RISK ASSESSMENT STUDY FOR EXTENSION OF KOYALI AHMEDNAGAR PIPELINE TO SOLAPUR

PROJECT PROPONENT

M/s. INDIAN OIL CORPORATION LTD. PIPELINES DIVISION: A-1, UDOYOG MARG, SECTOR-1, NOIDA – 201301 (U.P)

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Table of Contents

List of Tables

List of Figures

Annexure

CHAPTER-1: EXECUTIVE SUMMARY

1.1 Introduction

Indian Oil Corporation Ltd. operates a network of about 11,750 km long crude oil, petroleum product and gas pipelines with a throughput capacity of 85.5 million metric tonnes per annum of oil and 9.5 million metric standard cubic meter per day of gas. Cross-country pipelines are globally recognized as the safest, cost-effective, energy-efficient and environment-friendly mode for transportation of crude oil and petroleum products. As a pioneer in oil pipelines in the country, managing one of the world's largest oil pipeline networks, Indian Oil achieved the highest-ever throughput of 79.8 million tonnes during the year 2015-16, which was about 5.5% more than that of the previous year. About 525 km of additional pipeline length was added during the year, as part of Indian Oil's plans to continuously expand its network in line with growth in business. Projects currently under implementation would further increase the length of the pipelines network from 11,746 km currently to about 17,000 km, and throughput capacity from 85.5 to 102 million tons per year.

The proposed project envisages transportation of Petroleum products (Viz. MS, HSD & SKO) after receiving from Koyali-Ahmednagar Pipeline to delivery location at Solapur marketing terminals. New Pipeline will originate from Ahmednagar (Maharashtra) and terminate at Solapur district (Maharashtra). The length of Pipeline will be 230 km long of 18'' dia.

The Ahmednagar-Solapur pipeline having total capacity 5.0 MMTPA is section of the Koyali-Ahmednagar-Solapur pipeline. This pipeline starts from the existing POL depot at Akolner, Ahmednagar and Maharashtra to existing marketing depot at Pakni village of Solapur District, Maharashtra.

The proposed pipeline alignment in Ahmednagar-Solapur section passes through eco-sensitive zone of The Great Indian Bustard Wildlife Sanctuary and thus requires Environment Clearance which requires a detailed Risk Assessment (RA) and Disaster Management Program (DMP) report.

All the existing & proposed facilities of pumping station like fire fighting, electrical system, Pump house, Pipeline etc. would comply with national, international standards and M.B. Lal committee recommendations.

The facilities required for operation of the project, viz., pumping units with associated facilities have been planned to be steel structure. Other facilities like RCC civil structure have been planned to accommodate control panels, HT/LT panels, Batteries etc. All the safety factors like wind load, seismic load, soil bearing capacity etc have been taken into account while designing the civil structures.

Extension of Koyali-Ahmednagar product pipeline upto Solapur would broadly comprise of the following :

1) 230 Km long, 18'' OD X 0.25'' WT, API 5L-X70 grade pipeline, from Ahmednagar to Solapur in Maharashtra.
2) Pipeline facilities at Ahmednagar and Solapur.
3) Scraper launching facilities at Ahmednagar while scrapper receiving facilities at Solapur.

Table 1: Technical Details of the Ahmednagar-Solapur Pipeline

S. No.	Parameter	Detail
1.	Design Capacity (Ahmednagar-Solapur Section)	5.0 MMTPA
2.	Length	230 KM
3.	Outer Diameter	18 Inch
4.	Wall Thickness	0.25 Inch
5.	Grade	API-5L X70
6.	Maximum Allowable Operating Pressure (MAOP)	98 (Kg/Sq cm)
7.	Chainage (Ahmednagar)	517
8.	Chainage (Solapur)	747
9.	Altitude (Ahmednagar)	694
10.	Altitude (Solapur)	450

S. No.	Parameter	Detail
11.	Residual Head in Pipeline (Ahmedanagar)	271 mcl
12.	Residual Head in Pipeline (Solapur)	50 mcl

1.2 Consequence Analysis

Consequence analysis involves the application of the mathematical, analytical and computer models (PHAST software) for calculation of the effects and damages subsequent to a hydrocarbon/toxic release accident.

PHAST Software is used to predict the physical behavior of hazardous incidents. The model uses below mentioned techniques to assess the consequences of identified scenarios:

- Modeling of discharge rates when holes develop in process equipment/pipe work.
- Modeling of the size & shape of the flammable gas clouds from releases in the atmosphere.
- Modeling of the flame and radiation field of the releases that are ignited and burn as pool fire, jet fire, Overpressure (Blast Force) and flash fire.
- Modeling of the explosion fields of releases which are ignited away from the point of release.

The consequence analysis result of worst case of the proposed “Ahmednagar - Solapur section of KASPL pipeline” is tabulated below:

Table 2: Consequence Analysis results for worst case for proposed pipeline facilities at Ahmednagar Terminal

Scenario considered	Wind stability class	LFL concentration PPM	Flash fire At LFL concentration distance (m)	Pool Fire Damage distance for various heat loads (m)			Jet Fire Damage distance for various heat loads (m)			Maximum Pool radius (m)
				4 kW/m²	12.5 kW/m²	37.5 kW/m²	4 kW/m²	12.5 kW/m²	37.5 kW/m²	
	LINE RUPTURE									
Main Pipeline (18" OD)	2F	13000	822	306	178	N.R	1122	840	672	193
	3D		1039	328	183	N.R	1170	793	629	188
	5D		892	354	186	N.R	965	710	559	186
Manifold Area	2F	13000	932	260	146	N.R	952	711	569	193
	3D		925	279	151	N.R	924	682	539	188
	5D		732	302	154	N.R	828	607	477	186
SLB (Scrapper launching barrel)	2F	13000	1177	254	137	N.R	880	658	526	197
	3D		863	272	140	N.R	508	636	501	193
	5D		651	295	143	N.R	448	564	442	190
N.R - Not Reached/Not Recorded										

Table 3 : Consequence Analysis results for worst case for proposed pipeline facilities at Solapur Terminal

Scenario considered	Wind stability class	LFL concentration PPM	Flash fire At LFL concentration distance (m)	Pool Fire Damage distance for various heat loads (m)			Jet Fire Damage distance for various heat loads (m)			Maximum Pool radius (m)
				4 kW/m²	12.5 kW/m²	37.5 kW/m²	4 kW/m²	12.5 kW/m²	37.5 kW/m²	
	LINE RUPTURE									
Main Pipeline (18" OD)	2F	13000	822	306	178	N.R	1122	840	672	193
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	3D		925	279	151	N.R	924	682	539	188
	5D		732	302	154	N.R	828	607	477	186
SRB (Scrapper Receiving barrel)	2F	13000	1177	254	137	N.R	880	658	526	197
	3D		863	272	140	N.R	864	636	501	193
	5D		651	295	143	N.R	769	564	442	190
N.R - Not Reached/Not Recorded										

(Note: - All the results tabulated above are as per PHAST Risk & Hazard Software)

1.3 Risk Criteria

Individual risks are the key measure of risk acceptability for this type of study, where it is proposed that:

Risks to the public can be considered to be broadly acceptable (or negligible) if below 10^{-6} per year (one in 1 million per year). Although risks of up to 10^{-4} per year (1 in 10,000 per year) may be

considered acceptable *if* shown to be As Low As Reasonably Practicable (ALARP), since in India no any standard has been set, it is recommended that 10^{-5} per year (1 in 100,000 per year) is adopted for this study as the maximum tolerable criterion.

Risks to workers can be considered to be broadly acceptable (or negligible) if below 10^{-5} per year and where risks of up to 10^{-3} per year (1 in 1000 per year) may be considered acceptable in ALARP.

After assessment of the risk for KASPL pipeline, it is found that risk to public and worker from the Ahmednagar section of the pipeline lies in region having numerical value 3.80 E-006 per year which is in broadly acceptable zone of ALARP Triangle, Solapur Section of the pipeline lies in region having numerical value 3.23 E-005 per year which lies in ALARP zone whereas apart from these the pipeline section which passes closely to the eco-sensitive zone 'The Great Indian Bustard WLS' lies in the region having numerical value 1.00 E-008 per year which is in Broadly acceptable zone of ALARP triangle. The overall Societal Risk Contour for "Ahmednagar-Solapur Section of KASPL pipeline" along with the areas coming in Ecosensitive zone are shown in figures below:

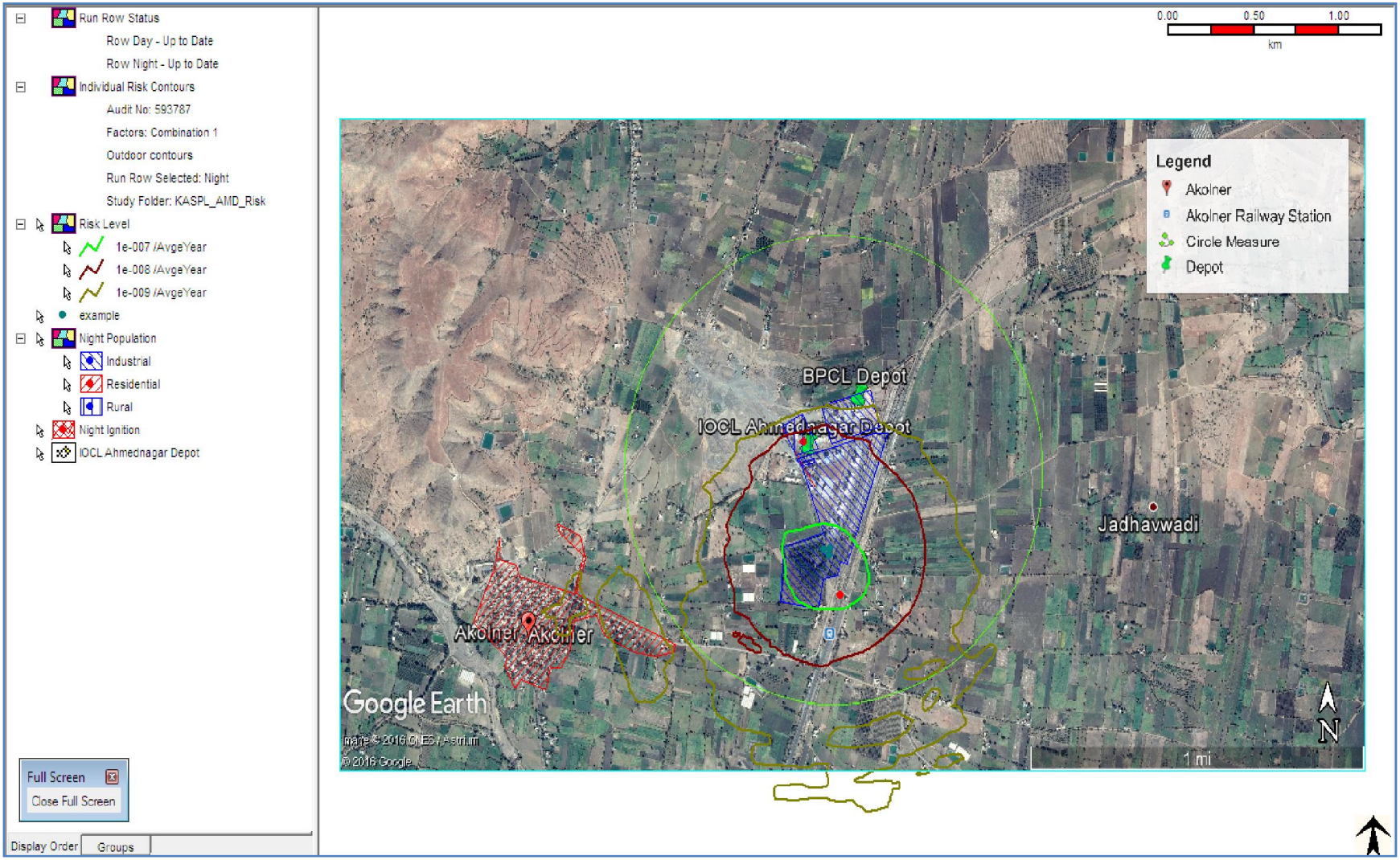


Figure 1:- Map showing Overall risk Scenario of Ahmednagar Depot

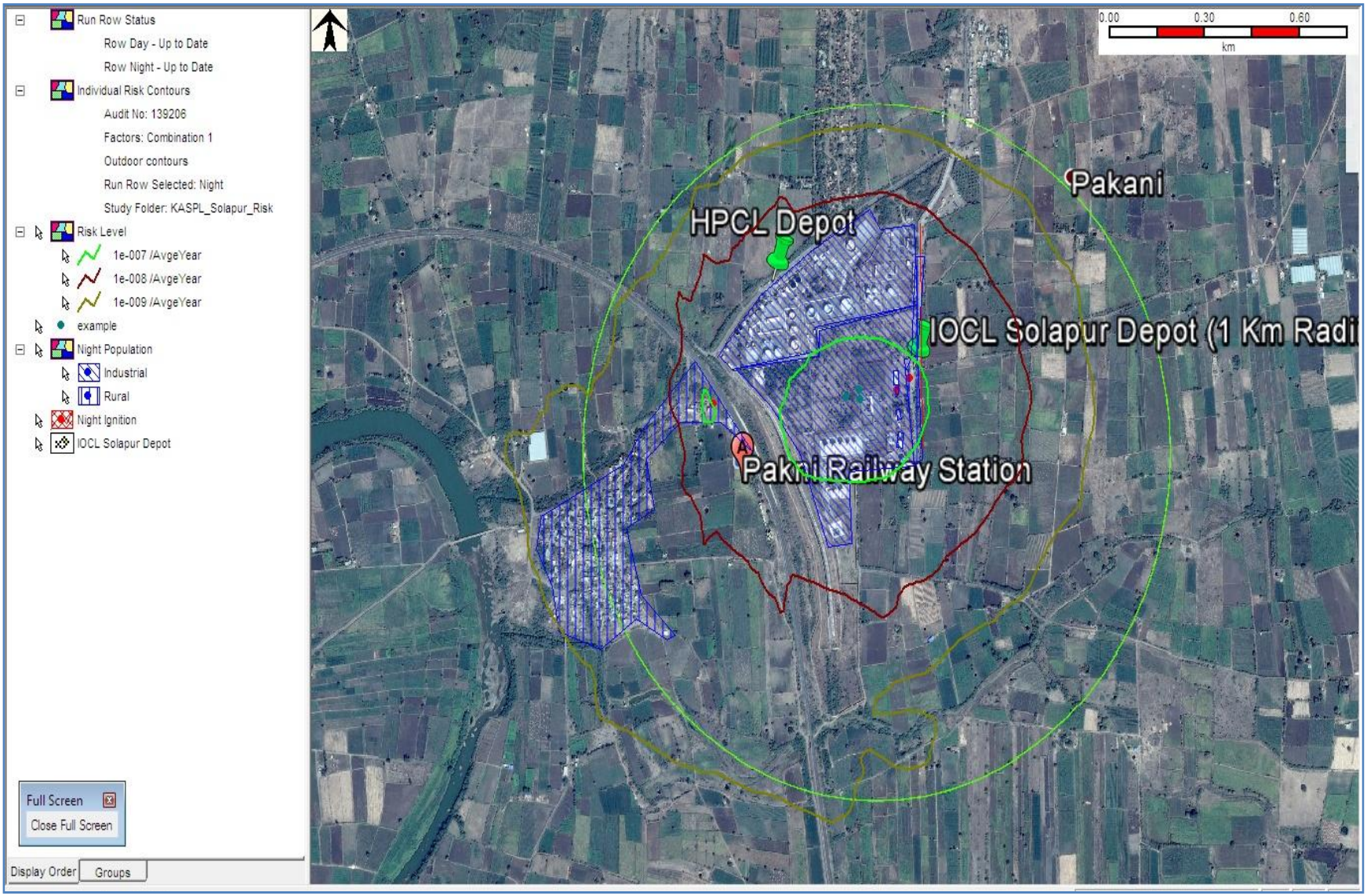


Figure 2 : Map showing Overall risk Scenario of Solapur Depot

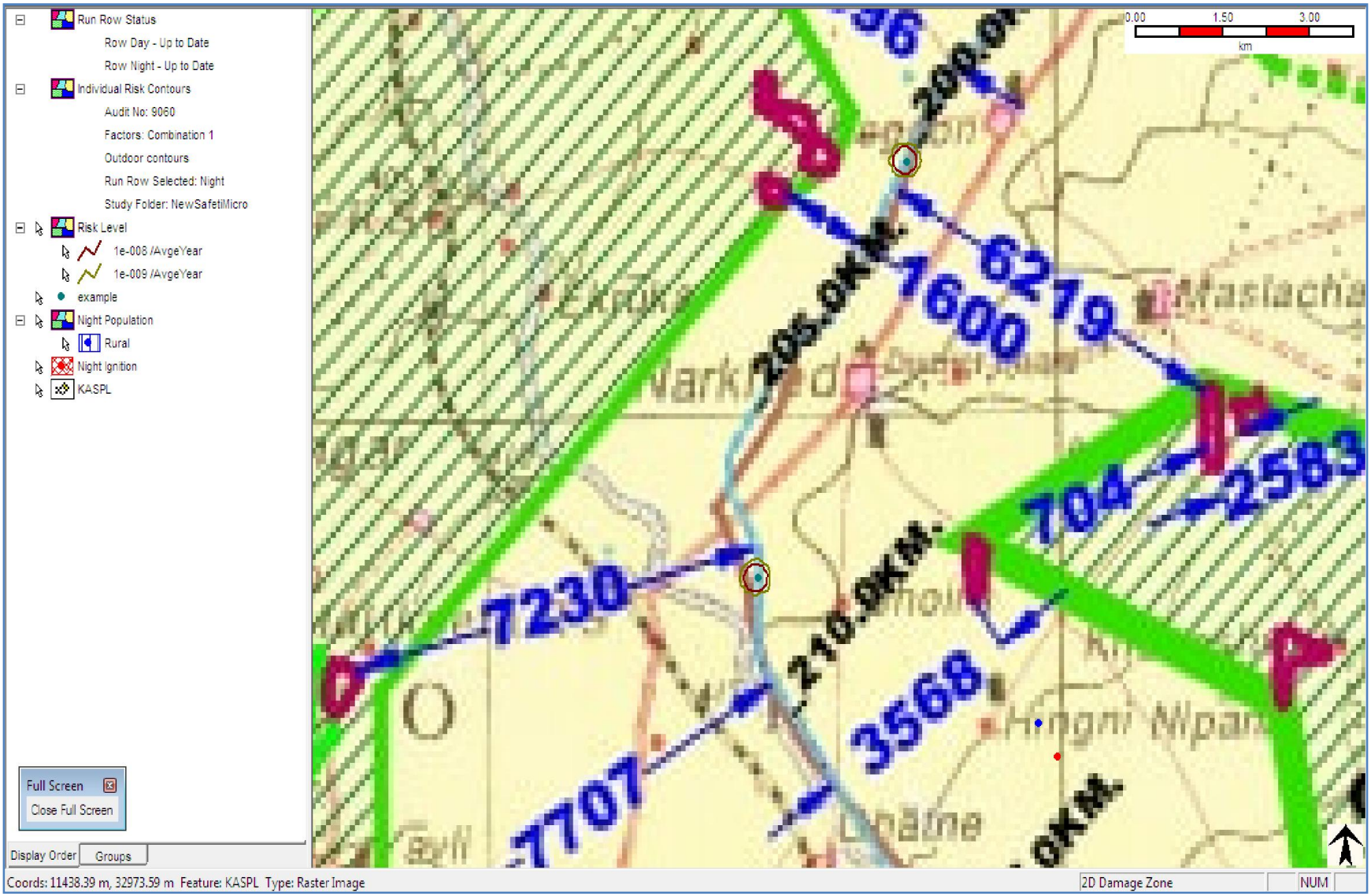


Figure 3: Map showing Overall Risk Scenario for Eco-sensitive Area (The Great Indian Busturd WLS)

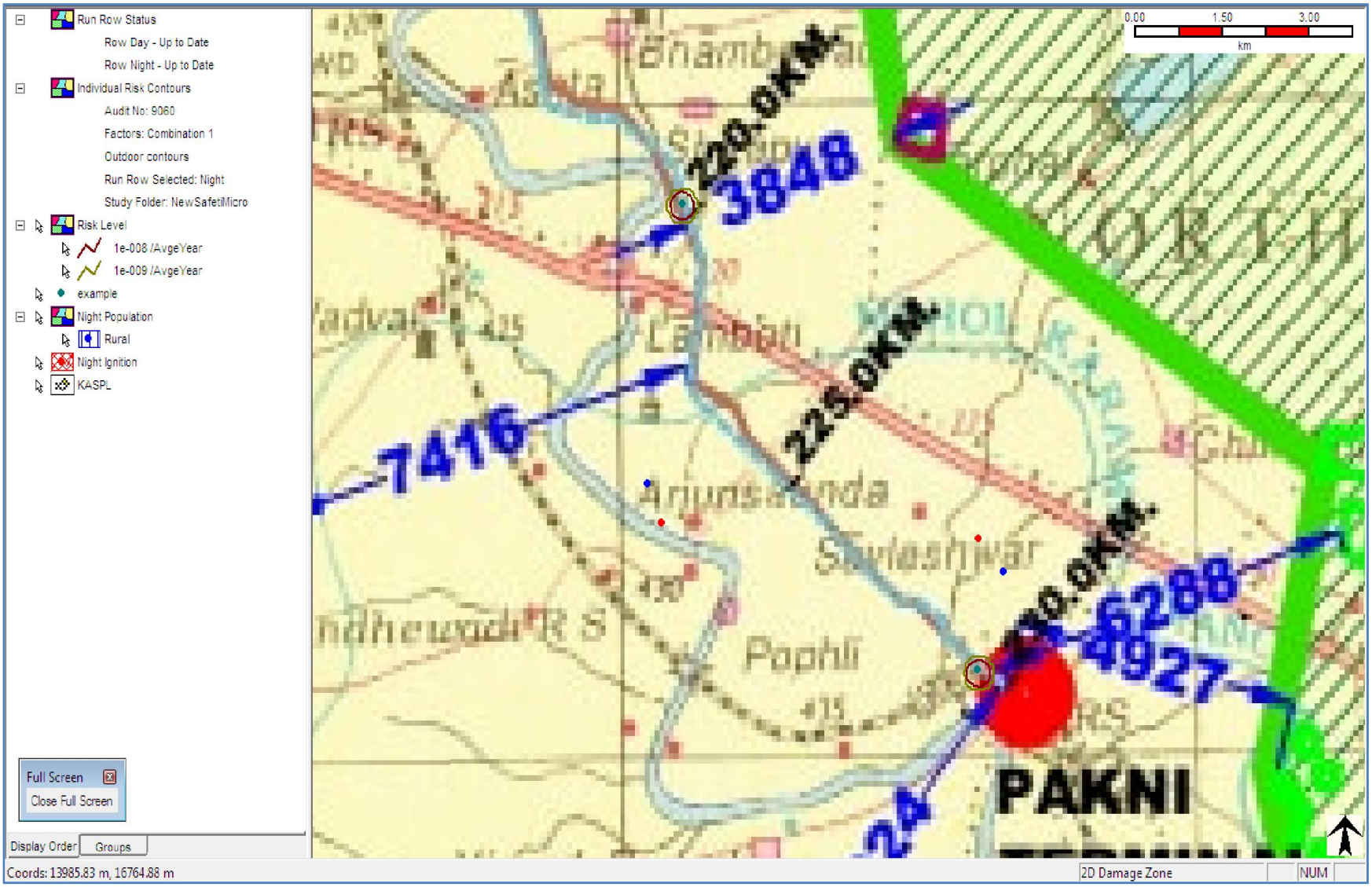


Figure 4: Map showing Overall Risk Scenario for Eco-sensitive Area (The Great Indian Busturd WLS)

The maximum LSIR in the Depots and Ecosensitive area are listed in **Table** below-

Table 4: Maximum Location Specific Individual Risk (LSIR) at Terminal

S. No.	Unit	Maximum LSIR	ALARP Region
1.	Ahmednagar Depot	3.80 E-006	Broadly Acceptable
2.	Solapur Depot	3.23 E-005	ALARP Zone
3.	Ecosensitive Zone (The Great Indian Bustard WLS)	1.00 E-008	Broadly Acceptable
ALARP – **A**s **L**ow **A**s **R**easonably **P**racticable			

1.3.1 Individual risk to worker (ISIR)

The Location specific individual risk (LSIR) is risk to a person who is standing at that point 365 days a year and 24 hours a day. The personnel in Ahmednagar & Solapur are expected to work 8 hour shift as well as general shift. The actual risk to a person i.e. "Individual Specific Individual Risk (ISIR)" would be far less after accounting for the time fraction a person is expected to spend at a location.

$ISIR_{Area} = LSIR \times (8/24)_{(8\ hours\ shift)} \times (Time\ spent\ by\ and\ individual/8\ hours)$

The maximum ISIR in the units are listed in Table below-

Table 5: Maximum Individual Specific Individual Risk (ISIR) at Terminal

S. No.	Unit	Maximum ISIR	ALARP Region
1.	Ahmednagar Depot	1.26 E-006	Broadly Acceptable
2.	Solapur Depot	1.07 E-005	ALARP Zone
3.	Ecosensitive Zone (The Great Indian Bustard WLS)	1.00 E-008	Broadly Acceptable
ALARP – **A**s **L**ow **A**s **R**easonably **P**racticable			

(Note: - Values of LSIR and ISIR obtained are as per PHAST risk & hazard software)

ALARP summary & comparison of Individual risk with acceptability criteria

The objective of this RA study is to assess the risk levels at KASPL Pipeline with reference to the defined risk acceptability criteria and recommend measures to reduce the risk level to **A**s **L**ow **A**s **R**easonably **P**racticable (**ALARP**).

From the results shown above, the maximum individual risk to depot personnel from Ahmednagar Terminal is 1.26 E-006 which is in Broadly Acceptable zone, Solapur Terminal is 1.07 E-005 which lies in ALARP Zone and Ecosensitive area of KASPL pipeline is 1.00 E-008 which is in Broadly Acceptable zone of 'As Low As Reasonably Practicable (ALARP) Triangle.

The comparison of maximum individual risk with the risk acceptability criteria is shown in Figure below-

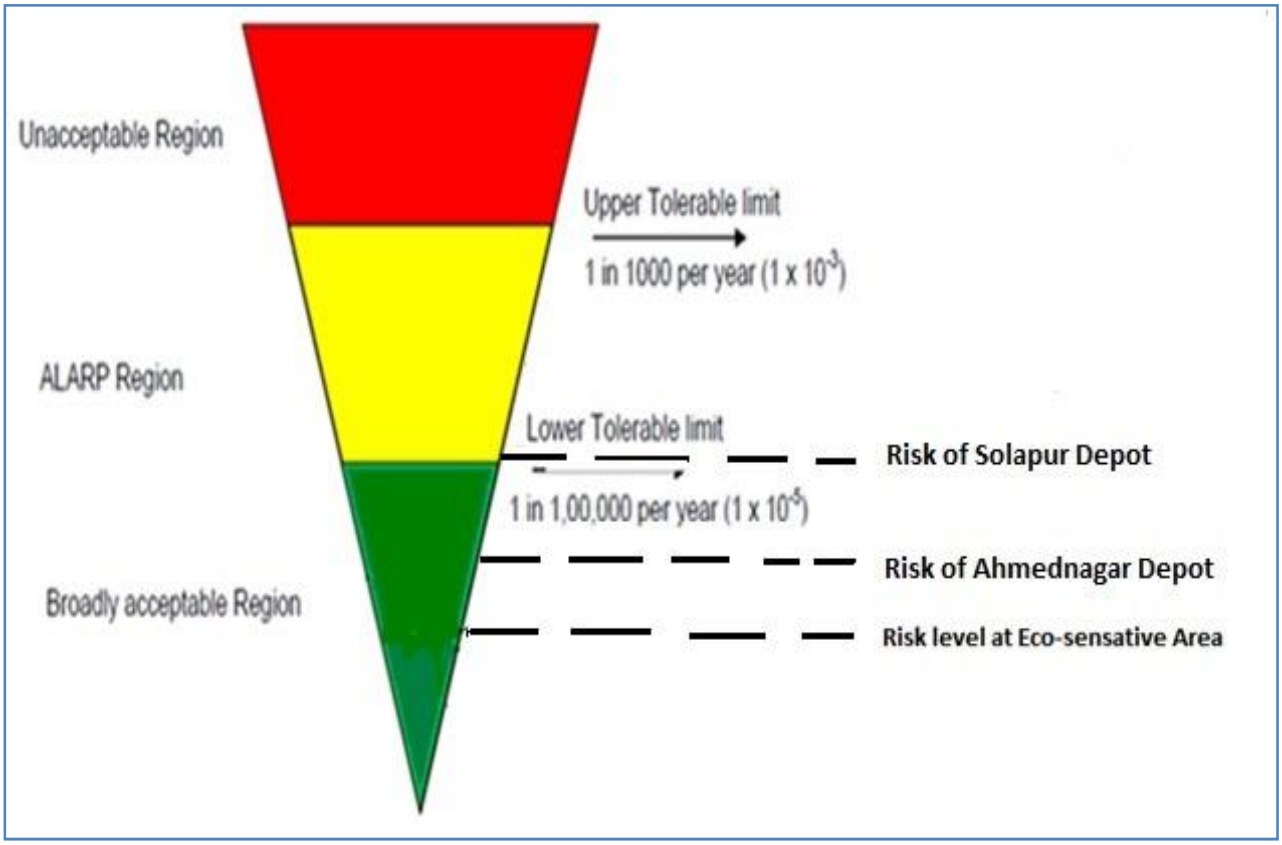


Figure 5:- Individual risk at Ahmednagar Solapur Pipeline

Societal risk criteria are also proposed, although these should be used as guidance only.

A criterion of 10^{-4} per year is recommended for determining design accidental loads for on-site buildings, i.e. buildings should be designed against the fire and explosion loads that occur with a frequency of 1 in 10,000 per year.

The result from the F-N curve show that the Societal risk for Ahmednagar Terminal is purely in broadly acceptable zone whereas for Solapur terminals it goes slightly the ALARP Region.For Eco-sensitive area no FN curve was generated because of the negligible human population around the region.

