हिन्दुस्तान पेट्रोलियम कॉर्पोरेशन लिमिटेड

(भारत सरकार उपक्रम) रजिस्टर्ड ऑफिस : 17, जमशेदजी टाटा रोड, मुंबई - 400 020.

HINDUSTAN PETROLEUM CORPORATION LIMITED

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CIN No.: L23201MH1952GOI008858

RP/17/AJ/RRP/02 **July 17, 2017**

The Member Secretary,
Expert Appraisal Committee (Industry-II)
Ministry of Environment, Forests and Climate Change,
Indira Paryavaran Bhawan,
Jor Bagh Road, Jor Bagh,
New Delhi-110003

Subject: Setting-up a Grass Root Rajasthan Refinery cum Petrochemical complex Project (RRP) of 9 MMTPA at Pachpadra Tehsil, District Barmer, Rajasthan by M/s. Hindustan Petroleum Corporation Limited (HPCL)-reg reconsideration of EC [IA/RJ/IND/24706/2013, J- 11011/87/2013-IA-II(I)].

Dear Sir,

This has reference to the MOM of 24th Expert Appraisal Committee (Industry-II) of MoEF&CC held during June 14-16, 2017, wherein subject Project proposal for reconsideration of EC was discussed and deliberated by the EAC Committee. The Committee suggested to submit the revised EIA/EMP report characterizing the environmental risk due to proposed change in crude mix

We are pleased to submit revised EIA/EMP report, Risk Assessment report for consideration in forthcoming Environment Appraisal Committee meeting for prior environmental clearance.

Request you to process our application for grant of environment clearance.

Thanking you,

Very Truly Yours,

Shekhar P. Gaikwad
Executive Director - Refineries Projects

Encl: a/a

REVISED ENVIRONMENTAL IMPACT ASSESSMENT STUDY FOR RAJASTHAN REFINERY PROJECT - GRASS ROOT REFINERY & PETROCHEMICAL COMPLEX

HINDUSTAN PETROLEUM CORPORATION LIMITED

REPORT NO. B068-1742-EI-1701

JULY 2017

इंजीनियर्स इंडिया लिमिटेड
(भारत सरकार का उपक्रम)
ENGINEERS INDIA LIMITED
(A Govt. of India Undertaking)

EXECUTIVE SUMMARY

1.0 INTRODUCTION

A 9.0 MMTPA grass-root Refinery cum Petrochemical Complex (Rajasthan Refinery Project, RRP) has been proposed in Pachpadra, Barmer District of Rajasthan by M/s HPCL Rajasthan Refinery Limited (HRRL), a joint venture company between Hindustan Petroleum Corporation Limited (HPCL) and Govt. of Rajasthan. The Complex will be designed with refinery capacity 9.0 MMTPA to process 1.5 MMTPA Rajasthan Crude + 7.5 MMTPA Arab mix crude for First 8 years and from 9th year onwards Arab mix crude of 9 MMTPA. The cost of the project is Rs. 43129 Crores.

The proposed site is spread over 4400.40 acres encompasses the villages Sajjiyali Roopji Kanthavad, Sambhara, Pachpadra Tehsil, District: Barmer, Rajasthan for Refinery cum Petrochemical Complex and Marketing Terminal and additional 413.26 acres is reserved for township and reservoir which will be located about 2.5 km from the complex. The entire area is sandy with flat terrain without any major undulations. The site will be accessible from National Highway NH-112 which connects Jodhpur to Barmer. NH-112 is about 0.5 km from the plot of proposed refinery cum petrochemical complex. The nearest railway station is Balotra Station about 12 km and the nearest airport is Jodhpur airport about 100 km from site. The proposed site has been identified by Government of Rajasthan (GoR) and has signed MoU with HPCL for the same and is also in close proximity to the Mangla fields. The proposed site comprising few villages (Sajiyali Roopji Kanthavad and Sambhara) will be used for Refinery cum Petrochemical complex. There are no wild life corridors, archaeological monuments, places of tourist interests and Defence installations within the study area. No Reserved forest, National park, Wildlife Sanctuary and Tiger Reserves etc. exists within 10-km radius study area.

As per the Environment Impact Assessment (EIA) Notification dated 14th September 2006, the proposed project falls under ‘Category A’, listed at S.No. 4(a) & 5(c), requires preparation of EIA & RA Report to obtain Environmental Clearance (EC) from the Central Expert Appraisal Committee (EAC), MoEFCC, New Delhi. The proposal has been discussed during the meeting of the Expert Appraisal Committee (Industry) held on July 29-31, 2013 and approved ToR have been issued by MoEF vide F.No. J-11011/87/2013-IAII (I) dated September 27, 2013. Further public hearing was held on 30th May 2014 and final report after incorporating proceedings of public hearing was submitted on 15th September 2014. The final EIA report was discussed during the meeting held on 18th February 2015 and MoEFCC sought additional information. The replies were provided on 22/05/2017. The replies were discussed during the 24th Expert Appraisal Committee (EAC) meeting held on 14-16th June 2017 and advised to submit revised EIA based on the changes in project configuration. MoEFCC directed to use the baseline data collected during October-December 2013 and Public Hearing conducted on 30th May 2014.

1.1 PROJECT DESCRIPTION

RRP is being proposed with the basis of achieving energy efficiency, environment friendly, high distillate yielding refinery cum petrochemical complex that will be producing clean fuels and petrochemicals.

Captive generation of all utilities including power is considered for meeting the total utility requirement of the refinery-cum-petrochemical complex. The raw water shall be sourced from the Indira Gandhi (IG) Canal which shall be supplied through a 46" raw water pipeline of approx. 200 km length.

The feed receipt/product dispatch facilities considered include Mangala Crude to be received from the Mangala Crude Facility, Arab Mix Crude (Imported Crude) with SPM/COT facilities for import of crude. New Natural Gas Pipeline is considered for natural gas from Cairn India’s Rageshwari Gas Terminal to the proposed refinery location.

For meeting the internal fuel requirement of the refinery complex, treated fuel gas will be the primary fuel supplemented by internally generated fuel oil and natural gas. Infrastructure facilities such as roads and buildings, water supply and public health (including ETP), work shop, etc will be developed. Safety facilities like flare system, fire water system, safe guard system, machine monitoring system, gas detectors etc. with suitable design capacities will be provided.

Process unit with capacities and product slate are given in Tables 1 & 2.

Table 1 Process Unit Capacities

Process Units	UNITS	Capacity
CDU	MMTPA	9.0
VDU	MMTPA	4.8
NHT	MMTPA	1.8
ISOM	MMTPA	0.26
CCR	MMTPA	0.3
DHDT	MMTPA	4.1
PFCC	MMTPA	2.9
DCU	MMTPA	2.4
PPU	MMTPA	2 x 0.49
Butene-1	KTPA	59
LLDPE/HDPE Swing	MMTPA	2 x 0.416
VGO HDT	MMTPA	3.5
DUEL FEED CRACKER	MMTPA	0.82
ETHLENE RECOVERY UNIT	MMTPA	0.077
BENZENE RECOVERY UNIT	MMTPA	0.096
Py gas HDT	MMTPA	0.55
BTX	MMTPA	0.55
PFCC GASOLINE DEPANTANIZER	MMTPA	0.87
GASOLINE HDT	MMTPA	0.53
FCC C5 Merox	MMTPA	0.22
SAT. LPG MEROX UNIT	KTPA	162
LPG DEPROPANIZER	KTPA	162
FG TREATING UNIT	TPD	1425
HYDROGEN GENERATION UNIT	KTPA	37
PSA	KTPA	28
SWS -I (HYDROP ROCESSING)	M3/HR	100
SWS -II (NON HYDROPROCESSING)	M3/HR	250
AMINE REGENERATION UNIT	M3/HR	3x480
SULPHUR RECOVERY UNIT	TPD	2 x 199

Table 2 Product slate for selected cases

CASE	Unit	1.5 MMTPA Rajasthan Crude + 7.5 MMTPA Arab Mix crude	9 MMTPA Arab Mix crude
FEED			
RAJASTHAN CRUDE	MT/DAY	4504	0
ARAB HEAVY	MT/DAY	11451	13741
ARAB LIGHT	MT/DAY	11069	13283
NATURAL GAS	MT/DAY	353	578
PRODUCTS			
POLYPROPYLENE	MT/DAY	2935	2942
BUTADINE	MT/DAY	668	707
LLDPE/HDPE	MT/DAY	1161/1161	1247/1247
BENZENE	MT/DAY	276	288
TOLUNE	MT/DAY	129	228
91 RON GASOLENE, BS-VI	KL/DAY	2678	2412
95 RON GASOLENE, BS-VI	KL/DAY	2678	2412
ULS DIESEL , BS-VI	KL/DAY	13096	12951
SULPHUR	MT/DAY	355	395
PetCoke	MT/DAY	-	100
FUELS & LOSSES	MT/DAY	5764	5821

1.2 DESCRIPTION OF ENVIRONMENT

Baseline environmental studies have been carried for three months (Oct-Nov-Dec 2013). Studies have been carried out within in 10-km radius from proposed project for soil quality, ambient air quality, water quality, noise level monitoring studies, flora and fauna studies and demography. The scope of the present study is in line with the Terms of References (ToR) issued by EAC, MoEF, New Delhi vide letter no. F. No. J-11011/ 87/2013-IA II (I) dated September 27, 2013.

1.2.1 Air Environment

The region represents mainly rural environment and few sampling locations fall in moderate commercial and vehicular activities. The ambient air quality within 10-km radius around the proposed site was assessed at 11 locations. The villages are located quite far from the proposed project site. The average PM10 concentrations at all the locations varied in the range of 59-87 µg/m3, which represents background concentrations of rural environment and could be attributed to windblown soil dust and unpaved roads in the region. The PM10 concentrations for other locations were observed to be below stipulated CPCB standards (24 hourly PM10 = 100 µg/m3).

The average PM2.5 concentrations ranged between 25-49 µg/m3, which were observed to be well below the stipulated CPCB standards (24 hourly PM2.5 = 60 µg/m3).

The average concentrations of SO2 and NOx ranged between 6-17 µg/m3 and 12-24 µg/m3 respectively. The levels of gaseous pollutants were below the 24 hourly CPCB standards of 80 µg/m3 each for the SO2 and NOx. The average concentration of ammonia ranged between 19-25 µg/m3. All these values are well within the stipulated

CPCB standards (400 µg/m3). The observed average concentration of O3 at all the locations ranged between 9-17 µg/m3, which were much below the stipulated CPCB standards (8 hourly =100 µg/m3). The Ni concentration at all the locations was found to be in the range of 1.7-5.2 ng/m3, whereas the permissible limit of CPCB for Ni is 20 ng/m3. The Pb, As and BaP were Below Detection Level (BDL). The carbon monoxide concentration at all the locations varied between 0.18-0.77 mg/m3, whereas total hydrocarbons concentrations were in the range of 270-278 µg/m3.

The area generally has low levels of pollutants in ambient air, which is well within the stipulated National Ambient Air Quality Standards (NAAQS).

1.2.2 Water Environment:

Eight surface water and three ground water samples were examined for physico-chemical, heavy metals and bacteriological parameters in order to assess background status of surface and ground water sources. The samples were analyzed as per the procedures specified in 'Standard Methods for the Examination of Water and Wastewater' published by American Public Health Association (APHA).

Surface Water: The range of various water quality parameters varied as; pH: 7.5-8.5, turbidity: 1-10 NTU, total dissolved solids (inorganic): 195-254 mg/l, total hardness: 52-97 mg/l, chlorides: 18-103 mg/l, and sulfate: 4-10 mg/l. Fluoride was found to be 0.09-0.88 mg/l. Nutrients content in the form of nitrate and total phosphates were in the range of 0.2-8.6 mg/l and 0.16-1.31 mg/l respectively. Dissolved oxygen was in the range of 6.8-7.9 mg/l, whereas oil & grease were observed as 1-7 mg/l. The heavy metals like cadmium, chromium, zinc and arsenic were not detected; whereas Nickel, copper, lead iron manganese, cobalt and aluminum were found to be in the range of ND-0.001, ND-0.006, 0.004-0.616, 0.003-0.008, ND-0.001 and 0.09-2.20 mg/l respectively.

It can be observed that the concentrations of all the parameters, in comparison with IS: 2296, come under Class ‘C’, category of drinking water source without conventional treatment but with disinfection.

Ground Water: The groundwater quality showed high mineral contents in the form of total dissolved solids, total hardness, chlorides, sulfates, chemical oxygen demand, biochemical oxygen demand, sodium and potassium with their respective concentrations in the range as 2960 - 4055 mg/l, 688 - 1986 mg/l, 855 - 1949 mg/l, 400 - 562 mg/l, 16 - 80 mg/l, 2.6 mg/l, 586 – 680 mg/l, and 11.4 - 73.6 mg/l respectively. Fluorides were in the range of 0.17 - 2.49 mg/l, which is above the permissible limit, observed at villages Kiyar and Meghwalo ki Dhani. It may be attributed to the geological formation in the region making the water unfit for drinking. Heavy metals were observed within the permissible except for iron: 0.11 - 23.9 mg/l and Zinc: ND-9.8 mg/l. Higher values were observed in the village Meghwalo ki Dhani; which makes water unfit for drinking without proper treatment.

1.2.3 Noise Environment:

The noise level (LAeq) in residential areas varied between 43-59 dBA during daytime and between 32-42 dBA during night time. The noise levels during day and night time were mostly below the stipulated noise levels in residential areas except Pachpadra due to National Highway 112 passing through, congested road pattern and dense pattern. (Day time= 55 and night time 45 dB (A)). The noise level (LAeq) in commercial area ranged between 57- 74 dB(A) during daytime and 40-54 dB(A) during night time. The noise levels were mostly around the stipulated noise levels as per the CPCB standards of commercial areas due to National Highway 112 passing through it and commercial place

for surrounding villages (day time= 65 and night time 55 dB(A)). The equivalent noise level (LAeq) recorded at different silence locations (schools) within the study area. Noise levels were found to be 41-56 dB(A) during daytime and 32 - 46 dB(A) during night time respectively. The noise levels (LAeq) were within the CPCB standards for silence zone except Pachapadra (day time= 50 and night time 40 dB (A)).

1.2.4 Land Environment:

Samples were collected and analyzed from eight locations as per approved methods of CPCB and MoEF. It is observed that the texture of soils in the region varies from sand to loamy sand. The pH of soil was observed to be in the range of 8.5-9.6, and the soil is moderate to strongly alkaline in nature. Electrical conductivity, a measure of soluble salts in soil is in the range from 0.13-0.85 dS/m. In general, the soil in the region has very low adsorption capacity as evident from the cation exchange capacity to be in the range of 6.2 to 9.8 cmol(p+) kg-1. Exchangeable sodium percentage ranged from 4.8 to 7.2 indicating that the soils are normal with respect to sodicity. The presence of sodium in exchange form may have deleterious effect on the physical and chemical properties of soil.

Organic carbon and available nitrogen, phosphorus and potassium are found to be in the range of 0.05 to 0.48 %, 85 to 142 kg/ha, 8.4 to 16.5 kg/ha and 10.2 to 25.8 kg/ha respectively. This shows that the soils are poor with respect to organic carbon content, nitrogen, phosphorus and potassium content.

1.2.5 Biological Environment:

There are no national parks or sanctuaries or reserve and protected forest in study area of Pachpadra, Barmer, Rajasthan. The district falls in the Hot Desert Region. The rainfall is very less but there are few flora present. Most of the flowering plants are shrubs and wild grasses. The grasses do not survive for more than a few months after the monsoon. The study area was found to be mostly sandy, uninhabited barren land with or without shrubs. The plants Khejri (Prosopis cineraria) in the desert have adopted various strategies to endure the intense heat, bitter cold and long dry spells.

The phyto-ecological structure of vegetation shows three different strata i.e. Top, Middle and Ground. In order to reduce transpiration, the leaves of most of the plants are of reduced size, e.g. dominant tree and shrub species of the area are Khejri (*Prosopis cineraria*), Bavar (Prosopis juliflora), Ber (Ziziphus mauritiana), Salvadora persica, Acacia species etc. Other associated tree and shrub species in the study area are *Tecomella undulate*, *Acacia nilotica*, *Acacia tortilis*, *Cassia fistula*, *Prosopis juliflora*, *Acacia Senegal*, *Salvadora oleoides*, *Ziziphus mauritiana*, etc.

Tree species come along with shrub species such as *Acacia jacquemontii*, *Capparis decidua*, *Leptadenia pyrotechnica*, *Zizyphus nummularia*, *Calligonum polygonidea*, *Calotropis gigantea* and *Calotropis procera*. Prominent herb and grass species recorded from the study area are *Aerva javanica*, *Echinops echinatus*, *Adhatoda zeylanica*, *Withania coagulans*, *Suaeda fruticosa*, *Fagonia indica*, *Cenchrus setigerus*, *Heteropogon contortus*, *Tridax procumbens*, *Convolvulus prostrates*, *Citrullus colycynthis*, *C. lanatus*, *Tephrosia purpurea*, *Crotalaria burhia*, *Suaeda fruticosa* etc. Frequency of occurrence for family Amaranthaceae and Gramineae was observed more in the study area as most of the plants of this family observed in the study area can resist to water scarcity. Secondary data on various aspects of biological environment was collected from various sources to fortify the primary data.

The birds of prey commonly seen in the study area are Tawny eagle, Steppe Eagle (*Aquila nipalensis*, Oriental Honey Buzzard (*Pernis ptilorhynchus*), Long Legged Buzzard (*Buteo rufinus*), White Eyed Buzzard (*Butastur teesa*), Shikra (*Accipiter badius*), Black-shouldered Kite (*Elanus axillaris*), Goshawk and Kestrel (*Falco tinnunculus*). There are vultures also which scavenge dead cattle and fauna. Common among them are the Egyptian vulture (*Neophron percnopterus*) and Cinereous Vulture (*Aegypius monachus*).

1.2.6 Socio-economic conditions:

The information available with respect to demographic structure, infrastructure base, economic structure, health status, cultural attributes, public awareness and their concerns regarding the proposed project was assessed through secondary data and also through primary survey in the region. Further, based on the data/information, socio economic status in relation to 'Quality of Life' of the people of the region was determined.

As per 2011 census, the total numbers of households in study area are 14763, with a total population of 84,459. Out of this, 43965 are male and 40504 are female. Out of the total population, numbers of Scheduled Castes is 12303 (14.56%) and numbers of Scheduled Tribes population is 5293 (6.26%) respectively. The sex ratio (number of female per thousand male) within the study area is 921/1000. The number of educated people in the survey villages is 52124 with a literacy rate of 61.75%. The total main worker population is 22421 (26.54%), while 4170 (4.93%) come under marginal worker category and 57868 (68.517%) belong to non-worker category.

The basic amenities like sanitation, health & medical, education etc. need in the villages are poor and need to be strengthened. Of the total population, nearly 88% of the population lives in Pachpadra Tehsil, where the facilities are reasonably good.

1.3 ANTICIPATED ENVIRONMENTAL IMPACTS

The environmental impacts associated with the proposed project during construction and operational phases of the project on various environmental components have been identified and are given in **Table 3**.

Table 3: Impact Identification Matrix

	Physical				Biological		Socio-economic	
Activities	**Ambient air quality**	**Ground / surface water (quantity / quality)**	**Ambient noise**	**Land (land use, topography & drainage, soil)**	**Flora**	**Fauna**	**Livelihood & occupation**	**Infrastructure**
CONSTRUCTION PHASE								
Site preparation	*		*	*	*	*	*	
Civil works	*		*	*				
Heavy equipment operations			*					
Disposal of construction wastes				*				
Generation/disposal of sewerage		*		*				
Transportation of materials	*		*					
OPERATION AND MAINTENANCE PHASE								
Commissioning of Process units, utilities and offsites	*	*	*		*	*	*	*
Storage of Products	*							
Waste management-liquid and solid waste		*		*				
Transportation of products	*		*					

Impacts have been assessed considering spatial, temporal, intensity and vulnerability scales and its overall significance value is given in Table 4.

Table 4: Impact Assessment Summary

Environmental component		Construction	Operation
Air		Low	Medium
Water	Consumption of Raw Water	Low	Medium
	Generation of Effluent	Low	Low
Land	Soil Quality	Low	Low
Noise		Low	Medium
Biological		Low	Low
Socio-Economic		Medium	Low

1.4 ENVIRONMENTAL IMPACT ASSESSMENT AND MITIGATION MEASURES

1.4.1 AIR ENVIRONMENT

Construction Phase

Impacts (Significance - Low)

- Dust will be generated from earth-moving, grading and civil works, and movement of vehicles on unpaved roads.
- PM, CO, NOx, & SO_2 will be generated from operation of diesel sets and diesel engines of machineries and vehicles.

Mitigation Measures

- Ensuring preventive maintenance of vehicles and equipment.
- Ensuring vehicles with valid Pollution under Control certificates are used.
- Implementing dust control activities such as water sprinkling on unpaved sites.
- Controlling vehicle speed on site

Operation Phase

Impacts (Significance - Medium)

- Emissions from new stacks (max GLCs) and baseline value of AAQ gives the resultant estimated SO2 concentration as 34.3 μg/m3 (within the standard 80 μg/m3).
- Emissions from new stacks (max GLCs) and baseline value of AAQ gives the resultant estimated NOx concentration as 35.6 μg/m3 (within the standard 80 μg/m3).

Mitigation measures

- A separate process unit for recovery of sulphur (SRU) will be developed.
- Developing adequate green belt in refinery cum petrochemical complex.
- Regular monitoring of air polluting concentrations.
- Ensuring preventive maintenance of equipment.
- Regular monitoring of air polluting concentrations.
- Provision of Low NOx burners is envisaged in all furnaces.

1.4.2 WATER ENVIRONMENT

Construction Phase

Impacts (Significance – Low)

- The effluent streams will be generated regularly that will comprise of Sewage, grey water from site area and washing water for vehicle and equipment maintenance area.

Mitigation Measures

- Monitoring water usage at work sites to prevent wastage.

Operation Phase

Impacts (Significance – Medium)

- The raw water consumption for the Refinery-cum-Petrochemical complex is estimated to be approximately 5300 m3/hr. Raw water will be sourced from IG Canal at Nachna.
- There shall be ~1650 m^3/hr of waste water generation from the proposed facilities. An Effluent Treatment Plant (ETP) will be developed for treating the waste water from all the units/sources.

Mitigation Measures

- Developing the possibility for increasing the amount of treated effluent from existing ETP.
- Zero effluent discharge to be adopted.
- Installation of rainwater harvesting structures to collect and use rainwater, thereby reducing abstraction.

1.4.3 NOISE ENVIRONMENT

Construction Phase

Impacts (Significance – Low)

- Noise generation due to operation of heavy equipment and machinery, movement of heavy vehicles in site preparation and civil works.

Mitigation Measures

- Ensuring preventive maintenance of equipments and vehicles.

Operation Phase

Impacts (Significance – Low)

- Noise level measurements were carried out in day and night times at numerous locations around the existing operating units within the refinery. No additional impact is envisaged.

Mitigation Measures

- Avoiding continuous (more than 8 hrs) exposure of workers to high noise areas.
- Provision of ear muffs at the high noise areas
- Ensuring preventive maintenance of equipment.

1.4.4 LAND ENVIRONMENT

Construction Phase

Impacts (Significance – Low)

- Generation of debris/construction material, but being the modifications limited to existing area, the generation of such waste shall be minimal.

Mitigation Measures

- Restricting all construction activities inside the project boundary.
- Ensuring any material resulting from clearing and grading should not be deposited on approach roads, streams or ditches, which may hinder the passage and/or natural water drainage.
- Developing project specific waste management plan and hazardous material handling plan for the construction phase.

Operation Phase

Impacts (Significance – Low)

- Spent Catalyst after every 3-4 years will be generated.

Mitigation Measures

- Spent catalyst will be sent back to manufacturer.
- Other solid waste will be disposed to secured landfill site inside refinery complex.
- Development of greenbelt area.

1.4.5 BIOLOGICAL ENVIRONMENT

Construction Phase

Impacts (Significance –Low)

- The impact of construction activities on fauna will be there due to proposed construction activities.

Mitigation Measures:

- Closing of trenches as soon as possible of construction.
- Prevent littering of work sites with wastes, especially plastic and hazardous waste.
- Training of drivers to maintain speed limits.
- Development of green belt during construction phase.

Operation Phase

Impacts (Significance – Low)

- The impacts due to proposed project activities during operation phase shall be insignificant due to minimal additional air emissions.

Mitigation measures

- Maintain the greenbelt already developed

1.4.6 SOCIO-ECONOMIC ENVIRONMENT

Construction Phase

Impacts (Significance – Medium)

- Generation of temporary employment of very substantial number of personnel. It can be observed that the number of personnel needed for the proposed project during the construction phase will be peak of about 2000 – 3500 people.
- Transport requirements will arise during the construction phase due to the movement of both the personnel and materials.
- An impact on basic necessities like shelter, food, water, sanitation and medical facilities for the temporary workers and truck drivers.
- The majority of skilled and unskilled laborers are available in the impact area itself, the incremental effect on housing during the construction phase will be minimal.

Mitigation measures

- Conducting awareness programs for workers.
- Determining safe, legal load limits of all bridges and roads that will be used by heavy vehicles and machinery.
- Determining allowable traffic patterns in the affected area throughout the work week will be made based on community use, include a consideration of the large turning.
- Providing prior notice to affected parties when their access will be blocked, even temporarily.
- Preventing use of drugs and alcohol in project-sites.

- Preventing possession of firearms by project-personnel, except those responsible for security.

Operation Phase

Impacts (Significance – Low)

- Employment generation, effects on transport and other basic infrastructure.
- Transport requirements will arise due to the movement of both the personnel and materials.

Mitigation measures

- Extending reach of CSR Program.

1.5 ENVIRONMENTAL MANAGEMENT PLAN AND MONITORING PROGRAM

Budget has been estimated for implementation of environmental management plan during construction and operational phases and is given in Table 5.

Table 5: Budget for Environmental Management Plan

	Details	Capital Cost for EMP (A)in crores	Recurring cost in crores (B)
1	Greenbelt Development	5.0	0.3
2	HSE Training	5.0	0.3
3	Personal protective equipments & noise monitoring	5.0	0.3
4	Equipment for Air Pollution Control, Noise Pollution Control & Water Management	827.0	57.1
	Total	**842**	**58**
	Total Cost for EMP (A+B)	**900**	

The proposed environmental monitoring program is mentioned in the below Table 6 and Table 7.

Table 6: Environmental Monitoring Program (construction phase)

Component	Parameters	Location / Frequency of Monitoring	No. of Samples / month
Air	SO_2, NO_x, PM_{10}&$PM_{2.5}$ (As per NAAQS 2009 standards)	At two locations, one at project site and another is at plant boundary. Twice in a month (except monsoon)	4
Water	Surface Water: CPCB surface water criteria; Ground Water: IS:10500	Atleast one surface water in the project site per month and another is adjacent to project site. Two Ground Water: One Up-gradient and One Down-gradient of project site per month.	2 (SW) 2 (GW)

Component	Parameters	Location / Frequency of Monitoring	No. of Samples / month
Noise	Noise Levels Leq (A)	At two locations, one at project site and another is at plant boundary. Twice in a month	4
Soil	As per standard practice	At one location, in the project site. Once in a month.	1

Table 7: Environmental Monitoring Program (operation phase)

Sl.No.	Potential impact	Action to be Followed	Parameters for Monitoring	Frequency of Monitoring
1	Air Emissions	Stack emissions to be optimized and monitored.	Gaseous emissions (SO_2, PM, CO, NOx).	Once in two month
		Ambient air quality within the premises of the proposed unit and nearby habitations to be monitored. Exhaust from vehicles to be minimized by use of fuel efficient vehicles and well maintained vehicles having PUC certificate.	PM_{10}, $PM_{2.5}$, SO_2, NOx Vehicle logs to be maintained	As per CPCB/ SPCB requirement or on monthly basis
		Measuring onsite data of Meteorology	Wind speed, direction, temp., relative humidity and rainfall.	Continuous
		Vehicle trips to be minimized to the extent Possible.	Vehicle logs	Daily records
2	Noise	Noise generated from operation of DG set to be optimized and monitored. DG sets are to be provided at basement with acoustic enclosures.	Spot Noise Level recording; Leq(night), Leq(day), Leq(dn)	Once in a month
		Generation of vehicular noise	Maintain records of vehicles.	Periodic (during operation phase)
3	Water Quality	Monitoring groundwater quality and levels around HRRL complex	Comprehensive monitoring as per IS 10500	Once in a month
4	Wastewater Discharge	No untreated discharge to be made to surface water, groundwater or soil. The cleaning water shall be routed to nearby ETP.	No discharge hoses in vicinity of water courses.	Once in a month
		Take care in disposal of wastewater generated such that soil and ground water resources are	Discharge norms for effluents as per ETP norms	Once in a month

		protected.		
5	Maintenance of flora and fauna	Vegetation and greenbelt / green cover development.	No. of plants species	Once in three months
6	Health	Regular health check-ups for employees and migrant labourers	All relevant parameters including audiometry	Regular check ups
7	Energy Usage	Energy usage power generation, air conditioning and other activities to be minimized. Conduct annual energy audit for the terminals	Energy audit report	Annual audits and periodic checks during operational phase

1.6 ADDITIONAL STUDIES

1.6.1 RAPID RISK ASSESSMENT

Rapid Risk Assessment study was carried out for Rajasthan Refinery cum Petrochemical Complex. Manjor recommendations and mitigation measures are given below.

The detailed consequence analysis of release of hydrocarbons in case of major credible failure scenarios have been modelled in terms of release rate, dispersion, flammability and toxic characteristics, which have been discussed in detail in the report. The major findings and recommendations arising out of the Rapid Risk analysis study for units are summarized below:

- Consequence modelling of High & low frequency scenarios for CDU/VDU Block is carried out and it is observed that the tank farm present on the western side of the unit & adjacent VGO-HDT unit may get affected from Radiation & Explosion effects emanating from the low frequency failure scenarios of the unit, depending upon the prevalent wind conditions & ignition source encountered at the time of release.
  It is recommended to install Fire & Gas detectors at suitable location within the unit and utilize these scenarios for preparation of Emergency Response Guidelines & Disaster Management Plan.

- Credible leakage scenarios are modelled for NHT-CCR, ISOM & Gasoline HDT units and their Explosion, Radiation & Toxic effects is studied. It is observed that the HGU, DHT & VGO-HDT units may get affected on account of leakage scenarios (Explosion & Radiation effects) from these units, depending upon the equipment location in the unit and prevalent weather conditions at the time of release. Moreover, Benzene & Toluene IDLH concentration from toxic failure scenarios may also affect operators present in these plants and may extend upto CDU-VDU, FCC Block & Offsite area. The Main Refinery Control Room may also get affected by Explosion & Radiation effects emanating from leakage scenarios in the NHT-CCR, ISOM & Gasoline HDT units, depending upon the equipment locations in the unit and prevalent weather conditions at the time of release.
  It is recommended to ensure the Blast Resistant Construction with Positive Pressurization of the Main Refinery Control Room.
  It is also recommended to install Fire & Gas (Flammable & Toxic) detectors at strategic locations within these units along with remotely operated isolation valves for inventory isolation in the event of any leakage.

The outcomes of these scenarios to be utilized for preparation of Emergency Response Guidelines & Disaster Management Plan.

- Flammable & Toxic failure scenarios are modelled for the DHT Unit, it is observed that affect zones arising out of the high & low frequency credible scenarios for HP & Toxic sections of the DHT shall cross the unit B/L's and may affect the nearby HGU, NHT, CCR, ISOM, Gasoline HDT & CDU-VDU units, depending upon the prevalent weather conditions at the time of release and equipment locations within unit.

  It is recommended to install Fire & Gas (Flammable & Toxic) detectors at strategic locations within unit along with remotely operated isolation valves for inventory isolation in the event of any leakage.

- Credible Failure scenarios are modelled for the FCC Block and it is observed that affect zones (Flammable & Explosion) arising out of the high & low frequency credible scenarios may cross the unit B/L's and may affect the Main Refinery Control Room, depending upon the prevalent weather conditions at the time of release and equipment locations within unit.

  It is recommended to ensure the Blast Resistant Construction with Positive Pressurization for the Main Refinery Control Room.
  It is also recommended to install Fire & Gas detectors at strategic locations within the unit along with remotely operated isolation valves for inventory isolation in the event of any leakage.

- High & low frequency credible Flammable & Toxic failure scenarios are modelled for the DCU, it is observed that Radiation, Explosion & Toxic effect zones may cross the unit's B/L. H_2S IDLH concentration in the event of 20 mm Leak at LPG Product Pump discharge circuit may cross the Refinery Compound Wall, depending upon the operating conditions, prevalent weather conditions at the time of release and equipment locations within unit.

  Hence, it is recommended to install Fire & Gas (Flammable & Toxic) detectors at strategic locations within the unit along with remotely operated isolation valves for inventory isolation in the event of any leakage.
  The outcomes of these scenarios to be also utilized for preparation of Emergency Response Guidelines & Disaster Management Plan.

- Various credible leak scenarios are modelled for the VGO-HDT unit and it is observed that Radiation, Explosion & Toxic effect zones for both high & low frequency failure scenarios may cross the B/L's of the unit and affect nearby CDU-VDU, DHT, NHT-CCR, ISOM & Gasoline HDT units, depending upon the equipment location & prevalent weather conditions at the time of the release.
  It is recommended to install Fire & Gas (Flammable & Toxic) detectors at strategic locations within the unit along with remotely operated isolation valves for inventory isolation in the event of any leakage.
  The outcomes of these scenarios to be also utilized for preparation of Emergency Response Guidelines & Disaster Management Plan.

- Flammable scenarios are modelled for Hydrogen Generation Unit (HGU), it is observed that the consequence outcomes for the Naphtha handling section of the unit may cross the unit's B/L and affect the nearby Main Refinery Control Room, depending upon equipment location & prevalent weather conditions at the time of the release.

  It is recommended to ensure the Blast Resistant Construction with Positive Pressurization for the Main Refinery Control Room.

It is also recommended to install Fire & Gas detectors at strategic locations within the unit along with remotely operated isolation valves for inventory isolation in the event of any leakage.

- Toxic Scenarios are modelled for the SRU / ARU / SWS unit and it is observed that the H_2S IDLH concentration may cross the unit's B/L's and affect the nearby facilities and personnel's present, depending upon the prevalent weather conditions at the time of the release.

  Hence, it is recommended to install Toxic gas detectors at strategic locations within the unit along with remotely operated isolation valves for inventory isolation in the event of any leakage.

  The outcomes of these scenarios to be also utilized for preparation of Emergency Response Guidelines & Disaster Management Plan.

- Flammable failure scenarios are modelled for the hydrocarbon Pumps in the Offsite and it is observed that Radiation & Explosion effects may affect the nearby Storage Tanks.

  It is recommended to provide the Fire & Gas detectors at strategic locations in the Offsite pump houses with adequate fire protection system for tankages & pump houses.

- Flammable failure scenarios are modelled for the Crude & Natural Gas Receipt lines and it is observed that Radiation & Explosion effects may affect the nearby Pipeline Control rooms, depending upon the prevalent weather conditions at the time of the release.

  It is recommended to ensure the Blast Resistant Construction with Positive Pressurization for the Pipelines Control Room or they need to be relocated to safe location.
  It is also recommended to install Fire & Gas detectors at strategic locations & outcomes of these scenarios to be also utilized for preparation of Emergency Response Guidelines & Disaster Management Plan

- From the Consequence modelling of High frequency scenarios in Butene-1 unit it is observed that the Radiation & Explosion effects may cause damage to equipments within the unit & may be realized beyond unit's B/L. Petrochemical Main Control Room may also get affected by Radiation & Explosion effects, depending upon equipment locations in the unit and prevalent weather conditions at the time of release. The low frequency failure scenarios explosion effects may affect the cooling tower on the north and MCR on the east, depending upon the prevalent wind conditions & ignition source encountered at the time of release and location of equipment's in the unit.

  Hence it is recommended to install fire & gas detectors at suitable locations in the unit along with remotely operated isolation valves for inventory isolation in the event of any leakage.

  It is recommended to ensure the Blast Resistant Construction with Positive Pressurization for the Petrochemical Main Control Room.

  The outcomes of these scenarios to be also utilized for preparation of Emergency Response Guidelines & Disaster Management Plan.

- From the Consequence modelling of High & low frequency failure scenarios in DFCU & associated units, it is observed that the Radiation & Explosion effects may cause damage to equipment's within the unit and may lead to escalation. Consequences may also be realized beyond unit's B/L depending upon the location of equipment's within the unit.

It is recommended to locate fire & gas detectors at suitable locations in the unit along with remotely operated isolation valves for inventory isolation in the event of any leakage to restrict the consequences and its after effects.

The outcomes of these scenarios to be also utilized for preparation of Emergency Response Guidelines & Disaster Management Plan.

- From the Consequence modelling of High & low frequency failure scenarios in LLDPE/ HDPE unit, it is observed that the Radiation & Explosion effects, if realized, may cause damage to piping/equipment within the unit with and may lead to escalation. There is a possibility that the consequences may be realized beyond unit's B/L and may affect the SRR in the neighboring PP unit depending upon the location of equipment's within the unit.

  It is recommended to locate fire & gas detectors at suitable locations in the unit along with remotely operated isolation valves for inventory isolation in the event of any leakage.

  The outcomes of these scenarios to be also utilized for preparation of Emergency Response Guidelines & Disaster Management Plan.

  It is recommended to ensure the SRR of PPU is of blast resistant construction with positive pressurization.

- Consequence Analysis for various failure scenarios in Offsite areas is carried out and following are the observations:

  - In case of a credible loss of containment event in the off spec ethylene sphere pump house, it is observed that there is a potential for flame impingement onto the spheres which may lead to significant secondary effects. Similarly, Butadiene spheres may be impacted by the jet fire in case of a leakage scenario in Butadiene sphere pump houses. Also the overpressure effects from the Butadiene sphere pump houses may affect the tankages and lead to escalation.

  ✓ *Hence following is recommended:*
  - *Provide a fire wall in between the Spheres & respective pump houses or ensure fire proofing of the spheres to withstand jet fire effects.*
  - *Provide fire & gas detectors at suitable locations in pump houses for early detection and mitigation.*
  - *Provide remotely operated isolation valves for inventory isolation in the event of any leakage.*

  - In case of a credible loss of containment event in the DWST area, the radiation and explosion effects may lead to localized damage and escalation in Boil off Gas (BOG) handling area.

  ✓ *Hence it is recommended to install fire & gas detectors at suitable locations in the storage area along with remotely operated isolation valves for inventory isolation in the event of any leakage.*

  - In case of a credible loss of containment event in the loading gantry area, it is observed that the IDLH concentration of 500 ppm for Toluene and Benzene may be realized beyond the complex boundaries.

  ✓ *Hence following is recommended:*
  - *Relocate the gantry further inside the complex away from the Refinery Complex compound wall.*

- *Ensure emergency isolation valves on loading lines for quick shut-off.*
- *Provide fire & gas detectors at suitable locations in pump houses for early detection and mitigation.*

❖ In case of a credible loss of containment event in the Product Storage pump house of Benzene/Toluene, it is observed that an accidental jet fire may affect the nearby tankages.

✓ *It is recommended to provide a fire wall in between the pump-house & Tankages for protection of tank.*

✓ *Provide fire & toxic gas detectors at suitable locations in pump houses for early detection and mitigation.*

➢ In case of a catastrophic rupture of Off spec Ethylene sphere, it is observed that the explosion overpressures may affect the adjacent Butadiene spheres, ULS HSD & Gasoline BS VI tankages. This may further lead to hazardous secondary effects. Similar consequences may be realized in case of catastrophic rupture of Butadiene spheres also.

The outcomes of this scenario to be utilized for preparation of Emergency Response Guidelines & Disaster Management Plan.

Detailed Preventive Maintenance Plan to be established for Sphere such as shell thickness monitoring, etc.

a. Recommendations for Construction Safety during execution of Project

✓ *Proper material movement path within the Refinery complex to be identified during the construction phase of the project.*

✓ *Detailed HSE Plan & HSE Philosophy to be developed by EPC contractors during construction phase of the project.*

✓ *It is recommended to carry out HAZID studies during pre-execution phase of the expansion project to get a detailed overview of the hazards during construction phase and those identified should be suitably mitigated.*

b. General Recommendations

✓ *No Operator Cabin to be located inside battery limits of units. Detailed QRA required to be carried out prior to fixing the location of any Operator Cabin in the close vicinity of Process units.*

✓ *Detailed Comprehensive QRA is required to be carried for the Refinery Complex along with Marketing Terminal during the detailed engineering stage.*

✓ *During the development of the Plot Plan of the Marketing Terminal, hazard from the Refinery complex area and vice versa to be addressed to rule out possibility of the Domino affects.*

✓ *Though Main Control Rooms for Refinery & Petrochemical are ought to be blast resistant, they are sandwiched between Process areas. It is recommended to review the possibility of shifting them to Safe area / Non Hazardous area.*

✓ *It is recommended to review the possibility of shifting the DWST and associated transfer system to the Offsite Tankages area as it is getting sandwiched between Process areas.*

✓ *Proper checking of contract people for Smoking or Inflammable materials to be ensured at entry gates to avoid presence of any unidentified source of ignition.*

✓ *Ensure that vehicles entering the Refinery complex should be fitted with spark arrestors as a mandatory item during normal operation of the Refinery Complex.*

- ✓ *In order to prevent secondary incident arising from any failure scenario, it is recommended that sprinklers and other protective devices provided on the tanks to be regularly checked to ensure that they are functional.*
- ✓ *It is recommended to have mounded type construction for bulk storages of pressurized products to maximum extent possible.*
- ✓ *Emergency security / evacuation drills to be organized at organization level to ensure preparation of the personnel's working in Refinery complex for handling any extreme situation.*
- ✓ *For positively pressurized building, both Hydrocarbon & Toxic detectors need to be placed at suction duct of HVAC. HVAC to be tripped automatically in event of the detection of any Hydrocarbon / toxic material by detector.*
- ✓ *It is recommended for usage of safer oxidizing agents (Chlorine free) in Cooling Water circuit.*
- ✓ *Development of any permanent residential / commercial establishment to be discouraged around the Refinery complex and same shall be as per the Land use planning Criteria agreed with the owner of the Refinery Complex. The same to be accorded with State district authorities.*

c. Mitigating Measures

Mitigating measures are those measures in place to minimize the loss of containment event and, hazards arising out of Loss of containment. These include:

- ✓ Rapid detection of an uncommon event (HC leak, Toxic gas leak, Flame etc.) and alarm arrangements and development of subsequent quick isolation mechanism (through shut-off valves) for major inventories such as Reflux Drum, Surge Drums, Coalescer, Column Bottoms handling Class A products, lighters and other hazardous materials. This shall be part of basic design philosophy.
- ✓ Measures for controlling / minimization of Ignition sources inside the Refinery complex to the extent possible.
- ✓ Active And Passive Fire Protection for critical equipment's and major structures
- ✓ Effective Emergency Response plans to be in place

d. Ignition Control

- ✓ Ignition control will reduce the likelihood of fire events. This is the key for reducing the risk within facilities processing flammable materials. As part of mitigation measure it strongly recommended to consider minimization of the traffic movement within the Refinery complex.

e. Escape Routes

- ✓ Ensure sufficient escape routes from the site are available to allow redundancy in escape from all areas.
- ✓ Ensure sufficient number of windsocks throughout the site to ensure visibility from all locations. This will help people to escape crosswind during flammable / toxic releases.
- ✓ Provide sign boards marking emergency/safe roads to be followed during any exigencies.

f. Preventive Maintenance for Critical Equipment's

- ✓ In order to reduce the failure frequency of critical equipment's, the following are recommended:
  a. High head pumps and Compressors, which are in flammable / toxic services, are needed to be identified.
     i. Their seals, instruments and accessories are to be monitored closely

ii. A detailed preventive maintenance plan to be prepared and followed.

b. Large inventory vessels handling flammable / toxic substances viz. Surge Drums / Reflux Drum's need to be identified. The rupture of these vessels may lead to undesirably high consequences. The following needs to be ensured for these vessels:
   i. Monitoring of vessel internals during shut down.
   ii. A detailed preventive maintenance plan to be prepared and followed.

g. Others

- ✓ Closed sampling system to be considered for pressurized services like LPG, Propylene etc.
- ✓ Recommended to use portable HC detector during sampling and maintenance etc.
- ✓ Provide breathing apparatus at strategic locations inside Refinery complex.

1.6.2 Public Hearing

In accordance with the provisions of EIA Notification no. S.O. 1533 dated 14.09.2006 and its subsequent amendment S.O. 3067 (E) dated 01.12.2009 issued by Ministry of Environment and Forests (MoEF), Govt. of India, New Delhi, Public Hearing for the proposed refinery cum petrochemical project was conducted on May 30, 2014 by Rajasthan State Pollution Control Board (RSPCB) at Shree Sambhra Aashapura Mataji Mandir, Sambhra, Village Sambhra, Taluka: Pachpadra, District: Barmer. On behalf of District Collector Barmer, Chief Executive Officer, Zila parishad, Barmer presided over the public hearing meeting. Regional Officer, Rajasthan State Pollution Control Board, Jodhpur and Balotra conducted the public hearing proceedings. About 1000 people attended the public hearing.

A power point presentation covering the proposed project details and the outcome of Environmental Impact Assessment and Risk Assessment (EIA & RA) studies was made in Hindi language (local and national language) in the Public Hearing meeting.

Queries on environmental issues related to salt mining, flora & fauna, air pollution, wastewater discharge, solid waste disposal from the complex were raised. The public also raised queries on various socio-economic issues like employment for local people, welfare activities in the villages, particularly for the salt mine owners/ workers, water catchment for the salt mines in the area etc. All these queries by various Gram Panchayats, local villagers and NGOs were appropriately answered by the RSPCB, NEERI and the Project Proponent.

The proceedings of the public hearing have been duly documented by Rajasthan State Pollution Control Board.

1.7 PROJECT BENEFITS

The benefits of proposed project are as follows

1. Economic benefits to the region and country
2. Advantage in-terms of Petrochemical Products by reducing dependency on imports and substantial savings in foreign exchange.
3. To produce BS VI quality fuel.
4. Positive impact on socio-economic environment due to improvement in infrastructure facilities in the region
5. Development of downstream industries in the vicinity

1.8 CONCLUSION

The proposed refinery cum petrochemical complex has certain level of marginal impacts on the local environment. However, with the implementation of the proposed pollution control and environment management measures, even the marginal impacts anticipated due to construction and operation of the proposed Project will be mitigated. There will be a beneficial effect of a flourishing production that will directly and indirectly boost the living standards of the people, save foreign exchange and with increase in industrial activities, create more jobs in the local economy. Thus, in view of considerable benefits from the project with marginal environmental impacts mitigated through robust EMP, the proposed Project will be advantageous not only for the Pachpadra region, but also for the Barmer District, Rajasthan State and Nation as a whole.

CHAPTER – 1

INTRODUCTION

1.1 INTRODUCTION

A 9.0 MMTPA grass-root Refinery cum Petrochemical Complex (Rajasthan Refinery Project, RRP) has been proposed in Pachpadra, Barmer District of Rajasthan by M/s HPCL Rajasthan Refinery Limited (HRRL), a joint venture company between Hindustan Petroleum Corporation Limited (HPCL) and Govt. of Rajasthan. The Complex will be designed with refinery capacity 9.0 MMTPA to process 1.5 MMTPA Rajasthan Crude + 7.5 MMTPA Arab mix crude for First 8 years and from 9th year onwards Arab mix crude of 9 MMTPA.

HPCL retained Engineers India Limited, Gurgaon to revise the EIA report submitted to Ministry of Environment, Forests & Climate Change (MoEFCC) vide 15th September 2014.

1.2 PROPOSED PROJECT

RRP is being proposed with the basis of achieving energy efficiency, environment friendly, high distillate yielding refinery cum petrochemical complex that will be producing clean fuels and petrochemicals.

Captive generation of all utilities including power is considered for meeting the total utility requirement of the refinery-cum-petrochemical complex. The raw water shall be sourced from the Indira Gandhi (IG) Canal which shall be supplied through a 46" raw water pipeline of approx. 200 km length.

The feed receipt/product dispatch facilities considered include Mangala Crude to be received from the Mangala Crude Facility, Arab Mix Crude (Imported Crude) with SPM/COT facilities for import of crude. New Natural Gas Pipeline is considered for natural gas from Cairn India's Rageshwari Gas Terminal to the proposed refinery location.

For meeting the internal fuel requirement of the refinery complex, treated fuel gas will be the primary fuel supplemented by internally generated fuel oil and natural gas. Infrastructure facilities such as roads and buildings, water supply and public health (including ETP), work shop, etc will be developed. Safety facilities like flare system, fire water system, safe guard system, machine monitoring system, gas detectors etc. with suitable design capacities will be provided.

1.3 NECESSITY OF PROJECT

The grass root refinery cum petrochemical complex is proposed to be set up to meet the increasing demand of petroleum and petrochemical products and take the opportunity to process local Rajasthan crude. In addition to the increase in availability of petroleum products in the northern states in general and Rajasthan state in particular, the project is expected to generate employment, both direct and indirect.

Setting up of RRP project at Pachpadra, Rajasthan will benefit to the Society and Nation on account of this project will accrue by way of self-sufficiency in manufacture of value added petroleum products thereby leading to reduced dependency on imports and substantial savings in foreign exchange through obviating heavy transportation costs for moving petroleum products to Rajasthan region from other locations.

1.4 PROJECT SITE

The location of proposed grass-root refinery is shown in Figure1.1. The proposed site is spread over 4400.40 acres encompasses the villages Sajjiyali Roopji Kanthavad, Sambhara, Pachpadra Tehsil, District: Barmer, Rajasthan for Refinery cum Petrochemical Complex and Marketing Terminal and additional 413.26 acres is reserved for township and reservoir which will be located about 2.5 km from the complex. The entire area is sandy with flat terrain without any major undulations. The site will be accessible from National Highway NH-112 which connects Jodhpur to Barmer. NH-112 is about 0.5 km from the plot of proposed refinery cum petrochemical complex. The nearest railway station is Balotra Station about 12 km and the nearest airport is Jodhpur airport about 100 km from site. The proposed site has been identified by Government of Rajasthan (GoR) and has signed MoU with HPCL for the same and is also in close proximity to the Mangla fields. The proposed site comprising few villages (Sajiyali Roopji Kanthavad and Sambhara) will be used for Refinery cum Petrochemical complex. The land allotment letter from Collector office, Barmer is given in **Annexure I**.

1.5 PROJECT COST AND SCHEDULE

The total cost of the proposed project is estimated at Rs. 43129 crores. Implementation of a grass root project of the magnitude of the Rajasthan Refinery with petrochemical complex integration as well as associated utilities, offsite and infrastructure facilities.

Based on the execution plan drawn up, the mechanical completion of the project is estimated to be 48 months from Zero date. The Zero date of the project execution is the date of receipt of BDEP of all units or environmental clearance whichever is later.

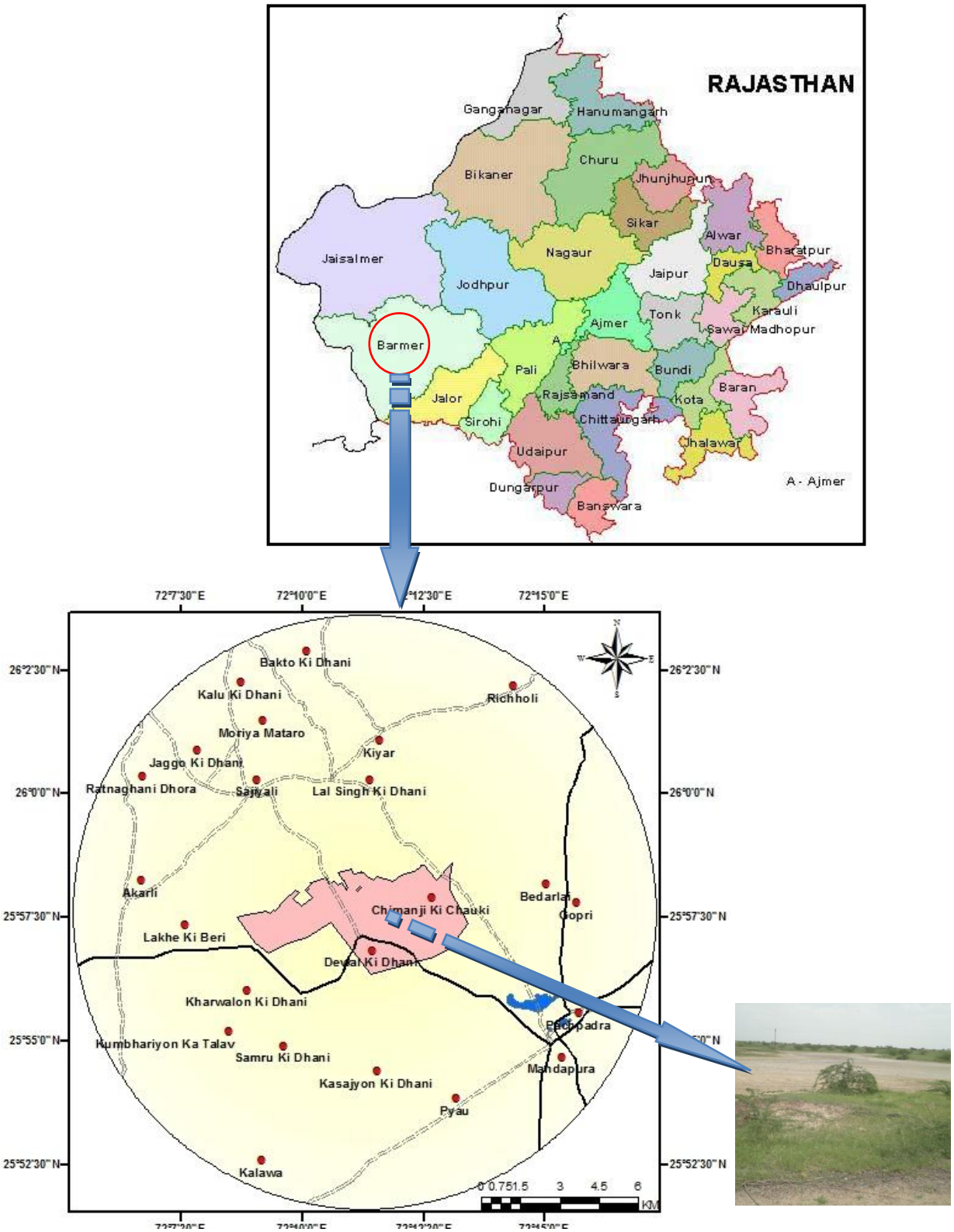


Fig. 1.1: Location Map of Proposed Grass Root Refinery cum Petrochemical complex at Pachpadra, Barmer Rajasthan

1.6 PROJECT PROPONENT

A **Joint Venture Company** incorporated as M/s HPCL Rajasthan Refinery Limited (HRRL) between HPCL and Government of Rajasthan for setting up of Rajasthan Refinery & Petrochemical Project.

1.6.1 Particulars of EIA Consultant

The EIA consultant is Engineers India Limited accredited by NABET/QCI. Details and certificate are given in Chapter 10. The complete address for correspondence is given below:

Mr. R. B. Bhutda
Head-Environment, Water & Safety Division
Engineers India Limited
Research & Development Complex, Sector-16, On NH-8
Gurugram – 122001, Haryana
Email: rb.bhutda@eil.co.in
Tel: 0124-3802034
Website: http://www.engineersindia.com

1.7 SCREENING AND SCOPING FOR EIA STUDY

The scope of proposed development as outlined by HPCL involves setting up of a grass-root Refinery cum Petrochemical Complex in Barmer with refinery capacity 9.0 MMTPA to process 1.5 MMTPA Rajasthan + 7.5 MMTPA Arab Mix & 9 MMTPA Arab mix (9th Year Onward). The MoEF notification dated September 14, 2006 and its subsequent clarifications and amendments for obtaining prior environmental clearance for any scheduled development project demands for screening and scoping process prior to undertaking an environmental impact assessment study. As per the screening process, the proposed development of grass-root petroleum refinery and petrochemical complex falls in category A, project activity 4(a) and 5(c) all projects as per schedule. The applicable procedure for proposed activity has been followed by HPCL through filling up of prescribed Form I and submitted to MoEF for necessary approval and Terms of Reference (ToR) for carrying out EIA study.

The proposal has been discussed during the meeting of the Expert Appraisal Committee (Industry) held on July 29-31, 2013 and approved ToR have been issued by MoEF vide F.No. J-11011/87/2013-IAII(I) dated September 27, 2013. Approved TOR letter is attached in **Annexure II**. Further public hearing was held on 30th May 2014 and final report after incorporating proceedings of public hearing was submitted on 15th September 2014. The final EIA report was discussed during the meeting held on 18th February 2015 and MoEFCC sought additional information. The replies were provided on 22/05/2017. The replies were discussed during the 24th Expert Appraisal Committee (EAC) meeting held on 14-16th June 2017 and advised to submit revised EIA based on the changes in project configuration. It is also directed to use the baseline data collected during October-December 2013 and Public Hearing conducted on 30th May 2014. The submitted letter to MoEF and Minutes of Meeting of 24th EAC are given in **Annexure III**.

1.8 ENVIRONMENTAL IMPACT ASSESSMENT

The objective of present study is preparation of Environment Impact Assessment (EIA) report is to revise the EIA report submitted to MOEFCC vide dated 15th September 2014. This Environmental Impact Assessment (EIA) study encompasses detailed studies for various environmental components viz. air, noise, water, land, biological and socio-economic for three months (Oct-Nov-Dec 2013).

1.9 FRAME WORK OF ASSESSMENT

Based on the scope of work, guidelines generally followed for EIA studies and past experience of EIL on such industrial projects, a corridor encompassing of area within 10 km radius of proposed project location is considered as spatial frame for the impact assessment. Temporal frame of assessment has been chosen to reflect the impacts in two distinct phases of the project as:

a) Construction phase, and
b) Operation Phase

Time frame and the type of impacts will be different for these phases of the project.

1.10 METHODOLOGY FOR ENVIRONMENTAL IMPACT ASSESSMENT

The methodology adopted for carrying out the Environmental Impact Assessment for the proposed expansion project is based on the Guidelines issued by MoEFCC and EIL's past experience of similar jobs. An effective environmental assessment calls for establishing sufficient background data on various environmental components through reconnaissance survey, sampling and available literature survey etc.

The methodology adopted in preparing this EIA report is outlined in the following sections:

1.10.1 Project Setting and Description

In this section, Environmental setting of the existing refinery and details of proposed facilities will be defined. The description also gives details of effluents (gaseous/liquid/solid/noise) generation sources. Coverage on environmental setting of the existing refinery in terms of site details, project description, products, its storage, existing pollution control devices/measures, emission summary, hazardous waste/chemicals management etc. will be described.

1.10.2 Identification of Impacts

In order to identify the impacts comprehensively, all the activities associated with the proposed project during the construction as well as operational phase are identified and listed. The environmental impacts associated with the proposed project on various environmental components such as air, water, noise, soil, flora, fauna, land, socioeconomic, etc. has been identified using Impact Identification Matrix.

1.10.3 Baseline Data Collection

Once the affected environmental parameters are identified, various environmental parameters of concern are identified to establish its baseline quality. M/s National Environmental Engineering Research Institute, Nagpur was carried out environmental baseline data collection during October-December 2013. Data thus collected has been utilized here to establish baseline quality of various environmental parameters.

1.10.4 Environmental Impact Prediction & Evaluation

In this part of the report, the sources of emissions (Gaseous, Liquid, Solid, Noise) due to the proposed activities will be identified and based on their emission loads their impacts are to be predicted. Such predictions are then superimposed on baseline quality (wherever there is an additional impact) and quantitative/qualitative assessments have been made for the impacts and synergistic impact is evaluated using the matrix method. The resultant matrix attempts to give an objective assessment to identify the mitigation measures needed for abatement of various impacts.

1.10.5 Environment Management Plan (EMP)

In order to mitigate or minimise the negative impacts (if any) of the proposed project, an effective EMP is delineated. Therefore, in the final part of the report, the planning and implementation of various pollution abatement strategies including the proposed monitoring/surveillance network has been described. Detailed Environment Management Plan (EMP) with specific reference to details of air pollution control system, water & wastewater management, monitoring frequency, responsibility and time bound implementation plan for mitigation measure is formulated.

1.11 CONTENTS OF THE EIA REPORT

An "**Executive Summary**" indicating a brief note on various chapters of EIA/RRA is prepared which provides a statement on various environmental issues. Further, the contents and its coverage are explained below:

Chapter-1: Introduction

This chapter provides background information of the proposed refinery expansion, scope, frame work & methodology of the study.

Chapter-2: Project Description

This chapter presents the details of the proposed project in terms of location, project configuration of proposed refinery & petrochemical facilities, description of the resources required and emissions, solid waste and wastewater anticipated to be generated.

Chapter-3: Description of Environment

This chapter describes the existing baseline status of environment components collected in a pre-defined study area based on primary and secondary data collection.

Chapter-4: Anticipated Environment Impacts and Mitigation Measures

This chapter describes the potential impacts of the proposed project and evaluates their significance based on parameters such as Intensity (I), Spatial extension (Sp), Temporal duration (T) and Environmental Vulnerability (V). Wherever applicable, mathematical models were used to quantify the intensity and spatial extension of the impacts. Impact avoidance and mitigation measures are delineated.

Chapter-5: Analysis of Alternatives

This chapter describes the alternative site for the proposed project.

Chapter-6: Environment Monitoring Programme

This chapter describes the details of the monitoring schedule to be implemented for checking the effectiveness of mitigation measures. It covers the parameters and its, frequency.

Chapter-7: Additional Studies (Risk Analysis & Public Hearing)

This chapter assesses the potential risks involved in the construction and operation of proposed facilities from this project. It also includes the public hearing compliance.

Chapter-8: Project Benefits

This chapter presents the details of direct and indirect benefits due to proposed project.

Chapter-9: Environmental Cost Benefit Analysis

This chapter presents the environmental cost benefit analysis due to proposed project.

Chapter-10: Environment Management Plan (EMP)

This chapter describes the existing environmental management system, existing CSR, impact analysis & mitigation measures for various components of environment. It also includes organizational structure and resources planned for implementing the mitigation measures and monitoring schedule.

Chapter-11: Summary and Conclusion

This chapter deliberates the summary and conclusion drawn due to proposed project.

Chapter-12: Disclosure of Consultants

This chapter contains the details of various functional areas in which the consultant is expertise as per Quality Council of India (QCI) to conduct Environment Impact Assessment (EIA) studies as per the MoEFCC Guidelines.

CHAPTER – 2

PROJECT DESCRIPTION

2.0 INTRODUCTION

This chapter describes the details of proposed project location, configuration, process description, utilities, environmental setting of the project etc.

2.1 TYPE OF PROJECT

The proposed Rajasthan Refinery project (RRP) is conceptualized as an energy efficient, environment friendly, high distillate yielding refinery cum petrochemical complex to produce clean fuels and petrochemicals.

2.2 NEED FOR THE PROJECT

The grass root Refinery cum Petrochemical Complex is proposed to be set up to meet the increasing demand of petroleum and petrochemical products and take the opportunity to process local Rajasthan crude. In addition to the increase in availability of petroleum products in the northern states in general and Rajasthan state in particular, the project is expected to generate both direct and indirect employment.

Setting up of RRP project at Pachpadra, Rajasthan will benefit to the Society and Nation. This project will produce value added petroleum and petrochemical products to reduce dependency on imports which will result in substantial savings in foreign exchange.

2.3 PROJECT LOCATION

The proposed grass root Refinery cum Petrochemical Complex and Marketing Terminal is located at Pachpadra (25 56.357 N, 72 11.401 E) in Barmer District of Rajasthan and is spread over 4400 acres of land and additional 413 acres is reserved for town ship and reservoir which will be located about 2.5 km from the complex. The location of proposed grass-root refinery is shown in **Figure.2.1.**

The entire area is sandy with flat terrain without any major undulations. The site will be accessible from National Highway NH-112 which connects Jodhpur to Barmer. NH-112 is about 0.5 km from the plot of proposed refinery cum petrochemical complex. The nearest railway station is Balotra Station about 12 km and the nearest airport is Jodhpur airport about 100 km from site.

The proposed site has been identified by Government of Rajasthan (GoR) and has signed MoU with HPCL for the same and is also in close proximity to the Mangla oil fields.

The proposed site comprising few villages (Sajiyali Roopji Kanthavad and Sambhara) will be used for construction of Refinery cum Petrochemical complex as per the plot plan as shown in **Figure 2.2.** The land allotment letter from Collector office, Barmer is given in **Annexure I**.

There is no national park/wild life sanctuary/reserve forest located within 10 km radius of the proposed project.

Similarly No other industries are located within 10 km radius of the proposed project.

Figure 2.1 Location of Refinery cum Petrochemical complex

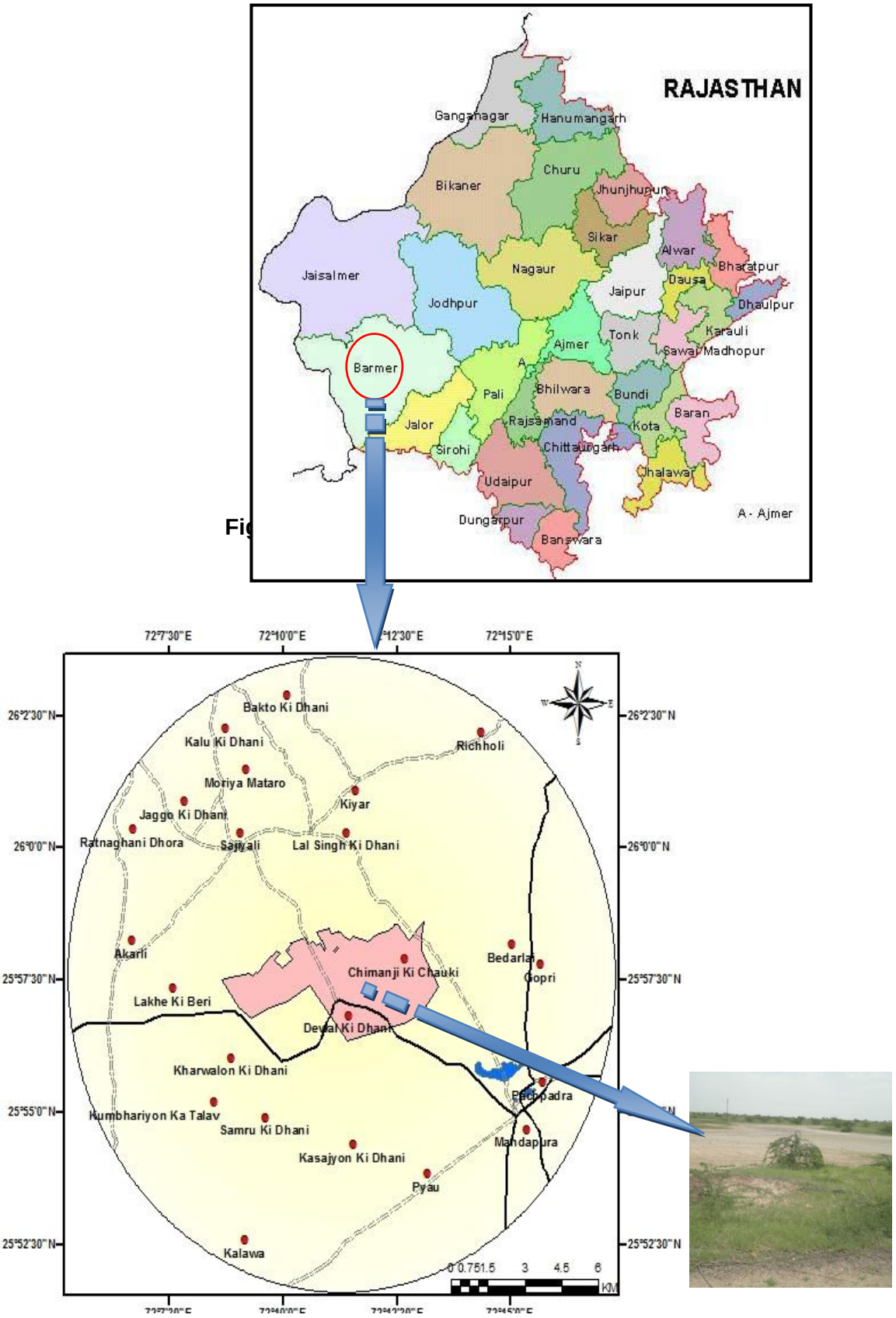


Figure 2.2 Overall plot plan of the Proposed Refinery and Petrochemical Plant at Pachpadra, Barmer, Rajasthan

2.4 PROJECT CAPACITY

The total crude processing capacity of the Refinery is 9.0 MMTPA with 1.5 MMTPA Rajasthan crude and 7.5 MMTPA Arab Mix crude. This refinery cum petrochemical complex will be implemented in single phase.

2.5 RAW MATERIAL AND PRODUCTS

Following are the details of feed and products slates of the proposed Refinery cum Petrochemical Complex

Table 2.1 Product Slate for Selected Cases

CASE	Unit	1.5 MMTPA Rajasthan Crude + 7.5 MMTPA Arab Mix crude	9 MMTPA Arab Mix crude
FEED			
RAJASTHAN CRUDE	MT/DAY	4504	0
ARAB HEAVY	MT/DAY	11451	13741
ARAB LIGHT	MT/DAY	11069	13283
NATURAL GAS	MT/DAY	353	578
PRODUCTS			
POLYPROPYLENE	MT/DAY	2935	2942
BUTADINE	MT/DAY	668	707
LLDPE/HDPE	MT/DAY	1161/1161	1247/1247
BENZENE	MT/DAY	276	288
TOLUNE	MT/DAY	129	228
91 RON GASOLENE, BS-VI	KL/DAY	2678	2412
95 RON GASOLENE, BS-VI	KL/DAY	2678	2412
ULS DIESEL , BS-VI	KL/DAY	13096	12951
SULPHUR	MT/DAY	355	395
PetCoke	MT/DAY	-	100
FUELS & LOSSES	MT/DAY	5764	5821

2.6 PROPOSED PROJECT SCHEDULE

Based on the execution plan drawn up, the mechanical completion of the project is estimated to be 48 months from Zero date. The Zero date of the project execution is the date of receipt of BDEP of all units or environmental clearance whichever is later. The expected year of start of operations of proposed Refinery cum Petrochemical Complex will be in the year 2023-24.

2.7 PROCESS DESCRIPTION

A brief description of the process units envisaged in the Refinery cum Petrochemical complex is presented in this section.

- Crude Distillation Unit/Vacuum Distillation Unit
- VGO Hydro-treater Unit
- Naphtha Hydrotreating Unit

- CCR Unit
- Isomerisation Unit
- LPG Treating Unit
- Diesel Hydrotreating Unit
- Fluid Catalytic Cracking (FCC)
- Delayed Coker Unit
- Fuel gas treating Unit
- Hydrogen Plant
- Sour Water Stripper-I
- Sour Water Stripper-II
- Sulphur Recovery Unit (With Tail Gas Treatment Unit)
- Amine Regeneration Unit
- Poly Propylene Unit
- Propylene Recovery Unit (polymer grade)
- Dual Feed Cracker
- Poly-Ethylene Unit (LLDPE/HDPE Swing Unit)
- Pyrolysis Gasoline HDT
- Butene-1 Unit
- FCC Gasoline HDT
- Recovery PSA
- BTX Fractionation Unit

The capacities of the main refinery units are tabulated below in Table 2.2.

Table-2.2: Process Unit Capacities

Process Units	UNITS	Capacity
CDU	MMTPA	9.0
VDU	MMTPA	4.8
NHT	MMTPA	1.8
ISOM	MMTPA	0.26
CCR	MMTPA	0.3
DHDT	MMTPA	4.1
PFCC	MMTPA	2.9
DCU	MMTPA	2.4
PPU	MMTPA	2 x 0.49
Butene-1	KTPA	59
LLDPE/HDPE Swing	MMTPA	2 x 0.416
VGO HDT	MMTPA-	3.5
DUEL FEED CRACKER	MMTPA	0.82
ETHLENE RECOVERY UNIT	MMTPA	0.077
BENZENE RECOVERY UNIT	MMTPA	0.096
Py gas HDT	MMTPA	0.55
BTX	MMTPA	0.55
PFCC GASOLINE DEPANTANIZER	MMTPA	0.87
GASOLINE HDT	MMTPA	0.53
FCC C5 Merox	MMTPA	0.22
SAT. LPG MEROX UNIT	KTPA	162
LPG DEPROPANIZER	KTPA	162
FG TREATING UNIT	TPD	1425
HYDROGEN GENERATION UNIT	KTPA	37
PSA	KTPA	28

Process Units	UNITS	Capacity
SWS -I (HYDRO PROCESSING)	M3/HR	100
SWS -II (NON HYDROPROCESSING)	M3/HR	250
AMINE REGENERATION UNIT	M3/HR	3x480
SULPHUR RECOVERY UNIT	TPD	2 x 199

2.7.1 Crude Distillation Unit

Crude Charge and Preheat Train-I

Crude from offsite storage is received at CDU/VDU plant battery limit. The crude is subsequently heated in preheat exchangers by hot streams of CDU/VDU. Crude picks up heat in the preheat exchangers before being routed to Crude desalter.

