7 RISK ASSESSMENT AND EMERGENCY RESPONSE PLAN

7.1 QUANTITATIVE RISK ASSESSMENT

This section summarises the results of the consequence analysis from potential hazards associated with the MPT Central Processing Terminal, RGT Processing Terminal, Well Pads, intra-field pipelines after capacity upgradation from 300,000 BOPD to 400,000 BOPD and 165 MMSCFD to 750 MMSCFD within existing RJ Block in Rajasthan, India and natural gas export pipeline of 500 MMSCFD capacity from RGT in Rajasthan to Bhogat in Gujarat. Accidental risk involves occurrence or potential occurrence of some accident consisting of an event or sequence of events resulting into fire, explosion or toxic event which poses risk to human health and environment.

The RA process outlines rational evaluations of the identified risks based on their significance and provides the outline for appropriate preventive and risk mitigation measures. The output of the RA will contribute towards strengthening of the Emergency Response Plan (ERP) in order to prevent damage to personnel, infrastructure and receptors in the immediate vicinity of the plant. Additionally, the results of the RA can also provide valuable inputs for keeping risk at As Low As Reasonably Practicable (ALARP) and arriving at decisions for mitigation of high risk events.

The following section describes the objectives, methodology of the risk assessment study and assessment for each of the potential risk separately. This includes identification of major hazards, hazard screening and ranking, frequency and consequence analysis for major hazards. The hazards have been quantitatively evaluated through a criteria base risk evaluation matrix. Risk mitigation measures to reduce significant risks to acceptable levels have also been recommended as a part of the risk assessment study.

7.2 RA STUDY OBJECTIVE

The overall objective of this RA with respect to the proposed project involves identification and evaluation of major risks, prioritizing risks identified based on their hazard consequences and using the outcome to guide and strengthen both onsite and offsite ERP. Hence in order to ensure effective management of any emergency situations that may arise during the de-bottlenecking and expansion activities, the following specific objectives need to be achieved.

- Review the detailed project design for the risk assessment study;
- Identify release scenarios for escape of flammable chemicals and gases from facilities, platforms and pipelines;
- Review historical databases to arrive at possible likelihood of such risk scenarios;
- Verify and present estimated damage distances for the accidental release based on different scenarios through Maximum Credible Accident analysis;

- Review and present suggestion of risk mitigation measures for process equipment based on consequence analysis;
- Review the adequacy of existing Disaster Management Plan for the proposed upstream and midstream expansion Project components.The Plan is already in operation to tackle onsite and offsite emergencies at MPT, RGT and associated facilities.

7.3 RISK ASSESSMENT STUDY METHODOLOGY

The risk assessment process is primarily based on likelihood of occurrence of the risks identified and their possible hazard consequences particularly being evaluated through hypothetical accident scenarios. With respect to the proposed project, major risks viz. leaks and rupture of major and critical equipment, atmospheric storage tanks and pipeline have been assessed and evaluated through a risk matrix generated to combine the risk severity and likelihood factor. Risk associated with the proposed expansion and debottlenecking activities have been determined semi-quantitatively as the product of likelihood/probability and severity/consequence by using order of magnitude data (*risk ranking = severity/consequence factor* x *likelihood/probability factor*). Significance of such project related risks was then established through their classification as high, medium, low, very low depending upon risk ranking.

The risk matrix is widely accepted as standardized method of risk assessment and is preferred over purely quantitative methods, given that it's inherent limitations to define a risk event is certain. Application of this tool has resulted in the prioritization of the potential risks events for the existing operations and proposed expansion thus providing the basis for drawing up risk mitigation measures and leading to formulation of plans for risk and emergency management. The overall approach is summarized below in ***Figure 7.1.***

Figure 7.1 Risk Assessment Methodology

7.3.1 Data Collection and Review

For the proposed upstream and midstream project compinents following information was reviewed:

- Details on processes and storages (inventories);
- Design and operating conditions;
- Material properties; and
- Sensitivie features prevailing in area surrounding the upstream and midstream project components (as identified through baseline section).

7.3.2 Hazard Identification

A hazard is an undesired event, which may cause harm to people or to the environment or damage to property.

System Definition

The study is primarily concerned with the identification and evaluation of accidental events associated, which have potential to cause major incident with proposed expansion related operations comprising of:

- Upstream project components i.e. MPT, new RGT and Enhanced Oil Recovery of crude oil and satellite gas well pads; and
- Midstream operations of inter and intra field pipelines and cross country new 30 inches natural gas pipeline.

The major incident is defined as:

- A fire, explosion due to release of a dangerous substance like flammable fluid or natural gas resulting from a work activity which could result in death or serious personal injury to people within the area of activity;
- Hazards associated include uncontrolled release (liquid and gas) and subsequent fire due to accidental loss of containment.

A structured and systemic approach to hazard identification has been adopted in this study to identify all potential major hazard scenarios which can lead to fatalities, injuries including damage to property and environment. Typically, the potential major hazardous incidents arising from the proposed project and its associated supporting facilities are mainly related to the leaks and rupture of hazardous liquids and gases processed in equipment, stored in tanks and transported through pipelines. Lists of hazards identified included in ***Table 7.1, Table 7.2*** and ***Table 7.3***.

Table 7.1 Description of Key Equipment

S. N.	Location	Equipment Type	Equip-ment Dia, m	Equip-ment Length, m	Operating Temp. °C	Operating Pressure, kPa g	Remarks
1	MPT	Slug Catcher (V-1201)	4.5	16	64-70	350	Rated Capacity of Slug Catcher 80,000 BOPD
2	SUPP	Slug Catcher (V-102)	4.6	20	100	10,000	Rated Capacity of Slug Catcher 150,000 BOPD
3	RDG	Slug Catcher (SP 981)	12.0	110	30-50	4,650	-
4	Well Head Platform P- 05	Test Separator (V-111)	2.2	4.5	60	4,550	Rated Capacity of Test Separator 15 MMSCFD
5	Gas fields KW-6	Gas Scrubber Dimensions V-301	1.8	6.0	43	1,200	-
6	Raag Wellpad #1 Satellite Oil Field	2-Phase Separa-tor – Slug Catcher V-212	0.968	3.5	85	350	-

Note: The number of leak or rupture scenarios for the above locations and equipment type are included in ***Table 7.12*** and ***Table 7.13***

Table 7.2 Description of Proposed Tanks

S. N.	Location	Equipment Type	Tank Dia, m	Tank Height, m	Tank Type	Operating Temp. °C	Operating Pressure, kPa g	Tank Inven-tory m^3
1	RDG	Propane storage Tank ((V-851)	2.2	7.1	Vertical	45	2100	27
2	Raag Wellpad #1 Satellite Oil Field	Export oil storage vessel (V-851)	2.4	12.5	Vertical	85	ATM	60
3	Mobile Trucks	Tube cylinder cascade	0.7175	11.514	Hori-zontal	Amb	25000	2.25

Note: The number of leak or rupture scenarios for the above locations and tanks are included in ***Table 7.12*** and ***Table 7.13***

Table 7.3 Description of Midstream Pipelines

S. N.	Location	Equipment Type	Pipe line Dia, m	Operating Temp. °C	Operating Pressure, kPa g	Pipeline Length km
1	RDG Wellpad Development Project	RDG Wellpad (HP from WP-08 to WP 05)	8	60	5,500	1.960
2	RDG Wellpad Development Project	RDG Wellpad LP Production Header - line size 20" from WP-05 to RGT & RDG	20	80	9,500	4.960
3	RDG Wellpad Development Project	Stabilized Condensate Pipeline RDG Terminal (New) to AGI_5 Existing	8	80	9,500	7.630
4	RGT to Bhogat	New gas pipeline (500 MMSCFD)	30	65	9,500	600.000 Note* (Emergency Shutdown valves given at every 20 km interval)

Note: The number of leak or rupture scenarios for the above locations and pipelines are included in ***Table 7.12*** and ***Table 7.13***

7.3.3 Frequency Analysis

The frequency analysis of the hazards identified with respect to the proposed project was undertaken to estimate the likelihood of their occurrences during the project life cycle. Hazard frequencies in relation to the proposed project were estimated based on the analysis of historical accident frequency data and professional judgment. Based on the range of probabilities arrived at for different potential hazards that may be encountered from equipment, storage tank and pipeline failures with respect to the proposed project, the following frequency categories and criteria have been defined (Refer ***Table 7.4***).

Table 7.4 Frequency Categories and Criteria

Likelihood Ranking	Criteria Ranking (cases/year)	Frequency Class
5	Likely to occur often in the life of the project, with a probability greater than 10^{-1}	Frequent
4	Will occur several times in the life of project, with a probability of occurrence less than 10^{-1}, but greater than 10^{-2}	Probable
3	Likely to occur sometime in the life of a project, with a probability of occurrence less than 10^{-2}, but greater than 10^{-3}	Unlikely
2	Unlikely but possible to occur in the life of a project, with a probability of occurrence less than 10^{-3}, but greater than 10^{-6}	Remote
1	So unlikely it can be assumed that occurrence may not be experienced, with a probability of occurrence less than 10^{-6}	Improbable

Source: Guidelines for Developing Quantitative Safety Risk Criteria – Centre for Chemical Process and Safety

7.3.4 Consequence Analysis

In parallel with the frequency analysis, hazard prediction / consequence analysis exercises were undertaken to assess the likely impact of project related risks on onsite personnel, infrastructure and environment. In relation to the proposed project as well as the existing activities, the estimation of the consequences for each possible event has been based on either accident

frequency, consequence modeling or professional judgment, as appropriate. Overall, the consequence analysis takes into account the following aspects:

- Nature of impact on community;
- Occupational health and safety;
- Asset and property damage;
- Corporate image; and
- Timeline for restoration of property damage.

The following criteria for consequence rankings (Refer ***Table 7.5)*** have been drawn up in context of the possible consequences of the risk events that may occur during the proposed project operations:

Table 7.5 Severity Categories and Criteria

Consequence	Ranking	Criteria Definition
Catastrophic	5	• Multiple fatalities/permanent total disability to more than 50 persons. • Net negative financial impact of >10 crores • International media coverage • Loss of corporate image and reputation
Major	4	• Single fatality/permanent total disability to one or more persons • Net negative financial impact of 5 -10 crores • National stakeholder concern and media coverage.
Moderate	3	• Short term hospitalization & rehabilitation leading to recovery • Net negative financial impact of 1-5 crores • State wide media coverage
Minor	2	• Medical treatment injuries • Net negative financial impact of 0.5 – 1 crore • Local stakeholder concern and public attention
Insignificant	1	• First Aid treatment • Net negative financial impact of <0.5 crores. • No media coverage

Risk Evaluation

Based on ranking of likelihood and frequencies, each identified hazard has been evaluated based on the likelihood of occurrence and the magnitude of consequences. The significance of the risk is expressed as the product of likelihood and the consequence of the risk event, expressed as follows:

Significance = Likelihood x Consequence

The ***Table 7.6*** below illustrates all possible product results for the five likelihood and consequence categories while the ***Table 7.7*** assigns risk significance criteria in three regions that identify the limit of risk acceptability. Depending on the position of the intersection of a column with a row in the risk matrix, hazard prone activities have been classified as low, medium and high thereby qualifying for a set of risk reduction / mitigation strategies.

Table 7.6 Risk Matrix

			Likelihood →				
			Frequent	**Probable**	**Unlikely**	**Remote**	**Improbable**
			5	**4**	**3**	**2**	**1**
Consequence ↑	**Catastrophic**	**5**	25	20	15	10	5
	Major	**4**	20	16	12	8	4
	Moderate	**3**	15	12	9	6	3
	Minor	**2**	10	8	6	4	2
	Insignificant	**1**	5	4	3	2	1

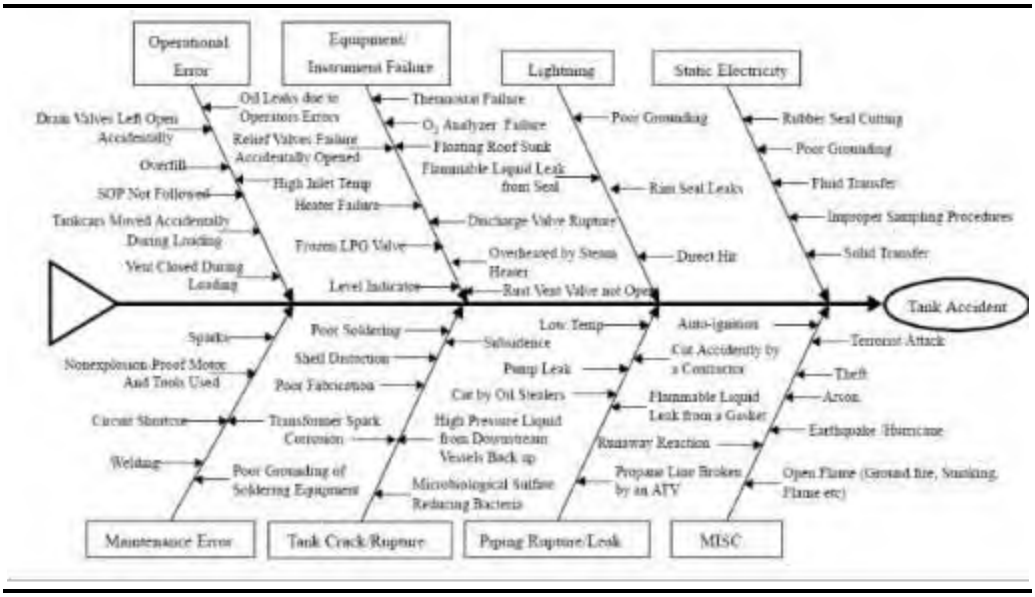
Table 7.7 Risk Criteria and Action Requirements

S.N.	Risk Significance	Criteria Definition & Action Requirements
1	**High (16 - 25)**	**"Risk requires attention"** – Project HSE Management need to ensure that necessary mitigation are adopted to ensure that possible risk remains within acceptable limits
2	**Medium (10 – 15)**	**"Risk is tolerable"** – Project HSE Management needs to adopt necessary measures to prevent any change/modification of existing risk controls and ensure implementation of all practicable controls.
3	**Low (5 – 9)**	**"Risk is acceptable"** – Project related risks are managed by well-established controls and routine processes/procedures. Implementation of additional controls can be considered.
4	**Very Low (1 – 4)**	**"Risk is acceptable"** – All risks are managed by well-established controls and routine processes/procedures. Additional risk controls need not to be considered

Storage Tank Failure Causes

In order to understand the possible causes of storage tanks failure necessary efforts were made towards analyzing the information provided in the research article titled "*A Study of Storage Tank Accidents*" by *James I. Chang & Cheng-Chung Lin* published in *Journal of Loss Prevention in the Process Industries*. The study identifies lightning as the major cause of tank accident followed by operational error, equipment failure, sabotage, crack and rupture, leak and line rupture, static electricity, open flames etc. The fish bone diagram highlighting the possible causes of storage tank failure as obtained from the above discussed research article has been presented in ***Figure 7.2***.

