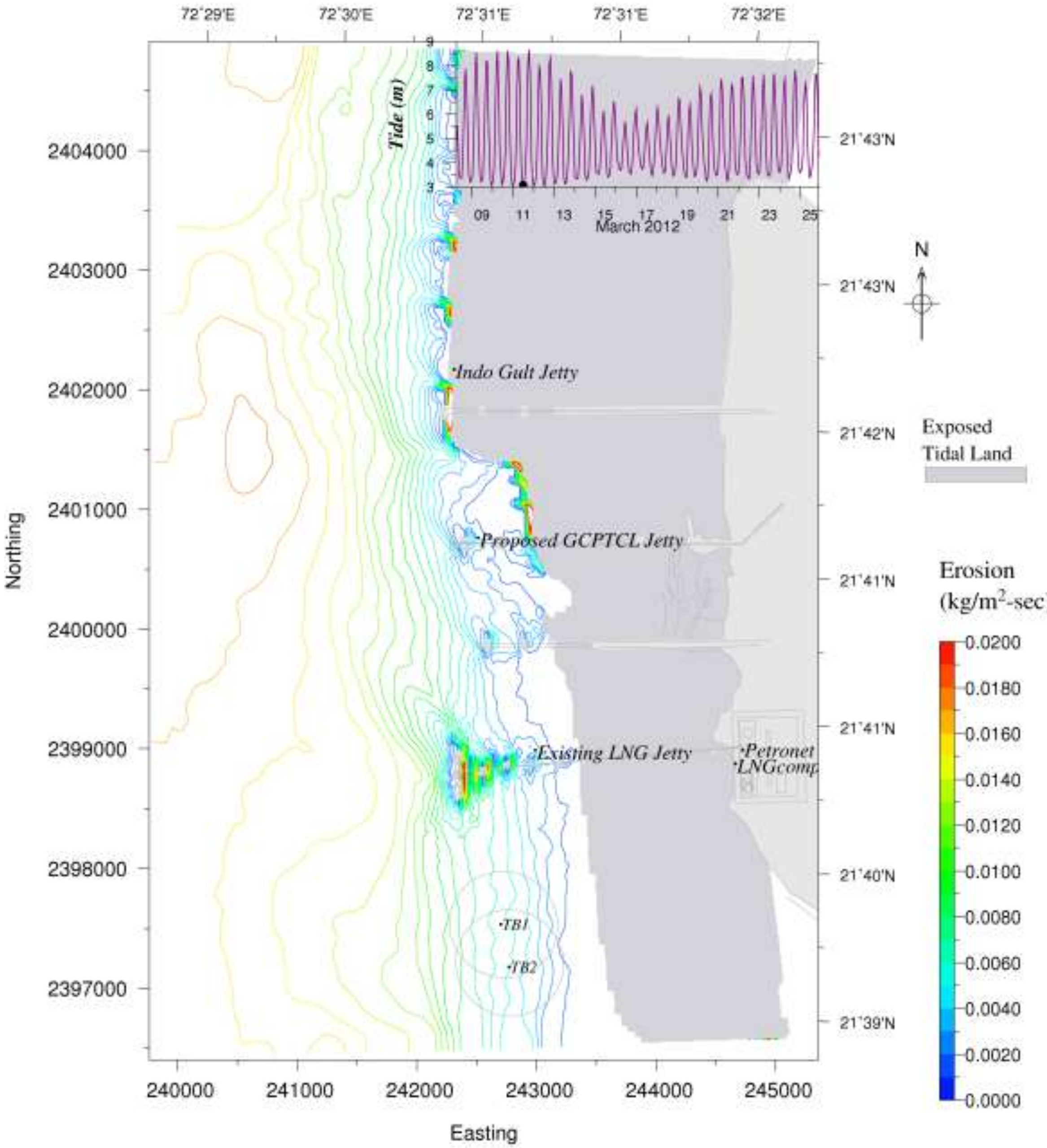


Fig.A4.9 Instantaneous rate of sediment erosion before development (at 11/03/2012 12:00hr) during spring tide (LLW)

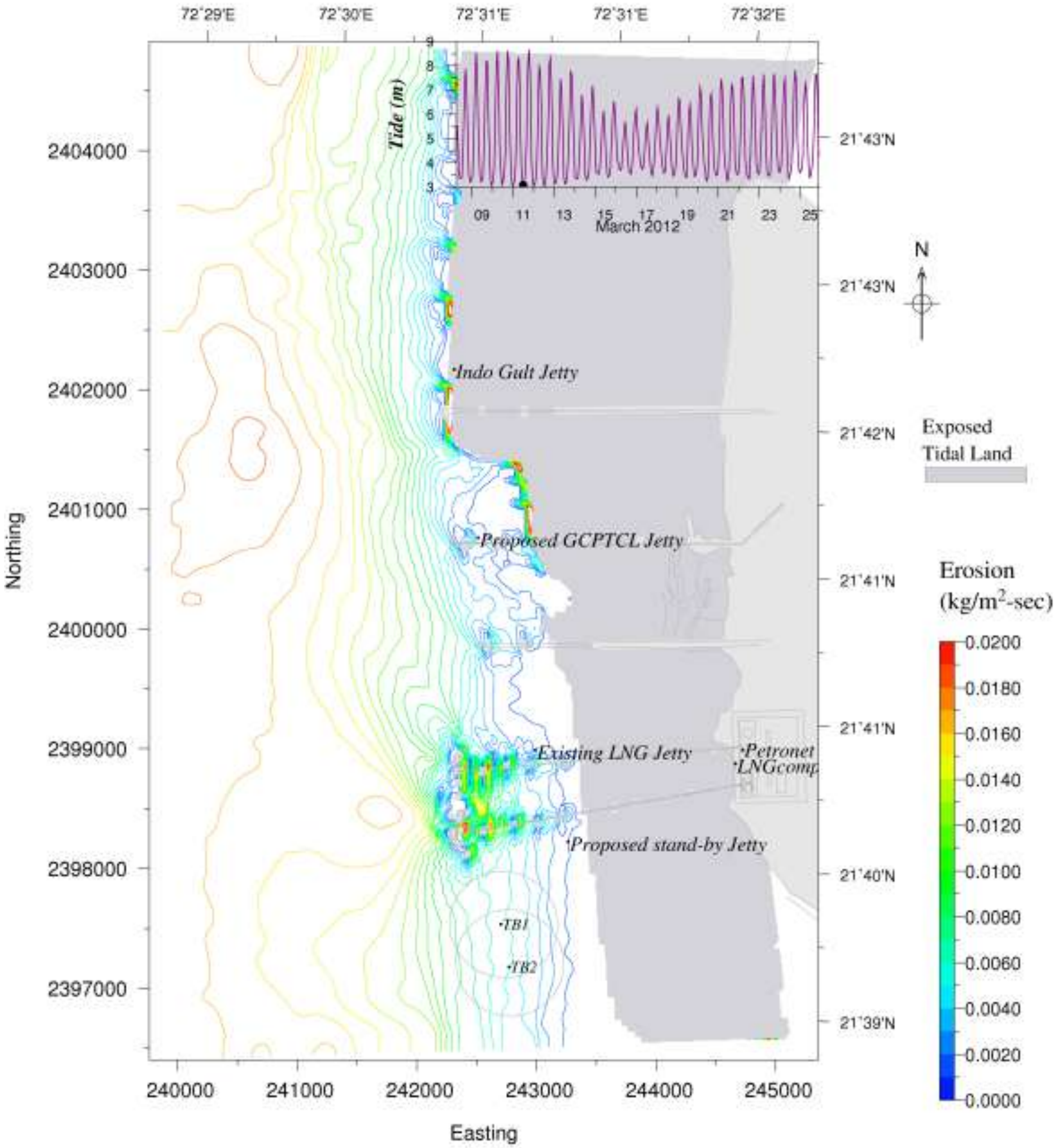


Fig.A4.10 Instantaneous rate of sediment erosion after development (at 11/03/2012 12:00hr) during spring tide (LLW)

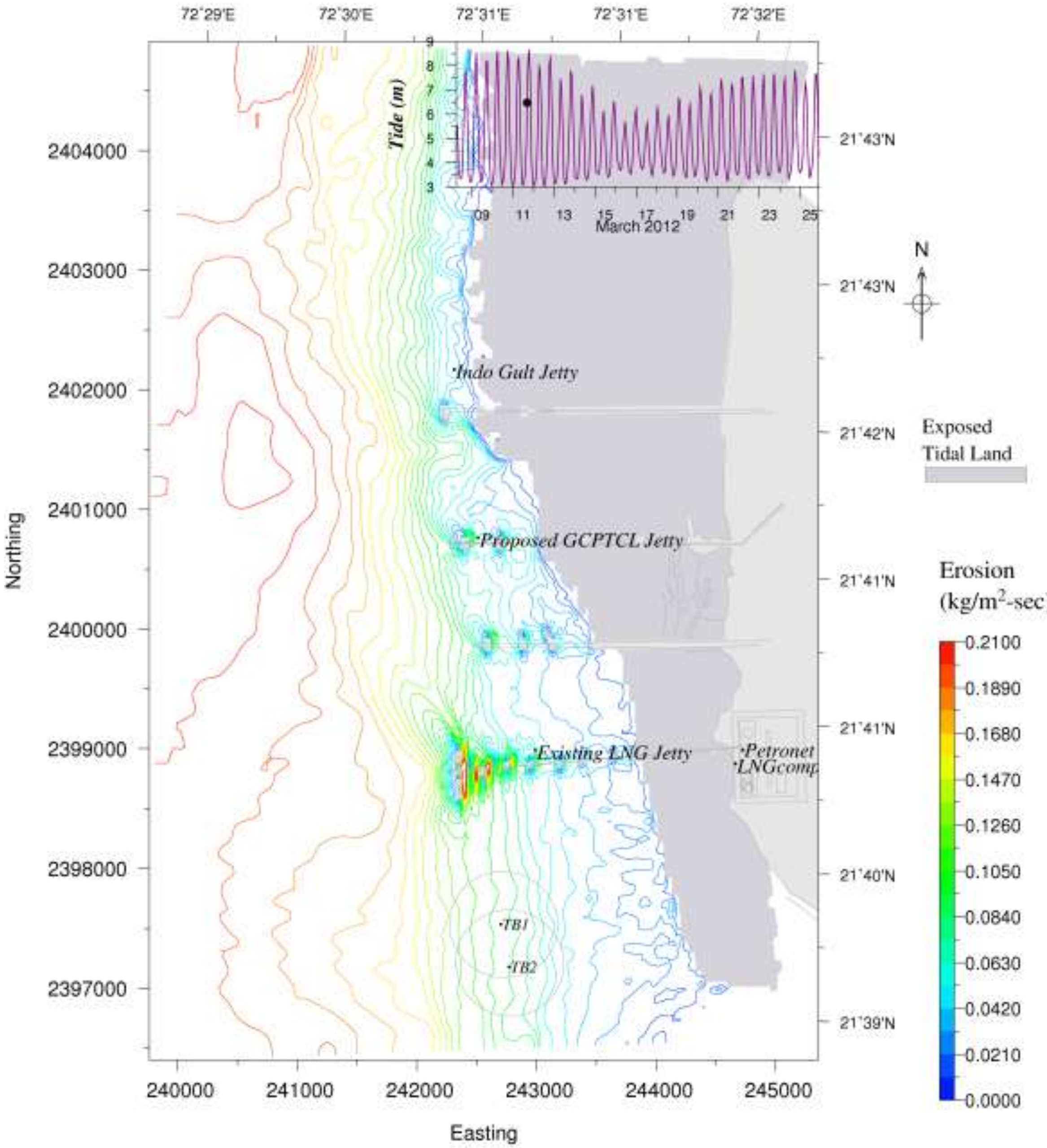


Fig.A4.11 Instantaneous rate of sediment erosion before development (at 11/03/2012 17:00hr) during spring tide (Peak Flood)

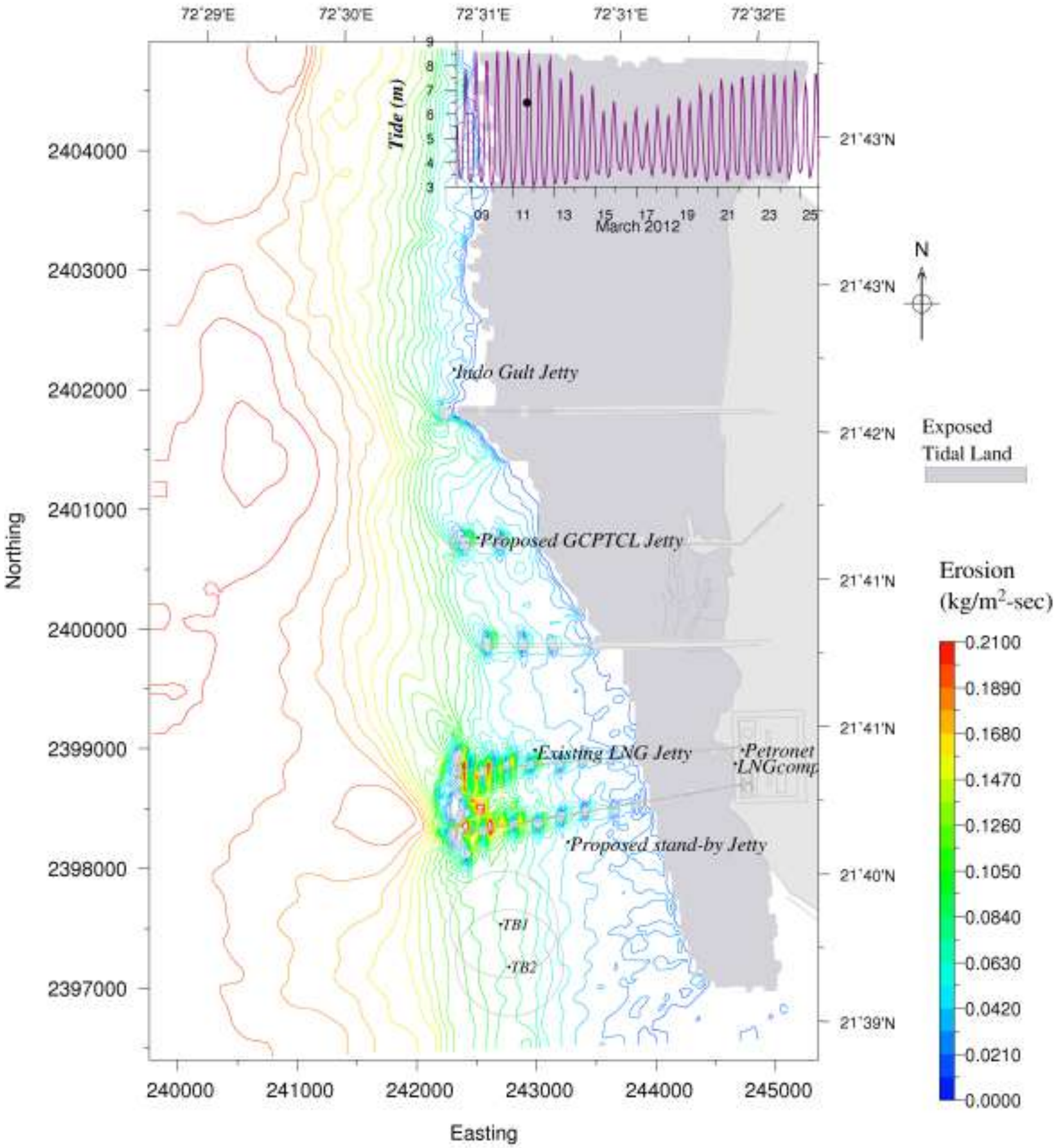


Fig.A4.12 Instantaneous rate of sediment erosion after development (at 11/03/2012 17:00hr) during spring tide (Peak Flood)

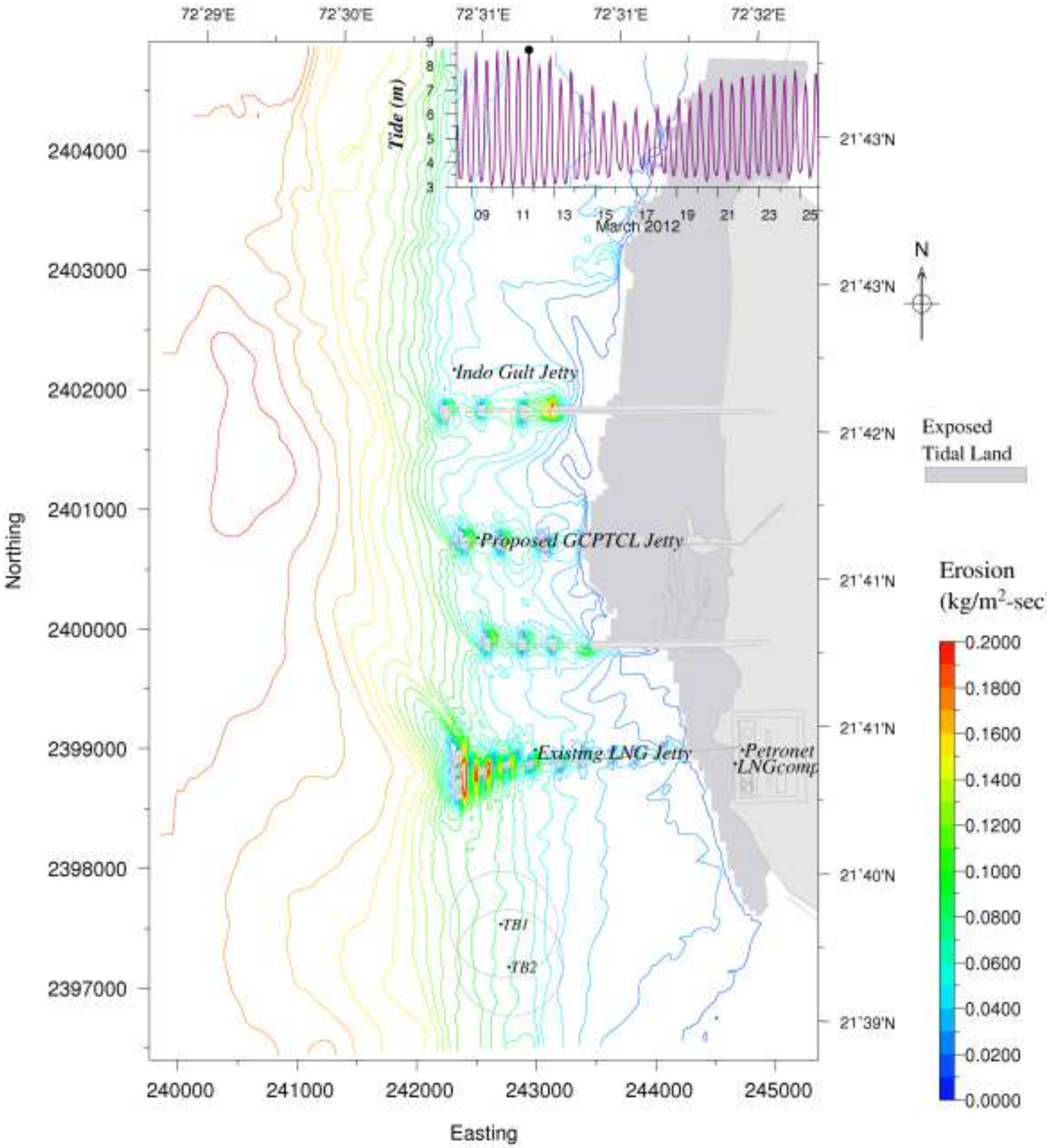


Fig.A4.13 Instantaneous rate of sediment erosion before development (at 11/03/2012 19:00hr) during spring tide (HHW)

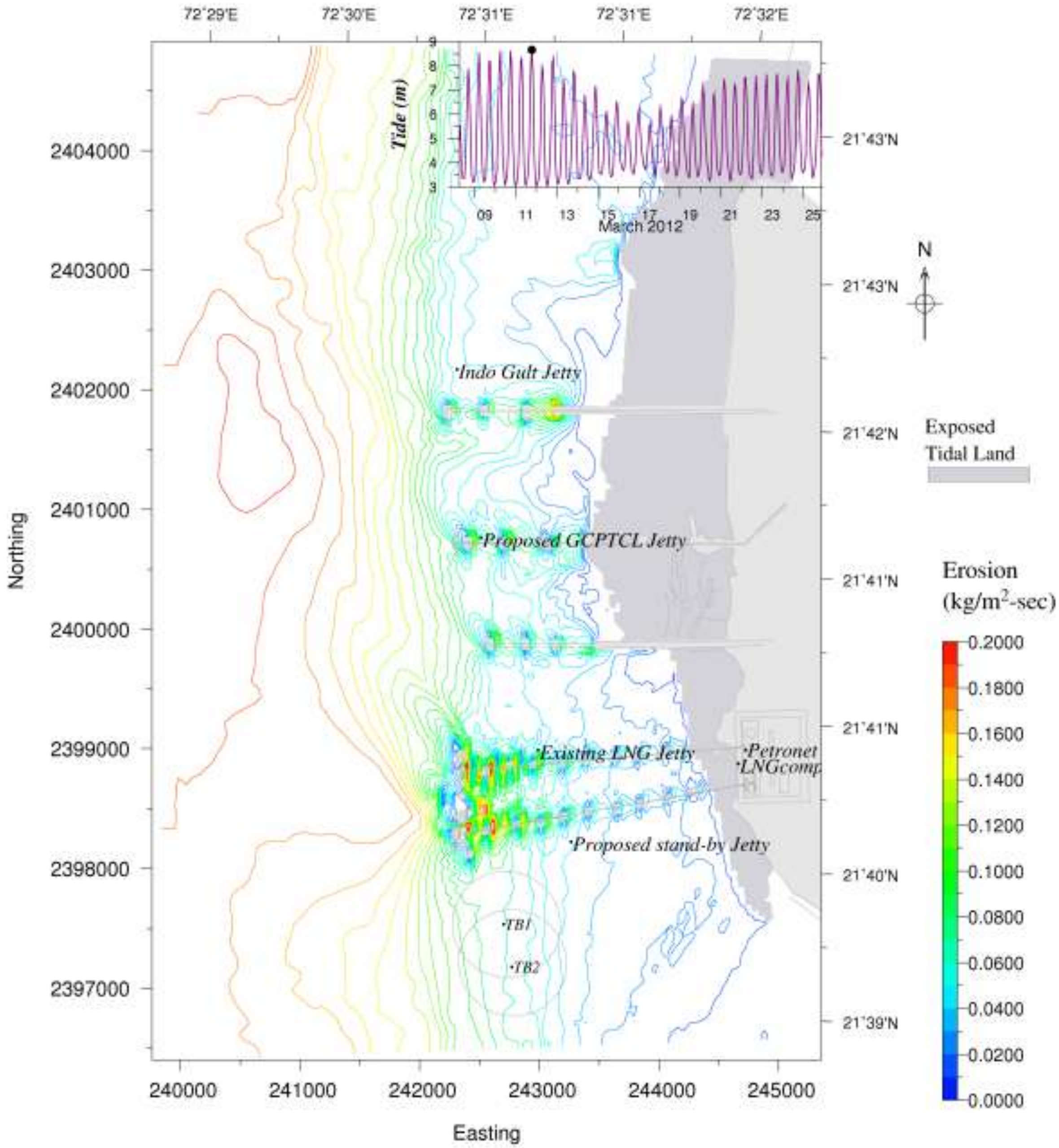


Fig.A4.14 Instantaneous rate of sediment erosion after development (at 11/03/2012 19:00hr) during spring tide (HHW)

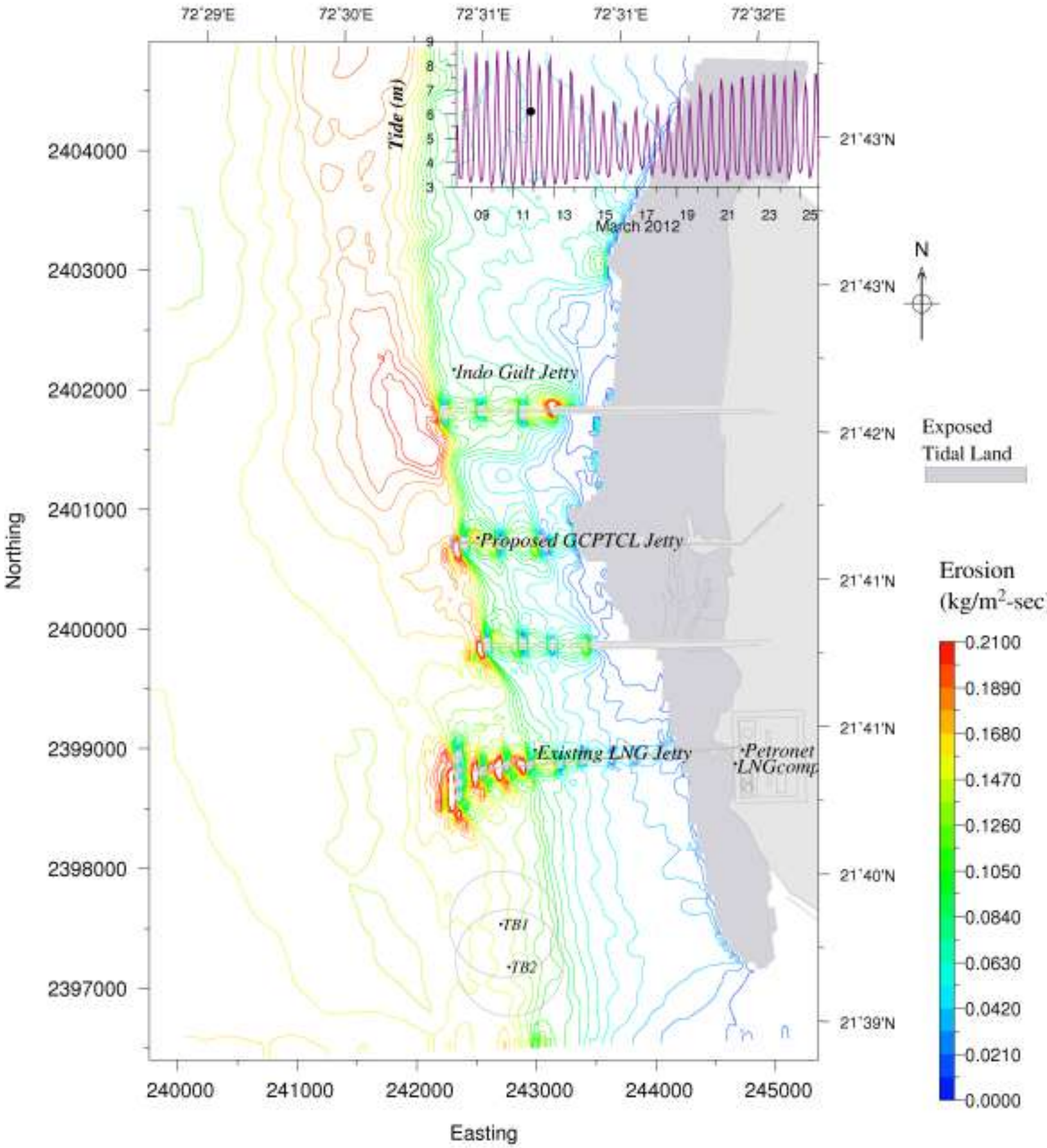


Fig.A4.15 Instantaneous rate of sediment erosion before development (at 11/03/2012 21:00hr) during spring tide (Peak EBB)

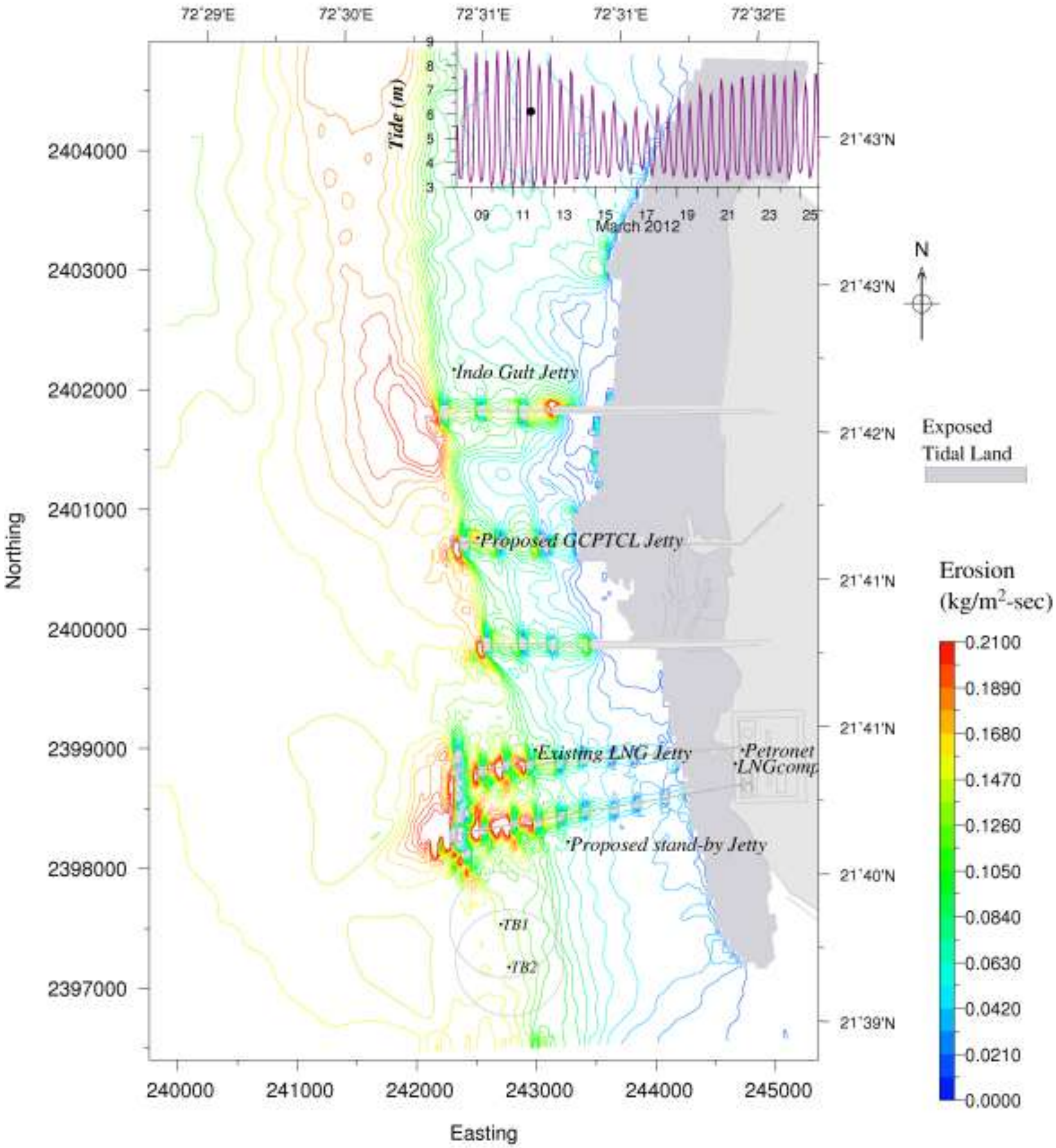


Fig.A4.16 Instantaneous rate of sediment erosion after development (at 11/03/2012 21:00hr) during spring tide (Peak EBB)

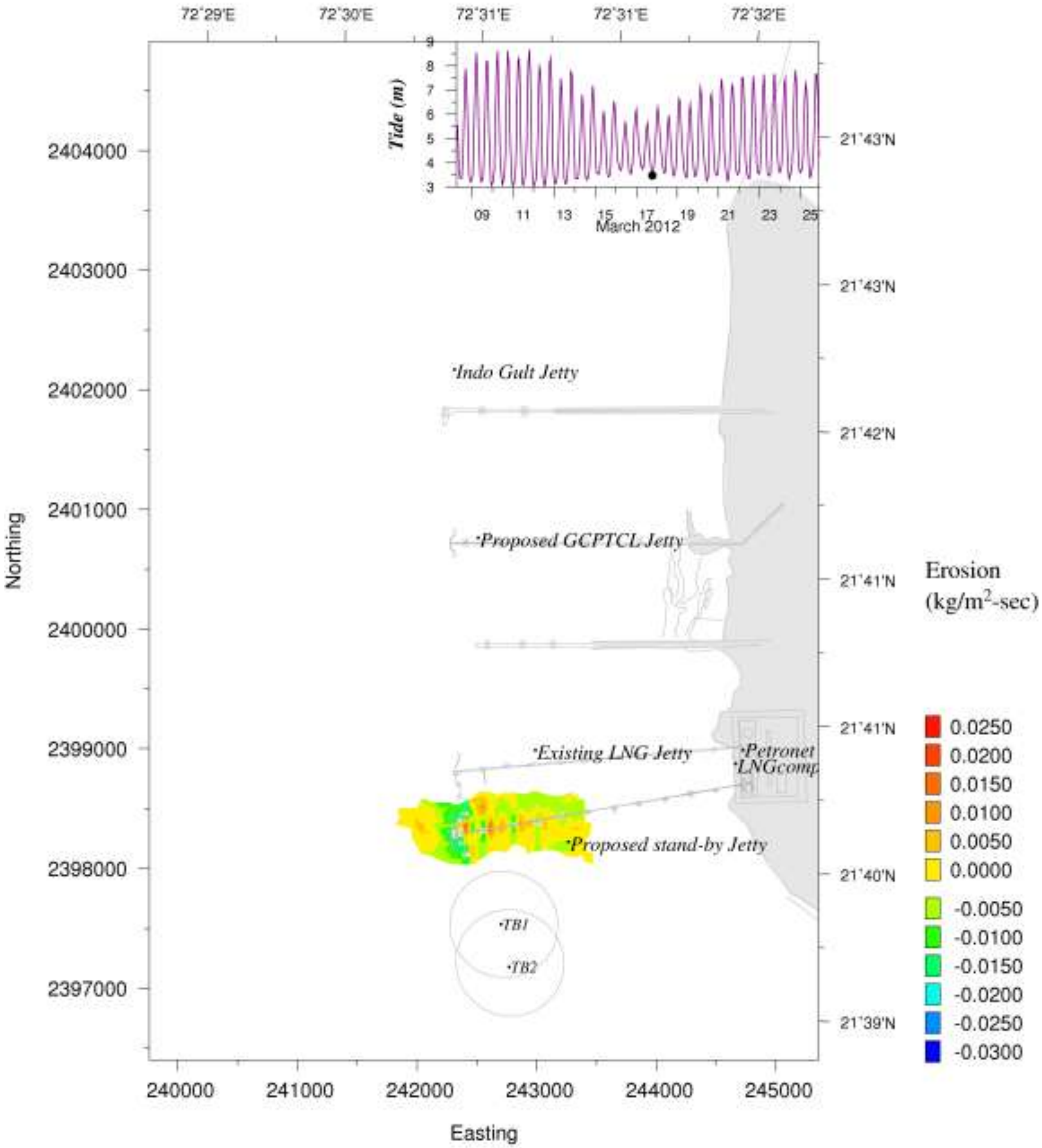


Fig.A4.17 Difference in sediment erosion between before and after development during LLW of neap tide (Mar 2012)

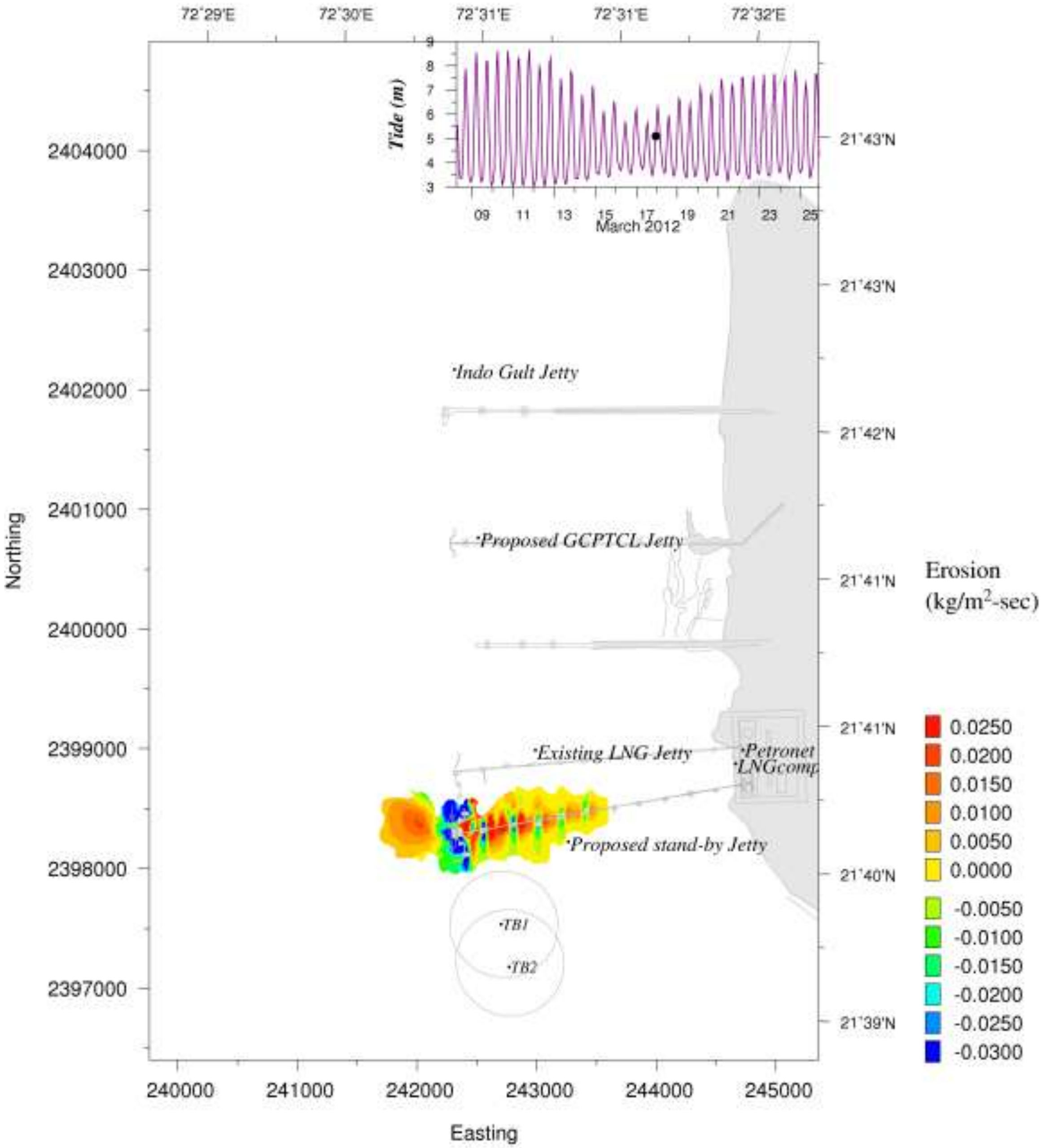


Fig.A4.18 Difference in sediment erosion between before and after development during Peak Flood of neap tide (Mar 2012)

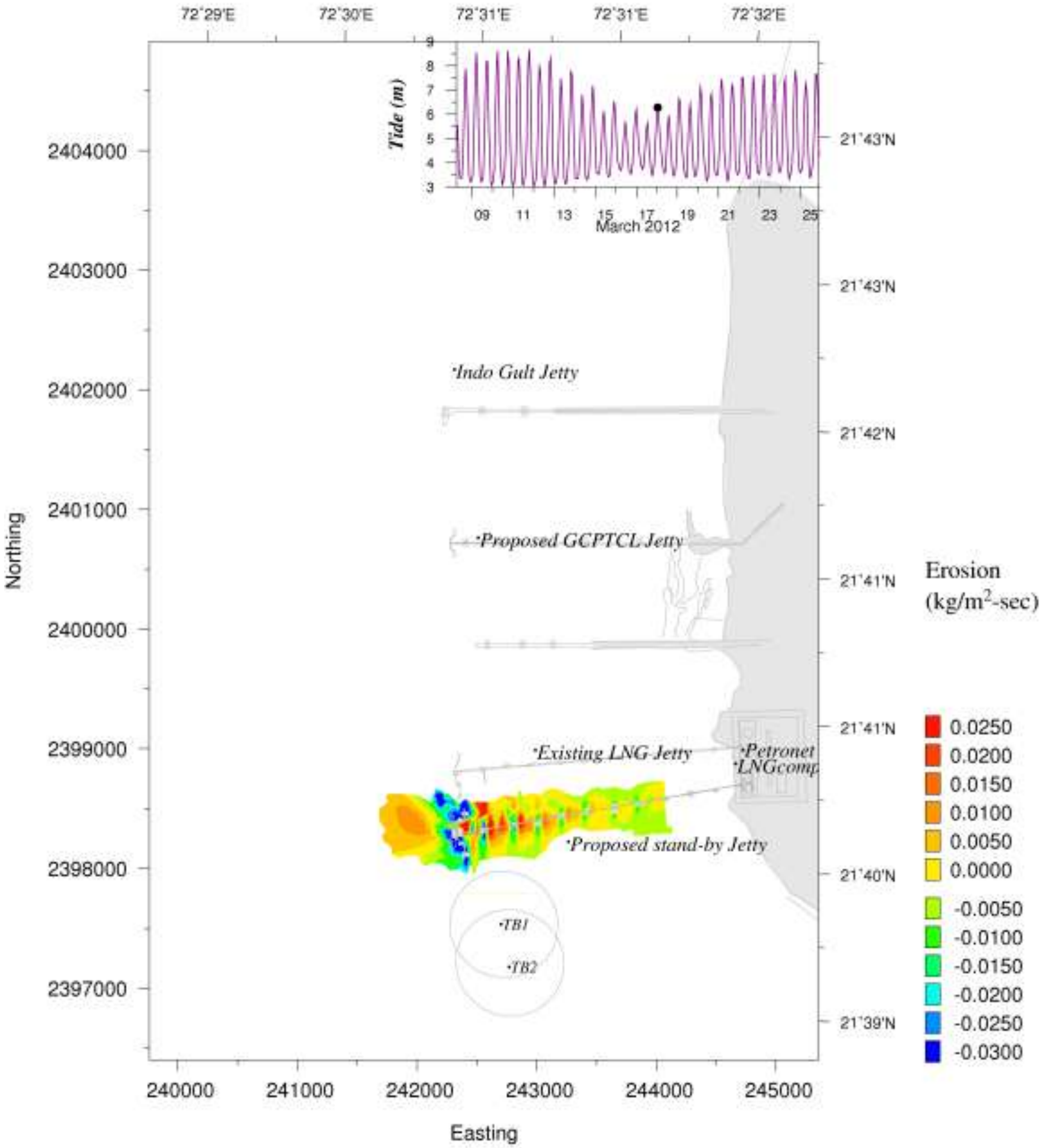


Fig.A4.19 Difference in sediment erosion between before and after development during HHW of neap tide (Mar 2012)

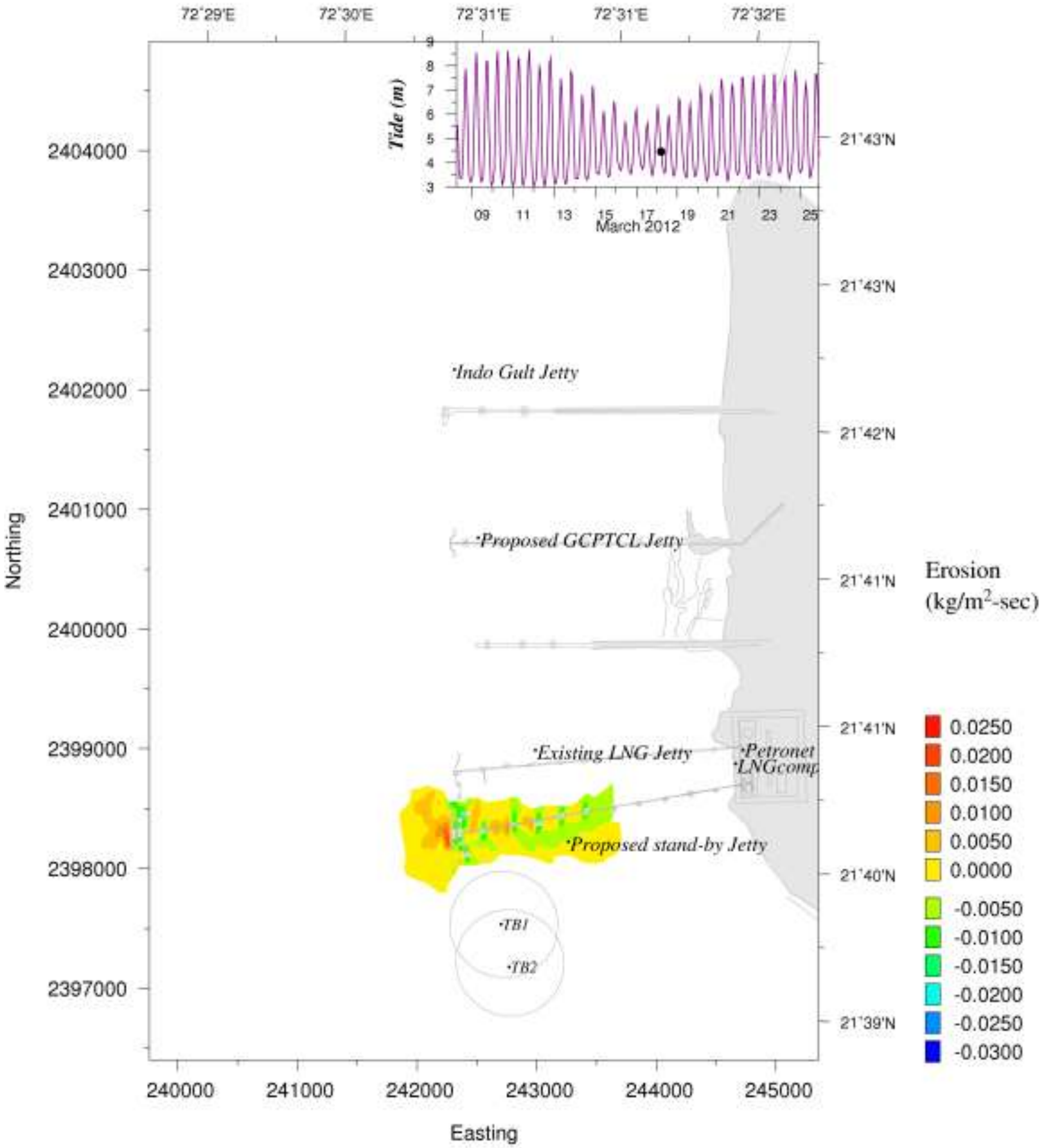


Fig.A4.20 Difference in sediment erosion between before and after development during Peak EBB of neap tide (Mar 2012)

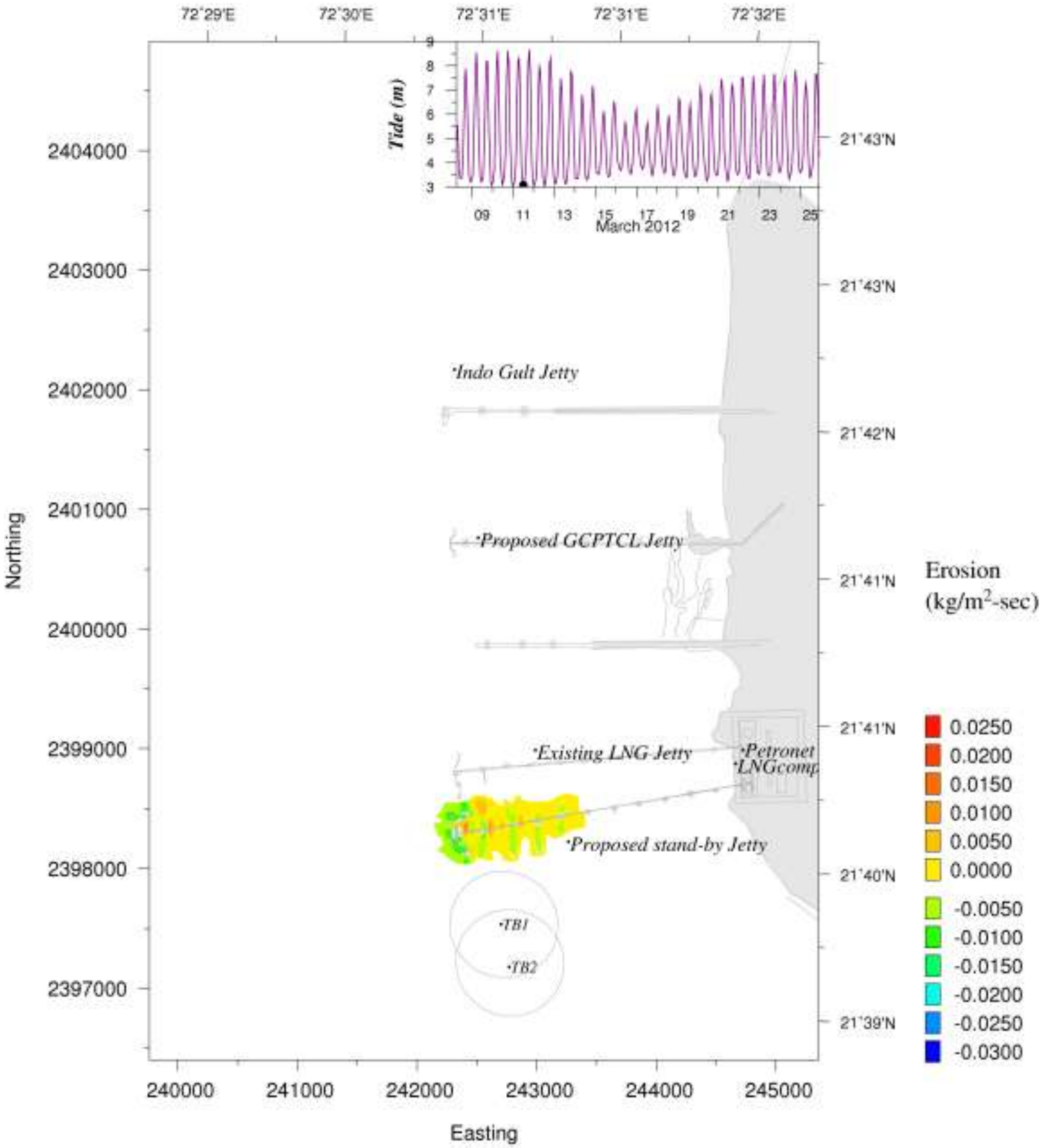


Fig.A4.21 Difference in sediment erosion between before and after development during LLW of spring tide (Mar 2012)

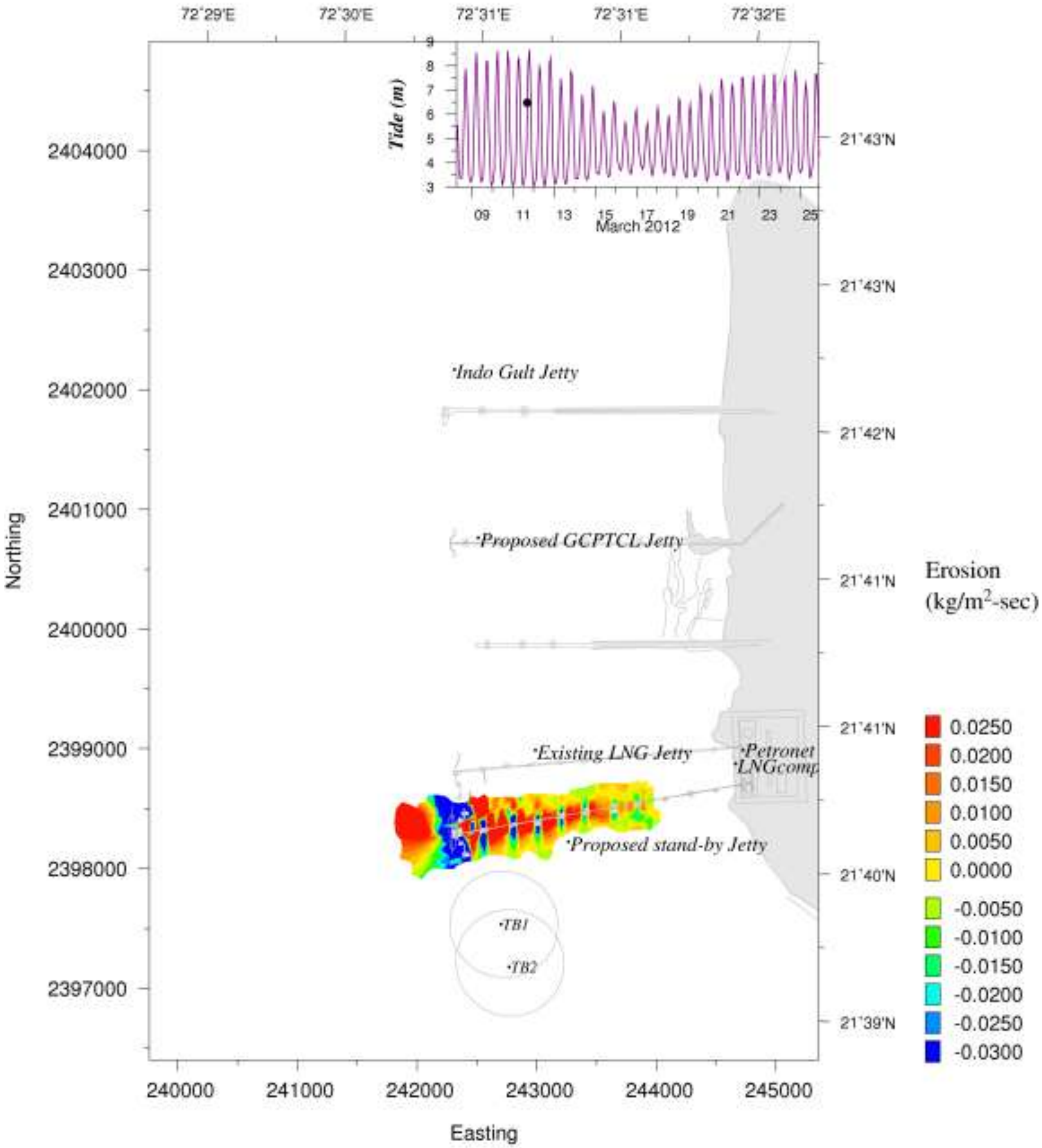


Fig.A4.22 Difference in sediment erosion between before and after development during Peak Flood of spring tide (Mar 2012)

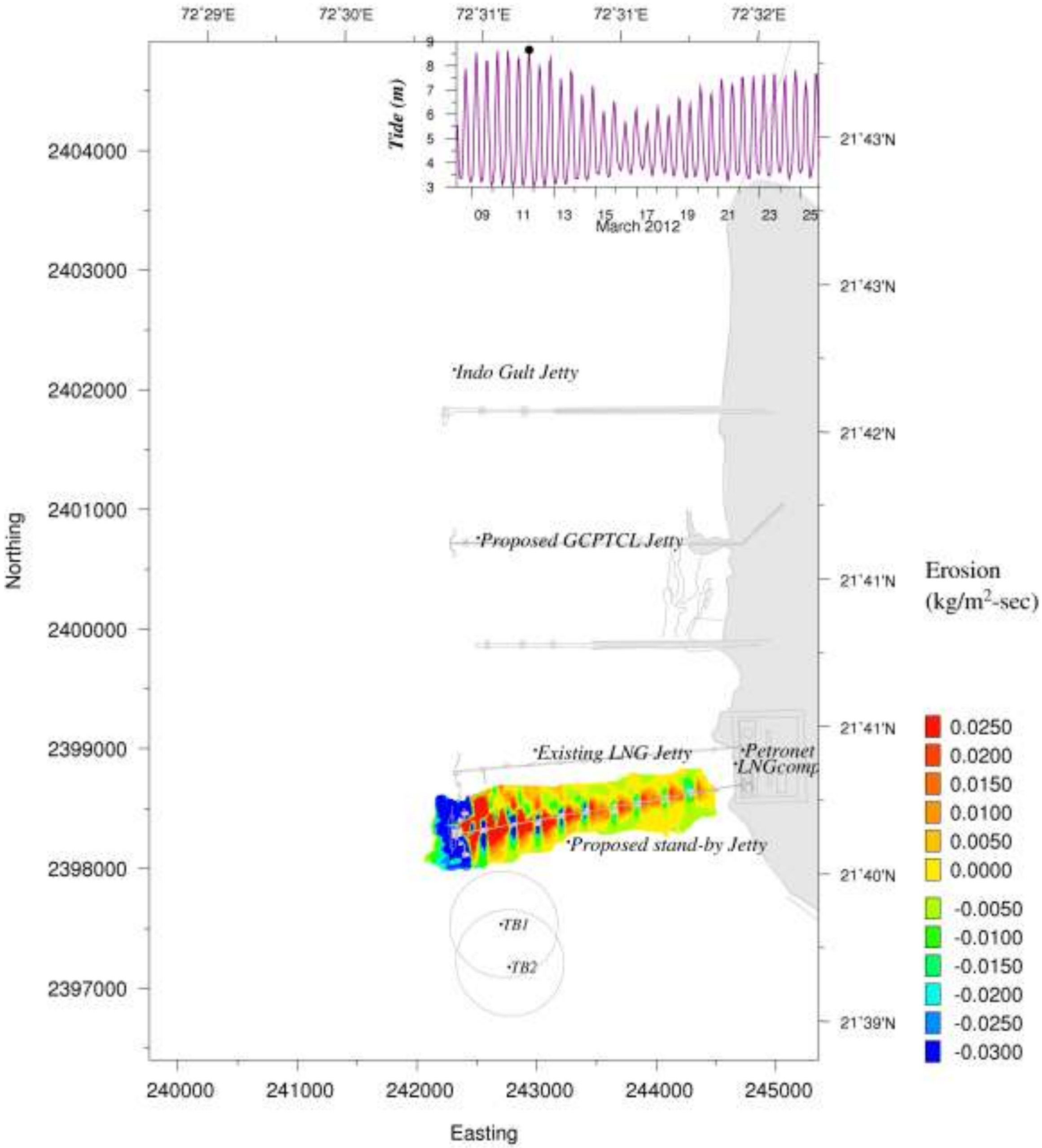


Fig.A4.23 Difference in sediment erosion between before and after development during HHW of spring tide (Mar 2012)

