DRAFT ENVIRONMENTAL IMPACT ASSESSMENT REPORT

VEDANTA LIMITED

(Division: Cairn Oil & Gas)

Onshore Oil and Gas Exploration and Appraisal in AA-ONHP-2017/14 Block in Karimganj, Hailakandi, Cachar Districts of Assam and Kolasib District of Mizoram

Sep' 2019

PREPARED BY

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Certificate No. NABET/EIA/1720/RA 0097

<u>UNDERTAKING</u>

This is to certify that M/s. SV Enviro Labs & Consultants is a NABL Accredited, ISO 9001:2008 certified company and is recognised by Ministry of Environment, Forest and Climate Change under Environment (Protection) Act, 1986.

Further, this Draft Environmental Impact Assessment Report for the proposed Onshore Oil and Gas Exploration and Appraisal in AA-ONHP-2017/14 Block in Karimganj, Hailakandi, Cacher Districts of Assam and Kolasib District of Mizoram has been carried out by M/s. SV Enviro Labs & Consultants and the prescribed ToR's have been complied with and the data submitted in the Draft EIA report is factually correct.

Thanks and Regards,

M. Murali Krishna

Managing Partner

September, 2019

DECLARATION BY EXPERTS CONTRIBUTING TO THE EIA

“Draft Environmental Impact Assessment” for the proposed Onshore Oil and Gas Exploration and Appraisal in AA-ONHP-2017/14 Block in Karimganj, Hailakandi, Cacher Districts of Assam and Kolasib District of Mizoram by Vedanta Limited (Division: Cairn Oil & Gas).

I hereby certify that I was a part of the EIA team in the following capacity that developed the above EIA/EMP.

EIA Co-ordinator :

Name : M. Murali Krishna

Signature :

Period of Involvement : March’ 2019 to June’ 2019

Functional Area Experts:

S.No	Functional Areas	Name of the Expert	Category as per NABET	Involvement (Period and task**)	Signature and Date
1	AP *	M. Murali Krishna V. Hema Latha (TM) K. Anitha (TM)	A	Air Pollution monitoring, prevention & control	
2	WP *	V. Hema Latha	A	Water Pollution monitoring, prevention & control	
3	SHW *	K. Anitha	A	Solid waste management	
4	SE *	Dr. B. Vijay Bhaskara Rao	A	Socioeconomic studies	
5	EB *	Dr. M. Tarakeswara Naidu	A	Ecology and Bio-diversity	
6	HG *	Dr. G.V.A Ramakrishna	A	Hydrology	

7	GEO *	Dr. G.V.A Ramakrishna	A	Geology	
8	SC *	D. Sunder Rao M. M. Tarakeswara Naidu (TM)	A	Soil conservation	
9	AQ *	M. Murali Krishna	A	Air quality modelling	
10	NV *	M. Murali Krishna	A	Noise and vibration	
11	LU *	Dr. G.V.A Ramakrishna	A	Land use studies	
12	RH *	Shaik Kasim V. Hema Latha (TM)	A	Risk and hazard study	Shaik Kasim

*One TM against each FAE may be shown

** Please attach additional sheet if required

Declaration by the Head of the accredited consultant organization/ authorized person

I, **M. Murali Krishna**, hereby, confirm that the above mentioned experts prepared the Draft EIA for proposed Onshore Oil and Gas Exploration and Appraisal in AA-ONHP-2017/14 Block in Karimganj, Hailakandi, Cacher Districts of Assam and Kolasib District of Mizoram.

Signature:

Name: M. Murali Krishna

Designation: Managing Partner

Name of the EIA consultant organization: SV Enviro Labs & Consultants

NABET Certificate No. & Issue Date: NABET/EIA/1720/RA0097 Dt: 26.07.2018

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EXECUTIVE SUMMARY

VEDANTA LIMITED
(Division: Cairn Oil & Gas)

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INTRODUCTION

Vedanta Ltd. (Division: Cairn Oil & Gas) has been allocated the AA-ONHP-2017/14 hydrocarbon block under the OALP (Open Acreage Licensing Policy) by MoP&NG, Govt. of India. RSC (Revenue Sharing Contract) has been signed between Vedanta Ltd and MoP&NG on 1st October, 2018 for the exploration and exploitation of hydrocarbons. Vedanta Ltd. (Division: Cairn Oil & Gas) proposes to carryout exploratory and appraisal drilling of 24 wells and setting up of Early Production Units (EPUs)/ Quick Production Units (QPUs) in AA-ONHP-2017/14 block.

SV Enviro Labs & Consultants a NABET-QCI Accredited firm has been entrusted to conduct an Environmental Impact Assessment (EIA) for the proposed activities in AA-ONHP-2017/14 hydrocarbon block. The application (Form-1, proposed ToR and PFR) was submitted on 10th April, 2019. The MoEF&CC approved the standard ToR for the proposed project vide F.No. IA-J-11011/148/2019-IA-II(I) dated 13th May, 2019.

BLOCK LOCATION & ACCESSIBILITY

The AA-ONHP-2017/14 block is located in Karimganj, Hailakandi, Cachar districts of Assam and Kolasib district of Mizoram. It encloses an area of 1719 Sq. Km. out of which 1716.5 Sq. Km. falls under Karimganj, Hailkandi and Cachar districts of Assam and the remaining 2.5 Sq. Km falls in the Kolasib district of Mizoram. Proposed well Locations in Block AA-ONHP-2017/14 on SOI Toposheet given in Figure 1.

Major portion of the block is traversed by two main roads, i.e. NH-154 which connects Badarpur with Hailakandi and the SH-39 which connects Karimganj-Hailakandi-Silchar. Majority of the wells can be accessed by Silchar-Hailakandi road and Karimganj road. Silchar is the main railway station for getting access to the rest of the block. The nearest airport to the block is Silchar Airport, which is approximately 21.68 km from the block boundary.Borail Wildlife Sanctuary ESZ boundary is at a distance of 8.76 km from the proposed block boundary.

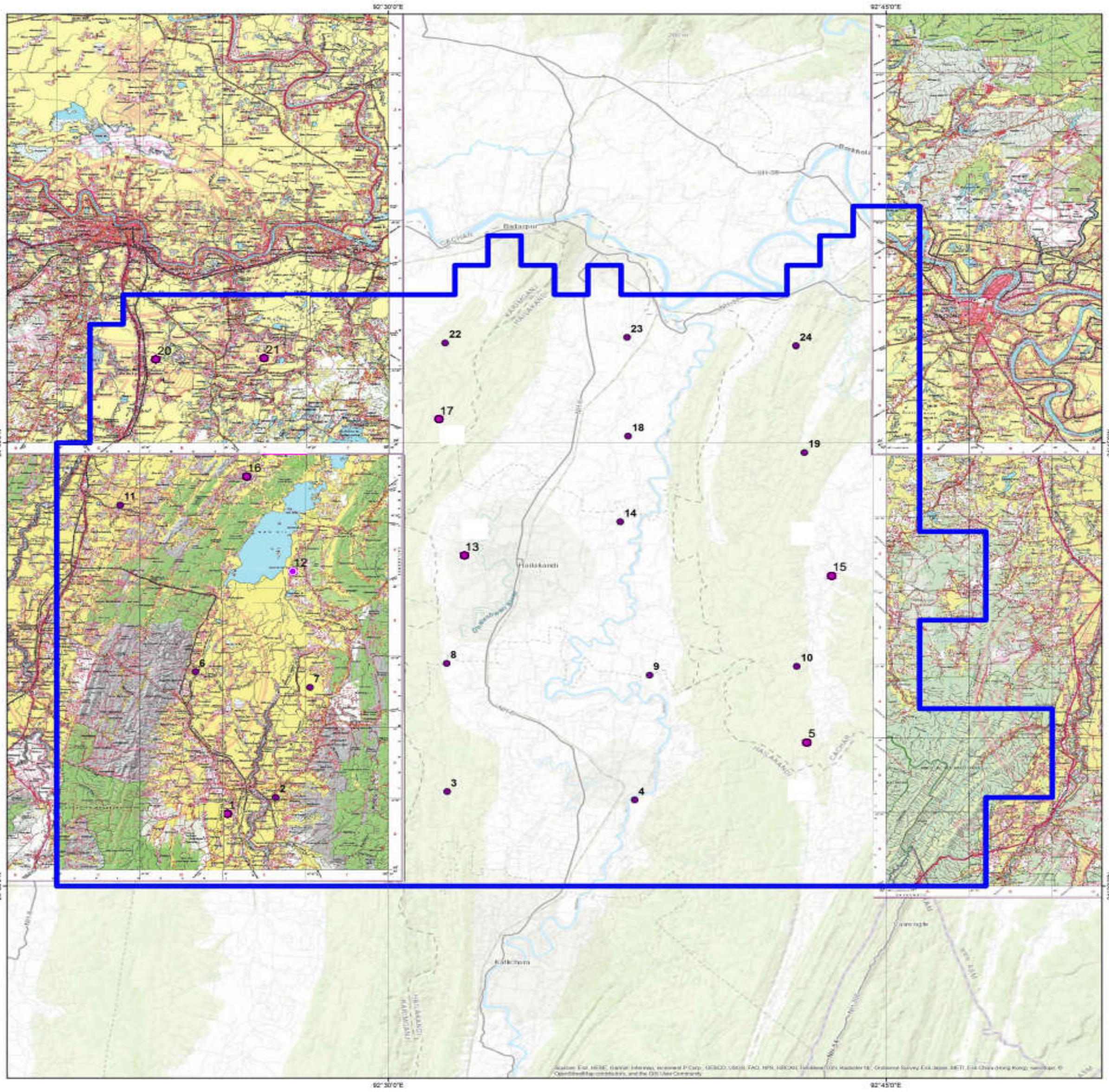


Fig. 1: Proposed well Locations in Block AA-ONHP-2017/14 on SOI Toposheet

PROJECT ACTIVITIES

The various activities involved as a part of the drilling of exploration wells are described in detail in the subsequent sections.

1. Site Selection

The seismic data interpretation of the seismic survey would decide the exact locations of the drilling well. Field surveys will be carried out to earmark the drill site location maintaining maximum possible distance from any settlement, sensitive receptors.

2. Site preparation

Site preparation will involve all activities required to facilitate the operation of the drilling rig and associated equipment and machineries. At the initial stage, the drilling site will be elevated to about 2.0 m from the existing ground level with minimal clearance of existing ground vegetation. The loose top soil will be removed by using mechanical means like bulldozer and saved at a nearby place for later use during site restoration. Levelling and compaction will be done with the help of graders and mechanical rollers. The land filling materials and rubbles will be required for the purpose of site preparation.

3. Drilling Activities

The proposed drilling would be carried out by using a standard land rig or a "Mobile Land Rig" with standard water based drilling fluid treatment system. This rig will be suitable for deep drilling up to the desired depth of 5000 meters (TVDSS) as planned for the project. Additionally, there will be other ancillary facilities like Drilling mud system, ETP, Cuttings disposal, Drill Cementing equipment etc. and utilities to supply power (DG sets), water, fuel (HSD) to the drilling process and will be set up as a part of the project. Drilling and wash wastewater generated will also be stored at onsite HDPE lined pit.

4. Well Testing & Flaring

During the exploration and appraisal drilling, where a hydrocarbon formation is found, initial well tests (generally about one month of duration) will be carried out to establish flow rates, formation pressure and other parameters. However, depending on the need, based on nature of the reservoirs, the exploratory and appraisal wells will be tested for longer/extended durations to ascertain the reservoir parameters. In case hydrocarbons are detected in the well, the quantity and quality will be tested.

Associated Facilities – Each drill site will be provided with facilities such as drilling rig foundation and cellar pit, waste and water storage pits, chemical storage area including fuel storages, drill cutting disposal pit, flare pit and modular/ mobile STPs, mobile ETP. The drill cuttings and spent mud pits will be provided with a HDPE lining for temporary storage. Adequate storm water drainage system also will be provided.

Liquid Mud Plant (LMP) – The Liquid Mud Plant (LMP) will be located at suitable location as may be required to prepare mud for the drilling operations.

Hydraulic Fracturing Activity – Hydraulic fracking may be conducted in wells with low permeability formation and the wells with low pressure. Fracking fluid will typically be 99% water and sand (or other granulated material) and approximately 1% gelled chemicals that will be pumped at a high rate (in excess of 20 bpm) and high pressure (up to 5000 psi) to fracture the formation and improve the well deliverability. Sites for the wells with more than 2 fracs per well (multi-stage fracturing) will have provision of additional space for water storage for better continuity of operation.

5. Completion of Drilling

On completion of activities, the well will be either plugged and suspended (if the well evaluations indicate commercial quantities of hydrocarbons) or will be killed and permanently abandoned. In the event of a decision to suspend the well, it will be filled with a brine solution containing very small quantities of inhibitors to protect the well. The well will be sealed with cement plugs and some of the wellhead equipment (Blind Flange) will be left on the surface (Cellar). If the well is abandoned it will be sealed with a series of cement plugs, all the wellhead equipment will be removed, by leaving the surface clear of any debris and the site will be restored.

Appraisal–When, exploratory drilling is successful, more wells (termed as Appraisal wells) will be drilled to determine the size and the extent of the field. The technical procedures and activities in appraisal drilling will be the same as those employed for exploration wells Deviated or directional drilling at an angle from a site adjacent to the original discovery well may be used to appraise other parts of the reservoir

Early Production Units (EPU)/ Quick Production Unit (QPU) – In case of commercially viable discovery, EPUs/QPUs will be installed for the processing of produced well fluid processing and early production of up to 8000 BOPD crude oil and up to 1.6 MMSCFD associated natural gas. A QPU will be a packaged/ modular mobile unit and will mainly consists of a three phase separator & production heater or heater-treater, oil storage tanks, oil tanker loading system, produced water (PW) separation and disposal system, power generation (GEG or DG), utility systems such as fuel gas, flare & Inst. Air packages, firefighting equipment, etc. Each QPU capacity will be ~2,000 BFPD (Barrels of Fluid per Day).

Camp Site – Temporarycamp site (porta cabin) for the drilling of exploratory (including) appraisal wells are envisaged, which will be dismantled after drilling of the wells. At any point of time, it is anticipated that about 50 personnel per shift will be housed in the campsite during the well drilling campaign.

6. Decommissioning & closure of wells

After the completion of the drilling activity, partial de-mobilization of the drilling rig and associated infrastructure will be initiated. As discussed earlier, well testing may be carried out immediately after the drilling is completed. The complete de-mobilization of the facilities at site will happen once well-testing completed successfully. This will involve the dismantling of the rig, all associated equipment and the residential camp, and transporting it out of the project area. If no indication of any commercially viable amount of oil or gas is encountered either before or after testing, the well will be declared dry and accordingly will be plugged of and abandoned, and the site will be restored in line with applicable regulations and good industry practice.

PROJECT UTILITIES AND RESOURCE REQUIREMENTS

Land Requirement

An area of approximately 300m x 300m would be taken on temporary short-term lease basis for the preparation of well pad (drill site) for exploratory and appraisal wells. For the preparation of suitable access roads connecting to well pads, accommodating OHL and other utilities in future, a width of 30m (approx.) Right of Use (RoU) will be required.

Power requirement during exploratory and appraisal well drilling

The power requirement for a drilling site and the campsites will be provided through diesel generator (DG) sets. Two (2) Nos. of DG set of 2x350 kVA (one working and one standby) capacities will be used at Camp site. Three (3) Nos. of DG set of 3x1000 kVA (two working and one standby) or 2 x 1850 kVA* (one working and one standby)capacities will be used at Drilling site. Two (2) Nos. of DG set of 2x100 kVA (one working and one standby) capacities will be used at Radio Room.

*Depending on the rig capacity & rig availability during E&A (exploratory & appraisal) drilling phase

Power requirement during early production

There will be 1 Gas Engine Generator (GEG) of 1MW output and D.G. set of 500 KVA (emergency) for each early production unit/quick production unit.

Water requirement during exploratory and appraisal well drilling

The water requirement in drilling rig is mainly meant for preparation of drilling mud apart from washings and domestic use. While former constitutes majority of water requirement, latter or the water requirement for domestic and wash use is minor. The water requirement for the water based drilling mud (WBM) preparation is envisaged to be of 600-1000 m^3/well and 150-300m^3/well will be required for preparing the synthetic based drilling mud (SBM). For domestic consumption, approx. 20 - 30 m^3/day water will be required during drilling period and 25-50 m^3/day for drilling operation like engine cooling, floor/equipment/string washing, firefighting storage / make up etc. The water requirement at the drilling sites during construction and drilling phase will be met through procurement of surface water from approved local sources/suppliers and partly through re-cycling of treated water from ETP.

Water requirement during early production

The water requirement during early production will be 15-18 m^3/day for each early production unit/quick production unit.

Manpower

Most of the workforce will be from local/nearby areas. During the site preparation for drilling, approximately 30-35 workmen will be employed per drill site. During the drilling phase, about 50 workmen per shift will be working on site. This will include technical experts, who will be responsible for various drilling related activities and some technical manpower. It is anticipated that, at any given time, there will be about 80 - 100 personnel working on site including technical staff, drilling crew, security staff etc.

BASELINE ENVIRONMENTAL STATUS

The study of the baseline environmental status helps in assessing the existing environmental conditions and identifying the critical environmental attributes. The study of the physical, biological and socio-economic environment of the Block and an area within a radius of 10 km (study area) comprises of the baseline environment.Primary and secondary data were collected for the EIA study.

Physical Environment

Climate and Meteorology

The study area falls under Humid Subtropical zone according to Koppen's classification of climate zones. Winter and early summer are long and dry; summer is exceedingly hot leading to heat waves. The rainy season lasts from Juneto September. Wind speed is high and found mostly between 2.4 – 1.0m/sec for all the months. The wind speed during summer recorded is high, and during rainy season, and winter recorded low. The predominant wind direction is from NE and East throughout the year.

Air Quality

The ambient air quality representing PM_{10}, $PM_{2.5}$ Sulfur Dioxide (SO_2), Nitrogen Oxides (NOx), Carbon Monoxide (CO)was monitored at eighteen different locations for 24 hours twice a week from March'19 to June'19. Volatile Organic Carbons (VOCs), Methane (CH_4), non-methane hydrocarbons(NMHCs), Ozone, Ammonia, Lead (Pb), Benzene (C_6H_6), Benzo(a)pyrene (BaP), Arsenic (As), Nickel (Ni) were monitored for the same period. All the parameters were found to be belowthe National Ambient Air Quality Standards (NAAQS), 2009. The average 24 hourly PM_{10} at monitoring locations ranged between 30.4-73.1 $\mu g/m^3$ (NAAQS-100 $\mu g/m^3$). The average 24 hourly $PM_{2.5}$ at monitoring locations ranged between 9.9-42.2 $\mu g/m^3$ (NAAQS-60 $\mu g/m^3$). The average 24 hourly SO_2 at monitoring locations ranged between 6.1-13.1 $\mu g/m^3$ (NAAQS-80 $\mu g/m^3$). The average 24 hourly NOxat monitoring locations ranged between 6.8-14.8 $\mu g/m^3$ (NAAQS-80 $\mu g/m^3$). Lead (Pb), Benzene (C_6H_6), Benzo(a)pyrene (BaP), Arsenic (As), Nickel (Ni), HC (methane and non methane Hydro Carbon), Volatile Organic Carbon (VOC) are remained below detection limit (BDL) in the study area.

Noise Quality

The noise quality was monitored for 24 hours at eighteen locations close to the drill sites. The ambient noise quality at day and night was in compliance to the Noise Limits set for the residential area as per Noise Pollution (Control and Regulations), 2000. The daytime noise level was found in the range between 49.0-62.3 dBA whereas the night time noise level was found in the range between 31.4-47.7 dBA

Geology

Geologically, the region can be divided into two major groups, i.e. unconsolidated deposits comprising alluvial deposits of Sub-Recent to Recent age and semi-consolidated Tertiary deposits of Bhaban, Bokabil, Girujan/ Tipam, Dupitila and Dihing formations of Miocene to Pliocene age. The alluvial deposits containing in the central parts mainly comprises of sand, silt and clay with gravel and occasional coal bands. The semi-consolidated rocks are exposed in the form of hillocks comprising shale, sandstone, ferruginous sandstone, mottle clay, pebble bed and boulder beds etc.

Hydrogeology

The hydrogeological formations are Alluvium, Dupitila and Tipam formations. Alluvial formation occurs along the banks of main rivers with thickness varying from 10 to 15 m.

In Karimganj valley there are six major aquifers within the depth of about 260 m. The cumulative thickness of aquifer zones is to a depth of 200 m. The aquifers are persistant throughout the valley with minor facies variations. The depth to water level during pre-monsoon period in phreatic aquifer varies from 0.35-2.80 m bgl and during post monsoon varies from 0.19-3.88 m bgl.

In Hailakandi district ground water occurs under unconfined condition in alluvial formation. In Dupitilla and Tipam formations ground water occurs under unconfined, semi confined to confined conditions.

In Cachar district ground water occurs in phreatic condition in shallow aquifer and in semi-confined condition in deeper aquifer. Flow of ground water is from the North to South in northern parts and from South to North in southern parts of the district. The area mostly represents a water logged area. The pre-monsoon water level is 1.05 m bgl while the post-monsoon water level is 1.62 m bgl.

Groundwater Quality

Groundwater was collected and analyzed as per IS: 10500:2012 from eighteen locations in the studyarea. All the parameters analyzed was under the acceptable and permissible limit of IS: 10500:2012except TDS, Chloride, Hardness that was found to be exceeding the permissible limit as per IS:10500:2012 in one sample. Heavy metals were found to be below detection limit.

Surface Water Quality

Surface water was sampled from eighteen representative locations. The water samples were analyzed and compared as perIS 2296. The pH of the surface water samples varied from 4.1-6.6. The DO levels at all thelocations exhibited values ranging from 4.2-7.3 mg/l. Chloride and nitratecontent of all collected surface water sample ranges from 6.8-9.9 mg/l and 0.13-0.36 mg/lrespectively. The total coliform count of the surface water samples varied between (380MPN/100ml) to 560 MPN/100ml. Though thewater quality is not coming under any class designated by CPCB Water Use Criteria, butduring the field visit it has been observed that the water is being used for irrigation, bathing,cleaning and for catching fishes.

Land Use

The land use of the study area shows that majority of the land (48%) in the area is open scrub. 29% land is used for agricultural purposes. 6% of land is occupied by water bodies. 6% of land is occupied by Roads and 6% of the land by Railwayswhereas Built up area constitutes only 5% of the total land.

Soil Quality

The soil of the region is almost the same like that in the Brahmaputra valley. It is characterized by an abundance of marshes and low lands, soil of which contains a large percentage of organic matter. The alluvial soil of the district is very fertile. The primary analyses ofthe soil sampled from 18 locations in the study area shows that the soils areclayey and acidic in nature and are high in available nitrogen content. The micronutrientlevels observed in the soil samples do not indicate any extraordinary enrichment of metals orcontamination from any external sources.

Natural Hazards

The study area lies in Zone V of the Bureau of Indian Standard (BIS) 2000 which might encounter earthquakes of maximum intensity. It was revealed from Flood Hazard Maps (1998-2007) prepared by National Remote Sensing Agency (NRSA) that part of the AA-ONHP-2017/14 Block is flood prone, but majority of the proposed exploratory wells are not located at the flood prone zones.

Biological Environment

Baseline Survey and Secondary data received from Forest Department's Website and other published and unpublished document regarding sensitive ecological habitat and sensitive flora and fauna in the study area revealed that the block falls in part of Katakhal Reserve Forest and Inner line Reserve Forest. However, none of the exploratory/ appraisal wells will fall in forest area. The study area has an undulating topography characterized by hills, hillocks (Locally known as tillah), wide plains, and low-lying waterlogged areas (locally known as beels). The vegetation is mixed evergreen and deciduous forestand inthis region, forests are degraded due to development of Tea Estates and Rubber plantations.

Traffic Survey

The vehicular traffic was monitored on National Highway NH-154, connects Badarpur with Hailakandi, NH-53 which connects Silchar with Karimganj and on SH-39 which connects Karimganj-Hailakandi-Silchar on hourly basis for 24 hours once during the study periodat six locations i.e. Srikona (NH-53), Duarbond (SH-39), Hailakandi (NH-154), Lalapur (NH-154), Chandrapur (SH-39) and Ramakrishna Nagar (Bishnunaga-Bhairabnagar road). Movement of traffic shall be very minimum which shall be used only for mobilization of manpower and consumable materials on continuous basis. Road Safety & Traffic Management Plan outlines specific measures would adopted and implemented by Vedanta Limited (Division: Cairn Oil & Gas) to mitigate any potential impact on community health and safety that may arise out of movement of vehicles and transportation of drilling rig and other heavy equipment during construction, drilling and decommissioning of well sites.

Socioeconomic Environment

The socio-economic baseline has been prepared on the basis of available secondary sources of information was generated through site observation , individual interviews and focus group discussion with the people living in the villages identified to be within the study area. In addition to this, Field survey was conducted in the villages from 115 participants. It has also been undertaken to assess their and awareness and perceptions about the proposed project. Random interactions were also made with the local communities, school teacher, PHC centre, stake holders, and anganwadi workers.

The entire Cachar district is divided into two Sub-divisions: such as Silchar and Lakhipur. Again each sub-division is divided into revenue circles and under revenue circles there are Mouzas comprising revenue villages. The district comprises of five Revenue Circles, Katigora, Silchar, Udarband, Lakhipur and Sonai covering 1040 villages.

From Karimganj, there are 7 towns (2 statutory towns and 5 Census towns) in the district. The district is comprised of 936 villages with 7 Community Development Blocks. The district possesses 5 Revenue Circles namely, Karimganj, Badarpur, Nilambazar, Patharkandi and Ramkrishna Nagar. The district area is divided among 7 Police Stations, namely Karimganj, Badarpur, Patharkandi, Ramakrishana Nagar, Ratabari, Nilambazar and Bazerichera.

The district Hailakandi is situated in the Barak Valley region of Assam. It comprises 4 Revenue Circle with 331 villages. It has 5 Community Development Blocks. There is no any jurisdictional changes taken place during 2001-2011. The district has 3 towns (2 statutory towns and 1 census towns).

The average literacy rate is Cachar in 79.34, Hailakandi, literacy rate of in 2011 were 74.33 and Karimganj is at 78.22.

ENVIRONMENTAL IMPACT ASSESSMENT AND MITIGATION MEASURES

The potential impacts of the project on different components of the environment was systematically identified and evaluated for significance. The principal concerns that emerged are:

Impact on Air Quality

The potential sources of air emissions at well sites will be as follows:

- Operation of vehicles and construction/ site preparation machinery
- Construction/ site preparation material transport, storage and handling

The operation of DG sets, movement of vehicles and machineries during construction/ site preparation anddrilling at drill sites will result in the generation of air pollutants viz. PM, NOx, SOx and CO whichmay affect the ambient air quality temporarily. Air pollutants like NOx will also be generatedas a result of flaring of natural gas.

Mitigation measures

- All vehicles used for transportation of loose and friable materials will not be loaded over the freeboard limit and will be covered.
- Water spraying will be done on the access roads to control re-entrained dust during dry season.
- Equipment, machinery and vehicles having inbuilt pollution control devices will be considered as a measure for prevention of air pollution at source.

Impact on Noise Quality

Potential impact on noise quality is anticipated from operation of construction/site preparation machineries/equipments and vehicular movement during site preparatory activities. Operation of heavy machinery/equipments and vehicular movement during site preparatoryand road strengthening/construction activities may result in the generation of increased noiselevels. Operational phase noise impacts are anticipated from operation of drilling rig andancillary equipment, shale shakers, mud pumps and diesel generators.

Mitigation measures

- Periodic maintenance of vehicles and machinery to be undertaken
- Providing Personnel Protective Equipments (PPEs) like ear plugs/muffs to workers at site.

Impact on Soil Quality

The soil of the block in the Assam province is silty alluvial in nature thereby contributing to the agricultural productivity of the region. Stripping of top soil is therefore likely to affect the soil fertility of the well site. Potential impact on soil quality may result from storage and handling of fuel, lubricants and from storage and handling of drilling mud and drill cuttings.However, such impact is considered to be temporary taking into account the fact the proper reinstatement of site will be undertaken by the proponent in case the exploratory wells are not indicative of any commercially exploitable hydrocarbon reserves.

Mitigation measures

- Carrying out adequate restoration of soil, to the extent possible;
- Implementing adequate sediment control measures to prevent discharge of untreated surface run-off characterized by increased sediment load to abutting agricultural land.
- Ensuring proper storage of drill cutting and chemicals to prevent any potential contamination from spillage.

Impact on Topography and drainage

Potential impact on drainage and topography viz. alteration of drainage pattern, water logging etc. are anticipated during well site preparation, widening/strengthening of access roads and surface runoff from construction sites. There would be slight change in topography at the drill site as it will be elevated from ground level to avoid storm water accumulation. This may lead to alteration of onsite micro-drainage pattern leading to potential problems of water logging in the agricultural land and settlements abutting the drill site.

Mitigation measures

- Leveling and grading operations will be undertaken with minimal disturbance to the existing contour, thereby maintaining the general slope of site;
- Loss of micro-watershed drainage, if any, is to be compensated through provision of alternate drainage.
- Disruption/alteration of micro-watershed drainage pattern will be minimized to the extent possible.
- Proper engineering control must be employed as mitigation measures so that the flow and the course of the stream will not be altered.

Impact on Water Quality and Hydrology

The surface run off from drilling waste (cuttings and drilling mud), hazardous waste (waste oil, used oil etc) and chemical storage facilities on open soil is likely to contaminate if allowed to flow into nearby water bodies viz. natural drainage channels, ponds etc.

Mitigation measures

- Drainage and sediment control systems at the well site will be efficiently designed
- Proper treatment of all wastewater and produced water discharges will be made to ensure that they comply with criteria set by the regulatory body (MoEF&CC and SPCB/CPCB)
- 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.

Impact on Biological Environment

Impact on the ecology will be mainly confined to drilling site and will vary with the proximity from the drilling locations.During the site preparation activities vegetation clearance would be nominal or minor. Efforts will be made to avoid areas of comparatively dense vegetation cover, unless absolutely essential. The land, in case the exploration drilling is unsuccessful, would be restored in its original condition.

Mitigation measures

- Minimum clearance of vegetation during site preparation

Impact on Socio economic Environment

The land requirement would be very less and on temporary short term lease and at a suitable distance from the settlements. If the identified lands are of private landowners then land lease mode will be applied and in case of govt. land, land allotment from Govt. to be applied. Initially temporary short term lease will be taken for 3-5 years for exploration purpose and in case of commercially viable discovery of hydrocarbon resources; the land lease would be converted into long term lease up to life of the project. Compensation to affected landowners for any loss of land, Vedanta Limited (Division: Cairn Oil & Gas) will ensure the livelihood of local community, if any affected by the proposed land take, are identified and compensated through adequate compensation.

The project will benefit the people living in the neighboring villages through direct & indirect employment opportunities associated with the various project activitiesand boosts the local economy.

Mitigation measures

- Construction/ site preparation phase could lead to creation of direct/indirect employment and procurement opportunities.

Quantitative Risk Assessment

The quantitative risk assessment has been done to provide a systematic analysis of the major risks associated with exploratory drilling activities in AA-ONHP-2017/14 Block. Oil spills, loss ofwell control/blow-out and process leaks constitute the major potential hazards of onshoredrilling.

Risk mitigation measures

- Necessary active barriers (e.g. 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;
- Penetration rate shall be monitored. In case of any drilling break, stop rotary table, pull out the Kelly, stop mud pump and check for self flow;
- Before starting drilling, hole should be centered to avoid touching of kelly with casing / wellhead and ensure that no damage is done to well head and BOP.

ENVIRONMENTAL MANAGEMENT PLAN AND MONITORING PLAN

Vedanta Ltd. (Division: Cairn Oil & Gas) has formulated a Health, Safety and Environment (HSE) Policy for its operations. Through the HSE Policy, Vedanta Ltd. (Division: Cairn Oil & Gas) is committed to protect the health and safety of everyone involved in its operations, and the sustainability of the environment in which it operates. Vedanta Ltd. (Division: Cairn Oil & Gas) strives for continual improvement and the adoption of national/international codes and standards. Vedanta Ltd. (Division: Cairn Oil & Gas) aims at ensuring that all its operations comply with applicable health, safety and environmental laws, regulations and other requirements.

A comprehensive environmental monitoring plan has been developed for the project. Monitoring of ambient air quality, noise levels, soil and groundwater quality to be carried out by MoEF&CC/NABL/SPCB recognized laboratories during pre and post drilling operations.

Proposed CER Strategy

As per MoEF&CC office memorandum number F.No 22-65/2017-IA-III dated 1st May, 2018, Corporate Environmental Responsibility requirement will be fulfilled.

PROJECT COST

The total project cost for the proposed project activities in the AA-ONHP-2017/14 block is estimated to be around 560.0 crores.

CHAPTER – I

INTRODUCTION

1.0 INTRODUCTION

Vedanta (erstwhile Cairn India Limited merged with Vedanta Limited w.e.f. April 11, 2017, pursuant to NCLT order dated March 23, 2017) is a globally diversified natural resources company. Vedanta Ltd. (Division: Cairn Oil & Gas) is the operator of the Onshore AA-ONHP-2017/14 block. The block covers an area of 1719 Sq. Km in Karimganj, Hailakandi, Cachar district of Assam and Kolasib district of Mizoram. Vedanta Ltd. has been allocated AA-ONHP-2017/14 block by Government of India under the Revenue Sharing Contract (RSC) for exploration and exploitation of hydrocarbons. A Revenue Sharing Contract (RSC) was signed between the Government of India (GoI) and Vedanta Ltd on 1st October 2018.

1.1. IDENTIFICATION OF PROJECT & PROJECT PROPONENT

1.1.1 Identificaiton of Project

Vedanta Limited (Division: Cairn Oil & Gas) proposes to carryout exploratory (including appraisal) well drilling and setting up of Early Production Units (EPUs)/ Quick Production Units (QPUs) in the block AA-ONHP-2017/14 at Karimganj, Hailakandi, Cachar district of Assam and Kolasib district of Mizoram. In case of a discovery (ies), the exploratory and appraisal well(s) will be tested for extended duration by flowing hydrocarbons to ascertain the reservoir parameters and assess the quality and commercial viability. Moreover, in case of commercially viable discovery (s) of hydrocarbons in the block and having established the size of the hydrocarbon field (s), field will be immediately brought into early production of crude oil and associated gas using some of the successful exploratory/ appraisal wells by setting up of temporary and mobile Early Production Units (EPUs)/ QPUs (Quick Production Units) for the processing of produced well fluids.

1.2. NATURE OF THE PROJECT

The proposed project is green field in nature. The project is an oil and gas exploration and early production project.

1.3. PURPOSE OF THE PROJECT

As per Environmental Impact Assessment EIA Notification dated 14th September, 2006 and subsequent amendments, onshore exploration, development and production of oil & gas project falls under category ‘A’ of activity 1(b) requires prior Environmental Clearance (EC) to be obtained from MoEF&CC before the commencement of ground activity.

Terms of Reference (TORs) for the preparation of EIA/EMP report has been issued by MoEF&CC vide letter reference F.No. IA-J-11011/148/2019-IA-II(I) dated 13th May 2019.

This Draft EIA Report is prepared in line with the TOR issued by MoEF&CC and addresses the anticipated environmental impacts of the proposed project and proposes the mitigation measures for the same for obtaining Environmental Clearance (EC) from MoEF&CC, New Delhi.

1.4 BRIEF DESCRIPTION OF NATURE, SIZE, LOCATION OF THE PROJECT

1.4.1 Nature of the Project

The proposed project is green field in nature. The project is an oil and gas exploration, appraisal & well testing and early production project.

1.4.2 Size of the Project

The proposed onshore oil and gas exploration, appraisal and early production is expected to carry out:

1. Drilling of 24 exploratory (including appraisal) wells and testing
2. Setting up of Early Production Units (EPUs)/ Quick Production Units (QPUs) for produced well fluid processing and early production of up to 8000 BOPD of crude oil and 1.6 MMSCFD of associated natural gas.

1.4.3 Location of the Project

The AA-ONHP-2017/14 block is located in Karimganj, Hailakandi, Cachar districts of Assam and Kolasib district of Mizoram. It covers an area of 1719 Sq. Km.

1.5 IMPORTANCE OF THE PROJECT TO COUNTRY AND REGION

The demand for petroleum has recorded a considerable increase over the last few years. There is a considerable increase in consumption of petroleum products due to the development activities in the country in the last few years. During the year 2016-17, the consumption of petroleum products in India was 194.60 MMT with a growth of 5.37% as compared to consumption of 184.67 MMT during 2015-16. The consumption of petroleum products during April-November, 2017 was at 134.60 MMT i.e. an increase of 3.40% over 130.17 MMT in April-November, 2016. The crude oil production for the year 2016-17 is at 36.01 Million Metric Tonnes (MMT) as against production of 36.94 MMT in 2015-16, showing a decrease of about 2.53%. Whereas Natural Gas production during the year 2016-

17 is at 31.90 Billion Cubic Meters (BCM) which is 1.09% lower than production of 32.25 BCM in 2015-16. Import of crude oil during 2016-17 was 213.93 MMT valued at 470159 crore as against import of 202.85 MMT valued at 416579 crore in 2015-16 which marked an increase of 5.46% in quantity terms and 12.86% in value terms as compared to the import of crude oil during 2015-16.

India is largely dependent on import of petroleum goods to meet its requirements. Facing an environment of increasing consumption, static reserves, increasing imports and increasing costs of crude as well as decreasing value of the Indian Rupee vis-à-vis the US Dollar, it follows that any accretion of hydrocarbon reserves in the country, is welcome.

Vedanta's proposed exploratory and appraisal drilling project could possibly result in the discovery of hydrocarbon and subsequent development and production would help in reducing India's dependence on imports. Consequently, the need for the project is evident. Additionally the proposed project would generate direct and indirect employment in the region.

1.6 SCOPE OF THE STUDY

The scope of the EIA study considers the impact due to drilling of 24 onshore exploratory and appraisal wells and setting up of Early Production Units (EPUs)/ Quick Production Units (QPUs) in AA-ONHP-2017/14 on physical, biological and socioeconomic environment of the surrounding areas in compliance to the approved ToR provided by MoEF&CC. The scope of the EIA study includes the following:

- To establish the prevailing environmental and socio-economic condition of the study area;
- To assess environmental and socioeconomic impacts arising out of the proposed activities;
- To recommend appropriate preventive and mitigation measures to eliminate or minimize pollution;
- To identify and propose management plans in terms of good practices that may help in abating environmental or socio-economic impacts due to the proposed project;
- To prepare a Disaster Management Plan (DMP) based on Risk Assessment/studies.

Environmental baseline monitoring has been carried out during March' 2019 to June' 2019 representing summer season and used to identify potential significant impacts.

1.7 ENVIRONMENTAL PARAMETERS IN THE STUDY AREA

Collection of base line data is an integral aspect of the preparation of draft Environmental Impact Assessment report. Base line data reflects the present scenario of Environment before the initiation of any activity of the proposed project. The possible effects due to the proposed project are estimated and superimposed on the compiled baseline data subsequently to asses Environmental impacts.

Pre project environment assessment was conducted in the study area during March' 2019 to June' 2019. Studies were under taken to generate base line data of the following:-

1. GEOLOGY
2. HYDROGEOLOGY
3. METEOROLOGY
4. AMBIENT AIR QUALITY
5. WATER QUALITY - GROUND WATER & SURFACE WATER
6. AMBIENT NOISE QUALITY
7. SOIL QUALITY
8. ECOLOGY
9. LAND USE / LAND COVER
10. SOCIO – ECONOMIC STATUS SURROUNDING THE PROJECT SITE.

1.8 GENERIC STRUCTURE OF EIA DOCUMENT

In terms of the EIA notification of the MoEF dated 14th September 2006 and subsequent amendments, the generic structure of the EIA document should be as under:

	Executive Summary of Draft EIA report
Chapter – I:	Introduction
Chapter – II:	Project Description
Chapter – III:	Environmental Baseline Study
Chapter – IV:	Impact Assessment & Mitigation Measures
Chapter – V:	Analysis of alternatives (Technology and site)
Chapter – VI:	Environmental Monitoring Programme
Chapter – VII:	Additional Studies
Chapter – VIII:	Project Benefits
Chapter – IX:	Environmental Management Plan
Chapter – X:	Summary & Conclusion
Chapter – XI:	Disclosure of Consultants engaged

1.9 COMPLIANCE TO ToR

ToR F. No.IA-J-11011/148/2019-IA-II(I) dated 13.05.2019

Sl. No.	TOR Points	TOR Compliance/Section No.
	Standard Terms of Reference	
1	Executive Summary of the Project	The same is attached along with EIA report.
2	Project Description, project objectives and Project Benefits	Project Description in section 2.7 of Chapter 2, Project Objectives in section 2.2 and Project Benefits provided in Chapter 8 of EIA report
3	Cost of Project and period of completion	Cost of Project provided in section 2.11 of Chapter 2
4	Site details within 1km of the each proposed well, any habitation, any other installation/activity, flora and fauna approachability to Site, other activities including agricultural/ land, satellite imagery for 10 km area. All the geological details shall be mentioned in the Topo sheet of 1:40000 scale, superimposing the well locations and other structures of the projects. Topography of the project site.	Site details within 2.5 km of the each proposed well given in section 2.6 of Chapter 2 Satellite image for 10 km area shown in Fig 2.2 of Chapter 2
5	Details of sensitive areas such as National Park, Wildlife sanctuary and any other eco-sensitive area along with map indicating distance.	Borail Wildlife Sanctuary ESZ boundary at a distance of 8.76 km from the proposed Block boundary. No project activities proposed within ESZ of the sanctuary. Map indicating the distance between the AA-ONHP-2017/14 block boundary and Borail Wildlife Sanctuary ESZ boundary attached as **Annexure-II**
6	Approval for the forest land from the State/Central Govt. under Forest (Conservation) Act, 1980, if applicable.	Approval for Forest Land from State/Central Govt. under Forest (Conservation) Act, 1980 will be obtained, if applicable. However, none of the project activity falls on forest land.

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.	No critically/severely polluted area is present within 10km radius of the AA-ONHP-2017/14 block.
9	Does proposal involve rehabilitation and resettlement? If yes, details thereof.	The proposed project will not require rehabilitation and resettlement.
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.	The Environmental considerations are given in section 2.3 of Chapter 2
11	Baseline data collection for air, water and soil for one season leaving the monsoon season in an area of 10 km radius with centre of Oil Field as its centre covering the area of all proposed drilling wells.	The baseline studies were carried out from March 2019 to June 2019 during Pre monsoon season. Details provided in Chapter 3 of EIA report.
12	Climatology and Meteorology including wind speed, wind direction, temperature rainfall relative humidity etc.	Climatological and Meteorological study including wind speed, wind direction, temperature, relative humidity, rainfall was conducted and the results are provided in Section 3.4 of Chapter 3
13	Details of Ambient Air Quality monitoring at 8 locations for PM2.5, PM10, SO2, NOx, CO, VOCs, Methane and non-methane HC.	Results of Ambient Air Quality monitoring are given in section 3.5 of Chapter 3.

14	Soil sample analysis (physical and chemical properties) at the areas located at 5 locations.	Details of Soil Sampling analysis are given in section 3.7 of Chapter 3.
15	Ground and surface water quality in the vicinity of the proposed wells site.	Surface water and ground water quality have been monitored and results are given in section 3.6 of Chapter 3.
16	Measurement of Noise levels within 1 km radius of the proposed wells	Noise level survey results are given in section 3.8 of Chapter 3.
17	Vegetation and land use; flora/fauna in the block area with details of endangered species, if any	Details of flora and fauna are given in section of 3.11 Chapter 3.
18	Incremental GLC as a result of DG set operation, flaring etc.	Incremental GLC concentration results are mentioned in section 4.3.2 of Chapter 4
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 is given in Chapter 4.
20	Actual source of water and 'Permission' for the drawl of water from the Competent Authority. Detailed water balance, wastewater generation and discharge.	The water requirement for the project activities will be sourced locally through approved/ authorized sources and surface water and/ or ground water after obtaining prior permission from concerned authority. Water requirement given in section 2.9.17 of Chapter 2. Wastewater generation details and mode of treatment are given in section 2.10 of Chapter 2.
21	Noise abatement measures and measures to minimize disturbance due to light and visual intrusions.	Noise control measures are given in section 4.3.3 of Chapter 4.
22	Details on wastewater generation, treatment and utilization /discharge for produced water/ formation	Wastewater generation details and mode of treatment are given in section 2.10 of Chapter 2 and section 4.3.6 of Chapter 4.

	water, cooling waters, other wastewaters, etc. during all project phases.	
23	Details on solid waste management for drill cuttings, drilling mud and oil sludge, produced sand, radioactive materials, other hazardous materials, etc. including its disposal options during all project phases.	Details on solid waste management given in section 9.4.2 of Chapter 9.
24	Disposal of spent oil and lube.	Management of used oil details are given in section 2.10 of Chapter 2.
25	Storage of chemicals and diesel at site. Hazardous material usage, storage and accounting.	Chemicals and diesels will be stored on paved areas, Bund wall will be provided to diesel storage area, Spill kits will be made available in chemical and diesel storage area, covered shed will be constructed for storage areas. Details provided in section 2.9.10 and 2.9.18 of Chapter 2.
26	Commitment for the use of water based mud (WBM) only	Given in section 2.9.15 of Chapter 2.
27	Oil spill emergency plans for recovery/ reclamation.	Oil Spill Management Plan given in section 9.4.4 of Chapter 9.
28	H_2S emissions control.	H_2S emissions control measures given in section 7.1.7 of Chapter 7.
29	Produced oil/gas handling, processing and storage/ transportation.	Produced oil stored temporarily in oil storage tanks. From oil storage tanks, oil will be pumped & loaded in to road tanker using the tanker loading facility for evacuation of crude oil to the nearby available facilities like terminals/ depots of consumers.
30	Details of control of air, water and noise pollution during production phase.	Provided in section 9.4.1, 9.4.5 9.4.6 and 9.4.7 of Chapter 9.

31	Measures to protect ground water and shallow aquifers from contamination.	Measures to protect ground water and shallow aquifers from contamination provided in section 4.3.6 of Chapter 4.
32	Whether any burn pits being utilised for well test operations.	Burn pits will not be used.
33	Risk assessment and disaster management plan for independent reviews of well designed construction etc. for prevention of blow out. Blowout preventer installation.	Risk and disaster management plan details are given in Additional studies Chapter 7 of EIA report.
34	Environmental management plan.	EMP provided in Chapter 9 of EIA report.
35	Total capital and recurring cost for environmental control measures.	Total capital and recurring cost for environmental control measures given in section 9.6 of Chapter 9.
36	Emergency preparedness plan	Emergency preparedness plan provided as **Annexure-III**
37	Decommissioning and restoration plans.	Decommissioning and restoration plans provided in section 2.8.3 of Chapter 2.
38	Documentary proof of membership of common disposal facilities, if any.	Not Applicable
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.	Regular health check up of Vedanta Limited (Division: Cairn Oil & Gas) personnel conducted as per Vedanta HSE Policy. Surveillance safety programs carried at regular intervals and documented.
40	A copy of Corporate Environment Policy of the company as per the Ministry's O.M. No. J-11013/	HSE Policy of Vedanta Limited (Division: Cairn Oil & Gas) given in **Annexure-IV**

	41/2006-IA.II(I) dated 26th April, 2011 available on the Ministry's website.	
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.	Not Applicable

1.10 LIMITATIONS

This EIA study is based on certain scientific principles and professional judgement to certain facts with resultant subjective interpretation. Professional judgement expressed herein is based on the available data and information.

This report has been developed based on the project related information provided by Vedanta Limited (Division: Cairn Oil & Gas) with the assumption that the information gathered is representative for the proposed drilling of 24 onshore exploratory and appraisal wells in **Karimganj, Hailakandi, Cachar Districts of Assam and Kolasib District of Mizoram**. If information to the contrary is discovered, the findings in this draft EIA may need to be modified accordingly. The impact assessment for the Project is based on the project configuration as described in Chapter 2 Project Description.

CHAPTER – II

PROJECT DESCRIPTION

2.0 INTRODUCTION

Vedanta Limited (Division: Cairn Oil & Gas) proposed drilling of 24 onshore exploratory and appraisal wells and Setting up of Early Production Units (EPUs)/ Quick Production Units (QPUs) for produced well fluid processing and production of up to 8000 BOPD crude oil and up to 1.6 MMSCFD associated natural gas in AA-ONHP-2017/14 block located in **Karimganj, Hailakandi, Cachar Districts of Assam and Kolasib District of Mizoram**.

In case of a discovery (ies), the exploratory and appraisal well(s) will be tested for extended duration by flowing hydrocarbons to ascertain the reservoir parameters and assess the quality and commercial viability. Moreover, in case of commercially viable discovery (s) of hydrocarbons in the block and having established the size of the hydrocarbon field (s), field will be immediately brought into early production of crude oil and associated gas using some of the successful exploratory/ appraisal wells by setting up of temporary and mobile Early Production Units (EPUs)/ QPUs (Quick Production Units) for the processing of produced well fluids.

2.1 OBJECTIVES OF PROPOSED PROJECT

Specific objectives of the proposed drilling activities are summarized below:

- To develop and produce hydrocarbons safely
- To Augment national production of oil & gas

2.2 OBJECTIVES OF PROPOSED DRILLING ACTIVITY

The project will ultimately cater to fulfill the energy requirement of India. The dependency of India on other countries will be lessened to an extent. Additionally, the project will benefit people living in neighboring villages in relation to direct & indirect employment associated with various project activities and will boost the local economy. The benefits of the project are listed below:

- Provision of more royalty to Assam Government and more cess to Govt. of India
- Provision of more employment opportunity to local people
- Development of infrastructure (roads, culverts, bridges etc.) in the area
- Increase in business opportunity for the local people
- Energy security for the country

2.3 LOCATION OF THE PROJECT

The AA-ONHP-2017/14 block is located in Karimganj, Hailakandi, Cachar districts of Assam and Kolasib district of Mizoram. It encloses an area of 1719 Sq. Km. and satellite imagery is shown in **Figure 2.1& 2.2**.

The block covers a total area of 1719 Sq. Km out of which 1716.5 Sq. Km falls under Karimganj, Hailkandi and Cachar districts of Assam and the remaining 2.5 Sq. Km falls in the Kolasib district of Mizoram. The map of the block with block co-ordinates is presented in**Figure 2.3** and the detailed co-ordinates are given in **Table 2.1**.

The locations for the drilling of wells will be fixed once the detailed interpretation of the acquired seismic survey is over. However, the wells will be strictly confined within the acquired block itself. Since the exact drilling locations are yet to be determined, the details of the block location are provided herewith. The tentative drilling locations are presented in Survey of India toposheet given in **Figure 2.4** and the proposed co-ordinates of the exploratory & appraisal wells are given in the **Table 2.2**

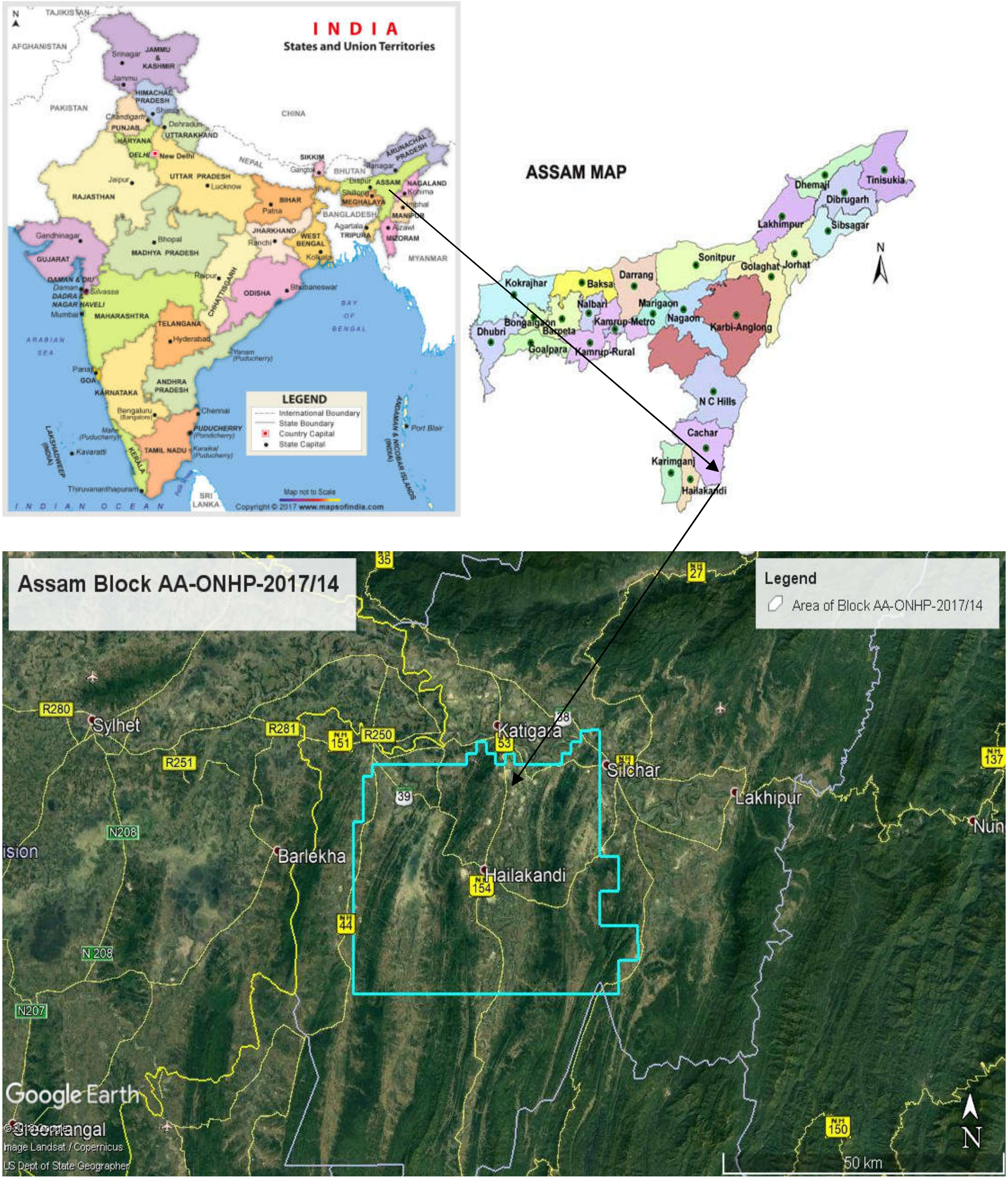


Fig 2.1 Location map

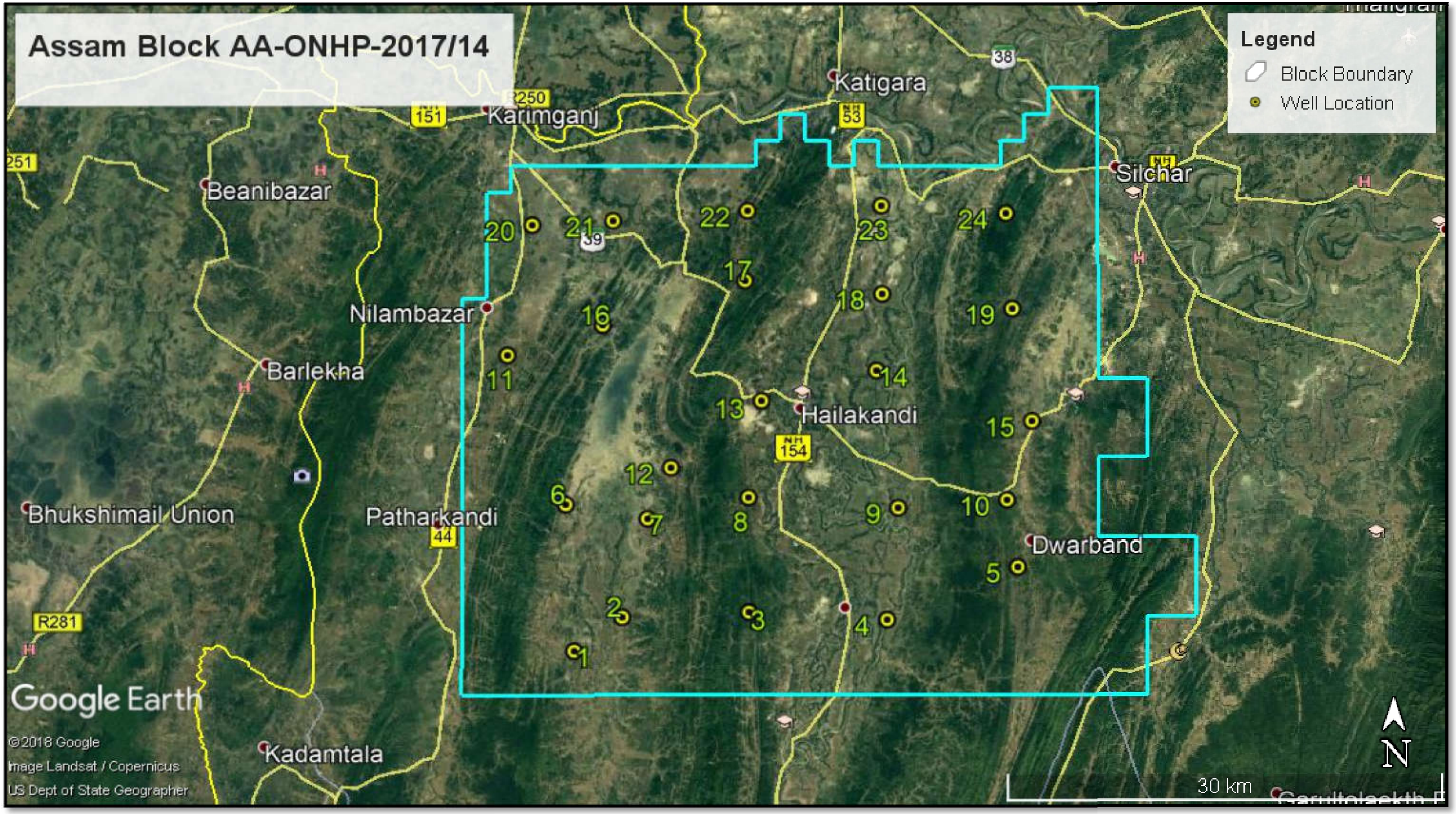


Fig 2.2 Map showing the Block boundary and Well Locations

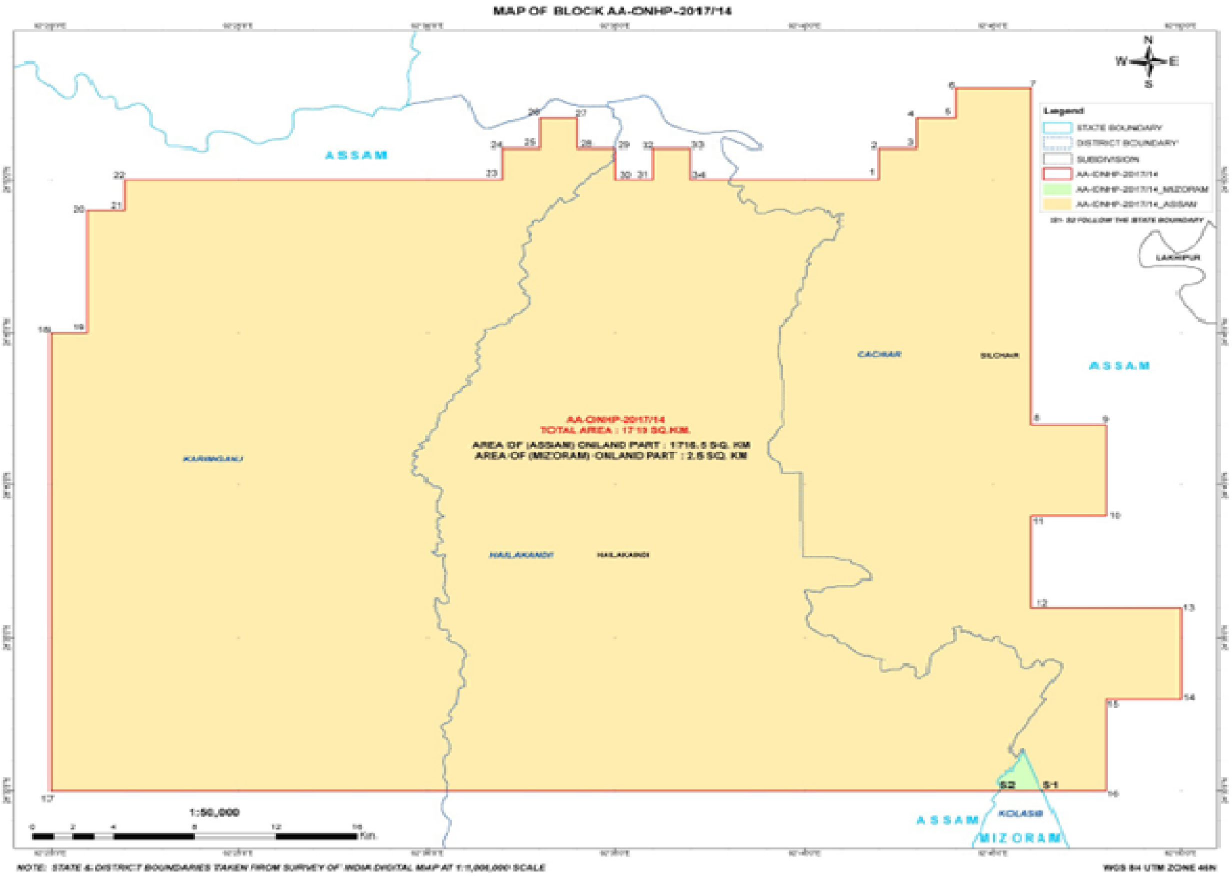


Fig. 2.3 Area map of block AA-ONHP-2017/14 falling under different state boundary

Table 2.1 Co-ordinates of Block AA-ONHP-2017/14 boundary *(as per RSC)*

Co-ordinates of Block AA-ONHP-2017/14 within state of Assam		
Points	**Latitude**	**Longitude**
1	24°50'	92°42'
2	24°51'	92°42'
3	24°51'	92°43'
4	24°52'	92°43'
5	24°52'	92°44'
6	24°53'	92°44'
7	24°53'	92°46'
8	24°42'	92°46'
9	24°42'	92°48'
10	24°39'	92°48'
11	24°39'	92°46'
12	24°36'	92°46'
13	24°36'	92°50'
14	24°33'	92°50'
15	24°33'	92°48'
16	24°30'	92°48'
17	24°30'	92°20'
18	24°45'	92°20'
19	24°45'	92°21'
20	24°49'	92°21'
21	24°49'	92°22'
22	24°50'	92°22'
23	24°50'	92°32'
24	24°51'	92°32'
25	24°51'	92°33'
26	24°52'	92°33'
27	24°52'	92°34'
28	24°51'	92°34'
29	24°51'	92°35'
30	24°50'	92°35'
31	24°50'	92°36'
32	24°51'	92°36'
33	24°51'	92°37'
34	24°50'	92°37'
Co-ordinates of Block AA-ONHP-2017/14 boundary within state of Mizoram		
1	24°30'	92°46'19.46"
2	24°30'	92°45'10.26"

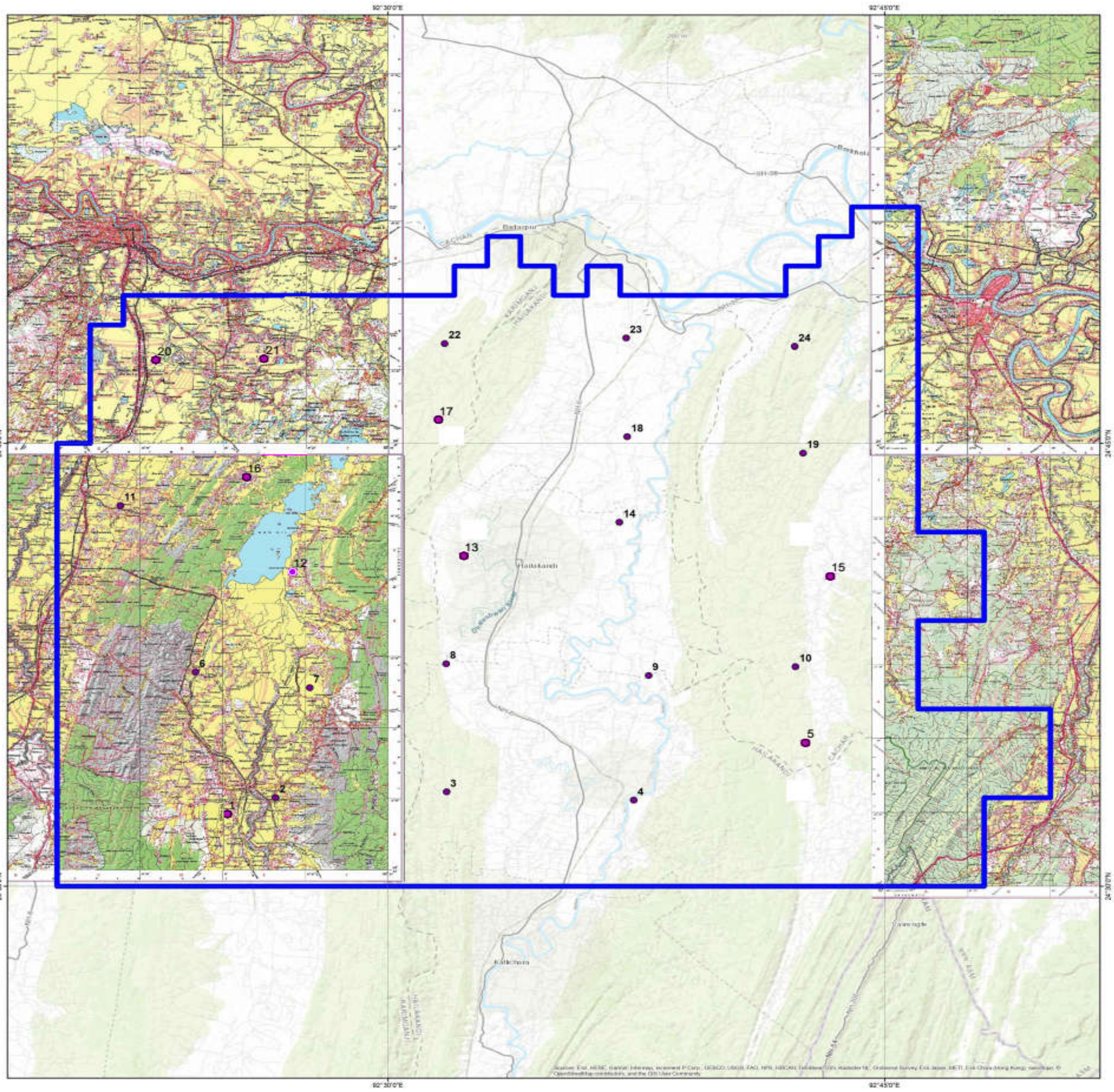


Fig. 2.4Proposed well Locations in Block AA-ONHP-2017/14 on SOI Toposheet

Table 2.2 Proposed well co-ordinates to be drilled in block AA-ONHP-2017/14

Well_id	Longitude	Latitude
1	92°24'38.83"E	24°31'42.90"N
2	92°26'36.47"E	24°32'59.90"N
3	92°31'46.37"E	24°33'11.80"N
4	92°37'24.76"E	24°32'54.70"N
5	92°42'45.03"E	24°34'53.84"N
6	92°24'18.13"E	24°37'15.18"N
7	92°27'38.36"E	24°36'43.29"N
8	92°31'45.40"E	24°37'31.86"N
9	92°37'51.87"E	24°37'8.26"N
10	92°42'18.30"E	24°37'26.06"N
11	92°21'54.96"E	24°42'53.70"N
12	92°28'35.59"E	24°38'39.29"N
13	92°32'17.26"E	24°41'11.14"N
14	92°36'58.88"E	4°42'19.63"N
15	92°43'19.86"E	24°40'25.11"N
16	92°25'48.18"E	24°44'2.59"N
17	92°31'36.90"E	24°45'43.46"N
18	92°37'13.06"E	24°45'13.42"N
19	92°42'31.91"E	24°44'39.96"N
20	92°22'55.09"E	24°47'49.27"N
21	92°26'13.43"E	24°47'59.13"N
22	92°31'42.93"E	24°48'22.14"N
23	92°37'11.03"E	24°48'33.52"N
24	92°42'16.66"E	24°48'16.37"N

Note: *Actual geographical surface coordinates of exploratory and appraisal well locations will be within 2000m radius of the proposed coordinates.*

2.4 SALIENT FEATURES OF THE PROJECT

The salient features of the project are given in **Table 2.3**

Table 2.3 Salient Features of the Proposed Project

Particulars	Details
Company Name	Vedanta Limited (Division: Cairn Oil & Gas)
Name of the Block	AA-ONHP-2017/14 block in Karimganj, Hailakandi, Cachar districts of Assam and Kolasib district of Mizoram
Area of Block	1719 Sq. Km
Category of the Project	As per EIA Notification dated 14th Sept., 2006 as amended from time to time, this project falls under S.No. 1 (Mining, extraction of natural resources and power generation),

	Project activity "1 (b)"- Offshore and onshore oil and gas exploration, development & production.
Co-ordinates of initial wells	Refer Table 2.2
Land Required for each well pad	About 300m x 300m would be taken on temporary short-term lease basis for the construction of well pad, drill site, etc.
Early production plan	Setting up of Early Production Units (EPUs)/ Quick Production Units (QPUs) for produced well fluid processing and early production of up to 8000 BOPD of crude oil and 1.6 MMSCFD of associated natural gas.
Depth of well	1750-5000 m
Duration of Drilling	45-60 days per well
Quantity of water requirement during drilling phase	Domestic – 20-30 m^3/day/well Drilling – 25-50 m^3/day/well
Power Requirement	The power requirement in the drilling site and the campsites will be provided through diesel generator (DG) sets.
Waste generation	Drill cuttings associated with SBM - 250-750 tons/well and Drill cuttings associated with WBM - 500-1500 tons/well Spent / Residual drilling mud of 250-500 tons per well Used /waste Oil – Approx. 1-2 ton per well
Manpower during drilling	80-100 (approx.)
Estimated Project Cost	560.0 crores

2.5 SIZE OR MAGNITUDE OF OPERATION

The proposed onshore oil and gas exploration,appraisaland early production isexpected to carry out:

1. Drilling of 24 exploratory (including appraisal) wells and testing
2. Setting up of Early Production Units (EPUs)/ Quick Production Units (QPUs) for produced well fluid processing and early production of up to8000BOPD of crude oil and 1.6 MMSCFD of associated natural gas.

2.6 SITE DETAILS / LANDUSE

The site details within 2.5 km radius of the 24 exploratory and appraisal well within Block area is given in Table 2.4

Table 2.4 Landuse/Site details of the proposed wells

Well_id	Village	Taluk	District	Site details
1	Boriali-Piyajgutti	Patharkandi	Karimganj	Agriculture field
2	Tingori	Ramkrishna Nagar	Karimganj	Agriculture field
3	Joynagar	Katlichara	Hailakandi	Open scrub, Rubber plantation
4	Nizvesnupur Pt II	Katlichara	Hailakandi	Agriculture field
5	Dwarbond	Silchar	Cachar	Rubber plantation, Tea plantation
6	Birgram	Ramkrishna Nagar	Karimganj	Agriculture field, Open scrub
7	Dolurpar	Ramkrishna Nagar	Karimganj	Agriculture field
8	Lakshinagar Pt II	Lala	Hailakandi	Open scrub, Agriculture field
9	Sudorshanpur Pt I	Lala	Hailakandi	Agriculture field
10	Duarbond Grant	Silchar	Cachar	Tea plantation
11	Singharia	Nilambazar	Karimganj	Agriculture field, Singharia village
12	Khalagaon	Ramkrishna Nagar	Karimganj	Agriculture field
13	Narainpur	Hailakandi	Hailakandi	Agriculture field
14	Bhajantipur	Hailakandi	Hailakandi	Agriculture field
15	Choto Jalenga	Silchar	Cachar	Agriculture field
16	Khagail-Morchidala	Nilambazar	Karimganj	Open scrub, Agriculture field
17	Adarkona Pt III	Badarpur	Karimganj	Open scrub, Agriculture field
18	Mohanpur Pt VI	Algapur	Hailakandi	Agriculture field
19	Chibitabichia Pt VII	Silchar	Cachar	Tea plantation, Agriculture field
20	Churadighirpar	Karimganj	Karimganj	Agriculture field
21	Chitanyanagar	Badarpur	Karimganj	Agriculture field
22	Ghatudaram	Badarpur	Karimganj	Agriculture field, Open scrub

23	Bakri Howar Pt VIII	Algapur	Hailakandi	Agriculture field, Open scrub
24	Digorsrikona Pt II	Silchar	Cachar	Open scrub

2.7 PROPOSED SCHEDULE FOR APPROVAL AND IMPLEMENTATION

The lifecycle of project activities for the proposed project has been divided into distinct steps and described in detail in the subsequent sections and will take approximately three months to complete drilling and testing activity at each well site. Vedanta Limited (Division: Cairn Oil and Gas) has planned to carry out the proposed project activities in the AA-ONHP-2017/14 Block over a period of 10-12 years.

The project lifecycle has been classified into three phases:

Pre-drilling activity

- Site selection
- Land procurement
- Site Preparation
- Site access road and drill site construction
- Pre-drilling activities, mobilization and Rigging up

Drilling activity

- Drilling of wells
- Testing of wells

Early Production- When, exploratory drilling is successful

- Drilling of Appraisal wells to quantify the hydrocarbon reserves
- Setting up of Early Production Units (EPUs)/Quick Production Units (QPUs)

Well decommissioning

- Well abandonment
- Site closure and decommissioning
- Site Restoration

2.8 PROCESS DESCRIPTION

2.8.1 Drilling of Exploration and Appraisal wells

A. Location & Description of Drilling of Exploration and Appraisal Wells

The locations for the drilling of wells will be fixed once the detailed interpretation of the acquired seismic survey is over. However, the wells will be strictly confined within the acquired block itself. Since the exact drilling locations are yet to be determined, the details of the block location are provided herewith. The proposed well depth may vary from 1750m to 5000m due to the subsurface structural configuration and the depth of occurrence of the primary reservoirs. Typically estimated drilling duration is 45-60 days/well. In general, exploratory and appraisal well testing duration is about 30 days/well. However, depending on the need,based on nature of the reservoirs, the exploratory and appraisal wells will be tested for longer (extended) durationsto ascertain the reservoir parameters. Water Base Mud (WBM) will be used as drilling fluid for initial, shallower sections where massive shale not encountered. The deeper and difficult to drill geological formations will be drilled using Synthetic Base Mud (SBM) as drilling fluid.

B. Exploratory & Appraisal well Drilling Process

All the 24 exploration & appraisal wells within the block will be drilled using an Electric Land Rig of around 1200-1500 HP capacity, equipped with a Rotary/Top Drive System.

To support drilling operation, the following systems and services will be included at the rig:

- Portable Living Quarters – to house essential personnel on site on a 24 hr basis. These nits are provided with Bath/Washroom.
- Crane-age - cranes for loading/offloading equipment and supplies.
- Emergency Systems - it includes fire detection and protection equipment.
- Environmental Protection – Blow out Prevention (BOP) system, wastewater treatment unit, cuttings handling equipment.

Additionally, there will be other ancillary facilities like Drilling mud system, Cuttings disposal, Cementing etc. and utilities to supply Power (DGsets), water, fuel (HSD) to the drilling process and will be set up as a part of the project.

The following shows the various phases of the drilling activities and model of drilling process respectively.

1. Site selection after prospect Identification
2. Temporary land acquisition on lease

3. Site and access road preparation
4. Drilling activities
5. Well testing
6. Complete the well and suspend for production in case of hydrocarbon find
7. Decommissioning & closure of wells in case no success

The various activities involved as a part of the drilling of exploration wells are described in detail in the subsequent sections.

1. Site Selection

The exploration history of the area exhibits the potential presence of the oil and gas in the region. The seismic data interpretation of the seismic survey would decide the exact locations of the drilling well.

2. Land acquisition

An area of approximately 300m x 300m would be taken on temporary short-term lease basis for the construction of well pad (drill site) for exploratory and appraisal wells. For the preparation of suitable access roads connecting to well pads, accommodating OHL and other utilities in future, a width of 30m (approx.) RoU will be required.

3. Site & Access road preparation

Site preparation will involve all activities required to facilitate the operation of the drilling rig and associated equipment and machineries. At the initial stage, the drilling site will be elevated to about 2.0 m from the existing ground level with minimal clearance of existing ground vegetation. The loose top soil will be removed by using mechanical means like bulldozer and saved at a nearby place for later use during site restoration. Levelling and compaction will be done with the help of graders and mechanical rollers. The land filling materials and rubbles will be required for the purpose of site preparation in sufficient amount.

Platforms for drill pad and all other heavy equipment systems or machinery, cast in-situ Reinforced Cement Concrete (RCC) will be used for the construction of foundation system. The rig foundation will be of 20m X 20m in size and will have an elevation of 0.6 m. For making the foundations of main rig structure, cast in-situ bored under- reamed piles of specified lengths will also be used.

The typical layout of a well pad /drill site for the exploratory/appraisal wells is shown in **Figure 2.5**

Each exploratory & appraisal well drill site will require the following:

- Potable office cabins / rest rooms (container type cubicles);
- Drilling rig foundation and cellar;
- Foundation / Pits for equipment;
- Space for drill rig equipment, working area and materials lay down area;
- Waste storage pits;
- Cutting disposal (impervious lined) pits;
- Solar evaporation pits (waste drilling fluid disposal);
- Water storage pit;
- Septic tank with soak pits;
- Paved and contained chemical storage area;
- Above ground Diesel storage tanks with paved and bunded area;
- Below ground level flare pit (well testing);
- Provisional space for definitive fracking program.
- Radio room;
- Storm water drainage system;
- Internal roads and fencing.

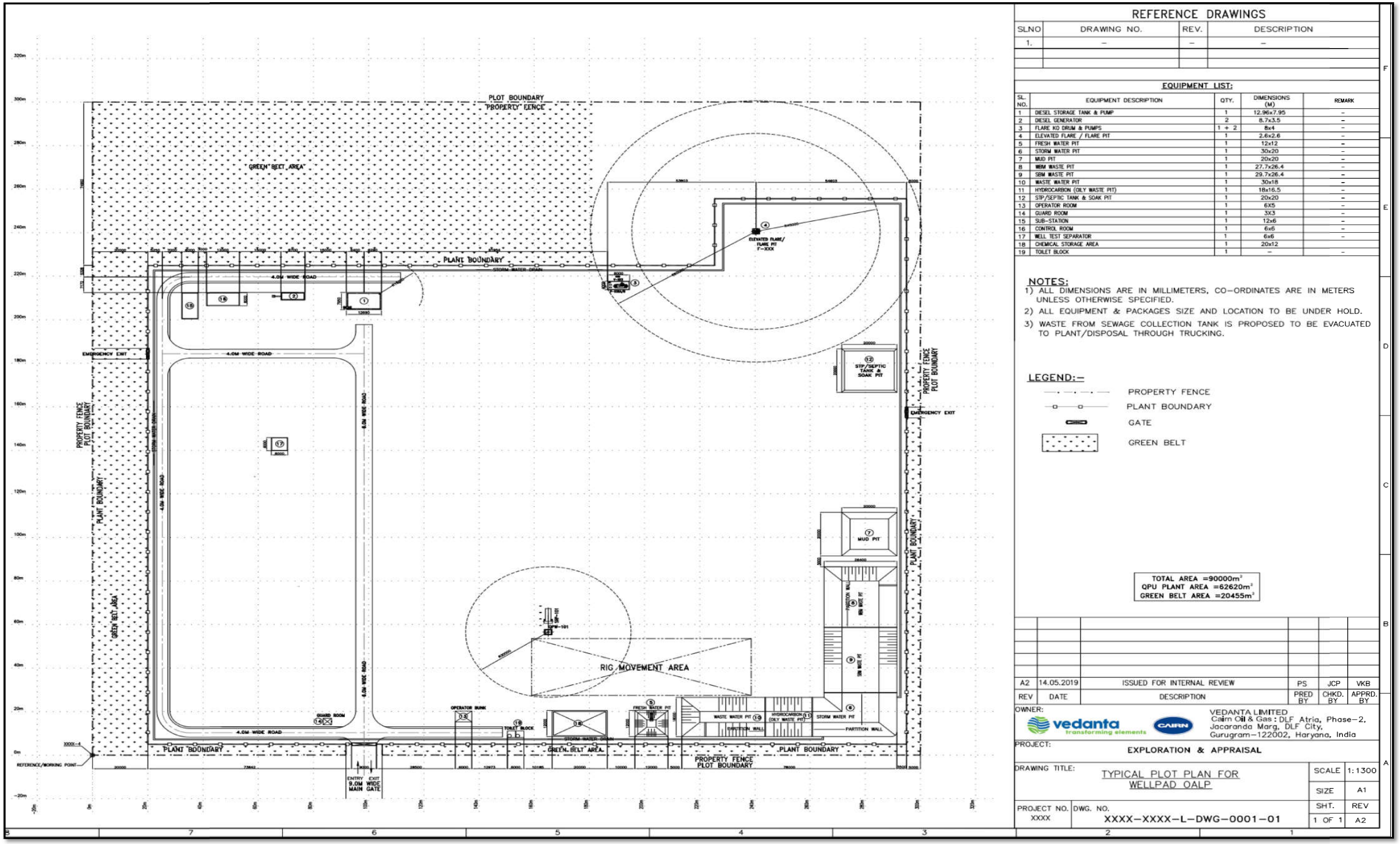


Figure 2.5 Typical Plot Plan for Well Pad

Specially designed pit of an impervious HDPE liner will be provided as part of the site development for disposal of drilling waste in the form of spent drilling mud and cuttings.