Figure 7.2 Fish Bone Diagram of Storage Tank Incident Causes



Potential Hazards – Storage Tank & Pipeline Failures

Storage tank failure may lead to the following possible hazard consequences as discussed below:

- Pool fire;
- Jet fire;
- Vapour Cloud Explosion (VCE);

In case of pipelines, jet fire has been identified as the possible consequences resulting from failures such as leaks and ruptures.

The aforesaid outcomes following rupture or leak scenarios depend on many factors such as the material, its phase, the operating conditions, tank and pipeline design specifications and the location of the release. More details on such outcomes have been discussed below.

Fire

A fire caused by inflammable chemical is a complex chain reaction where a fuel combines with oxygen to generate heat, smoke and light. Thermal radiation is the primary hazard associated with industrial fires. However, if it goes out of control, such fire hazards can also result in an explosion. In addition, as fire is a chemical reaction that mainly yields smoke and soot, it may also result in the formation of a number of gaseous by-products which can be hazardous. Industrial fires can be categorized:

- ***Pool Fire:*** A pool fire occurs when a flammable liquid spills onto the ground and is ignited. A fire in the liquid storage tank is also a form of pool fire. A pool fire may also occur on the surface of flammable liquid spilled onto water.
- ***Jet fire:*** A jet fire, also referred to as a flame jet, occurs when a flammable gas or gas liquefied under pressure is rapidly released from an opening in a container and immediately catches on fire.

- **Vapour Cloud Explosion:** Explosions are generally considered as the worst case possible hazardous outcome (relative to the other outcomes such as Jet Fires, Pool Fires, Flash Fires) due to the destructive nature and potential escalations. The extent of the explosion will depend on the inventory forming the explosion, its location and the result of any subsequent structural or process damage.

Thermal radiation from industrial fires is capable of damaging to both life and property. The determination of thermal radiation hazard zones involves the following three steps:

- Geometric characterization of fire, i.e., the determination of the burning rate and the physical dimensions of the fire;
- Characterization of the radiative properties of the fire, i.e., the determination of the average radiative heat flux from the flame surface; and
- Calculation of radiant intensity at a given location.

The vulnerability of humans exposed to thermal radiation depends on the intensity of the incident radiation and the duration of the exposure. Thermal radiation is measured in terms of energy flux and expresses in units of power per unit area. However, the potential to cause damage is measures by the dosage of thermal radiation that a receptor or person is exposed to and is a combination of the intensity of radiation and the time of exposure.

The level of concerns considered for different events resulting in radiation intensity for the proposed project related identified significant hazards consequences is provided in ***Table 7.8***:

Table 7.8 ***Levels of Concern for Thermal Radiation Intensity***

Element of Concern	**LOC-1 (potentially lethal within 60sec)**	**LOC-2 (2nd degree burns within 60 sec)**	**LOC-3 (Pain within 60 sec)**
Radiation Intensity	10.0kW/sq. m	5.0kW/sq. m	2.0kW/sq. m

Source: Handbook of Chemical Hazard Analysis and Procedures; FEMA

Explosion

Explosion is a sudden, intense release of energy that generates a pressure wave because of rapidly expanding gases and is often accompanied with a loud noise, high temperatures and flying debris.

One of the major hazards associated with any explosion is overpressure. Over pressure, also called a blast wave refers to the sudden onset of a pressure wave after an explosion. This pressure wave is caused by the energy released in the initial explosion and travels at the speed of sound radiating outward like a large burst of air with its strength weakening as it moves away from the source. If he pressure wave has sufficient power, it can cause widespread damage to both human life and property.

The levels of concern used for overpressure from identified events' consequence analysis for the proposed project is provided in ***Table 7.9.***

Table 7.9 Levels of Concern used for Vapour Cloud Explosion

Element of Concern	LOC-1 (Destruction of buildings)	LOC-2 (Serious Injury Likely)	LOC-3 (shatters glass)
Overpressure (psig)	8.0	3.5	1.0

Source: F.P Lees (1980) Loss Prevention in Process Industries

7.3.5 Storage Tank & Pipeline Failure Frequency Analysis

Frequency analysis of storage tank failures (leak and fire) for the proposed project has been established based on the *International Oil & Gas Producers (OGP) – Risk Assessment Data Directory (RADD) on Storage Incident Frequencies* and *Purple Book*. The leak frequencies for storage tanks based on type of release as obtained from the aforesaid OGP document have been presented in the ***Table 7.10*** below.

Table 7.10 Historical Storage Tank Leak Frequencies by Release

S. N.	Tank Type	Release Type	Leak Frequency (per tank year)	Frequency
1	Fixed/Floating Roof (single containment)	Instantaneous release of the complete inventory directly to the atmosphere	$3 X 10^{-6}$	Remote
2	Fixed/Floating Roof	Liquid spill outside tank	$2.8 X 10^{-3}$	Occasional/ Rare
3	Pressurised Tank/Vessels	Catastrophic rupture	$4.7 X 10^{-7}$	Improbable
4	Pressurised Tank/Vessels	Leak (3mm to 10mm hole dia)	$1.2 X 10^{-5}$	Remote

Source: International Oil & Gas Producers (OGP) – Risk Assessment Data Directory (RADD) on Storage Incident Frequencies

Thus, the probability of storage tank failure with respect to the proposed expansion is identified to be primarily as "***Remote***" (Refer ***Table 7.3***).

The pipeline failure frequency viz. leaks or rupture for the proposed Gas and condensate pipeline is established based on the interpretation of the database of European Gas Pipeline Incident Data Group (EGIG) representing almost 2 million kilometer year of pipeline operations. The failure rate reported by EGIG for on-shore gas pipeline with design pressure greater than 15 bar is **$4.76 x 10^{-4}$ km/year.** Full Bore Rupture (FBR) represents 13% of the cases (**$6.188 x 10^{-5}$ failure /km/yr**) and 87% of the cases represents Leaks (**$4.14 x 10^{-4}$ failure /km/yr**).

The frequency of pipeline failure computed for the both proposed and existing pipelines based on EGIG failure frequency is presented in the ***Table 7.11*** below.

Table 7.11 Pipeline Failure Frequency

S. N.	Pipeline Failure Case	EGIG Failure Frequency (per km.year)	Pipeline Length (km)	Project Pipeline Failure Frequency (per year)	Frequency
1	Well fluid HP Production Header from WP-08 to WP 05) Rupture	6.188×10^{-5}	1.96	1.21E-04	Remote
2	Well fluid HP Production Header from WP-08 to WP 05) Leak	4.14×10^{-4}	1.96	8.11E-04	Remote
3	Well fluid LP Production Header (Line Size) 20" from WP-05 to RGT & RDG Rupture	6.188×10^{-5}	4.96	3.07E-04	Remote
4	Well fluid LP Production Header (Line Size) 20" from WP-05 to RGT & RDG Leak	4.14×10^{-4}	4.96	2.05E-03	Occasional /Rare
5	Stabilized Condensate Pipeline RDG Terminal (New) to AGI_5 Rupture	6.188×10^{-5}	7.63	4.72E-04	Remote
6	Stabilized Condensate Pipeline RDG Terminal (New) to AGI_5 Leak	4.14×10^{-4}	7.63	3.16E-03	Occasional /Rare
7	RGT to Bhogat new gas pipeline (500 MMSCFD) Rupture	6.188 x 10-5	20	1.24E-03	Occasional /Rare
8	RGT to Bhogat new gas pipeline (500 MMSCFD) leak	4.14 x 10-4	20	8.28E-03	Occasionl /Rare

Thus, the probability of pipeline leak and rupture with respect to the proposed and existing pipeline is identified mostly to be as "Remote" respectively.

7.4 CONSEQUENCE ASSESSMENT OF IDENTIFIED PROJECT HAZARDS

As mentioned in the previous section, four major categories risk has been identified in relation to proposed expansion and deottlenecking project. A comprehensive risk assessment study has been undertaken to assess and evaluate significance of identified risks in terms of severity of consequences and likelihood of occurrence.

The consequence scenarios associated with the proposed project were modelled to determine their potential impact on the existing site infrastructure and surrounding area. The modelling took into account the chemical properties of the chemicals and fuel released from tanks and/or vessels, pipelines and the predominant meteorological conditions, where applicable. The risk scenarios have been modeled using ALOHA and interpreted in terms of Level of Concern (LOC) for Radiation Intensity and Overpressure. Risk assessment outcome for various scenarios have been summarized in the ***Table 7.12*** below:

Table 7.12 Equipment, Storage Tanks & Pipelines – QRA Output for Radiation Intensity

S.N.	Location	Equipment	Scenario No.	Scenario	Event	End point (m) for Radiation Intensity			Risk Significance for Highest LOC		
						LOC-1 10.0 kW/sq.m	LOC-2 5.0 kW/sq.m	LOC-3 2.0 kW/sq.m	Likelihood Ranking	Consequence Ranking	Risk Significance
1.	MPT	Slug Catcher (V-1201)	2	Liquid Spill Out	Pool Fire	20	24	33	2	3	**6**
2.	MPT	Slug Catcher (V-1201)	3	100mm leak	Pool Fire	18	22	30	2	2	**4**
3.	RDG	Slug Catcher (SP 981)	1	100mm leak	Jet Fire	39	55	85	2	3	**6**
4.	RDG	Slug Catcher (SP 981)	2	Liquid Spill Out	Pool Fire	138	182	265	2	3	**6**
5.	SUPP (Slug Catcher)	Slug Catcher (V-102)	1	Liquid Spill Out	Pool Fire	15	18	25	2	2	**4**
6.	RDG	Propane Storage Tank (V-851)	2	100mm leak	Jet Fire	99	139	213	2	3	**6**
7.	Well Head Platform P05	Test Separator (V-111)	2	100mm leak	Jet Fire	30	42	65	2	2	**4**
8.	Gas fields KW-6	Gas Scrubber Dimensions V-301	1	100mm leak	Jet Fire	15	20	31	2	2	**4**
9.	(RAAG WELL PAD#1) Sattelite Oil Field	2 Phase Separator (Slug Catcher) V-212	1	100mm leak	Jet Fire	10	10	11	2	2	**4**
10.	(RAAG WELL PAD#1) Sattelite Oil Field	2 Phase Separator (Slug Catcher) V-212	2	Liquid Spill Out	Pool Fire	14	17	23	2	2	**4**
11.	(RAAG WELL PAD#1) Sattelite Oil Field	Export Oil Storage Vessel V-213	4	Liquid Spill Out	Pool Fire	21	27	37	2	2	**4**
12.	RDG Well Pad Development Project	RDG WELL PAD (HP from WP-08 to WP 05), Line size 8" (natural gas)	1	100mm leak	Jet Fire	18	25	39	2	2	**4**
13.	RDG Well Pad Development Project	RDG WELL PAD (HP from WP-08 to WP 05), Line size 8" (natural gas)	2	25 mm leak	Jet Fire	10	13	20	3	2	**6**
14.	RDG Well Pad Development Project	RDG WELL PAD (HP from WP-08 to WP 05), Line size 8" (natural gas)	3	Rupture	Fire	43	60	93	1	2	**2**
15.	RDG Well Pad Development Project	RDG WELL PAD LP Production Header (Line Size) 20" from WP-05 to RGT & RDG (natural gas)	1	100mm leak	Jet Fire	23	32	50	2	2	**4**
16.	RDG Well Pad Development Project	RDG WELL PAD LP Production Header (Line Size) 20" from WP-05 to RGT & RDG (natural gas)	2	25 mm pin hole	Jet Fire	12	17	26	3	2	**6**
17.	Mobile Trucks	Tube Cylinder cascade (natural gas)	2	25mm leak	Jet Fire	39	55	85	2	3	**6**
18.	Well fluid HP Production Header from WP-08 to WP 05)	HP Production Header from WP-08 to WP 05) (8" dia) (natural gas)	1	100mm leak	Jet Fire	18	25	39	2	2	**4**
19.	Well fluid HP Production Header from WP-08 to WP 05)	HP Production Header from WP-08 to WP 05) (8" dia) (natural gas)	2	25 mm leak	Jet Fire	10	13	20	3	2	**6**
20.	Well fluid HP Production Header from WP-08 to WP 05)	HP Production Header from WP-08 to WP 05) (8" dia) (natural gas)	3	Rupture	Fire	43	60	93	1	2	**2**
21.	Well fluid LP Production Header (Line Size) 20" from WP-05 to RGT & RDG	LP Production Header (Dia 20")from WP-05 to RGT & RDG (natural gas)	1	100mm leak	Jet Fire	23	32	50	2	3	**6**
22.	Well fluid LP Production Header (Line Size) 20" from WP-05 to RGT & RDG	LP Production Header (Dia 20")from WP-05 to RGT & RDG (natural gas)	2	25 mm leak	Jet Fire	12	17	26	3	2	**6**
23.	RGT to Bhogat	New gas pipeline (500MMSCFD) (30″)	1	100 mm leak	Jet Fire	23	33	51	2	3	**6**
24.	RGT to Bhogat	New gas pipeline (500MMSCFD) (30″)	3	Rupture	Fire	311	432	666	2	5	**10**

Note:

