Pre-Feasibility Report

For

Onshore Oil and Gas Exploration and Appraisal in Block CB-ONHP-2017/5in Anand, Vadodara, Kheda Districts of Gujarat

VEDANTA LTD. (CAIRN OIL & GAS)

March, 2019

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1. Executive Summary

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 with interest in Zinc, Iron Ore, Aluminium, Copper, Power and Oil & Gas. Vedanta Ltd. (Cairn Oil & Gas) is the operator of the Onshore CB-ONHP-2017/5 block. The block covers an area of 990 Sq.Km in Anand, Vadodara, Kheda districts of Gujarat. Vedanta Ltd. (Cairn Oil & Gas)has been granted with an exploration and production license by Government of India under the Revenue Sharing Contract (RSC) on1st October 2018.

1.1 Project Details

1.1.1 Proposed facilities

Vedanta Limited (Cairn Oil & Gas) proposes to carryout seismic survey, exploratory including appraisal well drilling and setting up of Early Production Units (EPUs)/Quick Production Units (QPUs) and early production in the block **CB-ONHP-2017/5**.

1.1.2 Justification of the project

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.

Import of Crude Oil during April-November, 2017 was 144.72 MMT valued at 3,42,673 crore which marked an increase of 9.31% in quantity terms and 15.32% in value terms as against the imports of 143.81 MMT valued at 2,97,161 crore for the same period of last year. Therefore, 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 drilling, development and production project could possibly result in the discovery of hydrocarbon and in that case, would help in reducing India's dependence on imports.

1.2 Site Analysis

1.2.1 Climate

The study area experiences a humid and warm sub-tropical climate throughout the year except for a cold winter in December till February. Hourly micro-meteorological data collected during the pre-monsoon reveals that the pre-dominant wind direction is from South East with an average speed of 0.80 m/s.

1.3 Water and power requirements

1.3.1 Water Requirement

A. Water Requirement during Seismic Survey

The water requirement is 20 – 30 m3/day for domestic needs of the temporary campsite and will be sourced locally through approved authorities.

B. Water requirement during Exploratory and Appraisal well drilling

The most significant requirement of water for drilling activities is for mud preparation. The water requirement for WBM preparation will be 600-1000 m3/well. The water requirement for SBM preparation will be 150-300 m3/well. The other requirement approx. 25-50 m3/well/day would be for drilling activities like engine cooling, floor / equipment / string washing, fire-fighting storage / make-up. For domestic consumption, approx. 20 - 30 m3/day water will be required during drilling period. The water requirement will be sourced locally through approved authorities.

1.3.2 Power requirement

A. Power requirement during seismic Survey

Each camp site shall have access to 2x350KVA (1 standby) of DG sets. The required power supply will be provided either from diesel generators or state electricity grid.

B. Power requirement during Exploratory and Appraisal well drilling

The power requirement of drill rig will be met by three (03) DG sets (including one as standby) (3*1000 KVA), 2*350 KVA for drilling camp site and 2* 100 KVA for the radio room respectively.

1.4 Pollution control measures

1.4.1 Pollution Control measures during Seismic Operations

A. Air Emissions and Control Measure

Emissions to air include transient airborne dust raised by construction activities (e.g. preparation of seismic cut lines and moving vehicles and equipment) and emissions from vehicles and machinery. These emissions are transient and insignificant nature.

B. Noise Emissions and Control Measure

Noise emissions that could be released during the seismic operations will include those generated by blasting of dynamite charges in shot holes, field machinery (Bulldozer and support vehicles) and generators and work yard at the camp site. Adequate noise control measures will be taken to minimize the noise level.

C. Wastes treatment and disposal

The non-hazardous wastes like domestic wastes and effluents, plastics, and paper and disposal options include, compaction and removal from site and burying (especially for biodegradable material), or a combination of these activities.

1.4.2 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).

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. 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.Adequate control measures will be taken to minimize exposure of noise to drilling personnel.

C. Waste treatment and disposal

250-750tons/well for drill cuttings associated with WBM and 500-1500 tons/well for drill cuttings associated with SBM and 250-500 tons/well WBM spent/residual drilling mud will be generated at site during drilling operations. This will be stored in well-designed HDPE line pit.

Used /waste Oil – During the drilling approx. 1-2 tons of used oil,sludge containing oil and other drilling wastes will be 250-500tons/well will be generated per well. This oil will be sent to authorized recyclers.

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

All kinds of waste will be disposed in accordance with the requirements of CPCB/SPCB.

D. Waste water Treatment

The drilling waste water will be treated suitably.

1.5 Project schedule and cost estimate

Vedanta Ltd (Cairn Oil and gas) has planned to carryout proposed project activities in the CB-ONHP-2017/5 Block in next 10-12 years.

The cost of the project is estimated is given below:

1) Physical Surveys Cost estimated to be approximately INR 1.96 Crore.
2) Average Cost per well for exploratory & appraisal well is estimated to be INR 10.5 Crore.
3) Average cost of each EPU (Early Production Unit)/ QPU (Quick Production Unit)is estimated to be INR 44.13 Crore.

1.6 Employment Generation

The seismic surveys are expected to take about 6 to 8 months and will require a crew of approximately 400 to 500 persons. 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 engaged are either from Vedanta Limited or contractor's crew as applicable. 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.

1.7 Rehabilitations and Resettlements

For exploration, appraisal and production activities, the project does not envisage any R & R of the project, since 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.For sites selected having settlements if any, 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, Cairn 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 restoration activities directly or indirectly through CSR activities.

2. Introduction of the project

2.1 Identification of the project

Vedanta Ltd (Cairn Oil & Gas) has been awarded the CB-ONHP-2017/5 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 (Cairn Oil & Gas) proposes to carry out exploration (including seismic surveys, exploratory and appraisal well drilling), and early production of oil and gas in the block. 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)/QPU (Quick Production Unit) for the processing of produced well fluids.

2.2 Brief description of nature of the project

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

2.3 Need for the project and its importance to country and region

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 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. The proposed project would also contribute to the state Governments in terms of royalty through the mining lease. Additionally the proposed project would generate direct and indirect employment in the region.

2.4 Demand-supply Gap

As on 1.4.2017, In-place hydrocarbon volume of 10454 million tonnes of oil and oil equivalent gas could be established through exploration by ONGC, OIL and Private/JV companies. So, about 75% of resources are under "yet to find" category. Out of 10454 MMT of oil and oil equivalent gas of In-place volumes, the ultimate reserves which can be produced are about 4017 MMT of oil and oil equivalent gas since inception. The balance recoverable reserves are of the order of 1787 MMT of oil and oil equivalent gas.

2.4.1Production and Consumption

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. The demand for petroleum has recorded a considerable increase over the last few years 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

Therefore, India is largely dependent on import of petroleum goods to meet its requirements. Vedanta's proposed exploratory drilling project could possibly result in the discovery of hydrocarbon and in that case, would help in reducing India's dependence on imports.

2.4.2Imports

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. Import of Crude Oil during April-November, 2017 was 144.72 MMT valued at 3,42,673 crore which marked an increase of 9.31% in quantity terms and 15.32% in value terms as against the imports of 143.81 MMT valued at 2,97,161 crore for the same period of last year.

2.5 Import versus indigenous production and export

India imports more than 80% of the petroleum products of its daily requirement.

2.6 Domestic Markets

The produced oil & gas in case of commercially viable discoveries of hydrocarbons will be utilized for domestic purpose to supply the increasing demand in domestic market.

2.7 Employment generation

The seismic surveys are expected to take about 6 to 8 months to complete and will require a crew of approximately 400 to 500 persons. And 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 engaged are either from Vedanta Limited or contractor's crew as applicable. 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.

3 Project Description

3.1 Type of project

The proposed project is a green field project. There is no interlinked and inter-dependent project.