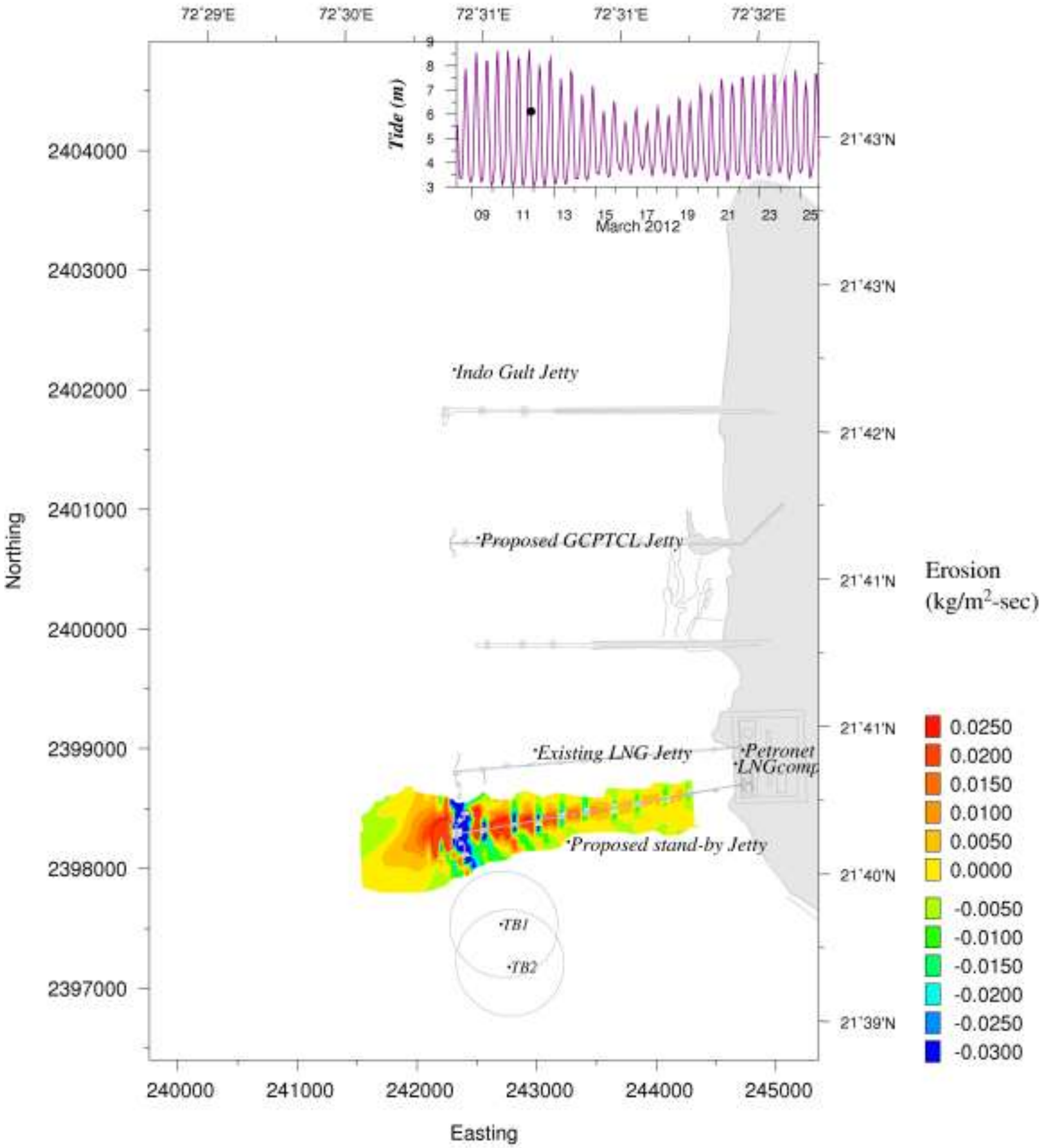


Fig.A4.24 Difference in sediment erosion between before and after development during Peak EBB of spring tide (Mar 2012)

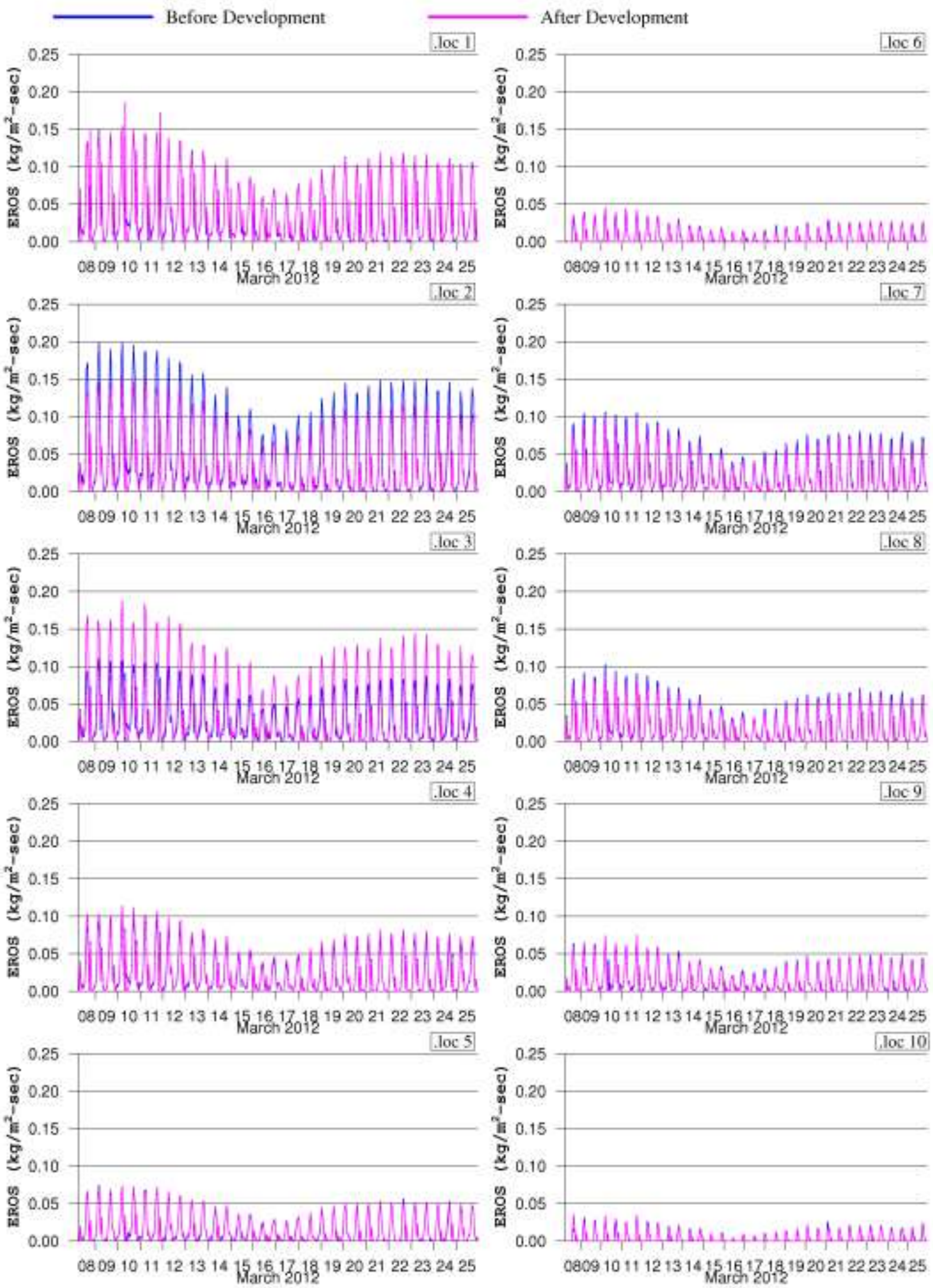


Fig.A4.25(a) Comparison of sediment erosion before and after development (Mar 2012)

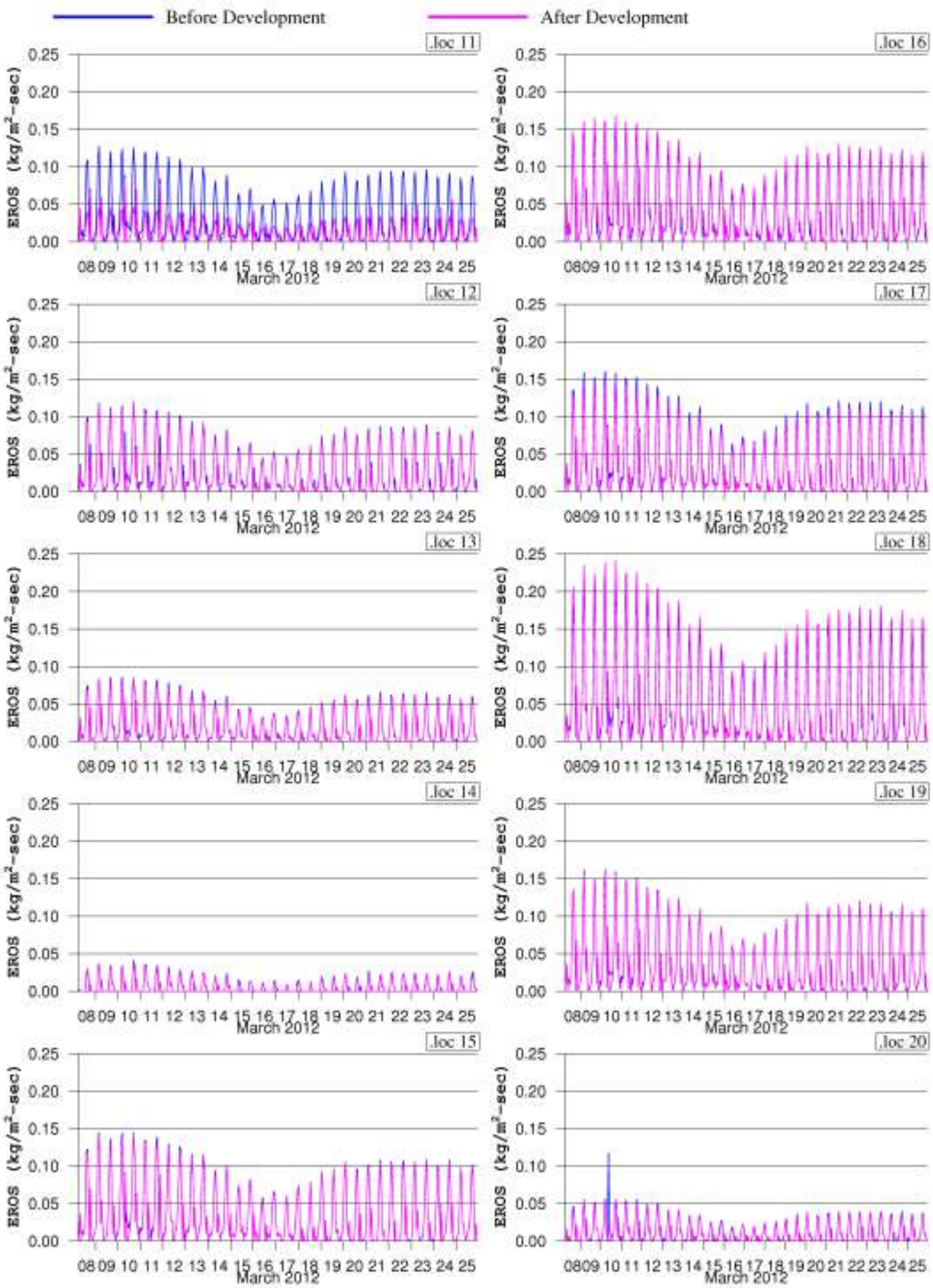


Fig.A4.25(b) Comparison of sediment erosion before and after development (Mar 2012)

ANNEXURE-X
MARINE MODELING STUDIES

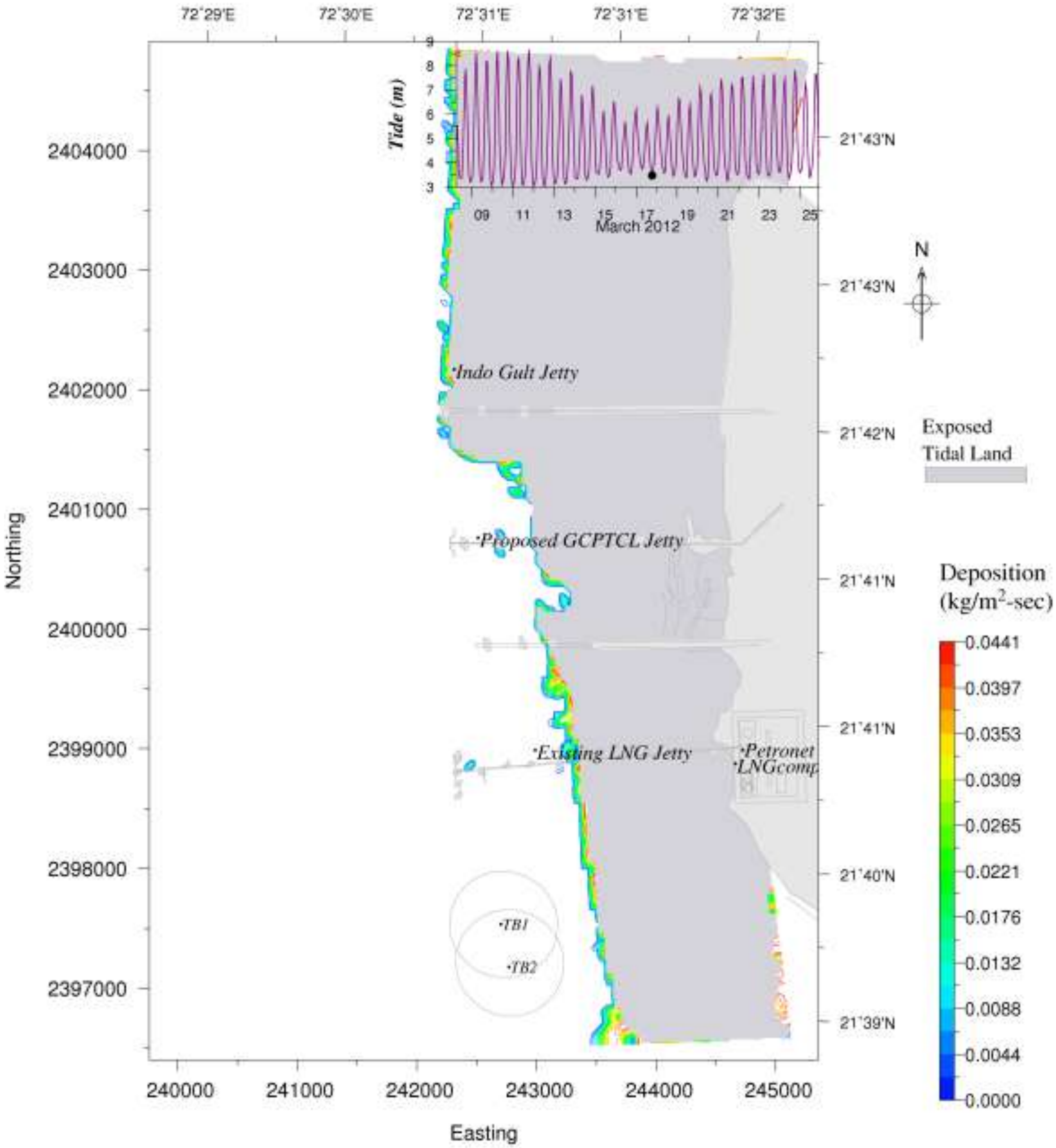


Fig.A5.1 Instantaneous rate of sediment deposition before development (at 17/03/2012 19:00hr) during neap tide (LLW)

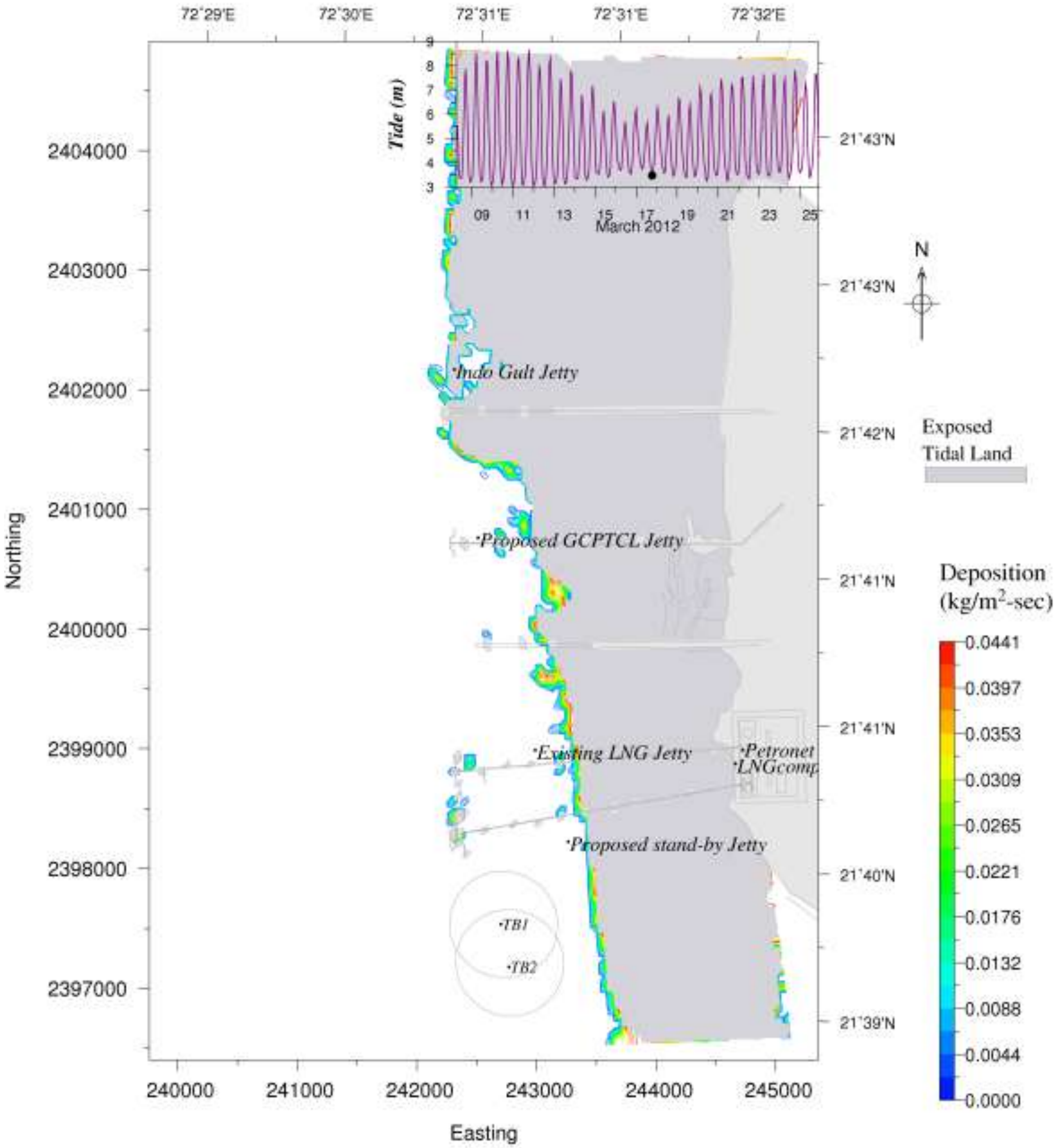


Fig.A5.2 Instantaneous rate of sediment deposition after development (at 17/03/2012 19:00hr) during neap tide (LLW)

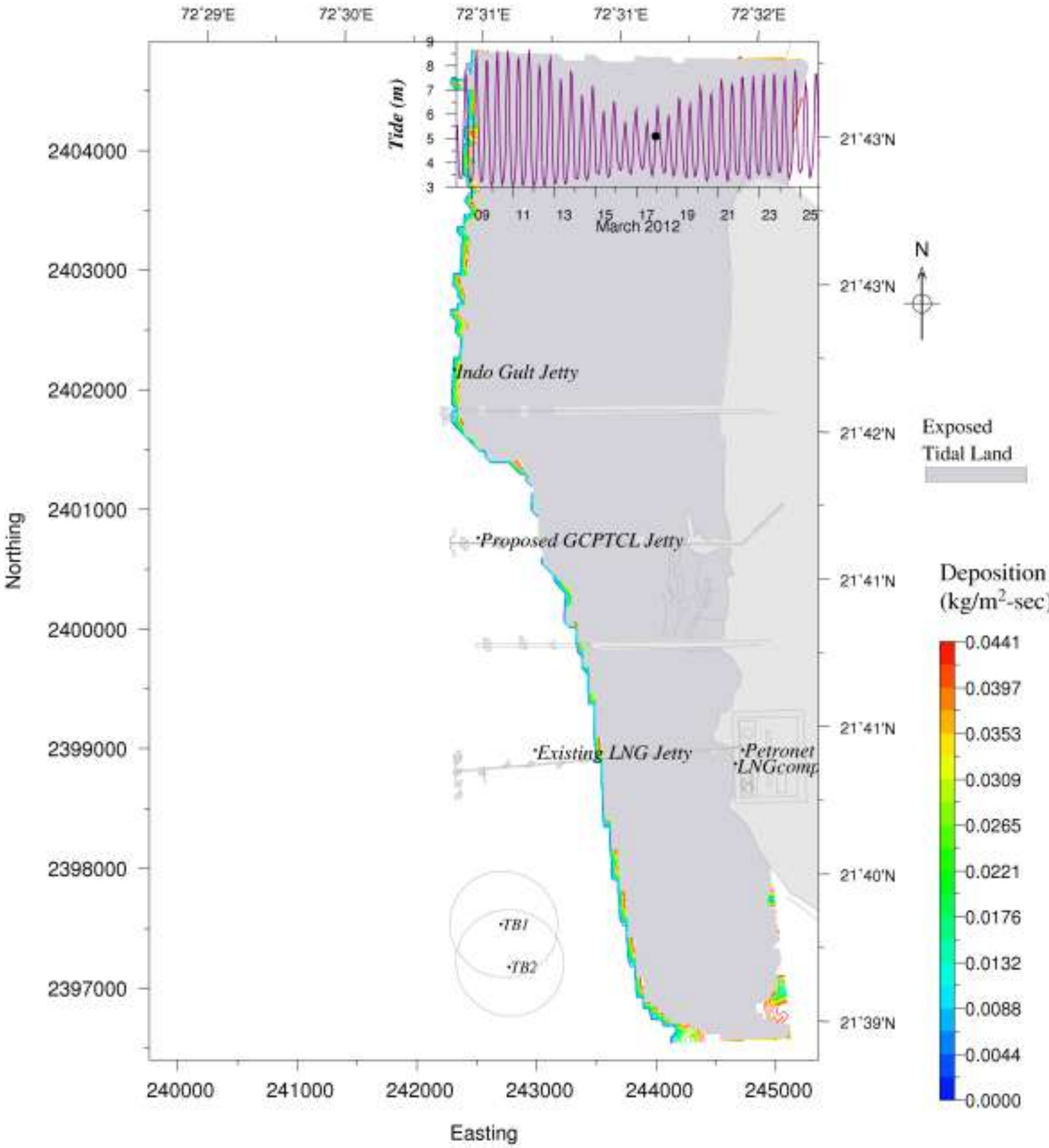


Fig.A5.3 Instantaneous rate of sediment deposition before development (at 17/03/2012 23:00hr) during neap tide (Peak Flood)

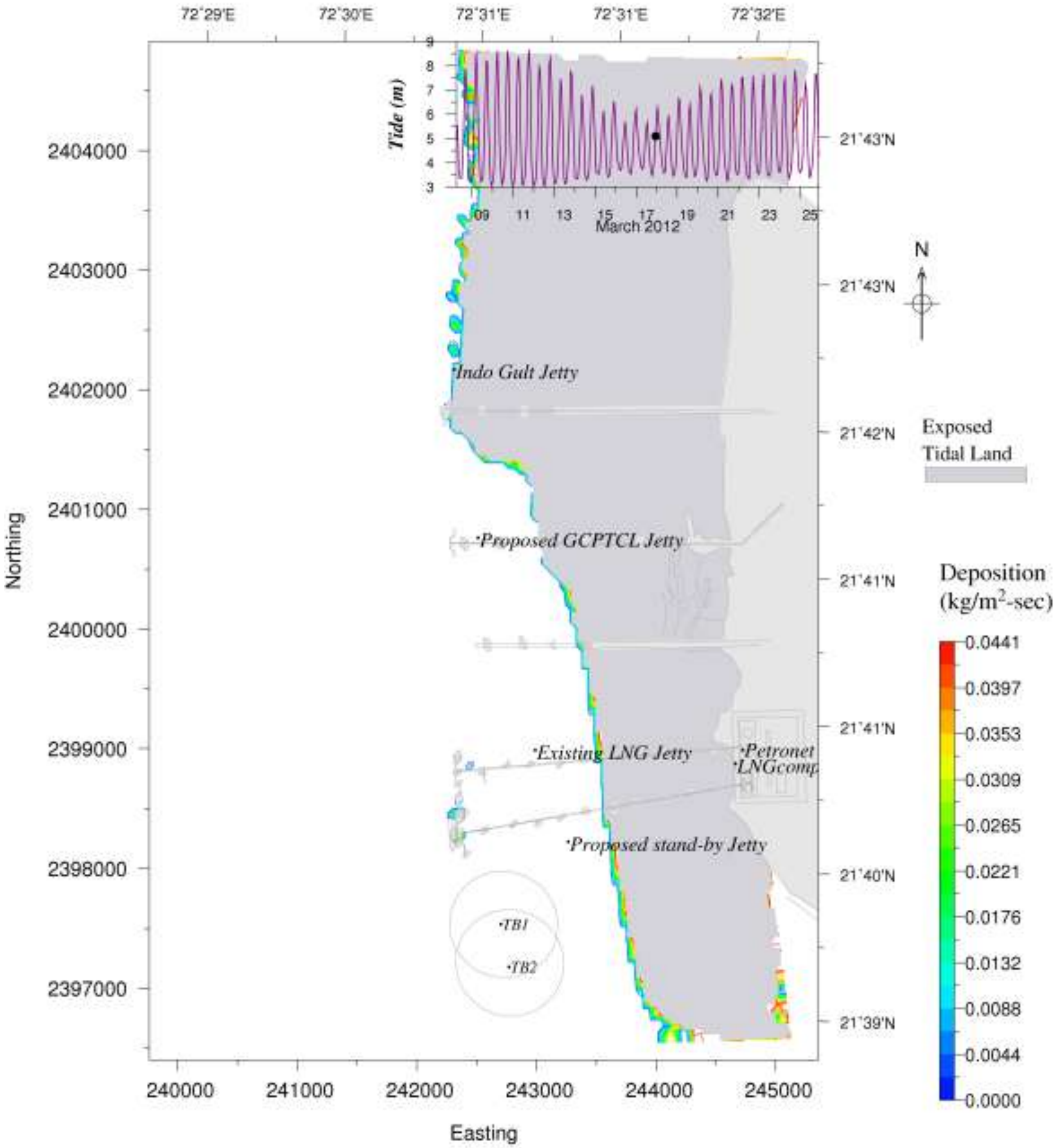


Fig.A5.4 Instantaneous rate of sediment deposition after development (at 17/03/2012 23:00hr) during neap tide (Peak Flood)

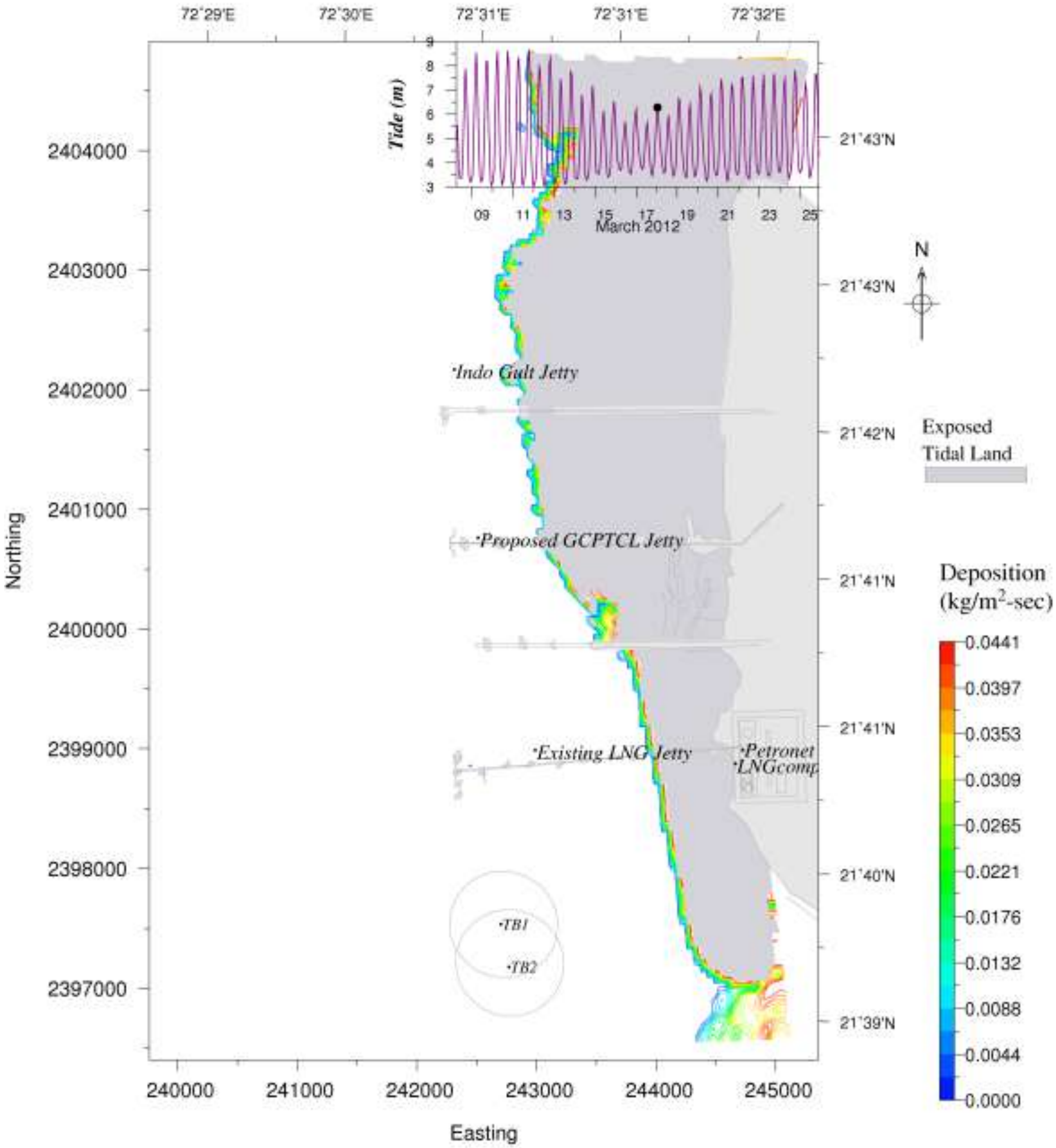


Fig.A5.5 Instantaneous rate of sediment deposition before development (at 18/03/2012 01:00hr) during neap tide (HHW)

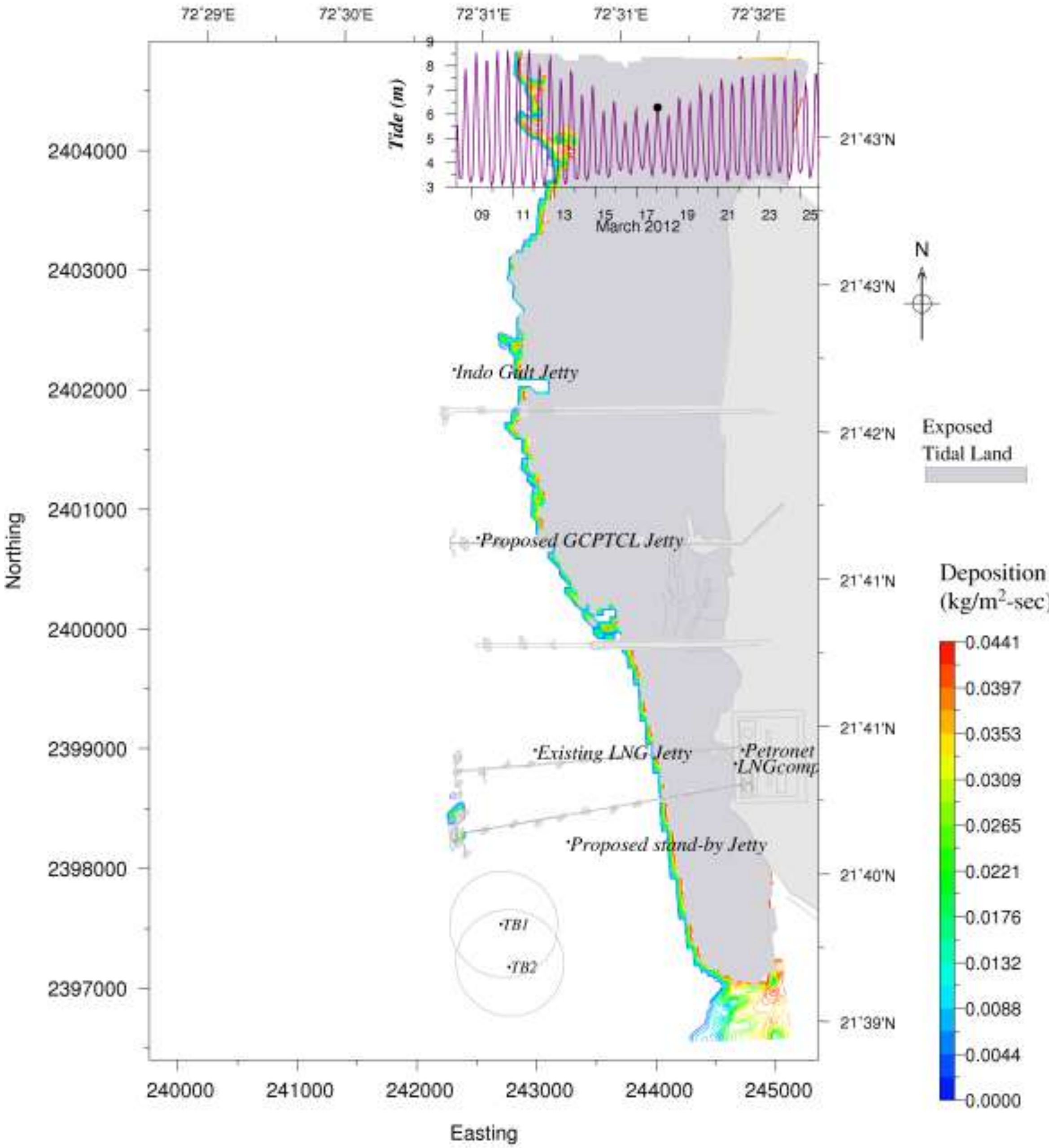


Fig.A5.6 Instantaneous rate of sediment deposition after development (at 18/03/2012 01:00hr) during neap tide (HHW)

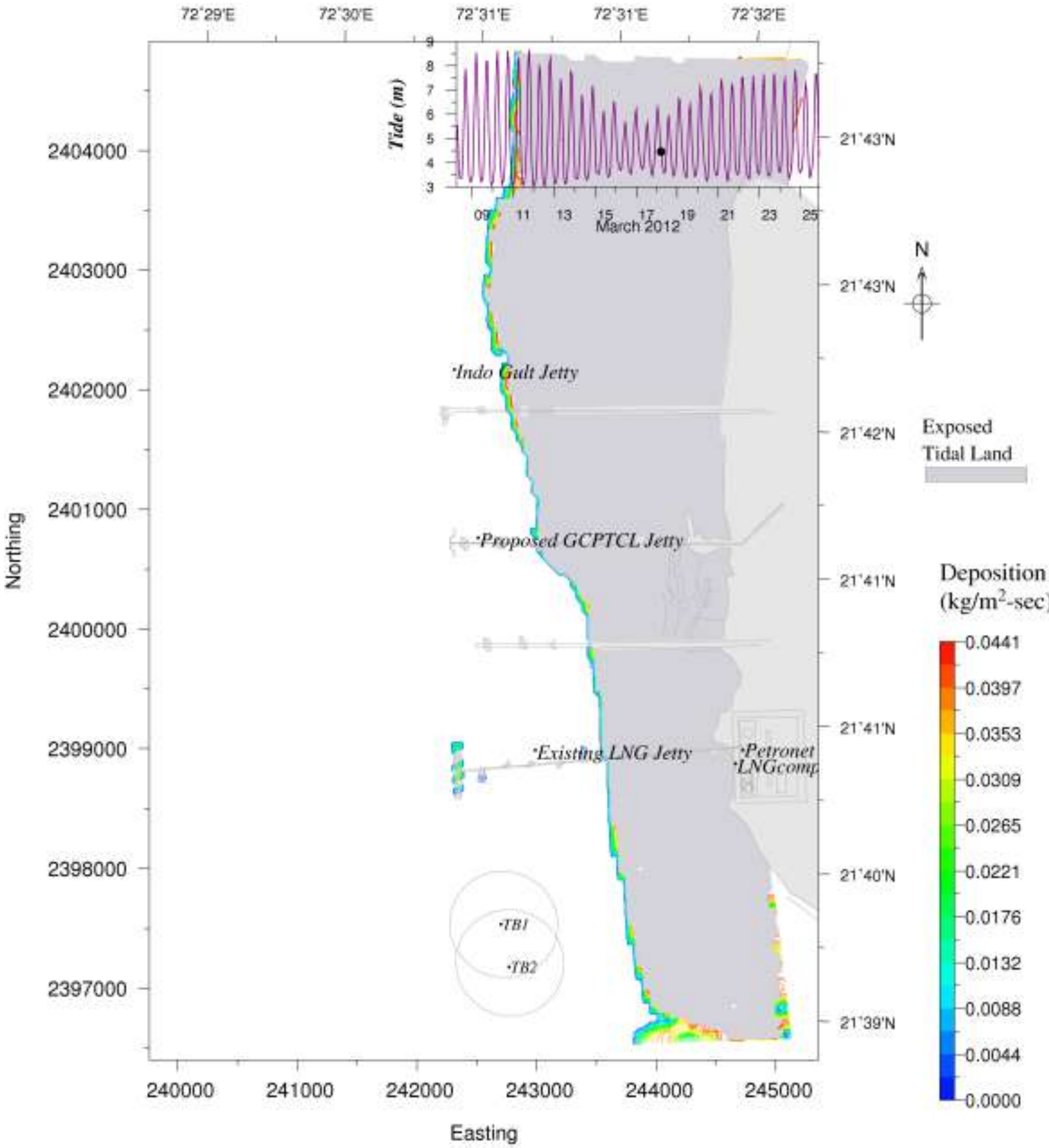


Fig.A5.7 Instantaneous rate of sediment deposition before development (at 18/03/2012 05:00hr) during neap tide (Peak EBB)

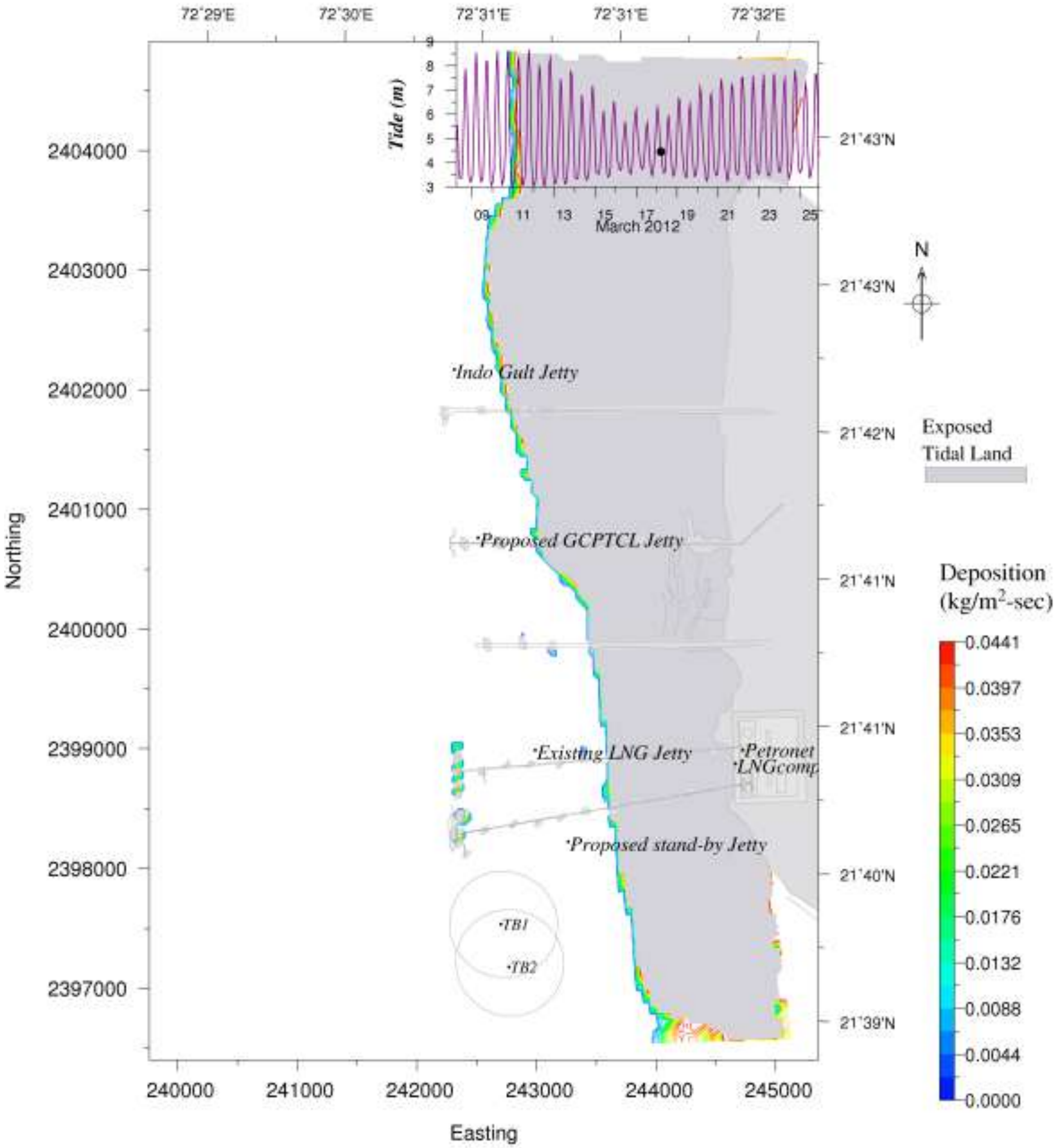


Fig.A5.8 Instantaneous rate of sediment deposition after development (at 18/03/2012 05:00hr) during neap tide (Peak EBB)

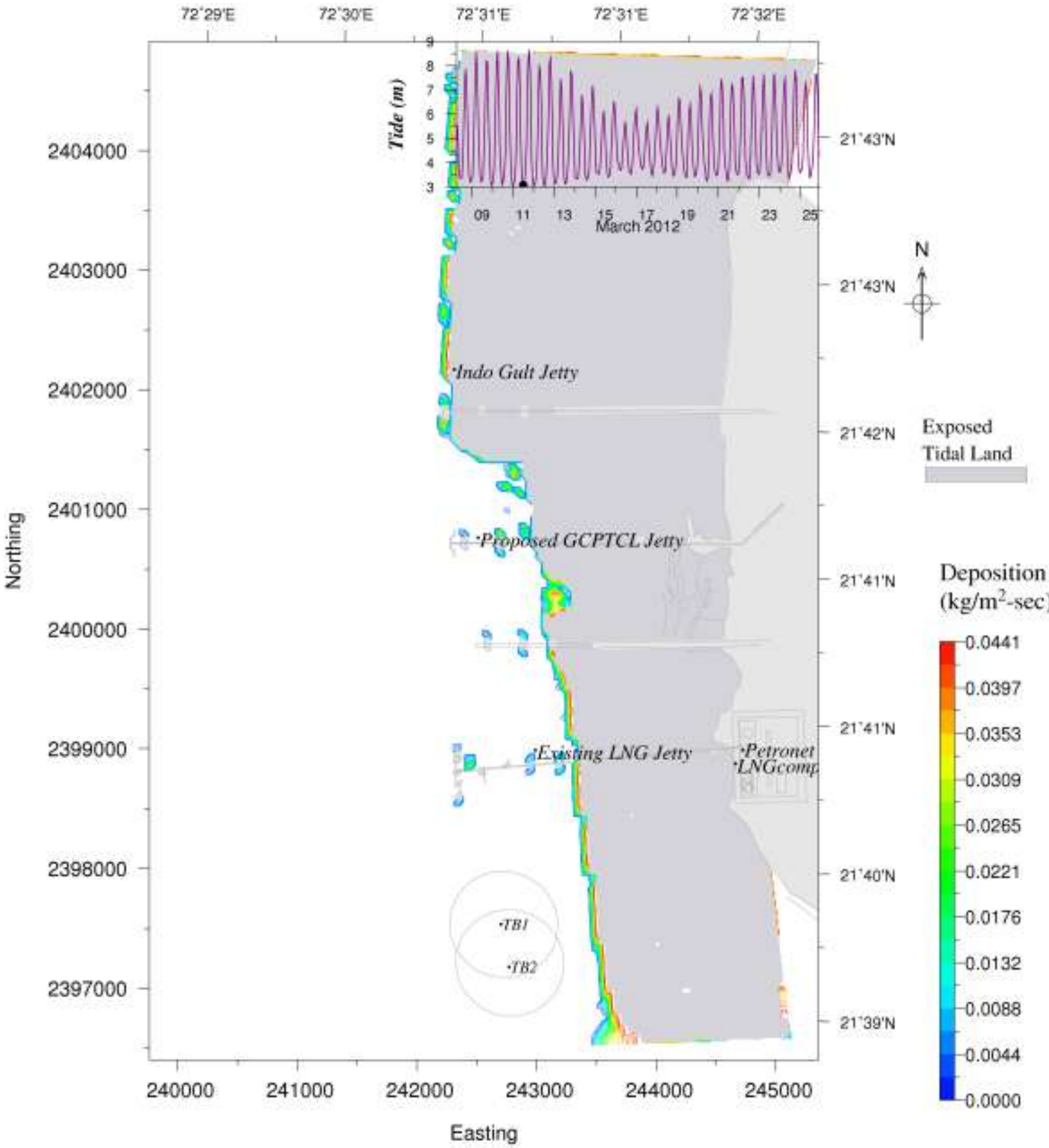


Fig.A5.9 Instantaneous rate of sediment deposition before development (at 11/03/2012 12:00hr) during spring tide (LLW)

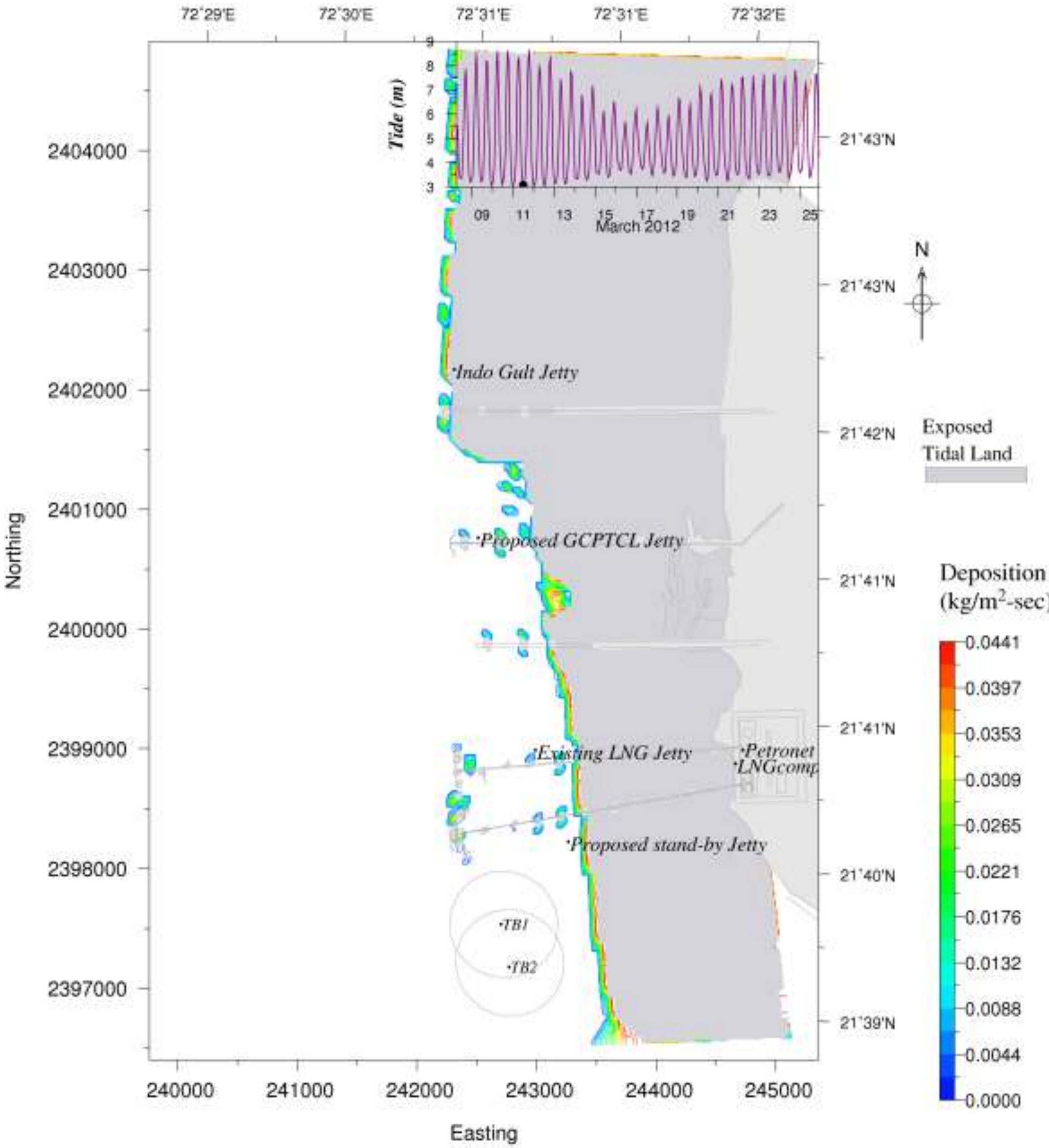


Fig.A5.10 Instantaneous rate of sediment deposition after development (at 11/03/2012 12:00hr) during spring tide (LLW)

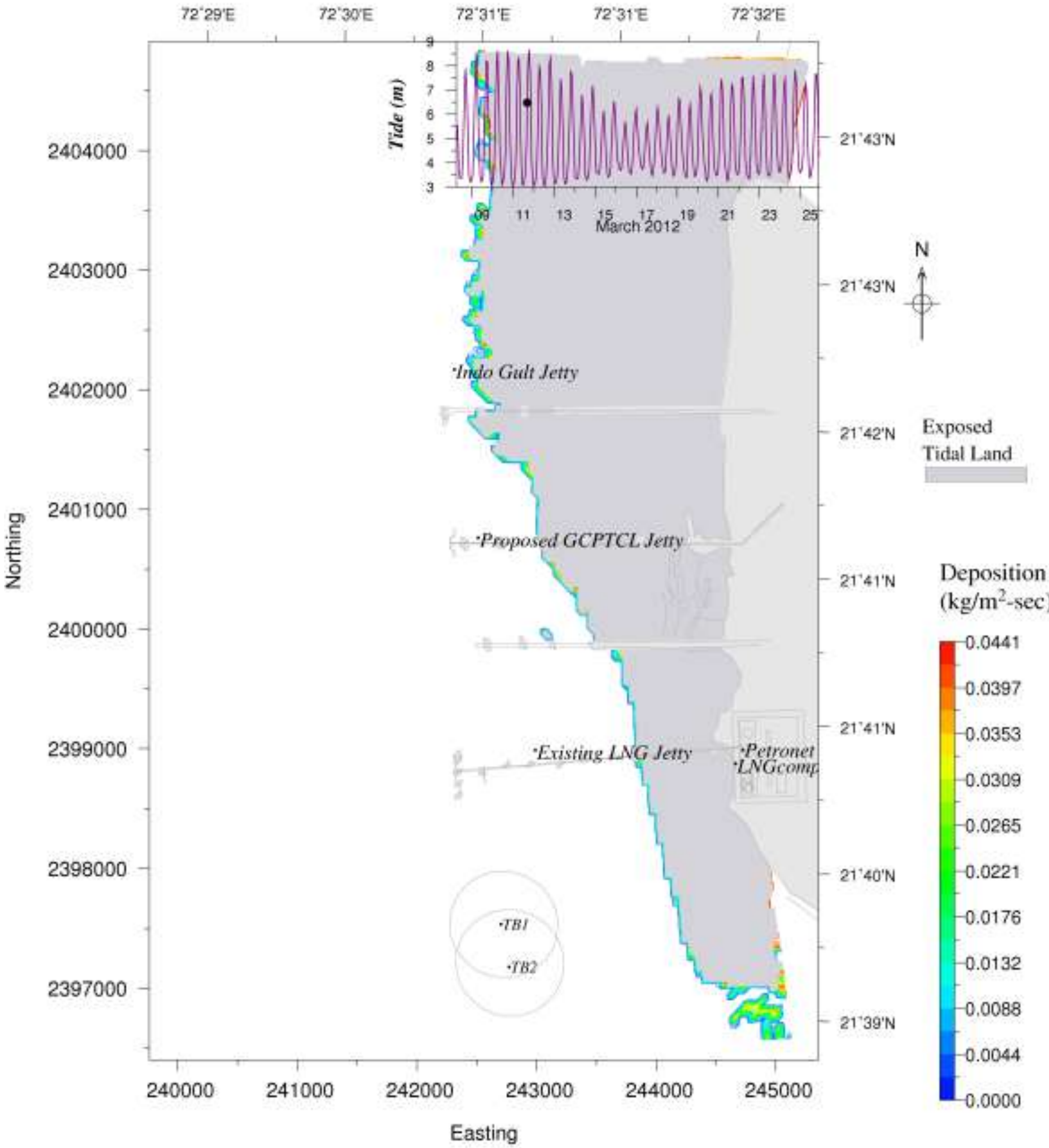


Fig.A5.11 Instantaneous rate of sediment deposition before development (at 11/03/2012 17:00hr) during spring tide (Peak Flood)

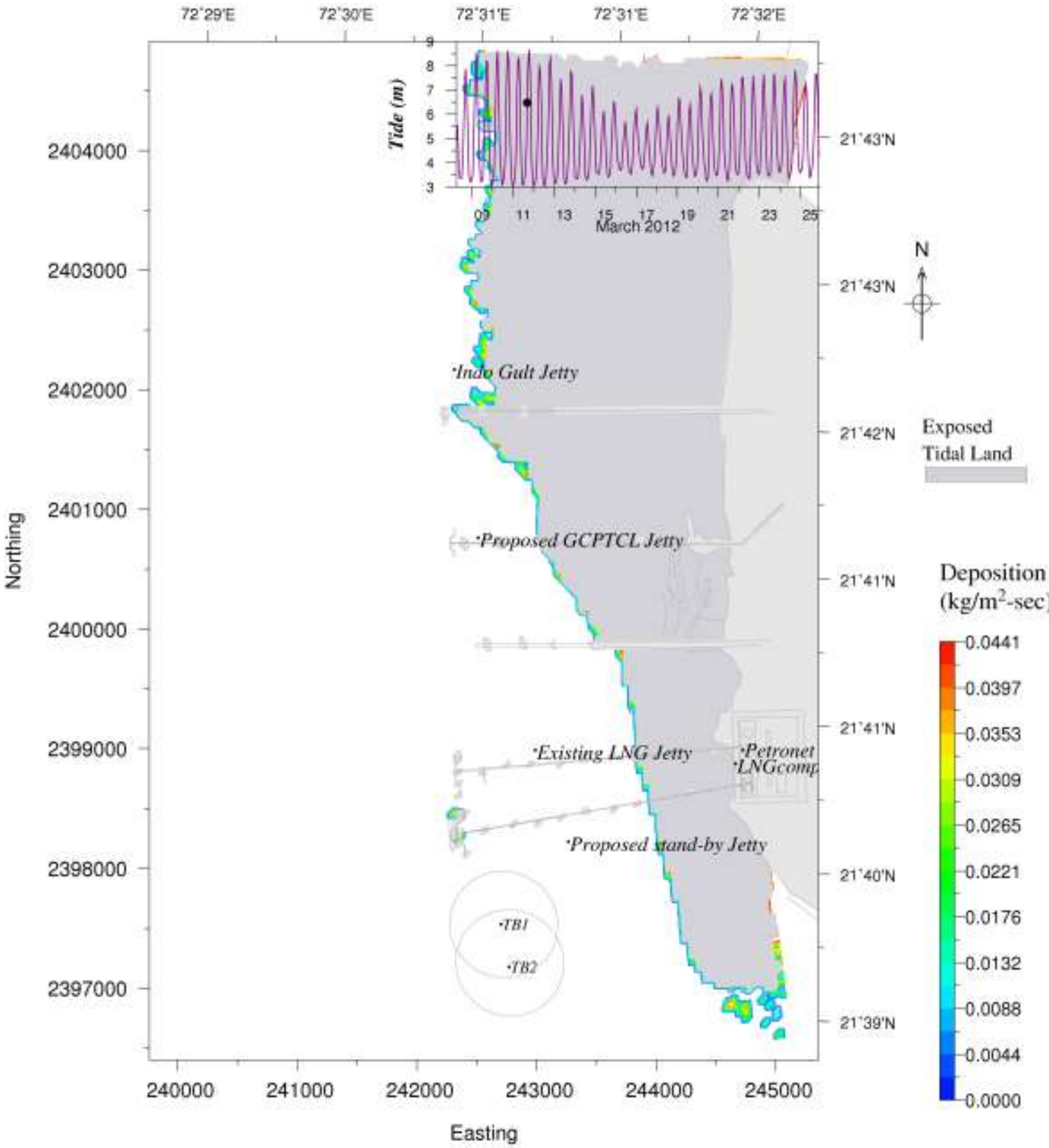


Fig.A5.12 Instantaneous rate of sediment deposition after development (at 11/03/2012 17:00hr) during spring tide (Peak Flood)