Though the rig and related equipments will be directly brought to site, spares, mud preparing chemicals and other materials will be stored at a warehouse near to the site and will be received to the site from that intermediate storage area. The rig equipment will however be transported directly to the drilling site during mobilization and will be de-mobilized directly from the site. The materials will be intermittently supplied from warehouse to the drilling site, during the operations - with some stock at the drilling site itself.

4. Drilling Activities

Drilling Rig Type

The proposed drilling shall be carried out by using a standard land rig or a "Mobile Land Rig" with standard water based drilling fluid treatment system. This rig will be suitable for deep drilling up to the desired depth of 5000 meters (TVDSS) as planned for the project. (Table 2.4) The typical configuration of a Drilling Rig is shown in the **Figure 2.6.** Additionally, there will be other ancillary facilities like Drilling mud system, ETP, Cuttings disposal, Drill Cementing equipment etc. and utilities to supply power (DG sets), water, fuel (HSD) to the drilling process and will be set up as a part of the Project. The details of the drilling rig are as follows.

Table 2.5 Specification of the Drilling Rig

Type of Rig	Electrical Rig
Drilling mud composition	Water based mud in shallower section and synthetic based mud in deeper section
Power generator type & nos.	AC – SCR Type.
Details of solids handling systems on rig	Shale Shakers - 1200 GPM Capacity Desander – 1200 GPM Capacity Desilter – 1200 GPM Capacity

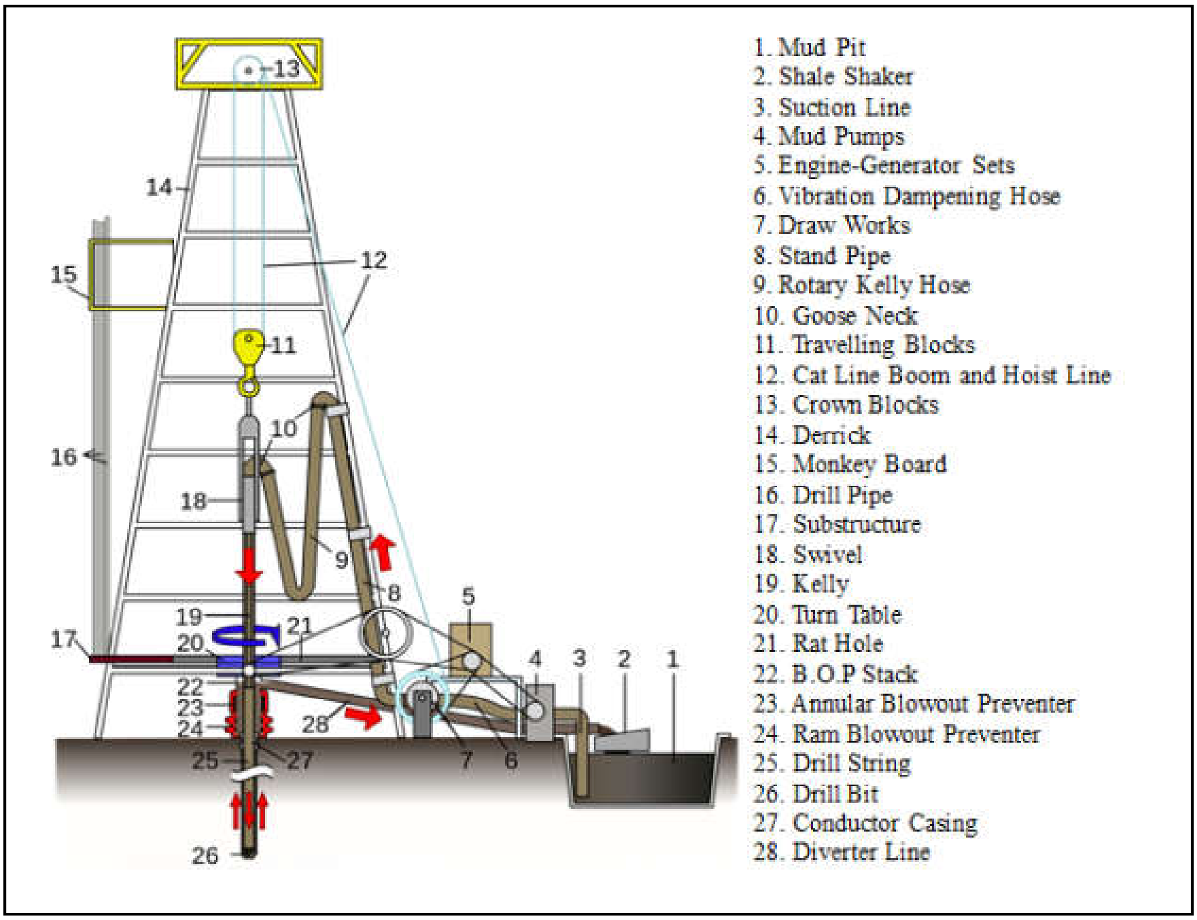


Figure 2.6 Typical configuration of a Drilling Rig

Drilling Operation

Wells will be 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/grouted. Conductor pipes provide a conduit for the return fluid during drilling next section and also prevent unconsolidated material falling into hole and potential washout problems. The lengths and diameters of each section of the well will be determined prior to the starting of the drilling activities and are dependent on the geological conditions through which the well is to be drilled. 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. "Casing" 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. After running casing, space between hole wall and "Casing" (annulus) will be cemented. This process of drilling and casing the hole section continues until the final well depth (target) is achieved.

Mud System and Cuttings

During drilling operations, the drilling fluid (or mud) is pumped through the drill string down to the drilling bit and returns at the drill pipe–casing annulus up to surface back into the circulation system after separation of drill cuttings /solids through solids control equipment. The primary function of drilling fluid is to ensure that the rock cuttings generated by the drill bit are continuously removed from the wellbore. The mud must be designed such that it can carry the cuttings to surface while circulating, suspend the cuttings while not circulating and drop the cuttings out of suspension at the surface. The drilled solids are removed at the surface by mechanical devices such as shale shakers, de-sanders and de-silters. The hydrostatic pressure exerted by the mud column prevents influx of formation fluids into the wellbore. The instability caused by the pressure differential between the borehole and the pore pressure can be overcome by increasing the mud weight. Hydration of the clays can be overcome by using non aqueous based muds, or partially addressed by treating the mud with chemicals which will reduce the ability of the water in the mud to hydrate the clays in the formation. Water based mud will be used for initial, shallower sections where massive shales are not encountered. The deeper and difficult to drill formations will be drilled using synthetic base mud (SBM). At the end of drilling a well almost the entire amount of the SBM is collected for re-use in next drilling operation. SBM systems promote good hole cleaning and cuttings suspension properties. They also suppress gas hydrate formation and exhibit improved conditions for well bore stability compared to most WBM. WBM typically consists of water, bentonite, polymers and barite. Other chemical additives viz. glycols and salts may be used in conjunction to mitigate potential problems related to hydrate formation. The mud to be used will be continuously tested for its density, viscosity, yield point, water loss, pH value etc. The mud will be prepared onsite (drill location) using centrifugal pumps, hoppers and treatment tanks.

During drilling activity, cuttings will be generated due to crushing action of the drill bit. These cuttings will be removed by pumping drilling fluid into the well via triplex mud pumps. The mud used during such operation will flush out formation cuttings from the well hole. Cuttings will be then separated from drilling mud using solids-control equipment. This will comprise a stepped system of processes consisting of linear motion vibrating screens called shale shakers, hydro-cyclones (including de-sanders and de-silters), and centrifuges to mechanically separate cuttings from the mud.

Figure 2.7 showsa typical view of Drill Cutting Separation & Treatment system.

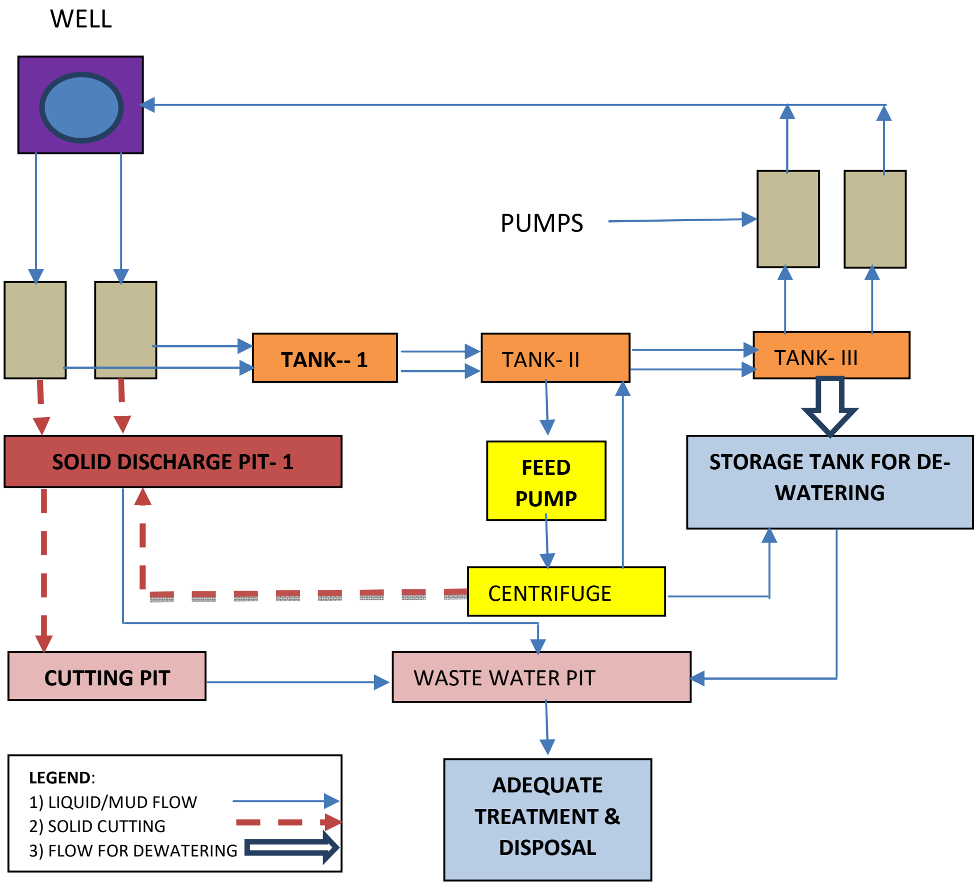


Figure 2.7Typical view of Drill Cutting Separation & Treatment system

Cementing

Cementing is a necessary aspect of exploratory and appraisal drilling oil and gas wells. Cement is used to fulfill the following works:

- Secure/support casing strings
- Isolate zones for production purposes

Well Evaluation

During the drilling operations for different zones, logging operations will be undertaken to get information on the potential type and quantities of hydrocarbons present in the target formations. Technicians employed by a specialist logging Service Company do well logging by different well logging techniques including electric, sonic and radioactive techniques. Logging instruments (sensors) are attached to the bottom of a wire line and lowered to the bottom of the well and they are then slowly brought back. The devices read different data as they pass each formation and record it on graphs, which will be interpreted by the geologist, geophysicist and drilling engineer. No emissions to the environment or any environmental harm is associated with wire line logging operations. The radioactive source required for well logging operations will be kept in specially designed container. In this drilling procedure, once the drilling is over, the well evaluation will be done by using electric wire line logs to assess the potential of the reservoir. This typically involves sampling the reservoir formation and pressure points during logging operations and reduces the requirement to flow hydrocarbons to the surface, significantly reducing the atmospheric emissions associated with the testing operation. Normally, in the event that hydrocarbons are encountered in sufficient quantities, as determined by electric wire line logs, a temporary drill stem test string may be run and the well fluids flowed to surface and processed using a surface well testing package, involving the oil being stored and trucked off the site and associated gas being flared to atmosphere.

Hydraulic Fracturing – for Tight Rock Reservoirs of Hydrocarbons

Hydraulic fracturing is used in tight rock reservoirs with low permeability, such as shale (i.e., the conductivity or ability of hydrocarbons to flow in the formation is low because of the small pore size in the rock). The goal of hydraulic fracturing in tight reservoir (shale) formations is to enable a well to produce the resource or to increase the rate at which a well is able to produce the resource. Hydraulic fracturing may be conducted in wells with low permeability formation and low pressure. Wells requiring hydraulic fracturing and numbers of stages of hydraulic fracturing per well will depend on seismic data acquired & interpreted and data acquired during the drilling phase of the project.

Hydraulic fracturing is a common technique used to stimulate the production of oil and natural gas by creating fractures or cracks that extend from the well hole into the rock formations. This is accomplished by injecting fluid, which is usually a mixture of water and high viscosity fluid additives, under extremely high pressure. The pressure of the water will then exceed the strength of the rock, causing fractures to enlarge. After the fractures take place, a “propping agent” known as proppant (which is usually sand) is injected into the fractures to keep them from closing. This allows the hydrocarbon to move more efficiently from the rock to the well. A single well may require up to 15,000 m^3 of water which may vary depending on the fracking requirements. For the hydraulic fracturing in a well, proppant mass of 150,000 – 200,000 lbs per stage and fluid volume of 2500 bbls – 4000 bbls per stage will be required.

Fracturing effluent generated will be discharged in the HDPE lined pits at the drilling well sites. The effluent will be treated for disposal and reuse to the extent possible.

Well kick situation & Control measures

While drilling, if the formation pressure exceeds the hydrostatic pressure exerted by the drilling fluid, formation fluids break out in to the well bore. This is called kick. Primary means of well control is to have sufficient over-balance over formation pressure. For some reason if an unexpected over-pressurized formation is encountered while drilling and if the well control situation arises, rig is equipped with equipment to control this situation. This set of equipment is called "Blowout Preventers (BOP)". Blow Out Preventer consists of, "Annular Preventer", which can generally close on any size or shape of tubular in the well bore and closes the annular space between drill string and casing. Another type of blowout preventer is a "Ram Preventer". Ram preventers are of two types i.e., Pipe Rams and Shear Rams. Pipe rams also close the annulus between drill string and casing, but they have a fixed size. As such a specific pipe rams can be closed on a specific size of pipe. Shear rams are generally the last choice of preventer to be operated as they shear drill string and shut off the well bore. After determining the existing formation pressure and other geological complexities from the seismic data, appropriate BOP will be used as per standard oil field guideline for the same. Typical BOP configuration is shown in **Figure 2.8**

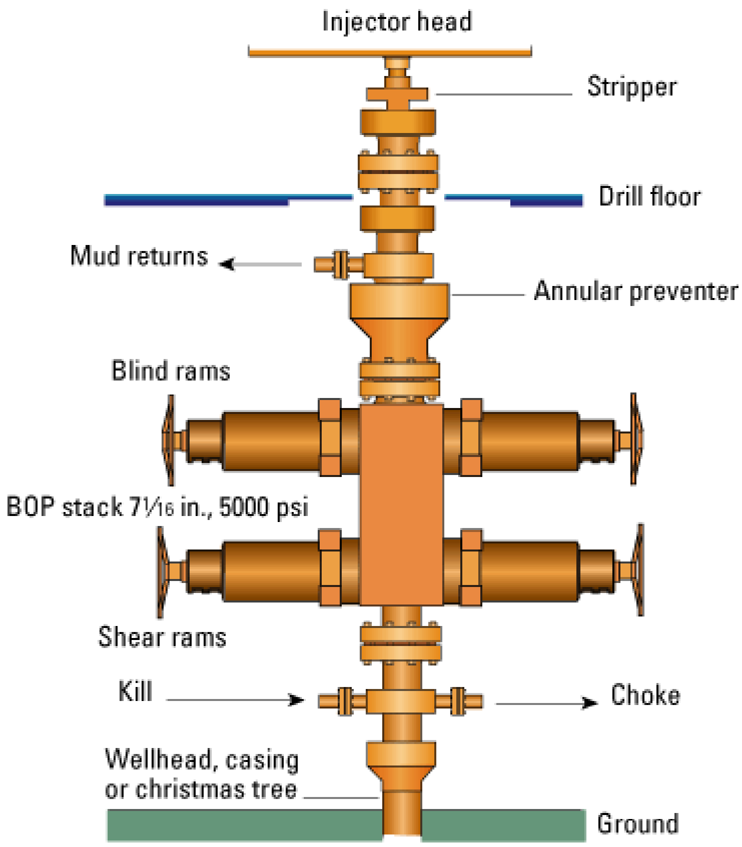


Figure 2.8 Typical BOP Configuration

5. *Well Testing & Flaring*

During the exploration and appraisal drilling, where a hydrocarbon formation is found, initial well tests (generally about one month of duration) will be carried out to establish flow rates, formation pressure and other parameters. However, depending on the need, based on nature of the reservoirs, the exploratory and appraisal wells will be tested for longer/extended durations to ascertain the reservoir parameters. In case hydrocarbons are detected in the well, the quantity and quality will be tested.

2.8.2 Early Production Units(EPUs)/ Quick Production Units (QPUs) andEarlyProduction

Vedanta Limited (Division: Cairn Oil & Gas), as an interim plan, in case of commercially viable discovery (s) of hydrocarbons in the block and having established the size of the hydrocarbon field (s), proposes to immediately bring the field (s) into production using one or more of the appraisal wells for the production of crude oil by setting up of Early Production Units (EPUs) or QPUs (Quick Production Units). Early production of the Crude oil will enable the Country to reduce dependence on import of crude oil.

Here, it may be noted that after the commercially viable discovery (s) of the hydrocarbon field(s), following the typical life cycle of Oil &Gas Exploration &Production sector, full-fledged field development plan including development well drilling, establishing crude oil & natural gas processing facilities, laying of intra-field & cross country pipelines and other associated physical and social infrastructures will be taken up and prior development EC and other approval will be obtained as applicable.The lead time for entire process is about 3 – 4 years for the production of crude oil and natural gas.Once the full-fledged field development comes up, the Early Production Unit(s)/ Quick Production Unit(s) will suitably be integrated with the full-fledged facilities and/ or phased out.

Early Production Units (EPUs) or Quick Production Units (QPUs) will be installed for the processing of produced well fluid.A EPU/ QPUwill be a packaged/ modular mobile unit and will mainly consists of a heater-treater separator or a production heaterfollowed with a three phase separator, electrostatic coalescer, oil storage tanks, oil tanker loading system, produced water separation and disposal system, power generation (GEG or DG), test separator skid, utility systems such as fuel gas, flare, Inst. Air package, diesel storage, firefighting equipment, etc. A QPF will bedesigned for a capacity of 2,000 BLPD (Barrels of liquid per Day) with water cut variation from 0 – 50 vol%.

Produced well fluid from one or more successful exploratory/ appraisal wells will be gathered & sent to heater-treater separator skid for primary separation & heating purpose. Gathered produced fluid will be heated & degassed in heater-treater separator skid operating at ~2.5 – 3 Barand ~70 – 80 ^{0}Cand separated in to gas, oil and water streams. The separated produced (associated) gas will be either routed to fuel gas system or to flare depending on the quantity of produced (associated) gas. In case of sufficient quantity of produced gas, a part of the produced gas will be used for power generation (using GEG), for firing in heater-treater separator skid and for blanketing & purging purpose. The surplus gas post internal consumption (if any) will be routed to flare for safe disposal purpose.

Separated oil from heater-treater separator skid will be sent to electrostatic coalescer separator (if needed, based on oil properties) to separate the residual water and achieve BS&W specifications. The treated crude oil from electrostatic coalescer separator will be sent to oil storage tanks. From oil storage tanks, oil will be pumped &loaded in to road tanker using the tanker loading facility for evacuation of crude oil to the nearby available facilities like terminals/ depots of consumers.

Separated produced water (PW) from heater-treater separator skid will be sent to degasser vessel operating at low pressure. The evolved HC gasesfrom degasser vessel will be routed to flare for safe disposal and the degassed water sent to PW treatment package.

The PW treatment package will consists of acompact flotation unit or other equivalent gas floatation based de-oiling (oil removal) system and a filtration system. The treated water from PW treated skid will be stored in PW storage tanks. The produced water will be treated to achieve MoEF&CC/ CPCB/ SPCB specifications (discharge standards) and will be disposed off. The treated effluent (i.e. produced water) will be disposed-off using either a nearby down hole disposal well (by reinjection in abandoned well) or other available and suitable onshore disposal medium or solar/ mechanical evaporators depending on the quantity and feasibility.

The power requirement will be met through either state electricity grid and/ or installation of Diesel/ Gas Engine Generator(s) using produced gas. If produced gas is sufficient quantity then power generation using produced gas will be preferred.

Along with above processing facility, a well test separator skid will be installed at pad. It will be used for well testing purpose. Well under testing will be routed to test separator skid. The separated gas, oil & water will be sent back to inlet of heater-treater separator skid for further processing.

Quick production set-up will have following utility systems & infrastructure for supporting the operations.

- Wells with selected artificial lift and flow lines
- Fuel gas system consisting of filters & a super-heater
- Instrument Air package or Instrument as system
- Chemical dosing packages i.e. corrosion inhibitor, de-mulsifier& scale inhibitor etc.
- Elevated flare system or enclosed ground flare or ground flare
- Closed drain system, storm water drain system
- Fresh water storage
- Diesel storage
- Power generation (GEG and / or DG)
- Firefighting equipment
- Domestic sewage treatment facility (mobile STP or septic tank & soak pit system);

A typical flow chart of Quick Production Unit/ Early Production Unit (2000 BLPD) is shown in **Figure 2.9**and a typical Plot Plan for well pad with Quick Production Unit (QPU) is shown in **Figure 2.10.**

6. Completion of Drilling

On completion of activities, the well will be either plugged and suspended (if the well evaluations indicate commercial quantities of hydrocarbons) or will be killed and permanently abandoned. In the event of a decision to suspend the well, it will be filled with a brine solution containing very small quantities of inhibitors to protect the well. The well will be sealed with cement plugs and some of the wellhead equipment (Blind Flange) will be left on the surface (Cellar). If the well is abandoned it will be sealed with a series of cement plugs, all the wellhead equipment will be removed, by leaving the surface clear of any debris and the site will be restored.

7. Decommissioning & closure of wells

After the completion of the drilling activity, partial de-mobilization of the drilling rig and associated infrastructure will be initiated. As discussed earlier, well testing may be carried out immediately after the drilling is completed. The complete de-mobilization of the facilities at site will happen once well-testing completed successfully. This 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 will take approximately 20-25 days and will involve the trucking away of materials, equipment and other materials from the site to bring it back to its original condition. It is estimated that about 50 truckloads will be transported out of site during this period. If no indication of any commercially viable amount of oil or gas is encountered either before or after testing, the well will be declared dry and accordingly will be plugged of and abandoned, and the site will be restored in line with regulations and good industry practice. The following steps will be typically involved to restore and rehabilitate the area:

- The wellhead and all casing string will be cut off to a minimum depth of 3 m (10 ft) below ground level.
- All concrete structures will be broken up, and the debris disposed off as per the regulatory requirements.
- 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.
- All fencing and access gates will be removed and all pits whose contents will show regulatory compliance for on-site disposal, 0at the time of site closure, will be backfilled and closed out as per the legal requirements.
- Restoration of unusable portion of the access track, removal of pilings and landscaping.

C. Appraisal

The technical procedures and activities in appraisal drilling will be the same as those employed for exploration wells. A number of wells may be drilled from a single well pad/ drill site. Deviated or directional drilling at an angle from a site adjacent to the original discovery well may be used to appraise other parts of the reservoir, in order to reduce the land requirement.

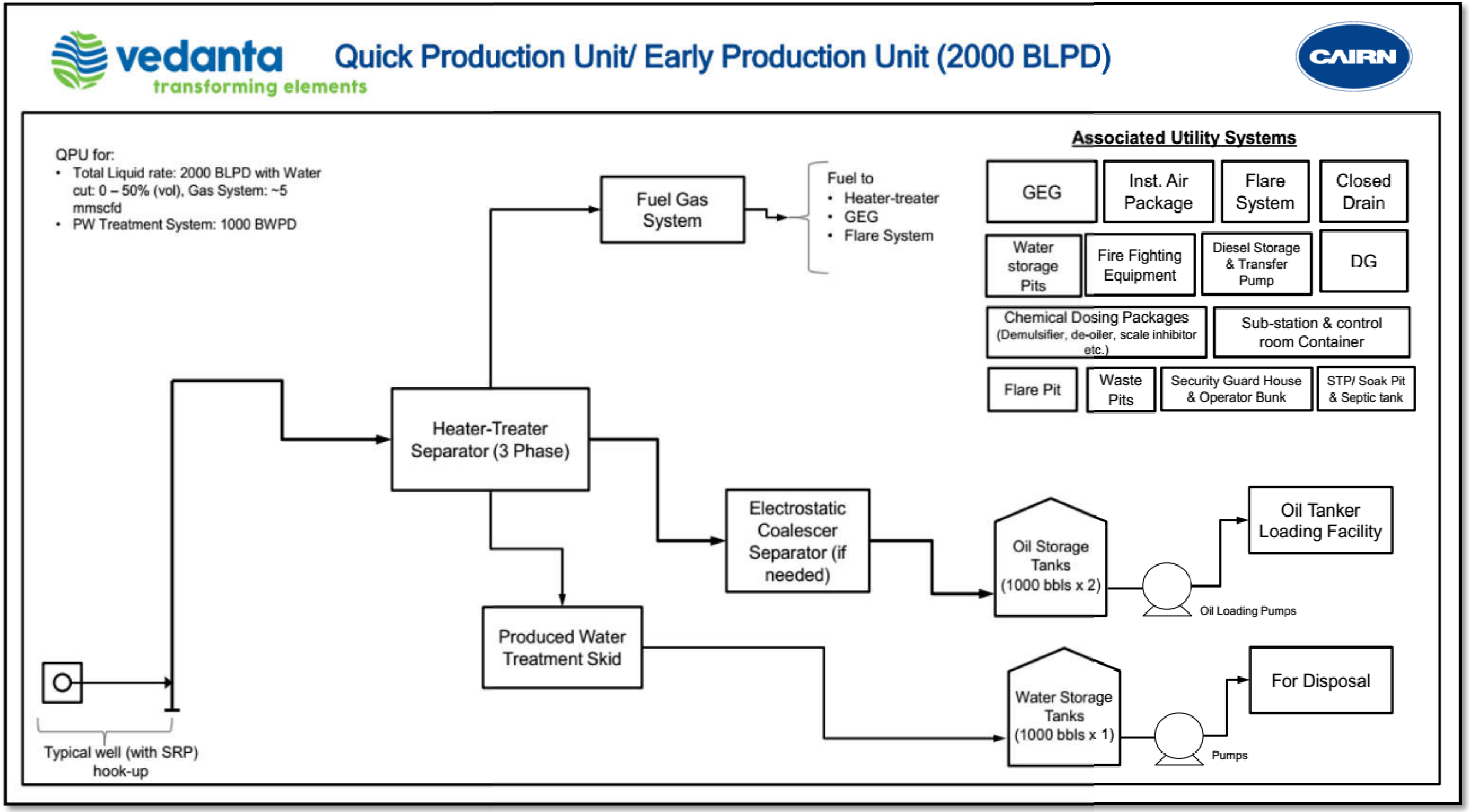
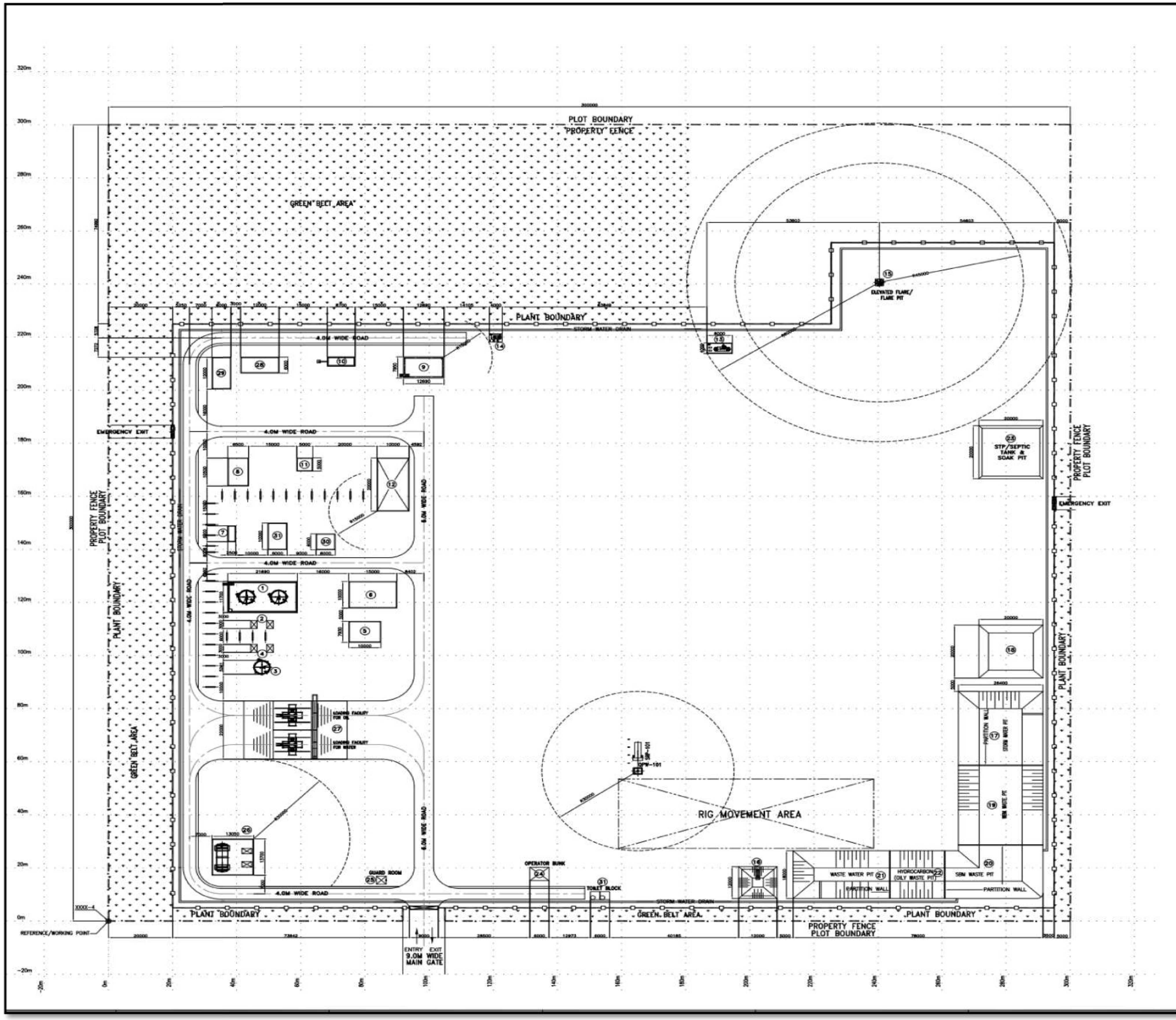


Figure 2.9: Typical Flow Chart of Quick Production Unit/ Early Production Unit



REFERENCE DRAWINGS

SLNO	DRAWING NO.	REV.	DESCRIPTION
1.	–	–	–

EQUIPMENT LIST:

SL. NO.	EQUIPMENT DESCRIPTION	QTY.	DIMENSIONS (M)	REMARK
1	OIL STORAGE TANK	2	5.2 Dia	–
2	OIL TRANSFER PUMPS	2	–	–
3	WATER STORAGE TANK	1	5.2 Dia	–
4	WATER TRANSFER PUMPS	2	–	–
5	INSTRUMENT AIR PACKAGE	1	10x7.93	
6	CHEMICAL INJECTION PACKAGE	1	15x10	–
7	ELECTROSTATIC COALESCER SEPARATOR	1	6x2.5	–
8	HEATER TREATER SKID	1	10.5x6.5	
9	DIESEL STORAGE TANK & PUMP	1	12.96x7.95	–
10	DIESEL GENERATOR	2	8.7x3.5	–
11	FUEL GAS SYSTEM	1	10x10	–
12	GEG PACKAGE	1	20x10	–
13	FLARE KO DRUM & PUMPS	1 + 2	8x4	–
14	CLOSED DRAIN SYSTEM & PUMPS	1 + 2	4x4	–
15	ELEVATED FLARE / FLARE PIT	1	2.6x2.6	–
16	FRESH WATER PIT	1	12x12	–
17	STORM WATER PIT	1	30x20	–
18	MUD PIT	1	20x20	–
19	WBM WASTE PIT	1	27.7x26.4	–
20	SBM WASTE PIT	1	29.7x26.4	–
21	WASTE WATER PIT	1	30x18	–
22	HYDROCARBON (OILY WASTE PIT)	1	18x16.5	–
23	STP/SEPTIC TANK & SOAK PIT	1	20x20	–
24	OPERATOR ROOM	1	6X5	–
25	GUARD ROOM	1	3X3	–
26	FIRE FIGHTING FACILITY & FIRE PUMPS	1 + 2	13.7x13	–
27	LOADING FACILITY AREA	1	–	–
28	SUB-STATION	1	12x6	–
29	CONTROL ROOM	1	6x6	–
30	WELL TEST SEPARATOR	1	6x6	–
31	PRODUCED WATER TREATMENT SKID	1	10x6	–
31	TOILET BLOCK	1	–	–

NOTES:

1) ALL DIMENSIONS ARE IN MILLIMETERS, CO-ORDINATES ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2) ALL EQUIPMENT & PACKAGES SIZE AND LOCATION TO BE UNDER HOLD.

LEGEND:–

PROPERTY FENCE
PLANT BOUNDARY
GATE
GREEN BELT

TOTAL AREA $=90000m^2$
QPU PLANT AREA $=62620m^2$
GREEN BELT AREA $=20455m^2$

REV	DATE	DESCRIPTION	PRED BY	CHKD. BY	APPRD. BY
A2	14.05.2019	ISSUED FOR INTERNAL REVIEW	PS	JCP	VKB

OWNER: vedanta transforming elements; CAIRN
VEDANTA LIMITED
Cairn Oil & Gas : DLF Atria, Phase-2, Jacaranda Marg, DLF City, Gurugram-122002, Haryana, India

PROJECT: EXPLORATION & APPRAISAL

DRAWING TITLE: TYPICAL PLOT PLAN FOR WELLPAD WITH QUICK PRODUCTION UNIT (QPU)

SCALE 1:1300 | SIZE A1 | SHT. 1 OF 1 | REV A2

PROJECT NO. XXXX | DWG. NO. XXXX-XXXX-L-DWG-0001-01

Figure 2.10: Typical Plot Plan for Well Pad with Quick Production Unit

2.9 UTILITIES, RESOURCE REQUIREMENTS AND ASSOCIATED FACILITIES

2.9.1 Liquid Mud Plant

The Liquid Mud Plant (LMP) shall be located at various locations of the fields to prepare synthetic based mud for the drilling operations. It is estimated around 3 – 5 LMP's will be set-up at any a given point of time for the proposed drilling operations. All the tanks, equipment's, civil works, pumps, mud laboratory with testing equipment along with the mud waste disposal pits will be constructed within a single location.

The entire LMP area shall be provided with containment area and with facilities for fork lift movement and transportation of solid waste skips. The area shall be designed to facilitate tanks for SBM mixing/ storage, tanks of base oil storage and another tanks for brine mixing/storage. These tanks are interconnected with piping and manifold with mixing hoppers, pumps connections, centrifuges connection with complete mud conditioning set-up, loading-unloading piping/hoses connections.

The Mud Plant area will be surrounded with a containment boundary wall. All the liquid transferred from the LMP to the drilling site will be through road tankers. For power supply requirement DG sets shall be required with one operational and one standby.

The LMP shall have water storage tanks, bunk houses for operating office and site laboratory, dry chemical storage area in paved surface, truck loading and unloading area with parking facility, cranes & forklifts maintenance and parking facility, septic tank with soak pits, DG area, diesel storage area and power distribution panel & facility.

2.9.2 Accommodation and Camp Site

Drilling camp sites will be set-up within vicinity of the drilling sites to allow for easy movement of the crew between the camp and the drilling sites. The camp site would generally comprise of transportable container cabins (portable cabin) of 20 feet and 40 feet size to provide accommodation to operational crew and the contractor personnel. Each cabin will house 2 to 4 persons. Toilet facilities will be built as part of the accommodation unit. The sewage lines from the units shall be connected through a pipeline system to a septic tank and soak pit system. Additionally, there will be dedicated cabins to serve as kitchen, cold storage, dining area, recreation area, laundry etc.

2.9.3 Approach and Internal Roads

The approach road to drill sites will be constructed and/or existing roads will be strengthened for movement of machinery, drilling rig, material supply vehicles, passenger vehicles etc.

depending on the location of drill site. In general, it is intended to make the maximum use of the existing road infrastructure.

2.9.4 Water Storage Pit

The water storage pit contains the water used for preparing drilling fluid and domestic purpose. Provision for additional water storage will be kept in case multi-stage fracturing is planned.

2.9.5 Chemical Storage Area

The chemicals to be used in preparing mud will be stored on a paved platform with kerb walls and protected against weather by an impervious covering. All the storage areas will be identified with labelling and sign boards. Material Safety Data Sheets (MSDS) shall be maintained for all chemicals that are stored and handled at the drill site. The storage area will be provided with adequate number of fire extinguishers.

2.9.6 Spent Drilling Fluid Disposal Pits

All wastewater from the drilling operations will be collected in the drilling fluid storage pit. The wastewater in this storage pits will be recycled and reused during drilling phase. The residual wastewater will be sent to solar evaporation pit for natural solar drying. The pits will be lined with HDPE sheet.

2.9.7 Drill Cutting Disposal (impervious lined) Pit

While recycling the mud, the drill cutting will be separated through shale shaker, which will be disposed off to cutting disposal pit. This pit will be similar in construction to the solar pit. It will be lined to avoid contaminationof land and groundwater. The pit will be soil bunded and HDPE lined to prevent any overflow to the surroundings.

2.9.8 Flare Pit (well testing)

To conduct ground flaring, all the sites will have a flaring pit with adequate burner. The flare pit will be made up of RCC / brick lining and are located preferably 90 degrees to the predominant wind direction. The location of the pit also depends on the entry to the site from the adjacent road side, processing units or tanks.

2.9.9 Flare Stack

A flare system consists of the flare stack or boom and pipes which collect the gases to be flared. The flare tip at the end of the stack or boom is designed to assist entrainment of air into the flare to improve burn efficiency. Seals installed in the stack prevent flashback of the flame, and a vessel at the base of the stack removes and conserves any liquids from the gas passing to the flare.

2.9.10 Diesel Storage Tank

The fuel (diesel) will be received in bulk quantity through tankers and shall be stored in above ground steel diesel tanks (approximately 60 KL capacity). The tank is provided with secondary containment of adequate capacity to control any accidental leaks.

2.9.11 Waste Storage

Hazardous wastes generated from drilling activities such as used oil from pumps and machinery, empty chemical and fuel barrels, contaminated oil rags and soil etc will be collected and stored in a designated storage area. The storage area will have paved flooring, containment bund and roof. Waste oil from pumps and machinery will be collected and stored in used oil barrels and shall be kept in a designated storage area. The contaminated soil and cotton rags will be disposed of at approved secured Land fill as per the legal provision. Used oil will be disposed off through recyclers/ re-processors registered with the Central Pollution Control Board and authorized by State Pollution Control Board.

2.9.12 Storm Water Drainage System

A garland drain will be provided all around the drilling site to prevent runoff of any oil containing waste water into the nearby natural drainage area. The storm water drain shall be provided with oil trap and the collected water shall be sent to storm water pit.

2.9.13 Spill Containment System

Containment systems and oil traps will be provided to trap any spillage of oil at the drilling site. All potential sources of spillage will be equipped with drip pans in order to contain spills.

2.9.14 Sewage Treatment Plant (STP)

Mobile STP or septic and soak pit of capacity 30 m^3/day for treatment of sewage and sullage Water generated within the well pad limits. Each well site and camp site will have toilets which will be provided with septic tanks and soak pit arrangement. To cater to about people that will stay in the camps site, adequately sized septic tanks and soak pits will be provided.

2.9.15 Raw Material Requirement

Maximum care will be taken for resource optimization, wherever possible with an aim of

- Resource Conservation
- Elimination of Waste Streams
- Minimizing Waste
- Reuse/recycle of Wastes
- The drill cuttings from the drilling operations associated with water-based mud will be used for filling low lying areas as a sub grade construction material in construction of well pads, etc.
- Synthetic base mud will be re-used in further drilling activities

Raw Material Required for Drilling

During drilling activities, materials like HSD, Steel (in the form of casings & tubulars) and chemicals like barite, oil well cement and bentonite will be required. Other production equipment like tubular (Casing and tubings), wellhead assembly, packer etc, and chemicals for mud and cementing required for the drilling operations and shall be procured by the company from within the country and from abroad before the commencement of operations.

Water based mud will be used for initial, shallower sections where massive shales are not encountered. The deeper and difficult to drill formations will be drilled using synthetic base mud (SBM). Synthetic based mud can be re-used. WBM typically consists of water, bentonite, polymers and barite. Other chemical additives viz. glycols and salts may be used in conjunction to mitigate potential problems related to hydrate formation.

- Requirement WBM (approx.) 800-1000 m3/well
- Requirement SBM (approx.) 600-800 m3/well

The role of the mud in pressure control is especially important. If the drill bit penetrates a formation containing oil, gas or water under pressure these fluids are prevented from flowing into the borehole by ensuring that the drilling mud is of sufficient density to the natural formation pressures. The density of the mud can be increased by the addition of barite weighting material. Bentonite is employed to improve the theological properties and enable the drill cuttings to be transported from the hole while drilling and also be suspended in the fluid while the drill bit is being changed.

2.9.16 Power Supply

Power Requirement during Drilling Operations

The power requirement in the drilling site and the campsites will be provided through diesel generator (DG) sets. The rated capacity of the DG sets required for onshore drilling site is provided in following **Table 2.6.**

Table 2.6: Details of DG sets of Onshore Drilling Activity

Location	DG Capacity
Camp site	2 x 350 kVA (one working and one standby)
Drilling site	3 x 1000 kVA (two working and one standby) or 2 x 1850 kVA* (one working and one standby)
Radio	2 x 100 kVA (one working and one standby)

*Depending on the rig capacity & rig availability during E&A (Exploration and Appraisal) drilling phase

Power requirement during Early Production

Gas Engine Generator (GEG) 1MW output and DG 500 kVA (emergency)for each early production unit/quick production unit.

2.9.17 Water Consumption and Supply

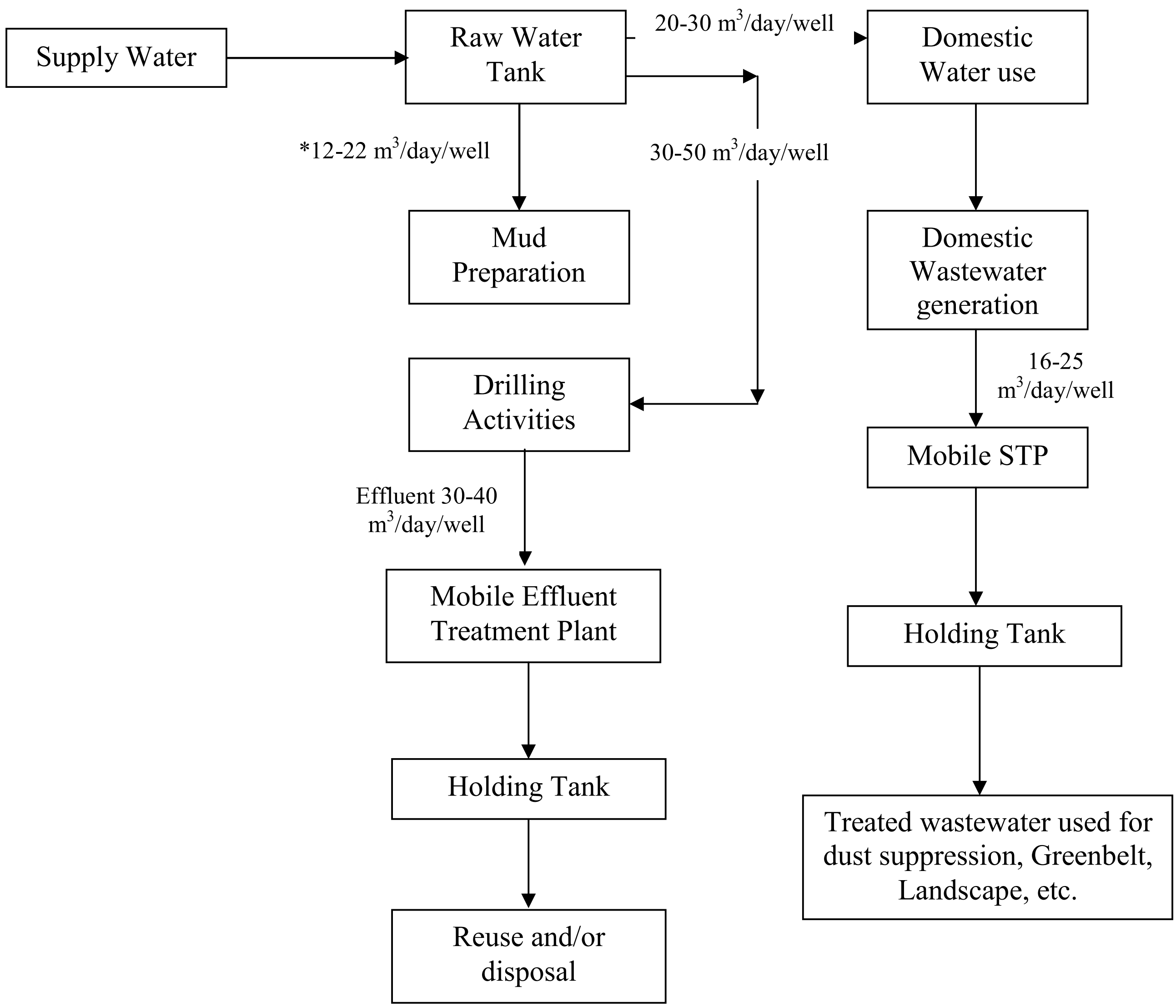
Water Requirement during Drilling Operations

The water requirement in drilling rig is mainly meant for preparation of drilling mud apart from washings and domestic use. While former constitutes majority of water requirement, latter or the water requirement for domestic and wash use is minor. The water requirement per well is shown in **Table 2.7.**

Table 2.7: Typical Water requirement per well

Description	Quantity (m^3/d)
Water for Water based mud	600-1000 (m^3/well)
Water for synthetic based mud	150-300 (m^3/well)
Water for domestic use	20-30 (m^3/day/well)

The water balance diagram is shown in **Figure 2.11**



*Note: Estimation of mud preparation water consumption is based on the assumption that the period of drilling well is 60 Days.

Figure 2.11 Water balance diagram

The water requirement for all the project activities will be sourced locally through approved/ authorized sources of surface water and/ or ground water (e.g. PHD bore wells, privately owned bore wells, Irrigation Dept./ Water Resources Dept. of State Govt.). In case, required water could not be sourced from locally available approved sources, ground water will be extracted after obtaining permission from CGWA/ State Govt.

2.9.18 Fuel Consumption and Storage

Fuel consumed during the drilling phase will mainly be diesel (HSD) used for various equipment and vehicles operating to transport goods and supplies to site. It is estimated that about 60 KL diesel will be required to power the off-road construction equipment and vehicles during site preparation phase.

During the drilling phase, consumption about 3.5 KLD of High-Speed Diesel will be required. Fuel will be supplied onsite by local supplier through mobile tankers. Out of this, a major part approximately 85% will be consumed by the rig (also include the DG sets) and about 15% will be required for the campsite.

2.9.19 Manpower

Most of the workforce will be from local area. During the site preparation for drilling, approximately 30-35 workmen will be employed per drill site. During the drilling phase, about 50 workmen per shift will be working on site. This will include technical experts, who will be responsible for various drilling related activities and some technical manpower. It is anticipated that, at any given time, there will be about 80 - 100 personnel working on site including technical staff, drilling crew, security staff etc.

2.10 POLLUTION CONTROL MEASURES

Pollution control measures during Drilling Operations

A. Air Emissions and Control Measure

The emissions to the atmosphere from the drilling operations shall be from the diesel engines, and power generator and temporary from flaring activity (during testing). Adequate control measures will be taken to reduce the air emissions.

B. Noise Emissions and Control Measure

The source of noise generation during this phase of operations would be the operation of rig and diesel generator sets. The expected noise generation at source is due to operation of rig.Besides, certain pumps are expected to be in operation during this phase, for mud circulation. The noise generation work however is transient and limited to the drilling period only. Appropriate control measures will be taken to minimize exposure of noise to drill personnel.

C. Waste treatment and disposal

Hazardous waste:

Drill cuttings of 250-750 tons/well will be generated during the drilling phase with Water Based Mud (WBM) whereas the amount of drill cutting generated during drilling with Synthetic Based Mud (SBM) will be of around 500-1500 tons per well depending on the depth to which the wells be drilled. These cuttings will be stored in well-designed HDPE line pit.

Spent / Residual drilling mud of 250-500 tons per well, sludge containing oil and other drilling waste will be around 250-500 tons/well is envisaged.

Used /waste Oil – During the drilling approx. 1-2 ton per well will be generated.

Non-Hazardous waste:

Domestic food waste of 25-30 kg/day per well will be generated at site, which shall be segregated at source (Organic / Inorganic) and disposed accordingly.

The expected waste generation from well drilling will be as per **Table 2.8**

Table 2.8: Quantity of generated waste from drilling operations

S.No.	Nature of waste	Quantity
A	**Hazardous Waste**	
1	Drill cuttings associated with SBM	250-750 tons/well
2	Drill cuttings associated with WBM	500-1500 tons/well
2	Residual drilling mud, sludge and other drilling waste	250-500 tons/well
3	Used Lubricating oil	1-2 tons/well
B	**Non Hazardous Waste**	
4	Food waste	25-30 Kg per/day
5	Non-combustible waste containing metallic residues	1000-1200 Kg per well
6	Packaging wastes including drums, wooden pallets, plastic containers, plastic foils.	1000-1200 kg per well
7	Left over chemicals and materials, scrap metal,sludges, scales, spentlubricants, filters etc.	250-300 kg per well
8	Cement, grit, blasting and painting wastes.	500-600 kg per well

All kind of waste will be disposed in accordance with the requirement of CPCB/SPCB.

D. Waste water Treatment and disposal

The drilling operation would generate wastewater in the form of wash water due to washing of equipment, string and cuttings etc. The only other source of wastewater generated from drilling operation is sewage from sanitation facilities. Around 15 to 25 m3/day/well of wastewater would be generated, which will be treated in modular Sewage Treatment Plant (STP) and the treated water will be used for dust suppression, green belt, etc. It is expected that wastewater in the form of Drill cutting washing + Rig washing+ cooling etc shall be generated at an average rate of around 30 to 40 m3/day/well during the drilling operations from a single well. Waste water will be discharged in HDPE lined evaporation pit for disposal. The wash water would contain variable quantities of mineral salts, solids, suspended and dissolved hydrocarbons, and other organic and inorganic components in very minor quantities. The drilling wash wastewater will be treated prior to discharge to comply with the regulatory standards. Treated effluent (PW) will be disposed off on the suitable onshore disposal medium or solar/mech. evaporators depending on feasibility. The quantity of wastewater generation and anticipated disposal methods is given in Table 2.9.

Table 2.9: Wastewater generated during Drilling and their disposal method

Wastewater	Quantity	Disposal
Drilling wash wastewater	30-40 m^3/day/well	The wastewater will be adequately treated as per the applicable rules/ regulations.
Domestic Wastewater	15-25 m^3/day/well	The domestic wastewater will be treated in mobile Sewage Treatment Plant / septic tank & soak pit system and the treated water will be used for dust suppression, green belt, etc.

2.11 PROJECT SCHEDULE AND COST ESTIMATE

Vendanta Limited (Division: Oil & Gas) has planned to carry out the proposed project activities over a period of 10-12 years. The total cost for the proposed project activities in the AA-ONHP-2017/14 block is estimated to be 560.0crores.

CHAPTER – III

ENVIRONMENTAL BASELINE STUDY

3.0 INTRODUCTION

This chapter describes the existing environmental and socio-economic baseline for the proposed project and its surrounding area. Baseline data establishes the present status of the environment identifies the sensitive receptors in the study area and provides the basis for assessment of the impacts due to the project, and enabling the development of a robust and comprehensive environmental management and monitoring plan.

The baseline quality of various components of the environment, viz. air, noise, water, land, biological, meteorological and socio-economic factors are assessed within the impact zone of 10 km radius around the proposed site. Secondary data has also been incorporated from authentic sources viz. Govt./Non-Governmental Agencies, Universities, Indian Meteorological Department (IMD), Ground Water Board etc. Various environmental components were monitored and samples analyzed.

The main purpose & objective of the study is:

- To delineate the prevailing environmental condition of project/study area as per awarded TOR issued by MoEF&CC for EIA study.
- To understand the project need and environmental characteristics of the area.
- To assess the existing environmental quality
- To identify environmentally significant factors or sensitive geographical locations.
- To generate &/or collect the information of physical-chemical properties of the environment of the project area, which includes data indicating quality & prevailing status of air, water resources, soil fertility, noise, flora & fauna, ecological habitats etc.
- To study & generate/prepare the Land Use/Land Cover map, Topographic map, Cartographic Map of 10 km radial area from the site.
- To generate &/or collect details regarding climatic condition of project area.

3.1 STUDY AREA

Study area covers 10 km radius from proposed project site located in Karimganj, Hailakandi, Cachar district of Assam and Kolasib district of Mizoram.

3.2 STUDY PERIOD

Primary baseline data was collected during March 2019 to June 2019, which has been considered as the ‘study period’ for the baseline. Primary baseline data has been supplemented with requisite secondary data wherever necessary. In line with the Terms of Reference (ToR) requirement prescribed by the Expert Appraisal Committee (EAC), a zone comprising a 10 km radius around the proposed project site is considered as the 'study area' for the EIA for land use aspects and ecology study.

3.3 METHODOLOGY OF EIA STUDY

A. Approach & Methodology of Baseline Study

The methodology for conducting the baseline environmental survey has been obtained from the guidelines provided in the "EIA Guidance Manual for Oil and Gas Exploration" issued by the Ministry of Environment, Forest and Climate Change (MoEF&CC).

B. Primary Data Collection: Monitoring Plan and Quality Assurance Procedures

The study period and methodology for primary data collection is followed as per the CPCB guidelines in line with ToR prescribed by MoEF&CC. Summary of monitoring plan with sampling testing methodology followed is summarised in Table 3.1.

Table 3.1 Summary of Methodology for Baseline Data Collection

S. No.	Environmental Attributes	No. of Locations/ Area	Duration and frequency of sampling and other remarks
1.	Meteorology Data	At one station	Meteorology data was collected on an hourly basis for 3 months.
2.	Ambient Air Quality	18	Twice a week for 24 hours; for 3 months
3	Ambient Noise Levels	18	For 24 hours each in a month; for 1 season
4	Surface Water Quality	18	Once per a month
5	Groundwater Quality	18	Once per a month
6	Soil Quality	18	Once per a month
7	Ecology & Biodiversity	Study area	Once during the study period
8	Socio-economic Studies	Study area	Primary consultations were carried out in villages within 10 km radius during study period. List of villages surveyed within 10 km radius is enclosed – Refer Social Baseline for details

3.4 MICRO-METEOROLOGICAL DATA

The study area falls under Humid Subtropical zone according to Koppen's classification of climate zones. Winter and early summer are long and dry; summer is exceedingly hot leading to heat waves. The rainy season lasts from June to September.

Historical meteorological data were obtained from climatological tables pertaining to Silchar (as the nearest representative IMD station) for the period 1960-1990 and is summarised in Table 3.2.

Table 3.2 Meteorological data of Period 1960-1990

Month	Temperature (^{0}C) daily		Relative Humidity, %		Rainfall in mm	Wind speed Kmph	Pre-dominant wind direction From
	Max	Min	Max	Min			
January	23.2	11.8	83	62	12.1	1.2	E, NE
February	25.7	13.6	75	55	41.6	1.6	E, NE
March	28.6	17.3	70	54	129.9	1.9	E, NE
April	29.5	20.8	76	66	305.2	2.1	E, NE
May	30.3	22.9	80	71	352.9	2.4	E, SE
June	30.2	24.3	87	81	587.0	1.7	E, NE
July	30.6	24.6	87	81	545.1	1.7	NE, E
August	30.7	24.6	87	79	435.6	1.4	NE, E
September	30.6	24.3	85	78	358.0	1.3	NE, E
October	29.8	22.3	83	77	224.9	1.1	E, NE
November	27.6	17.7	80	71	38.3	1.0	E, NE
December	24.6	13.2	83	66	12.1	1.0	E, NE

(Source-IMD Silchar)

3.4.1 Wind Speed and Direction

Wind speed is high and found mostly between 2.4 – 1.0 m/sec for all the months. The wind speed during summer recorded is high, and during rainy season, and winter recorded low. The predominant wind direction is from NE and East throughout the year (Fig 3.1).

3.4.2 Temperature:

December and January constitutes winter months with daily mean minimum temperature around 11.8ºC and daily mean maximum temperature around 30.7ºC. May is the hottest month with daily mean maximum temperature around 30.7ºC and daily mean minimum temperature around 20.8ºC in March of summer.

3.4.3 Rainfall

The distribution of rainfall in the region, which includes the study area, is regular. Annual total rainfall in the region is 3042.7 mm. Over 80% of the total annual rainfall is received during the monsoon period between June and September.

3.4.4 Site specific Met data

An automatic met station was established at site to collect the site-specific data. The predominant wind direction was from northwest and north direction. Clam conditions remain 11.44% of the time (Table 3.3).

Table 3.3 Site-specific meteorological data

S. No.	Parameters		16.03.2019 to 31.03.2019	Apr-19	May-19	01.06.2019 to 15.06,2019
1	Temperature (^{0}C)	Maximum	38.10	37.90	43.40	38.00
		Minimum	17.70	19.70	22.10	17.80
		Average	26.27	28.30	30.31	25.46
2	Relative Humidity (%)	Maximum	93.50	93.70	98.90	94.60
		Minimum	22.40	23.70	15.30	46.80
		Average	51.26	58.93	66.78	68.14
3	Wind Speed (m/s)	Maximum	4.94	4.67	5.52	5.43
		Minimum	0.00	0.00	0.00	0.00
		Average	1.51	1.02	1.01	1.36
4	Wind Direction (%)	E	3.92	2.08	14.65	14.29
		ENE	6.13	2.22	7.26	6.85
		ESE	1.96	2.36	3.49	3.87
		N	1.47	0.56	3.63	2.68
		NE	11.76	6.25	13.04	14.29
		NNE	1.72	1.53	3.90	3.27
		NNW	0.74	0.42	0.94	2.38
		NW	1.23	3.19	0.81	0.89
		S	1.72	2.92	1.34	1.79

			SE	2.21	3.33	2.15	3.27
			SSE	3.19	3.33	0.81	1.49
			SSW	0.74	2.22	0.67	0.89
			SW	10.29	9.03	0.94	2.38
			W	10.78	11.67	0.67	1.49
			WNW	2.45	3.33	0.13	0.60
			WSW	7.84	7.36	0.67	1.19
			CALM	**31.86**	**38.19**	**44.89**	**38.39**

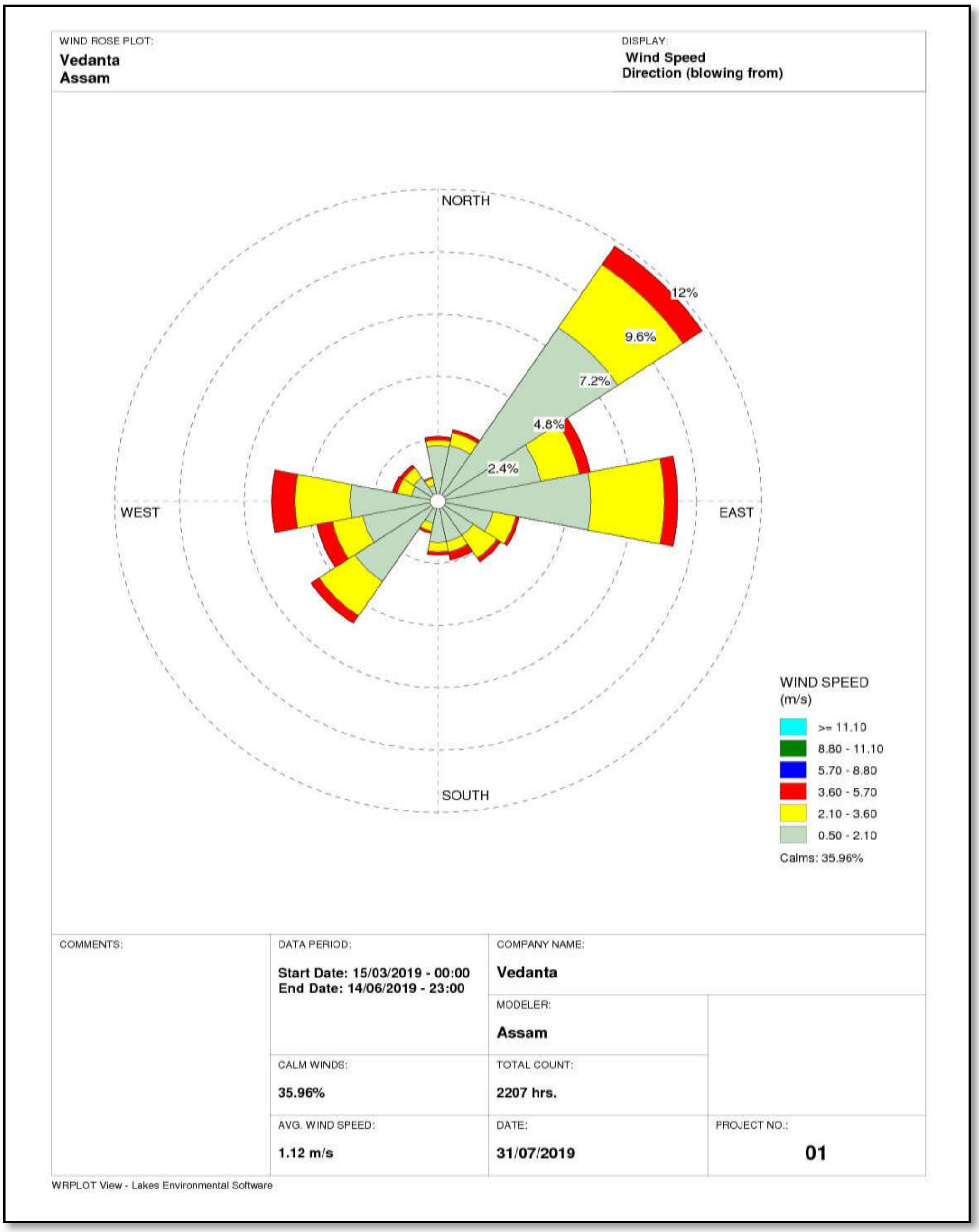


Fig 3.1 Wind rose for the period of March 2019 to June 2019

3.5 AIR ENVIRONMENT

3.5.1 Selection of Sampling Locations: To assess the baseline ambient air quality a scientifically designed ambient air quality monitoring network was established. Air quality monitoring study was carried out during pre-monsoon season (i.e. March'19 to June'19) within 10km radius of the project site. The ambient air quality monitoring stations were selected after a brief study based on the following considerations

- Meteorological conditions
- Topography of the study area
- Predominant wind direction
- Emission sources
- Receptors sensitivity

Ambient Air Quality Monitoring Stations were set up at Eighteen locations with due consideration to the above mentioned points. The locations of the sampling stations are given in the Table 3.5 and the same are shown in the Fig 3.2.

3.5.2 Methodology of Sampling and Analysis

Air samples collected were tested for the following parameters

- PM_{10}
- $PM_{2.5}$
- Sulphur Dioxide (SO_2)
- Oxides of Nitrogen (NOx)
- Carbon Monoxide (CO)
- Ozone (O_3)
- Lead (Pb)
- Ammonia (NH_3)
- Benzene (C_6H_6)
- Benzo(a)Pyrene (BaP)
- Arsenic (As)
- Nickel (Ni),
- Hydro Carbon HC (Methane and Non Methane)
- Volatile Organic Compound (VOC)

The sampling and analysis of ambient air quality parameters was carried out as per the procedures detailed in relevant parts of IS: 5182 (Indian Standards for Ambient Air Quality Test Methods).

The methods used for determining the above mentioned parameters and furnished hereunder in the Table 3.4.

Frequency of Sampling: 24 hourly samples for PM_{10}, $PM_{2.5}$, SO_2 and NOx were collected from each station (Table 3.5), at a frequency of twice a week for the pre-monsoon season

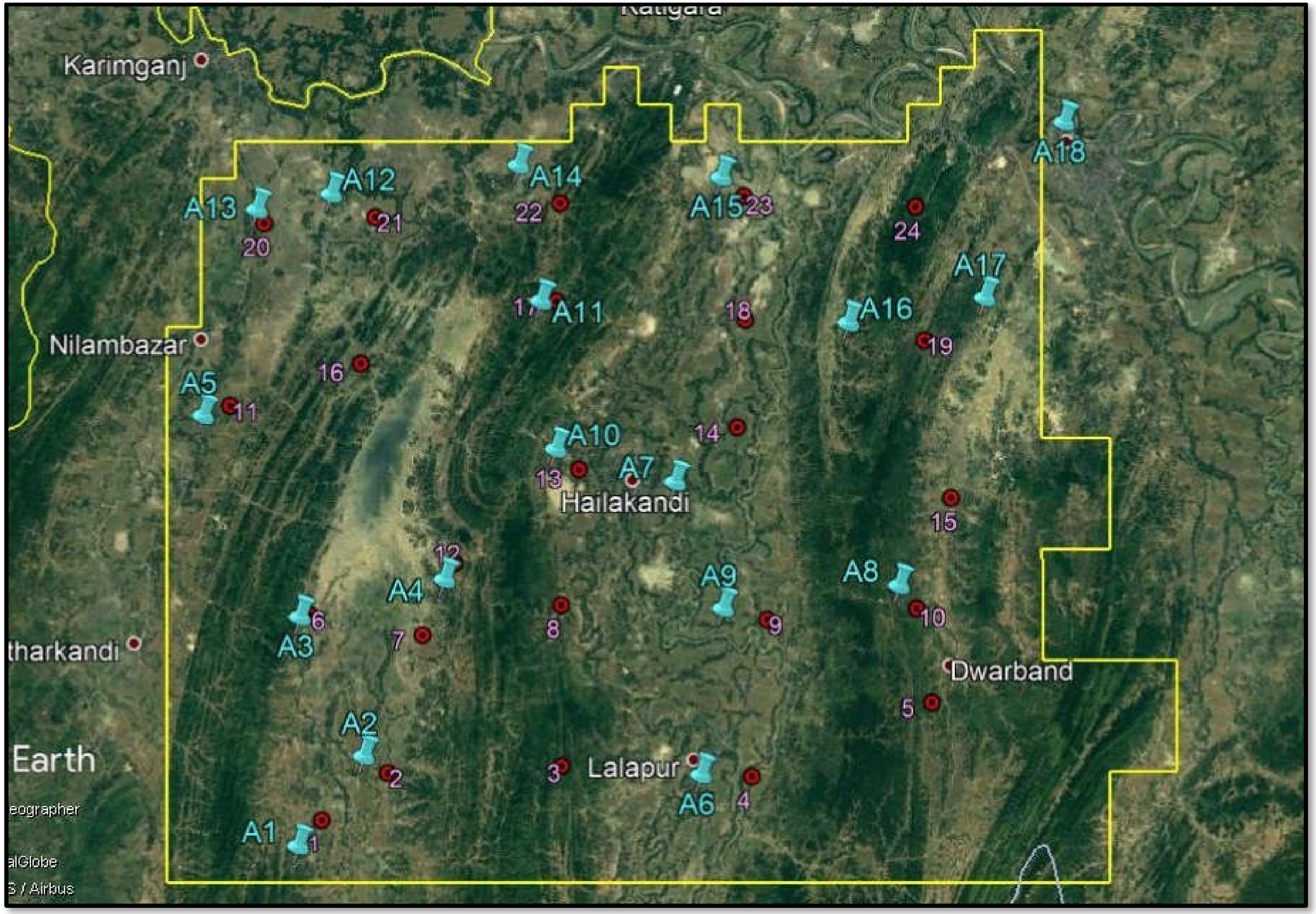
Table 3.4 Techniques and detectable limits for Ambient Air Quality Monitoring

S. No.	Parameter	Technique	Technical Protocol	Minimum Detectable Limit
1	PM10 (µg/m3)	Respirable Dust Sampler (Gravimetric method)	IS-5182 (Part-IV)	5.0 µg/m^3
2	PM2.5 (µg/m3)	Fine Particulate Sampler (Gravimetric method)	40 CFR USEPA Gravimetric	2.0 µg/m^3
3	Sulphur dioxide SO2 (µg/m3)	Modified West and Gaeke	IS-5182 (Part-II)	4.0 µg/m^3
4	Oxides of Nitrogen NOx (µg/m3)	Jacob &Hochheiser	IS-5182 (Part-VI)	4.0 µg/m^3
5	Carbon Monoxide (CO) mg/m$_3$	Non Dispersible Infra-red Spectroscopy (NDIR)	IS:5182 (Part-X)	0.10 mg/m^3
6	Ozone (O_3) µg/m^3	Chemical Method	IS:5182 (Part-IX)	10 µg/m^3
7	Lead (Pb) µg/m^3	ICP after sampling on EPM 2000 or equivalent filter paper	IS:5182 (Part-22)	0.06 µg/m^3
8	Ammonia (NH_3) µg/m^3	Indophenol blue method	IS:5182 (Indophenol Method)	20 µg/m^3
9	Benzene (C_6H_6) µg/m^3	Gas Chromatography	IS:5182 (Part-XI)	2.0 µg/m^3
10	Benzo(a)Pyrene (BaP) ng/m^3	Solvent extraction followed by GC	IS:5182 (Part-XII)	0.5 ng/m^3
11	Arsenic (As) ng/m^3	ICP after sampling on EPM 2000 or equivalent filter paper	CPCB guidelines	0.44 ng/m^3
12	Nickel (Ni), ng/m^3	ICP after sampling on EPM 2000 or equivalent filter paper	CPCB guidelines	0.6 ng/m^3
13	Hydro Carbon (Methane and Non Methane)	Gas Chromatography	IS-5182 (Part-XXI)	0.5 ppm
14	Volatile Organic Compound	GC Method	EPA 21 PID	0.5 ppm

Table 3.5 Location of Ambient Air Quality monitoring stations

S. No	Location	Station Code	Direction and Distance from Project Site	Latitude and Longitude	Environmental Setting
1	Kalachara Grant	A1	2.6km SW from Well No.1	24°30'27.77"N 92°23'44.31"E	Residential Area
2	Anipur	A2	1.6km West from Well No.2	24°32'53.48"N 92°25'41.13"E	Residential Area
3	Bajar Ghat	A3	1.5km SW from Well No.6	24°36'38.55"N 92°23'47.14"E	Residential Area
4	Nayadas gram	A4	1.9km SSW from Well No.12	24°37'39.73"N 92°28'4.57"E	Residential Area
5	Kandigram Pt-1	A5	2.2km SW from Well No.11	24°42'4.52"N 92°20'54.28"E	Residential Area
6	Abdullapur Pt-1	A6	2.9 km WSW from Well No.4	24°32'23.77"N 92°35'41.47"E	Residential Area
7	Hailakandi	A7	4.9km SW fromWell No14	24°32'24.63"N 92°43'12.76"E	Residential Area
8	Duarbund Grant	A8	1.2km West from Well No.10	24°37'29.98"N 92°41'33.97"E	Residential Area
9	Rajyeswarpur Pt-5	A9	2.6 km west from Well No.9	24°36'52.92"N 92°36'20.73"E	Residential Area
10	Serispore	A10	1.6km West from Well No.13	24°41'10.67"N 92°31'23.09"E	Residential Area
11	Adarkona Pt1	A11	1.6km West from Well No.17	24°45'10.36"N 92°30'56.42"E	Residential Area
12	Gharua	A12	2.6km West from Well No. 21	24°48'3.46"N 92°24'41.99"E	Residential Area

13	Ranigram Pt1	A13	0.8km SW from Well No.20	24°47'38.15"N 92°22'29.34"E	Residential Area
14	Harinadik	A14	2.6 km WNW from Well No. 22	24°48'50.22"N 92°30'16.35"E	Residential Area
15	Chimparasangan Pt3	A15	1.6 km W from Well No. 23	24°48'30.53"N 92°36'17.31"E	Residential Area
16	Chibitabichia Pt5	A16	4.5km East from Well No. 18	24°44'35.28"N 92°40'4.15"E	Residential Area
17	Kathal Grant	A17	3km NE from Well No. 19	24°45'15.54"N 92°44'7.68"E	Residential Area
18	Silchar	A18	8.2km NE from Well No. 24	24°49'59.42"N 92°46'29.28"E	Residential Area



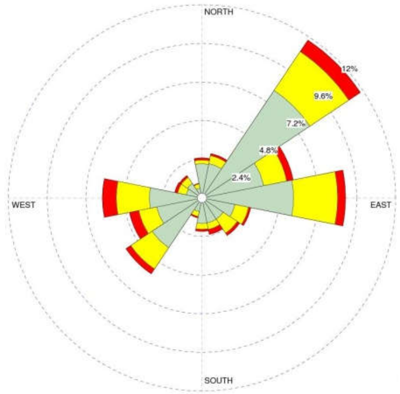


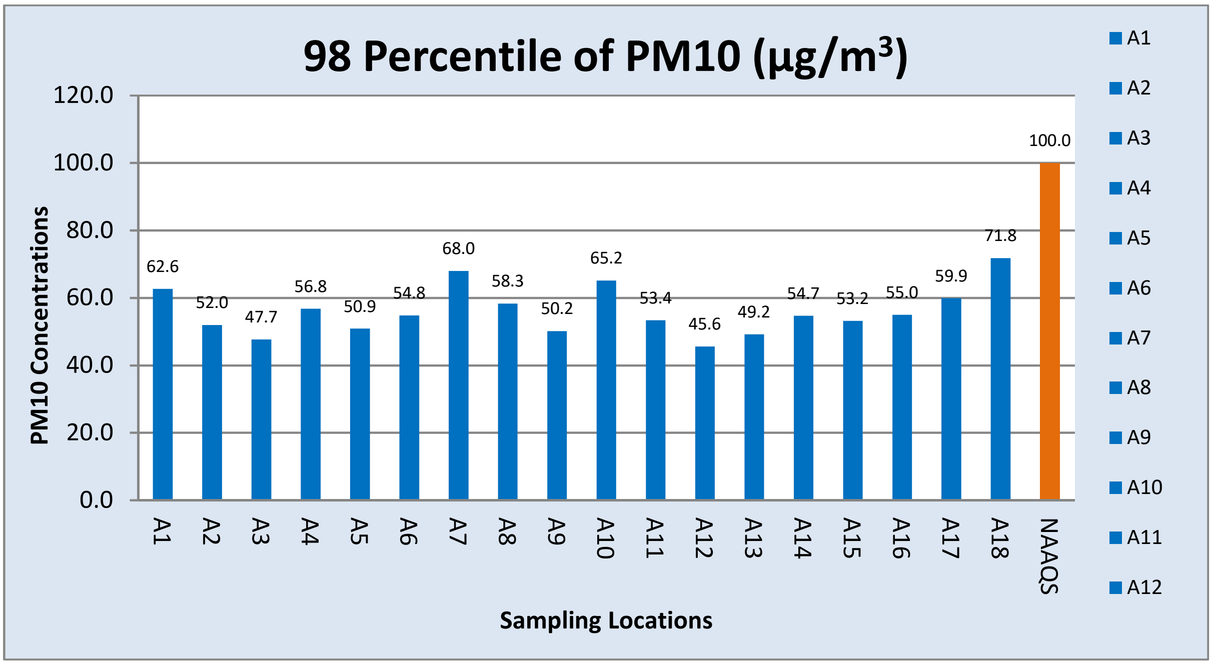
Fig 3.2 Ambient Air Quality Monitoring Location Map

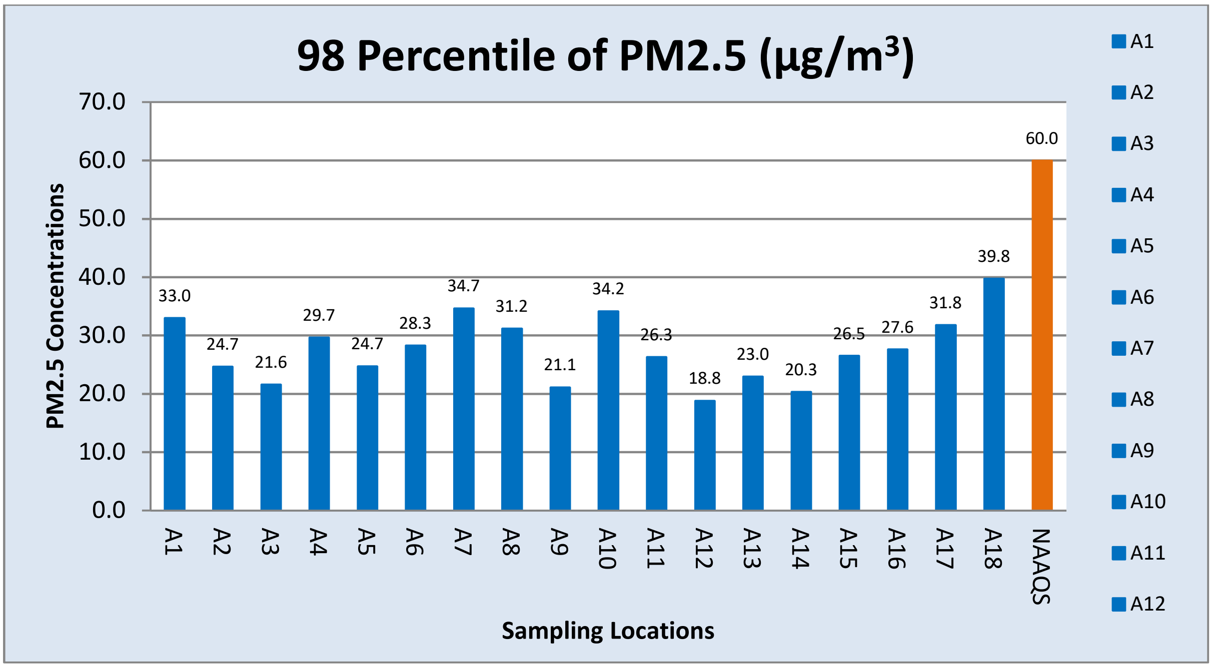
Table 3.6 Summary of analysis of Ambient Air Quality in the study area

Monitoring Locations	No of Samples	PM10(µg/m^3)				PM2.5(µg/m^3)				SO2(µg/m^3)				NOx(µg/m^3)			
		Max	Min	Mean	98 percentile	Max	Min	Mean	98 percentile	Max	Min	Mean	98 percentile	Max	Min	Mean	98 percentile
A1	26	63.5	48.3	56.1	62.6	33.8	20.6	27.2	33.0	11.8	9.2	10.6	11.7	13.4	10.6	12.2	13.2
A2	26	53.3	39.7	46.5	52.0	25.9	13.4	19.3	24.7	9.3	6.9	8.1	9.2	10.2	7.7	9.0	10.1
A3	26	47.8	34.9	43.0	47.7	22.8	12.2	16.6	21.6	9.1	7.2	7.9	8.9	9.8	7.7	8.8	9.7
A4	26	57.1	44.9	51.4	56.8	30.2	17.4	23.7	29.7	10.4	8.2	9.3	10.3	11.8	9.2	10.5	11.7
A5	26	51.2	38.2	46.3	50.9	25.6	14.8	19.4	24.7	9.5	7.6	8.6	9.4	10.7	8.2	9.5	10.5
A6	26	55.1	42.2	49.7	54.8	29.4	17.6	22.5	28.3	10.5	8.2	9.4	10.4	11.9	9.2	10.5	11.8
A7	26	69.5	51.1	59.6	68.0	35.1	22.6	29.5	34.7	12.9	9.7	11.5	12.8	14.5	11.6	13.3	14.3
A8	26	58.5	46.3	53.1	58.1	31.9	18.3	24.8	31.2	10.9	8.6	9.7	10.8	12.3	9.6	11.1	12.2
A9	26	56.4	31.6	39.7	50.2	21.6	10.2	14.4	21.1	8.6	6.6	7.3	8.3	9.1	7.1	8.1	9.0
A10	26	66.4	50.3	57.9	65.2	34.5	21.9	28.2	34.2	12.4	9.5	11.1	12.3	13.8	10.9	12.7	13.7
A11	26	54.1	42.2	48.3	53.4	27.3	14.6	20.9	26.3	9.9	7.3	8.6	9.7	10.8	8.3	9.4	10.7
A12	26	49.5	30.4	37.7	45.6	19.4	9.9	13.4	18.8	8.2	6.1	6.8	7.9	8.5	6.8	7.7	8.4
A13	26	49.8	36.4	44.4	49.2	24.3	13.2	12.8	23.0	9.4	7.4	8.3	9.3	10.1	8.1	9.2	10.0
A14	26	63.0	33.8	42.5	54.7	21.1	11.8	15.6	20.3	8.5	7.0	7.4	8.4	9.3	7.5	8.5	9.2
A15	26	53.5	40.3	48.1	53.2	27.5	15.9	20.7	26.5	10.1	7.8	9.0	10.0	11.2	8.7	10.0	11.0
A16	26	55.1	43.8	49.7	55.0	28.1	15.3	22.2	27.6	10.1	7.9	9.0	10.0	11.3	8.8	9.9	11.2
A17	26	60.2	47.0	54.5	59.9	32.2	19.5	26.0	31.8	11.4	8.9	10.1	11.2	12.9	9.9	11.5	12.7
A18	26	73.1	50.6	63.5	71.8	42.2	26.1	32.7	39.8	13.1	10.1	12.0	13.0	14.8	12.1	13.9	14.7
NAAQ Standards		**100(µg/m^3)**				**60(µg/m^3)**				**80(µg/m^3)**				**80(µg/m^3)**			