3.2 Location with co-ordinates

The block CB-ONHP-2017/5 is located in Anand, Vadodara, Kheda districts of Gujarat. It encloses an area of 990 Sq. Km. and is bounded by the points having following coordinates Table-1. A map of the area is shown in Figure 1.

BLOCK: CB-ONHP-2017/5

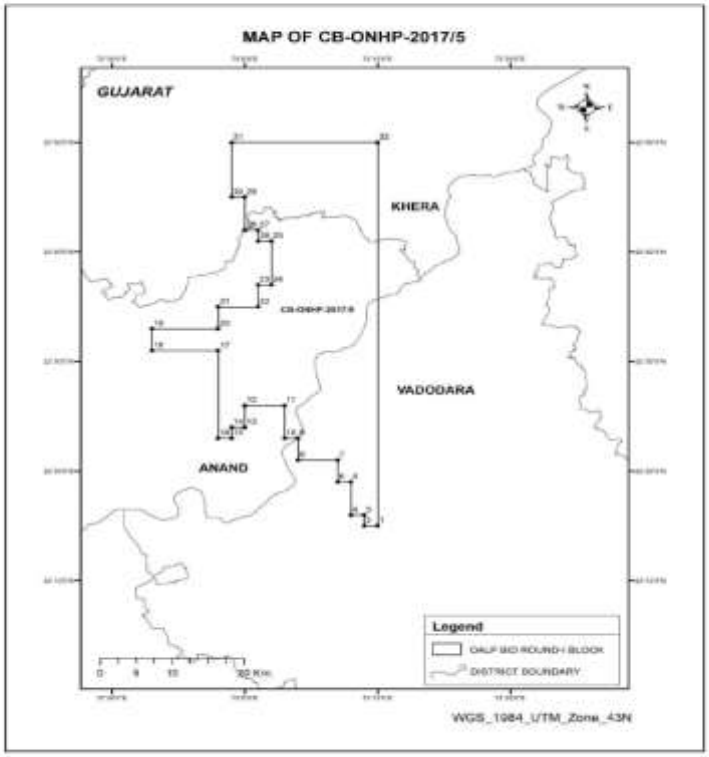

Figure-1: Location map of block CB-ONHP-2017/5 with state and district boundary

Co-ordinates of Block CB-ONHP-2017/5 (As per RSC)

Points	Longitude	Latitude
1	73° 10'	22° 15'
2	73° 9'	22° 15'
3	73° 9'	22° 16'
4	73° 8'	22° 16'
5	73° 8'	22° 19'
6	73° 7'	22° 19'
7	73° 7'	22° 21'
8	73° 4'	22° 21'
9	73° 4'	22° 23'
10	73° 3'	22° 23'
11	73° 3'	22° 26'
12	73° 0'	22° 26'
13	73° 0'	22° 24'
14	72° 59'	22° 24'
15	72° 59'	22° 23'
16	72° 58'	22° 23'
17	72° 58'	22° 31'
18	72° 53'	22° 31'
19	72° 53'	22° 33'
20	72° 58'	22° 33'
21	72° 58'	22° 35'
22	73° 1'	22° 35'
23	73° 1'	22° 37'
24	73° 2'	22° 37'
25	73° 2'	22° 41'
26	73° 1'	22° 41'
27	73° 1'	22° 42'
28	73° 0'	22° 42'
29	73° 0'	22° 45'
30	72° 59'	22° 45'
31	72° 59'	22° 50'
32	73° 10'	22° 50'

Table-1: Co-ordinates of Block CB-ONHP-2017/5 boundary (as per RSC)

3.3 Details of alternate site considered and the basis of selecting the proposed site

The block is allocated by the Government of India under the Revenue Sharing Contract (RSC). Vedanta Ltd. –(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 field/block. The locations of wells are selected considering the drilling configuration (reach to reservoirs).

3.4 Size/ magnitude of operation

Theproposed onshore oil and gas exploration, appraisal andearly production project is expected to carry out

1. Seismic data acquisition
2. Drilling of 44 exploratory (including appraisal) wells
3. Setting of Early production Units (EPUs) /Quick Production Unit(QPU)) for produced well fluid processing and production of up to16000 BOPD of crude oil and up to 2.4 MMSCFD of associated natural gas.
4. The exploratory and appraisal wells will be drilled to explore the reservoirs up to a depth of 2000m approx.

3.5 Project description with process details

3.5.1 2D & 3D Seismic survey:

Seismic surveys are a primary tool utilized during the exploration of hydrocarbons over land and water. A seismic survey is conducted by creating an energy wave commonly referred to as a 'seismic wave' on the surface of the ground/ over water along a predetermined line, using an energy source. This wave travels into and through the earth strata, where it is reflected and refracted by various subsurface formations, and returns to the surface where receivers called geophones are used to detect the waves and convey them to a recorder for analysis. Seismic waves can be induced by the following methods: small explosive charges, primarily dynamite, set off in shallow holes known as 'shot holes'; or by large 'Vibroseis' trucks equipped with heavy plates that vibrate on the ground or air guns for water based surveys. By analyzing the time it takes for the seismic waves to reflect off subsurface formations and return to the surface formations can be mapped and potential oil or gasdeposits identified.2D/3D surveys are acquired by laying out energy source points (vibroseis or dynamite charges) and receiver points (geophones) in a grid over the area to be surveyed. The receiver points - to record the reflected vibrations from the source points - are laid down in parallel lines (receiver lines), and the source points are laid out in parallel lines that are approximately perpendicular to the receiver lines. The spacing of the source and receiver points is determined by the design and objectives of the survey. In case of 2D seismic survey, the receiver points, to record the reflected vibrations from the source points, are laid down in between the receiver lines.**Figure 3** shows the typical layout of onland seismic survey.

