7 SCREENING OF ANTICIPATED IMPACTS AND PROPOSED MITIGATIONS

Potential impacts of establishment during the construction and operation phases of the dedicated LNG Terminal on the Physical, Biological and Socio-economic environment have been identified and assessed in the following sections.

The LNG Terminal at the proposed site in Port Qasim area is expected to respond to the needs of natural gas and LPG through import of raw natural gas as an environmental friendly fuel for the industrial, commercial and domestic consumers in Pakistan. The activities related to construction and operations of this facility are expected to have some small order environmental impacts on the baseline conditions in Port Qasim area.

Unlike other liquid bulk products handled at Port Qasim, the chemical and physical properties of LNG are such that physical conveyance is limited to the primary receptor. The product is liquid which shall be re-gasified at the terminal for delivery to SSGC network system.

A qualitative assessment of each impact has been made in the impact analysis. Each of the impacts has been reviewed for construction and operation phases of the LNG Terminal. Mitigation measures as appropriate have been identified for implementation.

The anticipated impacts are envisaged as follows:

- NATURE = Positive (Improvement) or Negative (Degradation)
- MAGNITUDE = Low, Medium or High
- DURATION = Temporary or Permanent / Cyclic (repetitive)
- TERM = Immediate, Short, Medium or Long Term.
- EFFECT = Local (Project site only), Regional (beyond project area) or Strategic (related to other issues)

Where required, mitigation measures for the significant negative impacts have been recommended.

The operational phase will involve berthing of a bulk LNG carrier, loading arm connection and pumping of LNG to FSRU vessel parked alongside the berthing facility. Subsequent processes are re-gasification and transporting of the RLNG to natural gas grid. Other than these activities, power generation shall be made as per demand on FSRU. Fugitive air emissions, operational leakages, venting of storage spheres etc. may lead to air receptor loading.

7.1- Environmental Mitigation Goals

The project is located in the Korangi Fish Harbour zone. As with other growing fishery and allied industries in such developing areas, negative impact on the environment will not take place. Keeping in view the environment mitigation objective, Pakistan GasPort Limited shall aim primarily to recognize the impacts and minimize or avoid such impacts on the environment. Mitigation measures have been suggested here and Environment Management Plan has been proposed for implementation at each stage of Project activity by having an organizational set up to closely monitor the performance.

7.1.1- Short/Near Term Goals

- Planning and design/fabrication of LNG handling facilities to control undesirable impacts on the environment.

- Address the environmentally sensitive issues such as mangrove ecology, marine water quality, air quality, etc.
- Construction operation to ensure precautionary measures to avoid incidents such as spillages, inadequate dredge disposal, mangrove cutting/grabbles.

7.1.2- Long Term Goals

- Long term objectives form part of the Environmental Management Plan aimed at creating a general awareness among operational phase staff and carry out periodical monitoring of quality of air and liquid effluents.

Some of the key objectives are:

- Setting up of a Monitoring and Reporting System
- Organizing a Supervisory and Monitoring Mechanism
- Drawing out plans for emergency situation and management
- Training of personnel in safe environmental practices
- Regular meetings and sessions to review safety, environmental quality and emergency procedures.

7.2- Impacts at Design Stage

7.2.1- Project Siting

Pakistan GasPort Limited LNG terminal is spread onshore and offshore. The onshore storage area is connected to offshore development via a sub-sea pipeline. The onshore area is located in an open area which is presently sporadically developed. The offshore jetty and sub-sea pipeline are primarily located in tidal waters and mangroves with no human settlements in the vicinity. However the onshore facility has some human settlements in proximity (1.5 km away).

The location of LNG terminal as described in chapter 3 has been carefully selected to reduce the impact on navigation and ecology. LNG berth at the proposed location seems to be well poised in the physical scenario.

While siting of the LNG berth, the onshore area and the pipeline alignment the following parameters were considered:

- Safe distance from population.
- Proximity to berth
- Length of delivery lines to customer network
- Infrastructure such as roads, utilities etc.
- Tank foundation
- Earthquake

The selected site however offers more than minimum required distance between the LNG berth and mangroves, thus minimising the disturbance to mangrove ecology during the construction and laying of the sub-sea pipeline.

7.3- Physical impacts during construction & operations

7.3.1- Noise due to LNG Terminal, Pipeline and Land Facilities

A- Impacts during Construction Phase

LNG terminal construction and associated activities onshore and offshore may have possible impact on ambient noise levels. In particular, works such as pile driving, dredging, drilling, earthworks, etc. as well as site plant such as compressors, would contribute to noise. The duration of the construction work is anticipated not to exceed over a years period.

Wind speed and direction data reveals that winds are inclined to blow from southwest. Offshore winds are also generated by convection changes as the land warms during the day. It is considered

likely that there would be regular occasions when the prevailing wind is such that noise is directed towards the land.

The acoustic effect of the creeks especially during low water would be to echo the noise, possibly causing a weak echo effect for sharp burst of noise such as those of pile driving. However, the open land would help the dissipation of construction noise. There are no notable buildings or topographical features in proximity to construction sites that would provide shielding or damping effects.

There are no developed residential areas close to the shore area. There is no school, hospital or library, however some human settlements mostly comprising earthen dwellings are scattered. The source of major noise in the area is Korangi Fish Harbour which is not of major concern. It is expected that on site noise levels during construction phase may not exceed the average noise of 85 dB(A) at 7.5m. Acceptable noise levels for construction equipment may vary from 75-100 dB(A) for which the workers will be provided ear plugs to be worn as protective measures.

Mitigations:

Dredging operations typically proceed for 24 hours a day. It is not necessary to restrict dredging times because there is no significant or densely populated residential area in the vicinity.

Other activities during construction that can be a source of noise and vibration would be the movement and operation of heavy construction equipment, excavation and fill operation for grading, pipeline cutting, welding, installation etc. The noise would be confined to the local surrounding and the impact will be of temporary nature.

The potential changes in sound quality on other local roads resulting from increased vehicle traffic during construction are not expected to be significant. The potential changes in ambient sound pressure levels are expected to be low.

Therefore no special mitigation measures are required.

B- Impacts due to Operation

As described earlier, there are several factors that would affect the potential noise from the terminal. Such factors include the distance from terminal to the residential areas, local acoustic, barriers to noise, and the tolerance of the local population. However, distance of the residential area from the site would be the major provider of cushion dampers for the noise and vibration generated due to construction activity.

The operation of LNG cargo unloading, storage and re-gasification etc. are low impact activities. Noise emissions during project operation is expected to be much lower and generally derived from facility operations such as pumps, engines, other on-site machinery, and from marine vessel unloading LNG at berth.

The shore facility is not particularly noisy as there are is only pipeline juncttion and measurement facility. There are no continuously noisy conveyor systems. The standby power generator would be housed in its own building, and occasional use is not considered a significant noise source.

The most intrusive noise source would be the terminal related traffic especially on the road outside the storage area. Traffic movements into and out of the storage area would continue over day hours. However, vehicles could arrive and / or depart at any time.

Sound emissions from the marine vessels would mainly be generated by the operation of the vessel's engines. The noise emissions from vessel engines are substantially dampened by their placement deep within the confines of the vessel. The increase in noise emissions from marine vessels using the berth is not expected to result in significant increase in level <3dB(A). Additionally, sound emissions from marine vessels will occur on an intermittent and infrequent basis.

Mitigations:

The sources of noise during operation of the project include vehicular movements, ships offloading operations, intermittent sounding of horns by the ships etc. The noise emitting from these sources will not be significantly higher than the background noise level.

As an occupational health and safety standards the workers wherever necessary will be provided with earmuffs as per specifications to meet the World Bank guidelines. The World Bank guidelines for ambient noise level within industrial sites recommend daytime and night time limits of 75dB (A) and 70dB (A) respectively. The NEQ standard of the EPA for external noise levels is 85dB (A) at 7.5 m. The IUCN report (1993) on the Environmental Review of Port Qasim area suggested noise level range from 35-45 dB (A) for small offices and 75-85dB (A) for maintenance areas.

7.3.2- Project Impact on Air Quality

Construction and operation of the Project is expected to result in emissions into the atmosphere that may affect air quality. The effects on air quality are likely to arise during construction from dust generation by earthwork at onshore site and during operation from fugitive emissions of natural gas, venting and accidental leakages in the components of the system

A- Impacts during Construction Phase

Fine particulates suspended in the air can be windblown from the site to adjacent windward areas. The main impact regarding fugitive emissions of dust is a nuisance effect. Certain construction activities can become major sources of dust, for example earth-moving, drilling and handling of aggregates besides operation of construction equipment, which could generate fugitive emissions. However, it is envisaged most of the ditching and excavation would be done in wet phase thereby minimising the impact arising due to dust and fugitive emissions.

Regular occurrence of high-level airborne dust emission is neither reported nor recorded for the site. The climate is dry and the surrounding land is typical of arid zone. Windy conditions prevail during the monsoons. As the land mass begins to warm up during the day, the resulting convection currents generate offshore winds starting from the noon hour. Dust storms are known to occur. However, it is unlikely that dust generated during construction would cause a significant nuisance impact.

During the levelling and grading operations in the storage area and handling of construction materials especially materials for concrete, some dust will be generated. The access to the site is over an existing paved road. The movement of trucks bringing in construction materials is therefore not expected to create significant dust emission.

Construction and transportation equipment (earth movers, graders, blasting, trucks, vessels, concrete batch plant, etc.) will likely generate dust and emit combustion gases, including greenhouse gases (GHGs), primarily carbon dioxide. Fugitive dust and particulate matter emissions from construction activities (such as clearing, grubbing, blasting, and similar earth-moving activities) and operational activities (such as vehicle travel) are transient in nature and are dependent on many factors such as the moisture in the soil, the level of activity at a particular location, and meteorological conditions at the time of the construction or operational activities. These emissions are expected to be nominal, and are expected to occur intermittently. Any potential for dust or particulate matter generation would likely occur during periods of high winds or extremely dry periods, and as such are expected to be of low frequency and short duration. Given the expected low magnitude of these emission sources, the low frequency of occurrence, limited duration of occurrence, and the mitigation that will be applied, dust and particulate matter emissions from construction and operation activities are not expected to be

substantive.

Further, emissions from construction equipment are another source of pollution. The air contaminants emitted during construction may include nitrogen oxides and carbon monoxide (due to operation of construction equipment and vehicular traffic at the site) besides the suspended particulates in the form of dust.

The predominant wind direction in the area is from the west that is from the sea to the land. The airborne dust and emissions from the construction site would be blown towards the nearby land area. However, these would be limited to construction period. As the site is located away from urban areas and human settlements which are not developed yet, these will not create significant adverse impacts.

Mitigations:

The construction contract will include requirements of dust control by frequent sprinkling of water. Activities such as grading of aggregates which generate too much dust will not be allowed at site and will be carried out off site.

During periods when the prevailing wind direction is north-easterly and strong enough to generate airborne dust naturally, consideration should be given to either wetting or avoiding works that would worsen such effects. It is not likely that dusty conditions would occur often enough to significantly disrupt the construction works.

B- Impacts due to Operation

i- Dust and Fugitive Emissions

Project operations, including LNG storage tanks, vaporisers used in regasification, demethanizer preheaters, marine vessels and vehicle traffic, will also generate fugitive emissions of natural gas, methane, particulate matter, combustion gases and GHGs (primarily carbon dioxide), and possibly small releases of natural gas (non-quantifiable). Air emissions during project decommissioning may also occur, although these are expected to be low.

As described above, under certain conditions fugitive emissions could cause nuisance. The prevailing wind data indicate that in some circumstance airborne dusts if any arising due to activities associated with disturbance to soil could be windblown from the terminal and storage area to inlands.

The operation of LPG Terminal and storage, however, does not generate any dust. Another source of GHGs emissions would be the trucks and bowsers taking LPG supplies to consumers. As the access to site is over paved roads and truck loading bays inside the LPG storage yard will also be paved, dust is not likely to be a problem. The traffic generated by the operation will be normal and within the design capacity of roads in the area.

Mitigations:

The normal dust on the site should be controlled by regular road sweeping. Dust suppression by water sprinkling is considered appropriate.

ii- Emissions from the Power Generators

The proposed LPG Terminal would have natural gas steam turbine generators as a principal source of energy and diesel power as standby. In case of natural gas fuel source emissions would largely be of carbon dioxide; however diesel generators emit a number of substances into the atmosphere including nitrogen oxides (NO_x), sulphur dioxide (SO_2), carbon monoxide (CO) and and particulate matter only during emergencies. The power generating plant will follow World Bank and EPA emission standards.

World Bank Environmental Guidelines for atmospheric emission of SO_2 and NO_x from stationary combustion sources are required to be followed. Limits given in the guidelines are as follows:

SO_2: Maximum allowable increase in ground level concentration = 50 µg/m^3 (one year average).

NO_x: 86 x 10-9 g/Joule heat input (fuel gas), 130 x 10-9 g/Joule heat input (when liquid fuelled)

Dust: When background levels of dust are high, dust emissions from the stack should not be greater than 100 mg/m^3.

It is ensured that the power generation plants meet the standards for emissions and manufacturer's specifications comply with the same.

Mitigations:

No mitigation measure is required as natural gas fired steam turbine power generators will be used.

iii- Fugitive Emissions of Natural Gas and LPG

The pipeline transportation and storage system for the natural gas and LPG is to be rated for zero leakage and designed as a closed system. Therefore, during operation of the facility there will be no leakages or spills of natural gas and LPG as the latest equipment provides for suction of disconnected volume. Hence, with the proposed safety equipment, the quantity of these releases will be very small, within the NFPA and US EPA specified limits and will quickly disperse with the wind. Thus the impact of operational releases of LPG to atmosphere is considered insignificant and will not be an issue.

Experiments made in several countries show that introduction of LPG and natural gas into the energy matrix has contributed to a considerable reduction in pollution rates. A major positive impact of national and strategic dimension is that the project, by facilitating the import of LNG and replacement of oil, wood and coal with gas as fuel will help reduce the air pollution and save scarce forest resources. Therefore the impact of operation of the LNG terminal on the local air quality would be negative. but low in magnitude and within acceptable limits.