Desalter

A 2-stage electrostatic Crude Desalter is provided for removal of salt and water from the crude to desired level. The principle of desalting operation requires mixing of preheated wash water in a mixing valve with the crude under controlled conditions and to extract impurities.

Crude Preheat Train-II and Preflash

The crude from Desalter outlet is routed to the 2nd train of pre heat exchangers. Crude picks up heat from hot streams of CDU/VDU and routed to Preflash drum. The liquid separated in the Preflash drum is pumped to crude preheat train-III.

Crude Preheat Train-III

The pre flashed crude is heated in 3rd preheat train exchangers. Crude picks up heat from hot streams of CDU/VDU and finally routed to crude heater.

Crude Heater

The preheated crude is fed to the crude heater and equally distributed to the heater passes through pass balancer control valve. The total crude flow to the unit signal is sent to the crude throughput controller, which sends signal to the furnace flow controllers.

Crude Distillation Column

Heated and partially vaporised crude enters crude column through feed nozzle. The column has five side draws normally namely Swing Naphtha (SN), Lt Kerosene (LKero), HVY Kerosene (HKero), Light Gas Oil (LGO) and Heavy Gas Oil (HGO).

Crude Column Overhead Circuit

The overhead system consists of a two stage condensing system with wash water circulation. Sour water separated in reflux drum is partly returned as wash water for atmospheric column overhead vapours. All the salt are dissolved in wash water and are purged out of the system through sour water purge stream to sour water stripper unit. Additionally Filming Amine is also injected in the crude column overhead line in order to protect the overhead line.

Swing/Heavy Naphtha Section

Swing naphtha is drawn as side product to side stripper. Stripper is provided with thermosiphon reboiler to knock off light ends from naphtha. The CDU hot stream is used as heating medium in reboiler. The bottom product of swing/heavy naphtha stripper is pumped to naphtha product cooler. The cooled product ex-product cooler is finally routed to storage. The light hydrocarbon vapours leaving the naphtha stripper is returned to the crude column.

Light Kerosene Section

Kerosene product is drawn from crude column. The kero product flows to the lt kero stripper under stripper level control. Lt. Kero stripper is a reboiled stripper using CDU hot stream as reboiling medium. The light hydrocarbon vapours leaving the kero stripper are returned to the crude column.

Heavy Kerosene Section

Heavy kerosene product & kero cr is drawn as a single stream from crude column. One stream as kero product flows to the hvy kero stripper under stripper level control. Hvy kero stripper is a reboiled stripper using CDU hot stream as reboiling medium. Light ends in heavy kerosene are knocked off. The light hydrocarbon vapours leaving the kero stripper are returned to the crude column.

Light Gas Oil Section

LGO product and LGO CR stream is drawn as a single stream from crude column. One stream as LGO product flows to the LGO Stripper under LGO stripper level control where it is stripped using MP steam under flow control and the stripped vapours are returned back to the Crude Column below.

Heavy Gas Oil Section

HGO product & HGO CR are drawn as a single stream from the Crude Column. One stream as HGO Product flows to the HGO Stripper under stripper level control where it is stripped using MP steam under flow control and stripped vapours are returned back to the Crude Column.

Reduced Crude Oil Section

Stripped RCO from the column bottom is sent to the Vacuum Heater under level control of atmospheric column bottom cascaded with the pass flow controller of Vacuum Heater. MP steam under flow control is introduced as stripping steam of the Crude column.

Crude Column Circulating Refluxes

Crude Column is provided with three Circulating Reflux streams for optimum vapour-liquid internal traffic and heat recovery.

Kero CR: Kero CR is drawn along with Hvy Kero product and is pumped by Kero CR pump. The heat available in Kero CR is removed in crude preheat exchangers.

LGO CR: LGO CR is drawn along with LGO product and is pumped by LGO CR Pump. The heat available in LGO CR is removed in crude preheat exchangers and reboiler.

HGO CR: HGO CR is drawn along with HGO product and is pumped by HGO CR Pump. The heat available in HGO CR is removed in crude preheat exchangers and reboiler.

Product Rundown Section

Swing/Heavy Naphtha Product Circuit

Swing/heavy naphtha from naphtha stripper bottom is pumped by Swing naphtha Product pump to Naphtha Air cooler followed by Swing naphtha Trim Cooler after heat recovery in preheat train. The hot naphtha stream is routed to NHT Unit and cooled product ex-product cooler is finally routed to storage.

Light Kero Product Circuit

Lt Kero product from Lt Kero Stripper bottom is pumped by Kero Product pump. After heat recovery, hot kero product is routed to DHT Unit. Kero product is further cooled in product coolers to required rundown temperature and routed to storage.

Heavy Kero Product Circuit

Heavy Kero product from Hvy Kero Stripper bottom is pumped by Hvy Kero Product pump. After heat recovery, hot Kero product is routed to ATF /DHT Unit. Kero product is further cooled in product coolers to required rundown temperature and routed to storage.

LGO Product Circuit

LGO Product from LGO Stripper is pumped by LGO product Pump. After heat recovery, hot LGO product is routed to DHT Unit. LGO product is further cooled in product coolers to required rundown temperature and routed to storage.

HGO Product Circuit

HGO Product from HGO Stripper is pumped by HGO Product Pump. After heat recovery, hot HGO product is routed to DHT Unit. HGO product is further cooled in product coolers to required rundown temperature and routed to storage.

RCO Product Circuit

Normally, Reduced Crude Oil (Crude Column residue, RCO) from Crude Column is pumped to vacuum unit without any cooling. However, provision is kept to cool the hot RCO stream in crude preheat circuit and coolers to facilitate to operate Crude unit alone without Vacuum unit and route the RCO stream to storage.

NAPHTHA STABILIZER

Naphtha Stabiliser Column

The Unstabilised naphtha consisting of all the fuel gas, LPG and Naphtha components is pumped to Naphtha stabiliser column after preheating in the stabiliser feed/bottom exchanger. The overhead products are partially condensed in the Stabiliser Overhead Condenser. Fuel gas and LPG are withdrawn from the overhead circuit. Fuel gas is routed to Fuel Gas ATU and LPG is routed to LPG Treater. Stabiliser column is a reboiled column using CDU hot stream as reboiling medium. Stabilised Naphtha product from Stabiliser Column bottom is pumped in Stabilised Naphtha PDT pumps and routed to NHT/H2 Unit.

Stabilised Naphtha is further cooled in the exchanger to required rundown temperature before routing the same to the storage.

2.7.2 VGO Hydrotreater Unit (VGOHDT)

VGO HDT unit shall treat the LVGO and HVGO from the CDU/VDU and gas oil from bottom processing unit. Fresh feed is preheated, pumped and mixed with the preheated recycle gas. The mixture is brought up to reaction temperature by the reaction furnace. In the reactors the reactions are highly exothermic; therefore, the temperature at the inlet of each bed is controlled by a quench gas injection. The reactor effluent is then fed into the hot HP separator drum. The vapor phase from hot HP separator is cooled and water is injected at the inlet of the air cooler. The air cooler effluent is collected in the cold HP separator drum where three phases are separated. The sour water is removed and routed to the sour water stripper system. The gas phase is sent to the recycle gas HP amine absorber where almost all H2S is removed. The recycle gas is separated in two parts, one towards quench and the other one with makeup gas to feed effluent exchanger. The hydrocarbon liquid phase from the cold HP separator drum is routed to the LP separator. At LP separator, the hydrocarbon liquid phase is combined with hot HP separator liquid phase and routed to the inlet of the stripper where stripping is ensured by injection of medium pressure steam at the bottom of the column. The overhead vapors from the stripper is partially condensed by air and cooling water and collected in the reflux drum. The liquid hydrocarbon phase is used part as reflux to the stripper and part is sent for gas recovery. The stripper bottom is heated and feeds the main fractionator where hydrotreated VGO is stripped with superheated LP steam in the bottom section of the column. Fractionator overhead stream is cooled and party refluxed back to the column and partly recovered as unstabilized naphtha which is routed to Debutanizer. The diesel fraction is routed to side stripper where part is recycled back to the column and part is obtained as diesel product. Fractionator bottom product preheats the fresh feed, fractionator feed and reboils the debutanizer and the deethanizer and also generates low-pressure steam and is finally cooled in an air cooler before it is sent to storage. LP separator vapor phase and stripper reflux drum vapor and liquid streams are routed to Deethanizer via Deethanizer feed drum. Deethanizer bottom combines with Fractionator reflux drum liquid phase to feed Debutanizer. Debutanizer overhead vapor are totally condensed and part is routed back to column and net distillate is pumped as LPG. The purpose of Absorber is to maximize LPG recovery which is achieved by counter flow of cooled naphtha coming from Debutanizer bottom. Absorber overhead vapor go to LP amine absorber from where sweet gas is obtained.

2.7.3 Naphtha Hydro treating Unit (NHT)

Naphtha feed to NHT passes through a surge drum and a charge pump. It is then combined with a H2-rich gas stream from the recycle gas compressor. The combined feed enters the reactor feed/effluent exchanger, where the feed is heated. The heated feed is brought up to the reaction temperature in a feed charge heater. The hot feed down-flows through a fixed-bed reactor where the catalyst reacts with the feed to remove sulphur as H2S, in presence of H2.The reactor effluent is cooled first in the reactor feed/effluent exchanger and then in the product air cooler. Wash water is injected into the reactor effluent upstream of the product air cooler so that any salt buildup in the condenser may be washed out. Reactor effluent flows out of the condenser at a low temperature to ensure complete recovery of naphtha and enters the separator. The separator is provided with a mesh coalescer to ensure complete separation of vapor, hydrocarbon liquid and sour water. Sour water is sent to SWSU, H2-rich vapor is recycled back to the reactor through recycle gas compressor. A H2-rich makeup stream is fed into the recycle stream through a makeup gas compressor. Liquid hydrocarbon from separator is heated by heat exchange with stripper bottoms in stripper feed/bottom exchanger and enters the stripper near its top. A steam reboiler

provides stripper heat duty. Overhead vapor from the stripper pass onto the stripper trim cooler partly condenses and separates into three phases in the stripper receiver. Net overhead gas from the stripper receiver is passed onto the refinery uel gas system after amine treatment to remove all H2S. Sour water from the receiver is sent to SWSU. Hydrocarbon liquid from the receiver is sent back to the stripper as total reflux. Hydro treated sweet naphtha from stripper bottom is cooled in stripper feed/bottom exchanger and then sent to naphtha cracker unit.

2.7.4 LPG treating unit

SR LPG AMINE TREATER

The objective of the LPG Amine Treater Unit is to remove H2S before LPG is sent for mercaptan removal. Sour LPG is routed to LPG Amine Absorber for removal of H2S. Lean Amine from ARU through Lean Amine Booster Pumps. About 70-80% of Lean Amine under flow control is mixed with LPG in online LPG-Lean Amine Mixer. Heat of absorption is removed in LPG-Amine Cooler, where LPG + Amine mixed stream is cooled to 40 Oc and fed to LPG Amine Absorber column. Balance 20-30 % Amine is routed to column top. Sweet LPG from top is routed to Amine Settler Drum. Any carryover of amine with LPG shall settle down in this vessel. From here, LPG is routed to mercaptan removal unit. Rich Amine from Regenerator Column bottom is routed to ARU section under interface level control. An Amine sump is also provided where the amine drain from LPG AAU equipment are collected.

CRACKED LPG AMINE TREATER

For process description, refer above description.

SR + CR LPG MEROX

The objective of the LPG Merox Unit is to remove any residual H2S and mercaptans before LPG product is sent to storage.

H2S Removal

The LPG feedstock from LPG Amine Treater Unit shall enter a batch caustic prewash where LPG is contacted with caustic solution to ensure the complete removal of H2S.

Merox Extraction

Extraction of mercaptans from the LPG into the aqueous phase is completed in a vertical, multi-trayed extraction column using strong sodium hydroxide (NaOH) solution containing a small amount of soluble Merox WS reagent. LPG from the prewash enters near the bottom of the column and regenerated caustic solution is pumped to the top. Each tray comprises a caustic inlet reservoir, a central mixing zone where the up-flowing LPG contacts the cross-flowing caustic and an outlet weir and down-comer to allow the caustic to transfer to the next tray by gravity flow. Treated LPG leaves the top of the column for post-treatment while the caustic now loaded with mercaptide [NaSR] is sent to the caustic regeneration section; the bottom of column serving as a caustic reservoir for the system.

Post Treatment

The Merox-treated LPG goes overhead through a caustic knockout drum to a sand filter which removes any trace of caustic solution before it passes out of the unit to storage.

Caustic Regeneration

The mercaptan-rich caustic solution exits the bottom of the extraction column to the caustic regeneration section through a small steam heater which helps maintain temperature in the oxidiser during cold weather. Air is continuously injected into the caustic stream as it flows upward through the oxidiser and where mercaptans as sodium mercaptide are readily converted to the corresponding disulfides in the presence of the Merox WS reagent. The 3-phase mixture of spent air, disulfide oil and regenerated caustic solution is then routed to a disulfide separator. Spent process air, depleted by about 50% of the oxygen content, is normally diluted with fuel gas and vented to a fired heater convenient to the Merox unit while the disulfide oil is decanted and sent to DHT/storage. The regenerated caustic stream complete with the Merox WS reagent is returned to the extraction column.

2.7.5 Diesel Hydro treating Unit

A blend of straight run and cracked distillate materials are filtered in a feed filter and fed to a surge drum. From this drum, the feed is pumped under flow control and is mixed with make-up/recycle hydrogen streams. The combined feed is then preheated in a reactor feed/effluent exchanger and then brought up to the required reaction temperature in a charge heater. The heated feed is first routed to the HDS reactor that operates down flow, and includes three beds in order to limit the temperature increase inside the reactor. Cold quenches are injected at inter bed sections. The HDS reactor effluent is quenched and sent to the HDT reactor that operates in down flow and has two beds. The HDT reactor effluent is used to exchange heat first with the stripper feed in the stripper feed preheater and then with the reactor feed in the reactor feed/effluent exchanger. Final cooling is achieved first in reactor effluent air condenser and then in trim condenser.

To avoid ammonium salt deposits and the risk of corrosion, wash water is injected at the inlet of reactor effluent air cooler. The wash water is a mixture of recycled water from cold HP separator and stripped water from SWS. Trim cooler effluent is collected in the cold HP separator, which is a V-L-L separator.

The sour water is partly recycled back as wash water, the hydrocarbon liquid is sent to the cold MP separator and the hydrocarbon vapor goes to HP amine absorber knock out drum. At the amine absorber, H2S is removed by amine wash. The sweetened gas is recycled back to the recycle gas compressor at the reaction section inlet. A stream of hydrogen-rich gas from battery limits through makeup gas compressor meets the recycle gas stream. The cold MP separator is also a V-L-L separator. Vapor is sent to the stripper overhead line, sour water withdrawn from the boot is routed to SWS and the hydrocarbon liquid is routed to the stripper.

The stripper is steam stripped to obtain hydro treated diesel with correct flash point. The overhead vapors are partly condensed in an air cooler followed by a trim cooler. The stripper reflux drum is a 3-phase separator. Sour water is sent to SWS, vapor is routed to LP amine absorber and liquid hydrocarbon is partly sent back to the stripper as reflux. The stripper bottom is cooled with stripper feed in a feed/bottom exchanger. It is then cooled in air/trim coolers before being routed to the storage. Net liquid from stripper reflux drum is sent to a stabilizer to remove any hydrogen sulfide and to adjust the butane content in order to minimize the RVP. The stabilizer has a steam reboiler. Vapor from the stabilizer is sent to LP amine absorber. Stabilized naphtha from stabilizer bottom is heat exchanged with stabilizer feed in a feed/bottom exchanger. It is then cooled in air/trim coolers before being routed to the storage.

2.7.6 Fluidised Catalytic Cracking (FCC)

FCC is a fluidized catalytic process for selectively cracking a variety of feed stacks to light olefins. PFCC is similar to conventional FCC in terms of basic process employed but processing conditions are a bit severe. The objective of PFCC is maximization of LPG with higher selectivity towards propylene. LPG yield is typically 30-40 percent and propylene is typically 13-20%. Dry gas produced from this unit is rich in ethylene. Hence, FCC unit provide opportunity for establishing downstream petrochemical units. Propylene is recovered from LPG in downstream PRU and sent to polypropylene unit. There is potential to use the dry gas rich in ethylene for the production of styrene monomer after reacting with benzene to form ethyl benzene. To achieve the higher conversions, unit operates at higher severity with reactor temperature of 555-565 deg C, higher quantity of dispersion steam in the reactor and higher catalyst to oil ratio. The catalyst employed is zeolitic in nature. High ZSM-5 to the extent of ~ 15% is added to achieve the desired conversions and propylene make. Some licensors offer the catalyst impregnated with ZSM-5.

The FCC reactor regenerator system utilizes a reactor/riser, catalyst stripper, 1st stage regeneration vessel, 2nd stage regeneration vessel, catalyst withdrawal well and catalyst transfer lines. Fresh feed, from upstream VGOHDT Bottom, is finely atomized with dispersion steam and injected into the riser through feed injection nozzles over a dense catalyst phase. The small droplets of feed contact the freshly regenerated catalyst and instantly vaporize. The oil molecules mix intimately with the catalyst particles and crack into lighter and more valuable products. As the reaction mixture travels up the riser, the catalyst, steam and hydrocarbon product mixture passes through a riser termination device. This device quickly disengages the catalyst from steam and product vapors. Reactant vapors are then ducted to the top of the reactor near the reactor cyclone inlets, while catalyst is discharged into the stripper through a pair of catalyst dip legs. The vapors with entrained catalyst pass through single-stage high-efficiency cyclones. Reactor products, inerts, steam and a minute amount of catalyst flow into the base of the main fractionators and are separated into various product streams. Below the dense catalyst bed in reactor vessel, a steam ring strips off volatile hydrocarbon material from reacted catalyst particles. Stripped catalyst leaves the reactor vessel through catalyst withdrawal pipes and enters the 1st stage regenerator through a catalyst distributor that disperses the catalyst onto the bed surface. Catalyst and combustion air flows counter currently in the 1st stage regenerator vessel. Partially regenerated catalyst exits near the bottom of the vessel through a hollow stem plug valve. A lift line conveys the catalyst into the 2nd stage regenerator vessel utilizing lift air. CO-rich flue gas from the regenerator vessel exits through two-stage high efficiency cyclones. A mushroom grid evenly distributes the catalyst in 2nd stage regenerator vessel. Any carbon remaining in the catalyst is completely burned off with an excess amount of air in this regeneration stage. This results in high temperatures. Several design features like external cyclones and a catalyst cooler are incorporated to minimize any mechanical and/or physical temperature limitation. Hot regenerated catalyst flows into a withdrawal well, through regenerated catalyst slide valves andinto the "wye" section at the base of riser. Here, it meets the hot feed.

The FCC gas recovery section employs a low pressure drop main fractionator design with warm reflux overhead condensers to condense the large amount of steam used in the convertor. A large wet gas compressor is required relative to FCC operation because of high amount of dry gas and LPG. The absorber and stripper columns, downstream of the wet gas compressor are specifically designed for enhanced C3 recovery at relatively gasoline rates. In addition to the above three products, the product fractionator separates the catalytically cracked material into heavy naphtha, light and heavy cycle oils and catalyst slurry. The heavy cycle oil is recycled back to the reactor. The catalyst slurry contains some lighter hydrocarbon oil, clarified oil, which is subsequently separated and may be recycled back to

either the reactor or to the internal fuel oil pool. The flue gas handling system downstream of the FCC regenerator requires considerations no different than those of as FCC system. It consists of a flue gas slide valve to control the differential pressure between the reactor and regenerator followed by an orifice chamber. Heat is recovered by flue gas cooler in the form of high-pressure superheated steam.

2.7.7 Fuel Gas Treating Unit

The basic purpose of the unit is to remove H2S from fuel gas. Sour fuel gas generated in various units is combined and routed to sour fuel gas knock out drum. Liquid particles in the fuel gas are separated in this drum. From the drum, the gases are routed to the bottom of the fuel gas amine absorber. Lean amine from ARU is introduced on the top the absorber. H2S from the sour gas gets absorbed in to the lean amine. The rich amine flows out under level control to ARU for regeneration. From the top of the absorber, the sweetened fuel gas under absorber pressure control is passed to sweet fuel gas separator, where any amine entrained in the gas is trapped and sweet fuel gas is routed to refinery fuel gas system. Liquid collected in the sweet fuel gas separator is periodically drained to the amine sump. Rich amine from column bottom is routed to ARU for regeneration.

2.7.8 Hydrogen Plant

The feedstock varies from hydrogen containing refinery off-gases over natural gas up to naphtha. Before entering the reformer, the feedstocks have to be desulphurized. Therefore they are preheated in the reformer convection section to desulphurization temperature of about 370 °C. The natural gas contains organic sulphur; therefore hydrogenation using a Co/Mo catalyst is necessary to convert the organic sulphur (mercaptans, thiophenes, etc.) to H2S before desulphurization. Desulphurization of the feed stocks carried out with a zinc oxide bed is needed since Sulphur can poison the reformer catalyst. After purification the feedstock is mixed with process steam to a steam/carbon ratio of 2.5 to 3.5. The feed/steam mixture is further preheated by reformer flue gas up to 650 °C before entering the reformer. The primary reformer contains tubes filled with nickel reforming catalyst. The catalyst converts feed gas at temperatures up to 950 °C and pressures between 20 and 35 bar to an equilibrium mixture of hydrogen, methane and carbon oxides. Most of the carbon monoxide in the reformer product is converted to carbon dioxide and additional hydrogen in the HT-shift reactor. The HT-shift catalyst is based on iron oxide. After cooling and separation of the process condensate, pure hydrogen of 99.9 % or higher purity is recovered by a pressure swing adsorption (PSA) unit. The absorbent being a mixture of activated carbon and zeolites removes all of the contaminants from the hydrogen product in a single step.

The PSA off-gas is utilised to provide the vast majority of the reformer fuel which is balanced by additional fuel in the order of approx. 10 % of total heat release in the reformer. Waste heat is available from two sources of the steam reformer: the heat in the reformer flue gases and the heat in the process gases coming out of the reformer. This heat is used to generate steam, superheat steam, preheat feed/steam mixture and feed, partial evaporation of process condensate and preheat air.

2.7.9 Sour Water Stripper Unit-I

Refinery Sour Water Stripper is designed to treat sour water from CDU, HGU and intermittent sour condensate from SRU & TGTU. The H2S recovered is sent to SRU for reduction to elemental merchant-grade Sulphur. The Ammonia-rich stream is considered to be disposed off by burning in the SRU Ammonia Incinerator. The stripped water from Single Stage SWS is sent to CDU desalter make-up and to ETP for disposal. Sour water from above described units is received from a common line in a sour water surge drum floating on

acid gas flare header back pressure. This surge drum is a three phase (V-L-L) separator. Flashed hydrocarbon vapors are separated and routed to acid gas flare. Oil carryover, if any, is skimmed off from drum and drained to OWS. Sour water from the surge drum is pumped by single stage SWS feed pump to single stage stripper column under surge drum level control cascaded to flow controller through feed/bottom exchanger. The feed/bottom exchanger preheats the sour water feed. The stripper is equipped with a LP steam heated reboiler and a pump around circuit consisting of recirculating pumps and air cooler. Column overhead temperature is controlled by varying flow through air cooler/by-pass in pump around circuit using a three-way control valve.

Column overhead pressure is controlled by controlling flow of sour gas (NH3+H2S) to SRU. This sour gas can also be routed to acid gas flare when SRU is under maintenance. The sour gas line to SRU should be steam jacketed. The steam flow to reboiler is controlled by a flow ratio controller that resets steam flow in accordance with sour water feed to column. Stripped water containing NH3 and H2S less than 50 wt.ppm each is pumped by stripped water pumps under level control. It is cooled in feed/bottom exchanger, before routing to CDU desalter. A water-cooled exchanger, which is designed to cool the stripped water to 40 ^{o}C if the water is to be sent to the WWTP. In order to prevent evolution of H2S/NH3 while draining sour water to an open sewer, a closed blow down drum (CBD) system is envisaged. The CBD system consists of a CBD drum and a CBD pump. The CBD drum is connected to the acid gas flare in order to route all H2S/NH3 rich vapors that may evolve during equipment draining to flare. Provision is kept for pumping all the drain liquid collected in CBD drum back to sour water surge drum for stripping.

2.7.10 Sour Water Stripper Unit - II

Hydroprocessing Sour Water Stripper Unit-II is designed to treat sour water from VGO HDT, DHDT and NHT. The stripped water from two stage stripper is sent separately to, VGO HDT, DHDT and NHT or to ETP. Hot Sour water from VGO HDT, DHDT and NHT is mixed with ammonia rich recycle (to keep H2S in solution & for constructive recovery), cooled in a water cooler to 37 0C, and received in a surge drum, a three phase (V-L-L) separator. Any hydrocarbon that flashes is separated out and joins ammonia stripper overhead line to be routed to incinerator. The entrained oil, if any, is skimmed off from drum and drained to OWS. The sour water is sent to sour water storage tanks under level control. The day tanks and stripper feed pumps are normally located behind SRU ammonia incinerator vent stack. The sour water day tanks serve the following urposes: A floating skimmer (with swivel joints and steam traced “try” lines are provided to skim off separated oil. The tanks are blanketed with nitrogen to keep off air/oxygen. The tanks release vapors containing H2S, ammonia (during out breathing if ammonia rich recycle stream is not available) through a fisher assembly to join SRU ammonia incinerator vent stack to release these vapors at safe height. The sour water from tanks is pumped by to the 1st stage H2S stripper column under flow control through feed/bottom exchanger where the incoming sour water feed is preheated against 2nd stage bottoms, i.e., stripper water. The feed enters the column feed tray. A slip stripped water stream quantity is taken from the inlet of feed/bottom exchanger and sent as hot wash water under flow control to the 1st stage stripper column. The temperature of this wash stream is very important for column steady performance. H2S stripper is equipped with MP steam heated kettle reboiler to provide the reboiling duty required. This column normally operates at a top pressure of 7.0 Kg/Cm2g and pressure is controlled by PIC in overhead vapour line. The stripping section removes most of the H2S coming in sour water feed. The overhead wash section condenses most of the steam and almost pure H2S is produced at the column top. This H2S gas is routed to SRU for Sulphur Recovery, in a steam traced line.

The MP steam flows to reboiler. Condensate withdrawal scheme are same as the single stage stripper column. MP condensate is routed to SRU condensate handling system. The

sour water from the H2S stripper bottom, containing almost all ammonia and small quantity of unrecovered H2S, is fed to second stage ammonia stripper column under level control. The ammonia stripper overhead is floating with the SRU ammonia incinerator header back pressure. The sour water is fed at the 2nd stage stripper feed tray.. Alternate feed tray is also provided for operational flexibility. The section below feed tray is stripping section with two pass trays. The required reboiling duty for this column is supplied by the LP steam heated kettle reboiler, LP steam flow/condensate withdrawal control scheme s similar to the other two columns. The FRC cascading is with sour water feed to H2S stripper to maintain a constant rate of steam to sour water feed. This ratio should be sufficient to bring down ammonia content below 50 ppmw in stripped water from column bottoms. LP condensate is routed to SRU condensate handling facility. The overhead pump-around circuit consists of circulating reflux pumps and circulating reflux air cooler. The pump takes suction from chimney tray and circulates at a constant rate under flow control (cascaded with column top temp.). This circulating reflux is fed at the column top. The ammonia (with small H2S quantity) coming out from column top is routed to SRU ammonia incinerator through a steam jacketed line. An ammonia-rich slip stream from pump-around circuit (before air cooler), under flow control, serves as recycle stream to be mixed in hot sour water feed, before feed mix cooler, during normal operation.

2.7.11 Sulfur Recovery Unit (With Tail Gas Treatment Unit)

Feed to SRU comprises of acid gas from ARU and sour gas from SWSU. Acid gas from ARU passes through acid gas knock out drum, to remove any liquid carryover, before feeding to main burner. Similarly, any liquid carryover in sour gas from SWSU is removed in sour gas knock out drum. The air to main burner is supplied by an air blower, which also supplies air to Super Claus stage and sulfur degassing. The air to the main burner is exactly sufficient to accomplish the complete oxidation of all hydrocarbons and ammonia present in the feed gas and to burn as much H2S as required to obtain desired concentration. The heat generated in the main burner is removed in the waste heat boiler by generating steam. Then the process gas is introduced into the first condenser in which it is cooled, sulfur vapor condensed and is separated from gas. Upstream of 1st Claus reactor, the process stream from waste heat boiler is heated in 1st steam reheater to obtain optimum temperature for the catalytic conversion. The effluent gases from 1st reactor passes onto 2nd sulfur condenser where sulfur vapor is condensed and uncondensed process gases pass to the 2nd steam reheater. Heated vapors are again subjected to conversion in the 2nd Claus reactor followed by cooling in the 3rd sulfur condenser. Then the process gas passes to the 3rd steam reheater and the 3rd Claus reactor. To obtain a high sulfur recovery the process gas is passed to the 4th and last catalytic stage indicated as the Super Claus stage. The process gas is heated in the 4th steam reheater, and mixed with preheated air. Proper mixing is achieved in a static mixer. In Super Claus stage, H2S is selectively oxidized into sulfur. The gas then passes to the 4th and last condenser. Sulfur condensed in condensers is routed via sulfur locks to sulfur cooler and drained into sulfur degasification vessel. Stripping air is supplied to the spargers located at the bottom side of the vessel. This strips off H2S from liquid sulfur and oxidizes the major part of H2S to sulfur. Air leaving the stripping columns, together with H2S released from sulfur degasification vessel, is routed to TGT Unit

TAIL GAS TREATMENT UNIT

Tail gas enters the hydrogenation reactor preheated at 130^{o}C. H2 reducing gas is mixed with Claus tail gas in the preheat effluent stream via a controller which is reset by the SO2 concentration in the downstream of the hydrogen reactor. The effluent is preheated under temperature controller by an electrical heater. A presulfiding line is provided to activate the TGU catalyst using acid gas from the acid gas KOD. Thus line is not used for normal

operation. The hot preheated effluent passes through the catalyst bed of the hydrogenation reactor where SO2 and other sulfur compounds are converted to H2S.

The reactor inlet temperature should be held reasonably steady to provide stable conditions in the reactor. To avoid excessive outlet temperature, the inlet gas may be controlled at somewhat lower temperature to compensate for more SO2 and/or S in the tail gas feed. However, excessively low reactor inlet temperature will result in poor conversion. The SO2 monitor at the reactor effluent is observed to maintain an excess of ~3% H2. In addition, if the circulating water in the quench loop shows the presence of finally divided sulfur this indicated incomplete reaction and the SO2 has reached the column to form sulfur via the Claus reaction:

$$2H2S + SO2 = 3S + 2H2O$$

This behavior should be monitored as the presence of the sulfur not only means the reaction is incomplete but the column can be plugged. Monitoring the pH of the quench water provides a pre-warning to an impending problem. The pH should be maintained near 7.0. Hot reactor exit gas must be cooled before entering the absorber. A first stage gas cooling is accomplished by generating steam at the TGU waste Heat Boiler, decreasing the process gas temperature. BFW is fed to the shell side of the TGUWHB on level control and low pressure steam is generated. When the steam flow and/or BFW flow rate changes, the water level in the steam generator vary. Rising level in the generator indicated that the BFW flow rate is exceeding the rate of steam generation. In this case, signal to the level control valve will decrease. If the steam generation exceeds the BFW rate, level will decrease. In this case, signal to the level control will increase. The process gas enters to the quench column.

The quench water recirculating loop consists of the quench water pump, filter and water cooler. The cooler remove the heat from the column, cooling the inlet gas. The water flow to the top of the column is controlled after being filtered by quench water filter. Decreasing the water flow rate will increase the bottom temperature. Increasing the water rate will increase the load in the quench water circulation pumps and flow through the quench water cooler and column. The quench column recirculation system has the provision to adjust the pH by addition of ammonia to the column recirculation line. The pH of the quench water to the water pump is monitored and kept at a value between 7 and 9 in an effort to prevent corrosion and inhibit colloidal sulfur formation. The water system should be visually inspected for cloudiness. Low pH will indicate incomplete reduction of sulfur compounds. Sour water condense from the inlet feed is removed from the quench water loop via a level controller from the quench column and is sent offsite to sour water storage. The rate depends on the water in the Claus tail gas, water produced in the hydrogenation reactor and the amount of water overhead in the quench column. The overhead line from the quench column flows to the absorber. The absorber is a packed column and is designed to absorb practically all the H2S in the recirculating Amine solvent. The absorber over head is routed to the incinerator. The absorber bottom liquid is pumped by the rich solvent pump to common amine regenerator section. The purpose of the incinerator system is to oxides all the sulfur compounds in the tail gas to SO2 and to vent the oxidized stream at high temperature and at a high elevation.

The incinerator system include two primary sections:

- In the incinerator burner, fuel gas is burned with excess air to a temperature over 1650oC. The temperature is sufficient to heat the tail gas from TGU to ~768oC. This temperature is sufficient to oxidize the residual H2S and sulfur compound, while minimize NOx and SO3 formation.

- The effluent is discharged to the incinerator stack. The stack height of 60 meters is set to ensure dispersion of SO2 and to meet ground level concentration limits. Effluent tail gas from the TGU absorber is thermally oxidized with air to convert reaming sulfur compounds to SO2. Fuel gas and excess air are combusted at high temperature at the incinerator burner. Then it is mixed with the absorber overhead tail gas in the primary oxidation chamber. The fuel gas and air rates are adjusted to control the temperature of the mixed and oxidized tail gas stream. The air is supplied by a dedicated incinerator air blower. Excess air is used to ensure sufficient oxygen is present to oxides the sulfur and other sulfur compound.

The incinerator effluent temperature is measured and used to adjust the flow rate of fuel gas to maintain the desired operating temperature of 768^{o}C. The incinerator is refractory lined with an external thermal shroud to control the shell temperature. Skin thermocouples are provided to monitor the shell temperature. The shell temperature should be maintained between 149 – 350oC. The air blower is designed to provide supply of air and stack while providing a minimum of 2% excess O2 at an operating temperature of 768oC. Ambient air is drawn through the inlet filter to remove solid debris and to protect against water during heavy rainfall. The combustion gas from the burner and combustion chamber flow into the incinerator where adequate residence time is provided for combustion. The incinerator stack vents the effluent to the atmosphere. A SO2/O2 analyzer is provided to determine the SO2 and O2 in the effluent stream.

2.7.12 Amine Regeneration Unit

The function of Amine Regeneration units is to remove the acid gases (H2S and CO2) from the rich amine streams produced in the refinery processing units. Rich amine from various absorber units is received in a flash column. Rich amine is allowed to flash in the column to drive off hydrocarbons. Some H2S also gets liberated. The liberated H2S is again absorbed by a slip stream of lean amine solution making counter current contact with liberated gases over a packed bed. From the flash column, the rich amine is pumped by rich amine pumps under flow control to amine regenerator, after preheating in lean amine/rich amine exchanger. In lean amine/rich amine exchanger, the heat is supplied to rich amine by hot lean amine on shell side from the bottom of amine regenerator under level control. The lean amine from lean amine/rich amine exchanger is further cooled in lean amine cooler and routed to amine storage tank. Another part of lean amine from lean amine cooler is used as slip steam to cartridge filter to remove solid particles picked up amine in the system. It is also used to remove foam causing hydrocarbon substances and thereafter routed to amine storage tank. In amine regeneration column, reflux water enters the column top and descends down. This prevents amine losses into the overhead and ensures complete removal of H2S. The reboiler vapors from the bottom of the tower counter currently contacts the rich amine and strips off H2S. The overhead vapors from regenerator are routed to regenerator overhead condenser, where most of the water vapors condense and are pumped by amine regenerator reflux pumps as reflux to the column. The acid gases are routed to the SRU. In case the pressure goes high, acid gases are released to the acid flare. Reboiler heat by LP steam is supplied to the column through amine regenerator reboiler.

2.7.13 Poly Propylene Unit

Fresh propylene from OSBL is fed through propylene dryer to the reactor along with the required catalyst, co-catalyst, hydrogen and stereo-modifier. For production of two special grades with small ethylene content, ethylene vapor is also fed to the reactor. The polymerization reactors each have a nominal volume of 75 m3 with identical stirrer and drive systems. Polymerization itself is carried out in a gas phase stirred reaction. Heat removal is managed by evaporative cooling. Liquid propylene entering the reactor vaporizes and

thereby removes the exothermic reaction energy. Reaction gas is continuously removed from the top of the reactor and filtered. Reactor overhead vapor ("Recycle Gas") is condensed and pumped back to the reactor as coolant. Non-condensable gases (mainly H2 and N2) in the recycle gas are compressed and also returned to the reactor. The polypropylene product powder is blown out of the reactor under reactor operation pressure. The carrier gas and powder pass into the powder discharge vessel where powder and gas are separated. The carrier gas is routed through a cyclone and filter to remove residual powder, then scrubbed with white oil and sent to compression. Powder from the discharge vessel is routed via rotary feeders to the purge vessels which are operating in parallel. Nitrogen is used to purge the powder off residual monomers. The overhead gas from the purge vessels is sent to a common membrane unit for monomer/nitrogen recovery. As refrigerant for the membrane unit fresh Propylene is used. The recovered nitrogen is sent back to the purge vessels for further use. The condensed monomers from the purge gas are combined with the filtered carrier gas, and then sent to scrubbing and subsequently to carrier gas compression. The PP powder from the purge vessels is pneumatically conveyed by a closed loop nitrogen system to the powder silos. The powder product from these silos is fed to the extruder where polymer powder and additives are mixed, melted, homogenized and extruded through a die plate, which is heated by hot oil. The extruding section is electrically/steam heated. Pelletizing of the final product is carried out in an underwater pelletizer where the extruded polymers - after passing the die plate - are cut by a set of rotating knives. The polymer/ water slurry is transported to a centrifugal dryer where polymer and water are separated. Water is recycled to a pellet water tank, for which demineralized water is used as make-up. The cooled pellets (~60°C) are pneumatically conveyed to the pellet blending silos by an air conveying system. After homogenization in the blending silos the pellets are conveyed to the bagging and palletizing system.

2.7.14 Propylene Recovery Unit (POLYMER GRADE)

The Feed to the PRU consists of LPG from upstream FCC and DCU Via Unsat LPG treating unit. The feed is first sent to a Depropanizer to recover a C3-rich cut from the LPG. The Depropanizer bottom is routed to the refinery LPG pool. The Depropanizer overhead is further processed in a Deethanizer to remove the fuel gas components. The Deethanizer overhead is routed to the refinery fuel gas system. The Deethanizer bottom is routed to downstream Propane/Propylene Splitter (PP Splitter). Because of a very low difference between the boiling points of propane & propylene, to recover polymer grade propylene from C3-stream; i.e., propylene purity > 99 wt%, the PP Splitter requires a very high reflux ratio with around 210 trays. Due to engineering limitations of maximum column height, the Splitter is configured as a two-column system. The PP Splitter fractionates propane & propylene; propane is sent from the bottom of the second column to refinery LPG pool. Propylene is taken as the first column overhead and sent to downstream for further processing. For a high LPG throughput with sufficiently large propylene content, the use of conventional condenser & reboiler system is uneconomical due to very high LP steam consumption and a consequently large cooling duty. Therefore, for these systems, a heat pump compressor functions as both the reboiler & the condenser. This reduces the overall equipment count and significantly lowers the fractionation pressure. Propylene is further processed to remove carbonyl sulfide (COS). After drying in an adsorbent chamber, the recovered propylene is treated to remove trace amounts of metal poisons. The purified propylene is then routed to storage.

2.7.15 Dual Feed Cracker Unit

LPG, Hydro treated Light Naphtha & Heavy Naphtha and off gases from FCC and DCU are used as feed for Naphtha cracker unit. Ethylene produced from cracker unit is sent to

LLDPE/HDPE Swing unit while propylene is sent to Polypropylene Unit for production of Polymers.

Feed, Cracking, Quench

Ethane rich and C3+ streams are supplied from the C2+ recovery unit to the GCU. Naphtha is supplied to the GCU from OSBL storage via pumps. Ethane rich feed is preheated against waste process heat and introduced into the cracking furnaces. The C3+ stream is vaporized and superheated prior to being introduced into the cracking furnaces. The naphtha feed is preheated against waste process heat and introduced into the cracking furnaces. Recycle ethane is mixed with the ethane rich fresh feed for cracking in the furnaces. Recycle C3 stream containing propane only is in a gaseous state and it is mixed with the C3+ fresh feed for superheating. The primary process step in producing olefins from hydrocarbon feeds is thermal cracking, usually referred to as pyrolysis. This process converts the feed to lower molecular weight hydrocarbons at relatively high temperature and low pressure. The cracking reactions take place in furnace coils to which dilution steam is added. Steam reduces the hydrocarbon partial pressure to promote the production of olefins and minimize the rate of coke deposition. Furnace coil operating conditions of temperature, residence time and hydrocarbon partial pressure will be selected to optimize olefin yields during the detailed design phase.

Periodic decoking is required to remove coke which accumulates gradually in the radiant coils and quench exchangers. The furnaces will be steam/air decoked when the tube metal temperature approaches its design limit. After several steam/air decoke cycles, fouling in the SLEs will require a cold shutdown to hydro blast the exchangers.

Effluent gas from the furnaces is rapidly quenched in quench exchangers by generating steam. Rapid cooling is necessary to avoid secondary reactions, which convert valuable products to heavier materials that tend to cause fouling in the exchangers. The steam generation pressure is set so that the tube wall temperature is high enough to prevent condensation of hydrocarbon in the SLEs. Steam generated in the quench exchangers is superheated in the cracking furnace convection sections and used in the turbine driver for the cracked gas compressor.

Furnace effluent gas is cooled further by direct contact with circulating quench oil and fractionated in a quench oil tower to remove the heavy fraction. This quench oil slip stream is stripped to control flash point and sent to storage as fuel oil product. Heat removed from the cracked gas by the quench oil is used to preheat naphtha feed, superheat gas feed, heat water stripper feed, and reboil the distillate stripper.

Overhead from the quench oil tower enters the quench water tower. Most of the dilution steam condenses in this tower, along with a portion of the gasoline fraction. Cooling is achieved by a circulating quench water system which is used as heating medium for deethanizer reboiler and additionally the propylene tower reboiler. Quench water is separated from hydrocarbon in the main compartment of the water quench tower and recycled through the exchangers and water coolers back to the tower. Hydrocarbon liquid is returned to quench oil tower as reflux.
The net process water condensate is pumped through a filter and coalescer to remove solids and free oil, and is then preheated, stripped and delivered to the dilution steam generator, where steam is generated by exchange with MP steam. Blow down from the dilution steam drum is cooled and delivered to battery limits for further treatment. With this system, dilution steam is generated in a closed loop, thereby reducing the quantity of feed water makeup and oily waste water from the plant.

Compression, Caustic Washing and Drying

Five total stages of compression are used. Cracked gas from the quench water tower is first compressed in four stages of the cracked gas compressor. Hydrocarbon condensate from the first four stages is fed to the distillate stripper which also receives hydrocarbon from the water quench tower. The stripped gasoline is pumped to OSBL.

Acid gases (H2S and CO2) produced in the cracking furnaces are removed from the cracked gas in a caustic wash tower. This column contains two caustic circulating sections followed by a water wash section to prevent caustic entrainment. Makeup caustic is diluted before injection. Spent caustic is deoiled using gasoline, degassed and pumped to the battery limits for treatment. Removal of acid gas at this point in the process allows all of the C4 and lighter hydrocarbons to be desulfurized together, eliminating the necessity to clean individual product streams.

Overhead gas from the caustic tower is cooled with propylene refrigerant, and the uncondensed portion goes forward to cracked gas dehydrators. The condensate is pumped forward to the HP depropanizer via the liquid dryer unit. Essentially, complete removal of water is necessary to prevent freeze-ups in subsequent low temperature equipment.

Depropanizers and Acetylene Removal

The dried gases are cooled and fed to the HP depropanizer, which separates the feed into an overhead vapor essentially free of C4 and heavier material and a bottoms product essentially free of C2 and lighter material. Tower overhead vapor is compressed in the fifth stage of the cracked gas compressor. Net bottom flows to the LP depropanizer.

If improperly operated, the depropanizers are subject to polymerization-type fouling, and it is necessary to keep temperatures and liquid holdup to a minimum in the stripping section. An inhibitor is added to the HP tower feed to reduce the likelihood of polymerization.

The LP depropanizer produces a raw C3 liquid distillate (containing propylene and propane) which is sent to C3 hydrogenation. The LP depropanizer produces a bottoms C4+ stream which is fed to the depentanizer.

Gas from the fifth stage of the cracked gas compressor is catalytically hydrogenated to remove acetylene. The reactor feed gas may either be cooled or heated, depending on the age and activity of the catalyst. Catalyst life is expected to be at least three years between regenerations. Three catalyst beds are used, with intercooling between beds to limit the temperature rise per bed. Essentially, all acetylene is converted to ethylene and ethane. Some of the methyl acetylene and propadiene is converted to propylene.

A spare reactor is not required because on-line regeneration is not required. Since the feed to the reactor contains an excess of hydrogen, make-up hydrogen is not required. Because of the high partial pressure of hydrogen, reactor operating temperature is lower and space velocity is much higher than in a back end acetylene converter. Green oil formation is very low, and most of the polymer that does form is returned to the HP depropanizer in the reflux stream. Effluent from the reactor is cooled and dried in a secondary dryer to remove any trace quantities of water.

Dried gas is cooled and partially condensed to provide reflux for the HP depropanizer. Net HP depropanizer overhead vapor goes forward to the demethanizer prefractionator feed chillers while net overhead liquid flows directly to the demethanizer prefractionator.

Cold Fractionation - Demethanizer System

HP depropanizer overhead vapor product is chilled by exchange with ethane recycle and successively colder levels of propylene and ethylene refrigeration. Liquids separated in the chilling train are fed to appropriate trays in the demethanizer prefractionator and demethanizer, according to composition.

The demethanizer prefractionator receives three feeds: liquid from the HP depropanizer reflux drum, liquid fractionated from the cracked gas in the demethanizer prefractionator feed drum and liquid condensed from the cracked gas in dephlegmator number 1. The prefractionator separates C3 and heavier material from C2 and lighter. The overhead vapor from the prefractionator, which contains essentially no C3 material, is sent to the demethanizer via the demethanizer feed rectifier. The prefractionator bottom is sent to the deethanizer.

The demethanizer makes a sharp separation between methane and ethylene. The tail gas streams are warmed in a series of core exchangers by exchange with demethanizer feed and propylene refrigerant liquid. Demethanizer reboiler heat is supplied by condensing propylene refrigerant vapor. The demethanizers, dephlegmators and core exchangers achieve the low temperature separation required at minimum energy cost and with very small loss of ethylene to tail gas streams.

The final cooling produces a crude hydrogen stream, which is reheated in the cold box exchangers and delivered to the PSA Unit.

Cold Fractionation - Deethanizer and C2 Splitter Systems

The deethanizer separates the demethanizer prefractionator bottoms into C2's and C3's. The net overhead, consisting principally of ethylene and ethane, is taken as a liquid to a C2 splitter, while the net bottom is fed to C3 hydrogenation. The reboiler is heated by quench water and the condenser heat is removed by propylene refrigerant.

The C2 splitter is a single tower operated at low pressure and temperature. Two Feeds enter the tower; an ethylene rich vapor stream from the demethanizer and the overhead liquid product from the deethanizer.

The C2 splitter operates with the C2 refrigeration compressor as a heat pump system. The overhead vapor from the tower is compressed, entering the third stage of the compressor. There are intermediate and bottom reboilers, heated by condensing ethylene refrigerant from the third and fourth stages of the ethylene refrigeration compressor, respectively.

The C2 splitter makes a sharp separation between ethylene and ethane. The ethylene product is pumped to high pressure, heated, and delivered to battery limit as a vapor product. If required, approximately 70 percent of the nameplate ethylene production can be sub cooled and sent out entirely as a liquid product. Ethane bottom from the splitter is pumped and vaporized by exchange with demethanizer feed, and recycled to the cracking furnaces.

Hot Fractionation - C3 Hydrogenation and C3 Splitter and Depentanizer Systems

Raw C3's from the deethanizer bottom and LP depropanizer overhead are catalytically hydrogenated to remove methyl acetylene and propadiene. The hydrogenation process is a mixed-phase process licensed by IFP. Methyl acetylene and propadiene are converted to

propylene. Hydrogen required for the reaction is supplied from the PSA unit. Refer to the IFP manual for more details about the process.

Hydrogenated C3's are pumped to the C3 splitter, which consists of two towers: a stripper and a rectifier. The overhead from the stripper is fed to the rectifier. Light ends, a result of the hydrogenation reaction, are removed in the pasteurizing section of the rectifier. Propylene is condensed and returned as reflux. Reflux for the stripper is obtained from the bottom of the rectifier. The stripper is reboiled by circulating quench oil and quench water. The rectifier overhead is condensed by cooling water.

The polymer grade propylene product is taken off as a liquid side draw. A propane rich stream is removed as a vapor product from a location two trays above the bottom of the stripper to be recycle cracked in the furnaces. The net bottom liquid is recycled back to the LP depropanizer to remove any green oil produced in the C3 hydrogenation unit.

The depentanizer receives a liquid feed from the LP depropanizer bottom. A separation is made between C4's / C5's and C6's. The overhead is condensed against cooling water. LP steam provides reboiler heat. The net overhead product is sent to the C4 /C5 hydrogenation unit and the bottom is combined with the distillate stripper bottom, cooled and sent to OSB as C6+ liquid product.

Hot Fractionation - C4/C5 Hydrogenation Unit

The C4/C5 hydrogenation unit selectively converts C5 diolefins to C5 mono olefins using hydrogen from the PSA unit. When C5 diolefins are converted to C5 olefins, C4 diolefins and C4 olefins hydrogenate to C4 saturates which is beneficial for producing ethylene in furnaces when the stream is recycle cracked. The unit consists of a single fixed-bed catalytic reaction system designed by IFP. The C4/C5 product stream is recycle cracked in the cracking furnaces.

Refrigeration

The ethylene and propylene refrigeration systems supply refrigeration at the following levels:

Ethylene	-101 degC, -83 degC, -61 degC
Propylene	-40 degC, -21 degC, -7 degC, +7 degC

Vapor from the ethylene compressor is desuperheated and condensed by exchange with all levels of propylene refrigerant and the C2 splitter reboiler. Vapor from the propylene compressor is desuperheated and condensed by exchange with cooling water.

LLDPE/HDPE Swing Unit

Catalyst preparation

Ziegler Catalyst High activity Ziegler catalyst is used for the production of narrow molecular weight distribution products. This catalyst is supplied ready-to-use by BP.

Polymerisation:
The reactor is designed to ensure good mixing and a uniform temperature within the fluidised bed. Polymer particles grow within the fluidised bed over a residence time of several hours. Operating conditions within the reactor are mild. The reactor is made from carbon steel and has three main sections:

A bottom section with a gas distributor to ensure homogeneous fluidisation.

- A cylindrical section containing the fluidised bed and equipped with catalyst injection and polymer withdrawal facilities.
- A conical bulb top section where gas velocity reduces, returning entrained polymer powder particles to the fluidised bed.

The gas leaving the reactor contains unreacted monomer, co monomers, hydrogen And inerts (primarily nitrogen and ethane). Conversion of monomers per pass is proximately 3%. Any fine particles leaving the reactor with the exit gas are collected by cyclones and recycled to the reactor. This greatly reduces fouling in the reactor loop and also prevents product contamination caused by particles formed in the loop, which may have different properties to the target grade. This is one of the reasons why the Innovene process makes such consistently high quality, gel-free products.

The gas then enters the first heat exchanger where the heat of polymerisation is removed before passing to the Enhanced High Productivity Separator. This specially designed vessel separates the condensed liquid, typically up to 15% by weight of the stream, from the loop gas, which is fed to the main fluidisation gas compressor. This provides the volumetric flow necessary to achieve the required fluidization velocity in the reactor. The separated liquid is then pumped into the reactor via proprietary liquid injection nozzles into the heat of the fluidised bed.

In the reactor, pressure and gas composition are controlled continuously by varying the flow of feedstock into the reaction loop. The relative proportions of the feedstock are adjusted to meet the specification of the required polymer product. This is achieved using on-line analysers for hydrogen, ethylene and co monomers. A purge is provided to prevent accumulation of inerts.

Polymer Withdrawal and Degassing

The polymer powder is withdrawn from the reactor by simple, robust proprietary lateral discharge system and passed on to the primary degasser, where a part of the gas is flashed off, filtered and recycled to the main loop via the recycle compressor.

The polymer powder is transferred to the secondary degasser, where most part of the residual hydrocarbon is removed and separated in the cryogenic Vent Recovery Unit. The degassed powder collected in the secondary degasser passes to a purge column, where trace hydrocarbons are removed and any residual catalyst activity is killed. Powder is then transferred to the extruder via an intermediate surge bin, mounted directly above the extruder, which allows for routine extruder maintenance.

Grade Changes

On-line DCS transition control ensures consistently rapid and reliable grade changes. Changes of grade are made quickly and easily, with the minimum loss of throughput and the minimum generation of wide-specification product.

Finishing: Product Blending and Extrusion (Pelletising)

Polyethylene powder is transferred pneumatically to the product powder silo. Powder master batch incorporating additives is prepared in mixers or may alternatively be supplied in flexible intermediate bulk containers. The additives are commercially available but the formulations, which are part of Innovene technology, will be disclosed when a licence agreement has been

signed. Virgin powder and additives are weigh-fed into the extruder. Pellets are extruded under water and are then dried before being conveyed by air to storage. The pellets conveyed from the pelletising section are homogenised in static homogenization silos. After homogenisation, the pellets are transferred to storage silos.

2.7.16 Pyrolysis Gasoline HDT Unit

The raw pyrolysis gasoline obtained from cracker and FCC C6 De-hexaniser contains diolefins, olefins and paraffins. The gum-forming di-olefins need to be eliminated to make the pyrolysis gasoline stable before it is used for gasoline pool. This is achieved by hydro treating the raw pyrolysis gasoline in single stage. The raw pyrolysis gasoline including the recycled wash-oil is fed to feed surge drum after being mixed with the C4/C5 heavies and the C4 acetylenics through static mixer. Free water, if any, can be purged from feed surge drum boots. The feed pump raises the feed pressure up to the reaction section pressure. Flow controlled feed is mixed with H2 make-up, and with liquid diluents. The role of dilution is to lower the feed reactivity and thus to allow a smooth control of temperature elevation in reactor first catalyst bed. The mixed streams are then charged to the reactor after heating through reactor feed/effluent heat exchanger, reactor inlet temperature is controlled by by-passing part of the reactor effluent around reactor feed/effluent heat exchanger. During start-up periods, the temperature is controlled by means of the steam preheater. The reactions (diolefins and alkenyl aromatics hydrogenation) occur in mixed phase (mainly liquid) in a fixed bed type reactor. The catalyst is divided into two beds.

The overall temperature profile through the reactor is controlled by dilution of feed and by the injection of quench under temperature flow control cascade (TC at the inlet of second bed). Reactor effluent, partly cooled through reactor feed/effluent heat exchanger, is flashed into separator. Part of the liquid is recycled and cooled down as quench or dilution through quench pump, quench cooler and quench trim cooler. The remaining is sent under level flow control cascade to stabilizer. Separator vapor phase is cooled down through separator vapor condenser whose boot liquid is sent back to separator.

Distillation Section

Stabilizer's purpose is to stabilize the reactor product by eliminating the light components which have been dissolved under high pressure in separator. The overhead vapors of stabilizer are condensed in stabilizer overhead condenser. Stabilizer reflux drum vapor phase is purged to OSBL under column pressure control. Stabilizer reflux drum liquid is pumped by Stabilizer reflux pump as external reflux under flow control reset by level control. Gasoline, the bottom product of the stabiliser column is sent to gasoline storage for sale.

2.7.17 FCC Gasoline HDT/FCC DEPENTANIZER, C5 Saturation and Sweetening

FCC DEPENTANIZER, C5 Saturation and Sweetening

FCC unit shall have an installed Depentanizer splitting C5and C6s,C5s will be saturated in a small saturation Unit for feeding in to Steam Cracker while a portion may be Meroxed for blending in gasoline pool. The feed for this unit is C6 range naphtha produced in FCC unit. The objective of this unit is to reduce the sulfur content of the feedstock whilst minimizing the octane number losses. The RFCC gasoline is processed in two steps:

Firstly, the FCC gasoline is processed in a selective hydrogenation unit (SHU), which converts selectively di-olefins into olefin and light mercaptans into heavier sulfur compounds. This step also allows drawing off from the first splitter, a light cut gasoline with a target sulfur content of <100 ppmw.

The second step is a selective hydro-desulfurization unit (HDS Unit), which converts heavy sulfur compounds into H2S and produces the heavy cut gasoline.

Selective Hydrogenation Unit (SHU) Section:

The unit feed is coming directly from upstream RFCC unit which will be routed to SHU reaction section through feed surge drum. The feed is preheated in the SHU feed/effluent exchanger. The hydrogen make-up comes from the source is mixed with the feed under feed flow ratio control and the resulting mixture is heated to meet the required reactor inlet conditions. The SHU reactors are two identical down flow single bed reactors. Both reactors are designed to operate in the lead/trail position or in a single reactor configuration to enable on-line catalyst replacement. The reactor effluent is cooled down and partially condensed before entering splitter. The purpose of the splitter is to separate SHU reactors effluent to produce light (LCN) cut naphtha and a heavy cut naphtha (HCN). Splitter overhead LCN is routed to rundown product storage and splitter bottom HCN is pumped to hydrodesulphurization (HDS) section.

Hydrodesulphurization (HDS) section:

The HDS hydrocarbon liquid feed is combined with the recycled hydrogen rich gas coming from the recycle gas compressors and is pre-heated and completely vaporized in the HDS feed/effluent exchangers before entering in HDS reactors. The HDS reactors are operates in down flow mode and in total vapor mode. The effluent from the reactor is cooled in the HDS feed/effluent exchangers and finally in HDS effluent air condenser. The liquid hydrocarbon phase is routed to the stabilizer and the vapor hydrocarbon phase is routed to recycle gas compression section after amine treatment of recycle gas. The stabilizer bottoms product is cooled in the stabilizer feed/bottom exchangers and mixed with LCN stream from splitter. The combined product is cooled down in the air cooler followed by trim cooler before routing it to storage.

2.7.18 Delayed Coker Unit (DCU)

The Delayed Coking Unit processes vacuum residuum oil. It uses a thermal cracking process to produce lighter liquid products and solid coke. The Delayed Coking Unit uses a semi-continuous process and employs two parallel coke drums. These coke drums are alternately switched on-line and off-line after filling with coke.

The primary feed material for the Delayed Coking Unit is vacuum residuum, which is the Vacuum Crude Distillation Column bottoms product. The feed material enters the bottom of the coker main fractionator where it mixes with condensed recycle material in the column. The combined stream is heated in one of the gas- fired coker charge heaters to initiate coke formation in the corresponding coke drum. Coke drum overhead vapor, the product of the thermal cracking reactions during coking, flows back to the coker main fractionator. This column separates the coke drum overhead vapor into various light hydrocarbon constituents to be returned to other refinery process units. These include coker naphtha, which is sent to the Naphtha Hydrotreater Unit for further processing into gasoline blendstocks; light coker gas oil, which is sent to the Distillate Hydrotreater Unit for further processing into jet and diesel blendstocks; and heavy coker gas oil, which is sent to the Hydrocracker Unit for conversion and upgrade to additional gasoline and distillate fuel products. Sour water is sent to the sour water collection system. The vapor recovery section separates the combined vapor and liquid overhead product from the coker fractionator into fuel gas LPG and naphtha. The wet gases from fractionator are compressed in wet gas compressor. The gases from this section enter the primary absorber. In this section LPG is absorbed from gases. Primary

absorber over head vapors flow to sponge absorber where lean sponge oil is fed to absorb a LPG and also reduce the loss of naphtha in fuel gas. The fuel gas from sponge oil absorber top is routed to Gas plant for further amine treatment.

The hydrocarbon liquid from wet gas compressor flows as feed to the stripper column lower. In this section ethane and lighter components are strip from LPG and Naphtha. Stripper bottoms flow under its own pressure to debutaniser column. The LPG from debutaniser top is further cooled and is routed to the gas concentration plant. Debutanizer bottom i.e. coker naphtha is pumped to offsities after cooling by air cooler followed by trim cooler. The coker naphtha is routed to Naphtha hydrotreating unit for further processing.

After coking reactions are complete, the full coke drum is switched off-line and is steamed out and cooled. (The other coke drum is brought on-line and the coking process continues in that reactor train.) Vapors emitted from the opened coke drum are captured by the enclosed blow down system and are recovered in the main fractionator. When cool, the coke drum bottom and top heads are removed. The coke is cut from the drum with a water jet and dropped into the Coke Pit.

Petroleum Coke Storage, Handling, and Loading

Petroleum coke from the Delayed Coking Unit is dropped into the Coke Pit where free water is separated from the coke and recycled. A bridge crane is used to transfer the moist coke from the Coke Pit to the Coke Pad, where it is stored in piles for further dewatering. A bridge crane is also used to transfer coke from the Coke

Pad to the Coke Crusher. The crushed, moist coke is then transferred via an enclosed belt conveyor to the Coke Silos. Coke from the Delayed Coking Unit is transferred via an enclosed belt conveyor to the Coke Loading Facility. This facility includes coke storage silos and loaders. The Petcoke generated from DCU shall be entirely consumed in the CFBC unit for Raj + Arab Mix Case. However, a small quantity of Petcoke (~33 KTPA) shall be available for sales when processing 100% AM Crude. This coke is proposed to be dispatched via road. Coke Handling Coke handling system shall be selected in a way to minimize emission of particulate matters including measures to reduce fugitive emissions. The coke that emerges from drum is saturated with water (>15% moisture) and eventually dries out during the time in coke pit, crushing and conveying.

By the time coke is loaded its moisture content is in the range of 2-8 wt%. Low Moisture content of the coke is the reason for more dust is emission at the tail end of coke handling system. Most dust emission system are more effective when applied at tail end of coke handling and it’s no surprise that water sprays are often utilized for maintaining moisture in coke piles. Enclosed storage is usually cost prohibitive depending on the amount of storage desired ,alternatively fences or partial wall in wind direction are yet another inexpensive and very effective dust mitigation measures. The loading area is yet another location accounting for most of the fugitive /dust emissions, these situations can be dealt with a number of loading chutes that can be specified to mitigate dust emissions.

For HPCL, use of a pit/pad with a bridge crane system for ISBL coke handling is recommended. The same can be finalized with technology licensor during process design stage. The pit will slope to one end near the coke drums, where the water will enter a maze for solid-liquid separation. The pit normally provides approximately 2-3 days of coke storage and the pad is located adjacent to coke storage. Inside the Pit/pad the green coke will be moved with the aid of a bridge crane and fed to feed hopper above a crusher. After sizing by crusher, the green coke will be moved out with an ISBL conveying belt.

2.7.19 Recovery PSA Unit

Hydrogen rich refinery gases from hydro processing units like DHDT, VGO HDT,NHT etc. are fed to PSA unit to recover high purity hydrogen. The PSA unit , consists of a prefabricated valve and piping skid, adsorber vessels, molecular sieve type adsorbent, control panel, instrumentation, and a tail gas surge tank. The unit is designed to permit outdoor unattended operation. It employs a pressure swing adsorption (PSA) process to purify the crude hydrogen stream supplied from the demethanizer system. The portion of the residue gas which feeds the PSA unit is heated to near ambient temperature in the PSA feed heater, a coil in the propylene refrigerant surge drum.

In order to obtain the pressure necessary to send hydrogen to various hydrogenation units, hydrogen compressors are to be used. The PSA process utilizes multiple beds to provide a continuous and constant hydrogen product flow. The adsorbers operate on an alternating cycle of adsorption and regeneration, with adequate beds always available for service. The unit produces a high purity hydrogen stream which fulfills both the export requirements and the in-plant needs. The hydrogen stream will have a minimum composition of 99.99 mole percent hydrogen. The balance and major portion of the feed gas is purged to the fuel gas system after recovery of desired quantity of hydrogen.

2.7.20 BTX Fractionation Unit

In the petroleum refining and petrochemical industries, the acronym BTX refers to mixtures of benzene, toluene, and the three xylene isomers, all of which are aromatic hydrocarbons. The xylene isomers are distinguished by the designations ortho, Meta, and para. Industrially, Benzene, toluene, and xylene can be made by two major processes Catalytic Reforming Steam Cracking In general, pyrolysis gasoline tends to be richer in total BTX than reformate, although an overlap occurs under extreme conditions. Production process utilized for the current configuration is vide steam cracking.

Process Description

Production process for producing BTX aromatics involves the steam cracking of hydrocarbons which typically produces a cracked naphtha product commonly referred to as pyrolysis gasoline, pyrolysis gas or pygas. The pyrolysis gasoline typically consists of C6 to C8 aromatics, heavier aromatics containing 9 to 11 or 12 carbon atoms, and non-aromatic cyclic hydrocarbons (naphthenes) containing 6 or more carbon atoms. Aromatics Fractionation Units (also called BTX units) are used to separate a mixture of aromatics into pure Benzene, Toluene, and mixed Xylenes. The resulting The typical reformate feed stock stream is rich in aromatics with impurities of light paraffins and light naphtenes (P&N), which are predominantly separated in the dehexanizer. In the benzene column, the benzene and the remaining impurities go overhead while the toluene, mixed xylenes, ethyl benzene, and C9+ aromatics go out the bottom. The overhead enters an absorber/stripper unit to purify the benzene. The remaining P&N enters the benzene recovery column, where any remaining benzene is stripped out before the impurities are sent on to further processing. The bottoms of the benzene column enter an absorber/stripper unit to remove any remaining P&N impurities. The overhead passes to the toluene recovery Column where toluene is stripped out before the impurities are sent onto further processing. The purified stream enters the toluene column to separate the toluene. Main features of distillation section are tabulated below.

Major Process Streams Process Objectives

Dehexanizer bottoms Minimize impurities before getting to the products stream Dehexanizer overhead Reduce benzene loss Benzene column overhead Minimize toluene overhead loss Minimize impurities reaching benzene product Benzene column bottoms Minimize benzene loss to Toluene stream Minimize impurities from toluene product stream

Benzene Extraction Unit

The completely hydrotreated C6-Heart Cut originated from pyrolysis gasoline hydrogenation unit is charged to the 30th tray of the rerun column on flow control, after being preheated in the solvent heated feed preheater. In the rerun column the high boilers (polymers) formed in the upstream hydrogenation unit are removed with the bottom C6+ product, which is routed by pump as a small portion of the feedstock to battery limits, either as hot C6+ cut or as cold C6+ Cut cooled by the C6 Cut Cooler. C6+ product also contains almost all the Toluene from the feedstock and a small amount of Benzene. Therefore the bottom product is fed back to the upstream pyrolysis gasoline separation where the Benzene and Toluene are recovered in the C6-cut distillation column, leading indirectly to no benzene losses in the rerun column. The rerun column operates under vacuum and is equipped with two reboilers. The NMP reboiler is solvent heated and the steam reboiler is heated with LP steam.

The overhead C6 cut after condensing in the water cooled condenser is collected in the reflux drum and then charged to tray 21 of the extractive distillation column on flow control. There, Benzene and non-aromatics are separated in the presence of the selective solvent N-Methylpyrrolidone (NMP), charged to the top of the column. By selectively reducing the velocity of Benzene, the NMP together with the benzene is pushed down to the bottom of the extractive distillation column. The nonaromatics and traces of NMP leave the top of the column as vapor product and are charged to the raffinate column. The extractive distillation Column also operates under vacuum and is equipped with two reboilers, of which NMP reboiler is solvent heated and steam reboiler is heated with MP steam. The raffinate leaving the top of the extractive distillation column still contains little amount of NMP. This NMP is separated from the raffinate in the raffinate column in order to the meet the raffinate specification on NMP. The NMP stream is recycled back to the extractive distillation column via the bottom of the raffinate column.

After condensing in the water-cooled condenser the raffinate is collected in the reflux drum and is sent to battery limits via raffinate pump. The raffinate cooler is designed to lower the temperature of the raffinate to battery limit conditions. The raffinate column also operates under vacuum condition is and is reboiled in the reboiler with MP steam.

The benzene together with the NMP leaves the bottom of the extractive distillation column and is supplied to tray 16 of the benzene stripper on flow control by feed pump. There, benzene and solvent are separated under vacuum condition. At lower pressure and higher bottoms temperature than in the extractive distillation column, here benzene and NMP are separated. The bottom product comprises NMP and about 1% benzene. The overhead benzene product, after condensing in the condenser and collecting in reflux drum leaves the plant as pure product, while the solvent, after heat exchanged in the Reboilers and the solvent cooler is returned to the extractive distillation column. The process configuration ensures maximum heat integration from the hot solvent. The MP steam heated reboilers and the water cooled condenser are attached to the benzene stripper. The column system of the unit is connected to a vacuum system consisting of the liquid ring vacuum pumps and the vacuum drum. The vacuum pumps are operating with solvent from the plant's solvent loop. Hydrocarbon saturated vapors are scrubbed by the pump's liquid ring. Liquid and gas are separated in the vacuum drum. The solvent leaves the vacuum system via NMP pump, the

cleanness as leaves the top of vacuum drum to the off gas separator. A small solvent regeneration consisting of the regeneration reboiler with the condenser and NMP regeneration drum as accumulator. During normal operation of the plant the operating of the regeneration is not necessary. Only in case of contamination of solvent with high boilers from the rerun column or other operation the regeneration system may be needed.

The plant has a closed slop system with NMP slop drum and hydrocarbon slop drum. Solvent containing systems are drained to the NMP slop drum and pumped to the recycle drum by NMP slop pump. From here the solvent is recycled to the plant. The recycle drum also serves as a run-down vessel which can take the entire solvent content of the plant and also as feed drum when during start-up offspec benzene and raffinate are circulated through the plant. The fresh NMP storage drum ensures to have enough NMP stock to be able to compensate plant losses caused by operational failures or mal operation. The NMP is transferred to the solvent recycle by the fresh NMP pump.

2.7.21 Butene-1 Unit

The dimerization reaction is activated by the mixing of two specific catalysts. The first one, named T.E.A, is an alkyl-aluminium compound, the second one, named LC 2253 (AXENS proprietary catalyst) is made of a titanium compound and a promotor. Both catalysts are separately stored in diluted T.E.A. day drum and LC 2253 storage drum, filtered and then pumped by metering pumps to the Reactor. The diluted alkyl-aluminium catalyst (T.E.A) and the diluted LC 2253 catalyst are fed to the reactor 32-R-201 through the pumparound loops. In case hexane is used (during start-up), it can be dried before using via Hexane Dryer, before being sent to Washing Hexane Drum. The regeneration of the dryer is carried out with hot nitrogen heated up in Nitrogen Heater. Effluents from regeneration are then sent to flare. Nitrogen Heater ensures also the drying of Pump around Loops after maintenance with hot nitrogen.

Reaction / Catalyst removal sections

The ethylene feedstock coming from Polymer Unit downstream of purification section or directly from cracker is mixed with the unconverted ethylene which is recycled from the recycle column reflux drum. The ethylene stream enters the reactor through a distributor, which improves the dispersion of the ethylene in the liquid.

The reaction is exothermic: the heat of reaction is removed by the pump around coolers installed on recirculation lines around the reactor. The recirculation is maintained by pumparound pumps. The liquid reactor effluent withdrawn from bottom of reactor must be vaporized to remove all the traces of catalysts. Part of the vaporization occurs in the vaporizers by steam condensation; the vapor and liquid phases are separated in the flash drum. The last step of vaporization is achieved through the thin film evaporator which is fed under flow-control reset by the level of the flash drum. The residual liquid is collected in the evaporator receiver drum and feeds under level control the spent catalyst drums which are connected to the flare and steam traced to remove the remaining light compounds. The remaining liquid is either sent to isocontainers and then to incinerator or sent to Fuel Oil. The vapors from the thin film evaporator flow through the evaporator K.O. drum which traps any liquid carryover. The vapors are then mixed to those got from the flash drum and to the vapor flow from the reactor top. The product, currently stripped from the catalysts, is condensed through the recycle column feed condenser and feeds the recycle column feed surge drum. To stabilize the product before vaporizing it, pure amine is injected to the reactant effluents filters. This prevents any detrimental isomerization of butene-1 into isobutene and butene-2, which could be promoted by temperature downstream, during the vaporization step, without

amine injection. The amine, unloaded from drums by the amine unloading pump, is stored in the amine storage drum, and sent to the process by the amine pumps.

Distillation section

The liquid phase from recycle column feed surge drum is pumped to the recycle column. A partial condensation of its overhead vapors takes place in the recycle column condenser. Due to the presence of methane and ethane in the feedstock, a slight venting to Naphtha Cracker is necessary to prevent from any incondensable vapor accumulation. The vapor (mainly ethylene) is recycled back under pressure control to the reactor feed line. The reboiling of the column is ensured in the recycle column reboiler under temperature control resetting the steam flow rate to the reboiler. The bottom product of the column is routed under flow-control, reset by level, to the butene-1 column.

The butene-1 column duty is to provide the specification in heavy components of butene-1 product. The butene-1 product is withdrawn as liquid distillate from the column overhead by means of the butene-1 column reflux pumps under level control of the butene-1 column reflux drum. The C6+ cut is withdrawn, at the butene-1 column bottom. The C6+ cut is routed, after cooling through the C6+ product cooler, to the C6+ storage drum.