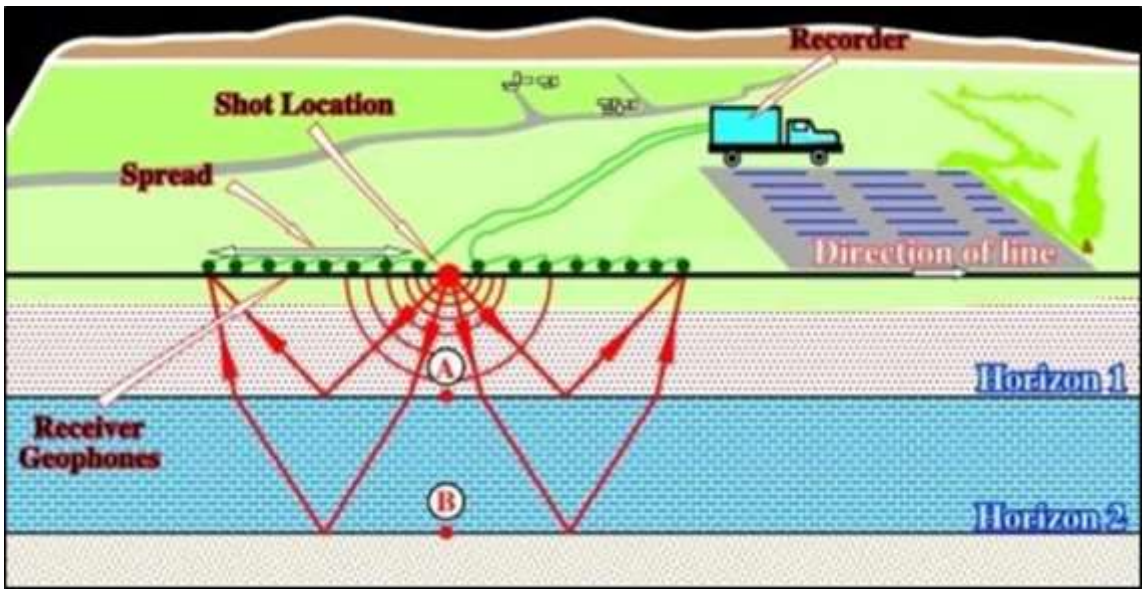

Figure-2: A typical illustration of online 3D seismic survey

To estimate the thickness and seismic velocity of the weathered zone as well as the sub-weathering velocity, Seismic 'upholes' (drill holes (20–50m in depth)) placed at regular intervals (1–2km) along exploration seismic lines. These data are then used in computing time corrections to a nominal seismic datum, which is a fundamental step in computer processing of seismic field data. The upholes will be drilled by a small truck-mounted rig usually using compressed air to lift soil cuttings, adding water occasionally to lift gravelly material. Apart from soil, ground sandstone and adding water occasionally to lift gravelly material. Apart from soil, ground sandstone and water, no chemicals will be added to the drilling fluid only small quantities of bentonite clay if required during backfilling to seal off any encountered groundwater. Once recordings have been made, the majority of the cuttings will be returned to the hole. The cuttings present no risk to the environment in toxicity terms. Excess cuttings at each Uphole, if any, are placed on top of the Uphole and will integrate into the soil over time.
3D seismic surveys are generally conducted in a similar way to 2D seismic surveys but with the variation of setting up six or eight geophone cables side by side at the same time at a distance in most cases of about 100 to 400 metres apart. Several “shots” from calculated positions along and between the receiver lines are taken, before the cables are moved up and the process repeated. 3D seismic surveys must be conducted over a large area in order to provide sufficient data for accurate interpretation of the subsurface geology. The data collected can later be combined into a single data set for processing and analysis, provided there is sufficient overlap of the areas covered by the surveys. Computer analyses of the recorded seismic waves provide a profile of the underlying rock strata and offer the basis for identifying potential hydrocarbon traps.

3.5.1.1 Seismic Survey Objective, Scale and Extent

The objective of the proposed seismic survey is to identify and delineate potential prospects, if any, in sufficient detail to be able to, at a later and different stage, test one or more by drilling.
2D & 3D Seismic data acquisition is planned within block area.
The seismic data acquisition exercise (Recording) will take approximately 6 to 8months. It should be noted that while there are pre-determined seismic line transects based on analysis of pre-existing data, the actual locations of the seismic transects may be varied prior to and/or during the seismic data acquisition exercise. The seismic survey operation will be constrained along the seismic survey lines and to the base and fly camps, as well as to the access roads to these areas.

3.5.1.2 Personnel and Facilities

The project requires a base camp to be constructed within the survey area. Base camps range in size and are constructed to accommodate 400 to 500 persons depending on the size of the project. There will, in addition, be small, mobile fly camps that will be serviced from the main base camp. A mobile fly camp is used to extend the operational reach of the seismic line crews during operations. Mobile fly camps rang in size from 50 to 100 persons. Thus, the base camp will support the crew, and “fly camps” will accommodate smaller-sized groups of personnel in outlying areas, and will be set up as and when required. Such campsites will be located away from community settlements. A fully equipped and staffed ambulance will be on standby in case of accidents or emergencies, and will be supported by a fully equipped and staffed clinic that will be located in the base camp.

3.5.2 Drilling of Exploration and Appraisal well:

Vedanta Ltd. (Cairn Oil & Gas) proposed to drill 69 exploration & appraisal wells within the present block boundary of CB-ONHP-2017/5.
The basic objective of the exploratory drilling will be as follows:-

- To determine the presence of potential hydrocarbon
- To appraise discovered oil & gas

The lifecycle of drilling activities involve well site selection, site and access road preparation and its maintenance, construction of drilling well, drilling activities, well testing and decommissioning and closure of wells, if not proved economically viable for production of oil and gas. The following are the commonly used terms in an oil and gas project.

3.5.2.1 Location & Description of Drilling Wells

The exact locations for the drilling of exploratory and appraisal 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. The acquired exploratory block CB-ONHP-2017/5 is situated in Anand, Vadodara, Kheda district of Gujarat. The tentative drilling locations are presented in satellite image **(Figure-3)** and Survey of India toposheet **(Figure-4).** Specific details are given in Table-2 and the tentative co-ordinate of the wells are given in the **Table 3.**

There is a wide variation in the target depths of the planned wells as the well depths 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 60-90 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) durations to 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.

Table-2: Specific details of the proposed wells

Well Details	Detailed Information
Well Locations	Tentative co-ordinates in Table-3
Depth of Wells	4500m
Total Estimation of drilling period	30-50 days/ well
Total Estimated Testing Period	25 - 30 days/ well
Proposed Drilling Fluid	WBM (Water Based Mud) in shallower section and SBM (Synthetic based mud) in the deeper section.

