Hindustan Oil Exploration Company Pvt. Ltd.

EIA Study of Development Drilling of 24 Drill Sites, Commissioning of two GGS, Capacity expansion of existing M-GPP and laying of underground transportation Pipeline at onshore Block AAP-ON-94/1 Tinsukia District, Assam

Draft Report

March 2019

EIA Consultant: ERM India Private Limited, Gurgaon – NABET Accredited as per Certificate No. NABET/EIA/1619/RA0055 dated Jun 21, 2017

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DRAFT REPORT

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March 2019

Reference # 0397126

NABET Approved EIA Coordinator for Oil & Gas Sector::	Salil Das	Salil Das
Reviewed & Approved by:	Debanjan Bandyopadhaya *Partner*	

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COMPLIANCE OF APPROVED TERMS OF REFERENCE (TOR) FOR THE EIA STUDY

The terms of reference (ToR) for conduct of EIA study as approved by EAC of MoEFCC are included in Annex A. The ToR requirements and their inclusion in the EIA study have been described in **Table.**

Table ***Requirements & Compliance of Approved Terms of Reference for the EIA***

Sl No.	ToR Point	Comments
Standard ToR		
1.	Executive summary of a project.	Executive summary in included at the beginning of the report.
2.	Project description, project objectives and project benefits.	Project description and Project objectives are presented in Chapter 2 while Project benefits are described in Chapter 8.
3.	Cost of project and period of completion.	The cost of Project and Project schedule is provided in Section 1.6.
4.	Site details within 1 km of the each proposed well, any habitation, any other installation/activity, flora and fauna, approachability to site, other activities including agriculture/land, satellite imagery for 10 km area. All the geological details shall be mentioned in the Tope sheet of 1:40000 scale, superimposing the well locations and other structures of the projects. Topography of the project site.	Site details within 1 km for the development well locations have been provided in Section 2.5. Land use and land cover in the study area is presented in Section 3.3.7. The Toposheet and Satellite Imagery showing well locations and production facilities are presented in Figure 2.1 and Figure 1.2 respectively. Floral/Faunal species recorded/reported in proximity to the proposed well locations and production facilities are presented in Section 3.4. The proposed development wells and production facilities are located in flat land. The topography of the study area is presented in Section 3.3.4.
5.	Details of sensitive areas such as National Park, Wildlife sanctuary and any other ecosensitive area along with map indicating distance.	The Dehing Patkai Wildlife Sanctuary within 10 km of the existing and proposed facility. Details are presented in Section 2.5 Environmental Setting of the Block and in Section 3.3.4.
6.	Approval for the forest land from the State/Central Govt. under Forest (Conservation) Act, 1980 as project involves forest land.	All the proposed drill sites, GGS and proposed pipelines are located in non-forest land; therefore, forest diversion is not applicable for this project.
7.	Recommendation of SCZMA/CRZ Clearance as per CRZ Notification, dated 6th January 2011 (if applicable)	Not Applicable
8.	Distance from nearby critically/severely polluted area as per Notification, if applicable. Status of moratorium imposed on the area.	There is no critically/severely polluted area within 10 km of the study area.

Sl No.	ToR Point	Comments
9.	Does proposal involve rehabilitation and resettlement? If yes, details thereof.	The proposal does not involve any rehabilitation and resettlement (refer Section 2.9.3)
10.	Environmental considerations in the selection of the drilling locations for which environmental clearance is being sought. Present any analysis suggested for minimizing the foot print giving details of drilling and development options considered.	Section 2.6.1 contains environmental consideration for selection of proposed wells.
11.	Baseline data collection for air, water and soil for one season leaving the monsoon season in an area of 10 km radius with center of Oil Field as its center covering the area of all proposed drilling wells.	Baseline data has been collected for ambient air-8 locations for one season, noise at 8 locations, surface water at 3 locations, groundwater at 4 locations and soil at 5 locations. The data has been collected from October 2017 to December 2017. The data has been provided in Section 3.3.
12.	Climatology and Meteorology including wind speed, wind direction, temperature, rainfall relative humidity etc.	Climatology and meteorology data comprising of wind speed, wind direction, temperature, rainfall, relative humidity has been collected at Moran during the study period (refer Section 3.3.1).
13.	Details of Ambient Air Quality monitoring at 8 locations for PM2.5, PM10, SO2, NOx, CO, VOCs, total and non-methane HC.	Details of ambient air quality at 8 monitoring locations for $PM_{2.5}$, PM_{10}, SO_2, NOx, CO, VOCs, total and Non-Methane HC have been provided in Section 3.3.2.
14.	Soil sample analysis (physical and chemical properties) at the areas located at 5 locations.	Soil samples were collected at 5 locations. The monitoring locations and the results have been provided in Section 3.3.8.
15.	Ground and surface water quality in the vicinity of the proposed wells site.	Ground and surface water quality in the vicinity of the proposed well locations has been provided in Sections 3.3.10 &. 3.3.12 respectively.
16.	Measurement of Noise levels within 1 km radius of the proposed wells.	Noise levels have been measured at 8 locations within 1 km of the proposed wells. The details are provided in Section 3.3.3.
17.	Vegetation and land use; flora/fauna in the block area with details of endangered species, if any.	Information on flora and fauna has been provided in Section 3.4. Land use and land cover has been provided in Section 3.3.7.
18.	Incremental GLC as a result of DG set operation, flaring etc.	Incremental GLC has been provided in Section 4.2.2
19.	Potential environmental impact envisaged during various stages of project activities such as site activation, development, operation/ maintenance and decommissioning.	Potential environmental impacts envisaged during various stages of project activities are discussed in Section 4.2.
20.	Actual source of water and 'Permission' for the drawal of water from the Competent Authority. Detailed water balance, wastewater generation and discharge.	Section 2.10.2 covers source and quantity of water required for each drill site. Water is planned to be sourced from authorised supplier. Water balance has been provided in Figure 2.10. The volume of wastewater generation and discharge options are discussed in Section 2.12.4.
21.	Noise abatement measures and measures to minimize disturbance due to light and visual intrusions.	Measures to mitigate light and noise related disturbances are given in Section 4.2.1 and 4.2.3 respectively.

Sl No.	ToR Point	Comments
22.	Details on wastewater generation, treatment and utilization /discharge for produced water/ formation water, coolin g waters, other wastewaters, etc. during all project phases.	The volume of wastewater generation and discharge options are provided in Section 2.12.4. Water balance has been provided in Figure 2.10.
23.	Details on solid waste management for drill cuttings, drilling mud and oily sludge, produced sand, radioactive materials, other hazardous materials, etc. including its disposal options during all project phases.	Details on solid waste management for drill cuttings, drilling mud and oily sludge, produced sand, radioactive materials, other hazardous materials, including its disposal options during all project phases has been discussed in Section 9.3 Waste Management Plan.
24.	Disposal of spent oil and lube.	Disposal options for used and spent oil have been provided in Section 9.3 Waste Management Plan.
25.	Storage of chemicals and diesel at site. Hazardous material usage, storage and accounting.	Some chemicals and diesel will also be stored at paved and bunded areas within the drill site (refer section 2.6.4). Hazardous material usage, storage and accounting is presented in Section 9.3 Waste Management Plan.
26.	Commitment for the use of water based mud (WBM) only	Water based mud will only be used as discussed in Section 2.6.8. However, eco-friendly polymer based mud will also be used if required for deeper sections after providing intimation to the Pollution Control Board.
27.	Oil spill emergency plans for recovery/ reclamation.	Spill Management Plan has been provided under Section 9.3
28.	H_2S emissions control.	Earlier explorations show the absence of H_2S in the study area. However, H_2S detector and self-containing breathing apparatus is available with HOEC (Refer Section 9.3).
29.	Produced oil/gas handling, processing and storage/transportation.	Information on Production Installations have been presented in Section 2.7 and Section 2.8 while information on Interconnected Pipelines is presented in Section 2.9
30.	Details of control of air, water and noise pollution during production phase.	Details of control of air, water and noise pollution during drilling and testing phases have been provided in Section 9.3.
31.	Measures to protect ground water and shallow aquifers from contamination.	Measures to protect groundwater and shallow aquifers from contamination has been provided in Section 9.3 Groundwater Quality Management Plan
32.	Whether any burn pits being utilised for well test operations.	Burn pits will not be utilized for well test operations.
33.	Risk assessment and disaster management plan for independent reviews of well designed construction etc. for prevention of blow out. Blowout preventer installation.	Risk assessment has been discussed in detail with a focus on blowouts in Chapter 7.
34.	Environmental management plan.	Environmental Management Plan is provided in Chapter 9.

Sl No.	ToR Point	Comments
35.	Total capital and recurring cost for environmental control measures.	The capital and recurring costs are presented in Section 9.4
36.	Emergency preparedness plan.	Emergency plan of OIL in case of emergency is provided in Section 7.5.
37.	Decommissioning and restoration plans.	Decommissioning Plan is presented in Section 9.3.
38.	Documentary proof of membership of common disposal facilities, if any.	Common disposal facility does not exist in Assam.
39.	Details of environmental and safety related documentation within the_ company including documentation and proposed occupational health and safety Surveillance Safety Programme for all personnel at site. This shall also include monitoring programme for the environmental.	HOEC maintains relevant information/ documents in their internal system. Refer Section 9.2 HOEC Environmental Management Policy and System
40.	A copy of Corporate Environment Policy of the company as per the Ministry's O.M. No. J-11013/41/2006-IA.II(I) dated 26th April, 2011 available on the Ministry's website.	A copy of Environmental Policy of HOEC has been provided as a part of the Environmental Management Plan in Box. 9.1.
41.	Any litigation pending against the project and or any direction/order passed by any court of law against the project. If so details thereof.	None

Executive Summary

Introduction

The block AAP-ON-94/1 (area 305 sq. km) is located in Tinsukia district of Assam. The Block AAP-ON-94/1 was first awarded for exploration to Joint Venture Consortium of Hindustan Oil Exploration Company Limited (HOEC), Oil India Limited [OIL] and Indian Oil Corporation Ltd (IOCL) by the Government of India (GoI). HOEC is the Operator and OIL is the Licensee of the block.

There are presently six gas producing wells, one gas gathering station (GGS), one gas processing plant (GPP) and connecting pipeline from GGS to GPP and from GPP to Kusijan GGS of OIL. In order to increase the hydrocarbon production from the block, HOEC proposed to drill 24 development wells, two GGS's, undertake expansion of GPP and lay pipelines of 5.5 km from GGS-1 (Vitor Powai) to trunk pipeline and 8 km pipeline from GPP to IOCL refinery (Digboi).

For conducting EIA study, HOEC had received ToR from MoEF&CC on April 23, 2018. ERM India Private Limited, a NABET-QCI accredited firm has been entrusted with the task of preparing the EIA report for the proposed project by HOEC.

Project Location and Accessibility

The existing wells, proposed wells and GGS are located in Tinsukia district of Assam. The NH-37 is the main road link between Tinsukia district and the rest of Assam and the country. HOEC's warehouse for storing equipment for drilling and other activities is located at Digboi town; which is approximately 17 km from well cluster. The proposed wells towards Dirok Tea Estate site and Vitor Powai site are connected with Margherita-Deomali Road and Makumkilla Road respectively.

Environmental settings of Wells, GGS & Pipeline

All the proposed wells and GSS are located in the non-forest area. 16 wells and one GGS is located in the Dirok area and 8 wells and one GGS is located in the Vitor Powai area. 14 number of wells and one GGS is located within tea gardens and 10 wells are located in agricultural land/ homestead land. All the proposed wells and GGS are located within 5.0 km radial area of Dehing Patkai Wildlife Sanctuary. HOEC has taken wildlife clearance for 11 wells and one GGS; and for remaining wells and GGS the required clearance will be taken from NBWL.

Project Description

Construction of drill site & access road: Site preparation will involve top soil scraping and storage for future use, increasing elevation of the site and the access road to 1m above HFL prevailing in the area with locally available fill material. Construction of HDPE lined pits for drill cuttings, waste mud and drilling fluid, storm water drainage system with oil/water separator.

Drilling and testing of wells: The wells will be drilled to a depth between 2500 m-3000 m where prospectively the target reservoir lies. Standard Land Rig or Mobile Land Rig with standard water based drilling mud will be used for the drilling. Drill cuttings generated will be collected and separated using a solid control system and disposed on-site in HDPE lined pits. Drilling and wash wastewater generated will also be stored at an onsite HDPE lined pit. The water will be adequately treated in a mobile ETP to ensure conformance to the S No. 72 A (ii) Schedule I Standards for Emission or Discharge of Environmental Pollutants from Oil Drilling and Gas Extraction Industry stipulated by CPCB.

Site closure and decommissioning: The drill sites will be properly reclaimed and rehabilitated if no commercial reserve is established. This process will involve the decommissioning of rig and all associated machineries; disposal of drilling waste as per CPCB guidelines, disposal of fill materials, top soil restoration.

Construction and Operation of GGS: The construction of the GGS will involve setting up of concrete boundary walls around the land parcel, clearing of vegetation, storage of top soil after craping. Storm water drains would be built along the periphery of the site to contain any sudden discharge to adjoining lands. Thereafter, a concrete pad will be constructed upon which the following components will be set up:

- Test Manifold;
- Production Manifold;
- Electrical Heater;
- Fire Water Tank and Pumps;
- Cathodic protection System;
- Compressor Unit
- DG Sets (400 KVA capacity)

Pipeline Laying: The laying of pipeline will involve similar land preparation as fencing (fluorescent ribbons), vegetation clearing, storage of top soil. Sections of pipes will be lowered after trenching and boring to suitable depth. The trench will be first backfilled by excavated soil barring stones or rocks after lowering the pipeline. The laying of pipeline will progress in a manner where each section of the pipeline will be laid individually, covered with soil and then the trenching for the next section will begin in continuum.

Project Utilities and Resource Requirements

Land

The approximate land requirement for each drill sites is 2.0 ha and land requirement for each GGS is 1.0 ha. The land will be procured through long term lease. For laying of pipeline ROW of existing road will be utilised.

Power

Wells -The power requirement for each drill sites will be met through the DG sets. Two DG sets of 670 KVA each will be simultaneously operable and one will be kept as standby during drilling operation. A 134 KW generator will be made available for lighting at residential camp and other emergency requirements.

GGS & GPP- One DG set of 400 KVA will be operated during operational phase. It is also proposed to install 2 x 600 KVA DG set for proposed expansion of GPP.

Water

Well: During the drilling operation, water requirement at site would be around 45 to 50 m^3/day. The water requirement will be met through approved local suppliers.

GPP – The existing consumption of GPP is 15 KLD; after expansion the total consumption will be 30 KLD.

Manpower

Well: During peak construction phase (including site preparation), approximately 45-50 personnel will be engaged at each well site including skilled and unskilled labour. The total number of personnel involved in the drilling activities is expected to be about 50. Both locals and labourers from outside will be engaged depending on skills and project requirements.

Production facility: Pipeline laying and construction work of GGS will involve 100-125 persons per day. During operational phase, about 50-60 person per day will be involved in GGS and GPP operation

Baseline Environmental Status

Baseline study was conducted between October to December 2017 for collecting information on physical environment, biological environment and socio-economic environment of the study area comprising of geographical expanse of 10 km radius around the proposed well cluster.

Climate & Meteorology

The maximum and minimum temperature reported during the study period was 33.8°C and 11.1°C. The average relative humidity was 84.51% during the study period. The average wind speed in the study period was 0.23 m/s. The maximum wind speed was 3.36m/s. The predominant wind direction during the study period was from North-East.

Air Environment

Ambient Air Quality (PM_{10}, $PM_{2.5}$, SO_2, NO_x, CO, Methane and Non-methane hydrocarbon was monitored at 8 locations for 24 hours twice a week for three months. The 24 hour average concentration of PM_{10} in the study area ranged between 57.2 µg/m^3 and 76.2 µg/m^3 and $PM_{2.5}$ ranged between 30.0 µg/m^3 and 40.96 µg/m^3. SO_2 in the study area ranged between 5.6 µg/m^3 to 6.7µg/m^3. NO_x in the study area ranged between 17.7 µg/m^3 and 20.5µg/m^3. CO in the study area ranged between 0.28 mg/m^3 and 0.37 mg/m^3. The above parameters were below the NAAQS levels.

The average total hydro-carbon concentration in the study area ranged between 1.38ppm and 2.36 ppm. Non-methane hydrocarbon was reported less than <0.5 ppm. Volatile Organic Compounds was reported between <2.08 and 4.3 µg/m^3

Noise Environment

Ambient Noise was monitored at 8 locations. The day time (51.3 to 53.9 dB(A)) and night time (39.4 to 44.1 dB(A)). The equivalent day time and night time noise values in all the were in compliance to the standard for residential areas.

Land Use & Land Cover

Land use and land cover study has been carried out through analysing satellite imagery (LANDSAT 8) and World Imagery dated 16th September, 2016 along with ground trothing. The predominant land use in the 10 km study area is 61.1% (including Reserve Forest, Wildlife Sanctuary and unclassed forest), and this is followed by Tea garden (14%), agriculture land (11.4%), settlement areas (8.2%), Rivers and streams (3%).

Soil Environment

The soil sampled in the study area was generally found to be acidic, high in Nitrogen but low in Phosphorus and Potassium at majority of the sampling locations but is not deficient in micro-nutrients. Heavy metal contamination is not observed. The texture of the soil is clayey and having low permeability.

Topography and Drainage

Dirok Development Field has a more or less flat topography with elevations ranging between 120-160 m MSL. The area gradually slopes towards the north with lower elevations toward the Buri Dihing River and upper elevations at the south towards the foothills of Arunachal Pradesh. There are number perennial and seasonal streams within the study area (viz. Lekhajan nala, Powai nala, Ongchap Jang nala, Namdang nala, Jonghu nala, Garumara Jan etc.) that drains into the Buri Dihing River.

Surface Water
Surface water has been monitored at 3 locations within the study area. The water bodies sampled are generally used for domestic purposes (Class B of Designated Best Use Category of CPCB). However, it is observed that coliform count of the water samples were high and hence not found suitable for Class B but is suitable Class D (Propagation of wildlife and fisheries).

Ground Water
Ground water was sampled from tube wells and an open well at four locations in the study area. The concentration of majority of the parameters analysed were within the desirable limit of IS 10:500, 2012 standard. The parameters e.g. Iron, were close to the permissible limit of Drinking Water Standard IS 10:500, 2012.

Biological Environment
A significant part of the study area falls within the western part of Upper Dihing Reserved forest and Dehing Patkai Wildlife Sanctuary. Two Elephant Corridors between Upper Dihing R. F. East and West Blocks at Bogapani and Golai-Powai are located within the study area on the eastern boundary. Apart from the protected areas tea garden plantation covers huge tracts of land within the study Area as well as in the surrounding region.

The ecological survey reveals that 180 plant species was recorded/ reported in the study area. The ecological survey also reveals that 11 species of mammalian species, 65 species of birds, 8 species of reptiles and 4 species of amphibian was recorded and reported in and around the proposed wells sites.

Five Schedule I species were recorded viz. Indian Pied Hornbill, Great Pied Hornbill, Hill Myna, Black Kite and Brahminy Kite. A total of 17 species of mammalian species were recorded/reported from the study area

Four Schedule I mammalian species (Common leopard, Slow Loris, Hoolock gibbon, Asian Elephant); six species of birds (oriental pied hornbill, Short-toed Snake Eagle, Shikra, Black-shouldered Kite, Common Kestrel, Black Kite), two species of reptiles (Indian rock python, Bengal Monitor Lizard) were reported in the study area.

Socioeconomic Environment
A total of 17 villages located in 1 revenue block in Tinsukia district lie within 1km radius of proposed wells, GGS and the pipeline alignment. In Dirok Development field, Dirok No 1 (3996) has the highest population among the study area villages followed by112/109/Nla Grant 2 Makum Tea Co. (3333). The lowest populations were recorded for Makum Block No. 2 with a total population of 305. The highest literacy rate was observed in Borkuruka (92.72%) and the lowest in 112/109/Nla Grant 2 Makum Tea Co. (42.10%). The total working population in the study area villages varies from 26.89% to 58.10%.

Basic Infrastructure and Amenities
Ground water is the main source of drinking water. Community consultation revealed that adequacy and quality is not a problem in case for drinking water

Medical facilities are one of the basic service indicators which need to be studied so as to know the quality of life in the area. All study area villages considered for the study have health sub center in panchayat level. Free medical facility also available in tea garden premises for tea garden workers. Primary Health centre is present only at Block. Other than that villagers have to go to Digboi and Margherita to avail the medical facility.

The study area possesses necessary educational infrastructure to cater to the educational needs of the both rural and urban population. Among the study area villages more than one primary school and one high school is present. ICDS is present in all the villages. For higher education student have to go to Digboi or Margherita.

Environmental Impact Assessment

The potential impacts arising due to the Project activities were assessed in terms of their severity, extent and duration. Potential impacts arising out of proposed project activities are as follows:

Impact on Air Quality
The operation of DG sets, movement of vehicles and machineries during drilling activity and construction of GGS and pipeline will result in the generation of air pollutants viz. PM, NO_x and SO_2 which may affect the local ambient air quality temporarily. Air pollutants like NOx, PM and HC will also be generated as a result of flaring of natural gas during testing of wells and from GPP. The impact on ambient air quality is assessed to be moderate.

Impact on Noise Quality
Operation of heavy machineries/equipment and vehicular movement during site preparatory and road strengthening/construction activities may result in the generation of increased noise levels. Operational phase noise impacts are anticipated from operation of drilling rig and ancillary equipment viz. shale shakers, mud pumps and diesel generators. The impact on ambient noise quality is assessed to be moderate.

Impact on Soil Quality
Stripping of top soil will affect the soil fertility of the well sites and proposed GGS. Potential adverse impacts on soil quality may also result from improper storage and handling of fuel, lubricants, drilling mud and drill cuttings. The impact on soil quality is assessed to be minor.

Impact on Topography and drainage

For the proposed drill sites and at the GCS location, raising, levelling and grading of site may lead to alteration of onsite micro-drainage pattern. Potential impact on topography and drainage is assessed to be minor

Water Quality and Hydrogeology:
All wastewater discharged from the drilling operations will be treated in the ETP and re-used. Discharges, if any, will conform to specified regulatory standards. As the drill sites are located in proximity to the Burhi Dehing River the treated wastewater discharge, if any, may reach the Burhi Dehing River. Uncontrolled surface runoff from the drill sites may compose of drilling waste fluids or storm water mixed with oil and grease and may pollute the surface water quality. However, the surface runoff will be treated with sedimentation tank and oil water separator at site and hence possibility of surface water contamination is not emphasized.

Biological Environment:
Clearance of vegetation would involve cutting of tea bushes, shed trees and trees at homestead land. Noise generated from drilling operations and vehicular movement within the drill sites and approach roads may affect the movement of reptiles, birds and mammals in the project area for a temporary period. Uncontrolled Surface runoff from the drill sites contaminated with sediment, may reach Burhi Dehing River and increase the suspended solids load of the stream water. Increase of suspended solid will increase the turbidity of river water that ultimately will adversely affect the DO level in the water. The turbid water and lower DO will affect the primary productivity of the impacted areas of the rivers. To mitigate the possible impacts, the effluent will be adequately treated in the ETP to meet the industrial effluent discharge standards. As discharge of treated effluent is not expected, perceptible changes in the water quality of the river is ruled-out.

Socio-Economic Environment:

Land will be procured from local communities and tea garden owners; however; no physical displacement during land procurement is anticipated. Land requirement for these wells will be 2 hectares each and 1 ha each for GGS. Additionally, land also be procured for construction of 100-150 m approach road to the drill site from nearest site access road. The dependency of the landowner in case of generation of livelihood is limited as the land is classified as mono-cropped agricultural land.

HOEC/its contractors would endeavour to provide maximum employment to the local people to meet its short term unskilled labour requirement during the project stage. However, the requirement will be purely temporary in nature and till the completion of the project activities only. Certain percentage of semi-skilled and highly skilled migrant labour would be used by contractors for manning technical activities.

The construction phase of the project is likely to generate both direct and indirect opportunities for employment. The estimated direct employment would be approximately 50 un-skilled workers during the peak construction phase that will primarily sourced from nearby areas. Indirect employment would be primarily in the supply chain as vendors, which are anticipated to be set up to support the construction.

Impact on Community Health & Safety:
Community health and safety of inhabitants residing close to the proposed well sites stand to get affected from frequent heavy vehicular movements along village access roads and due to noise from drilling rig operations, movement of heavy vehicles during construction and decommissioning etc. Traffic rules will be strictly followed by the project proponent for safety of the residents.

Environment Monitoring Program

Environmental monitoring Program will include the following

- Ambient Air Quality Monitoring – at 3 monitoring location; once during construction, twice during drilling and once during site decommissioning phase
- Stack emission monitoring at 3DG sets during drilling
- Ambient Noise Monitoring – 3 locations, once during construction, twice during drilling and once during site decommissioning phase
- Workplace noise monitoring -5 locations, twice during drilling
- Surface Water Quality Monitoring- 2 location, once during construction, once during drilling and once during site decommissioning phase
- Treated water -2 from ETP and 1 from oil/water separator- once each during drilling phase
- Ground Water Quality Monitoring, three location, once during drilling phase
- Soil Quality Monitoring - three locations, once each during pre-construction, drilling and post drilling phase

Risk Assessment and Mitigation

Quantitative Risk Assessment (QRA) aims to provide a systematic analysis of the major risks that may arise as a result of onshore drilling of 24 development wells in the Block and operation of GGS and pipeline. The QRA process outlines rational evaluations of the identified risks based on their significance and provides the outline for appropriate preventive and risk mitigation measures.

Three major categories of hazards that can be associated with proposed Project which includes:

- Blowouts leading to uncontrolled well flow, jet fires, pool fires;
- Hydrocarbon leaks due to loss of containment while drilling;

- Non-process fires / explosions, the release of a dangerous substance or any other event resulting from a work activity which could result in death or serious injury to people within the site; and
- Any event which may result in major damage to the structure of the rig.

Blow out from a hydrocarbon exploratory cum development well was modelled for Vapour Cloud Explosion (VCE) scenario with ignition at the rate of 50kg/s. For congested conditions, the blast overpressure of 1.0 psi is likely to be experienced within a radial distance of 428 m. The level of concern (LOC) was never exceeded at higher blast overpressures of 8.0 psi and 3.5 psi.

Potential failure cases in the form of gas leaks may result from the gas header extension at GGS due to corrosion, mechanical failure and/or faulty operations leading to process deviations. Risk scenarios with different rupture sizes (20mm, 50mm and complete rupture of Group Header) leading to Jet fire shows the Thermal Radiation of Concern (>10KW/sq.m) to reach a maximum distance of 11-15m.

Pipeline failure could lead to potential hazard due to ignition of leaks that might result into a jet fire or Vapour cloud explosion. The level of concern for thermal radiation from Jet Fire caused by a 20mm and 50mm rupture is 17m and 35m respectively (10KW/sq.m). The level of concern for overpressure caused by VCE was never exceeded for >8.0psi.

Risk Reduction Measures

Blow Out Risk reducing measures include:

- Kick simulation training for personnel;
- Presence of well-trained engineers;
- Appropriate well design;
- Good well control procedures;
- Appropriate mud weight formulations;
- Installation of primary and secondary blow out preventers; and
- Trained and skilled operation staff.

Accidents related to leaks from equipment can be minimised by:

- Ensuring that equipment is designed, installed and maintained as per international standards;
- Implementing a robust preventive maintenance system of all safety critical equipment; and
- Efficient test separator.

Risk from storage areas can be minimized by;

- Proper preventive maintenance and robust safety management and security systems.
- For the storage tank, secondary containment to be provided.

Other risk management can be achieved by;

- A hydrocarbon gas detection system with suitable alarm system will be provided at the drilling site for two alarm levels at 20% and at 60% LEL.
- Management of Oil Spills/Leaks and Soil contamination

Emergency Response Plan

- Drilling rig and related equipment to be used for drilling will be conformed to international standards specified for such equipment.
- Blow-out preventers and related well control equipment shall be installed, operated, maintained and tested generally in accordance with internationally recognized standards.
- Appropriate gas and leak detection system will be made available at each of the drilling location.
- Adequate fire-fighting equipment shall be provided at each drilling site.

Environmental Management Plan

The environmental management plan for proposed activities are as follows:

Air Quality Management Plan

- Vehicles delivering raw materials like fine aggregates will be covered to prevent fugitive emissions.
- Sprinkling of water on earthworks, material haulage and transportation routes on a regular basis during construction and decommissioning phase of the wells.
- Flare stacks of adequate height would be provided.
- DG set stacks would have adequate height, as per statutory requirements, to be able to adequately disperse exhaust gases
- Periodic monitoring of DG set stack emission will be carried out in accordance with the Environmental Monitoring Plan to assess compliance with CPCB DG set exhaust standards.

Noise Management Plan

- Selection and use of low noise generating equipment with in-built engineering controls viz. mufflers, silencers, etc.
- All DG sets would be provided with acoustic enclosures.
- Appropriate PPEs (e.g. ear plugs) will be used for by workers while working near high noise generating equipment.
- All vehicles utilized in transportation of raw materials and personnel will have valid Pollution under Control Certificates (PUC).
- All high noise generating equipment will be identified and subjected to periodic preventive maintenance.
- During construction and decommissioning stage, no night time operation of vehicles and construction activities will be undertaken.

Soil Quality Management Plan

- Drip trays to be used during vehicular/equipment maintenance and during re-fuelling operations.

- Spill kits will be made available at all fuel and lubricant storage areas. All spills/leaks contained, reported and cleaned up immediately.
- Dedicated paved storage area will be identified for the drilling chemicals, fuel, lubricants and oils within the drill sites.
- 1.5 mm HDPE lined pits will be considered for the disposal of unusable drilling mud cuttings and drilling wastewater etc.

Surface Water Quality Management Plan

- Levelling and grading operations will be undertaken with minimal disturbance to the existing site contours thereby maintaining the general slope and topographical profile of the site.
- During site preparation and construction, surface water run-off will be channelized through appropriately designed drainage system.
- Sediment filters and oil-water separators will be installed to intercept run-off and remove sediment before it enters water courses.
- Domestic wastewater generated from drill site will be treated through septic tank and soak pit system and then discharged.
- Process wastewater would be treated in Effluent Treatment Plant (ETP) at drill sites.

Ground Water Quality Management Plan

- Water based mud would be used as a drilling fluid for the proposed project.
- Eco-friendly synthetic based mud if required for deeper sections, will be used after providing intimation to the State Pollution Control Board/MoEF &CC;
- The drill cutting along with spent mud will be stored in HDPE lined pit.

Waste Management Plan

- Use of low toxicity chemicals for the preparation of drilling fluid.
- Management of drill cuttings, waste drilling mud, waste oil and domestic waste, wastewater in accordance with Standards for Emission or Discharge of Environmental Pollutants from Oil Drilling and Gas Extraction Industry of CPCB as modified in 2005.
- The hazardous waste (waste and used oil) will be managed in accordance with Hazardous Waste (Management, Handling & Transboundary Movement) Rules, 2016.
- The kitchen waste will be disposed in nearest municipal/village dumping site on a daily basis through approved waste handling contractors.
- The sewage generated will be treated through septic tank and soak pit system.
- Used batteries will be recycled through the vendors supplying lead acid batteries as required under the Batteries (Management & Handling) Rules, 2001.
- The drilling cuttings pit will be bunded and kept covered using tarpaulin sheets during monsoon.

Wildlife Management Plan

- Movement of heavy vehicles will be restricted at night time, especially if access roads pass though forest areas, as most of the mammals movement occurs during night;
- Noise levels at the drill sites will be controlled through selection of low noise generating equipment and installation of sufficient engineering controls viz. mufflers, silencers etc.
- No temporary electric supply connection line from the grid will be laid for the proposed project activity. All electric requirements will be supplied from the internal DG sets;

Road Safety & Traffic Management Plan

- The condition of roads and bridges identified for movement of vehicles and drilling rig will be assessed and if required strengthened by HOEC to ensure their safe movement.
- Precautions will be taken by the contractor to avoid damage to the public access routes including highways during vehicular movement.
- Traffic flows will be scheduled wherever practicable during period of increased commuter movement.

Occupation Health & Safety Management Plan

- All machines to be used in the construction will conform to the relevant Indian Standards (IS) codes, will be kept in good working order, will be regularly inspected and properly maintained as per IS provisions and to the satisfaction of the site Engineer.
- Hazardous and risky areas, installations, materials, safety measures, emergency exits, etc. shall be appropriately marked.

Management of Social issues and concerns

- People from adjoining areas especially given job preference for temporary unskilled labour requirement through local contractors.
- Prior to the commencement of the proposed activity, a consultation program will be conducted by HOEC with the target groups and local authorities. The primary objective of such consultation will be to share with the concerned villagers/stakeholders the objective of the proposed project associated impacts and their mitigation.
- HOEC will give emphasis and priority on periphery development, development of health facilities and provision for drinking water facility as per Corporate Social Responsibility (CSR) Plan.
- The drill site would be fenced and gates would be constructed so that the children are refrained from straying into the site.

Project Cost

The total cost of the project would be approximately USD 85 million. The tentative budget for implementation of the environmental management plans for drilling of wells is estimated to be INR 25.92 lakh per well and total budget for 24 wells is 622.32 lakhs.

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ABBREVIATIONS

ANSI	American National Standards Institute
API	American Petroleum Institute
BCF	Billion Cubic Feet
BOD	Biochemical Oxygen Demand
BOP	Blowout Preventer
CED	Chemically Enhanced Dewatering
CGWB	Central Ground Water Board
CO	Carbon mono-oxide
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CTM	Custody Transfer Metering
dB(A)	A-weighted decibels
DG	Diesel Generator
DO	Dissolved Oxygen
DOC	Declaration of Commerciality
EC	Environmental Clearance
EIA	Environmental Impact Assessment
EMP	Environment Management Plan
ETP	Effluent Treatment Plant
GG	Gas Generator
GGS	Gas Gathering Station
GPP	Gas Processing Plant
HC	Hydro-carbon
HDPE	High-density polyethylene
HOEC	Hindustan Oil Exploration Company
HW	Hazardous Waste
IBH	Indirect Bath Heater
ICAR	Indian Council for Agricultural Research
IMD	Indian Meteorological Department
IMD	India Meteorological Department
IOCL	Indian Oil Corporation Ltd
IUCN	International Union for Conservation of Nature
IVI	Important Value Index
JV	Joint Venture
KLD	Kilo Liter per Day
KVA	kilo-volt-ampere
KW	Kilo watt
MMSCFD	Million Standard Cubic Feet per Day
MoEFCC	Ministry of Environment, Forest and Climate Change

MoPNG	Ministry of Petroleum and Natural Gas
MSDS	Material Safety Data Sheet
MSL	**Mean Sea Level**
NAAQS	National Ambient Air Quality Standards
NABET	National Accreditation Board for Education and Training
NABL	National Accreditation Board for Testing and Calibration Laboratories
NH	National Highway
NOx	Oxides of Nitrogen
NOx	Oxides of Nitrogen
OIL	Oil India Limited
OISD	Oil Industry Safety Directorate
PCU	**Passenger Car Unit**
PM	Particulate Matter
PM	Particulate Matter
POD	Plan of Development
PPE	Personnel Protective Equipment
PSC	Production Sharing Contract
PUC	Pollution Under Control
QCI	Quality Council of India
RCC	Reinforced Cement Concrete
RF	Reserved Forest
ROU	Right of Use
SCADA	Supervisory Control and Data Acquisition
SO_2	Sulphur Dioxide
SO2	Sulphur di oxide
SOI	Survey of India
TDS	Total Dissolved Solids
ToR	Terms of Reference
TSS	Total Suspended Solids
VC	Variable Choke
VOC	**Volatile Organic Carbons**
VR	Vapour Recovery

1 INTRODUCTION

1.1 BACKGROUND

The block AAP-ON-94/1 (area 305 sq. km) is located in Tinsukia district of Assam. The block lies between Latitude 27°18'54.99'' to 27°11'30.00'' North and Longitude 95°56'55.92'' to 95°20'00.00'' East (***Refer Figure1.1***).

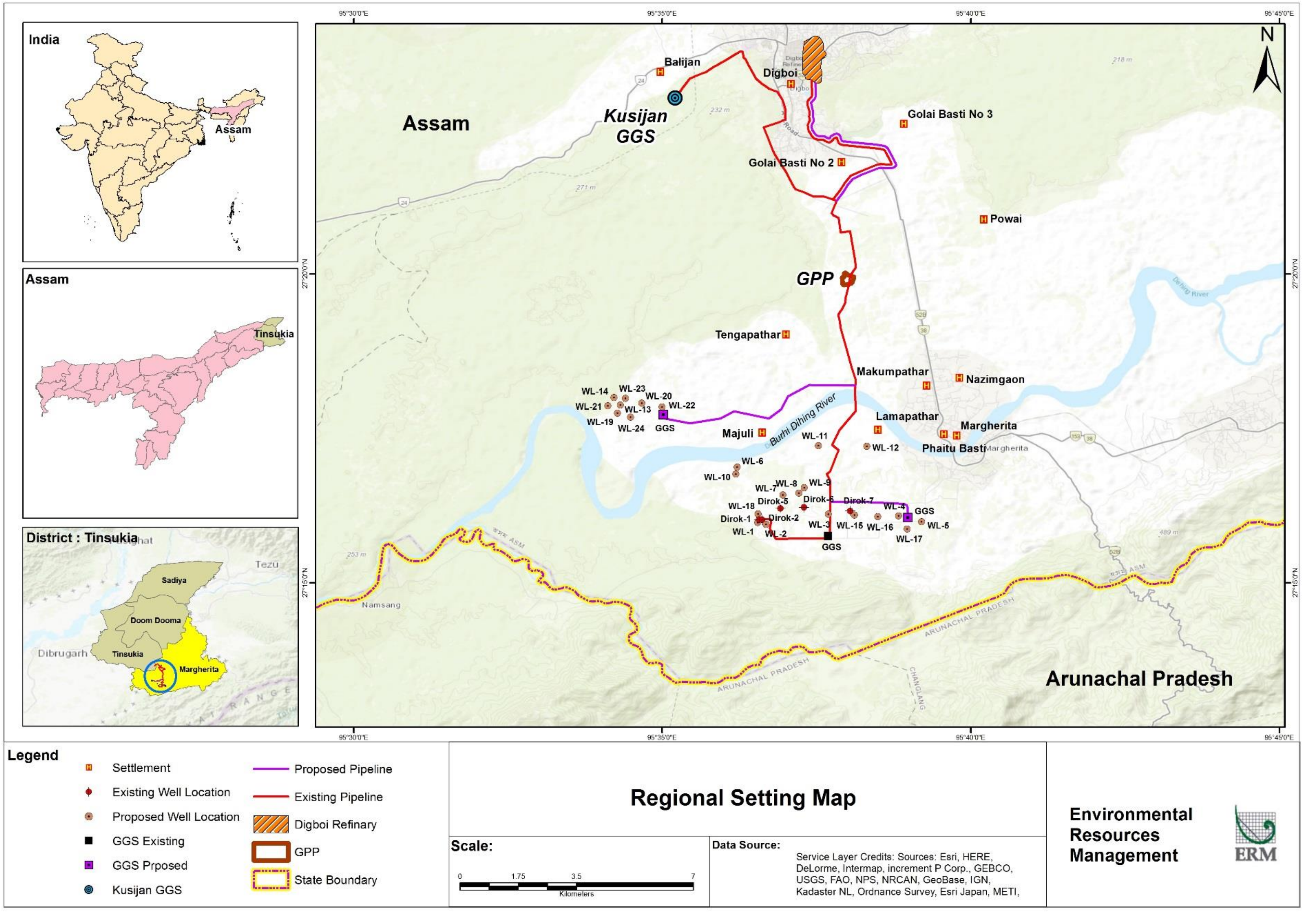
The Block AAP-ON-94/1 was first awarded for exploration to Joint Venture Consortium by the Government of India (GoI). Production Sharing Contract (PSC) for Block AAP-ON-94/1 was signed on June 30th 1998. Presently, the JV Consortium of the block comprises of Hindustan Oil Exploration Company Limited (HOEC), Oil India Limited [OIL] and Indian Oil Corporation Ltd (IOCL). Hindustan Oil Exploration Company limited is the Operator and Oil India Limited is the Licensee of the block. The Participating Interest of the JV Consortium in the development phase is as follows: HOEC (26.882%), OIL (44.086%) and IOCL (29.032%).

1.2 OVERVIEW OF THE PROJECT

Initial exploration in this Block began in November 2000 resulting in identification of multiple play types based on which the JV Consortium had acquired 2D/3D seismic data and drilled three exploratory and two appraisal wells in the block. Several sizeable prospects had been mapped and the Dirok wells drilled by the Consortium had confirmed the presence of multiple gas bearing sands. Based on the Dirok Discovery and subsequent drilling of appraisal wells in the block, which produced hydrocarbon from multiple sands from Girujan Formation; the Ministry of Petroleum and Natural Gas (MoPNG) had approved the Dirok discovery as commercial.

Consortium has been granted Environmental Clearance (EC) for two exploratory drill sites vide File No J-11011/50/2006-1A-II (I) during 2007. Public Hearing for the project was conducted at Ledo Railway Club, Ledo, Tinsukia. Pursuant to the aforesaid EC Consortium has drilled two exploratory wells within the Block. During 2009 another EC was granted to the Consortium via File no. NoJ-11011/112/2009-1A-II (I) for drilling of three exploratory wells within the Block. As part of this EC an exploratory well was drilled in the Block. During 2017 another EC was granted to the Consortium via File no. via File No. J-11011/245/2014-IA II (I) dated 31st January 2017 for six Development wells, Group Gathering Station (GGS), Gas Processing Plant (GPP) and 11.5 km Gas Pipeline from GGS to GPP (***Refer Annex 1.1***). Public Hearing for the project was conducted at Uttar Margherita Rangamancha, Margherita, Tinsukia, Assam on 3rd July 2015. As part of this EC, three existing wells put into production and three new wells were drilled and constructed the GGS, GPP and laid the Pipeline.

Figure 1.1 Regional Setting Map of Block AAP-ON-94/1



1.2.1 *Brief Status of Activities in Block AAP-ON-94/1*

Existing Wells

There are presently six onshore wells within the Block. All the six wells are self-producing wells. The location coordinates of the wells are given in ***Table 1.1***.

Table 1.1 Coordinates of Existing Wells and Facilities within AAP-ON-94/1 Block

S.N.	Facilities	Latitude	Longitude
A.	**Wells**		
1	DRK-1	27°16,01.4,,N	95°36,35.70′′E
2	DRK-2	27°16′01.70′′N	95°36′34.30′′E
3	DRK-4	27°15′45.42′′N	95°37′41.06′′E
4	DRK-5	27° 16′12.14′′N	95°37′03.74′′E
5	DRK-6	27° 16′13.85′′N	95°37′27.57′′E
6	DRK-7	27° 16′13.85′′N	95°37′48.18′′E
B.	**Gas Gathering Station**		
7	GGS-1	27°15′45.42′′N	95°37′41.06′′E
C.	**Gas Processing Plant**		
8	GPP	27°21′49.97′′N	95°37′42.99′′E

[Source: HOEC]

Gas Gathering Station (GGS)

The GGS is located in the in Dirok Tea Estate and it was constructed at DRK-4 well site.

GGS is installed for accumulation and transportation of raw natural gas directly from wellheads to gas processing plant (GPP). Gas extracted from existing wells is being sent to GGS by reducing the well pressure at wellheads. The raw gas is then sent to gas processing plant.

Gas Processing Plant (GPP)

The impurities and various non-methane hydrocarbons & fluids are separated to extract, what is known as "pipeline quality", dry natural gas at gas processing plant (GPP). A gas processing plant also recovers valuable natural gas liquids such as condensate, natural gasoline and liquefied petroleum gas. Once the processing is over, marketable components are transported Kusijan GCS via pipelines for further processing. The condensate is being transported to IOCL Refinary through pipeline from GPP to refinery.

Pipeline Network

Oil and gas from existing wells are routed through sub-surface pipelines to GGS located at Dirok Tea Estate. A 12 km long pipeline laid to transport unprocessed gas from GGS location to GPP, located at Borpowai/Agbandha village. The existing wells, GGS, GPP and Pipeline is presented in ***Figure 1.2.***

Chronology of Development and Environmental Clearance

A chronology of developments within the AAP-ON-94/1 and the Environmental Clearances, Forest Clearance and Wildlife Clearance obtained for oil and gas developmental activities from MoEFCC are listed in ***Table 1.2.***

Table 1.2 Chronology of Developments within Block AAP-ON-94/1

Period	Details
1988 :	Production Sharing Contract (PSC) for the Block AAP-ON-94/1 was signed
2000:	Initial exploration was carried out
2003:	2D/3D seismic survey was conducted
2007:	Environmental Clearance (EC) has been granted for 2 exploratory drill sites via. File No J-11011/50/2006-1A-II (I) during 2007
2008	Two exploratory wells drilled within the block
2009	Environmental Clearance (EC) has been granted for 3 exploratory drill sites via. File No. J-11011/112/2009-1A-II (I) during 2009
2010	One exploratory well and one appraisal well drilled
2015	Ministry of Petroleum and Natural Gas (MoPNG) had approved the Dirok discovery as commercial.
2017	EC was granted for six Development wells, Group Gathering Station (GGS), Gas Processing Plant (GPP) and 11.5 km Gas Pipeline from GGS to GPP via File No. J-11011/245/2014-IA II (I) dated 31st January 2017.
2017	Forest clearance for diversion 4.8444 ha of forest land was received vide F.N. 3-AS B061/2016-8III/1187-88 dated 13th July 2017 for laying of pipeline.
2017	Wildlife clearance was recommended by Standing Committee of NBWL on 30th May 2017 vide F.N. 6-69/2017 WL (42nd Meeting) for drilling of wells, construction of GGS, GPP and laying of pipeline.
2017	Oil & gas production started
2018	As part of this EC three existing wells put into production and three new wells were drilled. GGS and GPP has been constructed as well as pipeline has been laid.

1.3 PROJECT PROPOSAL

In order to increase the hydrocarbon production from AAP-ON-94/1 Block to the maximum extent possible, HOEC now proposes development wells, gas processing plant and pipeline, as presented in ***Table 1.3.*** The proposed location is presented in ***Figure 1.2***.

Table 1.3 Project Proposal

SN	Proposal	Description
1	Drilling of 24 development wells	a) 14 development wells at Dirok Tea Estate. b) 10 development wells at Powai Mukh, Jonghu Kuruka village
2.	Two nos. of GGS	a) GGS-1 at Vitor Powai village; b) GGS-2 at Dirok Tea Estate.
3.	Expansion of capacity of GPP	a) Capacity expansion of existing Modular Gas Processing Plant.

SN	Proposal	Description
4.	Pipeline	a) Laying of flowlines (underground pipelines) to connect well location. b) Laying of approx. 5.5 km underground pipelines from GGS to trunk pipeline (existing and connected with GPP). c) Laying of underground pipeline approx. 8km from existing GPP to IOCL terminal for distribution of gas

1.4 NEED OF THE PROJECT (PROJECT JUSTIFICATION)

The hydrocarbons sector plays vital role in the economic growth of the country. With the ever increasing gap between the demand and supply in the hydrocarbons, the scenario is a challenge for India. India depends on imported crude to meet 75- 80% of its rapidly growing demand for petroleum products. The hydrocarbon resources available in the AAP-ON-94/1 Block is of immense importance for the country and will help in the growth of the economy and stride to reduce gap of crude oil imports versus self-sufficiency. The enhanced production will benefit the country by reducing the import bill and save foreign exchange and contribute to annual revenue to the Government of India.

1.5 EMPLOYMENT GENERATION

The proposed development drilling project does not anticipate increase in the operations team. There would however be employment generation during construction of well site, drilling and laying pipelines. Wherever possible, engagement of local contractors and workers during the project phase will be preferred.

1.6 PROJECT SCHEDULE AND COST ESTIMATE

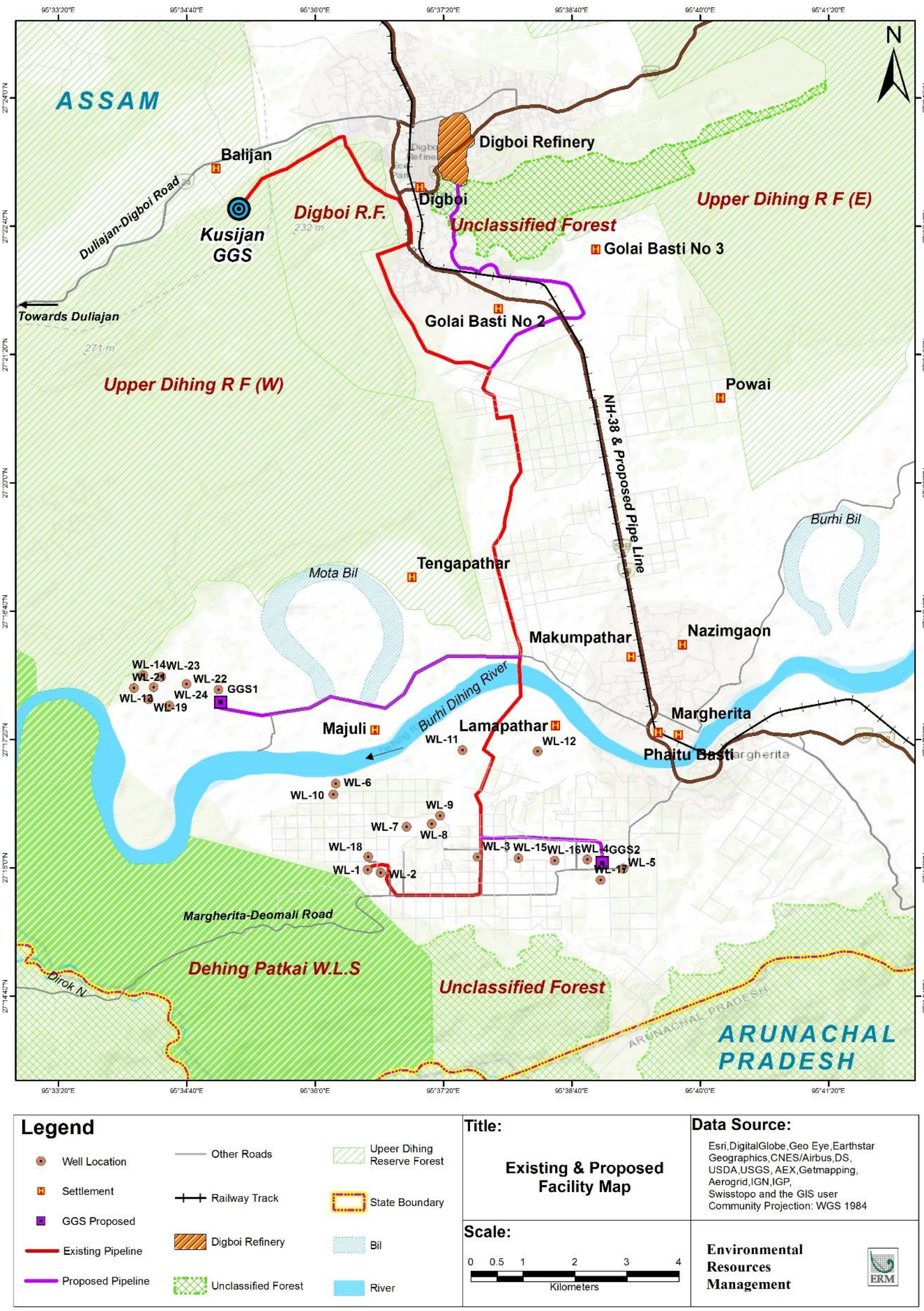
The JV Consortium has planned to develop the available hydrocarbon resources from the AAP-ON-94/1 Block in next 5 years.

The total cost of the project would be approximately USD 85 million. Cost break-up of individual components is presented in ***Table 1.4***.

Table 1.4 Expected Cost of the Project

Sl. No.	Field Development	Approximate Cost (million USD)
1.	Development Wells (24 nos, including field pipelines connecting to GGS)	72
2.	Two nos. of GGS	3
3.	Pipeline (Approx 13.5 Km)	3
4.	Expansion of GPP	7
	Total	85

Figure 1.2 Existing & Proposed Drilling Locations, GGS, GPP & Pipeline



1.7 *SCOPE OF THE EIA STUDY*

The scope of work involves conducting an EIA study as per terms of reference approved by Expert Appraisal Committee of MoEFCC for the proposed oil and gas development in existing Block AAP-ON-94/1. In this regard, the Term of Reference (TOR) for the EIA study has been issued by MoEFCC on April 23, 2018 and has been included under **Annex 1.2**.

Overall the EIA study covers the following key elements:

- Establishing the prevailing environmental and socio-economic condition of Block AAP-ON-94/1;
- Impact assessment, development of mitigation measures and environmental management plan together with development of sub management plans and procedures for effective environmental controls;
- Risk assessment and risk mitigation measures for safe operations in AAP-ON-94/1; and
- Environmental Management Plan including environmental monitoring planning for effective implementation of suggested mitigation measures required for the proposed oil and gas development activities in AAP-ON-94/1.

1.8 *LIMITATIONS*

This EIA study (including Risk Assessment) is based on certain scientific principles and professional judgment to certain facts with resultant subjective interpretation. Professional judgment expressed herein is based on the available data and information.

This report has been developed based on information provided by HOEC with the assumption that the information gathered is representative for the proposed oil and gas development. The impact assessment for the Project is based on the project capacities as described in ***Section 2*** on **Project Description**. If information to the contrary is discovered, the findings in this EIA may need to be modified accordingly.

ERM is not engaged in the impact assessment and reporting for the purposes of advertising, sales promotion, or endorsement of any client's interests, or other publicity purposes. The client acknowledges that any report prepared by ERM are for the exclusive use of the client and agrees that ERM's reports or correspondence will not be used or reproduced in full or in part for such promotional purposes, and may not be used or relied upon in any prospectus or offering circular for commercial purposes.

1.9 *CONTENTS OF THE EIA REPORT*

The EIA report is presented in two volumes, Volume 1 comprises of 12 sections while Volume 2 comprises of ***Annexes*** as described in **Table 1.5.**

Table 1.5 Contents of the EIA Report

Section	Description
Volume 1	
Section 0	Executive Summary of EIA study includes introduction about site and Project, Project Proposal, requirement of the EIA Study, summary compilation of Project description, prevailing baseline conditions, and impact assessment including mitigation measures proposed and environmental management plan and conclusion.
Section 1: Introduction	This section covers Project Background; Overview of the Project (including Operator of the Block, Project Location and Project proposal); Purpose of the EIA study; Need of the Project; Project Cost and Schedule; Scope of the EIA Study; Terms of Reference for EIA study; and Contents of the EIA report.
Section 2: Project Description	Presents a Description of the Block, Existing and proposed Facilities; Hydrocarbon Prospects; Existing Project and Process Details; Proposed Developments; Potential Pollution Sources and Control Measures, Adequacy Assessment; Raw Materials; and Photographs of Existing Areas.
Section 3: Description of the Environment	Includes a description of Existing Environmental and Social Baseline Conditions covering both onshore and offshore regions of the Project block and surrounding area.
Section 4: Impact Assessment and Mitigation Measures	Includes impact identification through scoping, assessment of impact, mitigation measures and evaluation of significance of residual impacts.
Section 5: Analysis of Alternatives	This section includes alternatives available with respect to establishment of proposed RI platform, drilling locations, pipeline routing and related technologies available and the reason for selection of the adopted alternatives.
Section 6: Environmental Monitoring Program	The environmental monitoring to be scheduled during construction and operation phase is provided
Section 7: Additional Studies	Risk assessment and Emergency Response Plan of the plant. Stakeholder assessment as per primary consultation.
Section 8: Project Benefits	The section includes financial benefits, social benefits; and On-going CSR activities.
Section 9: Environmental Management Plan	This section covers introduction and elements of EMP i.e. planning, implementation, checking and management review.
Section 10: Existing Environmental and Safety Approvals and Compliance Status	This section covers the compliance status on relevant environmental and safety approvals
Section 11:Summary and Conclusion	Presents the overall findings of the EIA study and includes overall justification for implementation of the project and provides explanation of how, adverse effects have been mitigated
Section 12: Disclosure about Consultant	Provides brief information about ERM and professionals who were engaged for completion of this study
Annexes	Annexure to EIA study

2 PROJECT DESCRIPTION

2.1 INTRODUCTION

The initial exploration in Block AAP-ON-94/1 began in November 2000 resulting in identification of multiple play types based on which the Consortium (HOEC, OIL and IOCL) acquired 2D/3D seismic data in 2003 and drilled three exploratory and two appraisal wells in the Block. Several sizeable prospects had been mapped and the Dirok wells drilled by the Consortium have confirmed the presence of multiple gas bearing sands. Based on the Dirok Discovery and subsequent drilling of appraisal wells in the Block, which produced hydrocarbon from sands of Girujan Formation; the MoPNG has approved the Dirok discovery as commercial. Based on the Declaration of Commerciality (DoC) report, a Plan of Development (PoD) has been submitted to DGH for the Dirok Field. The estimated reserve of the Dirok Field is 135 approximately Billion Cubic Feet (BCF) of natural gas.

2.2 BLOCK LOCATION, ACCESSIBILITY AND ENVIRONMENTAL SETTINGS

2.2.1 *Location of Block*

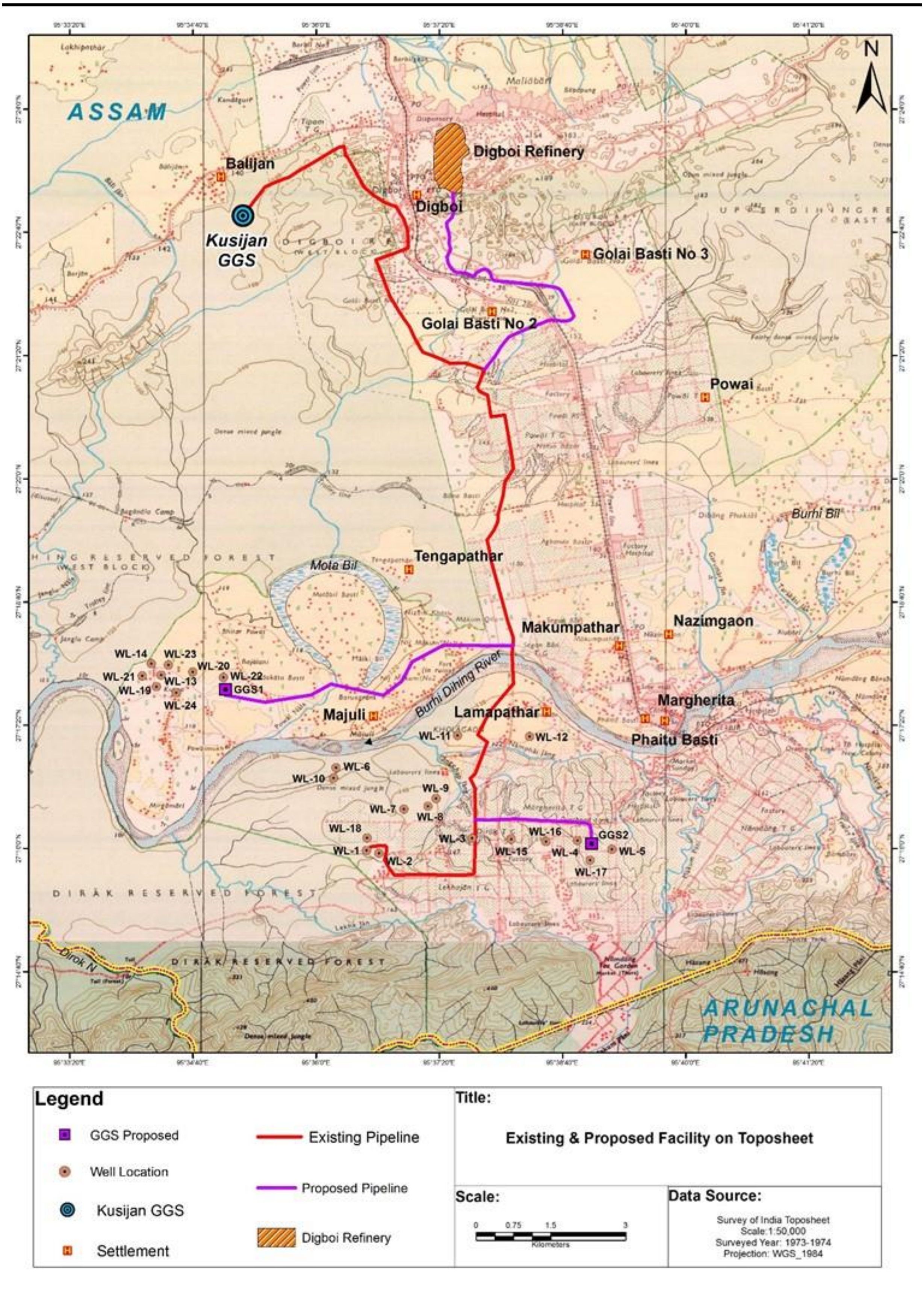
The block AAP-ON-94/1 is located in Tinsukia district of Assam. The block is bounded in the north by Digboi town and the Barajan, Tarajan and Jaipur settlements, in south by Tirap district of Arunachal Pradesh, in the east by Tirap River and in the west by Namrup and Hukanimuri settlements. The total area of the Block is 305 sq. km.

The block extends between:

- Latitude 27°18'54.99'' to 27°11'30.00'' North and
- Longitude 95°56'55.92'' to 95°20'00.00'' East

The Block AAP-ON-94/1 and existing facilities along with the proposed drill sites and facility on the Survey of India (SOI) toposheet and satellite imagery are shown in ***Figure 1.2***and ***Figure 2.1*** respectively. Existing Wells and

Figure 2.1 Existing & Proposed Wells, Facilities and Pipelines on the SOI Toposheet



2.2.2 *Accessibility*

Road

The existing wells, proposed wells, GGS is located in the Tinsukia district of Assam. The NH-37 is the main road link between Tinsukia district and the rest of Assam and the country. From Makum town NH-37 bifurcates and continues as NH-38 to the towns of Digboi, Margherita, Ledo etc. HOEC's warehouse for storing equipment for drilling and other activities is located at Digboi town, which is approximately 17 km from the planned cluster of wells. Apart from Digboi some other major towns in Tinsukia district are Tinsukia, Margherita, Doom Dooma and Makum which are interlinked with each other through the NH-37 & NH-38.

Wells towards Dirok Tea Estate

The existing and proposed wells and GGS are located in Dirok Tea Estate. Margherita town is located in the south of Digboi town at a distance of 17 km and connected with Digboi through NH-38. Deomali – Margherita road originates from NH-38 near Margherita tea estate factory and connects Dirok Tea Estate area with NH-38 and subsequently with Margherita. This road will provide access to all the wells (both proposed and existing) and proposed GGS locations. Proposed wells and GGS locations and existing well locations will be approached from Margherita-Deomali Road by using Dirok Tea Estates internal road network.

Wells towards Vitor Powai

The proposed wells and GGS located at Powai Mukh, Jonghu Kuruka village can be accessed through Makumkilla Road, which is connected with NH-38. The approximate road distance of Vitor Powai well cluster is approximately 10 km. The Makumkilla Road is all weathered road, though future strengthening may be required in certain locations.

The proposed GPP location has been selected near Borpowai / Agbanda village about 3.5 km from Digboi town. The location is approximately 500 m. from NH-38 and located on a paddy field. However, no approach road is present at this time to reach the proposed GPP location from NH-38.

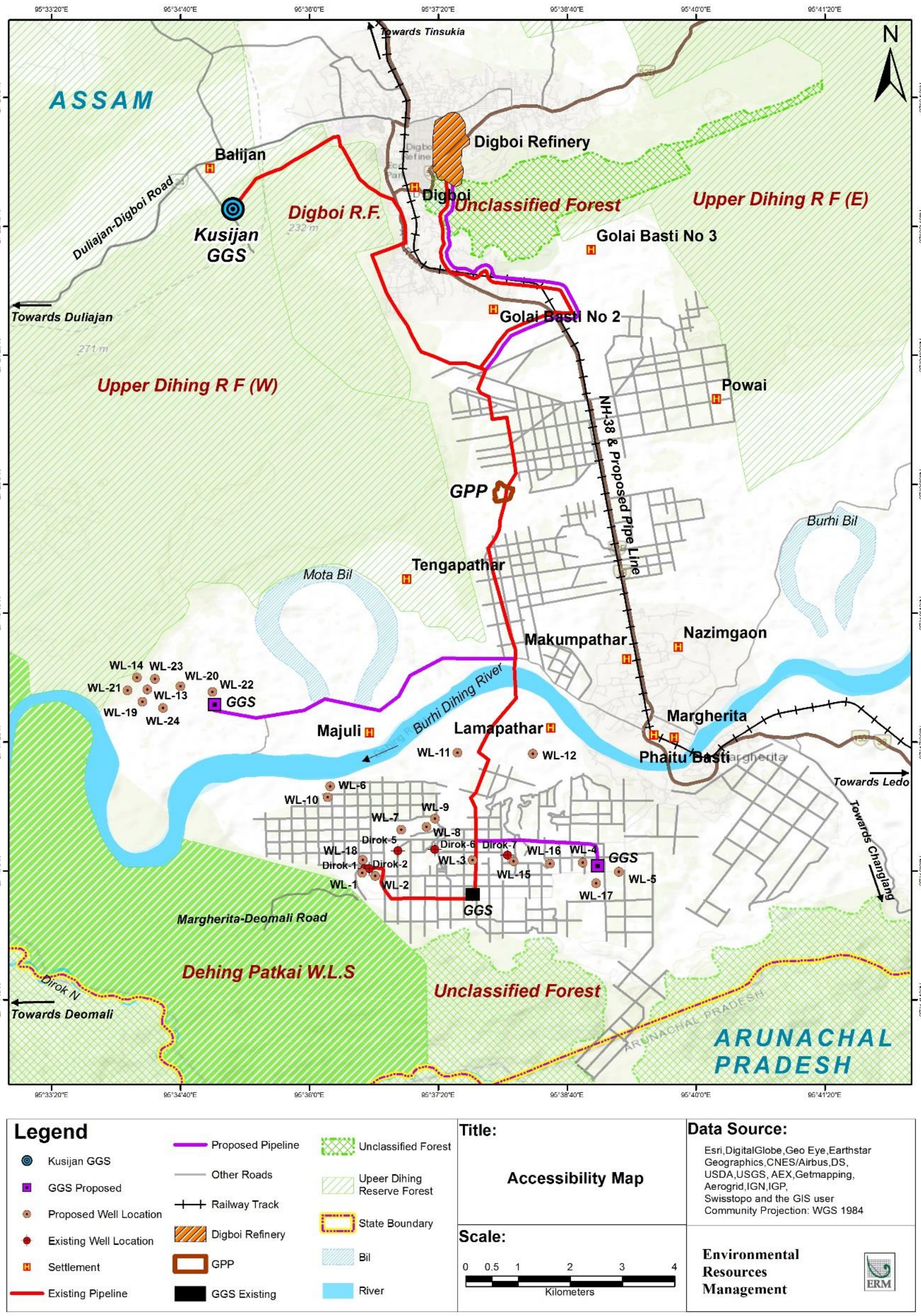
Railway

Tinsukia –Ledo line of North East Frontier Railway is one of the major lifelines that connects this area with rest of the Assam. Digboi railway station is located at distance of approxi 18 km from the existing and proposed wells and GGS locations.

Airport

Dibrugarh is the nearest civilian airport located at distance of 80 km from Digboi which is directly connected to the metropolis of Delhi, Kolkata and Guwahati. The accessibility to the different areas within the block is shown in ***Figure 2.2.***

Figure 2.2 Accessibility Map of Proposed Drill Sites



2.2.3 *Environmental Settings of Block*

The key physical features (***Refer Figure 2.3***) of AAP-ON-94/1 and Dirok Development Field have been described below:

- The Block is bounded in the north by Digboi town and the Barajan, Tarajan and Jaipur settlements, in south by Tirap district of Arunachal Pradesh, in the east by Tirap River and in the west by Namrup and Hukanimuri settlement.

- The Block lies south of the famous Digboi Field. Digboi town is located approximately 25 km away from the well site and GGS location.

- Margherita is the major town near the proposed drill sites and located approximately 4 km away in north-east direction. Some other important settlements present in this Block are Golai Gaon, Makum, Durgabari, Makumpathar etc.

- Upper Dihing and Digboi reserve forests and Dehing Patkai Wildlife Sanctuary (WLS) cover northern and western parts of the Block respectively. All the existing and proposed wells and proposed GGS will be located within an aerial distance of 2 km from the Dehing Patkai Wildlife Sanctuary. Proposed GPP will be located 2 km in east of the West Block of Digboi Reserve Forest and about 11 km from the WLS.

- Buri Dihing River flows through the centre of the block from ENE to WSW direction. The southern part of the Block is covered by uplands and hills. Rest of the area is covered by tea gardens. Few opencast and underground coal mines operated by Coal India Limited are situated in the eastern part of the Block.

- All the existing and proposed wells and proposed GGS will be located within Dirok Tea Estate. Proposed GPP will be located in agricultural land at Borpowai / Agbanda village which is outside of ecological sensitive zone.

- Dirok Development Field mostly comprises of small to large tea estates, rural area with agricultural lands, settlements and homestead plantation, tea processing plants etc. Apart from these tea estate labour colonies, hospitals, dispensaries, schools are present in the Field.

2.3 EXISTING PROJECT WITH PROCESS DETAILS

There are six producing wells in the Block (location of the wells are provided in Table 1.1). For the processing of gas, there are one GGS and GPP. For the transportation of gas from GGS to GPP; 12 km long sub-surface pipeline already laid. The process description of GGS and GPP has been discussed in following sections.

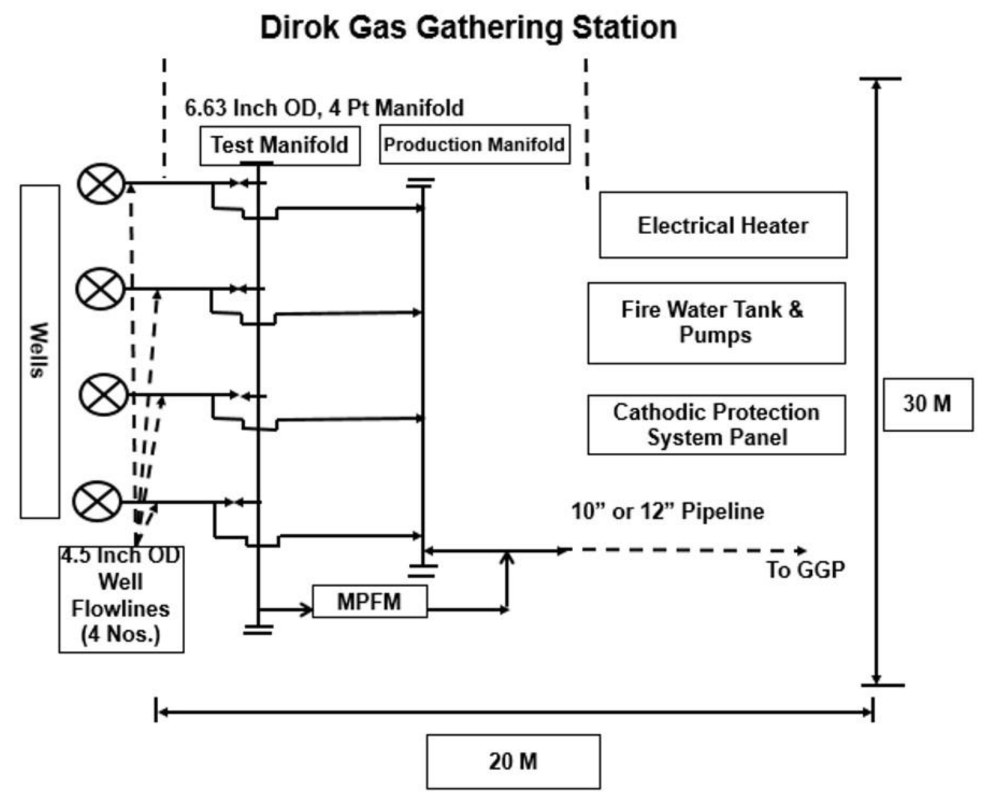
2.3.1 *Gas Gathering*

GGS is installed for accumulation and transportation of raw natural gas directly from wellheads to gas processing plant (GPP). The natural gas (along with associate gas) is compressed and pumped into pipeline for further processing in Gas Processing Plant. The GGS has the following components:

- Test Manifold;
- Production Manifold;
- Electrical Heater;
- Fire Water Tank and Pumps;
- Cathodic protection System;
- Compressor Unit
- DG Sets (400 KVA capacity)

The process flow diagram is presented in following figure.

Figure 2.3 Process Flow Diagram of GGS



2.3.2 *Gas Processing Plant*

The Modular Gas Processing Plant (MGPP) has the capability to process up to 35 MMSCFD of gas, 800 BPD of condensate and 1,000 BPD of produced water. The sales gas has been transported via flowline to Oil India Limited Kushijan. The condensate has been transported through pipeline to IOCL refinery for further processing.

The MGPP utilises modular processing equipment to provide the following main processing steps:-

- Gas-stream Fluid Inlet Separation
- Gas Conditioning System
- Sale Gas Heating
- Wet Condensate Second Stage Separation and Degassing
- Wet Condensate Heating
- Stabilised Condensate Pumping
- Stabilised Condensate Coalescing
- Stabilised Condensate Cooling
- Stabilised Condensate Storage
- Stabilised Condensate Pumping for pipeline export
- Stabilised Condensate Non-Fiscal Metering for pipeline export
- Stabilised Condensate Truck Pumping, Non-Fiscal Metering and Loading.
- Produced Water Separation & Treatment

Plus the following services / utilities:-

- Relief / Flare System
- Closed Drains System
- Open Drain System
- Reverse Osmosis Package (Future)
- Instrument and Utility Air System
- Diesel Storage System
- Fire Water System
- Chemical Injection System
- Gas Engine Generators
- Emergency Diesel Generator
- PLC Control System
- ESD & Fire and Gas Detection System

Gas processing

Well fluid is received from the Gas Gathering Station (GSS) through pipeline to the slug catcher.

The slug catcher is a conventional horizontal 2-phase separator vessel, 2400 mm I.D. x 9000 mm T/T, operating at 24 barg and up to 25°C with a slug handling capacity of 23 m^3 from NLL to LAH. It is designed to de-gas the incoming well fluids. The separated liquid phase flows under level control to the 2nd stage separator (300-V-002), whilst the gas phase is metered and flows under pressure control to the gas scrubber (300-V-004) to knock-out water and any hydrocarbon condensate carryover.

Inlet to the slug catcher is provided with an emergency shutdown valve (SDV-0003) to close on a process upset condition to protect downstream equipment. The slug catcher vessel is equipped with the following internals:

- Sampling Points;
- Slug Catcher Vessel Pressure Control;
- High and Low Pressure Shutdown;
- Pressure Transmitter Settings;
- Overpressure Protection;
- Flow metering;
- Liquid level control
- High and low liquid level shutdown
- Level transmitter settings;
- Temperature Monitoring;
- Liquid Outlet Shutdown Valve;
- Gas Blowdown Valves

2nd Stage Separator

The 2nd stage separator is an intermediate 3-phase submerged weir vessel designed for the separation of gas, condensate and produced water by gravity. The water phase is separated and metered through a turbine flow meter and flows under interface level control through LCV-0105 installed downstream of the deoiling hydrocyclone in the produced water treatment package. A basket type strainer (ST-0101) is provided upstream of the turbine flow meter with a differential pressure gauge (PDG-0101) to alert operators of a strainer basket blockage.

The condensate is metered through a turbine flowmeter (FIT-0102) and flows under level control through LCV-0101 (installed upstream of the LP separator) to the condensate heat exchanger (300-E-0001). A basket type strainer (ST-0102) is provided upstream of the turbine flow meter with a differential pressure gauge (PDG-0102) to alert operators of a strainer basket blockage. The separated gas flows through a pressure control valve (PCV-0101) to the flare header. A connection is taken from upstream of the pressure control valve and routed to the fuel / blanket gas header.

The 2nd stage separator is equipped with:

- Separator Vessel Internals;
- Sampling Points;
- Chemical Injection;
- Separator Vessel Pressure Control;
- High and Low Pressure Shutdown;

- Overpressure Protection;
- Condensate Level Control;
- Condensate / Water Interface Level Control;
- High and Low Condensate Level Shutdown;
- Low Condensate/ Water Interface Level Shutdown;
- Temperature Monitoring;
- Gas Blowdown Valves;
- Condensate Outlet Safety Shutdown Valve;
- Water Outlet Safety Shutdown Valve.

A brief schematic layout of GPP is provided in ***Figure 2.4***.

The capacity of the existing GPP is 20 mmscfd gas processing and handling capacity. The condensate storage and handling capacity at the GPP is 800 bpd.

Produce water Handling

Approximately 10 m^3/day produced water will be generated after gas processing; the water would be treated in an Effluent Treatment Plant (ETP) and discharged after compliance to the CPCB Discharge Standards or reused.

Fire Fighting Facilities

The dyked tank area with containment provisions will be provided with water sprinkler system and other fire fighting provisions like portable fire extinguishers, sand filled buckets, fire water tank, fire water pumps, jockey pumps, fire hydrants, monitors firewater rings, etc as per OISD 117 & 189. Further gas detectors of gases like hydrocarbons, smokes will be placed in different locations. The tanks will be grouped so as to provide optimum containment arrangement and prevent any spills and leaks to spread throughout the tank farm area.