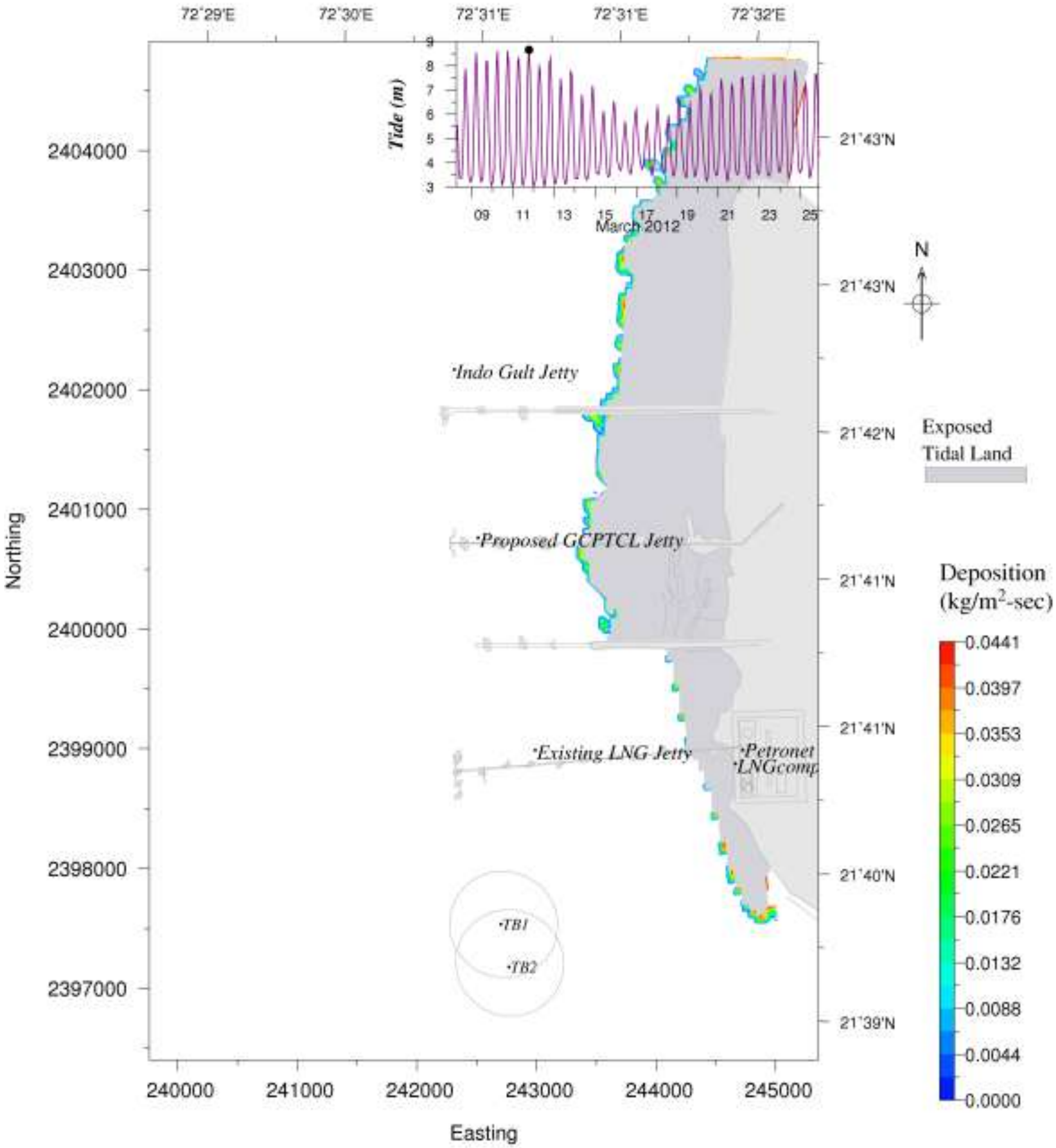


Fig.A5.13 Instantaneous rate of sediment deposition before development (at 11/03/2012 19:00hr) during spring tide (HHW)

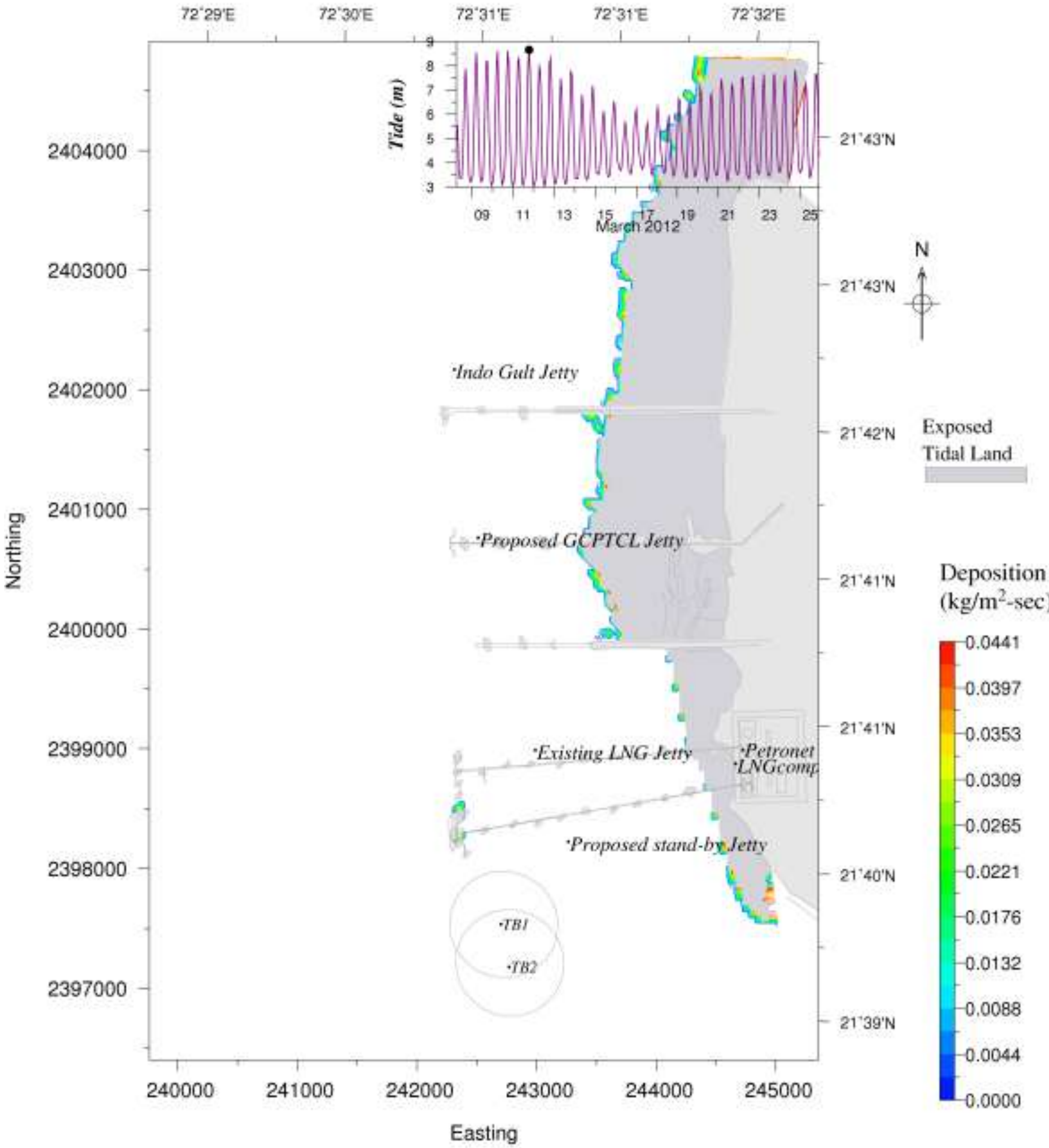


Fig.A5.14 Instantaneous rate of sediment deposition after development (at 11/03/2012 19:00hr) during spring tide (HHW)

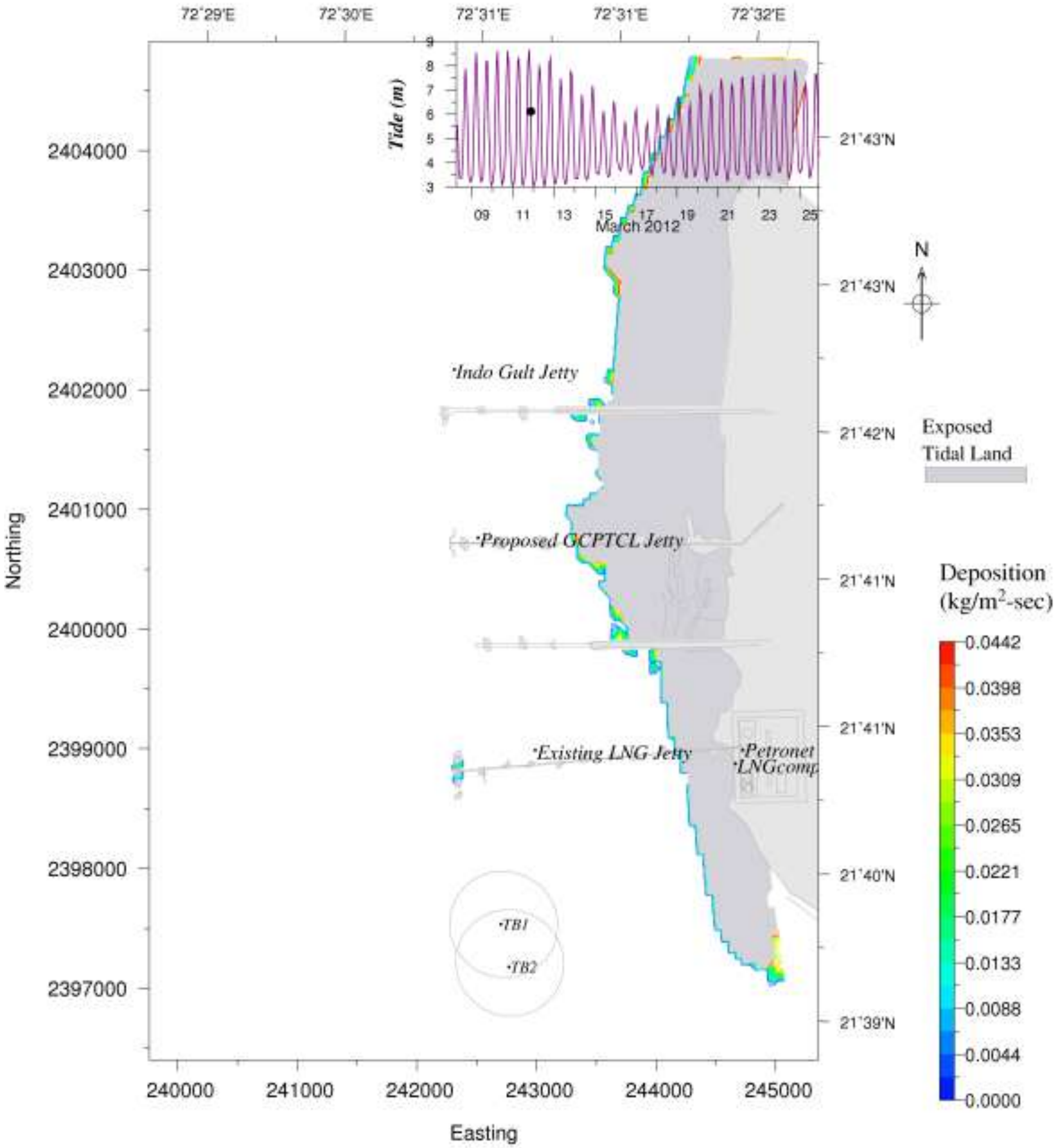


Fig.A5.15 Instantaneous rate of sediment deposition before development (at 11/03/2012 21:00hr) during spring tide (Peak EBB)

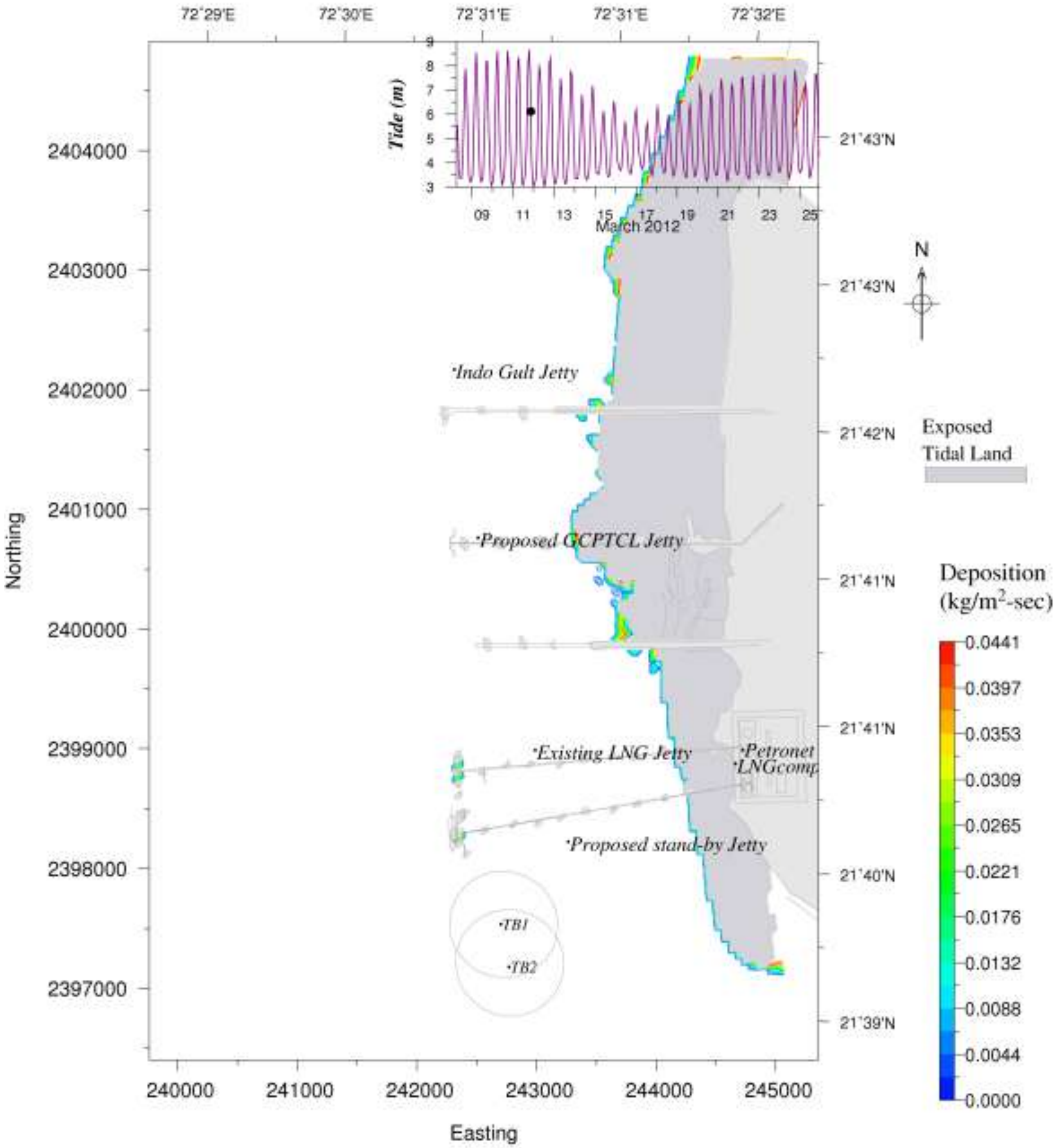


Fig.A5.16 Instantaneous rate of sediment deposition after development (at 11/03/2012 21:00hr) during spring tide (Peak EBB)

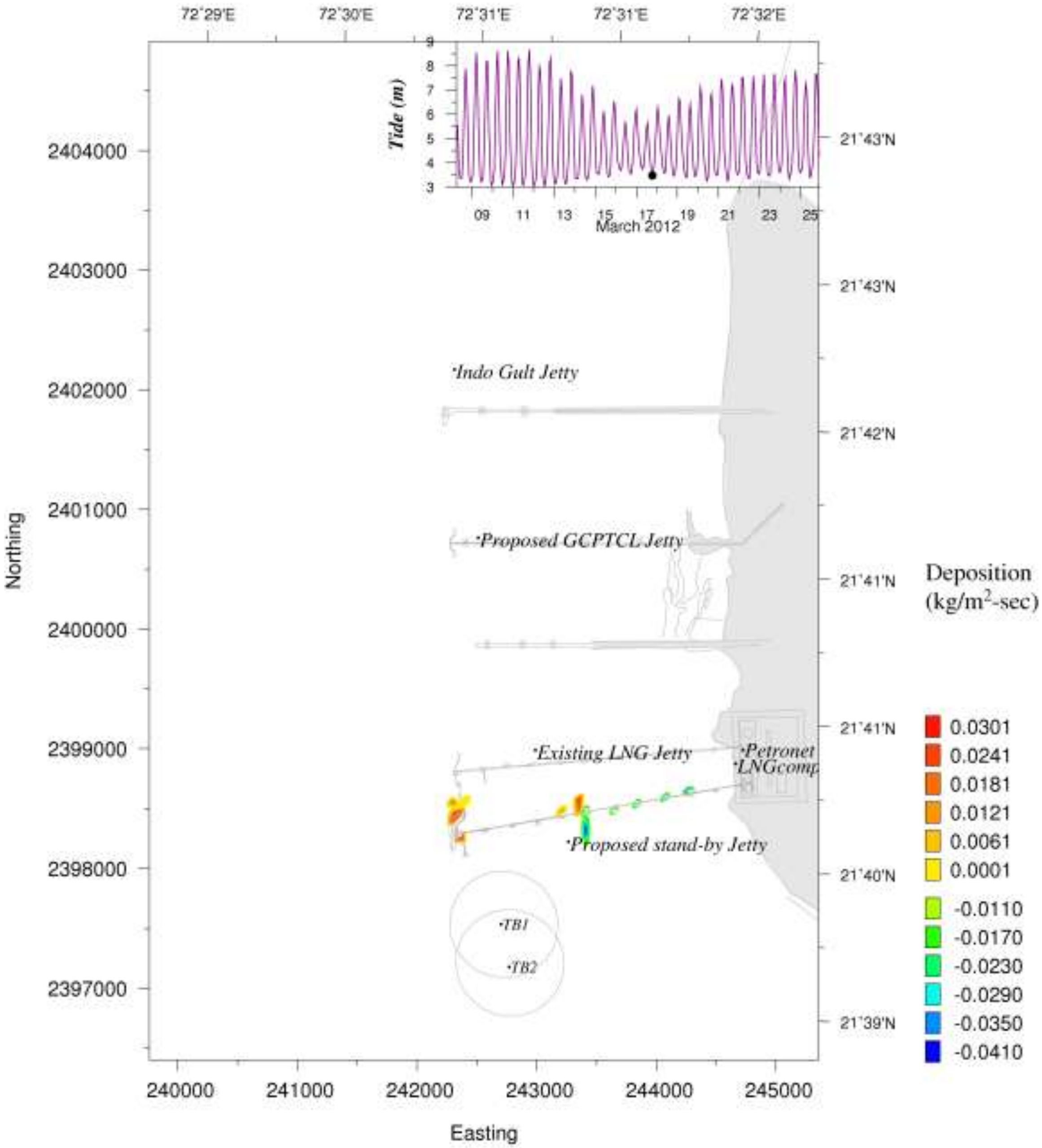


Fig.A5.17 Difference in sediment deposition between before and after development during LLW of neap tide (Mar 2012)

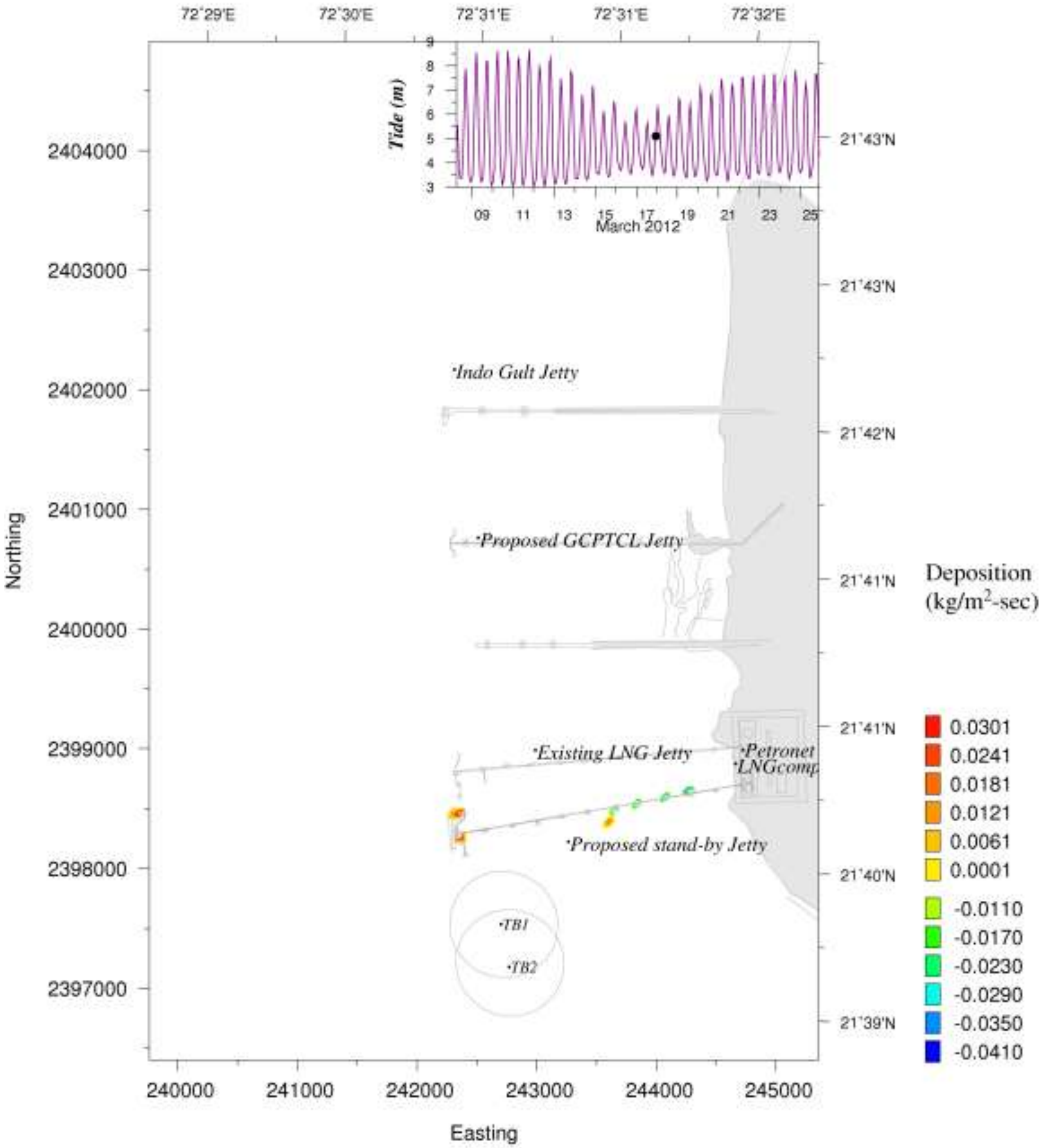


Fig.A5.18 Difference in sediment deposition between before and after development during Peak Flood of neap tide (Mar 2012)

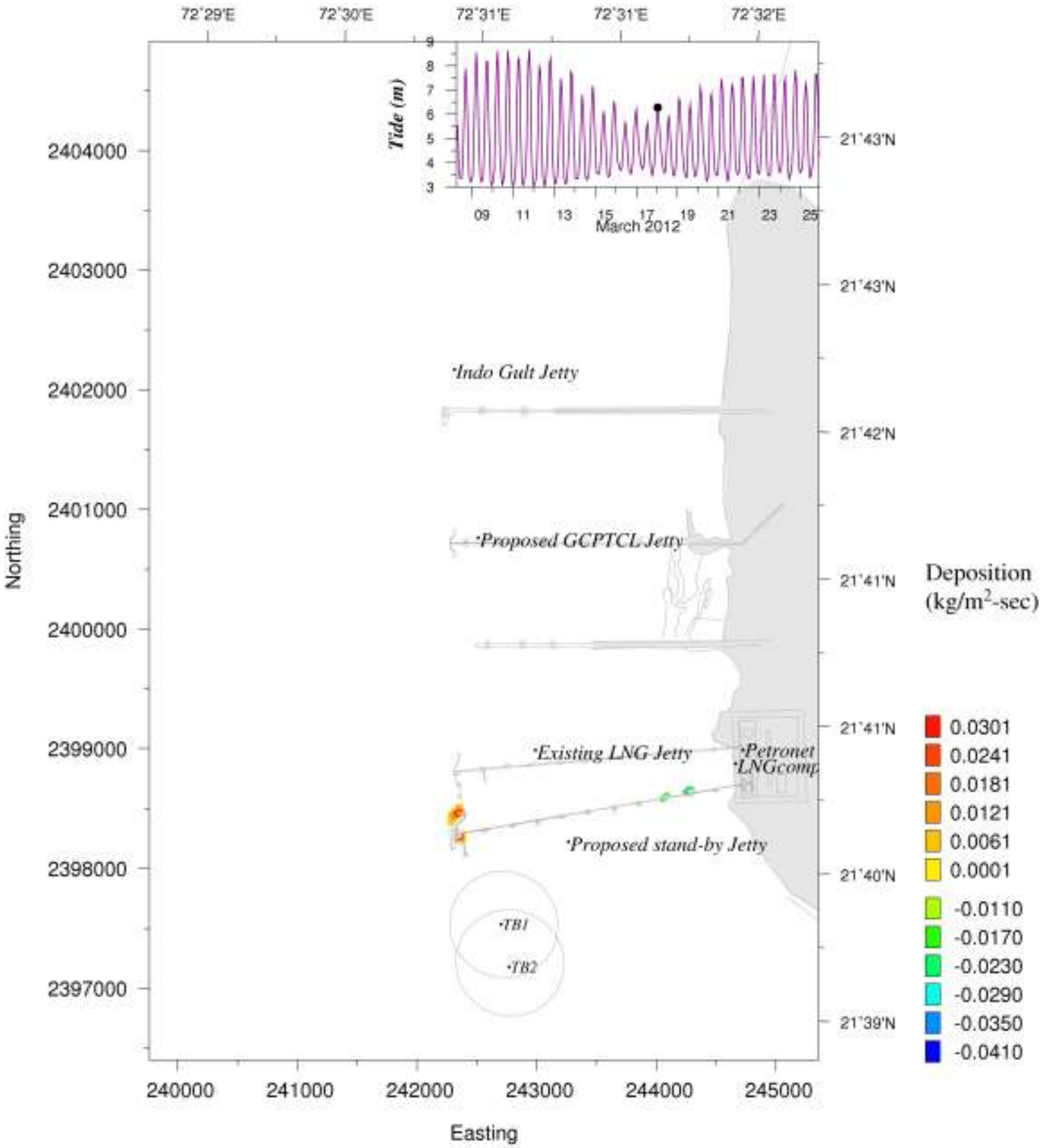


Fig.A5.19 Difference in sediment deposition between before and after development during HHW of neap tide (Mar 2012)

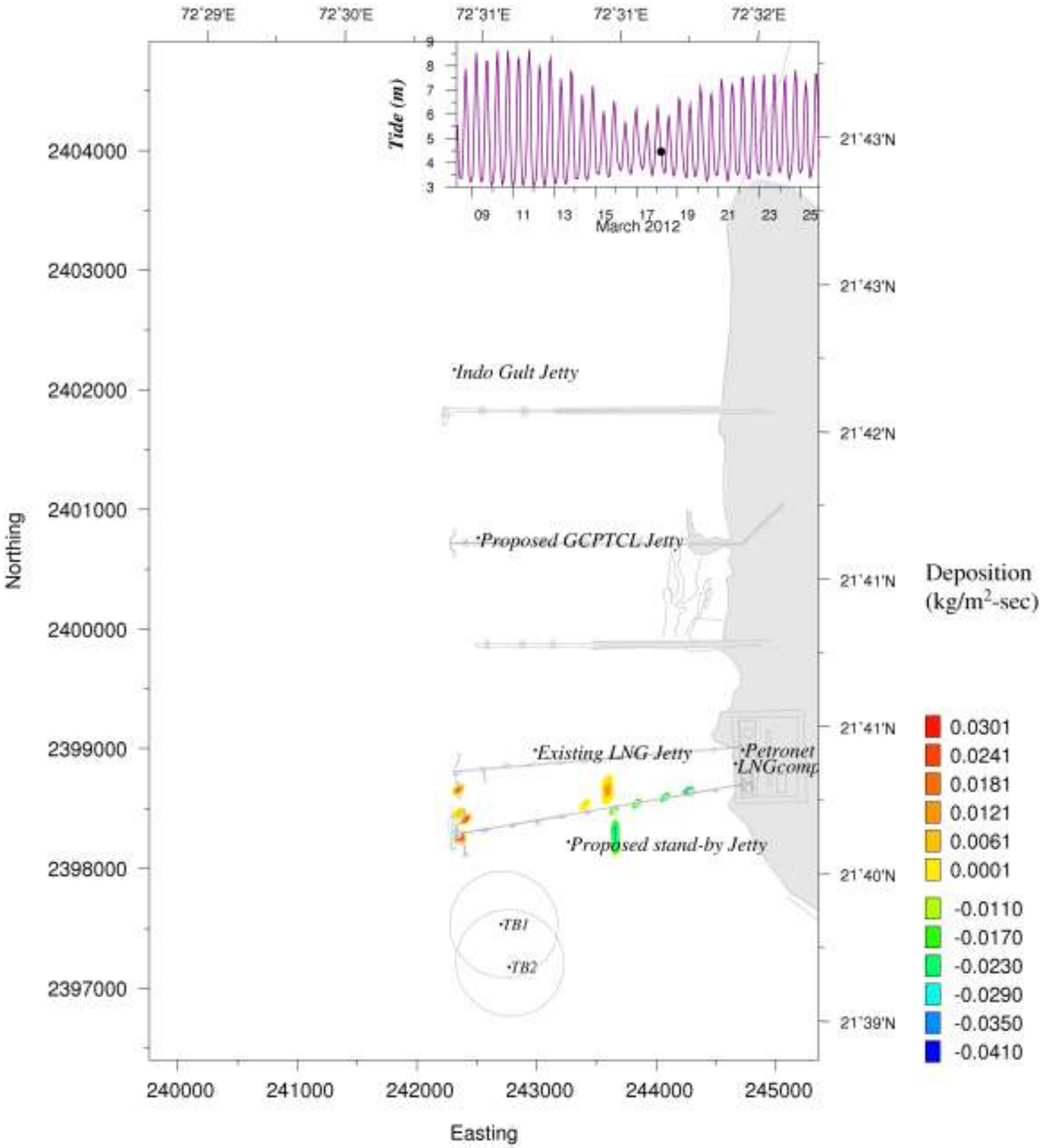


Fig.A5.20 Difference in sediment deposition between before and after development during Peak EBB of neap tide (Mar 2012)

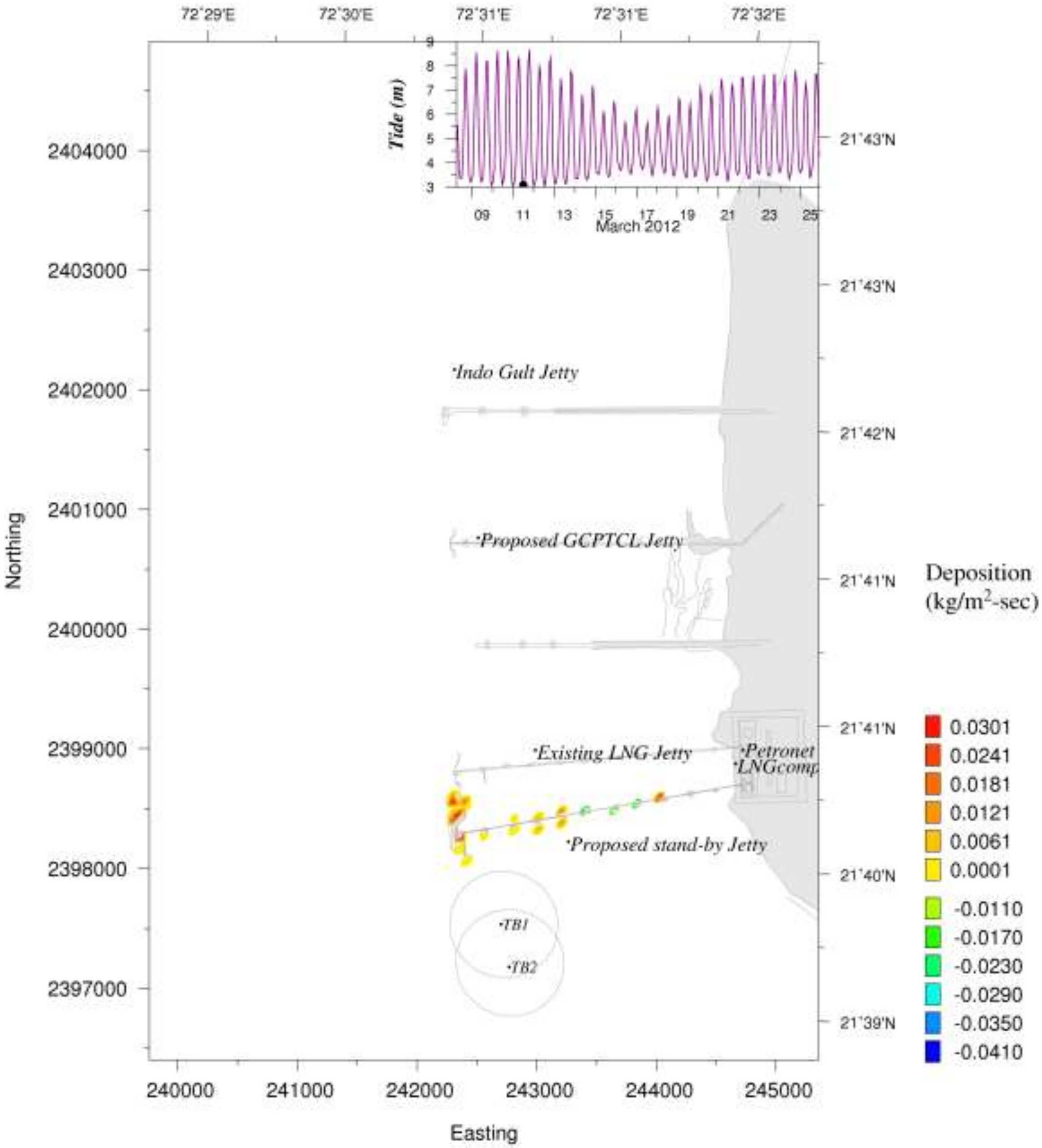


Fig.A5.21 Difference in sediment deposition between before and after development during LLW of spring tide (Mar 2012)

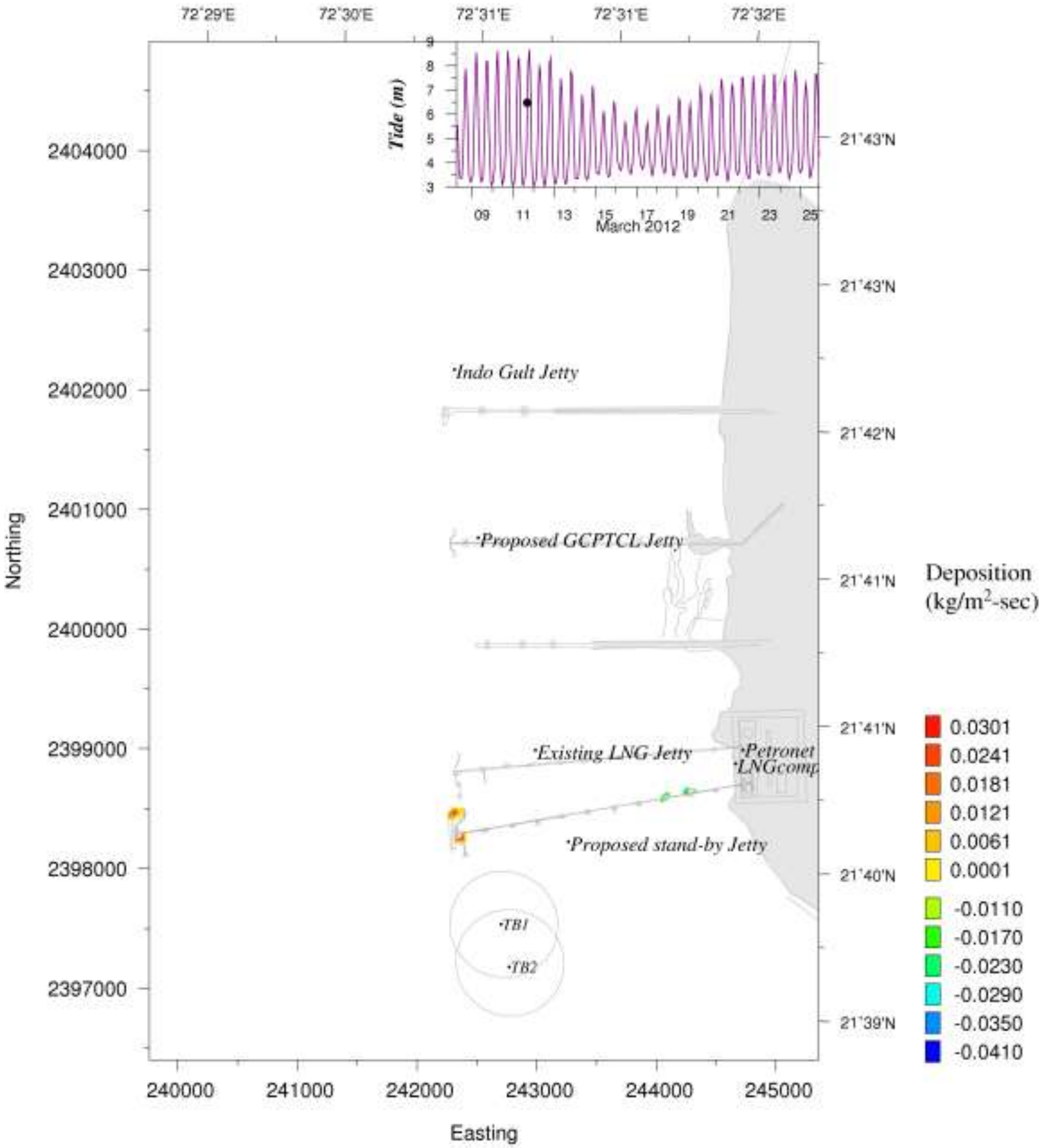


Fig.A5.22 Difference in sediment deposition between before and after development during Peak Flood of spring tide (Mar 2012)

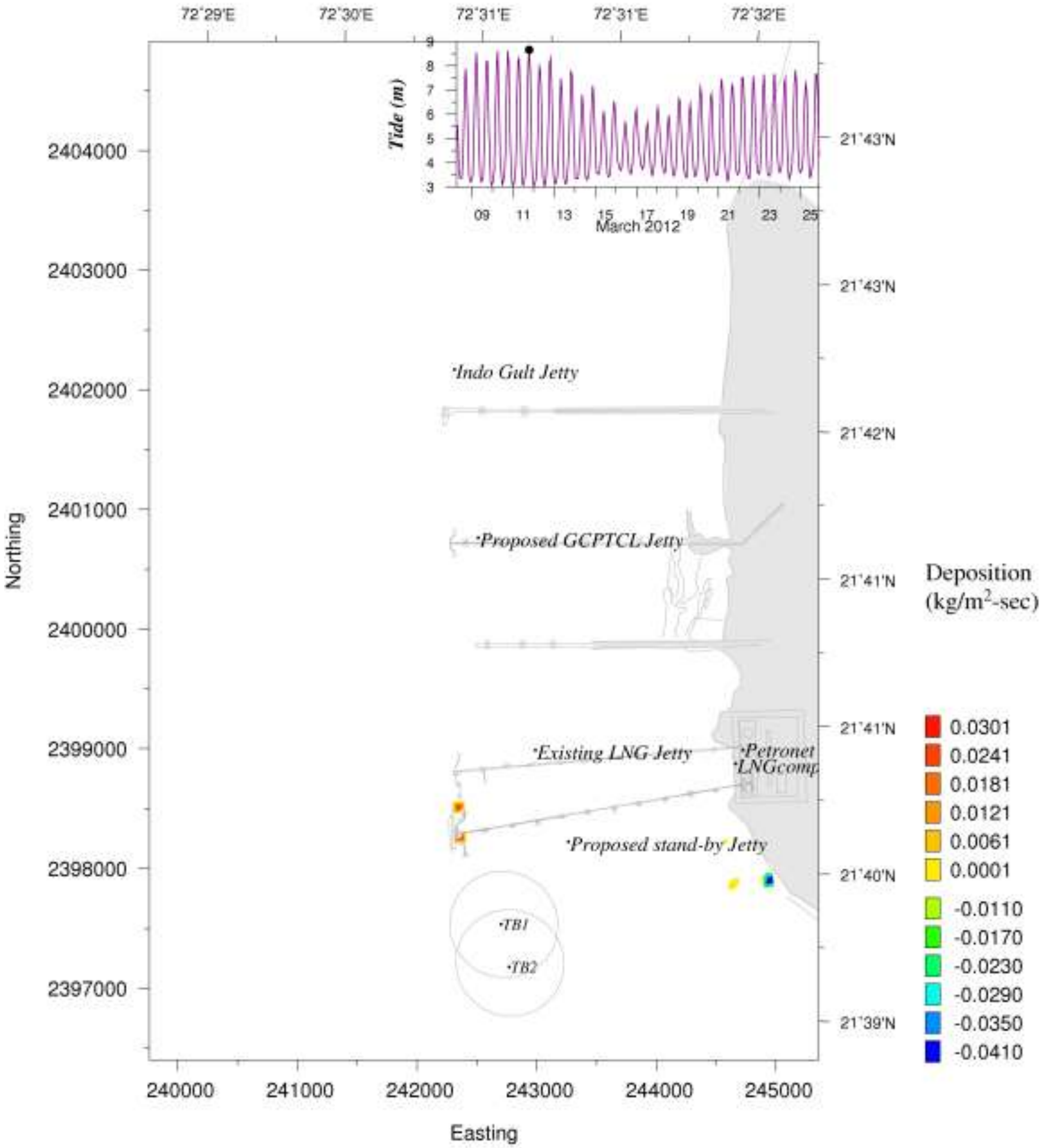


Fig.A5.23 Difference in sediment deposition between before and after development during HHW of spring tide (Mar 2012)

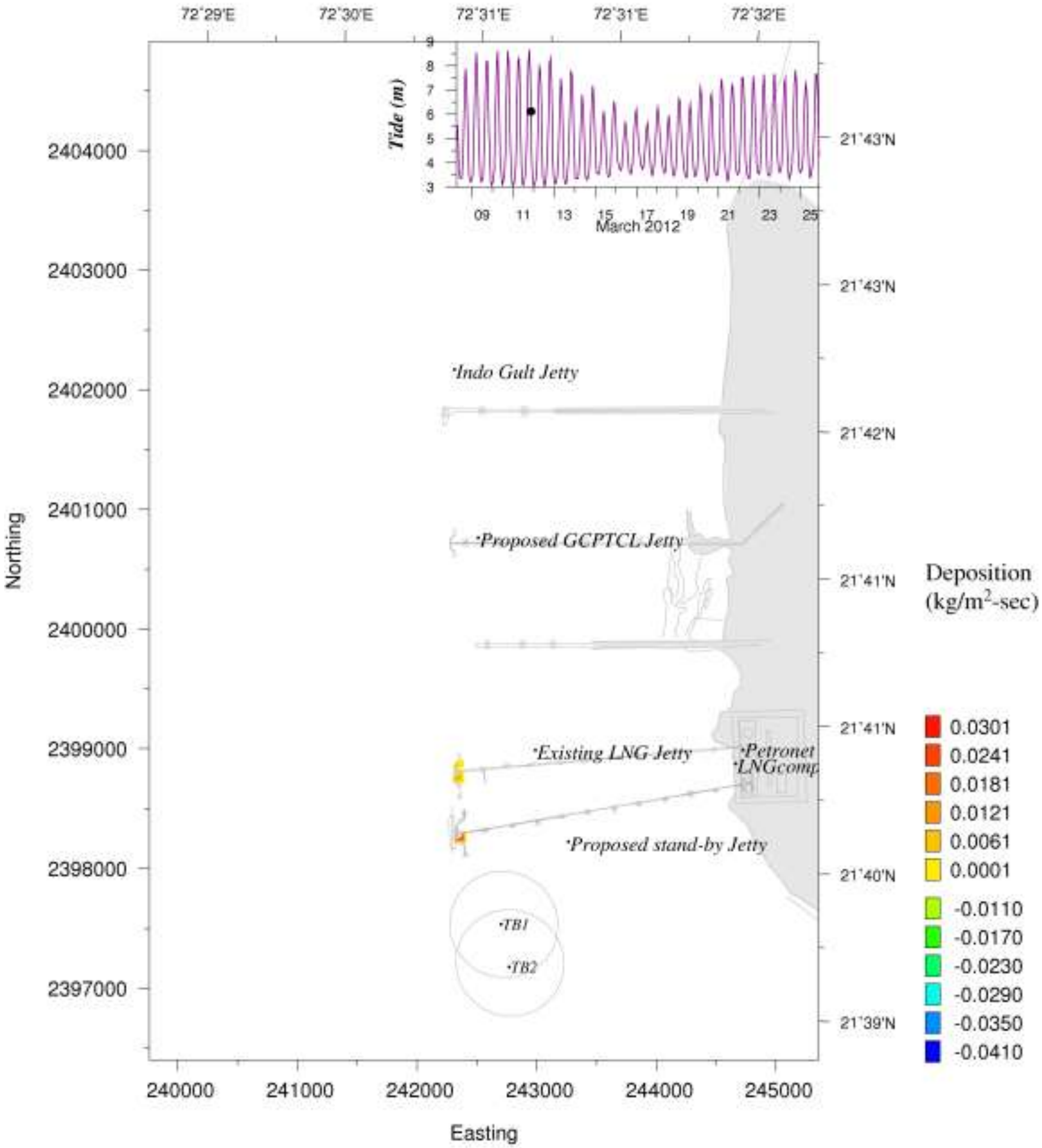


Fig.A5.24 Difference in sediment deposition between before and after development during Peak EBB of spring tide (Mar 2012)

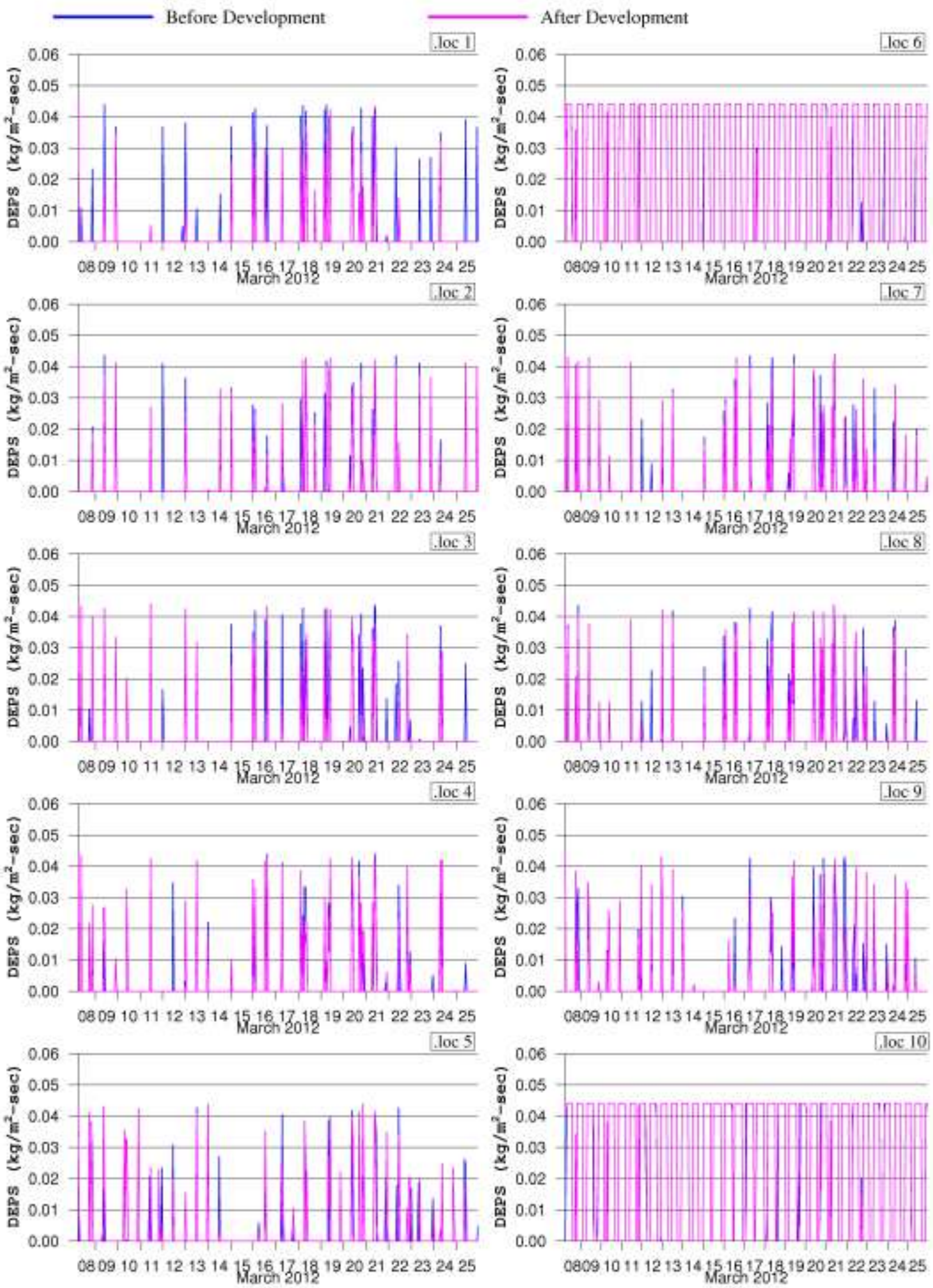


Fig.A5.25(a) Comparison of sediment deposition before and after development (Mar 2012)

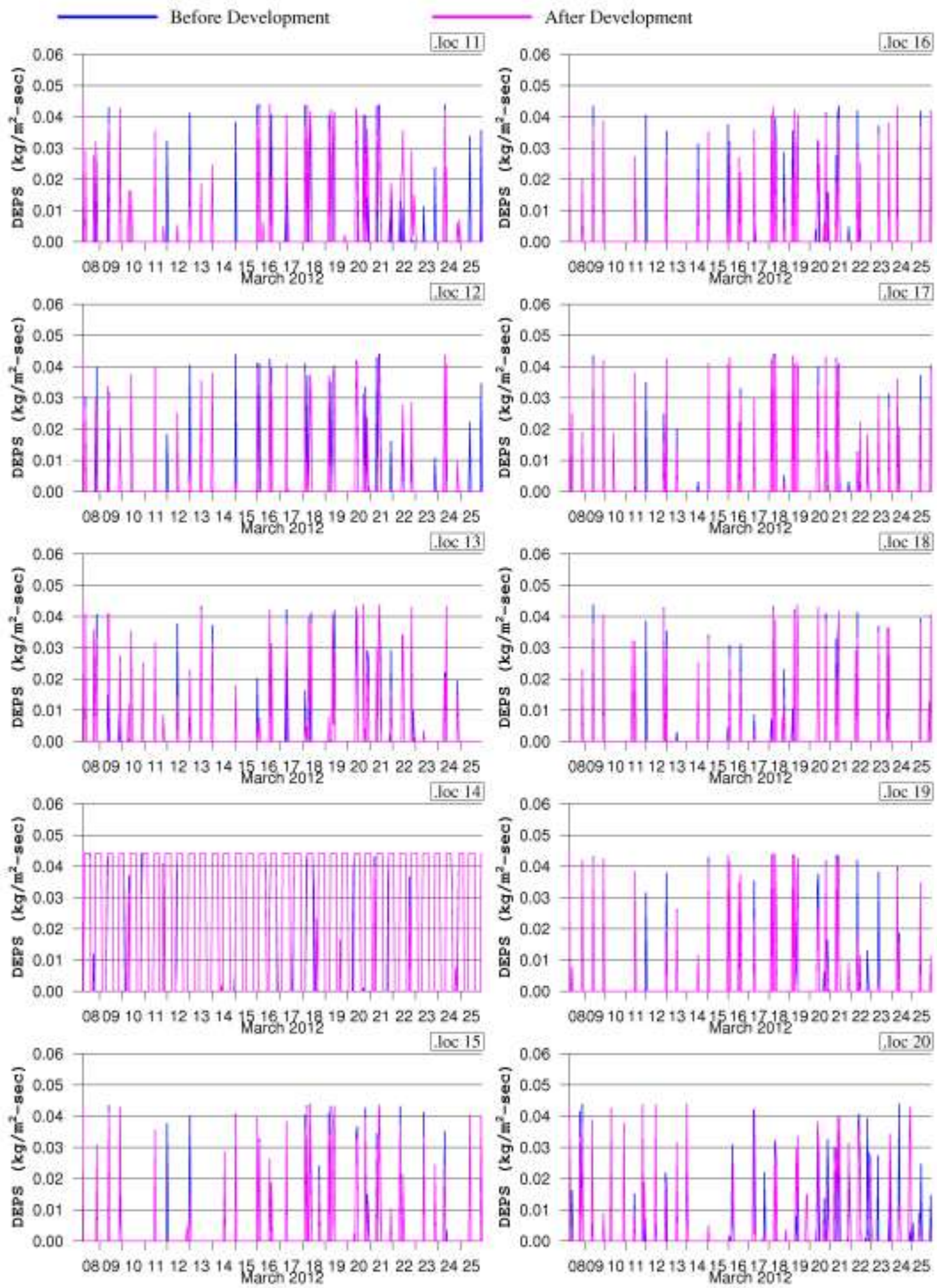


Fig.A5.25(b) Comparison of sediment deposition before and after development (Mar 2012)

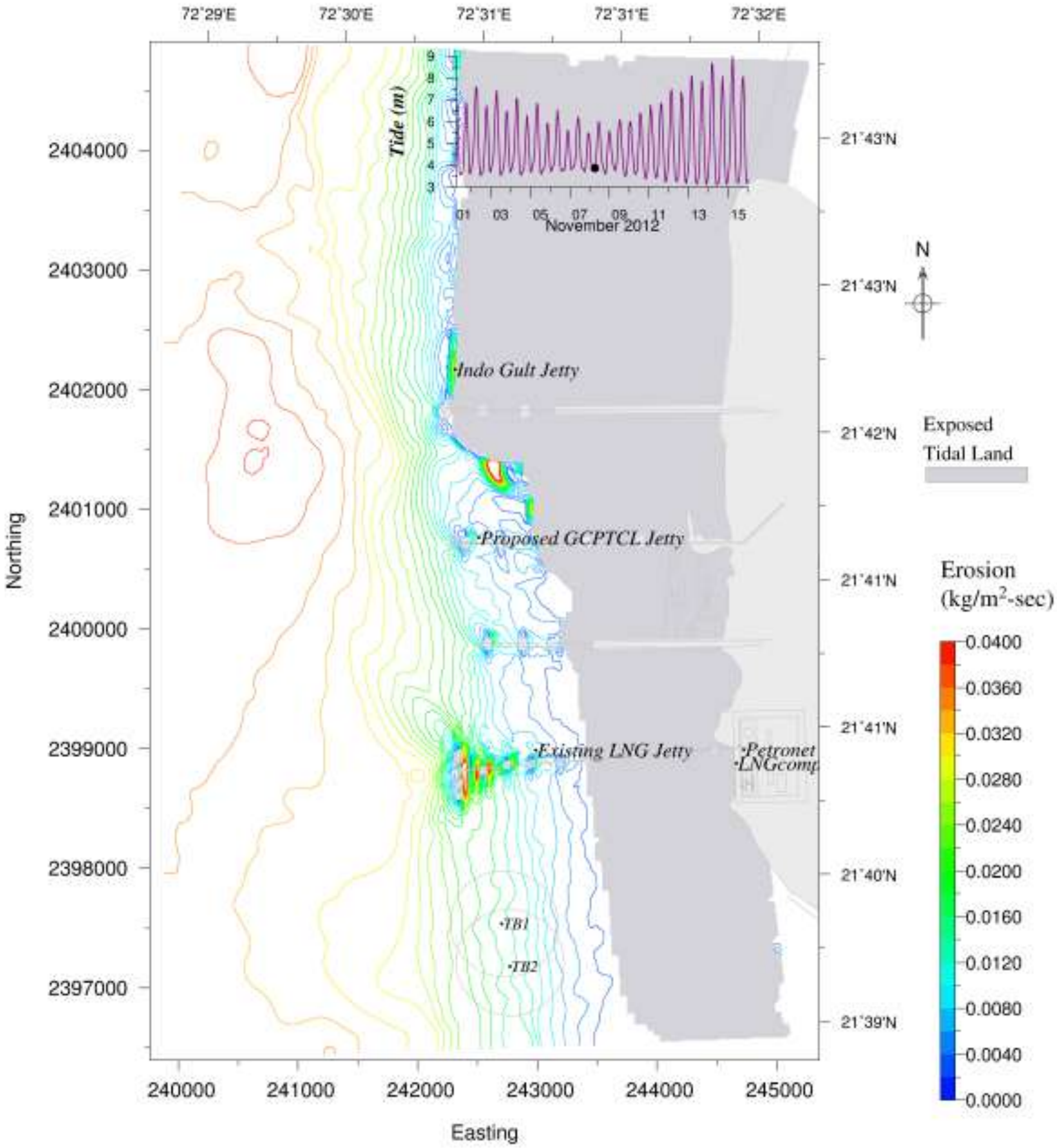


Fig.A6.1 Instantaneous rate of sediment erosion before development (at 08/11/2012 06:00hr) during neap tide (LLW)