Product storage

The butene-1 leaving the distillation section can be routed to any of the storage drums "on-spec" drum or an “off-spec” drum after has been cooled down at 40 deg. C in the butene-1 cooler. The butene-1 on-spec product is routed to OSBL storage tank after analysis, by means of the pump. The off-spec product is routed to C4 mix storage, but can also be recycled in the butene-1 column, if it’s content in C6 and heavier is too high. A part of this butene-1 product is used for flushing pump around pumps, reactor effluent pumps, passivation pumps and ethylene distributor by means of flushing pumps. Another part of this butene-1 is used as carrier or T.E.A. and LC 2253 catalysts to the reactor.

2.7.22 Ethylene Recovery Unit

The unit is proposed to be located within the Dual Feed Cracker Unit Battery Limits. Process Chemistry The purpose of the Low Pressure Ethylene Recovery (ER) Unit is to remove impurities found in the FCC and DCU off gas and to recover the ethylene for use in the downstream units to make value added polymers. Process Description The ER Unit is divided into the following areas:

1. ROG Amine System

The refinery off gas from OSBL is delivered to the ROG Treating Unit at the battery limit which is then sent to the ROG amine/water Column for bulk removal of CO2 and H2S.

2. ROG Caustic Treatment and Contaminants Removal

Amine treated gases are caustic washed to bring down H2S and CO2 content in acid gases down to specifications levels. The Spent caustic generated from the Column is sent to spent caustic treatment and neutralization before sending it to the Waste water system in OSBL. The refinery off gas vapor is then totally drawn off and sent to the ROG Oxygen Converter/Hydrogenator/Contaminant reactor removal after heating. The Oxygen Converter catalyst primarily removes oxygen, acetylene, and NOx by reaction to other species. Oxygen is converted to water and NOx is converted to ammonia and water. The Oxygen Converter

also hydrogenates acetylene to ethane and ethylene. The scheme provides a spare reactor bed for in situ regeneration of the catalyst.

3. Recovery Section

After reactor, the total stream is dried and then the Light fraction i.e C1- , which contains NOx, is removed from this stream. NOx in the stream may react with the cracked components mainly diolefins and may form NOx gums in the cold section of Cracker unit. The remaining fraction (C2+) fraction can be integrated to the front end separation systems, which can be dePropanizer or DeEthaniser located in the Cracker unit.

2.7.23 BDEU

The Butadiene Extraction Unit is designed to separate a C4 Hydrocarbon mixture containing butanes, butenes, butadienes, C3 and C4 acetylenes into two primary product streams- 1,3 Butadiene Product, C4 Raffinate.

The process used to perform this separation is a combination of extractive and conventional distillations. The separation process is essentially based on the difference in the relative solubility of the some of the feed components in N-Methylpyrrolidone (NMP) and the difference in the boiling points of some of the components. Based on this, the process unit is subdivided into the following sections:

- Extractive Distillation
- Distillation
- Degassing
- Solvent Regeneration

The vaporized C4 feedstock is directly fed to the Extractive Distillation 1 where it is counter currently contacted with the lean solvent. The solvent used is typically Nmethyl- pyrrolidone (NMP) with 8.3 wt% water.

The butenes, butanes, propane and propene are less soluble in NMP and leave the Main Washer Column as Raffinate-1. In the Extractive Distillation 2, the C4 acetylenes are separated from 1,3 butadiene by further washing with lean NMP solution, fed to the top of the after-washer column. The top product of this column is crude 1,3 butadiene and bottom product is Raffinate-2. This stream is washed with 1,3 butadiene reflux in order to remove traces of NMP. The crude butadiene stream is further purified in the conventional distillation section to remove propyne (first stage), and other C4 and higher components (second stage) to get butadiene product.

The solvent (NMP), from both the extractive distillation columns, collecting at the bottom of the lower part of the Rectifier Column is loaded with dissolved butadienes, C4 acetylenes, and some heavier components. It is partially degassed by heating in the solvent heat exchanger and sent to the degasser after further heating in the solvent heater. The solvent is completely degassed in the degasser and recycled to the extractive distillation stages as lean solvent.

Two vapor streams leave the Degasser:

- A side stream from the degasser, consisting of C4 acetylenes and water, is further washed with water in the Acetylene Washer to recover residual NMP, and the C4 acetylenes are ultimately condensed, mixed with raffinates and sent to the total C4 hydrogenation unit.

- The vapor stream leaving the top of the degasser is sent to the Cooling Column, then compressed and fed back to the lower part of the Rectifier.

2.7.24 Continuous Catalyst Regeneration Reforming Unit (CCR)

Hydrotreated heavy naphtha from NHT is combined with recycle gas, preheated by exchange with reactor effluent, heated to reaction temperature in the charge heater and sent to the first of a series of three to four reactors. Reforming reactions that take place in the reactors are predominantly endothermic; hence inter-reactor heaters are employed to maintain a constant inlet temperature profile for the individual reactors. Effluent from the last reactor is heat exchanged with the combined feed, condensed in the product trim cooler and sent to the separator. The total H2-rich gas from the separator is compressed in the recycle gas compressor. The recycle portion of the gas is returned to the combined feed exchanger and the net portion is sent to the recontact section. The net gas stream is first cooled in the net gas trim cooler, combined with the debutanizer overhead vapor, cooled further in 1st recontact trim cooler and separated in 1st recontact drum. A part of the net gas is compressed in 1st stage net gas compressor, combined with separator liquid, cooled in 2nd recontact trim cooler and separated in 2nd recontact drum. Vapor from 2nd recontact drum is compressed in 2nd stage net gas compressor, sent to net gas chloride treaters and routed to NHT. The remaining part of net gas is combined with vapor from debutanizer receiver and sent to a cryogenic LPG recovery section.

After recovery of LPG, the stream is routed to fuel gas header. The liquid from separator is pumped to the recontact section in a countercurrent manner with the high-pressure net gas stream as described above. Liquid from 1st recontact drum is sent to the debutanizer after being preheated in debutanizer feed/bottom exchanger. The debutanizer has a steam reboiler. Stabilized reformate is cooled in feed/bottom exchanger followed by air/trim coolers before being routed to storage. LPG from debutanizer receiver is sent to LPG chloride treater, cooled in LPG trim cooler and routed to storage. The regeneration section of the reformer provides a continual stream of clean coke- free active catalyst that is returned back to the reactors. Continuous circulation of regenerated catalyst helps maintain optimum catalyst performance at high severity conditions for long on-stream periods of reforming operation. Reformate from CCR is further split into light and heavy reformate to minimize Benzene content. Light reformate is routed to ISOM unit for Benzene saturation.

2.7.25 Isomerisation

The fresh C5 /C6 feed is combined with make-up and re-cycle hydrogen which is directed t o a charge heater, where the reactants are heated to reaction temperature. The heated combined feed is then sent to the reactor. Either one or two reactors can be used in series, depending on the specific application.

The reactor effluent is cooled and sent to a product separator where the recycle hydrogen is separated from the other products .Recovered recycle hydrogen is directed to the recycle compressor and back to the reactor section. Liquid product is sent to a stabilizer column where light ends and any dissolved hydrogen are removed. The stabilized isomerate product can be sent directly to gasoline blending.

2.8 UTILITY FACILITIES

The following utility systems are envisaged for the proposed Refinery cum petrochemical complex.

1. Raw water system
2. Cooling water system
3. DM water system
4. Compressed air system
5. Nitrogen system
6. Steam, power and BFW system
7. Condensate system
8. Internal fuel oil and fuel gas system

Capacity of the major utility systems are summarized below in **Table-2.3.**

Table 2.3: Utility Systems (Note – 1)

Broad Specs Of Utility Systems		
S.No.	**Description**	**Specification**
1. Raw Water System		
A	Raw Water reservoir	1 Reservoir of Capacity 37,44,000 m3 (equiv. 30 days storage)
B	Raw water treatment plant	2 Raw water treatment plants each of capacity 3000 m3/hr
C	Treated Water Storage	Capacity 42,000 m3
2. Cooling Water System		
A	Cooling Tower (Refinery)	(11+1) cells of 4000 m3/hr cap. each
	Cooling Tower (Cracker Block)	(15+1) cells of 4000 m3/hr cap. each
	Cooling Tower (Polymer Block)	(9+1) cells of 4000 m3/hr cap. each
	Cooling Tower (SRU Block)	(1+1) cells of 4000 m3/hr cap. each
	Cooling Tower (CPP)	(4+1) cells of 4000 m3/hr cap. each
B	Cooling Water Pumps (Refinery)	(6+2) Pumps of 8000 m3/hr cap. each
	Cooling Water Pumps (Cracker Block)	(8+2) Pumps of 8000 m3/hr cap. each
	Cooling Water Pumps (Polymer Block)	(5+2) Pumps of 8000 m3/hr cap. each
	Cooling Water Pumps (SRU Block)	(1+1) Pumps of 8000 m3/hr cap. each
	Cooling water pumps (CPP)	(2+1) pumps of 8000 m3/hr each
3. DM Water System (inclusive of Caustic system)		
A	RO DM Plant	1250 m3/hr capacity
4. Compressed Air System and Nitrogen Plant		
A	Air Compressor (Centrifugal)	(3 + 1) Nos. Air Compressors of 15000 Nm3/hr cap. each, Discharge Press=8.0Kg/cm2g

B	Nitrogen Plant Capacity	Gaseous = 24000 Nm3/hr Liquid = 500 Nm3/hr (Gas equivalent)
C	Cryogenic Nitrogen storage	4 storage vessels of 150 m3 cap each
5.Steam and Power System		
A	No. of utility boilers	1w+1s
B	Capacity	160 TPH
C	Steam level	110 kg/cm2g, 510 ^{o}C
D	CFBC (with lime based Flue gas Desulphuriusation Unit)	2 x 400 TPH VHP steam
E	CPP-GTG	4 GTG Fr VI of 33.0 MW each, GTG machines are equipped with HRSG for steam generation through waste heat recovery &auxiliary firing. Normal steam generation from each HRSG is 80 T/hr.
F	CPP-STG	5 extraction cum condensing type STG 26 MW each

Note – 1: system specifications will be finalized during detailed engineering phase.

2.8.1 Raw water system

The raw water consumption for the refinery-cum-petrochemical complex is estimated to be approximately 5300 m3/hr (normal).

The water requirement is proposed to be met from *IG Canal.* The raw water shall be sourced from IG Canal at Nachna through a 46" raw water pipeline of 200 KM length along with pumping facilities has been considered.

A raw water reservoir of capacity 37,44,000 m3 which is equivalent to 30 days of normal consumption is envisaged and is located within the township. A Water Balance diagram is shown in Figure 2.4.

2.8.2 Effluent handling and Disposal

In the storage, handling and transfer facilities liquid effluent is generated from tank/pump draining and cleaning during maintenance periods and from thermal safety valve discharges.

The disposal system shall be as below:
Low viscous liquid effluent disposal will be routed to waste water treatment plant through Oily Water Sewer (OWS)/ pit system. The system routing shall be designed based on the plot plan. Hydrocarbon recovered from the waste water treatment plant will be pumped back to the wet slop tanks. High viscous liquids shall be collected in localized pits and can be scrapped out as required. TSV discharge for all non-viscous fluids located in nearby area shall be routed to a common header. The header will finally discharge into the OWS system.

TSV discharge for viscous fluids shall be routed to localized pit. Gaseous effluent like C3, C4 will be routed to flare.

Effluent Treatment Plant

- Waste water treatment facilities for treating all the effluents are being provided.
- Storm water basins are being provided at different locations of the refinery to prevent runoff of oil contaminated water into adjoining areas during heavy rains
- An effluent treatment plant with capacity as per table 2.4 is envisaged.

Table 2.4 ETP Plant capacity

Effluent Stream	Units	Design Flow
Oily Effluent streams (excluding spent caustic and sanitary effluent)	m3/hr	650 m3/hr
Treated sanitary effluent	m3/hr	25
Spent caustic flow	m3/hr	7

2.8.3 Solid waste generation

There are primarily four types of solid wastes generated in the refinery:

1. Spent Catalysts
2. ETP Sludges
3. General Solid Wastes
4. Tank Bottoms

Spent Catalysts

Patented catalysts are used in various refinery process units. Some of the spent catalysts will be sent back to the original supplier for reprocessing. The other catalysts are normally sent to a secured landfill. Details of spent catalyst is attached as Annexure IV.

ETP Sludges

The sludge separated in different units of ETP, viz., oily & chemical sludge aprrox quantity 720 kg/d from API/TPI/DAF, will be thickened in a thickener and the thickened sludge will be dewatered in a centrifuge. The dewatered sludge will be sent to secured landfill. The bio sludge to the tune of 800 kg/d from bio-treatment section will be separately thickened and dewatered in a thickener and centrifuge respectively and sent for land fill/reuse as manure.

General Solid Wastes

Approximately 1500T/year of non-hazardous, non-recyclable solid waste consisting of waste refractory, spent insulation, decoking solid waste from CDU/VDU, used filter cartridges, spent charcoal, spent clay and sand will be generated. These wastes will be disposed off in landfill.

Tank Bottom Sludge

This sludge is generated periodically during the tank cleaning operations approx 1000 T/ tank. As this sludge is hazardous, ‘Tank form management system’ will be adopted.

The sequence of the system includes

- Collection of oily sludge in a sump
- Transfer of oily sludge in a melting pit
- Bio treatment of oily sludge or routing to Cement kiln

However, the sludge generated from product tanks will be nominal.

A secured land fill facility is envisaged inside the complex for temporary handling/storage purpose and after that hazardous wastes shall be disposed off in nearby authorized landfill facility.

2.8.4 Power Requirement

Total Power demand for the proposed RRP is 192 MW (Normal) and ~211 MW (Max.) excluding CPP internal requirement.

CPP Unit

CPP is envisaged to meet the total Steam & power requirement of the complex. CPP consists of Frame-VI GT machine with HRSG along with Utility boilers and CFBCs with STGs. Refinery fuel gas/Diesel are envisaged as fuels for GT. Two CFBC's have been considered and these shall utilize coke generated from DCU unit to produce steam/power.

Lime will be purchased from nearby sources for augmentation with coke for firing in CFBC. Estimated quantity of lime will be 50 – 55 TPH. The objective of lime addition is to reduce SOx emissions from coke firing. Further, 50 – 55 TPH of gypsum will be generated from these boilers.

2.9 OFFSITE FACILITIES

Feed, Intermediate Product and Finished Product Storage

Following facilities have been considered for crude and product storage

- ***Crude Storage***- Refinery crude tanks for crude storage have been provided for 15 days of refinery operation at 100% capacity.
- ***Intermediate product storage***-Tanks for intermediate streams have been provided with 50% of capacity of upstream / downstream unit (whichever is governing) for 7 days of unit operation
- ***Finished product Storage***- Finished product tanks having capacity equivalent to 15 days production have been provided for all products except LPG for which 7 days storage has been considered.

Solid Product storage / yard facility

Sulphur produced from SRU will be stored in open yard. The yard will be designed for storing solid sulphur corresponding to one week production. Coke produced from DCU shall be stored in open yard corresponding to one week production. Coke is considered as feed to CFBC boilers.

Storage tank details are given in Table 2.5.

Table 2.5 Storage Tanks List

Service	Liquid Stored, m3	Capacity per Tank, M3	Height/ Length, m	Dia, m	No of Tanks	Op. temp, DegC	Design Temp., DegC	Pressure Rating	Type
CRUDE FEED TANK									
CRUDE TANK	616495	60000	20	66	11.0	AMB	65	150	Floating
CRUDE WATER DRAIN TANK	-	3765	12.0	21	1.0	AMB	65	150	Cone roof
SURGE RELIEF TANK	-	425	6	10	1.0	AMB	65	150	Cone roof
FINISHED PRODUCT TANKS									
BUTADINE SPHERE	-	2340	-	17.5	11.0	15-45	(-)7 to 115	300	Sphere
BENZENE TANK	6164	3420	13.0	19.3	2.0	AMB	65	150	IFR
TOLUENE TANK	4880	3100	10.0	20.9	2.0	AMB	65	150	IFR
MIX XYLENE TANK	-	2700	12.0	17.8	1.0	AMB	65	150	IFR
MS BS-VI (92 RON and 95 RON) TANK	91725	14000	14.5	37.0	7.0	AMB	65	150	Floating
ULS DIESEL (HSD-BS VI) TANK	248760	58000	18.0	67.5	5.0	AMB	65	150	Floating

Service	Liquid Stored, m3	Capacity per Tank, M3	Height/Length, m	Dia, m	No of Tanks	Op. temp, DegC	Design Temp., DegC	Pressur e Rating	Type
INTERMEDIATE FEED TANKS									
NHT FEED TANK	31500	30000	20	44	2.0	AMB	65	150	Floating Roof
DHDT FEED TANK	73795	25000	20.0	42.1	3.0	AMB	65	150	Cone Roof
HGU FEED TANK	6678	11000	18.0	29.4	1.0	AMB	65	150	Floating Roof
FCC FEED TANK	42292	30000	20	46	2.0	80	100	150	Cone Roof
VGOHDT FEED TANK	49932	30000	20.0	46	2.0	140	180	150	Cone Roof
VR FEED TANK	31818	25000	20	42	4.0	140	180	150	Cone roof
ISOMERATE	10500	20000	20	33.0	1.0	AMB	65	150	Dome Roof
REFORMATE	15000	20000	20.0	38.0	1.0	AMB	65	150	Floating Roof
PRIME G FEED	16313	10000	20.0	27.0	2.0	AMB	65	150	Cone Roof
NCU FEED TANK	32250	30000	20	46	2.0	AMB	65	150	Floating roof
C3/C4 FEED TANK	18120	4520	85	7	5.0				Mounded Bullet
SWING FEED TANK	38243	24000	17.6	41.4	2.0	AMB	65	300	DWST
PROPYLENE (PPU FEED)	49889	24000	20	41	3.0	AMB	(-27)/ (+55)	300	DWST
BTX EXTRACTION FEED TANK	4132	2400	10.0	18	2.0	AMB	65	150	Int. Floating Roof
OFFSPEC ETHYLENE	2622	1500		15.0	2.0			300	SPHERE
OFFSPEC PROPYLENE	3634	1500		15.0	2.0			300	SPHERE

C4 MIX		2800		17.5	3			150	SPHERE
BUTENE-1		2800		17.5	1.0			150	SPHERE
C4 RAFFINATE		2800		17.5	1.0			150	SPHERE
OFFSPEC C4 MIX		2800		17.5	1.0			150	SPHERE
RPG	10795	6000	16.0	23.0	2.0	AMB.	65	150	DOME
HY. PYGAS	10795	6000	16.0	23.0	2.0	AMB.	65	150	INT. FLOATING
C9+ TANK		1670	10	15	2.0	AMB.	65	150	CONE ROOF
C6+ OLIGOMER		350	9.5	8.2	2.0	AMB.	65	150	INT. FLOATING
PFO/CBFS		1840	11	15	2.0	90	150	150	Cone Roof
LT. DRY SLOP TANK		4560	13.5	21.9	2.0	40-80	150	150	Floating Roof
HVY. DRY SLOP TANK		3425	13.5	18.9	2.0	80-160	180	150	Cone Roof
FLUSHING OIL TANK		5635	14.0	23.9	2.0	AMB	65	150	Floating Roof
FO TANK		5317	17.5	20.7	2.0	AMB	65	150	Cone Roof

2.10 FEED RECEIPT/PRODUCT DISPATCH FACILITIES

- ***Mangla Crude***- Crude shall be received from the Mangla Crude Facility via a 30", 80 KM electrically heated pipeline
- ***Arab Mix Crude (Imported Crude)***- COT facilities have been considered for import of crude. A new 30", 575 KM pipeline for importing crude from Bhogat to Pachpadra has been considered. Existing SPM facilities of M/s Cairn are proposed to be used for unloading the imported crude.
- ***Natural Gas*** -A 34" diameter, 80 km long pipeline is considered for importing natural gas from nearby source to refinery.
- ***Marketing Terminal***- Presently, No marketing terminal has been considered for disposal of products generated from the Rajasthan Refinery. However, space provision for locating the Marketing Terminal in the Refinery overall plot plan has been kept.
- ***Product Pipelines***- Transportation through pipelines is under conceptualization stage to examine its feasibility. Accordingly this mode of transportation will be considered at a later stage.. All solid products will be dispatched by road.

2.11 SUMMARY OF SULPHUR BALANCE & SOx MANAGEMENT

The SOx calculation for the proposed refinery configuration is indicated in Table 2.6.

Table 2.6:-Estimated SOX Emissions

Process Units	Total Absorbed Duty (MMKCAL/ hr)	Total Fired duty (MMKCAL/ hr)	Total Fuel Gas Consumption (Kg/Hr)	Total Fuel Oil Consumption (Kg/Hr	Estimated SOx, Kg/hr
CDU/VDU	111.0	126.1	2009.1	10886.6	109.2
DCU	59.0	67.1	1068.6	5790.4	58.1
VGO HDT	61.9	70.4	1121	6074.5	61
RFCC Gasoline HDT	3.1	3.5	54.4	294.9	2.9
PPU	2.6	3.0	47.1	255.4	2.6
DHDT	7.6	8.6	136.7	740.9	7.4
NHT	7.0	8.0	126.8	686.9	6.9
NSU	14.9	16.9	269.5	1460.2	14.7
CCR	6.4	7.3	116.2	629.4	6.3
BTX	7.2	8.2	130.1	695	10.6
Dual Feed Steam Cracker Unit	534.0	606.8	53698.4	0	10.1
PGHU	3.1	3.5	55.1	298.5	3.0
HYDROGEN GENERATION UNIT	19.6	22.3	591.8	0	0.1
Process Furnace Sub Total SOx (Kg/hr)	293.0				
Process Furnace Sub Total SOx TPD)	7.03				
CPP					
GTG / HRSG	77.5	88	3504	5095	52.8
GTG / HRSG	77.5	88	3504	5095	52.8
BOILER	155	130	5175	7525	77.8
CPP Sub Total SOx (Kg/hr)	183.4				
CPP Sub Total SOx (TPD)	4.4				
Sub Total SOx (Kg/hr) (Process Furnaces + CPP)	476.4				
Total SOx, TPD (A)	11.4				
SOx from CFBC					
UNIT	Unit Capacity (MMTPA)	Feed (TPD)	Feed **'S'** (wt %)	Eq. SOx (TPD)	
		2152	7	15	
Total SOx, TPD (B)	**15.0**				
SOx from FCC Coke					
UNIT	Unit Capacity (MMTPA)	Feed (TPD)	Feed **'S'** (wt %)	Eq. SOx (TPD)	
FCC	2.6	7882	0.0674	2.42	

Total SOx, TPD (C)	**2.42**			
SOx from SRU				
UNIT	SRU capacity (TPD)	H_2S to SRU (TPD)	Emission From SRU (Kg/Hr)	Emission From SRU (TPD)
SRU	398 (#)	423 (*)	35	0.84
Total SOx, TPD (D)	**0.84**			
Total SOx (A+B+C+D) ,TPD	**30**			

(#) SRU capacity will be 486 TPD based on 100% AM Crude case. However total SO2 emissions will not exceed 30 TPD.

(*) H2S quantity indicated corresponds to 395 TPD sulphur product from SRU

- All the data provided above is based on percentage of Fuel gas and Fuel oil firing in each unit is as indicated below.
  a. CPP- 55% FO & 45 % FG firing.
  b. DFCU- 100% FG firing.
  c. HGU- 70% PSA off gas & 30% FG firing.
  d. All other process units-18% FG & 82% FO firing.

Following are the basis considered for SOX calculation,

- Sulfur Recovery Units has been considered with TGT facilities. Total sulphur recovery is 99.9%.
- Refinery fuel gas with H_2S of 150 mg/NM3 and Fuel oil with sulphur 0.5 wt% shall be used in the fired furnaces of all units and Power Plant.
- SOx emission from fired heaters is based on the assumption that duty will be met by available fuel gas and remaining duty by fuel oil required to meet the demand.
- Sulphur Dioxide (SO2) emission limit for FCC regenerator is 500mg/NM3
- The Net calorific value and sulphur percentage considered for SOx emission for different fuels are as follows.

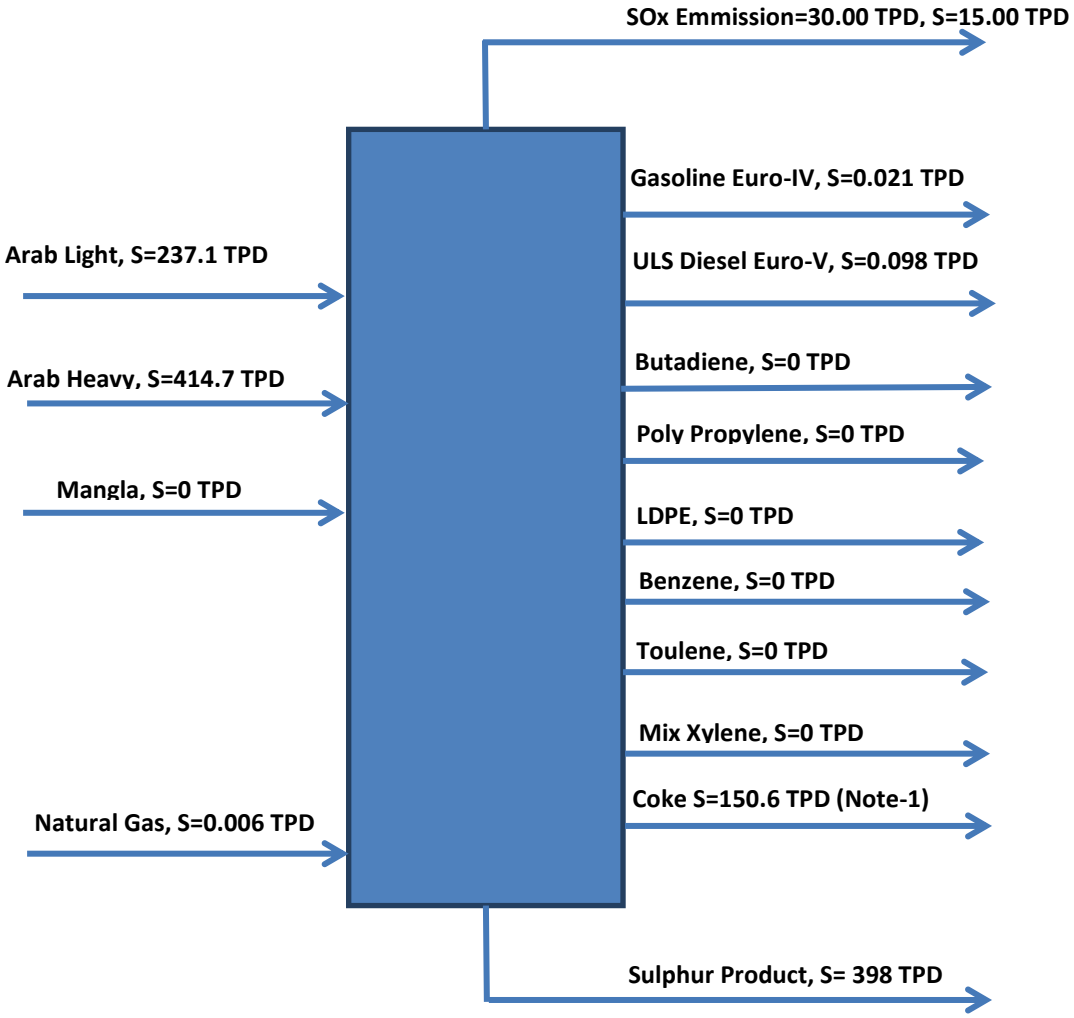
Table 2.7: FO/FG Properties

TYPE	NET CALORIFIC VALUE (KCal/Kg)	'S' IN FUEL, (wt%)
Fuel oil	9500	0.5
Fuel gas	11300	H_2S of 150 mg/NM3

SULPHUR BALANCE DIAGRAM

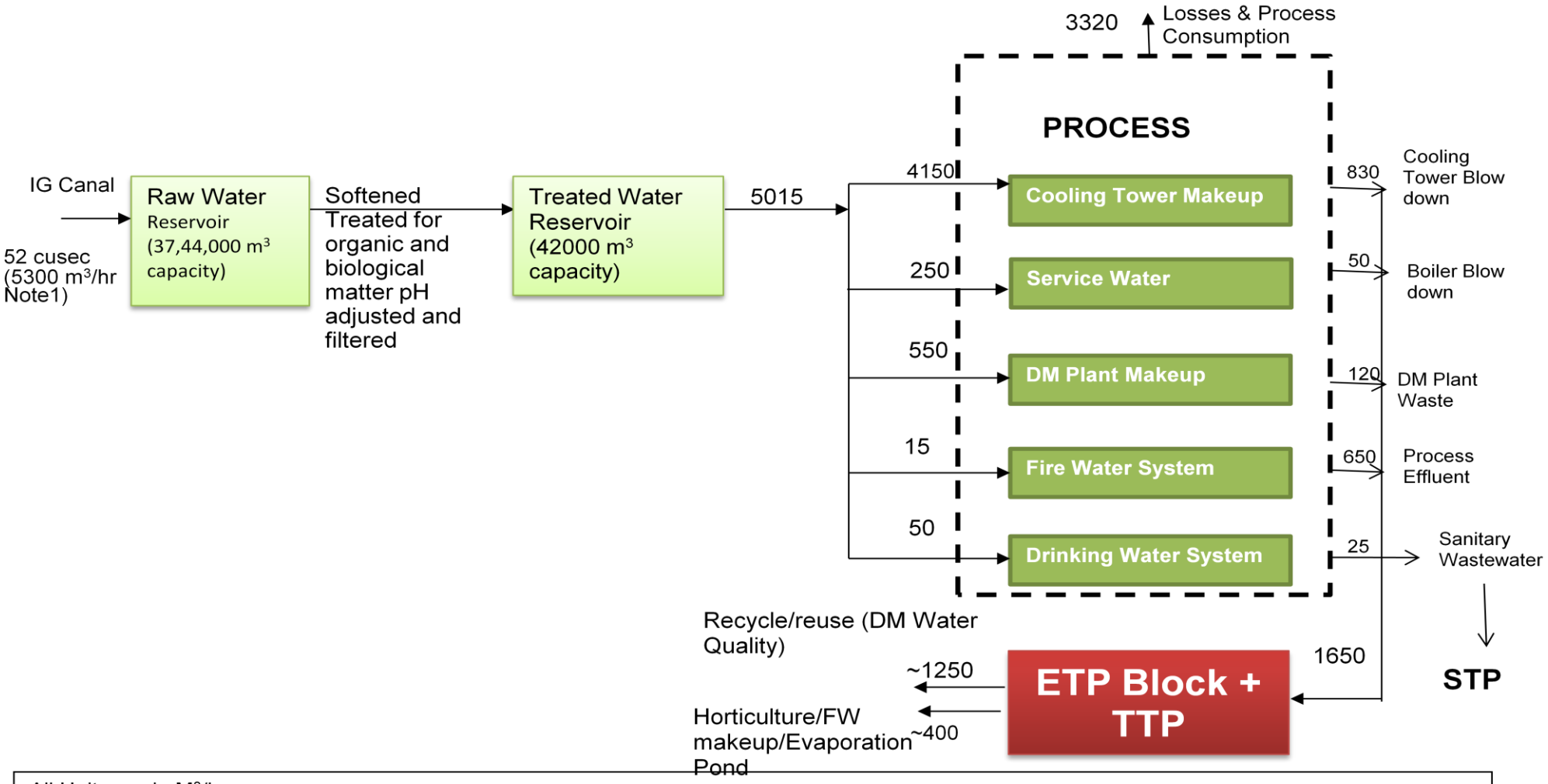
Sulphur balance diagram is indicated in figure 2.3 considering Fuel gas and Fuel oil firing in Furnaces.

Figure 2.3:- Sulphur balance diagram



(#) SRU capacity will be 486 TPD based on 100% AM Crude case. However total SO2 emissions will not exceed 30 TPD.

Figure 2.4: Water Balance diagram for RRP



All Units are in M³/h
Note 1: Continuous Raw Water requirement during operation phase is 5015 m3/hr; however, approval of 52 cusec (~5300 m3/hr) is taken from IGNP for design purpose.

CHAPTER – 3

DESCRIPTION OF THE ENVIRONMENT

3.0 DESCRIPTION OF THE ENVIRONMENT

Baseline data collection is already carried out by National Environmental Engineering Research Institute (NEERI), Nagpur during October-December 2013. As per MoEFCC instruction, the same data will be used for EIA report preparation with change in configuration details in refinery cum petrochemical complex.

3.1 SITE & SURROUNDINGS OF THE PROJECT SITE

It is proposed to setup a grass-root Refinery cum Petrochemical Complex (Rajasthan Refinery Project, RRP) at village Saajiyali Roopji Kanthawad, Tehsil Pachpadra, Barmer District, Rajasthan.

The proposed refinery cum petrochemical complex site spread over 4400.40 acres area which falls under the villages Sajjiyali, Roopji, Kanthavad and Sambhara, in Pachpadra Tehsil, District Barmer, Rajasthan. The land available for the refinery project site is mostly barren and flat with full government ownership, belonging to salt department. The site is located adjacent to NH-112 near Balotra town. The nearest railway station is at Balotra, about 13km and the nearest airport is at Jodhpur, about 100 km from the site. The proposed site has been identified by Government of Rajasthan. No national monument / major settlements are located within 10 Km of the site. Uttarlai Air Force Base is located at 80 km. International border with Pakistan is about 152 km.

As per 2011 Census, the total population of the study area covering 11 villages was 84,459. Of which 88% population resides in Pachpadra Tehsil. Remaining about 10,000 populations is distributed in the 10 villages. The houses in the rural area are sparsely located, mainly existing within or near the agricultural field of the farmers. Besides agriculture, salt mining is one of the major activities of the region. Nearly 250 salt mines are reported to be existing in the study area of 10 km radius, whereas about 70-80 salt pans exist within the project site. Sodium Chloride content is as high as 98%. Many people work as salt mine worker to clear salt during non-monsoon periods.

Topography and Climate

The proposed site lies in the Barmer district, which is located in the western part of the State forming a part of the Thar Desert. The district borders Jaisalmer district in the North, Jalore district in the South, Pali district and Jodhpur district in the East, and Pakistan in the West. The total area of the district is 28,387 km^2. The district is located between 24, 58’ to 26, 32’N Latitudes and 70, 05’ to 72, 52’ E Longitudes.

The longest river in the district is Luni. It is 480 km in length and drain into the Gulf of Kutch passing through Jalore. The variation in temperature in various seasons is quite high. In summers, the temperature soars to 46 °C to 51 °C. In winters, it drops to 0°C (41 °F). Primarily Barmer district is a desert where average rainfall in a year is about 277 mm. However, extreme rainfall of 549 mm rain between 16 August and 25 August 2006 occurred and left many dead and huge losses due to flood in a nearby town Kawas and as a result whole town got submerged. As many as twenty new lakes formed, with six covering an area of over 10 km^2.

3.2 BASELINE ENVIRONMENTAL QUALITY STATUS

Assessment of baseline status of environmental quality in the study are a helps in better identification, prediction and evaluation of impacts arising due to proposed developmental activity. The existing status of various environmental components viz. air, noise, water, land, biological and socio-economic are assessed through field studies within the impact zone around the proposed project site. Baseline monitoring for different environmental quality parameters was carried out within the 10 km radius study area from the project site during post-monsoon/winter (October-December 2013). Environmental component wise methodology adopted and results obtained are presented in the following sections.

3.3 AIR ENVIRONMENT

3.3.1 Methodology

Reconnaissance survey of the study area was carried out to understand and identify the sources of air pollution prior to the implementation of the project and to select air quality monitoring locations. Ambient air quality monitoring locations were selected based on the general guidelines of network sitting criteria involving:

- Topography/terrain of the study area
- Regional synoptic scale climatological normal
- Population distribution within the region
- Location of surrounding industries
- Representation of regional background
- Representation of valid cross-sectional distribution in downwind direction

Climatological/ Meteorological Features of Barmer Region

The study area lies in semi and transitional zone between desert in the West and the Aravali range towards East and has a dry climate, somewhat milder than other adjoining western areas. The winter season is from December to February. The maximum and minimum temperature goes up to 50°C in summer and below 0°C in winter respectively. The monsoon sets slightly late and monsoon period from late June to October.

Monthly Meteorological Data of Barmer

Meteorological data with respect to temperature, relative humidity and wind speed was collected from December 2012 to November 2013 and was analysed for monthly mean, maximum and minimum values as given in **Table 3.1** and **Figure 3.1**.

The winter season is considered from December to February (extended to March), whereas summer season starts towards to end of March till June. Monsoon during July to September and Post monsoon during October-November. An annual rainfall of about 275 mm is observed during the monsoon period.

Temperature

During the year, minimum temperature varied from 7.4°C (December) to 25.2°C (May), whereas maximum temperature varied from 30.0°C during December-January to 46.4 °C in May. Monthly mean temperature varied from 17.3 °C during January to 35.5 °C during May.

Table 3.1 Monthly Meteorological Data of Barmer (Dec. 2012-Nov. 2013)

Season/ Month	Temperature (ºC)			Humidity H (%)			Mean Wind Speed V(km/h)		
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
Winter									
December	18.4	30	7.4	45.9	72	30	1	3.7	0
January	17.3	30	7.6	39.7	83	28	1.2	3.7	0
February	20.4	32.7	10.6	45.1	73	27	2.6	8	0
Summer									
March	27.4	38.6	14.2	27.3	40	17	2.2	10.7	0
April	27.4	38.6	14.2	27.3	40	17	2.2	10.7	0
May	35.5	46.4	24.8	34	53	14	4.9	9.8	0
June	34.4	46	23.8	51.1	72	31	4.2	8	0
Monsoon									
July	32.1	42.2	23.6	63.8	86	52	3.1	8	0
August	29.9	37.4	25.2	72	98	62	2.3	5.2	0
September	30.1	40.4	20.2	62.6	98	42	2.4	14.4	0
Post-Monsoon									
October	28.2	37	20.2	60.2	79	38	0.5	4.6	0
November	21.3	32.7	14.4	49.2	58	37	0.4	2.8	0

Relative Humidity

During the year, minimum relative humidity was observed during summer months (14-53%), whereas maximum humidity was observed during monsoon months (86-98%). Monthly mean humidity varied from 27% during March to 72% during August.

Wind speed

During the year, maximum wind speed was observed during summer months (9.8-10.7 km/h), whereas monthly mean values varied from 0.4 km/h in November to 4.9 km/h during May.

Rainfall

Rain clouds deposit most of their moisture on the high ranges in Kathiawar in Gujarat or on the slopes of the Aravalli range. A record of the rainfall in the Barmer district is available from nine stations spread around the Barmer district. The average annual rainfall in 1995 in the Barmer district was 255 mm. The rainfall decreases towards the west of Barmer. Siwana near the eastern border of the Barmer district received 207.6 mm of rain. About 92 % of the rainfall occurs during the months from June to September. The variation of rainfall from year to year is very large. Rainless years or years with extremely scanty rainfall are not unknown particularly in the western part of the district. The average number of rainy days

(days with rainfall of 2.5 mm or more) in a year is 16.5. (Data Source: Climate of Rajasthan Indian Meteorological Department).

The average annual rainfall based on the 30 years (1951-1980) IMD data, was observed to be 314 mm. The monsoon sets in the month of June and continues till mid-October. The maximum amount of rainfall (112.5 mm) occurs in the month of August. The maximum numbers of rainy days were observed in July.

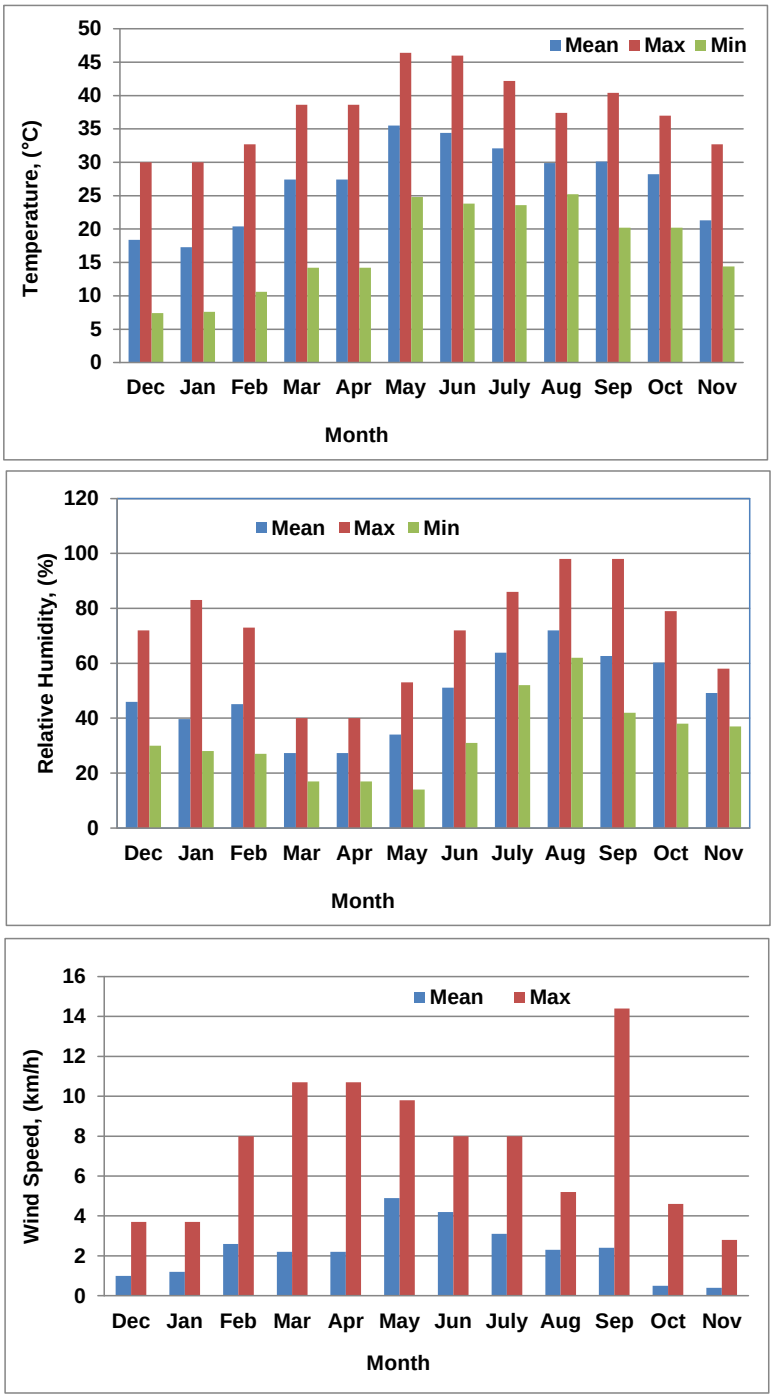


Figure 3.1: Monthly Meteorological Data for Barmer District (Dec 2012 – Nov. 2013)

Cloud Cover

During winter and pre-monsoon seasons, sky remains mostly very clear. In the post-monsoon season, generally light clouds were observed in the evenings, with clear mornings. During the monsoon season, both in the mornings and evenings, the sky is observed to be clouded.

Micrometeorology of the Area

The study of micro-meteorological conditions of a particular region is of utmost importance to understand the variations in ambient air quality status in that region. The prevailing micrometeorology at project site plays a crucial role in transport and dispersion of air pollutants released from the plant. The persistence of the predominant wind direction and wind speed at the project site will decide the direction and extent of the air pollution impact zone. The principal variables, which affect the micrometeorology, are horizontal transport and dispersion (average wind speed and directions), convective transport and vertical mixing (atmospheric stability) and also topography of the area towards local influences.

The collected meteorological data have been processed to draw windrose on 24 hourly basis during post-monsoon season (Oct-Dec, 2013). The windrose for post-monsoon season is shown in **Figure 3.2**.The predominant winds are observed from NW, N and NE directions. The wind speeds are observed in the range of 0.5 – 5.7 m/s and the calm conditions are found to be about 29% of the time during the post-monsoon season. The winds were recorded in NW, N, NE directions, thereby, projecting the impact zone in SE, S and SW directions with respect to the location of proposed plant.

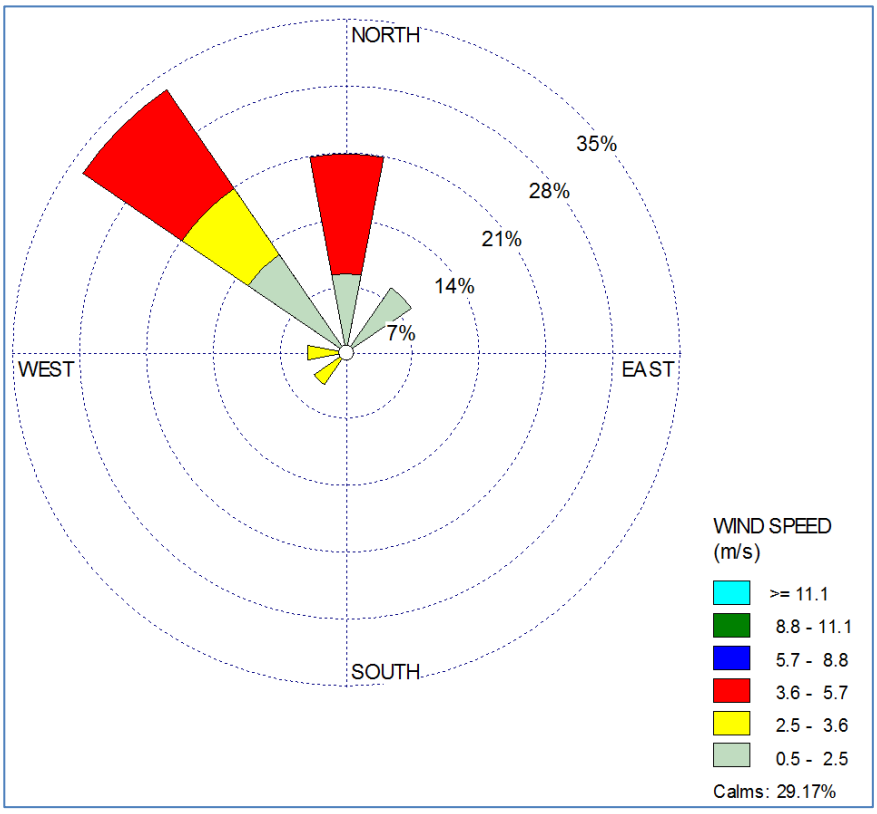


Figure 3.2: Windrose Diagram for Post-monsoon Season

Ambient Air Quality Monitoring Locations

Keeping in view the above site selection criteria and micrometeorological conditions, in all 10 air quality monitoring locations were selected in the study area. The sampling locations are shown in **Figure 3.3** and details are given in **Table 3.2**.

The conventional and project specific parameters as specified in ToR, such as PM_{10}, $PM_{2.5}$,Oxides of Nitrogen (NOx), Sulphur dioxide (SO_2), Ammonia (NH_3), Carbon Monoxide (CO), VOCs (mainly hydrocarbons) and Ozone were monitored at all the locations following CPCB guidelines. In addition, particulate associated toxic pollutants were also determined. The methods used for sampling and analysis of different air pollutants are given in **Table 3.3.** A field laboratory was setup at Balotra for the analysis of samples.

Table 3.2 Techniques Used for Ambient Air Quality Monitoring

Sr. No.	Parameter	Monitoring Technique
1.	Particulate Matter size < 10 microns or PM_{10}	Gravimetric
2.	Particulate Matter size less than 2.5 microns or $PM_{2.5}$	Gravimetric
3.	Sulphur Dioxide (SO_2)	EPA Improved West and Geake Method
4.	Oxides of Nitrogen (NO_X)	Modified Jacobs-Hoechheiser Method
5.	Ammonia (NH_3)	Indophenol Blue Method
6.	Ozone (O_3)	UV Photometric method
7.	Carbon Monoxide	Non Dispersive infra red (NDIR) Spectroscopy
8.	Lead (Pb)	AAS/ICP method for sampling on EPM 2000
9.	Benzene	Gas Chromatography based continuous analyzer (BTEX)
10.	Benzo(a)Pyrene	Solvent Extraction Followed by HPLC/GC Analysis
11.	Arsenic(As),	AAS/ICP method for sampling on EPM 2000 or equivalent filter paper
12.	Nickel (Ni)	AAS/ICP method for sampling on EPM 2000 or equivalent filter paper
13.	Hydrocarbon (HC)	Hydro carbon analyzer

Table 3.3 Ambient Air Quality Locations (Oct.-Dec. 2013)

Sr. No.	Location	Latitude / Longitude	Directions from Project Site	Distance From Project Site
1.	Dewal Ki Dhani	N $25^0$56'15.0''	CENTRE POINT	--
		E $72^0$11'01.7''		
2.	Sajiyali	N $26^0$00'02.7''	NW	5.7
		E $72^0$08'56.2''		
3.	Kalawa	N $25^0$52'28.8''	SSW	9.2
		E $72^0$08'55.5''		
4.	Akarli	N $25^0$57'58.7''	W	7.8
		E $72^0$06'20.5''		
5.	Samara ki Dhani	N $25^0$54'53.1''	SW	5.2
		E $72^0$09'22.5''		
6.	Kiyar	N $26^0$00'38.6''	N	5.9

		E 72^{0}11'20.1''		
7.	Richholi	N 26^{0}02'27.1'' E 72^{0}15'27.9''	NNE	9.4
8.	Gopri	N 25^{0}58'01.1'' E 72^{0}15'25.1''	E	7.1
9.	Pachpadra	N25^{0}55'14.9'' E72^{0}15'23.5''	ESE	8.2
10.	Mahdapura	N 25^{0}54'49.3'' E 72^{0}14'59.2''	SE	8.3
11.	Kasajiyon Ki Dhani	N 26^{0}01'09.9'' E 72^{0}11'30.9''	S	5.5

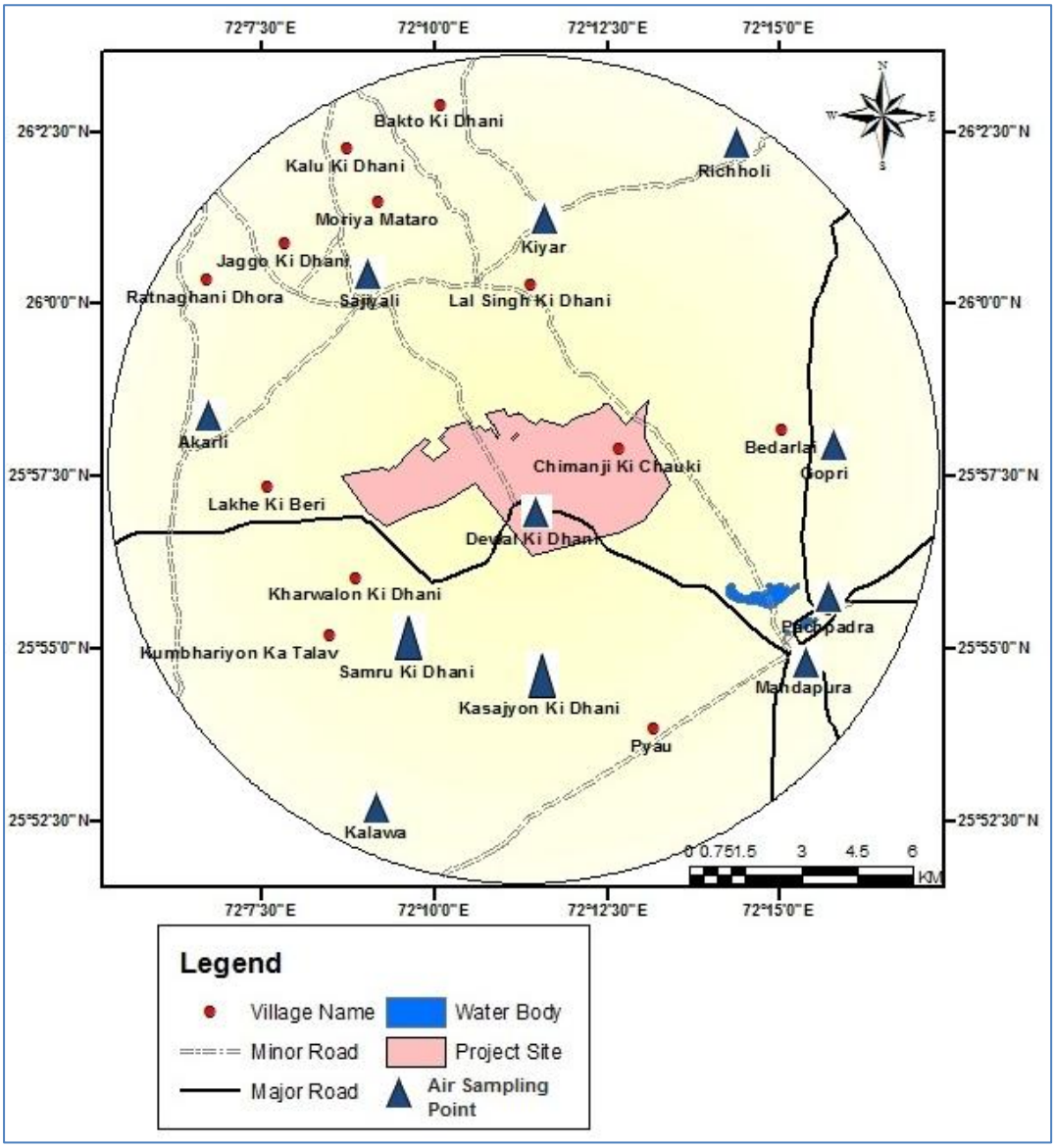


Figure 3.3: Ambient Air Monitoring Locations

3.3.2 Baseline Air Quality Status

Air quality status with respect to different air pollutants like particulate matter (PM10 and PM2.5) SO2, NOx, NH3, O3, particulate associated toxic pollutants (Pb, As, Ni and BaP), and other gaseous pollutants like CO and VOCs has been presented through **Tables 3.4 to 3.6**.

Table 3.4 Ambient Air Quality Status (Oct.-Dec. 2013)

Averaging Time: 24 hours
Unit: µg/m^3

Sr.No	Sampling location	PM_{10}	$PM_{2.5}$	SO_2	NOx	NH_3	O^*_3
1.	Deval ki Dhani (Project Site)	61±5 (55-67)	30±5 (23-38)	7±3 (4-11)	12±3 (9-17)	19±3 (13-22)	11±3 (8-16)
2.	Sajiyali	65±5 (57-72)	25±2 (22-28)	9±3 (6-13)	14±2 (11-16)	24±3 (19-28)	12±2 (9-16)
3.	Kalawa	67±3 (61-71)	32±6 (23-39)	9±2 (7-12)	16±2 (14-19)	25±3 (20-28)	12±2 (9-14)
4.	Akarli	61±5 (55-69)	31±4 (24-36)	6±2 (4-9)	14±3 (10-16)	24±2 (21-26)	13±1 (11-15)
5.	Samaru ki Dhani	59±5 (55-70)	30±3 (26-36)	7±1 (5-8)	16±6 (10-26)	25±2 (21-28)	10±2 (6-13)
6.	Kiyar	64±13 (44-75)	36±2 (33-39)	8±3 (6-12)	18±4 (11-24)	24±4 (17-29)	14±4 (10-21)
7.	Richholi	64±6 (58-75)	38±3 (34-44)	7±2 (5-9)	16±2 (12-18)	24±3 (21-29)	9±1 (7-10)
8.	Gopri	76±10 (62-87)	46±5 (39-54)	11±2 (9-14)	15±3 (12-19)	21±7 (19-26)	14±3 (10-19)
9.	Pachapadra	87±7 (78-98)	49±6 (41-59)	17±2 (13-20)	24±5 (19-31)	22±2 (19-25)	17±2 (15-21)
10.	Mahadpura	72±4 (69-79)	41±2 (39-44)	9±2 (7-12)	23±3 (19-26)	20±3 (15-25)	11±2 (9-13)
11.	Kasajiyon ki Dhani	63±4 (58-68)	32±3 (28-36)	7±1 (5-9)	15±4 (10-21)	23±2 (19-26)	14±2 (11-17)
NAAQS (2009) 24 h		**100**	**60**	**80**	**80**	**400**	**100***

*** 8 hours ozone (O_3) NAAQS = 100 µg/m^3**

3.3.2.1 Particulate Matter (PM10 & PM2.5)

The average PM10 concentrations at all the locations varied in the range of 59-87 µg/m3, which represents background concentrations of rural environment and could be attributed to windblown soil dust and unpaved roads in the region. The highest concentration was found at Pachpadra and lowest at Samru Ki Dhani. All The levels were observed for PM10 concentrations in the study area within the stipulated CPCB standards (24 hourly PM10=100 µg/m3) (**Table 3.4**).

The average PM2.5 concentrations ranged between 25-49µg/m3, which were observed to be well below the stipulated CPCB standards (24 hourly PM2.5=60 µg/m3).

Table 3.5 Levels of Particulate Associated (Pb, Ni, As and BaP) Toxic Pollutants (Oct.-Dec. 2013)

Sr. No.	Sampling location	Pb	Ni	As	BaP
		µg/m^3	ng/m^3	ng/m^3	ng/m^3
1	Deval ki Dhani (Project Site)	BDL	3.1	BDL	BDL
2	Sajiyali	BDL	1.7	BDL	BDL
3	Kalawa	BDL	3.8	BDL	BDL
4	Akarli	BDL	2.3	BDL	BDL
5	Samaru ki Dhani	BDL	2.8	BDL	BDL
6	Kiyar	BDL	3.3	BDL	BDL
7	Richholi	BDL	3.5	BDL	BDL
8	Gopri	BDL	3.7	BDL	BDL
9	Pachapadra	BDL	5.2	BDL	BDL
10	Mahadpura	BDL	4.3	BDL	BDL
11	Kasajiyon ki Dhani	BDL	3.2	BDL	BDL
NAAQM (2009)		**1**	**20**	**6**	**1**

BDL: Below Detectable Limit

3.3.2.2 Gaseous Pollutants

SO2 and NOx

The average concentrations of SO2 and NOx ranged between 6-17 µg/m3 and 12-24 µg/m3 respectively. The levels of gaseous pollutants were below the 24 hourly CPCB standards of 80 µg/m3 each for the SO2 and NOx.

Ammonia (NH_3)

Atmospheric ammonia (NH3) is a pollutant which is highly soluble in water, its major sink in the atmosphere is by wet deposition. The residence time of ammonia in the lower level of the atmosphere is a few hours, though in the calm environment it may exist for weeks. Ammonia is the major base present in the atmosphere and is therefore important in neutralizing acidic species such as SO2, H2SO4, HNO3 and HCl. To assess the levels of ammonia in air, samples were collected by passing air through absorbing media and analyzed by wet chemical method.

The average concentration of ammonia ranged between 19-25 µg/m3. All these values are well within the stipulated CPCB standards (400 µg/m3).

Table 3.6 Levels of Volatile Organic Pollutants (Oct.-Dec. 2013)

Spot concentration

Sr. No.	Sampling location	CO	Benzene	THC	MHC	NMHC
		mg/m^3	µg/m^3			
1	Deval ki Dhani (Project Site)	0.18	BDL	240	160	80
2	Sajiyali	0.24	BDL	266	180	86
3	Kalawa	0.67	BDL	272	182	90
4	Akarli	0.24	BDL	262	178	84
5	Samaru ki Dhani	0.19	BDL	265	185	80
6	Kiyar	0.39	BDL	262	170	92
7	Richholi	0.77	BDL	276	182	94
8	Gopri	0.52	BDL	261	177	92
9	Pachapadra	0.72	BDL	278	180	98
10	Mahadpura	0.31	BDL	276	186	90
11	Kasajiyon ki Dhani	0.19	BDL	264	182	82
NAAQM (2009)		**4**	**5**	**-**	**-**	**-**

THC=Total Hydrocarbon; MHC= Methane Hydrocarbon; NMHC=Non methane Hydrocarbon

Ozone (O_3)

Ozone (O3) is a secondary air pollutant formed by photochemical reactions involving oxides of nitrogen (NOx) and VOCs, mainly hydrocarbons. In the presence of solar radiation, nitrogen dioxide (NO2) dissociates to form nitric oxide (NO) and an oxygen atom (O). Ozone (O3) is then formed by molecular oxygen (O2) reacting with the oxygen atom (O). However, when hydrocarbons are present, NO is converted to NO2, thus leaving little NOx to react with O3. This reaction leads to a build-up of O3 in the atmosphere. Sources of NO2 and VOCs are primarily anthropogenic, generally produced during combustion processes from automobile emissions and industrial activities.

To assess the levels of ozone in air, samples were collected by passing air through absorbing media during day time (0800-1800 h) assuming ozone production occurs in the presence of solar radiation, NOx and VOCs. The samples were analyzed by wet chemical method. The observed average concentration at all the locations ranged between 9-17µg/m3 (Table 3.4) which were below the stipulated CPCB standards (8 hourly =100 µg/m3).

3.3.2.3 Particulate associated Toxic Pollutants

Airborne particles are important carriers of metals, some of which possess toxic properties. The concentrations and size distributions of trace metals are governed by the nature of emissions to the atmosphere, as well as rates of wet and dry deposition, cloud processing, and exchange of air between the boundary layer and the free troposphere, and chemical transformations. The elevated metal concentrations, can pose a serious risk to human health. Fossil fuel utilization, such as vehicular exhaust and lubricant residues, are considered important contributors of toxic pollutants. Four major toxic pollutants Pb, Ni, As, and BaP have been included in the National Ambient Air Quality Standards. Their significance and observed concentration levels are briefly summarized here.

Lead (Pb)

Lead (Pb) is a metal found naturally in the environment as well as in manufactured products. The major sources of lead emissions are motor vehicles (such as cars and trucks) and industrial sources such as lead smelters, waste incinerators, utilities and lead-acid battery manufacturers. Depending on the level of exposure, lead can adversely affect the nervous system, kidney function, immune system, reproductive and developmental systems and the cardiovascular system. Lead exposure also affects the oxygen carrying capacity of the blood. Lead is persistent in the environment and accumulates in soils and sediments through deposition from air sources, direct discharge of waste streams from mining, and erosion to water bodies. Ecosystems near point sources of lead demonstrate its adverse effects including losses in biodiversity, changes in community composition, decreased growth and reproduction rates in plants and animals, as also neurological effects in vertebrates.

The observed lead concentration at all the locations was found below detectable limit (BDL). The permissible CPCB limit for Pb is 1.0µg /m3.

Arsenic (As)

Arsenic (As), a naturally occurring element is widely distributed in the earth's crust and inorganic forms of arsenic are found throughout the environment. It is released into the air by volcanoes, weathering of arsenic-containing minerals and ores, and commercial or industrial processes. Metal smelters release elevated inorganic arsenic into the air. Other air sources of inorganic arsenic exposure include burning of plywood treated with an arsenic wood preservative. Acute (short-term) high-level inhalation exposure to arsenic dust or fumes can cause gastrointestinal effects (nausea, diarrhea, abdominal pain) and nervous system disorders. Chronic (long-term) inhalation exposure to inorganic arsenic can cause irritation of the skin and mucous membranes and lung cancer.

The arsenic concentrations at all the locations were found below detectable limit (BDL), whereas CPCB permissible limit is 6 ng/m3.

Nickel (Ni)

Nickel is a naturally occurring element and can be combined with other metals, such as iron, copper, chromium, and zinc, to form alloys. These alloys are used to make coins, jewelry, and items such as valves and heat exchangers. Most nickel is used to make stainless steel. Nickel can be released into ambient air from oil and coal combustion, nickel metal refining, sewage sludge incineration, and other sources. Respiratory effects are associated with chronic exposure to nickel in the

air. Workers who breathe very large amounts of nickel compounds develop chronic bronchitis and lung and nasal sinus cancers.

The Ni concentration at all the locations was found to be in ranged between 1.7-5.2, whereas the permissible limit of CPCB for Ni is 20 ng/m3.

Benzo (α) pyrene (BaP)

BaP is the most well-known polycyclic aromatic hydrocarbon (PAH) in a large group of organic compounds with two or more fused aromatic rings. PAHs are formed mainly as a result of incomplete combustion of organic materials during industrial and other anthropogenic activities including processing of coal and crude oil, combustion of natural gas, combustion of refuse, vehicular traffic, cooking and tobacco smoking, as well as natural episodes such as forest fires. Motor vehicle exhaust and their re-suspension are major contributors of PAHs, including benzo[α]pyrene. BaP will tend to be adsorbed onto particulates during cooling and condensation in the atmosphere and generally exist in the particle phase at normal ambient temperatures in the atmosphere. Particle sizes will be mostly <2.5 µm(aerodynamic diameter). Processes governing the fate of BaP in the atmosphere are the same processes that govern transport and removal of these small particles from the atmosphere.
The observed BaP concentrations were found below detection limit (BDL) in all locations whereas the permissible limits of CPCB for BaP is 1 ng/m3.

Carbon Monoxide (CO)

Carbon monoxide is a colorless and odorless gas. It is formed when substances containing carbon are burned with an insufficient supply of air. The combustion of fuels such as petrol, gas, coal and wood generate carbon monoxide. Gas and wood used for cooking and heating in appliances like stoves and barbecues add to such emissions. Apart from it, motor vehicles are also one of the main sources of carbon monoxide pollution in urban and sub-urban environment.

The results of CO are presented in **Table 3.6**. The observed carbon monoxide concentration at all the locations varied between 0.18-0.77 mg/m3, which are within the permissible limits of CPCB (CO for 1 hour = 4mg/m3).

3.3.2.4 VOCs

Hydrocarbons

Hydrocarbons present in atmosphere are from both natural and anthropogenic sources. Natural sources of hydrocarbons are from biological sources though hydrocarbons also come from geothermal areas, coal fields, natural gas from petroleum field and natural fires. The anthropogenic sources include transportation, emissions from fuel tanks etc. In rural areas the background levels are due to the natural ecological emissions of methane, methanogenesis (methane producing bacteria), which release methane into surrounding environment, rice paddy fields, ruminant animals particularly cow and goat produce methane when burp and defecate, termites, plant waste dumps etc.

Samples for hydrocarbons were collected in Tedlar bags and analyzed by HC Direct analyzer within 24 hours. The observed concentration of total hydrocarbons

varied in the range of 240-278 µg/m3, wherein methane concentration was in the range of 160 -186 µg/m3 (**Table 3.6**).

Benzene

The samples for benzene were collected in Tedlar bags and analyzed by BTEX analyzer within 24 hours. At all locations Benzene levels were observed to be below detectable level (BDL). The permissible limits of CPCB (Benzene = 5µg/m3).

3.4 NOISE ENVIRONMENT

Sound is mechanical energy generated by a vibrating source, transmitted through a medium and received by receiver. It can be transmitted through gases, liquids and solids. Sound can be wanted and unwanted, when it is unwanted, we call it noise pollution. The noise problem is said to exist when the sound level in the air causes interference in human activities such as disturbance in sleep, work and speech communication leading to annoyance. Many people are exposed to dangerous levels of noise without realizing it whether it is from loud music, a motorcycle, airplane or a running train.

Perception of noise by individuals varies depending on number of factors such as natural sensitivity/hearing ability, level of exposure, time of the day, socio-cultural activities etc. at the time of exposure to sound. The impact of noise at community level can have different effects varying from aesthetic impairment such as annoyance, frequent hypertension to as high as loss of hearing. The health impact of noise on individual depends on several factors, viz. physical dose (intensity of sound pressure level and duration of exposure), frequency spectrum, intermittency etc. as well as human factors like sex, age, health condition, occupational exposure etc. The continuous exposure to noise above 70 decibels dB (A) can lead to permanent hearing damage. Excessive noise levels can also lead to increase of heart beat, blood pressure and blood cholesterol. It also has the potential to harm the respiratory and digestive systems. Constant noise can lead to stress disorders, which could further develop into ulcers or high blood pressure. A large amount of noise every day not only causes stress for people but also contribute to mental illness and loss of productivity.

Noise pollution also effects the vegetation, causing poor quality of crops. It also damages the nervous system of animals. Loud noise also weakens the buildings, bridges and monuments.

Assessment of noise impacts and the significance of any impact as a result of development are dependent upon the number of factors such as the ambient or background noise levels in the vicinity of the site, the type of development and its operating characteristics. Therefore monitoring for noise levels was carried out to identify and quantify the existing sources of noise in the study area. The pre-project noise level status serves as the baseline upon which the predicted impacts from the proposed project are superimposed to derive the post-project scenario of noise levels after commissioning and operation of the proposed development.

Methodology for Noise Monitoring

Noise standards have been designated for different types of land use, i.e. residential, commercial, industrial and silence zones, as per 'The Noise Pollution

(Regulation and Control) Rules, 2000, Notified by the Ministry of Environment and Forests, New Delhi on February 14, 2000'. Different standards have been stipulated during day time (6 am to 10 pm) and night time (10 pm to 6 am).

The noise rating method as Leq i.e. equivalent sound pressure level has been adopted for the measurement of noise level at various selected sampling locations of this region. It is the energy means of the noise level over a specified period and is expressed in terms of decibels.

$$L_{eq} = 10\log\left(\frac{1}{T}\int_0^T 10^{LP(t)/10}\right)dtdB(A)$$

The noise scale A-weighted network in dB(A) was used for monitoring of noise level. Leq in dB(A) denotes the frequency weighting in the measurement of noise and corresponds to frequency response characteristics of human ear. The average of Leq at each location is calculated using energy average formula:

$$Energy..average = 10\log\left[\frac{1}{n}\sum_{i=1}^{n}10^{Lpi/10}\right]$$

At some locations total noise due to multiple sources at observer's location was calculated as follows:

$$Lp_{TOTAL} = 10\log\left[\sum_{i=1}^{n}10^{Lpi/10}\right]$$

Day night sound level (Ldn) for 24 hours equivalent sound level can be calculated as follows:

$$Ldn = 10\log\left[\frac{1}{24}\left(\sum_{i=1}^{16}10^{(Leq)i/10} + \sum_{j=1}^{8}10^{(Leq)j+10/10}\right)\right]$$

Where,

Ldn	:	Day night sound level
'i'	:	Denotes the sum over the 16 hours during the daytime
'j'	:	Denotes the sum over the 8 hours during the night time
$LAeq_{(i)}$	:	Equivalent noise level for 'i'th hours
$LAeq_{(j)}$	:	Equivalent noise level for 'j'th hours

The study area mainly consists of rural activity with sparse human settlement. Residential, commercial, and silence zones in the study area were identified. Equivalent noise levels (LAeq) for a period of about 60 minutes were measured at each monitoring location during day time and night time. The noise monitoring was carried out during Post Monsoon season (2013). The monitoring locations are shown in **Figure 3.4** and summarized in **Table 3.7**.

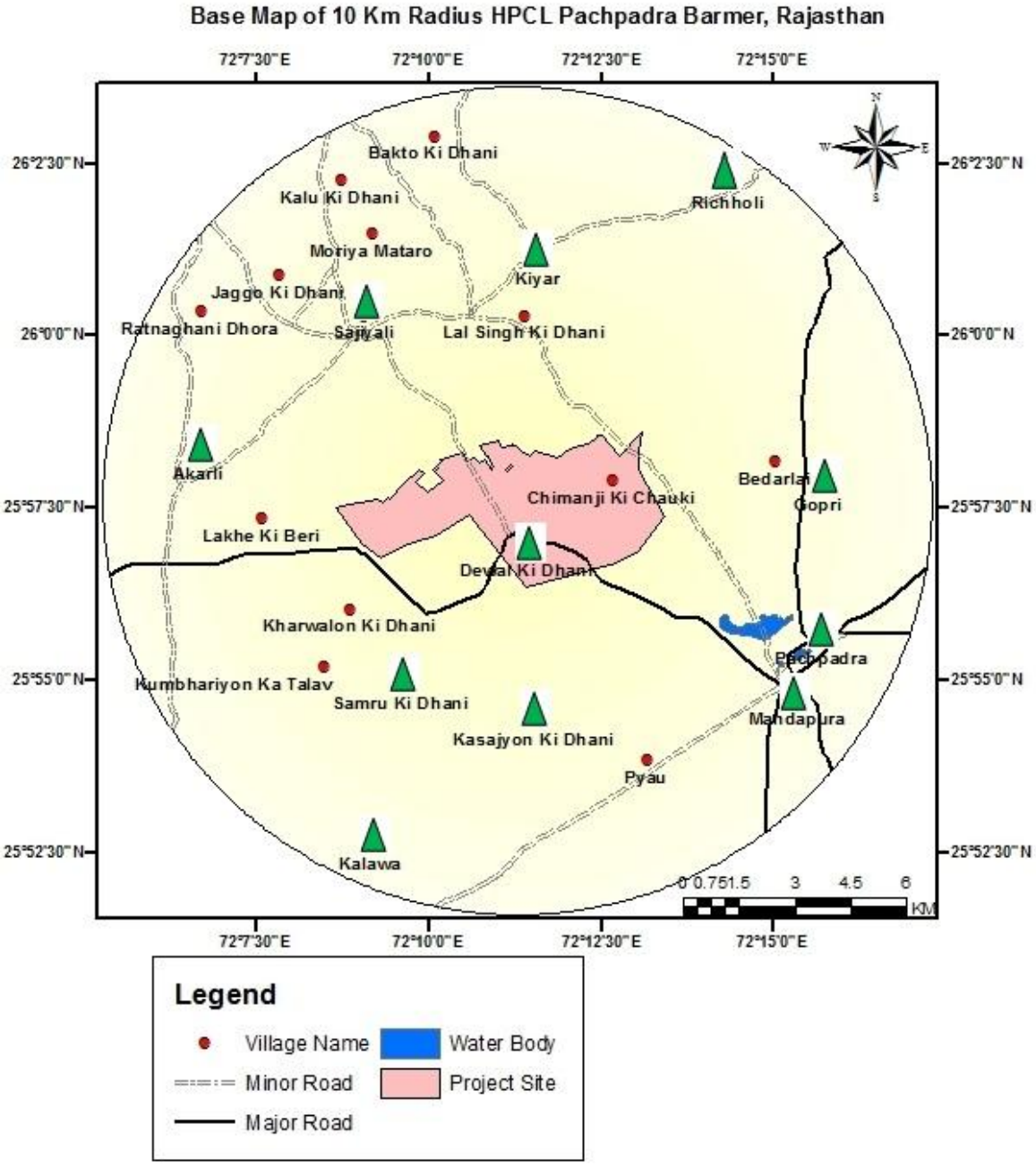


Figure 3.4: Noise Monitoring Locations

Background Noise Levels

The major noise sources included residential activity (11 locations), commercial activities (04 locations) and silence zone (08 locations). There is no industrial zone

within the study area. The background noise levels are compared with the stipulated standards of CPCB.