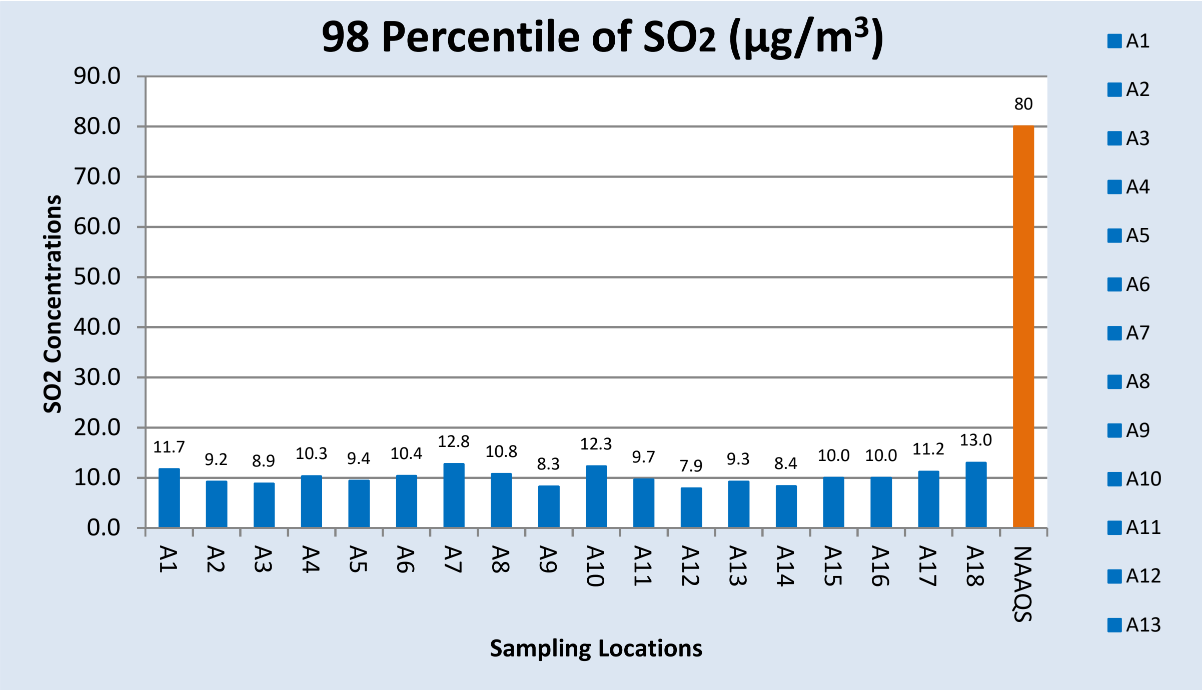
Monitoring Locations	No of Samples	CO(mg/m³)				O_3(µg/m³)				NH_3(µg/m³)			
		Max	Min	Mean	98 percentile	Max	Min	Mean	98 percentile	Max	Min	Mean	98 percentile
A1	26	0.24	0.13	0.18	0.23	40.0	21.0	30.0	39.0	28.0	<20	21.9	27.5
A2	26	0.15	0.10	0.11	0.14	36.0	20.0	27.5	35.0	26.0	<20	20.2	26.0
A3	26	0.13	0.10	0.10	0.12	27.0	11.0	19.4	26.5	<20	<20	<20	<20
A4	26	0.18	0.11	0.13	0.17	32.0	16.0	24.2	11.5	22.0	<20	17.3	21.5
A5	26	0.15	0.10	0.11	0.14	30.0	14.0	22.0	29.5	22.0	<20	15.5	22.0
A6	26	0.18	0.10	0.13	0.17	34.0	18.0	25.7	33.0	25.0	<20	18.5	24.5
A7	26	0.30	0.15	0.22	0.29	44.0	26.0	34.5	43.0	33.0	<20	26.5	32.5
A8	26	0.19	0.11	0.14	0.18	35.0	17.0	26.2	34.0	24.0	<20	18.9	23.5
A9	26	0.14	0.10	0.11	0.13	23.0	9.0	16.3	22.5	<20	<20	<20	<20
A10	26	0.28	0.14	0.20	0.27	42.0	23.0	31.4	40.0	31.0	<20	24.0	30.0
A11	26	0.17	0.10	0.11	0.16	28.0	13.0	20.4	27.5	20.0	<20	<20	19.5
A12	26	0.13	0.10	0.10	0.12	21.0	7.0	15.1	21.0	<20	<20	<20	<20
A13	26	0.14	0.10	0.10	0.13	28.0	13.0	20.0	27.5	22.0	<20	<20	21.5
A14	26	0.13	0.10	0.10	0.12	25.0	10.0	17.9	24.5	<20	<20	<20	<20
A15	26	0.14	0.10	0.11	0.13	32.0	16.0	23.7	31.0	24.0	<20	<20	23.5
A16	26	0.17	0.10	0.12	0.16	30.0	14.0	22.1	29.5	21.0	<20	<20	20.5
A17	26	0.23	0.12	0.15	0.22	37.0	19.0	28.0	36.0	26.0	<20	20.5	25.5
A18	26	0.36	0.16	0.24	0.34	46.0	28.0	36.7	45.0	36.0	21.0	28.54	35.5
NAAQ Standards		**4.0mg/m³ at 1hr**				**180µg/m³ at 1hr**				**400µg/m³**			

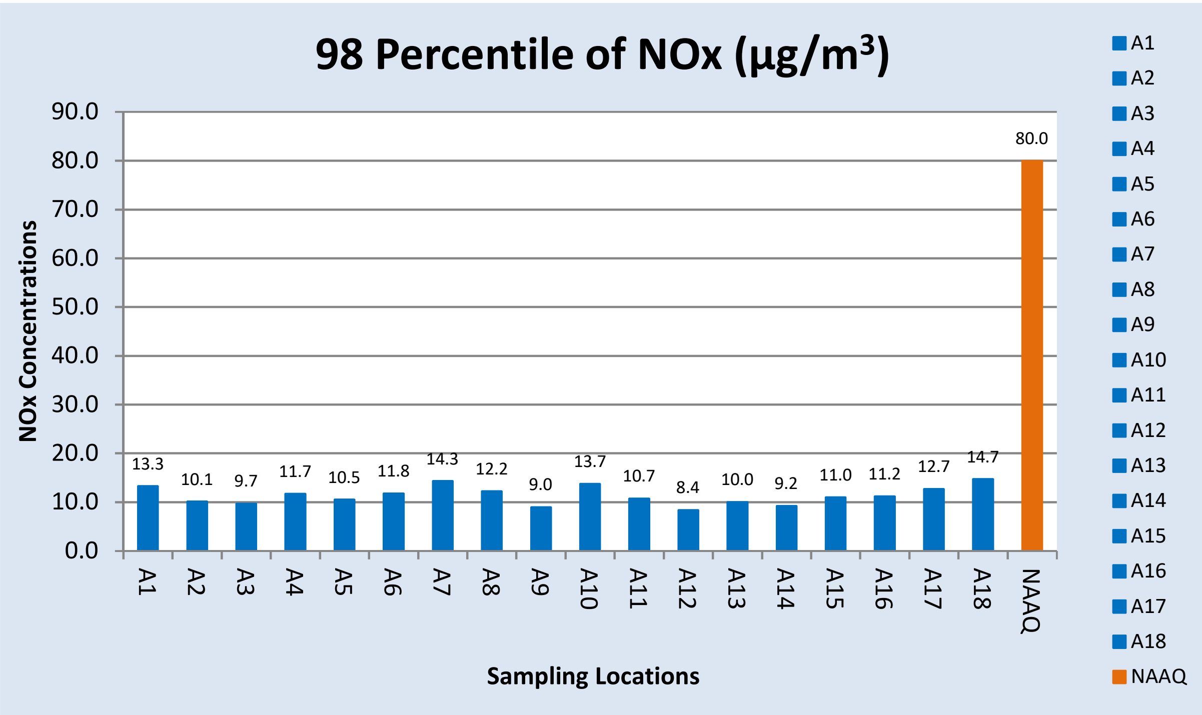
GRAPHICAL PRESENTATION OF AMBIENT AIR QUALITY IN THE STUDY AREA





GRAPHICAL PRESENTATION OF AMBIENT AIR QUALITY IN THE STUDY AREA





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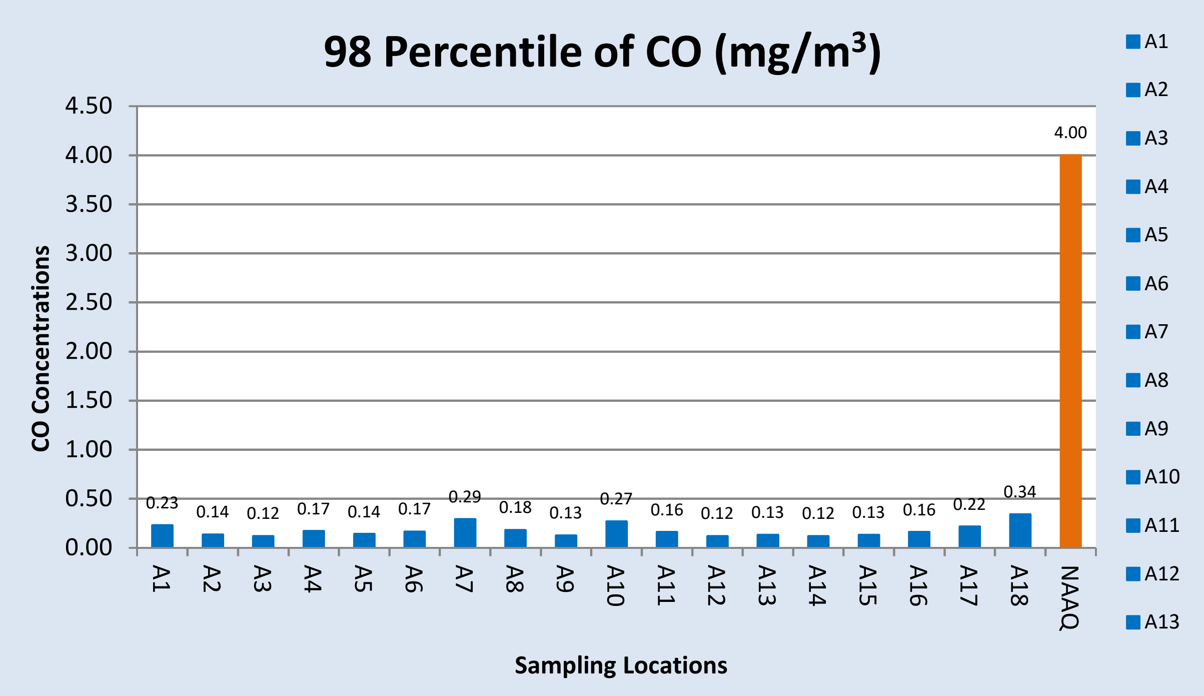
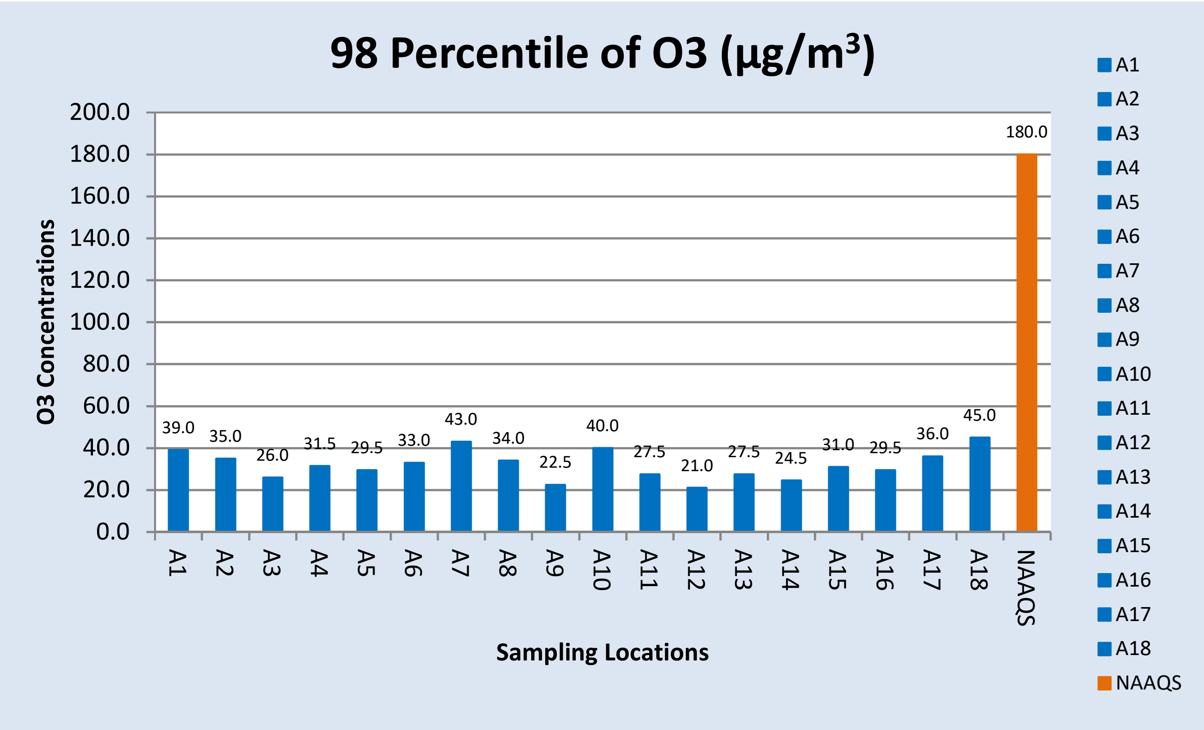
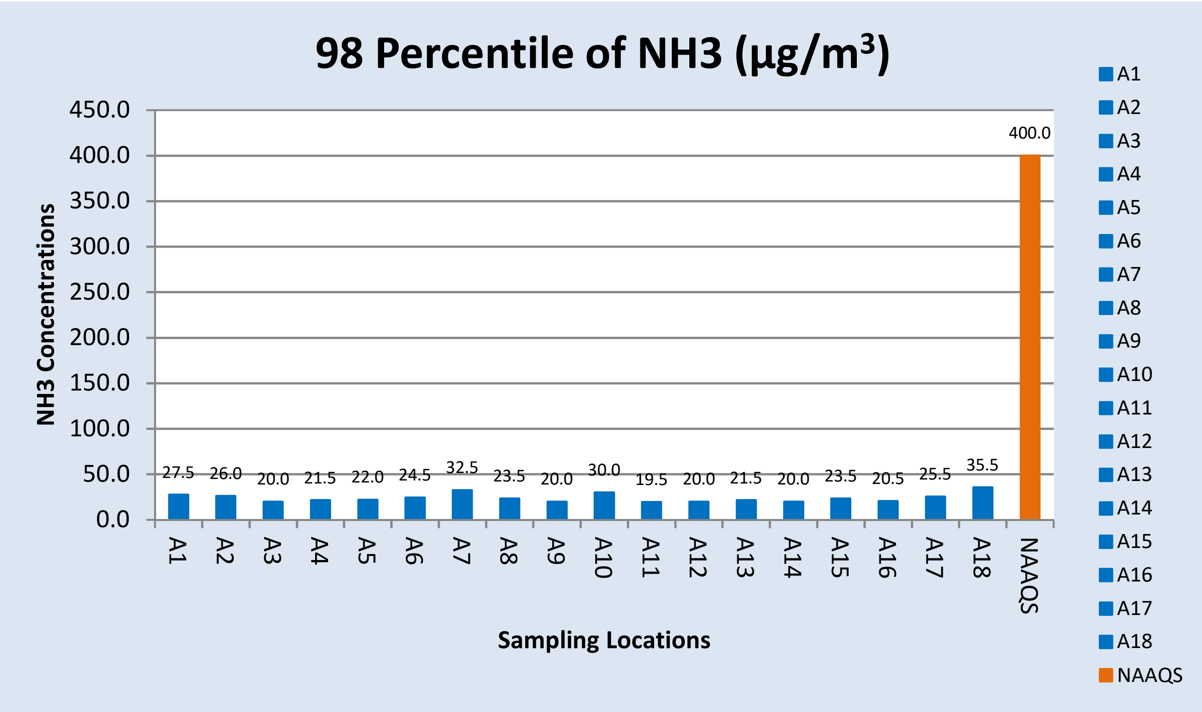




GRAPHICAL PRESENTATION OF AMBIENT AIR QUALITY IN THE STUDY AREA



3.5.3 Summary of Existing Ambient Air Quality

On the perusal of above summary of analysis of ambient air quality in the study are it is evident that all monitored values in various locations are well within the specified limits of CPCB. The results are summarized below:

PM_{10}: The highest PM_{10} concentration 73.1µg/m^3 was observed in the ambient air was recorded at station A18 while the lowest PM_{10} concentration was found to be 30.4µg/m^3 at A12. All the monitored values of PM_{10} are well below the specified limit of 100 µg/m^3.

$PM_{2.5}$: The highest $PM_{2.5}$ concentration 42.2µg/m^3 was observed in the ambient air was recorded at station A18 while the lowest $PM_{2.5}$ concentration was found to be 9.9µg/m^3 at A12. All the monitored values of $PM_{2.5}$ are well below the specified limit of 60µg/m^3.

SO_2: The highest SO_2 concentration 13.1µg/m^3 was observed in the ambient air was recorded at station A18 while the lowest SO_2 concentration was found to be 6.1µg/m^3 at A12. All the monitored values of SO_2 are well below the specified limit of 80 µg/m^3.

NOx: The highest NOx concentration 14.8µg/m3was observed in the ambient air was recorded at station A18 while the lowest NOx concentration was found to be 6.8µg/m3 at A12. All the monitored values of NOx are well below the specified limit of 80µg/m^3.

CO: The highest CO concentration 0.36mg/m3was observed in the ambient air was recorded at station A18 while the lowest CO concentration was found to be 0.10mg/m3 at A12. All the monitored values of CO are well below the specified limit of 4.0mg/m^3.

OZONE (O_3): The highest O_3 concentration 46.0µg/m^3 was observed in the ambient air was recorded at station A18 while the lowest O_3 concentration was found to be <10µg/m^3 at A9 and A12. All the monitored values of O_3 are well below the specified limit of 180µg/m^3.

Ammonia (NH_3): The highest NH_3 concentration 36.0µg/m^3 was observed in the ambient air was recorded at station A18 while the lowest O_3 concentration was found to be <20.0µg/m^3 at all locations. All the monitored values of NH_3 are well below the specified limit of 400µg/m^3.

Lead (Pb), Benzene (C_6H_6), Benzo(a)pyrene (BaP), Arsenic (As), Nickel (Ni), HC (methane and non methane Hydro Carbon), Volatile Organic Carbon (VOC) - are remained below detection limit (BDL) in the study area.

3.6 WATER ENVIRONMENT

The water resources, both surface and groundwater play an important role in the development of the area. Likewise, the water resources of the area have been studied to establish the current status of water quality in the area. The parameters of prime importance were selected under physical, chemical inorganic, chemical organic and heavy metal groups. Water samples from ground and surface water sources were collected. The water samples were collected in pretreated sampling cans and transported to laboratory for analysis. Due care was taken during sampling & transportation of these samples.

3.6.1 Surface Water and Ground Water Quality Assessment

In order to assess water quality impacts surface water and ground water samples are collected from the surrounding villages. The samples analyzed for various physical and chemical parameters to know the contamination levels and compared as per the IS Standards.

1. Ground water quality --- IS 10500-2012
2. Surface/canal/sea water quality --- IS 2296

3.6.2 Selection of sampling locations

Sampling locations (Table 3.9 & 3.10) were selected on basis of:

a) Drainage pattern
b) Location of residential areas respecting different activities
c) Likely areas those can represent baseline conditions

Samples for bacteriological analysis were collected in sterilized glass bottles. Selected physico-chemical and bacteriological parameters have been analyzed for projecting the existing water quality status in the study area. Water sampling locations are shown in fig 3.3.

The samples were analyzed in accordance with "Standard Methods for Examination of Water and Wastewater Analysis" published by APHA.

3.6.3 Sampling techniques

Samples for chemical analysis were collected in polyethylene carboys. Samples collected for metal content were acidified with 1 ml HNO_3. Samples for bacteriological analysis were collected in sterilized glass bottles. Selected physico-chemical and bacteriological parameters have been analyzed for projecting the existing water quality status in the study area. Parameters like temperature, Dissolved Oxygen (DO) and pH were analyzed at the time of sample collection.

The methodology for sample collection and preservation techniques was followed as per the Standard Operating Procedures (SOP) mentioned in Table 3.7.

Table 3.7 Standard Operating Procedures (SOP) for water sampling

Parameter	Sample Collection	Sample Size	Storage/ Preservation
pH	Grab sampling Plastic /glass container	50 ml	On site analysis
Electrical Conductivity	Grab sampling Plastic /glass container	50 ml	On site parameter
Total suspended solids	Grab sampling Plastic /glass container	100 ml	Refrigeration, can be stored for 7 days
Total Dissolved Solids	Grab sampling Plastic /glass container	100 ml	Refrigeration, can be stored for 7 days
BOD	Grab sampling Plastic /glass container	500 ml	Refrigeration, 48 hrs

Parameter	Sample Collection	Sample Size	Storage/ Preservation
Hardness	Grab sampling Plastic /glass container	100 ml	Add HNO_3 to pH<2, refrigeration; 6 months
Chlorides	Grab sampling Plastic /glass container	50 ml	Not required; 28 days
Sulphates	Grab sampling Plastic /glass container	100 ml	Refrigeration; 28 days
Nitrates	Plastic containers	100 ml	Refrigeration; 48 hrs
Fluorides	Plastic containers only	100 ml	Not required; 28 days
Alkalinity	Plastic/ glass containers	100 ml	Refrigeration; 14 days
Ammonia	Plastic/ glass containers	100 ml	Add H_2SO_4 to pH>2, refrigeration, 28 days
Heavy Metals (As, Cd, Mn, Cu, Fe, Zn, Pb etc.)	Plastic/ Glass rinse with 1+1 HNO_3	500 ml	Filter, add HNO_3 to pH>2; Grab sample; 6 months

Analytical Techniques

The analytical techniques used for water analysis is given in the **Table 3.8**.

Table 3.8 Analytical techniques for water analysis

Parameter	Method
pH	APHA-4500-H^+
Colour	APHA-2120 C
Odour	IS: 3025, Part-4
Temperature	APHA-2550 B
Dissolved Oxygen	APHA-4500 O
BOD	APHA-5210 B
Electrical conductivity	APHA-2510 B
Turbidity	APHA-2130 B
Chlorides	APHA-4500 Cl^-
Fluorides	APHA-4500 F^-
Total dissolved solids	APHA-2540 C
Total suspended solids	APHA-2540 D
Total hardness	APHA-2340 C
Sulphates	APHA-4500 SO_4^{-2}
Arsenic	APHA-3120 B/ APHA-3114 B/ APHA-3500 As

Parameter	Method
Calcium	APHA-3120 B/ APHA-3500 Ca
Magnesium	APHA-3120 B/ APHA-3500 Mg
Sodium	APHA-3120 B/ APHA-3500 Na
Potassium	APHA-3120 B/ APHA-3500 K
Manganese	APHA-3120 B/ APHA-3500 Mn
Mercury	APHA-3112 B/ APHA-3500 Hg
Lead	APHA-3120 B/ APHA-3500 Pb
Copper	APHA-3120 B/ APHA-3500 Cu
Cadmium	APHA-3120 B/ APHA-3500 Cd
Iron	APHA-3120 B/ APHA-3500 Fe
Zinc	APHA-3120 B/ APHA-3500 Zn
Boron	APHA-4500 B
Coliform organisms	APHA-9215 D
Alkalinity	APHA-2320 B
COD	APHA-5220 D
Phenolic Compounds	APHA-510 C
Nitrates	APHA 22nd Edition -4500- NO3- B
Residual Chlorine	IS : 3025 Part 32-1988 (Reaff: 2014)
Total kjeldal Nitrogen	APHA 22nd Edition -4500- NH3 B&C
Dissolved phosphates	IS : 3025 Part 31-1988 (Reaff:2014)
Hexavalent Chromium Cr+6	APHA-3120 B/ APHA-3500 Cr+6
Aluminum	APHA-3120 B/ APHA-3500 Al
Ionic Detergents	IS : 3025 Part 23- 1986 (Reaff:2012)
Barium	APHA-3120 B/ APHA-3500 Ba
SAR	Calculation
Free Ammonia	APHA 22nd Edition -4500- NH3 B&C
Salinity	APHA 22nd Edition -2520 B

Source: Standard Methods for the Examination of Water and Wastewater, Published By APHA, AWWA, WEF 23rd Edition, 2017

3.6.4 Water Sampling Stations

Table 3.9 Ground water sampling locations

Code	Station	Direction and distance	Latitude & Longitude	Source of collection
GW1	Tagribari PT	3.4km WNW from Well 2	24°33'32.28"N 92°24'42.97"E	Tube well
GW2	Damchera Tripur	3.5km WSW from Well 3	24°32'44.14"N 92°29'47.71"E	Tube well

GW3	Lalapur	2.2km NW from Well 4	24°33'36.06"N 92°36'24.89"E	Bore well
GW4	Bilaipur	7.2 NNW from Well 5	24°31'15.45"N 92°43'41.81"E	Bore well
GW5	Bahuranga Cherrag	6.3 km W from Well 6	24°36'55.02"N 92°20'36.93"E	Tube well
GW6	Monachura Grant	3.3km E from Well 8	24°37'28.27"N 92°33'35.63"E	Bore well
GW7	Choto Jalinga Grant	2.1km NNE from Well 10	24°38'31.24"N 92°42'38.47"E	Bore well
GW8	Loharbond	2.5km NE from Well 5	24°35'20.29"N 92°44'5.02"E	Tube well
GW9	Hailakandi	3.0km ESE from Well 13	24°40'43.68"N 92°33'57.36"E	Tube well
GW10	Patherkandi Pt1	5.1km SSW from Well 11	24°40'23.43"N 92°20'29.99"E	Bore well
GW11	Nilam Bazar Jatrapur	3.6km NNW from Well 11	24°44'34.27"N 92°20'56.42"E	Bore well
GW12	Purba Sonapur	1.6km NNE from Well 14	24°43'5.73"N 92°37'17.09"E	Tube well
GW13	Chibitabichia Pt10	3.2km SW from Well 19	24°43'33.46"N 92°41'3.21"E	Bore well
GW14	Sirajdhipur	2.0km WNW from Well 21	24°48'13.91"N 92°25'5.23"E	Bore well
GW15	Jikar	4.9km West from Well 22	24°48'20.83"N 92°28'49.23"E	Tube well
GW16	Piratikar	2.4km North from Well 22	24°49'37.31"N 92°31'33.74"E	Bore well
GW17	Elgin Grant	1.7km SE from Well 24	24°47'42.38"N 92°43'6.41"E	Dug well
GW18	Silchar	8.3km East from Well 24	24°48'31.00"N 92°47'8.87"E	Dug well

Table 3.10 Surface water sampling locations

Code	Station	Direction and distance	Latitude & Longitude	Source of collection
SW1	Sone Beel Lake	4.2km SE of well 16	24°42'8.51"N 92°27'13.30"E	Lake
SW2	Sunai River Upstream of Well 20	3.2km SSW of well.20	24°47'32.19"N 92°24'27.29"E	River

SW3	Sunai River Downstream of Well 20	3.1km WSW of Well 21	24°49'29.02"N 92°23'13.08"E	River
SW4	Khatakal River	2.8km NW of Well 9	24°38'14.42"N 92°36'44.55"E	River
SW5	Dhaleswari River	2.5km NE of Well 8	24°38'9.22"N 92°32'41.77"E	River
SW6	Rathakandi Beel	4.7km W of Well 17	24°45'43.58"N 92°28'53.27"E	Beel
SW7	Lake at Silcorie Grant	7km NE of Well 15	24°42'42.30"N 92°46'13.55"E	Lake
SW8	Barak River at Silchar	9km NE of Well 24	24°51'3.60"N 92°46'24.10"E	River
SW9	Barak River downstream	5.8km N of Well23	24°51'27.21"N 92°37'10.12"E	River
SW10	Khatakal-Barak River confluence point	3.2km NE of Well23	24°49'43.27"N 92°38'14.12"E	River
SW11	Pond near Serispor	1.3km WSW of Well 13	24°40'56.71"N 92°31'30.66"E	Pond
SW12	Pond near Jalalpur	5.2km ENE of Well 3	24°33'41.85"N 92°34'47.81"E	Pond
SW13	Pond Near Derby	6.8km E of Well 15	24°40'30.43"N 92°47'18.31"E	Pond
SW14	Stream Water near Nunaikhal Grant	3.9km SE of Well 4	24°30'57.01"N 92°38'21.19"E	Stream
SW15	Stream confluence point with Khatakal River	2.0km S of Well 4	24°31'45.83"N 92°37'2.75"E	River
SW16	Sunai River Upstream	7.8km W of Well 1	24°31'37.05"N 92°19'59.21"E	River
SW17	Sunai River Downstream	9.3km W of Well 1	24°33'49.92"N 92°19'42.95"E	River
SW18	Pond water at Amarkhal	1.3km NE of Well 2	24°33'21.87"N 92°27'20.66"E	Pond

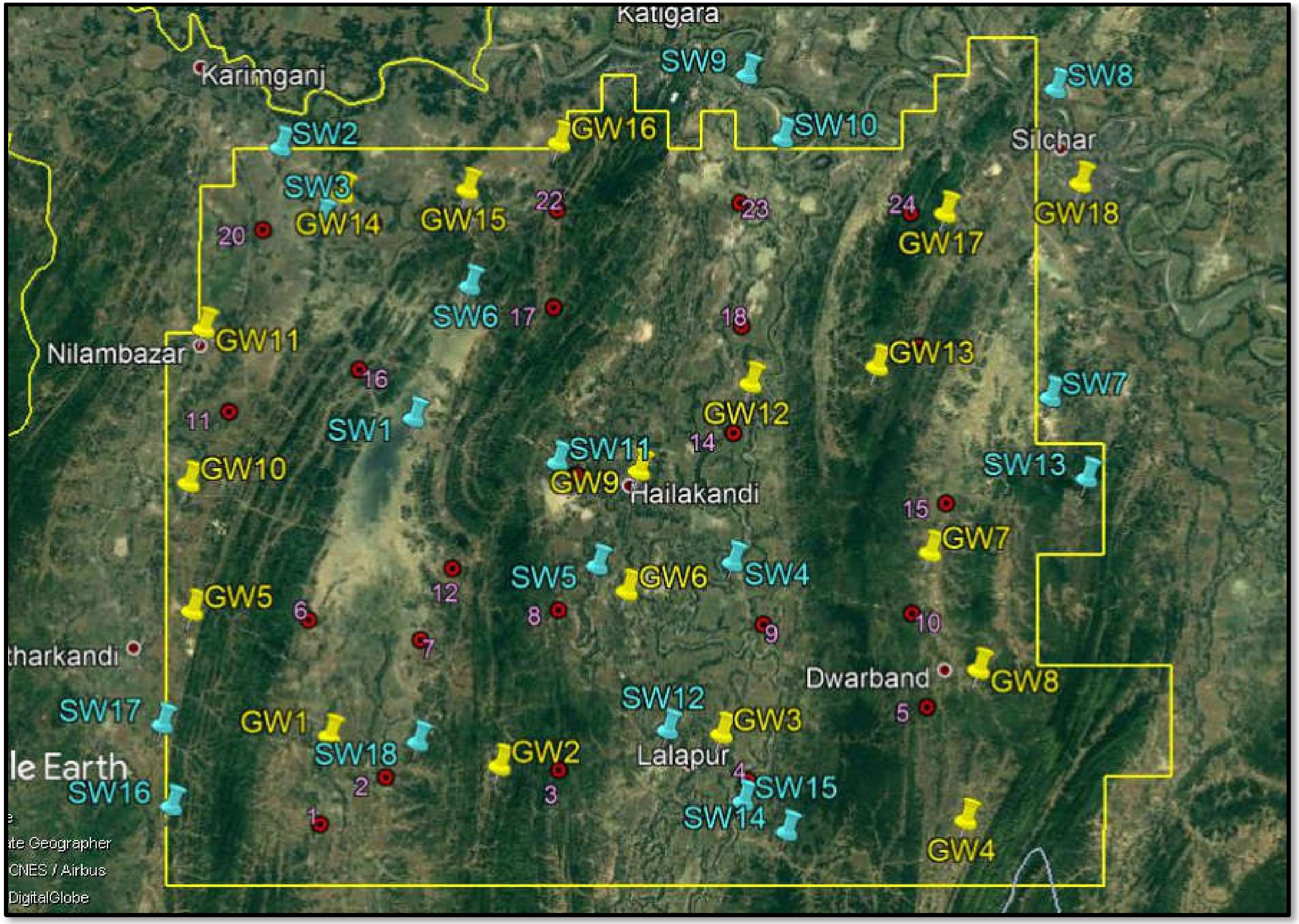


Fig 3.3 Groundwater and Surface water sampling location map

Table 3.11 Ground water quality of the study area

S.No.	PARAMETER	UNIT	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8	GW9	IS:10500-Standards	
												Acceptable	Permissible
1.	pH	-	5.93	5.79	6.0	5.66	5.9	6.4	5.5	5.1	5.4	6.5-8.5	6.5-8.5
2.	Temperature of Water	^0C	24.7	25.1	25.1	25.3	25.1	25.9	25.1	24.7	24.8	-	-
3.	Turbidity	NTU	0.4	0.34	0.53	0.29	0.43	0.6	0.22	0.49	0.2	1	5
4.	Electrical conductivity	mmhos/cm	212	188	255	174	218	209	148	232	149	-	-
5.	Total Dissolved Solids	mg/l	138	122	166	113	142	136	96	151	97	500	2000
6.	Total Hardness (as $CaCO_3$)	mg/l	40	45	58	41	47	65	45	54	44	300	600
7.	Total alkalinity (as $CaCO_3$)	mg/l	60	54	76	48	66	0.83	41	72	38	200	600
8.	Chlorides as Cl	mg/l	28.3	25.8	32.2	24.8	29.5	36.1	20.7	31.6	19.8	250	1000
9.	Sulphates as SO_4	mg/l	26	23	38	20	29	46	16	34	15	200	400
10.	Nitrates as NO_3	mg/l	2.7	2.3	3.3	2	2.9	4.1	1.4	3	1.3	45	45
11.	Residual Chlorine	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	-
12.	Fluoride as F	mg/l	0.48	0.42	0.64	0.38	0.51	0.76	0.27	0.59	0.25	1	1.5
13.	Sodium as Na	mg/l	10.1	8.3	10.7	7.6	9.9	11.3	6.9	8.4	3.7	-	-
14.	Potassium as K	mg/l	2.3	1.9	2.6	1.4	1.7	2.3	1.1	1.4	2.7	-	-
15.	Salinity	PSU	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
16.	Total kjheldal Nitrogen	mg/l	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	-	-
17.	Dissolved phosphates	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
18.	Dissolved Oxygen	mg/l	5.1	5.5	5.1	4.8	5.6	5.2	4.9	5.3	5.4	-	-
19.	Phenolic Compounds as C_6H_5OH	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.002
20.	Arsenic as As	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	0.05
21.	Cadmium as Cd	mg/l	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.003	0.003
22.	Mercury as Hg	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
23.	Nickel as Ni	mg/l	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-
24.	Manganese as Mn	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	0.3
25.	Hexavalent Chromium as Cr^{6+}	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	0.01
26	Lead as Pb	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	0.01
27	Iron as Fe	mg/l	1.63	1.52	1.79	1.39	1.66	1.91	1.19	1.73	1.16	0.3	0.3
28	Copper as Cu	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	1.5
29	Zinc as Zn	mg/l	0.16	0.14	0.28	0.12	0.18	0.35	0.09	0.24	0.09	5	15

30	Total Coliforms	MPN/100 ml	38	32	52	29	39	68	22	46	20	Not Detectable	Not Detectable
31	Faecal Coliforms	MPN/100 ml	Not Detectable	Not Detectable	Not Detectable	Not Detectable	Not Detectable	Not Detectable	Not Detectable	Not Detectable	Not Detectable	Not Detectable	Not Detectable
32	Aluminium (asAl)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
33	Ionic Detergents	mg/l	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	-	-
34	Barium as Ba	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
35	Calcium as Ca	mg/l	8.2	7.9	10.1	7.5	8.7	11.9	6.8	9.7	6.3	75	200
36	chloraminine as Cl2	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
37	Magnesium as Mg	mg/l	4.86	4.4	5.9	4.2	4.92	6.8	3.3	5.5	3.1	30	100
38	Mineral oil	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-
39	Selenium	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
40	Cyanide as Cn	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
41	Molybdenum as Mo	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
42	Pesticides	µg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
43	Polychlorinated biphenyles	ng/l	<10ng/l	<10ng/l	<10ng/l	<10ng/l	<10ng/l	<10ng/l	<10ng/l	<10ng/l	<10ng/l	-	-
44	PAH	ppb	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
45	Trialomethanes	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
46	SAR	milli eq/l	0.69	0.587	0.66	0.55	0.664	0.647	0.543	0.533	0.30	-	-
47	Free ammonia	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-

S.No.	PARAMETER	UNIT	GW10	GW11	GW12	GW13	GW14	GW15	GW16	GW17	GW18	IS:10500-Standards	
												Acceptable	Permissible
1.	pH	-	5.3	6.1	5.86	5.2	5.71	5.9	6.3	5.8	5.6	6.5-8.5	6.5-8.5
2.	Temperature of Water	^0C	25.1	25.3	24.9	24.7	24.7	24.6	25.8	24.7	25.3	-	-
3.	Turbidity	NTU	0.26	0.55	0.36	0.24	0.31	0.51	0.58	0.46	0.28	1	5
4.	Electrical conductivity	mmhos/cm	160	260	191	155	174	252	197	229	163	-	-
5.	Total Dissolved Solids	mg/l	104	169	124	101	113	164	128	149	106	500	2000
6.	Total Hardness (as $CaCO_3$)	mg/l	47	61	38	41	43	56	63	51	40	300	600
7.	Total alkalinity (as $CaCO_3$)	mg/l	44	78	56	42	51	74	80	69	47	200	600
8.	Chlorides as Cl	mg/l	22.4	33.1	26.5	21.9	25.1	31.9	35.3	30.2	23.1	250	1000
9.	Sulphates as SO_4	mg/l	18	41	24	17	21	36	44	31	19	200	400
10.	Nitrates as NO_3	mg/l	1.7	3.6	2.5	1.6	2.1	3.2	3.8	2.7	1.9	45	45
11.	Residual Chlorine	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	-
12.	Fluoride as F	mg/l	0.32	0.68	0.45	0.29	0.39	0.61	0.72	0.56	0.36	1	1.5
13.	Sodium as Na	mg/l	4.3	5.8	3.8	2.2	3.4	5.9	6.8	5.4	3.2	-	-
14.	Potassium as K	mg/l	1.7	1.9	1.4	1.1	1.6	1.9	2.7	1.9	1	-	-
15.	Salinity	PSU	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
16.	Total kjheldal Nitrogen	mg/l	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	-	-
17.	Dissolved phosphates	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
18.	Dissolved Oxygen	mg/l	5.1	4.9	4.7	5.3	5.1	5.2	5.5	5.3	4.7	-	-
19.	Phenolic Compounds as C_6H_5OH	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.002
20.	Arsenic as As	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	0.05
21.	Cadmium as Cd	mg/l	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.003	0.003
22.	Mercury as Hg	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
23.	Nickel as Ni	mg/l	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-
24.	Manganese as Mn	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	0.3
25.	Hexavalent Chromium as Cr^{6+}	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	0.01
26	Lead as Pb	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	0.01
27	Iron as Fe	mg/l	1.29	1.82	1.58	1.22	1.47	1.76	1.84	1.69	1.36	0.3	0.3
28	Copper as Cu	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	1.5
29	Zinc as Zn	mg/l	0.11	0.29	0.15	0.1	0.13	0.25	0.31	0.21	0.12	5	15

30	Total Coliforms	MPN/100 ml	26	58	35	24	30	49	63	43	27	Not Detectable	Not Detectable
31	Faecal Coliforms	MPN/100 ml	Not Detectable	Not Detectable	Not Detectable	Not Detectable	Not Detectable	Not Detectable	Not Detectable	Not Detectable	Not Detectable	Not Detectable	Not Detectable
32	Aluminium (asAl)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
33	Ionic Detergents	mg/l	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	-	-
34	Barium as Ba	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
35	Calcium as Ca	mg/l	7.2	10.6	8.1	7.1	7.6	9.9	11.1	9.2	7.4	75	200
36	chloraminine as Cl2	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
37	Magnesium as Mg	mg/l	3.7	6.1	4.6	3.5	4.3	5.7	6.5	5.1	4	30	100
38	Mineral oil	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-
39	Selenium	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
40	Cyanide as Cn	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
41	Molybdenum as Mo	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
42	Pesticides	µg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
43	Polychlorinated biphenyles	ng/l	<10ng/l	<10ng/l	<10ng/l	<10ng/l	<10ng/l	<10ng/l	<10ng/l	<10ng/l	<10ng/l	-	-
44	PAH	ppb	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
45	Trialomethanes	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
46	SAR	milli eq/l	0.324	0.351	0.264	0.168	0.244	0.369	0.40	0.354	0.235	-	-
47	Free ammonia	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-

Table 3.12 Surface water quality of the study area

S. No	PARAMETER	UNIT	SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8	SW9	IS:2296 – Standards
1.	Color	Hazen	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
2.	Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	-
3.	Taste	-	Taste less	Taste less	Taste less	Taste less	Taste less	Taste less	Taste less	Taste less	Taste less	-
4.	pH	-	5.8	6.3	5.8	6.6	7.1	6.8	6.6	6.9	6.4	6.50 – 8.50
5.	Temperature of Water	^{0}C	19.7	17.9	20.8	24.7	24.7	25.1	23.2	24.9	25.3	-
6.	Turbidity	NTU	1.5	1.3	1.7	2.1	2.3	2.4	1.7	2.5	2.7	-
7.	Electrical conductivity	mmhos/cm	121	116	127	143	151	157	137	158	154	-
8.	Total Dissolved Solids	mg/l	81	78	85	96	101	105	92	106	103	1500
9.	Total Hardness (as $CaCO_3$)	mg/l	28	26	23	25	29	31	33	42	31	-
10.	Total alkalinity (as $CaCO_3$)	mg/l	34	31	38	48	54	53	44	57	54	-
11.	Chlorides as Cl	mg/l	7.1	6.8	7.4	8.5	8.9	9.8	8	9.4	9.9	600
12.	Sulphates as SO_4	mg/l	0.86	0.79	0.92	1.3	1.5	1.9	1	1.7	2.1	400
13.	Nitrates as NO_3	mg/l	0.16	0.17	0.14	0.19	0.23	0.31	0.15	0.28	0.36	50
14.	Residual Chlorine	mg/l	ND	ND	ND	ND	ND	ND	ND	ND	ND	-
15.	Fluoride as F	mg/l	0.26	0.21	0.26	0.34	0.38	0.37	0.31	0.42	0.38	1.5
16.	Sodium as Na	mg/l	3.8	2.9	3.1	3.7	4.1	4.6	3.5	3.9	4.4	-
17.	Potassium as K	mg/l	4.3	4.1	4.6	5.6	6.1	6.2	5.1	6.6	6.4	-
18.	Salinity	PSU	1.8	1.5	1.1	2.7	1.4	1.2	1.9	1.4	1.8	-
19.	Total kjheldal Nitrogen	mg/l	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-
20.	Dissolved phosphates	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
21.	Dissolved Oxygen	mg/l	4.7	4.4	5.1	6.1	6.6	6.2	5.7	7.3	6.8	5.0 min
22.	Biochemical Oxygen Demand	mg/l	1.0	1.0	1.1	1.1	1.3	1.5	1.1	1.4	1.5	3
23.	Chemical Oxygen Demand	mg/l	3.16	3.2	3.26	3.34	3.42	3.61	3.26	3.52	3.74	-
24.	Phenolic Compounds as C_6H_5OH	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005
25.	Arsenic as As	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
26.	Cadmium as Cd	mg/l	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-
27.	Mercury as Hg	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
28.	Nickel as Ni	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
29.	Manganese as Mn	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-

30.	Hexavalent Chromium as Cr^{6+}	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.05
31.	Lead as Pb	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
32.	Iron as Fe	mg/l	0.18	0.14	0.22	0.36	0.41	0.46	0.26	0.44	0.49	-
33.	Copper as Cu	mg/l	1	1	1.12	1.1	1.3	1.48	1.1	1.43	1.53	1.5
34.	Zinc as Zn	mg/l	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	15
35.	Total Coliforms	MPN/100 ml	420	390	440	510	530	550	480	540	560	5000
36	Faecal Coliforms	MPN/100 ml	<2	<2	<2	<2	<2	<2	<2	<2	<2	Not specified
37	Aluminium (asAl)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
38	anIonic Detergents	mg/l	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	-
39	Barium as Ba	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
40	Calcium as Ca	mg/l	4.3	4.1	4.6	5.6	6.1	6.2	5.1	6.6	6.4	-
41	chloraminine as Cl2	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-
42	Magnesium as Mg	mg/l	3.9	3.6	4.2	4.8	5.8	5.5	4.3	5.9	5.1	-
43	Mineral oil	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
44	Selenium	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
45	Cyanide as Cn	mg/l	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-
46	Molybdenum as Mo	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
47	Pesticides	µg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
48	SAR	milli eq/l	0.03	0.25	0.25	0.27	0.28	0.32	0.27	0.26	0.31	-

S. No	PARAMETER	UNIT	SW10	SW11	SW12	SW13	SW14	SW15	SW16	SW17	SW18	IS:2296 – Standards
1.	Color	Hazen	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
2.	Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	-
3.	Taste	-	Taste less	Taste less	Taste less	Taste less	Taste less	Taste less	Taste less	Taste less	Taste less	-
4.	pH	-	6.7	7.2	6.6	7	7.1	6.8	6.6	6.9	7.2	6.50 – 8.50
5.	Temperature of Water	^{0}C	18.6	23.9	17.2	20.1	25.1	25.2	21.9	24.9	25.3	-
6.	Turbidity	NTU	1.4	1.9	1.2	1.6	2.4	2.2	1.6	2.2	2.6	-
7.	Electrical conductivity	mmhos/cm	118	152	125	139	155	146	130	151	164	-
8.	Total Dissolved Solids	mg/l	79	102	84	93	104	98	87	101	110	1500
9.	Total Hardness (as $CaCO_3$)	mg/l	27	28	24	29	31	27	26	30	34	-
10.	Total alkalinity (as $CaCO_3$)	mg/l	32	46	28	36	56	51	41	49	61	-
11.	Chlorides as Cl	mg/l	7	8.1	6.6	7.2	9.1	8.8	7.7	9.6	9.6	600
12.	Sulphates as SO_4	mg/l	0.83	1.1	0.75	0.88	1.6	1.4	0.96	1.8	1.8	400
13.	Nitrates as NO_3	mg/l	0.15	0.16	0.18	0.16	0.25	0.21	0.13	0.29	0.3	50
14.	Residual Chlorine	mg/l	ND	ND	ND	ND	ND	ND	ND	ND	ND	-
15.	Fluoride as F	mg/l	0.21	0.29	0.26	0.24	0.39	0.36	0.28	0.33	0.37	1.5
16.	Sodium as Na	mg/l	3.2	3.7	2.9	3.1	4.3	3.7	3.1	4.4	3.9	-
17.	Potassium as K	mg/l	4.2	5.4	3.8	4.4	6.4	5.9	4.8	5.9	6.8	-
18.	Salinity	PSU	0.9	1.1	0.87	0.94	1.2	1.8	0.86	1.3	1	-
19.	Total kjheldal Nitrogen	mg/l	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-
20.	Dissolved phosphates	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
21.	Dissolved Oxygen	mg/l	4.6	5.8	4.2	4.9	6.3	6.6	5.4	6.7	6.3	5.0 min
22.	Biochemical Oxygen Demand	mg/l	1.1	1.0	1.0	1.1	1.4	1.2	1.2	1.4	1.5	3
23.	Chemical Oxygen Demand	mg/l	3.3	3.1	2.9	3.22	3.47	3.38	3.34	3.4	3.6	-
24.	Phenolic Compounds as C_6H_5OH	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005
25.	Arsenic as As	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
26.	Cadmium as Cd	mg/l	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-
27.	Mercury as Hg	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
28.	Nickel as Ni	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
29.	Manganese as Mn	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-
30.	Hexavalent Chromium as Cr^{6+}	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.05

31.	Lead as Pb	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
32.	Iron as Fe	mg/l	0.16	0.28	0.13	0.19	0.43	0.39	0.24	0.43	0.46	-
33.	Copper as Cu	mg/l	1.1	1	1	1.1	1.4	1.2	1.16	1.42	1.5	1.5
34.	Zinc as Zn	mg/l	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	15
35.	Total Coliforms	MPN/100 ml	410	490	380	430	540	520	460	530	560	5000
36	Faecal Coliforms	MPN/100 ml	<2	<2	<2	<2	<2	<2	<2	<2	<2	Not specified
37	Aluminium (asAl)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
38	anIonic Detergents	mg/l	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	-
39	Barium as Ba	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
40	Calcium as Ca	mg/l	4.2	5.4	3.8	4.4	6.4	5.9	4.8	5.9	6.8	-
41	chloraminine as Cl2	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-
42	Magnesium as Mg	mg/l	3.6	4.8	3.1	3.9	5.2	5.1	4.2	5.1	5.9	-
43	Mineral oil	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
44	Selenium	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
45	Cyanide as Cn	mg/l	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-
46	Molybdenum as Mo	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
47	Pesticides	µg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
48	SAR	milli eq/l	0.27	0.27	0.26	0.25	0.30	0.26	0.24	0.32	0.26	-

3.6.5 Surface water quality results (Table 3.12) are summarized below:

- pH of the surface water collected was acidic with pH ranging from 5.8 – 7.2
- TDS was found to be 78 mg/l to 110 mg/l. The tolerance limit of 1,500 mg/l as per IS:2296
- Total hardness was found to be 23 mg/l to 42 mg/l
- Presence of Nitrate was recorded as 0.13 mg/l to 0.36 mg /l
- DO was observed as 4.2 mg/l to 7.3 mg /l
- Total coliform in water was 380MPN/100 ml to 560MPN/100 ml. The likely source of bacteriological contamination was due to the proximity to residential area
- All the heavy metals were found to be within below detectable limits.

3.6.6 Groundwater quality results (Table 3.11) are summarised below:

- During the study period, the pH of the groundwater was found varying between 5.1 and 6.4 and found to be acidic due to high iron content in the water.
- The TDS of all the samples were within the permissible limit of 2000 mg/l.
- The Chloride levels in the groundwater samples collected in the study area were ranging from 19.8-36.1 mg/l.
- In the groundwater samples collected from the study area, the hardness was found to be varying from 38 mg/l to 65 mg/l.
- In the groundwater samples of study area the fluoride values were found to be within a range of 0.25 mg/l to 0.76 mg/l.
- Total coliforms were present in the GW results due to human sewage or animal droppings which could contain other bacteria, viruses, or disease causing organisms.

All the heavy metals in all samples were found to be below the permissible limits except Iron (Fe).

3.7 SOIL ENVIRONMENT

3.7.1 Selection of sampling locations

For studying soil profile of the region, sampling locations were selected to assess the existing overall soil conditions around the project site. The study of the soil profile establishes the baseline characteristics and this will help in future for identifying the incremental concentrations if any, due to the proposed project. The sampling locations have been identified with following objectives.

a) To determine the baseline soil characteristics of the study area
b) To determine the impact of the project activities on soil characteristics

3.7.2 Sampling and analytical techniques

Eighteen sampling locations were selected to assess the existing soil conditions representing various land use conditions and geological features. At each location, soil samples were collected from three different depths viz. 30 cm, 60 cm and 90 cm below the surface and are homogenized. This is in line with IS: 2720 & Methods of Soil Analysis, Part-1, 2nd edition, 1986 of (American Society for Agronomy and Soil Science Society of America). The homogenized samples were analyzed for physical and chemical characteristics. The soil samples were collected at different locations (Table 3.14) and analyzed once in each season. The samples have been analyzed as per the established scientific methods for physico-chemical parameters. Soil sampling locations are shown in Figure 3.4.
The methodology adopted for each parameter is described in Table 3.13.

Table 3.13 Analytical techniques for Soil analysis

Parameter	Method (ASTM number)
Textural classification	Chart developed by Public Roads Administration
pH	pH meter (D 1293-84)
Electrical conductivity	Conductivity meter (D 1125-82)
Nitrogen	Kjeldahl distillation (D 3590-84)
Phosphorus	Molybdenum blue, calorimetric (D 515-82)
Potassium	Flame photometric (D 1428-82)
Sodium	Flame photometric (D 1428-82)
Calcium	IS:2720
Magnesium	IS:2720
Chlorides	Argentometric (D 512-81 Rev 85)

Table 3.14 Details of soil sampling locations

Code	Location/Villages	Latitude and Longitude	Direction & Distance (km)
S1	Bidya Nagar	24°31'5.62"N 92°26'49.64"E	3.5km SSE of well 2
S2	Ramchandi Pt3	24°31'10.45"N 92°33'46.71"E	5.0km SE of well 3
S3	Bilapur	24°32'5.31"N 92°43'56.84"E	5.7km SSE of well 5

S4	Rajyeswaripur pt7	24°36'9.20"N 92°38'5.37"E	1.9km SSE of Well 9
S5	Champak Nagar	24°36'46.44"N 92°28'48.38"E	2.1km ENE of Well 7
S6	Karimganj	24°35'45.80"N 92°24'20.06"E	2.7km S of Well 6
S7	Tatirbond	24°39'8.67"N 92°20'50.83"E	7.1km SSW of Well 11
S8	Chatiyapanji	24°41'33.41"N 92°24'7.46"E	4.4km SE of Well 11
S9	Chinal	24°40'17.37"N 92°28'9.61"E	3.2km NNW of Well 9
S10	Paikan	24°40'13.31"N 92°35'21.20"E	4.7km SW of Well 14
S11	Bondukmara	24°40'56.88"N 92°38'29.16"E	3.6km SE of Well 14
S12	Tarutazabari	24°42'14.10"N 92°43'21.12"E	3.5km N of Well 15
S13	Rampasha	24°45'28.08"N 92°22'52.11"E	4.3km S of Well 20
S14	Barbari	24°50'9.91"N 92°25'46.66"E	4.4km N of Well 21
S15	Branthal pt12	24°47'43.14"N 92°33'12.07"E	2.9km SE of Well 22
S16	Doldhar	24°50'2.99"N 92°35'5.75"E	4.6km NW of Well 23
S17	Bornagad	24°46'5.37"N 92°35'44.93"E	3.1km NW of Well 18
S18	Silchar	24°49'54.90"N 92°44'53.30"E	5.6km NE of Well 24

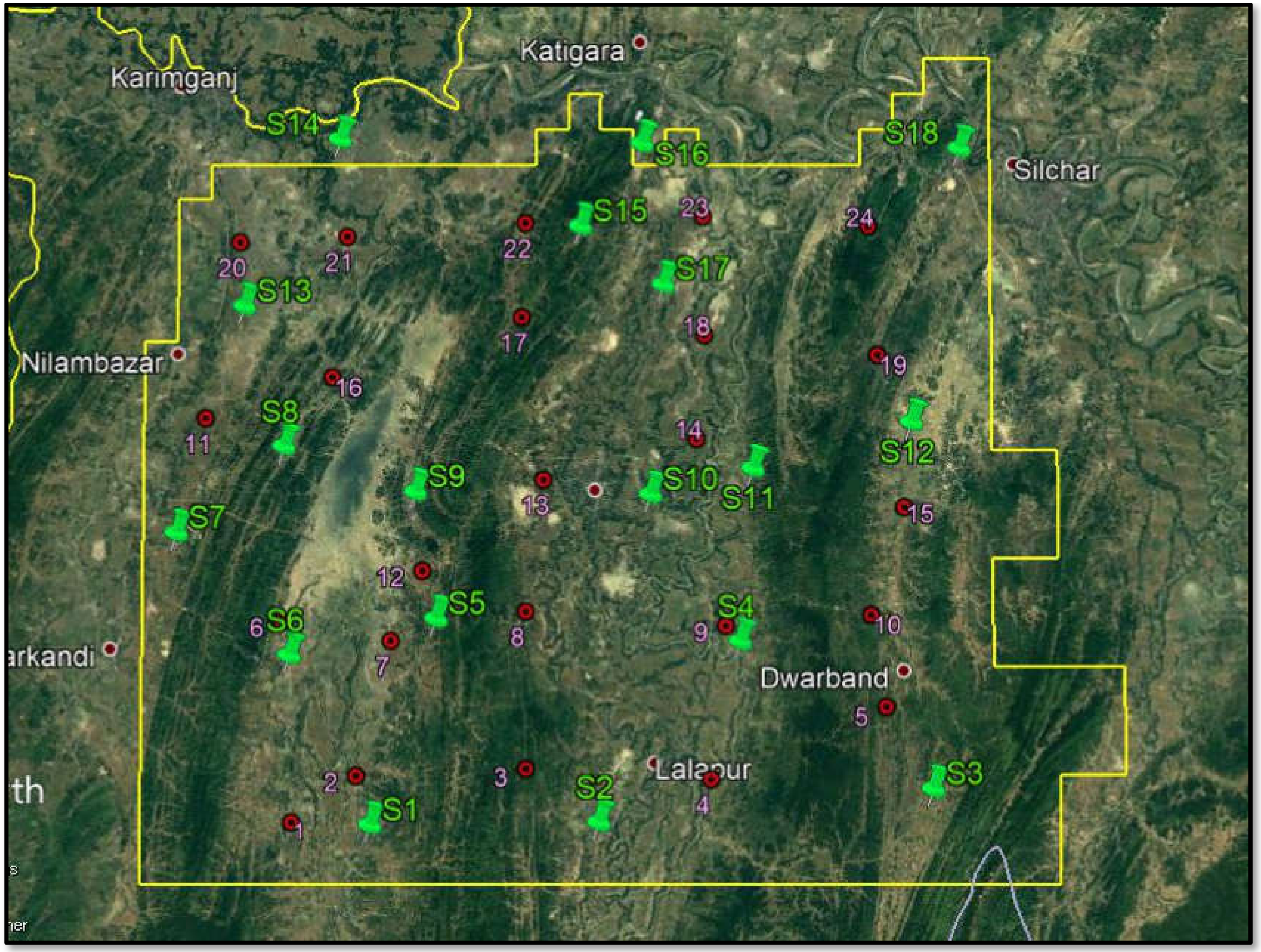


Fig 3.4 Soil sampling location map

Table 3.15 Soil analysis results in the study area

S.No	Parameter	Unit	S1	S2	S3	S4	S5	S6	S7	S8	S9
1	pH (1:5) Aq Extract	--	5.6	5.6	5.3	5.3	5.4	5.4	5.7	5.6	5.3
2	Conductivity (1:5 Aq Extract)	µ mhos /cm	67.1	68.2	61.7	56.8	65.7	59.8	69.5	70.3	54.1
3	Texture										
	(a) Sand	%	18.7	19.5	17.9	16.8	17.9	16.3	18.5	20.4	19.5
	(b) Silt	%	36.1	36.2	35.8	37.5	35.7	37.8	36.2	35.5	37.9
	(c) Clay	%	45.2	44.3	46.3	45.7	46.4	45.9	45.3	44.1	42.6
4	Bulk Density	gm/cm^3	2.2	2.1	1.8	2.3	2.6	2.1	2.4	2.6	2.2
5	Moisture Content	%	25.3	26.1	22.6	19.1	24.1	20.5	27.2	27.9	17.9
6	Availabe Nitrogen as N	kg/ha	294	299	278	256	288	261	306	311	246
7	Availabe Phosphorous as P	kg/ha	3.22	3.33	2.96	2.77	3.13	2.87	3.41	3.56	2.62
8	Available Potassium as K	kg/ha	22.4	22.7	18.7	16.2	20	17.9	23.4	24.1	14.7
9	Exchangeable Sodium as Na	mg/kg	105	108	96	88	101	92	113	121	82.2
10	Exchangeable Calcium as Ca	mg/kg	789	796	765	742	781	752	806	810	731
11	Exchangeable Magnesium as Mg	mg/kg	208	214	197	173	204	186	226	238	160
12	Water Soluble Chlorides as Cl	mg/kg	76	79	66	51	73	58	84	91	46
13	Water Soluble Sulphates as SO_4	mg/kg	274	280	261	244	271	251	291	302	231
14	Organic matter	%	0.91	0.95	0.76	0.59	0.85	0.68	1.04	1.16	0.51
15	Organic Carbon	%	0.56	0.64	0.43	0.31	0.49	0.36	0.78	0.90	0.23
16	Porosity	%	32	29	33	38	24	28	21	36	29
17	Infiltration capacity	mm/hr	12	10	13	16	9	11	8	14	12
18	Arsenic as As	mg/kg	0.06	0.04	0.08	0.07	0.05	0.09	0.07	0.05	0.08
19	Cadmium as Cd	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
20	Mercury as Hg	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
21	Nickel as Ni	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
22	Manganese as Mn	mg/kg	0.09	0.06	0.08	0.1	0.08	0.07	0.09	0.11	0.07
23	Hexavalent Chromium as Cr+6	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
24	Lead as Pb	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
25	Iron as Fe	mg/kg	0.83	0.74	0.62	0.69	0.57	0.66	0.71	0.63	0.6
26	Cupper as Cu	mg/kg	0.08	0.04	0.06	0.09	0.06	0.05	0.07	0.1	0.08
27	Zinc as Zn	mg/kg	4.1	3.8	4.6	4.4	3.5	4.4	3.9	3.6	4.2

28	SAR	m.eq/100g	4.8	6.2	8.1	5.4	2.9	5.6	5.1	4.8	5.6
29	Permiability	cm/hr	1.4	1.1	1.8	1.3	1.8	1.6	1.1	1.5	1.8
30	Water holding capacity	%	29	31	26	28	33	24	28	26	24
31	Metals: Sb	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
32	Ba	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
33	Cr+3	mg/kg	6.1	5.6	6.3	5.4	5.8	6.2	6.4	5.8	5.5
34	Co	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
35	Mo	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
36	Cyanide	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
37	Thiocyanide	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

***Note:** BDL values for Cd, Hg, Ni, Pb, Cr+6 are 0.01mg/kg; for Sb, Ba, Cr+3, Co, Mo is 0.02mg/kg and for Cyanide and thiocyanide is 0.1mg/kg

S .No	Parameter	Unit	S10	S11	S12	S13	S14	S15	S16	S17	S18
1.	pH (1:5) Aq Extract	--	5.7	5.5	5.6	5.8	5.2	5.5	5.5	5.5	5.4
2.	Conductivity (1:5 Aq Extract)	µ mhos /cm	67.8	53.1	55.7	69.1	60.5	58.4	66.1	63.9	70.1
3.	Texture										
	(a) Sand	%	19.2	18.8	20.2	19.8	18.3	19.8	18.2	17.5	20.2
	(b) Silt	%	36.1	37.4	36.2	35.5	36.8	36.3	35.7	36.7	35.1
	(c) Clay	%	44.7	43.8	43.6	44.7	44.9	43.9	46.1	45.8	44.7
4.	Bulk Density	gm/cm^3	2.7	2.3	1.9	2.2	2.4	1.9	2.4	2.1	1.8
5.	Moisture Content	%	25.7	17.5	18.7	26.8	21.9	19.8	24.9	23.8	27.6
6.	Availabe Nitrogen as N	kg/ha	296	241	253	304	268	259	291	281	309
7.	Availabe Phosphorous as P	kg/ha	3.28	2.58	2.69	3.35	2.93	2.81	3.15	3.06	3.53
8.	Available Potassium as K	kg/ha	22.5	13.9	15.8	23.1	18.2	16.9	21	19.6	23.6
9.	Exchangeable Sodium as Na	mg/kg	106	81.6	83	110	94	90	103	98	115
10.	Exchangeable Calcium as Ca	mg/kg	793	729	739	801	759	749	783	774	809
11.	Exchangeable Magnesium as Mg	mg/kg	211	158	166	219	192	179	206	201	233

12.	Water Soluble Chlorides as Cl	mg/kg	77	44	49	82	61	54	74	69	87
13.	Water Soluble Sulphates as SO_4	mg/kg	276	228	239	284	256	247	272	266	296
14.	Organic matter	%	0.93	0.49	0.54	0.98	0.73	0.63	0.88	0.79	1.10
15.	Organic Carbon	%	0.61	0.21	0.25	0.71	0.39	0.33	0.52	0.47	0.83
16	Porosity	%	30	27	25	36	31	28	35	32	27
17	Infiltration capacity	mm/hr	10	8	6	11	9	7	12	10	14
18	Arsenic as As	mg/kg	0.04	0.06	0.09	0.07	0.05	0.07	0.04	0.08	0.06
19	Cadmium as Cd	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
20	Mercury as Hg	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
21	Nickel as Ni	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
22	Manganese as Mn	mg/kg	0.06	0.08	0.08	0.06	0.09	0.12	0.09	0.1	0.07
23	Hexavalent Chromium as Cr+6	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
24	Lead as Pb	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
25	Iron as Fe	mg/kg	0.65	0.57	0.61	0.66	0.62	0.71	0.57	0.59	0.66
26	Cupper as Cu	mg/kg	0.06	0.09	0.06	0.04	0.07	0.1	0.08	0.09	0.06
27	Zinc as Zn	mg/kg	4.4	4.1	3.8	4.5	4.2	3.8	4.1	4.6	4
28	SAR	m.eq/100g	5.2	4.4	4.9	5.1	4.6	3.9	4.8	4.2	4.4
29	Permiability	cm/hr	1.3	1.7	1.6	1.2	1.4	1.7	1.3	1.1	1.5
30	Water holding capacity	%	29	31	27	26	23	28	30	34	28
31	Metals: Sb	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
32	Ba	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
33	Cr+3	mg/kg	5.9	5.4	5.7	5.1	5.8	5.4	5.7	5.4	5.2
34	Co	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
35	Mo	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
36	Cyanide	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
37	Thiocyanide	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

***Note:** BDL values for Cd, Hg, Ni, Pb, Cr+6 are 0.01mg/kg; for Sb, Ba, Cr+3, Co, Mo is 0.02mg/kg and for Cyanide and thiocyanide is 0.1mg/kg

3.7.3 Summary of Soil Analysis Data

The analytical results of the soil samples are summarized below.

The pH of the soil is an important property; The normal range of pH in the soils is 6.0 to 8.5. The pH values in the study area are varying from 5.2 to 5.8 indicating that the soils are falling in acidic soil.

Based on the electrical conductivity, the soils are classified into four groups (Normal, Critical for germination, Critical for growth of the sensitive crops, Injurious to most crops). The electrical conductivity in the study area is varying from 53.1 to 70.3 micro-mhos/ cm (µmhos/cm). This is average for germination.

The other important parameters for characterization of soil for irrigation are the primary nutrients – Nitrogen, Phosphorus and Potassium (N, P, K) and the secondary nutrients- Calcium, Magnesium and Sulphur (Ca, Mg, S). The primary and secondary nutrient elements are known as major elements. This classification is based on their relative abundance, and not on their relative importance.

Nitrogen encourages the vegetative development of plants by imparting a healthy green color to the leaves. The available Nitrogen as N in the study area is varying from 241 to 311 kg/ha. This is less for crops when compared with soil standards.

Phosphorus influences the vigour of plants and improves the quality of crops. In the study area available, Phosphorus was found in varying quantities of 2.58 to 3.56 kg/ha. This is less sufficient level when compared to soil standards.

Potassium enhances the ability of the plants to resist diseases, insect attacks, cold and other adverse conditions. The available potassium in the study area varies between 13.9 to 24.1 kg/ha. This is very less sufficient level for crops.

Organic Carbon in the study area ranges from 0.21 to 0.90%. This is very less level for crops.
Based on the above results, the soils in the region are average fertile enough for cultivation of crops.

Table 3.16 Standard soil classification

S. No	Soil Test	Classification
1.	pH	<4.5 Extremely acidic 4.51- 5.50 Very strongly acidic 5.51-6.00 moderately acidic 6.01-6.50 slightly acidic 6.51-7.30 Neutral 7.31-7.80 slightly alkaline 7.81-8.50 moderately alkaline 8.51-9.0 strongly alkaline >9.00 very strongly alkaline
2.	Electrical Conductivity (ppm) (1ppm = 640 µmhos)	Up to 1.00 Average 1.01-2.00 harmful to germination 2.01-3.00 harmful to crops (sensitive to salts)
3.	Organic Carbon	Up to 0.2: very less 0.21-0.4: less 0.41-0.5 medium, 0.51-0.8: on an average sufficient 0.81-1.00: sufficient >1.0 more than sufficient
4.	Nitrogen (Kg/ha)	Up to 50 very less 51-100 less 101-150 good 151-300 Better >300 sufficient
5.	Phosphorus (Kg/ha)	Up to 15 very less 16-30 less 31-50 medium 51-65 on an average sufficient 66-80 sufficient >80 more than sufficient
6.	Potassium (Kg/ha)	0 -120 very less 120-180 less 181-240 medium 241-300 average 301-360 better >360 more than sufficient

3.8 NOISE ENVIRONMENT

3.8.1 Identification of sampling locations

Noise at different generating sources (Table 3.17) has identified based on the activities in the village area, ambient noise due to industries and traffic and the noise at sensitive areas. A detailed survey on noise environment was carried in and around the project site to study the levels of noise, as the high dB (A) levels may cause adverse effect on human beings and associated environment, including structures, domestic animals and natural ecological systems. The locations were identified keeping in view the land use pattern and environmental setting .Spot noise levels were measured using a precision noise level meter at eight locations within study zone. Noise smapling locations are shown in figure 3.5.

3.8.2 Methodology

The monitoring was carried out at each location for a period of 24hrs, once during the study period. The locations were identified keeping in view the land use pattern and environmental setting. The day levels of noise have been monitored during 6 am to 10 pm and the night levels during 10 pm to 6 am. The Ld, Ln and Ldn were calculated based on the hourly Leq values. Spot noise levels were measured using a precision noise level meter at residential areas, industrial areas and commercial centers etc., in all eight locations which were covered with in study zone. The noise levels include vehicular movement and local activities.

Noise levels were recorded for every 15 minutes in a clock hour for a continuous 24-hour period at all locations.

Table 3.17 Noise Monitoring Locations

S.No	Location	Station Code	Direction & Distance	Latitude and Longitude	Environmental Setting
1	Kalachara Grant	**N1**	2.6km SW from Well No.1	24°30'27.77"N 92°23'44.31"E	Residential Area
2	Anipur	**N2**	1.6km West from Well No.2	24°32'53.48"N 92°25'41.13"E	Residential Area
3	Bajar Ghat	**N3**	1.5km SW from Well No.6	24°36'38.55"N 92°23'47.14"E	Residential Area
4	Nayadas gram	**N4**	1.9km SSW from Well No.12	24°37'39.73"N 92°28'4.57"E	Residential Area

5	Kandigram Pt-1	**N5**	2.2km SW from Well No.11	24°42'4.52"N 92°20'54.28"E	Residential Area
6	Abdullapur Pt-1	**N6**	2.9 km WSW from Well No.4	24°32'23.77"N 92°35'41.47"E	Residential Area
7	Hailakandi	**N7**	4.9km SW fromWell No14	24°32'24.63"N 92°43'12.76"E	Residential Area
8	Duarbund Grant	**N8**	1.2km West from Well No.10	24°37'29.98"N 92°41'33.97"E	Residential Area
9	Rajyeswarpur Pt-5	**N9**	2,6 west from Well No.9	24°36'52.92"N 92°36'20.73"E	Residential Area
10	Serispore	**N10**	1.6km West from Well No.13	24°41'10.67"N 92°31'23.09"E	Residential Area
11	Adarkona Pt1	**N11**	1.6km West from Well No.17	24°45'10.36"N 92°30'56.42"E	Residential Area
12	Gharua	**N12**	2.6km West from Well No. 21	24°48'3.46"N 92°24'41.99"E	Residential Area
13	Ranigram Pt1	**N13**	0.8km SW from Well No.20	24°47'38.15"N 92°22'29.34"E	Residential Area
14	Harinadik	**N14**	2.6 WNW from Well No. 22	24°48'50.22"N 92°30'16.35"E	Residential Area
15	Chimparasangan Pt3	**N15**	1.6 W from Well No. 23	24°48'30.53"N 92°36'17.31"E	Residential Area
16	Chibitabichia Pt5	**N16**	4.5km East from Well No. 18	24°44'35.28"N 92°40'4.15"E	Residential Area
17	Kathal Grant	**N17**	3km NE from Well No. 19	24°45'15.54"N 92°44'7.68"E	Residential Area
18	Silchar	**N18**	8.2km NE from Well No. 24	24°49'59.42"N 92°46'29.28"E	Residential Area

3.8.3 Description of Locations:

N1 to N18 – the locations have been selected to assess noise levels near to the project in residential areas with light Vehicular Movement.

3.8.3.1 Noise Levels in the Study Area

The noise level monitored during the study period are given in following Table 3.18 in the form of Lday, Lnight and Ldn compared with CPCB Standards.

Table 3.18 Noise levels in the study area

Location Code	Environmental Setting	CPCB norms Leq (dBA)		Leq day	Leq night
		Day	Night		
N1	Residential	55	45	59.5	47.7
N2	Residential	55	45	52.4	40.5
N3	Residential	55	45	51.4	41.6
N4	Residential	55	45	58.5	46.8
N5	Residential	55	45	54.4	42.7
N6	Residential	55	45	57.5	45.9
N7	Residential	55	45	55.4	43.8
N8	Residential	55	45	54.3	44.9
N9	Residential	55	45	61.7	43.6
N10	Residential	55	45	52.7	35.0
N11	Residential	55	45	58.2	40.1
N12	Residential	55	45	54.4	36.7
N13	Residential	55	45	60.0	41.9
N14	Residential	55	45	49.0	31.9
N15	Residential	55	45	56.3	38.6
N16	Residential	55	45	50.7	31.4
N17	Residential	55	45	50.9	38.7
N18	Residential	55	45	62.3	44.9

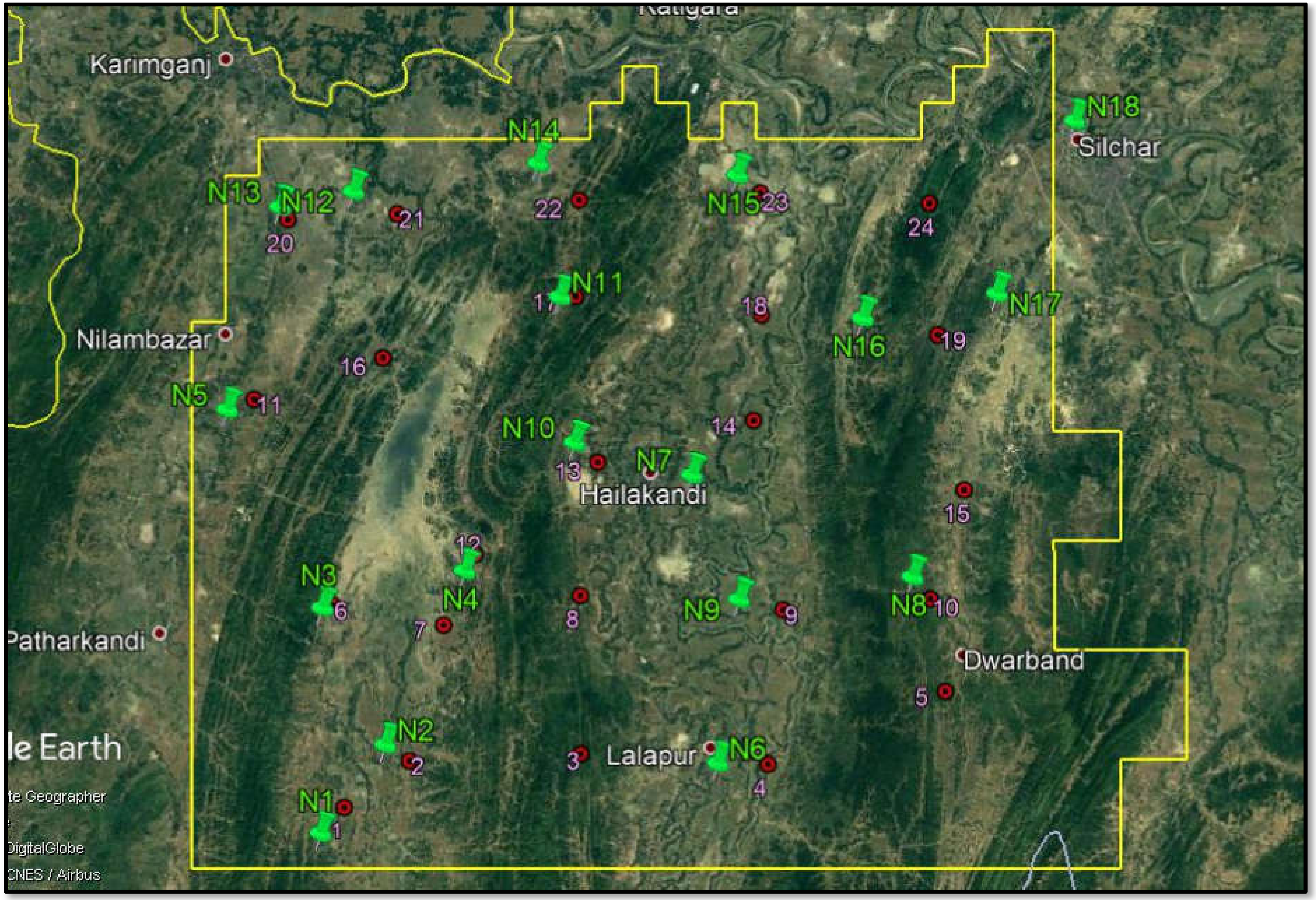
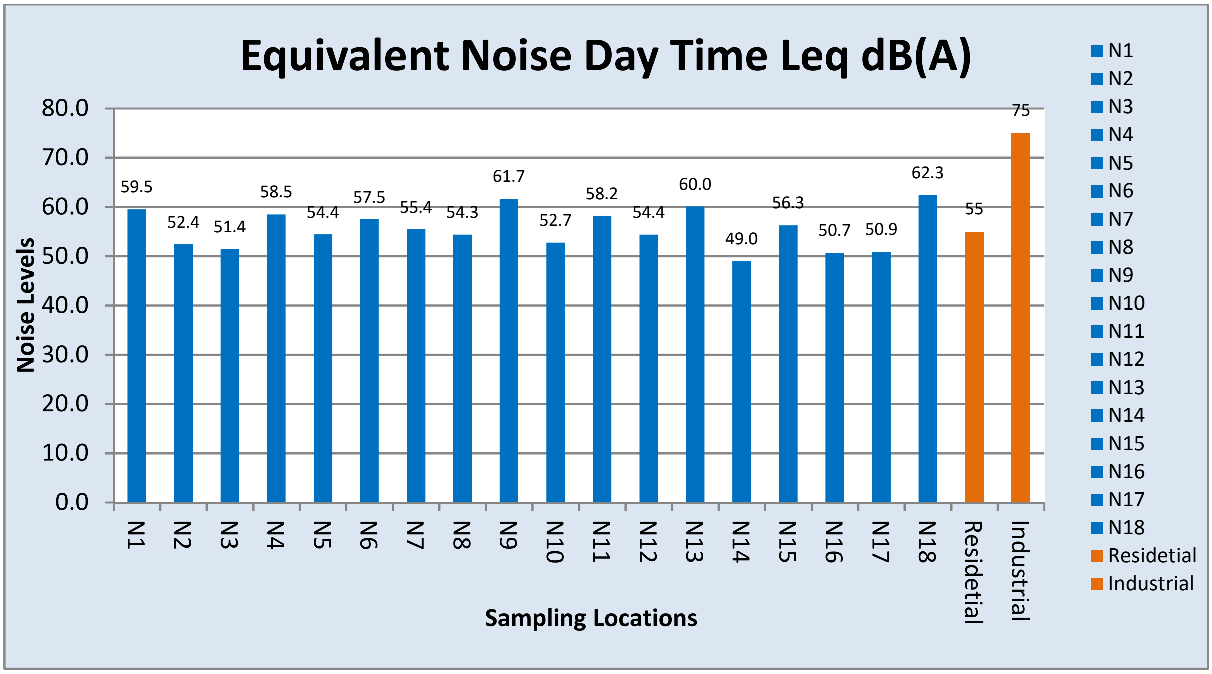
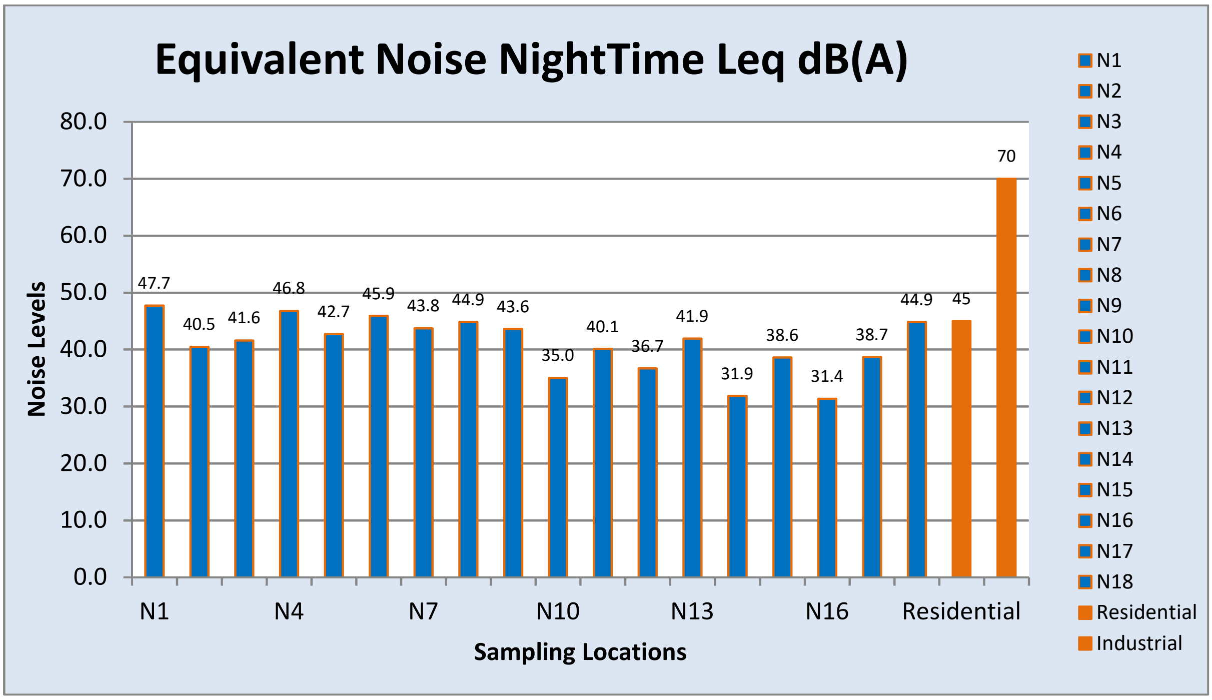


Fig 3.5 Noise Monitoring Location map

Graphical representation of Noise





3.9 GEOLOGY AND HYDROGEOLOGY

3.9.1 Drainage and physiography:

The drainage of block area is sub-parallel to parallel and dendritic. In general, drainage pattern of the area is in conformity with the topography, which area structurally controlled. Physiographically, the area can be divided into two parts.