Figure 2.4 Schematic Layout of GPP

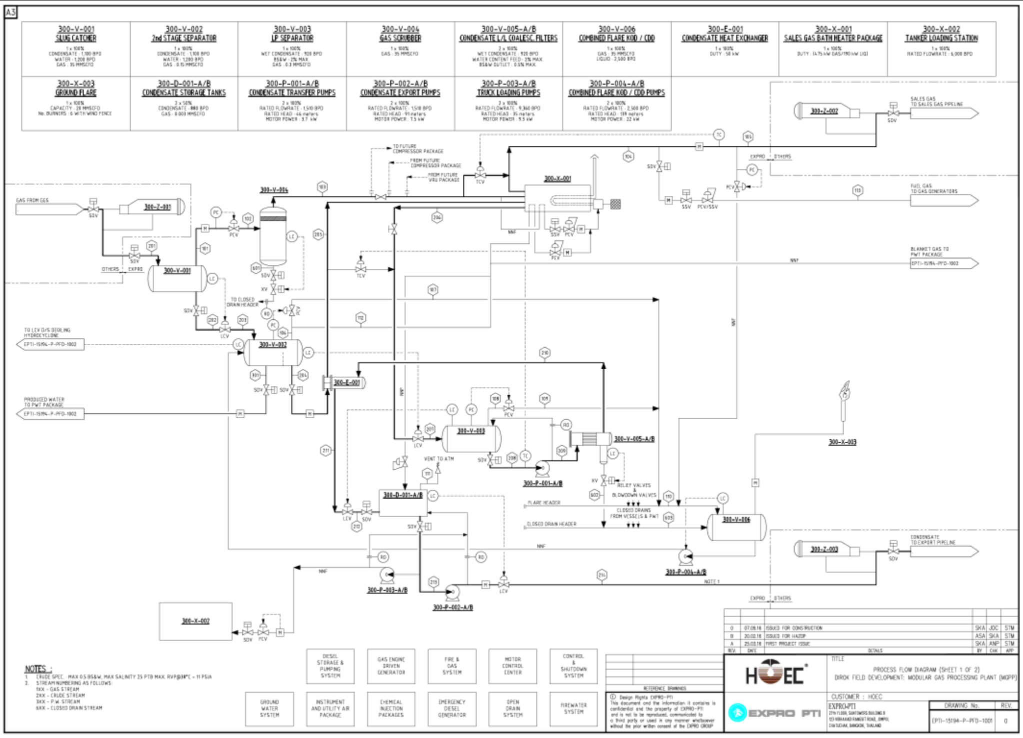


Figure 2.5 Photographs of Existing Operations

Production well

Production well

Gas Gathering Station (GGS)

Gas Processing Plant (GPP)

2.4 PROPOSED DEVELOPMENT

As discussed earlier the intention of this proposed project is to maximise production of hydrocarbons from the Block AAP-ON-94/1. The additional facilities proposed include:

- 24 number of Development wells;
- Setting up of 2 GSS
- Capacity expansion of existing Modular Gas Processing Plant from 20 mmscfd to 40 mmscfd.
- Laying of approx. 5.5 km underground pipelines from GGS to trunk pipeline (existing and connected with GPP).
- Laying of underground pipeline approx. 8km from existing GPP to IOCL terminal for distribution of gas

2.4.1 Development Wells

It is proposed to drill 16 number of development wells in Dirok area and 8 number of development wells Vitor Powai area. The locations of these development wells are proposed to be drilled are given in ***Table 2.1.***

The well fluids from the proposed wells at Dirok area will be routed to existing GGS and proposed GGS-2. The well fluids from the proposed wells at Vitor Powai area will be routed to proposed GGS-1.

Table 2.1 Locations of Proposed Developmental Wells

Sl. No.	Location Name	Latitude	Longitude
A.	**Development Wells**		
1	Well location 1	27°15'58.5524"N	95°36'32.8200"E
2	Well location 2	27°15'58.4121"N	95°36'35.0863"E
3	Well location 3	27°16'06.4737"N	95°37'41.4493"E
4	Well location 4	27°16'03.4489"N	95°38'56.4672"E
5	Well location 5	27°16'02.1674"N	95°39'01.7636"E
6	Well location 6	27°16'52.3106"N	95°36'12.9200"E
7	Well location 7	27°16'25.3338"N	95°36'57.1465"E
8	Well location 8	27°16'27.1416"N	95°37'12.7900"E
9	Well location 9	27°16'29.8819"N	95°37'14.7762"E
10	Well location 10	27°16'49.9009"N	95°36'12.3144"E
11	Well location 11	27°17'13.1228"N	95°37'31.8744"E
12	Well location 12	27°17'12.5205"N	95°38'18.7753"E
13	Well location 13	27°17' 52.8606"N	95° 34' 17.4600"E
14	Well location 14	27°17' 55.3594"N	95° 34' 16.3823"E
15	Well location 15	27°16' 05.8012"N	95°38' 06.8800"E
16	Well location 16	27°16' 04.2812"N	95°38' 29.4300"E
17	Well location 17	27°16'03.0418"N	95°38'58.9900"E
18	Well location 18	27°16' 03.6212"N	95°36' 33.7700"E
19	Well location 19	27°17' 49.5018"N	95° 34' 16.8000"E
20	Well location 20	27°17' 54.3930"N	95° 34' 40.0500"E
21	Well location 21	27°17' 51.8906"N	95° 34' 07.2100"E
22	Well location 22	27°17' 45.7618"N	95° 34' 59.7400"E
23	Well location 23	27°17' 59.0424"N	95° 34' 24.2600"E

Sl. No.	Location Name	Latitude	Longitude
24	Well location 24	27°17' 40.9024"N	95° 34' 29.2700"E
B.	**GGS**		
1	Gas Gathering Station 1	27°17′43.24′′N	95°35/ 1.17//E;
2	Gas Gathering Station 2	27°16′'03.0418"N	95°38'58.9900"E

2.4.2 *Gas Gathering Station*

It is proposed to construct two additional gas gather stations- one at Dirok area and 2nd one at Vitor Powai area. The location these GSS is provided in ***Table 2.1***.

2.4.3 *Expansion of GPP Capacity*

The existing capacity of the GPP is 20 mmscfd. The capacity of the GPP will be enhanced up to 40 mmscfd. No additional land will be required for the proposed expansion.

2.4.4 *Pipeline*

Pipeline from GGS-1 to Trunk Pipeline

A 12 inch diameter gas pipeline of approximately 5.5 km pipeline will be laid along the RoW of the existing Makumkila road to transport the natural gas from proposed GGS at Vitor Powai village to existing trunk pipeline. The proposed pipeline from the GGS would cross Pawai Nala on its way to Trunk Pipeline.

Pipeline from GPP to IOCL Pipeline

Additional condensate oil will be transported to the IOCL refinery at Digboi through an underground pipeline. HOEC has already laid one pipeline in this area and the proposed pipeline for HOEC project is planned to be laid in the ROU of existing IOCL pipeline. These pipelines shall be constructed conforming to international ANSI and also OISD Indian standards as per best industry practice. All the pipelines will be buried with earth cover of minimum 1.0 meter depth. Terrain along the entire route of the pipeline is more or less flat.

The proposed development wells and other infrastructure is presented in ***Figure 2.1***.

2.5 *Environmental Settings of Proposed Facility*

The proposed well sites and production facilities were selected based on environmental considerations *viz*. by avoiding locations that are sensitive, i.e. ecological habitats, settlements, schools/ hospitals, water bodies etc.

The proposed wells (24 numbers) and GGS (2 numbers) are located in non-forest area. 10 wells and one GGS is located in the tea garden area; and remaining 14 wells and one GGS is located in the agricultural land.

The proposed drill sites and GGS are away from the forest area; however, in case of Well No. 1, 2, 13, 14, 18, 19 21 and 23 forest land is located within 0.5 km.

Seasonal drainage channel or river is away from proposed drill sites or GGS. The proposed drill sites – Well No. 4 and 5 are located 0.02 km from a seasonal drainage channel.

Proposed drill sites and GGS are away from the human settlements; however, in case of Well No. 6, 10, 13, 14, 17, 19, 20, 22, 23, 24 and both the GSS human settlements are located within 500 m.

The nearest ecological sensitive area is Dehing Patkai Wildlife Sanctuary. The well no. 1, 2, 3 13, 14, 18 and 21 are located within 1.0km distance from sanctuary.

The pipeline from proposed GGS-1 at Vitor Powai area to Trunk pipeline will be laid along the ROU of Makumkilla Road. In the proposed alignment, there is no forest land or ecological sensitive area. The proposed pipeline will be passing through the Votor Powai No.1 and Makum Block No. 3 villages.

The pipeline from GGP to IOCL Digboi Refinery will be laid along the ROU of the existing road. A part of the pipeline line (1.70 km) will be passing through the tea garden and agricultural land. The proposed pipeline is not passing through any forest land or ecological sensitive area. The pipeline will be passing through Goli Goan No. 3 and Golai Goan No. 1.

Environmental settings of wells, GGS and pipeline is presented ***Table 2.2*** and ***Figure 2.6***.

Table 2.2 Environmental Settings of the Well, GGS & Pipeline

Well Name	Administrative Setup			Accessibility	Existing Land Cover	Stream/River	Settlements & Facility	Forest	Wildlife Sanctuary (Distance from Dehing Patkai WLS)- km	Wildlife Clearance Status
	Village	Revenue Block	District							
Well-1	Makum Block No 1	Margherita	Tinsukia	A road through tea garden is only 0.12km from Margheria Deomalia road.	Tea Garden	Seasonal drainage channel – approx. 0.09 km	Likhijan Gaon is 1.35 km away from the well location, and this well site is just beside HOEC DRK-1 & 2.	0.092 km Dehing Patkai WLS	0.092	Wildlife clearance will be taken from NBWL
Well-2	Makum Block No1	Margherita	Tinsukia	A road through tea garden is only 0.34km from Margheria Deomalia road.	Tea Garden	Seasonal drainage channel – approx.. 0.09 km	Likhajan gaon is 1.14 km away from the well location, and it is 0.13km away from the HOEC DRK-1 &2.	0.124 km Dehing Patkai WLS	0.124	Wildlife clearance will be taken from NBWL
Well-3	Makum Block No1	Margherita	Tinsukia	Site is connected with tea garden road and approx.. 0.73 km from Margheria Deomalia road.	Tea Garden	Seasonal drainage channel – approx.. 0.07 km	Dirok tea estate 11 No. staff colony is almost 1.44 km and Likhajan Gaon is 0.67km away from the well location.	0.915 km Dehing Patkai WLS	0.915	Wildlife clearance will be taken from NBWL

Well Name	Administrative Setup			Accessibility	Existing Land Cover	Stream/River	Settlements & Facility	Forest	Wildlife Sanctuary (Distance from Dehing Patkai WLS)- km	Wildlife Clearance Status
	Village	Revenue Block	District							
Well-4	112/109/NLA Grant. 1 Makum Tea	Margherita	Tinsukia	Site is connected with tea garden road and approx.. 0.20 km from Margheria Deomalia road.	Tea Garden	Seasonal drainage channel – approx.. 0.02 km	Margharita tea estate and Dirok tea estate 11 No. staff colony (0.55 km from the well location).	No forest within 1km of the proposed site	1.109	Wildlife clearance will be taken from NBWL
Well-5	112/109/NLA Grant. 1 Makum Tea	Margherita	Tinsukia	Margheria Deomali road is very near to the well, which is connected with the NH 38 and NH 52B.	Tea Garden	Seasonal drainage channel – approx.. 0.02 km	Margharita tea estate and Dirok tea estate 11 No. staff colony is present in within 1 km boundary from the well site.	No forest land within 1 km	1.060	Wildlife clearance will be taken from NBWL
Well-6	Makum Block No 1	Margherita	Tinsukia	Site is approx.. 0.10 km from nearest access road and 2.0 km from Margheria Deomali road.	Agriculture land	Dihing river is 0.43 km from site	Tea garden colony is located 0.40 km from the site,	No forest land within 1 km	1.262	Wildlife clearance will be taken from NBWL
Well-7	Makum Block No 1	Margherita	Tinsukia	Site is approx.. 0.17 km from existing site access road	Agriculture land	Seasonal drainage channel – approx.. 0.28 km	Likhajan Gaon is 1.21 km away from the well site.	No forest land within 1 km	1.147	Wildlife clearance will be taken from NBWL

Well Name	Administrative Setup			Accessibility	Existing Land Cover	Stream/River	Settlements & Facility	Forest	Wildlife Sanctuary (Distance from Dehing Patkai WLS)- km	Wildlife Clearance Status
	Village	Revenue Block	District							
				and 1.3 km from Margheria Deomali road						
Well-8	Makum Block No 1	Margherita	Tinsukia	Site is approx.. 0.20 km from existing site access road and 1.56 km from Margheria Deomali road	Agriculture land	Seasonal drainage channel – approx.. 0.40 km	Likhajan Gaon is 1.10 km away from the well site.	No forest land within 1 km	1.470	Wildlife clearance will be taken from NBWL
Well-9	Makum Block No 1	Margherita	Tinsukia	Site is adjacent to site access road and 1.53 km from Margheria Deomali road	Agriculture land	Seasonal drainage channel – approx.. 0.32 km	Likhajan Gaon is 1.10 km away from the well site.	No forest land within 1 km	1.575	Wildlife clearance will be taken from NBWL
Well-10	Makum Block No 1	Margherita	Tinsukia	Site is adjacent to site access road and 2.04 km from Margheria Deomali road	Tea Garden	Seasonal drainage channel – approx.. 0.06 km and Buri Dihing River 0.35 km	Tea garden colony is located 0.25 km from the site,	No forest land within 1 km	1.182	Wildlife clearance will be taken from NBWL

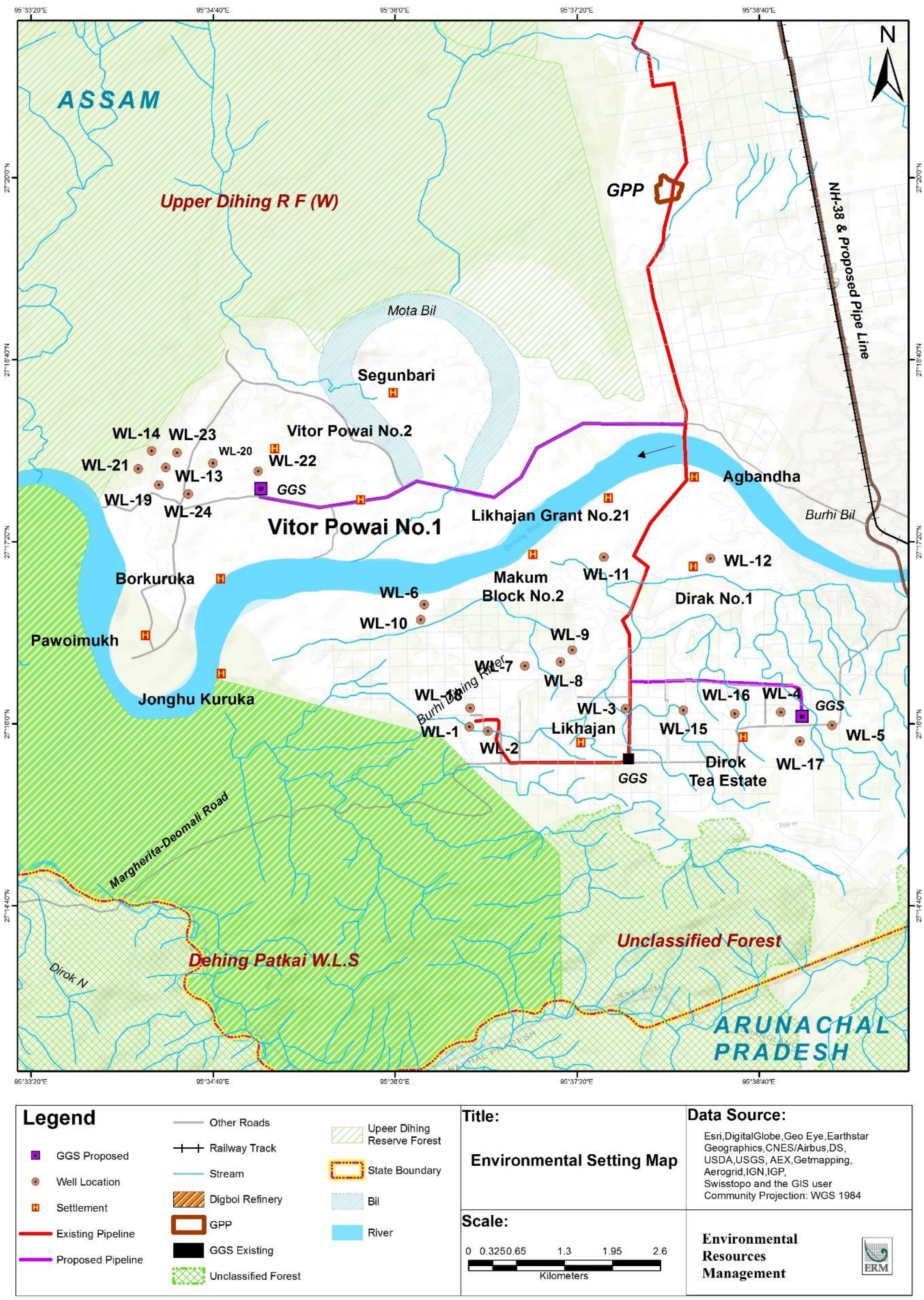
Well Name	Administrative Setup			Accessibility	Existing Land Cover	Stream/River	Settlements & Facility	Forest	Wildlife Sanctuary (Distance from Dehing Patkai WLS)- km	Wildlife Clearance Status
	Village	Revenue Block	District							
Well-11	Makum Block No. 2	Margherita	Tinsukia	Site is 0.35 km from existing site access road and 2.75 km from Margheria Deomali road	Agriculture land	Buri Dihing River 0.62 km	Tea garden colony is located 0.75 km from the site,	No forest land within 1 km	2.905	Wildlife clearance will be taken from NBWL
Well-12	Dirak No. 1;	Margherita	Tinsukia	Site is 0.41 km from existing site access road and 2.14 km from Margheria Deomali road	Agriculture land	Buri Dihing 0.78 km	Tea garden colony is located 0.75 km from the site,	No forest land within 1 km	3.132	Wildlife clearance will be taken from NBWL
Well-13	Vitor Powai village	Margherita	Tinsukia	Site is 0.15 km from existing site access road and 0.38 km from Makum Killa Road road	Agriculture land	Buri Dihing 0.92 km	Vitor Powali no. 2 is 0.15 km away from the well location	Upper Dehing Reserve Forest- 0.41km	0.550	Wildlife clearance will be taken from NBWL
Well-14	Vitor Powai village	Margherita	Tinsukia	Site is 0.05 km from existing site access road and 0.60 km from Makum Killa Road road	Agriculture land	Buri Dihing 0.92 km	Vitor Powali no. 2 is 0.07 km away from the well location	Upper Dehing Reserve Forest - 0.06 km	0.540	Wildlife clearance will be taken from NBWL

Well Name	Administrative Setup			Accessibility	Existing Land Cover	Stream/River	Settlements & Facility	Forest	Wildlife Sanctuary (Distance from Dehing Patkai WLS)- km	Wildlife Clearance Status
	Village	Revenue Block	District							
Well-15	112/109/NLA Grant. 1 Makum Tea	Margherita	Tinsukia	Site is adjacent to site access road and 0.70 km from Margheria Deomali road	Tea Garden	Seasonal drainage channel – approx.. 0.32 km	Dirok tea estate 11 No. staff colony-0.80km and Likhajan Gaon -1.29 km from the well site	No forest land within 1 km	2.350	Approval taken from NBWL
Well-16	112/109/NLA Grant. 1 Makum Tea	Margherita	Tinsukia	0.20 km from the Margheria Deomali road.	Tea garden	Seasonal drainage channel – approx.. 0.41 km	Tea estate colony- 0.06 km from site	No forest land within 1 km	2.790	Approval taken from NBWL
Well-17	112/109/NLA Grant. 1 Makum Tea	Margherita	Tinsukia	0.21 km away from the Margheria Deomali road.	Tea garden	Seasonal drainage channel – approx.. 0.04 km	Tea estate colony- 0.44 km from site	No forest land within 1 km	1.093	Approval taken from NBWL
Well-18	Makum Block No 1	Margherita	Tinsukia	Adjacent to tea garden road and approx.. 0.70 km Margheria Deomali road.	Tea garden	Seasonal drainage channel – approx.. 0.27 km	Tea estate colony- 0.58 km from site	Dehing Patkai WLS-0.31 km	0.310	Approval taken from NBWL
Well-19	Vitor Powai village, Margharita, Tinsukia	Margherita	Tinsukia	Site is 0.12 km from existing site access road and 0.43 km from	Agriculture land	Buri Dihing 0.75 km	Vitor Powali no. 2 is 0.14 km away from the well location	Upper Dehing Reserve Forest - 0.48 km	1.00	Approval taken from NBWL

Well Name	Administrative Setup			Accessibility	Existing Land Cover	Stream/River	Settlements & Facility	Forest	Wildlife Sanctuary (Distance from Dehing Patkai WLS)- km	Wildlife Clearance Status
	Village	Revenue Block	District							
				Makum Killa Road						
Well-20	Vitor Powai village	Margherita	Tinsukia	Site is 0.27 km from existing site access road and 0.72 km from Makum Killa Road	Agriculture land	Buri Dihing 1.47 km	Vitor Powali no. 2 is 0.19 km away from the well location	Dehing Patkai WLS- 1.71 km	1.710	Approval taken from NBWL
Well-21	Vitor Powai village	Margherita	Tinsukia	Site is 0.15 km from existing site access road and 0.74 km from Makum Killa Road	Agriculture land	Buri Dihing 0.63 km	Vitor Powali no. 2 is 0.18 km away from the well location	Upper Dehing Reserve Forest -0.14 km	0.820	Approval taken from NBWL
Well-22	Vitor Powai village	Margherita	Tinsukia	Site is 0.35 km from existing site access road and 0.33 km from Makum Killa Road	Agriculture land	Ox-bow lake 1.43 km	Vitor Powali no. 2 is 0.26 km away from the well location	Upper Dehing Reserve Forest -1.24 km	2.630	Approval taken from NBWL
Well-23	Vitor Powai village	Margherita	Tinsukia	Site is 0.17 km from existing site access road and 0.76 km from Makum Killa Road	Agriculture land	Buri Dihing 1.14 km	Vitor Powali no. 2 is 0.15 km away from the well location	Upper Dehing Reserve Forest -0.37 km	1.310	Approval taken from NBWL

Well Name	Administrative Setup			Accessibility	Existing Land Cover	Stream/River	Settlements & Facility	Forest	Wildlife Sanctuary (Distance from Dehing Patkai WLS)- km	Wildlife Clearance Status
	Village	Revenue Block	District							
Well-24	Vitor Powai village	Margherita	Tinsukia	Site is 0.05 km from existing site access road and 0.22 km from Makum Killa Road	Agriculture land	Buri Dihing 1.06 km	Vitor Powali no. 2 is 0.05 km away from the well location	Upper Dehing Reserve Forest -0.81 km	1.430	Approval taken from NBWL
GGS-1	Vitor Powai village	Margherita	Tinsukia	Site is 0.09 km from Makum Killa Road	Agriculture land	Buri Dihing 0.95km	Vitor Powali no. 2 is 0.22 km away from the well location	No forest land within 1 km	2.63	Approval taken from NBWL
GGS-2	112/109/Nla Grant 2 Makum Tea Co.	Margherita	Tinsukia	Site is 0.12 km from Margheria Deomali road	Tea Garden	Seasonal drainage channel – approx.. 0.05 km	Tea garden colony 0.34 km from site	No forest land within 1 km	1.93	Wildlife clearance will be taken from NBWL

Figure 2.6 Environmental Setting map of Proposed Project



2.6 *DRILLING OF DEVELOPMENT WELL*

The drilling of development wells has been classified into three stages:

- Pre-drilling;
- Drilling; and
- Site Decommissioning.

2.6.1 *Pre-Drilling*

Site Selection

The proposed drill sites are selected by HOEC's are based on geological data available. Suitable drilling locations were selected based on physical (terrain and access) and technical suitability. Detailed drill site and access road survey will be carried out prior to land procurement and construction of drill site.

Selecting drill site's environmental considerations is as below:

- Non-forest area and area with low vegetation.
- Away from organized human habitats.
- Easy access to area of interest
- Away from sensitive ecological habitat

A shift of 200m in the location of development wells can be expected on account of land availability.

2.6.2 *Land Procurement for Development Wells*

The approximate land requirement for each drill sites is 2.0 ha. 10 number of well at Dirok site is located in the Tea garden land. 14 number of wells (6 wells at Dirok site & 8 wells at Vitor Powai area) are located in agricultural land.

Procurement of Private Land

The private land will be taken on long-term lease. Residential / built-up land will not be acquired for the proposed drilling activity; hence rehabilitation and resettlement will not be associated with the project activities. Additionally, it is to be mentioned that, no rehabilitation and resettlement is required during construction or strengthening or widening of approach road.

Procurement of Tea Garden Land

The tea garden land will be taken on long-term lease basis. For procurement of tea garden land, HOEC will take sell purchase permission from State head quarter in Dispur for leasing this land from the Owner of the tea estate.

2.6.3 *Land Procurement for Access Road*

The accessibility map (Refer ***Figure 2.2***) shows that Well No.1, 2, 3, 4, 5, 7, 8, 9, 10, 13, 14, 15, 16, 17, 18, 19 and 24 has all weathered access road from Digboi. The existing road will be upgraded and strengthened for the rig movement. The well No. 6, 11, 12 20, 21, 22, 23 has no direct access road from nearest existing road network. The access road need to be developed for these wells; the road requirement is as follows:

Table 2.3 ***Road requirement for proposed Development Well***

Sl. No.	Well Pad	New Road Requirement (Approximate length from Existing Road
1.	Well 6	0.15 km
2.	Well 11	0.34 km
3.	Well 12	0.38 km
4.	Well 20	0.27 km
5.	Well 21	0.15 km
6.	Well 22	0.32 km
7.	Well 23	0.23 km

The land for proposed site approach roads will be procured on long term lease basis. Construction of site approach road will not require any forestland or involve displacement of any household. As far as possible, existing roads will be used. Cutting of trees will be avoided as far as possible. If necessary, existing road will be developed by widening, etc. Culverts and drainage channel will be maintained during site preparation.

2.6.4 *Construction of Drill Sites*

The environmental settings of the well site (*Refer Section 2.5*) reveals that 12 drill sites are located in tea garden area (having tea bushes and shed trees); four wells located in scrub land (having few trees and bushes) and 8 wells in agricultural field (no vegetation).

Vegetation Clearance: Once the approach road to the site is developed, the drilling site will be elevated. Firstly clearing of existing vegetation mainly comprised of tea plant, shed trees and small bushes at the proposed new drill sites will be carried out after obtaining permission from tea estate and forest department.

Stripping of Top Soil: After clearing of existing vegetation, the top soil (comprises of 150 mm loose top soil) will be removed and stored within the site for later use during site restoration.

Filling & Levelling: Levelling and compaction will be done with the help of graders and mechanical rollers. Earth and fill material and rubble will be used for land filling and site preparation. All such materials will be procured from government approved borrows and quarries. A total of about 9200 m^3 of earth and fill material and 13800 m^3 of rubbles have been estimated to be required for land filling and site preparation for each of the new drill sites. Subsequently, the proposed well site & campsite will be duly fenced using chain link and barbed wires. Quantity wise construction material requirement for each new drill site has been incorporated in ***Table 2.4***.

Table 2.4 ***Quantity of Construction Materials Required for each Drill Site***

Sl. No.	Materials	Quantity (m^3)
1.	Cement	34
2	Sand	137.1
3	Earth/ Fill Material	9200
4	Rubble	13800
5	Others (blue metal)	68.6

Source: HOEC

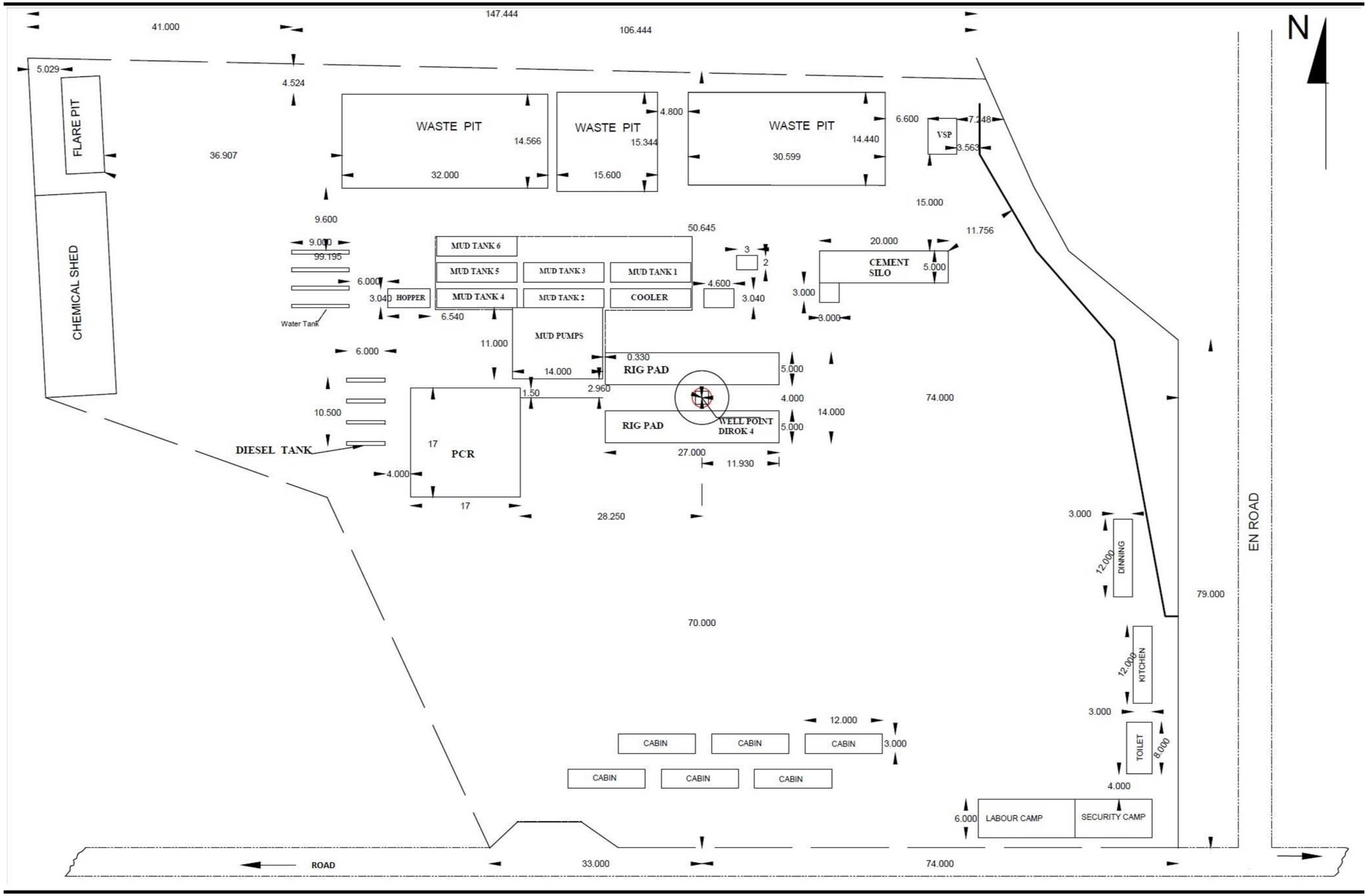
Construction of Platforms: For the construction of the foundation of platforms for drill pad and all other heavy equipment systems or machinery, cast in-situ Reinforced Cement Concrete (RCC) will be used. The rig foundation will be of size 20m X 20m and will have an elevation of 0.6 m. from rest of the site. For making the foundations of main rig structure, cast in-situ bored under-reamed piles of specified lengths will also be used. The elevated structures will have proper storm water drains with sufficient gradient, made up of brick masonry, to take care of surface runoff water.

Construction of Storage Area: The HOEC will use its own warehouse facility located at Digboi town approximately 25 km away from the proposed well sites. However, storage facilities will be built at each of the drilling sites to store flammable substances viz. diesel, lubricants and other necessary tools and chemicals etc. At each of the well site a diesel storage facility capable of storing 35 KL diesel as 7 days back up will be constructed.

Construction of Waste Pits: Disposal of drilling waste in the form of spent drilling mud and cuttings will be disposed on-site in specially designed pits provided with an impervious HDPE liner of 1-1.5 mm thickness. There will be a cuttings pit for disposal of drill cuttings and two waste pits of disposal of drilling mud and rig wash water. The following pits will be constructed:

- ***Cellar pit:*** 1.85m X 2.15m X 1.5 m for installation of well head and BOP
- ***Drill Cutting Storage Pit:*** of ~800m^3 for each well site for temporary storage and disposal of drill cutting
- ***Waste Water Storage Pit:*** Construction of HDPE lined pit of 3000 m^3 for temporary storage and disposal of drilling wash water;
- ***Spent mud pit***: Waste mud (800 m^3) and
- ***Rain water Pit***: Rain water (2200 m^3)

Figure 2.7 Schematic Layout of Drill Site



Construction of Campsites: The camp site will have rooms for drilling workers and HOEC personnel, sanitary facility, designated cooking area, septic tanks and soak pits for taking care of sewerage and waste water. Drilling contractor base camp would be established at Margherita town.

The schematic layout of proposed drill site is provided at ***Figure 2.6***.

2.6.5 Transportation of Rig and Associated Machineries

After completion of the construction activities and with the provision of the basic facilities, drill rig will be transported to the site. The drill equipment are designed as modular/ skid mounted type, which facilitates quick mobilization and demobilization. Rig essentially comprises of a mast, a draw work, rotary table, kelly or top drive, mud pumps engines, drilling fluid storage and handling tanks and generators.

The transport of rig including ancillary equipment and camp facilities to the site is expected to comprise around 100 trailer loads for each well drilling. Though the rig and related equipment will be directly brought to site, spares, chemicals and other materials will be received from HOEC's warehouse located at Digboi. Materials will be intermittently supplied from the warehouse to the drilling site, during operations; a provision will be kept for temporary storage of materials at the drilling site itself.

2.6.6 Rig Mobilization and Rig- up

A rig building process will follow the site preparation activities. This process involves transport of rig including auxiliary equipment and camp facilities, assembling of various rig parts and equipment to drill a well. Once the drilling rig is assembled, thorough rig inspection will be carried out to check equipment working capability and quality standards. The major components of drilling unit are Hoisting system, Rotating Equipment, Circulating System, Tubular Goods, Pressure Control, Derrick and Substructure.

2.6.7 Drilling Operation

The drilling process uses a rotating drill bit attached to the end of a drill pipe, referred to as the drill string. Drilling fluid is pumped down the drill string, through the drill bit and up the annular space between the drill string and the hole. As the bit turns, it breaks off small pieces of rock or drill cuttings, thus deepening the hole. The drilling fluid removes the cuttings from the hole, cools the drill bit, and maintains pressure control of the well as it is being drilled. As the hole becomes deeper, additional lengths of pipe are added to the drill string as necessary. Periodically, the drill string is removed and the unprotected section of the borehole is permanently stabilised by installing another type of pipe, called casing. Cement is then pumped into the annular space between the casing and the borehole wall to secure the casing and seal off the upper part of the borehole. The casing maintains well-bore stability and pressure integrity. Each new portion of casing is smaller in diameter than the previous portion through which it is installed. The process of drilling and adding sections of casing continues until final well depth is reached.

Drilling Sections

Wells are drilled in sections, with the diameter of each section decreasing with increasing depth. Before commencing the actual drilling, large diameter pipe (Conductor) will be lowered into a hole and cemented. Conductor pipes provide a conduit for the return fluid during drilling next section and also prevent the falling of unconsolidated material into the hole and potential washout problems. Typical depths of such pipes are 6m.

The lengths and diameters of each section of the well are determined prior to drilling and are dependent on the geological conditions through which the well is to be drilled. Spudding in well is the start of drilling activity. Top-hole section will be drilled to a desired depth based on well design. Once each section of the well is completed, the drill string is lifted and protective steel pipe or casing lowered into the well and cemented into place. The casing helps to maintain the stability of the hole and reduce fluid losses from the well bore into surrounding rock formations i.e. it provides support to hole wall and secures hole section. Other than that, it isolates problematic hole sections such as loss zones, shale sections, over pressurized formations, etc. This process of drilling and casing the hole section continues until the final well depth (target) is achieved. Proposed well profile and casing plan for the drill sites is given in ***Table 2.5***.

Table 2.5 Hole Sizes and Depths of the Drill Sites

Hole size (inches)	Casing size (inches)	Depth from (m md brt)	Depth to (m md brt)
26	20	15	275
17.5	13.375	275	1350
12.25	9.625	1350	2225
8.5		2225	2800

Blowout Preventer

A blowout preventer is a large valve or series of valves that can seal off an oil or natural gas well being drilled or worked on. If underground pressure forces oil or gas into the wellbore, operators can close the valve remotely (usually via hydraulic actuators) to forestall a blowout, and regain control of the wellbore. Once this is accomplished, often the drilling mud density within the hole can be increased until adequate fluid pressure is placed on the influx zone, and the BOP can be opened for operations to resume. BOPs are fitted with hardened steel shearing surfaces that can actually cut through drill pipe and tool strings, if all other barriers fail. BOPs come in two types i.e. ram and annular. A ram BOP utilizes horizontally opposed hydraulic rams that can be fitted out to, close around the drill string, shear through the drill string and then seal, or close off a wellbore when no drill pipe or tubing is in it. An annular BOP, utilizes a hemispherical donut-like rubber element reinforced with steel ribs. This closes around the drill string in a simultaneous upward and inward motion. Both Ram and Annular type BOPs are used together during drilling, called the BOP stack.

After N/U BOP, the bit and BHA is made up and run to just above the cement inside the surface casing. To ensure that it is safe to drill ahead, a leak-off test will be performed immediately after drilling out of the casing shoe. The next section of hole is drilled to the required depth, cleaned out and the intermediate casing is run and cemented. If required, drilling may continue to greater depths by drilling a next hole and running and cementing casing. The Details of Blowout Preventer has been provided in ***Annex 2.1***.

Well Cleaning, Testing and Completion

The well may be perforated with casing guns prior to the running of the tubing. The production casing will be cleaned up and the drilling fluid displaced with brine after the drilling operation is complete. A tubing string with a tubing hanger attached is run through the drilling riser and BOP, on either a completion riser or drill pipe, and landed in the wellhead. The pressure integrity of the tubing string, tubing hanger to wellhead seals and the production packer are then tested. The operation of the subsurface safety valve is also tested. Wireline plugs are set in the tailpipe of the packer and the tubing hanger and the completion riser is unlatched from the tubing hanger and retrieved. The BOP stack is unlatched from the wellhead and the stack and riser system is retrieved. A Christmas tree is installed over the well head. The well head is energized and all major functions are tested. The wireline plugs are retrieved from the tubing string. The perforating guns are run and the production casing is perforated. Flow from the well is then initiated and the well is cleaned up and tested. Well testing represents a major source of data to engineers and geoscientists investigating the viability of the reservoir. Testing involves a range of techniques for establishing the characteristics of the reservoir and fluid such as pressure, temperature and flow rate. There will be a controlled flow of hydrocarbons back to the drill unit where they will be tested and subsequently flared. The exact volume of hydrocarbons to be flared during any testing period will not be known until the well is tested. The wells may be allowed to flow and hydrocarbons flared for 2 - 3 days.

2.6.8 Drilling Mud System & Disposal of Cuttings

Drilling Mud

During drilling operations drilling fluid (or 'mud') will be pumped through the drill string down to the drilling bit and returns between the drill pipe – casing annulus up to surface back into the circulation system after separation of drill cuttings /solids through solids control equipment. Drilling fluid is essential to the operation and helps in controlling down-hole pressure, lift soil/rock cuttings to the mud pit, prevent cuttings from settling in the drill pipe, lubricate, cool and clean the drill bit amongst other functions. Drilling mud basically comprises of inert earth materials like bentonite which is capable of forming highly dispersed colloidal solution, barite in water with several additives to give mud weight, fluidity and filter cake characteristics while drilling. The requirements and the constituents of drilling mud are dictated by the temperature/pressure conditions of the wells. The mud is continuously tested for its density, viscosity, yield point, water loss, pH value etc. to ensure that the drilling operations can be sustained without any down hole complications.

A uniform water-based mud system will be used in all the proposed wells. Unlike an oil-based mud system, usage of water-based mud will not pose higher risk of contamination to subsurface formations, but disposal of the fluid and cuttings will be less problematic. Because of the anticipated borehole instability problems it may be necessary to introduce a base salt, such as Potassium Sulphate (K_2SO_4) into the system. Chemicals required for the preparation of drilling fluid will be centrally stored in Digboi. Additionally, some chemicals will also be stored in the drill site. The storage area will be paved and bunded and will be provided with a shed.

Based on the type of formation encountered the mud system used in the earlier drilling operations in Dirok composed off

- Dirok 1: Water Base Mud: Gel Polymer and K_2SO_4 Polymer (Potassium Sulphate).
- Dirok 2: Water Base Mud: Pre Hydrated Gel Polymer (PHGP) and Potassium Sulphate Polymer System (POAS).
- Dirok 4: Water Base Mud: PHB (Polyhydroxybutyrate), K_2SO_4 Mud and KLA-GARD.

It is expected the mud composition would be similar in nature for the proposed wells as they will be drilled through the similar geological formation.

Disposal of Waste Drill Mud and Drill Cutting

The under flow from the solids control equipment (de-sander and de-silter/ centrifuges) will be collected in a waste mud pit. The waste mud pit will also contain spent mud generated during post drilling operations.

The cuttings will be separated from the drilling mud using a solids-control and waste management package. This will comprise a stepped system of processes consisting of linear motion vibrating screens called shakers, de-sander, de-silter and centrifuges to mechanically separate cuttings from the mud fluid. Both the cuttings from the shale shakers and centrifuge are collected in a Solid Discharge pit and then removed to a specially designed pit lined with 1-1.5mm thickness of HDPE. This cuttings pit has a certain slope to drain off water in the adjacent waste pit.

The total amount of cuttings produce during the entire drilling period is projected to be about 450-500 m^3 per well. After completion of the drilling activities, cuttings will be tested for hazardous nature and based on nature of the drill cuttings, final disposal pathway will be finalized by HOEC.

Once the cuttings have been separated, the drilling fluid will be reused or processed after further treatment in a chemically enhanced dewatering (CED) system designed to remove suspended solids that are too fine for mechanical separation in the solids control package. The CED system comprises a chemical mixing and dosing unit and decanting centrifuges. The unusable portion of the drilling mud after dewatering shall be disposed on-site in a lined pit (HDPE 1-1.5mm thickness) conforming to the regulatory requirements. The drilling and wash wastewater will be confined to a similar HDPE lined waste pit and then treated by the on-site Effluent Treatment Plant. The dewatered mud will subsequently be disposed in a similar manner as for waste cuttings.

Disposal of mud and cuttings is dependent on establishing non-hazardous or hazardous nature after the end of operations. However, HOEC plans to dispose the spent mud in a lined pit (1mm HDPE) on site confirming to the regulatory requirements.

The whole process by which the drilling fluid will be reused during the drilling operation is commonly known as a "closed loop system." This system is ideal for drilling operations in sensitive environments as it cuts down immensely on the total water consumption for the formulation of drilling mud and also saves on the consumption of chemicals. ***Figure 2.8*** shows the schematic layout of Drilling Mud and Solids discharge system involved for the wells. ***Figure 2.9*** shows the drilling fluid circulation system which is designed to enable the drilling fluid to be recycled and maintained in good condition throughout the operation.

Figure 2.8 *Drilling Waste Management*

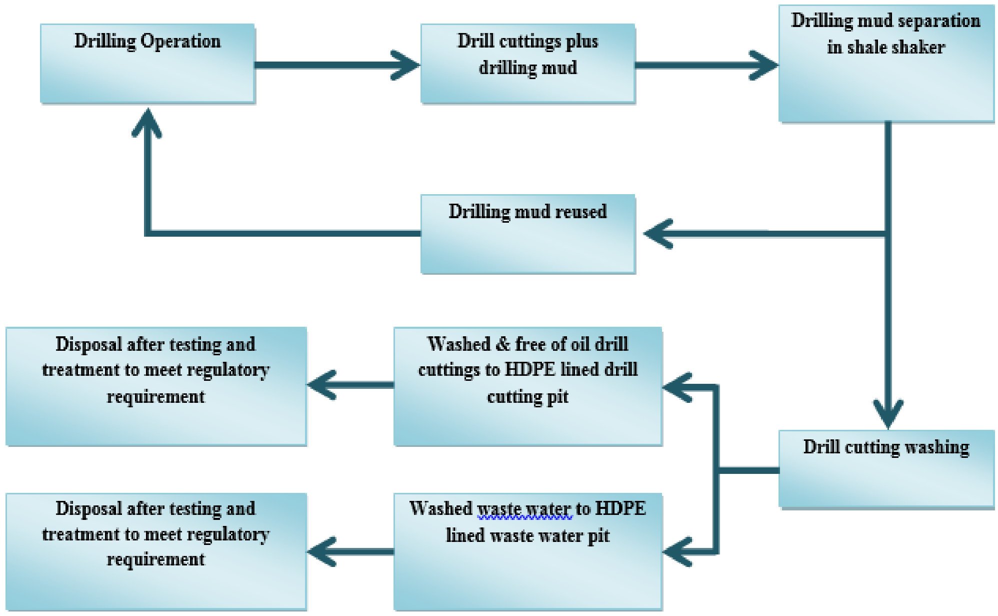
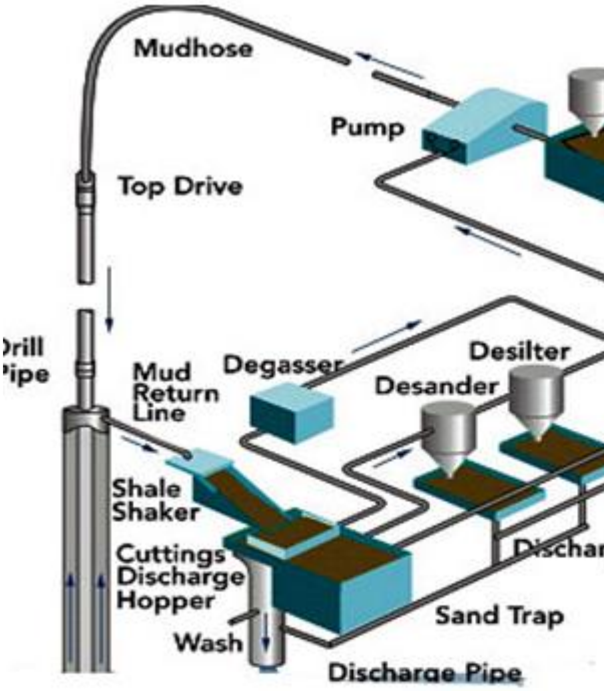


Figure 2.9 Typical Drilling Fluid Circulation System



Cementing Programme

Cementing is a necessary aspect of drilling oil and gas wells. Cement is used to

- Secure/support casing strings
- Isolate zones for production purposes
- Solve various hole problems

Cementing generally utilizes Portland cement (API Class G Oil Well Cement) with various additives in small quantities as accelerators/retarders, density adjusters, dispersants, fluid loss additives, anti gas migration additives, etc.

2.6.9 Well Decommissioning

Site Closure and Decommissioning

After the wells are put into production de-mobilisation of drilling rig and associated infrastructure will be initiated. Only a small part of the drilling platform along with the production tubing will be kept on site. Decommissioning will involve the dismantling of the rig, all associated equipment and the residential camp, and transporting it out of the project area. It is expected that demobilization phase will last about 10 days and will involve the trucking away of materials, equipment and other materials from site to bring it back to original condition. It is estimated that about 100 truckloads will be transported out of site during this period.

Subsequently, following steps will be typically involved to restore and rehabilitate the area:

- All concrete structures will be broken up, and the debris disposed off;
- All other waste products, solid and liquid, will be disposed of in accordance with the requirements of the EIA and will be treated to render them harmless;
- The pit used for drill cutting storage will be covered with HDPE liners and covered with layer of excavated topsoil during the site closure.

The following decommission activities would be conducted after the completion of production activities

- The well will be sealed with cement plugs and wellhead fittings (blind flange) left on the surface (Cellar)
- The wellhead and all casing string will be cut off to a minimum depth of 3 m (10 ft) below ground level
- All fencing and access gates will be removed
- Restoration of unusable portion of the access track, removal of pilings and Landscaping

Site Restoration

All drill sites after the completion of production activities will be restored back to its near original condition. After decommissioning of site, it will be de-compacted and stored top soil will be overlain on the de-compacted site with certain moisture conservation measures and seeding of leguminous plant for restoration soil nutrient level naturally. In this regard a consultation will be made with the land owner. Depending on the preference of the land owner, land will be returned as it is or reinstated as it was prior to the project activity.

2.7 GAS GATHERING STATIONS (GGS)

The construction of proposed GGS will involve the following steps:

2.7.1 Construction activity

Land requirement for GGS construction would be about 1.0 ha. Proposed GGS-1 site is located at Vitor Powai village in agricultural land. GGS-2 site is located at Dirok Tea estate. Approach road to reach well namely GGS-2 is already present and this road will also be used as approach road for proposed GGS. GGS-1 has no site approach road, approximately 0.1km site approach road will be constructed.

The proposed GGS-1 site has no trees and any other permanent structure. Therefore, tree felling and any demolition will not be required. The GGS-2 site has tea bushes and shed trees; therefore, clearance of vegetation is required. The proposed GGS sites will be duly fenced to a height of about 2 m using RCC structure and brick wall to restrict unlawful entry into the site.

For proposed GGS the construction work will entail construction of civil foundation, erection of manifolds, flow line and valve network. No building will be constructed in proposed GGS facility. A fire water tank will be constructed and along with that a fire pump will be installed. The process flow diagram of the GGS is presented in ***Figure 2.3.***

2.7.2 *Operation of GGS*

GGS is installed for accumulation and transportation of raw natural gas directly from wellheads to gas processing plant (GPP). The natural gas (along with associate gas) is compressed and pumped into pipeline for further processing in Gas Processing Plant.

2.8 *EXPANSION OF GAS PROCESSING PLANT (GPP)*

2.8.1 *Construction of GPP*

The existing capacity of the GPP is 20 mmscfd: the capacity will be enhanced to 40 mmscfd. The proposed expansion activity will be carried out within the existing site. The expansion activity includes the following components.

The facilities and components of GPP will be similar to existing GPP (*Refer Section 2.4.3*)

2.8.2 *Operation of GPP*

Wells at Vitor Powai area will be connected through flow lines and manifolds to a common pipeline for transportation of well fluids to proposed GGS-1. Wells at Dirok site will be conned with existing GGS or proposed GGS-2. From these three GGS (one existing + two proposed) the fluids would be transported to GPP located in Borpowai / Agbanda village by transportation pipelines. Fluid from GGS would be first routed to a 3 phase inlet separator where condensate and water from the gas would be separated. The separated gas would be sent to a scrubber/filter and then to the processed gas pipeline. The GPP would be planned for 40 mmscfd (existing 20 mmscfd + 20 mmscfd-expansion) gas processing and handling capacity. The condensate would be separated from water by first and second stage separators and stored at the condensate storage tanks. Planned condensate storage and handling capacity at the GPP would be 800 bpd. Produced water generated from separation process (approximately 1-2 m^3/day) would be stored at produce water storage tank and treated in Effluent Treatment Plant (ETP) to conform to the CPCB discharge standard.

2.9 *PIPELINE LAYING*

Pipelines will be laid to transport the unprocessed natural gas from gas field to GPP via GGS. The trunk is passing adjacent to proposed GGS-2; only 2.41

km linked pipeline will be required. A 12 inch diameter gas pipeline of approximately 5.5 km will be laid along the RoW of the existing Makumkila road to transport the natural gas from proposed GGS at Vitor Powai village to existing trunk pipeline. The proposed pipeline from the GGS would cross Pawai Nala on its way to Trunk Pipeline. The pipeline will be laid conforming to the international ANSI/API and also OISD standards as per the best industry practice. The proposed pipeline will be laid and buried at a depth of 1.2 to 1.5m alongside the existing road. The construction details regarding the laying pipeline have been discussed in detail below Pipeline laying activity.

2.9.1 Designing and Planning

Before starting any construction work, a detailed route survey will be undertaken to document the existing condition of the pipeline route and the access roads. The exact route of the pipeline will first be pegged out, while simultaneously staking out the width of the work strip on both sides of the route.

2.9.2 Land Procurement

The land for laying the pipeline will be acquired on Right of Use (RoU) basis. The RoU width for the proposed pipeline will be 8 m. Pipeline will be underground and are planned within RoU/privately acquired land for pipe track & having access from existing roads with the permission of private land owners, local authorities and related government departments.
The land for laying the underground pipeline will be used under the provisions of the Right of User of Land (Petroleum and Pipelines Act, 1962) and land acquisition by private negotiations. The land ownership is permanently rested with the landowner in case of land procured through RoU. The owner of the land will have the right to use the land and plant seasonal cultivation like paddy & horticulture without setting up any construct work over the pipeline route. Whenever maintenance of the pipeline needed to be undertaken during the crop period, the landowner will be compensated for the loss of any standing crops by HOEC.

2.9.3 Rehabilitation and Resettlement

No resettlement issues are envisaged as no permanent land acquisition is involved. Residential / built-up land will not be acquired for the proposed pipeline; hence, rehabilitation and resettlement will not be associated with the project activities. Therefore, the proposed project does not involve any displacement of people.

2.9.4 Clearing and Grading

8 m RoU area will be cleared off vegetation and other obstacles such as boulders. The RoU area will then be levelled to the required gradient. Stripping of top soil will be undertaken and will be stockpiled in the form of a

continuous ridge along the edge of the strip. Required height of top spoil will be maintained to prevent depredation of the soil and will kept free from disturbance to reduce the possibility of physical damage and compaction. The work strip will then be made level, using typical construction site machinery to eliminate irregularities, large stones, tree stumps and other features.

2.9.5 Trenching

Manual or excavated methods will be used to dig the trench for laying the pipeline. The topsoil will be removed segregating the remaining backfill material. The topsoil will be replaced in its position during the backfilling operation. The width of trench shall be such that a minimum clear distance of 200mm for trench in normal soil and 300mm for trench in rock is maintained between edge of pipe and the trench wall at the bottom of trench. The pipeline will be generally buried to a minimum depth of 1m however in case of rivers/water bodies, which are prone to scour and erosion, adequate safe cover (minimum 1.5 metre) shall be provided below the predicted scour profile expected during the life time of the pipeline. Further details regarding minimum cover for buried have been discussed in section 7.3.3 of the OISD-STD-141.

2.9.6 Pipe Hauling and Fabrication

Pipe transported to the site on trucks will be offloaded using side booms. The selection of access road for pipeline transportation will be based on prior study to minimize adverse effects on the local traffic and commuters. The pipes then will be strung adjacent to the trench. Trailers and cranes will be used for the manoeuvring of pipes. The pipes shall be strung in such a way that normal use of the surrounding area is disturbed as little as possible. However necessary care will be taken during stringing to prevent any possible disturbance to the surrounding land use.

Bending and Welding

- The pipe will be bent using a bending machine to the appropriate angle to match the vertical and horizontal alignment of the trench.
- Welding will be done using conventional manual/ semi automatic welding involving a crew of welders and fitters. Once the pipe is strung a line-up crew will position the pipe using side booms in preparation for welding. Pipe strings to be welded shall be effectively earthed. The process is likely to be carried out inside a mobile shelter that covers the section that is being welded and worker group involved, thereby controlling the environment under which the weld is made. All welds will be subject to nondestructive examination (NDE) prior to application of the field joint coating.

Following the completion of each working day or pipeline section, open pipe ends shall be effectively closed and shall not be opened until work restarts.

The length of the pipe string has to be limited to ensure integrity and safety due to thermal expansion effects.

Pipeline Lowering

Following weld NDE and field joint coating of the welds, the joined pipeline sections will be carefully laid in their individual, parallel trenches. This operation will be completed using side boom tractors in a continuous operation. In rocky or uneven ground where the potential for pipe coating damage exists, the trench bottom will be given a protective bed of sand.

Coating

After welding at each weld joint, coating of field joints of bare pipes and the repair of FBE coating shall be done by site application of High built liquid epoxy coating.

Hydro-testing

All pipelines shall be tested in-place after construction. Cased crossings (rail/road) and river crossing sections shall be hydrotested before and after installation at least for 4 hours at 1.25 times (for Class 1 & Class 2) or 1.4 times (for Class 3 & Class 4), the design pressure. Water used for the test medium shall be inhibited water i.e. water to which suitable doses of corrosion inhibitors and oxygen scavenger are added depending upon quality of the water.

Backfilling

The pipe trench will be backfilled in the reverse order in which it was excavated, and where possible, using the same soil that was taken from the trench. In areas where the backfill material is deemed likely to damage the pipe coating due to the presence of rocks or stones, sand will be used to protect the pipeline. Backfilling will be completed by covering the trench with topsoil from the previously established stockpile. To minimize damaging exposure of the excavated soils while they are in storage, the trench will be back-filled as early as possible after each pipeline section is installed, so creating a single, continually advancing work-front.

Reinstatement

After re-grading of the work strip to reflect the original ground profile, it will be de-compacted using bulldozers to spike and drag the soil in all directions, followed by spreading of the remaining topsoil over the entire surface. Large stones and debris will be removed prior to topsoil replacement. The final step in the restoration process will be the reconstruction of walls, fences and other such features that may have been affected by the works. After re-instatement, the area will be monitored and maintained, as required, over a fixed period until normal growth patterns are re-established.

2.10 UTILITIES & RESOURCE REQUIREMENT

2.10.1 Power Supply

Construction of Drill Site

The power requirements at the site development and construction of drill sites and GGS will be met by DG Sets. During construction phase 135 KVA DG set will be utilised.

Drilling of Wells

The power requirement for during drilling and operation of GGS and GPP will be sourced from DG sets. It is anticipated that four diesel-engine generators, each with a capacity of 670 KW, will be sufficient for rig operations. Three generators will be used at a time and one will be kept on standby. A 134 KW generator will be made available for lighting at residential camp and other emergency requirements.

GGS & GPP

One 400 KVA DG set at each sites will be used for construction and operation of GGS.

The existing power generation capacity at GPP is 2 X 750 KVA captive gas generators. It is proposed to install additional 2x 600 KVA captive gas generator for proposed expansion activity.

2.10.2 Water Consumption and Sourcing

Construction of Well Site

The total water requirement for the site preparation and construction phase of the project is estimated about 1200 KL per well. With average time requirement for well site preparation being about 30 days, about 20 KLD (peak demand) of water will be consumed on an average for each well.

Drilling of Wells

Average consumption of water during the drilling phase will be about 45- 50 KLD. Domestic water requirement will be 6.75 KLD for every 50 site persons deployed at site.

Decommissioning of Drill Sites

During decommissioning phase the peak demand of water requirement as estimated would be 10KLD.

Construction & Operation of GGS

Apart from this 25 KLD and 5 KLD of water will be consumed during construction and operation phase of GGS respectively.

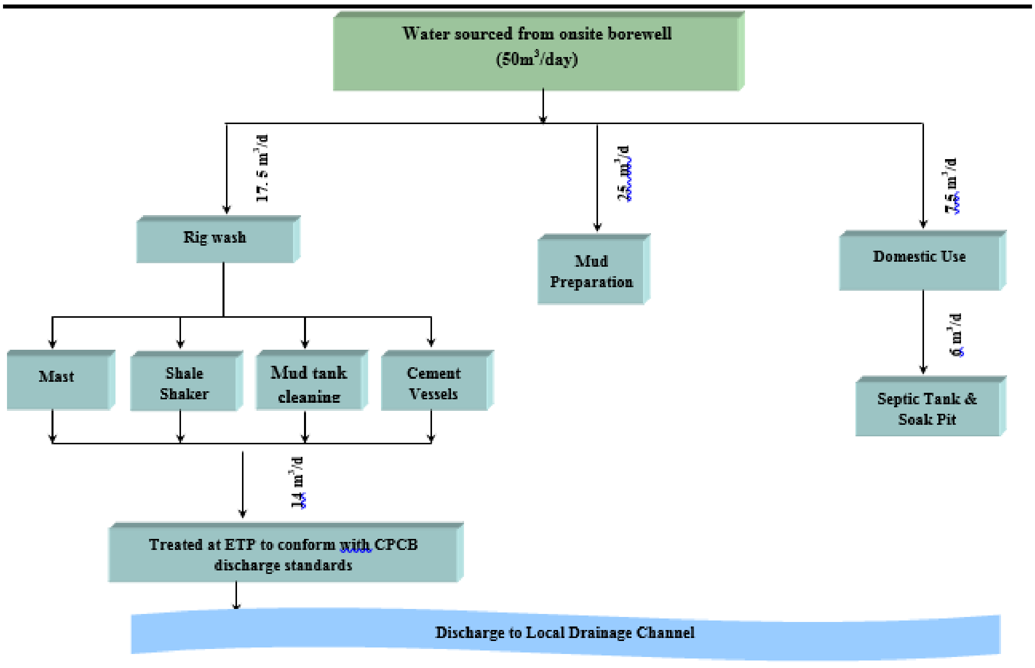
Operation of GPP

The existing consumption of GPP is 15 KLD; after expansion the total consumption will be 30 KLD.

Sourcing of Water

Water requirement during different phases of project will be met through surface water sources through authorized vendors. HOEC will take permission from water resource department regarding sourcing of surface water for drinking and other domestic purpose, if required. The water balance diagram for well sites is presented in ***Figure 2.10***.

Figure 2.10 ***Water Balance Diagram: Drilling Phase***



2.10.3 *Fuel Consumption*

The fuel consumed will mainly be diesel used by rig, various equipment, and vehicles operating to transport goods and supplies to the site. During the drilling phase, the consumption of diesel is estimated to be about 4.5-5 KLD. Out of this, a major part comprising about 85% will be consumed by the rig (also including the DG sets) and about 15 % will be required for the Campsite.

There will be provision for storing of about 7 days of fuel back up which means storage of about 35 KL. The fuel will be provided by the drilling contractor and transported to site through tankers. Fuel will be stored at onsite storage facility as per Petroleum Rules, 2002 in a paved and bunded area.

2.10.4 *Manpower / Employment*

Site preparation phase of 30 days will employ on an average about 45 to 50 workmen preferably from local settlements. The total number of personnel involved in the drilling activities is expected to be about 50. This will include technical experts, who will be responsible for various drilling related activities.

Pipeline laying and construction work of GGS will involve 100-125 persons per day. During operational phase, about 50-60 person per day will be involved in GGS and GPP operation.

2.10.5 *Accommodation and Campsites*

A camp facility will be provided to accommodate all operational crew and contractor personnel. It has been anticipated that about 50-60 staffs and security personnel will stay in the camp during site preparation and drilling phase. Rest of the staff will be housed in Digboi and will continue on 12hrs shift basis to the well-site.

Toilet facilities will be built as part of the accommodation units. Sewage lines from units will be connected through a pipeline system to septic tank and soak pit system for the treatment of domestic sewage and it will be constructed as per the requirements of local laws. Food and other organic waste will be subjected to bio-degradation through organic composting.

2.11 *WASTE & EMISSION*

2.11.1 *Air Emissions*

Exhaust emissions are expected from diesel generators to be used for the operation of drilling rig. The emissions from each of the diesel generators will be limited to the following levels:

- Particulate matter: < 75 mg/Nm^3,
- SO_2 : < 100 mg/Nm^3
- NOx : < 1320 mg/Nm^3
- CO : <150 mg/Nm^3
- HC : <100 mg/Nm^3

Emissions are also expected from flaring of gases during drill well testing operations and production of onshore wells - as gases produced along with crude oil from onshore wells will be flared during initial phase of production.

Vehicular emissions are likely to occur during the transportation of construction materials, equipment and workforce to onshore drilling location. Fugitive emission during site preparation, handling and transportation of construction materials.

2.12 *WASTES & EMISSIONS*

2.12.1 *Air Emission*

Onshore Drilling Activity

Exhaust emissions are expected from diesel generators to be used for the operation of drilling rig. The emissions from each of the diesel generators will be limited to the following levels:

- Particulate matter: < 75 mg/Nm^3,
- SO^2 : < 100 mg/Nm^3
- NOx : < 1320 mg/Nm^3
- CO : <150 mg/Nm^3
- HC : <100 mg/Nm^3

Emissions are also expected from flaring of gases during drill well testing operations and production of onshore wells - as gases produced along with crude oil from onshore wells will be flared during initial phase of production. In such event, the expected emissions during flaring would be:

- PM : < 50 mg/Nm^3
- SO^2 : Nil (the field being sweet in nature)
- NOx : < 145 mg/Nm^3
- HC : < 130 mg/Nm^3
- CO : < 350 mg/Nm^3

Vehicular emissions are likely to occur during the transportation of construction materials, equipment and workforce to onshore drilling location.

2.12.2 *Noise Generation*

Construction Activity

Noise will occur from operation of construction equipment like loaders, tippers, bull dozers etc., for onshore well pads. The expected noise generated will be around 60-65 dB (A). During erection offshore rigs noise will be generated in the range of 80 to 85 dB(A).

Drilling Operation

The operations of drilling rig and associated machinery including diesel generators will lead to noise emissions. The diesel generators would be provided with acoustic enclosures to comply with the regulatory requirements.

Noise emissions during drilling of wells at the rig include the following:

- Drilling rig: 100 dB(A)
- Diesel Generators: 75 to 85 dB(A) at 1 m from enclosure
- Mud Pumps at the Rig: 90 to 95 dB(A)
- Water pumps: 90 dB(A)
- Shale Shakers: 75 dB(A)
- Desander & Desilter: 80 dB(A)
- Miscellaneous: 80 to 85 dB (A)
- Control Room and living quarters at the rig: 50 to 60 dB (A)

2.12.3 *Solid & Hazardous Waste*

The waste generated from drilling activities are drill cuttings, residual drilling mud and used oil and lubricant. Other waste generated from the drill sites are municipal waste. The expected waste generation from well drilling will be as per ***Table 2.6.***

Table 2.6 Waste Generation from Well Drilling

Waste Type	Quantity	Characteristics	Disposal
Drill Site			
Kitchen Waste	25 kg per day	Organic waste (Non HW)	Will be stored in compost pits on daily basis.
Drill Cuttings	450-500 m^3/ well	Mainly Inert material Consisting of shales, sands and clay; about 1% of drilling mud. (Non HW)	Drill cuttings will be disposed off in a well designed pit lined with impervious liner located on site as per Sl No. 72 C.1.a Schedule I Standards for Emission or Discharge of Environmental Pollutants from Oil Drilling and Gas Extraction Industry of CPCB as modified in 2005.
Waste Drilling Mud (Fluid)	15-20 m^3/ day	Barite, Bentonite and Traces of Heavy metals (HW)	The mud will be tested for hazardous contaminants and will be disposed as per Sl. No. 72 C.1.a Schedule I Standards for Emission or Discharge of Environmental Pollutants from Oil Drilling and Gas Extraction Industry of CPCB as modified in 2005
Acid – Lead Batteries	2 – 3 Batteries per drilling of well	Lead – Acid (HW)	Will be recycled through the vendors supplying acid – lead batteries as required under the Batteries (Management & Handling) Rules, 2001 and Amendment Rules, 2010 .
Oily waste-used oil & spent Oil and loose	0.3 m^3 5-10 Kg	Used & Waste oil	Will be collected in metal drums kept in secured dyked area & disposed as per. Used Oil rules in approved used oil recycling facility

Waste Type	Quantity	Characteristics	Disposal
Recyclables *viz*. packaging wastes, paper, plastic, packaging wastes	Depending on usage	-	Proper segregation and storage of recyclable waste in designated bins onsite. Recyclables will be periodically sold to local waste recyclers.
GGS/GPP			
Kitchen Waste	25 kg per day	Organic waste (Non HW)	Will be stored in compost pits on daily basis.
Oily waste- used oil & spent oil and loose	Quantity could not be ascertained at present	Used & Waste oil	Will be collected in metal drums kept in secured dyked area & disposed as per Used Oil rules in approved used oil recycling facility
Recyclables *viz*. packaging wastes, paper, plastic, packaging wastes	Depending on usage	-	Proper segregation and storage of recyclable waste in designated bins onsite. Recyclables will be periodically sold to local waste recyclers.

2.12.4 *Liquid Waste*

During the drilling operations, drilling wastewater generated (approximately 15- 20 m^3 per day) as a result of rig wash, spent drilling fluid and dewatering of spent mud and washing of drill cuttings. The drilling waste water around 1000 -1200 m^3 will be generated during the entire drilling period. The wastewater may have high suspended solids, high sulphate content (as potassium sulphate-based mud is proposed), oil and grease, dissolved salts and heavy metals. The rig wash water and drilling wastewater generated is proposed to be collected in a wastewater pit constructed at the drilling site. The pit will be lined by 1-1.5mm thick HDPE to prevent any contamination to sub-surface aquifers. This waste water will be treated and reused and recycled. Effluents from, floor washings, pump, seal leakages, spillages will comprise of chemical ingredients of drilling fluid thereby rendering effluent to be polluted. The characteristics of drilling and wash wastewater will be primarily dependent on type and composition of drilling fluid used for drilling. As HOEC is proposing the use of water-based drilling mud, the potential for contamination of such waste water is significantly lower. To ensure that effluent from the project comply with the waste water discharge standards as mentioned in the Sl No. 72 A (ii) Schedule I Standards for Emission or Discharge of Environmental Pollutants from Oil Drilling and Gas Extraction Industry of CPCB, a mobile Effluent Treatment Plant will be installed.

Small quantities of domestic waste water and sewage will be generated from the kitchen, wash rooms and laundry facilities. Domestic waste water generated (about 2.4 m3 per day for the drilling camp) will be treated through a soak pit/septic tank arrangement.

The quantities of the liquid wastes, their characteristics and anticipated disposal methods are given in ***Table 2.7***.

Table 2.7 Liquid Wastes Generated and Disposal

Waste Type	Quantity	Disposal
Drill Site		
Drilling and Wash wastewater	15- 20 m^3 per day	The water will be adequately treated in an ETP to ensure conformance to the CPCB onshore oil and gas extraction industry effluent standards
Domestic wastewater	6 m^3 per day	Septic tank followed by soak pit
Produced water	Could not be ascertained at present	The water will be adequately treated in an ETP to ensure conformance to the CPCB onshore oil and gas extraction industry effluent standards
GGS		
Domestic wastewater	6 m^3 per day	Septic tank followed by soak pit
GPP		
Domestic wastewater	6-7 m^3 per day	Septic tank followed by soak pit
Produced water	1-2 m^3 per day	The water will be adequately treated in an ETP to ensure conformance to the CPCB onshore oil and gas extraction industry effluent standards

3 *DESCRIPTION OF THE ENVIRONMENT*

The baseline data is collected through primary survey or from secondary sources with reference to the project specific approved ToR provided by Ministry of Environment Forest and Climate Change (MoEFCC). This data has been collected through the following:

- Reconnaissance Survey and Field Visits;
- Primary monitoring of key environmental parameters like air, water, soil, noise and meteorology;
- Survey of flora and fauna;
- Stakeholder consultations with local people, government departments such as Forest, Panchayats, etc.; and
- Review of secondary literatures available on public domain

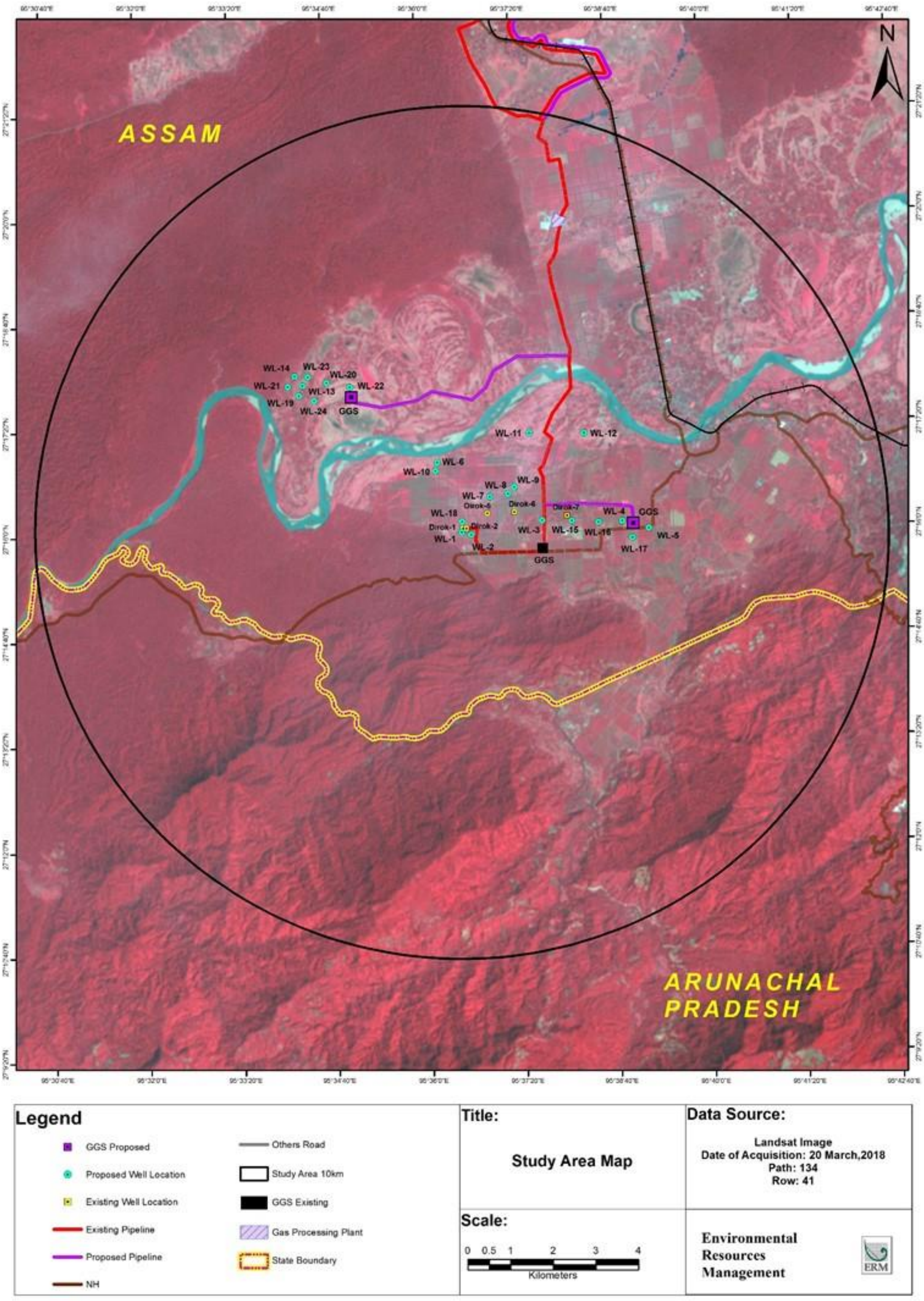
3.1 *STUDY AREA*

An area with a radius of about 10 km around the centre of the Dirok Development Field would be included under the study area for baseline data collection (Figure 3.1). This delineation has been done based on the nature of the project and also after gaining understanding of the surrounding areas through the initial reconnaissance surveys. While selecting locations for primary monitoring of air, noise, water, soil and meteorology special emphasis is given to receptors that are likely to be impacted by the proposed project. Monitoring stations for air and noise were selected in proximity to the proposed well sites, GPP and access roads. Monitoring locations for surface water quality was selected based on the macro and micro watershed and drainage pattern of the area. Soil sample locations were selected based on the land-use and land cover of the study area. Locations of ecological and social surveys were also selected based on receptor locations; in addition, special emphasis is given to areas within 1 km radius of the well sites.

3.2 *STUDY PERIOD*

The baseline study was conducted between October 2017-December 2017 for collecting information on physical environment, biological environment and socio-economic environment. Mitra S.K Pvt. Ltd., a NABL certified laboratory was engaged for conducting primary monitoring for the EIA study. The NABL certificate is attached as ***Annex 3.1***. The primary monitoring data was collected under the supervision of different Functional Area Experts of ERM.

Figure 3.1 Study Area Map



3.3 PHYSICAL ENVIRONMENT

3.3.1 Climate and Meteorology

The study area falls under the humid sub-tropical climate zone with warm seasons.

Seasons

There are four well defined seasons as shown below:
Pre-monsoon : March-May
Monsoon : June- September
Post-monsoon : October- November
Winter : December- February

The meteorological data of IMD station at Dibrugarh has been used for interpretation of longer-term temperature profile, rainfall pattern, relative humidity and wind speed and wind direction in the study area.

Interpretation of IMD Dibrugarh Data

Temperature

The mean monthly maximum and mean monthly minimum recorded over a period of 1961 to 1990 shows that mean monthly maximum temperature is experienced in April (33.5°C) and the mean monthly minimum temperature is experienced in January (9.9°C). The diurnal variation temperature is observed to be maximum in January (a difference of 15°C).

Rainfall

Rainfall begins from late April and continues up to early October, with the months of June, July and August and September receiving maximum rainfall (***Table 3.1***). Total rainfall varied between 1903.9-2663.6 mm for Tinsukia district as per five year district rainfall data of IMD. Analysis of the rainfall pattern is therefore considered important in context of the present study for effective scheduling of both drilling and development operations.

Table 3.1 Rainfall Recorded in Tinsukia District

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	23.1	6.8	29.9	304.7	216.5	417.3	488	329.7	636.5	187.1	6.2	17.8
2013	8.9	4.5	141.5	246	335	289	424	298.4	199.3	176.6	0.4	2.2
2014	3.3	37.6	40.4	56.2	361.1	240.2	214.7	546.8	367.4	33.7	2.5	0
2015	17.1	44.9	72.1	334.3	247.1	493.2	301.5	627.8	233.7	84.4	20.6	30.6
2016	13.2	70	150.6	551.7	306.1	221.5	484.6	244	354.7	135.1	13.1	7.1

Source: Customized Rainfall Information System (CRIS), IMD.
http://hydro.imd.gov.in/hydrometweb/(S(z0ghqpza5odnsd55rcebbirf))/DistrictRaifall.aspx

Relative Humidity

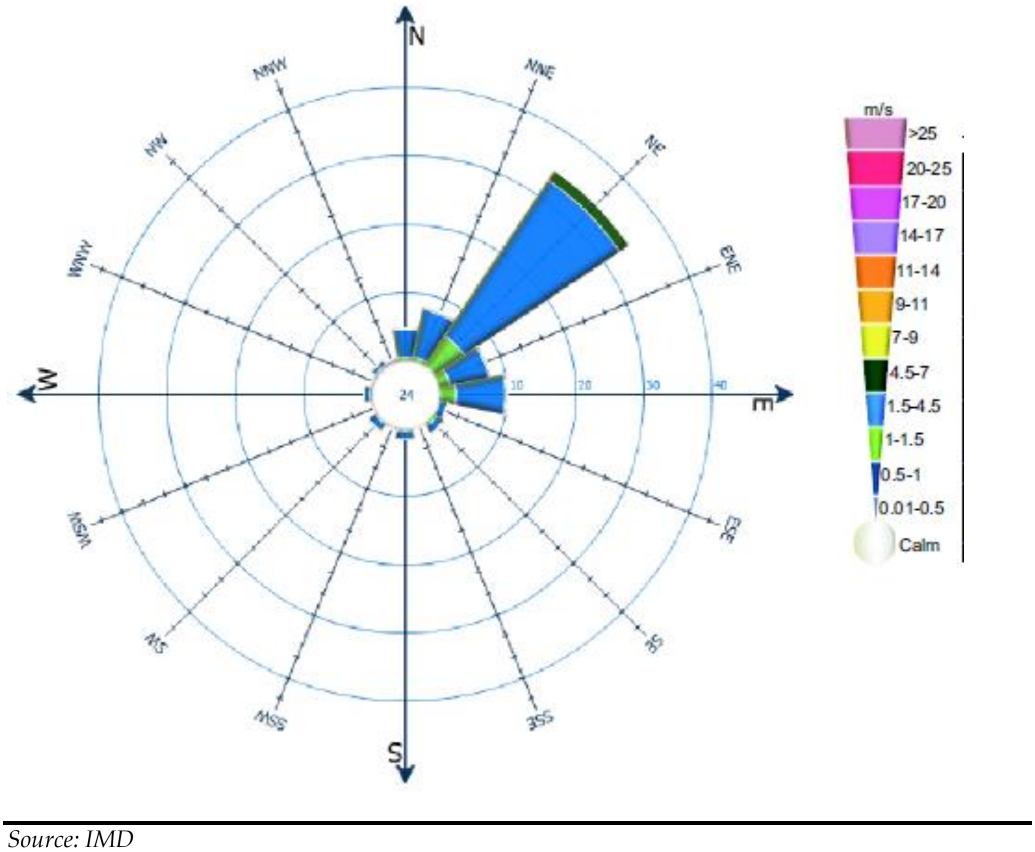
Relative humidity values measured twice daily at 0830 hrs and 1730 hrs at the Dibrugarh IMD station for 2009 revealed high average monthly relative humidity values ranging from 54.68%-87.65%. Maximum monthly average relative humidity values were observed in monsoon months of June to August. The average humidity values recorded for these months during both 0830 hrs and 1730 hours generally varied between 85.97% – 87.65% and 72.67% – 78.71% respectively.