Regionally and nationally the impact of LNG import will provide a cleaner fuel substituting for heavy oils and will be positive, large, permanent, direct and long term. It will go a long way in reducing the pollution with increased substitution of natural gas for other fuels.The 3.13 million tons of imported LNG will replace 3.94 million tons of High sulfur Furnace oil. The annual reduction in CO_2 will be 3.5 millions tons (29 %),NO_X by 26 thousand tons (79 %), SO_X by 83 thousand tons (99.9 %) and Particulate Matter by 6 thousand tons (92 %).Additionally 25,000 tons import of diesel consumed in transporting HSFO will be saved and consequential emissions and road congestion will be eased.

Mitigation

Adequate and proper maintenance of all pumps, valves and pipelines must be ensured to limit any fugitive natural gas and LPG emissions within acceptable limits.

C- Air Pollution Dispersion Modelling

The project is associated with a risk due to handling, storage and transport of LNG and LPG. Hence it was appropriate to carry out air dispersion modelling to investigate into the impact on the ambient air quality.

Modelling Methodology

The TANK4.0 software is employed for evaluation of emission from Liquefied Natural Gas (LNG) storage tanks. The TANK software calculates emissions based on the equations developed by American Petroleum Institute (API) using the background information available from different sources (literature survey and electronic sources). The physical information of Floating Storage Unit (FSU) and physical and chemical properties of the Liquefied Natural Gas (LNG) were used for evaluation emissions for various scenarios enlisted for various normal and emergency conditions.

Modelling Scenarios

Following modelling a number of scenarios are taken into consideration based upon various environmental, storage and decking condition:

i- Normal Scenario

Emission of liquefied natural gas (LNG) vapours (Loss of containment) at normal atmospheric conditions.

ii- Emergency Scenario

Following emergency scenarios were considered in the dispersion modelling:

- Scenario-1: Emission of liquefied natural gas (LNG) vapours (Loss of containment) due to failure of temperature control system as a result of collision, Tsunami or other freak weather incidence.
- Scenario-2: Emission of incomplete combustion products of LNG (Loss of containment) in fire condition

Equation

$2CH_4 + 3O_2$ ----> $2CO + 4H_2O$

- Scenario-3: Emission of combustion products of LNG (Loss of containment) in explosion condition (100%)

Equation

$CH_4 + 5O_2 + 3(3.76)N_2$ ----> $4NO + {}_xNO_2 + CO_2 + 2H_2O$

Modelling Applications

The TANKS 4.0 software was used for estimating the emissions. The emissions were calculated according to EPA's AP-42. The information requisite for the use of software was provided and emissions for the storage tank containing liquid LNG calculated. The software has evaluated the emission related the above scenarios assumed for modelling. These emissions are summarized in the following table:

Gaussian dispersion model AerMod software has been used for evaluating the Ground Level Concentrations (GLC) i.e. quantitative amount of emissions from the storage tanks of Liquefied Natural Gas (LNG) affecting the ambient air quality has been determined. Monthly Meteorological Data of Karachi Airport has been used for the Dispersion Modelling. The dispersions of emissions of vapours and hazardous chemical as per given scenarios have been evaluated at distances of 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 2000, 3000 meters from the source towards 16 direction racially keeping north at 0 Degree.

Normal Scenario

Emission of liquefied natural gas (LNG) vapours (Loss of containment) at normal atmospheric conditions.

Contour map shows in Figures 7.1 & 7.2 is one such case for normal scenario (please refer to Annexure-VII for full detailed report on modelling). The 24-hourly average ground level concentration of CH_4 vapours increases from the minimum level of 63.65 $\mu g/m^3$ in May to maximum level of 214.11 $\mu g/m^3$ in December and it decreases from the maximum level of 214,011 $\mu g/m^3$ in December to the minimum level of 63.65 $\mu g/m^3$ in May with little increase in April.

Average monthly ground level concentration of CH_4 vapours increases from minimum level of 31.26$\mu g/m^3$ in February to level of 47.12$\mu g/m^3$ in June. Then it starts increasing and reaches the maximum level of 13.51$\mu g/m^3$ in the November. From November, it again decreases to the minimum level of 31.26$\mu g/m^3$ in February. Also the direction of dispersion is SW from Nov-Feb and NE from Mar-Oct. In the month of February direction of dispersion is both in SE and SW.

Emergency Scenario 1

Emission of liquefied natural gas (LNG) vapours (Loss of containment) due to failure of temperature control system in result of some collision, Tsunami or other freak weather incidence.

The colour contour graphical and spatial representation of one such case of the dispersion of gaseous pollutants emitted for emergency scenarios of failure of temperature control system due to collision, Tsunami or other freak weather incidence are shown in Figure-7.3 and 7.4 (refer to Annexure-VII for extensive details).

Table 7.1: Nature of Emissions in Scenarios

Scenario	Emission in gm/sec	Contents
Normal	2.0636289	CH_4 Vapors
Emergency-1	1196.316494	CH_4 Vapors
Emergency-2	67.03	CO Vapors
Emergency-3	198.10739	NO_x Vapors

Above contour map shows on such emergency scenario, failure of temperature control system due to collision, Tsunami or other freak weather incidence, the 24-hourly average ground level concentration of CH_4 vapours increases from the minimum level of 38,066.87 µg/m³ in May to maximum level of 128,038.92 µg/m³ in December and it decreases from the maximum level of 128,038.92 µg/m³ in December to the minimum level of 38,066.87 µg/m³ May with exceptional little increase in April.

Average monthly ground level concentration of CH_4 vapours decreases from maximum level of 67,880.64µg/m³ in November to minimum level of 18,696.45µg/m³ in February. With little increase to a level of 35,483.22µg/m³, average monthly concentration decreases to the level of 28,181.20µg/m³ in June. From July it again increases to the maximum level of 67,880.64µg/m³ in November.

Also the direction of dispersion is SW from Nov-Feb and NE from Mar-Oct. In the month of February direction of dispersion is both in SE and SW.

Emergency Scenarios 2 and 3

Emission of incomplete combustion products of LNG (Loss of containment) at fire condition

Equation

$2CH_4 + 3O_2 \quad ---> \quad 2CO + 4H_2O$

The colour contour graphical and spatial representations of the dispersion of gaseous pollutants emitted emergency scenarios at incomplete combustion are shown in Figures 7.5 & 7.6 (please refer to Annexure-VII for full details).

Above contour maps show that for emergency scenario (incomplete combustion), the 24-hourly average ground level concentration of CO increases from the minimum level of 2,132.50 µg/m³ in May to maximum level of 7,172.74 µg/m³ in December and it decreases from the maximum level of 7,172.74 µg/m³ in December to the minimum level of 2,132.50 µg/m³ in May with little increase in April.

Average monthly ground level concentration of

Table 7.2: 24-hourly Conc. of CH_4 in Normal Scenario

Months	Concentration (µ/m³)
Jan	139.04
Feb	120.13
Mar	101.22
Apr	107.73
May	63.65
Jun	80.51
Jul	107.62
Aug	121.01
Sep	124.81
Oct	123.60
Nov	200.72
Dec	214.11

Table 7.3: Monthly Conc. of CH_4 in Normal Scenario

Months	Concentration (µ/m³)
Jan	42.87
Feb	31.26
Mar	59.33
Apr	55.75
May	50.94
Jun	47.12
Jul	49.57
Aug	57.84
Sep	72.16
Oct	63.69
Nov	113.51
Dec	96.38

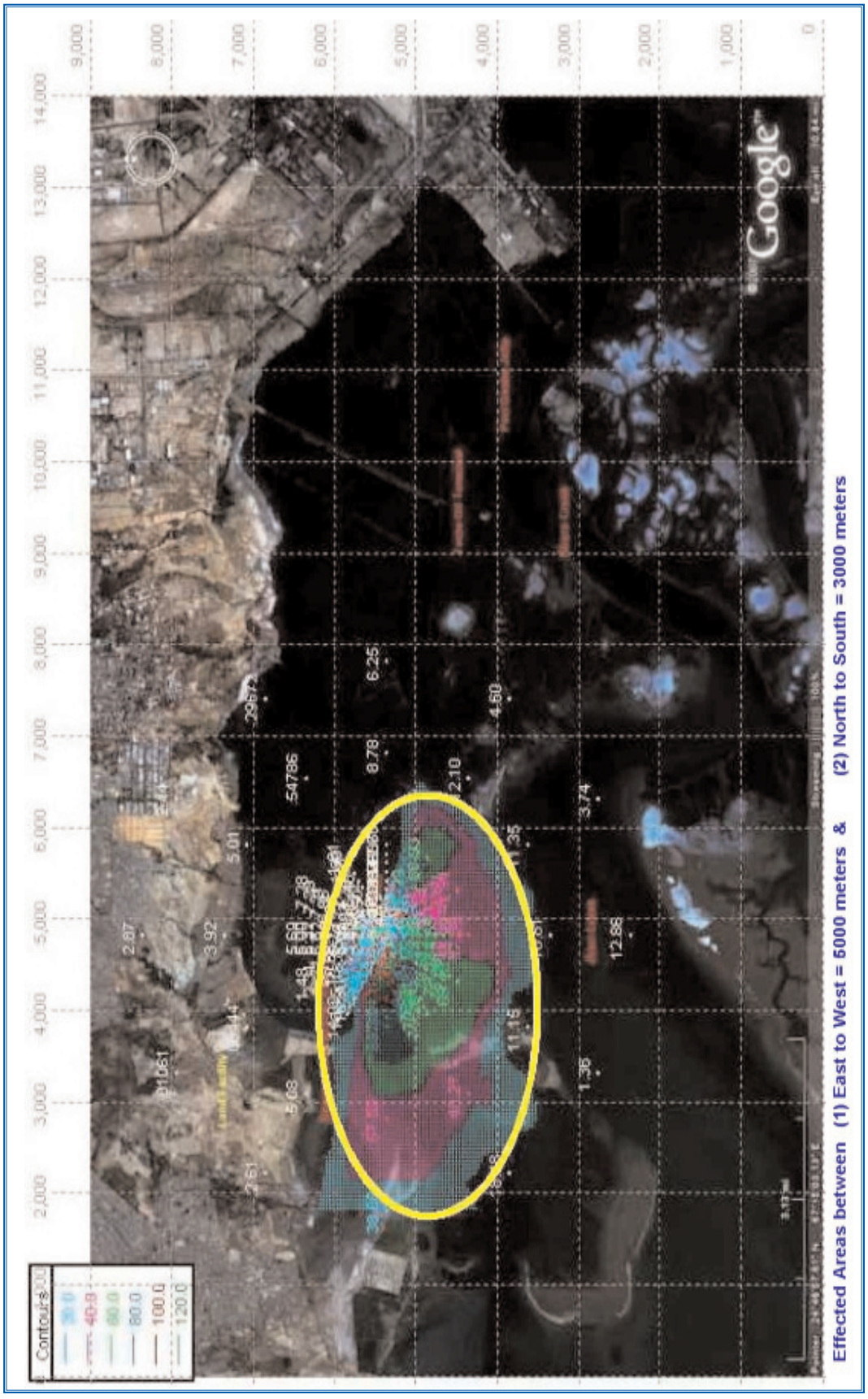

Figure-7.1: Contour Map showing 24-H Avg. Concentration of Methane for the month of January (Normal Scenario)

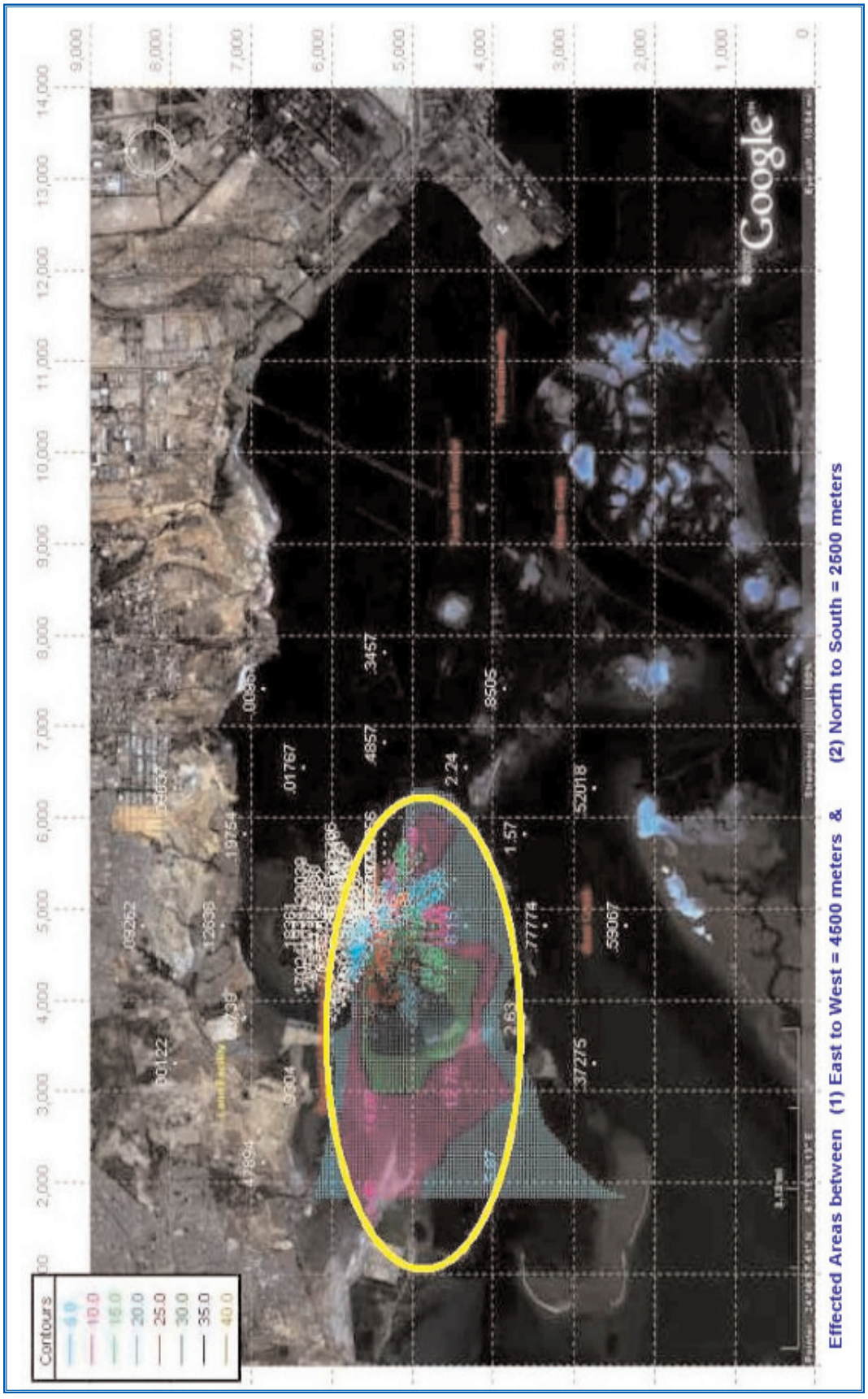

Figure-7.2: Contour Map showing monthly Concentration of Methane for the month of January (Normal Scenario)

CO decreases from maximum level of 3,802.66µg/m^3 in November to minimum level of 1,047.37µg/m^3 in February, with little increase in March to the level of 1,987.77µg/m^3 which again decreases to the level of 1,578.71µg/m^3 in June. From June it starts increasing and reaches to the level of 2,417.67µg/m^3 in September.