- Anticlinal hill ranges and
- Synclinal flat-bottomed valleys

The hill ranges are tightly folded. The major hill ranges in part of

Karimganj	Chatachura Range, Admil range, Dudalia range and Bhadrepur range. The trend of the hill ranges is almost NE-SW and occasionally varying N-S. The height of the hill ranges decreases from south to north and the highest elevation being 636 m above msl at Chhatachura. The lowest hill range is Bhadrapur with average height of 150 m above msl. Broad synclinal valleys occur in the area are Karimganj and Anipur valleys. The average elevation of the valleys is about 15 m. All the valleys become narrow and constricted towards south and widens towards north. The major slope of the valleys is towards north.
Hailakandi	Anticlinal hill ranges and Synclinal flat-bottomed valleys. The hill ranges are tightly folded. The major hill ranges are Chatachura Range, Katakhal and Inner line hills covered with forests. The trend of the hill ranges is almost NE-SW. The broad synclinal valleys occurring in the district are valley. The average elevation of the valley is about 25 m above msl.
Cachar	Area consists of resistant structural hills in the borders with an elongated valley in the central part. The general trend of the hills is NE-SW. Structural features like hog's back and steep escarpments are commonly present. The valley area comprises of low land with swamps and alluvial flat land. The southern part has number of field depressions and these are permanent water bodies commonly known as beel.

3.9.2 Hydrogeological setting

Karimganj area

The hydrogeological formations are Alluvium, Dupitila and Tipam formations. Alluvial formation occurs along the banks of main rivers with thickness varying from 10 to 15 m. Ground water occurs under unconfined condition. Ground water Development in the area has not been very significant because of high content of clay and sandy clay. Ground water in the area is developed through dug wells and hand pumps.

The Dupitila formation is nearly horizontal in deposition. The formation mainly consists of clay and silt with some intercalations of gritty and ferruginuous sandstones. It is exposed along valley flanks- has low permeability and low storage capacity due to high clay content. Ground water development in Dupitila formation is through dug wells, shallow tube wells and deep tube wells. The Sandstone of Tipam formation constitutes the principal aquifer in the area. The permeability of this sandstone is much higher than that of Dupitila sandstone. The recharge area of the sandstone is in the anticlinal hills. This formation consists of sub-rounded, fine to medium grained, friable sandstone with intercalated clay. The exposures of Tipam formation is found mainly along the foothill areas. Ground water occurs under semi-confined to confined conditions and is developed mainly by deep tube wells. Aquifer system of the district is divided into two types, viz shallow aquifer within 50 m bgl and deep aquifer between 50-300 m bgl.

Hailakandi Valley

Five major aquifers are present in addition of phearic aquifer. The cumulative thickness of granular zones down to a depth of 230 m varies from 69-100 m. All these aquifers are persistent and uniformly extensive in nature. The aquifer materials are more clayey around Hailakandi. The thickness of surfacial clay increases steadily from 27 m in the south to 52 m in the north. The granular zones that comprise fine to medium grained sand have effective grain size of 0.08 to 0.16 mm in the depth range upto 100 m. The effective grain size however, increases towards north. By and large, the sediments are predominantly clayey beyond a depth of 200 m down to the explored depth of 300 m.

Cachar area

Geologically, the district can be divided into two major groups, i.e. unconsolidated deposits comprising alluvial deposits of Sub-Recent to Recent age and semi-consolidated Tertiary deposits of Bhaban, Bokabil, Girujan/ Tipam, Dupitila and Dihing formations of Miocene to Pliocene age. The alluvial deposits containing in the central parts mainly comprises of sand, silt and clay with gravel and occasional coal bands. The semi-consolidated rocks are exposed in the form of hillocks comprising shale, sandstone, ferruginous sandstone, mottle clay, pebble bed and boulder beds etc

Karimganj	
Nature and depth of Aquifer system	In Karimganj valley there are six major aquifers within the depth of about 260 m. The cumulative thickness of aquifer zones is to a depth of 200 m. The aquifers are persistant throughout the valley with minor facies variations. In Anipur valley six aquifers are present within a depth of 220 m. These aquifer zones are uniformly extensive in nature with minor lithofacies variations. However, towards north beyond Ratakandi the top clayey formations become thick and increases to about 70 m with thin sand lenses.
Depth to water level	The depth to water level during pre-monsoon period in phreatic aquifer varies from 0.35-2.80 m bgl and during post monsoon varies from 0.19-3.88 m bgl. The seasonal fluctuation of water level varies between 0.48 to 2.96 m.
Ground water resources	The main source of ground water recharge in the district is precipitation. Other sources of ground water recharge in the area are return flow from irrigation and seepage from ponds/tanks. Ground water in the area is mostly used for domestic and irrigation purposes. Ground water draft for industrial purpose is 26.36 mcm. Net ground water available in the area is 425.5 mcm and ground water draft for all uses is 28.36 mcm. The stage of ground water development of is only 7 % and categorized as Safe.
Hailakandi	
Occurrence of ground water Depth to water level	Ground water occurs under unconfined condition in alluvial formation. In Dupitilla and Tipam formations ground water occurs under unconfined, semi confined to confined conditions. In major part of the area ground water occurs under unconfined condition in shallow aquifers and under semi confined to confined conditions in deeper aquifers.
Ground water resources	The main source of ground water recharge in the district is precipitation. Other sources of ground water recharge in the area are return flow from irrigation and seepage from ponds/tanks. Recharge from rainfall in the area accounts for 99.6% of the total annual recharge. Comparison of monsoon and non-monsoon rainfall recharge shows that monsoon recharge accounts for

	89.9% and non-monsoon recharge accounts for 10.1% of total rainfall recharge. Ground water in the area is mostly used for domestic and irrigational purposes. Ground water draft Net ground water available in the district is 308.51 MCM and ground water draft for all uses is 21.19 MCM. Ground water draft for irrigation and drinking purposes accounts for 34.5% and 65.5% of total ground water draft respectively. The stage of development of the district is only 7% categorised as Safe.
Cachar area	
Occurrence of ground water	Ground water occurs in phreatic condition in shallow aquifer and in semi-confined condition in deeper aquifer. Flow of ground water is from the North to South in northern parts and from South to North in southern parts of the district. The area mostly represents a water logged area. The pre-monsoon water level is 1.05 m bgl while the post-monsoon water level is 1.62 m bgl. There is no significant decline observed in long term trends. The water level fluctuation in general is less than 1.00 m. However, in fringe areas of Mohanpur, Srikona, Rangpur, Kashipur and Rajabazar, it ranges from 4.41 to 6.96 m.
Depth to water level	The water level fluctuation, in general, is less than 1 m, however, in places like Mohanpur, Srikona, Kashipur, Rajabazar etc. it is from 4.52 to 7.0 m. In the central parts of the district around Dholai, Palanghat etc. it is only 0.20 m indicating low fluctuation in fine grained deposits.
Ground water resources	The net ground water availability estimated in the year 2009 is 1020.02 mcm. The gross ground water draft 39.21 mcm and the stages of development are 4% only. Future provision for domestic and Industrial use is 52.46 mcm and for Irrigation use is 966.99 mcm. In Cachar district stage of ground water development is 4%, which shows under the SAFE category. As long-term water level trend does not show any major change so the whole district may be considered as Safe.

3.10 LAND USE/LAND COVER

3.10.1 Land use Pattern-Remote Sensing data

The basic purpose of land use pattern and classification in an EIA study is to identify the manner in which different parts of land area is utilized or not utilized. Remote sensing data provides reliable accurate baseline information for land use mapping as it is a rapid method of acquiring up-to-date information of over a large geological area.

Studies on land use aspects of eco-system play an imperative role in identifying susceptible issues and to take appropriate action to uphold ecological equilibrium in the region. The main objective of this section is to provide a baseline status of the study area covering 10 km radius around the proposed plant site so that temporal changes due to the industrial activities on the surroundings can be assessed in future.

The objectives of Land use Pattern are to:

- Determine the present Land use pattern
- Study area with proposed unit as epicenter 10 km radius from the core area of AA-ONHP-2017/14 block boundaries is considered for land use study.

Satellite Data: The Satellite IRS P-6 LISSIV images are obtained from National Remote Sensing Centre (NRSC) Hyderabad. The satellite image of the site is presented in **Fig. 3.6**.

Topographical Data: Topographical maps of Survey of India (SOI) were obtained for land use study as well to develop contour and drainages pattern of area from 83D5, 83D6, 83D13 and 83D14.

3.10.2 Methodology: The overall methodology **(Fig.3.7)** adopted and followed

- Collection of source data of Survey of India (SOI) toposheets. These are the main inputs for the preparation of essential layers
- Satellite data of IRS P-6 LISSIV sensor is geometrically corrected and enhanced using principal component method and nearest neighborhood resampling technique
- Preparation of basic themes like layout map, transport & settlement map and contour map from the source data. Then updating of layout map, transport map and drainage map from the satellite image by visual interpretation
- Essential maps (related to natural resources) like Land use / Land cover map are prepared by visual interpretation of the satellite imagery. Visual interpretation is carried out based

on the image characteristics like tone, size, shape, pattern, texture, location, association, background etc. in conjunction with existing maps/ literature

- Preliminary quality check and necessary corrections are carried out for all the maps prepared
- All the maps prepared are converted into soft copy by digitization of contours and drainages. In that process editing, labeling, mosaicking, quality checking, data integration etc. are done, finally Land use areas are measured in Sq.km.

3.10.3 Land use Map Analysis

Land use Map Analysis carried out based on the image color, texture, Tone etc. Following steps are used to analyze the Land use pattern of project site:

- Collection of scanned toposheets and Geo-reference the scanned image using the available coordinates
- Collection of IRS LISS IV images and made fused and blended the images for color combinations using Image interpreter-Utilities and Layer stack option available in ERDAS
- Identification Area of interest (AOI) and made a buffer of 10 km radius.
- Enhance the Fused and blended LISS IV image using the Spatial, Radiometric and Temporal options in ERDAS
- Rectified the LISS IV image using Geo-referencing technique, Toposheet to get UTM coordinate system
- Subset the LISS images and Toposheet using 10 km buffer AOI
- Automatic classifications done for LISS IV images using maximum iterations and number of options in unsupervised classification options
- Created the signature file by selecting the more samples of different features with AOI on Unsupervised classification image
- Visual interpretation and supervised classification mixed with recoding practice
- Verified through the QC / QA and finalized the data.

3.10.3.1 Spatial Data from SOI Topographical Sheets

Creating a GIS spatial database is a complex operation, and is the heart of the entire work; it involves data capture, verification and structuring processes. Raw geographical data are available in many different analogue and digital form such as toposheets, aerial photographs, satellite imageries and tables. Out of all these sources, the source of toposheets is of much concern to natural resource scientist and an environmentalist.

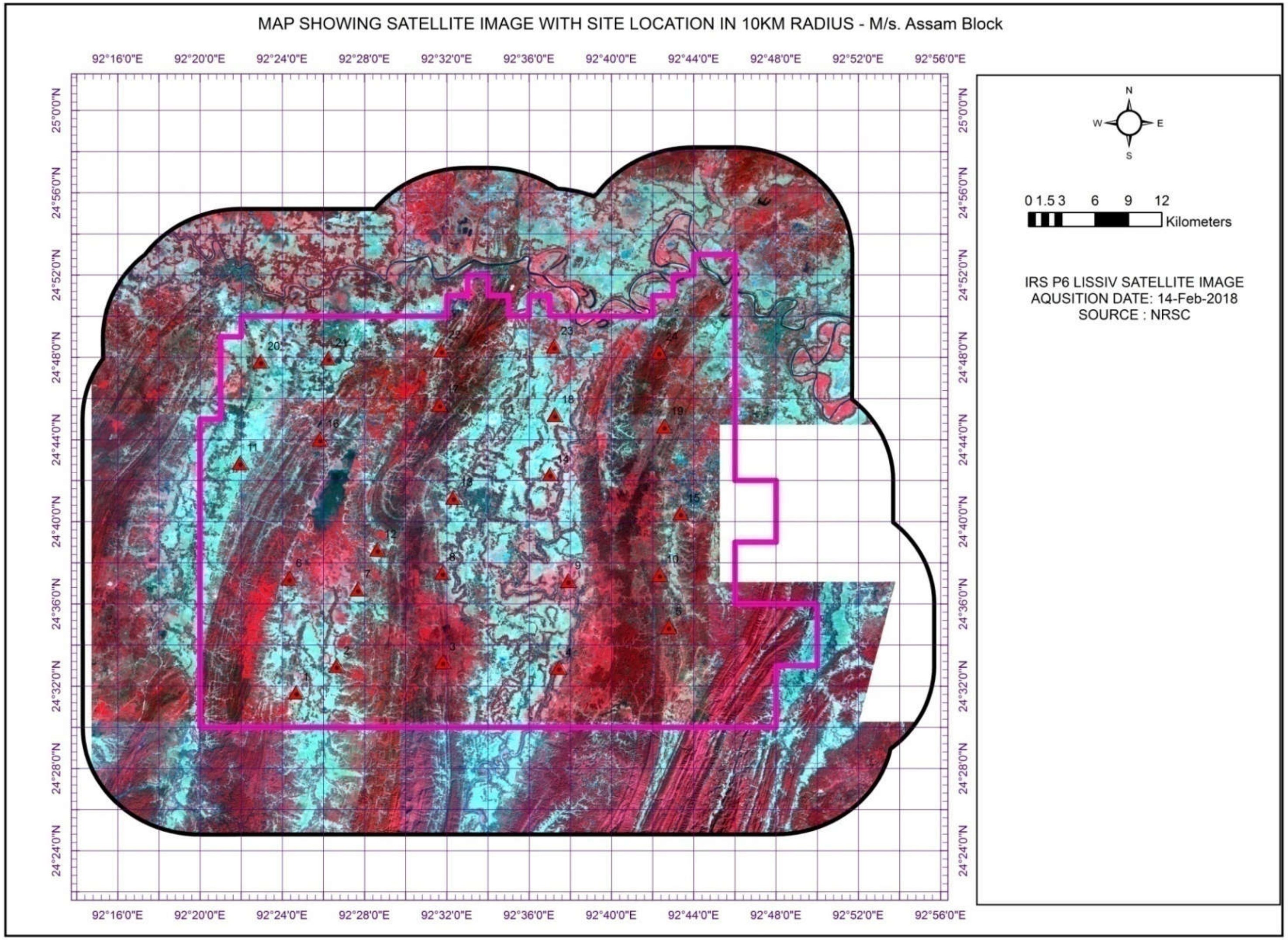


Fig 3.6 Satellite image

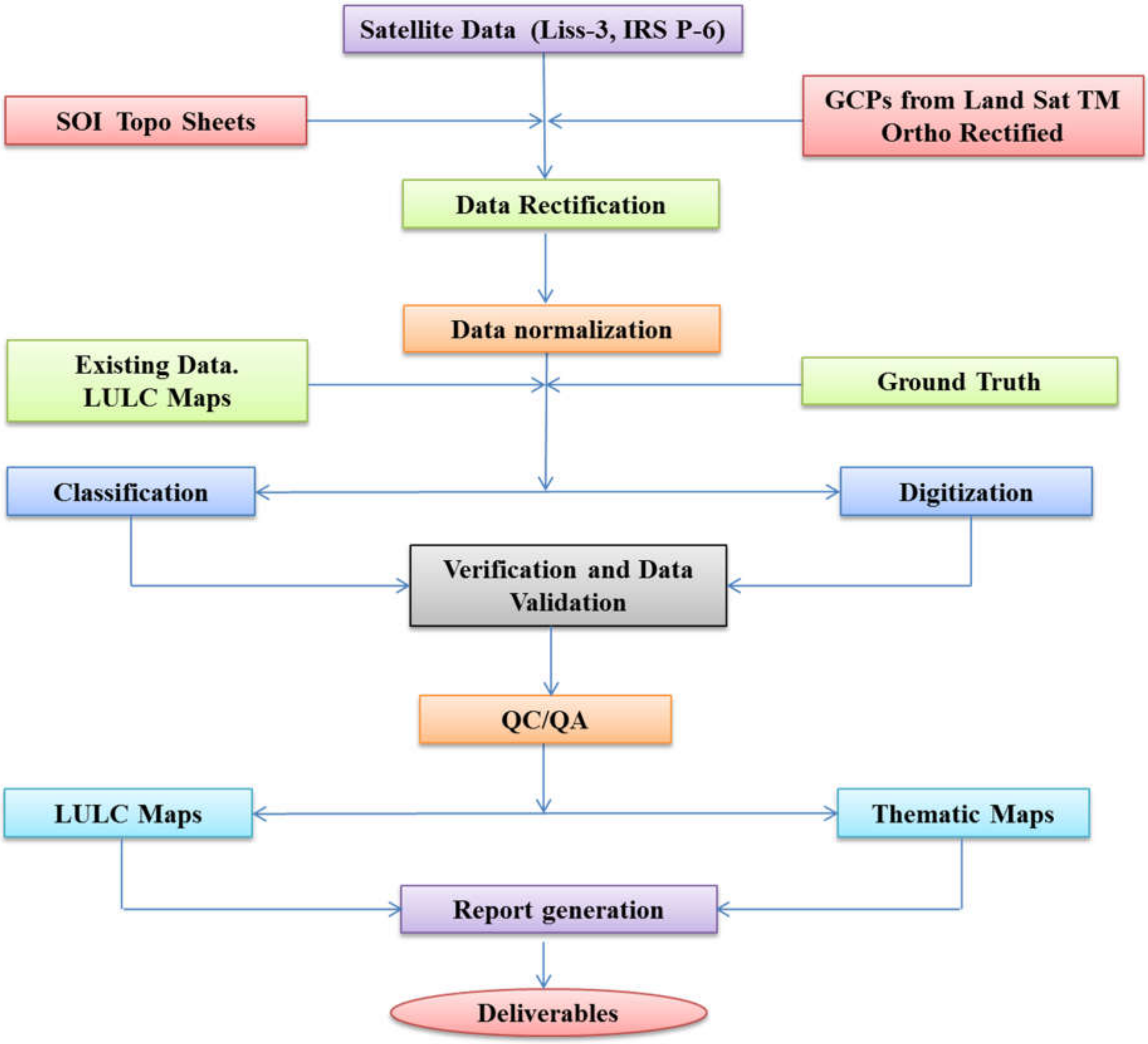


Fig 3.7 Flow chart of methodology

In the present study, the essential maps generated from SOI topographical maps. Using the topographical maps, the drainage map (Fig. 3.8) and contour Map were also developed. The maps are prepared to a certain scale and with attributes complying with the requirement of terms of reference (ToR). The location of entities on the earth's surface is then specified by means of an agreed co-ordinate system. For most GIS, the common frame of co-ordinate system used for the study is UTM co-ordinates system. All the maps are first Geo-referenced. The same procedure is also applied on remote sensing data before it is used to prepare the Essential maps.

There is a road network connecting built-up areas (Fig 3.9). As the terrain conditions are alluvial type soil and site elevation bit undulations also there is a drainage network around the site location, there is no chance of flooding. Hence risk factors are less. No Bird sanctuaries located in the study area.

3.10.3.2 Contour Map and Elevations of Study Area

The contours in Toposheet have been digitized in the GIS environment and assigned the respective elevation values in meters with reference to the mean sea level. Using the SRTM (Shuttle Radar Topography Mission) data, the elevation values has been verified. Thereafter final contour map has been prepared with combination of Toposheet and SRTM ith contour interval of 10 m. Project site contours vary from 85m to 88m above MSL and the study area contours vary from 20 m to 60 m above MSL. From the project site the No high range hill area were observed towards North West direction and the lowest contours were observed in South west direction. While the remaining areas showed variations with respect to contours. Contour Map and Elevations of Study Area is presented in **Fig.3.10.**

3.10.3.3 Topography (Digital Elevation Model)

A digital elevation model (DEM) is a digital representation of ground surface topography or terrain **(Fig.3.11).** It is also widely known as a digital terrain model (DTM). A DEM can be represented as a raster (a grid of squares, also known as a height map when representing elevation) or as a triangular irregular network. The proposed plant location is shown in that Relief map. For the relief study of the area very higher quality SRTM (Shuttle Radar Topography Mission) and DEM is downloaded. These DEMs of the Terra represents elevation at a 30 m resolution.

3.10.3.4 Land use land cover statistics of buffer zone

Map showing the Land Use Land Cover classification in the study area is presented in Figure **3.12**. It is clearly that the area is covered with Agricultural Fallow around 29 % respectively of the total area which is taken up for non-cultivation but is temporarily allowed to rest, un-cropped for one or more season, but not less than one year. Thus, total non-cultivable land is 29 %.Other class is Around the Agricultural Fallow edges the Settlement (Built-up area) is located and occupies around 5 %, and Roads 6 % of the total study area. It is an area of human habitation developed due to non-agricultural use and that has a cover of buildings, transport and communication, utilities in association with water, vegetation and vacant lands. The open scrub is 48 % respectively in the total study area. The proposed project is on open scrub with bit undulations terrain and does not have any significant impact on the surrounding villages and habitation. The water bodies cover 6% of the total area. The water bodies cover nala, ponds etc. These area have a very prominent signature and can be seen as almost Dark blue and light blue in the satellite image. The statistical break-up of the land use classes of buffer zone are presented in **Table 3.19** and depicted in **Fig. 3.13.**

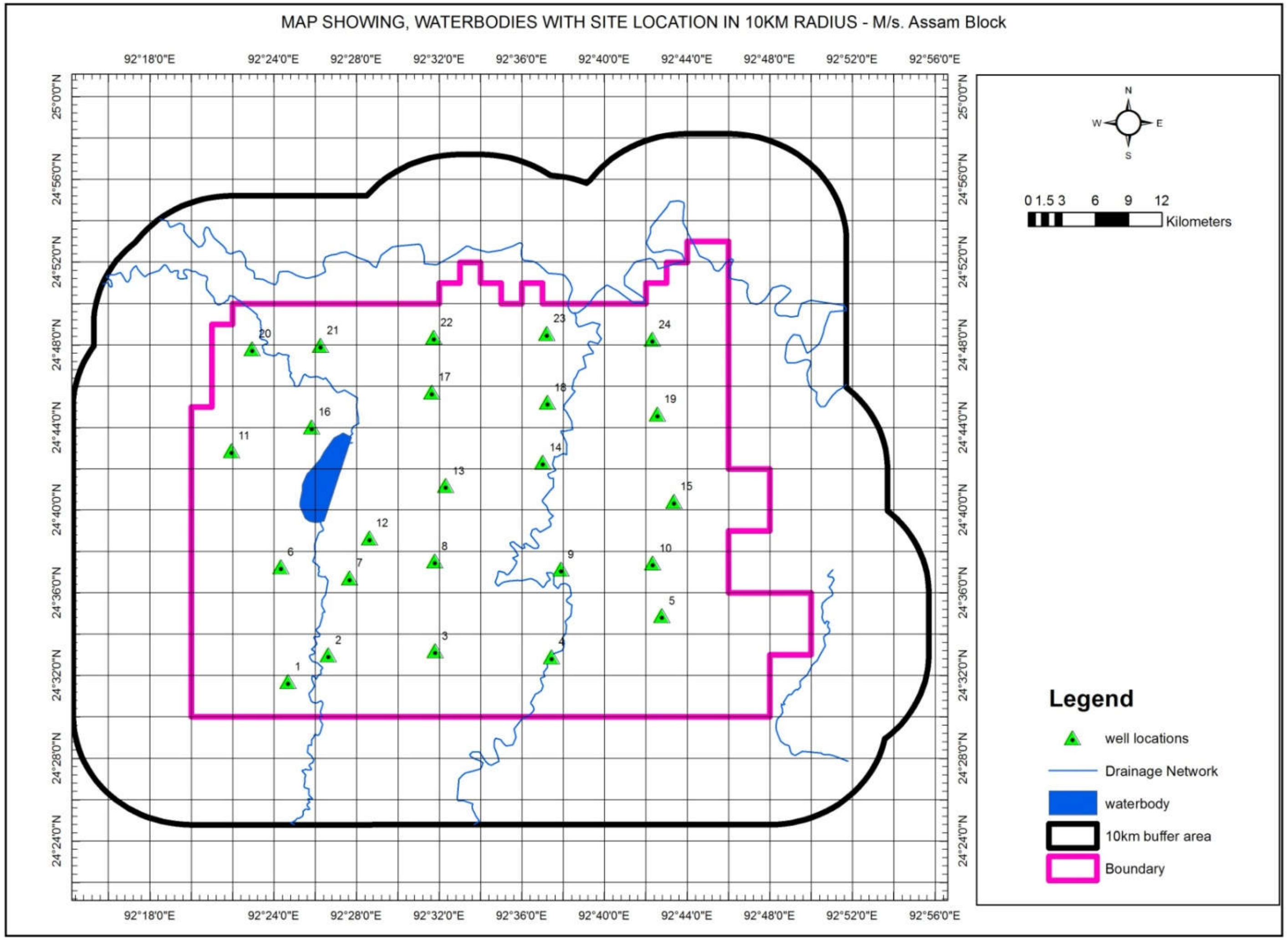


Fig 3.8 Drainage map

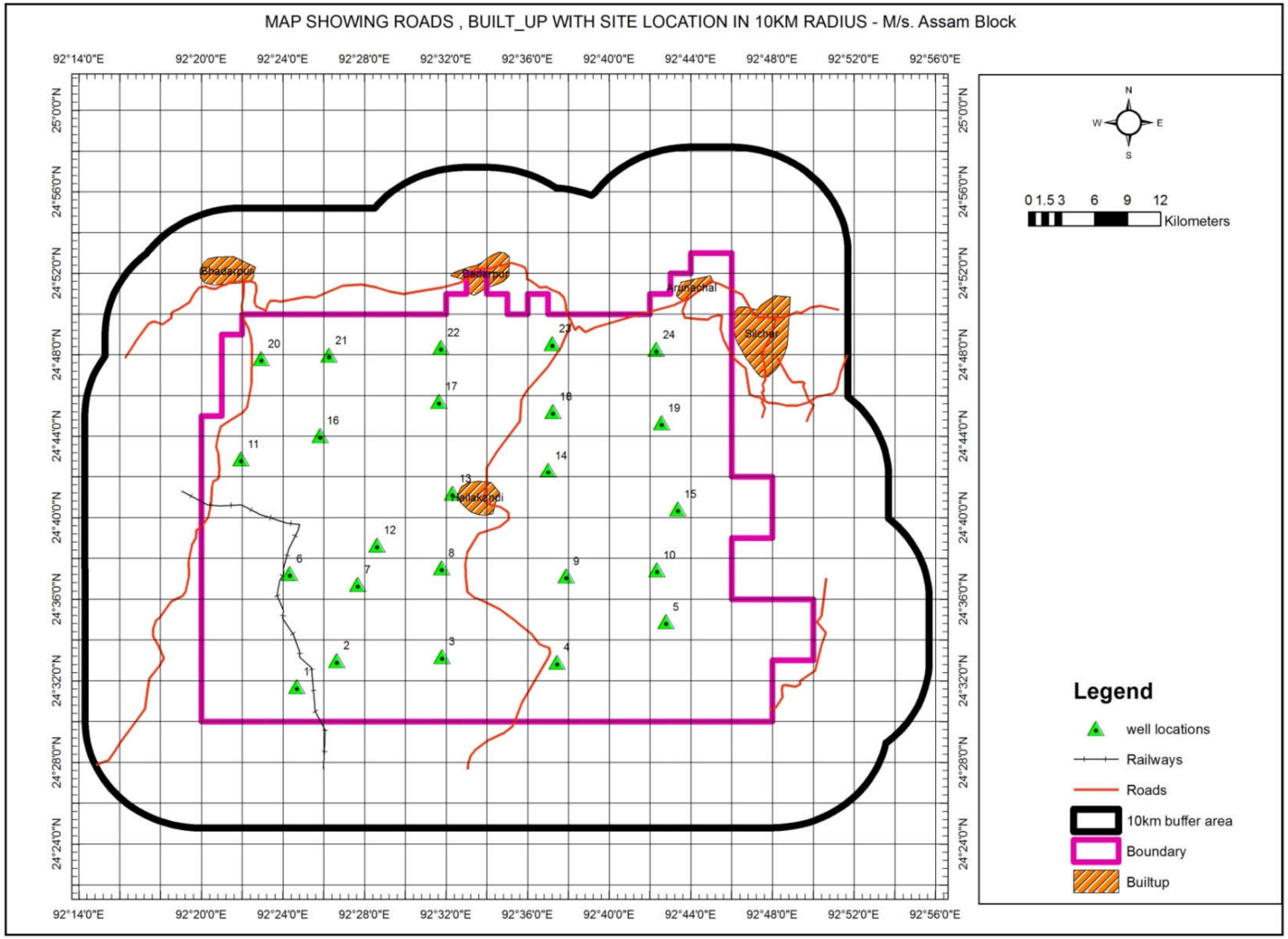


Fig 3.9 Roads and Builtup map

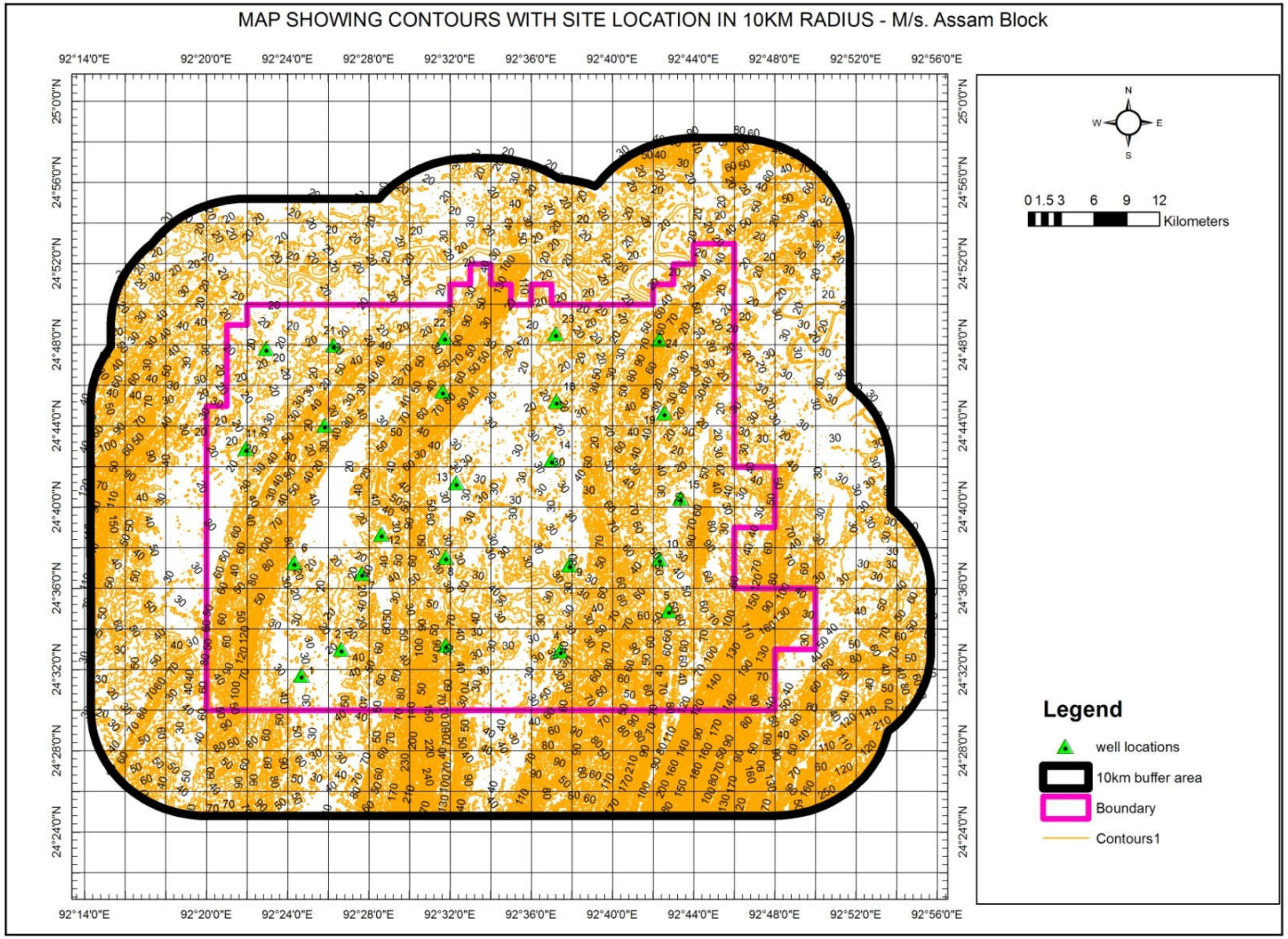


Fig. 3.10 Contour map of the study area

Fig 3.11 Digital Elevation map

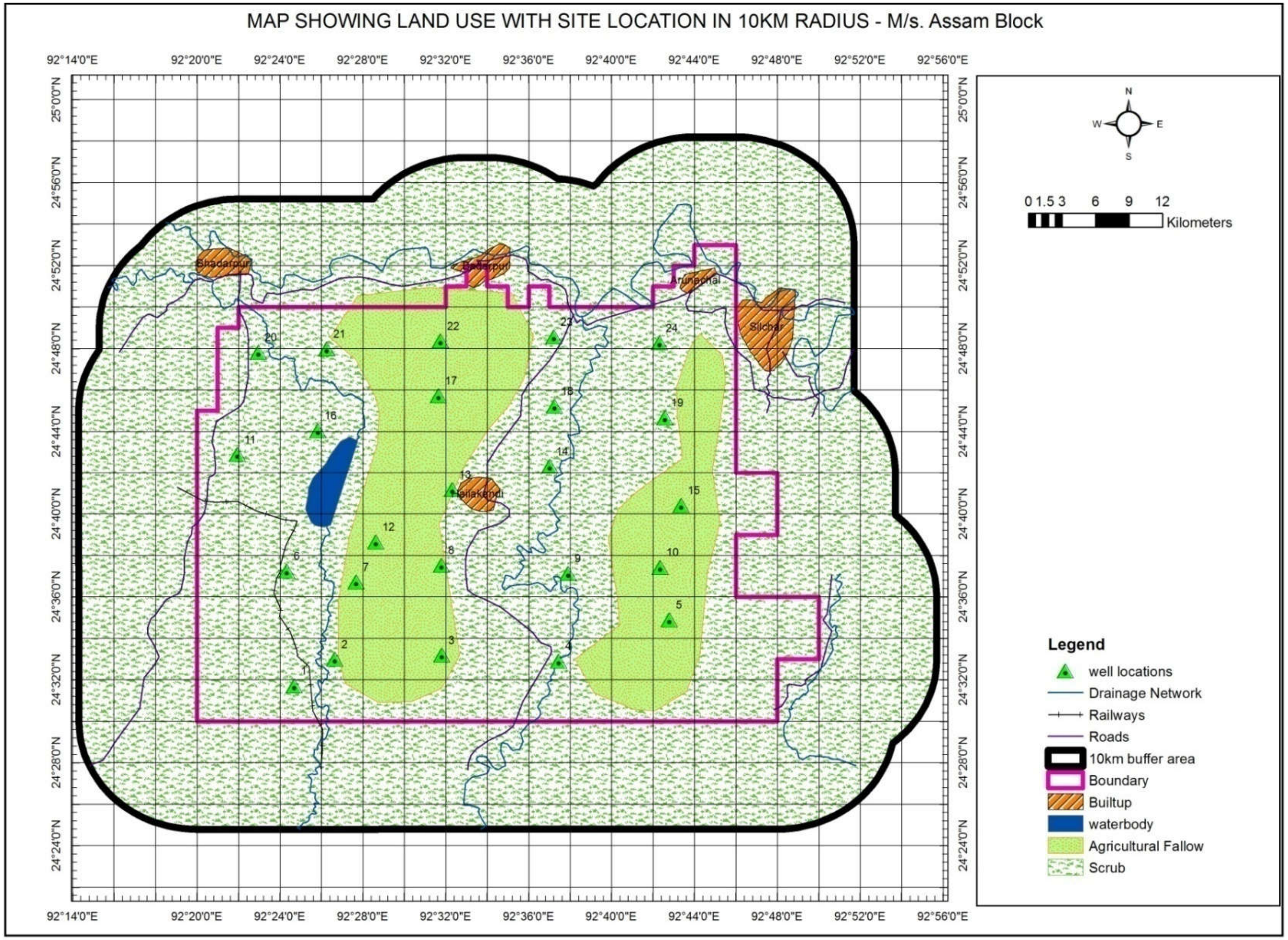


Fig. 3.12 Land Use/Land Cover map

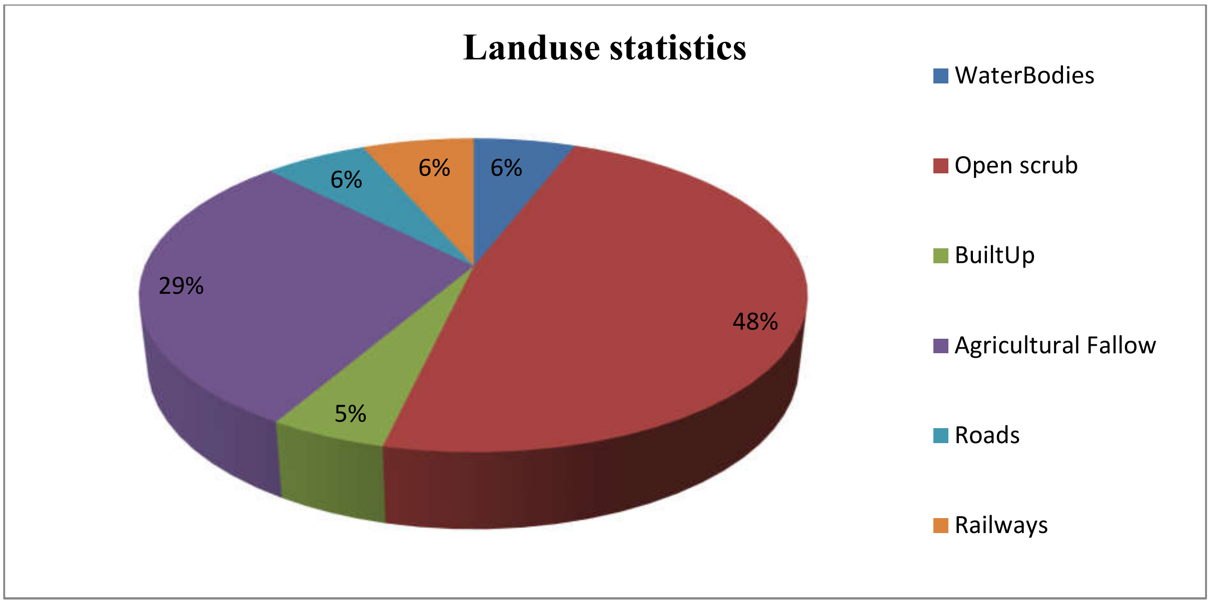


Fig. 3.13 Graphical Presentation of Land Use Statistics

Table 3.19 Land Use Land Covers Statistics of Buffer Zone

SL No	LULC_Class	Area (Ha)	Area (%)
1	WaterBodies	10100.00	6%
2	Open scrub	82000.00	48%
3	BuiltUp	8200.00	5%
5	Agricultural Fallow	50100.00	29%
6	Roads	10200.00	6%
9	Railways	11100.00	6%
Total		171700.00	100%

3.11 BIOLOGICAL ENVIRONMENT

3.11.1 Introduction

An ecological survey of the study area was conducted particularly with reference to recording the existing biological resources in the study area. Ecological studies are one of the important aspects of Environmental Impact Assessment with a view to conserve environmental quality and biodiversity. Ecological systems show complex inter- relationships between biotic and abiotic components including dependence, competition and mutualism. Biotic components comprise of both plant and animal communities, which interact not only within and between themselves but also with the abiotic components viz. physical and chemical components of the environment.

Generally, biological communities are good indicators of climatic and edaphic factors. Studies on biological aspects of ecosystems are important in Environmental Impact Assessment for safety of natural flora and fauna. The biological environment includes terrestrial and aquatic ecosystems.

The animal and plant communities co-exist in a well-organized manner. Their natural settings can get disturbed by any externally induced anthropological activities or by naturally occurring calamities or disaster. So, once this setting is disturbed, it sometimes is either practically impossible or may take a longer time to come back to its original state. Hence, changes in the status of flora and fauna are an elementary requirement of Environmental Impact Assessment studies, in view of the need for conservation of environmental quality and biodiversity. Information on flora and fauna was collected within the study area. Relevant details on aquatic life within the study area were collected from related government offices.

3.11.2 Objectives

(i) Assess and document the flora in the project location and status its environmental conditions

(ii) Assess and document the fauna in the project location and its environment

3.11.3 Vegetation types in Assam state

Vegetation of Assam is primarily of tropical and sub-tropical types. On the basis of floristic composition, the forest area can be divided as follows:

Type of Forest	Composition of Species
Tropical wet evergreen forests	Often, single species dominance in the top canopy are observed such as *Dipterocarpus retusus*, *Mesua assamica*, *Mesua ferrea*, *Shorea assamica*, etc. in upper Assam while *Dipterocarpus tirbinatus*, *Mesua floribunda*, etc. in Barak valley, characteristic floristic elements include: *Altingia excelsa*, *Dipterocarpus retusus*, *Dipterocarpus turbinatus*, *Magnolis* sp , *Mesua assamica*, *Mesua ferrea*, *Schima wallichii*, *Shorea assamica*, *Stereospermum tetragonum*, *Terminalia chebula*, eta.
Tropical semi-evergreen forests	Common tree species include *Phoebe goapalensis* in the western Assam districts and *Phoebe cooperiana* and *Phoebe attenuata* in Sivasagar and other similar localities. Other tree species include *Castanopsis indica*, *Dillenia indica*, *Dillenia scabrella*, *Dysoxylum* sp, *Michelia champca*, *Schima wallichii*, *Cedrela toona* etc along with deciduous species.
Tropical moist Deciduous forests	The dominant species in the Sal forest areas is *Shorea robusta*. Other species include *Derris robusta*, *Dillenia pentagyna*, *Gmelina arborea*, *Lagerstroemia parviflora*, *Schima wallichii*, *Cedrela toona* etc. Woody climbers and lainas are scares. The common ones include *Combretum* sp, *Bauhinia vahlii* etc.
Grasslands	Vegetation studies reveal that there are two different types of grasslands in Assam: (1) Grasslands occurring in recent alluvial deposits in low lying and Char areas annually inundated and flood water retained for a considerable period of time. These are wet alluvial pure grasslands. Some of the dominant grasses are *Apluda mutica*, *Arundo donax*, *Brachiaria villosa*, etc. (2) Grasslands in old alluvium deposits of high land. The dominant grasses include: *Apluda mutica*, *Digitaria abludens*, *Imperata cylindrica*, *Neyraudia reynaudiana,* *Panicum auritum*, *Saccharum arundinaceum* etc.
Riparian forests	These forests occur all over the evergreen and semi-evergreen zones in Assam along river banks and extended in several areas. In low areas, species like *Albizia lebeck*, *Dillenia indica*, *Dalbergia stipulacea*, and

	Semecarpus anacardium are some of the common species while in slightly higher level, species like *Mesua ferrea*, *Michelia doltsopa* etc are found.
Subtropical Broad-leaved forests	Common species include *Alseodaphne petiolaris*, *Antidesma bunius*, *Chaetocarpus castanocarpus*, *Cinnamomum tamala*, *Ficus albelii*, *Ficus squamosa*, *Glochidion zeylanicum*, *Glochidion sphaerogynum*, *Helicia robusta*, *Litsea nitida*, *Phoebe lanceolata*, and *Schima wallichii*.
Subtropical Pine forests	These forests occur at an elevation from 900-1800m, having moderate rainfall and found in areas of Dima Hasao bordering Jaintia hills of district Meghalaya and Karbi Anglong district. The pine forests i.e. mainly Pinus kesiya are intercepted by tree species like Cinnamomum sp, Engel hardia spicata, Myrica esculenta, Quercus grifithii, Schima walichii, Symplocos sp etc.
Bamboo forests and cane breaks	Pure bamboo forests are found in the two hill districts of Assam and mostly along the foothills of Barail range near Jatinga of Dima Hasao and in hilly slopes of Karbi Anglong district predominated with *Chimonobambusa callosa* and *Melocanna baccifera*. Langting Mupa Reserved forests of Dima Hasao and in parts of Karbi Anglong are mostly with *Melocanna baccifera* in association with *Bambusa tulda*, *Dendrocalamus hamiltonii*, *Dendrocalamus hookeri*, *Dendrocalamus structus*, *Gigantochloa parvifolia*, *Phyllostachys mannii* interrupted by moist semi-evergreen and deciduous species.

3.11.4 General introduction to the study area

The present study was carried out in three districts which are Cachar, Hailakandi, and Karimganj. The study area has an undulating topography characterized by hills, hillocks (Locally known as tillah), wide plains, and low-lying waterlogged areas (locally known as beels). Physiographically the study area may be divided into eight classes ranging from high hills with elevations exceeding 300m to perennially water logged beels. The valley experiences a warm humid climate with a mean annual rainfall of 2444-4100 mm, most of which falls during the southwest monsoon season (May to September), and mean monthly maximum and minimum temperatures of 33.9° and 9.2°C. Cachar, Karimganj and Hailakandi districts comprises a total of sixteen Reserve Forests, out of which two located in Hailakandi district, seven reserve forest each in Karimganj and Cachar district respectively. The Inner-line reserve forest is the largest one, covering an area of 424 sq. km. in Cachar district and approximately 81 sq. km. in the district of Hailakandi and is continuous with the neighbouring state of Mizoram.

The area owes its name 'Barak Valley' as the main River 'Barak' (having its origin in south-western part of neighbouring state Manipur) passes through the valley. The branches and tributaries (like Jiri, Chiri, Maghura, and Jatinga in the north and Sonai, Dholeswari and Rukni in the south) sprawling along the landscape of the area merges with the main river, Barak at various points. Geographically the area is 'Surma Valley' of the undivided India consisting of the old districts of Sylhet (now included in Bangladesh) and Cachar. Out of the areas under erstwhile Surma Valley, only Cachar and a part of Karimganj subdivision of Sylhet district form the present Barak Valley. In these districts, forests are degraded due to development of Tea Estates and Rubber plantations.

The vegetation is mixed evergreen and deciduous forest. Common deciduous trees in the forest area are *Artocarpus lakoocha*, *Dillenia indica*, *Careya arborea*, *Acanthocephalus cinensis*, *Mangifera indica*, *Sterosperrnum personatum*, and *Dysoxylum benectariferum*. Important evergreen trees are *Ficus bengalensis*, *Syzigium jambulana*, *Garcinia cowa*, and *Pterospermum acerifolum*. Most of these trees make up a closed canopy about 20-30 m above the ground. Other notable vegetation includes bamboo and canes. Adjacent to the reserve forests, all fringe forest patches are surrounded by the Jhum-fields (shifting cultivation), mostly near the villages. Cultivated orchard fruit trees (mango, jackfruit, orange and guava) also form part of the habitat. The reserve forest is rich in other wildlife species including primates Caped langur (*Trachypithecus pileatus*), Phyre's leaf monkey (*Trachypithecus phayrei*), Rhesus monkey (*Macaca mulatta mulatta*), Assamese monkey (*Macaca assamensis*) and Slow loris (*Nycticebus bengalensis*)], Barking deer (*Muntiacus muntjak*), Samber (*Cervus unicolor*), Red serow (*Capricornis rubidus*), Jungle cat (*Felis chaus*), Marble cat (*Pardofelis marmorata*), Large Indian civet (*Paradoxurus hermaphrodites*), Small Indian civet (*Vivericula indica*), Pangolin (*Manis pentadactyla*), Jackal (*Canis aureas*) etc., many of which are listed in the IUCN Red data list and some are included in Schedule- I and part of Schedule- II of the wildlife (Protection) Act, 1972.

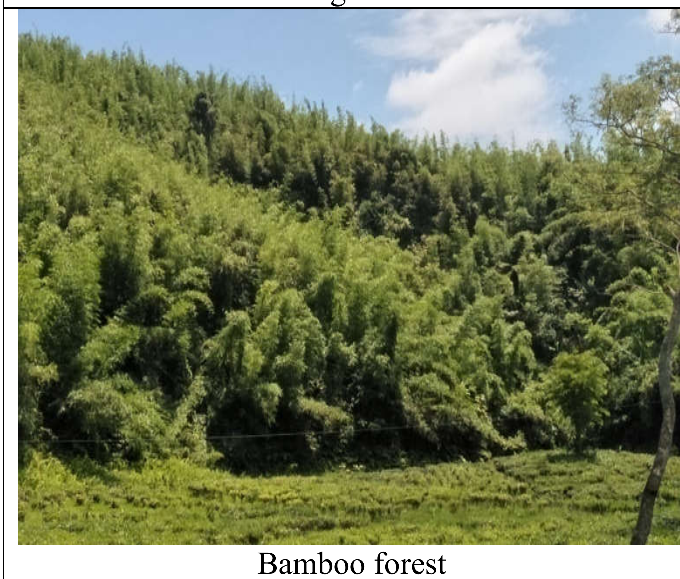
 Son Beel	 Son Beel
 Paddy fields	 Home garden
 Fish pond	 Fish pond


Katakal River


Water logging areas


Tea gardens


Tea gardens


Bamboo forest


Invasion of *Mikania micrantha*


Rubber plantation


Rubber plantation

Homegardens exhibit a complex structure, both vertically and horizontally. In the present study, the vegetation of the homegarden showed five different canopy layers, viz. emergent layer (15 m or more tall), main canopy (10 to 15 m), understory (5 to10 m), shrubs (1 to 5 m), and herb (less than 1 m) layer. The emergent layer was mainly composed of *Artocarpus heterophyllus*, *Bambusa balcooa, and Areca catechu*. The main canopy layer was dominated by *Mangifera indica*, *Parkia timoriana, Tectona grandis,* and *Toona ciliata.* Understory consisted of *Citrus grandis, Musa balbisiana,* and *Toona ciliata* and the shrub layer was dominated by *Melastoma malabathricum and Adhatoda vasica*. Herb layer composed of vegetables and tree saplings (e.g., *Clerodendrum indicum, Corchorus capsularis*, *Areca catechu*, and *Citrus grandis*). Ten horizontal zones were also recorded in the study gardens, although these were not systematically arranged. These microzones included bamboo groves, spice zone (e.g., *Allium odorum*), cattle sheds, courtyards in front of the house, out-house, ponds used for fishery and for planting *Neptunia prostrata* and *Ipomea aquatica*, residential zone, vegetable growing area, boundary zone, and the sacred zone.

3.11.5 Methodology

A comprehensive list of the plant species of the study area was made based on the plant species collected during summer season by the survey teams. The species were further separated in to trees and shrubs (perennials), herbaceous species, medicinal plants and aquatic plants. For the purpose of calculation of Importance value indices (IVI), quadrat and line intercept methods were used for estimation of frequency, density, cover. For the determination of frequency and density of the herbaceous species, a nested quadrat of 1 m x 1 m was used. A total of 20 quadrats from each sampling site were taken at random. However, for the determination of the frequency and density of different shrubs 10 quadrats of 5m x 5 m were used. For the determination of the frequency and density of different trees 10 quadrats of 20m x 20m were taken. In other words, one tree is considered equivalent to 10 shrubs or 100 herbs and one shrub as equivalent to 10 herbs for the purposes of calculation of Importance value indices, indices of diversity, dominance and evenness. Such kind of equivalencies is useful for calculation of indices of natural communities composed of herbs, shrubs and trees. But the cover in case of both the herbaceous species as well as the trees including shrubs was estimated by a modified line intercept method as the percent cover. The distance intercepted, overlaid or laid under by each species along a line transect of 100 m in case of herbaceous species and 250 m in case of shrubs and trees were measured and calculated as the % cover based on the distance intercepted. Density was calculated as the number per m^2 in case of herbaceous plants and as number per hectare in case of trees and tree like plants. The IVI values were calculated as the sum of relative frequency, relative density and relative dominance (dominance was based on cover). Frequency, density, abundance, IVI values and the indices of diversity of the plant species in the study area including the area of submergence were determined basing on standard ecological methods widely used in phytosociology as outlined hereunder:

$$\textbf{Frequency} = \frac{\text{Total number of quadrates in which the species occur}}{\text{Total number of quadrates studied}} \text{ X } 100$$

$$\textbf{Density} = \frac{\text{Total number of individuals of a sepcies inall quadrates}}{\text{Total number of quadrates studied}}$$

$$\textbf{Abundance} = \frac{\text{Total number of individuals of a species in all quadrates}}{\text{Total number of quadrates in which the species occurred}}$$

$$\textbf{Relative frequency} = \frac{\text{Frequency of individuals of a species}}{\text{Total frequency of all species}} \text{ X } 100$$

$$\textbf{Relative density} = \frac{\text{Density of individuals of a species}}{\text{Total total density of all species}} \text{ X } 100$$

$$\textbf{Relative abundance} = \frac{\text{Abundance of individuals of a species}}{\text{Total abundance of all species}} \text{ X } 100$$

Important Value Index = Relative density + Relative frequency + Relative abundance

Based on the IVI values, Shannon –Wiener Indices of Diversity, Simpson Index of dominance and Jaccard index of Evenness were calculated by using a computer progamme called "PAST". The data collected were also used to compute community indices like species diversity (H') of different tree species was calculated by using the Shannon- Weiner Index (Shannon and Weiner, 1963), as such:

$$H' = -\Sigma (ni/N)/ n (ni/N),$$

Where, ni/N, which denotes the importance probability of each species in a population, ni= Importance of value of species and N is the total number of individuals of all species in that vegetation type. Species dominance (Cd) was calculated following Simpson (Simpson, 1949): Such that

$$Cd = \Sigma (ni/N)^2,$$

Where, ni and N are the same as those for Shannon-Weiner information function.

Phytoplankton

Few horizontal hauls were made to collect plankton samples using plankton nets with a mesh size of 50µm and 120 µm. Samples were immediately transported to the laboratory and preserved using 40% formalin. After thoroughly shaking the concentrate sample, an aliquote sub-sample (1 ml), was transferred on to a microscopic slide examined. On an average, five such replicates were taken and the results computed for 1 ml of the concentrated sediment samples and identified using Edmondson (1959), Anand (1988).

Zooplankton

For the qualitative and quantitative analysis of zooplankton, an aliquote sub sample (2 ml) was taken from the concentrated sample, after thoroughly shaking and ensuring uniform distribution of the plankton, were qualitatively enumerated. Five such enumerations were made and averages calculated for 1 ml of each sample (Battish 1992).

3.11.6 Floristic diversity

Commercial cultivation of Tea gardens (*Camella sinensis*) is widely found in the study area. Arecanut palms (Betel nut), *Aquilaria malacensis* trees (Sasigas or Agarwood) is importance tree of commerce for aromatic oil production in the region. Paddy cultivation is main staple crop of the three districts i.e. Cachar, Hailakandi and Karimganj.

The study area is totally- non-urbanized area such as villages, agricultural lands and forest areas. Vegetation is mixed and varying in condition, composition and density. Dependence of villagers on natural vegetation in hits region is more for timber and firewood. Total plants species are observed in the study area is given in the **table 3.20.**

Table 3.20. List of plant species observed in core and buffer zones of the study area

S.No.	Plant Name	Vernacular name	Family	Habit
1	*Abelmoschus moschatus*	Gorukhia-korai	Malvaceae	Herb
2	*Abutilon indicum*	Pera petari	Malvaceae	Herb
3	*Acalypha indica*	Muktajuri	Amaranthaceae	Herb
4	*Achyranthes aspera*	Kathapatta	Amaranthaceae	Herb
5	*Acmella oleracea*	Pirazha	Asteraceae	Herb
6	*Acorus calamus*	Daruga	Araceae	Herb
7	*Aegle marmelos*	Bel	Rutaceae	Tree
8	*Aeschynomene aspera*	Kankula	Fabaceae	Shrub
9	*Aeschynomene indica*	Kuhila	Fabaceae	Herb
10	*Ageratum conyzoides*	Gondhoa-bon	Asteraceae	Herb
11	*Aglaia spectabilis*	Amari	Meliaceae	Tree
12	*Ailanthus grandis*		Simaroubaceae	Tree
13	*Alocasia indica*	Mankochu	Araceae	Herb
14	*Alpinia galanga*	Kulajan	Zingiberaceae	Herb
15	*Alseodaphne owdeni*	Tilsundi	Lauraceae	Tree
16	*Alstonia scholaris*	Sotiona, Chhatim	Apocynaceae	Tree
17	*Alysicarpus vaginalis*		Fabaceae	Herb
18	*Amaranthus spinosus*	Cauli	Amaranthaceae	Herb
19	*Amomum aromaticum*	Bodoelachi	Zingiberaceae	Herb
20	*Andrographis paniculata*	Kalmeg	Acanthaceae	Herb
21	*Anisomeles indica*	Gobara	Lamiaceae	Herb
22	*Annona squamosa*	Atlash kothal	Annonaceae	Tree
23	*Anodendron paniculatum*		Apocynaceae	Climber
24	*Antidesma ghesaembilla*	Mikhan-tenga	Euphorbiaceae	Tree
25	*Aphanamixis polystachya*	Hakhori-bakhori	Meliaceae	Tree
26	*Aporosa octandra*	Kokra	Euphorbiaceae	Tree
27	*Ardisia solanacea*	Banjam	Primulaceae	Tree
28	*Areca catechu*	Supari	Arecaceae	Tree
29	*Argyreia nervosa*	Gogul	Convolvulaceae	Climber
30	*Artocarpus heterophyllus*	Kathal	Moraceae	Tree
31	*Artocarpus lacucha*	Bohot	Moraceae	Tree
32	*Arundo donax*	Gabnol	Poaceae	Grass
33	*Asparagus racemosus*	Satmul	Liliaceae	Climber
34	*Azadirachta indica*	Neem	Meliaceae	Tree
35	*Baccaurea sapida*	Leteku	Phyllanthaceae	Tree
36	*Bacopa monnieri*	Brahmisag	Scrophulariaceae	Herb
37	*Bambusa balcooa*	Bhuluka bhan	Poaceae	Shrub

38	*Bambusa tulda*	Bijuli banh	Poaceae	Shrub
39	*Bambusa vulgaris*	Tansti banh	Poaceae	Shrub
40	*Barringtonia acutangula*	Hijal	Lecythidaceae	Tree
41	*Bauhina variegata*	Kotora	Fabaceae	Tree
42	*Bauhinia acuminata*	Kanchan	Fabaceae	Tree
43	*Bauhinia purpurea*	Kanchan	Fabaceae	Tree
44	*Begonia picta*	Maikhi Phagla	Begoniaceae	Herb
45	*Bidens bipinnata*		Asteraceae	Herb
46	*Bischofia javanica*	Urim	Euphorbiaceae	Tree
47	*Blumea lacera*	Kukur-sunga	Asteraceae	Herb
48	*Boehmeria macrophylla*	Dieng sohkhra	Urticaceae	Shrub
49	*Bomabax insigne*	Bon semal	Malvaceae	Tree
50	*Bombax ceiba*	Simolu	Malvaceae	Tree
51	*Bryophyllum calycimum*	Patherkuchi	Crassulaceae	Herb
52	*Byttneria aspera*		Malvaceae	Climber
53	*Caesalpinia bonduc*	Letaguti-goch	Fabaceae	Shrub
54	*Callicarpa arborea*	Gunmola	Lamiaceae	Tree
55	*Canarium bengalene*	Dhuna	Burseraceae	Tree
56	*Carex dimorpholepis*		Cyperaceae	Sedge
57	*Carica papaya*	Omita	Caricaceae	Tree
58	*Caryota urens*	Chewa guch	Arecaceae	Tree
59	*Cassia fistula*	Shonalu	Fabaceae	Tree
60	*Cassia javanica*	Bandor loti	Fabaceae	Tree
61	*Catharanthus roseus*	Nayantara	Apocynaceae	Herb
62	*Cayratia trifolia*	Chepeta-lota	Vitaceae	Climber
63	*Centella asiatica*	Thunkuni	Apiaceae	Herb
64	*Chassalia curviflora*	Tita-hutuka	Rubiaceae	Tree
65	*Chenopodium album*	Bathuasag	Chenopodiaceae	Herb
66	*Chukrasia tabularis*	Boga poma	Meliaceae	Tree
67	*Cinnamomum glanduliferum*	Gonhorai	Lauraceae	Tree
68	*Citrus maxima*	Robab tenga	Rutaceae	Tree
69	*Clausena heptaphylla*	Koronful	Rutaceae	Tree
70	*Cleome gynandra*	Bhutmala	Cleomaceae	Herb
71	*Cleome viscosa*	Hurhuriya	Cleomaceae	Herb
72	*Clerodendrum infortunatum*	Bhetita	Lamiaceae	Herb
73	*Clerodendrum glandulosum*	Nephaphu	Lamiaceae	Shrub
74	*Clerodendrum hastatum*		Lamiaceae	Shrub
75	*Clerodendrurm indicum*	Akal-bih	Lamiaceae	Shrub
76	*Coccinia grandis*	Belipoka	Cucurbitaceae	Climber
77	*Colocasia esculenta*	Panikochu	Araceae	Herb
78	*Combretum indicum*	Rangan	Combretaceae	Climber
79	*Combretum pilosum*		Combretaceae	Climber

80	*Combretum wallichii*	Pani-bokul-jirkiri	Combretaceae	Climber
81	*Cordia myxa*	Bowal	Boraginaceae	Tree
82	*Costus speciosus*	Kewpachla	Zingiberaceae	Herb
83	*Crassocephalum crepidioides*		Asteraceae	Herb
84	*Crateva religiosa*	Barun	Capparaceae	Tree
85	*Crotalaria pallida*	Jhun-jhuniya	Fabaceae	Shrub
86	*Croton bonplandianus*	Bon-tulsi	Euphorbiaceae	Herb
87	*Curcuma amada*	Amada	Zingiberaceae	Herb
88	*Curcuma aromatica*	Jangli-halud	Zingiberaceae	Herb
89	*Cuscuta reflexa*	Halodhiya-lata	Convolvulaceae	Climber
90	*Cyanthillium cinereum*	Kukshim	Asteraceae	Herb
91	*Cynodon dactylon*	Durba	Poaceae	Grass
92	*Cyperus compactus*		Cyperaceae	Sedge
93	*Cyperus compressus*		Cyperaceae	Sedge
94	*Dalbergia sericea*		Fabaceae	Tree
95	*Debregeasia longifolia*		Urticaceae	Shrub
96	*Dendrobium densiflorum*	Melei Leishna	Orchidaceae	Herb
97	*Dendrocalamus hamiltonii*	Kako banh	Poaceae	Herb
98	*Dentella repens*		Rubiaceae	Herb
99	*Desmodium gangeticum*		Fabaceae	Shrub
100	*Desmodium heterocarpon*	Salpani	Fabaceae	Shrub
101	*Desmodium heterophyllum*		Fabaceae	Herb
102	*Desmodium triflorum*	Kodalia	Fabaceae	Herb
103	*Dichrocephala integrifolia*	Lalukok	Asteraceae	Herb
104	*Dillenia indica*	Outenga	Dilleniaceae	Tree
105	*Dillenia pentagyna*	Akshi	Dilleniaceae	Tree
106	*Dioscorea bulbifera*	Gosh Alu	Dioscoreaceae	Climber
107	*Dioscorea esculenta*	Moa Alu	Dioscoreaceae	Climber
108	*Dioscorea pentaphylla*	Pan-patia-aloo	Dioscoreaceae	Climber
109	*Dipterocarpus robusta*		Dipterocarpaceae	Tree
110	*Duabanga grandiflora*	Ramdala	Lythraceae	Tree
111	*Dysoxylum gotadhora*	Bandarfela	Meliaceae	Tree
112	*Eclipta prostrata*	Bhringaraj	Asteraceae	Herb
113	*Ehretia acuminata*	Pojhar	Boraginaceae	Tree
114	*Elaeocarpus floribundus*	Jalphai	Elaeocarpaceae	Tree
115	*Elaeocarpus lanceifolius*	Saklong	Elaeocarpaceae	Tree
116	*Elephantopus scaber*		Asteraceae	Herb
117	*Eleusine indica*	Bobosa-bon	Poaceae	Grass
118	*Eragrostis pilosa*		Poaceae	Grass
119	*Erigeron canadensis*		Asteraceae	Herb
120	*Erythrina variegata*	Boga Modar	Fabaceae	Tree
121	*Euphorbia hirta*	Gakhiroti bon	Euphorbiaceae	Herb

122	*Ficus auriculata*	Mon dimoru	Moraceae	Tree
123	*Ficus benghalensis*	Bat	Moraceae	Tree
124	*Ficus benjamina*	Jari gach	Moraceae	Tree
125	*Ficus glomerata*		Moraceae	Tree
126	*Ficus hispida*		Moraceae	Tree
127	*Ficus racemosa*	Dumur	Moraceae	Tree
128	*Ficus religiosa*	Anhat gach	Moraceae	Tree
129	*Garuga pinnata*	Bombuk	Burseraceae	Tree
130	*Girardinia diversifolia*	Dimoru	Urticaceae	Shrub
131	*Glochidion lanceolarium*		Euphorbiaceae	Tree
132	*Gmelina arborea*	Gamari	Verbenaceae	Tree
133	*Goniothalamus sesquipedalis*		Annonaceae	Shrub
134	*Gynocardia odorata*	Bonsha	Salicaceae	Tree
135	*Hedychium coronarium*	Pakhila Phul	Zingiberaceae	Herb
136	*Helichrysum luteoalbum*		Asteraceae	Herb
137	*Holarrhena pubescens*	Dhulkari, Kurchi	Apocynaceae	Tree
138	*Hoya pendula*		Apocynaceae	Climber
139	*Illigera khasiana*	Kerkerilata	Hernandiaceae	Climber
140	*Impatiens balsamina*	Damdeuka	Balsaminaceae	Herb
141	*Imperata cylindrica*	Sonkher	Poaceae	Grass
142	*Indigofera tinctoria*	Neel bam	Fabaceae	Shrub
143	*Ipomoea aquatica*	Kalmisag	Convolvulaceae	Herb
144	*Ipomoea cairica*		Convolvulaceae	Climber
145	*Ipomoea cheirophylla*		Convolvulaceae	Climber
146	*Ipomoea hederifolia*		Convolvulaceae	Climber
147	*Ipomoea nil*	Nil Kalmou	Convolvulaceae	Climber
148	*Ipomoea purpurea*	Longuti-lata	Convolvulaceae	Climber
149	*Kaempferia rotunda*	Bhuichampa	Zingiberaceae	Herb
150	*Kyllinga brevifolia*		Cyperaceae	Sedge
151	*Lannea coromandelica*	Kohimola	Anacardiaceae	Tree
152	*Lantana camara*	Gubon	Verbenaceae	Shrub
153	*Leucas aspera*	Don-kolosh	Lamiaceae	Herb
154	*Licuala peltata*	Chatta-pat	Arecaceae	Tree
155	*Litsea glutinosa*	Baghnala	Lauraceae	Tree
156	*Litsea monopetala*	Sowalu	Lauraceae	Tree
157	*Ludwigia hyssopifolia*		Onagraceae	Herb
158	*Ludwigia prostrata*		Onagraceae	Herb
159	*Macaranga peltata*	Morali	Euphorbiaceae	Tree
160	*Mallotus philippensis*	Kamala	Euphorbiaceae	Tree
161	*Mangifera indica*	Aam	Anacardiaceae	Tree
162	*Melastoma malabathricum*	Phutkola	Melastomataceae	Shrub
163	*Melia azedarach*	Ghura neem	Meliaceae	Tree

164	*Meliosma pinnata*	Hengunia	Sabiaceae	Tree
165	*Mesua ferrea*	Nageswar	Clusiaceae	Tree
166	*Micromelum integerrimum*		Rutaceae	Tree
167	*Mikania micrantha*		Asteraceae	Climber
168	*Mimosa diplotricha*		Mimosaceae	Shrub
169	*Mimosa pudica*	Choymora	Mimosaceae	Herb
170	*Mimusops elengi*	Bakul	Sapotaceae	Tree
171	*Momordica charantia*	karela	Cucurbitaceae	Climber
172	*Morinda angustifolia*	Akal-bih	Rubiaceae	Tree
173	*Moringa oleifera*	Sojina	Moringaceae	Tree
174	*Mucuna imbricata*	Makori ghila	Fabaceae	Climber
175	*Neolamarckia kadamba*	Kadam	Rubiaceae	Tree
176	*Nyctanthus arbortristis*	Sewali	Oleaceae	Tree
177	*Olax acuminata*	Dieng-tilut	Olacaceae	Shrub
178	*Oplismenus compositus*	Banh-potia-bon	Poaceae	Grass
179	*Oreocnide integrifolia*	Bon rhea	Urticaceae	Tree
180	*Oroxylum indicum*	Thukuna gach	Bignoniaceae	Tree
181	*Oxalis corniculata*	Amrulsak	Oxalidaceae	Herb
182	*Paederia foetida*	Paduri lota	Rubiaceae	Climber
183	*Pajanella longifolia*	Kawarnoa	Bignoniaceae	Tree
184	*Panicum brevifolium*		Poaceae	Grass
185	*Papilionanthe teres*	Bhatou-phul	Orchidaceae	Herb
186	*Paranopsis paniculata*	Huhuni Sak	Convolvulaceae	Climber
187	*Pegia nitida*	Dhindoal-bogori-lata	Anacardiaceae	Climber
188	*Peperomia pellucida*	Ponounuwa	Piperaceae	Herb
189	*Persicaria barbata*		Polygonaceae	Herb
190	*Persicaria chinensis*		Polygonaceae	Climber
191	*Phanera glauca*		Fabaceae	Climber
192	*Phanera vahlii*	Kanchan lota	Fabaceae	Climber
193	*Phragmites karka*	Nal-khagra	Poaceae	Grass
194	*Phyla nodiflora*	Jal-pipali	Verbenaceae	Herb
195	*Phyllanthus amarus*		Phyllanthaceae	Herb
196	*Phyllanthus emblica*	Amlakhi	Euphorbiaceae	Tree
197	*Phyllanthus griffithi*	Bhuimala	Euphorbiaceae	Herb
198	*Phyllanthus indicus*	Ningthouthai	Euphorbiaceae	Herb
199	*Physalis minima*	Pokmou	Solanaceae	Herb
200	*Piper acutistigmum*		Piperaceae	Climber
201	*Piper nigrum*	Jaluk	Piperaceae	Climber
202	*Plumeria rubra*	Goalanchi	Apocynaceae	Tree
203	*Polygonum glabrum*	Bhihongi	Polygonaceae	Herb
204	*Polygonum plebeium*	Chemti Sag	Polygonaceae	Herb
205	*Pongamia pinnata*	Karchaw	Fabaceae	Tree
206	*Premna benghalensis*	Gohora	Lamiaceae	Tree

207	*Psidium guajava*	Madhuriam	Myrtaceae	Tree
208	*Pueraria montana*	Kudzu	Fabaceae	Climber
209	*Rhynchostylis retusa*	Kopou-phul	Orchidaceae	Herb
210	*Rhynchotechum ellipticum*		Fabaceae	Shrub
211	*Sabia lanceolata*		Sabiaceae	Climber
212	*Sapindus mukorossi*	Ritha	Sapindaceae	Tree
213	*Sapium baccatum*	Bella	Euphorbiaceae	Tree
214	*Saraca asoca*	Ashok	Fabaceae	Tree
215	*Saurauia cerea*	Rata Gagon	Actinidiaceae	Tree
216	*Saurauia roxburghii*	Arbeng-thing	Actinidiaceae	Tree
217	*Schima wallichii*	Makria	Theaceae	Tree
218	*Senna alata*	Khorpat	Caesalpiniaceae	Shrub
219	*Senna occidentalis*	Hant-thenga	Caesalpiniaceae	Herb
220	*Senna sophera*	Medeluwa	Caesalpiniaceae	Herb
221	*Senna tora*	Soru-medelua	Caesalpiniaceae	Herb
222	*Shorea robusta*	Sal	Dipterocarpaceae	Tree
223	*Sida acuta*	Boriala	Malvaceae	Herb
224	*Sida cordifolia*	Son-borial	Malvaceae	Herb
225	*Sida rhombifolia*		Malvaceae	Herb
226	*Siegesbeckia orientalis*		Asteraceae	Herb
227	*Sloanea sterculiacea*	Bandar-kakoi	Elaeocarpaceae	Tree
228	*Smilax zeylanica*	Kumarika	Snmilacaceae	Climber
229	*Solanum aculeatissimum*	Kochi	Solanaceae	Herb
230	*Solanum indicum*	Tit bhek	Solanaceae	Herb
231	*Solanum torvum*	Bhi-tita	Solanaceae	Shrub
232	*Sonchus wightianus*		Asteraceae	Herb
233	*Spondias pinnata*	Amora	Anacardiaceae	Tree
234	*Stachytarpheta jamaicensis*		Verbenaceae	Herb
235	*Stellaria media*	Thun thuni xak	Caryophyllaceae	Herb
236	*Stemona tuberosa*		Stemonaceae	Climber
237	*Sterculia versicolor*	Durong	Malvaceae	Tree
238	*Stereospermum chelonoides*	Paroli	Bignoniaceae	Tree
239	*Styrax serrulatus*	Bhakuli-potol	Styracaceae	Tree
240	*Syzygium cumini*	Jamuk	Myrtaceae	Tree
241	*Syzygium kurzii*	Bogi jamuk	Myrtaceae	Tree
242	*Tamarindus indica*	Teteli	Fabaceae	Tree
243	*Tectona grandis*	Segun	Verbenaceae	Tree
244	*Terminalia arjuna*	Arjun	Combretaceae	Tree
245	*Terminalia bellerica*	Bhumora	Combretaceae	Tree
246	*Terminalia chebula*	Silikha	Combretaceae	Tree
247	*Terminalia myriocarpa*	Hollokh	Combretaceae	Tree
248	*Thunbergia grandiflora*	Kukua loti	Acanthaceae	Climber
249	*Thysanolaena latifolia*	Jharu-bon	Poaceae	Grass

250	*Tinospora crispa*	Gulancha	Menispermaceae	Climber
251	*Toona ciliata*	Poma	Meliaceae	Tree
252	*Trema orientalis*	Jiban	Ulmaceae	Tree
253	*Trevesia palmata*	Snowflake tree	Araliaceae	Tree
254	*Trichosanthes cochinchinensis*		Cucurbitaceae	Climber
255	*Trichosanthes tricuspidata*	Koa-bhaturi	Cucurbitaceae	Climber
256	*Tridax procumbens*		Asteraceae	Herb
257	*Unona longiflora*	Unboi	Annonaceae	Shrub
258	*Urena lobata*	Honborolua	Malvaceae	Herb
259	*Viburnum cylindricum*		Caprifoliaceae	Tree
260	*Wedelia calendulacea*	Bhingaraj	Asteraceae	Herb
261	*Xanthium strumarium*	Aagora	Asteraceae	Herb
262	*Ziziphus mauritiana*	Bogori	Rhamnaceae	Tree
263	*Zizphus rugosa*	Suran	Rhamnaceae	Tree
Bryophytes				
264	*Anthoceros fusiformis*	Hornwort	Anthocerotopsida	
265	*Anthoceros laevis*	Smooth Hornwort	Anthocerotopsida	
266	*Bryuma piculatum*	---	Bryopsida	
267	*Polytrichum xanthopilum*	Juniper Haircap	Bryopsida	
268	*Riccia discolor*	Leafy Liverworts	Hepaticopsida	
269	*Riccia melanospora*	Leafy Liverworts	Hepaticopsida	
270	*Marchantia polymorpha*	Umbrella Liverwort	Marchantia	
Pteridophytes				
271	*Adiantum caudatum*	Maiden Hair Fern	Adiantaceae	
272	*Adiantum pedatum*	Maiden Hair Fern	Adiantaceae	
273	*Azolla pinnata*	Aquatic fern	Salviniaceae	
274	*Botrychium virginianaum*	Moonwort fern	Ophioglassaceae	
275	*Drynaria mollis*	Polypodiaceae fern	Polypodiaceae	
276	*Equisetum diffusum*	Horse tails	Equisetaceae	
277	*Equisetum sylvaticum*	Horse tails	Equisetaceae	
278	*Gleichenia linearis*	Wild fern	Gleicheniaceae	
279	*Lycopodium cernum*	Lycopodium	Lycopodiaceae	
280	*Marsilea hirsuta*	Aquatic fern	Marseliaceae	
281	*Marsilea minuta*	Aquatic	Marseliaceae	
282	*Ophioglossu mnudicaule*	Ophioglossumnudicaule	Ophioglassaceae	
283	*Pteris cretica*	---	Pteridaceae	
284	*Salvinia auriculata*	Aquatic fern	Salviniaceae	

3.11.6.1 Phytosociology of the plants

Species dominance is calculated based on the Important Value Index (IVI) and was calculated every species found in each study sites. It is usually practiced in ecological scrutinizes; IVI indicates the ecological importance of a species in a specific ecosystem which can be used for computing species conservation and management through which species having low IVI value require soar protection preference. The IVI for a species was calculated as the sum of its relative basal area, relative frequency, and relative density and often to describe and compare the species dominance of the sites.

Sample plots were selected in such a way to get maximum representation of different types of vegetation and plots were laid out in different part of the study area. Analysis of the vegetation will help in determining the relative importance of each species in the study area and to reveal if any economically valuable species is threatened in the process. In the study area, the highest IVI value recorded for *Antidesma gaseambella* (10.15) and was found to be the dominant species owing to high values of relative density and Relative frequency, followed by *Ailanthus grandis* (14.83), *Alstonia scholaris* and *Aeglemarmelos* and detailed phytosociological studies shown in table **3.21**.

Distribution of shrubs and climbers in the study area of the proposed project, the various quadrats indicated that *Clerodendrum indicum* (50.57) and *Allophyllus zeylanica* (40.03) are the dominant followed by *Atlantia monophylla* and *Crotalaria pallida*) remaining species were given in the table **3.22**.

As the study area is dominated by the waterlogged grass lands and crop fields, the area is with remarkably rich herbaceous ground cover. The herbs observed in the sampling plots, during the survey period, *Alocasia indica* is the dominant species followed by *Eclipta prostrata*, *Phragmites karka* and *Bacopa monnieri* have been enlisted in the table **3.23**.