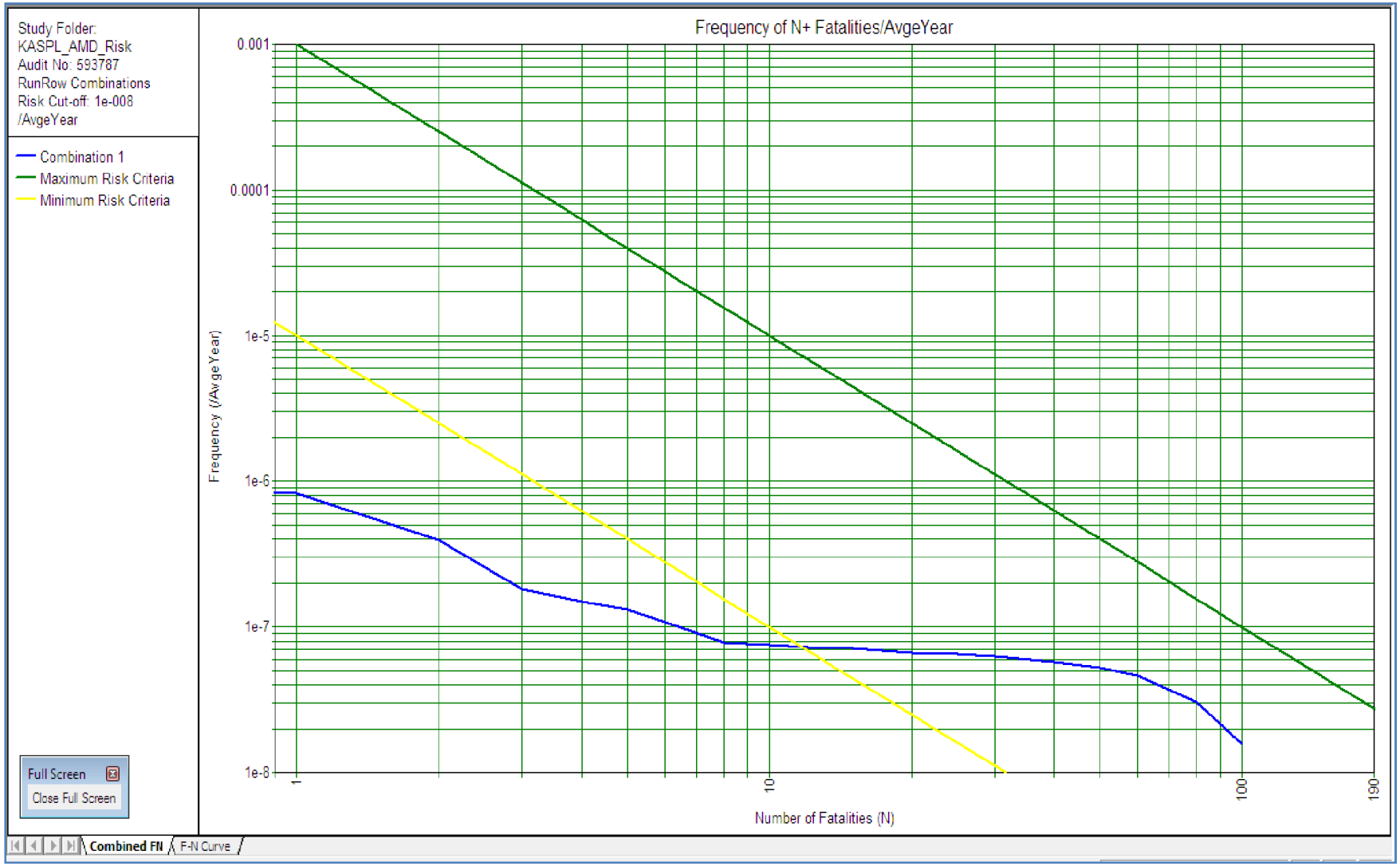


Figure 6: F-N Curve for Group Risk of Ahmednagar depot

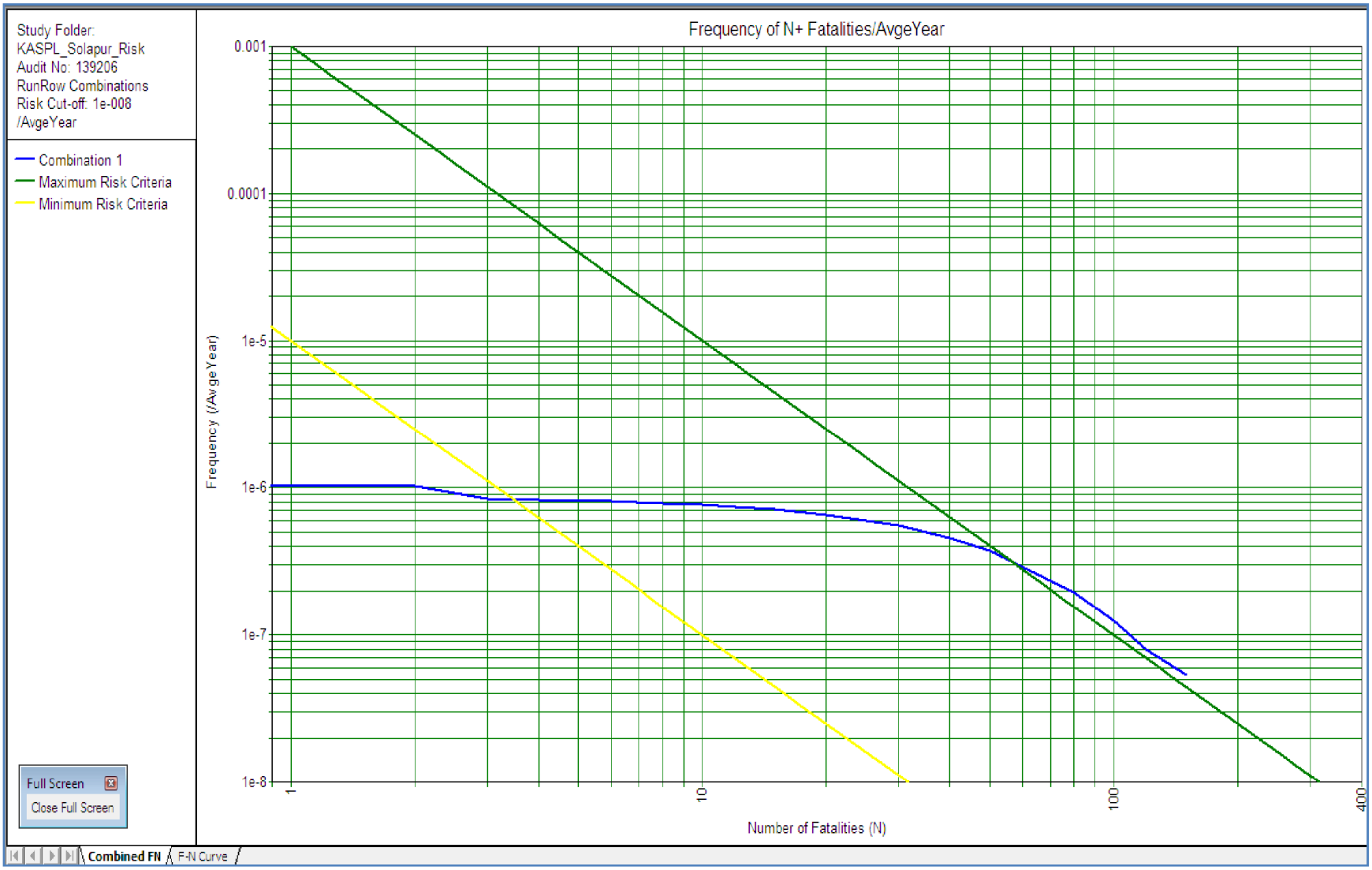


Figure 7 : F-N Curve for Group Risk of Solapur depot

1.4 Top risk contributors (Group Risk)

This presents major contributing scenarios to societal risk from depots acceptable as it is within the ALARP region.

1.5 Conclusions and Recommendations

Although the results of this Risk analysis show that the risks to the public will become acceptable only after proper mitigation measures, they will be sensitive to the specific design and/or modeling assumptions used.

The maximum risk to persons working in the terminal is 3.23 E-005 per year which is in ALARP. It is observed that the ISO-risk contour of 1.0 E-009 per year is observed for the locality of Ahmednagar and Solapur Terminals incuding the Ecosensitive areas. The major conclusions and recommendations based on the risk analysis of the identified representative failure scenarios are summarized below:

- The Pipeline station inside Depot/Terminal is covered in the process safety management system of IOCL.
- It is necessary to provide extensive fire detection system in the Terminal as per OISD guidelines. Operators are well trained about the fire and gas detection system.
- It is recommended to have necessary provision for emergency shut off of critical equipments from control room (during commissioning) in the event of major leak/flash fire.
- The vehicles entering the depot should be fitted with spark arrestors.
- Routine checks to be done to ensure and prevent the presence of ignition sources in the immediate vicinity of the depot (near boundaries).
- Clearly defined escape routes shall be developed for each individual plots and section of the Depot taking into account the impairment of escape by hazardous releases and sign boards be erected in places to guide personnel in case of an emergency.
- Windsocks shall be considered in the plant to ensure visibility from all directions. This will assist people to escape in upwind or cross wind direction from flammable releases.
- In order to further reduce the probability of failure of catastrophic rupture of pipeline and equipments, critical equipments shall be identified and inspection methodologies to be finalized for continuous monitoring during operation and shutdown maintenance.

- The active protection devices like fire water hydrant, water monitor and other protective devices shall be tested at regular intervals.
- There should be an SOP established for clarity of actions to be taken in case (during commissioning of pipeline project) of fire/leak emergency.

1.6 General Recommendations

1. Ensure that combustible flammable material is not placed near the Critical instrument of the depot. These could include oil filled cloth, wooden supports, oil buckets etc. these must be put away and the areas kept permanently clean and free from any combustibles. Secondary fires probability would be greatly reduced as a result of these simple but effective measures.
2. ROSOV & Hydrocarbon detector should be provided to the Storage Tanks inside the terminal as per OISD guidelines.
3. Proper lighting arrangements and CCTV should be provided at terminal for new facilities inside the terminal.

CHAPTER-2: INTRODUCTION

2.1 Introduction

IOCL has proposed a project which envisages transportation of Petroleum products after receiving from Koyali-Ahmednagar Pipeline to delivery location at Solapur marketing terminals. New Pipeline will originate from Ahmednagar (Maharashtra) and terminate at Solapur district (Maharshtra). The length of Pipeline will be 230 km long of 18'' dia. This is done considering the importance of Maharashtra market in the overall business plan of IOC for positioning its own products in the region through a cost-effective mode. Majority of requirement in this region are at present met by sourcing product from other oil marketing companies (OMCs) like HPCL and BPCL both having refineries within the state.

The Ahmednagar-Solapur pipeline having total capacity 5.0 MMTPA is section of the Koyali-Ahmednagar-Solapur pipeline. This pipeline starts from the existing POL depot at Akolner, Ahmednagar and Maharashtra to existing marketing depot at Pakni village of Solapur District, Maharashtra.

The proposed pipeline alignment in Ahmednagar-Solapur section passes through eco-sensitive zone of The Great Indian Bustard Wildlife Sanctuary and thus requires Environment Clearance which requires a detailed Risk Assessment (RA) and Disaster Management Program (DMP) report.

All the existing & proposed facilities of pumping station like fire fighting, electrical system, Pump house, Pipeline etc. would comply with national, international standards and M.B. Lal committee recommendations.

The facilities required for operation of the project, viz., pumping units with associated facilities have been planned to be steel structure. Other facilities like RCC civil structure have been planned to accommodate control panels, HT/LT panels, Batteries etc. All the safety factors like wind load, seismic load, soil bearing capacity etc have been taken into account while designing the civil structures.

The general topography of the area is simple flat and the elevation across the study area varies from 649 m at Ahmednagar and 458 m in Solapur.

The study is broadly divided into the following:

- Identification of hazards (HAZID)
- Consequence Analysis
- Risk Analysis
- Risk Estimation & Reduction
- Disaster Management Plan

2.2 Scope of Study

Mantec Consultants Pvt. Ltd, D-36, Sector-6, NOIDA (U.P.) is appointed for carrying out the Risk Analysis study. The objective of the Risk Analysis study is to identify vulnerable zones, major risk contributing events, understand the nature of risk posed to nearby areas and form a basis for the Disaster Management Plan (DMP). In addition, the Risk Analysis study is also necessary to ensure compliance to statutory rules and regulations. Risk assessment methodology is given in Figure below-

Risk Analysis broadly comprises of the following steps:

- Project Description
- Identification of Hazards and Selection of Scenarios
- Effects and Consequence Calculations
- Risk Calculation
- Risk assessment (using an acceptability criteria)
- Risk Mitigation Measures

The following flow chart shows the step by step procedure for Risk Assessment:

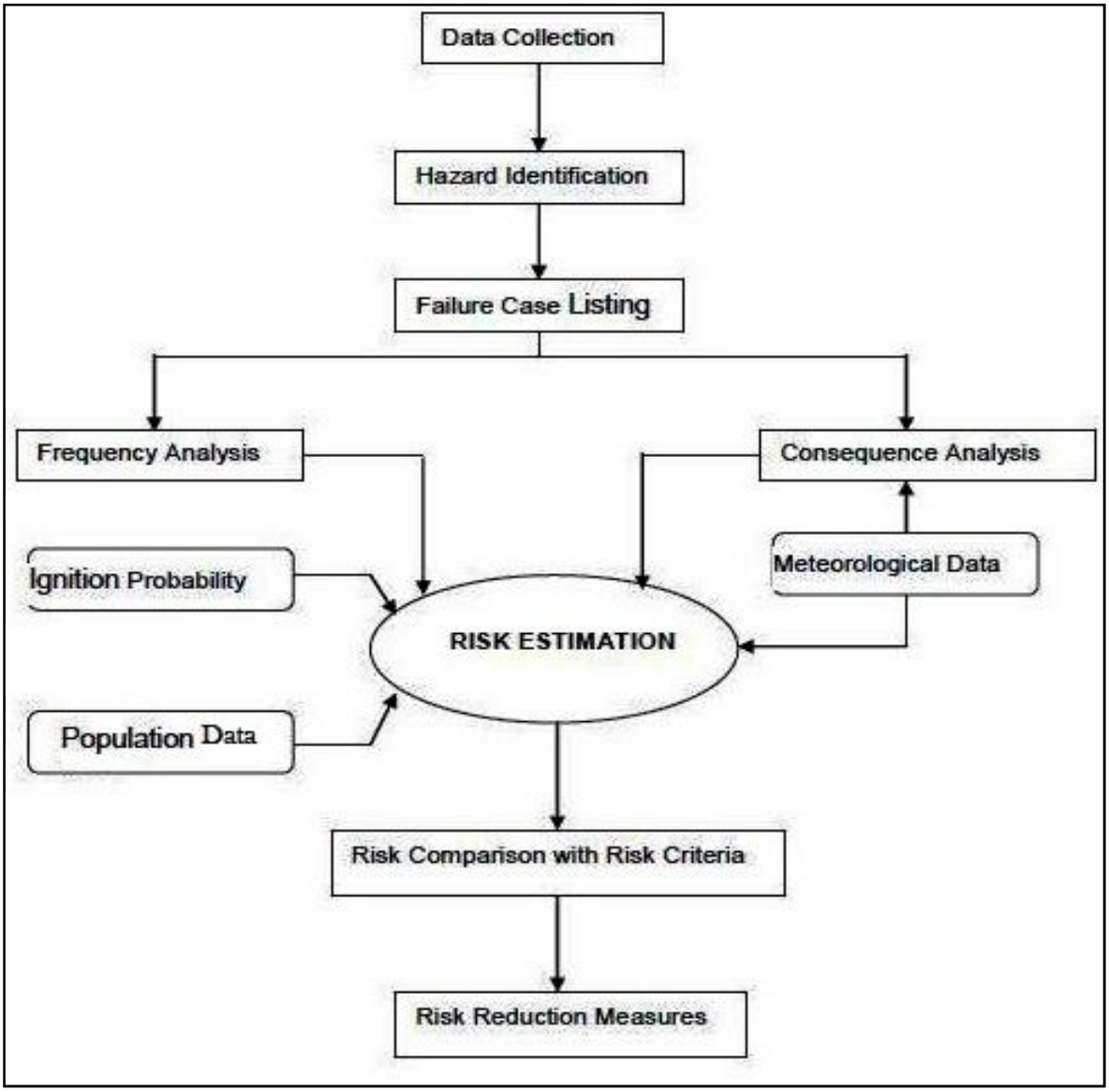


Figure 8: Risk Assessment Methodology

2.3 Execution Methodology

The methodology adopted for executing the assignment is briefly given below-

2.3.1 Kick off meeting with Mantec

This was used to set the study basis, objectives and related matters and also identify in detail the facilities to be covered in the RA.

2.3.2 Study of IOCL operations

This was carried out for studying the risk assessment study for "Ahmednagar - Solapur section of KASPL pipeline" Project.

2.3.3 Study of IOCL operating parameters

This involved collection of pertinent project information on the operation process details such as P&ID's, process flow diagram and Plant Layout. Critical instruments their temperature and pressure and other details. The data so collected would ensure a more realistic picture for the risks subsequently identified and estimated.

2.3.4 Identification of hazards

This includes estimation of possible hazards through a systematic approach. It typically covers identification and grouping of a wide ranging possible failure cases and scenarios. The scenario list was generated through generic methods for estimating potential failures (based on historical records based on worldwide and domestic accident data bases) and also based on IOCL's experience in operating the facilities.

2.3.5 Consequence Effects Estimation

This covers assessing the damage potential in terms of heat radiation. Proper graphs related to the hazards along with the map are made which shows the exact areas where the effects can be experienced. The models are generated with the help of PHAST software.

CHAPTER-3: PROJECT DESCRIPTION

3.1 Brief Description

The Ahmednagar-Solapur pipeline having total length 230 Km and capacity 5.0 MMTPA is section of the Koyali-Ahmednagar-Solapur pipeline. This pipeline starts from the existing POL depot at Akolner, Ahmednagar and Maharashtra to existing marketing depot at Pakni village of Solapur District, Maharashtra.

Technical Details of the Ahmednagar-Solapur Pipeline:

The proposed Pipeline under study i.e. Ahmednagar-Solapur Pipeline has following features:

S. No.	Parameter	Detail
1.	Design Capacity (Ahmednagar-Solapur Section)	5.0 MMTPA
2.	Length	230 KM
3.	Outer Diameter	18 Inch
4.	Wall Thickness	0.25 Inch
5.	Grade	API-5L X70
6.	Maximum Allowable Operating Pressure (MAOP)	98 (Kg/Sq cm)
7.	Chainage (Ahmednagar)	517
8.	Chainage (Solapur)	747
9.	Altitude (Ahmednagar)	694
10.	Altitude (Solapur)	450
11.	Residual Head in Pipeline (Ahmedanagar)	271 mcl
12.	Residual Head in Pipeline (Solapur)	50 mcl

3.2 Location

The "Ahmednagar - Solapur section of KASPL pipeline" starts from chainage number 517 on KASPL at IOC POL Depot in Akolner village of Ahmednagar district in Maharashtra. The pipeline terminates at chainage number 747 at IOC Solapur Depot at Pakni, district Solapur, Maharashtra.

The coordinates of the marketing depots are:

S. No.	Name of the Site	Co - Ordianates
1.	Ahmednagar Depot	18°59'29.66"N, 74°39'58.66"E 18°59'12.86"N, 74°40'01.56"E 18°59'36.44"N, 74°40'16.93"E 18°59'37.22"N, 74°40'01.53"E
2.	Solapur Depot	17°43'39.82"N, 75°47'02.15"E 17°43'18.65"N, 75°46'55.34"E 17°43'32.44"N, 75°46'52.18"E 17°43'29.48"N, 75°47'04.00"E

The general topography of the area is simple flat and the elevation across the study area varies from 649 m at Ahmednagar and 458 m in Solapur. The location map is given below in Figure below and showing the specific location of the pipeline.

Location Map of the project is given in **Figure** below-

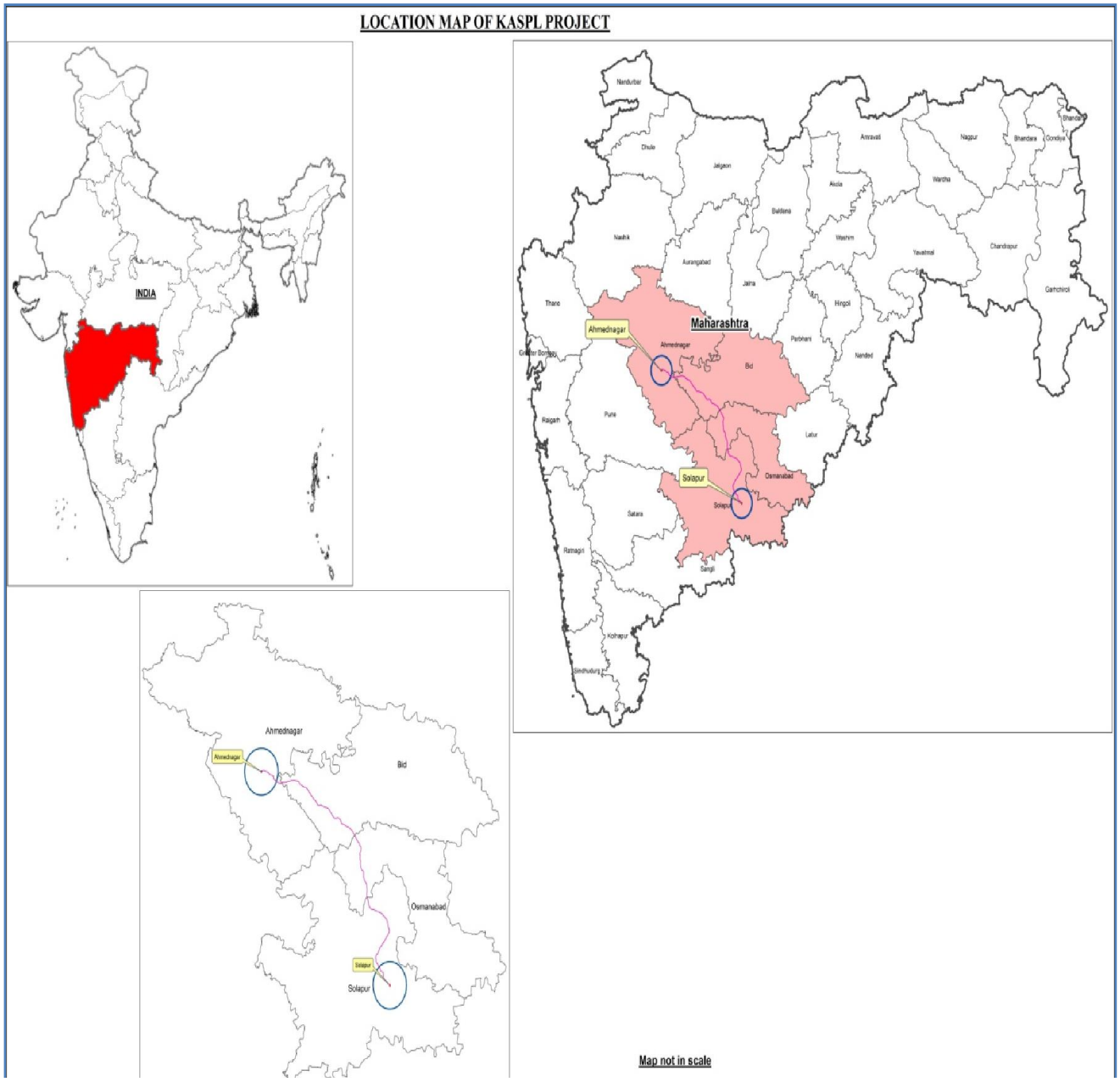


Figure 9: Location of Ahmednagar solapur section of KASPL

Plant Layout is attached as **Annexure-A**.

The land use of stations is flat and land use of Pipeline is varying from place to flat to simple terrain. The pipeline crosses many rivers / canals, agricultural land etc. after laying the pipeline the RoW of the agricultural land will be used for agricultural purposes. The pipeline would be laid in new acquired RoW. The compensation of agricultural crop and for acquired RoW will be given to the farmers during laying of the Pipeline.

3.3 Salient Features of the Project

Extension of Koyali-Ahmednagar product pipeline upto Solapur would broadly comprise of the following :

1) 230 Km long, 18'' OD X 0.25'' WT, API 5L-X70 grade pipeline, from Ahmednagar to Solapur in Maharashtra.
2) Pipeline facilities at Ahmednagar and Solapur.
3) Scraper launching facilities at Ahmednagar while scrapper receiving facilities at Solapur.

Other features related to the project are detailed in the following subsections:

3.3.1 Manpower details

Manpower will be required during construction and operation phase of the project. The executing agency shall provide required manpower for construction. The operation requirement will be met through internal deployment as well as by induction of competent personnel, who will be trained suitably. Manpower requirement would be about 87 during construction phase and 77 for operation of the pipeline, excluding line patrolmen (LPM). The requirement of man power is expected to be met through internal deployment as well as by induction of competent personnel. The requirement of LPM for new right-of-way is envisaged to be outsourced.

3.3.2 Ignition Source

The ignition sources within and outside the Depot/station is a key factor in performing RA Study. The ignition sources, combined with their ignition probability, wind directional probability and presence

of flammable hydrocarbon is a key factor in determining the delayed ignition probability of the cloud which further results in flash fire and overpressure scenarios.

3.3.3 Meteorological Condition

Meteorological Data as obtained from the climatological sheets issued by IMD (India Meteorological Department) for Ahmednagar and Solapur is given as in- **Annexure B**

The consequences of released flammable material are largely dependent on the prevailing weather conditions. For the assessment of major scenarios involving release of flammable materials, the most important meteorological parameters are those that affect the atmospheric dispersion of the releasing material. The critical variables are wind direction, wind speed, atmospheric stability and temperature. Rainfall does not have any direct bearing on the results of the risk analysis; however, it can have beneficial effects by absorption/washout of released materials. Actual behavior of any release would largely depend on prevailing weather condition at the time of release.

3.4 Pasquill Stability

One of the most important characteristics of atmosphere is its stability. Stability of atmosphere is its tendency to resist vertical motion or to suppress existing turbulence. This tendency directly influences the ability of atmosphere to disperse pollutants released from the facilities. In most dispersion scenarios, the relevant atmospheric layer is that nearest to the ground, varying in thickness from a few meters to a few thousand meters. Turbulence induced by buoyancy forces in the atmosphere is closely related to the vertical temperature gradient.

Temperature normally decreases with increasing height in the atmosphere. The rate at which the temperature of air decreases with height is called Environmental Lapse Rate (ELR). It varies from time to time and place to place. The atmosphere is considered to be stable, neutral or unstable according to ELR is less than, equal to or greater than Dry Adiabatic Lapse Rate (DALR), which is a constant value of 0.98°C/100 meters.

Pasquill stability parameter, based on Pasquill – Gifford categorization, is a meteorological parameter, which describes the stability of atmosphere, i.e., the degree of convective turbulence.

Pasquill has defined six stability classes ranging from `A' (extremely unstable) to `F' (stable). Wind speeds, intensity of solar radiation (daytime insulation) and night time sky cover have been identified as prime factors defining these stability categories.

The Pasquill stability classes are shown in **Table** below-

Table 6: Pasquill stability classes (Criterion)

Surface Wind	Day time solar radiation.			Night time cloud cover		
Speed(m/s)	Strong	Slight	Slight	Thin< 40%	Medium	Overcast >80%
< 2	A	A-B	B	-	-	D
2-3	A-B	B	C	E	F	D
3-5	B	B-C	C	D	E	D
5-6	C	C-D	D	D	D	D
>6	C	D	D	D	D	D

Table 7: Pasquill Stability Classes (Description)

Class	Description
A	Very unstable-sunny, light winds
A/B	Unstable-as with A only less sunny or more windy
B	Unstable -as with A/B only less sunny or more windy
B/C	Moderately unstable-moderate sunny and moderate windy
C	Moderately Unstable-very windy /sunny or overcast /light wind
C/D	Moderately unstable- moderate sun and high wind
D	Neutral- little sun and high wind or overcast/windy night
E	Moderately-stable -less overcast and less windy night than D
F	Stable -night with moderate clouds and light/moderate wind
G	Very stable -possibly fog

When the atmosphere is unstable and wind speed is moderate or high or gusty, rapid dispersion of pollutants will occur. Under these conditions, pollutant concentration in air will be moderate or low and the material will be dispersed rapidly. When the atmosphere is stable and wind speed is low, dispersion of material will be limited and pollutant concentration in air will be high.

Stability category for this study is identified based on the cloud amount, day time solar radiation and wind speed.

Table 8: Weather parameters used in consequence analysis in PHAST software

S. No.	Wind Speed(m/s)	Pasquill Stability
1.	2	F
2.	3	D
3.	5	D

3.4.1 Fire fighting facilities (Common for Marketing & Pumping division)

All fire fighting facilities in the dispatch Station would be as per OISD-117/118 norms. The facilities provided consist of the following units and more:

1) Fire Water Storage Tanks
2) Fire Water Pumps and Jockey Pumps
3) Fire Water Piping
4) Fire Hydrants
5) Fixed Foam System
6) Water/foam Monitors
7) Fixed Water Spray Systems
8) Mobile Fire Fighting Equipment
9) Portable Extinguishers

3.4.2 Other Facilities

As per the OISD guidelines, CCTVs and Lightning arrangements would be provided at the relevant location.

CHAPTER-4: IDENTIFICATION OF HAZARD AND SELECTION OF SCENARIOS

4.1 Hazard identification

A classical definition of hazard states that hazard is in fact the characteristic of system/plant/process that presents potential for an accident. Hence all the components of a system/plant/process need to be thoroughly examined in order to assess their potential for initiating or propagating an unplanned event/sequence of events, which can be termed as an accident.

In Risk Analysis terminology a hazard is something with the potential to cause harm. Hence the Hazard Identification step is an exercise that seeks to identify what can go wrong at the major hazard installation or process in such a way that people may be harmed. The output of this step is a list of events that need to be passed on to later steps for further analysis.

The potential hazards posed by the facility were identified based on the past accidents, lessons learnt and a checklist which includes leak in pipe work and tanks. Small Leak (diameter below 1 inch), Large Leak (diameter above 1 inch) and pump seal failure are the cases considered for this project.