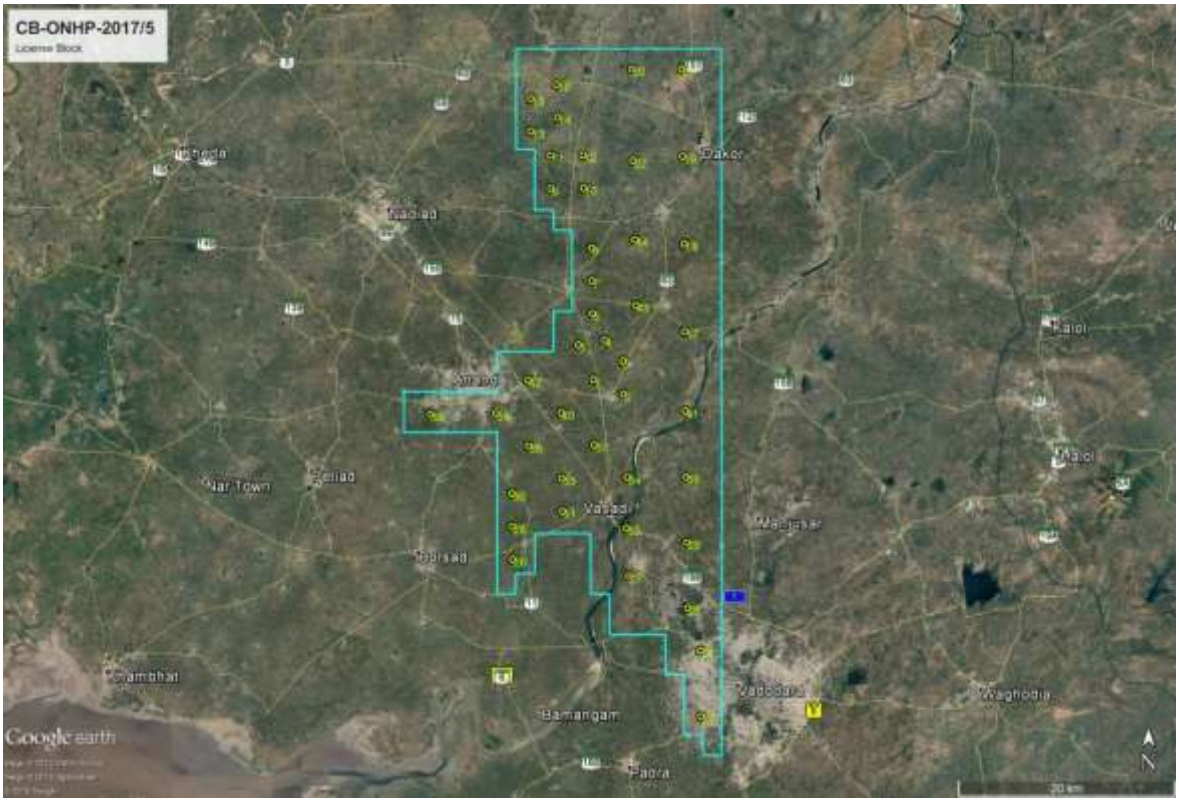

Figure-3. Google map with Tentative Location of proposed wells on satellite map

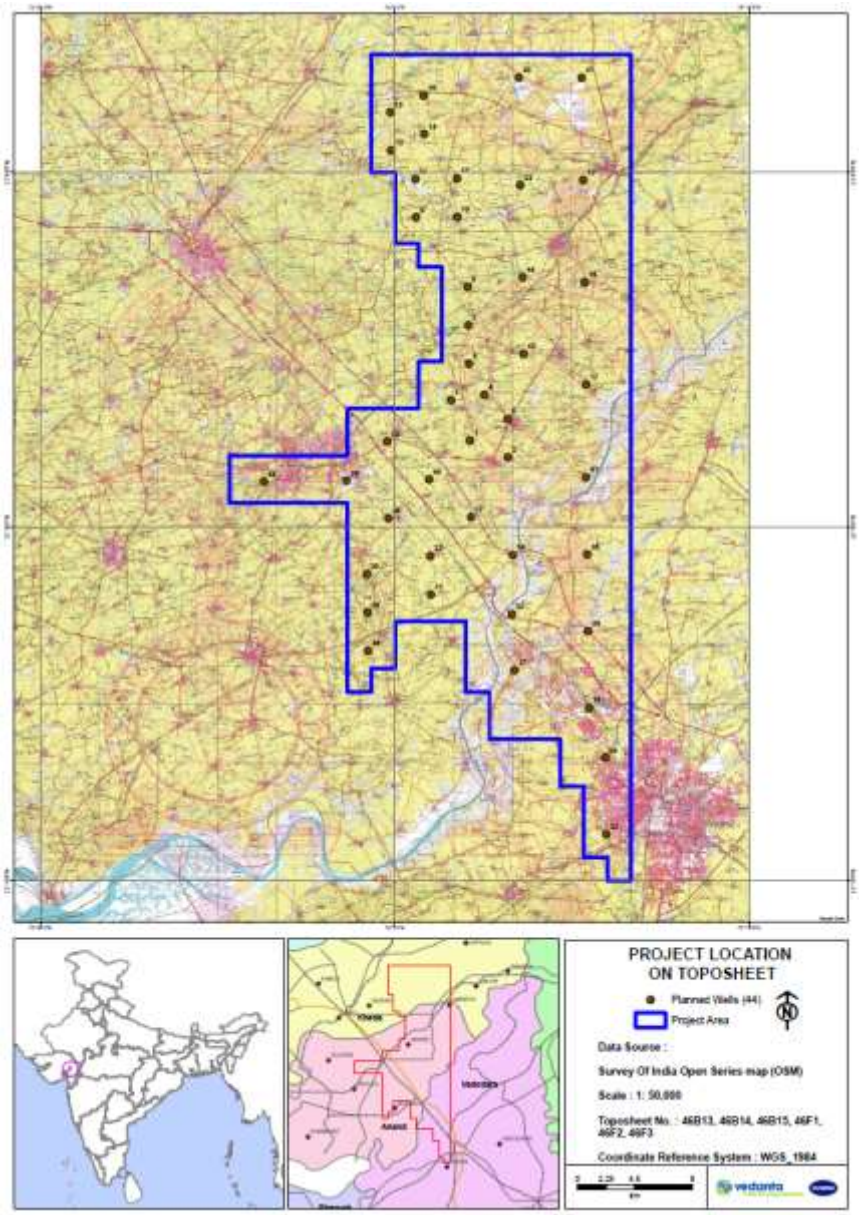

Figure 4 Toposheet map with Tentative Location of proposed wells on satellite map

Table 3: Tentative well co-ordinates to be drilled in block CB-ON-HP-2017/5

Wellid	Long_DMS	Lat_DMS	Village	Taluk	District
1	73° 3' 10.796" E	22° 33' 38.933" N	Sarsa	Anand	Anand
2	73° 4' 47.456" E	22° 32' 55.800" N	Sarsa	Anand	Anand
3	73° 2' 22.466" E	22° 35' 21.408" N	Rasnol	Anand	Anand
4	73° 3' 47.925" E	22° 35' 34.904" N	Kunjrao	Anand	Anand
5	73° 4' 46.105" E	22° 34' 33.311" N	Khambholaj	Anand	Anand
6	73° 3' 8.053" E	22° 36' 53.952" N	Sardarpura	Umreth	Anand
7	73° 3' 6.678" E	22° 38' 31.462" N	Bhalej	Umreth	Anand
8	73° 3' 5.302" E	22° 40' 8.970" N	Untkhari	Umreth	Anand
9	73° 0' 53.803" E	22° 43' 5.792" N	Zala Bordi	Umreth	Anand
10	73° 2' 38.908" E	22° 43' 7.087" N	Ardi	Umreth	Anand
11	73° 0' 52.395" E	22° 44' 43.297" N	Paldi	Mahudha	Kheda
12	73° 2' 37.521" E	22° 44' 44.595" N	Chunel	Mahudha	Kheda
13	72° 59' 50.159" E	22° 45' 55.563" N	Sanali	Mahudha	Kheda

Wellid	Long_DMS	Lat_DMS	Village	Taluk	District
14	73° 1' 14.623" E	22° 46' 37.707" N	Nagvel	Mahudha	Kheda
15	72° 59' 48.732" E	22° 47' 33.067" N	Kadi	Mahudha	Kheda
16	73° 1' 13.215" E	22° 48' 15.212" N	Mirjapur	Mahudha	Kheda
17	73° 8' 5.356" E	22° 36' 0.592" N	Shili	Umreth	Anand
18	73° 8' 1.873" E	22° 40' 20.631" N	Bechari	Umreth	Anand
19	73° 7' 58.376" E	22° 44' 40.667" N	Malai	Thasra	Kheda
20	73° 5' 14.910" E	22° 49' 1.099" N	Bordi	Thasra	Kheda
21	73° 7' 54.865" E	22° 49' 0.702" N	Chandasar	Thasra	Kheda
22	73° 5' 18.638" E	22° 44' 27.901" N	Khijalpur Talpad	Thasra	Kheda
23	73° 8' 57.148" E	22° 16' 58.052" N	Soudagar Park	Thasra	Kheda
24	73° 8' 54.568" E	22° 20' 13.088" N	Ankodiya	Vadodara	Vadodara
25	73° 8' 13.438" E	22° 22' 19.803" N	Petrochemical complex	Vadodara	Vadodara
26	72° 58' 52.090" E	22° 24' 44.682" N	Ambav	Thasra	Kheda
27	73° 5' 3.840" E	22° 23' 55.119" N	Anagadh	Vadodara	Vadodara
28	72° 58' 50.676" E	22° 26' 22.189" N	Haldari	Anklav	Anand
29	73° 8' 10.838" E	22° 25' 34.837" N	Sankarda	Vadodara	Vadodara
30	72° 58' 49.260" E	22° 27' 59.696" N	Kasumbad	Borsad	Anand
31	73° 1' 31.352" E	22° 27' 7.616" N	Sundan	Anand	Anand
32	73° 4' 56.975" E	22° 26' 17.608" N	Fajalpur	Vadodara	Vadodara
33	73° 1' 29.969" E	22° 28' 45.125" N	Adas	Anand	Anand
34	73° 4' 59.821" E	22° 28' 47.659" N	Anklavdi	Anand	Anand
35	73° 8' 8.230" E	22° 28' 49.869" N	Moksi	Savli	Vadodara
36	72° 59' 43.642" E	22° 30' 21.338" N	Vadod	Anand	Anand
37	73° 3' 13.530" E	22° 30' 23.912" N	Ramnagar	Anand	Anand
38	72° 54' 27.357" E	22° 31' 54.835" N	Nand Tanuj Society	Anand	Anand
39	72° 57' 57.273" E	22° 31' 57.527" N	Mangal Nagar	Anand	Anand
40	73° 1' 27.198" E	22° 32' 0.143" N	Mogar	Anand	Anand
41	73° 8' 5.614" E	22° 32' 4.899" N	Khanpur	Anand	Anand
42	72° 59' 40.826" E	22° 33' 36.351" N	Chikhodra	Anand	Anand
43	73° 5' 27.174" E	22° 37' 18.445" N	Khankuva	Umreth	Anand
44	73° 5' 24.476" E	22° 40' 33.468" N	Parvata	Umreth	Anand

Note:- Actual geo-graphical surface coordinates of exploratory and appraisal well locations would be within 2000m radius of the proposed coordinates.