The dispersion of CO is prominent in the directions of SW from Nov-Feb and NE from Mar-Oct. In the month of February direction of dispersion remains both in SE and SW.

Emission of combustion products of LNG (Loss of containment) in explosion condition (100%)

Equation

$CH_4 + 5O_2 + 3(3.76)N_2 \text{ ---> } 4NO + xNO_2 + CO_2 + 2H_2O$

The graphical and spatial representations of the dispersion of gaseous pollutants emitted as a result of emergency scenarios causing 100% combustion are shown in Figures 7.7 & 7.8 (please refer to Annexure-VII for full details).

Table 7.4: 24-hourly Conc. of CH_4 under Emergency Scenario 1

Months	Concentration (µ/m^3)
Jan	83,151.78
Feb	71,842.93
Mar	60,534.7
Apr	64,426.58
May	38,066.87
Jun	48,150.00
Jul	64,356.95
Aug	72,368.093
Sep	74,639.51
Oct	73,912.85
Nov	120,036.25
Dec	128,038.92

Table 7.5: Monthly Conc. of CH_4 under Emergency Scenario 1

Months	Concentration (µ/m^3)
Jan	25,642.13
Feb	18,696.45
Mar	35,483.22
Apr	33,340.71
May	30,465.01
Jun	28,181.20
Jul	29,644.04
Aug	34,589.41
Sep	43,157.10
Oct	38,089.81
Nov	67,880.64
Dec	57,638.97

Contour maps show that for emergency scenario (explosion condition), the 24-hourly average ground level concentration of NO_x increases from the minimum level of 5,729.12µg/m^3 in May to maximum level of 19270.06µg/m^3 in December and it decreases from the maximum level of 19,270.06 µg/m^3 in December to the minimum level of 5,729.12µg/m^3 in May with little exceptional increase in April.

Average monthly ground level concentration of NO_x decreases from maximum level of 10,216.09µg/m^3 in November to minimum level of 2,813.84µg/m^3 in February, with little increase to the level of 5,340.28µg/m^3 and later, the average monthly concentration of NO_x decrease to the level of 4,241.33µg/m^3 in June. Increasing trend is shown for NO_x concentration from June to November. Also the direction of dispersion of NO_x is SW from Nov-Feb and NE from Mar-Oct. During the month of February direction of dispersion remains both SE and SW.

It is observed from plots of the data that the ground level concentration decreases with distance and is maximum in the direction of wind. The dispersion is maximum in direction of 45 and 225 degrees from north; hence the North-East and South-West direction are more effected by the emissions from the FSUs. The concentration of emitted vapours & gaseous pollutants decreases with distance from the source. The emitted pollutants are above danger level up to two kilometres.

The emission of CH_4 vapours in normal atmospheric conditions according to Air Quality Modelling, be diluted and dispersed so as not to alter the quality of airshed, which fall in the unpolluted category with an average 24-Hourly and monthly mean values for each month of a year as given in Table-7.10.

The emission of CH_4 vapours in failure of

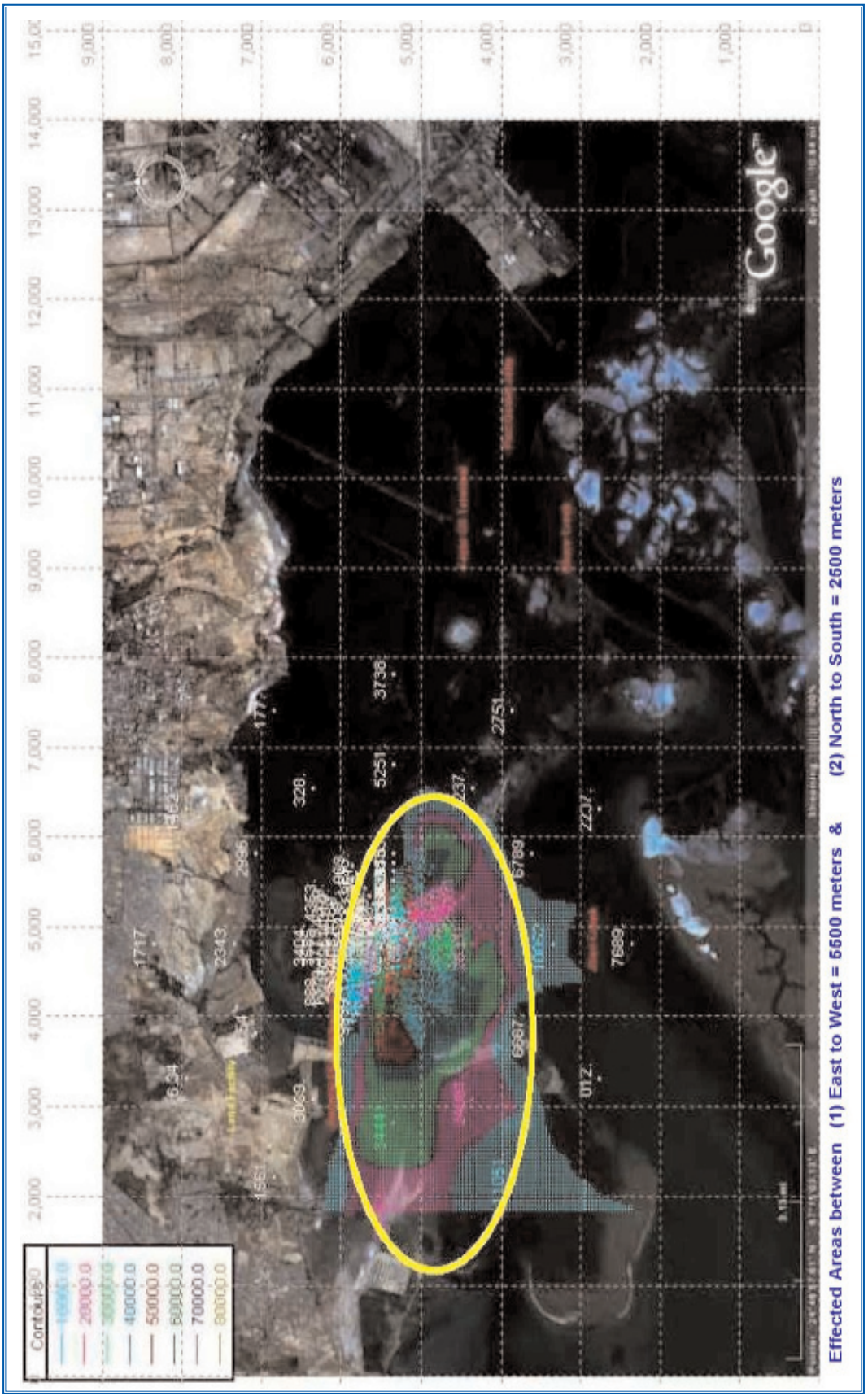

Figure-7.3: Contour Map showing 24-Hrly Avg. Concentration of Methane for the month of January (Emergency Scenario)

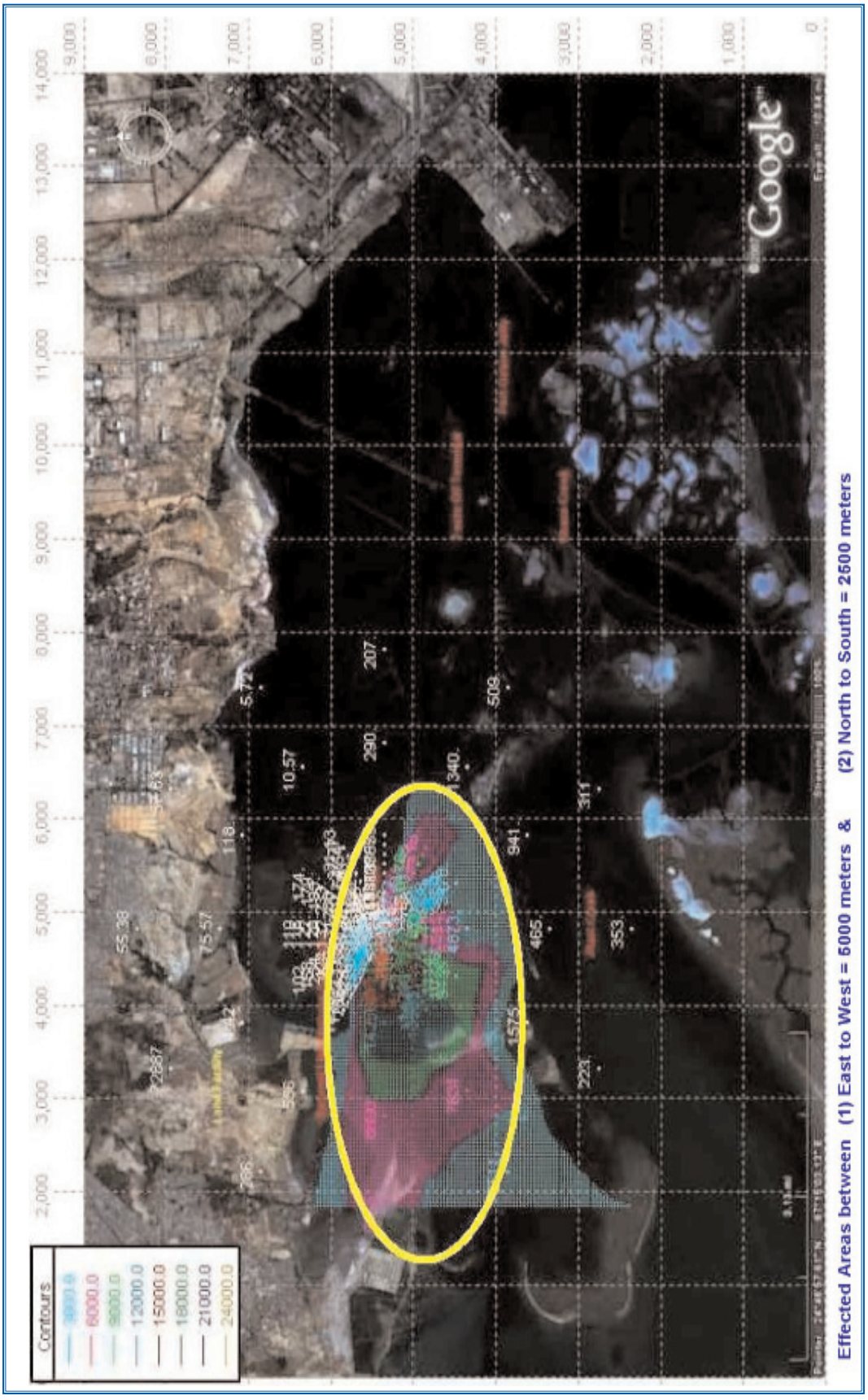

Figure-7.4: Contour Map showing monthly Concentration of Methane for the month of January (Emergency Scenario)

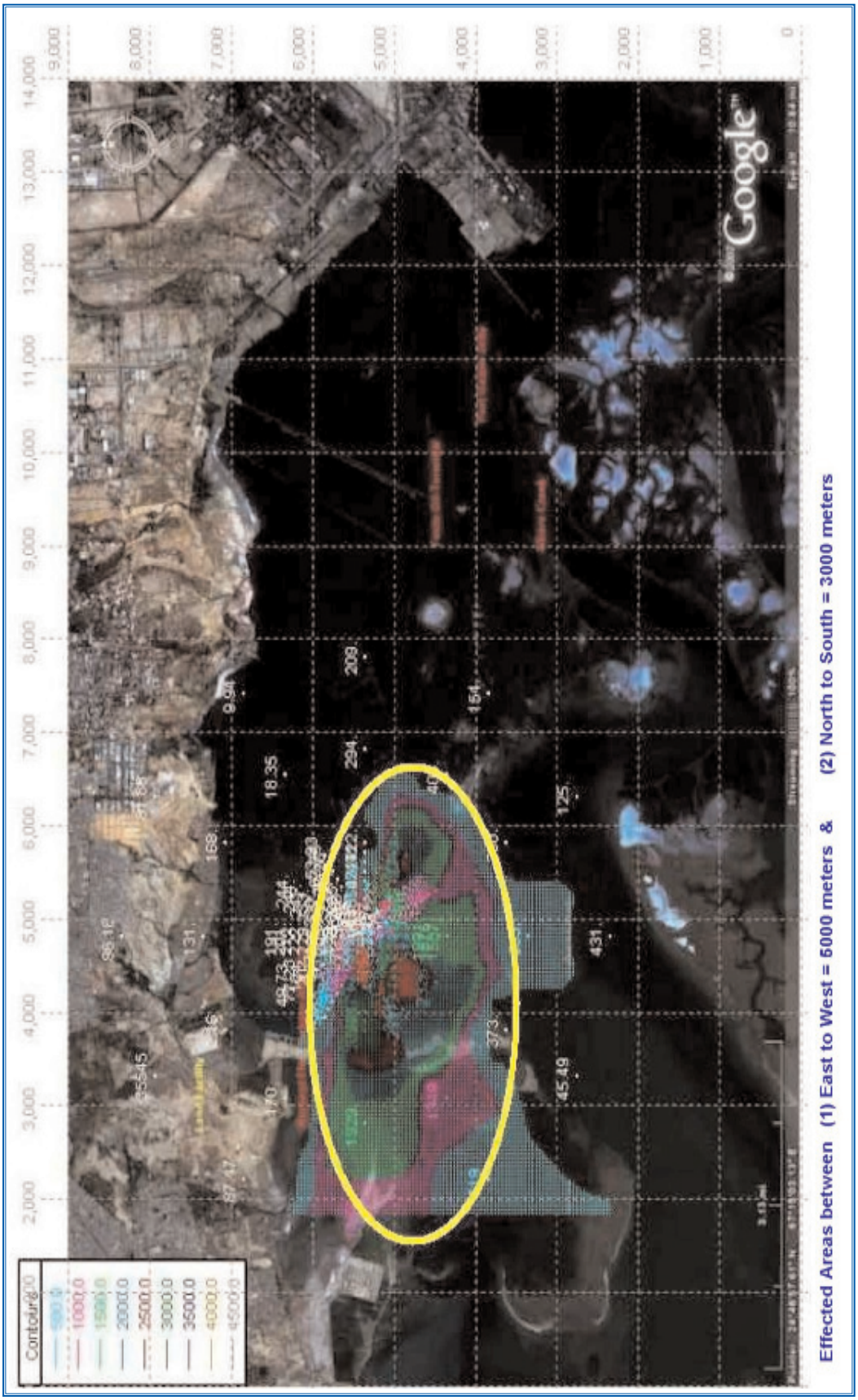

Figure-7.5: Contour Map showing 24-Hrly Avg. Concentration of CO for the month of January