Modes of Failure

There are various potential sources of large leakage, which may release hazardous chemicals and hydrocarbon materials into the atmosphere. These could be in form of gasket failure in flanged joints, bleeder valve left open inadvertently, an instrument tubing giving way, pump seal failure, guillotine failure of equipment/pipeline or any other source of leakage. Operating experience can identify lots of these sources and their modes of failure. A list of general equipment and pipeline failure mechanisms is as follows:

Material/Construction Defects

- Incorrect selection or supply of materials of construction
- Incorrect use of design codes
- Weld failures
- Failure of inadequate pipeline supports

Pre-Operational Failures

- Failure induced during delivery at site
- Failure induced during installation
- Pressure and temperature effects
- Overpressure
- Temperature expansion/contraction (improper stress analysis and support design)
- Low temperature brittle fracture (if metallurgy is incorrect)
- Fatigue loading (cycling and mechanical vibration)

Corrosion Failures

- Internal corrosion (e.g. ingress of moisture)
- External corrosion
- Cladding/insulation failure (e.g. ingress of moisture)
- Cathode protection failure, if provided

Failures due to Operational Errors

- Human error
- Failure to inspect regularly and identify any defects

External Impact Induced Failures

- Dropped objects
- Impact from transport such as construction traffic
- Vandalism
- Subsidence
- Strong winds

Failure due to Fire

- External fire impinging on pipeline or equipment
- Rapid vaporization of cold liquid in contact with hot surfaces

4.2 Hazards associated with the Depot handling Flammable product and Pipeline

The pipeline and their associated depot handle hazardous materials POL(like MS, HSD, SKO etc) Products which have a potential to cause fire and explosion hazards. Details regarding the product handled are given in detail below:

4.3 Hazards associated with the Flammable Hydrocarbons

The lists of hazardous materials handled at the station are as follows:-

4.3.1 Motor Spirit (MS)

The motor Spirit is also known as the Petrol or Gasoline. The properties (chemical and physical) of MS and Fire and Explosion Data is indicated in Table (MSDS Table) given in Table below-

IDENTITY OF MATERIAL

Table 9: Material Safety data sheet of Motor Spirit

PRODUCT NAME	PETROL, MOTOR SPIRIT
TRADE NAME	GASOLINE
FORMULA	COMPLEX MIXTURE OF HYDROCARBONS
UN No.	1203
CAS No.	86290-81-5
HAZCHEM CODE	3Y*E
LABEL/CLASS	RED & WHITE FLAMMABLE LIQUID/3.2 GROUP II

Table 10: Physical and Chemical Properties of Motor Spirit (MS)

PHYSICAL STATE	LIQUID	**BOILING POINT/RANGE (^{0}C)**	30 to 215
APPEARANCE	COLOURLESS	**MELTING/FREEZING POINT/RANGE (^{0}C)**	90 to -75
SOLUBILTY in WATER	INSOLUBLE	**VAPOR DENSITY (AIR=1)**	3 to 4

CALORIFIC VALUE (Kcal/Kg)	4.5E+07	**SPECIFIC GRAVITY, 20^{0}C**	0.72 to 0.77
VAPOR PRESSURE at	300 to 600	**HEAT OF VAPORIZATION, Kcal/Kg**	2.93E+05
EVAPORATION RATE at 30^{0}C	10 APPROX.	**SPECIFIC HEAT LIQUID J/Kg**	2.2E+03

Table 11: Fire and Explosive Data of Motor Spirit (MS)

EXPLOSIVITY	MODERATE	**AUTO IGNITIN TEMP., ^{0}C**	257	**FLASH POINT,^{0}C**	<23
FLAMMABILITY	DANGEROUS	**EXPLOSIVE LIMITS, %**	1.3-7.6	**BURNING RATE**	4 mm/min

4.3.2 High Speed Diesel (HSD)

The High Speed Diesel is commonly known as the Diesel Oil. The properties (chemical and physical) of HSD and Fire and Explosion Data is indicated in Table (MSDS Table) given in Table below-

IDENTITY OF MATERIAL

Table 12: Material Safety Data Sheet of High Speed Diesel (HSD)

PRODUCT NAME	DIESEL OIL,GAS OIL
TRADE NAME	HSD
FORMULA	COMPLEX MIXTURE of HYDROCARBONS
UN No.	1202
HAZCHEM CODE	3Y*
LABEL/CLASS	RED FLAMMABLE LIQUID

Table 13: Physical and Chemical Properties of High Speed Diesel (HSD)

PHYSICAL STATE	LIQUID	**BOILING POINT/RANGE (^{0}C)**	150-400
APPEARANCE	LIQUID BROWN	**VAPOR DENSITY (AIR=1)**	18 to 46
SOLUBILTY in WATER	INSOLUBLE (30 ppm)		
CALORIFIC VALUE (Kcal/Kg)	4.34E+07	**SPECIFIC GRAVITY, 20^{0}C**	0.82 to 0.86
VAPOR PRESSURE at 38^{0}C, mm Hg	<1	**HEAT OF VAPORIZATION, Kcal/Kg**	2.71E+05
DYNAMIC VISCOSITY (PA.SC 30 ^{0}C)	0.81 to 0.91	**SPECIFIC HEAT LIQUID J/Kg**	2.343E+03

Table 14: Fire and Explosive Data of High Speed Diesel (HSD)

EXPLOSIVITY	MODERATE	**AUTO IGNITION TEMP (^{0}C)**	256.6	**FLASH POINT ^{0}C**	32 to 96
FLAMMABILITY	MODERATE	**EXPLOSIVE LIMITS, %**	0.7-5	**BURNING RATE**	4 mm/min

4.3.3 Superior Kerosene Oil (SKO)

The Superior Kerosene Oil is also known as the Stove Oil. The properties (chemical and physical) of SKO and Fire and Explosion Data is indicated in Table (MSDS Table) given in Table below-

IDENTITY OFMATERIAL

Table 15: Material Safety Data Sheet of Superior Kerosene Oil (SKO)

PRODUCT NAME	KEROSENE, STOVE OIL, ILLUMINATING OIL
TRADE NAME	SKO

FORMULA	COMPLEX MIXTURE OF HYDROCARBONS
UN No.	1223
HAZCHEM CODE	3Y
LABEL/CLASS	RED FLAMMABLE LIQUID/3.3 GROUP II

Table 16: Physical and Chemical Properties of Superior Kerosene Oil (SKO)

PHYSICAL STATE	LIQUID	**BOILING POINT/RANGE (^{o}C)**	145-300
APPEARANCE	COLOURLESS	**VAPOR DENSITY (AIR=1)**	4.1
SOLUBILTY in WATER	0.0002 to 0.0004		
CALORIFIC VALUE (Kcal/Kg)	4.35E+07	**SPECIFIC GRAVITY, 20^{o}C**	0.80 to 0.85
VAPOR PRESSURE at 20^{o}C, mm Hg	5	**HEAT of VAPORIZATION, Kcal/Kg**	2.72E+05
MELTING/FREEZING POINT (^{o}C)	43 to -49	**SPECIFIC HEAT LIQUID J/Kg**	2.09E+03

Table 17: Fire and Explosive Data of Superior Kerosene Oil (SKO)

EXPLOSIVITY	MODERATE	**FLAMMABILITY**	256.6	**FLASH POINT, ^{o}C**	Min. 35

4.4 Selected Failure Cases

A list of failure cases was prepared based on process knowledge, engineering judgment, experience, past incidents associated with such facilities and considering the general mechanisms for loss of containment. The cases have been identified for the consequence analysis is based on the following.

- Cases with high chance of occurrence but having low consequence:

Example of such failure cases includes two-bolt gasket leak for flanges, seal failure for pumps, sample connection failure, instrument tapping failure, drains, vents, etc. The consequence results will provide enough data for planning routine safety exercises. This will emphasize the area where operator's vigilance is essential.

- Cases with low chance of occurrence but having high consequence (The example includes catastrophic failure of lines, process pressure vessels, etc.)

This approach ensures at least one representative case of all possible types of accidental failure events, is considered for the consequence analysis. Moreover, the list below includes at least one accidental case comprising of release of different sorts of highly hazardous materials handled in the depot. Although the list does not give complete failure incidents considering all equipments, units, but the consequence of a similar incident considered in the list below could be used to foresee the consequence of that particular accident.

Table 18: Selected failure case for Pipeline

Equipment	Scenario	Flow rate (Kl/hr)	Temp (^{0}C)	Failure Frequency (per year)
Pipeline facilities	Line Rupture and Leakage from the Pipeline	130 kl/hr	Equal to ambient	1.0 E-06 (as per OGP data)

4.5 Hazard identification as per NFPA

The fire and health hazards are also categorized based on NFPA (National Fire Protection Association) classifications, described in **Table** below-

Table 19: NFPA for MS, HSD and SKO

S. No	PETROLEUM PRODUCT	N_h	N_f	N_r
1.	MS (Motor Spirit)	1	3	0
2.	HSD (High Speed Diesel)	0	2	0
3.	SKO (Superior Kerosene Oil)	0	2	0

N_h - NFPA health hazard factor

N_f - NFPA flammability hazard factor

N_r - NFPA reactivity hazard factor

Evaluation of the hazard based on the F&E Index is done based on the following guidelines:

Table 20: Explanation of NFPA classification

Classification	Definition
Health Hazard	
4	Materials, which on very short exposure could cause death or major residual injury even though prompt medical treatments were given.
3	Materials, which on short exposure could cause serious temporary or residual injury even though prompt medical treatments were given.
2	Materials, which on intense or continued exposure could cause temporary incapacitation or possible residual injury unless prompt medical treatment is given.
1	Materials, which on exposure would cause irritation but only minor residual injury even if no treatment is given.
0	Materials, which on exposure under fire conditions would offer no hazard beyond that of ordinary combustible material.
Flammability	
4	Materials which will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature, or which are readily dispersed in air and which will burn readily.
3	Liquids and solids that can be ignited under almost all ambient temperature conditions.
2	Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur.
1	Material that must be preheated before ignition can occur.
0	Materials that will not burn.

Reactivity	
4	Materials which in themselves are readily capable of detonation or of explosive decomposition or reaction at normal temperature and pressures.
3	Materials which in themselves are capable of detonation or explosive reaction but require a strong initiating source or which must be heated under confinement before initiation or which react explosively with water.
2	Materials which in themselves are normally unstable and readily undergo violent chemical change but do not detonate. Also materials which may react violently with water or which may form potentially explosive mixtures with water.
1	Materials which in themselves are normally stable, but which can become unstable at elevated temperature and pressures or which may react with water with some release of energy but not violently.
0	Materials which in themselves are normally stable, even under fire exposure conditions, and which are not reactive with water.

4.6 Characterizing the failures

Accidental release of flammable vapors can result in severe consequences. Delayed ignition of flammable vapors can result in blast overpressures covering large areas. This may lead to extensive loss of life and property. Toxic clouds may cover yet larger distances due to the lower threshold values in relation to those in case of explosive clouds (the lower explosive limits). In contrast, fires have localized consequences. Fires can be put out or contained in most cases; there are few mitigating actions one can take once a vapor cloud is released.

In a petroleum processing installation such as the plant in question, the main hazard arises due to the possibility of leakage of petroleum product during transportation. To formulate a structured approach to identification of hazards and understanding of contributory factors is essential.

4.7 Operating Parameters

4.7.1 Inventory

Inventory Analysis is commonly used in understanding the relative hazards and short listing of release scenarios. Inventory plays an important role in regard to the potential hazard. Larger the inventory of the vessel or a system, larger the quantity of potential release. A practice commonly used

to generate an incident list is to consider potential leaks and major releases from fractures of pipelines and vessels containing sizable inventories. Each section is then characterized by the following parameters required for consequence modeling:

- Mass of flammable material in the process/storage section(oil/gas)
- Pressure, Temperature and composition of the material
- Hole size for release

4.7.2 Loss of Containment

Plant inventory can get discharged to Environment due to Loss of Containment.. Certain features of materials to be handled at the plant need to the clearly understood to firstly list out all significant release cases and then to short list release scenarios for a detailed examination.

4.7.3 Vaporization

The vaporization of released liquid depends on the vapor pressure and weather conditions.

Such consideration and others have been kept in mind both during the initial listing as well as during the short listing procedure. Initial listing of all significant inventories in the process plants was carried out. This ensured no emission through inadvertence.

Based on the methodology discussed above a set of appropriate scenarios was generated to carry out Risk Analysis calculations for Pool fire, jet fire, fire ball, flammability threat zone, overpressure etc.

CHAPTER-5: EFFECTS & CONSEQUENCE ANALYSIS

5.1 General

Consequence analysis involves the application of the mathematical, analytical and computer models for calculation of the effects and damages subsequent to a hydrocarbon/toxic release accident.

Computer models are used to predict the physical behavior of hazardous incidents. The model uses below mentioned techniques to assess the consequences of identified scenarios:

- Modeling of discharge rates when holes develop in process equipment/pipe work.
- Modeling of the size & shape of the flammable gas clouds from releases in the atmosphere.
- Modeling of the flame and radiation field of the releases that are ignited and burn as jet fire, Overpressure (Blast Force) .
- Modeling of the explosion fields of releases which are ignited away from the point of release.

The different consequences (Flammable, Jet fire and Overpressure (Blast force) effects) of loss of containment accidents depend on the sequence of events & properties of material released leading to the either flammable area dispersion or Jet fire or Overpressure (Blast Force) or both.

5.2 Consequence Analysis Modeling

5.2.1 Discharge Rate

The initial rate of release through a leak depends mainly on the pressure inside the equipment, size of the hole and phase of the release. The release rate decreases with time as the equipment depressurizes. This reduction depends mainly on the inventory and the action taken to isolate the leak and blow-down the equipment.

5.2.2 Dispersion

Releases of gas into the open air form clouds whose dispersion is governed by the wind, by turbulence around the site, the density of the gas and initial momentum of the release. In case of flammable materials the sizes of these gas clouds above their Lower Flammable Limit (LFL) are

important in determining whether the release will ignite. In this study, the results of dispersion modeling for flammable materials are presented with LFL quantity.

5.2.3 Flash Fire

A flash fire occurs when a cloud of vapors/gas burns without generating any significant overpressure. The cloud is typically ignited on its edge, remote from-the leak source. The combustion zone moves through the cloud away from the ignition point. The duration of the flash fire is relatively short but it may stabilize as a continuous jet fire from the leak source. For flash fires, an approximate estimate for the extent of the total effect zone is the area over which the cloud is above the LFL.

5.2.4 Jet Fire

Jet fires are burning jets of gas whose shape is dominated by the momentum of the release. The jet flame stabilizes on or close to the point of release and continues until the release is stopped. Jet fire can be realized, if the leakage is immediately ignited. The effect of jet flame impingement is severe as it may cut through equipment, pipeline or structure. The damage effect of thermal radiation is depended on both the level of thermal radiation and duration of exposure.

5.2.5 Pool Fire

A cylindrical shape of the pool fire is presumed. Pool-fire calculations are then carried out as part of an accidental scenario, e.g. in case a hydrocarbon liquid leak from a vessel leads to the formation of an ignitable liquid pool. First no ignition is assumed, and pool evaporation and dispersion calculations are being carried out. Subsequently late pool fires (ignition following spreading of liquid pool) are considered. If the release is bounded, the diameter is given by the size of the bund. If there is no bund, then the diameter is that which corresponds with a minimum pool thickness, set by the type of surface on which the pool is spreading.

While modeling cases of lighter hydrocarbons in the range of ATF wherein the rainout fraction have been minimal (not leading to pool formation) due to the horizontal direction of release, downward impingement has been considered for studying the effects of pool fire for consequence analysis only.

Pool fires occur when spilled hydrocarbons burn in the form of large diffusion flames. Calculating the incident flux to an observer involves four steps, namely

- Characterizing the flame geometry
- Estimation of the flame radiation properties
- Computation of the geometric view factors
- Estimation of flame attenuation coefficients and computation of geometric view factors between observer and flame.

The size of the flame will depend upon the spill surface and the thermo chemical properties of the spilled liquid. In particular the diameter of the fire, the visible height of the flame, the tilt and drag of the flame etc. The radioactive output of the flame will depend upon the fire size, the extent of mixing with air and the flame temperature. Some fraction of the thermal radiation is absorbed by the carbon dioxide and water vapor in the intervening atmosphere. In addition, large hydrocarbon fires produce thick smoke which significantly obscure flame radiation.

The calculations for radiation damage distances start with estimation of the burning velocity:

$$Y= 92.6\ e - 0.0043T_bMw10^{-7}/(D\ X\ 6)$$

Where, y= burning velocity in m/s

Mw= molecular weight in kg/kg mol

T_b= normal boiling point

The next step involves calculation of the equivalent diameter for the spreading pool- this depends upon the duration of the spill (continuous, instantaneous, finite duration etc.). This is calculated using expressions like:

$$D_{eq.} =2(V/3.142y)^{1/2}$$

Where $D_{eq.}$ Is the steady state diameter of the pool in m

V= liquid spill rate in m^3/s

Y= Liquid burning rate in m/s

In the absence of frictional resistance during spreading, the equilibrium diameter is reached over a time given by:

$T_{eq.}= 0.949\ D_{eq.}/(\Delta\ y\ X\ D_{eq.})^{1/3}$

The visible flame height is given by;

$H_{flame}= 42D_p\ ((BvD/D_a(gD_p)1/2)^{0.61}$

Where H_{flame} = flame height in m

D= density in kg/m^3

D_a= air density in kg/m^3

g = gravitational acceleration or 9.81 m/s^2

The emissive power of a large turbulent fire is a function of the black body emissive power and the flame emissivity. The black body emissive power can be computed by Planck's law of radiation. The general equation used for the calculation is:

$E_P= -0.313T_b+117$

Where E_p is the effective emissive power in kw/m^2

T_b= normal boiling point of the liquid in °F

Materials with a boiling point above 30 °F typically burn with sooty flames-the emissive power from the sooty section is about 20 kW $/m^2$. The incident flux at any given location is given by the equation:

$Q_{incident} = EP * t * V_F$

Where, $Q_{incident}$ = incident flux in kw/m^2

t= transmitivity (a function of path length, relative humidity and flame temperature) often taken as 1 and the attenuation of thermal flux due to atmospheric absorption ignored.

V_F= geometric view factor

The view factor defines the fraction of the flame that is seen by a given observer.

$V_F = 1.143 (R_p/X) 1.757$

Where, X= distance from the flame center in m

R_p= pool radius in m

Based on the radiation received, the fatality levels are calculated from Probit equation, which for protected clothing is given by:

$Pr. = -37.23 + 2.56 \ln (t \times Q^{4/3})$

Where Pr. = Probit No.

t= time in seconds

Q heat radiation in w/m^2

5.2.6 Blast Overpressures

Blast Overpressures depend upon the reactivity class of material and the amount of gas between two explosive limits. Lets take an example of MS, MS could give rise to a VCE due to their vapor pressures - however, as the results will indicate, the cloud flammable masses are quite small due to the high boiling point and low vapor pressures. In addition, unless there is sufficient extent of confinement, it is unlikely to result in any major explosion. Examples where flammable mixtures could be found are within storage tanks and road tankers. Open-air explosions are unlikely. As a result, damage would be limited.

Equations governing the formation of overpressures in an explosion are given later. Blast overpressures are calculated based on comparison of combustion energy per unit mass of a vapor cloud with that of TNT and taking into account that only a fraction of the energy will contribute to the explosion. Overpressure data compiled from measurements on TNT are used to relate overpressure data to distance from explosions. The equivalent mass of TNT is calculated using the equations:

$M_{TNT} = (M_{cloud} \times (\Delta H_c.)/1155 \times Y_f)$

Where M_{TNT} is the TNT equivalent mass (lb)

ΔH_c = Heat of combustion is in Kcals/kg

M_{cloud} is mass in cloud in lbs

Y_f is the yield factor

The distance to a given overpressure is calculated from the general equation:

$$X=M_{TNT}\ 1/3 \exp (3.5031-0.7241 \ln (O_p) + 0.0398 (\ln O_p))^2$$

Where X is the distance to a given overpressure in feet

O_p is the peak overpressure

5.3 Size and Duration of Release

Leak size considered for selected failure cases are as listed in **Table** below-

Table 21: Leak size of selected failure scenario

Failure Description	Leak Size
Small hole	20 mm hole size
Large hole	50 mm hole size
Catastrophic failure	Complete Line Rupture of Pipeline

The duration of release is a very important input to the consequence analysis as this directly dictates the quantity of material released. General basis for deciding the duration of release is given in the **Table** below-

Table 22: Duration of release

Blocking system configuration	Isolation Time(m)
Fully automatic blocking system(including automatic detection and closure of block valves)	2
For remote operated blocking systems (detection is automatic, but control room operator must validate alarm signal and close block valve remotely)	10
For hand-operated blocking systems (detection is automatic, but control room	30

operator must validate alarm, go to field and manually close block valve)	

The discharge duration is taken as 10 minutes for continuous release scenarios as it is considered that it would take plant personnel about 10 minutes to detect and isolate the leak.

5.4 Damage Criteria

In order to appreciate the damage effect produced by various scenarios, physiological/physical effects of the blast wave, thermal radiation or toxic vapor exposition are discussed.

5.4.1 LFL or Flash Fire

Hydrocarbon vapor released accidentally will spread out in the direction of wind. If a source of ignition finds an ignition source before being dispersed below lower flammability limit (LFL), a flash fire is likely to occur and the flame will travel back to the source of leak. Any person caught in the flash fire is likely to suffer fatal burn injury. Therefore, in consequence analysis, the distance of LFL value is usually taken to indicate the area, which may be affected by the flash fire.

Flash fire (LFL) events are considered to cause direct harm to the population present within the flammability range of the cloud. Fire escalation from flash fire such that process or storage equipment or building may be affected is considered unlikely.

5.4.2 Thermal Hazard Due to Pool Fire, Jet Fire

Thermal radiation due to pool fire, jet fire or fire ball may cause various degree of burn on human body and process equipment. The following table details the damage caused by various thermal radiation intensity.

Table 23: Effects due to incident radiation intensity

Incident Radiation (kW/m^2)	Type of Damage
0.7	Equivalent to Solar Radiation
1.6	No discomfort for long exposure
4.0	Sufficient to cause pain within 20 sec. Blistering of skin (first degree burns are likely)

Incident Radiation (kW/m^2)	Type of Damage
9.5	Pain threshold reached after 8 sec. Second degree burns after 20 sec.
12.5	Minimum energy required for piloted ignition of wood, melting plastic tubing etc.
25	Minimum energy required to ignite wood at indefinitely long exposure
37.5	Sufficient to cause damage to process equipment

Source: Major Hazard Control, ILO

5.4.3 Vapor Cloud Explosion

In the event of explosion taking place within the plant, the resultant blast wave will have damaging effects on equipment, structures, building and piping falling within the overpressure distances of the blast. Tanks, buildings, structures etc. can only tolerate low level of overpressure. Human body, by comparison, can withstand higher overpressure. But injury or fatality can be inflicted by collapse of building of structures. The following table illustrates the damage effect of blast overpressure.

Table 24: Damage due to Overpressures

Peak Overpressure	Damage Type
12.04 psi	Total Destruction
4.35 psi	Heavy Damage
1.45 psi	Moderate Damage
0.44 psi	Significant Damage
0.15 psi	Minor Damage

5.5 Generic Failure Rate Data

Generic leak frequency data published by International Association of Oil and gas Producers (OGP) are used in this RA study. An extract from OGP Risk assessment data directory- report no.434 (March-2010) used in present study is reported in the **table below**-

Table 25: Failure frequency (OGP Data)

Equipment overall failure frequency(per year)						
Equipment Name	**Minor Leak**	**Medium Leak**		**Major Leak**	**Full bore Rupture**	**Total**
	[3mm]	**[10mm]**	**[25mm]**	**[100mm]**	**[>100mm]**	
Process Pipe <2”	9.00E-05	3.80E-05	2.70E-05			1.6 E-4
Process Pipe <6”	4.10E-05	1.70E-05	7.40E-06	7.60E-06		7.3 E-5
Process Pipe <12”	3.70.E-05	1.60E-05	6.70E-06	1.40E-06	5.90E-06	6.7 E-5
Process Pipe 18”	3.6E-05	1.5E-05	6.5E-06	1.4E-06	5.9E-06	6.5E-05
Flanges<2”	4.40E-05	1.80E-05	1.50E-05			7.7 E-5
Flanges<6”	6.50E-05	2.60E-05	1.10E-05	8.50E-06		1.1 E-4
Flanges<12”	9.60E-05	3.90E-05	1.60E-05	3.20E-06	7.00E-06	1.6 E-4
Manual Valves<2”	4.40 E-05	2.30E-05	2.10E-05			8.8 E-5
Manual Valves<6”	6.60E-05	3.40E-05	1.80E-05	1.10E-05		1.3 E-4
Manual Valves<12”	8.40E-05	4.30E-05	2.30E-05	6.30E-06	7.80E-06	1.6 E-4
Actuated Valves<2”	4.20E-04	1.80E-04	1.10E-04			7.1 E-4
Actuated Valves<6”	3.60E-04	1.50E-04	6.60E-05	3.30E-05		6.1 E-4
Actuated Valves<12”	3.30 E-04	1.40E-04	6.00E-05	1.30E-05	1.80E-05	5.6 E-4
Instrument Connections	3.50E-04	1.50E-04	6.50E-05			5.7 E-4
Pumps-Centrifugal	5.10E-03	1.80E-03	5.90E-04	1.40E-04		7.6 E-3
Compressor - Reciprocating	4.50E-02	1.70E02	6.70E-03	2.00E-03		7.1 E-2

5.6 Plant Data

RA study conducted is based on the data available from current engineering documents developed for the depot. These documents are given in **Table below**-

Table 26: List of documents used in study

S. No.	Location (Terminal)	Document / Drawing Title	Document / Drawing No.
1.	IOCL Ahmednagar Terminal	P & ID For Ahmednagar Intermediate Delivery Station	920-10607-302-051-00
2.	IOCL Ahmednagar Terminal	General Layout Plan For Ahmednagar Delivery Station	9200-10607-302-001-00
3.	IOCL Solapur Depot	General Layout Plan For Solapur Delivery station	9200-10609-302-001-00

5.7 Consequence analysis for Terminal

5.7.1 Scenarios

The scenarios for consequence analysis have been identified as listed in (consequence analysis – scenario Results) Table below-

Table 27: Consequence Analysis Result for Ahmednagar Terminal (Proposed Pipeline Facilities)

Scenario considered	Wind stability class	LFL concentration PPM	Flash fire At LFL concentration distance (m)	Pool Fire Damage distance for various heat loads (m)			Jet Fire Damage distance for various heat loads (m)			Maximum Pool radius (m)
				4 kW/m²	12.5 kW/m²	37.5 kW/m²	4 kW/m²	12.5 kW/m²	37.5 kW/m²	
Scenario	**LINE RUPTURE**									
Main Pipeline (18'' OD)	2F	13000	822	306	178	N.R	1122	840	672	193
	3D		1039	328	183	N.R	1170	793	629	188
	5D		892	354	186	N.R	965	710	559	186
Manifold Area	2F	13000	932	260	146	N.R	952	711	569	193
	3D		925	279	151	N.R	924	682	539	188
	5D		732	302	154	N.R	828	607	477	186
SLB (Scrapper launching barrel)	2F	13000	1177	254	137	N.R	880	658	526	197
	3D		863	272	140	N.R	864	636	501	193
	5D		651	295	143	N.R	769	564	442	190
N.R - Not Reached/Not Recorded										

Scenario considered	Wind stability class	LFL concentration PPM	Flash fire At LFL concentration distance (m)	Pool Fire Damage distance for various heat loads (m)			Jet Fire Damage distance for various heat loads (m)			Maximum Pool radius (m)
				4 kW/m²	12.5 kW/m²	37.5 kW/m²	4 kW/m²	12.5 kW/m²	37.5 kW/m²	
Scenario	**Small Leak (20 mm)**									
Main Pipeline (18'' OD)	2F	13000	104	N.R	N.R	N.R	80	62	51	N.R
	3D		82	N.R	N.R	N.R	78	59	47	N.R
	5D		69	N.R	N.R	N.R	74	55	44	N.R
Manifold Area	2F	13000	102	N.R	N.R	N.R	77	59	49	N.R
	3D		80	N.R	N.R	N.R	74	56	45	N.R
	5D		65	N.R	N.R	N.R	71	52	41	N.R
SLB (Scrapper launching barrel)	2F	13000	93	N.R	N.R	N.R	72	55	45	N.R
	3D		75	N.R	N.R	N.R	69	52	42	N.R
	5D		59	N.R	N.R	N.R	66	49	39	N.R
N.R - Not Reached/Not Recorded										

Scenario considered	Wind stability class	LFL concentration PPM	Flash fire At LFL concentration distance (m)	Pool Fire Damage distance for various heat loads (m)			Jet Fire Damage distance for various heat loads (m)			Maximum Pool radius (m)
				4 kW/m²	12.5 kW/m²	37.5 kW/m²	4 kW/m²	12.5 kW/m²	37.5 kW/m²	
Scenario	**Large Leak (50 mm)**									
Main Pipeline (18" OD)	2F	13000	293	N.R	N.R	N.R	185	141	115	N.R
	3D		229	N.R	N.R	N.R	179	134	108	N.R
	5D		193	N.R	N.R	N.R	172	126	99	N.R
Manifold Area	2F	13000	293	N.R	N.R	N.R	185	141	115	N.R
	3D		229	N.R	N.R	N.R	179	134	108	N.R
	5D		193	N.R	N.R	N.R	172	126	99	N.R
SLB (Scrapper launching barrel)	2F	13000	247	67	48	37	165	125	102	30
	3D		197	64	54	42	159	119	95	14
	5D		159	57	51	44	152	111	88	6
N.R - Not Reached/Not Recorded										

Table 28 : Consequence Analysis Result at Solapur Terminal (Proposed Pipeline Facilities)

Scenario considered	Wind stability class	LFL concentration PPM	Flash fire At LFL concentration distance (m)	Pool Fire Damage distance for various heat loads (m)			Jet Fire Damage distance for various heat loads (m)			Maximum Pool radius (m)
				4 kW/m²	12.5 kW/m²	37.5 kW/m²	4 kW/m²	12.5 kW/m²	37.5 kW/m²	
Scenario	**LINE RUPTURE**									
Main Pipeline (18'' OD)	2F	13000	822	306	178	N.R	1122	840	672	193
	3D		1039	328	183	N.R	1170	793	629	188
	5D		892	354	186	N.R	965	710	559	186
Manifold Area	2F	13000	932	260	146	N.R	952	711	569	193
	3D		925	279	151	N.R	924	682	539	188
	5D		732	302	154	N.R	828	607	477	186
SRB (Scrapper Receiving barrel)	2F	13000	1177	254	137	N.R	880	658	526	197
	3D		863	272	140	N.R	864	636	501	193
	5D		651	295	143	N.R	769	564	442	190
N.R - Not Reached/Not Recorded										

Scenario considered	Wind stability class	LFL concentration PPM	Flash fire At LFL concentration distance (m)	Pool Fire Damage distance for various heat loads (m)			Jet Fire Damage distance for various heat loads (m)			Maximum Pool radius (m)
				4 kW/m²	12.5 kW/m²	37.5 kW/m²	4 kW/m²	12.5 kW/m²	37.5 kW/m²	
Scenario	**Small Leak (20 mm)**									
Main Pipeline (18'' OD)	2F	13000	104	N.R	N.R	N.R	80	62	51	N.R
	3D		82	N.R	N.R	N.R	78	59	47	N.R
	5D		69	N.R	N.R	N.R	74	55	44	N.R
Manifold Area	2F	13000	102	N.R	N.R	N.R	77	59	49	N.R
	3D		80	N.R	N.R	N.R	74	56	45	N.R
	5D		65	N.R	N.R	N.R	71	52	41	N.R
SRB (Scrapper Recieving barrel)	2F	13000	93	N.R	N.R	N.R	72	55	45	N.R
	3D		75	N.R	N.R	N.R	69	52	42	N.R
	5D		59	N.R	N.R	N.R	66	49	39	N.R
N.R - Not Reached/Not Recorded										

Scenario considered	Wind stability class	LFL concentration PPM	Flash fire At LFL concentration distance (m)	Pool Fire Damage distance for various heat loads (m)			Jet Fire Damage distance for various heat loads (m)			Maximum Pool radius (m)
				4 kW/m²	12.5 kW/m²	37.5 kW/m²	4 kW/m²	12.5 kW/m²	37.5 kW/m²	
Scenario	**Large Leak (50 mm)**									
Main Pipeline (18" OD)	2F	13000	293	N.R	N.R	N.R	185	141	115	N.R
	3D		229	N.R	N.R	N.R	179	134	108	N.R
	5D		193	N.R	N.R	N.R	172	126	99	N.R
Manifold Area	2F	13000	293	N.R	N.R	N.R	185	141	115	N.R
	3D		229	N.R	N.R	N.R	179	134	108	N.R
	5D		193	N.R	N.R	N.R	172	126	99	N.R
SRB (Scrapper Recieving barrel)	2F	13000	247	67	48	37	165	125	102	30
	3D		197	64	54	42	159	119	95	14
	5D		159	57	51	44	152	111	88	6
N.R - Not Reached/Not Recorded										

(Note: - All the results tabulated above are as per PHAST Risk & Hazard Software)

CHAPTER-6: RISK ANALYSIS

6.1 Individual Risk

The results of Risk Analysis are often reproduced as Individual Risk. Individual Risk is the probability of death occurring as a result of accidents at a fixed installation or a transport route expressed as a function of the distance from such an activity.