Material considered in case of Gas Fields – Methane

Material considered in case of Oil Fields – n-Heptacosane

Table 7.13 Equipment, Storage Tanks & Pipelines – QRA Output for Overpressure

S.N.	Location	Equipment	Scenario No.	Scenario	Event	End point (m) for Overpressure			Risk Significance for Highest LOC		
						LOC-1 8.0 psi	LOC-2 3.5 psi	LOC-3 1.0 psi	Likelihood Ranking	Consequence Ranking	Risk Significance
1.	RDG	Slug Catcher (SP 981)	3	Rupture	VCE	LOC never exceeded	LOC never exceeded	242	1	3	**3**
2.	RDG	Slug Catcher (SP 981)	4	100mm leak	VCE	LOC never exceeded	LOC never exceeded	158	2	3	**6**
3.	RDG	Propane Storage Tank (V-851)	1	100mm leak	VCE	LOC never exceeded	168	293	2	3	**6**
4.	RDG	Propane Storage Tank (V-851)	5	Rupture	VCE	LOC never exceeded	264	346	2	3	**6**
5.	Well Head Platform P05	Test Separator (V-111)	1	100mm leak	VCE	LOC never exceeded	LOC never exceeded	88	2	3	**6**
6.	Well Head Platform P05	Test Separator (V-111)	3	Rupture	VCE	LOC never exceeded	LOC never exceeded	637	1	4	**4**
7.	Gas fields KW-6	Gas Scrubber Dimensions V-301	2	100mm leak	VCE	LOC never exceeded	LOC never exceeded	37	2	2	**4**
8.	RDG Well Pad Development Project	RDG Well Pad (HP from WP-08 to WP 05), Line size 8"	4	Rupture	VCE	LOC never exceeded	LOC never exceeded	157	1	4	**4**
9.	RDG Well Pad Development Project	RDG Well Pad (HP from WP-08 to WP 05)	5	100mm leak	VCE	LOC never exceeded	LOC never exceeded	71	2	3	**6**
10.	RDG Well Pad Development Project	RDG Well Pad LP Production Header (Line Size) 20" from WP-05 to RGT & RDG	3	Rupture	VCE	LOC never exceeded	LOC never exceeded	1,000	1	5	**5**
11.	Mobile Trucks	Tube Cylinder cascade	1	Rupture	VCE	LOC never exceeded	LOC never exceeded	77	2	3	**6**
12.	Well fluid HP Production Header from WP-08 to WP 05)	HP Production Header from WP-08 to WP 05) (8" dia)	4	Rupture	VCE	LOC never exceeded	LOC never exceeded	157	1	4	**4**
13.	Well fluid HP Production Header from WP-08 to WP 05)	HP Production Header from WP-08 to WP 05) (8" dia)	5	100mm leak	VCE	LOC never exceeded	LOC never exceeded	71	2	3	**6**
14.	Well fluid LP Production Header (Line Size) 20" from WP-05 to RGT & RDG	LP Production Header (Dia 20")from WP-05 to RGT & RDG	3	Rupture	VCE	LOC never exceeded	LOC never exceeded	1,000	1	5	**5**
15.	RGT to Bhogat	New gas pipeline (500MMSCFD) (30″)	2	100 mm leak	VCE	LOC never exceeded	LOC never exceeded	100	2	3	**6**
16.	RGT to Bhogat	New gas pipeline (500MMSCFD) (30″)	3	Rupture	VCE	LOC never exceeded	LOC never exceeded	1,100	2	5	**10**

Note:

Material considered in case of Gas Fields – Methane

7.5 *RA OUTCOME*

The review of the RA results for equipment, storage tanks and pipelines indicates that in most of the scenarios involving leakages leading to pool/jet fire, the risk significance assessed to be "very low" to "low". The risk was assessed as 'Medium' for both fire and explosion due to pipeline rupture for the new 30" gas pipeline.

For scenarios with low risk significance, the effective distance for damage in terms of radiation intensity (Pool / Jet fire) and overpressure for the considered LOCs is given below:

Consequence Scenarios	Distance (m)		
	LOC 1	LOC 2	LOC 3
Radiation Intensity	10 to 138	10 to 182	11 to 265
Overpressure	LOC never exceeded	LOC never exceeded to 264	37 to 1,000

Source: Extract from ***Table 7.12 and 7.13***

Hence, damaging effect is evaluated to be limited to neighbouring process equipment's and machineries, and may include occupation injuries/fatalities to site personnel and workers operating in the immediate vicinity. These risks can be mitigated through well-established controls (leak detection) and routine response processes/procedures already practiced at Cairn as discussed in the subsequent sections.

Medium risk significance includes catastrophic failures of 30" new gas pipeline (500 MMSCFD) from RGT, Rajasthan to Bhogat, Gujarat. For medium risk significance, the effective distance for damage in terms of radiation intensity and overpressure for the LOCs are given below:

Consequence Scenarios	Distance (m)		
	LOC 1	LOC 2	LOC 3
Radiation Intensity	311	432	666
Overpressure	LOC never exceeded	LOC never exceeded	1,100

Source: Extract from ***Table 7.12 and 7.13***

Any potential emergencies arising from pipeline failure need to be effectively managed through emergency resources available within Cairn and assistance of mutual aid groups. The midstream 30" natural gas will be buried and provided with emergency shut down valves at appropriate locations.

The Consequence Analysis mapping is included as ***Annex G***.

7.6 *EMERGENCY PREPAREDNESS AND RESPONSE PLAN*

Emergency Response Philosophy: Cairn Emergency Response Philosophy is to provide "reasonable assurance that adequate measures can and will be taken in the event of an incident or emergency." The added feature of emergency planning provides that, even in the unlikely event of an incident or release to the environment, there is reasonable assurance that actions can be taken to

preserve life, prevent injury to people, damage to plant or the environment. To respond effectively to emergencies and incidents, an agreed and approved pre-established organization, on-call and capable of mobilizing and responding effectively need to be in place. Cairn is staffed with competent individuals, organized into teams, with allocated and clearly defined roles and responsibilities. Based on the Disaster Management Plan (DMP) case studies, following are the scenarios where Plant / Operation abandoning is required:

- Oil/Gas Well Blow out
- Pipeline major leakage
- Earthquake
- Flood
- Any other cases where received the directives from the District & Central Government.

Cairn Incident and Emergency Management Organizations: Cairn emergency management procedure for Rajasthan and Gujarat uses four primary organizations for response and management of incidents and emergencies. These are:

1. **Incident Response Team** (IRT) based at the each operating and or associated fields such as MPT, RGT, Bhagyam, Aishwariya, Saraswathi, Guda, Viramgam terminal, Bhogat terminal etc.,
2. **Emergency Response Team** (ERT) based in the town of Barmer in Rajasthan and Viramgam Terminal, Gujarat.
3. **Emergency Management Team** (EMT) based in the Cairn head office in Gurgaon.
4. **Crisis Management Team** (CMT) based in the Cairn head office in Gurgaon.

Cairn's Rajasthan and Gujarat operations have a support organization the Emergency Response Team (ERT) based in Barmer and Viramgam Terminal, Gujarat. Details of the linkages between the organizations and how assistance is provided to the IRT by the ERT and EMT is given in the IRP document number RJ/QHSE/PLA/021.

Incident Response Teams (IRT): Whenever IRT is mobilized, ERT team leader is notified. Incident Response Team comprise of two main organizations these being:

- Incident Control Team, (ICT) responsible for management and control of the incident
- Forward Response Team (FRT) responsible for at the scene response

Emergency Response Team (ERT): The Barmer and Viramgam Terminal, Gujarat based Emergency Response Team (ERT) will provide support to the facilities teams in the event of an incident or emergency. Particularly for any Tier 1 & 2 events.

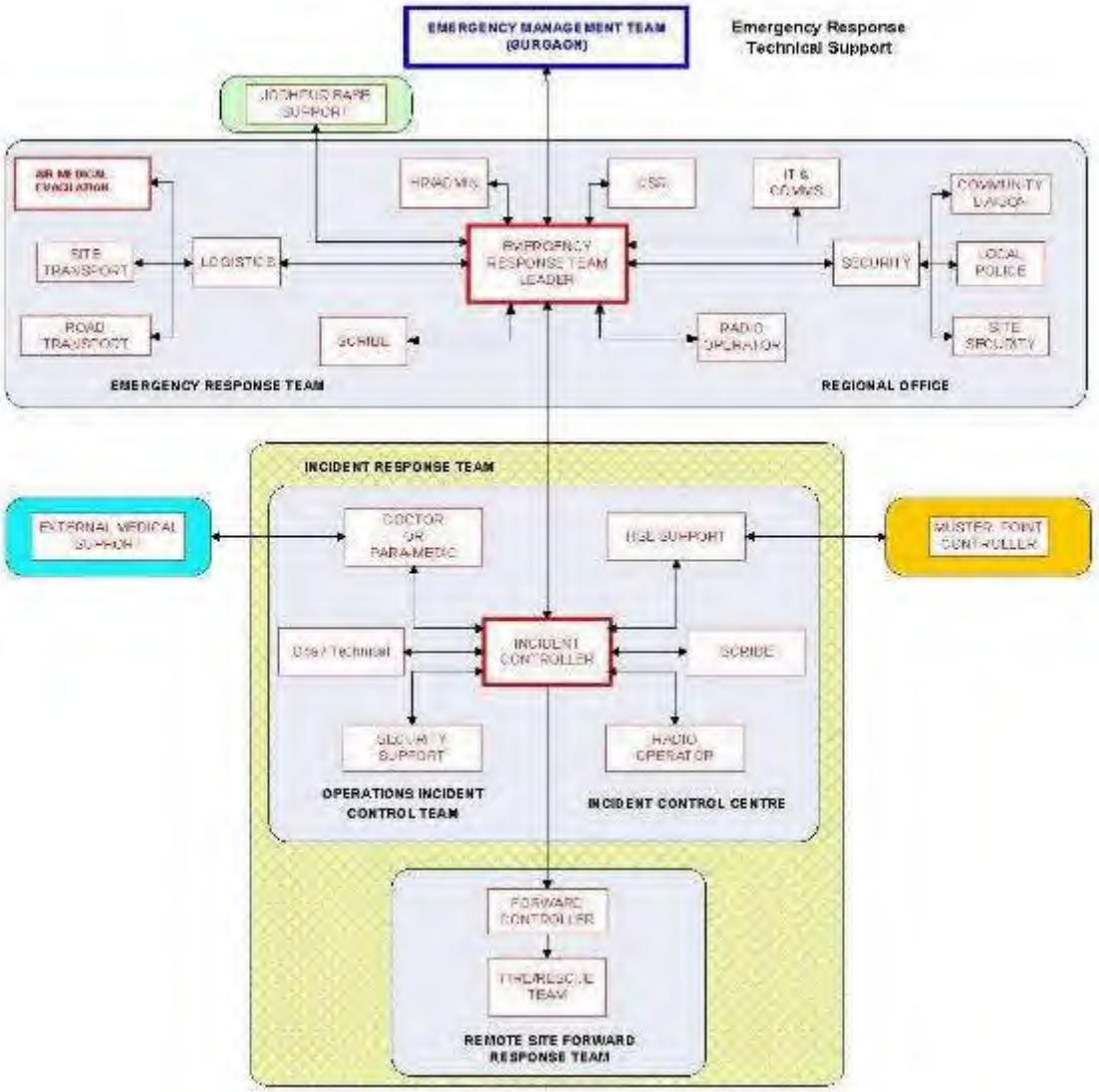
Emergency Management Team (EMT) – Tactical Response: Based in the Cairn Gurgaon Office, the Emergency Management Team (EMT) is responsible for

providing tactical response, support, assistance and advice to all Tier 2 & 3 incident and emergency situations.

Crisis Management Team (CMT) - Strategic Response: The Crisis Management Team is the Cairn corporate body located in the Corporate Office in Gurgaon with the responsibility for defining response strategy for major Tier 3 incidents. As well as having support from the Gurgaon based EMT and CMT, Cairn Rajasthan and Gujarat operations are also supported by a regional Emergency Response Organization based in the Barmer and Viramgam. Mutual assistance is provided to the concerned Team by the adjacent teams such as drilling, operations, construction groups etc.

IRT Organization support: The IRT is competent to manage all identified incidents or emergency situations which may occur at any time. The roles of various teams and support matrix is illustrated below in ***Figure 7.3***.

Figure 7.3 IRT Organizational Support Matrix



Source: Cairn

7.6.1 Management and Control of Emergencies

The Installation Manager / DGM / GM shall assume command and control of any emergency occurring within the area of Terminal and Well pads. The Terminal and well pad is provided with certain features to limit or prevent the escalation of accidents, incidents these include:

- Separation of equipment to prevent potential escalation
- Fire Resistance Protection for critical structures
- Fire retardant and Low Smoke cables
- Automated Fire & Gas Detection System
- Automatic water spray system and Foam pourer system
- Dedicated Fire water hydrant system
- Sequential Blow Down system
- Remotely operated shutdown valves
- Surface shutdown valves at Well Pads

Evacuation, Escape and Muster: Cairn is committed to providing adequate arrangements, facilities, resources and training to facilitate the safe mustering, evacuation and escape of personnel from the facility in the event of any life threatening emergency and or the integrity of the facility. Muster Points or temporary safety areas must be clearly identified and personnel must muster at these areas when the emergency alarm or signal is activated. Muster Points are detailed in the facilities emergency locations plans and at each locations. The Muster Points are situated in areas which provide some distance from the effects of the incident or emergency. Refer to Fire Contingency Plan (RJON-RGF-HSS-PLN-0001) for more details. Muster Checkers are provided with radio's to allow uninterrupted communications with the Incident Control Centre (ICC). In the event of an incident in any area of the facility where entrapment is possible, local escape and evacuation facilities are in place to allow personnel to move away from that area.

Emergency Signals and Alarms: The Terminal and Well Pads facilities will have a recognizable and identifiable emergency signal and or alarm to notify all personnel on the facility that an incident or emergency situation has occurred. Where applicable, alarm tones and the duration comply with the requirements of OISD – STD – 189.

Escape: The terminal and Well Pads has clearly marked primary and alternative escape routes. These are described in the safety induction and demonstrated as part of the facilities orientation process.

Muster: All personnel working or visiting the Terminal and Well Pads shall be allocated a Muster Point which is clearly identified in the facilities safety induction process. On hearing the Emergency Alarm, personnel shall report to their allocated muster point, on arrival at the muster point they must give their name to the Muster Checker. If personnel are unable to get to their allocated muster point they should report to the nearest alternative muster point. Instructions will be in place for Muster Checkers and those in charge of the

Incident and Medical Response Teams to account for and report to the Muster coordinator the status of the muster.

Muster (Accounting for Personnel): The method used for accounting of personnel is by use of a Register / Electronic system (most of the locations access card with thumb impression already provided including visitors) where people's movements are tracked. The register will be maintained by the security team who will hold an up-to-date record of all those on the facility. In the event of an incident on the facility the Register / Electronic system will be marked to show each person accounted for from the muster roll call. All non-emergency personnel shall report **on foot** to their nearest muster point on hearing the alarm, unless instructed to do otherwise via, radio or agreed alternative method of communication. No vehicles, including emergency vehicles, will be utilized after a Facilities Alarm has been initiated unless under the direct instructions of the Incident Controller or their designated team member. All personnel with emergency duties, including the Incident Controller, must ensure they can safely gain access to their respective emergency response locations; if unable to do this, they should report to the nearest Muster Point, contact the Incident Control Centre or, failing this, advise the most senior member of staff and respond in accordance with the instructions given.

Evacuation: The Installation Manager will decide to evacuate the facility of all personnel if, following an incident, he deems the facility is becoming unsafe. This will be done in a controlled manner using all available means of evacuation.