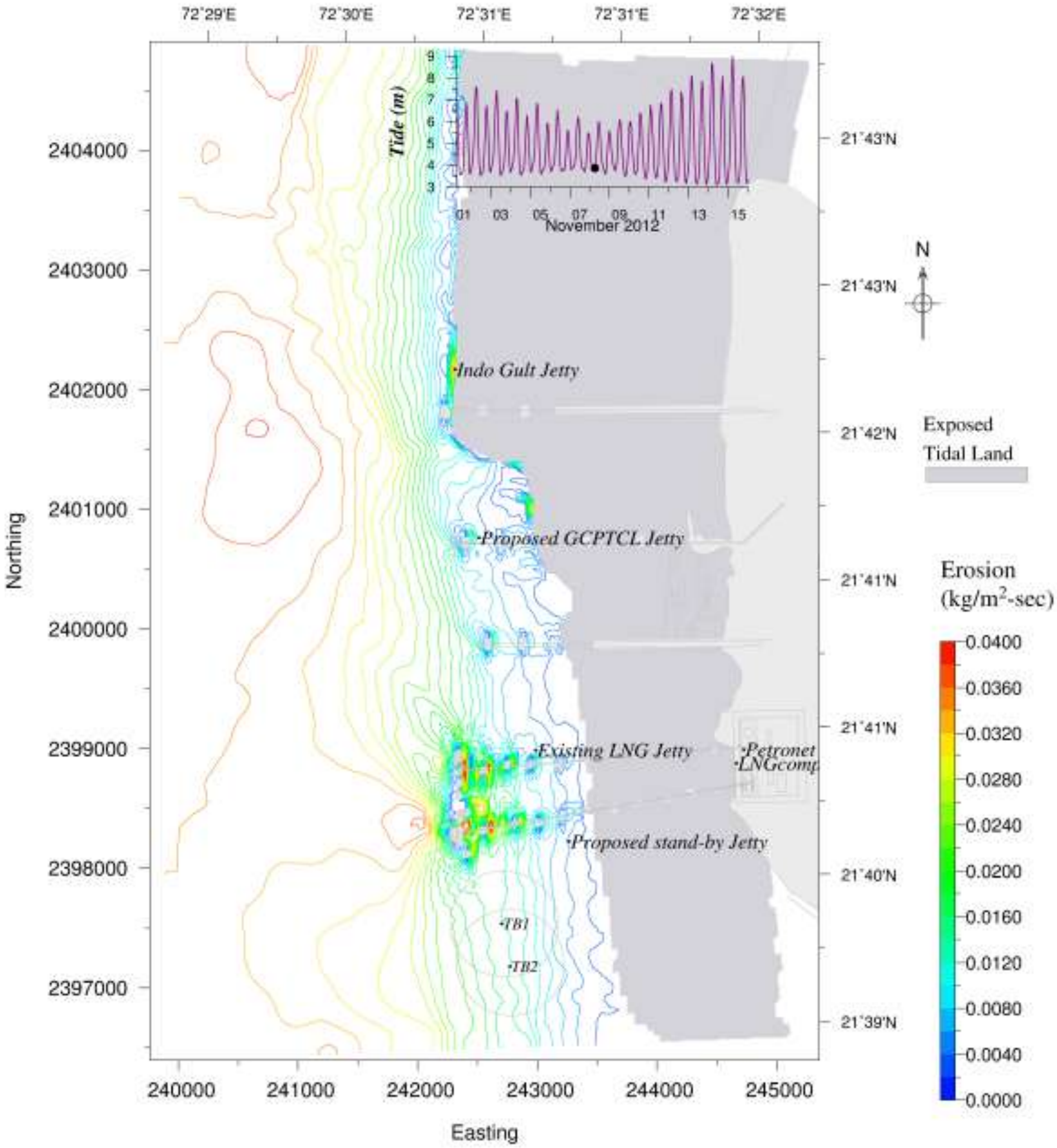


Fig.A6.2 Instantaneous rate of sediment erosion after development (at 08/11/2012 06:00hr) during neap tide (LLW)

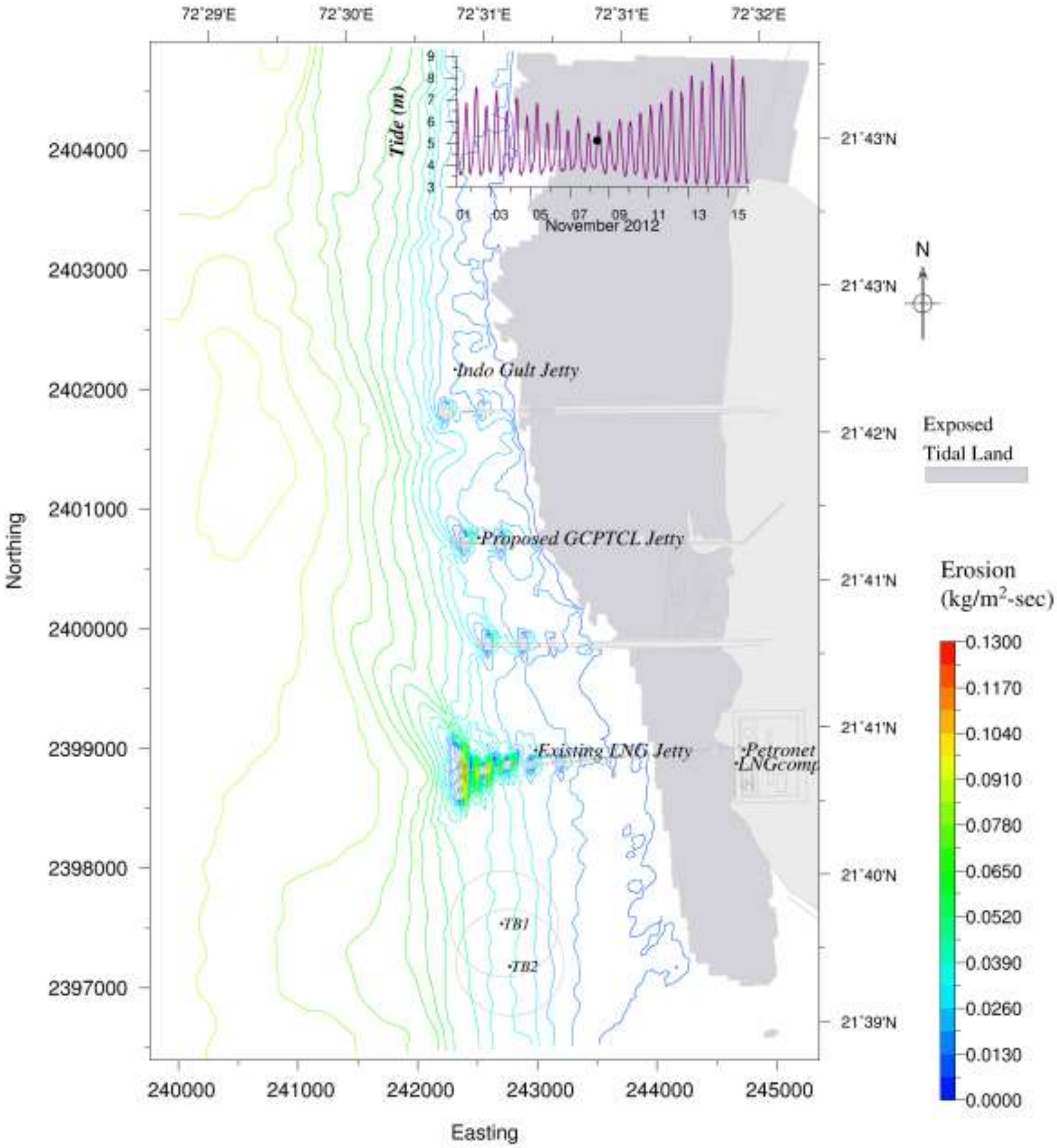


Fig.A6.3 Instantaneous rate of sediment erosion before development (at 08/11/2012 09:00hr) during neap tide (Peak Flood)

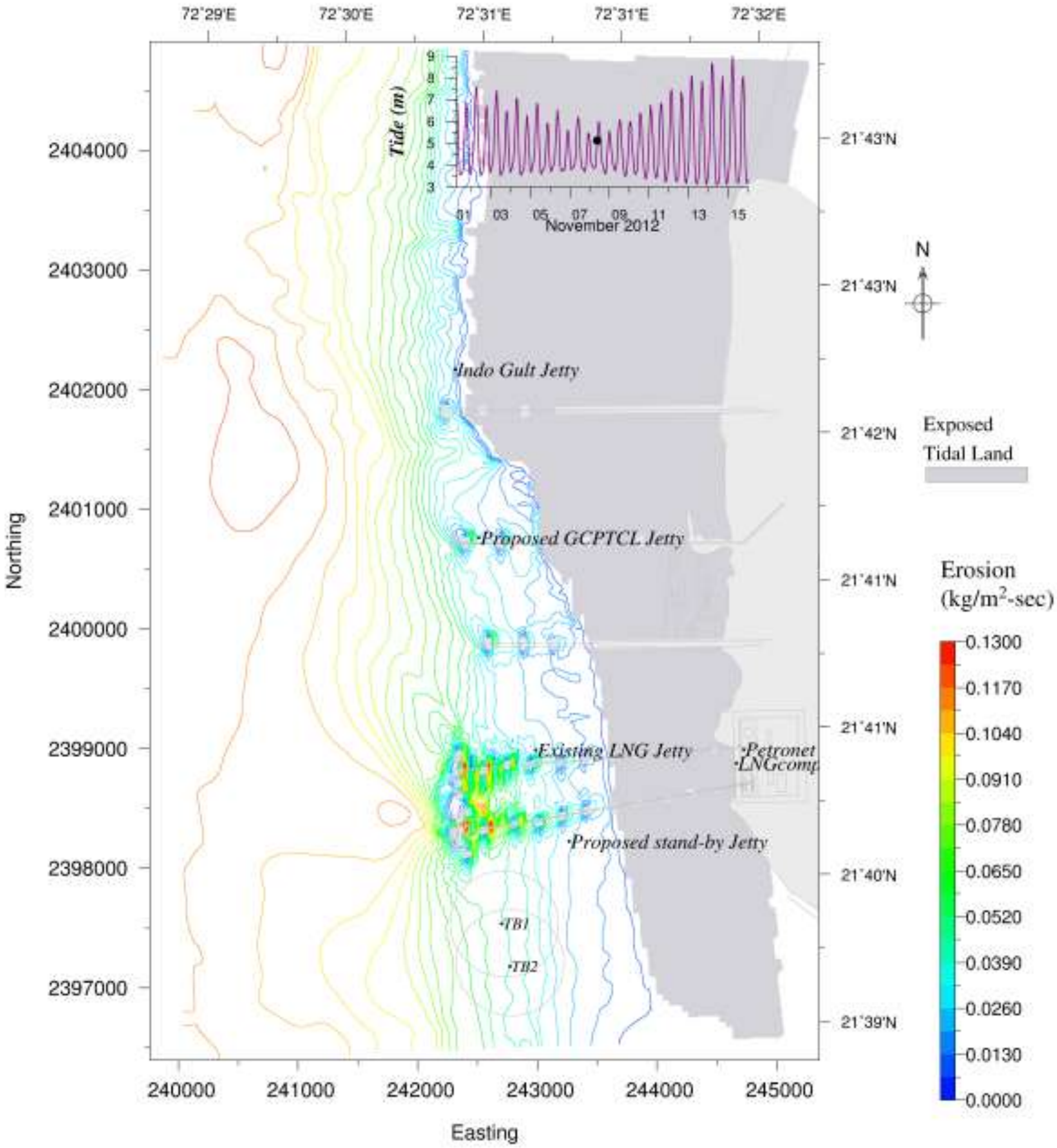


Fig.A6.4 Instantaneous rate of sediment erosion after development (at 08/11/2012 09:00hr) during neap tide (Peak Flood)

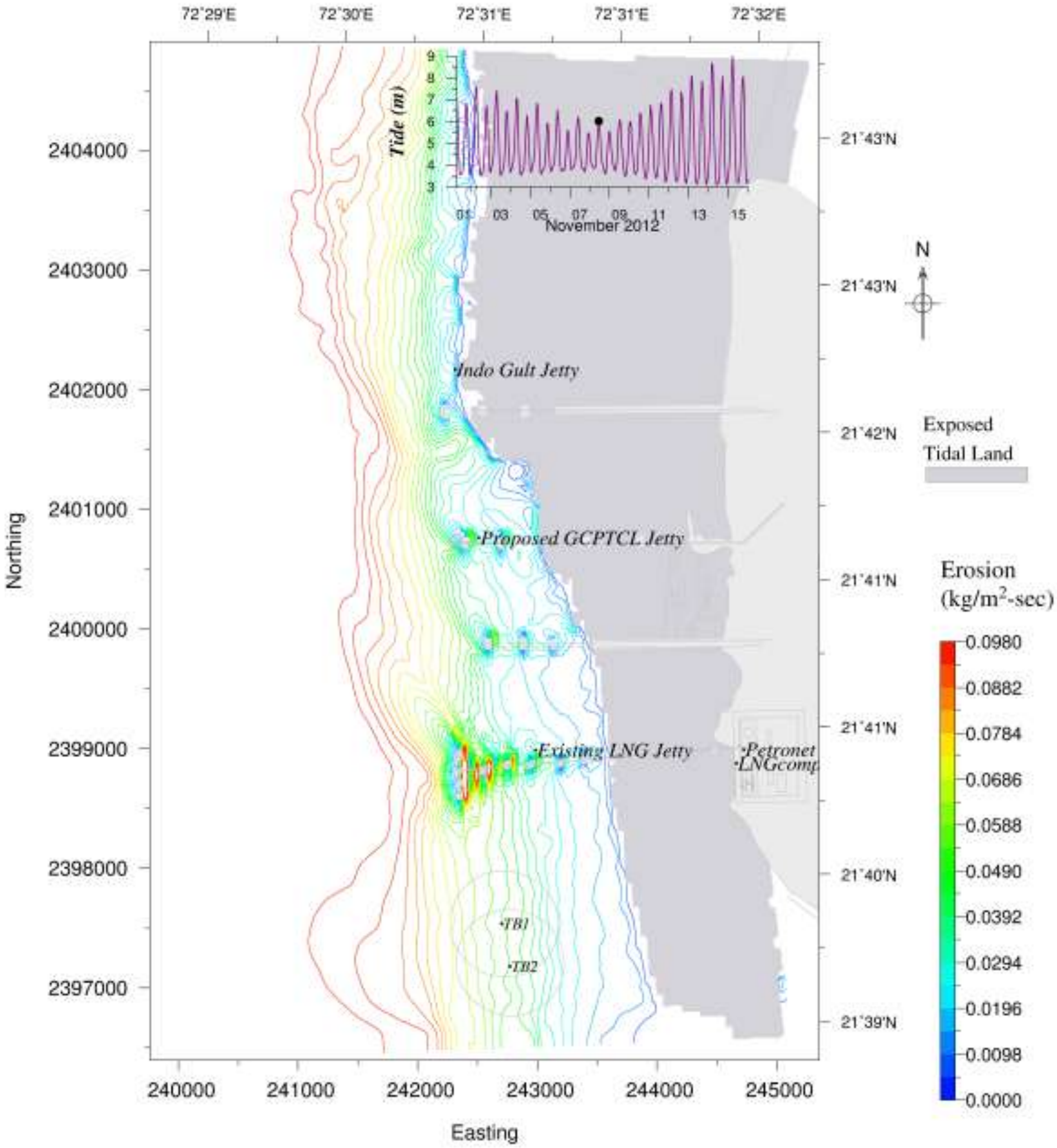


Fig.A6.5 Instantaneous rate of sediment erosion before development (at 08/11/2012 11:00hr) during neap tide (HHW)

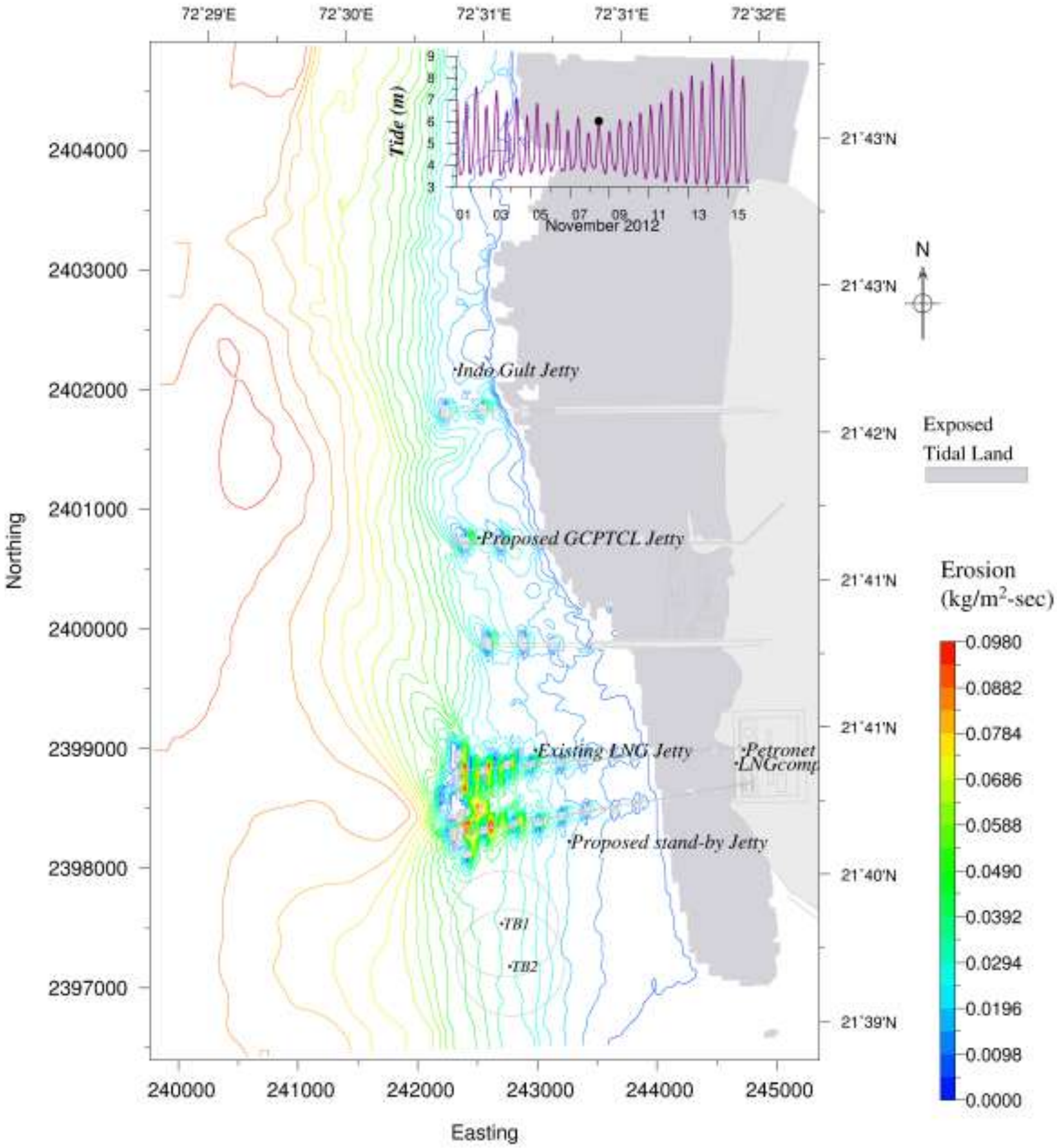


Fig.A6.6 Instantaneous rate of sediment erosion after development (at 08/11/2012 11:00hr) during neap tide (HHW)

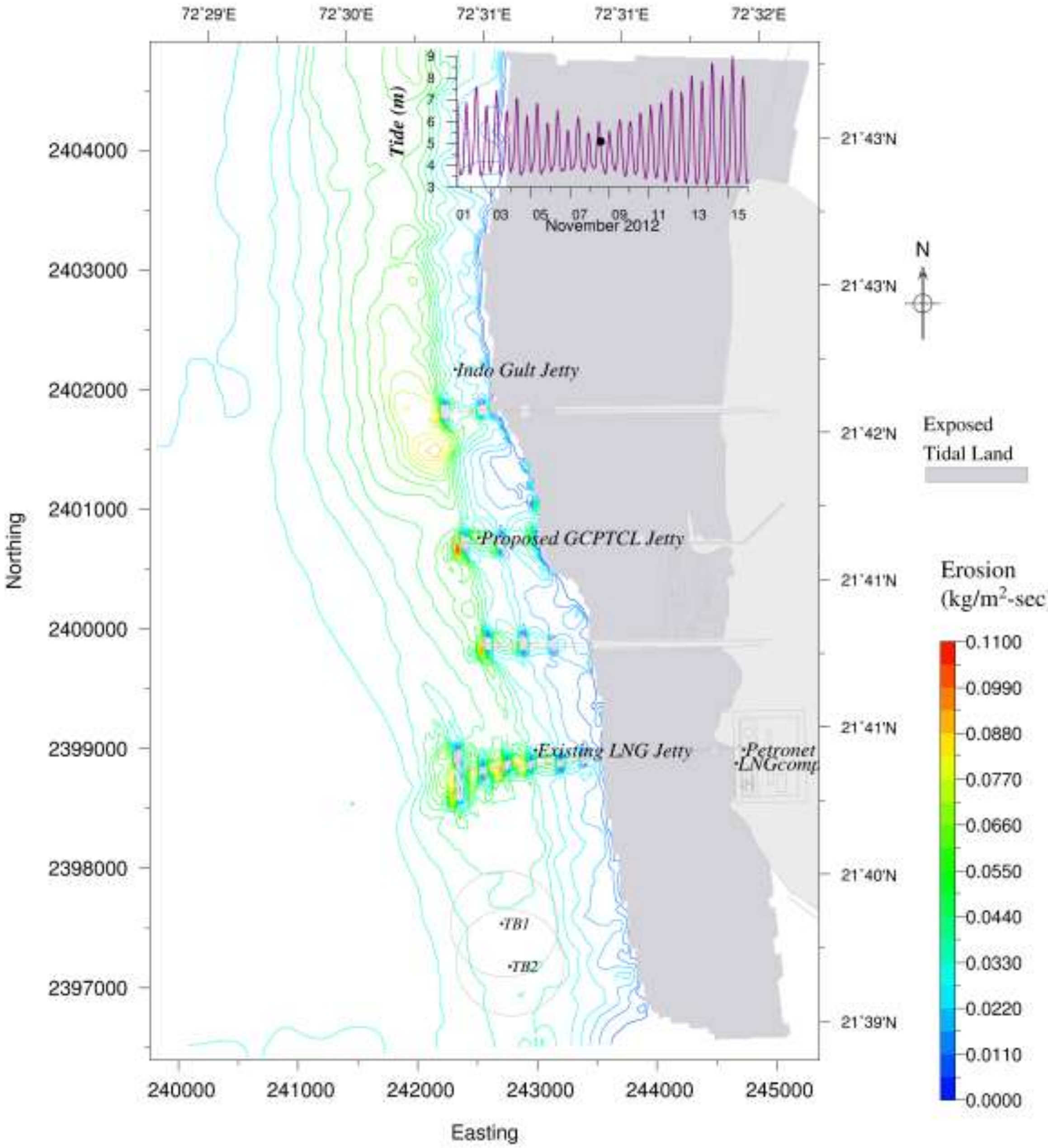


Fig.A6.7 Instantaneous rate of sediment erosion before development (at 08/11/2012 14:00hr) during neap tide (Peak EBB)

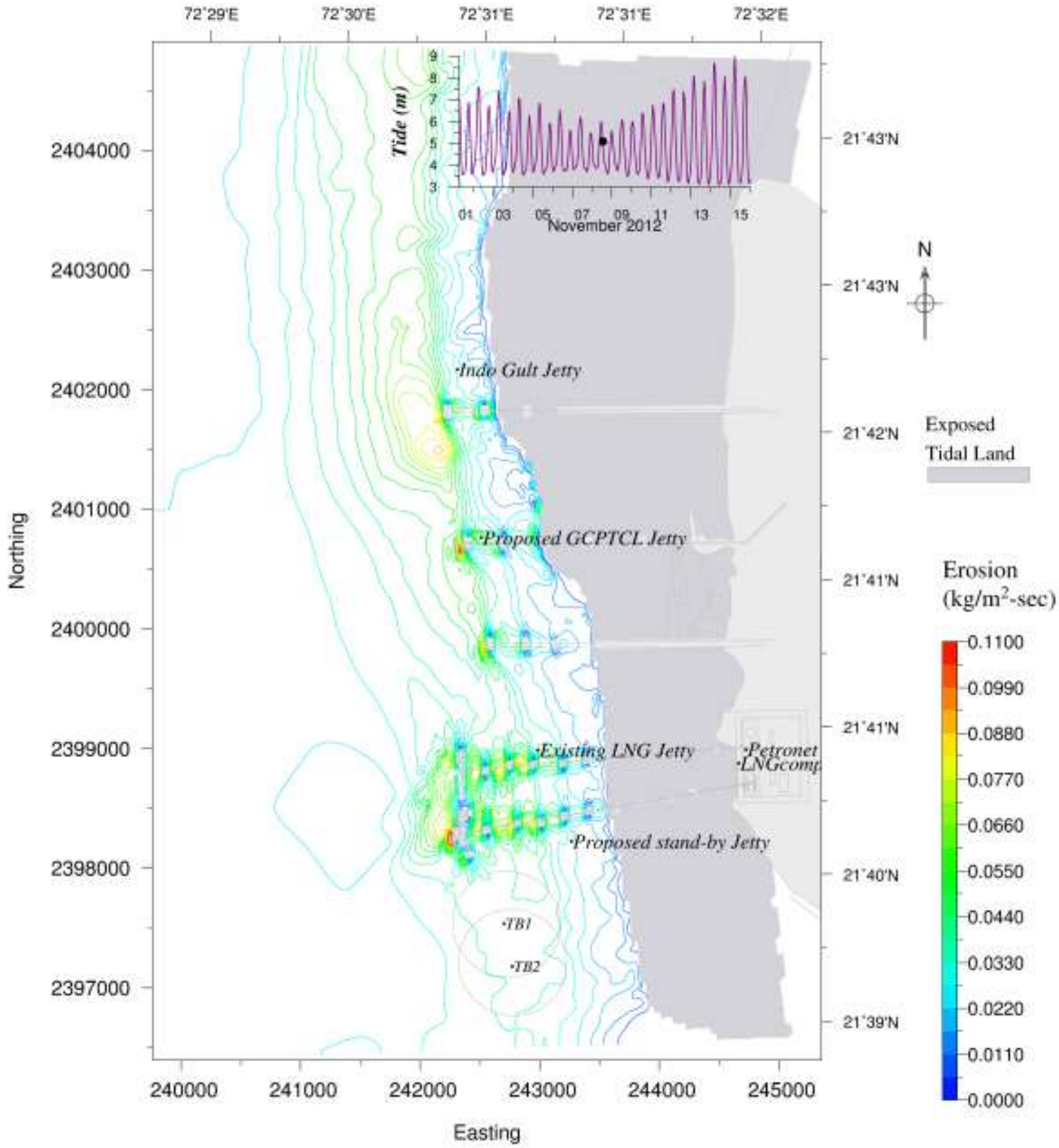


Fig.A6.8 Instantaneous rate of sediment erosion after development (at 08/11/2012 14:00hr) during neap tide (Peak EBB)

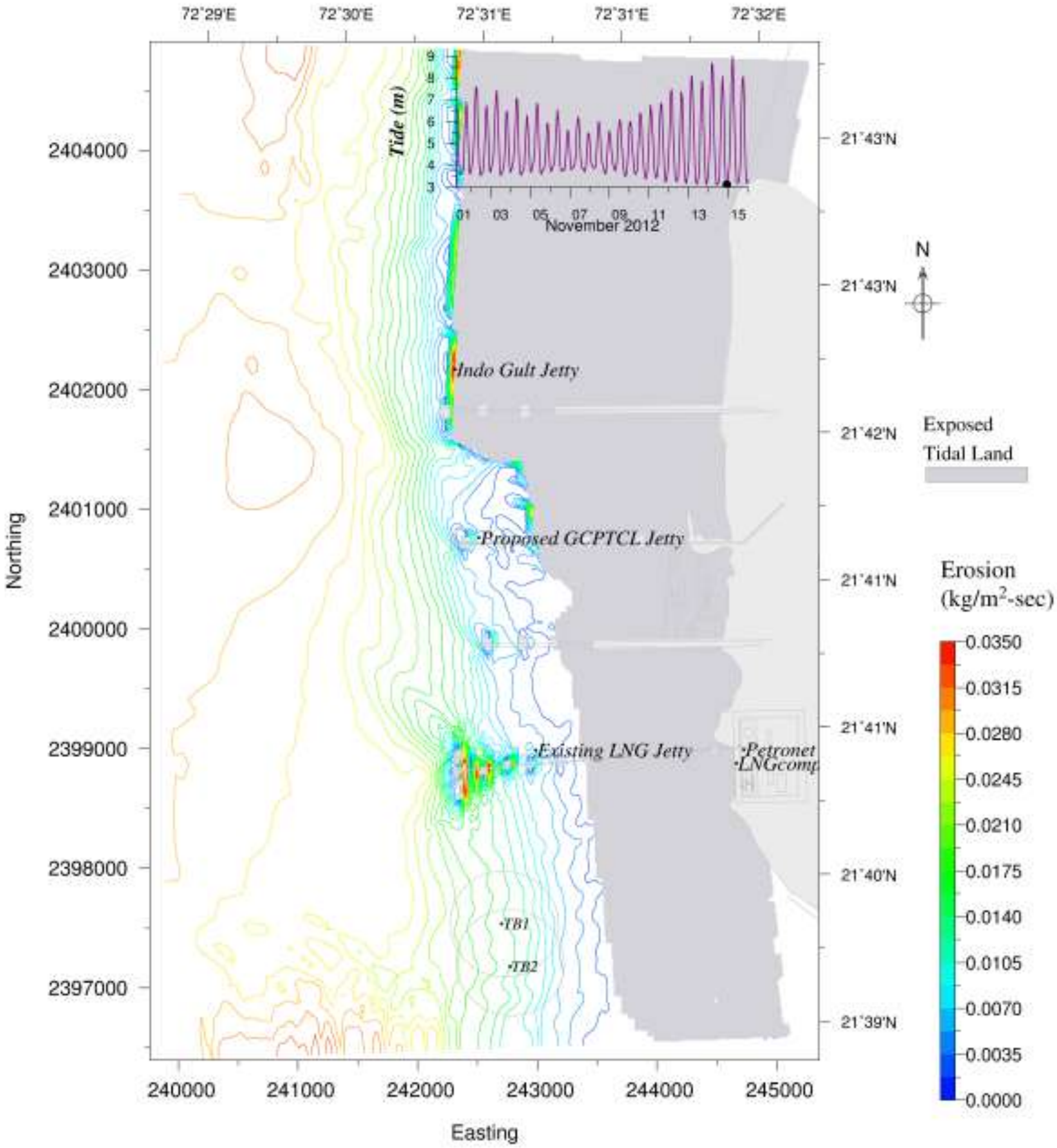


Fig.A6.9 Instantaneous rate of sediment erosion before development (at 14/11/2012 22:00hr) during spring tide (LLW)

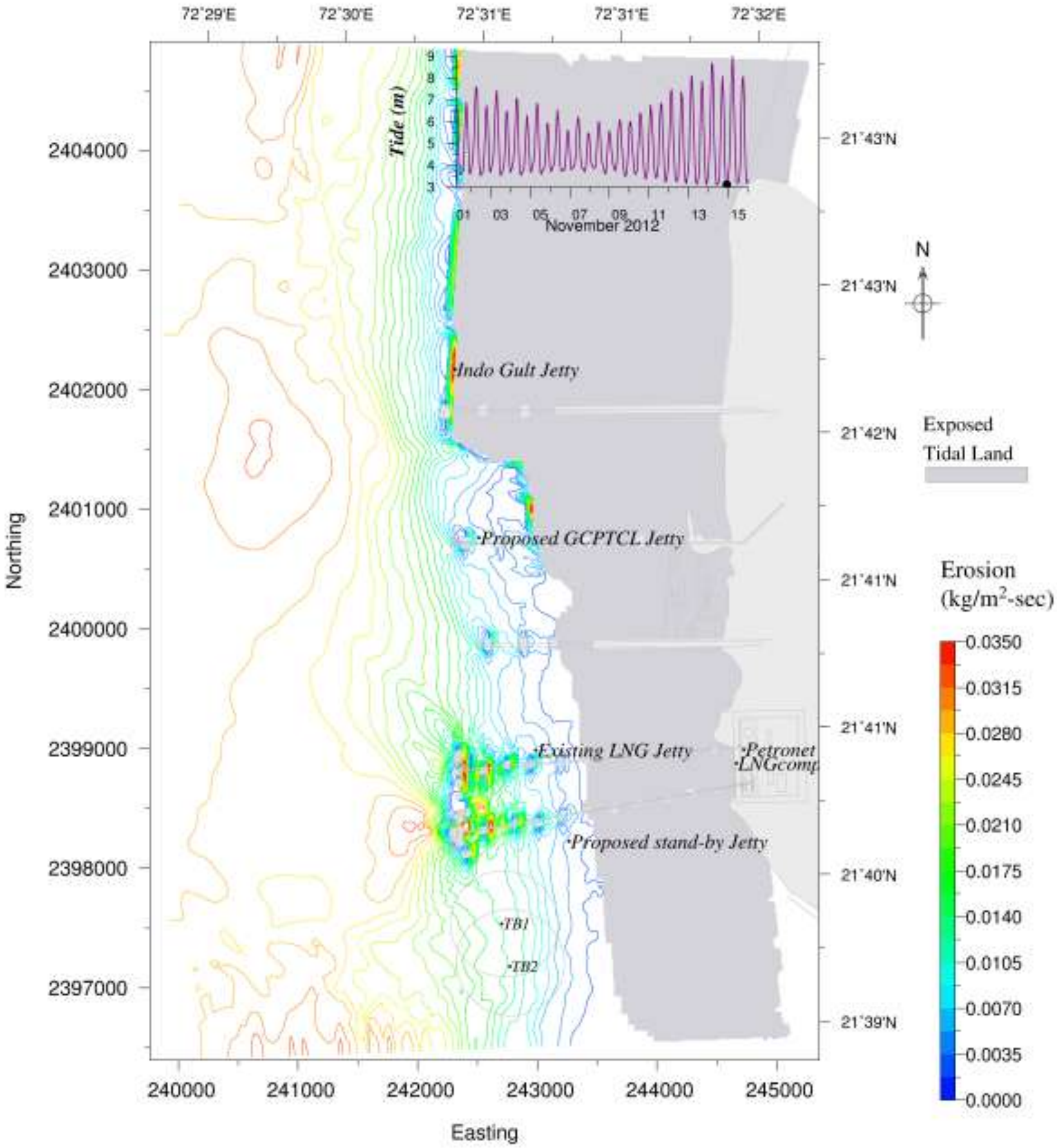


Fig.A6.10 Instantaneous rate of sediment erosion after development (at 14/11/2012 22:00hr) during spring tide (LLW)

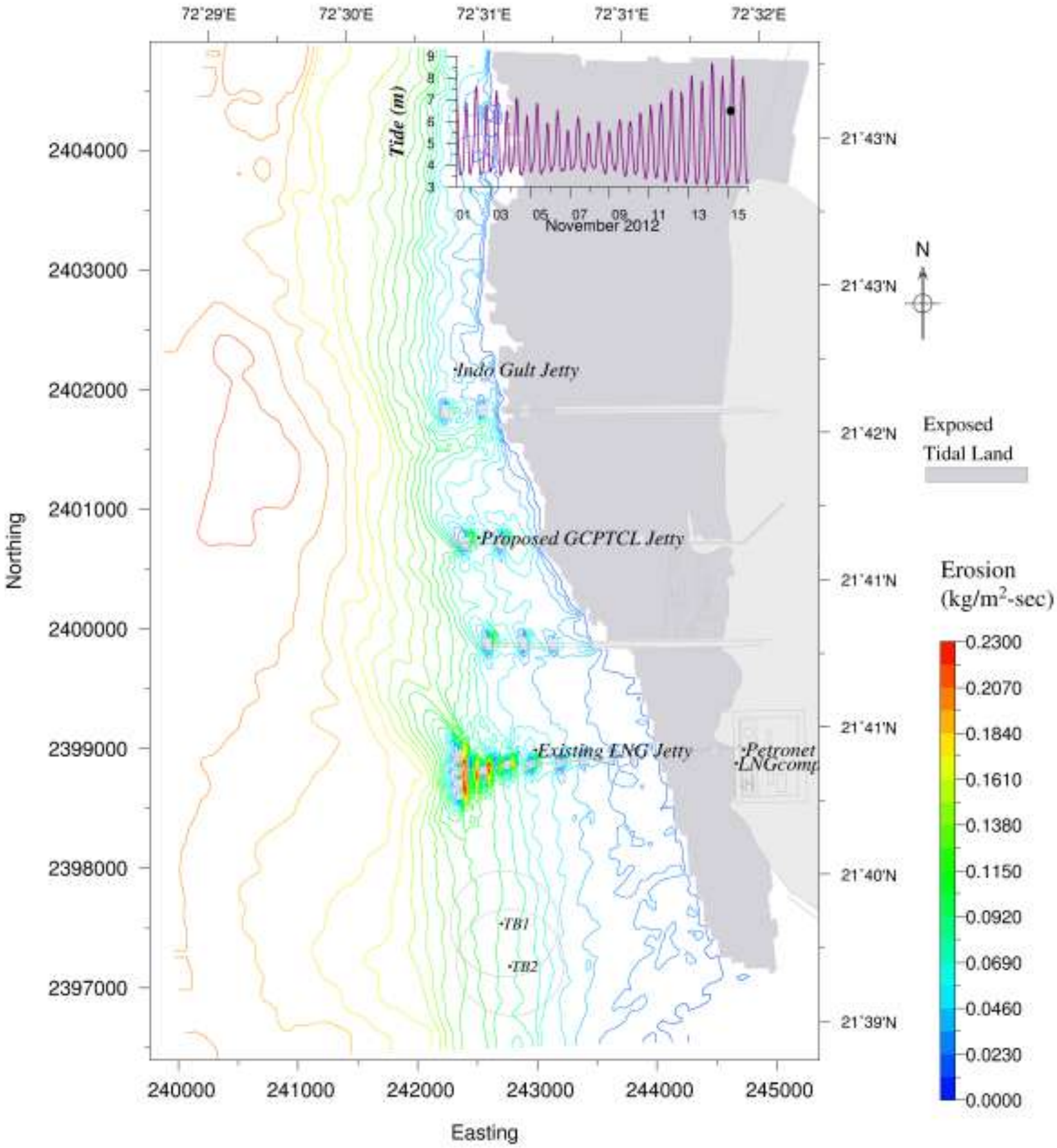


Fig.A6.11 Instantaneous rate of sediment erosion before development (at 15/11/2012 03:00hr) during spring tide (Peak Flood)

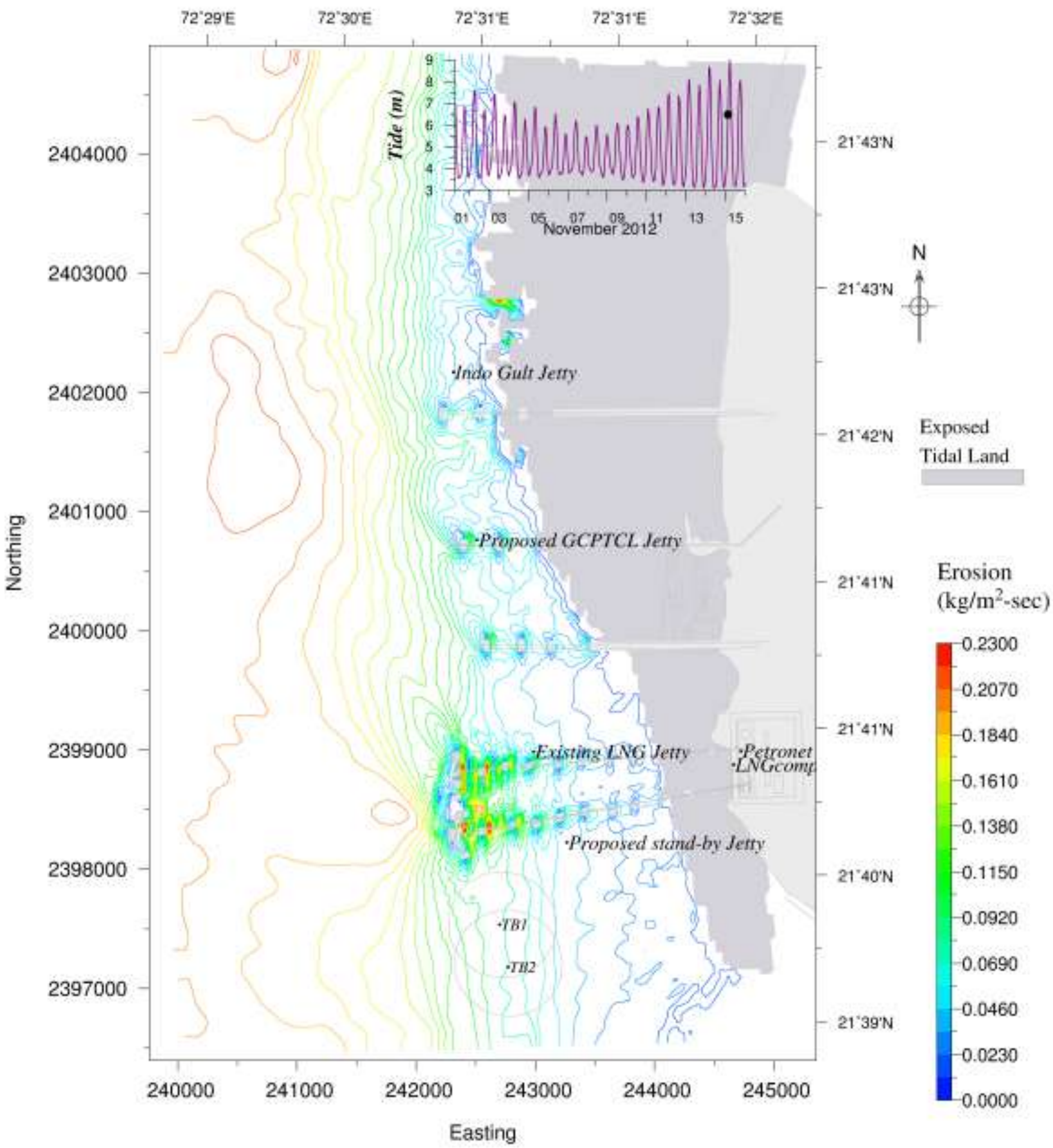


Fig.A6.12 Instantaneous rate of sediment erosion after development (at 15/11/2012 03:00hr) during spring tide (Peak Flood)

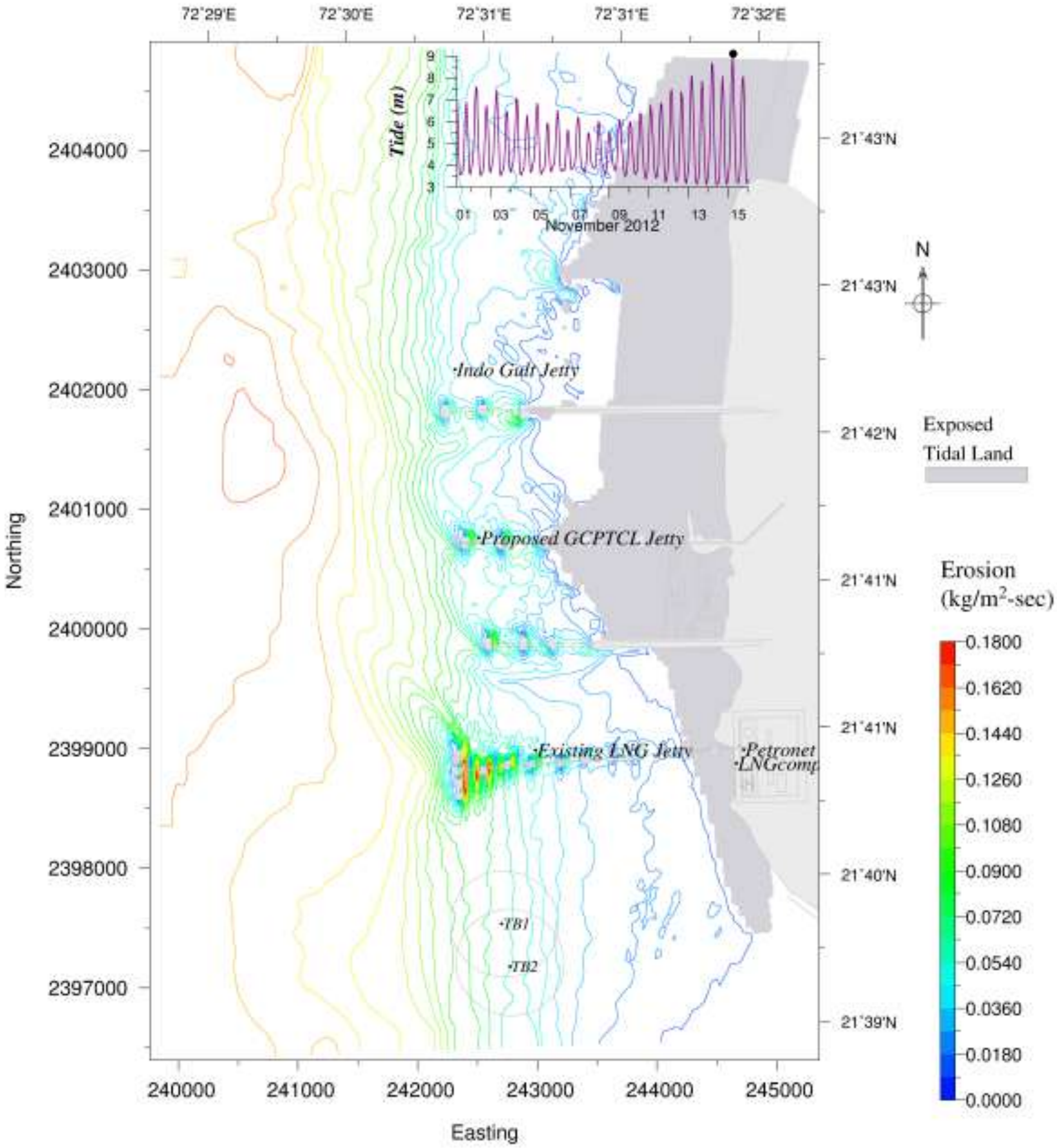


Fig.A6.13 Instantaneous rate of sediment erosion before development (at 15/11/2012 05:00hr) during spring tide (HHW)

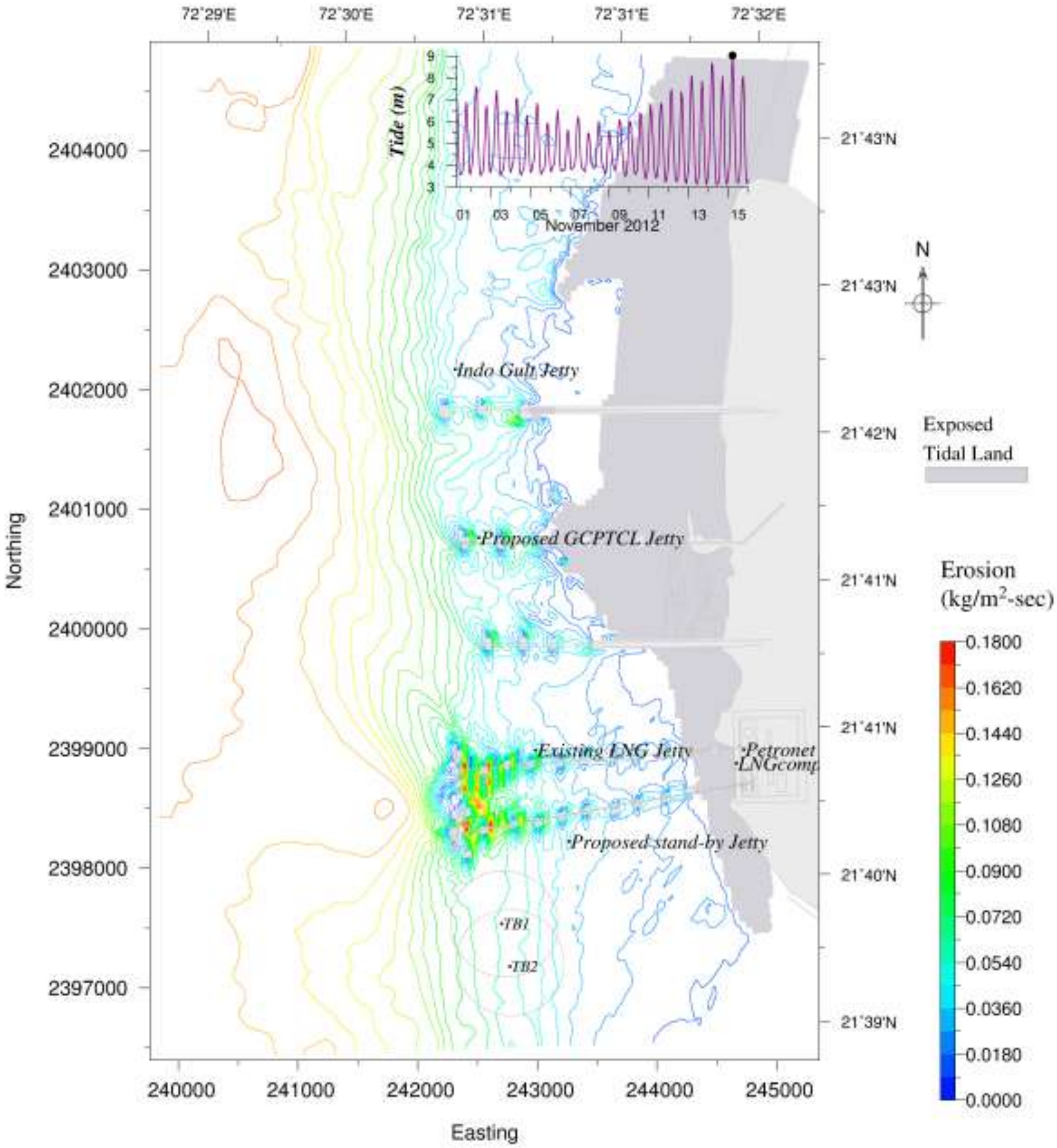


Fig.A6.14 Instantaneous rate of sediment erosion after development (at 15/11/2012 05:00hr) during spring tide (HHW)

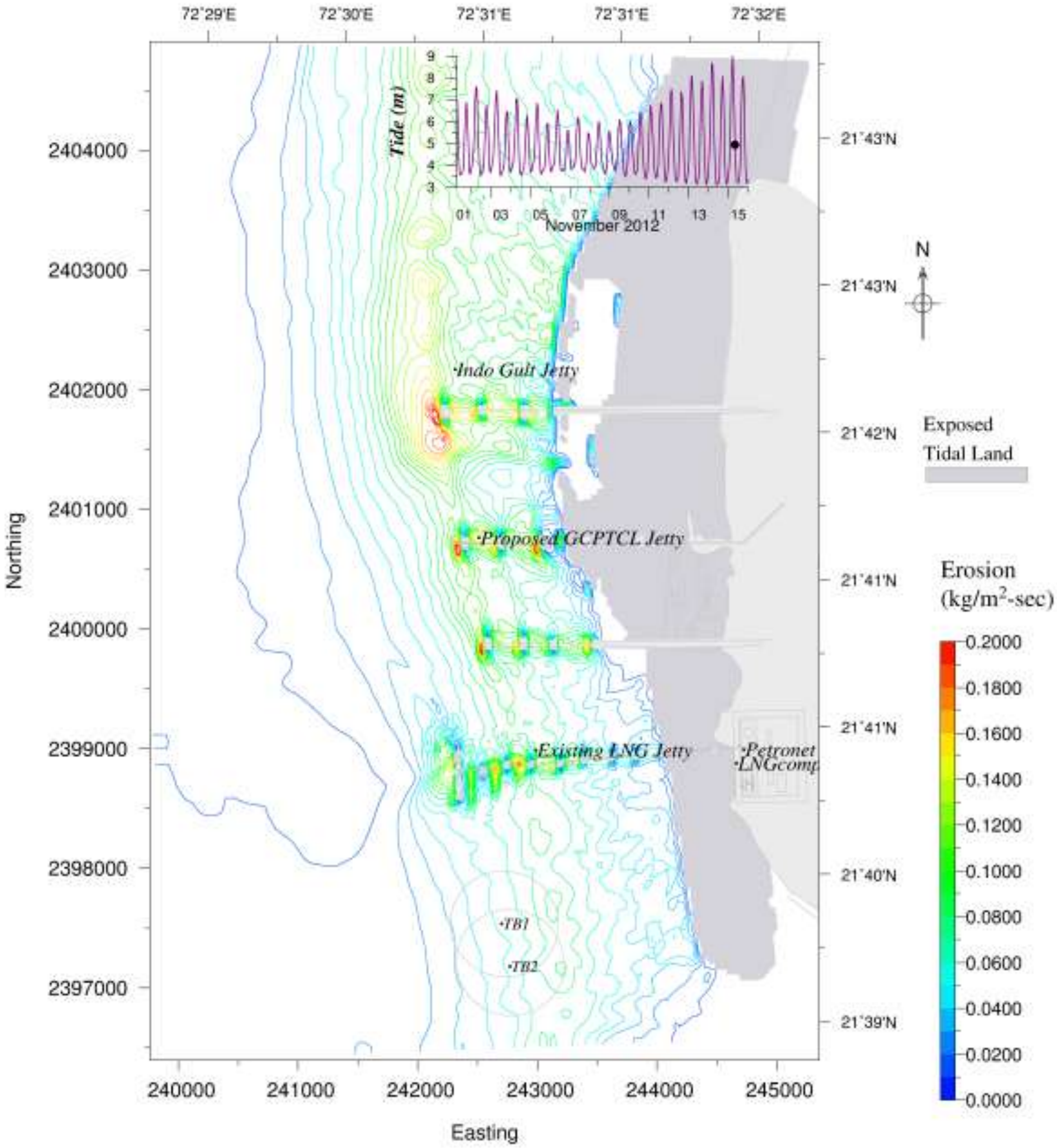


Fig.A6.15 Instantaneous rate of sediment erosion before development (at 15/11/2012 08:00hr) during spring tide (Peak EBB)

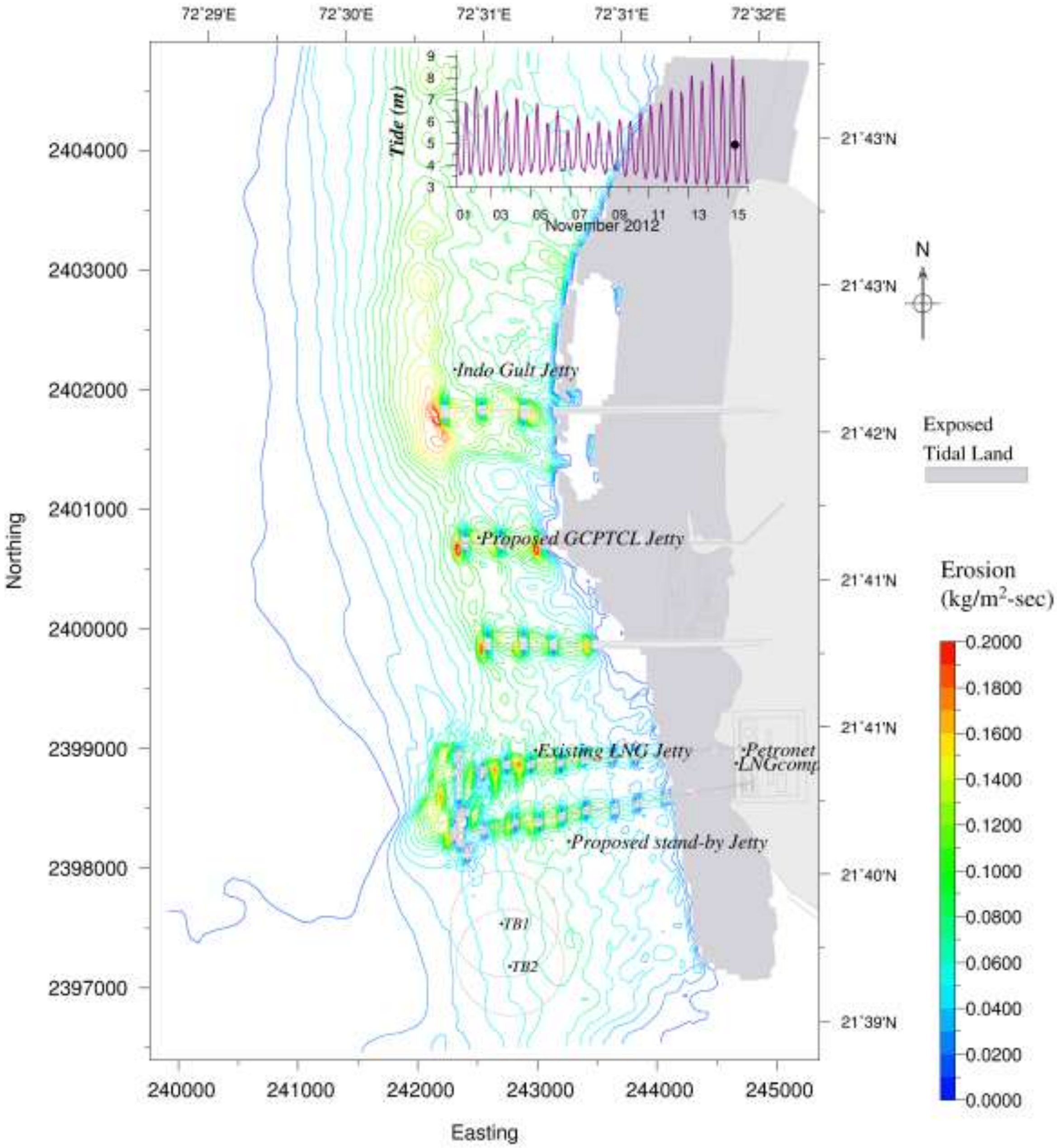


Fig.A6.16 Instantaneous rate of sediment erosion after development (at 15/11/2012 08:00hr) during spring tide (Peak EBB)

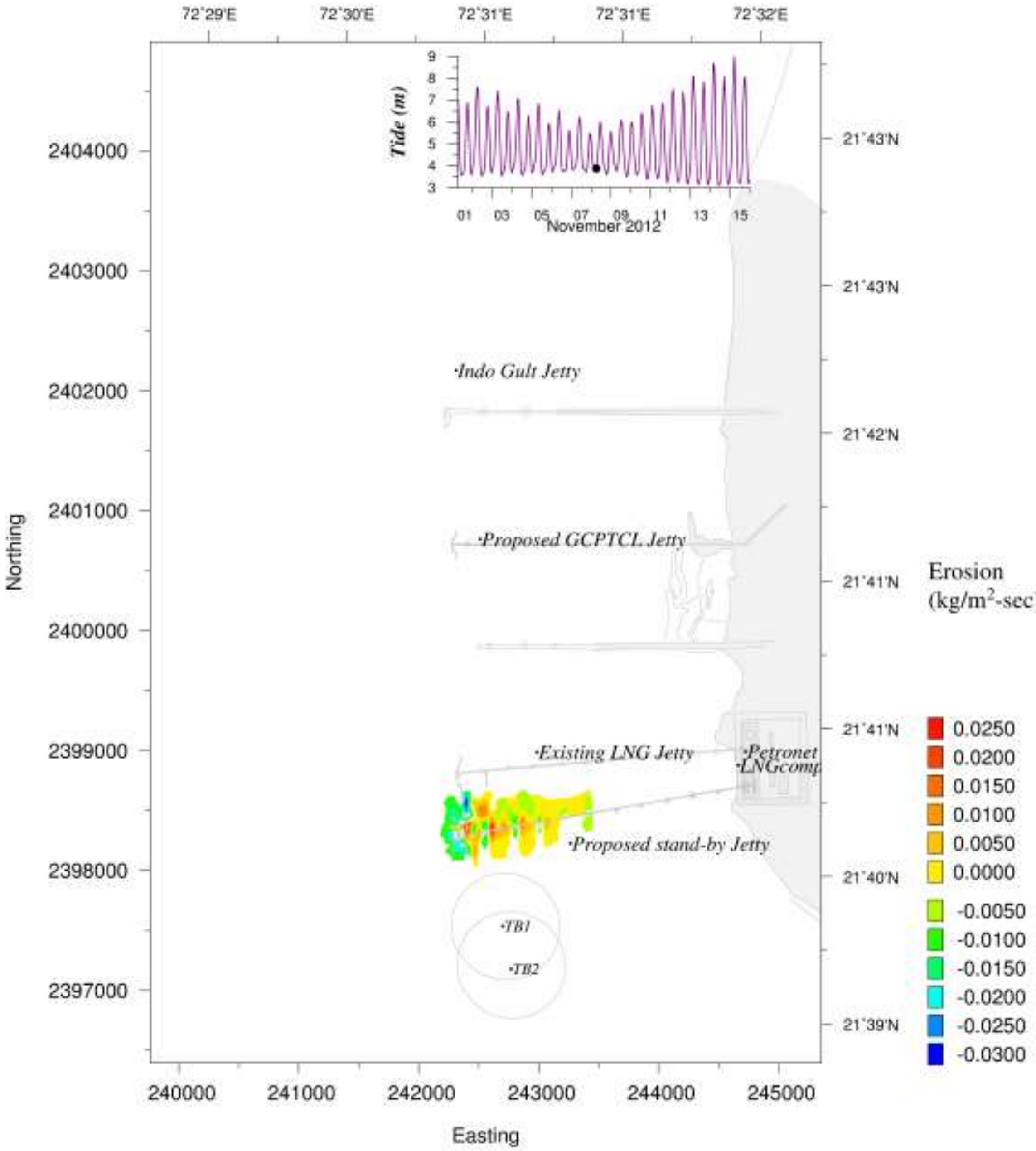


Fig.A6.17 Difference in sediment erosion between before and after developments during LLW of neap tide (Nov 2012)