Table 3.21 Importance Value Index of tree species in the study area

Plant name	Family	RF	Rden	Rdom	IVI
Antidesma ghaseambella	Phyllanthaceae	3.83	4.9	1.41	10.15
Ailanthus grandis	Simaroubaceae	3.45	3.68	1.42	8.54
Alstonia scholaris	Apocyanaceae	2.3	2.33	1.4	6.03
Aegle marmelos	Rutaceae	2.3	2.33	1.33	5.96
Aphanamixis polystachya	Meliaceae	2.3	2.08	1.4	5.79
Mangifera indica	Anacardiaceae	2.11	2.21	1.35	5.67
Artocarpus lakoocha	Moraceae	2.11	1.96	1.27	5.34
Rhus chinensis	Anacardiaceae	2.11	1.84	1.3	5.24

Artocarpus heterophyllus	Moraceae	1.92	1.96	1.33	5.2
Lannea coromandelica	Anacardiaceae	1.72	2.08	1.36	5.17
Anthocephalus cadamba	Rubiaceae	1.92	1.84	1.4	5.15
Michelia champaca	Magnoliaceae	1.92	1.84	1.35	5.1
Ficus religiosa	Moraceae	1.72	1.96	1.38	5.06
Albizia lebbeck	Mimosaceae	1.92	1.72	1.4	5.03
Syzygium cumini	Myrtaceae	2.11	1.47	1.3	4.87
Anthocephalus chinensis	Rubiaceae	1.72	1.59	1.39	4.71
Terminalia chebula	Combretaceae	1.53	1.84	1.34	4.71
Spondias pinnata	Anacardiaceae	1.72	1.72	1.23	4.67
Antidesma acidum	Phyllanthaceae	1.53	1.59	1.26	4.39
Caryota urens	Arecaceae	1.34	1.72	1.32	4.37
Ficus glomerata	Moraceae	1.34	1.72	1.31	4.37
Callicarpa arborea	Lamiaceae	1.34	1.59	1.39	4.32
Bombax ceiba	Malvaceae	1.34	1.47	1.39	4.2
Dipterocarpus robusta	Dipterocarpaceae	1.34	1.47	1.39	4.2
Ficus bengalensis	Moraceae	1.34	1.72	1.14	4.2
Canarium bengalensis	Burseraceae	1.34	1.47	1.26	4.07
Ficus racemosa	Moraceae	1.15	1.47	1.37	3.99
Terminalia bellerica	Combretaceae	1.34	1.35	1.29	3.98
Ficus ariculata	Moraceae	1.34	1.35	1.25	3.94
Glochidion lanceolarium	Euphorbiaceae	1.34	1.35	1.24	3.93
Tectona grandis	Verbenaceae	1.34	1.23	1.28	3.85
Chassalia curviflora	Rubiaceae	1.15	1.47	1.2	3.82
Elaeocarpus floribundus	Elaeocarpaceae	1.15	1.23	1.38	3.75
Gmelina arborea	Verbenaceae	1.15	1.23	1.37	3.74
Styrax serrulatus	Styracaceae	1.34	1.1	1.29	3.73
Terminalia arjuna	Combretaceae	1.34	1.23	1.13	3.7
Holarrhena pubescens	Apocyanaceae	1.15	1.23	1.3	3.68
Azadirachta indica	Mimosaceae	1.92	1.72	0.03	3.67
Sterculia versicolor	Sterculiaceae	1.34	0.98	1.34	3.66
Sapium baccatum	Euphorbiaceae	1.15	0.98	1.29	3.42
Dillenia indica	Dilleniaceae	0.96	0.98	1.31	3.25
Mesua ferrea	Clusiaceae	0.19	1.47	1.35	3.01
Toona ciliata	Meliaceae	0.96	0.86	1.18	2.99
Cassia fistula	Caesalpiniaceae	0.77	0.98	1.15	2.9
Chrysophyllum roxburghii	Sapotaceae	0.77	0.98	1.1	2.85
Sloanea sterculiacea	Elaeocarpaceae	0.96	0.61	1.08	2.65
Mallotus philippensis	Euphorbiaceae	0.57	0.49	1.3	2.37
Chukrasia tabularis	Meliaceae	0.57	0.49	1.1	2.17
Cinnamomum glanduliferum	Lauraceae	0.57	0.37	1.2	2.14
Baccaurea sapida	Phyllanthaceae	0.57	0.37	1.11	2.05

Ficus hispida	Moraceae	0.57	0.49	0.95	2.01
Sterculia villosa	Sterculiaceae	0.52	0.37	0.94	1.88
Garuga pinnata	Burseraceae	0.38	0.37	1.09	1.84
Dillenia pentagyna	Dilleniaceae	0.38	0.37	1.05	1.8
Randia dumetorum	Rubiaceae	0.38	0.37	1.03	1.78
Elaeocarpus lanceifolius	Elaeocarpaceae	0.38	0.37	1	1.75
Ehretia acuminata	Boraginaceae	0.38	0.25	1.1	1.73
Terminalia myriocarpa	Combretaceae	0.57	0.37	0.59	1.53
Macaranga peltata	Euphorbiaceae	0.38	0.37	0.72	1.47

Table 3.22 Phytosociology of the shrubs and climbers in the study area

Plant name	Family	RF	Rden	Rdom	IVI
Clerodenrdurm indicum	Lamiaceae	15.753	24.4211	10.398	50.572
Allophyllus zeylanica	Sapindaceae	13.356	20.6316	6.0427	40.03
Atlantia monophylla	Rutaceae	0.3425	0.2105	38.207	38.76
Crotalaria pallida	Fabaceae	11.986	10.1053	5.158	27.25
Phanera glauca	Fabaceae	0.3425	0.2105	21.284	21.837
Indigofera tinctoria	Fabaceae	6.5068	6.9474	1.3229	14.777
Aralia thompsonii	Araliaceae	3.4247	4	1.4031	8.8277
Pegia nitida	Anacardiaceae	4.1096	2.7368	1.672	8.5184
Clausena heptaphylla	Rutaceae	5.137	3.1579	0.1027	8.3976
Olax acuminata	Olacaceae	4.1096	2.5263	0.9034	7.5393
Desmodium gangeticum	Fabaceae	1.3699	1.0526	4.5453	6.9678
Phanera vahlii	Fabaceae	3.7671	2.3158	0.0602	6.1431
Thunbergia grandiflora	Acanthaceae	3.0822	2.1053	0.648	5.8354
Pavetta indica	Rubiaceae	2.3973	2.1053	0.723	5.2255
Mussaendra glabra	Rubiaceae	2.7397	2.3158	0.0728	5.1283
Melastoma malabathricum	Melastomataceae	2.7397	2.3158	0.0108	5.0663
Pueraria montana	Fabaceae	2.3973	1.4737	0.0338	3.9048
Sabia lanceolata	Sabiaceae	1.7123	1.4737	0.5793	3.7653
Hippocratus indica	Hippocrataceae	1.3699	1.0526	0.6034	3.0259
Dunberia conspersa	Fabaceae	1.3699	0.8421	0.7368	2.9488
Unona longifolia	Annonaceae	1.0274	0.6316	1.1798	2.8388
Argyreia nervosa	Convolvulaceae	1.3699	1.0526	0.0087	2.4311
Solanum torvum	Solanaceae	0.6849	0.4211	1.2107	2.3167
Cephalanthus occidentalis	Rubiaceae	1.0274	0.6316	0.4557	2.1147
Combretum pilosum	Combretaceae	1.0274	0.8421	0.2272	2.0967
Clerodendrum hastatum	Lamiaceae	1.0274	0.6316	0.3287	1.9877
Rhynchotechum ellipticum	Fabaceae	0.6849	0.4211	0.6523	1.7583
Boehmeria macrophylla	Urticaceae	0.6849	0.4211	0.3585	1.4645

Paranopsis paniculata	Convolvulaceae	0.6849	0.6316	0.1267	1.4432
Ipomoea cheirophylla	Convolvulaceae	0.6849	0.4211	0.1838	1.2898
Senna alata	Caesalpiniaceae	0.3425	0.2105	0.2124	0.7654
Caesalpinia bonduc	Fabaceae	0.3425	0.2105	0.166	0.719
Debregeasia longifolia	Urticaceae	0.3425	0.2105	0.1406	0.6936
Mikania micrantha	Asteraceae	0.3425	0.2105	0.0639	0.6169
Tinospora crispa	Menispermaceae	0.3425	0.2105	0.0533	0.6063
Lantana camara	Verbenaceae	0.3425	0.2105	0.0507	0.6037
Combretum indicum	Combretaceae	0.3425	0.2105	0.0371	0.5901
Abrus precatorius	Fabaceae	0.3425	0.2105	0.0346	0.5876
Illigera khasiana	Hernandiaceae	0.3425	0.2105	0.0031	0.5561

Table 3.23 Phytosociology of the herbs in the study area

Name of the plant	Family	R.F	R.D	R.A	IVI
Alocasia indica	Araceae	3.46	3.91	2.06	9.44
Eclipta prostrata	Asteraceae	3.46	3.59	1.89	8.94
Phragmites karka	Poaceae	3.19	3.45	1.98	8.62
Bacopa monnieri	Scrophulariaceae	3.46	2.99	1.58	8.03
Stachytarpeta jamaicansis	Verbenaceae	3.46	2.99	1.58	8.03
Periscaria barbata	Polygonaceae	1.91	2.99	2.85	7.76
Achyranthes aspera	Amaranthaceae	2.82	2.99	1.93	7.75
Curcuma aromatica	Zingiberaceae	2.73	2.99	2	7.72
Acorus calamus	Araceae	2.28	2.99	2.4	7.67
peperomia pellucida	Piperaceae	2.28	2.99	2.4	7.67
Leucas aspera	Lamiaceae	2.55	2.72	1.94	7.21
Begonia picta	Begoniaceae	2.46	2.62	1.95	7.03
Cleome gynandra	Cleomaceae	1.91	2.39	2.28	6.59
Elephantopus scaber	Asteraceae	2.19	2.35	1.96	6.49
Eleusine indica	Poaceae	2.55	2.25	1.61	6.42
Solanum aculeatissimum	Solanaceae	2.55	2.21	1.58	6.34
Carex dimorpholepis	Cyperaceae	2.19	2.21	1.84	6.24
Sonchus wightianus	Asteraceae	2.37	2.07	1.6	6.04
Hedychium coronarium	Zingiberaceae	2.28	2.07	1.66	6.01
Papilionanthe teres	Orchidaceae	1.73	2.07	2.18	5.99
Bryophyllum calycimum	Crassulaceae	1.91	2.07	1.98	5.96
Erigeron canadensis	Asteraceae	2.09	1.93	1.68	5.71
Dichrocephala integtrifolia	Asteraceae	1.82	1.93	1.94	5.69
Alpinia galanga	Zingiberaceae	1.09	1.66	2.77	5.52
Kyllinga brevifolia	Cyperaceae	2.19	1.75	1.46	5.39
Solanum indicum	Solanaceae	2.46	1.61	1.2	5.27

Cyperus compressus	Cyperaceae	1.37	1.61	2.15	5.13
Senna sophera	Caesalpiniaceae	1.37	1.61	2.15	5.13
Urena lobata	Malvaceae	1.37	1.61	2.15	5.13
Abelmoschus moschatus	Malvaceae	1.91	1.61	1.54	5.06
Desmodium heterophyllum	Fabaceae	1.55	1.61	1.9	5.06
Costus speciosus	Zingiberaceae	1.64	1.61	1.79	5.04
Thysanolaena latifolia	Poaceae	1.64	1.56	1.74	4.95
Curcuma amada	Zingiberaceae	1.09	1.43	2.38	4.9
Sigesbeckis otientalis	Asteraceae	1.64	1.47	1.64	4.75
Cyanthillium cinereum	Asteraceae	1.73	1.43	1.5	4.66
Eragrostis pilosa	Poaceae	1.73	1.43	1.5	4.66
Andrographis paniculata	Acanthaceae	1.64	1.43	1.59	4.65
Panicum brevifolium	Poaceae	1.09	1.29	2.15	4.53
Crassocephalum crepidioides	Asteraceae	1.37	1.29	1.72	4.38
Dentella repens	Rubiaceae	0.91	1.15	2.31	4.37
Helichrysum luteoalbum	Asteraceae	0.91	1.1	2.21	4.23
Kaempferia rotunda	Zingiberaceae	1.09	1.15	1.92	4.16
Alysicarpus vaginalis	Fabaceae	1.64	1.15	1.28	4.07
Physalis minima	Solanaceae	1.37	1.1	1.48	3.95
Amomum aromaticum	Zingiberaceae	1.09	0.97	1.61	3.67
Stellaria media	Caryophyllaceae	1.55	0.97	1.14	3.65
Chenopodium album	Chenopodiaceae	1.28	0.97	1.38	3.62
Acmella oleracea	Asteraceae	0.91	0.87	1.75	3.54
Phyllanthus indicus	Euphorbiaceae	1.09	0.87	1.46	3.43
Polygonum glabrum	Polygonaceae	0.73	0.69	1.73	3.15
Arundo donax	Poaceae	0.82	0.69	1.54	3.05
Phyllanthus griffithi	Euphorbiaceae	0.82	0.64	1.43	2.9
Ludwigia hyssopifolia	Onagraceae	0.82	0.55	1.23	2.6
Ludwigia prostrata	Onagraceae	0.46	0.32	1.29	2.07

3.11.6.2 Biodiversity indices

Biodiversity index is a quantitative measures that reflects how many different types of species, there are in a dataset, and simultaneously takes into account how evenly the basic entities are distributed among those types of species. The value of biodiversity index increases both when the number of types increases and when evenness increases. For a given number of type of species, the value of a biodiversity index is maximised when all type of species are equally abundant. Biodiversity indices values are given in the table **3.24**.

Table 3.24 Biodiversity indices of the study area

Community	Shannon-Wiener Index (H)	Simpson Diversity Index (1/D)	Species Evenness
Tree	3.39	0.95	0.82
Shrub & Climbers	2.59	0.87	0.37
Herb	3.9	0.97	0.89

3.11.7 Faunal observations

For the documentation of the faunal biodiversity of the study area with respect to birds, reptiles, amphibians, and butterfly species, a baseline survey conducted in March-May, 2019. To prepare a detailed report on the status of faunal diversity within study area of 10 Km radius around Block AA-ONHP-2017/14 area, field studies were conducted. Both direct (sighting) and indirect (evidences) observations methods were used to survey the faunal species around the study area. Additionally reference of relevant literatures (published/unpublished) and dialogues with local people were also varied out to consolidate the presence of faunal distribution in the area (Smith 1933-43, Ali and Ripley 1983, Daniel 1983, Prater 1993).

Livestock like cattle, goat, poultry, duck and pig are reared for dairy products, meat, egg and for agriculture purpose. Majority of cattle are of local variety. Backyard poultry farms are mostly common in this area.

No wild mammalian species was directly sighted during field survey and conversation with local people located within the study area also could not confirm presence of any wild animal in that area, Indian porcupine, Common five stripped Squirrel, Common Indian Mongoose, Indian Rabbit, Large Indian Squirrel were observed during primary survey. Since birds are considered to be the indicators for monitoring and understanding human impacts on ecological systems attempt was made to gather quantitative data on the avifauna by walk through survey within the entire block area and in the agricultural lands within the close proximity to the large water body of this region Sone beel. Systematic account of the fauna along with birds in the study area with the status of occurrence is given in the Table **3.25**.

Table 3.25 Checklist of fauna observed in the study area

S.No	Common name	Scientific name	Schedule of the Indian Wildlife (Protection) Act
Mammals			
1	Rhesus Macaque	*Macaca radiata*	Schedule-II
2	Assames Macaque	*Macaca assamensis*	Schedule-II

3	Stumptailed Macaque/Sendiria Bandar	*Macaca speciosa*	Schedule-II
4	Common flying fox	*Pteropus giganteaus*	Schedule-V
5	Large Bamboo rats	*Rhizomis sinensis*	Schedule-V
6	Indian Hare	*Lepus nigricollis*	Schedule-IV
7	Wild Boar	*Sus scrofa*	Schedule-III
8	Elephant	*Elephas maximus*	Schedule-I
9	Leopard	*Panthera pardus*	Schedule-I
10	Gangetic Dolphin	*Plantista gangetica*	Schedule-I
11	Jungle cat	*Felis chaus*	Schedule-II
12	Otter	*Luthra perspicilliata*	Schedule-II
13	Bay Bamboo rat	*Cannomys badius*	Schedule-V
14	Large indian Civet cat	*Viverra zibetha*	Schedule-II
15	Hog deer	*Axis porcinus*	Schedule-III
16	Flying squirrel	*Petaurista petaurista*	
Avi fauna			
17	Common house crow	*Corvus splendens*	Schedule-V
18	Jungle crow	*Corvus macrorhynchos*	Schedule-IV
19	Red vented bulbul	*Pycnonatus cafer*	Schedule-IV
20	Red whiskered bulbul	*Pycnonotus jocosus*	Schedule-IV
21	Common drongo	*Dicrurus adsimilis*	Schedule-IV
22	Common house myna	*Acridotheres tristis*	Schedule-IV
23	The pied myna	*Sturnus contra*	Schedule-IV
24	House Sparrow	*Passer domesticus*	Schedule-IV
25	Indian Tree pie	*Dendrocitta vagabunda*	Schedule-IV
26	Common babbler	*Turdoides caudatus*	Schedule-IV
27	Great Racket tailed Drongo	*Dicrurus paradiseus*	Schedule-IV
28	Jerdons chloropsis	*Chloropsis jerdoni*	Schedule-IV
29	Striated green bulbul	*Ploceus phillippinus*	Schedule-IV
30	The shama	*Copsychus malabaricus*	Schedule-IV
31	Indian Wren Warbler	*Prinia subflava*	Schedule-IV
32	Streaked fantail warbler	*Cisticola juncidis*	Schedule-IV
33	Tailor bird	*Orthotomus sutorius*	Schedule-IV
34	Jungle myna	*Acredotheres fuscus*	Schedule-IV
35	Hill myna	*Gracula religiosa*	Schedule-IV
36	Black headed oriole	*Oriolus xanthornus*	Schedule-IV
37	Baya weaver bird	*Ploceus philippinus*	Schedule-IV
38	White wagtail	*Motacilla alba*	Schedule-IV
39	Yellow headed wagtail	*Motacila citreola*	Schedule-IV
40	Grey wagtail	*Motacilla cinerea*	Schedule-IV
41	Spotted munia	*Lonchura punctulata*	Schedule-IV
42	Red munia	*Amandava amandava*	Schedule-IV
43	White munia	*Lonchura striata*	Schedule-IV

44	Purple sunbird	*Nectarinia asiatica*	Schedule-IV
45	Purple rumped sunbird	*Nectarinia zeylanica*	Schedule-IV
46	Indian yellow backed sunbird	*Aethopyga siparaja*	Schedule-IV
47	Scarlet minivet	*Pericrocotus flammeus*	Schedule-IV
48	Indian roller of the blue jay	*Coracias benghalensis*	Schedule-IV
49	Common Bee eater	*Merops orientalis*	Schedule-IV
50	White breasted king fisher	*Halcyon smyrensis*	Schedule-IV
51	Common kingfisher	*Alcedo atthis*	Schedule-IV
52	Black capped king fisher	*Halcyon pileata*	Schedule-IV
53	Indian Hoopoe	*Upupa epops*	Schedule-IV
54	Indian cukoo	*Cuculus micropterus*	Schedule-IV
55	Pied crested cukoo	*Clamator jacobinus*	Schedule-IV
56	Crow pheasant	*Centropus sinensis*	Schedule-IV
57	Common Koel	*Eudynamis scolopacea*	Schedule-IV
58	Blossom-headed parakeet	*Psittacula cynocephala*	Schedule-IV
59	Indian Red breatsed Parakeet	*Psittacula fasciatus*	Schedule-IV
60	Eastern rose ringed Parakeet	*Psittacula krameri*	Schedule-IV
61	Brown fish owl	*Ketupa zeylonensis*	Schedule-IV
62	Scops owl	*Otus scops*	Schedule-IV
63	Indian spotted Dove	*Spilopelia chinensis*	Schedule-IV
64	Red jungle fowl	*Gallus gallus*	Schedule-IV
65	Water cocks	*Gallicrex cinera*	Schedule-IV
66	Sarus crane	*Grus antigone*	Schedule-IV
67	Bronze winged jacana	*Metopidius indicus*	Schedule-IV
68	Pheasant tailed jacana	*Hydrophasianus chirurgus*	Schedule-IV
69	Stone Curiew	*Burhinus oedicnemus*	Schedule-IV
70	Red wattled lapping	*Vanellus indicus*	Schedule-IV
71	White necked stork	*Ciconia episcopus*	Schedule-IV
72	Cattle Egret	*Bulbulcus ibis*	Schedule-IV
73	Paddy bird or the pond Heron	*Ardeola grayii*	Schedule-IV
74	Night Heron	*Nyclricorax nucticorax*	Schedule-IV
75	Chestnut Bittern	*Ixobrychus cinnamomeus*	Schedule-IV
76	Shovellers	*Anas clypeata*	Schedule-IV
77	Common Teal	*Anas crecca*	Schedule-IV
78	Cotton Teal	*Nettapus coromandelianus*	Schedule-IV
79	Lesser Golden Backed Woodpecker	*Dinopium benghalensis*	Schedule-IV
80	Common coot	*Fulia atra*	Schedule-IV
81	Indian Darter	*Anhinga melanogostar*	Schedule-IV
82	Black winged Stilts	*Himantopus himantopus*	Schedule-IV
83	Openbilled stork	*Anastomus ocitans*	Schedule-IV
84	Himalayan Griffon Vulture	*Gyps himalayensis*	Schedule-I
85	White rumped Vulture	*Gyps benghalensis*	Schedule-I

86	Slender Billed Vulture	*Gyps indicus*	Schedule-I
87	Palla's fish Eagle	*Haliaeetus leucoryphus*	Schedule-I
88	Bar headed goose	*Anser indicus*	Schedule-IV
89	Lesser Adjutant Stork	*Leptoptilos javanicus*	Schedule-IV
90	Greater Adkitant Stork	*Leptoptilos dubius*	Schedule-IV
91	Red crested Ponchard	*Netta rufina*	Schedule-IV
92	Eurasian wigeon	*Anas penelop*	Schedule-IV
93	Northern Shoveller	*Anas cypeata*	Schedule-IV
94	Garganey	*Anas acuta*	Schedule-IV
95	Greylagloose	*Anser anser*	Schedule-IV
96	Spot billed duck	*Anas poecilorhyncha*	Schedule-IV
97	Mallard	*Anas platyrhynchos*	Schedule-IV
98	Barn owl	*Tyto alba*	Schedule-IV
99	Spot billed Pelican/Grey Pelican	*Pelicanus phillippensis*	Schedule-IV
Reptiles			
100	Cobra	*Naja naja*	Schedule-II
101	Rat snake	*Ptyas mucosus*	Schedule-II
102	Common krait	*Bungarus coeruleus*	Schedule-II
103	Russell's viper	*Vipera russelli*	Schedule-II
104	Garden Lizard	*Calotes versicolor*	Schedule-IV
105	Indian Chameleon	*Chameleon zeylanicus*	Schedule-II
106	Assam Roofed Turtle	*Pangshura sylhetensis*	Schedule-I
107	Spotted pond Turtle	*Geocelmys hamiltonii*	Schedule-I
108	Asian leaf Turtle	*Cycelmys gemelli*	Schedule-I
109	Gangetic siftshell Turtle	*Aspideres gangeticus*	Schedule-I
110	Red Crown roof Turtle	*Batagur kachuga*	Schedule-I
111	River terrapian	*Batagur baska*	Schedule-I
Amphibians			
112	Cricket frog	*Fejervarya limnocharis*	Schedule-IV
113	Indian Bull forg	*Hoplobatrachus tigerinus*	Schedule-IV
Butterflies			
114	Blue Pansy	*Junonia orytha*	Schedule-IV
115	Blue Tiger	*Tirumala limniace*	Schedule-IV
116	Chocolate Pansy	*Junonia iphita*	Schedule-IV
117	Common Baron	*Euthalia garuda*	Schedule-IV
118	Common Cerulean	*Jamides celeno*	Schedule-IV
119	Common emigrant	*Catopsilia pomona*	Schedule-IV
120	Common Grass yellow	*Eurema hecabe*	Schedule-IV
121	Common Indian Crow	*Euploea core*	Schedule-IV
122	Common Jezebel	*Delias eucharis*	Schedule-IV
123	Common Leopard	*Phalanta phalanta*	Schedule-IV
124	Common Mormon	*Papilio polytes*	Schedule-IV

125	Common sailor	*Neptis hylas*	Schedule-IV
126	Glassy Tiger	*Parantica algae*	Schedule-IV
127	Gram Blue	*Euchrysops cnejus*	Schedule-IV
128	Great Egg Fly	*Hypolimnas bolina*	Schedule-IV
129	Grey Pansy	*Junonia atlites*	Schedule-IV
130	Indian Skipper	*Spialia galba*	Schedule-IV
131	Lemon Pansy	*Junonia lemonias*	Schedule-IV
132	Peacock Pansy	*Junonia almana*	Schedule-IV
133	Pioneer	*Anaphaeis aurota*	Schedule-IV
134	Plain Tiger	*Danaus chrysippus*	Schedule-IV
135	Plum Judy	*Abisara echerius*	Schedule-IV
136	Striped Tiger	*Danaus genutia*	Schedule-IV
137	Yellow Pansy	*Junonia hierta*	Schedule-IV

Source: Forest and Environment Department, field study and public consultation

3.11.8 Aquatic ecological status

The impact of pollution on aquatic ecosystem manifests itself first on the biotic aquatic communities. The species composition of aquatic organisms in natural communities is directly influenced by ambient water quality. The responses of plants to pollutants, when measured quantitatively give an insight about the conditions of existing aquatic ecosystem.

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

Phytoplankton and Zooplankton

Phytoplankton can be broadly grouped into two categories those with plant origin are called 'Phytoplankton' and those with animal origin are called 'Zooplankton'.

Generating data by actual field sampling and analysis in these areas through field visits during study period; samples were collected from different fresh water systems (river) under investigation. In order to get a clear picture and to assess the various parameters of water, three sampling locations were identified for sampling which are Barak River, Sone beel and Kathkal River.

3.11.8.1 Phytoplankton

Phytoplanktons are the major primary producers of organic matter in the aquatic ecosystem and especially oceans whose 90% productivity is from the planktons. Collectively, they directly or indirectly support the entire animal population. When the water column becomes shallow in spring, phytoplanktons are exposed to higher light intensity in the upper sunlight. Light is one of the major abiotic factors that favour the growth of phytoplankton. The massive build up of phytoplankton in spring directly contributes new organic carbon to support the Zooplankton, which, in turn, benefits larger aquatic animals including fish, crustaceans, molluscs, birds. Phytoplankton were concentrated by centrifugation and analysed microscopically in laboratory. The checklist of phytoplankton given in table 3.26.

Table 3.26 Phytoplankton observed in the study area

Family	Phytoplankton species	$\mu M^3/Ml$
Bacillariophyceae	*Navicula* sp	13240.8
	Diatoms sp	5500.1
	Synedra sp	4894.98
	Cyclotella sp	5460.2
	Gomphonema sp	1066.5
	Nitischia sp	2151.56
Cyanophyceae	*Chlorella* sp	1330.1
	Scenedesmus sp	4750.42
	Nostoc sp	1224.25
Chlorophyceae	*Merismopidia*	1124.4
Euglenophyceae	*Euglena* sp	1560.25

Table 3.27 Aquatic sampling locations

Location	Shannon-Weiner index
Barak river	1.56
Sone beel	1.59
Kathkal river	1.54

3.11.8.2 Zooplankton

The significance of Zooplanktons is found in their role in transferring biological production from phytoplankton to larger organisms in the food web. A large number of phytoplankton species are grazed upon by the microscopic protozoans, tunicates, copepods and other cruastaceans. These in turn become food for the other animals further linking the food web.

Therefore, variability in the production of planktons would affect the survival of young fish that depend on them.The result of the Zooplankton analysis is tabulated in Table **3.28**.

Table 3.28 Zooplankton species in the study area

Family	Phytoplankton species	µM³/Ml
Rotifera	*Brachinous* sp	6680.3
Arthropoda	*Nauplius* sp	2290.6
	Acroperus sp	6890.5
	Macrothrix sp	1250.5
	Ceriodaphnia sp	1423.9
	Simocephalus sp	2350.59

3.11.8.3 Fishes

The following are fish species obsrved in the study area of Block AA-ONHP-2017/14 which includes three districts. Total fishes listed in the table **3.29**.

Table 3.29 Checklist of fishes in the study area

S.No.	Scientific name	Local name	English name
1	*Catla catla*	Katal/Catla	Katla
2	*Labeo rohita*	Rui	Rohu
3	*Labeo calbasu*	Baush kalibaush	Calbasu/Black Rohita
4	*Labeo gonius*	Goinya	Goania
5	*Cirrhinus mrigala*	Mrigal/mikra	Mrigal
6	*Labeo bata*	Bata	Bata
7	*Cirrhinus reba*	Bhanga	Reba
8	*Hilsa ilisha*	Ilish	Indian Shad
9	*Rhinomugil corsula*	Corsula/Nadir bata	Corsula mullet
10	*Hypophthalmichthys molitrix*	Silver carp	Silver carp
11	*Hypophthalmichthys nobilis*	Big head	Big head
12	*Ctenopharyngodon idellus*	Grass carp	Grass carp
13	*Cyprinus caprio*	Carpio/Japani rui	Common carp/Scale carp
14	*Putinus javanicus*	Japani puti	Java puti
15	*Oreochromis mossambica*	Tilapia	Tilapia/Mozambique cichlid

3.12. SOCIO-ECONOMIC ENVIRONMENT

3.12.1 Overview

The socio economic study includes the processes of analyzing, monitoring and managing the intended and unintended social consequences, both positive and negative aspects. The socio-economic baseline on demographic patterns, economic and livelihood profile and infrastructure facilities, community perception and mitigation measures in the study area. Based on the data is compiled in this section, the impact assessment will predict and evaluate any potential impacts of the proposed project on the local community, livelihoods and other social systems. The study area presented in the socio-economic baseline comprises of the following:

Proposed project location – within the limits of study area

- Profile of settlements within a radius of 10 km around the proposed project location.
- Public awareness and their concern about the project and need assessment of the local communities.
- To identify the impact of socioeconomic factors and mitigating measure within the study areas.

The socio-economic baseline has been prepared on the basis of available secondary sources of information was generated through site observation , individual interviews and focus group discussion with the people living in the villages identified to be within the study area. In addition to this, Field survey was conducted in the villages from 115 participants. It has also been undertaken to assess their and awareness and perceptions about the proposed project. Random interactions were also made with the local communities, school teacher, PHC centre, stake holders, and anganwadi workers.

3.12.2 Administration and Social characteristics

The proposed study areas are located part of Karimganj, Hailakandi, Cachar Districts of Assam. The entire Cahchar district is divided into two Sub-divisions: such as Silchar and Lakhipur Again each sub-division is divided into revenue circles and under revenue circles there are Mouzas comprising revenue villages. The district comprises of five Revenue Circles, Katigora, Silchar, Udarband, Lakhipur and Sonai covering 1040 villages.

From Karimganj, there are 7 towns (2 statutory towns and 5 Census towns) in the district. The district is comprised of 936 villages with 7 Community Development Blocks. The district possesses 5 Revenue Circles namely, Karimganj, Badarpur, Nilambazar, Patharkandi and Ramkrishna Nagar. The district area is divided among 7 Police Stations, namely Karimganj, Badarpur, Patharkandi, Ramakrishana Nagar, Ratabari, Nilambazar and Bazerichera.

The district Hailakandi is situated in the Barak Valley region of Assam. It comprises 4 Revenue Circle with 331 villages. It has 5 Community Development Blocks. There is no any jurisdictional changes taken place during 2001-2011. The district has 3 towns (2 statutory towns and 1 census towns).

3.12.3 Demographic details of the study area

Karimganj had population of 1,228,686 of which male and female were 625,864 and 602,822 respectively. There was change of 21.90 percent in the population compared to population as per 2001. The density of Karimganj district for 2011 is 679 people per sq. km and district administers 1,809 square kilometers of areas. The average literacy rate is 78.22. If things are looked out at gender wise, male and female literacy were 84.12 and 72.09 respectively (Fig 3.13). With regards to Sex Ratio, it stood at 963 per 1000 male. Data regarding child under 0-6 age were with ration of 969 male.

With Regard to Hailakandi, literacy rate of in 2011 were 74.33 compared. If things are looked out at gender wise, male and female literacy were 80.74 and 67.60 respectively. Total literate in Hailakandi District were 407,366 of which male and female were 226,836 and 180,530 respectively. With regards to Sex Ratio in Hailakandi, it stood at 951 per 1000 male. Data regarding child under 0-6 age were 111,278 children with ratio of 954 compared to 927 of census 2001 (**Table 3.30**).

Table 3.30 Demographical details of three districts

Description	Kariganj	Cacher	Hailakandi
Population	12.29 Lakhs	17.37 Lakhs	6.59 Lakhs
Actual Population	12,28,686	17,36,617	6,59,296
Male	6,25,864	8,86,284	3,37,890
Female	6,02,822	8,50,333	3,21,406
Population Growth	21.90%	20.19%	21.45%
Area Sq. Km	1,809	3,786	1,327
Density/km2	679	459	497
Proportion to Assam Population	3.94%	5.57%	2.11%
Sex Ratio (Per 1000)	963	959	951
Child Sex Ratio (0-6 Age)	969	954	954
Average Literacy	78.22	79.34	74.33
Male Literacy	84.12	84.78	80.74
Female Literacy	72.09	73.68	67.6
Total Child Population (0-6 Age)	2,11,960	2,56,774	1,11,278
Male Population (0-6 Age)	1,07,638	1,31,417	56,936
Female Population (0-6 Age)	1,04,322	1,25,357	54,342
Literates	7,95,297	11,74,128	4,07,366

Male Literates	4,35,942	6,39,946	2,26,836
Female Literates	3,59,355	5,34,182	1,80,530
Child Proportion (0-6 Age)	17.25%	14.79%	16.88%
Boys Proportion (0-6 Age)	17.20%	14.83%	16.85%
Girls Proportion (0-6 Age)	17.31%	14.74%	16.91%

Source: https://www.census2011.co.in/census/district

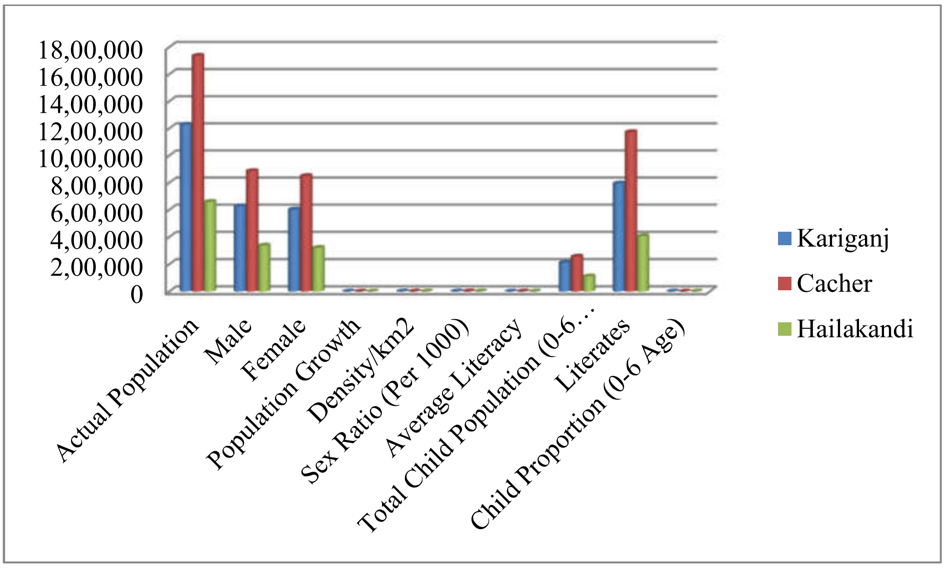


Fig.3.14 Demographic details of the study area

Table 3.31 Population details within the study area

DT Name	Name	No_HH	TOT_P	TOT_M	TOT_F	P_06	P_SC	P_ST	P_LIT
Cachar	Tapang	13285	59598	30648	28950	9551	21136	313	32955
	Barjalenga	20896	93516	48121	45395	14338	26148	255	58146
	Narsingpur	36184	164286	83159	81127	25641	22684	3950	109621
Karimganj	South Karimganj	1608	7358	3776	3582	982	1378	51	5713
	Badarpur	24963	126216	64381	61835	22135	11722	26	86349
	Badarpur	5142	25189	12807	12382	3119	1855	38	20252
	Patharkandi	37736	189835	96661	93174	34997	9743	118	119851
	Lowairpoa	29605	142944	73366	69578	24684	23450	372	81781
	Ramkrishna Nagar	22552	113716	57594	56122	19766	35160	233	72154
	Dullavcherra	34439	168148	86165	81983	29673	20878	783	99863
Hailakandi	Algapur	26783	121379	62627	58752	19693	15554	144	78334
	Hailakandi	29922	133260	68975	64285	23472	8002	8	80023
	Lala	42144	191172	97613	93559	32824	18287	302	114200

Source: http://censusindia.gov.in/pca/cdb_pca_census/Houselisting-housing-ASSAM.html

3.12.4 Social Characteristics

Social life Among the Hindus, the property is generally held by head of the family who manages it as its custodian. After the death of the father, the sons and daughters inherit the properly. The joint family system was common in the past. But now-a-days; it is loosing its hold. The caste distinction is not rigid as it was a few decades ago, nevertheless, the inter caste marriage is not very frequent in this study. Although permitted by law re-marriage of widow is not looked upon. In rural family, every household particularly Assamese family has their distinct types of houses for their different uses. In most of rural folk households their houses are made of thatch & bamboo. At present, who can afford have constructed their houses on modern line using C.I. sheets and brick and cement. Male dress for Assamese & Bengali includes Dhoti, Chadar, Shirt, Kamij, Trousers and Coats, but Muslim males use Lungi. Female dress for Assamese consists of Riha, Mekhela, Chadar, Sari & Blouse but Bengali females do not use Riha, Mekhela, Chadar. This study area people use only Sari & Blouse. Similarly the Muslim female use Sari and Blouse only. The biggest festival of the year in the district is Durga Puja which is observed by both Assamese and Bengali people. Sivaratri & Doljatra are also observed by both sections of the people. Assamese people observe three Bihus namely the Rangali Bihu (April 14), Bhogali Bihu (Jan. 13 or 14) and Kati Bihu (Oct.14th) which are associated with the cycles of cultivation. Rangali Bihu is the festival, where groups of Assamese people dance and sing the Bihugeet, the boys play on flute and beat drums and blow the pepa, made of buffalo-horn and taka. The Namghar is the community prayer hall of the villagers, who held prayer services known as nam-kirtan during religious festivals. Most of the indigenous games played in the district in the past have now been replaced by western games and sports. Football, Cricket, Volleyball etc are now very popular among the youths. Indoor games like Caroms, Cards, Chess, Ludo are played in the towns & villages.

3.12.5 Livelihood

The livelihood is very much dependent on natural and economic endowments and institutional arrangements. Agriculture holds significant position in the economy of in these three districts. Most of the people within the study area are dependent on agriculture as their primary occupation. Animal husbandry is also a widely prevalent occupation within the study area. However, people now a day have started working in the nearby factories and manufacturing units present within the study area (**Table 3.32**).

Table 3.32 Livelihood details of population within the study area

Distrct	Sub Division	TOT_WORK_P	TOT_WORK_M	TOT_WORK_F	MAINWORK_P	MARGWORK_P	NON_WORK_P
Cachar	Tapang	22183	16397	5786	17422	4761	37415
	Barjalenga	35518	26262	9256	25980	9538	57998
	Narsingpur	56169	44090	12079	43576	12593	108117
Karimganj	South Karimganj	75156	60945	14211	54466	20690	161957
	South Karimganj	2293	2002	291	1743	550	5065
	Badarpur	36115	31242	4873	26545	9570	90101
	Badarpur	6849	6176	673	5812	1037	18340
	Patharkandi	56273	47147	9126	40836	15437	133562
	Lowairpoa	54080	38247	15833	36287	17793	88864
	Ramkrishna Nagar	37658	30238	7420	27543	10115	76058
	Dullavcherra	59541	45146	14395	44025	15516	108607
Hailakandi	Algapur	38469	31358	7111	28410	10059	82910
	Hailakandi	43304	34178	9126	30418	12886	89956
	Lala	61525	49580	11945	49237	12288	129647

Source: http://censusindia.gov.in/pca/cdb_pca_census/Houselisting-housing-ASSAm.html

3.12.5.1 Agriculture and allied sectors in the study area

These three districts of Cachar, Hailakandi and Karinganj are primarily an agricultural district. As per discussion with village Panchayat President and local people majority of households are involved in agriculture and its allied activities as a source of livelihood which is evident from the land use classification where agricultural land is predominant about 80% of the total population in this study area people depends on agriculture. Paddy is the major crop. The other important crops are mustard, pulses, cereals wheat, jute, vegetables etc. Pulses like Matidal, Kalai, Masur, Matar, Mug, are grown in the district. Commercial crops like sugarcane and potato are also grown. Capsicum, Peas, Cauliflower, Cabbage, Radish, turnip etc. are grown in the district. The agro climatic conditions of the Cachar district are conductive for various agricultural activities. Agriculture in the district is characterized by over dependence on rainfall, predominance of seasonal crops and traditional cultivation. In Hailakandi, Lahi rice is grown in higher fields which is an important production of the in this study area. The Joha is the finest variety of rice commonly grown in the district. In Karimganj, the soil of the district is almost the same like that in the Brahmaputra valley. It is characterized by an abundance of marshes and low lands, soil of which contains a large percentage of organic matter. The alluvial soil of the district is very fertile. The climatic condition of the area is good enough for agricultural activities.

3.12.5.2 Animal Husbandry

This proposed three are practiced by most of the small and marginal farmers and landless laborers. Traditionally, dairy farming is a subsidiary occupation of the farmers in the study area. Despite the large population of livestock, the milk production in the district is low mainly due to predominance of local cows with a poor genetic make-up. Various kinds of livestock are available in the district. Cattle, Goats, are main animal for most of the families of the district. Moreover, sheep, horses, pigs, fowls, and ducks are also available in the district.

Livestock is the wealth next to Agriculture of a large chunk of rural population. Livestock plays an important role in state economy which is primarily agrarian in the district. The Department of Animal Husbandry and Veterinary has been constantly helping the farmers for their animals.

3.12.5.3 Industries/Factories

The Cachar district is one of the industrially backward districts in Assam. The existing industries of the district can be classified mainly into (i) food and kindred products (ii) forest products (iii) manufacture excluding transport equipment and (iv) cotton textile.. A large number of families in study areas are also engaged in traditional jobs like black smithy, brick industries, carpentry, weaving, mat making etc. The viable industries in the district based on local resources like cane, bamboo, pineapple and other agro based and fruit processing industries have potential for growth. The major manufacturing units in the district comprises of food product and beverages and non- metallic mineral products.

In Hailakandi, the Hindustan Paper Mill is the only major industry. No other major industry is available in this district. There are, however some registered factories relating to manufacture of food products, Cotton Textiles, wood and wood products including furniture and fixtures etc. are available in the study area

Karimganj district also is one of the industrially backward districts of Assam. There is not a single major public sector industry located in the district, except the age old tea industry. The existing industries in the study area are classified mainly into (I) food and kindred products (II) forest products (III) manufacturing excluding transport equipment and (IV) Cotton textile. Karimganj has a number of factories engaged in manufacture of food products. There are few rice mills in the district. The study area is, however, rich in cottage industries like pottery, blacksmith, gold and silver cane and bamboo works, sericulture, weaving, brick industries etc.

3.12.6 Education Facilities

It was observed that majority of the study areas are well equipped with educational facilities with primary schools, secondary schools and senior secondary school within the study area. Facilities for higher education are average within the study area. Aspiring students go to other towns and cities to pursue higher education. The villages in the study area have primary and schools upto class 8th while in few villages one could find schools upto class 10th. The villagers go to the nearby bigger villages or city for higher education. The average education attainment of most of the village dwellers is upto class 10th minimum. In some villages, villagers have studied upto graduated level. The average literacy rate is Cachar in 79.34, Hailakandi, literacy rate of in 2011 were 74.33 and Karimganj is at 78.22.

3.12.7 Infrastructure (Physical)

The statistics regarding to the prevalence of basic infrastructure within the study area are given in the study area is well connected by roads and railways. Almost all the villages within the study area are facilitated with average infrastructure facilities (**Table 3.33**).

3.12.7.1 Banking: In the long past, there was no banking establishment in the study area. Loans businesses are conducted by shopkeeper who combine their regular trade with money lending and also by the wealthy land holders. But with the lapse of time, the relative position of credit sources changed to a great extent. The Co-Operative Societies have come up in a big way to meet credit requirement in rural areas. There is a wide network of banks at presents in this study area. Good progress has been made in the spread of branches of Commercial Banks since nationalization in urban as well as in rural areas also. There are some branches offices of Commercial to play a vital role as a source of credit for rural people. Scheduled Banks. The functioning of different Banks in the district has improved rapidly and the banks operative in the districts is found.

3.12.7.2 Electricity and Power:

Cachar district does not have any electricity and depends entirely upon supply from outside under the rural electrification scheme. In Cachar district, the electricity facilities are not so much developed. As per Statistical Handbook, 2012 the number of villages electrified in Cachar district is 890 out of its total 1,040 villages However, about 88.0 percent villages have been provided with electricity facilities in the district.

In Hailakandi district the electricity facility is not developed up to desirable extent. As mentioned in Statistical Handbook Assam – 2012, the number of villages electrified in Hailakandi district is 309 in 2010-2011 out of total 331 villages and even after one year the number raised to 313. However, 94 percent villages have been provided with electricity facility. Karimganj district and study area does not possess power plant for generation of electricity. It has to depend entirely on supply from outside. Under the rural electrification scheme, electrification of the villages of the district started in a big way. Till 2000, most of the villages of study are covered by rural electrification scheme.

3.12.7.3 Roads:

Economic and social development depends mostly on efficient system of communication. Road transport is the life line of the economy of any district. The transport system in the study was poor in ancient days. But gradually transportation system has been developed in these areas. At present study area is connected with the rest of the state and the country by rail, road and air.

3.12.7.4 Drinking Water Facilities:

Multi Village Water Supply Scheme (MVWS) provides water to all the villages of the study area. In some villages organized piped water supply is also in operation. However, treating and piping water from remote sources is often complex and expensive, and it is felt that the cost of supply can be reduced and options broadened if a number of villages are served by one scheme. In some villages, people use water from natural water bodies present within the study area.

Multi Village Water Supply

3.12.8 Social Welfare

There are different social cultures in this study area. A social life among the Hindus, the property is generally held by head of the family who manages it as its custodian. After the death of the father, the sons and daughters inherit the properly. The joint family system was common in the past. But now-a-days; it is loosing its hold. Among the Bengali Hindus marriage by negotiation is common. The caste distinction is not rigid as it was a few decades ago; nevertheless, the intercaste marriage is not very frequent among them. Although permitted by law re-marriage of widow is not looked upon. In rural family, every household particularly Assamese family has their distinct types of houses for their different uses. But the Bengali & Muslim families have not different types of houses for different uses. In most of rural folk households their houses are made of thatch & bamboo. At present, who can afford have constructed their houses on modern line using C.I. sheets and brick and cement. Male dress for Assamese & Bengali includes Dhoti, Chadar, Shirt, Kamij, Trousers and Coats, but Muslim males use Lungi. Female dress for Assamese consists of Riha, Mekhela, Chadar, Sari & Blouse but Bengali females do not use Riha, Mekhela, Chadar. They use only Sari & Blouse. Similarly the Muslim female use Sari and Blouse only. Ornaments like Neckless, Earring, Bracelets, Kharu, Chain are commonly used by all females of all regions Colorful festivals observe in the district enliven the lives of the people. The biggest festival of the year in the district is Durga Puja which is observed by both Assamese and Bengali people. Sivaratri and Doljatra are also observed by both sections of the people. Assamese people observe three Bihus namely the Rangali Bihu (April 14), Bhogali Bihu (Jan. 13 or 14) and Kati Bihu (Oct.14th) which are associated with the cycles of cultivation. Rangali Bihu is the festival, where groups of Assamese people dance and sing the Bihugeet, the boys play on flute and beat drums and blow the pepa, made of buffalo-horn and taka.

Table 3.33 Distribution of villages according to availability of different amenities, 2011

Sr. No.		Name of CD Block	Number of inhabited villages	Type of amenity available									
				Education	Medical	Drinking water	Post office	Telephone	Transport communications	Banks	Agricultural credit societies	Approach by pucca road	Power supply
1		2	3	4	5	6	7	8	9	10	11	12	13
1	HAILAKANDI	Algapur	69	68 (98.55)	68 (98.55)	69 (100)	17 (24.64)	67 (97.1)	50 (72.46)	4 (5.8)	0 (0)	19 (27.54)	68 (98.55)
2		Hailakandi	64	64 (100)	62 (96.88)	64 (100)	23 (35.94)	64 (100)	50 (78.12)	2 (3.12)	3 (4.69)	29 (45.31)	64 (100)
3		Lala	87	87 (100)	80 (91.95)	87 (100)	34 (39.08)	66 (75.86)	75 (86.21)	10 (11.49)	7 (8.05)	42 (48.28)	81 (93.1)
2	KARIMGANJ	0162-South Karimganj	179	171 (95.53)	134 (74.86)	179 (100)	8 (4.47)	167 (93.3)	122 (68.16)	6 (3.35)	3 (1.68)	39 (21.79)	170 (94.97)
3		0163-Badarpur	80	76 (95)	55 (68.75)	80 (100)	13 (16.25)	67 (83.75)	64 (80)	7 (8.75)	2 (2.5)	26 (32.5)	71 (88.75)
4		0164-Patharkandi	134	131 (97.76)	108 (80.6)	134 (100)	17 (12.69)	118 (88.06)	87 (64.93)	5 (3.73)	0 (0)	41 (30.6)	128 (95.52)
5		0165-Lowairpoa	110	104 (94.55)	71 (64.55)	110 (100)	3 (2.73)	94 (85.45)	57 (51.82)	7 (6.36)	0 (0)	28 (25.45)	96 (87.27)
6		0166-Ramkrishna Nagar	125	116 (92.8)	70 (56)	125 (100)	13 (10.4)	77 (61.6)	59 (47.2)	15 (12)	2 (1.6)	14 (11.2)	113 (90.4)
7		0167-Dullavcherra	159	152 (95.6)	114 (71.7)	159 (100)	18 (11.32)	91 (57.23)	60 (37.74)	5 (3.14)	0 (0)	15 (9.43)	127 (79.87)
7	CACHAR	0152-Tapang	40	36 (90)	24 (60)	40 (100)	7 (17.5)	20 (50)	15 (37.5)	2 (5)	1 (2.5)	9 (22.5)	32 (80)
9		0154-Barjalenga	44	42 (95.45)	26 (59.09)	44 (100)	8 (18.18)	29 (65.91)	22 (50)	2 (4.55)	2 (4.55)	13 (29.55)	40 (90.91)
10		0155-Narsingpur	112	107 (95.54)	67 (59.82)	112 (100)	27 (24.11)	87 (77.68)	88 (78.57)	9 (8.04)	2 (1.79)	40 (35.71)	96 (85.71)

3.12.9 Primary survey

3.12.9.1 Community perception:

A primary perception survey was conducted to predict the intended and unintended consequences in the study area. A method of survey was administered for this study. In this connection, samples of 115 participants are participated from 26 villages **(Table 3.34)**. Data were collected by covering various socioeconomic variables of age groups, communities, gender, educational qualification, nature of work, economical status and other major variable. In this connection, respondents were asked for their awareness/opinion about the project and also of their opinion about the impacts of the project, which is an important aspect of socioeconomic environment viz. job opportunities, education, health care, housing, transportation facility and economic status. Apart from the demographical and other primary information, the survey questionnaire was focused on 41 items with 6 major dimensions such as: 1) Economical; 2) Public Infrastructure and services; 3) Social/cultural; 4) Environmental; 5) Health and well-being 6) Psychological/personal.

Table 3.34 Particulars of the primary survey

S.No.	Sub division	Name of the Village	No of participants
1	Tapang	Digorsrikona Pt I	5
2		Alambag	4
3		Chibitabichia	3
4		Ratanpur	5
5	Barjalenga	Choto Jalenga Grant	4
6		Noarbond Grant	5
		Bag-O-Bahar	6
7	Narsingpur	Clever House	4
8		Derby T.E.	8
9	South Karimganj	Medal	5
10		Umarpur	6
11		Bakarshal	5
12		Gharua Chak	4
13	Badarpur	Lamajuar	2
14		Jum	2
15	Patharkandi	Eraligool	2
16		Hafania Kitte Kachimpur	4
17		Maina	3
18		Durlovpur	2
19	Lowairpoa	Gopalpur	2
20		Achairghat	3
21	Dullavcherra	Bakri Howar	4
22		Daluachera Grant	2

23	Lala	Barbari	4
24		Kuchila Grant	5
25		Rajyeswarpur	6
26		Joynagar	4
			115

Source: Primary Survey

3.12.9.2 Community Perception and Impact of Various Domains

It was observed from the participants that most (70%) of the people are not aware about this project. Remaining 30%) people said that there are aware about this project from friend and family members and other related source.

Fig 3.15 Need assessment survey in the study area

3.12.9.3 Economical Impact

This domain focuses on respondents' perception on economical impact. In this connection, the items of increasing of land, labour cost, overall income and other related questions were incorporated.

Development and operation of oil and gas assets can contribute positive social gains to local, regional and national communities. Local economic benefits of oil and gas development and production can include new business opportunities and employment generated for communities, royalties paid to mineral and land owners, and taxes paid to governments. On a per employee basis, the oil and gas industry is a high-output, high-wage industry that has a multiplier effect on local economies. In addition to generating thousands of direct jobs and wages, the oil and gas sector purchases goods and services from other industries, thereby building transferrable skill sets and creating broad capacity in the community. Memberships and donations made to local communities, schools, universities and organizations can also benefit the community

This proposal would mean to development of this area on lines with progressive policy. the proponent has plan to recruit numbers of skilled, semi-skilled and unskilled manpower during the drilling phase and indirect employment through contracts for civil, mechanical erection, electrification, piping works and associated amenities During the operation phase, the proposed project is expected to employ about 100 people of various skills and semi skilled and unskilled for various required position. It was observed that most of the local community people have education and qualification, Hence, by proving skill based training programs would be helpful to the local qualified people.

3.12.9.4 Social & Cultural impacts

This domain focused on social and cultural aspect such as; effect of migration, culture, social norms, and other major aspect. It was observed that social aspects, who are living in study area need not be relocated their place because the most of the proposed locations are in empty or barren lands (govt. and private). However, the proposed well location has chances for adjustment based on seismic survey report. Hence, it can be said the there is no chance of relocation of the people. With regard to cultural point, most of the people in the study are aware and connected with these type oil and gas related works. It means that there would be no impact on social and cultural related aspects. It was also observed from the primary consultation and interaction with local respondents that there would be no impact on their cultural and tradition, no break ups in cohesion and differences in social and cultural norms due to this project.

3.12.9.5 Health & wellbeing impacts:

This dimension focused health and wellbeing related impact due to proposed project. In this connection, the questions related to health are raised like; any chronic diseases, effect on next generation, medical dependence with this project. Majority of the people responded that there would not be any health impact due to this project. From negative points of view, it was generally observed the following impacts: In case of leakage of Oil and gas and oily wastes beaches and spoil recreational activities, which cause serious damage to the soil and nearest cultivate land.

3.12.10 Environmental Impact:

This domain focuses on environmental related impact within the study area. In this regards, questions related to damage of water, air and soil were asked with participants. Respondents said that there is no adverse effect on environment unless and until any negative consequences. Oil operations on land require drilling fluids (sometimes called "mud") that are injected into the wellbore to lubricate the drilling bit. These fluids are supposed to be captured in lined pits for disposal, but very often they are spilled and splashed around the well pad. This process would have minimal effect on land Other than this no adverse affect on environmental aspect. Another side, frequent transportation may cause for water and air pollution, sometimes, unexpected accident may cause for human and animal death.

3.12.11 Public infrastructure & services

This dimension covered the public infrastructure and services related items. Construction activities associated with oil and gas drilling leave behind radical impacts to the landscape. Well pad and road construction require the use of heavy equipment such as bulldozers, road graders and gravel trucks development of oil and gas complexes. The proposed project has less faculties with public infrastructure and services. People in the study area have an expectation from the potential of improvement in new roads, public infrastructure in the immediate vicinity of the project area.

3.12.12 Psychological and personal Impact

Personal and psychological impact is related to perception towards this project. i.e., attitude on project, benefits for you and your village and fear of losing your goal with this project and other major personal and psychological aspects. It was noticed that most of the respondents believed that this project enhance their quality of life due to social and economical growth. They said that increasing of land and labour cost, employment generation and other civic amenities will generate positive attitude for individual and community people.

3.12.13 Need assessment

The Primary consultations survey has ascertained certain key expectations that are also indicative of the local community's attitude towards industrial development in the study area. The fig 3.14 shows the different needs and expectation of the respondents in hierarchy with this proposed project

- Majority of the respondents (75%) from individual and group discussion of have more expectations on job and business opportunities.
- Educated and younger (40%) people shared their view on conducting skill development programs for the local communities; this will help them to enhance their skills for future jobs.
- Some of the people in the study area are expecting development of roads and civic amenities.
- few people expected government assistance at the time floods and other natural calamities
- Special care for old or late adults and women on related to health related benefits.

The proposed project would create certain impacts with beneficial as well as adverse effects on the socio economic environment.

Hence, it is necessary to identify the extent of these impacts for further planning of control measures leading to mitigation of the adverse impacts. The impacts due to proposed project on parameters of human interest socio-economic have been assessed as below:

Impact Area	Pre Mitigation Significance	Mitigation	Post mitigation significance
Relocation of Local Community	Low/NIL	No R&R required for this project	Low
General Characteristics and trends in population of region	Low	No potential change on population of region due to this project & hence no mitigation envisaged.	Low
Migration trends in study area	Low/NIL	No Impact on migration trends as local labour utilized during work	Low

		process and very few people of non locals with necessary expertise during drilling & Operation stage	
Population characteristics in study area, including distributions by age, sex, ethnic groups, educational level and family size	Low	No Impact on population Distributions, and hence no mitigation envisaged.	Low
Distinct settlement of ethnic groups or deprived economic/ minority groups	Low	No Disruption in settlement patterns of people envisaged	Low
Economic history for the region	Medium	Positive Impact due to Increase of income levels of the region due to this project	High
Employment pattern in study area, including occupational distribution and location and availability of work force	Low	Temporary or regular employment is expected to work during pre and post production period and laying activity.	High
Income levels and tends for study area	Medium	Positive Impact - Increase the income levels	High
Land values in study area	Medium	Positive Impact - Increase land values around the vicinity	High
Housing characteristics in study area, including in types of housing and occupancy levels	Low	No Change Envisaged	Low
Health and social services in study area, including health, workforce, law enforcement, fire protection,	Medium	Periodic Health Check up during drilling Workers & necessary medication if required Periodic Check on Potable Water supplied	Low

water supply, wastewater treatment facilities, solid waste collection and disposal and utilities		and good housekeeping practices.	
Public and private educational resources in study area	Medium	No Change Envisaged	High
Community cohesion, including organized community groups	Low	No Potential impact on community cohesions	Low
Areas of unique significance such as cemeteries of religious camps	Low	No Disruption of unique areas	Low
Archaeological Heritage Sites effected	Low	No Archaeological Heritage Sites are disturbed or lost or effected in any way and hence no preservation plan required,	Low
Population characteristics in study area, including distributions by age, sex, ethnic groups, educational level and family size	Low	No Impact on population Distributions, and hence no mitigation envisaged.	Low
Distinct settlement of ethnic groups or deprived economic/ minority groups	Low	No Disruption in settlement patterns of people envisaged	Low
Economic history for the region	Medium	Positive Impact due to Increase of income levels of the region due to this project	High
Employment pattern in study area, including occupational distribution and location and	Low	Temporary or regular employment is expected to work during drilling and operation period and laying activity.	High

availability of work force			

3.12.14 Summary and major findings

The main objective of impact assessment is to bring about a more ecologically, socio-culturally and economically sustainable and equitable environment. Impact assessment, therefore, promotes community development and empowerment, builds capacity, and develops social capital. Every project has certain pros with cons while launching new project. The present study is mainly focused to know identify socioeconomic changed in the study area and the community perception about this project. Based on the study, the data were collected from 115 people, which are having participation of different socioeconomic people in and around the proposed project. And other main variables of age, gender and locality also focused in this study. The data were collected from primary and secondary sources and whereas the primary data is statistically analyzed by using the SPSS 20.0 version to assess the significant different in various demographical variables. The following findings are identified.

- Most of the participants are responded that they are not aware about this project.
- Majority of the people are encouraged to start this project for employment and better quality of life.
- With regarding economical aspect people reported that they would be having job opportunities with this project and other side there would be rapid changes in land and labor cost, open the door for the business development.
- From public infrastructure and services dimension, most of the people answered that there would be more development of roads, transportation facilities, which is more advantageous developments for Govt. and private facilities.
- There is less impact on forest environment and also said the no loss of wild and domestic animals due to this project
- There is no change in traditional family roles, community cohesion, and sense of place, community leadership and cultural heritage.
- It can be said from environmental dimension, all community people were optimistically responded that there would be no loss or ruin of soil, water contamination and other environmental aspects. Even though a very less quantity of people predicts that there would be impact of sounds and vibration due to frequent transportation.
- It was also noticed from personal and psychological aspect. People have positive

attitude to towards proposed project, which is shows positive impact on their life style and quality of life to reach their goals and objectives. It was also observed they also they encouraged to starting new projects.

3.12.15 Conclusion

Social Impact Assessment (SIA) has traditionally involved the use of technical and participatory analytical methods to anticipate change but also encouraging the life cycle of projects to minimize negative outcomes and maximize benefits. The early consideration of social impacts, the alignment of activities with regional and community planning objectives, and meaningful participation of community in decision making are key features. Apart from the SIA process and findings it can be concluded that most the respondents have positive pulse towards implementation of the proposed project.

CHAPTER – IV

ANTICIPATED ENVIRONMENTAL IMPACTS & MITIGATION MEASURES

4.0 INTRODUCTION

The objective of the impact identification is to formulate Environmental Management Plan (EMP) tomitigate the probable negative impacts that might arise during the project activities to the maximumpossible extent. Therefore, in order to come to a strategic EMP it is imperative to identify the possibilitiesat various project stages, impact type and affected environmental component, extent and severity. EIA isan activity designed to identify and predict the impact on the environment, on human health and ecology,taking into account the requirements of legislative proposals, policies, programs, operational proceduresand to communicate information about the impact.This chapter describes the identification of impacts, appraisal of various impactsduring exploratory drilling of well and production.

4.1 IMPACT ASSESSMENT

This section discusses the impacts of the project activities during exploratory drillingoperations on the environmental receptors that stand to get affected adversely by the project.It discusses probable impacts during various phases of the project lifecycle on theenvironmental and socioeconomic components.Adequate Environmental management measures were incorporated during the entire planning of construction and operation stages of the project to minimize the adverse Environmental impacts and assure sustainable development of the area.

4.2 IDENTIFICATION OF IMPACTS

Generally, the environmental and social impacts can be categorized as either primary orsecondary. Primary impacts are those, which are attributed directly by the project andsecondary impacts are those, which are indirectly induced and typically include theassociated investment and changed patterns of social and economic activities by theproposed actions.

The impact of exploratory (including appraisal) well drilling and setting up of Early Production Units (EPUs)/ Quick Production Units (QPUs) and early production within the Assam block on each environmental attribute was assessed. The operation phase considered to identify the possible impacts due to drilling activities andtesting of hydrcarbons.

4.3 IMPACTS DURING EXPLORATORY DRILLING OF WELL AND PRODUCTION

The drilling sites will contain all equipment, storage, workshops, etc. using distancesbetween various rig components in line with existing rules and regulations for the area ofoperation and the hazardous area drawing of the drilling/ work over rig.Drilling operation basically involves two steps; first – drilling of development wells andsecond – testing of well. Drilling process is associated with various hazards such as wellactive situation (kicks), blowouts, H_2S situation (if any) etc., in addition to discharges ofair emissions, waste water and solid wastes.Various activities and their likely impacts due to exploratory drilling have beenidentified and shown in the **Table 4.1.**

Table4.1: Activities – Impacts/Risks Interaction Environmental Sensitivities

	Environmental Sensitivities													
Impacts/Risk	**Physical**			**Biological**			**Socio-economic**							
Activities	**Soil & Sediments**	**Water Resource & Quality**	**Air Quality**	**Flora**	**Fauna**	**Reserve Forest/ Protected Forest**	**Living Condition**	**Local Economy**	**Existing Oil and Gas Business**	**Traffic Hazards**	**Onsite Risk (Occupational Exposure)**	**Culture/ Archaeological places**	**Tourism / Leisure**	**Land Use (Mudflats / Agriculture)**
Drilling Site Preparation														
Physical Presence including Land acquisition/ Lease							√	√						√
Site Clearance	√			√	√			√						
Site Preparation		√	√											
Equipment Transportation	√			√				√						√
Campsite	√	√	√					√						√
Drilling Operation														
Atmospheric emissions			√								√			
Noise & Vibrations			√		√		√				√			
Waste generation	√	√												√
Storage of Flammables	√		√								√			
Well kick			√								√			

√ - Shows Impact

On completion of activities, the well will be either plugged and suspended (if the well evaluations indicate commercial quantities of hydrocarbons) or will be killed and permanently abandoned. In the event of a decision to suspend the well, it will be filled with a brine solution containing very small quantities of inhibitors to protect the well. The well will be sealed with cement plugs and some of the wellhead equipment (Blind Flange) will be left on the surface (Cellar). If the well is abandoned it will be sealed with a series of cement plugs, all the wellhead equipment will be removed, by leaving the surface clear of any debris and the site will be restored.

The proposed exploratory (including appraisal) well drilling and setting up of Early Production Units (EPUs)/ Quick Production Units (QPUs) and early production within the Assam blockincludes activitiesrelated to clearance of site, leveling of site, preparation of suitable access roads connecting to well pads, accommodating OHL and other utilities.

4.3.1 Impact on Land Environment

Impact on land use and aesthetics is expected to be from vegetation clearance, excavation, levelling andgrading of the site. Thus there might be need for clearing crops and trees. An area of approximately 300m X 300m would be taken on temporary short-term lease basis for the construction of well pad (drill site) for exploratory and appraisal wells.If the identified lands are of private landowners then land lease mode will be applied and in case of govt. land, land allotment from Govt. to be applied. Initially temporary short term lease will be taken for 3 - 5 years for exploration purpose and in case of commercially viable discovery of hydrocarbon resources; the land lease would be converted into long term lease up to life of the project.For the preparation of suitable access roads connecting to well pads, accommodating OHL and other utilities in future, a width of 30m (approx.) RoU will be required.

Site preparation will involve all activities required to facilitate the operation of the drilling rig and associated equipment and machineries. At the initial stage, the drilling site will be elevated to about 2.0 m from the existing ground level with minimal clearance of existing ground vegetation. The loose top soil will be removed by using mechanical means like bulldozer and saved at a nearby place for later use during site restoration. Levelling and compaction will be done with the help of graders and mechanical rollers. The land filling materials and rubbles will be required for the purpose of site preparation in sufficient amount.Movement of heavy vehicles, earth moving equipment, piling ofremoved soil at the site periphery during construction would have aesthetic impacts.

A Campsite of size 100 x 50m, elevated to the height as that of the drilling site (approx.2.0 m), will be set up adjoining the well site. Local earth and rubble will be used as the fill material. The surface will have a 150mm thick WBM layer. Proper surface gradients and brick masonry drains will take care of the run-off water, where as separate septic tanks and soak pits will be provided along with the labour camp for disposal of domestic waste water.

Mitigation measures

- All the construction/site preparation activity will be restricted within the designated site
- Dust nuisance from construction site will be suppressed through periodical water spraying at disturbance area;
- Construction wastes and municipal solid waste temporarily stored at the sites will be transported to the designated disposal site/facility at regular intervals;
- After decommissioning of rig and associated facilities, drill sites will be restored – drill platform will be removed, pits & garland drains will be filled up, construction materials will be removed & disposed;
- Site will be rehabilitated through laying of top soil.

4.3.2 Impact on Air Environment

The potential sources of air emissions at well sites will be as follows:

- Operation of vehicles and construction machinery
- Construction material transport, storage and handling

During the short period of site preparation mechanical shovels and earthmovers will be used forvegetation clearance, cut & fill and other site levelling activities. During construction phase, aggregates and borrow material will be required at each well sitelocation for road construction/strengthening and site preparatory activities. Approach roadsare required to be constructed or strengthened or widened for all proposed exploratory wells.Fugitive emission is therefore anticipated from transportation, storage and handling ofconstruction materials. These activities could generate dustparticles which will be mobilized by wind and could impact the ambient air conditions. However, theseactivities will be only temporary, the impact to ambient air quality wouldbe within the close proximity of well site.

Operation of Diesel Generator (DG) sets

The power requirement in the drilling site and the campsites will be provided through diesel generator (DG) sets. The proposed project will involve the operation of two DG sets of capacity 350 KVA (one working and one standby) at Campsite, three DG sets of capacity 1000 KVA (two working and one standby) or two DG sets of capacity 1850 kVA* (one working and one standby) at Drilling site and two DG sets of capacity 100 KVA at Radio Room and one DG set of capacity 500 KVA (emergency) during Early production. The operation of DG sets will therefore result in thegeneration of air pollutants viz. PM, NO_x, and SO_2 thereby affecting the ambient air quality.The dispersion of these air pollutants may affect the receptors viz. village settlements locatedin near vicinity of the well site only under exceptional combination of meteorologicalconditions. However, considering the temporary nature of drilling phase (approx 60-90 days),wet and humid conditions prevalent in the exploratory block region and provision of adequateDG set stack height for effective dispersion of air pollutants, no significant impact to thisregard is envisaged. Additionally the proponent also plans to adopt and implement necessarymitigation measures as discussed in the subsequent section to effectively address potential airquality impacts from DG set operation.

*Depending on the rig capacity & rig availability during E&A (Exploration and Appraisal) drilling phase.

Flaring of Gases

Flaring provides means of safe disposal of vapor streams from its facilities, by burning themunder controlled conditions such that adjacent equipment or personnel are not exposed tohazards. With combustion gas products depending on feed gas composition, the flaring ofgases may lead to the generation of NO_x. These pollutants emitted may therefore contributeto air pollutant load of the ambient air thereby affecting well site receptors nearby viz. villagesettlements, schools etc. As the proposed drilling is exploratory in nature, therefore onlychances of flaring will generate from well testing and therefore the impacts anticipated to below.

Fugitive Emissions

Fugitive emissions in the form of material dust is expected during drilling operations (loading, unloading,handling of drilling fluid, chemical additives, cement and cement additives). Some fugitive emissions arealso anticipated from storages of volatile chemicals and fuel at the site, if the storages are not properlycapped or are handled without due care. However, such emissions will not disperse widely and can onlyaffect workers and people at site. Fugitive emissions during drilling operations are however not assignificant as during site preparation. Fugitive emissions during drilling are not expected to travel beyondproject boundaries. Workers working near fugitive emission sources are only susceptible which would bemitigated through use of PPEs in these areas.

Air Pollution Modelling

In order to predict the Ground Level Concentrations (GLCs) at various distances from the source of the above mentioned pollutants, an air modeling exercise has been undertaken and is discussed in the impact prediction section below. Inthe present case, **AERMOD** dispersion model based on steady state gaussian plume dispersion,designed for multiple point sources for short term and developed by United States EnvironmentalProtection Agency [USEPA] has been used for simulations from point sources.Air quality dispersion modeling is done through AERMOD to predict the ground level concentration of emissions in 10 KM radius of project activity.

Model inputs and Results

The air pollution modeling carried out represents the worst case and normaloperating scenarios. The pollutants considered for modeling include particulatematter, sulphur dioxide and oxides of nitrogen. Meteorological data of 24 hour mean of one period considered in the study. Ambient air quality studies done during the baseline study were considered are considered as baseline to estimate the impact of the activity on post project air quality.The details of the stack andemission rates envisaged from the proposed operation of DG 1000 kVA, Flaring during exploratory/appraisal drilling and Flaring during Early Production phaseare given in Table 4.2

Table: 4.2 Source and Emission Characteristics for Dispersion Modelling

S.No	Particulars	Flare stack (testing)	DG set (1000 kVA)	Flare stack (EPS Flare)
1	Fuel feed rate (m^3/hr)	94 (Natural gas)	0.135 (HSD)	94 (Natural gas)
2	Height of stack (m)	30	10	30
3	Dia. Of stack (m)	0.078	0.305	0.3
4	Temperature (K)	1273	573	1273
5	Stackgas velocity (m/s)	20	4.52	1.23
6	PM10 (g/s)	-	0.07	-
	SO_2 (g/s)	0.000625	0.006	0.0025
	NOx (g/s)	0.023	2.04	0.093

Model for Prediction:

Air dispersion modelling is done using AERMOD approved by USEPA. To predict the GLC (Ground Level Concentration) 10 KM radius from project site is considered in the prediction. Ground Level Concentrations (GLCs) for pollutants as mentioned above have been calculated for following:

- Scenario 1 – Operation of 1000 kVA*2 and Testing Flare
- Scenario 2 – GEG 1 MW output and EPS Flare

The isopleths for PM, SO_2 and NOx concentrations are depicted as given below.