Medical Evacuation: In the event of a medical evacuation being required the medical team shall immediately notify the Incident Controller of the need to evacuate a patient or patients, the Incident Controller or their nominated deputy shall immediately inform the ERT Leader. The company doctor will ensure the medical and logistical support organizations are prepared. The company doctor in consultation with the facilities doctor will determine the method of evacuation and location for treatment.
Abandon Plant: If the emergency continues to deteriorate, the procedure authorizes the Incident Controller, through a series of process to abandon the facility.

Medical Facilities and Support: To ensure prompt response and minimize delays in the treatment and transportation of patients needing hospital care, medical facilities such as clinics or first response units such as mobile clinics or ambulances are available. For 24 hour operations the Installation Manager will ensure sufficient medical support are available to cover the period of the operation.

Emergency Communications: Reliable communications equipment and support are available for use during an emergency situation and enable communications to be made throughout the Rajasthan Field and Gujarat pipeline operations, with neighboring facilities and the regional emergency center and Gurgaon. The radio center is located inside Terminal.

Communications facilities available at the primary control center include the following:

- UHF radio
- Telephone Network (PSTN- Public Switched telephone Network)
- IP phones (operations facilities)

Drills and Exercises: Details covering drills and exercises are provided in the Rajasthan, Gujarat (Pipeline Operations and Terminals) Incident Response Plan and as mentioned in the annual HSE plan. The workforce will be practiced in reacting to any reasonably foreseeable event which could occur.

Arrangements: In all foreseeable circumstances the prior arrangements are provided for the management of emergency or incident response. These arrangements include:

- The prevention, detection, control and mitigation of incidents.
- Manual intervention.
- Informing all personnel of what their response to emergencies should be
- Informing all personnel of hazardous conditions; their response, and accounting for all personnel following an incident.
- Partial or full facility evacuation.
- Firefighting and rescue.
- Co-ordination of the response and the co-operation of all those involved.
- External support and response.

As part of the planning and consultation process, arrangements are mad in place with the Cairn Gurgaon Office Emergency Management Team so that they will respond promptly if additional logistical, medical, environmental, media or business continuity assistance is required.

Preparation and Planning: Cairn Management have an obligation under various statutory regulations to identify, so far as is reasonably practicable, all hazards and their risks which could affect activities and personnel are put in place measures which will reduce these risks to levels considered to be 'As Low As Reasonably Practicable' (ALARP). By recognizing and assessing these residual risks and what the potential results of incidents could be, adequate prior arrangements - preparation and planning - can be put in place so that if there is an incident, there will be an immediate and appropriate response.

Detection of Incidents: Incidents and potential incidents are detected by either Fire and Gas automatic gas detection system and or Personnel working at the facility.

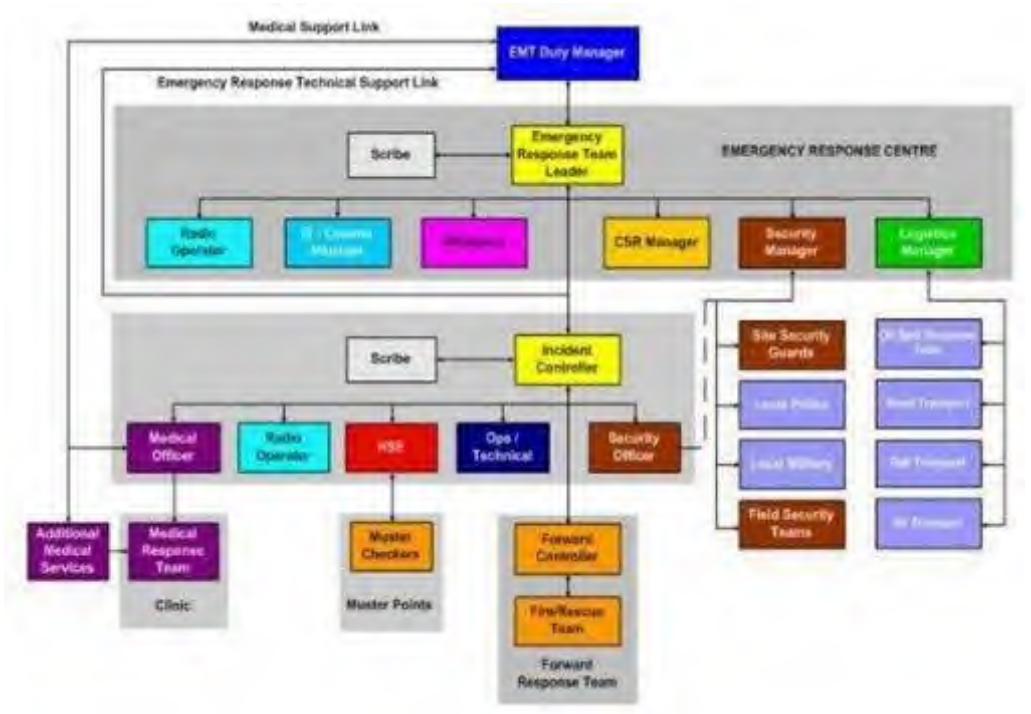
Environmental Response: Some incidents can result in environmental damage, these will primarily result from spillage or leak of crude oil, Condensate, propane, diesel, chemical, however, many actions associated with response to hydrocarbon incidents, such as isolation and depressurization, also provide mitigation against environmental damage. Further information is provided in the Cairn Oil Spill Response document RJON-RX-HSS-PRO-0034.

Security Incidents: The well Pads, Terminal and Pipeline is a remote site and exposed to potential security incidents. How to manage security incident, e.g. unauthorized entry to the facility, extortion, kidnapping etc. is covered by the Cairn Emergency Management Manual.

External Support: The corporate Cairn Crisis Management Plan provides details of the Cairn Crisis Management Team's activities in support of the field response teams in such aspects as the involvement of external emergency services i.e. Police, public and media enquires etc.

Rajasthan and Gujarat Incident Response Organizations and Links: The formations of the Incident Response Organizations for Rajasthan and Gujarat (four incident response are fundamentally the same for each facility; the facilities Incident Control and Forward Response organizations and numbers are determined by the size of the facility, location of the facility and organization in relationship to the Field Emergency Response Team and supporting groups. There are clear links between the facilities Incident Response Teams, the Emergency Response Team and the Gurgaon Emergency Management Team. With the exception of technical support, the regional Emergency Response Team provides the external support in the event of an incident.

Figure 7.4 Rajasthan and Gujarat Operations Emergency Response Links Diagram



Source: Cairn

7.6.2 Reporting and Notification Reporting

Incident Reporting: All incidents and emergencies must be reported and investigated in order to establish what happened and the causes of the incident

or emergency in order to introduce measures to prevent the incident or emergency occurring again. The incident reporting procedure is contained in the document CIL/HSE/08/000566. Details of the reporting process/protocol and forms to use are contained in the Incident Response Plan.

Incident Controller, must firstly notify the **Emergency Response Team Leader** and they must ensure they also notify the **Emergency Management Team Duty Manager**.

Media Communication: In the event of an incident or emergency there will inevitably be some media interest. Details covering the process for responding to the media are covered in the Incident Response Plan.

Emergency Response Procedures: There is no single procedure or process that if followed will ensure a successful outcome for those managing an incident or responding to an emergency, they are not a guarantee that the incident will be contained, controlled or prevented from escalation. These procedures can at best be a guide to the team managing the incident or emergency situation. The most effective method for ensuring a successful outcome is by training and practice by those charged with the responsibility of responding to and controlling incidents and emergencies.

Roles and Responsibilities: The composition and mobilization of the IRT and ERT will vary depending upon the nature of the incident or emergency. The duty ERT Leader will decide on any additional support required. A situation may arise where the ERT Leader or team members may require mobilizing additional Cairn staff to assist them in responding to an incident or emergency situation. The role and responsibility covering each member of the IRT and ERT are located in the Incident Response Plan. Duty IRT members will be identified on a duty rota which will be issued weekly or whenever there is a change made to the IRT. The initial actions for the first person(s) to arrive in the Emergency Control Centre are to initiate the actions contained within First to Arrive Check List and to ensure that:

- Telephones and communications systems are set up and functioning
- Establish and maintain communications with the incident or emergency location
- Identify the facts of the emergency and ensure that they are written up on the status boards
- Continue with actions as laid down in the arrival check list

7.6.3 Community Based Disaster Management Plan

Community Based Disaster Management Plan

Disaster Management is a planned and systematic approach to minimize damage to life, property and environment. It involves the systematic observation and analysis of measures relating to disaster prevention, mitigation, preparedness, emergency response, rehabilitation and reconstruction. It is also to be realized that disaster management involves community preparedness so as to achieve desired objective of minimization of

damage. Community preparedness involves all pre disaster planning to reduce the loss.

Community Based Disaster Management Plan was prepared district wise. There are totally nine districts, where the upstream and midstream operations are involved. These include two districts in Rajasthan state they are Barmer and Jalore, and seven districts in Gujarat state, they are Ahmedabad, Banaskantha, Patan, Surendranagar, Rajkot, Jamnagar and Devbhumi Dwarka.

The districts en-route of the facilities and pipeline are with diverse socio-economic and geographical profiles. Some of them have harsh desert environment, erratic climatic conditions, coupled with poverty, illiteracy of the community, drought conditions, occasionally flood conditions with impact to human life, economy and environment. Therefore the Community Based Disaster Management Plan was prepared to minimize the potential risk by:

1. Identifying the potential hazards and its impacts in on-site and off-site areas
2. Providing measures resources to minimize the incidents and the damage
3. Prepare and implement developmental plans to provide resilience to such disasters
4. Developing early warning strategies
5. Mobilize resources including communication and medical services and
6. To help in rehabilitation and post disaster reconstruction

Thus the developed community based DMP document reviews all Maximum Credible Loss Scenarios (MCLS) and presents the systematic plan with suitable framework for engagement and role of the communities and local administration in disaster preparedness and response. The following are the documents to be referred for community based disaster management plan prepared district wise.

1. MDPP-MPX-HSS-PLN-ABS1-0003-A7-Community Based Disaster Management Plan Midstream Facility Ahmedabad District, Gujarat.
2. MDPP-MPX-HSS-PLN-ABS1-0004-A6-Community Based Disaster Management Plan Midstream Facility Banaskantha District, Gujarat.
3. MDPP-MPX-HSS-PLN-ABS1-0005-A6-Community Based Disaster Management Plan Midstream Facility Patan District, Gujarat.
4. MDPP-MPX-HSS-PLN-ABS1-0006-A6-Community Based Disaster Management Plan Midstream Facility Surendranagar District, Gujarat.
5. MDPP-MPX-HSS-PLN-ABS1-0007-A6-Community Based Disaster Management Plan Midstream Facility Rajkot District Gujarat.
6. MDPP-MPX-HSS-PLN-ABS1-0008-A6-Community Based Disaster Management Plan Midstream Facility Jamnagar District, Gujarat.
7. MDPP-MPX-HSS-PLN-ABS1-0009-A6-Community Based Disaster Management Plan Midstream Facility Jalore District, Rajasthan
8. MDPP-MPX-HSS-PLN-ABS1-0010-A6-Community Based Disaster Management Plan Midstream Facility Barmer District, Rajasthan.

7.7 *BLOW OUT PREVENTER INSTALLATION AND PHILOSOPHY*

Drilling operations in hydrocarbon exploration and production is hazardous in nature, which can pose risk to life and property in an unlikely event of sudden release of hydrocarbon due to unsafe acts and conditions.

In order to address the risks posed by these activities, policy framework has been developed to ensure that integrity of the wells are properly accounted in the design, planning and operations preventing any uncontrolled influx of formation fluid into the wellbore. The framework describes

- Well Delivery Process Manual
- Well Constructions and Operations Minimum Standards Policy
- Well Integrity management system and Well Integrity management manual

Well delivery process manual defines the entire process of well delivery. The 5 stages of the Well Delivery Process (WDP) are: Scope> Design > Plan > Operations > Closeout.

Design, planning and operations phases are critical in preventing the occurrence of well control events. A 'Statement of requirement (SOR) is prepared stating the surface drilling locations, subsurface targets along with the details of geological hazards and the data related to pore pressures and fracture pressures of the various layers in lithology. Based on the SOR, a specific well plan and design to penetrate the reservoir targets is prepared. The selection of rig, various drilling tangibles and equipment depends upon the expected pressures that need to be withstood during the entire well construction process and life cycle of the well. Risk assessment for each stage of well delivery process is carried out and risk registers are maintained.

Well construction & operations minimum standards policy outlines the minimum requirements for well construction, testing, completion, well intervention and related rig operations. The requirements set out are based on regulatory and international best practices such as:

- Oil Industry Safety Directorate (OISD) - Standards and recommended practices (as applicable);
- American Petroleum Institute (API) standards (as applicable);
- ISO standards (as applicable); and
- International Oil & Gas industry best practices and standards such as NORSOK D-010, BSEE Well Control Rule Apr 2016 etc. as applicable on case to case basis.

For the prevention of any potential well control incident, the 'Well Constructions and Operations Minimum Standards Policy' states the minimum requirements are well barriers, primary and secondary well control, and pressure testing requirements of casings and well control equipment among other requirements. Few key elements of the policy are:

- **Well integrity barriers:** During all well construction/ well intervention operations, a minimum of 2 independently verified barriers are

maintained, of at least one is a mechanical barrier for potential flow such as annular BOP, Ram BOPs, Blind/Shear ram BOPs, Casing pack-off seals, cement behind casing etc. API STD 53 & API RP 53 are followed for the BOP equipment systems.

- **Minimum overbalance requirement:** a minimum 200 psi or 0.8 ppg overbalance, whichever is lower is maintained above the formation pressure during the entire drilling process to prevent any formation fluid influx in the wellbore during the well construction process.
- **Casing design for the mechanical and pressure integrity:** Casing grades/ weights/ metallurgy are selected such that they provide complete mechanical and pressure integrity to the well during well construction using the latest design methods and HSE guidelines. As per international practices, safety factors are taken into account while selecting casings/tubings, where the mechanical and hydraulic integrities are ensured.

Collapse	1.00…….for partial evacuation 0.85 …….for complete evacuation
Burst	1.10
Tension	1.60
Tri-axial	1.10

- **Casing pressure tests:** All casing strings are pressure tested for mechanical and pressure integrity at pressure 500 psi + maximum anticipated load during the life of the well.

Well blowout prevention: Well blowout is uncontrolled flow of formation fluids from a well. This happens because of the failure to maintain any of the above mentioned barriers. If well blowout occurs, then it cannot be contained using previously installed barriers and require specialized services intervention. A blowout may consist of water, oil, gas or a mixture of these. Blowouts may occur during any types of well construction operations or well intervention.