Exploratory and Development well Drilling Process

The exploitation of hydrocarbons requires the construction of a conduit between the surface and the reservoir, which is achieved by the drilling process. Exploration and Appraisal wells will be drilled using an Electric Land Rig of around 1200-1500 HP capacity, equipped with a Rotory/Top Drive System.

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

- Portable Living Quarters – to house essential personnel on site on a 24 hr basis.
  These units are provided with Bath/Washroom.
- Crane-age - cranes for loading/off-loading 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, ETP,Cuttings disposal, Drill Cementing equipment 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 flow chart of **Figure 5 and Figure 6** shows the various phases of the drilling activities and model of drilling process respectively:

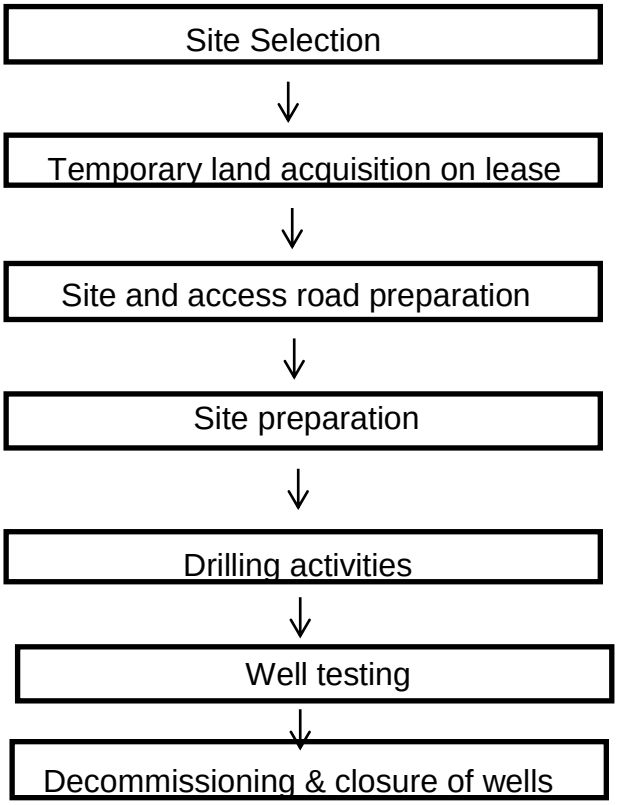

Figure-5: Flow Chart Showing Various Phases of Drilling Activities

Figure-6: Model of Drilling Process

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

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. Wells drilled to quantify the hydrocarbon reserves found are called as 'appraisal' wells. The appraisal activity will be carried out with an aim to evaluate the size and nature of the reservoir, to determine the number of confirming or appraisal wells required, and whether any further seismic survey is necessary. 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.

Well Testing:

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 on the need, based on the nature of the reservoirs, the exploratory and appraisal wells will be tested for longer/ extended durations to ascertain the reservoir parameters. During the well testing, crude oil, natural gas and produced water could be generated and will be treated/ disposed appropriately. Hydrocarbons will be flared. Efficient test flare burner will be used to minimize incomplete combustion. As an alternative option, if feasible, crude oil/ slop oil will be transferred to nearby refinery for processing or will be sent to authorized recyclers.

Site Selection

The exploration history of the area exhibits the potential presence of the oil and gas in the region. Although the exact location of the wells has not been finalized, and the seismic data interpretation of the seismic survey would decide the exact locations of the drilling well; however, the wells will be strictly confined within the acquired block itself.

Land requirement

An area of about 300m X 300m would be taken on temporary lease basis for the construction of well pad, drill site, etc.For the preparation of suitable access roads connecting to well pads, laying of infield interconnecting pipelines, OHL and laying pipelines for utilities in future, a width of 30m RoU (approx.) will be required.

Site & Access road preparation

The site is already well connected with the state highways. The internal village roads will be strengthened for transportation of machineries, equipment's and drilling crew members. Additionally strengthening of the existing approach road to the site can be done if required for transportation of drilling rig & associated equipment. In general, movement of drilling rig and ancillary equipment would involve around 20-25 truck load for approximately one and half years. A provision will be kept for parking of these cars within the developed site or its nearby area.

Site Preparation

Site preparation will involve all activities required to facilitate the operation of the drilling rig and associated equipment's 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. Leveling 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. All such materials will be procured by Vedanta through contractors and it will be ensured that they source the materials from government approved borrows and quarries. A backhoe will be used for all excavation and cutting activities (for construction of pits) on site. Subsequently, the proposed well site & campsite will be duly fenced using chain link and barbed wires.

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 elevated structures will have proper garland drains for storm water with sufficient gradient, made of brick masonry, to take care of surface runoff water.

Specially designed pit of an impervious HDPE liner of 1-1.5 mm thickness will be provided as part of the site development for disposal of drilling waste in the form of spent drilling mud and cuttings. In addition to that, a cuttings pit of 28m X 24m for disposal of drill cuttings and two waste pits of 17m X 12m for disposal of drilling mud and rig wash water will be provided.

A Campsite of size 100 x 50m approx., 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 rubble will be of 60cms and the filling material will be for the remaining 40cms. 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. The transport of the Rig including auxiliary equipments and camp facilities to the site are expected to comprise around 20-25 truckloads. 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.

Mobilization of Rig

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 2000 meters (TVDSS) as planned for the project. The typical configuration of a Drilling Rig is shown in the **Figure 7** and given in Table 2.2. 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.

Details of the drilling rig

Type of Rig	Electrical Rig
Drilling mud composition	Water based Drilling Fluid
Power generator type & nos.	AC – SCR Type. (03 Nos.)
Details of solids handling systems on rig	Shale Shakers - 1200 GPM Capacity Desander – 1200 GPM Capacity Desilter – 1200 GPM Capacity