Table 3.7 Location for Monitoring Noise Levels (Oct.-Dec. 2013)

Sr. No.	Location	Latitude / Longitude	Directions from Project Site	Distance From Project Site
1	Dewal Ki Dhani	N 25^{0}56'15.0'' E 72^{0}11'01.7''	CENTRE POINT	--
2	Sajiyali	N 26^{0}00'02.7'' E 72^{0}08'56.2''	NW	5.7
3	Kalawa	N 25^{0}52'28.8'' E 72^{0}08'55.5''	SSW	9.2
4	Akarli	N 25^{0}57'58.7'' E 72^{0}06'20.5''	W	7.8
5	Samara ki Dhani	N 25^{0}54'53.1'' E 72^{0}09'22.5''	SW	5.2
6	Kiyar	N 26^{0}00'38.6'' E 72^{0}11'20.1''	N	5.9
7	Richholi	N 26^{0}02'27.1'' E 72^{0}15'27.9''	NNE	9.4
8	Gopri	N 25^{0}58'01.1'' E 72^{0}15'25.1''	E	7.1
9	Pachpadra	N25^{0}55'14.9'' E72^{0}15'23.5''	ESE	8.2
10	Mahdapura	N 25^{0}54'49.3'' E 72^{0}14'59.2''	SE	8.3
11	Kasaiyon Ki Dhani	N 26^{0}01'09.9'' E 72^{0}11'30.9''	S	5.5

3.4.1 Noise Levels in Residential Zone

The equivalent noise level (LAeq) recorded at different residential locations within the study area as given in **Table 3.8**, ranged between 43-59 dB (A) during day time and 32-42 dB(A) during night time. The noise levels during day and night time were mostly below the stipulated noise levels in residential areas except Pachpadra due to National Highway 112 passing through, congested road pattern and dense pattern. (Day time= 55 and night time 45 dB (A)).

3.4.2 Noise Level in Commercial Zone

The equivalent noise level (LAeq) recorded at different commercial locations within the study area is given in **Table 3.9**. The noise level (LAeq) ranged between 57- 74 dB(A) during daytime and 40-54 dB(A) during night time. The noise levels were mostly around the stipulated noise level as per the CPCB standards of commercial areas due to National Highway 112 passing through it and commercial place for surrounding villages (day time= 65 and night time 55 dB(A)).

3.4.3 Noise Level in Silence Zone

The equivalent noise level (LAeq) recorded at different silence locations (schools) within the study area are given in **Table 3.10**. Noise levels were found to be 41-56

dB(A) during daytime and 32 - 41 dB(A) during night time respectively. The noise levels (LAeq) were within the CPCB standards for silence zone accept Pachapadra. (day time= 50 and night time 40 dB (A)).

Table 3.8 Noise Level in the Residential Area (Oct.-Dec. 2013)

Sr. No.	Sampling Location	Day Time Leq. (dBA)	Night Time Leq. (dBA)
1.	Deval ki Dhani (Project Site)	43	32
2.	Sajiyali	51	36
3.	Kalawa	49	38
4.	Akarli	47	36
5.	Samaru ki Dhani	45	34
6.	Kiyar	50	37
7.	Richholi	49	38
8.	Gopri	56	40
9.	Pachapadra	59	42
10.	Mahadpura	57	36
11.	Kasajiyon ki Dhani	46	34
	CPCB Standard	**55**	**45**

Table 3.9 Noise Level in Commercial Area (Oct.-Dec. 2013)

Sr. No.	Sampling Location	Day Time dB(A)	Night Time dB(A)
1.	Pachpadra	74	54
2.	Mahadpura	66	49
3.	Sajiyali	57	40
4.	Gopri	66	49
	CPCB Standard	**65**	**55**

Table 3.10 Noise Level in Sensitive Zone (Oct.-Dec. 2013)

Sr. No.	Sampling Location	Day Time dB(A)	Night Time dB(A)
1.	Rajkiya Mahavidhyalaya School, Akarli Dhansingh	42	32
2.	State Primary Health Centre, Sajiyali	41	39
3.	Primary Health Centre, Kosariya	43	38
4.	High School, Pachpadra	56	46
5.	Rajkiya Primary School, Kiyar	47	38
6.	High School Gopri	41	37
7.	Primary School, Kalawa	42	38
8.	Primary Health Centre, Richholi	51	37
	CPCB Standard	**50**	**40**

3.4.4 Vehicular Count

Movement of vehicles, particularly heavy duty vehicles generate, is a major source of air as well as noise pollution. Air pollution is generated not only from the exhaust pipes, but also movement of vehicles lead to re-suspension of dust from the roads. Further, vehicles become a major source of noise pollution due to vibrations and blowing of horns.

National Highway No 112 from Barmer to Jodhpur exists in the study area. Traffic was counted with respect to different category of vehicles, like 2-Wheelers, 4-Wheelers (car, jeep etc.), light commercial vehicles, buses, trucks and tractors & tankers. Classified average traffic count observed at the Pachpadra, Richholi and Sajiyali Square (near Hotel Naganaray) is given in **Table 3.11**.

Table 3.11 Vehicle Count within Study Area on NH 112 (Oct.-Dec. 2013)

Sr. No.	Type of Vehicle	Average Vehicle count per day
1.	Two wheelers (Scooter, Motorcycle)	1478
2.	Four Wheelers (Car, Jeep and Vans)	870
3.	Light Commercial Vehicles	448
4.	Standard Buses	338
5.	Trucks	690
6.	Tractor and tanker	67
7.	Cycles	53
	Total	**3944**

3.5 WATER ENVIRONMENT

3.5.1 Reconnaissance

The proposed project site is located in Balotra tehsil of Barmer district which is at a distance of about 100 km from Barmer (Rajasthan). In this area, the traditional techniques of rainwater harvesting provide convenient, moderately clean and sweet water for drinking which eliminates the need to search for water in the hot months.

The principal source of recharge of groundwater in Rajasthan is rainfall. Irrigation is limited by the scarcity of water and has traditionally been restricted to deep wells and groundwater harvesting systems. The depth of dug well ranges from 80m - 200m respectively as per the information provided by local villagers to the monitoring team during sampling. Traditionally there have been a lot of manmade efforts to harvest water in this region. Harvesting of rainwater is in the Storage tank. The rainwater is collected in the Storage tank and is taken through pipes to the underground tank built within the main house or in the courtyard. The Balotra region also has kunds, which are underground storage system of rainwater harvested during the monsoon.

The limited groundwater resources are used for drinking and irrigation purposes. The nearby area of the project site has not been developed yet.

A study was undertaken and monitoring locations were decided on the basis of location of residential areas representing different activities/likely impact areas and other areas, which can represent baseline conditions.

3.5.1.1Methodology for Water Quality Assessment

Samples were collected from the identified locations of surface water (Gulab Sagar Lake and Kumabhariyo ka Talaw), rainwater stored in tank and groundwater resources existing in the study area as depicted in **Figure 3.5** and details provided in **Table 3.12**. One surface water sample was collected from the identified location Indira Gandhi Canal which is the source of water to the proposed HPCL refinery. It is approximately about 200 km from the study area. Samples were analyzed for selected physico-chemical and bacteriological parameters to study the intrinsic quality of water resources. The analysis protocol was followed as per the procedures specified in 'Standard Methods for the Examination of Water and Wastewater' published by American Public Health Association (APHA) and 'A Course Manual for Water and Wastewater Analysis' by NEERI, Nagpur.

Samples for chemical analysis were collected in polyethylene carboys. Samples collected for metal content were acidified with HNO3 acid (conc. 98%) to pH < 2. Samples for bacteriological analysis were collected in sterilized glass bottles. Selected physico-chemical and bacteriological parameters have been analyzed for assessing 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. Standard Operating Procedure (SOP) for water and wastewater sampling and analysis presented in **Table 3.13**; was ensured during sampling and analysis. The results were compared with the environmental standards as per IS 10500 (1991).

3.5.1.2 Surface Water Quality

In all 8 surface water samples were collected from project site, among which 3 samples were collected from canal and Gulab Sagar lake water and 5 samples were collected from rain water harvesting storage tank. The physico-chemical characteristics of canal and lake water in Post-monsoon season 2013 are summarized in the **Tables 3.14** to **3.16**. The water quality indicated: pH 7.5 - 8.5, turbidity 1 - 10 NTU, total dissolved solids (inorganic) 195 – 254 mg/l, total hardness 52 – 97.2 mg/l, chlorides 17.99 – 102.96 mg/l, and sulphate 3.5 – 10 mg/l. Fluoride was found to be 0.0886 – 0.875 mg/l. Nutrients content in the form of nitrate and total phosphates was in the range of 0.20 – 8.63 mg/l and 0.158 – 1.31 mg/l respectively. Dissolved oxygen was in the range of 6.8 – 7.9 mg/l whereas oil & grease were observed as 1– 7 mg/l. The heavy metals like cadmium, chromium, zinc and arsenic were not detectable; whereas Nickel, copper, lead, iron, manganese, cobalt and aluminum were found to be in the range of ND-0.001, ND-0.006, 0.004-0.616, 0.003-0.008, ND-0.001 and 0.090-2.200 mg/l respectively.

The physico-chemical characteristics of Rain water harvesting storage tanks are summarized in the **Tables 3.3.2** to **3.3.5**. The water quality indicated: pH 7.6 – 8.3, turbidity 1 - 21 NTU, total dissolved solids (inorganic) 140 – 2600 mg/l, total hardness 22 – 134.4 mg/l, chlorides 3.99 – 129.55 mg/l, and sulphate 2 – 425 mg/l. Fluoride was found to be 0.875 – 1.18 mg/l (1.18 mg/l fluorides was found in village Kasaiyon ki dhani). Nutrients content in the form of nitrate and total phosphates was in the range of 0.29 – 2.56 mg/l and 0.025 – 1.54 mg/l respectively. Dissolved oxygen was in the range of 6.1 – 7.1 mg/l whereas oil & grease was observed as 3– 10 mg/l which may be due to various utensils used for drawing water from rain water harvesting storage tank or oiling and greasing of the top cover of the tank. The heavy metals like Nickel, copper, lead, iron, manganese and zinc were observed in the

range of ND-0.03, ND-0.016, ND-0.020, 0.078-0.607, 0.001-0.440 and ND-0.003 mg/l; whereas other heavy metals were not detectable.

3.5.1.3 Groundwater Quality

In all 4 groundwater samples (one dug well and 3 hand pump) were collected in and around the project site. The physico-chemical characteristics of groundwater are presented in **Tables 3.13** to **3.16**. The groundwater quality showed high mineral contents in the form of total dissolved solids, total hardness, chlorides, sulphates, chemical oxygen demand, biochemical oxygen demand, sodium and potassium with their respective concentration as 2960 – 4055 mg/l, 688 – 1986 mg/l, 855 – 1949 mg/l, 400 – 562.5 mg/l, 16 – 80 mg/l, 2.6 mg/l, 585.7 – 679.5 mg/l, and 11.4 – 73.6 mg/l respectively. It could be attributed to the geological formation in the region. Fluorides were in the range of 0.171 – 2.49 mg/l which is above the permissible limit which includes villages Kiyar and Meghwalo ki dhani. It may be attributed to the geological formation in the region making the water unfit for drinking. Heavy metals were observed within the permissible limit except for iron: 0.110-23.920 mg/l and Zinc: ND-9.830 mg/l. Higher values were observed in village Meghwalo ki dhani; which makes water unfit for drinking.

3.5.2 Bacteriological Characteristics

Coliform group of organisms are indicators of bacterial pollution. The water samples were analyzed for estimating total and faecal coliforms using membrane filtration techniques and specific growth media. The bacteriological count of surface water (canal and lake water), rain water storage tank and groundwater in post-monsoon season 2013 are presented in **Table 3.17**.

Total coliforms and fecal coliforms count in canal and lake water was found to be in the range of 190-290 CFU/100 ml and 35 - 75 CFU/100ml; whereas total coliforms and fecal coliforms count in rain water storage tank were 5 - 10 CFU/100 ml and ND CFU/100ml respectively. Total coliforms and fecal coliforms count in groundwater was found to be in range of 15 – 45 CFU/100 ml and 2 – 9 CFU/100ml respectively indicating that the water is not fit for drinking without disinfection.

3.5.3 Characteristics of Treated Effluent to be Re-used

Since, HPCL proposes to utilize, treated effluent from the existing Balotra CETPs as a water source during construction purpose, the treated effluent from CETP outlet was collected and analysed for physico-chemical parameters and is given in **Table 3.18**. As per the analysis, the treated effluent needs to be further treated before utilizing for construction purpose for removal of organics.

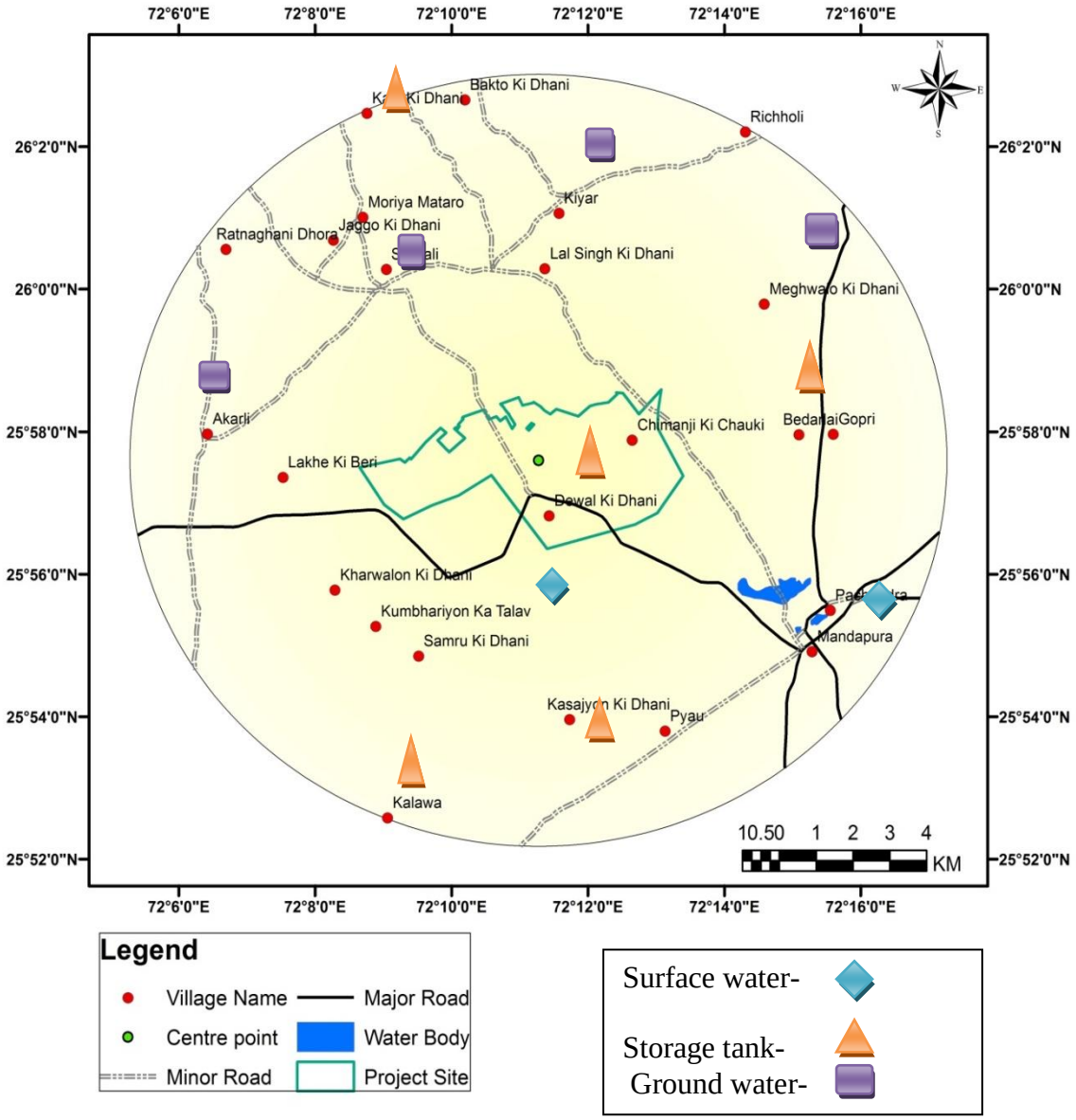


Figure 3.5: Water Sampling Locations

Table 3.12 Water Quality – Sampling Locations (November 2013)

Sr. No.	Sampling Locations
	Surface Water
1	Indira Gandhi Canal
2	Gulab Sagar Lake- village Mandapur
3	Kumabhariyo Ka Talaw
	Tank Water
4	Village Bedarlai

5	Village Kalu ki dhani
6	Village Dewal ki dhani
7	Village Kasaiyon ki dhani
8	Village Kalua
	Ground Water
	Dug Well
9	Village Akarli
	Hand pump
10	Village Meghwalo ki dhani
11	Village Kiyar
12	Village Sajiyali

Table 3.13 Water Quality - Physical Parameters (November 2013)

Sr. No.	Sampling Locations	pH	Temp. (^{0}C)	Turbidity (NTU)	Total suspended solids (mg/l)	Total Dissolved Solids (mg/l)	Conduc-tivity (µS/cm)
	Surface Water						
1	Indira Gandhi Canal	7.5	21	1	3	195	330
2	Gulab Sagar Lake-village Mandapur	8.5	24	10	13	220	320
3	Kumabhariyo Ka Talaw	7.6	23	5	5	254	425
	Tank Water						
4	Village Bedarlai	8.2	26	1	3	2600	4700
5	Village Kalu ki dhani	7.8	25	3	4	165	270
6	Village Dewal ki dhani	8.3	23	2	4	2256	3700
7	Village Kasaiyon ki dhani	8.0	25	21	18	140	220
8	Village Kalua	7.6	24	20	12	396	640
	Ground Water						
	Dug Well						
9	Village Akarli	8.4	30	1	8	3250	5800
	Hand pump						
10	Village Meghwalo ki dhani	7.6	29	23	83	4055	6200
11	Village Kiyar	8.0	29	15	13	3630	6600
12	Village Sajiyali	8.2	31	1	3	2960	5300

Table 3.14 Water Quality- Inorganic Parameters (November 2013)

Sr. No.	Sampling Locations	Total Alkali-nity	Total Hardness	Calcium Hardness	Chloride	Sulphate	Sodium	Pota-ssium
		(as $CaCO_3$)						
		mg/l						
Surface Water								
1	Indira Gandhi Canal	88	97	69	18	10	30	3
2	Gulab Sagar Lake- village Mandapur	88	52	44	39	9	54	4
3	Kumabhariyo Ka Talaw	60	81	72	103	4	65	4
Tank Water								
4	Village Bedarlai	330	662	224	994	325	592	12
5	Village Kalu ki dhani	376	113	104	4	2	10	7
6	Village Dewal ki dhani	178	484	264	763	425	542	11
7	Village Kasaiyon ki dhani	400	22	16	12	3	46	4
8	Village Kalua	370	134	80	130	25	95	5
Ground Water								
Dug Well								
9	Village Akarli	165	886	432	1145	487	586	74
Hand pump								
10	Village Meghwalo ki dhani	310	1986	1076	1949	525	640	12
11	Village Kiyar	92	1064	400	1560	400	679	16
12	Village Sajiyali	110	688	392	855	562	598	11

Table 3.15 Water Quality - Nutrient and Demand Parameters (November 2013)

Sr. No.	Sampling Locations	Nitrate as N	Total Phos - phates	Dissolved oxygen	Chemical Oxygen Demand	Bio-chemical oxygen demand	Oil & Grease	Fluoride
		mg/l						
Surface Water								
1	Indira Gandhi Canal	8.63	0.16	7.9	24	2.0	1	0.088
2	Gulab Sagar Lake-village Mandapur	8.27	1.31	6.8	20	2.6	6	0.875
3	Kumabhariyo Ka Talaw	0.20	0.10	7.7	16	2.3	7	0.291
Tank Water								
4	Village Bedarlai	7.47	0.02	6.3	48	5	10	1.060
5	Village Kalu ki dhani	0.29	0.33	6.9	56	8	9	0.00
6	Village Dewal ki dhani	1.56	1.54	7.1	60	10	3	0.875
7	Village Kasaiyon ki dhani	1.50	1.24	6.7	16	4.3	7	1.180
8	Village Kalua	2.56	0.17	6.1	32	6	7	0.00
Ground Water								
Dug Well								
9	Village Akarli	13.10	1.52	4.1	40	8	-	1.040
Hand pump								
10	Village Meghwalo ki dhani	1.81	1.28	3.1	-	-	-	0.171
11	Village Kiyar	9.03	1.45	3.3	-	-	-	2.490
12	Village Sajiyali	5.05	0.05	2.6	-	-	-	1.180

ND- Not Detectable

Table 3.16 Water Quality-Heavy Metals (November 2013)

Sr. No	Sampling Locations	Ni	Cd	Cr	Cu	Pb	Fe	Mn	Zn	Co	As	Al
		mg/l										
Surface Water												
1	Indira Gandhi Canal	ND	ND	ND	0.006	ND	0.004	0.003	ND	ND	ND	0.090
2	Gulab Sagar Lake-village Mandapur	0.001	ND	ND	ND	0.006	0.616	0.006	ND	0.001	ND	2.200
3	Kumabhariyo Ka Talaw	ND	ND	ND	ND	ND	0.149	0.008	ND	ND	ND	0.513
Tank Water												
4	Village Bedarlai	ND	ND	ND	ND	ND	0.078	0.001	ND	ND	ND	ND
5	Village Kalu ki dhani	0.001	ND	ND	ND	ND	0.105	0.440	ND	ND	ND	ND
6	Village Dewal ki dhani	ND	ND	ND	ND	ND	0.065	0.001	ND	ND	ND	ND
7	Village Kasaiyon ki dhani	0.003	ND	ND	ND	ND	0.607	0.009	ND	ND	ND	ND
8	Village Kalua	ND	ND	ND	0.016	0.020	0.465	0.002	0.003	ND	ND	ND
Ground Water												
Dug Well												
9	Village Akarli	ND	ND	ND	ND	ND	0.110	0.002	ND	ND	ND	0.023
Hand pump												
10	Village Meghwalo ki dhani	ND	0.001	ND	0.001	ND	23.920	0.362	9.830	ND	ND	ND
11	Village Kiyar	ND	ND	ND	0.001	ND	0.205	0.063	2.609	0.001	ND	2.140
12	Village Sajiyali	ND	ND	ND	ND	ND	0.065	0.001	0.034	ND	ND	ND

ND- Not Detectable

Table 3.17 Water Quality – Bacteriological Parameters (November 2013)

Sr. No.	Sampling Locations	Total Coli-form	Faecal Coliform	Bacterial Genus			
				Enterococci	Vibrio	Salmonella	Shigella
		CFU/100ml		CFU/ml			
Surface Water							
1	Indira Gandhi Canal	190	35	1	ND	ND	ND
2	Gulab Sagar Lake-village Mandapur	290	75	2	ND	ND	3
3	Kumabhariyo Ka Talaw	210	55	ND	1	ND	2
Tank Water							
4	Village Bedarlai	10	ND	ND	ND	ND	ND
5	Village Kalu ki dhani	5	ND	ND	ND	ND	ND
6	Village Dewal ki dhani	ND	ND	ND	ND	ND	ND
7	Village Kasaiyon ki dhani	5	ND	ND	ND	ND	ND
8	Village Kalua	ND	ND	ND	ND	ND	ND
Ground Water							
Dug Well							
9	Village Akarli	45	9	1	ND	ND	ND
Hand pump							
10	Village Meghwalo ki dhani	25	2	ND	ND	ND	ND
11	Village Kiyar	ND	ND	ND	ND	ND	ND
12	Village Sajiyali	15	ND	ND	ND	ND	ND

CFU : Colony Forming Unit ND : Not detected

Table 3.18 Physico-chemical Characteristics of Treated Effluent from Balotra CETP (November 2013)

Sr. No.	Parameters	CETP Outlet
1	pH	8.0
2	Alkalinity (mg/l) as $CaCO_3$	870
3	Total Suspended Solid (mg/l)	267
4	TDS (mg/l)	13259
5	Chlorides (mg/l)	6498
6	Sulphate (mg/l)	800

7	Sulphide (mg/l)	70
8	Fluoride (mg/l)	0.3
9	BOD (mg/l)	44
10	Oil & Grease (mg/l)	16
11	Total Phosphates (mg/l)	2.8
Heavy Metals (in mg/l)		
12	Nickel	ND
13	Cadmium	ND
14	Chromium	ND
15	Copper	0.0159
16	Lead	0.020
17	Iron	0.4652
18	Aluminium	1.417
19	Arsenic	ND
20	Manganese	0.0015
21	Zinc	0.0033
22	Cobalt	ND

ND: Not Detectable

3.6 LAND ENVIRONMENT

The impacts of any major developmental projects on land environment generally depend on type/category of proposed development. For example, the grass root /green field development requires land acquisition/procurement, site grading/ construction and operation. In such cases the impacts on land environment would be in the form of permanent change in landuse pattern as well as direct and indirect impacts on surrounding land due to pollution discharge in the form of flue gases, fugitive emission, liquid and solid wastes as well as subsequent urbanization. Apart from the above, the importance of impacts on land environment also depends on several factors like the project location, landuse / land cover in surrounding area, ecological or otherwise sensitivity of the surrounding regions etc. There is no tribal land acquired for Proposed RRP Project.

3.6.1 Geology, Hydrogeology & Seismicity of Barmer Region

3.6.1.1 Geological Features

Barmer district contains a variety of rock types ranging in age from upper Proterozoic to Quaternary. The district is underlain by intrusive rocks at the basement (Post Delhi formation) consisting of Jalore and Siwana granite & Malani rhyolite and granite. The pre- Malani ligneous Suit comprises volcanic phase (rhyolite, agglomeratetuff), plutonic phase (granite) and dyke phase rhyolite, felsites, prophyrite, basalt). The Malani

volcanics are dominated by acid volcanic flows. Three phases of acid volcanism, separated from each other by pyroclastic material, have been identified.

The basement is followed by Mesozoic and Tertiary formations consisting of sandstone, shale, conglomerate. Mesozoic is consisting with Lathi series of Jurassic and Abur series of Cretaceous period. It is represented by sandstone, siltstone, conglomerate and pockets of clay. Over most part of the area they are covered by Quaternary sediments and could be seen in dug well section. The Fatehgarh formation uncomfortably overlying the Lathi sandstone comprises sequences of conglomerate, gritty sandstone.On top of these lies a thick succession of Tertiary (Palaeocene and Eocene) sandstones, clay stones and lignite that were deposited in a predominantly fluvio-deltaic and marginal marine environment. Alluvium and Aeolian deposits of Quaternary to Recent age drape nearly all of the Tertiary formations, except for isolated areas located in the north of the block.

Lithostratigraphic units of the Barmer Basin Formation

Formation	Unit	Thickness	Lithology
Akli Formation & younger		0->1,000 m	Shales and lignites; sands in Miocene
Thumbli Formation / Tertiary Sandstone	Thumbli Sand	250-600 m	Sand and semi-consolidate sandstone with interbedded shales
Thumbli Formation / Tertiary Sandstone	Thumbli Shale (locally absent)	0-300 m	Shale
Dharvi Dungar Formation		200-1,200 m	Shales, locally carbonaceous, rare sands
Barmer Hill Formation		100-1,000 m	Shales and siltstones
Fatehgarh Formation		50-400 m	Sandstones and shales
Basement			Rhyolites and granites

The principal geological unit of Thumbli Formation is essentially identical to the Tertiary Sandstone unit. The Thumbli Formation sub-crops beneath a blanket of sand dune. The formation deepens towards the south where it is overlain by sediments of the Akli Formation and younger strata. The base of the Thumbli rests un-conformably on the
Dharvi Dungar Formation.

Geologically this is a stable zone and the area has not recorded any major seismic activity.

i) Shallow Geology

The soils are predominantly derived from alluvium and are covered by thick Wind - blown sand in arid sectors of the study area. The soils of the area can be classified as follows:

- Sandy soil (thal) covering approximately ¾ of the study area.
- Sandy clay (nayar) which can be salt impregnated.

- Patches of deposited loam near river beds.
- Accumulated deposits (par) at the foot of limestone ridges.

The last two classes of soil are very suitable for agriculture and can produce up to two crops per year, sometimes without irrigation.

Geomorphologically, the district is classified into seven geomorphic units, namely, alluvial plain, obstacle dune, complex/composite dune, parabolic dune, sand sheet, rocky desert and denudational hill. Geological features of Barmer district is show in **Figure 3.6**.

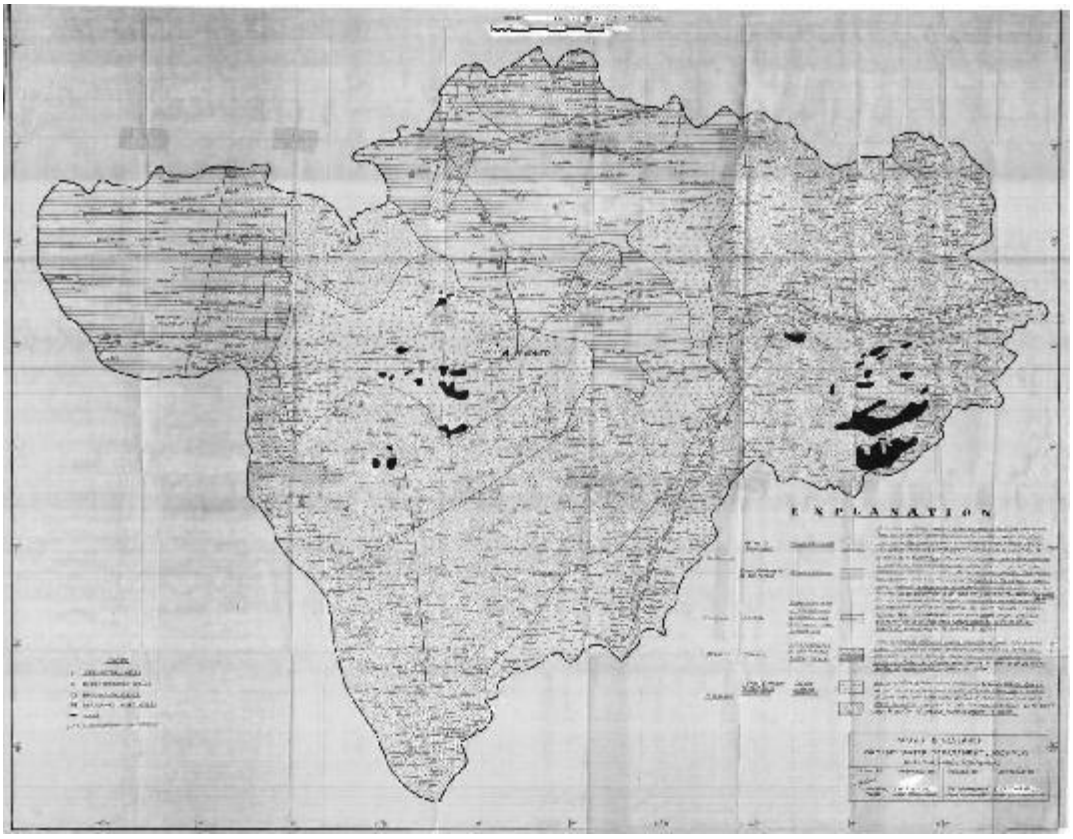


Figure 3.6 Map Showing Geological Features of Barmer District

3.6.1.2 Hydrogeology of Barmer District

The principal source of recharge to ground water in Rajasthan is rainfall, which is about

27 cm annually. Geo-hydrologically, the Barmer district is classified into three hydrological domains (unconsolidated alluvium and pebble; semi consolidated formations; and consolidated fissured formations). The main water bearing formations in the district are rhyolites and granites of post Delhi; Lathi sandstone, Tertiary sandstone and Quaternary alluvium. In quaternary alluvium, ground water occurs under semi confined to unconfined conditions, in semi consolidated tertiary and Mesozoic formations it occurs under unconfined to confined conditions and in weathered and fractured zones in hard rock's under phreatic conditions. Though groundwater occurs in all the formations but the most productive are the Lathis, Barmer sandstones and the Quaternary sediments. The Territories, which are predominantly clayey and argillaceous, are not found as productive except locally in the sandstone horizon. In general, the fractured and weathered zones in hard rock's

form poor aquifers. Hydrogeological fetures of Barmer district are presented in **Figure 3.7.**

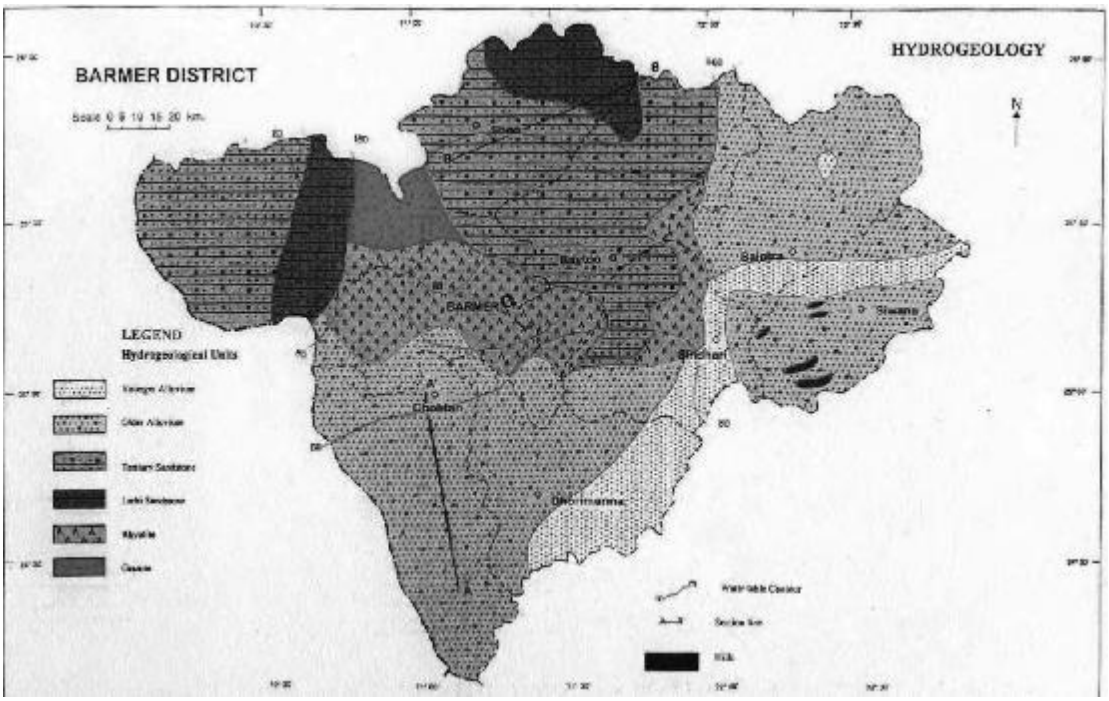


Figure 3.7 Map Showing Hydrogeological Features of Barmer District

A. Consolidated formations:

Consolidated formations include intrusive of Malani rhyolite and granite and Jalore & Siwana granites of Post Delhi. It lies in north western part of district, south of Siwana and entire western part of Barmer up to Harsani. It forms the poor aquifer.Ground water occurs under water table condition in fractured and weathered residuum down to a depth of 99 m. The rhyolites are partially impervious. They are sparingly jointed and weathered into a clayey impervious residum lessen the water bearing capacity. The rocks have secondary porosity and the water yielding capacity of rock units diminishes
with depth. Yield of dug wells taping rhyolites is lowest and ranges from 15 to 50 m3/day.

B. Semi consolidated formations:

Semi consolidated formations encompass Tertiary formation (alternate layers of clay and shale) which is unproductive aquifer. Lathi sandstone forms the most potential aquifer.

Lathi sandstone: Lathi sandstone forms the most potential aquifer and is constituted of medium to coarse grained sandstone with subordinate amount of gravel. It covers the total area of 7500 sq. km, and the extent of saturated Lathis with utilizable quality of ground water comprises about 3270 sq. km. The aquifer portion of the Lathi formation ranges in thickness from less than 100 m in the east to over 800 m in the northern part, east of Jaisalmer. The ground water in Lathi occurs under perched as well as main water table conditions and under confined condition. The eastern part of Lathis is unsaturated, except for perched saturated zone which supply water locally to

villages.The depth to water level and piezometric heads ranges from 30 m to over 120 m. The perched water table occurs between 6 and 30 mbgl. The piezometeric surface is shallower in area north of Jaisalmer-Pokaran road due to lower topography.

Tertiary Formation: Tertiary formations consisting of alternative layers of clay and shale associated with fuller's earth are unproductive aquifers. The boreholes tapping these formations were abandoned due to very poor yield and due to salinity of formation water.

C. Unconsolidated Formation:

Unconsolidated formation includes Quaternary alluvium that is most extensive,forms the potential aquifer and covers entire southern part and extreme western portion of the district. The exploration drilling data indicate that alluvium is composed of heterogeneous sequence of sand, silt, clay and kankar with occasional tongues and lenses of gravel and cobbles. The thickness of alluvium varies from 40 to 100 m. The ground water occurs under water table condition to semi confined condition. The perched water table condition occurs at shallow depth in clay beds and kankars which arrest the rain water of local precipitation.

Depth of Water Level during Pre & Post Monsoon-

Depth to water level in Barmer district ranges from 10.43 to 71.35 m bgl during pre-monsoon and 1.30 to 59.70 m bgl during post-monsoon, respectively. In Balotra block, the depth to water level varies between 14.4 m to 24.0 m during pre-monsoon and 14.12 m to 28.48 m during post monsson. Block-wise depth to water level for Balotra and Barmer is as follows:

Block	Pre-monsoon water level (mbgl)		Post-monsoon water level (mbgl)		Water level fluctuation during Pre & Post Monsoon (m)			
					Rise		Fall	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Balotra	14.4	24.03	14.12	28.48	0.22	7.62	4.45	4.45
Barmer	10.43	71.35	1.3	59.7	0.3	19.1	1.4	1.4

During pre monsoon, shallow water level of 10 to 20 mbgl exists in eastern region and 20 to 40 mbgl covered remaining of the blocks of Barmer.

Decadal Fluctuation in Water Level

Long term pre-monsoon (1997-2006) water level data of Hydrograph Stations show rise and declining trend of 0.02 and 0.08 m/year in Balotra block. During post monsoon decadal trend shows rise & decline of 0.04 and 0.05 m/year respectively. It is observed that over a major part of the district (lying in eastern and western part) shows maximum decline. Block-wise pre & post monsoon decadal trend for Balotra and Barmer is as follows:

Block	Pre-monsoon Trend (m/yr)		Post-monsoon Trend (m/yr)	
	Rise	Fall	Rise	Fall
Balotra	0.02	0.08	0.02	0.04
Barmer	0.01	0.04	0.04	0.05

Block-wise Long term pre-monsoon (1997-2006) and pre & post-monsoon 2006 water level trend observed in State Ground Water Department key wells is as follows:

Block	Change in Water level during Pre monsoon Period (1997-2006) (+ rise) (- fall)	Change in Water level during Pre & Post-monsoon Period (1997-2006) (+ rise) (- fall)
Balotra	- 7.21 m	+ 1.55 m
Barmer	- 1.38 m	+ 3.20 m

The significant decline of 7.21 m duirng the 10 years period (1997-2006) was observed due to increased ground water draft.

However, due to widespread and good rainfall in Barmer district in August 2006, rise in water level was observed in most of the blocks during pre & post monsoon period. Balotra and Barmer blocks recorded more than 4 m rise in water level.

Quality of Ground Water Aquifers

Ground water quality with respect to electrical conductivity, fluoride and nitrate contents of aquifers in Barmer District of earlier years.

The quality of ground water in water table aquifer varies widely from the composition of saline in Pachpadra salt lake to fresh water close to the hilly tract. Specific conductance ranges between 385 to 46,580 micro mhos/ cm at 25°C. It has been observed that by and large, concentration of specific conductivity confirms broadly with
that of chlorides. In greater part (about 60%) of the area, it is within 5000 micro mhos/ cm at 25°C. Higher values of specific conductance have been observed in the eastern parts of the district around Jasol, Central part around Hathi Tala and Sanwara, in northern part around Bisu kallan and in the north-western part around Napat. In general the quality of ground water deteriorates from upland and hilly tracts towards Luni River and its tributaries in the lower reaches and also in depressions in the vicinity of the saline lake.

The chloride content ranges from 10 to 19,099 ppm in phreatic aquifer and from 98 to 76470 ppm in deeper aquifer. Exploration has revealed that thickness of brine zone reaches up to about 60 m. The most extensive brine tract is between Thob and Chawa through Pachpadra.

Fluoride in the ground water ranges between traces and 11.30 mg/l. In major parts of the area, it is within the limit of 2.0 mg/l except in small pockets in the central part

around Chawa; in northern part around Kashmir and Sau Padam Singh; in north western parts around Sandra and in the southern parts around Shamu Ki Dhani.

The Nitrates in ground water varies widely. Its concentration ranges between traces to as high as 745 ppm. In north eastern part of the district, the concentration of nitrate is under permissible limit.

Ground Water Availability

The overall statge of ground water development of Barmer district as on March 2004 is 104.11% (excluding saline) whereas of saline ground water is 4.66%. Ground water availability as on March 2004, which shows that out of total eight blocks, 1 block (Barmer) falls in safe, 2 blocks (Chohtan, Sindhari) in critical and 5 blocks (Baetu, Balotra, Dhorimanna, Sheo, Siwana) in over-exploited categories. Most of the blocks (including Balotra) have over-expoited the groundwater and withdrawl of ground water in and around project site could not be permitted.

3.6.1.3 Seismic Zone of the Study Area

As per **Figure 3.8** illustrating Seismic zone Map of India (No. IS 1893 (Part 1):2002) prepared by IMD, it is clear that study area falls in Seismic Zone II. It means that seismic activities (earthquake, geotectonic etc.) are less active in the study area of RRP Project.

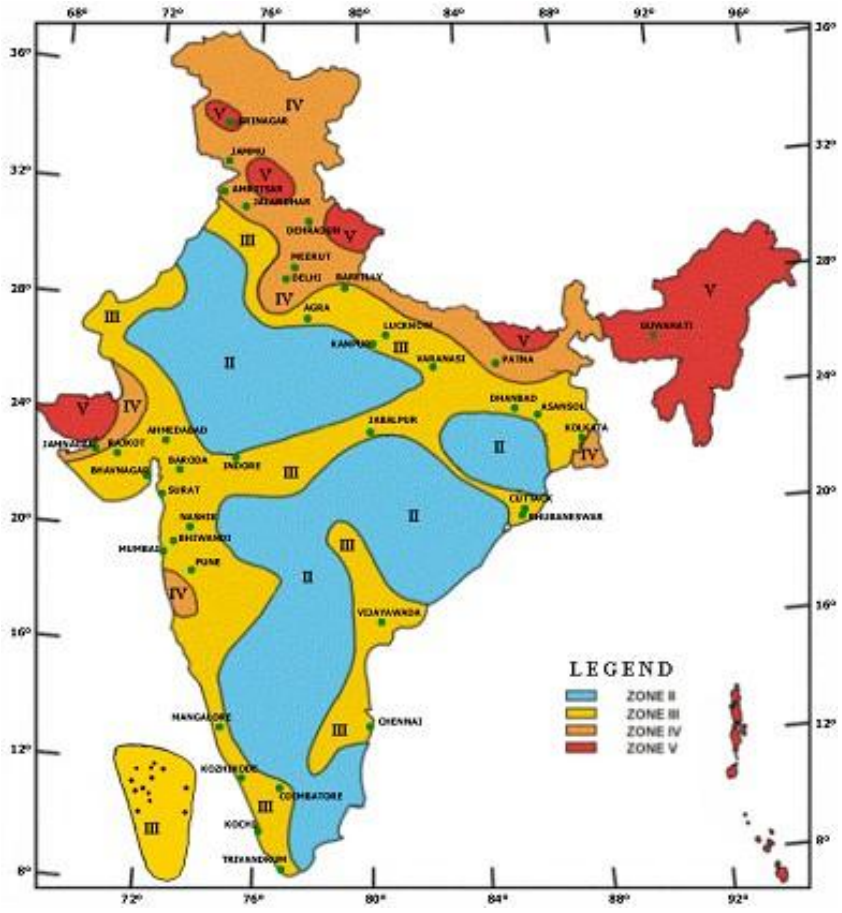


Figure 3.8 Seismic zonation map of India

Sources for Geology, Hydrogeology and Seismicity

1. Dirstrict Groundwater Brochure of Barmer District, Rajasthan prepared by CGWB, Western Region, Jaipur (July 2008),
2. Rajasthan State Groundwater Board Data,
3. http://www.imd.gov.in/section/seismo/static/seismo-zone.htm.
4. A Report on "Land use / Land Cover Analysis in and around the Onshore Oil Exploration Area of Rajasthan Block (RJ-ON-90/1) using Remote Sensing and GIS Techniques" by Regional Remote Sensing Service Centre, ISRO, Dept. of Space, Jodhpur.
5. ruidp.rajasthan.gov.in/.../Water%20Supply%20Project%20of%20Barmer (Initial Environmental Examination: Barmer Water Supply Subproject).

3.6.2 Soil Quality Assessment

3.6.2.1 Reconnaissance

The proposed study area is located in Pachpadra, Barmer districts of the southwestern Rajasthan i.e., within the Indian Thar. It has a unique natural ecosystem having low and extremely uncertain rainfall, soil deficient in organic matter and nutrients (NPK ratio), soil prone to salinization, and shifting sand dunes. The study area is 100 km from equidistance from Jodhpur and Barmer. The study area is barren land and uninhabited with sandy nature. National highway (NH-112) is 500 m away from the proposed project. There is no major population concentration has been found and it is dispersed in pockets throughout the study area. There is a saline depression at Pachpadra with characteristic halophytic vegetation. Soil samples were collected from 10 km radial distance.

Cropping pattern: The district comes under arid zone of the State and on account of non-availability of adequate water, cropping pattern is, by and large, single only. Only 3.22% of the net cultivated area are being utilised for double / multiple cropping. The total area under Kharif crop is 1190284 hectare and area under Rabi crop is only 34329 hectares. During Kharif, Bajra, Jowar, Moong and Moth are the main crops cultivated and during Rabi Wheat, Barley, Mustard and Taramira are the main crop in the district.

The study area also comes under arid zone, on account of non-availability of adequate water, cropping pattern is, by and large, single only. Only small area is used form double cropping. During Kharif, Bajra, Jowar, Moong and Moth are the main crops cultivated and during Rabi small area of Wheat, Barley, Mustard and Taramira are grown in the study area. Minimum area comes under irrigation due to poor ground water potential.

Rainfall & Climate

The study area experiences arid type of climate. Mean annual rainfall (1971-2005) of the study area is 281.8 mm whereas normal rainfall (1901-1971) is lower than average rainfall and placed at 277.5 mm. Almost 90% of the total annual rainfall is received during the southwest monsoon, which enters the study area in the first week of July and withdraws in the mid of September.

As the study area lies in the desert area, extreme of heat in summer and cold in winter is the characteristic of the desert. Both day and night temperature increases gradually and reaches their maximum values in May and June. The temperature varies from 48 degree in summer to 2 degree in winter. Atmosphere is generally dry except during the monsoon period. The humidity is highest in August with mean daily relative humidity is 43%. The annual maximum potential evapotranspiration in the study area is1850 mm and it is highest (260 mm) in the month of May and lowest (77 mm) in the month of December.

Rainfall in the study area is in the range of 156 - 247 mm in the months of June to August. Irrigation is mainly through Drip irrigation, Sprinkler and Bore irrigation.

Rainfall in the study area for the year 2008-2012 (in mm)

S.No.	Year	Actual Rainfall
1	2008-2009	306
2	2009-2010	156
3	2010-2011	422
4	2011-2012	232
5	2012-2013	247

3.6.2.2 Soil Sampling

Eleven (11) village's samples were identified from the study area within 10 km radial distance. Location of soil sampling is depicted in **Figure 3.9** and summarized in **Table 3.19**. Representative soil samples from depth (0-15 cm) were collected from these villages around the project site for estimation of the physico-chemical characteristics of soil. Standard methods have been followed for the analysis of soil samples.

3.6.2.3 Soil Sampling

The International Pipette Method (Black, 1964) was adopted for determination of particle size analysis. The textural diagram was generated using "SEE Soil Class 2.0 version based on United States Department of Agriculture (USDA) classification of soils. Physical parameters such as bulk density, porosity and water holding capacity were determined by following KR Box Method (Keen and Raczkowski, 1921).

The chemical characteristics of soil were determined by preparing soil extract in distilled water in ratio 1:2 (as per Jackson procedure, 1967). Organic carbon was determined by Walkley and Black method (1972). Fertility status of soil in terms of available nitrogen was determined by Kjeldhal method and available phosphorus was determined by Chloro slanus Reduced Molybdo Phosphorus Blue clour, Olsen's method (1954) and available potassium was determined by flame photometer method (Jackson M.L. 1967).

Heavy metals in the soil were determined by digesting the soil with conc. H2SO4 and Concentration. HNO3 on hot plated and extracting the digesting soil followed by analysis on ICP or AAS (APHA, 1995).

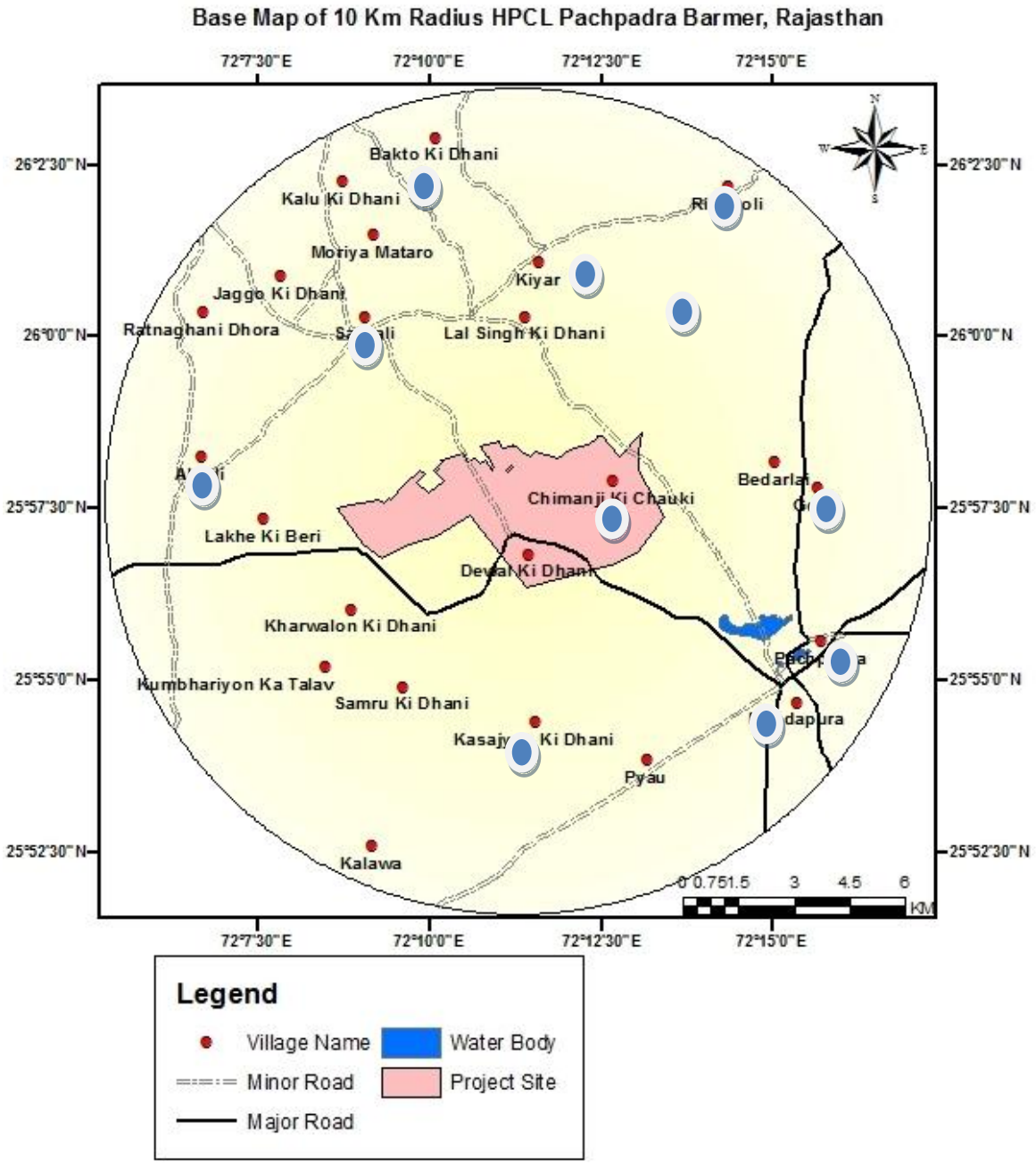


Fig. 3.9: Soil Sampling Location in the Study Area

Physical Characteristics of Soil

Physical characteristics of the soils are delineated through specific parameters such as particle size distribution, texture, bulk density, porosity and water holding capacity. The particle size distribution in terms of percentage of sand, silt and clay is presented in **Table 3.20**. It is observed that the texture of soils in the region varies from sand to loamy sand. The textural diagram for soil classification is presented in **Figure. 3.10**.

Regular cultivation practices increase bulk density of soils thus indicating compaction. This results in reduction in water percolation rate and penetration of root through soil.

The bulk density of the soil in the study area was observed to be varying from 1.34 - 1.68 gm/cm3 which is considered to be moderate to high.

Table 3.19 Soil Sampling Location

Sr. No.	Sampling Location
1.	Proposed site
2.	Sajjiyali
3.	Kalu ki Dhani
4.	Pachpadra
5.	Godaro ki Dhani
6.	Gopri
7.	Richoli
8.	Kyar Charnara
9.	Akarli
10.	Kasaiyo ki Dhani
11.	Mandapura

Table 3.20 Textural Class of Soil

Sr. No.	Sampling Location	Particle Size Distribution (%)				Textural Class
		Coarse Sand	Fine Sand	Silt	Clay	
1.	Proposed site	5.99	85.32	3.49	5.20	Sand
2.	Sajjiyali	5.21	79.42	7.57	7.80	Loamy Sand
3.	Kalu ki Dhani	5.30	80.18	7.92	6.60	Loamy Sand
4.	Pachpadra	13.20	75.54	5.86	5.40	Sand
5.	Godaro ki Dhani	2.26	78.65	9.89	9.20	Loamy Sand
6.	Gopri	3.60	74.66	15.34	6.40	Loamy Sand
7.	Richoli	6.22	82.55	4.03	7.20	Sand
8.	Kyar Charnara	9.34	76.20	7.66	6.80	Loamy Sand
9.	Akarli	5.38	80.85	7.57	6.20	Loamy Sand
10.	Kasaiyo ki Dhani	1.97	89.07	3.76	5.20	Sand
11.	Mandapura	18.35	69.01	3.84	8.80	Loamy Sand

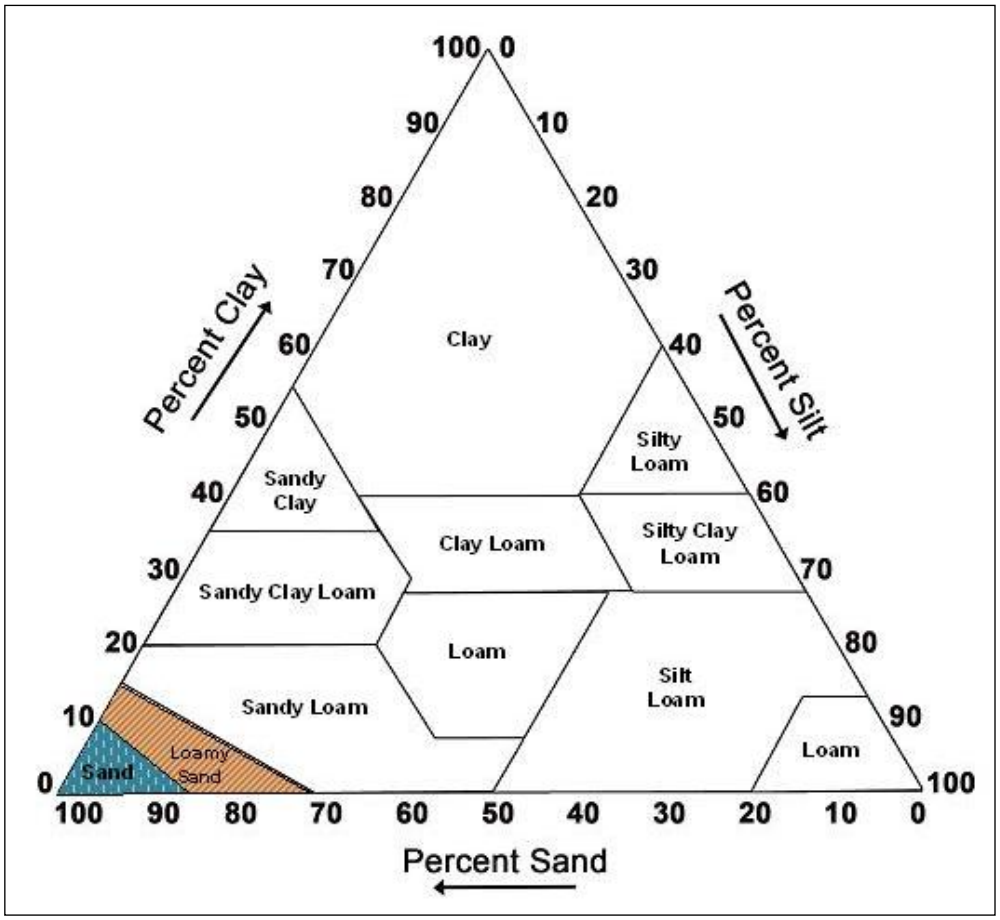


Figure 3.10 Textural Diagram for Study Area

Soil porosity is a measure of air filled pore spaces and provides information about movement of gases, inherent moisture, and development of root system and strength of the soil. Variation in soil porosities are presented in **Table 3.21**. The porosity and water holding capacity of soils are in the range of 15.12 – 32.40 % and 10.71 – 22.68 % respectively.

Table 3.21 Physical Characteristic of Soil

Sr. No.	Sampling Location	Bulk Density (gm/cm^3)	Porosity %	Water Holding capacity %
1.	Proposed site	1.38	32.40	15.60
2.	Sajjiyali	134	21.69	20.20
3.	Kalu ki Dhani	1.57	21.69	20.94
4.	Pachpadra	1.68	18.95	10.83
5.	Godaro ki Dhani	1.51	27.39	22.40
6.	Gopri	1.40	21.18	19.20
7.	Richoli	1.38	18.95	10.71
8.	Kyar Charnara	1.38	24.95	22.68
9.	Akarli	1.48	17.06	10.80
10.	Kasaiyo ki Dhani	1.42	15.12	16.91
11.	Mandapura	1.36	22.74	20.06

Chemical Characteristics of Soils

Data collected for chemical characterization of soils through select parameters, viz. pH, electrical conductivity, soluble anions and cations, cation exchange capacity (CEC), exchangeable cations, exchangeable sodium percentage, nutrients, organic carbon and heavy metals are reported in **Table 3.22** to **Table 3.27**.

pH is an important parameter which indicative of the alkaline or acidic nature of the soil. It greatly affects the microbial population as well as the solubility of metal ions and regulates nutrient availability. The pH of soil in the study area was observed to be in the range of 8.5 to 9.6, the soil is moderate to strongly alkaline in nature **Table 3.22.**

Electrical conductivity, a measure of soluble salts in soil is in the range from 0.13 to 0.85 dS/m. The most important cation present in soluble state in the soil is calcium and magnesium. It was observed that calcium and magnesium are in the range of 0.4 - 1.0 me/l and 0.20 - 0.40 me/l respectively, whereas sodium and potassium are in the range of 0.07 - 1.38 me/l and 0.05 - 0.30 me/l respectively (**Table 3.22**).

In general, the soil in the region has very low adsorption capacity as evident from the cation exchange capacity to be in the range of 6.2 to 9.8 cmol(p+) kg-1 **(Table 3.23)**. Amongst the exchangeable cations, Ca+2 and Mg+2 were observed in the range of 2.8 to 4.6 and 1.6 to 2.8 cmol(p+) kg-1 of soil respectively while sodium and potassium are in the range of 0.31 to 0.58 and 0.011 to 0.034 cmol(p+)kg-1 of soil respectively. Exchangeable sodium percentage ranged from 4.8 to 7.2 indicating that the soils are normal with respect to sodicity **(Table 3.23).** The presence of sodium in exchange form may have deleterious effect on the physical and chemical properties of soil. ESP, 4 to 10 can be considering as satisfactory. The classification of soil and their relationship between productivity and absorptivity based on cation exchange capacity in the soils shows in **Tables 3.24** to **Tables 3.25**. Soil is very low productive and low adsorptivity on the basis of cation exchange capacity.

Table 3.22 Chemical Characteristics of Soil Extract

Sr. No.	Sampling Location	pH (1:2)	EC dS/m	Cal-cium	Magne-sium	Sodi-um	Pota-ssium
				me/l			
1.	Proposed site	8.7	0.16	0.8	0.4	0.35	0.23
2.	Sajjiyali	8.8	0.15	1.0	0.2	0.18	0.08
3.	Kalu ki Dhani	8.5	0.85	1.0	0.4	0.09	0.30
4.	Pachpadra	9.6	0.33	0.6	0.4	1.38	0.07
5.	Godaro ki Dhani	9.2	0.21	0.6	0.2	0.80	0.05
6.	Gopri	8.6	0.21	0.8	0.4	0.42	0.06
7.	Richoli	8.8	0.15	0.8	0.2	0.10	0.07
8.	Kyar Charnara	8.6	0.13	0.6	0.2	0.07	0.10
9.	Akarli	9.3	0.25	0.4	0.2	0.96	0.06
10.	Kasaiyo ki Dhani	8.6	0.15	0.8	0.2	0.15	0.06
11.	Mandapura	8.7	0.16	1.0	0.2	0.23	0.06

Table 3.23 Cation Exchange Capacity of Soil

Sr. No.	Sampling Location	Ca++	Mg++	Na+	K+	CEC	ESP
		cmole(p^+) kg^{-1}					
1.	Proposed site	3.4	2.2	0.31	0.011	6.4	4.8
2.	Sajjiyali	4.6	2.4	0.47	0.020	8.8	5.4
3.	Kalu ki Dhani	3.2	2.8	0.41	0.034	7.4	5.5
4.	Pachpadra	3.3	1.8	0.40	0.020	6.4	6.2
5.	Godaro ki Dhani	4.4	2.6	0.58	0.015	9.8	5.9
6.	Gopri	4.6	2.8	0.46	0.024	8.6	5.4
7.	Richoli	4.2	2.6	0.44	0.014	8.2	5.4
8.	Kyar Charnara	3.8	1.8	0.42	0.031	7.6	5.5
9.	Akarli	3.4	1.6	0.49	0.026	6.8	7.2
10.	Kasaiyo ki Dhani	2.8	1.8	0.33	0.013	6.2	5.4
11.	Mandapura	4.6	2.8	0.47	0.016	9.2	5.2

Table 3.24 Relationship of CEC with Productivity

CEC	Range (cmol (p+) Kg^{-1})	Productivity	Location Sr. Nos.
Very low	<10	Very low	1,2,3,4,6,7,8,9,10,11
Low	10-20	Low	
Moderate	20-50	Moderate	
High	>50	High	

Table 3.25 Relationship of CEC with Adsorptivity

CEC	Range (cmol (p+) Kg-1)	Adsorptivity	Location Sr. Nos.
Limited or Low	<10	Limited or Low	1,2,3,4,6,7,8,9,10,11
Moderate	10-20	Moderate	
High	20-30	High	
Very High	>30	Very High	

Nutrient Status of Soil

Organic matter present in the soil influences the soil physical and chemical properties. Organic matter commonly accounts as one third or more of the cation exchange capacity of surface soils. It is also responsible for stability of soil aggregates.

Organic carbon and available nitrogen, phosphorus and potassium are found to be in the range of 0.05 to 0.48 %, 85.28 to 142.32 kg/ha, 8.39 to 16.51 kg/ha and 10.20 to 25.84 kg/ha respectively. This shows that the soils are poor in organic carbon content and with respect to nitrogen fertility level is poor and the fertility levels with respect to phosphorus and potassium in the soils are poor. Fertility status of the soils of the study area has been presented in **Table 3.26**.

Heavy Metal Content in the Soil

The heavy metals occur in the solution as cations are absorbed by the negatively charged soil particles. They are held strongly as complex on the surface of clay

alumina silicates hydrated oxide and humus. In heavy metal pollution is serious because it can persist for many decades. The heavy metals also create problems in the nutrient utilization in plant and also marked reduction in chlorophyll content.

Plants require heavy metals at microgram level for their metabolic activities as micronutrients. Their deficiency becomes a limiting factor in plant growth but at the same time, their higher concentration in soils may lead to toxicity to the plants. Levels of heavy metals in soils are presented in **Table 3.27**.

Table 3.26 Fertility Status of Soil in Study Area

Sr. No.	Sampling Locations	Organic carbon (%)	N	P_2O_5	K_2O
			Kg/ha		
1.	Proposed site	0.11	102.32	8.39	13.48
2.	Sajjiyali	0.08	98.42	10.42	10.20
3.	Kalu ki Dhani	0.36	138.28	16.51	25.84
4.	Pachpadra	0.48	142.32	13.36	12.79
5.	Godaro ki Dhani	0.22	128.44	9.88	12.92
6.	Gopri	0.16	114.56	11.82	12.07
7.	Richoli	0.31	129.46	11.73	12.29
8.	Kyar Charnara	0.19	120.68	15.21	15.35
9.	Akarli	0.14	118.72	7.56	12.76
10.	Kasaiyo ki Dhani	0.11	103.22	9.88	16.22
11.	Mandapura	0.05	85.28	8.39	15.79
Level in poor soil		<0.5	<280	<23	<133
Level of medium Soil		0.5-0.75	280-560	23-57	133-337
Level in fertile soil		>0.75	>560.0	>57.0	>337.0

Table 3.27 Heavy Metals in Soil

Sr. No.	Location Name	Ni	Co	Cu	Zu	Pb	Cd	Cr	Mn	Fe
		mg/Kg								
1.	Proposed site	8.2	2.6	3.3	10.6	3.3	0.1	4.3	167.7	4085
2.	Sajjiyali	9.4	2.9	4.0	12.1	1.7	0.09	15.1	137.0	5770
3.	Kalu ki Dhani	12.2	3.5	5.6	22.8	2.2	0.09	21.3	162.6	6385
4.	Pachpadra	8.5	2.7	3.6	10.0	2.7	0.07	17.9	143.6	4903
5.	Godaro ki Dhani	10.5	3.4	5.8	13.9	1.8	0.10	17.5	145.0	6194
6.	Gopri	11.7	3.4	5.1	14.8	1.5	0.09	22.2	131.2	9569
7.	Richoli	8.6	3.1	4.7	12.3	1.8	0.09	12.4	122.2	5830
8.	Kyar Charnara	10.6	4.0	8.8	22.2	4.8	0.23	18.5	177.2	7912
9.	Akarli	4.0	1.1	1.3	4.9	1.1	0.03	4.4	54.8	2765
10.	Kasaiyo ki Dhani	4.2	1.4	1.5	5.3	1.2	0.03	4.6	55.5	2863
11.	Mandapura	10.0	3.3	5.7	12.9	2.8	0.12	21.0	135.1	6181

Soil Microbiology

Soil organisms play a key role in nutrient transformation, organic forms are transformed into their respective inorganic form and plants are able to absorb them for their growth. Physical, Chemical and physic-chemical characteristics of soil and its nutrient status influence the microbial population.

Various ecological cycles in the Rhizospheric zone of the plant depend upon microbiological population. The population of bacteria, fungi and Actinomycetes are the vital components of soils and they help in maintaining their stability. Characteristics of soil micro-organisms are presented in **Table 3.28**.

Table 3.28 Microbiological Characteristic of Soil

Sr. No.	Sampling Location	TVC	Fungi	Actinomy-cetes	Rhizo-bium	Azotobac-ter
		CFU/g of soil				
1.	Proposed site	63×10^6	18×10^4	32×10^4	5×10^4	14×10^4
2.	Sajjiyali	68×10^6	23×10^4	23×10^4	9×10^4	18×10^4
3.	Kalu ki Dhani	27×10^6	14×10^4	9×10^4	4×10^4	9×10^4
4.	Pachpadra	23×10^6	32×10^4	18×10^4	9×10^4	14×10^4
5.	Godaro ki Dhani	41×10^6	18×10^4	14×10^4	4×10^4	9×10^4
6.	Gopri	50×10^6	27×10^4	23×10^4	14×10^4	18×10^4
7.	Richoli	22×10^6	18×10^4	9×10^4	4×10^4	4×10^4
8.	Kyar Charnara	45×10^6	36×10^4	27×10^4	18×10^4	18×10^4
9.	Akarli	18×10^6	14×10^4	9×10^4	5×10^4	9×10^4
10.	Kasaiyo ki Dhani	32×10^6	23×10^4	14×10^4	9×10^4	14×10^4
11.	Mandapura	27×10^6	9×10^4	4×10^4	4×10^4	5×10^4

Azotobactor are non-symbiotic nitrogen fixing microorganisms and improve soil fertility by fixing nitrogen in the soil. Fungi also constitute an important part of the micro-flora of normal soil. They are active in initial stages of decomposition of plant residues and actively participate in the process of soil aggregation. Total viable microbial population per gram of soil varied from 18x106 to 68x106 CFU. Different microflora observed per gram of soil samples were fungi (9x104 to 36x104 CFU), Actinomycetes (4x104 to 32x104 CFU), Rhizobium (4x104 to 18x104) and Azotobacter (4x104 to 18x104 CFU).

3.6.3 Remote Sensing Studies

Remote Sensing technology has emerged as a powerful tool in providing reliable information on various natural resources at different levels of spatial details, it has played an important role in effective mapping and periodic monitoring of natural resources including environment.

With the availability of high resolution remote sensing data, newer areas of remote sensing applications have been identified, techniques of data processing have been improved and computer based image processing systems have become more effective.

Data Used

In order to strengthen the baseline information on existing land use pattern, the following data covering approx. 25°51’22.33”N - 26°02’07.36”N latitude and 71°35’43.90”E - 71°47’39.33”E longitude are used.

A. Remote sensing data

IRS P6 LISS III Scene

Path 091 - Row 053

Dated 22-APR-2011; CD format

B. Collateral data

Survey of India Toposheet (OSM) bearing No.G42L12,G42L16, G42L4, G42L8, G42R1, G42R13, G42R5, G42R9 (1:50,000 scale)

Methodology

Salient features of Methodology are given below:

- Acquisition of Satellite data
- Data loading
- Data processing
- Geo-referencing Image
- Rectification
- Supervised Classification of Land use /Land cover
- Ground Truth / field checks using Global Positioning System
- Masking

The spatial resolution and the spectral bands in which the sensor collects the remotely sensed data are two important parameters for any land use survey. IRS P6 LISS III data offers spatial resolution of 23.5 m with the swath width of 141 x 141 km. The data is collected in four visible bands namely green (Band 2) (0.52-0.59μ), red (Band 3) (0.62-0.69μ), near Infrared (NIR) (Band 4) (0.77-0.89μ), Short wave infrared band (Band 5) (1.55-1.75μ) with orbit repeat period of 24 days (three days revisit). The shapes, sizes, colors, tone and texture of several geomorphic features are visible in IRS data. Four spectral bands provide high degree of measurability through band combination including FCC generation, bands rationing, classification etc. These features of the IRS data are particularly important for better comprehension and delineation of the land use classes. Hence, IRS P6 LISS-III data has been used for land use mapping.

The digital image processing was performed on PCI GEOMATICA 10.1 System on high-conFigureured computer. This software package is a collection of image processing functions necessary for pre-processing, rectification, band combination, filtering, statistics, classification etc. Apart from contrast stretching, there are large numbers of image processing functions that can be performed on this station. Arc Map 10 is used for final layout presentation.