Prevention of blow outs rests on control of any kick/ influx in the well bore. It is achieved by maintaining primary well control. In case the primary well control fails, then secondary well control measures are applied by closing the rams of the well control equipment called Blowout Preventer (BOP) and subsequently circulating the kick (influx) out of the wellbore.

Primary well control: This is achieved by overbalance of hydrostatic pressure of the drilling fluid over and above the pore pressure at the corresponding drilling depths.

- Conventional drilling, completion and work over activities must be carried out with a kill weight fluid column in the hole to prevent an influx of formation fluids. Kill weight is defined as providing a minimum 200 psi or 0.8 ppg overbalance, whichever is lower.
- As a minimum, the following kick detection equipment are used for operational of the wells. The includes active pit volume monitors, flow indicator equipment, gas detection at header box, Rate of penetration recorder (during drilling phase), Mud weight in and out (mud balance) and trip Tank

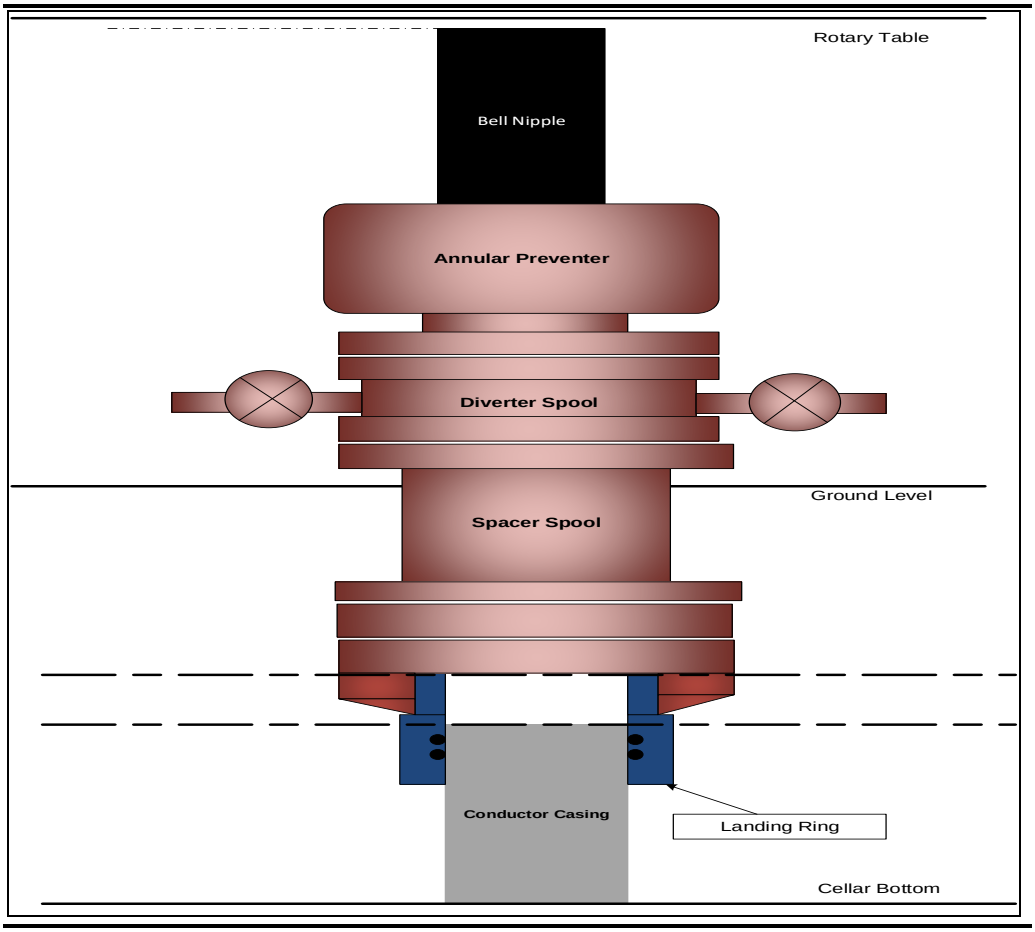
Secondary well control: This is implemented when primary well control has failed to prevent the influx from formation to the wellbore. Secondary well control measures are applied by closing the rams of the well control equipment called Blowout Preventer (BOP) and subsequently circulating the kick out of the wellbore.

- The BOP stack and wellhead in place at any point during the course of the well must be of sufficient working pressure to contain 10% above maximum anticipated surface pressure from the total depth of the current open hole section.
- Kick detection and shut-in drills shall be held once per week with both crews.
- The Company preferred procedure for shutting-in a well is the HARD SHUT-IN (HCRs closed /Shut- in on Annular) method.
- Wells will be killed with the drill string as near to the bottom of the well as conditions dictate. The constant bottom hole circulation method will be used to kill the well.

In case of failure to maintain primary and secondary well control, which may result in a blowout, then 'Blowout contingency plan and recommended practices' are adopted. Cairn has an contract for Emergency Well Control and Firefighting with Wild Well Control Inc, a contractor of international repute to deal with any contingency situation.

Well control equipment: This includes the diverter system, BOP stack, BOP control system, wellhead, wellhead connector, Kelly cocks, drill string safety valves (inside BOPs), the kill and choke lines and manifold and all associated pipework and valves. All the well control equipment are regularly tested and inspected for its effectiveness. For onshore wells in Rajasthan, diverter for the surface hole drilling and BOP stack for the intermediate & production hole drilling, are used as the blowout prevention equipment.

Diverter equipment and minimum requirements: The diverter is used when the well cannot be shut in because of fear of formation breakdown or lost circulation due to shut in of BOP. All onshore wells, where shallow gas hazard have been identified have a diverter system installed for the surface section drilling. The diverter is installed on a conductor casing with large diverter pipe pointing to a downwind area.



BOP and minimum equipment requirements: In a well, after the surface casing, blow-out prevention (BOP) equipment is installed and maintained before resuming drilling. A typical BOP stack contains a number of ram preventers like Annular BOP, Pipe ram, Shear ram and Blind ram etc. the configuration of the BOP stack depends upon the well depth and expected pressures. A typical 5 ksi BOP is shown below in ***Figure 7.5***

- An annular-type blowout preventer can close around the drill string, casing or a non-cylindrical object, such as the Kelly.
- Pipe rams close around a drill pipe, restricting flow in the annulus (ring-shaped space between concentric objects) between the outside of the drill pipe and the wellbore, but do not obstruct flow within the drill pipe.
- Blind shear rams are intended to seal a wellbore, even when the bore is occupied by a drill string, by cutting through the drill string as the rams close off the well.

The minimum requirements are as follows:

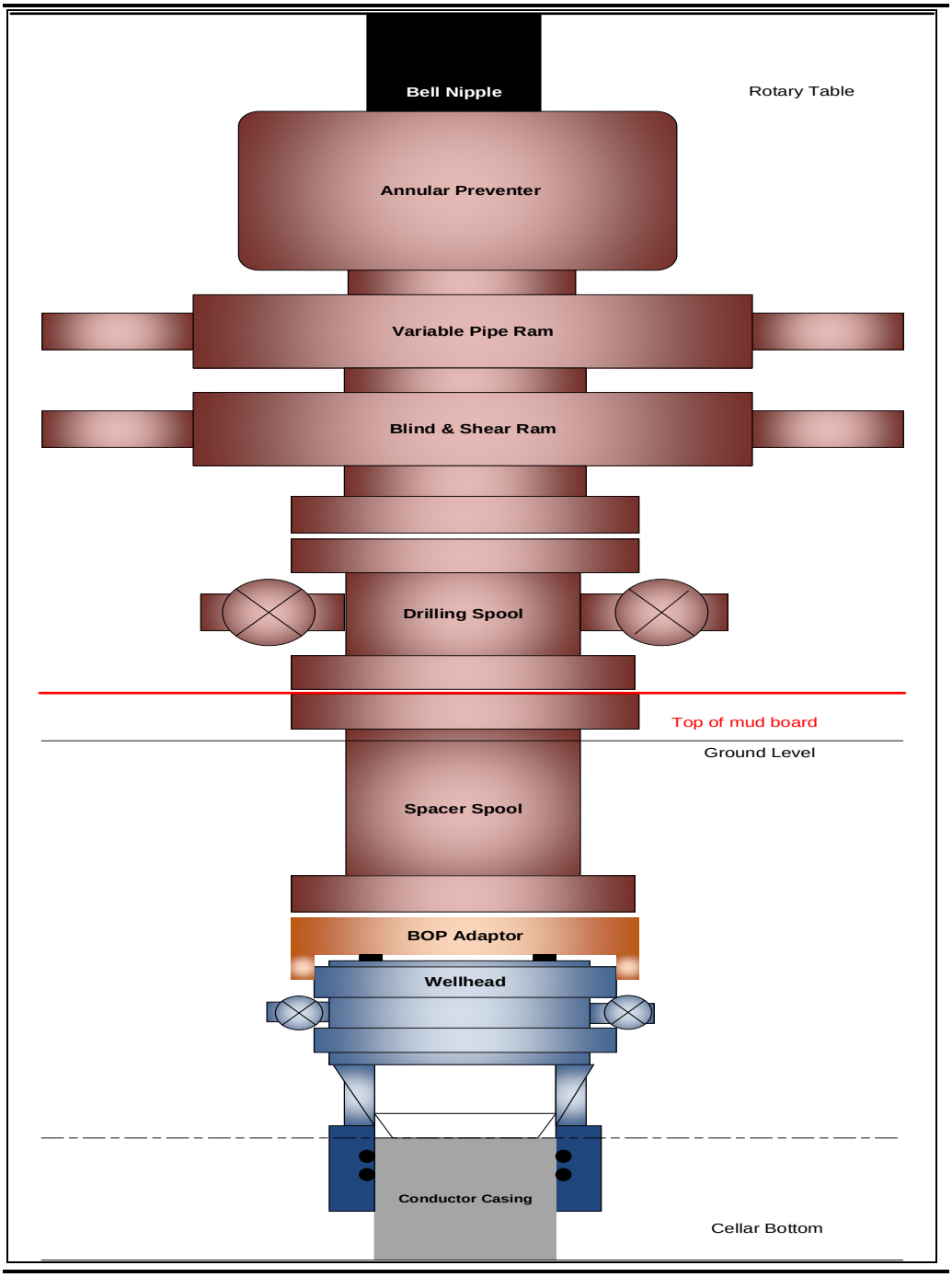
- 5,000 psi or less systems Onshore:1 x Annular and 2 x Rams (1 x pipe and 1x blind shear ram)
- 10,000 psi Onshore: 1 x Annular (5 ksi) and 3 x Rams (1 x blind and shear)
- 15,000psi systems: Onshore: 1 x Annular (10 ksi) and 3 x Rams (1 x blind and shear)

Personnel Requirements

- The well site supervisor ensures that all personnel of cadre 'Driller' and above have a valid 'IWCF Well Control Certification'. '

- The well site supervisor maintain a separate mud material inventory and ensures that adequate weighting up material is available on the rig site at all times for well control requirements as stated in the well construction and operations minimum standard policy.
- All the well control equipment atr inspected and certified as per OEM recommendations as well as to comply with the OISD requirements.
- The wells control equipment's are installed and tested to the required capacities duly witnessed by the Cairn representative.

Figure 7.5 Illustrative 5 ksi BOP



Source: Cairn

7.8 OIL SPILL RESPONSE PLAN

There are three different oil spill response plan prepared by the competent authorities in consultation with Cairn existing procedure and system. OSRP prepared separately for Rajasthan operations (covers all activities within the Rajasthan Block), midstream pipeline operations (covering pipeline and three terminals – Radhanpur, Viramgam and Bhogat) and Bhogat marine operations. Prevention of oil accidental spillage is first priority. To support this strategy, all land based production and drilling facilities are designed, installed and operated to avoid possibility of oil spills. Facilities and resources supplied by third parties are also required to meet national pollution prevention guidelines and operation standards.

Cairn shares the community's concern for the protection of the natural environment from oil spills. Cairn also work and consult with appropriate government bodies and the local community to address any issues relating to oils spills. Cairn is committed to integrating into its plans and operations a process to identify oil & chemical spill risks and to implement appropriate spill response and clean-up strategies. This Oil & polymer Spill Response Plan details Cairn's organizational framework for preparedness and response to oil & chemical spill incident that may arise from its upstream operations in Rajasthan and pipeline operation both in Rajasthan and Gujarat. In addition separate oil spill response plan is prepared for Bhogat marine operations. The principal strategy is for rapid Response, Containment and Clean–up.

7.8.1 *Rajasthan and Midstream Pipeline Operations (OSRP)*

The area of operation is extremely large with a very wide range of natural conditions and circumstances which may be encountered. Oil & chemical spills are unique events and will require individual assessment and development of response actions specific to the conditions encountered at the time of the incident. Cairn has adopted the recognized national / international standard for defining oil spill size by use of Tier levels for onshore activities. The definitions of the tiers within Cairn with respect to spill quantities are as follows:

- Tier 1 event: A small local spill (100T) requiring no outside intervention and can be dealt with on site by local staff and stockpiled equipment.
- Tier 2 event: A large spill (>100T but <1,000T) that would require additional outside resources and manpower, such as an oil spill response contractor. The oil spill response contractor with the spill containment resources is already placed both in Rajasthan and Gujarat. A separate oil spill response contractor is in place at Bhogat terminal for marine operations.
- Tier 3 event: A large (>1,000T) possibly ongoing spill which will require additional regional and possibly government resources. Such spills are very rare and would only occur through full diameter pipe rupture or storage tank collapse or spillage from vessel during loading of oil at SPM location. The response to clean up operation for a Tier 3 event will be augmented by additional resources from an external contractor. Cairn has

a contract in place with the international oil spill and response limited organization, Singapore for any marine related spills.

Incident Response: The Rajasthan Incident Response Plan (RIRP) document no. RJ/QHSE/PLA/921 provides the foundation for incident response. Oil & chemical Spill Response is integral within Cairn Crisis Response System. The emergency classification and details of the tier levels is shown below in ***Figure 7.6*** and is based on the Cairn Risk Evaluation guidelines.