There are no specified risk acceptance criteria as yet in our country for Individual Risk levels. A review of risk acceptance criteria in use in other countries indicates the following:

- For fixed installations Official Individual Risk Criteria have been developed by various countries and the review indicates that Individual Risk of fatality to the members of the public outside the installation boundaries may be adopted as higher 10^{-5} per year (in populated areas) for intolerable risk and lower than 10^{-6} per year for negligible risk. The region in between is the so-called ALARP region where risk is acceptable subject to its being **A**s **L**ow **A**s **R**easonably **P**racticable (The ALARP principle).
- The individual risk results show the geographical distribution of risk. It is the frequency at which an individual may be expected to sustain a given level of harm from the realization of specified hazards and is normally taken as risk of death (fatality). It is expressed as risk per year.
- Individual risk is usually presented in the form of Individual Risk Contours, which are also commonly known as ISO Risk Curves. This is the risk to a hypothetical individual being present at that location continuously there for 24 hours a day and 365 days a year.

6.1.1 Individual Risk Acceptability Criteria

As per IS15656:2006 Indian Standard code of practice on hazard identification & Risk analysis, in many countries the acceptable risk criteria has been defined for the industrial installations and are shown in **Table** below-

Table 29: Acceptable Risk Criteria of various countries

Authority and Application	Maximum tolerable risk (per year)	Negligible risk (per year)
VROM, the Netherlands (New)	1×10^{-6}	1×10^{-8}
VROM, the Netherlands (Existing)	1×10^{-5}	1×10^{-8}
HSE, UK (Existing hazardous industries)	1×10^{-4}	1×10^{-6}
HSE, UK (Nuclear power station)	1×10^{-5}	1×10^{-6}
HSE, UK (Substance transport)	1×10^{-4}	1×10^{-6}
HSE, UK (New Housing near plants)	3×10^{-5}	3×10^{-7}
Hong Kong Government (new plants)	1×10^{-5}	Not Used

Since there are no guidelines on the tolerability of fatality risk sanctioned in India to date, to demonstrate the risk to employee and public the following are considered based upon the standards listed in the table above.

- If the average expectation of life is about 75 years, then the imposition of an annual risk of death to individual is 0.01 (one in one hundred years), it seems unacceptable. Hence 1 in 1000 years, it may not be totally unacceptable if the individual knows of the situation, has been considered as upper limit of the ALARP triangle for people working inside the depot complex.
- Lower limit of ALARP triangle is taken as 1×10^{-5} per year for people working inside the depot complex.
- Upper limit of tolerable risk to a member of general public is taken as 1×10^{-3} per year.
- Similarly, 1×10^{-6} per year (Negligible risk) is considered for public to demonstrate the risk. This is the lower limit of the ALARP triangle.

The Individual Risk per Annum levels discussed above is demonstrated graphically in the so called "ALARP triangle" represented in **Figure-20.** In the lower region, the risk is considered negligible, provided that normal precautions are maintained. The upper region represents an intolerable risk must be reduced. The area between these two levels is the "ALARP Region (As Low As Reasonably Practicable)" in which there is a requirement to apply ALARP principle. Any risk that lies between

intolerable and negligible levels should be reduced to a level which is "As Low As Reasonably Practicable".

For Transportation facilities, the Risk tolerability criteria as set in the ACDS *Transport Hazards Report* published by the HSE of the UK adopts fatality risk 10^{-3} per year as 'intolerable' while fatality risk of 10^{-6} per year is adopted as 'broadly acceptable'. The ALARP principle then implies that if the fatality risk from a particular transport activity lies between 10^{-6} per year and 10^{-3} per year, then efforts should be made to reduce to it to as low a level as reasonably practicable.

The individual risks from an activity are the result of the cumulative of risks connected with all possible scenarios.

The individual risk results show the geographical distribution of risk. It is the frequency at which an individual may be expected to sustain a given level of harm from the realization of specified hazards and is normally taken as risk of death (fatality). It is expressed as risk per year.

In case of depot, the Individual Risk Contours run close to the plant. The overall risk for KASPL Pipeline project is given in the **Figure** below –

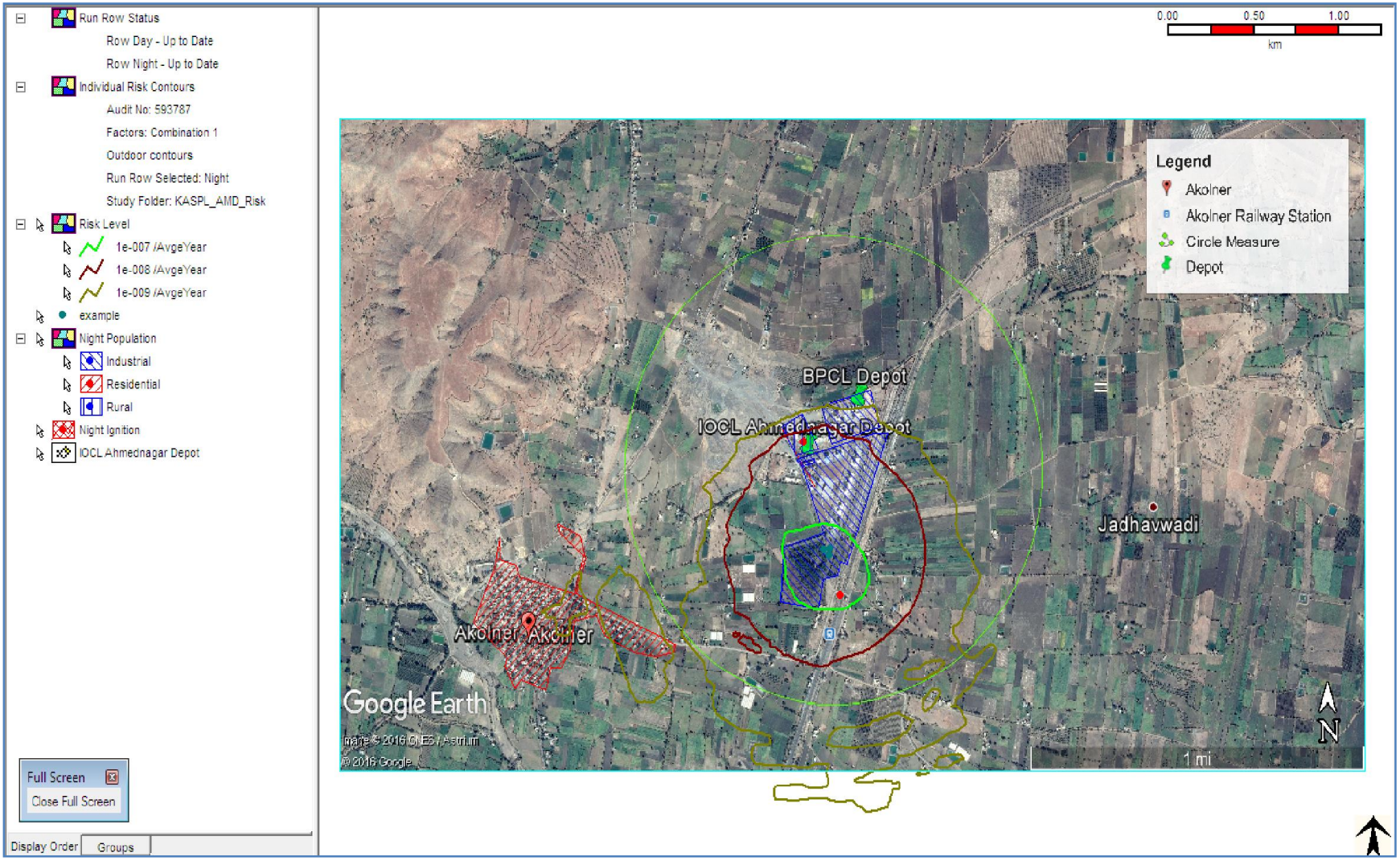


Figure 10:- Map showing Worst Case Scenario for Ahmedabad Depot

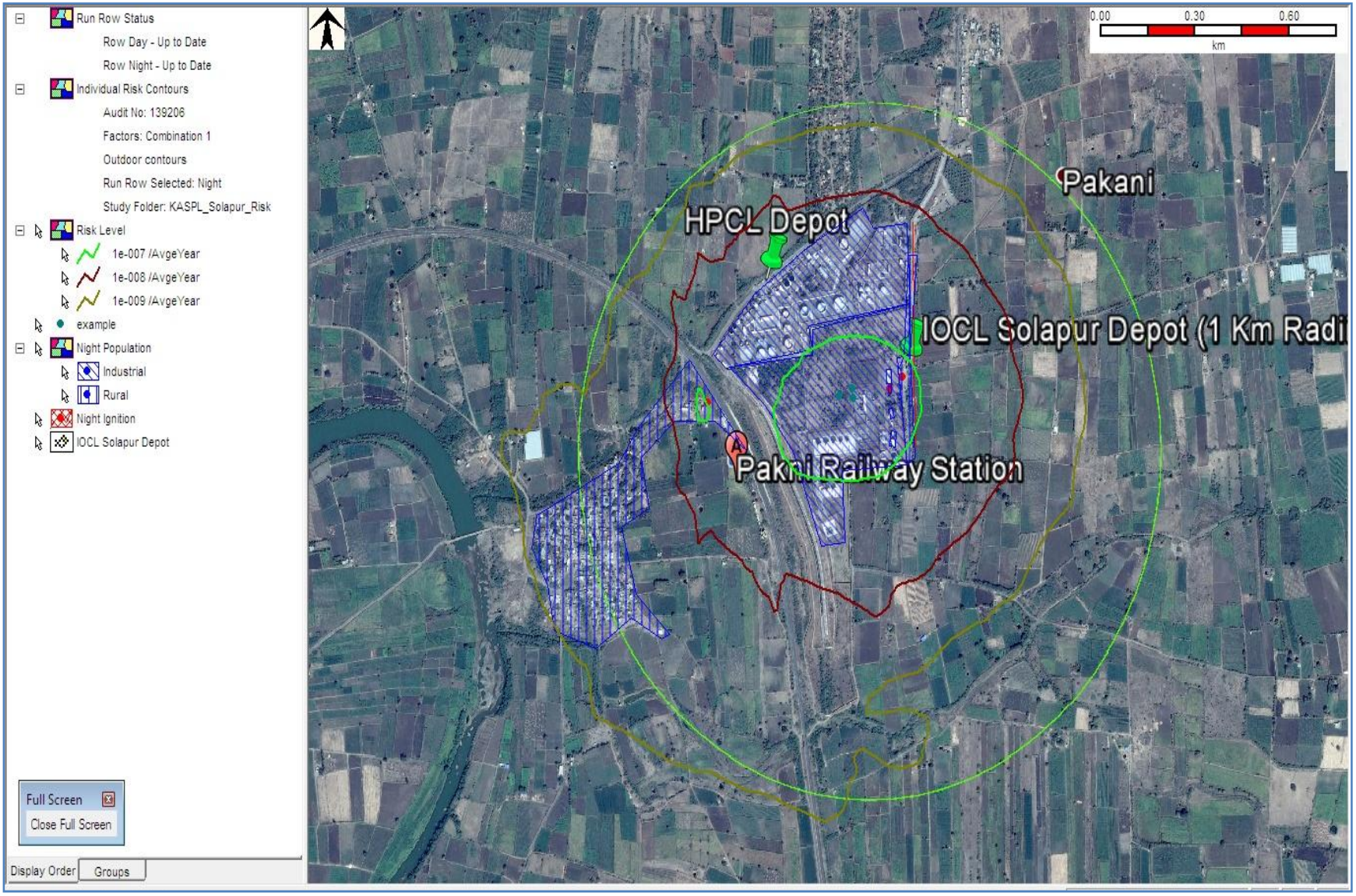


Figure 9:- Map showing Overall risk Scenario of Solapur Depot

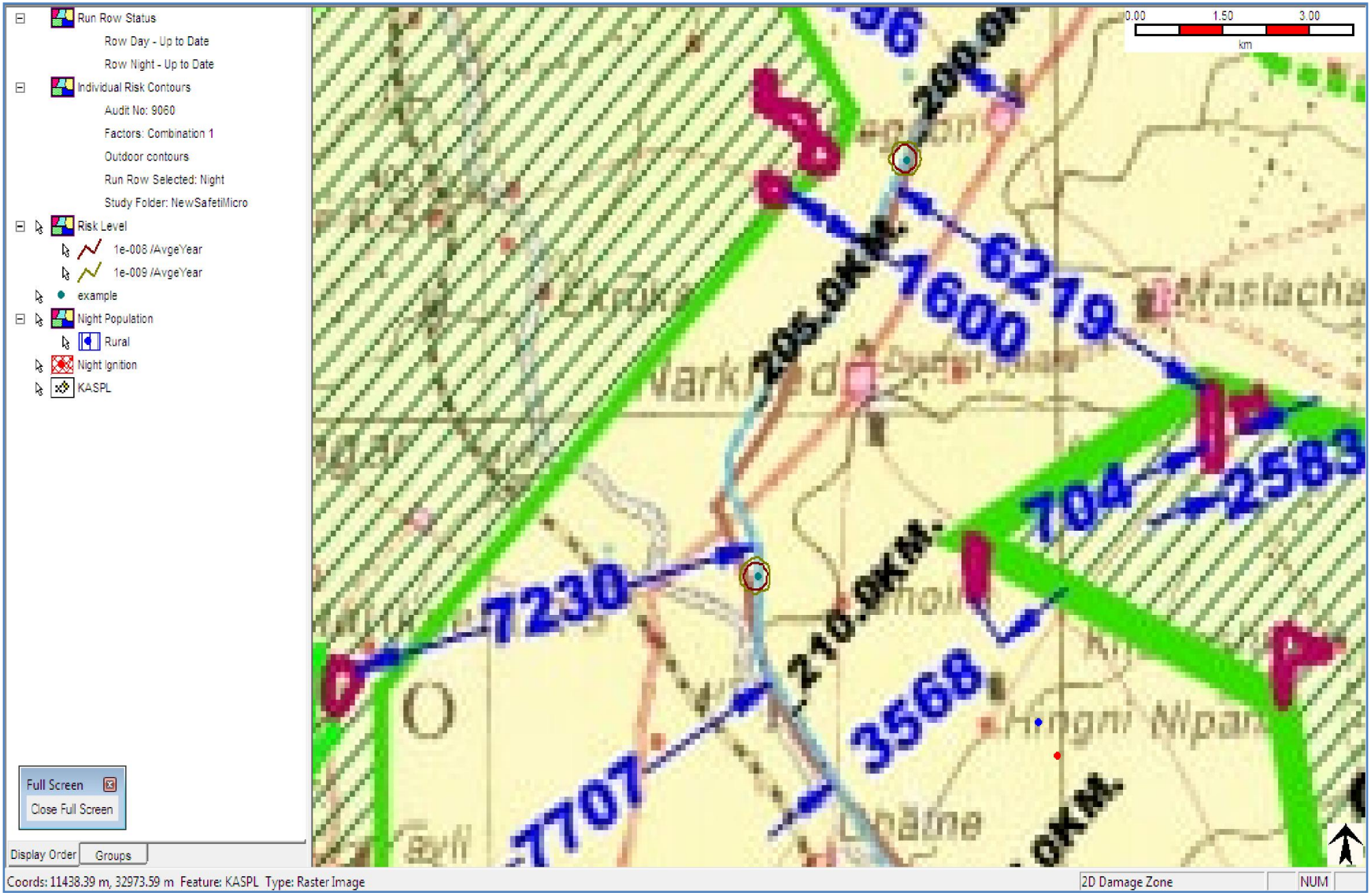


Figure 11: Map showing Overall Risk Scenario for Eco-sensitive Area (The Great Indian Bustard WLS)

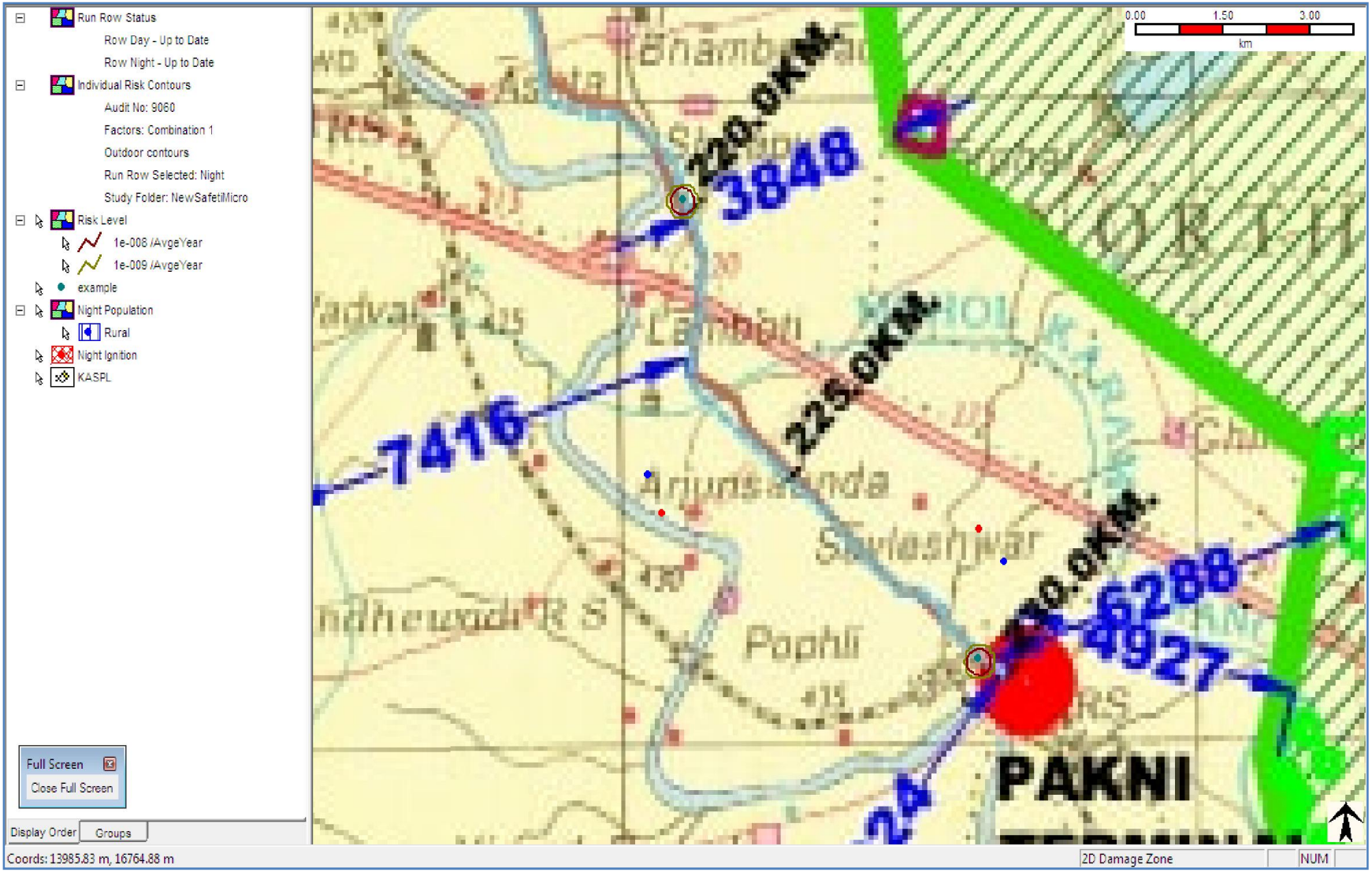


Figure 12 Map showing Overall Risk Scenario for Eco-sensitive Area (The Great Indian Bustard WLS)

6.1.2 Location Specific Individual Risk (LSIR)

The highest location-specific individual risk (LSIR) contour at Ahmednagar section of the pipeline lies in region having numerical value 3.80 E-006 per year which is in broadly acceptable zone of ALARP Triangle, Solapur Section of the pipeline lies in region having numerical value 3.23 E-005 per year which lies in ALARP zone whereas apart from these the pipeline section which passes closely to the eco-sensitive zone 'The Great Indian Bustard WLS' lies in the region having numerical value 1.00 E-008 per year which is in Broadly acceptable zone of ALARP triangle. The overall Societal Risk Contour for "Ahmednagar-Solapur Section of KASPL pipeline" along with the areas coming in Ecosensitive zone are shown in figures below: The maximum LSIR in the unit are listed in Table below-

Table 30: Maximum LSIR at Terminal

S. No.	Unit	Maximum LSIR	ALARP Region
1.	Ahmednagar Depot	3.80 E-006	Broadly Acceptable
2.	Solapur Depot	3.23 E-005	ALARP Zone
3.	Ecosensitive Zone (The Great Indian Bustard WLS)	1.00 E-008	Broadly Acceptable
ALARP – **A**s **L**ow **A**s **R**easonably **P**racticable			

6.1.3 Individual Specific Individual Risk (ISIR)

Individual risk to worker at terminal calculated as a person who is standing at that point 365 days a year and 24 hours a day. The people in plant are expected to work in 8 hour shift as well general shift. The actual risk to a person "Individual Specific Individual Risk" (ISIR) would be far less after accounting the time fraction a person spent at location.

$ISIR_{Area} = LSIR \times (8/24)_{(8\ hours\ shift)} \times$ (Time spend by an individual / 8 hours)

The comparison of maximum individual risk with risk acceptability criteria is given in Table below-

Table 31: Maximum Individual Specific Individual Risk (ISIR) at Terminal

S. No.	Unit	Maximum ISIR	ALARP Region

S. No.	Unit	Maximum ISIR	ALARP Region
1.	Ahmednagar Depot	1.26 E-006	Broadly Acceptable
2.	Solapur Depot	1.07 E-005	ALARP Zone
3.	Ecosensitive Zone (The Great Indian Bustard WLS)	1.00 E-008	Broadly Acceptable
ALARP – **A**s **L**ow **A**s **R**easonably **P**racticable			

(Note: - Values of LSIR and ISIR obtained are as per PHAST risk & hazard software)

ALARP summary & comparison of Individual risk with acceptability criteria

The objective of this RA study is to assess the risk levels of KASPL pipeline project with reference to the defined risk acceptability criteria and recommend measures to reduce the risk level to As Low As Reasonably Practicable (ALARP).

The comparison of maximum individual risk with the risk acceptability criteria is shown in Figure below-

From the results shown above, the maximum individual risk to depot personnel from Ahmednagar Terminal is 1.26 E-006 which is in Broadly Acceptable zone, Solapur Terminal is 1.07 E-005 which lies in ALARP Zone and Ecosensitive area of KASPL pipeline is 1.00 E-008 which is in Broadly Acceptable zone of 'As Low As Reasonably Practicable (ALARP) Triangle.

The comparison of maximum individual risk with the risk acceptability criteria is shown in Figure below-

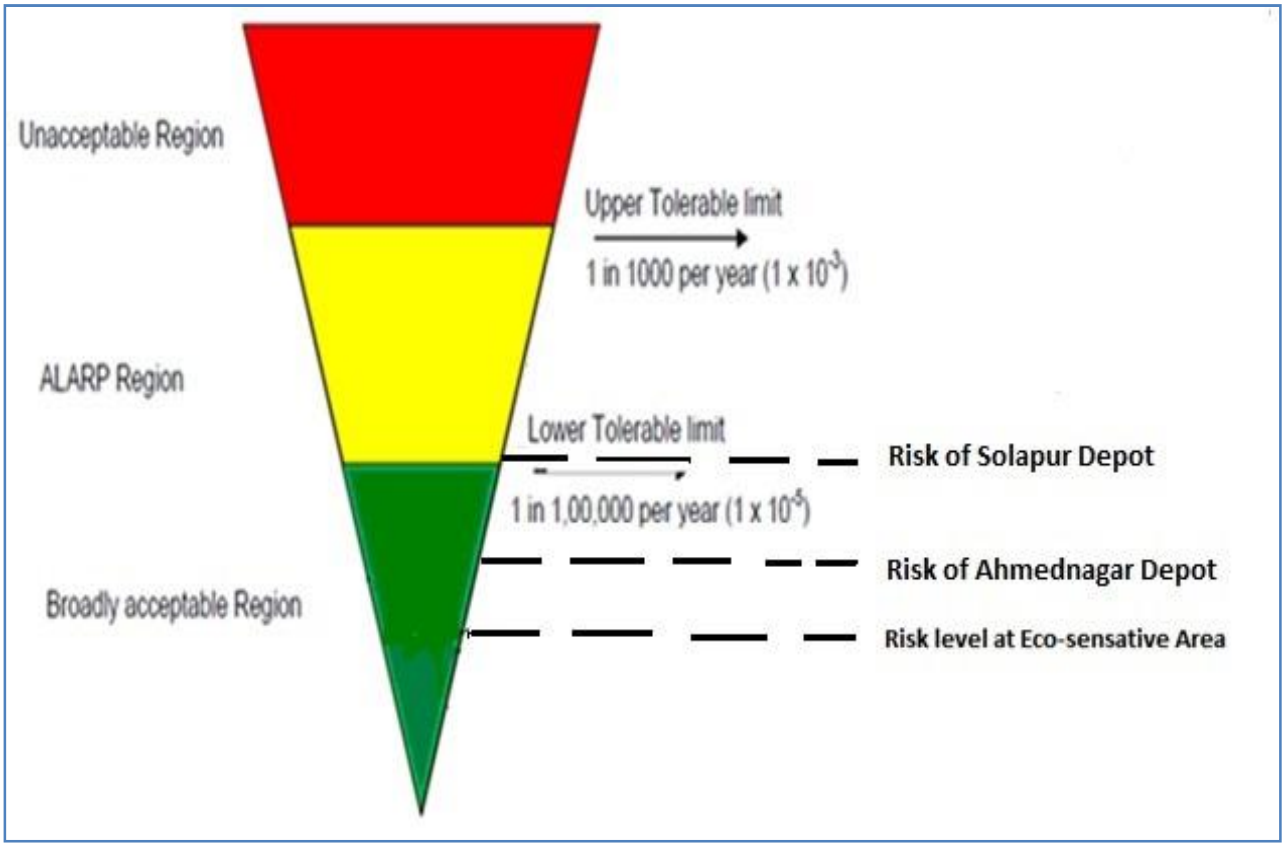


Figure 13: Individual risk at Ahmednagar Solapur Pipeline Project

6.2 Societal Risk

It is the risk experience in a given time period by the whole group of personnel exposed, reflecting the severity of the hazard and the number of people in proximity to it. It is defined as the relationship between the frequency and the number of people suffering a given level of harm (normally taken to refer to risk of death) from the realization of the specified hazards. It is expressed in the form of F-N curve.

Societal risk acceptability criteria

A formal risk criterion is used at all for societal risk; the criterion most commonly used is the F-N curve. Like other forms of risk criterion, the F-N curve may be cast in the form of a single criterion curve or of two criterion curves dividing the space in to three regions – where the risk is unacceptable, where it is negligible and where it requires further assessment. The latter approach corresponds to application to societal risk of the ALARP principle. In the absence of any Indian standard, risk criteria as set by Netherlands have been considered for the present study. A criterion of 10^{-4} per year is recommended for determining design accidental loads for on-site buildings, i.e.

buildings should be designed against the fire and explosion loads that occur with a frequency of 1 in 10,000 per year.