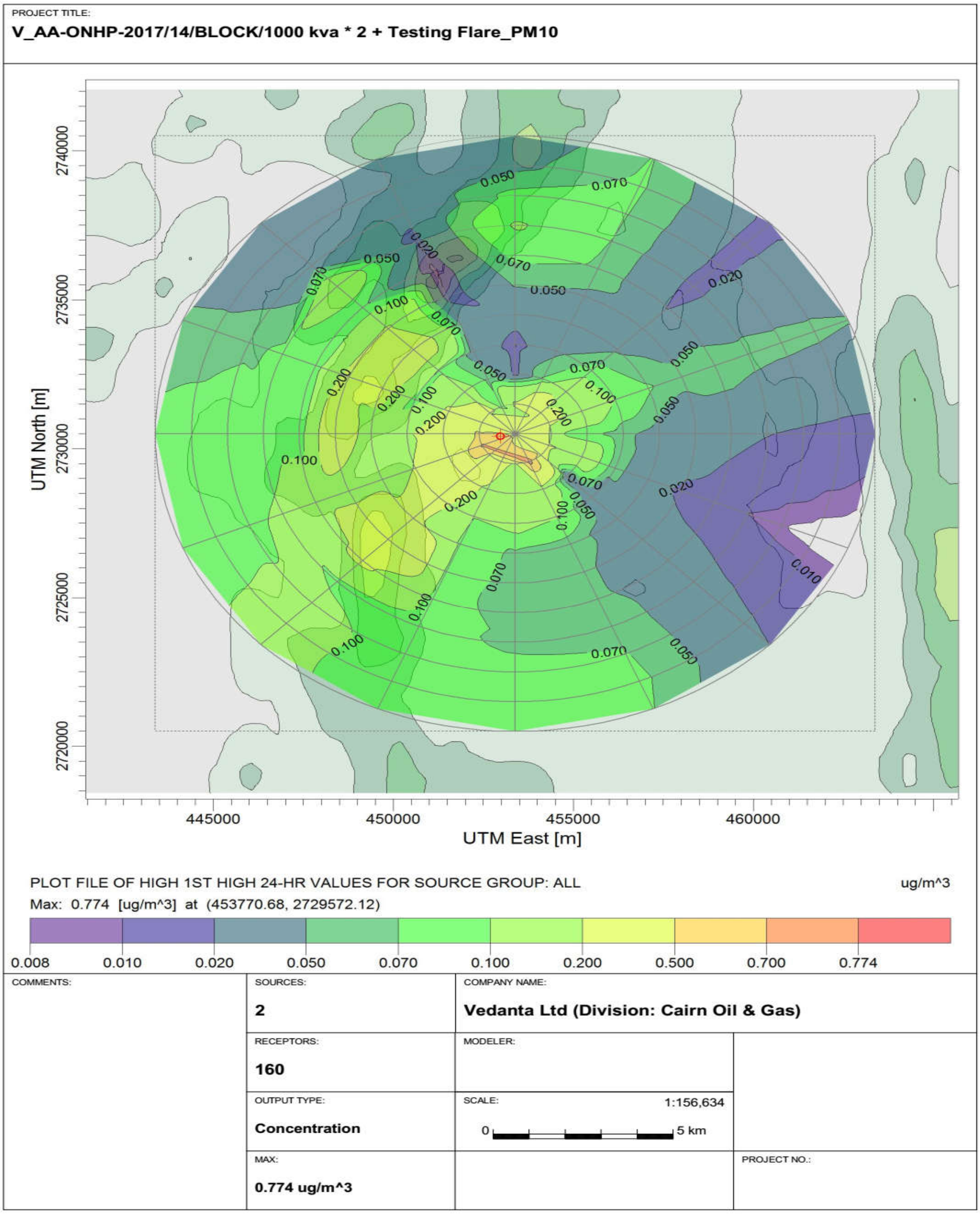


Fig 4.1 Maximum GLC Increase of PM10 (Scenario 1)

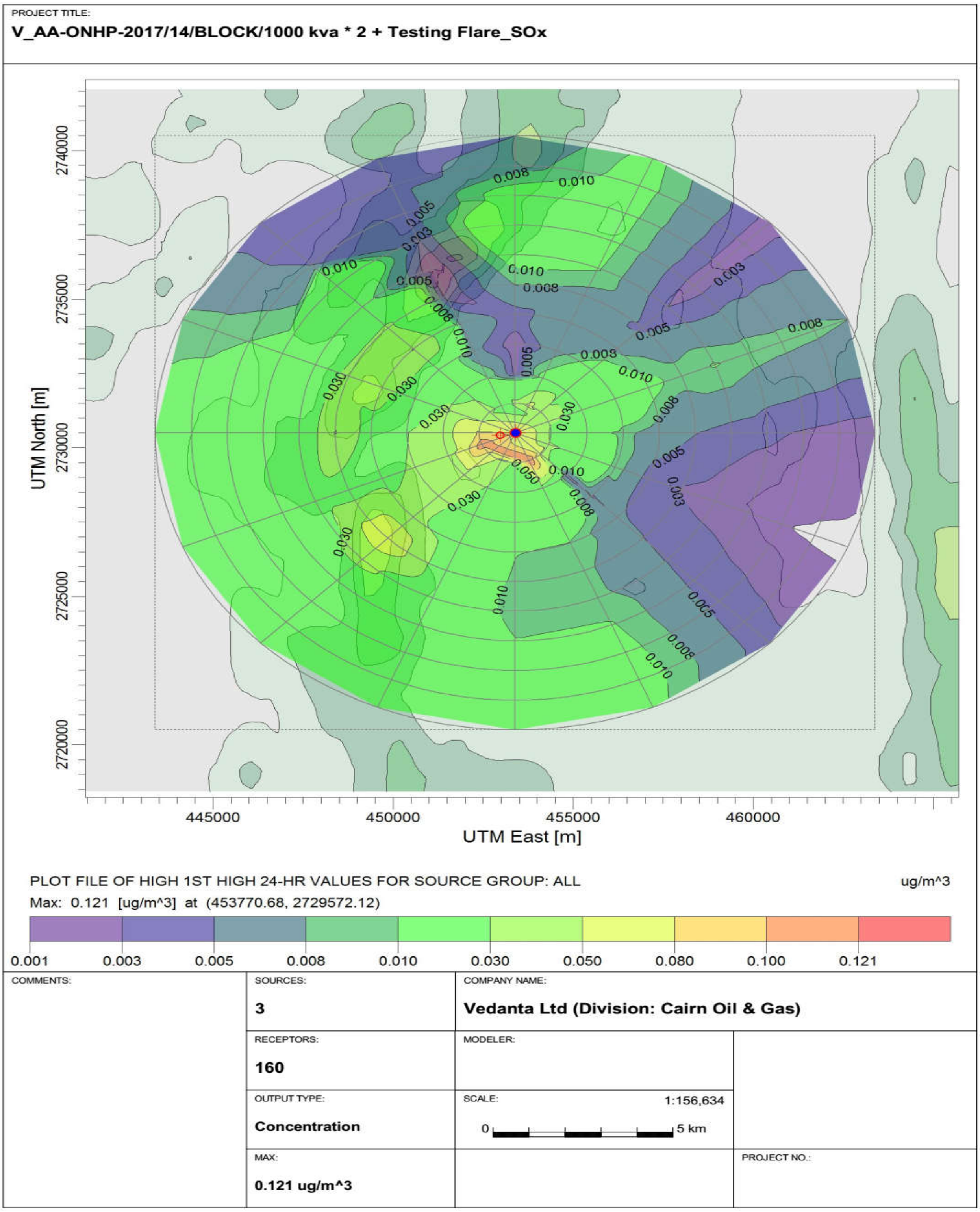


Fig 4.2 Maximum GLC Increase of SO_2 (Scenario 1)

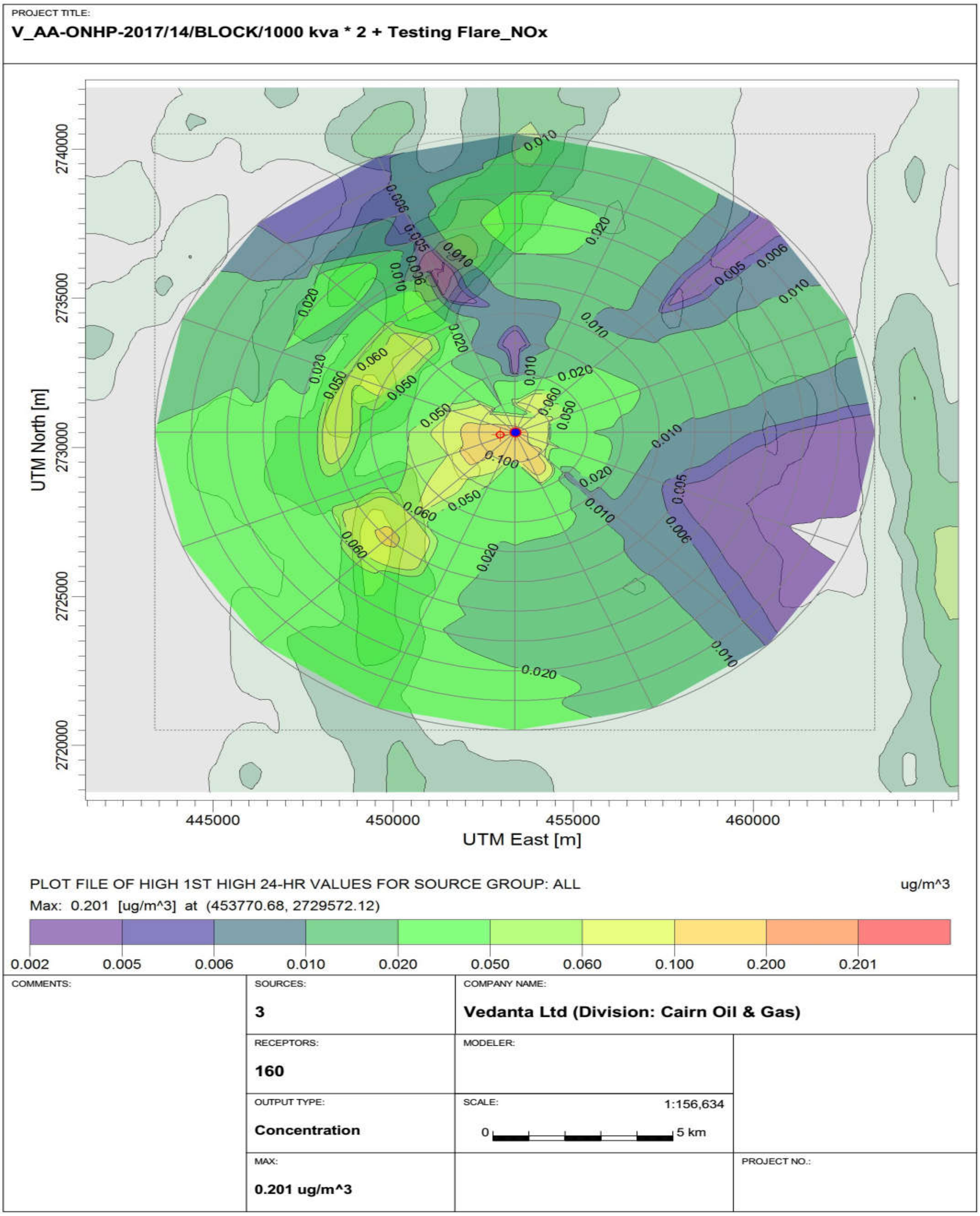


Fig 4.3 Maximum GLC Increase of NO_x (Scenario 1)

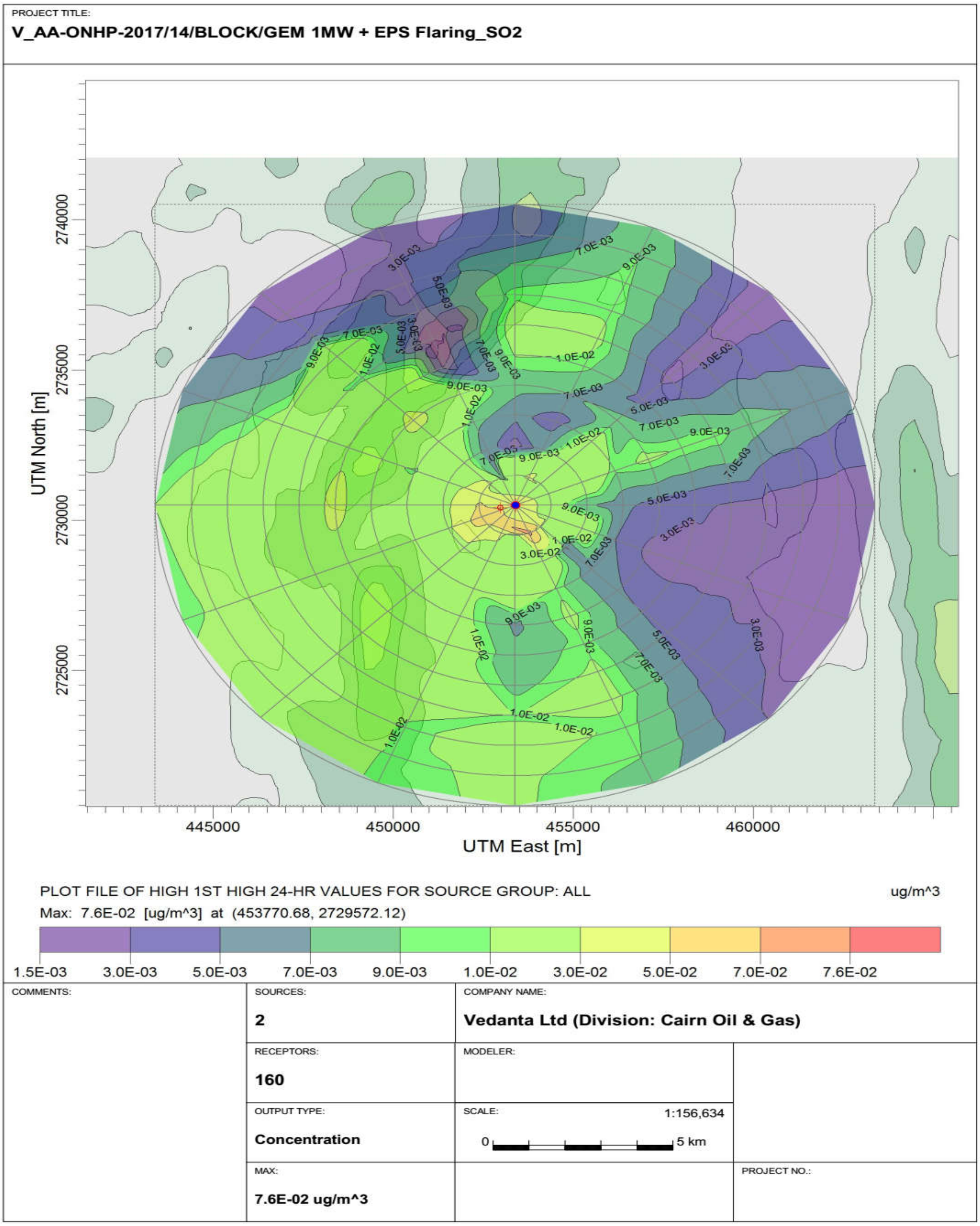


Fig 4.4 GLC Increase of SO_2 (Scenario 2)

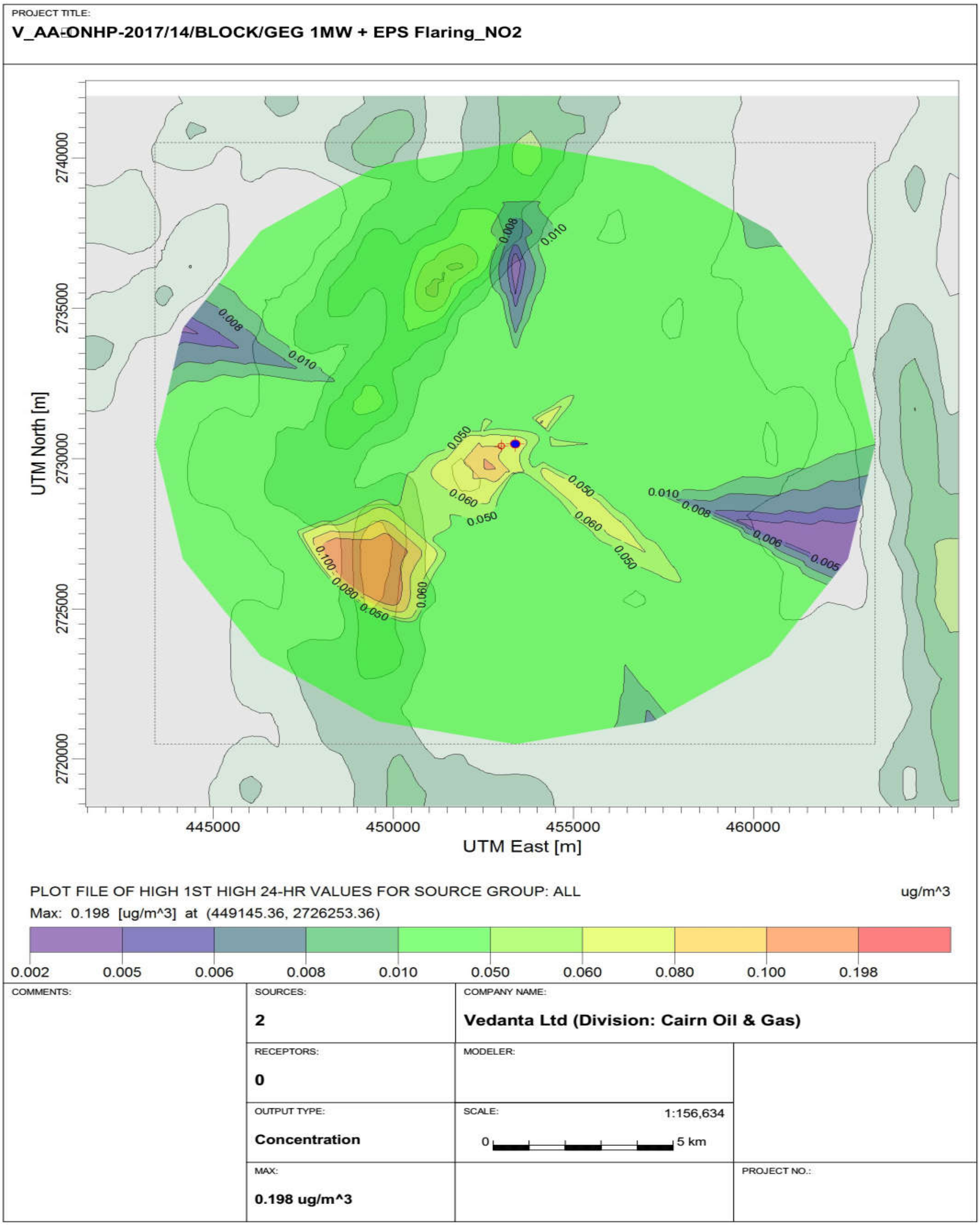


Fig 4.5 GLC Increase of NO_2 (Scenario 2)

Resultant concentrations after implementation of the project

The maximum incremental GLCs due to the proposed project for PM10, SO_2 and NOx are superimposed on the maximum baseline concentrations recorded during the study to arrive at the likely resultant concentrations after commissioning of the proposed drilling. The cumulativeconcentrations (baseline + incremental) after implementation of the project are tabulated below in Table - 4.3

Table: 4.3 Results of predicted GLC

Particulars	Predicted 24-Hour Average Maximum Concentration (µg/m^3)		
	PM10	**SO_2**	**NOx**
Scenario 1 Maximum GLCs	0.774	0.121	0.201
Scenario 2 Maximum GLCs	-	0.076	0.198
Maximum Concentration recorded in Ambient Air as Baseline	73.1	13.1	14.8
Maximum Projected Concentration in Ambient Air	73.874	13.221	15.001

The maximum GLCs for PM10, SO_2 and NOx after implementation of the proposed project are likely tobe within the prescribed standards for rural and residential areas. Based on the above details, it can be inferred that the ambient airquality in the study area is unlikely to be affected due to the proposed activity. The above air quality datareveals that even after considering incremental concentration in to baseline air quality from variousoperations, Ground Level Concentrations (GLCs) does not exceeds limits as prescribed by CPCB's NationalAmbient Air Quality Standards (NAAQS). It may be concluded that impact of proposed activities will beof insignificant.

Mitigation measures

- All vehicles used for transportation of loose and friable materials will not be loaded over the freeboard limit and will be covered.
- Water spraying will be done on the access roads to control re-entrained dust during dry season.
- DG set of appropriate stack height will be utilized.
- All the vehicles should be PUC certified
- Providing Personnel Protective Equipments (PPEs) like mask to workers at site.

4.3.3 Impact on Noise Environment

Potential impact on noise quality is anticipated from operation of constructionmachineries/equipments and vehicular movement during sitepreparatory activities.

Operation of heavy machinery/equipments and vehicular movement during site preparatoryactivities and road strengthening may result in the generation of increased noise levels.However, thesenoise sources are temporary in nature and operated mostly during daytime and for shortduration.The noise related disturbance is likely to be experienced by communities residing inproximity of the construction site and along material transportation routes. The environmentalsetting of well sites reveals that settlements are close to the proposed well site and siteaccess road. Distance of settlements varies from 100m to 2.0 km from the proposedexploratory drilling locations. Considering the construction phase activities to be oftemporary nature, limited daily movement of project vehicles (3-4 nos. vehicles fortransportation of personnel and 8-10 nos. for material transport) and adequate mitigationmeasures viz. equipment maintenance etc. to be implemented by the project proponent,impact is not considered as significant.

During Construction Phase, potential noise emissions will be mainly from:

Heavy Duty Construction equipment: 75 to 90 dB(A)

Vehicular Noise: 70 dB(A) (at the edge from the centerline of the road)

Operational phase noise impacts are anticipated from operation of drilling rig and ancillaryequipment *viz.* shale shakers, mud pumps and diesel generators. Studies indicated that noisegenerated from operation of drilling rig generally varies in the range of 88-103 dB(A). Other contributors of high noise level at the developmental well site include shale shakers, mudpumps and diesel generators. General noise levels generated from them are as per given below in **Table 4.4.**

Table 4.4 General Noise Levels of Sources

Source of Noise/ Equipment	Equivalent Noise levels in dB(A)
Drilling Rig	88-103
Mud Pumps	80-90
Diesel Generators	90-95
Control Room and Quarters	50-60

The general noise level due to other activities during development drilling of well such as preparation of site, commissioning of rig, cementing, surface test flaring, well logging etc may sometimes go upto 90 dB(A) at the work sites during day time.

On the basis of expected noise levels calculated through standard attenuation model, it is observed thatthe noise levels in the region would be within the standard limits (IS: 4954). The increase will only bemarginal in comparison to the existing noise levels. The impact of the noise on general population istherefore expected to be insignificant.

Occupational Health Hazards from Noise Pollution

Exposure to noise levels, above Threshold Limit Value (TLV), has been reported to have detrimental effect on the workers' health. Personnel’s working for more than 4 to 4.5 hours per shift near the sound pressure level of 90 dB(A) will be greatly affected, unless suitable mitigation measures are taken. The adverse effects of high noise levels on exposed workers may result in:

- Annoyance;
- Fatigue;
- Temporary shift of threshold limit of hearing;
- Permanent loss of hearing; and
- Hypertension and high blood cholesterol, etc.

Noise pollution poses a major health risk to the workers near high noise source. If the magnitude of noiseexceeds the tolerance limits, it is manifested in the form of discomfort leading to annoyance and inextreme cases to loss of hearing. Detrimental effects of noise pollution are not only related to soundpressure level and frequency, but also on the total duration of exposure and the age of the person. **Table 4.5**below gives noise levels and associated mental and physical response of humans.

During drilling operation, the personnel required to continually present in high noise source like DG isremote. All personnel working on rig are given noise abatement personnel protective equipment’s likeearmuffs etc.

Table 4.5: Noise Exposure Levels & its Effects

Noise Levels dB(A)	Exposure Time	Effects
85	Continous	Safe
85-90	Continous	Annoyance and irritation
90-100	Short term	Temporary shift in hearing threshold, generally with complete recovery
Above 100	Continous	Permanent loss of hearing
	Short term	Permanent hearing loss can be avoided
100-110	Several years	Permanent deafness
110-120	Few months	Permanent deafness
120	Short term	Extreme discomfort
140	Short term	Discomfort with actual pain
150 and above	Single Exposure	Mechanical damage to the ear

Source: OSHA

Mitigation measures

- Re-locating noise sources to less sensitive areas to take advantage of distance andshielding
- Providing Personnel Protective Equipments (PPEs) like ear plugs/muffs to workers atsite.

4.3.4 Impact on Transport and Traffic

The impact of transport and traffic could be anticipated from movement of trucks, trailers andprivate vehicles during construction phase. The drill site approach roads (i.e. Village road, tea garden roads) are notbusy vehicular route. Additionally approach road to most of the exploratory well sites are kucha in nature and movement of vehicle will have a definite effect on the integrity of theroad. Therefore, movement of heavy vehicles will have a definite effect on integrity of the road.Increased traffic load can also pose disturbance to the settlement in terms of increased noiselevel and can arise safety related issues. However, as all the approach roadswill be strengthened and mitigative measures to be adopted to curb the anticipated impactgenerated from noise from traffic, it is considered to be of medium significance.

Traffic Survey:

Traffic monitoring has been carried out at major highway intersections around the block on hourly basis for 24 hours once during the study period. Six locations i.e. Srikona (NH-53), Duarbond (SH-39), Hailakandi (NH-154), Lalapur (NH-154), Chandrapur (SH-39) and Ramakrishna Nagar (Bishnunaga-Bhairabnagar road) were considered. Traffic survey results are tabulated and described in Table 4.6

Table 4.6 Traffic Analysis

Location	No. of vehicles per day							
	2W		3W		LMV		HMV	
Srikona (NH-53) Badarpur to Silchar	716	685	136	121	392	409	546	587
Duarbond (SH-39) Silchar-Irongmara-Hailakandi road	286	274	232	248	186	138	83	76
Hailakandi (NH-154) Panchgram to Hailakandi	355	416	289	251	173	207	219	186
Lalapur (NH-154) Hailakandi to Lalapur	234	267	115	96	84	112	58	42
Chandrapur (SH-39) Karimganj to Hailakandi	328	381	227	183	268	288	279	357
Ramakrishna Nagar (Bishnunaga-Bhairabnagar road)	217	198	264	233	328	354	127	94

Two wheelers and HMV are found to be high on Srikona (NH-53) Badarpur to Silchar road as it is the major transportation way from Assam to Imphal. The concentration of Three wheelers found to be high on Hailakandi (NH-154) Panchgram to Hailakandi road and Duarbond (SH-39) Silchar-Irongmara-Hailakandi road due to the presence of villages and settlements.

Traffic Volumes

During the civil operations earth moving equipment will be working on the access road and the well location. It is anticipated that there will be an average of 10 truck movements a day to cater the site preparation for an average period of about 30 days. Prior to and after the drilling operation, when building the rig or rig move, up to 80 heavy truckloads over a period of 4-5 days are envisaged. During the drilling operation, supply truck movements are estimated on an average of eight to ten per day. Small vehicles movements are used mainly for transport of personnel, visitors etc. which might be as much as 10 per day.

The drill site approach roads (i.e. Village road, tea garden roads) are notbusy vehicular route.A traffic management plan for the area will be developed to ease the situation. All the vehicles related to the project activity will restrict their speed in sensitive areas viz. hospitals, schools etc. without affecting the community in the vicinity of the project.

Mitigation measures

- Installation of sufficient engineering control on equipment and machinery (likemufflers & noise enclosures) to reduce noise and vibrationemission levels at source
- Minimize use of roads by planning vehicle movements
- Placing the warning board on the vehicles during transportation of machinery and materials;
- Undertaking preventive maintenance of vehicles and machinery to reduce noiselevels.

4.3.5 Impact on Topography and Drainage

Potential impact on drainage and topography viz. alteration of drainage pattern, water logging etc. are anticipated during well site preparation, widening/strengthening of access roads and surface runoff from construction sites. There would be slight change in topography at the drill site as it will be elevated from ground level to avoid storm water accumulation. Thismay lead to alteration of onsite micro-drainage pattern leading to potential problems of waterlogging in the agricultural land and settlements abutting the drill site. This problem is likelyto be further aggravated due to heavy rainfall experienced by Karimganj, Hailakandi and Cachar district throughout theyear. The approach roads in major portion of the block are characterized by unpaved rural roadswhich are adversely affected during intense rainfall received by the region.

The major impacts arising out of site preparation and construction of EPU/QPU is alteration of local topography. The raising of the height of the construction site above the surroundingland may lead to waterlogging of the adjacent land or disupt the existing drainage pattern.A storm water drain will be built at the periphery of the EPU/QPU to contain the site drainageduring excessive rain. The storm water drain will be led into the small ponds present atthe proposed site after silt and oil and grease trapping.

Mitigation measures

- Leveling and grading operations will be undertaken with minimal disturbance to the existing contour, thereby maintaining the general slope of site;
- Loss of micro-watershed drainage, if any, is to be compensated through provision of alternate drainage.
- Disruption/alteration of micro-watershed drainage pattern will be minimized to theextent possible.
- Proper engineering control must be employed as mitigation measures so that theflow and the course of the stream will not be altered.

4.3.6 Impact on Water Quality

Due to Site clearance and stripping of top soil during site construction will result in anincrease in soil erosion that might lead to an increased silt load when there is surface runoff during rainfall. As the area experiences high rainfall, the site will generate considerable volume of runoffsduring such rainy periods. The water requirement is for domestic needs of the temporary campsite and will be sourced locally through approved authorities and no ground water extraction will be undertaken to cater the domestic needs of construction labour. Noticeable impacts to water quality in nearby watercourses are more likely to occur as a result of increased suspended particle load. During the well site preparation the extentof impact to nearby watercourses will be function of:

- Area cleared;

- Amount of rainfall from the period between site construction and drilling;
- Distance of the watercourse from the well site; and
- Mitigation measures to prevent any soil erosion within well site.

The storm water generally contains high concentration ofsuspended matter eroded from the soil by the runoff. There is also a potential forcontamination of the storm-water if the runoff picks up contaminants in the form ofchemicals, oil and lubricants, etc. that could have been spilled or if material is stored inopen areas (uncovered) in any particular area like the fuel storage or the non hazardouschemical storage areas. This may result in a potential impact to the receiving water body. However, if the site preparation activities were conducted in dry season, the above impact would be negligible or insignificant. Overall, with the appropriate measures to protect the well site and preventdischarges, installation of soil erosion control measures, prevention of spillages while handling andmanagement of chemicals, the likely chances of impact on surface water will be minor.

Discharge of Drillling mud and process wash water

Domestic waste water of 15-25 m^3/day per well shall be generated and the domestic waste water will be treated suitably in STP or septic tank followed by soak pits. It is expected that wastewater in the form of Drill cutting washing + Rig washing+ cooling etc shall be generated at an average rate of around 30-40 m^3/day during the drilling operations from a single well. The drilling waste so generated may be characterizedby the presence of oil & grease, barites and heavy metal which on discharge to nearby naturaldrainage channels and/or rivers may lead to possible surface water contamination.Waste water will be discharged in HDPE lined evaporation pit for disposal, size of the pit is generally 50mx20mx1.5m. The treated effluent (produced water) will be disposed off using either a nearby down hole disposal well (by reinjection in abandoned well) or other available & suitable onshore disposal medium or solar/ mechanical evaporators depending on feasibility. However considering usage of water based mud for the proposed project, temporarily storage of drilling waste in an HDPE lined pit and subsequent treatment to ensure conformance withCPCB Industry Specific Standards for Oil Drilling & Gas Extraction Industry and guidelinesprovided by the MoEF under the Hazardous Wastes (Management, Handling &Transboundary Movement) Rules, 2016 the impact is not considered to be of significance.

Groundwater Pollution

The compaction of the working areas for setting up heavy machineries and equipmentslike the rig may lead to increased runoff and reduced infiltration, thereby affecting localised subsurface groundwater recharge. However, given that the occupation of thearea is temporary and the area experiences high rainfall and thereby high rechargepotential, the effect on the groundwater regime of the area will not affect wateravailability in neighbouring wells and tube wells and any resulting conflict with other users of groundwater in the area.Overall, with the appropriate management practices in place impacts on groundwaterquality at the site is likely to be insignificant.

Mitigation measures

- Drainage and sediment control systems at the well site will be efficiently designed
- Proper treatment of all wastewater and produced water discharges will be made toensure that they comply with criteria set by the regulatory body (MoEF&CC and SPCB)
- All chemical and fuel storage areas, process areas will have proper bunds so thatcontaminated run-off cannot escape into the storm-water drainage system.

4.3.7 Impact on Soil Quality

The soil ofexploratory block coming into the Assam province is silty alluvial in nature thereby contributing to the agricultural productivity of the region. Stripping of top soil is therefore likely to affect thesoil fertility of the well site. However, such impact is considered to be temporary taking intoaccount the fact the proper reinstatement of site will be undertaken by the proponent in case the exploratory wells are not indicative of any commercially exploitable hydrocarbonreserves.

Site preparatory activities will involve the sourcing of earth-fill from borrow areas. Suchsourcing activity may lead to direct and indirect long-term major adverse impacts on theenvironment due to loss of productive top soil if located on agricultural land/tea garden. Theloss of top soil may also enhance the soil erosion potential of the area resulting in increasedsediment load in surface run-off. Since most of the construction materials would be availablefrom existing quarries nearby, relatively few new borrow areas will be required. Furthernecessary mitigation measures will be implemented by the proponent with respect to theborrow area reinstatement (particularly those located on agricultural land) and run-off controlto prevent any possible impact on soil quality. Considering above scenario the impact isconsidered to be of low significance.

Storage and disposal of drill cuttings and drilling mud

Drill cuttings of 250-750 tons/well will be generated during the drilling phase with Water Based Mud (WBM) whereas the amount of drill cutting generated during drilling with Synthetic Based Mud (SBM) will be of around 500-1500 tons per well depending on the depth to which the wells be drilled. Improper storageand disposal of such process waste on open soil or unlined areas may therefore lead to thecontamination of soil onsite and abutting land if not properly managed.These cuttings will be stored in well-designed HDPE line pit. Drilling operations are typically associated with a range of wastes such as drilling mud,used oils, hydraulic fluids and various discarded chemical products, empty drums andsacks, acids, surfactants, cement, biocides, solvents, and camp wastes. The drilling mudand the cuttings shall be inert in nature but could also add to the sub surfacecontamination if not handled appropriately and is not anticipated to pose any potentialthreat to the soil environment.

Storage and handling of fuel and chemicals

The contamination of soil can result from the project activities if certainoperations like storage of chemicals and fuels, spent oil and lubricants are not managedefficiently. Storage of chemicals and fuels, spent lubricants on unpaved surfaces also havepotential for contamination of soil. Accidentally, if chemicals, oil and lubricants are spilled,either during transportation or handling, on open soil may contribute to soil contamination.However, considering that appropriate spill prevention and control measures to beimplemented by the proponent the impact is not considered to be of significance.

Mitigation measures

- Carrying out adequate restoration of soil, to the extent possible;
- Implementing adequate sediment control measures to prevent discharge of untreatedsurface run-off characterized by increased sediment load to abutting agricultural land.
- Ensuring proper storage of drill cutting and chemicals to prevent any potentialcontamination from spillage.

4.3.8 Impact due to Solid/ Hazardous waste

Generation of solid waste in the form of excavated earth is envisaged during the construction period.Specificmitigation measures will be implemented by the proponent to stabilize the top soil to preservetheir fertility characteristics during site restoration.During site preparation and development of drill site approach roads some solid materials are expected to be generated. Cement bags, plastic buckets, coal tar drums, damaged tools and other containers are used during construction and discarded as solid wastes.

Hazardous Waste

The hazardous materials used during the construction phase may include diesel, waste oil etc. These will disposed carefully through authoirsed agencies.

Drill cuttings of 250-750 tons/well will be generated during the drilling phase with Water Based Mud (WBM) whereas the amount of drill cutting generated during drilling with Synthetic Based Mud (SBM) will be of around 500-1500 tons per well depending on the depth to which the wells be drilled. These cuttings will be stored in well-designed HDPE line pit. It will be tested for its hazardous constituents (Oil and Grease).

Spent / Residual drilling mud of 250-500 tons per well, sludge containing oil and other drilling waste will be around 250-500 tons/well is envisaged.

Used /waste Oil – During the drilling approx. 1-2 ton per well will be generated.

Non-Hazardous waste

Domestic food waste of 25-30 kg/day per well will be generated at site, which shall be segregated at source (Organic / Inorganic) and disposed accordingly.

Mitigation measures

- All kind of waste will be disposed in accordance with the requirement of CPCB/SPCB Industry Specific Standards for Oil Drilling & Gas Extraction Industry and guidelinesprovided by the MoEF under the Hazardous Wastes (Management, Handling &Transboundary Movement) Rules, 2016

4.3.9 Impact on Biological Environment

Impact on the ecology will be mainly confined to drilling site and will vary with the proximityfrom the drilling locations.During the site preparation activities vegetationclearance would be nominal or minor. Efforts will be made to avoid areas of comparativelydense vegetation cover, unless absolutely essential. The land acquired for drilling site & road would not be available for agriculture or any use fora period of about one year. The land, in case the exploration drilling is unsuccessful, would be restored in its original condition. Otherwise, land shall be acquired for development ofwell for production.

There are no rare and endangered plant and animal species in the study area and hence no changes are anticipated. As regards soil microbiology, no oil bearing waste will be discharged to the ground and adequate emergency control measures in place to take care of any accidental spills.

Impact on Terrestrial Environment

It has been observed that 19 wells i.e. 1, 2, 4, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 20, 21, 22 and 23 are located on agricultural fallow where no prominent vegetation was observed except seasonalcrops. On the other hand, five (5) wells i.e. 3, 5, 10, 19 and 24 are located on thescrub land. Therefore utmost care will be taken to conserve the floraldiversity of these areas. The nearest wild lifesanctuary from the study area is Borail WLS located at an approximate distance of 8.76 km. Noother WLS are coming under 10km radius of the study area. Taking all these scenarios into consideration, nomajor impact is anticipated on Sensitive Ecological Habitat due to drilling activity within theblock.

Impact on Aquatic Environment

The major rivers viz. Barak, Sonai, Jiri, Rukni and Chiri forms the aquatic ecosystem in the study area. It has been established in the baseline studies, that existing water quality of the surface water bodies is quite favorable to support diverse range of aquatic fauna and flora. Therefore, in case of any discharge of untreated waste water from exploratory drilling site may result in the possible contamination of receiving streams and their ecological habitat.Waste mud and effluents from drilling activity will be contained in HDPE lined waste pit within the drill sitepremises and there will be no discharge to any aquatic environment. No disturbance or damage will beexpected to the aquatic environment.

The flora and faunal habitats in the study area may be affected by erosion, siltation and water stagnationarising from run-on and runoff at the well site, if suitable mitigative measures are not implemented. Themitigative measures pertain to surface run-off from well site, wastewater discharges, solid waste disposal,erosion abatement measures, etc; As long as strict environmental management measures are put inplace, including adequate measures for supervision of contractors and staff, negative effects on faunawill be minimized. There are however, likely to be some residual, unavoidable, impacts, linked to therequirement of optimal clearing the vegetation to facilitate drilling activities. Based on air dispersionmodelling studies the resultant concentrations of ambient air pollutants were found to be well within theprescribed standards. Hence the impact on the ecology will be negligible.

Mitigation measures

- Minimum clearance of vegetation during site preparation

4.3.10 Impact on Socio-economic Environment

During Construction phase/ site preparation and development of drill site approach roads requires manpower. The required manpower would be engaged locally to the extent possible. In addition to the opportunity of getting employment as construction workers, the local population would also have employment opportunities in related service activities like commercial establishments, small contracts/sub-contracts and supply of construction materials for buildings and ancillaryinfrastructures etc. There will be positive impact for the local workforce during construction phase of the project.

The land requirement would be very less and on temporary short term lease and away from the settlements. If the identified lands are of private landowners then land lease mode will be applied and in case of govt. land, land allotment from Govt. to be applied. Initially temporary short term lease will be taken for 3-5 years for exploration purpose and in case of commercially viable discovery of hydrocarbon resources; the land lease would be converted into long term lease up to life of the project.Compensation to affected landowners for any loss of land, Vedanta Limited (Division: Cairn Oil & Gas) will ensure the livelihood of local community, if any affected by the proposed land take, are identified and compensated through adequate compensation.

Impact on Health

Majority of wells are located in close proximity to settlement. Inhabitants residing close toapproach roads will get affected due to noise and dust generated from vehicular movementduring site preparation, setting up of rig and associated facilities, decommissioning of rig andassociated facilities. Considering proximity of human settlement and short term activity withproper mitigation measures, impact will be of Medium significance.

Ecological productivity of Agricultural Fields

Ecological productivity of the agricultural land taken up for exploratory drilling activitystands temporarily affected during the entire lifecycle of the project. Reinstatement ofecological productivity will be dependent on successful restoration of soils, their structure, drainage characteristics and possibly other physical factors, such as micro-topography. Thesewill provide a basis for successful recovery of ecological populations, whether allowed tooccur naturally or aided by seeding and cultivation. However, considering necessarymitigation measures like top soil preservation, process water treatment, etc. will beimplemented by the proponent, the impact in this regard is considered to be of lowsignificance.

Employment Oppurtunities

Project will benefit people living in the neighboring villages bygiving preference to them in relation to direct & indirect employment associated with thevarious project activities. Primary survey showed that the local people desired to work withVedanta Limited (Division: Cairn Oil & Gas). Drilling process will involve a number of skilled and unskilled workers. There is a possibility that local people willbe engaged for this purpose to the extent possible and hence improve existing employmentscenario of the region. In addition to direct employment, several opportunities for locals will be available in terms of supply of construction materials & machinery, vehicles and other essential commodities. In the event of commercial quantities of hydrocarbons are discovered, more long termemployment opportunities would be created and enhance the availability of fuel to variousindustries in this region.

Exploratory drilling is a temporary activity which lasts for about 4-5 months at each location. Thus, theenvironmental impacts are transient in nature and there will not be any residual impact on the environment.

- Construction phase / site preparation could lead to creation of indirect employment and procurement opportunities.
- Self-employment options for individuals possessing vocational or technical training skills like electricians, welders, fitters etc, which are likely to be sourcedlocally.
- There would be influx of workers during construction phase/site preparation which could lead to pressure on key local infrastructure such as water, healthcare, electricity.

4.3.11 Impact on Occupational Health & Safety

Occupational injuries and ill-health have huge socio-economic implications on individuals,their families and communities.Major occupational health risks encountered in proposeddrilling activity include noise from drilling activity, operation of heavy vehicles andmachinery, handing of chemicals.However, the proponent will adopt necessary control measures through implementation ofmitigation measures and provision of proper PPEs to workers operating in aforesaid area toprevent and/or mitigate adverse health related impacts. Hence any possible occupational health impact from exposure to such fugitive dust is not likely to be of major significance.

Community health and safety of inhabitants residing close tothe drilling site stands to get affected from frequent heavy vehicular movement along villageaccess as well as approach roads and due to noise from drilling rig operations. Health andsafety impact arising from technological emergencies viz. well blow outs, explosions will bedealt separately in the Risk Assessment section. Although the aforesaid activities are temporary in natureit may not adversely affect community health and safety and hence is considered to be ofmedium significance.

4.4 OVERALL EVALUATION OF IMPACTS

The evaluation of the impacts of the proposed exploratory drilling and production activity on theenvironment, both in terms of quality & quantity have been made. The summary of identified impacts and proposed mitigation measures are shown below in **Table 4.7**

Table 4.7Summary of Identified Impacts and Proposed Mitigation Measures

S.No.	Impacts	Mitigation Measures
1.	Air Emissions • Emissions from DG sets • Emissions from vehicular movement;	• Fugitive emissions may result from handling andstorage of hydrocarbons (crude & diesels) whichare very minor. • At the time of transportation dust will begenerated. • Water spraying to be done on the access roads tocontrol re-entrained dust during dry season(if required); • The engines and exhaust systems of all vehiclesand equipment used will be maintained as such,that exhaust emissions are low and do not breachstatutory limits set for the concernedvehicle/equipment type; • D.G set shall be properly maintained; • Ensuring the availability of valid Pollution UnderControl Certificates (PUCC) for all vehicles
2.	Noise Generation • Noise from Production Operation • Noise from vehicular Traffic / movement • Noise from DG set / fire engine	Sufficient engineering control during installation of equipment's and machineries (like mufflers in DG sets) is to be ensured to reduce noise levels at source; • Proper and timely maintenance of vehicles is to be adopted to reduce noise levels; • Personal Protective Equipment's (PPE) like earplugs/muffs is to be provided to all the workers

		atsite and it shall be ensured that the same areworn by everyone during their shift. • All noise generating operations, (except anything directly related to Production operations) to be restricted to daytime only to the extent possible;
3.	Wastewater Generation	• Domestic and produced waste water generated will be treated suitably. • Waste water generation will be from domestic usage and produced water from the wells. • Produced water will be collected, separated and treated suitably. • The treated effluent (produced water) will be disposed off using either a nearby down hole disposal well (by reinjection in abandoned well) or other available & suitable onshore disposal medium or solar/ mechanical evaporators depending on feasibility. • All chemical and fuel storage areas shall have proper bunds so that contaminated run-off cannot meet the storm-water drainage system; • Chemical shall be stored in proper packing undershed, Spill control mechanism. • Re-injection/disposal system will be created and then treated water will be either used for green belt development of if salinity is high, it will be injected through injection wells in the field. (Depth below of 1000 m from ground level) • Company shall strive continually on Reduce, Recycle, and Fuel and Crude oil shall be stored in

		Reuse principle.
4.	Land	• Optimization of land requirement through proper site lay out design. • On completion of works (installation of additionalTanks, Separators etc) at EPS site, surplusmaterials and wastes will be completely removed.
5.	Soil	• Chemicals / HSD to be stored at concrete paveddesignated area, with roofs. • Management of spillage of contaminants such asoil from equipment’s, etc. on the Soil; • Proper arrangement of soak pits to be provided atthe production site for disposal of domestic wastewater; • Hazardous waste generated at site shall besegregated at source based on the categories and stored on concrete paved designated area withroofs.
6.	Soil and Hazardous Waste Management	• Generation of Waste oil/ Used oil in very negligible quantity and shall be used for internal purpose. • Oil sludge generated will be sent to authorize recyclers. • Hazardous waste generation shall be restricted to EPU site only. • Hazardous Waste storage shall be properly designated and concreted. • Domestic Solid waste generated at site will be segregated at source (Organic / inorganic) &

		disposed accordingly. • General wastes, scrap metal and wood will be segregated and will be disposed of appropriately to authorized recyclers. • All plastic/paper waste will be collected and will be disposed of to scrap dealers. • Waste lubricants and hydraulic oil generated from the equipment will be disposed of the authorized waste recyclers. • Containers of oil and other materials will be sold to SPCB/CPCB authorized recyclers. • Provision of concrete pit for storage of waste (produced) water.
7.	Socio-economic	• Generation of indirect employment in the region due to the requirement of workers, supply of raw material, auxiliary and ancillary works, which would marginally improve the economic status of the people. • Result in an increase in local skill levels through exposure to drilling activities. • As the existing loose / soft surface roads, shall be upgraded to facilitate the movement of the heavy equipment required, the project in turn would lead to improvement in transport facilities.
8.	Flora and Fauna Impact on terrestrial fauna • Project infrastructure and well development will disturb agriculture land of	• Development of plantation of native species tosubstitute the access cutting, site preparation,which shall provide habitat, food and breedingareas to birds, small animals and insects • Use existing facilities (e.g. Access Roads) to

	site • Spillage, leakage and well treatment may produce chemical spillage which will disrupt agriculture of nearby farm • Production activity (tanker movement) may increase deposition of dust and dust settling on the vegetation which may alter or limit plants' abilities to photosynthesize and/or reproduce	theextent possible to minimize the amount of new disturbance. • Avoid use of unnecessary lighting at night to avoid attracting avifauna.
9.	Occupational Health and risk to surrounding community • Noise generated during operational activity mayaffect the workers and staff members. • Handling of chemicals,fuel, may cause healthhazard if not handledproperly. • Uncontrolled flow of hydrocarbon or other fluids during blow out may cause serious health • Injuries including fatality of	• Providing PPE to site workers and staff member. • Acoustic enclosures will be provided to DG sets and other noise generating equipment. • Vedanta Limited(Division: Cairn Oil & Gas) will develop and implement a spillmanagement plan to prevent risk of spill whichmay cause health problem. • All operational activities shall be carried out in confirmation with applicable OISD and OMR standards/regulations/guidelines. • Regular internal / external HSE inspection shall be carried out. • Community awareness with regards to Operation activities and Risk and Hazards associated with the same shall be carried out.

	workers as well as damage to surrounding communities.	

4.5 CONCLUSION

In view of the above facts, it may be concluded thatproposed exploratory (including appraisal) well drilling and setting up of Early Production Units (EPUs)/ Quick Production Units (QPUs) and early production within the Assam block by Vedanta Limited (Division: Cairn Oil & Gas)shall not impart any adverse impact on physical features, water, noise and air environment. The proposed project shall generate employment and indirect service sector enhancement in the region and would help in the socio-economic upliftment of the state as well as the local area.

CHAPTER – V

ANALYSIS OF ALTERNATIVES

5.0 GENERAL

The analysis of alternative is the process of comparing potential impacts and mitigation options of a series of alternative location, technologies, operation to identify optimal alternatives that meets national legislation. These alternatives can include variations in layout, alternative engineering process, routing, linear facilities and screening of material suppliers to select those with appropriate environmental and risk management system.

5.1. Alternate Location for the Proposed Project

The block is allocated by the Government of India under the Revenue Sharing Contract (RSC). Vedanta Ltd. (Division: Cairn Oil & Gas) is the Operator for this block. 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 location is within the existing RSC boundary of the block. The proposed well locations are selected considering the drilling configuration (reach to potential reservoirs).

5.2. Alternative Technology

The technical and process related alternatives are discussed in the section.

5.2.1 Use of Water Based and Synthetic Based Mud

During drilling operation, drilling mud will be used, which is essential to lubricate and cool drill bits, removal of drilled rock (i.e. cuttings) from the bottom of the hole and transporting it to the surface and maintaining hydrostatic head in the well to counter natural formation pressures.

Drilling mud is basically a suspension / mixture of solids suspended in a liquid phase, which is blended with clays, polymers, salts and weighting agents. The main component/ solvent of drilling fluid are water, oil or synthetic and accordingly they are called as oil-based, water-based, and synthetic-based muds (OBMs, WBMs, and SBMs). All the three types of muds have certain advantages and disadvantages as discussed below.

Though the WBMs is a least cost option and widely used but is not found efficient in high temperature and also for water sensitive substrata, i.e., shales and mud. To overcome these limitations, OBM and SBM are used and of the two, SBM is preferred choice and it may be used in different set of environments like high temperatures, hydratable shales, high-angle, extended-reach wells, high-density mud and drilling through salt.

Table 5.1 Ranks/Comparison of Different Types of Mud

Aspects	Water Based Mud	Oil Based Mud	Synthetic Based Mud
Least Cost	1	2	3
Quantity of Waste discharge	3	2	1
Least Quantity of Water Required for Preparation	3	2	1
Toxicity	1	3	2
Reduced drill time	3	2	1

5.3 Conclusion

The project will have positive benefits in terms of revenue generation to central and state government. Job opportunities will increase for local/nearby people. Final well site selection will be based on the seismic survey and considerations to all environmental considerations.

CHAPTER – VI

ENVIRONMENTAL MONITORING PROGRAMME

6.0 INTRODUCTION

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

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

6.1 OBJECT OF MONITORING

The objectives of monitoring are to:

- Verify effectiveness of planning decisions;
- Measure effectiveness of operational procedures;
- Confirm statutory and corporate compliance; and
- Identify unexpected changes.

6.2 MONITORING SCHEDULE

Periodic environmental monitoring schedules are prepared covering various phases of project advancement. This comprises the duration of proposed exploratory drilling as well as post-drilling phase, when the hydrocarbon is established in the wells and production program is undertaken as well as the Decommissioning/Closure Phase. In order to assess the extent and nature of impacts on environment due to drilling operations, the monitoring on various attributes of environment will be carried out during various phases of drilling as under:

Pre-Drilling Phase: Prior to the start of drilling activities, the environmental status around the proposed drilling locations shall be monitored. These results will represent the baseline environment status, against which the monitoring results from the other phases are compared.
Drilling Phase: Monitoring during drilling phase serves as a measure of the impact on the environment due to drilling operations. Besides, the analysis of drill cuttings and drilling mud at various depths shall be carried out as per CPCB guidelines on disposal of drilling wastes.

Post-Drilling Phase: Monitoring shall be carried out after completion of drilling and testing operations to determine if there has been any residual impact on the environment due to drilling and testing operations.

Monitoring requirements have been described in the following Table 6.1. Frequency of monitoring

Table 6.1 Environmental Monitoring Programme

Monitoring	Locations	Frequency	Parameters
Ambient Air Quality (AAQ) monitoring	Adequate number of representative locations	Pre-drilling, during drilling and post-drilling	As per NAAQS and HC, NMHC, H_2S and VOC
D.G. Stack	-	Once during operation	As per GSR 771 (E) or as specified by Consent to operate issued by State pollution control board (SPCB)
Ambient Noise Level at Fence/ boundary	Adequate number of representative locations	Pre-drilling, during drilling and post-drilling	Leq (night), Leq (day), Leq (24hourly)
Work Place noise Monitoring	Monitoring at point sources of noise emissions	During drilling	8 Hourly (TWA)

Sewage Water Quality Monitoring	Treated domestic wastewater	Once during operation	pH, TSS, TDS, BOD, COD, oil & grease, fecal coliform (MPN per 100 milliliter, MPN/100ml or as per CTE/CTO issued by SPCB
Ground water monitoring	Adequate number of representative locations	Pre-drilling and post-drilling	As per IS 10500: 2012
Soil Quality	Adequate number of representative locations	Pre-drilling and post-drilling	pH, conductivity, texture, bulk density, Ca, Mg, Na, K, P, N, organic matter, organic carbon, Cl, SO4, sodium absorption ratio, Al, Fe, Mn, Boron, Zn, Hg and PAH
Fresh Synthetic Based Mud (SBM)	During drilling	One sample / well during drilling	Aromatic content, Toxicity, (LC_{50}, 96 hours), Hg
Fresh Water Based Mud (WBM)	During drilling	One sample / well during drilling	(LC_{50}, 96 hours), Mercury
Barite used for mud preparation	During drilling	One sample / well during drilling	Hg, Cd
Drill cuttings associated with WBM	During drilling	One sample / well during drilling	Oil and grease, (LC_{50}, 96 hours), Hg and parameters for

			disposal of waste
Drill cuttings associated with SBM	During drilling	One sample / well during drilling	Oil and grease, (LC_{50}, 96 hours), Hg and parameters for disposal of waste
Spent WBM before disposal	During drilling	One sample / well during drilling	(LC_{50}, 96 hours), Hg and parameters for disposal of waste

CHAPTER – VII

ADDITIONAL STUDIES

7.0 PUBLIC CONSULTATION

As per the EIA Notification 2006 and its subsequent amendments, public consultation is mandatory to seek the opinion of the people regarding the proposed project through public hearing organized by the State Pollution Control Board.

The issues raised during the public hearing, the response of the proponent along with action plan and budgetary allocation will be given in the final EIA report and submitted to MOEF&CC for obtaining environment clearances.

7.1 RISK ASSESSMENT

Environmental Risk Assessment is a scientific analysis for identification of credible risk and thereafter estimating the safe distances from any hazardous installations/processes in the eventuality of an accident. Estimation of near-accurate safe distances is absolutely necessary to protect the public, property and environment. Risk Assessment' also known as 'Hazard Analysis' and 'Vulnerability Assessment' is a procedure for identifying hazards and determining their possible effects on a community and environment. Risk or hazard by itself is not an event - it is the potential for an event.

This section on Risk Assessment aims to provide a systematic analysis of the major risks that may arise as a result of onshore exploration activities by Vedanta Limited in AA-ONHP-2017/14 Block. The Risk Assessment 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 Risk Assessment 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.

7.1.1 Objective of Risk Assessment

The main objective Risk Assessment is to determine the potential risks of major accidents having damage potential to life and property and provide a scientific basis for decision makers to be satisfied about the safety levels of the facilities to be set up. This is achieved by the following:

- Identification of hazards that could be realized from the proposed drilling and other activities.

- Identify the potential failure scenarios that could occur within the facility.
- Analyze the possible likelihood and frequency of such risk scenarios by reviewing historical accident related data for onshore & offshore oil and gas industries.
- To assess, the potential risks associated with identified hazards to which the project and its personal and community outside may be subjected. Consequences analysis of various hazards is carried out to determine the vulnerable zones for each probable accident scenario.
- Evaluate the process hazards emanating from the identified potential accident scenarios.
- Analyze the damage effects to the surroundings due to such accidents.
- Conclusion and Recommendation to mitigate measures to reduce the hazard / risks.
- To provide guidelines for the preparation of On-site response plan.

7.1.2 Risk Assessment Methodology

Risk analysis consists of hazard identification studies to provide effective means to identify different types of hazard during the operation of the facility. This is followed by an assessment of the impacts of these hazards. Hazard is present in any system, plant or unit that handles or stores flammable materials. The mere existence of hazards, however, does not automatically imply the existence of risk. Screening & ranking methodologies based on Preliminary Hazard Analysis (PHA) techniques have to be adopted for risk to be evaluated.

Risk Analysis techniques provide advanced quantitative means to supplement other hazard identification, analysis, assessment, control and management methods to identify the potential for such incidents and to evaluate control strategies. The methodology adopted for the study has been depicted in the Flow chart given below in **Fig 7.1**

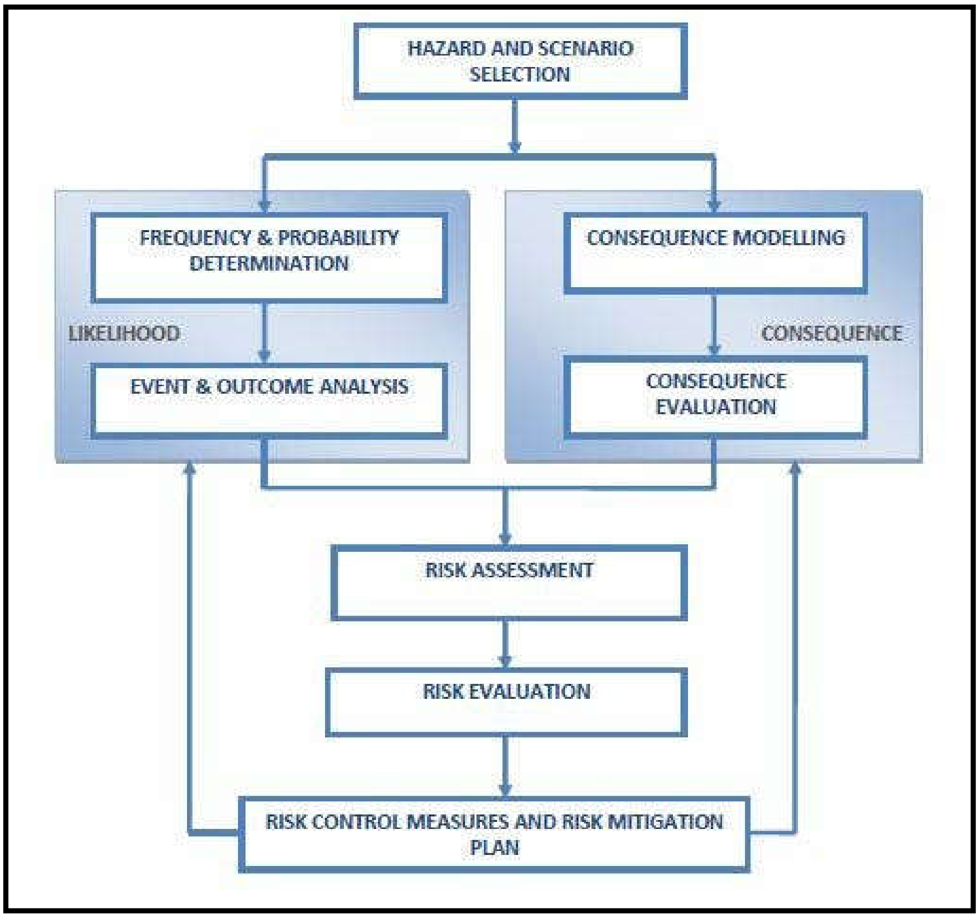


Fig 7.1 Risk Assessment Methodology

Hazard Identification

A major hazard is defined as an event, which may have the potential to cause one or more fatalities and also the potential to affect the integrity of the facility as a whole. The aim of this step is to create a complete tabulation of identified hazards. Identification of hazards in the proposed project campaign is of primary significance in the analysis, quantification and cost effective control of accidents involving chemicals and process. Hence, all the components of a system/process need to be thoroughly examined to assess their potential for initiating or propagating an unplanned event/sequence of events, which can be termed as an accident.

Hydrocarbon exploration and testing operations are generally hazardous in nature by virtue of intrinsic chemical properties of hydrocarbons or their temperature or pressure of operation or a combination of these factors. Fire, explosion due to hazardous release of crude oil, gas, H_2S or a combination of these are the hazards associated with hydrocarbon exploration and testing operations. These have resulted in the development of more comprehensive, systematic and sophisticated methods of safety engineering, such as, hazard identification and risk assessment to improve upon the integrity, reliability and safety of hydrocarbon operations.

Taking into account the applicability of different risk aspects in context of the drilling operations to be undertaken in the AA-ONHP-2017/14 block, there are three major categories of hazards that can be associated with proposed project which has been dealt with in detail. This includes:

- Hydrocarbon escapes due to high geological pressures lead to possibility of fire, explosion, gasingress to sensitive areas, contamination or toxic hazards arising from wells, test equipment fuel supply systems, storage, pipe work systems, etc.;
- Structural or foundation failure, including effects of corrosion, fatigue, extreme weather, overloading, seismic effects, abuse or accidental loading;
- Possibility of H_2S release while drilling; and
- Fire, including fires in accommodation, electrical fires, hot work, oxygen enrichment

The complete list of hazards and Occupational Hazards applicable to onshore drilling are presented in **Table-7.1** and **Table-7.2**.

Table 7.1 List of Major Hazards

S.No.	Hazard Source/Reason	Description	Impacts
1	Fire and explosion	Occurrence of blow out	Topsides blow out
		Non hydrocarbon fires	Electrical fire in control room
			Fire in accommodation
2	Impacts and collisions	Objects dropped from a crane/ derrick	Fatal accidents
			Loss of materials and equipment
3	Loss of station/ stability	Loss of stability	Structural failure Tug failure (during towing)
4	Extreme weather conditions	Extreme winds	Loss of lives and materials
			Temporary withdrawal of well operations
5	Earthquakes	Sudden ground movement	Strong vibrations, failure
6	War, crisis	Crisis situation	-

Table 7.2 List of Occupational Hazards

S.No.	Hazard	Description	Specific Hazard
1	Working at heights	Fall	Fall
			Man overboard
2	Disease/ Illness	Illness	Medical evacuation
3	Storage of chemicals	Release of Chemicals	Exposure to chemicals, inhalation, ingestion, body contact etc.

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.

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. Based on the range of probabilities arrived at for different potential hazards that may be encountered during the proposed drilling activities, following criteria for likelihood rankings have been drawn up as presented in the Table 7.3.

Table 7.3: Frequency Categories and Criteria

Livelihood Ranking	Criteria Ranking	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

Quantification of the damage can be done by means of various models, which can then be translated interms of injuries and damage to the exposed population and buildings. Oil and gas may be released and result into jet fire & less likely unconfined vapour cloud explosion causing possible damage to the surrounding areas. Extent of the damage depends upon the nature of release. The release of flammable material and subsequent ignition results in heat radiation, pressure wave or vapour cloud depending upon the flammability and its physical state.

The risk presented by a blowout (hydrocarbons release event) is determined by the frequency and consequence of its possible outcomes. The consequence of igniting a hydrocarbon release during blowout depends on the type of material released, the mass release rate, the timing of the ignition, and the environment into which the hydrocarbon is released. Briefly, typical outcomes are:

- ***Jet fires:*** *produced by an ignited jet of gas or liquid spray released under pressure;*
- ***Pool fires:*** *produced by ignition of a liquid release that accumulates on the surface and ignites;*
- ***Flash fires:*** *produced by igniting a gas cloud so that a fire propagates through the gas cloud (without generating a significant overpressure);*
- ***Explosions:*** *produced by igniting a gas cloud in conditions where the resultant accelerating flame front produces a significant overpressure.*

Damage effects of various peak over pressures and incident radiation intensities are detailed in **Table 7.4** and **Table 7.5** respectively

Table 7.4 Damage due to peak over pressure

Human Injury		Structural Damage	
Peak Over Pressure – bar	**Type of Damage**	**Peak Over Pressure – bar**	**Type of Damage**
5-8	100% lethality	0.3	Heavy (90 % damage)
3.5-5	50% lethality	0.1	Repairable (10 % damage)
2-3	Threshold lethality	0.03	Damage of Glass
1.33-2	Severe lung damage	0.01	Crack of windows
1-3.66	50 % Eardrum rupture	-	-

Table 7.5 Damage due to Incident Radiation Intensities

S.No.	Incident Radiation (kW/m^2)	Type of Damage Intensity	
		Damage to Equipment	Damage to People
1	37.5	Damage to process equipment	100% lethality in 1 min. 1% lethality in 10 sec.
2	25.0	Minimum energy required to ignite wood at indefinitely long exposure without a flame	50% lethality in 1 min. Significant injury in 10sec.
3	19.0	Maximum thermal radiation intensity allowed on thermally unprotected adjoining equipment	--
4	12.5	Minimum energy to ignite with a flame; melts plastic tubing	1% lethality in 1 min
5	4.5	--	Causes pain if duration is longer than 20 sec, however blistering is unlikely (First degree burns)
6	1.6	--	Causes no discomfort on long exposures

Risk Mitigation Measures

Based on consequence analysis and risk summation findings, risk mitigation measure swill be suggested in view of applicable standards, guidelines and best practices to reduce risk and enhance safety at the proposed exploratory (including appraisal) well drilling and setting up of Early Production Units (EPUs)/ Quick Production Units (QPUs) and early production within the Assam block.

7.1.3 Risk Calculation

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 7.6 below illustrates all possible product results for five likelihood and consequence categories while the Table 7.7 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 7.6 Risk Matrix

Consequence			**Likelihood**				
			Frequent	**Probable**	**Remote**	**Not Likely**	**Improbable**
			5	**4**	**3**	**2**	**1**
	Catastrophic	**5**	**High**	**High**	**Medium**	**Medium**	**Low**
	Major	**4**	**High**	**High**	**Medium**	**Low**	**Very Low**
	Moderate	**3**	**Medium**	**Medium**	**Low**	**Low**	**Very Low**
	Minor	**2**	**Medium**	**Low**	**Low**	**Very Low**	**Very Low**
	Insignificant	**1**	**Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**

Table 7.7 Risk Criteria and Action Requirements

Risk Significance	Criteria Definition & Action Requirements
High	**"Risk requires attention"** – Project HSE Management need to ensure that necessary mitigation are adopted to ensure that possible risk remains within acceptable limits
Medium	**"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	**"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	**"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 Model Used for Consequence Analysis

PHAST (Version 7.11) software of DNV has been used to perform the consequence calculations. PHAST is a consequence and risk assessment software for calculation of physical effects (fire, explosion, atmospheric dispersion) of the escape of hazardous materials. PHAST software allows detailed modeling and quantitative assessment of release of pure and mixtures of liquid and gaseous chemicals.

7.1.5 Risk Assessment of Identified Project Hazards

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.

Blowouts/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 producing 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)
- Rig forced off station (e.g. by anchor failure) damaging Blow Out Preventor (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:

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.

If the hydrostatic head exerted by the column of drilling fluid is allowed to drop below the formation pressure then formation fluids will enter the well bore (this is known as a kick) and a potential blowout situation has developed. Fast and efficient action by operating personnel in recognizing the above situations and taking precautionary measure can avert a blowout.

Presence of Sour Gas (Hydrogen Sulphide-H_2S) in Blowout

Presence of Sour Gas (H_2S) in blowouts wells can pose immediate dangers to life and health at and around the rig area. Operators drilling wells where H_2S is a known hazard may or may not have a clear-cut policy regarding ignition of the well if a blowout occurs. Burning H_2S creates sulfur dioxide (SO_2) that is also highly toxic. Therefore, the situation is still dangerous, and a safety system should be put in place to monitor for H_2S. Hydrogen Sulphide gas (H_2S) is extremely toxic, even very low concentrations can be lethal depending upon the duration of exposure. Without any warning, H_2S may render victims unconscious and death can follow shortly afterwards. In addition it is corrosive and can lead to failure of the drill string or other tubular components in a well.

7.1.6 Scenarios Wise Findings of Consequence Analysis

Subsequent to the accidental release of hydrocarbon, the consequence depends on various factors e.g. type and quantity, presence and location of an ignition source, meteorological conditions, etc. The consequence analysis for the selected accident scenarios for hydrocarbon releases have been carried out to estimate the effect distances and outcomes of same have been described in subsequent sections.

Consequence Analysis Results

- **HSD Leak from 60 KL storage tank (25 mm)**

An amount of 60 KL HSD is stored at rig site for supplying to rig system. The HSD is stored at atmospheric pressure. Detailed computations for the jet fire and pool fire have been carried out and the results for heat radiation effects and various damage distances are given below.

Jet Fire

The intensity radii for jet fire reached maximum distance of 2.011 m as per weather category 1.5/F at radiation level of 4 KW/m^2.

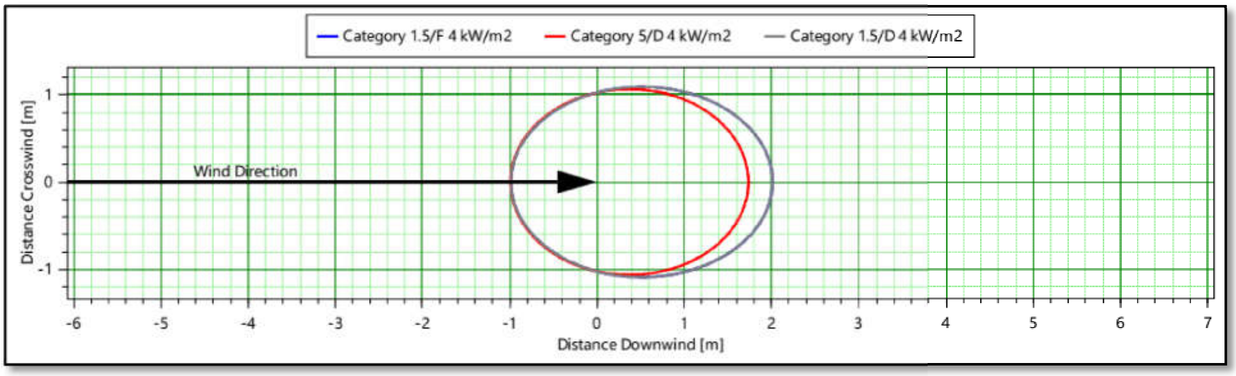


Fig 7.2 Intensity Radii for Jet Fire – HSD storage tank leak

Table 7.8: HSD jet fire radiation effects:

			Distance (m)		
			Category1.5/F	Category5/D	Category1.5/D
Radiation level	4	KW/m^2	2.011	1.734	2.011
Radiation level	12.5	KW/m^2	2.011	1.734	2.011
Radiation level	37.5	KW/m^2	Not Reached	Not Reached	Not Reached

Pool Fire

The intensity radii for pool fire reached maximum distance of 30.92 m as per weather category 5/D at radiation level of 4 KW/m^2 for HSD storage tank leak.

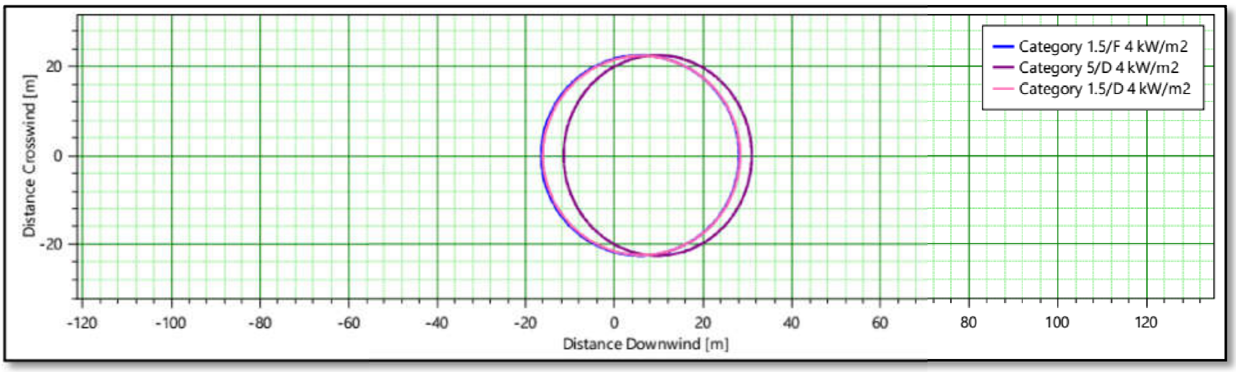


Fig 7.3 Intensity Radii for Late pool Fire – HSD storage tank leak

Table 7.9: HSD pool fire radiation effects:

			Distance (m)		
			Category1.5/F	Category5/D	Category1.5/D
Radiation level	4	KW/m^2	28.1262	30.9293	28.2863
Radiation level	12.5	KW/m^2	15.77	20.8464	16.0232
Radiation level	37.5	KW/m^2	5.9099	7.0922	6.1650

The intensity radii for pool fire reached maximum distance of 30.92 m as per weather category 5/D at radiation level of 4 KW/m^2 for HSD storage tank rupture.

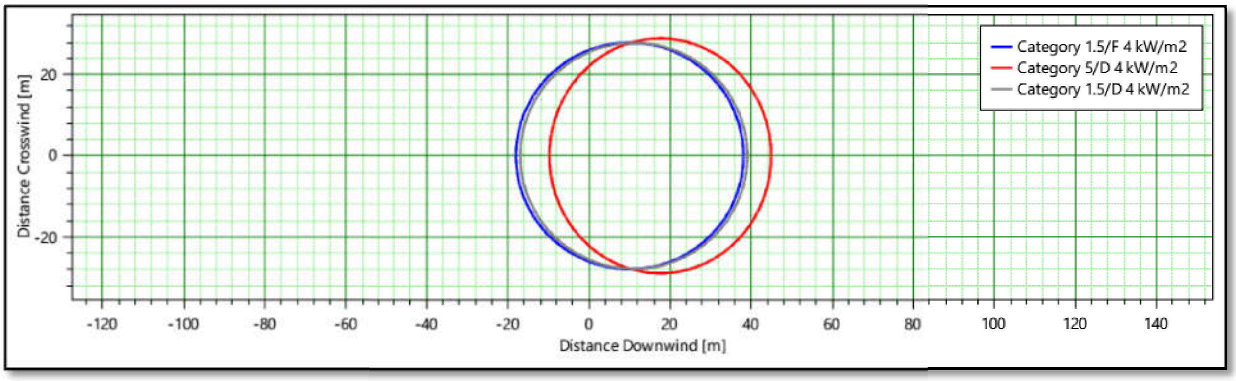


Fig 7.4 Intensity Radii for Late pool Fire – HSD storage tank rupture

			Distance (m)		
			Category1.5/F	**Category5/D**	**Category1.5/D**
Radiation level	4	KW/m^2	38.1197	44.9307	39.0853
Radiation level	12.5	KW/m^2	19.361	28.2556	20.4119
Radiation level	37.5	KW/m^2	Not Reached	15.0344	12.9485

Risk Calculation:

Significance = Likelihood (3) x Consequence (3)

= **9 i.e. Low**

- **Blowout during drilling of Well**

A well blow out can lead to uncontrolled release of oil into the atmosphere. Blow out is an incident where formations fluid flows out the well or between formation layers after all the predefined technical well barriers or the activation of the same have failed. Formation pressure in hydrocarbon wells, typically may be high, thus conventional BOP stack is used at drilling rig.

Release of Hydrocarbon through 150 mm hole containing 3 % H2S gas due to Blowout

IDLH Concentration of 3 % H_2S

In the event of vertical release of hydrocarbon, IDLH concentration of hydrogen sulphide (H_2S) will not reach to the ground. Therefore, no hazard is anticipated.

IDLH Concentration	IDLH Concentration Distance (m)		
	Category1.5/F	Category5/D	Category1.5/D
100 ppm	No hazard	No hazard	No hazard

Flash Fire envelope

On ignition of Hydrocarbon gas, flash fire envelope will be formed as per details given below:

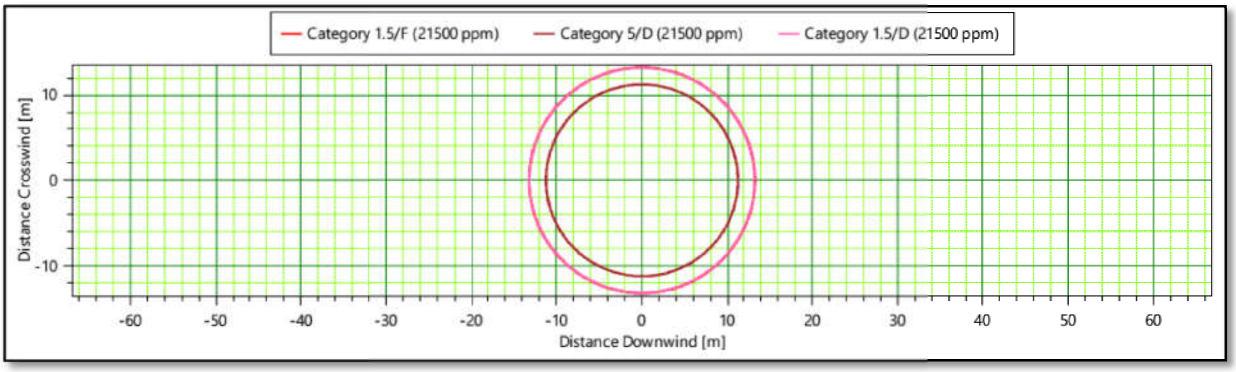


Fig 7.5 Flash Fire envelope

Table 7.10 Flash Fire Envelope
All flammable results are reported at the cloud centerline height

		Distance (m)		
		Category 1.5/F	Category 5/D	Category 1.5/D
Furthest Extent	21500 ppm	13.233	11.2526	13.2032
Furthest Extent	43000 ppm	6.9305	6.4184	6.9275

Jet Fire

In the event of ignition of blow out, computed thermal radiation, distances resulting from jet fire are as per given hereunder:

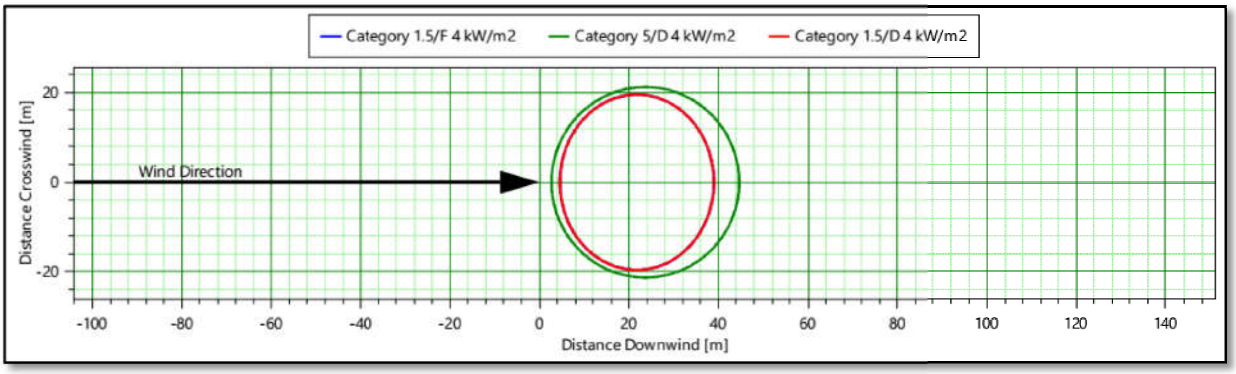


Fig 7.6 Intensity Radii for Jet Fire

Table 7.11: Blowout jet fire radiation effects:

			Distance (m)		
			Category1.5/F	Category5/D	Category1.5/D
Radiation level	4	KW/m^2	38.9714	44.6018	38.9714
Radiation level	12.5	KW/m^2	Not Reached	Not Reached	Not Reached
Radiation level	37.5	KW/m^2	Not Reached	Not Reached	Not Reached

Failure Frequency Analysis

A blowout is defined as an uncontrolled release of fluid, viz., hydrocarbon (oil and/or gas), but drilling mud, completion fluid or water from a well. It is most hazardous when the fluid is hydrocarbon. Blowouts are important because they have the potential to release large amounts of hydrocarbons and are very difficult to control. A well control incident is one in which a high potential release which may result in blowouts either does not occur or is quickly stopped. They typically involve formation fluid accidentally entering the wellbore, but controlled by the available barriers such as the blowout preventer (BOP). These incidents usually have relatively minor consequences, and are not well reported.

Blowout and well release 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 drilling operations, blow out frequencies per well drilled have been considered. The frequency of well blowout and well release is discussed in The International Association of Oil & Gas Producers Risk Assessment Data Directory. Table shows the expected frequency of such events based on historical data from recent years.

Table 7.12 Blowout and Well release frequencies

Operation	Frequency			
Category	**Average**	**Gas**	**Oil**	**Unit**
Blowout	6.0E-05	7.0E-05	4.8E-05	Per drilled well
Well Release	4.0E-04	5.7E-04	3.9E-04	Per drilled well

Source: OGP Oil & Gas Producers

Based on the given frequency and information provided by Vedanta Limited (Division: Cairn Oil & Gas) on the proposed exploratory drilling project the blow out frequency is calculated as follows:

No of exploratory wells to be drilled = 24 (A)

Blow out frequency for onshore drilling = 4.9×10^{-4} per well drilled (B)

Frequency of blow out occurrence for the proposed project = (A X B)

= $24 \times 4.9 \times 10^{-4} = 1.17 \times 10^{-2}$ per well drilled

Thus, the blow out frequency for the proposed project is calculated at 1.17×10^{-2}per well drilled i.e. the likelihood of its occurrence is "Occasional/Rare"

Blowout ignition Probability

The details of immediate ignition probabilities used in this analysis are given in **Table-7.13**

Table 7.13 Probability of Ignition for leaks of flammable fluids

Release Rate Category	Release Rate (kg/s)	Gas Leak Probability	Oil Leak Probability
Minor	<1	0.01	0.01
Major	1-50	0.07	0.03
Massive	>50	0.3	0.08

Risk Calculation:

Significance = Likelihood (3) x Consequence (4)

= **12 i.e. Medium**

Individual Risk

Individual risk is the probability at which an individual may be expected to sustain a given level of harm from the realization of specified hazards. In simple terms it is a measure to assess the overall risk of the area concerned thus to protect each individual against hazards involving hazardous chemicals, irrespective of the size of the accident that may occur. Graphically it represents as iso-risk contour which connects all of the geographical locations around a hazardous activity with the same probability of fatality. In order to generate different level of iso-risk curves for the area concerned, it is required to estimate the respective contribution of each reference scenario. Accordingly, individual risk of each scenario was estimated by combining the frequency of the initiating event, the conditional probability of that scenario sequence and the Probit value of the effect footprints. In particular following expression was used to estimate the Individual Risk (IR) at a given geographical location for each reference scenario:

$IR(x, y,i) = fi. PFi$

where:

- fi is the frequency of the accident scenario i ($year^{-1}$); calculated as multiplicative factor of the frequency of the initiating event and the probability that the sequence of events leading to the accident scenario i will occur: $fi = f_{incident\ i} . P_{sequencei}$

- PFi is the probability of fatality that the accident scenario i will result at location (i.e. Probit).

The individual risk so obtained is then compared with the Tolerance Criteria of Individual Risk as provided in the Figure 7.2 below.

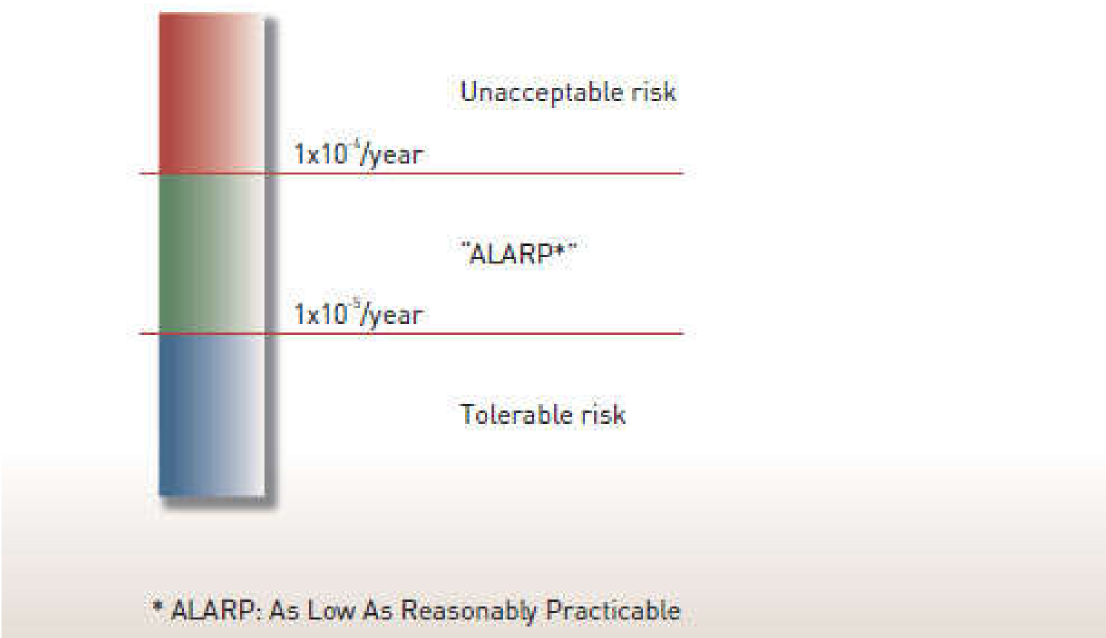


Fig 7.7 Tolerance Criteria for Individual Risks

Table 7.14 The individual risk assessment criteria

Acceptable Criteria	Maximum Individual Risk Criteria for Workers	Maximum Individual Risk Criteria for Public
Benchmark	IR < $2x10^{-5}$	IR < $1x10^{-5}$
Unacceptable	IR > $1x10^{-3}$	IR > $1x10^{-4}$
Acceptable	IR < $1x10^{-5}$	IR < $1x10^{-6}$

Source: E&P Forum

No predicted fatality has been established for the consequence modeling undertaken for natural gas release ignition from blow outs and/or valves/flanges and individual risk for the proposed project is below tolerable risk.

Societal Risk

Societal risk is defined as the relationship between frequency and the number of people suffering from a specified level of harm in a given population from the realization of specified hazards. Societal risk evaluation is concerned with estimation of the chances of more than one individual being harmed simultaneously by an incident. The likelihood of the primary event (an accident at a major hazard plant) is still a factor, but the consequences are assessed in terms of level of harm and the numbers affected (severity), to provide an idea of the scale of an accident in terms of numbers killed or harmed.

Societal risk can be represented by FN curves, which are plots of the cumulative frequency (F) of various accident scenarios against the number (N) of casualties associated with the modeled incidents. The plot is cumulative in the sense that, for each frequency, N is the number of casualties that could be equalled or exceeded. Often ‘casualties’ are defined in a risk assessment as fatal injuries, in which case N is the number of people that could be killed by the incidents. FN curves cannot easily be compared with one another for the purpose of ranking (judging which curve represents the higher overall societal risk). Although all FN curves have a generally similar shape, the detail can be very different.

FN Curve – Comparision against Risk Acceptance Criteria

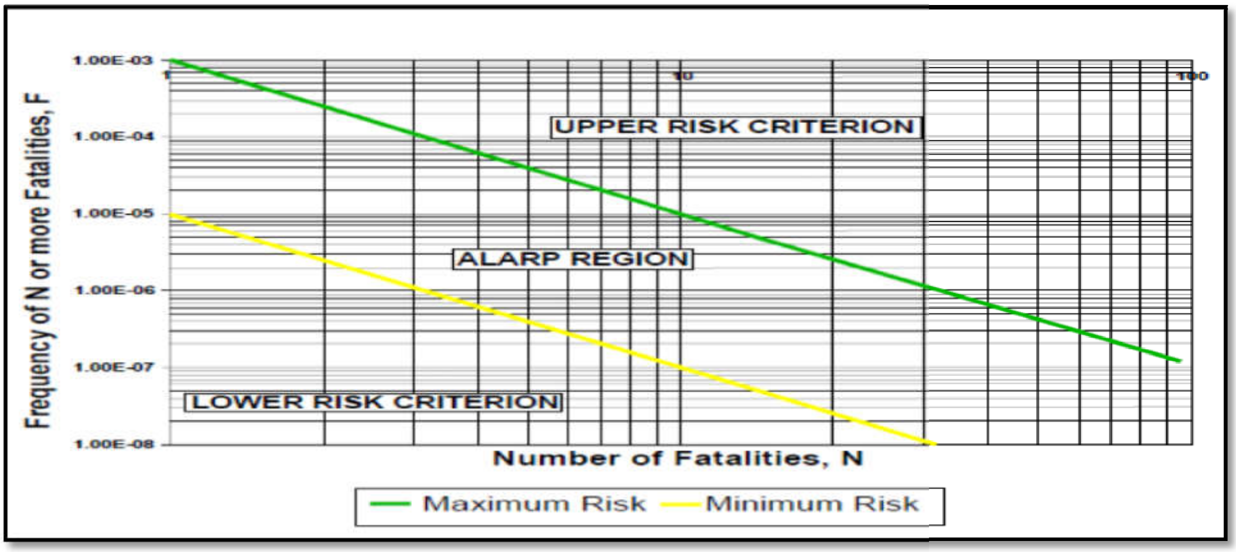


Fig 7.8 FN Curve

Location specific individual risk (LSIR)

The Location specific individual risk (LSIR) is risk to a person who is standing at that point 365 days a year and 24 hours a day.

7.1.7 Risk Reduction Measures

This section discusses the measures for risk reduction and enhancement of safety during exploratory drilling operations:

Risk Mitigation to Control Hazards

Occurrence of blowout and sour gas (H_2S) are the two major hazards. Occurrence of H_2S along with oil and gas is the major hazard during exploratory drilling and production testing (The past experience and historical information available for drilling, exploration and production of hydrocarbons in the area reveal that H_2S gas shall not be found in hydrocarbon reserves of the region. However, in the event of occurrence of H_2S during drilling operations, associated hazards and risk are considered for completeness of the study).

Blowout

Blowouts being events which may be catastrophic to any well operation, it is essential to takeup as much a preventive measures as feasible. This includes:

- Necessary active barriers (e.g. Well-designed Blowout Preventor) 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
- Marking of hazardous zone (500 meters) around the well site and monitoring of human movements in the zone.
- Installation of mass communication and public address equipment.
- 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.
- An appropriate Emergency Response Plan be finalized and implemented by Vedanta Limited.
- Good layout of well site and escape routes.