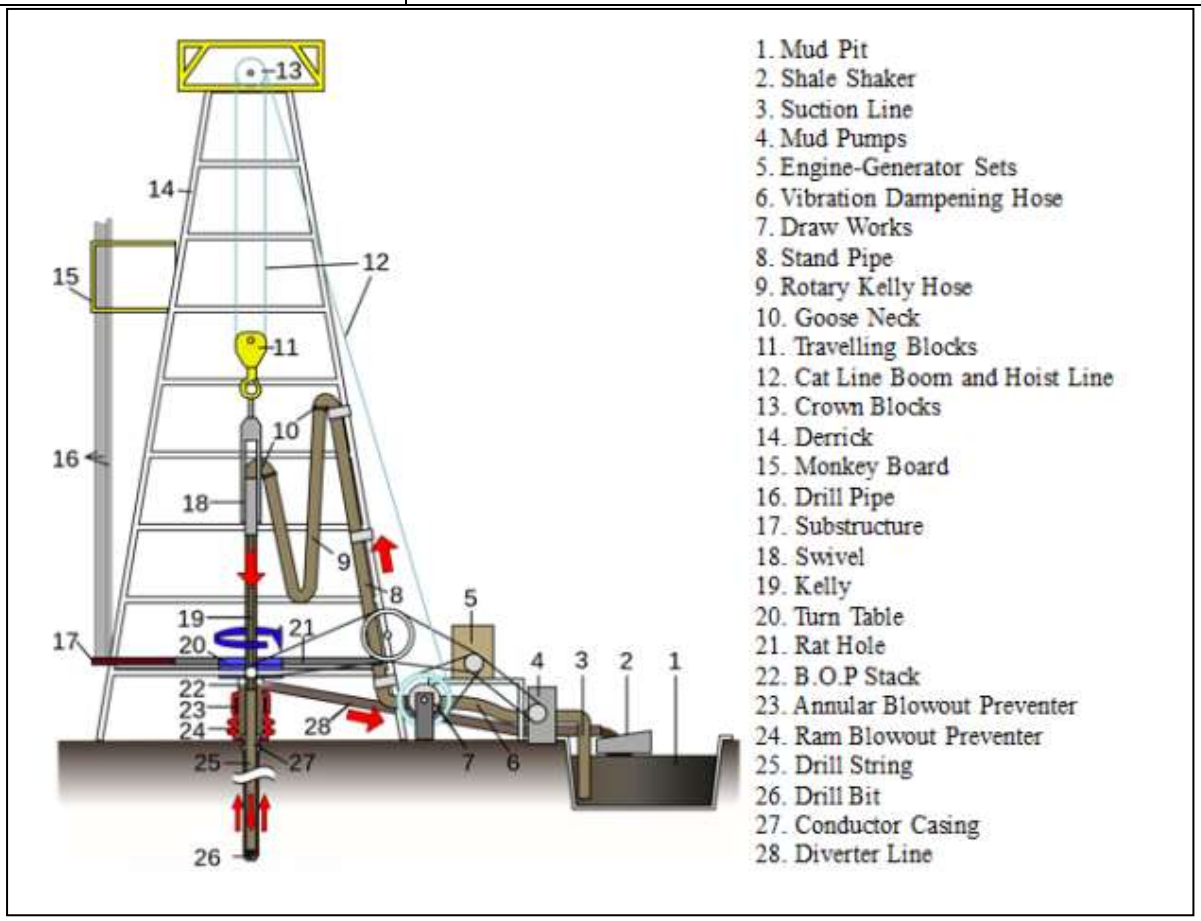

Figure-7: Typical configuration of a Drilling Rig

Drilling Activities

Initial Well Construction

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 whole unconsolidated material falling into hole and potential washout problems. Typical depths of such pipes are 6m. 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. The casing helps to maintain the stability of the hole and reduce fluid losses from the well bore into surrounding rock formations.

The Drilling Process

A rig will be installed at the potential site of drilling after thorough inspection for its working capability and quality standards. Well spudding shall be the start of drilling activity. Top-hole section will be drilled to a desired depth based on well design. After drilling top-hole section, it will be cased with a pipe called "Casing". "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. Drilling process is associated with various hazards such as well active situation (kicks), blowouts, H2S situation etc.

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). Synthetic base mud unlike oil based mud (OBM) is biodegradable but can be re-used. 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 3-12 shows the schematic layout of drilling mud & solids discharge involved as a part of the drilling system for exploratory wells.

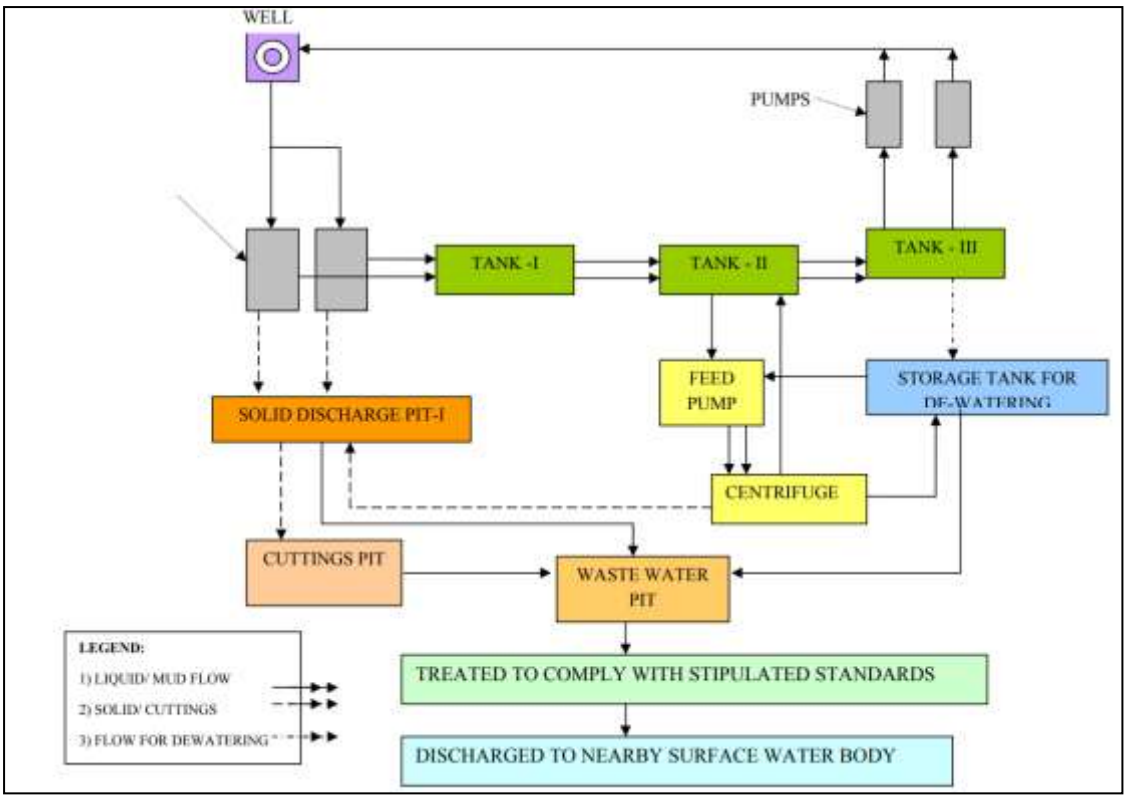

Figure-8 : Flow Chart for Drilling Mud & Solid Discharge

Cementing Programme

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

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

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

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.

Drill-stem testing

A drill-stem test is frequently performed to evaluate the formation or zone from which the gas show was observed. Drill-stem tests may also be performed when the driller observes a decrease in the time required to drill a foot of rock, known as a "drilling break." Since porous rock may be drilled easier than nonporous or less porous rock, a drilling break indicates the presence of porosity, one of the qualities of reservoir rock. A drill-stem test enables the exploration company to obtain a sample of the fluids and gases contained in the formation or interval being tested as well as pressure information, which is determined by special gauges within the test tool. Drill-stem testing is accomplished by removing the drill string from the bore hole. The drill bit is removed and a drill-stem test tool with a packer is attached. The test tool, packer, and drill string are inserted back into the bore hole to the desired depth. The packer, which is an expandable device, is set and expanded at the predetermined depth to isolate the zone to be tested. The test tool contains a valve which may be opened and closed to allow formation fluids to enter the test tool and drill string. If there is sufficient fluid and pressure within the zone being tested, the formation fluid may rise to the surface and flow into special test tanks used for that purpose. If gas is present, it is burned at the surface as a flare. By analyzing the rate of flow or the amount of formation fluid recovered in the drill string and the formation pressures recorded, obtaining a good indication of reservoir characteristics such as porosity, permeability, and the nature of the fluids or gas contained therein is possible.

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. Additional land will be procured wherever required. For effective recycling and reuse of the frac fluid, effluent treatment plant (ETP) will be installed, thus raw water required for fracturing will be minimized.

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. During the well testing, crude oil, natural gas and produced water could be generated and will be treated/ disposed appropriately. Hydrocarbons will be flared. Efficient test flare burner will be used to minimize incomplete combustion. As an alternative option, if feasible, crude oil/ slop oil will be transferred to nearby refinery (terminals/depots) for processing or will be sent to a GPCB authorized recyclers.