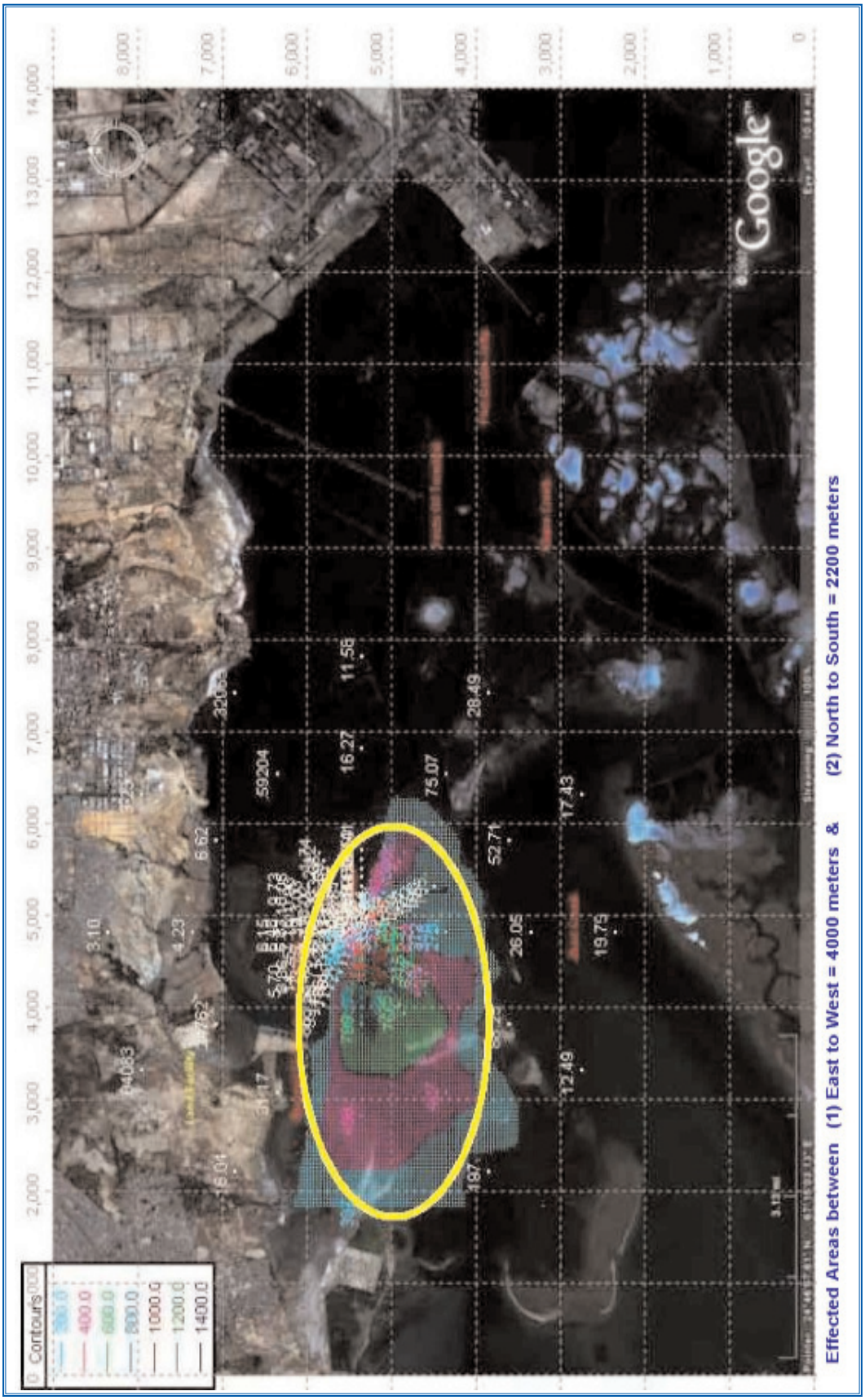

Figure-7.6: Contour Map showing monthly Concentrations of CO for the month of January

temperature control system due to collision, Tsunami or other freak weather incidence is diluted and dispersed. The quality of airshed will be altered, putting it in the polluted category with an average 24-Hourly and monthly mean values for each month of a year as given in Table-7.11.

Table 7.6: 24-hourly Conc. of CO under Emergency Scenario 2

Months	Concentration (µ/m³)
Jan	4,658.16
Feb	4,024.64
Mar	3,391.16
Apr	3,609.18
May	2,132.50
Jun	2,697.36
Jul	3,605.28
Aug	4,054.06
Sep	4,181.30
Oct	4,140.60
Nov	6,724.43
Dec	7,172.74

Table 7.7: Monthly Conc. of CO under Emergency Scenario 2

Months	Concentration (µ/m³)
Jan	1,436.47
Feb	1,047.37
Mar	1,987.77
Apr	1,867.74
May	1,706.64
Jun	1,578.71
Jul	1,660.65
Aug	1,937.69
Sep	2,417.67
Oct	2,133.80
Nov	3,802.66
Dec	3,228.93

The emissions of CO due to incomplete combustion of LNG in fire condition will spread in the direction of wind altering the quality of airshed of the region. The 24-hourly and monthly ground level concentrations of CO will remain as given in Table-7.12.

The emissions of NO_x due to explosion and complete burning of LNG at fire conditions will pollute the airshed and disperse to larger distance. The 24-Hourly and monthly ground level concentration are modelled as given in Table-7.13.

Impacts of Disperssed Air

The above tables and contour maps leads to the conclusion that gaseous emissions from normal atmospheric conditions for the proposed LNG project would not add any of the priority pollutants beyond the limits set by World Bank Guidelines and would not degrade the quality of airshed. The limits set by NEQS also suggest that the quality of airshed would not be altered to hazardous state by the emissions from the LNG Project. However, in case of accidental rupture/explosion the emissions of CH_4 vapors and gaseous pollutants will exceed the NEQS limits and ambient air quality criteria of WHO & US EPA. Adequate mitigation measures are required to be implemented to avoid such catastrophe.

Table 7.8: 24-hourly Conc. of NO_x under Emergency Scenario 3

Months	Concentration (µ/m³)
Jan	12,514.48
Feb	10,812.48
Mar	9,110.57
Apr	9,696.30
May	5,729.12
Jun	7,246.65
Jul	9,685.82
Aug	10,891.51
Sep	11,233.36
Oct	11,124.00
Nov	18,065.65
Dec	19,270.06

Table 7.9: Monthly Conc. of NO_x under Emergency Scenario 3

Months	Concentration (µ/m³)
Jan	3,859.18
Feb	2,813.84
Mar	5,340.28
Apr	5,017.83
May	4,585.04
Jun	4,241.33
Jul	4,461.47
Aug	5,205.75
Sep	6,495.23
Oct	5,732.60
Nov	10,216.09
Dec	8,674.74

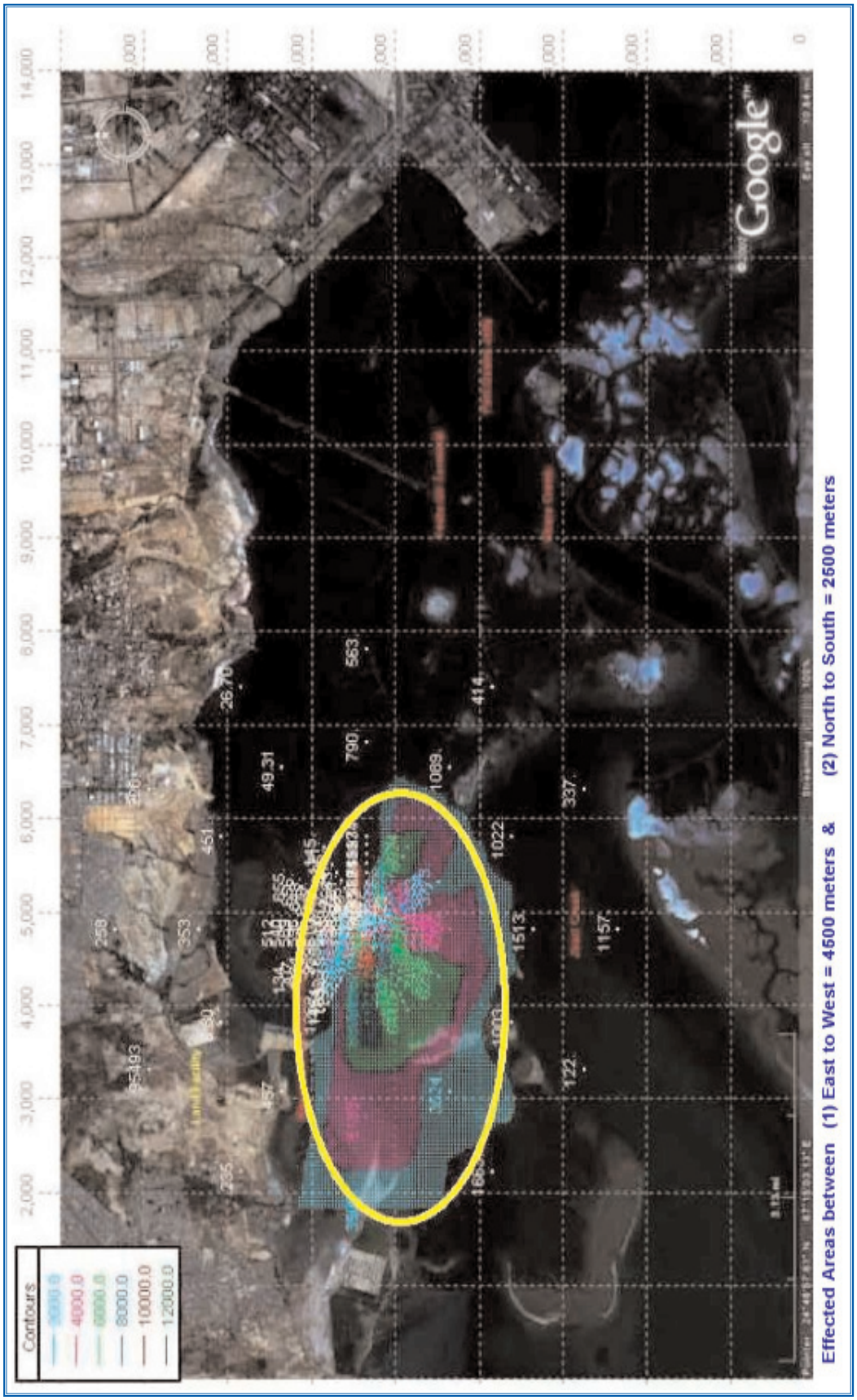

Figure-7.7: Contour Map showing 24-Hrly Average Concentration of NOx for the month of January

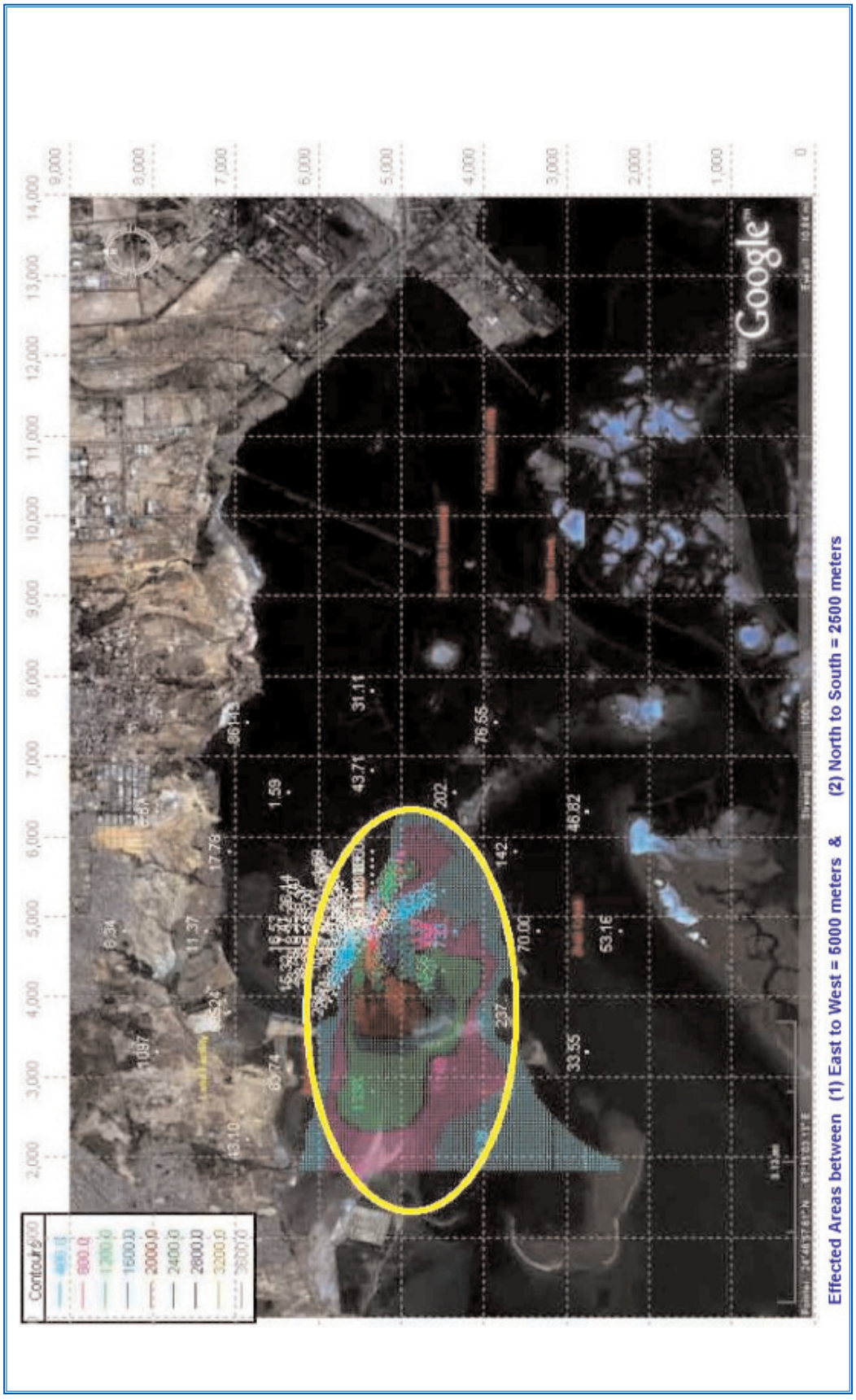

Figure-7.8: Contour Map showing monthly Concentration NOx for the month of January

Mitigations

- Regular maintenance and checks be ensured to prevent any leakage or accident
- An emergency safety plan be devised to handle any emergency / fire situation.