Figure 7.6 Emergency Classifications and Details of Tier Level

Emergency Level	Category	Response	Health & Safety	Environment	Security
Tier 3	Crisis situation appears likely. Duty CMT leader's decision to call out CMT members. Duty CMT leader must notify the Chief Executive Officer.	Crisis Management Team	• Incident leading to loss of facility • Incident leading to significant financial loss • Kidnap or extortion / threat • Incident leading to multiple injuries or a fatality • Total loss of marine vessel • Incident which could lead to international media interest • Major traffic incident with multiple casualties	• Major pollution - Oil spill > 1000T (7000bbls) • Effluent discharge / flaring beyond acceptable limits • Flood or Cyclone warning - Yellow alert - within 12 hours • Major Earthquake	• Terrorist activities / bomb threat • Kidnap or extortion / threat • Major civil unrest
Tier 2	Substantial incident. Duty EMT leader's decision to call out EMT members. Duty EMT leader must notify duty CMT leader.	Emergency Management Team	• Fire & or explosion • Injury or illness requiring evacuation • Traffic accident requiring external assistance • Marine incident like vessel collision • Flood or Cyclone warning - Blue alert - within 48 hours	• Oil spill from > 100T but < 1000T (700 - 7000bbls) • Offsite environmental exposure contained with outside help • Earthquake • Flood or Cyclone warning - Blue alert - within 48 hours	• Civil unrest or security breach • Major Criminal activity
Tier 1	A minor incident where site/location requires no external assistance and can control the incident with location resources. Incident Controller must notify leader of the ERT or EMT of the situation.	Incident and Emergency Response Teams	• Minor medical or injury case requiring no external support • Equipment damage without loss of production • Minor fire without injury or plant damage • Rescue of trapped and injured personnel	• Minor oil spill < 100T (700bbls) • Onsite environmental exposure contained with internal effort e.g. chemical spill • Notification of cyclone within 72 hours	• Notification of cyclone within 72 hours

Source: Cairn

Cairn defines emergency situations in three tiers of severity, related to the scale of the incident and the capability of the organization to respond effectively. The Site Incident Controller is responsible for coordinating the on-site tactical response to any Oil & chemical Spill emergency that may occur within Rajasthan Field. The Incident Controller will notify and liaise with the Emergency Management Team Leader in Gurgaon via Emergency Team Leader based at Barmer. The Installation Manager is designated as site Incident Controller for oil spill emergencies. The relationships between the various response organizations is shown below in ***Figure 7.7***.

Figure 7.7 Incident Response Activation Based on Tier Levels

Source: Cairn

7.8.2 Oil Spill Support agencies

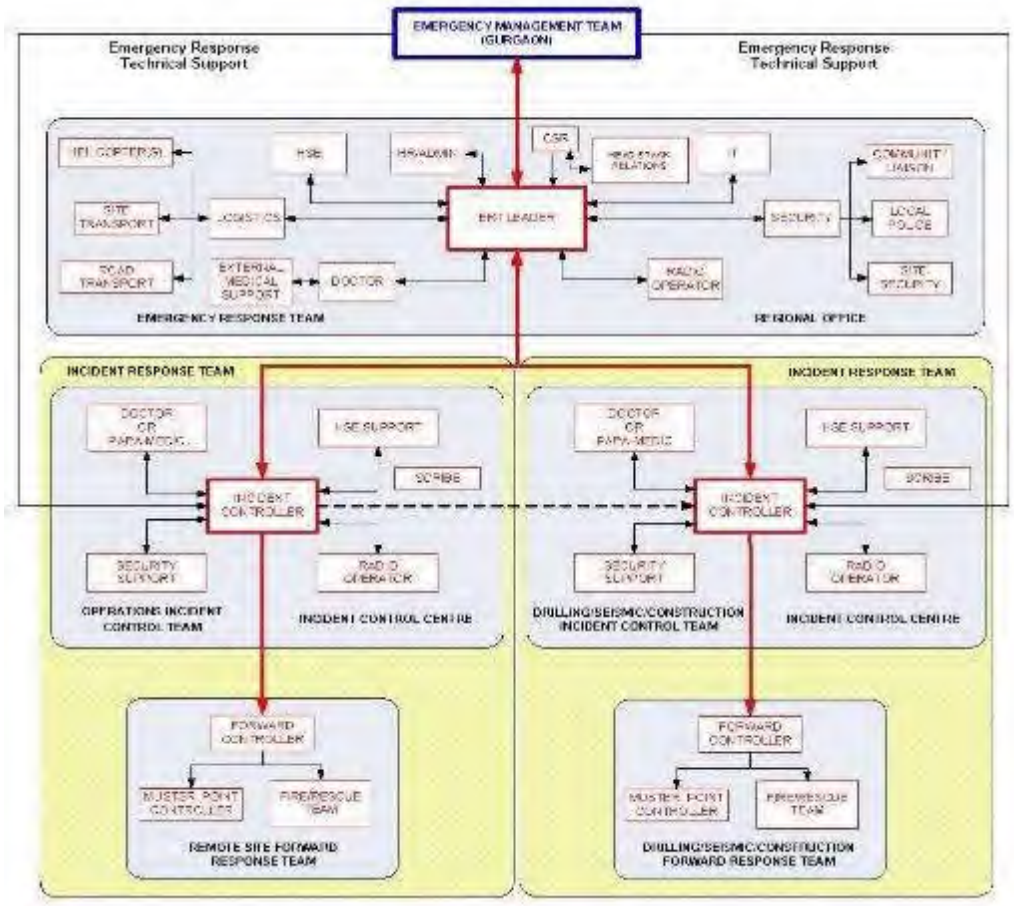
Tier 1 Contractor: Cairn is into an agreement with a third party service provider capable of providing such services to respond to Tier-1 level of oil spills. Based on the software simulation models, it has been identified that the maximum credible oil spill scenario may result from Bhagyam-MPT trunk line and accordingly the oil spill response has been established to manage and recover spills up to 700 MT of well fluids/450 MT of crude oil. This service will cover a entire Rajasthan operations. In case of major oil spill or leak, the spill response team will be backed up by Cairn's forward controller team and Incident Response Team based in each fields. The resource for the Tier 1 response such as boom, skimmer, oil dispersant, oil absorbing socks/pads, working tools, PPEs etc., is located at MPT (refer ***Table 7.14*** for details of containment and clean up material)and shall be dispatched on need basis to various locations.

Table 7.14 Containment and clean up material available at site (each at MPT and Viramgam)

S. N.	Items Description	Quantity	Capacity
1.	Bunk container (20'x8'x8) with 04 nos.	1 no.	-
2.	Truck 4x4 for OSR equipment's	1 no.	-
3.	Power pack unit for the Supplies air to air bottle	1 no.	24.8 HP
4.	Air Compressor	1 no.	200 Liters
5.	High pressure jet cleaner unit for surface cleaning	1 no.	3.88 kW
6.	DG single phase - for site for electrical lighting.	1 no.	5kV/230 V
7.	Hose 3" (12 nos., 15 m each) for transferring Oil from pump to portable tanks	12 nos.	15 m each
8.	Air hoses 20 mm connection to compressor and Weldon pump	1 no.	110 m
9.	Hydraulic hand/pallet - Lifting of equipment and shifting	1 no.	2.5 T

S. N.	Items Description	Quantity	Capacity
10.	Engine driven gear pump For transferring Oil	1 no.	20TPH
11.	Sala roll power pack unit	1 no.	10TPH
12.	Sala roll pump Transferring Oil to portable tanks	1 no.	-
13.	Weldon pump Transferring Oil to portable tanks	2 nos.	15TPH
14.	Fire Extinguisher For first Aid Fire Fighting	1 no.	5 kg
15.	Medical first Aid box	1 no.	-
16.	Open storage tank - Consist of Angular pipe- 40 nos., T types pipe - 40 nos., C type pipe - 80 nos. and Straight pipe - 40 nos.	10 nos.	10 T each
17.	Chain pulley 5 M	01 nos.	03 T
18.	Road barrier/safety cone	06 nos.	-
19.	Halogen light	04 nos.	-
20.	"D" shackles	16 nos.	3¼ T
21.	Lifting belt 3mtrs	08 nos.	02 T
22.	Wooden Planks	11 nos.	-
23.	LEL meter dual gas detector	01 nos.	-
24.	Foot pump - Used for filling of air in tyres	01 nos.	-
25.	Petroleum remediation powder - Used for bioremediation		200 kg
26.	Wind sock with 06 m pipe	06 nos.	-
27.	Red flag 3x2 with 10 ft. pipe	06 nos.	-
28.	Shovel, bucket, tarpaulin each	15 nos.	-
29.	Brush skimmer	01	10 TPH
30.	Floating tank	05 nos.	10 T each
31.	Cleaning soda	01 nos.	50 kg
32.	Foam filled boom	01 no.	500 m
33.	Plastic sheet	01 no.	100 m
34.	PVC bag	15 nos.	-
35.	PVC sag	45 nos.	-
36.	Rag piece	01 no.	200 kg
37.	Nose mask	60 nos.	-

Figure 7.8 Emergency Organizations and Relation ship



Source: Cairn

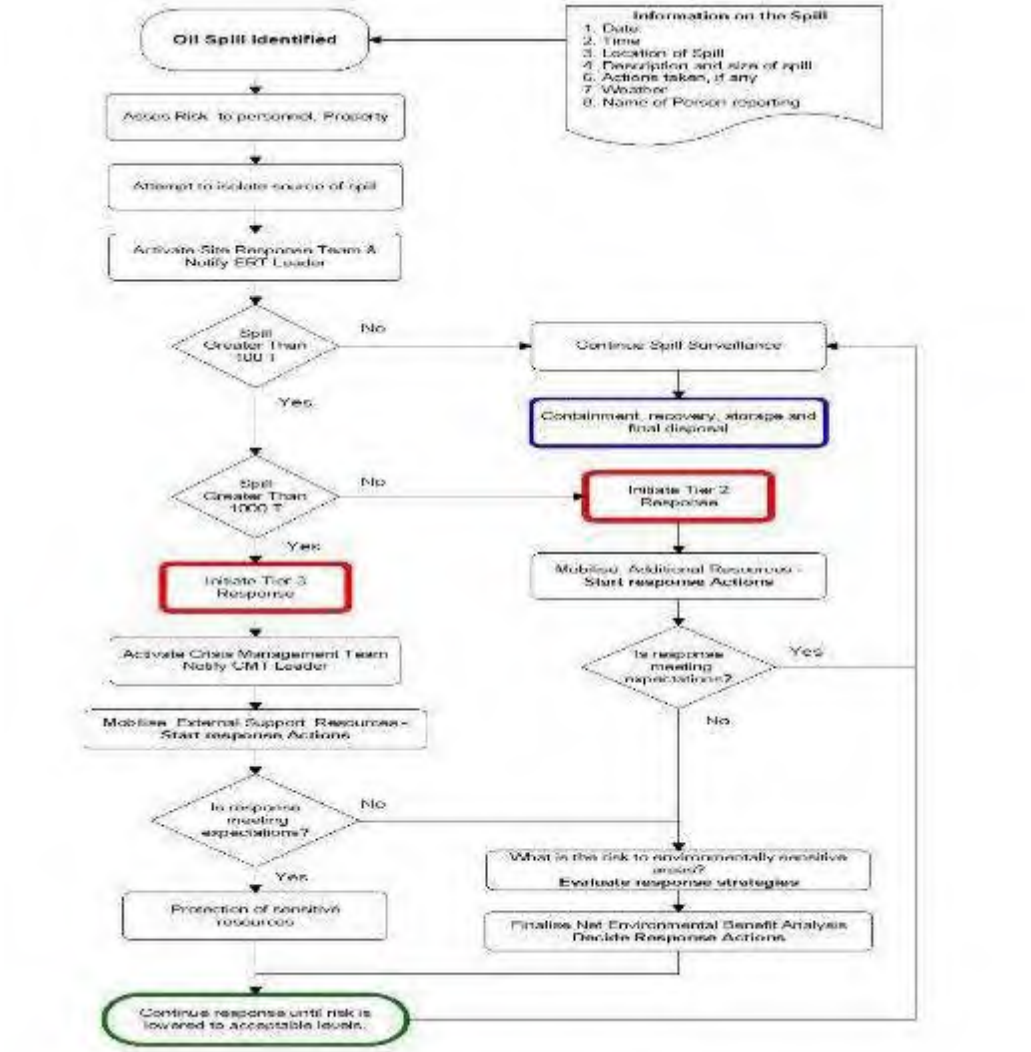
Tier 2 & 3 Contractor: Cairn has a membership with an organization namely "Oil Spill Response (OSR)" at Singapore who is the world's largest international oil spill preparedness and response organization. They provide technical response and resources to mitigate Tier 2 and 3 oil spills. In addition to the supply of equipment, they also provide experienced personnel to assist in the response. The Incident Controller can notify ERT / EMT to activate OSR's services from Singapore, during major oil spill related incident and place them on alert. It is the Emergency Management Team Leader's responsibility to initiate the mobilization of the contractor.

'Oil Spill Response Decision Tree' is shown below in ***Figure 7.9***. It provides a guide to the Installation / Site Management team in formulating their response to an oil spill. Effective response to an oil spill requires rapid mobilization of resources depending on a number of factors, one of the most critical of which is the time taken to activate this plan and mobilize equipment and resources to the scene of the spill. To ensure efficiency of response, a Tiered approach is employed by Cairn in line with national guidelines. This OSRP takes into account the response time needed to mobilize, transport and deploy increasing amounts of resources to the scene of a spill for spills of different sizes and locations.

Tier 1: Mobilization of Cairn's field based land oil spill equipment and response personnel to deal with operational spills of up to 100 tons within 6 hours particularly for those spills that are associated with the interfiled pipelines.

Tier 2 & 3: Mobilization of spill control team, response equipment and personnel plus assistance from local resources within 24 hours to deal with spills up to 1,000 tons. The availability of these resources and the response time are to be ascertained.

Figure 7.9 Oil Spill Response Decision Tree



Source: Cairn

Disposal of Oil and debris: The recoverable oil in Rajasthan shall be put back in to off-spec tank at MPT for further processing. Recovered oil and oily debris in RJ field will be sent at dedicated captive hazardous waste landfill at MPT and or towards co-processing to the cement industry along with other type of waste disposal (mainly drill cuttings). The oil spill waste collected in Gujarat will be disposed to the authorized TSDF.

Training, Drills and Exercises: To ensure the effectiveness of the OSRP, Chief HS officer of RJ operations will develop the mock drill calendar for various

scenarios of oil spillage to be conducted annually. Also there shall be training calendar to train the site personnel on OSRP.

7.8.3 Bhogat Marine Operations OSRP

The Bhogat Marine Oil Spill Contingency Plan (OSCP) is developed for personnel dealing with an unexpected discharge of oil from the marine facilities of Bhogat terminal. Its primary purpose is to facilitate the implementation of the necessary actions to stop or minimize the discharge and to mitigate its effects. The plan has been prepared for marine oil spills, ranging from local through to international significance, based on the tiered response concept. The development of the Bhogat Marine OSCP is guided by the OISD (Oil Spill Industry Directorate of India) Guidelines for Preparation of Oil Spill Response Contingency Plan, India NOSDCP (National Oil Spill Disaster Contingency Plan) Circular No:02/2012 and the IPIECA (International Petroleum Industry Environmental Conservation Association) recommended format.
OSRL carried out various oil spill modelling scenarios of crude oil and LFO spill in the SPM and other locations. Based on the spill outcome, the minimum equipment's required to contain the spill if any was finalized.