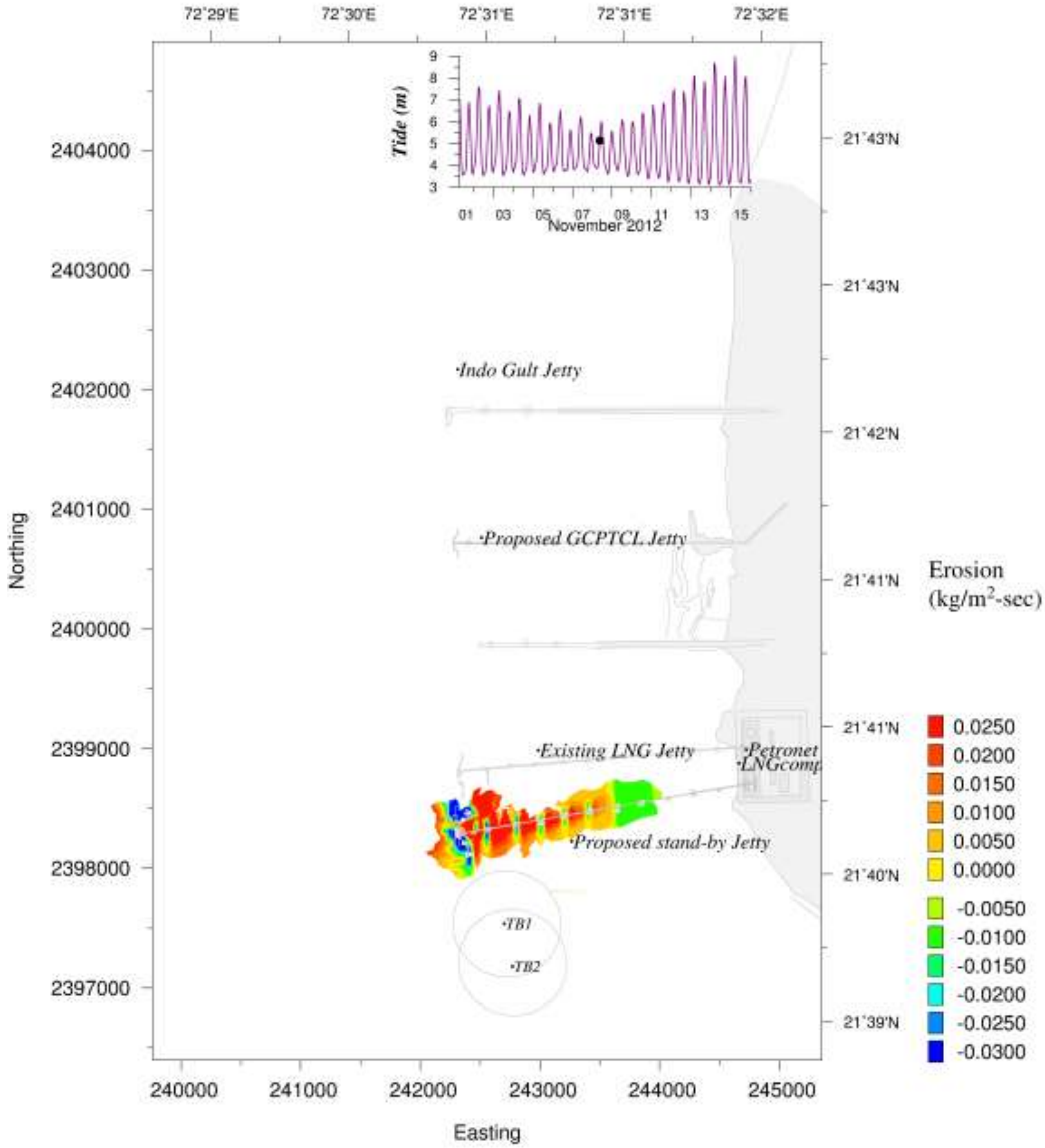


Fig.A6.18 Difference in sediment erosion between before and after developments during Peak Flood of neap tide (Nov 2012)

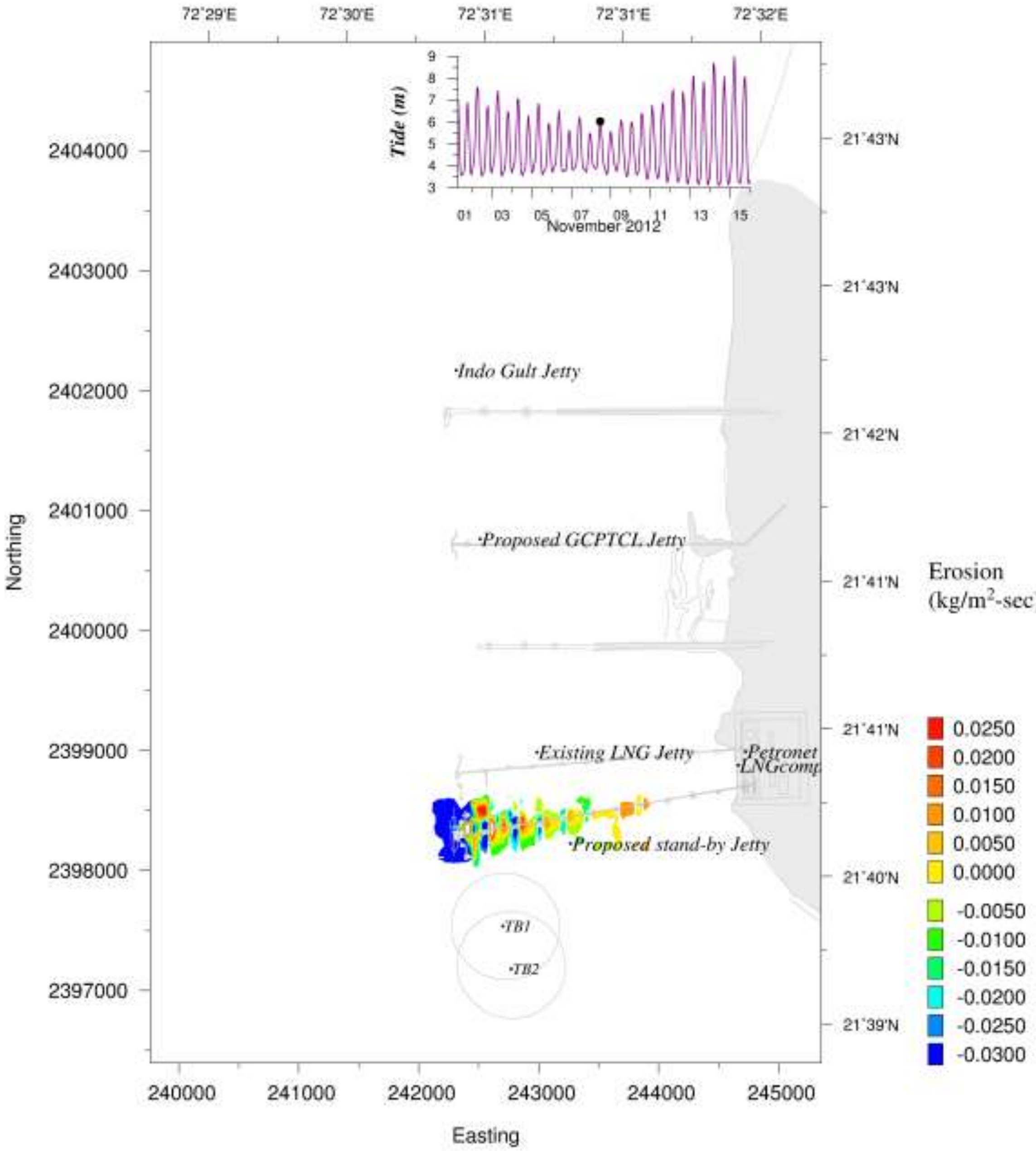


Fig.A6.19 Difference in sediment erosion between before and after developments during HHW of neap tide (Nov 2012)

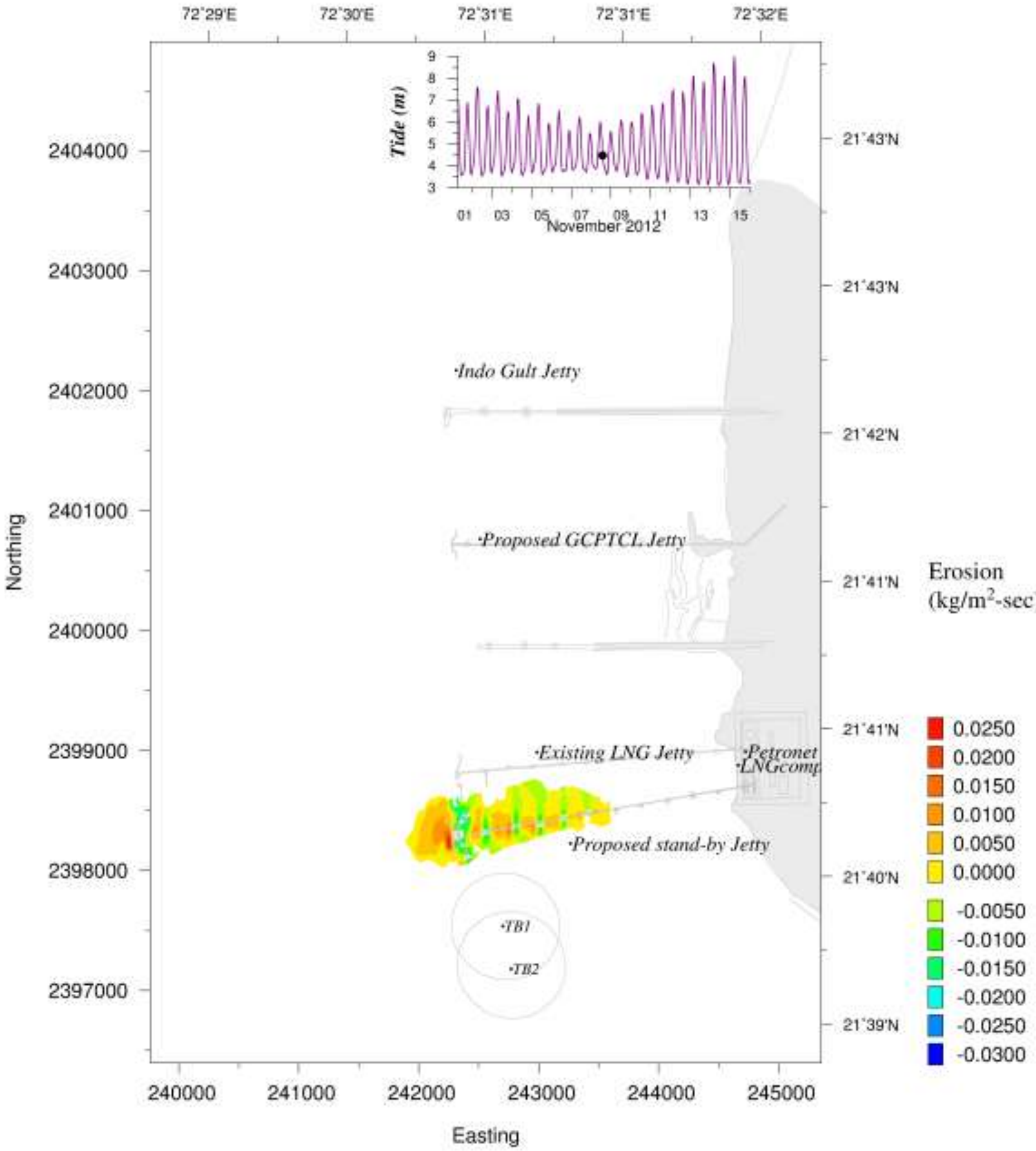


Fig.A6.20 Difference in sediment erosion between before and after developments during Peak EBB of neap tide (Nov 2012)

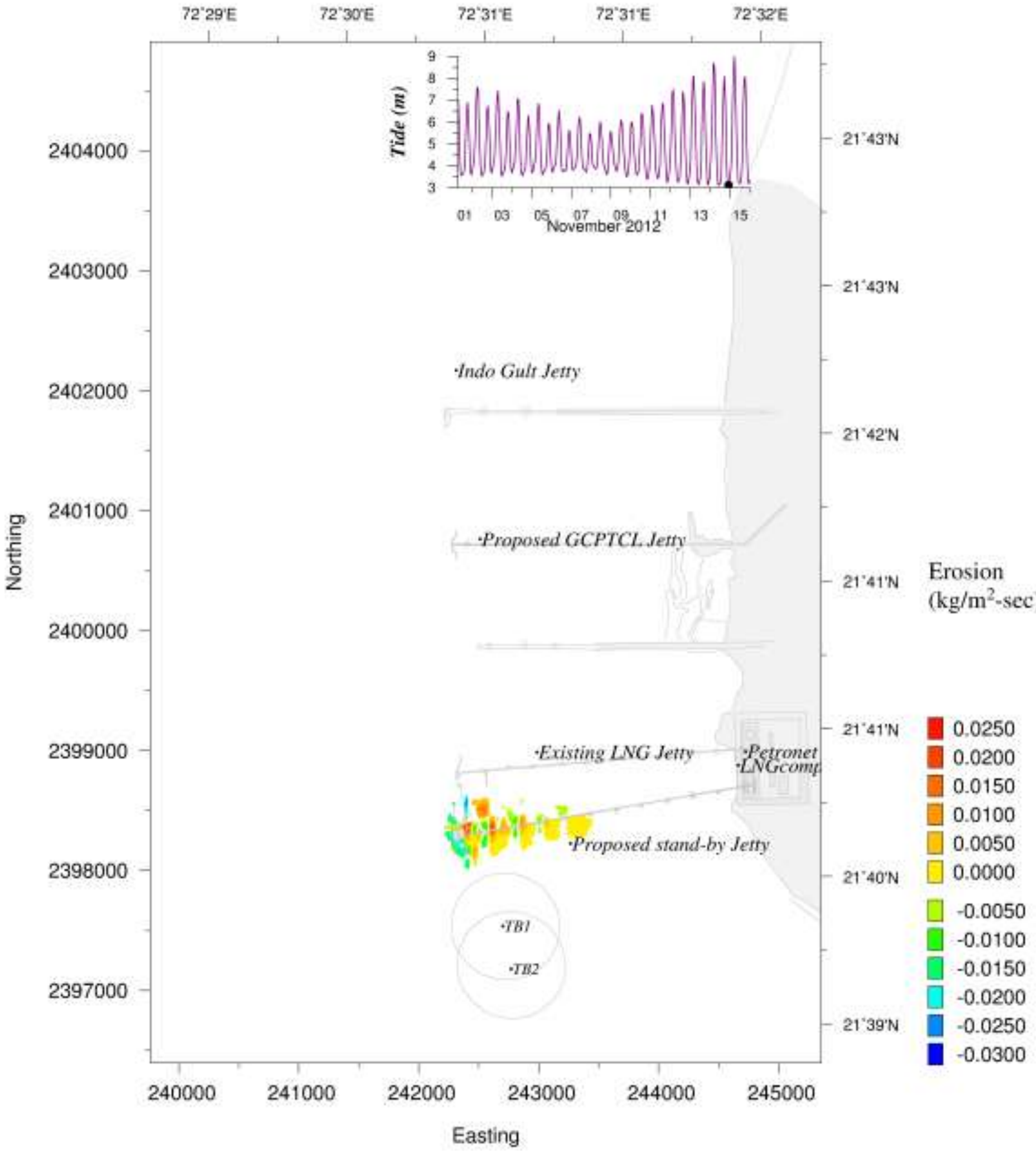


Fig.A6.21 Difference in sediment erosion between before and after developments during LLW of spring tide (Nov 2012)

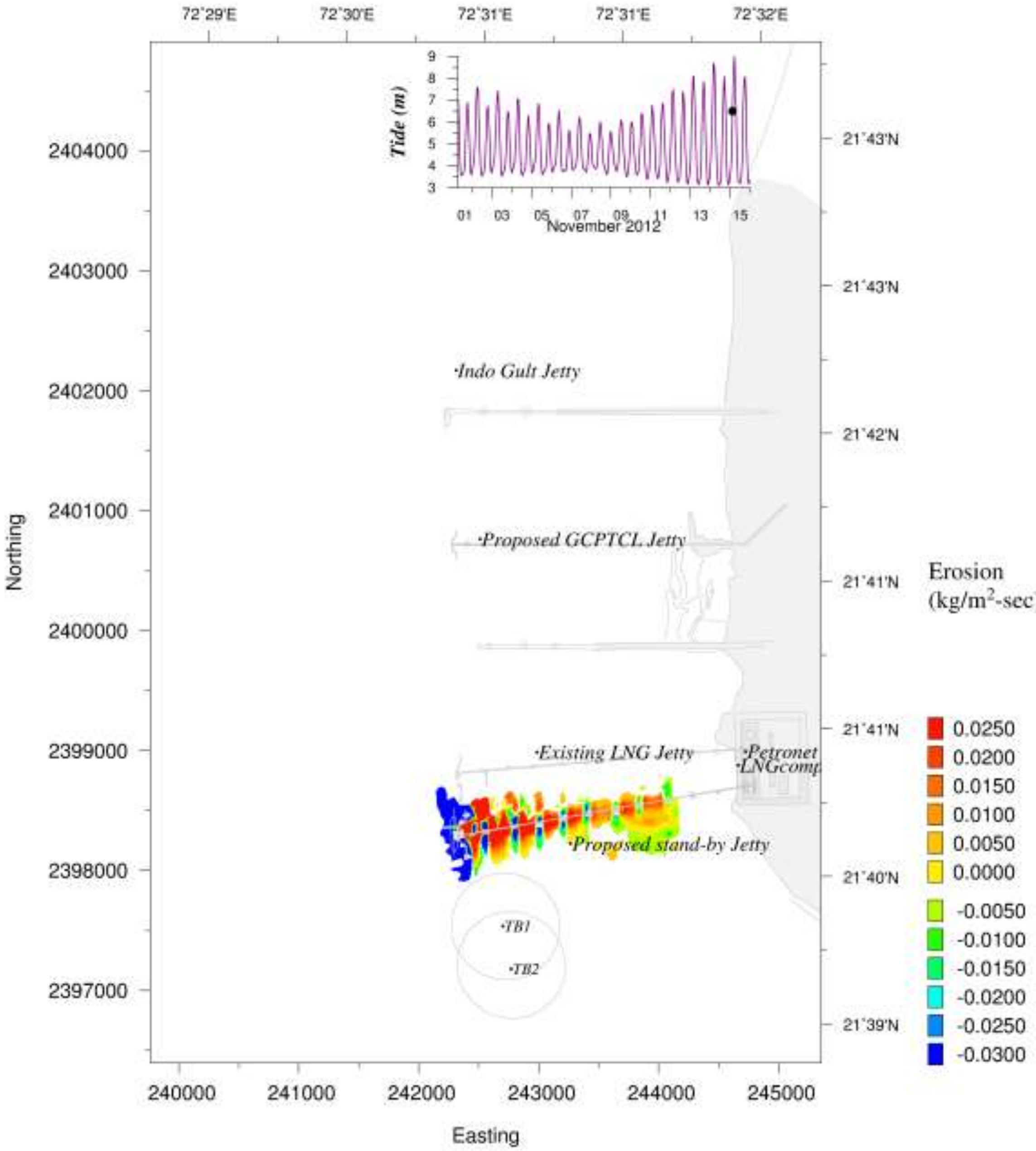


Fig.A6.22 Difference in sediment erosion between before and after developments during Peak Flood of spring tide (Nov 2012)

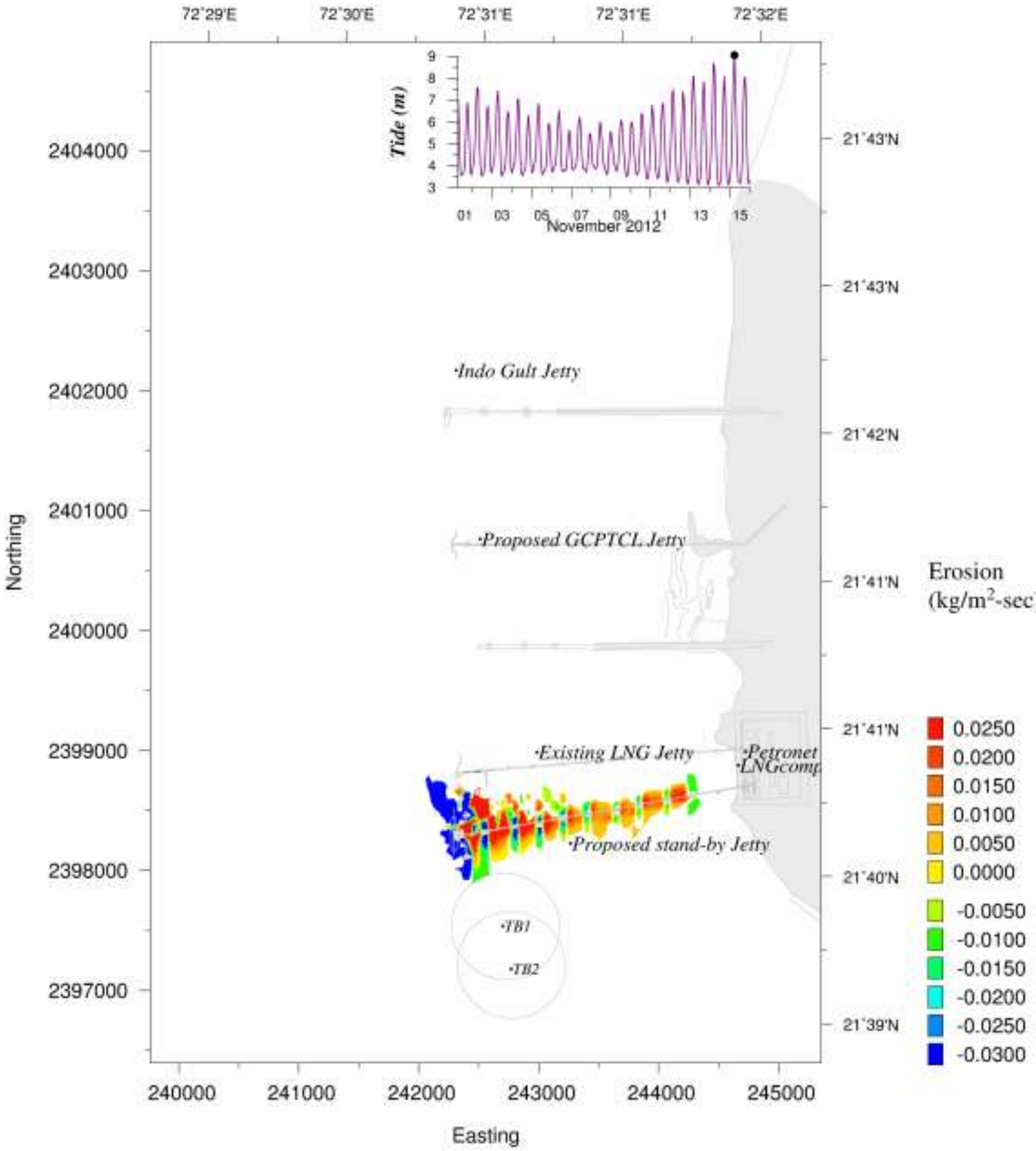


Fig.A6.23 Difference in sediment erosion between before and after developments during HHW of spring tide (Nov 2012)

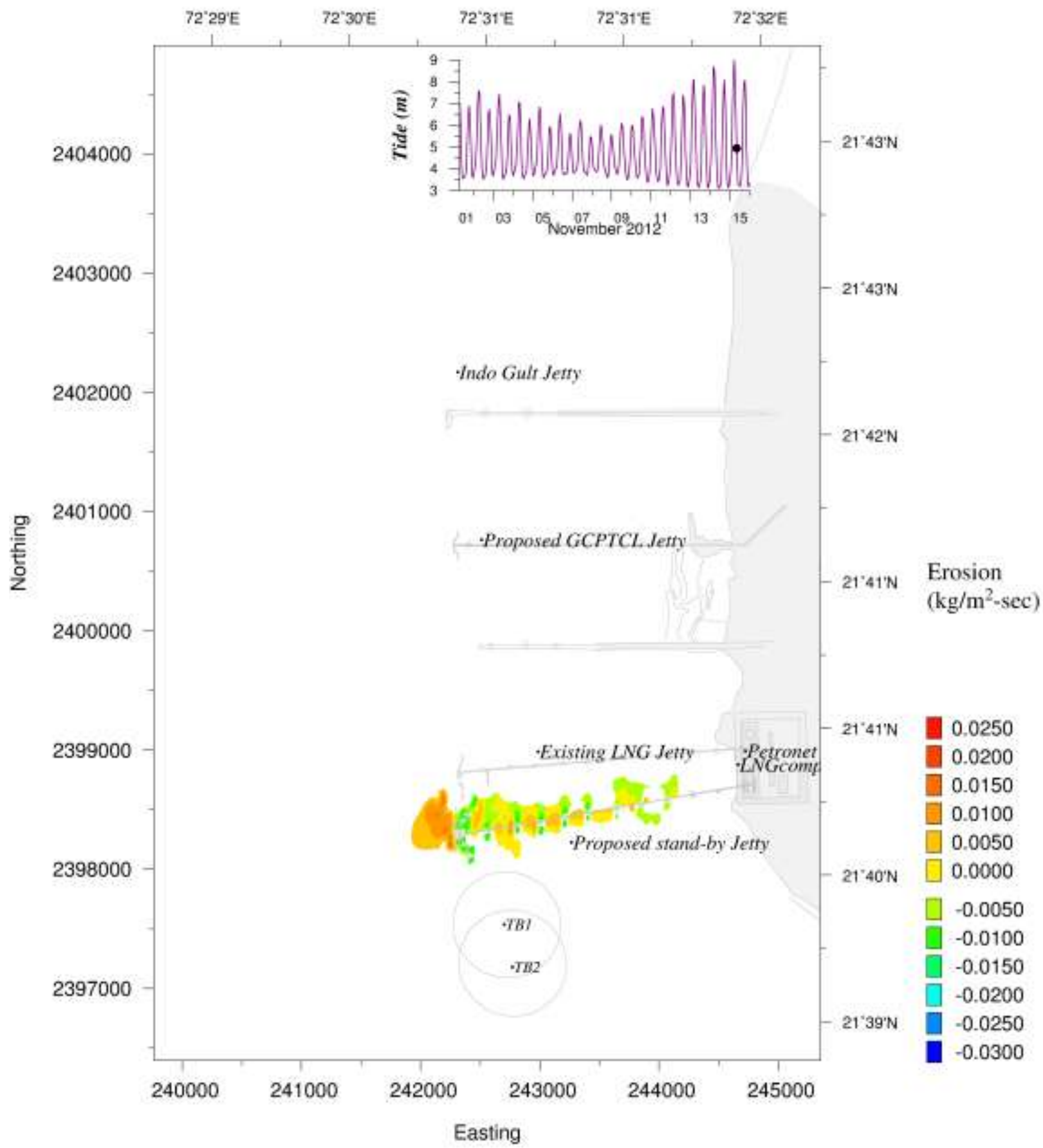


Fig.A6.24 Difference in sediment erosion between before and after developments during Peak EBB of spring tide (Nov 2012)

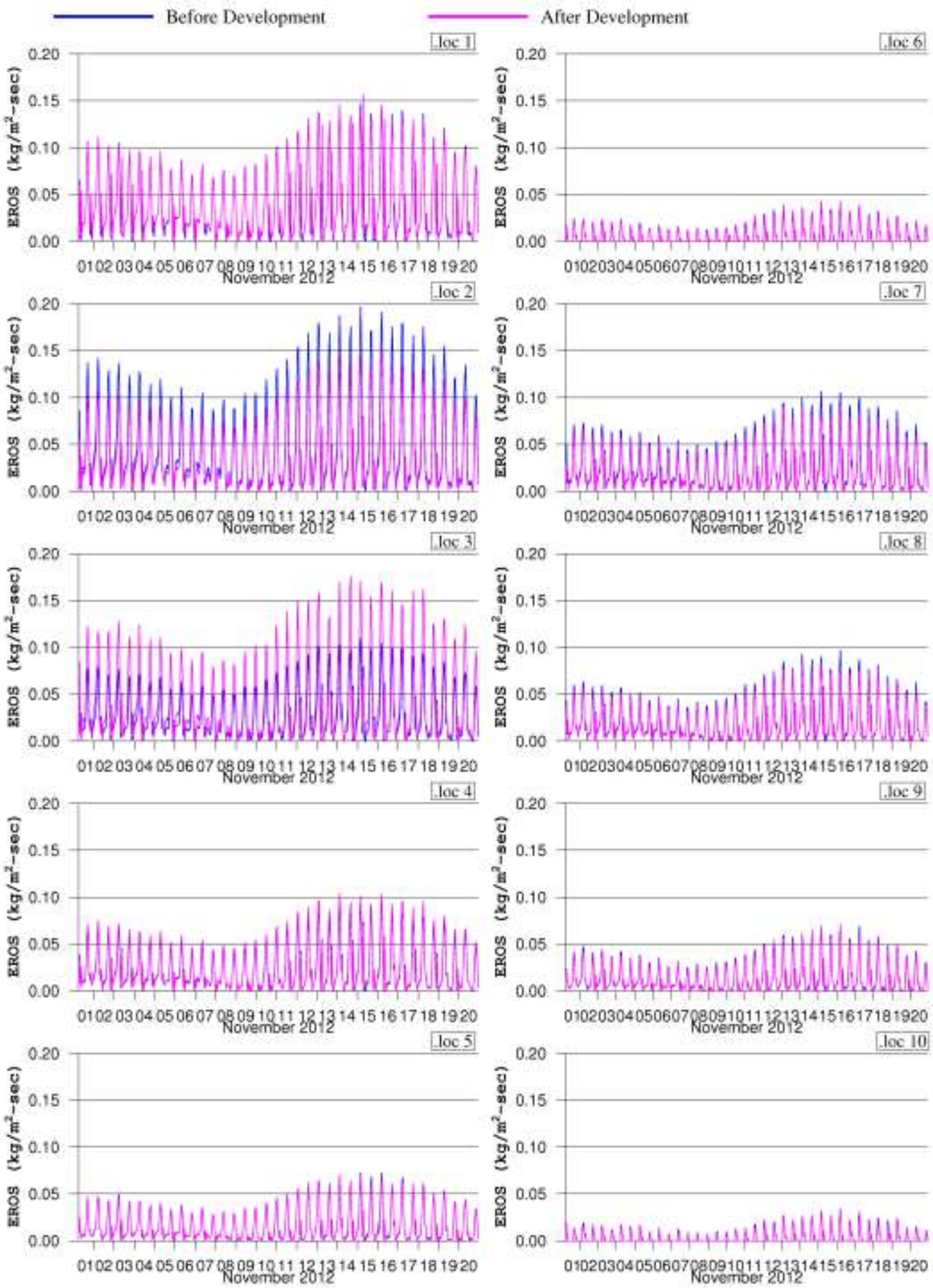


Fig.A6.25(a) Comparison of sediment erosion before and after development (Nov 2012)

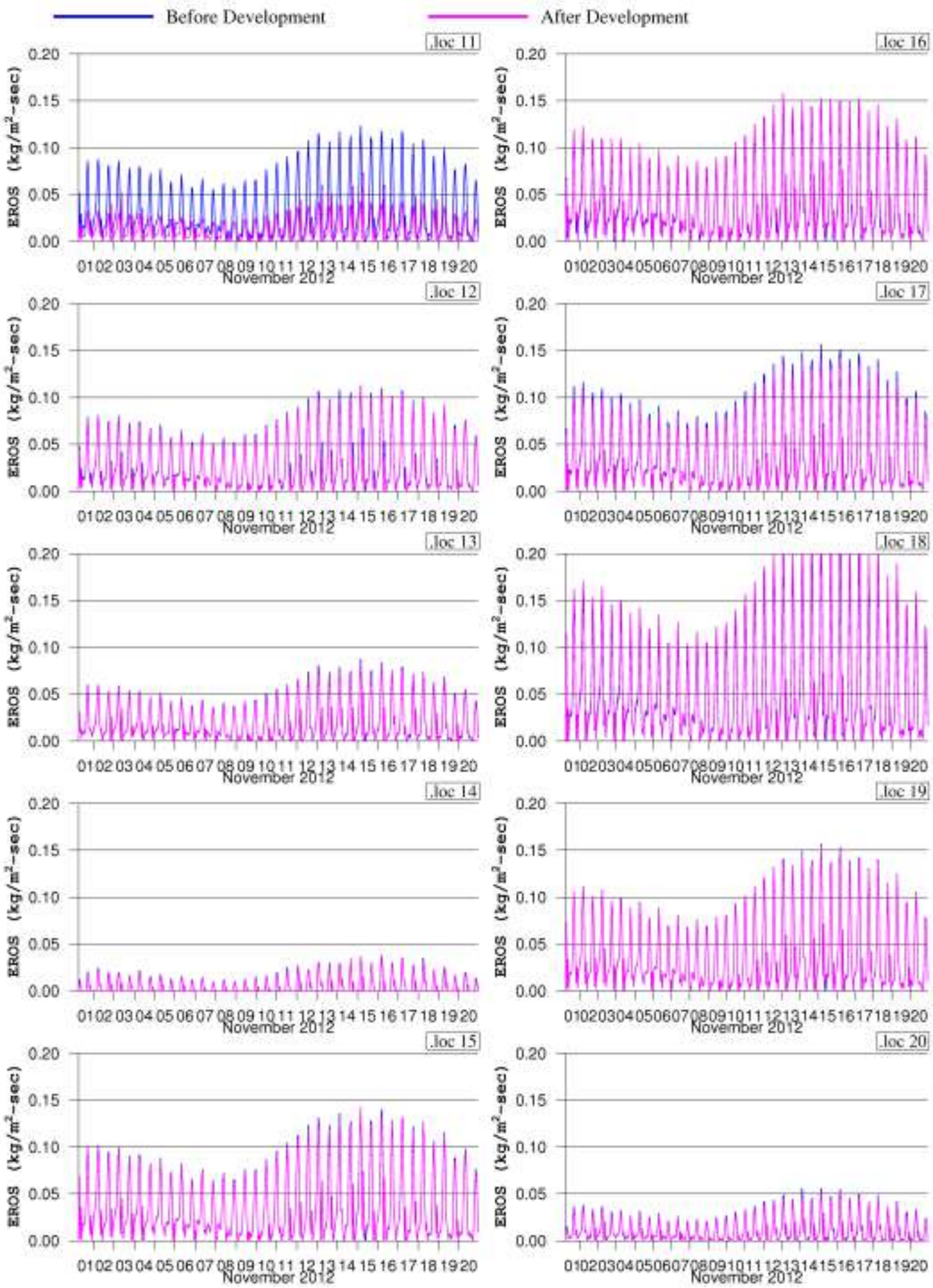


Fig.A6.25(b) Comparison of sediment erosion before and after development (Nov 2012)

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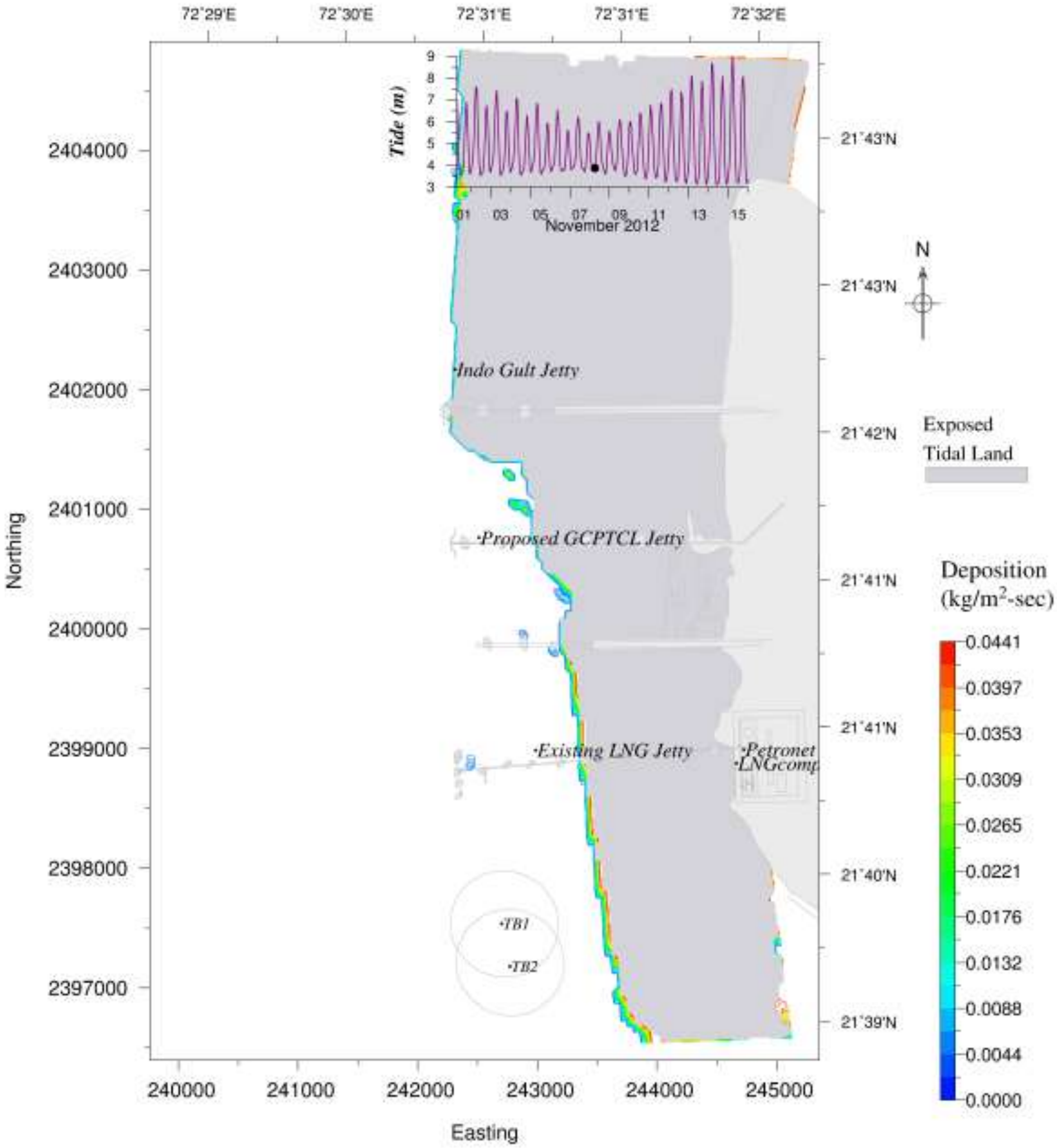

Fig.A7.1 Instantaneous rate of sediment deposition before development (at 08/11/2012 06:00hr) during neap tide (LLW)

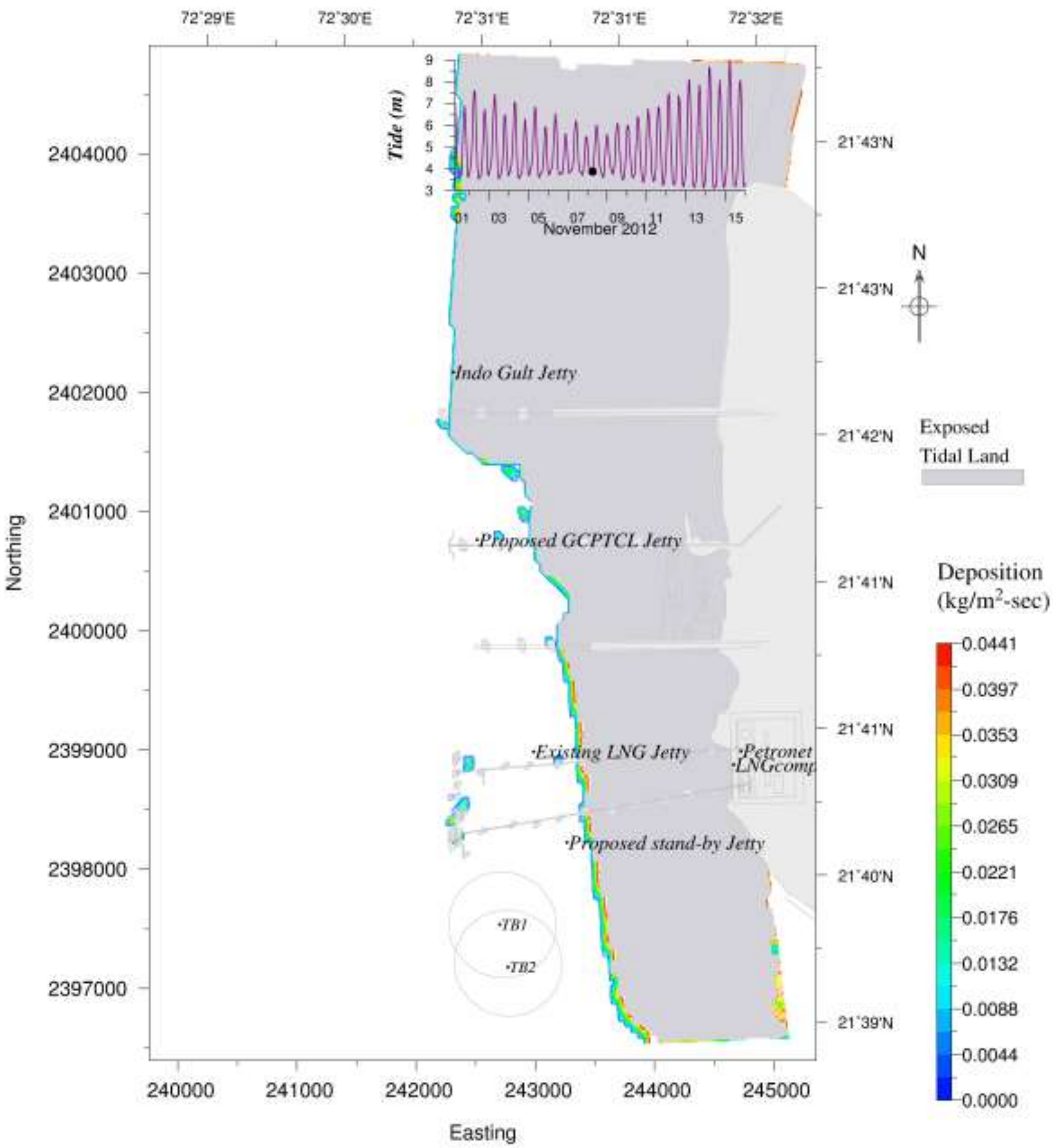

Fig.A7.2 Instantaneous rate of sediment deposition after development (at 08/11/2012 06:00hr) during neap tide (LLW)

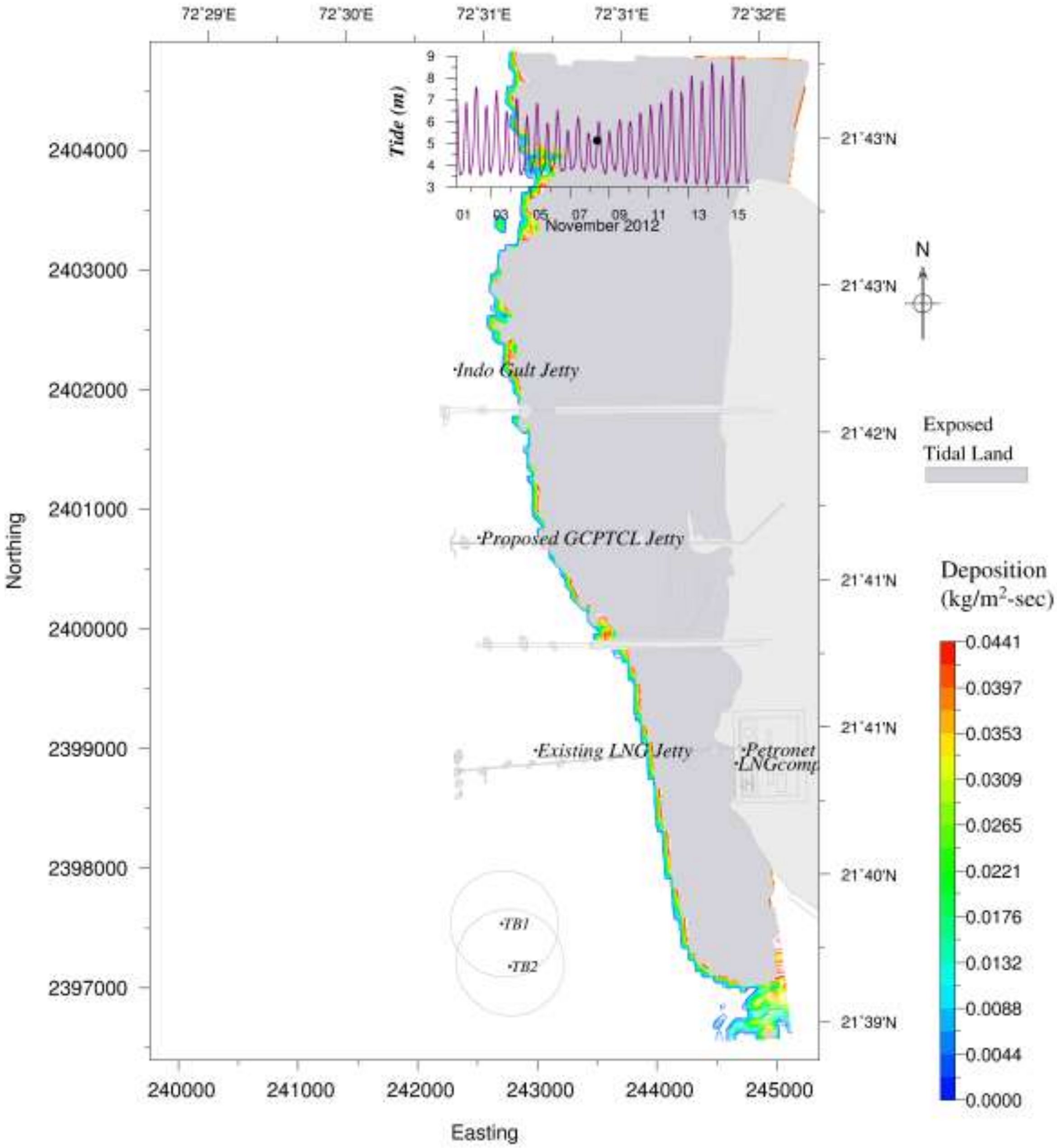

Fig.A7.3 Instantaneous rate of sediment deposition before development (at 08/11/2012 09:00hr) during neap tide (Peak Flood)

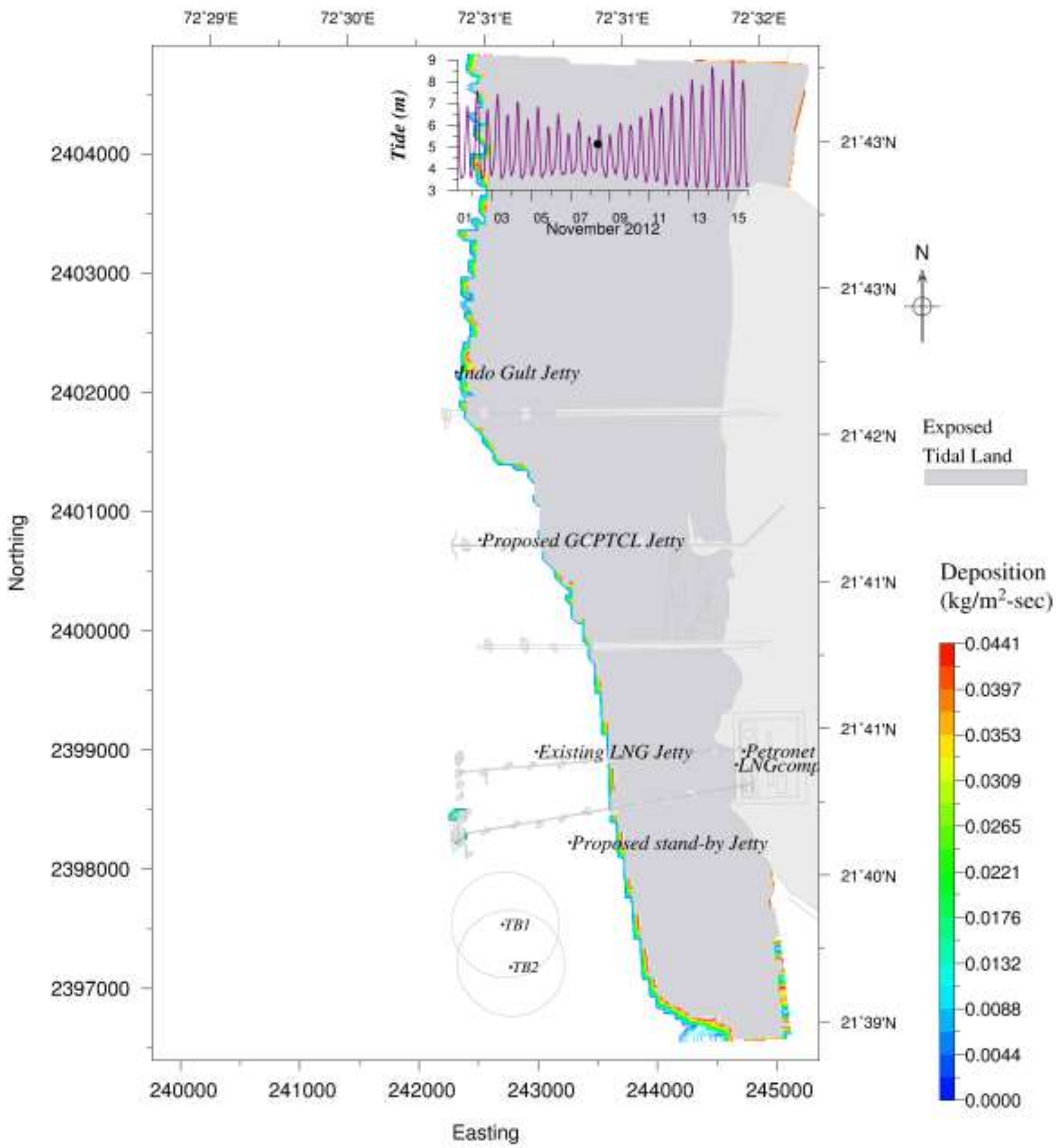

Fig.A7.4 Instantaneous rate of sediment deposition after development (at 08/11/2012 09:00hr) during neap tide (Peak Flood)

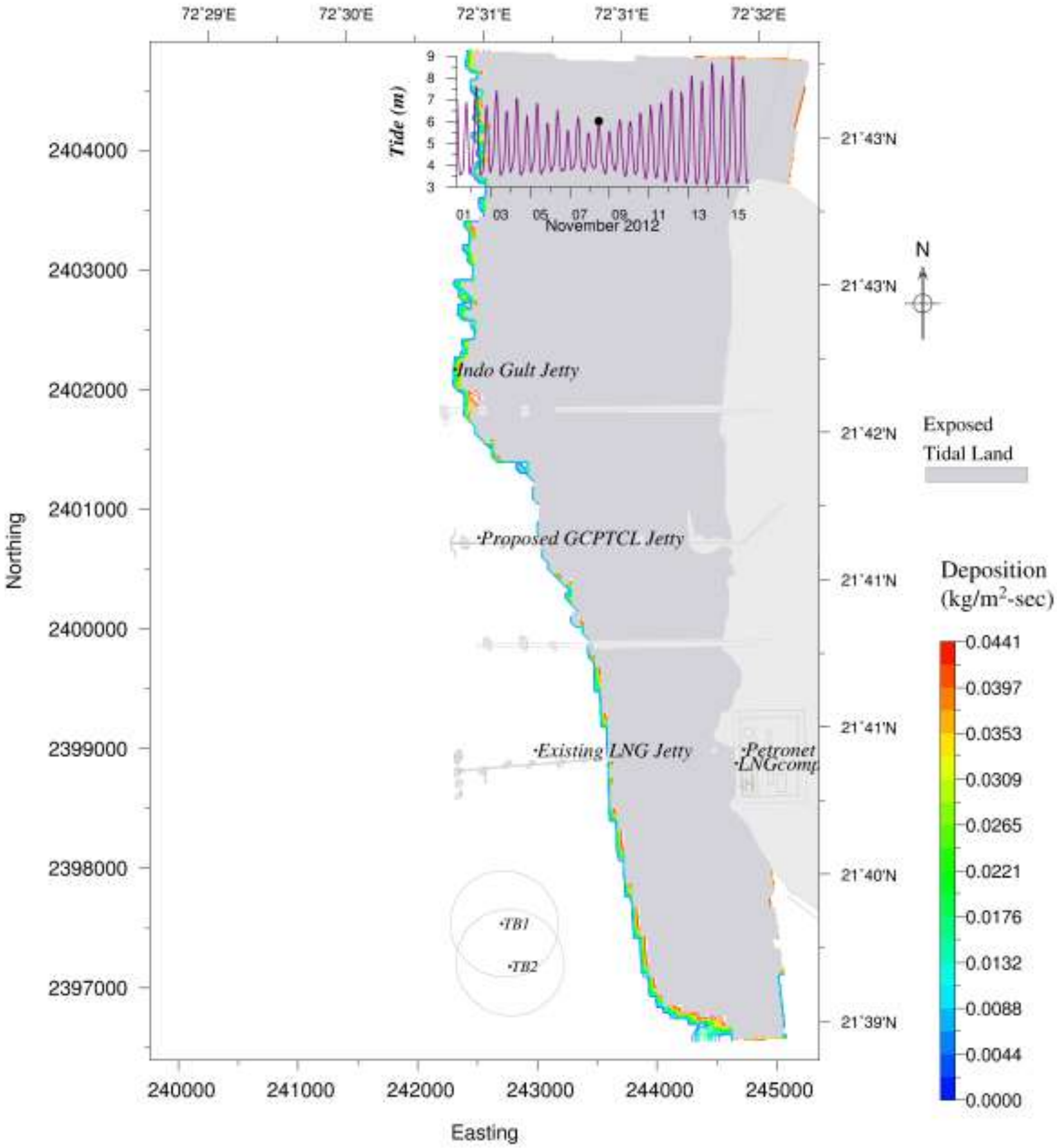

Fig.A7.5 Instantaneous rate of sediment deposition before development (at 08/11/2012 11:00hr) during neap tide (HHW)

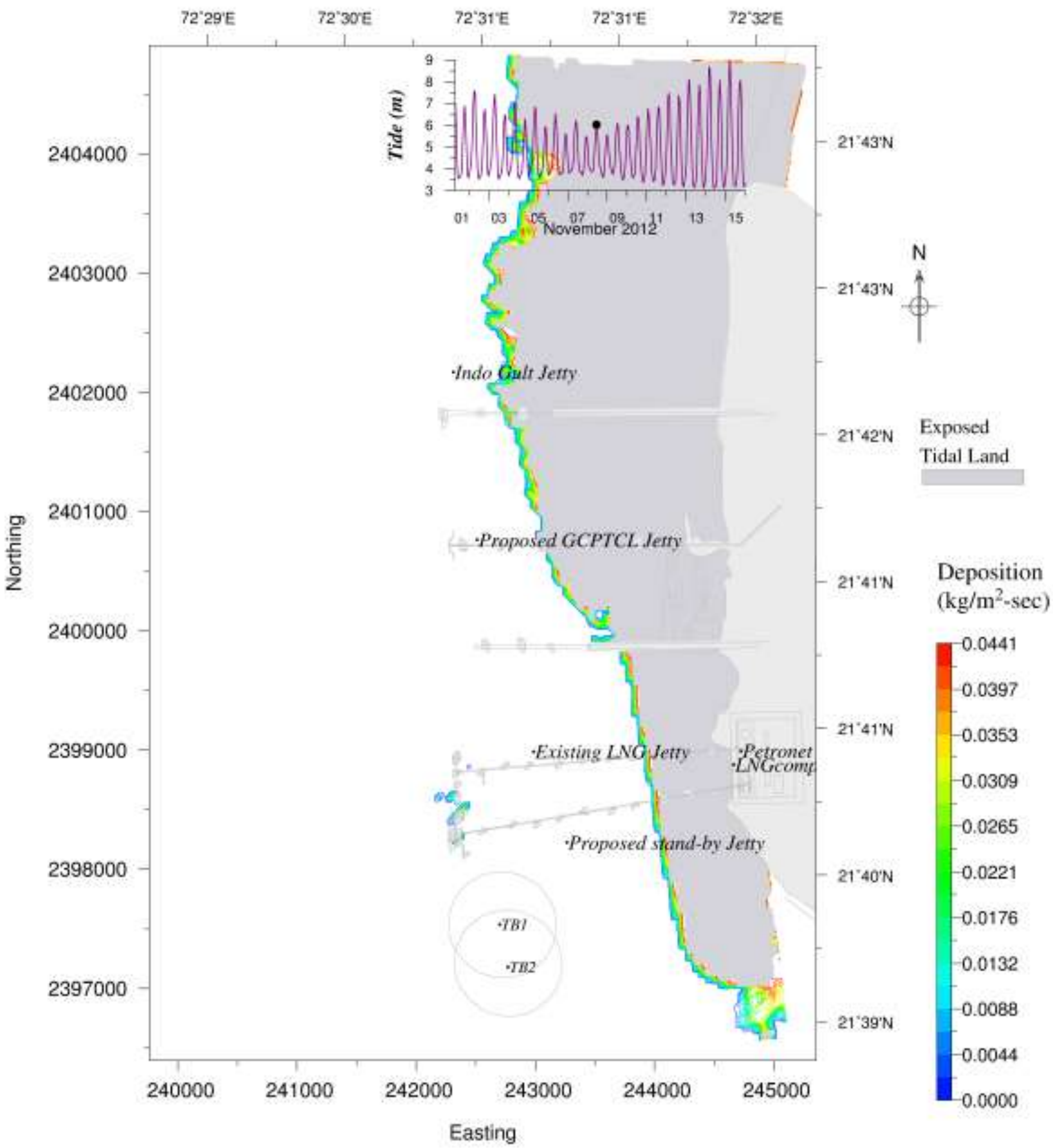

Fig.A7.6 Instantaneous rate of sediment deposition after development (at 08/11/2012 11:00hr) during neap tide (HHW)