7.3.3- Impacts on Maritime Navigation

A- Impacts during Construction Phase

During construction of the LNG Jetty, there may be occasional temporary obstruction to navigation during manoeuvring of the floating construction equipment (piling barge) and mostly will be off from navigational channel. However any movement will be coordinated with Port Authority. As the proposed jetty is located on the confluence of Kadiro and Phitti Creek well separated away from the main navigation channel, there will be no obstruction to shipping during routine construction operations.

Mitigation

No mitigation measures are required.

B- Impacts due to Operation

No impact on navigation in the main channel of the port is expected. The Port Authority will regulate the traffic in the channel according to regulations.

Mitigation

No Mitigation measures are required.

Table 7.10: Expceted 24-hourly and monthly mean conc. of CH_4 after diluation and good dispersion in the normal atmospheric conditions

Months	24-Hourly Conc (μ/m^3)	Distance from source (meters)	Direction (Degree)	Monthly Conc (μ/m^3)	Distance from source (meters)	Direction (Degree)
Jan	139.04	300	247.5	42.87	300	2447.5
Feb	120.13	800	202.5	31.26	900	157.5
Mar	101.22	800	67.5	59.33	600	67.5
Apr	107.73	800	67.5	55.75	600	67.5
May	63.65	600	67.5	50.94	600	67.5
Jun	80.51	600	67.5	47.12	600	67.5
Jul	107.62	800	67.5	49.57	600	67.5
Aug	121.01	800	67.5	57.84	600	67.5
Sep	124.81	800	67.5	72.16	600	67.5
Oct	123.60	400	22.5	63.69	600	67.5
Nov	200.72	800	202.5	113.51	800	202.5
Dec	214.11	800	202.5	96.38	600	202.5

Table 7.11: Expceted 24-hourly and monthly mean conc. of CH_4 after diluation and good dispersion in the faliure of temperature control system

Months	24-Hourly Conc (μ/m^3)	Distance from source (meters)	Direction (Degree)	Monthly Conc (μ/m^3)	Distance from source (meters)	Direction (Degree)
Jan	83151.78	300	247.5	25642.13	300	247.5
Feb	71842.93	800	225	18696.45	900	157.5
Mar	60534.7	800	67.5	35483.22	600	67.5
Apr	64426.58	800	67.5	33340.71	600	67.5
May	38066.87	600	67.5	30465.01	600	67.5
Jun	48150.00	600	67.5	28181.20	600	67.5
Jul	64356.95	800	67.5	29644.04	600	67.5
Aug	72368.093	800	67.5	34589.41	600	67.5
Sep	74639.51	800	67.5	43157.10	600	67.5
Oct	73912.85	400	45	38089.81	600	67.5
Nov	120036.25	800	225	67880.64	800	225
Dec	128038.92	800	225	57638.97	600	225

Table 7.12: Expceted 24-hourly and monthly mean conc. of CO due to incomplete combustion of LNG at fire condition

Months	24-Hourly Conc (µ/m³)	Distance from source (meters)	Direction (Degree)	Monthly Conc (µ/m³)	Distance from source (meters)	Direction (Degree)
Jan	4658.16	300	247.5	1436.47	300	247.5
Feb	4024.64	800	202.5	1047.37	900	157.5
Mar	3391.16	800	67.5	1987.77	600	67.5
Apr	3609.18	800	67.5	1867.74	600	67.5
May	2132.50	600	67.5	1706.64	600	67.5
Jun	2697.36	600	67.5	1578.71	600	67.5
Jul	3605.28	800	67.5	1660.65	600	67.5
Aug	4054.06	800	67.5	1937.69	600	67.5
Sep	4181.30	800	67.5	2417.67	600	67.5
Oct	4140.60	400	22.5	2133.80	600	67.5
Nov	6724.43	600	225	3802.66	800	225
Dec	7172.74	800	225	3228.93	600	225

Table 7.13: Expceted 24-hourly and monthly mean conc. of NO_x due to explosion and complete burning of LNG at at fire condition

Months	24-Hourly Conc (µ/m³)	Distance from source (meters)	Direction (Degree)	Monthly Conc (µ/m³)	Distance from source (meters)	Direction (Degree)
Jan	12514.48	300	247.5	3859.18	300	247.5
Feb	10812.48	800	202.5	2813.84	900	157.5
Mar	9110.57	800	67.5	5340.28	600	67.5
Apr	9696.30	800	67.5	5017.83	600	67.5
May	5729.12	600	67.5	4585.04	600	67.5
Jun	7246.65	600	67.5	4241.33	600	67.5
Jul	9685.82	800	67.5	4461.47	600	67.5
Aug	10891.51	800	67.5	5205.75	600	67.5
Sep	11233.36	800	67.5	6495.23	600	67.5
Oct	11124.00	400	22.5	5732.60	600	67.5
Nov	18065.65	800	202.5	10216.09	800	202.5
Dec	19270.06	800	202.5	8674.74	600	202.5

7.3.4-Impacts on Geology, Geomorphology & Hydrogeology

A- Impacts during Construction Phase

The proposed LNG jetty and mooring dolphins will be supported on tabular steel piles while the sub-sea delivery main will run through the inter-tidal mud flats. This type of construction will not have any negative impact on the geology, geomorphology and hydrogeology of the area.

The LPG terminal is proposed to be located on-shore close to high water line and will require fill to raise, level and grade the area. The material to be deposited as fill will need to be granular to aid drainage of subsoil and settlement. The graded area will drain to the creek. This construction will not have any impact on geology, geomorphology and hydrogeology.

The dredging of a berthing pocket will not be adjacent to the existing navigation channel, also the dredging activity would be insignificant in comparison to the maintenance dredging of navigation channel being carried out regularly by Port Qasim Authority. The hydraulic model studies for Port Qasim have extensively studied the impacts of dredging of navigation channel and the spoil areas for over a decade. No significant impact on geology, geomorphology and hydrogeology has yet been identified. The comparatively moderate dredging for the berthing pocket and disposal of spoil in the areas designated by Port Qasim Authority however may cause some negative impact on the channel

geomorphology but this will be insignificant.

No obstruction to the main navigation channel will be caused by construction and operation of the project.

The site is located in a seismic ally moderate to major hazard (seismic zone 3 of Pakistan) area and design of all facilities shall be based accordingly.

The construction of the proposed project is therefore expected to have however low and negative impact on geomorphology due to the considerable dredging activity i.e. around 3.8 million cubic meter of mud flat and its subsequent disposal as dredged material to remote site around 4-5km away. The impact as quantified would be however low, direct, long term but local.

Mitigation

Following measures will further reduce this impact:

Disposal of dredged material in the areas designated by Port Qasim Authority as will require considerably long haulage of the dredged material has been proposed and recommended to mitigate the impact on navigation and geomorphology of the creek area.

No obstruction or filling up of any drainage or channel in the area,

The structural design of facilities to take into account the seismic risk factor of 0.3 for Operational Basis Earthquakes (OBE) and a factor of 1/15 g for Maximum Credible Earthquake (MCE)

The delivery of fill material to site to be equalized with spreading and compaction of fill layers to avoid spillage into the water

Spoils from piling works to be disposed outside the channels and in areas designated by the Port Authority.

Protection of fill slopes against erosion. During construction these to be protected by sand bags until permanent protection by properly designated stone rip rap. A cofferdam for containment of the dredged material has been proposed and designed to retain the disposed material. Placement of the dredge material has been sited per PQA requirements. The area selected is exposed low sloping mud flats that are not used commercially or for residences. Cofferdam construction will take place from barges used to place and secure the interlocking dam material. As the work will take place from floating platforms, disturbance to sediments will be localized and of short duration. Once in place, the area behind the cofferdam will be dewatered, and a fabric liner placed shoreward to minimize infiltration of dredge material into the waterway.

B- Impacts due to Operation

The operation of the LPG terminal will not have any impact on the geology, geomorphology and hydrogeology of the area.

Mitigation

No mitigation measures are required.

7.3.5- Hydrological Impacts

A- Impacts during Construction Phase

The construction of the project does not interfere with the natural drainage of the area. The soil proposed to be used as fill is granular. The fill slopes on the creek side will be protected against erosion by stone pitching. However, during construction, some spillage of fill material and waste on to the foreshore areas may be unavoidable. Careful construction operation will limit it to minimum with no significant impact.

The ground water is saline. The subsoil being fine grained and largely plastic, the permeability is very low. Due to the proximity of the seawater creeks, the subsoil drainage is towards the creeks. The construction of the LNG terminal facility, in particular the jetty laying of sub-sea pipe, will result in short term increases in the suspended solid loading of the creek system.

i- General Impact on Water Quality

The construction of the proposed project does not interfere with the natural drainage of the creek system of the area. The construction of the LNG Jetty including the sub-sea laying of pipeline will result in short term increase in the suspended material in the water column of the creeks causing increased turbidity. In addition to this release of contaminants / wastes, loss of benthic flora and fauna and mangroves may happen.

The re-suspended sediments can also be transported and re-deposited elsewhere in the surrounding causing negative impact on benthic fauna and fishery resource.

Direct impacts on water quality arise when the sediments are contaminated. The release of any heavy metal, hydrocarbons, or other hazardous chemicals into the water column can cause toxic effects on marine biota. The release of organic wastes could cause localized oxygen depletion in the water column creating stressful conditions for aquatic biota.

During the construction phase there will be generation of some sewage material due to personnel involved in the construction work. The disposal of these sewage materials into the marine environment will also have minimum adverse impact on the water quality as well as marine biota. Efforts should be made to minimize the impact of this pollutant. Since it is a purely temporary phase and short term, no mitigation measure is required for the purpose.

Mitigation

Since it is a purely temporary phase and short term activity, no mitigation measures are required except careful use of heavy machinery and precautions because it is a short term activity.

ii- Impact on Sediment Quality

The sediment quality (Table 7.14) reported by Khan et al (1999) for the Korangi Creek, the site of the proposed LNG Jetty indicate that the sediment quality to be excavated/dredged or disturbed due to construction work of the jetty and laying of pipeline is not contaminated with heavy metals to any significant level.

Sediment contamination could have been of concern because the disturbance caused by dredging/excavation/ reclamation or construction work would have released contaminants into the water column either by solution or re-suspension of particulate matter. However, as the quality of sediment does not fall under highly contaminated category, the disturbance caused due to construction work is not expected to have an adverse impact on water quality of the surrounding environment or potential toxic impacts on aquatic biota due to the bio-availability of any contaminants.

Mitigation

No mitigation measures are required as the construction of the LNG Jetty and laying of sub-sea pipeline is a short term process.

iii- Effects of Dredging on Water Quality

The disturbance of bed sediments through activities such as dredging can lead to a number of impacts on marine water quality including:

- turbidity plumes;
- release of contaminants;
- oxygen depletion.

The re-suspension of sediments during dredging can cause dense turbidity plumes. Turbidity plumes are usually detrimental to aquatic ecosystems because of the effect of reduced light penetration through the water column. Re-suspended sediments can also be transported and re-deposited causing the smothering of benthic fauna and fishery resources.

Direct impacts on water quality tend to arise when the sediments are contaminated. The release of any heavy metals, hydrocarbons, organo-halogen compounds, etc. from the sediment into the water

column can cause toxic effects on aquatic biota. The release of organic wastes can cause localized oxygen depletion of the water, again creating stressful conditions for aquatic biota. The sediment quality survey of the area adjacent to the proposed LNG Jetty indicated that the sediments to be dredged from the site area are not contaminated to any significant level. Sediment contamination would have been of concern because the disturbance caused by dredging would have released contaminants into the water column, either by solution or re-suspension of particulate matter. However, as the quality tests have demonstrated that the sediments are effectively not contaminated, the dredging is not expected to have an adverse impact on water quality, In addition, potential toxic impacts on aquatic biota due to the bio-availability of any contaminants are not expected.

Mitigation

No mitigation measures are required.

iv- Effects of Disposal of Dredge Spoil on Water Quality

The volume of material to be dredged for the berthing pocket and temporary access canal is considerable and dredging spoil of about 3.8 million m_3 is expected to be disposed in the designated area of tidal mud flat in vicinity of the shore area for reclamation or disposed at the specified disposal areas specified by PQA.

Guidance of the London Convention recommends that consideration be given to the environmental characteristics of marine disposal site. The actual location for disposal is to be chosen from the sites approved by the Port Authority, by the contractor appointed to undertake the dredging. However, in terms of water quality, consideration should be given to the potential effects of turbidity and the introduction to the disposal site of any contaminants that may be present in the dredged material.

Disposal of dredging spoil from Port Qasim channel have been in progress since 1970's and is monitored by Hydraulic Research Laboratory, Wallingford (UK). To date no significant impacts from disposal have been reported.

The sediment to be dredged and disposed does not appear to be contaminated. It is therefore expected that water quality would not be adversely affected on long-term basis by the dredging and disposal of spoil.