Wind Speed and Wind Direction

The wind speed and wind direction of an area influences the dispersal of pollutants from a point and non-point sources. As the proposed drilling and testing activities involve the operation of both point (DG sets) and non-point pollutant emissions sources, analysis of wind speed and direction data is considered important for predicting the air quality impacts based on pollutant dispersion.

The annual wind rose (***Figure 3.2***) for Dibrugarh prepared from daily surface wind data recorded at 3:00am from 1971- 2000 indicates that 65% of the year, the wind blows from northeast.

Figure 3.2 ***Annual Wind Rose at Dibrugarh, Assam***



Source: IMD

Primary Micrometeorology

An automatic micro-meteorological station was installed at Digboi during the study area. The parameters monitored included wind speed, wind direction, ambient temperature, relative humidity, rainfall. The result of primary meteorological monitoring is presented in the subsequent section.

Temperature: The maximum and minimum temperature reported during the study period was 33.8°C and 11.1°C. The average temperature was in the range of 20.79°C during the study period.

Relative humidity: The average relative humidity was 84.51% during the study period. Relative humidity ranged between 43.5% and 99.8% during the study period.

Rainfall: Rainfall occurred on few days of the study period. Total rainfall recorded during the study period was 163 mm. Total 6 rainy days (rainfall>2.5 mm/day) were recorded during the study period.

Summary of meteorological data is presented in ***Table 3.2***. The detail monitoring results is presented in ***Annex 3.2***.

Table 3.2 ***Summary of Micro-Meteorological Data***

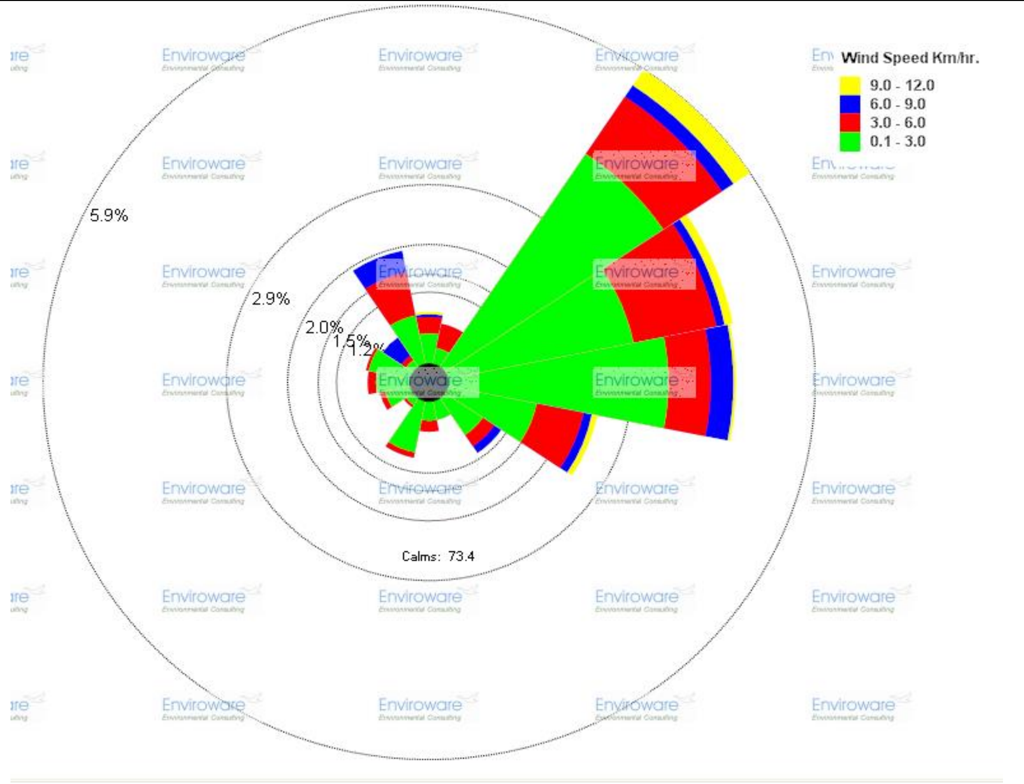
Particulars	Temperature (°C)	Relative Humidity (%)	Wind Speed (m/s)	Rainfall (mm)
Maximum	33.8	99.80	3.36	-
Minimum	11.1	43.49	0.00	-
Average	20.79	84.51	0.23	-
Total	-	--	-	163

Source: ERM Primary Monitoring

Wind Speed and Direction

The average wind speed in the study period was 0.23 m/s. The maximum wind speed was 3.36m/s. On average 73% of the study period, wind speed was at calm. The predominant wind direction during the study period was from North East. The wind rose for the study period is shown in ***Figure 3.3.***

Figure 3.3 Wind rose of Study Area during Study Period



Source: ERM Primary Monitoring

3.3.2 *Ambient Air Quality*

Primary monitoring of the ambient air quality was undertaken in the study area to establish baseline levels of air pollutants in the area. Location of the proposed wells, GGS, pipeline route, access routes, predominant wind direction etc. are important in selection of the ambient air quality sampling stations as any gaseous and particulate emissions from the project activities will disperse based on the wind directions and affect the receptors. Thus the analyzed values for the pre project environment can be compared during and after the project activities.

The study area resembles a pre-dominantly rural landscape with villages interspersed between plantations, agricultural lands and tea gardens. The major emission sources within the Dirok Development Field are vehicular emission, emission from cooking etc. Industrial emission sources within the Dirok Development Field area includes emissions from IOCL refinery in Digboi.

The major sources of air emissions due to the proposed drilling and producing activities would be exhaust gases generated from operation of DG sets, vehicular movements and flaring from production facilities etc.

Primary Air Quality Monitoring

Ambient air quality was monitored at eight locations across the study area during October 2017-December 2017. The parameters studied were Particulate Matter (PM_{10} and $PM_{2.5}$), Oxides of Nitrogen (NOx), Sulfur dioxide (SO_2), Carbon Monoxide (CO), Hydrocarbon (Total and Non-methane) and Volatile Organic Carbons (VOCs). Air quality monitoring locations were selected in residential areas. The monitoring locations were selected upwind, downwind and crosswind directions with respect to the study area to understand the baseline air environment in the study area. The monitoring location details are given in ***Table 3.3***. The air monitoring locations have been provided in ***Figure 3.5.***

Table 3.3 Air Monitoring Locations

Stn. Code	Monitoring Location	Geo-coordinates		Rationale for Selection
AQ1	Agbondhagaon	27° 19' 30.600" N	95° 38' 57.962" E	The location is upstream to the pipeline alignment and all the facilities for the project
AQ2	Philkhana	27° 15' 19.399" N	95° 38' 0.396" E	The location is down wind to Wells 16, 4, 17, 5 and GGS-2
AQ3	15 No. Line Likhajan Tea Estate	27° 15' 54.833" N	95° 37' 59.004" E	The location is downwind to the well locations 15, 16, 4. Crosswind to the locations 1, 2,3,18, 7 and 8.
AQ4	Khagoripathar	27° 16' 32.457" N	95° 35' 17.804" E	Location downwind to the locations 6, 10, 11, 12. Crosswind toe the well locations at the north of Buri Dihing River
AQ5	Makumkila	27° 17' 34.191" N	95° 34' 5.288" E	Downwind to all the well locations at the north of Buri Dihing River
AQ6	Jonghu Kuruka	27° 18' 4.610" N	95° 35' 22.777" E	Upwind to all the well locations at the north of Buri Dihing River
AQ7	Makum Block No. 2	27° 17' 52.951" N	95° 37' 14.443" E	Location in proximity to the new pipeline alignment. Upwind to the well locations 6, 10, 7, 1, 2, 18. Crosswind to the locations 11, 12 and all the well locations north of the Buri Dihing River.
AQ8	1 no. Golai Road	27° 22' 22.314" N	95° 21' 55.499" E	Location in proximity to the new pipeline alignment near Golai.

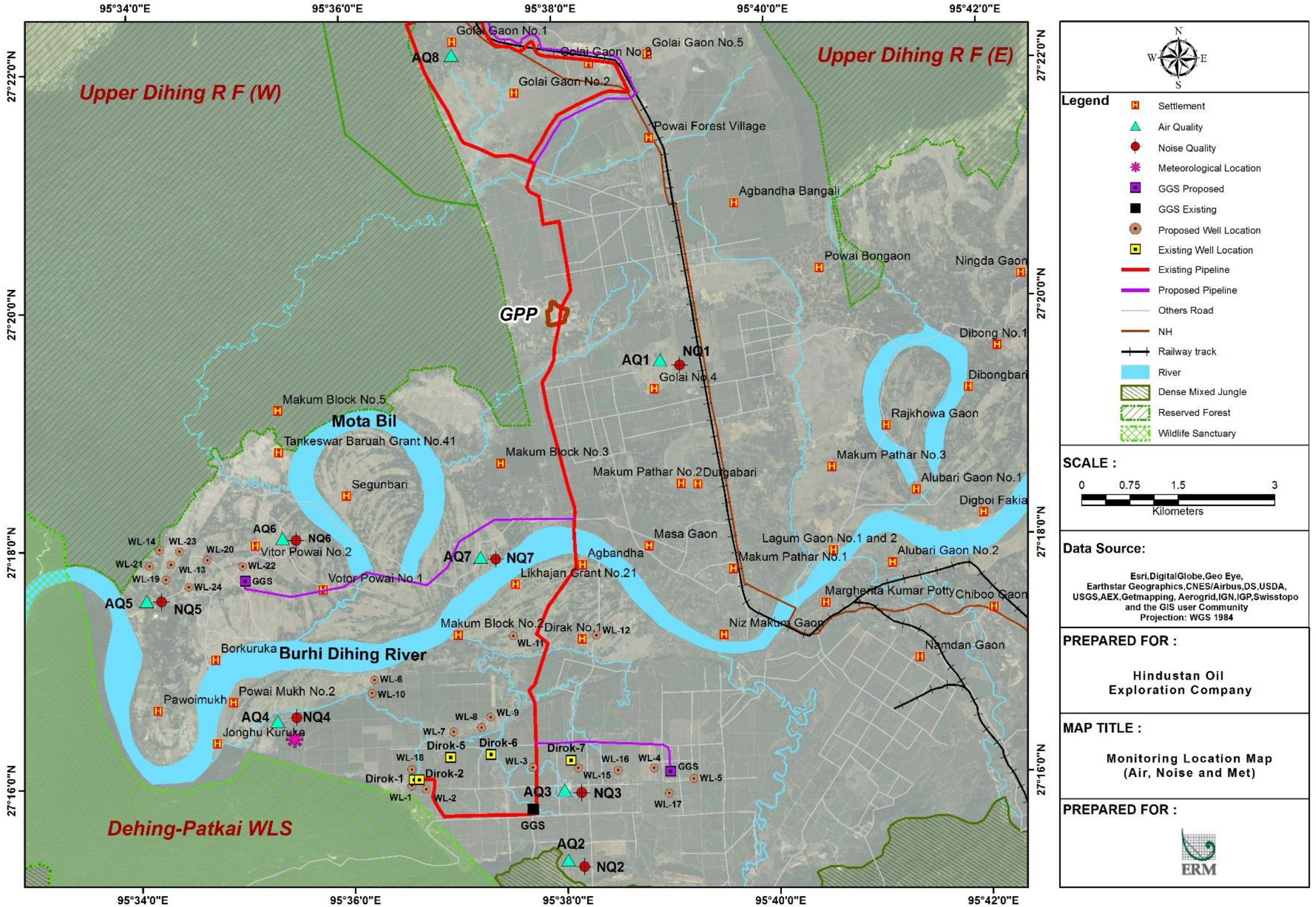
Source: ERM Primary Monitoring

Figure 3.4 Photographs of Air Monitoring


Monitoring at Agbandhagaon


Monitoring at Golai No. 1

Figure 3.5 Air, Noise and Traffic Monitoring Locations



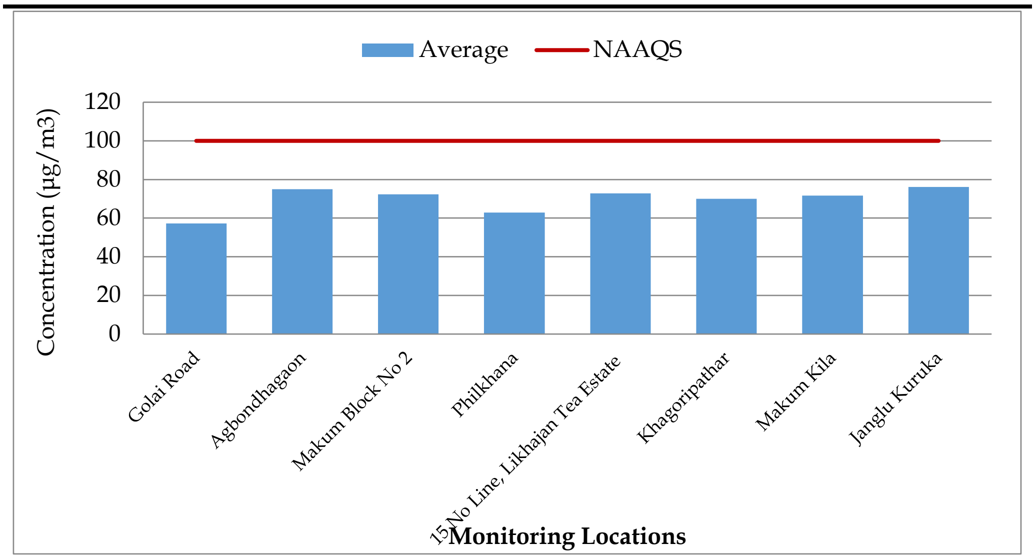
Interpretation of Monitoring Results

The result of the parameters monitored has been discussed in context of compliance to National Ambient Air Quality Standards (NAAQS)[1] of residential, commercial and industrial area. The station wise summary results are ***Table 3.3***. The in-detail results are provided in ***Annex.3.3***.

Particulate Matter 10 (PM_{10})

The average concentration of PM_{10} in the Study Area ranged between 57.2 and 76.2 µg/m³. The average concentration of PM_{10} values at all stations were found to be in compliance to the NAAQS value of 100 µg/m³. Variation of PM_{10} values in at the monitoring stations are presented in the figure below.

Figure 3.6 Concentration of Particulate Matter 10 (PM_{10}) in the Study Area



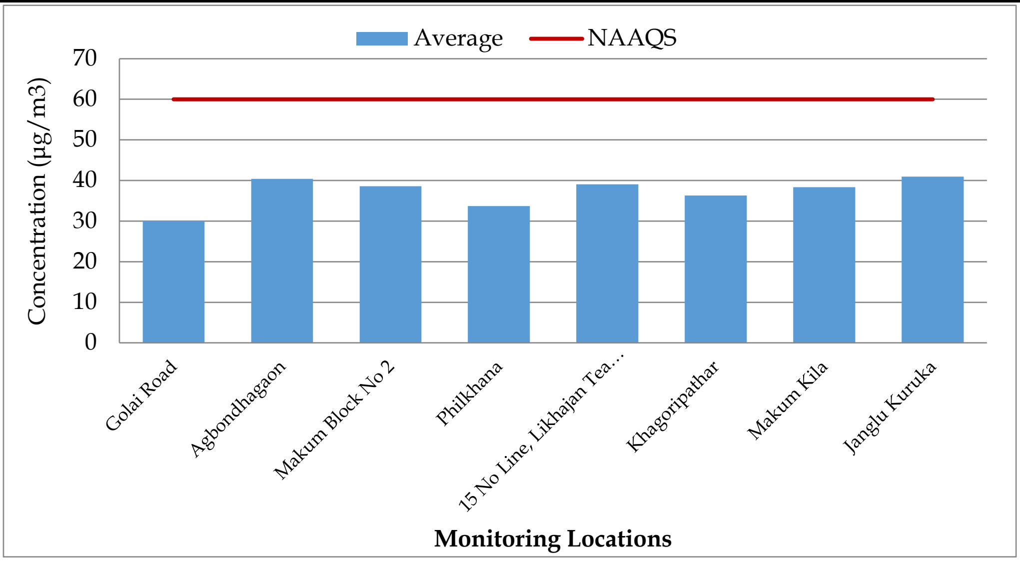
Source: ERM Primary Monitoring

Particulate Matter 2.5 ($PM_{2.5}$)

The average concentration of Particulate Matter 2.5 ($PM_{2.5}$) in the study area ranged between 30 and 40.96 µg/m³. The average concentration was within the stipulated standard of 60 µg/m³. Variation of $PM_{2.5}$ values in at the monitoring stations are presented in the figure below.

[1] http://www.moef.nic.in/sites/default/files/notification/Recved%20national.pdf

Figure 3.7 Concentration of Particulate Matter 2.5 ($PM_{2.5}$) in the Study Area

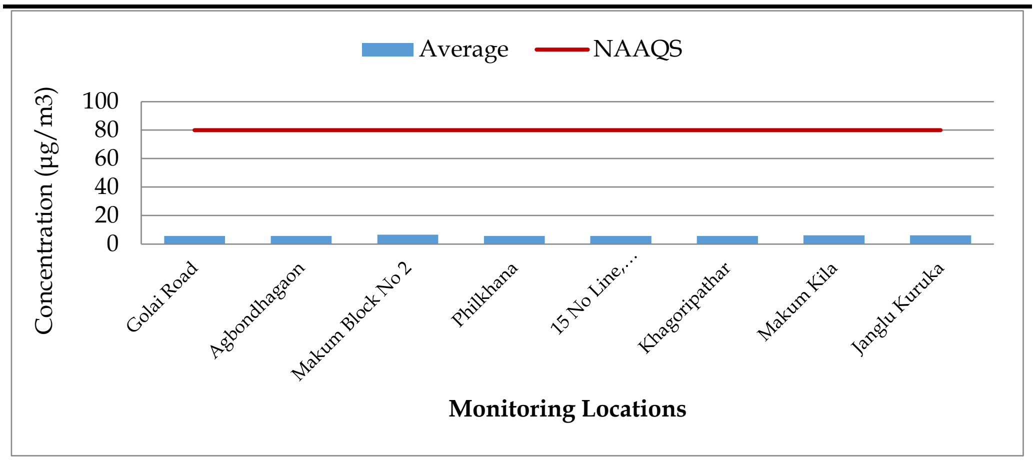


Source: ERM Primary Monitoring

Sulfur Dioxide (SO_2)

The average concentration of Sulfur Dioxide (SO_2) in the study area ranged between 5.6 and 6.7 µg/m^3. The average concentration reported across all the 8 monitoring locations were below the NAAQS value of 80 µg/m^3. Variation of SO_2 values in at the monitoring stations are presented in the figure below.

Figure 3.8 Concentration of Sulfur Dioxide (SO_2) within Study Area

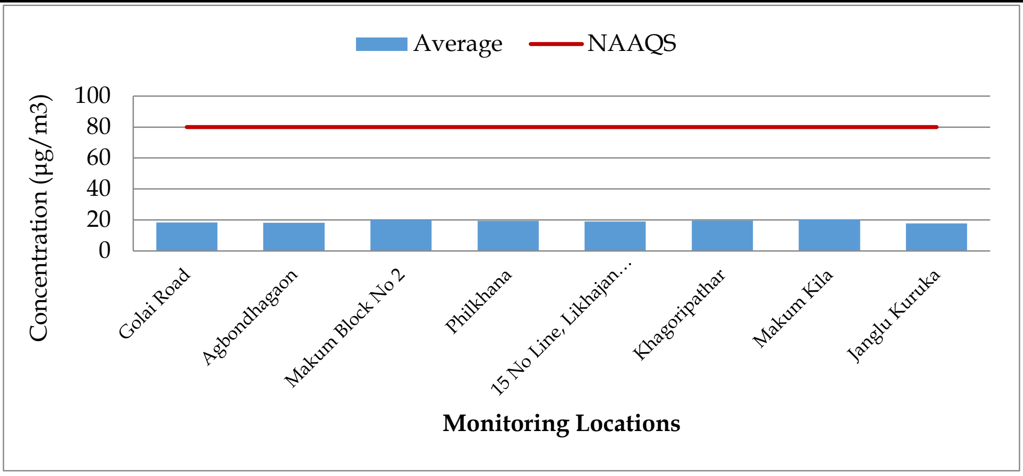


Source: ERM Primary Monitoring

Oxides of Nitrogen Dioxide (NO_X)

The average concentration of NOx in the study area ranged between 17.7 and 20.5 µg/m^3. The average concentration reported across all the 8 monitoring locations were below the NAAQS value of 80µg/m^3. Variation of NO2 values in at the monitoring stations are presented in the figure below.

Figure 3.9 Concentration of Nitrogen Dioxide (NO_2) in the Study Area

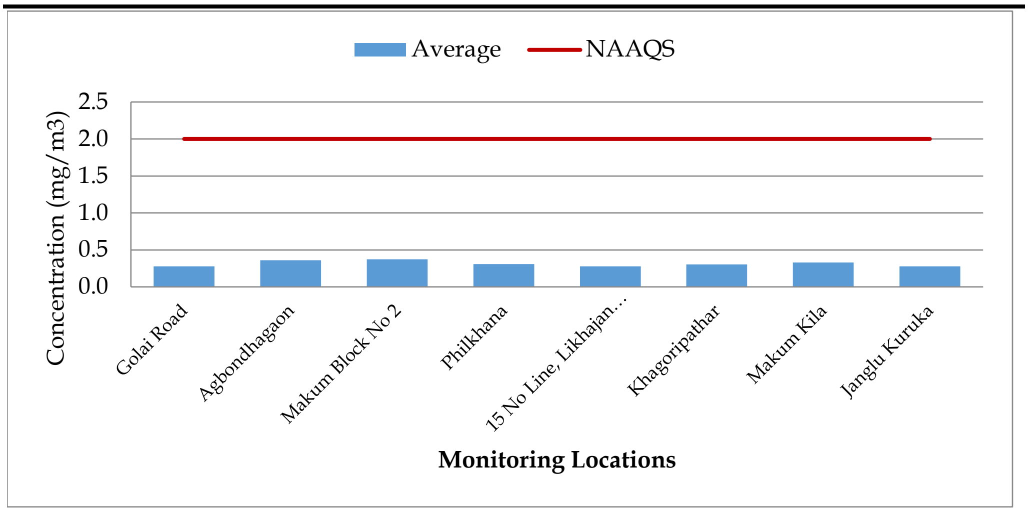


Source: ERM Primary Monitoring

Carbon Monoxide (CO)

The 8 hour average concentration of Carbon Monoxide in the study area ranged between 0.28 and 0.37 mg/m^3. The 8 hour average concentration of CO reported across monitoring locations were in compliance the NAAQS value of 2mg/m^3. Variations of CO values in at the monitoring stations are presented in Figure below.

Figure 3.10 Concentration of Carbon Monoxide (CO) in Study Area



Source: ERM Primary Monitoring

Total Hydrocarbons

The average hydrocarbons concentration in the study area ranged between 1.38 and 2.36 ppm. There is no standard value for hydrocarbon in NAAQS.

Hydrocarbons-Non-Methane

The concentrations of non-methane hydrocarbon is <0.5 ppm in all sample collected from the study area. There is no standard value for Non-Methane hydrocarbon in NAAQS

Volatile Organic Carbons (VOCs)

The concentrations of VOCs in the study area were recorded to be ranging between <2.08-4.3 μg/m³.There is no standard value for VOCs in NAAQS.

Conclusion

The study area represents primarily rural environmental setting. The source of emission to air includes emission from plying of vehicles at the dilapidated roads within the study area. Lower values for the pollutant levels at all the stations could be attributed to the rural setting and absence of major industries in the study area.

Table 3.4 Summary of Ambient Air Monitoring

	PM_{10} (μg/m³)	$PM_{2.5}$ (μg/m³)	SO_2 (μg/m³)	NO_2 (μg/m³)	CO (mg/m³)	Total Hydrocarbon (ppm)	Hydrocarbon (as Non-Methane) ppm	VOC (μg/m³)
AAQ-1: Golai Road								
Average	57.2	30.00	5.6	18.3	0.3	1.38	-	3.24
Min	32.0	14	4.5	11.2	0.15	0.48	<0.5	2.33
Max	85	46.0	7.5	25.5	0.48	2.22	<0.5	4.2
AAQ-2: Agbondha Gaon								
Average	75.0	40.42	5.83	18.12	0.36	2.36	-	-
Min	45	22.00	4.5	10.2	0.15	0.67	<0.5	<2.08
Max	135	72.00	8.2	26.3	0.68	18.5	<0.5	<2.08
AAQ-3: Makum Block No 2								
Average	72.38	38.58	6.7	20.10	0.37	1.86	-	4.3
Min	34	18.00	4.5	10.20	0.15	0.65	<0.5	<2.08
Max	165	78.00	9.5	34.20	0.66	3.22	<0.5	4.7
AAQ-4: Philkhana								
Average	62.88	33.71	5.79	19.33	0.31	1.53	-	3.4
Min	29.00	14.00	4.20	10.20	0.16	0.72	<0.5	<2.08
Max	123.00	66.00	8.50	26.60	0.67	2.66	<0.5	4.6
AAQ-5: 15 No Line, Likhajan Tea Estate								
Average	72.83	39.04	5.68	19.02	0.28	1.44	-	3.1
Min	40.00	24.00	4.10	10.30	0.12	0.62	<0.5	<2.08
Max	132.00	72.00	7.50	28.50	0.58	2.33	<0.5	4.1
AAQ-6: Khagoripathar								
Average	69.96	36.29	5.84	19.67	0.31	1.59	-	3.3
Min	45.00	23.00	4.20	12.30	0.13	0.65	<0.5	<2.08
Max	99.00	56.00	8.50	34.20	0.68	2.33	<0.5	4.2
AAQ-7: Makum Kila								

	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	SO_2 (µg/m³)	NO_2 (µg/m³)	CO (mg/m³)	Total Hydrocarbon (ppm)	Hydrocarbon (as Non-Methane) ppm	VOC (µg/m³)
Average	71.67	36.29	6.28	20.45	0.33	1.59	-	4.1
Min	32.00	23.00	4.50	12.20	0.13	0.74	<0.5	<2.08
Max	132.00	56.00	8.60	31.20	0.67	2.33	<0.5	5.2
AAQ-8: Jonghu Kuruka								
Average	76.21	40.96	6.24	17.70	0.28	1.57	-	3.5
Min	35.00	17.00	4.80	10.20	0.13	0.58	<0.5	<2.08
Max	132.00	68.00	8.20	26.30	0.57	2.66	<0.5	4.2

[Primary Monitoring 2017]

3.3.3 *Ambient Noise Quality*

The ambient noise level at the project area resembles that of a rural landscape with occasional plying of public transport vehicles like, two wheelers, tractors, trekkers and cars at the internal village roads.

Noise Monitoring

Ambient noise monitoring was conducted at 8 stations within the study area. The noise levels have been monitored at residential zones to assess and evaluate the impact on ambient noise environment. The location of the ambient noise monitoring stations have been presented in ***Table 3.5*** and ***Figure 3.5***.

Table 3.5 ***Ambient Noise Monitoring Locations***

Stn, Code	Monitoring Location	Geographical Coordinates		Category of Area/Zone
		Latitude	Longitude	
NQ1	Likhjan Gaon	27° 19' 27.774" N	95° 39' 8.939" E	Residential
NQ2	Makum 1 No	27° 15' 15.963" N	95° 38' 9.429" E	Residential
NQ3	Powai Mukh	27° 15' 53.274" N	95° 38' 8.591" E	Residential
NQ4	Makum	27° 16' 34.037" N	95° 35' 28.765" E	Residential
NQ5	Dirok Staff Colony	27° 17' 33.794" N	95° 34' 13.658" E	Residential
NQ6	Dhodar Ali Road	27° 18' 3.398" N	95° 35' 30.410" E	Residential
NQ7	1 No Vitor Powai Gaon	27° 17' 51.885" N	95° 37' 22.796" E	Residential
NQ8	Powai Gaon	27° 19' 27.774" N	95° 39' 8.939" E	Residential

Source: ERM Primary Monitoring

The 24-hour baseline noise monitoring was conducted by using the portable sound meter (Lutron, SL-0423SD, unit: dB(A). Noise level (LAeq) were measured and recorded at a ten-minute interval and averaged at an hourly and daily (i.e. 24-hour) interval using the following formula:
$LAeq = 10*\log_{10}(\text{Average}(10^{((X)/10)}))$ where X is measured noise in dB(A). Sound pressure level (SPL) measurements in dB(A) was recorded for 24 hours with the equivalent noise values computed as Leq (Daytime) and Leq (Night time) for each location. Daytime is considered between 06:00 to 22:00 hours and night from 22:00 hours to 06:00 hours. The results so obtained were

compared with ambient noise standards specified for respective category under the *Noise Pollution (Regulation & Control) Rules, 2000*.

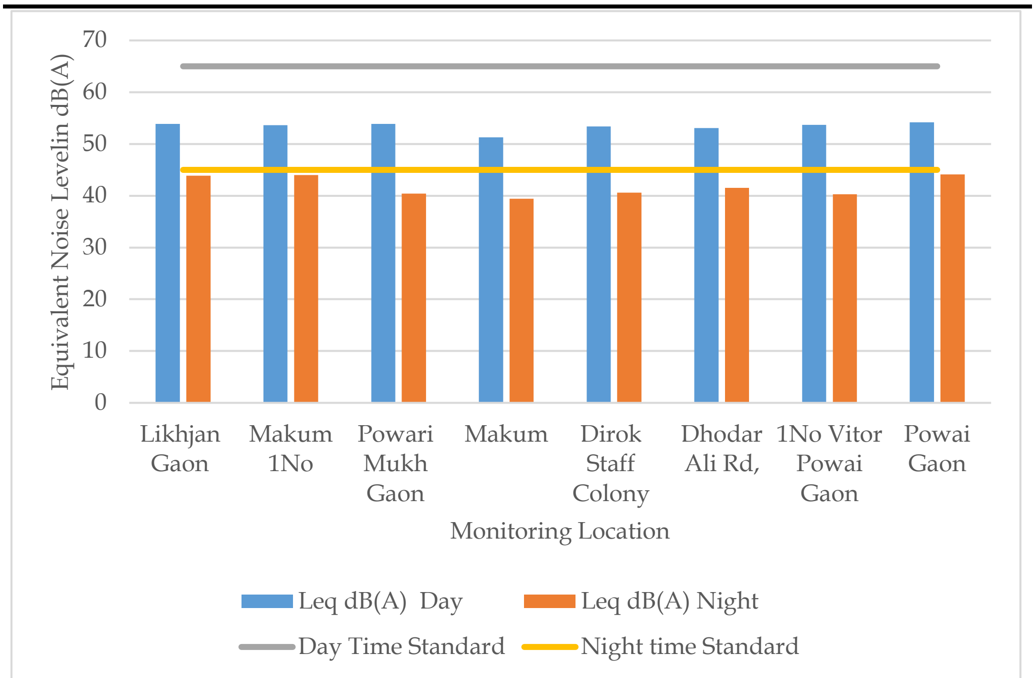
Noise Monitoring Results

The equivalent day time and night time noise levels in comparison to the respective CPCB standards are presented in ***Table 3.7*** and ***Figure 3.11***. The hourly noise quality monitoring results is presented in **Annex-3.4**

Table 3.6 Ambient Noise Quality in the Study Area

Stn Code	Sampling Location	Leq Day (dBA)	Leq Night (dBA)	CPCB Limits Leq (dBA)	
				Day	Night
NQ1	Likhjan Gaon	53.9	43.9	55	45
NQ2	Makum 1 No	53.6	44.0	55	45
NQ3	Powai Mukh	53.9	40.4	55	45
NQ4	Makum	51.3	39.4	55	45
NQ5	Dirok Staff Colony	53.4	40.6	75	70
NQ6	Dhodar Ali Road	53.1	41.5	55	45
NQ7	1 No Vitor Powai Gaon	53.7	40.3	55	45
NQ8	Powai Gaon	54.2	44.1	55	45

Figure 3.11 Ambient Noise Monitoring Results



Source: ERM Primary Monitoring

Interpretation of Primary Monitoring Results

The equivalent noise level as measured at the residential areas range between 51.3 -53.9 dB(A) at day time and between 39.4-44.1 dB(A) at night time. The equivalent day time noise values in all the were in compliance to the day time standard of 55 dB(A) for residential areas. The equivalent night time noise values in all the locations were in compliance to the night time standard of 45 dB(A) for residential areas.

The major sources of noise in residential areas are anthropogenic activities such as traffic movement etc. At night time, the major sources of noise are television sets and traffic movement.

3.3.4 *Road & Traffic*

As discussed in ***Section 2.3.2***, the proposed locations in Dirok Development Field area can be accessed through NH 37 Road and Naharkatia-Moran Road and Dibrugarh –Digboi Road. Traffic monitoring station was selected at NH 37 near Moran and at Naharkatia-Moran Road near Kenduguri and Dibrugarh-Digboi Road near Tengakhat. Traffic survey was conducted continuously for 24 hours, one time during the study period. The traffic survey was done for both way movement of vehicles and categorized as heavy motor vehicles (truck, bus, dumper, tanker and trailer), light motor vehicle (car, jeep, van, matador, tractor, tempo and mini bus), two/three wheelers (scooter, motor cycle, auto, moped) and non-motorized vehicles (bicycle, tricycle). Summary of traffic observed in the study area is presented in ***Table 3.7,*** detail result is provided in ***Annex 3.5***.

Table 3.7 Traffic Values observed in the Project study area

Description	Likhajan	Barua Grant
Heavy Motor Vehicles (in Number), 24 hours	174	238
Light Motor Vehicle (in Number), 24 hours	664	750
Two/Three Wheelers (in Number), 24 hours	645	707
Non-motorized Vehicles	398	405
Total PCU (Nos.) in 24 Hours (To & From)	2665	3130
Average PCU Flow/Hr	111	130
Max PCU (Nos)/Hr	258	292
Min PCU (Nos)/Hr	0	0
Minimum PCU Hours	00:00-06:00	01:00-06:00
Maximum PCU Hours	08:00-09:00	16:00-17:00

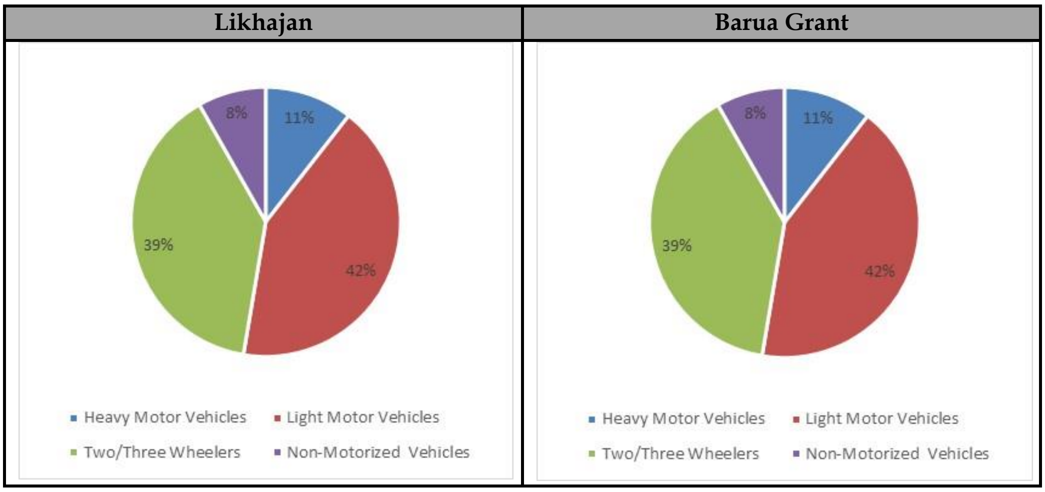
Source: ERM Primary Monitoring

Interpretation of Traffic Survey Results

Total 2665 PCU and 3130 PCU was recorded at the traffic monitoring station at Likhajan and Barua Grant respectively. As per observation made for traffic density, on an average 111 PCU and 130 PCU was recorded per hour at the locations, respectively. It was also noticed that major contributor (nearly 35% in each location) of the vehicular traffic at Likhajan and Barua Grant was light motor vehicle (Car, Jeep, Van, Matador, Tractor, Tempo, Mini Bus).

Figure 3.12 illustrates contribution of different type of vehicle towards total vehicular traffic at Likhajan, Barua Grant.

Figure 3.12 Contribution of Different Type of Vehicle at Likhajan and Barua Grant



3.3.5 Topography

Dirok Development Field has a more or less flat topography with elevations ranging between 120-160 m msl. The area gradually slopes towards the north with lower elevations toward the Buri Dihing River and upper elevations at the south towards the foothills of Arunachal Pradesh. The elevations within the study area at the north of Buri Dihing River range between 120-200 m.

3.3.6 Physiography and Geology

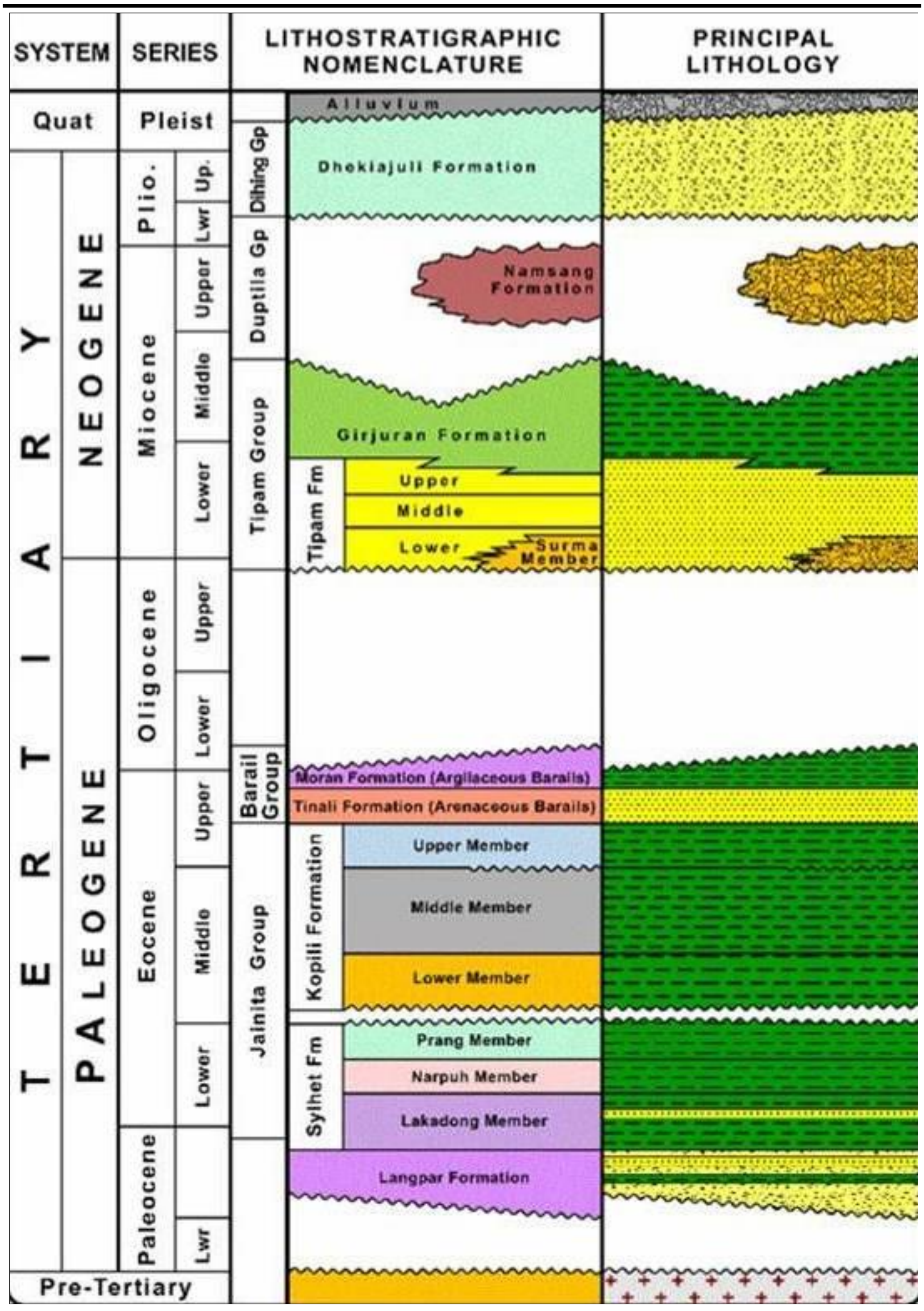
The Block AAP-ON-94/1 lies mainly at the foothills (south) of the first thrust (Naga Thrust) of the Assam-Arakan Foldbelt and contains Naga, Margherita and Disang thrust zones. A relatively small part of the Block only occurs within the Assam Shelf or Foreland trend, and this exists below and adjacent to the Naga Thrust, and is essentially a continuation of the 'Nahorkatiya/ Jorajan oil fields' or 'Nahorkatiya dome' trend that plunges beneath the Naga Thrust. This Assam Shelf structural trend is broadly termed the Brahmaputra Arch and is bounded to the north by the Himalayan and to the south by the Assam-Arakan Fold belt.

The area developed as a passive margin on the Indian craton from Mesozoic to Oligocene times, facies becoming progressively more marginally marine as the collision of India and Asia developed during the Paleogene. The base Tipam/top Barail Oligocene unconformity divides the stratigraphy into two mega-sequences that correlate with the two tectonic episodes of extension and compression. The Paleogene mega-sequence was deposited during continental rift and drift, and the Neogene sequence is dominated by sediments (fluvial and ultimately molasse) deposited during continental collision.

This extensional system (now inverted to some degree) consists of older basement faulting that reactivated along existing Pre-Girujan (Miocene) extensional trends. In the Nahorkatiya/Jorajan fields, the sequence up to Tipam exhibits normal faulting that is clearly seen on sections oriented normal to the basin axis. The Foothills thrust-front progressively encroached northwards during the uplift phase, the Naga Thrust being the most northerly thrust sheet. Coincident with the thrust faulting and compression, inversion has also taken place in the un-thrusted autochthonous foreland to the northwest.

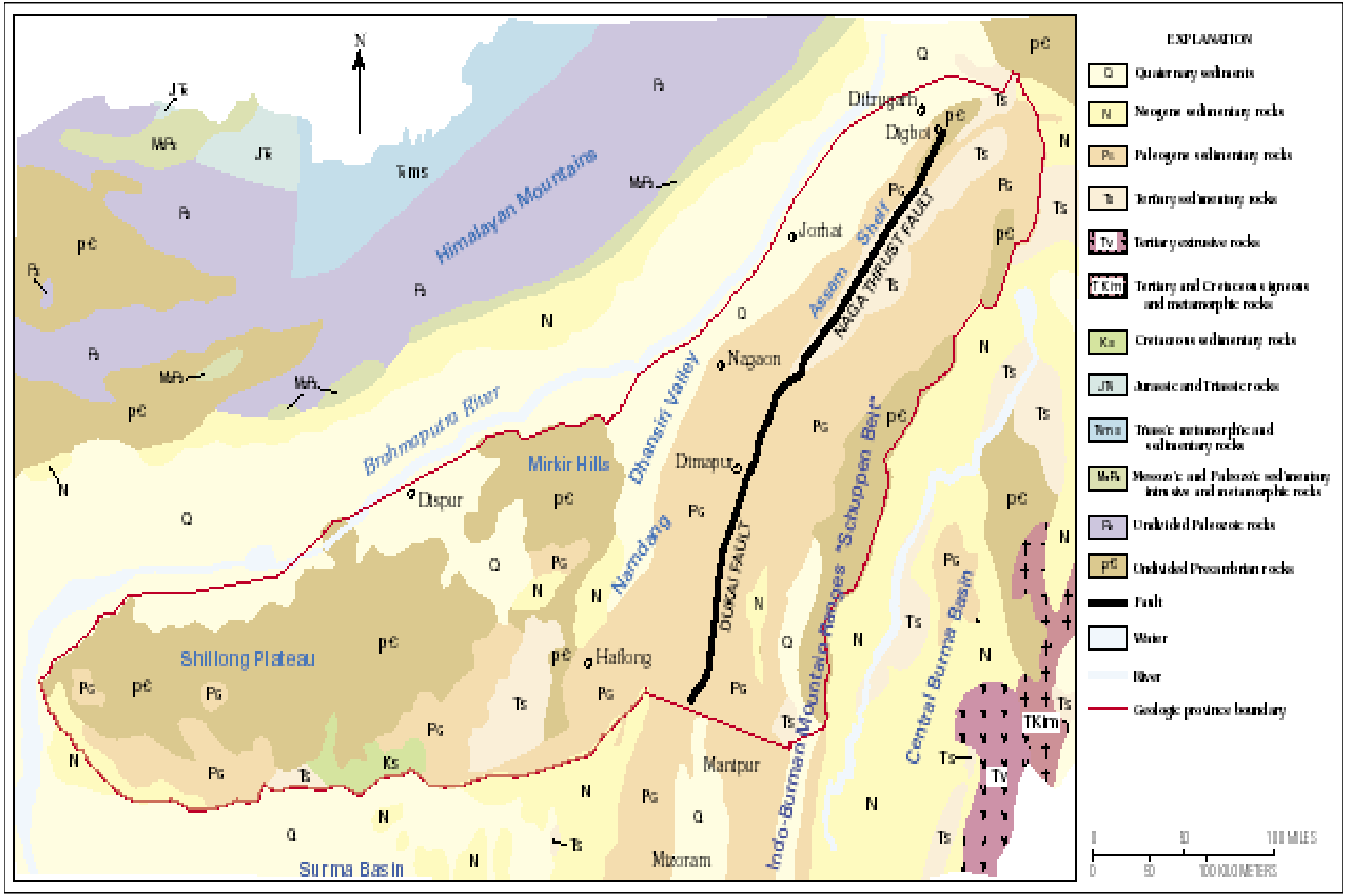
The stratigraphy of the area is presented in ***Figure 3.13*** and the geological formations are presented in ***Figure 3.14.***

Figure 3.13 Regional Stratigraphy of the Area



Source: HOEC

Figure 3.14 Regional Geology Setting of the Area



Source: USGS Report

Regional Tectonic Setting

From a tectonic point of view, Assam-Arakan basin is classified as Foreland basin. The Block AAP-ON-94/1 lies mainly in the foothills side of the first thrust (Naga Thrust) of the Assam-Arakan foldbelt and contains Naga, Margherita & Disang thrust zones. Only a small part of the Block occurs within the foreland trend and this exists below and adjacent to the Naga Thrust. Between the Himalayas and the Naga-Disang thrust complex occurs an autochthonous zone, the Foreland Spar containing sediments ranging in age from Eocene to Pleistocene. These are intersected by a number of gravity faults. Further east in the Patkai Range Tertiary sedimentation took place under deeper water conditions punctuated by slight emergence at some places. Oligo-Miocene was also the time when the deposits of Assam-Arakan basin were over thrusted towards the northwest over the north eastern extension of the Indian Shield. The outermost of this thrust, the Naga thrust belt consist of a succession of six thrust sheets. The whole northeast India is a tectonically active zone due to presence of active thrusts, fault planes and very fragile loose sediments, steep slope angle leading to frequent landslides in the hilly areas. The courses of rivers are also influenced by these active tectonic lineaments.

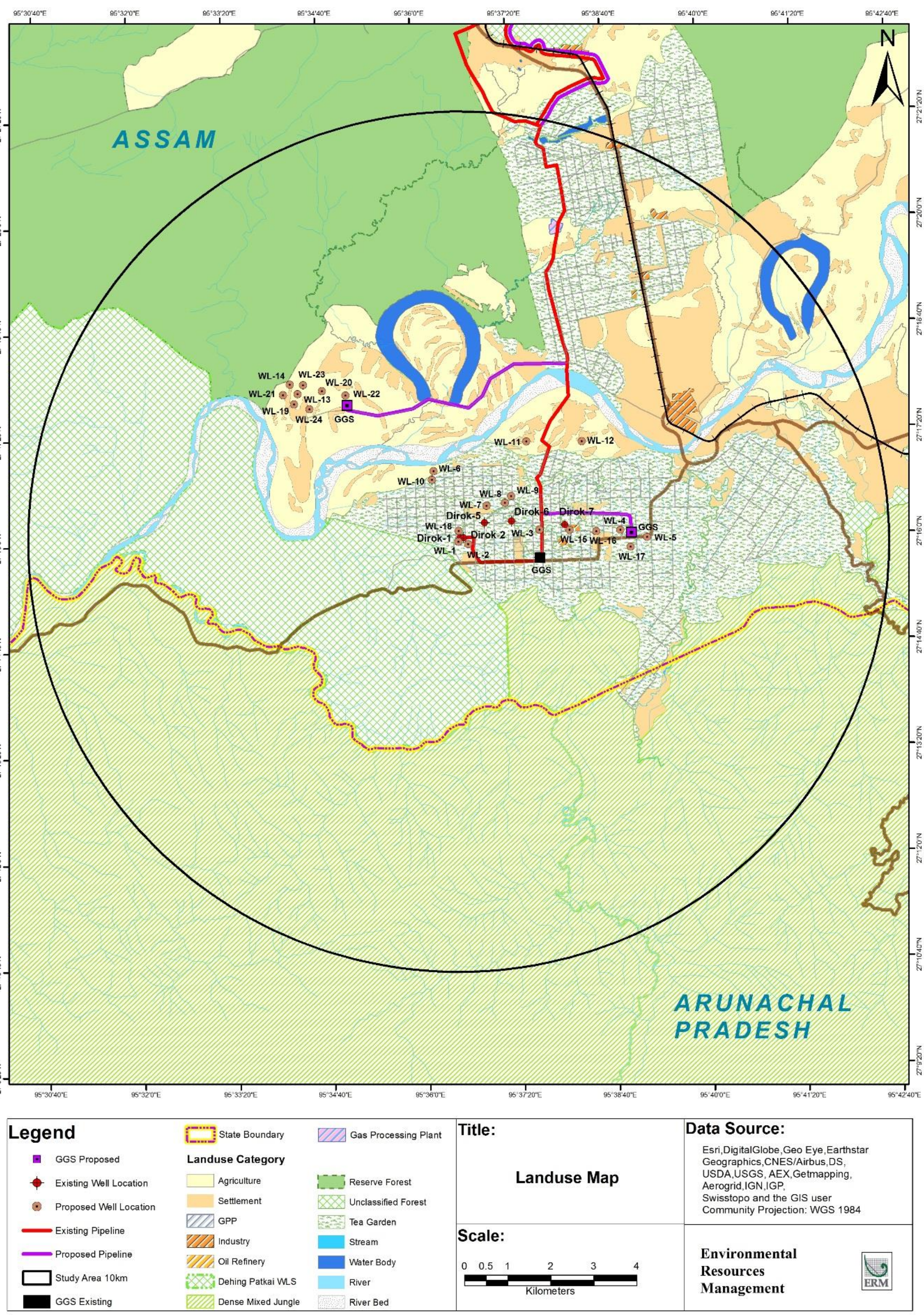
3.3.7 Land use and Land Cover

The land use of the study area has been interpreted utilising multispectral satellite imagery (LANDSAT 8) and World Imagery dated 16th September, 2016 along with ground truthing surveys undertaken during site reconnaissance. The land use distribution of the study area is presented in ***Table 3.8***, while the land use map is presented in ***Figure 3.15.***

Table 3.8 Distribution of Land use and Land Cover in Study Area

Sl No.	Land Use Category	Area (in sq.km)	Percentage (%)
1.	Agriculture	27.43	8.72%
2.	Dehing Patkai WLS	49.13	15.63%
3.	Dense Mixed Jungle	114.72	36.49%
4.	Industry	0.79	0.25%
5.	Railway Track	0.07	0.02%
6.	Reserve Forest	38.96	12.39%
7.	River	4.27	1.36%
8.	River Bed	4.32	1.37%
9.	Road Network	0.24	0.08%
10.	Settlement	21.76	6.92%
11.	Stream	0.48	0.15%
12.	Tea Garden	48.70	15.49%
13.	Unclassified Forest	0.61	0.19%
14.	Water Body	2.90	0.92%
	Total	314.00	100%

Figure 3.15 Distribution of land use and land cover in the Study Area



Forest lands including the Dehing Patkai Wildlife Sanctuary, Reserve Forest and Unclassified forest cover 64.51% of the total stud area. Tea garden areas cover 15.49% of the total study area followed by agricultural land (8.72%), settlement areas (6.92%), Rivers and streams (2.89%). Road networks and railway tracks cover 0.8% and 0.2% of the study area respectively.

3.3.8 Soil Quality

Tinsukia District is situated in the extreme north eastern part of Assam. The district is situated in the Upper Brahmaputra Valley in an alluvial plain surrounded all sides by hills except in the west. Major soil types of Tinsukia district are red soil, sandy soil, sandy loamy soil and sandy clayey soil. The soil character of cultivable land in Tinsukia is mainly alluvial and composed of mixture of sand (coarse to fine) and clay in varying proportions. The general geochemical characteristic of the soil is moderate to slightly acidic. The alluvial soils of the Brahmaputra valley are highly fertile and are very much suitable for farming of varieties of crops round the year such as cereals, pulses, oilseeds, plantation crops etc. The well drained, deep, acidic alluvial soils of upper Assam with good proportion of phosphoric content are mostly suitable for the tea plantation.

Primary Soil Monitoring

Soil quality of the site assumes significance as it will be returned to land owners after the completion of the project activities. The soil is presently being used to for tea plantation or paddy cultivation and it will be crucial that the soil does not loose it texture and fertility when handed over after the expiry of the lease.

Soil was monitored from five different locations in the Dirok Development Field. An effort was made to represent the major land uses present in the study area such as agricultural field, homestead plantation and tea garden soils and assess the quality. The details of the soil monitoring locations are provided in ***Table 3.9*** and ***Figure 3.16***. The soil locations have been shown in ***Table 3.10.***

Table 3.9 Soil Monitoring Locations in Study Area

Stn. Code	Monitoring Location	Latitude	Longitude	Land Use
S1	Likhajan (Tong Line)	27° 16' 4.889" N	95° 39' 36.328" E	Tea Garden
S2	Margherita tea Estate	27° 15' 50.929" N	95° 38' 5.679" E	Tea Garden
S3	Dirok Tea Estate	27° 16' 4.731" N	95° 36' 17.531" E	Tea Garden
S4	Makum Kila	27° 18' 9.294" N	95° 34' 55.618" E	Agricultural land
S5	Jonghu Kuruka	27° 17' 34.164" N	95° 36' 30.112" E	Homestead Vegetation

Source: ERM Primary Monitoring

Figure 3.16 Soil, Groundwater and Surface water Monitoring Locations Map

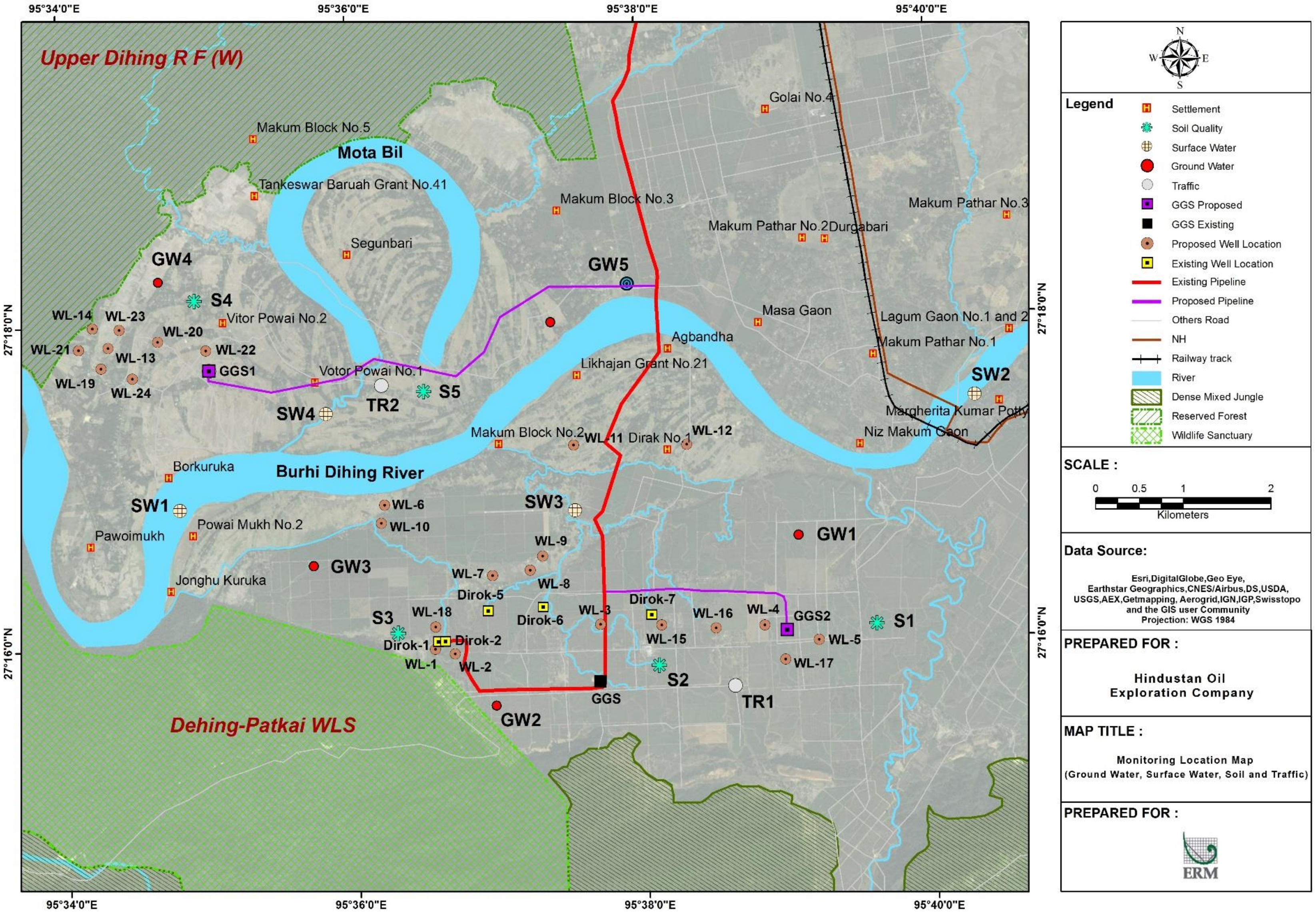


Table 3.10 Results of Soil Monitoring Results

Parameter	Unit	Location				
		S1: Makumkila	S2: Dirok Tea Estate	S3: Margherita tea Estate	S4: Likhajan (Tong Line)	S5: Jonghu Kuruka
Texture	None	silty clay	Clay	Clay	Clay	clay
Particle Size Distribution	%	Sand:18.4 silt:39.5 clay:42.1	Sand:22.8 Silt:17.3 Clay:59.9	Sand:17.7 silt:15.1 clay67.2	Sand:15.1 silt:11.4 clay73.5	Sand:14.6 silt:12.5 clay:72.9
pH (1:2.5) at 25 Deg C	None	6.54	4.58	4.89	5.24	5.03
Electrical conductivity (EC) at 25 Deg C	µS/cm	528	137	92	116	103
Specific gravity	None	2.43	2.10	2.28	2.49	2.1
Bulk Density	gm/cc	1.18	1.05	1.03	1.03	1.18
Porosity	%	51.4	50.0	54.8	58.6	43.8
Moisture	%	8.0	17.1	23.7	31.9	18.9
Permeability	Cm/hr	1.2	0.051	0.037	0.012	0.017
Infiltration rate	mm/Hr	6.3	2.7	2.0	1.9	2.7
Cation Exchange Capacity	meq/100 gm	21.6	7.6	8.4	10	11.6
Sodium (as Na)	mg/kg	17	14	10	16	19
Calcium (as Ca)	mg/kg	1372	392	588	784	588
Potassium (as K)	mg/kg	146	148	52	86	32
Sodium Adsorption Ration (as SAR)	None	0.05	0.08	0.05	0.07	0.09
Chloride (as Cl)	mg/kg	127	118	98	59	29
Sulphate (as SO4)	mg/kg	267	<15	<15	<15	<15
Carbonate ion as (Co3)-2	mg/kg	Nil	Nil	Nil	Nil	Nil
Nitrogen (as N)	mg/kg	157	307	414	376	302
Phosphorus (as P)	mg/kg	<3	<3	<3	<3	<3
Hexavalent Chromium (as Cr+6)	mg/kg	<2.0	<2	<2	<2	<2.0
Boron (as B)	mg/kg	56	27	27	52	24
Copper (as Cu)	mg/kg	22	12	9	21.4	8
Iron (as Fe)	mg/kg	612	68	98	508	1088
Lead (as Pb)	mg/kg	11	9	8.4	18	7
Mercury (as Hg)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1

Parameter	Unit	Location				
		S1: Makumkila	S2: Dirok Tea Estate	S3: Margherita tea Estate	S4: Likhajan (Tong Line)	S5: Jonghu Kuruka
Arsenic(as As)	mg/kg	<0.25	<0.25	<0.25	<0.25	<0.25
Zinc (as Zn)	mg/kg	60	36	46	34	29
Acidity	mg/kg	Nil	Nil	Nil	Nil	nil
Alkalinity (as CaCO3)	mg/kg	70	46	46	70	44
Cadmium (as Cd)	mg/kg	<2.0	<2.0	<2.0	<2.0	<2.0
Magnesium (as Mg)	mg/kg	294	118	176	118	176

Source: ERM Primary Monitoring

Soil Monitoring Results

The results of the primary soil monitoring are discussed below:

pH: Soil acidity has a correlation with the availability of nutrients in terms of their deficiency and toxicity. A soil having pH less than 6.5 is considered as acidic. The soil in the study area was found to be varying from very strongly acidic to slightly acidic as the pH ranged between 4.58 and 5.24 whereas only one sample collected from Makumkila showing 6.54 pH which is neutral.

Texture and Electrical Conductivity: Texture is an expression to indicate the coarseness or fineness of the soil as determined by the relative proportion of the various sized primary particles in the soil mass. The textures of the collected soil samples were found to be clayey and clay loam.

The EC values for the soils monitored at the study area range between 92 and 528 µs/cm. For a productive soil, the electrical conductance (EC) should be < 1000µs/cm.

Macronutrient: Nutrient status of the soil samples can be determined from the concentration of N, P, K and organic carbon in soil samples. Standard rating chart for soil nutrients is provided in ***Table 3.4.*** Nitrogen contents in the soil samples ranged between 157-414 mg/kg (70.08-184.82 kg/ha), phosphorus content in the soil samples ranged between <3 mg/kg (<1.3 kg/ha) and potassium contents ranges between 32-148 mg/kg (14.28-66.08 kg/ha). With comparison to the rating chart nitrogen status is good to better, phosphorus and potassium status is very less.

Table 3.11 Rating chart for the soil test data for few selected soil parameters

S.N.	Soil Test Parameters	Classification
1	pH	<4.5 Extremely acidic 4.51-5.00 Very strongly acidic 5.00-5.50 slightly acidic 5.51-6.0 moderately acidic 6.01-6.50 slightly acidic 6.51-7.30 Neutral 7.31-7.80 slightly alkaline 7.81-8.50 moderately alkaline 8.51-9.0 strongly alkaline 9.01 very strongly alkaline
2	Salinity Electrical Conductivity (mmhos/cm) (1 ppm = 640 mhos/cm)	Upto 1.00 Average 1.01-2.00 harmful to germination 2.01-3.00 harmful to crops (sensitive to salts)
3	Nitrogen (kg/ha)	Upto 50 very less 51-100 less 101-150 good 151-300 Better >300 sufficient
4	Phosphorus (kg/ha)	Upto 15 very less 16-30 less 31-50 medium,

S.N.	Soil Test Parameters	Classification
		51-65 on an average sufficient 66-80 sufficient >80 more than sufficient
5	Potash (kg/ha)	0-120 very less 120-180 less 181-240 medium 241-300 average 301-360 better >360 more than sufficient

Source: Handbook of Agriculture; Indian Council of Agricultural Research, New Delhi, 2015

Metals: Heavy metals such as Copper (8-22 mg/kg), Lead (7.0 – 18.0 mg/kg) and Zinc (29-60 mg/kg) were detectable in the soil of the study area. Cadmium (<2mg/kg) and Mercury (<0.1mg/kg) concentrations were found to be below detectable limit. The concentration of copper, lead and in the soil sample was much below the soil remediation intervention values specified in Dutch Soil Remediation Circular (Refer ***Annex 3.3***).

Sodium Absorption Ratio (SAR) - Sodium absorption ratio for the samples varied between 0.05-0.09.

Conclusion

The soil samples were found to be clayey and clay loam in nature with acidic pH. The macronutrient contents *viz*. NPK values of the soil samples were found to be low. Metal contamination has not been observed.

3.3.9 Hydrogeology

The study area is made up of weathered sediment of sand (stone) with pebbles of Pliocene to Pleistocene age and in the west, Surma group of rock sandstone, siltstone and mudstone of early to middle Miocene. The weathered rock occurring in upland area act as very good recharge zone, have a very good water holding and water yielding capabilities. These unconfined aquifers does not get dried up during the dry period and also contribute water to the surface water bodies and the nearby streams. The base flow which is the stream flow originating from the ground water discharge is the cause of perennial nature of nalas.

Ground Water Resources

The annual dynamic groundwater availability are estimated to be 159036 ha m, while the net annual ground water draft is 16697 ha m. The stage of ground water development is only 12%. As per CGWB records depth to groundwater levels both in pre-monsoon and post-monsoon at Dirok Development Field in 2-5 metre below ground level (mbgl). (**Figures 3.17** and **3.18**).

Figure 3.17   Depth to Water Level during Post- Monsoon in Dirok Development Field

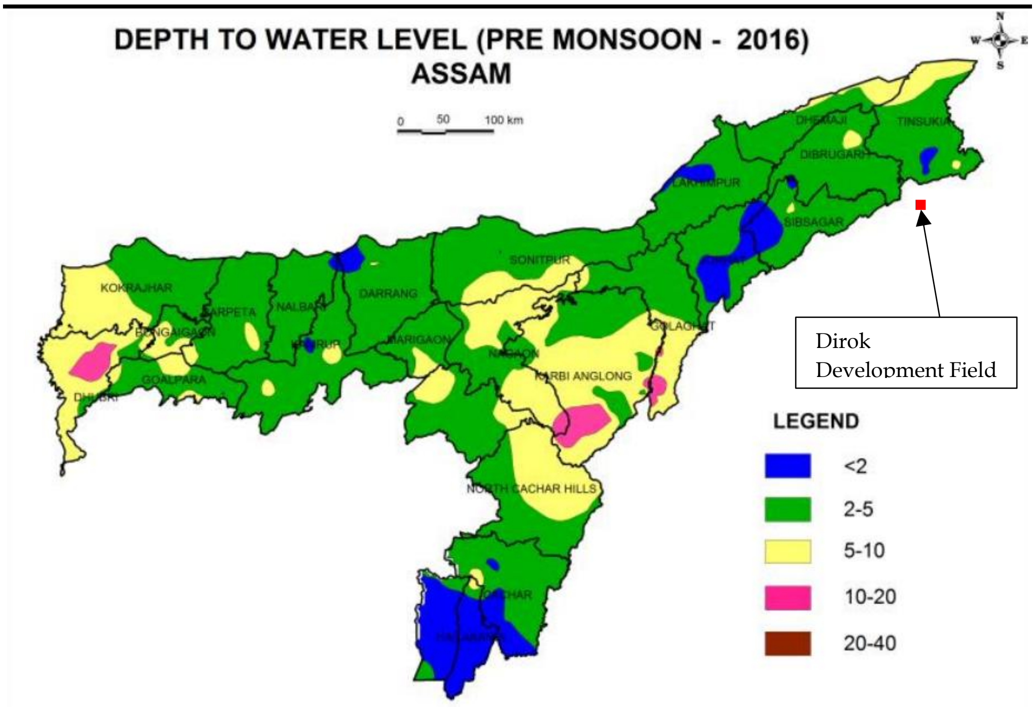
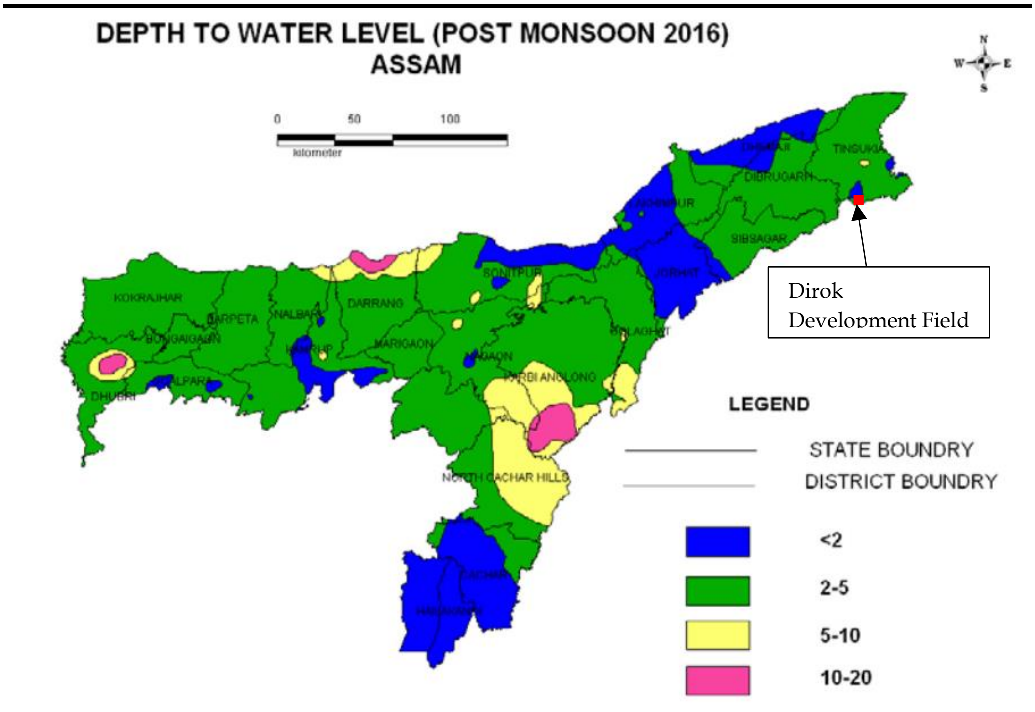


Figure 3.18   Depth to Water Level during Post- Monsoon in Dirok Development Field



3.3.10   *Groundwater Quality*

In order to establish the groundwater quality in the study area, monitoring was conducted at four stations within the study area. The ground water sampling has been conducted from tube wells adjacent to the project site to capture the existing quality of the ground water that can be used as a reference for future studies during construction and operation phase. The location of the groundwater monitoring stations has been presented in ***Table 3.12*** and ***Figure 3.16.***

Table 3.12 Groundwater Monitoring Locations in the Study Area

Sl No.	Monitoring locations	Station No	Latitude	Longitude	Source
1.	Dirok Tea Estate	GW-1	27° 18' 16.480" N	95° 34' 40.625" E	Tubewell
2.	Likhajan Colony	GW-2	27° 17' 58.862" N	95° 37' 23.205" E	Tubewell
3.	Vitor Powai	GW-3	27° 16' 38.203" N	95° 39' 4.443" E	Dug Well
4.	Makum Kila	GW-4	27° 15' 37.199" N	95° 36' 57.691" E	Tubewell

Source: ERM Primary Monitoring

Figure 3.19 Photographs of Ground water Sampling


Groundwater sampling at Dirok Tea Estate


Groundwater sampling at Vitor Powai

Groundwater Quality Results

The result of groundwater quality as sampled in the study area has been provided in ***Table 3.134.***

Interpretation of Monitoring Results of Groundwater Quality

The results of the groundwater quality have been discussed with reference to Drinking water Standard IS: 10500; 2012:

- **pH** of the groundwater samples were recorded in the range of 6.4 to 7.2. The pH values of ground water samples of Likhajan Colony was below the Acceptable Limit of 6.5 to 8.5 while the rest of the ground water samples were in compliance to the IS: 10500, 2012 drinking water standard of 6.5 to 8.5.
- **Turbidity** values in all four of the groundwater samples were below the acceptable limit of 5 NTU.
- **Dissolved Solids** –Concentration of dissolved solids in groundwater ranges between 90-276 mg/l. The values are lower than the acceptable limit of 500 mg/l and were in compliance to the permissible limit 2000 mg/l.

Table 3.13 Result of Ground Water Sampling

Sl No	Parameter	Unit	Desirable Limit	Permissible Limit	GW-1: Dirok Tea Estate	GW-2: Likhajan Colony	GW-#: Vitor Powai	GW-4: Makum Killa
1.	Colour	Hazen	5	25	<1.0	<1.0	<1.0	<1.0
2.	Odour		Agreeable	Agreeable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
3.	Taste		Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
4.	Turbidity	NTU, Max	5	10	<1	<1	3.2	1.7
5.	Ammonia		0.5	No relaxation	<0.1	<0.1	<0.1	<0.1
6.	pH		6.5-8.5	No relaxation	7.2	6.4	6.9	6.9
7.	Dissolved Solids	mg/l	500	2000	90	108	276	168
8.	Total Hardness (as $CaCO_3$)	mg/l	300	600	84	80	188	116
9.	Copper (Cu)	mg/l	0.05	1.5	<0.02	<0.02	<0.02	<0.02
10.	Iron (Fe)	mg/l	0.3	1	<0.05	0.1	2.0	1.6
11.	Manganese (Mn)	mg/l	0.1	0.3	<0.02	<0.02	<0.02	<0.02
12.	Arsenic		0.01	0.05	<0.005	<0.005	<0.005	<0.005
13.	Chloramines (as Cl_2)	mg/l	4	No relaxation	<0.3	<0.3	<0.3	<0.3
14.	Cobalt (as Co)	mg/l			<0.5	<0.5	<0.5	<0.5
15.	Selenium	mg/l	0.01	No relaxation	<0.005	<0.005	<0.005	<0.005
16.	Total Chromium	mg/l	0.05	No relaxation	Not Detected	Detected	Not Detected	Detected
17.	Silver	mg/l	0.1	No relaxation	<0.005	<0.005	<0.005	<0.005
18.	Nitrate (NO_3)	mg/l	45	No relaxation	9.5	9.5	<0.5	<0.5
19.	Fluoride (F)	mg/l	1	1.5	0.12	<0.1	0.13	0.11
20.	Zinc (Zn)	mg/l	5	15	<0.02	<0.02	<0.02	<0.02
21.	Aluminium (Al)	mg/l	0.03	0.2	<0.01	<0.01	<0.01	<0.01
22.	Chlorides (Cl)	mg/l	250	1000	39	35	14	14
23.	Sulphate (SO_4)	mg/l	200	400	<1	<1	<1	<1
24.	Alkalinity as $CaCO_3$	mg/l	200	600	17	38	210	147
25.	Calcium (Ca)	mg/l	75	200	19.0	16.0	8.0	8.0
26.	Magnesium (Mg)	mg/l	30	100	9	10	40	23
27.	Residual free chlorine	mg/l	0.2	1	<0.1	<0.1	<0.1	<0.1
28.	Phenolic Compounds(C_6H_5OH)	mg/l	0.001	0.002	<0.001	<0.001	<0.001	<0.001
29.	Mineral Oils	mg/l	0.01	0.03	<0.01	<0.01	<0.01	<0.01
30.	Anionic detergents (MBAS)	mg/l	0.2	1	<0.02	<0.02	<0.02	<0.02

Sl No	Parameter	Unit	Desirable Limit	Permissible Limit	GW-1: Dirok Tea Estate	GW-2: Likhajan Colony	GW-#: Vitor Powai	GW-4: Makum Killa
31.	Boron (B)	mg/l	0.3	1.5	<0.5	<0.5	<0.5	<0.5
32.	Barium (Ba)	mg/l	0.7	No relaxation	<0.05	<0.05	<0.05	<0.05
33.	Hydrogen Sulphide (as H2S)	mg/l	0.05	No relaxation	<0.01	<0.01	<0.01	<0.01
34.	Mercury (Hg)	mg/l	0.001	No relaxation	<0.001	<0.001	<0.001	<0.001
35.	Cadmium (Cd)	mg/l	0.003	No relaxation	<0.001	<0.001	<0.001	<0.001
36.	Cyanide	mg/l	0.05	No relaxation	<0.01	<0.01	<0.01	<0.01
37.	Lead (Pb)	mg/l	0.01	No relaxation	<0.005	<0.005	<0.005	<0.005
38.	Polynuclear Aromatic Hydrocarbon (PAH)	mg/l	0.0001	No relaxation	<0.0001	<0.0001	<0.0001	<0.0001
39.	Polychlorinated biphenyls (as PCB)	mg/l	0.0005	No relaxation	<0.0005	<0.0005	<0.0005	<0.0005
40.	*E. coli*	/100ml	Shall not be detectable in 100 ml sample	Detected	Not Detected	Not Detected	Not Detected	Detected
41.	Total coliform	MPN/100ml	Shall not be detectable in 100 ml sample	Detected	Not Detected	Detected	Not Detected	Detected
42.	Bromoform	mg/l	0.1	No relaxation	<0.05	<0.05	<0.05	<0.05
43.	Bromodichloromethane	mg/l	0.6	No relaxation	<0.05	<0.05	<0.05	<0.05
44.	Dibromochloromethane	mg/l	0.1	No relaxation	<0.05	<0.05	<0.05	<0.05
45.	Chloroform	mg/l	0.2	No relaxation	<0.05	<0.05	<0.05	<0.05
46.	**Pesticides**							
47.	Alachlor	µg/l	20	-	<0.02	<0.02	<0.02	<0.02
48.	Atrazine	µg/l	2	-	<0.02	<0.02	<0.02	<0.02
49.	Aldrin	µg/l	0.03	-	<0.01	<0.01	<0.01	<0.01
50.	Alpha-HCH	µg/l	0.01	-	<0.01	<0.01	<0.01	<0.01
51.	Beta-HCH	µg/l	0.01	-	<0.01	<0.01	<0.01	<0.01
52.	Butachlor	µg/l	125	-	<0.02	<0.02	<0.02	<0.02
53.	Chlorpyrifos	µg/l	30	-	<0.02	<0.02	<0.02	<0.02
54.	Delta-HCH	µg/l	0.04	-	<0.01	<0.01	<0.01	<0.01
55.	Dieldrin	µg/l	0.3	-	<0.01	<0.01	<0.01	<0.01
56.	2,4-Dichlorophenoxy acetic acid	µg/l	30	-	<0.01	<0.01	<0.01	<0.01
57.	o,p-DDD	µg/l	1	-	<0.01	<0.01	<0.01	<0.01

Sl No	Parameter	Unit	Desirable Limit	Permissible Limit	GW-1: Dirok Tea Estate	GW-2: Likhajan Colony	GW-#: Vitor Powai	GW-4: Makum Killa
58.	o,p-DDE	µg/l		-	<0.01	<0.01	<0.01	<0.01
59.	o,p-DDT	µg/l		-	<0.01	<0.01	<0.01	<0.01
60.	p ,p-DDD	µg/l		-	<0.01	<0.01	<0.01	<0.01
61.	p,p-DDE	µg/l		-	<0.01	<0.01	<0.01	<0.01
62.	p,p-DDT	µg/l		-	<0.01	<0.01	<0.01	<0.01
63.	Alpha -endosulfan	µg/l	0.04	-	<0.01	<0.01	<0.01	<0.01
64.	Beta-Endosulfan	µg/l	0.04	-	<0.01	<0.01	<0.01	<0.01
65.	Endosulfan sulfate	µg/l	0.04	-	<0.01	<0.01	<0.01	<0.01
66.	Ethion	µg/l	3	-	<0.02	<0.02	<0.02	<0.02
67.	Gama-HCH(Lindane)	µg/l	2	-	<0.01	<0.01	<0.01	<0.01
68.	Isoproturon	µg/l	9	-	<0.02	<0.02	<0.02	<0.02
69.	Malathion	µg/l	190	-	<0.02	<0.02	<0.02	<0.02
70.	Methyl parathion	µg/l	0.3	-	<0.02	<0.02	<0.02	<0.02
71.	Monocrotophos	µg/l	1	-	<0.02	<0.02	<0.02	<0.02
72.	Phorate	µg/l	2	-	<0.02	<0.02	<0.02	<0.02

Source: ERM Primary Monitoring

- **Total hardness** (as $CaCO_3$) –The values of total hardness ranged between 80 and 188 mg/l. The values in compliance to the acceptable limit of 300mg/l
- **Chlorides** – The concentration of chlorides ranged between 14 and 39 mg/l. All the stations revealed chloride concentrations in compliance to the acceptable limit of 250 mg/l.
- **Alkalinity as $CaCO_3$**–The alkalinity of the water samples monitored at study area ranged between 17 and 210 mg/l. Alkalinity were reportedly in compliance with the acceptable limit (200 mg/l) at three locations except in Jonghu Kuruka where Alkalinity is slightly higher (210 mg/l)
- **Fluoride**-Fluoride levels in the groundwater samples ranges between <0.1 and 0.13 mg/l. The samples were found to be in compliance to the acceptable limit of 1.0 mg/l.
- **Sulphate**- Sulphate concentrations in the groundwater samples were found to be <1.0 mg/l. Sulphate concentrations in all the samples were found to be within the acceptable sulphate concentration limit of 200 mg/l.
- **Nitrate**-Nitrate concentrations in all groundwater samples were found to be in the range of <0.5-9.5 mg/l. Nitrate concentrations in all the samples were found to be within the acceptable nitrate concentration limit of 45 mg/l.
- **Iron**- Iron- The concentration of iron monitored at 4 locations ranges between <0.05 and 2 mg/l. Iron concentration of the collected water samples were found to be exceeding the acceptable limit of 0.3 mg/l in two water samples. The concentration of Fe beyond 0.3 mg/l affects the taste/appearance, has adverse effect on domestic uses and water supply structures. It also promotes iron feeding bacteria. It has already been reported in CGWB report, 2000 that iron is present in groundwater in exceedance (0.002-0.888 mg/l) to IS: 10500 limits and need treatment before use.
- **Calcium-** The concentration of calcium ranged between 8.0 and 19 mg/l in the study area. Calcium levels at all stations were found to be incompliance to the acceptable limit of 75 mg/l.
- **Magnesium** – The concentration of magnesium was observed to be in the range of 9 and 40 mg/l. Magnesium levels at three stations were found to be incompliance to the acceptable limit of 30 mg/l except in Jaglu Kuruka where it is 40 mg/l.
- **Levels of cyanide** (<0.01 mg/l), mineral oil (<0.01 mg/l), phenolic compounds (<0.001 mg/l), anionic detergents (<0.02 mg/l), were found to be below detection limits in all the groundwater samples.
- **Pesticides** levels in the collected samples were found to be below detection limits.
- **Concentrations of metals** Cd, Cu, Hg, Pb, Mn were found to be below detection limits in the groundwater samples.