The satellite data from the compact disc is loaded on the hard disk and by studying quick looks (the sampled image of the appropriate area); the sub-scene of the study area is extracted.

Supervised classification using all the spectral bands can separate fairly accurately, the different land use classes at level II on the basis of the spectral responses, which involve the following three steps:

1. Acquisition of ground truth
2. Calculation of the statistics of training area

3. Classification using maximum likelihood algorithm

The training areas for classification were homogeneous, well spread throughout the scene with bordering pixels excluded in processing. Several training sets have been used through the scene for similar land use classes. After evaluating the statistical parameters of training sets, the training areas were rectified by deleting no congruous training sets and creating new ones.

Results

Land use refers to man's activities on land, utilitarian in nature whereas land cover denotes the vegetation cover, water body cover and artificial constructions etc.

The land use / land cover classification system standardized by Department of Space, for mapping different agro-climatic zones has been adopted. This classification system has six major land use classes at level I and twenty-eight at level II **(Table 3.29).** The six major classes at level I was further enunciated in the following six categories:

- Built up land: It is defined as an area of human habitation developed due to non-agricultural use and that which has a cover of buildings, transport, communication utilities in association with water, vegetation and vacant lands.
- Land with or without scrub: They occupy (relatively) higher topography like uplands or high grounds with or without scrub. These lands are generally prone to degradation or erosion. These exclude hilly and mountainous terrain.
- Fallow land: It is described as agricultural land which is taken up for cultivation but is temporarily allowed to rest un-cropped for one or more seasons, but not less than one year. These lands are particularly those which are seen devoid of crops at the time when the imagery is taken of both seasons.
- Dense Evergreen Forest: It is described as a forest, which comprises of thick and dense canopy of tall trees, which predominantly remain green throughout the year. It includes both coniferous and tropical broad-leaved evergreen trees. Semi-evergreen forest is a mixture of both deciduous and evergreen trees but the latter predominate.
- Water bodies: Area persistently covered by water such as river and Reservoir, lakes.

Land use / land cover distribution in the study area has been estimated as given below using the above classification system and digital analysis techniques.

FCC of Study Area

The false colour composite of LISS III sensors, IRS P6 satellite Image showing 314 sq. Km study area around Baytu, Barmer District, Rajasthan. In the image, vegetation (dense vegetation, vegetation, shrub,) appears red, water bodies as blue. Attributes such as colour, tone, texture, shape and size are used to interpret the image visually. Morphologically the area is an elevated terrain. The Built-up area visible clearly which

reflect bluish colour in FCC. Barren land is also depicted in the imagery by its white colour.

Table 3.29 Land use/Land Cover Classification System

Sr. No.	Level - I		Level – II
1.	Built-up Land	1.1	Built-up land
		1.2	Road
		1.3	Railway
2.	Agricultural Land	2.1	Crop land
		2.2	Fallow (Residual)
3.	Forest	3.1	Evergreen/Semi-evergreen forest
		3.2	Deciduous forest
		3.3	Degraded/Scrub land
		3.4	Forest blank
		3.5	Forest plantation
		3.6	Mangrove
		3.7	Cropland in forest
4.	Wasteland	4.1	Salt affected land
		4.2	Waterlogged land
		4.3	Marshy/Swampy land
		4.4	Gullied/Ravenous land
		4.5	Land with or without scrub
		4.6	Sandy area (coastal and desert)
		4.6	Barren rocky/Stony Waste/sheetrock area
5.	Water bodies	5.1	River/Stream
		5.2	Lake/Reservoir
		5.3	Tank/Canal
6.	Others	6.1	Grassland/Grazing land
		6.2	Shifting cultivation

Land use Land cover Study area

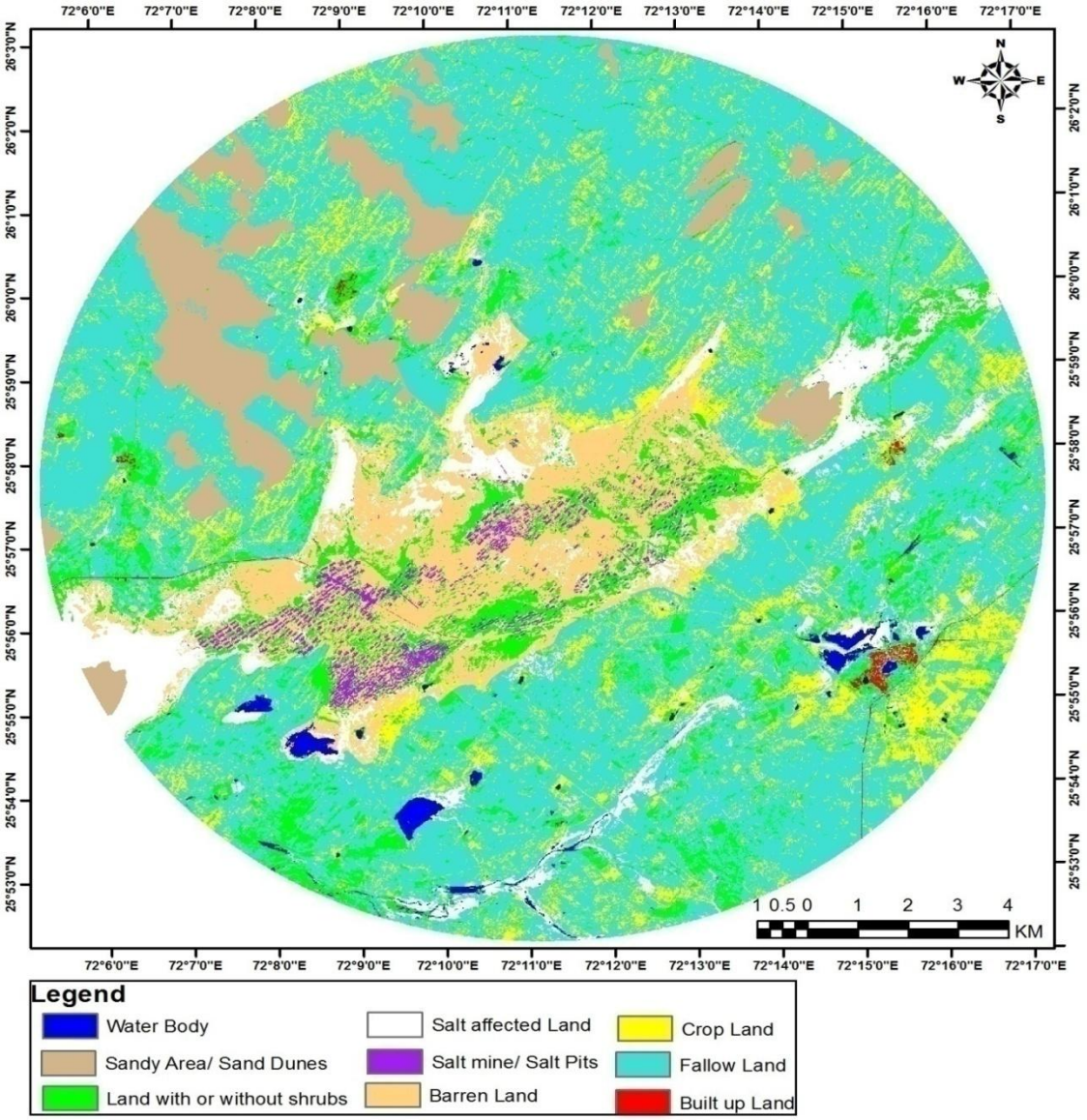
It is the colour-coded output of supervised classification with colours assigned to various classes in the study area around project site. In this image, colours are assigned to various classes as given in legend. Six different classes are identified within study area. The land use / land cover classification indicated by 60.54% area covered Sand and assigned by gray colour.

Water body (lakes / ponds) is indicated by blue colour and covered 0.09%. Vegetation covered 1.51% is assigned by green colour. Fallow land spread in 23.60% of the area and assigned by the orange colour. While the human settlement area (Built-up land) covered by 3.03% shows in red colour.

Review of Plate II and **Table 3.30** indicate that the land use/land cover is distributed mainly over six categories that is Water body, Vegetation, Fallow land, Waste land, Sand and Built-up land. Land use land cover map is given in **Figure 3.11**.

Table 3.30 Inventory of Landuse / Land cover for RRP

Sr. No.	Land use/Land cover Classes	Area in (Sq. Km) 314	Area in (%)
1	Water Body	0.28	0.09
2	Vegetation	4.73	1.51
3	Fallow Land	74.11	23.60
4	Waste Land	35.29	11.24
5	Sand	190.09	60.54
6	Built Up Land	9.50	3.03
	TOTAL	**314.00**	**100.00**



Fugure 3.11 Land use land cover map of the study area

3.6.4 Topography and Digital Elevation Model (DEM)

The topography of land identified for proposed RRP falls under rural environment. A DEM is a raster representation of a continuous surface, usually referring to the surface of the earth. The DEM is used to refer specifically to a regular grid of spot heights. It is the simplest and most common form of digital representation of topography. The Digital Elevation model for the study area was generated from the Tin. The average height 90 meters above mean sea level .The Maximum height is above 126 meters above mean sea level where as lowest height is about 54 meter above mean sea level.

For DEM generation first extract contour shown in **Figure 3.12**, then TIN shown in **Figure 3.13** and after DEM Generation shown in **Figure 3.14** and **Figure 3.15**.

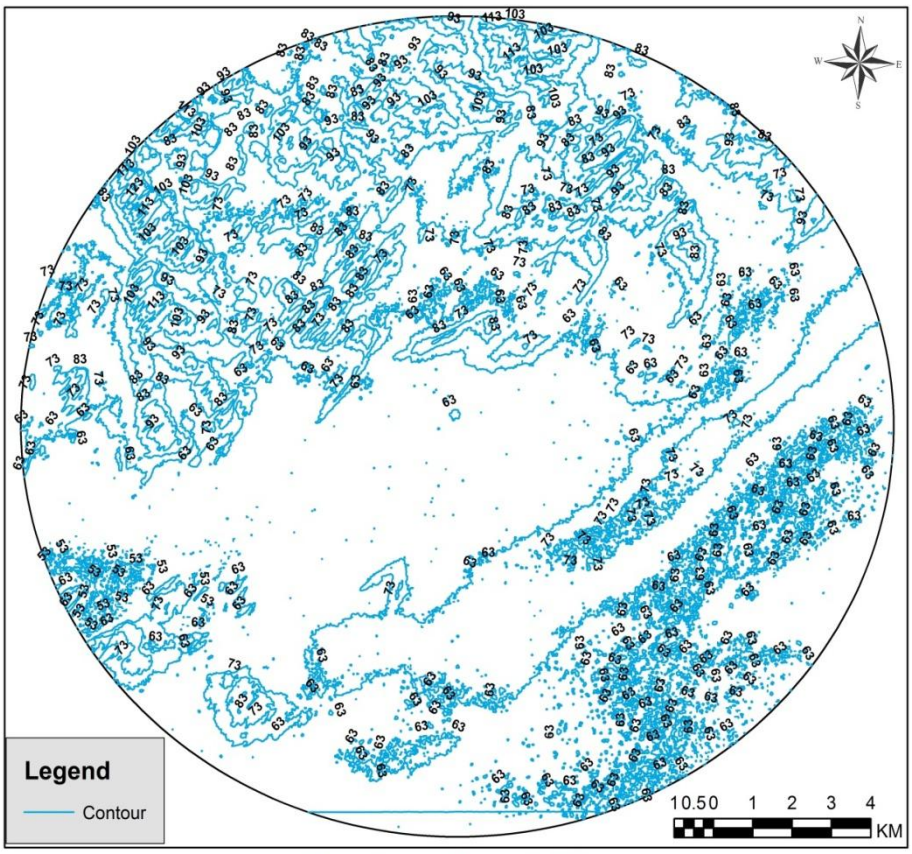


Figure 3.12: Contour Map of Study Area

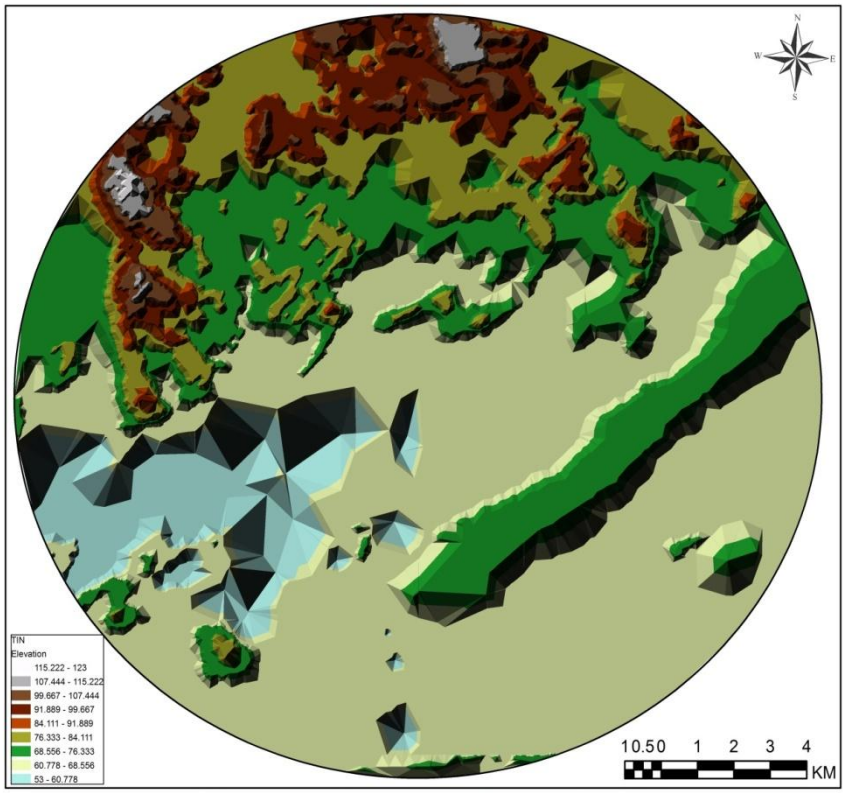


Figure 3.13 : TIN Map of Study Area

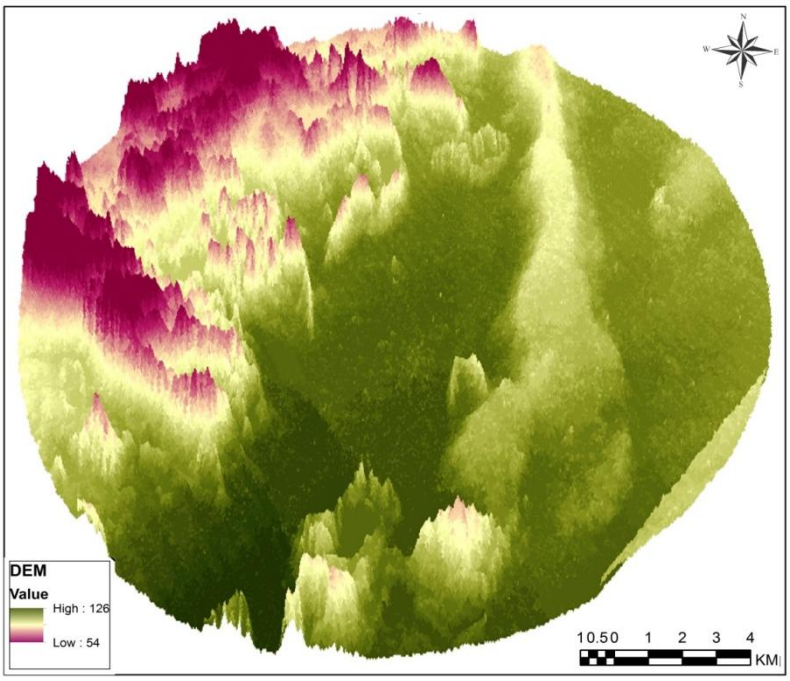


Figure 3.14: 3-D DEM of Study Area

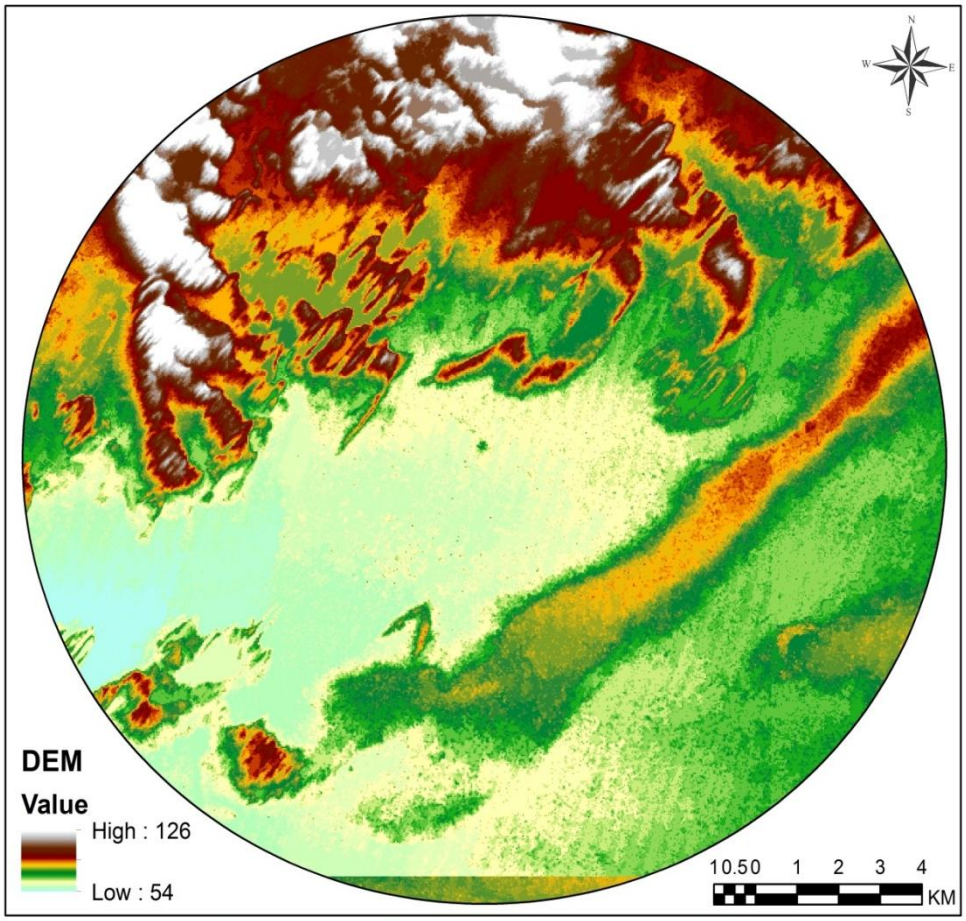


Figure 3.15: DEM of Study Area

3.7 BIOLOGICAL ENVIRONMENT

3.7.1 Floral Biodiversity

3.7.1.1 Introduction

Man has been relaying on the natural resources to meet the basic requirements since time immemorial. With the unprecedented increase in the population during the last few decades, clearly mankind faces formidable problem to ensure food and nutritional security for all, considering reduced per capita land, reduced availability of water, depleting biodiversity and need to preserve ecology and environment. Deserts cover more than one fifth of the Earth's land, and they are found on every continent. Deserts are basically very fragile ecosystems. The erratic rainfall and poor soil fertility have marked effect on the vegetation of the Indian desert. Deserts cover more than one fifth of the Earth's land, and they are found on every continent. Far from being barren wastelands, deserts are biologically rich habitats with a vast array of animals and plants that have adapted to the harsh conditions there. The Thar Desert or Great Indian Desert is the world's tenth largest desert and forms a significant portion of

western India and covers an area of about 2,78,330 sq km, of which 1,96,150 sq km (70%) is in Rajasthan, 62,180 sq km (23%) in Gujarat and about 20,000 sq. km. (7%) in Punjab and Haryana states. Despite the prevailing harsh climatic conditions, the Indian Thar desert comprises richest plant diversity among the other desert of the world. Barmer exhibits a variety of landscapes and ecological conditions which are noticeable in the types of vegetation **(Figure 3.16).** While studying the ecosystem and biological environment we specifically considered the combine effect of climate, soil, land information and topography. The study area is located in Barmer district of the western Rajasthan i.e., within the Indian Thar. The Thar Desert can be understood as a unique natural ecosystem having the following attributes:

- Low and extremely uncertain rainfall,
- Considerable diurnal and seasonal temperature variation,
- Soil deficient in organic matter and nutrients (NPK ratio)
- Soil prone to salinization,
- Shifting sand dunes,

Despite the adversities, Thar is not devoid of bountiful life supporting systems with abundance of animal and plant species making it a unique biodiversity region in the world.

Life in the Indian Desert is extraordinary and in spite of massive biotic and abiotic stresses, the world's largest concentration of large mammals and winter migratory birds exists in the desert. The global significance of the Indian desert lies in the fact that it is not an isolated arid zone but forms part of an extensive desert belt comprising the Sahara and the arid regions of Arabia, Iran and Pakistan.

3.7.1.2 Study Area and Climate

Barmer district of Rajasthan is surrounded by Jaisalmer district in the north, Jalore district in the south, Pali district and Jodhpur district in the east and Pakistan in the west. The whole district lies between 24°58’ - 26°32’ N Latitudes and 70°5’ - 72°52’ E Longitudes.It has an average elevation of 106 m amsl. falls in Agroclimatic Zone Hot and Dry Arid .The soil texture is Sand, Loamy Sand, Sandy Loam and Loam. The major crops in the area are Bajra, Gwar, Moong, Moth, Till. Balotra is famous for its textile industry for last 60 years and has more than 5000 textile unit is depicted in **Figure 3.16**.

The region is characterized by low and uneven distribution of rainfall causing high soil water stress throughout the year. High potential evaporation and strong wind also add adversity to the area. The summer is the most dominant season characterized by high temperature spreading over March to mid of July, coupled with high wind velocity and drifting sands. Area receives less than ten inches (25 centimeters) of precipitation a year, total area of the city is 29.01 km2 or regions where the potential evaporation rate is twice as great as the precipitation. Three seasons that can be distinguished in this region are long dry season from March to mid of July; a short monsoon season from mid July to September receiving most of the rainfall and a winter season from November to February. The long dry season is generally pronounced and predictable, while the short rainy seasons are unreliable both in time and amount of rainfall. The region is characterized by low and uneven distribution of rainfall causing high soil water stress throughout the year. High potential evaporation and strong wind also add adversity to the area. The summer is the most dominant season characterized by high temperature spreading over March to mid of July, coupled with high wind velocity and

drifting sands. Three seasons that can be distinguished in this region are long dry season from March to mid of July; a short monsoon season from mid July to September receiving most of the rainfall and a winter season from November to February. The long dry season is generally pronounced and predictable, while the short rainy seasons are unreliable both in time and amount of rainfall. The variation in temperature in various seasons is quite high. In summers the temperature soars to 46°C to 51°C. In winters it drops to 0°C (41°F). Primarily Barmer district is a desert where average rainfall in a year is 277 mm.

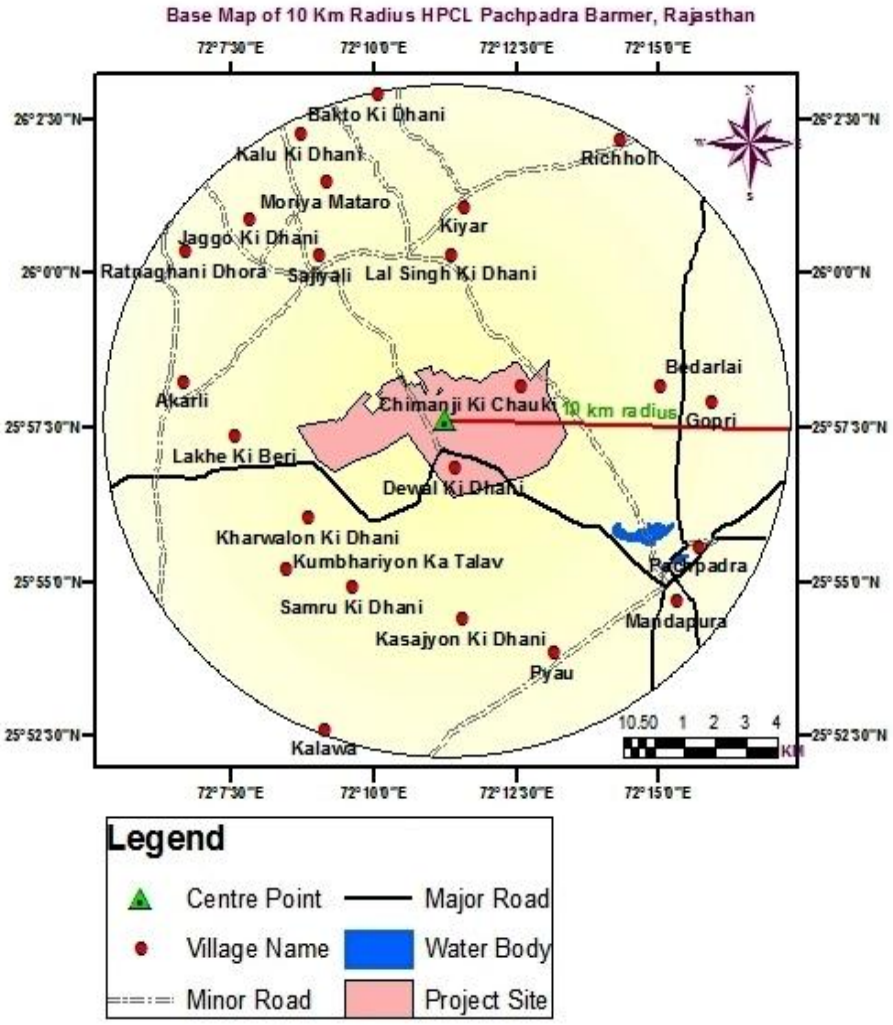


Figure 3.16 Sampling Locations for Biological Monitoring

3.7.1.3 Reconnaissance

The present ecological study of the biological environment in the project area of HPCL, Barmer (Rajasthan) was undertaken with special reference to Flora characteristics and impact with the objectives of:

- Collection of available information on flora and fauna including rare and endangered species in the region
- Assessment of density, abundance, species diversity, *etc.* within the study area

- Assessment of impacts on terrestrial flora and fauna due to gaseous emissions, effluent discharge and land use changes
- Prediction of biological stress in the study area
- Delineation of measures for abatement/reduction of biological stress
- Identification of rare plants of economic importance including medicinal plants and wildlife species which require protection and conservation
- Identification of measures for protection and conservation of flora, fauna including wildlife, migratory avi-fauna, rare and endangered species, medicinal plants *etc.*
- Collection of secondary data on agricultural activity, crops and their productivity, and irrigation facilities

A detailed survey was carried out in November 2013 to provide detailed profile of the biological environment for the concerned area **(Figure. 3.17)**. The site survey included the geological and meteorological data, topography, flora and fauna and socio-economic status.

3.7.1.4 Sampling Locations

A total 11 sampling locations were selected for study on biological aspects based on topography, land use, vegetation pattern, etc. **(Table 3.31).** The proposed project site is located in Barmer district of Rajasthan. The study area is around 10 km radial distance from the proposed project site. All 11 locations were selected for study on biological aspects. Selection of sampling locations was made with reference to topography, land use, vegetation pattern, etc. The observations were taken on forest legal categories and non forest area (agricultural field, in plain areas, village wasteland, etc.) as per the objectives and guidelines of MoEF for Environmental Impact Assessment. All observations were taken in and around sampling locations for quantitative representation of different species. The terrestrial vegetation consists of thorny, shrubby and xerophytic scrub vegetation. The vegetation is extremely sparse dominated by shrubby growth of Prosopis juliflora. However, it has good growth in low-lying areas, by the side of agriculture fields and near villages. Secondary data was collected from various Government Departments and project authority to substantiate primary data.

Table 3.31 List of Sampling Locations for In-Depth Exploration of Biological Environment of the Study Area

Sr. No.	Sample Location	Gram Panchayat	Latitude Longitude	Directions	Km
1.	Sajiyali	Sajiyali Padamsingh	N 26^{0}00’09.9” E072^{0}09’13.5”	NNW	5.5
2.	Akarli Dhansingh	Akarli Dhansingh	N 25^{0}57’57.4” E072^{0}06’18.4”	WNW	6.5
3.	Kyar	Kyar Charnan	N 26^{0}01’00.3” E072^{0}11’09.1”	N	5.0
4.	Richholi	Gopri	N 26^{0}02’24.4” E072^{0}15’30.5”	NNE	9.0
5.	Gopri	Gopri	N 25^{0}58’03.3” E072^{0}15’26.1”	E	6.5
6.	Sambhra	Sambhara	N 25^{0}54’55.9” E072^{0}09’32.0”	S	4.5

7.	Kalawa	Kalawa	N 25^{0}52'27.5" E072^{0}08'55.9"	SSW	9.0
8.	Kisanjiyon Ki Dhani	Sambhra	N 25^{0}53'52.6" E072^{0}11'47.1"	S	5.0
9.	Deval Ki Dhani	Sambhra	N 25^{0}56'14.0" E072^{0}11'02.1"	S	1.0
10.	PachpadraP.H.C.	Pachpadra	N 25^{0}55'37.5" E072^{0}15'30.9"	ESE	8.5
11.	Madhpura	Madhpura	N 25^{0}54'36.4" E072^{0}14'28.7"	SE	8.5

3.7.1.5 Floral Assessment

3.7.1.5.1 Forest Types in Study Area

The proposed project site for HPCL refinery is located near Balotra Forest Range district Barmer, Rajasthan. As per revised classification of forest types of India by Champion and Seth, 1968; Tropical thorn forests are found in arid and semi-arid regions of western Rajasthan. According to Champion and Seth, the vegetation in the study area can be classified as Dry Tropical Type and Tropical Dry Thorn type. The vegetative pattern changes with rainfall gradient from grassland with isolated trees to open scrublands. The forest type is Tropical Thorn forest. These are low, open and pronouncedly xerophytic forests in which thorny leguminous species predominate. The major tree species are Prosopis cineraria, Prosopis juliflora, Capparis decidua, Zizyphus mauritiana, Tamarix aphylla and Salvadora oleoides. The list of total number of different plant species (trees, shrubs and herbs) recorded during field survey is depicted in **Table 3.32** was prepared based on site observations along with public consultation, available literature and data received from state forest department office.The vegetative pattern changes with rainfall gradient from grassland with isolated trees in north western parts to open scrubland in the middle, and open-to-dense in pockets near small streams of water. A major portion of the area and surrounding 10 km is occupied either by dry open grassland or by grassland interspersed with trees and thorny bushes. On account of the prevailing desert conditions in Barmer, vegetation is very scarce. The vegetation of this area included in Tropical Thorn forest and scrub lands as per revised classification of forest types of India by Champion and Seth, 1968. Most of the flowering plants found in the area are shrubs and wild grasses which, however, do not survive for more than a few months after the rains. Entire area is high salinity zone.

Table 3.32 List of Plants Recorded from the study area

Sr. No.	Botanical Name	Local Name	Family	Refinery (Barmer Dist.)
Trees				
1.	*Acacia catechu*	Khair	Fabaceae	+
2.	*Acacia leucophloea*	Chhonkda	Fabaceae	+
3.	*Acacia nilotica**	Babul	Fabaceae	+
4.	*Acacia Senegal*	Kumtha	Fabaceae	+
5.	*Acacia tortilis*	Israeli Babul	Fabaceae	+
6.	*Ailanthus excelsa**	Maharukh	Simaroubaceae	+
7.	*Albizia lebbeck**	Kala Siras	Fabaceae	+

Sr. No.	Botanical Name	Local Name	Family	Refinery (Barmer Dist.)
8.	*Albizia procera*	Safed Siras	Fabaceae	+
9.	*Azadirachta indica**	Neem	Meliaceae	+
10.	*Bauhinia purpurea**	Kaivlor	Caesalpiniaceae	+
11.	*Bombax ceiba**	Semal	Malvaceae	-
12.	*Boswellia serrata*	Salai	Burseraceae	-
13.	*Butea monosperma*	Palas, Chhewla	Fabaceae	+
14.	*Cassia fistula**	Amaltas	Fabaceae	+
15.	*Cassia siamea*	Kesia	Fabaceae	-
16.	*Chloroxylon swietenia*	Bhirra	Rutaceae	-
17.	*Dalbergia sissoo*	Shisham	Fabaceae	+
18.	*Eucalyptus sp.*	Nilgiri	Myrtaceae	-
19.	*Ficus benghalensis*	Bad	Moraceae	+
20.	*Ficus glomerata*	Gular	Moraceae	-
21.	*Ficus religiosa**	Pipal	Moraceae	+
22.	*Mangifera indica*	Aam	Anacardiaceae	+
23.	*Prosopis cineraria**	Khejri	Fabaceae	+
24.	*Prosopis juliflora**	Vilayti Khejra	Fabaceae	+
25.	*Salvadora oleoides**	Pilu	Salvadoraceae	+
26.	*Tamarindus indica*	Imli	Fabaceae	+
27.	*Tecomella undulata**	Rohida	Bignoniaceae	+
28.	*Tectona grandis*	Sagwan	Verbenaceae	-
29.	*Ziziphus jujuba**	Ber	Rhamnaceae	+
30.	*Zizyphus xylopyra**	Ghont	Rhamnaceae	+
31.	*Salvadora persica**	Jal	Salvadoraceae	+
Shrubs and Under Shrubs				
32.	*Acacia jacquemontii*	Boli	Fabaceae	+
33.	*Achyranthes aspera**	Apamarg, Chirchita	Amaranthaceae	+
34.	*Aerva javanica**	Bui	Amaranthaceae	+
35.	*Argemone mexicana*	Satyanashi	Papaveraceae	+
36.	*Calligonum polygonoides**	Phog	Polygonaceae	+
37.	*Calotropis gigantea**	Aak	Asclepiadaceae	+
38.	*Calotropis procera**	Akdo	Asclepiadaceae	+
39.	*Capparis decidua**	Kair, Karril	Capparaceae	+
40.	*Crotalaria burhia**	Sania	Fabaceae	+
41.	*Echinops echinatus**	Oontkateli	Asteraceae	+
42.	*Euphorbia caducifolia*	Thor	Euphorbiaceae	+
43.	*Euphorbia neriifolia*	Thuar	Euphorbiaceae	+
44.	*Fagonia indica**	Dhamasa	Zygophyllaceae	+
45.	*Farsetia hamiltonii*	Kuneria		-
46.	*Indigofera cordifolia**	Camaria		+
47.	*Lantana camara*	Raimunia	Verbenaceae	+
48.	*Leptadenia pyrotechnica**	Khimp	Asclepiadaceae	+
49.	*Ricinus communis*	Arandi	Euphorbiaceae	+
50.	*Solanum virginianum*	Ringani	Solanaceae	+
51.	*Tridax procumbens**	Baramasi	Asteraceae	+

Sr. No.	Botanical Name	Local Name	Family	Refinery (Barmer Dist.)
52.	*Xanthium strumarium*	Chhota Datura	Asteraceae	+
53.	*Ziziphus oenoplia**	Ber	Rhamnaceae	+
54.	*Zizyphus nummularia*	Jharber	Rhamnaceae	
Grasses				
55.	*Aristida adscensionis**	Needle grass	Poaceae	+
56.	*Aristida funiculate**	Needle grass	Poaceae	+
57.	*A. mutabilis*	Needle grass	Poaceae	+
58.	*Brachiaria ramose**	Ghas	Poaceae	+
59.	*Cenchrus biflorus**	Bhurat	Poaceae	+
60.	*Cenchrus ciliaris*	Chhaman	Poaceae	-
61.	*C. biflorus*	Ghas	Poaceae	+
62.	*C. setigerus*	Ghas	Poaceae	+
63.	*Chloris virgata*	Ghas	Poaceae	+
64.	*Cymbopogon jwarncusa*	Ghas	Poaceae	+
65.	*Cyperus rotundus*	Ghas	Poaceae	+
66.	*C. arenarius*	Ghas	Poaceae	+
67.	*Dactyloctenium sindicum*	Ghas	Poaceae	+
68.	*D. aegyptium*	Ghas	Poaceae	+
69.	*Dichanthium annulatum*	Ghas	Poaceae	+
70.	*Eragrostis ciliaris*	Ghas	Poaceae	+
71.	*E. tremula*	Ghas	Poaceae	+
72.	*Eleusine conmpressa*	Ghas	Poaceae	+
73.	*Fimbristylis dichotoma*	Ghas	Poaceae	+
74.	*Heteropogon contortus*	Spear grass	Poaceae	+
75.	*Lasiurus sindicus**	Siwan	Poaceae	-
76.	*Panicum turgidum**	Bunchgrass	Poaceae	+
77.	*Panicum antidotale*	Ghas	Poaceae	+
78.	*Sporobolus marginatus*	Ghas	Poaceae	+
79.	*S. helvolus*	Ghas	Poaceae	+
80.	*Scirpus roylei*	Ghas	Cyperacea	+
81.	*Tetrapogon tenellus*	Ghas	Poaceae	+
82.	*Tragus racemosus*	Ghas	Poaceae	-
Herbs				
83.	*Adhatoda zeylanica**	Vasaka	Acanthaceae	+
84.	*Convolvulus prostrates**	Hiranpag	Convolvulaceae	+
85.	*Citrullus colycynthis**	Tumba	Cucurbitaceae	+
86.	*C. lanatus**	Tumba	Cucurbitaceae	+
87.	*Chenopodium foliolosum**	Bathua	Chenopodiaceae	+
88.	*Haloxylon salinicornicum*	Lana	Amaranthaceae	+
89.	*Pullicaria crispa**	Khar	Fabaceae	+
90.	*Suaeda fruticosa**	Loni	Amaranthaceae	+
91.	*Salsola baryosma*	Kali	Amaranthaceae	+
92.	*Tephrosia purpurea**	Sarpunkha	Fabaceae	+
93.	*Withania coagulans*	Ginseng	Solanaceae	+
Aquatic Plants				
94.	*Ceratophyllum*	-	Ceratophyllaceae	+

Sr. No.	Botanical Name	Local Name	Family	Refinery (Barmer Dist.)
95.	*Hydrilla verticillata*	-	Hydrocharitaceae	+
96.	*Ipomea aquatica*	-	Convolvulaceae	+
97.	*Nymphea*	-	Nymphaeaceae	+
98.	*Vallisneria spiralis*	-	Hydrocharitaceae	-

Source: *NEERI team in consultation with concern state forest officials and local people*
**: species observed by NEERI Team*

3.7.1.5.2 Grasslands

More than 80% of land surface of Barmer is dominated by grass species. People of this region maintain small patches of grassland for hay production. Sewan (Lasiurus sindicus) is one of the best fodder grasses, that grows luxuriantly in small shower as little as 100 mm rainfall. When rainfall is good, numerous patches of private grasslands are dotted all over the region. Dry fodder of L. sindicus grass can be used for even ten years. Other common grasses are Cenchrus ciliaris, C. setigerus, Eleusine compressa etc. In most of the villages, grasslands are termed 'Gauchar' and the community forestlands are termed 'Oran'. Unfortunately, most of these valuable community resources (Gauchar and Oran) have been destroyed because of expansion of villages, illegal occupation, severe overgrazing and mis management, etc. Most of the Oran and Gauchars have Salvadora oleoides and Capparis deciduas and become the living place of the wildlife. The grasslands of the Thar deserts come under Lasiurus- Cenchrus- Dichanthium type. Grasses of Rajasthan have been classified into four habitats comprising:

i. perennial drought resisting plants,
i. perennial drought evading plants,
ii. ephemeral drought evading plants, and
iii. sand binders and sand dwellers

Some of the important grasses are Aristida funiculata, A. adscensionis, A. mutabilis, Brachiaria ramosa, Cenchrus ciliaris, C. biflorus, C. setigerus, Chloris virgata, Cymbopogon jwarncusa, Dactyloctenium sindicum, D. aegyptium, Dichanthium annulatum, Eragrostis ciliaris, E. tremula, Eleusine conmpressa, Lasiurus sindicus, Panicum antidotale, P. turgidum, Sporobolus marginatus, S. helvolus, Tetrapogon tenellus and Tragus racemosus. Out of these, the most important grasses are Cenchrus ciliaris, C. setigerus, Dichanthium annulatum, Lasiurus sindicus, and Panicum antodotale for livestock production and and are significant in range management to improve the production. Distribution of main grassland types is related to climate, soil type and ecology in western Rajasthan **(Table 3.33).** Tree species like *Prosopis cineraria*, *Zizyphus nummularia*, *Salvadora oleoides* and Acacia *senegal*, which provides top feed to the livestocks are associated with these grass species.

Table 3.33 Dominant Species in Forest, Community and Farmer Lands around the Project Site

Name	Tree	Shrub	Grasses
Forest land	*P. juliflora* *P. cineraria*	*Capparis decidua,* *Z. nummularia*	*Aristida adsensionis, C. ciliaris, C. biflorus,*

	A. Senegal *S. oleoides* *S. persica*	*Leptadenia pyrotechnica* *Balanites aegiptiaca*	*Panicum turgidum, C. ciliaris, L. sindicus*
Community land	*S. persica* *S. oleoides* *P. juliflora* A. nilotica	*Capparis decidua* *Z. nummularia* *C. procera* *Crotalaria burhia*	*C. biflorus, C. ciliaris, Aristida adsensionis*
Farmers land	*P. cineraria* *T. undulate* *A. leucophloea* *Ailanthus excelsa* *Azadirachta indica*	*C. decidua* M. emarginata *Balanites aegyiptiaca* *C. procera*	*Aristida adscensionis, C. ciliaris, C. biflorus, L. sindicus, Boerhaavia hirta, Tribulus terrestris*

Ecological Conditions of Some Potential Grasslands in Western Rajasthan

Grassland type	**Rainfall**	**Number of dry days**	**Mean temp of coldest days**	**Soil association**
Dichanthium-Sehima type	250-450	250-300	15-20	Hills (gravel)
Cenchrus-Dichanthium type	200-450	250-300	15-20	Older alluvium of desert plain
Cenchrus type	200-400	250-300	15-20	Well drained alluvial, sand to sandy loam
Eleusine-Aristida type	100-400	250-300	15-20	Skeletal soils of gravelly Pain
Haloxylon-Eleusine type	100-250	300	15	Old flood pain
Lasiurus sindicus type	100-250	300	15-20	Sandy plain
Sporobolus-Dichanthium type	200-400	250-300	15-20	Playa soils
Panicum turgidum type	100-300	250-300	15-20	Undifferentiated sand dunes
Cenchrus-Desmostachya type	100-500	250-300	15-20	Younger alluvium

3.7.1.5.3 Protected Areas (National Park/ Wildlife Sanctuary/Protected Forest)

There are no National Parks or Sanctuaries or Protected Forest in and around the proposed project site for HPCL refinery, Barmer.

3.7.1.6 Survey Methodology

The identification of the flora of the project site and surrounding 10 km of the study area were made mainly based on the personal observations and in-depth exploration of the entire area by following random sampling. The structure and composition of vegetation was studied by taking observations on diverse plant species and their numerical composition at each sampling site. Diversity of plant species was studied by using Simpson's Diversity Index **(Table 3.34).** The plants in the desert have adopted various strategies to endure the intense heat, bitter cold and long dry spells. Coexistence and competition both are affected directly by the number of individuals in the community. Therefore, it is essential to know the quantitative structure of community. To characterize the community as a whole, certain parameters are used. The parameters like frequency, dominance and Diversity Index give a clear picture of community structure in quantitative terms. The values of these parameters are derived from the sampling observations done in the field, which are close to the real value. The structure and composition of vegetation was studied by quadrate method Phyto-sociological association of vegetation in a community was studied. The quadrate method includes laying down of a square sample of suitable size for detailed analysis of vegetation. While studying forest community quadrates, equivalent to one tenth ha (10 m x 10 m) were used for studying Trees. The quadrates of smaller size (5m x 5m) were used and for Shrubs and for low herbaceous community, the quadrates of still smaller size (1m x 1m) were used. To characterize the vegetation in the study area, the data was collected and analyzed for describing the properties of vegetation with reference to species composition and structural attributes. The diversity measurements reflect as to how many diverse species are present, the density measurements indicate number of individuals of a species in a sample plot; the dominance measurements denote which species is largest in terms of its presence; the frequency measurements indicate, and how widely a species is distributed or occurred. Species diversity is the best measure of community structure. It is sensitive to environmental stresses that affect the community. Low value of Simpson's Diversity Index indicates healthy ecosystem and the high value shows that an ecosystem is under environmental stress. Information was collected on the indigenous flora of the locality from the State/Central Government Departments. This information has been incorporated in the report wherever essential.

Table 3.38 Importance Value Index (IVI) of tree species in the study area, district Barmer Rajasthan

	Species	Relative Frequency	Relative Density/ha.	Relative Basal Area/ha.	Important Value Index (IVI)
1	*Acacia leucophloea*	6.25	5.39	5.33	16.97
2	*Acacia nilotica*	2.08	1.24	0.78	4.11
3	*Acacia Senegal*	4.17	2.49	4.69	11.34
4	*Acacia tortilis*	4.17	2.49	2.60	9.26
5	*Ailanthus excelsa*	2.78	1.66	1.56	6.00

6	*Albizia lebbeck*	2.78	1.66	1.56	6.00
7	*Albizia procera*	7.64	4.56	4.69	16.89
8	*Bauhinia purpurea*	2.08	2.07	1.82	5.98
9	*Butea monosperma*	0.69	0.41	0.52	1.63
10	*Prosopis cineraria*	9.03	10.37	10.16	29.56
11	*Prosopis juliflora*	13.89	32.78	32.29	78.96
12	*Salvadora oleoides*	6.94	6.22	5.73	18.90
13	*Tecomella undulata*	9.03	5.39	5.47	19.89
14	*Ziziphus jujuba*	11.11	9.54	9.38	30.03
15	*Zizyphus xylopyra*	6.25	3.73	3.39	13.37
16	*Salvadora persica*	11.11	9.96	10.16	31.23
	Sum Total	**100**	**100**	**100.12**	**300.12**

Table 3.34 Simpson's Diversity Index (SDI) of Flora in the Study Area

Sr. No	Category of Flora	Simpson's Diversity Index (SDI)
1	Trees	0.1632
2	Shrubs	0.1984
3	Herbs	0.2497

3.7.1.6.1 Structure and Composition of Vegetation in the Study Area

Vegetation is extremely irregular and varying considerably in condition, composition, and density. Generally trees observed here have low stunted branches, diffuse crown. Dependency of villagers on natural vegetation in this region is more for timber and firewood. Most of the vegetation aggregates are near villages (**Table 3.33**).

A major portion of the area is occupied by high saline zone of land interspersed with trees, thorny bushes and scrub lands. The vegetation consists of drought-resistant stunted, thorny or prickly shrubs and perennial herbs. Normally the area is covered with coarse and low perennial grasses and other non-grass species. The floristic study reveals species composition, which represents poor gene pool uniformly spread in restricted vegetation patches around human settlements. Collection of dead and dried branches for fuel, hard wood and local trees for construction purpose, grazing practice on vegetated land is also common. The nature of vegetation cover in this region is mixed, tropicaldry, uneven-aged-deciduous vegetation.

The phyto-ecological structure of vegetation shows three different strata i.e. Top, Middle and Ground.In order to reduce transpiration the leaves of most of the plants are reduced in size, for e.g. dominant tree and shrub species of the area are Khejri (Prosopis cineraria), Bavar (Prosopis juliflora), Ber (Ziziphus mauritiana), Salvadora

persica, Acacia species etc. Other associated tree and shrub species in the study area are Tecomella undulate, Acacia nilotica, Acacia tortilis, Cassia fistula, Prosopis juliflora, Acacia senegal Salvadora oleoides, Ziziphus mauritiana, etc.

Tree species come along with shrub species such as Acacia jacquemontii, Capparis decidua, Leptadenia pyrotechnica, Zizyphus nummularia, Calligonum polygonidea, Calotropis gigantea and Calotropis procera. Prominent herb and grass species recorded from the study area are Aerva javanica, Echinops echinatus, Adhatoda zeylanica, Withania coagulans, Suaeda fruticosa, Fagonia indica, Cenchrus setigerus, Heteropogon contortus, Tridax procumbens, Convolvulus prostrates, Citrullus colycynthis, C. lanatus, Tephrosia purpurea, Crotalaria burhia, Suaeda fruticosa etc. Frequency of occurrence for family Amaranthaceae and Gramineae was observed more in the study area as most of the plants of this family observed in the study area can resist water scarcity. Secondary data on various aspects of biological environment was collected from various sources to fortify the primary data.

Stabilized Sand dunes and Interdunal plains

Most of the part of study area is covered with stabilized sand dunes and interdunal plains. Stabilized dunes are generally covered with Capparis decidua (Kair), Calotropis procera (Aak), Leptadenia pyrotechnica, Calligonum polygonoides (Phog), Acacia senegal (Kumat), Prosopis cineraria (Khejri), Aerva javanica (Bui), Aristida funiculata, Aristida adscensionis and other psammophytic species. At the base of the dunes and interdunal plains, which retain comparatively more moisture, the vegetation consist of trees and shrubs such as Prosopis juliflora, Prosopis cineraria, Tecomella undulata, Salvadora persica and Zizyphus nummularia. Citrullus colocynthis and C. lanatus are the creepers.

Sandy plains

Besides some of the trees and shrubs mentioned above, sandy plains may also have herbs and shrubs like as Crotalaria burhia, Farsetia hamiltonii, Indigofera cordifolia, Leptadenia pyrotechnica and Tephrosia purpurea.

Gravelly pediments

Beside, the sandy plains and sand dunes, the most common feature of the study area is gravelly pediments and low hills. The dominant tree is Prosopis juliflora and Salvadora persica. Dominant shrub species are of Maytenus emarginata (Hingot), Calotropis procera, Capparis decidua and Zizyphus nummularia. Common grass is Aristida funiculata. There are a large number of shrubs, annual herbs and climbers recorded in the region.

Saline flats and depressions

There are many saline depressions in the Thar with their characteristic halophytic vegetation consisting of Salsola baryosma, Chenopodium, Haloxylon salinicornicum and Sueda fruticosa. The major grasses and sedges are Eleusine compressa, Eragrostis ciliaris, Dactyloctenium aegyptium, Cyperus rotundus and C. arenarius. The most famous saline depressions are in Pachpadra Lake. The major vegetation around Pachpadra lake consists of Fimbristylis dichotoma, Cyperus rotundus, Prosopis juliflora, Capparis decidua.

Wetlands

Interestingly there are few tanks and ponds in the project site for storing and collecting rainwater, salt mining etc. These smaller wetlands and village ponds have Pullicaria crispa, Cyperus rotundus, Fimbristylis dichotoma and Scirpus roylei along the edge and Ceratophyllum, Hydrilla verticillata, Ipomea aquatica, Nymphea and Vallisneria spiralis in the water.

3.7.1.7 Important Plant Species Observed in the Area

3.7.1.7.1 Bawar (Prosopis juliflora)

Prosopis juliflora (Sw.) DC is an evergreen tree native to South America, Central America and the Caribbean. In the dylands of India, P. juliflora is considered one of the most valuable tree species. P. juliflora belongs to the family Fabaceae, sub-family Mimosae. The Forest Department in late 1950s planted exclusively this species in many parts of the country. Subsequently, the frequent droughts, increasing salinity and extensive livestock grazing, enabled this species to spread in many parts of the country as a prominent invasive. As a result, most of the grassland areas has already been turned to woodland. P. juliflora pods are used as vegetable in the dried and green form in many parts of the Thar desert in Rajasthan. It is an answer to food security issue in drought driven arid parts of the country. The leafy portion, known locally in India as “loong’ is available for 4-5 months (June-October), during which it is used as dry fodder for animals and is sometimes mixed with animal feed. It is an excellent domestic fuel, also giving high-quality charcoal (5,000 kcal/kg). Principally used as firewood and is sustainable and eco-friendly. Principal NWFP (Non Wood Forest Products) obtained from Prosopis is honey and wax. Used widely as a traditional medicinal source. P. juliflora syrup prepared from ground pods has various medicinal values. It is given to children showing weight deficiency or retardation in motor development, the syrup is believed to increase lactation. It is also used for preparing various medicinal syrups, particularly for expectorants. Tea made from P. juliflora is thought to be good for digestive disturbances and skin lesions. Tree is widely used in intercropping, soil reclamation, arresting soil erosion, wind breakers, sand-dune stabilization as well as nitrogen fixation in nutrient deficient soils.

3.7.1.7.2 Khejri (Prosopis cineraria)

Khejri (Prosopis cineraria) is a tree endemic to hot deserts of India, belonging to family Leguminosae found mainly in area. Khejri is also state tree of Rajasthan. Khejri, the golden tree of Indian deserts, plays a vital role in preserving the ecosystem of arid and semi-arid areas. It is the symbol of socio-economic development and religious significance to the people of the arid regions. Khejri is the preferred plant species for livestock grazing in the area, and it provides shelter to the grazing animals, people and birds with its shade. It is a multipurpose tree; its thorny twigs are used to form barriers between fields to keep animals away from the crops, while its leaves are dried and used as fodder, fruits are eaten ripe and when unripe these are cooked and eaten locally known as Sangri. The utility list goes on further, like, the wood is used for furniture and the branches as fuel.

3.7.1.7.3 Rohida (Tecomella undulata)

Tecomella undulata is a deciduous or nearly evergreen tree of desert or dry regions belonging to family Bignoniaceae. Rohida flowers are state flower of Rajasthan. It thrives very well on stabilized sand dunes, which experience extreme low and high

temperatures. Cattle and goats eat leaves of the tree. Camels, goats and sheep consume flowers and pods. Tecomella undulata acts as a soil-binding tree by spreading a network of lateral roots on the top surface of the soil. It acts as a windbreak and helps in stabilizing shifting sand dunes. It is considered as the home of birds and provides shelter for other desert wildlife.

3.7.1.7.4 Kair/ Kerda (Capparis decidua)

Kair is an economically important plant in its marginal habitat belonging to family Capparidaceae. Its spicy fruits are used for preparing vegetables, curries and pickles and attract polinators; the plant also used in various traditional medicine. In last few years, the impact climate related vulnerabilities can also be observed in this plant as it produces flowers and fruits twice a year and pehenological changes are also quite prominent across the study area. Second time flowering were also observed during the survey in the month of November.

3.7.1.7.5 Sania (Crotalaria burhia)

Sania Crotalaria burhia belongs to family Fabaceae. Plant is a good soil binder and has medicinal value. It is used to make ropes and sheds for livestock in the desert and also used to made jhumpa (desert huts). It is a feed for goats.

3.7.1.7.6 Bui (Aerva javanica)

Bui is herbaceous, multi-stemmed, soft-wooded, with broad leaves belonging to family Amaranthaceae; it often has an erect habit. One of the most common desert shrubs superbly adapted to growing in deep sand. Bui (also buari) has cottony flowers and fruit and sometimes covers large expanses following lines of natural drainage. Bui cotton is used by desert people to stuff mattresses and pillows, making make cow shed boundaries and also for thawing purpose.

3.7.1.7.7 Kheemp (Leptadenia pyrotechnica)

Being highly drought-resistant, Leptadenia pyrotechnica belonging to family Ascepiadaceae has played an important role in the desert afforestation programs. The herb khimp is a strong soil binder and as such is one of the pioneer species in sand dune fixation. The plant is used in thatching huts. Pods of this shrub known as khimpoli, ripen in the month of March which are of medicinal value and used as vegetables. The plant fiber is used for making ropes. The plant is browsed by all stock, but especially by camels for which it is considered a good fodder.

3.7.1.7.8 Medicinal Plants

The arid ecosystem of western Rajasthan exhibits a great variety of geology, physiography, and peculiar edaphic and climatic conditions. The region is a rich repository of genetic material of important arid medicinal plant wealth. These plants are not valued as herbal drugs but utilized for food, fodder, gums & resins, essential oils, dyes, fatty oils, condiments, spices etc. According to an all India ethnobiological survey carried out by the Ministry of Environment & Forests, Government of India, there are over 8,000 species of plants being used by the people of India (Report of the Task Force on Conservation &sustainable Use of Medicinal Plants). Arid zone of Rajasthan is fortunately gifted with 628 species belonging to 352 genera and 87 families. About one fourth of the total plants of the Indian Thar desert are useful for the welfare of human beings and domestic animals for food, fuel, fodder, medicine and other requirements. The erratic rainfall and poor soil fertility have marked effect

on the vegetation of the Indian desert. The Barmer district a part of Thar Desert is very rich in herbal plant wealth. About one fourth of the total plants of the Indian Thar desert are useful for the welfare of human beings and domestic animals for food, fuel, fodder, medicine and other requirements. The herbal plants of this region have great potential to be used in drug and pharmaceutical industries (**Table 3.35**). These herbal plants have been used by local people, tribal communities, vendors, native doctors such as Ojhas, Bhagats Bhopas and experts of Ayurvedic fields since long time in herbal and folk remedies. Kalbelia, Naths, Bhils, Vishnoi, Raika, Bhopas, Banjara, Gadolia-Lohar Langa and Manganiars communities of this district have a rich knowledge of plants based traditional medicines. The inhabitants of remote areas of arid zone of Rajasthan are totally dependent on indigenous system of medicine for their health care as it is difficult for them to get modern medical facilities for their day to day health problems. The traditional healers and inhabitants of arid zone have a rich knowledge of traditional plant based medicines. Ground floor in study area is covered by herbaceous vegetation, which has many Ayurvedic medicinal plants. In addition, the area abounds in production of many kinds of fruits, flowers, seeds and leaves.

The common herbal medicinal flora of the study area consists of Prosopis cineraria, Prosopis juliflora, Commiphora wightii, Commiphora stoksiana, Acacia senegal, Crotalaria burhia, Echinops echinatus, Calotropis procera, Xanthium strumarium, Cassia fistula, Tamarindus indica, Ficus bengalensis, Ziziphus mauritiana, Ricinus communis, Vitex Negundo etc. However, the scattered distribution and low density of these plants does not allow their commercial use.

Table 3.35 List of Medicinal Plants in Study Area

Sr. No.	Botanical Name	Common Name	Family	Medicinal Use
	Acacia nilotica	Babul	Fabaceae	Demulcent
	Crotalaria burhia	Sania	Fabaceae	Fruits are used in the treatment of enlarged spleen, rheumatism and fever
	Fagonia indica	Dhamasa	Zygophyllaceae	Plant is used for high acidity, gonorrhoea, skin problems; stomachic, tonic, expectorant, anti-inflammatory, vulnerary, good for hepatic problems, fever, swellings, wounds and kidney stones
	Salvadora oleoides	Pilu	Salvadoraceae	Leaves are used against chronic fever, heat stroke and against internal pain of bones due to injury or by any means
	Prosopis cineraria	Khejari	Fabaceae	Bark of the tree is dry, acrid, bitter with a sharp taste; cooling anathematic; tonic, cures leprosy, dysentery, bronchitis, asthma, leucoderma, piles and tremors of the muscles.
	Prosopis juliflora	Bawar	Fabaceae	weight deficiency or retardation in motor development among children, the syrup is believed to increase lactation. It is also used

Sr. No.	Botanical Name	Common Name	Family	Medicinal Use
				for preparing various medicinal syrups, particularly for expectorants. Tea made from *P. juliflora* is thought to be good for digestive disturbances and skin lesions.
	Asparagus racemosus	Shatavar	Asparagaceae	Used as a galactagogue and for disorders of female genitourinary tract
	Azadirachta indica	Neem	Meliaceae	Fever, Skin diseases
	Bauhinia variegata	Kachnar	Fabaceae	Used in diarrhoea, dysentery, worm infestation, piles and tumours.
	Butea monosperma	Palash	Fabaceae	Liver disorders
	Calotropis gigantea	Mudar	Asclepiadaceae	Rottning of teeth, Migraine
	Cassia fistula	Amaltas	Fabaceae	Purgative, Febrifugal, Astringent, Antibilious
	Ficus religiosa	Peepal	Moraceae	Astringent, antiseptic, Alterative, laxative, haemostatic
	Ficus bengalensis	Bargad	Moraceae	Diabetes, dysentery
	Tribulus terrestris	Gokhru	Zygophyllaceae	Diuretic, Demulcent, Anti-inflammatory, Anabolic, Spasmolytic, Muscle relaxant, Hypotensive, Hypoglycaemic

Source: NEERI team in consultation with concern state forest officials and local communities

3.7.1.8 Threatened Flora

Important plant species reported to be rare or threatened are Commiphora wightii (arn) Bhandari and Tecomella undulata, which are of great economic importance. Some of other species threatened according to IUCN, 2000 guidelines present in the study area are B. prionitis var. Dicantha, Cenchrus prieurii (Kunth) Ammaninnia desertorum, Dipcadia erythreaum, Enncapogon brachystachyus, Ephedra foliata, Heliotropioum rarifloraum, Limenum indicum, Moringa concanensis, Ryhnchosia schimperi, Sesuvium sesuviodes, Tephrosia falciformis, Tribulus rajasthanensis and Zizyphus truncate.

3.7.1.9 Agriculture practices

Agriculture is the main source of livelihood other than the livestock rearing. Rainwater is the main source for irrigation and drinking water in the region, tube wells also supplement as a source of water for irrigational purposes, sprinkler systems are utilized for irrigating crops through tubewells. During the monsoon people prefer to grow pearl millet, commonly called as Bajra (Pennisetum typhoides). The other main crops are mungbean (Vigna radiata), moth (Vigna aconitifolia), til (Sesamum indicum) and the cash crop gaur (Cyamopsis tetragonoloba). In most of the region, a single crop is harvested, i.e the rainfed. Under irrigated conditions wheat (Triticum

aestivum), bajra (Penisetum glaucum), zeera (Cuminum cymium), Isabgol (Plantago ovata) are the common crops sown. Details of crops, cropping patterns and yield are provided in **Table 3.36**. Agriculture practiced in the area is Rainfed and no irrigation facility is available in the area. Productivity of the agricultural crops in this region is very low because of poor soil quality, infrequent and inadequate rainfall, water scarcity, low consumption of fertilizer, shifting cultivation, lack of improved agricultural technology and improper communication.

Table 3.36 Season wise list of cropping pattern and Species wise production at study site

Sr. No.	Kharif (Rainfed)	Production (Quintal/ha.)	Rabi (Rainfed)	Production (Quintal/ha.)
1	Bajra	8-10	Cumin	6-7
2	Moong	6-7	Wheat	20-22
3	Moth	6-7	Mustard	7-8
4	Cluster Bean	7-9		
5	Seasum	3-4		

3.7.1.10 Survey Data Analysis

Density, Abundance, stand basal area and resource sharing was studied in the study area. The density measurements indicate number of individuals of a species in a sample spot . Density of tree species was maximum for Prosopis juliflora i.e. 263 individulas/ha followed by 83 individuals/ha. for P.cineraria and 80 individuals/ha for Salvadora persica. Basal Area sq.m./ha of tree species in the in the study area was recorded maximum again for Prosopis juliflora i.e. 1.24 m2/ha followed by 0.39 m2/ha for P.cineraria and for Salvadora persica. Total basal area occupied by tree species recorded from the study areas was 3.84 1.24 m2/ha. Abundance recorded in the study area for tree species is abundance of Prosopis juliflora, P.cineraria as dominant trees whereas, Butea monospermea, Acacia species, Salvadora oleoides were less abundant. The IVI are depicted in **Table 3.34** and shows the rarity and dominance of species in the study area. Species diversity is the best measure of community structure and it is sensitive to various environmental stresses **(Table 3.34).** . Currently the study area is less diverse in terms of trees and shrub species but there is huge diversity of grass and herb species. Study area indicates healthy ecosystem in terms of grass and herb diversity. Simpson's Diversity Index (SDI) ranges from (0.09-0.2) which indicates good to medium diversity for desert environment adapted tree species and is presented in **Table 3.34**.

Diversity Curves (D-D Curves)

Dominance Diversity Curves exhibits the community organization in terms of resources share. The dominance-diversity curves have been repeatedly used to interpret the community organization in term of resource share and niche space. It is plotted by taking log values of IVI of all the species in different sites. Generally, we get three types of distribution models viz. geometric, log normal and log series models depending on the competitive ability and organism in utilizing or sharing of resources. Dominance Diversity (D-D) curve is depicted in **Figure. 3.18** and shows resource sharing initially by few dominat species. Curve fits the Preston's (1948) log normal situation though; initially they followed geometric distribution of species. Species occupying the maximum niche space in these forests were i.e. Prosopis juliflora, P.cineraria and S.persica.

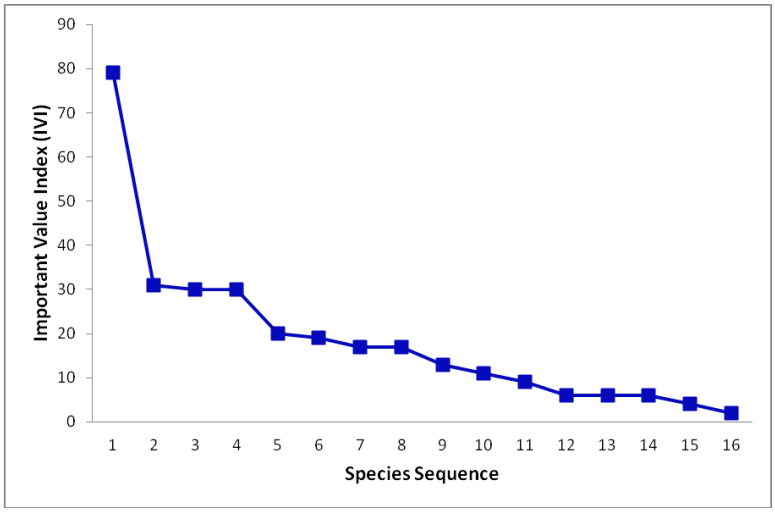


Figure 3.18 Stand density and Basal area in the in the study area, district Barmer Rajasthan

Figure. 3.17 - An overview of desert biological environment of the study area with special reference to flora of study area, District Barmer, Rajasthan.

***Prosopis cineraria* (*Khejri*) state tree and endemic to Rajasthan in the study area**

***Prosopis juliflora* (*Bavar*) an invasive tree can be seen growing luxuriantly in the study area**

Khimp Shrub (*Leptadenia pyrotechnica*)

Bui Herb (*Aerva javanica*)

Dhamasa Herb (*Fagonia indica*)

Citrullus colycynthis

Tephrosia purpurea

Crotolaria burhia

Suaeda fruticosa

***Fimbristylis dichotoma* near Pachpadra Lake**

Bui (*Aerva javanica*) used as prominent cow shed boundary and thatching material by Kalbeliya community at the study site

3.7.2 Faunal diversity

The survey was carried out in November 2013 to assess the eco-status of fauna in and around project site in district Barmer. The study area consists of dry and thorny vegetation.

NEERI Team has conducted the primary field survey and observed Chinkara (Gazella bennettii), Indian Hare (Lepus nigricollis) and Mongoose (Herpestes edwardsi) Indian fox (Vulpes bengalensis), nilgai (Boselaphus tragocamelus) spotted deer (Axis axis), wild boar (Sus scrfa), black buck (Antelope cervicaps) in the study area.

The area provides suitable conditions for survival of a number of species of lizards, gerbils and snakes. The spiny tailed lizards with their prehistoric looks are quite common in many areas of the Barmer district. Among the snakes the saw scaled viper, the large rat snake and sand boa are noteworthy. Most of these animals can survive in the scarcity of water by adopting special mechanism so that life can go on without water.
They reduce their physical activity considerably and avoid exposure to hot winds by keeping in shade of shrubs or by burrowing down in the sand. Earth act as an admirable insulator against heat and aridity and an animal burrowing a few centimeters below the surface will comfortably survive the hottest day and coolest night.

3.7.2.1 Mammalian diversity in the region

Chinkara, the Indian Gazelle (Gazella bennetti) is small slender and gracefully built animal, with male bearing annulated horns (maximum length 40 cm) while females are normally with small, straight, smooth, thin spikes, curving backward without any annulations. During summer the coat colour is reddish buff with the fur smooth and highly glossy. This is probably an important adaptation for reflecting back some of the sun's rays and thus minimizing heat absorption during the very high day temperatures experienced in its habitat (**Figure 3.19**).

Chinkara prefers to live in arid to semi arid habitat, and can withstand without drinking water for more then 2-3 weeks. It is a browser and mainly thrives on the scrub vegetation and can maintain water balance through metabolic process. The main dominated vegetation in its natural habitat is Crotalaria-Ziziphus-Capparis type. It changes its food choice time to time and fed on variety of plants like, Calotropis procera, Calligonum polygonoides, Acacia senegal, Prosopis cineraria, Acacia jacquemontii, Tecomella undulata, Salvadora oleoides and Ziziphus nummularia. Similarly, Indian Desert Gerbil (Meriones hurrianae) which serves as staple food for the Indian Desert Fox (Vulpes vulpes pusilla) and the desert cats, provide much of the water to these species (**Figure 3.19**).

Hare (Lapus nigricollis), hedgehog (Parachinus micropus), jungle cat (Felis caus), mangoose (Herpestes edwardis) and wolf (Canis lapus) are the common animals in the region. The chinkara, which cannot enter a burrow, go under the shade of bushes. They can tolerate a rise in body temperature up to seven degrees above normal without serious injury to any vital organ. These animals can withstand considerable haemo-concentrations or blood thickening, which takes plated. Chinkara for example can go without water for a number of days by feeding on green plants like Aak (Calotropis procera) and obtaining water from its leaves.

Three microchiropteran species i.e. Rhinopoma microphyllum kinneari, Pipistrellus tenuis, Taphozous perforatus perforatus were recorded in this area. Few species from microchiropterans are Rhinopoma hardwickii, Taphozous melanopogon, Taphozous nudiventris and from megachiroptera are Cynopterix sphinx, Pteropus giganteus giganteus were also recorded.

3.7.2.2 Endangered animal species in the study area

Blackbuck, Chinkara, Grey Wolf, Indian Desert Cat and Desert Fox are the endangered animal species, normally observed in the Desert Environment of Barmer District. These species may also exist in the study area, however, only Chinkara was observed by the NEERI Survey team during the field studies. Salient characteristic of these species are given here:

1. Blackbuck (Antelope cervicapra): The Blackbuck is an animal of short grass plains where surface water is easily available, as it has to drink frequently.

2. Chinkara or Indian Gazelle (Gazella bennetti): It is the state animal of Rajasthan. The Chinkara was observed by NEERI team and widely distributed in the study area, at varying population levels. It is found in nine states of India but the highest concentrations are found in the desert.

3. Grey Wolf (Canis lupus pallipes): It has totally disappeared from flat, sandy areas, where it can be followed by its footprints. It survives only in rocky, undulating areas such as present in study area.

3.7.2.3 Diversity of herpetofauna

Herpetofauna includes both, amphibians and reptiles. These two classes of animals are blessed with unique adaptations to cope with the varying climatic conditions and the environmental niche. These species have a prominent role in the ecological balance and natural conservation. Destruction of biotopes by peoples for their own uses caused a large number of amphibians and reptiles to become endangered today. Many species were killed in very large numbers during last few decades for food, skin and various other reasons.

Amphibians are generally restricted to freshwater or they depend upon water bodies for breeding purpose. This indicates the importance of freshwater body for their life cycle. They are not harmful to nature rather helpful, their food mainly consists of small insects and their larvae and pupae etc., which are pests of crop and vectors of diseases. All the hydrophilic species of frogs namely Rana tigerina. Rana cyanophlyctis, Rana hexadactyla, Rana limnocharis and Microhyla ornata and toads Bufo melanostictus and Bufo andersoni are rare and endangered in proposed study area. Toad like burrowing frog, Rana breviceps is widely spread within the area, but not common. On the whole, the amphibian fauna in study area is quite poor in diversity as well as in population. Reptiles are cold-blooded vertebrates, which breathe by lungs throughout their existence. They have a body covered with scales.

Lizards are most common species recorded in Barmer division. Three species of Gekkonids i.e., Stenodactylus orientalis, Bark gecko, Hemidactylus leschenaulti and Yellow bellied house gecko, Hemidactylus flaviv and two species of Agamids i.e., Calotes versicolor and Brilliant Agama, Agama agilis. One species of skinks namely Indian sand skink, Ophiomorus tridactylus and one species of Lacertids like Indian

fringe-toed sand lizard, Acanthodactylus cantoris cantoris have also been recorded in the area.

The lizard species in abundance and without any threat are Stenodactylus orientalis, Cyrotodactylus scaber, Cyrtodactylus kachhensis, Cyrtodactylus watsoni, Hemidactylus brooki, Hemidactylus triedrus, Hemidactylus leschenaulti, Hemidactylus flaviviridis, Calotes versicolor, Agama nupta fusca, Agama agilis. Ablepharus grayanus, Ophisops microlepis, Ophisops jerdoni, Ophiomorus tridactylus, Acanthodactylus cantoris cantoris.