The dredged material however would be released into the sea either from the dredger's hopper or a barge and as the material is likely to comprise silts and clays, dispersal by currents during its fall through (the water column could cause localized conditions of high turbidity at disposal site. The silts and clays are believed to be relatively well consolidated so it is likely that the majority of the disposed material would fall directly to the bed, reducing potential for dispersion of low density material by thermal water layers. As the dredge

Table 7.14: Metal Concentration in the Sediment Samples

METAL	NETHERLANDS SOIL QUALITY GUIDELINES		AVERAGE CONCENTRATION OF METAL IN KORANGI CREEK mg/kg
	Target Value mg/kg	Intervention Value mg/kg	
Cadmium	NS	NS	0.071
Copper	36	190	39.18
Chromium	100	380	96.46
Lead	85	530	19.96
Mercury	0.3	10	0.071
Zinc	140	720	75.56

SOURCE: Khan et al 1999, Netherlands framework for soil remediation
NS=Not Specified

spoil is released below the surface, turbidity is not therefore expected to be high, although some low-density material may be dispersed. In case of disposal of dredged spoil in areas earmarked by the Port Authority for reclamation, the slurry will be properly contain in settling ponds to allow suspended solids to settle down and a relatively clean effluent will be released to the creek. The structure of the cofferdam especially designed to retain the dredged material is lined with geotextile material to ensure sediment retention and low turbidity characteristics during the tidal surges in the containment area. The overall effect of the disposal operation is therefore not though likely to cause significantly adverse turbid conditions.

Mitigation

In terms of water quality, no mitigation measures are required. However, due regard should be given to the mitigations concerning the potential impacts of disposal on other characteristics of the marine environment as discussed in the following sections.

v- Spillages of Construction Materials and Piling Wastes

During the construction of LNG terminal it is possible that construction materials could either be lost accidentally or dumped intentionally into the aquatic environment. Although materials like rock, concrete, plastics, etc. are relatively inert, other materials such as metals, fuels, etc. can cause deleterious effects on the water quality.

Other than a large scale accidental spill of fuels or other mechanical fluids, the impact of an individual event is likely to be small and not significantly adverse.

However, the cumulative impact of a number of events over the construction period could have wider implications for aesthetic quality, fisheries and coastal ecosystems. In addition, large quantities of debris on the sea bed could hinder dredging operations. For example, a bucket dredger may encounter large sized debris, adding extra time and costs to the dredging operations.

It is further anticipated that the piling operations associated with the jetty construction will produce small spoil material. Samples of the spoil material produced from mud flats may be tested for contamination and, if found heavily contaminated, should be disposed off-site. The dumping of this spoil otherwise would be restricted to the areas immediately adjacent to the jetty construction site.

The estimated quantity is considerably low and unlikely to cause adverse impact on long-term basis.

No handling and use of any contaminants during construction is required. However, some oily wastes from construction equipment may be released but their quantity being insignificant, no impact on marine water quality is expected.

Any negative impact on the soil due to construction will be small, reversible, temporary, direct but short term and local. No impact on ground or sub-marine soil water is anticipated.

Mitigation

In order to minimize any impacts from losses or spillages of site materials and wastes during construction, the contractor undertaking the construction should ensure that there are no losses of potentially polluting materials to the water and that any spillages on land are removed and cleaned up immediately. The latter point would be important to ensure that substances such as fuels and oils are not left to soak away. A clause to ensure this takes in effect therefore need to be included within the contract package of the construction works. In addition, before commencing any work that could involve spillages of polluting materials, the contractor should produce an effective plan of prevention and clean-up measures (refer EMP as described in chapter 8 of this document).

The resident engineer at site should be consulted

and should approve such measures.

A further clause in the construction contract should ensure that the contractor keeps all working areas, storage areas, waterways and berths clear of any rubbish, debris and obstructions at all times. All debris and rubbish should be regularly removed from the site. Lastly, all possible precautions should be taken to provide for the safe storage and use of fuels, gas bottles and all other hazardous materials temporarily brought at site by contractor.

B- Impacts due to Operation

i- Industrial Effluents & Spills

The port operations at Karachi and Port Qasim would suggest that contaminating substances are discharged and deposited into the deep water channel. Therefore, despite the mitigation measures incorporated into the design of the Port facilities and recommendations of good practice, the sediments that accumulate in the deep water channel become contaminated from wastes discharged from other port terminals, berths and industrial effluents.

The transportation and storage system is designed for zero leakage. Any accidental spill will immediately vaporize and disperse with wind. However, as a further safety measure, the tank farm shall be provided with an impermeable barrier below the ground surface to prevent infiltration in soil and contain any major leaks or spill from the tanks within the bunds.

Mitigation

While no mitigation measures are required as far as the operation of LNG terminal is concerned but in view of other sources of pollutants within the port, periodic monitoring of water and sediment quality is therefore recommended. A monitoring programme should be executed by the Port Qasim Authority to keep a close watch on the water and sediment quality and ensure enforcement of EPA standards on various port users in the area in future. Monitoring would record any accumulation of contaminants and should be used as an indicator for targeting reduction of contaminating inputs. In this way it is hoped that significant quantities of contaminants would not accumulate.

ii- Drainage from the Berth and Storage Areas

In many long established port areas, the run-off from quays and storage areas has been allowed to flow unchecked into the adjacent water. Run-off can contain various contaminants and substances detrimental to the aquatic environment. For example, typical ship to shore operations at jetties could lead to spillages of fuels, oil and grease, etc. Although each spill may contribute little, many spills over the long term can cause the chronic concentrations of contaminants and the significant degradation of water quality. Such conditions have arisen at both Karachi Port and Port Qasim, probably through a combination of limited maintenance of facilities and working practices.

The LNG terminal facility would have least discharges of pollutants to soil and water. The storm water run off from storage areas and berth will be having minimal contaminant discharges except for sediments and some traces of oils. Run off from the built surfaces will be allowed to flow through a series of catch pits leading to drains that discharge directly to the water. The jetty platform and storage area is hard surfaced. The storm runoff will be collected by open drains and discharged to the nearest storm water drain.

As the rainfall in the area is scarce, the run-off from the onshore area would be minimal. In addition, it is planned to regularly sweep the hard areas to remove the littered/spilled solid wastes and dust.

Mitigation

No mitigation measures are required as far as the proposed LNG terminal and storage facility is concerned. However, good working and house

keeping practices would need to be emphasized. Evidence from working practices at Karachi Port and Port Qasim indicate that current practices include the discharging and dumping of waste materials directly into harbour waters without regard for subsequent environmental damage. It is therefore proposed that LNG terminal staff be given short term training in observing good house keeping practices beside their respective job. More specifically managers as well as workers will be made aware of the implications of unhealthy practice on the environment.

In addition, it is recommended that the PQA should establish a water and sediment quality monitoring programme. Under this programme, all terminal operators & PQA should be jointly responsible for monitoring the change in contaminant concentration in the water and bed sediments in the Port for any remedial measures that may become necessary.

iii- Oily Spills

The LNG Jetty for berthing of ship as well as the handling area will not be handling any hydrocarbon based fuel and hazardous chemical, the spillage during operation will be negligible. The only minor pollution will be added to the marine environment will be due to shipping traffic. The ship will be anchored / handled at the site very near to already navigational Channel of Port Qasim which is receiving the regular discharges from Port Qasim activities. The minor discharges from LNG. Terminal will be of no significant level. It is also not going to create any change is geomorphology, geology and hydrodynamics of the area. Moreover the water quality will also be not adversely impacted.

Spillage of oil and other hydrocarbon-based fuels, such as diesel, discharges of untreated oily slops or ballast water has marked pollution effects on the quality of water and damages aquatic environment & ecosystems. In enclosed channels such as at PQA the breakdown of fuel to its more toxic fractions can cause the mortality of many aquatic faunal species.

Although the LNG terminal is not to handle bulk oil, the storage area does include installations to store diesel in certain quantity for use by power generator which will be part of the jetty structure of the terminal. There is potential likelihood of small scale spillages near the diesel tank to cause minor adverse impacts locally. There would be no possibility for a spill large enough to cause impacts on the seawater or local ecosystems. In order to contain any spill, a dyke would surround the diesel tank. It is recommended to construct a dyke capable of containing the spilled contents of the tank plus another 10% in accidental cases, when a pipe or tank were to rupture, the diesel oil would be well contained.

Mitigation

No mitigation measures required, as the stored quantity of oil is small and is located onshore nor any possible spillage can mix with sea water or groundwater.

iv- Discharges from the Septic Tank

Incident of discharge of untreated sewage into the creeks could have potentially adverse effects on water quality. Any impact would be influenced principally by the effluent quality and quantity, and the dilution and dispersion effects around the point of discharge. For example, the discharge of raw sewage with a high BOD to low energy in sheltered water could cause localized oxygen depletion.

The industries in Port Qasim area are required to treat their industrial sewage and discharge the treated effluent meeting EPA's NEQS. The LNG terminal will have only domestic sewage from its offices which shall be collected and treated in a septic tank or otherwise transported to shore for disposal.

Mitigation

No mitigation measures are required as the

effluent is treated in septic tank before its discharge into PQA sewerage system or creek waters.

v- Discharges of Ships' Wastes

The discharge of ships' wastes into the main channel & onto port waters could cause the contamination of water and sediments. Secondary impacts could arise, such as the degradation of fisheries and aquatic habitats, large commercial vessels are a major source of waste generated by port operations. MARPOL 73/78, seeks to prevent the discharge of polluting substances from ships into the marine environment. MARPOL 73/78 contains several annexes with restrictions on the discharge of wastes including:

Annex I, Oil: Prohibits the discharge of oil, oily bilge water, etc. containing > 15 ppm oil within 12 miles of land. Also establishes other conditions for discharges beyond 12 miles of land;

Annex IV, Sewage: Prohibits discharge of ships' sewage unless treated or discharged at a certain distance from land;

Annex V, Garbage: Prohibits discharge of ships' food waste, sludge, packaging etc. to sea under certain conditions. Any discharge of plastic wastes is banned.

As per Annexure-I of MARPOL 73/78, where the oil content of the separated waters is below 15 ppm, the water can be discharged into the harbour, In Pakistan, the EPA standard for grease and oil in municipal and liquid industrial effluents is 10 mg per litre (i.e. equivalent to 10 ppm).

The discharge of ship's garbage causes the collection of waste products on the shoreline. In addition to the adverse aesthetic impact, garbage such as plastics and glass are not biodegradable.

Mitigation

The ships calling on LNG terminal will be required to follow MARPOL 73/78. As no facilities for reception of ships bilge water, ballast or solid waste and their treatment are proposed at the LPG Terminal, the ships will be advised accordingly. All waste material will be taken away by qualified contractors for disposal according to World Bank and Pakistan regulatuions for each material.

7.4- IMPACTS ON ECOLOGY

The biota at site comprises of the terrestrial ecology, mangroves and marine ecology. These are reviewed below:

7.4.1- Terrestrial Ecology

The construction of the proposed LNG Terminal, storage area and sub-sea pipeline will not result in significant damage to the ecosystem that is already sparsely vegetated with a few plant species, each of which is prevalent in the Karachi region. It is estimated that on shore ecology will not be much affected. Some land will be used for construction but it is expected that any unique habitat will not be lost. Similarly, during operation phase terrestrial ecology will remain unaffected.

A- Impacts during Construction Phase

The grading operation for the LPG storage tank farm will cause removal of some sparse vegetation close to the high water line. This vegetation is of a low grade scrub, abundant in the adjacent areas and all over Karachi. Removal of this from an area of about 6 ha will be required. This will impact the habitat of some birds and other animals which are expected to migrate to the adjacent busy on the east and west of the site. No rare or endangered species of plants or animals are reported in the area.

The laying of the sub-sea pipeline from onshore storage to the LPG terminal across the fore-shore inter-tidal mud flats will disturb the sparse shrub near high water line of similar nature as in the storage area besides some mangroves between Korangi and Kadiro Creeks. Some of these plants will need removal at the location of the trenched pipeline. This will be minimal and the rest of the

plants other than the 3m width (of the aligned root) shall remain in tact. The impact will be though negative but small and local with minimal disturbance of plant and animal habitat in the area.

Mitigation

The construction contract should include provisions to limits the removal of any bushes or mangrove to absolute necessity. All other plants in the vicinity will need to be protected against damage by construction operations. The areas beyond the limits of site shall not be disturbed or otherwise damaged. Mangrove plant,trees and shrubs be planted around the boundary of the storage area to compensate for the loss of shrubs and shield the development form visual intrusion.

B- Impacts due to Operations

The operation of the LNG terminal and LPG storage will not affect the terrestrial ecology of the area. LNG after its gasification will be natural gas and its fugitive emissions or spillage will cause no special remedial measures other than proper ventilation and diffusion in atmosphere. LPG being highly volatile, any spills will quickly evaporate to atmosphere. Hazards of any accidental release of LNG and LPG are discussed in subsequent chapter on Risk Assessment. No impacts on the terrestrial ecology are likely from the normal operation of the LNG Terminal.

Mitigation

No mitigation measures are required.

7.4.2- Mangroves

A- Impacts during Construction Phase

For the construction of sub-sea delivery pipeline, jetty and dolphins some mangrove plants will need removal at the locations along the alignment of the pipeline and jetty area. The proposed design ensures that no major damage to this important asset is caused. The technique employed for laying of the pipeline underneath the sea bed is environment friendly causing minimal disturbance to ecology particularly relating to mangroves and benthos. Similarly for construction of jetty, access to the area would be required and dredging activity would be undertaken. It is recommended that the dredged material is to be saved as refilled in the temporary canal on completion of work. This will help in replanting, rehabilitation and re-colonizing of the mangroves in the area and the impact will be temporary. Therefore, the impact of construction on mangroves will be though negative but, small, reversible, temporary, direct, short term and local.

Mitigation

On completion of construction, the temporary canal should be back-filled and mangrove saplings planted to ensure re-colonization.

B- Impacts due to Operations

The operations at the jetty are requiring special arrangements particularly in context to leakages and fugitive emissions of LNG which when exposed to atmosphere vaporizes as methane or natural gas. It is ensured that the system is zero-tolerant to leakages owing to design of the storage and transfer system and operations. At the on-shore area the impact of fugitive emissions due to highly volatility of gas, during its routine handling will have no impact on marine ecology including mangrove ecosystems. Fugitive emission will soon be dispersed, diluted and carried away due to strong wind current.

Liquid effluent from offices and the facilities will be domestic sewage and will be treated using an appropriate system such as a septic tank to meet NEQS before discharge into the drainage system. There fore the operation of the LNG terminal will have no impact on mangroves.