The result from the F-N curve show that the Societal risk for Ahmednagar Terminal is purely in broadly acceptable zone whereas for Solapur terminals it goes slightly the ALARP Region.For Eco-sensitive area no FN curve was generated because of the negligible human population around the region. F-N curve of the depots are represented in **Figure** below-

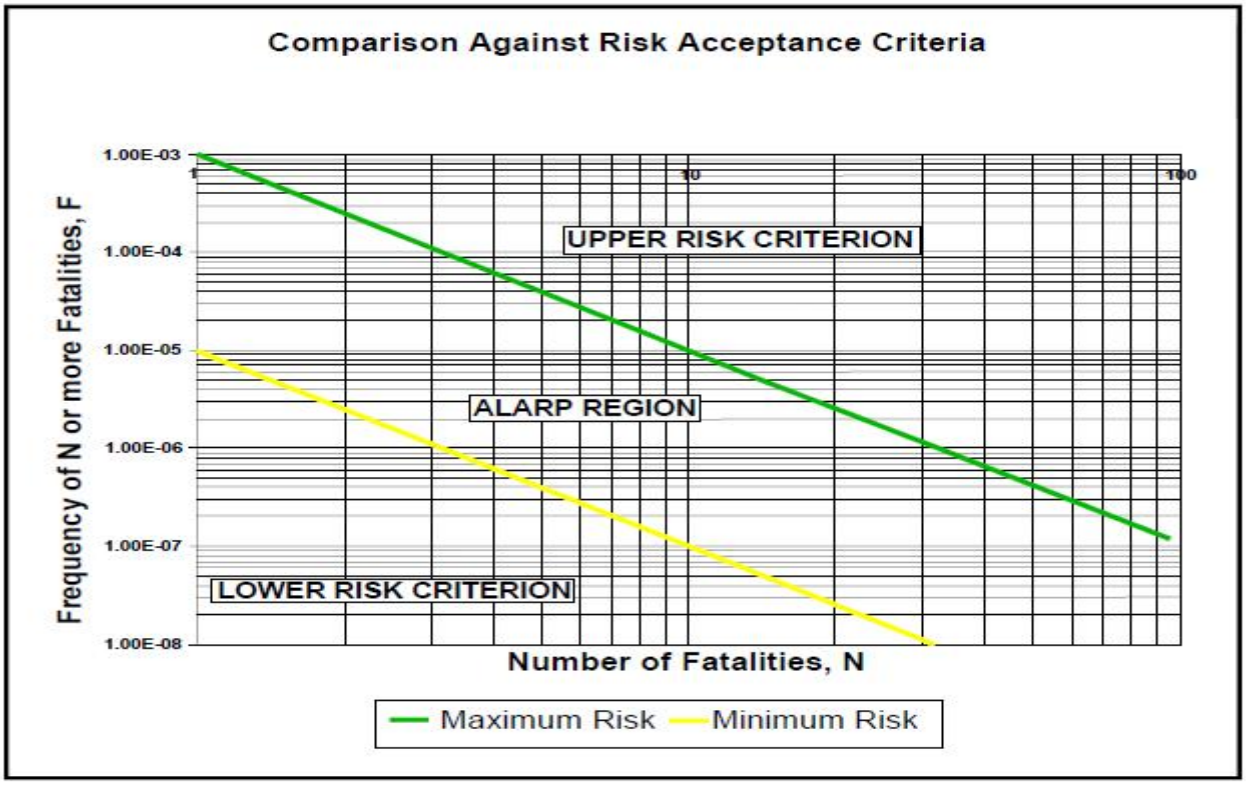


Figure 14: Societal Risk Criteria.

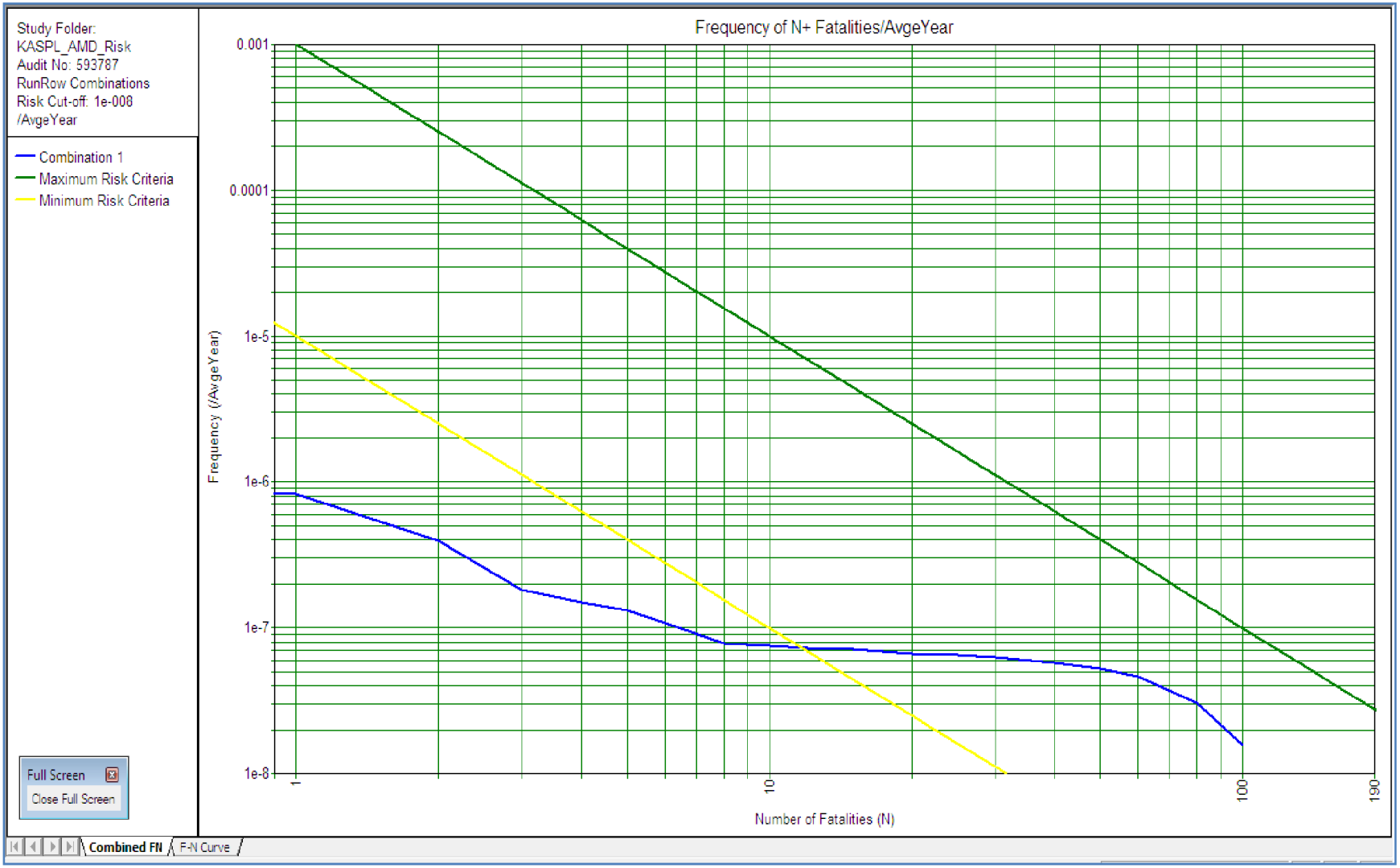


Figure 15: F-N Curve for Group Risk of Ahmednagar depot

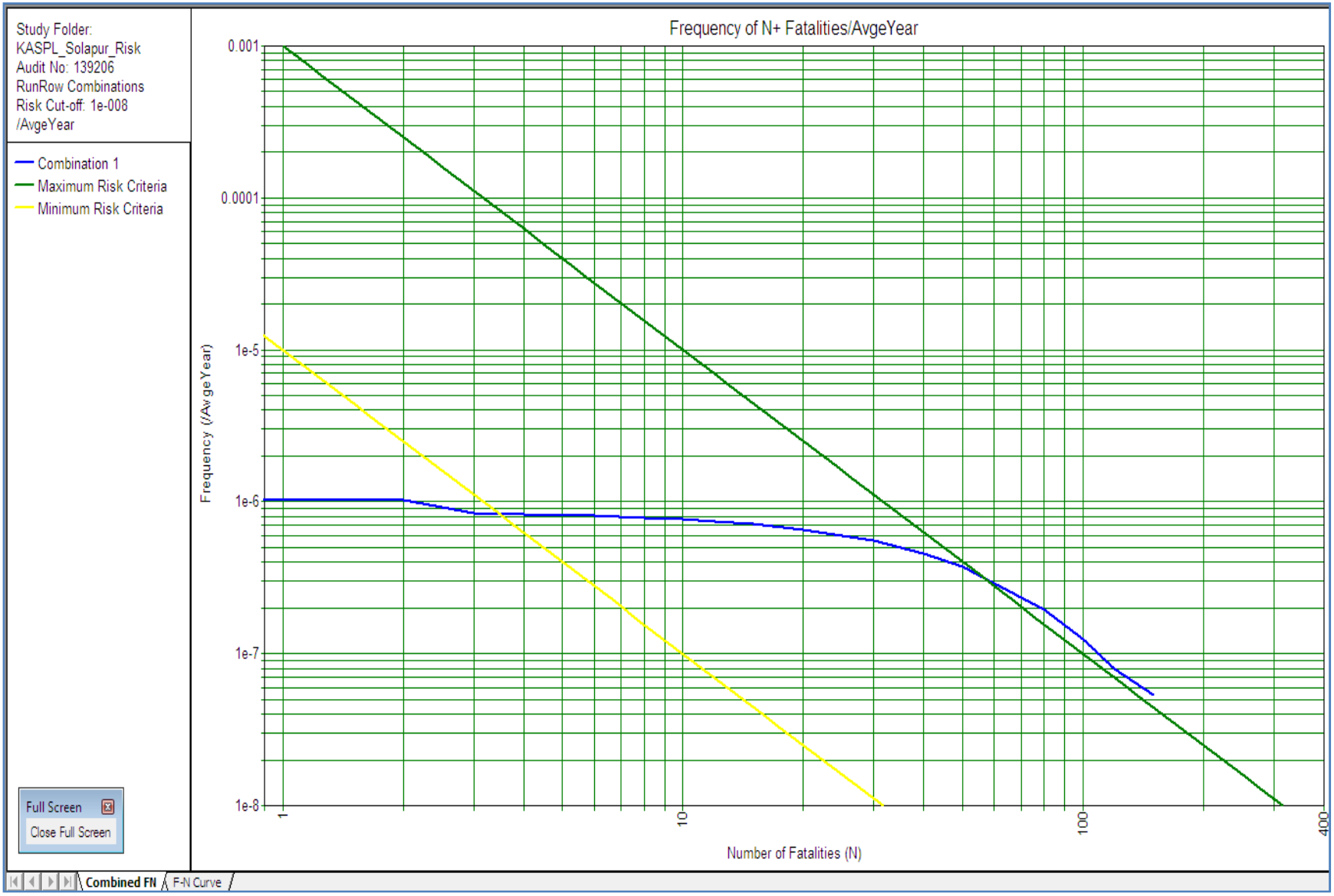


Figure 16 : F-N Curve for Group Risk of Solapur depot

Top risk contributors (Societal risk)

The present major contributing scenarios to societal risk form depot is broadly acceptable as it is lower part of ALARP region.

6.3 Fault Tree Analysis

Graphical representation of the logical structure displaying the relationship between an undesired potential event (top event) and all its probable causes

- Top-down approach to failure analysis
- Starting with a potential undesirable event - top event
- Determining all the ways in which it can occur
- Mitigation measures can be developed to minimize the probability of the undesired event.

6.3.1 Fault Tree can help to:

The following are the benefits of fault tree analysis.

- Quantifying probability of top event occurrence
- Evaluating proposed system architecture attributes
- Assessing design modifications and identify areas requiring attention
- Complying with qualitative and quantitative safety/reliability objectives
- Qualitatively illustrate failure condition classification of a top-level event
- Establishing maintenance tasks and intervals from safety/reliability assessments.

6.3.2 Fault tree construction

The following gates are used while construction of fault tree for a given process. The meaning and purpose of these are given in the below table.

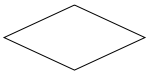
	**AND gate** The AND-gate is used to show that the output event occurs only if all the input events occur
	**OR gate** The OR-gate is used to show that the output event occurs only if one or more of the input events occur
	**Basic event** A basic event requires no further development because the appropriate limit of resolution has been reached
	**Intermediate event** A fault tree event occurs because of one or more antecedent causes acting through logic gates have occurred
	**Transfer** A triangle indicates that the tree is developed further at the occurrence of the corresponding transfer symbol
	**Undeveloped event** A diamond is used to define an event which is not further developed either because it is of insufficient consequence or because information is unavailable

Figure 17: Fault Tree Construction

6.3.3 Guidelines for developing a fault tree

Following guidelines are to be kept in mind while developing fault tree-

- Classify an event into more elementary events.
- Replace an abstract event by a less abstract event.
- Identify distinct causes for an event.
- Couple trigger event with 'no protective action'.
- Find co-operative causes for an event.
- Pinpoint a component failure event.

Below diagram shows the fault tree for the Project.

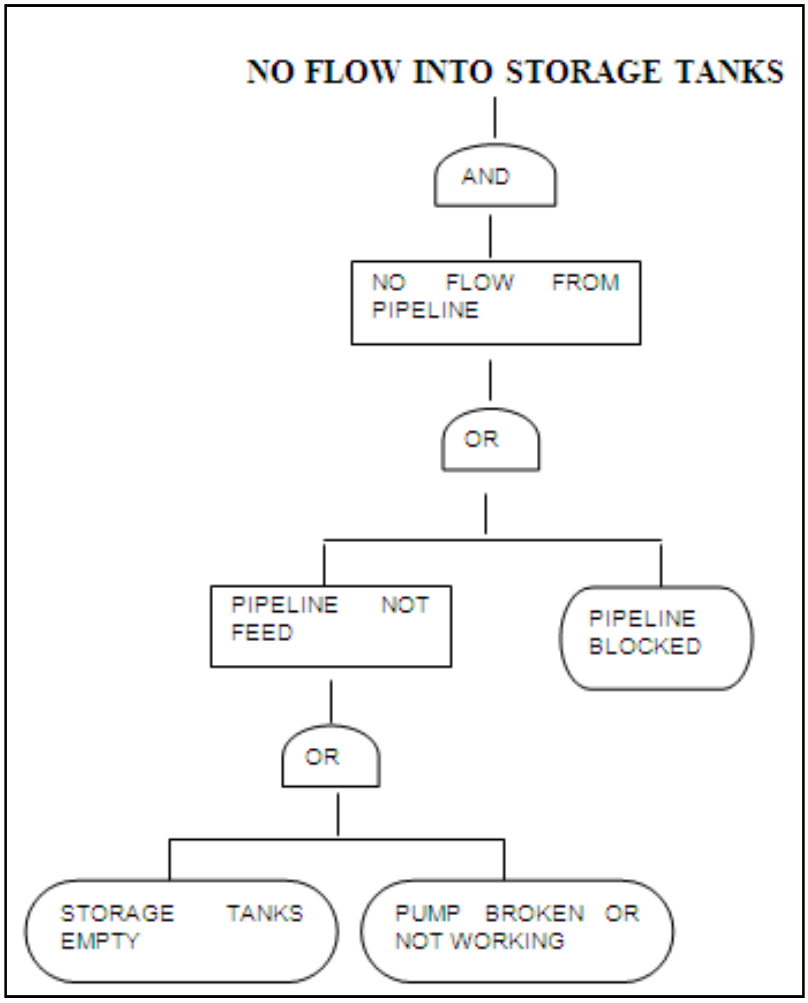


Figure 18: Fault Tree for the Project

6.4 Event Tree Analysis

An event tree is used to develop the various event outcome of a release and thereby estimate the result event frequency. An event tree is constructed by defining an initial event and the possible consequences that flow from this. The initial event is usually placed on the left and the branches are drawn to the right, each branch representing a different sequence of events and terminating in an outcome.

Each branch of the event tree represents a particular scenario. The tree is a means of estimating the frequency of the outcome for that scenario. For example, for a flammable release, a typical series of models are vapour dispersion, ignition, jet fire, pool fire and explosion.

The data used in Event tree analysis are discussed below:

6.4.1 Immediate Ignition

This is the probability that the release ignites immediately, at the release point, before the cloud has begun to disperse and to reach ignition sources away from the release point.

6.4.2 Delayed Ignition

The immediate ignition outcomes are defined to occur with precisely the probability defined by the event tree probabilities. On the other hand the delayed ignition outcomes occur at a frequency calculated by available ignition sources which are fired heater, ignition due to vehicle movement, general ignition (canteen, smoking booth), high tension line etc. The outcome of the delayed ignition of released hydrocarbon results in flash fire or explosion. An un-ignited release will normally disperse with little or no consequence (unless the gas is toxic), whereas a fire or explosion can potentially escalate to endanger the whole installation.

6.4.3 Explosion

The ignition of a free gas cloud may result in both explosion and flash-fire upon ignition. This is modelled as two separate events: as a pure flash fire and a pure explosion. The fraction that is modelled as an explosion has been considered as 0.42.

6.4.4 Materials that is both flammable and toxic

In reality the risk to personnel for a given event could be the result of toxic or flammable effects or combination of the two depending on the properties of the materials being released. Common examples of such flammable and toxic materials include hydrogen sulphide and hydrogen with lighter hydrocarbon (recycle gas section of hydro-treating). In such scenario, non-ignition probability shall be used to define the frequency of a subsequent toxic calculation.

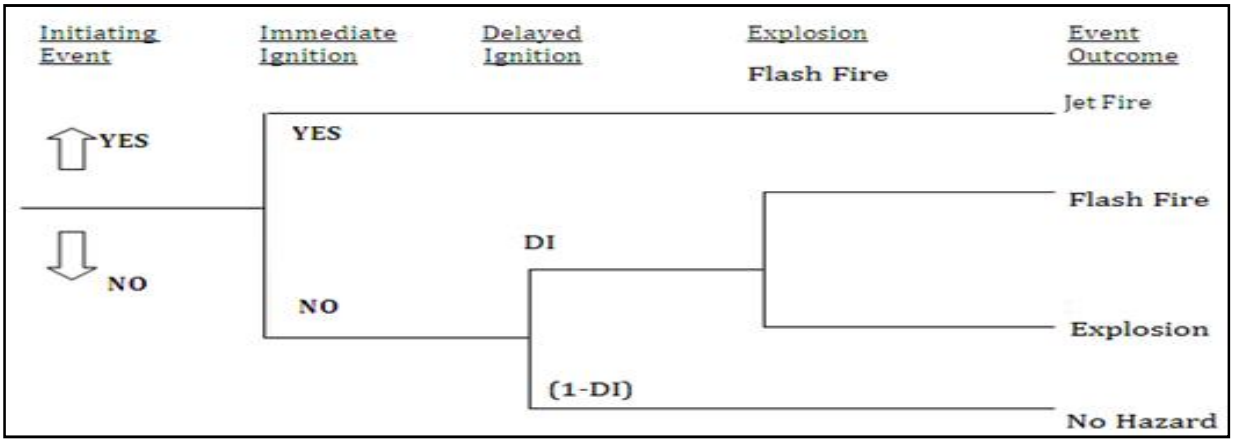


Figure 19: Event Tree for Continuous Gas Release

6.4.5 Delayed Ignition Probability (DI)

Delayed ignition probability to be calculated based on available ignition source on down-wind direction of released hydrocarbon. Available ignition source may be due to fired heaters, vehicle movement, smoking booth etc.

CHAPTER-7: COMPARISON AGAINST RISK ACCEPTANCE CRITERIA

A risk analysis provides a measure of the risks resulting from a particular facility or activity. It thus finds application as a decision making tool in situations where judgment has to be made about the tolerability of the risk posed by an existing/proposed activity. However, risk analysis produces only numbers, which themselves provide no inherent use. It is the assessment of those numbers that allows conclusions to be drawn and recommendations to be developed. The normal approach adopted is to relate the risk measures obtained to risk acceptance criteria.

Risk criteria, if they are to be workable, recognizes the following:

- There is a level of risk that is so high that it is considered unacceptable or intolerable regardless of the benefits derived from an activity.
- There is also a level of risk that is low enough as to be considered negligible.
- Levels of risk in between are to be considered tolerable subject to their being reduced As Low As is Reasonably Practicable (ALARP). (The meaning of ALARP is explained in the following sub-section.)
- The above is the formulation of the, now well-established, three tier structure of risk criteria and risk control.
- The risk criteria simply attempt to establish whether risk is “tolerable”. Below is a list of words generally in use and their meaning.

ACCEPTABLE RISKS: Since risks in general are unwelcome no risk should be called “acceptable”. It might be better to say that the activity may be acceptable generally, but the risks can only ever be tolerable.

TOLERABLE RISKS: are risks the exposed people are expected to bear without undue concern. A subtle difference is made out here between Acceptable Risks and Tolerable Risks though these terms are sometimes used interchangeably.

NEGLIGIBLE RISKS: are risks so small that there is no cause for concern and there is no reason to reduce them.

7.1 The ALARP Principle

The ALARP (As Low As is Reasonably Practicable) principle seeks to answer the question "What is an acceptable risk?" The definition may be found in the basis for judgment used in British law that one should be as safe as is reasonably practicable. Reasonably practicable is defined as implying "that a computation must be made in which the quantum of risk is placed on scale and the sacrifice involved in the measures necessary for averting the risk (whether in money, time, or trouble) is placed on the other, and that, if it be shown that there is a gross disproportion between them – risk being insignificant in relation to the sacrifice – the defendants discharge the onus upon them" The ALARP details are represented in the **Figure** given below-

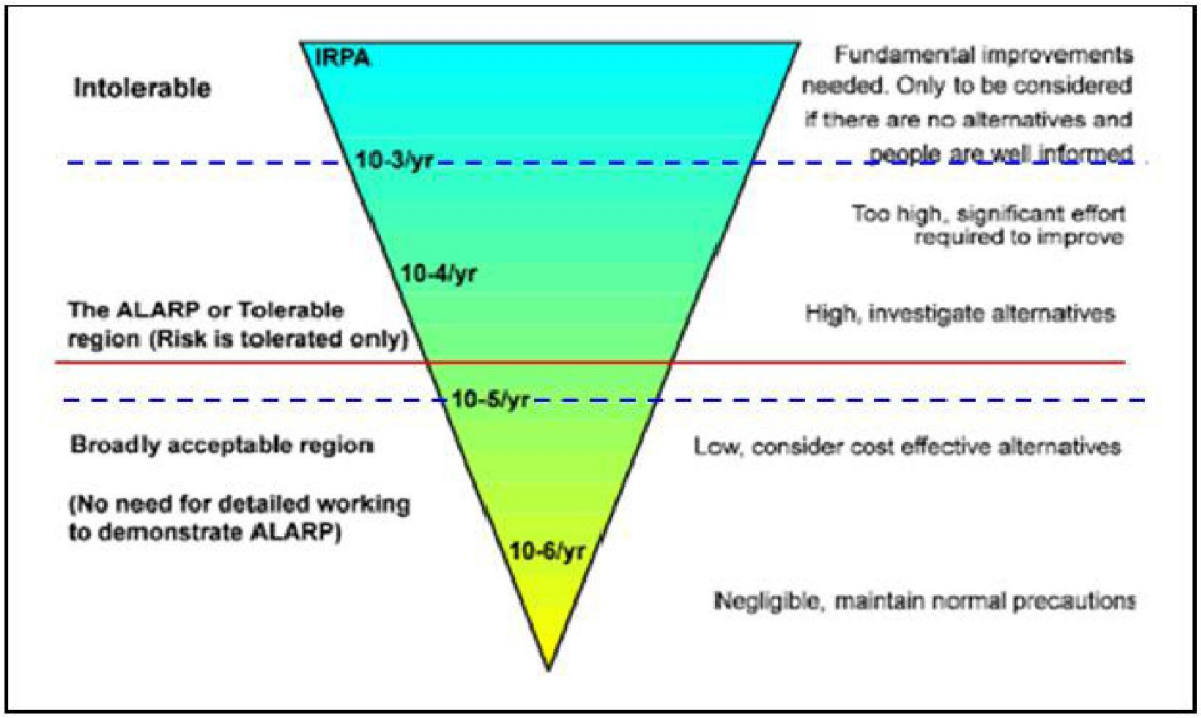


Figure 20: ALARP Detail

ALARP summary: The Individual and Societal risk per year of depot is lower of ALARP region and it is broadly acceptable.

CHAPTER-8: RECOMMENDATIONS FOR RISK REDUCTION

8.1 Conclusion and Recommendations

Although the results of this Risk analysis show that the risks to the public are broadly acceptable (or negligible), they will be sensitive to the specific design and/or modeling assumptions used.

The maximum risk to persons working in the terminal is 3.23 E-005 per year which is in the acceptable and in ALARP region. It is observed that the ISO-risk contour of 1.0 E-009 per year exists outside the terminal.

The major conclusions and recommendations based on the risk analysis of the identified representative failure scenarios are summarized below:

- KASPL Pipeline Project is covered in the process safety management system of IOCL.
- It is necessary to provide extensive fire detection system in the depot as per OISD guidelines. Operators are well trained about the fire and gas detection system.
- It is recommended to have necessary provision for emergency stop of critical equipments from control room (during commissioning) in the event of major leak/flash fire.
- The vehicles entering the Terminal should be fitted with spark arrestors.
- Routine checks to be done to ensure and prevent the presence of ignition sources in the immediate vicinity of the depot (near boundaries).
- Clearly defined escape routes shall be developed for each individual plots and section of the Depot taking into account the impairment of escape by hazardous releases and sign boards be erected in places to guide personnel in case of an emergency.
- Well defined Assembly points in safe locations shall be identified for personnel in case of an emergency.
- Windsocks shall be considered in the plant to ensure visibility from all directions. This will assist people to escape in upwind or cross wind direction from flammable releases.
- In order to further reduce the probability of failure of catastrophic rupture of pipeline and equipments, critical equipments shall be identified and inspection methodologies to be finalized for continuous monitoring during operation and shutdown maintenance.
- The active protection devices like fire water hydrant, water monitor and other protective devices shall be tested at regular intervals.

- There should be an SOP established for clarity of actions to be taken in case (during commissioning of pipeline project) of fire/leak emergency.

8.2 General Recommendations

1. Ensure that combustible flammable material is not placed near the Critical instrument of the depot. These could include oil filled cloth, wooden supports, oil buckets etc. these must be put away and the areas kept permanently clean and free from any combustibles. Secondary fires probability would be greatly reduced as a result of these simple but effective measures.
2. ROSOV at the Tanks and Hydrocarbon detector should be provided to the Storage tanks inside the terminal as per OISD guidelines.
3. Proper lighting arrangements and CCTV should be provided at terminal for new facilities inside the terminal.

8.3 Risk Reduction Recommendation and Mitigation Plan During Natural and Man Made Disaster:

8.3.1 Natural Calamities

Some general natural calamities are given in Table below-

S. No.	Natural Disaster	Mitigation Plan
1.	Flood	Main flood management programs includes various aspects such as construction of embankments, drainage improvements etc. When warning of impending flood conditions are recovered via weather broadcasts or the police / fire department, the following steps needs to be taken. • All the movable equipment and supplies are to be moved to other elevated areas • Outside areas are to be checked for equipment and materials that could be damaged by floodwaters • If time allows, sandbagged dykes are to be constructed to augment existing dykes and to protect high-risk items • Storage tanks/vessels are checked and secured.
2.	Earth Quake	• During earthquake, all personnel should evacuate buildings and proceed to areas away from walls and windows. • If evacuation is not possible, employees are to seek shelter under a desk, table etc., or in doorways that offer protection from falling objects. After the initial earthquake, aftershocks should be expected. • The shift officer should contact operators for a report on employee safety and a condition of plant facilities and equipment. The emergency brigade should begin rescue,

		first aid and damage control activities. • Emergency shutdown: As soon as possible, emergency shutdown procedures should be implemented, Operate ROV's, isolate valves. • After earth quake subsides, the personnel should inspect all the facilities for rescue, first aid and damage control activities, damage assessment, clean-up, restoration and recovery
3.	Excessive Rains	If the All the Print/Electronics media & all India radio issues a "Excessive Rains'', personnel should be assigned to monitor weather conditions, listen for broadcast warnings and report on the threatening conditions. The following steps are to be taken: • Personnel will be notified by the alarm • All plant personnel are to seek shelter in the administrative building, ground level interior rooms or rest rooms. • All non-essential utilities should be shut-off. • Closed watch of the level of floating roof tanks and OWS and other oil sumps and pits. Action to be taken accordingly. After the passing of a high wind, personnel should inspect their areas for damage, if the plant was stuck; emergency brigade personnel will begin rescue, first aid and damage control activities. Damage assessment, clean up and restoration and other recovery activities should follow.
4.	High Winds	If the All the Print/Electronics media & all India radio issues a "high wind caution'', personnel should be assigned to monitor weather conditions, listen for broadcast warnings

		and report on the threatening conditions. If a warning is issued by the Print/Electronics media & all India radio (meaning that a high wind has actually been shifted in the area) or if a funnel cloud is seen by plant personnel. The following steps are to be taken: • Personnel will be notified by the alarm • The emergency brigade is placed on alert • Plant personnel are to seek shelter in the administrative building, ground level interior rooms or rest rooms. • All non-essential utilities should be shut-off after the passing of a high wind, personnel should inspect their areas for damage, if the plant was stuck; emergency brigade personnel will begin rescue, first aid and damage control activities. Damage assessment, clean up and restoration and other recovery activities should follow.

8.3.2 Extraneous

S.No.	Man Made Disaster	Mitigation Plan
1.	Riots/Civil Disaster/ Mob Attack	Ensure police, mall security, district, regional and corporate notifications have been made as determined by corporate office and/or corporate legal. Do not confront rioters or looters to prevent property damage of looting of merchandise. Protect employees and customers from injury. Remind managers and employees, and customers as necessary, about safety protocols.
2.	Terrorism	Protect surveillance records and safeguard areas touched by Terrorist suspects in case of terrorism.

3.	Sabotage	Awareness of potential civil disturbance. Establish policies and safety protocols to address civil disturbances. Security for organizations needs to get tighter.
4.	Bomb Threat	Most bomb threats are hoaxes, intended to be disruptive, and if the threat evaluation indicates a response is warranted, must develop an incident action plan (IAP). As part of the pre-emergency planning, determine when you will activate the IAP, whether on receipt of the threat or on discovery of a suspicious package in the target area.
5.	War/ Hit by missiles	Protect surveillance records. Protect employees and customers from injury. Remind managers and employees, and customers as necessary, about safety protocols.
6.	Abduction	Security for organizations needs to get tighter.
7.	Food Poisoning/water Poisoning	Food poisoning occurs when sufficient numbers of particular types of bacteria, or their toxins, are present in the food you eat. These bacteria are called pathogens. Contact local council health department nearby hospitals. Contact local police in case of emergency.

8.4 Lessons to Be Learnt

Based on the San Juan incident a few lessons learnt are highlighted:

a) Facilities and installations with inherently high hazards should incorporate redundancy in safety systems and ensure their upkeep at all times.

b) Management should ensure that reliable systems are in place to give timely feedback on the current practices and state of readiness in different facilities.

c) Management must ensure that identified actions are being carried out.

d) A high priority on safety from the senior and top management groups will send the right signals down the line to ensure safety and production.

e) High degree of operational competence should be maintained at all times by building on the combined knowledge and experience of all the professional groups. The lessons learnt from all major incidents should be shared and widely disseminated in the entire Industry preferably through an appropriate website.

8.4.1 Safety Management System (SMS)

The failure probabilities largely depend upon how effectively Safety is being managed. This in turn necessitates formal documented Safety Management System (SMS), one that is effective. The features of a Safety Management System are described below.