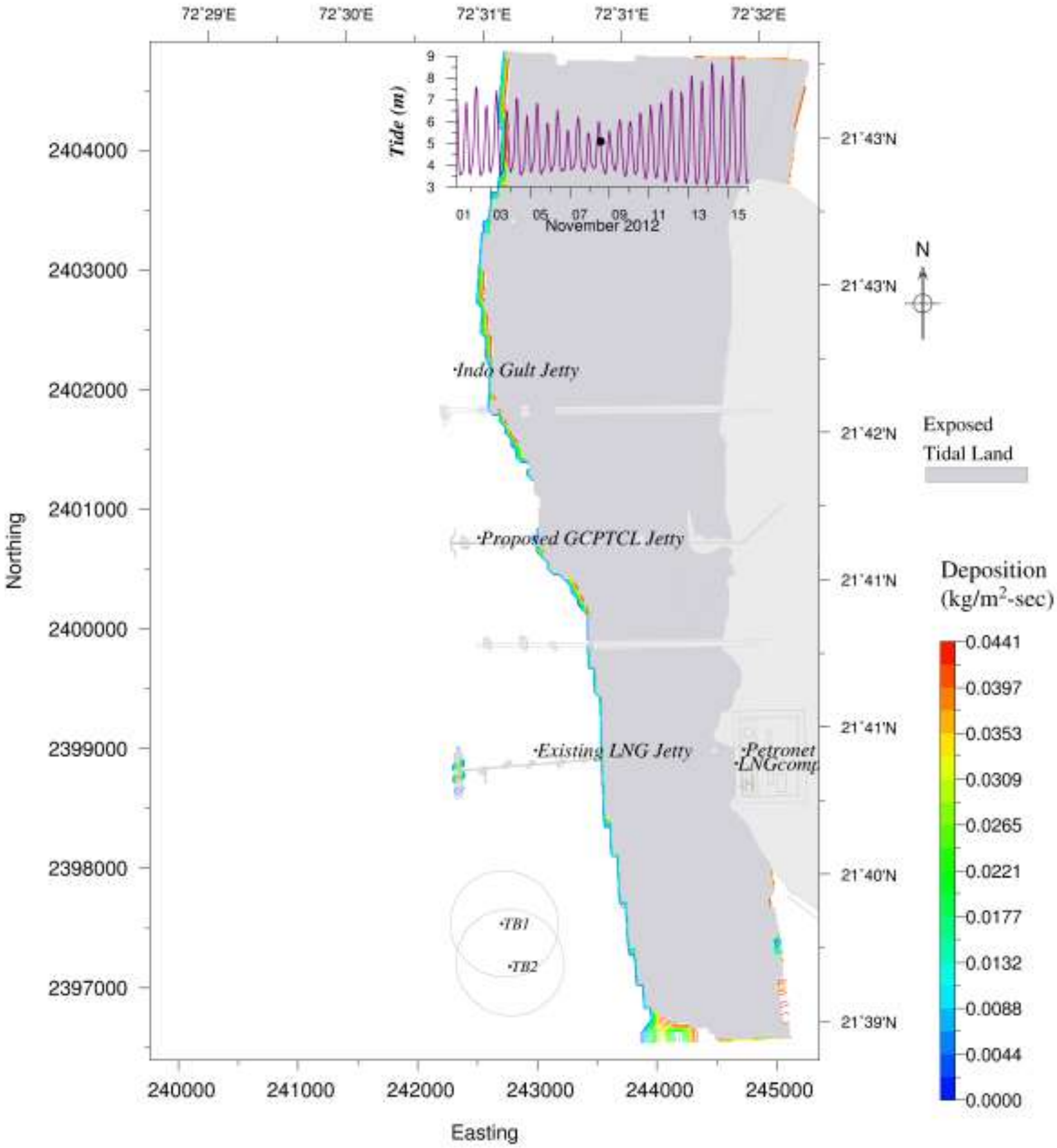

Fig.A7.7 Instantaneous rate of sediment deposition before development (at 08/11/2012 14:00hr) during neap tide (Peak EBB)

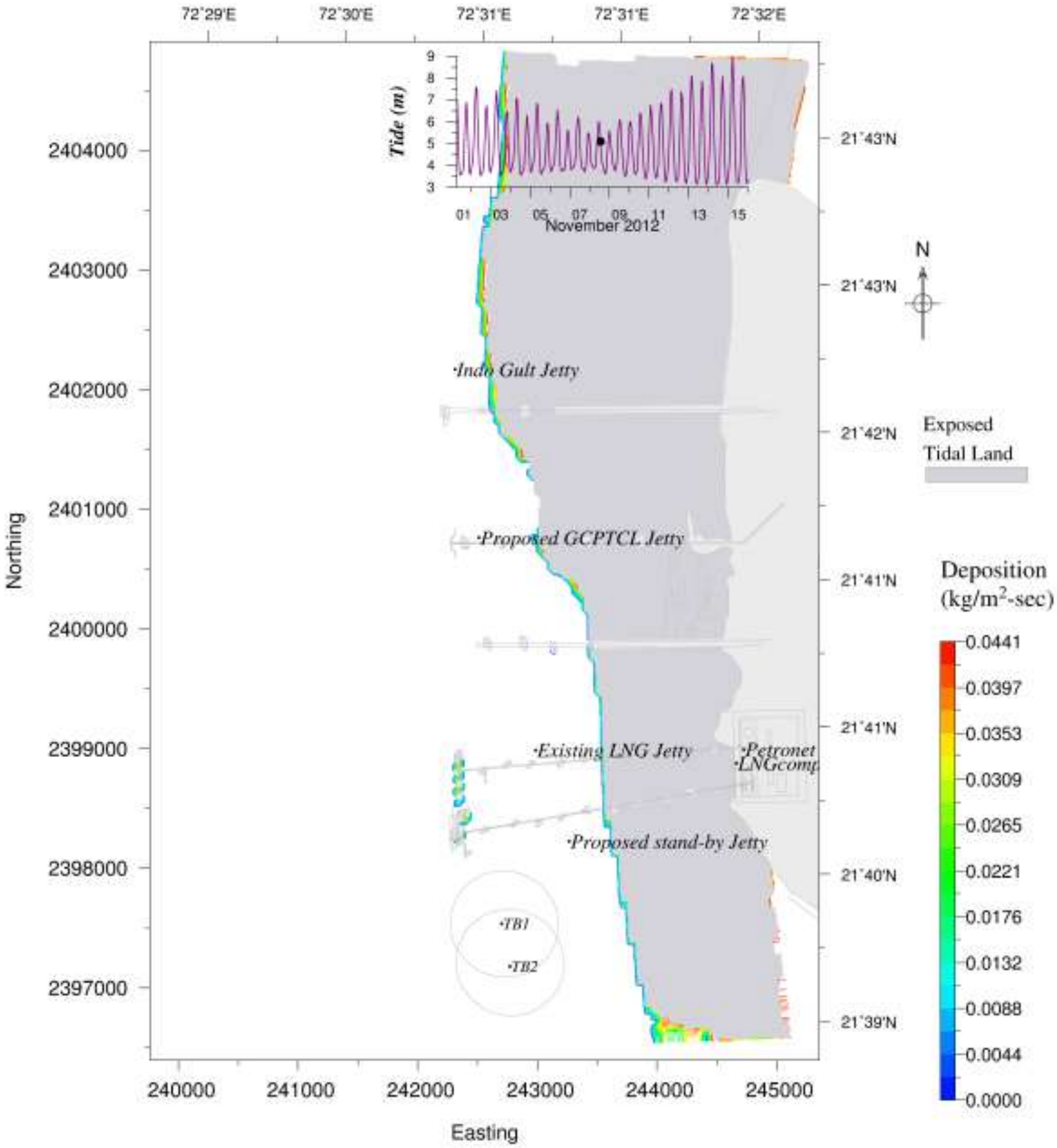

Fig.A7.8 Instantaneous rate of sediment deposition after development (at 08/11/2012 14:00hr) during neap tide (Peak EBB)

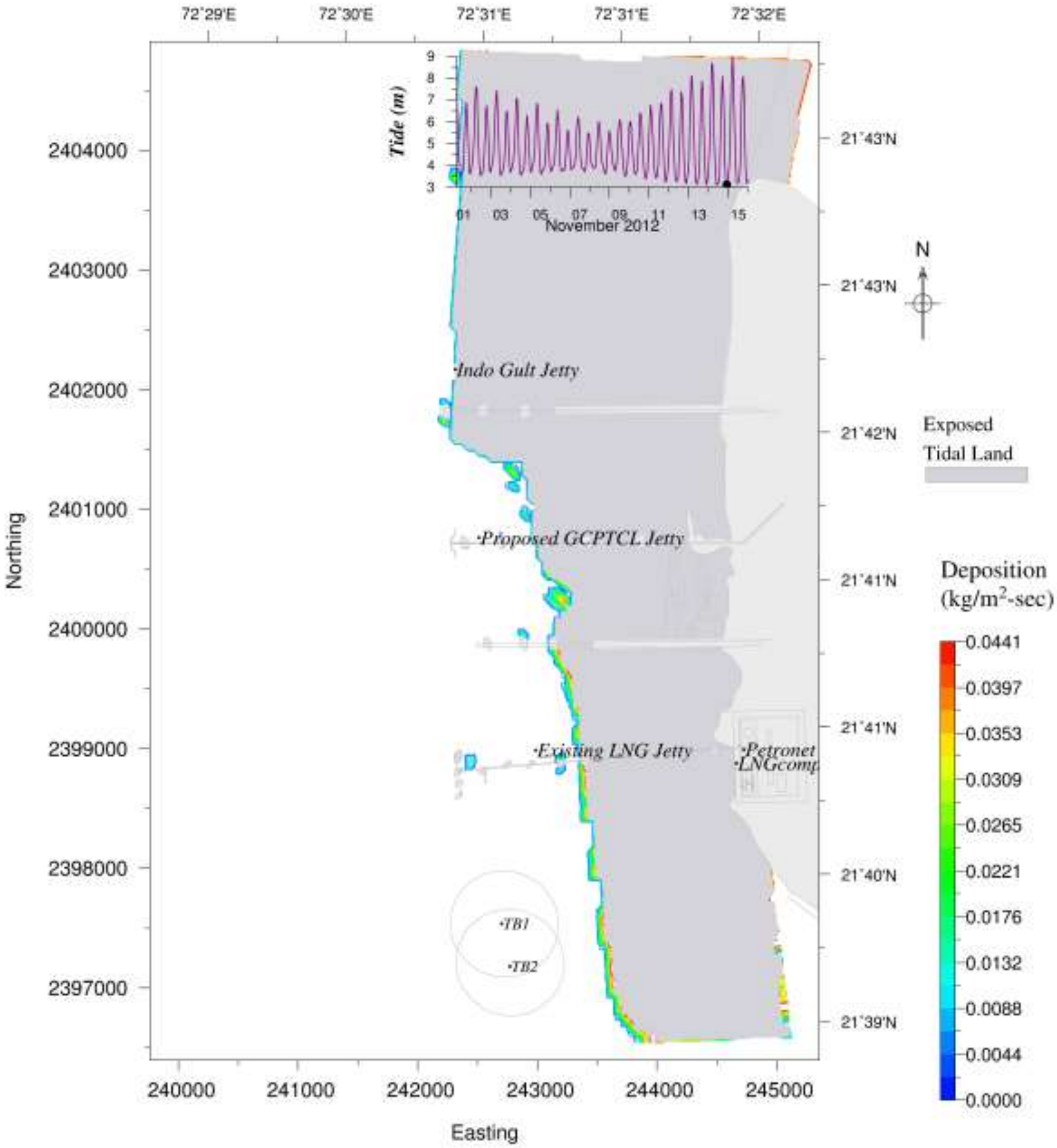

Fig.A7.9 Instantaneous rate of sediment deposition before development (at 14/11/2012 22:00hr) during spring tide (LLW)

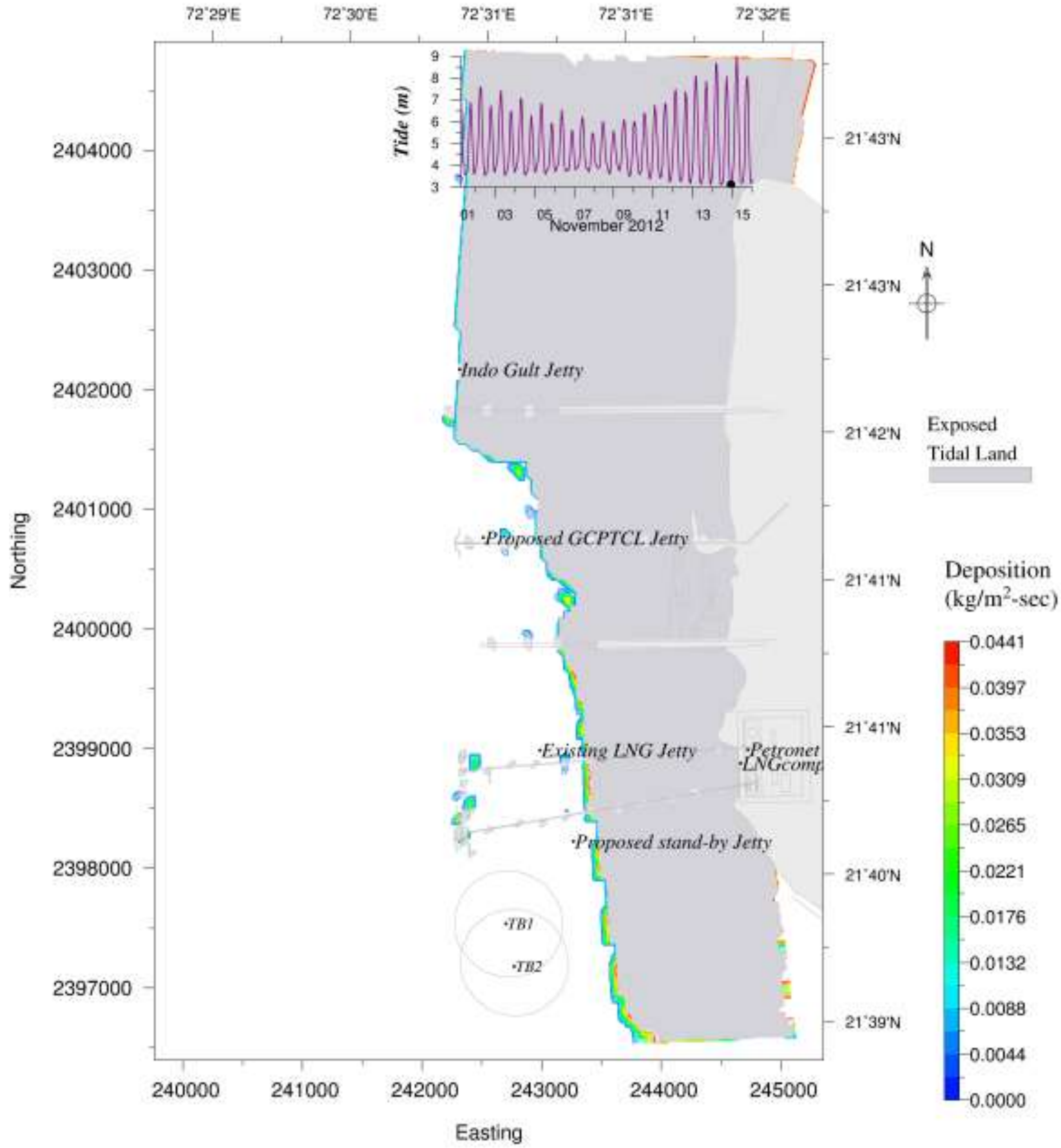

Fig.A7.10 Instantaneous rate of sediment deposition after development (at 14/11/2012 22:00hr) during spring tide (LLW)

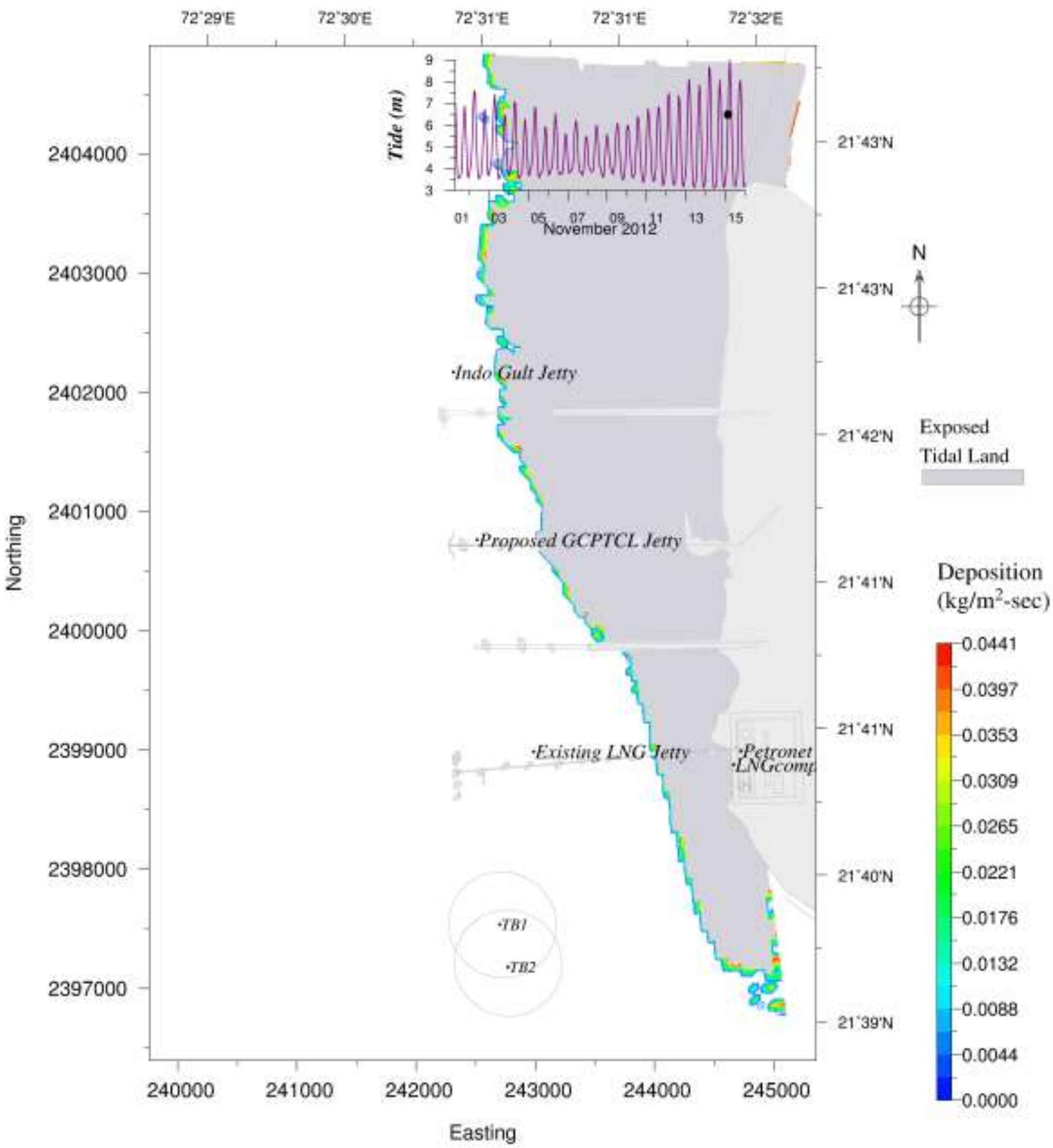

Fig.A7.11 Instantaneous rate of sediment deposition before development (at 15/11/2012 03:00hr) during spring tide (Peak Flood)

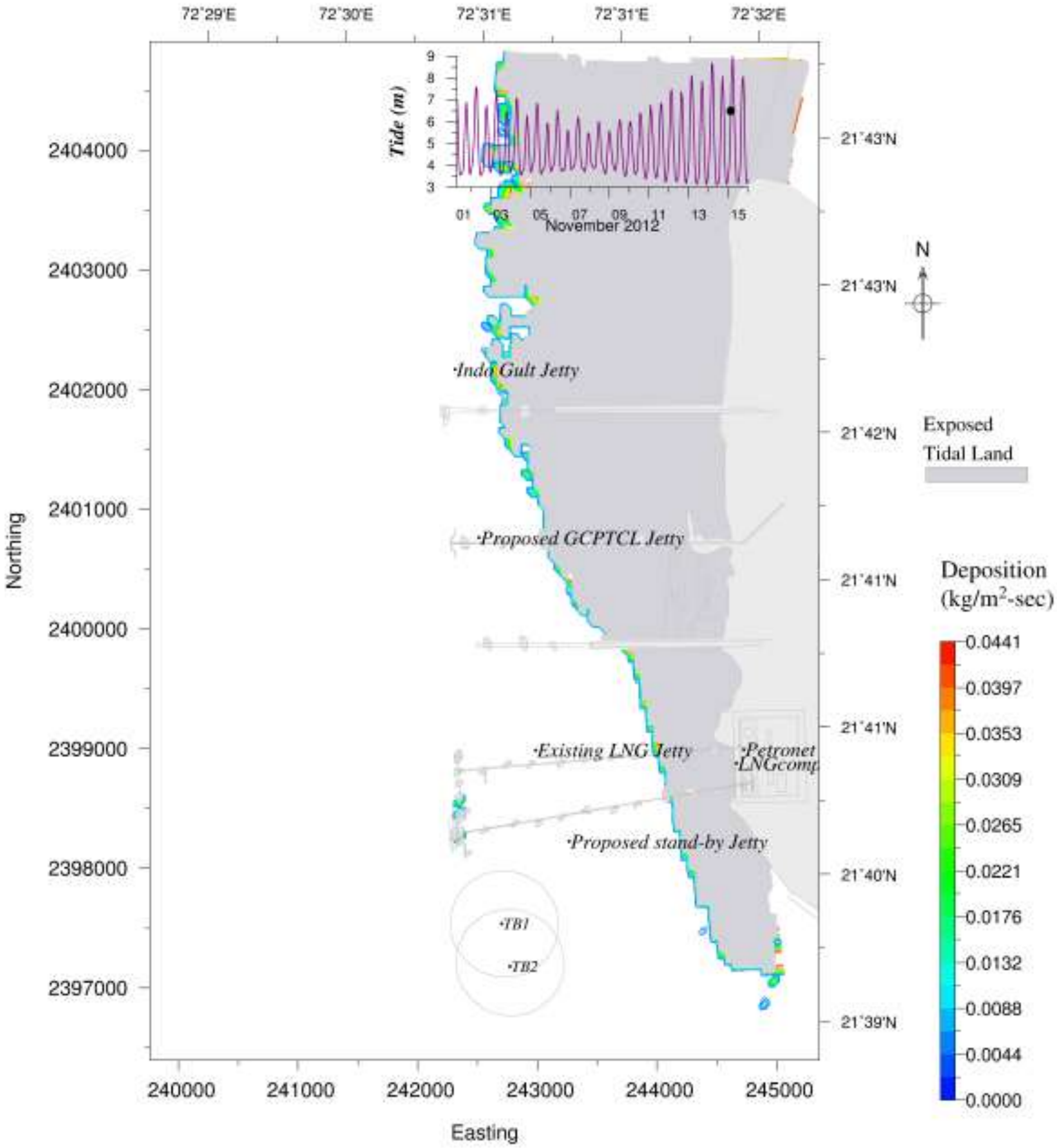

Fig.A7.12 Instantaneous rate of sediment deposition after development (at 15/11/2012 03:00hr) during spring tide (Peak Flood)

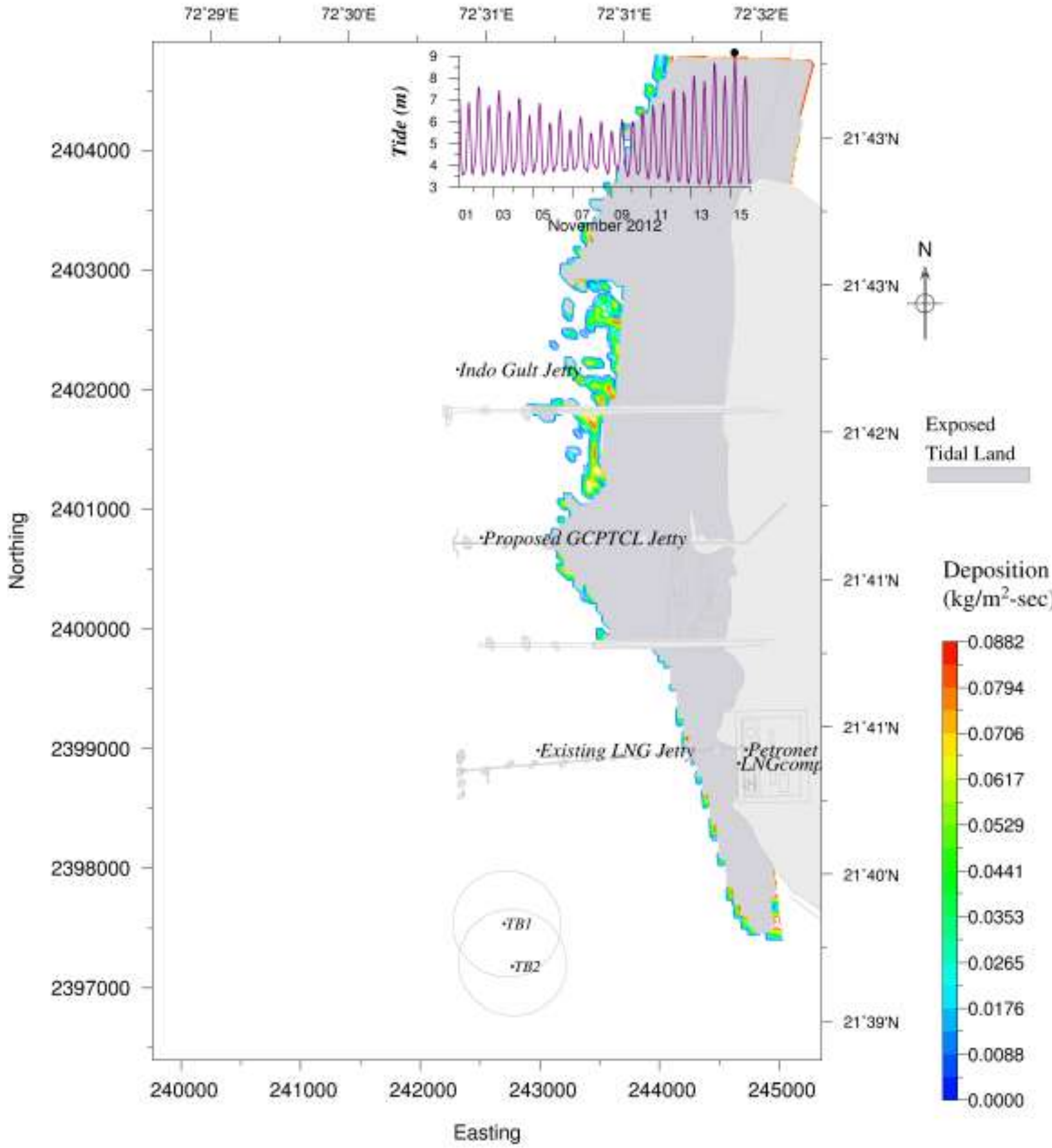

Fig.A7.13 Instantaneous rate of sediment deposition before development (at 15/11/2012 05:00hr) during spring tide (HHW)

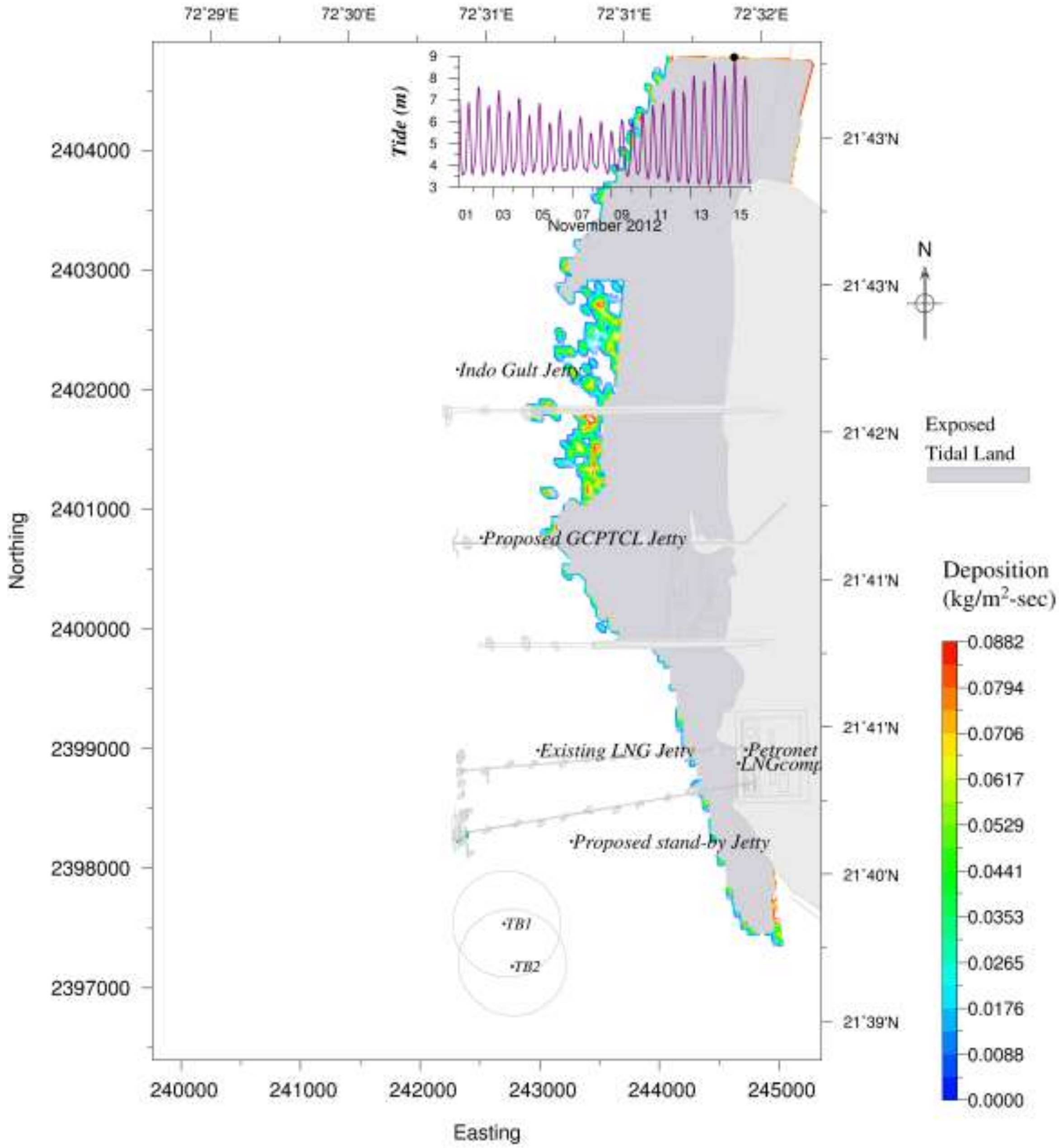

Fig.A7.14 Instantaneous rate of sediment deposition after development (at 15/11/2012 05:00hr) during spring tide (HHW)

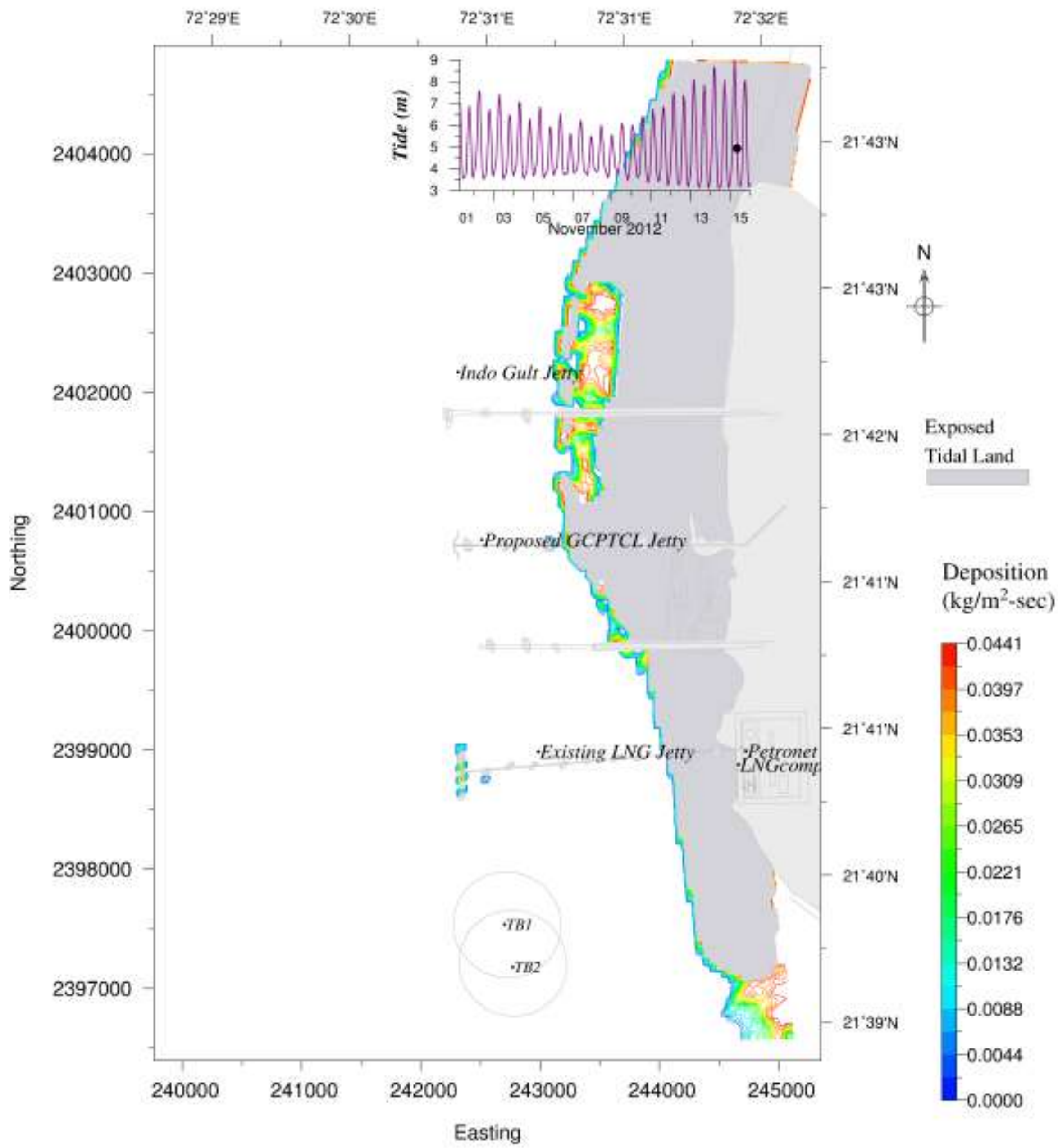

Fig.A7.15 Instantaneous rate of sediment deposition before development (at 15/11/2012 08:00hr) during spring tide (Peak EBB)

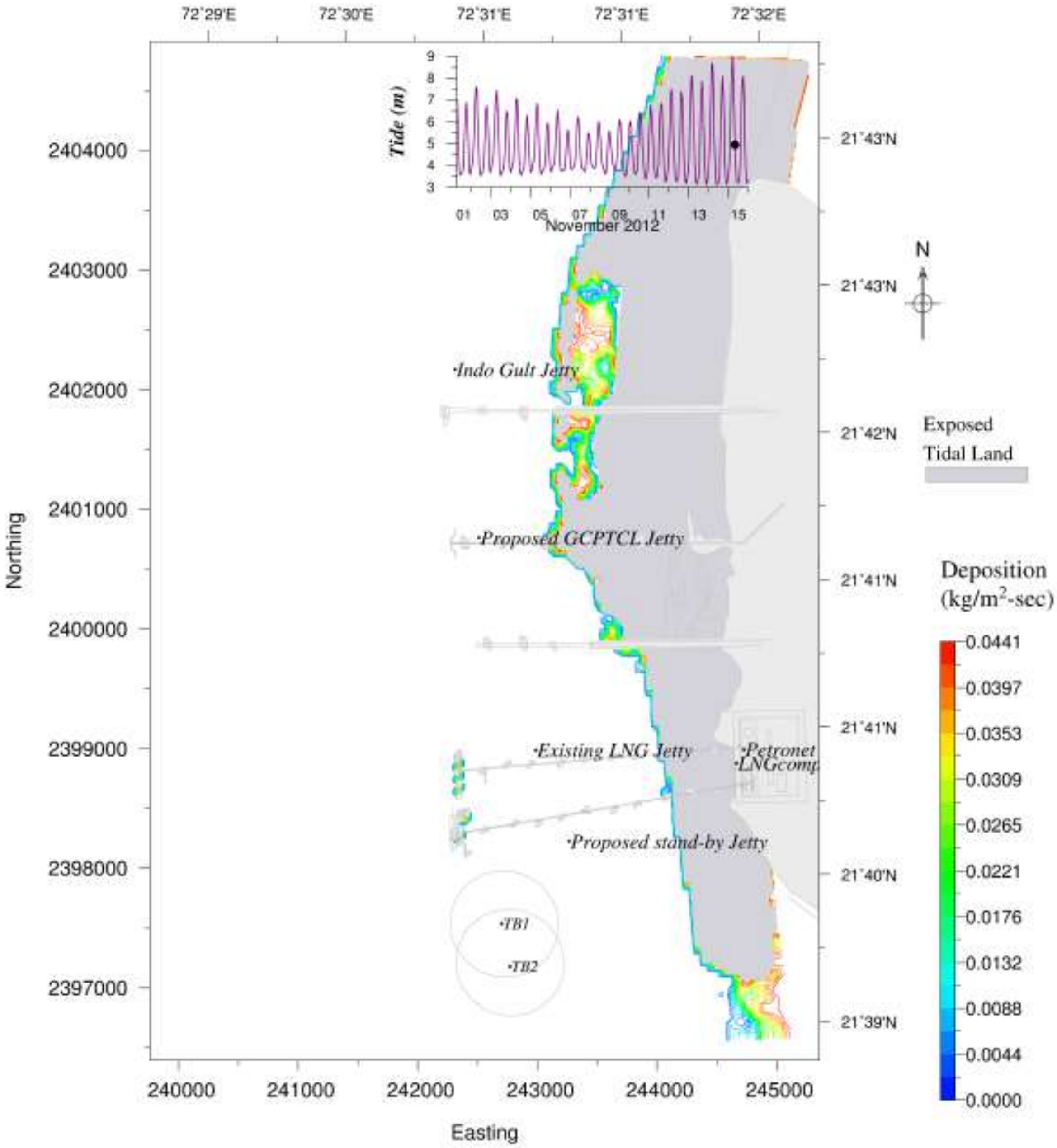

Fig.A7.16 Instantaneous rate of sediment deposition after development (at 15/11/2012 08:00hr) during spring tide (Peak EBB)

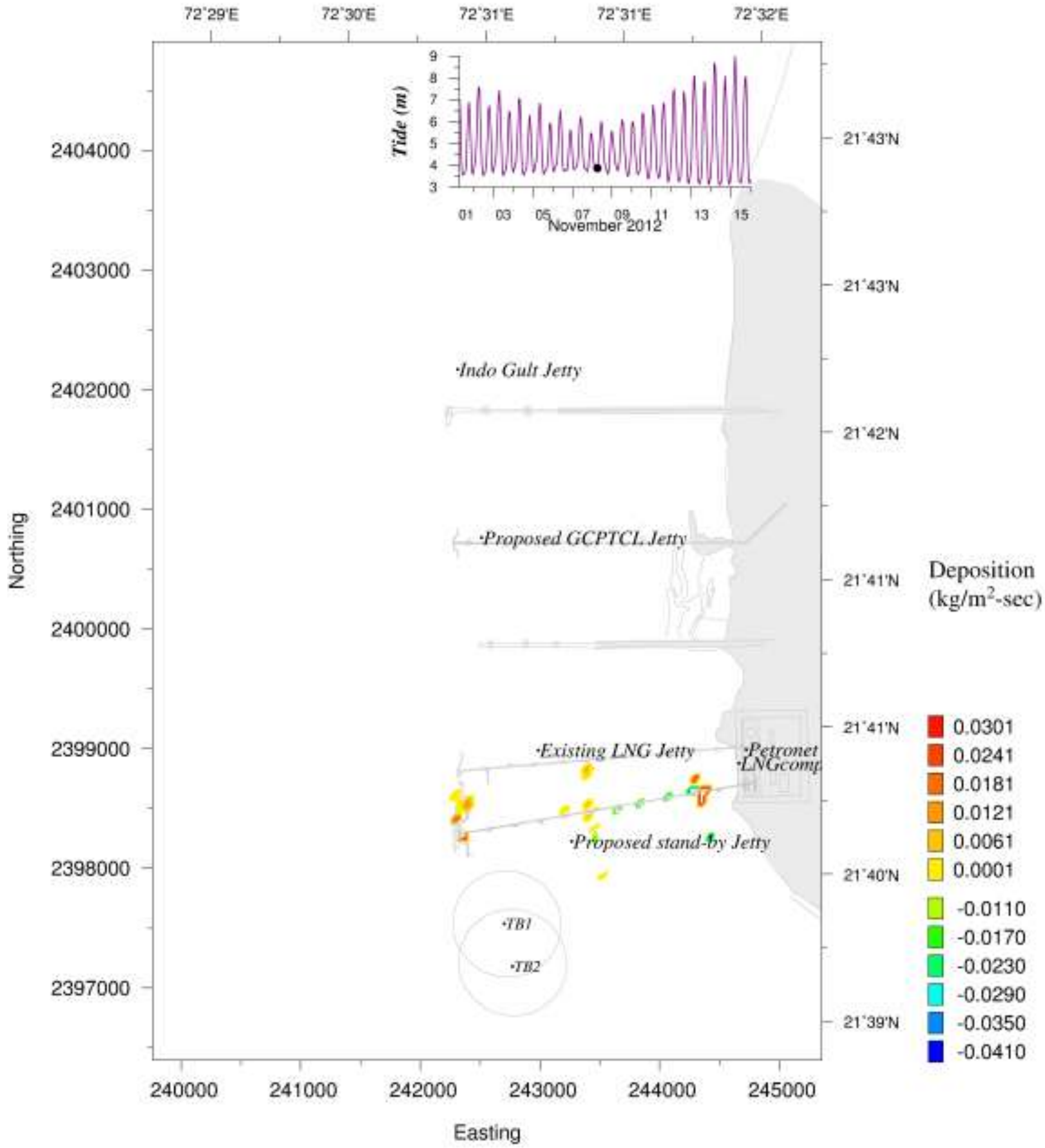

Fig.A7.17 Difference in sediment deposition between before and after developments during LLW of neap tide (Nov 2012)

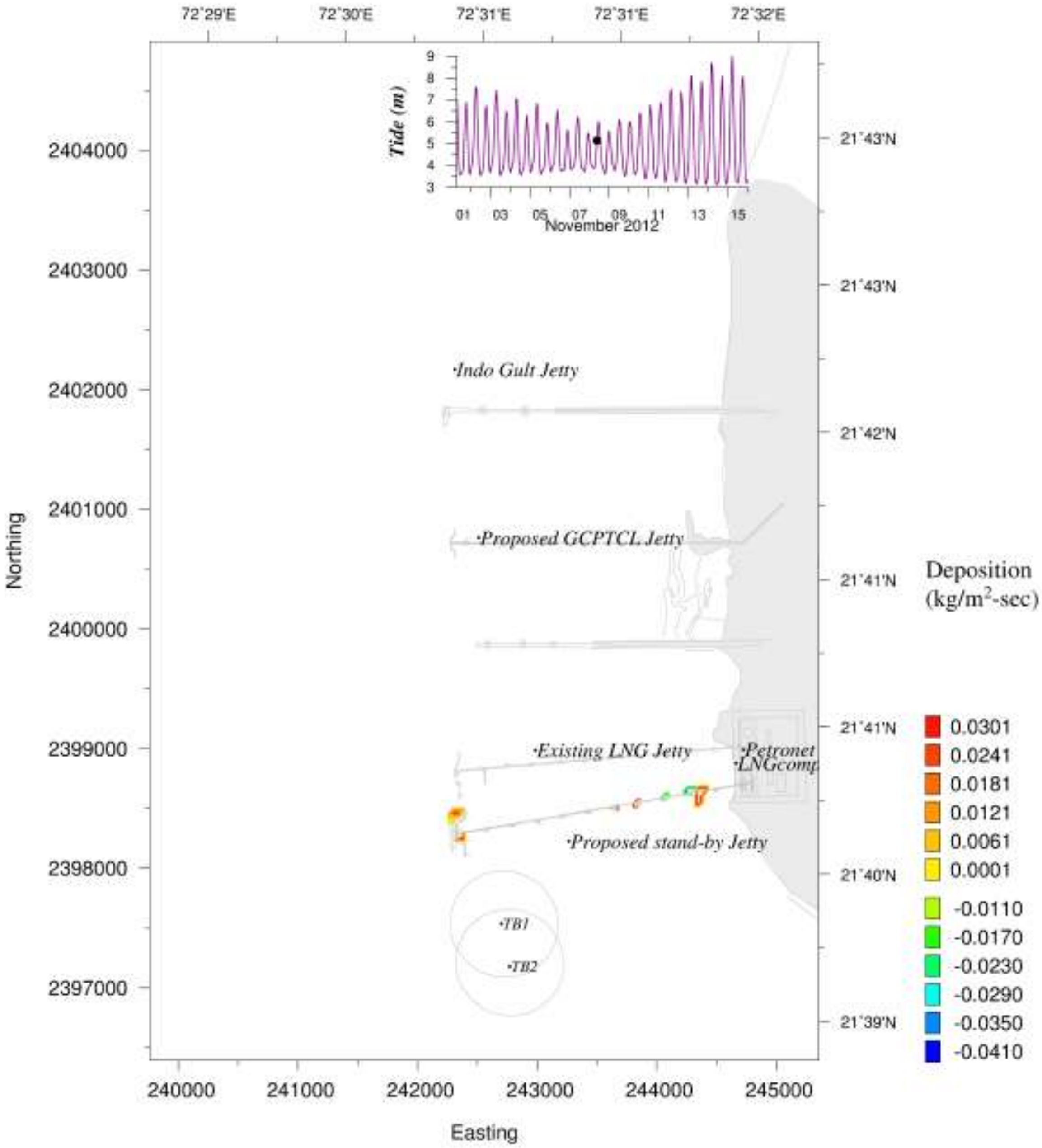

Fig.A7.18 Difference in sediment deposition between before and after developments during Peak Flood of neap tide (Nov 2012)

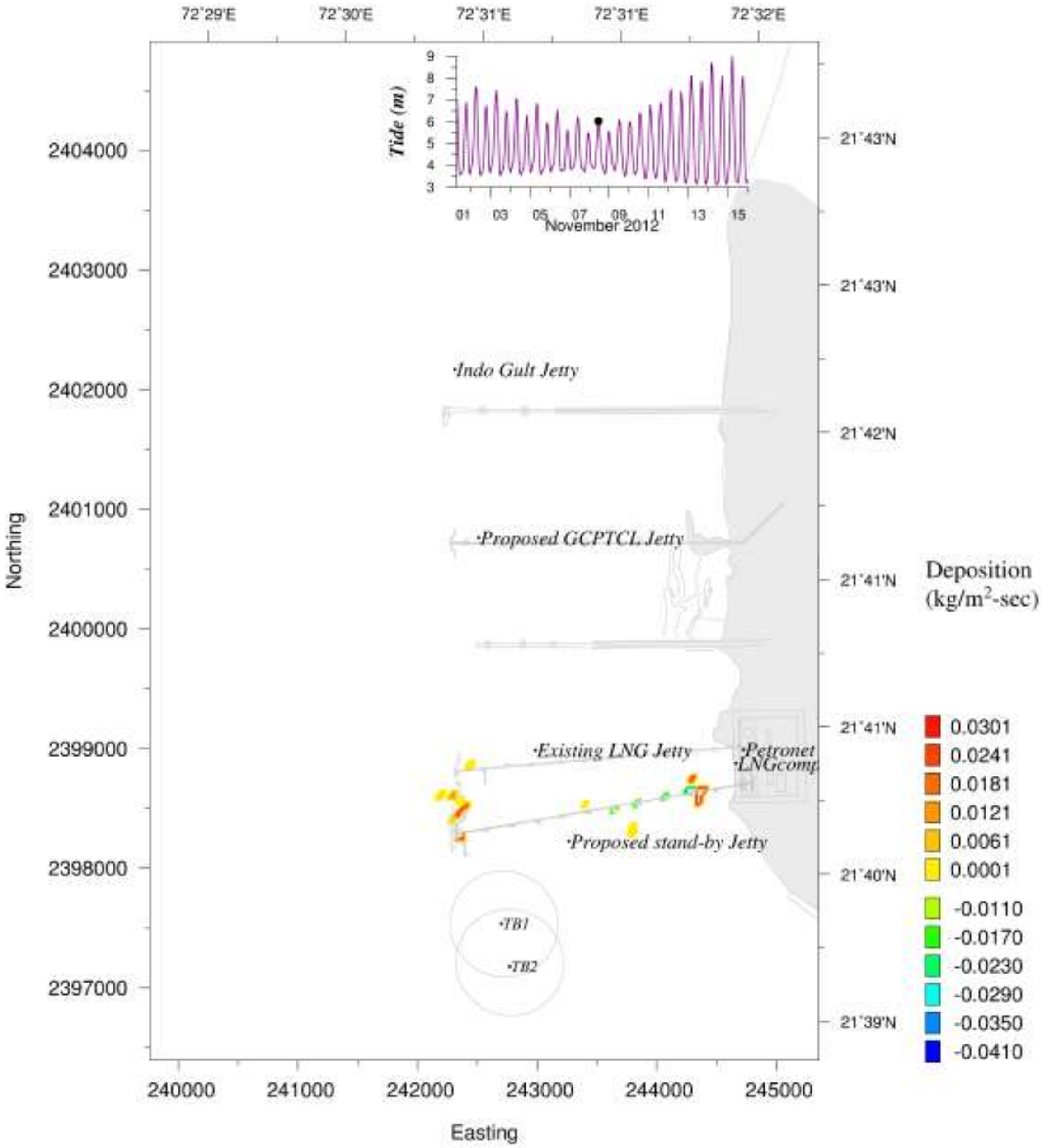

Fig.A7.19 Difference in sediment deposition between before and after developments during HHW of neap tide (Nov 2012)

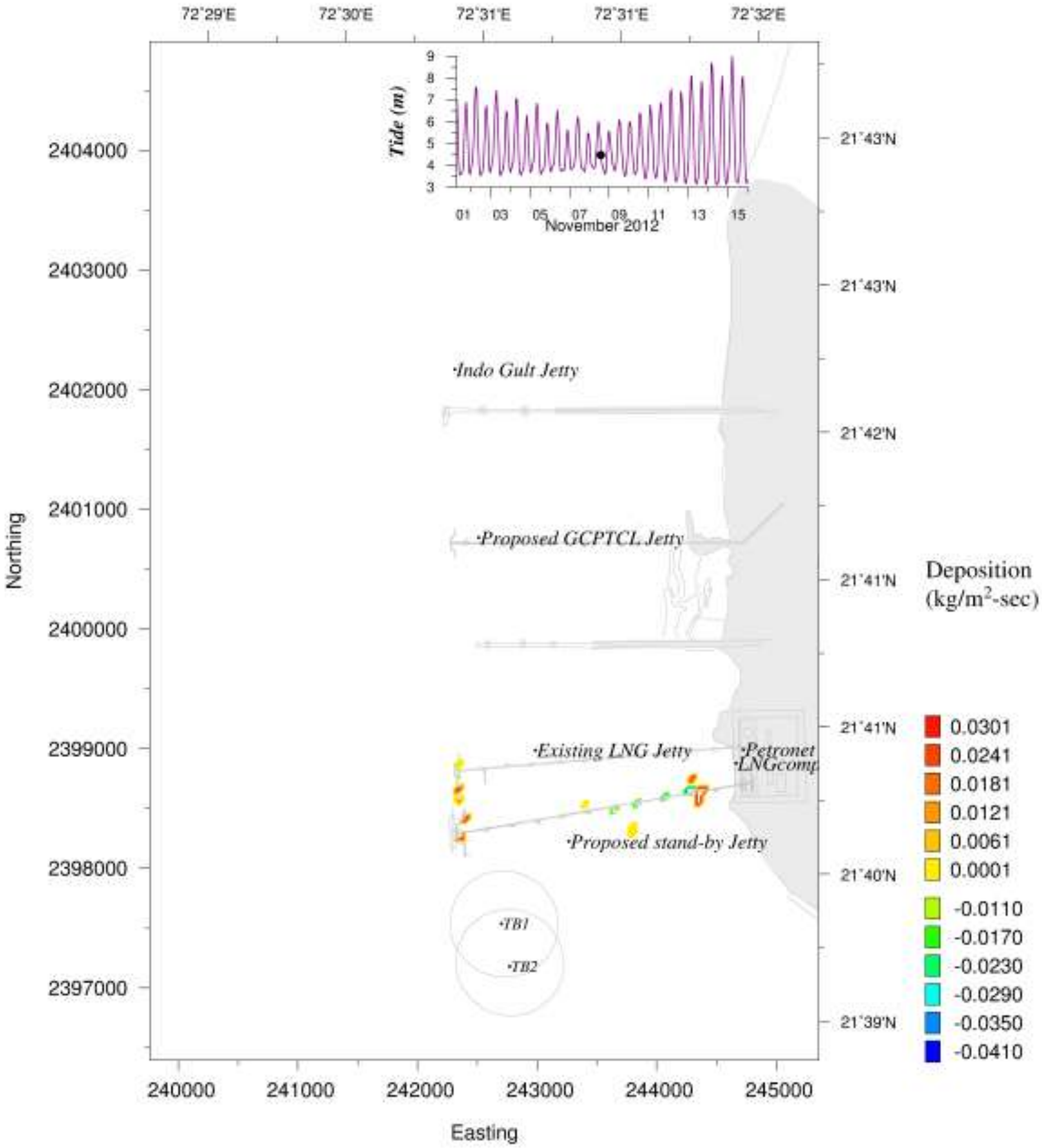

Fig.A7.20 Difference in sediment deposition between before and after developments during Peak EBB of neap tide (Nov 2012)

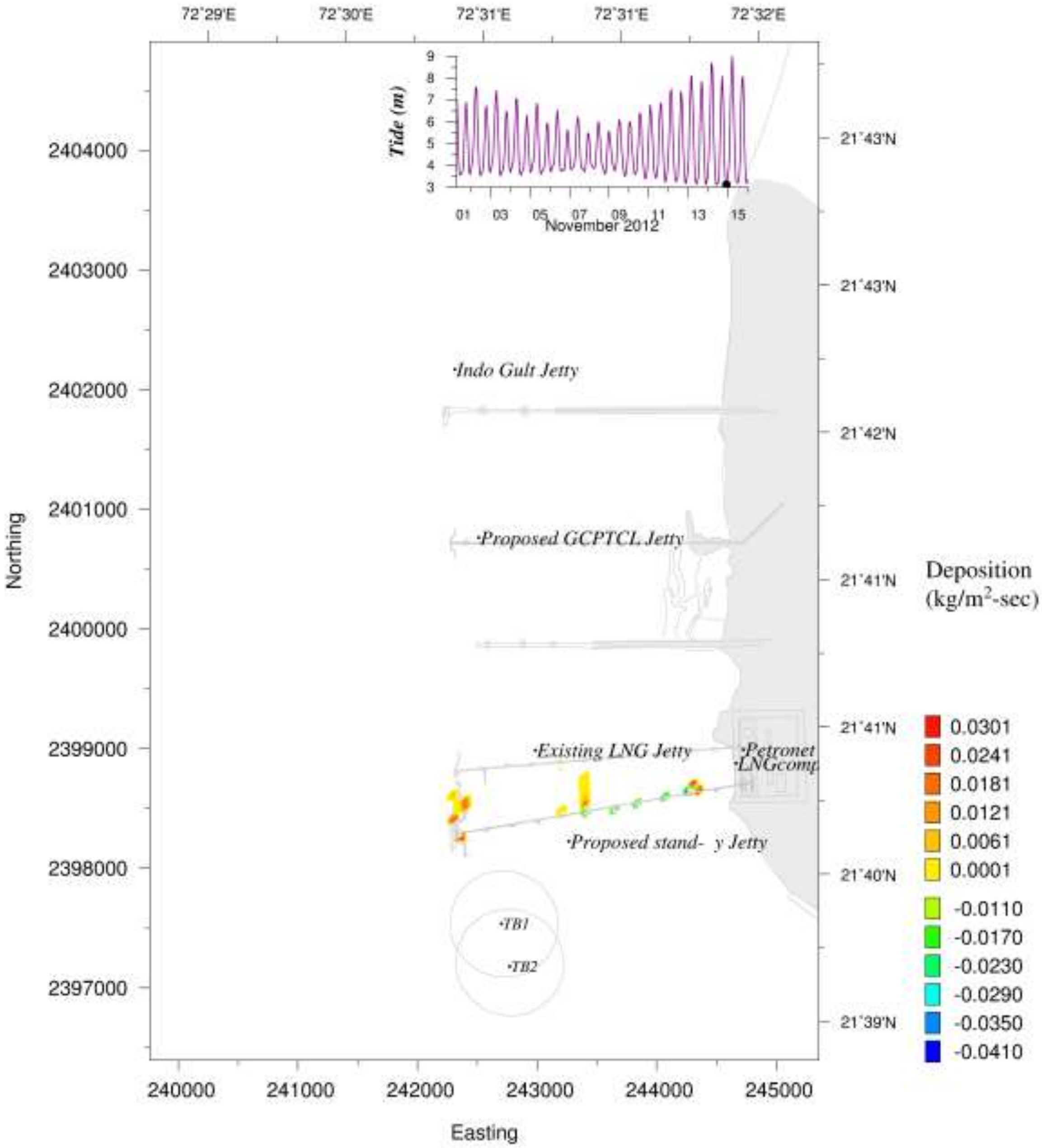

Fig.A7.21 Difference in sediment deposition between before and after developments during LLW of spring tide (Nov 2012)