Control Measures for H_2S during Drilling

H_2S Detection system

H_2S gas detection system should be provided. Sensors should be positioned at optimum points for detection, actual locations being decided on site but likely to be at or near to:

- Well Nipple
- Rig Floor
- Shaker header tank

- Substructure cellar

The detection system should be connected to an audio visual (siren and lights) alarm system. This system should be set to be activated at a concentration of 15 ppm H_2S.The mud logging will have a completely independent detection system which is connected toan alarm in the cabin. This system will be adjusted to sound an alarm at a concentration level of 10 ppm H_2S as suggested in the Drilling and Production Safety Code for Onshore Operators issued by The Institute of Petroleum. A stock of H_2S scavenger will be kept at drilling site for emergency use.

General Safe Practices during Drilling Operation

- Penetration rate shall be monitored. In case of any drilling break, stop rotary table, pull out the Kelly, stop mud pump and check for self flow;
- Different type of drill pipes should not be mixed up during making up the string;
- Proper ventilation be arranged for in hazardous area to allow for inflammable gases to dissipate, when a release has occurred;
- Protectors should be used on drill pipes while lifting and laying down the pipes on catwalk;
- Drill pipe rubber protector should be installed on drill pipes body while being used inside the casing;
- Before starting drilling, hole should be centered to avoid touching of kelly with casing / wellhead and ensure that no damage is done to well head and BOP;
- Continuous monitoring of the gain/loss of mud during;
- Effective barriers in the form of blast walls, blast relief panels, etc. be installed to shield workers from high risk area where explosions may occur;
- BOP mock drill should be carried during drilling / tripping and under mentioned operations;
- Safe Working Conditions and Practices to be Adopted During Drilling Operations; etc
- Strict implementation of permit to work system and hazardous zone classification.
- Basic firefighting training to all working on the drilling rig.
- Installation of electrical equipment as per the hazardous zone classification.

7.1.8 Fire Fighting Facility for Drilling Rig

To detect the release of hydrocarbon during exploration and testing, hydrocarbon detectors should be placed, so that control measures may be taken to prevent fire and explosion. A temporary closed grid hydrant system with monitors, hydrant points and fire hose boxes may be installed to cover exploration wells, oil and gas production facilities and oil and diesel fuel storage tanks. Portable fire extinguishers of DCP, mechanical foam and CO_2 types of sufficient capacity and in sufficient numbers along with sand buckets should also be placed at strategic locations. Adequate personal protective equipments including sufficient number of breathing apparatus must also be kept ready in proper working condition.

As per Oil Industry Safety Directorate (OISD) Standard, for the drilling rigs and well testing following fire fighting system/equipments should be provided:

- Fire water system; and
- First aid fire fighting system

7.2 DISASTER MANAGEMENT PLAN

In view of the hazardous nature of products / process handled by the Vedanta, a Disaster ManagementPlan (DMP) has been prepared. This plan is based on various probable scenarios like well blow out,fire, explosion, natural calamities etc. The consequence arising out of such incidents are accuratelypredicted with the help of latest technique available by various risk analysis studies. To minimize theextent of damage consequent to any disaster and restoration of normalcy is the main purpose of DMP.

7.2.1 Objectives of Disaster Management Plan

The primary objective of the DMP is to provide a safe, timely, effective and coordinatedresponse by the onsite Emergency Response Team (ERT), along with the other local andgovernment agencies/departments to prevent or minimize any major emergencies that mayarise from possible failures/risks viz. blow outs, oil spill, fire & explosion etc. associated withexploratory and development drilling.The main objectives of this plan are:

- To minimize the risk for human life, environment and common property resources, bymeans of an effective and efficient intervention;

- Protection of the environment;
- Protection of public safety;
- To initiate the early and efficient response throughout the utilization of all available sources.

7.2.2 Purpose

The purpose of the DMP is to effectively manage and control the emergencies occurring during project operations. This DMP ensures

- emergency response group is effective & adequate;
- clear roles and responsibilities of key personnel & support groups;
- availability and adequacy of emergency infrastructure & resources; and
- efficient emergency communication
- emergency identified
- emergency classification & response team

7.2.3 Key Elements of DMP

Following are the key elements of Disaster Management Plan:

- Basis of the plan
- Accident/emergency Management Plan
- On-site Disaster Management Plan
- Off-site Disaster Management Plan

Basis of the Plan

Identification and assessment of hazards is crucial for onsite emergency planning and it is thereforenecessary to identify what emergencies could arise in production of various products and their storage.Hazard analysis or consequence analysis gives the following results:

- Hazards from spread of fire or release of flammable and toxic chemicals from storage and production units; and
- Hazards due to formation of pressure waves due to vapor cloud explosion of flammable gasesand oil spill hazards

On-site Disaster Management Plan Purpose

The on-site DMP deals with handling of the emergency within boundary of the proposed project well site mainly with the help of industry's own resources.

- To protect persons and property of processing equipments in case of all kinds of accidents,emergencies and disasters.
- To inform people and surroundings about emergency if it is likely to adversely affect them.
- To inform authorities including helping agencies (doctors, hospitals, fire, police transport etc.) inadvance, and also at the time of actual happening.
- To identify, assess, foresee and work out various kinds of possible hazards, their places, potential and damaging capacity and area in case of above happenings. Review, revise, redesign, replace or reconstruct the process, plant, vessels and control measures if so assessed.

Off-site Disaster Management Plan Purpose

Emergency is a sudden unexpected event, which can cause serious damage to personnel life, propertyand environment as a whole, which necessitate to evolve Off-site Emergency Plan to combat any sucheventuality. In Offsite disaster management plan, many agencies like government, revenue, public health,fire services, police, civil defense, home guards, medical services and other voluntary organization areinvolved. Thus, handling of such emergencies requires an organized multidisciplinary approach.

Evacuation of people, if required, can be done in orderly way. The different agencies involved in evacuation of people are civil administration (both state and central), non Govt. organizations, factoryInspectorate and Police authorities.

7.2.4 Emergency Classification

Due consideration is given to the severity of potential emergency situation that may arise as a result of storage tank and pipeline accident events as discussed in the **Risk Assessment** 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 responseprocedures can be effectively implemented by the Vedanta Emergency/Crisis Management
Team.

Level 1 – Emergency

An event that can be dealt with by on-site/location personnel and resources; the event does not have any effect outside the site and external agencies are unlikely to be involved. There is unlikely to be danger to life, to the environment, or to Company assets or reputation. The Disaster Management Plan and relevant procedures are activated; the Site Head is notified.

Level 2 – Emergency

It is an event which may be dealt by the Vedanta Emergency/Crisis Management Team but requires involvement of wider Company support and external services. The initial event may be "on-site", having some effects outside the site or be "off-site", and external emergency services will be involved. There is likely to be a danger to life, the environment, or company assets or reputation. The Disaster Management Plan and relevant procedures are activated; local administrative bodies and Emergency Response Groups including Vedanta Corporate are notified.

Level 3 – Emergency

It is a major event which requires the involvement of District or State Crisis Management Group. For Company this may result from insufficient local resources and/or because the incident has broader implications such as reputation, legal prosecution, financial loss etc. Under such circumstances, the Disaster Management Plan is activated; Vedanta Corporate, District/State Administrative Authorities and other Emergency Response Groups are notified.

Emergency Classification - Tiers of Emergency Response

Response strategies shall be commensurate with the nature, scale and associated hazards and risks for relevant emergency event.

The emergencies are classified as Tier 1, 2 & 3. The examples of Tier 1, 2 and 3 incidents are given in **Table 7.15**

Table 7.15 Emergency Classification & Response Team

Emergency Levels	Category	Response	Health & Safety	Environment	Security / Community
Tier 1 Local Reactive	— A minor Incident where site / location team requires no external assistance and can control the incident with local resources — Incident Controller must notify the leader of the ERT or EMT as applicable	Emergency Response Teams (IRT)/(ERT)	— Minor medical or injury case requiring no external support — Equipment damage with loss of production — Minor fire with minor injury or plant damage — Rescue of trapped and injured personnel	— Minor oil spill < 100T(700b bls) — Onsite environmental Exposure contained with internal efforts e.g. chemical spill — Notification of cyclone within 72 hrs	— Minor security breach — Theft from site — Local unrest
Tier 2 Tactical	— Substantial Incident — EMT leader decides to activate EMT — EMT leader must notify CMT Leader	Emergency Management Team (EMT)	— Any incident requiring additional / external resources — Fire or Explosion — Injury or illness requires evacuation	— Oil spill from >100T but <1000T (700–7000bbls) — Environmental exposure requiring outside help — Earthquake — Flood or Cyclone	— Community protest or security breach — Major criminal activity

			— Traffic accident requires external assistance — Well blow out	warning Yellow alert –within 12 hours	
Tier 3 Strategic	— Crisis situation — CMT leader decides to activate CMT CMT leader must notify the Chief Executive Officer	Crisis Management Team (CMT)	— Incident leading to loss of facility — Incident leading to significant financial loss — Incident leading to multiple injuries or fatality — Total loss of marine vessel / vessel hitting platform — Helicopter crash — Well blowout — Incident which could lead to international media interest — Major traffic incident with multiple casualties	— Oil spill more than 1000T (7000bbls) — Major Earthquake	— Terrorist activities /bomb threat — Kidnap or extortion /threat — Major civil unrest /community protest

7.2.5 On-site Emergency Response Plan

The Onsite & Offsite Disaster Management Plan (DMP) and Emergency Response Plan (ERP) are planned for facilities, which are also extended to proposed activities. The scope of the DMP On-site Emergency Preparedness Plan is to evaluate the various types of emergencies that can occur at rig installations and processing/production facilities (Drilling and Production activities) and to formulate emergency plans, procedures that can be implemented by Vedanta Ltd. (Division: Cairn Oil & Gas) in house. In case the contingency exceeds in dimension or geographical coverage beyond Vedanta Ltd. (Division: Cairn Oil & Gas)'s capability, the offsite Emergency plan shall be activated concurrently with the help of District administration

Based on the incident classification and response team matrix mentioned above, Incident Response Team, Emergency Response Team and Emergency Management Team gets involved.

Tier 1 Incident Response Team (IRT):

- The emergency or incident can be effectively and safely managed, and contained within the site, location or facility by local staff.
- Emergency or incident has no impact outside the site, location or facility. IRT may provide support through effective interaction with local stakeholders.
- Loss of life or severe environmental damage or material loss of asset or organisation's reputation is not a consequence of event / emergency.

Tier 1 incidents are managed by Site IRT, each site has own IRT.

Tier 1 Emergency Response Team (ERT):

- The ERT provide assistance and local support to the IRT's in relevant area.
- The ERT have access to local outside site / external emergency services.
- For tier 2 emergency events.

Tier 2 Emergency Management Team (EMT)

- The incident cannot be effectively and safely managed or contained at the site location or facility by operational local staff and additional support is required.

- The incident is having or has potential of impact beyond the site, location or facility and external support may be required.
- Loss of life or severe environment damage or loss of asset or organisation's reputation is possible consequence of event / emergency.
- IRT may provide support through effective interactions with local stakeholders.
- ERT acts as interface between EMT and IRT for Midstream pipeline operations.

Tier 2 EMT is primarily for tactical response to the incident but may on occasions required to act in reactive mode.

Tier 3 Crisis Management Team (CMT):

- The incident has escalated to a level having potential of loss of life, adverse effect on public or company's operations / reputation.
- Incident may have requirement of immediate action / guidance from Top Management.

Tier 3 incidents are incident escalating to the point requiring involvement of CMT

Responsibilities of the Individual Response Organisations

The Incident Response Team is responsibility for managing all incidents and emergencies which may occur at or in close proximity to their operational area. For emergencies where additional / external support is required the person in charge of the incident response, the Incident Controller at a remote location, site or facility must notify and request support and assistance from the next level in the emergency management organisation. The ERT / EMT should be notified of all incidents within 30 minutes of the IRT activation at a remote location, site or facility.

The key role and responsibilities of the IRT Leader will be

- To manage the response to any and all incident or emergencies at the Site, Plant or Field Location
- To Control the incident by preventing escalation and minimizing risk to personnel
- Direct and coordinate the activities of the Incident Control and Forward Response Teams.
- Ensuring sufficient trained and competent personnel are available to support the Response Teams.

- Ensuring the safety of all personnel working at the Site, Plant or Field location
- Evaluate and initiate immediate actions, to contain and mitigate effects of the incident or emergency. Monitor the situation & determine need for evacuation.
- Establish head count and potential whereabouts of any missing personnel and if necessary prepare search, rescue and recovery plan.
- Follow Incident Response Plan and if required develop a plan of action to deal with the incident or emergency and communicating this plan to the IRT members

Emergency Response Team (ERT) – Pipeline (Reactive/Tactical)

This is Emergency Response Team, responsible for coordinating overall incident and emergency response for pipeline incident at any of midstream pipeline locations.

The role and responsibilities of the ERT Leader will be:

- Co-ordination and Support of responses for all incident and emergency situations for the pipeline;
- Reporting all incident and emergency situations in the pipeline operations to the EMT Leader in line with notification requirements;
- Provide and deploy additional resources as needed by the Incident Controller;
- Ensure all direct communications with the EMT;
- Determine the actual and possible impact of the incident;
- Ensure that information associated with the incident is promptly considered by the Support Team;

Emergency Management Team (EMT) – Tactical/Strategic Response

In the event of an incident or emergency the Emergency Management Team Leader will make a decision whether or not to mobilise the EMT. If the decision is taken to mobilise the EMT then all EMT duty personnel are required to proceed promptly to the Emergency Management Team Room and manage emergency in accordance with their role, responsibility and as directed by the duty EMT Leader. DOA shall be nominated for absence.

The EMT organisation has following roles and responsibilities:

- EMT Leader – In overall in-charge / team leader, responsible for Company's tactical response to all emergency situations in respective SBU. They are also responsible for reporting incidents to the regulating authorities.
- Human Resources Coordinator – Responsible for providing HR services advice and support
- Logistics Co-ordinator – Responsible for providing transport and logistics support as required
- Operation and Technical Coordinator – Responsible for providing operational and technical support and advice
- Finance – Responsible for providing financial support and advice.
- HSE Coordinator – Responsible for providing health, safety, environmental support and response.
- Recorder – Responsible for maintaining a timed log of key events and actions
- Security Coordinator – Responsible for providing security support advice and assisting others as required by EMT Leader

The above list identifies a number of key EMT roles, following additional supporting roles may be called on when as and when required, typical roles being:

- Air Medevac Nodal Officer – Responsible for facilitating air medevac.
- IT/Telecommunication Co-ordinator – Responsible for providing the EMT with technical support associated with the communications hardware and software
- Company Medical Officer – Responsible for providing advice and assistance on health and medical issues.
- Legal – Responsible for providing support on legal / regulatory aspects.
- Public Relation / Corp Com – Responsible for communication with media and external stake holders.
- Contractor's representatives – who may be called in to assist the EMT should the incident involve members of their organisation

Crisis Management Team (CMT) Roles

The Crisis Management Team is comprised of small core of senior executives. The CMT will collectively have responsibility for all major actions taken before; during, and after the crisis situation has occurred.

The role and responsibilities of the CMT will be:

- Select additional specialist resources to join the CMT or to advise the CMT during a crisis, depending on the nature of the crisis
- Develop and implement crisis management strategy
- Develop and communicate the operating mandate of the CMT to those with responsibility for the on-scene activities
- Nominate spokesperson to cover media interviews
- Establish contact and communicate with appropriate government or other agencies
- Prepare to coordinate business continuity and recovery strategy

Emergency Response Strategies / Evacuation Plan

Emergency response strategies (ERS) are the documented decisions on required emergency response measures for identified emergencies, based on risk evaluation and assessment process. It shall consider all statutory requirements applicable to the installations.

The objective of ERS is to identify the means to be used to secure adequate emergency response. It provides basis for monitoring of the adequacy of the emergency response measures so that they can be modified when essential. ERS should include appropriate standard of performance for response measures associated with each type of identified major accident hazard and installation specific factors.

ERS should include the following elements:

- Organisation
- Procedures
- Equipment
- Information
- Competency building measures (Training & refresher courses and Drills & exercises)
- The role of any other measure essential for achieving successful emergency response

Emergency response measures shall consider the available resources as below:

- Installation resources: They are immediately available on the installation and are under control of installation Manager / In-charge. These include personnel and equipment that can be assigned emergency role.
- Area resources: These resources are available on the installations in the vicinity, within same area and are not under control of Installation In-charge. The resources may be available within the Vedanta Ltd. (Cairn Oil & Gas) or available by a mutual aid or cooperation agreement.
- External resources: These resources are available by a mutual aid or cooperation agreement at regional, national or international level and include organisations, professional bodies and resource persons.

The general requirements as per Vedanta Technical Standard VED/CORP/SUST/TS 13 on Emergency and Crisis Management are:

- Crisis situations shall be managed centrally by Cairn Oil and Gas business, in accordance with the requirements outlined in the standard.
- SBU operations shall also have procedures in place to ensure crisis situations are escalated to Cairn Oil and Gas business and Vedanta Group as appropriate.
- Emergency situations shall be managed by SBU operations and reported to Cairn Oil and Gas business and Vedanta Group as appropriate.
- Incidents shall be managed at the SBU operation level and reported in accordance with SBU operations, Cairn Oil and Gas business, Vedanta Group and regulatory reporting requirements. Also refer Management Standard MS11 on Incident Reporting, Escalation and Investigation.
- Emergency Preparedness and Response Plans shall be developed, implemented and maintained at the SBU operation, Cairn Oil and Gas business and Group level to deal with incidents, emergencies and crisis situations.

Additional Vedanta Ltd. (Cairn Oil and Gas) requirements are:

- The objective of emergency response planning is to have clear written procedures for expected actions during anticipated emergencies. Emergency response plan includes operational and procedural requirements for various emergency scenarios that are relevant for the installation.

- Ensure that appropriate resources and incident / emergency response plans are prepared, practiced and available. The procedures shall include provision for emergency arrangements with contractors.
- Critical resources of emergency response should include:
  - Emergency power systems
  - Fire and gas detection systems
  - Active fire protection
  - Passive fire protection
  - Shutdown system
  - Explosion mitigation and protection systems
  - Evacuation, escape and rescue arrangements
- Every Cairn business unit (including projects and offices) shall be covered by trained Incident and Emergency Management Teams who will manage and execute the emergency plans.
- All members of the emergency organisations should be trained and competent to perform their assigned role within the incident response (IRT) / emergency response (ERT) / emergency management (EMT).
- Arrangements for emergency medical treatment shall consider injuries to persons as a result of minor accidents & major accidental events, illness of persons on installation, transportation & evacuation of sick and injured personnel.
- Controlled medicines shall be stored in a secure place accessible only to those who are trained to administer these.
- The level of medical facilities and trained personnel provided should be in line with the requirements identified in emergency response strategy. Key points to be considered is identification of medical facilities / hospitals
- Emergency response plans shall comply with all relevant legislative and regulatory requirements to ensure emergency capabilities are maintained and achieved.

- Procedure for designing emergency response measures should be based on:
- Integration of emergency response with / into design and operations
- Automatic or remotely operated safety systems to mitigate the effects of an incident
- Emergency response organisation structure
- Wherever applicable offsite emergency response / disaster management plans shall be ensured.
- Essential safety system (such as control stations, temporary refuge, muster areas, fire pumps) shall be located where they are least likely to be affected by fires and explosions.
- Emergency shut down (ESD) system shall be designed such, that it is capable of fulfilling its function under the conditions of incident. If installation is in operation, the essential shutdown functions shall be available during maintenance activities, which affect the operation of the ESD system. ESD system shall contain facilities for testing of both input / output devices and internal functions.
- Evacuation and escape routes shall be provided from all areas of an installation where personnel may be expected to be present during their normal activities. Alternative means to allow persons to safely leave the installation in an emergency shall be provided.
- Evacuation and escape routes shall have adequate illumination with emergency lighting and shall be marked to ensure that 'they can be used during emergency conditions'. All escape routes shall be unobstructed (including vertical clearance) and readily accessible.
- Personal protective equipment for use in major accident hazards should be suitable for the circumstances in which it may have to be used and the individuals who may have to use it.
- PPE for use in an emergency should be for all persons on the installation for use in condition of fire, heat, gas release or smoke to enable them to reach muster areas, temporary refuges and evacuation or escape points. Those with specific emergency duties shall also be provided appropriate PPE for use like fire suits and breathing apparatus etc.
- During an emergency, security arrangements shall ensure that unauthorised persons do not enter the incident site by controlling assess and if need arises the area around the site can be evacuated and cordoned to ensure safety of the persons.

- Environmental emergency response should consider:
  - Oil-pollution control equipment that should be located on the installation
  - Environmental conditions that may be present when the equipment is deployed
  - Capacity of the oil recovery system
  - Characteristics of the oil / emulsion to be recovered
  - Means to identify the extent of the spill
  - Facilities to handle any recovered oil.
- International conventions have introduced the requirements to develop national plans for oil-spill response in offshore, and Offshore Assets / SBUs / Operations should ensure that their installations' emergency response plans are aligned with the national requirements.

Responsibilities of the Employees

The establishment and maintenance of best possible conditions of work is, no doubt, the responsibility of the Project Management. It is also necessary that each employee follows prescribed safe methods of work. He should take reasonable care for the health and safety of himself, or his fellow employees and of other persons who may be affected by his action at work. With this in mind, employees shall be trained to be health and safety conscious in the following aspects:

Report	**Potential Hazards**
Observe	Safety rules, procedures and codes of practice
Use	Tools and equipments with all care and responsibility
Participate	In safety training course when called upon to do so.
Make	Use Of safety suggestion schemes.
Take	An active and personal interest in promoting health and safety

Each unit shall identify and document the resources required to ensure the effective implementation of the emergency and crisis management procedures. Resource requirements shall meet the requirements of the Vedanta Management Standard MS01 on Leadership, Responsibilities and Resources. The following resources shall be considered and made available as necessary:

- Trained and competent personnel;

- Equipment and other materials including Personal Protective Equipment (PPE);
- Warning devices;
- Medical services, including personnel trained in first aid, and medical equipment that is appropriate to the type of operation;
- Emergency services support; and
- Emergency funding, along with an appropriate mechanism for delivering funds.

The capacity of external resources, such as local firefighting capacity, shall be assessed, and additional resources acquired and maintained at the operation where external resources are deemed insufficient.

The resources identified shall be maintained and tested on a regular basis, and their adequacy reviewed periodically.

Communication Systems

Emergency response relies upon effective and reliable communication between all personnel involved in response. Communication systems shall:

- Provide sufficient reliable information / alarm to personnel on the installation to enable them to take the appropriate emergency actions.
- Provide means for those on the installation to communicate with the person in overall charge.
- Provide reliable arrangements to allow the person in overall charge to communicate with all personnel on the installation regarding the nature of any emergency and the actions they are required to take.
- Provide reliable means to allow the person in overall charge to communicate with area and external resources who have a role in emergency response.
- Suitable equipment, information processing and procedures shall be in place to enable effective communications. The means of communication shall be selected based on the need for communication in likely scenarios including operational conditions under which they are to function like, noise, ambient conditions and susceptibility to damage. So far as

reasonable, communication arrangements should remain available throughout the emergency

- Alarm signals used and their meanings should be described in the emergency response plan along with the procedures to be followed in the event of an alarm. Persons should be provided with adequate information to allow them to, initiate alarms where necessary, distinguish between alarms and respond to alarms.
- Adequate alarms and warning devices, along with other forms of communication, shall be maintained to reliably alert persons across the whole site in the event of an emergency.
- Independent secondary / back-up communications systems shall be provided in case the emergency incident makes the normal communication system inoperable.
- Ensure that the means are in place to alert to the connected installations, the local community / neighboring businesses in the event of an emergency that has the potential interface with them.

Training and Emergency Response Drills / Mock

All persons on the installation or in connected activities (including contractor's personnel) shall be trained periodically for emergency response and evacuation procedures. Training for employees having assigned roles in emergency response shall be completed before they are called upon to perform in real emergencies. Emergency response organisation structure (IRT/ERT/EMT/CMT) shall ensure command by competent persons, which can be maintained, so far as is practicable, throughout an emergency.

- Key persons such as the Installation Incharge and Shift Incharge / control room operator shall be assessed for required competence to perform emergencies duties before assigning of duties. As far as possible, assessment should be under simulated emergency conditions.
- Competency and training needs shall meet the requirements of the Vedanta management Standard MS06 on Competency, Training and Awareness
- An emergency response table top exercise / emergency response drill is a focused activity that places the participants in a simulated situation requiring them to function in the capacity that would be expected of them in a real event. Its purpose is to ensure preparedness by testing policies and plans and by training personnel. One objective of an

exercise is to be able to identify problem areas for resolution/ corrective action before an actual emergency occurs.

- The drills need to address the readiness of personnel and their familiarity / proficiency with emergency equipment and procedures. All personnel on the installation involved including contractor's employees should participate in the drills.
- The drills and table top exercises shall be carried out as often as appropriate, against documented schedule. To be scheduled regularly, at least once a year for full drills and six monthly for desk-based exercises, although the exact frequency and type of drills may depend on the nature and scale of the operations, and the associated risks.
- Emergency response plan shall be reviewed and revised as appropriate in line with the findings from drills and table top exercises.
- Involve external emergency response agencies and other external stakeholders, where appropriate.

Performance Measures

- Key elements of functionality, survivability, reliability and availability shall be included in performance standards. Achievability of performance standards should be validated.
- Effective operations, inspection, testing and maintenance procedures shall be established to ensure that the functional requirements of the equipment and systems provided for emergency escape, evacuation and rescue response are maintained.
- A written scheme shall be prepared, detailing the inspection, testing and maintenance routines and frequencies to be followed. All emergency equipment and systems shall be thoroughly inspected, following established procedures. Adequate records of the results of the inspection, testing and maintenance shall be kept and shall be periodically reviewed to confirm that the written scheme is appropriate and is being adequately implemented.

Monitoring, Evaluation and Review

Documented reviews should be carried out after all drills and actual emergency responses to determine the effectiveness of the Emergency Preparedness and Response Plans, with a full debrief to identify what worked well and what aspects require improvement.

Lessons learned following exercises or actual emergency situations/incidents shall be documented, and any gaps in planning and implementation shall be addressed in revised versions of the Emergency Preparedness and Response Plans. Lessons learned shall be shared across Vedanta's operations where appropriate.

All Emergency Preparedness and Response Plans shall be reviewed and updated periodically, at least on an annual basis, to ensure they remain appropriate and relevant. Reviews shall also meet the requirements of the Vedanta Management Standard MS14 on Management Review and Continual Improvement.

Preventive and Mitigation Measures for Well Blow out

Blow-out (uncontrolled gushing of oil & gas) is the worst situation, which may arise at oil wells during drilling, work-over operations, perforation, and reservoir studies at active wells, etc. or due to some unforeseen reasons.

A blow out, though rare, in a drilling operation is often accompanied by fire and explosion exposing workers to serious danger to their lives, burns and poisoning. To understand the failure modes resulting to formation of kick and subsequent blow outs, one has to understand the safety systems installed for blow out prevention.

Prevention of blow outs rests primarily on control of any kick in the well bore. A kick means entry of formation fluids into well bore in large enough quantity to require shutting in the well under pressure. Once a kick is detected, steps can be taken to control entry of formation fluids into the well bore by over balancing the expected bottom hole pressure with properly conditioned mud and operation of safety valves i.e. Blow Out Preventer (BOP), whereby the space between the drill pipes and the casings can be closed and well itself shut off completely. Several instruments are provided on a drilling rig for detection of kicks.

Instrumentation in Mud System

Continuous monitoring of condition of mud in the well provides information useful for well control. The following processes are used in the drilling mud system for this purpose:

- A pit level indicator registering increase or decrease in drilling mud volume. It is connected with an audio-visual alarm near the drillers control panel.
- A trip with float-marking device to accurately measure the volume of mud going in to the well. This is useful to keep the well fed with required quantity of mud at all times.

- A gas detector or explosive meter installed at the primary shale shaker together with an audio-visual alarm at the drillers control panel to indicate the well presence of gas-cut mud in the well.
- The kick in the well is prevented by keeping the hydrostatic head of the drilling fluid greater than the formation pressure. The primary control can be lost in the following situations:
- If there is reduction in hydrostatic pressure in the well due to swabbing, which maybe caused if the drilling string is pulled out too fast or by a balled-up or clogged bit, which is indicated by insufficient filling of mud.

Preventive Measures for Handling Natural Gas

The natural gas is a colourless, odourless, flammable gas, mainly methane which may cause flash fire. Electrostatic charge may be generated by flow, agitation etc. No occupational exposure limits have been established for natural gas. The preventive measures to be taken to avoid impact due to leakages are

- Provide local exhaust ventilation system: Ventilation equipment should be explosion-resistant if explosive concentrations of material are present.
- Gloves: Wear appropriate chemical resistant gloves.
- Respirator: Under conditions of frequent use or heavy exposure, respiratory protection may be needed.

Leakage of H_2S Gas

Hydrogen sulphide is a colourless, flammable, extremely hazardous gas with "rotten egg" smell. Low concentrations of H2S irritate the eyes, nose, throat and respiratory system e.g. burning / tearing of eyes, cough, and shortness of breath. Repeated or prolonged exposures may cause eye inflammation, headache, fatigue, irritability, insomnia, digestive disturbances and weight loss.

The preventive measures to be taken up in case of leakages are:

- Stop the source of leakage (i.e. close the well)
- Remove victim, if any to fresh air, if breathing, maintain victim at rest & administer oxygen, if available, if person is not breathing, start artificial respiration immediately or

start mechanical/ automatic resuscitator. Call ambulance and sent victim to hospital or doctor.

- Avoid & extinguish all naked flames
- Pull out all inflammable material i.e. HSD, Gas Cylinders, Chemicals etc. from the premises of well / installation.
- Pull out all possible equipment to safe distances.
- Call for fire tender and start spraying water on the sources of leakage to dissolve H2S in water.
- Evacuate personnel in 500 mts area from down wind direction.
- Warn nearby inhabitants, if required.
- Cordon off the area & do not allow entry of any unauthorized person.

Vedanta Ltd. (Cairn Oil & Gas)'s operations in the Block have indicated that there is no naturally occurring H2S in the reservoir and therefore release of H2S during drilling operations is not expected.

Preventing Fire and Explosion Hazards

Fire is one of the major hazards, related to oil and natural gas well. Fire prevention and code enforcement is the area of responsibility of the fire service. Safe operating practices reduce the probability of an accidental fire on a platform. Personnel should understand their duties and responsibilities and be attentive to conditions that might lead to fire. The following precautions are recommended:

- Fire control cannot be achieved until the source of fuel and ignition is isolated. Fire control cannot be achieved until the source of fuel and ignition is isolated. An emergency shut down (ESD) system shall be provided to isolate the installation from the major hydrocarbon inventories within pipelines and reservoirs, which if released on failure, would pose an intolerable risk to personnel, environment and the equipment / assets.
- There should be provision for safe handling and storage of dirty rags, trash and waste oil. Flammable liquids and chemicals spilled on platform should be immediately cleaned.

- Containers of paints and HC samples, gas cylinders should be stored properly. Gas cylinders should be transported in hand-carts
- Cutting and welding operations should be conducted in accordance with safe procedures
- Smoking should be restricted to designated platform areas and "no smoking" areas should be clearly identified by warning signs
- Platform equipment should be maintained in good operating condition and kept free from external accumulation of dust and hydrocarbons. Particular attention should be given to crude oil pump, seals, diesel and gas engines which could be potential source of ignition in the event of a failure
- The Disaster Management Plan will address the issue of a fire event at any location on the well and the procedure to be adopted in the very unlikely event of this occurring. If a fire starts in any well, that section of the well will be isolated by closing the section (block) valves, as quickly as possible and surrounding facilities will be cooled with water.

7.2.6 Off-site Emergency Plan

The Off-Site Emergency Plan is a compilation of various emergency scenarios and also includes the probable impact off-site locations due to emergency and the action plan to combat / mitigate the consequences of a disaster situation. Emergency is a sudden unexpected event, which can cause serious damage to personnel life, property and environment as a whole, which necessitate evolving off-site emergency plan to combat any such eventuality. Emergencies can be handled by an organized multi-disciplinary approach. If it becomes necessary to evacuate people, then this can be done in orderly way.

Under the Environmental (Protection) Act 1986, the responsibility of preparation of Off-Site Emergency Plan lies with the State Government. The Collector/ Deputy Collector by virtue of their occupation are normally nominated by the concerned State Government to plan Off-Site Emergency Plan. The different agencies involved in evacuation of people are civil administration (both state and central) and police authorities.

Purpose

- To save life and prevent/reduce loss of properties
- To make explicit inter related set of actions to be undertaken in the event of an accident posing hazards to the community

- To plan for rescue and recuperation of casualties and injuries. To plan for relief and rehabilitation
- To plan for prevention of harms, total loss and recurrence of disaster. It will be ensured that absolute safety and security is achieved within the shortest time

The activities of the government, Non-Government organizations and concerned personnel involved in off-site disaster management plan are as follows:

These will include the safety procedures to be followed during emergencies such as posters, talks and mass media in different languages including local language. Leaflets containing do's/ don'ts should be circulated to educate the people in vicinity

Medical Help consisted of doctors and supporting staff for medical help to the injured persons because of disaster should be formed. Functions and duties of the committee include, providing first Said treatment for injured at the spot or at some convenient place and shift those to nearby hospitals for further treatment if required.

The police will assist in controlling of the accident site, organizing evacuation and shifting of injured people to nearby hospitals.

The fire brigade shall organize to put out fires other than gas fires and provide assistance as required. Approach roads to accident site and means of escape should be properly identified. Chief fire officer should co-ordinate entire fire control measures. Routine training of fire fighting equipment and special rescue equipment should be carried out. Concerned officer should ensure adequate supply of fire water and fire fighting agents at the site of emergency. Maintenance of standby equipment / personnel for fire fighting should be ready at any given time.

Mutual Aid

Disaster / emergency / risk, when becomes difficult to control by in house team / management, help from nearby industries, institutions, etc. can be taken. A group of mutual aid can be formed where emergency control systems like ambulance, firefighting equipment, medical & fire-fighting team, etc. can be shared in the event of need.

Post Emergency Relief to the Victims

The Public Liability Insurance (PLI) Act, 1991 provides for the owner who has control over handling hazardous substances to pay specified amount of money to the victims as interim relief by taking insurance policy for this purpose. The District Collector has definite role in implementation of this act. After proper assessment of the incident, he shall invite applications for relief, conduct an enquiry into the claims and arrange payment of the relief amount to the victims.

General Health and Safety

The project will adhere to health & safety norms of The Factories Act, 1948 and Rajasthan Factory Rules, 1951, as applicable along with Best Industry Practices.

General health and safety issues during various project activities are similar to those of most large infrastructure and industrial facilities and their prevention and control. These issues include among others, exposure to dust and hazardous materials, hazardous materials components, and physical hazards associated with the use of heavy equipment, etc.

Specific health and safety issues primarily include the following:

- Physical hazards
- Chemical hazards
- Confined spaces

Physical Hazards - The main sources of physical hazards are associated with machinery and vehicles. General electrical equipment safety, working in confined spaces, hot work, high temperature areas are expected to be present.

Chemical Hazards - workers may be exposed to chemical hazards especially if their work entails direct contact with fuels or chemicals, flare & DG set emission or depending on the nature of activities. Work with fuels may present a risk of exposure to volatile organic compounds (VOC) via inhalation or skin contact during normal use or in the case of spills.

Noise - Noise sources include drilling, DG operations, including vehicular traffic, and boats. In order to evaluate the impacts of proposed project on the health of workers, baseline health studies will be carried out on every worker before joining their duties.

The hierarchy of control specific for health & safety (in order of priority):

- Eliminate the use of a harmful product or substance and use a safer one;
- Substituting wherever reasonably practicable, a non-hazardous material which presents no risk to health, where a hazardous material is used intentionally, i.e. use a safer form of the product;
- Modifying a process to eliminate the use of risk, the production of a hazardous by-product or waste product, including reducing the quantities of the hazardous material which are used & stored, i.e. change the process to emit less of the substance;
- Enclose the process so that the product does not escape;
- Extract emissions of the substance near the source;
- Provide personal protective equipment (PPE) such as gloves, coveralls and a respirator. PPE must fit the wearer.

Personal Protective Equipment

Often it is not possible, or practicable, to eliminate exposure to materials hazardous to health completely. In such cases, operations should consider how to prevent employees being exposed and the prevention of exposure should be achieved by measures other than the use of PPE or Respiratory Protective Equipment (RPE), which is the last line of defence.

Situations where PPE/RPE will normally be necessary include:

- where adequate control of exposure cannot be achieved solely by good practice and the application of operational or engineering measures;
- where new or revised assessment shows that PPE/RPE is necessary until adequate control is achieved by other means;
- where there is temporary failure to achieve adequate control of the process, e.g. because of plant failure, and the only practicable solution to maintain adequate control in the time available may be the provision and use of suitable PPE/RPE; and
- where maintenance operations have to be carried out.

Key personal protective equipments will include:

- Body suit
- Hand gloves
- Helmet

- Safety shoes
- Safety harness
- Breathing apparatus
- Eye shield
- Ear muffs

First Aid

Medical services, including personnel trained in first aid, and medical equipment that is appropriate to the type of operation will be provided at project.

All persons on an installation should have at least basic training in emergency response, basic first aid, use of life saving appliances and firefighting. Individual competencies shall be periodically tested to identify further requirement of training and knowledge to perform emergency duties.

It will be ensured that any auxiliary medical teams e.g. nurses and first aid personnel are fully trained and conversant with their roles and responsibilities.

Contact details & capacities of nearby medical facilities and medical experts will be made available at strategic locations.

Disaster Management Plan for Natural Hazard

Pre-Incident:

1. The District Magistrate is overall in-charge of all emergency operations to deal with Disaster arising anywhere in thedistrict.
2. Assessment of possible major hazards in the district with special focus on major hazard industry/ installations, major railway/ road accidents, air raids and the natural calamities
   a. e.g. Earth quake, lighting etc.
3. Make the assessment of facilities and equipment available with all departments, organization and to suggest improvement for the up gradation of facilities and equipment for dealing withemergency.
4. Formulate District Disaster Management Control plan in order to mitigate the effects of disaster so as to minimize the loss of life property & environment. Nominate additional DDM Controller or his subordinate to take charge of control room in case ofdisaster.
5. To establish the District Disaster control room with suitably skilled person for taking

action in case of emergency and to equip it with necessary information, documents route map, MSDS, composition and sufficient & effective means ofcommunication.

6. Issue instructions, standing order to all departments, organization, industries and services to prepare and act in accordance with the District Disaster ManagementPlan.
7. Be familiar with the major hazards industries and installation as well as possible effects of naturalcalamities.
8. Ensure the training of all the members ofDDM/P.
9. Ensure awareness in respect of the public emergency preparedness through News Paper, Radio, T.V. & D. P.R.O.etc.
10. Hold periodical mock/ training exercise to ensure optimum operationalpreparedness.
11. Review the efficiency of theDDM/P.

During the Emergency / Incident:

1. On getting information of the incident Deputy Commissioner will contact the site incident controller or other sources of information for detailed information regarding the level of emergency.
2. If he is satisfied that the emergency is major he will immediately put all the emergency services into action as per procedure laid down in the District Disaster Management Plan. After that he will rush to the seen of emergency if it islocalized.
3. On reaching the accident site he will assess the gravity of theemergency.
4. He will ensure the arrival of all the emergency services at thesite.
5. Direct and co-ordinate the activities of various agencies involved in the emergency operation like fire fighting, rescue operation, evacuation of employees and General public, shifting of injured to hospitals and management ofcausalities.
6. Keep in constant tough with District emergency controlroom.
7. Take latest information of thesituation.
8. Direct the rescue operation.
9. Seek help from State crises group and Central Crisis group, adjoining Districts and Central Government ifrequired.

After the emergency / incident:

1. Declare the emergency to beover.
2. Arrange for the rehabilitation of evacuatedpublic.
3. Ensure essential amenities for thepublic.

4. Keep watch on any disease/ epidemics due to and after effects of theemergency.
5. Arrange for the treatment rehabilitation of effected employees andpublic.
6. Provide relief under public liability Insurance Act1991.
7. Investigate the cause of accident/ major emergency or constitute an investigating committee.
8. Arrange for the implementation of remedial action to prevent the recurring of emergency based oninvestigation.
9. Keep records of weakness/ shortfalls/ lapses and causes of failure of disaster control management plan during emergency operation and suggest measures forimprovement.

CHAPTER –VIII

PROJECT BENEFITS

8.0 PROJECT BENEFITS

The proposed exploration and appraisal project will establish the potential of hydrocarbons in the Block. The development of the oil Block will result in considerable growth of service sector and will also generate direct/indirect employment and business opportunities in the area. The major benefits of the project include reduction of the oil import bill of the nation as well as reduction of the imbalance in oil production and consumption.

The commercial development will also lead to investment in Assam, bringing oil and gas revenues both to the State and to the Central Government. The presence of Vedanta Limited (Division: Cairn Oil & Gas) in the region will substantially improve the socio-economic conditions of the region. Employment opportunity for local people as contract/daily wages in nearby areas.

8.1 REVENUE EARNING OF CENTRAL & STATE GOVERNMENT

In the event of hydrocarbon discovery and then its production, central as well as state government will get benefited.

8.2 EMPLOYMENT POTENTIAL

The employment of local people in primary and secondary sectors of project shall upgrade the prosperity of the region. This in-turn will improve the socio-economic conditions of the area.

- During operation phase of the project, this project will provide employment to many unskilled and semi-skilled workers; During the site preparation for drilling, approximately 30-35 workmen will be employed per drill site.
- During the drilling phase, about 50 workmen per shift will be working on site. This will include technical experts, who will be responsible for various drilling related activities and some technical manpower. It is anticipated that, at any given time, there will be about 80 - 100 personnel working on site including technical staff, drilling crew, security staff etc.
- This project will also help in generation of indirect employment to those people who render their services for the personnel directly working in the project; and

- In the event of hydrocarbon discovery in the Block, considerable number of people will be benefited by provision of services to the residents including hotels, restaurants, transport services etc. Thus, the direct and indirect employment generation by this project.

8.3 CORPORATE SOCIAL RESPONSIBILITY

CSR measures will be taken up by Vedanta Limited (Division: Cairn Oil & Gas) in case of commercially viable hydrocarbon discovery & further full-fledged development of the fields and production and associated facilities as per the provision of Govt. regulation and guidelines.

CHAPTER – IX

ENVIRONMENTAL MANAGEMENT PLAN

9.0 INTRODUCTION

This chapter provides a description of the administrative aspects of ensuring that mitigative measuresare implemented and their effectiveness monitored, after approval of the EIA.Based on the evaluation of impacts and baseline conditions, an Environmental Management Plan (EMP)has been delineated to mitigate the adverse impacts. The EMP includes formulation, implementation andmonitoring of environmental protection measures. The EMP features guidelines and methodologies to beadopted at different stages of the proposed project for mitigating the impacts of various activities.The EMP is herein outlined after taking into account the various Acts, Rules and Regulations/Standardsconcerned with the environmental management.Thus, it is a planned and integrated programme aimed at ensuring that both identifiedand unidentified impacts that may arise during the various phases of the project are brought to an acceptable level.

9.1 EMP DURING VARIOUS PROJECT PHASES

Environmental Management Plan (EMP) is the key to ensure a safe and clean environment. The desiredresults from the environmental mitigation measures proposed in the project may not be obtained withouta management plan to assure its proper implementation and function. The EMP envisages the plans forthe proper implementation of mitigation measures to reduce the adverse impacts arising out of the projectactivities. EMP has been prepared addressing the issues like:

- Pollution control/mitigation measures for abatement of the undesirable impacts caused duringthe construction and operation phase of the project.
- Details of management plans (air pollution control devices/measures, utilization of treatedeffluents, solid waste management plan etc.).
- Institutional set up identified/recommended for implementation of the EMP.
- Post project environmental monitoring programme to be undertaken
- Expenditures for environmental protection measures and budget for EMP.

The environmental management plan has to be implemented to minimize the adverse impact on environment such as reduction in atmospheric emissions, liquid effluents, solid wastes and noise generation.

9.2 HSE ORGANOGRAM

A dedicated team at site will be responsible to ensure project operations with due reference to environment management and the Safety of the workers. Vedanta Limited (Division: Cairn Oil & Gas) HSE Organizational structure is shown in **Fig 9.1**

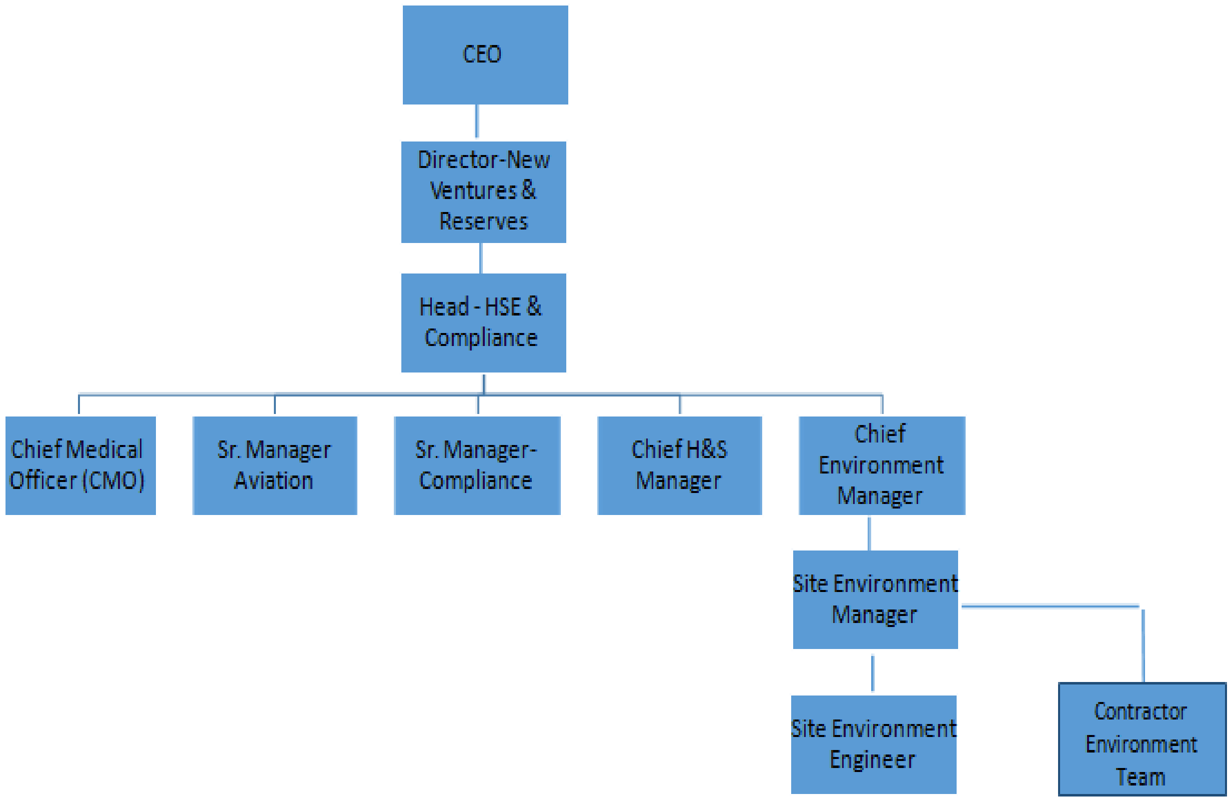


Fig 9.1: HSE Organizational structure

The HSE team will have the following responsibilities:

Ensure effective implementation of the Environmental Management Plan (EMP) through review and periodic updation.

Vedanta Limited (Division: Cairn Oil &Gas) would have the ultimate responsibility of implementing the environment management plan along with drilling contractor. The drilling contractor will have an HSE management system, which will be reviewed by Vedanta Limited (Division: Cairn Oil &Gas) prior to implementation.

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HSE Policy

At Vedanta Resources Plc, we believe in sustainable development and are committed to effective management of health, safety and the environment as an integral part of our business. The health and safety of our employees and stakeholders who may be impacted by the company's operations is of paramount importance and our aim is zero harm to people and to the environment.

Vedanta Resources and its subsidiaries strive to:

- Comply with applicable national, regional and local Health, Safety and Environment ('HSE') regulations and statutory obligations and other requirements as appropriate. The company develops, implements and maintains HSE management systems aligned with our sustainable commitments and beliefs and consistent with world-class standards. We will drive continuous improvement in HSE through setting and reviewing targets, assessing and reporting HSE performance, using appropriate best available practices and providing all employees with appropriate training;
- Prevent injury and ill health to the company's employees and contractor' s employee's by providing a safe and healthy work environment and by minimising risks associated with occupational hazards;
- Improve and enhance environmental conditions and avoid, reduce, mitigate or compensate the environmental impacts to neighbouring communities in which we operate including air, water emissions and noise;
- Conserve natural resources, through adopting environmentally friendly and energy efficient technology and process improvements. The Company is committed to managing waste of our operations and we adopt the principles of waste avoidance, reuse, recycling and beneficial utilisation to minimise discharge and disposal to the environment;
- Promote a positive HSE culture within our organisation through effective communication, participation and consultation with employees in the workplace;
- Implement regular health surveillance and risk-based monitoring of all employees;
- Influence our contractors and suppliers to adopt principles and practices adopted by us and in accordance with our own policies;
- Communicate with all our stakeholders on the progress and performance of HSE management.

Vedanta Ltd. and Konkola Copper Mines (KCM) the wholly owned subsidiaries of Vedanta Resources sign this policy, which is implemented throughout their businesses. The content and robustness of implementation of this policy will be reviewed periodically and revised accordingly, and includes sharing best practices throughout the group.

We will also measure progress against this policy and review performance on a periodic basis to ensure ongoing management of Health, Safety and Environment.

Signed by:

Tom Albanese
Group CEO, Vedanta Resources plc

Date: *1st April 2014*

Fig 9.2: HSE Policy

9.3 ENVIRONMENTAL MANAGEMENT PLAN

The Draft EIA for the exploratory drilling programme has identified a number of impacts that are likely to ariseduring site preparation, drilling, well testing and demobilization. Environmental management plan (EMP) includes action to protect environment by using instruments, adoption of industrial best practices, surveillance and statutory norms. The EMP provides a delivery mechanism to address potential adverse impacts, to instruct contractorsand to introduce standards of good practice to be adopted for all project works. The EMP can bedeveloped into a standalone document covering each stage of the exploratory drilling programme.

Environmental Management Plan of the project provide the details of environmental quality controlmeasures which will be taken up and which are proposed by complying with the stipulated standard limitsspecified by CPCB and State Pollution Control Board. Environmental Management Plan which will beimplemented is detailed under the following heads.

- Air Pollution Control
- Noise Mitigation
- Biological Environment
- Soil environment
- Socio Economic Environment
- Wastewater Management
- Solid Waste Management

9.3.1 Air Quality Management Plan

The Air Quality Management Plan (AQMP) encompasses both constructions, drilling and early production phase activities for the proposed project that has the potential to adversely affect ambient air quality due to the proposed project.

The AQMP establishes specific measures and guidelines aimed at effectively addressing and mitigating the air quality impacts that may arise as result of construction of well sites and Early production, drilling operations, operation of early production unit and decommissioning/site closure of well sites. The plan also details out roles and responsibilities of Vedanta Limited (Division: Cairn Oil & Gas) and the contractors to ensure effective implementation of the plan.

Mitigation Measures

Phase	Mitigation Measures
Construction/ drill Site Preparation	**<u>Designing, Planning & Procurement</u>** • Vehicles delivering raw materials like fine aggregates will be covered to prevent fugitive emissions; • Storage and handling of construction material and debris to be carefully managed to prevent generation of fugitive dust; • All vehicles use 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 vehicular Emission; • The top soil stripped from site clearance activities will be stored in designated area; • Adequate stack height to be provided to DG sets in accordance with CPCB standards. **<u>Dust Suppression</u>** • Sprinkling of water on earthworks, material haulage and transportation routes on a regular basis, especially in dry season.
Drilling and early production	**<u>Operation of Machineries, Vehicle & Drilling Rig</u>** • Exhausts of diesel generators will be positioned at a sufficient height to ensure

Phase	Mitigation Measures
	dispersal of exhaust emissions; engines will not be left running unnecessarily; • Vehicles involved in the transportation of project personnel will have valid PUC Certificate and will be subjected to periodic preventive maintenance; **Periodic Maintenance of Machinery and Vehicles** • Periodic maintenance of DG / GEG sets will be undertaken; • Flaring will be undertaken in accordance with the CPCB Guidelines for Gaseous Emissions for Oil & Gas;

9.3.2 Waste Management Plan

The Waste Management Plan (WMP) is applicable for all process and non-process waste streams which are generated during various phases of Vedanta Limited (Division: Cairn Oil & Gas) proposed drilling and testing of hydrocarbons in this block. The major waste streams covered under this plan includes drill cuttings, waste drilling mud, drilling wash water, kitchen waste and sewage. In addition, waste oil and lead acid batteries generated from the proposed project operations have also been dealt in this plan.

The WMP establishes specific measures to ensure proper collection, storage, treatment and disposal of the identified process and non-process waste streams in accordance with the applicable national regulations and guidelines and also to ensure compliance with Vedanta Limited (Division: Cairn Oil & Gas) corporate HSE Policy. The plan also outlines roles and responsibilities of both Vedanta Limited (Division: Cairn Oil & Gas) and the contractors involved in the implementation of the plan.

Mitigation Measures

The following mitigation measures need to be adopted and implemented by Vedanta Limited (Division: Cairn Oil & Gas) and its contractors for the major waste streams identified in the plan.

Waste	Quantity	Mitigation Measure
Drill Cuttings	Drill cuttings associated with WBM: 250-750 tons/well, Drill Cuttings associated with SBM (500-1500 tons/well)	— Drill cuttings separated from drilling fluid will be adequately washed and temporarily stored and disposed — All drill cuttings will be disposed as per Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016;
Spent WBM	250-500 tons/well	— The mud will be disposed as per Hazardous Waste Rules, 2008
Waste oil/ Used oil	1-2 tons/well	— Hazardous waste (waste and used oil) would be managed in accordance with Hazardous Waste (Management, Handling & Transboundary Movement) Rules, 2008. —
Municipal Solid Waste	25-30 kg/well	— The waste will be segregated at source (organic/inorganic) and disposed accordingly. — All kinds of waste will be disposed in accordance with the requirement of CPCB/RSPCB.
Sewage	15-25 m^3/day per well	— Sewage generated from campsite would be treated through mobile STP. — Treated waste water will be used for

Waste	Quantity	Mitigation Measure
		dust suppression, green belt, landscape, etc
Recyclables *viz.* paper, plastic, packaging waste etc.	Depending on usage	— Proper segregation and storage of recyclable waste in designated bins. — Recyclables will be periodically sold to local waste recyclers.

9.3.3 Soil Quality Management Plan

Soil Quality Management Plan is applicable for construction of well sites, drilling operations, operation of early production facilities and decommissioning/site closure that has the potential to adversely impact the soil quality.

Mitigation Measures

Project Phase	Mitigation measures
Site Preparation	— Site preparation and road strengthening/widening activities would be restricted within defined boundaries. — Use appropriate machinery and/or protective boarding during top soil stripping to ensure minimum compaction. — Debris and excavated material generated during construction activities would be stockpiled in designated areas onsite. — Top soil will be stored properly. — Drip trays to be used during vehicular/equipment maintenance and during refueling operations. — In case of a spill, the spilled soil is to be removed and stored in hazardous waste storage area.

Project Phase	Mitigation measures
Drilling	— Fuel and chemical storage areas would be paved and properly bunded. — Spill kits would be made available at all fuel and chemical storage areas. All spills/leaks contained, reported and cleaned up immediately. — Drip pans/trays would be used in areas identified having spillage potential but not limited to drill rig engine; electric generator engine; pumps or other motors; maintenance areas; fuel transfer areas. — In case of a spill, the spilled soil is to be removed and stored in hazardous waste storage area — Management of drill cuttings, waste drilling mud, waste oil and domestic waste would be made in accordance with "*Waste Management Plan*"
Decommissioning/Site Closure	— Decommissioning at the end of project life/drilling would have some adverse impacts in terms of increase in soil erosion and would require adequate mitigation measures to minimize any adverse impacts. The mitigation measures would be similar to those outlined for construction phase activities as discussed earlier.

9.3.4 Spill / Release Management Plan

Potential spill / release scenarios

The following section details the potential spill scenarios associated with the drilling activities as well as the oil spill incident responses. Spill incidents from drilling activities can be classified into three types based on the level of response required. A description of the three types are as follows:

Type 1

A small oil or chemical spill incident which can respond to and can be controlled with the existing resources, equipment and resources at the site and without any further escalation. Most of the potential drill stage spill risks are Type 1. As the spill / release incident as the volumes involved are limited due to the extent of hydrocarbons or chemicals used or stored at site. Such possible incidents are likely to include:

- Diesel spills from refuelling i.e., drill rig - hose leaks, overfilling or connection/disconnection incidents.
- The use of liquid chemicals i.e., during drilling the volumes are limited by the storage containers used, drums etc.
- Hydraulic oil spill resulting from a split hydraulic hose or failed connector (moderate pressure, low volume lines).
- Drilling fluid leaks from tanks, pumps or other associated equipment within the closed loop recirculation system.

Type 2

Type 2 spill / release incidents are those that are beyond capability of the immediate resources on-site to effectively manage and contain, requiring additional external resources to assist with the response to the spill incident. Type 2 spill incidents may require initiate Emergency operations and will involve call out of the Fire Service (in the event of danger to people) and/or regional resources. For such potential spill incidents, the resources of the local administration or suppliers may be required. Such possible incidents are likely to include:

- Transportation incidents associated with the delivery of diesel or drilling fluids to site i.e., truck rollover or collision from external suppliers (drilling fluids and diesel).
- Complete failure of an on-site drilling fluid (base oil) storage tank(s).

Type 3

Type 3 spill / release incidents are significant spill incidents that escalate from a Type 1 or 2 and exceed the capabilities of the on-site and local administrative resources to respond, requiring a State /National response. An uncontrollable well blow out scenario would fall into this category.

Spill / Release Response Strategies

Spill / release response strategies for combating spill / release incidents include:

- Prevent or reduce further spillage.
- Monitoring and evaluation (no active intervention but the spill is under observation).
- Mechanical containment and recovery.
- Protection of sensitive areas.
- Clean-up, and
- Any combination of the above strategies.

A brief explanation of these various response strategies is provided in the following sections.

Prevent or reduce a spill / release incident

One of the first response actions, if safe to do so, is the isolation or prevention of the source of the spill / release in an attempt to limit any further discharge. Such first response actions can involve an emergency shutdown of the particular equipment, isolation of a valve or line causing the spill or providing some immediate containment to prevent the further spread of a spill / release. Such measures are only a first immediate response prior to a more coordinate effort being planned and undertaken.

Monitoring and Evaluation

Knowing the position of spillage / release source and having the ability to forecast its movement or direction is an essential component of spill response. Monitoring and evaluation is used to:

- Determine the location and movement of the spill / release (if any).
- Describe its appearance.
- Estimate the size and quantity of the spill / release
- Note changes in the appearance and distribution of the spill over time.
- Assess the potential threat to the environment and the resources required to combat the spill / release (more effective and coordinate response)

Mechanical Containment and Recovery

Mechanical containment and recovery is the restriction of a spill / release movement through the use of booms or some other form of physical barriers and its subsequent removal using skimmers and other mechanical means. These operations may be required for large spills or spills / release which may impact environmentally sensitive areas. This response option will be used if the spill / release:

- Threatens environmental sensitive areas, or
- The spill is unlikely to be removed by natural processes.

The feasibility of a containment and recovery response is dependent upon having surface pollution that is capable of being contained and recovered and having suitable conditions for equipment deployment. The spill containment plan shall be addressed in line with the recommendation of QRA analysis as prescribed in chapter 7.

Waste Management

Spill response operations have the potential to generate liquid and solid wastes, if there are clean-up operations. The types and quantities of waste material largely depend on the amount of liquid material spilt and the specific clean-up methods employed. Disposal options for oily wastewater may include high temperature incineration, bioremediation or disposal at secured landfill sites. Any disposal option selected will need to comply with the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016.

9.3.5 Noise quality Management Plan

The noise control plan is applicable for construction of well sites, early production system, drilling operations and decommissioning/site closure of well sites.

The noise control plan to ensure specific measures to minimize noise levels in the project site as 75 dB(A) per CPCB noise rules. The plan also outlines roles and responsibilities of both Vedanta Limited (Division Cairn Oil & Gas) and the contractors involved in the implementation of the plan.

Mitigation Measures

Project Phase	Mitigation measures
Site Preparation	— Selection and use of low noise generating equipment equipped with engineering controls *viz.* mufflers,

Project Phase	Mitigation measures
	silencers etc. — All vehicles utilized in transportation of raw material and personnel will have valid Pollution under Control (PUC) Certificate — Periodic maintenance of vehicles — Periodic maintenance of equipment be undertaken. — Engines of vehicles and construction equipment would be turned off when not in use for long periods.
Drilling	— Siting of drilling rig and facilities away from sensitive receptors *viz*. schools, settlements etc. with all reasonable screening being utilized where necessary. — Installing acoustic enclosures and muffler on engine exhaust of DG sets to ensure compliance with generator noise limits specified by CPCB. — Periodic monitoring of noise levels.
Decommissioning/Site Closure	— Management measures to address noise impacts with respect to operation of heavy equipment/machinery and movement of vehicles during decommissioning/site closure phase are similar to those discussed in the "Construction / site preparation Phase" of this section

9.3.6 Surface Water Quality Management

The Surface Water Quality Management Plan is applicable during construction of well sites, early production system, drilling operations, operation of early production facilities and decommissioning/site closure of well sites that has the potential to adversely affect the surface water quality. The Surface Water Quality Management Plan establishes specific measures and guidelines aimed at addressing and mitigation of surface water quality impacts that may arise at different phases of the project.

Project Phase	Mitigation measures
Site Preparation	— During site preparation, surface water run-off will be managed through implementation of proper drainage system.
Drilling	— Drip trays would be used during preventive maintenance of rig installations, vehicles and machinery. — Hazardous chemicals and fuel container will be stored in bunded and lined area equipped with proper spill control equipment and secondary containment.
Decommissioning/Site Closure	— No significant impacts to surface water quality can be associated with activities during decommissioning/site closure phase. Any possible impacts that may arise due to surface run-off will be mitigated in manner similar to that discussed during construction/site preparation phase activities.

9.3.7 Ground Water Quality Management Plan

Ground Water Quality Management Plan is applicable for construction of well sites and drilling operations, operation of early production facilities and decommissioning/site closure of well sites that has the potential to adversely affect the ground water quality.

Project Phase	Mitigation measures
Site Preparation / Construction	— No significant impact on the ground water quality can be associated with the construction phase activities
Drilling	— Proper casing and cementing of well will be done. — Periodic monitoring of ground water quality will be

Project Phase	Mitigation measures
	carried out for surrounding wells located outside the project boundary to assess the level of ground water contamination, if any. — Storage and disposal of drill cutting and waste mud to be planned in accordance with "Solid & Hazardous Waste Management Plan"
Decommissioning/Site Closure	— No significant impacts to ground water quality can be associated with activities during decommissioning/site closure phase

9.3.8 Storm Water Management Plan

The following mitigation measures need to be adopted and implemented by Vedanta Limited (Division: Cairn Oil & Gas) and its contractors in construction, operation and decommissioning phase.

- Necessary measures would be undertaken during site preparation phase to prevent earth and stone material from blocking cross drainage structures.
- Periodic cleaning will be undertaken to cross drainage structures and road drainage system to maintain uninterrupted storm water flow.

9.3.9 Road Safety & Traffic Management Plan

Road Safety & Traffic Management Plan outlines specific measures would adopted and implemented by Vedanta Limited (Division: Cairn Oil & Gas) to mitigate any potential impact on community health and safety that may arise out of movement of vehicles and transportation of drilling rig and other heavy equipment during construction, drilling and decommissioning of well sites.

Mitigation Measures

- Project vehicular movement will be restricted to defined access routes.
- Proper signage will be displayed at important traffic junctions along the predefined access routes.

- Traffic flows would be scheduled wherever practicable during period of increased commuter movement;
- Adequate training on traffic and road safety operations would be imparted to the drivers of project vehicles.

9.3.10 Occupational Health & Safety Management Plan

The Occupation Health & Safety Management Plan (OHSMP) has been formulated to address the occupational health and safety related impacts that may arise from proposed project activities viz. drilling and testing, operation of construction machinery/equipment, storage and handling of fuel and chemicals, and decommissioning/site closure.

Mitigation Measures

The following mitigation measure need to be adopted and implemented by Vedanta Limited (Division: Cairn Oil & Gas) and its contractors in construction, drilling, and early production and decommissioning phase.

- All workers will be provided with proper PPEs viz. safety boots, masks, protected glass etc.
- Provision of ear plugs/ear muffs etc. and rotation of workers operating near high noise generating areas, would be ensured.
- Hazardous and risk prone areas, installations, materials, safety measures, emergency exits, etc. would be appropriately marked in every conspicuous location.
- All chemicals and hazardous materials storage container will be properly labeled 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.
- Workplace to be equipped with fire detectors, alarm systems and fire-fighting equipment after the requirement. Equipment shall be periodically inspected and maintained to keep in good working condition.
- Adequate sanitation facilities will be provided
- Garbage bins would be provided in the camp and regularly removed and the garbage disposed off in a hygienic manner.

- Training programs would be organized for the operational workforce regarding proper usage of PPEs, handling and storage of fuels and chemicals etc.

9.3.11 Flare & Illumination Management Plan

The glare from the flare and illumination not only cause visual impacts but also causes ecological impacts.

Enclosed Ground Flaring

Ground flaring pit eliminates the visual impacts of burning produced gas in a processing facility. Apart from that enclosed ground flare will decrease the amount of smoke and noise.

Work Zone Illumination

Low height, sodium vapour lamp that are most energy efficient can help to reduce the ecological impacts. Further, illumination will be provided only in required locations and has placed UV filters on lamps. Such UV filtered lights have been found to be less distractive.

9.3.12 Site Closure Plan

The site closure plan will identify all the activities which would be performed during the restoration of a well site in case the well is not economically viable, and no further use of that particular well bore is envisaged. Along with the well site the approach road connecting the well will be restored accordingly.

The following activities would be considered in the closure plan:

- Plugging & Abandonment of well: Close the well head properly to prevent any further leakage
- Decommissioning Phase: Removal of the materials form the site
- Waste/mud pit closure and reclamation
- Reinstatement Phase: regeneration of the land
- Handover Phase: Returning the land to the original owner

Plugging & Abandonment of well

As and when the well will be declared as unsuccessful / to be suspended / non-productive, plugging of the well will be performed to close and abandon the well to prevent any leakage of oil or gas.

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:

- 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 guidelines of State pollution control board.
- Road Restoration: The fill materials should be removed, and the site would be restored to previous conditions or as per recommendation of administrative department of Tehsil.

Waste and Mud Pit Closure and Reclamation

Following decommissioning and abandonment of the well site the waste and mud pits would be subject to closure through onsite burial of solids in accordance with lease and obligations and with local, state and national regulations. Reclamation of closed pits or any other temporary retaining pits, including reserve pits, would be carried out within a period of one year from well closure/abandonment. All such reclamation activities would be carried out based on the climatic conditions.

Reinstatement

The reinstatement phase includes all activities for preparation of the soil for plantation of trees at the concerned site. The preparation of topsoil and fertility regeneration of topsoil would be same as referred earlier. Site restoration shall be taken up matching to the surrounding land use pattern. Selection of plants for plantation would be undertaken based on the species that were cut down at the time of site preparation activities.

9.4 SUMMARY OF ENVIRONMENT MANAGEMENT PLAN AND ACTIONS

Summary of Environmental Management Plan for the proposed project and actions is given in Table 9.1

Table 9.1 Environmental Management Plan

S.No	Activity	Potential Impact	Management / Mitigation Measures	Responsibility
1.	Land Procurement	• Loss of Income • Issues pertaining to compensation	• If the identified lands are of private landowners then land lease mode will be applied and in case of govt. land, land allotment from Govt. to be applied. Initially temporary and short-term lease will be taken for 3 - 5 years for exploration purpose and in case of commercially viable discovery of hydrocarbon resources, the land lease would be converted into long term lease up till life of the project. For sites selected are having any settlements, Resettlement & rehabilitation (R&R) plan will be developed and implemented as per the applicable State/ Central Govt. policy. Compensation to affected landowners for any loss of land will be ensured by Vedanta Limited. (Division Cairn Oil & Gas). Vedanta Limited (Division Cairn Oil & Gas) will ensure the livelihood of local community, if any affected by the proposed land take, are identified and compensated through adequate compensation and other livelihood	• Vedanta Limited (Division: Cairn Oil & Gas)

S.No	Activity	Potential Impact	Management / Mitigation Measures	Responsibility
			restoration activities directly or indirectly through CSR activities.	
2.	Site Clearance and Grading	• Dust Generation • Loss of top soil • Increased runoff • Loss of vegetation	• The final site selection to be done for site with minimum trees, and involving minimum cutting; • Top soil would be properly stored for future use. • Water sprinkling to be carried out while working in proximity of agricultural fields or settlements/habitations;	• Vedanta Limited (Division: Cairn Oil & Gas
3.	Construction/ site preparation	• Handling of excess earth material; • Noise generation • Increase in traffic volumes • Health & Safety risks	• Temporary storage sheds to be provided for construction material such as cement; • Excavated soil to be used during site preparation; • All pits to be fenced during construction after each day's work to prevent injury to wild animals due to accidental fall; • Provision and usage of adequate PPEs to workers as applicable and identified for the respective activity.	• Vedanta Limited (Division: Cairn Oil & Gas) •
4.	Installation Camp of Site	• Structural Failure of crane	• Surface conditions to be examined prior to movement of crane;	• Vedanta Limited (Division: Cairn

S.No	Activity	Potential Impact	Management / Mitigation Measures	Responsibility
		• Crane overturning/Collapse • Falling Objects • Health & Safety risks	• Provision and usage of adequate PPEs to workers as applicable and identified for the respective activity.	Oil & Gas) • Vedanta Limited (Division: Cairn Oil & Gas)
5.	Transportation of Drilling Components and Rig	• Congestion of roads • Road accidents • Vehicular emissions • Damage to road conditions • Oil leaks	• Only trained drivers with knowledge of on defensive driving to be involved in the movement of rigs. • All movement of major equipment would be scheduled in the lee hours keeping consideration of the traffic movement in the connecting major arterial road. • Local administration and village administration as applicable to be informed during movement of rigs through village roads;	• Vedanta Limited (Division: Cairn Oil & Gas)
6.	Drilling and Well Testing	• Additional stress on the local water resources;	• Water will be sourced from locally approved sources the approved vendor through tanker • If not possible that it will be taken from ground water with prior approval from CGWA	• Vedanta Limited (Division: Cairn Oil & Gas)
		• Potential for	• Two separate Drill cutting disposal pits to be	• Vedanta Limited

S.No	Activity	Potential Impact	Management / Mitigation Measures	Responsibility
		contamination due to handling, storage and transportation of wastes	provided for WBM and SBM cuttings; • Drill waste pits to be provided with HDPE lining on bottom and side surfaces; • Used hazardous chemical barrels, used oil and other hazardous waste to be sent to authorized recyclers; • Vedanta Limited (Division: Cairn Oil & Gas) to also explore disposing drill cuttings containing for co-processing as alternate fuel and or raw material (AFR) in cement industry based on suitability and availability.	(Division: Cairn Oil & Gas) Waste Manager • Vedanta Limited (Division: Cairn Oil & Gas) Drilling contractor- HSE
		• Generation of noise	• Rotary equipment on rig for drilling to be provided with silencers, rubber claddings and noise isolators; • Effective noise barriers to be set up at fence line when working at a distance of less than 300m from centre of the well site; • Equipment upkeep and regular maintenance to minimise noise generation from all rotary equipment;	• Vedanta Limited (Cairn Oil & Gas) Drilling contractor- HSE

S.No	Activity	Potential Impact	Management / Mitigation Measures	Responsibility
			• PPE's such as ear plugs, muffs to be provided to workers at site; • Periodic maintenance of vehicles and machinery to be undertaken; • DG sets to be provided with acoustic enclosures as per requirements under CPCB guideline.	
		• Air emissions	• All the emitting stacks including the flare pit shall be positioned orthogonal direction to the prevailing wind direction; • Cold venting of gas not to be carried out. • Adequate stack heights to be provide for generators, adhering to the EPA standards for diesel generators;	• Vedanta Limited (Division: Cairn Oil & Gas) Drilling contractor- HSE
		• Influx of migrant labour • Conflict with local community	• Locals to be given preference over the migrant labourers based on skill base; • Migrant labour to be sensitized towards customs and traditions of the local population;	• Vedanta Limited (Division: Cairn Oil & Gas) • Drilling contractor- HSE
		• Occupational Health &	• Blowout preventers to be provided;	• Vedanta Limited

S.No	Activity	Potential Impact	Management / Mitigation Measures	Responsibility
		Safety Risks	• Flare pit to be placed at a safe distance from the well head and fuel storage areas; • Firefighting measures to be provided near all welding operations;	(Division: Cairn Oil & Gas) Drilling contractor-HSE
7	Operation of Campsites	• Stress on water resources; • Potential contamination from generation of biomedical waste • Wastewater generation • Waste generation	• Safe drinking water to be provided at campsites; • All waste to be collected in bins located near each set of porta cabins. Segregation of waste at the source of generation to be put in practice. • All hazardous waste to be collected and stored on secure and paved area, and subsequently sent to authorised recyclers • Food waste to be stored in a closed container; • STP to be provided for campsites. • Waste generation to be separated and disposed of as per the regulatory requirements.	• Vedanta Limited (Division: Cairn Oil & Gas) • Drilling contractor-HSE
8	Operation of mud (WBM/SBM)	• Waste generation • Potential contamination due to mud preparation	• Effective stacking of the materials to be followed to protect from the environmental situations such as wind, rain and sunlight	•

S.No	Activity	Potential Impact	Management / Mitigation Measures	Responsibility
	plant and warehouses	• Dust due to stacking of the materials • Emission due to the forklifts and crane usages	• If area not paved, then periodic sprinkling shall be carried out • All diesel operated generators shall have acoustic enclosures and effective stack heights • Waste shall be effectively segregated at the source of generation and disposed as per the waste management plan • All the vehicles to be operated inside the mud plant and warehouse shall follow all the HSE requirements to protect environment and have safety operations such as load test, proper maintenance etc.	
9	Decommissioning and Abandonment	• Demolition of drill cutting pits;	• A site restoration approved plan shall be prepared with the detailed checklist; • All drill cuttings, spent mud, waste oil and other waste to be completely removed from the site and sent to designated disposal place prior to commencement of demolition work; • All concrete or steel installations will be removed to	• Vedanta Limited (Division: Cairn Oil & Gas) •

S.No	Activity	Potential Impact	Management / Mitigation Measures	Responsibility
			at least 1 m below ground level, so as to ensure that there will be no protruding surface structures. The casing wellhead and the top joint of the casings will be cut below the ground level and capped with a cement plug. • Prior to commencement of any demolition, a planned programme of site clearance will be formulated. All pits, cellars and holes will be removed and filled to ground level, any oil or otherwise contaminated soil will be removed and disposed suitably.	

9.5 EMP BUDGET

The company will comply with the 1st May, 2018 OM of Government of India w.r.t. CER and the cost would be assessed on actual project capex expenditure of that particular financial year.

CHAPTER – X

SUMMARY AND CONCLUSIONS

AA-ONHP-2017/14 hydrocarbon block is located at Karimganj, Hailakandi, Cachar district of Assam and Kolasib district of Mizoram and covers a total area of 1719 Sq. Km. The Vedanta Limited (Division: Cairn Oil & Gas) intends to carry out further Exploration and Appraisal Drilling activities in the Block, wherein 24 new drilling (exploratory and appraisal) wells are proposed to be drilled over a period of 10-12 years. In the event of successful discovery of crude oil, setting up of Early Production Units (EPUs)/ Quick Production Units (QPUs) for produced well fluid processing and production of up to 8000 BOPD crude oil and up to 1.6 MMSCFD associated natural gas for captive power generation.

MoEF&CC has approved ToR dated on 13.05.2019 vide File No. IA-J-11011/148/2019-IA-II(I). The baseline monitoring and all primary data collection has been connected for the summer season during March 2019 to June 2019 as per the requirements of the ToR. This Draft EIA report has been prepared for conducting the public hearing.

The draft EIA report has assessed the overall significance of environmental impacts likely to arise from Drilling of proposed exploratory and appraisal wells. The overall impacts from the individual drilling sites have been assessed to be of moderate to minor in nature when appropriate mitigation measures would be implemented with proper planning and design.

To adequately address the impacts, mitigation measures and management plans suggested are as per the best practices followed in the Oil & Gas Industry. These plans include environmental management plan, monitoring plan, labour management plan, traffic management plan. Vedanta Limited (Division: Cairn Oil & Gas) shall put in place a robust mechanism with adequate resources to implement the suggested mitigation measures am management plans. The measures will help to prevent any deterioration, contamination of air, groundwater, surface water and soil quality beyond the prevailing status. Adequate safety measures would be adopted along with suitable emergency response and disaster management plan to safeguard against all man-made and natural disasters. Environmental monitoring of ambient air quality, noise levels, surface & groundwater quality etc. would be carried out at regular intervals to monitor and prevent any deterioration of baseline environmental quality due to the proposed project.

Compliance to all legal requirements and adherence to the suggested mitigation measures and plans will also enable Vedanta Limited (Division: Cairn Oil & Gas) in minimizing its impact on environmental and social parameter. This Draft EIA Report would be finalized after obtaining the comments and observations of public during the consultation to modify and strengthen any mitigation measures as required before it is submitted to MoEF&CC for obtaining Environmental Clearance (EC) of the project.

CHAPTER – XI

DISCLOSURE OF CONSULTANTS

11.0 DISCLOSURE OF CONSULTANT ENGAGED

Baseline Data have been carried out by M/s. SV Enviro Labs & Consultants, Visakhapatnam and Environmental Impact Assessment report has been prepared based on the Standard Terms of Reference.

11.1 ABOUT SV ENVIRO LABS & CONSULTANTS (SVELC):

SV ENVIRO LABS & CONSULTANTS pioneered its way in the mid 90's in Yanam, the evergreen Union Territory, to provide the quality services in the area of environmental pollution. The laboratory serves have been set up in an extent of 7500 sq.ft in the city of destiny Visakhapatnam to provide analytical expertise in the field of Environmental Engineering. Our technical expertise is one among the best in the country, providing economical & sound environmental and safety solutions.

SVELC is an ISO 9001:2008 company and is accredited by:

- ISO 9001:2008
- ISO 14001: 2004
- Ministry of Environment, Forests & Climate Change (MoEF&CC), Govt. of India, New Delhi
- National Accreditation Board for Education & Training (NABET) registered Environmental consultants by Quality Council of India (QCI).
- National Accreditation Board for Testing and Calibration Laboratories (NABL) in the field of testing
- OSHAS 18001: 2007

11.2 SERVICES OFFERED BY SV ENVIRO

Environmental:

- Environmental Impact Assessments
- Environmental Management Plan
- Environmental Audits preparation
- Solid and hazardous waste management
- Risk assessment and disaster management plans
- Occupational health and safety studies

- Socio-economic studies
- Marine impact assessment
- Rehabilitation and resettlement studies

Analysis:

- Environmental monitoring for air, water, soil, noise, ecology, hazardous waste, etc
- Industrial emission source monitoring
- Offshore sampling and analysis of marine water and sediments
- Analysis of water, wastewater, soil, solid waste, hazardous waste, lube oils, etc
- Noise quality monitoring
- Work zone source emission analysis

The firm has been engaged in the work of Environmental Impact Assessment studies for category – A & B projects, preparation of Environmental management plans (EMP) for the last 10 years for the purpose of obtaining clearance from Ministry of Environment, Forests & Climate Change.

Quality Council of India

National Accreditation Board for Education & Training

CERTIFICATE OF ACCREDITATION

SV Enviro Labs & Consultants

Enviro House, Block –B, B -1, Ida, Autonagar,
Visakhapatnam -530012, A.P

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) NABET	Sector (as per) MoEFCC	Cat.
1	Mining of minerals opencast only	1	1 (a) (i)	A
2	Offshore and onshore oil and gas exploration, development & production	2	1 (b)	A
3	River Valley projects	3	1 (c)	A
4	Chemical fertilizers	16	5 (a)	A
5	Synthetic organic chemicals industry (dyes & dye intermediates; bulk drugs and intermediates excluding drug formulations; synthetic rubbers; basic organic chemicals, other synthetic organic chemicals and chemical intermediates)	21	5 (f)	A
6	Distilleries	22	5 (g)	A
7	Isolated storage & handling of Hazardous chemicals (As per threshold planning quantity indicated in column 3 of schedule 2 & 3 of MSIHC Rules 1989 amended 2000)	28	6 (b)	B
8	Ports, harbours, break waters and dredging	33	7 (e)	A
9	Common Municipal Solid Waste Management Facility (CMSWMF)	37	7 (i)	B
10	Building and construction projects	38	8 (a)	B
11	Townships and Area development projects	39	8 (b)	A

Note: Names of approved EIA Coordinators and Functional Area Experts are mentioned in RA AC minutes dated Jan. 12, 2018 posted on QCI-NABET website.

The Accreditation shall remain in force subject to continued compliance to the terms and conditions mentioned in QCI-NABET's letter of accreditation bearing no. QCI/NABET/ENV/ACO/18/0716 dated July 26, 2018.The accreditation needs to be renewed before the expiry date by SV Enviro Labs & Consultants, Visakhapatnam, following due process of assessment.

Sr. Director, NABET
Dated: July 26, 2018

Certificate No.
NABET/ EIA/1720/ RA 0097

Valid till
15.04.2020

For the updated List of Accredited EIA Consultant Organizations with approved Sectors please refer to QCI-NABET website.