- **Lizards**: Commonly occurring lizards are Eublepharis macularius, Sitana ponticeriana, Agama minor, Phrynocephalus laungwalensis. Eumes taeniolatus, Mabuya macularia, Mabuya carinata, Riopa punctata and Eremias guttulata watsonana.
- **Snakes:** About twenty species of snakes have been recorded so far from different regions of Barmer Division.
- **Family Typhlopidae** includes Brahminy, blind snake, (Ramphotyphlops bramina) and beaked Blind Snake (Typhlina acutus).
- **Family Leptotyphlopidae includes beaked Thread Snake, (Leptotyphlops macrorhynchus).**
- **Family Boidae** includes Indian Sand Boa (Eryx johni johni) and Russell's Sand Boa (Eryx conicus).
- **Family Colubridae** includes Dhaman (Ptyas mucosus), Trinket Snake (Elaphe Helena), Glossy-bellied racer (Argyrogena ventromaculatus), Royal Snake (Sphalerosophis atriceps), Diadem Snake or Rajatbansi (Sphalerosophis diadema diadema), Red Spotted Diadem Snake (Sphalerosophis arenarius), Wolf Snake (Lycodon aulicus), Checkered Keelback (Xenochrophis piscator), Green Keelback (Macropisthodon plumbicolor), Green Whip Snake (Ahaetulla nasutus); Indian Cat Snake (Boiga trigonata) and Afro-Asian Sand Snake (Psammophis schokari).
- **Family Elapidae** includes Indian Krait (Bungarus caeruleus), Binocellate Cobra, (Naja naja), Oxus Cobra or Black Cobra (Naja naja oxiana).
- **Family Viperidae** includes Saw Scaled Viper (Echis carinatus), Viper (Vipera russelli russelli).

3.7.2.4 Avian diversity

Over 250 bird species including partridges, quails, sand grouses, Great Indian bustard, shrikes, bayas, sparrows, munias, crows, mynas, starlings, parakeets, kites, hawks, shikras, vultures, doves, bee eaters, bulbuls, babblers, larks, ducks, pea fowls, finches, hoopoe, lapwings, coursers, teals, woodpeckers, pigeons and cranes etc are recorded from the study area. Occurrence of these bird species in low numbers is evidently due to hostile climatic factors, sparse vegetation cover, very little tree cover with small canopy and almost rare water bodies and above all no surety of regular food availability. However, in the central region spectacular avian biodiversity is witnessed, 81 species belonging to 37 families. Birds observed during recent survey by NEERI team indicates the presence of pea fowl or peacock (Pao cristatus), bhat titar (Pterocles exuslus), Common Babbler (Turdoides caudata), gidh (Neophron peronoterus), house crow (Corvus splendense), wood pecker (Piecoides nanus), Baya (Ploceus philippinus), kabboter (Columbia livia), owl (Bubo bubo), house

sparrow (Passer domesticus), chil (Falco jugger), Lesser Whitethroat (Sylvia curruca) and Baj or eagle (Corcatus gallicus) **(Figure 3.19, 3.20 and 3.21).**

3.7.2.4 Kurja (Demoiselle crane): at Pachpadra Lake

Pachpadra Lake is a salt water lake lies near Pachpadra Tehsil in Barmer District. It is said that the lake comprises of 98% Sodium chloride. The source of water in lake is rain water only. The water in lake is observed normally during monsoon and post-monsoon season.Pachpadra lake is situated at about 5 km from the project site

Kurja (Demoiselle crane) was observed in large number near the pachpadra lake **(Figure: 3.22)** during the visit of NEERI team in the month of Nov., 2013. Demoiselle cranes are called Kurja in local language. According to bird experts, thousands of kurja birds came for a sojourn to Pachpadra every year in the month of September from cold countries. The atmosphere of Pachpadra is conducive to these migratory birds. The Demoiselle is 85-100 cm long with a 155-180 cm wingspan. It is therefore slightly smaller than the Common Crane, with similar plumage. However it has a long white neck stripe and the black on the fore neck extends down over the chest in a plume. During their migratory flight, demoiselles fly like all cranes, with their head and neck straight forward and their feet and legs straight behind **Figure: 3.22).** Demoiselle Cranes form a perfect “V” shape with their leader at the pointed tip of the “V”.

3.7.2.5 Bird Census and Survey Techniques

Area Search

This method involves searching a set area and recording data only from within the pre-defined search zone. The area is usually covered by walking a route which is entirely flexible, but in some cases parallel, equally-spaced transects are used to ensure complete coverage of the area.

Transect surveys

Transect surveys usually involve recording birds that are seen or heard while travelling a pre-determined path between two fixed points of known distance apart. Alternatively, transects may be travelled for a fixed period of time without regard for distance, though this approach is less common. Transects typically follow a straight path but can follow roads, rivers, coastlines or contours. They are usually done on foot, though travel by motor vehicle may be appropriate where target species are conspicuous.

Transects may also be done by ship or aircraft and these forms of survey are detailed in separate sections. The optimal length of transects will depend on the aim of the survey. For surveys that aim only to detect particular taxa, transect lengths may vary and be dictated by the dimensions of patches of habitat favoured by the target taxa/taxon. For example, transects may be placed across a wetland at regular intervals but the length of each transect will vary with the width of the wetland at that location.

Point surveys

Point surveys involve recording the presence and usually number of individuals, of each taxon detected at a series of specified locations. The sampling points are usually pre-determined and selected either randomly or systematically within the study area.

Rolling Bird Survey

In this method, observers stop at a series of survey points (often separated by equal distances). A set time period (usually five minutes) is spent at the site before moving on to the next survey point. During the stops, birds seen or heard are recorded.

Stationary Count

As the name implies, stationary counts involve data recording during a single stop where the observer remains in the one place. There is usually a set duration of data recording. This method is similar to the stops on the Rolling Bird Survey. Great care needs to be taken when checking nests, and disturbance to the breeding birds must be avoided.

3.7.2.6 Avifauna Species observed in the Study Area

Birds were noted, counted and identified with the help of Nikon 50 binocular and standard field identification guides. All the records were reviewed under IUCN and Wildlife (Protection) Act, 1972 for their conservation status. Some of the common birds observed during survey are Peacock (Pavo cristatus), Common Babbler (Turdoides caudata), Purple Sunbird (Cinnyris asiaticus), Plain Prinia (Prinia inornata), Blue Rock Pigeon (Columba livia), Taiga Flycatcher (Ficedula albicilla), Green Bee-eater (Merops orientalis), Southern Grey Shrike (Lanius meridionalis), Rosy Starling (Sturnus roseus), Oriental Magpie-Robin (Copsychus saularis), Black Redstart (Phoenicurus ochruros), Grey francolin (Francolinus pondicerianus), House crow (Corvus splendens), Common Myna (Acridotheres tristis), House sparrow (Passer domesticus), Black Winged Stilt (Himantopus himantopus), Indian Robin (Saxicoloides fulicata), Hoopoe (Upupa epops), White Eared Bulbul (Pycnonotus leucotis), Jungle Crow (Corvus macrorhynchos), Lesser Whitethroat (Sylvia curruca) (**Figure: 3.20** and **3.21**).

The birds of prey commonly seen in the study area are Tawny eagle, Steppe Eagle (Aquila nipalensis), Oriental Honey Buzzard (Pernis ptilorhynchus), Long Legged Buzzard (Buteo rufinus), White Eyed Buzzard (Butastur teesa), Shikra (Accipiter badius), Black-shouldered Kite (Elanus axillaris), Goshawk and Kestrel (Falco tinnunculus). There are also vultures which scavenge dead cattle and fauna. Common among them are the Egyptian vulture (Neophron percnopterus) and Cinereous Vulture (Aegypius monachus), one of the least gregarious of vultures.

The fauna and avifauna commonly noted by local people and confirmed by concerned forest department officials of Barmer, Rajasthan are presented in **Tables 3.37** and **3.38** respectively.

3.7.2.7 Conservation Status

One species of Mammal, namely Gazella bennettii, as reported in the study area is included in Schedule-I of Wildlife (Protection) Act (1972). Out of 9 species, 1 species;

Gazella bennettii has been placed in 'Vulnerable' category of IUCN. Besides, 9 species of Mammals and Reptiles have been categorized under Schedule-II.

Among Aves, 32 species from the study area are categorized in Schedule-IV of Wildlife (Protection) Act (1972). Species viz. Pavo cristatus and Corvus splendens have been placed in Schedule-I and Schedule-V respectively. Cinereous Vulture and Egyptian Vulture are placed in 'Near Threatened' and 'Endangered' category of IUCN respectively.

Table 3.37 List of Fauna recorded in Study Area

Sr. No.	Zoological Name	Local Name	Family	Status in Wildlife (Protection) Act-1972	Status in IUCN Category
Mammals					
1.	Felis chaus	Jangli Billi	Felidae	Schedule II	Least Concern
2.	Funambulus pennanti*	Gilhari	Sciuridae	Schedule IV	Least Concern
3.	Gazella bennettii*	Chinkara	Bovidae	Schedule I	Vulnerable
4.	Herpestes edwardsii	Nevala	Herpestidae	Schedule II	Least Concern
5.	Lepus nigricollis	Khargosh	Leporidae	Schedule IV	Least Concern
6.	Meriones hurrianae*	Chuha	Muridae	Not Enlisted	Least Concern
7.	Paraechinus micropus*	Jhau Chuha	Erinaceidae	Not Enlisted	Least Concern
8.	Presbytis entellus	Langur	Columbidae	Schedule II	Not Evaluated
9.	Vulpes vulpes pusilla*	Lomadi	Canidae	Schedule II	Not Evaluated
Reptiles					
10.	Calotes versicolor*	Chipkali	Agamidae	Not Enlisted	Not Evaluated

Source: NEERI team in consultation with concern state forest officials and local people
*: species observed by NEERI Team

Table 3.38 List of Avifauna

Sr. No.	Scientific Name	Common Name	Family	Status in Wildlife (Protection) Act-1972	Status in IUCN Category
1.	Accipiter badius*	Shikra	Accipitridae	Not Enlisted	Not Evaluated
2.	Accipiter nisus	Eurasian Sparrow Hawk	Accipitridae	Not Enlisted	Least Concern
3.	Acridotheres tristis*	Common Myna	Sturnidae	Schedule IV	Least Concern
4.	Aegypius monachus*	Cinereous Vulture	Accipitridae	Schedule IV	Near Threatened
5.	Aquila nipalensis*	Steppe Eagle	Accipitridae	Not Enlisted	Least Concern
6.	Aquila rapax	Tawny Eagle	Accipitridae	Not Enlisted	Least Concern
7.	Athene brama	Spotted Owlet	Strigidae	Schedule IV	Least Concern
8.	Bubo bubo	Eurasian Eagle-Owl	Strigidae	Schedule IV	Least Concern
9.	Butastur teesa*	White-eyed Buzzard	Accipitridae reat Cormorant	Schedule IV	Least Concern
10.	Buteo rufinus*	Long Legged Buzzard	Accipitridae	Not Enlisted	Least Concern
11.	Centropus sinensis	Greater Coucal	Cuculidae	Schedule IV	Least Concern
12.	Cinnyris asiaticus*	Purple Sunbird	Nectariniidae	Schedule IV	Least Concern
13.	Columba livia*	Blue Rock Pigeon	Columbidae	Not Enlisted	Not Evaluated
14.	Copsychus saularis*	Oriental Magpie-Robin	Muscicapidae	Schedule IV	Least Concern
15.	Coracias benghalensis*	Indian Roller or Blue Jay	Coraciidae	Schedule IV	Least Concern
16.	Corvus macrorhynchos*	Jungle Crow	Corvidae	Not Enlisted	Least Concern
17.	Corvus splendens*	House Crow	Corvidae	Schedule V	Least Concern
18.	Coturnix coromandelica	Rain Quail	Phasianidae	Schedule IV	Least Concern
19.	Coturnix coturnix	Common Quail	Phasianidae	Schedule IV	Least Concern
20.	Cuculus varius	Common Hawk-Cuckoo	Cuculidae	Schedule IV	Least Concern
21.	Dicrurus macrocercus*	Black Drongo	Dicruridae	Schedule IV	Least Concern
22.	Elanus caeruleus*	Black-winged Kite	Accipitridae	Not Enlisted	Least Concern
23.	Eremopterix grisea	Ashy Crowned Sparrow Lark	Alaudidae	Not Enlisted	Least Concern
24.	Eudynamys scolopaceus	Koel	Cuculidae	Schedule IV	Least Concern

Sr. No.	Scientific Name	Common Name	Family	Status in Wildlife (Protection) Act-1972	Status in IUCN Category
25.	Falco tinnunculus*	Common Kestrel	Falconidae	Not Enlisted	Least Concern
26.	Ficedula albicilla*	Taiga Flycatcher	Muscicapidae	Schedule IV	Least Concern
27.	Francolinus pictus	Painted Partridge	Phasianidae	Schedule IV	Least Concern
28.	Francolinus pondicerianus*	Grey Partridge	Phasianidae	Schedule IV	Least Concern
29.	Himantopus himantopus*	Black Winged Stilt	Recurvirostridae	Schedule IV	Least Concern
30.	Lanius meridionalis*	Southern Grey Shrike	Laniidae	Not Enlisted	Not Evaluated
31.	Lanius schach*	Rufous Backed Shrike	Laniidae	Not Enlisted	Least Concern
32.	Merops orientalis*	Green Bee-eater	Meropidae	Not Enlisted	Least Concern
33.	Neophron percnopterus*	Egyptian Vulture	Accipitridae	Schedule IV	Endangered
34.	Passer domesticus*	House Sparrow	Passeridae	Not Enlisted	Least Concern
35.	Pavo cristatus*	Common Peafowl	Phasianidae	Schedule I	Least Concern
36.	Perdicula asiatica	Jungle Bush Quail	Phasianidae	Schedule IV	Least Concern
37.	Pernis ptilorhynchus	Honey Buzzard	Accipitridae	Not Enlisted	Not Evaluated
38.	Phoenicurus ochruros*	Black Redstart	Muscicapidae	Schedule IV	Least Concern
39.	Prinia inornata*	Plain Prinia	Cisticolidae	Not Enlisted	Least Concern
40.	Psittacula krameri	Rose Ringed Parakeet	Psittaculidae	Schedule IV	Least Concern
41.	Pycnonotus cafer*	Red Vented Bulbul	Pycnonotidae	Schedule IV	Least Concern
42.	Pycnonotus leucotis*	White Eared Bulbul	Pycnonotidae	Schedule IV	Least Concern
43.	Saxicola maurus*	Siberian Stonechat	Muscicapidae	Schedule IV	Not Evaluated
44.	Saxicoloides fulicata*	Indian Robin	Muscicapidae	Schedule IV	Least Concern
45.	Spilornis cheela	Crested Serpent Eagle	Accipitridae	Not Enlisted	Least Concern
46.	Streptopelia chinensis*	Spotted Dove	Columbidae	Schedule IV	Least Concern
47.	Streptopelia decaocto*	Eurasian Collared Dove	Columbidae	Schedule IV	Least Concern
48.	Sturnus pagodarum	Brahminy Myna	Sturnidae	Schedule IV	Least Concern
49.	Sturnus roseus*	Rosy Starling	Sturnidae	Schedule IV	Least Concern

Sr. No.	Scientific Name	Common Name	Family	Status in Wildlife (Protection) Act-1972	Status in IUCN Category
50.	Sylvia curruca*	Lesser Whitethroat	Sylviidae	Not Enlisted	Least Concern
51.	Turdoides caudatus*	Common Babbler	Timaliidae	Schedule IV	Least Concern
52.	Turdoides striatus	Jungle Babbler	Timaliidae	Schedule IV	Least Concern
53.	Upupa epops*	Hoopoe	Upupidae	Not Enlisted	Least Concern
54.	Vanellus indicus*	Red-Wattled Lapwing	Charadriidae	Not Enlisted	Least Concern

3.7.2.8 Insect diversity

A xerocole, commonly referred to as the animals adapted to live in the desert. The main challenges they must overcome are lack of water and excessive heat. To conserve water, they both avoid evaporation and concentrate excretions (i.e. urine and feces). Xerocoles have developed a variety of mechanisms to reduce water loss via evaporation. Mammalian xerocoles sweat much less than their non-desert counterparts. For example, the camel can survive ambient temperatures as high as 49 °C (120 °F) without sweating and the kangaroo rat lacks sweat glands entirely. Both birds and mammals in the desert have oils on the surface of their skin to "waterproof" it and inhibit evaporation.

Desert insects use a similar method, as their cuticles are waxy to prevent water from escaping; however at critical temperatures (ex. 30 °C (86 °F) for cockroaches), the wax molecules in the cuticle rearrange to become permeable and permit evaporative cooling. Life of insects in the desert is easier than for most vertebrates as they have a water proof cuticle or skin to retain water and frequently short life cycle, often combined with metamorphosis which enables vulnerable stage to tide over the adverse season. Some of the insects inhabit soils while others lead subterranean life. In view of the adaptability of insects to desert environment, there is likelihood of occurrence of far larger number of insect species as compared to 1.5% of the species reported from Indian desert. Zoological Survey of India, Jodhpur, carried out a systematic collection of insects. In addition, the study carried out indicated the presence of insects belonging to the 29 families of the orders of Odonata, orthoptera, Dermaptera, Isoptera, Malaphaga, Hemiptera, Neurooptera, Lepidoptera, Diptera, Hymenoptera and coleoptera. The *springtails* are among the most abundant of all soil-dwelling arthropods. Indian fauna of Collembola represents 299 species in 103 genera under 18 families. They are considered to be useful organisms, whose role is beneficial to the health of soil. The soil arthropods largely regulate the soil nutrient status in arid zone because there is no scope of extra organic inputs in desert areas. Therefore, the fertility building characteristics of soil fauna are of some importance in arid region of Barmer.

The commonly known ‘dragon flies’ belongs to order Odonata. Major part of life cycle of these insects is passed as immature forms in fresh water. A total of 5,500 species are known from the world of which 494 are from India. The result of these studies indicated 30 species from the desert region. The group, which has been fairly explored in the desert region by the Zoological Survey of India and the Directorate of Plant Protection, is order orthoptera. A total of 8500 species of Orthoptera are known

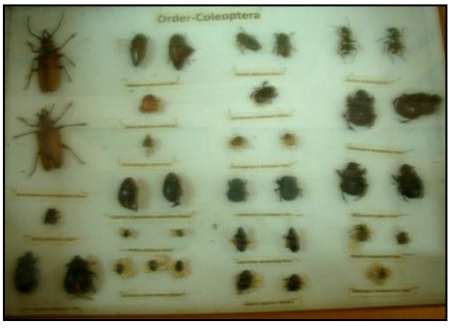
from the world of which 892 are from India. The work on Acridoidea carried out by indicated the presence of 40 species of Orthoptera in the desert region. The insects of order Dermaptera are commonly known as 'Earwig', constitutes a well-defined group of homogenous insects, characterized by a pair of unsegmented chitinised cerci. These are cosmopolitan in distribution but only five species have been reported from the desert region.

The order Dictyoptera constitutes cockroaches and mantids. Only 20 species have been reported from the Indian desert. The popularly known white ants belong to order Isoptera. These are one of the most fascinating groups of insects. The extensive studies conducted on arid zone fauna indicated a total of 46 species in the desert area. The order Hemiptera constitutes small to medium sized insects called 'bugs' with piercing and sucking type of mouthparts. A detailed study on this group of insects indicated about 56-75 species from the desert.

The Thysanopterans of order Thysanoptera are commonly known as thrips of fringe wing or bladder footed insects. They are one of the smallest pterygote insects and 30 most of them are phytophagous. The studies on Indian thrips indicated nearly 21 species from the desert region of Rajasthan. The Alder flies, Lace wings, Ant Lions, etc. are belongs to of order Neuroptera. It has reported 13 species from the western Rajasthan. Commonly known 'beetle' is a part of order Coleoptera. A total of 3,50,000 species of beetles are known from the world of which about 15088 are from India and only 34 from the Indian desert. The order Diptera comprising mosquitoes, midges and flies, are among the most highly specialized members of the class insecta. They have adapted themselves to every situation for breeding and colonisation. Work is available on the dipteran fauna from the desert showed 80 species from the desert region. Butterflies and moths belong to the order Lepidoptera and are cosmopolitan in distribution. There are about 300 species of Lepidoptera mainly butterflies have been recorded from Rajasthan (**Table** -**3.39**). The insects of hymenoptera order are soft to hard bodies.

Insects recorded during the field visit in study area

1. Schistocerca gregaria (Forskal)
2. Eumenes dimidiatipennis sauss.
3. Xylocopa fenestrate fabr.
4. Mylabris phalerata (Pallas)
5. Mylabris pustulata Thunberg
6. Cylindrothorax audoniui (Haag-Rutenberg)
7. Cyaneolytta coerulea (Leuckart)
8. Cyaneolytta pictus (Laporte)
9. Cyaneolytta violacea Brandt
10. Acanthophorus serraticornis Olivier
11. Myllocerus discolor Boh.
12. Myllocerus fabricii Gur.
13. Myllocerus severini Mshl.
14. Myllocerus sabulosus Mshll.
15. Crytozemia dispar Pasc.
16. Spyrathus sp.
17. Scarabaeus cristatus Fabricius
18. Scarabaeus gangaticus Castelnau
19. Scarabaeus brahminus Castelnau
20. Scarabaeus andrewesi Felsche



21. Scarabaeus devotus Redtenbucher
22. Scarabaeus erichsoni Harold
23. Caccobius pantherinus Arrow
24. Trox indicus Har.
25. Onitis philemon Fabricius
26. Caccobius pantherinus Arrow
27. Onthophagus catta Fabricius
28. Onthophagus bonasus Fabricius
29. Onthophagus philemon Fabricius
30. Onthophagus seniculus Fabricius
31. Onthophagus kuluenis Baps.
32. Heliocopris Bucephalus Fabr.
33. Danaus chrysippus
34. Papilio demoleus.

Table 3.39 Approximate number of insect species in desert of Rajasthan

Phylum	Class	Order	No. of Species
Arthropoda	Insecta	Ephemeroptera	2
Arthropoda	Insecta	Odonata	31
Arthropoda	Insecta	Orthoptera	40
Arthropoda	Insecta	Dermaptera	7
Arthropoda	Insecta	Dictyoptera	20
Arthropoda	Insecta	Isoptera	46
Arthropoda	Insecta	Mallophaga	40
Arthropoda	Insecta	Hemiptera	75
Arthropoda	Insecta	Thysanoptera	21
Arthropoda	Insecta	Neuroptera	13
Arthropoda	Insecta	Lepidoptera	300
Arthropoda	Insecta	Diptera	80
Arthropoda	Insecta	Siphonaptera	5
Arthropoda	Insecta	Hymenoptera	65
Arthropoda	Insecta	Coleoptera	60

Source: Desert Regional Centre, ZSI, Jodhpur

3.7.2.10 Conclusion

Despite of the tough climatic conditions the region harbours variety of wild life and flora along with human and livestock population. The region has important floral and faunal species and some of them have been endangered or threatened. However, ecological planning such as thick green belt inside refinery premises, landscaping and strict environmental management as outlined in environmental management plan taking into consideration all aspects should be considered for proposed project.

Chinkara (Gazella bennettii)

Indian Desert Gerbil (*Meriones hurrianae*)

Indian Desert Fox (*Vulpes vulpes pusilla*)

Egyptian Vulture (*Neophron percnopterus*)

Male (*Pavo cristatus*)

Female Indian Peafowl (*Pavo cristatus*)

Figure 3.19 : Mammals and the birds present in the study area

Common Babbler (*Turdoides caudata*)

Taiga Flycatcher (*Ficedula albicilla*)

Rosy Starlings (*Sturnus roseus*) Foraging on Kair Shrub

Grey Francolin (*Francolinus pondicerianus*)

White Eared Bulbul (*Pycnonotus leucotis*)

Jungle Crow (*Corvus macrorhynchos*) feeding on Carcass of Chinkara

Figure 3.20: Birds Present in the Study Area

Steppe Eagle (*Aquila nipalensis*)

Long Legged Buzzard (*Buteo rufinus*)

White Eyed Buzzard (*Butastur teesa*)

Shikra (*Accipiter badius*)

Lesser Whitethroat (*Sylvia curruca*)

Cinereous Vulture (*Aegypius monachus*)

Figure 3.21: Birds present in the study area

Figure 3.22: Pachpadra lake at a glance

3.7.3 Aquatic Ecology

3.7.3.1 Biological Characteristics

Studies on biological characteristics of water are important in EIA studies in view of the conservation of environmental quality and safety of natural flora and fauna including human being. As biological community depends on the conditions and resources of its location, it changes according to the changes in the habitat. The impact of pollution on aquatic ecosystem manifests itself first on the biotic aquatic ecosystem communities. The species composition of aquatic organisms in natural communities is directly related to water quality. The response of animals and plants to pollutants when measured quantitatively, gives an insight into the condition of existing aquatic ecosystem.

Because of complex inter-relationship, a change in the ecosystem causes one or more of the pollutants to change and be replaced by others, distinguishable as a different community. The changes in the diversity of biological communities, as a result of pollution in an aquatic ecosystem, can be mathematically expressed as diversity indices. Organic wastes eliminate sensitive organisms and provide food for the surviving tolerant forms. However, with natural stream purification, water quality improves so that the tolerant forms can flourish and subsequently diversity increases. On the other hand, toxic material eliminates sensitive organisms, and because of the restriction of food to that naturally occurring in the stream, numbers of tolerant surviving forms are limited. Very toxic materials may eliminate all organisms below a waste source. Thus, the nature and quality of such biological species in a particular environment is dependent on various physico-chemical characteristics of water and also on the nature of water body.

Estimation of plankton community structure in a water body would indicate its quality as follows:

(a) Indicator Organisms

Organisms have been listed in standard publications according to increasing tropic levels of aquatic environment. Increasing dominance of diatoms, flagellates, ciliates etc. indicate progressively increasing tropic conditions. Presence of euglenophyceae indicates highly eutrophic conditions. Also, an increase in the abundance of total rotifers indicates advancing eutrophication.

(b) Diversity

Diversity of planktons depends on physico-chemical characteristics of water especially on trophic levels. In oligotrophic water, diversity of plankton is high while with increasing levels of pollution such as mesotrophic and eutrophic condition diversity of plankton's decreases. Shannon Wiener Index is a measure of diversity of planktons, which takes into account the total count, and individual species count in a water sample.

$$d = - \Sigma (ni/n) \log_2 (ni/n)$$

Where,

d = Shannon Wiener Diversity Index

ni = number of individuals of each species in the sample

n = total number of individuals of each species in the sample

It is also noted that the diversity is susceptible to other parameters like turbidity, color, flow rate etc.

A widely accepted ecological concept is that the communities with large number of species (i.e. with high diversity) will have high stability that can resist adverse environmental factors and thus greater is the structural complexity of the food web. The index values of 3 and above are generally considered healthy conditions of water bodies. The values between 1 & 3 and less than 1 are believed to be for semi and poor-productivity respectively.

3.7.3.2 Phytoplankton

Phytoplankton forms the vast array of minute and microscopic plants passively drifting in natural waters and mostly confined to the illuminated one. In an ecosystem these organisms constitute primary producers forming the first in the food chain. Phytoplankton since long have been used as indicators of water quality. Some species flourish in highly eutrophic waters while others are very sensitive to organic and/or chemical waters. Some species develop noxious blooms sometimes creating offensive tastes and odours or anoxic or toxic conditions resulting in animal death or human illness. Because of their short life cycles, plankton responds quickly to environmental changes. Hence, their standing crop in terms of biomass, cell counts and species composition are more likely to indicate the quality of the water mass in which they are found. Generally, phytoplankton standing crop is studied in terms of biomass by estimating chlorophyll a and primary productivity and in terms of population by counting total number of cells and their generic composition. When under stress or at the end of their life cycle, chlorophyll in phytoplankton decomposes with phaeophytin as one of the major products.

For aquatic ecosystem, water samples were collected from IG Canal, GulabSagar lake and Kumbhariyon ka Talav, where ground water was collected from village Aakarli (sampling locations same as given in Section 3.3).

The biological characteristics in terms of phytoplankton for surface and ground water samples are presented in **Table 3.40**.Total number of species present in surface water varied from 76-142 species per ml of sample. Composition in terms of Chlorophyceae, Bascillariophyceae, Cyanophyceae and Myxophyceae showed dominance of Chlorophyceae. The Shannon Wiener Diversity Index value ranged between 1.19 and 1.62, indicating medium polluted water. The type of species observed in the surface and ground water samples are listed in **Table 3.41**.

3.7.3.3 Zooplankton

By virtue of sheer abundance arid intermediate role between phytoplankton and fish, zooplankton are considered as the chief index of utilization of aquatic biotope at the secondary trophic level. Zooplankton includes arrays of organisms, varying in size from microscopic protozoan of a few microns to some jelly organisms with tentacles of several meters long. In natural aquatic ecosystem, zooplanktons by their heterotrophic activity initially handle and manage the biogenic organic materials of primary and secondary production to a considerable extent. The data on zooplankton in surface and ground water samples are presented in **Table 3.42**.

Total number of zooplankton species present in surface water varied from 311-422 species per m3of sample, whereas in dug well it was observed to be 152 species per m3. Composition in terms of Rotifera, Copepoda and Cladocera showed dominance of Rotifera. The Shannon Wiener Diversity Index value ranged between 1.19 and 1.96, indicating medium polluted water quality. The zooplankton species observed in the surface and ground water samples are listed in **Table 3.43**.

Table 3.40 Biological Parameter – Phytoplankton (November 2013)

Sr. No.	Sampling Locations	Phytoplankton No/ml	% Composition				Shannon Wiener Diversity Index
			Chlor-ophyceae	Bascill-ariophyceae	Cyano-phyceae	Myxo-phyceae	
	Surface Water						
1	Indira Gandhi Canal	142	49	21	18	12	1.24
2	Mandapur,GulabSagar Lake	88	52	31	8	9	1.62
3	KumabhariyokaTalaw	76	59	22	19	-	1.19
	Ground Water - Dug Well						
4	Village Aakarli	71	34	26	19	21	1.18

Ranges of Shannon Wiener Diversity Index

<1: Indicate maximum impact of pollution or adverse factor

1-2: Indicate medium impact of pollution or adverse factor

>2: Indicate lowest or no impact of pollution or adverse factor

Table 3.41 Phytoplankton Species observed in Water Samples (November 2013)

Family and Name of Specie			
Chlorophyceae	**Bscillariophyceae**	**Cyanophyceae**	**Myxophyceae**
Phacotus	*Cyclotella*	*Chroococcus*	*Gomphosphosphaeria*
Gonium	*Cocconeis*	*Gloeocapsa*	*Microcystis*
Actinastrum	*Tabellaria*		*Stigonema*
Oocystis	*Meridion*		
Chlorella			
Tetraedron			
Ankistrodemus			
Characium			
Scenedesmus			
Botryococcu			
Cosmarium			
Staurastrum			
Micraterias			
Xanthidum			

Table 3.42 Biological Parameters – Zooplankton in Surface water (November 2013)

Sr. No.	Sampling Locations	Zoopla-nkton No/m^3	% Composition of Groups			Shannon Wiener Diversity Index
			Rotifera	Copepoda	Cladocera	
	Surface Water					
1	Indira Gandhi Canal	422	59	28	13	1.24
2	Mandapur (Gulab Sagar Lake)	339	51	31	18	1.19
3	Kumabhariyo kaTalaw	311	47	25	28	1.96
	Ground Water -Dug Well					
4	Village Aakarli	152	76	24	-	1.63

Ranges of Shannon Wiener Diversity Index
1: Indicate maximum impact of pollution or adverse factor
1-2: Indicate medium impact of pollution or adverse factor
>2: Indicate lowest or no impact of pollution or adverse factor

Table 3.43 Zooplankton Species identified in water samples (November 2013)

Group and Genus of Zooplankton Species		
Rotifera	**Copepoda**	**Cladocera**
Keratella sp.	*Nauplius*	*Monospilus sp.*
Brachionus sp.	*Cyclops sp.*	*Alona sp.*
Euchlanis sp.		*Ceriodaphnia*
Dipleuchanis sp.		
Lepadella sp.		
Lecane sp.		
Cephalodella sp.		

3.8 SOCIO-ECONOMIC STATUS

Socio-economic study is a socio-scientific study that examines how economic activity affects social processes in a particular region. In general it analyzes how societies progress, stagnate, or regress because of their local or regional economy, or even the global economy, but moreso because of the local regional changes.

It is a well known fact that establishing industries and related projects not only craft their impacts on environment by utilizing natural resources and in turn generating wastes in the local environment but also craft socio-economic impacts on the local population. Thus there is a need to conduct a socio-economic study and analyze any possible impacts of the industry on the local residents along with analyzing their present or proposed quality of living. To achieve sustainable development, it is required that utilization of natural resources is done appropriately and all pollution prevention, mitigation and control measures are implemented precisely.

All developmental projects have direct and also sometimes indirect correlation with socio-economic status and progression of the region. Overall, public acceptability of the project is usually given the top priority. Thus, it becomes imperative to ensure that the proposed project may not be causing any negative impacts on the socio-economic status with reference to the prevailing social, cultural & economic status of the local residents of the project area. As per the Ministry of Environment & Forests, Govt. of India EIA guidelines, the issues to be addressed in socio-economic status are - demographic structure, availability of basic amenities such as housing, education, health and medical services, occupation, water supply, sanitation, communication and power supply, and also studying the prevalent diseases in the region. In addition to the above issues, centres of tourists' attraction and monuments of archaeological importance are also to be considered as a part of the socio-economic studies. The study of these parameters helps in identifying, predicting and evaluating the likely impacts of the project.

This study has been done for "EIA and RRA study for proposed grass-root refinery with Petrochemical Complex at Pachpadra, Barmer, Rajasthan."

3.8.1 Reconnaissance

The total area of Barmer district is 28,387 km² and the district lies between 24°58′ – 26°32′ N and 70°5′ – 72°52′. On its north lies Jaisalmer, to the south is Jalore, and Pali and Jodhpur lies to the east of Barmer district. Pakistan is only 270 km to the west of Barmer and only about 152 km from the proposed site.

3.8.2 Baseline Status

Baseline information is collected after delineation of the baseline study area in order to study the socio-economic profile of the project affected area. The process related to baseline database analysis includes:

- Demographic structure
- Infrastructure base in the area
- Economic structure
- Health status
- Cultural attributes
- Salient observations of field

- Public awareness and their concerns regarding the proposed project
- Socio economic status in relation to 'Quality of Life'

The primary socio economic data was collected through field survey in sample villages of the study area as well as the observations by the survey team. It has been supplemented with relevant socio-economic data from secondary sources of various official records. viz., Census records, District statistical abstract, District health office, District industry center, District tourism office etc. It is from the Primary Census Abstract (PCA 2011) of villages that demographic details have been abstracted for Housing, Household Amenities and Assets Village Directory (VD) 2001 of Rajasthan state. The sampling villages identified for baseline socio-economic survey of the study area is given in **Table 3.44** and the survey map villages is visualized in **Figure 3.23**.

3.8.2.1 Demographic Structure

The details concerning the demographic structure of the study area were collected from Census record of Barmer district. The baseline study has been done for a 10km radius around the project site, thus the study area includes one district and one Tehasil. The over-all demographic survey summary is provided in **Table 3.45** and the details about baseline of 10 km radius' demographic structure is given in **Table 3.46**. The district's salient features including Baseline study of 10 km radius of demographic structure are as follows:

- Total area in hectare is 20,126 and population density is 23 per person sq/km.
- Total numbers of households in survey area are 14,763.
- Total population of the survey area as per 2011 census is 84,459 out of which 43,955 are male and 40,504 are female.
- Out of the total population Scheduled Caste population is 12,303 (14.56%) and Scheduled Tribe population is 5,293 (6.26%) respectively. The detail regarding village wise population including SC and ST is visualized in **Figure 3.24**.
- Total literate population in the study area is 52,124 thus the literacy rate of the population in the survey area is 61.75%.The village wise, total male and female literacy population is shown in **Figure. 3.25.**
- Total main worker population in the study area is 22,421 (26.54%), out of which 4,170 (4.93%) come under marginal worker category and 57,868 (68.51%) belong to non-workers category. The existing scenario of village wise employment pattern detail is given in **Figure. 3.26.**
- Sex ratio (number of female per thousand male) in the survey area is 921 which shows that male population is higher in the survey area as compared to the female population as shown in **Figure. 3.28.**

3.8.2.2 Infrastructure Resource Base

The infrastructure resource base of the survey area with reference to education, medical facility, water supply, post and telegraph, transportation and communication facility and power supply etc is mentioned here. As the Census data (VD 2011) of villages is not published yet; hence currently infrastructure resources details have been abstracted from Housing, Household Amenities and Assets VD 2001 of Rajasthan state, Barmer District. The details regarding infrastructure facility of 10 km baseline is given in **Table 3.47**.

The District Statistical Office was visited by the survey team and it came to the notice, that post 2004, the Statistical Handbook has not been published for the Barmer district; thus the demographic data regarding livestock, fisheries, irrigation, crop pattern and agricultural production etc. have been analyzed only on the basis of available database.

3.8.2.3 Economic Attributes

Economic resource base of any region mainly depends upon its economically active group i.e. the working population involved in productive work, where 'Work' may be defined as participation in any economically productive activity. Such participation may be physical or mental in nature. 'Work' involves not actual work but also effective supervision and direction of work. It also includes unpaid work on farm or in family enterprise.

- Total main other workers are 19,766 (88.15%) and the main cultivators are 1,455 (6.48%).
- There are 361 (1.61%) people working as agriculture workers and main house hold workers are only 839 (3.74%) as shown in **Figure 3.27**.

3.8.2.4 Health Status

Government health institutions in a rural setup has a fourfold hierarchy i.e. District level hospital, Rural hospital, Primary health center (PHC) and a Sub center.

PHC remains the first contact between village community and medical officer. As per the standard a Medical officer is supported by 14 Paramedical and other staff members. The PHC acts as a referral unit for 6-sub centers and has 4-6 beds for patients.

Sub-centers: The sub-center is the most peripheral health unit and first contact point between the primary health center system and the community. Each sub-center is required to have one female health worker, one female assistant and a male health assistant.

During the discussion with the district Medical officer of community health center, Pachpadra and local people, it was revealed that the general prevailing diseases in the project area are Malaria, Cold Cough, Respiratory infections, Skin Diseases, viral fever and kidney stone etc. The health problems as reported could be attributed to improper sanitation, mosquito nuisance and water scarcity in the villages. In the survey area, there are sufficient Government health institutions like Sub-center, PHC etc. but the service that is required to be provided by these health institutions is not good qualitatively, inspite of the present infrastructure. The details regarding morbidity pattern of the area is given in **Table 3.48** & **Table 3.49**.

3.8.2.5 Cultural and Aesthetic Attributes

As per literature review Barmer is known for its folk music and dance. There are singers at Barmer that compose music in honor of the deities and war heroes. The folk musicians of the place belong to a community called the Muslim Dholis (drummers). To many people of Barmer, this is their means of livelihood. During the festivals and other social occasions, people sing many songs to the accompaniment of the Kamayacha (a stringed instrument played with a bow). The other musical instrument popular in Barmer is the algoza (two flutes played together). However, in the study area, there were no cultural and aesthetic attributes.

3.8.3 Socio-economic Survey Methodology

Sampling Method i.e. a judgmental and purposive sampling method was used for choosing respondents of various sections of the society i.e. Sarpanch, adult males and females, teachers, medical practitioners, businessmen, agriculture laborers, unemployed group etc. Judgmental and purposive sampling method includes the right cases from the total population that helps to fulfill the purpose of research needs. Observations are restricted to this group & conclusions from these observations are generalized to the total population. Judgment or purposive sampling is very precarious, because stronger assumptions can be made about the population and sampling procedure than required while employing probability sampling.

Data Collection Method i.e. in order to assess and evaluate the likely impacts arising out of any development or Industrial projects on socio-economic aspect of the environment, it is necessary to gauge the apprehensions of the people in the project area. For the process of data collection through primary and secondary sources, several methods are used like Field Survey and Observations, Interview Method etc.

'Field Survey and Observations' is made at each sampling village and the quality of life of that region is studied. Visits are made at hospitals, primary health centers and sub-centers to know the health status of the region. Various governmental organizations such as Statistical Department, Department of Census Operations are visited to collect the population details of that region.

Group-Discussion method is employed to establish contact with the localites in order to identify potential informants which is followed by Interview Method i.e. a structured interview method is used to collect data regarding the awareness and opinion from the sample selected of the various socio- economic sections of the community. Structured interviews involve the use of a set of pre-designed questionnaire that includes fixed and alternative questions. The questionnaire mainly highlights the parameters such as income, employment and working conditions, housing, food, clothing, water supply, sanitation, health, energy, transportation and communication, education, environment and pollution to assess the quality of life of that particular region and general awareness and opinion of the respondents about the project. The interview method has the advantage that almost all perfect sample of the general population can be reached and respond to the approach. Interview method helps to collect more correct and accurate information as the interviewer is present during the field survey.

3.8.4 Salient Observations

Socio-economic survey was conducted in 11 out of a total of 23 villages/Dhani within the study area located in all directions with reference to the project site. Thus the percentage sampling has been 48%. Socio- economic survey was done also as group discussions with Government officials, authorities and village leaders.

The respondents were asked about their awareness/opinion about the project and its impacts, which is an important aspect of socio-economic environment, viz. job opportunities, education, health care, transportation facility and economic status.

During the survey the socio-economic team made several important observations like there were several Dhanies and in every Gram Panchayat there are about five to six Dhanies and one Dhani's population is about 30-60 households and every household is about 400m-600m away from the neighboring household. The study area is thinly populated thus the household density in the area is low but the household size is large i.e. approximately 7-8 people in every household. Thus, most of the households are in the farms itself.

Anganwadi centres, Primary Schools, Post Office and Water-Tanks were evidently present during the survey. Water i.e. available for domestic purpose is usually hard and thus the villagers are using Rain-Water for their domestic purposes by rain water harvesting systems; wherein they store the rain water in cemented tanks. According to survey record, the latest feature about survey area is described below:

- Some of the villages have their Group Gram Panchayat building in surveyed area.
- While the socio-economic team was conducting the survey, the photographs that were clicked**.**
- As per the survey record, all villages have one or the other education facilities in the form of Anganwadi, Primary school and Middle schools. Out of 11 villages, all the villages have Anganwadies and Primary schools. For Higher education students are required to travel 5 to 25 Km from their villages and one of the High Schools**.**
- It is important to note that very few villages have medical facility in the surveyed area. Only two villages having health sub-centers and all the villages in the surveyed area have Asha workers. Health status seemed to be satisfactory but the villagers are not satisfied with the health facility because according to them they are not getting the proper expected care from Govt. hospitals and thus as an alternative to Govt. hospitals they prefer private hospitals and nursing homes thus at times they have to travel long distances for medical treatment and pay huge amounts of money; in their own Tehsil or district.
- Mostly the houses of villagers are 'kachca' thus not-constructed as far as their built structure is concerned.
- Approach roads to almost all the surveyed villages are mainly cemented and private bus service and other private Autos, Jeeps are available for accessing these villages but the frequency of these services is very low. Roads from adjoining regions are well connected with the Barmer district. The roads, particularly in the study area are mainly of 2 types i.e. constructed and not-constructed i.e. Kaccha. Inside most of the surveyed villages there are kaccha-sandy roads which are not in good condition.

However, some villagers do not even have proper roads, so people either prefer walking or using cycle as a medium for transport. As per the survey record only 3 villages have post offices.

- Almost all villages have rain water harvesting systems and some villages having public water tank facility too, but even then water scarcity is a major problem. Thus, due to lack of water, villagers wash their vessels first with sand and only then with water.
- Majority of the population in the study area have camels and sheeps as pet animals.
- Sanitation facility in these villages is in a poor condition because according to the survey report, very few people are using toilets. People are used to open defecation.
- The survey team came to know that electricity is available but frequent load shedding is one of the major problems with the electricity supply there, thus electricity is used only for domestic purposes.
- Main occupation in the survey area is Agriculture, but the agriculture is completely rain-dependent because and thus the fields yield at most only one crop and that too during the rainy season only. There are two crops i.e. Kharif and Rabi in the area with Bajra, moong, moth, clusterbean, gawar and sesamum as main Kharif crops and Cumin, wheat, mustard and Tarameera as the main Rabi produce.
- The production of the Kharif crops is as follows:
- Bajara 8-10 Quintal/Hectare
- Moong 6-7 Quintal/Hectare
- Moth 6-7 Quintal/Hectare
- The production of the Rabi crops is as follows:
- Cumin 6-7 Quintal/Hectare
- Mustard 7-8 Quintal/Hectare
- Wheat 20-22 Quintal/Hectare
- Wood is the major cooking fuel and the other secondary fuels that are used for cooking are kerosene, LPG etc.
- The official language of the region is Hindi and people mostly speak Hindi language but with their own different dialects of Marwarhi and Rajasthani.
- During the survey, it was also observed that the study area has several salt pans and it becomes imperative to note that the project site area for the refinery alone has about 70-80 big and small salt pans. The largest of the salt pans is approximately 100m x 400m and the smallest is about 30m x 120m. There is large number of salt pans in the study area spread over, mainly the villages ChotaSaambhra, BadaSaambhra, Hiragarh and Posahli.Out of these, Hiragarh Salt pan is the largest one.
- The local ‘Kharwal’ community has been ancestrally involved in this process of salt extraction through these salt pans. The Kharwal community claims an approximate income of 2-5 lakh INR per annum from these salt pans. The laborers that work in the salt pans are paid approximately 200-350Rs. per day. It has been observed that there are a total of about 300 laborers that

work on and off on different salt pans depending on the availability of work in these pans.

3.8.5 Awareness and Opinion

Awareness is the state or ability to perceive, to feel, or to be conscious of events, objects or sensory patterns. In this level of consciousness, sense data can be confirmed by an observer without necessarily implying understanding. In general, an opinion is a subjective belief, and is the result of emotion or interpretation of facts. An opinion may be supported by an argument, although people may draw opposing opinions from the same set of facts. For assessing the awareness and opinion about the project activity socio-economic survey was conducted in the sampling villages. The salient observations drawn through survey are described below:

- Respondents are aware about the proposed HPCL Refinery project
- Local residents hold a neutral opinion about the proposed refinery project however there is some insecurity amid them regarding the promised employment opportunities as they fear that they will only be given labour work and that too, on a contract basis.

3.8.6 Quality of Life

Definition of Quality of life

Daily living enhanced by wholesome food and clean air and water, enjoyment of unfettered open spaces and bodies of water, conservation of wildlife and natural resources, security from crime, and protection from radiation and toxic substances. It may also be used as a measure of the energy and power a person is endowed with that enable him or her to enjoy life and prevail over life's challenges irrespective of the handicaps he or she may have.

Quality of life (QoL) is a term, which indicates overall status of socio-economic environment in a given area. Quality of life (QoL) is defined as a function between “objective conditions” and “subjective attitudes” involving a defined “area” of concern.

Quality of life index is based on a unique methodology that links the results of subjective life satisfaction surveys to the objective determinants of quality of life across countries. The “objective conditions” are defined as numerically measurable artifacts of a physical, sociological event or economic event. Objective conditions may be defined as any number, which stands for a given quantity of a variable of interest so long as it is independent of subjective opinion. Subjective attitude” is primarily concerned with affective and cognitive dimensions. It is specifically concerned with ‘how aspects of cognition vary as objective conditions vary’.

Once objective measures are obtained for each factor they are transformed to a normal scale varying from 0 to 1 (value function curve) in which 0 corresponds to the lowest or least satisfactory measure, and 1 corresponds to the highest. The weights are assigned to each factor by ranked-pair wise technique (by the expert group) based on the secondary data and general observations.

For each objective measure, a corresponding subjective measure is developed for each individual of the sample population by asking him to rate his satisfaction scale (value function curve). In addition, it is used such that 0 corresponds to the lowest level of attitudinal satisfaction and 1 corresponds to the highest level of satisfaction. Weights are assigned to each factor using ranked - pair wise comparison techniques.

The Socio-economic Indicators for QoL Assessment are:

1. Income
2. Employment and Working Conditions
3. Housing
4. Food
5. Clothing
6. Water Supply
7. Sanitation
8. Health
9. Energy & Fuel
10. Transportation
11. Communication
12. Education
13. Environment and Pollution
14. Recreation
15. Social Security
16. Human Rights

Subjective QoL calculations are as follows:

$$QoL(s) = 1/p \sum_{i=1} \sum_{j=1} QIij \times Wi$$

Where,

QoL(s) = Subjective quality of life index
p = No. of respondents, j = 1, ..., p
m = No. of factors, i = 1, ..., m
QIij = Subjective quality index for ith factor assigned by jth respondent
$\sum$ Qiij = Subjective quality index for ith factor assigned by all respondents in an area
Wi = Relative weightage of the ith factor

Objective QoL calculations are as follows:

$$QoL(o) = \sum_{i=1}^{i=n} QIi \times Wi$$

Where,

QoL(o) = Objective quality of life index
n = No. of QoL Factors
i = 1... n
QIi = Satisfaction level (assigned by the expert group) for the ith objective indicator
Wi = Normalized weight for its factor

The **cumulative index of QoL** calculations is as follows:

$$QoL(c) = \frac{QoLo + QoLs}{2}$$

Thus, the average QoL index values are estimated as:

QoL (s) = 0.41

QoL (o) = 0.47

QoL (c) = 0.44

The average QoL index value for the study area is leaning neutral to poor level. Due to poor economic status like income, employment, educational facilities and also non availability of basic needs, viz. transportation, food, clothing, and housing. The subjective Quality of Life is less than objective quality of Life which indicates that people are not satisfied with their present condition. The QoL table is shown as **Table 3.51.**

Group Discussion with Local people of Sajiyali Village

Group Discussion with Sarpanch and Local people of Kyar Village

Group Discussion with Local people Richholi village

Discussion with School Teacher at Akarli Dhansingh Village

Discussion with School Teacher at Mandpura Village

Water Harvesting system in surveyed area at Samru ki Dhani

Water-tank at Kyar viilage

Water-pond at Kumbhariyon ka talao

High school at Pachpadra Village

Middle school at Akarli Dhan Singh Village

Post-Office facility in Sambhra Village

Well-constructed road at Pachpadra

Majority of the area in the study region is arid and wild Bawar trees

Rajiv Gandhi Sewa Kendra at Sambhra Village

The study area has several Camels, Sheeps etc.

A few villagers also have sheep as pet for milk and wool

Community Health Centre at Balotra

Power supply lines in the study area

Salt Pans in the study area

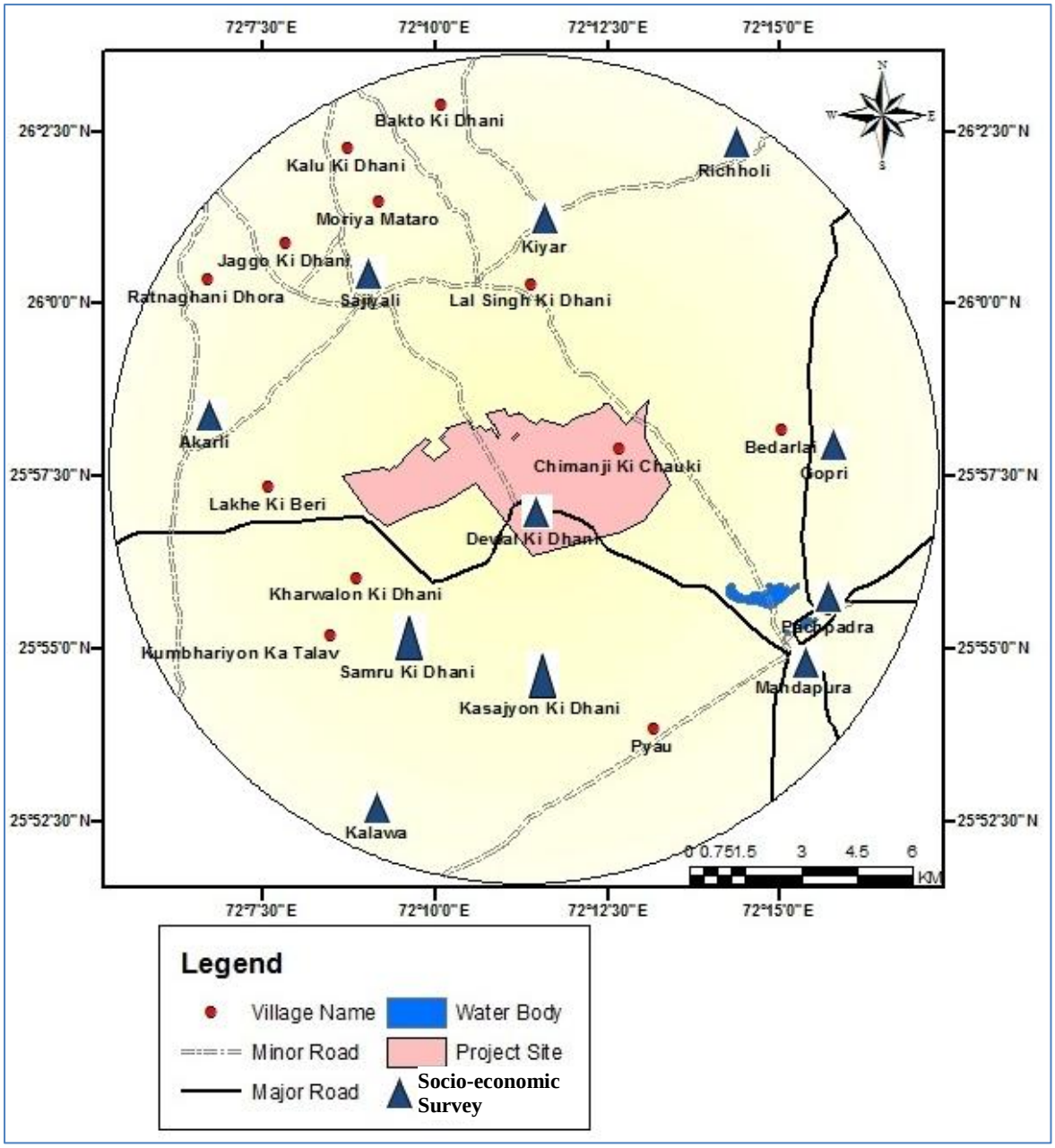


Figure.3.23: Surveyed area Map of the Study Area

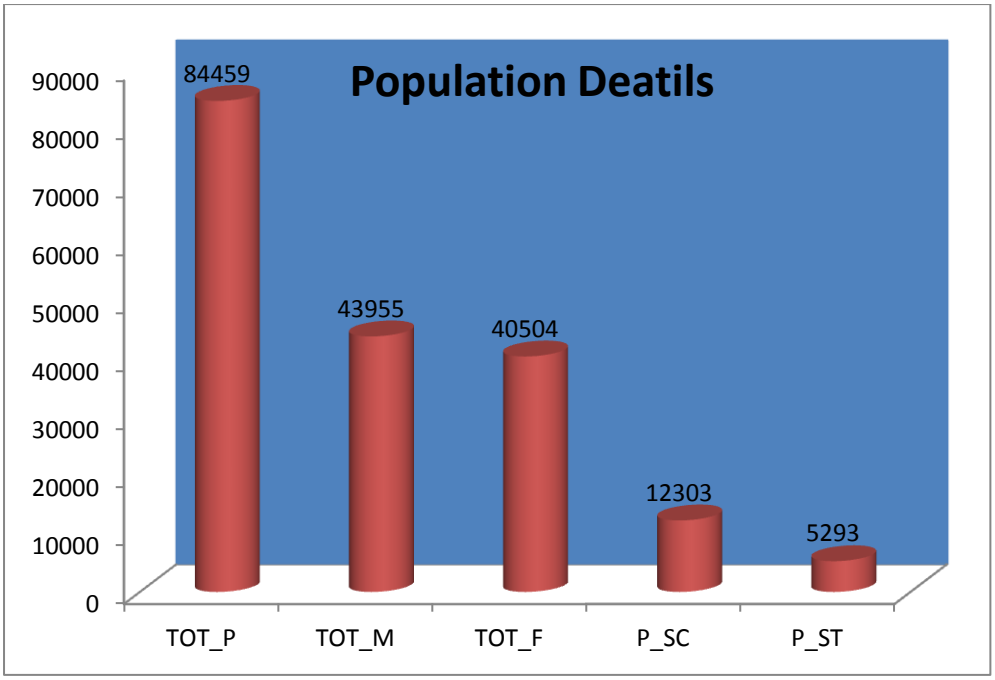


Figure 3.24: Population Details in the study area

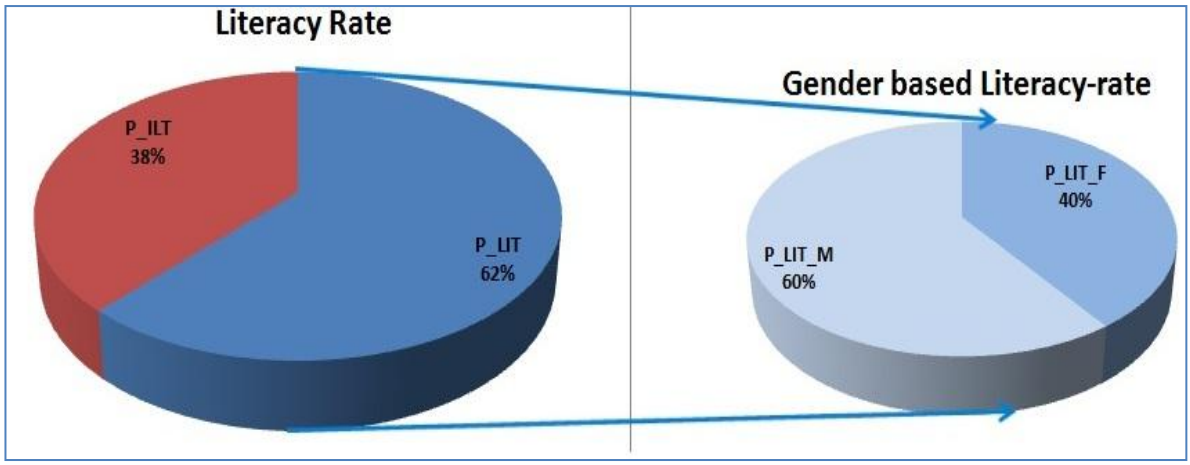


Figure 3.25: Total Literacy Rate in the Study Area

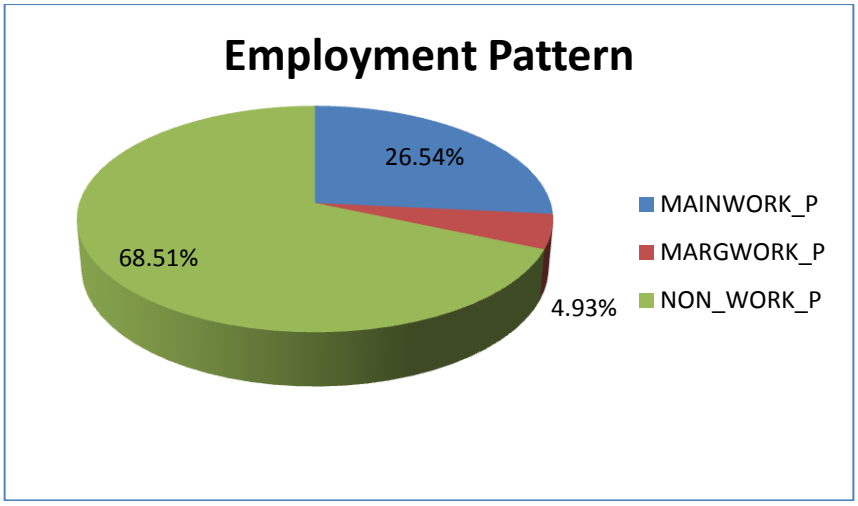


Figure 3.26: Employment Pattern of the study area

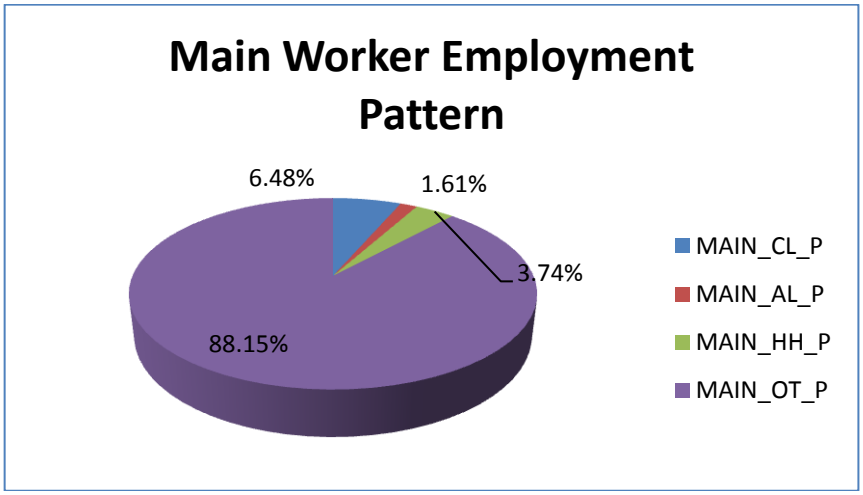


Figure 3.27: Main Worker Employment Pattern in the study area

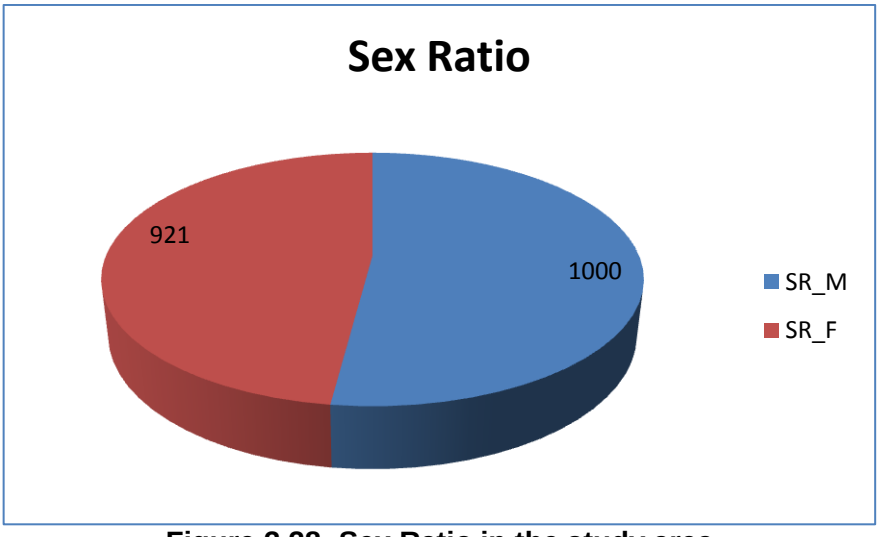


Figure 3.28: Sex Ratio in the study area

Table 3.44 List of the Villages (Dhani) Surveyed in Study Area

S. No.	Sample Location	Gram Panchayat	Latitude Longitude	Directions	Km
1	Sajiyali	Sajiyali Padamsingh	N 26^{0}00'09.9" E072^{0}09'13.5"	NNW	5.5
2	Akarli Dhansingh	Akarli Dhansingh	N 25^{0}57'57.4" E072^{0}06'18.4"	WNW	6.5
3	Kyar	Kyar Charnan	N 26^{0}01'00.3" E072^{0}11'09.1"	N	5.0
4	Richholi	Gopri	N 26^{0}02'24.4" E072^{0}15'30.5"	NNE	9.0
5	Gopri	Gopri	N 25^{0}58'03.3" E072^{0}15'26.1"	E	6.5
6	Sambhra	Sambhara	N 25^{0}54'55.9" E072^{0}09'32.0"	S	4.5
7	Kalawa	Kalawa	N 25^{0}52'27.5" E072^{0}08'55.9"	SSW	9.0
8	Kisanjiyon Ki Dhani	Sambhra	N 25^{0}53'52.6" E072^{0}11'47.1"	S	5.0
9	Deval Ki Dhani	Sambhra	N 25^{0}56'14.0" E072^{0}11'02.1"	S	1.0
10	PachpadraP.H.C.	Pachpadra	N 25^{0}55'37.5" E072^{0}15'30.9"	ESE	8.5
11	Madhpura	Madhpura	N 25^{0}54'36.4" E072^{0}14'28.7"	SE	8.5

Table 3.45 Summary of Demographic Structure of Study Area

Demographic Parameters	Details
No of States	01
No. of District	01
No. of Tehsil	01
No. of Total Villages (Dhani)	23

No. of Villages Surveyed (Dhani)	11
Total Area of surveyed village(ha)	20126 (2001 p.c.a.)
Total No. of Households	14763
Total Population	84459
Density of Population (km^2)	23
Sex ratio **(N0. of female\ 1000 males)**	921
Scheduled castes	12303(14.56%)
Scheduled Tribes	5293(6.26%
Literate	52124(61.75%)
Main Worker	22421(26.54%)
Marginal Worker	4170(4.93%)
Non Worker	57868(68.51%)

Source: Census 2011, Barmer District, State Rajasthan

Table 3.46 Demographic Structure in Surveyed Villages

Sr. No	Villages	Area in Hectares	House Hold	Population			SC	ST	Literates			Main Worker	Marginal Worker	Non-Worker
				TP	M	F			TL	M	F			
1.	Sajiyali Padamsingh	1215	185	951	513	438	496	8	400	268	132	464	91	396
2.	Akarli Bakshiram	1348	178	915	478	437	456	229	348	232	116	266	123	526
3.	Akarli Dhansingh	1518	131	724	385	339	88	34	352	233	119	3	291	430
4.	Sambhra	3722	157	788	415	373	0	447	316	222	94	110	329	349
5.	Gopri	1623	180	879	439	440	65	258	282	174	108	287	91	501
6.	Kalawa	3169	222	1071	572	499	182	515	388	285	103	405	197	469
7.	Pachpadra	2818	12911	74496	38715	35781	10579	2511	47965	28364	19601	19829	1896	52771
8.	Bedarlai	993	95	465	253	212	58	175	133	94	39	117	131	217
9.	Madhpura	2970	602	3429	1788	1641	212	1116	1581	1009	572	567	1018	1844
10.	Kyar Charnan	750	102	741	397	344	167	0	359	283	76	373	3	365
Total		**20126**	**14763**	**84459**	**43955**	**40504**	**12303**	**5293**	**52124**	**31164**	**20960**	**22421**	**4170**	**57868**

Source: Census 2011, Barmer District, State Rajasthan

Table 3.47 Infrastructure Resource Base of Surveyed Villages

Sr. No.	Villages	Education	Medical	Drinking Water	Communication	Transport	Road Approaches	Power supply
1	Akarli Bakshiram	P,O,	-	W,O	PH	BS	MR	-
2	Sajiyali Padamsingh(Kanthwara)	P(2)	-	T	-	BS	MR	-
3	Akarli Dhansingh	P,M	-	T,TK	PH	BS	MR,FP	ED
4	Sambhra	P(3),M	-	T,TK	PO,PH	BS,RS	-	ED
5	Gopri	P,M	H	T,TK	PO,PH	BS	-	ED
6	Kalawa	P	-	T	PH	BS	-	ED
7	Pachpadra	P(5),M	PH	T,TK	PO,PH	BS	MR,FP	EA
8	Bedarlai	P	PHS	T	-	BS	FP	ED
9	Mandapura	P,O,	-	T	-	-	FP	ED
10	Kyar Charnan	P,O,	-	O	PH	-	MR,FP	-

Source: Village Directory 2011, Barmer District, State Rajasthan

Abbreviations

Medical Facility			Education Facility			Power Supply		
H	:	Allopathic Hospital	P	:	Primary or elementary school	EA	:	Electricity of all Purpose
D	:	Allopathic Dispensary	M	:	Middle school	ED	:	Electricity for Domestic Purpose
MCW	:	Maternity &Child Welfare	S	:	Secondary School	EAG		Electricity for Agriculture Purpose
MH	:	Maternity Home	PUC	:	Senior Secondary School	**Communication Facility**		
HC	:	Health Centre	C	:	College			
PHC	:	Primary Health Centre	AC	:	Adult literacy centre	PO	:	Post office
FWC	:	Family Welfare Centre	O	:	Other	TO	:	Telegraph Office
RMP	:	Registered Private Medical Practitioner	TR	:	Training School	PTO	:	Post &Telegraph Office
CHW	:	Community Health Worker	HS	:	Higher Secondary school	PH	:	Telephone connection
SMP	:	Subsidized Medical Practitioner	**Drinking water Facility**			**Approach Road**		
D. HOME	:	Homeopathy Dispensary	W	:	Well water	PR	:	Paved road
HA	:	Ayurvedic Hospital	TK	:	Tank water	MR	:	Mud Road
DA	:	Ayurvedic Dispensary	HP	:	Hand pump	FP	:	Foot Path
TB	:	T.B Clinic	R	:	River	NR	:	Navigation river
NH	:	Nursing Home	C	:	Canal			
HC	:	Health Centre	TW	:	Tube well Water			
DU	:	Unini Dispensary	T	:	Tap Water			

Table 3.48 Main Worker Employment Pattern of Study Area

Sr. No.	Villages	Main Cultivator	Main Agriculture	Main Household	Main Other Worker
1.	Sajiyali Padamsingh(Kanthwara)	416	1	0	47
2.	Akarli Bakshiram	150	7	0	109
3.	Akarli Dhansingh	0	0	1	2
4.	Sambhra	19	55	7	29
5.	Gopri	188	90	2	7
6.	Kalawa	242	12	13	138
7.	Pachpadra	270	135	621	18803
8.	Bedarlai	60	2	1	54
9.	Mandapura	44	59	23	441
10.	Kyar Charnan	66	0	171	136
Total		**1455**	**361**	**839**	**19766**

Source: Primary Census Abstract 2011, Barmer District, State Rajasthan

Table 3.49 Health Data; PHC Pachpadra, District Barmer

Sr. No	Morbidity Pattern	2008-2009	2009-2010	2010-2011	2011-2012	2012 to till
1.	General Diseases	39187	41885	37189	34433	26614
2.	Diarrhea Disease	1103	1019	687	672	461
3.	Malaria	47	97	43	30	40
4.	Tuberculosis	24	31	36	12	10
5.	Respiratory infection	10072	6780	6559	6597	5912
6.	Cancer	Nil	Nil	Nil	Nil	Nil
7.	Eye disease	154	223	178	158	94
8.	Skin diseases	1044	1578	1126	1391	917
9.	STI/RTI & HIV/AIIDS	Nil	Nil	Nil	Nil	Nil

Source-Primary Health Centre Pachpadra, District Barmer

Table 3.50 Health Data; C.H.C. Balotra, Tehsil-Pachpadra, District –Barmer

Sr. No	Morbidity Pattern	2008-2009	2009-2010	2010-2011	2011-2012	2012 to till
1.	General Diseases	6527	6962	9867	7675	6856
2.	Diarrhea Disease	1114	973	750	1057	1207
3.	Malaria	255	44	132	174	66
4.	Tuberculosis	611	619	1232	1285	436
5.	Respiratory infection	13856	18722	21729	15404	25625
6.	Cancer	13	11	32	33	47
7.	Eye disease	42	58	80	90	262
8.	Skin diseases	719	368	399	597	749
9.	STI/RTI & HIV/AIIDS	Nil	Nil	Nil	Nil	Nil

Source-Community Health Centre Balotra, Tehsil-Pachpadra, District -Barmer (Rajkiya Nahta Hospital, Balotra)

Table 3.51 Quality of Life Existing in the Villages surveyed

Sr. No.	Villages / CT	$QoL_{(S)}$	$QoL_{(O)}$	$QoL_{(C)}$
1.	Sajiyali	0.39	0.46	0.42
2.	Akadli Dhansingh	0.39	0.51	0.45
3.	Kyar	0.39	0.46	0.43
4.	Richholi	0.41	0.44	0.42
5.	Gopadi	0.37	0.47	0.42
6.	Sambhara	0.41	0.49	0.45
7.	Kalawa	0.41	0.50	0.46
8.	Kisanjiyon Ki Dhani	0.45	0.44	0.44
9.	Deval Ki Dhani	0.39	0.46	0.42
10	Pachpadra	0.48	0.47	0.47
11	Mandpura	0.47	0.51	0.49
Average		**0.41**	**0.47**	**0.44**

CHAPTER – 4

IMPACT ASSESSMENT

4.0 IMPACT ASSESSMENT

In this chapter the likely impacts during construction and operation phases are identified. Further, the impacts are assessed and evaluated considering spatial, intensity, temporal and vulnerability scales. An overall assessment in terms of significance value is derived by integrating all scales. Detailed methodology is given in subsequent sections.

4.1 METHODOLOGY

The methodology adopted for assessing the potential positive and negative environmental impacts from the proposed project is described below.

Step1: Identification of Environmental Impacts

All potential releases (emissions to air, generation of noise, effluent discharge, etc.) from the construction & operation phases of the proposed project have been identified. The potential positive and negative environmental impacts from these releases and other activities of the project have been identified.

Step2: Environmental Impact Assessment

The Significance (S) of the Environmental Impacts is identified and assessed by the following characteristics:

- **Intensity (I)** of the environmental impact;
- **Spatial extension (Sp)** of the environmental impact;
- **Temporal duration (T)** of the environmental impact;&
- **Environmental Vulnerability (V)** of the impacted area.