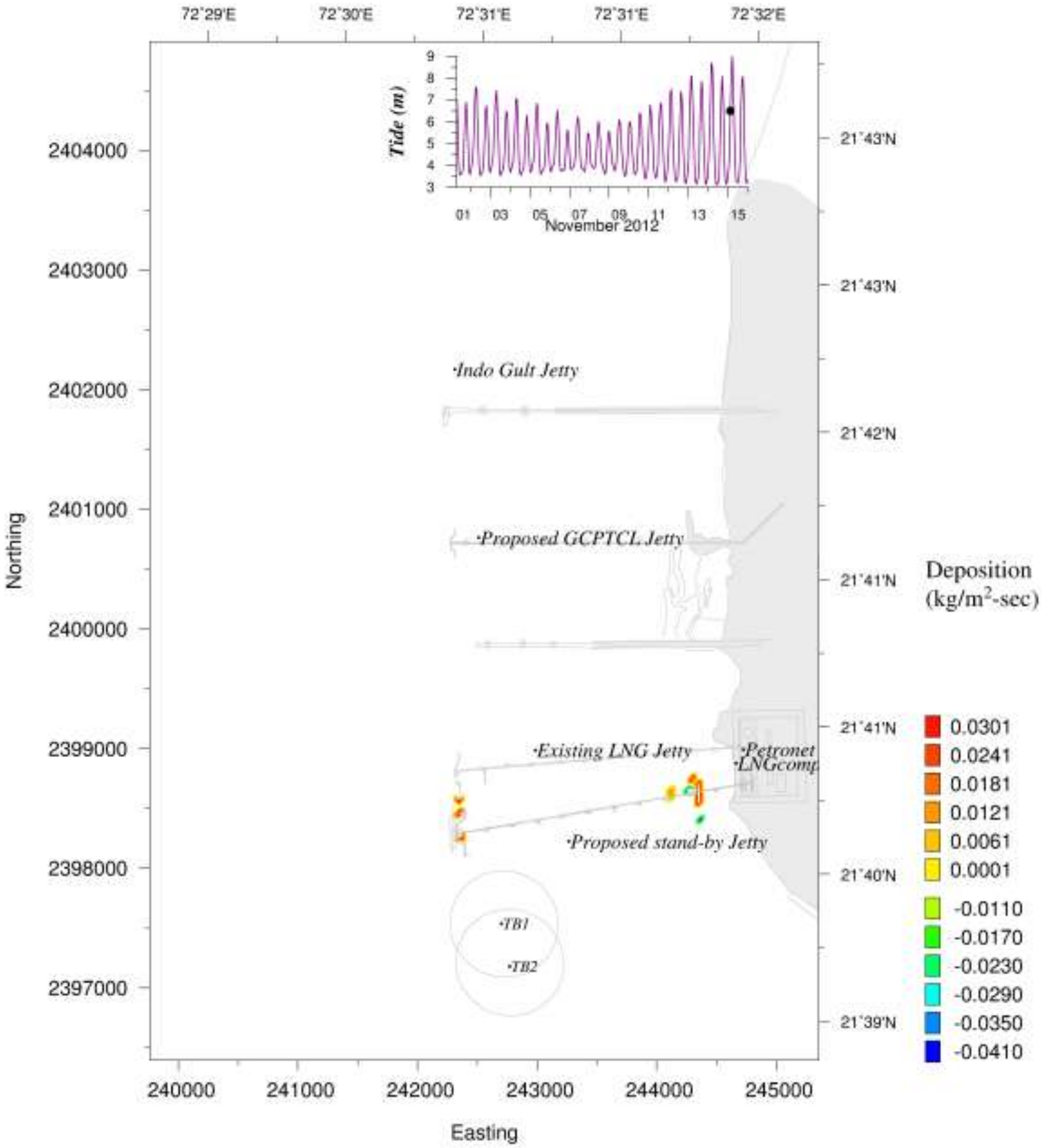

Fig.A7.22 Difference in sediment deposition between before and after developments during Peak Flood of spring tide (Nov 2012)

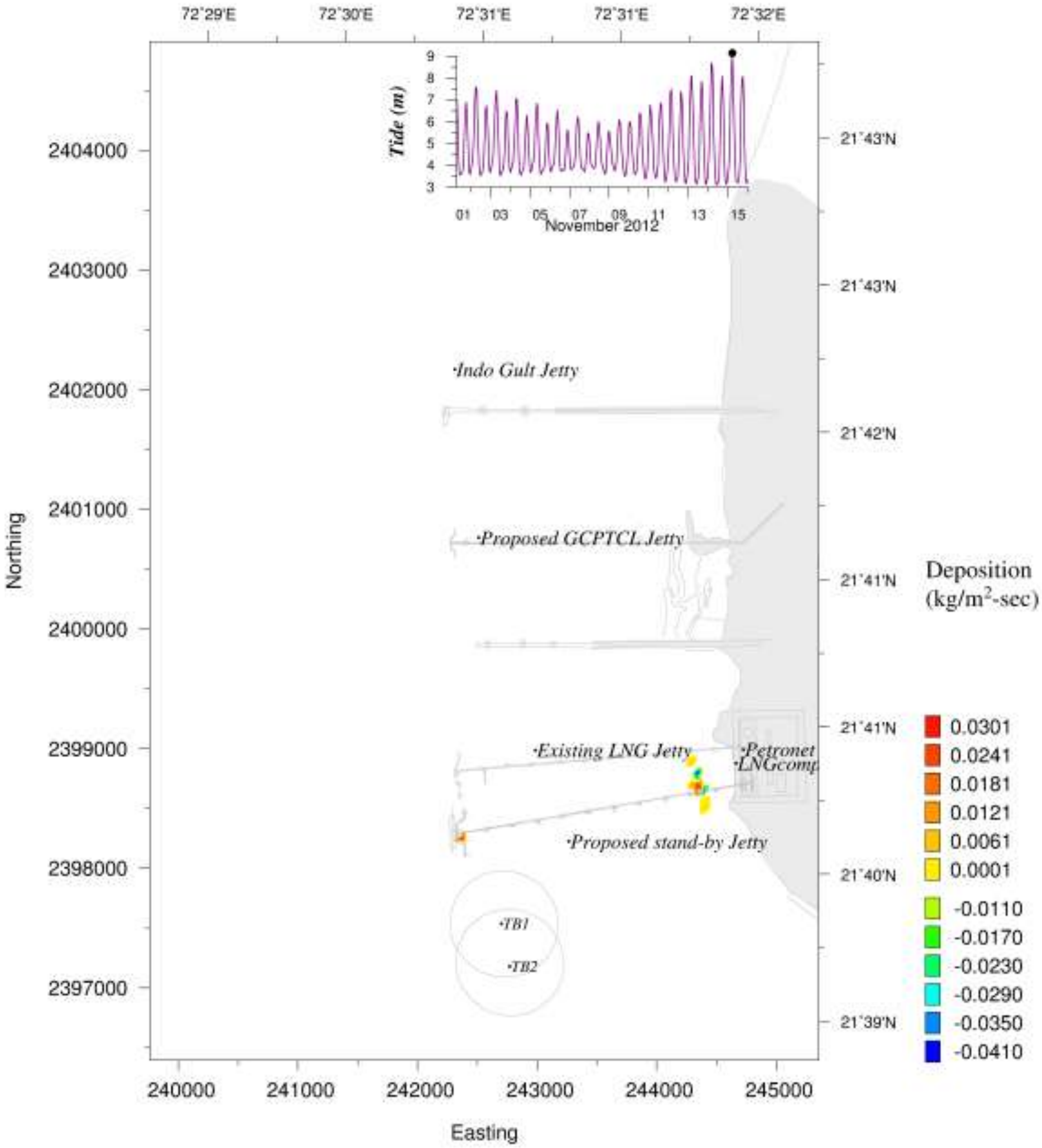

Fig.A7.23 Difference in sediment deposition between before and after developments during HHW of spring tide (Nov 2012)

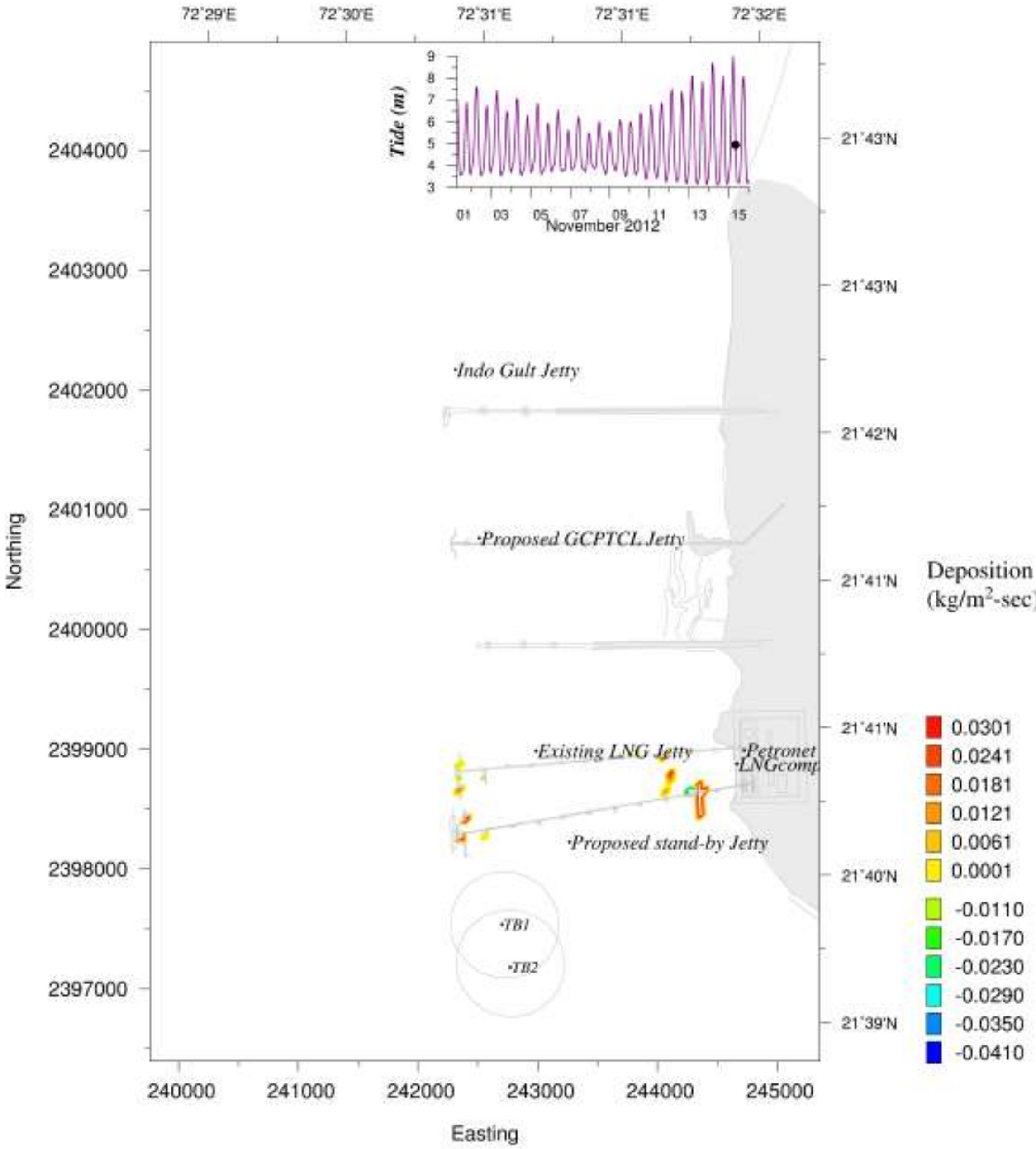

Fig.A7.24 Difference in sediment deposition between before and after developments during Peak EBB of spring tide (Nov 2012)

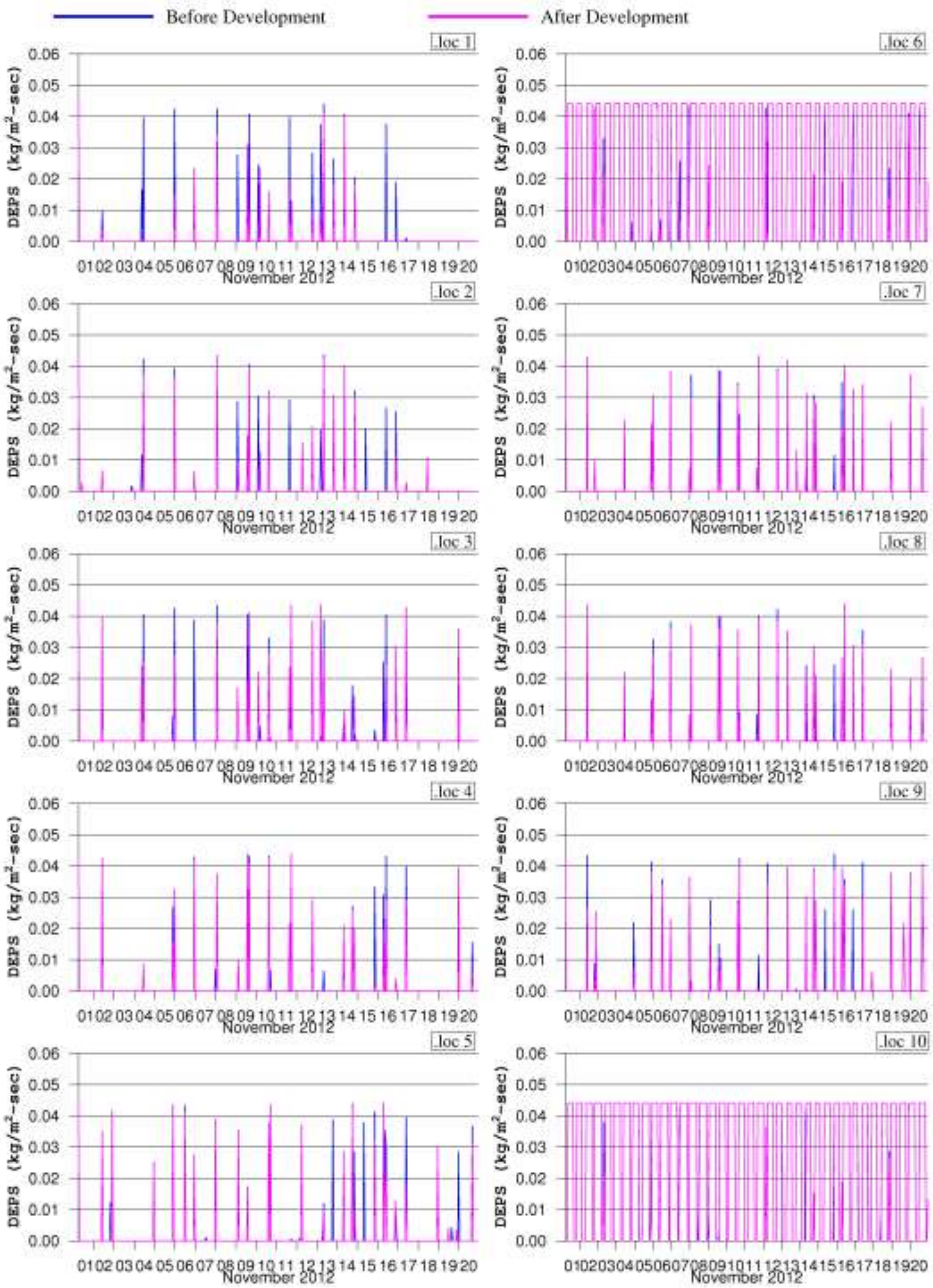

Fig.A7.25(a) Comparison of sediment deposition before and after development (Nov 2012)

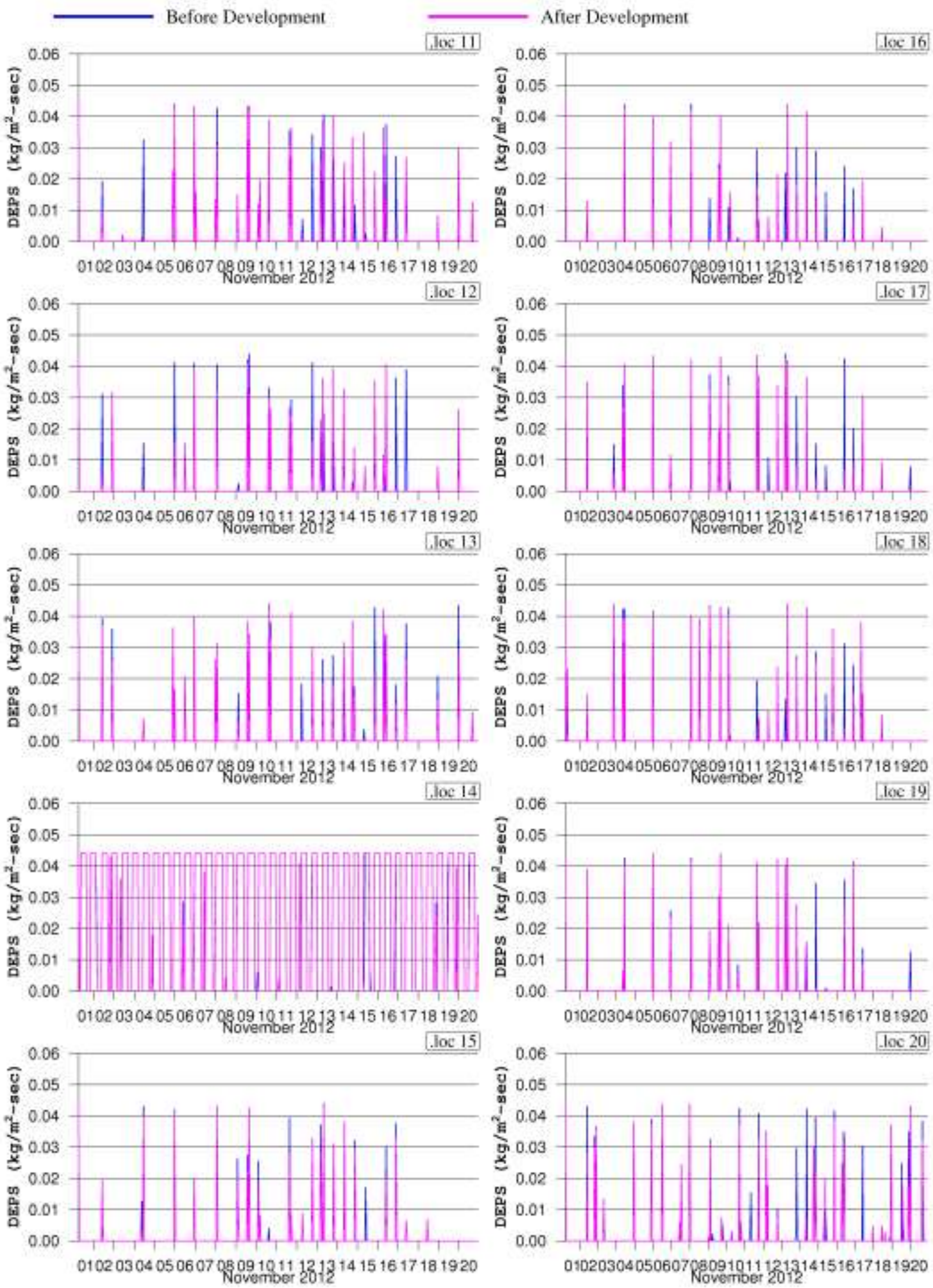

Fig.A7.25(b) Comparison of sediment deposition before and after development (Nov 2012)

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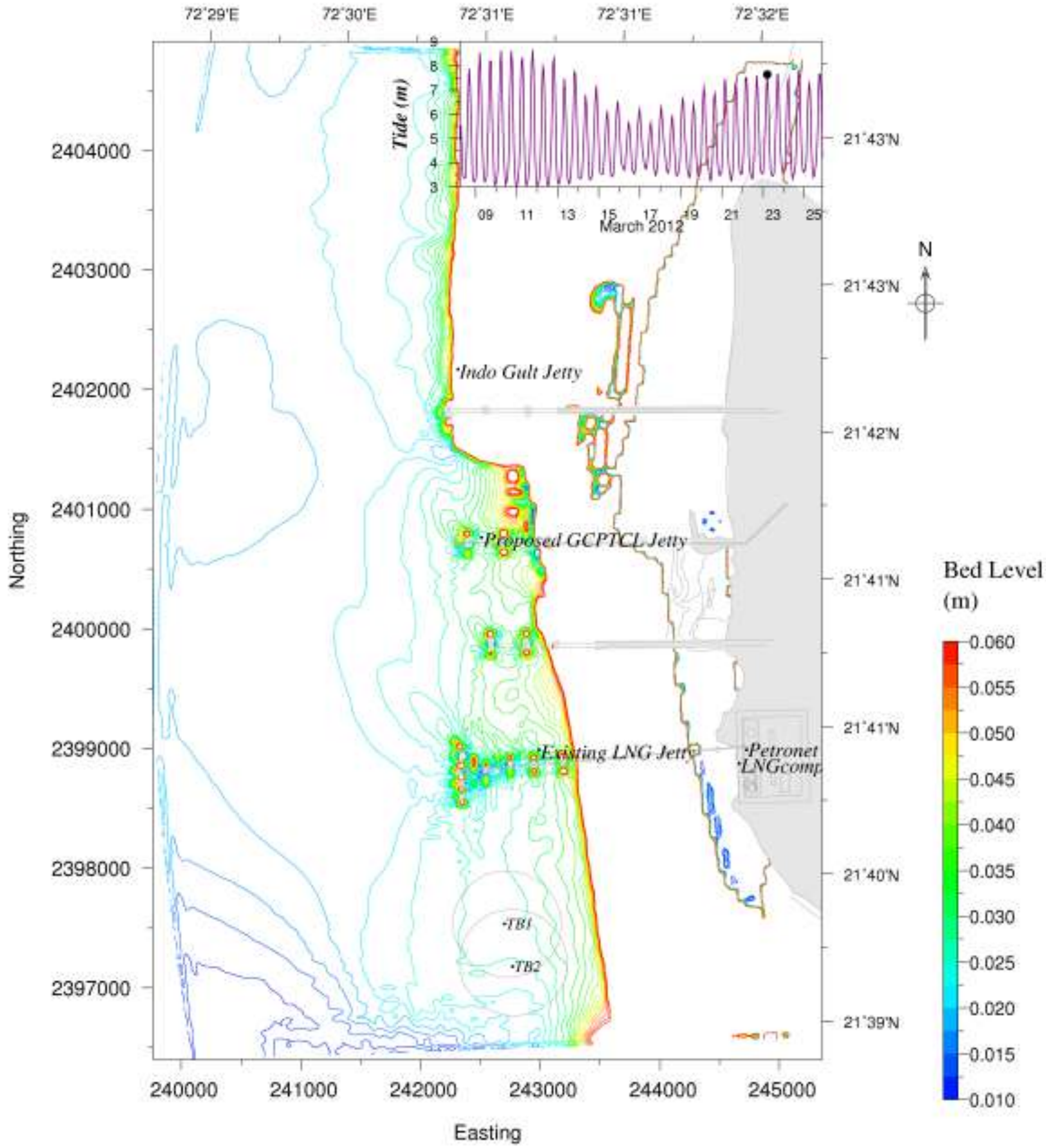


Fig.A8.1 Bed levels after 15 days – March 2012 (Before Development)

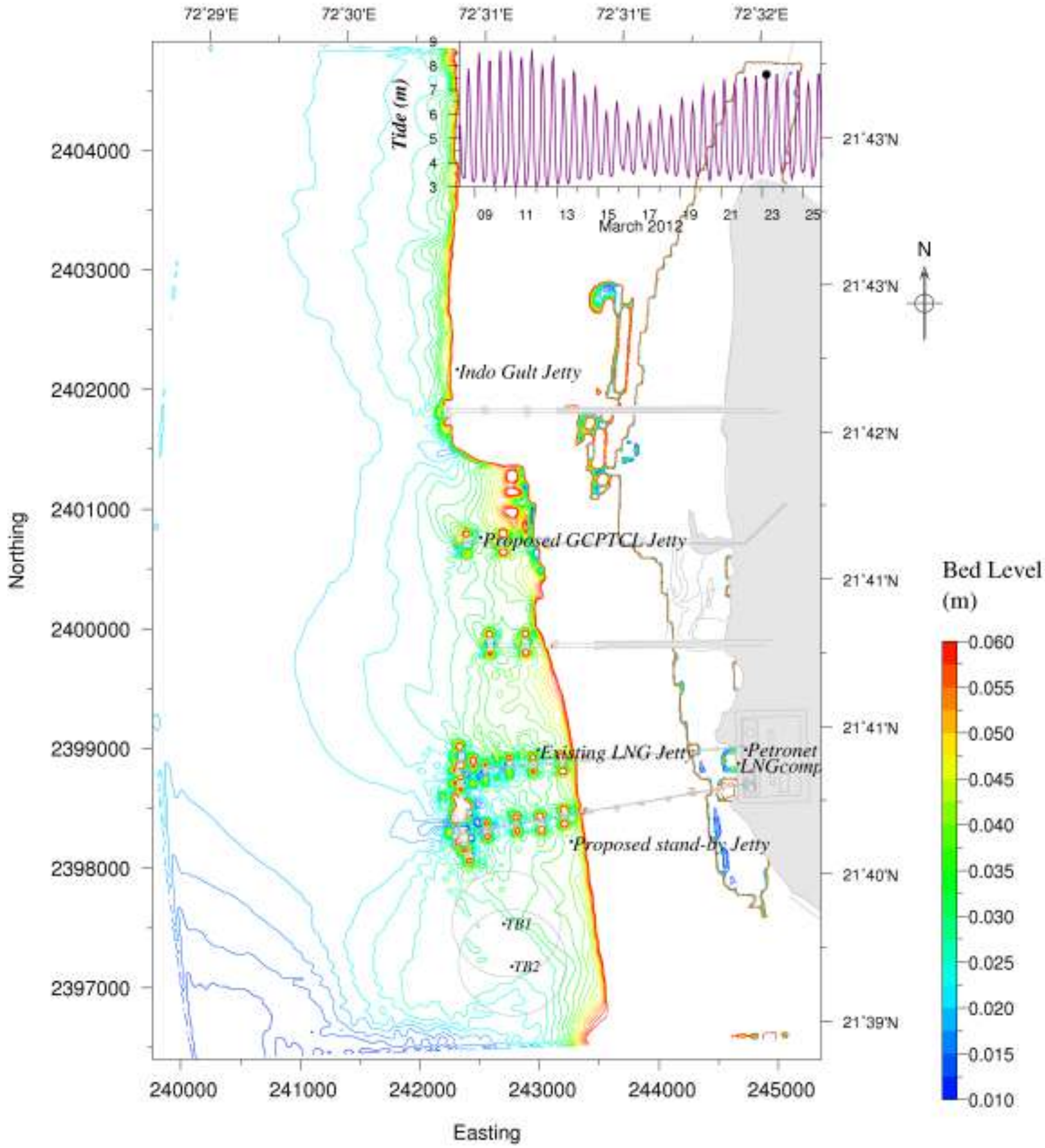


Fig.A8.2 Bed levels after 15 days – March 2012 (After Development)

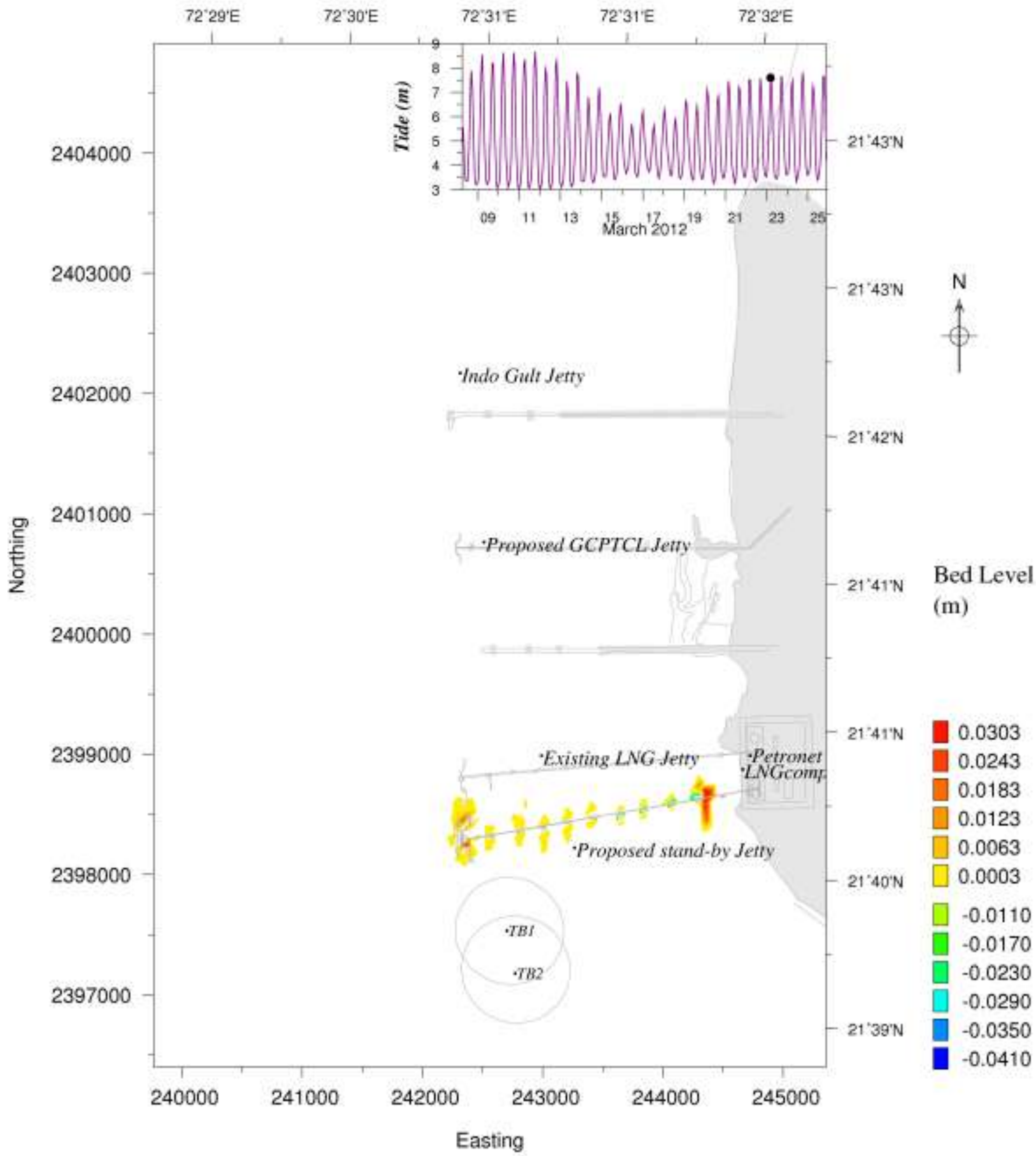


Fig.A8.3 Difference in Bed level between before and after developments (after 15 days) - March 2012

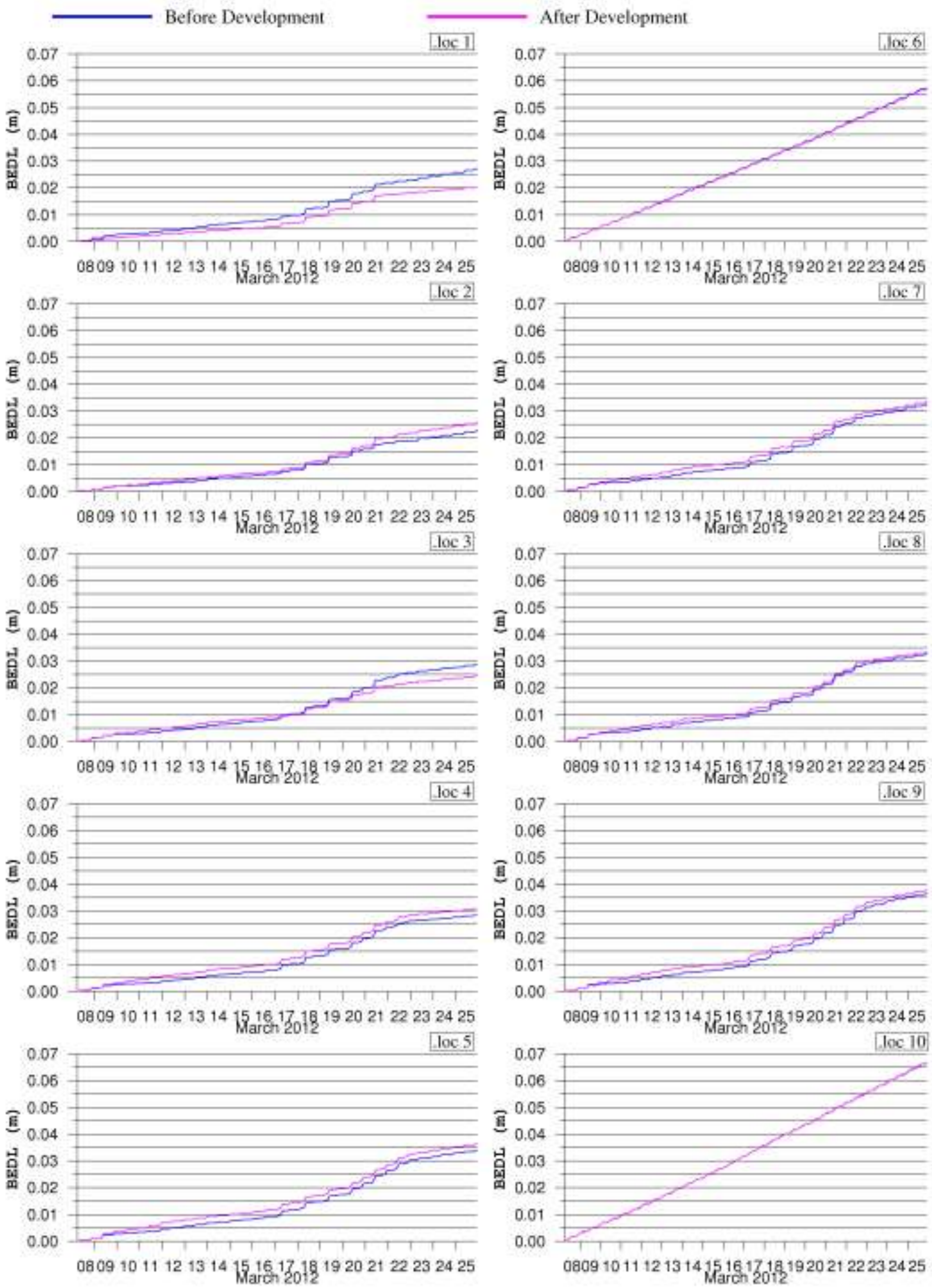


Fig.A8.4(a) Comparison of Bed levels before and after development (March 2012)

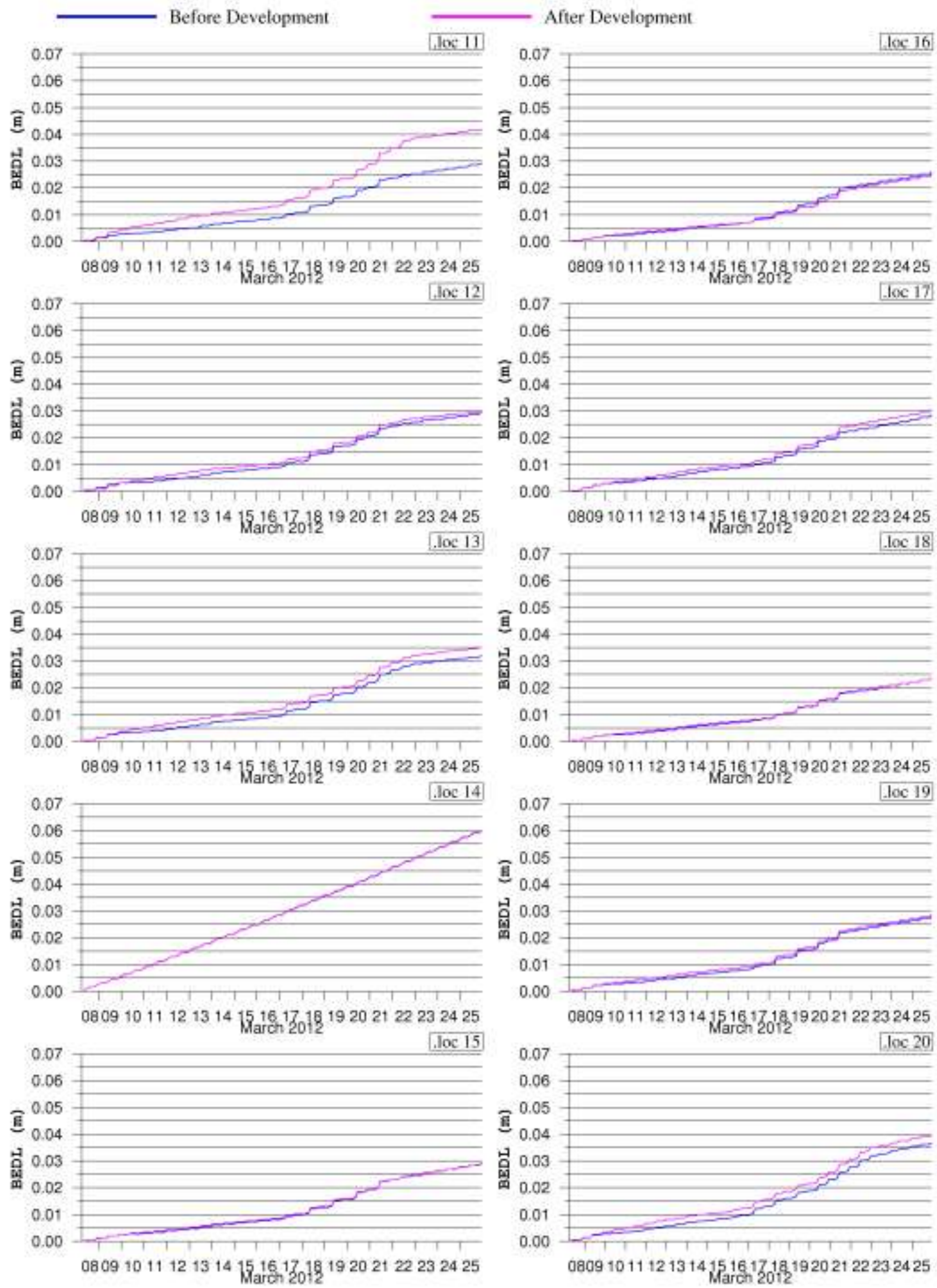


Fig.A8.4(b) Comparison of Bed levels before and after development (March 2012)

ANNEXURE-X
MARINE MODELING STUDIES

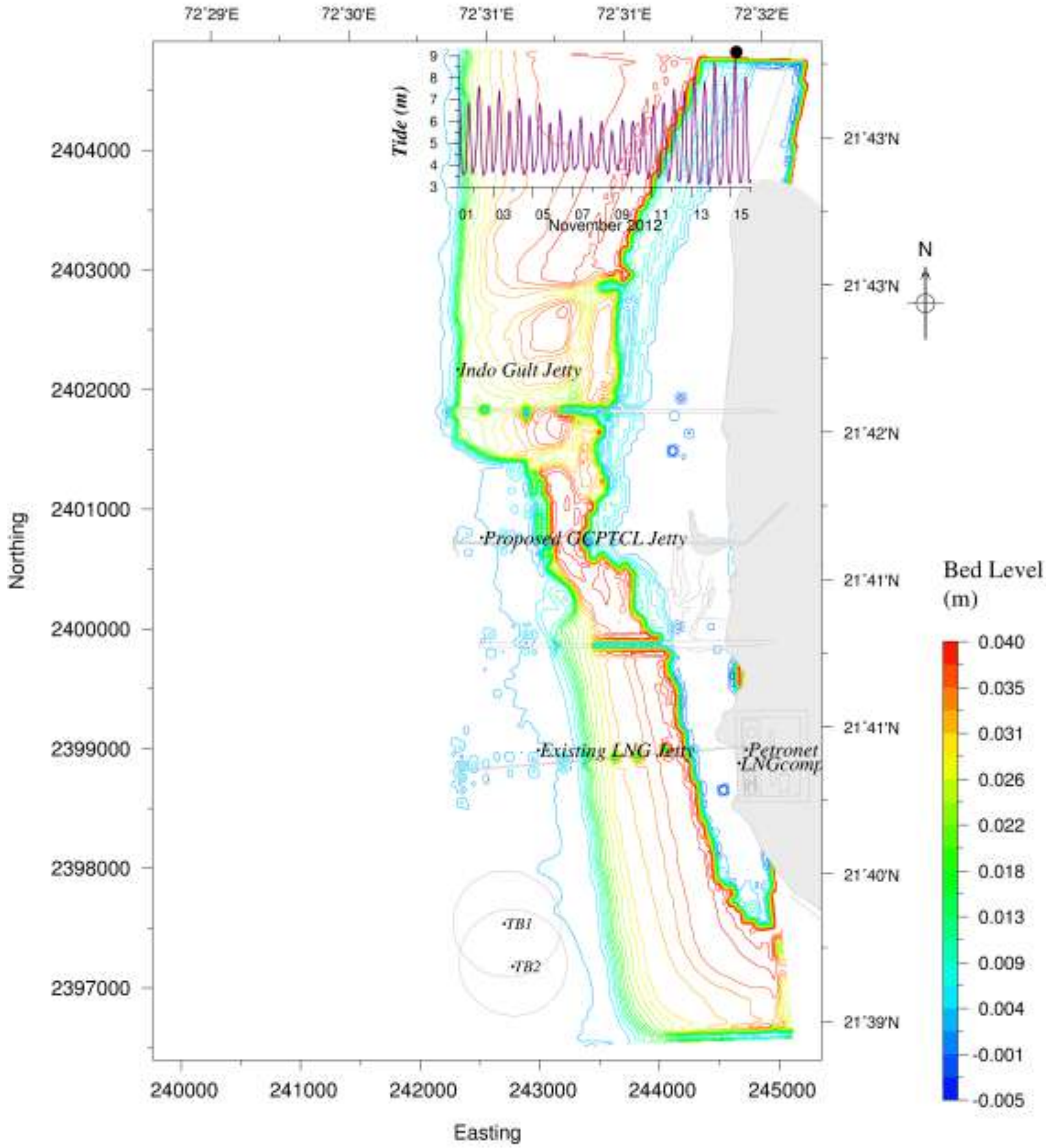


Fig.A9.1 Bed levels after 15 days – November 2012 (Before Development)

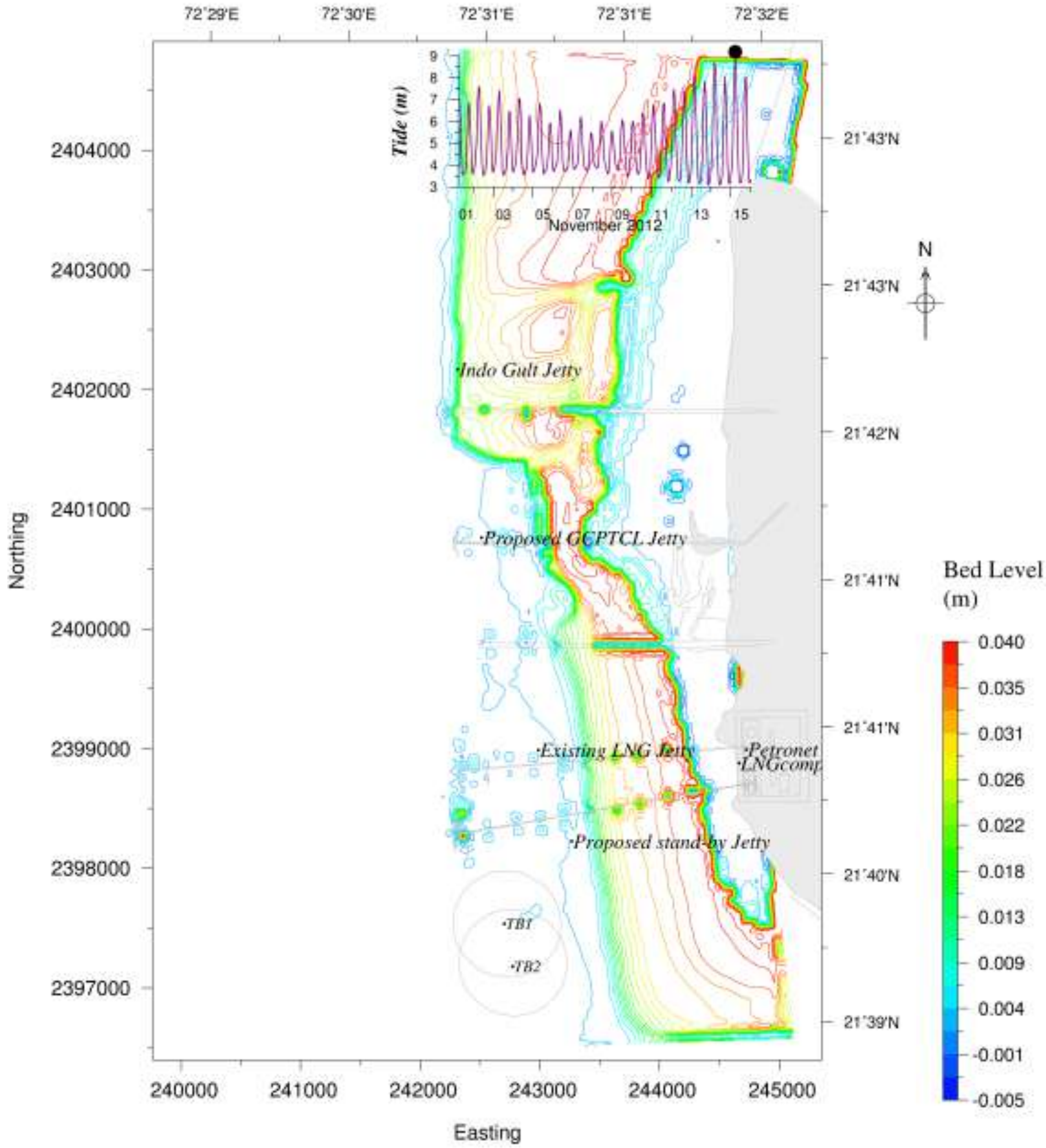


Fig.A9.2 Bed levels after 15 days – November 2012- November 2012 (After Development)

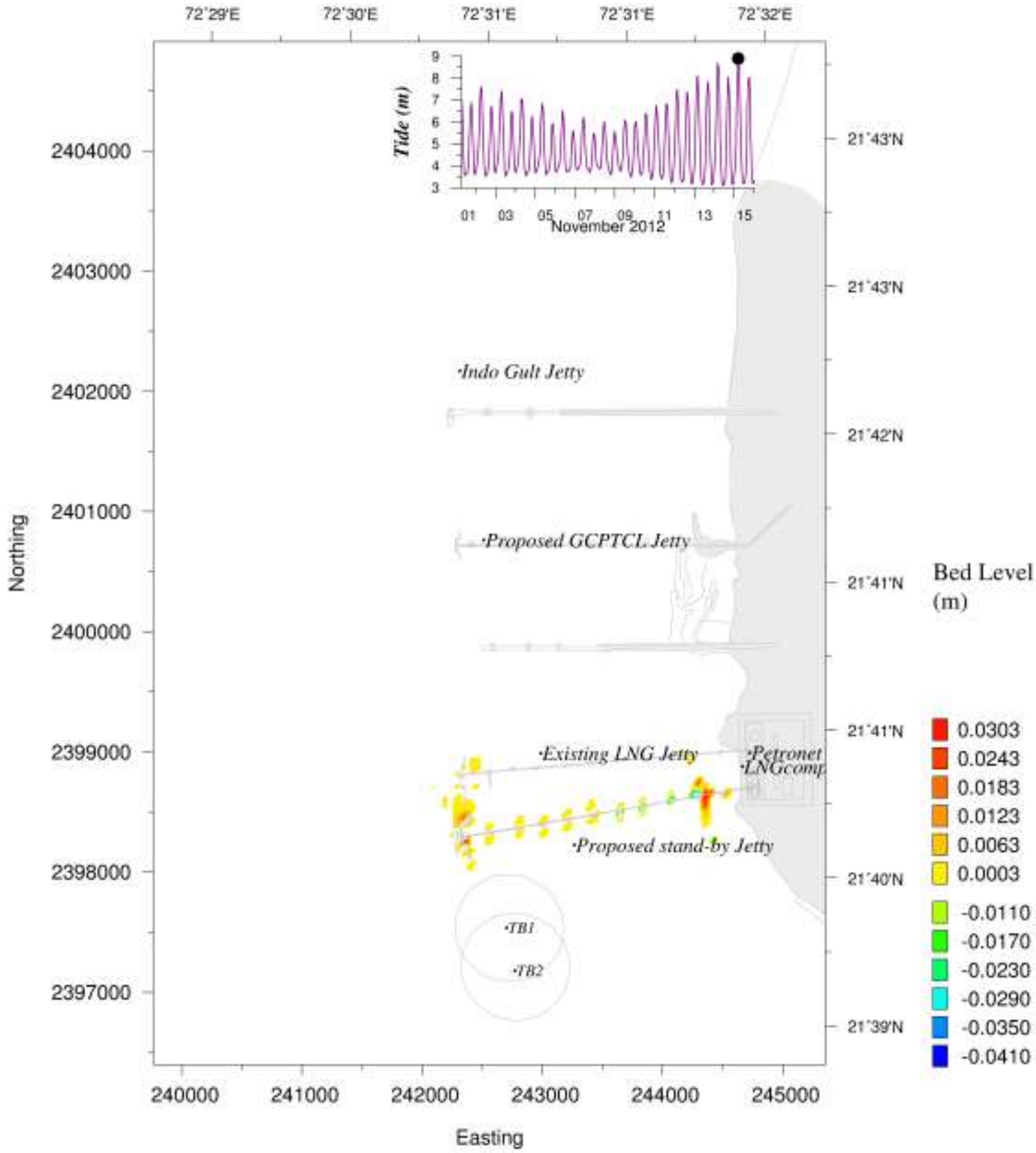


Fig.A9.3 Difference in Bed level between before and after developments (after 15 days) - November 2012

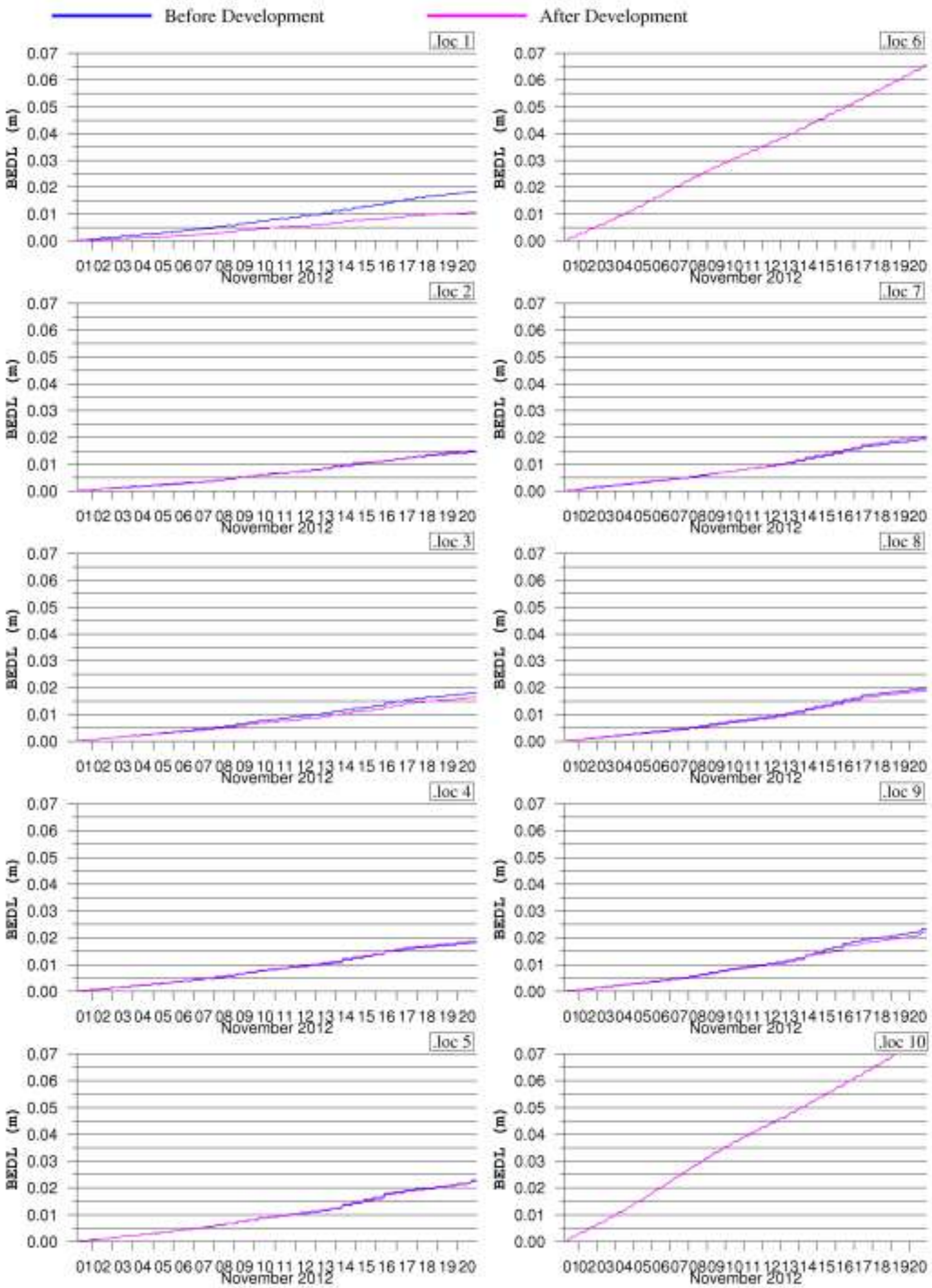


Fig.A9.4(a) Comparison of Bed level before and after development (November 2012)

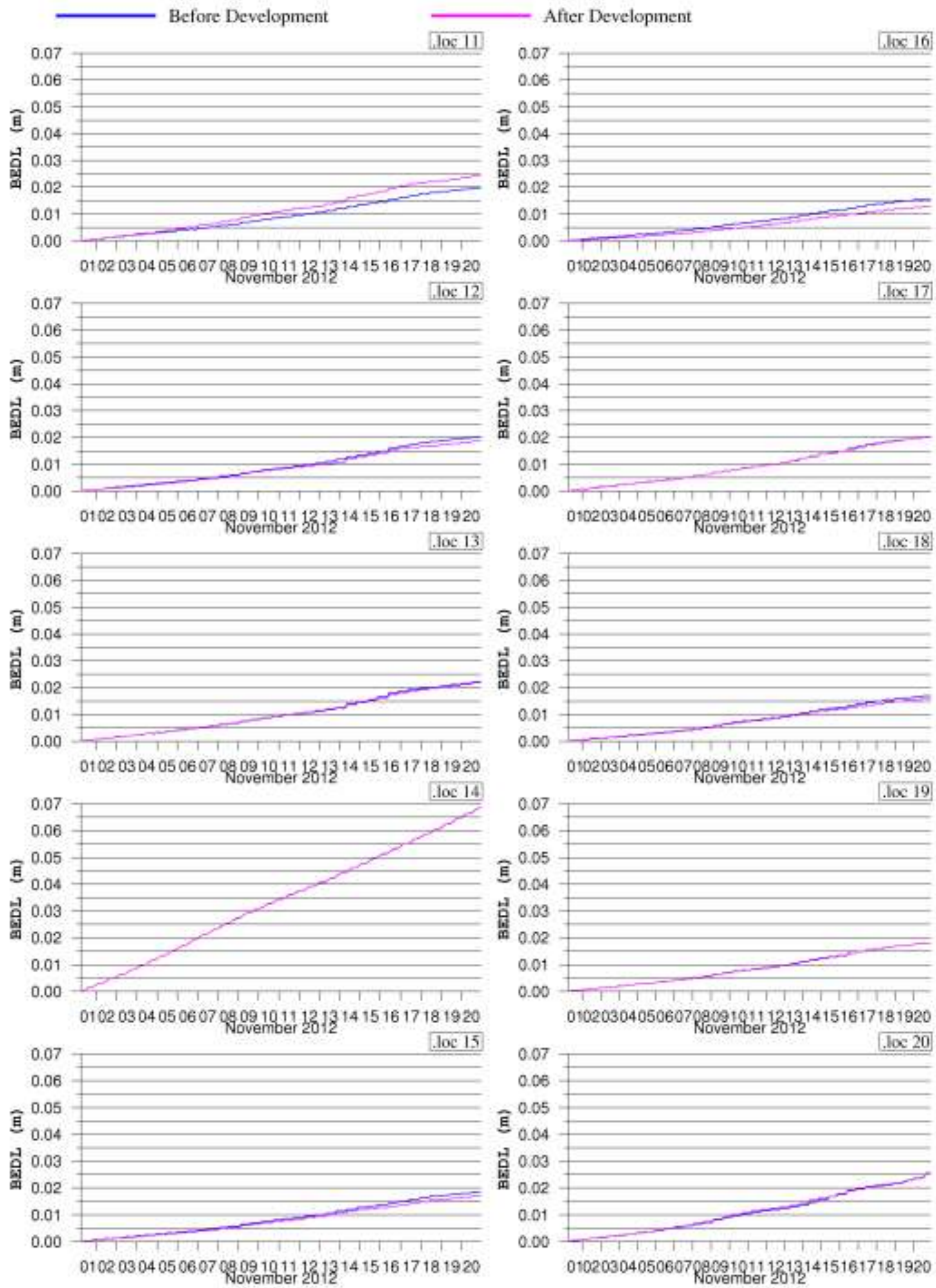


Fig.A9.4(b) Comparison of Bed level before and after development (November 2012)

ANNEXURE-XI
QHSE POLICY

PETRONET LNG LIMITED

QUALITY, HEALTH, SAFETY AND ENVIRONMENT POLICY

Petronet LNG Limited, Dahej Terminal is committed to manage all operations in a manner that protects the environment and the health & safety of employees, customers, contractors and the public. To accomplish this, we will:

- **Safeguard the interest of Environment. Life & Property and pursue highest standards of QHSE performance.**
- **Receive, Process and supply LNG to meet the needs and expectations of the customers so as to enhance their satisfaction.**
- **Comply with all applicable legal and other requirements related to Health, Safety, Environment and product quality.**
- **Upgrade on technology, Skills, processes & knowledge of our coworkers and strive continually for improvement in process effectiveness, customer satisfaction, preventing pollution and providing a safe healthy working environment.**
- **Inculcate Safety, Health, Environment and Quality Awareness among all employees, contractual workers and stakeholders through participative culture for Cleaner, Greener, Safer and better organization.**
- **Effectively implement the QHSE system, constantly review the set objectives, provide resources and improve on its performance.**

This policy shall be communicated to all employees of Petronet LNG Limited, public and interested parties. PLL will remain committed to the protection of Health, Safety and Environment *for ever.*

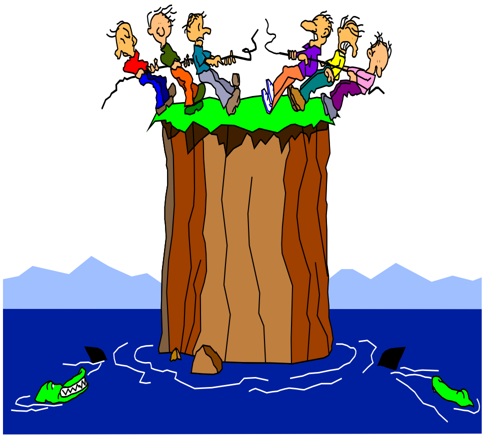
Date: 01.10.2005

P. Dasgupta
MD & CEO

ANNEXURE-XII
DISASTER MANAGEMENT PLAN

ON-SITE

EMERGENCY RESPONSE PLAN



To safeguard the health and safety of employees and neighbours alike, a force stands in constant readiness, trained and equipped to handle any emergency from any quarter. Response to an emergency involves planning and practice well in advance of a potential incident.