Tiered Response Approach: The concept of Tiered Preparedness and Response provides a structural approach to design and build levels of oil spill preparedness to respond to an incident in such a manner that additional resources can be called upon and integrated into a response operation as an incident grows in severity. Indian legislation identifies three tiers for the control and management of oil spills. These are as follows:

Tier 1: Operational Spills up to 700 tons that can be dealt by individual ports or oil handling facilities
Tier 2: Spills up to 10,000 MT that may require the pooling of government or privately owned resources at a local level
Tier 3: A major or catastrophic oil spill incident of more than 10,000 MT, where additional assistance is sought from governmental or international organizations for oil spill response

7.8.4 Oil Spill Response Resources

Tier 1 Capability: Cairn has in-house capability to handle Tier 1 spills. The Tier 1 equipment available at the Bhogat Terminal & OKHA port warehouse. The response inventory is positioned on SPM support vessel along with trained personal during tanker operations. The complete inventory lists of Tier 1 is as per the NOSDCP guidelines. The activation of Tier 1 resources would be by the Incident Controller of IRT.

Tier 2 Arrangements: Cairn has Tier 2/ mutual aid agreement in place for CIL's Bhogat Marine Terminal facilities. The oil spill response equipment held by operators in the same area such as ESSAR and reliance would be utilized based on need basis.

Tier 3 Arrangements: Cairn has an associate member agreement with OSRL for Bhogat Marine facilities, which are covered under the membership agreement with OSRL. In the event of an incident from the Bhogat Marine facilities, Cairn may have to activate Third Party Agreement with OSRL in consultation with EMT/CMT leader. The details of Notification and Activation procedure for OSRL and the complete list of response equipment available can be found in the OSRL website; www.oilspillresponse.com. In the event that OSRL is activated for response support for a Tier 3 oil spill incident from Bhogat Marine Terminal and associated facilities, the resources would most likely be mobilized from OSRL's Singapore Operational Base. To be able to respond as quickly as possible OSRL will mobilize its equipment using its own Hercules aircraft from Singapore. The nearest port of entry identified is the Ahmadabad International Airport. Upon receiving the necessary customs and immigration clearance, the aircraft will then fly to Porbandar airport. The approximate time it will take to fly from Singapore to Porbandar, excluding clearance of immigration and customs is 18-20 hours.

Figure 7.10 Response Strategy Decision Flow Chart

Source: Cairn

Reference:

1. Oil and Polymer Spill response Plan - RJON-MRX-HSS-PLN-0002, June 2017
2. Oil Spill Response and Containment Plan prepared for midstream pipeline operations, 2005

3. Marine Oil Spill Contingency Plan prepared by OSRL, Singapore - MDPP-BRX-OSC-REA-OSR1-0001, Rev.03, September 2014.

7.9 OCCUPATIONAL HEALTH AND SAFETY

Cairn has developed a guideline document no. Document No: CIL/HSEQ/GDL/16/000008 for "Pre-employment & periodic medical check-up". As per this guidelines, the scope of pre-employment, periodical medical examination and exit medical examination Protocols, periodicity and fitness forms are maintained at RJ-ON-90/1 Block as per the Mines Act, 1952, Mines Rules, 1955; whenever Radiography activities and Radioactive source are used, Atomic Energy Act, 1962 read with Atomic Energy (Radiation Protection) Rules, 2004 are applicable and accordingly Pre-Employment& Periodic Medical Examinations are conducted. Whereas for the midstream pipeline operations in Gujarat state, the Factory act 1948 and Gujarat Factory Rules are followed.

The pre-employment medical examination (PEME) and periodical medical examination process is applicable for the following categories prior to their appointment and after continuing the services in the company:

- National Employees
- National Direct Consultants
- Third Party Consultants and Contract workers
- Tenure/ Term based Staff
- Graduate/Management Trainees
- Expat Employees
- Expat Consultants (Short Term Expat Contract)

Periodicity of medical examination has been prescribed as per - Statutory requirements as below.

Type of medical examination	**Employee to be covered**	**Periodicity**
Pre-employment medical examination	• National Employees • National Direct Consultants • Third Party Consultants and Contract workers • Tenure/ Term based Staff • Graduate/Management Trainees • Expat Employees • Expat Consultants (Short term expat contract)	Prior to the employment.
Periodic medical examination as per Cairn medical procedure	For all Cairn employees below 35 years of age.	Once in 3 years.
	For all Cairn employees 35 years & above 35 years of age.	Annually
Periodic medical examination as per Oil Mines Regulations &	For all third party consultants and contract workers. (As per OMR: medical examination is to be done once in 5 years or 10% of employees	Up to 10% of employees are to be examined in a particular year or once in 5 years as per the statutes. However, if the

Type of medical examination	Employee to be covered	Periodicity
Mines act – 1952, OISD rules 2008.	are to be examined in a particular year.)	contract validity is for 3 years, PEME will be done initially during employment and PME is to be done once in every 3 years or whenever contract changes. If contract period is below 3 years PEME shall be conducted.
Periodic medical examination (for daily casual workers)	For all daily casual workers	Annually
Periodic medical examination as per the Gujarat Factory Rules	For all personnel (mentioned under section 2.1) engaged in pipeline operations - non- hazardous locations. For all personnel (mentioned under section 2.1) engaged in pipeline operations - hazardous locations.	Annual medical check-up, including Chest X-Ray. Half yearly medical checkup (chest X-Ray not required). However in annual medical check-up Chest X-Ray is required.
Intermediate medical examination	For those Employees who have suffered from major diseases / accidents or in specific cases requiring medical investigation.	Intermediate medical examination.

Source: Cairn

- Medical examination will be conducted at Cairn approved Hospitals / FHPL tie-up hospitals. Corporate Medical Advisor who will be the authority to certify a candidate as medically fit/ unfit/ temporarily fit/ unfit in respect of all employments in the company.

- The Corporate Medical Advisor will forward the medical fitness certificate to the HR SPOC, declaring the candidate- "Fit", "Fit with recommendation", "Conditionally fit", "Temporarily unfit" or "Unfit". Where a candidate has been declared "Temporarily Unfit" by reasons of short term sickness, which is curable within a period of not more than thirty days, the candidate will be required to undergo a re-examination within thirty days from the date of his/her being declared "Temporarily Unfit". At the time of re-examination, he/she will be required to produce proof of treatment and certificate of cure from the Doctor who treated him/her. After submission of medical fitness post short term sickness, the Corporate Medical Advisor will certify the candidate as medically fit. The period may be relaxed depending upon the job requirement or as per the mutual agreement of the respective management. However the Corporate Medical Advisor has the authority to discuss with the Specialist Doctor, giving the fitness certificate prior to declare him/her fit on Company roles / as assigned.

Occupational health surveillance program: Cairn adopts the occupational health surveillance as per the applicable statutory requirements and Cairn procedure, which are detailed below in ***Table 7.15***

Table 7.15 Details of OHS Surveillance Program

S.N.	Title of Requirement	Acts/ Rules/ Regulations	Reference Clause	Requirement Description as per the Act	Frequency	Form/Records to be maintained
1	Initial medical examination for employees	Mines Act, 1952 and Mines Rules, 1955	Rule 29B(a)	Every owner, agent and manager of mine shall arrange initial medical examination of persons employed in the mine	Initial (Pre-employment)	Form-O
2	Medical examination of employees	Mines Act, 1952 and Mines Rules, 1955	Rule 29B clause b, Rule 29D, Sub-rules 1&2	Every owner, agent and manager of mine shall arrange periodical medical examination of every person employed in the mine every 5 years. Note: a notice at least 20 days prior to the person to be examined should be provided in Form M and send a copy of the notice to the examining authority	Every 5 years	Form-M
3	Retention and transfer of medical certificates	Mines Act, 1952 and Mines Rules, 1955	Rule 29G(1)	Every owner, agent and manager of mine shall maintain all medical examinations history depicting occupational dust exposure profiles of persons employed till a person is employed and ten years thereafter		
4	Issue notice to person who is not present for Medical reexamination	Mines Act, 1952 and Mines Rules, 1955	Rule 29J, Sub-rule 2(b)	Every owner, agent and manager of mine shall issue a notice in Form R to the person who has failed to submit himself for reexamination without furnishing any reasonable cause		Form-R
5	Cost of medical examination	Mines Act, 1952 and Mines Rules, 1955	Rule 29O	Every owner, agent and manager of mine shall bear the complete cost of all the medical examinations prescribed under these rules		
6	Health Surveillance of workers	Atomic Energy Act, 1962 read with Atomic Energy Radiation Protection) Rules, 2004	Rule 25	The employer must ensure to provide services of a physician to undertake occupational health surveillance of classified workers. Health surveillance of workers shall be carried on. Workers on employment and thereafter shall be subject to medical examination once every 3 years.	Every 3 Years	
7	Responsibilities of an employer	Atomic Energy Act, 1962 read with Atomic	Rule 20	The employer must ensure to cater to the following responsibilities – 1. As mentioned below	Annual/Termination	

S.N.	Title of Requirement	Acts/ Rules/ Regulations	Reference Clause	Requirement Description as per the Act	Frequency	Form/Records to be maintained
		Energy (Radiation Protection) Rules, 2004		a) ensure that provisions of these rules are implemented by the licensee, Radiological Safety Officer and other worker(s), b) provide facilities and equipment to the licensee, Radiological Safety Officer and other worker(s) to carry out their functions effectively in conformity with the regulatory constraints, c) prior to employment of a worker, procure from his former employer, where applicable, the dose records and health surveillance reports, d) upon termination of service of worker provide to his new employer on request his dose records and health surveillance reports, e) furnish to each worker dose records and health surveillance reports of the worker in his employment annually, as and when requested by the worker and at the termination of his service, f) inform the competent authority if the licensee or the Radiological Safety Officer or any worker leaves the employment, and g) Arrange for health surveillance of workers as specified under rule 25. 2. The employer shall be the custodian of radiation sources in his possession and shall ensure physical security of the sources at all times. 3. The employer shall inform the competent authority, within twenty four hours, of any accident involving a source or loss of source of which he is the custodian.		
8	Conducting medical examination of the workers	Atomic Energy Act, 1962 read with Atomic Energy (Working of the Mines, Minerals and Handling of Prescribed Substances) Rules, 1984	Rule 7 (j)	The licensee shall ensure to arrange for pre-employment and post termination/ Retirement medical examination of all employees. Only after declaring fit post medical examination shall a worker be employed and he must be subject to annual medical examination including Chest X -	Annual/ Termination	

S.N.	Title of Requirement	Acts/ Rules/ Regulations	Reference Clause	Requirement Description as per the Act	Frequency	Form/Records to be maintained
				Ray, general laboratory investigations such as examination of blood and excreta, and special investigation such as examination of skin, hands, fingers, finger nails, ears and eyes.		
9	Maintenance of records	Atomic Energy Act, 1962 read with Atomic Energy (Working of the Mines, Minerals and Handling of Prescribed Substances) Rules, 1984	Rule 7 (k)	The licensee shall ensure to maintain complete and up-to date records of personal, medical and occupational histories of radiation workers and workers in mines in prescribed form.		Prescribed Form
10	Occupational diseases- Payment of fees of the medical practitioner	Mines Act, 1952 and Mines Rules, 1955	Rule 82	Every owner, agent and manager of mine shall pay the medical practitioner a fee not exceeding Rupees sixteen for every clinical examination or X-ray examination made.		
11	Making available health records to workers	Factories Act, `1948 & Gujarat Factories Rules	Rule 68-R	The occupier of every factory involving a 'hazardous process' shall make accessible the health records including the record of worker's exposure to hazardous process or as the case be, the medical records of any worker for the perusal under the following conditions: a) once in every six months or immediately after the medical examination whichever is earlier; b) if the Factory Medical Officer or the Certifying Surgeon as the case' may be, is of the opinion that the worker has manifested signs and symptoms of any c) notifiable-disease as specified in the Third Schedule of the Act; d) if the worker leaves the employment; e) if any one of the following authorities so direct :- - The Chief Inspector of Factories; - The Health Authority of the Central or State Government; - Commissioner of Workmen's Compensation;	Six Month/ Termination	

S.N.	Title of Requirement	Acts/ Rules/ Regulations	Reference Clause	Requirement Description as per the Act	Frequency	Form/Records to be maintained
				- The Director General, Employees State Insurance Corporation; - The Director. Employees State Insurance Corporation (Medical Benefits); and - The Director General, Factory Advice Service and Labour Institutes.		
12	Medical Examination	Factories Act, `1948 & Gujarat Factories Rules	Rule 68-T	68-T. Medical examination- 1. Workers employed in a 'hazardous process' shall be medically examined by a qualified medical practitioner hereinafter referred to as Factory Medical Officer, in the following manner: a) Once before employment, to ascertain physical fitness of the person to do the particular job; b) Once in a period of 6 months, to ascertain the health status of all the workers in respect of occupational health hazards to which they are exposed: and in cases where in the opinion of the Factory Medical Officer it is necessary to do so at a shorter interval in respect of any workers; c) The details of pre-employment and periodical medical exam, carried out as aforesaid shall be recorded in the Register in Form No. 32. 2. No person shall be employed for the first time without a certificate of fitness in Form No. 33 granted by the Factory Medical Officer. If the Factory Medical Officer declare a person unfit for being employed in any process covered under sub rule (1), such a person shall have the right to appeal to the Inspector who shall refer the matter to the Certifying Surgeon whose opinion shall be final in this regard. If the Inspector is also a Certifying Surgeon, he may dispose of the application himself.	Six Month	Form-32 & Form-33

S.N.	Title of Requirement	Acts/ Rules/ Regulations	Reference Clause	Requirement Description as per the Act	Frequency	Form/Records to be maintained
				3. Any findings of the Factory Medical Officer revealing any abnormality or unsuitability of any person employed in the process shall immediately be reported to the certifying Surgeon who shall in turn, examine the concerned worker and communicate his findings to the occupier within 30 days. If the Certifying Surgeon is of the opinion that the worker so examined is required to be taken away from the process for health protection, he will direct the occupier accordingly, who shall not employ the said workers in the same process. However, the worker so taken away shall be provided with alternate placement unless he is in the opinion of the Certifying Surgeon, fully incapacitated in which case the worker affected shall be suitably rehabilitated. 4. A Certifying Surgeon on his own motion or on a reference from an Inspector may conduct medical examination of a worker to ascertain the suitability of his employment in a hazardous process or for ascertaining his health status the opinion of the Certifying Surgeon in such a case shall be final. The fee required for this medical examination shall be paid by the occupier. 5. The worker taken away from employment in any process under sub rule (2) may be employed again in the same process only after obtaining the Fitness Certificate from the Certifying Surgeon and after making entry to that effect In the Health Register. 6. The worker required to undergo Medical Examination under these rules and for any Medical Survey conducted by or on behalf of		