- **E. Coli** were detected in one groundwater samples collected from Makum Kila and Total Coliform detected in two sample collected from Makum Kila and Likhajan Colony.

Conclusion

In summary the groundwater quality in the study area were found to be suitable for drinking except in one sample collected from Makum Kila where E. Coli was detected in water sample. Apart from that two samples reveal values of iron in exceedance to the permissible limit. pH values of one groundwater samples were found to be below drinking water standard of IS 10500, 2012.

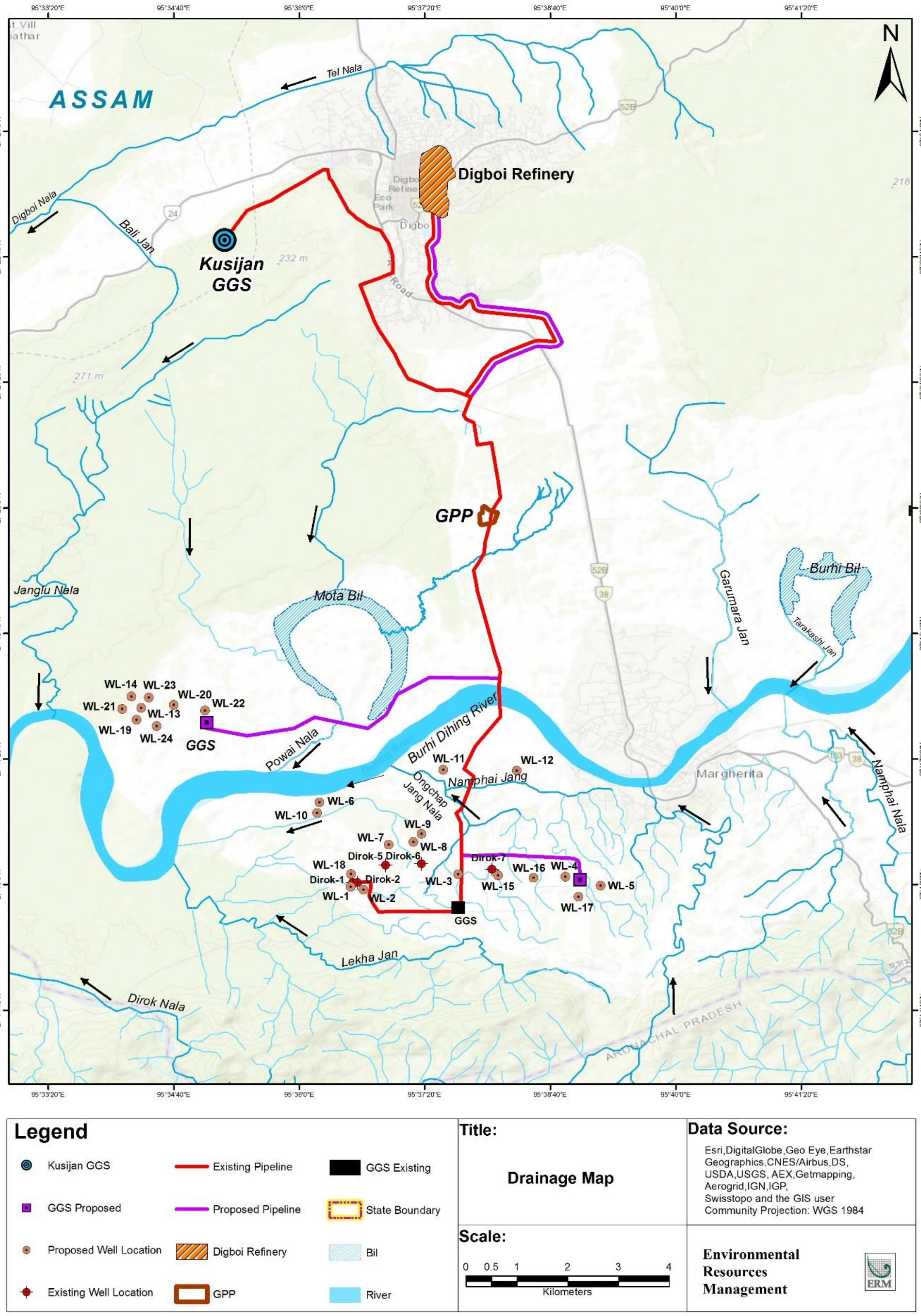
3.3.11 Drainage

The study area falls within the catchment of the Buri Dihing River. The river system originates in the hilly terrain of the Singphome range extending up to Myanmar border on the south east and the Patkai range of hills of Tirap district of Arunachal Pradesh. The total area of the Buri Dihing basin is 8730 sq. kms. Out of the total catchment area, an area of 2465 sq. km. is in district of Dibrugarh and Tinsukia in the State of Assam while the rest 6265 sq km in the district of Tirap, Changlang and Lohit in the State of Arunachal Pradesh. The major tributaries of Buri Dihing are Tirap, Digboi, Tipling, Sessa, Dirak, Namsang and Disam. Apart from these tributaries, there are number perennial and seasonal streams within the study area (viz. Lekhajan nala, Powai nala, Ongchap Jang nala, Namdang nala, Jonghu nala, Garumara Jan etc.) that drains into the Buri Dihing River.

The drainage pattern in this region is dendritic. The drainage density is moderately high indicating more runoff than infiltration. The average annual rainfall in the basin is about 2400 mm. The major amount of rains spread out during the monsoon months from June to September.

The natural slopes in proximity to the drill sites, GGS are crucial to determine the course of surface water drainage at a micro-scale level and may assume significance with respect to the run-off laden with contamination (if any). All the minor drainage channels in the area flow towards Buri Dihing River. The small ephemeral drainage channels near the well cluster and GGS flowing within the Dirok garden discharge to perennial Ongchap Jang and Namphai Jang nala which flow north to meet the Buri Dihing River. The northern tributaries of the Buri Dihing River within the study area are Powai nala, Jonghu nala, Garumara Jan and Tarakashi Jan. Few oxbow lakes are also discernible within the study area viz. Mota Bil, Buri Bil etc. which represent the old course of the Buri Dihing River. The drainage map of the Dirok Development Field is shown in ***Figure 3.18.***

Figure 3.20 Drainage Map



3.3.12 *Surface Water Quality*

Surface water has been monitored at four locations within the study area. The sampling locations have been designed to capture the water quality of the water bodies within the study area that could be impacted due to the proposed drilling and production activities. The surface water monitoring locations in detail has been provided in ***Table 3.14*** and the locations are shown in ***Figure 3.16.***

Table 3.14 Surface water-monitoring locations

Sl No	Location	Station No	Latitude	Longitude
1	Buri Dihing River (Down Stream)	SW 1	27° 16' 51.660" N	95° 34' 47.855" E
2	Buri Dihing River (Up Stream)	SW 2	27° 17' 29.010" N	95° 40' 18.621" E
3	Ongchapjang Nala	SW 3	27° 16' 48.969" N	95° 37' 31.784" E

Source: ERM Primary Monitoring

Water sampling and analysis[1] was done during November 2017 following CPCB standard guidelines for physical, chemical and bacteriological parameters. Field parameters *viz.* temperature, pH, dissolved oxygen were analysed at the site. The results of the samples collected from the drainage channels in the study area have been discussed below with respect to CPCB's Water Use Criteria as provided in ***Annex 3.6***.

Figure 3.21 Photographs of Surface Water Quality Monitoring

	
Surface water sample collection from Ongchapjang Nala	Surface water sample collection from Buri Dihing River

Surface water Monitoring Results

The surface water primary monitoring results have been provided in ***Table 3.16.***

1 http://www.cpcb.nic.in/latest/guidelines-water.doc

Table 3.15 Surface-water Monitoring Results

Sl No	Parameter	Unit	Location		
			SW-1: Buri Dihing River (Down Stream)	SW-2: Buri Dihing River (Up steam)	SW-3: Ongchapjang Nala
1.	Temperature	°C	20	21	23
2.	pH at 25°C	None	7.10	7.30	6.01
3.	Turbidity	N.T.U.	8	2	6
4.	Salinity	In respect to KCl, equivalent salinity 35	0.13	0.16	0.08
5.	Electrical conductivity	µS/cm	283	282	134
6.	Oil and Grease	mg/l	<1.4	<1.4	<1.4
7.	Total Alkalinity (as CaCO3)	mg/l	101	105	34
8.	Dissolved Oxygen	mg/l	.6	7.2	7.8
9.	Biochemical Oxygen Demand (as BOD)	mg/l	<2.0	<2.0	2.4
10.	Chemical Oxygen Demand (COD)	mg/l	<4.0	<4.0	12
11.	Total Dissolved Solids (as TDS)	mg/l	188	190	80
12.	Total Hardness (as CaCO3)	mg/l	96	92	32
13.	Free Ammonia	mg/l	<0.1	<0.1	<0.1
14.	Chloride (as Cl)	mg/l	9.7	9.7	12
15.	Fluoride (as F)	mg/l	0.16	0.16	<0.1
16.	Nitrate (as NO3)	mg/l	<0.5	<0.5	3.4
17.	Sulphate (as SO4)	mg/l	21	19	<1.0
18.	Total Phosphorus	mg/l	<0.05	<0.05	<0.05
19.	Total Nitrogen (as N)	mg/l	<0.3	<0.3	1.4
20.	Arsenic	mg/l	<0.005	<0.005	<0.005
21.	Sodium (as Na)	mg/l	4.7	4.9	2.9
22.	Potassium (as K)	mg/l	1.4	1.5	2.9
23.	Iron (as Fe)	mg/l	0.3	0.4	<0.05
24.	Manganese (as Mn)	mg/l	<0.02	<0.02	<0.02
25.	Copper (as Cu)	mg/l	<0.02	<0.02	<0.02
26.	Zinc	mg/l	<0.02	<0.02	<0.02
27.	Lead (as Pb)	mg/l	<0.005	<0.005	<0.005
28.	Mercury (as Hg)	mg/l	<0.001	<0.001	<0.001
29.	Nickel (as Ni)	mg/l	<0.02	<0.02	<0.02
30.	Boron (as B)	mg/l	<0.5	<0.5	<0.5
31.	Polynuclear Aromatic Hydrocarbons (as PAH)	None	<0.0001	<0.0001	<0.0001
32.	Cadmium (as Cd)	mg/l	<0.001	<0.001	<0.001
33.	Sodium Adsorption Ration (as SAR)	None	0.2	0.22	0.22

Sl No	Parameter	Unit	Location		
			SW-1: Buri Dihing River (Down Stream)	SW-2: Buri Dihing River (Up steam)	SW-3: Ongchapjang Nala
34.	Phenol	mg/l	<0.001	<0.001	<0.001
35.	Hexavalent Chromium (as Cr+6)	mg/l	<0.01	<0.01	<0.01
36.	Faecal coliform	Detected/ Not Detected	Present	Present	Present
37.	Total coliform	MPN/100ml	70	130	1600

Source: ERM Primary Monitoring

Interpretation of Surface water Monitoring Results

Results of the water quality sampled near project site, upstream and downstream of site in Buri Dihing River, Ongchapjang Nala are discussed below:

- **pH** – The pH value of the water samples collected from Buri Dihing River and Ongchapjang Nala between 6.01-7.30.
- Dissolved Oxygen (DO)–DO concentrations of the River water ranged between 7.2-7.8 mg/l.
- **Biochemical Oxygen Demand (BOD)** – The concentration of BOD for all surface water samples were reported to be between <2.0 and 2.4 mg/l.
- **Chemical Oxygen Demand (COD)** – The concentration of COD for all the river water samples was found to be ranging between <4.0-12 mg/l.
- **Coliform bacteria**–the load of total coliform was highest in the water sample of Ongchapjang Nala collected near the project site (1600 MPN/100 ml); followed by Buri Dihing River up stream water sample (130 MPN/100 ml) and Buri Dihing River Upstream (70 MPN/100 ml. Faecal coliform was detected in all the surface water samples.
- **Total Dissolved Solids (TDS)** - The TDS concentrations of River water samples ranged between 80-190 mg/l.
- **Total Suspended Solids** – The suspended solids concentrations of the river water samples ranged between <2.5 – 52 mg/l.
- **Boron**- Boron concentrations were found to be less than 0.5 mg/l for all the samples
- **Sodium Absorption Ratio (SAR)** - Sodium absorption ratio for the river water samples is 0.22
- **Salinity**-Salinity values of the Buri Dihing River and Ongchapjang Nala water samples were found to be varying between 0.08-0.16 (In respect to KCl, equivalent salinity 35).
- **Oil and grease** – The concentration of oil and grease in all the water samples were observed to be less than 1.4mg/l.
- **Concentrations of phenol** (<0.001 mg/l was found to be below detection limit for all the samples.

- **Concentration of metals** like lead (<0.001 mg/l), mercury (<0.001 mg/l), cadmium (<0.001 mg/l), Hexavalent Chromium (<0.01mg/l) were found to be below detection limits for all the samples.
- **Arsenic** – The concentration of Arsenic were found to be less than 0.005 mg/l.
- **Free Ammonia** - The concentration of Free Ammonia were found to be less than 0.1 mg/l.

Conclusion

River water in the area is used for the purpose of bathing and washing clothes (Class B of Designated Best Use Category of CPCB) and for catching fish. Due to presence of Total Coliform Organisms in numbers less than 500 MPN/100 ml, water samples collected from Buri Dihing river is found to suitable for outdoor bathing. The analyzed values reveal that all the samples were in compliance to the CPCB Class D i.e. *Propagation of Wild life and Fisheries*.

3.3.13 Natural Disaster

Assam is prone to natural hazards such as earthquake and flood.

Earthquakes

Assam lies in Zone V, the most severe seismic zone (as per Bureau of Indian Standards (BIS) 2000). The region has experienced a large number of earthquakes of tectonic origin. The risk probabilities of earthquake are less over the entire Brahmaputra valley. Two major earthquakes of magnitude 8.7 (occurred in 1897) and 8.6 (occurred in 1950) causing large scale damage to lives and properties in this region.

3.4 BIOLOGICAL ENVIRONMENT

3.4.1 Introduction

The State of Assam is located in the Bio-geographic zone of both 9A: Brahmaputra Valley and 9B-North-East Hills (Rodgers & Panwar, 1988[1]) and is extremely rich in bio-diversity. Situated in the Indian sub-region of Oriental Zoo-geographic region, local flora and fauna bear a very close affinity and resemblance with floral and faunal components of Indo-Malayan and Indo-Chinese sub-regions.

3.4.2 Objectives

Primary ecological surveys were conducted as a part of this EIA with the following objectives:

- Identification of different types of habitat in the study area;

[1] Rodgers, W.A. and Panwar, S.H. (1988) Biogeographical classification of India. New Forest, Dehra Dun, India.

- Identification of areas protected under international conventions, national or local legislation for their ecological, landscape, cultural or other related value;
- Identification of areas which are important or sensitive for ecological reasons including their breeding, nesting, foraging, resting, over wintering areas including wildlife migratory corridors /avian migratory routes;
- Identification of floral species (terrestrial and aquatic) within the study area;
- Classification of flora for any endangered or protected species or endemic floral species prevailing in study area;
- Identification of fauna (specifically amphibians, birds, mammals and reptiles);
- Identification and classification of any species recognized as threatened (in accordance with International Union for the Conservation of Nature [IUCN] Red List ver. 2017-3), or according to the schedules of the Wildlife (Preservation) Act 1972 and amendments);

3.4.3 Methodology

Desktop Review & Secondary Data Collection

A desktop review (published document, etc.) was conducted to determine the forest area (Toposheet and Satellite imagery), vegetation type (Champion and Seth, 1968), floral and faunal assemblage in the study area. Secondary baseline data regarding sensitive ecological habitat (Wildlife Sanctuary, Ecological Sensitive Area, Migratory Corridor, etc.), flora & fauna in the study area, forest cover was collected from published and unpublished documents. Stakeholder consultations (Forest Department, local people etc.) were also carried out to understand the major flora & fauna in the study area, pressure on forest resources, presence of any Schedule I species.

Baseline & Primary Survey

Baseline survey was carried out to determine the existing ecological conditions and was designed to fill any data gaps, and to facilitate an adequate assessment of the project's impacts upon ecology and the development of appropriate mitigation measures. Baseline survey was conducted during December 2017 for habitat survey, flora & faunal assemblage within study Area.

Primary survey was carried out in the targeted study area for habitats (terrestrial and aquatic), identification of floral and faunal species (terrestrial and aquatic) and related sensitivities. Special attention was paid to those areas (primarily within 1 km of the proposed drill sites and production facilities), which are likely to be impacted by proposed activities.

Floral Analysis

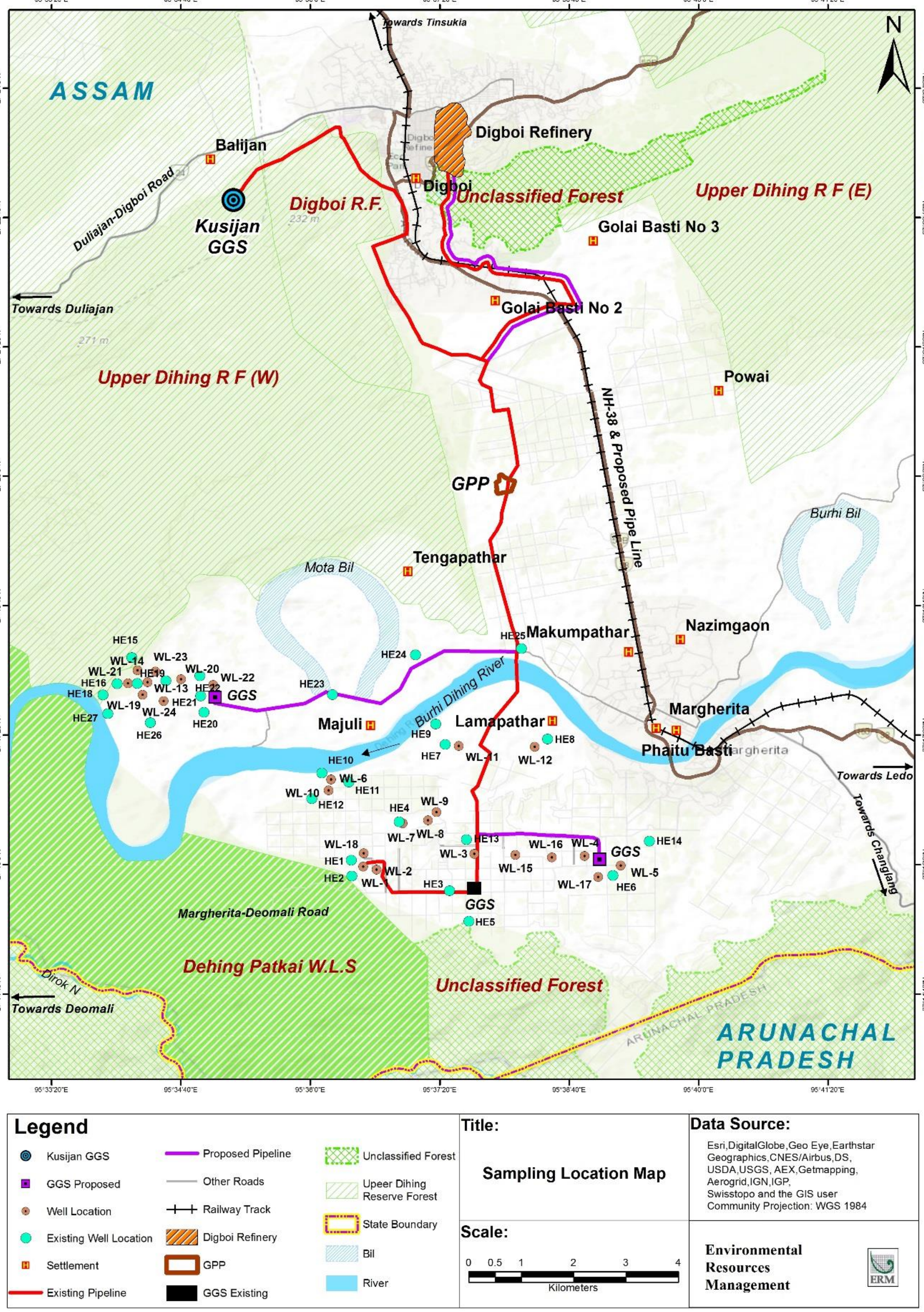
Twenty seven (27) sample plots were studied covering various habitats within study area. The details of the sample plot studied are given in ***Table 3.16*** and ***Figure 3.22.***

Table 3.16 Details of the Sample Plot

Code	Habitat Type	Latitude (Northing)	Longitude (Easting)
HE1	Agriculture	27° 16' 6.556" N	95° 36' 28.640" E
HE2	Homestead Vegetation	27° 15' 57.887" N	95° 36' 25.291" E
HE3	Homestead Vegetation	27° 15' 43.707" N	95° 37' 26.030" E
HE4	Agriculture	27° 16' 26.365" N	95° 36' 54.830" E
HE5	Forest	27° 15' 24.796" N	95° 37' 37.877" E
HE6	Tea Plantation	27° 16' 0.707" N	95° 39' 1.416" E
HE7	Agriculture	27° 17' 14.176" N	95° 37' 30.227" E
HE8	Homestead Vegetation	27° 17' 14.171" N	95° 38' 20.716" E
HE9	Riparian Vegetation	27° 17' 27.956" N	95° 37' 14.331" E
HE10	Riparian Vegetation	27° 16' 56.475" N	95° 36' 6.961" E
HE11	Agriculture	27° 16' 53.222" N	95° 36' 14.398" E
HE12	Tea Plantation	27° 16' 42.658" N	95° 36' 4.666" E
HE13	Tea Plantation	27° 16' 8.987" N	95° 37' 40.594" E
HE14	Tea Plantation	27° 16' 14.323" N	95° 39' 29.540" E
HE15	Forest	27° 18' 3.006" N	95° 34' 10.254" E
HE16	Forest	27° 17' 51.734" N	95° 34' 0.419" E
HE17	Forest	27° 17' 44.795" N	95° 33' 51.639" E
HE18	Homestead Vegetation	27° 17' 54.634" N	95° 34' 11.586" E
HE19	Agriculture	27° 17' 53.484" N	95° 34' 21.123" E
HE20	Agriculture	27° 17' 44.629" N	95° 35' 0.217" E
HE21	Homestead Vegetation	27° 17' 41.407" N	95° 34' 58.122" E
HE22	Homestead Vegetation	27° 17' 56.496" N	95° 34' 51.539" E
HE23	Riparian Vegetation	27° 17' 44.891" N	95° 36' 13.484" E
HE24	Agriculture	27° 18' 9.433" N	95° 37' 4.968" E
HE25	Tea Plantation	27° 18' 13.388" N	95° 38' 10.371" E
HE26	Homestead Vegetation	27° 17' 27.560" N	95° 34' 20.975" E
HE27	Riparian Vegetation	27° 17' 33.907" N	95° 33' 52.355" E

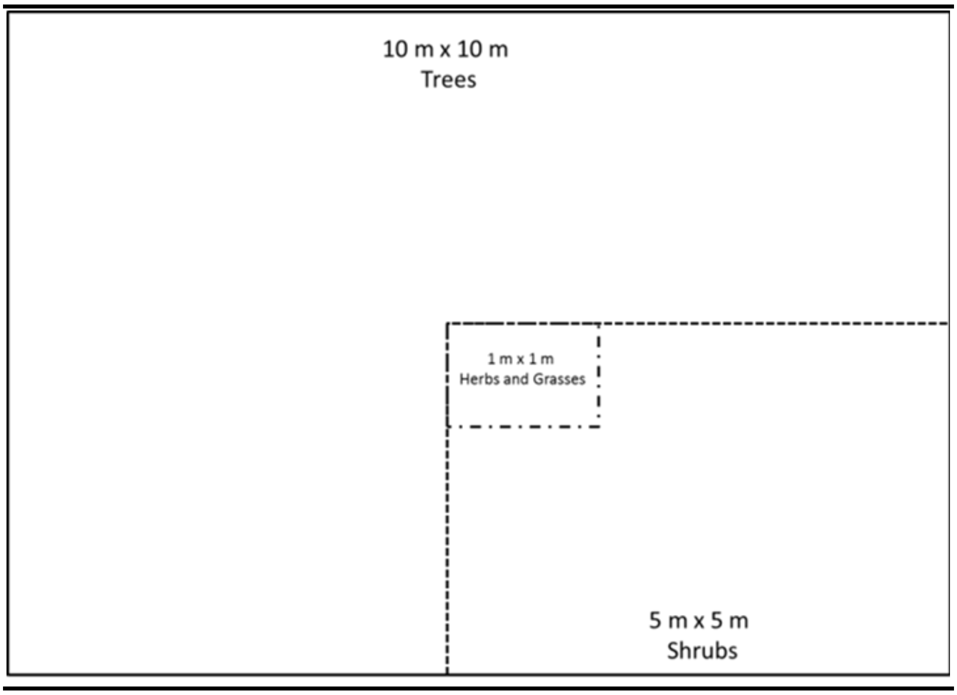
Source: ERM Primary Monitoring

Figure 3.22 Ecological Survey Location Map



Quantitative data was collected using standard quadrate methods of sample plot size 10 m x 10 m for trees, 5 m x 5 m for shrubs and 1 m x 1 m for herbs and grasses. Frequency, Density, Abundance and IVI were calculated. Sample plot is described in ***Figure 3.23***.

Figure 3.23 *Description of Sample Plot*



Species diversity was calculated based on Shannon Weiner Index(1) for the trees, shrubs and herbs.

Phyto-sociological Analysis

Phytosociology provides frequency, abundance, density and Important Value Index (IVI) of plant species. Formulae used for calculating IVIs are provided *in Annex* ***3.7***.

3.4.4 Terrestrial Ecosystem

The terrestrial ecosystem in the study area comprises of natural habitat (forest and riparian vegetation) and modified habitat (tea garden, agricultural land, homestead vegetation, road side plantation).

Forest

Forest Resources

The study Area falls under administrative districts of Tinsukia in Assam. Tinsukia district has 1536 sq. km under the forest cover, i.e. 40.53 percent of its total geographical area. (State of Forest Report 2011, FSI). The land use/ land cover study shows that 202.81 sq. km is under forest. The forest area

(1) Shannon CE & W Weaver 1949 The Mathematical Theory of Communication. University of Illionis Press. Urbana, IL USA.

comprises of Wildlife Sanctuary, Reserve Forest and Unclassed forest. The proposed facilities are falling in the forest area.

Forest Types

Owing to the huge amount of annual rainfall, forest types occurring in this region are primarily of Tropical Evergreen Forest and Tropical Semi-Evergreen Forest (Champion and Seth Forest classification).

Tropical Evergreen Forests: This type of forest is mainly a two storied forest with the main constituents being *Dipterocarpus turbinatus* (Garjan), *Palaquim polyanthum*, *Polymorphum*, *Cynometra pollyandra, Dyspyros spp., Mesua euginias, Euphorbia longana, Sapium baccatum,Vatica lancefolia, Canarium spp., Hereteria acuminata, Kayea floribunda* and a host of other species.

Tropical Semi- Evergreen Forests: This type of forest comprises of mixed forest of evergreen and deciduous species. Main species of this type of forests include *Artocarpus chaplasha*, *Dipterocarpus turbinatus* (Garjan), *Palaquim spp., Tetrametes nudifilora, Adina cordifolia, Protcum serratum, Albizzia procera, Permna bengalensia, Gmelina arborea, Bombax insignis, Streprospermum* etc.

Riparian Vegetation

Vegetation along riverbanks of Buri Dihing and its tributaries like Lekhajannala, Powai nala, Janglu nala, Ongchap Jang nala, etc. within the study area provided the habitat for riparian vegetation. The species like *Anthocephalus sinensis, Alstonia scholaris, Bombax ceiba, Ficus hispida*, *Syzygium cumini, Gmelina arborea* etc., are recorded during survey.

Roadside Plantation

Trees planted along the major roads in the study area. Some important tree species are *Alstonia scholaris, Aegle mermelos, Melia azedarach, Artocarpus heterophyllus, Samanea saman, Bombax ceiba, Ficus religiosa, Lagerstroemia speciosa*.

Homestead Vegetation

Naturally or planted trees on community or private land within the settlement areas. Bamboo and timber woods are planted in this area. Some important tree species are *Mangifera indica, Melia azedarach, Aegle mermelos, Delonix regia, Ficus religiosa, Syzygium cumini, Gmelina arborea, Areca catechu,* etc.

Tea Garden

The total tea garden area in the study area is 48.7 sq. km. Most of the tea gardens have shade trees and plantation along the garden roads. These are mostly nitrogen fixing plant species, viz. *Albizia* sp., other species include *Gmelina arborea, Areca catechu, Artocarpus heterophyllus* etc.

Agricultural Land

The study area falls under Upper Brahmaputra Valley Zone Agro-climatic zone. The land use/ land cover study shows that approximately 27.43 sq. km area is agricultural land. The agriculture land in the study area is rainfed area; and *Kharif cultivation* has been carried out. The major crops cultivated in the area are Paddy, Maize, Blackgram, Sesamum and Arhar.

Figure 3.24 Photographs of Different Type of Habitats in the Study Area

Upper Dihing Reserve Forest

Upper Dihing Reserve Forest

Riparian Vegetation near Buri Dehing River

Homestead Plantation at Vitor Powai

Agricultural Land- Vitor Powai

Tea Plantation- Dirok Tea Estate

Floral Diversity

Due to diverse physiography, edaphic and climatic condition, Assam boasts of profuse diversity of floristic elements. Floral diversity of the different habitats within the study area is presented below

Natural Habitat: Forest

Forest within the study Area include the reserve forests viz. Upper Dehing Reserve Forest, Digboi Reserve Forest and Dehing-Patkai Wildlife Sanctuary. Vegetation observed within the reserve forest areas include the top canopy with species viz. *Dipterocarpus macrocarpus*, *Amoora wallichii, Terminalia myriocarpa, Artocarpus chaplasha e*tc. Middle canopy is dominated by *Mesua ferrea, Terminalia belerica, Terminalia chebula,* etc. Bamboo species such as *Dendrocalamus hamiltonii*, *Pseudostachyum polymorphum* and climbers such as *Derris oblonga* are common.

Modified Habitat

The tree species recorded in the modified habitat (homestead plantation, tea garden, road side plantation) are *Alistonia scholaris, Zizyphus jujube, Anthrocephalus sinensis, Azadirachta indica, Acacia auriculoformis, Artocarpus heterophyllus, Delonix regia, Phyllanthus embilica, Ficus religiosa, Mangifera indica, Lagerstroemia speciose, Aegle marmelos, Dalbergia sisso, Ficus religiosa, Ficus bengalensis, Gmelina arborea* etc.

Floral Diversity

255 numbers of plant species has been recorded from the area, which includes 103 species of trees, 46 species of shrubs, 72 species of herbs and grasses, 34 species of climbers and woody climbers. The detailed listing of floral species recorded in the study area is given in ***Annex 3.8.***

Endemic, Threatened & Endangered Floral Species

The Wildlife (Protection) Act 1972 prohibits picking, uprooting, damaging, destroying, acquiring or collecting six species of plants from forest land and any area specified, by notification, by the Central Government [Clause 17A of Chapter IIIA (Protection of Specified Plants), page 346 of Handbook Vol. 1]. The six species are: Beddome's cycad (*Cycas beddomei*), Blue Vanda (*Vanda coerulea*), Kuth (*Sassurea lappa*), Ladies slipper orchids (*Paphiopedilum* spp.), Pitcher plant (*Nepenthes khasiana*), Red Vanda (*Renanthera imshootiana*). None of these species is recorded in the forests of the study area during the EIA.

Phytosociological Analysis

Out of the total four enumerated tree species from tea plantation areas maximum relative density and IVI values were observed for *Albizia chinensis (*RD-53.85/IVI-109.3*)* followed by *Albizia lebbek* (RD-31.6/IVI-63.3) and *Albizia procera* (RD-14.6/IVI- 32.0).

Out of the total fourteen enumerated tree species from homestead vegetation areas maximum relative density was observed for *Areca catechu* (21.67), followed by *Lagerstroemia speciosa* (13.33) and *Livistona jenkinsiana* (10.10*)*. Highest IVI value was recorded for *Lagerstroemia speciosa* (31.4*)* followed by *Areca catechu* (25.9*)* and *Livistona jenkinsiana (*22.3*)*.

Out of the total eight enumerated tree species from riparian vegetation maximum relative density and IVI values were observed for *Syzygium cumini*

*Bombax ceiba (*RD-25.00/IVI-51.3*)* followed by *Lagerstroemia speciosa* (RD-20.00/IVI-43.7) and *Bombax ceiba* (RD-15.00/IVI-35.9).

Out of the total ten enumerated tree species from agricultural lands maximum relative density was observed for *Lagerstroemia speciosa* and *Ailanthus excelsa* (15.79). Highest IVI was recorded for *Ficus religiosa* (38.5) followed by *Lagerstroemia speciosa* (27.4) and *Ailanthus excelsa* (26.1).

Out of the total fourteen enumerated tree species from forest areas maximum relative density and IVI values were observed for *Bombax ceiba* (RD-15.15/IVI-33.5) followed by *Lagerstroemia speciosa* (RD-12.12/IVI-27.3).

The list of tree species and their ecological parameters are given in *Error! Reference source not found.*

Table 3.17 Phytosociology of Tree species within the Study Area

Plant Species	Relative Frequency	Relative Density	Relative Dominance	IVI
Tea Plantation				
Albizia lebbeck	1.0	30.77	31.6	63.3
Albizia procera	2.0	15.38	14.6	32.0
Albizia chinensis	1.8	53.85	53.7	109.3
Homestead Plantation				
Areca catechu	2.2	21.67	2.1	25.9
Melia azedarach	1.3	8.33	10.0	19.6
Terminalia chebula	1.0	3.33	4.5	8.8
Lagerstroemia speciosa	1.3	13.33	16.8	31.4
Gmelina arborea	1.3	6.67	5.9	13.9
Alstonia scholaris	1.0	5.00	4.3	10.3
Mangifera indica	1.0	5.00	5.2	11.2
Thespesia populnea	1.0	1.67	1.1	3.8
Phoenix sylvestris	1.0	3.33	3.7	8.0
Livistona jenkinsiana	1.2	10.00	11.1	22.3
Ficus hispida	1.3	6.67	11.6	19.6
Dillenia indica	1.0	3.33	3.7	8.1
Mesua ferrea	1.5	5.00	2.8	9.3
Ailanthus grandis	1.0	3.33	5.2	9.6
Ficus religiosa	1.0	3.33	11.9	16.2
Riparian Vegetation				
Ficus hispida	1.0	10.00	9.6	20.6
Ziziphus mauritiana	1.0	5.00	1.4	7.4
Lagerstroemia speciosa	1.3	20.00	22.3	43.7
Gmelina arborea	1.0	10.00	5.0	16.0
Ficus religiosa	1.0	5.00	9.2	15.2
Alstonia scholaris	1.0	10.00	7.9	18.9
Bombax ceiba	1.0	15.00	19.9	35.9
Syzygium cumini	1.3	25.00	25.1	51.3
Agricultural land				

Plant Species	Relative Frequency	Relative Density	Relative Dominance	IVI
Ziziphus mauritiana	1.0	5.26	1.1	7.4
Bombax ceiba	1.0	10.53	12.4	24.0
Ficus religiosa	1.0	10.53	27.0	38.5
Ficus benghalensis	1.0	5.26	15.6	21.9
Ailanthus excelsa	1.0	15.79	9.3	26.1
Syzygium cumini	1.0	10.53	7.6	19.1
Lagerstroemia speciosa	1.0	15.79	10.6	27.4
Ficus hispida	1.0	5.26	5.0	11.3
Dillenia indica	1.0	10.53	6.1	17.7
Mesua ferrea	1.0	10.53	4.6	16.1
Forest				
Lagerstroemia speciosa	1.3	12.12	13.8	27.3
Gmelina arborea	2.0	6.06	5.5	13.5
Artocarpus chaplasha	1.0	9.09	14.0	24.1
Bombax ceiba	1.7	15.15	16.6	33.5
Terminalia bellirica	1.0	3.03	3.0	7.0
Dipterocarpus macrocarpus	1.5	9.09	9.8	20.4
Ailanthus grandis	1.0	3.03	2.6	6.7
Ailanthus excelsa	1.5	9.09	6.8	17.4
Dillenia indica	2.0	6.06	5.6	13.6
Mesua ferrea	1.0	6.06	3.9	11.0
Syzygium cumini	1.0	6.06	4.6	11.7
Duabanga grandiflora	1.0	6.06	5.4	12.4
Oroxylum indicum	1.0	6.06	4.9	12.0
Neolamarckia cadamba	1.0	3.03	3.2	7.2

Source: ERM Primary Survey

Shrubs in the study area were represented by thirteen species. *Camelia sinensis* was found to be the most dominant species having highest relative density as recorded at tea plantation areas. *Lantana camara* was dominant with high relative density in homestead vegetation, agricultural lands and ripariang vegetation areas while *Ocimum tenuiflorum* was dominant in forest lands.

The list of shrub species and their ecological parameters are given in ***Table 3.18***.

Table 3.18 Phytosociology of Shrub species

Plant Species	Relative Frequency	Relative Density	RVI
Tea Plantation			
Melastoma malabathricum	1.0	2.04	3.0
Lantana camara	1.3	4.08	5.4
Camelia sinensis	18.4	93.88	112.3
Homestead Plantation			
Melastoma malabathricum	1.5	8.82	10.3
Hibiscus rosa-sinensis	1.3	14.71	16.0
Lantana camara	1.5	26.47	28.0

Plant Species	Relative Frequency	Relative Density	RVI
Camelia sinensis	1.3	11.76	13.1
Datura strontium	1.0	2.94	3.9
Nerium indicum	1.0	8.82	9.8
Nyctanthes arbor tristis	0.3	2.94	3.3
Ricinus communis	1.5	17.65	19.1
Riparian vegetation			
Lantana camara	3.5	45.16	48.7
Tamarix sp.	1.0	3.23	4.2
Ricinus communis	3.5	22.58	26.1
Ocimum tenuiflorum	2.3	29.03	31.3
Agricultural land			
Ocimum tenuiflorum	1.8	29.73	31.6
Lantana camara	4.0	54.05	58.1
Nerium indicum	1.5	16.22	17.7
Nyctanthes arbor tristis	1.3	10.81	12.1
Ricinus communis	1.8	18.92	20.7
Forest			
Phlogacanthus sp	1.5	6.67	8.2
Lantana camara	3.0	20.00	23.0
Ocimum tenuiflorum	3.0	26.67	29.7
Cleodendron viscosum	3.0	13.33	16.3
Solanum indicum	1.0	4.44	5.4
Datura strontium	1.0	6.67	7.7
Nerium indicum	1.3	8.89	10.2
Nyctanthes arbor tristis	1.0	4.44	5.4
Ricinus communis	2.0	4.44	6.4
Tamarix sp.	1.0	4.44	5.4

Source: ERM Primary Survey

Herbs and fern species in the study area are represented by seventeen species. *Ageratum conyzoids*, *Oxalis corniculata, Parthenium* sp., *Leucas aspera* and *Dryopteris filix-ma*s were found most dominant herb species in tea plantation areas. *Parthenium* sp. was found to be the most dominant species in homestead vegetation. *Ageratum conyzoids* was found to be the most dominant species in riparian vegetation, agricultural lands and forest areas. The list of herbs species and their ecological parameters are given in ***Table 3.19.***

Table 3.19 Phytosociology of Herbs

Plant Species	Relative Frequency	Relative Density	RVI
Tea Plantation			
Ageratum conyzoids	1.0	20.00	21.0
Oxalis corniculata	1.0	20.00	21.0
Parthenium sp.	1.0	20.00	21.0
Leucas aspera	1.0	20.00	21.0
Dryopteris filix-mas	1.0	20.00	21.0

Plant Species	Relative Frequency	Relative Density	RVI
Diplazium esculentum	1.0	10.00	11.0
Polygonum sp.	1.0	10.00	11.0
Homestead Vegetation			
Ageratum conyzoids	1.5	7.69	9.2
Oxalis corniculata	1.0	7.69	8.7
Parthenium sp.	2.0	25.64	27.6
Mimosa pudica	1.5	15.38	16.9
Colocasia esculenta	1.3	12.82	14.1
Polygonum sp.	1.3	12.82	14.1
Centella asiatica	1.0	7.69	8.7
Dryopteris filix-mas	1.3	10.26	11.6
Riparian Vegetation			
Ageratum conyzoids	3.5	31.82	35.3
Eupatorium odoratum	1.5	6.82	8.3
Parthenium sp.	1.8	15.91	17.7
Eclipta alba	1.5	6.82	8.3
Ranunculus sceleratus	1.0	4.55	5.5
Ipomoea fistulosa	2.0	13.64	15.6
Phragmites karka	2.3	20.45	22.7
Agricultural lands			
Ageratum conyzoids	1.2	22.58	23.7
Leucas asperra	1.3	12.90	14.2
Colocasia esculenta	1.3	12.90	14.2
Eupatorium odoratum	1.0	9.68	10.7
Parthenium sp.	1.7	16.13	17.8
Eclipta alba	1.5	9.68	11.2
Ipomoea fistulosa	1.3	16.13	17.4
Forest			
Eupatorium odoratum	1.5	9.09	10.6
Ageratum conyzoids	3.0	27.27	30.3
Oxalis corniculata	1.0	6.06	7.1
Leucas asperra	1.5	9.09	10.6
Dryopteris filix-mas	1.0	9.09	10.1
Diplazium esculentum	1.0	6.06	7.1
Pteris sp.	1.0	6.06	7.1
Spilanthes acmella	1.5	9.09	10.6
Parthenium sp.	1.3	12.12	13.5
Mimosa pudica	1.0	6.06	7.1

Source: ERM Primary Survey

Species Richness

The species richness of the different habitats was calculated based on total number of species. Species richness was highest for homestead plantation (47 plant species) followed by agricultural and forest (28 plant species each), tea plantation (16 plant species). Species richness was lowest for riparian with 16 plant species.

Species Diversity

The species diversity [1] is calculated based on Shannon Weiner Index (H'). The H' values calculated for different habitat types are presented in ***Table 3.20***. Highest diversity value was observed for forest lands (H'=2.4349) followed by homestead vegetation (H'=2.216), tea plantation (H'=2.100) and riparian vegetation (H'=1.898).

Table 3.20 Species Richness and diversity within Study Area

Sl No.	Habitat Type	Total no. of plots studied	Species Richness	Shannon Weiner Index (H')
1	Tea plantation	5	13	2.100
2	Homestead vegetation	7	31	2.216
3	Riparian vegetation	4	19	1.898
4	Agricultural lands	7	22	2.139
5	Forest lands	4	34	2.434

Source: ERM Primary Survey

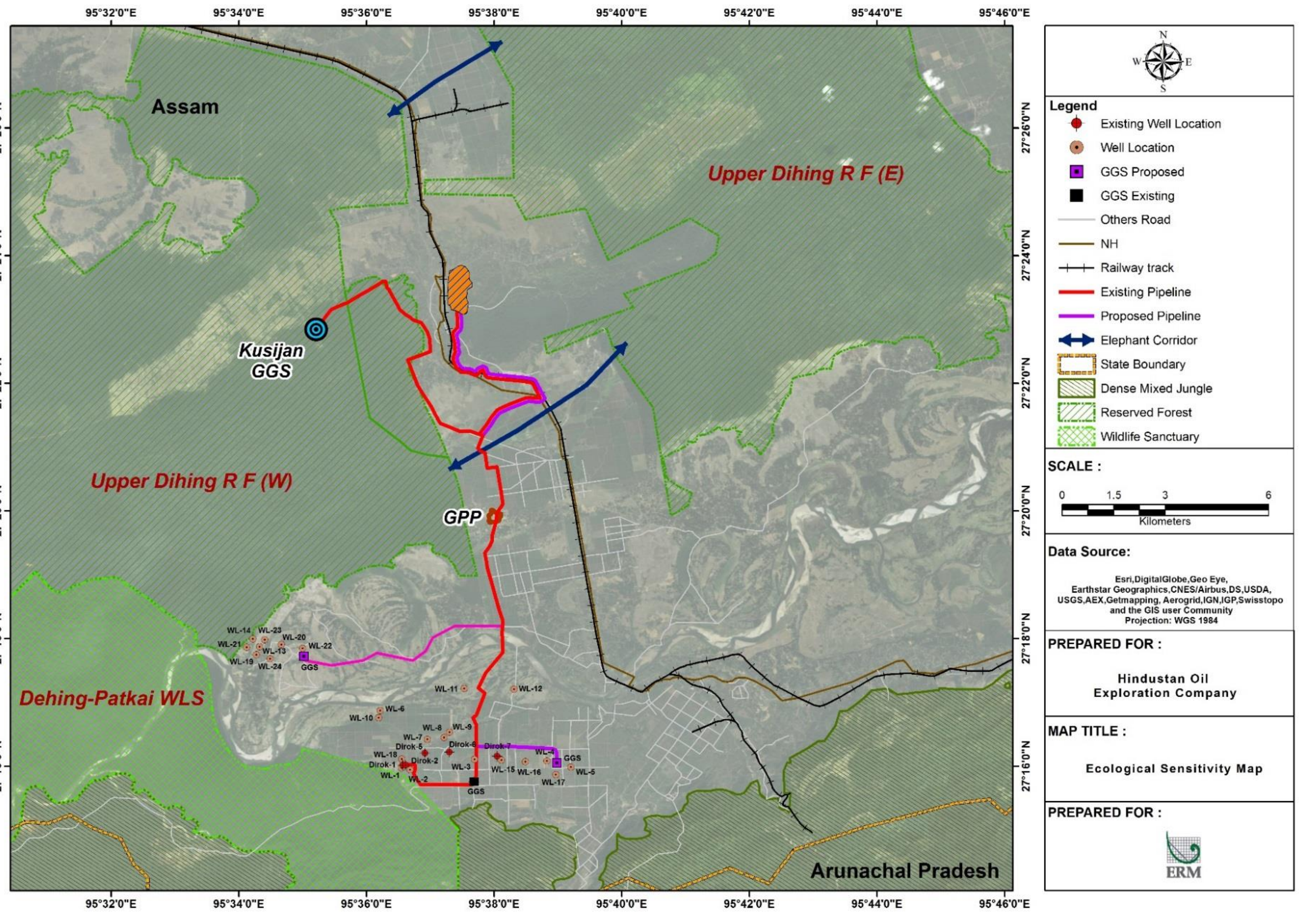
The Importance Value gives an overall estimate of the influence of importance of a plant species in the community. It can be interpreted from the phytosociological survey that *Albizia chinensis* was found to be the most dominant plant species in the tea plantation area, *Lagerstroemia speciosa* in homestead vegetation and agricultural lands, *Syzygium cumini* in riparian vegetation areas and *Bombax ceiba* in forest lands. All the habitat excepting the riparian vegetation areas showed high H' values which indicate diverse plant communities, a greater number of successful species and ecologically stable ecosystems. Lesser diversity index value for the tea plantation areas are primality due to the plantation of tea plants and shade trees (*Albizia* sp.) Among the habitat types under study the forest areas showed most diverse ecosystem compare to the other habitat types.

(1) On the diversity scale, biologically r3ealistic H' values range from 0 (only one species present with no uncertainty as to what species each individual will be) to about 4.5 (high uncertainty as species are relatively evenly distributed). In theory, the H'value can be much higher than 4.5, although most real world estimates of H' range from 1.5 to 3.5

Wildlife Habitat

A significant part of the study area falls within the western part of Upper Dihing Reserved forest and Dehing Patkai Wildlife Sanctuary. Two Elephant Corridors between Upper Dihing R. F. East and West Blocks at Bogapani and Golai-Powai are located within the study area on the eastern boundary. Apart from the protected areas tea garden plantation covers huge tracts of land within the study Area as well as in the surrounding region. As tea gardens have very low human population density and settlement within them are isolated and patchy, tea gardens acts as wildlife movement corridor between isolated protected areas, as well as habitat for huge diversity of avian fauna and even large cats like leopards. Wells located within the eco-sensitive zones (10 km radius from the boundary of the wildlife sanctuary) are presented at the ***Table* 2.2**. The eco-sensitive map of study area along is shown at ***Figure 3.25***.

Figure 3.25 Ecological Sensitivity Map



Prevailing flora and fauna of Dehing Patkai WLS is presented in ***Box 3.1***.

Box 3.1 Dehing Patkai Wildlife Sanctuary

Dehing Patkai Wildlife Sanctuary

The Sanctuary with an area of 111.19 sq. kms. is located in Dibrugarh and Tinsukia districts and is famous for Assam Valley Tropical Wet Evergreen Forests bordering Arunachal Pradesh. It includes part of Jeypore RF, Upper Dihing RF and is part of the Dihing-Patkai Elephant Reserve. The Dehing Patkai forms the largest stretch of tropical low-land rainforests in India.

The different trees of this four layered rainforest are laden with many exotic species of orchids. There is an abundance of ferns, epiphytes, Wild Banana, orchids, Arums, climbers and linas in this humid forest habitat. Some of the importance tree species found in this forest area are – Hollang, Mekai, Dhuna, Udiyam, Nahar, Samkothal, Bheer, Hollock, Nahor, Au – tenga (elephant apple), different species of Dimoru etc. The towering Hollong tree which is also the state tree of Assam dominates the emergent layer of this rainforest. The forests are wet tropical evergreen Assam valley forests. The important species of overwood are *Dipterocarpus mncrocarpus, Mesua ferrea, Castanopsis indica, Shorea assamica, Vatica lanceaefolia, Amoora wallichii, Dysoxylum hinectiferum etc.* The other species found in under storey are *Garcinia lanceaefolia, Michelia muni, Baccaureu supida, Bischqfia javanica, Myristica limifolia* etc. The shrub and herb layer has *Glochidion* spp., *Alpinia* spp., *Mallotus philippinensis*, Wild Banana, Tree fern, Pepper etc. The ground cover mainly has *Melanstoma*, *Leea* and other species. So far, 101 species of orchids within 45 genera have been recorded there. Of these, 79 are epiphytic, 21 are terrestrial and 1 species is a saprophyte. Eight of the species found here are critically endangered, 15 species are endangered, 5 species are near threatened and 28 species are in the vulnerable category.

Huge diversity of Mammals of Oriental as well as Malayan origin can be found in this WLS, like Chinese pangolin, Flying fox, Slow loris, Stump-tailed macaque, Assamese macaque, Rhesus macaque, Capped langur, Hoolock gibbon, Malayan Sun bear, Hog –badger Wild pig, Sambar, Barking deer, Gaur, Serow, Malayan giant squirrels, Porcupine, Pig-tailed macaque [1]etc. More over recent camera trapping in Dehing Patkai WLS have confirmed the co-existence of seven wild cats in the forest of this region, namely clouded leopard (*Neofelis nebulosa*), marbled cat (*Pardofelis marmorata*), and golden cat (*Catopuma temminckii*), tiger (*Panthera tigris*), leopard (*Panthera pardus*), leopard cat (*Prionailurus bengalensis*), and jungle cat (*Felis chaus*).

Birds like Lesser Adjutant Stork, White Winged Wood duck, White-backed Vulture, Slender-billed Vulture, White cheeked Hill Partridge, Khaleej Pheasant, Grey Peacock-Pheasant, Rufus necked Hornbill, Wreathed Hornbill, Great Pied Hornbill, Beautiful Nuthatch, Black-browed Leaf Warbler, Green Imperial Pigeon, Purple wood or Pale capped Pigeon etc can be found in this forest.

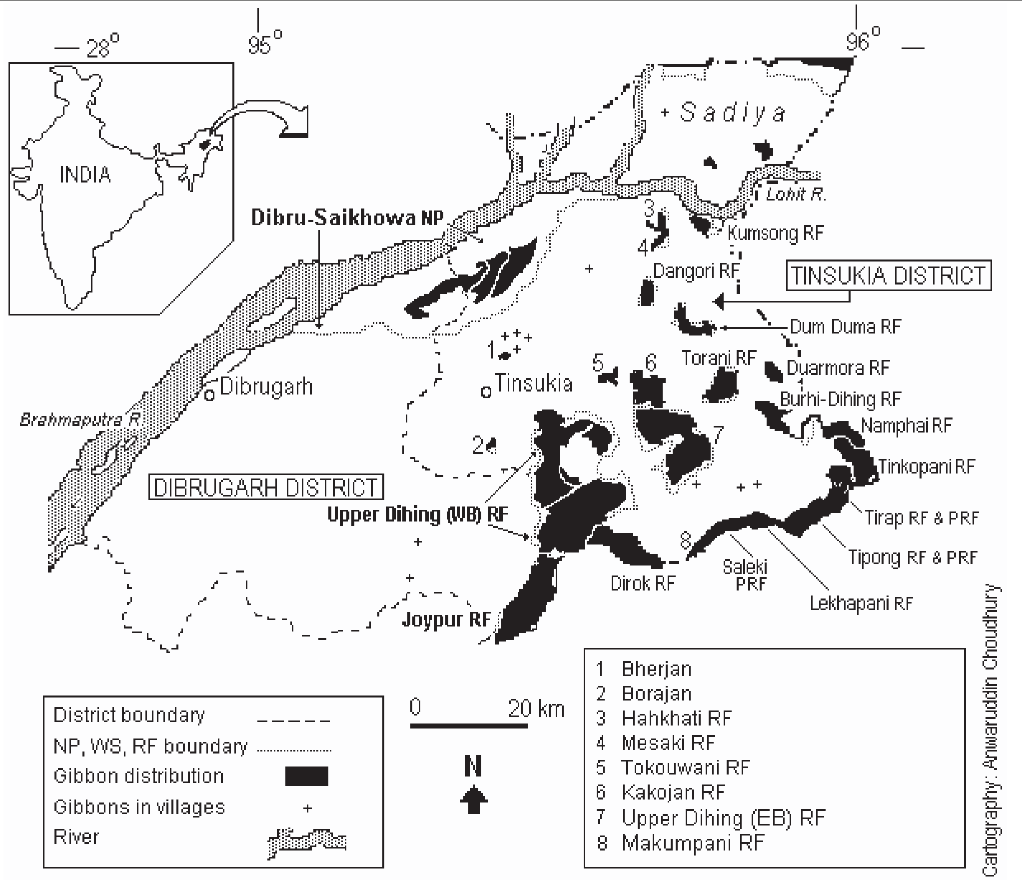
Source: Department of Environment & Forests, Govt. of Assam

The different animal habitats observed at the study area are described below:

[1] Dehing Patkai Wildlife Sanctuary, Department of Environment & Forests, Govt. of Assam

Primate Habitat: The tropical wet evergreen forests provide an ideal habitat for primate species. Within the study area Hoolock gibbon (*Hylobates hoolock*) population is present within the Dehing Patkai WLS, Upper Dehing reserve Forest areas. In the Reserve Forest and Wildlife Sanctuary other primates like Assamese macaque (*Macaca assamensis),* Pig tailed macaque (*Macaca nemestrina),* Rhesus macaque (*Macaca mulatta),* Capped Langur (*Presbytis pileatus),* are also reported. Species which are not strictly confined to top canopy like Rhesus macaque and Assamese Macaque can be found throughout the study area, including in proximity to the settlements.

Figure 3.26 Hoolock gibbon habitat in Tinsukia and Dibrugarh districts



Source: Anwaruddin Choudhury; The Hoolock Gibbon (Hoolock hoolock) in Tinsukia and Dibrugarh districts of Assam, India, Asian Primates Journal 1(2), 2009.

*Carnivores***:** The lesser carnivores like, Leopard Cat (*Prionailurus bengalensis*), Jungle Cat (*Felis chaus*), Large Indian Civet (*Viverra zibetha*), Small Indian Civet (*Viverricula indica*), Indian Fox (*Vulpes bengalensis*), Common Mongoose (*Herpestes edwardsi*), small Indian Mongoose (*Herpestes auropunctatus*) etc. has been reported in the Forest Working Plan and reported by the locals. Larger carnivore like Leopard (*Panthera pardus*) has been also reported by the locals during consultation and recorded at the Forest Working Plan. A large portion of the study area is under tea garden plantation. These large tea garden plantations also act as leopard habitat. Leopards prefer residing in surrounding tea gardens where prey in the form of dogs and livestock is available.

Herbivores: Elephants are herbivores that favour bamboo, berries, mangoes, bananas, shrubs, fruits etc. They prefer thick forests with abundant food and shade. They also like muddy areas and swamps. The Dehing Patkai Wildlife Sanctuary and it surrounding reserve forest area has a substantial population of the Asiatic Elephant (*Elephas maximus).* The Dihing Patkai Elephant Reserve with total area of 937 sq. km. and a total of 295 wild elephants. There was evidence of regular movement of elephant herds in the Upper Dihing Reserved forest of the Field.

Elephant Corridor

Dehing Patkai Elephant Reserve – Dehing Patkai Elephant reserve[1] falls within the Eastern South Bank Landscape of Elephant range in India. The Eastern South Bank occupy about 4500 sq. km of forest on the Southern bank of Brahmaputra river. 937 sq. km of forest land within Tinsukia and Dibrugarh district adjoining Arunachal Pradesh and Nagaland was declared Dehing Patkai Elephant Reserve on 17th April 2003. The Elephant reserve gets its name from the two most dominant geographical features in the landscape, the Buri Dehing River and the Patkai Hills. Dehing Patkai Wild life Sanctuary, Upper Dehing West and East Block Reserve Forest and Digboi Reserve Forest are part of the Dehing Patkai Elephant Reserve. According to the 2005 elephant population census, 295 elephants were found in the Dehing Patkai Elephant Reserve. Elephants from Digboi Forest Divisions move to forest areas of Changlang district of Arunachal Pradesh near Buri Dihing River. Movement between Upper Dihing East and West block takes place mainly through tea gardens and agricultural land. There are two elephant corridor between Upper Dehing East Block and Upper Dehing West Block. One of the corridor, the Golai Powai elephant corridor falls within the Study area.

Elephant Corridor- Upper Dihing East-Upper Dihing West Block at Bogapani: This corridor lies between the Upper Dihing East and West block of forestland and passes through Bogapani tea estate and a few settlements. Tea gardens, heavy traffic of NH-38 and a railway line (Digboi-Tinsukia) are the major impediments for elephant movement. The length and width of the corridor is 3.0 km and 0.5 km respectively. The frequency of usage of the corridor by elephant is regular (seasonal).

Elephant Corridor- Upper Dihing East-Upper Dihing West Block between Golai-Pawai: This corridor facilitates elephant movement between the Upper Dihing East and West blocks. The length and width of the corridor is 6-7 km and 0.5 km respectively. The frequency of usage of the corridor by elephant is regular.

Birds - Assam harbours a highly diverse bird life. Choudhury (2000)[2] has listed 820 bird species from the State, which include some 280 migrants from the northern latitudes. This richness and diversity in bird species is due to the fact that the northeast India and Assam in particular, is a meeting place of two

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[1] The report of the Elephant Task Force, Ministry of Environment and Forests, August 31, 2010.
[2] Anwaruddin Choudhury.2000. The Birds of Assam. Gibbon Books. WWF North East Regional Office.

zoogeographic sub regions, the Indian and the Indo-Chinese, within the framework of the Oriental (or Indo-Malayan) Zoogeographic Region (Choudhury 2000).

Faunal Diversity

Amphibians

A total of four species of amphibians were observed or identified during consultation with local villagers within 1 km of the proposed well sites and production facilities. None of the species bear any conservational significance. The details of the species are given in ***Table 3.21***.

Table 3.21 Amphibians observed/reported from the study Area

Sl. No.	Scientific Name	Common Name	Source	Wildlife Schedule	IUCN Category
1	*Duttaphrynus melanostictus*	Common Indian Toad	CC, PS	-	LC
2	*Hoplobactrachus tigerinus*	Common Indian Bull Frog	CC, PS	V	Not assessed
3	*Limnonectus limnocharis*	Field Frog	CC, PS	-	Not assessed
4	*Ploypedates sp.*	Tree Frog	CC	-	Not assessed

Notes: PS- Primary survey by ERM; CC-Community Consultation; Schedule – V (Indian Wildlife Protection Act -1972); LC-Least Concern, (IUCN Version 2017-3)

Reptilian Species

Reptilian fauna recorded/reported within 1 km of the well sites and production facilities during primary survey include *Python molurus*, *Bungarus fassiatus*, *Ptyas mucosus*, *Calotes versicolor* and *Mabuya carinata etc*. The details of reptiles are given in ***Table 3.22.***

Table 3.22 Reptiles observed/reported from the study Area

Sl. No.	Scientific Name	Common Name	Source	Wildlife Schedule	IUCN Category
1.	*Bungarus fasciatus*	Banded krait	CC	II	LC
2.	*Calotes versicolor*	Common garden lizard	PS	-	LC
3.	*Hemidactylus flaviviridis*	House wall lizard	PS	-	LC
4.	*Mabuya carinata*	Common skink	CC, PS	-	LC
5.	*Naja naja*	Indian cobra	CC	II	LC
6.	*Ptyas mucosus*	Rat snake	CC	II	LC
7.	*Python molurus*	Indian rock python	CC	I	NT
8.	*Varanus bengalensis*	Bengal Monitor Lizard	FD,CC	I	Least Concern

Notes:; PS- Primary survey by ERM; CC-Community Consultation; Schedule – I-III (Indian Wildlife Protection Act -1972); LC-Least Concern, (IUCN Version 2017-3); NT-Near Threatened (IUCN Version 2017-3)

The detailed checklist of reptilian species reported by the forest department has been presented in ***Annex 3.9.***

Avifauna

Primary survey within 1 km of the proposed well sites recorded 65 avian species. The list include six Schedule I species viz. Shikra (*Accipiter badius*), Black Kite (*Milvus migrans*), Black-winged Kite (*Elanus caereleus*), Short-toed Snake Eagle (*Circaetus gallicus*), Oriental pied hornbill (*Anthracocerus albirustris*) and Common Kestrel (*Falco tinnunculus*). Identified avifaunal species from the study Area is provided in ***Table 3.23.***

Table 3.23 Avifaunal Species observed in the study Area during Primary Survey

Sl. No	Scientific Name	Common Name	Wildlife Schedule	IUCN Category
1.	*Acridotheres tristis*	Indian Myna	IV	LC
2.	*Aegithina tiphia*	Common Iora	IV	LC
3.	*Alcedo atthis*	Small Blue Kingfisher	IV	LC
4.	*Amaurornis phoenicurus*	White breasted Waterhen	IV	LC
5.	*Apus affinis*	House swift	IV	LC
6.	*Ardeola grayi*	Pond Heron	IV	LC
7.	*Athene brama*	Spotted Owlet	IV	LC
8.	*Bubulcus ibis*	Cattle Egret	IV	LC
9.	*Caracias benghalensis*	Blue Jay or Roller	IV	LC
10.	*Columba livia*	Common Pigeon	IV	LC
11.	*Corvus macrorhynchos*	Jungle Crow	IV	LC
12.	*Corvus splendens*	House Crow	IV	LC
13.	*Cuculus micropterus*	Indian Cuckoo	IV	LC
14.	*Dendrocitta vagabunda*	Rufous Tree Pie	IV	LC
15.	*Dicrurus adsimilis*	Black Drongo or King Crow	IV	LC
16.	*Dicrurus remifer*	Lesser racket-tailed drongo	IV	LC
17.	*Dinopium benghalense*	Golden backed Woodpecker	IV	LC
18.	*Eudynamys scolopacea*	Asian Koel	IV	LC
19.	*Halcyon smynensis*	White breasted Kingfisher	IV	LC
20.	*Hydrophasiarzus chirugus*	Pheasant-tailed Jacana	IV	LC
21.	*Lanius schach*	Long-tailed Shrike	IV	LC
22.	*Metopidius indicus*	Bronze winged Jacana	IV	LC
23.	*Milvus migrans*	Black Kite	I	LC
24.	*Motacilla alba*	White Wagtail	IV	LC
25.	*Motacilla caspica*	Grey Wagtail	IV	LC
26.	*Nectarinia asiatica*	Purple Sunbird	IV	LC
27.	*Oriolus xanthornus*	Black headed Oriole	IV	LC
28.	*Passer domestica*	House sparrow	IV	LC
29.	*Psittacula Krameri*	Roseringed Parakeet	IV	LC
30.	*Pycnonotus cafer*	Redvented Bulbul	IV	LC
31.	*Streptopelia chinensis*	Spotted Dove	IV	LC

Sl. No	Scientific Name	Common Name	Wildlife Schedule	IUCN Category
32.	*Sturnus contra*	Pied Myna	IV	LC
33.	*Vanellus indicus*	Red wattled Lapwing	IV	LC
34.	*Megalaima asiatica*	Blue-throated Barbet	IV	LC
35.	*Copsychus saularis*	Oriental Magpie Robin	IV	LC
36.	*Saxicola torquata*	Common Stonechat	IV	LC
37.	*Tachybaptus ruficollis*	Lilttle Grebe	IV	LC
38.	*Hirundo rustica*	Barn Swallow	IV	LC
39.	*Anas crecca*	Common Teal	IV	LC
40.	*Anastomus Oscitans*	Asian Openbill	IV	LC
41.	*Lanius cristatus*	Brown Shrike	IV	LC
42.	*Sturnus malabaricus*	Chestnut-tailed Starling	IV	LC
43.	*Anas poecilorhyncha*	Indian Spot Billed Duck	IV	LC
44.	*Himantopus himantopus*	Black-winged Stilt	IV	LC
45.	*Casmerodius albus*	Great Egret	IV	LC
46.	*Porphyrio porophyrio*	Purple Swamphen	IV	LC
47.	*Hydrophasianus chirurgus*	Pheasant-winged Jacana	IV	LC
48.	*Accipiter badius*	Shikra	I	LC
49.	*Elanus caeruleus*	Black-shouldered Kite	I	LC
50.	*Falco tinnunculus*	Common Kestrel	I	LC
51.	*Phalacrocorax niger*	Little Cormorant	IV	LC
52.	*Actitis hypoleucos*	Common Sandpiper	IV	LC
53.	*Tadorna ferruginea*	Ruddy Shelduck	IV	LC
54.	*Circaetus gallicus*	Short-toed Snake Eagle	I	LC
55.	*Charadrius dubius*	Little Ringed Plover	IV	LC
56.	*Hierococcyx varius*	Common Hawk Cuckoo	IV	LC
57.	*Nycticorax nycticorax*	Black-crowned Night Heron	IV	LC
58.	*Oriolus xanthornus*	Black-hooded Oriole	IV	LC
59.	*Acridotheres fuscus*	Jungle Myna	IV	LC
60.	*Cisticola joncidis*	Zitting Cisticola	IV	LC
61.	*Prinia inornata*	Plain Prinia	IV	LC
62.	*Orhotomus sutorius*	Common Tailorbird	IV	LC
63.	*Turdoides striatus*	Jungle Babbler	IV	LC
64.	*Nectarinia asiatica*	Purple Sunbird	IV	LC
65.	*Anthracocerus albirustris*	Oriental pied hornbill	I	LC

Notes: Schedule – I-IV (Indian Wildlife Protection Act -1972); VU- Vulnerable; NT-Near Threatened, LC-Least Concern, (IUCN Version 2017-3)

Mammals

The Reserve forests in the study area and Dehing Patkai WLS are also home to a wide variety of mammals like Asian Elephant, Slow Loris, Assamese macaque (*Macaca assamensis*), Pig tailed macaque (*Macaca nemestrina*), Rhesus macaque (*Macaca mulatta*), Capped Langur (*Presbytis pileatus*), Stump tailed macaque (*Macaca arctoides*), Hoolock gibbon (*Hylobates hoolock*), leopards, wild pigs, lesser cats, common giant flying squirrel (*Petaurista petaurista*), Pallas's squirrel (*Callosciurus erythraeus*), Irrawady squirrel (*Callosciurus pygerythus.)*

etc. The mammalian species recorded during primary survey or reported by the local villagers and forest department personnel from within 1 km of the proposed drill sites and production installations are presented at ***Table 3.24.***

Table 3.24 Mammalian species recorded/reported in the study Area

Sl. No	Scientific Name	Common Name	Source	Wildlife Schedule	IUCN Category
1.	*Canis aureus*	Jackal	CC	II	LC
2.	*Felis chaus*	Jungle Cat	CC	II	LC
3.	*Herpestes edwardsi*	Common Mongoose	CC	II	LC
4.	*Macaca mulata*	Rhesus Macaque	CC+PS	II	LC
5.	*Macaca assamensis*	Assamese Macaque	CC+PS	II	NT
6.	*Pteropus giganteus*	Indian Flying Fox	CC+PS	IV	LC
7.	*Rattus rattus*	Common House Rat	CC+PS	-	LC
8.	*Panthera pardus*	Common leopard	CC	I	VU
9.	*Nycticebus bengalensis*	Slow Loris	CC	I	VU
10.	*Hylobates hoolock*	Hoolock gibbon	CC+PS	I	EN
11.	*Elephas maximus*	Asian Elephant	CC	I	EN

Notes: PS-Primary Survey; CC-Community Consultation. Schedule – I, IV (Indian Wildlife Protection Act -1972); EN- Endangered; VU- Vulnerable; NT-Near Threatened, LC-Least Concern, (IUCN Version 2017-3)

The detailed checklist of mammalian species reported by the forest department has been presented in ***Annex 3.10.***

3.4.5 Aquatic Ecosystem

Aquatic Habitat: The study Area falls within the catchment of Buri Dihing River. There are also numbers of seasonal streams in the study area. All these rivers and nalas form the aquatic ecosystem. Following aquatic ecological groups has been studied.

Macrophytes

Aquatic waterbodies including seasonal wetlands and marshy lands are suitable habitat for aquatic macrophytes. Ten species of aquatic macrophytes were recorded from these aquatic ecosystems. The most dominant macrophytes encountered during the survey are *Eichhornia crassipes, Azolla pinnata, Jussiaea diffusa*, *Cleome hassleriana, Pistia stratiotes, Nymphea nouchali*, *Trapa* sp., *Ipomoea fistulosa, Salvinia perpusilla, Phragmites karka* etc.

Plankton

For the study of plankton, 50 L water was filtered through plankton net. The water sample then preserved by adding formaldehyde solution and transferred to 100ml vial for microscopic analyses. Plankton genera/species recorded from the study area during primary survey is presented at the table below.

Table 3.25 Plankton Recorded from the Study Area

S No	Monitoring Location Code	Monitoring Location Name	Phytoplankton recorded	Zooplankton recorded
1	SW1	Ongchapjang Nala	*Navicula* sp., *Nitzschia* sp., *Chlorella* sp.	*Brachionus angularis, Keratella cochlearis, Ceriodaphnia cornuta*
2	SW2	Buri Dehing River (Down Stream)	*Chlorella* sp., *Phacus* sp.	*Brachionus urceolaris, Moina micrura, Mesocyclops leuckarti*
3	SW3	Buri Dehing River (Up Stream)	*Navicula* sp., *Nitzschia* sp., *Phacus* sp.,	*Brachionus angularis, Keratella cochlearis, Moina micrura, Mesocyclops leuckarti*

Source: ERM Primary Survey

Icthyofauna

Fish species recorded from the study area include *Amblypharyngodon mola, Cirrhinus reba, Cirrhinus mrigala, Esomus danrica, Puntius sophore, Puntius sarana, P. ticto, Chanda nama, Mystus tengara, Cyprinus carpio, Ctenopharyngodon idella, Labeo gonius, Ompok pabda, Osteobrama cotio cotio, Wallago attu, Heteropneustes fossilis, Trichogaster lalius, Trichogaster fasciata, Hypophthalmichthys molitrix* etc.

Deori et al. (2015)[1] reported 50 fish species from Buri Dehing River.The list of fish species reported are presented in ***Annex 3.11.***

Aquatic Birds

13 species of aquatic birds were recorded from the study area. The lists includes Common Kingfisher (*Alcedo atthis*), Pond Heron (*Ardeola grayi*), Cattle Egret (*Bubulcus ibis*), White breasted Kingfisher (*Halcyon smynensis*), White Wagtail (*Motacilla alba*), Red wattled Lapwing (*Vanellus indicus*), Black-winged Stilt (*Himantopus himantopus*), Little Cormorant (*Phalacrocorax niger*), Common Sandpiper (*Actitis hypoleucos*), River Tern (*Sterna aurentia*), White breasted Waterhen (*Amaurornis phoenicurus*), Bronze Winged Jacana (*Metopidius indicus*), Little Egret (*Egretta garzetta*).

Aquatic Mammals

One aquatic mammal, Eurasian otter (*Lutra lutra*) was reported from the study area.

[1] Dibya Jyoti Deori, Santoshkumar Abujam and Shyama Prasad Biswas (2015). Fish diversity and habitat ecology of Dihing river - A tributary of Brahmaputra river. International Journal of Fisheries and Aquatic Studies 2015; 2(4): 190-197

3.5 *SOCIOECONOMIC ENVIRONMENT*

This section provides the socio-economic baseline for the project area identified for the project

3.5.1 *Methodology*

The socio-economic baseline for this project has been developed on the basis of a combination of secondary information, as well as the inferences drawn from stakeholder consultations undertaken for the EIA.

Secondary Data Analysis

To evaluate socio-economic environment in the study area, secondary information from the 2011 Census handbook has been referred to and details pertaining to habitations in the study area have been extracted and assessed.

Stakeholder Consultation

Stakeholder Identification: At the beginning of the EIA process, the ERM team conducted a preliminary identification of probable stakeholders. An inventory of actual / potential stakeholders, including local groups and individuals, local institutions like the panchayats which may be directly or indirectly affected by the project or with interest in the development activities of the region was made at preliminary.

Stakeholder Consultations: Consultations with community are a continuous process that was carried in the EIA process and would be continued during entore phase of drilling as well as operation of GGS & GPP. Issues like land and resource damage, social disturbance, noise and air pollution, employment opportunities, need for development of basic infrastructure, safe drinking water, sanitation facilities in the villages located in 1 km periphery of proposed facility. The consultations also helped in developing preliminary understanding of the requirement of social development initiatives, which are required in the project village and may be undertaken as part of the HOEC's CSR activity.