EMERGENCY CONTACT NO. 101 / 102

PETRONET LNG LTD., DAHEJ

ANNEXURE-XII
DISASTER MANAGEMENT PLAN
INDEX

ANNEXURE-XII
DISASTER MANAGEMENT PLAN

1. INTRODUCTION

1.1 Background

Petronet Dahej LNG Terminal stores and regasify Liquefied Natural Gas (LNG) for export to the GAIL transmission system. LNG/NG leakage and fires/explosion can pose great risk to personnel, plant and offsite facilities. With a view to bring about improvements in the matter of Safety, Health and the Environment, the Government of India mandates the development of Emergency Response Plans (ERP) by the companies that are handling hazardous materials. In the light of the above, the ERP is prepared to mitigate against damage to health and environmental damages from fires, explosions & toxic releases etc.

1.2 Emergency

An emergency is an uncontrolled event that could lead to a disaster that would result in significant loss to life, equipment or the environment.

1.2.1 Types of Emergency

1. Natural Calamities
   - Earthquake
   - Cyclone
   - Flood
2. Man Made
   - Civil disturbance
   - War
   - Riots
   - Industrial
3. Man made emergency, which are encountered in any industry are
   - Fire
   - Explosion
   - Gas leak
   - Poisoning (liquid, gaseous and or chemical poisoning)
   - Those arising out of abnormalities in operation, maintenance, start up / Shutdown, failure of equipment and use of sub-standard / wrong material
   - Civil commotion and armed conflicts
   - Sabotage
   - Road accidents involving hazardous / toxic / radioactive / corrosive chemicals

1.2.2 Level of Emergencies:

Classification of Level of Emergencies as well as Management:

Level 1 Emergency:

The Emergency, which can be managed / controlled on site with the sources of factory concerned in accordance with the On Site Emergency plan.

Level 2 Emergency:

The Emergency, which can be managed / controlled by the concerned factory with mutual aid arrangements and outside resources.

Level 3 Emergency:

The Emergency, which will spread over to Off Site (out side factory) and require actions from the Off Site Emergency i.e. Local Crisis Group & District Crisis Group.

Level 4 Emergency:

The Emergency, which will require assistance and help from the State Government and Central Government.

1.3 Emergency Response Plan

The Emergency Response Plan identifies the type of incidents that are typical of an LNG terminal, the actions to be taken to manage these incidents and the roles and responsibilities of key personnel.

1.4 Purpose of the Plan

The purpose of the emergency response plan is to identify the emergency scenarios that are likely to occur, to evolve pre-planned responsibilities and actions required and to train all persons at site through regular mock drill exercise using this document.

1.5 Scope of the Plan

Risk scenarios identified based on Quantitative Risk Analysis (QRA) carried out during design stage and accident history experience in LNG industry will be the basis of emergency response plan.

2. DESCRIPTION OF THE FACILITY

2.1 Description

The Petronet Dahej LNG Terminal is designed for an annual throughput of 10 million tons of LNG (liquefied natural gas). The LNG is delivered by membrane type LNG tankers having a maximum cargo capacity of 138,000 m^3. This is imported into the Terminal via the jetty head by means of two 30”, 2.3 kilometre long unloading lines. The maximum import rate is 10,000m^3/hr.

The LNG is stored in four specially constructed 148,000m^3 storage tanks at a temperature of (-)160 deg. C and at pressures up to 250 mbarg pressure. The inner tanks are constructed from 9% Nickel steel with an outer pre-stressed concrete shell. Each tank has 3 submerged canned type pumps rated at 520 m^3/hr. When there is no LNG import taking place, LNG @ about 400m^3/h from LP LNG pump discharge is circulated around the jetty loading lines to keep them cool and ready for the next importation. With LNG being held at its boiling point, boil off gas is generated as a consequence of heat ingress to the tanks. During LNG import most of this gas is returned to the tanker via Boil off Gas (BOG) Compressors via a 10" line to the jetty head. During send out, boil- off gas is re-condensed to prevent flare losses. If there are no BOG Compressors available, a high level flare is available for the safe disposal of this gas.

For send out operation, LNG is pumped by the in-tank pumps to the suction of the HP LNG pumps at rates corresponding to send out requirement & 7 to 8 barg pressure. Further the LNG pressure is raised to about 90 barg by 10 numbers HP LNG pumps. This high pressure LNG is vaporised via 14 shell and tube vaporizers (STV), one hot water STV and 4 submerged combustion vaporisers (SCV) to produce natural gas for exporting to GAIL at pressures up to 90 barg. HP LNG pump throughput is 1142 TPH at nominal terminal capacity of 10 MMTPA.

For transporting LNG by road tankers, a side stream from In-tank LNG pumps is routed to Truck Loading Facility where LNG is loaded into semi trailers through LNG hoses.

Power for the Terminal is generated on site by four Gas Turbine Generators (GTG) & one GTG as standby with power generation capacity of 7.1 MW maximum each. Hot water circulating through the heating coils of the GTG exhaust ducts is fed to the SCV tanks to provide heat recovery which is supplemented by the use of submerged gas burners. In addition to the 5 GTG, there is an Emergency Diesel Generator (EDG) capable of producing 1500 KW of power. This power is sufficient to keep all essential services operable. The diesel for the EDG is stored in a storage tank with capacity of 58.3 m^3 maximum.

2.2 The main sections of the Terminal are:

- LNG Unloading System
- LNG Storage Tanks and LP Pumps
- LNG Recondenser and BOG Compressors
- LNG Truck loading Facility
- LNG HP Pumps
- LNG vaporizers
- Gas Metering
- Vent and Flare System
- Glycol / Water System
- Hot Water System
- Diesel Fuel Storage and Distribution
- Drainage and Effluent Treatment
- Nitrogen System
- Instrument and Plant Air System
- Electrical Power Generation, Heat Recovery & Substation
- Potable and Industrial Water System
- Fire Water Pump house

2.3 Description of Fire, Gas and Spill Detection

ANNEXURE-XII
DISASTER MANAGEMENT PLAN

The Fire, Gas and Spill Detection facility installed on this LNG Terminal identifies following areas for constant monitoring. These Areas are:

- Jetty Head
- Trestle and Unloading Drain Drum
- LNG Tank T-101 / 102 /103 / 104
- Recondenser
- LNG HP Pumps
- BOG Compressors
- LNG Truck Loading Skid
- Shell and Tube vaporizers A to G in phase-1
- Shell and Tube vaporizers A to H in phase-2
- Process Drain Drum
- Submerged Combustion vaporizers
- Fuel Gas Heater
- Metering Station
- Pig Launcher and Metering

The area identification, other than Truck Loading Skid, is displayed on a mimic panel in the Main Control Room (MCR). Dependent upon the risks in that area various detection devices are located in the plant areas to detect gas leak, fire or LNG spill. For gas leak detection alarms at 20% and 60% LEL are sounded in the MCR. The gas detectors are catalytic and will lead to emergency alarm / shutdown via 2 gas detectors sensing 60%LEL voting system. The fire detectors are of the UV/IR type and any two of which in a given plant area will automatically activate that area's firewater deluge system.

LNG truck Loading Facility has a dedicated PLC. The TTLF-ESD is caused under following conditions:

- Signals from two detectors of identical type.
- Signals from two detectors of different type.
- Initiation of manual Call point.
- ESD of main plant.

Further, signals of 60%LEL gas detection stop LNG filling operation.

LNG spill detection is provided in the following areas:

- Jetty platform
- Unloading line LNG Drain Drum pit
- LNG Tank T-101 / 102 /103 / 104 annular space
- BOG Compressor Suction Drum and Drain pit
- Process Area LNG Drain Drum pit
- BOG Recondenser
- LNG HP Send out Pumps
- LNG Truck Loading Skid

Buildings are protected by smoke detectors being installed in all rooms, cable trenches and sub-floor areas. If fire is detected in a building, common alarm is activated on the Fire alarm system panel as well as in FGS system in control room and fire station.

In addition to the above the plant area and buildings have Manual Call Points installed at strategic locations.

2.4 Description of Fire Protection System

2.4.1 Fire Water Pumps and Jockey pumps

18,000m^3 of industrial water is stored in two firewater tanks T-1001 A/B. Minimum amount of firewater available to fight a fire is 16,800m^3 which is sufficient to fight the worst case fire for up to 4 hours for two major fire. A 10" pipe supplies industrial water from GIDC at a rate of 144m^3/hr to the firewater storage tanks. Also condensate water from Air heater is being used as makeup.

There are two 125 m^3/hr electric Firewater Jockey Pumps deigned to keep the fire main pressurised to 14 kg/cm^2. On a falling fire main pressure the lead jockey pump will automatically cut in at 13 kg/cm^2 to return the fire main to its normal pressure. Should the lead jockey pump fail to start then the second pump will automatically start after 30 seconds. Should any main fire water pump start then all jockey pumps are automatically stopped. The jockey pumps can be started manually from their local control panels.

Should the fire main pressure continue to fall the four diesel driven firewater pumps rated at 1088 m^3/hr, automatically start sequentially at 12.0, 11.5, 11.0 and 10.5 kg/cm^2 respectively. The diesel firewater pumps can be started from either from local or MCR FGS panel but can only be stopped locally. Each diesel driven pump has its own fuel tank with up to 8 hours fuel supply available.

There are two 1050 m^3/hr electrically driven firewater pumps also available. In the automatic mode they cut in at a fire main pressure of 10 kg/cm^2. These pumps can also be started manually from either local or MCR FGS panel but can only be stopped locally.

The firewater pumps system is designed to supply firewater at a minimum pressure of 7 kg/cm^2. Double headed fire hydrants are provided around the processing area at 30 metre intervals. Hose boxes are located at the same position each containing two x 15m 2½" hoses with branch pipe with nozzle and a universal nozzle rated at 54 m^3/hr at 7 kg/cm^2. Similar facilities are also available at various buildings.

2.4.2 Jetty Head Facilities

Two tower mounted remote controlled monitors are installed at the jetty head on 15m towers. Their discharge capacity is 360m^3/hr at 7 kg/cm^2. They are combined fog / jet 360 deg. with locking device and -90 to+90 deg. elevation angle. Their effective throw is 80 m horizontally. Both tower monitors can be operated either from the main panel located in the jetty control room or from the slave panel on the jetty head lower deck. Four double headed hydrants with hose box and accessories are also provided.

2.4.3 Firewater Deluge System

Medium velocity fixed water spray facilities, which are automatically activated on detection of a fire by two separate sensors or by manual from the FGS panel in the MCR, are installed at the following locations:

- BOG Compressor Suction Drum
- BOG Compressors
- Recondenser
- HP LNG Send out Pumps
- Metering piping
- Fuel gas electric and ambient heaters
- STV structure
- SCV area
- LNG manifold (jetty area)
- LNG Drain Drum
- Diesel oil tank
- Electrical transformers above 5MVA

For Truck loading skid, single flame detection initiates.
Manual spray facilities are also provided for the LNG Drain Drums.
Dense water curtains are also provided in the following locations:

- Jetty face and personnel access route
- HP LNG Pump shed
- BOG Compressor shed

Activation is automatic via the respective area's two separate flame detectors or manually from the FGS panel in the MCR.

2.4.4 High Expansion Foam

A high expansion foam installation has been installed for the LNG drain pits V-902 and 903 which is automatically activated on the detection of an LNG spill. The foam generators can also be activated from a local control panel or remotely from the FGS panel in the MCR. A foam depth of 1.8m can be achieved within 1 minute with foam storage for 1 hour operation being made available. Foam system will stop after 3 minutes and needs to be manually restarted if required.

2.4.5 Clean Agent System

Clean agent (Inergen) has been provided for the rack, Engineering and UPS rooms in the Main Control Building. It is also provided for the Gas Turbine Generators panel room. These systems are designed for automatic discharge in the event of fire detection. The facility has 100% standby. Highly visible alarms are provided within each of the rooms being protected to give pre-warning of chemical discharge. Alarms are also positioned outside the rooms to indicate that the chemicals have been discharged. Use BA set provided at control room for rescue operations before entering rooms where clean agent has been already released.

2.4.6 Berthing Aid System

Jetty head has been equipped with berthing Aid system which has

1) LASER sensors to monitor ship approach velocity and ship position.
2) To monitor tension in the mooring ropes with over tension alarms.
3) To measure weather conditions such as tide/wind conditions.

2.4.7 Powered Emergency Release Coupler (PERC)

Each unloading arm has been equipped with PERC system for automatic disconnection of arms if arm movement is detected beyond specified limit using position monitoring system. This situation may be possible due to bad weather conditions.

2.4.8 Occupational Health Centre (OHC)

Occupational health centre is equipped to provide medical assistance during emergencies. Round the clock ambulance and medical assistance is available at site. Medical officer (Doctor specialised in industrial accident treatment) is also available on Monday and Thursday.

2.4.9 Safety procedure implemented at jetty

Ship shore safety inspection using checklist is being carried out for every shipment. Testing of emergency shutdown (ESD) is being done before unloading operation of every shipment.

3. RISK ASSESSMENT AND STRATEGY

3.1 Risks Assessed at Dahej LNG Terminal

Major incidents identified for Dahej LNG terminal based on QRA study and historical accident experiences of LNG industry are as follows,

1. Loading arm PERC failure leading to breakage in loading arms and sudden draining of LNG from loading arms and its connected pipelines into seawater. Rapid Phase Transition (RPT) explosion may be possible depending upon quantity of LNG released into sea water.
2. Trestle LNG pipeline failure (may be due to vehicle impact) leading to breakage and sudden draining of LNG from trestle pipelines into seawater. Rapid Phase

Transition (RPT) explosion may be possible depending upon quantity of LNG released into sea water.

3. Pool fire due to LNG leakage in unloading lines flange connection at jetty.
4. Small fire on top of LNG tanks due to flange leakage.
5. Roll over on LNG tanks leading to sudden rise in tank pressure due to abnormal BOG generation.
6. Jet fire in NG high pressure lines.
7. Fire in flare due to LNG entering into flare system.
8. Fire/explosion in submerged combustion vaporizer due to formation of flammable mixture.
9. Pool fire in diesel tank.
10. Confined explosion in GTG cabin.
11. Significant Gas leak from our or GAIL metering station.
12. Ship related emergency like fire/explosion in ship or bad weather conditions while berthing at our jetty.
13. Natural disasters like earthquake/flood/cyclone.
14. Cold vent fire at jetty.
15. Emergency situation arising from nearby plant say GSPL pipeline leak.
16. Emergency situation arising from nearby jetty say GCPTCL or Birla copper.
17. Fire in Main control room.
18. Sabotage (Bomb threat).
19. Emergency situation due to LNG cargo hits the jetty.
20. High pressure equipment i.e. Recondenser, N2 liquid storage vessel, STV, SCV bursting/failure due to high pressure.
21. Overfilling of road tanker.
22. During TTLF loading, leakages from valves & loading hoses (hose rupture/improper connection).
23. Leakage of LNG while driving LNG tanker inside the terminal.
24. Fire at LNG Loading (TTLF) Skid.
25. Fire on the LNG tanker while driving inside the terminal.

3.2 Port operations related special risk and Security Threat

3.2.1 Category 1 Incidents

1. Significant Gas Leakage at the Manifold

3.2.2 Category 2 Incidents

1. LNG Tanker Grounding in Dahej Port Area
2. Fire and / or Explosion aboard Vessel
3. Fire and / or Explosion on Jetty whilst Vessel Discharging

3.2.3 Category 3 Incidents

1. Other vessel Drifting and Striking LNG Jetty or Trestle
2. Collision between LNG Tanker / Other Vessel

3.2.4 Category 4 Incidents

3.2.5 Security Threat

Refer concerned emergency response plan for detailed action plan.

3.3 Emergency Response Strategies

The development of any emergency can be considered in the following way:

- Warning Phase
- Impact Phase
- Rescue Phase
- Relief Phase
- Rehabilitation Phase

3.3.1 Warning Phase

It is possible that the emergency may due to early weather forecasts predicting cyclones in the Dahej area. For such eventualities the following actions may be taken;

- Stop unloading of LNG ship and un berth ship
- Stop all hot work on site
- Reduce personnel on site to a minimum to provide the necessary support to ensure continued safe operation
- Inform GAIL of possible loss of gas supply.

If the emergency is due to LNG/NG leak and fire/explosion then plant operator and shift security supervisor will take action to eliminate following ignition sources inside the plant and nearby area,

- Hot works like welding, grinding which can generate sparks.
- Workshop activities
- Electrical transmission lines/lights
- Hot surfaces
- Canteen (open flame cooking)
- Temple activities
- Smoking/vehicle movement inside/outside the plant boundary
- Tugboats at jetty

The Field Operators are alerted to gas leaks, LNG leaks or fire via walkie talkies, telephone, paging system or the siren being sounded. Since the top of the LNG tanks are approximately 50m above ground, flashing lights with hooters are provided at all LNG tank top as well as jetty head upper deck (Flashing Light code - Red for gas leak, Blue for Fire and white for LNG spill).

3.3.2 Impact Phase

The period of impact may be short duration up to 15 minutes long where gas leaks, fires or explosions may occur. Weather caused emergencies or major storage tank fires could be for a number of days.

Actions to be taken by all personnel on site are described below.

3.3.3 Rescue Phase

The rescue phase starts immediately after the impact and continues until the necessary measures have been taken to bring the emergency under control.

3.3.4 Relief Phase

This phase covers organising the relief measures that may well include external mutual aid or Government agencies to help provide medical aid, evacuation of personnel, food etc.

3.3.5 Rehabilitation Phase

Prior to re-streaming gas production, an investigation of the causes of the emergency needs to be carried out by Operation and HSE team and inform the incident investigation report to senior management / legal authorities for preventive action. For significant large events, a full senior management review must be carried out before authorisation for resuming production can be given.

4. Duties of Key Personnel for emergency action, rescue and evacuation

4.1 First Responder

Anyone discovering Gas Leak, LNG Leak, Fire or Injuries to Personnel takes the following actions.

4.1.1 In case of Injuries to Personnel

- First Contact by telephone Main Control Room on Extn. No 101/102 then OHC 456 and clearly state your name, the location of the injured person and the type of assistance needed i.e. ambulance, rescue at height etc.

4.1.2 In case of small fire (Note: small fire is defined as fire that can be extinguished by portable extinguishers)

- If the fire is small and if you have received training in the use of portable fire extinguishers, try to extinguish the fire.
- If not trained on fire fighting, activate the fire alarm by breaking the glass in MCP (Manual call point) or SPB (Safety push button).
- First Contact by paging or telephone Main Control Room on Extn. No 101/102 then fire station 444/445 and clearly state your name, the location of the fire and if possible some description of fire.
- Upon extinguishing the fire, standby with a new portable fire extinguisher until Emergency Services (fire tender and ambulance) arrive on site.
- Standby in safe location to direct the Emergency Services (fire tender and ambulance) to the incident site.

4.1.3 In case of major fire: (Note: Major fire is defined as fire that can not be extinguished by portable extinguishers)

- Activate the fire alarm by breaking the glass in MCP (Manual call point) or SPB (Safety push button).
- First Contact by paging or telephone Control Room on Extn. No 101/102 then fire station 444/445 and clearly state fire, fire, the location of the fire and if possible some description of fire.
- Standby in safe location to direct the Emergency Services (fire tender and ambulance) to the incident site.
- Later on wait at respective assembly point until all clear Siren has been sounded.
- All persons other than emergency services assemble at nearby assembly points on hearing the evacuation sirens.

4.1.4 In case of Significant Gas or LNG Leak (Note: Significant leak means forming visible vapour cloud):

- Activate the fire alarm by breaking the glass in MCP(Manual call point) or SPB(Safety push button).

- First Contact by paging or telephone Control Room on Extn. No 101/102 then fire station 444/445 and clearly state leak, leak, the location of the leak and if possible some description of leak.
- Standby in safe location to direct the Emergency Services (fire tender and ambulance) to the incident site.
- In case of LNG leak, do not enter into visible vapour cloud.
- Later on wait at respective assembly point until all clear Siren has been sounded.
- All persons other than emergency services assemble at nearby assembly points on hearing the evacuation sirens.

4.1.5 Leakage of LNG during Tanker loading at TTLF Skid (Minor LNG spill / Hose rupture during loading/ Hose improperly connected and loading started)

- Operator to inform the MCR first by paging or telephone to Control Room on Extn. No 101/102 then fire station 444/445 and clearly state leak, the location of the leak and if possible some description of leak and activate ESD-TTLF.
- Close the Tanker emergency shut down valves.
- Isolate the skid LNG isolation valves as per SOP.
- Standby in safe location to direct the Emergency Services (fire tender and ambulance) to the incident site.
- Do not enter into visible vapour cloud.
- Later on wait at respective assembly point until all clear Siren has been sounded.
- All persons other than emergency services assemble at nearby assembly points on hearing the evacuation sirens.

4.1.6 Leakage of LNG while driving inside the terminal

- Truck Filling Operator (TFO) to inform the MCR first by paging or telephone Control Room on Extn. No 101/102 then fire station 444/445 and clearly state leak, the location of the leak and if possible some description of leak.
- Tanker driver to stop the engine & Barricade the area by cordoning tape.
- Standby in safe location to direct the Emergency Services (fire tender and ambulance) to the incident site.
- Do not enter into visible vapour cloud.
- Later on wait at respective assembly point until all clear Siren has been sounded.
- All persons other than emergency services assemble at nearby assembly points on hearing the evacuation sirens.

4.1.7 Fire on the LNG tanker while driving inside the terminal (Possible spread of fire)

- Tanker driver to stop the engine & extinguish fire with dry chemical powder fire extinguisher installed on the tanker.
- Activate the fire alarm by breaking the glass in MCP (Manual call point) or SPB (Safety push button).
- First Contact by paging or telephone to Control Room on Extn. No 101/102 then fire station on Extn. No 444/445 and clearly state fire, the location of the fire and if possible some description of fire.
- Standby in safe location to direct the Emergency Services (fire tender and ambulance) to the incident site.
- Later on wait at respective assembly point until all clear Siren has been sounded.
- All persons other than emergency services assemble at nearby assembly points on hearing the evacuation sirens.

Do:

✓ Break the nearest fire alarm point glass (MCP/SPB) to call the fire brigade.
✓ Immediately inform the concerned plant control room (101/102).
✓ Act to control the incident as per the instructions.
✓ Reach to the assembly point, located at right angles to wind direction.

Don't:

X **Don't** Get panicky or spread rumours.
X **Don't** Approach control room without work.
X **Don't** Engage telephone.
X **Don't** Be a spectator.

4.1.8 Anyone on receiving bomb threat call,

- Keep the caller engaged in conversation as long as possible.
- Try to get maximum information from caller and background noise.
- Do not cut the phone from your side.
- Immediately inform emergency control centre and Duty Security officer.

4.2 Control Room Officer (CRO)

On receipt of phone/paging call or activation of the Fire and Gas alarm console:

- Inform the Shift in Charge.
- Inform fire station about location of incident.
- Take actions as shown on the relevant Contingency Plan sheets.
- Inform SIC of his actions from the Contingency Plans.
- Initiate emergency shutdown (ESD 1 or 2 or 3) as per instruction from shift incharge.

- Arrange for Field Operator to meet mutual aid support for fire team if summoned.
- Initiate sirens as per instruction from shift incharge for emergency evacuation.

4.3 Shift Incharge (Emergency Controller)

On receipt of information from the Control room Operator:

- Take actions as shown on the relevant Contingency Plan sheets to isolate the affected area.
- Advise CRO to initiate emergency shutdowns after monitoring process parameters.
- Inform the CM (Operations) / GM (Plant Head) (via CRO if necessary)
- Shift Incharge will proceed to site of emergency and act as Emergency Controller.
- CM (Operations) / GM (Plant Head) arrive at control room.
- Advise shift fire crew to reach the location with fire tender to control incident.
- Inform first aid and ambulance service for readiness.
- Advise CRO to call in mutual support aid if incident can not be managed by shift Emergency Team.
- Ensure that guidance available at main gate to direct mutual aid to safe location to address incident.
- Instruct CRO to initiate siren for emergency evacuation if required. Use paging siren (F1 key) also if required to alert people.
- Co-ordinate all emergency responses and support until GM (Plant Head) or next incharge arrives on site.

4.4 Shift Fire Operator

On receipt of information:

- Gather wind direction information either from control room or looking at wind sock at potable water tank.
- Ensure that fire tender along with the ambulance reaches the agreed safe location (upwind direction) to attack the fire or control the gas leak.
- Carry out duties as per fire drill.
- Inform fire crew/ shift persons to use BA set (kept at various locations at site) for entering into confined space and use first aid box (kept at various locations) for rescue operations.
- Inform shift incharge for initiating site evacuation alarm if required.
- Inform shift Security Supervisor for head count.
- Inform Main control room if any emergency communication received directly at fire station.
- Inform OHC if fire station receives any emergency call.

4.5 Shift Security officer

On receipt of information:

- Eliminate all ignition sources outside the plant boundary in consultation with shift incharge.
- Inform all security guards to arrange for assembly of persons in assembly point.
- Take head count at assembly points based on attendance register.
- Report the missing persons information to emergency control centre.

4.6 Plant operator

- Stop all Hot/cold work and evacuate persons in his area.
- Reach Main control room or emergency area as per instructions from shift incharge.
- Involve in emergency isolation and operation requirements as per instructions from shift incharge.
- Eliminate all ignition sources inside the plant in consultation with shift in charge.

4.7 Medical Service

- On hearing the emergency siren or on hearing the fire tender moves with siren in the plant, immediately ambulance also should move along with fire tender to the emergency site and stationed at safe location.
- Provide first aid service at the site and transfer the victim to OHC.
- If the fire tender moves outside the plant, ask security department whether ambulance to be sent along with fire tender or not and act accordingly.
- If the injury call is received directly from site, immediately send the ambulance to site. Then inform Main control room, HSE department and Security department.

4.8 HSE officer

- Reach to site and assess the emergency.
- Monitor the emergency action and provide necessary advice for all emergency services.
- Coordinate with emergency controller and arrange for mutual aid support.

4.9 Emergency Control Centre

Main control room will be the emergency control centre. Shift in charge will take control of emergency situation until GM (Plant Head) arrives to main control room. In case of emergencies, Chief Managers and all managers during day shift will be reporting at emergency control centre to GM (Plant Head) or to whom GM (Plant Head) hands over charge will be in charge of overall control of emergency.

Shift in charge, in absence of GM (Plant Head), will inform key persons about the emergency. Contact numbers of key persons are enclosed as annexure (II). Only GM (Plant Head) is authorised for media address.

Main control room will be the emergency control & communication centre.

On hearing siren, all persons should assemble at assembly points for head count except emergency controlling services like operation team, HSE, Fire, OHC, Security, concerned persons from Electrical, instrumentation, mechanical dept., GAIL office, OSL port service contractor and other concerned persons. In general, all emergency concerned persons should carryout their duties during emergency and they should not assemble at assembly point.

4.10 ASSEMBLY POINTS

In case of emergency, these people will assemble at following assembly points,

1) Near Main gate
2) Opposite PLL canteen
3) South side Gate
4) Opposite to Maritime guard house (Jetty entrance)
5) Opposite to Jetty substation building
   Exact locations of assembly points are shown in layout plan as appendix (I).

Respective Security supervisor will take head counts at assembly points and will report to shift in charge for missing persons.

4.11 Personnel Manning at Dahej Plant

Site will have 35 people in shift duty while ship is berthed and this number may be less when ship is not berthed at jetty. During general shift, maximum number of people at site will be around 200 including contractor workers.

4.12 Mutual Aid Support

Petronet LNG is member of Disaster Management centre, Dahej and hence can request for nearby Industries help in case of major fire. Nearby industries such as RIL (IPCL), Birla copper, GACL, ONGC C2-C3 and GCPTCL have fire tender with full-fledged fire fighting team. Familiarisation programme has been conducted for nearby industries fire/safety professionals to explain about possible fire scenarios in the plant.

5. HAZARDS and TYPES OF SIREN

5.1 Hazards of chemicals:

Material safety data sheet of chemicals handled at site namely LNG, NG, Glycol, Nitrogen and Chlorine is kept at file in the Main control room and Fire station.

Important LNG/NG hazards are listed below,

- LNG on exposure to human body cause cold burns.
- LNG cold vapors is heavier than air at less than (-)110 deg C and forms visible white cloud which delimits flammable cloud.

- LNG spill on water can create RPT explosion.
- NG is flammable (5-15 % range).
- NG is colorless and odorless.
- NG can cause breathing problem in confined space.

5.2 Fire fighting information

- Use dry powder for NG fire.
- Use foam first and then dry power for LNG pool fire.
- Use CO_2 or dry powder (if CO_2 is not available) for electrical fires.
- Never use water on LNG pool leaks or start water sprinkler/curtain system for process facilities under LNG pool leak as this can cause RPT explosion.
- In case of LNG/NG fire, start water spray system of nearby facilities for cooling purpose.

5.3 Types of sirens

No siren – No siren will be sounded for injuries to personnel and small fire cases and small LNG/NG leak. Small fire / leak is based on assessment by Shift Incharge.

Evacuation siren (On-site emergency) – It will be sounded for major fire and significant LNG/NG leak. The siren shall be wailing sound for 2 minutes.

Wailing sound : UP DOWN siren for two minutes duration.

Disaster Siren (Off-site emergency) - For disaster situation, the siren shall be wailing sound for 2 minutes repeated thrice with one minute gap in between (Total eight minutes duration).

All clear siren - For all clear situation, the siren shall be straight run sound for 2 minutes continuously.

Straight run siren for 2 minutes continuously

Siren during Mock Drill - In case of mock drill, evacuation siren should be sounded. The purpose of siren is to check effectiveness of emergency response procedures.

5.4 ERP Testing:

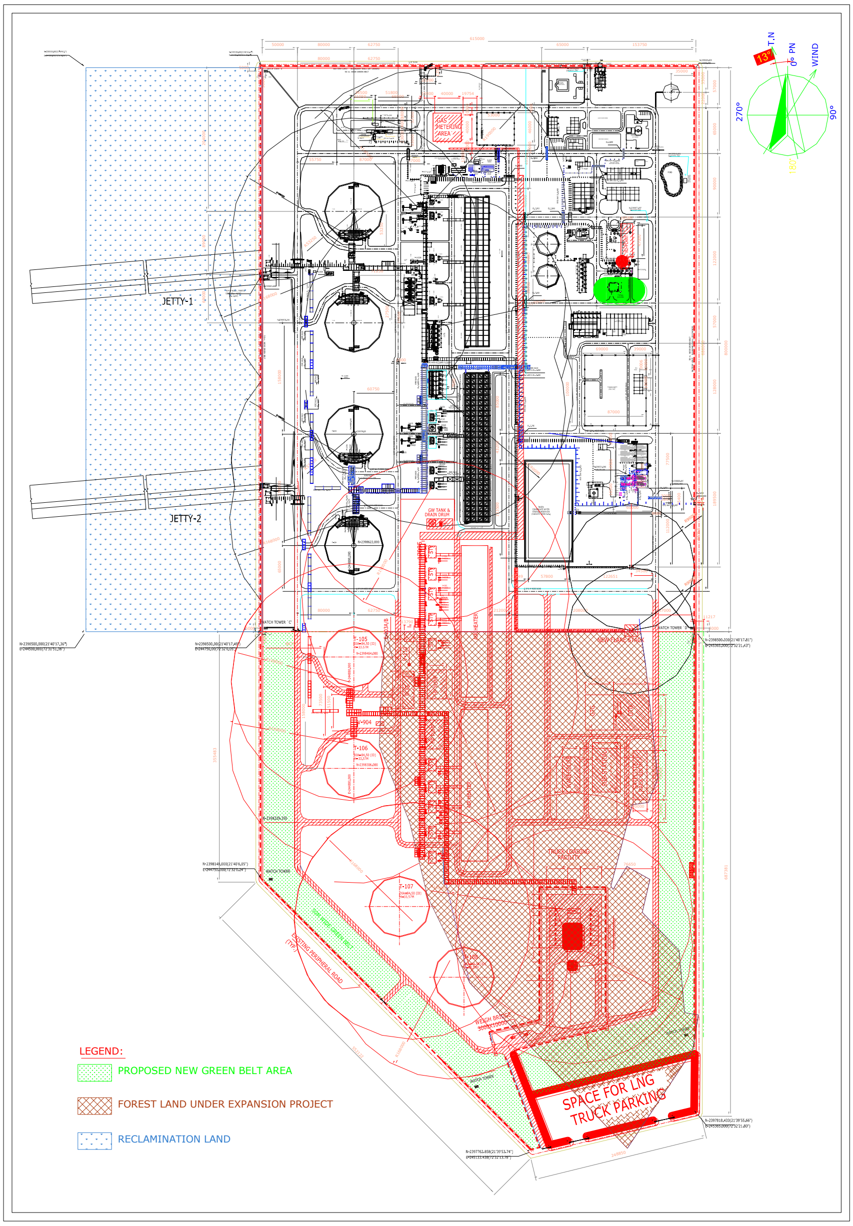
Mock drill should be conducted every three months in order to check the effectiveness of emergency response plan and procedures.

5.5 ERP Training:

All persons in the plant should be given training on emergency response procedures atleast once in a year.

6. APPENDIX

APPENDIX (I): Layout of the terminal with marking of assembly points



ANNEXURE-XII
DISASTER MANAGEMENT PLAN

APPENDIX (II): LIST OF KEY PERSONS CONTACT NUMBERS FOR EMERGENCY HANDLING

PLL	**Petronet LNG Terminal, Dahej, India** **SITE CONTACT LIST**		
PLL Contact Numbers			
Name	Emergency Title	Location	Numbers
Sr Vice President (Mr. Rajender Singh)	Over all Controller	Petronet Delhi Head Office	(M) 9953215141
General Manager (Mr.S.B.Singh)	Chief Emergency Controller	Petronet Dahej site	02641-300300/301 (M) 09662526271
General Manager (Mr.S.Baitalik)	Standby - Chief Emergency Controller	Petronet Dahej site	02461-300251 (M) 09662526274
Shift Incharge	**Site Emergency Controller**	Petronet Dahej site	**02641-300103** **(M) 9662522198**
Port Operations Incharge	Port Operations Controller	Petronet Dahej site	02641-300323 (M) 9662526306
CM Operation (Mr. Sanjay Kumar)	Operations Coordinator	Petronet Dahej site	02641-300111 (M) 9662526281
CM Port Operation (Capt. H.K.Varma)	Port Operations Coordinator	Petronet Dahej site	02641-300321/322 (M) 9662526272
Manager Security (Maj. J. S. Chauhan)	Security Coordinator	Petronet Dahej site	02641-300342/343 (M) 9662526291
Manager Safety (Mr. S.Venugopal)	Safety Coordinator	Petronet Dahej site	02641-300451/452 (M) 9662526295
CM HR & Admin (Mr. Hemant Bahura)	Welfare Coordinator	Petronet Dahej site	02641-300305 (M) 9662526276
Manager Electrical (Mr. Sumit Kumar Pal)	Communications Coordinator	Petronet Dahej site	02641-300201/205 (M) 9662526302

APPENDIX (III): LIST OF NEARBY FIRE STATION WITH TELEPHONE NUMBERS

Name	Title	Location	Numbers
Nearby Fire station			
GCPTCL Fire Station	Mr. SanjayVaidya Dy. Mgr. (Incharge Fire & Safety)	Dahej (1 km)	02641-261035/261101 (M) 9998011229 (M) 9998950550
Reliance Industries Ltd. (IPCL) Fire Station	Mr. P. Singh, AVP (FSD)	Dahej (5 km)	02641-282431/32, 282000, 282433, 282400 (M) 9998975878
Birla Copper (HINDALCO) Fire Station	Col. C. K. Singh (Security & Fire Services)	Dahej (7 km)	02641-256004-06 /251008-09 (M) 9723709840
BASF (Styrolution India Pvt. Ltd.) Fire & Safety dept.	Mr. N. S. Swarup Mgr. (EHS)	Dahej (8Km)	02641-256571 to 256575 02641-257206 (M) 9824704606
GACL Fire Dept.	Pankaj Patel Mgr. (Fire)	Dahej (10Km)	02641-256315-17 (M) 9909918873
Bharuch Fire Station		Bharuch	02642-240008/101/102
DPMC, Ankleshwar Fire station		Ankleshwar	02646 – 653101 (M) 9426889616

ANNEXURE-XII
DISASTER MANAGEMENT PLAN
APPENDIX (IV): LIST OF HELTH CENTERS / FIRST AID CENTERS

Name	Title	Location	Numbers
Health / First Aid Centres			
Reliance Industries (IPCL) Occupational Health Centre	Dr. Paren shah MBBS, GM (MS) Dr. V.N.Sheth MBBS, Sr.Mgr.(MS)	Dahej (5 Km)	02641-282032/33/34, 282000 (M) 9998987298 (M) 9998975822
Birla Copper First Aid Center	Dr. A.A.Rawal MS, Medical officer	Dahej (7 km)	02641-256004/5/6, 251008/9 (M) 9904402622
GCPTCL	Dr. Himanshu Vanza MBBS, Medical Officer Sanjay Panchal Medical Assistant	Dahej	02641-261031 (M) 9824143883 (M) 9998011237
BASF	Dr. Himanshu Vanza MBBS, Medical Officer	Dahej	02641-256571 to 75, 257206 (M) 9824143883
GACL	Dr. M. P. Vyas MBBS,Medical Officer Dr. Himesh Mehta MBBS, CIS	Dahej (5 Km)	02641-2486407 / 507, 240889, 2489371 (M) 9825298432
Bharuch Hospital (Patel Welfare Hospital)	Dr. Suketu Dave Medical Superintendent	Jambusar Road, Nr. Bharuch tower	02642-242520/ 244881 (M) 9824141681
Bhailal Amin general Hospital	Dr. Darshan Desai	Bhailal Amin Marg, Vadodara	0265-2280300/ 2381301 / 2286666 / 2282155
Civil Hospital	Dr. S R Patel (Chief Dist. Medical Officer & Civil Surgeon)	Bharuch	02642-243515 (Emergency), 241759

APPENDIX (V): LIST OF DISTRICT AUTHORITIES IMPORTANT TELEPHONE NUMBERS

ANNEXURE-XII
DISASTER MANAGEMENT PLAN
(OFFSITE EMERGENCY)

IMPORTANT TELEPHONE NUMBERS - DISTRICT AUTHORITY

Sr. No.	Name & Designation	Phone No.		Mobile
		(Office)	(Residence)	
1	Mr. Jitendra patel Secretary, Disaster Management Center, Dahej	02641-266011/ 256670		(M) 9824475576
2	Capt. Alok kumar Gujarat Maritime Board Port officer – Bharuch	02642-243140		
3	Smt. Roopvant singh District Collector, Bharuch	(02642) 240600 243499	(02642) 223701	(M) 9978406205
4	Shri B.G.Prajapati Dy. Collector	241400		(M) 9978405177
5	Shri Dhiren Pandya SDM, Bharuch	(02642) 241980	-	(M) 9978405256
6	Shri Gautam Parmar Dist. Superintendent of Police, Bharuch	(02642) 223633	(02642) 223330	(M) 9978405066
7	Shri N. A. Munia Dy. Superintendent of Police, Bharuch	(02642) 269533	-	(M) 9825356700
8	Shri D M Pandya Mamlatdar, Vagra	(02641) 225221	(02641) 225236	(M) 9925944006
9	Shri R.G.Desai Police Inspector, Dahej	(02641) 256233	-	(M) 9825130105
10	Shri D. M. Jadeja Police Sub Inspector, Vagra	(02641) 225233	-	(M) 9825327308
11	**District Collector Office Control Room, Bharuch**	**(02642) 242300 (Fax) 251900**	**Emergency No. (02642) 1077**	
12	**DSP Office Control Room, Bharuch**	**(02642) 223084 223303**	**-**	-
13.	**D.P.M.C., Ankleshwar Mr. Manoj Kotadiya**	**(02646) 220229**		9426889616

DIRECTORATE (INDUSTRIAL, SAFETY & HEALTH)

Sr. No.	Name & Designation	Phone No.		Mobile
		(Office)	(Residence)	
14	Shri D. C. Chaudhary Director (IS&H), Ahmedabad	(079) 25502349 25502357 25502356 25502364 25502346	(079) 27487070	(M) 9825049360
15	Shri VIJAY S PATEL Dy. Director of (IS&H), Bharuch	(02642) 240421	(02641) 225838	(M) 9909094455

GUJARAT POLLUTION CONTROL BOARD (GPCB)

Sr. No.	Name & Designation	Phone No.		Mobile
		(Office)	(Residence)	
16	Dr. K. U. Mistry Chairman, GPCB, Gandhinagar	(079) 23222425	-	
16	Shri Hardik Shah Member Secretary, Gandhinagar	(079) 23232152	-	
17	Shri D.L.Bhatt Regional Officer, Bharuch	(02642) 246333, 248665	-	
18	Prof. S.P. Gautam Chairman, CPCB, New Delhi	(011) 22304948, 22307233		

DEPARTMENT OF EXPLOSIVE

Sr. No.	Name & Designation	Phone No.		Mobile
		(Office)	(Residence)	
19	Shri. T.R. Thomas Chief Controller - Explosives, Nagpur	(0712) 2510103	-	-

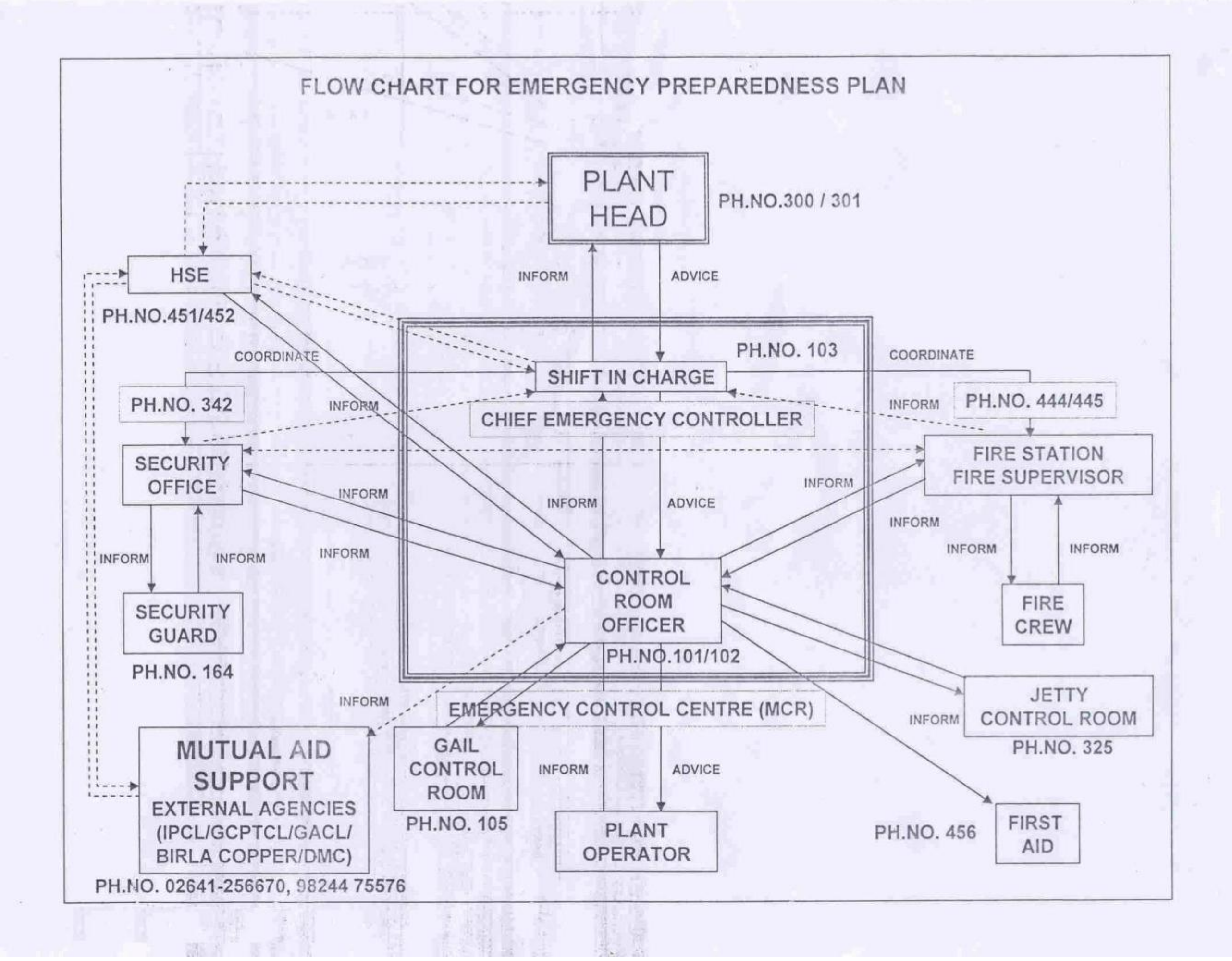
Sr. No.	Name & Designation	Phone No.		Mobile
		(Office)	(Residence)	
20	Shri. P.C. Srivastava Joint Chief Controller of Explosives, Nagpur	(0712) 2512094		
21	Shri S. C. Maiti Jt.Chief Cont. Explosives, Mumbai	(022) 27575946	-	-
22	Shri. R.C. Kaul Dy. Chief Controller Expl., Vadodara	(0265) 2225159 2361035	-	-

DEPARTMENT OF ENVIRONMENT & FOREST (DoEF)

Sr. No.	Name & Designation	Phone No.		Mobile
23	Shri J. K. Vyas Director (Env.&For.), Ahmedabad	(079) 23251062 23252154	-	-

ANNEXURE-XII
DISASTER MANAGEMENT PLAN

APPENDIX (VI): FLOWCHART FOR EMERGENCY PREPAREDNESS PLAN



APPENDIX (VII): REFLEX SHEET FOR MAXIMUM HAZARD DISTANCE FOR LNG DISPERSION / NG FIRE / NG EXPLOSION

Hazard distances for pool fires, jet fires and flash fires were evaluated in the detailed QRA and are summarised in terms of the following dimensions:

- *d*: maximum downwind distance;
- *c*: maximum crosswind width;
- *s*: offset distance (distance between source and upwind end of effects zone). Note that a negative offset distance indicates that the upwind end of the effects zone is located upwind of the source; and
- *m*: distance between release source and location of maximum crosswind width.

ANNEXURE-XII
DISASTER MANAGEMENT PLAN

Thermal radiation contours are calculated to 40kW/m^2, 30kW/m^2 and 12kW/m^2 corresponding to fatality probabilities of 0.9, 0.5 and 0.01 respectively.

TERMINOLOGY

Section Code	Equipment	Facility Area
LA	Unloading Arms	Jetty
TP	Pipeline (Jetty to Plant)	Piping from Plant to Jetty
TA	LNG Tanks (T101 – T104)	LNG Storage
TO	Tank Outlet	LNG Storage
SO	HP Pump Outlet	Vaporisation & Send-out
CV	SCVs (E106 / E107)	Vaporisation & Send-out
SV	STVs (E104 / E105)	Vaporisation & Send-out
MT	Metering (U101 / U103)	Metering
FG	Fuel Gas Pipeline	Piping from Metering station to Power plant
CL	Chlorination Package	Chlorine
TT1	6” main feed line	TTLF
TT2	3” feed line (upstream of FV – 13001)	TTLF
TT3	3” feed hose	TTLF
TT4	4” recirculation line	TTLF
TT5	Truck tanker	TTLF

ANNEXURE-XII
DISASTER MANAGEMENT PLAN

Hazardous Effects Zone for Pool Fires

Section Code	Thermal Radiation (KW/m^2) & Fatality Probability (%)	Consequence Distances for small pool fire due to 12mm leak (m)								Consequence Distances for small pool fire due to 25mm leak (m)							
		2F				5D				2F				5D			
		d	c	s	m	d	c	s	m	d	c	s	m	d	c	s	m
TT3	40 (90%)	0	0	0	0	0	0	0	0	9	3	3	6	10	3	4	7
	30 (50%)	7	2	3	5	7	2	4	6	11	3	3	7	12	3	4	8
	12(1%)	7	2	3	5	7	2	4	6	15	6	3	9	16	6	4	10
TT4	40 (90%)	0	0	0	0	0	0	0	0	9	3	3	6	10	3	4	7
	30 (50%)	7	2	3	5	7	2	4	6	11	3	3	7	12	3	4	8
	12(1%)	7	2	3	5	7	2	4	6	15	7	2	9	16	6	4	10
TT5	40 (90%)	0	0	0	0	0	0	0	0	9	3	3	6	10	3	5	7
	30 (50%)	7	2	3	5	7	2	4	6	11	3	3	7	12	3	4	8
	12(1%)	7	2	3	6	7	2	4	6	15	6	3	9	16	6	4	10

Section Code	Thermal Radiation (KW/m^2) & Fatality Probability (%)	Consequence Distances for small pool fire due to 50 mm leak (m)								Consequence Distances for Large pool fires (m)							
		2F				5D				2F				5D			
		d	c	s	m	d	c	s	m	d	c	s	m	d	c	s	m
LA	40 (90%)	60	60	-68	0	85	65	-45	0	60	60	-55	0	90	70	-50	0
	30 (50%)	72	72	-55	0	100	80	-50	0	71	71	-68	0	110	87	-58	0
	12 (1%)	125	130	-120	0	165	140	-93	0	125	130	-120	0	180	150	-103	0
TP	40 (90%)	60	60	-68	0	85	65	-45	0	78	75	-70	0	100	80	-60	0
	30 (50%)	72	72	-55	0	100	80	-50	0	90	90	-85	0	120	100	-70	0
	12(1%)	125	130	-120	0	165	140	-93	0	155	160	-150	0	200	175	-125	0
TA	40 (90%)	40	40	-40	0	40	40	-40	0	40	40	-40	0	40	40	-40	0
	30 (50%)	40	40	-40	0	40	40	-40	0	40	40	-40	0	40	40	-40	0
	12(1%)	130	130	-130	0	180	115	-50	0	130	130	-130	0	180	115	-50	0
TO	40 (90%)	50	48	-40	0	75	50	-25	0	55	54	-50	0	80	55	-35	0
	30 (50%)	58	55	-50	0	90	60	-30	0	65	65	-60	0	95	70	-40	0
	12(1%)	95	100	-90	0	130	105	-60	0	110	110	-100	0	140	115	-70	0
SO	40 (90%)	50	48	-40	0	75	50	-25	0	55	54	-50	0	80	55	-35	0
	30 (50%)	58	55	-50	0	90	60	-30	0	65	65	-60	0	95	70	-40	0
	12(1%)	95	100	-90	0	130	105	-60	0	110	110	-100	0	140	115	-70	0
CV	40 (90%)	50	48	-40	0	75	50	-25	0	55	54	-50	0	80	55	-35	0
	30 (50%)	58	55	-50	0	90	60	-30	0	65	65	-60	0	95	70	-40	0
	12(1%)	95	100	-90	0	130	105	-60	0	110	110	-110	0	140	115	-70	0
SV	40 (90%)	50	48	-40	0	75	50	-25	0	55	54	-50	0	80	55	-35	0
	30 (50%)	58	55	-50	0	90	60	-30	0	65	65	-60	0	95	70	-40	0
	12(1%)	95	100	-90	0	130	105	-60	0	110	110	-110	0	140	115	-70	0
TT3	40 (90%)	-	-	-	-	-	-	-	-	12	7	-2	5	14	7	-2	6
	30 (50%)	-	-	-	-	-	-	-	-	15	8	-3	6	18	9	-2	8
	12(1%)	-	-	-	-	-	-	-	-	25	16	-8	8	25	16	-6	10

TT4	40 (90%)	7	4	-1	3	8	4	-1	3	6	4	-3	2	7	5	-2	2
	30 (50%)	9	5	-1	4	10	5	-1	5	8	5	-3	3	9	5	-2	4
	12(1%)	15	9	-3	6	16	9	-2	7	14	10	-5	5	14	9	-3	6
TT5	40 (90%)	20	9	2	11	23	9	3	13	90	-50	16	43	109	-56	10	48
	30 (50%)	24	11	1	13	28	11	2	16	105	-64	25	40	123	-68	16	55
	12(1%)	35	21	-6	15	37	20	-2	17	158	-114	68	47	168	-115	54	57

The Small pool fire due to 12 mm and 25 mm leak were assessed for TTLF only. For Section Code TT3, 50 mm case was not assessed since the size of pipe 3" and hence not meaningful to assess for 50 mm leak case.

Hazardous Effects Zone for Jet Fires

Section Code	Thermal Radiation (KW/M2) & Fatality Probability(%) (a)	Consequence Distances for small jet fire due to 12mm leak (m)								Consequence Distances for small jet fire due to 25mm leak (m)							
		2F				5D				2F				5D			
		d	c	s	m	d	c	s	m	d	c	s	m	d	c	s	m
TT1	40 (90%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	30 (50%)	0	0	0	0	33	5	1	17	0	0	0	0	62	9	0	30
	12(1%)	47	8	1	24	40	10	0	20	87	17	1	43	73	12	0	36
TT2	40 (90%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	30 (50%)	0	0	0	0	33	5	1	17	0	0	0	0	62	9	0	30
	12(1%)	47	8	1	24	40	10	0	20	87	17	1	43	73	12	0	36

Section Code	Thermal Radiation (KW/M2) & Fatality Probability	Consequence Distances for small jet fire due to 50 mm leak (m)								Consequence Distances for Large jet fires (m)							
		2F				5D				2F				5D			
		d	c	s	m	d	c	s	m	d	c	s	m	d	c	s	m
MT	40 (90%)	75	25	5	40	70	25	1	30	150	60	1	75	145	60	1	75
	30 (50%)	90	50	-1	40	80	50	-10	35	175	110	-25	75	175	110	-25	75
	12(1%)	110	75	-20	40	100	75	-25	40	210	145	-50	75	200	145	-50	75
FG	40 (90%)	21	5	5	12	19	5	2	10	55	20	1	30	55	20	1	30
	30 (50%)	25	12	1	12	24	12	0	10	65	40	-5	30	65	40	-5	30
	12(1%)	28	16	-3	12	26	17	-5	10	79	50	-10	30	79	50	-10	30
TT1	40 (90%)	0	0	0	0	107	14	0	52	0	0	0	0	219	33	0	110
	30 (50%)	136	15	2	70	114	19	0	58	270	35	0	136	232	43	-1	115
	12(1%)	139	37	0	80	134	43	-2	66	321	80	-4	160	271	94	-9	132
TT2	40 (90%)	-	-	-	-	-	-	-	-	184	19	2	97	154	22	1	78
	30 (50%)	-	-	-	-	-	-	-	-	195	23	2	100	164	29	0	82
	12(1%)	-	-	-	-	-	-	-	-	226	53	0	112	191	65	-4	94

The Small jet fire due to 12 mm and 25 mm leak were assessed for TTLF only. For Section Code TT2, 50 mm case was not assessed since the size of pipe 3" and hence not meaningful to assess for 50 mm leak case.

Hazardous Effects Zone for Toxic Dispersion

Section Code	CL Concentration (mg/m3) & Fatality Probability (%) (a)	Consequence Distances for Continuous Vapour Releases (m)								Consequence Distances for continuous Two Phase Releases (m)								Consequence Distances for Instantaneous Releases (m)							
		2F				5D				2F				5D				2F				5D			
		d	c	s	m	d	c	s	m	d	c	s	m	d	c	s	m	d	c	s	m	d	c	s	m
CL	7700 (90%)	23	2	0	13	10	1	0	5	200	20	0	120	100	16	0	65	55	20	0	35	50	10	0	27
	4400 (50%)	42	3	0	27	16	2	0	12	290	25	0	165	125	20	0	75	80	22	0	35	70	11	0	30
	1600 (1%)	90	20	0	82	43	4	0	15	640	50	0	375	225	25	0	100	145	24	0	35	140	13	0	30

Pool Fire Effects on Critical Plants

Source	Hazard Distance (m)	Offsite	Distance to Sensitive Equipment / Area			
			LNG Tanks	Firewater Tanks	Control Room	Admin Building
Unloading Arms	85	>2000	>2000	>2000	>2000	>2000
Pipeline (Jetty to Plant)	85	255	100	390	430	480
Tank T - 101 [(a)]	40	167	77	220	260	300
Tank T - 102 [(a)]	40	322	77	222	295	370
Tank T - 103 [(a)]	40	240	77	290	388	480
Tank T - 104 [(a)]	40	85	77	410	522	615
T - 101 Outlet	75	246	77[(b)]	230	280	332
T - 102 Outlet	75	394	77[(b)]	230	338	423
T - 103 Outlet	75	239	77[(b)]	300	437	534
T - 104 Outlet	75	166	77[(b)]	415	530	622
P - 104 Outlet	75	342	79[(b)]	140	233	329
P - 105 Outlet	75	342	79[(b)]	186	300	388
SCV E - 106	75	206	30	170	215	263
SCV E - 107	75	206	30	256	366	458
STV E - 104	75	190	68	146	200	256
STV E - 105	75	190	68	230	344	435
TTLF	23 [(c)]	115	60	235	260	235

(a.) Modelled as a Tank Top Fire.
(b.) T - 101 to 104 hazard distances to tanks are so close, it is assumed that they will affect the tanks.
(c.)Based on Truck Transfer (TT5) results, which are the worst among all section analyzed for TTLF.