Fig: 11.1 – NABET Certificate

ANNEXURES

Annexure –I – ToR Copy

Annexure- II – Map indicating the distance between the AA-ONHP-2017/14 block boundary and Borail Wildlife Sanctuary ESZ boundary

Annexure- III- Emergency Preparedness Plan

Annexure –IV – HSE Policy of Vedanta Limited (Division: Cairn Oil & Gas)

Annexure – I

ToR Copy

No.IA-J-11011/148/2019-IA-II(I)
Goverment of India
Minister of Enviroment,Forest and Climate Change
Impact Assessment Division
***

Indira Paryavaran Bhavan,
Vayu Wing,3rd Floor,Aliganj,
Jor Bagh Road,New Delhi-110003
13 May 2019

To,

M/s M/s Vedanta Limited(Division Cairn Oil & Gas)
Cairn Oil & Gas, Vedanta Limited, DLF Atria, DLF Phase-2, DLF City, Gurgaon, Haryana - 122002Gurgaon,
Gurgaon-122002
Haryana

Tel.No.124-4594176; Email:dilipkumar.bera@cairnindia.com

Sir/Madam,

This has reference to the proposal submitted in the Ministry of Environment, Forest and Climate Change to prescribe the Terms of Reference (TOR) for undertaking detailed EIA study for the purpose of obtaining Environmental Clearance in accordance with the provisions of the EIA Notification, 2006. For this purpose, the proponent had submitted online information in the prescribed format (Form-1) along with a Pre-feasibility Report. The details of the proposal are given below:

1. Proposal No.:	IA/AS/IND2/101876/2019
2. Name of the Proposal:	Onshore Oil and Gas Exploration and Appraisal in AA-ONHP-2017/14 block in Karimganj, Hailakandi, Cachar districts of Assam and Kolasib district of Mizoram
3. Category of the Proposal:	Industrial Projects - 2
4. Project/Activity applied for:	1(b) Offshore and onshore oil and gas exploration, development & production
5. Date of submission for TOR:	10 Apr 2019

In this regard, under the provisions of the EIA Notification 2006 as amended, the Standard TOR for the purpose of preparing environment impact assessment report and environment management plan for obtaining prior environment clearance is prescribed with public consultation as follows:

1(b):STANDARD TERMS OF REFERENCE FOR CONDUCTING ENVIRONMENT IMPACT ASSESSMENT STUDY FOR OFFSHORE AND ONSHORE OIL AND GAS EXPLORATION, DEVELOPMENT AND PRODUCTION PROJECTS AND INFORMATION TO BE INCLUDED IN EIA/EMP REPORT

B. STANDARD TOR FOR ONSHORE OIL AND GAS EXPLORATION, DEVELOPMENT & PRODUCTION

1. Executive summary of a project.
2. Project description, project objectives and project benefits.
3. Cost of project and period of completion.
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 Topo sheet of 1:40000 scale, superimposing the well locations and other structures of the projects. Topography of the project site.
5. Details of sensitive areas such as National Park, Wildlife sanctuary and any other eco-sensitive area alongwith map indicating distance.
6. Approval for the forest land from the State/Central Govt. under Forest (Conservation) Act, 1980, if applicable.
7. Recommendation of SCZMA/CRZ clearance as per CRZ Notification dated 6th January, 2011 (if applicable).
8. Distance from nearby critically/severely polluted area as per Notification, if applicable. Status of moratorium imposed on the area.
9. Does proposal involve rehabilitation and resettlement? If yes, details thereof.
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.
11. Baseline data collection for air, water and soil for one season leaving the monsoon season in an area of 10 km radius with centre of Oil Field as its centre covering the area of all proposed drilling wells.
12. Climatology and Meteorology including wind speed, wind direction, temperature rainfall relative humidity etc.
13. Details of Ambient Air Quality monitoring at 8 locations for PM2.5, PM10, SO2, NOx, CO, VOCs, Methane and non-methane HC.
14. Soil sample analysis (physical and chemical properties) at the areas located at 5 locations.
15. Ground and surface water quality in the vicinity of the proposed wells site.

16. Measurement of Noise levels within 1 km radius of the proposed wells.
17. Vegetation and land use; flora/fauna in the block area with details of endangered species, if any.
18. Incremental GLC as a result of DG set operation, flaring etc.
19. Potential environmental impact envisaged during various stages of project activities such as site activation, development, operation/ maintenance and decommissioning.
20. Actual source of water and 'Permission' for the drawl of water from the Competent Authority. Detailed water balance, wastewater generation and discharge.
21. Noise abatement measures and measures to minimize disturbance due to light and visual intrusions.
22. Details on wastewater generation, treatment and utilization /discharge for produced water/ formation water, cooling waters, other wastewaters, etc. duringallprojectphases.
23. Details on solid waste management for drill cuttings, drilling mud and oil sludge, produced sand, radio activematerials, other hazardous materials, etc. including its disposal options during all project phases.
24. Disposal of spent oil and lube.
25. Storage of chemicals and diesel at site. Hazardous material usage, storage and accounting.
26. Commitment for the use of water based mud (WBM) only
27. Oil spill emergency plans for recovery/ reclamation.
28. H2S emissions control.
29. Produced oil/gas handling, processing and storage/transportation.
30. Details of control of air, water and noise pollution during production phase.
31. Measures to protect ground water and shallow aquifers from contamination.
32. Whether any burn pits being utilised 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.
34. Environmental management plan.
35. Total capital and recurring cost for environmental control measures.
36. Emergency preparedness plan.
37. Decommissioning and restoration plans.
38. Documentary proof of membership of common disposal facilities, if any.
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.
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.
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.

***

Annexure –II

Map indicating the distance between the AA-ONHP-2017/14 block boundary and Borail Wildlife Sanctuary ESZ boundary

vedanta
transforming elements

CAIRN

Date: 28/05/2019
Ref. AA-ONHP2017/14/NOC-WL/1

To,
The PCCF & HoFF,
Aranya Bhawan, Panjabari
Guwahati, Assam – 781037

Subject: Request for authentication of map indicating the distance from the AA-ONHP-2017/14 hydrocarbon block boundary to the notified ESZ boundary of the Borail Wildlife Sanctuary.

Dear Sir,

Vedanta Limited (Division: Cairn Oil & Gas), formerly known as **Cairn India Limited** is one of the largest independent oil and gas exploration and production companies in India. Vedanta Ltd. (Cairn Oil & Gas) has been allocated the Onshore AA-ONHP-2017/14 hydrocarbon block by MoP&NG, Govt. of India (GoI) under the OALP Round–I. Vedanta Ltd. (Cairn Oil & Gas) proposes to carry out oil and gas exploration and appraisal in the block. Terms of Reference (ToR) (File No. IA-J-11011/148/2019-IA-II(I), dated 13.05.2019) has been issued from MoEF&CC for carrying out EIA study and subsequently obtaining EC.

The AA-ONHP-2017/14 block is located at a distance of 8.76 km from the notified ESZ (Ref- **S.O. 1364(E)** MoEF&CC, New Delhi Notification dated 08.04.2016) boundary around the Borail Wildlife Sanctuary. The boundary coordinates of the block as allocated by the MoP&NG as a part of the RSC (Revenue Sharing Contract) is enclosed as **Annexure-1.** A map indicating the distance from the ESZ to block boundary is provided as **Annexure-2**.

We request you to kindly authenticate the map indicating the distance from AA-ONHP-2017/14 Block to the ESZ of the Borail Wildlife Sanctuary.

We hope you will find the enclosed documents in order. For any additional information or clarification required, we will be pleased to provide the same.

Thanking you,
For Vedanta Limited (Division: Cairn Oil & Gas)

VEDANTA LIMITED
DLF Atria Phase 2, Jacaranda Marg, DLF City Gurugram - 122002 Haryana
Cairn Oil & Gas

K. K. Nayak
Head – HSE & Compliance
Enclosures: As above

31/05/19

VEDANTA LIMITED
(Formerly known as Sesa Sterlite Limited)

Cairn Oil & Gas : DLF Atria, Phase 2, Jacaranda Marg, DLF City, Gurugram-122002, Haryana, India
T +91-124 459 3000 F +91-124 414 5612 | www.cairnindia.com

Registered Office: Vedanta Limited, 1st Floor, 'C' wing, Unit 103, Corporate Avenue, Atul Projects, Chakala, Andheri (East), Mumbai-400093, Maharashtra, India | T +91-22 664 34500 | F +91-22 664 34530 | www.vedantalimited.com

CIN: L13209MH1965PLC291394

REVENUE SHARING CONTRACT

BETWEEN

<u>THE GOVERNMENT OF INDIA</u>

AND

<u>VEDANTA LIMITED</u>

UNDER

HYDROCARBON EXPLORATION AND LICENSING POLICY

WITH RESPECT TO CONTRACT AREA IDENTIFIED

-AS BLOCK

<u>AA-ONHP-2017/14</u>

K.K. Asolkar
US(E.II), MoPNG

Atul Gupta
(ATUL GUPTA)
DGH

(Sudhir Mathur)
Vedanta Limited

TABLE OF CONTENTS

APPENDICES

REVENUE SHARING CONTRACT
FOR ONLAND AREAS

This Contract made on this **1st October**, Two thousand and Eighteen between: The President of India, acting through the **Joint Secretary (E)**, Ministry of Petroleum and Natural Gas (hereinafter referred to as "the Government") of the FIRST PART;

AND

Vedanta Limited, a company incorporated under the laws of India (hereinafter referred to as "**Vedanta**" or "**Contractor**") having its registered office at 1st Floor, C wing, Unit 103, Corporate Avenue Atul Projects, Chakala, Andheri (East) Mumbai, Mumbai City Maharashtra-400093 India which expression shall include its successors and such assigns as are permitted under Article 26 hereof, of the SECOND PART;

WITNESSETH:

WHEREAS

(1) The Oilfields (Regulation and Development) Act, 1948 (53 of 1948) (hereinafter referred to as "the Act") and the Petroleum and Natural Gas Rules, 1959, made there under (hereinafter referred to as "the Rules") make provisions, inter alia, for the regulation of Petroleum Operations and grant of Licenses and Leases for exploration, development and production of Petroleum in India;

(2) The Rules provide for the grant of Licenses and Leases in respect of land vested in a State Government by that State Government with the previous approval of the Central Government;

(3) Rule 5 of the Rules provides for an agreement between the Government and the Licensee or Lessee containing additional terms and conditions with respect to the License or Lease;

(4) The Government desires that all types of Petroleum resources which may exist in India, whether within territorial waters (ultra-deep, deep or shallow water), exclusive economic zone, the continental shelf of India, or Onland, be discovered and exploited in accordance with Good International Petroleum Industry Practices (GIPIP) with utmost expedition in the overall interests of India;

(5) The Government has formulated and approved a new exploration and licensing policy named 'Hydrocarbon Exploration and Licensing Policy' ("HELP") vide Resolution dated 30.03.2016, whereby it has been determined to provide a uniform license to enable E&P operators to explore and extract all hydrocarbon resources including conventional and unconventional oil and gas resources including CBM, Shale Gas/Oil, Tight Gas, Gas Hydrates and any other resource to be identified in future which fall within the definition of 'Petroleum" and "Natural Gas" under the Rules;

Atul

(6) The Government, pursuant to HELP, invited companies to submit competitive bids to obtain the right to undertake exploration, discovery and commercial production of Petroleum resources within India, which would also be governed by Applicable Laws governing Petroleum Operations within India formulated by the Government;

(7) **Vedanta** has committed that it has, or will acquire and make available, the necessary financial and technical resources and the technical and industrial competence and experience necessary for proper discharge and / or performance of all obligations required to be performed under this Contract in accordance with Good International Petroleum Industry Practices (GIPIP) and will provide guarantees as required in Article 27 for the due performance of its obligations hereunder; and

(8) As a result of discussions between representatives of the Government and **Vedanta** on the bid submitted by **Vedanta**, the Government has agreed to enter into this Contract with **Vedanta** with respect to the Contract Area identified as Block **AA-ONHP-2017/14** and detailed in Appendix A and Appendix B (hereinafter referred to as "the Block") on the terms and conditions herein set forth.

NOW, THEREFORE, in consideration of the premises and covenants and conditions herein contained, IT IS HERE BY AGREED between the Parties as follows

IN WITNESS WHEREOF, the representatives of the Parties to this Contract being duly authorized have hereunto set their hands and have executed these presents this 1st October, Two thousand and Eighteen.

Signed for and on behalf of the President of India

By: Amarnath

अमर नाथ / AMAR NATH
संयुक्त सचिव/Joint Secretary
पेट्रोलियम एवं प्राकृतिक गैस मंत्रालय
Ministry of Petroleum & Natural Gas
भारत सरकार/Govt. of India
नई दिल्ली/New Delhi

In presence of ______________________

संजय कुमार जैन / SANJAY KUMAR JAIN
निदेशक / Director
पेट्रोलियम एवं प्राकृतिक गैस मंत्रालय
Ministry of Petroleum & Natural Gas
भारत सरकार / Govt. of India
नई दिल्ली / New Delhi

Signed for and on behalf of Vedanta Limited

By: ______________________

In presence of ______________________

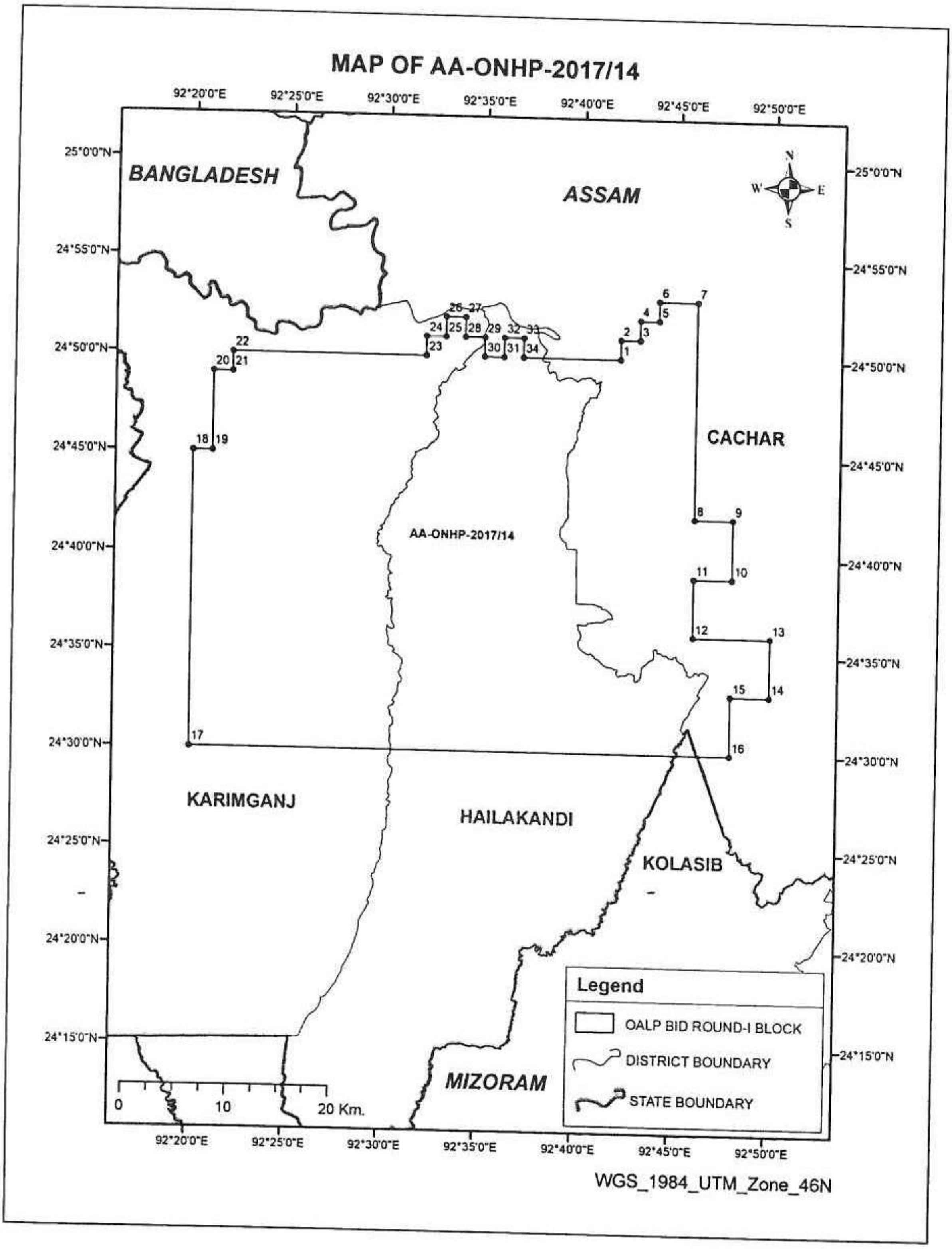
APPENDIX A
DESCRIPTION OF THE CONTRACT AREA

The area comprising approximately 1719 Sq. km. onshore/offshore India identified as block AA-ONHP-2017/14 described herein and shown on the map attached as Appendix B ("Map of the Contract Area"). Longitude and latitude measurements commence at points 1, 2, 3...,34 are given below:

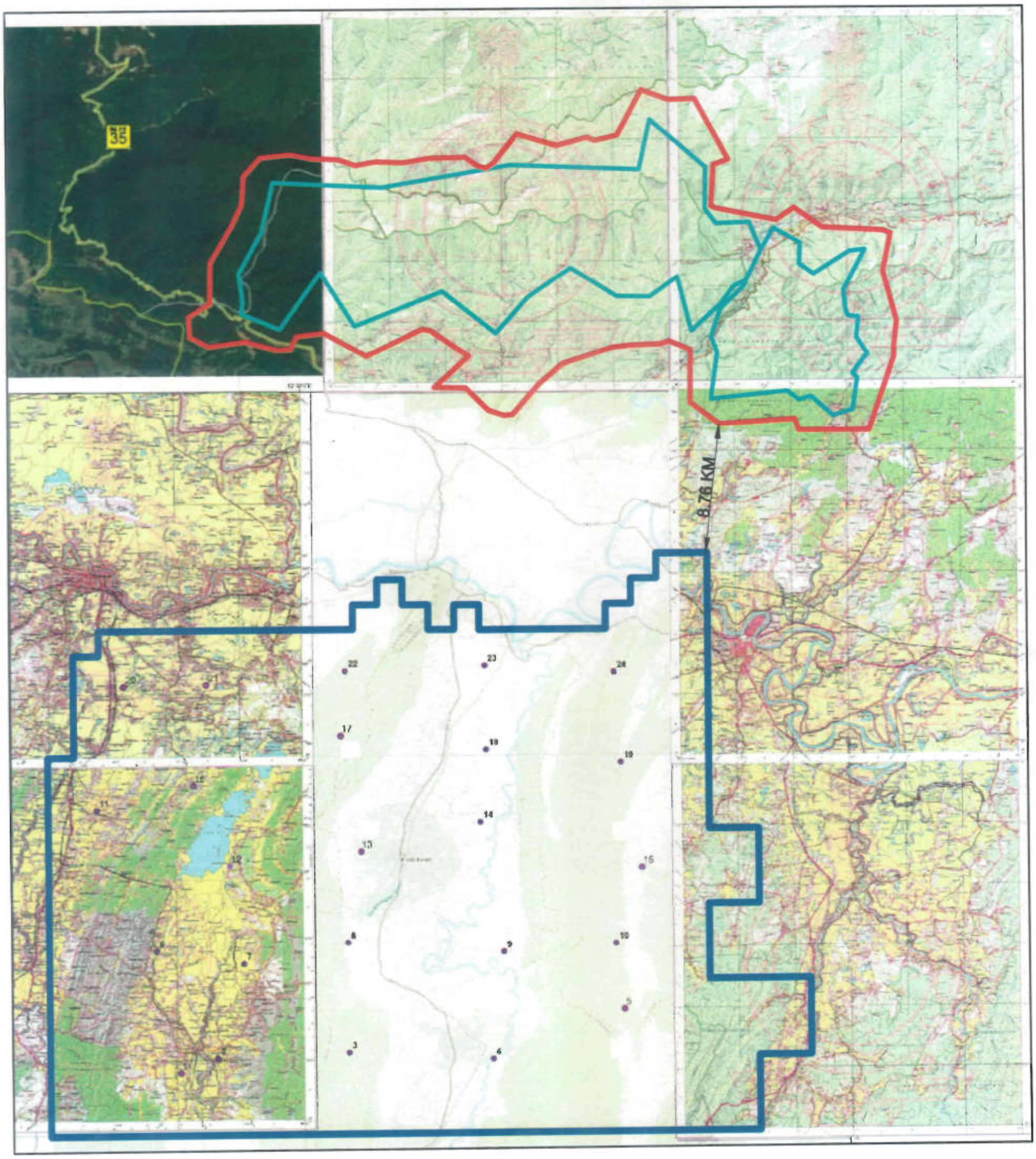
Points	Longitude	Latitude
1	92° 42'	24° 50'
2	92° 42'	24° 51'
3	92° 43'	24° 51'
4	92° 43'	24° 52'
5	92° 44'	24° 52'
6	92° 44'	24° 53'
7	92° 46'	24° 53'
8	92° 46'	24° 42'
9	92° 48'	24° 42'
10	92° 48'	24° 39'
11	92° 46'	24° 39'
12	92° 46'	24° 36'
13	92° 50'	24° 36'
14	92° 50'	24° 33'
15	92° 48'	24° 33'
16	92° 48'	24° 30'
17	92° 20'	24° 30'
18	92° 20'	24° 45'
19	92° 21'	24° 45'
20	92° 21'	24° 49'
21	92° 22'	24° 49'
22	92° 22'	24° 50'
23	92° 32'	24° 50'
24	92° 32'	24° 51'
25	92° 33'	24° 51'
26	92° 33'	24° 52'
27	92° 34'	24° 52'
28	92° 34'	24° 51'
29	92° 35'	24° 51'
30	92° 35'	24° 50'
31	92° 36'	24° 50'
32	92° 36'	24° 51'
33	92° 37'	24° 51'
34	92° 37'	24° 50'

APPENDIX B

MAP OF THE CONTRACT AREA



MAP INDICATING THE DISTANCE BETWEEN AA-ONHP-2017/14 BLOCK BOUNDARY AND BORAIL WILDLIFE SANCTUARY ECO SENSITIVE ZONE



LEGEND

- BORAIL WILD LIFE SANCTUARY BOUNDARY
- BORAIL WILDLIFE SANCTUARY ESZ BOUNDARY
- BLOCK BOUNDARY
- PROPOSED EXPLORATORY AND APPRAISAL WELLS

VEDANTA LIMITED
DLF Atria, Phase 2, Jacaranda Marg, DLF City, Gurugram - 122002 Haryana
Cairn Oil & Gas

VEDANTA LIMITED
Onshore Oil and Gas Exploration and Appraisal in Block AA-ONHP-2017/14 in Karimganj, Hailakandi, Cachar Districts of Assam

Annexure –III

Emergency Preparedness Plan

VEDANTA LIMITED (Division: Cairn Oil & Gas)

Emergency Preparedness & Response

Vedanta Limited (Division: Cairn & Oil Gas) has in place a Disaster Management Plan which has been developed to set up the appropriate mechanism and course of action to mitigate the impact of an Emergency event viz. blow out, fire, explosion etc.

Roles and Responsibilities

Each SBU shall clearly define the roles and responsibilities of all personnel involved in the implementation of Emergency Preparedness and Response Plans. All roles and responsibilities should be documented and communicated to the relevant people. This should include the following: Employees; Contractors / Partners; Emergency resources / service providers. Flexibility in the make-up of the emergency response teams is required, as it will depend on the exact nature of each emergency, all personnel shall therefore be made aware of the Emergency Preparedness and Response Plans.

Business Unit (SBU) Head

Each SBU has a responsibility to ensure appropriate and effective emergency management plans are developed and in place for their respective operations and are kept updated.

SBU Heads are responsible for ensuring:

- Emergency response plans are in place for each of their facilities.
- Emergency response organizations with trained and competent personnel are in place for SBU's operations.
- Facilities under their management are provided with adequate emergency equipment to enable effective response.

Chief HSEQ Officer (CHSEO) and Chief Health and Safety Officer (CHSO)

CHSEO and CHSO have responsibility for ensuring emergency plans are developed covering both Emergency and Crisis Management. Where necessary HSE team will provide the guidance required for development of the plans. CHSO is responsible for:

- Development and readiness of emergency response management plans.
- Providing advice and support to management and to the businesses on matters of emergency response.
- Ensuring a programme of training courses, drills and exercises are in place to ensure the competence of all emergency response staff.

- Monitoring the implementation of learnings from these emergency events / emergency drills and ensuring that they are disseminated to all relevant parties.

Emergency Response Requirements

Identification of Potential Emergency Situations

- Each SBU shall systematically identify all reasonably foreseeable emergency and crisis situations, including low probability / high consequence events.
- Although wide range of potential major accident events can be identified, focus shall be on the events, which are reasonably foreseeable. The assessment process should identify the factors, which influence the way an event may occur and develop, as these will affect the ability of any measure put in place to deal with the emerging emergency scenarios.
- The potential impacts of each possible emergency situation shall be assessed and documented by competent personnel through risk assessment, using methodologies appropriate to the scale and nature of the risk. This will include consideration of the individuals and communities that might be affected by potential emergency situations.
- Neighboring activities adjacent to the Cairn Oil and Gas sites shall also be considered, along with potential off-site emergency and crisis situations.

Typical emergency situations which the Cairn Oil and Gas business has identified that could occur within its field of operations are:

- Fire and / or explosion
- Hydrocarbon (Oil / Gas) leak
- Aviation (Helicopter crash) and Marine / vessel incidents (Offshore)
- Building collapse
- Human Injury / Fatality / Medical evacuation
- Stakeholder impact / Community concern
- Oil spill / loss of containment from pipeline
- Earthquake
- Hazardous material (Radioactive) loss
- Oil spill / loss of containment at facility
- Well blow-out
- Motor Vehicle / Road Incident
- Structural failure
- Toxic material (H_2S) release

- Security incident / Terrorist activities / Kidnap / Bomb threat
- Severe Weather (Flood / Storm) conditions

General Requirements

Emergency response strategies (ERS) are the documented decisions on required emergency response measures for identified emergencies, based on risk evaluation and assessment process. It shall consider all statutory requirements applicable to the installations.

Objective of ERS is to identify the means to be used to secure adequate emergency response. It provides basis for monitoring of the adequacy of the emergency response measures so that they can be modified when essential.

ERS should include appropriate standard of performance for response measures associated with each type of identified major accident hazard and installation specific factors.

ERS should:

- Define and explain the objectives of the emergency response
- Explain in general how these objectives are to be achieved
- Define the role of resources
- Consider any installation & location specific factors that have significant influence on emergency response

ERS should include the following elements:

- Organization
- Procedures
- Equipment
- Information
- Competency building measures (Training & refresher courses and Drills & exercises)
- The role of any other measure essential for achieving successful emergency response

ERS should be based on maximum number of persons who may be involved in an emergency. During modification / construction work the number of persons on the installation can be significantly higher than considered in strategy; in such cases impact of increase in number should be assessed and required additional measures are to be implemented before number of persons is increased.

Emergency response measures shall consider the available resources as below:

- Installation resources: these resources are immediately available on the installation and are under control of installation Manager / Incharge. These include personnel and equipment that can be assigned emergency role.
- Area resources: these resources are available on the installations in the vicinity, within same area and are not under control of Installation In-charge. The resources may be available within the Cairn Oil and Gas or available by a mutual aid or cooperation agreement.
- External resources: these resources are available by a mutual aid or cooperation agreement at regional, national or international level and include organizations, professional bodies and resource persons.

General requirements as per Vedanta Technical Standard VED/CORP/SUST/TS 13 on Emergency and Crisis Management are:

i. Crisis situations shall be managed centrally by Cairn Oil and Gas business, in accordance with the requirements outlined in the standard.

ii. SBU operations shall also have procedures in place to ensure crisis situations are escalated to Cairn Oil and Gas business and Vedanta Group as appropriate.

iii. Emergency situations shall be managed by SBU operations and reported to Cairn Oil and Gas business and Vedanta Group as appropriate.

iv. Incidents shall be managed at the SBU operation level and reported in accordance with SBU operations, Cairn Oil and Gas business, Vedanta Group and regulatory reporting requirements. Also refer Management Standard MS11 on Incident Reporting, Escalation and Investigation.

v. Emergency Preparedness and Response Plans shall be developed, implemented and maintained at the SBU operation, Cairn Oil and Gas business and Group level to deal with incidents, emergencies and crisis situations.

Additional Cairn Oil and Gas requirements are:

i. The objective of emergency response planning is to have clear written procedures for expected actions during anticipated emergencies. Emergency response plan includes operational and procedural requirements for various emergency scenarios that are relevant for the installation.

ii. Ensure that appropriate resources and incident / emergency response plans are prepared, practiced and available. The procedures shall include provision for emergency arrangements with contractors.

iii. Critical resources of emergency response include:

   a. Emergency power systems
   b. Fire and gas detection systems
   c. Active fire protection
   d. Passive fire protection
   e. Shutdown system
   f. Explosion mitigation and protection systems
   g. Evacuation, escape and rescue arrangements

iv. Business continuity and recovery programme (BCP) to be developed, implemented, tested and maintained. The BCP shall be risk-based, documented and communicated.

v. Every Cairn business unit (including projects and offices) shall be covered by trained Incident and Emergency Management Teams who will manage and execute the emergency plans.

vi. All members of the emergency organizations should be trained and competent to perform their assigned role within the incident response (IRT) / emergency response (ERT) / emergency management (EMT).

vii. Arrangements for emergency medical treatment shall consider injuries to persons as a result of minor accidents & major accidental events, illness of persons on installation, transportation & evacuation of sick and injured personnel.

viii. Controlled medicines shall be stored in a secure place accessible only to those who are trained to administer these.

ix. The level of medical facilities and trained personnel provided should be in line with the requirements identified in emergency response strategy. Key points to be considered is identification of medical facilities / hospitals.

x. Emergency response plans shall comply with all relevant legislative and regulatory requirements to ensure emergency capabilities are maintained and achieved.

xi. Procedure for designing emergency response measures should be based on:
☐ Integration of emergency response with / into design and operations

☐ Automatic or remotely operated safety systems to mitigate the effects of an incident
☐ Emergency response organization structure

i. The assessment of emergency response measures includes analysis of their performance followed by a judgment on their adequacy. The role of different measures should be considered in an integrated manner so that the functioning of one measure does not prevent another from meeting its required performance standard.
ii. Arrangements shall be in place to provide for effective interfacing with other operators / industry organization, local administration and their emergency plans / procedures, where necessary.
iii. Wherever applicable offsite emergency response / disaster management plans shall be ensured.
iv. Essential safety system (such as control stations, temporary refuge, muster areas, fire pumps) shall be located where they are least likely to be affected by fires and explosions.
v. Fire control cannot be achieved until the source of fuel and ignition is isolated. An emergency shutdown (ESD) system shall be provided to isolate the installation from the major hydrocarbon inventories within pipelines and reservoirs, which if released on failure, would pose an intolerable risk to personnel, environment and the equipment / assets.
vi. ESD system shall be designed such, that it is capable of fulfilling its function under the conditions of incident. If installation is in operation, the essential shutdown functions shall be available during maintenance activities, which affect the operation of the ESD system. ESD system shall contain facilities for testing of both input / output devices and internal functions.
vii. Evacuation and escape routes shall be provided from all areas of an installation where personnel may be expected to be present during their normal activities. Alternative means to allow persons to safely leave the installation in an emergency shall be provided.
viii. Evacuation and escape routes shall have adequate illumination with emergency lighting and shall be marked to ensure that 'they can be used during emergency conditions'. All escape routes shall be unobstructed (including vertical clearance) and readily accessible.

ix. Personal protective equipment for use in major accident hazards should be suitable for the circumstances in which it may have to be used and the individuals who may have to use it.

x. PPE for use in an emergency should be for all persons on the installation for use in condition of fire, heat, gas release or smoke to enable them to reach muster areas, temporary refuges and evacuation or escape points. Those with specific emergency duties shall also be provided appropriate PPE for use like fire suits and breathing apparatus etc.

xi. In offshore, PPE like life jackets and survival suits (wherever needed), shall be available in sufficient quantity at accommodation and other suitable locations so that all persons will have ready access to them in the event of evacuation or escape. 'Sufficient quantity' and 'suitable locations' shall be based on risk assessment besides applicable regulations / guidelines.

xii. During an emergency, security arrangements shall ensure that unauthorized persons do not enter the incident site by controlling access and if need arises the area around the site can be evacuated and cordoned to ensure safety of the persons.

xiii. The offsite emergency response / disaster management plan shall describe the role of civil authorities such as District Collector and Public Authorities and other agencies.

xiv. In case of offshore, the emergency response shall include the role of concerned agencies like Indian Coast Guard, Indian Navy, Port Authority, Directorate General of Shipping and Directorate General of Civil Aviation.

xv. Designing the environmental emergency response should be based on an evaluation of environmental hazards in the event of unplanned discharge. Criteria should be based on available scientific data. These data may vary with the seasons and should be factored in the basis for establishing the emergency response.

xvi. Environmental emergency response should consider:

☐ Oil-pollution control equipment that should be located on the installation

☐ Environmental conditions that may be present when the equipment is deployed

☐ Capacity of the oil recovery system

☐ Characteristics of the oil / emulsion to be recovered

☐ Means to identify the extent of the spill

☐ Facilities to handle any recovered oil.

☐ International conventions have introduced the requirements to develop national plans for oil-spill response in offshore, and Offshore Assets / SBUs / Operations should ensure that their installations' emergency response plans are aligned with the national requirements.

Crisis Management

In the case of incidents having become emergencies and are deemed sufficiently serious in nature to require external support then the CMT Leader will activate Cairn Oil and Gas Crisis Management Team and inform Cairn CEO. Cairn CEO will inform Vedanta Group CEO and Vedanta Group Head HSE and Sustainability. Procedures for crisis management should be established as follows:

i. A crisis management team shall be established at the Cairn Oil and Gas business level.
ii. Members of the crisis management teams and their alternates shall be made aware of their roles and responsibilities, and adequate training provided.
iii. The crisis management team shall be capable of coordinating the provision of extraordinary resources where it is required to bring an incident under control.

Tiers of Emergency Response

Response strategies shall be commensurate with the nature, scale and associated hazards and risks for relevant emergency event. Due to the geographical nature of the Cairn Oil and Gas business operations, each facility or site e.g. operation, drilling, seismic etc. has an Incident Response Team, who are responsible for management and control of localized incidents and emergencies. Each remote location, site or facility has a specific Incident Response Plan and an Incident Response Team who are trained to manage incidents and emergency situations at their location.

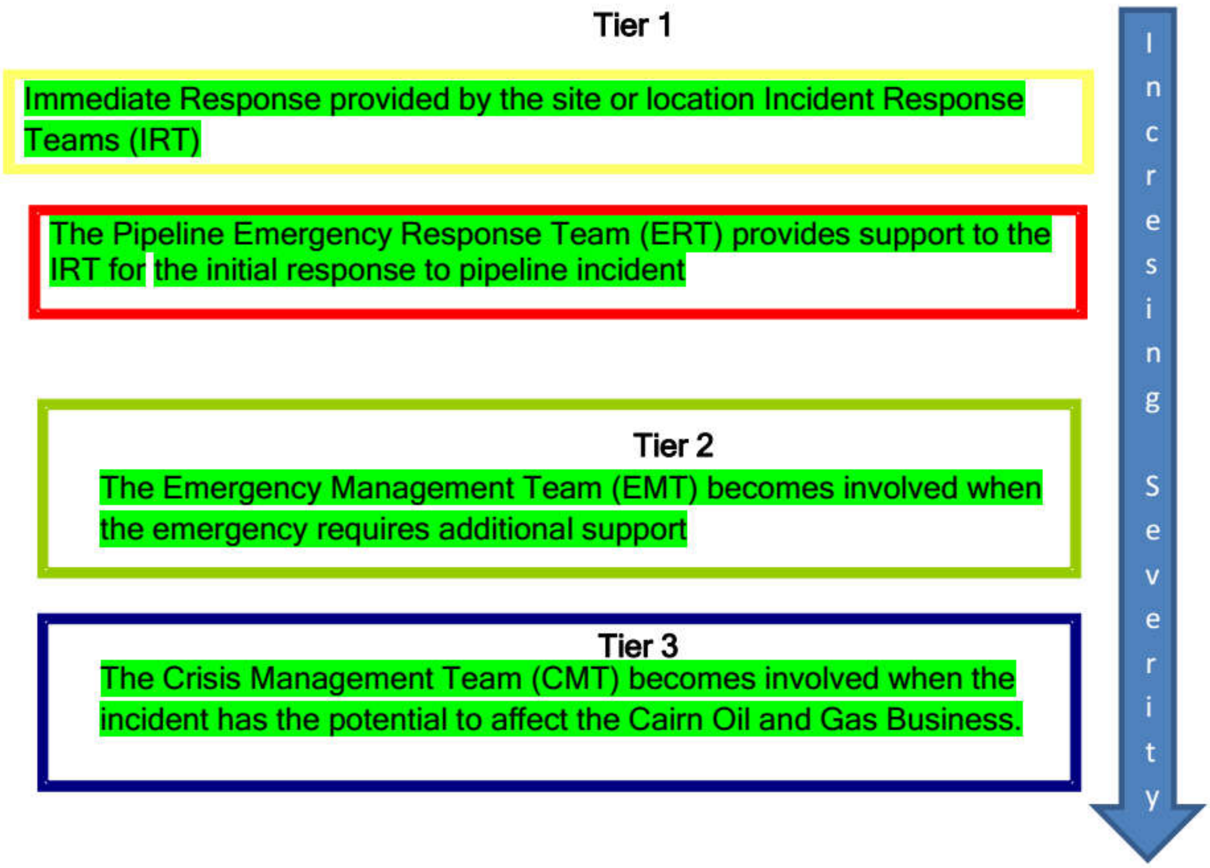


Fig: Tiers of Emergency Response

Responsibilities of the Individual Response Organizations

Incident Response Team (IRT) – Reactive Response

The Incident Response Team is responsibility for managing all incidents and emergencies which may occur at or in close proximity to their operational area. For emergencies where additional / external support is required the person in charge of the incident response, the Incident Controller at a remote location, site or facility must notify and request support and assistance from the next level in the emergency management organization. The ERT / EMT should be notified of all incidents within 30 minutes of the IRT activation at a remote location, site or facility. The role and responsibilities of the Incident Controller/IRT Leader are:

Role Purpose

- Manage and lead the response to an incident or emergency situation to minimize potential for escalation of incident. Protect life and limit damage to the equipment, plant and the environment by taking effective actions to control incident events.

- Manage and co-ordinate the activities of the Incident Control Team and site Response Teams
- If required interact with local external stakeholders.
- Ensure that all essential notifications are implemented both on-site and offsite. Communicate with the EMT Leader and External Emergency Services.

Responsibilities:

- To manage the response to any and all incident or emergencies at the Site, Plant or Field Location
- To Control the incident by preventing escalation and minimizing risk to personnel
- Direct and coordinate the activities of the Incident Control and Forward Response Teams.
- Ensuring sufficient trained and competent personnel are available to support the Response
  Teams.
- Ensuring the safety of all personnel working at the Site, Plant or Field location
- Evaluate and initiate immediate actions, to contain and mitigate effects of the incident or
  emergency. Monitor the situation & determine need for evacuation.
- Establish head count and potential whereabouts of any missing personnel and if necessary
  prepare search, rescue and recovery plan.
- Follow Incident Response Plan and if required develop a plan of action to deal with the incident or emergency and communicating this plan to the IRT members.
- Determine level and quality of local resources available to manage incident.
- Identifying, requesting and mobilizing any additional resources required.
- Ensure emergency procedures are followed, incident log is maintained, check lists are followed and preparation of statutory reporting documents.
- Arranging Medical Evacuation support.
- Planning and preparation for relocation of any evacuated personnel.
- Interaction with local external stakeholders as per requirement.
- Notify and liaise with Emergency Response Team / EMT Leader
- Ensuring appropriate action is taken to make the incident or emergency site safe before activities are allowed to resume.

Emergency Management Team (EMT) – Tactical/Strategic Response

In the event of an incident or emergency the Emergency Management Team Leader will make a decision whether or not to mobilize the EMT. If the decision is taken to mobilize the EMT then all EMT duty personnel are required to proceed promptly to the Emergency Management Team Room and manage emergency in accordance with their role, responsibility and as directed by the duty EMT Leader.

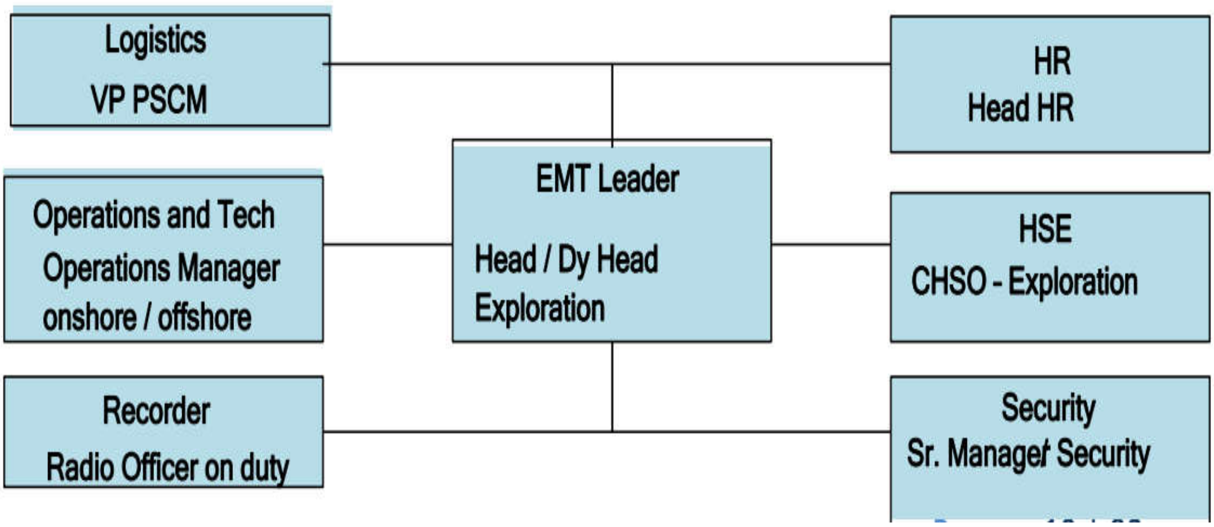


Fig: Emergency Management Team (EMT) Exploration including OALP

EMT Response Requirements

Cairn expects all incident and emergency responses to be treated with the highest professional level of competence and in line with the following:

1. Respond with following hierarchy, first priority for the safety of people and the preservation of life, second priority the preservation of the environment and third priority for assets.
2. Comply with all Company procedures and good business and safe working practices.
3. Gather and record all information about the incident or emergency and actions taken as this information will be required at a later date to review actions taken and may be used in the event of a formal inquiry.
4. To exercise best management judgment in deciding what, how and to whom information should be disseminated. Remembering, that where information involving people is concerned, next of kin must be considered and informed first.
5. Notify and comply with all local and national regulatory authorities as per legal requirements and instructions.

The role and responsibilities of the EMT leader and members of the team are as follows

EMT Leader

- Responsible for making the decision to mobilize partially or totally the EMT members and initiating the call-out of the appropriate EMT personnel;
- Responsibility for notifying the Crisis Management Team leader. In all situations which have resulted in a total or partial mobilization of the EMT the CMT leader must be notified;
- Responsible for correctly identifying and managing the emergency situation in an appropriate manner. Providing advice, support and assistance to the Incident Controller at the incident location;
- Responsible for developing and implement an appropriate plan of action in order to deal with the situation;
- Responsible for ensuring appropriate local and national government authorities are notified;
- Responsible for the preparation of media statements, obtaining approval from the CMT and releasing such statements once approval received;
- Responsible for ensuring the response to the incidents / emergencies is in line with Company procedures;
- Responsible for coordinating business continuity / recovery from the incident;
- Responsible for ensuring next of kin are notified in a timely manner;
- Responsible for coordinating any specialist support required.

EMT Human Resource Coordinator

The Human Resources Coordinator's emergency response role is to provide professional HR support to the EMT Leader and to implement the emergency response actions described below.

- Is responsible for maintaining accurate and up-to-date information on all of the Company's national and international staff, their location and identification details;
- Responsible for gathering information regarding all personnel at the incident location and information about any casualties and / or missing persons;
- Responsible for maintaining personal and next of kin data for staff members and contractor personnel (including expatriate persons) at all Cairn locations;
- Responsible for making arrangements for the timely notification of the next of kin of personnel as per requirement;

- Responsible for ensuring that an list of all personnel working at Cairn sites is maintained by the HR function containing, as a minimum:
    - Name, Date of birth, Nationality, Passport Number, Medical or identification details, Permanent and temporary address (telephone number & mobile number), Name and address of Next-of-kin (telephone number & mobile number);
- Responsible for ensuring the required support to next of kin;
- Responsible for managing all administration arrangements.

EMT HSE Coordinator

The HSE Coordinator's emergency management role is to provide professional health, safety, environmental and HSE regulatory requirement advice to the EMT Leader and for implementing the emergency response actions described below:

- Responsible for ensuring that Company procedures are being applied appropriately to the incident or emergency situation;
- Responsible for ensuring that safe working and environmental practices are being adhered to in dealing with the incident or emergency;
- Responsible for ensuring the appropriate level of Health and Safety of all personnel involved with the emergency response is considered throughout the incident or emergency;
- Responsible for liaising with the Logistics coordinator, in order to arrange the appropriate level of environmental response in the event of a major environmental incident;
- Responsible, in coordination with company doctor, for making onward medical arrangement for casualties who have been evacuated from the incident location.

EMT Operation and Technical Coordinator

The Operations and Technical Coordinator's emergency management role is to provide professional operations, engineering and technical advice to the EMT Leader and for implementing the emergency management actions below:

- Responsible for correctly identifying the type of incident and the level of technical advice and support required;
- Responsible for mobilizing the appropriate technical expertise from within or outside the company in order to provide required support at the emergency location;

- Responsible for identifying appropriate equipment and personnel to be sent to the emergency location if required;
- Responsible for liaising with the Logistics Coordinator in order to arrange for the transportation of equipment and personnel to the emergency location;
- Responsible for liaising with HR for coordinating contractor representative callout as per requirement.

EMT Logistics Coordinator

The Logistics Coordinator's emergency response role is to provide professional logistics advice and guidance to the EMT Leader and for the implementation of the emergency response actions described below:

- Responsible for the initiation and co-ordination of appropriate road, air and marine transport required during the management of an emergency situation;
- Responsible for the initiation and co-ordination of the resources required for the control and clean up in the event of a land or sea pollution event;
- Responsible for the co-ordination of the logistics and transport required in the event of a partial or total evacuation of personnel from an incident or emergency location.

EMT Security Coordinator

The Security Coordinator is responsible to the EMT Leader during any incident or emergency situation and for implementing the actions below:

- Maintaining security of the incident location;
- Ensuring security in the event of civil unrest or when required organizing additional security at the emergency scene;
- Obtain initial briefing from EMT Leader and provide security information and status reports to EMT Leader;
- Assess the emergency, identify security specific problems and recommend solutions to EMT Leader.
- Assume responsibility for any task delegated by EMT Leader;

EMT Recorder

The Recorders responsibility is to maintain an accurate timed record of key information received from the incident or emergency location and to record the actions initiated by the EMT Leader and for implementing the emergency response actions below:

- Record key incident events / actions on incident status board or electronically.
- Ensure all status information is up to date and correctly recorded / displayed.

EMT Radio Officer

The Radio Officer's emergency role is to support the EMT Leader by establishing and maintaining communications throughout the emergency and for implementing the actions below:

- When receiving notification of an emergency responsible for ensuring details are recorded accurately and when required for establishing contact with the EMT Leader;
- Initiate the EMT callout procedure when instructed to do so by the EMT Leader
- Establishing and maintaining communications with outside agencies, air and road transport etc.;
- For any media calls received by Call Centre, ensure EMT Leader is informed about it
- Notify the EMT Leader if communications are interrupted or lost with any respondents during the emergency.

EMT Public Relations / Corp Com

The Public Relations Coordinator's emergency response role is to provide professional public affairs and media communications advice to the EMT Leader and for the implementation of the emergency response actions described below:

- Responsible for gathering accurate information from and about the incident or emergency situation from EMT members and for preparing the media statements for approval by the EMT Leader and authorization by the CMT leader;
- Responsible for briefing the CMT member who is to brief the media or making any media releases if designated to do so;
- Responsible for arranging and coordinating briefings to the media;
- Responsible in coordination with HR for providing approved visitor list to the Security Coordinator;
- Responsible for arranging and coordinating liaison with the Community in the location of the incident or emergency.

EMT IT / Telecommunications Coordinator

The Telecommunications Coordinator's role is to ensure the EMT Room communications systems are functioning throughout the emergency and for the actions below:

- Responsible for ensuring the EMT members and EMT Centre's IT equipment and systems are maintained to a high standard to ensure they remain functional throughout the emergency;

- Responsible for ensuring a back-up communication system is available in the event of the EMT Control Centre not being available;
- Provide quality and diverse communication systems for use in routine and emergency situations.

EMT Legal Coordinator

Provides advice on legal aspects that need to be considered during the emergency response:

- Identify legal resources that might be of assistance, both internally and externally
- Identify legal requirements and constraints on action related to potential crises.
- Determine and advise on legal responsibilities liabilities towards a victim and dependents.
- Consider need for additional legal advice or support
- Assess the potential long term legal implications and prepare plan accordingly.

Doctor

Ensure all Site medical staff is fully trained and conversant with the medical equipment and emergency response procedures.

- Ensure sufficient medical staff are available to cover each operating site
- Ensure recommended area hospitals and their facilities are of the required standard
- Ensure any auxiliary medical teams e.g. nurses and first aid personnel are fully trained and conversant with their roles and responsibilities.
- Support and advise the EMT Leader on medical matters.
- Coordinate Level 1 emergencies with the local site/camp Doctor for all patient referrals to hospital. Monitor medical treatment and liaise with any other hospitals.
- Advisor for medical problems as required for the field doctors
- For all Level 2 emergencies guide and direct field doctors on course of action to be taken.
- Coordinate for Medivac Cases and Aero Medivac and the local hospitals for any stabilization cases
- Advise on readiness status with escalation process to HSE manager for ambulances
- Arrange for additional medical support to be available, liaise with external medical support, and organize hospitals for the reception and treatment of casualties.
- Maintain communications with site doctor/medics.
- To ensure any additional emergency medical equipment and medical transport are kept ready to deploy to the incident scene.

- Update EMT on status of casualties and any further requirements, especially for urgent evacuations.

Mobilization of the Emergency Management Team

Once the duty EMT Leader has established communications with the Location reporting the incident or emergency the following information shall be established:

- An overview of the incident or emergency and the general situation
- Time and exact location of the incident or emergency
- What will be the impact of the incident on people, environment, reputation and business?
- What support or action is required from the EMT

Once the duty EMT Leader has made contact with the location Incident Controller or the Emergency Response Team Leader the EMT Leader will then decide whether there is a requirement for the Emergency Management Team to be fully or partially activated. When the EMT is mobilized, the group members will normally meet in the designated Emergency Coordination Centre (EMT Room) located in the Gurgaon Office Building or at the site location (if EMT members are in the field).

Termination of Emergency, Deactivation of EMT Team

Once the emergency situation has been brought under control, EMT will evaluate situation and conclude further emergency response is not required. EMT will analyze emergency response, debrief and deactivate EMT.

Crisis Management Team (CMT) – Strategic Response

The Crisis Management Team, based in the Company's Corporate Office in Gurgaon, is responsible for providing the Company's strategic response to incident and emergency situations that have or have the potential cause damage to the Company's business e.g. loss of life, damage to reputation, significant financial loss, shareholder loss of confidence, litigation, international media interest. When a potential crisis situation appears likely, the CMT will be mobilized to manage issues pertaining to the reputation and the continued commercial well-being of the Company.

Crisis Management Team's Responsibilities

a. Ensuring an effective crisis response capability is in place for Cairn Oil and Gas,
b. Establishing policy related to the management of crisis, and

c. Ensuring that the impact from, and the implications of, the incident for the company as a whole are understood and addressed.

The purpose of the Crisis Management Team is to control and minimize loss (human, financial, resource, reputational) related to an escalating critical incident or crisis, and to protect the company's interests. The CMT is responsible for resolving a crisis, should one develop, and for providing strategic direction to the Emergency Management Team (EMT), Midstream ERT and Incident Response Teams (IRT's) at each location. In a crisis, the role of the CMT will be to:

- ➢ Confirm the situation;
- ➢ Analyze the facts;
- ➢ Identify objectives;
- ➢ Consider possible courses of action;
- ➢ Decide, and implement, courses of action;
- ➢ In coordination with the Cairn Oil and Gas CEO, the wider operational issues and ramifications;
- ➢ Ensure effective liaison with all stakeholders;
- ➢ Recover and resume the company business.

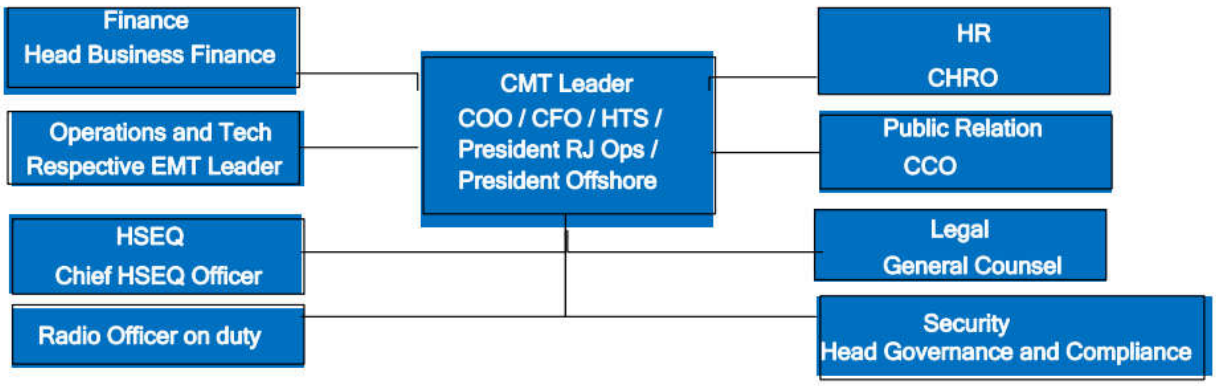
The duty CMT Leader is in charge during all crisis situations. The role of the CMT Leader covers:

- ➢ Crisis assessment including
    - Event tracking
    - Damage assessment
    - Assessment of resources and options
- ➢ Establishing Strategy for contingencies including
    - Managing human considerations
    - Managing communications
    - Co-ordination with external bodies
    - Controlling information
    - Managing public / community expectations
    - Managing legal requirements

The CMT members must be prepared for crisis prevention, management of a crisis and damage control after a crisis. Crisis situations may be prompted by any of the following occurrences:

- ❖ Incident Leading to Multiple Injuries or a Fatality

- Major Fire or Explosion
- Total Loss of a Marine Vessel
- Floods or Cyclone Impact
- Major Earthquakes
- Terrorism Activities / Bomb Threats
- Incident that could Lead to International Media Attention
- Effluent Discharge / offshore oil spill
- Incident Leading to Significant Financial Loss
- Major Traffic Incident with Multiple Casualties
- Incident Leading to Loss of a Facility
- Major Community Unrest
- Kidnap or Extortion Threat
- Pipeline Damage or Major Oil Spill



DOA shall be nominated for absence

Fig: Crisis Management Team

The above are considered being the most likely crisis events that could affect the Cairn Oil and Gas, however there may be other types of crisis situations the management may be exposed to, which are not identified in the list. If a crisis event of any type occurs, it can do irreparable damage to the reputation and future of the company if not handled appropriately. When the CMT Leader has made contact with the EMT Leader and has details of the incident they will decide whether full Crisis Management Team to be activated.

Termination of Emergency, Deactivation of CMT Team

Once the emergency situation has been brought under control, CMT will evaluate situation and conclude further emergency response is not required. CMT will analyze emergency response, debrief and deactivate CMT.

Crisis Management Team Roles

The Crisis Management Team is comprised of small core of senior executives. The CMT will collectively have responsibility for all major actions taken before; during, and after the crisis situation has occurred.

CMT Leader

Pre-Incident

- Be familiar with the content of the Crisis Management Process and Role and responsibilities of CMT Leader
- Be familiar with the Cairn Emergency Response Structure
- Participate in training and CMT drills programme as per requirement.

During a Crisis

- Mobilize CMT members, as required, and ensure that all members of the CMT are fully briefed and updated on the incident.
- Chair the proceedings of the CMT.
- Provide general oversight and direction, as per requirement, to the EMT working to resolve the emergency situation.
- Select additional specialist resources to join the CMT or to advise the CMT during a crisis, depending on the nature of the crisis
- Develop and implement crisis management strategy
- Develop and communicate the operating mandate of the CMT to those with responsibility for the on-scene activities.
- In consultation with EXCO nominate spokesperson to cover media interviews.
- Establish contact and communicate with appropriate government or other agencies.
- Through discussions with the EXCO determine the need to involve the CEO in communications or making statements.
- Brief other senior Vedanta personnel including CEO
- Prepare to coordinate business continuity and recovery strategy

Post Crisis

- Declare that the crisis is over
- Ensure a full debriefing and evaluation is conducted following resolution of the crisis.

CMT Legal

Pre-Incident

- Be familiar with the role and responsibilities of Legal representative
- Be familiar with the Cairn Emergency Response Structure
- Identify legal resources that might be of assistance, both internally and externally
- Identify legal requirements and constraints on action related to potential crises.

During a Crisis

- Advise on legal aspects that need to be considered in the resolution of a crisis.
- Determine and advise on legal responsibilities liabilities towards a victim and dependents.
- Provide legal advice to business continuity team on key actions e.g. critical media releases.
- Advise on implications to JV partners and contractual agreements
- Consider need for additional legal advice or support
- Advise on the content of documentary records, the extent of permitted access to these records and their potential production in a court of law.
- Arrange the secure storage of all documentary records

Post Crisis

- Assess the potential long term legal implications and prepare plan accordingly.
- Establish focal point within the legal team to deal with any on-going or long term legal issues

CMT Public Relations

Pre-Incident

- Be familiar with role and responsibilities of Public relations coordinator
- Be familiar with the Cairn Emergency Response Structure
- Ensures contact data for external support is maintained
- Prepare standard media messages that could be used within the first hour of a crisis.
- Ensure stakeholder communication plan is in place (who contacts who and how)

During a Crisis

- Coordinating public communication response

- Develop a crisis communication strategy specific to the crisis in consultation with the Legal.
- Draft a statement for approval by the EXCO and prepare appropriate background information material to distribute to the media.
- Prepares media releases and coordinates content with Legal and CMT Leader
- Manage media personnel
- If necessary establish 'Media Room'
- Monitor media response to incident
- Provides information to internal and external stakeholders
- Ensures media monitoring is undertaken throughout the crisis period
- Organize media conference if deemed necessary by CMT Leader or EXCO.

Post Crisis

- Monitor on-going media attention following closure of crisis
- Arrange for focal point for on-going media or public attention following closure of crisis

CMT Human Resources

Pre-Incident

- Be familiar with the role and responsibilities of Human Resources representative
- Be familiar with the Cairn Emergency Response Structure
- Be familiar with the location of the key telephone numbers
- Ensure SBU HR offices store up-to-date contact information for all company and contract staff.
- Ensure SBU HR teams are conversant with company polices on actions to take in emergency and crisis situations.
- Ensure appropriate processes are in place to deal with victim's next of kin.

During a Crisis

- Provide regular briefings to the family of a victim(s) on the progress of the incident and to arrange the timing and content of such briefings.
- Arrange the provision of assistance and welfare to the family of any victim.
- Monitor employee morale and advise the CMT on employee communications.
- Provide the CMT with relevant personal details of the victim and his/her family.
- Review the security of the family of any victim and any others who may require it and to recommend increased measures for CMT approval.

- Establish Trauma counseling if required

Post Crisis

- Continue to monitor staff following closure of crisis
- Arrange for focal point for on-going HR services to staff and family members.

CMT Finance

Pre-Incident

- Be familiar with the role and responsibilities of Finance representative
- Be familiar with the Cairn Emergency Response Structure
- Maintain adequate insurance coverage.
- Establish the procedure to be used in accounting for money necessary to be disbursed in the resolution of the crisis.
- Establish authorities for expenditure of Cairn funds by Crisis Management Team and Emergency Response Team during a crisis.

During a Crisis

- Ensure that funds are available, as necessary for resolution of the crisis and for the operating expenses of emergency response teams.
- Collect necessary information for preparation of any insurance claims.
- Establish authorities for expenditure of funds by CMT/EMT during a crisis
- Provide support to Business Continuity activities requiring funds
- Review liability and insurance scenarios
- Maintain records of all financial transactions

Post Crisis

- Continue to manage financial impact on company following closure of crisis

CMT CHSEO (HSE)

Pre-Incident

- Ensure that the Crisis Management Preparedness is reviewed at least once a year and amended as necessary.
- Ensure all the emergency and business continuity plans are up to date.
- Ensure all statutory regulations for each area are available and complied with.
- Distribute the Crisis Management guidance and amendments to CMT members, alternates, and other management persons as appropriate
- Ensure that knowledge of the crisis management is disseminated to key members of staff throughout the company.

- Ensure that the CMT meets at least annually to maintain awareness and training where appropriate
- Arrange suitable briefings and training for those persons involved in the CMT
- Prepare and maintain a CMT Control Centre (EMT Room) in a ready state.
- Arrange scheduled crisis simulation training and evaluation exercises.

During a Crisis

- Advise CMT Leader on any known Risk and HSE aspects
- Assess damage and potential damage to the environmental and sensitive areas which may be or are affected by the incident
- Advise CMT Leader on any health issues, liaise with company doctor
- Advice CMT Leader on any additional equipment or services required to mitigate incident.

Post Crisis

- Organize a lessons learned session for CMT
- Update the crisis management guidelines.

Emergency Preparedness and Response Plans (ERP)

i. Emergency and crisis management plans shall be established as early as possible. Key components include: communication systems, emergency resources, training and updating, and business continuity and contingency.

ii. Emergency Preparedness and Response Plans commensurate with the risks of the facility shall be developed and implemented at the SBU operation level, and this will usually form the basis of the primary response to an incident, emergency or crisis. In most cases these may be sufficient to effectively manage the emergency through at the site level. However, in the case of a crisis situation where there is a risk of the situation escalating further, further assistance may be required.

iii. ERP should include general procedures for everyone and detailed procedures for those with specific duties in an emergency, including the roles and responsibilities of the members of IRT/ERT as applicable.

iv. Key points for development of procedures are:

    - Communicating with authorities, media, relatives of affected personnel and others
    - Mobilizing company equipment, resources and personnel
    - Mobilizing third party resources for emergency support

- Evacuation, rescue and rehabilitation
- Preventing, mitigating and monitoring adverse environmental effects due to emergency actions
- Managing media
- Arrangements for training response teams and for testing the emergency systems and procedures

v. Incident detection: The method and speed of response of the system used to detect the need for emergency response shall be based on an understanding of the speed with which the incident can escalate.
   - The detection system should be adequately maintained and contingency arrangements which may require limiting operational activities should be established for situations where all or part of a detection system is not available for example during maintenance.
   - The alarm and communication systems provided should be appropriate for the range of identified reasonably foreseeable emergencies and capable of performing their function during the emergency. They should be capable of transmitting clear information to personnel, wherever they are likely to be on the installation, taking account of the conditions likely to be encountered in an emergency. Alarms should include audible and visual alarms and voice communication systems.
   - Everyone on the installation shall be aware of the meaning of different alarm signals. Key point to be considered is that alarm systems are maintained in operating conditions for identifying emergencies.
   - Decision on appropriate type of alarm should be based on their location, the environment in which they are expected to work, the speed with which the incident is likely to escalate, and expected number of personnel at the installation and their locations.
   - In the cases when it is not reasonable to make provision of automatic alarm, clear procedure should be there for communicating with appropriate person when an incident is detected.
   - The detection system should provide sufficient information on the nature and location of the incident so that appropriate response activities are initiated.

vi. Stakeholder engagement including employees, contractors, local emergency services, government / regulators / authorities, JV Partners, DGH and local communities, shall be carried out to ensure that inputs from all relevant stakeholders are incorporated in the identification of risks and development of Emergency Response Plans,.

vii. Emergency Preparedness and Response Plans shall be communicated to all relevant stakeholders in a clear and timely manner. Roles and responsibilities shall be established and clearly communicated to ensure adequate resourcing for the implementation of Emergency Preparedness and Response Plans.

viii. The plans will provide an effective response for the mitigation, control and recovery from incidents which can impact or disrupt the business and/or its managed site(s) and activities.

ix. The process for managing incident communications, notification and reporting shall be integrated into the Emergency and Crisis Management Plans and clearly:
a) Identify who is responsible for incident communication, notification and reporting.
b) Define how communication protocols are to be conducted with internal and external stakeholders.

x. There shall be a specific management representative who oversees the updating and maintenance of the Incident / Emergency Response Plans.

xi. Review of key stakeholder emergency management documentation and where possible, input from external partners should be sought. This process will add the extra assurance that the business is linked in with relevant agencies and others to assist in developing the broader environmental picture and in identifying Emergency Management related interdependencies.

xii. The Incident / Emergency Response Plans must be resourced. This process involves assessing available resources including supporting departments' emergency support functions and their ability to respond. Key questions to consider include:

- Do we have the needed resources and capabilities to respond?
- Will external resources be able to respond to us as quickly as we may need them, or will they have other priority areas to serve?

xiii. In addition to bringing an incident, emergency or crisis situation under control, each SBU should also consider how business continuity can be most effectively achieved during and in the aftermath of emergency and crisis situations and to allow business management teams to manage the ongoing business after the initial response. As a minimum, each Cairn Oil and Gas SBU shall consider creating a backup of critical information held in a secure and separate location.

xiv. SBU operations shall also identify and provide appropriate and sufficient backup resources, including:

- Alternative sources of water, electricity and fuel;
- Alternative facilities from which to operate temporarily;
- Alternative or additional manpower; and
- Alternative supply chain options.

Resources

- Each SBU shall identify and document the resources required to ensure the effective implementation of the emergency and crisis management procedures. Resource requirements shall meet the requirements of the Vedanta Management Standard MS01 on Leadership, Responsibilities and Resources.
- The following resources shall be considered and made available as necessary:
  - Trained and competent personnel;
  - Equipment and other materials including Personal Protective Equipment (PPE);
  - Warning devices;
  - Medical services, including personnel trained in first aid, and medical equipment that is appropriate to the type of operation;
  - Emergency services support; and
  - Emergency funding, along with an appropriate mechanism for delivering funds.
- The capacity of external resources, such as local firefighting capacity, shall be assessed, and additional resources acquired and maintained at the operation where external resources are deemed insufficient.
- The resources identified shall be maintained and tested on a regular basis, and their adequacy reviewed periodically.

Communication Systems

Emergency response relies upon effective and reliable communication between all personnel involved in response.

Communication systems shall:

- Provide sufficient reliable information / alarm to personnel on the installation to enable them to take the appropriate emergency actions.
- Provide means for those on the installation to communicate with the person in overall charge.

- Provide reliable arrangements to allow the person in overall charge to communicate with all personnel on the installation regarding the nature of any emergency and the actions they are required to take.
- Provide reliable means to allow the person in overall charge to communicate with area and external resources who have a role in emergency response.

Suitable equipment, information processing and procedures shall be in place to enable effective communications. The means of communication shall be selected based on the need for communication in likely scenarios including operational conditions under which they are to function like, noise, ambient conditions and susceptibility to damage. So far as reasonable, communication arrangements should remain available throughout the emergency. Communications related to emergency response shall be given in a manner that will be readily understood by the recipient. The following factors should be considered and included in the communication procedures for each type of incident:

- What information needs relaying?
- Who needs this information?
- When is the information required?
- How long will communications be required?
- Information overload from non-essential information.

Adequate provision for communicating with persons at other locations who may have to take action in an emergency and with possible sources of external assistance should be ensured. Alarm signals used and their meanings should be described in the emergency response plan along with the procedures to be followed in the event of an alarm. Persons should be provided with adequate information to allow them to, initiate alarms where necessary, distinguish between alarms and respond to alarms.

I. Adequate alarms and warning devices, along with other forms of communication, shall be maintained to reliably alert persons across the whole site in the event of an emergency.

II. Independent secondary / back-up communications systems shall be provided in case the emergency incident makes the normal communication system inoperable.

III. Ensure that the means are in place to alert to the connected installations, the local community / neighboring businesses in the event of an emergency that has the potential interface with them.

IV. A process should be in place to communicate emergency information to the media, through a trained and appointed spokesperson who can interact with relevant stakeholders, and through written press releases.

V. A process and sufficient equipment should be in place to handle incoming calls from government representatives, family members, local, national and international media persons etc.

VI. A contact list for all internal and external resources and personnel should be maintained in hard and soft copies and made easily accessible, so they can be easily contacted in the event of an emergency.

Training and Emergency Response Drills

All persons on the installation or in connected activities (including contractor's personnel) shall be trained periodically for emergency response and evacuation procedures. SBU operations shall ensure that information, training and instructions given are sufficient for personnel to be able to respond in an appropriate manner.

Training for employees having assigned roles in emergency response shall be completed before they are called upon to perform in real emergencies. Such trainings should include the various elements of emergency response plan, standard operating procedures for handling emergencies, emergency equipment operations and the PPE to be worn. They should be familiar with their roles and responsibilities, and the use of emergency response resources. The exact training needs shall be identified based on the requirements, roles and responsibilities, and capabilities of the individual(s) concerned.

Realistic assumptions shall be made for likely pattern of human behavior in an emergency like reduced performance level under stress. Persons shall not be assigned multiple conflicting roles for emergency response.

Competencies required, in all those responsible for decision making or involved in executing the emergency response plan, shall be identified and documented. Requisite competence shall be ensured through training, experience and knowledge, backed up by practice and refresher training.

Emergency response organization structure (IRT/ERT/EMT/CMT) shall ensure command by competent persons, which can be maintained, so far as is practicable, throughout an emergency. Key persons such as the Installation In-charge and Shift In-charge / control room operator shall be assessed for required competence to perform emergencies duties before assigning of duties. As far as possible, assessment should be under simulated emergency conditions.

SBUs shall ensure sufficient number of competent persons at all times on the manned installation to undertake emergency duties and operate relevant equipment.

All persons on an installation should have at least basic training in emergency response, basic first aid, use of life saving appliances and firefighting. Individual competencies shall be periodically tested to identify further requirement of training and knowledge to perform emergency duties.

SBUs shall ensure that every person who may be called upon to assist in implementing the emergency response plan is provided with adequate instructions and written information to be used during the emergency.

It shall be ensured that all persons new to the installation are given such instructions or training in the aspects of the emergency response plan, which are related to them during their stay on the installation.

Competency and training needs shall meet the requirements of the Vedanta management Standard MS06 on Competency, Training and Awareness.

The effectiveness of emergency response shall be demonstrated through a programme of drills and table top exercises that:

- Tests and develops the command structure and communication arrangements including offsite support
- Tests emergency equipment under realistic conditions
- Maintains and develops individual competencies in emergency response, including command and control activities
- Monitors the performance of individuals to identify areas of improvement and any additional training requirements
- Verifies data and assumptions used in the emergency response assessment

An emergency response table top exercise / emergency response drill is a focused activity that places the participants in a simulated situation requiring them to function in the capacity that would be expected of them in a real event. Its purpose is to ensure preparedness by testing policies and plans and by training personnel. One objective of an exercise is to be able to identify problem areas for resolution/ corrective action before an actual emergency occurs.

The drills need to address the readiness of personnel and their familiarity / proficiency with emergency equipment and procedures. All personnel on the installation involved including contractor's employees should participate in the drills. Scenarios should be varied to avoid drills being perceived as monotonous.

- Include, desk-based table top exercises, emergency response drills that involve the testing of equipment and logistics, and full evacuations.
- The drills and table top exercises shall be carried out as often as appropriate, against documented schedule. To be scheduled regularly, at least once a year for full drills and six monthly for desk-based exercises, although the exact frequency and type of drills may depend on the nature and scale of the operations, and the associated risks.
- Where it can be safely undertaken, consideration should be given to conducting some drills without pre-warning in order to test the effectiveness of the emergency response procedures.
- Safety shall be of prime consideration while carrying out these exercises and management judgment shall be exercised to ensure that unnecessary risks are avoided.
- An analysis and critique of each drill and exercise has to be documented to identify and correct weaknesses.
- Emergency response plan shall be reviewed and revised as appropriate in line with the findings from drills and table top exercises.
- Involve external emergency response agencies and other external stakeholders, where appropriate.

Objectives of conducting drills are:

- Test and evaluate plans, policies and procedures for effectiveness and adequacy;
- Evaluate adequacy of resources;
- Improve organizational coordination and communications;
- Clarify roles and responsibilities;
- Improve individual performance; and
- Meet regulatory requirements

Exercises can be designed to test individual essential elements, interrelated elements, or the entire plan(s). They can take many forms, such as:

- Drills;
- Table top exercises;
- Full-scale exercises; and
- Functional exercises.

Adequate safety briefing should be provided to short-term contractors who may have to carry out particular activities during emergencies.

Monitoring, Evaluation and Review

Documented reviews should be carried out after all drills and actual emergency responses to determine the effectiveness of the Emergency Preparedness and Response Plans, with a full debrief to identify what worked well and what aspects require improvement. Lessons learned following exercises or actual emergency situations/incidents shall be documented, and any gaps in planning and implementation shall be addressed in revised versions of the Emergency Preparedness and Response Plans. Lessons learned shall be shared across Vedanta's operations where appropriate. All Emergency Preparedness and Response Plans shall be reviewed and updated periodically, at least on an annual basis, to ensure they remain appropriate and relevant. Reviews shall also meet the requirements of the Vedanta Management Standard MS14 on Management Review and Continual Improvement.

Offsite Emergency Preparedness Plan

Vedanta Limited (Cairn Oil & Gas) will develop off site emergency plan which also includes linkages with local administration, local communities and other operators in the area to provide necessary support to manage the emergency.

The main aspects which will be included in the Off-Site Emergency Plan are:

- ***Organization***

  Detail of command structure, warning systems, implementation procedures, emergency control centers.

  Names and appointments of incident controller, site main controller, their deputies and other key personnel.

- ***Communications***

  Identification of personnel involved, communication center, call signs, network, lists of telephone numbers.

- ***Specialized Knowledge***

  Details of specialist bodies, firms and people upon whom it may be necessary to call i.e. those with specialized chemical knowledge, laboratories

- ***Voluntary Organizations***

  Details of organizers, telephone numbers, resources etc

- ***Chemical Information***

Details of the hazardous substances stored or procedure on each site and a summary of the risk associated with them.

- ***Meteorological Information***

Arrangements for obtaining details of weather conditions prevailing at the time and weather forecasts

- ***Humanitarian Arrangements***

Transport, evacuation centers, emergency feeding treatment of injured, first aid, ambulances, temporary mortuaries

- ***Public Information***

(a) Dealing with the media press office and

(b) Informing relatives, etc.

- ***Assessment of Emergency Plan***

Arrangements for:

(a) Collecting information on the causes of the emergency;

(b) Reviewing the efficiency and effectiveness of all aspects of the emergency plan.

Role of the Emergency Co-ordinating Officer

The various emergency services will be co-ordinated by an emergency coordinating officer (ECO), who will be designated by the district collector. The ECO will liase closely with the site main controller. Again depending on local arrangements, for very severe incidents with major or prolonged off-site consequences, the external control will be passed to a senior local authority
administrator or even an administrator appointed by the central or state government.

Role of the Local Authority

The duty to prepare the off-site plan lies with the local authorities. The emergency planning officer (EPO) appointed will carry out his duty in preparing for a whole range of different emergencies within the local authority area. The EPO will liase with the works, to obtain the information to provide the basis for the plan. This liaison will ensure that the plan is continually kept up-to-date. It will be the responsibility of the EPO to ensure that all those organizations which will be involved off site in handling the emergency, know of their role and are able to accept it by having for example, sufficient staff and appropriate equipment to cover their particular responsibilities. Rehearsals for off-site plans will be organized by the EPO.

Role of Police

Formal duties of the police during an emergency include protecting life and property and controlling traffic movements. Their functions will include controlling bystanders evacuating the public, identifying the dead and dealing with casualties, and informing relatives of death or injury.

Role of Fire Authorities

The control of a fire will be normally the responsibility of the senior fire brigade officer who would take over the handling of the fire from the site incident controller on arrival at the site. The senior fire brigade officer will also have a similar responsibility for other events, such as explosions and toxic release. Fire authorities in the region will be apprised about the location of all stores of flammable materials, water and foam supply points, and fire-fighting equipment. They will be involved in on-site emergency rehearsals both as participants and on occasions, as observes of exercises involving only site personnel.

Role of Health Authorities

Health authorities, including doctors, surgeons, hospitals, ambulances, and so on, will have a vital part to play following a major accident, and they will form an integral part of the emergency plan. For major fires, injuries will be the result of the effects of thermal radiation to a varying degree, and the knowledge and experience to handle this in all but extreme cases may be generally available in most hospitals. For major toxic releases, the effects vary according to the chemical in question, and the health authorities will be apprised about the likely toxic releases from the plant which will enable them in dealing with the aftermath of a toxic release with treatment appropriate to such casualties. Major off-site incidents are likely to require medical equipment and facilities additional to those available locally, and a medical "mutual aid"scheme should exist to enable the assistance of neighboring authorities to be obtained in the event of an emergency.

Role of Government Safety Authority

This will be the factory inspectorate available in the region. Inspectors are likely to want to satisfy themselves that the organization responsible for producing the off-site plan has made adequate arrangements for handling emergencies of all types including major emergencies. They may wish to see well documented producers and evidence of exercise undertaken to test the plan. In the event of an accident, local arrangements regarding the role of the factory inspector will apply. These may vary from keeping a watching brief to a close involvement in advising on operations. In cases where toxic gases may have been released, the factory inspectorate may be the only external agency with equipment and resources to carry out tests.

Safety Plan

Safety of both men and materials during construction and operation phases is of concern. The preparedness of an industry for the occurrence of possible disasters is known as emergency plan. The disaster in the plant is possible due to leakage of hazardous chemicals, collapse of structures and fire/explosion etc. Keeping in view the safety requirement during construction, operation and maintenance phases has formulated safety policy with the following regulations:

- To allocate sufficient resources to maintain safe and healthy conditions of work;
- To take steps to ensure that all known safety factors are taken into account in the design, construction, operation and maintenance of plants, machinery and equipment;
- To ensure that adequate safety instruction are given to all employees;
- To provide wherever necessary protective equipment, safety appliances and clothing, and to ensure their proper use;
- To inform employees about materials equipment or processes used in their work which are known to be potentially hazardous to health or safety;
- To keep all operations and methods of work under regular review for making necessary changes from the point of view of safety in the light of experience and upto date knowledge;
- To provide appropriate facilities for first aid and prompt treatment of injuries and illness at work;
- To provide appropriate instruction, training, retraining and supervision to employees in health and safety, first aid and to ensure that adequate publicity is given to these matters;
- To ensure proper implementation of fire prevention methods and an appropriate firefighting service together with training facilities for personnel involved in this service;
- To organize collection, analysis and presentation of data on accident, sickness and incident involving personnel injury or injury to health with a view to taking corrective, remedial and preventive action;
- To promote through the established machinery, joint consultation in health and safety matters to ensure effective participation by all employees;

- To publish/notify regulations, instruction and notices in the common language of employees;
- To prepare separate safety rules for each types of occupation/processes involved in a project; and
- To ensure regular safety inspection by a competent person at suitable intervals of all buildings, equipment, work places and operations.

Annexure – IV

HSE Policy of Vedanta Limited (Division: Cairn Oil & Gas)

HSE Policy

At Vedanta Resources Plc, we believe in sustainable development and are committed to effective management of health, safety and the environment as an integral part of our business. The health and safety of our employees and stakeholders who may be impacted by the company's operations is of paramount importance and our aim is zero harm to people and to the environment.

Vedanta Resources and its subsidiaries strive to:

- Comply with applicable national, regional and local Health, Safety and Environment ('HSE') regulations and statutory obligations and other requirements as appropriate. The company develops, implements and maintains HSE management systems aligned with our sustainable commitments and beliefs and consistent with world-class standards. We will drive continuous improvement in HSE through setting and reviewing targets, assessing and reporting HSE performance, using appropriate best available practices and providing all employees with appropriate training;
- Prevent injury and ill health to the company's employees and contractor' s employee's by providing a safe and healthy work environment and by minimising risks associated with occupational hazards;
- Improve and enhance environmental conditions and avoid, reduce, mitigate or compensate the environmental impacts to neighbouring communities in which we operate including air, water emissions and noise;
- Conserve natural resources, through adopting environmentally friendly and energy efficient technology and process improvements. The Company is committed to managing waste of our operations and we adopt the principles of waste avoidance, reuse, recycling and beneficial utilisation to minimise discharge and disposal to the environment;
- Promote a positive HSE culture within our organisation through effective communication, participation and consultation with employees in the workplace;
- Implement regular health surveillance and risk-based monitoring of all employees;
- Influence our contractors and suppliers to adopt principles and practices adopted by us and in accordance with our own policies;
- Communicate with all our stakeholders on the progress and performance of HSE management.

Vedanta Ltd. and Konkola Copper Mines (KCM) the wholly owned subsidiaries of Vedanta Resources sign this policy, which is implemented throughout their businesses. The content and robustness of implementation of this policy will be reviewed periodically and revised accordingly, and includes sharing best practices throughout the group.

We will also measure progress against this policy and review performance on a periodic basis to ensure ongoing management of Health, Safety and Environment.

Signed by:

Tom Albanese
Group CEO, Vedanta Resources plc

Date: *1st April 2014*