Figure 3.27 Photographs of Stakeholder Consultations

Consultation at Makum Killa

Consultation at Vitor Powai village

Consultation at Powai Likhajan Tea Estate	Consultation at Dirok Tea Estate

3.5.2 *Area of Influence*

The study area for detail socio economic assessment and community consultation was limited in the villages located within 1 km radius around the proposed wells and production facility as these are the villages which are directly or indirectly most impacted by the project. These villages are primarily selected based on reconnaissance surveys, census data information, topo sheet maps, understanding of the project and professional judgment. Total 17 villages located in Margherita revenue circle in Tinsukia districts are located within the area of influence. Proposed well and production facility wise list of village has been provided ***Figure 3.28.***

3.5.3 *Demographic Profile*

The demographic profile in terms of total population, household size and sex ratio of the above-mentioned selected villages in the block has been summarized in the sections below, while the detailed demographic profile of the study area villages has been provided in ***Annex 3.12.***

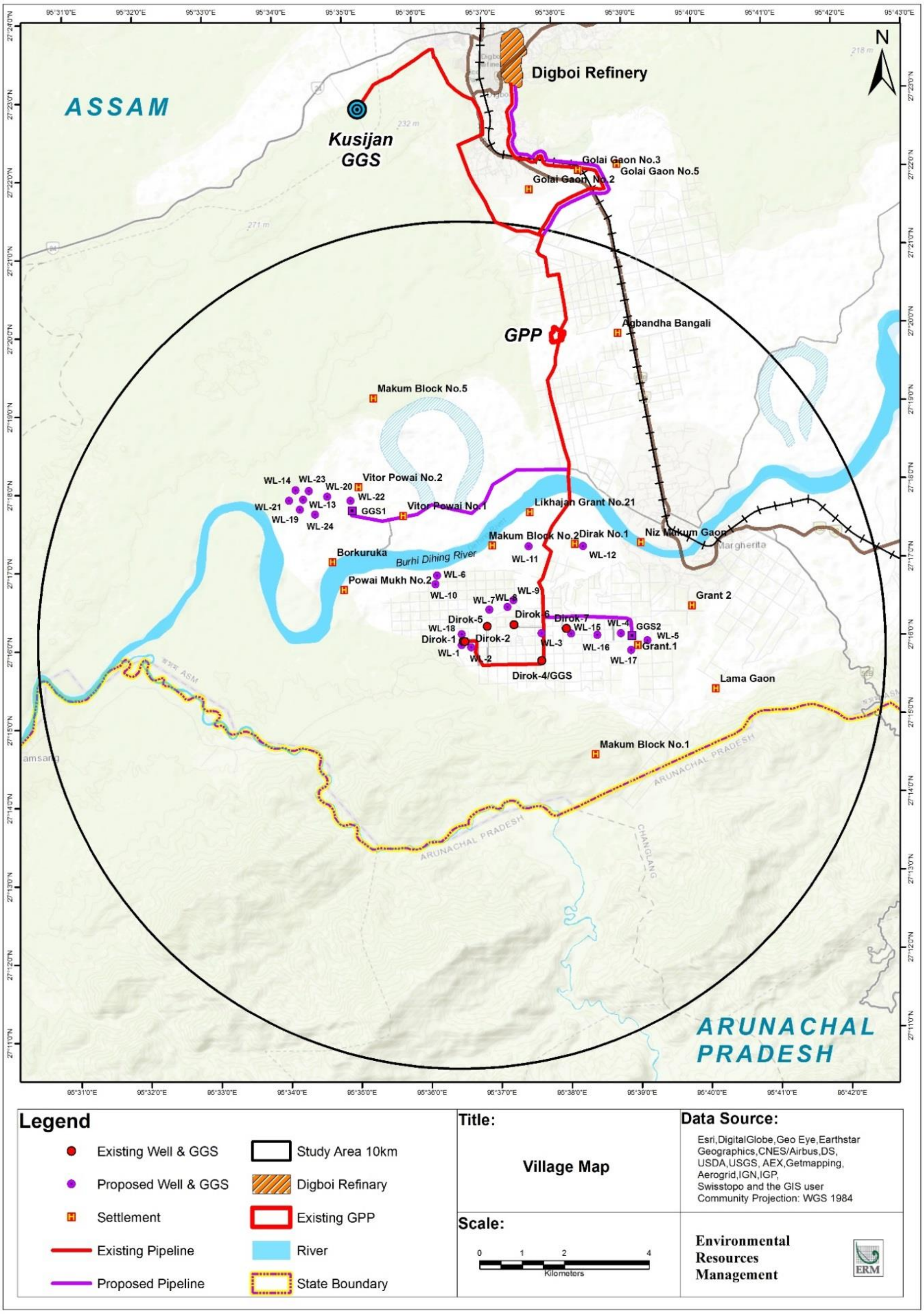
Population and Household Size

The total population in the selected 17 villages in the area of influence was 20,603. Dirok No.1 (3996) has the highest population among the study area villages followed by 112/109/Nla Grant 2 Makum Tea Co. (3333). The lowest populations were recorded in Makum Block No. 2 with a total population of 305. The household size of the study area villages generally ranged within 4.43 to 5.81 with an average household size of 4.85. Population and household of those villages summarized in the ***Annex 3.12.***

Sex Ratio

The average sex ratio of the area of influence is 967 and it is higher than the state averages of Assam (958) and also higher than country average (943). The highest sex ratio is recorded in Makum Block No. 2 (1089) followed by 112/109/Nla Grant.1 Makum Tea Co. (1083) and the lowest sex ratio was been recorded at Golai Gaon (847). Detail is summarized in ***Annex 3.12.***

Figure 3.28 Villages located in the Area of Influence



Scheduled Caste (SC) & Scheduled Tribes (ST)

The overall demographic data of study area villages shows 1.31% of the population to be under SC category and 2.17% population belongs to scheduled Tribe category. Highest schedule tribe (20.53%) was observed in Vitor Powai No. 1 and highest schedule cast (20.92%) population was observed in Powai Mukh No. 2. Apart from that Details of SC and ST population are given in ***Annex 3.12.***

Education & Literacy

The study of the literacy profile in the region is relevant in order to have an understanding whether the proposed project can utilize skilled human resources available within the area.

According to 2011 census data, the literacy rate in Tinsukia district is 69.7%, where as the state literacy rate of Assam is 73.18%. But the average literacy rate of area of influence observed as 67.73% which is lower than the state and district literacy rate. The highest literacy rate was observed in Borkuruka (92.72%) and the lowest in 112/109/Nla Grant 2 Makum Tea Co. (42.10%). Average male and female literacy rate in the study area was recorded at 74.98% and 60.23%, which is lower than the district percentage of 85.8% and 74.7% of Tinsukia, respectively. Details are given in ***Annex 3.13.***

Economic Activity & Livelihood Pattern

The relevance of economic activity and livelihood pattern is important in the context of the study since depending on the existing situation one can predict the impact of the project activity on the economy of the region.

The total working population ratio in the study area villages varies from 26.89% to 58.10%, of the total workforce, Niz Makum Gaon revealed the highest percentage of workforce with 58.10% workers while Makum Block No 2 revealed the lowest workforce percentage (26.89%).Village wise details are incorporated in ***Annex 3.14.***

The "Other worker" category contribute highest workforce category constituting about 51.81% of the working population of 17 selected villages as major populations in the selected villages work in tea gardens whereas agriculture contribute only 15.22% of the working population. This area mainly comprises of mono cropped land and paddy is the major agricultural produce.

3.5.4 *Basic Amenities and Infrastructure*

Drinking Water facilities

Ground water is the main source of drinking water. Community consultation revealed that adequacy and quality is not a problem in case for drinking water. Good quality water is available to the villagers around the year. Villages where river or stream present, people also use this for their domestic purpose.

Medical Facilities

Medical facilities are one of the basic service indicators which need to be studied so as to know the quality of life in the area. All study area villages considered for the study have health sub center in panchayat level. Free medical facility also available in tea garden premises for tea garden workers. Primary Health centre is present only at Block. Other than that villagers have to go to Digboi and Margherita to avail the medical facility.

Educational Facilities

The study area possesses necessary educational infrastructure to cater to the educational needs of the both rural and urban population. Among the study area villages more than one primary school and one high school is present. ICDS is present in all the villages. For higher education student have to go to Digboi or Margherita.

Transport & Communication

NH-38 is the major road connecting the study area with Digboi and Margherita is being used by the local people as a route of transportation. Margherita-Deomali road and some other major district roads connect the study area with NH-38 and nearest town. Pucca paved road is present in almost every village.

Power Supply

Electricity is available in all study area villages through a stable 220V electricity supply adequate for domestic, agricultural and other purposes. In case tea gardens labour line, dedicated power supply line from tea estate is available. Frequent power cut is problem for this area.

Post and Telecommunication

In this era of telecommunication, access to mobile phone is within every bodies reach. All villages from sample study area have the access to post-office and other private courier services.

4 IMPACT ASSESSMENT AND MITIGATION MEASURES

This section identifies and assesses the potential impacts in the environment that could be expected from the proposed oil & gas development drilling and construction and operation of production facilities in Block AAP-ON-94/1. The Project activities will affect the physical, social and ecological environment in different phases:

a. Pre-drilling
b. Drilling
c. Decommissioning
d. Construction of GGS
e. Operation of GGS & GPP
f. Laying of pipeline

Impacts are identified and predicted based on the analysis of the information collected from the following:

- Project information (as outlined in Chapter**2**);
- Baseline information (as outlined in Chapter**3**).

The identification of likely impacts during construction and operation phases has been carried out based on likely activities having their impact on environmental and socio-economic parameters. The details of the activities and their impacts have been worked out in the following sections.

4.1 IMPACT ASSESSMENT METHODOLOGY AND APPROACH

4.1.1 Identification of Potential Impact

The potential impacts have been identified through a systematic process whereby the activities (both planned and unplanned) associated with the project have been considered with respect to their potential to interact with environmental and social resources or receptors. The Impact Identification matrix is presented in ***Table 4.1***.

4.1.2 Impact Assessment Methodology

Impact identification and assessment starts with scoping and continues through the remainder of the impact assessment process (IAP). The principal impact assessment (IA) steps are summarized in ***Figure 4.1.*** Detailed Impact Assessment Methodology is presented in ***Annex 4.1***

Figure 4.1 Impact Assessment Process

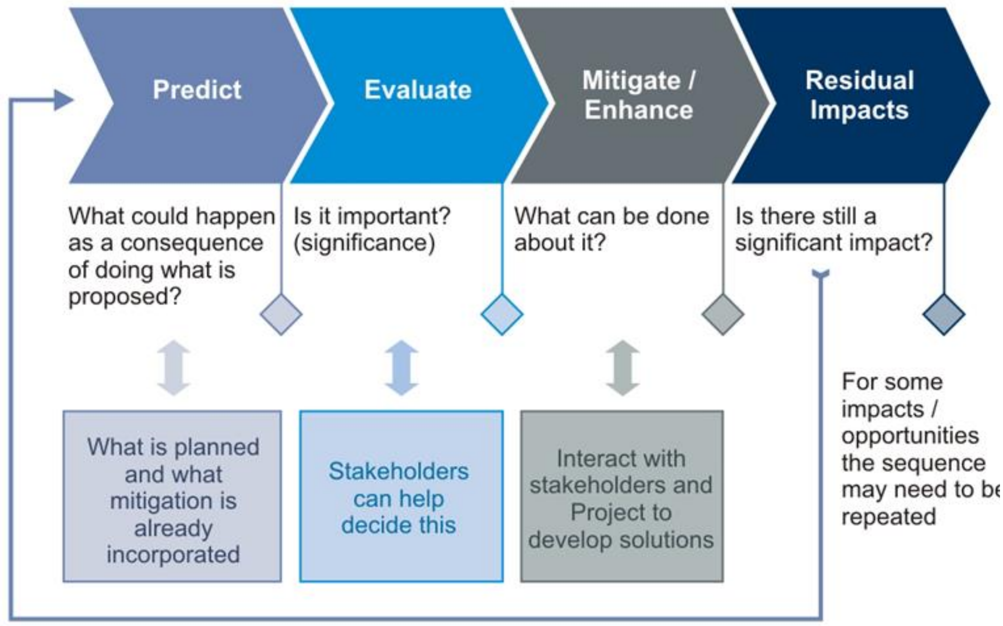


Table 4.1 Impact Identification Matrix

			Physical Environment										Biological Environment				Socio-economic Environment						
	Project Activity	**Aspect**	Aesthetics & Visual	Air Quality	Noise Quality	Land use	Soil Quality	Local Drainage & Physiography	Surface water quality	Ground water Resources	Ground water quality	Road & Traffic	Terrestrial Habitat & Flora	Wildlife habitat & Fauna	Aquatic Habitat & flora,	Aquatic wildlife habitat & fauna	Influx of Population	Common Property Resources	Job & Economic Opportunity	Economy & Livelihood	Conflict with local people	Occupational Health & Safety	Community Health & Safety
A.	**Pre-Drilling and Construction of Production facilities**																						
A.1	Land procurement for drill sites																						
A.1.1		*Procurement of tea garden land*				X														X			
A.1.2		*Procurement of agricultural land*				X														X			
A.2	Clearance of vegetation																						
A.2.1		Removal of vegetation	X										X										
A.3	Site development (filling, grading & levelling)																						
A.3.1		*Loss of top soil*					X																
A.3.2		*Raising of site with earth material*						X															
A.3.3		*Compaction of soil*					X																
A.3.4		*Generation of dust*	X	X									X									X	X
A.3.5		*Surface runoff from construction site*							X						X	X							
A.4	Earth Work for construction of waste pits cellar pit																						
A.4.1		*Storage of earth and fugitive emission during dry season*	X	X									X									X	X
A.4.2		*Surface runoff from excavated material storage area into land/stream*					X		X							X							
A.5	Transport of fill materials, construction material, equipment & manpower																						
A.5.1		*Exhaust emission and fugitive from fill materials, construction materials*		X									X									X	X
A.5.2		*Generation of noise*			X									X									X
A.5.3		*Generation of re-entrained dust*	X	X									X									X	X
A.5.4		*Plying of vehicle through narrow access road*																					X
A.5.5		Road accident																					X
A.6	Storage and handling of construction material																						
A.6.1		*Generation of fugitive dust*	X	X									X									X	X
A.6.2		*Surface runoff from construction material storage area into nearby land/stream*					X		X						X	X							
A.7	Storage & handling of fuel, lubricants, paints & other chemicals, etc.																						
A.7.1		*Spillage of oil, lubricant, etc. from storage & handling*					X				X												X
A.7.2		*Surface runoff from spillage area into nearby land/stream*					X		X		X												X
A.10	Operation of heavy machineries & equipment																						
A.10.1		*Exhaust emission*		X									X										X
A.10.2		*Generation of noise*			X									X									X
A.10.3		*Spillage of oil*																					
A.10.4		*Discharge of machineries wash water into open soil & river*					X		X						X	X							
A.11	Souring of construction water																						

			Physical Environment										Biological Environment				Socio-economic Environment						
	Project Activity	Aspect	Aesthetics & Visual	Air Quality	Noise Quality	Land use	Soil Quality	Local Drainage & Physiography	Surface water quality	Ground water Resources	Ground water quality	Road & Traffic	Terrestrial Habitat & Flora	Wildlife habitat & Fauna	Aquatic Habitat & flora,	Aquatic wildlife habitat & fauna	Influx of Population	Common Property Resources	Job & Economic Opportunity	Economy & Livelihood	Conflict with local people	Occupational Health & Safety	Community Health & Safety
A.11.1		*Sourcing of ground water for construction activity*								X								X					
A.12	Generation & disposal of construction waste																						
A.12.1		*Storage construction waste on open soil*					X				X												X
A.12.2		*Disposal of construction waste in non-designated area*	X				X				X												X
A.12.3		*Spillage of used oil from storage area*					X				X												X
A.12.4		*Surface runoff from construction waste storage area*					X		X						X	X							
A.13	Sourcing of construction workers																						
A.13.1		*Engagement of local person for construction work*															X		+	+	X		
A.13.2		*Hiring of construction workers from outside*																			X		
A.14	Operation of labour camp																						
A.14.1		*Sourcing of ground water for potable use*								X								X					
A.14.2		*Generation of MSW, storage & disposal of open soil*	X				X				X												X
A.14.3		*Generation of domestic waste water & discharge without treatment*									X												X
A.14.4		*Interaction with local community*																					X
B	**Drilling of wells**																						
B.1	Physical presence of drilling facility																						
B.1.1		*Illumination from facility*	X																				
B.1.2		*Drill Rig, DG Set, Pota cabins, machineries*	X																				
B.2	Operation of Drilling rig & associate machineries																						
B.2.1		*Noise generation from rig, mud pump, etc.*			X																	X	X
B.2.2		*Cutting of ground water table*								X													
B.2.3		*Accidental leakage of drill mud in ground water*								X													X
B.3	Storage and disposal of drill cuttings & spent mud																						
B.3.1		*Improper disposal of drill cuttings & spent mud from waste pits*				X					X												X
B.3.2		*Accidental leakage of spent mud and leachate from waste pit*				X					X												X
B.3.3		*Surface runoff from waste pit*				X			X						X	X							
B.4	Storage, treatment and discharge of process waste water																						
B.4.1		*Accidental discharge of untreated waste water into nearby land, stream*					X		X		X				X	X							
B.4.2		*Overflow of untreated waste water from waste pit*					X		X		X				X	X							
B.5	Storage and handling of oil, lubricant, chemical, etc.																						
B.5.1		*Spillage on open soil*					X				X												
B.5.2		*Surface runoff from spillage site*					X		X		X				X	X							
B.6	Storage, handling and disposal of waste oil and other hazardous waste																						
B.6.1		*Spillage on open soil*					X				X												
B.6.2		*Surface runoff from spillage site*					X		X		X				X	X							
B.6.3		*Disposal on non-designated site*					X				X												
B.7	Operation DG sets																						
B.7.1		*Exhaust emission*		X																			X

	Project Activity	Aspect	Physical Environment										Biological Environment				Socio-economic Environment						
			Aesthetics & Visual	Air Quality	Noise Quality	Land use	Soil Quality	Local Drainage & Physiography	Surface water quality	Ground water Resources	Ground water quality	Road & Traffic	Terrestrial Habitat & Flora	Wildlife habitat & Fauna	Aquatic Habitat & flora,	Aquatic wildlife habitat & fauna	Influx of Population	Common Property Resources	Job & Economic Opportunity	Economy & Livelihood	Conflict with local people	Occupational Health & Safety	Community Health & Safety
B.7.2		*Generation of noise*			X																	X	X
B.8	Transport of chemical, oil & lubricant, equipment & manpower																						
B.8.1		*Exhaust emission from transport vehicles*		X																			X
B.8.2		*Generation of noise*			X																	X	X
B.8.3		*Generation of reinternal dust*	X	X																			X
B.8.4		*Plying of vehicle through narrow access road*										X											X
B.8.5		*Road accident*																					X
B.9	Storage and Disposal of MSW																						
B.9.1		*Spillage of MSW from storage bin*				X					X												
B.9.2		*Disposal in non-designated site*	X			X					X												
B.10	Sourcing of process water																						
B.10.1		*Souring from ground water*								X								X					
B.11	Sourcing of construction workers																						
B.11.1		*Engagement of local person for drilling work*																	+	+			
B.11.2		*Hiring of construction workers from outside*																			X		
B.13	Flaring during testing																						
B.13.1		*Emission from flare stack*		X																			X
C.	**Decommissioning of Wells**																						
C.1	Dismantling of rig and production facilities																						
C.1.1		*Noise generation during dismantling of rigs and associate facilities*			X									X									X
C.1.2		*Improper capping of waste pits and generation of leachate*									X			X									
C.2	Transport of drilling rigs, machineries & equipment and fill materials																						
C.2.1		*Exhaust emission from transport vehicles*		X																			X
C.2.2		*Generation of noise*			X									X								X	X
C.2.3		*Generation of reinternal dust*																					
C.2.4		*Plying of vehicle through narrow access road*										X											X
C.2.5		*Road accident*																					X
D.1	**Operation of GCS and GPP**																						
D.1.1	Flaring of excess gas	*Emission of pollutants*		X																			
D.1.2	Separation of oil &gas from formation water	*Discharge of formation water*							X						X								
D.1.3		*Spillage of oil*					X																
E	**Laying of pipeline**																						
E.1.1	Site clearance and soil removal	*Removal of vegetation and top soil*	X	X									X										
E.2.1	Trenching	*Generation of dust*																					
E.3.1	Transportation of pipes	*Exhaust emission*		X																			
E.4.1	Workforce engagement	*Generation of domestic solid waste & disposal*					X																
E.5.1	Testing of pipeline	*Wastewater discharge*							X														

4.2 ASSESSMENT OF IMPACT

Based on the Impact Identification Matrix (***Table 4.1***) for Project activities and likely impacted resources/ receptors from construction and operational phases of the proposed Project, the potential impacts are discussed in the following sections:

4.2.1 *Impact Aesthetic and Visual*

Source of Impact: Aesthetics and visual impacts from different phases of the project activities can result from:

- Pre-drilling Phase and Construction of Production facilities and laying of pipeline:
  - Removal of vegetation from the land required for the drilling of development wells and GGS;
  - Emission of fugitive dust and deposition on vegetation and property;
  - Storage of construction materials;
  - Storage and disposal of construction waste, municipal waste etc.
- Drilling Phase:
  - Physical presence of rig and associated equipment;
  - Emission of fugitive dust and deposition on vegetation and property;
  - Disposal of MSW in non-designated area.
- Decommissioning:
  - Unplanned disposal of decommissioning waste materials in the vicinity of the well sites;
  - Emission of fugitive dust and deposition on vegetation and property.
- Presence of GPP:
  - Operation of flare stacks.

Embedded Control Measures: The project embedded control measures are as follows:

- Storage facility for construction materials will be provided within the proposed well sites and production facilities;
- Labour camp with sanitation facility, solid waste collection facilities will be set up in within the proposed well sites and production facilities.

Impacts and Receptors: The potential impact due to above-mentioned activities has been discussed in following section.

Removal of vegetation: The proposed development well sites will be developed to house the drill pad, storage facilities, drilling facility, site office etc. The environmental settings of the drill sites reveals that 10 drill sites are located in tea garden area (having tea bushes and shed trees); 14 wells located in agricultural land – having no vegetation or few trees and bushes in the peripheral bunds. The clearance of vegetation is likely to cause visual and aesthetic impacts at surrounding localities such as Vitor Powai village and labour lines of tea garden.

Storage of construction & fill materials: The construction materials will be stored in the covered shed as well in open stack within the well sites/production facilities. Improper storage of these materials is likely to cause visual and aesthetic impacts on surrounding localities.

Fugitive dust emission: Fugitive dust emission will happen during construction and decommissioning of drill sites as well as construction of GPP and laying of pipelines. The dust will be deposited in the nearby vegetation and property and likely to cause visual and aesthetic impacts on surrounding localities.

Disposal of MSW: The villages within the APP-ON-94/1 have no municipal solid waste disposal site; as practice most of the organic waste is disposed within the homestead land for manure and other wastes are either recycled or disposed in their own premises. MSW will be generated from the drill sites and production facilities during will be collected and it will be disposed in the Margirita Municipal MSW Disposal site. Impact on aesthetic and visual only can happen, if the MSW disposed in the nearby open area around the villages.

Disposal of decommissioning waste: The waste material will be generated during site decommissioning phase. If these materials disposed in non-designated area, this is likely to cause visual and aesthetic impacts at surrounding localities.

Physical presence of rig and associated equipment: The setting up of rig, DG set and other machineries will create an impression of an industrial setup at the drill sites. The drill sites are all located in rural settings. The industrial setup is likely to cause visual and aesthetic impacts at surrounding localities. The drill site would have bright illumination arrangements. The physical presence and illumination at the project facilities is likely to cause visual and aesthetic impacts at surrounding localities of the area.

Flare stack at GPP: The illumination from flare stack through all night may be source of visual discomfort for the local people or fauna.

Laying of interconnected pipelines: The trenching activity, the storage of soil on the ROW (10m) of the pipeline and the temporary storage of pipelines will create visual disturbance and will be aesthetically displeasing.

The visual and aesthetic impact due to above mentioned activities can be easily revert to earlier stage with mitigation; so the scale of impact is ***medium***. The visual impact can be noticed by the nearby people; i.e. within 0.5 km from the project site- so the extent of impact is ***local***. The above-mentioned activities can occur only in phase of drilling life cycle; however, vegetation removal has ***long-term*** impact. Hence, the impact magnitude is **medium**.

The environmental setting of the area reveals that the study area has a typical rural setting - flat terrain with agricultural land, villages with homestead plantation and tea garden. The people in the area have experienced drilling activity. The receptor sensitivity can be categorized as ***medium***.

The aesthetics and visual impact is assessed to be ***moderate*** (*Ref.* ***Table 4.7:*** *Impact Significance Matrix without mitigation*).

<u>*Mitigation Measures*</u>: The mitigation measures to minimize the above-mentioned impacts are as follows:

- Minimise the vegetation clearance only the working area of the site;
- Restore the site after completion of drilling activity and carry the plantation activity;
- Greenbelt plantation in the production facility and production wells.
- All the construction activities will be restricted within the designated site;
- Fugitive dust will be suppressed with periodic water sprinkling;
- Appropriate shading of lights to prevent scattering;
- On completion of work all temporary structures, surplus materials and wastes will be completely removed from site and disposed at a designated area;
- Construction wastes, decommissioning waste and municipal solid waste temporarily stored at the sites will be transported to the designated disposal site/facility at regular intervals;
- The pipelines once laid will be covered with burrowed soil and levelled as per the surrounding land.

Residual Impact: Considering the implementation of above-mentioned mitigation measures the residual impact is assessed to be **minor** (*Refer* ***Table 4.8*** *Impact Significance Matrix with mitigation*).

4.2.2 *Impact on Ambient Air Quality*

Source of Impact

Potential impacts due to air emissions will result in increase in pollutant concentration in ambient air, which causes health hazards to human and biological/ecological receptors. The atmospheric emissions during drilling of developmental wells and operation of GGS & GPP will result from:

- Construction of drill sites, GGS & laying of pipeline
    - Fugitive emission during drill site development and pipeline laying;
    - Fugitive emission during transportation, storage, handling of construction material, disposal of construction waste;
    - Vehicular emission during transportation of rig and associate machinery;
    - Point source due to operation of DG sets

- Drilling Phase
    - Point source due to operation of DG sets;
    - Point source due to flaring of hydrocarbon during well testing;
    - Fugitive dust generation during loading of bulk solids
- Decommissioning phase
    - Fugitive emission during decommissioning of rig and associated facilities;
    - Vehicular emission during transportation of de-mobilised rigs and machineries.
- Operation of GGS & GPP
    - Point source due to flaring of hydrocarbon at GPP;
    - Point source due to operation of GG sets at GGS and GPP

Embedded Control Measures: Project embedded control measures are as follows:

- Vehicle, equipment and machinery used for drilling would conform to applicable emission norms;
- Drilling chemical and materials would be stored in covered areas to prevent fugitive emissions;
- DG/GG set stacks would have adequate height, as per statutory requirements, to be able to adequately disperse exhaust gases; and
- Flare stacks of adequate height would be provided.

Impacts & Receptos: The potential impact due to above mentioned activities has been discussed in following section.

Fugitive emission: Fugitive dust emissions due to the proposed project will be principally associated with emissions of dust during the site preparation and laying of pipeline. The dust generated would be primarily from the handling and transportation of fill material and re-entrainment of dust during movement of the vehicles on roads and earth work at site and pipeline laying. However, generation of such fugitive dust is likely to be governed by micro-meteorological conditions (wind speed and direction). Effects of dust emissions are heightened by dry weather and high wind speeds and effectively reduced to zero when soils and/or ambient conditions are wet. However, dust generated from the site development and construction activity will generally settles down on the adjacent areas (i.e. < 500 m from the source) within a short period due to its larger particle size.

Emissions from Vehicles/Equipment: The pre-drilling, drilling and decommissioning operations would involve movement of diesel operated vehicles and operation of machineries and equipment. Heavy vehicles will be particularly intense during site preparation and decommissioning phases. Gaseous pollutants such as NO_x, SO_2, CO and hydrocarbons are likely to be emitted from operation of vehicles and machineries.

Operation of DG sets: The emission from each of the diesel engines at drill sites will be due to combustion of diesel. There will be three DG each of 670 KVA capacities attached to the drilling rig and 135 KVA DG set at camp site. For power requirement Rig during Short duration of average 45 days for development well drilling. In no case with mobilization and demobilisation, drilling of a well will exceed 90 days per well.

Test Flaring will be done only during well testing phase. The emission from the test flaring will be only for a short period of 1 to 2 days per drilling location. The emission characteristics from the power generation due to diesel combustion and test flaring are summarised in ***Table 4.2.***

Table 4.2 Emissions Characteristics during Power Generation on Rig & Test Flaring

S.N	Parameter	Diesel Generators		Temporary Well Test Flaring
1	Rating	670 KVA	134 KVA	Ground flaring
2	Average Fuel Consumption	94 kg/hr/DG set	20 kg /hr/DG set	4,000 kg/hour (in case hydrocarbon is observed, temporary Test flaring @ flow assumed rate of 0.105 mmscmd)
3	No. of units operative at any point of time	3	1	1
4	Hours and Days of operation	24 hours per day for 45 to 90 days per drilling of a well	24 hours per day for 45 to 90 days per drilling of a well	24 to 48 hours per drilling of a well
5	Exhaust Gas Diameter	0.305 m	`0.2 m	0.078 m flare dia (2.03 m effective stack dia)
6	Stack Height above mean sea level	5.0 m	2.3 m	At ground level
7	Exhaust Gas Temperature	300 °C	310 °C	1000 °C
8	Exhaust Gas Flow	2,285 Nm^3/hour	800 Nm^3/hour	62,800 Nm^3/hour
9	Exhaust Gas Velocity	16.7 m/sec	13.8 m/sec	20 m/sec
10	Emission of pollutants			
i	Particulate matter (PM_{10})	0.045 g/sec (@ 0.3g/kw-hr)	0.009 g/sec (@ 0.3g/kw-hr)	0.52 g/sec (@30 mg/Nm^3)
iii	Sulphur Dioxide (SO_2)	0.0523 g/sec (@ 0.1% of "S" in diesel)	0.0105 g/sec (@ 0.1% of "S" in diesel)	Negligible
iii	Oxides of Nitrogen (NOx)	1.367 g/sec (@ 9.2 g/kw-hr)	0.273 g/sec (@ 9.2 g/kw-hr)	2.52 g/sec (@< 145 mg/Nm^3)
iv	Carbon Monoxide (CO)	0.523 g/sec (@ 3.5 g/kw-hr)	0.105 g/sec (@ 3.5 g/kw-hr)	6.1 g/sec (< 350 mg/Nm^3)
v	HC	0.194 g/sec (@ 1.3g/kw-hr)	0.039 g/sec (@ 1.3g/kw-hr)	2.26 g/sec (< 130 mg/Nm^3)

Emission from GGS and GPP

After completion of development drilling, it is assumed that all the development wells will comes under production. And during this stage, the existing GGS and two proposed GGS as well as GPP will be operated simultaneously with full capacity. The air emission source and characteristics of pollutant is summarised in following table.

Table 4.3 *Point & Flare Air Emissions Sources from GGS & GPP*

Parameters	Gas Generator at GGS-1	Gas Generator at GGS-2	Gas Generator at GGS-3	Gas Generator at GPP	Flaring at GPP
Rating	400 KVA	400 KVA	400 KVA	600 KVA	Ground flaring
Average Fuel Consumption	56 kg/hr	56 kg/hr	56 kg/hr	105 kg/hr	273.15 kg/hr 352Nm^3/hr
No. of units operative at any point of time	1	1	1	2	2
Location of stack					
Hours and Days of operation	24 hours per day	24 hours per day	24 hours per day	24 hours per day	24 hours per day
Exhaust Gas Diameter	0.2m	0.2m	0.2m	0.305 m	0.4 m
Stack Height above mean sea level	4.0m	4.0m	4.0m	5.5.0m	10m
Exhaust Gas Temperature	310°C	310°C	310°C	300°C	1273 K
Exhaust Gas Flow	800 Nm^3/hr	800 Nm^3/hr	800 Nm^3/hr	2285 Nm^3/hr	4290 Nm^3/hr
Exhaust Gas Velocity	13.8 m/sec	13.8 m/sec	13.8 m/sec	13.8 m/sec	20m/sec
Emission of pollutants					
Particulate matter (PM_{10})	0.027 g/sec	0.027 g/sec	0.027 g/sec	0.049 g/sec	0.0357
Sulphur Dioxide (SO_2)	0	0	0	0	0
Oxides of Nitrogen (NOx)	0.818 g/sec	0.818 g/sec	0.818 g/sec	1.532 g/sec	0.0707
Carbon Monoxide (CO)	0.311 g/sec	0.311 g/sec	0.311 g/sec	0.583 g/sec	0.417
HC	0.115 g/sec	0.115 g/sec	0.115 g/sec	0.216 g/sec	0.1549

The main emissions considered for modelling from power generating diesel engines include pollutants NOx and SO_2, and CO while CO and NO_x are the main pollutant from test flare. ***Table 4.2*** and **Table 4.3** describes the emission characteristics assumed for the modelling exercise from engines and test flaring.

The background ambient air quality concentrations as observed AAQ results as monitored at various locations is presented in ***Table 3.4*** in ***Section 3.3.2.***

Air Quality Modelling

In order to predict the Ground Level Concentrations (GLCs) at various distances from the source, of the above mentioned pollutants, an air modelling exercise ISC-ST3 has been undertaken and information as described in the above ***Table 4.2***.

Incremental maximum GLCs have been worked out for pollutants (Refer Table 4.4).

Table 4.4 Projected Ambient Air Quality Concentrations from Drill Site

Pollutants	**Incremental Concentration ($\mu g/m^3$)**	**Average Baseline Values ($\mu g/m^3$)**	**Predicted Total Concentration ($\mu g/m^3$)**
DG Set			
NOx	2.63847	19.02	21.65847
PM	0.01395	72.83	72.84395
HC	0.0176	1.44	1.4576
Flaring Stack			
NOx	0.0943	19.02	19.1143

The ambient levels of PM_{10}, NO_x, SO_2 and CO suggest that the air quality is generally well within the NAAQS. The pollutants concentrations have been found to be well within the corresponding National Ambient Air Quality Standard (NAAQS). The increase in concentration of NO_x and SO_2 is low in comparison with the background on the rig and will only persist for a short period.

Figure 4.2 Isopleth of PM- max. incremental concentrations for operation of DG set

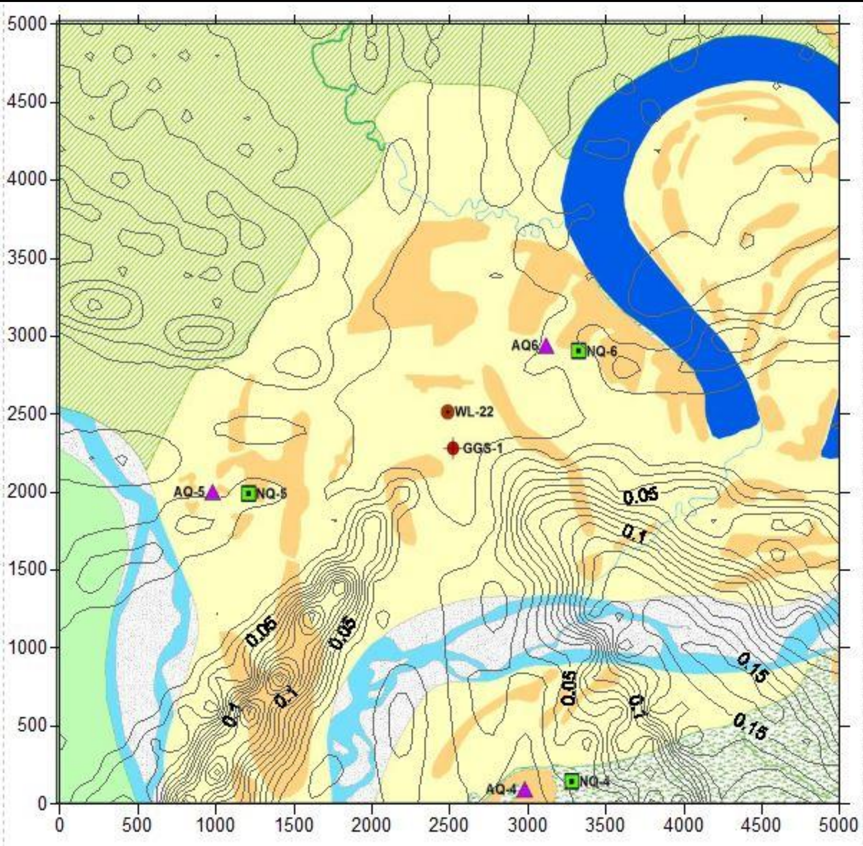


Figure 4.3 Isopleth of NOx- max. incremental concentrations for operation of DG set

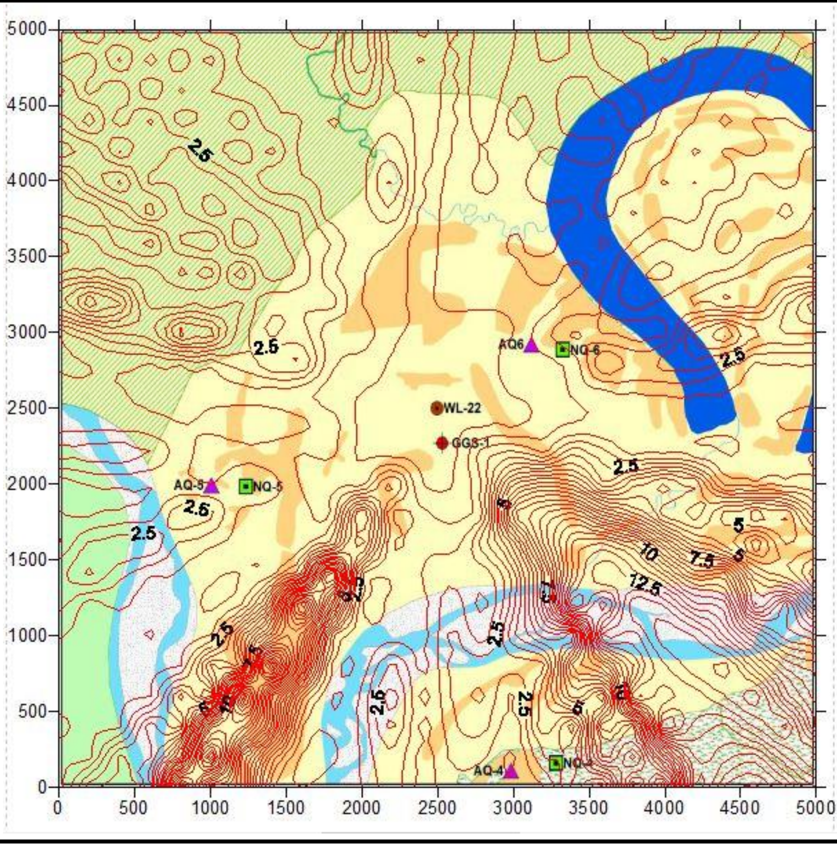


Figure 4.4 Isopleth of HC- max. incremental concentrations for operation of DG set

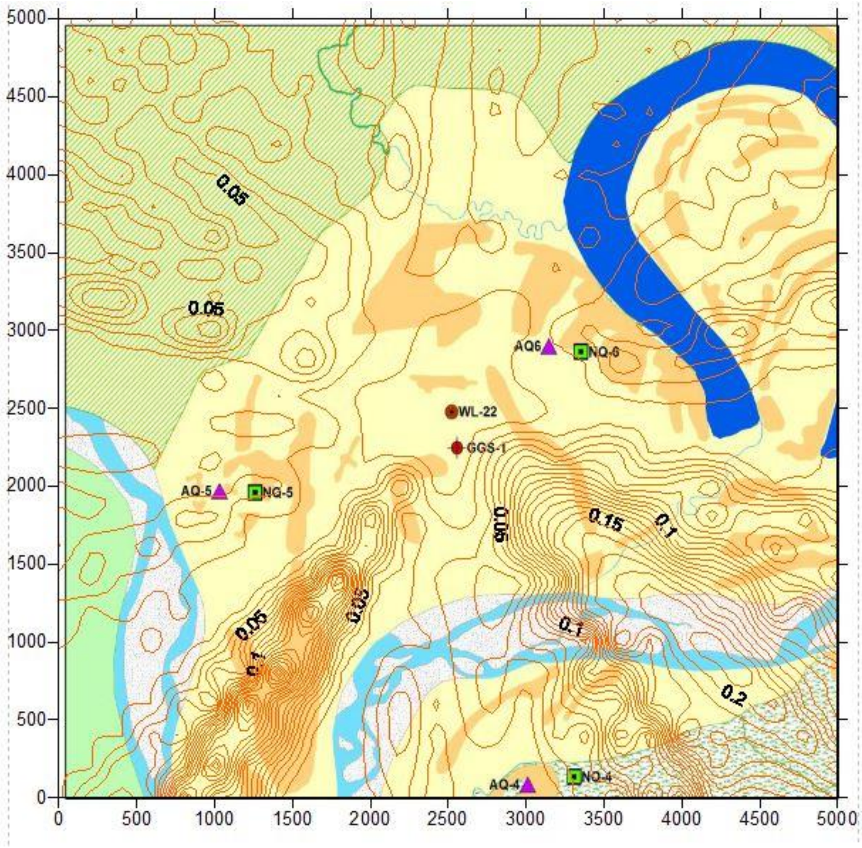


Figure 4.5 Isopleth of NOx- max. incremental conc. -Flaring well testing

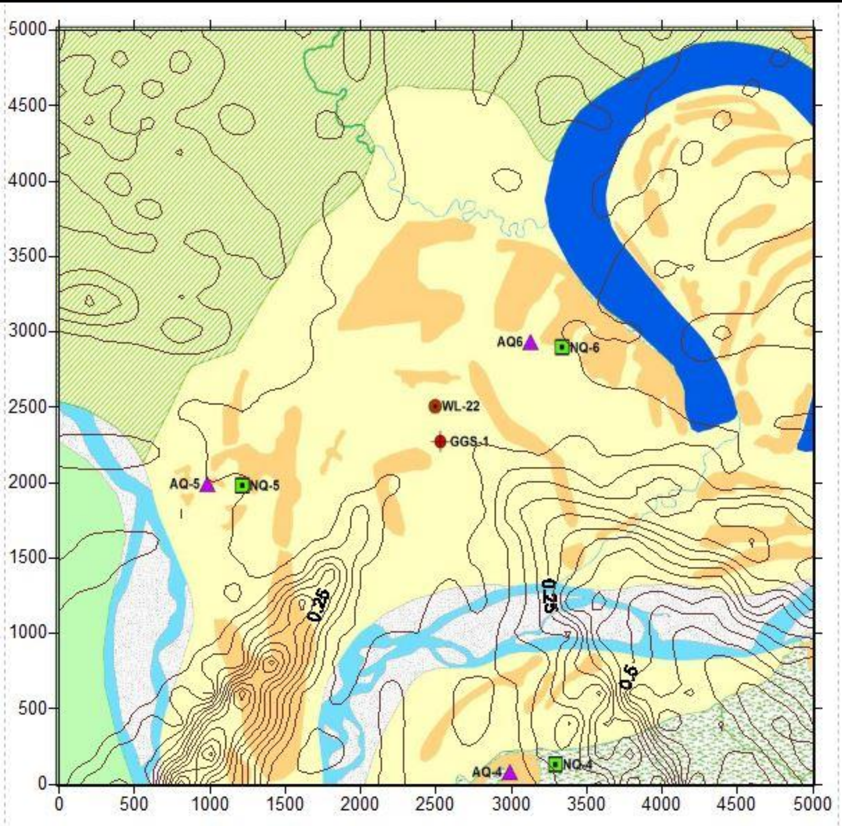
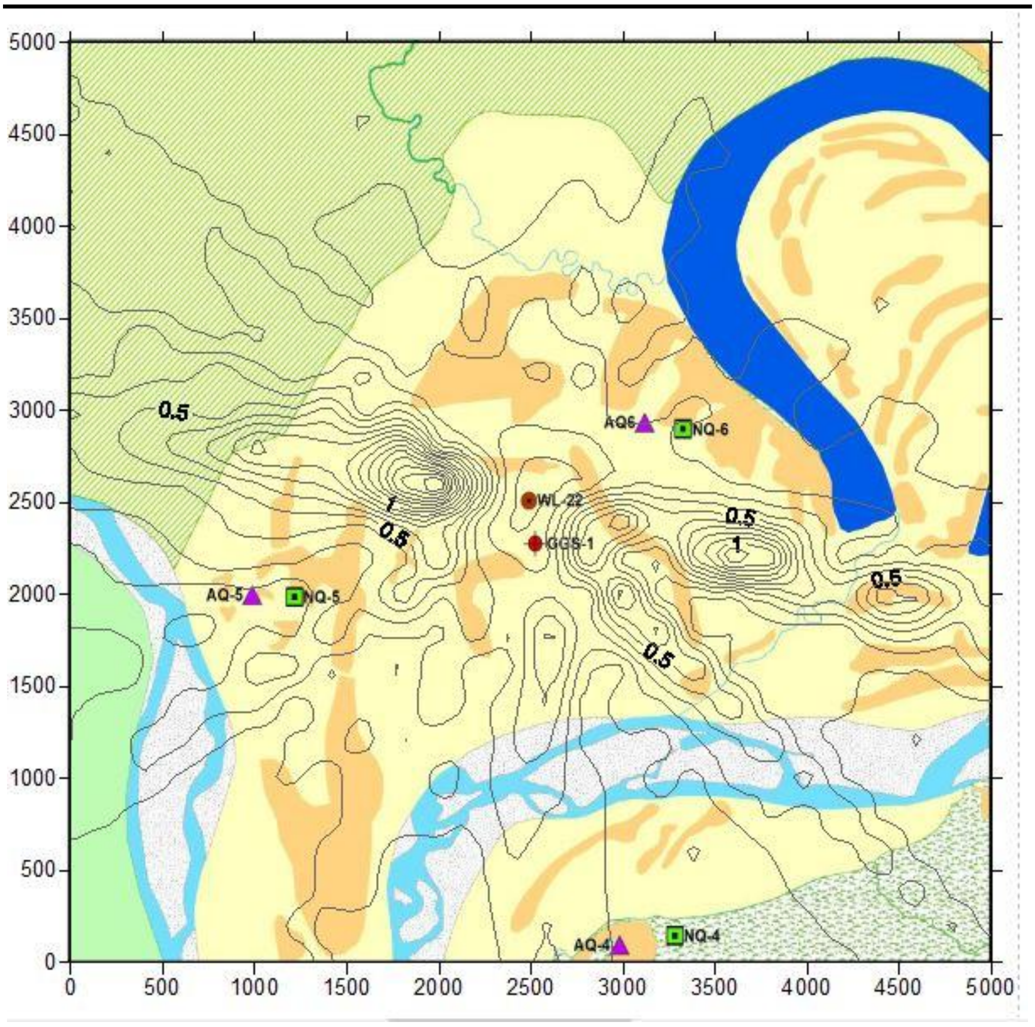


Figure 4.6 Isopleth of Nox- max. incremental concentrations for operation of GGS



Emissions of methane and other VOCs will occur but are expected to be small in relation to the amount of volatile hydrocarbons stored on the drill sites and will not contribute significantly to local or global air pollution. The impacts caused are therefore, considered to be negligible.

The resultant ambient air quality in the study area due to development drilling is expected to remain well within the NAQQS. The impact of air emissions from proposed onshore activities have been predicted to remain within a few kilometer from the emission sources. The impact magnitude is assessed to be **moderate**.

Mitigation Measures

Mitigations of atmospheric impacts caused by combustion products are achieved through the following measures:

- Carry out regular water sprinkling at the site during dry season especially during the construction and decommissioning activities;
- Efforts would be made to maintain the stockpile against the wall or obstruction so that it works as a windbreak and the fugitive emissions by strong winds can be avoided;

- The trucks used for transport of fill material during the site preparation and debris transport during the decommissioning shall be provided with impervious sheeting;
- During construction, the approach road will be kept clean, free from mud and slurry to prevent any entrainment of dust;
- Maintenance of diesel power generators to achieve efficient combustion, fuel efficiency and therefore reduce emissions;
- Use of low sulphur diesel oil (approx. 0.2% or less); and
- No cold venting to be resorted during well testing. Management of the well test programme by dedicated team for prevention of trips in product supply to the flare and flame out. Many of the above measures including checking of methane emissions, which may occur during well testing, are incorporated into management of the drilling operations. The well testing procedure involves the dedicated observation of the flare and radio communication to well test manager. In the event that product pressure drops in the well test flare, diesel can be injected to maintain combustion otherwise the feed line would be shut off;
- The vent boom shall be so located that any H_2S and HC gas concentration on the platform remains within acceptable limits for personnel safety, under worst operating & environmental conditions.
- Other fugitive emissions from diesel fuel etc. will be reduced by appropriate storage and handling;

Residual Impact: Considering the implementation of above mentioned mitigation measures, the significance of residual impact on ambient air quality during construction phase is assessed as **Minor**.

4.2.3 *Impact on Noise Quality*

Source of Impact: The potential impacts on noise quality may arise out of the following:

- Pre-drilling phase- Construction of drill sites
    - Operation of machineries & equipment;
    - Vehicular traffic;
    - Operation of DG sets.
- Drilling phase:
    - Operation of DG sets and drilling rig;
    - Operation of machineries & equipment;
    - Vehicular traffic.
- Decommissioning phase:
    - Demobilization activity
    - Vehicular traffic.
- Pipeline Laying
    - Operation of machineries
    - Hydro-testing
- Operation of GGS & GPP

- o Power generation
- o Compressor & pump

Embedded Control Measures: The project embedded control measures are as follows:

- All vehicle and equipment involved in site development and drilling activity will be provided with noise control measures;
- Well maintained equipment and vehicles will be used;
- All DG/GG sets would be provided with acoustic enclosures; and
- Appropriate PPEs (e.g. ear plugs) will be used for by workers while working near high noise generating equipment.

Assessment of Impact: The potential impact due to above-mentioned activities has been discussed in following section.

Operation of construction machinery/equipment: The construction activities such as transportation of raw materials for civil works, operation of heavy equipment and construction machinery are likely to cause increase in the ambient noise levels in and around the drill sites and proposed GGS sites. The noise generated from the above mentioned activities likely to be attenuated within 500m from the construction sites. The noise generated from drill and GGS sites may cause discomfort for the villagers who are within 500m.

Noise from Vehicular Traffic: As vehicles supplying, material and manpower to the sites will pass through site access and approach road, it will result in increase in traffic density (compared to existing traffic) in the approach road and resultant significant increases in noise levels in the settlements immediate adjacent to the road. The impact will be more significant for residents living adjacent to the approach road where houses are located very close to the road. The noise pressure level caused by movement of a heavy truck, at a distance of about 5 m from the road, has been measured to be as high as 75- 80 dB(A) though it gets averaged out when expressed in Leq terms. This may cause considerable incremental noise disturbances to residents near site approach roads.

Operation of drilling rig and ancillary equipment: Operational phase noise impacts are anticipated from operation of drilling rig and ancillary equipment *viz*. shale shakers, mud pumps and diesel generators. Studies indicate that noise generated from operation of drilling rig generally varies in the range of 88-103 dB(A). Other contributors of high noise level at the well site include shale shakers, mud pumps and diesel generators. The average equivalent noise levels of drilling rig and ancillary equipment is estimated to 95 dB(A).

Noise Level Prediction

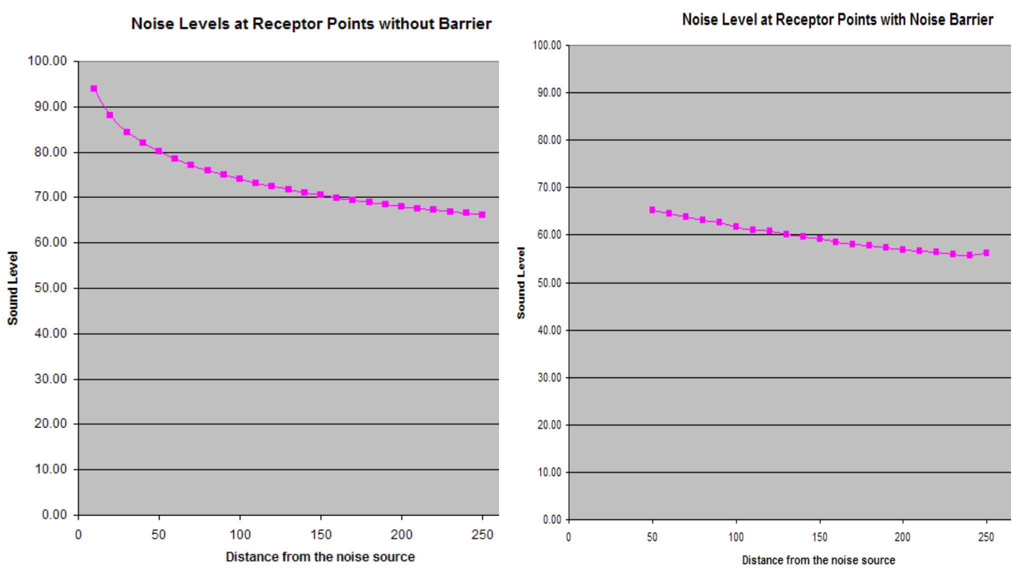
A noise modelling exercise has been undertaken based on standard noise attenuation equations to predict noise levels from drilling rig near sensitive receptors. A noise attenuation plot has been developed considering natural attenuation by distance with noise level predictions only expected to help in planning and decision-making.

The cumulative noise generated from rig, mud pump, DG sets and shale shakers was calculated to be 95.0 dB(A). Noise attenuation equations (without any noise barrier) show that the normal attenuated noise at any receptor points located at a distance of about 100 m and 200 m from the fence-line of the rig, will be in the range of about 75.0 dB(A) and 69.0 dB(A) respectively. In the absence of an acoustic barrier, the predicted noise levels were found to exceed the daytime noise standard of i.e. 55 dB(A) which may lead to discomfort to neighbouring communities.

Noise generated from the operation of production facilities will be from DG sets, running of crude oil despatch pump sets, gas compressors, formation water pumps, boilers, etc. Acoustic DG sets will be used in the installations. Sound generated from the GG sets and pumps would be in similar as compared to the drill sites and they area also expected to be attenuated to baseline levels within 0.5 km from the site.

Further, considering drilling to be a continuous operation, noise generated from aforesaid equipment has the potential to cause discomfort to the local communities residing in proximity (within 500m) of the rig facility. Occupational health and safety impacts *viz*. Noise Induced Hearing Loss (NIHL) is also anticipated for personnel working close to such noise generating equipment until they are wearing appropriate personnel protective equipment.

Figure 4.7 Predicted Noise Pressure Levels at Receptor Points



Laying of Pipeline

Laying of the pipeline will include the noise generating activities like soil stripping, trenching, pipe stringing, welding and laying, and backfilling. However, such noise generating activities will occur intermittently, primarily during the daytime. After pipe laying, the pipeline will be hydrostatically pressure tested leading to noise generation from operation of pumps. Hydrostatic testing will take place on a continuous basis over a period of several days.

Construction methods and generic plant items have been reviewed to estimate typical worst-case noise emission levels from both temporary and continuous construction situations. Assuming noise propagation away from the construction site, it has been possible to calculate the critical distance within which the noise assessment criteria for the two situations are likely to be exceeded. These critical distances have been presented in Table 4.5. It should be noted that the critical distances are the worst case ones, i.e. no allowance has been made for mitigation, use of quieter techniques or the attenuating effects of ground and intervening terrain.

Table 4.5 Critical Distance- Ambient Noise will be attenuated

Sl. No.	Construction Activity	Critical Distance (m)
A.	*Pipeline Construction - Day*	
1	Soil Stripping	230
2	Trenching	90
3	Pipe Stringing	40
4	Bending	90
5	Welding and Lowering	175
6	Back Filling	130
B.	*Major Works – Day*	
7	Excavation	165
8	Blasting (annoyance)	115
9	Blasting (structural damage)	40

[Source: BTC Pipeline – Construction Impacts & Mitigation, June 2002]

Operation of GGS and GPP

Gas based generator for power, compressor and pumps will be operated in the GGS and GPP. The noise generated from the above mentioned activities likely to be attenuated within 500m from the construction sites. The noise generated from GGS and GPP sites may cause discomfort for the villagers who are within 500m.

The scale of impact of the above mentioned activities is considered to be **high** as the changes of baseline noise level the immediate vicinity of the drill sites/production facilities are likely to regularly exceed the standard regularly. The extent of impact is considered as **local** as noise would be attenuated within 0.5 km of the sites. The duration of impact is also considered as **medium-term** spread across several phases of the project lifecycle. The magnitude of impact assessed to be **medium**. The sensitivity of the receptors is **medium** as human receptors are present beyond 0.5 km of all the well sites. The impact on ambient noise level assessed to be **moderate**.

The additional mitigation measures as proposed are as follows:

- Maintenance of vehicles and machineries;
- Restrict all noise generating operations, except drilling, to daytime;
- Provide Personnel Protective Equipment (PPE) like ear plugs/muffs to workers at site;
- Restriction of unnecessary use of horns by trucks and vehicles near settlement areas;
- Provide noise barrier in sensitive locations.

Residual Impact: Considering the implementation of above mentioned mitigation measures, the residual impact on noise quality is assessed to be **minor**.

4.2.4 Impact on Road & Traffic

Source of Impact: The source of impact is additional traffic load during:

- Predrilling phase, construction of site approach road and laying of pipeline
    - Transportation of construction materials and manpower;
    - Transportation of drilling rig and machineries;
- Drilling phase
    - Transportation of drilling chemical and fuel
    - Transportation of manpower
- Decommissioning phase
    - Transportation of decommissioned drilling rigs and machineries;
    - Transportation of excavated fill material and decommissioning waste materials.

Impacts & Receptors: Approximately, 100 trucks/trailers load materials will be transported to drill site during predrilling phase. During drilling activity 5-7 trucks/trailers load materials will be transported to drill site; additionally, 10 to 15 vehicles will be required for transport of site workers.

Based on the traffic survey conducted (*Refer* ***Section 3.3.4***), it is noted that Margherita-Deomali Road and Makum Killa Road from HOEC central storage facility located at Digboi through NH will be used for transportation of construction material and drilling rig and machineries.

The increase of traffic during construction phase will cause perceptible changes in the existing road traffic volume. This may cause deterioration of existing road infrastructure. The increased traffic may also affect community health and safety of the nearby villagers and at sensitive man-made habitat like schools. Impact on community health & safety is discussed in a subsequent section.

During drilling phase traffic movement would be primarily for the movement of manpower to the drill sites.

The scale of impact considering traffic movement due to the proposed project is considered to be **medium** as the increase of traffic during construction phase will cause perceptible changes in the existing traffic load (however, no perceptible change to the existing traffic load is expected during drilling phase). The extent of impact is considered as **local** as impact will be mostly limited to the access and approach roads to the site. The duration of impact is considered as **short term**. The magnitude of impact assessed to be **medium**. The sensitivity of the receptors is also considered as **medium** as human receptors are present adjacent to the access routes and likely to be affected by the project. The potential impact on road and traffic due to project activities is assessed to be **moderate**.

Mitigation Measures: Precautions as mentioned will be taken to minimize impact on road and traffic:

- Upgrade /strengthened the existing road;
- Regular maintenance of the access roads;
- Avoid the traffic movement during school hours and market times;
- Deploying traffic marshals at important road junctions and near sensitive receptors (e.g. schools) for maintenance of project traffic..

Residual Impact: Considering the implementation of above mentioned mitigation measures, the residual impact disturbance/ discomfort to local communities due to increased traffic is assessed to be **minor**.

4.2.5 *Impact on Land Use*

Source of impact: The sources land use impacts can result from:

- Procurement of land for development wells (~2 ha per well) and GGS (~1 ha per well).

Impacts & Receptors: Land will be required for proposed drill sites and the associated production facilities. As mentioned in *Section 3.3.7,* 10 drill sites are proposed in tea garden, 14 wells in agricultural land. The one GGS is proposed in agricultural land and another GGS in tea gardens. This will lead to conversion of land use from tea garden, homestead plantation, agricultural and forestland to industrial land.

Land use change may lead to impact on income and livelihood; this has been discussed in socio-economic impact section.

As discussed (*Ref. Section 2.6.2 and 2.6.3 land procurement process*), HOEC will procures land through long term lease. HOEC will reinstate the land after drilling activity; hence, the land use change is ***long term*** impact. As per preliminary assessment, approximately 21 ha of tea garden land, 29 ha of agricultural land, 8 ha of scrub land/homestead land will be required for this project. If compared with the total area of study area, the conversion is 1.09% for agricultural land, 0.41% for tea garden areas. Hence, the scale of impact is ***low***. The impact will be limited to the local since the land belongs to people living in and around the proposed sites, however the duration will be long term. The magnitude will be ***small***. The resource sensitivity is ***low*** since the maximum land impacted will be of homestead plantation, tea garden and agricultural land. The impact on land use is assessed to be ***minor*** (*Ref.* ***Table 4.7:*** *Impact Significance Matrix without mitigation*).

Mitigation Measures: The mitigation measures to minimize the above-mentioned impacts are as follows:

- Restrict the construction activities within the demarcated site;
- Immediate restoration of permanently procured land for pipeline and brought to its best achievable original state after completion of the buried pipeline laying activity,
- Remove all wastes from area surrounding drill sites and pipeline corridor;
- Restore the drill site and brought to its best achievable original state after completion of drilling activity and hand over the land except production facility.

Residual Impact: Considering the implementation of above-mentioned mitigation measures the residual impact is assessed to be **minor** (*Refer* ***Table 4.8*** *Impact Significance Matrix with mitigation*).

4.2.6 *Impact on Soil Quality*

Source of Impact: Soil quality impacts can result from:

- Pre-drilling Phase and construction of production facilities and laying of pipelines:
  - Removal of top soil from the land procured;
  - Compaction of soil;
  - Disposal of construction waste/ MSW in non-designated area;
  - Spillage of chemical/oil on open soil;
  - Surface runoff from material & waste storage areas and oil spillage area.
- Drilling Phase/Operation of Production facilities:
  - Spillage of chemical, spent mud, hazardous waste, etc.;
  - Surface runoff from waste storage area and spillage area.
- Decommissioning Phase:
  - Disposal of decommissioning waste materials in open soil.

Embedded Control Measures: The project embedded control measures are as follows:

- Construction waste generated from the drill sites/production facilities will be utilized for backfilling within the site itself;
- MSW generated from the labour camp and construction sites will be transferred to the disposal site at Margarita in consultation with authority;
- Dedicated paved storage area will be identified for the drilling chemicals, fuel, lubricants and oils within the drill sites;
- Paved storage areas will be provided for storage of oils, lubricants at the production facilities
- HDPE lined pits will be considered for the disposal of unusable drilling mud cuttings and drilling wastewater etc.

Impacts & Receptors: The potential impact due to above mentioned activities has been discussed in following section.

Removal of top soil: Before site development activity, the top soil of the site if not properly stripped and stored for future use, the entire volume of top soil will be permanently lost or fertility/soil characteristics will be changed.

Handling of oil, chemical and waste: The drilling chemicals, cement for mud preparation, fuel & lubricants will be stored in dedicated paved storage areas within drill sites/production facilities. The hazardous waste (spent oil & used oil), batteries, e-waste and municipal waste will be stored within the drill sites/production facilities before final disposal. Thus, the contamination of soil can happen only due to accidental spillage of fuel, lubricants and paints from storage areas and during the transfer of fuels and chemicals. The contamination of soil with fuel, lubricants and paints may affect the soil microbes and bacterial growth and can affect the soil quality.

Storage and disposal of drill cuttings and spent mud: It is estimated that nearly about 450-500m^3 drill cuttings and 1350-1500 m^3 spent drilling mud is likely to be generated from each drilling operation. The project design takes into account construction of a HDPE lined impervious pits for storage of drill cuttings, drilling mud and drilling fluid respectively and their disposal in accordance with "CPCB Oil & Extraction Industry Standard – Guidelines for Disposal of Solid Wastes" in their planning stage. The flooding history of the area and rainfall intensity will be taken into account while designing the depth of the pits. It can be stated here as high flood levels taken into considerations for the previous drilling programmes at the drill sites, the same considerations would also be undertaken here. Further, with HOEC committing to the use of primarily water based mud and it is anticipated borehole instability problems it may be necessary to introduce a base salt, such as Potassium Sulphate (K_2SO_4) into the system.

The drill cuttings and waste drilling mud generated are likely to be non-hazardous in nature. Spillage of drill cuttings and spent mud on nearby open soil may lead to change of soil characteristics due to chemical contamination.

Surface runoff during monsoon season from disturbed construction site, construction material & waste storage area and spillage area have the potential to degrade soil quality due to deposition of foreign materials, hydrocarbon and other hazardous waste.

Pipeline
The soil dug during trenching will be reused for covering after laying the pipelines. Care will be taken to restore the location of the concealed pipelines to its earlier state. The process will be completed within a very short period of time (1-2 months).

Primary monitoring results of soil quality results shows that there is no contamination of heavy metals in the nearby agricultural land, homestead plantation or tea garden areas (*Refer Section 3.3.8*) hence the resource sensitivity is termed as **medium**.

Contamination of soil from wastes, contaminated surface runoffs from the drill sites/production facilities may cause perceptible changes of the soil quality hence, the scale of impact is considered to be ***medium***. The above mentioned soil quality impacts will be localized within the project site or immediate vicinity hence the extent of impact would be ***local***. The duration of impact will spread across phases of the project life cycle hence duration is considered as ***medium*** term. The magnitude of the impact is assessed to be **medium**.

The significance of impact on soil quality is assessed to be **moderate** (*Ref.* ***Table 4.7:*** *Impact Significance Matrix without mitigation*).

<u>*Mitigation Measures*</u>: The mitigation measures to minimize the above-mentioned impacts are as follows:

- Assess the top soil depth & volume likely to be generated;
- Demarcate the top soil storage area within the site;
- Assess the soil quality (phyco-chemical characteristics including contamination)
- Properly stripping of top soil and conserve it for future use like site restoration/ greenbelt plantation;
- The top soil will be stored in mound form, with height less than 2m, slope of angle not more than 30° , catch drain and sedimentation tank and covered with jute mat to prevent erosion;
- Utilise the top soil for restoration of site or greenbelt plantation in production facility/ producing well.

- Restrict movement of vehicles within the site only to designated areas to prevent any compaction of soil;
- Restricted project and related activities during monsoon season;
- Drainage system at site is to be provided with sedimentation tank and oily-water separator to prevent contaminants, especially oil and grease, from being carried off by surface runoff;
- Manage spills of contaminants on soil using spill kits;

- Storage of construction waste/ MSW in designated areas within drill sites/production facilities;
- Adopt best practices e.g. use pumps and dispensing nozzle for transfer of fuel, use drip trays etc.

<u>Residual Impact</u>: Considering the implementation of above mentioned mitigation measures, impact on soil quality is assessed to be ***minor*** (*Refer* ***Table 4.8*** *Impact Significance Matrix with mitigation*).

4.2.7 *Impact on Topography & Drainage*

Source of Impact: Alteration of drainage pattern and water logging is anticipated due to following activities:

- Site raising and leveling of drill sites and GGS;
- Construction of site approach road;
- Laying of pipelines;
- Discharge of waste water and produce water from drill sites.

<u>*Impacts & Receptors*</u>: The potential impact due to above mentioned activities has been discussed in following section.

Drill Site construction at Dirok Tea garden area: The drill sites located at tea garden area are high land. Levelling and grading will be required for construction of drill sites. The environmental settings of the drill sites reveals that 1st order drainage channels are located near the proposed drill sites. The unplanned leveling and grading may disturbed the local drainage.

Drill site construction at Agricultural land: The drill sites located in the Vitor Powai area are located in the agricultural land. There is no drainage channel near the proposed drill sites. Surface runoff from the drill sites drains into Buri Dehing River by gravity flow. The sites will be raised to a height of one and half a meter more than the high flood level of past ten-twenty years. This may lead to alteration of onsite micro-drainage pattern leading to potential problems of water logging in the agricultural land and low lying areas abutting the drill site.

Site approach road development: Approach roads have to be constructed for few proposed sites. The length of the site approach road will vary between 0.15 km to 0.38 km. Approach road may interfere with the drainage of surface run-off during rainfall.

Pipeline laying: The proposed pipeline route reveals that, the pipeline will cross a river. It is proposed to lay the pipeline by HDD method. Mud will be generated from HDD activities and if it is disposed in the drainage channel, drainage may be disturbed.

The extent of the impact will be **local**, i.e. within the site and immediate vicinity; duration will be **long term.** The modification of drainage irreversible but can be brought back to original conditions with mitigations. The magnitude will be **medium**. The sensitivity will be **medium**, as human receptors in the vicinity may experience the impact, the impact significance is assessed to be ***moderate*** (*Ref.* ***Table 4.7:*** *Impact Significance Matrix without mitigation*).

Mitigation Measure

- Levelling and grading operations will be undertaken with minimal disturbance to the existing contour, thereby maintaining the general slope of site; and
- Cross drainage structures will be constructed in approach road for drainage of run-off.

Residual Impact Significance

The implementation of the above mitigation measures will help mitigate the impacts on topography and drainage however, the residual impact significance will reduce to **minor** (*Refer* ***Table 4.8*** *Impact Significance Matrix with mitigation*).

4.2.8 Impact on Surface Water Quality

<u>*Source of Impact:*</u> Potential impact on surface water quality can arise due to the following activities;

- Predrilling phase, construction of drill sites and site approach roads and laying of pipeline:
  - o Surface runoff from construction site, spill area;
  - o Hydrotest water from pipeline testing;
  - o Generation and disposal of domestic waste water from construction camp.
- Drilling phase:
  - o Discharge of drilling wash water;
  - o Generation and disposal of domestic waste water from drill sites;
  - o Surface runoff from drill sites;
  - o Accidental discharge from waste pit.
- Decommissioning phase:
  - o Surface runoff from site.
- Operation of GGS & GPP
  - o Generation & discharge of produce water from GPP

<u>*Embedded Control Measures*</u>: The embedded control measures are as follows:

- Each drill site will have modular ETP for treatment of waste water generated from the drill sites;

- Domestic waste water will be treated through septic tank & soak pit/ modular STP;
- Hydrotest water will be taken to the ETP at GPP site for treatment and disposal;
- Produce water will be treated through ETP.

Impacts & Receptors: The potential impact due to above-mentioned activities has been discussed in following section.

Surface run-off from the drill site: The site development activity *viz.* site raising with soil/ sands during site construction may result in increase in soil erosion that might lead to an increased silt load in the surface run-off. The surface run off from drilling waste (cuttings and drilling mud) storage areas, hazardous waste (waste oil, used oil, etc.) storage areas and chemical storage areas is likely to be contaminated. To prevent these run-offs, waste pits, storm water drains and tankers (that will regularly carry the treated water) will be provided during the drilling phase. Further, the boundaries of the waste pits will be raised to prevent any runoff. Any accidental runoff from drill sites and production facilities will create an adverse impact upon the receiving streams and river. This situation is likely to be more pronounced considering high rainfall received in these areas. The surface run offs may contain high sediment load, oil residues, organic wastes, etc. The higher value of suspended solid and organic rich sediment load may affect the lowering of DO levels in the nearby water bodies and affect the aquatic ecology. Impact on aquatic ecology is discussed under the section on ecological impact assessment.

Discharge of drilling wastewater: It is estimated that nearly about 10-15 m^3/day process wastewater and waste mud is likely to be generated during drilling operation. The drilling waste so generated may be characterized by the presence of oil & grease, barites and heavy metal which on discharge to nearby natural drainage channels and/or rivers may lead to possible surface water contamination. The process wastewater and formation water will be generated during drilling activity. The process wastewater treated through ETP would meet the CPCB discharge standards before it is discharge. Resultantly no significant change in the surface water quality is envisaged. However, accidental discharge of untreated process effluent will adversely affect the surface water quality.

Discharge of Domestic Waste Water: The domestic wastewater will be generated during all the phases of the project. The domestic wastewater will be treated through septic tank & soak pit or modular STP.

Discharge of Produced Water from GPP: It is estimated that nearly about 1-2 m^3/day produce water is likely to be generated during treatment of gas at GPP. The produce water may be characterized by the presence of oil & grease, high TDS which on discharge to nearby natural drainage channels and/or rivers may lead to possible surface water contamination. Produced water will be treated in ETP to comply with the CPCB discharge standards before discharging to local stream. The discharge of treated water in the stream /river is not expected to cause significant change in the surface water quality. However, accidental discharge of untreated water will adversely affect the surface water quality.

Laying of Pipeline: The proposed pipeline stretch traverses through local stream (Refer section 2.9.1). Potential surface water quality impacts are primarily envisaged as increased sediment load during pipeline laying. Untreated or inadequately treated hydrotest water from pipeline hydrotesting operations will also possibly be leading to surface water contamination during the pipeline laying stage.

With respect to the proposed project the watercourse crossings will be designed to avoid affecting the stability and long-term performance of riverbanks. In this regard HOEC will be referring to the OISD standard OISD-STD-141- Design & Construction Requirements of Cross Country Hydrocarbon Pipelines for the appropriate water crossing technique (open cut/HDD) and construction considerations to prevent any adverse impacts on surface water quality and natural drainage as identified above. The pipeline will be installed below the watercourse bed, at a level such that the gradients on the channel beds are not impaired or future re-grading does not become more difficult. Construction details for water crossing will be prepared by the construction contractor in line with the relevant OISD standard and will be approved by HOEC and established through method statements, which will be prepared for Buri Dihing crossing. These plans and procedures will also deal with spills in water comprising of immediate reporting techniques, deployment of a boom downstream of the spill source spanning the entire watercourse, angling of the boom to direct pollutant to one of the banks, use of floating absorbent and/or skimmers to remove the pollutant, and removal of contaminated material from the site to a suitable licensed disposal location. For further details refer to the "Surface Water Quality Management Plan" in Chapter

The riverine habitat in the study area is not legally ecologically protected habitat. The water quality of the river is fit the use of propagation of wildlife (CPCB Use Class category D) and also no major contamination was recorded (*Refer* ***Section 3.3.12***).

Discharge of surface run-off, treated wastewater can cause reversible damage to water quality but likely to easily revert to earlier stage with mitigation, hence, scale of impact is ***medium***. The duration of impact will be **short term**; i.e. surface runoff may get discharged at the time of rainfall and formation water may get discharged accidentally. The extent of impact is ***regional*** as treated wastewater and surface run-off may reach beyond 0.5 km from the drill sites**.** The potential impact on surface water quality is assessed to be ***moderate***

Mitigation Measures: The mitigation measures are as follows:

- Construction activities *viz*. stripping, excavation etc., during monsoon season will be restricted to the extent possible;
- Construct periphery drain and provides sedimentation tank with appropriate size and oil-water separator;
- Channelize all surface runoff from the construction site through storm water drainage system and provide adequate size double chambered sedimentation tank;
- Proper treatment of all wastewater and produced water discharges will be made to ensure that they comply with criteria set by the regulatory bodies (MoEFCC and SPCB);
- All chemical and fuel storage areas, process areas will have proper bunds so that contaminated run-off cannot escape into the storm-water drainage system;
- An oil-water separator will be provided at the storm water drainage outlet, to prevent discharge of contaminated run-off;
- Spill kits to be used for removal of any oil or chemical spillage on site;
- Additional storage area to be provided to store formation water within the drill site.
- The OISD standard OISD-STD-141- Design & Construction Requirements of Cross Country Hydrocarbon Pipelines for the appropriate water crossing technique (open cut/HDD) will be followed to laying of pipeline through stream.
- The pipeline will be installed below the watercourse bed, at a level such that the gradients on the channel beds are not impaired or future re-grading does not become more difficult.

Residual Impact: Considering the implementation of above mentioned mitigation measures, the residual impact on surface water quality due to above mentioned activity is still assessed to be **minor**.

4.2.9 *Impact on Ground Water Resources*

Source of Impact: Potential source of ground water resources could arise due to:

- Abstraction of ground water for drilling;
- Cutting of aquifer and discharge during drilling

Embedded Control Measures: The project embedded control measures are as follows:

- Casing and cementing during drilling activity.

Impacts & Receptors: The potential impact on groundwater resource is discussed below:

Ground water extraction: Water requirement for drilling would be sourced from surface water sources, thus in this regard no impact to the groundwater resource is envisaged.

Aquifer cutting: The drilling will be carried out to a depth of 2500-3500 m. Though, the data logging service HOEC will be aware of the depth where the drill will cut through the aquifer zone, an unquantified sudden huge gush of water does flow out as the rig cuts across the aquifer zone before cementing and casing is done. As part of the project activity, cementing and casing will be done within few hours to protect the groundwater resource. Moreover, the project area is demarcated by the Central Ground Water Board (CGWB) as "safe" which do not suffer from heavy withdrawal of water leading to rapid fall in the aquifer level the impact significance is envisaged to be low.

The quantity of formation water and the abstracted water is low compared to likely potential yields of aquifers hence the scale of impact is **low**. The geographical extent of potential impact due to withdrawal of water is anticipated to be **regional**, impact duration is expected to be **medium term i.e.** across some phases during the entire duration of the project. The impact on ground water resources is assessed to be **minor**.

4.2.10 Impact on Ground water Quality

Source of Impact: Potential impact on ground water quality could arise due to:

- Spillage of fuel and chemical, hazardous waste storage,
- Spillage of drill cuttings and spent mud from storage;
- Contamination of drilling mud into aquifer during drilling.

Embedded Control Measures: The project embedded control measures are as follows:

- The drill cutting along with spent mud will be stored in HDPE lined pit.
- After the drilling activity, this waste pit will be capped by HDPE liner and soil will be put over it.
- Impervious storage area to be provided especially for fuel and lubricant, chemical, hazardous waste, etc.

Impacts & Receptors: The potential impact on groundwater quality is discussed below:

Contamination from fuel, lubricant & chemical storage areas, drill cutting & waste mud storage and disposal area: Fuels, chemical lubricant etc., would be stored at a designated paved area within drill site. Thus, contamination of groundwater can happen only due to accidental spillage of fuel, lubricants and chemicals from storage areas and during the transfer of fuels and chemicals.

The drill cutting and the spent mud would be stored in HDPE lined pits at site. Improper lining system or any puncture in the liner system can lead to the potential leakage of chemical like cadmium, mercury, etc. (present of mud chemical) and has potential to contaminate soil and subsequently ground water. Leachate will be generated, if the rainwater percolates into waste disposal area. This leachate can pass through the any puncture in the liner system and will have potential to contaminate the ground water.

Contamination during drilling of wells: The other impact on the groundwater quality will be due to the drilling activity. Water based mud will only be used as discussed in ***Section 2.6.8***. Possibility of contamination of subsurface and unconfined aquifers may also exist if the casing and cementing of the well is not carried out properly leading to infiltration or seeping of drilling chemicals or mud into porous aquifer regions.