S.N.	Title of Requirement	Acts/ Rules/ Regulations	Reference Clause	Requirement Description as per the Act	Frequency	Form/Records to be maintained
				the Central or the State Government shall not refuse to undergo such a medical examination.		
13	DGMS Returns by Contractors	XIth Conference on Mine Safety (Implementation of Recommendations) – email July 2015	S. No. 1.8.2 (i)	The contractor shall submit to DGMS returns indicating – Name of his firm, Registration number, Name and address of person heading the firm, Nature of work, type of deployment of work persons, Number of work persons deployed, how many work persons hold VT Certificate, how many work persons undergone IME and type of medical coverage given to the work persons. The return shall be submitted quarterly (by 10th of April, July, October and January) for contracts of more than one year. However, for contracts of less one year, returns shall be submitted monthly.	Quarterly/ Monthly	DGMS returns
14	Medical fitness of offshore going employees	Petroleum and Natural Gas (Safety in Offshore Operations) Rules, 2008.	Rule-39	The operator shall ensure that-(a) minimum physical efficiency criteria are laid down to maintain and enhance safety standards; and(b) only medically fit persons who meet the minimum physical efficiency standards are allowed to work on the installation.	Initial (Pre-employment)	
15	Medical examination of the employees	Petroleum and Natural Gas (Safety in Offshore Operations) Rules, 2008.	Reg. 42	The operator shall ensure that the employees are offered periodic medical check-up to ascertain any long term effects of working environment causing occupational diseases and take remedial measures.	PME	

References: Medical surveillance program is carried out as per the Mines Act – 1952; Oil Mines Regulations (OMR); Gujarat Factory Rules; Atomic Energy Act, 1962 read with Atomic Energy (Radiation Protection) Rules, 2004; Petroleum and Natural Gas (Safety in Offshore Operations) Rules, 2008; and OISD standards.

Annex G

Consequence Analysis Map

Figure 1 *Scenario 2 - MPT Slug Catcher V-1201 (100 mm Pool Fire)*

Figure 2 *Scenario 3 - MPT Slug Catcher V-1201 (100 mm Jet fire)*

Figure 3 *Scenario 5 - SUPP Slug Catcher V-102 (Pool fire)*

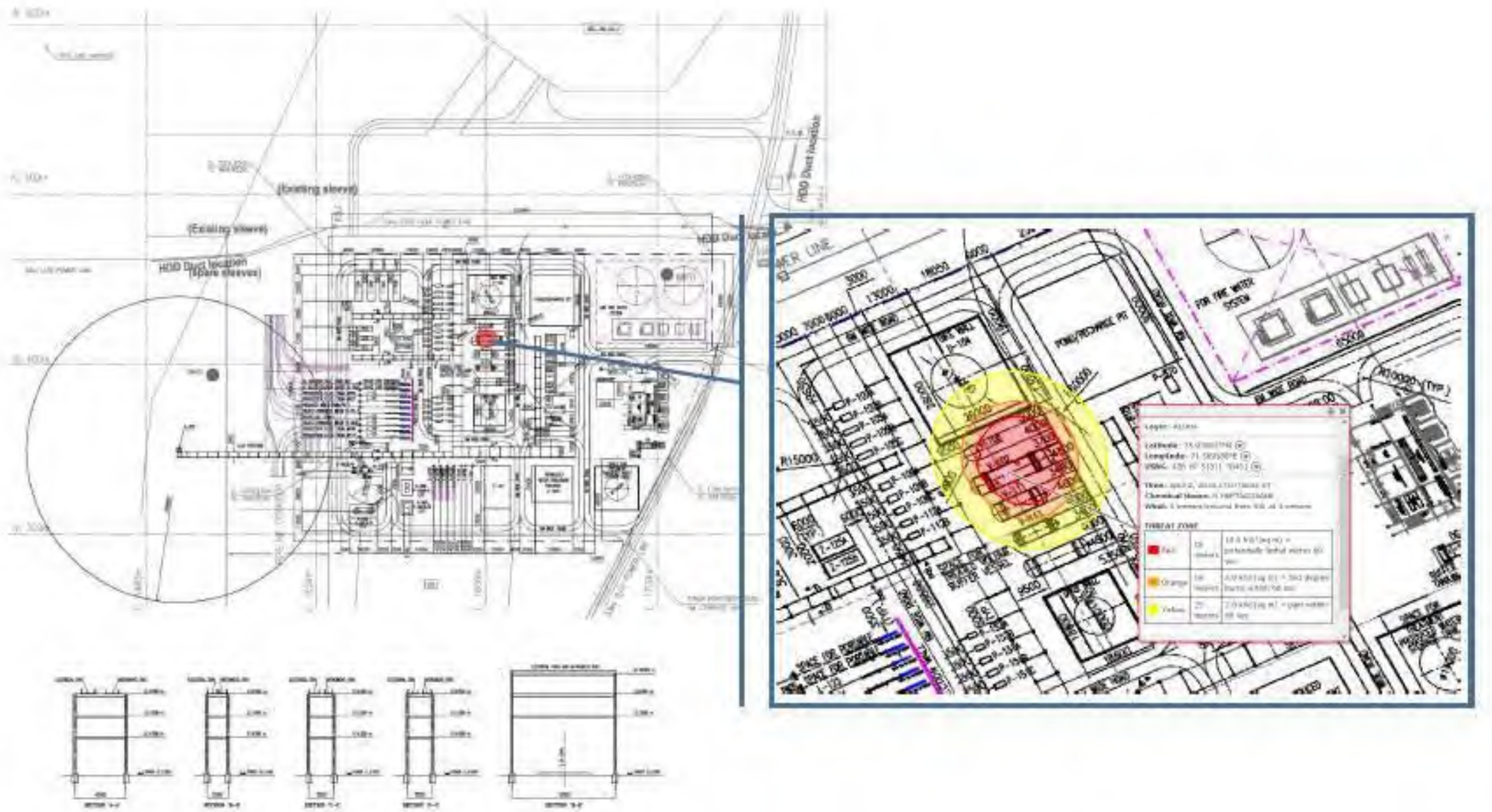


Figure 4 *Scenario 11 - RDG Slug catcher SP 981 (100mm jet fire)*

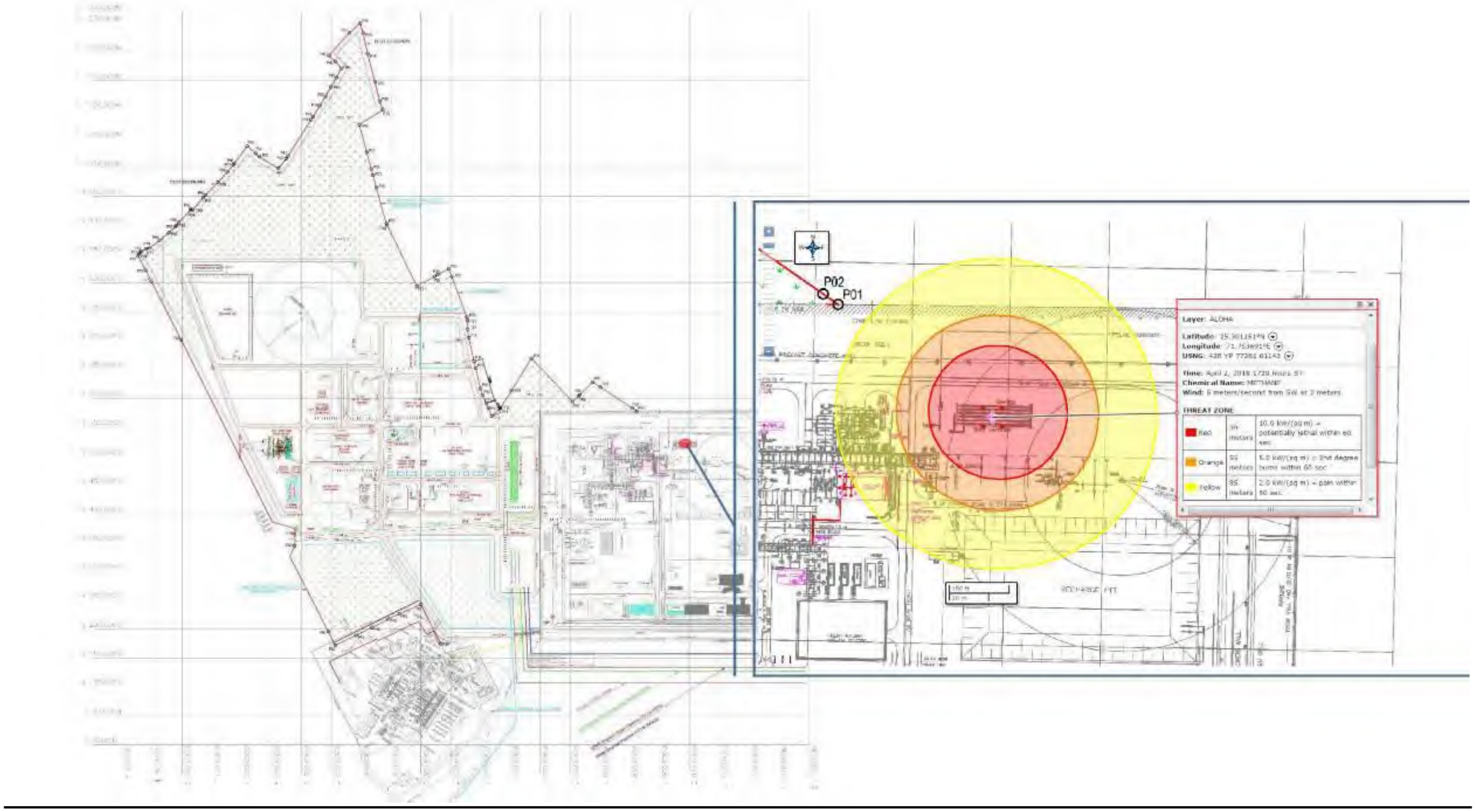


Figure 5 *Scenario 12 - RDG Slug catcher SP 981 (pool fire)*

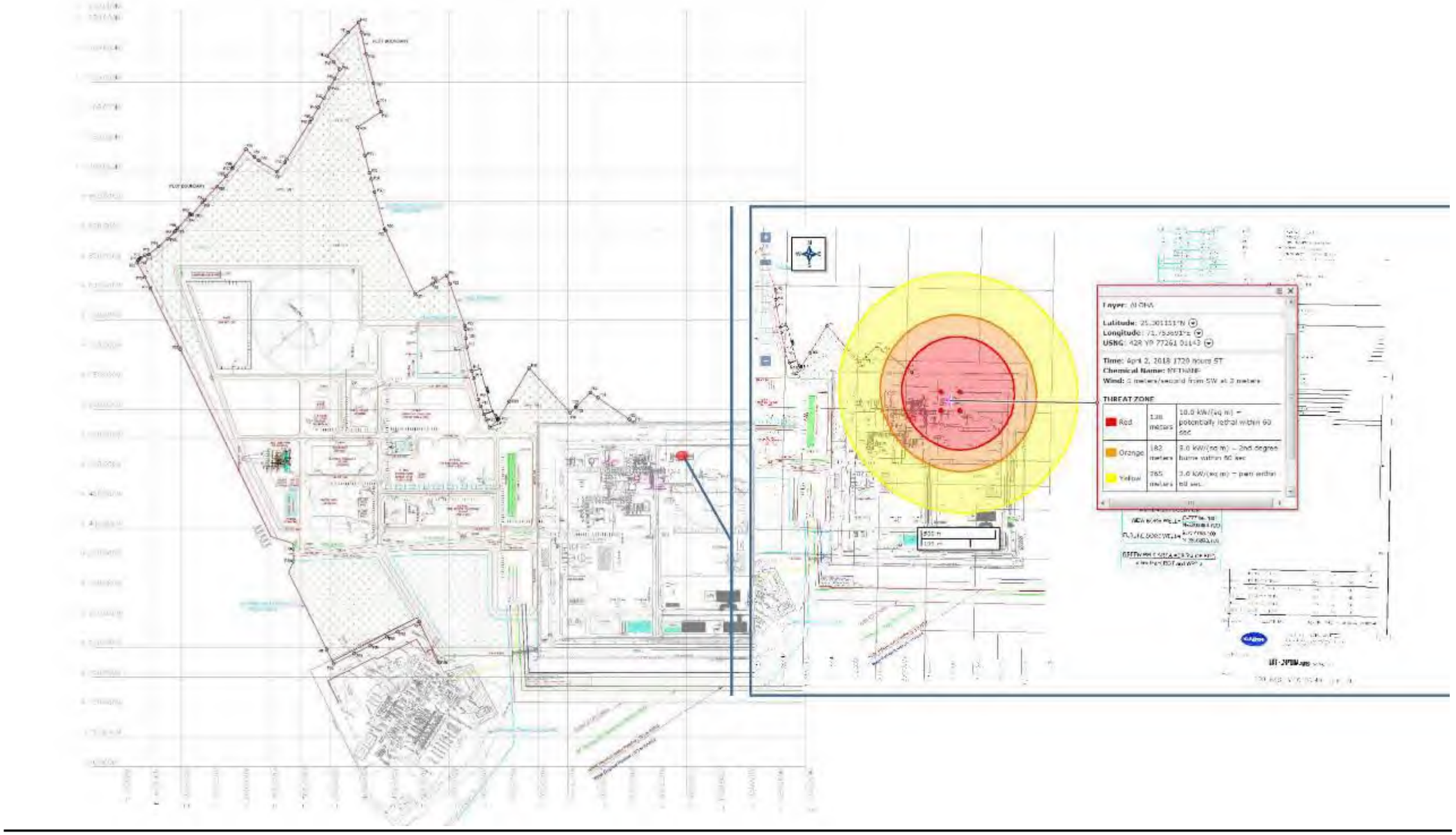


Figure 6 *Scenario 14 - RDG overpressure contours from a 100mm leak case slug catcher SP 981 (VCE)*

Figure 7 *Scenario 22 - RDG over pressure from instant release from propane storage tank V-851 (Rupture- VCE)*