Analysis of industrial accidents and disasters has clearly shown that these are not simply a consequence of direct technical failure or operator tasks carried out incorrectly. The underlying causes may be deeply rooted in management aspects of the organization. In some cases, the incidents could have been prevented with a formal Safety Management System (SMS). In other situations, a safety management system was in place, but did not prevent the occurrence of the incident. This suggests the need for a wider application of "best practice" safety management system in industry. Moreover, it raises the question of the quality of such systems.

Safety, Health and Environment (SHE) should be a function reporting at the highest management level. There is nothing unusual about this suggestion since such is the practice followed by renowned multi-nationals.

SHE management comprises of a number of elements. For the sake of completeness, as an example, the contents of the SHE program covered in the current practice are given below:

8.5 SMS Elements

- Management leadership, commitment and accountability
- Risk Analysis, Assessment and Management

- Facilities design and construction
- Process and facilities information and documentation
- Personnel safety
- Health
- Personnel
- Training
- Operation and Maintenance procedures
- Work permits
- Inspection and Maintenance
- Reliability and Control of defeat of critical systems & devices
- Pollution prevention
- Regulatory compliance
- Product stewardship
- Management of change
- Third party services
- Incident reporting, analysis and follow-up
- Emergency preparedness
- Community awareness
- Operations integrity assessment and improvement

These elements cannot be used as such. They need to be converted into workable procedures. The twenty one elements listed above for illustration, embrace over 100 distinct requirements with corporate guideline for each. These system and procedures should detail at least the following:

* Objectives and scope (What is required to be achieved)?
* Tools and procedures (How is it going to be achieved)?
* Resources and responsibilities (Who is responsible? Does he have commensurate resources?)
* Plans and measurement (How is the performance going to be measured?)
* System of monitoring and control (Audit procedures)

8.6 Mock Drill Exercises

Mock drill should be conducted once in six months. Exercises or Drills have two basic functions, namely training and testing. While exercises do provide an effective means of training in response procedures, their primary purpose is to test the adequacy of the emergency management system and to ensure that all response elements are fully capable of managing an emergency situation.

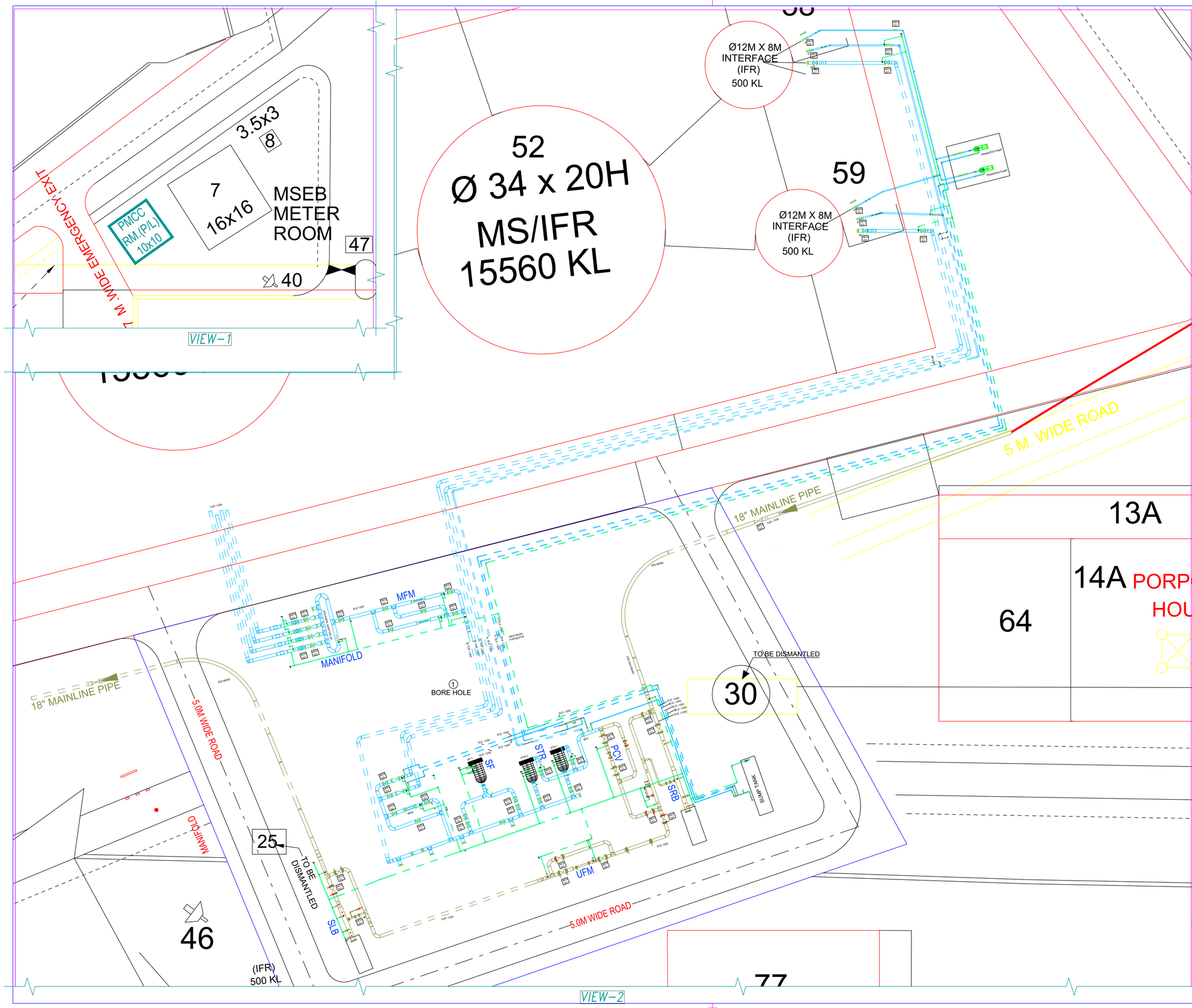
Mock drills are best means of accomplishing the following goals and objectives:

1. To reveal weaknesses in the plans and procedures before emergencies occur.
2. To identify deficiencies in resources (both in manpower and equipment).
3. To clarify each individual's role and areas of responsibility
4. To improve the level of co-ordination among various response personnel, departments and agencies.

ANNEXURE-A

Plant layouts

(Ahmednagar Delivery station)



NOTES:-

1. THIS IS A TYPICAL LAYOUT ONLY.
2. DETAILED LAYOUT WILL BE FINALIZED DURING ENGINEERING STAGE.
3. REQUIREMENT OF LAND SHALL BE AS PER ANNEXURE–II OF SCHEMATIC.
4. FACILITIES PROPOSED SHALL BE AS PER SCHEME NOTE.

S.NO.	REFERENCE DRAWING	DWG. NO.

PURPOSE: FOR TENDER PURPOSE ONLY

NO.	DATE	INI.	SIG.	INI.	SIG.	INI.	SIG.	INI.	SIG.	REVISION
00	27.01.17	SRS		BM		GKK		KLP		

DRAWN | DESIGNED | CHECKED | APPROVED | SUBJECT OF REVISION

इंडियन ऑयल कॉर्पोरेशन लिमिटेड (पाइपलाइन्स)
IndianOil INDIAN OIL CORPORATION LIMITED (PIPELINES)

KOYALI – DHULE – MANMAD–AHMEDNAGAR–SOLAPUR PRODUCT PIPELINE

GENERAL LAYOUT PLAN FOR AHMEDNAGAR DELIVERY STATION

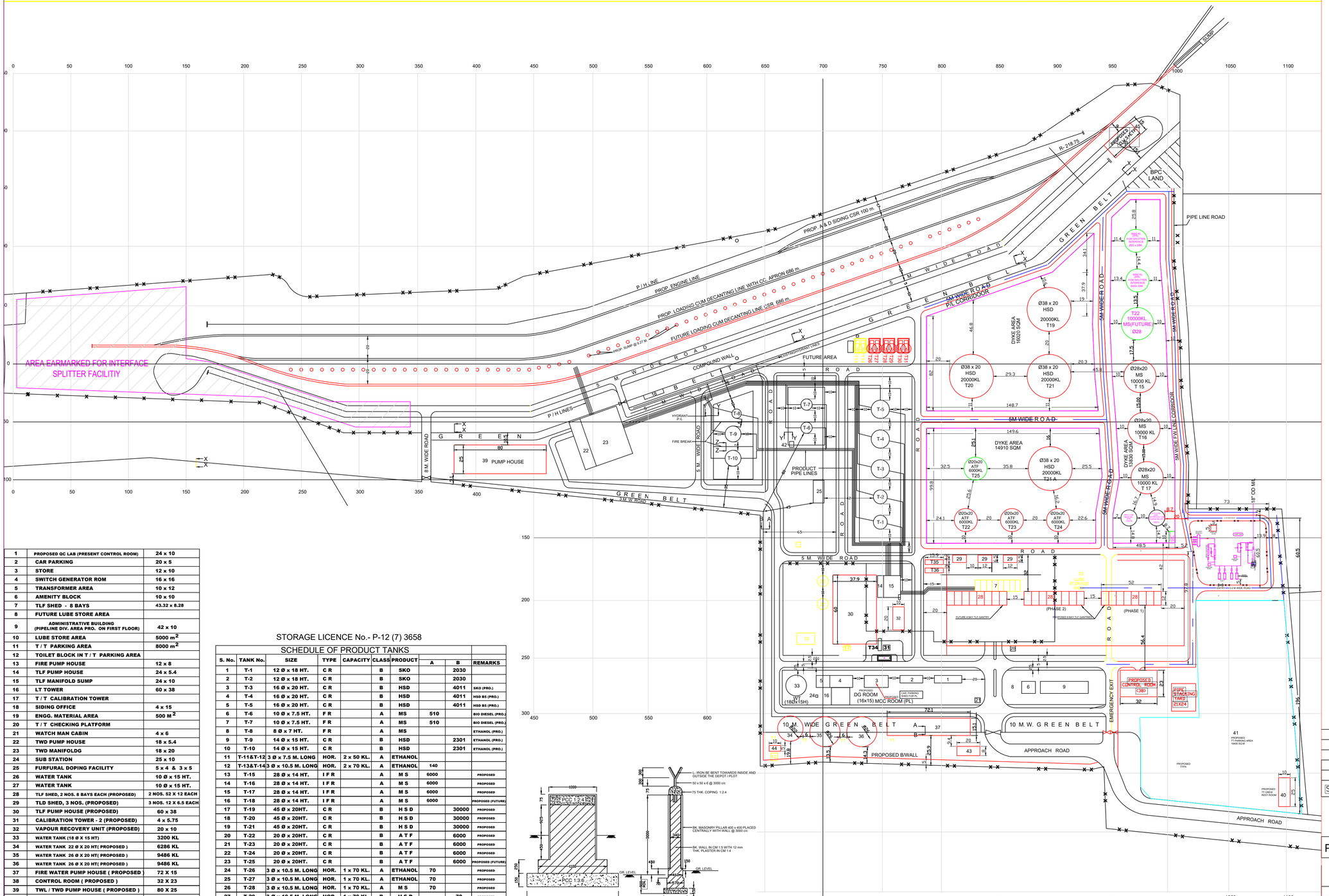
CAD FILE NO	DWG. NO.	SCALE	SIZE	SHEET
KASPL-118-00	9200-10607-302-001-00	1:300	A1	1 OF 1

IOCL A1 841x594

ANNEXURE-A

Plant layouts

(Solapur Delivery Station)



1	PROPOSED QC LAB (PRESENT CONTROL ROOM)	24 x 10
2	CAR PARKING	20 x 5
3	STORE	12 x 10
4	SWITCH GENERATOR ROM	16 x 16
5	TRANSFORMER AREA	10 x 12
6	AMENITY BLOCK	10 x 10
7	TLF SHED - 8 BAYS	43.32 x 8.28
8	FUTURE LUBE STORE AREA	
9	ADMINISTRATIVE BUILDING (PIPELINE DIV. AREA PRO. ON FIRST FLOOR)	42 x 10
10	LUBE STORE AREA	5000 m^2
11	T / T PARKING AREA	8000 m^2
12	TOILET BLOCK IN T / T PARKING AREA	
13	FIRE PUMP HOUSE	12 x 8
14	TLF PUMP HOUSE	24 x 5.4
15	TLF MANIFOLD SUMP	24 x 10
16	LT TOWER	60 x 38
17	T / T CALIBRATION TOWER	
18	SIDING OFFICE	4 x 15
19	ENGG. MATERIAL AREA	500 m^2
20	T / T CHECKING PLATFORM	
21	WATCH MAN CABIN	4 x 6
22	TWD PUMP HOUSE	18 x 5.4
23	TWD MANIFOLDG	18 x 20
24	SUB STATION	25 x 10
25	FURFURAL DOPING FACILITY	5 x 4 & 3 x 5
26	WATER TANK	10 Ø x 15 HT.
27	WATER TANK	10 Ø x 15 HT.
28	TLF SHED, 2 NOS. 8 BAYS EACH (PROPOSED)	2 NOS. 52 X 12 EACH
29	TLD SHED, 3 NOS. (PROPOSED)	3 NOS. 12 X 6.5 EACH
30	TLF PUMP HOUSE (PROPOSED)	60 x 38
31	CALIBRATION TOWER - 2 (PROPOSED)	4 x 5.75
32	VAPOUR RECOVERY UNIT (PROPOSED)	20 x 10
33	WATER TANK (18 Ø X 15 HT)	3200 KL
34	WATER TANK 22 Ø X 20 HT(PROPOSED)	6286 KL
35	WATER TANK 26 Ø X 20 HT(PROPOSED)	9486 KL
36	WATER TANK 26 Ø X 20 HT(PROPOSED)	9486 KL
37	FIRE WATER PUMP HOUSE (PROPOSED)	72 X 15
38	CONTROL ROOM (PROPOSED)	32 X 23
39	TWL / TWD PUMP HOUSE (PROPOSED)	80 X 25
40	TT CREW REST ROOM (PROPOSED)	25 X 10
41	TT PARKING AREA (PROPOSED)	18400 SQ.M
42	SAMPLE ROOM	5 X 5
43	CENTRALIZED FOAM PH (PROPOSED)	20X 8
44	STATIC WATER TANKS (PROPOSED)	100 K L
45	MECHANIZED OWS+ ETP (PROPOSED)	30 X 15

STORAGE LICENCE No.- P-12 (7) 3658

SCHEDULE OF PRODUCT TANKS

S. No.	TANK No.	SIZE	TYPE	CAPACITY	CLASS	PRODUCT	A	B	REMARKS
1	T-1	12 Ø x 18 HT.	C R		B	SKO		2030	
2	T-2	12 Ø x 18 HT.	C R		B	SKO		2030	
3	T-3	16 Ø x 20 HT.	C R		B	HSD		4011	SKO (PRO.)
4	T-4	16 Ø x 20 HT.	C R		B	HSD		4011	HSD BS (PRO.)
5	T-5	16 Ø x 20 HT.	C R		B	HSD		4011	HSD BS (PRO.)
6	T-6	10 Ø x 7.5 HT.	F R		A	MS	510		BIO DIESEL (PRO.)
7	T-7	10 Ø x 7.5 HT.	F R		A	MS	510		BIO DIESEL (PRO.)
8	T-8	8 Ø x 7 HT.	F R		A	MS			ETHANOL (PRO.)
9	T-9	14 Ø x 15 HT.	C R		B	HSD		2301	ETHANOL (PRO.)
10	T-10	14 Ø x 15 HT.	C R		B	HSD		2301	ETHANOL (PRO.)
11	T-11&T-12	3 Ø x 7.5 M. LONG	HOR.	2 x 50 KL.	A	ETHANOL			
12	T-13&T-14	3 Ø x 10.5 M. LONG	HOR.	2 x 70 KL.	A	ETHANOL	140		
13	T-15	28 Ø x 14 HT.	I F R		A	M S	6000		PROPOSED
14	T-16	28 Ø x 14 HT.	I F R		A	M S	6000		PROPOSED
15	T-17	28 Ø x 14 HT.	I F R		A	M S	6000		PROPOSED
16	T-18	28 Ø x 14 HT.	I F R		A	M S	6000		PROPOSED (FUTURE)
17	T-19	45 Ø x 20HT.	C R		B	H S D		30000	PROPOSED
18	T-20	45 Ø x 20HT.	C R		B	H S D		30000	PROPOSED
19	T-21	45 Ø x 20HT.	C R		B	H S D		30000	PROPOSED
20	T-22	20 Ø x 20HT.	C R		B	A T F		6000	PROPOSED
21	T-23	20 Ø x 20HT.	C R		B	A T F		6000	PROPOSED
22	T-24	20 Ø x 20HT.	C R		B	A T F		6000	PROPOSED
23	T-25	20 Ø x 20HT.	C R		B	A T F		6000	PROPOSED (FUTURE)
24	T-26	3 Ø x 10.5 M. LONG	HOR.	1 x 70 KL.	A	ETHANOL	70		PROPOSED
25	T-27	3 Ø x 10.5 M. LONG	HOR.	1 x 70 KL.	A	ETHANOL	70		PROPOSED
26	T-28	3 Ø x 10.5 M. LONG	HOR.	1 x 70 KL.	A	M S	70		PROPOSED
27	T-29	3 Ø x 10.5 M. LONG	HOR.	1 x 70 KL.	B	H S D		70	PROPOSED
28	T-30	3 Ø x 10.5 M. LONG	HOR.	1 x 70 KL.	B	S K O		70	PROPOSED
29	T-31	3 Ø x 10.5 M. LONG	HOR.	1 x 70 KL.		SLOP		70	PROPOSED
30	T-32	10 Ø x 10HT.	I F R		A	INTERFACE	500		PROPOSED
31	T-33	10 Ø x 10HT.	I F R		B	INTERFACE		500	PROPOSED
32	T-34	3 Ø x 10.5 M. LONG	HOR.	1 x 70 KL.		WATER			PROPOSED
33	T-35&T-36	4.2 Ø x 15.9M. LONG	HOR.	2 x200 KL.		BIO DIESEL	400		PROPOSED

S.NO.	REFERENCE DRAWING	DWG. NO.

PURPOSE: FOR TENDER PURPOSE ONLY

NO.	DATE	INI.	SIG.	INI.	SIG.	INI.	SIG.	INI.	SIG.	REVISION	DRAWN	DESIGNED	CHECKED	APPROVED	SUBJECT OF REVISION
00	26.04.17	DN		BM		VS		LM							

इंडियन ऑयल कॉर्पोरेशन लिमिटेड (पाइपलाइन्स)
IndianOil INDIAN OIL CORPORATION LIMITED (PIPELINES)
KOYALI – AHMEDNAGAR – SOLAPUR PRODUCT PIPELINE

GENERAL LAYOUT PLAN FOR SOLAPUR DELIVERY STATION

CAD FILE NO	DWG. NO.	SCALE	SIZE	SHEET
KASPL-119-00	9200-10609-302-001-00	1:500	A1	1 OF 1

N-24130

IOCL A1 841x594

ANNEXURE- B
Meteorological Sheets
(AHMEDNAGAR)

जलवायवी सारणी
CLIMATOLOGICAL TABLE

BACK

स्टेशन : अहमदनगर **अक्षांश** LAT. 19° 05' N **देशांतर** LONG. 74° 48' E **समुद्री तल माध्य से ऊंचाई** *HEIGHT ABOVE M.S.L.* 657 मीटर *METRES* **प्रक्षणों पर आधारित** **BASED ON OBSERVATIONS** **1961-1990**

STATION : Ahmednagar

माह / MONTH		स्टेशन का सतह दाब / STATION LEVEL PRESSURE	वायु तापमान / AIR TEMPERATURE										आर्द्रता / HUMIDITY		मेघ की मात्रा / CLOUD AMOUNTS		वर्षा / RAINFALL						
			माध्य / MEAN						चरम / EXTREMES														
			शुष्क बल्ब / DRY BULB	नम बल्ब / WET BULB	दैनिक अधिकतम / DAILY MAX	दैनिक न्यूनतम / DAILY MIN	माह में उच्चतम / HIGHEST IN THE MONTH	माह में निम्नतम / LOWEST IN THE MONTH	उच्चतम / HIGHEST	दिनांक और वर्ष / DATE AND YEAR	निम्नतम / LOWEST	दिनांक और वर्ष / DATE AND YEAR	सापेक्ष आर्द्रता / RELATIVE HUMIDITY	वाष्प दाब / VAPOUR PRESSURE	समस्त मेघ / ALL CLOUDS	निम्न मेघ / LOW CLOUDS	मासिक योग / MONTHLY TOTAL	वर्षा के दिनोंकी संख्या / NO. OF RAINY DAYS	वर्षसहित सबसे नम महीने का योग / TOTAL IN WETTEST MONTH WITH YEAR	वर्षसहित शुष्कतम महीने का योग / TOTAL IN DRIEST MONTH WITH YEAR	24 घंटोकी सबसे भारी वर्षा / HEAVIEST FALL IN 24 HOURS	दिनांक और वर्ष / DATE AND YEAR	माध्य पवन गति / MEAN WIND SPEED
		एच.पी.ए hPa	डि. से °C	डि. से °C	डि. से °C	डि. से °C	डि. से °C	डि. से °C	डि. से °C		डि. से °C		प्रतिशत %	एच.पी.ए hPa	आकाश के अष्ठमाश Oktas of sky		मि.मि. mm		मि.मि. mm	मि.मि. mm	मि.मि. mm		कि.मी. प्र. घं. Kmph
जनवरी / JAN	I	941.3	16.7	12.2	30.6	12.3	33.2	8.6	36.1	19	2.2	07	58	11.3	1.1	0.3	0.3	0.0	58.9	0.0	51.6	08	5.0
	II	937.8	28.3	17.8						1897		1945	34	13.1	1.3	0.6			1920			1941	
फरवरी / FEB	I	940.2	19.1	13.1	33.1	14.1	35.9	9.7	38.9	19	2.8	02	48	11.1	0.7	0.2	1.4	0.1	66.5	0.0	42.9	08	5.8
	II	936.7	31.1	18.4						1897		1911	28	12.5	1.0	0.4			1894			1894	
मार्च / MAR	I	939.2	23.9	15.2	36.3	17.8	39.2	12.9	41.0	29	7.5	17	38	11.3	0.9	0.3	4.9	0.4	94.2	0.0	88.4	26	6.6
	II	935.3	34.3	19.1						1973		1980	21	11.2	1.8	1.0			1938			1938	
अप्रैल / APR	I	937.3	27.9	17.9	39.3	21.4	41.8	17.2	43.5@	14	10.6	22	36	13.4	1.3	0.5	5.1	0.5	76.7	0.0	71.9	19	7.6
	II	933.1	37.0	20.6						1981		1926	20	12.5	2.4	1.4			1937			1937	
मई / MAY	I	935.2	28.4	20.4	39.4	22.7	42.1	19.0	43.9	11	15.2	19	48	18.4	1.6	0.6	22.2	1.6	165.6	0.0	119.9	16	9.2
	II	931.1	36.7	22.1						1967		1982	27	15.9	2.9	1.6			1933			1915	
जून / JUN	I	932.5	25.6	22.3	33.8	22.2	39.0	20.3	43.3@	03	18.3@	18	74	24.5	5.0	2.3	85.3	5.7	404.4	0.0	177.3	28	9.9
	II	929.4	30.3	23.2						1920		1907	56	23.5	5.6	3.2			1892			1931	
जुलाई / JUL	I	931.7	24.4	22.1	30.2	21.4	33.9	20.0	37.7	11	17.8	19	81	24.9	6.2	3.2	84.9	5.8	325.6	4.3	174.0	06	10.3
	II	929.4	27.6	23.0						1966		1944	68	24.9	6.2	3.4			1938	1971		1911	
अगस्त / AUG	I	932.8	23.7	21.5	29.4	20.8	33.0	19.0	39.5	02	16.1	29	82	24.2	6.0	3.1	85.7	5.5	269.7	0.0	147.3	03	9.1
	II	930.3	26.8	22.5						1982		1913	69	24.2	6.1	3.2			1958			1957	
सितम्बर / SEP	I	935.6	23.6	21.3	30.9	20.2	34.3	17.4	38.2	15	10.7	16	82	23.9	4.6	2.4	174.3	8.4	446.5	0.0	190.0	18	6.6
	II	932.4	27.7	22.6						1972		1979	65	23.7	5.6	3.2			1933			1970	
अक्तूबर / OCT	I	938.7	23.9	19.6	32.6	18.7	35.3	14.6	39.7	22	10.6	24	67	20.0	2.4	1.0	68.9	3.4	504.2	0.0	148.0	25	6.0
	II	935.4	29.5	21.1						1981		1914	48	19.4	3.2	1.6			1990			1990	
नवम्बर / NOV	I	940.8	20.9	16.4	30.9	15.4	33.4	11.1	35.6	10	5.6	21	63	15.7	1.8	0.6	30.6	1.7	256.0	0.0	124.7	23	5.6
	II	937.7	27.5	19.2						1898		1892	46	16.7	2.3	0.8			1922			1948	
दिसम्बर / DEC	I	941.7	17.5	13.3	29.8	12.5	32.2	8.3	35.0	20	3.3	28	62	12.6	1.6	0.6	11.8	0.7	129.4	0.0	70.2	03	4.7
	II	938.4	26.8	17.9						1980		1926	41	14.3	1.7	0.6			1962			1962	
वार्षिक योग या माध्य / ANNUAL TOTAL OR MEAN	I	937.3	23.0	17.9	33.0	18.3	42.3	7.6	43.9		2.2		62	17.6	2.8	1.3	575.4	33.8	1150.0	205.3	190.0		7.2
	II	933.9	30.3	20.6									44	17.7	3.3	1.8			1990	1972			
वर्षोंकी सं / NUMBER OF YEARS	I	30	30	30	30	29	30	29	99		99		30	29	29	28	30	30	100	100	100		30
	II	30	30	30									30	29	29	28							

जलवायवी सारणी
CLIMATOLOGICAL TABLE

स्टेशन : अहमदनगर
STATION : Ahmednagar

		मौसम परिघटना						पवन												मेघ										दृश्यता				
		के साथ दिनों की संख्या						पवन की गती के साथ दिनों की संख्या (कि. मी. प्र. घं.)				पवन की दिशा के दिनों की संख्या का प्रतिशत										मेघ मात्रा (सभी मेघ) सहित दिनों की संख्या - अष्ठमांश					निम्न स्तरी मेघ मात्रा सहित दिनों की संख्या - अष्ठमांश						दृश्यता सहित दिनों की संख्या				
माह		वर्षण 0.3 मि.मि.या अधिक	ओले	गर्जन	कुहरा	धूल भरी आंधी	चंड वात	62 या अधिक	20-61	1-19	0	उ	उपू	पू	दपू	द	दप	प	उप	शांत	0	ले-2	3-5	6-7	8	0	ले-2	3-5	6-7	8	कुहरा 8	1 कि.मी. तक	1-4 कि.मी.	4-10 कि.मी.	10-20 कि.मी.	20 कि.मी. से अधिक
		WEATHER PHENOMENA						WIND													CLOUD										VISIBILITY				
		No. OF DAYS WITH						No. OF DAYS WITH WIND SPEED (Km. p. h.)				PERCENTAGE No. OF DAYS WIND FROM									No. OF DAYS WITH CLOUD AMOUNT (ALL CLOUDS) O K T A S					No. OF DAYS WITH LOW CLOUD AMOUNT O K T A S						No. OF DAYS WITH VISIBILITY				
MONTH		PPT 0.3 mm Or more	HAIL	THUN DER	FOG	DUST STORM	SQU ALL	62 Or more	20-61	1-19	0	N	NE	E	SE	S	SW	W	NW	CALM	0	T-2	3-5	6-7	8	0	T-2	3-5	6-7	8	FOG 8	UP TO 1 Km.	1-4 Kms.	4-10 Kms.	10-20 Kms.	OVER 20 Kms.
जनवरी	I	0.1	0.0	0.0	0.0	0.0	0.0	0	0	19	12	2	6	0	15	4	6	2	25	40	23	3	2	2	1	27	2	1	1	0	0	0.1	2.8	5.3	4.4	18.4
JAN	II							0	0	24	7	3	21	2	13	5	16	2	16	22	21	3	4	2	1	25	3	2	1	0	0	0.0	0.0	0.3	7.0	23.7
फरवरी	I	0.2	0.0	0.1	0.0	0.0	0.0	0	0	18	10	2	7	0	9	4	4	3	35	36	23	2	2	1	0	26	1	1	0	0	0	0.0	1.1	4.9	4.5	17.5
FEB	II							0	0	24	4	4	17	1	10	1	17	3	32	15	19	4	4	1	0	23	3	2	0	0	0	0.0	0.0	0.3	5.1	22.6
मार्च	I	0.8	0.0	0.3	0.0	0.0	0.0	0	0	24	7	6	12	1	7	2	4	1	43	24	24	2	3	2	0	28	2	1	0	0	0	0.0	1.8	5.4	4.4	19.4
MAR	II							0	0	27	4	4	20	1	8	2	13	3	37	12	18	3	6	3	1	22	5	3	1	0	0	0.0	0.2	0.7	5.4	24.7
अप्रैल	I	0.9	0.0	0.3	0.0	0.0	0.0	0	0	25	5	7	12	1	5	2	4	1	49	19	21	2	4	2	1	26	2	2	0	0	0	0.0	1.3	4.7	3.9	20.1
APR	II							0	1	25	4	5	20	1	5	1	8	3	43	14	15	3	6	4	2	18	5	4	2	1	0	0.0	0.1	0.6	6.0	23.3
मई	I	2.1	0.0	0.3	0.0	0.0	0.0	0	0	27	4	6	6	1	3	1	6	3	61	13	20	3	4	2	2	25	3	2	0	1	0	0.1	1.5	5.1	3.4	20.9
MAY	II							0	2	27	2	4	14	1	3	0	9	2	60	7	13	3	8	5	2	15	7	6	2	1	0	0.0	0.1	1.9	6.3	22.7
जून	I	8.0	0.0	0.6	0.0	0.0	0.0	0	1	27	2	2	1	0	2	0	39	14	34	8	4	2	8	9	7	11	8	6	3	2	0	0.0	1.7	6.3	9.6	12.4
JUN	II							0	4	24	2	1	4	0	1	1	36	12	40	5	2	1	7	13	7	6	8	10	3	3	0	0.0	1.0	3.9	9.6	15.5
जुलाई	I	9.5	0.0	0.1	0.0	0.0	0.0	0	1	28	2	0	1	0	1	1	56	14	20	7	1	1	6	11	12	6	9	9	2	5	0	0.1	1.4	7.6	13.7	8.2
JUL	II							0	4	26	1	0	2	0	1	0	49	15	30	3	1	1	7	10	12	4	9	11	3	4	0	0.0	0.7	6.0	13.0	11.3
अगस्त	I	9.3	0.0	0.1	0.0	0.0	0.0	0	0	29	2	1	1	0	1	0	47	16	26	8	1	1	7	10	12	6	11	7	3	4	0	0.0	3.1	5.4	12.7	9.8
AUG	II							0	2	27	2	1	2	0	1	0	37	17	35	7	1	1	7	12	10	4	10	10	3	4	0	0.0	0.4	5.0	12.0	13.6
सितम्बर	I	11.0	0.0	0.1	0.0	0.0	0.0	0	0	25	5	6	7	0	4	0	21	7	37	18	6	3	8	6	7	12	8	5	2	3	0	0.0	1.3	4.7	10.4	13.6
SEP	II							0	1	25	4	3	15	1	3	1	17	7	41	12	3	1	8	10	8	6	8	10	3	3	0	0.0	0.4	2.9	10.1	16.6
अक्तूबर	I	4.7	0.0	0.1	0.0	0.0	0.0	0	0	23	8	6	19	0	13	2	8	1	26	25	15	4	6	3	3	20	6	3	1	1	0	0.0	1.0	4.3	5.6	20.1
OCT	II							0	0	28	3	5	47	3	9	1	5	1	19	10	12	3	7	5	4	15	8	5	2	1	0	0.0	0.1	1.6	6.1	23.2
नवम्बर	I	1.8	0.0	0.0	0.1	0.0	0.0	0	0	20	10	2	11	1	23	3	6	2	18	34	19	3	3	2	3	24	2	2	1	1	0	0.1	1.2	4.4	3.9	20.4
NOV	II							0	0	24	6	2	48	3	14	1	5	0	7	20	16	3	5	3	3	22	4	2	1	1	0	0.0	0.2	1.2	4.9	23.7
दिसम्बर	I	0.9	0.0	0.0	0.0	0.0	0.0	0	0	17	14	1	6	1	16	4	7	1	17	47	20	3	4	2	2	26	2	1	1	1	0	0.0	1.1	6.6	3.4	19.9
DEC	II							0	0	23	8	2	38	3	11	3	10	1	5	27	19	3	5	2	2	24	4	2	1	0	0	0.0	0.0	0.6	6.1	24.3
वार्षिक योग या माध्य ANNUAL TOTAL OR MEAN	I	49.3	0.0	2.0	0.1	0.0	0.0	0	2	282	81	3	7	0	8	2	17	5	33	23	177	29	57	52	50	237	56	40	14	18	0	0.4	19.3	64.7	79.9	200.7
	II							0	14	304	47	3	21	1	7	1	19	6	30	13	140	29	74	70	52	184	74	67	22	18	0	0.0	3.2	25.0	91.6	245.2
वर्षोंकी सं NUMBER OF YEARS	I	30						30				30									28					28						29				
	II							30				30									28					28						29				