Considering project embedded control measures, the scale of impact is considered to be ***low***. The geographical extent of potential impact due to above activity is anticipated is ***local***; however, impact duration of impact is considered to be ***long-term***- contamination may spread beyond lifecycle of the project. The impact magnitude is assessed to be **low**. The sensitivity is **low**, as the water is unpolluted and provides services as, domestic uses. The impact on ground water quality assessed to be **minor.**

Mitigation Measures: The proposed mitigation measures are as follows:
- Prevent & mitigate spill of paint/fuel within the construction site;
- Conduct all fuel transfer operations in paved areas;
- Regularly monitoring ground water quality in the vicinity of well sites.

Residual Impact: Considering the implementation of above mentioned mitigation measures, impact on ground water quality is assessed to be **minor**.

4.2.11 Impact on Terrestrial Flora

Source of Impact: The potential impacts on terrestrial ecology may arise due to:
- Vegetation clearance;
- Fugitive dust emission and deposition on vegetation;
- Air emission from DG set Gas generator

Embedded Control Measures: The control measures are as follows:
- Engineering control for emission

Impact Assessment: The potential impact on terrestrial ecology is discussed below:

Vegetation Clearance: Clearance of vegetation would be required for 10 numbers of drill and GGS sites located at tea garden area. Clearance of vegetation would happen in small area (approximately 2.0 ha. for each drill sites, 1.0 ha for GGS and 10 m RoW for interconnected pipelines).

The ecological survey in the study area reveals that the vegetation species composition in the non-forest areas (agricultural lands, scrub land/homestead plantation and tea garden areas) comprise of planted species are common in the area. The cleared vegetation can be brought back to near original condition with plantation programme.

Fugitive Emission: The fugitive emissions are likely to be generated during site construction and decommissioning phases. Due to relatively large particulate matter sizes associated with the fugitive emission from construction site and the relatively short release height of the pollutants, such negative impacts are usually confined in relatively small areas; estimated to be 100 to 200 m from the construction site. The deposited particulate matter may block the plant leaf stomata hence inhibiting gas exchange, or smother the plant leaf surfaces reducing photosynthesis levels. In the non-forest areas within the 200 m from the proposed project sites, there is no natural vegetation; the major vegetated area is the homestead plantations, tea garden and agricultural land. However, for the proposed drill sites close to forest areas the fugitive emission during drill site preparation, drilling and decommissioning phases will be deposited to the natural forest vegetation in the vicinity.

Air Emission from DG & flaring: The major pollutant from the operation of DG sets is NOx. The baseline average NOx level in the area varies from between 17.7 and 20.5 $\mu g/m^3$. The operation of DG sets will also contribute NOx emissions. The predicted concentration of NOx from DG sets (baseline concentration + incremental concentration) will be 20.3 $\mu g/m^3$ to 23.1 $\mu g/m^3$.

Nitrogen-containing air pollutants can affect vegetation indirectly, via. chemical reactions in the atmosphere, or directly after being deposited on vegetation, soil or water. The critical level (CLE) is the concentration in the atmosphere above which these is direct adverse effects on receptors, such as plants, ecosystems. The Critical Levels for NO_2 is cited in 'Effects of nitrogen containing air pollutants: critical levels; Air Quality Guidelines – Second Edition[1]'.

Table 4.6 Critical Levels for NO_2

Concentration ($\mu g/m^3$)	Exposure Time	Remarks
95	4 hours	The incremental value of NO_2 in ambient air during the current drilling programme clearly indicates that concentration will be below critical level.
30	Annual mean	
800	1 hour	
60	Growing season	
40	Winter	

Source: WHO. 2000. Effects of nitrogen containing air pollutants: critical levels; Air Quality Guidelines – Second Edition

With respect to critical level value, the NO_2 levels in ambient air during the current drilling programme is expected to be low. Hence, the proposed drilling and production activities is not envisaged to cause damage to the vegetation in the area.

The above mentioned activities may not cause measurable changes of species composition or floral diversity; scale of impact is assessed to be low. Duration of impact will be ***medium*** i.e. during the entire drilling phase and in some phases of the production operations and extent of impact will be ***regional*** as

[1] http://www.euro.who.int/__data/assets/pdf_file/0005/123098/AQG2ndEd_11no2level.pdf?ua=1

emission from DG/GG sets may reach a distance of 2-3 km (refer ***Table 4.3***). The impact magnitude is assessed to be **medium**.

The tree species present in the non –forest and forest area in proximity to the well sites and production facilities are common; however, the ecosensitive habitat, i.e. Dehing Patkai WLS is located within the study area the resource sensitivity would be **high**. Overall impact on terrestrial flora is assessed to be **moderate** (*Ref.* Table 4.7***:*** *Impact Significance Matrix without mitigation*).

Mitigation Measures

A range of measures will be adopted during drilling/production activities to mitigate potential impacts on the terrestrial flora including the following.

- The working area which has to be disturbed will be kept minimum at all times;
- Restore the drill site and brought to its best achievable original state after completion of drilling activity and hand over the land except production facility;
- Sourcing of timber and fuel wood from forest area will be prohibited;
- Regular maintenance of vehicles and machineries to control air pollutant emission;
- Low sulphur diesel (S<0.5%) will be used in diesel powered equipment and best management practices would be adhered to;
- Fugitive dust will be suppressed with periodic water sprinkling.
- Greenbelt would be developed and maintained at the production well sites and production facilities

Residual Impact: Considering the above mentioned mitigation measures, the residual impact on terrestrial flora is assessed to be **minor** (*Refer* ***Table 4.8*** *Impact Significance Matrix with mitigation*).

4.2.12 *Impact on Terrestrial Fauna & Protected Species*

Source of Impact: The potential impacts on terrestrial fauna may arise due to:

- Habitat fragmentation due to vegetation clearance;
- Illumination from site;
- Noise & vibration.

Embedded Control Measures: The control measures are as follows:

- Engineering control measures to minimise the noise level from construction machineries and equipment.

Impacts & Receptors: The potential impact on terrestrial fauna is discussed below:

Vegetation Clearance: As discussed in *Section 4.2.11*, the vegetation clearance would be required for 10 number of drill sites and GGS. The vegetation cover reveals that tea garden area has tea bushes and shed trees and homestead plantation area have very low/scattered vegetation hence vegetation clearance is not expected to cause habitat fragmentation for the faunal species. Moreover, only IUCN threatened species found particularly at the non- forest area is Common Leopard which is reported from the tea garden areas.

Noise Emission: Seven numbers of wells are located within 1.0 km from the Dehing Patkai WLS. Ecological baseline study reveals that study area and also Dehing Patkai WLS are habitats for tiger, elephant, hoolock gibbon, leopard, leopard cat, jungle cat, capped langur, slow loris, hornbills, vulture etc. Some protected wildlife species are also reported in proximity (within 1 km) of the well sites.

Noise generated from various operational activities from the proposed locations during the drilling phase in presence of fence line barrier (*refer Potential Impact on Noise Quality Section 4.2.2*) is expected to get attenuated to baseline levels within 200-300 m from the locations. The higher noise level in the impacted area may cause disturbance and behavioural changes of the faunal species.

Noise will be generated from the operation of GGS which is approximately 1.26 km from the WLS. Noise will be attenuated within 500 m from the GGS. Therefore, potential impact of noise due to operation of GGS is not expected to be significant. The GGS would not involve any gas processing activity, the gas processing will be conducted at the GPP which will be located about 11 km from the WLS boundary, hence, noise related impact due to gas processing on the animals inhabiting the WLS is also not envisaged.

Physical Presence & Illumination: The physical presence of drilling rig is also to be felt at night because of the illuminated at night by lighting arrangements. Other possible sources of illumination will be flaring conducted during testing phase (2-3 days). Artificial lighting and well testing flares may result in the attraction of some wildlife leading to their disorientation and confusion behaviour. Therefore, impact of illumination from all the drill/production sites on the animals residing at the WLS is anticipated from the proposed drilling and development activity.

The GGS would also be located at about 1.26 km from the WLS boundary hence impact of illumination of the GGS on the animals residing at the WLS is also anticipated. No flaring would be conducted at the GGS; however, regular flaring is expected from GPP which will be located 11km away from WLS and may have some adverse impact on wildlife on the Upper Dihing Reserve Forest adjacent to GPP.

The scale of impact is high. The extent of impact is considered to be **regional** i.e. within 5 km of the proposed drill sites and production facilities. The duration of impact will be **medium-term** during the entire drilling phase. The magnitude of the ecological impact would be **medium**. The impact significance on terrestrial fauna & scheduled animal is thus assessed to be **moderate.**

Mitigation Measures

A range of measures will be adopted during construction and drilling and production activities to mitigate potential impacts on the terrestrial fauna, including the following.

- The working area which has to be disturbed will be kept minimum at all times;
- Sourcing of timber and fuel wood from natural vegetated area will be prohibited;
- Regular maintenance of vehicles and machineries to control noise and air pollutant emission;
- Restrict all noise generating operations, except drilling, to daytime;
- Provide noise barrier in sensitive locations;
- Appropriate shading of lights to prevent scattering;
- The movement of construction vehicles will be minimised and a speed of 20 km/hr will be enforced along the access and approach roads;

Residual Impact: Considering the above mentioned mitigation measures, the residual impact on terrestrial fauna would be **minor** (*Refer **Table 4.8** Impact Significance Matrix with mitigation*).

4.2.13 Impact on Aquatic Ecology

Source of Impact: Impacts on surface water quality and its aquatic habitat may happen due to:

- Discharge of untreated surface runoff;
- Discharge of wastewater from treated waste water

Embedded Control Measures: The control measures are as follows:

- Treatment of domestic waste water through septic tank & soak pit/ modular STP;
- Storage of diesel, lubricant and waste oil in paved surface with secondary containment;
- Treatment of process effluent and re-use in the process.

Impacts and Receptors:

Surface Runoff: Surface runoff from the drill sites contaminated with sediment, site may reach Buri Dehing River through Ongchap Jang, Namphai Jang, Powai nala etc and increase the suspended solids load of the river water. Increase of suspended solid will increase the turbidity of river water that ultimately will adversely affect the Dissolved Oxygen (DO) level in the water. The turbid water and lower DO will affect the primary productivity of the impacted areas of the rivers.

During site development and drilling activities, production activities operation of machineries and vehicles will take place at site. For the operation of construction machineries and vehicle, oil (diesel) and lubricant will be utilised; accidental spillage and leakage of oil and lubricant is likely to be mixed up with surface runoff. The discharge of oil and grease contaminated runoff water without treatment has the potential to impact water quality of the receiving waterbody. The degradation of water quality will affect the primary productivity of the river.

Discharge of Effluent/Drilling Wastewater/Formation water: The process effluent will be adequately treated in the ETP to meet the industrial effluent discharge standards. The discharge of treated effluent is not expected to cause perceptible changes in the water quality of the river.

Accidental discharge of formation water to the local small channels may reach Buri Dehing River and have the potential to affect the river water quality.

Discharge of Domestic Wastewater: The domestic wastewater will be treated through septic tank and soak pit; hence, water pollution due to domestic wastewater is envisaged.

The extent of impact will be **regional** as surface run-off, discharge of treated wastewater and formation water from the drill sites may reach Buri Dehing River through small streams. The duration of impact will be **short term**; i.e. only during monsoon season. The discharge of pollutants if reaches the river water may cause affect and affect the productivity; however, the system could revert to its original condition after the settling of the suspended solids. Oil and chemicals present in the surface runoff will be lower in volume and diluted after reaching the large waterbodies *viz.* Buri Dehing River. Oil and chemical may be deposited at the benthic ecosystem of the rivers hence the scale of the impact would be **medium**. The impact magnitude is assessed to be **small**.

The rivers mentioned above provides habitat to fish. Discharge of surface runoff, formation water from the well site may reach the rivers and affect the sediment load, productivity of the river water and cause habitat disturbance to the aquatic species. Hence, the sensitivity of the habitat is assessed to be **medium.**

The potential impact on aquatic ecology due to abovementioned activity is assessed to be **minor**.

Mitigation Measures

A range of measures will be adopted to mitigate potential impacts on the ecology and biodiversity, including the following:

- Earth works and other construction activities during heavy rains to be avoided;

- All accidental discharges would be controlled before it reaches any surface water body through sedimentation tank and oil-water separator;
- Spill kits to be used for removal of any oil or chemical spillage on site;
- All process and domestic wastewater would be adequately treated before discharge;
- Additional storage area to be provided to store formation water within the drill site;
- Proper monitoring of indicator species will be carried out and compared to baseline conditions to understand any negative impacts.

Residual Impact: The residual impact on aquatic ecology and biodiversity is still considered to be minor (Refer Table 4.8 Impact Significance Matrix with mitigation).

4.2.14 *Potential Impact on Socio-economic Environment*

The assessment of socio-economic impacts due to the proposed drilling and production activity have considered the following context and project activities:

- New land will be procured for the proposed drill sites and GGS, construction of production facility and road infrastructure for transport of plant and machineries however, no physical displacement due to land purchase is envisaged;
- There will be incremental change in the workforce during construction and operations phase. A majority of the workforce is likely to be from the local areas.

Adverse Impact

- Loss of livelihood/Income due to land purchase
- Conflict with Local People

Embedded Control Measures

- HOEC follow the compensation calculation procedure of Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (LARR Act of 2013) and that is highest land value they offer to the land owner;
- For the assets over the land HOEC, provide surface compensation to the landowner as per the Assets Rate List of concerned district authority;
- HOEC organize continuous consultation with the local people and also timely disclosure of project activities;
- HOEC has established grievance redressal process to deal with conflict with local communities.

Assessment of Impacts: The impact on economic-economic impact due to above mentioned activities has been discussed as follows:

Loss of livelihood & Income Generation

As discussed in *Section 4.2.5*; 24 developmental wells will be drilled and two GGS and with associated road infrastructure will be constructed in different location within the AAP-ON-94/1 block. Approximately 2.0 ha. of land parcel would be required for drilling of each well (total 24 wells) and 2.0ha for GGS (total 2 GGS) which will be procured from from local communities and tea garden. Discussion with HOEC officials reveals that mostly agricultural, tea garden and homestead plantation land will be selected and no physical displacement during land procurement is anticipated. Affected landowners will be adequately compensated for the land parcels, any assets over the land and for the standing crop.

Community consultation reveals that the dependency of the landowner in case of generation of livelihood is limited as most of the agricultural land in this region is classified as monocropped agricultural land hence the resource sensitivity is ***medium***. As discussed, only 2 ha land for a drill site and 1.0 ha. land for a production facility will be procured from different location within the block hence extent of impact would be ***local***. Land procurement will cause permanent change of land use hence the scale of impact would be ***high*** and duration would be ***permanent***. Impact magnitude is assessed to be **medium.** The impact significance would be **moderate**.

However, adequate compensation will be provided for land parcels, the significance of the impact will be reduced to **minor**

Conflict with Local People

Consultations in the neighbouring villages indicate that the people in the area look forward to new employment to be generated by the project. Even though HOEC/its contractors would endeavour to provide maximum employment to the local people, there would be constraints due to the lack of required technical skills and expertise in the local population. So, certain percentage of semi-skilled and highly skilled migrant labour would be used by contractors for manning these activities. It is anticipated that occasional conflicts would arise with the local community over the recruitment of migrant workers.

Conflict with local people may also arise due to different project activities *viz*. movement of vehicles, generation of dust and noise due to project activities, surface water discharge to nearby agricultural fields, use and damage of common property resources etc. The receptor significance would be **high** as drill site and access road is located in close proximity to habitated area. The scale of the impact would be ***medium*** as people in this region are familiar with the oil and gas-drilling activities. Apart from that, HOEC also has structured grievance redressal procedure to deal with the community conflicts. The extent of the impact would be ***local*** as it would be limited to immediate vicinity of the sites selected for drilling activity and production facility and access roads. The duration of the impact would be ***short term*** as conflict may arise at any point of time during the project activity; however, the same is expected to be addressed through active grievance redressal system of HOEC. The magnitude of impact is assessed to be **small**. The significance of impact would be **moderate** (*Refer **Table 4.7** Impact Significance Matrix without mitigation*).

Mitigation Measures

- An effective grievance redressal mechanism to address the concern of local people;
- Migrant labours would be provided training on local culture and traditions;
- Labours to be provided with proper sanitation facilities.

Residual Impact: Considering the above-mentioned mitigation measures the residual impact will remain same, i.e. **moderate** (*Refer **Table 4.8** Impact Significance Matrix with mitigation*).

Benefit to Local Enterprises

The project is likely to influence development of entrepreneurs in the area. The local enterprises, particularly involved in production and sale of construction materials are expected to be potential benefactors of the civil works to be undertaken for the project. Similarly, local transporters of construction materials will also benefit from the project.

Employment Generation

The construction phase of the project is likely to generate both direct and indirect opportunities for employment. The estimated direct employment would be approximately 50 un-skilled workers during the peak construction phase that will primarily sourced from nearby villages. Indirect employment would be primarily in the supply chain as vendors, which are anticipated to be set up to support the construction. The local people are expected to be having options for such indirect employment, even if they are not directly involved as construction labour. Overall construction activity would have positive impact on the socio-economic conditions in general and employment scenario in particular in the study area.

4.2.15 Potential Impact on Occupational Health & Safety

Construction Phase

<u>*Source of Impact*</u> Occupational health and safety impacts during construction phase are anticipated primarily from:

- Pre-drilling Phase
    - Operation of construction machineries/equipment;
    - Exposure to high noise generation areas.
    - Exposure to dust

- Drilling Phase
    - Operation of rig and machineries,
    - Exposure in high noise generation area.
- Site Decommissioning Phase
    - Operation of construction machineries/equipment;
    - Exposure to high noise generation areas.
    - Exposure to dust

Embedded Control Measures The project embedded control measures are as follows:

- All potential occupational health hazards will be identified;
- Permit to work system to be in place;
- Provision of proper PPEs for the contractor workers onsite;
- Provision of drinking water facility, sanitation and cooking facilities.

Impacts & Receptors: Impact on occupational health and safety due to above mentioned activates has been discussed in the following section

Exposure to High Noise Level: Impact on occupational health and safety of contractor workers is anticipated from exposure to high noise generated from operation of heavy machineries/equipment. It is estimated that about 50-60 workers will be deployed by the contractor at each drill site and 10-20 workers in the production facility. The outstation project workforce will be housed in labour camp located within the drill site. Continuous exposure of workers to high noise levels and fugitive dust and inadequate facilities and unhygienic conditions at such camps may lead to adverse health impacts *viz*. headache, hearing loss etc.

Exposure to dust: During drill site construction, site access road development, pipeline laying and decommissioning activities fugitive dust likely to be generated from the site. Inhaling of dust may cause asthma, allergy, respiratory problems of workers.

The extent of the impact is limited to the well site and production facility only hence the impact will be ***local***. Also considering the temporary nature of the construction phase activities, intermittent operation of machineries/ equipment duration will be ***short term*** and with provision of proper PPEs and training for the workers scale of the impact will be ***low***. Hence, the impact magnitude for occupation health and safety due to above mentioned construction activities is assessed to be ***medium and*** significance would be ***moderate*** (*Refer* ***Table 4.7*** *Impact Significance Matrix without mitigation*).

Mitigation Measures

The mitigation measures are as follows:

- Provision of healthy living conditions will be ensured in the contractor labour camp as per National Policy on Safety, Health & Environment at Work Place;
- Exposure of workers operating near high noise generating sources will be reduced to the extent possible;

- Health surveillance of contractor workforce will be conducted;
- Occupational health and safety of contractor workforce will be assured through the formulation of an "Occupational Health & Safety Management Plan".

Residual Impact: Considering the implementation of above mentioned mitigation measures, impact on occupational health and safety is assessed to be **minor** (*Refer* ***Table 4.8*** *Impact Significance Matrix with mitigation*).

Production Facility

Main impact on occupational health safety in production facility will limited to operation of heavy vehicles and machinery, handing of chemicals etc. However, involved of the personal in a production facility per shift is maximum up to 10 person and it is understood that they will be trained. Hence, the resource sensitivity will be ***medium***. As all the activity of production facility will be carried out within secure premise extent of impact will be ***local***. In an oil and gas site production installation will be **permanent** in nature and continues is operation up to 20 years hence the impact will be permanent in nature. As the risk level of a production facility is high as it is handling highly inflammable hydrocodone embedded control of any production facility is very strong so the scale of the impact will be ***medium***. Hence, the magnitude of the impact will be ***medium*** and significant of the impact is assessed to be ***moderate*** (*Refer* ***Table 4.7*** *Impact Significance Matrix without mitigation*).

Mitigation measures: The mitigation measures are as follows:

- Regular onsite surveillance to be conducted so that the workers use the designated PPEs all the time;
- Health surveillance will be conducted of personnel working in the aforesaid areas;
- Regular health and safety training to be provided to workers.

Residual Impact: Considering the implementation of above mentioned mitigation measures, impact on occupational health and safety is assessed to be **minor** (*Refer* ***Table 4.8*** *Impact Significance Matrix with mitigation*).

4.2.16 Potential Impact on Community Health and Safety

Source of Impact: The community health and safety impacts may arise due to:

- Changes in environmental quality,
- Influx of non-resident workers to the area;
- Movement of project traffic.

Embedded Control Measures: The embedded control measures are as follows:

- Engineering control measures to minimize the noise level from construction machineries;
- Dust suppression measures.

Impacts & Receptors: Impact on community health and safety due to above mentioned activates has been discussed in the following section.

Dust and Noise Discomfort: Proposed project site is surrounded by several rural settlements. Inhabitants residing close to site and access roads will get affected due to noise and dust generated from vehicular movements, site preparation operation of machineries, construction activities etc. The construction noise level will be attenuated within 200 m from the construction site. Incremental noise level will remain within the ambient noise quality standard for residential area. The scale of impact is assessed to be **low.**

Influx of non-residential workers: Approximate 50 workers will be employed during the construction phase of the project and it is anticipated that about 50% of the workers would be non-locals. The influx of workers to the community may cause impacts to public health, especially an increase in prevalence of diseases. Influx of migrant labours during construction can cause mixing of the migrant workforce with the local people. This mixing of the groups may cause some adverse impacts to public health in the neighbouring villages with the potential for spread of infectious diseases such as AIDS.

Improper sanitation facilities and disposal of municipal solid waste from the construction labour camps can also trigger vector borne diseases. Measures such as proper collection, storage and disposal of wastes, construction of septic tanks to prevent contamination of water resources from sanitary effluents generated from labour camps will be implemented. Taking these measures into account, the scale of impact is assessed to be **low**.

Traffic Movement in site approach road: An increase in traffic during the peak construction activities and may create public safety issues for local residents. Potential impacts may include blocking access, congestion and traffic accidents along the approach road. With mitigation measures as speed control in place the scale of impact to communities from heavy vehicular movement is assessed to be **low.**

As mentioned above that most of the well site, production facility and access road will be located adjacent to the habitation area hence the receptor sensitivity will be ***high***. However all the drill site and production facility will be stand alone and any impact arises from the facility will be affect the nearby area of the drill site hence the extent of the impact will be **local**. It is understood that all the impact will be limited to the construction phase and affect will be over after completion of the construction hence the duration of the impact will be ***short term***. It can also be anticipated that with proper embedded control all the impact will be very limited hence, the scale of the impact will be ***medium***. Then the impact magnitude on community health and safety due to above mentioned activities is assessed to be ***medium*** and significance of impact will be ***moderate*** (*Refer* ***Table 4.7*** *Impact Significance Matrix without mitigation*).

Mitigation Measures

The following mitigation measures will be put in place to reduce impacts to community to as low as reasonably practicable:

- Emphasizing safety aspects among drivers, particularly with regard to safe driving speeds;
- Ensuring that only licensed drivers are employed by the project;
- Avoiding peak hours for heavy vehicles movement where possible;
- Regular maintenance of vehicles and use of manufacturer approved parts to minimize potentially serious accidents caused by equipment malfunction or premature failure;
- Collaboration with local communities and responsible authorities to improve signage, visibility and awareness of traffic and pedestrian safety.

Residual Impact: Considering the above mentioned mitigation measures, the residual impact on community health and safety is assessed to be ***minor*** (*Refer* **Table 4.8** *Impact Significance Matrix with mitigation*).

Table 4.7 Impact Significance Matrix without Mitigation Measures

Impact	Nature			Type			Duration			Extent			Scale			Magnitude					Sensitivity			Significance			
	Negative	Positive	Neutral	Direct	Indirect	Induced	Shor term	Medium term	Long term	Local	Regional	National	Low	Medium	High	Positive	Negligible	Small	Medium	Large	Low	Medium	High	Negligible	Minor	Moderate	Major
Aesthetic & visual	X			X			X		X	X				X					X			X				X	
Air Quality	X			X				X			X			X					X			X				X	
Noise Quality	X			X				X		X					X				X				X				X
Road & Traffic	X			X				X			X			X					X			X				X	
Land Use	X			X					X	X			X					X			X				X		
Soil Quality	X			X				X		X				X					X			X				X	
Topography & Drainage	X			X					X	X			X						X			X				X	
Surface Water Quality	X			X			X				X			X					X				X			X	
Ground water resource	X			X				X			X		X					X			X				X		
Ground Water Quality	X			X				X			X			X					X			X				X	
Terrestrial Flora	X			X	X			X	X	X	X		X	X				X	X		X			X		X	
Terrestrial Fauna/ Protected Species	X			X	X			X			X				X					X				X		X	
Aquatic Ecology	X			X	X		X				X			X				X					X			X	
Livelihood & Income	X			X	X				X	X					X				X			X				X	
Conflict with local people	X			X	X			X		X				X				X					X			X	
Benefit to Local Enterprises		X		X	X				X		X					X											
Employment Generation		X		X	X		X				X					X											
Occupational health & safety	X			X				X		X				X				X				X			X		
Community health & safety	X			X	X			X			X			X					X			X				X	

Table 4.8 Impact Significance Matrix with Mitigation Measures

Impact	Nature			Type			Duration			Extent			Scale			Magnitude					Sensitivity			Significance			
	Negative	Positive	Neutral	Direct	Indirect	Induced	Shor term	Medium term	Long term	Local	Regional	National	Low	Medium	High	Positive	Negligible	Small	Medium	Large	Low	Medium	High	Negligible	Minor	Moderate	Major
Aesthetic & visual	■			■			■			■			■					■				■			■		
Air Quality	■			■				■			■		■					■				■			■		
Noise Quality	■			■				■		■			■					■					■			■	
Road & Traffic	■			■				■			■		■					■				■			■		
Land Use	■			■					■	■			■					■			■				■		
Soil Quality	■			■				■		■			■					■				■			■		
Topography & Drainage	■			■					■	■			■					■				■			■		
Surface Water Quality	■			■			■				■			■				■					■		■		
Ground water resource	■			■				■			■		■					■			■				■		
Ground Water Quality	■			■				■			■							■	■			■			■		
Terrestrial Flora	■			■	■			■	■	■	■		■					■			■				■		
Terrestrial Fauna/ Protected Species	■			■	■			■			■				■				■				■			■	
Aquatic Ecology	■			■	■		■				■		■					■					■		■		
Livelihood & Income	■			■	■				■	■			■						■			■			■		
Conflict with local people	■			■	■			■		■			■					■					■		■		
Benefit to Local Enterprises		■		■	■				■		■					■											
Employment Generation		■		■	■		■				■					■											
Occupational health & safety	■			■				■		■			■					■				■			■		
Community health & safety	■			■	■			■			■		■						■			■			■		

5 ANALYSIS OF ALTERNATIVES

This section provides an analysis of alternatives in relation to the conception and planning phase of the project. This includes the following:

5.1 ALTERNATIVE LOCATIONS

The location of proposed development wells and GGS will remain within the existing AAP-ON-94/1 Block. It is proposed to construct 24 numbers of development wells and 2 GGS. An analysis of alternatives for locations for the proposed oil and gas developments is given in following section.

5.1.1 *Development Wells*

The drilling locations are proposed based on geo-scientific information and alternate sites cannot be considered for the proposed project facilities due to the following reasons:

- The locations identified for drilling are tentative with a flexibility of 200m radius, however larger deviations are not possible as oil and gas development and exploration are based on the information generated from the seismic surveys conducted in the block. Identification of locations for drilling of wells is determined based on data suggesting presence of oil and gas in the area. It is therefore implied that the location for drilling cannot be altered.
- However, during selection of location following parameters has been considered:
    - Away from Dehing Patkai Wildlife Sanctuary. HOEC has received NBWL approval for drilling on 10 wells and one GGS and pipeline located at a distance of 0.310 m (minimum) to 2.790 km (maximum). The remaining 14 wells are located at distance of 0.092 km (minimum) to 3.132 (maximum).
    - Away from human settlement- the closest settlement is approximately 0.02km.
    - Non-forest area- all the proposed drilling sites, GGS and pipeline are located in the non-forest land.

5.1.2 *New Pipeline*

A 12 inch diameter gas pipeline of approximately 5.5 km will be laid along the RoW of the existing Makumkila road to transport the natural gas from proposed GGS at Vitor Powai village to existing trunk pipeline. The major part of the pipeline will be constructed along the ROW of existing road. The proposed alignment has been avoided use of agricultural land as well as crossing of Mota bill.

It is also proposed to laid 12 inch diameter gas pipeline of approximately 8.0 km pipeline from existing GPP to IOCL terminal. The proposed pipeline will be only laid along the existing ROW only.

5.2 OPTIONS ON METHODOLOGIES AVAILABLE FOR PIPELINE INSTALLATION

The proposed pipeline route reveals that pipeline is passing through Powai nala. The proposed pipeline laying method has been discussed in following section.

Trenching method

It is proposed to lay pipeline passing along the existing road and open land through trenching method. Before starting any construction work, a detailed route survey will be undertaken to document the existing condition of the pipeline route and the access roads. These records will be used as the standard against which the quality of the restoration work will be judged when the construction work is completed. The exact route of the pipeline will first be pegged out, while simultaneously staking out the width of the work strip on both sides of the route.

Manual or excavated methods will be used to dig the trench for laying the pipeline. The topsoil will be removed segregating the remaining backfill material. The topsoil will be replaced in its position during the backfilling operation. The pipeline will be generally buried to a minimum depth of 1m.

HDD Method

With the proposed pipeline likely to traverse through Powai nala, appropriate construction techniques viz. Horizontal Directional Drilling (HDD) will be utilized by HOEC. In this regard specific work procedures and method statements will be developed and implemented by HOEC to prevent and/or minimize any potential significant impact on the water bodies viz. enhanced sediment load, disturbance to ecological flow etc.

Further special considerations will be required as per OISD-STD-141 for submerged crossings generally characterized by their perennial nature, meandering course, steep and potentially erodable banks, potentially scouring bed, both during the design and installation of such crossings. In case of creek/backwater, which are prone to scour and erosion, adequate safe cover (minimum 1.5 m) shall be provided below the predicted scour profile expected during the lifetime of the pipeline.

5.3 OPTIONS FOR USE OF DRILLING MUD

The options available on use of drilling mud include water based drilling mud or non – aqueous drilling muds i.e. synthetic based drilling mud. To make drilling safe and environmentally acceptable, drilling mud selection depends upon conditions of well bore, geological formation, gas hydrate, lubricate, mud density, etc.

Water Based Drilling Muds are safe for environment as it generally contains biodegradable constituents however its offshore disposal is subject to its toxicity. As per the Environment (Protection) Rules, GSR no. 546 dated 30 August 2005, which specifies amongst other the toxicity of chemical additives used in the drilling fluid (DF) (WBM or OBM or SBM) should be biodegradable (mainly organic constituents) and should have toxicity of 96 hours LC50 value of > 30,000 mg/litre as per mysid toxicity

The composition of WBM depends on density to be maintained. Typically by weight, WBM consists of 75% of water, 15% barite, 7% bentonite and remaining salts and additives.

In comparison to WBM, the SBM reduces drill solids and liquid waste volumes and recyclable. SBM allows faster drilling rates and reduces drilling problems.

HOEC will ensure to use WBM; however, in case of anticipated borehole instability problems it may be necessary to introduce a base salt, such as Potassium Sulphate (K2SO4) into the system.

5.4 NO PROJECT SCENARIO

The no project scenario has been analysed to understand what would be reasonably expected to occur in the near future if the proposed development drilling of hydrocarbons and production of hydrocarbon are not conducted in the area. In such a scenario, there would not be any pressure on use of local resources and infrastructure, and no adverse effect on local ecology or incremental pollution to baseline environmental components (air, water and noise levels). At the same time, there would not be any positive impact on socioeconomic status of the area resulting from direct and indirect economic benefits that such a project can provide.

Oil and gas exploration, development and production activities will lead to exploration of new hydrocarbon reserves in the country leading to energy security for the country; provision of more royalty to Assam Government and Government of India; increase in employment and business opportunity for the local people; development of infrastructure (roads, culverts, bridges, schools etc.) in the area.

In case of no project scenario, there would not be any production of the untapped hydrocarbon reserves of AAP-ON-94/1 Block. There would also be no opportunity of employment and induced development associated with the drilling in the area. Thus, the proposed project scenario involving the drilling of hydrocarbons is considered to be a preferred scenario compared to no project scenario.

Monitoring is one of the most important components of a management system. Continuous monitoring needs to be carried out for regulatory requirements, to monitor the environmental quality and to determine performance of proposed mitigation measures. Monitoring indicators have been developed for each of the activity considering the mitigation measures proposed. Indicators have been developed for ascertaining the environmental quality and performance of the EMP implementation through Environmental Quality Indicators (EQI's) and Environmental Performance Indicators (EPI's) respectively which focus not only on quantifying or indexing activity-environment interactions that may potentially impact the environment but at the same time also help in comparing different components of environmental quality against previously established baseline values. Monitoring results will be documented, analyzed and reported internally to HSE Manager of HOEC. Monitoring requirements have been described in the following ***Table 6.1***. Frequency of monitoring and responsibility of carrying out the monitoring have also been presented in the table below.

Table 6.1 Proposed Monitoring Program for each Drill Site, GGS, GPP & Pipelines

A) Environmental Performance Monitoring

EPI No.	Environmental Performance Indicator (EPI)	Monitoring Parameter	Location	Period & Frequency	Responsibility
A.	**Design & Planning**				
A.1	Proximity of sensitive environmental habitat	Distance between the drill site and sensitive environmental habitat	Site	Once in project lifecycle	HOEC/Contractor
A.2	Proximity of nearest habitation	Distance between the drill site and nearest habitation	Site	Once in project lifecycle	HOEC/Contractor
A.3	Location and land required	Number of land owners affected Total area procured for drill site (Ha)	Site	Once in project lifecycle	HOEC/Contractor
A.4	Approval / Authorization of quarries	Validity of the Approval / Authorization	Quarry	Once in project lifecycle	HOEC/Contractor
A.5	Land use	Land use type	Quarry/ Borrow Area	Once in project lifecycle	HOEC/Contractor
A.6	Haul Routes	Distance of quarry / borrow area from project site Condition of haul road	Quarry / Borrow Area	Once in project lifecycle	HOEC/Contractor
B.	**Site Development**				
B.1	Topsoil stripping and storage	Area occupied for topsoil storage/ Area planned for topsoil storage	Site	Once during each site preparation	HOEC/Contractor
B.2	Local drainage pattern	Number of Cross Drainage structures constructed to actual number of cross drainage structures designed	Site	Once in project lifecycle	HOEC/Contractor
B.3	Fugitive emission of dust during site preparation	Visual observation of dust in air by haziness	Site & approach roads	Daily during site preparation	HOEC/Contractor

EPI No.	Environmental Performance Indicator (EPI)	Monitoring Parameter	Location	Period & Frequency	Responsibility
B.4	Air emissions from vehicles and machinery	$PM_{2.5}$, PM_{10}, NOx, SO_2, CO, HC, VOC based on emission factors Visual observation of emissions (black signifying more pollution) % of vehicles possessing valid PUC Certificates	Exhausts	Once in project lifecycle Daily Once in project life cycle	HOEC through Contractors operating vehicles
B.5	Noise emissions from vehicles and machinery	Noise pressure level in dB(A) near noise sources (5m)	Site & approach road	Daily during site preparation	HOEC/Contractor
B.6	Accident reporting	Number of casualties / Number of fatalities	Site & Haul Routes	During life cycle of project	HOEC/Contractor
B.7	Fugitive emission of dust during material handling and storage	Visual observation of dust in air by haziness	Near stockpiles and storages	Daily during the entire project life-cycle	HOEC/Contractor
C.	**Drilling & Testing**				
C.1	Gaseous pollutant emissions from DG Set	Pollutant concentrations in gaseous emissions and maintenance parameters (air, fuel filters & air-fuel ratio) of DG sets influencing air emissions Visual observation of exhaust smoke characteristics	DG Stack	Monthly during drilling & testing Daily during drilling & testing	HOEC/Contractor
C.2	Noise emission from DG Sets	Noise pressure level in dB(A)	Near noise sources (5m)	Monthly during the entire project life-cycle	HOEC/Contractor
C.3	Noise emission from rig	Noise pressure level in dB(A) Number of cases of workers not using PPE	On the rig floor Near noise sources (5m) Site	Monthly during drilling Monthly during drilling	HOEC/Contractor
C.4	Accident reporting	Number of casualties / Number of fatalities	Site	As and when accident occurs	HOEC/Contractor

EPI No.	Environmental Performance Indicator (EPI)	Monitoring Parameter	Location	Period & Frequency	Responsibility
C.5	Spilled Chemicals/Oil	Area of Spill / Quantity Spilled / Severity of Spill / Characterization of Spilled Substances for Contaminants (Heavy Metals, Toxics, etc.)	Site	As and when spills occur	HOEC/Contractor
C.6	Fugitive emission of cement dust during handling and storage	Visual observation of cement dust in air by haziness	Near stockpiles and storages	Daily during the entire project life-cycle	HOEC/Contractor
C.7	Runoff from temporary storage areas	Supervision of functioning of conduits / drains, channels	Site	Fortnightly during drilling phase	HOEC/Contractor
C.8	Emissions from Flaring	Total CO, total hydrocarbon, Non-Methane Hydrocarbons, NOx emission estimates based on emission factors	Flare Stack	As and when flaring occurs	HOEC/Contractor
C.9	Wastewater quantity & quality (Process water viz. rig wash, formation water etc.)	Volume estimate CPCB General discharge parameters and Oil & Gas Extraction Industry Standards	At discharge point	Weekly during drilling Quarterly during drilling	HOEC/Contractor
C.10	Storm water/wash down water discharge	CPCB General discharge parameters and Oil & Gas Extraction Industry Standards	At discharge point	Depending on generation particularly during monsoon	HOEC/Contractor
C.11	Drill cutting storage and disposal	Total volume generated Concentration of hazardous constituents as per Hazardous Waste Management and Handling Rules CPCB Onshore discharge standards for Oil & Gas Extraction Industry	At storage location	Once during drilling period	HOEC/Contractor
D.	**Decommissioning/ Site Closure**				
D.1	Noise pressure level in dB(A)	Near noise sources (5m)	Site & Approach road	Once per site	HOEC/Contractor
D.2	Air emissions from vehicles	Standards of vehicular emission Visual observation of emissions (black signifying more pollution)	Exhausts	Once in project lifecycle Daily	HOEC/Contractor

EPI No.	Environmental Performance Indicator (EPI)	Monitoring Parameter	Location	Period & Frequency	Responsibility
D.3	Fugitive emission of dust during transport of drilling facilities	Visual observation of dust in air by haziness	Near stockpiles and storages	Daily during the entire activity	HOEC/Contractor
E.	**Operation of Production facilities**				
E.1	Any discharge of effluent	CPCB General discharge parameters and Oil & Gas Extraction Industry Standards	At discharge point	Depending on generation particularly during monsoon	HOEC/Contractor
E2	Gaseous pollutant emissions from GG Set	Pollutant concentrations in gaseous emissions of GG sets	GG Stack	Once per six months	HOEC/Contractor
E.2	Noise Emission	Noise pressure level in dB(A)	High noise generating equipment	Once per six months	HOEC/Contractor

B) Environmental Quality Monitoring

EQI No.	Environmental Performance Indicator (EQI)	Monitoring Parameter	Location	Period & Frequency	Responsibility
A.	**Site Development for Wells, Production facilities and Pipelines**				
A1	Soil Fertility	Fertility parameters like pH, NPK ratio, Total Carbon, etc.	Site & adjacent areas-three locations	Once before site preparation	HOEC/Contractor
A2	Quality of water	Analysis of Parameters as per CPCB Use-class	Natural drainage channel receiving run-off discharges; 1-2 location, based on availability	Once during site works	HOEC/Contractor
A4	Ambient Air Quality	Measurement of PM_{10}, $PM_{2.5}$, NOx, SO_2, CO, HC using ambient air sampler	At Surrounding receptor points; three	Once during site works	HOEC/Contractor
A5	Ambient noise quality	Hearing / perception Measurement of Noise Pressure Level in dB(A)	At surrounding receptor points – three locations	Once during site works	HOEC/Contractor

EQI No.	Environmental Performance Indicator (EQI)	Monitoring Parameter	Location	Period & Frequency	Responsibility
A6	Soil Contamination	Analysis for suite of contaminants (heavy metals, TPH, organics, pesticides).	Site, adjacent areas and Waste disposal site	In event of spills over an area of 10 sq.m	HOEC/Contractor
B.	**Drilling & Testing**				
B1	Ambient Air Quality	Measurement of PM_{10}, $PM_{2.5}$, NOx, SO_2, CO, HC using ambient air sampler	At Surrounding receptor points– three locations	Twice during drilling and testing	HOEC/Contractor
B2	Stack Emission Monitoring	Measurement of PM_{10}, $PM_{2.5}$, NOx, SO_2, CO, HC	At three DG sets within drill site	Once during drilling	HOEC/Contractor
B3	Ambient noise quality	Hearing / perception Measurement of Noise Pressure Level in dB(A)	At surrounding receptor points- three locations	Twice during drilling and testing	HOEC/Contractor
B4	Workplace Noise Monitoring	Hearing / perception Measurement of Noise Pressure Level in dB(A)	5 locations within drill site	Twice during drilling and testing	HOEC/Contractor
B5	Soil Contamination	Analysis for suite of contaminants (heavy metals, TPH, organics, pesticides).	Site, adjacent areas and Waste disposal site	In event of spills over an area of 10 sq.m; once after drilling	HOEC/Contractor
B5	Quality of water	Analysis of Parameters as per CPCB Use-class	Natural drainage channel receiving run-off discharges – 3 locations	Once during drilling & testing	HOEC/Contractor
B6	Treated water quality	Analysis of Parameters as per CPCB Discharge Standards for Oil and Gas Industry	Two from ETP and one from oil water separator	Once during drilling & testing	HOEC/Contractor
B7	Groundwater Quality	Analysis of Parameters as per IS:10500, 2012	At surrounding receptor points- three locations	Once during drilling & testing	HOEC/Contractor
C.	**Decommissioning / Closure**				
C1	Ambient noise quality	Hearing / perception Measurement of Noise Pressure Level in dB(A)	At surrounding receptor points- three locations	Once during decommissioning	HOEC/Contractor

EQI No.	Environmental Performance Indicator (EQI)	Monitoring Parameter	Location	Period & Frequency	Responsibility
C2	Quality of water	Analysis of Parameters as per CPCB Use-class	Natural drainage channel receiving run-off discharges	Once after decommissioning	HOEC/Contractor
C3	Ambient Air Quality	Measurement of PM_{10}, $PM_{2.5}$, NOx, SO_2, CO, HC , using ambient air sampler	At Surrounding receptor points– three locations	Once during decommissioning	HOEC/Contractor
C4	Soil Fertility	Fertility parameters like pH, NPK ratio, Total Carbon, etc.	Site & adjacent areas-three locations	Once after site restoration	HOEC/Contractor
D.	**Operation of Production facilities**				
D.1	Ambient noise quality	Hearing / perception Measurement of Noise Pressure Level in dB(A)	At surrounding receptor points within 1 km- three locations	Once every six months	HOEC/Contractor
D.2	Workplace Noise Monitoring	Hearing / perception Measurement of Noise Pressure Level in dB(A)	5 locations within drill site	Once every six months	HOEC/Contractor
D.3	Ambient Air Quality	Measurement of PM_{10}, $PM_{2.5}$, NOx, SO_2, CO, HC , using ambient air sampler	At Surrounding receptor points– three locations	Once every six months	HOEC/Contractor
D.4	Quality of water	Analysis of Parameters as per CPCB Use-class	Natural drainage channel receiving run-off discharges	Once after decommissioning	HOEC/Contractor
D.5	Soil Fertility	Fertility parameters like pH, NPK ratio, Total Carbon, etc.	Site & adjacent areas-three locations	Once after site restoration	HOEC/Contractor

7 ADDITIONAL STUDIES

7.1 QUANTITATIVE RISK ASSESSMENT

7.1.1 Introduction

This section on Quantitative Risk Assessment (QRA) aims to provide a systematic analysis of the major risks that may arise from 24 development wells drilling and laying of interconnecting gas pipeline in GGS-1 to trunk pipeline. The QRA process outlines rational evaluations of the identified risks based on their significance and provides the outline for appropriate preventive and risk mitigation measures. Results of the QRA provides valuable inputs into the overall project planning and the decision-making process for effectively addressing the identified risks. This will ensure that the project risks stay below As Low As Reasonably Practicable (ALARP) levels at all times during project implementation. In addition, the QRA will also help in assessing risks arising from potential emergency situations like a blow out and develop a structured Emergency Response Plan (ERP) to restrict damage to personnel, infrastructure and the environment.

The risk study for the onshore drilling and testing activities has considered all aspects of operation of the drilling rig and other associated activities during the development phase. Loss of well control / blow-out and process/pipeline leaks constitute the major potential hazards that may be associated with the proposed onshore development and production of oil and natural gas at the identified well locations within the AAP-ON-94/1 block.

The following section describes objectives, methodology of the risk assessment study and then presents the assessment for each of the potential risk separately. This includes identification of major hazards, hazard screening and ranking, frequency and consequence analysis for major hazards. The hazards have subsequently been quantitatively evaluated through a criteria based risk evaluation matrix. Risk mitigation measures to reduce significant risks to acceptable levels have also been recommended as a part of the risk assessment study.

7.1.2 Objective of the QRA Study

The overall objective of this QRA with respect to the proposed project involves identification and evaluation of major risks, prioritizing risks identified based on their hazard consequences and formulating suitable risk reduction/mitigation measures in line with the ALARP principle. Hence in order to ensure effective management of any emergency situations (with potential individual and societal risks) that may arise during the development drilling activities, following specific objectives need to be achieved.

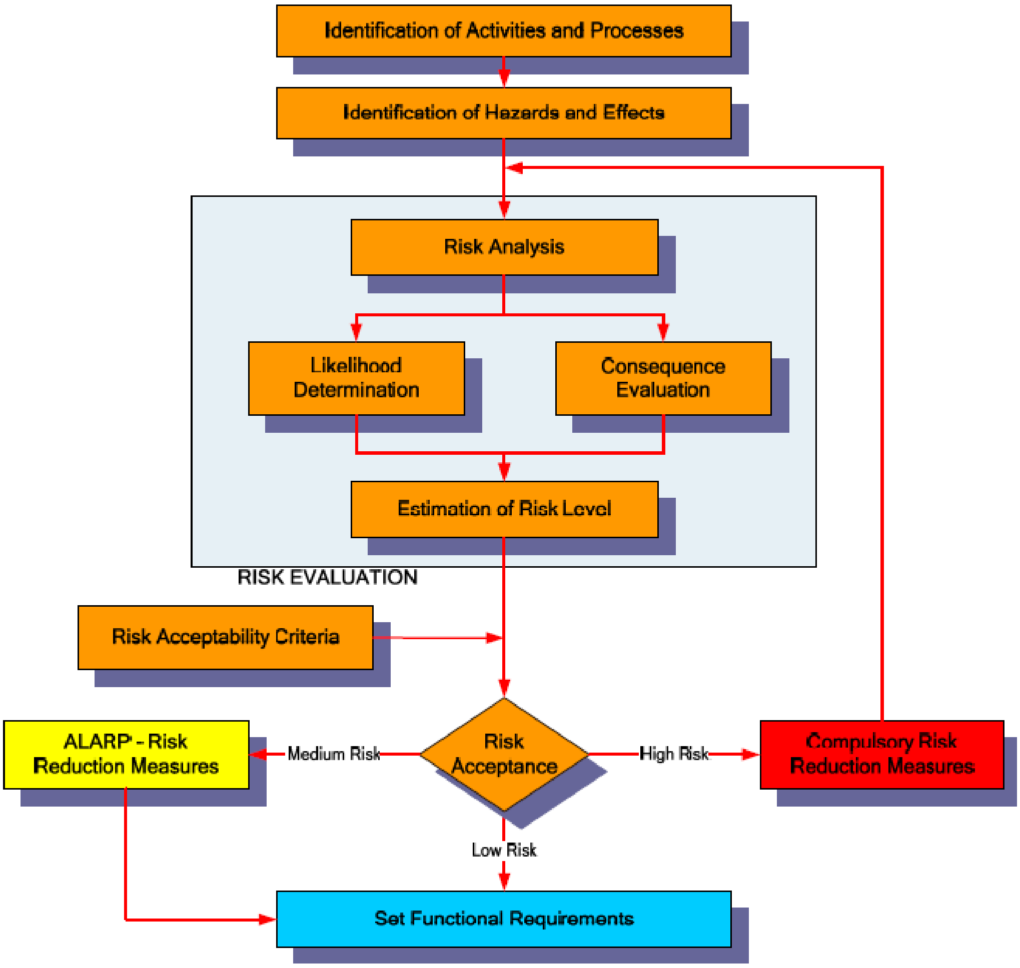
- Identify potential risk scenarios that may arise out of proposed development well drilling, operations of gas pipelines and associated equipment's, mud chemicals storage and handling etc.
- Analyse the possible likelihood and frequency of such risk scenarios by reviewing historical accident related data for onshore oil and gas industries.
- Predict the consequences of such potential risk scenarios and if consequences are high, establish the same by through application of quantitative simulations.
- Recommend feasible preventive and risk mitigation measures as well as provide inputs for drawing up of Emergency Management Plan (EMP) for the Project.

7.1.3 Risk Assessment Methodology

The risk assessment process is primarily based on likelihood of occurrence of the risks identified and their possible hazard consequences particularly being evaluated through hypothetical accident scenarios. With respect to the proposed Project, major risks viz. blow outs, pipeline and process leaks, non-process fires etc. have been assessed and evaluated through a risk matrix generated to combine the risk severity and likelihood factor. Risk associated with the well development activities have been determined semi-quantitatively as the product of likelihood/probability and severity/consequence by using order of magnitude data (risk ranking = severity/consequence factor X likelihood/probability factor). Significance of such project related risks was then established through their classification as high, medium, low, very low depending upon risk ranking.

The risk matrix is a widely accepted as standardized method of quantitative risk assessment and is preferred over purely quantitative methods, given that its inherent limitations to define a risk event is certain. Application of this tool has resulted in the prioritization of the potential risks events for the drilling activity thus providing the basis for drawing up risk mitigation measures and leading to formulation of plans for risk and emergency management. The overall approach is summarized in the ***Figure 7.1***.

Figure 7.1 *Risk Assessment Methodology*



Hazard Identification

Hazard identification for the purposes of this QRA comprised of a review of the Project and associated activity related information provided by HOEC. In addition, guidance provided by knowledge platforms/portals of the upstream oil & gas industry including OGP, ITOPF, EGIG and DNV, Norwegian Petroleum Directorate etc. are used to identify potential hazards that can arise out of the proposed Project activities. Taking into account the applicability of different risk aspects in context of the development drilling operations to be undertaken in the identified well locations, there are three major categories of hazards that can be associated with proposed Project which has been dealt with in detail. This includes:

- Blowouts leading to uncontrolled well flow, jet fires;
- Non-process fires / explosions, the release of a dangerous substance or any other event resulting from a work activity which could result in death or serious injury to people within the site;
- Leaks from interconnecting pipeline network/trunk pipeline leading to jet fire; and
- Any event which may result in major damage to the structure of the rig

Well control incident covers a range of events which have the potential of leading to blow-outs but are generally controlled by necessary technological interventions. Hence, such incidents are considered of minor consequences and as a result not well documented. Other possible hazard scenarios like mud chemical spills, falls, etc. has also not been considered for detailed assessment as preliminary evaluation has indicated that the overall risk that may arise out of them would be low. In addition, it is understood that, causative factors and mitigation measures for such events can be adequately taken care of through exiting safety management procedures and practices of HOEC.

It must also be noted here that many hazards identified are sometimes interrelated with one hazard often having the ability to trigger off another hazard through a domino effect. For example, a large oil spill in most instances is caused by another hazardous incident like a blowout or process leak. This aspect has been considered while drawing up hazard mitigation measures and such linkages (between hazards) has also been given due importance for managing hazards and associated risks in a composite manner through HOEC's Health, Safety & Environmental Management System (HSEMS) and through the Emergency Management Plan, if a contingency situation so arises.

Frequency Analysis

Frequency analysis involves estimating the likelihood of each of the failure cases identified during the hazard identification stage. The analysis of frequencies of occurrences for the key hazards that has been listed out is important to assess the likelihood of such hazards to actually unfold during the lifecycle of the project. The frequency analysis approach for the proposed Project is based primarily on historical accident frequency data, event tree analysis and judgmental evaluation. Major oil and gas industry information sources viz. statistical data, historical records and global industry experience were considered during the frequency analysis of the major identified risks[1].

For QRA for the proposed Project, various accident statistics and published oil industry databases have been consulted for arriving at probable frequencies of identified hazards. However, taking into account the absence of representative historical data/statistics with respect to onshore operations[2], relevant offshore accident databases have been considered in the frequency analysis of identified hazards. The same has been recommended in the "*Risk Assessment Data Directory" published by the International Association of Oil & Gas Producers (OGP). Key databases/reports referred as part of the QRA study includes Worldwide Offshore Accident Databank (WOAD), Outer Continental Shelf (OCS) Reports,*

[1]It is to be noted that the frequency of occurrences are usually obtained by a combination of component probabilities derived on basis of reliability data and /or statistical analysis of historical data.

[2]Although Alberta Energy & Utilities Board (EUB) maintains a database for onshore incidents for the period 1975-1990 the same has not been considered in the context of the present study as the Alberta wells are believed to be sour with precaution being taken accordingly to minimize the likelihood of release

Norwegian Petroleum Directorate Directives, Offshore Reliability Data (OREDA) Handbook, HSE Offshore Incident Database, SINTEF Offshore Blowout Database etc.

Based on the range of probabilities arrived at for different potential hazards that may be encountered during the proposed well development activities, following criteria for likelihood rankings have been drawn up as presented in the ***Table 7.1***.

Table 7.1 Frequency Categories and Criteria

Likelihood Ranking	Criteria Ranking (cases/year)	Frequency Class
5	>1.0	Frequent
4	$>10^{-1}$ to <1.0	Probable
3	$>10^{-3}$ to $<10^{-1}$	Occasional/Rare
2	$>10^{-5}$ to $<10^{-3}$	Not Likely
1	$>10^{-6}$ to $<10^{-5}$	Improbable

Consequence Analysis

In parallel to frequency analysis, hazard prediction / consequence analysis exercise assesses resulting effects in instances when accidents occur and their likely impact on project personnel, infrastructure and environment. In relation to the proposed Project, estimation of consequences for each possible event has been based either on accident experience, consequence modelling or professional judgment, as appropriate.

Given the high risk perception associated with blow outs in context of onshore drilling operation, a detailed analysis of consequences has been undertaken for blow outs taking into account physical factors and technological interventions. Consequences of such accidental events on the physical, biological and socio-economic environment have been studied to evaluate the potential of the identified risks/hazards. In all, the consequence analysis takes into account the following aspects:

- Nature of impact on environment and community;
- Occupational health and safety;
- Asset and property damage;
- Corporate image
- Timeline for restoration of environmental and property damage
- Restoration cost for environmental and property damage

The following criterion for consequence rankings (***Table 7.2***) is drawn up in context of the possible consequences of risk events that may occur during proposed well development activities:

Table 7.2 Severity Categories and Criteria

Consequence	Ranking	Criteria Definition
Catastrophic	5	• Multiple fatalities/Permanent total disability to more than 50 persons • Severe violations of national limits for environmental emission • More than 5 years for natural recovery • Net negative financial impact of >10 crores • Long term impact on ecologically sensitive areas • International media coverage • National stakeholder concern and media coverage
Major	4	• Single fatality/permanent total disability to one or more persons • Major violations of national limits for environmental emissions • 2-5 years for natural recovery • Net negative financial impact of 5 -10 crores • Significant impact on endangered and threatened floral and faunal species • Loss of corporate image and reputation
Moderate	3	• Short term hospitalization & rehabilitation leading to recovery • Short term violations of national limits for environmental emissions • 1-2 years for natural recovery • Net negative financial impact of 1-5 crores • Short term impact on protected natural habitats • State wide media coverage
Minor	2	• Medical treatment injuries • 1 year for natural recovery • Net negative financial impact of 0.5 - 1 crore • Temporary environmental impacts which can be mitigated • Local stakeholder concern and public attention
Insignificant	1	• First Aid treatment with no Lost Time Incidents (LTIs) • Natural recovery < 1year • Net negative financial impact of <0.5 crores. • No significant impact on environmental components • No media coverage

Risk Evaluation

Based on ranking of likelihood and frequencies, each identified hazard has been evaluated based on the likelihood of occurrence and the magnitude of consequences. Significance of risks is expressed as the product of likelihood and consequence of the risk event, expressed as follows:

Significance = Likelihood X Consequence

The ***Table 7.3*** below illustrates all possible product results for five likelihood and consequence categories while the ***Table 7.4*** assigns risk significance criteria in four regions that identify the limit of risk acceptability. Depending on the position of intersection of a column with a row in the risk matrix, hazard prone activities have been classified as low, medium and high thereby qualifying a set of risk reduction / mitigation strategies.

Table 7.3 Risk Matrix

Consequence ↑		Likelihood → Frequent	Probable	Remote	Not Likely	Improbable
		5	4	3	2	1
Catastrophic	**5**	25	20	15	10	5
Major	**4**	20	16	12	8	4
Moderate	**3**	15	12	9	6	3
Minor	**2**	10	8	6	4	2
Insignificant	**1**	5	4	3	2	1

Table 7.4 Risk Criteria and Action Requirements

Risk Significance	Criteria Definition & Action Requirements
High (16 - 25)	**"Risk requires attention"** – Project HSE Management need to ensure that necessary mitigation are adopted to ensure that possible risk remains within acceptable limits
Medium (10 – 15)	**"Risk is tolerable"** – Project HSE Management needs to adopt necessary measures to prevent any change/modification of existing risk controls and ensure implementation of all practicable controls.
Low (5 – 9)	**"Risk is acceptable" –** Project related risks are managed by well-established controls and routine processes/procedures. Implementation of additional controls can be considered.
Very Low (1 – 4)	**"Risk is acceptable" –** All risks are managed by well-established controls and routine processes/procedures. Additional risk controls need not to be considered

7.1.4 Risk Assessment of Identified Project Hazards

As already discussed in the previous section, three major categories risk have identified in relation to proposed development drilling activities. A comprehensive risk assessment study has been undertaken to assess and evaluate significance of identified risks in terms of severity of consequences and likelihood of occurrence. Risk assessment study details have been summarized in the subsequent sections below:

Blow Outs/Loss of Well Control

Blow out is an uncontrolled release of well fluid (primarily hydrocarbons viz. oil and/or gas and may also include drilling mud, completion fluid, water etc.) from an exploratory or development well. Blow outs are the result of failure to control a kick and regain pressure control and are typically caused by equipment failure or human error. The possible blow out cause events occurring in isolation or in combination have been listed below:

- Formation fluid entry into well bore;
- Loss of containment due to malfunction (viz. wire lining);
- Well head damage (e.g. by fires, storms, dropped object etc.); and
- Rig forced off station (e.g. by anchor failure) damaging Blow Out Preventer (BOP) or wellhead.

The most common cause of blow out can be associated with the sudden/unexpected entry/release of formation fluid into well bore that may arise as a result of the following events as discussed in the ***Box 7.1***below:

Box 7.1 ***Primary Causes of Blow Outs***

Shallow gas
In shallow formations there may be pockets of shallow gas. In these instances there is often insufficient mud density in the well and no BOP is in place. If the hole strikes shallow gas the gas may be released on the drilling rig very rapidly. Typical geological features which suggest the presence of shallow gas can then be detected. Historically, striking of shallow gas has been one of the most frequent causes of blowouts in drilling.

Swabbing
As the drill pipe is pulled upwards during trips out of the hole or upward movement of the drill string, the pressure in the hole beneath the drill bit is reduced, creating a suction effect. Sufficient drilling mud must be pumped down-hole to compensate for this effect or well fluids may enter the bore. Swabbing is also a frequent cause of drilling blowouts.

High formation pressure
Drilling into an unexpected zone of high pressure may allow formation fluids to enter the well before mud weight can be increased to prevent it.

Insufficient mud weight
The primary method of well control is the use of drilling mud; in correct operation, the hydrostatic pressure exerted by the mud prevents well fluids from entering the well bore. A high mud weight provides safety against well fluids in-flows. However, a high mud weight reduces drilling speed, therefore, mud weight is calculated to establish weight most suitable to safely control anticipated formation pressures and allows optimum rates of penetration. If the required mud weight is incorrectly calculated then well fluid may be able to enter the bore.

Lost Circulation
Drilling mud circulation can be lost if mud enters a permeable formation instead of returning to the rig. This reduces the hydrostatic pressures exerted by the mud throughout the well bore, and may allow well fluids from another formation to enter the bore.

Gas cut mud
Drilling fluids are denser than well fluids; this density is required to provide the hydrostatic pressure which prevents well fluids from entering the bore. If well fluids mix with the mud then its density will be reduced. As mud is circulated back to surface, hydrostatic pressure exerted by the mud column is reduced. Once gas reaches surface it is released into the atmosphere.

Source: A Guide to Quantitative Risk Assessment for Offshore Installations; John Spouge – DNV Technical Publication 99/100a

For better understanding, causes of blow outs have been systematically defined in terms of loss of pressure control (failure of primary barrier), uncontrolled flow of fluid or failure of secondary barrier (BOP). The blow out incidents resulting from primary and secondary failures for proposed operations as obtained through comprehensive root cause analysis of the Gulf Coast (Texas, OCS and US Gulf of Mexico) Blow Outs[1] during 1960-1996 have been presented in the ***Table 7.5***below.

Table 7.5 ***Blow Out Cause Distribution for Failures during Drilling Operations***

Sl. No.	Causal Factors	Blow Out Incidents (Nos.)
A.	**Primary Barrier**	
1	Swabbing	77
2	Drilling Break	52
3	Formation breakdown	38
4	Trapped/expanding gas	09
5	Gas cut mud	26
6	Low mud weight	17
7	Wellhead failure	05
8	Cement setting	05
B.	**Secondary Barrier**	
1	Failure to close BOP	07
2	Failure of BOP after closure	13
3	BOP not in place	10
4	Fracture at casing shoe	03
5	Failure to stab string valve	09
6	Casing leakage	06

Thus, underlying blowout causes as discussed in the above table can be primarily attributed to swabbing as the primary barrier failure which is indicative of insufficient attention given to trip margin and controlling pipe movement speed. Also, it is evident from the above table that lack of proper maintenance, operational failures and absence of BOPs as secondary barrier contributed to majority of blowout incidents (approx.. 30 nos.) is recorded.

Blowout Frequency Analysis

Blow out frequency estimates is obtained from a combination of incident experience and associated exposure in a given area over a given period. For the purpose of calculation of blow out frequency analysis in context of the present study involving developmental drilling, blow out frequencies per well drilled have been considered.

The blowout frequencies presented in this report are extracted from the latest revision of the Scandpower[2] report and are presented in ***Table 7.6*** below. The blowout probability is determined from blowouts in the North Sea. (I.e.

[1] "Trends extracted from 1200 Gulf Coast blowouts during 1960-1996" – Pal Skalle and A.L Podio

[2] "Blowout and Well Release Frequencies" - Based on SINTEF Offshore Blowout Database 2010, Report, Scandpower Risk Management. Report no. 19.101.001-3009/2011/R3, 05.04.2011.

British, Dutch and Norwegian sectors) given comparable data for onshore operations are not readily available.

Table 7.6 ***Blow Out Frequencies Recommended per Drilled Well***

Drilling Operation	Well Category	Frequency, gas well	Frequency, oil well
Exploration	Normal	1.12E-04	1.23E-04
Wild Cat	Normal	9.70E-05	1.17E-04
Appraisal	Normal	1.07E-04	1.30E-04
Development	Normal	2.16E-05	2.62E-05

Based on the aforesaid frequency and information provided by HOEC the blow out frequency for the proposed project has been computed as follows:

No of wells to be drilled per year = 6 (A)

Blow out frequency for development drilling (gas) = 2.16 X 10^{-5} per well drilled (B)

Frequency of blow out occurrence for the proposed project (gas) = (A X B) = 6 X 2.16 X 10^{-5}

= 1.29 X 10^{-4} per well drilled

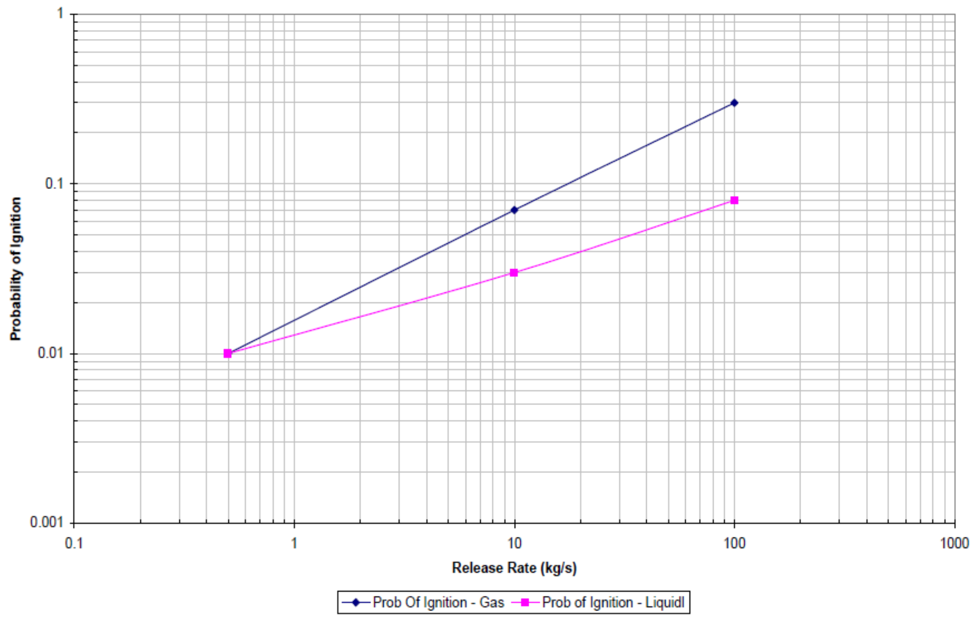
Thus, the blow out frequency for the proposed project for gas wells have been computed to be **1.29 X 10^{-4} per well drilled per year i.e. the likelihood of its occurrence is identified to be as "Not Likely**"

Blowout Ignition Probability

Review of SINTEF database indicates that a rounded ignition probability of 0.3 has been widely used for the purpose of quantitative risk analysis arising from blow outs. As per this database generally ignition occurred within first 5 minutes in approximately 40% of the blowouts leading to either pool and/or jet fire. Blow out leading to flammable gas release has a greater probability of ignition compared to liquid releases[1] (***Figure 7.2***).

[1]Fire and Explosion – Fire Risk Analysis by Daejun Change, Division of Ocean System and Engineering

Figure 7.2 Ignition Probability Vs Release Rate



An alternative to the blowout ignition probabilities given by the UKOOA look-up correlations can be obtained from Scandpowers's interpretation of the blowout data provided by SINTEF 2. The most significant category is that for deep blowouts which indicates an early ignition probability of 0.09. For the purpose of the QRA study this can be taken as occurring immediately on release and calculation provided below:

No of wells to be drilled per year = 6 (A) Blow out frequency for development drilling (gas) = 2.16 X 10^{-5} per well drilled (B) Blow out ignition probability = 0.09 (D) Probability of Blow out ignition for the proposed project (gas) = (A X B X D) = 6 X 2.16 X 10^{-5} X 0.09 = 1.16 X 10^{-5}= ~ 0.0011%

Hence based on the aforesaid calculation the probability of ignition of blow out releases of hydrocarbons for the proposed development project for gas wells is computed to be around ~0.0011% and can be considered to be as negligible.

Blowout Consequence Analysis

Blow out from a hydrocarbon development gas wells with respect to the proposed project may cause jet fires resulting from ignited gas blow outs.

Ignition of Flammable Gas Release leading to Jet Fire

Jet fires are burning jet of gas or sprays of atomized liquids resulting from gas and condensate release from high pressure equipment and blow outs. Jet fires may also result in the release of high pressure liquid containing dissolved gas due to gas flashing off and turning the liquid into a spray of small droplets. In context of the present study, formation of jet fires can be attributed by the high pressure release and ignition of natural gas if encountered during exploration of block hydrocarbon reserves.

Natural gas as recovered from underground deposits primarily contains methane (CH_4) as a flammable component, but it also contains heavier gaseous hydrocarbons such as ethane (C_2H_6), propane (C_3H_8) and butane (C_4H_{10}). Other gases such as CO_2, nitrogen and hydrogen sulfide (H_2S) are also often present. Methane is typically 90 percent, ethane 5-15 percent, propane and butane, up to 5 percent. Thus, considering higher percentage of methane in natural gas, the thermo-chemical properties of the same has been utilized in the jet fire blow out consequence modelling. The following risk scenarios (***Table 7.7***) have been considered for nature gas release consequence modelling:

Table 7.7 Natural Gas Release Modelling Scenario

Scenario	Release Rate (kg/s)	Release Type
Scenario - I	1	Small
Scenario - II	5	Medium
Scenario – III (Worst Case)	10	Large

The modelling of nature gas releases has been carried out using ALOHA. A Flammable Level of Concern approach has been utilized for assessing safety risk associated with the release of flammable gases (here methane) from well blow outs. In ALOHA, a flammable Level of Concern (LOC) is a threshold concentration of fuel in the air above which a flammability hazard may exist. While modelling the release of a flammable gas that may catch fire—but which is not currently burning—ALOHA can predict the flammable area of the vapour cloud so that flammability hazard can be established.

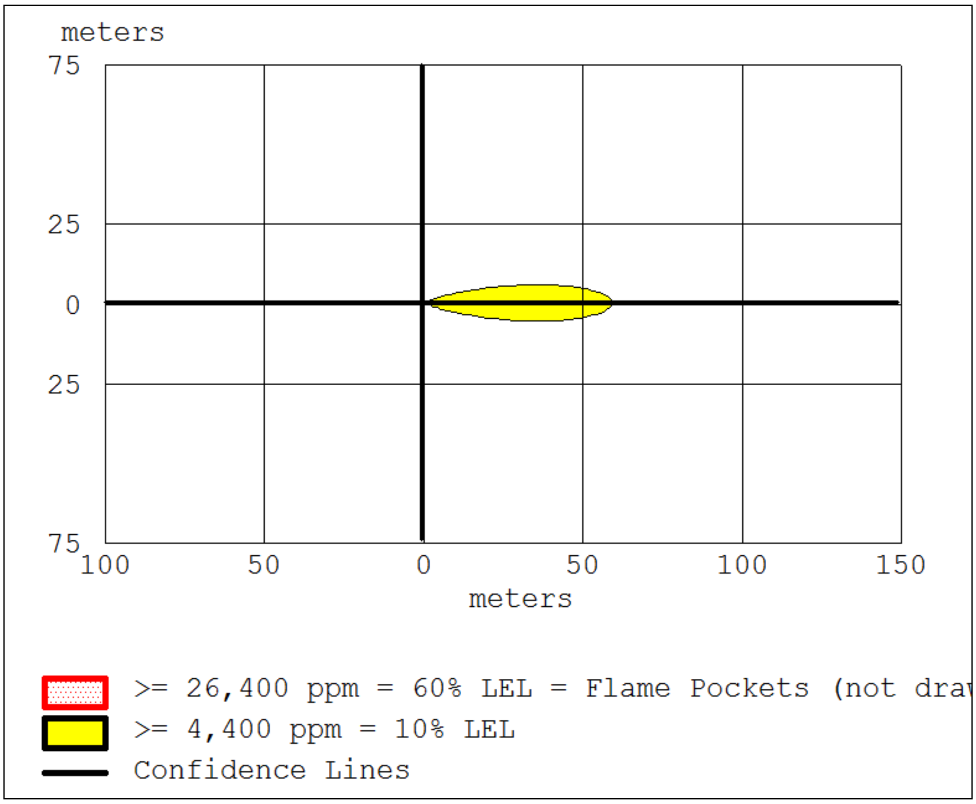
The flammable area is the part of a flammable vapor cloud where the concentration is in the flammable range, between the Lower and Upper Explosive Limits (LEL and UEL). These limits are percentages that represent the concentration of the fuel (that is, the chemical vapor) in the air. If the chemical vapor comes into contact with an ignition source (such as a spark), it will burn only if its fuel-air concentration is between the LEL and the UEL—because that portion of the cloud is already pre-mixed to the right mixture of fuel and air for burning to occur. If the fuel-air concentration is below the LEL, there is not enough fuel in the air to sustain a fire or an explosion—it is too lean. If the fuel-air concentration is above the UEL, there is not enough oxygen to sustain a fire or an explosion because there is too much fuel—it is too rich.

When a flammable vapor cloud is dispersing, the concentration of fuel in the air is not uniform; there will be areas where the concentration is higher than the average and areas where the concentration is lower than the average. This is called concentration patchiness. Because of concentration patchiness, there will be areas (called pockets) where the chemical is in the flammable range even though the average concentration has fallen below the LEL. Because of this, ALOHA's default flammable LOCs are each a fraction of the LEL, rather than the LEL itself. ALOHA uses 60% of the LEL as the default LOC for the red threat zone, because some experiments have shown that flame pockets can occur in places where the average concentration is above that level. Another common threat level used by responders is 10% of the LEL, which is ALOHA's default LOC for the yellow threat zone. The flammable LOC threat zones for methane release are as follows:

Red : 26,400 ppm = 60% LEL = Flame Pockets
Yellow: 4,400 ppm = 10% LEL

Well site risk contour maps for worst case scenario prepared based on ALOHA modeling of natural gas releases for flammable vapour cloud has been presented in ***Figures 7.3-7.5*** below.

Figure 7.3 ***Scenario I: Risk Contour Map***



THREAT ZONE:
Threat Modelled: Flammable Area of Vapor Cloud

Model Run: Gaussian

Red : 25 meters --- (26,400 ppm = 60% LEL = Flame Pockets)

Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.

Yellow: 60 meters --- (4,400 ppm = 10% LEL)

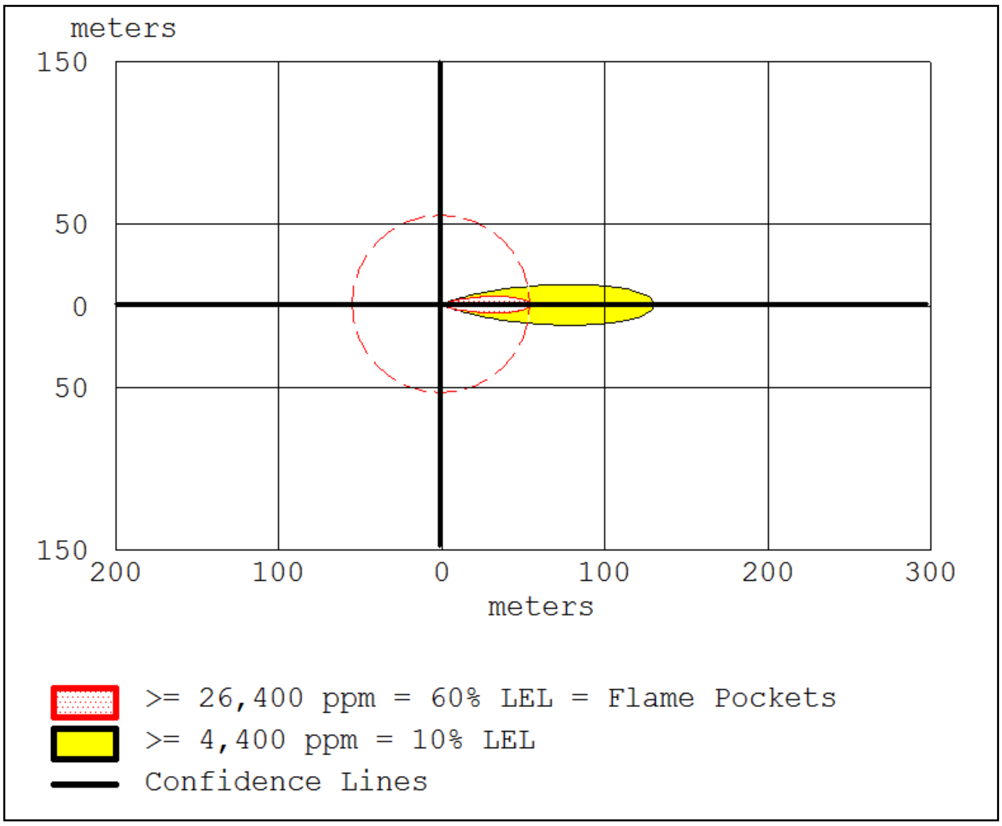


Figure 7.4 Scenario II: Risk Contour Map

THREAT ZONE:

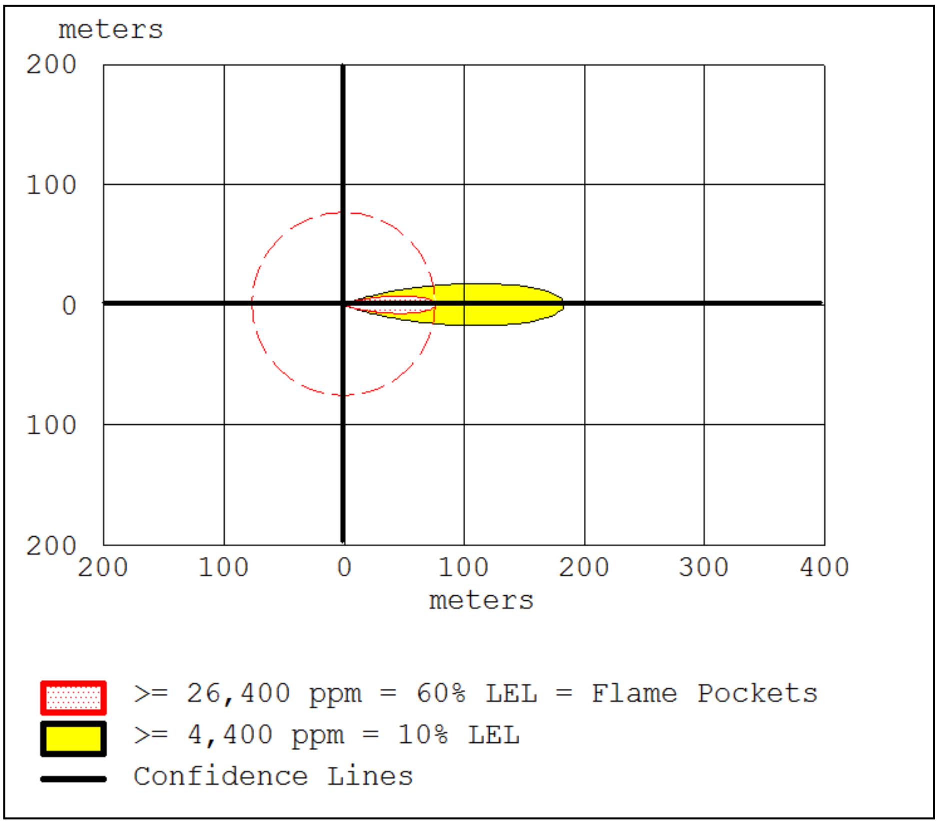
Threat Modeled: Flammable Area of Vapor Cloud

Model Run: Gaussian

Red : 55 meters --- (26,400 ppm = 60% LEL = Flame Pockets)

Yellow: 131 meters --- (4,400 ppm = 10% LEL)

Figure 7.5 Scenario III: Risk Contour Map



THREAT ZONE:

Threat Modelled: Flammable Area of Vapour Cloud

Model Run: Gaussian

Red: 77 meters --- (26,400 ppm = 60% LEL = Flame Pockets)

Yellow: 183 meters --- (4,400 ppm = 10% LEL)

The zone of flammable vapour cloud calculated for hypothetical natural gas release under risk scenarios discussed in the earlier sections have been presented in the ***Table 7.8*** below.