Determination of Impact Intensity (I):

Impact Intensity has been assessed based on the following criteria:

H (High):

- Emissions/generation of highly pollutant substances, emissions/generation of high quantity of pollutant substances and/or high noise emission.
- High consumption of resources (such as energy, water, land, fuel, chemicals)
- Felling of large of trees or death of fauna

M (Medium):

- Emissions/generation of moderately pollutant substances, emissions/generation of moderate quantity of pollutant substances and/or moderately high noise emission
- Moderate consumption of resources (such as energy, water, land, fuel, chemicals)
- Felling of few trees or physical damage of fauna

L (Low):

- Emissions/generation of low pollutant substances, emissions/generation of low quantity of pollutant substances and/or low noise emission
- Low consumption of resources (such as energy, water, land, fuel, chemicals)
- Damage to few trees or disturbance/ disorientation of fauna

N (Negligible):

- Emissions/generation of very low pollutant substances, emissions/generation of very low quantity of pollutant substances and/or very low noise emission
- Very low consumption of resources (such as energy, water, land, fuel, chemicals)
- No measurable damage to flora/fauna

Determination of Impact Spatial extension (Sp) and Spatial Criteria (Is):

Impact Spatial extension has been assessed based on the following criteria:

- **H (High):** the impact extends in a wide area outside the site (about 10 km or more)
- **M (Medium):** the impact extends in a restricted area outside the site (< 10 km)
- **L (Low):** the impact extends inside the site.
- **N (Negligible):** the impact extends in a restricted area inside the site.

The product of Impact Intensity and Impact Spatial extension gives the impact evaluation as per **Spatial criteria (Is)**.

Table 4.1: Matrix for Evaluating Spatial criteria

Impact evaluation as per SPATIAL CRITERIA (Is)		Impact Spatial extension (Sp)			
		HIGH	MEDIUM	LOW	NEGLIGIBLE
Impact Intensity (I)	HIGH	H	H	H	H
	MEDIUM	H	M	M	M
	LOW	M	L	L	L
	NEGLIGIBLE	N	N	N	N

Determination of Impact Temporal duration (T) and Temporal Criteria (It)

Impact Temporal Duration has been assessed based on the following criteria:

- **H (Very High):** the impact has an important long-term effect (> 5 years)
- **H (High):** the impact has an important long-term effect (1-5 years)
- **M (Medium):** the impact has a medium-term effect (1 week – 1 year)
- **L (Low):** the impact has a temporary and short-term effect (1 day – 1 week)
- **N (Negligible):** the impact has an immediate effect and it is solved in a very short time.

The product of Impact Temporal duration and Spatial criteria gives the **Impact Evaluations** as per Temporal Criteria (It).

Table 4.2: Matrix for Evaluating Temporal criteria

Impact evaluation as per TEMPORAL CRITERIA (It)		Impact Temporal duration (T)				
		VERY HIGH	HIGH	MEDIUM	LOW	NEGLIGIBLE
Impact Is	HIGH	H	H	H	H	H
	MEDIUM	H	M	M	M	L
	LOW	M	M	L	L	L
	NEGLIGIBLE	N	N	N	N	N

Determination of Environmental Vulnerability (V) and Significance (S)

Environmental Vulnerability has been assessed based on the following criteria:

- **H** (High): Particular interesting area from the environmental, historical, social point of view. Parks, natural reserves and / or special areas of conservation. Contaminated areas in which a further impact may generate non-compliance with local environmental limits.
- **M** (Medium): Interesting area from the environmental, historical, social point of views. Residential areas with low population density. Agricultural areas, forests, public parks.
- **L** (Low): Industrial and commercial areas.

The product of Vulnerability and Temporal criteria gives the **Significance** of the impact.

Table 4.3: Matrix for Evaluating Significance

Impact evaluation as per VULNERABILITY CRITERIA (SIGNIFICANCE S)		VULNERABILITY (V)		
		HIGH	MEDIUM	LOW
Impact It	HIGH	H	H	M
	MEDIUM	H	M	M
	LOW	M	M	L
	NEGLIGIBLE	L	N	N

The **Impact Significance (S)** levels obtained from the above-matrix are defined as follows:

- **H** (High): Causes severe and acute effects to receptors, severe and irreversible deterioration of the quality of environment, and irreversible modification of landscape or of ecological equilibrium.
- **M** (Medium): Causes moderate effects to receptors, reversible deterioration of the quality of environment, and reversible modifications of landscape or ecological equilibrium.
- **L** (Low): Causes limited effects to receptors, quickly reversible deterioration of the quality of environment, and slight and reversible modification of landscape or ecological equilibrium.
- **N** (Negligible): Causes negligible or no effects to receptors, slight and reversible deterioration of quality of the environment, no measurable changes at landscape or ecological level.

The assessment has been carried out for each of the potential environmental impacts during both construction and operation, and has been discussed in this chapter.

4.2 IDENTIFICATION OF ENVIRONMENTAL IMPACTS

The environmental impacts associated with the proposed project on various environmental components such as air, water, noise, soil, flora, fauna, land, socioeconomic, etc. has been identified using Impact Identification Matrix (**Table 4.4**).

AIR ENVIRONMENT

The major air pollutants from a refinery cum petrochemical complex are SO_2, NOx, PM_{10}, HC and VOCs. Out of which, SO_2 and NOx are emitted continuously from stacks (point sources) associated with fuel combustion in process units. The emissions from point sources at refinery cum petrochemical complex are very important for impact assessment as the emissions from these sources are comparatively large in quantities, continuous in nature and released at higher elevations above ground level. The impacts on air environment from stacks depend on the type of fuel used and may extend to far distances depending on meteorological conditions.

The fugitive emissions are primarily due to intermittent leakage or evaporation of volatile organic compound from plant and storage areas. The fugitive emissions are generally less in quantity and they are released relatively closer to ground level which cause impact to very limited distances (about 1-3 Km). Amongst the continuous point source emissions, SO_2 and NO_x will be of prime concern as it is emitted depending on the type of fuel used (liquid/gas) and the rate of fuel combustion.

4.2.1 CONSTRUCTION PHASE

Construction activities are anticipated to take place over a period of at least four years from Zero date.

Table 4.4 : Impact Identification Matrix

	Physical				Biological		Socio-economic	
Activities	**Ambient air quality**	**Ground / surface water (quantity / quality)**	**Ambient noise**	**Land (land use, topography & drainage, soil)**	**Flora**	**Fauna**	**Livelihood & occupation**	**Infrastructure**
CONSTRUCTION PHASE								
Site preparation	*		*	*	*	*	*	
Civil works	*		*	*				
Heavy equipment operations			*					
Disposal of construction wastes				*				
Generation/disposal of sewerage		*		*				
Transportation of materials	*		*					

OPERATION AND MAINTENANCE PHASE								
Commissioning of Process units, utilities and offsites	*	*	*		*	*	*	*
Storage of Products	*							
Waste management-liquid and solid waste		*		*				
Transportation of products	*		*					

Potential emissions sources during construction phase include the following:

- Site preparation and civil works
- Storage and handling of construction material (e,g. sand, cement) at proposed project site.
- Operation of temporary Diesel Generator (DG) sets
- Movement of vehicles carrying equipment, construction material and project-related personnel
-

The impacts are described below:

- Dust will be generated from earth-moving, grading and civil works, and movement of vehicles on unpaved roads.
- PM, CO, NOx, & SO_2 will be generated from operation of diesel sets and diesel engines of machineries and vehicles.

The significance of the impacts of air emissions on ambient air quality during construction phase is summarized in **Table 4.5**.

Table 4.5: Impact of air emissions (construction phase)

Factors of assessment	Value of assessment	Justification
Intensity	Low	Emissions of low quantity/Low consumption of power
Spatial	Low	Impact extends inside the site
Temporal	Low	The impact has a temporary and short term effect
Vulnerability	Low	Open area
Evaluation of factors		
Impact(I_s)	Low	By combining intensity and spatial factors as per methodology given in Section 4.1
Impact(I_t)	Low	By combining Is and temporal factors as per methodology given in Section 4.1
Overall Significance Value of Impact (S)	**Low**	By combining It and Vulnerability factors as per methodology given in Section 4.1

Mitigation Measures

- Ensuring preventive maintenance of vehicles and equipment.
- Ensuring vehicles with valid Pollution under Control certificates are used.
- Avoiding unnecessary engine operations.

- Implementing dust control activities such as water sprinkling on unpaved sites.
- Controlled vehicle speed on site
- Ensuring vehicle are covered during transportation of material

4.2.2 OPERATION PHASE

4.2.2.1 EMISSIONS FROM COMBUSTION SOURCES

INDUSTRIAL SOURCE COMPLEX SHORT TERM - 3 (ISCST3) MODEL

The model used in the present study is Industrial Source Complex Version 3, which is a AERMOD Dispersion Modeling Program designed to estimate pollutant concentrations for simple, intermediate, or complex terrain. The Industrial Source Complex Short Term or in brief ISCST model is one of the United States Environmental Protection Agency (USEPA)'s UNAMAP series of air quality models.

The Industrial Source Complex (ISC3) models are used to predict pollutant concentration from continuous point, area and volume sources. These versatile models are preferred by the USEPA because of many features that enable the user to estimate the concentrations nearly any type of source emitting non-reactive source.

The ISC short-term model for stack uses Steady State Gaussian plume equation for the continuous elevated source. For the cross wind and downwind distances, the model uses either polar or rectangular Cartesian co-ordinates as specified by the user. For wind speed profile, wind power law is used to adjust the observed wind speed to the stack or release height. For computation of plume rise, Briggs plume rise formula is used. The distance dependent momentum plume rise equations are used to determine if the wake region for the building downwash calculations affects the plume. In order to consider the stack tip downwash, modification in stack height is performed using Briggs (1974). The point source dispersion parameters are computed using the Turners (1970) equation that approximately fits the Pasquill-Gifford curves. In order to take in account for the wake effect, plume dispersion theory of Huber (1976) and Snyder (1977) has been used. The buoyancy-induced dispersion has been taken care off using Pasquill method. The vertical term and dry depositions are also taken into account by this model.

Besides the above, for a given land use category (e.g., Auer Land use category), the model can be used for either Urban or Rural dispersion coefficient. The model also calculates the downwash from the nearby building and the fumigation conditions. The terrain variation is also included in form of flat, simple, intermediate and complex terrain. The input requirements for the ISC model short-term computer program consist of four categories of information:

- Hourly meteorological data
- Source data
- Receptor data
- Program control parameters

Meteorological inputs required by the program include hourly estimates of the wind direction, wind speed, ambient air temperature, mixing height, wind profile exponent and vertical temperature gradient. Some of the data required as mentioned above e.g., vertical temperature gradient, wind profile exponent and mixing depths call for a detailed study in itself, which in this case was not possible. Therefore, USEPA approved default values of wind exponents and temperature gradient as available in ISC3 have been used.

In the present study, the micro-meteorological data i.e., wind speed, wind direction, relative humidity and ambient temperature was collected in situ at project site for the months of October-December 2013 was used. The source data i.e. continuous stack emissions from different process units have been furnished from the knowledge of the respective process units.

The input data requirements for each source include data specific to the source and its type (whether point, area or volume source). The source-input requirements for running the program are the emission height, location, exit velocity, exit temperature and strength. The receptor data can be given either as polar, rectangular Cartesian or discrete ones. The program control includes options regarding pollutant type, dispersion options, averaging time, flag pole receptor and exponential decay etc.

4.2.2.2 Impacts due to releases of SO_2 and NOx

The status of SO_2 and NOx releases from the proposed refinery cum petrochemical projects are depicted below in **Table 4.6 and Table 4.9**.

4.2.2.3 Impacts of Emissions from stacks

From **Table 4.6**, it can be noted that presently for a total release of 1250 kg/hr of SOX and 970.7 kg/hr of NOx, the resultant baseline ambient air quality measured is 17 ($\mu g/m^3$) SOx and 24 ($\mu g/m^3$) NOx.

Table 4.6 : Impact of emissions from RRP

Pollutants	Total emissions released (kg/hr)	Measured (98th Percentile) ambient air quality (μg/m3)
SO_2	1250	17
NOx	970.7	24

An air modeling has been carried out for predicting max ground level concentrations (GLC) using Aermod. Details of modeling and isopleths are given in Figures 4.1 & 4.2.

The summary of resultant GLC's are estimated and given below in **Table 4.7**.

Table 4.7: Resultant GLC (SOx)

Description	Maximum GLC $\mu g/m^3$	Maximum GLC Co-ordinates (m)	Location from the plant Centre (m)	Maximum 98 Percentile Baseline Value (within 10 km radius) $\mu g/m^3$	Resultant 98 Percentile Value $\mu g/m^3$
Release of emission sources from stacks	17.3	9245, 1250	In SE direction at around 2 km from center of the plot	17	34.3

From the table 4.7, the resultant SO_2 (maximum 24 hr Ground Level Concentration (GLC)) due to operation of RRP are predicted as 17.3 $\mu g/m^3$. Maximum 98 Percentile Baseline Value (within 10 km radius) estimated during the baseline data collection study is 17 μg/m3. This GLC is occurring in SE direction and at around 2 km from center of the plot. By superimposing the same with background SO_2 level, the maximum GLC observed is 34.3 μg/m3 (24 hourly average) which is well within the standard limits for 24 hourly average for industrial area i.e. 80 $\mu g/m^3$. Isopleth for SOx is attached in **Figure 4.1**.

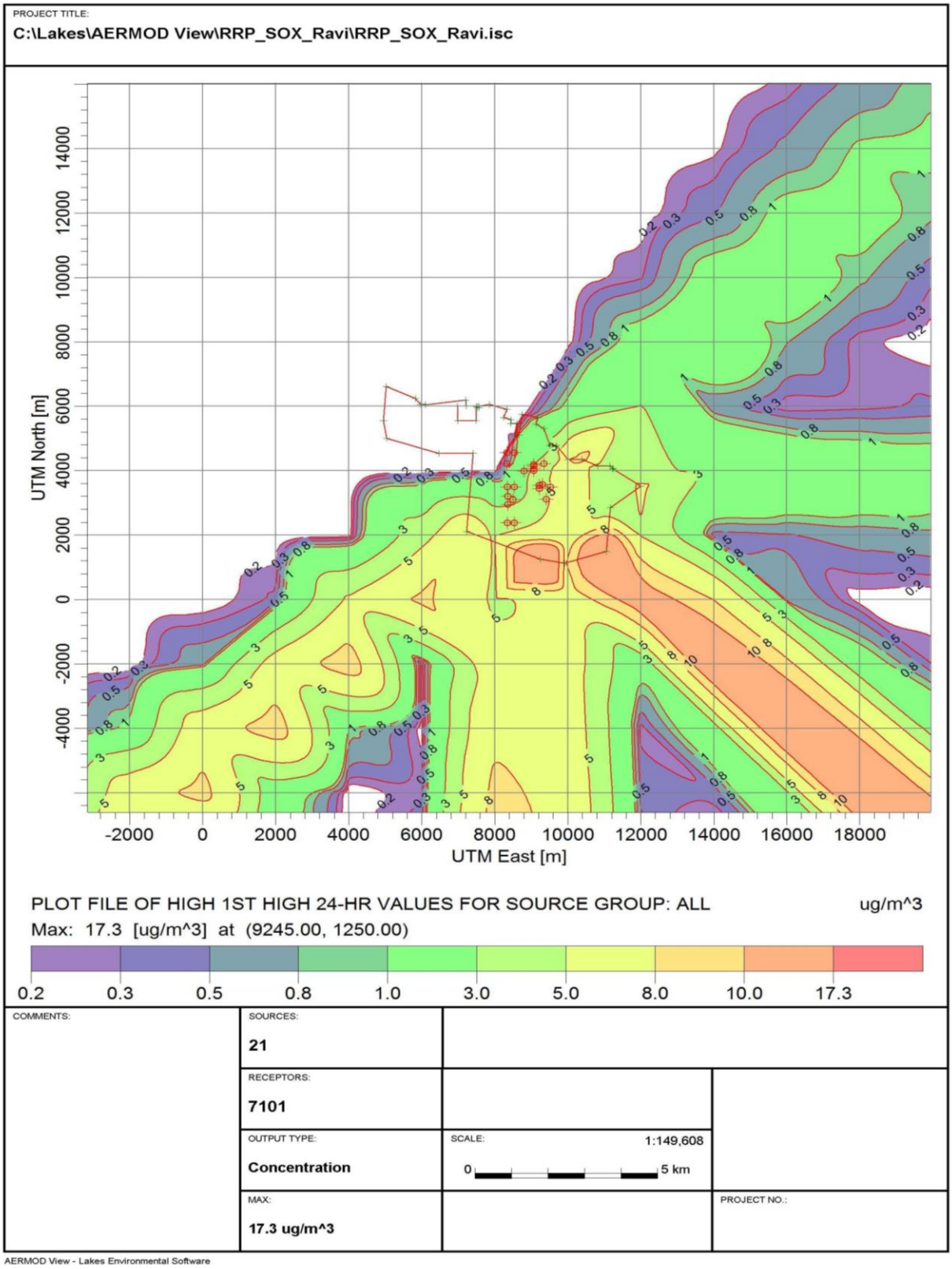


Figure. 4.1 – ISOPLETHS OF SOx

4.2.2.4 NOx emissions

Considering the emissions given in **Table 4.6**, air quality modeling has been carried out. The isopleths for 24 hourly maximum average for NOx for the proposed RRP Stacks have been shown in Figure 4.2 and the results are tabulated in **Table 4.8**.

TABLE 4.8 : Predicted values of GLC for NOx

	NOx (24 hourly maximum)				
	Maximum GLC μg/m³	**Maximum GLC Co-ordinates (m)**	**Location from the plant Centre (m)**	**Maximum 98 Percentile Baseline Value (within 10 km radius) μg/m³**	**Resultant 98 Percentile Value μg/m³**
Release of emission sources from stacks	11.6	9245, 1250	In SE direction at around 2 km from center of the plot	24	35.6

From the **Table 4.8,** the resultant NOx (maximum 24 hr Ground Level Concentration) due to operation of RRP stacks is predicted as 11.6 μg/m³. Maximum 98 Percentile Baseline Value (within 10 km radius) is 24 μg/m³**.** This GLC is occurring in SE direction at around 2 km from center of the plot. By superimposing the same with background NOx level, the maximum GLC observed is 35.6 μg/m³ (24 hourly average) which is well within the standard limits for 24 hourly average for industrial area i.e. 80 μg/m³.

4.2.2.5 Summary of Impacts

a. The resultant SO_2 with ambient air quality concentration is estimated as 34.3 μg/m³ which is well within the standard limits for 24 hourly average for industrial area i.e. 80 μg/m³.
b. The resultant NOx ambient air quality concentration is estimated as 35.6 μg/m3 which is less than which is well within the standard limits for 24 hourly average for industrial area i.e. 80 μg/m³.

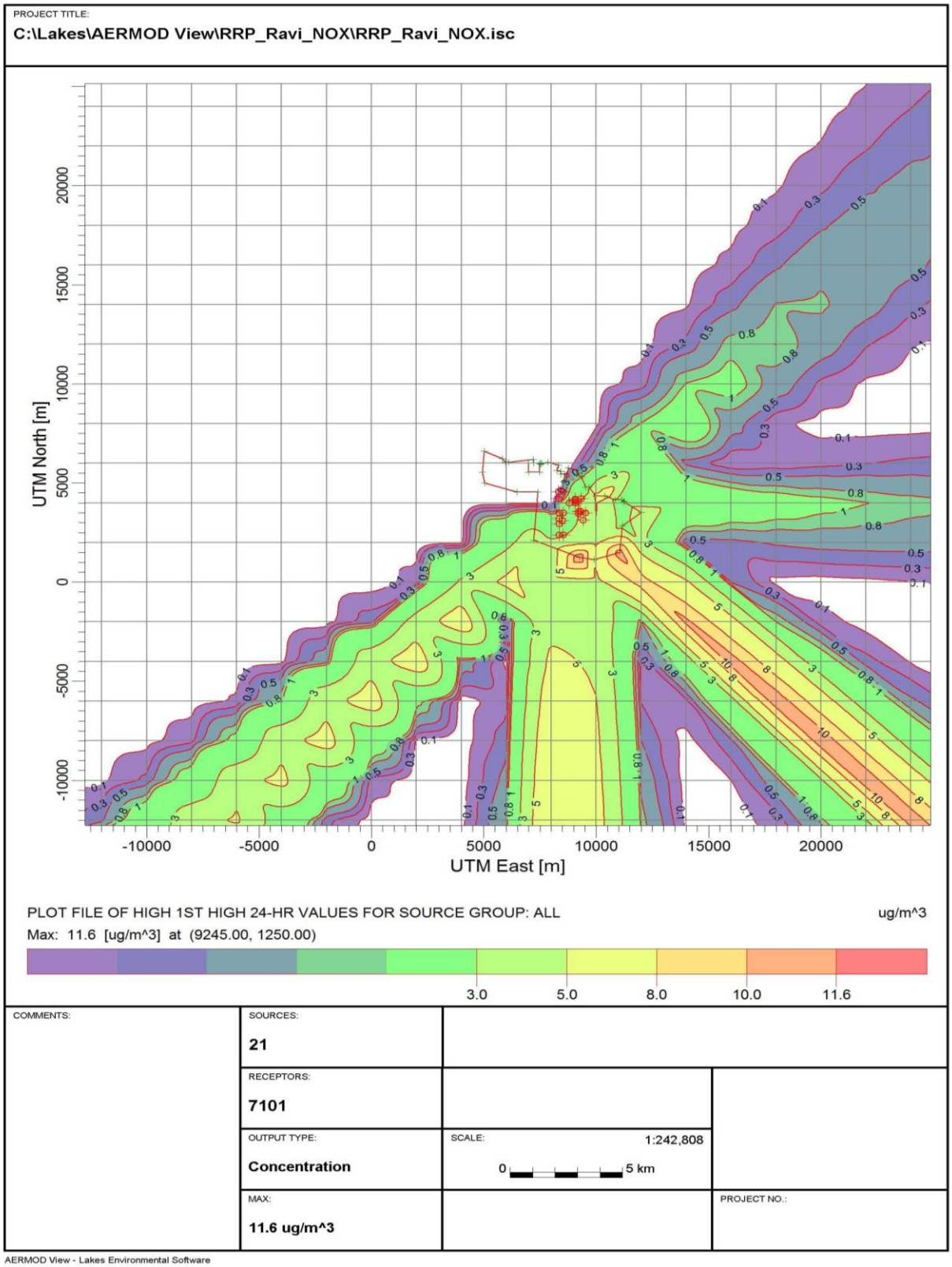


Figure 4.2 – ISOPLETHS OF NOx

Table 4.9:DETAILS OF VARIOUS STACKS EMISSIONS

Stack attached to Process Units	Total Absorbed Duty (MMkcal/kr)	Total Fired Duty (MMkcal/hr)	Total Flue Gas Quantity, (kg/hr)	Estimated SOx, (kg/hr)	Estimated NOx, (kg/hr)	Estimated Stack Flue Gas Temperature, (°C)	Desity of Flue Gas, (kg/m3)	Flowrate Volumetric of Flue Gas, (m3/s)	Estimated Stack Tip. Velecity, (m/s)	Estimated Stack Height, (m) (Top of stack) - Note-2	Estimated Stack Tip Dia, (m)
CDU / VDU (2 stacks)	111.00	126.10	235490.40	109.20	60.00	150.00	0.81	80.50	10.00	75.00	3.20
DCU	59.00	67.10	125308.50	58.10	32.00	150.00	0.81	42.80	10.00	65.00	2.34
VGO HDT	61.90	70.40	136622.00	61.00	34.80	150.00	0.81	46.70	10.00	65.00	2.44
RFCC Gasoline HDT	3.10	3.50	6792.30	2.90	1.70	325.00	0.57	3.30	10.00	40.00	0.65
PPU	2.60	3.00	5822.00	2.60	1.50	300.00	0.60	2.70	10.00	40.00	0.59
DHDT	7.60	8.60	16689.60	7.40	4.30	400.00	0.51	9.10	10.00	55.00	1.08
NHT	7.00	8.00	15525.20	6.90	4.00	330.00	0.57	7.60	10.00	55.00	0.98
NSU	14.90	16.90	31560.60	14.70	8.00	225.00	0.69	12.70	10.00	60.00	1.27
CCR	6.40	7.30	13632.70	6.30	3.40	230.00	0.68	5.50	10.00	55.00	0.84
BTX	7.20	8.20	15913.40	10.60	4.10	325.00	0.57	7.70	10.00	55.00	0.99

DFCU (8 STACKS)	534.00	606.80	1100831.90	33.00	131.80	130.00	0.85	358.60	10.00	(Note-3)	6.76
PGHU	3.10	3.50	6792.30	3.00	1.70	350.00	0.55	3.40	10.00	40.00	0.66
Hydrogen Generation Unit	19.60	22.30	48086.40	0.30	9.30	160.00	0.79	16.80	10.00	60.00	1.46
HRSG (1+1 Stacks)	77.50	88.00	160742.40	52.80	37.90	140.00	0.83	53.70	15.00	65.00	2.13
HRSG (1+1 Stacks)	77.50	88.00	160742.40	52.80	37.90	140.00	0.83	53.70	15.00	65.00	2.13
Boiler	104.00	130.00	237460.40	77.80	55.90	140.00	0.83	79.30	15.00	80.00	2.59
FCC Start-up Heater (Note-4)	12.20	14.70	27452.10	12.90	6.80	325.00	0.57	13.30	10.00	60.00	1.30
FCC Regenerator	2.6 (MMTPA Unit Capacity)	**By Licensor**	101.00	**76.68**	**By Licensor**						
SRU	197.5 (TPD Capacity)	35500.00	17.50	7.00	300.00	0.60	16.40	15.00	80.00	1.18	
SRU	197.5 (TPD Capacity)	35500.00	17.50	7.00	300.00	0.60	16.40	15.00	80.00	1.18	
CFBC	2152 TPD of Feed with 7 wt% S	**By Vendor**	625	**123.61**	**By Vendor**						

Notes

1. All the data provided above is based on percentage of fuel gas and fuel oil firing in each unit as indicated below:

- **(a) CPP-55% FO & 45% FG Firing.**
- **(b) DFCU - 100% FG firing**
- **(c) HGU-70% PSA off gas & 30% FG firing**
- **(d) All other process units - 18% FG & 82% FO firing**

2. FCC start up heater shall not be running during normal operation.

3. Total number of stacks = 30 nos.

4.2.3 FUGITIVE EMISSIONS

In compliance to Refinery and Petrochemical environmental standards, Leak detection survey to be carried out at regular interval at all the unit areas, offsites within the complex. It is envisaged that all leaks will be identified through LDAR programme.

The significance of the impacts of air emissions on ambient air quality during operation phase is summarized in **Table 4.10.**

Table 4.10: Impact of air emissions (operation phase)

Factors of assessment	Value of assessment	Justification
Intensity	Low	Resultant baseline concentrations for SO_2 & NOx are found well within prescribed National Ambient Air Quality Standards (NAAQS)
Spatial	Low	Dispersion of these emissions leading to Ground level concentration (GLC) lies inside the site.
Temporal	High	the impact has an important long-term effect
Vulnerability	Low	Open area
Evaluation of factors		
Impact(I_s)	Low	By combining intensity and spatial factors as per methodology given in Section 4.1
Impact(I_t)	Medium	By combining I_s and temporal factors as per methodology given in Section 4.1
Overall Significance Value of Impact(S)	**Medium**	By combining I_t and Vulnerability factors as per methodology given in Section 4.1

Mitigation measures

- A separate process unit for recovery of sulphur (SRU) will be developed
- Developing green belt in the proposed new premises.
- Ensuring preventive maintenance of equipment.
- Regular monitoring of air polluting concentrations.
- Provision of Low NOx burners is envisaged in all furnaces.

4.3 WATER ENVIRONMENT

4.3.1 CONSTRUCTION PHASE

During construction phase, raw water will be required for the following purposes:

- Civil works (such as cement preparation, curing)
- Hydro testing (of tanks and associated piping)
- Domestic use (such as washing, laundry etc.)
- Water sprinkling on site for dust abatement

About 13000 m3/day of water will be required for a period of 24 months. A new water pipeline with tap-off at Bagundi from ongoing Pokhran – Shiwana pipeline will

be laid to meet the construction water demand. Water will be taken through tankers from Nagna, till water is available from above new line.

The significance of the impact of raw water consumption on local water resources during construction phase is summarized in **Table 4.11**.

Table 4.11: Impact of water consumption (construction phase)

Factors of assessment	Value of assessment	Justification
Intensity	Low	Local source (Nagna/Bagundi)
Spatial	low	The impact extends in a restricted area within the site
Temporal	Medium	The impact has a temporary and short term effect
Vulnerability	Low	Designated Industrial area
Evaluation of factors		
Impact(I_s)	Low	By combining intensity and spatial factors
Impact(I_t)	Low	By combining I_s and temporal factors
Overall Significance Value of Impact(S)	**Low**	By combining I_t and Vulnerability factors

The effluent streams that will be generated regularly during construction stage include the following:

- Sewage and grey water from work sites
- Cleaning and washing water for vehicle and equipment maintenance area.

During construction, waste materials would contribute to certain amount of water pollution. But these would be for a short duration. All liquid waste will be collected and disposed to identify water impoundment within the construction site. Later at frequent intervals the same shall be disposed through tankers using gully suckers to common waste treatment facility.

The significance of the impact of waste water generation during construction phase is summarized in **Table 4.12**.

Table 4.12: Impact of effluent generation (construction phase)

Factors of Assessment	Value of assessment	Justification
Intensity	Low	Releases of low quantity
Spatial	Low	Impact extends in a restricted area inside the site (< 1 km)
Temporal	Low	The impact has a temporary and short term effect (1 day – 1 week)
Vulnerability	Low	Open area
Evaluation of factors		
Impact(I_s)	Low	By combining intensity and spatial factors
Impact(I_t)	Low	By combining I_s and temporal factors
Overall Significance Value of Impact(S)	**Low**	By combining I_t and Vulnerability factors

Mitigation Measures

- Monitoring water usage at work sites to prevent wastage.
- A new STP as a part of envisaged ETP will be installed for treatment of sanitary waste water.

Operation Phase

Impact Evaluation

The impact on water environment during the operation phase of the proposed changes shall be in terms of water consumption and waste water generation due to process activities. The raw water consumption for the Refinery-cum-Petrochemical complex is estimated to be approximately 5300 m^3/hr. Raw water will be sourced from *IG Canal* at Nachna. HRRL has already obtained consent from Irrigation Department, Barmer for drawl of ~ 5300 m3/hr. (**Annexure V**).

The impact of water consumption on local resources during operation phase is summarized in **Table 4.13**.

Table 4.13: Impact of water consumption (Operation phase)

Factors of assessment	Value of assessment	Justification
Intensity	Low	Treated waste water is reused to the maximum
Spatial	low	The impact extends in a restricted area within the site
Temporal	Medium	Throughout the life cycle of complex
Vulnerability	Low	No ground water abstraction shall be carried out during construction / operational phase, the region being water scarce.
Evaluation of factors		
Impact(I_s)	Medium	By combining intensity and spatial factors
Impact(I_t)	Medium	By combining I_s and temporal factors
Overall Significance Value of Impact (S)	**Medium**	By combining I_t and Vulnerability factors

There shall be ~1650 m^3/hr of waste water generation from the proposed facilities. An Effluent Treatment Plant (ETP) will be developed for treating the waste water from all the units/sources. About 1250 m^3/hr of treated effluent will be recycled and about 400 m^3/hr of treated effluent including rejects from RO plant will be routed to evaporation pond.

In summary, there will be no discharge of treated effluent from the complex.

The impact of effluent generation during operation phase is summarized in **Table 4.14**.

Table 4.14: Impact of effluent generation (operation phase)

Factors of assessment	Value of assessment	Justification
Intensity	Low	Zero discharge (Treated waste water is reused and reject is evaporated)
Spatial	Low	Impact extends in a restricted area within the site.
Temporal	Low	The impact has a temporary and short term effect (1 day – 1 week)
Vulnerability	Low	Open area
Evaluation of factors		
Impact(I_s)	Low	By combining intensity and spatial factors
Impact(I_t)	Low	By combining I_s and temporal factors
Overall Significance Value of Impact (S)	**Low**	By combining I_t and Vulnerability factors

Mitigation Measures

- Installation of rainwater harvesting structures to collect and use rainwater, thereby reducing abstraction.
- Proposed ETP shall recycle the treated effluent to achieve zero discharge from refinery cum petrochemical complex.

4.4 NOISE ENVIRONMENT

4.4.1 CONSTRUCTION PHASE

The main sources of noise during construction will be:

- Site preparation.
- Civil works
- Heavy equipment operations

Construction noise levels associated with typical machinery based on “BS 5228: 1997 Noise and Vibration Control on Construction and Operation Sites” are summarized in the **Table 4.15**.

Table 4.15: Sound Pressure (noise) levels of Construction Machinery

Item Description	Noise Level dB(A)	Reference Distance
Earth Movers		
Front Loaders	72-84	0.9 m
Backhoes	72-93	"
Tractors	72-96	"
Scrapers, Graders	80-93	"
Pavers	86-88	"
Trucks	82-94	"
Material Handlers		

Concrete Mixers	75-88	0.9 m
Concrete Pumps	81-83	"
Cranes (movable)	75-86	"
Cranes (derrick)	86-88	'
Item Description	**Noise Level dB(A)**	**Reference Distance**
Stationary Equipment		
Pumps	69-71	0.9 m
Generators	71-82	"
Compressors	74-86	"

The impact of noise emissions on ambient noise levels are summarized in **Table 4.16.**

Table 4.16: Impact on Ambiant Noise (construction phase)

Factors of assessment	Value of assessment	Justification
Intensity	Low	Releases of low quantity
Spatial	Low	Impact extends inside site
Temporal	Low	The impact has a temporary and short term effect (1 day – 1 week)
Vulnerability	Low	Open area
Factors of assessment	**Value of assessment**	**Justification**
Evaluation of factors		
Impact(I_s)	Low	By combining intensity and spatial factors
Impact(I_t)	Low	By combining I_s and temporal factors
Overall Significance Value of Impact (S)	**Low**	By combining I_t and Vulnerability factors

Mitigation Measures

- Ensuring preventive maintenance of equipments and vehicles.
- Avoiding unnecessary engine operations (e.g. equipments with intermitted use switched off when not working).
- Ensuring DG sets are provided with acoustic enclosures and exhaust mufflers.

4.4.2 OPERATION PHASE

During operational phase of the proposed project, the noise shall be caused due to various rotating equipment viz. Pumps, Compressors & Mixers, Cooling Tower etc. The **Table 4.15** gives the listing of various noise generating sources along with their design noise level considered.The impact of these noise emissions during operation is summarized in **Table 4.17**.

Table 4.17: Impact on ambient noise (operation phase)

Factors of assessment	Value of assessment	Justification
Intensity	Low	Releases of low quantity
Spatial	Low	The impact extends inside the site.
Temporal	High	The impact has an important and long term effect (1 – 5 years)

Vulnerability	Low	Open area
Evaluation of factors		
Impact(I_s)	Low	By combining intensity and spatial factors
Impact(I_t)	Medium	By combining I_s and temporal factors
Overall Significance Value of Impact (S)	**Medium**	By combining I_t and Vulnerability factors

Mitigation Measures

- Avoiding continuous (more than 8 hrs) exposure of workers to high noise areas.
- Provision of ear muffs at the high noise areas
- Ensuring preventive maintenance of equipment.
- Ensuring DG sets have acoustic enclosures and exhaust mufflers as per design.

4.5 LAND ENVIRONMENT

The thematic map of Land use indicating buildup, Agriculture, Industrial, Residential, Commercial etc within study area super imposed with project boundary is carried out and given in Chapter 3. From the map it, can be noted that the proposed project location is situated at industrial area.

4.5.1 CONSTRUCTION PHASE

The impact on land environment during construction phase shall be due to generation of debris/construction material, which shall be properly collected and disposed off. However, being the modifications limited to existing area, the generation of such waste shall be minimal.

During construction, there will be no routine discharge or activity potentially impacting soils and groundwater.

The impact on land use and topography during construction phase is summarized in **Table 4.18**.

Table 4.18: Impact on Land Use & Topography (construction phase)

Factors of assessment	**Value of assessment**	**Justification**
Intensity	Low	Solid waste is generated during the construction period and the same shall be disposed suitably.
Spatial	Low	The impact extends inside the site.
Temporal	Medium	the impact has a medium-term effect (1 week – 1 year)
Vulnerability	Low	Open area
Evaluation of factors		
Impact(I_s)	Low	By combining intensity and spatial factors
Impact(I_t)	Low	By combining I_s and temporal factors
Overall Significance Value of Impact (S)	**Low**	By combining I_t and Vulnerability factors

There is potential for impact on soil quality due to project-related spills and leaks of fuel and chemicals and uncontrolled disposal of wastes and wastewater. Care will be taken to avoid spills and leaks of hazardous substances and all project-related wastes. Littering of

sites and areas beyond the site will be controlled. A Secured Landfill Facility is proposed inside the refinery cum petrochemical complex.

The impact on soil quality during construction phase is summarized in **Table 4.19**.

Table 4.19: Impact on soil quality (construction phase)

Factors of assessment	Value of assessment	Justification
Intensity	Low	Releases of low quantity
Spatial	Low	The impact extends inside the site.
Temporal	Medium	The impact has a medium-term effect (1 week – 1 year)
Vulnerability	Low	Open area
Evaluation of factors		
Impact(I_s)	Low	By combining intensity and spatial factors
Impact(I_t)	Low	By combining I_s and temporal factors
Overall Significance Value of Impact (S)	**Low**	By combining I_t and Vulnerability factors

Mitigation Measures

- Restricting all construction activities inside the project boundary.
- Ensuring the top soil is not contaminated with any type of spills.
- Ensuring any material resulting from clearing and grading should not be deposited on approach roads, streams or ditches, which may hinder the passage and/or natural water drainage.
- Developing project specific waste management plan and hazardous material handling plan for the construction phase.

4.5.2 OPERATION PHASE

The impact on land environment during operational phase shall be due to disposal of solid and hazardous waste generated during operation. Details of solid waste that will be generated from the proposed project has been already covered in chapter 2. The impacts on soil quality during operation phase are summarized in **Table 4.20**.

Table 4.20: Impact on soil quality (operation phase)

Factors of assessment	Value of assessment	Justification
Intensity	Low	Solid waste is disposed in secured landfill
Spatial	Low	The impact extends inside the site.
Temporal	Low	The impact has a short term effect
Vulnerability	Low	Solid waste is disposed in secured landfill
Evaluation of factors		
Impact(I_s)	Low	By combining intensity and spatial factors
Impact(I_t)	Low	By combining I_s and temporal factors
Overall Significance Value of Impact (S)	**Low**	By combining I_t and Vulnerability factors

Mitigation Measures

A secured land fill facility is envisaged inside the complex for temporary handling/storage purpose and after that hazardous wastes shall be disposed off in nearby authorized landfill facility.

4.6 BIOLOGICAL ENVIRONMENT

4.6.1 Construction phase

Impact Evaluation

There will be minimal number of cutting of trees in the proposed site. The impacts on flora and fauna during construction phase are summarized in Table 4.21.

Table 4.21: Impact on Biological Environment (construction phase)

Factors of assessment	Value of assessment	Justification
Intensity	Low	Clearing of scanty vegetation
Spatial	Low	Impact extends inside the site
Temporal	Low	The impact has short term effect due to clearance of scanty vegetation.
Vulnerability	Low	Barren land
Evaluation of factors		
Impact(I_s)	Low	By combining intensity and spatial factors
Impact(I_t)	Low	By combining I_s and temporal factors
Overall Significance Value of Impact (S)	**Low**	By combining I_t and Vulnerability factors

Mitigation Measures:

- Closing of trenches as soon as possible of construction.
- Prevent littering of work sites with wastes, especially plastic and hazardous waste.
- Training of drivers to maintain speed limits.

4.6.2 Operation phase

Impact Evaluation

The impacts due to proposed project activities during operation phase shall be limited to long run impact of emissions and traffic movement. Details of all type of impacts that can occur during operation phase are listed below.

Impacts on Flora & Fauna during operation phase are summarized in **Table 4.22**.

Table 4.22: Impact on Biological Environment (operation phase)

Factors of assessment	Value of assessment	Justification
Intensity	Low	Resultant GLC's within the ambient air quality standards
Spatial	Low	Impact extends inside the site

Temporal	Low	Impact has an temporary and short term effect
Vulnerability	Low	No clearing of vegetation
Evaluation of factors		
Impact(I_s)	Low	By combining intensity and spatial factors
Impact(I_t)	Low	By combining I_s and temporal factors
Overall Significance Value of Impact (S)	**Low**	By combining I_t and Vulnerability factors

Mitigation measures

- Development of greenbelt during construction phase
- Maintenance and plant additional trees during operation phase

4.7 SOCIO ECONOMIC ENVIRONMENT

4.7.1 CONSTRUCTION PHASE

The issues need to be addressed during the construction phase of the project include the effect of employment generation and additional transport requirements on local infrastructural facilities. These are only short term impacts lasting during the construction phase of the project.

4.7.1.1 Employment Generation

The construction phase is expected to span for four years. During this phase, the major socio-economic impact will be in the sphere of generation of temporary employment of very substantial number of personnel. Based upon the information on the construction of other similar plants, it can be observed that the number of personnel needed for the proposed project during the construction phase, average manpower requirement is 2000 people and during third & fourth year is around 3500 people.

At any time, the share of managerial, skilled and unskilled people can be taken to be 20%, 30% and 50% respectively.

Required construction labourers will be hired for construction of the proposed plant which may increase the employment opportunities.

4.7.1.2 Effect on Transport

Transport requirements will arise during the construction phase due to the movement of both the personnel and materials.

The site is well connected to direct road on four sides.

(a) **Transport of Personnel**

Transport of the managerial personnel is likely to increase the vehicular traffic on the roads connecting the proposed site to the town. The incremental traffic for the additional people would be about 300 cars.

(b) Transport of construction materials

The transport of construction materials to the project site will result in increased traffic in the impact area. The constructions of capital intensive structures such as reactors and

columns require iron and steel, heavy construction equipment and other construction materials. They will have to be transported to the site using trucks. Roughly, on an average of approximately 20 trucks per day will be needed for transporting the construction materials.

(c) Effect on local traffic

The incremental daily traffic during construction phase works out to be about 100 cars and 10 buses per day.

4.7.1.3 Effect on Other Local Infrastructure

The majority of skilled and unskilled labourers are available in the impact area itself, the incremental effect on housing during the construction phase will be minimal. But, during the working hours of the day, the demand for food, water, sanitation and health facilities at the construction site will go up.

Though the truck drivers appear to form a floating population, there will be a general flow of this group throughout the duration of the construction phase. There will be an impact on basic necessities like shelter, food, water, sanitation and medical facilities for the truck drivers.The impact of construction activities on socio-economic environment during construction phase is summarized in **Table 4.23**.

Table 4.23: Impact on Socio-Economic Environment (construction phase)

Factors of assessment	Value of assessment	Justification
Intensity	Low	Involvement of labour, infrastructure and other utilities in a phased manner. Also it is considered as a positive impact in terms of employment generation
Spatial	Low	Impact extends in a restricted area outside the boundary (< 2 km). Also this is a positive impact in terms of employment generation.
Temporal	Medium	The impact has an medium term effect (1 week – 3 year). Also this is a positive impact in terms of employment generation and infrastructure development
Vulnerability	Medium	Increase in traffic
Evaluation of factors		
Impact(I_s)	Low	By combining intensity and spatial factors
Impact(I_t)	Low	By combining I_s and temporal factors
Overall Significance Value of Impact(S)	**Medium**	By combining I_t and Vulnerability factors

Mitigation Measures

- Conducting awareness programmes for workers.
- Monitoring speed and route of project-related vehicles

- Determining safe, legal load limits of all bridges and roads that will be used by heavy vehicles and machinery.
- Determining allowable traffic patterns in the affected area throughout the work week will be made based on community use, include a consideration of the large turning requirements of certain vehicles/machineries that might increase congestion and traffic hazards
- Consolidating deliveries of materials and personnel to project sites, whenever feasible, to minimize flow of traffic
- Minimizing interruption of access to community for use of public infrastructure
- Providing prior notice to affected parties when their access will be blocked, even temporarily.
- Preventing use of drugs and alcohol in project-sites
- Preventing possession of firearms by project-personnel, except those responsible for security.

4.7.2 OPERATIONAL PHASE

Operational phase of the plant covers the entire life span of the plant. Hence the impacts of the operational phase extend over a long period of time. These impacts include employment generation, effects on transport and other basic infrastructure. Moreover, all area required for refinery cum petrochemical complex are government owned land. Hence there is no applicability of Rehabilitation and Resettlement policy (R&R) for this project.

Employment Scenario

Employment for 1000 employees directly and another 200 for additional contract employees for regular maintenance is envisaged during the operation phase.

Effect on Transport

Transport requirements will arise due to the movement of both the personnel and materials.

(a) **Transport of Personnel**

There shall be increase in additional load on traffic due to transport of personnel.

(b) **Transport due to movement of materials/products**

Approximately 300 trucks are envisaged during operation phase for transport of different products.

(c) Effect on local traffic

The incremental traffic during the operational phase works out to be about 6 buses per day. The impact of these activities on socio-economic environment during operation phase is summarized in **Table 4.24**.

Table 4.24: Impact on Socio-Economic Environment (operation phase)

Factors of assessment	Value of assessment	Justification
Intensity	Low	Involvement of labour, infrastructure and other utilities in marginal quantities/Nos.
Spatial	Medium	Impact extends in a restricted area outside the site
Temporal	Medium	The impact has a medium term effect
Vulnerability	Low	Marginal increase in traffic
Evaluation of factors		
Impact(I_s)	Low	By combining intensity and spatial factors
Impact(I_t)	Low	By combining I_s and temporal factors
Overall Significance Value of Impact (S)	**Low**	By combining I_t and Vulnerability factors

Mitigation Measures

- CSR Program to spread across all villages
- Monitoring speed and route of project-related vehicles

4.8 SUMMARY OF IMPACTS

Based on the above evaluation the significance value of impact on various components of environment during construction and operation phases is summarized and is given in **Table 4.25**.

Table 4.25: Summary of Impact Evaluation in terms of Significance Value

Environmental component		Construction	Operation
Air		Low	Medium
Water	Consumption of Raw Water	Low	Medium
	Generation of Effluent	Low	Low
Land	Soil Quality	Low	Low
Noise		Low	Medium
Biological		Low	Low
Socio-Economic		Medium	Low

CHAPTER – 5

ANALYSIS OF ALTERNATIVE SITE

5.0 ALTERNATIVE SITE

5.1 ANALYSIS OF ALTERNATIVE SITES

In this chapter, alternatives considered for the proposed RRP project are evaluated and discussed with particular emphasis on environmental considerations. Study for alternatives sites analysis was carried out by M/s EIL. The project alternatives discussed here include the rational for the proposed project sitting, raw materials availability etc. Prior to arriving at a conclusion regarding establishment of proposed project, a number of alternatives were examined and reviewed. The options considered for site selection criteria were:

5.2 SITE SELECTION CRITERIA

The major parameters considered for site selection are as below:

- Land features, availability & status.
- General infrastructure availability & access to site.
- Access for construction (roads, railways) proximity of raw materials.
- Soil conditions.
- Power Source.
- Construction and Permanent water source.
- Rail / Road System.
- Social infrastructure.
- Crude / Natural gas/ Product pipe line lengths.
- Environmental requirements.
- Defence requirements.
- Proximity to International border.
- Topography of site & development requirement.
- Availability of additional land for downstream industries.

The above parameters were studied in details and evaluated based on different site selection and arrived at single site suitable and economical for proposed grass root refinery cum petrochemical complex.

5.3 SITE SELECTION OBSERVATION

The three sites as per the details given in **Table 5.1** were evaluated. Decision analysis method is used to systematically evaluate each site in relation to the matrix. In this matrix weightages are assigned to the evaluation criteria based on the perceived relative importance. The site with the most favorable characteristics is selected.

Table 5.1 Comparison of Alternate Sites Selection

Sr. No.	Description of Site Location	-	Option 1	Option-II
		Baytu	Pachpadra (Kalawa)	Pachpadra (Sajiyali)
1	District	Barmer	Barmer	Barmer
2	Tehsil	Baytu	Balotra	Balotra
3	Location	8 km from NH-112 and 40 km from Barmer town	Adjacent toNH-112 and SH-28 and close to Balotra town (19 km)	Adjacant to NH-112 and SH-28 and close to Balotra town
4	Landuse	Barren Agriculture	Predominantly Barren	Predominantly Barren
5	Land ownership	Private	Govt./private (90 & 10%)	Govt/private (98 & 2 %)
6	Site topography	Undulated, needs grading 2-5 m	Undulated needs grading	Fairly flat minimal grading
7	National Highway	8 km from NH-112	0.5 km to NH-112	0.5 km to NH-112
8	Railway Line	10-12 km	10-12 km Balotra	10-12 km Balotra
9	Power source	Barmer (46 km)	Balotra (20 km)	Balotra (20 km)
10	Water source	Indira Gandhi Canal (185 km)	Indira Gandhi Canal (~200 km)	Indira Gandhi Canal (~200 km)
11	Social Infrastructure	40 km Barmer	19 km Balotra 90 km Jodhpur 100 km Barmer	17km Balotra 90 km Jodhpur 100 km Barmer
12	Length of Crude pipeline (MPT)	30 km	70 km	70 km
13	Length of NG pipeline (MPT)	20 km	60 km	60 km
14	Length of Product Pipeline	140 km	95 km	80 km
15	Nearest Defence Installation	Uttarlai-26 km	Uttarlai-80 km	Uttarlai-80 km
16	Distance from Pakistan Border	120 km	152 km	152 km

I. Pachpadra (Kalawa) , Barmer (Plot C)

- Land features, availability & status: 3500 acre land which is barren / agriculture and undulating with government private ownership. (90% govt. /10% private ownership). The government land belongs to salt department.
- General infrastructure availability & access to site & proximity of raw material: Site is located adjacent to NH-112 & SH-28 near Balotra town. NH-112 is passing through north east corner of proposed land area.
- Soil conditions: The site has sandy soil.
- Power Source: 33KV /220 KV Power source is available at Balotra (20 Km).
- Construction and Permanent water source: Permanent & Construction Water source is not available nearby. Water to be brought from Indira Gandhi Canal (185 Km). However, for construction water, possibility of water to be sourced from under construction “Pokhran Falsoond Balotra Siwana Lift project Pipeline” need to be explored.
- Crude pipe line lengths: From Mangla Oil Field, the site is located at 70 km.
- Natural Gas Pipeline Length: From Raageshwari Site, it is located at 60 km.
- Product Pipeline Length: From Pachpadra (Kalawa) to Salawas, the distance is 95 km.
- Environmental requirements: No national monument / major settlement is located within 25 km of site.
- Defence requirements: Uttarlai Air Force Base is located at 80 km
- Proximity to International border: International border is 152 km
- Topography of site & development requirement: The topography is undulating (medium) with salt pans and low lying area on northern parts.
- Availability of additional land for downstream industries: Additional land under Government ownership is available for future development of downstream industries.

II. Pachpadra (Sajiyali) , Barmer (Plot D)

- Land features, availability & status: 3500 acre land which is barren / agriculture and flat with full government ownership. The government land belongs to salt department.
- General infrastructure availability & access to site & proximity of raw material: Site is located adjacent to NH-112 & SH-28 near Balotra town.
- Soil conditions: The site has sandy soil.
- Power Source: 33KV /220 KV Power source is available at Balotra (20 km).
- Construction and Permanent water source
- Permanent & Construction Water source is not available nearby. Water to be brought from Indira Gandhi Canal (185 km). However, for construction water possibility of water to be sourced from under construction “Pokhran Falsoond Balotra Siwana Lift project Pipeline” need to be explored.
- Crude pipe line lengths: From Mangla Oil Field the site is located at 70 km
- Natural Gas Pipeline Length :From Raageshwari Site, it is located at 60 km
- Product Pipeline Length: From Pachpadra (Sajiyali) to Salawas, the distance is 80 km
- Environmental requirements: No national monument / major settlement is located within 25 km of site.

- Defence requirements : Uttarlai Air Force Base is located at 80 km.
- Proximity to International border : International border is at 152 km.
- Topography of site & development requirement: Topography of land is fairly flat (without any major undulations).
- Availability of additional land for downstream industries: Additional land under Government ownership is available for future downstream industries.

III. Baytu (Lilala), Barmer

- Land features, availability & status: 3500 acre land which is barren / agriculture and undulated & 2-3 m variation with private ownership.
- General infrastructure availability & access to site & proximity of raw material: Site is located at 8 km from NH-112 near Barmer town.
- Soil conditions: The site has sandy soil at Baytu and requires higher cost for site development for undulations.
- Power Source: 33KV /132/220 KV Power source is available at Baytu / Barmer (46 km).
- Construction and Permanent water source
- Permanent & Construction Water source is not available nearby. Water to be brought from Indira Gandhi Canal (185 km)
- Crude pipe line lengths: From Mangla Oil Field the site is located at 30 km
- Natural Gas Pipeline Length: From Raageswari Site, it is located at 20 km
- Product Pipeline Length: From Baytu to Salawas, the distance is 140 km
- Environmental requirements: No national monument / major settlement is located within 25 km of site.
- Defence requirements: Uttarlai Air Force Base is located at 26 km
- Proximity to International border
- International border is 120 km from site.
- Topography of site & development requirement: Topography of the site is highly undulating with major sand dunes.
- Availability of additional land for downstream industries: No additional land under Government control is available for future downstream industries.

5.4 SUMMARY OF TECHNICAL FEATURES OF SITE

a. Land features, availability & status:

Land at Baytu is 100 % Private owned, land at Plot C in Pachpadra is 90% owned by GOR whereas lant at Plot D in Pachpadra is 98 % owned by GOR.“Acquisition time for land can vary from 6 to 8 months for privately owned lands at Baytu. Majority of Baytu land is sandy. NH-112 is passing through north east corner of proposed land area at Pachpadra (Kalawa) Plot-C, and adjoining Plot D which needs re-routing outside the proposed land area.

b. General infrastructure & access to site:

Raw materials have to brought from 15 to 20 km for all sites. Access to sites available from SH or NH with 1 to 8 km. Approach road to be developed for Plot C. Adequate infrastructure & Supply of resources for operation & maintenance is fairly available.

c. Soil Conditions:

Based on preliminary soil data at Plot C in Pachpadra and Plot D in Pachpadra, it is inferred that due to corrosive nature of soil following precautions need to be taken:

i. Concrete foundations need adequate precautions in term of increase of cover and bitumen coating to U/G concrete surface.

ii. Enhanced corrosion protection to under ground steel structures like vessels, piping etc shall be required.

Whereas this additional precaution is not required at Baytu.

d. Power Source:

Construction Power (132/220KV) & permanent power (220 KV) is available within 20 km for Pachpadra and 46 km for Baytu.

e. Construction Water and Permanent Water sources :

Permanent & Construction Water source is not available nearby any of the sites. Water needs to be brought from Indira Gandhi Canal. However, at Pachpadra sites (Plot C & D) possibility of sourcing construction water to be done from under construction “Pokhran Falsoond Balotra Siwana Lift project Pipeline”. The same needs to be explored. For Baytu site, construction water availability from Nimbla aquifer to be explored.

f. Environmental requirements

Zero discharge for storm water & effluent water is considered. There are no national monuments, sanctuaries etc. within 25 km of sites. State Pollution Board has no negative observation on all site locations.

g. Rail / Road System

The sites are adequately connected with SH / NH network. Railway lines are 10 to 12 km nearby for all the three Plots.

h. Social Infrastructure

Good social infrastructure is available nearby for Pachpadra (Plot C & D) site at Balotra (12 km). For Baytu social infrastructure of is available at Barmer 40 km.

i. Crude pipeline

For Baytu Crude pipeline length is 30 Km and for Pachpadra sites it is 70 km.

j. Natural Gas

For Baytu Natural gas pipeline length is 20 km and for Pachpadra sites it is 60 km.

5.5 SOCIO - ECONOMIC CONSIDERATIONS

Large investment in the area would provide a tremendous benefit to Barmer area even though lack of facilities would initially give less benefit. Comparatively Baytu is 40 km from Barmer & Pachpadra is 17 to 19 km from Balotra, both cities are yet to get developed to provide good comparable social infrastructure.

5.6 RECOMMENDED SITES

I. Pachpadra (Kalawa), Plot C, is suitable as

- Land for Pachpadra (Kawala) site is medium undulating, government / privately owned (90% govt and 10% private owned) and located very adjacent to NH-112 & SH-28 and just 19 km from Balotra town which has textile industry. As the site is predominantly Government owned, land acquisition time is nominal. The raw material required are available within 25 km. Pachpadra site is located equidistance from Jodhpur and Barmer towns. Thus drawing benefits of well developed social infrastructure of Jodhpur city and infrastructure & resources required for operation & maintenance.
- It has medium infrastructure cost
- Crude Pipe length (70 km)
- Natural Gas Pipeline length (60 km)
- Proximity to Balotra town (19 km) which should provide fair resources for operation & maintenance, fairly good social infrastructure.
- Well connected with National / State Highways network.
- Adequate social infrastructure needs to be created within the township.
- NH-112 is passing through north east corner of proposed land area at Pachpadra (Kalawa) site-C, which needs re-routing outside the proposed land area for refinery complex.

II. Pachpadra (Sajiyali), Plot D, is suitable as

- Land for Pachpadra (Sajiyali) site is fairly flat, predominantly government owned (98% govt and 2% private owned) and located very adjacent to NH-112 & SH-28 and just 17 km from Balotra town which has textile industry. As the site is almost fully owned by Government, land acquisition time is almost negligible. The raw material required are available within 25 km. Pachpadra site is located equidistance from Jodhpur and Barmer towns. Thus drawing benefits of well developed social infrastructure of Jodhpur city and infrastructure & resources required for operation & maintenance.
- It has medium infrastructure cost
- Crude Pipe length (70 km)
- Natural Gas Pipeline length (60 km)
- Proximity to Balotra town (17 km) which should provide fair resources for operation & maintenance, fairly good social infrastructure.
- Well connected with National / State Highways network.
- Adequate social infrastructure needs to be created within the township
- Reasonably plain land. No major undulation, marsh land, low lying area as compare to Plot C.

III. Baytu (Lalila) is suitable as

- Land for Baytu site is highly undulated and having sand dunes at many location in the plot, privately owned and located 8 km from NH-112 and 40 km from Barmer town. The raw material required are available within 30 to 50 km. The site as on today has less developed infrastructure & resources for operation & maintenance as well as less social infra structure nearby.

- It has minimum infrastructure cost.
- Shorter Crude pipe length (30 km)
- Shorter Natural Gas Pipeline length (20 km)
- Adequate social infrastructure needs to be created within the township

5.7 RECOMMENDATION AND CONCLUSION

Based on the overall analysis, Pachpadra site (Sajiyali) Option-II is selected among the three sites which will be more appropriate for the proposed project on the basis of following criteria.

- Site is fairly flat
- Predominantly government land
- Less land acquisition time
- Very adjacent to NH-112 and SH-28
- Nearer to Balotra town (17 km)
- Equi-distance from Barmer and Jodhpur
- Well connected National and State Highway
- Crude pipeline length (70 km)
- Natural gas pipeline length (60 km)

Based on the above discussion, it is evident that proposed site is the best suited site and shall contribute to social and economic development of the study area and the country in general.

CHAPTER – 6

ENVIRONMENTAL MONITORING PROGRAM

6.0 INTRODUCTION

Monitoring is an essential component for sustainability of any developmental project. It is an integral part of any environmental assessment process. Any development project introduces complex inter-relationships in the project area between people, various natural resources, biota and the many developing forces. Thus, a new environment is created. It is very difficult to predict with complete certainty the exact post-project environmental scenario; hence, monitoring of critical parameters is essential in the post-project phase.

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

6.1 ENVIRONMENTAL MONITORING AND REPORTING PROCEDURE

Development of the programme during the planning process shall be conducted or supported by environmental specialists. However, the implementation responsibility rests with working managers of the organization, who should, therefore, ensure they fully understand and subscribe to the commitments being made. These commitments will include the legal and statutory controls imposed on the operation as well as other corporate commitment to responsible environment management.

HRRL will be set-up an Engineering Group to review the effectiveness of environment management system during construction and operational phase of proposed project. The Environment Section is a part of Engineering Group who works for monitoring and meet regularly to review the effectiveness of the EMP implementation. The data collected on various EMP measures would be reviewed by EMC and if needed corrective action will be formulated for implementation. A Health, Safety, Environmental and Quality policy will be formulated by HRRL.

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

6.2 OBJECTIVES OF MONITORING

To ensure the effective implementation of the proposed mitigation measures, the broad objectives of monitoring plan are:

- To evaluate the performance of mitigation measures proposed in the environmental monitoring programme.
- To evaluate the adequacy of Environmental Impact Assessment
- To suggest improvements in management plan, if required
- To enhance environmental quality
- To undertake compliance monitoring of the proposed project operation and evaluation of mitigative measure.

6.3 CONSTRUCTION PHASE

Chapter 4 describes the impacts and mitigation measures envisaged during construction phase vis-à-vis the environmental components which are likely to get impacted in case mitigation measures are not adequately followed. In view of the same the environmental components/ indicators which are to be monitored during construction phase are air, water, noise levels and soil.

The air quality (at the project site and ambient air quality in the surrounding nearby villages) will indicate to which extent the mitigation measures are being followed. Similarly the up-stream and downstream surface water quality (w.r.t. project site), will indicate the quality and extent of wastewater from the project site. Likewise the monitoring of ground water, up-gradient and down-gradient of project site will indicate seepage of pollutants in to ground water from the construction site.

The noise levels at the project site and surrounding premises has been planned to be assessed to which the construction workers are exposed during construction phase. This will indicate the level of noise mitigation measures being followed during the construction phase.

The soil quality at the project site will indicate the pollutant fallout from the construction site.

The environmental monitoring programme during construction phase is presented in **Table 6.1**. The implementation of monitoring will be contractor's responsibility and the supervision will be done by HRRL.

Table 6.1 Environmental Monitoring Programme– Construction Phase

Component	Parameters	Location / Frequency of Monitoring	No. of Samples / month
Air	SO_2, NO_x, PM_{10}&$PM_{2.5}$ (As per NAAQS 2009 standards)	At two locations, one at project site and another is at plant boundary. Twice in a month (except monsoon)	4
Water	Surface Water: CPCB surface water criteria; Ground Water: IS:10500	Atleast one surface water in the project site per month and another is adjacent to project site. Two Ground Water: One Up-gradient and One Down-gradient of project site per month.	2 (SW) 2 (GW)
Noise	Noise Levels Leq (A)	At two locations, one at project site and another is at plant boundary. Twice in a month	4
Soil	As per standard practice	At one location, in the project site. Once in a month.	1

6.4 OPERATION PHASE

The components / indicators of different environmental monitoring program are as under.

6.4.1 Monitoring For Pollutants

As stated under Chapter 4, the environmental stresses from pollutants are marginal. Often the range of impact is limited to the plant and in its immediate vicinity, the monitoring schedule is evolved accordingly.

6.4.2 Meteorology

Meteorology forms one of the important categories of environment in the area as it directly controls the levels of air quality parameters. As such, a programmable microprocessor based wind monitor system will be installed inside the refinery premises to collect various meteorological parameters like wind speed, wind direction, temperature and relative humidity on a continuous basis.

6.4.3 Ambient Air Quality

Ambient Air Quality will be monitored regularly in and around the plant. All 12 parameters as per MoEF notification dated 16th November 2009 shall be monitored.

Stack Emission

Continuous on-line stack monitoring analysers for the measurement of SO_2 & NOx will be installed at all major stacks of Rajasthan Refinery for continuous monitoring of emission level.

Fugitive emission

Fugitive emissions will be monitored periodically (on quarterly basis) at all the relevant locations of the Refinery.

6.4.4 Liquid Effluent

Treated effluent will be monitored and analysed on daily basis for the parameters required for MINAS.

6.4.5 Ambient Noise

Noise monitoring will be conducted at distinct locations inside the plant, as well as outside the refinery boundary.

6.4.6 Ground Water

Ground water quality will be checked on regular basis to detect any contamination arising out of the solid waste disposal area and the plant area.

6.4.7 Soil Quality

Soil samples from one location in the project site shall be analysed once in three months after the implementation of proposed project.

6.4.8 Solid/Hazardous Waste Disposal

Periodic surveillance monitoring will be conducted to ensure that the solid wastes are disposed in the manner as specified by SPCB. Spent catalyst will be collected and sold to authorized recyclers.

6.4.9 Socio-Economic Development

Rajasthan Refinery is improving the infra-structure & socio-economic conditions of the region. It is suggested that the plant management under Corporate Social Responsibility (CSR) plan will have structured interactions with the community to disseminate the measures planned and also to elicit suggestions from stake-holders for overall improvement for the development of the area.

The proposed environmental monitoring programme during operation phase is mentioned below **Table 6.2.**

Table 6.2 Proposed Environmental Monitoring During Operational Phase

Sl.No.	Potential impact	Action to be Followed	Parameters for Monitoring	Frequency of Monitoring
1	Air Emissions	Stack emissions to be optimized and monitored.	Gaseous emissions (SO_2, PM, CO, NOx).	Once in two month
		Ambient air quality within the premises of the proposed unit and nearby habitations to be monitored. Exhaust from vehicles to be minimized by use of fuel efficient vehicles and well maintained vehicles having PUC certificate.	PM_{10}, $PM_{2.5}$, SO_2, NOx Vehicle logs to be maintained	As per CPCB/ SPCB requirement or on monthly basis
		Measuring onsite data of Meteorology	Wind speed, direction, temp., relative humidity and rainfall.	Continuous
		Vehicle trips to be minimized to the extent Possible.	Vehicle logs	Daily records

2	Noise	Noise generated from operation of DG set to be optimized and monitored. DG sets are to be provided at basement with acoustic enclosures.	Spot Noise Level recording; Leq(night), Leq(day), Leq(dn)	Once in a month
		Generation of vehicular noise	Maintain records of vehicles.	Periodic (during operation phase)
3	Water Quality	Monitoring groundwater quality and levels around HRRL complex	Comprehensive monitoring as per IS 10500	Once in a month
4	Wastewater Discharge	No untreated discharge to be made to surface water, groundwater or soil. The cleaning water shall be routed to nearby ETP.	No discharge hoses in vicinity of water courses.	Once in a month
		Take care in disposal of wastewater generated such that soil and ground water resources are protected.	Discharge norms for effluents as per ETP norms	Once in a month
5	Maintenance of flora and fauna	Vegetation and greenbelt / green cover development.	No. of plants species	Once in three months
6	Health	Regular health check-ups for employees and migrant labourers	All relevant parameters including audiometry	Regular check ups
7	Energy Usage	Energy usage power generation, air conditioning and other activities to be minimized. Conduct annual energy audit for the terminals	Energy audit report	Annual audits and periodic checks during operational phase

6.5 RESPONSIBILITY OF MONITORING AND REPORTING SYSTEM

The overall responsibility of monitoring the above parameters shall lie with the Management. The Environment section shall be responsible for day to day monitoring of effluent, raw water and treated water quality. The ambient air quality, stack emissions, soil, noise and water quality shall be monitored by either third party (approved MoEF/NABL laboratory) or by the EMC.

Records shall be maintained for the analysis of raw effluents and treated effluents, ambient air quality data, stack emissions monitoring results, meteorological data and noise levels. These records are not only required for the perusal of the Pollution Control Board authorities but also to derive at the efficiencies of the pollution control equipment as the objective of the project proponent is not only compliance with statutory regulations, but also a serious commitment towards clean environment.

The industry shall maintain the records as per the Hazardous waste regulations and EPA regulations and apply for the annual consents for the air and water, and renewal of authorization for the storage of hazardous waste as per Hazardous Waste (Handling & Management) Rules, 1989 and Amendment in 2000. The records of hazardous waste manifest will be maintained. Reporting system provides the necessary feedback for project management to ensure quality of the works and that the management plan in implementation. The rationale for a reporting system is based on accountability to ensure that the measures proposed as part of the Environmental Management Plan get implemented in the project.

6.6 SUBMISSION OF MONITORING REPORTS TO MoEF

As per the requirements, the status of environmental clearance stipulation implementation will be submitted to Regional MoEF office, Lucknow in hard and soft copy in December and June months of every calendar year. These reports will be put up on MoEF web site as per their procedure and will be updated every six months. The pollutants will be monitored and reports will be submitted to SPCB and CPCB respectively, as per the requirements.

CHAPTER – 7

ADDITIONAL STUDIES

7.0 ADDITIONAL STUDIES

In addition to the main EIA study, Rapid Risk Assessment (RRA) has been carried out by EIL. The summary of Public Hearing and RRA study are provided below.

7.1 PUBLIC CONSULTATION

In accordance with the provisions of EIA Notification no. S.O. 1533 dated 14.09.2006 and its subsequent amendment S.O. 3067 (E) dated 01.12.2009 issued by Ministry of Environment and Forests (MoEF), Govt. of India, New Delhi, Public Hearing for the proposed refinery cum petrochemical project was conducted on May 30, 2014 by Rajasthan State Pollution Control Board (RSPCB) at Shree Sambhra Aashapura Mataji Mandir, Sambhra, Village Sambhra, Taluka: Pachpadra, District: Barmer. On behalf of District Collector Barmer, Chief Executive Officer, Zila parishad, Barmer presided over the public hearing meeting. Regional Officer, Rajasthan State Pollution Control Board, Jodhpur and Balotra conducted the public hearing proceedings. About 1000 people attended the public hearing.

A power point presentation covering the proposed project details and the outcome of Environmental Impact Assessment and Risk Assessment (EIA & RA) studies was made in Hindi language (local and national language) in the Public Hearing meeting.

Queries on environmental issues related to salt mining, flora & fauna, air pollution, wastewater discharge, solid waste disposal from the complex were raised. The public also raised queries on various socio-economic issues like employment for local people, welfare activities in the villages, particularly for the salt mine owners/ workers, water catchment for the salt mines in the area etc. All these queries by various Gram Panchayats, local villagers and NGOs were appropriately answered by the RSPCB, NEERI and the Project Proponent.

The proceedings of the public hearing have been duly documented by Rajasthan State Pollution Control Board. Summary of the key issues/concerns raised in public hearing and their responses are given in **Table 7.1**.

Table 7.1 Summary of Public Hearing Proceedings: Key Issues and Responses

Sr. No.	Speaker	Observation/Key issues/ Concerns	Response
1.	**Sri Jaisingh Kharwal** Chairman, Salt Production Union, Kharwal Samaj, Pachpadra	a. He welcomed the project for the development of the region, and expressed concerns about the 600 years old profession of salt mining by Kharwal Samaj in the area having about 1250 mines. He further added that about 150 salt mines under the Rajasthan Refinery Project (RRP) site shall be directly affected and shall be closed due to refinery.	GoR has allotted 4800 acre (12034.10 bigha) government land to HRRL for the project. Hence, the provision of R & R does not apply to this land.
		b. He asked about impact of proposed refinery on environment	With adequate pollution mitigation measures and implementation of environmental management plan (EMP) effectively as

			detailed in EIA/RA report, there will be insignificant impact of refinery emissions on different environmental components. The Environment Management Plan prepared for the proposed RRP project aims at minimizing the Pollution at source.
		c. He further showed concern about loss of flora and fauna including migratory birds in the study area	Adequate mitigation measures and implementation of EMP as detailed in the EIA report (Biological environment) shall ensure proper preservation/ protection/ conservation of flora & fauna of the region. Some major mitigation measures are: a. Thick Greenbelt Development inside the refinery complex b. Plantation along roads and villages
2.	Shri Dinesh Kharwal	He expressed concern about discharge and management plan of Solid/ Hazardous waste	Solid/Hazardous waste shall be disposed off through Secured Land Fill (SLF) and / or authorized TSDF facilities as per the approved policy of MoEF.
3.	Shri Vijay Singh Kharwal	a. He expressed concern about wages towards salt mining and requested that salt mining should be continued in the project area	GoR has allotted 4800 acre (12034.10 bigha) government land to HRRL for the project. Hence, the provision of R & R does not apply to this land.
		b. He further showed concern on cutting of trees at RRP site	The project site has mainly shrubs and efforts will be made to protect trees and even if any tree is required to be cut, then they will be counted and three times of trees cut shall be planted as per the protocol.
		c. He further asked about wastewater treatment plan	Wastewater will be treated and recycled/reused within the RRP premises and proper care will be taken to prevent groundwater pollution.
4.	Shri Bhagwati Prasad	He showed concern on Salt mining coming in the project site/ study area. He opined that salt mining should be adopted by HPCL to continue their	GoR has allotted 4800 acre (12034.10 bigha) government land to HRRL for the project. Hence, the provision of R & R does not apply to this land.

		livelihood.	
5.	Advocate Vijay Singh Kharwal	a. He also raised several questions about employment to local villagers and salt affected people on priority basis as they have been doing this business for more than 600 years.	Employment opportunity may be provided to local people during operation phase considering their skills and abilities as per procedures & practices adopted by company. Other requirements during construction phase will be sourced through Contractors on Competitive Bidding Process.
		b. He enquired about discharge of wastewater by refinery, which may pollute ground water, thereby affecting quality of salt produced in the area.	Wastewater will be treated and recycled/reused within the RRP premises and proper care will be taken to prevent ground water pollution. No wastewater will be disposed off in underground water.
		c. He said that 100 % wastewater cannot be treated in one day and also cannot be pure as ground water.	Effluent Treatment plant will be designed for zero discharge. Wastewater will be treated and recycled/reused within the RRP premises and proper care will be taken to prevent ground water pollution Wastewater shall be treated and reused in process, green belt development etc.
		d. Treated wastewater may be given to villagers for irrigation.	The treated wastewater shall be utilized within the refinery complex for development of green belt.
		e. Employment should be given to local/salt affected people falling in study area.	Employment opportunity may be provided to local people during operation phase considering their skills and abilities as per procedures & practices adopted by company. Other requirements during construction phase will be sourced through Contractors on Competitive Bidding Process.
6.	Shri Om Prakash Meghwal	He expressed concern about grazing of domestic animals, which will be affected due to RRP complex boundary. How & where these animals will graze?	There is no Charagah/ Gochar land in GoR allotted government land.
7.	Shri Mahesh Kharwal	He raised question that in summer, ambient temperature is about 48^0C and it may further rise due to upcoming refinery.	Adequate emission control measures will be taken during operational phase, and further green belt development in the area shall help in maintaining ambient temperature in the surrounding environment.