7.4.3- Marine Ecology

A- Impacts during Construction Phase

Most studies on the impact of dredging on marine benthos show that dredging can result in a 30 to 70% reduction in species variety, a 40 to 95 % reduction in the number of individuals and a similar reduction in biomass in dredged areas (Newell et al., 1998). The process of recolonization and recovery is a complex one involving initial colonization by fast growing animals (opportunistic) species. In stable environments these are replaced and supplemented by a wider species diversity of slow-growing (equilibrium) species after cessation of dredging. In more disturbed habitats the community is dominated by opportunistic species, which do not move towards an equilibrium community of repeated environmental disturbance.

The dredging process has important potential impacts outside the boundaries of the dredge site. The dredged material comprises of a large inorganic particulate load and also contains significant quantities of organic matter. Such material has a lower specific gravity than inorganic components of the dredge outwash and is detectable at distances of as much as more than 3 km downstream of a dredger. Material derived from the dredging process may also be carried as a benthic plume for significant distances along the sea bed. The impact of dredging within the intensively exploited anchor dredged site is limited to the dredge area. Impacts include suppression of species variety, population density and biomass as well as differences in species composition compared with the surrounding deposits. Generally, there are no suppression of species diversity, population density or biomass of benthic macrofauna outside the immediate boundaries of the dredged sites.

The other environmental impacts may be summarized as follows:

Physical disturbance of nesting and spawning, destruction of habitats, especially

- disturbance of spawning habitats
- physical removal of benthic faunal communities
- physical removal of protected plants
- disturbance of fish ,shrimps and benthic faunal feeding habitats

Detrimental effects of suspended sediments, turbidity and sedimentation, especially

- disturbance of fish spawning and nursery habitats
- disturbance of fish and shrimp larval development
- effects on the behaviour of migrating organisms
- effects on feeding of larval, juvenile and adult fishes and crustaceans
- burial of benthic fauna communities
- disturbance of benthic fauna development
- enhancement of photosynthetic oxygen production of planktonic algae
- burial of benthic plants

Degradation of water quality, especially in zones with low energy and in waters with sediments with high organic content

- impairment of larval development of marine animals
- impact on adult and crustaceans (e.g. bioaccumulation)
- impact on benthic organisms
- enhancement of algal growth

In the light of above discussion regarding impact of dredging and reclamation for the proposed LNG Jetty will have very localized impact on the macrofauna near the site. Moreover, recolonisation of most species would occur after the construction of the proposed LNG Jetty when the stable environment will prevail.

i- Effect of Turbidity Plumes on Aquatic Species during Dredging

When dredging and disposing of non-contaminated fine materials in estuaries and

coastal waters, the main environmental effects are associated with suspended sediments and increases in turbidity. All methods of dredging release suspended sediments into the water column, during the excavation itself and during the flow of sediments from hoppers and barges. In many cases, the locally increased suspended sediments and turbidity associated with dredging and disposal is obvious from the turbidity 'plumes' which may be seen trailing behind dredgers or disposal sites.

Turbidity plumes are caused by the re-suspension of sediments in the water column. If suspended at sufficient concentrations for long periods of time, then the penetration of sunlight through the water column may be reduced. Light is fundamental to photosynthesizing aquatic life such as algae and species associate with coral, and other organisms. In addition, increase in turbidity can cause the clogging of gills and feeding structures of certain species (e.g. Shellfish and filter feeding species including worms and mollusks). Similarly, young fish can be damaged if suspended sediments become trapped in their gills and increased fatalities of young fish have been observed in heavily turbid water. Adult fish are likely to move away from or avoid areas of high suspended solids, such as dredging sites, unless food supplies are increased as a result of increases in organic material. Hence, turbidity can promote reduced productivity and in extreme cases can be fatal. For maintenance dredging, the extent of these environmental affects is near-field and temporary generally only lasting as long as dredging operations are taking place.

The degree of re-suspension of sediments and turbidity from maintenance dredging and disposal depends on four main variables:

- The sediments being dredged (size, density and quality of the material), method of dredging (and disposal),
- Hydrodynamic regime in the dredging and disposal area (current direction and speed, mixing rate, tidal state), and
- The existing water quality and characteristics (background suspended sediment and turbidity levels).

The considerable dredging activity proposed for the berthing pocket and temporary access channel (that may be required) would last for around 12 months but not in one location.. It is envisaged that the creation of turbidity plumes during dredging could adversely affect certain marine species. Dense plume of turbid water is expected depending upon the method employed for dredging. However the activity will not be a 'fixed point' operation therefore the impact of dredging will not be significant. It is also recommended that hydraulic dredging be employed to minimize the disturbance caused to the sea bed. The bed sediments to be dredged comprise fine materials, predominantly fine silty sands, silts and silty-clays. It is the finer material which tends to remain in suspension for relatively long periods of time, thereby causing significant impacts on transparency of seawater. Initial site investigations indicate that the bed sediments are reasonably well consolidated. It would be reasonable to assume that an efficient trailing suction or cutter suction dredger would remove most sediment only re-suspending relatively small volumes of particulates in the low layers of the water column. In the low energy conditions of the sheltered creeks, it is anticipated that the majority of re-suspended material would soon resettle on the bed while any turbidity created would have no adverse long-term impact.

The dredging of berthing pocket of Kadiro Creek and the dredging of the temporary access canal will have negative impact on the marine habitat and the benthos of the creek to adversely affect fisheries reproduction. However, carefully regulated construction program and disposal of spoil only in the designated areas as suggested and refilling of temporary canal would minimize and localize these impacts. In view of the extensive dredging and disposal of spoils carried out for Port

Qasim over the last decade or so, has greatly reduced the benthic habitat. PGPL has ensured the adoption of careful methods to reduce the impact of construction on marine ecology of the site.

Mitigation

There are a number of mitigation measures which can be implemented in order to reduce the significance of this potential impact. These are given below (a combination of most practical measures will be adopted):

- For use of dredged spoil for reclamation, coffer dam is being built to retain the dredged material which is especially designed to strain water without releasing considerable sediment load back into the marine ecosystem.
- Reduce overspill as far as practically possible
- Ensure that the discharge pipe is located at a suitable depth in the water
- Use an efficient trailing suction hopper dredger, wherever possible

It is recommend that, as a minimum standard, the World Bank guidelines are adhered to, in terms of the acceptable limit of suspended sediment concentration allowed. This equates to 2,000 mg per lit. (World Bank Technical Paper 140) and is derived in order to prevent covering valuable benthic species (e.g. shellfish) which are particularly sensitive to increased suspended sediment concentration. Studies by Palermor et al (1990) and Appleby and Scaratt (1989) indicate that suspended sediment concentration of 500 mg per lit. and 1,000 mg per litre at 500m distance from the dredger can be considered safe for fish because they are mobile and can avoid adverse aquatic conditions. It is also recommended that dredging is restricted during critical spawning periods for shellfish.

No endangered species are reported to exist in the area. The impact of construction on the marine ecology will therefore be local, small and temporary.

ii- Removal of Benthos by Dredging

During the dredging process, there will be an inevitable removal of some benthic species. Some of the species could be of importance in themselves, or as a source of food for other marine fauna, including fish. The substrate with in the proposed dredging area is consistent with that in the rest of the port area. It is also reported that the species found within the proposed dredging area are found elsewhere within the study area. In addition, the sediment which will remain after dredging is likely to be very similar to that which exists at present. It is likely that the species from adjacent areas will re-colonize the dredged area following dredging. The exact composition of species, in terms of abundance and distribution, may not re-colonize the area initially as the area will first be colonized by opportunistic species which are short-lived an reproduce rapidly. As the rate of siltation in the inner channel of the port is very low, yearly maintenance dredging is not required normally.

Mitigation

No particular mitigation measures are required.

iii- Smothering of Benthos during Dredging

Sediments dispersed during maintenance dredging and disposal may resettle over the seabed and the animals and plants that live on and within it. This blanketing or smothering of benthic animals and plants may cause stress, reduced rates of growth or reproduction and in the worse cases the effects may be fatal. Generally sediments settle within the vicinity of the dredged area, where they are likely to have little effect on the recently disturbed communities, particularly in areas where dredging is a well-established activity. However, in some cases sediments are distributed more widely within the estuary or coastal area and may settle over adjacent sub-tidal or inter-tidal habitats possibly some distance from the dredged area. The most susceptible species will be the sessile species such

as sedentary worms and the slow moving species such as mollusks. The significance of this impact will be dependent on the amount of sediment in suspension, the sediment size distribution and the current movements around the dredging area.

The sensitivity of marine animals and plants to siltation varies greatly. In areas with high natural loads of suspended sediments, the relatively small increases in siltation away from the immediate dredging area are generally considered unlikely to have adverse impacts on benthic populations.

Mitigation

The mitigation measures proposed to control turbidity plumes will also help mitigate the above impacts.

iv- Release of Contaminants during Dredging and Disposal

Dredging and disposal activities can potentially cause the remobilization of contaminated sediment. Contaminated sediment may not be necessarily harmful to aquatic organisms living in the sediment due to contaminant's adsorption behaviors. However, if sediment conditions are changed such that contaminants become released into the water column (either dissolved or as particulate matter), then they may become bio-available and can cause toxic effects The results of the sediment quality analysis indicate that the sediments to be dredged are not contaminated to any significant level. Therefore no adverse impacts are expected in terms of release of contaminants by dredging and uptake by aquatic organisms.

Mitigation

No mitigation measures are required.

v- Noise Disturbance to Marine Fauna

Dredging activity can have an impact on marine fauna by causing noise disturbance. The significance of this impact depends on the ambient noise levels, the acoustic nature of the area to be dredged, the sensitivity of the species affected and the type of dredger used. However, very little work has been carried out relating to the sensitivity of marine fauna to noise levels. The ambient levels of noise within the study area are relatively low, in comparison to t he noise of a dredger. The area of dredging is relatively very small which should limit the significance of the impact. The species thought to be most susceptible to noise are fish. It is likely that fish will be able to avoid noisy areas and it is therefore considered that this particular impact will be of minor, local and temporary significance.

Mitigation

No mitigation measures are necessary.

vi- Impacts on Marine Animals during Construction Phase

The bottom sediments to be excavated comprise of fine materials predominantly fine silty sands, silty clays and silt. Due to re-suspension of sediments, turbidity plumes are formed in the water column. If the suspended material remains for longer period at higher concentrations then the penetration of sunlight through the water column may be reduced. Moreover, the turbidity can cause the clogging of gills and feeding structures of fish and shell fish and filter feeding species including molluscs and worms. Hence, the enhanced turbidity will lead towards reduced productivity and may be fatal in extreme cases.

The excavation of the area for pipeline laying; dredging of the creek as well as reclamation for, and back filling of desired land will have negative impact on the habitat of the proposed site and the benthos of the Korangi Creek, which will be adversely affected if proper care is not taken during construction. There will be inevitable removal of some benthic species at the construction site. Some of the species could be important in themselves or as a source of food for other marine fauna including fishes of the

adjoining area. It is a natural phenomenon that after construction phase is over the species from adjacent areas will recolonize at the site. The exact composition of species in terms of abundance and distribution may not recolonize in the area initially but with the passage of time and stability in the ecology of the area, the habitat may become similar in nature prior to the construction by long lived species. Since the pipeline laying is a short term activity, the impact may not be very significant because the severity of impact is dependent on the amount of sediment in suspension, sediment size distribution and the current movement in the operation area. It is anticipated that the turbidity thus caused would not have significant impact.

Mitigation

Careful and regulated excavation, back filling and construction methods should be employed by the contractors. It is proposed that the method of pipe-laying would be a more sophisticated one involving non-destructive technique. The aligned area would then be jetted resulting in vibration of soil leading to mudflow of the top few feet of the seabed thereby enabling placing of the pipeline in the bed soil at the required depth. The foreign material for filling purpose would then be free from contaminant or alien soil. These measures would minimize and localize the adverse impacts. Since the activity is short-term, the above-noted mitigation measures would be adequate and no special measures would be necessary.

B- Impacts due to Operation

The operational activity involves shipping traffic, off loading of LNG at jetty, LPG storage, transmission and transportation activities at the land based terminal. It is mandatory for all shipping companies to follow all the principles of safe navigation to minimize accidents. Even if a LNG carrier runs ground it will face minimal damage since the channel is formed in mud and sand. There are no rocks in the vicinity of channel. The jetty and the LPG storage facility have been designed keeping in view the standard international safety specification for handling the cargo. All necessary control measures have been incorporated to ensure that no fugitive emissions enter the marine ecosystem.

The nature of the project is such that it will have minimal impact on marine ecology. The liquid effluents from the offices will be treated to meet EPA standards and will have no potential for pollution of the habitats occupied by juvenile fish and other commercially important species. The potential threat to the fish is from the untreated industrial and municipal sewage already being discharged into the creeks. The operation of LNG terminal facility will have no impact on the marine ecology of the area.

The proposed LNG jetty project area is not known to contain any rare or endangered species and the terminal / jetty is not expected to disturb the ecology of the core area significantly. The project is also not expected to release any pollutants during normal operations. Its location and operation is not expected to affect the breeding habitats of marine animals or migratory paths of any bird species. No adverse impacts are anticipated on the marine life during operation. The only probability of degrading the ecosystem will be collision of ships, boats or tankers. An oil spill due to tanker accident would contaminate the environment leading to adverse impacts. However, the ecological impact would be confined to the ecosystem around the spill zone and the effects would dissipate after a short period.

Mitigation

No mitigations measures would be required during operation. However the proponent has developed a contingency plan to combat oil spills in case of emergency. It will maintain an in-house capability to fight small to medium oil spill due to accidents, besides being participant in the Contingency Plan developed by and in implementation at Port Qasim.

7.5- Socioeconomic Impacts

The socioeconomic evaluation and assessment of the

impact arising due to the project was not simple exercise as it was dependent upon the needs and expectations of the community being evaluated for the LNG project. Keeping in considerations the expectations and prevailing conditions, the following points can be made:

- The project is currently conducting a study and evaluation of fishing in the project area to determine the fishing pressure of the local fishing community. Any impacts upon local fishermen from the project will be evaluated and compensated if warranted under the Community Grievance Procedures detailed in Chapter 6.
- The ESIA study has not identified any settlements, habitations or commercial buildings or operations impacted by the project and no resettlements are anticipated. If any resettlement issues arise during project planning, construction, or operation, they will be addressed under the projects on-going programmatic system for identifying, evaluating and fully compensating any loss or impact as addressed in Chapter 6.
- The project is currently conducting a study and evaluation of fishing in the project area to determine the fishing pressure of the local fishing community. Any impacts upon local fishermen from the project will be evaluated and compensated if warranted under the Community Grievance Procedures detailed in Chapter 6.
- The project is committed to providing employment and service contract access to the local community to the extent reasonable and feasible per the community outreach program outlined in Chapter 6.