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. The Crude oil produces during the well testing at appraisal stage will be collected and sent to nearly and approved waste oil recyclers.

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.

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.

Setting up of Early Production Units (EPUs)/ Quick Production Facility (QPF) and Early Production

Vedanta Ltd (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 QPUs (Quick Production Unit) will be installed for the processing of produced well fluid. A EPU/ 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 EPU/ QPU capacity will be ~2,000 BFPD (Barrels of Fluid per Day).

The EPUs/ QPUs will be installed near the already established exploration and appraisal well location within the well pad in the commercially viable discovered oil field. The separated crude oil will be stabilized further, stored in storage tanks and subsequently send through road tankers to the nearing available facilities like terminals/ depots. The produced gas will be used for internal heating, power generation purpose as far as possible & surplus gas will be safely disposed off using flare system.

The produced water will be treated to achieve MoEF/ CPCB/ SPCB specification (discharge standards) and will be disposed off. 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 the feasibility.

The power requirement will be met through state electricity grid and/ or installation of Diesel/ Gas Engine Generator(s) using produced gas.

The water requirement for the oil and gas processing will be sourced locally through approved authorities or through extraction of ground water. In case of extraction of ground water, permission (NOC) will be obtained from CGWA/ CGWB (Central Ground Water Authority/ Board) of from State Govt. Installation of raw water treatment plant will be done depending on the need for process water and domestic water consumption.

The typical broad requirements envisaged for the well fluid processing and production of crude oil and associated natural gas through QPF are the following:

- Wells with selected artificial lift; & flow lines;
- Combination of Heater (using produced gas) & 3 phase separator or single heater-treater
- Stabilized Crude oil storage, pumping & tanker loading facilities;
- PW separation and disposal system;
- Fuel gas system, Instrument air/ gas system;
- Flare system, Firefighting equipment, Raw water treatment plant;
- Diesel/ Gas Engine Generator (s);

- Domestic sewage treatment facility (STP or septic tank & soak pit system);

3.6 Raw materials required and source

Broad requirements of raw materials:

Seismic Acquisition

The seismic survey will be conducted using dynamite charges. The explosive sources (dynamites) and drilling fluid chemicals for shot hole drilling will be procured by the company before commencement of the operations. During surveying the main tasks include initial installation of a small number of survey control points, then setting-out source points and receiver stations for use. This would be done by the conventional survey method of using RTK GPS backpack surveying units and biodegradable markers. Cutting activities though minimal for the receiver and source lines shall be done manually or mechanically where appropriate. In open areas where there is clear line of sight no cutting shall be done. Recording involves laying of geophones on the receiver stations and generating energy (vibrations) on the perpendicular source lines to generate seismic energy, which are reflected and recorded on magnetic tapes via the recording instrument.

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 equipments 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 base mud unlike oil based mud (OBM) is biodegradable but 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 m^3/well
- Requirement SBM (approx.) 600-800 m^3/well

3.7 Resource optimazation/ recycling and reuse envisaged in the project

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 and surface facilities.
- ✓ Synthetic base mud will be re-used in further drilling activities.

3.8 Water and power requirement

3.8.1 Water Requirement

Seismic Operations:

The water required during seismic operation will be mostly for domestic use which is about 20-30 m3/day.

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. Water for both process and domestic uses would be procured through surface water sources. The water requirement per well is shown in **Table 4.**

Table 4: Water Requirement per well

Description	Quantity
Water for domestic use	20 - 30 m3/well/day
Drilling water consumption for mud preparation	600-1000 m^3/well (WBM) and 150-300 m^3/well (SBM)
Water requirement for miscellaneous use (Engine cooling, floor/equipment/string wasteline, firefighting, storage/makeup) during drilling phase	25-50 m^3/well/day

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.

3.8.2 Power Requirement

During Seismic Operations

The power requirement during seismic is 350 KVA will be provided through diesel generator (DG) sets or state electricity grid.

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.

Table 5: 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)
Radio Room	2X100 kVA

3.9 Quantity of waste to be generated and its disposal

During Seismic Operation:

Insignificant amount of waste water will be generated from domestic use and the same shall be disposed through septic tanks/soak pits. The Air emissions and noise emissions will be also very insignificant and

will be temporary in nature. Domestic effluent of about 15-25 m3/day is anticipated. Also, non-hazardous solid wastes like food waste, paper, etc. are expected.

During Drilling Operations:

Waste water generation

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 15-25 m3/day/well, which shall be disposed through mobile STP. 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 m3/day/well during the drilling operations from a single well. Waste water will be discharged in HDPE lined evaporation pit for disposal, size of the pit is generally 50mx20mx1.5m. 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.

Waste Management

The drill cuttings and spent drilling mud will be generated at site per well during drilling operations. This shall be stored in well-designed HDPE line pit. It will be tested for its hazardous constituents (Oil and Grease), If found to be hazardous, It will be handed over to authorized TSDF. In case of Nonhazardous, it will be disposed insitu in HDPE lined pit.

Used /waste Oil – During the drilling approx. 1-2 tons/well of spent oil will be generated per well. This oil will be sent to authorized recyclers.

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

The expected waste generation from well drilling will be as per Table 6

S.No	Nature of waste	Quantity during Drilling Activities
A	**Hazardous Waste**	
1	Drill cuttings associated with WBM Drill cuttings associated with SBM	250-750 tons/well m3 per well 500-1500 tons/well
2	Spent /Residual drilling mud	250-500 tons/well
3	Used Lubricating oil, Sludge containing oil and other drilling work	1-2 tons/well 250-500 tons/well
B	**Non Hazardous Waste**	
4	Food waste	25-30 Kg per well
5	Non-combustible waste containing metallic residues, glass	1000-1200 Kg/well
6	Packaging wastes including drums, wooden pallets, plastic containers, plastic foils.	1000 kg/well
7	Left over chemicals and materials, scrap metal, sludges, scales, batteries, spent acids, spent lubricants, filters etc.	250-300 kg/well
8	Cement, grit, blasting and painting wastes.	500 kg per well

Disposal of wastes will be as per prior approval of State Pollution Control Board (SPCB).

3.10 Schematic of Feasibility Drawing

The typical layout of a well pad/drill site for exploratory and appraisal wellis as below:

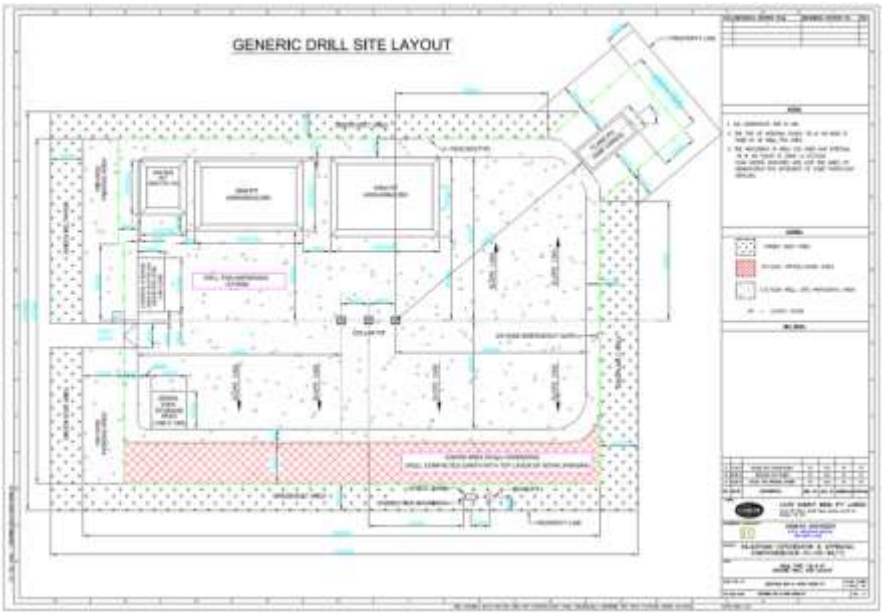

Figure 9: Schematic for a typical Well Pad

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.