8.	Shri Govind Prajapat	He asked about the start of construction of RRP complex boundary and how much time will be required?	The total time period of construction period is 48 months.
9.	Shri Asuram Meghwanshi	He asked about the impact of RRP complex on surrounding environment	With adequate pollution mitigation measures and implementation of environmental management plan (EMP) effectively as detailed in EIA/RA report, there will be insignificant impact of refinery emissions on different environmental components. The Environment Management Plan prepared for the proposed RRP project aims at minimizing the Pollution at source.

In general, there was support for the proposed project from almost all the local people and their representatives gathered at the Public Hearing. People welcomed industrial development in the region and expected certain welfare measures to be undertaken by the project proponent in the villages through CSR activities.

7.2 RAPID RISK ASSESSMENT STUDY

Rapid Risk Assessment study was carried out for Rajasthan Refinery cum Petrochemical Complex. Manjor recommendations and mitigation measures are given below.

The detailed consequence analysis of release of hydrocarbons in case of major credible failure scenarios have been modelled in terms of release rate, dispersion, flammability and toxic characteristics, which have been discussed in detail in the report. The major findings and recommendations arising out of the Rapid Risk analysis study for units are summarized below:

- Consequence modelling of High & low frequency scenarios for CDU/VDU Block is carried out and it is observed that the tank farm present on the western side of the unit & adjacent VGO-HDT unit may get affected from Radiation & Explosion effects emanating from the low frequency failure scenarios of the unit, depending upon the prevalent wind conditions & ignition source encountered at the time of release.
  It is recommended to install Fire & Gas detectors at suitable location within the unit and utilize these scenarios for preparation of Emergency Response Guidelines & Disaster Management Plan.

- Credible leakage scenarios are modelled for NHT-CCR, ISOM & Gasoline HDT units and their Explosion, Radiation & Toxic effects is studied. It is observed that the HGU, DHT & VGO-HDT units may get affected on account of leakage scenarios (Explosion & Radiation effects) from these units, depending upon the equipment location in the unit and prevalent weather conditions at the time of release. Moreover, Benzene & Toluene IDLH concentration from toxic failure scenarios may also affect operators present in these plants and may extend upto CDU-VDU, FCC Block & Offsite area. The Main Refinery Control Room may also get affected by Explosion & Radiation effects emanating from leakage scenarios in the NHT-CCR, ISOM & Gasoline HDT units, depending upon the equipment locations in the unit and prevalent weather conditions at the time of release.
  It is recommended to ensure the Blast Resistant Construction with Positive Pressurization of the Main Refinery Control Room.

It is also recommended to install Fire & Gas (Flammable & Toxic) detectors at strategic locations within these units along with remotely operated isolation valves for inventory isolation in the event of any leakage.
The outcomes of these scenarios to be utilized for preparation of Emergency Response Guidelines & Disaster Management Plan.

- Flammable & Toxic failure scenarios are modelled for the DHT Unit, it is observed that affect zones arising out of the high & low frequency credible scenarios for HP & Toxic sections of the DHT shall cross the unit B/L's and may affect the nearby HGU, NHT, CCR, ISOM, Gasoline HDT & CDU-VDU units, depending upon the prevalent weather conditions at the time of release and equipment locations within unit.

  It is recommended to install Fire & Gas (Flammable & Toxic) detectors at strategic locations within unit along with remotely operated isolation valves for inventory isolation in the event of any leakage.

- Credible Failure scenarios are modelled for the FCC Block and it is observed that affect zones (Flammable & Explosion) arising out of the high & low frequency credible scenarios may cross the unit B/L's and may affect the Main Refinery Control Room, depending upon the prevalent weather conditions at the time of release and equipment locations within unit.

  It is recommended to ensure the Blast Resistant Construction with Positive Pressurization for the Main Refinery Control Room.
  It is also recommended to install Fire & Gas detectors at strategic locations within the unit along with remotely operated isolation valves for inventory isolation in the event of any leakage.

- High & low frequency credible Flammable & Toxic failure scenarios are modelled for the DCU, it is observed that Radiation, Explosion & Toxic effect zones may cross the unit's B/L. H_2S IDLH concentration in the event of 20 mm Leak at LPG Product Pump discharge circuit may cross the Refinery Compound Wall, depending upon the operating conditions, prevalent weather conditions at the time of release and equipment locations within unit.

  Hence, it is recommended to install Fire & Gas (Flammable & Toxic) detectors at strategic locations within the unit along with remotely operated isolation valves for inventory isolation in the event of any leakage.
  The outcomes of these scenarios to be also utilized for preparation of Emergency Response Guidelines & Disaster Management Plan.

- Various credible leak scenarios are modelled for the VGO-HDT unit and it is observed that Radiation, Explosion & Toxic effect zones for both high & low frequency failure scenarios may cross the B/L's of the unit and affect nearby CDU-VDU, DHT, NHT-CCR, ISOM & Gasoline HDT units, depending upon the equipment location & prevalent weather conditions at the time of the release.
  It is recommended to install Fire & Gas (Flammable & Toxic) detectors at strategic locations within the unit along with remotely operated isolation valves for inventory isolation in the event of any leakage.
  The outcomes of these scenarios to be also utilized for preparation of Emergency Response Guidelines & Disaster Management Plan.

- Flammable scenarios are modelled for Hydrogen Generation Unit (HGU), it is observed that the consequence outcomes for the Naphtha handling section of the unit may cross the unit's B/L and affect the nearby Main Refinery Control Room, depending upon equipment location & prevalent weather conditions at the time of the release.

It is recommended to ensure the Blast Resistant Construction with Positive Pressurization for the Main Refinery Control Room.
It is also recommended to install Fire & Gas detectors at strategic locations within the unit along with remotely operated isolation valves for inventory isolation in the event of any leakage.

- Toxic Scenarios are modelled for the SRU / ARU / SWS unit and it is observed that the H_2S IDLH concentration may cross the unit's B/L's and affect the nearby facilities and personnel's present, depending upon the prevalent weather conditions at the time of the release.

  Hence, it is recommended to install Toxic gas detectors at strategic locations within the unit along with remotely operated isolation valves for inventory isolation in the event of any leakage.

  The outcomes of these scenarios to be also utilized for preparation of Emergency Response Guidelines & Disaster Management Plan.

- Flammable failure scenarios are modelled for the hydrocarbon Pumps in the Offsite and it is observed that Radiation & Explosion effects may affect the nearby Storage Tanks.

  It is recommended to provide the Fire & Gas detectors at strategic locations in the Offsite pump houses with adequate fire protection system for tankages & pump houses.

- Flammable failure scenarios are modelled for the Crude & Natural Gas Receipt lines and it is observed that Radiation & Explosion effects may affect the nearby Pipeline Control rooms, depending upon the prevalent weather conditions at the time of the release.

  It is recommended to ensure the Blast Resistant Construction with Positive Pressurization for the Pipelines Control Room or they need to be relocated to safe location.
  It is also recommended to install Fire & Gas detectors at strategic locations & outcomes of these scenarios to be also utilized for preparation of Emergency Response Guidelines & Disaster Management Plan

- From the Consequence modelling of High frequency scenarios in Butene-1 unit it is observed that the Radiation & Explosion effects may cause damage to equipments within the unit & may be realized beyond unit's B/L. Petrochemical Main Control Room may also get affected by Radiation & Explosion effects, depending upon equipment locations in the unit and prevalent weather conditions at the time of release. The low frequency failure scenarios explosion effects may affect the cooling tower on the north and MCR on the east, depending upon the prevalent wind conditions & ignition source encountered at the time of release and location of equipment's in the unit.

  Hence it is recommended to install fire & gas detectors at suitable locations in the unit along with remotely operated isolation valves for inventory isolation in the event of any leakage.

  It is recommended to ensure the Blast Resistant Construction with Positive Pressurization for the Petrochemical Main Control Room.

  The outcomes of these scenarios to be also utilized for preparation of Emergency Response Guidelines & Disaster Management Plan.

- From the Consequence modelling of High & low frequency failure scenarios in DFCU & associated units, it is observed that the Radiation & Explosion effects may cause damage

to equipment's within the unit and may lead to escalation. Consequences may also be realized beyond unit's B/L depending upon the location of equipment's within the unit.

It is recommended to locate fire & gas detectors at suitable locations in the unit along with remotely operated isolation valves for inventory isolation in the event of any leakage to restrict the consequences and its after effects.

The outcomes of these scenarios to be also utilized for preparation of Emergency Response Guidelines & Disaster Management Plan.

- From the Consequence modelling of High & low frequency failure scenarios in LLDPE / HDPE unit, it is observed that the Radiation & Explosion effects, if realized, may cause damage to piping/equipment within the unit with and may lead to escalation. There is a possibility that the consequences may be realized beyond unit's B/L and may affect the SRR in the neighboring PP unit depending upon the location of equipment's within the unit.

  It is recommended to locate fire & gas detectors at suitable locations in the unit along with remotely operated isolation valves for inventory isolation in the event of any leakage.

  The outcomes of these scenarios to be also utilized for preparation of Emergency Response Guidelines & Disaster Management Plan.

  It is recommended to ensure the SRR of PPU is of blast resistant construction with positive pressurization.

- Consequence Analysis for various failure scenarios in Offsite areas is carried out and following are the observations:

  - In case of a credible loss of containment event in the off spec ethylene sphere pump house, it is observed that there is a potential for flame impingement onto the spheres which may lead to significant secondary effects. Similarly, Butadiene spheres may be impacted by the jet fire in case of a leakage scenario in Butadiene sphere pump houses. Also the overpressure effects from the Butadiene sphere pump houses may affect the tankages and lead to escalation.

  ✓ *Hence following is recommended:*
  - *Provide a fire wall in between the Spheres & respective pump houses or ensure fire proofing of the spheres to withstand jet fire effects.*
  - *Provide fire & gas detectors at suitable locations in pump houses for early detection and mitigation.*
  - *Provide remotely operated isolation valves for inventory isolation in the event of any leakage.*

  - In case of a credible loss of containment event in the DWST area, the radiation and explosion effects may lead to localized damage and escalation in Boil off Gas (BOG) handling area.

  ✓ *Hence it is recommended to install fire & gas detectors at suitable locations in the storage area along with remotely operated isolation valves for inventory isolation in the event of any leakage.*

  - In case of a credible loss of containment event in the loading gantry area, it is observed that the IDLH concentration of 500 ppm for Toluene and Benzene may be realized beyond the complex boundaries.

  ✓ *Hence following is recommended:*
  - *Relocate the gantry further inside the complex away from the Refinery Complex compound wall.*

- *Ensure emergency isolation valves on loading lines for quick shut-off.*
- *Provide fire & gas detectors at suitable locations in pump houses for early detection and mitigation.*

❖ In case of a credible loss of containment event in the Product Storage pump house of Benzene/Toluene, it is observed that an accidental jet fire may affect the nearby tankages.

✓ *It is recommended to provide a fire wall in between the pump-house & Tankages for protection of tank.*

✓ *Provide fire & toxic gas detectors at suitable locations in pump houses for early detection and mitigation.*

➢ In case of a catastrophic rupture of Off spec Ethylene sphere, it is observed that the explosion overpressures may affect the adjacent Butadiene spheres, ULS HSD & Gasoline BS VI tankages. This may further lead to hazardous secondary effects. Similar consequences may be realized in case of catastrophic rupture of Butadiene spheres also.

The outcomes of this scenario to be utilized for preparation of Emergency Response Guidelines & Disaster Management Plan.

Detailed Preventive Maintenance Plan to be established for Sphere such as shell thickness monitoring, etc.

a. Recommendations for Construction Safety during execution of Project

✓ *Proper material movement path within the Refinery complex to be identified during the construction phase of the project.*

✓ *Detailed HSE Plan & HSE Philosophy to be developed by EPC contractors during construction phase of the project.*

✓ *It is recommended to carry out HAZID studies during pre-execution phase of the expansion project to get a detailed overview of the hazards during construction phase and those identified should be suitably mitigated.*

b. General Recommendations

✓ *No Operator Cabin to be located inside battery limits of units. Detailed QRA required to be carried out prior to fixing the location of any Operator Cabin in the close vicinity of Process units.*

✓ *Detailed Comprehensive QRA is required to be carried for the Refinery Complex along with Marketing Terminal during the detailed engineering stage.*

✓ *During the development of the Plot Plan of the Marketing Terminal, hazard from the Refinery complex area and vice versa to be addressed to rule out possibility of the Domino affects.*

✓ *Though Main Control Rooms for Refinery & Petrochemical are ought to be blast resistant, they are sandwiched between Process areas. It is recommended to review the possibility of shifting them to Safe area / Non Hazardous area.*

✓ *It is recommended to review the possibility of shifting the DWST and associated transfer system to the Offsite Tankages area as it is getting sandwiched between Process areas.*

✓ *Proper checking of contract people for Smoking or Inflammable materials to be ensured at entry gates to avoid presence of any unidentified source of ignition.*

✓ *Ensure that vehicles entering the Refinery complex should be fitted with spark arrestors as a mandatory item during normal operation of the Refinery Complex.*

✓ *In order to prevent secondary incident arising from any failure scenario, it is recommended that sprinklers and other protective devices provided on the tanks to be regularly checked to ensure that they are functional.*

- ✓ *It is recommended to have mounded type construction for bulk storages of pressurized products to maximum extent possible.*
- ✓ *Emergency security / evacuation drills to be organized at organization level to ensure preparation of the personnel's working in Refinery complex for handling any extreme situation.*
- ✓ *For positively pressurized building, both Hydrocarbon & Toxic detectors need to be placed at suction duct of HVAC. HVAC to be tripped automatically in event of the detection of any Hydrocarbon / toxic material by detector.*
- ✓ *It is recommended for usage of safer oxidizing agents (Chlorine free) in Cooling Water circuit.*
- ✓ *Development of any permanent residential / commercial establishment to be discouraged around the Refinery complex and same shall be as per the Land use planning Criteria agreed with the owner of the Refinery Complex. The same to be accorded with State district authorities.*

c. Mitigating Measures

Mitigating measures are those measures in place to minimize the loss of containment event and, hazards arising out of Loss of containment. These include:

- ✓ Rapid detection of an uncommon event (HC leak, Toxic gas leak, Flame etc.) and alarm arrangements and development of subsequent quick isolation mechanism (through shut-off valves) for major inventories such as Reflux Drum, Surge Drums, Coalescer, Column Bottoms handling Class A products, lighters and other hazardous materials. This shall be part of basic design philosophy.
- ✓ Measures for controlling / minimization of Ignition sources inside the Refinery complex to the extent possible.
- ✓ Active And Passive Fire Protection for critical equipment's and major structures
- ✓ Effective Emergency Response plans to be in place

d. Ignition Control

- ✓ Ignition control will reduce the likelihood of fire events. This is the key for reducing the risk within facilities processing flammable materials. As part of mitigation measure it strongly recommended to consider minimization of the traffic movement within the Refinery complex.

e. Escape Routes

- ✓ Ensure sufficient escape routes from the site are available to allow redundancy in escape from all areas.
- ✓ Ensure sufficient number of windsocks throughout the site to ensure visibility from all locations. This will help people to escape crosswind during flammable / toxic releases.
- ✓ Provide sign boards marking emergency/safe roads to be followed during any exigencies.

f. Preventive Maintenance for Critical Equipment's

- ✓ In order to reduce the failure frequency of critical equipment's, the following are recommended:
  a. High head pumps and Compressors, which are in flammable / toxic services, are needed to be identified.
     i. Their seals, instruments and accessories are to be monitored closely
     ii. A detailed preventive maintenance plan to be prepared and followed.
  b. Large inventory vessels handling flammable / toxic substances viz. Surge Drums / Reflux Drum's need to be identified. The rupture of these vessels may lead to

undesirably high consequences. The following needs to be ensured for these vessels:

i. Monitoring of vessel internals during shut down.
ii. A detailed preventive maintenance plan to be prepared and followed.

g. Others

- ✓ Closed sampling system to be considered for pressurized services like LPG, Propylene etc.
- ✓ Recommended to use portable HC detector during sampling and maintenance etc.
- ✓ Provide breathing apparatus at strategic locations inside Refinery complex.

The detailed Rapid Risk Assessment report is attached in Annexure VII.

CHAPTER – 8

Project Benefits

8.0 PROJECT BENEFIT

8.1 ECONOMIC BENEFITS OF GRASS ROOT REFINERY AND ASSOCIATED FACILITIES AT PACHPADRA, BARMER, RAJASTHAN

HPCL intends to set up a Grass-root Refinery-cum-Petrochemicals Complex for processing 9.0 MMTPA of crude at Barmer, Rajasthan. The demand for petroleum has recorded a considerable increase over the years. This growing demand poses a big challenge to value added petroleum products producing company including HPCL. Also new proposed refinery and their associated facilities will lead to reduction in India's dependence on imported crude oil and thereby results in considerable saving in foreign exchange. There will be a beneficial effect of a flourishing production that will directly and indirectly boost the living standards of the people, save foreign exchange and with increase in industrial activities; more jobs will be created enhancing in the local economy.

8.2 ADVANTAGE IN-TERMS OF PETROCHEMICAL PRODUCTS

Energy security is prime concern for rapidly developing countries like India, which is deficient in domestic energy resources. In order to meet the growing demand, RRP is the one of the most viable options. Setting up of RRP project at Pachpadra, Rajasthan will benefit to the Society and Nation. Self-sufficiency in manufacture of value added petroleum products will reduce dependency on imports and resultant savings in foreign exchange.

8.3 ENERGY CONSERVATION

The proposed Rajasthan Refinery project will be energy efficient, environment friendly, high distillate yielding refinery cum petrochemical complex that will be producing clean fuels and petrochemicals. Design of all the units and facilities has been conceptualized to achieve a high standard of energy efficiency. The experience of the existing refineries and the latest trends in energy conservation in similar industries worldwide are being incorporated in the project in its design stage itself. This is expected to yield appreciable benefits by reduced energy costs and minimum accountable losses.

8.4 ENVIRONMENTAL SUSTAINABILITY OF THE PROJECT

Industrial development is essential for growth and betterment of the living conditions of the society. Industrial development, however, is endemic with its effect on the environment. It is essential that even while the industrial development is spurred for growth, the environment is conserved and protected. The proposed Rajasthan Refinery Project is a step in the direction of spurring industrial activity in the Western region. Notwithstanding this fact, it has been considered essential to adopt environmental protection measures and adhere to legislations such that the ecology and the habitat of the area are not disturbed.

The proposed Rajasthan Refinery project (RRP) in India is the safest plant from environmental and safety assessment point of view as proposed RRP project situated in the arid region of Pachpadra, Barmer Rajasthan. In order to minimize the impact of the project on the environment, due attention is being given for implementing effective pollution control measures. The design stage endeavour's to mitigate the problems related to health, safety and environment at the process technology/source level itself. The design basis for all process units lays special emphasis on measures to minimize the effluent generation at source. During the operation of the refinery, the advance technology will be implemented to minimize the pollutants in stack emissions and fugitive emissions of hydrocarbons from the process units and storage tanks along with disposal of treated effluent. Handling, treatment and disposal of hazardous wastes will be as per standard guidelines.

8.5 SOCIAL AND ECONOMIC BENEFITS

Critically analyzing the baseline status of the socioeconomic profile and visualizing the scenario with the project, the impacts of the project would be of varied nature. Expected change in subjective and cumulative quality of life (QoL) in the project region is presented in **Chapter 4** of this report. This RRP project, besides general economic desirability, would result in substantial socio economic benefit to the country in general and more specifically to the region. These socio economic benefits are as follows:

8.5.1 Social Up-liftment of the Region

Implementation of the Rajasthan Refinery Project will be a boon to the region and give various benefits to the nation and society as presented below:

- It is expected that by creation of vast employment potential and industrialization of this area, poor / weaker sections of the society will see an up-liftment in their living conditions.
- Improvement in living condition will result in further reduction of population below poverty line, which is one of the prime policy objective of the Government.

8.5.2 Infrastructure Development

The project will accelerate the economic and infrastructural development in and around the area, such as rail, road, transport and communication facilities.

- Equipment and material supplies, such as plates, pipe fittings, valves, pumps, compressors, electrical machinery and material.
- Construction material and other services like sand, cement, steel, bricks, structural steel etc.
- Construction equipment like excavators, road rollers, dumpers, trucks, batching plans, mixers and other items.
- Hospitality services such as hotels / lodgings houses, restaurants, fast food joints, transport services, couriers, travel, shopping, amusement park, communication facilities, hospitals / nursing homes etc.
- Education facilities such as schools, colleges and other professional institutes / coaching centers.

8.5.3 Development of Industries, Trade and Crafts

- Major downstream industries like fertilizer, petrochemical and plant equipment manufacturing.
- Petrochemical based industries such as synthetic fibers, pipes, PVC, paints, chemicals and allied industries
- Agro based industries based on fertilizers
- Facilitate small Entrepreneurs, Craftsman and Artisan
- Ancillary and small scale industries development in the following area:
  - Mechanical, fabrication shops, machining and assembly units

- Pipe fitting manufacturing industry
- Testing houses
- Auto spares and services
- Sand blasting and painting shop
- Distributors and agencies for various equipment and material

- Employment during construction period
- Indirect employment to the tune of 25000 personnel during peak time and service employment for lakhs of population
- Improvement in existing schools / colleges and hospitals because of increased business activities.
- Savings in transportation costs while supplying petroleum products to nearby demand centers.
- During execution stage of the refinery complex, a unique opportunity will be there for the highly industrious and skilled people of Rajasthan to provide services for approx. more than 100 contractors, various suppliers and stockiest.

8.5.4 Corporate Social Responsibility (CSR)

- Under Corporate Social Responsibility, the HPCL is committed to work towards improvement in the living conditions of local population near the project, particularly in the areas of health & hygiene, civic amenities, infrastructure, education & training, water supply etc.
- For Rajasthan Refinery Project, HPCL will implement a CSR Activities and Community Development Plan in phased manner through a dedicated cell, starting from the construction phase onwards.
- For purposes of focusing its CSR efforts in a continued and effective manner, the following Areas have been identified:
  - Infrastructure Development
  - Skill Development / Empowerment
  - Drinking water/ Sanitation
  - Education/Literacy Enhancement
  - Healthcare/ Medical facility
  - Community Development
- HPCL will implement the same with the help of NGOs/Government Organizations in the region.

CHAPTER – 9

Environmental Cost Benefit Analysis

9.0 ENVIRONMENTAL COST BENEFIT ANALYSIS

Environmental Cost-Benefit Analysis, or CBA, refers to the economic appraisal of policies and projects that have the deliberate aim of improving the provision of environmental services or actions that might affect (sometimes adversely) the environment as an indirect consequence. Vital advances have arisen in response to the challenges that environmental problems and environmental policy pose for CBA. It also compares the monetary value of benefits with the monetary value of costs in order to evaluate and prioritize issues. The effect of time (i.e. the time it takes for the benefits of a change to repay its costs) is taken into consideration by calculating a payback period. In its simple form, CBA uses only financial costs and financial benefits.

A more sophisticated CBA approach attempts to put a financial value on intangible costs and benefits (example- the cost of environmental damage or the benefit of quicker and easier travel to work) through measuring WTP ('willingness to pay' for an environmental gain) and WTA ('willingness to accept' compensation for an environmental loss). CBA has been widely practiced, notably in the fields of environmental policy, transport and healthcare. Many of those developments have been generated by the special challenges that environmental problems and environmental policy pose for cost-benefit analysis.

HRRL has proposed to set up a 9.0 MMTPA grass-root Refinery cum Petrochemical Complex in Barmer District of Rajasthan. The Complex will be designed to process 1.5 MMTPA Rajasthan Crude + 7.5 MMTPA Arab mix crude for First 8 years and from 9^{th} year onwards Arab mix crude of 9 MMTPA. Rajasthan Refinery project will be energy efficient, environment friendly, high distillate yielding refinery cum petrochemical complex that will be producing clean fuels and petrochemicals.

At the end of 12th five year plan, there will be sufficient demand for the Polypropylene, LLDPE under Polyethylene group and Toluene under BTX (Benzene, Toluene and Xylene) group of petrochemicals. In addition to this, an integrated refinery-cum-petrochemical complex will also have cost advantage over those petrochemical complexes which source raw material from refineries at a higher cost. This would facilitate penetrating existing markets.

The proposed site is barren / agriculture with 2-3 m undulation. There is no national monument located within 10 km of the study area. The project does not involve loss of vegetation and biodiversity will not be affected as the vegetation is similar in the whole area with no sensitive ecosystem or rare and endangered flora or fauna and hence no environmental loss will be there in terms of net productivity value.

Besides the tangible benefits, the project has got number of intangible benefits like no adverse impact on environment, socio economic benefits to the local people and the region, generation of revenue for the state apart from growth through industrialization by way of setting up of various ancillaries and associated industries, and enhancement of the petrochemical products for the country. The establishment of RRP at Barmer, Rajasthan, when operated will provide significant supply of petrochemical products to the consumer's across the country in the interest of nation.

CHAPTER – 10

ENVIRONMENTAL MANAGEMENT PLAN

10.1 ENVIRONMENT MANAGEMENT

Environmental Management Plan (EMP) is planning and implementation of various pollution abatement measures for any proposed project. The EMP lists out all these measures not only for the operational phase of the plant but also for the construction phase and planning phase. The EMP is prepared keeping in view all possible strategies oriented towards the impact minimisation.

Environmental Management Plant (EMP) is a tool to address and manage the environmental aspects and impacts related to the grass root Rajasthan Refinery Project (RRP) and their associated facilities in Pachpadra, Barmer district, Rajasthan.

The EMP for the proposed project is divided into two phases i.e. Construction and Operational phase. The planning phase lists out the control strategies to be adopted during the design considerations. The construction and operational phase details the control/abatement measures to be adopted during these phases.

10.2 ENVIRONMENTAL MANAGEMENT AT PLANNING PHASE

Design Considerations

Government of India has made many legislations/rules for the protection and improvement of environment in India. Various environmental legislations/rules applicable to the proposed project facilities are given in **Table 10.1**.

Table 10.1 Indian Environmental Legislation/Rules

Legal Instrument	Relevant articles/provisions
The Environment (Protection) Act, 1986, amended up to 1991	Section 7: Not to allow emission or discharge of environmental pollutants in excess of prescribed standards Section 8: Handling of Hazardous substances Section 10: Power of entry and inspection Section 11: Power to take samples Section 15 – 19: Penalties and procedures
Environment (Protection) Rules, 1986 (Amendments in 1999, 2001, 2002, 2002, 2003, 2004, March 2008)	Rule 3: Standards for emissions or discharge of environmental pollutants Rule 5: Prohibition and restriction on the location of industries and the carrying on process and operations in different areas Rule 13: Prohibition and restriction on the handling of hazardous substances in different areas Rule 14: Submission of environmental statement
The Air (Prevention and Control of Pollution) Act 1981, as amended upto 1987.	Section 21: Consent from State Boards Section 37: Penalties and Procedures

Legal Instrument	Relevant articles/provisions
MoEF notification dated November 18, 2009 vide circular no G.S.R 186(E) for ambient air quality	National Ambient air quality standards
The Water (Prevention and Control of Pollution) Act, 1974, as amended upto 2003.	Section 3: Levy and Collection of Cess Section 24: Prohibition on disposal Section 25: Restriction on New Outlet and New Discharge Section 26: Provision regarding existing discharge of sewage or trade effluent
EIA Notification 2006 and subsequent amendments	Requirements and procedure for seeking environmental clearance of projects
Noise Pollution (Regulation and Control) Rules, 2000, amended up to 2010.	Ambient noise standards and requirements of DG sets
MoEF notification dated August 21, 2009 vide circular no G.S.R 595(E) for Oil Refinery Industry	Revised standards for Load/mass based standards for SRU.
MoEF notification dated March 18, 2008 vide circular no G.S.R 186(E) for Oil Refinery Industry	Revised standards for emissions or discharge of environmental pollutants
Manufacture storage and import of hazardous chemicals rules 1989 amended 2000	Rule 4: Responsibility of operator
MoEF notification dated March 18, 2016 vide circular no G.S.R 320(E) for Plastic Waste (Management and Handling) Rules	Section 8: Responsibility of waste generator
MoEF notification dated March 23, 2016 vide circular no G.S.R 338(E) for e-waste (Management) Rules	Section 5: Responsibility of producer
MoEF notification dated April 4, 2016 vide circular no G.S.R 338(E) for Hazardous and Other Wastes (Management and Transboundary	Section 4: Responsibilities of the occupier for management of hazardous and other wastes Section 6: Grant of authorisation for managing hazardous and other wastes Section 8: Storage of hazardous and other wastes

Legal Instrument	Relevant articles/provisions
Movement) Rules, 2016	Section 9: Utilisation of hazardous and other wastes
MoEF notification dated April 8, 2016 vide circular no G.S.R 1357(E) for Solid Waste Management Rules, 2016Solid Waste Management Rules, 2016	Section 4: Duities of waste generators

Proposed project shall be designed taking into account the above-referred legislations/rules and as per the directives of Environmental Clearance documents. Besides this the proposed effluent and emission standards will also be compiled for this Project.

During the design stage, all piping and instrumentation diagrams and plant layout shall be reviewed as a part of HAZOP/HAZAN studies to assess the risks involved.

The mitigation measures for the potential negative impacts anticipated from the proposed project and environmental monitored schedule are described in this chapter.

ENVIRONMENTAL MANAGEMENT DURING CONSTRUCTION PHASE

The overall impact of the pollution on the environment during construction phase is localized in nature, reversible and is for a short period.

Environmental impacts during construction phase, will be mainly due to civil works such as site preparation, RCC foundation, construction etc.; material and machinery transportation, fabrication and erection etc. The construction phase impacts are temporary (approx. 2-4 years) and localized phenomena except the permanent change in local landscape and landuse pattern at the project site. However, they require due consideration with importance during project execution and also wherever applicable detailed protocol/procedures shall be implemented to prevent/mitigate adverse impacts and occupational hazards.

The work force during construction phase would be significant in numbers and may temporarily migrate to project site. Sites for construction and workers camp should be clearly demarcated to prevent occupational hazard. The indigenous technology for constructing shelters should be adopted for the labourers Project proponents shall ensure provision for necessary basic needs and infrastructure facilities such as water supply, sanitary facilities, housing, domestic fuel etc. to the construction workforce.

10.2.1 Air Environment

Construction phase (Impact significance: Low)

- Preventive maintenance of vehicles and equipment.
- Vehicles with valid Pollution under Control certificates to be used.
- Unnecessary engine operations to be minimized.
- Implementing dust control activities such as water sprinkling on unpaved sites.

- Controlled vehicle speed on site.
- Vehicle to be covered during transportation of material
- Providing dust collection equipment at all possible points
- Following care would be taken for management of air quality during construction phase
  - The storage and handling of soil, sub-soil, topsoil and materials will be carefully managed to minimize the risk of wind blow down material and dust
  - There will be no on-site burning of any waste arising from any construction activity.
  - Dust masks should be provided to construction workers, while carrying out operations that may entails potential for dust generation.
  - All vehicles delivering construction materials or removing soil will be covered to prevent escape of dust.

Operation phase (Impact significance: Low)

- Ensuring preventive maintenance of equipment.
- Monitoring of air polluting concentrations.
- Online flue gas monitors including PM10, SO2, NOx, CO, HCs, etc. (flue gas constituents) as well as flue gas flow rates and temperature shall be provided for all stacks
- Furnaces/fuel combustion facilities shall be operated with optimum quantity of air so that fuel consumption as well as emissions of SO2 and NOx are minimized.
- Installation of Low NOx burners
- The sensors/monitors for hydrocarbons (methane and non-methane) shall be installed at strategic locations preferably at gas receipt/gas skid, gas distribution system (manifold) and upstream of gas combustion chambers to ensure 'No detectable' concentration leading to mitigation of fugitive emissions through leaks/escapes
- Vapour recovery units with high efficiency are to be installed to reduce VOC emissions from storage tanks

Traffic Management of RRP

- Vehicular congestion on the approach road to RRP complex in view of movement of men and machinery due to proposed project can be prevented by following measures, implementation of which will considerably reduce the traffic on the road.

- To carry out the prefabrication work outside of site for structural fabrication and piping pre fabrication for the project, so that only finished products will be transported to the project site. Also any other items require pre fabrication, will be done away from site. This action will drastically reduce the truck movements carrying raw materials.

- Plan to transport the fabricated material during night to reduce the traffic during day time.

- Transportation of bulks (fabricated spools) in a controlled manner, i.e. allow them to transport the bulks as per the project schedule requirement, rather than allowing them to transport and dump the bulks at site as and when the prefabrication is completed at their workshop. Plan in such way that minimum

required materials for the work is brought to site from pre-fabrication shops and stored at site. (Materials required for one week erection job only would be allowed to keep at site)

- Opting for Ready Mix Concrete (RMC) for concrete works will avoid the constant movement of the trucks carrying materials such as cement, sand and aggregates. Similarly option for use of pre- cast units also will be explored.

- Usage of tower cranes to minimize crane movements and vehicle movements inside refinery. This will be used for civil works, structural erection and erection of piping spool.

- By carrying out the major fabrication at outside the project site and opting for RMC and other mechanized construction / use of advanced technologies, the manpower requirement for project execution also will be reduced substantially, which in turn reduce the vehicles carrying the manpower for the project as well as avoid the traffic snag due to the large no of workers entry / exit during morning and evening hours.

- Proper planning and close monitoring for transporting heavy equipments and ODC consignments including route survey inside the refinery and outside the refinery.

- All ODC consignments will be brought to site only during night time and all arrangement for getting the equipment/consignment unloaded immediately up on arrival will be done upfront to avoid any traffic congestion at site and outside the site

- Area for lorries parking will be within the Refinery Plot (Contractors Area at the south side of layout plan) while the construction works are in progress. Post construction, the trucks will be parked in East side of marketing plot as that is the only area where lorries will enter and exit.

- The road width are provided for 4 lanes with adequate no. of gates (Total 10 gates distributed on all sides – North, East, West and South) of the plot for easy approach and exit to avoid congestion.

10.2.2 Water environment

Construction phase (Impact significance: Consumption of water - Low)

- Sewage and grey water from construction camps and work sites.
- Cleaning and washing water for vehicle and equipment maintenance area.
- During construction phase, used construction water is the only effluent generated due to construction activities and most of the effluent generated will be so small that it will either get percolated to ground or get evaporated.

Construction phase (Impact significance: Generation of effluent - Low)

- Monitoring water usage at construction camps to prevent wastage.
- Ensuring there are no chemical or fuel spills at water body crossings.
- Marginal additional sanitary water will be routed to existing STP.
- Usage of existing toilets for construction staff.

Operation phase (Impact significance: Consumption of water -Low, Generation of effluent - Low)

- Tracking of consumption.
- Development of rainwater harvesting pits
- Maximum Utilization Of Treated Water
- Zero liquid discharge concept to be adopted.

Rainwater Harvesting

Considering the climatic conditions and the scarce surface as well as groundwater availability in the region, state of the art rain water harvesting system is strongly recommended in the proposed project. Since the petroleum refinery cum petrochemical complex encompasses huge land area, there will be substantial surface runoff during monsoon season. The run-off from the most of the paved surfaces could be routed through a suitably designed storm water drainage system and collected in storm water collection sump. For augmenting the ground water resources in the proposed plant premises, number of rainwater harvesting wells could be constructed with internal drains where excess rain water flowing in drain could be diverted to rain water storage sumps for reuse.

To facilitate water harvesting, collection and storage of rainwater, the rain water storage system needs to be located at an appropriate location on the site keeping in view the slope contours and collection point. Provision should also be made for temporary collection of storm water and routing it to the water harvesting structures to recharge the ground water table. The designing of the system depends on various factors and needs to be undertaken during detailed engineering design of the project. The existing practice of rainwater storage by local villagers in the region may be studied for its implementation. Guidance from Central Ground Water Board (CGWB) could be taken for finalization of appropriate rain water harvesting technology. However, it must be ensured that these wells will be utilized only during monsoon and no wastewater should find way to these wells during operation phase of the refinery cum petrochemical complex.

10.2.3 Land environment

Construction phase (Impact significance: Land use & topography - Low, Soil quality - Low)

- Sufficient protective measures shall be adopted to avoid soil erosion during construction in the rainy season.
- Restricting all construction activities to the maximum possible extent inside the project boundary.
- The top-soil soil stock pile is not contaminated with any type of spills.
- Any material resulting from clearing and grading should not be deposited on approach roads, streams or ditches, which may hinder the passage and/or natural water drainage.
- After final site grading is complete, ensuring that the excess excavated material is not dumped indiscriminately but used for filling low lying areas construction by locals.
- Developing project specific waste management plan
- Developing and maintaining dedicated waste storage areas

Operation phase (Impact significance: Soil quality - Low)

- Developing and maintaining dedicated waste storage areas,
- Disposing of spent catalysts to manufacturers for recycling.
- Rajasthan refinery is having secured land fill facility for temporary handling/storage purpose after that disposing of hazardous wastes to be done at authorized landfill sites.

10.2.4 Noise environment

Construction phase (Impact significance: Low)

- Preventive maintenance of equipment and vehicles
- Unnecessary engine operations to be minimized (e.g. equipment with intermitted use switched off when not working)
- DG sets to be provided with acoustic enclosures and exhaust mufflers.

Operation phase (Impact significance: Low)

- Avoiding continuous (more than 8 hrs) exposure of workers to high noise areas.
- Provision of ear muffs at the high noise areas
- Ensuring preventive maintenance of equipment.

Mitigation of Vibration Impacts

- The necessary spacing between individual power modules shall be provided as per the requirement to subside the vibrations generated at individual units.
- Low vibration generating machines/equipment may be selected for the indent purpose with rugged bases to minimize propagation of vibrations.
- Personnel working near the vibrating machines in different units should be provided with well-designed vibration resistant handgloves/footwares.
- Vibration generating sources and their platforms should be maintained properly to mitigate vibrations.
- Regular checkup of workers who are subjected to hand-arm vibrations and body vibrations are essential. The general principles of medical screening will follow those for hearing protection. Before employment in a high vibration area, there should be an initial screening which should include seeking information about previous vibration exposure of a worker and relevant medical conditions.
- Training of personnel is recommended to generate awareness about damaging effects of vibrations.

10.2.5 Biological environment

Construction phase (Impact significance: Low)

- Avoid cutting of tress wherever possible, especially the endangered species observed in the study area.
- Exploring opportunities for conservation of endangered species.
- Closing of trenches as soon as possible of construction.
- Prevent littering of work sites with wastes, especially plastic.
- Training of drivers to maintain speed limits and avoid road-kills.

Operation phase (Impact significance: Low)

- As the project is going to proposed in desert ecosystem, development of green belt with carefully selected (tolerant to water scarcity) plant species is of prime importance due to their capacity to reduce noise and air pollution impacts by attenuation/assimilation and for providing food and habitat for local macro and micro fauna.
- Survival rate of the planted trees should be closely monitored and the trees, which could not survive should be replaced by more tolerant native species.
- Social awareness program about the importance of conservation of flora and fauna especially medicinal plants, rare and endangered species and their ecological role need to be conducted.
- Plantation and maintenance of additional trees during operation phase.

10.2.6 Socio-economic environment

Construction phase (Impact significance: Low)

- Training contractors on company safety policy requirements
- Monitoring speed and route of project-related vehicles within the project area
- Determine of the safe, legal load limits of all bridges and roads that will be used by heavy vehicles and machinery.
- Upgrading local roads, wherever required, to ensure ease of project activity and community safety
- Consolidating deliveries of materials and personnel to project sites, whenever feasible, to minimize flow of traffic
- Minimizing interruption of access to community use of public infrastructure
- Providing prior notice to affected parties when their access will be blocked, even temporarily.
- Monitoring construction camp safety and hygiene
- Preventing use of drugs and alcohol in project-sites
- Preventing possession of firearms by project-personnel, except those responsible for security
- Project-related waste and wastewater is disposed in a responsible manner

Operation phase (Impact significance: Low)

- Employment opportunity may be provided to local people during operation phase considering their skills and abilities as per procedures & practices adopted by company.
- It must be ensured that the agricultural activity near the project sites must not get affected.
- Required collaboration between project authority and local bodies is necessary for the smooth functioning of the project as well as for the progress of the region.
- The facilities like education, medical, transportation, sanitation are poor in rural area. This provision needs to be strengthened under social welfare activity.
- For all the social welfare activities to be undertaken by the project authorities, collaboration should be sought with the local administrations viz. Gram Panchayat, C.D. Block office etc. for better co-ordination and also to reach to the public.
- Sanitation facilities in rural area are inadequate. The unsanitary conditions cause health problems. The medical facilities in the area are very poor. As such

health camps for general health, eye check up, family planning, health awareness should be conducted for the rural people.

- Communication with the local community should be institutionalized & done on regular basis by the project authorities to provide as opportunity for mutual discussion.
- Project authorities should organize regular environmental awareness programmes to bring & environmental management measures being undertaken for improving their quality of life.
- For social welfare activities to be undertaken by the project authorities collaboration may be sought with local administration gram panchayat block development office etc for better co-ordination.

10.3 MEASURES FOR IMPROVEMENT OF BIOLOGICAL ENVIRONMENT

The resultant ambient air quality levels after the operation of the plant will be within the prescribed limits; impact on flora and fauna is not envisaged. The following recommendations are suggested for further implementation:

- Clearing of existing vegetation should be kept to minimum and should be done only when absolutely necessary;
- Plantation programme should be undertaken in all available areas. This should include plantation in the expanded areas, along the roads, on solid waste dump yards etc;
- Use of biogas, solar energy, should be encouraged both at individual and at society levels; and
- Plantation should be done along the roads, without affecting plant operational safety. This will not only improve the flora in the region but will add to the aesthetics of the region.

10.3.1 Greenbelt Development Plan

An area of 33% of the total plot area will be earmarked for greenbelt development. HRRL has earmarked 588.39 Ha out of 1779.82 Ha for greenbelt development. EIL has made a detailed greenbelt plan and suggested plant species for plantation purpose. HPCL will plant and look after the planted species taking suggestions of appropriate consultant for greenbelt development.

10.3.2 Guidelines for plantation

The plant species identified for greenbelt development will be planted using pitting technique. The pit size will be either 45 cm x 45 cm x 45 cm or 60 cm x 60 cm x 60 cm. Bigger pit size is preferred on marginal and poor quality soils. Soil proposed to be used for filling the pit will be mixed with well decomposed farm yard manure or sewage sludge at the rate of 2.5 kg (on dry weight basis) and 3.6 kg (on dry weight basis) for 45 cm x 45 cm x 45 cm and 60 cm x 60 cm x 60 cm size pits respectively. The filling of soils will be completed at least 5 - 10 days before the actual plantation. Healthy seedlings of identified species will be planted in each pit.

10.3.3 Species Selection

Based on the regional background and soil quality, greenbelt will be developed. In greenbelt development, monocultures are not advisable due to its climatic factor and other environmental constrains. Greenbelt with varieties of species is preferred to

maintain species diversity, rational utilization of nutrients and for maintaining health of the trees. Prepared in this way, the greenbelt will develop a favorable microclimate to support different micro- organisms in the soil and as a result of which soil quality will improve further.

During the course of survey, it has been observed that the soil quality of the plant site is fairly good and can support varieties of dry deciduous plant species for greenbelt development. Manure and vermin-compost may be mixed with the soil used for filling the pit for getting better result for survival of plant species. Adequate watering is to be done to background, extent of pollution load, soil quality, rainfall, temperature and human interactions, a number of species have been suggested to develop greenbelt inside and outside the HPCL refinery. These species can be planted in staggering arrangements within the plant premises. Some draught resistant plant species have been identified which can be planted for greenbelt development if sufficient water is not available (CPCB book on Guidelines for Developing Greenbelts). The suitable species for greenbelt development program are given in Table 10.2 to maintain the growth of young seedlings.

Table 10.2 Suggested species for plantation in greenbelt development

Sl. No.	Species Name	Family	Type	Areas to be planted
1	*Acacia auriculiformis* A.Cunn.ex Benth.	Mimosaceae	Tree	Avenue
2	*Acacia catechu* Willd.	Mimosaceae	Tree	Greenbelt
3	*Acacia farnesiana* (L.) Willd.	Mimosaceae	Tree	Avenue
4	*Acacia ferruginea* DC.	Mimosaceae	Tree	Avenue
5	*Acacia leucophloea* (Roxb.) Willd.	Mimosaceae	Tree	Greenbelt
6	*Acacia pennata* Willd.	Mimosaceae	Tree	Greenbelt
7	Acacia Senegal Willd.	Mimosaceae	Tree	Greenbelt
8	Acacia sinuata (Lour) Merill	Mimosaceae	Tree	Greenbelt
9	Acacia tortilis Hayne	Mimosaceae	Tree	Greenbelt
10	*Adenanthera pavonia* L.	Mimosaceae	Tree	Avenue
11	*Aegle marmelos* (L.) Correa ex Roxb.	Rutaceae	Tree	Residential
12	*Albizia amara*	Mimosaceae	Tree	Greenbelt
13	*Albizia lebbeck*	Mimosaceae	Tree	Greenbelt
14	*Albizia moluccana* Mig.	Mimosaceae	Tree	Avenue
15	*Albizia odoratissima* Benth.	Mimosaceae	Tree	Greenbelt
16	Albizia procera Benth	Mimosaceae	Tree	Greenbelt
17	*Annona reticulata* L.	Annonaceae	Tree	Residential
18	*Annona sqamosa* L.	Annonaceae	Tree	Residential
19	*Aphanamixis polystachya* (Wall) Parker	Meliaceae	Tree	Avenue

Sl. No.	Species Name	Family	Type	Areas to be planted
20	*Azadirachta indica* A. Juss.	Meliaceae	Tree	Avenue
21	*Balanites roxburghii* Planch.	Zygophyllaceae	Tree	Avenue
22	*Bambusa arundinacia* (Retz.) Roxb.	Poaceae	Shrub	Park/Office
23	*Bambusa vulgaris* Schrad.	Poaceae	Shrub	Park/Office
24	*Bauhinia acuminata* L.	Caesalpiniaceae	Tree	Avenue
25	*Bauhinia purpurea* L.	Caesalpiniaceae	Tree	Avenue
26	*Bauhinia racemosa* Lam.	Caesalpiniaceae	Tree	Avenue
27	*Bauhinia semla* Wanderlin	Caesalpiniaceae	Tree	Avenue
28	*Bauhinia variegata* L.	Caesalpiniaceae	Tree	Avenue
29	*Bischofia javanica* Blume	Euphorbiaceae	Tree	
30	*Bougainvillea spetabilis* Willd.	Nyctaginaceae	Shrub	Park/Office
31	*Bridelia squamosa* Lamk.	Euphorbiaceae	Tree	Greenbelt
32	*Butea monosperma* (Lam.) Taub.	Papilionaceae	Tree	Greenbelt
33	Calophyllum inophyllum L.	Clusiaceae	Tree	Greenbelt
34	*Callistemon citrinus* (Curtis) Stapf	Myrtaceae	Shrub	Park/Office
35	Clerodendrum infortunatum L.	Verbenaceae	Shrub	Park/Office
36	*Ceiba pentandra* (L.) Gaertn.	Bombacaceae	Tree	Greenbelt
37	*Dalbergia sisoo* Roxb.		Tree	Greenbelt/Avenue
38	*Delonix regia* (Bojer) Rafin.	Caesalpiniaceae	Tree	Avenue
39	*Dendrocalamus strictus* Nees	Poaceae	Shrub	Park/Residential
40	*Pongamia pinnata L.*	Fabaceae	Tree	Greenbelt
41	*Duranta repens* L.	Verbenaceae	Herb	Park
42	*Embryopteris peregrina* Gaertn.	Ebenaceae	Tree	Greenbelt
43	*Erythrina variegata* L.		Tree	Avenue
44	*Eucalyptus citriodora* Hook.	Myrtaceae	Tree	Greenbelt
45	*Eucalyptus hybrid*	Myrtaceae	Tree	Greenbelt
46	*Ficus benghalensis* L.	Moraceae	Tree	Greenbelt
47	*Ficus benjamina* L.	Moraceae	Tree	Avenue

Sl. No.	Species Name	Family	Type	Areas to be planted
48	*Ficus elastica* Roxb.ex Hornem	Moraceae	Tree	Park/Office
49	*Ficus gibbosa* Blume	Moraceae	Tree	Avenue
50	*Ficus hispida* (L.) F.	Moraceae	Tree	Avenue
51	*Ficus racemosa* L.	Moraceae	Tree	Greenbelt
52	*Ficus religiosa* L.	Moraceae	Tree	Greenbelt
53	*Ficus virens* Ait	Moraceae	Tree	Avenue
54	*Gardenia jasminoides* Ellis	Rubiaceae	Shrub	Park/Residential
55	*Gardenia resinifera* Roth	Rubiaceae	Shrub	Park/Residential
56	Guazma ulmifolia Lamk.	Sterculiaceae	Tree	Greenbelt
57	*Heterophragma roxburghii* DC.	Bignoniaceae	Tree	Greenbelt
58	*Hibiscus rosa-sinensis* L.	Malvaceae	Shrub	Park/Office
59	*Hippophae rhamnoides* L.	Elaeganaceae	Tree	Avenue
60	*Holoptelia integrifolia* (Roxb.) DC.	Ulmaceae	Tree	Greenbelt
61	*Ixora coccinea* L.	Rubiaceae	Herb	Park
62	*Ixora undulata*	Rubiaceae	Tree	Park
63	Lawsonia inermis L.	Lythraceae	Shrub	Park/Office
64	*Lantana camara* L. var. *aculeata* (L.) Mold.	Verbenaceae	Herb	Park/Office
65	*Mangifera indica* L.	Anacardiaceae	Tree	Greenbelt
66	*Murraya paniculata* (L.) Jack	Rutaceae	Shrub	Residential
67	*Nerium oleander* L.	Apocynaceae	Shrub	Park/Residential
68	*Ouginia oojeinensis* (Roxb.) Hochr.	Fabaceae	Tree	Greenbelt
69	*Phoenix sylvestris* (L.) Roxb.	Arecaceae	Shrub	Park
70	*Plumeria alba* L.	Apocynaceae	Shrub	Park/Residential
71	*Plumeria rubra* L.	Apocynaceae	Shrub	Park/Residential
72	*Pithecellobium dulce (Roxb.) Benth.*	Mimosaceae	Tree	Avenue/Residential
73	*Polyalthia longifolia* (Sonn.) Thw	Annonaceae	Tree	Residential/Office

Sl. No.	Species Name	Family	Type	Areas to be planted
74	Prosopis pallida	Mmosaceae	Tree	Greenbelt
75	Prosopis stephaniana Kunth.	Mimosaceae	Tree	Greenbelt
76	*Psidium guajava* L.	Myrtaceae	Tree	Residential
77	*Samanea saman* (Jacq.) Merr.	Mimosaceae	Tree	Avenue
78	*Sapium sebiferum* Roxb	Euphorbiaceae	Tree	Greenbelt
79	*Sesbania grandiflora* (L.) Poir.	Caesalpiniaceae	Shrub	Residential
80	*Sesbania speciosa* Taub. ex Engl.	Caesalpiniaceae	Shrub	Residential
81	Spondias pinnata L.f.	Anacardiaceae	Tree	Greenbelt
82	*Syzigium cumini* L.	Myrtaceae	Tree	Residential
83	*Taberneamontana divaricata* (L.) Burkill	Apocynaceae	Shrub	Residential/Park
84	*Tamarindus indica* L.	Caesapiniaceae	Tree	Avenue/Residential
85	*Tecoma stans* (L.) Kunth	Bignoniaceae	Shrub	Residential/Park
86	*Tectona grandis* L.	Verbenaceae	Tree	Greenbelt
87	*Terminalia arjuna* (Roxb.ex DC.) Wight & Arn.	Combretaceae	Tree	Greenbelt/Avenue
88	*Terminalia chebula* Retz.	Combretaceae	Tree	Greenbelt
89	*Trema orientalis* Blume	Ulmaceae	Tree	Greenbelt
90	*Ziziphus mauritiana* Lam.	Rhamnaceae	Tree	Park/Residential
91	*Zizyphus oenoplia* Mill	Rhamnaceae	Shrub	Park/Residential
92	*Zizyphus rugosa* Lamk.	Rhamnaceae	Shrub	Park/Residential
93	*Zizyphus xylopyra* Willd.	Rhamnaceae	Shrub	Greenbelt
94	*Tecommella undulata* Sm. Seem.	Bignoniaceae	Tree	Avenue
95	*Salvadora persica* L.	Salvadoraceae	Shrub	Greenbelt
96	*Salvadora oleoides* Decne	Salvadoraceae	Shrub	Greenbelt

The species suggested here are commonly seen in and around the project area, fast growing and drought resistant. Seedlings / saplings of these species can be easily procured from local nurseries. The selection of plant species for the green belt development depends on various factors such as climate, elevation and soil. The plants suggested for green belt were selected based on the following desirable characteristics.

- Fast growing and providing optimum penetrability.
- Evergreen with minimal litter fall.
- Wind-firm and deep rooted.
- The species will form a dense canopy.
- Indigenous and locally available species.
- Trees with high foliage density, larger of leaf sizes and hairy on surfaces.
- Ability to withstand conditions like inundation and drought.
- Soil improving plants, such as nitrogen fixing plants, rapidly decomposable leaf litter.
- Attractive appearance with good flowering and fruit bearing.
- Bird and insect attracting plant species.
- Sustainable green cover with minimal maintenance
- Species which can trap/sequester carbon

10.3.4 Phase wise Greenbelt Development Plan

Greenbelt will be developed in a phase wise manner right from the construction phase of the proposed project. In the first phase along with the start of the construction activity all along the plant boundary, open space areas, and major roads will be planted. In the second phase the office building like Canteen, Administrative building, Fire Safety office area and other constructed buildings will be planted. In the third phase when all the construction activity is complete plantation will be taken up in the gap areas of plant area, around different units, in stretch of open land and along other connecting roads, parks and residential quarters.

The total construction period is 48 months from the date of starting of construction. The first phase of the plantation programme will start immediately with the start of construction and run upto 18^{th} months. The second phase will start after 18 months and continue upto 36^{th} months. The third phase will start after 36^{th} months and continue upto 48^{th} months or the end of construction which is earlier.

10.4 ENVIRONMENT CELL

Environment Department will be constituted having well-qualified and experienced technical personnel from the relevant fields to look after environment mitigation measures during the construction and operation phase.

10.5 IMPLEMENTATION OF EMP IN CONSTRUCTION PHASE

The overall impact of the pollution on the environment during construction phase is localised in nature and is for a short period at all sites. In order to develop effective mitigation plan, it is important to conceive the specific activities during construction phase causing environmental impact.

All the construction activities are undertaken, controlled and managed by EPC contractor with the guidance of PMC consultant. It is mandatory for EPC contractor to develop site/project specific HSE Policy, HSE Plan, HSE management system for complete EPC phase of the project. The various HSE requirements/Deliverables that will be developed is given in **Table 10.3**.

Table 10.3 Elements of HSE Management System during EPC Phase

S.No.	Element of HSE Management System	HSE Requirements/Deliverables
1.0	Preservation	Development of Principal Environmental Flow Diagram and Environmental Balance
2.0	Progress	HSE Measurement Requirements
3.0	Durable Development	Implementation Plan for Environmental Management Plan indicated in Final EIA report (Approved by MoEF)
4.0	Regulation	Environmental Philosophy & Safety Philosophy
5.0	Prevention and Proactive Management of Risk	Implementation of findings of Risk Assessment Study
6.0	Continuous Improvement	
6.1		HSE Close out Report
6.2		HSE Audit Requirements
6.3		Project HSE Review
7.0	Formation and Sensitisation	HSE Training Requirements
8.0	Information and Communication	
8.1		HSE Communication Requirements
8.2		HSE Resources
8.3		Competency Requirements
8.4		HSE Documentation
8.5		HSE Records
8.6		HSE Procedures
9.0	Responsibilities	HSE Management System Requirements

10.5.1 Air Quality

As mentioned in Chapter-4, there will be minimal increase in particulate matter levels in ambient air during construction of proposed activities. The proposed activities are to be developed within the Rajasthan Refinery premises.

All the major dust generation construction activities will be regularly planned and controlled under the supervision of HS Manager. As indicated in **Table 10.3** of S. No. 8.5 records will be documented for the ambient air quality monitored before and during all dust generation construction activities. Necessary control and management will be taken at site by HS manager as appropriate. Also as indicated in **Table 10.3** of S. No. 6.3, all such records will be reviewed for corrective and preventive action.

10.5.2 Noise Quality

Ambient noise levels measured at various locations surrounding the proposed Rajasthan Refinery area are found within limits. All the major noise generation construction activities will be regularly planned and controlled under the supervision of HS Manager. As indicated in **Table 10.3**, Sl. No. 8.5 records will be documented for the ambient noise monitored before and during all noise generation construction activities. Necessary control and management will be taken at site by HS manager as appropriate. Also as indicated in **Table 10.3** of Sl. No. 6.3, all such records will be reviewed for corrective and preventive action.

10.5.3 Water Quality

All the major water consumption and waste water generation construction activities will be regularly planned and controlled under the supervision of HS Manager. As indicated in **Table 10.3** of S. No. 8.5 records will be documented for the total water supplied by tankers and wastage of the same shall be monitored before and during all such construction activities. Necessary control and management will be taken at site by HS manager as appropriate. Also as indicated in **Table 10.3** of S. No. 6.3, all such records will be reviewed for corrective and preventive action.

10.5.4 Socio-economic

The presence of highly skilled labour force around the plant area will ensure the availability of labour at construction site. This will lead to non-requirement of any kind of temporary housing near the construction site but may put stress in the existing transport system and traffic density. A proper traffic and man power management may reduce this problem in a substantial way. The health records of all construction force will be collected and will be supervised by medical in-charge specially appointed by EPC Contractor.

10.5.5 Biological Environment

The existing green belt will be maintained and further developed within the existing premises.

10.6 IMPLEMENTATION OF EMP IN OPERATION PHASE

All the operation activities are undertaken, controlled and managed by EPC contractor with the guidance of PMC consultant before the plant gets ready. It is mandatory for EPC contractor to develop site/project specific HSE Policy, HSE Plan, HSE management system for complete commissioning and operational phases of the project. The various HSE requirements that will be carried out by the HSE team of the organization are listed below:

a. Review and assessment of adequacy of measures implemented as per Environmental Management Plan, Disaster Management Plan (Onsite and Offsite) and Emergency Preparedness Plan and all other measures suggested by Statutory Authorities.
b. Monitoring of Environmental balance and its parameters and its compliance to requirements specified as per statutory requirements/design requirements.
c. Mock Safety drills to assess the readiness of the control of major accidents and hazards

d. Conducting HSE audits and Reviews.

The environmental management plan during the operational phase of the plant shall therefore be directed towards the following:

- Ensuring the operation of various process units as per specified operating guidelines/operating manuals.
- Strict adherence to maintenance schedule for various machinery/equipment.
- Good Housekeeping practices.
- Post project environmental monitoring.

10.7 OCCUPATIONAL HEALTH

For the proposed project, action plan for the implementation of OHSA Standards as per OSHAS/USEPA is as shown below:

- Display of Occupational Health & Safety Policy;
- To comply with statutory legal compliance related to the OHC dept.;
- Develop Onsite and Offsite emergency plan as Emergency Procedures to respond to Potential Emergencies;
- Schedule Regular Emergency Evacuation Drills by active participation and evaluation as and when drill planned by safety department;
- Six monthly periodic medical examinations of all workers working with the hazardous process;
- Reporting of all incidence and accidents by Accident & Incidence Reporting System;
- Investigation of all incidence and accidents by Investigation Report System;
- MSDS of all chemicals of company;
- Review of first aid facility;
- Preparing first aider & its information at work place;
- Identifying training needs of all the departments;
- Awareness of Occupational Hazards & General health promotional in workers by conducting lectures for occupational health hazards in annual planner at training center;
- Up-keep of ambulance & OHC by maintaining records.

10.7.1 Health

In order to provide safe working environment and safeguard occupational health and hygiene, the following measures will be undertaken:

- Periodic compulsory medical examination for all the plant employees as per OSHA requirement and specific medical examination.

- All the employees shall be trained in Health, Safety and Environment (HSE) aspects related to their job.

- Exposure of workers to noise, particularly in areas housing equipment which produce 85dB(A) or more will be monitored by noise decimeters. Audiometric tests are also done at periodic intervals for all the plant employees.

Regular (6 monthly) periodic medical checkup of contract and subcontract workers working at hazardous processes is done as per clause 68 T of Factory's Act.

10.8 CSR ACTIVITIES

Various Corporate Social Responsibility activities already carried out by HPCL in the Pachpadra area with budget for the last 5 years are given in **Table 10.4.**

Table 10.4 Details of HPCL CSR Expenditure in Rajasthan state and Barmer district

S. No.	Particulars	Amount (in Rs. Lakhs)				
		2012-13	2013-14	2014-15	2015-16	2016-17
1	CSR Expenditure in Rajasthan state	114.42	118.43	163.20	349.55	227.54
2	CSR Expenditure in Barmer district	23.60	45.75	92.73	32.12	42.09

Various CSR activities are listed below:

2012-13:

- Project Unnati – Providing Basic Computer training to less privileged students studying in govt. schools (Rs 9.36 Lakhs)
- Project Swavalamban – Providing Skill Development training in trades like Basic Electrical, Automobile repair to unemployed youth (Rs. 8.74 lakhs)
- Skill development training program for unemployed youths from economically & socially backward communities in Barmer region through NSFDC (Rs. 5.50 lakhs)

2013-14:

- Project Dhanwantari- Providing basic medical facilities in remote villages thru Mobile Medical vehicle (Rs. 29.11 lakhs)
- Project Swavalamban – Providing Skill Development training to unemployed youths in different trades to enhance their employability (Rs. 16.64 lakhs)

2014-15:

- Project Dhanwantari- Providing basic medical facilities in remote villages thru Mobile Medical vehicle (Rs. 32.0 lakhs)
- Project Swavalamban – Providing Skill Development training to unemployed youths in different trades to enhance their employability (Rs. 43.11 lakhs)
- Project Unnati – Providing Basic Computer training to less privileged students studying in govt. schools (Rs 2.62 Lakhs)
- Project Dil Without Bill- Assistance in conducting free heart surgeries for economically & socially backward communities (Rs. 1.50 lakhs)
- Provision of water purifier facility in Pachpadra tehsil (Rs. 13.50 lakhs)

2015-16:

- Project Dhanwantari- Providing basic medical facilities in remote villages thru Mobile Medical vehicle (Rs. 28.69 lakhs)
- Project Unnati – Providing Basic Computer training to less privileged students studying in govt. schools (Rs 3.43 Lakhs)

2016-17:

- Project Dhanwantari- Providing basic medical facilities in remote villages thru Mobile Medical vehicle (Rs. 26.70 lakhs)
- Project Unnati – Providing Basic Computer training to less privileged students studying in govt. schools (Rs 9.39 Lakhs)
- Project Dil Without Bill- Assistance in conducting free heart surgeries for economically & socially backward communities (Rs. 6.00 lakhs)

10.9 ENVIRONMENTA BUDGET

Considering all measures suggested above, budget is worked out for implementation of environmental management plan and same is given in **Table 10.5.**

Table 10.5 Budget of Environmental Management Plan (cost in crores)

S.No.	Details	Capital Cost for EMP (A)	Recurring cost (B)
1	Greenbelt Development	5.0	0.3
2	HSE Training	5.0	0.3
3	Personal protective equipments & noise monitoring	5.0	0.3
4	Equipment for Air Pollution Control, Noise Pollution Control & Water Management	827.0	57.1
	Total	842	58
	Total Cost for EMP (A+B)	900	

CHAPTER – 11

Summary & Conclusions

11.0 SUMMARY & CONCLUSION

Hindustan Petroleum Corporation Limited (HPCL) has proposed to set up a 9.0 MMTPA grass-root Refinery cum Petrochemical Complex (RRP) in Barmer District of Rajasthan. This will be an energy efficient, environment-friendly, high distillate yielding refinery cum petrochemical complex that will produce clean fuels conforming to BS VI standards and petrochemicals like polyethylene and polypropylene.

One season based EIA and RA study carried out by EIL evaluated the environmental parameters measured in terms of prediction of impacts and environmental management plan for the proposed grass root refinery cum petrochemical complex. The study area (10 km radius) data reflected background concentrations, which has been generated covering three months (Oct-Nov-Dec 2013) against known standards and criteria. The study did not find any parameter that has increased/will increase the background concentrations level beyond the environmental standards mandated by the CPCB/MoEFCC.

The predictions for the future quality of environment with the setting up of proposed grassroot refinery cum petrochemical complex included air, noise, water, land, biological and socio-economic impacts. The predictions associated with the proposed activities will have overall significance value from Low-Medium with reference to impact evaluation matrix.

Rapid Risk assessment study has been carried out for the units under RRP. Credible leakage scenarios (high frequency & low consequence and low frequency & high consequence) has been modeled for various process facilities. Detailed analysis of the various credible leakage scenarios is covered in the RRA Report and recommendations & mitigation measures are reported in the Executive Summary of RRA Report.

That the proposed grassroot refinery cum petrochemical project is aiming towards implementing Environmental Management Systems and obtaining ISO 14000 certification is encouraging and is in line with HPCL commitment to prevention of pollution and continual improvement.

The project does have marginal pollution involved under construction and operation phase. Proper mitigation measures will be followed to minimize the impact in air, water, noise, land, biological and socio-economic environment. There may be risk only under extreme conditions during operation phase for which HPCL is capable of handling through its Emergency Response Procedures and Disaster Management Plans as per the guidelines imposed upon to safeguard the RRP. The project is therefore considered to be acceptable. Rajasthan State Pollution Control Board conducted public hearing at proposed site. All queries of local people were answered and addressed in the Minutes of Meeting.

As per MoEFCC direction, revised EIA & RRA report is prepared with new configuration details and submitted for getting environmental clearance.

CHAPTER-12

DISCLOSURE OF CONSULTANTS

12.1 GENERAL INFORMATION

Name of Organization: Engineers India Limited
Address: Head - Environment, Water & Safety Division
Tower-I, Ground floor,
R&D centre, Engineers India Limited, Gurgaon
(On NH-8), Haryana-122001
Telephone Nos. : 0124-3802034
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12.2 ESTABLISHMENT

Engineers India Limited (EIL) was established in 1965 to provide engineering and related services for Petroleum Refineries and other industrial projects. Over the years, it has diversified into and excelled in various fields. EIL has emerged as Asia's leading design, engineering and turnkey contracting company in Petroleum Refining, Petrochemicals, Pipelines, Onshore Oil & Gas, Mining & Metallurgy, Offshore Oil & Gas, Terminals & Storages and Infrastructure. EIL provides a wide range of design, engineering, procurement, construction supervision, commissioning assistance and project management as well as EPC services. It also provides specialist services such as heat & mass transfer equipment design, environment engineering, information technology, specialist materials and maintenance, plant operations & safety including HAZOPS & Risk Analysis, refinery optimization studies and yield & energy optimization studies.

Engineers India has earned recognition for jobs executed in India and several countries of West Asia, North Africa, Europe and South East Asia including Algeria, Bahrain, Kuwait, Korea, Malaysia, Norway, Qatar, Saudi Arabia, Sri Lanka, UAE and Vietnam. EIL is diversifying into the areas of Water & Waste Management, Nuclear Power, Thermal and Solar Power and City Gas Distribution.

EIL has its head office in New Delhi, regional engineering offices in Gurgaon, Chennai, Kolkata and Vadodara and a branch office in Mumbai. It has inspection offices at all major equipment manufacturing locations in India and a wholly owned subsidiary

Certification Engineers International Ltd. (CEIL) for undertaking independent certification & third party inspection assignments. Outside India, EIL has offices in Abu Dhabi (UAE), London, Milan and Shanghai and a wholly owned subsidiary, EIL Asia Pacific Sdn. Bhd. (EILAP) in Malaysia. EIL has also formed a joint venture Jabal EILIOT with IOTL & Jabal Dhahran for tapping business opportunities in Saudi Arabia.

Backed by its unmatched experience, EIL enjoys a high professional standing in the market and is known as a versatile and competent engineering company that can be relied upon for meeting the clients' requirements. Quality Management System with respect to EIL's services conforms to ISO 9001:2008 The Design Offices are equipped with state-of-the-art computing systems, design tools and infrastructure.

12.3 EIL'S VISION

To be a world-class globally competitive EPC and total solutions Consultancy Organization.

12.4 EIL'S MISSION

- Achieve 'Customer delight' through innovative, cost effective and value added consulting and EPC services.
- To maximize creation of wealth, value and satisfaction for stakeholders with high standards of business ethics and aligned with national policies.

12.5 CORE VALUES OF EIL

- Benchmark to learn from superior role models.
- Nurture the essence of Customer Relationship and bonding.
- Foster Innovation with emphasis on value addition.
- Integrity and Trust as fundamental to functioning.
- Thrive upon constant Knowledge updation as a Learning organization.
- Passion in pursuit of excellence.
- Quality as a way of life.
- Collaboration in synergy through cross-functional Team efforts.
- Sense of ownership in what we do.

12.6 QUALITY POLICY OF EIL

- Enhance customer satisfaction through continuous improvement of our technologies, work processes, and systems and total compliance with established quality management system.
- Consistently improve the quality of products /services with active participation of committed and motivated employees and feedback from stakeholders.
- Provide added value to customers through timely and cost effective services/deliverables.
- Ensure total compliance with applicable health, safety and environment requirements during design and delivery of products to enrich quality of life.

12.7 HSE POLICY OF EIL

- Ensure compliance with requirements of health, safety and environment, during design and delivery of products/ services as per applicable National and International codes, standards, procedures, engineering practices, and statutory requirements including customer's requirements.
- Ensure safety and health of employees, personnel of clients and associates.
- Create awareness on health, safety and environment aspects for all employees and associates.

12.8 ENVIRONMENTAL POLICY OF EIL

- Ensure compliance with applicable environmental requirements/ regulations during design and delivery of products / service and our operations.
- Consider environmental impact in decision making processes.
- Promote/develop green technologies for sustainable development.
- Promote environmental awareness among all employees.
- Adopt the adage-reduce, reuse and recycle in all our operations.

12.9 RISK MANAGEMENT POLICY OF EIL

- EIL is committed to effective management of risks across the organization by aligning its risk management strategy to its business objectives through
- Instituting a risk management structure for timely identification, assessment, mitigating, monitoring and reporting of risks.
- Risk management at EIL is the responsibility of every employee both individually as well as collectively.

The present EIA report has been prepared by EIL, an engineering and consultancy organization in the country. EIL has been preparing regularly EIA / EMP reports for different projects. The environmental Engineering Division of EIL has carried out more than 300 numbers of Environmental Impact Assessment projects.

National Accreditation Board for Education and Training (NABET) - under the Accreditation Scheme for EIA Consultant Organizations has accredited EIL as EIA consultant for 11 EIA Sectors, vide NABET notification dated 29.09.14 and certification No.- 43/2014. The list of sectors for which the accreditation has been accorded by NABET is given in **Figure. 12.1**. The same can be referred from the NABET website "www.qcin.org/nabet/about.php", by following the link - EIA Accreditation Scheme – Accreditation Register – Accredited Consultant.

Scope of Accreditation **Annexure I**

NAME OF THE CONSULTANT ORGANIZATION: Engineers India Limited,
Bhikajicama Palace,
New Delhi-110066

Sl. No.	Sector No. as NABET Scheme	As per MoEF & CC notification and its subsequent amendments	Name of Sector	Cat.
1.	1	1 (a) (i)	Mining of minerals (Open cast only)	B
2.	4	1 (d)	Thermal Power Plant	A
3.	8	3 (a)	Metallurgical industries (ferrous & nonferrous)- both primary & secondary	A
4.	10	4 (a)	Petroleum refining industry	A
5.	16	5 (a)	Chemical Fertilizers	A
6.	18	5 (c)	Petro-chemical complexes (industries based on processing of petroleum fractions & natural gas and/or reforming to aromatics)	A
7.	27	6 (a)	Oil & gas transportation pipeline (crude and refinery/ petrochemical products), passing through national parks/ sanctuaries/coral reefs /ecologically sensitive Areas including LNG terminal	A
8.	28	6 (b)	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)	A
9.	29	7 (a)	Airports	A
10.	32	7 (d)	Common hazardous waste treatment, storage and disposal facilities (TSDFs)	B
11.	33	7 (e)	Ports, harbours, jetties, marine terminals, break waters and dredging	A
12.	39	8 (b)	Townships and Area development Projects	B

17/03/16
(A K Jha)
Senior Director

Figure. 12.1 : EIL Accreditation Certificate by NABET

इंजीनियर्स इंडिया लिमिटेड
(भारत सरकार का उपक्रम)

ENGINEERS INDIA LIMITED
(A Govt. of India Undertaking)

पंजीकृत कार्यालय : इंजीनियर्स इंडिया भवन, 1, भीकाएजी कामा प्लेस, नई दिल्ली-110066
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