The project will boost the natural resources of the region by providing a cheap and environment friendly fuel source. Hence it will add to the economic prosperity of the country that will in-turn play a constructive role in the national development. The project will in improvement in quality of life of the citizens of Pakistan.

7.5.1- Site Selection and Resettlement Issues

Number of different sites under PQA's jurisdiction was examined in the coastal waters of Port Qasim area for locating the proposed LNG terminal of which a location just north of Qutub Point in Kadiro Creek linking main Port Qasim navigation channel with Korangi Creek in Port Qasim waters was selected as the preferred site for PGPL's LNG import terminal project.

PQA provided guidelines and recommended the sites in the Kadiro-Korangi Creek. Following aspects have been taken into account while selecting the site for locating the LNG terminal:

- Siting of LNG terminal in sheltered locations, remote from other Port users and populated areas.
- The Location is so chosen as to reduce the risk of passing ships striking a berthed LNG carrier.
- Siting the terminal in a position that reduces the possibility of surging by large ships passing near the jetty.
- Providing adequate backup area.

The international practice imposes a safety and security zone around LNG vessels while in transit and during the berthing operation. The zone is applied on the astern, ahead and on either side. The exclusion zones and safety distances are applicable to LNG vs other ships/activity and not between two LNG carrier. Following LNG safety and security zones are applied by existing US, European and Far East NG terminals:

- US (enforced by the US Coast Guard):

Ahead: 1.5 - 3 km

Astern: 0.5 - 1.5 km

Port and starboard: 500 meters

- European & Far East Terminals:

Ahead: - 800 meters

Astern: - 800 meters

Port and starboard: typically the channel width

The macroenvironment of concern for the consideration of socioeconomic and environmental of the LNG projects is outside of the safety and security zone recommended by PQA and international guidelines such as SIGTTO for siting the LNG terminals.

No living population and indigenous people - with a social and cultural identity distinct from the existing dominant society that makes them vulnerable to being disadvantaged in the development process of the LNG Project are known to exist in and around the proposed site. As such the aspect of relocation of population or loss of business opportunity does not emerge in the situation. No population will be displaced directly or indirectly during the construction stage and operation of LNG terminal.

The recommended site for Jetty location is a sheltered area remote from other port users where other ships do not pose a collision risk and where any gas escape cannot affect a local population. Moreover the location has been selected that reduces the risk of passing ships striking a berthed LNG carrier. The populated areas are far away and are not found within the safety zones recommended for siting the LNG terminal by PQA, US & European guidelines.

The onshore facility comprises gas measuring station for custody transfer of gas and for connection to existing SSGC pipeline system. The onshore facility will not impact the nearest living population in Goth Ali Muhammad located approximately 1.5 km NW from the proposed land terminal facility.

Table 7.15: Significant Population Centres in the Area

S.No.	Location	Rural /Urban	Population (Approx.)	KM from Jetty	Direction
1	Port Qasim Colony	Urban	1,260	5	NE
2	Wireless Colony	Urban	238	7	NE
3	Gulshan-e-Hadeed	Urban	20,000	10	NE
4	Steel Town	Urban	12,000	10	NE
5	Nasirabad	Urban	12,500	8	NE
6	Railway Marshaling Yard	Urban	2,500	10	NE
7	Nishtrabad	Urban	1,400	7	NE
8	Edu Goth	Rural	2,400	8	NE
9	Pir Nau Goth	Rural	1,000	8	W
10	Razzakabad	Rural	3,500	6	NE
11	Abdullah Goth	Rural	1,050	6.5	NE
12	Ranju Goth	Rural	750	8	NE
13	Kamran Khan Goth	Rural	325	10	NE
14	Allah Dino Goth	Rural	230	10	NE
15	Muhammad Raheem Goth	Rural	250	10.5	NE
16	Mai Hur Goth	Rural	230	11	NE
17	Abdul Latif Goth	Rural	200	12	NE
18	Muhammad Saleem Goth	Rural	180	10.5	NE
19	Morund Khan Goth	Rural	200	12	NE
20	Mayo Khan Goth	Rural	150	12	NE
21	Ali Khan Goth	Rural	270	12	NE
22	Asmaj Goth	Rural	85	12	NE
23	Ahmed Goth	Rural	78	12	NE
24	Khan Muhammad Goth	Rural	120	12	NE
25	Allah Bakh Goth	Rural	80	12	NE
26	Abdul Rehman Goth	Rural	70	12	NE
27	Abdul Raza Goth	Rural	80	12	NE
28	Muhammad Ahsan Goth	Rural	80	12	NE

The site on the north of Qutub Point in Kadiro Creek is linked with main navigation channel of Port Qasim and with Korangi Creek. Kadiro-Korangi Creek system is part of the 48 creeks in the Phitti-Kadiro-Korangi-Gharo creek system.

Major human settlements in the macro-environment beyond 5 kilometers from LNG terminal site are the several large and small rural villages and urban townships. The following populated places are reported in the macroenvironment of Port Qasim (Table 7.15):

The microenvironment of the LNG terminal site is scattered over the coastal area of Bin Qasim District, which includes the settlements of Rehri and Goth Muhammad Ali Khaskheli that are approximately 3.5 km east and 1.5 km NW and from the LNG terminal proposed site respectively.

The marine environment of the area between the shoreline and the proposed site in Kadiro creek is highly degraded. It has totally lost the aquatic/marine biodiversity due to discharge of effluent from the cattle barns in Cattle Colony, and the industrial estates. As such the marine fauna including the shrimps and the flora including the mangroves have hardly survived.

The project is currently conducting a study and evaluation of fishing in the project area to determine the fishing pressure of the local fishing community. Any impacts upon local fishermen from the project will be evaluated and compensated if warranted under the Community Grievance Procedures detailed in Chapter 6.

The above note confirms that that there would be no displacement of persons or impacts on livelihood of people since they do not rely on fishing in the waters of the area. Most of them have had to change their profession from fishing to working as unskilled labor. For the same reason there is no question of compensation for lost business.

The project will also not cause displacement of population in the microenvironment. The population will not be affected due to the operations of LNG regasification and associated facilities. Mitigation measures have also been proposed in this regard which PGPL will have to follow in letter and spirit. Pakistan Fisherfolk Forum (PFF) being the major stakeholder will be taken on board during the monitoring phase of project.

The Proponent is alive to the impoverished condition of the Goth and would do whatever it can in terms of maintaining good company-community relation.

Following are the positive impacts of the project being committed by PGPL:

- The interaction of local communities with the proposed project staff would increase sympathy and sense of realization of the problems being faced by the community.
- With the development of the project and introduction of related infrastructure will improve the socioeconomic conditions of the local community.
- Project would improve the health and education quality of the local community by providing them a window of opportunity to improve the basic facilities.
- The project would enhance the skill and capabilities of the people through providing jobs.

7.6- Cumulative Environmental and Social Impacts

The FSRU will have three 6 megawatt steam turbine generators to provide electric power for the FSRU, re-gas and jetty operations. One of the STGs will be held in reserve to support forced or scheduled outages. Steam is supplied to the STG's from an on-board boiler fired from boil off gas from the FSRU's LNG tanks. The total project GHG emissions have been calculated at 220,456 tons /CO_2/year. The IFC emission standard for NOx for steam thermal generators is 320 mg/Nm^3 at 3% O_2. The steam/electric plant on the FSRU produces 125mg/Nm^3 or less of NOx, in full compliance with IFC standards.

LNG import is not only economically viable, but more importantly is environmentally beneficial. Since 2005 when the demand for electricity increased the availability of indigenous natural gas decreased for

Table 7.16: Emissions to air: The FSRU shall operate on gas fuel except during start-up and emergency operations, where MDO will be used temporarily. The following World Bank Standards to be applied. AIR POLLUTION WORLD BANK STANDARDS

POLLUTANT	UNIT mg/Nm³	UNIT mg/Nm³	
	BOILERS	GAS TURBINE	
Particulate		50	
Sulfur oxides		2,000	
carbon mono oxide		no standard	
nitrogen oxide	125	320	

Table 7.17: GAS CONSUMPTION IN POWER SECTOR MMCF

	2004 - 05	2005 - 06	2006 -007	2007 - 08	2008 - 09	2009 - 10	ACGR %
MMCF	503,983	490,142	432,607	429,892	404,140	366,906	-6.2
MMCFD	1,380	1,343	1.185	1,178	1,107	1,005	

Table 7.18: GAS CONSUMPTION IN POWER SECTOR MMCF

	2004 - 05	2005 - 06	2006 -007	2007 - 08	2008 - 09	2009 - 10	ACGR %
HSFO	3,308,574	4,076,897	6,521,503	6,741,614	7,210,211	8,339,330	20.3
HSD	55,899	32,176	45,125	168,449	173,947	262,499	36.3
GAS	10,305,897	8,694,561	8,640,101	8,492,919	7,830,065	7,160,962	-7.2

NB: 1 TOE = 41.9 million BTU
ACGR = Accumulated Compound Growth Rate

power generation.

The HSFO & HSD movement is largely by road (75 %) and this figure would increase as both rail & pipelines are operating at full capacity, as consumption of HSFO and HSD continued to grow at 20 % and 36 % respectively. This is turn would increase the HSD consumption for road transportation of these commodities to Central and Northern parts of Pakistan where the storage of Natural Gas are more pronounced.

no alternative but to accept what is available. Until year 2000 the average calorific value was high around 1000 BTU / CFT which has declined currently to around 920 BTU / CFT.

The induction of high CV LNG would restore the CV as well as BTU through put capacity of National Grid. The positive environmental affect due to replacement of HSFO (3% sulfur) and HSD would are given in the following table.

Table 7.19: Savings in Emissions by replacing HSFO with LNG as fuel for Power Stations in equivalent quantity
LNG quantity 3 millions / year

Pollutant	LNG	HSFO	Savings	Percentage Savings
Particulate Matter	515	6,186	5,670	92
Carbon Dioxide	8,615,636	12,076,617	3,460,982	29
Sulfur Oxide	74	82,622	82,548	99.9
Nitrogen Oxide	6,775	32,990	26,215	80

The import of 3.1 Million tons per annum of LNG would replace 3.8 Million tons of HSFO (3.7 TOE). There is capacity in national Gas grid to transport this to various power stations and may well reduced the consumption of gas required for consumption by the pipeline system. Also the system is plagued by low BTU gas (high nitrogen gas) as the two companies have

Table 7.20: SAVINGS IN EMMISSIONS FROM DIESEL CONSUMPTION FOR TRANSPORTATION OF HSFO EQUIVALENT TO 3.1 MTPA OF LNG

	TONS / YEAR
CO2	72,357
NOx	1,933
SOx	295

Additionally: power generation on RLNG would lead to higher efficiencies in form of technology such as combined cycle system, cleaner operation, reduced operation and maintenance cost, increased plant availability and longer life of equipment.

IN POOR COUNTRIES, MORE PEOPLE DIE PREMATURELY FROM INDOOR AIR POLLUTION-SMOKE FROM WOOD, COAL, PEAT, AND DUNG THAN FROM MALARIA.

Noise: Including the proposed PGPL-LNG import terminal at Korangi Creek and proposed EVTL LNG import terminal at Kadiro Creek (Khiprianwala), no other LNG terminals are planned to be developed in the vicinity of project site. As per the information provided by Port Qasim, other terminals are coming in Chhan Waddo Creek which is at a distance of more than 10 km from project site. There is limited information available as to the planned development of these proposed projects or the scale and timing of their development. The cumulative effect of the noise emission from LNG facility and any other proposed industrial developments (including any other proposed LNG facilities) is assessed not to exceed the recommended ambient noise levels, on the basis that any other proposed industrial development would be required to achieve the same noise criteria which are acceptable for the proposed PGPL-LNG project. In some circumstances, the existing ambient noise level may already be above the recommended noise levels. In such cases, noise generated by the LNG facility will be maintained below the existing ambient noise levels. This should ensure that ambient cumulative noise impacts of the project will be negligible. Also other proposed industrial developments (including potential LNG facilities) are likely to include some or all of the proposed mitigation measures outlined within, thereby minimizing cumulative impact on the receiving environment.

Dredging and Removal of Mangroves: Siting of the LNG re-gasification terminals and laying the pipeline so as to connect the FSRUs with the receiving station (s) would require considerable land take for the Right of Way (RoW) and removal of mangrove trees and transportation of dredging spoil to locations identified by PQA or where extensive erosion has taken place, for example; at Bundal Island itself in consultation with PQA and other stakeholders.

The excavated dredged material can also be used as the substrate for mangrove habitat development. Within various habitats, several distinct biological communities may occur. For example, the development of a dredged material can reinforce eroded banks by providing coastal nourishment. The sediments can be used for reclamation of Bundal Island can also be developed after initiating necessary coastal hydraulic studies. PQA may have to undertake extensive environmental impact assessment and Quantitative Risk Assessment (QRA) before taking the final decision on designing the channel and locating the LNG facilities thereon.

PGPL will dispose off the dredged material within cofferdam which is the best solution for dredged spoil management.

Like PGPL, if other project developers commit and take necessary steps to compensate for removal of mangroves, the impact would be minimized since mangroves *(Avicenna Marina)* is the key specie of the coastal ecosystem.

Effluent Discharge: National Environmental Quality Standards for disposal of effluent as well as other International Guidelines e.g. World Bank are in force which have to be followed by all project developers to save the marine ecosystem. Cumulative impact would be minimized through the adoption of mitigation measure which include treatment of effluent to NEQS/WB Standardsbefore discharge.

National Economy: There are undoubted positive impacts of an expanding gas sector on employment, competitiveness and sustainable development. However, the gas sector is a relatively modest creator of employment, and has contributed mostly as a substitute for coal in power generation. However NG is being used in the transport sector as CNG and also for cooking and heating. It is the main raw material for fertilizer production. These uses have modest impacts on competitiveness but have clear environmental benefits. In the drive to a low carbon economy, gas is a transitional fuel rather than the ideal fuel of the low-carbon economy. It nonetheless contributes to policies of sustainable development.

The cumulative impact on the National economy will be a strongly positive one. Significant additional resources will be realized by the nation as a result of this project, which is consistent with the government's long-term development plan. The additional licensing income, among other sources of additional income, will add to the government revenues and economic growth resulting from expanded and diversified business development in Pakistan in future.