The drill site is restricted access area and is fenced all round with round the clock watch. Entry of vehicles into the drilling site area is prohibited except for material movement. Adequate parking are provided outside the drilling location.

4. Site Analysis

4.1 Connectivity

The project location is situated in Anand, Kheda and Vadodara districts of Gujarat. The part of the major districtAnand & Vadodara is located within the block area. The project location is well connected by road,

rail and by Air.NH-48,SH-60, SH-83, SH-150, SH-151 and SH-188 passes through the block. Dakor, Bhalej, Anand, Vallabh Vidyanagar, Karamsad, Vadod, Adas, Vasad, Ranoli, Bajva, Atldara, Railway Stations are located within the block and Vadodara Airport (5Km,East from the block boundary).

4.2 Land form, land use and land ownership

Mahi River flows through the block.Part of Anand and Vadodara district is located within the block area.

4.3 Topography

The district Vadodara is a part of Gujarat Plain and is sub-divided into seven Submicro regions, namely, Khambhat Slit, mahi river plain, Vadodara plain, Orsang- Heran Plain, Vindhyan hills,Narmada Gorge and Lower topography.The block area is almost flat topography with elevation varying approximately 8m to 56m across area as the Mahi River flows inside the block. The terrain of the Vadodara districts is flat level plain with an altitude ranging from 32 m to 40 m above MSL. The slope gradient of this district is from SE to NW. The eastern part of the district is relatively higher and attains the maximum altitude of 40 m above MSL and the elevation gradually decreases towards south and west. Figure 4 below shows the Topographic map of the study area. Topography sheet is given in Fig. 4 of this document.

4.4 Existing land use pattern and relative location of protected areas

The entire block area is divided into following land use types

- ✓ Agriculture land
- ✓ Land with scrubs
- ✓ Land without scrubs
- ✓ Habitation
- ✓ Water bodies

Among this agriculture land is major land use type in the block. Jambughoda Wildlife Sanctuary is 37 km from the block.

4.5 Existing infrastructure / Industries

The block area is located in Anand, Kheda and vadodara districts and well equipped with existing infrastructure like roads, rail lines, water supply, power supply, sewerage facility, telecommunication facilities, hospitals, schools etc.

4.6 Soil Classification

The Soils of Vadodara, Panchmahal and Dahod district belong to shallow to deep in soil depth class. whereas they vary from moderately deep to very deep in Anand & Kheda district. In Vadodara district the soils are dominantly fine textured (clayey) followed by medium textured (loamy) and towards adjoining Vadodara. The soils adjoining to Anand, Kheda, Panchmahal districts are coarser (Sandy).

4.7 Climatedata from secondary sources

The climatological summary details of parameters like temperature, relative humidity, rainfall, cloud cover, wind speed and wind direction monitored at IMD Vadodara is given below:

Table 7: Climatological Summary at IMD Vadodara (1971 – 1993)

Month	Daily mean Temp. (0C)	Relative Humidity (%)	Rainfall (mm)	Cloud cover (in Okta)	Mean Wind Speed (km/h)

	Max	Min	8:30	17:30	Monthly Total	No. of Rainy days	8:30	17:30	
January	30	12.9	68	32	0.8	0.2	1	0.9	4.5
February	32.2	14.8	61	26	0.2	0	1.1	1.1	4.6
March	36.5	19	53	21	0.1	0	0.9	1	4.3
April	39.9	23.7	58	21	2.5	0.2	1	1	5.7
May	40.4	26.8	64	28	7.5	0.4	1.6	0.5	9.2
June	37.4	27.4	74	50	135.9	5	4.3	3.4	11.5
July	32.7	25.9	86	70	265.6	12.3	6.5	6.1	9.7
August	31.5	25.1	89	73	266.2	11.2	6.7	6.4	8
September	33.7	24.7	84	60	100.1	5.8	4.1	3.8	5.6
October	36	22.3	73	41	30.4	1.4	1.6	1.4	4
November	33.7	17.6	65	38	10.1	1	1.2	1.2	3.6
December	30.9	14.4	69	38	3.5	0.2	1.1	1.2	4.1
Annual or Mean	34.6	21.2	70	42	822.9	37.8	2.6	2.3	6.3

Source:India Meteorological Department (IMD)

4.7.1 Wind

The monthly mean wind speed varied from 3.6 to 11.5km/hr occurring in November and June months respectively.The predominant wind during winter season was recorded from SE and E direction.

4.7.2 Storms and cyclones

The block area doesn't fall under high risk zone with respect to cyclone and storms as per Gujarat Cyclone Hazard Risk Zonation.

4.7.3 Rainfall

Rainfall occurred maximum in August (266.2 mm) followed by July(265.6 mm). The total rainfall received in the year is about 822.9 mm with total number of rainy days of about 38 days.

4.7.4 Temperature and humidity

The monthly mean maximum temperature varied from 30°C in January to 40.4°C in May while monthly mean minimum varied from 12.9°C in January to 27.4°C in June indicating January as the coldest while May as hottest month.

5 Planning Brief

5.1 Planning concept

The project is a green field oil and gas exploration, & appraisal and early production in CB-ONHP-2017/5.

The present area of 990 km2.

Well sites and roads will be built or upgraded for transportation of rig and its equipment for seismic acquisition and drilling. The drilling will be carried out following the international safety standards. Upon

successful exploration the well will be completed and suspended for further activities and the wells devoid of hydrocarbon will be plugged and abandoned. The land will be restored back to its original form.

5.2 Population projection

Direct and indirect employment will be created due to project. Temporary influx of people will be there as the managerial and supervisory staff will generally be outsider.

5.3 Land use planning (break up along with green belt, etc)

The well within the block will not be taken completely for drilling of the wells. An area of about 300m X 300m would be taken on temporary short-term lease basis for the construction of well pad, drill site etc.

5.4 Assessment of Infrastructure demand

No major infrastructure (physical and social) is envisaged. Access road will be taken up by Vedanta (Cairn Oil & Gas) for the drilling well site for the movement of heavy equipment.

5.5 Amenities and facilities

The amenities/ facilities

- Potable drinking water
- Firefighting/ alarm system and ambulance, First Aid Facility/Centre, Para-medics will be providedfor emergency
- Drinking water, canteen and electricity facilities is provided
- Separate sanitation facilities will be provided for men and women.

6. Proposed Infrastructure

No measure physical and social infrastructure is envisaged. Only drill site / well pad and temporary camp site (Porta cabin) for the drilling of exploratory (including) appraisal wells are envisaged, which will be dismantled after drilling of the wells.

7. Rehabilitation and resettlement (R&R) Plan

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 to life of the project.

For sites selected having settlements if any, 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, Cairn 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 restoration activities directly or indirectly through CSR activities.

8. Project schedule and cost estimate

8.1 Project schedule

Vedanta Ltd (Cairn Oil and gas) has planned to carryout 3D seismic data acquisition, exploration and appraisal in the CB-ONHP-2017/5 Block in next 10-12 years.

8.2 Project cost

The cost of the project is estimated is given below:

1) Physical Surveys Cost estimated to be approximately INR 1.96 Crore.
2) Average Cost per well for exploratory & appraisal well is estimated to be INR 10.5 Crore.
3) Average cost of each EPU (Early Production Unit)/QPF (Quick Production Facility is estimated to be INR 44.13 Crore.

9. Analysis of Proposals (Final Recommendations)

The implementation of this project will not have any adverse effect on the environment as appropriate pollution control measures will be taken from the initial stage itself.
Proposed drilling activities will result in growth of the surrounding areas by increasing direct and indirect employment opportunities in the region.