ANNEXURE B
Meteorological Sheets
(Solapur)

जलवायवी सारणी
CLIMATOLOGICAL TABLE

BACK

स्टेशन : सोलापुर
STATION : Solapur

अक्षांश LAT. 17° 40' N देशांतर LONG. 75° 54' E समुद्री तल माध्य से ऊंचाई *HEIGHT ABOVE M.S.L.* 479 मीटर *METRES* प्रक्षणों पर आधारित **BASED ON OBSERVATIONS** **1961-1990**

माह / MONTH		स्टेशन का सतह दाब / STATION LEVEL PRESSURE	वायु तापमान / AIR TEMPERATURE — माध्य / MEAN: शुष्क बल्ब / DRY BULB	नम बल्ब / WET BULB	दैनिक अधिकतम / DAILY MAX	दैनिक न्यूनतम / DAILY MIN	माह में उच्चतम / HIGHEST IN THE MONTH	माह में निम्नतम / LOWEST IN THE MONTH	चरम / EXTREMES: उच्चतम / HIGHEST	दिनांक और वर्ष / DATE AND YEAR	निम्नतम / LOWEST	दिनांक और वर्ष / DATE AND YEAR	आर्द्रता / HUMIDITY: सापेक्ष आर्द्रता / RELATIVE HUMIDITY	वाष्प दाब / VAPOUR PRESSURE	मेघ की मात्रा / CLOUD AMOUNTS: समस्त मेघ / ALL CLOUDS	निम्न मेघ / LOW CLOUDS	वर्षा / RAINFALL: मासिक योग / MONTHLY TOTAL	वर्षा के दिनोंकी संख्या / NO. OF RAINY DAYS	वर्षसहित सबसे नम महीने का योग / TOTAL IN WETTEST MONTH WITH YEAR	वर्षसहित शुष्कतम महीने का योग / TOTAL IN DRIEST MONTH WITH YEAR	24 घंटोकी सबसे भारी वर्षा / HEAVIEST FALL IN 24 HOURS	दिनांक और वर्ष / DATE AND YEAR	माध्य पवन गति / MEAN WIND SPEED
		एच.पी.ए hPa	डि. सें °C	डि. सें °C	डि. सें °C	डि. सें °C	डि. सें °C	डि. सें °C	डि. सें °C		डि. सें °C		प्रतिशत %	एच.पी.ए hPa	आकाश के अष्ठमाश Oktas of sky		मि.मि. mm		मि.मि. mm	मि.मि. mm	मि.मि. mm		कि.मी. प्र. घं. Kmph
जनवरी / JAN	I	961.3	19.6	14.8	30.9	16.2	33.3	12.5	36.7	31	4.4	07	59	13.6	1.3	0.2	4.6	0.2	59.2	0.0	48.8	06	7.0
	II	957.3	29.5	18.2						1897		1945	30	12.7	1.9	0.7			1926			1943	
फरवरी / FEB	I	959.9	21.7	15.0	34.1	18.2	36.6	14.2	39.4	25	6.1	02	47	12.4	0.9	0.1	6.7	0.6	47.0	0.0	34.3	04	7.1
	II	955.6	32.6	19.0						1886		1911	25	12.3	1.7	0.8			1928			1928	
मार्च / MAR	I	958.6	25.7	17.3	37.4	21.8	40.1	17.2	43.9	28	12.2	10	42	13.8	1.2	0.1	5.6	0.5	85.9	0.0	43.0	27	7.3
	II	953.8	36.0	20.6						1892		1886	22	13.1	2.4	1.5			1893			1989	
अप्रैल / APR	I	956.4	28.9	20.7	39.9	24.8	42.4	21.2	44.7@	27	13.9	02	47	18.7	1.8	0.4	10.0	0.9	100.3	0.0	48.0	26	7.7
	II	951.2	38.1	22.1						1973		1905	23	14.9	3.6	2.3			1907			1907	
मई / MAY	I	954.4	28.9	22.8	40.2	25.2	43.0	22.0	46.0	10	16.1	26	59	23.4	2.7	0.6	30.2	2.5	141.2	0.0	76.0	04	9.8
	II	949.2	37.9	22.9						1988		1885	26	16.9	4.2	2.5			1893			1966	
जून / JUN	I	952.4	26.3	23.1	34.8	23.4	39.9	21.2	45.6	01	17.2	27	76	25.9	5.3	1.8	119.8	7.0	378.9	11.9	143.8	07	10.3
	II	948.5	32.0	23.4						1923		1922	49	22.4	6.1	3.6			1990	1884		1882	
जुलाई / JUL	I	952.0	25.0	22.6	31.7	22.5	35.2	21.0	38.9	01	18.3	09	81	25.7	6.0	2.1	131.7	8.8	369.6	3.3	160.3	16	10.0
	II	948.9	29.2	22.9						1912		1914	59	23.5	6.8	3.9			1989	1899		1907	
अगस्त / AUG	I	952.9	24.3	22.0	31.0	21.9	34.6	20.6	40.0	10	15.0	30	81	24.8	5.7	1.9	135.3	8.7	518.8	7.9	191.0	12	9.2
	II	949.5	28.7	22.5						1965		1956	59	22.8	6.7	3.8			1958	1921		1940	
सितम्बर / SEP	I	955.3	24.4	21.9	31.9	21.8	35.1	20.0	37.2@	28	17.5	16	80	24.5	5.0	1.6	189.2	9.5	462.6	2.3	169.9	07	7.6
	II	951.3	29.4	22.1						1972		1959	54	21.4	6.2	3.4			1981	1896		1895	
अक्तूबर / OCT	I	958.1	24.9	20.6	32.8	21.0	35.3	17.4	38.5	07	12.8	27	67	21.2	3.1	0.8	89.5	4.5	277.2	0.0	125.5	24	7.7
	II	954.2	30.4	20.5						1965		1882	41	17.0	4.2	2.0			1975			1957	
नवम्बर / NOV	I	960.5	22.6	17.8	31.2	18.2	33.4	14.1	36.1	28	7.8	24	62	17.0	2.3	0.5	25.1	1.6	210.3	0.0	127.8	20	8.4
	II	956.7	29.1	18.8						1915		1881	36	14.2	3.0	1.2			1916			1896	
दिसम्बर / DEC	I	961.8	20.0	15.5	30.0	16.0	32.3	12.1	34.4	26	6.7	14	62	14.6	1.8	0.3	8.0	0.6	105.2	0.0	97.5	12	7.5
	II	957.8	28.3	18.0						1896		1945	34	13.2	2.4	0.7			1902			1886	
वार्षिक योग या माध्य / ANNUAL	I	957.0	24.4	19.5	33.8	20.9	43.3	11.3	46.0		4.4		64	19.6	3.1	0.9	755.7	45.4	1296.0	306.5	191.0		8.3
TOTAL OR MEAN	II	952.8	31.8	20.9									38	17.0	4.1	2.2			1990	1972			
वर्षोंकी सं / NUMBER OF YEARS	I	30	30	30	30	30	30	30	109		110		30	29	30	29	30	30	110	110	110		27
	II	30	30	30									30	29	30	29							

जलवायवी सारणी
CLIMATOLOGICAL TABLE

स्टेशन : सोलापुर
STATION : Solapur

		मौसम परिघटना						पवन														मेघ										दृश्यता				
		के साथ दिनों की संख्या						पवन की गती के साथ दिनों की संख्या (कि. मी. प्र. घं.)				पवन की दिशा के दिनों की संख्या का प्रतिशत										मेघ मात्रा (सभी मेघ) सहित दिनों की संख्या - अष्ठमांश					निम्न स्तरी मेघ मात्रा सहित दिनों की संख्या - अष्ठमांश						दृश्यता सहित दिनों की संख्या				
माह		वर्षण 0.3 मि.मि.या अधिक	ओले	गर्जन	कुहरा	धूल भरी आंधी	चंड वात	62 या अधिक	20-61	1-19	0	उ	उपू	पू	दपू	द	दप	प	उप	शांत	0	ले-2	3-5	6-7	8	0	ले-2	3-5	6-7	8	कुहरा 8	1 कि.मी. तक	1-4 कि.मी.	4-10 कि.मी.	10-20 कि.मी.	20 कि.मी. से अधिक
		WEATHER PHENOMENA						WIND														CLOUD										VISIBILITY				
		No. OF DAYS WITH						No. OF DAYS WITH WIND SPEED (Km. p. h.)				PERCENTAGE No. OF DAYS WIND FROM										No. OF DAYS WITH CLOUD AMOUNT (ALL CLOUDS) O K T A S					No. OF DAYS WITH LOW CLOUD AMOUNT O K T A S						No. OF DAYS WITH VISIBILITY				
MONTH		PPT 0.3 mm Or more	HAIL	THUN DER	FOG	DUST STORM	SQU ALL	62 Or more	20-61	1-19	0	N	NE	E	SE	S	SW	W	NW	CALM	0	T-2	3-5	6-7	8	0	T-2	3-5	6-7	8	FOG 8	UP TO 1 Km.	1-4 Kms.	4-10 Kms.	10-20 Kms.	OVER 20 Kms.
जनवरी	I	0.5	0.0	0.1	0.0	0.0	0.0	0	0	22	9	4	13	13	30	4	2	1	3	30	20	4	4	3	0	29	1	1	0	0	0	0.1	0.8	7.0	23.1	0.0
JAN	II							0	0	22	9	6	9	12	25	7	7	3	3	28	14	7	7	3	0	21	6	4	0	0	0	0.0	0.0	0.3	30.4	0.3
फरवरी	I	0.8	0.0	0.4	0.1	0.0	0.0	0	0	19	9	8	18	7	18	3	4	2	8	32	19	4	3	2	0	27	1	0	0	0	0	0.0	0.5	4.6	22.9	0.0
FEB	II							0	0	22	6	10	9	7	16	7	14	9	8	20	13	7	6	2	0	18	6	4	0	0	0	0.0	0.0	0.1	27.5	0.4
मार्च	I	1.1	0.0	1.4	0.0	0.0	0.0	0	0	22	9	10	18	6	15	4	4	5	10	28	21	4	4	2	0	28	2	1	0	0	0	0.0	0.4	1.6	29.0	0.0
MAR	II							0	0	24	7	10	11	5	13	5	12	11	12	21	9	8	10	4	0	12	10	8	1	0	0	0.0	0.0	0.6	30.2	0.2
अप्रैल	I	3.0	0.1	4.5	0.1	0.2	0.0	0	0	23	7	13	12	5	10	3	8	8	19	22	15	7	4	4	0	25	3	2	0	0	0	0.0	0.0	0.7	29.3	0.0
APR	II							0	1	24	5	12	13	5	12	4	11	10	15	18	4	7	11	7	1	6	10	13	1	0	0	0.0	0.0	1.3	28.6	0.1
मई	I	4.8	0.0	3.9	0.0	0.1	0.0	0	1	26	4	10	5	1	4	2	9	22	35	12	11	6	7	6	1	24	4	3	0	0	0	0.0	0.0	0.7	30.3	0.0
MAY	II							0	1	25	5	15	11	2	5	3	10	17	22	15	2	6	12	10	1	5	11	14	1	0	0	0.0	0.0	1.3	29.6	0.1
जून	I	11.4	0.0	4.8	0.0	0.2	0.0	0	0	27	3	2	2	0	0	1	43	28	15	9	1	3	8	13	5	12	8	9	1	0	0	0.0	0.0	1.7	28.3	0.0
JUN	II							0	2	26	2	4	3	1	1	2	37	32	12	8	0	1	6	17	6	1	6	19	4	0	0	0.0	0.1	3.7	26.2	0.0
जुलाई	I	13.6	0.0	1.4	0.0	0.0	0.0	0	0	27	4	1	0	0	0	1	50	30	5	13	0	3	6	13	9	11	8	10	2	0	0	0.0	0.1	3.2	27.7	0.0
JUL	II							0	2	27	2	2	1	0	1	1	44	37	7	7	0	0	4	15	12	1	5	20	5	0	0	0.0	0.3	5.2	25.5	0.0
अगस्त	I	14.2	0.0	1.9	0.0	0.0	0.0	0	0	26	5	1	1	0	1	1	40	34	6	16	1	3	7	12	8	12	7	10	2	0	0	0.0	0.1	3.7	27.2	0.0
AUG	II							0	1	27	3	3	1	0	1	0	33	44	9	9	0	0	5	15	11	1	5	21	4	0	0	0.0	0.2	5.6	24.9	0.3
सितम्बर	I	13.2	0.0	5.2	0.0	0.0	0.0	0	0	23	7	6	4	1	2	1	20	24	19	23	1	4	8	11	6	14	7	7	2	0	0	0.0	0.2	2.7	27.1	0.0
SEP	II							0	1	24	5	10	7	3	1	2	16	28	15	18	0	1	6	16	7	1	8	18	3	0	0	0.0	0.1	4.2	25.7	0.0
अक्तूबर	I	6.4	0.0	2.6	0.0	0.0	0.0	0	0	22	9	9	23	9	9	1	3	7	10	29	9	7	6	7	2	22	4	4	1	0	0	0.0	0.1	2.8	28.1	0.0
OCT	II							0	1	24	6	13	29	14	7	1	3	7	6	20	3	7	8	10	3	9	11	10	1	0	0	0.0	0.0	2.3	28.7	0.0
नवम्बर	I	2.5	0.0	0.6	0.0	0.0	0.0	0	0	22	8	2	25	19	19	2	1	1	2	29	16	4	4	5	1	25	2	2	1	0	0	0.0	0.2	4.3	25.5	0.0
NOV	II							0	0	23	7	6	31	20	14	2	1	1	1	24	11	6	5	7	1	17	6	6	1	0	0	0.0	0.1	1.3	28.6	0.0
दिसम्बर	I	1.1	0.0	0.1	0.1	0.0	0.0	0	0	22	9	2	19	23	23	2	1	1	1	28	16	5	5	4	1	28	2	1	0	0	0	0.0	0.9	5.7	24.4	0.0
DEC	II							0	0	23	8	6	16	23	22	3	2	1	1	26	10	7	8	5	1	22	5	4	0	0	0	0.0	0.0	0.5	30.4	0.1
वार्षिक योग या माध्य ANNUAL TOTAL OR MEAN	I	72.6	0.1	26.9	0.3	0.5	0.0	0	1	281	83	6	12	7	11	2	15	14	11	23	130	54	66	82	33	257	49	50	9	0	0	0.1	3.3	38.7	322.9	0.0
	II							0	9	291	65	8	12	8	10	3	16	17	9	18	66	57	88	111	43	114	89	141	21	0	0	0.0	0.8	26.4	336.3	1.5
वर्षोंकी सं NUMBER OF YEARS	I	30						30				30									29					29						29				
	II							30				30									29					29						29				

Annexure C

Material Safety Data Sheets

HSD- High Speed Diesel
SKO- Superior kerosene Oil
MS-Motor Spirit

Safety Data Sheet

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND COMPANY/UNDERTAKING

Material Name	:	**Diesel (ULSD/Gasoil)**
Recommended Use / Restrictions of Use	:	Fuel for on-road diesel-powered engines. Fuel for use in off-road diesel engines, boilers, gas turbines and other combustion equipment.
Supplier	:	**Shell Eastern Trading (PTE) Ltd** 9 North Buona Vista Drive, #07-01, Tower 1, The Metropolis Singapore 138588 Singapore
Telephone	:	+65-6384 8000
Emergency Telephone Number	:	+44 (0) 151 350 4595

2. HAZARDS IDENTIFICATION

GHS Classification	:	Flammable liquids, Category 3 Aspiration hazard, Category 1 Acute toxicity, Category 4, Inhalation Skin corrosion/irritation, Category 2 Carcinogenicity, Category 2 Specific target organ toxicity - repeated exposure, Category 2, Blood., Thymus., Liver Hazardous to the aquatic environment - Long-term Hazard, Category 2 Acute hazards to the aquatic environment, Category 2
GHS Label Elements Symbol(s)	:	
Signal Words	:	Danger
Hazard Statement	:	PHYSICAL HAZARDS: H226: Flammable liquid and vapour. HEALTH HAZARDS:

H304: May be fatal if swallowed and enters airways.
H315: Causes skin irritation.
H332: Harmful if inhaled.
H351: Suspected of causing cancer.
H373: May cause damage to organs or organ systems through prolonged or repeated exposure.

ENVIRONMENTAL HAZARDS:
H411: Toxic to aquatic life with long lasting effects.
H401: Toxic to aquatic life.

GHS Precautionary Statements

Prevention : P210: Keep away from heat/sparks/open flames/hot surfaces. - No smoking.
P261: Avoid breathing dust/fume/gas/mist/vapours/spray.
P280: Wear protective gloves/protective clothing/eye protection/face protection.

Response : P301+P310: IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician.
P331: Do NOT induce vomiting.

Disposal: : P501: Dispose of contents and container to appropriate waste site or reclaimer in accordance with local and national regulations.

Other Hazards which do not result in classification : Vapour in the headspace of tanks and containers may ignite and explode at temperatures exceeding auto-ignition temperature, where vapour concentrations are within the flammability range.
May ignite on surfaces at temperatures above auto-ignition temperature.
This material is a static accumulator. Even with proper grounding and bonding, this material can still accumulate an electrostatic charge. If sufficient charge is allowed to accumulate, electrostatic discharge and ignition of flammable air-vapour mixtures can occur.

Additional Information : This product is intended for use in closed systems only.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Mixture Description : Complex mixture of hydrocarbons consisting of paraffins, cycloparaffins, aromatic and olefinic hydrocarbons with carbon

numbers predominantly in the C9 to C25 range. May also contain several additives at <0.1% v/v each. May contain cetane improver (Ethyl Hexyl Nitrate) at <0.2% v/v.

May contain catalytically cracked oils in which polycyclic aromatic compounds, mainly 3-ring but some 4- to 6-ring species are present.

Classification of components according to GHS

Chemical Identity	Synonyms	CAS	Hazard Class (category)	Hazard Statement	Conc.
Fuels, diesel	Fuels, diesel	68334-30-5	Flam. Liq., 3; Asp. Tox., 1; Acute Tox., 4; Skin Corr., 2; Carc., 2; STOT RE, 2; Aquatic Chronic, 2; Aquatic Acute, 2;	H226; H304; H332; H315; H351; H373; H411; H401;	60.00 - 100.00 %
Distillates (Fischer-Tropsch) C8-26 - Branched and Linear	Distillates (Fischer-Tropsch) C8-26 - Branched and Linear	848301-67-7	Asp. Tox., 1; Flam. Liq., 4;	H304; H227;	0.00 - 30.00 %
Kerosine (Fischer Tropsch), Full range, C8-C16 branched and linear alkanes	Kerosine (Fischer Tropsch), Full range, C8-C16 branched and linear alkanes	848301-66-6	Asp. Tox., 1; Flam. Liq., 3;	H304; H226;	0.00 - 10.00 %

Additional Information : Dyes and markers can be used to indicate tax status and prevent fraud. Contains Cumene, CAS# 98-82-8 Contains Naphthalene, CAS # 91-20-3.

Refer to Ch 16 for full text of H phrases.

4. FIRST-AID MEASURES

Inhalation : Remove to fresh air. If rapid recovery does not occur, transport to nearest medical facility for additional treatment.

Skin Contact : Remove contaminated clothing. Immediately flush skin with

		large amounts of water for at least 15 minutes, and follow by washing with soap and water if available. If redness, swelling, pain and/or blisters occur, transport to the nearest medical facility for additional treatment. When using high pressure equipment, injection of product under the skin can occur. If high pressure injuries occur, the casualty should be sent immediately to a hospital. Do not wait for symptoms to develop.
Eye Contact	:	Flush eye with copious quantities of water. If persistent irritation occurs, obtain medical attention.
Ingestion	:	If swallowed, do not induce vomiting: transport to nearest medical facility for additional treatment. If vomiting occurs spontaneously, keep head below hips to prevent aspiration. If any of the following delayed signs and symptoms appear within the next 6 hours, transport to the nearest medical facility: fever greater than 101° F (38.3°C), shortness of breath, chest congestion or continued coughing or wheezing. Give nothing by mouth.
Most Important Symptoms/Effects, Acute & Delayed	:	If material enters lungs, signs and symptoms may include coughing, choking, wheezing, difficulty in breathing, chest congestion, shortness of breath, and/or fever. The onset of respiratory symptoms may be delayed for several hours after exposure. Skin irritation signs and symptoms may include a burning sensation, redness, or swelling.
Immediate medical attention, special treatment	:	Treat symptomatically.

5. FIRE-FIGHTING MEASURES

Clear fire area of all non-emergency personnel.

Specific hazards arising from Chemicals	:	Hazardous combustion products may include: A complex mixture of airborne solid and liquid particulates and gases (smoke). Oxides of sulphur. Unidentified organic and inorganic compounds. Carbon monoxide may be evolved if incomplete combustion occurs. Will float and can be reignited on surface water. Flammable vapours may be present even at temperatures below the flash point. The vapour is heavier than air, spreads along the ground and distant ignition is possible.
Suitable Extinguishing Media	:	Foam, water spray or fog. Dry chemical powder, carbon dioxide, sand or earth may be used for small fires only.
Unsuitable Extinguishing Media	:	Do not use direct water jets on the burning product as they could cause a steam explosion and spread of the fire. Simultaneous use of foam and water on the same surface is to be avoided as water destroys the foam.

Protective Equipment & Precautions for Fire Fighters	:	Proper protective equipment including chemical resistant gloves are to be worn; chemical resistant suit is indicated if large contact with spilled product is expected. Self-Contained Breathing Apparatus must be worn when approaching a fire in a confined space. Select fire fighter's clothing approved to relevant Standards (e.g. Europe: EN469).
Additional Advice	:	Keep adjacent containers cool by spraying with water. If possible remove containers from the danger zone. If the fire cannot be extinguished the only course of action is to evacuate immediately. Contain residual material at affected sites to prevent material from entering drains (sewers), ditches, and waterways.

6. ACCIDENTAL RELEASE MEASURES

Avoid contact with spilled or released material. For guidance on selection of personal protective equipment see Chapter 8 of this Material Safety Data Sheet. See Chapter 13 for information on disposal. Observe the relevant local and international regulations. Evacuate the area of all non-essential personnel. Ventilate contaminated area thoroughly. Take precautionary measures against static discharges.

Personal Precautions, Protective Equipment and Emergency Procedures	:	Do not breathe fumes, vapour. Do not operate electrical equipment. Shut off leaks, if possible without personal risks. Remove all possible sources of ignition in the surrounding area and evacuate all personnel. Attempt to disperse the gas or to direct its flow to a safe location for example by using fog sprays. Take precautionary measures against static discharge. Ensure electrical continuity by bonding and grounding (earthing) all equipment. Monitor area with combustible gas meter.
Environmental Precautions	:	Take measures to minimise the effects on groundwater. Contain residual material at affected sites to prevent material from entering drains (sewers), ditches, and waterways. Prevent from spreading or entering into drains, ditches or rivers by using sand, earth, or other appropriate barriers.
Methods and Material for Containment and Cleaning Up	:	Take precautionary measures against static discharges. For small liquid spills (< 1 drum), transfer by mechanical means to a labelled, sealable container for product recovery or safe disposal. Allow residues to evaporate or soak up with an appropriate absorbent material and dispose of safely. Remove contaminated soil and dispose of safely. For large liquid spills (> 1 drum), transfer by mechanical means such as vacuum truck to a salvage tank for recovery or safe disposal. Do not flush away residues with water. Retain as contaminated waste. Allow residues to evaporate or soak up with an appropriate

absorbent material and dispose of safely. Remove contaminated soil and dispose of safely. Shovel into a suitable clearly marked container for disposal or reclamation in accordance with local regulations.

Additional Advice : Notify authorities if any exposure to the general public or the environment occurs or is likely to occur. Local authorities should be advised if significant spillages cannot be contained. Maritime spillages should be dealt with using a Shipboard Oil Pollution Emergency Plan (SOPEP), as required by MARPOL Annex 1 Regulation 26.

7. HANDLING AND STORAGE

General Precautions : Avoid breathing vapours or contact with material. Only use in well ventilated areas. Wash thoroughly after handling. For guidance on selection of personal protective equipment see Chapter 8 of this Material Safety Data Sheet. Use the information in this data sheet as input to a risk assessment of local circumstances to help determine appropriate controls for safe handling, storage and disposal of this material. Air-dry contaminated clothing in a well-ventilated area before laundering. Prevent spillages. Use local exhaust ventilation if there is risk of inhalation of vapours, mists or aerosols. Never siphon by mouth. Contaminated leather articles including shoes cannot be decontaminated and should be destroyed to prevent reuse.
Maintenance and Fuelling Activities - Avoid inhalation of vapours and contact with skin.

Precautions for Safe Handling : Avoid inhaling vapour and/or mists. Avoid prolonged or repeated contact with skin. When using do not eat or drink. Extinguish any naked flames. Do not smoke. Remove ignition sources. Avoid sparks. Earth all equipment. Properly dispose of any contaminated rags or cleaning materials in order to prevent fires. Use local exhaust ventilation if there is risk of inhalation of vapours, mists or aerosols. The vapour is heavier than air, spreads along the ground and distant ignition is possible.

Conditions for Safe Storage : Drum and small container storage: Drums should be stacked to a maximum of 3 high. Use properly labelled and closeable containers. Tank storage: Tanks must be specifically designed for use with this product. Bulk storage tanks should be diked (bunded). Locate tanks away from heat and other sources of ignition. Must be stored in a diked (bunded) well-ventilated area, away from sunlight, ignition sources and other sources of heat. Vapours from tanks should not be released to

		atmosphere. Breathing losses during storage should be controlled by a suitable vapour treatment system. The vapour is heavier than air. Beware of accumulation in pits and confined spaces. Keep container tightly closed and in a cool, well-ventilated place. Keep in a cool place. Electrostatic charges will be generated during pumping. Electrostatic discharge may cause fire. Ensure electrical continuity by bonding and grounding (earthing) all equipment to reduce the risk. The vapours in the head space of the storage vessel may lie in the flammable/explosive range and hence may be flammable. Refer to section 15 for any additional specific legislation covering the packaging and storage of this product. Keep in a bunded area with a sealed (low permeability) floor, to provide containment against spillage. Prevent ingress of water.
Product Transfer	:	Avoid splash filling. Wait 2 minutes after tank filling (for tanks such as those on road tanker vehicles) before opening hatches or manholes. Wait 30 minutes after tank filling (for large storage tanks) before opening hatches or manholes. Keep containers closed when not in use. Contamination resulting from product transfer may give rise to light hydrocarbon vapour in the headspace of tanks that have previously contained gasoline. This vapour may explode if there is a source of ignition. Partly filled containers present a greater hazard than those that are full, therefore handling, transfer and sampling activities need special care. Even with proper grounding and bonding, this material can still accumulate an electrostatic charge. If sufficient charge is allowed to accumulate, electrostatic discharge and ignition of flammable air-vapour mixtures can occur. Be aware of handling operations that may give rise to additional hazards that result from the accumulation of static charges. These include but are not limited to pumping (especially turbulent flow), mixing, filtering, splash filling, cleaning and filling of tanks and containers, sampling, switch loading, gauging, vacuum truck operations, and mechanical movements. These activities may lead to static discharge e.g. spark formation. Restrict line velocity during pumping in order to avoid generation of electrostatic discharge (<= 1 m/s until fill pipe submerged to twice its diameter, then <= 7 m/s). Avoid splash filling. Do NOT use compressed air for filling, discharging, or handling operations.
Recommended Materials	:	For containers, or container linings use mild steel, stainless steel. Aluminium may also be used for applications where it does not present an unnecessary fire hazard. Examples of suitable materials are: high density polyethylene (HDPE) and Viton (FKM), which have been specifically tested for compatibility with this product. For container linings, use

amine-adduct cured epoxy paint. For seals and gaskets use: graphite, PTFE, Viton A, Viton B.

Unsuitable Materials : Some synthetic materials may be unsuitable for containers or container linings depending on the material specification and intended use. Examples of materials to avoid are: natural rubber (NR), nitrile rubber (NBR), ethylene propylene rubber (EPDM), polymethyl methacrylate (PMMA), polystyrene, polyvinyl chloride (PVC), polyisobutylene. However, some may be suitable for glove materials.