Table 7.8 Zone of Flammable Vapour Cloud-Natural Gas Release Scenarion

Release Type	Release Rate (kg/s)	Red -60% LEL (m)	Yellow -10% LEL (m)
Small	1	25	65
Medium	5	55	131
Large	10	77	183

Hence for a worst case scenario (10kg/s) the flammable vapor cloud zone/flame pockets' resulting from accidental release of natural gas will be covering a radial zone of 77m from source with the flammable gas concentration within this zone being 26,400 ppm.

Based on the flammable vapour cloud concentration modelled for the worst case scenario (10 kg/s) an effort was made to establish the overpressure (blast force zone) that may result from delayed ignition of vapour cloud generated from any such accidental release. For overpressure risk modelling using ALOHA a delayed ignition time of 5 minutes was considered of the vapour cloud mass. However the threat modelled revealed that Level of Concern (LOC) was never exceeded that may possibly lead to damage to property or life within the blast radius. The results have been provided in ***Figure 7.6*** below.

Figure 7.6 Scenario III (Worst Case) – Overpressure Risk Modeling

```
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Time of Ignition: 5 minutes after release begins
Type of Ignition: ignited by spark or flame
Level of Congestion: uncongested
Model Run: Gaussian
Explosive mass at time of ignition: 188 kilograms
Red   : LOC was never exceeded --- (8.0 psi = destruction of buildings)
Orange: LOC was never exceeded --- (3.5 psi = serious injury likely)
Yellow: LOC was never exceeded --- (1.0 psi = shatters glass)
```

The risk significance for the potential blow out scenario resulting from development drilling has been presented below. For calculating the risk significance, the likelihood ranking is considered to be "2" as the frequency analysis for blow outs incidents is computed at "*$1.29 X 10^{-4}$*" whereas the consequence ranking has been identified to be as "4" given the worst case scenario modelling (blast overpressure) indicates that the LOC was never exceeded leading to multiple fatalities (For criteria ranking please refer to Table 7.1 & 7.2).

Risk Ranking – Blowout Natural Gas Release (Worst Case Scenario)

Likelihood ranking	**2**	**Consequence ranking**	**4**
Risk Ranking & Significance = 8 i.e. "Low" i.e. Risk is Tolerable and can be managed through implementation of existing controls..			

Hydrocarbons Leaks Due to Loss of Containment While Drilling & Testing

The releases of hydrocarbons that may be isolated from reservoir fluids include gas releases in the mud return area during drilling. The consequences of gas releases are described in this section. ALOHA model has been used to model the releases from failure of the test separator.

Frequency Analysis

Review of the hydrocarbon release database (HCRD) of 2003 for **One North Sea Platform** indicates the process gas leak frequencies for large releases (>10 kg/s) to be about **6.0×10^{-3} per year**. The same frequency has been considered for potential release from leaks due to loss of containment while drilling.

Gas Releases during Drilling

a) Flash Fire

If gas is entrained in the mud then it could be released from the mud pits or shakers. The amount of gas returned is unlikely to be so great that a jet fire could occur, but the gas could build up into a flammable vapour cloud in the mud pit area. If the cloud then ignites it will result in a flash fire or vapour cloud explosion. Again, there is also the potential for a toxic cloud to be present if the release is during a period when sour crude is a possibility. The mud return typically contains around 50% water this means it cannot be ignited in liquid form so there is no danger of pool fires. Liquid mud fires are therefore not considered further.

The mud - gas separator can be other source that contains both flammable liquid and gas.

A well test separator rupture could result in release of gas when a gas cloud will form, initially located around the release point. If the release is ignited immediately then a fireball will be formed. If this cloud is not immediately ignited, then a vapour cloud will form, which will disperse with the wind and diluted as a result of air entrainment. The principal hazard arising from a cloud of dispersing flammable material is its subsequent (delayed) ignition, resulting in a flash fire. Large-scale experiments on the dispersion and ignition of flammable gas clouds show that ignition is unlikely when the average concentration is below the lower flammability limit (LFL).

As in the case for blow outs, an effort was made to establish the overpressure (blast force zone) that may result from delayed ignition of vapour cloud generated from any such accidental release. For overpressure risk modelling using ALOHA a delayed ignition time of 5 minutes was considered of the vapour cloud mass. However the threat modelled revealed that Level of Concern (LOC) was never exceeded that may possibly lead to damage to property or life within the blast radius. The results have been provided in ***Figure 7.7*** below.

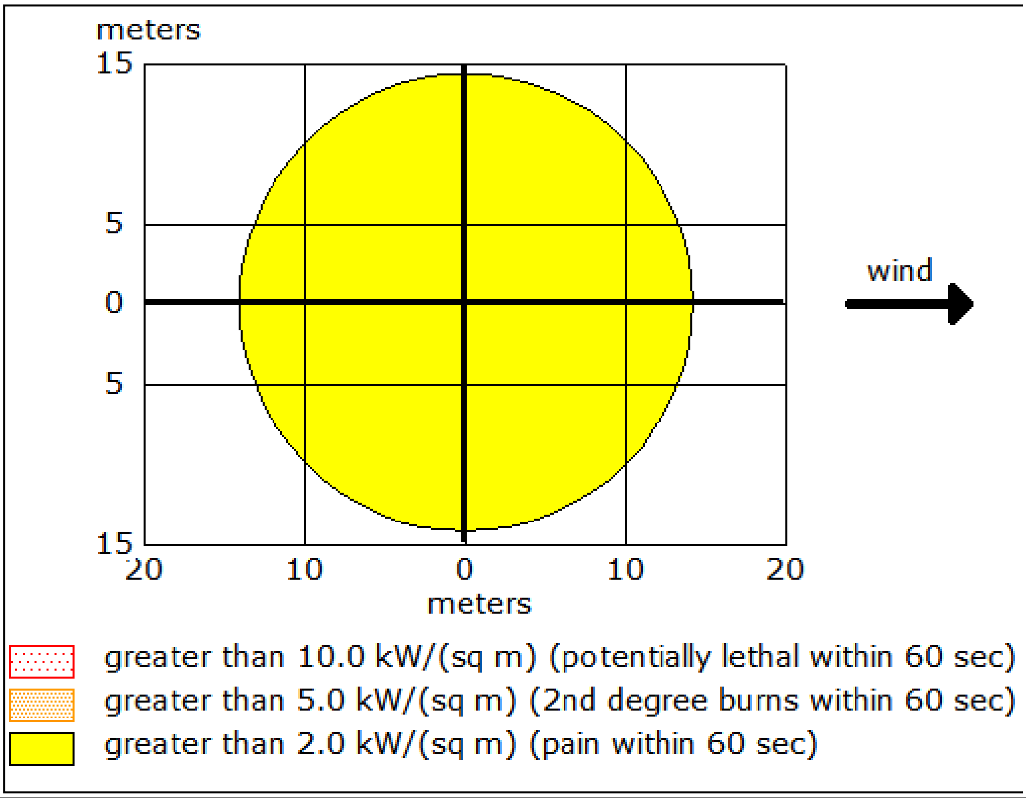
Figure 7.7 Overpressure Risk Modeling – Well Releases during drilling

Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame
Level of Congestion: uncongested
Model Run: Gaussian
Red : LOC was never exceeded --- (8.0 psi = destruction of buildings)
Orange: LOC was never exceeded --- (3.5 psi = serious injury likely)
Yellow: LOC was never exceeded --- (1.0 psi = shatters glass)

b) Jet Fire

The term jet fire is used to describe the flame produced due to the ignition of a continuous pressurised leakage from the pipe work. Combustion in a jet fire occurs in the form of a strong turbulent diffusion flame that is strongly influenced by the initial momentum of the release. Flame temperatures for typical jet flames vary from 1600°C for laminar diffusion flames to 2000°C for turbulent diffusion flames. The principal hazards from a jet fire are thermal radiation and the potential for significant knock-on effects, such as equipment failure due to impingement of the jet fire. The thermal radiations distances due to Jet Flame are shown in *Figure 7.8* and *Figure 7.9* below.

Figure 7.8 ***Thermal Radiation Distances of Jet Flame due to Leak of 25 mm size***



THREAT ZONE:

Threat Modelled: Thermal radiation from jet fire

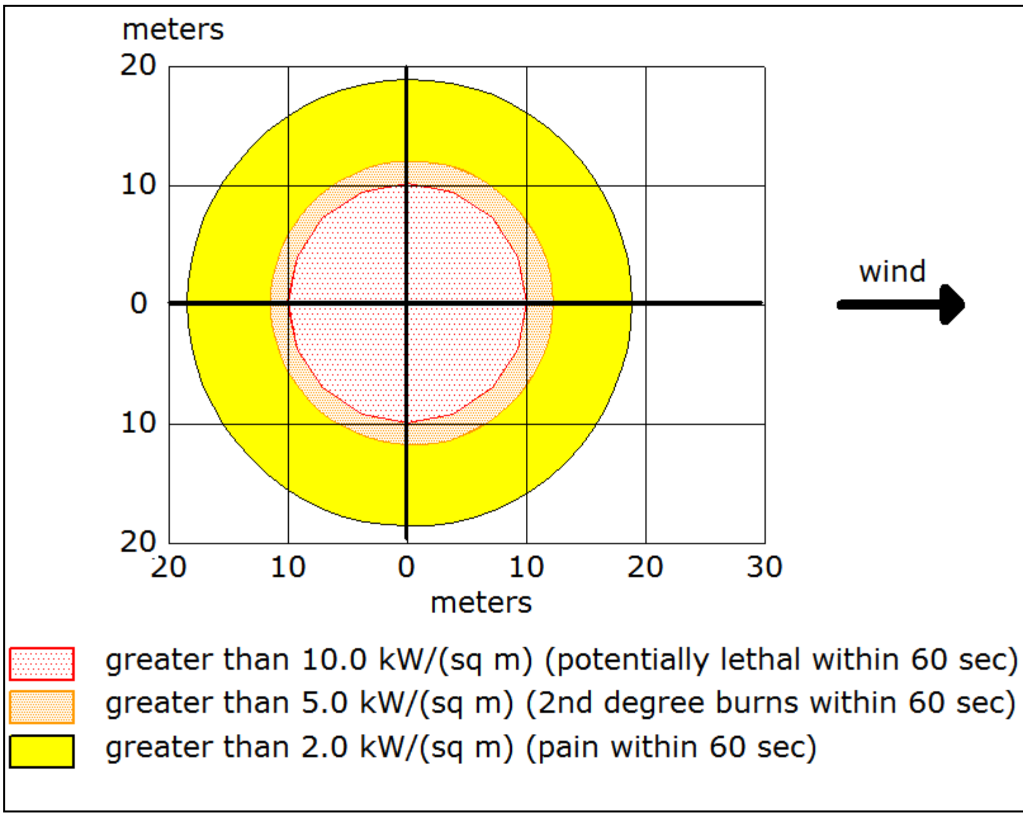
Model Run: Gaussian

Red: < 10 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)

Orange: < 10 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)

Yellow: 14 meters --- (2.0 kW/(sq m) = pain within 60 sec)

Figure 7.9 Thermal Radiation Distances of Jet Flame due to Leak of 50 mm size



THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

Model Run: Gaussian

Red : 10 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)

Orange: 12 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)

Yellow: 19 meters --- (2.0 kW/(sq m) = pain within 60 sec)

The zone of thermal radiation calculated for hypothetical release and ignition of natural gas during well testing have been presented in the ***Table 7.9*** below.

Table 7.9 Thermal Radiation Zone -NG Release Scenario during Well Testing

Release Type	Red (kW/sqm)	Orange (kW/sqm)	Yellow (kW/sqm)
Leak of 25 mm size	<10	<10	14
Leak of 50 mm size	10	12	19

Hence for a worst case scenario (50 mm leak) the ignition of natural gas release will be resulting in generation of thermal radiation which will be lethal within a maximum radius of 10m within 1 minute of its occurrence.

The risk significance for the potential well release scenario resulting from exploratory drilling has been presented below. For calculating the risk significance, the likelihood ranking is considered to be "3" as the frequency analysis for loss of containment is computed at "$>1 \times 10^{-3}$" whereas the consequence ranking has been identified to be as "3" given the worst case scenario modelling (blast overpressure)/jet fire indicates that the LOC was never exceeded leading to multiple fatalities (For criteria ranking please refer to Table 7.1 & 7.2).

Risk Ranking – Jet Fire/Blast Overpressure from Well Releases (Worst Case Scenario)

Likelihood ranking	3	**Consequence ranking**	3
Risk Ranking & Significance = 9 i.e. "Low" i.e. Risk is Tolerable and can be managed through implementation of existing controls and technologies.			

Interconnecting Hydrocarbon Pipeline Network

As discussed in the project description section, the following gas pipelines will be laid

- Pipeline-1: 5.5 km from GGS to Trunk pipeline of 12 inch dia
- Pipeline-2: 8.8 km pipeline from GPP to IOCL Terminal of 12 inch dia

The failure of the aforesaid gas pipeline may lead to the following hazards:

- Jet fires associated with pipework failures;
- Vapour cloud explosions; and
- Flash fires.

Each of these hazards has been described below.

<u>Jet Fire</u>

Jet fires result from ignited releases of pressurized flammable gas or superheated/pressurized liquid. The momentum of the release carries the material forward in a long plume entraining air to give a flammable mixture. Jet fires only occur where the natural gas is being handled under pressure or when handled in gas phase and the releases are unobstructed.

<u>Flash Fire</u>

Vapour clouds can be formed from the release of vapour of pressurized flammable material as well as from non-flashing liquid releases where vapour clouds can be formed from the evaporation of liquid pools or leakage/rupture of pressurized pipelines transporting flammable gas.

Where ignition of a release does not occur immediately, a vapour cloud is formed and moves away from the point of origin under the action of the wind. This drifting cloud may undergo delayed ignition if an ignition source is reached, resulting in a flash fire if the cloud ignites in an unconfined area or vapour cloud explosion (VCE) if within confined area.

Vapour Cloud Explosion

If the generation of heat in a fire involving a vapour-air mixture is accompanied by the generation of pressure then the resulting effect is a vapour cloud explosion (VCE). The amount of overpressure produced in a VCE is determined by the reactivity of the gas, the strength of the ignition source, the degree of confinement of the vapour cloud, the number of obstacles in and around the cloud and the location of the point of ignition with respect to the escape path of the expanding gases.

However, in the case of the interconnecting gas pipeline network *jet fire* has been identified as the most probable hazard.

Pipeline Frequency Analysis

An effort has also been made to understand the primary failure frequencies of pressurised gas/oil to be transported through the interconnecting pipeline network. Based on the European Gas Pipeline Incident Data Group (EGIG) database the evolution of the primary failure frequencies over the entire period and for the last five years has been provided in ***Table 7.10*** below.

Table 7.10 Primary Gas Pipeline Failure Frequency

Period	No. of Incidents	Total System Exposure (km.yr)	Primary failure frequency (1000 km.yr)
1970-2007	1173	$3.15.10^6$	0.372
1970-2010	1249	$3.55.10^6$	0.351
1970-2013	1309	$3.98.10^6$	0.329
1974-2013	1179	$3.84.10^6$	0.307
1984-2013	805	$3.24.10^6$	0.249
1994-2013	426	$2.40.10^6$	0.177
2004-2013	209	$1.33.10^6$	0.157
2009-2013	110	$0.70.10^6$	0.158

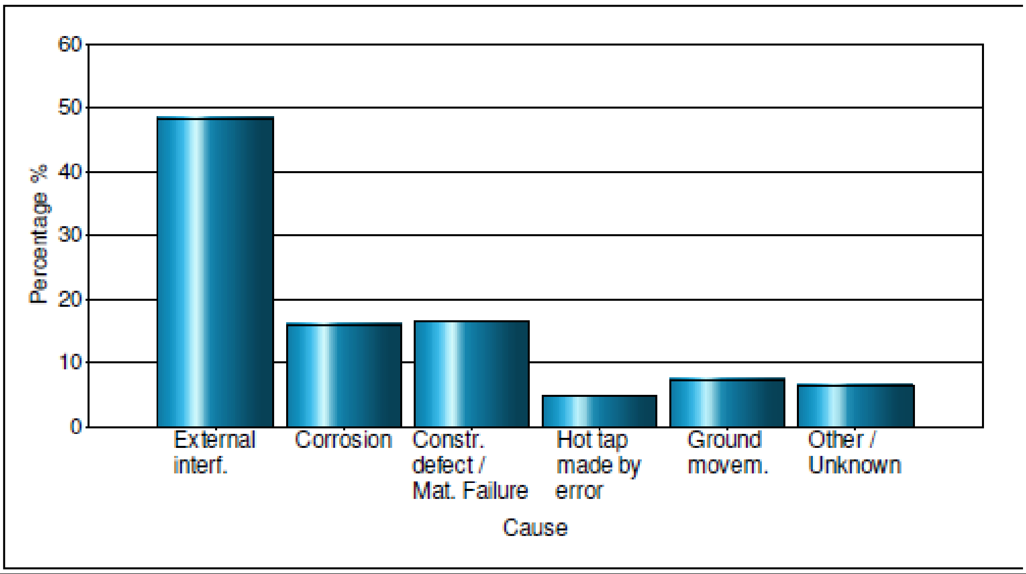
Source: 9th EGIG Report

As referred in the above table the overall failure frequency (0.33) of the entire period (1970-2013) is slightly lower than the failure frequency of 0.35 reported in the 8th EGIG report (1970-2010). The failure frequency of the last 5 years was found to be 0.16 per 1000km.year, depicting an improved performance over the recent years.

Incident Causes

Gas pipeline failure incidents can be attributed to the following major causes viz. external interference, construction defects, corrosion (internal & external), ground movement and hot tap. The distribution of incidents with cause has been presented in the ***Figure 7.10*** below.

Figure 7.10 Gas Pipeline Failure – Distribution of Incident & Causes



Source: 8th EGIG Report

The interpretation of the aforesaid figure indicated external interference as the major cause of pipeline failure contributing to about 48.4% of the total failure incidents followed by construction defects (16.7%) and corrosion related problems (16.1%). Ground movement resulting from seismic disturbance, landslides, flood etc. contributed to only 7.4% of pipeline failure incident causes.

Review of the 9th EGIG report indicates that primary failure frequency varies with pipeline diameter, and the same has been presented in ***Table 7.11*** below.

Table 7.11 Primary Failure Frequency based on Diameter Class (1970-2013)

Nominal Diameter (inch)	Primary failure frequency (per km.yr)		
	Pinhole/Crack	**Hole**	**Rupture**
diameter < 5"	4.45×10^{-4}	2.68×10^{-4}	1.33×10^{-4}
5" ≤ diameter < 11"	2.80×10^{-4}	1.97×10^{-4}	6.40×10^{-5}
11" ≤ diameter < 17"	1.27×10^{-4}	0.98×10^{-4}	4.10×10^{-5}
17" ≤ diameter < 23"	1.02×10^{-4}	5.00×10^{-5}	3.40×10^{-5}
23" ≤ diameter < 29"	8.50×10^{-5}	2.70×10^{-5}	1.20×10^{-5}
29" ≤ diameter < 35"	2.30×10^{-5}	5.00×10^{-6}	1.40×10^{-5}
35" ≤ diameter < 41"	2.30×10^{-5}	8.00×10^{-6}	3.00×10^{-6}
41" ≤ diameter < 47"	7.00×10^{-6}	-	-
diameter ≥ 47"	6.00×10^{-6}	6.00×10^{-6}	6.00×10^{-6}

Source: 9th EGIG Report

The pipeline failure frequency viz. leaks or rupture for the natural gas pipeline has been computed based on the aforesaid table. Considering the gas pipeline to be laid for the proposed project has a dia of 12 inches, the failure frequency has been presented in ***Table 7.12*** below.

Table 7.12 Interconnecting Pipeline - Failure Frequency

Sl. No	Pipeline Failure Case	EGIG Failure Frequency (per km.year)	Pipeline Dia (mm)	Avg. Pipeline Length (km)	Project Pipeline Failure Frequency (per year)	Frequency
1	Pipeline Rupture	4.10×10^{-5}	304.8	5.5	2.25×10^{-4}	Not Likely
2	Pipeline Leak	1.27×10^{-4}	304.8	5.5	6.98×10^{-4}	Not Likely
3	Pipeline Rupture	4.10×10^{-5}	304.8	8.0	3.28×10^{-4}	Not Likely
4	Pipeline Leak	1.27×10^{-4}	304.8	8.0	1.01×10^{-3}	Occasional/ Rare

Thus the probability of pipeline leak and rupture with respect to the interconnecting hydrocarbon pipeline network is primarily identified to be as "*Not Likely*".

<u>*Pipeline Failure – Ignition Probability*</u>

The ignition probability of natural gas pipeline failure (rupture & leaks) with respect to the proposed expansion project is derived based on the following equations as provided in the IGEM/TD/2 standard

$P_{ign} = 0.0555 + 0.0137pd2$; for $0 \leq pd^2 \leq 57$
(For pipeline ruptures)
$P_{ign} = 0.81$; for $pd^2 > 57$

$P_{ign} = 0.0555 + 0.0137(0.5pd2)$; for $0 \leq 0.5pd^2 \leq 57$
(For pipeline leaks)
$P_{ign} = 0.81$; for $0.5pd^2 > 57$

Where:

P_{ign} = Probability of ignition
p = Pipeline operating pressure (bar)
d = Pipeline diameter (m)

The ignition and jet fire probability of natural gas release from a leak/rupture of interconnected pipeline network is calculated based on the above equations and presented in ***Table 7.13*** below.

Table 7.13 Interconnecting Pipeline – Ignition & Jet Fire Probability

Sl. No	Pipeline Failure Case	Pipeline Dia (mm)	EGIG Pipeline Failure Frequency (per year)	Ignition Probability	Jet Fire Probability
1	Pipeline Rupture	304.8	4.10×10^{-5}	0.076	3.11×10^{-6}
2	Pipeline Leak	304.8	1.27×10^{-4}	0.066	8.32×10^{-6}

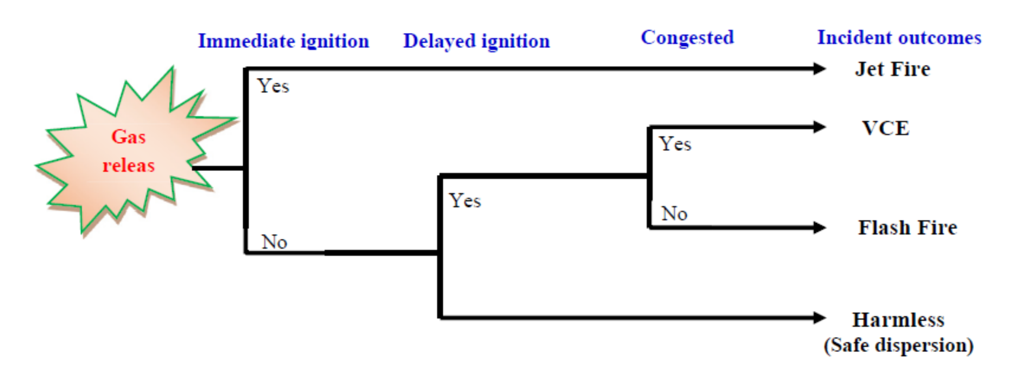
Hence from the above table it can be concluded that ignition probability of natural gas that may be released from the project related proposed gas pipelines due to any accidental event is mostly considered to be "***Improbable***".

Consequence Analysis – Pipelines & GCS

Pipelines generally contains large inventories of oil or gas under high pressure; although accidental releases from them are remote they have the potential of catastrophic or major consequences if related risks are not adequately analysed or controlled. The consequences of possible pipeline failure is generally predicted based on the hypothetical failure scenario considered and defining parameters such as meteorological conditions (stability class), leak hole & rupture size and orientation, pipeline pressure & temperature, physicochemical properties of chemicals released etc.

In case of pipe rupture containing highly flammable natural gas, an immediate ignition will cause a jet fire. Flash fires can result from the release of natural gas through the formation of a vapour cloud with delayed ignition and a fire burning through the cloud. A fire can then flash back to the source of the leak and result in a jet fire. Flash fires have the potential for offsite impact as the vapour clouds can travel considerable distances downwind of the source. Explosions can occur when a flammable gas cloud in a confined area is ignited; however where vapour cloud concentration of released material is lower than Lower Flammability Limit (LFL), consequently the occurrence of a VCE is highly unlikely. VCE, if occurs may result in overpressure effects that become more significant as the degree of confinement increases (Refer ***Figure 7.11***). Therefore, in the present study, only the risks of jet fires for the below scenarios have been modelled and calculated.

Figure 7.11 Natural Gas Release – Potential Consequences



[*Source: "Safety risk modelling and major accidents analysisof hydrogen and natural gas releases: Acomprehensive risk analysis framework" - Iraj Mohammadfam, Esmaeil Zarei*]

Based on the above discussion and frequency analysis as discussed in the earlier section, the following hypothetical risk scenarios (Refer ***Table 7.14***) have been considered for consequence analysis of the interconnecting pipelines.

Table 7.14 Interconnecting Pipeline Risk Modelling Scenarios

Scenario	Source	Pipeline dia (mm)	Accident Scenario	Design Pressure (bar)	Pipeline length (km)	Potential Risk
1	Pipeline	304.8	Leak of 50mm dia	17.23	5.5	Jet Fire
2	Pipeline	304.8	Complete rupture	17.23	5.5	Jet Fire
3	Pipeline	304.8	Leak of 50mm dia	17.23	8.0	Jet Fire
4	Pipeline	304.8	Complete rupture	17.23	8.0	Jet Fire

The pipeline failure risk scenarios have been modeled using ALOHA and interpreted in terms of Thermal Radiation Level of Concern (LOC) encompassing the following threshold values (measured in kilowatts per square meter) for natural gas (comprising of ~95% methane[1]) to create the default threat zones:

Red: 10 kW/ (sq. m) -- potentially lethal within 60 sec;

Orange: 5 kW/ (sq. m) -- second-degree burns within 60 sec; and

Yellow: 2 kW/ (sq. m) -- pain within 60 sec.

For vapour cloud explosion, the following threshold level of concern has been interpreted in terms of blast overpressure as specified below:

Red: 8.0 psi – destruction of buildings;

Orange: 3.5 psi – serious injury likely; and

Yellow: 1.0 psi – shatters glass

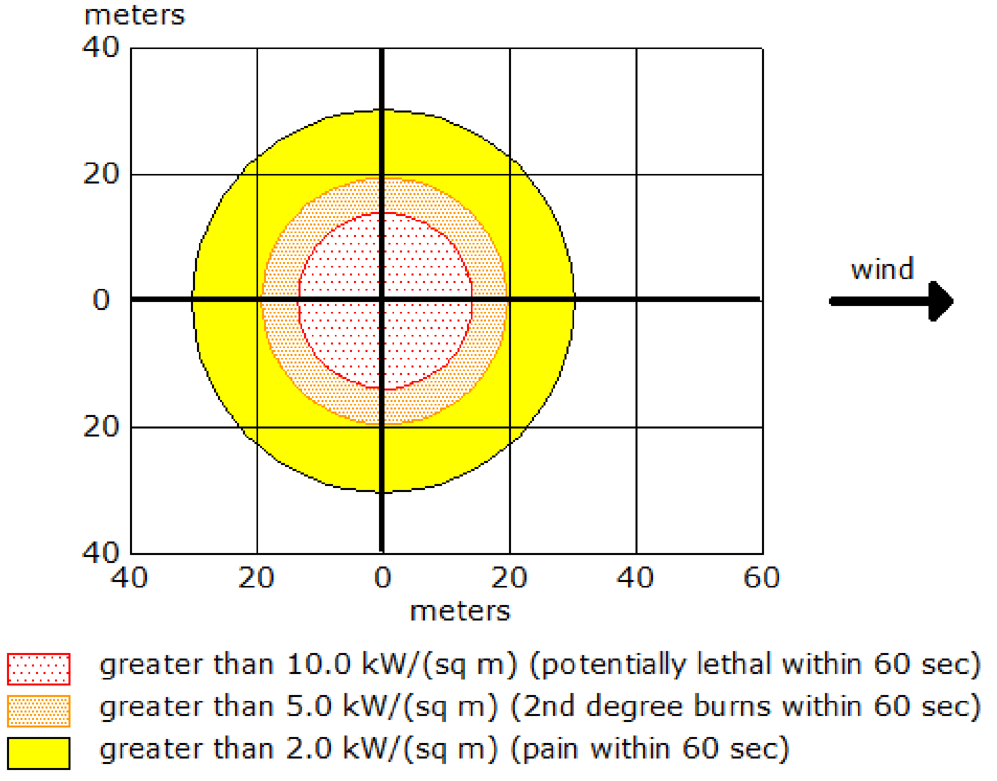
The risk scenarios modelled for pipeline failure has been presented below:

[1] https://www.naesb.org//pdf2/wgq_bps100605w2.pdf
http://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=18&ved=0ahUKEwjF7MiDttPRAhVCMI8KHd7aD6cQFghrMBE&url=http%3A%2F%2Fwww.springer.com%2Fcda%2Fcontent%2Fdocument%2Fcda_downloaddocument%2F9781848828711-c1.pdf%3FSGWID%3D0-45-862344-p173918930&usg=AFQjCNEaJklfYKl3fRUdi6xiRYeW-FJb2A

Scenario 1: 5.5km Pipeline Leak (50mm dia)

The jet fire threat zone plot for release and ignition of natural gas from 5.5km long pipeline leak of 50mm dia is represented in ***Figure 7.12*** below.

Figure 7.12 Threat Zone Plot –5.5km pipeline leak (50mm dia)



Source: ALOHA

THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

Red : 14 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 20 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

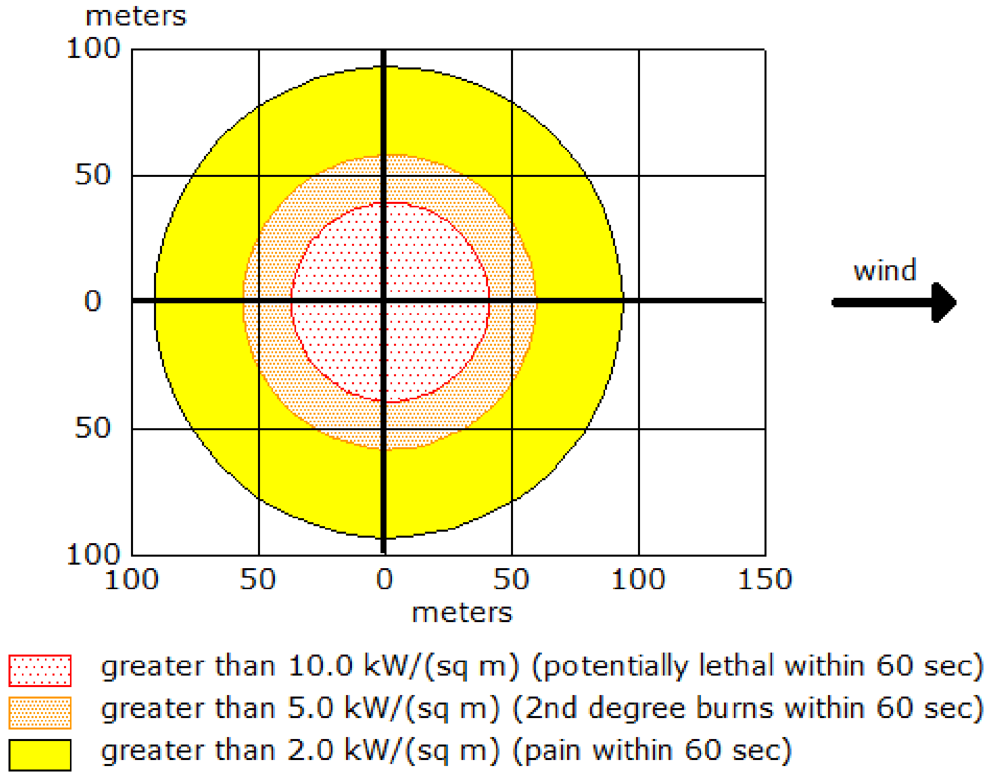
Yellow: 30 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of natural gas from 5.5km long pipeline leak of 50mm dia will be experienced to a maximum radial distance of 14m from the source with potential lethal effects within 1 minute.

Scenario 2: 5.5km Pipeline Complete Rupture

The jet fire threat zone plot for release and ignition of natural gas from 5.5km long pipeline rupture is represented in ***Figure 7.13*** below.

Figure 7.13 Threat Zone Plot – 5.5km pipeline complete rupture



Source: ALOHA

THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

Red : 41 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 60 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

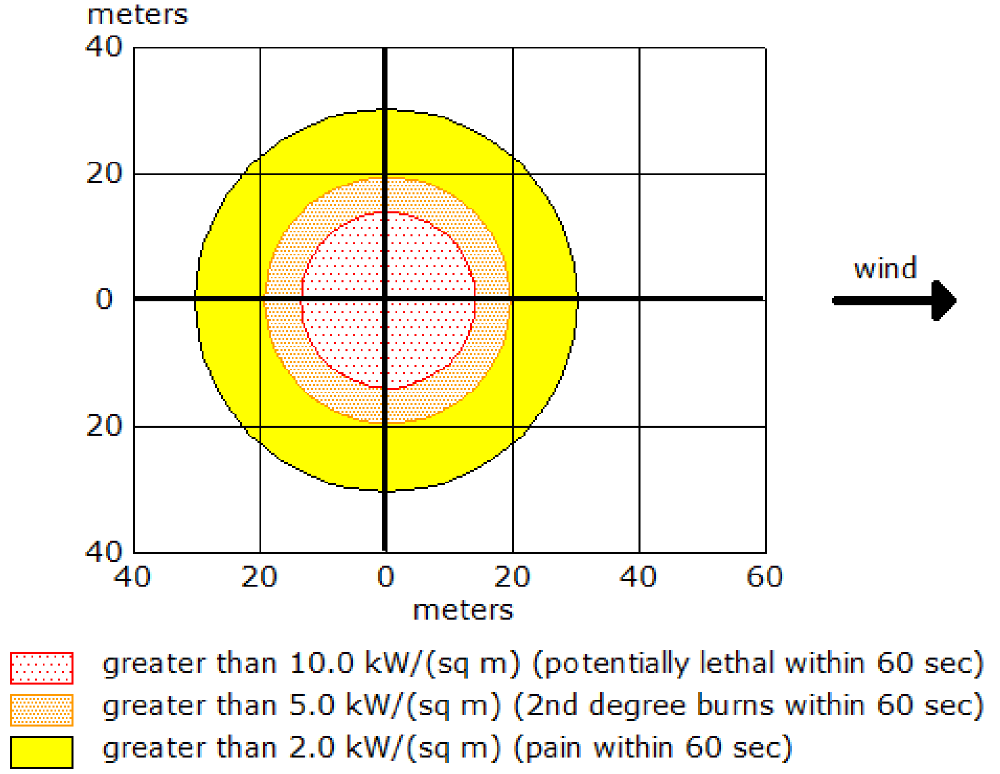
Yellow: 94 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of natural gas from the complete rupture of 5.5km long gas pipeline will be experienced to a maximum radial distance of 41m from the source with potential lethal effects within 1 minute.

Scenario 3: 8km Pipeline Leak (50mm dia)

The jet fire threat zone plot for release and ignition of natural gas from 8km long pipeline leak of 50mm dia is represented in ***Figure 7.14*** below.

Figure 7.14 Threat Zone Plot –8km pipeline leak (50mm dia)



Source: ALOHA

THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

Red : 14 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 20 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

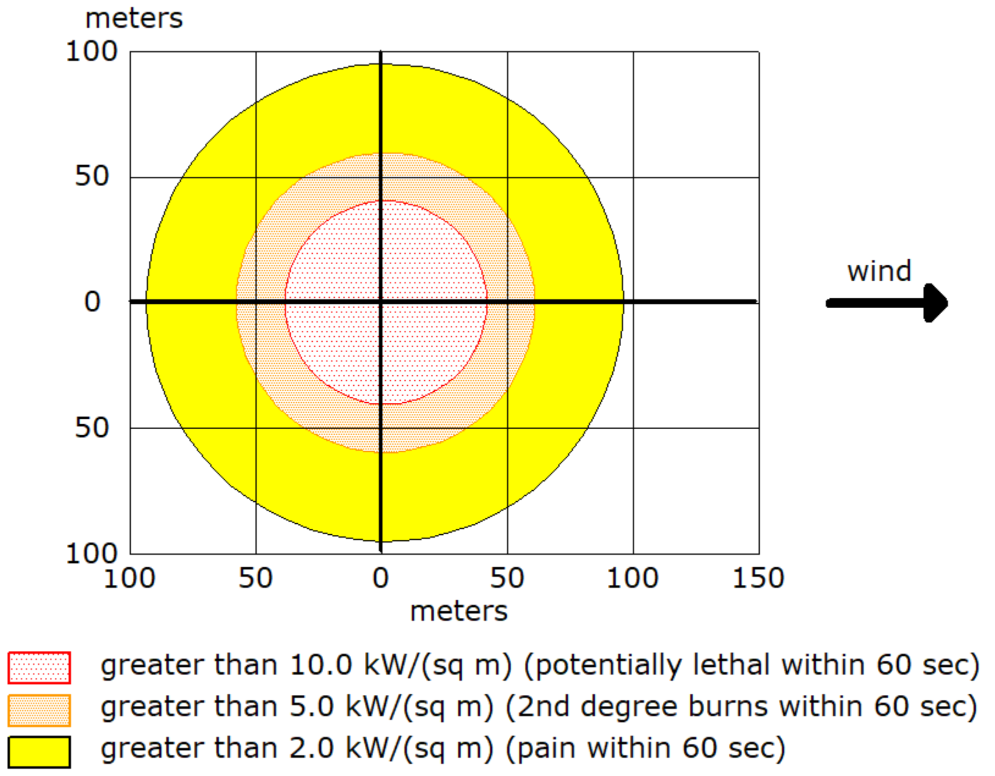
Yellow: 30 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of natural gas from 8km long pipeline leak of 50mm dia will be experienced to a maximum radial distance of 14m from the source with potential lethal effects within 1 minute.

Scenario 4: 8km Pipeline Complete Rupture

The jet fire threat zone plot for release and ignition of natural gas from 8km long pipeline rupture is represented in ***Figure 7.15*** below.

Figure 7.15 Threat Zone Plot – 8km pipeline complete rupture



Source: ALOHA

THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

Red : 42 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 61 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

Yellow: 96 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of natural gas from the complete rupture of 8km long gas pipeline will be experienced to a maximum radial distance of 42m from the source with potential lethal effects within 1 minute.

For VCE modelled for catastrophic failure of the proposed project gas pipeline the LOC level was never exceeded

THREAT ZONE:

Threat Modeled: Overpressure (blast force) from vapor cloud explosion

Type of Ignition: ignited by spark or flame

Level of Congestion: uncongested

Model Run: Heavy Gas

Red : LOC was never exceeded --- (8.0 psi = destruction of buildings)

Orange: LOC was never exceeded --- (3.5 psi = serious injury likely)

Yellow: LOC was never exceeded --- (1.0 psi = shatters glass)

For calculating the risk significance of natural gas pipeline, the likelihood ranking is considered to be "3" as the probability of pipeline rupture is computed to be ~10^{-4} per year; whereas the consequence ranking has been identified to be as "3" as given for a worst-case scenario (rupture) lethal effects is likely to be limited within a radial zone of ~42m. Further as discussed in the earlier section, adequate number of gas leak and fire detection system of appropriate design will be provided for the interconnecting pipeline network including GCS to prevent for any major risk at an early stage of the incident.

Risk Ranking – Pipeline Rupture (Worst Case Scenario)

Likelihood ranking	3	**Consequence ranking**	3
Risk Ranking & Significance = 9 i.e. "Low" i.e. Risk is Tolerable and can be managed through implementation of existing controls and technologies.			

Hazardous Material Releases or Mishaps

Release of following materials are not considered as major accidents and therefore are not quantified in terms of frequency, consequence and the resulting risk.

- Diesel fuel;
- Lubricants;
- Mud Chemicals;
- Explosives.

Exposure to such hazards would be **occupational** rather than **major** hazards.

External Hazards

External hazards which may impair the safety of the rig include the following:

- Severe weather conditions;
- Earthquake or ground movement; and
- Security breaches.

Extreme weather conditions are primarily lightening, cyclones and high winds and heavy rains. They may result in injury (through slips trips of personnel) or equipment damage. Cyclones and high winds may damage the rig structure. There are potential hazards to workers from direct impact of the structure i.e. falling equipment and any subsequent hydrocarbon releases caused by equipment damage. However, no fatalities are expected from such conditions i.e. the risk to workers is low, providing:

- Reliable weather forecasts are available;
- Work or rig move is suspended if conditions become too severe;
- Design and operational limits of the rig structure are known and not exceeded.

Other natural hazards, such as earthquake are predominant in Assam region. The risk of external hazards causing blowouts has been considered in the frequency estimation of oil and gas blowouts in the earlier sections.

7.1.5 Disaster Management Plan

Objective

Disaster Management is a process or strategy that is implemented when any type of catastrophic event takes place. The Disaster Management Plan envisages the need for providing appropriate action so as to minimize loss of life/property and for restoration of normalcy within the minimum time in event of any emergency. Adequate manpower, training and infrastructure are required to achieve this.

The objectives of Disaster Management Plan are as follows:

- Rapid control and containment of the hazardous situation;
- Minimising the risk and impact of occurrence and its catastrophic effects;
- Effective rehabilitation of affected persons and prevention of damage to Property and environment;
- To render assistance to outside the factory.

The following important elements in the disaster management plan (DMP) are suggested to effectively achieve the objectives of emergency planning:

- Reliable and early detection of an emergency and careful response;
- The command, co-ordination, and response organization structure along with efficient trained personnel;
- The availability of resources for handling emergencies;
- Appropriate emergency response actions;
- Effective notification and communication facilities;
- Regular review and updating of the DMP;
- Proper training of the concerned personnel.

Emergency Response - Organizational Structure

HOEC will constitute emergency response teams to respond to Environmental issues, fire, accidents and technical emergencies. These teams will be made up from operations personnel, who can be called upon 24 hours a day, supported by senior management field personnel as and when required. The emergency response teams will receive specific training for their roles and exercised on a regular basis.

The emergency response set-up is categorized into

- Emergency Response Group (ERG) members
- Emergency Management Team (EMT) members

The Emergency Response Group (ERG) is the field-based team, which activates the emergency response immediately on realizing the emergency. The ERG is organized as:

- Emergency Response Group (ERG) leader
- Forward Controller (FC)
- Incident Controller (IC)
- Emergency Response Team (ERT) members
- Rig HSE Engineer
- Event logger (to be appointed by Rig Manager as per requirement)

The Drilling Supervisor shall be the Emergency Response Group (ERG) leader located at drilling Rig site. The Drilling Rig Manager shall presume the role of 'Forward Controller' (FC). The Tool Pusher shall presume the role of 'Incident Controller' (IC) and shall be at the scene of the incident along with his team members, to control the emergency. The Forward Controller shall be located at the Rig control room. He shall direct and advise the Incident Controller (IC) on the course of action to be taken in consultation with Drilling Supervisor. The Incident Controller will be present at the scene of emergency and will be the person in the field responsible to control the emergency. He will report the situation to the Forward Controller and to the Drilling Supervisor (ERG leader). The Drilling Supervisor and the Forward Controller (FC) shall constantly update the Drilling Superintendent who in turn updates the other members of the Emergency Management Team (EMT) at Chennai Head Quarters.

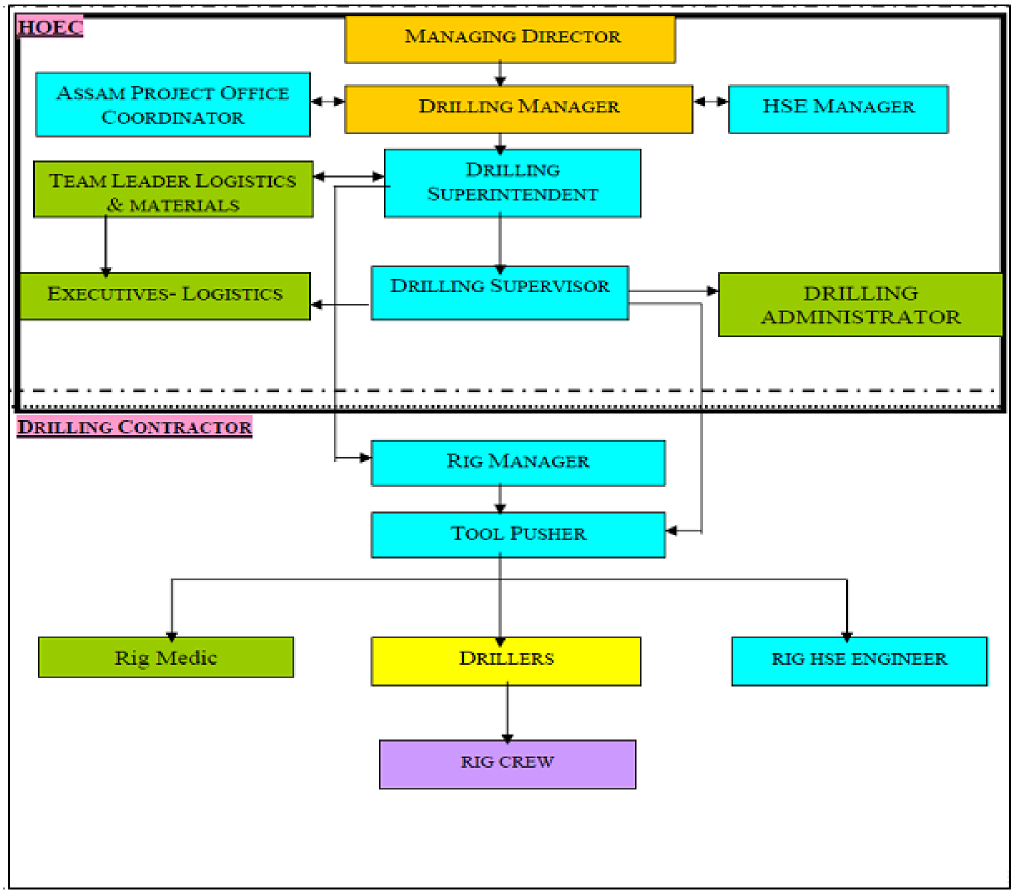
The Emergency Management Team (EMT) shall comprise of the following members:

- Managing Director (Emergency Response Manager)
- Drilling Manager (EMT Leader)
- Drilling Superintendent
- Logistics In-charge
- Project Office In-Charge Assam
- HSE Manager
- Drilling Administrator

Once the emergency message is received from the Rig, the Drilling Superintendent shall inform to Drilling Manager who in turn after discussion with the Emergency Response Manager Managing Director and the team at Chennai (if necessary) will activate the Emergency Management Teams (EMT) to the Emergency Control Room.

The organizational chart for emergency response is presented in Figure 7.16 below

Figure 7.16 Emergency Response Organizational Chart



Emergency Identified

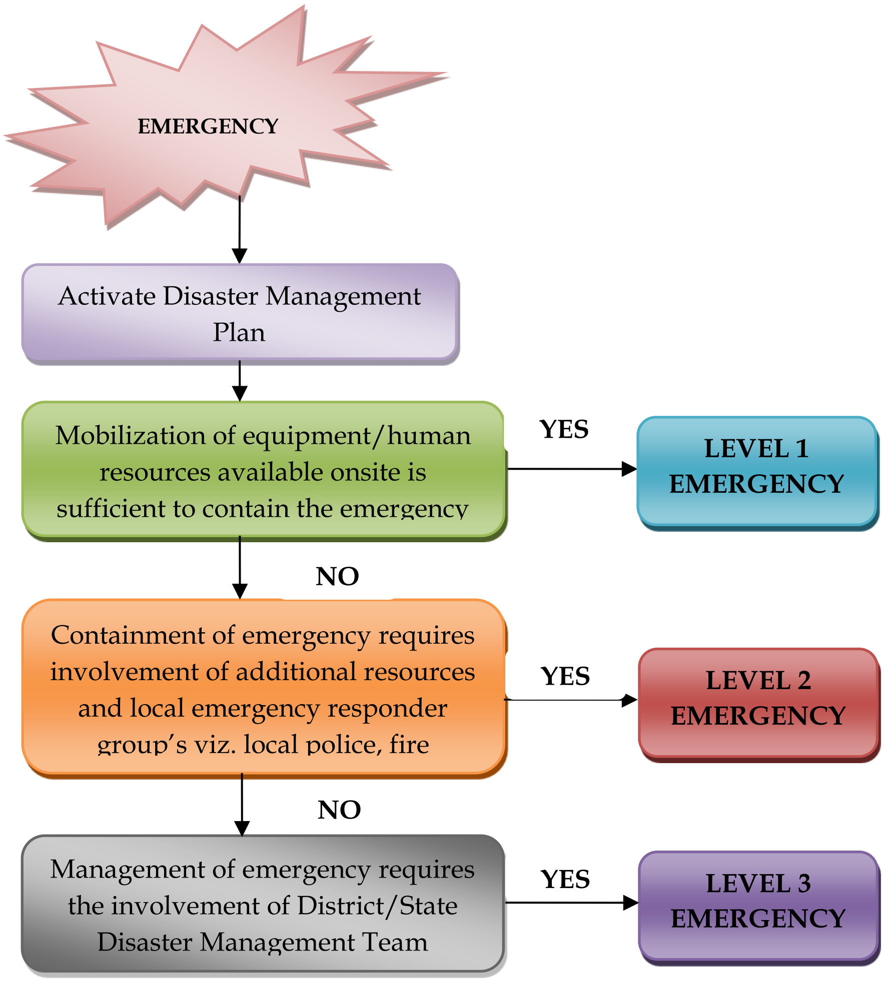
Emergencies that may arise:

- Such an occurrence may result in on-site implications like :
    - Fire or explosion;
    - Leakage of natural gas; and
    - Oil spillage and subsequent fire.
- Incidents having off-site implications can be:
    - Natural calamities like earthquake, cyclone, lightening, etc.
- Other incidents, which can also result in a disaster, are :
    - Agitation / forced entry by external group of people;
    - Sabotage.

Emergency Classification

Due consideration is given to the severity of potential emergency situation that may arise as a result of accident events as discussed in the **Risk Analysis (RA)** study. Not all emergency situations call for mobilization of same resources or emergency actions and therefore, the emergencies are classified into three levels depending on their severity and potential impact, so that appropriate emergency response procedures can be effectively implemented by the Emergency Response Team. The emergency levels/tiers defined with respect to this project based on their severity have been discussed in the subsequent sections with 'decision tree' for emergency classification being depicted in ***Figure 7.17.***

Figure 7.17 Emergency Classification "Decision Tree"



The emergency situations have been classified in three categories depending upon their magnitude and consequences. Different types of emergencies that may arise at the project site can be broadly classified as:

Level 1 Emergency

The emergency situation arising in any section of one particular plant / area which is minor in nature, can be controlled within the affected section itself, with the help of in-house resources available at any given point of time. The emergency control actions are limited to level 1 emergency organization only. But such emergency does not have the potential to cause serious injury or damage to property / environment and the domino effect to other section of the affected plant or nearby plants/ areas.

Level 2 Emergency

The emergency situation arising in one or more plants / areas which has the potential to cause serious injury or damage to property / environment within the affected plant or to the nearby plants / areas. This level of emergency situation will not affect surrounding community beyond the power plant facility. But such emergency situation always warrants mobilizing the necessary resources available in-house and/or outsources to mitigate the emergency. The situation requires declaration of On – Site emergency.

Level 3 Emergency

The emergency is perceived to be a kind of situation arising out of an incident having potential threat to human lives and property not only within the power plant facility but also in surrounding areas and environment. It may not be possible to control such situations with the resources available within HOEC facility. The situation may demand prompt response of multiple emergency response groups as have been recognized under the off-site district disaster management plan of the concerned district(s).

Preventive and Mitigation Measures for Blow Outs

Blowouts being events which may be catastrophic to any well operation, it is essential to take up as much preventive measures as feasible. This includes:

- Necessary active barriers (eg.. Well-designed Blowout Preventer) be installed to control or contain a potential blowout.
- Weekly blow out drills be carried out to test reliability of BOP and preparedness of drilling team.
- Close monitoring of drilling activity be done to check for signs of increasing pressure, like from shallow gas formations.
- Installation of hydrocarbon detectors.
- Periodic monitoring and preventive maintenance be undertaken for primary and secondary barriers installed for blow out prevention, including third party inspection & testing
- An appropriate Emergency Response Plan be finalized and implemented by HOEC.
- Marking of hazardous zone (500 meters) around the well site and monitoring of human movements in the zone.
- Training and capacity building exercises/programs be carried out for onsite drilling crew on potential risks associated with exploratory drilling and their possible mitigation measures.
- Installation of mass communication and public address equipment.
- Good layout of well site and escape routes.

Additionally, HOEC will be adopting and implementing the following Safe Operating Procedures (SOPs) developed as part of its Onsite Emergency Response Plan to prevent and address any blow out risks that may result during drilling and work over activities:

- Blow Out Control Equipment
- Choke lines and Choke Manifold Installation with Surface BOP
- Kill Lines and Kill Manifold Installation with Surface BOP
- Control System for Surface BOP stacks
- Testing of Blow Out Prevention Equipment
- BOP Drills.

Preventive Measures for Handling of Natural Gas

- Leak detection sensors to be located at areas prone to fire risk/ leakages;
- All safety and firefighting requirements as per OISD norms to be put in place;
- High temperature and high pressure alarm with auto-activation of water sprinklers as well as safety relief valve to be provided;
- Flame proof electrical fittings to be provided for the installation;
- Periodical training/awareness to be given to work force at the project site to handle any emergency situation;
- Periodic mock drills to be conducted so as to check the alertness and efficiency and corresponding records to be maintained;
- Signboards including emergency phone numbers and 'no smoking' signs should be installed at all appropriate locations;
- Plant shall have adequate communication system;
- Pipeline route/equipment should be provided with smoke / fire detection and alarm system. Fire alarm and firefighting facility commensurate with the storage should be provided at the unloading point;
- 'No smoking zone' to be declared at all fire prone areas. Non sparking tools should be used for any maintenance; and
- Wind socks to be installed to check the wind direction at the time of accident and accordingly persons may be diverted towards opposite direction of wind.

Preventive Measures for Interconnecting Pipeline Risk Management

- Design all pipes to cope with maximum expected pressure;
- Install pressure transmitters that remotely monitor high- and low-pressure alarms;
- Design equipment to withstand considerable heat load;
- Conduct regular patrols and inspections of pipeline easements;
- Fit pumps with automatic pump shutdown or other safety devices;
- Minimise enclosed spaces where flammable gas may accumulate;

- Where necessary, automate emergency shutdown systems at production facilities;
- Consider installing flow and pressure instrumentation to transmit upset conditions and plant shutdown valves status;
- Install fire and gas detection systems;
- Implement security controls;
- Install emergency shutdown buttons on each production facility;
- Bury gathering lines at a minimum depth of 600 mm and where above ground, maintain a clear area;
- Implement management of change processes; and
- Conduct pressure testing and inspection of equipment and pipelines.

Preventing Fire and Explosion Hazards

- Proper marking to be made for identification of locations of flammable storages;
- Provision of secondary containment system for all fuel and lubricating oil storages;
- Provision of fire and smoke detectors at potential sources of fire and smoke;
- Storing flammables away from ignition sources and oxidizing materials;
- Providing specific worker training in handling of flammable materials, and in fire prevention or suppression;
- Equipping facilities with fire detectors, alarm systems, and fire-fighting equipment;
- Fire and emergency alarm systems that are both audible and visible;
- For safety of people the building, regulations concerning fire safety to be followed. Some of the requirements include:
- Installation of fire extinguishers all over the building;
- Provision of water hydrants in operative condition;
- Emergency exit;
- Proper labelling of exit and place of fire protective system installation;
- Conducting mock drills;
- Trained personnel to use fire control systems.

General Health and Safety

- The facility will adopt a total safety control system, which aims to prevent the probable accidents such as fire accidents or chemical spills.
- Fire fighting system, such as sprinklers system, portable extinguishers (such as CO_2) and automated fire extinguishers shall be provided at strategic locations with a clear labelling of the extinguisher so the type of the extinguisher is easily identifiable. Also a main hydrant around the buildings will be available. On all floors an automated fire detection system will be in place.
- The site operations manager will take steps to train all emergency team members and shall draw up an action plan and identify members. The

appointed emergency controller shall act as the in-charge at the site of the incident to control the entire operation.
- The staff shall be trained for first-aid and firefighting procedures. The rescue team shall support the first-aid and firefighting team.
- A first-aid medical centre will be onsite to stabilise the accident victim. The emergency team will make contact with a nearby hospital for further care, if required.
- A training and rehearsal of the emergency response by emergency team members and personnel on site will be done regularly.
- A safe assembly area will be identified and evacuation of the premises will be practised regularly through mock drills.
- In case an emergency is being declared, the situation shall be reported to the authorities such as local police, the chief inspector of factories and the state pollution control board as per rules and regulation of law of the land.
- Safety manual for storage and handling of Hazardous chemicals shall be prepared.
- All the personnel at the site shall be made aware about the hazardous substance stored and risk associated with them.
- Personnel engaged in handling of hazardous chemicals shall be trained to respond in an unlikely event of emergencies.
- A written process safety information document shall be compiled for general use and summary of it shall be circulated to concerned personnel.
- MSDS shall be made available and displayed at prominent places in the facility.
- Safe work practices shall be developed to provide for the control of hazards during operation and maintenance
- In the material storage area, hazardous materials shall be stored based on their compatibility characteristics.
- Near miss and accident reporting system shall be followed and corrective measures shall be taken to avoid / minimize near miss incidents.
- Safety measures in the form of DO and Don't Do shall be displayed at strategic locations.
- Safety audits shall be conducted regularly.
- Firefighting system shall be tested periodically for proper functioning.
- All hydrants, monitors and valves shall be visually inspected every month.
- Disaster Management Plan shall be prepared and available with concerned personnel department.

Personal Protective Equipment

In certain circumstances, personal protection of the individual maybe required as a supplement to other preventive action. It should not be regarded as a substitute for other control measures and must only be used in conjunction with substitution and elimination measures. PPEs must be appropriately selected individually fitted and workers trained in their correct use and maintenance. PPEs must be regularly checked and maintained to ensure that the worker is being protected.

First Aid

First aid procedures and facilities relevant to the needs of the particular workforce should be laid down and provided in consultation with an occupational physician or other health professional.

Health assessment should form a part of a comprehensive occupational health and safety strategy. Where employees have to undergo health assessment, there should be adequate consultation prior to the introduction of such program. Medical records should be kept confidential. Site should be able to relate employee health and illness data to exposure levels in the workplace.

7.2 PUBLIC CONSULTATION

7.2.1 Community Consultation

Public consultation was carried out with the objective of finding out about people's views and opinion on issues relating to the project, its operations and also to the peripheral development. The village wise consultation is presented in ***Annex 7.1***.

The summary findings of the consultations carried out have been discussed below:

- Majority of the people in the area are tea garden worker. Some people also involved in agriculture and paddy is main agriculture produce
- Water requirement is catered through household borewell/tube well facility in the village areas. Good quality drinking water is available to them trough out the year.
- It was reported during consultations that majority of the parents send their children to the primary school. Almost every village has a primary school; however, percentage of students pursuing higher education is comparatively less.
- The medical facilities in the area are also not satisfactory. During the public consultations the household members expressed their concern about the health facilities. According to them although there exists primary health centers, doctors are infrequent and moreover since transportation facilities are poor, sometimes they find it hard to mobilize serious patients to Digboi and Margherita.
- The local communities at the tea garden mentioned about the facilities they receive from the tea estates like hospitals and ambulance services, incentives during marriages for the family members and other infrastructure like utensils etc.,

- Community consultation revels that wild life mainly elephant is a major problem in this area. Village hamlet like Khagoripathar Golai III, Golai II located just beside the Dehing Patkai wildlife sanctuary faced problem of the man animal conflict mainly with the elephant to the maximum. As per the villages, last year one villager lost his life due to man animal conflict.

8 PROJECT BENEFITS

8.1 FINANCIAL BENEFITS

Following financial benefits are expected from the proposed oil & gas program:

(a) Majority of the infrastructure for processing of production/well fluid are already available through the operating GPP and OIL's gas processing facility. Therefore, 24 development well pads and the connecting pipelines are proposed to harness the hydrocarbon potential of the block.

(b) The increase in production of oil and gas within the already approved capacity will add to the energy independence of the nation and will reduce the import bills. Please note that in-spite of the incremental increase in production the total production will be within the approved quantity;

(c) Based on the comparative cost benefit analysis, the project is found to be economically viable.

(d) Considering the marginal field development, the platform proposed as the minimum facility with no additional process facilities required.

8.2 SOCIAL BENEFITS

Following social benefits are expected:

(a) Limited interference with the local community as the proposed project involves development drilling mostly in the tea garden area and away from the villages;

(b) HOEC is already taking up of corporate social responsibility (CSR) actions in the region which will be continued to be taken up as described in the following section.

8.3 CSR ACTIVITIES

HOEC has taken up various CSR initiatives in and around HOEC's operational areas for the benefit of the residents as per the CSR Act and Rules, Govt. of India. First of all HOEC would initiate a need assessment study in the area which will help to find out the infrastructure deficiencies, local demands and in course would help to delineated the detailed CSR plan.

The broad areas to be focused under the CSR plan would include;

(c) Health - arranging mobile health camps including eye camps, school health programmes which includes free dental awareness examination camps and free check-ups of the students; universal immunization programme etc.

(d) Education - Providing financial assistance to institutions towards purchasing of furniture and required amenities to school, libraries, auditoriums, teacher's common room etc.

(e) Funding for sports, cultural events etc.

9 ENVIRONMENTAL MANAGEMENT PLAN

The objective of the Environmental Management Plan (EMP) is to identify Project specific environmental actions that will be undertaken to mitigate and manage impacts associated with the proposed oil and gas development in AAP-ON-94/1 Block.

The EMP focuses on potential direct impacts and potential risks, which have been identified in this EIA as part of the Impact Assessment and Risk Assessment processes (refer to ***Sections 4 & 7***). The EMP also sets out a monitoring programme for key parameters to monitor environmental performance (refer to ***Section 6***).

9.1 ELEMENTS OF EMP

EMP includes four major elements:

- *Planning*: This includes identification of environmental impacts, legal requirements, commitments and policies, setting environmental objectives and HSE compliance;
- *Implementation*: This comprises of resources available for the project, accountability of contractors, documentation of measures to be taken; and
- *Checking - Measurement & Evaluation*: This includes monitoring, corrective actions and record keeping and
- *Management Review*: Actions are taken to continually improve the HSE performance.

9.2 ENVIRONMENTAL MANAGEMENT SYSTEM

9.2.1 Commitments & Policies

Hindustan Oil Exploration Company Limited (HOEC) recognizes the responsibility to operate with proper regard for environment and for the health and safety of its employees and any other persons who at any point of time may be affected by its activities and to conduct its operations in a manner that provides optimum protection to the environment in which these operations are conducted. The HSE Policy of HOEC will adequately address the environmental impacts likely to arise from the proposed development activities in Dirok Development Field. HSE and Corporate Sustainability policies of HOEC is given in ***Figure 9.1.***

Figure 9.1 HOEC's HSE Policy

HOEC

Hindustan Oil Exploration Company Limited

INTEGRATED HSE POLICY

(Health, Safety, Environment, Quality)

"ALL LIVES HAVE EQUAL VALUE"

HOEC is aware that Health, Safety, Environment and Quality best practices play a significant role in all successful management initiatives, in addition to being a statutory requirement. The Company has the objective and the duty to comply with all relevant legislations and requirements while carrying out Oil & Gas Exploration & Production activities in India, in line with the commitments undertaken with the Government of India. While conducting the business and operational activities, HOEC promotes and pursues excellence in:

- *The protection of Health and Safety of employees and the local communities in the vicinity of Company's areas of Exploration & Production (E&P) Operations;*
- *The development and welfare of the communities in areas where the Company conducts its Production operations;*
- *The protection and preservation of the Environment and the biodiversity as well as the adoption of principles and values of environmental sustainability; and*
- *The continuous improvement of the Quality of processes and services inherent to Company's activities and operations, in line with the Company's procedures.*

HOEC is engaged in activities where a certain level of risk is unavoidable HOWEVER is aware that the majority of incidents can be prevented through effective risk management i.e. through identifying, evaluating, controlling and mitigating the risks associated with the Company's E&P activities and consequential impact. HOEC is committed to achieve the objective of conducting E&P operations by making use of an Integrated Health, Safety, Environment and Quality (HSEQ) Management System, strongly supported by the Board, deeply rooted within the respective site management teams and made known to all involved personnel - within and outside - the Company. With the seamless contribution and co-operation over time from all the stakeholders, HOEC is also committed to a continuous improvement of the Integrated HSEQ Management System, with special emphasis on:

HEALTH: The Company shall protect the health of employees by the identification, reduction and monitoring of health risks related to the work processes and the environment in accordance with the local legislations and industry best practices. The Company will promote relevant health information to the workforce, including the service contractors and the communities with which it interacts with the aim of improving their health and wellbeing;

SAFETY: The Company shall make every effort to provide a safe working environment and system for employees and service contractors as well as make them fully understand that they have a duty to protect themselves, their colleagues and the environment. The Company shall develop, apply and maintain an appropriate communication system and more specifically an emergency response plan for own E&P operating facilities such that in the unlikely event of an incident prompt and effective actions can be taken to prevent escalation and mitigate the impact on personnel and assets;

ENVIRONMENT: The Company shall provide adequate attention to the environment by ensuring the protection of air, water, soil and biodiversity from any adverse effects that could be originated by Company's E&P operations, and the avoidance or minimization of the environmental impact for routine as well as emergency situations;

QUALITY: The Company shall ensure quality management in operations by applying consistent contractual specifications and statutory requirements aimed at ensuring that competent and well-trained employees, as well as qualified service contractors, will be engaged to carry out E&P activities.

HOEC Board and the Management undertake responsibility and endeavour to apply the Integrated HSE Policy and trust that all the employees and service contractors' personnel shall implement and comply with the Policy completely and successfully to enable HOEC to stand at the forefront of the Oil & Gas Companies operating in India.

Chennai, February 2, 2015

P. Elango
Managing Director

9.2.2 HOEC Environment Management Policy and System

The HSE- Management System (HSE-MS) of HOEC is based on the 'Key Result Areas' (KRA), which have a direct impact on the HSE performance of industry. Following three KRA have been identified for HSE-MS and each element in turn has sub-elements that detail the objectives, methodology and performance standards.

- Safety Management Systems (SMS)
- Occupational Health & Hygiene (OH& H)
- Environmental Management System (EMS)

Safety Management System (SMS) comprises of the following elements;

- Leadership and Commitment
- Induction & Training
- Rules and Permits
- Hazard Identification and Assessment
- Planned Inspections and Preventive Maintenance
- Incident Investigation and Analysis
- HSE Communications
- Emergency Preparedness
- Audits and reviews
- Personal Protective Equipment
- Procurements and Contracts Management
- Change Management
- Promotions and awards

Occupational Health and Hygiene (OH &H) comprises of the following elements

- Management of Health and Medical Examination
- Industrial Hygiene Management

Environmental Management System comprises of the following elements Environmental Guidelines

- Environmental Management
- Environmental Regulations and Compliance
- Waste Management
- Oil Spill Management

9.2.3 Roles & Responsibility

Roles and responsibilities of HOEC personnel and contractors have been defined for environment management during different phases of the proposed development activities are described below.

Objective

To ensure that HSE is integrated into every job profile, thereby ensuring that everyone is accountable for his/ her HSE performance. To create a profound awareness amongst employees that safety is a way of life and each employee has a vital role to play to enhance the Company's overall HSE performance. The organogram for HSE management is presented at the figure below:

Figure 9.2 Organogram for HSE Management

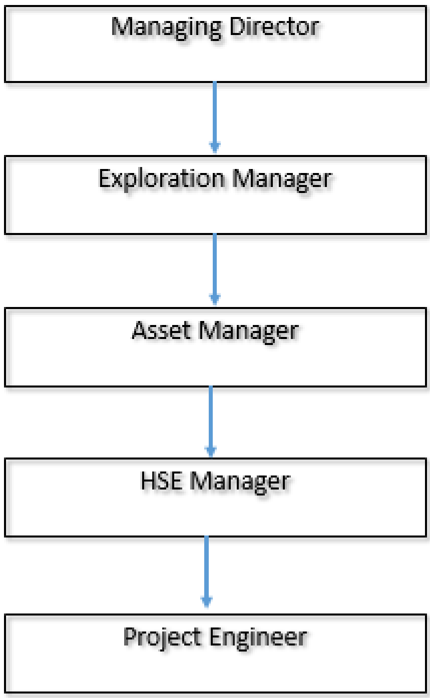
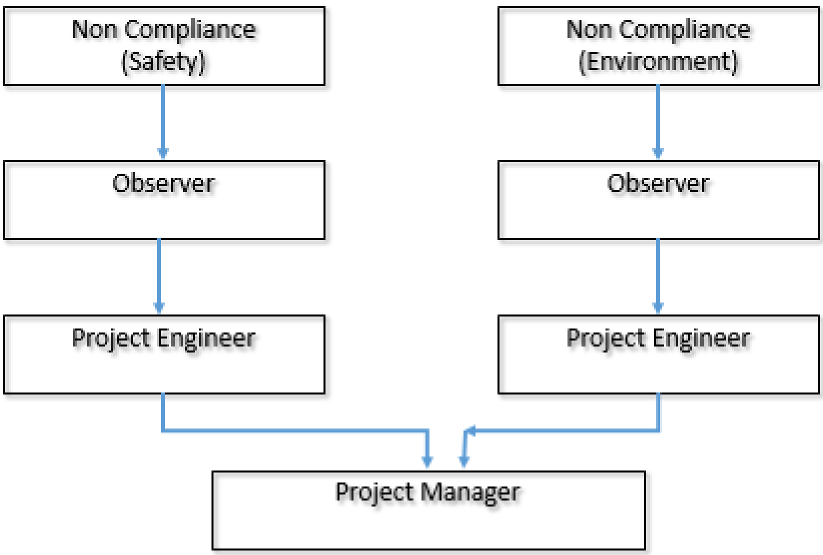


Figure 9.3 Non-Compliance Protocol



9.2.4 *Roles & Responsibility*

Top Management

The Company is aware and believes in principle of Top - Down management system, as the right way for percolating good industrial practices down the line.

The Management is committed to provide required resources like manpower, budgets, training, appropriate equipment and support for drilling, gas processing and transportation, construction and operations.
To demonstrate its commitment, the Management has directed that all meetings in the company, starting from the board level and review of HSE performance.

Human Resources

- Ensure that the selection process incorporates HSE criteria for every job profile;
- Induction and HSE training shall be organised and monitored for all new recruits.

G&G

- Prioritize and secure clearances from statutory bodies prior to the commencement of development activities;
- Obtain essential details pertaining to ecologically and environmentally sensitive areas, forests and social aspects of the blocks during the bidding stage;
- Formulate proper strategy and systematic approach towards the project, such that the proposed operations do not hinder or adversely impact the environmental sensitivity and the local social set-up;
- Ensure that all development activities are carried out as per the Company and regulatory standards.

Finance and Accounts

- Prioritising budget allocation and ensuing approvals for HSE requirements. Review along with various Departmental Heads for completion of pending HSE issues and approve budgets, carried over from the previous financial year;
- Enabling statutory and legal payments in time with due diligence, ensuring that no penalties arise from delayed payments;
- Ensure that no penalties arise from delayed statutory fee payments.

Well Construction Department Head

- Implement Company's HSE policy effectively;
- Set goals for the drilling team, by involving everyone in identifying the goals;

- Ensure that all Health, Safety, Environment and related issues are incorporated and addressed, while procuring new rigs, vessels, services and chemicals etc.
- Assign responsibility for implementation of safety requirements / recommendation by statutory authorities / internal & external audits;
- Encourage incident reporting and investigate all accidents/ incidents reported on rigs and other associated facilities;
- Appraise drilling contractors on their HSE performance, suggest/ reject future contracts based on the HSE appraisal;
- Organize Monthly Contractor's Safety Meeting for discussing HSE performance and action plan for corrective measures identified through incident investigations, inspections and audits.

Production Operations- Head

- Implement Company's HSE policy effectively at the production installations;
- Set goals for the production team, by involving everyone in identifying the goals;
- Ensure that all Health, Safety, Environment and related issues are incorporated and addressed, while hook-up & commissioning new installations, routine productions, and regular logistical facilities;
- Ensure that all Safe Operating Procedures are in place covering all activities at the installations;
- Encourage incident reporting and ensure investigation of all incidents/ accidents reported by the installations;
- Assign responsibility for implementation of safety requirements / recommendation by statutory authorities like DGH, DGMS, Pollution Control Boards, etc and internal/ external audits;
- Ensure Monthly Installation HSE Meetings for discussing HSE performance and action plan for corrective measures identified through incident investigations, inspections and audits
- Audit the installations at least once in a year.

Facilities / Projects Department - Head

- Implement Company's HSE policy effectively at the project and construction sites;
- Set goals for the project / facilities team by involving everyone in identifying the goals;
- Ensure that all Health, Safety, Environment and related issues are incorporated and addressed;
- Ensure that HSE criteria are well defined in Project Contractor's scope and evaluate the potential contractor's HSE Performance and Capability during the tendering and evaluation stage;
- Ensure that all Safe Operating Procedures are in place covering all activities at the installations;

- Encourage incident reporting and ensure investigation of all incidents/ accidents reported by the project sites;
- Assign responsibility for implementation of safety requirements / recommendation by statutory authorities like DGH, DGMS, Pollution Control Board normss, etc and internal/ external audits;
- Ensure Monthly Installation HSE Meetings for discussing HSE performance and action plan for corrective measures identified through incident investigations, inspections and audits;
- Audit the project sites at least once in a year/ during the course of the project activity.

Installation Manager

- Conduct HSE inspections of the Installation at least once in a month along with the Production In-charge;
- Investigate all incidents/ accidents reported at the installations. Encourage incident reporting by the teams. Ensure all incident reports are documented and reviewed by Operations Head;
- Identify all operations at the installation, requiring Safe Operating Procedures (SOP) and review all SOPs with the concerned teams;
- Conduct Monthly Installation HSE meetings within the first week of every month and review the outcome with the 'Operations Head';
- Ensure 'Fortnightly Safety Talks' within groups in the installation and review the reports;
- Develop an action plan to implement the inspections and audit findings by internal and external sources;
- Implement 'Permit to Work' systems and review the records daily;
- Ensure HSE clause is an integral part of all contracts. The contract should mention the requirements of the Company and the minimum expected standard from the Contractor;
- Ensure that all equipment and material procured pertains to industrial standards. Materials of inferior quality that would adversely impact the safety of employees or operations shall not be procured;
- Develop a HSE questionnaire that would help assess the contractor / service provider of (for drilling unit charter, process equipment supply, EPC projects, chemical supply and manpower supply), for their HSE performance and attitude towards safety. The HSE questionnaire would invariably be attached to bid/ tender, and the Service Requestor and HSE Manager shall evaluate responses;
- Ensure while procuring that all chemicals are supplied with relevant information and test reports and the chemicals are environmental friendly. However all chemical supply shall invariably come with the MSDS (Material Safety Data Sheet) and containers shall be appropriately labeled providing information as per UN standards for labeling chemicals;

- Ensure that the contractor/ supplier meet all related statutory requirements. And ensure that the contractor/ supplier provides all information regarding any handling, storage and transportation procedures, while supplying the product;
- Ensure that service requestor/ end user evaluates/ apprises & documents the HSE performance of the contractor/ service provider. The HSE evaluation shall be reviewed to while awarding future contracts and preference shall be given to the best performer.

HSE

- Render advice to management on policy;
- Coordinate implementation of HSE-MS and create awareness. Review PTW and other systems compliance, review and ensure implementation of inspection and audit findings;
- Review incidents / accidents and advise remedial actions for any substandard conditions/ situations;
- Analyse accident reports and prepare statistics;
- Ensure all HSE meetings at conducted regularly.

9.2.5 Implementation

Management Control

Prior to start of proposed oil and gas development activities, HOEC will ensure that equipment and procedures will be designed to achieve the levels of HSE and social performance by all personnel and contractor.

Implementation of the EMP will involve HOEC staff and its contractors, subcontractors and its logistics providers. This will involve the incorporation of the commitments contained in the EMP, including relevant mitigation and control measures, working practices and overall management procedures as appropriate.

Communication & Documentation - Internal & External Reporting

Communication and internal reporting will be maintained with the Contractors for Project related information dissemination. Contractors will play a key role in EMP implementation. This will include discussions and negotiations during the planning stage leading to the finalization of the contract with necessary allocation of responsibility for implementing of environmental mitigation measures.

External Reporting will be taken up with government agencies like the MoEFCC, PCB, OISD, DGH, Tinsukia District Administration, etc. Necessary clearance / consents / permits for the Project are being pursued with the regulatory agencies. The same is expected to continue throughout the duration of the proposed Project.

9.2.6 *Checking*

Environmental monitoring and audits will be undertaken prior to start of the Project as well as during and after the oil and gas development programme to ensure that the environmental management measures are being satisfactorily implemented and that they are delivering the appropriate level of environmental performance.