Container Advice : Containers, even those that have been emptied, can contain explosive vapours. Do not cut, drill, grind, weld or perform similar operations on or near containers.

Other Advice : Ensure that all local regulations regarding handling and storage facilities are followed. See additional references that provide safe handling practices for liquids that are determined to be static accumulators: American Petroleum Institute 2003 (Protection Against Ignitions Arising out of Static, Lightning and Stray Currents) or National Fire Protection Agency 77 (Recommended Practices on Static Electricity). CENELEC CLC/TR 50404 (Electrostatics – Code of practice for the avoidance of hazards due to static electricity).

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

If the American Conference of Governmental Industrial Hygienists (ACGIH) value is provided on this document, it is provided for information only.

Occupational Exposure Limits

Material	Source	Type	ppm	mg/m3	Notation
Naphthalene	ACGIH	TWA	10 ppm		
	ACGIH	STEL	15 ppm		
	ACGIH	SKIN_DES			Can be absorbed through the skin.
	SG OEL	TWA	10 ppm	52 mg/m3	
	SG OEL	STEL	15 ppm	79 mg/m3	

Fuels, diesel	ACGIH	SKIN_DES(Inhalable fraction and vapor.)			Can be absorbed through the skin.as total hydrocarbons
	ACGIH	TWA(Inhalable fraction and vapor.)		100 mg/m3	as total hydrocarbons
Cumene	ACGIH	TWA	50 ppm		
	SG OEL	TWA	50 ppm	246 mg/m3	

Additional Information : Skin notation means that significant exposure can also occur by absorption of liquid through the skin and of vapour through the eyes or mucous membranes.

Biological Exposure Index (BEI)

Material	Determinant	Sampling Time	BEI	Reference
Naphthalene	1-Naphthol, with hydrolysis + 2-Naphthol, with hydrolysis	Sampling time: End of shift.		ACGIH BEL (02 2013)

Appropriate Engineering Controls : The level of protection and types of controls necessary will vary depending upon potential exposure conditions. Select controls based on a risk assessment of local circumstances. Appropriate measures include: Use sealed systems as far as possible. Adequate explosion-proof ventilation to control airborne concentrations below the exposure guidelines/limits. Local exhaust ventilation is recommended. Eye washes and showers for emergency use. Always observe good personal hygiene measures, such as washing hands after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants. Discard contaminated clothing and footwear that cannot be cleaned. Practice good housekeeping. Define procedures for safe handling and maintenance of controls.

Educate and train workers in the hazards and control measures relevant to normal activities associated with this product. Ensure appropriate selection, testing and maintenance of equipment used to control exposure, e.g. personal protective equipment, local exhaust ventilation. Firewater monitors and deluge systems are recommended. Drain down system prior to equipment break-in or maintenance. Retain drain downs in sealed storage pending disposal or for subsequent recycle.

Individual Protection Measures : Personal protective equipment (PPE) should meet recommended national standards. Check with PPE suppliers.

Respiratory Protection : If engineering controls do not maintain airborne concentrations to a level which is adequate to protect worker health, select respiratory protection equipment suitable for the specific conditions of use and meeting relevant legislation. Check with respiratory protective equipment suppliers. Where air-filtering respirators are suitable, select an appropriate combination of mask and filter. Where air-filtering respirators are unsuitable (e.g. airborne concentrations are high, risk of oxygen deficiency, confined space) use appropriate positive pressure breathing apparatus. All respiratory protection equipment and use must be in accordance with local regulations. Select a filter suitable for combined particulate/organic gases and vapours [boiling point >65°C(149 °F)].

Hand Protection : Personal hygiene is a key element of effective hand care. Gloves must only be worn on clean hands. After using gloves, hands should be washed and dried thoroughly. Application of a non-perfumed moisturizer is recommended. Suitability and durability of a glove is dependent on usage, e.g. frequency and duration of contact, chemical resistance of glove material, dexterity. Always seek advice from glove suppliers. Contaminated gloves should be replaced. For continuous contact we recommend gloves with breakthrough time of more than 240 minutes with preference for > 480 minutes where suitable gloves can be identified. For short-term/splash protection we recommend the same, but recognise that suitable gloves offering this level of protection may not be available and in this case a lower breakthrough time may be acceptable so long as appropriate maintenance and replacement regimes are followed. Glove thickness is not a good predictor of glove resistance to a chemical as it is dependent on the exact composition of the glove material. Select gloves tested to a relevant standard (e.g. Europe EN374, US F739). When prolonged or frequent repeated contact occurs, Nitrile gloves may be suitable. (Breakthrough

		time of > 240 minutes.) For incidental contact/splash protection Neoprene, PVC gloves may be suitable.
Eye Protection	:	Chemical splash goggles (chemical monogoggles). If a local risk assessment deems it so, then chemical splash goggles may not be required and safety glasses may provide adequate eye protection.
Protective Clothing	:	Chemical resistant gloves/gauntlets, boots, and apron (where risk of splashing).
Thermal Hazards	:	Not applicable.
Monitoring Methods	:	Monitoring of the concentration of substances in the breathing zone of workers or in the general workplace may be required to confirm compliance with an OEL and adequacy of exposure controls. For some substances biological monitoring may also be appropriate. Validated exposure measurement methods should be applied by a competent person and samples analysed by an accredited laboratory. Examples of sources of recommended exposure measurement methods are given below or contact the supplier. Further national methods may be available. National Institute of Occupational Safety and Health (NIOSH), USA: Manual of Analytical Methods http://www.cdc.gov/niosh/ Occupational Safety and Health Administration (OSHA), USA: Sampling and Analytical Methods http://www.osha.gov/
Environmental Exposure Controls	:	Local guidelines on emission limits for volatile substances must be observed for the discharge of exhaust air containing vapour. Information on accidental release measures are to be found in section 6. Take appropriate measures to fulfil the requirements of relevant environmental protection legislation. Avoid contamination of the environment by following advice given in Chapter 6. If necessary, prevent undissolved material from being discharged to waste water. Waste water should be treated in a municipal or industrial waste water treatment plant before discharge to surface water.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	:	Colourless to yellowish. Liquid.
Odour	:	May contain a reodorant
Odour threshold	:	Data not available
pH	:	Not applicable
Initial Boiling Point and Boiling Range	:	170 - 390 °C / 338 - 734 °F
Pour point	:	<= 6 °C / 43 °F
Flash point	:	> 55 °C / 131 °F
Upper / lower Flammability or	:	1 - 6 %(V)

Explosion limits		
Auto-ignition temperature	:	> 220 °C / 428 °F
Vapour pressure	:	1 hPa at 20 °C / 68 °F
Relative Density	:	Data not available
Density	:	0.8 - 0.89 g/cm3 at 15 °C / 59 °F
Water solubility	:	Data not available
Solubility in other solvents	:	Data not available
n-octanol/water partition coefficient (log Pow)	:	3 - 6
Dynamic viscosity	:	Data not available
Kinematic viscosity	:	1.5 - 6 mm2/s at 40 °C / 104 °F
Vapour density (air=1)	:	Data not available
Electrical conductivity	:	Low conductivity: < 100 pS/m, The conductivity of this material makes it a static accumulator., A liquid is typically considered nonconductive if its conductivity is below 100 pS/m and is considered semi-conductive if its conductivity is below 10 000 pS/m., Whether a liquid is nonconductive or semi-conductive, the precautions are the same., A number of factors, for example liquid temperature, presence of contaminants, and anti-static additives can greatly influence the conductivity of a liquid.
Evaporation rate (nBuAc=1)	:	Data not available
Decomposition Temperature	:	Data not available
Flammability	:	Not applicable.

10. STABILITY AND REACTIVITY

Chemical stability	:	Stable under normal use conditions.
Possibility of Hazardous Reactions	:	No hazardous reaction is expected when handled and stored according to provisions.
Conditions to Avoid	:	Avoid heat, sparks, open flames and other ignition sources.
Incompatible Materials	:	Strong oxidising agents.
Hazardous Decomposition Products	:	Hazardous decomposition products are not expected to form during normal storage. Thermal decomposition is highly dependent on conditions. A complex mixture of airborne solids, liquids and gases, including carbon monoxide, carbon dioxide and other organic compounds will be evolved when this material undergoes combustion or thermal or oxidative degradation.
Sensitivity to Static Discharge	:	Yes, in certain circumstances product can ignite due to static electricity.

11. TOXICOLOGICAL INFORMATION

Information on Toxicological effects

Basis for Assessment	:	Information given is based on product data, a knowledge of the components and the toxicology of similar products. Unless indicated otherwise, the data presented is representative of the product as a whole, rather than for individual component(s).
Likely Routes of Exposure	:	Exposure may occur via inhalation, ingestion, skin absorption, skin or eye contact, and accidental ingestion.
Acute Oral Toxicity	:	Low toxicity: LD50 > 5000 mg/kg , Rat
Acute Dermal Toxicity	:	Low toxicity: LD50 >2000 mg/kg , Rabbit
Acute Inhalation Toxicity	:	Harmful if inhaled. LC50 > 1.0 - <= 5.0 mg/l , 4 h, Rat High concentrations may cause central nervous system depression resulting in headaches, dizziness and nausea; continued inhalation may result in unconsciousness and/or death.
Skin corrosion/irritation	:	Irritating to skin.
Serious eye damage/irritation	:	Expected to be slightly irritating.
Respiratory Irritation	:	Inhalation of vapours or mists may cause irritation to the respiratory system.
Respiratory or skin sensitisation	:	Not expected to be a sensitiser.
Aspiration Hazard	:	Aspiration into the lungs when swallowed or vomited may cause chemical pneumonitis which can be fatal.
Germ cell mutagenicity	:	Positive in in-vitro, but negative in in-vivo mutagenicity assays.
Carcinogenicity	:	Limited evidence of carcinogenic effect. Repeated skin contact has resulted in irritation and skin cancer in animals.

Material	:	**Carcinogenicity Classification**
Naphthalene	:	ACGIH Group A4: Not classifiable as a human carcinogen.
Naphthalene	:	NTP: Reasonably Anticipated to be a Human Carcinogen.
Naphthalene	:	IARC 2B: Possibly carcinogenic to humans.
Naphthalene	:	GHS / CLP: Carcinogenicity Category 2

Fuels, diesel	:	ACGIH Group A3: Confirmed animal carcinogen with unknown relevance to humans.
Fuels, diesel	:	GHS / CLP: Carcinogenicity Category 2
Distillates (Fischer-Tropsch) C8-26 - Branched and Linear	:	GHS / CLP: No carcinogenicity classification
Kerosine (Fischer Tropsch), Full range, C8-C16 branched and linear alkanes	:	GHS / CLP: No carcinogenicity classification
Cumene	:	IARC 2B: Possibly carcinogenic to humans.
Cumene	:	GHS / CLP: No carcinogenicity classification

Reproductive and Developmental Toxicity : Not expected to impair fertility. Not expected to be a developmental toxicant.

Specific target organ toxicity - single exposure : Not classified.

Specific target organ toxicity - repeated exposure : May cause damage to organs or organ systems through prolonged or repeated exposure. Blood. Thymus. Liver.

Additional Information : Classifications by other authorities under varying regulatory frameworks may exist.

12. ECOLOGICAL INFORMATION

Basis for Assessment : Information given is based on a knowledge of the components and the ecotoxicology of similar products. Fuels are typically made from blending several refinery streams. Ecotoxicological studies have been carried out on a variety of hydrocarbon blends and streams but not those containing additives. Unless indicated otherwise, the data presented is representative of the product as a whole, rather than for individual component(s).

Acute Toxicity : Expected to be toxic: LL/EL/IL50 > 1 <= 10 mg/l (to aquatic organisms) LL/EL50 expressed as the nominal amount of product required to prepare aqueous test extract.

Fish : Expected to be toxic: LL/EL/IL50 > 1 <= 10 mg/l

Aquatic crustacea : Expected to be toxic: LL/EL/IL50 > 1 <= 10 mg/l

Algae/aquatic plants : Expected to be toxic: LL/EL/IL50 > 1 <= 10 mg/l

Microorganisms : Expected to be practically non toxic: LL/EL/IL50 > 100 mg/l

Chronic Toxicity

Fish : NOEC/NOEL expected to be > 0.01 - <= 0.1 mg/l (based on

		modeled data)
Aquatic crustacea	:	NOEC/NOEL expected to be > 0.1 - <= 1.0 mg/l (based on modeled data)
Mobility	:	Partly evaporates from water or soil surfaces, but a significant proportion will remain after one day. If product enters soil, one or more constituents will be mobile and may contaminate groundwater. Large volumes may penetrate soil and could contaminate groundwater. Floats on water.
Persistence/degradability	:	Major constituents are inherently biodegradable. The volatile constituents will oxidize rapidly by photochemical reactions in air.
Bioaccumulative Potential	:	Contains constituents with the potential to bioaccumulate. Log Kow > =4
Other Adverse Effects	:	Films formed on water may affect oxygen transfer and damage organisms.

13. DISPOSAL CONSIDERATIONS

Material Disposal	:	Recover or recycle if possible. It is the responsibility of the waste generator to determine the toxicity and physical properties of the material generated to determine the proper waste classification and disposal methods in compliance with applicable regulations. Do not dispose into the environment, in drains or in water courses. Do not dispose of tank water bottoms by allowing them to drain into the ground. This will result in soil and groundwater contamination. Waste arising from a spillage or tank cleaning should be disposed of in accordance with prevailing regulations, preferably to a recognised collector or contractor. The competence of the collector or contractor should be established beforehand.
Container Disposal	:	Send to drum recoverer or metal reclaimer. Drain container thoroughly. After draining, vent in a safe place away from sparks and fire. Residues may cause an explosion hazard if heated above the flash point. Do not puncture, cut or weld uncleaned drums. Do not pollute the soil, water or environment with the waste container. Comply with any local recovery or waste disposal regulations.
Local Legislation	:	Disposal should be in accordance with applicable regional, national, and local laws and regulations. Local regulations may be more stringent than regional or national requirements and must be in compliance.

14. TRANSPORT INFORMATION

Land (as per ADR classification): Regulated

Class	:	3
Packing group	:	III
Hazard indentification no.	:	30
UN number	:	1202
Danger label (primary risk)	:	3
Proper shipping name	:	DIESEL FUEL
Environmentally Hazardous	:	Yes

IMDG

Identification number	UN 1202
Proper shipping name	DIESEL FUEL
Class / Division	3
Packing group	III
Environmental hazards:	Yes

IATA (Country variations may apply)

UN number	:	1202
Proper shipping name	:	Diesel fuel
Class / Division	:	3
Packing group	:	III

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code

Pollution Category	**:**	Not applicable.
Ship Type	**:**	Not applicable.
Product Name	**:**	Not applicable.
Special Precaution	**:**	Not applicable.
Additional Information	**:**	MARPOL Annex 1 rules apply for bulk shipments by sea.

15. REGULATORY INFORMATION

The regulatory information is not intended to be comprehensive. Other regulations may apply to this material.

Local Regulations

Workplace Safety and Health Act & Workplace Safety and Health (General Provision) Regulations	:	This product is subject to the requirement in the Act/ Regulations.
Environmental Protection and Management Act and Environmental Protection and Management	:	This product is subject to the requirement in the Act/ Regulations.

(Hazardous Substances) Regulations		
Maritime and Port Authority of Singapore (Dangerous Goods, Petroleum and Explosives) Regulations	:	This product is subject to the requirement in the Act/ Regulations.
Fire Safety Act and Fire Safety (Petroleum & Flammable Materials) Regulations	:	This product is subject to the requirement in the Act/ Regulations.
Classification triggering components	:	Contains fuels, diesel.
Other Information	:	IARC has classified diesel exhaust emissions as a Class 1 carcinogen - carcinogenic to humans. Steps should be taken to prevent personal exposure to diesel exhaust emissions.

16. OTHER INFORMATION

Hazard Statement

H226	Flammable liquid and vapour.
H227	Combustible liquid.
H304	May be fatal if swallowed and enters airways.
H315	Causes skin irritation.
H332	Harmful if inhaled.
H351	Suspected of causing cancer.
H373	May cause damage to organs or organ systems through prolonged or repeated exposure.
H401	Toxic to aquatic life.
H411	Toxic to aquatic life with long lasting effects.

Additional Information	:	This document contains important information to ensure the safe storage, handling and use of this product. The information in this document should be brought to the attention of the person in your organisation responsible for advising on safety matters.
SDS Version Number	:	1.1
SDS Effective Date	:	10.03.2014
SDS Revisions	:	A vertical bar (|) in the left margin indicates an amendment from the previous version.
Uses and Restrictions	:	This product must not be used in applications other than those recommended in Section 1, without first seeking the advice of the supplier. This product is not to be used as a solvent or cleaning agent;

Safety Data Sheet

for lighting or brightening fires; as a skin cleanser.

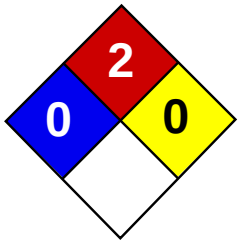
SDS Distribution : The information in this document should be made available to all who may handle the product.

Key/Legend to Abbrevations used in this SDS : The standard abbreviations and acronyms used in this document can be looked up in reference literature (e.g. scientific dictionaries) and/or websites.

Flam. Liq.	Flammable liquids
Asp. Tox.	Aspiration hazard
Acute Tox.	Acute toxicity
Skin Corr.	Skin corrosion/irritation
Carc.	Carcinogenicity
STOT RE	Specific target organ toxicity - repeated exposure

Key Literature References : The quoted data are from, but not limited to, one or more sources of information (e.g. toxicological data from Shell Health Services, material suppliers' data, CONCAWE, EU IUCLID date base, EC 1272 regulation, etc).

Disclaimer : This information is based on our current knowledge and is intended to describe the product for the purposes of health, safety and environmental requirements only. It should not therefore be construed as guaranteeing any specific property of the product.



Health	2
Fire	2
Reactivity	0
Personal Protection	H

Material Safety Data Sheet
Kerosene MSDS

Section 1: Chemical Product and Company Identification

Product Name: Kerosene

Catalog Codes: SLK1048

CAS#: 8008-20-6 or 64742-81-0

RTECS: OA5500000

TSCA: TSCA 8(b) inventory: Kerosene

CI#: Not available.

Synonym: Astral Oil; Coal Oil, Fuel Oil No. 5, Deobase, Astral Oil, Jet A Fuel; Jet Fuel JP-1; JP-5 Navy Fuel; Kerosine, petroleum; Range Oil; K1 Kerosene; Kerosene, hydrodesulfurized; Kerosine

Chemical Name: Kerosene

Chemical Formula: Not available.

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call: 1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Kerosene	8008-20-6 or	100
	64742-81-0	

Toxicological Data on Ingredients: Kerosene: ORAL (LD50): Acute: 15000 mg/kg [Rat]. 20000 mg/kg [Guinea pig]. 2835 mg/kg [Rabbit].

Section 3: Hazards Identification

Potential Acute Health Effects:
Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (permeator). Severe over-exposure can result in death.

Potential Chronic Health Effects:
Slightly hazardous in case of skin contact (sensitizer). CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Mutagenic for bacteria and/or yeast. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance is toxic to the nervous system. The substance may be toxic to blood, kidneys, liver, central nervous system (CNS). Repeated or prolonged exposure to the substance can produce target organs damage. Repeated exposure to a highly toxic material may produce general deterioration of health by an accumulation in one or many human organs.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.

Skin Contact:
In case of contact, immediately flush skin with plenty of water. Cover the irritated skin with an emollient. Remove contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

Serious Inhalation:
Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. WARNING: It may be hazardous to the person providing aid to give mouth-to-mouth resuscitation when the inhaled material is toxic, infectious or corrosive. Seek immediate medical attention.

Ingestion:
If swallowed, do NOT induce vomiting. If swallowed, do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Flammable.

Auto-Ignition Temperature: 210°C (410°F)

Flash Points: CLOSED CUP: 38°C (100.4°F). (Tagliabue.)

Flammable Limits: LOWER: 0.7% UPPER: 5% - 7%

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances: Flammable in presence of open flames and sparks, of heat.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:
Flammable liquid, insoluble in water. SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray or fog. Cool containing vessels with water jet in order to prevent pressure build-up, autoignition or explosion.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill: Absorb with an inert material and put the spilled material in an appropriate waste disposal.

Large Spill:

Toxic flammable liquid, insoluble or very slightly soluble in water. Poisonous liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal.

Section 7: Handling and Storage

Precautions:
Keep locked up.. Keep away from heat. Keep away from sources of ignition. Ground all equipment containing material. Do not ingest. Do not breathe gas/fumes/ vapor/spray. Wear suitable protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents.

Storage:
Store in a segregated and approved area. Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Avoid all possible sources of ignition (spark or flame).

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.

Personal Protection:
Splash goggles. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Liquid. (Oily liquid.)

Odor: Not available.

Taste: Not available.

Molecular Weight: Not available.

Color: Yellow. Clear (Light.)

pH (1% soln/water): Not applicable.

Boiling Point: 149°C (300.2°F) - 325 C

Melting Point: Not available.

Critical Temperature: Not available.

Specific Gravity: 0.775 - .840(Water = 1)

Vapor Pressure: 0.1 kPa (@ 20°C)

Vapor Density: 4.5 (Air = 1)

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: Not available.

Solubility:
Insoluble in cold water, hot water. Miscible with other petroleum solvents

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Heat, ignition sources (sparks, flames), incompatible materials

Incompatibility with various substances: Reactive with oxidizing agents.

Corrosivity: Not considered to be corrosive for metals and glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Absorbed through skin. Eye contact.

Toxicity to Animals: Acute oral toxicity (LD50): 2835 mg/kg [Rabbit].

Chronic Effects on Humans:
MUTAGENIC EFFECTS: Mutagenic for bacteria and/or yeast. Causes damage to the following organs: the nervous system. May cause damage to the following organs: blood, kidneys, liver, central nervous system (CNS).

Other Toxic Effects on Humans:
Hazardous in case of skin contact (irritant), of ingestion, of inhalation (lung irritant). Slightly hazardous in case of skin contact (permeator).

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: May affect genetic material (mutagenic)

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: Causes moderate to severe skin irritation. It can cause defatting dermatitis. Eyes: May cause eye irritation. Inhalation: May cause respiratory tract and mucous membrane irritation and a burning sensation in the chest. Because of its relatively low volatility, overexposure by inhalation is uncommon, but it can occur in poorly ventilated areas or by inhalation of mists or aerosols. Symptoms of inhalation overexposure include central nevous system (CNS) depression (transient euphora, headache, irritability, excitement, ringing in the ears, weakness, incoordination, confusion, disorientation, drowsiness, tremor, somnolence, hallucinations, seizures, coma, death). May affect the heart (cardiac arrythmias), liver, kidneys, and respiration(asphyxia, apnea, acute pulmonary edema, dyspnea, fibrosis, or cyanosis) Ingestion: Causes gastrointestinal tract irritation with burning sensation in mouth, esophagus, and stomach, a b d o m i n a l p a i n , n a u s e a , v o m i t i n g , h y p e r m o t i l i t y , d i a r r h e a , h e a d a c h e , m a l a i s e . M a y a f f e c t respiration/ trachea/bronchi through accidental pulmonary aspiration which can cause hypoxia, chemical pneumonitis, and noncardiogenic pulmonary edema, pulmonary hemmorrhage, coughing, breathing difficulty, acute or chronic pulmonary edema, emphysema, respiratory stimulation. It may also affect the heart (dysrrhythmias, myocardial depression, tachycardia), liver, endocrine system (pancreas - hypoglycemia), behavior/central nervous system (symptoms similar to that of inhalation). Chronic Potential Health Effects: Inhalation: Repeated or prolonged inhalation may cause respiratory tract irritation and affect behavior/central nervous system with symptoms similar to that of acute inhalation. It may also affect the blood (changes in white blood cell count, changes in serum compositon, pigmented or nucleated red blood cells, leukopenia, normocytic anemia) , cardiovascular

system, respiratory system (trachea, bronchi), and may cause kidney damage. Ingestion: Repeated or prolonged ingestion may affect the liver, endocrine system (adrenal gland, pancreas, spleen), and metabolism (weight loss), and blood. Skin: Repeated or prolonged skin contact may cause defatting dermatitis, erythema, and eczema-like skin lesions, drying and cracking of the skin, and possible burns.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: Not available.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: CLASS 3: Flammable liquid.

Identification: : Kerosene UNNA: 1223 PG: III

Special Provisions for Transport: Not available.

Section 15: Other Regulatory Information

Federal and State Regulations:
Connecticut hazardous material survey.: Kerosene Rhode Island RTK hazardous substances: Kerosene Pennsylvania RTK: Kerosene Massachusetts RTK: Kerosene Massachusetts spill list: Kerosene New Jersey: Kerosene TSCA 8(b) inventory: Kerosene

Other Regulations:
OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200). EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada):
CLASS B-3: Combustible liquid with a flash point between 37.8°C (100°F) and 93.3°C (200°F). CLASS D-2B: Material causing other toxic effects (TOXIC).

DSCL (EEC):
R10- Flammable. R65- Harmful: may cause lung damage if swallowed. S23- Do not breathe gas/fumes/vapour/spray S24- Avoid contact with skin. S62- If swallowed, do not induce vomiting: seek medical advice immediately and show this container or label.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 2

Reactivity: 0

Personal Protection: h

National Fire Protection Association (U.S.A.):

Health: 0

Flammability: 2

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Splash goggles.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/09/2005 05:54 PM

Last Updated: 05/21/2013 12:00 PM

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Material Safety Data Sheet
Gasoline

MATERIAL SAFETY DATA SHEET
Gasoline/Petrol

1. Chemical identity

Chemical name: Petrol		*Chemical classification*: Flammable liquid	
Synonyms: Gasoline, Motor spirit		*Trade name*: Petrol	
Formula: mixture of hydrocarbons *C.A.S. NO*. 8006-61-9.		*U.N.NO*. 1203.	
Regulated identification Codes/Label:	*Shipping name*: Gasoline, Petrol *Hazchem code*: class 3 *Hazardous waste ID No*: N.A.		
Hazardous ingredients	*C.A.S.NO.*	*Hazardous ingredients*	*C.A.S. NO.*
Gasoline	*8006-61-9*	*n-Hexane Trace*	*110-54-3*
		Benzene Trace	*71-43-2*
Gasoline is complex mixture of hydrocarbons .It's exact composition depends on the source of crude oil from which it is produced and the refining methods used			

2. Physical and chemical data

Boiling point/Range (deg.C) : 30 to 215 C *Physical state*: Liquid *Appearance*: Orange, red	
Melting/freezing point (deg.C) : -90 to -75.	
Vapor pressure: 300 to 600 mm Hg (20 deg C)	
Odor: Characteristic odor *Vapor density*: 3-4	
solubility in water @ 30 deg.C: 1-100ppm /100 ml water	
Specific Gravity 0.75-0.85 at 20 deg C.	*ph* NA
Others: Floatability (water): Floats;	

3. Fire and explosion Hazard data

Flammability: yes ignited by Sparks/flames.	*LEL*: 1.4%	*UEL*: 7.6%.
Flash point(deg C) : typically about -38 to -42 (CC)		
TDG Flammability: Class 3		
Ignition Temp (deg C) : 456		
Explosion sensitivity to impact: not sensitive to Mechanical Impact		
Explosion sensitivity to static electricity: For vapors sensitivity exist		
Hazardous Combustion Products: carbon monoxide, Nitrogen oxide. and other aromatic hydrocarbons		
Hazardous Polymerization: N.A.		
Combustible liquid: Yes	*Explosive material*: Yes	*Corrosive material*: No

Flammable material: Yes	*Oxidiser*: N.A.	*Others*: N.A.
Pyrophoric material: N.A.	*Organic peroxide*: N.A.	

4. Reactivity data

Chemical stability: Stable *Incompatibility with other material*: oxidizers such Peroxides ,Nitric acid and Perchorates
Hazardous reaction products: on fire it will liberate some amount carbon monoxide, Nitrogen oxide. and other aromatic hydrocarbons

5. Health Hazard data

Routes of entry: Inhalation, Skin absorption ,ingestion *Effects of Exposure/ symptoms*: **Inhalation:** excessive inhalation Vapors cause rapid breathing, excitability, staggering, headache ,fatigue ,nausea and vomiting, dizziness, drowsiness, narcosis convulsions, coma, **Skin Contact**: Skin-dryness, cracking, irritation eyes watering, stinging and inflammation.
Emergency treatment: in case of contact with Skin flush with fresh water, remove containment clothing, in case of excessive inhalation move the victim to fresh air, obtain medical assistance.
TLV (ACGIH) : 300 ppm *STEL*: 500 *Permissible Exposure limit*: $L.D_{50}$ *(Oral-Rat)* : 13.6 g/kg $L.C_{50}$: (rat for 4hrs) 43g/m3 *Odor threshold*: N.A.

NFPA Hazard signals	*Health*	*Flammability*	*Reactivity/Stability*	*Special*
	0	3	0	-

6. Preventive measures

Personal Protective equipment: Gloves, eye protection preferred.
Handling and storage precautions: eliminate all sources of ignition at storage, ensure good ventilation, ground and bond the containners

7. Emergency and first aid measures

Fire: *Fire extinguishing media*: Foam, Carbon dioxide, Dry Chemical Powder. Water may be used to cool fire-exposed containers. *Special procedure*: Shut off leak, if safe to do so, .Keep non-involved people away from spill site. Issue warning: " FLAMMABLE". Eliminate all sources of ignition. *Unusual hazards*: Vapor heavier than Air it will spread along the ground and collect in sewers
Exposure:

First aid measures: **Skin contact** ; in case of contact with Skin flush with fresh water, remove containment clothing, **Inhalation**: in case of excessive inhalation move the victim to fresh air, If problem in breathing give artificial respiration; give oxygen. obtain medical assistance **Ingestion**: Give water to conscious victim to drink; do not induce vomiting. *Antidotes/Dosages*: N.A.
Spills: *Steps to be taken*: Shut off leak, if safe to do so, .Keep non-involved people away from spill site. Eliminate all sources of ignition. Prevent spill entering in to sewers, for Major spillage contact Emergency services *Waste Disposal method*: N.A.

8 . Additional Information /reference

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9 . Manufacture/Suppliers Data

Manufacture(Name Of Firm.) : Hindustan Petroleum Corporation
Supplier/dealer Data.
Name Mailing address Telephone Contact Persons

10 . DISCLAIMER

Information contained in this material data sheet is believed to be reliable but no representation, guaranty or warranties of any kind are made for suitability for particular application or result o be obtained from it. It is up the seller to ensure the Product sold by them is relevant to information contained in MSDS

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