Inspections & Auditing

The audit programme will include pre-commissioning audits of the facilities focusing on the compliance of equipment and procedures to deliver the specified level of performance to ensure that all environmental requirements are met. Regular audits will check:

- the integrity and function of physical systems;
- compliance with operating procedures;
- testing and review of emergency procedures;
- compliance with maintenance procedures and records; and
- competence and training of operatives and rig and field management staff.

Audit results will be reported to management and field staff responsible for the process or equipment in question. Where audits reveal non-compliance with requirements, corrective actions will be implemented. These will be prioritised according to the significance of the environmental risks arising.

Monitoring

The inspections and audit process will be further supported by monitoring i.e. ensuring practical achievement of implementation of required actions. Sampling and analysis as per the identified monitoring plan will be implemented to check level of compliance of discharges, emissions and required environmental conditions.

Inspections and monitoring by regulators i.e. APCB, MoEFCC and OISD, DGH, District Administration and other agencies will also help ensuring effective checking process of the implementation of the required actions.

Records of all of the monitoring activities will be maintained and will be available for review as required by the management representative.

Environmental and pollution monitoring related requirement have been separately specified in ***Section 6***.

9.2.7 *Management Review*

HOEC management will review the performance against the required actions before, during and after completion of the proposed oil and gas developmental activities in AAP-ON-94/1. Prior to start of the Project components, required organization of HOEC and Contractor will be reviewed to ensure that responsible personnel are aware of their duties for effective implementation of required actions. HOEC will ensure the following:

1 HOEC's representative (HSE Manager) will evaluate the contractor to review the contractor's management system and environment protection procedures to ensure compatibility with HOEC's HSE policies and Guidelines;
2 HOEC's Commercial Manager and HSE Manager will ensure that the contract documents (with contractors) include environmental performance criteria to be maintained for the Project components;
3 HOEC will review all the conditions of environmental clearance, consent to establish, consent to operate and other permits and ensure their compliance is fully achieved;
4 Any specific environmental training needs will be identified for key personnel and training executed either directly by HOEC or through expert agency/contractor;
5 A bridging document will be prepared to clearly define responsibilities and reporting requirements for contractors;
6 Prior to commencing operations all personnel will be briefed on the environmental sensitivities relevant to the operations and measures in place for the proposed Project;
7 All personnel will be encouraged to take an active part in meeting the environmental performance criteria;
8 HOEC's representative (HSE Manager) will be in all key activities associated with ensuring compliance with agreed procedures to protect the environment;
9 Environmental performance will be discussed during regular review meetings between HOEC representative and the contractor representative. It will be the responsibility of HOEC representative to ensure that appropriate action is taken to address any non-compliance. Senior management of HOEC will receive regular performance assessments or progress reports in implementing the EMP;
10 A review of the performance of the contractor will be undertaken on completion of Project components; and
11 In the event of non-compliance, HOEC will ensure that the deficiencies are rectified with a defined corrective action plan in a time bound manner.

9.3 MANAGEMENT ACTIONS

Table 9.1 sets out specific actions and monitoring requirements for the issues identified in ***Section 4.*** HOEC has also developed action plans to be available and communicated to all concerned during implementation of the proposed Project components.

Table 9.1 Environmental Management Plan

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
1	**Environmental Issues related to Development Drilling and construction of GGS**						
A.	Aesthetic & Visual Quality						
A.1	*Pre-drilling: Construction of drill sites & GGS*						
		• Clearance of vegetation • Site development (filling, grading & levelling) • Earth Work for construction of waste pits cellar pit • Storage of construction materials • Storage and disposal of construction waste, municipal waste etc.	• Removal of tea bushes, shed trees for drill sites located at tea garden area (xx no. of wells) and trees and bushes for drill sites located at homestead plantation area (xx no. of wells). • Generation of dust and deposition on property and vegetation • Generation of dust and deposition on property and vegetation • Unplanned storage- like outside the proposed drill sites; haphazard storage within the site; • Storage and disposal of construction waste and MSW from labour camp at non designated area	Change of environmental setting of the site- like cleared vegetated area in large tea garden area; visual nuisance due to deposition of dust on property & vegetation and disposal of construction waste, decommission waste and MSW	Moderate	***1. Site Designing & Planning*** a. Storage facility/area within the drill sites; b. Labour camp with sanitation facility, solid waste collection facilities; c. Minimise the vegetation clearance only the working area of the site; d. All the construction activities will be restricted within the designated site	HOEC/ Drilling Contractor
						2. Construction waste management a. On completion of work all temporary structures, surplus materials and wastes will be completely removed from site; b. Recyclable materials will be sold to authorised vendor; c. Inert waste will be reused for construction of site and site access road.	Drilling Contractor
						3. MSW Management a. Separate bins will be provided for storage of segregated MSW; b. Segregated MSW will be temporarily stored in different bin within the sites; c. MSW will be disposed at disposal site/facility at regular intervals.	Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						4. Dust suppression measures a. Dust suppression measures at site and site access road (populated area)- water sprinkling through mobile water sprinkling arrangement (at least three times during dry season) ;	Drilling Contractor
						5. Monitoring ***a.*** Site inspection, documents review and record keeping.	HOEC/ Drilling Contractor
A.2	*Drilling Phase*						
		• Physical presence of rig and associated equipment • Storage and disposal of MSW	• Stack of DG set, flare stack; • Drilling rig and other machineries; • Illumination from facility • Storage and disposal of MSW from drill site at non designated area.	Impact on aesthetic and visual quality (Ref. A.1)	Moderate	***1. Illumination management*** a. Appropriate shading of lights will be provided to prevent scattering.	HOEC/ Drilling Contractor
						2. MSW Management Ref. A.1.3	Drilling Contractor
						3. Monitoring a. Site inspection, documents review and record keeping	HOEC/ Drilling Contractor
A.3	*Decommission phase*						
		• Disposal of decommissioning waste • Earth Work for decommissioning of drill site	• Unplanned disposal of decommissioning waste materials in the vicinity of the well sites • Generation of dust and deposition on property and vegetation	Impact on aesthetic and visual quality (Ref. A.1)	Moderate	***1. Decommission waste management*** a. Demission waste will be disposed as per best practices; b. Earth and aggregates will be disposed in consultation with village panchayat for reuse for construction road	Drilling Contractor
						2. Site reclamation a. Restore the site after completion of drilling activity and carry the plantation activity; b. Greenbelt plantation in the production facility and production wells.	HOEC/ Drilling Contractor
						3. Monitoring	HOEC/ Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						a. Site inspection, documents review and record keeping	
B.	***Ambient Air Quality***						
B.1	*Pre-drilling: Construction of drill sites & GGS*						
		• Site development (filling, grading & levelling) • Earth Work for construction of waste pits cellar pit • Transport of fill materials, construction material, equipment & manpower • Storage and handling of construction material • Operation of DG and heavy machineries & equipment	• Emission of fugitive dust from earth work, handing of construction materials; • Gaseous emission from DG set and diesel operated machineries & equipment and transport vehicles; • Generation of re-entrained dust from transport route.	Fugitive emission and emission of gasses with potential to degrade the ambient air quality; potential to cause adverse impact on workers, and nearby community.	Moderate	***Air Quality Management Plan*** ***1. Designing, Planning & Procurement*** a. All vehicles utilized in transportation of raw material and personnel will have valid Pollution under Control Certificate (PUC). Vehicular exhaust will be complying with the CPCB specified emission norms for heavy diesel vehicles; b. Adequate stack height to be provided to DG sets in accordance CPCB standards.	HOEC/ Drilling Contractor
						2. Fugitive Dust Emission Control Measure a. Vehicles delivering raw materials like fine aggregates will be covered to prevent fugitive emissions; b. Efforts would be made to maintain the stockpile against the wall or obstruction so that it works as a windbreak and the fugitive emissions by strong winds can be avoided; c. The top soil generated from site clearance activities will be stored in designated area and stabilized to prevent fugitive dust emissions; d. During construction, the approach road will be kept clean, free from mud and slurry to prevent any entrainment of dust.	Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						3. ***Dust suppression measures*** a. Dust suppression measures at site and site access road (populated area)- water sprinkling through mobile water sprinkling arrangement (at least three times during dry season).	Drilling Contractor
						4. ***Monitoring*** a. Site inspection and documentation; b. Environmental monitoring as per Env. Monitoring program.	HOEC/ Drilling Contractor
B.2	*Drilling Phase*						
		• Operation DG sets • Transport of chemical, oil & lubricant, equipment & manpower • Flaring during testing	• Emission of fugitive dust from material handing; • Gaseous emission from DG set, diesel operated machineries & equipment, flare stack and transport vehicles.	Impact on ambient air quality (Ref. B1.)	Moderate	1. ***Designing, Planning & Procurement*** a. Exhausts of diesel generators will be positioned at a sufficient height to ensure dispersal of exhaust emissions; engines will not be left running unnecessarily; b. An efficient test flare burner head equipped with an appropriate combustion enhancement system will be selected to minimize incomplete combustion, black smoke and hydrocarbon fallout;	HOEC/ Drilling Contractor
						2. ***Emission control measures*** ***a.*** Use of low sulphur diesel oil (approx. 0.2% or less); ***b.*** Flaring will be undertaken in accordance with the CPCB Guidelines for Discharge of Gaseous Emissions for Oil & Gas Extraction Industry; ***c.*** No cold venting to be resorted during well testing. Management of the well test programme by dedicated team for prevention of trips in product supply to the flare	HOEC/ Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						and flame out. Many of the above measures including checking of methane emissions, which may occur during well testing, are incorporated into management of the drilling operations. The well testing procedure involves the dedicated observation of the flare and radio communication to well test manager. In the event that product pressure drops in the well test flare, diesel can be injected to maintain combustion otherwise the feed line would be shut off.	
						3. Maintenance of Machineries & equipment a. Preventive maintenance of DG sets will be undertaken as per manufacturers schedule to ensure compliance with CPCB specified generator exhaust; b. Maintenance of diesel engines which are to be used as prime movers for mainline & fire water pumps, instrument air compressors and emergency generators will be carried out in accordance with OISD Standard "OISD-STD-121- Inspection of Turbines & Diesel Engines";	HOEC/ Drilling Contractor
						4. H_2S emission control measures a. HOEC never encountered H2S and no such evidence exists in the field of operation of HOEC in AAP-ON-94/1 Block. However, action is being initiated to develop a contingency plan for H2S release.	HOEC/ Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						H2S detector and self containing breathing apparatus will be made available to drill sites and production facilities.	
						5. *Monitoring* a. Site inspection and documentation; b. Periodic monitoring of DG set stack emission will be carried out in accordance with the Environmental Monitoring Plan to assess compliance with CPCB DG set exhaust standards; c. Ambient Air quality monitoring as per Env. Management plan.	HOEC/ Drilling Contractor
B.3	***Decommissioning Phase***						
		• Site decommissioning (earth work) • Transport of drilling rigs, machineries & equipment and fill materials • Operation of DG set	• Fugitive dust emission • Exhaust emission from DG set and transport vehicles; • Generation of re-entrained dust		Moderate	**1. *Fugitive dust control measures*** Ref. B.1.2	Drilling Contractor
						2. *Dust suppression measures* Ref. B.1.3	Drilling Contractor
						3. *Monitoring* a. Site inspection and documentation; b. Ambient Air quality monitoring as per Env. Management plan.	HOEC/ Drilling Contractor
C.	Noise Quality						
C.1	***Pre-drilling: construction of drill sites & GGS***						
		• Operation of heavy machineries & equipment • Operation of DG set • Transport of construction materials & rig & machineries	Noise emission	Increase in ambient noise levels potential to cause impact on site workers, nearby community and wildlife	Moderate	***Noise quality management plan*** **1. *Planning, Designing & Procurement*** a. Selection and use of low noise generating equipment equipped with engineering controls viz. mufflers, silencers etc.; b. All vehicles utilized in transportation of raw material and	HOEC/ Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						personnel will have valid PUC Certificate; c. All high noise generating equipment will be identified and subjected to periodic preventive maintenance;	
						2. *Noise control measures* a. No night time operation of vehicles and construction activities will be undertaken; b. Site personnel will be trained in the proper use and maintenance of tools and equipment, including the positioning of machinery on site to reduce noise related to neighbouring communities.	HOEC/ Drilling Contractor
						3. *Monitoring* a. Site inspection and documentation; b. Workplace noise monitoring c. Ambient Noise quality monitoring as per Env. Management plan.	HOEC/ Drilling Contractor
C.2	***Drilling Phase***						
		• Operation of DG sets and drilling rig; • Operation of machineries & equipment; • Transportation of drilling chemicals, oil and manpower.	Noise emission	Impact on noise quality (Ref. C.1)	Moderate	**1. *Operation and maintenance of machineries*** a. Installing acoustic enclosures and muffler on engine exhaust of DG sets to ensure compliance with generator noise limits specified by CPCB; b. Undertaking preventive maintenance of the mainline and booster pumping units in accordance with guidelines and schedule referred in the OISD Standard- "OISD-STD-119 – Inspection of Pumps"; c. Relevant guidelines/standards viz. API 615--Sound Control of	HOEC/ Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						mechanical equipment etc. will be followed in controlling noise generated from mechanical equipment and machineries.	
						2. *Monitoring* a. Site inspection and documentation; b. Workplace noise monitoring c. Ambient Noise quality monitoring as per Env. Management plan.	HOEC/ Drilling Contractor
C.3	Decommissioning Phase						
		• Operation of machineries & equipment; • Transport of de-mobilised drilling and machineries.	Noise emission	Impact on noise quality (Ref. C.1)	Moderate	**1. *Noise control measures*** Ref. C.1.2 **2. *Monitoring*** a. Site inspection and documentation; b. Ambient Noise quality monitoring as per Env. Management plan.	HOEC/ Drilling Contractor
D.	Road & Traffic						
D.1	***Pre-drilling: construction of drill sites & GGS***						
		• Transportation of construction materials and manpower; • Transportation of drilling rig and machineries.	• Plying of vehicle through narrow access road; • Road accident.	• Increase of traffic and disturbance of daily traffic movement; • Potential to cause damage of road; • Potential to cause community health and safety	Moderate	***Traffic Management Plan*** **1. *Planning & Designing*** a. Project vehicular movement will be restricted to defined access routes to be identified in consultation with locals and concerned authorities; b. Upgrade /strengthened the existing road which will be used for site access; c. Proper signage will be displayed at important traffic junctions along the predefined access routes to be used by construction and operational phase traffic. d. The signage will serve to prevent any diversion from designated	HOEC/ Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						routes and ensure proper speed limits are maintained near village residential areas; e. Precautions will be taken to avoid damage to the public access routes including highways during vehicular movement; f. Safe and convenient passage for vehicles, pedestrians, tea garden workers and livestock to and from side roads and property accesses connecting the project road will be provided; g. A Journey Management Plan will be formulated and implemented to control construction and operational phase traffic;	
						2. *Control Measures* a. Parking of project vehicles along village access roads prohibited; b. Traffic flows will be scheduled wherever practicable during period of increased commuter movement; c. Personnel will be deployed at major traffic intersection for control of traffic; d. Clear signs, flagmen & signal will be set up at major traffic junctions and near sensitive receptors viz. schools in discussion with Gram Panchayat and local villagers; e. Movement of vehicles during night-time will be restricted. Speed limits will be maintained by vehicles involved in	HOEC/ Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						transportation of raw material and drilling rig; f. Routine maintenance of project vehicles will be ensured to prevent any abnormal emissions and high noise generation. g. Adequate training on traffic and road safety operations will be imparted to the drivers of project vehicles. Road safety awareness programs will be organized in coordination with concerned authorities to sensitize target groups viz. school children, commuters on traffic safety rules and signage.	
						3. Monitoring a. Site inspection and grievance redrassal system	
D.2	Drilling Phase						
		• Transportation of drilling chemical and fuel; • Transportation of manpower.	• Plying of vehicle through narrow access road; • Road accident.	Ref. D.1	Moderate	1. ***Control Measures*** Ref. D.1.2 ***2. Monitoring*** a. Site inspection and grievance redrassal system	HOEC/ Drilling Contractor
D.3	***Decommissioning Phase***						
		• Transportation of decommissioned drilling rigs and machineries; • Transportation of excavated fill material and decommissioning waste materials.	• Plying of vehicle through narrow access road; • Road accident.	Ref. D.1	Moderate	1. ***Control Measures*** Ref. D.1.2 ***2. Monitoring*** a. Site inspection and grievance redrassal system	HOEC/ Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
E.	Land Use						
E.1	***Pre-drilling: construction of drill sites & GGS***						
		• Land procurement for 24 drill sites and 2 GGS	• Long term lease / Procurement of tea garden land/ agricultural land/ homestead plantation land (2.0 ha per drill site and 1.0 ha per GGS)	• Conversion of tea garden land/ agricultural /homestead plantation land to industrial land; which have impact on income generation livelihood	Minor	***Land Use Mitigation Measures and Site Restoration Plan*** ***1. Planning & Designing*** a. The shortest distance between well pad site and road head, should be considered for access road; b. Restrict the construction activities within the demarcated site; c. Remove all wastes from area surrounding drill sites;	HOEC /Drilling Contractor
						2. Monitoring a. Site inspection and grievance redrassal system.	HOEC /Drilling Contractor
E.2	Decommissioning Phase						
E.2.1						***1. Site Restoration*** a. Restore the drill site and brought to its best achievable original state after completion of drilling activity and hand over the land except production facility.	HOEC /Drilling Contractor
E.2.2						***2. Monitoring*** Site inspection and grievance redrassal system.	HOEC /Drilling Contractor
F.	Soil Quality						
F.1	***Pre-drilling: construction of drill sites & GGS***						
		• Site development (filling, grading & levelling); • Storage & handling of fuel, lubricants, paints & other chemicals, etc.;	• Loss of top soil; • Spillage of oil, lubricant, etc. from storage & handling; • Spillage of fuel and lubricant;	• Loss of top soil and soil fertility; • Change of soil characteristics; • Contamination of chemical, toxic	Moderate	***Soil Quality Management Plan & Waste Management Plan*** ***1. Top Soil Management Plan*** a. Assess the top soil depth & volume likely to be generated; b. Demarcate the top soil storage area within the site;	HOEC /Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
		• Operation of heavy machineries & equipment; • Generation & disposal of construction waste	• Disposal of construction waste in non-designated area	metal, hydro-carbon.		c. Assess the soil quality (phyco-chemical characteristics including contamination) d. Properly stripping of top soil and conserve it for future use like site restoration/ greenbelt plantation; e. The top soil will be stored in mound form, with height less than 2m, slope of angle not more than 30□, catch drain and sedimentation tank and covered with jute mat to prevent erosion; f. Utilise the top soil for restoration of site or greenbelt plantation in production facility/ producing well.	
						2. ***Oil & Lubricant, Chemical & Hazardous Waste storage site designing & Planning*** a. Fuel and lubricant storage areas will be paved and properly bunded. Bunded areas will be designed to accommodate 110% of the volume of spilled material; b. All chemicals will be stored in designated area and to an extent possible all such areas would away from drainage channels; c. The flooring of the area would be impervious (paved or HDPE lining) and bunding to be provide on all sides of the chemical storage areas; d. The chemical storage area to be covered to ensure it has the minimum runoff; e. All transfers of chemicals to be done with proper care and under the supervision of the Store Supervisor;	HOEC /Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						3. Spill Prevention & Control measures a. Drip trays to be used during vehicular/equipment maintenance and during re-fuelling operations; b. Spill kits will be made available at all fuel and lubricant storage areas. All spills/leaks contained, reported and cleaned up immediately; c. Once a spill incident has occurred, identify the chemical involved and check hazardous property of the chemical from the Material Safety Datasheet (MSDS); d. Thereafter, the substance will be properly collected and stored in a separate labelled container marked "hazardous waste – do not burn"; and dispose in accordance with Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016.	HOEC /Drilling Contractor
						4. Monitoring a. Site inspection & documentation; b. Soil quality monitoring as per Env. Monitoring plan.	HOEC /Drilling Contractor
F.2	Drilling phase						
		• Storage and disposal of drill cuttings & spent mud; • Storage and handling of oil, lubricant, chemical, etc.;	• Improper disposal of drill cuttings & spent mud from waste pits; • Accidental leakage of spent mud and leachate from waste pit; • Spillage cuttings and mud on open soil;	Impact on soil quality (Ref. F.1)	Moderate	1. ***Drilling Waste Management: Planning, Designing & Procurement*** a. Use of water based mud primarily for drilling of wells; eco-friendly polymer mud system may also be used if required for deeper sections after providing intimation to the Pollution Control Board.; b. Use of low toxicity chemicals for the preparation of drilling fluid	HOEC /Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
		• Storage, handling and disposal of waste oil and other hazardous waste; • Storage and Disposal of MSW	• Disposal of hazardous waste on non-designated site; • Disposal of MSW in non-designated site			c. Barite used in the preparation of drilling fluid shall not contain Hg>1mg/kg and Cd>3 mg/kg; d. Protection of the surrounding environment of a drilling waste (cutting & spent mud) storage and disposal site can be effectively achieved by using an impermeable liner on the base and sides to prevent contamination soil and groundwater; e. The liner system for the proposed waste pit has been designed based on recommendation of the MoEFCC for construction of a non-permeable lining system at the base and wall of waste disposal site area. The liner will have, at a minimum, a composite barrier having HDPE geo-membrane. f. Design aspects of the impervious waste disposal pit will be communicated/ shared by HOEC with Assam State Pollution Control Board (ASPCB). g. The drilling cuttings pit will be bunded and kept covered using tarpaulin sheets during monsoon.	
						2. *Prevention of Contamination during Drilling Period* a. Drill cuttings separated from drilling fluid will be adequately washed and temporarily stored and disposed in an impervious pit lined by HDPE	HOEC /Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						b. Drilling wastewater will be stored in HDPE lined pit and treated prior disposal c. Recycling of drilling mud will be ensured to the maximum extent possible d. Temporary storage of drilling fluid and wash waste water will be done in an impervious pit lined with HDPE e. Disposal of drilling wash-water will be achieved through necessary treatment through onsite ETP to comply with the CPCB onshore effluent discharge standard for oil and gas industry f. The waste pit after it is filled up will be covered with impervious liner over which a thick layer of native top soil with proper top slope will be provided.	
						3. Storage and Disposal of Used oil & Spent Oil a. The hazardous waste (waste and used oil) will be managed in accordance with Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016; b. The hazardous waste will be stored in properly labelled and covered bins located in paved and bunded area; c. Necessary spill prevention measures viz. spill kit will be made available at the hazardous material storage area;	HOEC /Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						d. Storage details of onsite hazardous waste generated will be maintained and periodically updated; e. Adequate care will be taken during storage and handling of such waste viz. use of proper PPEs by personnel; f. The hazardous waste so stored to be accounted and to be periodically sent to ASPCB registered used and/or waste oil recyclers/ facilities; g. Proper manifest as per Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 to be maintained during storage, transportation and disposal of hazardous waste.	
						4. Storage and Disposal of Lead Acid Batteries a. Will be recycled through the vendors supplying lead acid batteries as required under the Batteries (Management & Handling) Rules, 2001 and Batteries (Management & Handling) Amendment Rules 2010; b. Proper manifest will be maintained as per Batteries (Management & Handling) Rules, 2001.	HOEC /Drilling Contractor
						5. Storage & Disposal of MSW a. The waste will be segregated and stored in designated waste bins; b. All such waste bins will be properly labelled and covered; c. The kitchen waste will be disposed in nearest dumping site available;	HOEC /Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						on a daily basis. Discussion with the local panchayat/municipality authorities in this aspect would be conducted.	
						6. Monitoring a. Site inspection and documentation b. Periodic monitoring and analysis of drill cuttings will be undertaken to establish its nature and characteristics; c. Soil quality monitoring as per Env. Management plan.	HOEC /Drilling Contractor
F.3	***Decommissioning Phase***						
		• Dismantling of rig and production facilities; • Restoration of site	• Improper capping of waste pits and generation of leachate; • Improper removal of fill material; • Improper de-compaction of soil; • Improper to soil restoration.	Impact on soil quality (Ref. F.1)	Moderate	***Site Closure*** The following activities have been considered in the closure plan for well sites: ***1. Plugging & Abandonment of well*** a. As and when the well will be declared as non productive, plugging of the well will be performed to close and abandon the well to prevent any leakage of oil or gas.	HOEC /Drilling Contractor
						2. Well site decommissioning The decommissioning phase includes activities dismantling and removal of surface facilities from the well site and storage in the Material Dumping Area. The activities which are envisaged during this phase are: a. Waste Management: clean up the site and remove all waste materials e.g. HDPE liners, any waste material etc. The waste will be dumped in the designated area as per the	HOEC /Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						guidelines of local pollution control board; ***b.*** Road Restoration: The fill materials should be removed and restore the site or it may be left for further local community use as per the agreement with community.	
						3. Waste and mud pit closure and reclamation a. The well site the waste and mud pits will be subject to closure through onsite burial of solids in accordance with lease and landowner obligations and with local, state and national regulations. b. Reclamation of closed pits or any other temporary retaining pits, including reserve pits, will be carried out within a period of one year from well closure/ abandonment. c. All such reclamation activities will be carried out based on the climatic conditions and will be in accordance with reasonable landowner's wishes, and/or resemble and contour of the adjoining lands.	HOEC /Drilling Contractor
						4. Site Reinstatement The reinstatement phase includes all activities for preparation of the soil for forest, plantation/agricultural land as all the wells sites. The following activities would be carried out for reinstatement. Decommissioning: a. The decommissioning phase includes activities dismantling and removal of surface facilities from the	HOEC /Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						well site and storage in the Material Dumping Area; b. Sub soil preparation: The sub soil would be tilled till a depth of 6" to de-compaction the soil; c. Overlaying of Topsoil: The topsoil would be spread evenly on each of the terraces as per the thickness specified by the applicable guidelines; d. Top soil preparation: The bio manure will be mixed with the top soil to increase its fertility (if required). Regular water with mulching will be carried out for more effective soil preparation; e. Seeding of Soil: Seeds of Leguminous crops would be sown on the plots to continuously improve fertility of the soil.	
						5. Monitoring a. Site inspection b. Soil quality monitoring as per Env. Monitoring plan	HOEC /Drilling Contractor
G.	***Topography & Drainage***						
G.1	***Pre-drilling: construction of drill sites & GGS***						
		• Site development (filling, grading & levelling)	• Site raising and levelling; • Construction of site access road	Impact on micro-drainage	Minor	1. Planning & ***Designing*** a. Assess the site specific drainage and prepare site development plan; b. Provide the peripheral drainage and linkage with nearby drainage channel; c. Provide cross drainage structure.	HOEC /Drilling Contractor
						2. Monitoring a. Site visit & inspection	HOEC /Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
G.2	***Decommissioning Phase***	• Site reclamation	• Site levelling & grading	Impact on micro-drainage	Minor	1. Planning & ***Designing*** a. Levelling and grading of the de-commissioned site as per original site condition;	HOEC /Drilling Contractor
						2. Monitoring a. Site visit & inspection	HOEC /Drilling Contractor
H.	***Surface water quality***						
H.1	***Pre-drilling: construction of drill sites & GGS***						
		• Site development (filling, grading & levelling); • Earth Work for construction of waste pits cellar pit; • Storage and handling of construction material; • Generation & disposal of construction waste • Storage & handling of fuel, lubricants, paints & other chemicals, etc.; • Operation of labour camp	• Surface runoff from construction site, construction material storage site, construction waste storage site; • Surface runoff from spillage area into nearby land/stream; • Generation of domestic waste water & discharge without treatment	• Increased sediment load in the receiving surface water body potential to cause decrease of DO and increase of BOD; • Contamination of surface water body due to mixing of hydro-carbon and chemical; potential to cause adverse impact on aquatic ecology	Moderate	***Surface Water Quality Management Plan*** ***1. Planning, designing & procurement*** a. Levelling and grading operations will be undertaken with minimal disturbance to the existing contour thereby maintaining the general slope of site; b. Minimize clearing and construction activities during monsoon season (as far as practicable); c. Sediment filters and oil-water separators will be installed to intercept run-off and remove sediment before it enters water courses; d. Channelize all surface runoff from the construction site through storm water drainage system and provide adequate size double chambered sedimentation tank; e. Septic tank and soak pit or Potable STP will be provided to treat the domestic waste water; f. All chemical and fuel storage areas, process areas will have proper bunds so that contaminated run-off cannot escape into the storm-water drainage system.	HOEC /Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						2. Control Measures a. During discharge, care shall be taken to properly dispose the water in order to avoid pollution, damages to fields under cultivation and/or existing structures and interference with the traffic. The water will be subjected to adequate treatment (if required) to ensure compliance with CPCB "General Standards for Discharge of Environmental Pollutants – Inland Surface Water" prior to final discharge;	HOEC /Drilling Contractor
						3. Monitoring a. Site inspection & documentation; b. Periodic monitoring of treated runoff will be conducted in accordance with the Environment Monitoring Program c. Monitoring of surface water quality as per Env. Monitoring plan.	HOEC /Drilling Contractor
H.2	*Drilling Phase*						
		• Storage and disposal of drill cuttings & spent mud; • Storage, treatment and discharge of process waste water; • Storage and handling of oil, lubricant, chemical, etc.; • Storage, handling and disposal of	• Surface runoff from waste pit; • Accidental discharge of untreated waste water into nearby land, stream; • Overflow of untreated waste water from waste pit; • Surface runoff from spillage site; • Generation of domestic waste water &	Impact on surface water quality (Ref. H.1)	Moderate	***1. Site runoff control, produced water and domestic water*** a. Run-off from vehicular wash and chemical storage areas will be channelled through closed drainage system provided with an oil-water separator prior to silt trap and sedimentation tank to disposal to nearby drainage channels/surface water bodies; b. Drip trays will be used during preventive maintenance of vehicles and machinery;	HOEC /Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
		waste oil and other hazardous waste; • Drilling camp	discharge without treatment			c. Hazardous chemicals and fuel drum will be stored in bunded and lined area equipped with proper spill control equipment; d. Discharge of collected run-off in the siltation chamber to nearby drainage channels will be conforming to CPCB Inland Water Discharge Standards; e. Waste water generated from the drilling activity will be treated through ETP; part of the treated water will be utilized in drilling activity and rest of treated water will be discharged into the local stream, conforming to CPCB Inland; Water Discharge Standards; f. Domestic wastewater generated from camp area will be treated through septic tank and soak pit; g. Produced water generated at the production facilities will be treated in an ETP and discharged in conformance to CPCB Inland Water Discharge Standards;	
		•	•			**2. *Monitoring*** a. Site inspection & documentation; b. Periodic monitoring of treated runoff, treated wastewater will be conducted in accordance with the Environment Monitoring Program; c. Periodic monitoring of surface water quality of local streams will be conducted in accordance with the Environment Monitoring Program.	HOEC /Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
H.3	*Decommissioning Phase*	• Earth work site; • De-commissioned waste storage site; • Operation of machineries & equipment.	• Surface runoff from earth work site and waste storage site; • Surface runoff from spillage site;	Impact on surface water quality (Ref. H.1)	Moderate	***1. Control Measures*** a. Minimize decommissioning activities during monsoon season (as far as practicable);	HOEC / Drilling Contractor
I	**Ground Water Resource**						
	Drilling Phase						
		• Drilling of well	• Cutting of aquifer and discharge during drilling.	Depletion of ground water resource	Minor	***Ground water resource management Plan*** ***1. Control Measures*** a. Casing and cementing during drilling activity.	HOEC / Drilling Contractor
						2. Monitoring a. Maintain the record for generation of formation water	HOEC / Drilling Contractor
J	**Ground Water Quality**						
J.1	*Pre-drilling: construction of drill sites & GGS*						
		• Storage & handling of fuel, lubricants, paints & other chemicals, etc.; • Operation of heavy machineries & equipment;	• Loss of top soil; • Spillage of oil, lubricant, etc. from storage & handling; • Spillage of fuel and lubricant; • Disposal of construction waste in non-designated area			***Ground water quality management Plan*** ***1. Oil & Lubricant, Chemical & Hazardous Waste storage site designing & Planning*** Ref: F1.2 ***2. Spill Prevention & Control measures*** Ref: F1.3 3. ***Monitoring*** Ref: F1.4	
J.2	*Drilling Phase*						
		• Storage and disposal of drill	• Improper disposal of drill cuttings & spent mud from waste pits;			***1. Drilling Waste Management: Planning, Designing & Procurement*** Ref: F2.1	HOEC / Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
		cuttings & spent mud; • Storage and handling of oil, lubricant, chemical, etc.; • Storage, handling and disposal of waste oil and other hazardous waste; • Storage and Disposal of MSW	• Accidental leakage of spent mud and leachate from waste pit; • Spillage cuttings and mud on open soil; • Disposal of hazardous waste on non-designated site; • Disposal of MSW in non-designated site			**2. *Prevention of Contamination during Drilling Period*** Ref: F2.2 **3. *Storage and Disposal of Used oil & Spent Oil*** Ref: F2.3 **4. *Storage and Disposal of Lead Acid Batteries*** Ref: F2.4 **5. *Storage & Disposal of MSW*** Ref: F2.5 **6. *Monitoring*** Ref: F2.6	
K.	**Terrestrial Floral Habitat & Flora**						
K.1	***Pre-drilling: construction of drill sites; GGS; Drilling & Site Decommissioning***						
		• Site clearance • Operation of DG Sets, machineries & equipment	• Removal of tea bushes, shed trees at tea garden area and trees and bushes in homestead plantation area; • Fugitive and gaseous emission for various activities	• Adverse impact (shrinkage and fragmentation) modified habitat like tea garden, homestead plantation, agricultural land; • Impact on primary productivity of plants		***Ecology & Biodiversity management plan*** **1. *Control Measures*** a. The working area which has to be disturbed will be kept minimum at all times; b. Sourcing of timber and fuel wood from forest area will be prohibited. **2. *Fugitive Dust & Emission Control*** Ref. B.1.2; B.1.3 & B.2.2	HOEC /Drilling Contractor
						3. *Site Restoration & Plantation* a. Restore the drill site and brought to its best achievable original state after completion of drilling activity	HOEC /Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						and hand over the land except production facility. b. Greenbelt would be developed and maintained at the production well sites and production facilities	
						4. Monitoring a. Site Inspection and documentation	HOEC /Drilling Contractor
L	***Terrestrial Fauna & Habitat***						
L.1	***Pre-drilling: construction of drill sites; GGS, Drilling & Site Decommissioning***						
		• Site clearance • Operation of DG Sets, machineries & equipment	• Habitat fragmentation due to vegetation clearance; • Illumination from site; • Noise & vibration.	• Disturbance to the wildlife in the project impacted area; • Behavioural changes	Moderate	***Wildlife Management Plan*** ***1. Wildlife Habitat Protection Measures:*** a. The project site (drill sites, GGS and GPP) will be properly fenced (chain-linked) to avoid straying of any outsider as well as wildlife; b. No temporary electric supply connection line from the grid will be laid for the proposed project activity. All electric requirements will be supplied from the internal DG sets; c. Movement of heavy vehicles will be restricted at night time, especially in access road within the forest area as most of the mammals movement occurred during night; d. Cutting, uprooting of existing plants, especially tress along the proposed pipeline should be minimized and all other plants within the site shall be minimized; e. Cutting, uprooting and coppicing of trees present in and around the project site for cooking, burning or	HOEC /Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						heating purposes by the labourers should be prohibited and suitable alternatives (fuel like kerosene shall be made available to the labourers by the contractor) for this purpose should be provided. f. Noise Levels at the drill sites, GGS and GPP will be controlled through selection of low noise generating equipment and installation of sufficient engineering controls viz. mufflers, silencers etc.	
						2. *Anti Depredation Measures* An anti-depredation squad is to be created and stationed at Lekhajan Beat office. The squad will consist of 2 trackers well versed with the terrain of the locality, behavior of elephants and their routes of movement. a. Any wild animal species if trapped during site development or operation of drilling would be released into suitable habitat b. If elephant migrates into the drill site, then with the help of Forest Department personnel, the animal will be driven back into its suitable habitat	HOEC /Drilling Contractor
						3. *Erection of Signboard* a. For awareness of public on conservation of wildlife and forests, it is recommended to put / construct some signboard in and around Dirok site.	HOEC /Drilling Contractor
						4. *Wildlife Awareness Program* a. Wildlife awareness program will be conducted among the villagers, oil	HOEC /Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						& gas drilling workers even forest personnel working in the vicinity are to be made aware about the importance of wildlife, wildlife behavior, mode of attack, application of first-aid; details of information regarding official compensation for loss of property; b. District Forest Administration. Forest officials may plan to educate the public through preparation of brochures in local language, film show, street drama and display of information in the board, etc.	
						5. ***Management Cell*** An Environment Management Cell (EMC) will be developed for implementation of environmental mitigation & management plan. Forest personnel and veterinary doctor will be taken into the management cell for implementing the wildlife management plan. The environment cell would look after the following measures: a. Proper monitoring of indicator species will be carried out and compared to baseline to understand any negative impacts b. In case of any accidental injuries to any wild animal by any project related activity, the EMC's Veterinary Doctor's help will be taken c. All sightings of sensitive species in and around the project site will be reported and adequate steps will be taken with the help of forest	HOEC / Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						personnel to reduce conflict between such animals and project activities or people working at site. d. The Environment Compliance Officer will hold training program for all the HOEC employees and sub-contractor on the applicable practice and mitigation measures contained within the Wildlife Management Plan.	
M.	***Aquatic Ecology***						
M.1	***Pre-drilling: construction of drill sites; GGS; Drilling & Site Decommissioning***						
		• Surface runoff from site; • Accidental discharge of untreated waste water	• Discharge of untreated surface runoff; • Discharge of wastewater from treated waste water	Impact on surface water quality and potential to cause impact on aquatic ecology-primary productivity, etc	Minor	***1. Surface runoff control and waste water management plan*** Ref. H.1 & H.2	HOEC /Drilling Contractor
N.	***Socio-economic Issues***						
	Pre-drilling: construction of drill sites; GGS; Drilling & Site Decommissioning						
		• Land procurement; • Labour requirement.	• Procurement of land for proposed drill sites and GGS; • Sourcing of outside workers.	• Loss of livelihood/Income due to land purchase; • Conflict with Local People	Moderate	***1. Compensation & Livelihood Measures*** a. HOEC follow the compensation calculation procedure of Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (LARR Act of 2013) and that is highest land value they offer to the land owner; b. For the assets over the land HOEC, provide surface compensation to the landowner as per the Assets Rate List of concerned district authority;	HOEC /Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						c. HOEC organize continuous consultation with the local people and also timely disclosure of project activities; ***d.*** HOEC has established grievance redressal process to deal with conflict with local communities**.**	
						2. Conflict Addressing System a. An effective grievance redressal mechanism to address the concern of local people; b. Migrant labours would be provided training on local culture and traditions; ***c.*** Labours to be provided with proper sanitation facilities**.**	HOEC /Drilling Contractor
						3. Job opportunity a. During site construction non technical jobs will be generated. Most of the people employed during this stage would be semi-skilled or unskilled. People from adjoining areas especially given preference through local contractors according to the skill sets possessed. b. Local contractor will be given preference for contract job.	HOEC /Drilling Contractor
						4. Corporate Social Responsibility From inception of its activities HOEC has taken up various CSR initiatives in and around HOEC's operational areas for the benefit of the residents as per the CSR Act and Rules, Govt. of India. HOEC's CSR Vision Statement envisages 2% allocation of its net profit towards CSR. Based on the site specific assessments the CSR plan for this project	HOEC

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						would be framed. –The broad areas to be focused under the CSR plan would include; a. Health - arranging mobile health camps including eye camps, School health programmes which includes free dental awareness examination camps and free check-ups of the students; universal immunization programme etc. b. Education - Providing financial assistance to institutions towards purchasing of furniture and required amenities to school, libraries, auditoriums, teacher's common room etc. c. Funding for sports, cultural events etc.	
O.	***Occupational Health & Safety***						
	Pre-drilling: construction of drill sites; GGS; Drilling & Site Decommissioning						
O.1		• Drill site construction; • Operation of drilling rig & machineries; • Decommissioning activity.	• Operation of construction machineries/ equipment; • Operation of drilling rigs, machineries; • Handling of chemicals & waste • Exposure to high noise generation areas. • Exposure to dust	Occupational health & safety impacts like: Injuries/ fatality; Hearing loss; Pulmonary diseases;	Moderate	***Occupational Health & Safety Management Plan*** ***1. Designing, Planning & Procurement*** a. All machines to be used in the construction will conform to the relevant Indian Standards (IS) codes, will be kept in good working order, will be regularly inspected and properly maintained as per IS provisions and to the satisfaction of the site Engineer b. Hazardous and risky areas, installations, materials, safety	HOEC /Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						measures, emergency exits, etc. shall be appropriately marked c. All chemicals and hazardous materials storage container will be properly labelled and marked according to national and internationally recognized requirements and standards. Materials Safety Data Sheets (MSDS) or equivalent data/information in an easily understood language must be readily available to exposed workers and first-aid personnel d. The workplace must be equipped with fire detectors, alarm systems and fire-fighting equipment. Equipment shall be periodically inspected and maintained to keep good working condition	
O.2						***2. PPE & Basic Facilities*** a. Contractor workers involved in the handling of construction materials viz. borrow material, cement etc. will be provided with proper PPEs viz. safety boots, nose masks etc. b. No employee will be exposed to a noise level greater than 85 dB(A) for a duration of more than 8 hours per day. Provision of ear plugs, ear muffs etc. and rotation of workers operating near high noise generating areas	HOEC /Drilling Contractor
						3. Occupational Health Care & Check-up a. Health problems of the workers will be taken care of by providing basic	HOEC /Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						health care facilities through health centres temporarily set up for base camp b. Adequate sanitation facilities will be provided onsite for the operational workforce both during construction and operational phase of the project. c. HOEC will also be complying with the relevant provisions of "OISD-GDN-166- Guidelines for Occupational Health Monitoring for Oil & Gas Industry" to ensure effective prevention and monitoring occupational health and safety risks of workforce.	
						4. Operation & Maintenance of facility a. The sewage system for the camp must be properly designed, built and operated so that no health hazard occurs. b. Garbage bins will be provided in the camp and regularly emptied and the garbage disposed off in a hygienic manner	HOEC /Drilling Contractor
						5. Training a. Training programs will be organized for the operational workforce regarding proper usage of PPEs, handling and storage of fuels and chemicals etc. b. Entry of personnel into tank farm for maintenance and related activities is to be subjected to wearing of approved breathing apparatus and/or written	HOEC /Drilling Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						permission from the concerned supervisor.	
P.	***Community Health & safety***						
P.1	***Pre-drilling: construction of drill sites; Drilling & Site Decommissioning***						
		• Air & noise emission; • Operation of labour camp; • Traffic movement	• Changes in environmental quality, • Influx of non-resident workers to the area; • Movement of project traffic.	Community health & safety impacts like: Injuries/ fatality; Discomfort due to change of environment quality; Communicable diseases	Moderate	***1. Pollution Control Measures*** Ref. Air quality Management plan Ref. Water quality management plan Ref. Noise quality management plan Ref. Road & Traffic management plan	HOEC /Drilling Contractor
2.	***Environmental Issues Associated with Laying of Pipeline***						
A.	Land Use	• Land procurement for pipeline	• ROU for pipeline • Temporary use of adjacent land during laying of pipeline	Short term change of land use	Minor	***1. Restoration of site*** a. Immediate restoration of acquired land for pipeline to its best achievable original state after completion of the buried pipeline laying activity, thus to merge it with the best achievable surrounding land use. b. Remove all wastes from area surrounding pipeline corridor;	HOEC / Contractor
B.	Soil Quality	• Stripping of top soil; • Handling of hazardous material • Surface runoff from spilled area	• Stripping activity and mixing of top soil with sub-soil • Spillage of chemical, hazardous waste, etc.; • Surface runoff from material & waste storage areas and oil spillage area	• Loss of soil fertility , compaction of soil and change of soil characteristics; • Soil contamination	Minor	***1. Soil Quality Management*** a. Topsoil will not be mixed with subsoil or any other inert material during and same will be utilised for backfilling of the pipeline trench; b. Spill prevention measures should be in place	HOEC / Contractor

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
C.	Surface Water Quality	• Hydro-testing • Surface runoff from construction site • Operation of flying camp	• Generation of hydro-test water and discharge; • Surface runoff from construction sites, spill areas; • Generation and disposal of domestic waste water from construction camp;	• Surface water quality	Minor	***1. Surface water quality management Plan*** a. Hydrotest water will be taken to the ETP at Terminal for treatment. b. Construction activities viz. stripping, excavation etc., during monsoon season will be restricted to the extent possible; c. All chemical and fuel storage areas, process areas will have proper bunds so that contaminated run-off cannot escape into the storm-water drainage system; d. Septic tank & soak pit have been considered in the design of the construction camps for treatment of the domestic black water; e. HDD material will be disposed away from surface water channel.	HOEC / Contractor
D.	Road & Traffic	• Transpiration of pipes; • Stacking of pipes along the side of the road	• Plying of vehicle through narrow access road; • Road accident.	• Increase of traffic and disturbance of daily traffic movement; • Potential to cause damage of road; • Potential to cause community health and safety	Moderate	*Traffic Management Plan* 1. Planning & Designing: (Refer D-1) 2. Control & Mitigation Measures: (Ref. D-2) 3. Monitoring: (Ref. D-3)	HOEC / Contractor
3.	*Environmental Issues Associated with Operation of GGS & GPP*						
A	Ambient Air Quality	• Operation of DG sets at GGS and GPP • Flaring at GPP	• Emission of gaseous pollutants like PM, SO_2, NOx and HC	• Emission of gasses with potential to degrade the ambient air quality; potential to cause adverse impact on	Minor	*Air Quality Management Plan* ***1. Designing, Planning & Procurement*** a. Exhausts of diesel generators and flare stack will be positioned at a sufficient height to ensure dispersal of exhaust emissions;	HOEC

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
				workers, and nearby community.		b. An efficient flare burner head equipped with an appropriate combustion enhancement system will be selected to minimize incomplete combustion, black smoke and hydrocarbon fallout.	
						2. Maintenance of Machineries & equipment a. Preventive maintenance of DG sets will be undertaken as per manufacturers schedule to ensure compliance with CPCB specified generator exhaust;	HOEC
						3. Monitoring a. Site inspection and documentation; ***b.*** Periodic monitoring of DG set stack and flare stack emission will be carried out in accordance with the Environmental Monitoring Plan to assess compliance with CPCB DG set exhaust standards; ***c.*** Ambient Air quality monitoring as per Env. Management plan.	HOEC
B.	***Noise Quality***	• Operation of DG; • Operation of pump & compressor	Noise emission	Impact on ambient noise quality	Moderate	***Noise quality Management plan*** ***1. Operation and maintenance of machineries*** a. Installing acoustic enclosures and muffler on engine exhaust of DG sets, compressors and pumps to ensure compliance with generator noise limits specified by CPCB; b. Undertaking preventive maintenance of the mainline and booster pumping units in	HOEC

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						accordance with manufacturer guidelines.	
						2. *Monitoring* a. Site inspection and documentation; b. Workplace noise monitoring c. Ambient Noise quality monitoring as per Env. Management plan.	HOEC
C.	***Surface water quality***	• Discharge of treated produce water; • Spillage of oil, chemical.	• Discharge without treatment or partly treated effluent	• Potential to affect the surface water quality	Moderate	***Surface water quality management plan*** ***1. Site runoff control, produced water and domestic water*** a. Run-off from vehicular wash and chemical storage areas will be channelled through closed drainage system provided with an oil-water separator prior to silt trap and sedimentation tank to disposal to nearby drainage channels/surface water bodies; b. Drip trays will be used during preventive maintenance of vehicles and machinery; c. Hazardous chemicals and fuel drum will be stored in bunded and lined area equipped with proper spill control equipment; d. Domestic wastewater generated from camp area will be treated through septic tank and soak pit; e. Produced water generated at the production facilities will be treated in an ETP and discharged in conformance to CPCB Inland Water Discharge Standards.	HOEC

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						2. ***Monitoring*** a. Site inspection & documentation; b. Periodic monitoring of treated runoff, treated wastewater will be conducted in accordance with the Environment Monitoring Program; c. Periodic monitoring of surface water quality of local streams will be conducted in accordance with the Environment Monitoring Program.	HOEC
D.	***Soil & Ground Water Quality***	• Generation and disposal of Hazardous waste; • Storage & handling of oil, lubricant and chemical; • Generation and handling of MSW	• Spillage of oil, lubricant, chemical, hazardous waste on open soil; • Disposal in non-designated area; • Surface runoff from spilled area	• Potential to cause soil quality and ground water quality	Minor	1. ***Oil & Lubricant, Chemical & Hazardous Waste storage site designing & Planning*** a. Fuel and lubricant storage areas will be paved and properly bunded. Bunded areas will be designed to accommodate 110% of the volume of spilled material; b. All chemicals will be stored in designated area and to an extent possible all such areas would away from drainage channels; c. The flooring of the area would be impervious (paved or HDPE lining) and bunding to be provide on all sides of the chemical storage areas; d. The chemical storage area to be covered to ensure it has the minimum runoff; e. All transfers of chemicals to be done with proper care and under the supervision of the Store Supervisor;	HOEC
						2. ***Spill Prevention & Control measures*** a. Spill kits will be made available at all fuel and lubricant storage areas.	HOEC

Sl. No.	Project Stage / Affected Aspect	Project Activity	Aspect	Impact	Impact Significance	Control/ Mitigation Measures	Responsibility
						All spills/leaks contained, reported and cleaned up immediately; b. Once a spill incident has occurred, identify the chemical involved and check hazardous property of the chemical from the Material Safety Datasheet (MSDS); c. Thereafter, the substance will be properly collected and stored and dispose in accordance with Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016.	
						3. Monitoring a. Site inspection & documentation; b. Soil quality monitoring as per Env. Monitoring plan.	HOEC
E	***Occupation health & safety***	• Operation of machineries; • Handling of chemical & waste.	• Operation of machineries; • Handling of chemicals & waste • Exposure to high noise generation areas.	Occupational health & safety impacts like: Injuries/ fatality; Hearing loss;	Moderate	***Occupational Health & safety Management Plan*** 1. Designing, Planning & Procurement (Ref. O.1) 2. PPE & Basic Facilities (Ref. O.2) 3. Occupational Health Care & Check-up (Ref. O.3) 4. Operation & Maintenance of facility (Ref. O.4) 5. Training (Ref. O.5)	HOEC

9.4 *BUDGET ALLOCATION FOR THE ENVIRONMENTAL MANAGEMENT PLAN*

The tentative budget for implementation of the environmental management plans for drilling of each well is calculated to be 25.93 lakhs. Hence the total budget for EMP implementation for 24 wells will be 622.32 lakhs. Detail of cost breakup are provided at the ***Table 9.2***.

The tentative budget for implementation of the environmental management plans for GGS & GPP is calculated to be 9.62 lakhs per year. Detail of cost breakup are provided at the ***Table 9.3***.

Table 9.2 Tentative Budget for EMP Implementation for Each Well

EMP Ref	Particulars of Work	Budget (in lakh Rs.)
1.	**Environmental Issues related to Development Drilling and construction of GGS**	
A	Aesthetic & Visual Quality	
A.1	*Pre-drilling: Construction of drill sites & GGS*	
A1.1	Site Designing & Planning (Management time)	0.0
A.1.2	Construction waste management (Budget is included in the side development budget)	0.0
A.1.3	MSW Management: (provision of 2 numbers of covered bins @ Rs. 5000 x 2 no) Transport of MSW to nearest disposal site (Rs. 1000 per day x 45 day construction period)	0.55
A.1.4	Monitoring: Site inspection, documents review and record keeping (Management time)	0.0
A.2	Drilling Phase	
A.2.1	Illumination management (cost is included in the drill side development)	0.0
A.2.1	MSW Management: (provision of 4 numbers of covered bins @ Rs. 5000 x 4 no) Transport of MSW to nearest disposal site (Rs. 1000 per day x 60 day construction period)	0.80
A.2.3	Monitoring: Site inspection, documents review and record keeping (Management time)	0.0
A.3	Decommissioning phase	
A.3.1	Decommission waste management (budget included in the site decommissioning cost)	0.0
A.3.2	a. Site reclamation (budget included in the site decommissioning cost) b. Greenbelt plantation in the producing wells and its maintenance (Rs. 2.5 lakh)	0.0 2.5
A.3.3	Monitoring: Site inspection, documents review and record keeping (Management time)	0.0
B.	Ambient Air Quality Management Plan	
B.1	Pre-drilling: Construction of drill sites & GGS	
B.1.1	Designing, Planning & Procurement of vehicles and machineries (budget included in the site development cost)	0.0

EMP Ref	Particulars of Work	Budget (in lakh Rs.)
B.1.2	Fugitive Dust Emission Control Measure –through planning and control measures (Budget included in the site development cost)	0.0
B.1.3	Fugitive Dust Suppression Measure through mobile water sprinkler (@ Rs. 3500 per day x 45 construction period)	1.575
B.1.4	Monitoring-ambient air quality (@ Rs. 65000 x 3 locations x 2 samples each)	0.39
B.2	Drilling Phase	
B.2.1	Designing, Planning & Procurement of vehicles and machineries (budget included in the drilling cost)	0.0
B.2.2	Emission control measures –through adoption in the process and implementing the industrial good practices (no separate budget will be required)	0.0
B.2.3	Maintenance of machineries & equipment (follow the standard operating procedure and industrial good practices)	0.0
B.2.4	H_2S emission control measures- implementing the standard operating procedure	0.0
B.2.5	Monitoring-ambient air quality (@ Rs. 65000 x 3 locations x 2 samples each) Monitoring of DG set Stacks (Rs. 2000 per DG set x 4 DG set)	0.47
B.3	Decommissioning Phase	
B.3.1	Fugitive Dust Emission Control Measure –through planning and control measures (Budget included in the site development cost)	0.0
B.3.2	Fugitive Dust Suppression Measure through mobile water sprinkler (@ Rs. 3500 per day x 45 construction period)	1.575
B.3.3	Monitoring-ambient air quality (@ Rs. 65000 x 3 locations x 2 samples each)	0.39
C.	Noise quality Management Plan	
C.1	Pre-drilling: Construction of drill sites & GGS	
C.1.1	Planning, Designing & Procurement (budget included in the site development cost)	0.0
C.1.2	Noise control measures (implement the standard operating procedure)	0.0
C.1.3	Monitoring: Ambient noise quality (Rs. 2000 per location x 5 location) Work place noise monitoring (Rs. 1000 x 3 locations)	0.13
C.2	Drilling Phase	
C.2.1	Operation and maintenance of machineries (budget included in the drilling cost)	0.0
C.2.2	Monitoring: Ambient noise quality (Rs. 2000 per location x 5 location) Work place noise monitoring (Rs. 1000 x 3 locations)	0.13
C.3	Decommissioning Phase	
C.3.1	Noise control measures (implement the standard operating procedure)	0.0
C.3.2	Monitoring: Ambient noise quality (Rs. 2000 per location x 5 location) Work place noise monitoring (Rs. 1000 x 3 locations)	0.13
D.	Road & Traffic	
D.1	Pre-drilling: construction of drill sites & GGS	
D.1.1	Planning & Designing (budget included in the site development cost)	0.0
D.1.2	Control Measures	1.1

EMP Ref	Particulars of Work	Budget (in lakh Rs.)
	Signage in the transport route & its maintenance (Rs. 100,000 + Rs. 10,000) Deployment of traffic personnel in sensitive area – 10 persons (@ Rs. 6000 per month x 6 months) Training on traffic and road safety operations will be imparted to the drivers of project vehicles (@ Rs. 50,000 per month x 6 months)	3.6 3.0
D.1.3	Monitoring (management time)	0.0
D.2	Drilling phase	
D.2.1	Control measures (Ref. D.1.2)	0.0
D.2.2	Monitoring (Ref. D.1.3)	0.0
D.3	Decommissioning Phase	
D.3.1	Control measures (Ref. D.1.2)	0.0
D.3.2	Monitoring (Ref. D.1.3)	0.0
E.	Land Use & Site Restoration	
E.1	Pre-drilling: Construction of drill sites & GGS	
E.1.1	Planning & Designing (cost in included in the site development)	0.0
E.1.2	Monitoring (management time)	0.0
E.2	Decommissioning Phase	
E.2.1	Site restoration (cost included in the site decommissioning activity)	00
E.2.2	Monitoring (management time)	0.0
F.	Soil Quality & Waste Management Plan	
F.1	Pre-drilling: construction of drill sites & GGS	
F.1.1	Top Soil Management Plan Cost involved in top soil quantity, characteristics assessment, soil stripping and proper storage is part of side development cost.	0.0
F.1.2	Oil & Lubricant, Chemical & Hazardous Waste storage site designing & Planning (Cost included in project planning)	0.0
F.1.3	Spill Prevention & Control measures (Cost included in project planning)	0.0
F.1.4	Monitoring (@ Rs. 7000 x 3 samples x once during site construction and drilling and decommissioning phase)	0.63
F.2	Drilling Phase	
F.2.1	Drilling Waste Management: Planning, Designing & Procurement (cost included in the project budget)	0.0
F.2.2	Prevention of Contamination during Drilling Period (cost included in the project budget)	0.0
F.2.3	Storage and Disposal of Used oil & Spent Oil (cost included in the project budget)	0.0
F.2.4	Storage and Disposal of Lead Acid Batteries (cost included in the project budget)	0.0
F.2.5	Storage & Disposal of MSW (Ref. A.2.1)	0.0
F.2.6	Monitoring Periodic monitoring of drill cuttings (@ Rs. 8,000 x 2 times) Soil quality (Rs. 7500 x 3 locations x 2 times)	0.61
F.3	Decommissioning Phase	
F.3.1	Site closure (cost is included in the project cost)	0.0
F.3.2	Well site decommissioning (cost is included in the project cost)	0.0
F.3.3	Waste and mud pit closure and reclamation (cost is included in the project cost)	0.0
F.3.4	Site Reinstatement (cost is included in the project cost)	0.0
F.3.5	Monitoring (Ref. F.2.6)	0.0

EMP Ref	Particulars of Work	Budget (in lakh Rs.)
G.	Topography & Drainage	
G.1	Pre-drilling: construction of drill sites & GGS	
G.1.1	Planning & Designing (Cost included in the site development)	0.0
G.1.2	Monitoring (Management time)	0.0
G.2	Decommissioning Phase	
G.2.1	Planning & Designing (Cost included in the site closure)	0.0
G.2.2	Monitoring (Management time)	0.0
H.	Surface water quality	
H.1	Pre-drilling: construction of drill sites & GGS	
H.1.1	Planning & Designing (Cost included in the site development)	0.0
H.1.2	Control Measures (budget included in the project cost)	0.0
H.1.3	Monitoring Periodic monitoring of treated effluent (@ Rs. 5000 x 3 times) Periodic monitoring of surface water quality (Rs. 7500 x 2 locations x 3 times)	0.6
H.2	Drilling phase	
H.2.1	Site runoff control, produced water and domestic water (Budget included in the project cost)	0.0
H.2.2	Monitoring (Ref. H.1.3)	0.0
H.3	Decommissioning Phase	
H.3.1	Control measures (Budget included in the project cost)	0.0
I	Ground Water Resource	
I.1	Drilling phase	
I.1.1	Control measures (Budget included in the project cost)	0.0
I.1.2	Monitoring (management time)	0.0
J	Ground water quality	
J.1	Pre-drilling: construction of drill sites & GGS	
J.1.1	Oil & Lubricant, Chemical & Hazardous Waste storage site designing & Planning (included in the project cost)	0.0
J.1.2	Spill Prevention & Control measures (included in the project cost)	0.0
J.1.3	Monitoring (ref. F.1.4)	0.0
J.2	Drilling Phase	
J.2.1	Drilling Waste Management: Planning, Designing & Procurement (included in the project cost)	0.0
J.2.2	Prevention of Contamination during Drilling Period (included in the project cost)	0.0
J.2.3	Storage and Disposal of Used oil & Spent Oil (included in the project cost)	0.0
J.2.4	Storage and Disposal of Lead Acid Batteries (included in the project cost)	0.0
J.2.5	Storage & Disposal of MSW (included in the project cost)	0.0
J.2.6	Monitoring (Ref. F.2.6)	0.0
K.	Terrestrial Floral Habitat & Flora	
K.1	Pre-drilling: construction of drill sites; GGS; Drilling & Site Decommissioning	
K.1.1	Control Measures (Planning & awareness)	0.5
K.1.2	Fugitive Dust & Emission Control (Ref. B.1.2; B.1.3 & B.2.2)	0.0
K.1.3	Site Restoration & Plantation	3.0
K.1.4	Monitoring (management time)	0.0
L.	Terrestrial Fauna & Habitat	

EMP Ref	Particulars of Work	Budget (in lakh Rs.)
L.1	Pre-drilling: construction of drill sites; GGS; Drilling & Site Decommissioning	
L.1.1	Wildlife Habitat Protection Measures (site management and various control measures) – budget included in the project cost	0.0
L.1.2	Anti Depredation Measures (cost of hiring of anti-depression team member – Rs. 25,000 x 2 persons x 6 months for drilling activity of well)	3.0
L.1.3	Erection of Signboard (Rs. 50,000)	0.5
L.1.4	Wildlife Awareness Program (Rs. 10,000 per meeting x 2 meeting during drilling of a well)	0.2
L.1.5	Management Cell (Review meeting)	0.05
M	Aquatic ecology	
M.1	Pre-drilling: construction of drill sites; GGS; Drilling & Site Decommissioning	
M.1.1	Surface runoff control and waste water management plan (Ref. H.1 & H.2)	0.0
N.	Socio-economic Issues	
N.1	Pre-drilling: construction of drill sites; GGS; Drilling & Site Decommissioning	
N.1.1	Compensation & Livelihood Measures (cost is included in the land lease budget)	0.0
N.1.2	Conflict Addressing System (management cost0	0.0
N.1.3	Job opportunity (positive impact)	0.0
N.1.4	CSR Plan (budget is provided in CSR plan)	0.0
O.	Occupational Health & Safety	
O.1	Occupational Health & Safety Management Plan	
O.1.1	Designing, Planning & Procurement (budget included in the project cost0	0.0
O.1.2	PPE & Basic Facilities (budget included in the project cost)	0.0
O.1.3	Occupational Health Care & Check-up (budget included in HOEC/ Contractor internal budget)	0.0
O.1.4	Operation & Maintenance of facility (budget included in the project cost0	0.0
O.1.5	Training	0.5
P.	Community Health & safety	
P.1	Pre-drilling: construction of drill sites; Drilling & Site Decommissioning	
P.1.1	Pollution Control Measures Ref. Air quality Management plan Ref. Water quality management plan Ref. Noise quality management plan	0.0
	Total Budget per well site	**25.93**
2.	**Environmental Issues Associated with Laying of Pipeline**	
A.	Restoration of site (budget included in the project cost0	0.0
B.	Soil Quality Management (budget included in the project cost0	0.0
C.	Surface water quality management Plan (budget included in the project cost0	0.0
D.	Traffic Management Plan (Ref. D-1, D-2 and D-3)	3.0
	Total EMP budget for Pipeline laying	**3.0**

Table 9.3 Tentative Budget for EMP Implementation for GGS & GPP per year

EMP Ref.	Particulars of Work	Budget (in lakh Rs.)
A.	Ambient Air Quality	
A.1	Designing, Planning & Procurement (budget included in the project cost)	0.0
A.2	Maintenance of Machineries & equipment (budget included in the project cost)	0.0
A.3	Monitoring Periodic monitoring of DG set stack (Rs. 3000 x 7 DG set x 2 times in a year) Periodic monitoring of ambient air quality (Rs. 6500 x 5 locations x 20 samples per year)	6.92
B.	Noise quality	
B.1	Operation and maintenance of machineries (budget included in the project cost)	
B.2	Monitoring Ambient noise quality (Rs. 2000 per location x 5 location x 2 times in year) Work place noise monitoring (Rs. 1000 x 3 locations x 2 times in a year)	0.26
C.	Surface water quality	
C.1	Site runoff control, produced water and domestic water (budget included in the project cost)	0.0
C.2	Monitoring Periodic monitoring of treated effluent (@ Rs. 5000 x 3 times) Periodic monitoring of surface water quality (Rs. 7500 x 2 locations x 3 times)	0.6
D.	Soil & Ground Water Quality	
D.1	Oil & Lubricant, Chemical & Hazardous Waste storage site designing & Planning (budget included in the project cost)	0.0
D.2	Spill Prevention & Control measures (budget included in the project cost)	0.0
D.3	Monitoring Ground water quality (@ Rs. 7000 x 3 samples x two times per year) Soil quality (@ Rs. 7000 x 3 samples x two times per year)	0.84
E.	Occupation health & safety	
E.1	Designing, Planning & Procurement (Ref. O.1)	0.0
E.2	PPE & Basic Facilities (Ref. O.2)	0.0
E.3	Occupational Health Care & Check-up (Ref. O.3)	0.0
E.4	Operation & Maintenance of facility (Ref. O.4)	0.0
E.5	Training (Ref. O.5)	1.0
	Total EMP Budget for operational phase of GGS & GPP per year	**9.62**

Additionally HOEC proposed to allocate 2.0 % of the total project cost for CSR activities. Recommended 2 % of the CSR spend net to HOEC for FY 2018-19 : ₹ 53 Lakhs.

10 EXISTING ENVIRONMENTAL AND SAFETY APPROVALS AND COMPLIANCE STATUS

On behalf of Joint Venture Consortium, HOEC has been carrying out oil and gas operations in AAP-ON-94/1 Block since it has taken over operations from Command Petroleum in 1998 as part of the AAP-ON-94/1 joint venture.

HOEC is committed towards compliance with all applicable environmental regulatory requirements as stated in its HSE policy (refer to ***Section 10*** on EMP). In line with the applicable regulatory framework, HOEC has been obtaining environmental approvals from MoEFCC, ASPCB and other regulatory authorities for oil and gas development in the AAP-ON-94/1 Block. The environmental approvals/permits obtained for the operations of existing operations in AAP-ON-94/1 Block are described in the following section.

10.1 EXISTING PROJECT RELATED APPROVALS

10.1.1 Environmental Clearances

Overview

The environment clearance requirement for new projects or modernization / expansion of existing projects was first mandated through the EIA notification of 1994 [under the Environment (Protection) Rules 1986]. The Notification was later revised in 2006. HOEC has obtained following eight environmental clearances from the MoEFCC for oil and gas development activities in AAP-ON-94/1 Block. A list of Environmental Clearances issued for oil and gas exploration and development related activities in AAP-ON-94/1 block are included in ***Table 1.2*** in ***Section 1***. A copy of the recent report against compliance to the conditions stated in the environmental clearances submitted to MoEFCC is presented in ***Annex 10.1.***

Certificate of Compliance from MoEFCC Regional Office

As required under the MoEFCC Circular dated 31 May 2012, a certified report of the status of compliance of the conditions stipulated in the Environmental Clearances for the operations of HOEC in AAP-ON-94/1 Block, Assam by the Regional Office of MoEFCC will be obtained.

Public Consultations under EIA Notification, 2006

HOEC has been operating in the AAP-ON-94/1 Block for last 20 years. It has proactively sought the partnership of the local community from the very inception of its activities in the Block. Statutory public consultation for the will be carried out for the proposed Project by ASPCB as per the procedure defined in the EIA Notification, 2006. After completion of the Public

Consultation, the environmental concerns expressed during the consultation will be incorporated to finalize EIA Report. Prior to this last public hearing for the oil and gas development in AAP-ON-94/1 took place on 3 July 2015.

10.1.2 Ecologically Sensitive Areas Related Approval

Dehing Patkai Wildlife sanctuary is located within 10 km around of the project area. Therefore wildlife clearance from NBWL is applicable for this project. HOEC has prepared the site specific wildlife management plan and received wildlife clearance from Standing Committee of National Wildlife Board on 21 July 2017 for existing and proposed development wells, GGS, GPP and pipeline (***Refer Annex 10.2***).

10.1.3 Forest Diversion Approval

All the existing wells and proposed development wells are located in non-forest area. HOEC had laid 23 km pipeline from Dirok GGS to GPP at Borpowai / Agbanda village and from there to OIL India Kusijan GGS. A part of the pipeline (8.074 km) is passing through the forest. For laying of pipeline HOEC has taken forest clearance from Forest Department, vide File No. 3-AS B061/2016-SH1/1187-88 dated 13th July 2017 (***Refer Annex 10.3***).

10.1.4 Consents to Establish & Operate

Industries having emissions to air and waste water discharges are required to comply with the Air (Prevention & Control of Pollution) Act and Water (Prevention & Control of Pollution) Act. HOEC had earlier obtained 'Consent to Establishment (CTE)' as required by the two acts from the ASPCB. The 'Consent to Operate (CTO)' has been obtained for the present production capacity at AAP-ON-94/1. Reports on compliance to prescribed conditions are regularly being submitted to the ASPCB.

10.1.5 Hazardous Waste Authorization

During the extraction and production of hydrocarbons hazardous wastes are generated in the form of drill cuttings containing oil, oily sludge, used oil, slope oil etc. These wastes are to be handled, stored and disposed of in accordance with the Hazardous & Other Wastes (Management and Transboundary Movement) Rules, 2016. Hazardous waste authorization under the said Rules has been obtained by HOEC from ASPCB for generation and storage of hazardous wastes in individual facilities for oil and gas development in AAP-ON-94/1.

10.1.6 DGMS Approval

Installation of Group Gathering Stations in the Block is approved by the Directorate General of Mines Safety (DGMS) under the Oil Mines Regulation 1984. All high voltage installations have been approved by the DGMS

(Electrical) under the Indian Electricity Rules 1956. DGMS inspections occur periodically to check the conformance of the facilities with the provisions of the Oil Mines Regulations.

10.2 CONFORMANCE TO OISD STANDARDS

The relevant Oil Industry Safety Directorate (OISD) standards pertaining to Exploration and Production have been reportedly incorporated during design phase of the facilities in the block. OISD inspections occur periodically to check adherence of the facilities to the standards.

11 SUMMARY AND CONCLUSION

The EIA study has been undertaken to assess the potential significant adverse environmental effects due to the proposed drilling and developmental activities in AAP-ON-94/1 Block.

Mitigation measures have been proposed as part of EMP to minimize adverse environmental impacts, if any. Risk assessment includes Jet Fire and Vapour Cloud Explosion for blowout of wells, tank and pipeline failure etc. The existing Emergency Management Plan of HOEC will be extended to this project, strengthened as necessary and implemented in the event of any emergency arising due to above mentioned risks.

The present impact assessment study indicates that the overall impact from the proposed project will be short to medium term, reversible, localised and are not expected to contribute significantly to the surrounding environment. Also, with the implementation of the pollution control and strengthen the existing environment management measures, these anticipated impacts due to proposed site preparation, drilling, construction and operation of production facilities and pipelines and decommissioning activities of the proposed project will be mitigated. Summary of impact significance without mitigation measures and with mitigation measures is presented at the table below.

Table 11.1 Summary of Impact Significance without and with Mitigation Measures

Impact	Impact significance without mitigation measures	Impact significance with mitigation measures
Aesthetic & visual	Moderate	Minor
Air Quality	Moderate	Minor
Noise Quality	Major	Moderate
Road & Traffic	Moderate	Minor
Land Use	Minor	-
Soil Quality	Moderate	Minor
Topography & drainage	Moderate	
Surface Water Quality	Moderate	Moderate
Ground water resource	Minor	Minor
Ground Water Quality	Moderate	Minor
Terrestrial Flora	Moderate	
Terrestrial Fauna/ Protected Species	Moderate	
Aquatic Ecology	Moderate	Moderate
Livelihood & Income generation	Moderate	Moderate
Conflict with local people	Moderate	Moderate
Benefit to Local Enterprises	Positive	-
Employment Generation	Positive	-
Occupational health & safety	Minor	Minor
Community health & safety	Moderate	Minor

HOEC will also ensure that the environmental performances of all the activities are monitored throughout execution of the project during site preparation, drilling and decommissioning phases. Monitoring will be carried out for ambient air quality, stack emission, noise quality, quality of treated effluents, surface and groundwater qualities, waste generated and disposed etc. and verified that they meet the prescribed standards. HOEC will continue to report environmental performance and submit monitoring reports regularly to statutory authorities.

The effective management system coupled with monitoring of environmental components and efforts for continual improvements will result in satisfactory environmental performance of the proposed oil and gas drilling and development project.

12 *DISCLOSURE OF CONSULTANTS*

Environmental Resources Management (ERM) is the world's leading provider of environmental, health, safety, risk, social consulting and sustainability related services. With a history that spans more than four decades, ERM today has a global footprint of 160 offices in 40 counties, employing more than 5000 best-in-class professionals. In the last three years, ERM has worked with more than 50% of the Global Fortune 500 Companies.

ERM India Private Limited (ERM India) was formally established in 1995 with its headquarters in Delhi and regional office in Mumbai (Maharashtra), Bangalore (Karnataka), Ahmadabad (Gujarat) and Kolkata (West Bengal). The contact address of ERM India is as follows:

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12.1 *ERM'S ACCREDITATION AS EIA CONSULTANT*

ERM has been accredited as EIA consultant for various sectors including Offshore and Onshore Oil and Gas Exploration Development and Production from National Accreditation Board for Education and Training (NABET) of Quality Council of India (QCI) under the Accreditation Scheme for EIA Consultant Organisation as per the requirement of MoEFCC.

ERM's Accreditation Certificate from National Accreditation Board for Education and Training (NABET) is presented as ***Figure 12.1.***

Figure 12.1 ERM's Accreditation from NABET

QCI

Quality Council of India

National Accreditation Board for Education & Training

NABET

CERTIFICATE OF ACCREDITATION

ERM India Private Limited

Building 10, Tower A, 4th Floor, DLF Cyber City, Gurgaon- 122 002

are accredited as Category - A organization under the QCI-NABET Scheme for Accreditation of EIA Consultant Organizations: Version 3 for preparing EIA/EMP reports in the following sectors:

Sl.No.	Sector Description	Sector (as per)		Cat.
		NABET	MoEFCC	
1	Mining of minerals including opencast / underground mining	1	1 (a) (i)	A
2	Offshore and onshore oil and gas exploration, development & production	2	1 (b)	A
3	River Valley	3	1(c)	A
4	Thermal power plants	4	1 (d)	A
5	Secondary Steel only	8	3 (a)	B
6	Cement plants	9	3 (b)	A
7	Chlor-alkali industry	13	4 (d)	A
8	Chemical fertilizers	16	5 (a)	A
9	Pesticides industry and pesticide specific intermediates	17	5 (b)	A
10	Petro-chemical complexes	18	5(c)	A
11	Petrochemical based processing	20	5 (e)	A
12	Synthetic organic chemicals industry	21	5 (f)	A
13	Oil & gas transportation pipeline	27	6 (a)	A
14	Isolated storage & handling of Hazardous chemicals	28	6 (b)	B
15	Airports	29	7(a)	A
16	Industrial estates (EPZs), (SEZs), Biotech Parks, Leather Complexes	31	7 (c)	A
17	Common hazardous waste treatment, storage and disposal facilities	32	7(d)	A
18	Highways	34	7(f)	A
19	Common Municipal Solid Waste Management Facility (CMSWMF)	37	7 (i)	B
20	Building and construction projects	38	8 (a)	B
21	Townships and Area development projects	39	8 (b)	B
22	Automobile and Auto Components	40(i)	-	-

Note: Names of approved EIA Coordinators and Functional Area Experts are mentioned in RA AC minutes dated Apr. 21, 2017 posted on QCI-NABET website.

The Accreditation shall remain in force subject to continued compliance to the terms and conditions mentioned in NABET's letter of accreditation bearing no. QCI/NABET/ENV/ACO/17/0345 dated 21 June 2017. The accreditation needs to be renewed before the expiry date by ERM India Private Limited following due process of assessment.

C.E.O NABET
Dated: Jun.21, 2017

Certificate No.
NABET/ EIA/1619/ RA 0055

Valid till Date
Oct. 31, 2019

For the updated List of Accredited Consultants with approved sectors please refer QCI-NABET website.

12.2 EIA TEAM

Experts contributing to the EIA for Onshore Oil & Gas Development Drilling project in AAP-ON-94/1 Tinsukia District, Assam.

I hearby, certify that I was a part of the EIA team in the following capcity that developed the above EIA.

EIA Coordinator:	Salil Das
Name:	Salil Das
Signature & Date:	28.06.2018

The professionals that were engaged for this study included in ***Table 12.1***.

Table 12.1 Professionals Engaged for the EIA Study

S.N	Role in the EIA	Name of the Expert	Involvement	Signature
1	**[EIA Coordinator** for Offshore and Onshore Oil & Gas Exploration, Development and Production]	Salil Das	Coordination with experts; Impact assessment methodology development; Inputs related to given functional areas related baseline and impact assessment;	Salil Das
2	**[Functional Area Expert**: Air Pollution Monitoring, Prevention and Control (AP) and Risk Assessment and Hazard Management (RH)]	Dr. Debanjan Bandyopadhyay	Selection of air quality monitoring stations; Discussion with client on various air pollution control aspects; Inputs for impact assessment and development of EMP; Risk assessment and hazard management.	[illegible]
3	**[Functional Area Expert**: Water Pollution Monitoring, Prevention and Control (WP)]	Dhritiman Ray	Selection of water monitoring stations; Interpretation of analysis results; Inputs for impact assessment and development of EMP.	Dhritiman Ray
4.	**[Functional Area Expert**: Air Quality Modelling (AQ)]	Dr. Indrani Ghosh	Modelling. Model input data related to emissions and micrometeorology interpretation of modelling results and development of EMP	Indrani Ghosh
5.	**[Functional Area Expert**: Noise Quality (Noise)]	Dr. Indrani Ghosh	Undertaking Noise Quality Modelling; Selection of noise sampling locations for baseline monitoring,	

S.N	Role in the EIA	Name of the Expert	Involvement	Signature
			model input data, interpretation of modelling results and development of EMP.	
6.	**[Functional Area Expert**: Ecology and Biodiversity (EB)]	Dr. Abhishek Roy Goswami	Ecological survey and assessment of flora and fauna; Impact assessment and development of EMP.	
7.	**[Functional Area Expert**: Socio-economics (SE)]	Tufail Khan Souvik Basu	Support for socio economic baseline, stakeholder consultations and impact assessment.	
8.	**[Functional Area Expert**: Solid & Hazardous Waste Management (SHW)]	Dr. Koel Kumar	Review of existing SHW management and support for impact assessment, and development of EMP.	
9.	**[Functional Area Expert**: Land use (LU)]	Dr. Karunakaran Nagalingam Dibyendu Chakraborty	Preparation of all maps including LU/LC and impact assessment.	

I, Neena Singh, hereby, confirm that the above mentioned experts prepared the EIA Study of Development Drilling of 24 Drill Sites, Commissioning of two GGS, Capacity expansion of existing M-GPP and laying of underground transportation Pipeline at onshore block AAP-ON-94/1 Tinsukia District, Assam. I also confirm that the consultant organization shall be fully accountable for any misleading information mentioned in this statement.

Signature:

Name: Neena Singh

Designation: Managing Director
Name of the EIA consultant organization: ERM India Private Limited